PCM-4
PCM Channel Measuring Set

BN 0984/01, Series AK ...

Operating Manual

Wandel & Goltermann
Communications Test Solutions

Please direct all enquiries to your local Wandel & Goltermann sales company. The addresses are given at the end of this handbook.

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Addendum to PCM-4, Operating Manual, BN 0984

Supplement to section 1.41GENERAL SPECIFICATIONS

Electromagnetic compatibility (EMC)

Spurious emissions

This instrument fulfils the requirements of EN 50 081-1 and thus the limit class B of EN 55 022 (identical to CISPR 22:1985 modif., DIN VDE 0878 Part 3) and of FCC Rules Part 15 Subpart J Class A. The instrument meets the safety targets of European Directive 89/336/EWG of May 3, 1989 with respect to spurious emissions. No special operating permit is required. Sufficient shielding must be provided.

This instrument has been inspected such that the requirements for spurious emissions from this instrument are also meet when it is used as part of a system.

The prerequisite is a correctly designed system and the use of proper connection cables, with special attention paid to the presence of sufficient shielding.

If the device under test (DUT) to which this instrument is connected can produce spurious emissions itself (e.g. if the connection to the DUT is not uniformly shielded), the operator must take pains to ensure that no unallowed spurious emissions are generated. Suitable shielding must be provided.

Immunity to electrostatic discharge per IEC 801-2

*Reduced functioning, automatic recovery up to . . . . . 8 kV

Immunity to electromagnetic fields per IEC 801-3

Fully functional up to . . . . . 3 V/m

in the frequency range . . . . . 26 to 1000 MHz

Immunity to rapid, transient disturbances per IEC 801-4

On the supply network
*Reduced functioning, automatic recovery up to . . . . . 1 kV

On the signal lines
*Reduced functioning, automatic recovery up to . . . . . 500 V

* Definition of "Reduced functioning, automatic recovery up to":

During the impairment, the signal received by the instrument can be impaired such that an error is detected or a measurement error can occur. This can be a code error, for example, and depending on the point in time, a bit, FAS or parity error. Error bursts can cause alarms. The errors or alarms occur only during the impairment.

To minimize the influence of the impairment, the system must be correctly designed and proper connection cables used. Sufficient shielding must also be provided. (This applies especially to the measurement of low level signals.)

EC Declaration of Conformance / CE Label

This instrument fulfils the requirements of EN 50 081-1 and EN 50 082-1.

Change in the operating manual for the PCM-4, BN 0984

Option: "Analog interface"

for measuring signalling distortion and
crosstalk of the signalling signal.

The signalling measurements listed in the specifications (section 1.26) and described in the operating part (sections 3.8.6 and 3.8.7) are available from series AU onwards as a option.

The ordering information is as follows: **Analog Interface BN 984/00.19**

Accessory: "LabWindows® driver"

for integrating the instrument into automatic test systems
used in development, production and service/calibration.

Using the LabWindows driver, it is easy to integrate the PCM-4 into software platforms. This is ideal for tests and measurements in development, production and calibration. Click with your mouse and the PCM-4 and a MU-30 test point scanner (if present) are set using the prepared instrument driver. Once these commands are copied, the test sequence is integrated into the application.

The ordering information is as follows: **LabWindows driver BN 984/95.99**

31. January 1995

I M P O R T A N T

The series number of the hardware and the instrument serial number are printed in a small window in the lower part of the front panel.

The software version can be seen on menu page MODE A0 by pressing

/MODE LIST A/

/0/

/1/

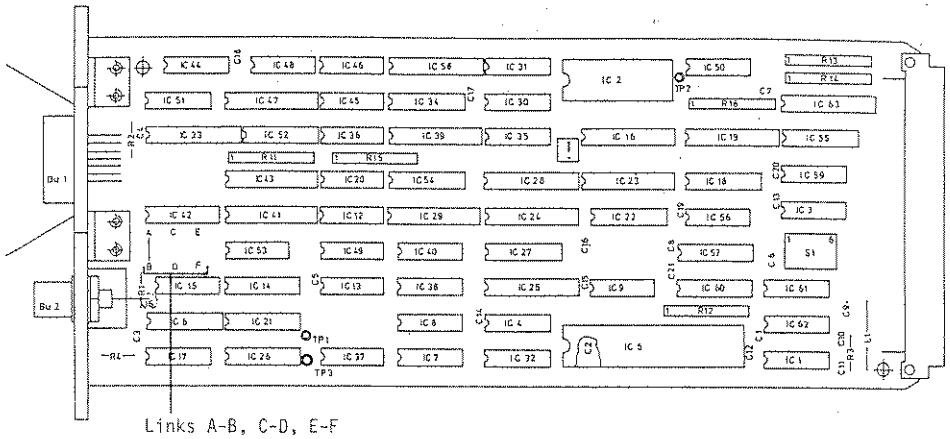
/ENTER/.

This number, together with the series and serial number, should always be quoted when making enquiries about the instrument.

1. Change in trigger signal output from socket [61]

Different trigger signals can be obtained from socket [61] by closing one of the wire links A-B, C-D or E-F on board 984-T1 of the PCM-4.

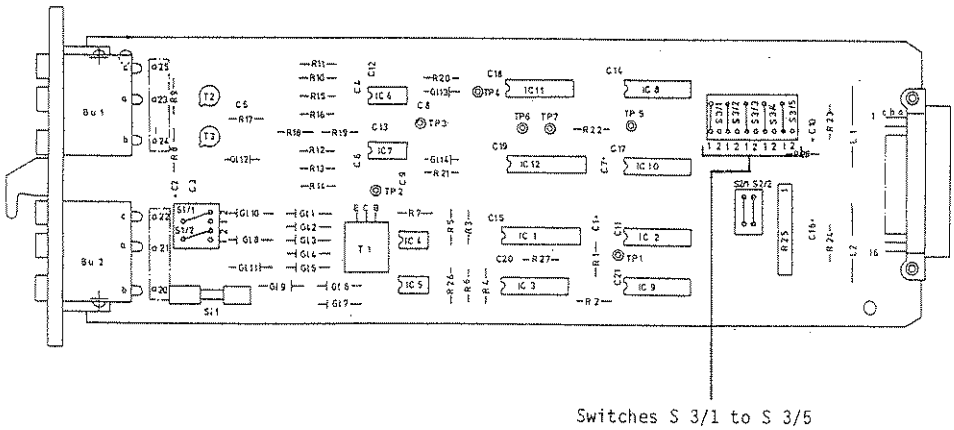
Link	Signal	Synchronous with rising edge of
A-B	8 kHz	Frame trigger signal
C-D	4 kHz	Not frame trigger signal NFAS
E-F	4 kHz	Frame alignment signal FAS



2. Inversion of signalling distortion signal

The signalling distortion signal can be inverted (positive/negative logic) using switches S 3/1 through S 3/5 on board 984-N.

Position of switches S 3/1 to S 3/5	
1	negative
2	positive



TABLES

I N T R O D U C T I O N

Rising costs have forced telecoms authorities and industrial users to seek economical solutions to test and measurement problems. The PCM-4, equally suitable for manual or remote-controlled operation, has all the functions needed for a complete coder/decoder test set, representing a cost-effective answer to this particular test requirement. All measurements conform to the relevant CCITT standards.

COMPACT CONSTRUCTION

The PCM-4 covers the functions of several different test sets, making measurements easier and reducing the number of connections required. A further plus is the reduced transport cost.

Four main parts make up the signal generator and receiver unit:

- an analog signal generator for sine-, multitone-, and "noise" signals;
- a digital signal generator which provides various signals via a 64 kbit/s interface or inserts them into standard PCM frames;
- an analog receiver for rapid wideband measurements in the telephone channel or for out-of-band measurements up to 128 kHz and for selective measurements at particular frequencies;
- a digital receiver for evaluating the digital words in both speech and signalling channels, the signal status being indicated by LEDs.

These units, together with a processor system comprising several microprocessors, make a wide range of measurements possible. These are summarised in the table at the end of this introduction.

SIMPLE OPERATION

The use of a VDU and three operator levels make working with the PCM-4 very easy:

- All the different types of measurement are contained in two lists, list A for the measurements which are often used, and list B for the less common ones. To select a measurement, the measurement number is entered. A list of parameters, such as signal type, frequencies and signal level, is shown on the screen. Once you have selected one of these parameters, the VDU shows all the relevant parameters and tolerance masks for the selected measurement. The PCM-4 is ready to make the measurement.

  The framework for the various measurements, i.e. the parameters, are set to standard values when the instrument is switched on for the first time. These parameters can be altered if required, but are reset to the standard values if /GENRL. RESET/ is pressed, or if the back-up batteries become discharged before the instrument is switched on again.

- If you need to alter the parameters, press /GENRL. PARAM./. This causes a menu to appear on the VDU, showing a number of parameter lists. Entering the list number causes the selected list to be displayed. Parameter changes are made by selecting one from a number of possibilities or by entering a new value. The PCM-4 displays error messages which warn you if you have selected a combination of parameters which is illegal or has no meaning. The new values are stored and used for all subsequent measurements and are not erased when the instrument is switched off and on again.

- Once you are familiar with the instrument and its operation, it is also possible to make changes in the individual measurement modes to suit requirements. This is done using the /VAR. MODE/ key. This allows different reference values or integration times to be selected, for example. These alterations are erased when a new measurement mode is chosen or if the PCM-4 is switched off.

MINIMAL MEASUREMENT ERROR

One of the most important features of the PCM-4 is its accuracy. This is of particular importance when making half-channel (analog-digital or digital-analog) measurements, as the allowable error is half that permitted for full-channel measurements.

The two descriptions which follow may serve to explain how it is possible to obtain such a small measurement error:

- All actual signal processing is at the digital level. Received analog signals are sampled and digitised and a digital filter is used for weighting the resultant digital signal. The tolerances for such filters can be calculated, and are independent of temperature or ageing effects. In this way, the analog filter, which is a major source of errors, is dispensed with.
- Only one highly accurate attenuator is used in the PCM-4. This is a transformer-type attenuator, the accuracy of which is solely determined by the turns ratios. All of the remaining attenuators are tapped resistor chains. When the instrument is calibrated, first the receiver attenuator and then the generator attenuator are compared with the transformer attenuator. Any deviations are noted for each attenuator stage, these being stored as correction factors which are taken into account for each subsequent setting of the attenuators.

CLEAR DISPLAY OF RESULTS

All results are displayed clearly on the VDU. You have a choice between:
- graphical display versus the "running" or X-axis parameter, or
- numerical display in tabular form.

If you want to keep a record of the results, a video plotter, graphics plotter or printer can be used. For the video plotter or graphics plotter, an IEC 625 interface is required.
The following can be output on the printer:
- the complete contents of the measured value memory on manual command
- each complete result automatically, or
- measured values which are outside given tolerance limits. If required, the limit value can be printed together with each measured value.

RAPID AUTOMATIC TESTING

Forty complete instrument settings (setups) can be stored and recalled as required. The PCM-4 can automatically call up and execute all the setups in address order. When coupled with a printer programmed to print out values which are out of tolerance, the PCM-4 forms a powerful automatic test set.

The use of a desk-top computer and IEC 625 bus network opens up further possibilities. For example, the computer can be used to call up and start preset setups, only the running parameter (e.g. frequency) being changed between measurements. As the data transfer and the measurements overlap, measurements are not interrupted when new settings are made.

If a full-scale computer is used, the PCM-4 becomes more than just a test set; here are two examples:

- Statistical evaluation of the results allow test engineers to determine the accuracy of error predictions made during development;
- Long-term measurements on transmission systems can be used to determine the effects of ageing on the various component parts of the network. In this way, trends can be recognised, so that threatened failures or out-of-tolerance performance of a given module can be seen easily.

Table of measurements which can be made using the PCM-4

Measurement mode	Measurement conditions	A-A	A-D	D-A	D-D
Level measurement	With sinusoidal signal 20 Hz to 4 kHz (72 kHz). With noise signal to CCITT Rec. O.131 and North American standards	•	•	•	•
Overall loss Echo return loss Singing return loss Transhybrid loss	With sinusoidal signal at 813 or 1014 Hz [1] and a level of – 10 or 0 dBm0 With noise signal ERL and a level of – 10 dBm0, to North American standards With noise signal SRL or SRL HI and a level of – 10 dBm0, to North American standards 2-wire termination with 910 Ω · 39 nF [2]	• • • •	• • • 	• • • 	• • • •
Variation of gain with frequency	With sinusoidal signal 20 Hz to 4 kHz and a level of – 10 or 0 dBm0. Ref. frequency 813 or 1014 Hz [1] (other reference frequencies available using VAR. MODE)	•	•	•	•
Variation of gain with input level	With sinusoidal signal at 813 or 1014 Hz [1]. With noise signal to CCITT Rec. O.131 and North American standards	•	•	•	•
Total distortion	With noise signal at 350 Hz ... 550 Hz or sinusoidal signal at 422 Hz, to CCITT Rec. O.131 and North American standards. With sinusoidal signal at 813 or 1014 Hz [1], psoph. or C-message weighted to CCITT Rec. O.132 and North American standards. With sinusoidal signal at 300 Hz ... 3350 Hz	•	•	•	•
Idle channel noise	At 300 Hz ... 3350 Hz or weighting with psoph. or C-message filter. Activating tone at 2 kHz possible	•	•	•	•
Crosstalk diff. channel Crosstalk same channel	With sinusoidal signal at 301, 813, 1014 [1] or 3343 Hz. With "Conventional Telephone Signal" to CCITT Rec. G.227 and North American standards, (BN 984/01 psoph. wtd/BN 984/02 C-message weighted). With sinusoidal signal at 301, 813, 1014 [1] or 3343 Hz	• •	• 	• 	• •
Out-of-band measurement	With sinusoidal signal in the range 4.6 ... 72 kHz; receive range 0.2 .. 4 kHz With sinusoidal signal in the range 0.2 ... 4 kHz; receive range 4.6 ... 128 kHz	• •	• 	 •	
Harmonic distortion 4-tone intermodulation	2nd or 3rd order harmonic ratio with sinusoidal signal at 1014 Hz [1] 2nd or 3rd order distortion with four equal-level tones at 857 Hz, 862 Hz, 1373 Hz and 1388 Hz	• •	• •	• •	• •
Return loss (option)	Using BN 984/00.10 bridge: reference impedances 600, 900 Ω and complex [3] Using BN 984/00.11 bridge: reference impedances 600/850 Ω and complex [3]	Audio frequency ports			
Longitudinal conversion loss (option)	Measured to CCITT Rec. O.121 Using BN 984/00.10 bridge: reference impedances 600, 900 Ω Using BN 984/00.11 bridge: reference impedances 600, 850 Ω	Audio frequency ports			
Longitudinal conversion transfer loss (option)	Measured to CCITT Rec. O.121 Using BN 984/00.10 bridge: reference impedances 600, 900 Ω Using BN 984/00.11 bridge: reference impedances 600, 850 Ω	•	•	•	
Overload capacity Peak load Coder offset	With pos. or neg. peak code, at 813 Hz or 1014 Hz [1]		• • •		 • •
Absolute group delay Group delay distortion	Loop measurements: AM-Signal with 8 fixed measuring frequencies similar to the signal described in CCITT Rec. O.81 and IEEE Standards	• •	• •	• •	• •
Signalling distortion	Measures the duty cycle deviation of a rectangular signal of 10 or 20 Hz. Duty cycle settable in steps between 10 and 90 %	•	•	•	•
Interference from signalling	Weighted measurement (to CCITT Rec. O.41 and North American standards) in voice channel. Duty cycle of rectangular signal adjustable	•	•	•	•
Error measurements	Framing errors (FAS and MFAS), CRC errors. Error ratio, error count and error free seconds with pseudorandom sequences or user programable 8 bit word in one channel at 64 kbit/s or via 64 kbit/s interface				•
RX frame evaluation	Evaluation on screen of words and bits		•		•
MUX/DEMUX operation	One channel multiplexer: with 64 kbit/s input (option) only One channel demultiplexer: with 64 kbit/s output (option) only				• •

1) BN 984/02: 1004 Hz
2) Complex impedance can be modified at factory
3) 220 Ω in series with 820 Ω ‖ 115 nF, can be modified at factory
Note: Measurements on digital Transmit (TX) or Receive (RX) interfaces can be carried out using the 2048 kbit/s (BN 984/01), 1544 kbit/s (BN 984/02) or 64 kbit/s interface (option). The following TX/RX combinations are possible: 2 M/2 Mbit/s; 64 k/64 kbit/s; 64 k/2 Mbit/s; 2 M/64 kbit/s; 1.5 M/1.5 Mbit/s; 64 k/64 kbit/s; 64 k/1.5 Mbit/s; 1.5 M/64 kbit/s.

Measurements of return loss, harmonic- and intermodulation distortion are available in instruments from series E onwards, or from software version 0984-0093.061.

OPTIONS

1 SPECIFICATIONS

Unless otherwise stated, the limit values given below are valid within the specified nominal ranges of use for the influence quantities.

ANALOG SIGNAL GENERATOR

1.1 GENERATOR OUTPUT

GENERATOR OUTPUT..... balanced, floating 3 pole CF connector

Output impedance, switchable..... 600, 850, 900 Ω and complex[1)]

Return loss

Output impedance	20 Hz to 200 Hz	200 Hz to 4 kHz	4 kHz to 72 kHz
600 Ω, 850 Ω, 900 Ω	≥ 34 dB	≥ 46 dB	≥ 30 dB
complex	—	≥ 30 dB	—

Longitudinal conversion transfer loss (CCITT 0.121)
for all real impedance values:
in range 20 Hz to 20 kHz..... ≥ 50 dB
in range 20 kHz to 72 kHz..... ≥ 46 dB
For complex impedance (measured with 900 Ω resistive bridge)
in range 200 Hz to 4 kHz..... ≥ 40 dB

D.C. loading

Permissible d.c. voltage to earth..... ≤ 60 V
Overvoltage protection switches at..... > 11 V
between lines a and b

Loop holding circuit (d.c. free output) and d.c. decoupling circuit can be connected externally (both available as options).

1.2 GENERATOR SIGNALS

Sinusoidal signals

Frequency range..... 20 Hz to 72 kHz

Frequency entry via keypad
in range 20 Hz to 4 kHz in 10 Hz steps
in range 4 kHz to 72 kHz in 100 Hz steps

The best approximation to the selected frequency is found and displayed. The frequency comb does not contain sub-harmonics of the 8 kHz sampling frequency. The generated frequency is crystal accurate ($\pm 50 \times 10^{-6}$). The generator can be synchronised with an 8 kHz system clock signal.

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1) Complex impedance 200 Ω in series with 115 nF in parallel with 820 Ω. Other values available on request.

Generator frequency comb

Frequency range	Possible frequency values (Hz)
20 Hz to 4 kHz	n x 10.03752; n = 2 to 398
4 kHz to 72 kHz	m x 100.3752; m = 40 to 717
100 Hz to 4 kHz	k x 100.8291; k = 1 to 39
Direct subharmonic	2000

Harmonic ratio

for fundamental oscillations in the range
20 Hz to 200 Hz..... $\geq$ 40 dB
200 Hz to 4 kHz..... $\geq$ 60 dB
4 kHz to 72 kHz..... $\geq$ 40 dB

Measured with generator level 0 dBm0. Evaluation includes the 3rd harmonic, but is in any case up to at least 20 kHz.

Pseudo random noise signals

Noise band	Recommendation	Spectral line spacing	Peak factor 20 log V_p/V_{rms}
350 to 550 Hz	CCITT O.131	3.906 Hz	10.5 $\pm$ 0.5 dB
350 to 550 Hz	CCITT O.131	7.813 Hz	10.5 $\pm$ 0.5 dB
Conventional telephone signal	CCITT G.227	7.813 Hz	10.5 $\pm$ 0.5 dB
560 to 1965 Hz (ECHO RETURN LOSS)	Correspond to North American standards	7.813 Hz	10.5 $\pm$ 0.5 dB
260 to 500 Hz (SINGING RETURN LOSS)		7.813 Hz	10.5 $\pm$ 0.5 dB
2200 to 3400 Hz (SINGING RETURN LOSS HIGH)		7.813 Hz	10.5 $\pm$ 0.5 dB

Group delay measuring signal

Similar to the signal recommended by CCITT O.81 and IEEE standards.
The measurement is made in loop mode, so an internally generated reference pulse is fed to the receiver instead of a reference signal.
Measuring frequencies..... 292, 500, 604, 1000, 1792, 2604, 2792 and 3396 Hz
Modulation frequency..... 41.66 Hz $\pm$ 0.5%
Modulation depth..... m = 0.4 $\pm$ 0.05
or
Modulation frequency..... 83.33 Hz $\pm$ 0.1 %
Modulation depth..... m = 0.5 $\pm$ 0.05

Four tone signal

Four tones at equal levels..... at 857 Hz, 862 Hz, 1373 and 1388 Hz

1.3 GENERATOR LEVEL

Calibrated as power level (dBm0), switchable to voltage level (dB0).

Relative level

Input in steps of 0.1 dB..... -19.9 to +9.9 dBr

Levels relative to 1 mW at 0 relative level

for generator signals outlined in 1.2..... input in steps of 0.01 dB

Level range in the preferred range of relative level -17 to +3 dBr into 600 Ω
for sinusoidal signals ($f \geq 200$ Hz), at least..... -60.0 to +10.0 dBm0
for sinusoidal signals ($f < 200$ Hz), at least..... -60.0 to +2.0 dBm0
for noise, at least..... -60.0 to +2.0 dBm0
for all other send signals, at least..... -30.0 to +2.0 dBm0

Output level range
Output impedance Z_{out}:

noise signal: from $(-77 - L_{rel} - K)$ to $(+3 - L_{rel} - K)$ dBm0
sinusoidal signals: from $(-77 - L_{rel} - K)$ to $(+13 - L_{rel} - K)$ dBm0

Correction factor K:

Z_{out}	Power level	Voltage level
600 Ω	0 dB	0 dB
850 Ω	1.51 dB	0 dB
900 Ω	1.76 dB	0 dB
CPLX	1.76 dB	0 dB
≈ 0	7.78 dB	0 dB

If customer-specified impedances have been factory-fitted, the relevant power level correction factors will be stored in the tolerance mask EPROM and will be automatically applied to the test results.

The correction factor for a modified complex impedance refers to the apparent power level at approx. 1 kHz.

1.4 OTHER OUTPUTS

Auxiliary signal for crosstalk measurements; pseudo random noise signal in frequency range 350 to 550 Hz or the subharmonic 2 kHz.

Balanced output

Output impedance..... 600 Ω

Return loss
in frequency range 300 Hz to 500 Hz..... ≥ 26 dB
500 Hz to 3.4 kHz..... ≥ 30 dB

Signal balance ratio
to CCITT 0.121 in the frequency range 300 Hz to 3.4 kHz..... ≥ 46 dB

Max. d.c. voltage to earth..... 60 V
Max. d.c. voltage between lines a and b..... 60 V

Coaxial output

Output impedance and return loss..... same as balanced output

Output level

Input takes into account the relative level setting L_{rel} in dBm0.
If a level of L_x is input, the level L_a [1] will be output and displayed:
Balanced output, level range L_a..... $(-72 - L_{rel})$ to $(-40 - L_{rel})$ dBm0
Coaxial output, level range..... $(-32 - L_{rel})$ to (L_{rel}) dBm0

Error limits of output level L_a referred to indicated value..... ±0.5 dB

ANALOG RECEIVER

1.5 RECEIVER INPUT..... same as generator output

with additional input impedance of..... ≥ 30 kΩ

Signal balance ratio to CCITT O.121
for all real impedance values
in the range 20 Hz to 20 kHz..... ≥ 50 dB
in the range 20 kHz to 128 kHz..... ≥ 46 dB [2]
For complex input impedance (measured with 900 Ω resistive bridge)
in the range 200 Hz to 4 kHz..... ≥ 40 dB

2 wire input/output

Generator output for Analog/Digital measurements, receiver input for Digital/Analog measurements. For Digital/Digital measurements, the 2-wire connection may be terminated with a complex impedance [3] or switched to a high impedance value.

Loop holding circuit (d.c free output) and d.c. decoupling circuit can be connected externally (both available as options).

1.6 RECEIVE LEVEL

Calibrated in power level (dBm0), switchable to voltage level (dB0).

Relative level (key "RECV dBr")

Input in steps of 0.1 dB from..... -19.9 to +9.9 dBr

Levels relative to 1 mW at 0 relative level

Level range within the preffered relative level range -9.9 to +9.9 dBr into 600 Ω
for signal level measurements, at least..... -60.0 to +10.0 dBm0
for noise and crosstalk measurements, at least..... -80.0 to 0.0 dBm0

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1) Balanced output: $L_a = -40\ \text{dBm0} - 1.5 \left[\frac{|L_x| - 40\ \text{dBm0}}{1.5}\right]^{*)} - L_{rel}$

*) integer value

2) From 20 kHz to 72 kHz ..... ≥ 40 dB
from 72 kHz to 128 kHz ..... ≥ 30 dB
if customer-specified 120 kHz low pass filter (BN 984/00.14) fitted.

3) Complex impedance: 910 Ω in parallel with 39 nF

1.7 RECEIVE FILTERS

Wideband filters

Attenuation		Passband range	Attenuation	
> 30 dB	3 dB		3 dB	> 30 dB
100 Hz	177 Hz	200 Hz to 4 kHz	4.3 kHz	4.8 kHz
-	2 Hz	20 Hz to 4 kHz	4.3 kHz	4.8 kHz
180 Hz	303 Hz[1)]	330 Hz to 3100 Hz	3.35 kHz[1)]	3.9 kHz
-	2 Hz	20 Hz to 72 kHz	-	-
3.6 kHz	3.95 kHz	4.6 kHz to 128 kHz	165 kHz	approx. 220 kHz

Filters for measuring harmonic- and IM distortion

		Passband
2nd harmonic	ak^2	2000 to 2028 Hz
3rd harmonic	ak^3	3000 to 3042 Hz
2nd order	B - A	480 to 560 Hz
IM product	B + A	2229 to 2251 Hz
3rd order IM product	2 B - A	1855 to 1920 Hz

Filters for weighted noise measurements

Psophometer filter (CCITT P.53/0.41)
C-message weighting filter (to North American standards)
3 kHz flat filter (to North American standards)
Psophometer filter with 2 kHz notch filter
C-message weighting filter with 2 kHz notch filter
Bandpass 300 to 3350 Hz with 2 kHz notch filter

Narrow band filters

Attenuation		Passband	Attenuation	
> 30 dB	3 dB ± 0.5 dB		3 dB ± 0.5 dB	> 30 dB
250 Hz	281 Hz[2)]	301 Hz	320 Hz[2)]	360 Hz
700 Hz	792 Hz	813 Hz	828 Hz	910 Hz
900 Hz	992 Hz	1014 Hz	1028 Hz	1110 Hz
3250 Hz	3298 Hz	3343 Hz	3356 Hz	3400 Hz
200 Hz (> 19 dB)	312 Hz	350 to 550 Hz	580 Hz	690 Hz

1) 3 dB ± 0.5 dB
2) 3 dB ± 1 dB

Filters for S/N measurements

Signal filter	Noise filter	Recommen-dation
350 to 550 Hz	800 to 3350 Hz	CCITT 0.131
800 to 855 Hz	Channel filter with 813 Hz notch	-
800 to 855 Hz	Psophometer with 813 Hz notch	CCITT 0.132
1000 to 1025 Hz	Channel filter with 1014 Hz notch	-
1000 to 1025 Hz	Psophometer with 1014 Hz notch	-
1000 to 1025 Hz	C-message weighting filter with 1014 Hz notch	CCITT 0.132

D I G I T A L S I G N A L G E N E R A T O R

1.8 PCM F R A M E S T R U C T U R E

32 channel PCM frame containing either
30 telephone channels..... to CCITT Rec. G.704 (red book)
information is injected in time slot 16 either internally or from an external source
or 31 telephone channels..... time slots 1 to 31
Time slot 16 is assigned a telephone channel
or 32 telephone channels..... all time slots (0 to 31) used
Start of frame indicated by 8 kHz trigger signals.

1.9 G E N E R A T O R O U T P U T S, D I G I T A L S I G N A L & C L O C K

Interface characteristics..... to CCITT Rec. G.703
Line codes..... NRZ, AMI and HDB3
Coaxial output*..... Versacon® 9 universal connector system
can be adapted to all commonly used connectors
Output impedance..... 75 Ω
Balanced output..... 3 pole CF connector
Output impedance..... 120 Ω
Return loss
within frequency range 40 kHz to 2.5 MHz..... > 20 dB
Output pulse shape..... approximates square wave
Pulse amplitude
Coaxial output terminated with 75 Ω..... 2.37 V ± 10%
Balanced output terminated with 120 Ω..... 3 V ± 10%
Pulse width for AMI and HDB3
at half pulse height..... 244 ns ± 30 ns
Rise time from 10% to 90%..... approx. 15 ns
Phase relationship between digital and clock signals:
The leading edge of the signal and the rising edge of the clock ($V_{b/a}$ symmetrical) are in phase.

1.10 OPERATING MODES AND CLOCK GENERATION

Loop-through measurement (THROUGH 2 Mbit/s)

Insertion of a test pattern into one channel of a PCM frame which is looped-through the PCM-4. The digital signal analyser and the digital signal generator are combined for this measurement.

Generator operation with internal clock

Bit rate..... 2048 kbit/s
Bit rate error limit..... $\pm 25 \times 10^{-6}$

Generator operation with external clock

Bit rate..... 2048 kbit/s
Max. deviation from nominal value..... $\pm 100 \times 10^{-6}$

8 kHz synchronising signal
internal derivation of frame, time slot, and bit clock from the external synchronising signal.
Max. deviation from nominal value..... $\pm 100 \times 10^{-6}$

External clock and synchronising signal input
If "HIGH" pulse width > 488 ns, for RX and TX terminated with 75 Ω
Input impedance, switchable..... approx. 75 Ω or > 3 kΩ
Input voltage range (square wave signal)..... 1 V to 5 V
Duty cycle, external clock..... 0.5

Generator operation with receiver clock

The digital signal generator is driven from the clock recovered in the digital signal analyser.

Digital loop circuit

2 Mbit/s loop, all time slots switched through.
2 Mbit/s loop, selected time slot switched through (send and receive channels chosen separately).
64 kbit/s loop at relevant interfaces (option).

1.11 DIGITAL WORDS IN TIME SLOTS 0 AND 16

with 30 telephone channels, or time slot 0 with 31 telephone channels; may be set as required.

Standard values (follow RESET TO STANDARD VALUES)

Frame alignment signal without CRC-4 check bits in time slot 0
of every second frame..... X0011011

Frame alignment signal with CRC-4 check bits in time slot 0
of every second frame in the CRC multiframe..... C0011011

Not frame alignment signal without CRC-4 check bits in time slot 0
of every frame not containing a frame alignment signal..... X1011111

Not frame alignment signal with CRC-4 check bits in time slot 0
of every frame not containing a frame alignment signal..... M1011111

Multiframe alignment signal
in time slot 16 of frame 0 (bits 1 to 4)..... 0000

Not multiframe alignment signal
in time slot 16 of frame 0 (bits 5 to 8)..... 1011

Idle channel signalling word in time slot 16 of frames 1 to 15
for the time slots 1 to 15 and 17 to 31..... 1111

Signalling word
in time slot 16, assigned to selected telephone channel..... 1111

1.12 DIGITAL WORDS IN TELEPHONE CHANNELS

Telephone channel selection

Code word may be inserted as required into one of the telephone channels 1 to 30 (or 31, 32), or into all channels, or into all channels with the exception of the selected channel.

Idle channel code word (idling code)

may be set as desired; standard value..... 11010101

Coding law, to CCITT G.711,

selectable..... A-law, μ-law

A-law coding:
symmetrical binary coding of digital words with inversion of bits 2, 4, 6, 8.

μ-law coding:
symmetrical binary coding of digital word with inversion of bits 2 to 8.

Theoretical load capacity

The peak value of an ideal sinusoidal signal P_s at a level of +3.14 dBm0 (A-law coding) or 3.17 dBm0 (μ-law coding) corresponds to the virtual decision value 128.

Transmission level definition

The transmission level P_s is defined as that input level which would produce at the output of an ideal coder (A) the same PCM words as those supplied by the digital signal generator (B).

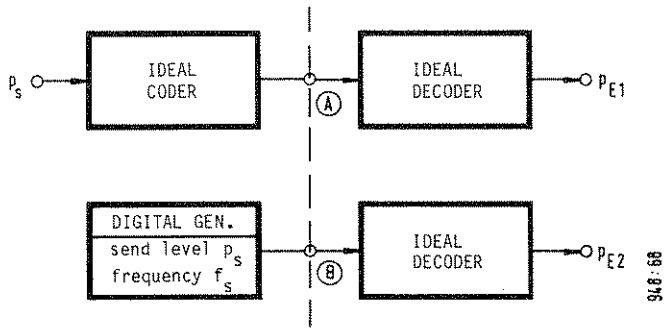

Figure 1-1 Definition of transmission level

Level errors:

P_{E2}-P_{E1}: Digital signal generator error

P_{E2}-P_S: Difference between actual simulated level and set level due to quantising error, including the digital signal generator error.

Total distortion error:
All error values quoted refer to the theoretical value of the generated signal[1].

1) The theoretical and actual values are given in a separate table.

1.13 GENERATOR SIGNALS

Sinusoidal signals

Frequency range..... 20 Hz to 3.99 kHz
Frequency selected via keypad. When a frequency value is input, the nearest possible value will be selected and the actual frequency displayed. The frequency comb avoids direct subharmonics of the 8 kHz sampling frequency. The frequency generated is crystal accurate.

Generator frequency comb

Frequency range	possible frequency value (Hz)
20 Hz to 4 kHz (STANDARD)	n x 10.0376; n = 2 to 398
100 Hz to 4 kHz (VAR. MODE)	k x 101.266; k = 1 to 39
Direct subharmonics 0 dBm0 level (VAR. MODE)	250, 500, 800 i x 250; i = 4 to 15
Direct subharmonics -45 dBm0 level (VAR. MODE)	2000

Generator level
Level range, in 0.1 dB steps..... -60.0 to +7.5 dBm0
Error limits of simulated level within the standard range of sinusoidal signal, selective measurement (see figure 1-1):

A-law coding, in generator level range

P_S	$P_{E2} - P_{E1}$	$P_{E2} - P_S$
+7.5 to +3.2 dBm0	±0.02 dB	-
+3.1 to -40.0 dBm0	±0.02 dB	±0.05 dB
-40.1 to -50.0 dBm0	+0.02/-0.03 dB	+0.2/-0.3 dB
-50.1 to -60.0 dBm0	+0.04/-0.02 dB	+0.9/-1.2 dB

μ-law coding, in generator level range

P_S	$P_{E2} - P_{E1}$	$P_{E2} - P_S$
+7.5 to +3.2 dBm0	±0.02 dB	-
+3.1 to -40,0 dBm0	±0.02 dB	+0.06/-0.05 dB
-40.1 to -50.0 dBm0	±0.02 dB	+0.10/-0.11 dB
-50.1 to -60.0 dBm0	±0.02 dB	+0.3/-0.5 dB

Frequency response
Max. frequency dependent error in simulated level (P_{E2}) for constant level setting.
Reference frequency 813 Hz.

Level range	Frequency range	Δp
+3.2 to -60 dBm0	20 Hz to 3.9 kHz	± 0.01 dB

Noise signals
Pseudo random noise signal, 350 to 550 Hz corresponding to CCITT Rec. 0.131,
spectral line separation..... 3.906 Hz
Pseudo random noise signal 350 to 550 Hz, spectral line separation..... 7.813 Hz
Peak factor..... 10.5 ± 0.5 dB

Generator level
Level range, in 0.1 dB steps..... -65.0 to +7.5 dBm0
Error limits of simulated level for noise signal to CCITT 0.131, measured in the frequency range 350 to 550 Hz

A-law coding, in generator level range	$P_{E2} - P_{E1}$	$P_{E2} - P_S$
-4.5 to -40.0 dBm0	± 0.01 dB	± 0.02 dB
-40.1 to -60.0 dBm0	± 0.03 dB	± 0.10 dB

μ-law coding, in generator level range	$P_{E2} - P_{E1}$	$P_{E2} - P_S$
-4.5 to -45.0 dBm0	± 0.01 dB	± 0.02 dB
-45.1 to -60.0 dBm0	± 0.02 dB	± 0.05 dB

For levels outside the theoretical load capacity (noise > -45 dBm0), the absolute output level P_S is limited by the A-law or μ-law coding characteristics.
Error limits for total distortion ratio for simulated noise signal to CCITT 0.131 referred to the theoretical value (reference bandwidth Δf = 3100 Hz).
A- and μ-law coding, in send level range -65.0 to -4.2 dBm0..... ± 0.2 dB
Other noise signals
Broadband noise signal in telephone channel, noise band..... 300 to 3400 Hz[1)]
Generator level range..... -65.0 to 0.0 dBm0
Conventional telephone signal..... to CCITT G.227[1)]
Generator level range..... -30.0 to 0.0 dBm0
ECHO RETURN LOSS test signal, noise band..... 560 to 1965 Hz[1)]
SINGING RETURN LOSS, noise band..... 260 to 500 Hz[1)]
SINGING RETURN LOSS HIGH, noise band..... 2200 to 3400 Hz[1)]
Generator level range..... -30.0 to 0.0 dBm0

1) Spectral line separation 7.813 Hz

Group delay test signal (see: Send signals; Analog signal generator)
Generator level range..... -30.0 to 0 dBm0

Four tone signal (see: generator signals; Analog signal generator)
Generator level range..... -30.0 to -5.0 dBm0

Idle channel signals
Fixed as well as periodically- or pseudo-randomly variable (between two adjacent values) codewords can be selected as desired.

Idle channel signals following RESET TO STANDARD VALUES:

Fixed idle channel code word (FIX)	(A-law)..... 11010101 (+0) (μ-law)..... 11111111 (+0)
Idle channel code word with pseudo random sign change, frequency range 0 to 4 kHz	(A-law)..... between 11010101 (+0) and 01010101 (-0)
Idle channel code word with periodic sign change at same frequency as set sinusoidal signal	(μ-law)..... between 11111111 (+0) and 01111111 (-0)

Digital pulse patterns
The following are available for bit error measurements:
Pseudo random sequence to CCITT V.52..... length 2^9-1 bit
Pseudo random sequence to CCITT 0.152..... length 2^{11}-1 bit
Freely selectable 8 bit word

External analog signal
Externally generated analog signals can be processed with the aid of a PCM coder.
External coder input..... 3 pole CF socket
Input impedance..... 600 Ω
Relative level..... 0 dBr
Theoretical load capacity, A-law..... 3.14 dBr
μ-law..... 3.17 dBr
Residual attenuation at 814 Hz and 0 dBm0..... ≤ 0.5 dB
Frequency response between 300 Hz and 3350 Hz..... ≤ 0.5 dB

1.14 TEST FACILITIES AND ERROR INJECTION

AIS signal

A continuous sequence of 1's is transmitted (no frame structure).

Frame alignment test

Generation of a bit error rate for the frame alignment signal, selectable..... 10^{-4} or 10^{-3}
Generation of frame alignment signal containing error..... 2 out of 4 or 3 out of 4 words containing errors
Generation of CRC multiframe alignment signal errors..... 2 out of 4 or 3 out of 4 words containing errors

Multiframe alignment test

Generation of multiframe alignment signal containing error..... 1 out of 2 or 2 out of 2 words containing errors

Signalling in the selected time slot

Parallel input on back panel for externally set 4 bit signalling words; operates with frame structures to CCITT G.704 and "time slot 16 internal".
Input voltage..... TTL level

1.15 TRIGGER OUTPUTS..... coaxial BNC sockets

Frame trigger output [61]
Frame trigger signal with rising edge corresponding to start of time slot 0.
Output voltage..... TTL level
Max. delay of start of time slot 0 referred to frame trigger..... 60 ns
If generator is used with external frame triggering ([64] ext. sync.), the 8 kHz input or output trigger signals are kept in phase.
Max. deviation of output trigger signal from input trigger signal..... ±30 ns

Generator signal trigger output [32]
Trigger signal synchronous with the generator signal in the selected channel.
Output voltage..... TTL level

DIGITAL SIGNAL RECEIVER

1.16 PCM FRAME STRUCTURE

32 channel PCM frame, containing
30 telephone channels..... to CCITT Rec. G.704
or 31 telephone channels..... time slots 1 to 31,
if time slot 16 is a telephone channel,
or 32 telephone channels..... all time slots
if an external frame alignment signal is available.

1.17 DIGITAL SIGNAL INPUTS

Interface characteristics..... to CCITT Rec. G.703
Line codes..... NRZ, AMI, HDB3
Coaxial input*..... Versacon® 9 universal connector system adaptable to all commonly used connectors
Input impedance..... 75 Ω or > 3 kΩ

Balanced input..... 3 pole CF connector
Input impedance..... 120 Ω or > 3 kΩ

Return loss within the frequency range 40 kHz to 2.5 MHz..... > 20 dB

Input voltage
Pulse amplitude required..... 30 mV to 3 V
Max. r.m.s. input voltage..... 4 V

Max. tolerable peak-peak jitter

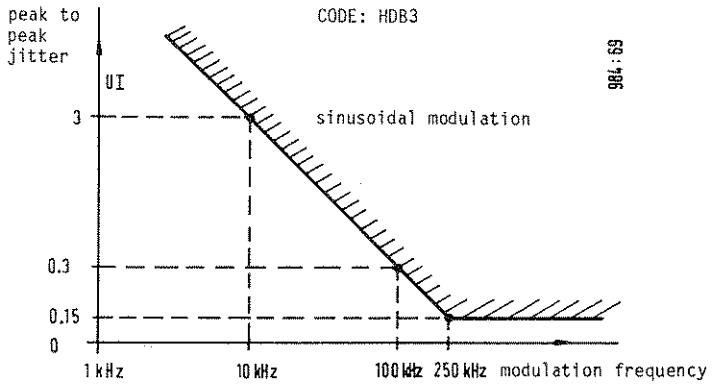

Figure 1-2 Maximum tolerable peak-peak jitter

Input signal monitoring via LEDs

NO SIGNAL..... signal amplitude too low
AIS..... Alarm Indication Signal (continuous sequence of "1"s)
NO FRAME..... errored frame alignment
NO MULTIFRAME..... errored multiframe alignment

Clock

Clock recovery
Internal clock recovery from 2 048 kbit/s digital signal input
Pulling range, clock regenerator..... $\pm 100 \times 10^{-6}$

Recovered bit clock output [65]
Output voltage..... TTL level

External frame trigger input [63]
indicates the start of a frame when there is no frame alignment signal
Max. deviation of rising edge of frame trigger signal from start of time slot 0..... ±150 ns
Signal input voltage required..... TTL level

1.18 EVALUATION OF DIGITAL WORDS IN TELEPHONE AND SIGNALLING CHANNELS

Telephone channel selection

A code word from one telephone channel from 1 to 30 (or 31, 32) can be evaluated.

Code word measurements

Positive or negative drive range or coder offset may be determined.

Range..... +0 to +127 or -0 to -127

1.19 ANALOG MEASUREMENTS ON TELEPHONE CHANNELS

Method: the r.m.s. values are calculated after the digital signal has been expanded and passed through a digital filter.

Decoding law..... same as digital signal generator coding law

Load capacity..... same as digital signal generator

Receive level range at least..... -80 to +6 dBm0

1.20 RECEIVE FILTERS

Wideband filter

Passband range, selectable..... 200 Hz to 4 kHz, 20 Hz to 4 kHz, 300 to 3 350 Hz

Attenuation frequency range..... same as analog receiver

Narrow band filter..... same as analog receiver

Noise weighting filters..... same as analog receiver

S/N measurement filters..... same as analog receiver

1.21 ANALOG DECODER OUTPUT [37]

Output impedance..... 600 Ω

Relative output level..... 0 dBr

Frequency range..... 300 to 3400 Hz

Transmission loss at 814 Hz and 0 dBm0..... ≤ 0.5 dB

Attenuation/frequency response, 300 Hz to 3350 Hz..... ≤ 0.5 dB

1.22 ERROR MEASUREMENTS

may be made in telephone channels (64 kbit/s) using the bit patterns from the digital signal generator.

Displayed as a histogram with X axis corresponding to time intervals (max. 50) or telephone channels.

Test time interval may be set between..... 1 s and 99 h 59 min 59 s

Error ratio (MODE B82)

Determination of bit and octet error ratios

Error count (MODE B83)

Counting of bit and octet errors

Error free seconds (MODE B84)

Percentages of error free and errored seconds occuring during the test period.

1.23 EVALUATION AND INDICATION OF THE DIGITAL WORDS WITHIN A FRAME

LED indication of the digital words:

Octet in telephone channel..... bit 1 ... 8
Frame alignment signal..... bit 1 ... 8
Signalling word..... bit 1 ... 4
Multiframe alignment signal and signalling word..... bit 1 ... 4 and 5 ... 8
Character signals for "send"..... bit 1 ... 4
for "receive"..... bit 5 ... 8

VDU display of the digital words:

frame alignment signal (FAS)	multiframe alignment signal (MFAS)
not frame alignment signal (NFAS)	non multiframe alignment signal (NMFAS)
signalling word	octet in telephone channel

1.24 ERROR COUNTS ON FRAME AND MULTIFRAME ALIGNMENT SIGNALS

Displayed as histogram; test time interval may be set (MODE B81)
between..... 1 s and 99 h 59 min 59 s
Bit errors in frame alignment signals.
Word errors in frame alignment signals.
Word errors in multiframe alignment signals.
CRC word errors.

1.25 PARALLEL OUTPUTS [62] (on back panel)

Output voltages..... HS CMOS

Error outputs

PCM frame errors..... Errored frame alignment signal
Errored multiframe alignment signal
CRC word errors
Code errors..... for AMI and HDB3 codes

Output of 4 bit signalling words for selected time slot

For PCM frame structure conforming to CCITT Rec. G. 704 and for "time slot 16 internal" (Parameter 221).

1.26 SIGNALLING DISTORTION MEASUREMENTS

Method: measures the duty cycle deviation of a rectangular signal.

Signalling generator

Frequency setting..... 10 or 20 Hz
Duty cycle, settable in steps of 10 (1)% between..... 10 and 90%

Output [39] (back panel)
Output impedance (mark)..... < 30 Ω
(space)..... > 20 kΩ
Max. d.c. loading..... 200 mA
Max. switching voltage..... 70 V

Signalling receiver

Measuring range..... ±10 ms
Resolution..... 0.1 ms

Input [38] (back panel)
The input must be switched to ground.
Closing restistence of drive switch..... < 250 Ω
Input impedance (connected internally to -15 V)..... 750 Ω
Short-circuit current..... 20 mA

If the closing impedance Z > 300 Ω and the opening impedance Z < 20 kΩ, this is indicated by "Z" in front of the result "0.0" shown on the screen or on the printout.

1.27 ERROR LIMITS

Within the recommended range for relative level (TX: -17 to +3 dBr and RX: -10 to +10 dBr), analog signal generator terminated with Z_o.
See 1.12 for definition of errors for digital signal generator.

1.27.1 LEVEL MEASUREMENT

Mode A	Send signal	Receive frequency range	Level [1] range	Error limits: Analog signal generator	Analog signal receiver	Digital signal generator	Digital signal receiver	Remarks
<11>	sinus-oid	200 Hz to 4 kHz	+10 to -40 dBm0	±0.1 dB	±0.1 dB	±0.02 dB	±0.02 dB	
			-40 to -60 dBm0	±0.15 dB	±0.15 dB	+0.04/ -0.03 dB	±0.02 dB	
<12>	sinus-oid	20 Hz to 4 kHz	+10 to -40 dBm0	±0.1 dB [2]	±0.1 dB [3]	±0.02 dB	±0.02 dB	
			-40 to -60 dBm0	±0.15 dB [2]	±0.15 dB [3]	+0.04/ -0.03 dB	±0.02 dB	
<13>	sinus-oid	20 Hz to 72 kHz	+10 to -40 dBm0	* ±0.3 dB	* ±0.3 dB [3]	-	-	
			-40 to -60 dBm0	** ±0.4 dB	** ±0.4 dB [3]	-	-	
<14>	noise 350 to 550 Hz	350 to 550 Hz	0 to -40 dBm0	±0.15 dB	±0.15 dB	±0.01 dB	±0.02 dB	
			-40 to -60 dBm0	±0.2 dB	±0.2 dB	±0.03 dB	±0.02 dB	

1) Upper level range limit for digital generator (sinusoidal signal): +7.5 dBm0
for digital receiver (sinusoidal signal): +6.0 dBm0

2) Additional analog generator error 20 Hz to 50 Hz ... +0/-0.25 dB
50 Hz to 200 Hz ... +0/-0.1 dB

3) Additional analog receiver error 20 Hz to 50 Hz ... +0/-0.2 dB

* ±0.1 dB if 120 kHz lowpass filter fitted (BN 984/00.14)

** ±0.6 dB if 120 kHz lowpass filter fitted (BN 984/00.14)

1.27.2 INSERTION LOSS

Mode A	Send signal	Receive frequency range	Receive level range	Error limits: A-A	A-D	D-A	D-D	Remarks
<21> to <24>	sinusoid 813 Hz or 1014 Hz level: 0 dBm0 or -10 dBm0	filter 200 Hz to 4 kHz	+3 to -40 dBm0	±0.05 dB	±0.05 dB	±0.05 dB	±0.05 dB	
			-40 to -60 dBm0	±0.1 dB	±0.1 dB	±0.1 dB	±0.1 dB	
<25> to <27>	noise ERL SRL SRL HI level: -10 dBm0	200 Hz to 4 kHz	Results range					
			0 to +50 dB	±0.5 dB	±0.4 dB	±0.4 dB	±0.3 dB	

1.27.3 FREQUENCY RESPONSE, referred to the value at 814 Hz or 1 014 Hz

Mode A	Send signal	Receive frequency range	Receive [1] level range	Error limits A-A	A-D	D-A	D-D	Remarks
<31> to <34>	sinusoid 0 or -10 dBm0	200 Hz to 4 kHz	+3 to -40 dBm0	* ±0.05 dB	±0.05 dB	* ±0.05 dB	±0.02 dB	
			+10 to -60 dBm0	** ±0.1 dB	±0.08 dB	*** ±0.08 dB	±0.02 dB	
<35> to <38>	sinusoid 0 or -10 dBm0	20 Hz to 4 kHz	+3 to -40 dBm0	±0.05 dB [2) 3)]	±0.08 dB [2)]	±0.08 dB	±0.02 dB	additional error at 20 Hz: -0.05 dB
			+10 to -60 dBm0	±0.1 dB [2) 3)]	±0.1 dB [2)]	±0.1 dB	±0.02 dB	

1) Digital signal receiver: max. +7.5 dBm0

2) Additional error due to analog generator, 20 Hz to 50 Hz ... +0/-0.25 dB
50 Hz to 200 Hz ... +0/-0.1 dB

3) Additional error due to analog receiver, 20 Hz to 50 Hz ... +0/-0.2 dB

* ±0.07 dB
** ±0.12 dB } if 120 kHz lowpass filter fitted (BN 984/00.14)
*** ±0.1 dB

1.27.4 VARIATION OF GAIN WITH INPUT LEVEL, referred to the value at -10 dBm0

Mode A	Send signal	Receive frequency range	Receive level range	Error limits A-A	A-D	D-A	D-D	Remarks
<41> to <44>	sinusoid 813 Hz or 1014 Hz	selective or 200 Hz to 4 kHz	+3 to -40 dBm0	±0.1 dB	±0.08 dB	±0.08 dB	±0.05 dB	
			-40 to -60 dBm0	±0.15 dB	±0.12 dB	±0.12 dB	±0.05 dB	
<45> to <46>	noise 350 to 550 Hz	350 to 550 Hz or 200 Hz to 4 kHz	0 to -40 dBm0	±0.1 dB	±0.08 dB	±0.08 dB	±0.05 dB	
			-40 to -60 dBm0	±0.15 dB	±0.1 dB	±0.1 dB	±0.05 dB	

1.27.5 TOTAL DISTORTION (including quantising distortion)

Mode A	Send signal	Receive level range	Results range	Error limits A-A	Error limits A-D	Error limits D-A	Error limits D-D	Remarks
<51> <52>	noise 350 to 550 Hz or sinusoid 422 Hz	distortion ≥ -72 dBm0	0 to 40 dB	±0.5 dB	±0.4 dB	±0.4 dB	±0.3 dB	The results of unweighted measurements are expressed in terms of Δf = 3 100 Hz; weighted measurements in terms of the bandwidth of an ideal weighting filter
<53> <55> <56>	sinusoid 813 Hz or 1014 Hz	weighted distortion ≥ -76 dBm0	0 to 44 dB	±0.5 dB	±0.5 dB	±0.5 dB	±0.5 dB	
<54> <57>	sinusoid 813 Hz or 1014 Hz	unweighted distortion ≥ -74 dBm0	0 to 42 dB	±0.5 dB	±0.4 dB	±0.4 dB	±0.3 dB	

1.27.6 IDLE CHANNEL NOISE

Mode A	Send signal	Receive frequency range	Results range	Error limits A-A	Error limits A-D	Error limits D-A	Error limits D-D	Remarks
<61> <62> <63>	generator "off" or static idle channel signal	weighted or unweighted	0 to -70 dBm0	±0.5 dB	±0.3 dB	±0.5 dB	±0.3 dB	The results of unweighted measurements are expressed in terms of Δf = 3 100 Hz; weighted measurements in terms of the bandwidth of an ideal weighting filter
			-70 to -80 dBm0	±1 dB	±0.5 dB	±1 dB	±0.5 dB	
<64> <65> <66>	generator "off" or static idle channel signal	weighted or unweighted	0 to -70 dBm0	±0.5 dB	±0.3 dB	±0.5 dB	±0.3 dB	
			-70 to -80 dBm0	±1 dB	±0.5 dB	±1 dB	±0.5 dB	

1.27.7 CROSSTALK AND GO-TO-RETURN CROSSTALK

Mode A	Send signal	Receive frequency range	Results range	Error limits A-A	A-D	D-A	D-D	Remarks
<71> to <74> <76> to <79>	sinusoid 301 Hz 813 Hz 1014 Hz 3343 Hz	selective	0 to -70 dBm0	±0.3 dB	* ±0.2 dB	* ±0.3 dB	±0.2 dB	The use of an activating signal is recommended for crosstalk measurements in order to reduce idle channel noise from the test object falling in the measurement bandwidth.
			-70 to -80 dBm0	±0.5 dB	* ±0.3 dB	* ±0.5 dB	±0.3 dB	
<75>	conventional telephone signal	weighted psophometrically	0 to -70 dBm0	±0.5 dB	±0.3 dB	±0.5 dB	±0.3 dB	
			-70 to -80 dBm0	±0.8 dB	±0.3 dB	±0.8 dB	±0.3 dB	

* A-D and D-A configurations not possible in MODEs A76 to A79

1.27.8 OUT OF BAND MEASUREMENTS

Mode A	Send signal	Receive frequency range	Results range	Error limits A-A	A-D	D-A		Remarks
<81>	sinusoid 4.6 kHz to 72 kHz	200 Hz to 4 kHz	0 to -60 dBm0	±0.4 dB	±0.2 dB	-		
<82>	sinusoid 200 Hz to 3.6 kHz	4.6 kHz to 128 kHz	0 to -40 dBm0	* ±0.4 dB	-	** ±0.3 dB		additional error between 4.6 and 5 kHz +0 dB/-0.2 dB
			-40 to -50 dBm0	*** ±0.5 dB	-	* ±0.4 dB		
<83>	generator "off"	4.6 kHz to 128 kHz	0 to -40 dBm0	±0.4 dB	-	±0.3 dB		
			-40 to -50 dBm0	±0.5 dB	-	±0.4 dB		

* ±0.6 dB
** ±0.5 dB
*** ±0.7 dB
} at frequencies below 72 kHz if 120 kHz lowpass filter fitted (BN 984/00.14)

1.27.9 HARMONIC- AND IM DISTORTION

Mode A	Send signal	Receive frequency range[1]	Result range	Error limits A-A	A-D	D-A[2]	D-D[2]	Remarks
<91> <92>	sinusoid 1004 Hz	2000 to 2028 Hz or 3000 to 3042 Hz	0 to +45 dB	±0,5 dB	±0,5 dB	±0,5 dB	±0,5 dB	2) Excluding PCM distortion in digital signal generator
			+45 to +52 dB	±0,5/-1,0	±0,5/-1,0	±0,5/-1,0	±0,5/-1,0	
<93>	four tone signal	B-A 480 to 560 Hz and B+A 2229 to 2251 Hz	0 to +35 dB	± 0,5 dB	±0,5 dB	±0,5 dB	±0,5 dB	
			+35 to +42 dB	±0,5/-1,0	±0,5/-1,0	±0,5/-1,0	±0,5/-1,0	
<94>		2 B-A 1885 to 1920 Hz	0 to +40 dB	± 0,5 dB	±0,5 dB	±0,5 dB	±0,5 dB	
			+40 to +47 dB	±0,5/-1,0	±0,5/-1,0	±0,5/-1,0	±0,5/-1,0	

1) Receive level range for sinusoidal and 4 tone signal -30 to 0 dBm0

1.27.10 RETURN LOSS AND LONGITUDINAL CONVERSION LOSS

Mode B	Send signal	Receive frequency range	Results range	Error limits TX/RX	A-A	A-D	D-A	Remarks
<11> <12>	sinusoid -10 dBm0	200 Hz to 4 kHz	0 to 30 dB	±0.5 dB	"	-	"	reference impedance 600, 850, 900 Ω
			30 to 40 dB	±0.8 dB	"	-	"	
<13>	sinusoid -10 dBm0	200 Hz to 4 kHz	0 to 30 dB	±0.8 dB	"	-	"	reference impedance complex
			30 to 40 dB	±1 dB	-	-	-	
<21> <22>	sinusoid 0 dBm0	200 Hz to 4 kHz	0 to 40 dB	±0.5 dB	"	-	"	reference impedance 600, 850, 900 Ω
			40 to 50 dB	±0.8 dB	"	-	"	
			50 to 60 dB	±1.2 dB	-	-	-	
<31> <32>	sinusoid 0 dBm0	200 Hz to 4 kHz	0 to 40 dB	"	±0.8 dB	±0.5 dB	±0.5	reference impedance 600, 850, 900 Ω
			40 to 50 dB	-	±1 dB	±0.8 dB	±0.8	
			50 to 60 dB	-	±1.5 dB	±1.2 dB	±1.2	

1.27.11 OVERLOAD CAPACITY and PEAK CODE DETECTION MEASUREMENT

Mode B	Send signal	Receive range	Results range	Error limits A-D	Error limits D-D			Remarks
<41> to <44>	sinusoid 813 Hz or 1014 Hz	relative number of the code word No. 127	+2 to +4 dBm0	±0.05 dB	-			
<45>	sinusoid		code words +0 to +127 and -0 to -127	generator see section 1.30.1 receiver: direct indication of peak code value.				

1.27.12 GROUP DELAY[1)]

Mode B	Send signal	Receive range[2)]	Results range	Error limits[3)] A-A	A-D	D-A	D-D	Remarks
<51>	see 1.2 for details of test signal	292 Hz to 3.4 kHz	MODE B51 0 to 20 ms and MODE B53	±15 µs	±15 µs	±15 µs	±15 µs	Including the oscillation caused by the total distortion of the test object.
			0 to 10 ms	±2 µs	-	-	±1 µs	Excluding total distortion of test object.
<52>	see 1.2 for details of test signal	292 Hz to 3.4 kHz	MODE B52 -10 ms to +10 ms and MODE B54	±30 µs	±30 µs	±30 µs	±30 µs	Including the oscillation caused by the total distortion of the test object.
			-5 to +5 ms	±4 µs	-	-	-	Excluding total distortion of test object.

1) MODEs B51 and B53: absolute group delay
MODEs B52 and B54: group delay distortion, referred to the value at 1 792 Hz.

2) Receive range -10.0 to 0.0 dBm0.

3) Measurement time approx. 5 s. The effect of the oscillation, caused by the total distortion of the test object, can be reduced by extending the measurement time.

1.27.13 SIGNALLING DISTORTION and CROSSTALK

Mode B	Send signal	Receive range	Results range	Error limits				Remarks
				A-A	A-D	D-A	D-D	
<61> to <69>	square-wave 10/20 Hz duty cycle 10 to 90%		±10 ms	±0.2 ms	±0.2 ms	±0.2 ms	±0.2 ms	Measurement or simulation on the digital side of bits a, b, c or d.
<71> to <79>	square-wave 10/20 Hz duty cycle 10 to 90%	weighted psophometrically	0 to -70 dBm0	±0.5 dB	±0.3 dB	±0.5 dB	±0.3 dB	
			-70 to -80 dBm0	±1 dB	±0.5 dB	±1 dB	±0.5 dB	

1.28 MEASUREMENT TIMES

The average measurement time is dependent on the mode, the relationship between the measured value and the expected value, and the number of discrete steps and channels for each test sequence.

Typical average values for measurement time are given in the following table:

MODE	No.	Average measurement time per step
LEVEL	<11> <12> to <14>	approx. 250 ms approx. 300 ms
INSERTION LOSS	<21> to <24>	approx. 300 ms
VARIATION OF GAIN WITH FREQUENCY	<31> to <34> <35> to <38>	approx. 250 ms approx. 300 ms
VARIATION OF GAIN WITH LEVEL	<41> to <44> <45> to <46>	approx. 250 ms approx. 300 ms
TOTAL DISTORTION	<51> to <57>	approx. 800 ms
IDLE CHANNEL NOISE	<61> to <66>	approx. 500 ms
CROSSTALK	<71> to <79>	approx. 300 ms
OUT OF BAND MEASUREMENTS	<81> to <83>	approx. 300 ms
RETURN LOSS and LONGITUDINAL CONVERSION LOSS	B <11> to <13> B <21>, <22> B <31>, <32>	approx. 300 ms
HARMONIC/IM DISTORTION	<91> to <94>	approx. 800 ms

O P T I O N S

1.29 C O D I R E C T I O N A L 64 kbit/s I N P U T, BN 984/00.01

Serial interface to CCITT Rec. G.703 for incorporating a 64 kbit/s digital signal to be transmitted with 64 kHz and 8 kHz clock signals as a 256 kbaud combination signal.

Data and clock signals..... balanced
Input impedance..... 120 Ω
Return loss between 20 kHz and 520 kHz..... > 20 dB

Input signal shape and coding..... to CCITT Rec. G.703, fig. 4

Pulse amplitude required..... 0.5 to 3 V
Max. r.m.s. input voltage..... 4 V
Max. tolerable peak-peak jitter..... 7.5 bits[1)]

Use as 64 kbit/s receiver (RX)

All digital measurements are possible on the received 64 kbit/s signal.

Use as multiplexer:

Insertion of 64 kbit/s signal in time slot 16 or the selected time slot.
In this mode, the 2 048 kHz send clock signal of the PCM-4 is derived from the 8 kHz input signal by means of a PLL.

1.30 C O D I R E C T I O N A L 64 kbit/s O U T P U T, BN 984/00.02

Serial interface to CCITT Rec. G.703 for transmission of 64 kbit/s digital signal to be transmitted with 64 kHz and 8 kHz clock signals as a 256 kbaud combination signal.

Data and clock signals..... balanced
Output impedance..... 120 Ω
Return loss between 20 kHz and 520 kHz..... > 20 dB

Coding..... to CCITT Rec. G.703, fig. 4

Centre of pulse amplitude (120 Ω termination)..... 1.0 V ± 0.1 V
Pulse shape..... rectangular
"No pulse" amplitude..... 0 V ± 0.1 V
Pulse duration..... 3.9 µs or 7.8 µs

Amplitude ratio positive to negative at centre of pulse..... 0.95 to 1.05
Pulse duration ratio, positive to negative, 0.5 V pulse voltage..... 0.95 to 1.05

1) Jitter value referred to 64 kbit/s

Use as 64 kbit/s generator (TX)

All available digital generator signals may be transmitted.

External jitter modulator may be connected
Clock frequency..... 256 kHz

Clock output for non-jittered clock signal
Output voltage..... TTL level

Jittered clock signal input
Input voltage..... TTL level

Use as demultiplexer

Output of the 64 kbit/s signal from time slot 16 or the selected time slot.

1.31 64 kbit/s CONTRADIRECTIONAL INPUT BN 984/00.03

Serial interface to CCITT G.703 for receiving 64 kbit/s data signals. The 8 kHz octett timing signal is transmitted as a bipolar violation of the 64 kHz clock signal.

Data and clock signals..... symmetrical
Input impedance..... 120 Ω
Return loss, 20 to 520 kHz..... > 20 dB
Input signal shape and code..... to CCITT G.703, figure 7
Input pulse amplitude required..... 0.5 to 3 V
Max. input voltage, V_{rms}..... 4 V
Max. allowable peak to peak jitter..... 7.5 bits referred to 64 kbit/s

Operation as 64 kbit/s receiver (RX)

(Parameters 112 or 114)

All digital measurements which can be selected with MODE can be carried out on the received 64 kbit/s signal.

A 64 kbit/s loop (LOOP, PARAM. 124) can be formed if a contradirectional 64 kbit/s interface is fitted.

The digital- and clock signals are codirectional.

Operation as multiplexer

(PARAM. 212 or MODE B92)

Insertion of a 64 kbit/s signal into TS 16 or a selected output TS.

The digital- and clock signals are contradirectional.

1.32 64 kbit/s C O N T R A D I R E C T I O N A L O U T P U T BN 984/00.04

Serial interface to CCITT G.703 for transmitting 64 kbit/s data signals. The 8 kHz octet timing signal is transmitted as a bipolar violation of the 64 kHz clock signal.

Data and clock signals..... symmetrical
Input impedance..... 120 Ω
Return loss, 20 to 520 kHz..... > 20 dB
Output signal shape and code..... to CCITT G.703, figure 7
Pulse amplitude at mid-point,
terminated with 120 Ω..... 1.0 ± 0.1 V
Pulse shape..... rectangular
"No pulse" amplitude..... 0.0 ± 0.1 V
Pulse width..... 7.8 or 15.6 µs
Positive to negative amplitude ratio at mid-point..... 0.95 to 1.05
Positive to negative pulse width ratio,
measured at pulse amplitude of 0.5 V..... 0.95 to 1.05

Operation as 64 kbit/s transmitter (TX)

(Parameters 112 or 113)

All output signals which can be selected with MODE or VAR. MODE can be transmitted.

The digital- and clock signals are contradirectional.

Operation as demultiplexer

(PARAM. 222 or MODE B92)

Output of the 64 kbit/s signal from TS 16 or a selected input TS.

The digital- and clock signals are codirectional.

1.33 64 kbit/s TTL S E R I A L I N P U T, BN 984/00.05

Serial interface for receiving of 64 kbit/s signals. The accompanying 64 kHz and 8 kHz signals may be co- or contradirectional depending on application.

Input and output voltages..... TTL level

Use as 64 kbit/s receiver (RX)

All digital measurements are possible with the received 64 kbit/s signal. A 64 kbit/s loop (CODEC LOOP) can be connected to the 64 kbit/s TTL output.
The rising edge of the 8 kHz clock signal must correspond to the start of the first bit of a received PCM octet.

Duty cycle of codirectional timing signal required..... 0.5

Use as multiplexer

Feeding of 64 kbit/s signal into time slot 16 or into the selected time slot.
The direction of the 64 kHz and 8 kHz timing signals may be switched internally between co- and contradirectional.

Codirectional 64 kbit/s input

In this mode, the 2 048 kHz generator clock signal of the PCM-4 is derived from the 8 kHz input signal by means of a PLL.
The rising edge of the 8 kHz signal must correspond to the start of the first bit of a received PCM octet.
Duty cycle of codirectional timing signal required..... 0.5

Contradirectional 64 kbit/s input
The output signal amplitude of the 64 kbit/s clock may be switched between asymmetrical TTL voltage and symmetrical about zero.
Duty cycle, 64 kbit/s clock..... 0.5

Duty cycle of 8 kHz output signal and phase relationship with the PCM octet switchable between the following:
Rising edge of 8 kHz clock corresponds to the start of the first bit of received PCM octet.

Duty cycle..... 0.5
or
Rising edge of the 8 kHz clock corresponds to the start of the eighth bit of a received PCM octet.
Pulse duration..... 7.8 µs

1.34 64 kbit/s TTL SERIAL OUTPUT, BN 984/00.06

Serial interface for transmission of 64 kbit/s signals. Either co- or contradirectional timing signals can be used depending on application.

Input and output voltages..... TTL level

Use as 64 kbit/s generator (TX)

All available digital generator signals may be transmitted. A 64 kbit/s loop (CODEC LOOP) can be connected to the 64 kbit/s TTL serial input.

The direction of the 64 kHz and 8 kHz timing signals may be switched internally between co- and contradirectional.

Codirectional 64 kbit/s output
The rising edge of the 8 kHz signal corresponds to the start of the first bit of a PCM octet in the 64 kbit/s signal.
Duty cycle of timing signal..... 0.5

Contradirectional 64 kbit/s output
Duty cycle of 64 kHz clock signal..... 0.5
Duty cycle of 8 kHz clock and phase relationship with the PCM octet switchable between the following:
Rising edge of 8 kHz clock corresponds to the start of the first bit of a PCM octet in the 64 kbit/s signal,
Duty cycle..... 0.5
or
rising edge of 8 kHz clock corresponds to the start of the eighth bit of a PCM octet in the 64 kbit/s signal
Pulse duration..... 7.8 µs

Use as demultiplexer:

Outputs a 64 kbit/s signal from time slot 16 or from the chosen time slot.
The rising edge of the 8 kHz signal corresponds to the start of the first bit of a PCM octet in the 64 kbit/s signal.
Duty cycle of codirectional timing signal..... 0.5

1.35 64 kbit/s TTL P A R A L L E L I N P U T, BN 984/00.07

Parallel interface for receiving PCM octets.
The 8 kHz timing signal may be co- or contradirectional as required.

Input and output voltages..... TTL level

Use as 64 kbit/s receiver (RX)

All digital measurements are possible with the received PCM octet.
A 64 kbit/s loop (CODEC LOOP) can be connected to the 64 kbit/s TTL output.
The data and signalling bit of a 7 bit μ-law word at the octet input must become valid with the incidence of the rising edge of the 8 kHz input signal.
Min. pulse duration of 8 kHz signal..... 400 ns
Signalling of 7 bit word..... L signal

Use as multiplexer

Insertion of PCM octets into time slot 16 or into the selected time slot.
The data at the octet input must become valid with the incidence of the rising edge of the contradirectional 8 kHz output signal.
Duty cycle of 8 kHz clock signal..... 0.5

1.36 64 kbit/s TTL P A R A L L E L O U T P U T, BN 984/00.08

Parallel interface for transmission of PCM octets.
The 8 kHz timing signal may be co- or contradirectional depending on application.

Output and input voltages..... TTL level

Use as 64 kbit/s generator (TX)

All available digital signals may be transmitted.
A 64 kbit/s loop (CODEC LOOP) can be connected to the 64 kbit/s parallel TTL input.
The 8 kHz clock signal direction can be switched internally between co- and contradirectional.

Codirectional octect output
The data at the octet output changes with the falling edge of the 8 kHz output signal.
Duty cycle of 8 kHz signal..... 0.5

Contradirectional octet output
The data at the octet output changes approx. 500 ns after the falling edge of the 8 kHz input signal.
Min. pulse duration of 8 kHz signal..... 400 ns

Use as demultiplexer

Output of PCM octets from time slot 16 or from the selected time slot.
The data at the octet output changes with the falling edge of the codirectional 8 kHz output signal.
Duty cycle of 8 kHz signal..... 0.5

1.37 64 kbit/s V.11 I N T E R F A C E BN 984/00.09

Serial interface with electrical characteristics to CCITT Rec. V.11; for transmitting and receiving 64 kbit/s signals. The 15 pin connector is configured to conform with CCITT Rec. X.24 (ISO 4903).

Output lines

Data-, timing- and control signals..... symmetrical TTL signals
Pulse characteristics..... LOW = < 0.5 V
HIGH = > 2.5 V

Input lines

Data-, timing- and control signals..... symmetrical

High load impedance; if the lines are unterminated, cable lengths of up to 100 m are possible. If longer runs are required, suitable terminating resistors can be soldered into the appropriate positions on the p.c.b provided.

Differential input voltage..... > 200 mV
Common-mode input voltage..... < ± 7 V
Max. permissible differential voltage..... ± 25 V
Max. permissible common-mode voltage..... ± 15 V

Operation as 64 kbit/s transmitter (TX) and receiver (RX)

(PARAM. 112, 113, 114)

All digital transmit- and receive modes which can be selected with MODE are available. If A-A configuration is used, the 64 kbit/s loop (PARAM. 124) can be closed. If PARAM. 112 (64k/64k) is selected, the PCM-4 acts as a DTE.

Operation as MUX/DEMUX

(MODE B92 or PARAM. 212, 222)

Insertion and extraction of separately selectable 64 kbit/s signals.
Timeslot 16 is always selected if PARAM. 212 or 222 is used. In MUX/DEMUX mode, the PCM-4 acts as a DCE.

1.38 R E T U R N L O S S A N D L O N G I T U D I N A L C O N V E R S I O N T R A N S F E R L O S S B R I D G E to CCITT Rec. O.121

For measurement of return loss and longitudinal conversion transfer loss of 2-wire/4-wire connections on the analog transmit and receive sides of multiplexer installations. Measurement of longitudinal conversion loss can be made from the analog to the analog level, as well as across levels (A-D, D-A).

1.38.1 RETURN LOSS AND LONGITUDINAL CONVERSION TRANSFER LOSS BRIDGE, BN 984/00.10[1)]

Reference impedance..... 600 Ω, 900 Ω and complex [2)]

1.38.2 RETURN LOSS AND LONGITUDINAL CONVERSION TRANSFER LOSS BRIDGE, BN 984/00.11[1)]

Reference impedance..... 600 Ω, 850 Ω and complex[2)]

1.38.3 SPECIFICATIONS

Max. d.c. voltage to earth..... 60 V
D.C. voltage between lines a and b..... not permissible

Error limits
within the recommended range for relative level (TX: -17 to +3 dBr and RX: -10 to +10 dBr) see 1.27.9.

1.39 R E M O T E C O N T R O L V I A <IEC 625>/IEEE 488 I N T E R F A C E B U S

Option: <IEC 625> interface board BN 958/21 with IEEE 488 connector

1.39.1 EXTERNAL CONTROL COMPUTER

Remote control of all functions and interrogation of results of measurements.

1.39.2 CONTROL OF MU-30 TEST POINT SCANNER

The PCM-4 can be used to control the channel selection of an MU-30 connected to the IEC bus system, without the need for a control computer.

1.39.3 GRAPHICS PLOTTER (using HP Graphics Language)

Plots screen contents in graphical form.

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1) Either one or the other of the bridges can be fitted to the PCM-4

2) Complex impedance for return loss measurements:
220 Ω in series with 115 nF in parallel with 820 Ω; other values available on request.

1.40 V I D E O O U T P U T

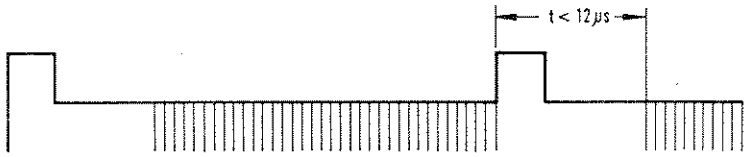
Connection for video plotter or external monitor for display of screen contents as hard copy or at remote locations.

Output to CCIR recommendations:

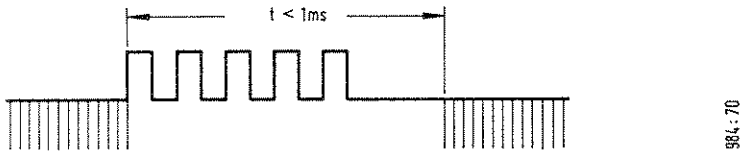
Output level into 75 Ω ..... 1 Vpp
Line frequency ..... 15.6 kHz
Frame frequency ..... 50 Hz

Monitor requirements:

- BAS signal input
- Line sync. on 180° phase shift < 0.6 ms
- Horizontal sync.



- Vertical sync



Recommended type:
ELECTROHOME Mod. EVM-1410X MNTR, No. 38-V10422-62/220 V 50 Hz

1.41 G E N E R A L S P E C I F I C A T I O N S

Unless otherwise stated, the limit values given in the preceding sections are valid within the nominal ranges of use for the influence quantities specified below.

1.41.1 POWER SUPPLY

Voltage selector setting	Nominal range
110 V	96.5 to 121 V
117 V	103 to 129 V
127 V	111.5 to 140 V
220 V	193 to 242 V
227 V	199 to 250 V
237 V	208 to 261 V

Mains frequency, nominal range of use ..... 47.5 to 63 Hz
Power consumption ..... approx. 150 VA
Safety class to IEC 348 and VDE 0411 1

1.41.2 AMBIENT CONDITIONS

Temperature

Reference temperature ..... 23°C
Nominal range, use ..... +5 to +40°C
Absolute maximum range, use ..... -10 to +55°C (for 2 hours)
Storage and transport ..... -40 to +70°C

Air humidity

Reference range ..... 45 to 75% r.h.
Nominal range, use ..... 20 to 80% r.h., in any case ≤ 20 g/m^3
Absolute maximum range, use ..... 20 to 90% r.h., in any case ≤ 25 g/m^3

Condensation

Accidental condensation is permissible.
The PCM-4 may be operated if condensation is present, and will be fully operational 60 minutes after switch-on. Conformity with specified limits cannot, however, be guaranteed under such conditions.[1)]

Mechanical stress ..... Group 1[2)]

1.41.3 MECHANICAL CHARACTERISTICS

Dimensions

Dimension	Bench model	19" rack mount model (DIN 41494) chassis	front panel + handles
Width	477 mm	443 mm	483 mm
Height	244 mm	220 mm[3)]	220 mm
Depth	434 mm	379 mm	55 mm

Weight ..... approx. 25 kg

1) The PCM-4 conforms to point 4.3 of preliminary standard FTZ 27 AN 1 (edition 4.82).
2) Further details can be found in the publication "Mechanical & climatic capabilities of measuring equipment", which we will gladly send on request (order no. e 2482).
3) The rack-mount chassis is the same height as the bench model without locating strips, feet and compartment for short-form operating manual. Corresponds to standard 5 U height.

1.42 A C C E S S O R I E S

1.42.1 D.C. LOOP HOLDING CIRCUIT GH-1, BN 984/00.12

Two d.c. loop holding circuits with a.c. coupled outputs in one housing. For maintaining the loop current on the analog send and receive sides of multiplexers.

Inputs and outputs ..... balanced, floating, 3 pole CF connector
Signal balance ratio to CCITT 0.121
from 200 Hz to 6 kHz ..... > 46 dB
Max. d.c. voltage to earth ..... 60 V
Dynamic internal impedance
from 200 Hz to 6 kHz ..... approx. 100 kΩ
from 6 kHz to 20 kHz ..... approx. 50 kΩ
Max. holding current ..... 100 mA
Voltage drop at 60 mA ..... approx. 12.5 V

Ambient temperature
Nominal range, use ..... +5 to +40°C
Storage and transport ..... -40 to +70°C
Air humidity, use, relative ..... 20 to 80%
absolute ..... ≤ 20 g/m^3
Condensation ..... see 1.41.2
Dimensions (w x h x d) in mm ..... 149 x 47 x 108
Weight ..... approx. 400 g

1.42.2 PCMZ-4 D.C. DECOUPLING UNIT, BN 984/00.13

Capacitive decoupling of the analog signal generator [25], the analog receiver [23] and the 2-wire input/output [24]. Can be switched in or out on a- and b-wires. Capacitance value is 100 µF switched in parallel with 1 MΩ.

Max. d.c. voltage to earth ..... 60 V
Max. d.c. voltage between a- and b-wires with decoupling capacitor switched in ..... 60 V
Insertion loss, decoupling capacitor shorted out ..... < 0.02 dB
Insertion loss, decoupling capacitor switched in
for input and load impedances $Z_{in} = Z_{out}$ ..... ≥ 600 Ω
in the frequency range 20 Hz to 50 Hz ..... < 0.5 dB
50 Hz to 120 Hz ..... < 0.1 dB
120 Hz to 4 kHz ..... < 0.02 dB
Longitudinal conversion transfer loss with
600 Ω termination, as per CCITT Rec. 0.121/2.3 ..... > 50 dB
Ambient temperature
Nominal range, use ..... +5 to +40°C
Storage and transport ..... -40 to +70°C

Air humidity, nominal range, use
relative ..... 20 to 80%
absolut ..... ≤ 20 g/m^3
Condensation ..... see 1.38.2
Dimensions (b x h x t) in mm ..... 198 x 50 x 52
Weight ..... approx. 320 g

1.43 ORDERING INFORMATION

PCM Channel Measuring Set PCM-4	
2048 kbit/s version, menu in English	BN 984/01
1544 kbit/s version, menu in English, WECO connectors	BN 984/02
2048 kbit/s version, menu in German	BN 984/03
1544 kbit/s version, menu in English, I 214 APS connectors	BN 984/05
Options (charged extra)	
Codirectional 64 kbit/s input	BN 984/00.01
Codirectional 64 kbit/s output	BN 984/00.02
Electrical characteristics to CCITT G.703	
Contradirectional 64 kbit/s input	BN 984/00.03
Contradirectional 64 kbit/s output	BN 984/00.04
Electrical characteristics to CCITT G.703	
Serial 64 kbit/s TTL input	BN 984/00.05
Serial 64 kbit/s TTL output	BN 984/00.06
Co- or contradirectional, depending on mode	
Parallel 64 kbit/s TTL input	BN 984/00.07
Parallel 64 kbit/s TTL output	BN 984/00.08
Parallel 8 bit input/output with 8 kHz clock signal	
64 kbit/s V.11 interface	BN 984/00.09
input/output via 15 way plug to CCITT X.24	
Return Loss and Longitudinal Conversion	
Transfer Loss Bridge 600/900 Ω [1]	BN 984/00.10
Transfer Loss Bridge 600/850 Ω [1]	BN 984/00.11
120 kHz low pass filter	BN 984/00.14
for out-of-band noise suppression	
Analog generator output impedance modified to $Z_{out} \approx 0$ Ω in place of complex impedance	BN 984/00.34
Tolerance masks programmed to user specifications	BN 984/00.35

1) Only one bridge can be fitted at any one time. For return loss measurements: additional complex impedance 220 Ω in series with 820 Ω//115 nF; can be modified at factory.

Software retrofitted to the latest status for	
PCM-4 BN 984/01	BN 984/00.41
PCM-4 BN 984/02	BN 984/00.42
PCM-4 BN 984/03	BN 984/00.43
<IEC 625> Interface Card	BN 958/24
with IEEE 488 connector and connecting cable K 420	
Accessories (charged extra)	
Test Point Scanner MU-30	BN 823/11
with <IEC 625> Interface Card	
Balanced through-switching of 24 or 30 VF channels	
in TX and RX directions	
D.C. Loop Holding Circuit GH-1	BN 984/00.12
with capacitor-couples output	
1.5 m connecting cable	K 348
CF (male) to WECO 310 (ADC jack)	
1.0 m connecting cable	K 438
CF (male) to I 214 APS (male)	
D.C Decoupling for analog inputs and outputs, PCMZ-4	BN 984/00.13
for use with BN 984/01 and BN 984/03 only.	
(Not required if GH-1 is used).	
IEEE 488/<IEC 625> Adaptor (m-m)	S 832
for <IEC 625> interface card	
Front and Back Panel Covers SD-5, (1 set)	BN 700/00.25
19" conversion kit	BN 700/00.05

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* Equipped with the Versacon® 9 75 Ω basic connector and BNC adaptor. For other adaptor types, see "Specification Sheet Versacon® 9", and order chosen type when ordering instrument.

2 General information

2.1 Important safety instructions

A.C. mains voltage

Before switching on the equipment, make sure that it is set to the voltage of the power supply.

Safety Class

This is a safety Class I equipment (see IEC 348 or VDE 0411). The power cord supplied with the instrument has a protective ground conductor. The a.c. mains plug must be plugged into an a.c. mains socket that has a protective ground contact. Any interruption of the protective conductor inside or outside the apparatus or disconnection of the protective earth terminal is likely to make the apparatus dangerous; intentional interruption shall not be attempted.

Protective earth conductor

Before the instrument is connected to the measuring circuit, a protective ground connection shall be made. If the protective ground conductor of the a.c. mains can serve for this purpose, then plug the instrument into the mains first. If the measuring circuit has its own protective ground conductor, then this should be connected to the instrument casing before the rest of the test circuit is connected.

Safety procedure for damaged or malfunctioning instruments

If the instrument

- shows visible damage
- fails to perform the intended measurements
- has been subjected to damp conditions,

it shall be considered a hazard, and shall be made inoperative and secured against any unintended operation.

Fuses

Only the specified fuses shall be used.

Opening the instrument

It may be necessary to remove the instrument covers to carry out repairs, maintenance and adjustments. This may expose live circuits, so the instrument shall be disconnected from all power sources before it is opened. Repair, maintenance and calibration of the opened equipment under voltage shall be carried out by a skilled person who is aware of the hazard involved.

Repairs

Repairs must be made by competent technicians. Care must be taken to ensure that the safety characteristics of the instrument are not altered. In particular, the dimensions of clearances and creepage distances and insulation must not be modified.

Spare parts

If spare parts other than those specified are used, then always ensure that the safety specifications of the instrument are retained.

Safety tests after repair and maintenance

Protective ground conductor test:

Check the cable for visible signs of damage and poor connections. Measure the resistance of the protective ground conductor between the a.c. mains plug contact and the instrument casing. The resistance should be < 0.5 Ω. Shake the cable during the measurement; resistance variations mean that the cable is faulty.

Insulation test:

Measure the insulation resistance between the mains conductor terminals (shorted together) and the protective conductor terminal of the instrument using a 500 V d.c. insulation tester. Ensure that the mains switch of the instrument is in the "ON" position. The insulation resistance must be > 2 MΩ.

2.2 Ventilation and rack mounting

Temperature, ventilation

The PCM-4 can be used in ambient temperatures between +5°C and +40°C. The instrument does not employ forced ventilation, so it is particularly important that the convectional air flow through the instrument is not obstructed by covering the ventilation slots in the panels.

When stacking several instruments together, ensure that the upper temperature limit will not be exceeded.

Rack mounting

The case dimensions conform to DIN 41 494, IEC 297 and ASA C 83.9 (USA). The instrument can therefore be fitted into a 19" rack.

The instrument feet and the plastic guides must be removed, and the two mounting brackets screwed into position (figure 2-1). A 19" conversion kit, complete with fixing screws, can be ordered (BN 700/00.05).

Temperature within rack

The maximum temperature limit must not be exceeded when the instrument is rack-mounted. A space of 1 U (44.4 mm) should be left above and below the instrument. The spaces at the front of the rack can be covered with dummy panels.

Ventilation

The rack must be adequately ventilated. It may be necessary to build in a fan which draws air through a filter in order to minimise problems caused by the accumulation of dust.

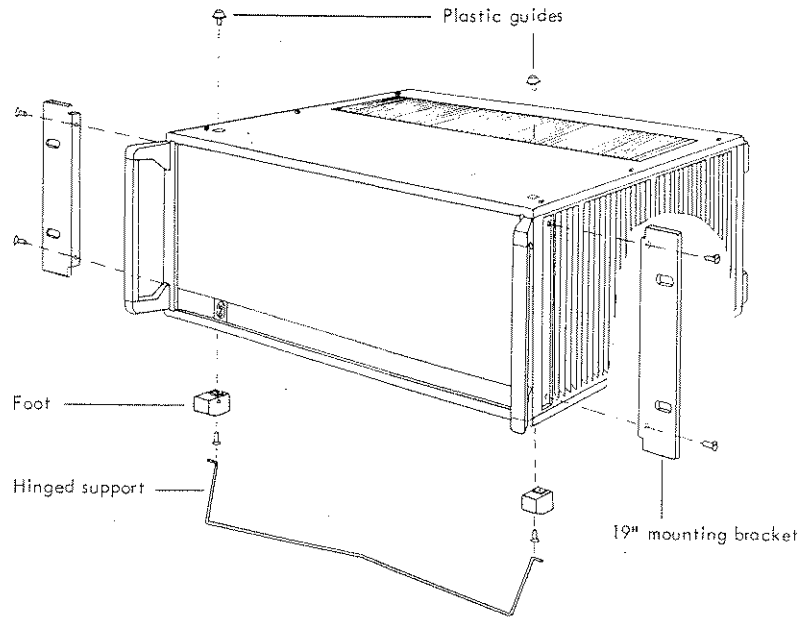


Figure 2-1 Converting the bench model for rack mounting

2.3 Power supply, fuses

Mains frequency

A.C. mains with a frequency between 47.5 and 63 Hz can be used to power the PCM-4. The nominal mains voltage must not vary by more than +10% or -12%.

Setting the mains voltage

The mains voltage selector switch on the back panel of the instrument is factory-set to 220 V.

It can be altered to select the following mains voltages: 110, 117, 127, 227 and 237 V. The fuse should be changed if a voltage between 110 and 127 V is selected.

Fuses

We specify the following fuse values and types:
110, 117, 127 V: T 2 A (2 A anti-surge)
220, 227, 237 V: T 1 A (1 A anti-surge)
One of each type of fuse is found in the compartment on the back of the PCM-4.

Mains connection

The instrument conforms to VDE 0411 or IEC 348 Safety Class I. The casing and ground connector are thus directly connected to the protective ground conductor.

Therefore

- the instrument should only be connected to a mains socket having a protective ground contact
- the mains cable supplied with the instrument should be used whenever possible
- if another mains cable is used, it must have a protective ground conductor.

2.4 Switch-on

Mains switch

This is situated in the lower right-hand corner of the PCM-4. In the "ON" position, the button colour changes to red.

Self test

After switch-on, the instrument performs a self test. All the important functions of the MASTER, DISPLAY, MEAS. FLOW and EVAL.-CIRCUIT processors are checked by this routine.

If a fault is detected, the test is aborted; in such cases the PCM-4 cannot be used. Depending on the type of fault, flashing LEDs and/or an acoustic signal indicate the defective area of the processor. Fault location procedures are explained in Appendix B. Normally, the LEDs light up for 2 s at the start of the test. If no faults are detected, the message "O.K." will be displayed on the screen.

Brightness

As soon as the EHT voltage has reached its nominal value, the result of the self test is displayed on the screen. The display brightness can be regulated with the control on the back panel [34].

Calibration procedure

The amplifiers and attenuators in the PCM-4 are calibrated. During the calibration process, the relays inside the instrument will be heard switching, and the message "CALIBRATING" will appear on the display. If this process is successful, the message "O.K." will appear, and the instrument is then ready for use.

Figure 2-2 Display following successful self test and calibration

Readiness for use

The key functions are enabled approximately 20 s after switch on when the screen display changes automatically. This means that the PCM-4 is ready for use. The last settings used before the instrument was switched off are stored in RAM (for approx. 1 month) and are restored, so that the instrument is set up with these old settings.

The screen display will be a list of all MODE A measuring mode options, (see figure 2-3), or a graphical display (see figure 2-4), or a numerical display (see figure 2-5). Both the latter displays will, of course, not show any results.

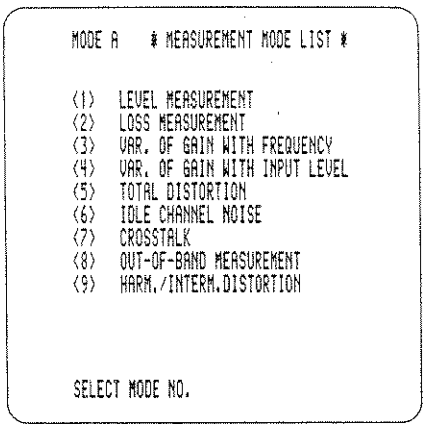


Figure 2-3 MODE A listing

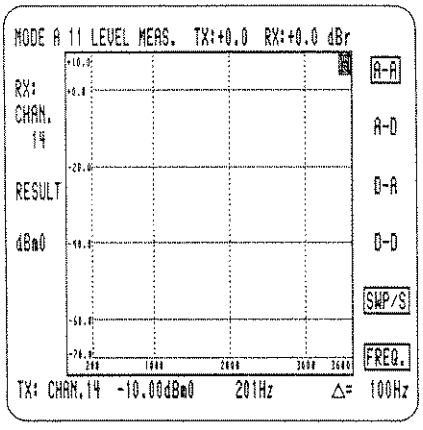


Figure 2-4 Graphical display of results (MODE A 11 shown here as example)

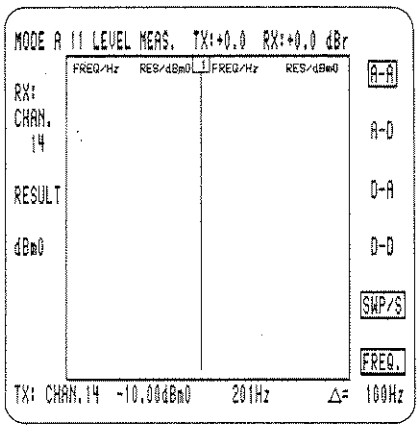


Figure 2-5 Numerical display of results (MODE A 11 shown here as example)

2.5 Disposal of built-in batteries

NiCd batteries are used in this instrument to back up data. These rechargeable batteries contain heavy metals which could be a danger to the environment when the instrument is scrapped.

Therefore, never get rid of the batteries using the normal waste disposal services, but instead remove them as described in Annex C, Chapter C.7 and then

- hand them in at the nearest toxic waste collection point or
- entrust them to a toxic waste disposal company who will recycle them or
- send them to your nearest Wandel & Goltermann Service Center.

This is a simple way of doing something for the environment.

The disassembly instructions in Annex C only apply when the instrument is being scrapped at the end of its useful life. If the batteries have to be removed for any other reason, contact your nearest Wandel & Goltermann Service Center.

The Service Center should also be contacted if you do not want to remove the batteries yourself.

3 OPERATING INSTRUCTIONS

3.1 FRONT PANEL CONTROLS AND CONNECTORS

For locations, see figure 3-1 at the end of this operating manual.

SET FUNCTION [1]

All MODE A measurement modes are displayed on the screen. A measurement mode is selected by pressing the MODE number key in the DATA ENTRY keypad [6].

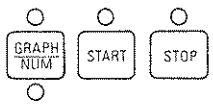
All MODE B measurement modes are displayed on the screen. A measurement mode is selected by pressing the MODE number key in the DATA ENTRY keypad [6].

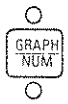
All GENERAL PARAMETERS are displayed on the screen. A PARAMETER GROUP is selected by pressing the appropriate number key in the DATA ENTRY keypad [6].

Stores a complete instrument setting.
A results page must previously have been displayed on the screen (see 3.4).

Recalls a previously stored instrument setting (see 3.4).

MEAS. RUN [2]





Selection between GRAPHIC display (results shown as a graph or bar chart) and NUMERIC display (results shown as a sequence of numerical values).

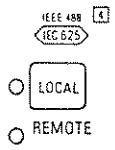
START measurement; green LED lights and key functions are disabled except for /STOP/ and /GENERAL RESET/.

STOP measurement; red LED lights and key functions are enabled. The [MAN/S] and [SWP/S] measurement sequences stop automatically.

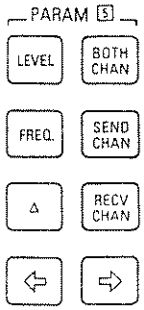
SPECIAL FCT [3]

A page of results must be displayed on the screen before the MODE MODIFICATION list can be called up using the VAR MODE key. Choice of VARIABLE MODE is made by pressing the appropriate number key in the DATA ENTRY keypad [6].

N.B.: MODE MODIFICATION is not part of the normal operating sequence and should not be attempted unless absolutely necessary for the measurement required.



REMOTE LED lights when PCM-4 is remote controlled via the <IEC 625>/IEEE 488 interface. The front panel keys are disabled. Switch over to manual control by pressing /LOCAL/.



If a send level is displayed in the last line of the results page, this can be treated as a parameter and altered.
After pressing /LEVEL/, the new value can be entered using the DATA ENTRY keypad [6]. The new value is displayed in reverse field characters and is valid only after the ENTER key has been pressed. If the level entered is too low or too high, a BEEP will be heard when the ENTER key is pressed, and the level will be set to the nearest limit value.

If a send frequency is displayed in the last line of the results page, this can be treated as a parameter and altered. After pressing FREQ., the new value can be entered using the DATA ENTRY keypad [6]. The new value is displayed in reverse field characters. When the ENTER key is pressed, the frequency will be set to the nearest possible frequency value to the one chosen within the following ranges:

20 Hz to 3.99 kHz	in 10 Hz steps with possible frequency values in Hz: n x 10.0375; n = 2 to 398
4 kHz to 72 kHz	in 100 Hz steps with possible frequency values in Hz: m x 100.375; m = 40 to 717

Both sets of fixed frequencies avoid any direct subharmonics of the 8 kHz sampling frequency.

If the frequency selected is too low or too high, a BEEP will be heard when the ENTER key is pressed, and the frequency will be set to the nearest limit value.

Δ

Sweep/Single [SWP/S] and Sweep/Repetitive [SWP/R] measurements are made on the basis of measurement steps which are determined by the increment switch /Δ/. Δ depends on the running parameters, such as level step, frequency step or channel step, which are displayed in the lower right-hand corner of the results page. If /Δ/ is pressed, new values for the level or frequency step (but not the channel step) can be entered using the DATA ENTRY keypad [6]. The new value is displayed in reverse field characters, and only becomes valid when the ENTER key is pressed. Level steps can be set with 0.1 dB resolution in the range 0.1 Hz to 10.0 kHz; frequency with 10 Hz resolution in the range 10 Hz to 10 kHz. Too high or too low a value is indicated by a BEEP when ENTER is pressed. The parameter will automatically be set to the nearest limit value.

BOTH CHAN

A different send and receive channel can be entered using the DATA ENTRY keypad [6] after pressing /BOTH CHAN/. The new channel number (for both send and receive) is displayed in reverse field characters and is valid only after ENTER is pressed. Only the telephone channels 1 to 30 will be accepted in the basic setting.

SEND CHAN

As for BOTH CHAN but only for send channel TX: CHAN.

RECV CHAN

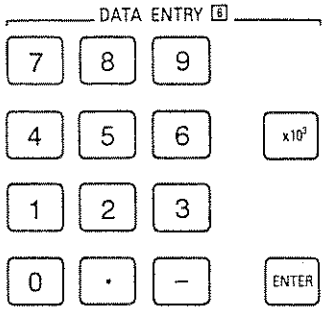
As for BOTH CHAN but only for receive channel RX: CHAN.

⇨

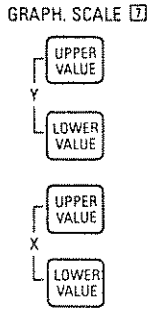
Every time / ⇨ / is pressed, the running parameters (level, frequency and receive channel) are increased by the value of Δ . If pressed continuously, the parameter is increased in steps of Δ automatically.

⇦

Every time / ⇦ / is pressed, the running parameters (level, frequency or receive channel) are decreased by the value of Δ . If pressed continuously, the parameter is decreased in steps of Δ automatically.



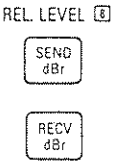
Keypad for input of all screen menu codes or for entry of all parameters and values for the measurement sequence and the display of results. Keypad entries which are displayed in reverse field characters become valid only after /ENTER/ has been pressed.



To optimise the graphical display of the results, the upper and lower scale limits of the X and Y axes can be altered after the results page is displayed. By pressing one of the GRAPH. SCALE [7] keys, the scale limits are displayed on the screen and the particular value to be altered is displayed in reverse field. The new value can be entered using the DATA ENTRY keypad [6]. This new value is also displayed in reverse field characters, and becomes valid when /ENTER/ is pressed.

NOTE: The value entered for UPPER VALUE must always be the highest value entered. The difference between the scale limits must be
≥ 0.3 dB for level,
≥ 30 Hz for frequency, and
> 3 for channel.

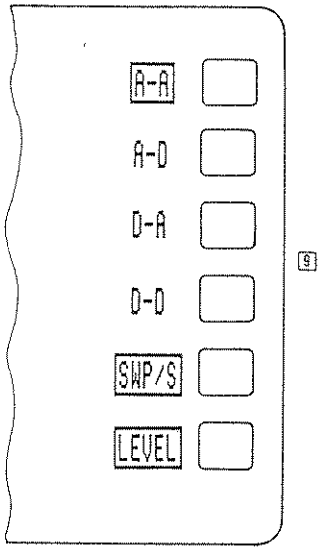
The new axes are displayed after softkey 6 [RTN] is pressed. If the scales have been correctly entered, the results curve previously displayed will automatically be redrawn to fit the new scales.



IF TX: - - is displayed in the top line of the results page (digital send signals) then relative send levels cannot be used. Otherwise, a relative send level can be set in steps of 0.1 dB within the range -19.9 to +9.9 dBr by first pressing /SEND dBr/ and entering the value with the DATA ENTRY keypad [6]. This relative level will be added to the send level when /ENTER/ is pressed.

If RX: - - is displayed in the top line of the results page (digital received signals) then relative receive levels cannot be used. Otherwise, a relative receive level can be set in steps of 0.1 dB within the range -19.9 to +9.9 dBr by first pressing /RECV dBr/ and then entering the value with the DATA ENTRY keypad [6]. This relative level will be subtracted from the receive level when ENTER is pressed.

The softkey functions are defined in software, and depend on the MODE selected; the key functions are displayed next to each key on the screen.



Softkeys 1 to 4

Depending on the MODE selected, up to four test configurations are available (except in MODE B1, B2 and B8). The actual configuration is indicated on the screen by an enclosing frame.

A-A Softkey 1 is pressed for Analog-Analog measurements between the analog signal generator and the analog receiver of the PCM-4.

A-D Softkey 2 is pressed for Analog-Digital measurement on PCM coders (half-channel) between the analog signal generator and the digital receiver of the PCM-4.

D-A Softkey 3 is pressed for Digital-Analog measurements on PCM decoders (half-channel) between the digital signal generator and the analog receiver of the PCM-4.

D-D Softkey 4 is pressed for Digital-Digital measurements on transmultiplexers and digital circuits between the digital signal generator and the digital receiver of the PCM-4.

Softkey 5

Softkey 5 determines the measurement sequence.

MAN/S One-shot (Manual/Single) measurement using the parameters selected; numerical display of the result is under RESULT on the left-hand side of the screen.

MAN/R Repetitive measurement (Manual/Repetitive) using the parameters selected; numerical display of the result is under RESULT on the left-hand side of the screen.

SWP/S

Displays result of a single sweep measurement (Sweep/Single) in the form of a graph. The measurement steps are determined by the value of Δ set previously.

Displays results of repetitive sweep measurements (Sweep/Repetitive) in the form of a graph which is overwritten by successive measurements. The measurement steps are determined by the value of Δ set previously.

FREQ.

Softkey 6

The measurement results are displayed against frequency, the frequency set for the send channel being shown at the lower edge of the screen. [SWP/S] and [SWP/R] measurements start from this value.

LEVEL

The measurement results are displayed against level, the level set for the send channel TX being shown at the lower edge of the screen. [SWP/S] and [SWP/R] measurements start from this value.

CHAN.

The results are displayed in the form of a bar chart, each bar corresponds to the receiver channel that has been set (displayed at the bottom of the screen as RX: CHAN). SWP/S or SWP/R measurements start with the RX: CHAN. thus displayed.

HISTG

The results of measurements made in MODE BB (bit error rate) are displayed in the form of a histogram.

The softkeys 4 to 6 are assigned additional functions.

By pressing softkey 4, the next page of results is displayed on the screen.

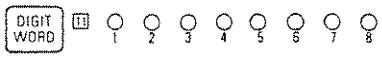
By pressing softkey 5, the previous page of results is displayed on the screen.

RTN

By pressing softkey 6 the original page of results will be returned to the screen.

GENRL. RESET

Standard settings are reset by pressing this button.



All the possible digital PCM words which can be indicated by the LED array (corresponding to bits 1 to 8) are displayed on the screen. The PCM word is displayed by the LEDs after it has been selected by pressing the appropriate key in the DATA ENTRY keypad [6].

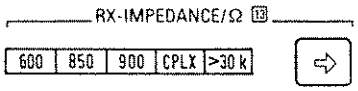
Results displayed as points are joined up to form a graph by pressing /LINK RESLT/.

If the results are given in numerical form, successive pages of results are displayed by pressing this key. After the last page, the display will revert to the first page.

Clears numerical or graphical results displayed on the screen.

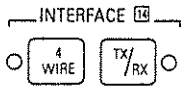
Depending on the setting of GEN. PARAM PRINTER/PLOTTER, the results can be output as hardcopy on a HP-GL compatible plotter connected via the <IEC 625>/IEEE 488 interface, or on a suitable printer (see 3.6.10).

Note:
- PCM-4 must be in system controller mode; SC switch on <IEC 625>/IEEE 488 interface board should be set to ON.
- Plotter address = 29
- Printer address = 30
- Switch on printer (plotter) before switching on the PCM-4.

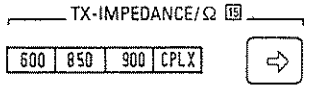


Sets the analog signal receiver input impedance. The display scans through the settings if the key is held down. The impedance is switched into circuit as soon as the key is released.

CPLX: 220 Ω in series with 820 Ω in parallel with 115 nF fitted as standard.



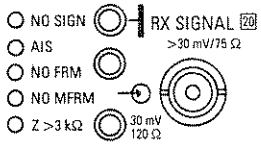
/TX/RX/ can only be used for A-D or D-A measurements. The analog send signal can be taken from the 2 wire output [24] for A-D measurements when /TX/RX/ is pressed. The analog received signal can be fed into the 2 wire input [24] for D-A measurements when the TX/RX key is pressed.



Sets the analog signal generator output impedance. The display scans through the settings if the key is held down. The impedance is switched into circuit as soon as the key is released.

"CPLX": 220 Ω in series with 820 Ω in parallel with 115 nF is fitted as standard.

Note: If the impedance value has been modified, refer to section 1.3. If $Z_{in} \approx 0$ has been fitted in place of Z_{in} = CPLX, measurement of analog-analog overall loss in modes A21, A22, A23 and A24 is not possible if this impedance is selected.



Digital receiver input with 2 048 kbit/s interface to CCITT G.703.

The line code setting following GENERAL RESET is HDB3, which means that a 2 048 kbit/s HDB3 coded signal can be input via the balanced 120 Ω input or the 75 Ω coaxial input. The line code can be changed to AMI or NRZ using PARAM. 4 of the GENERAL PARAMTERS; the impedance can also be changed to > 3 kΩ in this way.

NOTE: If the digital receiver line code is set to NRZ, the signal can only be input via the 75 Ω coaxial input. The balanced input can only be used for HDB3 and AMI (pseudo-ternary) coded signals. The r.m.s. input voltage must not exceed 4 V.

○ NO SIGN. The pulse amplitude of the input signal can be between 30 mV and 3 V. If the signal amplitude is too low, the LED lights.

○ AIS

If the AIS LED lights, and Alarm Indication Signal has been received. It consists of a continous sequence of 1s (no frame structure) and simulates an interrupted connection.

○ NO FRM

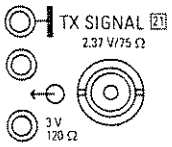
The frame structure is monitored for conformity with CCITT G.732 after a GENERAL RESET. The NO FRM LED lights if there is an errored frame indication.
The frame identification LED can be disabled (PARAM. 224) for use with 32 telephone channels with external 8 kHz frame synchronisation.

○ NO MFRM

The frame structure is monitored for conformity with CCITT G.732 after a GENERAL RESET. The NO MFRM LED lights if an errored multiframe identification is detected.
The multiframe identification LED can be disabled for use with 30 channels with external time channel 16 (PARAM. 222), as well as 31 or 32 telephone channels (PARAM. 223 or 224).

○ Z > 3 kΩ

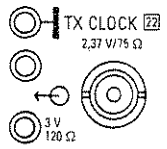
For monitoring the signal, the input impedance of both inputs can be set to > 3 kΩ using PARAM. 4. The Z > 3 kΩ LED lights to indicate this condition.



Digital signal generator output with 2 048 kbit/s interface to CCITT G.703.

In the basic setting which follows GENERAL RESET, HDB3 code signals at 2 048 kbit/s may only be taken from the 120 Ω balanced output. The line code can be altered to AMI or NRZ using PARAM. 3 of the GENERAL PARAMETERS. If the output impedance is changed to 75 Ω using PARAM. 3, then the 2 048 kbit/s signal can only be taken from the coaxial output.

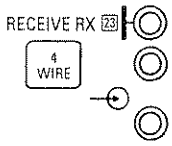
NOTE: NRZ coded signals can only be taken from the coaxial output.



2 048 kHz clock signal output

In the basic setting following GENERAL RESET, the 2 048 kHz clock is generated by the PCM-4 and can only be taken from the 120 Ω output. If the impedance is changed to 75 Ω using PARAM. 3 of the GENERAL PARAMETERS, then the 2 048 kHz clock can only be taken from the coaxial output.

Phase relationship between clock and digital signal:
The leading edge of the signal bit and the rising edge of the clock signal are in phase (if $V_{b/a}$ is symmetrical).



4-wire input for analog receiver, balanced, floating. The input impedance RX-IMPEDANCE/Ω [13] can be altered by pressing /⇨/.

W A R N I N G

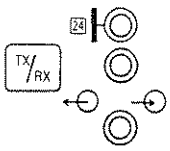
D.C. loading:

- Max. d.c. voltage referred to earth potential..... 60 V
- Overvoltage protection circuit operates if a voltage > 12 V_p is present between wires a and b.

The message OVERL will be displayed on the graphic or numeric display of results under RESULT.

Measurements are not possible under these conditions!

This problem can be avoided if a GH-1 d.c. loop holding circuit, BN 984/00.12 is fitted, or if a PCMZ-4 d.c. decoupling unit, BN 984/00.13 is plugged in to the front panel.



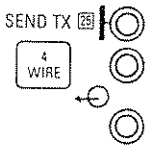
2-wire in- or output, balanced, floating.
2-wire output from analog signal generator for A-D measurements only, by pressing /TX/RX/. Output impedance (TX-IMPEDANCE/Ω [15]) is changed by pressing /⇨/.

NOTE: D.C. loading - as for 4 wire output [25].

2 wire input to analog signal receiver for D-A measurements only, by pressing /TX/RX/. Input impedance (RX-IMPEDANCE/Ω [13]) is changed by pressing /⇨/.

NOTE: D.C. loading - as for 4 wire input [23].

REMARKS: For D-D measurements, the 2 wire connection can be terminated with a complex impedance of 910 Ω in parallel with 39 nF by selecting PARAM. 914 of the GENRAL PARAMETERS (use: hybrid loss measurements).



4 wire output of analog signal generator, balanced, floating.

Output impedance (TX-IMPEDANCE/Ω [15]) is changed by pressing /⇨/.

W A R N I N G

D.C. loading:

- Max. d.c. voltage referred to earth potential..... 60 V
- Overvoltage protection circuit operates if a voltage > 11 V_p is present between lines a and b.

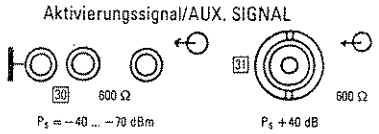
The message OVERL will be displayed on the graphic or numeric display of results under RESULT.

Measurements are not possible under these conditions!

This problem can be avoided if a GH-1 d.c. loop holding circuit, BN 984/00.12 is fitted, or if a PCMZ-4 d.c. decoupling unit, BN 984/00.13 is plugged in to the front panel.

3.2 BACK PANEL INPUTS AND OUTPUTS (EXCLUDING OPTIONS)

For locations, see figure 3-2 at the end of this operating manual.

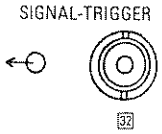


Auxiliary signal outputs

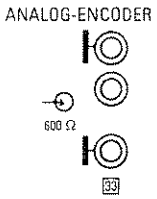
A quasi-random noise signal, frequency range 350 to 550 Hz, is automatically available as auxiliary signal only when crosstalk measurements are being made. The signal levels are -45 dBm at the 600 Ω balanced output and approx. -5 dBm from the 600 Ω coaxial output (relative send level of 0 dBr).

If an analog auxiliary signal is required for other purposes, then after the results page is displayed, a MODE MODIFICATION can be entered using the /VAR. MODE/ key. VAR MODE 152 sets the pseudo-random noise signal, and VAR. MODE 153 is used to set a 2 kHz sinusoidal subharmonic signal. The signal output levels can be set (in dBm0) using VAR. MODE 154, in steps of 1.5 dB referred to the relative send level.

Level range: (-70 - rel. level) to (-40 - rel. level) dBm0.
The coaxial output signal level is approx. 40 dB higher.

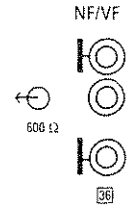


Signal trigger output [32], output impedance 75 Ω.
A HIGH TTL pulse is available at output [32] as a trigger signal (synchronous with the transmitted signal in the selected TS).

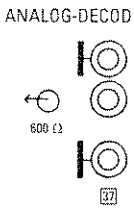


Analog encoder input [33]
An analog signal input at [33] can be applied to the chosen TX: CHANNEL via an encoder for D-A or D-D measurements. Before this can be done, a MODE MODIFICATION is necessary using the /VAR. MODE/ key. VAR. MODE 245 should be set in this case.

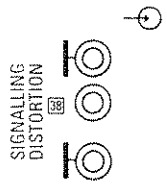
Input impedance ..... 600 Ω
Relative level..... 0 dBr
Frequency range..... 300 Hz to 3 400 Hz
Loading capacity..... 3.14 dBr (A-law)
3.17 dBr (μ-law)



Unbalanced LF output [36], output 600 Ω.
The analog receiver LF input signal is available at auxiliary output [36] with a level in the range -3 to +3 dB.

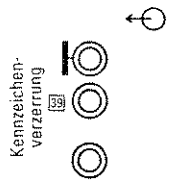


Analog decoder output, unbalanced, output impedance 600 Ω [37].
Code words received from the selected RX: CHAN. are decoded and output from [37] as analog signals.



Signalling distortion input [38], input impedance 750 Ω referred to internal d.c. voltage of -15 V.

The input must be switched to earth.
Closed resistance of driving switch... < 300 Ω
Opened resistance..... > 20 kΩ
Short circuit current..... 20 mA
The signalling distortion input is used to measure the duty cycle deviation of a 10 Hz or 20 Hz rectangular signal.



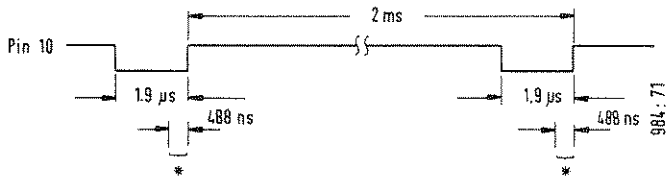
Signalling distortion output [39], a.c. coupled.

By setting a MODE MODIFICATION, using the VAR. MODE key after a results page has been displayed, the duty cycle of the 10 Hz signal can be varied in 1% (A-A or A-D configurations) or 2% (D-A or D-D configurations) steps within the range 10% to 90%. This is done with VAR. MODE 711. VAR. MODE 722 is used to change the output frequency of the signal to 20 Hz.

60 SIGNALLING INPUT

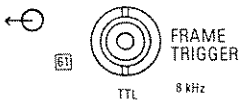
Output impedance (electronic switch):
Pulse..... < 30 Ω
Pause..... > 20 kΩ
Max. d.c. loading..... 200 mA
Max. switch voltage..... 70 V

Signalling input [60]
In place of a static signalling setting (PARAM. 518), the status of the signalling bits a, b, c, d for the selected TX: CHAN. can be varied dynamically by means of TTL levels applied to pins 1 to 4. For this, pin 11 must be pulled LOW and PARAM. 211 of the GENERAL PARAMETERS must be selected.



* Data on pins 1 to 4 must be valid.

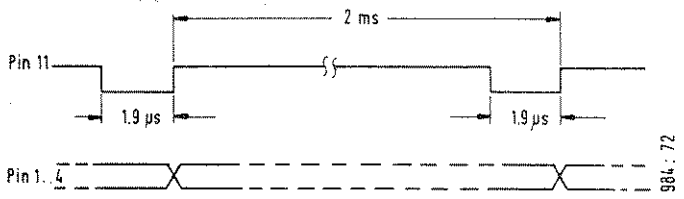
Pin 1: a bit input
Pin 2: b bit input
Pin 3: c bit input
Pin 4: d bit input
Pin 10: 500 Hz clock output
Pin 11: LOW for ext. signalling
Pin 13: +5 V, 50 mA
Pin 14: ⏚



Frame trigger output [61]
Frame trigger signal with TTL level, rising edge corresponds to start of time slot 0.
Permissible devaiation of start of timeslot 0 referred to the frame trigger signal:
< 60 ms.
No signal for A-A measurements.
When operating the generator with external frame trigger (PARAM. 333), socket [64] ensures phase continuity between the 8 kHz input and output trigger signals (permissible deviation ±30 ns).

62 SIGNALLING/ERROR OUTPUT

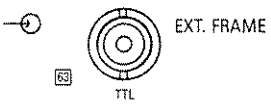
Signalling/Error output [62]
If PARAM. 221 of the GENERAL PARAMETERS is selected, the status of the signalling bits a, b, c, d of the RX: CHAN. selected are output at pins 1 to 4. The 500 Hz clock signal is only available at pin 11 when PARAM. 221 is selected.



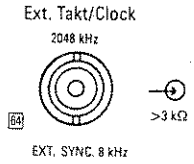
Data exchange with rising edge of clock on pin 11.

Pin 1: a bit output
Pin 2: b bit output
Pin 3: c bit output
Pin 4: d bit output
Pin 5: approx. 125 µs error pulse if frame error detected
Pin 6: Error pulse, duration approx. 125 µs, output each time a CRC error is detected by the 2 048 kbit/s receiver.
Pin 7: approx. 125 µs error pulse if multiframe error detected
Pin 8: 488 ns error pulse if code error detected
Pin 11: 500 Hz clock output
Pin 13: +5 V, 50 mA
Pin 14: ⏚

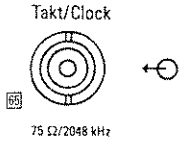
Error pulses will only be output at pin 5 or pin 7 when frame- or multiframe errors occur, if the frame or multiframe structure corresponding to G.732 is still recognised by the digital receiver and the NO FRM or NO MFRM LEDs are not lit.



Ext. Frame trigger input [63]
For operation without a frame signalling word (PARAM. 224), an external 8 kHz frame signal is needed to signal the start of each frame. The rising edge of the frame trigger signal corresponds to time slot 0. Max. deviation of rising edge of trigger signal from start of time slot 0 is ±150 ns.



Clock and synchronisation input [64]
If the PCM-4 is to be synchronised to the 2 048 kHz clock or the 8 kHz synchronising signal from the test item, then PARAM. 332 or PARAM. 333 or the GENERAL PARAMETERS should be selected respectively. The input impedance can be switched between 75 Ω and > 3 kΩ. The slide switch for this purpose is accessible by pulling out the plug-in module. The rectangular input signal required must be between 1 and 5 V.
Clock frequency
required:..... 2048 kHz $\pm$ 100 x 10^{-6}
Duty cycle 0.5
or..... 8 kHz $\pm$ 100 x 10^{-6}
If terminated with 75 Ω (TX and RX sides), high pulse (width > 488 ns) also available.



2 048 kHz clock output [65]
Recovered bit clock output, TTL level. A free-running oscillator is synchronised with the 2 048 kbit/s signal. Pulling range of regenerator..... $\pm$100 x 10^{-6}

3.3 OPERATING PROCEDURE FOR THE PCM-4

FLOWCHART

The operating procedure for the PCM-4 can be rapidly understood from the three page flowchart. Important aids to selection and other remarks are in the following section; these should be studied carefully beforehand.

MAINS ON

- A self test routine is run in the PCM-4. The important functions of the MASTER, DISPLAY, MEAS. FLOW, and EVAL.-CIRCUIT processors are checked.

SELF TEST

- During the self-test, the LEDs will light for 2 s. The switching of the relays will be audible.
- When the EHT line reaches its nominal voltage, the screen will display the results of the self test. If no errors are detected during the self test, the legend O.K. will be displayed. (If this is not the case, refer to the functional tests given in Appendix B)

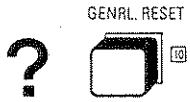
CALIBRATING

- The CALIBRATING display indicates that the amplifiers and attenuators in the PCM-4 are being calibrated. If this procedure gives the result O.K., then the instrument is ready for use.

BATTERY CHECK

- When the PCM-4 is switched off, the RAM contents are retained if the rechargeable back-up batteries are sufficiently charged. If the PCM-4 is operated continuously for 24 hours, the battery charge is sufficient to maintain the RAM contents for 3 to 4 weeks at normal room temperature.

NOTE: If insufficient charge is available, it is possible that the memory contents will be lost, leading to incorrect operation.
For this reason, if BATTERY CHECK BAD is displayed, the instrument automatically resets to standard values. This means that any setups must be entered again.



The MODE A list or the results page (without results!) will be displayed on the screen with the previous measuring sequence settings.

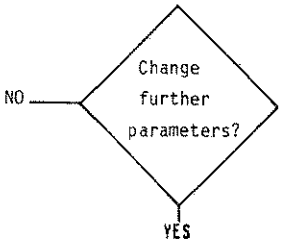
If there is any doubt that these settings are correct - particularly the GENERAL PARAMETERS - then press /GENRL. RESET/. The instrument will then revert to the standard settings.

EXCEPTION: Settings made in STORE MODE will be retained.

Before starting a measurement

NOTE the following points:

- Wait until the result page is complete on the screen
- Check the parameters which are displayed at the edges of screen to see that they correspond to the new measuring mode:
  - Test configuration
  - Relative level
  - Receive and send channels
  - Running parameters
  - Measurement sequence
  - Increment
  - X and Y scale limits
- Make any alterations necessary using the softkeys and the PARAM. [5], REL. LEVEL [8], and GRAPH SCALE [7] keys.
- Check that RX and TX impedances are correct and alter if necessary.
- Set analog interface to 2 or 4 wire configuration.



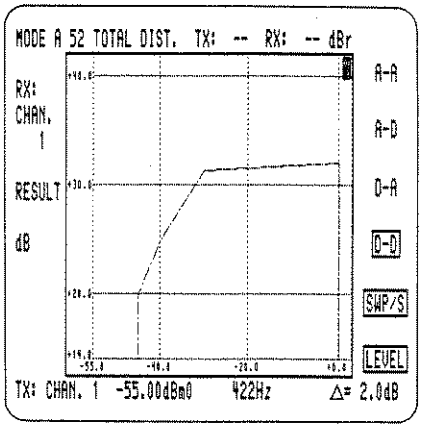
Other parameters are very important (as GENERAL PARAMETERS) for setting up the PCM-4 correctly, particularly the settings of the digital signal generator and receiver.

If digital signals are to be sent and/or received, (D-D, D-A, or A-D configurations), then the GENERAL PARAMETERS should be checked and corrected if necessary.

3.4 STORAGE AND RECALL OF INSTRUMENT SETTINGS (SETUPS)

The STORE and RECALL functions allow complete instrument settings to be stored and recalled. Standard or modified GENERL. PARAM. and VAR MODE values are stored together with the measurement mode.

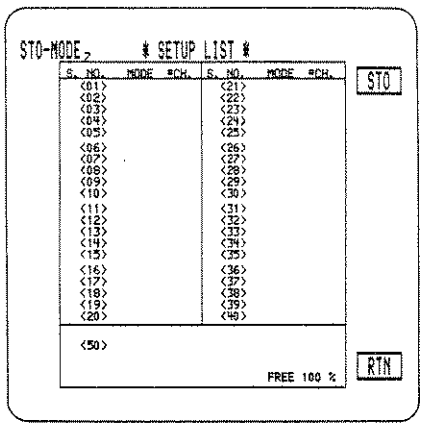
STORE function



To store a measurement mode as a setup, a results page must previously have been displayed on the screen.

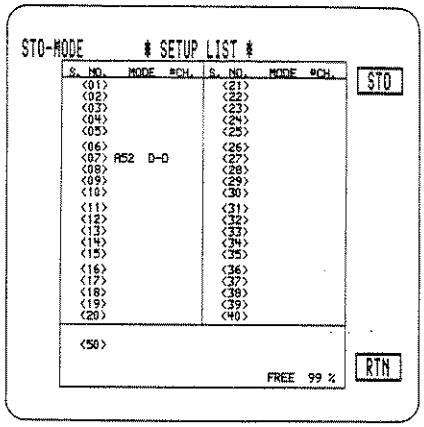
Example:
Mode A52 is to be stored as a setup.

This is achieved by pressing:
/MODE LIST A/ + /5/ + /2/ + /ENTER/.
Mode A5 = total distortion.
Submode 2 = 422 Hz sine wave, to CCITT 0.131



The heading STO MODE and a list of all setups is displayed on the screen when /STO MODE/ is pressed. If no setups have been stored yet, the memory position numbers (01 to 40) and the available memory space (100%) will be displayed. The measurement mode setup can be assigned to any memory position by pressing the appropriate number key(s) followed by /ENTER/ (memory position 7 has been used in the example).

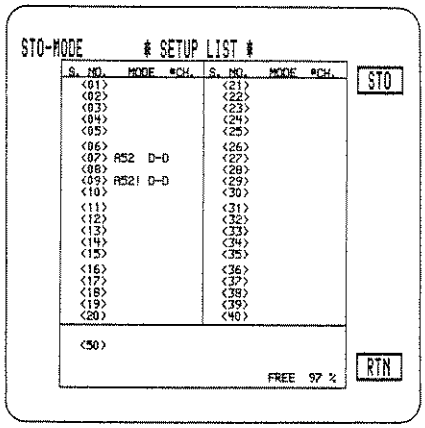
Important: A program for HP 9816 is given in section 4.5.4 which allows the setup memory to be transferred to/from diskette.



The measurement mode and configuration are then immediately displayed next to the memory position number: "A52 D-D". The memory space remaining is 99%.

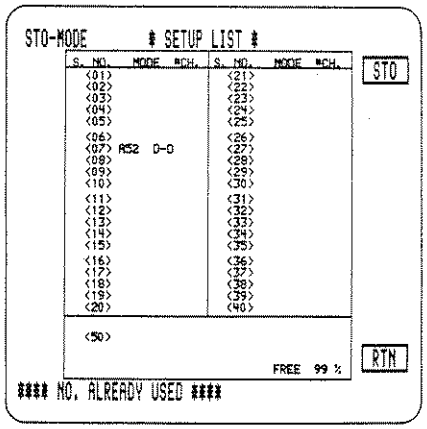
A further 39 setups can be stored in a similar manner. To leave the STORE mode, press softkey 6 "RTN".

NOTE: Results (numerical values, points and curves) are not stored.



If an alteration has been made to a measurement mode via the VAR. MODE key, this will be indicated by ! when the mode is stored.
Example: "A52! D-A"

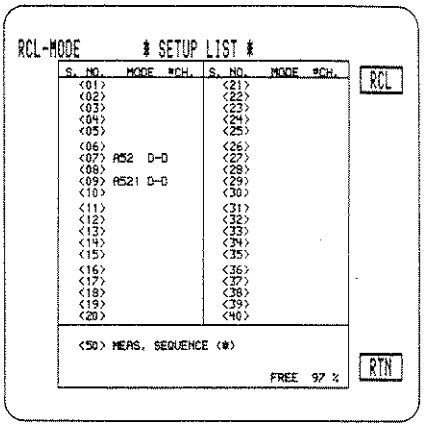
Memory CLEAR



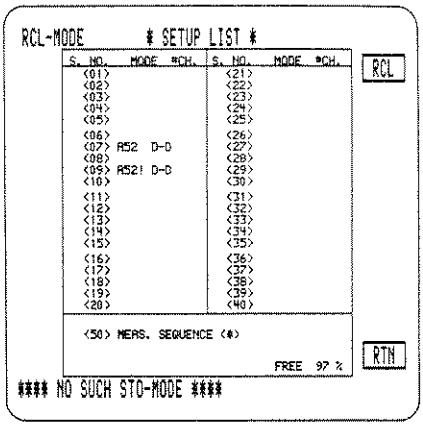
Measurement modes stored in memory positions are protected against accidental overwriting. If this is attempted, the message NO. ALREADY USED will be displayed. If it is, however, desired that the memory contents be overwritten, the previously stored information must first be erased. This is done by entering the memory position number preceeded by a minus sign (e.g. -9) and followed by /ENTER/. This clears the memory position concerned, which can now be filled by the new mode data.

The complete contents of the setup memory can be cleared by entering -99.

RECALL function



A measurement mode can be recalled from the memory by pressing /RCL MODE/. The current setup list is displayed on the screen, this time with the heading "RCL-MODE". The memory position number of the required setup should then be entered and /ENTER/ pressed. Exit from RECALL mode is achieved by pressing softkey 6 "RTN". The PCM-4 will then be set to the measurement mode which has been recalled. Measurement can then be started by pressing /START/.



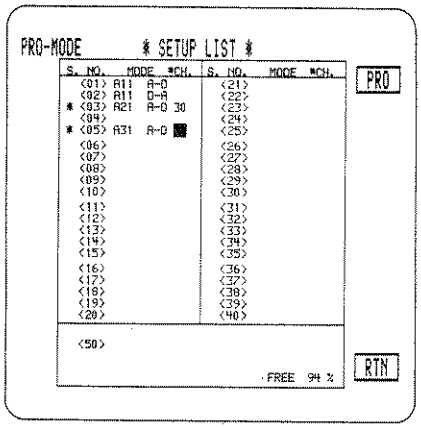
If an unused memory position is selected for recall, the message NO SUCH STO MODE will be displayed on the screen. Simply enter the right memory position number followed by /ENTER/ to continue.

3.4.1 LINKING SETUPS TOGETHER TO FORM A SEQUENCE

The setups (max. 40) listed in the SETUP LIST can be linked together into a sequence, thus allowing any stored instrument settings to be made automatically within a series of measurements.

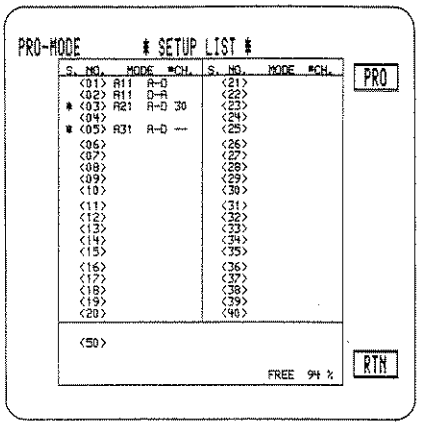
Note: If the results are to be output onto an ASCII printer connected to the IEEE 488 bus, the PRINTER/PLOTTER parameters (PARAMETERS 06 to 09) must be set accordingly before the settings are stored in STORE MODE.

The SETUP LIST is called up using /STO MODE/ or /RCL MODE/. /STO MODE/ can only be used if a graphic or numeric results display is already shown on the screen. Pressing softkey STO in STORE MODE or RCL in RCL MODE calls up the PROGRAM MODE. The upper softkey is then labelled PRO and the SETUP LIST is indicated by PRO MODE.



Any of the setups under the SETUP LIST can now be linked together into a sequence. Selecting the address of the setup in the list and pressing /ENTER/ causes a * to appear in the S (sequence) column next to the chosen setup, and an input field ■ is indicated under #CH. (no. of channel steps) so that you can input the number of channel steps to be carred out for this measurement setup.

Example: A measurement of the variation of gain with frequency in MODE A31 is to be carried out in all channels with frequency as the running parameter, before storing MODE A31 in STORE MODE, the starting channel number for the send- and receive sides is set with CHAN.1. The maximum number of channel steps is 30, so this value is also input. This will then cause MODE A31 to be executed in channels 1 ... 30 with the running parameter of frequency. If, for example, channel 4 is given as the starting channel, the measurement will still consist of 30 steps, carried out in the sequence CHAN. 4 ... 30, CHAN. 1 ... 3.



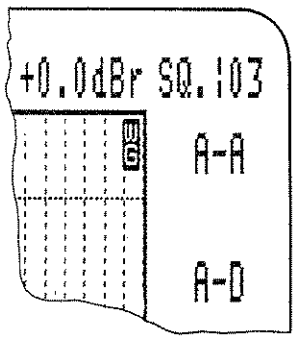
Note: If channel has already been chosen as the running parameter by pressing softkey CHAN, the symbol -- will be shown under #CH., and it will not be possible to input the number of channel steps to be executed.

Exception: Channel is preselected as running parameter for MODE A7 CROSSTALK. A possible input of the number of channel steps to be carried out refers to the send channels. In this way, 29 receive channels can be checked for each of the 30 send channels.

3.4.1.1 Removing a setup from a sequence

With the SETUP LIST in PRO MODE, any SETUP (*) can be removed from a sequence simply by pressing /-/ before entering the address.

3.4.2 RUNNING A SEQUENCE



A sequence of measurements can only be started with the SETUP LIST in RCL MODE. This menu is called up by pressing /RCL MODE/. In the lowest line of the SETUP LIST under address <50>, the words MEAS. SEQUENCE (*) are shown. If the address 50 is entered and the /ENTER/ key then pressed, the results page for the measurement setup in the sequence with the lowest address will be displayed. The address is shown in the top right hand side of the screen (e.g. SQ.: 03). This information is updated as the sequence continues. The sequence is started by pressing /START/, and all setups marked with a * will then be carried out in numerical order of their addresses.

Note: The speed at which measurements can be made is considerably decreased if all the measurement results are printed out via the ASCII printer. It is therefore a good idea to print out only those results which lie outside certain limits (PARAMETER 07 or also PARAMETER 09).

NB: The time taken for the setting up of a new display on the screen when the measurement mode or the configuration is changed can be eliminated only if the screen is switched off with the instrument operating under remote control.

3.4.2.1 Interrupting a sequence

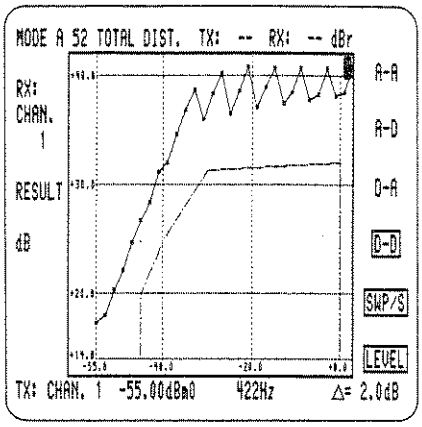
A sequence can be interrupted by pressing /STOP/. If the GENERAL PARAMETERS are changed or a MODE MODIFICATION is made subsequently, the sequence mode will be exited, and the setup address (*) at the top of the screen display will be erased. To restart in such cases, address <50> must be entered again. If a menu page which does not have a RTN (return) function, such as MODE LIST A, is called up, this also forces the sequence to restart.

Changes in the parameters for the setup (*) that has been called up will be accepted if made using the keys [5]. In such cases, the sequence will not be exited, and pressing /START/ will cause the sequence to resume from where it was halted.

3.4.2.2 Clearing a sequence

By entering -50, the sequence set under PROG. is cleared. Setups stored in memory are not affected.

3.5 GRAPHIC DISPLAY OF RESULTS



Example of a page of results as a graphic display for a MODE A52 measurement.

MODE A 52 TOTAL DIST.

Display of mode chosen from the MODE LISTs A or B. In this case, MODE A 5 and SUBMODE NO. 2 have been selected, i.e. TOTAL DISTORTION using SINE WAVE 422 Hz, CCITT. O.131.

TX: -- RX: -- dBr

Display of relative send- (TX) and receive- (RX) levels in dBr. In this case, relative levels cannot be shown, since send- and receive-side measurements are made using digital signals (D-D).

A-A

A-D

D-A

D-D

Depending on the mode chosen, up to four measurement configurations can be selected (except in MODE B1, B2 and B8). The actual setting is indicated on the screen by an enclosing frame.

A-A for Analog-Analog measurement between analog signal generator and analog receiver.

A-D for Analog-Digital measurement between the analog signal generator and digital receiver.

D-A for Digital-Analog measurement between the digital signal generator and the analog receiver.

D-D for Digital-Digital measurement between the digital signal generator and digital receiver.

SWP/S

Single sweep measurement (Sweep/Single). Measurement steps correspond to the value of the increment Δ set previously.

LEVEL

The results are displayed as levels (X-axis = send level). In this case, the range of levels is between -55.0 and +3.0 dBm0.

Δ= 2.0dB

Increment display Δ.

TX: CHAN. 1 -55.00dBm0 422Hz

Code words are sent from the digital signal generator (D-D measurements) in channel 01 at a level of -55.00 dBm0, and at a frequency of 422 Hz.

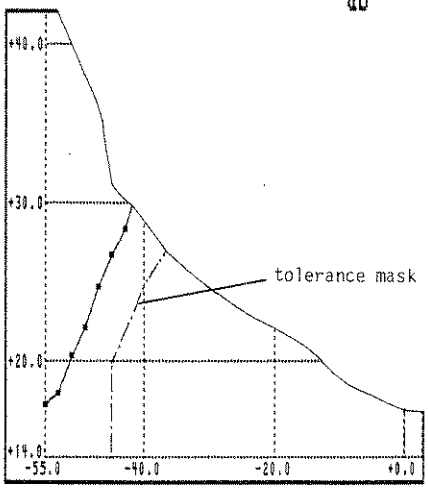
After the start of the measurement, the level displayed is increased by Δ = 2.0 dB for each measurement step in SWP/S mode.

RX:
CHAN.
1

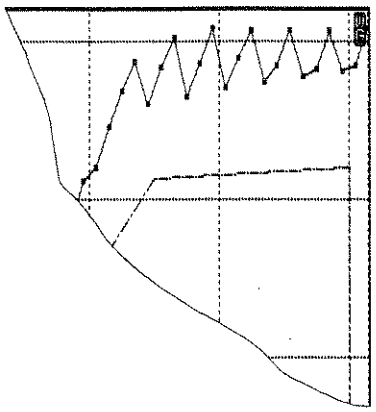
RESULT

dB

The code words received in channel 01 by the digital receiver (D-D measurement) are evaluated and the result is displayed as a point corresponding to the send level. The results are displayed as numerical values under RESULT only if one-shot manual (MAN/S) or repetitive manual (MAN/R) measurements are being made.



The scale limits for the X and Y axes are present using MODE A 52.
These limits can be altered using the GRAPH. SCALE keys [9].
The tolerance mask can be erased using PARAM. 924.



When the result corresponding to the upper value of the X axis has been plotted (in this case, +3.0 dBm0), the SWP/S measuring sequence will stop. The red LED above /STOP/ will light. The points on the screen can be joined up with straight lines by pressing /LINK RESULT/.

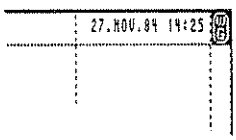
RESULT
SORT.
dBm0

N.B.

This process can occasionally take quite some tine, depending on the number of points to be sorted, particularly if a few additional measurements are made after a large number of measurements, or if measurements are made in SWP/R sequence with a very small increment Δ.

After pressing /LINK RESULT/, the points on the graph are not displayed on the screen until the sort process has ended. The prompt SORT. appears on the left-hand side of the screen and flashes on and off. SORT. flashes more rapidly as the end of the process is reached.
When the sort process is complete, the SORT. prompt is erased, and at the same time, the points are plotted and joined together.

If the sort process takes longer than 1 m 45 s a BEEP will be heard. In this case, the control processor of the PCM-4 assumes that the points cannot be sorted, and no further entries can be made. This condition is reset by pressing /GENRL. RESET/, which will also erase the points and the MODE setting.



The date (format DD.MM.YY) and the time (HH.MM) can be entered using PARAM. 931 and PARAM. 932 respectively. These values will be displayed on the results page (graphical display) by entering PRAM. 934.

(N.B. DD.MM.YY = Day Day. Month Month. Year Year;
HH.MM = Hour Hour.Minute Minute).

3.5.1 DISPLAY OF MARKERS INSTEAD OF MEASUREMENT RESULTS

During the course of a measurement run, it is possible that changes in the test object may influence the measurement and render it impossible to display a meaningful result. In such cases, the PCM-4 displays an indicator in place of the test result. The indicator is shown on graphics and numerical displays under RESULT, and in numerical listings next to the corresponding running parameter.

RESULT
< -95.0
dBm0

< indicator
Warns that the measurement is below the lower range limit. The value of the lower range limit is displayed alongside the < symbol (e.g. < -90.0 dB if the output level is interrupted when making difference measurements in MODE A21 OVERALL LOSS).

RESULT
> +90.0
dB

> indicator
Warns that the upper range limit has been exceeded. The value of the upper range limit is displayed alongside the > symbol (e.g. > +90.0 dB if the output level is interrupted when making difference measurements in MODE A21 OVERALL LOSS).

Note: The > indicator, together with a measurement result, will also be displayed if the input stage of the analog receiver is overdriven by a large out-of-band or in-band noise level when the signal level to be measured is small. A broadband measurement up to 128 kHz may be helpful; this can be set via VAR.MODE 533 for all MODE LIST A measurements with the exception of MODE A13 and MODE A81 to A83.

RESULT
OVERLD

OVERLD indicator
If a voltage > 11 V (analog generator output) or > 12 V (analog receiver input) is present between wires a and b, the overvoltage protection circuit operates, making measurements impossible. OVERLD will be displayed. If the voltage subsequently falls below these threshold values, the overvoltage protection circuit will cease to operate and the OVERLD warning will no longer be displayed after a period of about 100 ms.

Note: D.C. isolation of the inputs and outputs can be achieved by using a GH-1 d.c. loop holding circuit, BN 984/00.12.

N.B. If PARAM 921 (MEAS. NOT POSSIBLE HALT) is selected, further measurements will be impossible if OVERLD is displayed. The measurement run will continue if PARAM 922 (MARK AND CONTINUE) is set.

Exception: If OVERLD occurs in the first measurement step, further measurements will be impossible in MODE A3, A4 and B5.

RESULT
< >
dBm0

< > indicator

If the indicator < > is shown instead of a result when the measurement cannot be carried out, it should be possible to locate the source of the problem with reference to the measurement mode and the configuration. The following notes are intended as a guideline:

A-A or D-A measurement configuration

- No result will be possible if the auto-ranging circuit
  - makes more than 13 attempts to decrease the sensitivity of the input attenuator in steps of 6 dB;
  - makes more than 4 attempts to increase the sensitivity of the input attenuator;
  - more than 10 alternations of the attenuator setting are made.
- The analog signal is overlaid with a d.c. voltage. The resulting change in offset level when the input attenuator switches will not normally affect the measurement as the software increases the wait time or delay before making the measurement. If the offset is still too large after this delay, a measurement will be impossible and < > will be displayed. VAR.MODE 421, DELAY BEFORE MEASUREMENT may be of help here.
- An internal reference measurement is made in MODE A2 [A-A], B1 and B2. If the level here is outside the range ± 1 dB in MODE A2 or ± 2 dB in MODE B1 or B2, a measurement will be impossible.
- For measurements in MODE A5 and A9, the wide band result is ≤ 80 dB.

- If an error occurs in the reference measurement for modes where a difference value is calculated (e.g. OVERALL LOSS), then no measurement can be made. Possible also in MODES A2, A3, A4, B1, B2 and B3.

A-D or D-D measurement configuration

- If the digital receiver in the PCM-4 outputs a NO FRM signal to the LED display next to the input, it will not be possible to display a measurement result.

  If loss of synchronisation occurs during the measurement in MODE B81 ... B84, NO SYNC will be displayed instead of < >.

- Group delay measurements in MODE B51 .... B54 cannot be carried out if the modulation depth (m) of the receive side group delay signal lies outside the following limits:
  - modulation frequency 41.666 Hz:
    m = 0.16 ... 0.25
  - modulation frequency 83.333 Hz:
    m = 0.20 ... 0.32

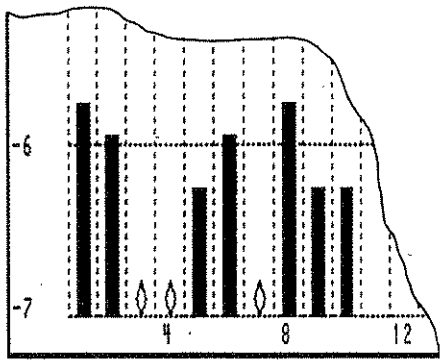
  The receive signal level must be $\geq$ 27 dBm0, as the LOWER RANGE LIMIT is -27 dBm0. VAR.MODE 521 can be used to set another value.

- If no change in the input signal occurs within 200 ms, no measurement will be possible in MODE B6 and B7.

Note: If PARAM 921 (MEAS. NOT POSSIBLE HALT) is selected, further measurements will be impossible if < > is displayed. The measurement run will continue if PARAM 922 (MARK AND CONTINUE) is set.

Exception: If < > occurs in the first measurement step, further measurement will be impossible in MODE A3, A4 and B5.

RESULT
BIT ER
NO SYNC
OCT ER
SYNC



3.00	¦	+24.5.
-45.00	¦	+26.82
-41.00	¦	+29.81
-37.00	¦	+31.82
-33.00	¦	+30.54 *
-29.00	¦	+34.85
-25.00	¦	+33.40 *
-21.00	¦	+36.45
-17.00	¦	+34,85
13.00	¦	+34.00
00	¦	+36

RESULT
Z +0.0
ms

NOSYNC indicator

If the digital receiver in the PCM-4 outputs a NO FRM signal to the LED display a measurement result in MODE B81 ... B84. NOSYNC will be displayed instead of < > if loss of synchronisation occurs during the measurement.

Note: If PARAM 921 (MEAS. NOT POSSIBLE HALT) is selected, further measurements will be impossible if NO SYNC is displayed. The measurement run will continue if PARAM 922 (MARK AND CONTINUE) is set.

$\overset{\wedge}{\vee}$ indicator

As well as the NOSYNC or < > display in the left hand screen margin, the $\overset{\wedge}{\vee}$ indicator will be shown in the channel or time interval position on the graphics display for MODE B81 ... B84.

* indicator

If the result exceeds the tolerance threshold, the numerical value of the result shown on the screen will be marked with *.

Note: The tolerance threshold values can be printed out on a printer through the use of parameters 08 and 09 (see 3.6.10).

Z indicator

Signalling distortion measurement results in MODE B6 are marked with Z if the closing and opening resistances of the test object lie within the range 300 Ω to 20 kΩ.

3.6 GENERAL PARAMETERS

```
PARAM.        * GENERAL PARAMETERS *

(1)  DIGITAL CONFIGURATION
(2)  FRAME SELECTION
(3)  DIGITAL TX INTERFACE
(4)  DIGITAL RX INTERFACE
(5)  DIGITAL WORDS IN TX FRAME
(6)  TX ERROR INSERTION
(7)  PCM ENCODING
(8)  SCANNER PARAMETER
(9)  SPECIAL PARAMETER

(0)  PRINTER / PLOTTER

                                  RTN

SELECT PARAMETER GROUP NO. OR RTN
```

All the general parameters for the PCM-4 are given in lists 1 to 0. These lists are displayed by pressing the appropriate number key. The individual parameters in the lists are selected by entering the two-figure number followed by /ENTER/. Parameters selected in this way are marked with ** on the screen.

The parameters are used to configure the PCM-4 for the particular measurement to be made. If a parameter cannot be used, an error message is shown on the screen. The following sections describe the general parameters in detail.

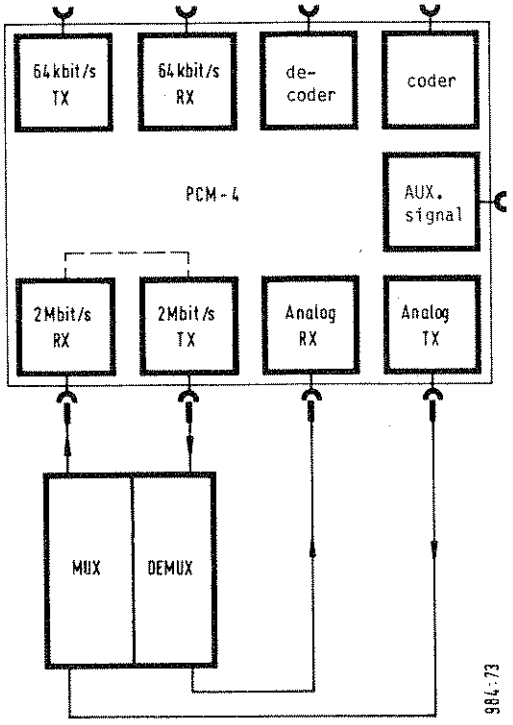
Parameters which are set when /GENRL RESET/ is pressed are marked (*) in this section.

3.6.1 PARAMETER LIST 1: DIGITAL CONFIGURATION

```
   PARAM.1       * DIGITAL CONFIGURATION *

** (11) GENERAL CONFIG. TX/RX 2M/ 2Mbit/s
   (12)                     64k/64kbit/s
   (13)                     64k/ 2Mbit/s
   (14)                      2M/64kbit/s
   (15)              THROUGH 2Mbit/s TRANSP.
   (16)              THROUGH 2Mbit/s INSERT.

   (21) DIGITAL LOOP (A-A) 2Mbit/s/ALL TS
   (22)                    2Mbit/s/SLCT TS
** (23)                    OPEN/AUX.SIGN.
   (24)                    64kbit/s

                                   RTN

   SELECT NO. ENTER OR RTN
```

All possible digital configurations of the PCM-4 are listed in parameter list 1 of the GENERAL PARAMETERS. The activation of the digital generator and/or receiver for both the 2 048 kbit/s and 64 kbit/s interfaces is dependent on the choice of parameters and the chosen measurement configuration (A-A, A-D, D-A or D-D). If the digital generator is active, the selected signal is output, otherwise the idle channel signal is used (parameter 516).

3.6.1.1 Parameter 111 (*)



GENERAL CONFIG. TX/RX 2M/ 2 Mbit/s

After parameter 111 has been selected, the generator and receiver for the 2 048 kbit/s interface can be activated by selecting a measurement configuration.

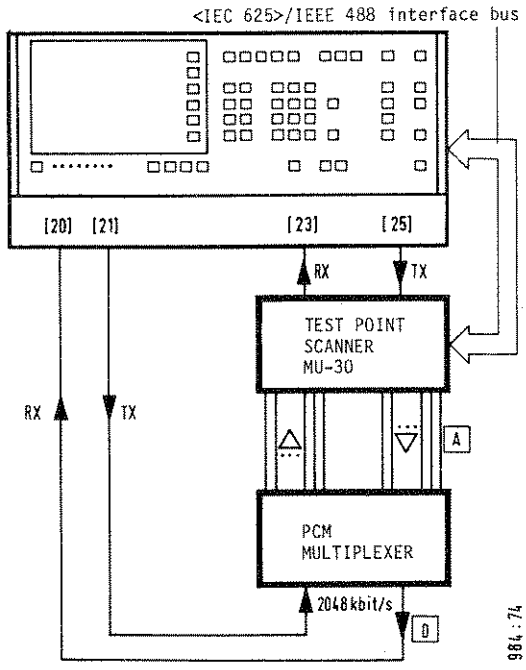
Parameter 121 and A-A measurement configuration

Selection of parameter 121 causes a transparent loop to be set up between the receiver and transmitter of the 2 048 kbit/s interface. Selecting A-A measurement configuration activates the transmitter and generator of the analog interface. If a 2 048 kbit/s signal is fed to the digital receiver, the entire bit stream will be retransmitted unchanged by the transmitter. A typical application for this combination of parameters is for measurements on PCM MUX/DEMUX equipment.

NOTE: You can only select parameter 121 when the line (interface) codes for the transmitter (parameter list 3) and the generator (parameter list 4) are the same. If this is not so, the error message

LINE CODES TX/RX DIFFERENT

will be displayed on the screen.

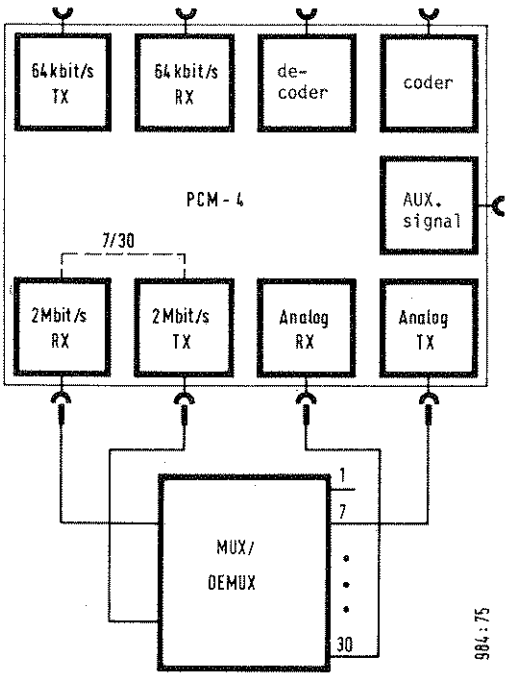


For automatic measurements, a test point scanner can be used. The MU-30 can be controlled by the PCM-4 directly, via the IEEE 488 bus (see 4.2.2.1).

NOTE: The MU-30 must be switched on before or at the same time as the PCM-4, and in any case before the end of the PCM-4 calibration sequence, otherwise remote control from the PCM-4 will not be possible.

The signal from the analog generator in the PCM-4 is fed to the multiplexer inputs. The 2 048 kbit/s digital signal from the multiplexer is looped through from receiver to generator and fed back to the demultiplexer. The decoded signal is then fed back to the analog receiver in the PCM-4.

111 122 A-A



Parameter 122 and A-A measurement configuration

Parameter 122 allows for digital channel switching at the 2 048 kbit/s level. This configuration is specially intended for measurements on 2-wire MUX/DEMUX systems. In this case, only one channel is looped through, the others being fed with the idle channel signal set with parameter 516. The PCM-4, however, is connected for 4-wire operation. The analog receiver and generator are each connected to a channel of the MUX/DEMUX. The switching between channels is done by the PCM-4 on the 2 Mbit/s side. In this way, the channel with the best characteristics (in the example: channel 30) can be used as reference for all the other channels.

Example:

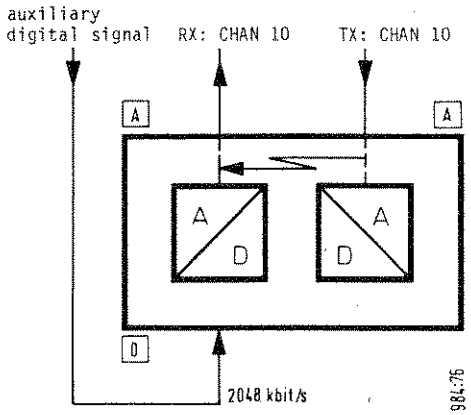
The contents of channel 7 are to be transferred to channel 30.

The entries under "TX" and "RX" shown on the screen apply to the 2 Mbit/s digital interface. In this example, "RX = 7" and "TX = 30" would be entered. This causes the analog generator to transmit a signal from the 4-wire output of the PCM-4 to the 2-wire input of channel 7 of the MUX/DEMUX. The digital information in channel 7 is switched through to channel 30 by the PCM-4 and the idle channel signal is fed to channel 7. The signalling bits for channel 7 (bits 1-4 in timeslot 16 of frame 7) are transmitted in bit positions 5-8 of timeslot 16 in frame 15. The analog signal from the 2-wire output for channel 30 of the MUX/DEMUX must be fed to the 4-wire input to the analog receiver in the PCM-4.

Channel switching with 4-wire MUX/DEMUX equipment is also possible. For this, the use of an MU-30 test point scanner is good idea.

NOTE: This switching is only in one direction, i.e. the contents of channel 7 are switched to channel 30, but the contents of channel 30 are not switched to channel 7.

111 123 A-A



Parameter 123 (*) and A-A measurement configuration

This is the basic setting of the PCM-4. Parameter 123 does not cause a digital loop to be formed at the 2 048 kbit/s level. In this case, the digital generator can be used to provide an auxiliary signal selected under "VAR.MODE 2xx". A typical application for this parameter configuration is for sidetone level measurements (MODE A76 ... A79).

111 124 A-A

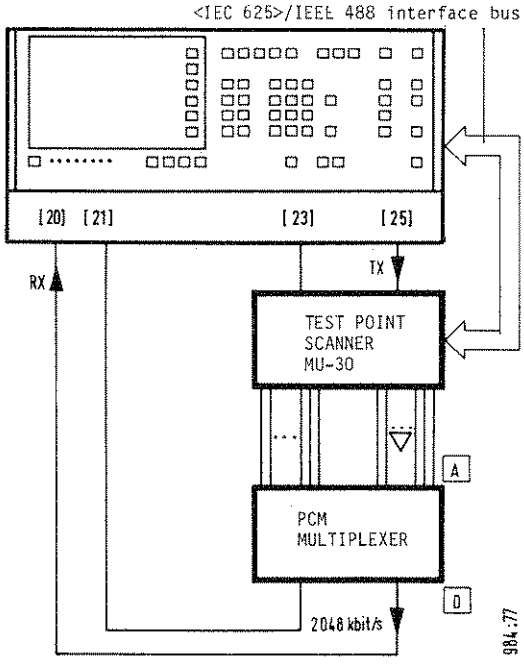
Parameter 124 and A-A measurement configuration

Parameter 111 and 124 cannot be selected together, as parameter 124 is intended for operation with 64 kbit/s interfaces. If the two parameters are selected together, the error message

DIGITAL LOOP NOT POSSIBLE

will be displayed on the screen.

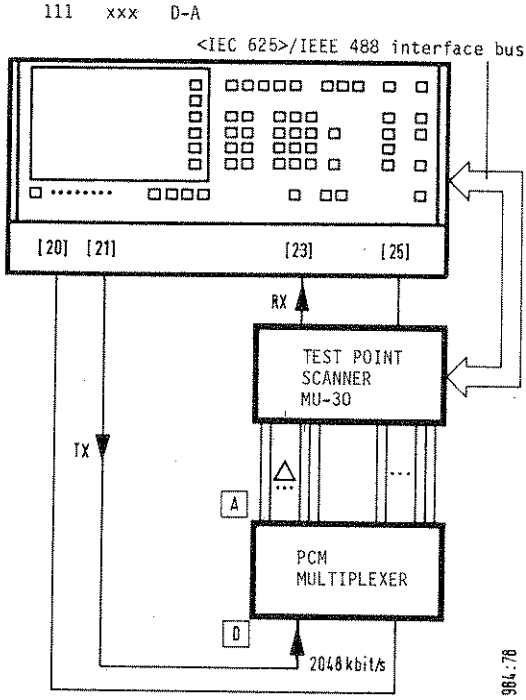
111 xxx A-D



A-D measurement configuration (half-channel measurements)

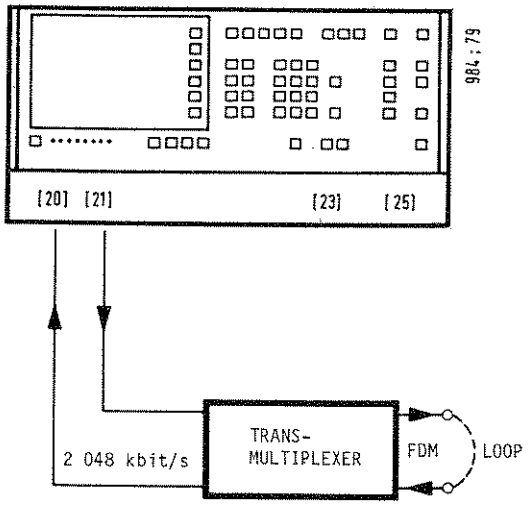
If softkey 2 is pressed, the A-D measurement configuration will be set up for half-channel measurements on PCM multiplexers. The analog generator and the digital receiver are active. In this setting, parameters 121, 122 or 123 in list 1 have no meaning.

The digital signal generator supplies a 2 048 kbit/s signal in which all channels contain a static idle channel signal. The signal is available at output [21]. The code word for the signal in the selected channel is found under "VAR.MODE 251", that for the non-selected channels being under "GENERAL PARAMETER 516".



D-A measurement configuration (half channel measurements)

The D-A measurement configuration for half-channel measurements on PCM demultiplexers is set up by pressing softkey 3. The digital generator and the analog receiver are active; the analog generator is switched off ("VAR.MODE 141"). Parameters 121, 122 or 123 in list 1 have no meaning in this measurement configuration.



D-D measurement configuration

The D-D measurement configuration for investigations between digital interfaces is set up by pressing softkey 4. This enables measurements on transmultiplexers to be made, for example. The analog generator is switched off ("VAR.MODE 141"). Parameters 121, 122 or 123 in list 1 have no meaning in this measurement configuration.

111 xxx B82 ... B84

Bit error measurement modes (B82 ... B84)

This measurement configuration is specially intended for bit error measurements on a selected 64 kbit/s channel.

Overview table of measurement configurations with parameter 111, TX/RX 2 Mbit/s-2 Mbit/s:
X = send signal
0 = idle channel signal (can be changed with "VAR.MODE 2xx") or analog generator off.

Config-uration	2 048 kbit/s TX	2 048 kbit/s RX	64 kbit/s TX	64 kbit/s RX	analog TX	analog RX
[A-A]	0				X	X
[A-A]	loop				X	X
[A-D]	0	X			X	
[D-A]	X				0	X
[D-D]	X	X			0	
and B82 to B84	X	X			0	

3.6.1.2 Parameter 112

GENERAL CONFIG. TX/RX 64k/64 kbit/s

This interface is intended for two areas of operation:

- Mode list A and B measurements on CODECS
- Bit error measurements (B82 ... B84).

PCM-30-F multiplexers can be fitted with both speech and data channels. The data channels (as with those of data multiplexers) normally have codirectional interfaces to CCITT Rec. G.703, operating at 256 kbaud. When parameter 112 has been selected, the selection of a measurement configuration will activate the generator and receiver for the 64 kbit/s interface (see 5.1).

112 121 A-A

Parameter 121 and A-A measurement configuration

Here, parameter 121 does not cause a loop at the 2 048 kbit/s level on the digital side. Selecting the A-A measurement configuration activates the analog generator and receiver.

The digital generator provides an idle channel signal ("VAR.MODE 251").

112 123 A-A

Parameter 123 and A-A measurement configuration

The 64 kbit/s generator provides an idle channel signal ("VAR.MODE 251").

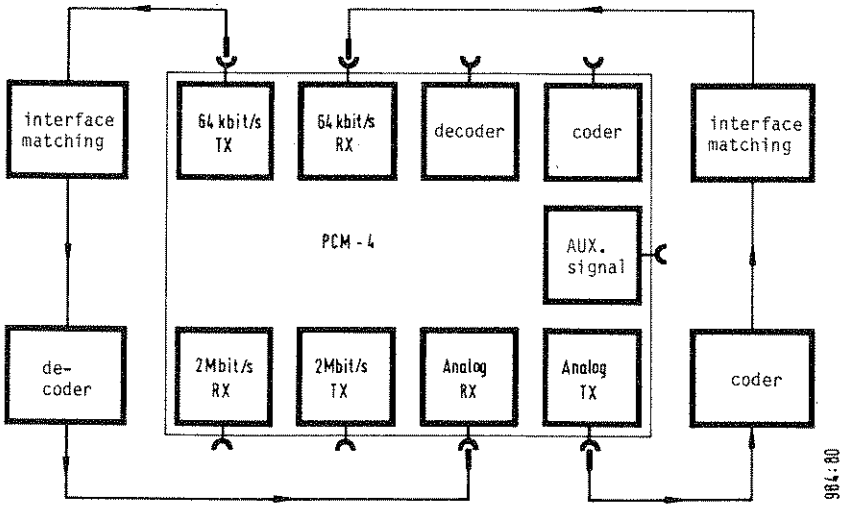
112 124 xxx

The parameter combination 112 + 124 is intended for A-A or A-D measurements on CODECS.

NOTE: Since there are very few CODECS which have either an 8 bit parallel or a 64 kbit/s serial interface, some kind of interface matching must be provided at the input to the coder, decoder or CODEC so that it can be connected to the 64 kbit/s interface of the PCM-4, or else an interface converter must be switched into the circuit.

112 124 A-A

Parameter 124 and A-A measurement configuration

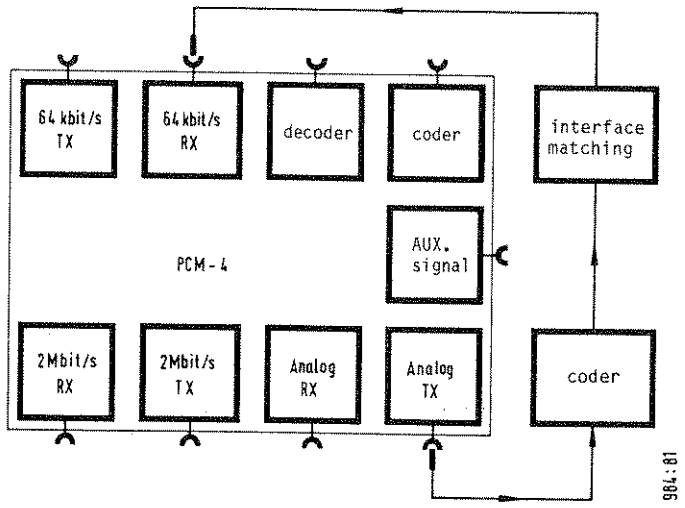


This combination of parameters is not typical for measurements on PCM CODECS. Any coder at point A can be connected to any decoder at point B. A-A measurements are, however, possible. Half-channel measurements are normally required under standard test procedures. Parameter 124 causes a transparent loop to be set up between the receiver and generator for the 64 kbit/s interface. Selecting A-A measurement configuration renders the receiver and generator of the analog interface active. If a 64 kbit/s signal is fed to the digital receiver, this will be retransmitted unchanged by the generator. The array of 8 LEDs below the screen of the PCM-4 shows the PCM octets which are looped through.

NOTE: If the codirectional interface to CCITT Rec. G.703 (BN 984/00.01) is used, the octets can be displayed, but the 64 kbit/s loop cannot be completed.

112 xxx A-D

A-D measurement configuration

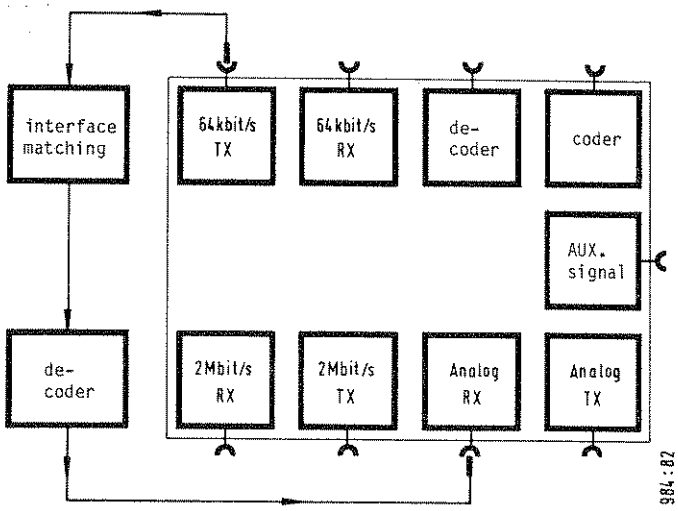


This is a typical half-channel coder measurement. The A-D configuration for testing PCM coder modules is set by pressing softkey 2. The analog generator and the 64 kbit/s digital receiver are active.

In this configuration, parameters 121, 123 and 124 in list 1 have no meaning.

112 xxx D-A

D-A measurement configuration

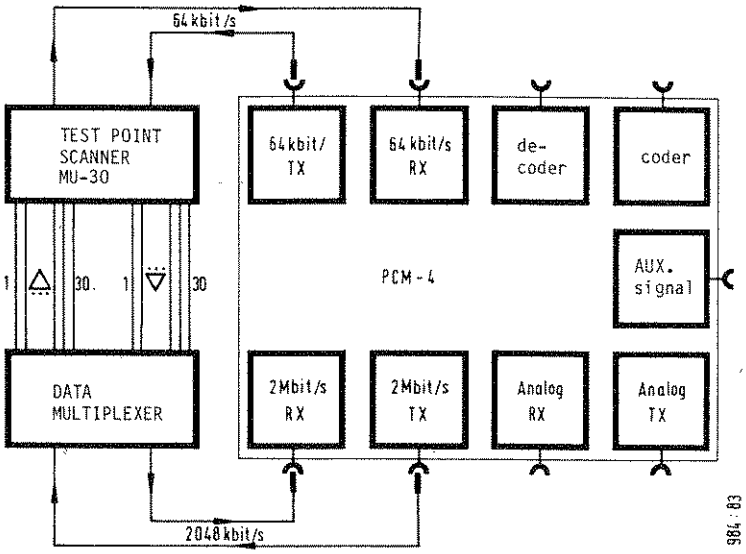


This is a typical half-channel decoder measurement. The D-A measurement configuration for testing PCM decoder modules is set by pressing softkey 3. The 64 kbit/s digital generator and the analog receiver are active. The analog generator is switched off.

In this configuration, parameters 121, 123 or 124 in list 1 have no meaning.

112 121

Parameter 121 and modes B82 ... B84



D-D measurements can made, but are not sensible. Data multiplexers can be checked for faults using a pseudorandom sequence (see modes B82 ... B84). Both the digital receiver and the generator for the 64 kbit/s interface are active. The important point about this particular configuration is that an internal loop is set up between the receiver and generator at the 2 048 kbit/s digital level. This makes it possible to make error measurements on data multiplexers and demultiplexers. For this application, a MU-30 test point selector is used, which can be controlled directly by the PCM-4 via the IEEE 488 bus.

NOTE: Parameter 122 and Modes B82 to B84

The 2 048 kbit/s loop (Param. 122) allows switching of the 64 kbit/s signal from any RX channel to any TX channel.

The 64 kbit/s digital signal from the PCM-4 is fed to the inputs of the data multiplexer. The 2 048 kbit/s signal from the data multiplexer is looped through from the receiver to the generator on the 2 048 kbit/s interface, and fed back to the data demultiplexer. Channel information is fed back to the 64 kbit/s receiver via the MU-30 test point scanner.

Overview table of measurement configurations available with parameter 112, TX/RX 64 kbit/s-64 kbit/s:

X = send signal

0 = idle channel signal (can be altered using "VAR.MODE 2xx") or analog generator off.

Config-uration	2 048 kbit/s TX	2 048 kbit/s RX	64 kbit/s TX	64 kbit/s RX	analog TX	analog RX
[A-A]			0		X	X
[A-A]			loop		X	X
[A-D]			0	X	X	
[D-A]			X		0	X
[D-D]	loop		X	X	0	
and B82	loop		X	X	0	
to B84						

Parameter 113

GENERAL CONFIG. TX/RX 64k/ 2Mbit/s

This configuration is primarily for error measurements (B82 ...B84) on data multiplexers. Other configurations are possible, but are either covered by other parameters or are not sensible.

After selecting parameter 113, the 2 048 kbit/s receiver can be activated by selecting a measurement configuration. This setting is only possible if parameter 222 (which affects the 64 kbit/s output) has not been selected. Otherwise, the error message:

64 kbit/s OUTPUT NOT AVAILABLE

will be shown on the screen.

The only second parameter allowable in this configuration is parameter 123 (OPEN/AUX.SIGN.). If parameters 121, 122 or 124 are selected after parameter 113 has been selected, the error message

DIGITAL LOOP NOT POSSIBLE

will appear on the screen.

113 123 A-A

A-A measurement configuration

The analog generator and receiver are active. The generator for the 64 kbit/s interface can be used to provide an auxiliary signal ("VAR.MODE 2xx").

This setting is already covered by parameter 112.

113 123 A-D

A-D measurement configuration

The A-D configuration is set by pressing softkey 2. The analog generator and the 2 048 kbit/s digital receiver are active. The generator for the 64 kbit/s interface can be used to provide an auxiliary signal ("VAR.MODE 2xx"). This setting is already covered by parameter 111.

113 123 D-A

D-A measurement configuration

The D-A configuration is set by pressing softkey 3. The 64 kbit/s digital generator and the analog receiver are active. The analog generator is switched off.

This setting is already covered by parameter 112.

113 123 D-D

D-D measurement configuration

The D-D configuration is set by pressing softkey 4. The 64 kbit/s digital generator and the 2 048 kbit/s receiver are active. The analog generator is switched off. A typical application for this configuration is for measurements on digital multiplexers.

Overview table of measurement configurations available with parameter 113, TX/RX 64 kbit/s-2 Mbit/s:

X = send signal

0 = idle channel signal (can be altered with "VAR.MODE 2xx") or analog generator off.

Config-uration	2 048 kbit/s		64 kbit/s		analog	
	TX	RX	TX	RX	TX	RX
[A-A]			0		X	X
[A-D]		X	0		X	
[D-A]			X		0	X
[D-D]		X	X		0	
and B82 to B84	X	X			0	

Parameter 114

GENERAL CONFIG. TX/RX 2M/64kbit/s

This configuration is primarily intended for making error measurements (B82 ... B84) on data demultiplexers. The other measurement configurations are possible, but are either covered by other parameters, or are not sensible.

After parameter 114 has been selected, the 2 Mbit/s generator and the 64 kbit/s receiver can be activated by selecting a measurement configuration. This setting is only possible if parameter 212 (which affects the 64 kbit/s input) has not already been selected. Otherwise, the error message:

64 kbit/s INPUT NOT AVAILABLE

will be displayed on the screen.

The only second parameter allowable in this configuration is parameter 123 (OPEN/AUX.SIGN.). If parameters 121, 122 or 124 are selected after parameter 114 has been selected, the error message:

DIGITAL LOOP NOT POSSIBLE

will be displayed on the screen.

114 123 A-A

A-A measurement configuration

The analog generator and receiver are active. The 2 Mbit/s generator can be used to provide an auxiliary signal.

This setting is already covered by parameter 111.

114 123 A-D

A-D measurement configuration

The A-D configuration is set by pressing softkey 2. The analog generator and the 64 kbit/s digital receiver are active. The 2 Mbit/s digital generator can be used to provide an auxiliary signal.

This setting is already covered by parameter 112.

114 123 D-A

D-A measurement configuration

The D-A configuration is set by pressing softkey 3. The 2 Mbit/s digital generator and the analog receiver are active. The analog generator is switched off.

This setting is already covered by parameter 111.

114 123 D-D

D-D measurement configuration

The D-D configuration is set by pressing softkey 4. The 2 Mbit/s digital generator and the 64 kbit/s receiver are active. The analog generator is switched off.

A typical application for this configuration is for measurements on digital demultiplexers.

Overview table of measurement configurations available with parameter 114, TX/RX 2 Mbit/s-64 kbit/s:

X = send signal

0 = idle channel signal (can be altered with "VAR.MODE 2xx") or analog generator off.

Configuration	2 048 kbit/s		64 kbit/s		analog	
	TX	RX	TX	RX	TX	RX
[A-A]	0				X	X
[A-D]	0			X	X	
[D-A]	X				0	X
[D-D]	X			X	0	
and B82 to B84	X			X	0	

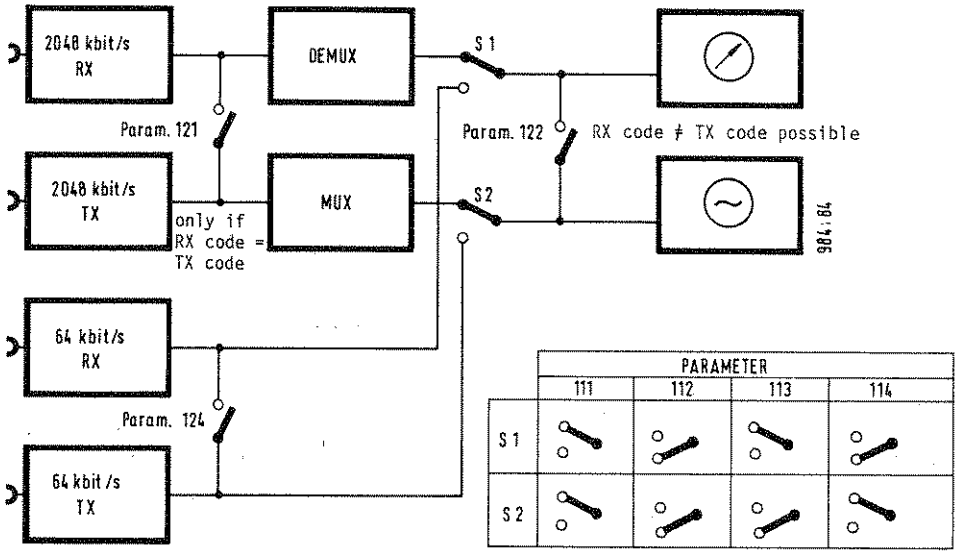


Figure 3-4 Digital loops

Parameter 115

GENERAL CONFIG. THROUGH 2Mbit/s TRANSP.

<u>If parameter 115 is selected, measurement and observation of the signal are impossible.</u>

Parameter 115 is the standby state for parameter 116. The 2 048 kbit/s digital interface is active and a loop is set up between the receiver and the generator. The received bit stream is transferred unchanged to the digital generator.

It is then only necessary to select parameter 116 when measurements or signal injections are to be made.

This setting is only possible if neither parameter 212 nor parameter 222 has been selected, otherwise the error message:

FRM. TYPE TS 16 EXT. NOT POSSIBLE

will be displayed on the screen.

The only second parameter allowable in this configuration is parameter 123 (OPEN/AUX.SIGN.). If parameters 121, 122 or 124 are selected after parameter 115 has been selected, the error message:

DIGITAL LOOP NOT POSSIBLE

will be displayed on the screen.

Parameter 116

GENERAL CONFIG. THROUGH 2 Mbit/s INSERT.

Parameter 116 allows for measurements on and insertion of signals into the through data traffic to be made.

This setting is only possible if neither parameter 212 nor parameter 222 has been selected, otherwise the error message:

FRM. TYPE TS 16 EXT. NOT POSSIBLE

will be displayed on the screen.

The only second parameter allowable in this configuration is parameter 123 (OPEN/AUX. SIGN.). If parameters 121, 122 or 124 are selected after parameter 116 has been selected, the errror message:

DIGITAL LOOP NOT POSSIBLE

will be displayed on the screen.

Parameter 116 and 123

Incoming 2 048 kbit/s signal:

Measurements in one channel of the incoming 2 048 kbit/s signal are only possible if the digital receiver of the PCM-4 can be synchronised to the received signal, i.e. the correct signal is evaluated and the measurement run is synchronous.

Measurements in MODE B82 ... 84 are useful here, as synchronicity of the measurement run can be ignored if the correct pattern is set (e.g. pseude-random sequence 2^9-1).
A typical application for this is measurement of the signalling bits in the selected RX channel in MODE B91.
In MODE B92, the signal in the selected RX channel can be output via 64 kbit/s interface in DEMUX operation.

NOTE: DEMUX operation with parameter 116 using a codirectional 64 kbit/s unit (BN 984/00.01) is not possible.

Outgoing 2 048 kbit/s signal:

In this configuration, a signal can be inserted into the chosen TX channel. All other channels are looped-through unchanged. The signal to be inserted can be generated by the PCM-4 or from an external source via the 64 kbit/s interface input in MUX operation in MODE B92.

NOTE: MUX operation with parameter 116 using a codirectional 64 kbit/s unit (BN 984/00.01) is not possible. MUX operation with parameter 116 using a serial or parallel 64 kbit/s unit (BN 985/00.05 or BN 984/00.07) is only possible if the DIL switch (see 6.1.2 or 6.1.4) is set to contradirectional.

A typical application is the insertion of dialling signals into the TX channel of the outgoing bit stream, either with a static signal (parameter 517) or with an externally generated dynamic signal input via the auxiliary input [60] (parameter 518).

3.6.2 PARAMETER LIST 2: FRAME SELECTION

```
PARAM.2      * FRAME SELECTION *

## (11) TX FRAME TYPE  G.704 / TS 16 INT.
   (12)               G.704 / TS 16 EXT.
   (13)               G.704 / TS 16 TELEPH.
   (14)               ALL 32 TS TELEPH.

## (21) RX FRAME TYPE  G.704 / TS 16 INT.
   (22)               G.704 / TS 16 EXT.
   (23)               G.704 / TS 16 TELEPH.
   (24)               ALL 32 TS TELEPH.

## (31) CRC-4 MULTIFRAME  OFF
   (32)                   ON          RTN

SELECT NO. ENTER OR RTN
```

Parameter list 2 of the GENERAL PARAMETERS lists the available send- and receive frame structures for the PCM-4. To a certain extent, the send- and receive frames can be independently selected.

If the 64 kbit/s interface is selected for TX and/or RX (using parameter list 1) settings for this configuration taken from parameter list 2 have no effect.

Parameter 211 (*)

TX FRAME TYPE G.732/TS 16 INT.

Parameter 221 (*)

RX FRAME TYPE G.732/TS 16 INT.

In this case, the PCM-frames for send- and receive signals are configured to CCITT G.732, with a multiframe in timeslot 16. The format of the multiframe is determined by parameter 5xx. Parameter 211 can be matched with parameter 222 and parameter 221 with parameter 212 if required.

Parameter 212

TX FRAME TYPE G.732/TS 16 EXT.

Parameter 222

RX FRAME TYPE G.732/TS 16 EXT.

Parameter 212 and 222 also refer to PCM-frames for send- and receive signals to CCITT G.732, with the difference that an external bit stream can be inserted into timeslot 16 via the 64 kbit/s interface input (parameter 212), or the contents of timeslot 16 can be extracted from the 64 kbit/s interface output (parameter 222). Measurements in all the other channels can be carried out as before. Parameter 212 can be combined with parameter 221 and parameter 222 with parameter 211 if required.

Parameter 213

TX FRAME TYPE G.732/TS 16 TELEPH.

Parameter 223

RX FRAME TYPE G.732/TS 16 TELEPH.

In this case, the send- and receive frames (to CCITT G.732) have 31 channels available for telephone- or other signals. No multiframe is formed in timeslot 16.

Parameter 213 can only be used together with parameter 223. If one of these parameters has been set, the other will be selected automatically.

Parameter 214

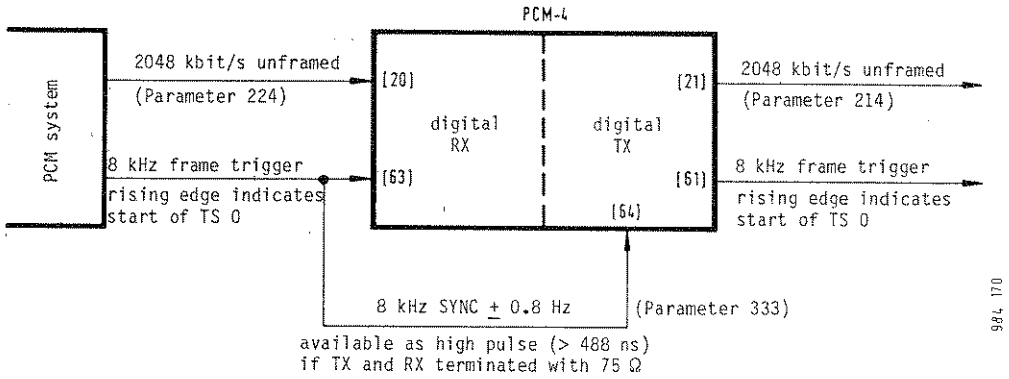
TX FRAME TYPE ALL 32 TS TELEPH.

Parameter 224

RX FRAME TYPE ALL 32 TS TELEPH.

These parameters provide for a send- and receive frame structure without alignment- and alarm signals. All 32 channels can be used for telephone signals. The digital generator delivers a 8 kHz clock signal for synchronisation purposes. The rising edge of this clock

signal is in phase with the start of timeslot Ø. The digital receiver requires an identical signal for synchronisation purposes. Parameter 214 can only be selected with parameter 224. If either parameter is selected, the other will be set automatically.



Parameter 231 (*)

CRC-4 MULTIFRAME OFF
In the PCM-4 basic setting, no CRC-4 check words are transmitted with the 2 048 kbit/s signal from the digital generator.
Note: 2 048 kbit/s transmission systems which use CRC-4 multiframe procedures should be compatible with systems not using CRC-4, according to CCITT Rec. G.704, § 2.3.3. PCM-4s of series A...D are therefore also compatible with systems which use CRC-4 multiframe structure.

Parameter 232

CRC-4 MUTLIFRAME ON
In this setting, CRC-4 word errors can be injected into the 2 048 kbit/s output signal of the PCM-4, so that CRC alarms and synchronisation thresholds can be tested. A CRC word error rate from 0.1 to 99.9% in steps of 0.1% can be set using parameter 929. Errored CRC multiframe alignment signals (2 IN 4 or 3 IN 4) can be set with parameters 627 and 628, enabling synchronisation criteria to be tested.

In MODE B81, CRC-4 errors can be detected and measured.
Detected CRC-4 errors are output in the form of a pulse on pin 6 of connector [62] on the back of the PCM-4.

CRC error detection in 2 048 kbit/s transmission systems

A major disadvantage is that normally only a small proportion of the bit stream is checked for accuracy of transmission. CCITT Rec. G.704 (red book) recently suggested the use of a so-called CRC (cyclic redundancy check) method to provide complete monitoring for transmission errors in 2 048 kbit/s digital systems.

CRC-4 check word

To form the CRC-4 word, a total of 2 048 bits from 8 consecutive frames are used. This block of data forms a submultiframe SMF(N), which is multiplied by x^4 (i.e. four zeros are added) and then divided by the generator polynominal $x^4 + x + 1$ (i,e, the binary number 1001). The remainder, which is a 4 bit word, is transmitted with the next SMF, SMF(N + 1), to the receiver.

The original submulitframe, SMF(N), is processed in the receiver in the same way as in the transmitter, so that in theory the identical CRC word will be formed. Any difference between the CRC word thus formed and the CRC word received in SMF(N + 1) indicates that at least one bit has been incorrectly received, and the CRC error counter will be incremented. The following binary calculation shows how the CRC word is formed from a 4 bit block of data as an example.

Data block processing on the generator side:

```
data block        multiplier     generator polynominal
    |                 |                  |
    1 0 1 0 0 0 0 0   :   1 0 0 1 1
    1 0 0 1 1
      1 1 1 0 0
      1 0 0 1 1
        1 1 1 1 0
        1 0 0 1 1
          1 1 0 1    <---- remainder transmitted to receive side
```

Data block processing on the receiver side:

```
data block        remainder      generator polynominal
    |                 |                  |
    1 0 1 0 1 1 0 1   :   1 0 0 1 1
    1 0 0 1 1
      1 1 0 1 0
      1 0 0 1 1
        1 0 0 1 0
        1 0 0 1 1
        0 0 0 0 0    <---- remainder is zero if no bit error has occurred
```

Division is done by modulo 2 addition without carry. This is done using an exclusive OR (EX-OR) circuit.

CRC multiframe structure

The extra capacity required to transmit the CRC word is achieved by making use of the spare bit at the start of each frame alignment signal (FAS). The CRC word is formed without being dependent on the multiframe structure which has multiframe alignment signal (MFAS) in timeslot 16 of frame 0. Synchronisation of the CRC word to be recieved is accomplished through the use of an additional alignment signal. A further multiframe structure (see figure 1) with CRC MFAS is thus formed. The CRC MFAS is the bit pattern 001011 and is inserted into bit position 1 in frames 1, 3, 5, 7, 9 and 11 of the CRC multiframe. The CRC word C_1 to C_4 (remainder) is contained in SMF(I) and SMF(II) of the CRC multiframe.

	Sub-multiframe (SMF)	Frame number	Bits 1 to 8 of the frame							
			1	2	3	4	5	6	7	8
Multiframe	I	0	C_1	0	0	1	1	0	1	1
		1	0	1	A	S_n	S_n	S_n	S_n	S_n
		2	C_2	0	0	1	1	0	1	1
		3	0	1	A	S_n	S_n	S_n	S_n	S_n
		4	C_3	0	0	1	1	0	1	1
		5	1	1	A	S_n	S_n	S_n	S_n	S_n
		6	C_4	0	0	1	1	0	1	1
		7	0	1	A	S_n	S_n	S_n	S_n	S_n
	II	8	C_1	0	0	1	1	0	1	1
		9	1	1	A	S_n	S_n	S_n	S_n	S_n
		10	C_2	0	0	1	1	0	1	1
		11	1	1	A	S_n	S_n	S_n	S_n	S_n
		12	C_3	0	0	1	1	0	1	1
		13	S_i	1	A	S_n	S_n	S_n	S_n	S_n
		14	C_4	0	0	1	1	0	1	1
		15	S_i	1	A	S_n	S_n	S_n	S_n	S_n

C_1	C_2	C_3	C_4	
0	0	1	0	CRC check bits
1	1	0	1	CRC MFAS

S_i: Spare bits for international use
S_n: Spare bits received for national use
A: Remote alarm indication

Figure 3-5 CRC multiframe structure to CCITT Rec. G.704 table 1b

CRC error evaluation and resynchronisation

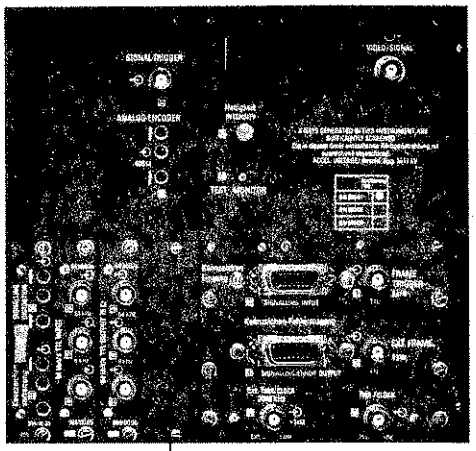
Manufacturers of 2 048 kbit/s primary systems have settled on a standard monitoring period of 1 second. During this interval, 1000 CRC comparisons can be made on the receive side. Setting various CRC error thresholds can be very useful. For example, it can be assumed that frame alignment has been lost if more than 913 errored SMFs are received in the 1 s interval.

At the start of resynchronisation, a search is made for the FAS. If the FAS, NFAS and then the FAS are correctly detected in three consecutive frames, frame alignment has been achieved. After this, at least two CRC MFAS must be correctly received within the next 8 ms (duration of 4 multiframes), before a new monitoring period of 1 s is started. If less than 914 errors are detected during this period, the receiver is synchronised to the generator signal. This method ensures better maintenance of synchronism than that previously available, as the usual frame alignment is augmented by CRC multiframe alignment and CRC errors not exceeding a given threshold value. Incorrect synchronisation is no longer possible.

3.6.2.1 Setting the CRC-4 error threshold

A counter circuit is used to record the number of CRC-4 word errors which occur during continuous monitoring of the frames (PARAMETER 232: CRC-4 MULTIFRAME ON). If a given threshold is exceeded, a resynchronisation of the digital receiver will be triggered. The threshold can be set using a pair of DIL switches located on the CRC p.c. board, which can be removed from the PCM-4 after taking off the cover plate on the back panel (see figure 3-6).

Note: Only PCM-4s from series E onwards are fitted with a CRC board. It cannot be retrofitted to series A to D instruments.



CRC p.c. board

Figure 3-6 Location of CRC p.c. board

The two switches S1 and S2 are located on the left hand side of the p.c.board, as shown in figure 3-7.

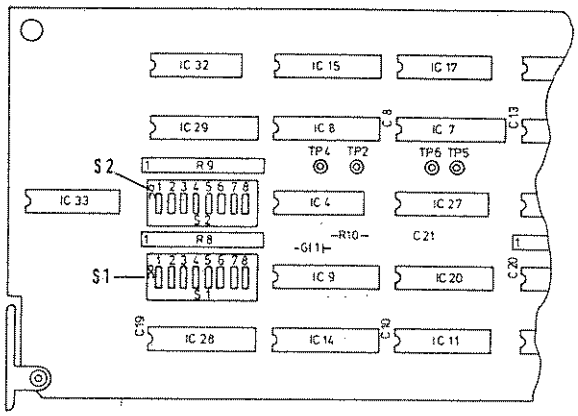


Figure 3-7 Part of component side of the CRC p.c. board showing switches S1 and S2

The CRC error threshold can be set in the form of a binary number using the two switches. The threshold is set in steps of 0.1% from 0.1 to 99.9%.

$$\text{Error threshold (\%)} = \frac{\text{number of CRC errors per interval (1000 ms)}}{\text{1000 sub-multiframes}} \times 100$$

Note that the binary number to be set on switches S1 and S2 is one less than the number of CRC errors per interval, i.e.:

$$N_{binary} = (\text{number of CRC errors per interval}) - 1$$

Thus, for example, the standard setting of 91.4% is set as follows:

$N_{binary} = 914 - 1 = 913$

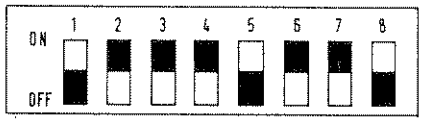
$N_{binary} = 1\ 1\ 1\ 0\ 0\ 1\ 0\ 0\ 0\ 1$

$N_{decimal} = 512 + 256 + 128 + 0 + 0 + 16 + 0 + 0 + 0 + 1 = 913$

This is set on the switches as follows:

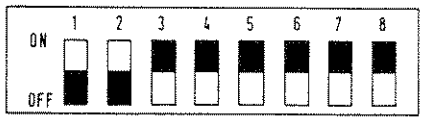
OFF = logic 1
ON = logic 0

Switch S1/	1	2	3	4	5	6	7	8
Binary value	1	2	4	8	16	32	64	128
Setting	1	0	0	0	1	0	0	1



Schalter (switch) S1

Switch S2/	1	2	3	4	5	6	7	8
Binary value	256	512	-	-	-	-	-	-
Setting	1	1	0	0	0	0	0	0



Schalter (switch) S2

Note: A setting of a decimal number above 998 (corresponding to an error threshold of 99.9%) is not sensible, as the counter will have no criteria for resynchronisation under such circumstances, i.e. any pattern would be recognised as a CRC multiframe. For this reason, switch positions S2/3 to S2/8 must remain ON.

3.6.3 PARAMETER LIST 3: DIGITAL TX INTERFACE

```
PARAM.3      * DIGITAL TX INTERFACE *

** (11)  LINE CODE              HDB-3
   (12)                        AMI
   (13)                        NRZ

** (21)  OUTPUT IMPEDANCE 120 OHM BAL
   (22)                     75 OHM UNBAL

** (31)  CLOCK          INT. 2048 kHz
   (32)                EXT. 2048 kHz
   (33)                EXT.    8 kHz
   (34)                FROM RECEIVER
                                  RTN

SELECT NO. ENTER OR RTN
```

Parameter list 3 of the GENERAL PARAMETERS lists all the parameters for the digital transmission interface of the PCM-4.

3.6.3.1 Parameter 311 to 313, LINE CODE

Parameter 311 (*)
Parameter 312
Parameter 313

A choice of three line codes is available:

- HDB3
- AMI
- NRZ

The line codes for the generator (Parameter 3) and the receiver (Parameter 4) can be different, except if parameter 121 (DIGITAL LOOP (A-A) 2 Mbit/s/ALL TS) is selected. In this case, if the line code for the generator or receiver is changed, the same line code will be set for both.

3.6.3.2 Parameter 321 and 322: OUTPUT IMPEDANCE

Parameter 321 (*)
Parameter 322

Two impedances are available for the generator and clock outputs. Changing the output impedance also automatically changes the output socket to which the generator signal is fed:

- 120 Ω, balanced, CF connector
- 75 Ω, unbalanced, coaxial connector

If parameter 313 (NRZ) is selected after parameter 321 (OUTPUT IMPEDANCE 120 OHM BAL), the output impedance will automatically be switched back to 75 Ω and the output will be available from the coaxial connector.

If parameter 321 is chosen after parameter 313, however, the error message:

120 OHM BALANCED NOT POSSIBLE

will be displayed on the screen.

3.6.3.3 Parameters 331 to 334: CLOCK

The clock driving the digital generator can be obtained in four different ways:

Parameter 331 (*)

The 2 048 kHz clock signal is generated by an internal crystal oscillator.
Accuracy: 25×10^{-6}.

Parameter 332

An externally generated 2 048 kHz clock signal can be fed in via the coaxial socket [64] on the back panel. The input impedance of this socket can be switched between 75 Ω and > 3 kΩ.

Parameter 333

An externally generated 8 kHz clock signal can be fed in via the coaxial socket [64] on the back panel. Internal phase-locked loops generate a 2 048 kHz clock from the 8 kHz signal. Parameter 333 is useful if the system only has an 8 kHz clock signal available. The digital generator is synchronised with the system in this way, so that bit slips do not occur.

NOTE:
If measurements are to be made using an analog noise signal as send signal, the external clock signal must be input via [64] after selecting parameter 332 or 333.

The analog noise signal is generated digitally, and the 10 kHz clock required for this process is derived from the externally generated clock signal.

Parameter 334

This parameter can be used to derive the clock signal from the input signal to the digital receiver.

Note: This input signal must also be present in A-A or A-D modes, otherwise the 10 kHz clock used to read out the amplitude samples will not be phase-locked.

The clock signal thus obtained is fed to the generator, so that both operate synchronously, eliminating the possibility of bit slips occuring.

If any of the following parameters are chosen:

- 115 (THROUGH 2 Mbit/s TRANSP.),
- 116 (THROUGH 2 Mbit/s INSERT.),
- 121 (DIGITAL LOOP (A-A) 2 Mbit/s/ALL TS)
- 121 (DIGITAL LOOP (A-A) 2 Mbit/s/SLCT TS),

the clock signal will automatically be derived from the received signal. The parameter list 3 display will not change to indicate this, however.
Parameter 324 must be selected for measurements on codirectional cards (64 k / 2 M). The clock is not automatically recovered for this measurement.

3.6.4 PARAMETER LIST 4: DIGITAL RX INTERFACE

```
PARAM.4      * DIGITAL RX INTERFACE *

** (11) LINE CODE                HDB-3
   (12)                          AMI
   (13)                          NRZ

** (21) INPUT IMPEDANCE      120/75 OHM
   (22)                        > 3 kOHM




                                 RTN

SELECT NO. ENTER OR RTN
```

Parameter list 4 of the GENERAL PARAMETERS lists all the parameters for the digital receiver interface of the PCM-4.

3.6.4.1 Parameters 411 to 413: LINE CODE

Parameter 411 (*)
Parameter 412
Parameter 413

A choice of three line codes is available:

- HDB3
- AMI
- NRZ

The signal input to the receiver is constantly monitored for code errors. Each code transgression causes a pulse (width = 488 ns) to be output at pin 8 of connector [62] on the back panel.

The line codes for the generator (parameter 3) and the receiver (parameter 4) can be different, except if parameter 121 (DIGITAL LOOP (A-A) 2 Mbit/s/ALL TS) has been selected. In this case, if the line code for the generator or receiver is changed, the same line code will be set for both.

3.6.4.2 Parameters 421 and 422: INPUT IMPEDANCE

Parameter 421 (*)
Parameter 422

Two input impedance values are available:

- 120/75 Ω
- > 3 kΩ

The balanced 120 Ω CF connector and the 75 Ω coaxial connector are always in circuit and cannot be switched out. Both inputs for the 2 048 kbit/s receiver interface can be switched to high impedance using parameter 422.

3.6.5 PARAMETER LIST 5: DIGITAL WORDS IN TX FRAME

For details of the frame structure, see figure 3-8 at the end of the operating manual.

Parameters 511 (*) to 518

```
PARAM.5      # DIGITAL WORDS IN TX FRAME #

** (11) FRM.WORDS RESET TO STANDARD VALUES
   (12)          FRAME ALIGNM  :10011011
   (13)          NOT FR. ALIGNM:11011111
   (14)          MULTIFR.ALIGNM:0000
   (15)          NOT MF. ALIGNM:1011
   (16)          FREE TS (FRM) :11010101
   (17)          FREE TS (MFRM):1111
   (18)          SIGNALLING    :1111
```

All the standard PCM frame signals are shown in parameter list 5, including multiframe signals. By altering parameters 512 to 518, it is possible to manipulate the standard PCM frame. As long as none of the standard words have been changed, parameter 511 is marked with the double asterisk (**). To alter the individual words, procede as follows:

* Select the parameter required; the current bit pattern will be displayed in inverse field characters
* using the numeric keypad, select the bit number to be altered. Each time the key is pressed, the bit at the position corresponding to the key number is inverted (keys 1 to 8).
* Press /ENTER/. The new bit pattern will be entered and displayed and the (**) symbol will be erased.

Parameter 512

FRAME ALIGNMENT signal in timeslot 0 of each alternate frame

Standard setting: 1 0 0 1 1 0 1 1

Parameter 513

NOT FRAME ALIGNMENT signal in timeslot 0 of all frames not containing the frame alignment signal.

Standard setting: 1 1 0 1 1 1 1 1

Parameter 514

MULTIFRAME ALIGNMENT signal in timeslot 16 (bits 1 to 4) of frame 0.

Standard setting: 0 0 0 0

Parameter 515

NOT MULTIFRAME ALIGNMENT signal in timeslot 16 (bits 5 to 8) of frame 0.

Standard setting: 1 0 1 1

Parameter 516

IDLE CHANNEL SIGNAL in telephone channel without send signal (FREE TS (FRM)).

Standard setting: 1 1 0 1 0 1 0 1

Parameter 517

Idle channel signalling word FREE TS (MFRM) in timeslot 16 of frames 1 to 15, i.e.

- bits 1 to 4 for channels 1 to 15,
- bits 5 to 8 for channel 16 to 30.

Standard setting: 1 1 1 1 (bits a b c d).

Parameter 518

SIGNALLING word in timeslot 16; assigned to the selected telephone channel.

Standard setting: 1 1 1 1 (bits a b c d)

The signalling bits can be dynamically controlled via input [60] on the back panel (see 3.2).

If parameter 511 is chosen and /ENTER/ is pressed, all the frame words will be reset to their original standard values, and the (**) symbol will return to parameter 511.

If a 64 kbit/s output is selected (parameters 112, 113) or a "THROUGH MODE" (parameters 115, 116) or parameter 214 ("TX FRAME TYPE ALL 32 TS TELEPH."), it is possible to alter parameters 512 to 518, but these have no effect on the transmitted frame structure. If parameter 212 ("TX FRAME TYPE G.732/TS 16 EXT:") or parameter 213 ("TX FRAME TYPE G.732/TS 16 TELEPH.") is selected, parameters 514 (MFAS) and 515 (NMFAS) can be altered but will not be inserted into timeslot 16.

Parameter 521 (*) - 523

```
** <21> SEND SIGN.IN SELECT. CHAN.
   <22>          ALL CHAN.
   <23>          ALL CHAN. EXCL. SELECT.    RTN
   SELECT NO. ENTER OR RTN
```

Parameter 521 is the normal setting, with the send signal in the selected telephone channel.
If parameter 522 is selected, the signal is transmitted in all channels simultaneously.

Note: Only the transmit channel selected on the results page contains the signalling word set with parameter 518. All other channels contain the signalling word selected with parameter 517.

Parameter 523 provides a send signal such as is required for satellite measurements. The send signal is transmitted in all channels except the chosen one. The idle channel signal (parameter 518) is transmitted in the chosen channel. As all channels are supplied with a defined signal, it is possible to measure any crosstalk which may be present in the selected channel.

3.6.6 PARAMETER LIST 6: TX ERROR INSERTION

```
PARAM.6      * TX ERROR INSERTION *

** (11) INSERTION                OFF
   (12)                          AIS
   (13) ERROR INSERTION          ON
   (21) FRAME ALGNMT BIT ERRORS  10E-4
   (22)                          10E-3
   (23) FRAME ALGNMT WORD ERRORS 2 IN 4
   (24)                          3 IN 4
   (25) MULTIFRAME ALGNMT ERRORS 1 IN 2
   (26)                          2 IN 2
   (27) CRC-4 MFAS WORD ERRORS   2 IN 4
   (28)                          3 IN 4
   (29) CRC-4 WORD ERROR RATIO   91.3 %  RTN
  SELECT NO. ENTER OR RTN
```

Errors can be inserted into the outgoing bitstream by selecting an appropriate parameter from list 6. Errors provided by parameters 621 to 626 are caused by altering bit 2 of the pattern, the other bits remaining unchanged.

Parameter 612 causes an AIS to be generated. The 2 048 kbit/s send frames are broken down completely and an all ones signal is transmitted. This parameter can be selected directly.

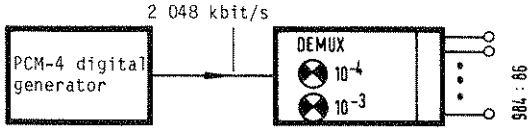
All other types of error insertion must be selected via parameter 613. A double asterisk (**) appears next to 13 on the list, and a second (**) indicates the type of error insertion last chosen (21 with GENERAL RESET).

Parameter 621

FRAME ALGNMT BIT ERRORS 10E-4

Parameter 622

FRAME ALGNMT BIT ERRORS 10E-3



Parameters 621 and 622 cause the frame alignment signals to be generated with a bit error rate of 10^{-4} or 10^{-3}. These error rates are useful for testing the auto thresholds of multiplexer input circuits, so that the line quality can be assessed. If the errors are distributed evenly and a long monitoring interval is used, it is possible to determine the channel error rate from the frame alignment signal error rate.

Example:

The FAS consists of 7 bits. It occurs every 250 ns, corresponding to a channel transmission capacity of 28 kbit/s or 4000 words/s.

- Parameter 621: bit error rate 10^{-4}, test interval 10 s. No. of errors per test interval:
  28000 bit/s x 10^{-4} x 10 s = 28.

- Parameter 622: bit error rate 10^{-3}, test interval 10 s. No. of errors per test interval:
  28000 bit/s x 10^{-3} x 10 s = 280.

Parameter 623

FRAME ALGNMT WORD ERRORS 2 IN 4

Two out of every four frame alignment signals are errored, causing the system to resynchronise.

Parameter 624

FRAME ALGNMT WORD ERRORS 3 IN 4

Three out of every four frame alignment signals are errored, so that the system can no longer synchronise. The NO FRM and NO MFRM on LEDs the front panel come on.

Example:

- Parameter 623 (2 in 4): word error rate 0.5, test interval 10 s.
  No. of word errors per test interval:
  4000 words/s x 0.5 x 10 s = 20000.
  No. of bit errors per test interval:
  28000 bit/s x 0.5/7 bit x 10 s = 20000.
  As only one bit is altered in each word, the number of bit errors is the same as the number of word errors.

Parameter 625

MULTIFRAME ALGNMT ERRORS 1 IN 2

Every other MFAS is errored, so that the system must resynchronise.

Parameter 626

MULTIFRAME ALGNMT ERRORS 2 IN 2

All MFAS are errored, so that the system cannot be synchronised. The NO MFRM LED on the front panel comes on.

Example:

The MFAS consists of 4 bits. It occurs every 2 ms in the signalling frame, corresponding to a channel transmission capacity of 2 kbit/s or 500 words/s.

- Parameter 625 (1 IN 2): MFAS error rate 0.5, test interval 10 s.
  No. of word errors per test interval:
  500 words/s x 0.5 x 10 s = 2500.

Error rate	Parameter	Bit errors	Word errors	Notes
10^{-4}	621	28	28	
10^{-3}	622	280	280	
0.5 (2 IN 4)	623	20000	20000	System must synchronise
0.75 (3 IN 4)	624			NO FRM, NO MFRM, no synchronisation.
0.5 (1 IN 2)	625		2500	System must synchronise.
1 (2 IN 2)	626			NO MFRM, no synchronisation

Table 3-1 Bit and frame errors referred to a 10 s test interval

Parameter 627

CRC-4 MFAS WORD ERRORS 2 IN 4

Insertion of errors into the CRC multiframe alignment signal can only be done if parameter 232 CRC MULTIFRAME ON has been selected (see also explanations of parameter 232).

Once frame alignment has been achieved in the 2 048 kbit/s receiver equipment, it is necessary that at least two CRC multiframe alignment signals are correctly recognised within the next 8 ms in order to achieve multiframe alignment.

If parameter 627 is selected, it is possible to test these synchronisation criteria, as the digital signal generator continuously inserts errors into two out of every four transmitted CRC multiframes. The error injection is produced by inverting bit 2 of the CRC MFAS.

correct: 0 0 1 0 1 1
errored: 0 1 1 0 1 1

Parameter 628

CRC-4 MFAS WORD ERRORS 3 IN 4

(see also parameter 627)
The digital signal generator continuously inserts errors into three out of every four CRC multiframe alignment signals. This means that the 2 048 kbit/s receiver equipment cannot synchronise to the CRC multiframe.

Parameter 629

CRC-4 WORD ERROR RATIO

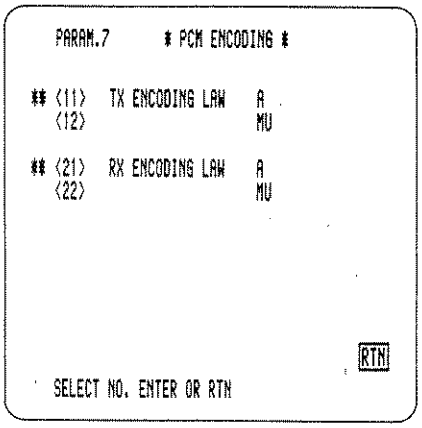
A CRC-4 word error ratio between 0.1 and 99.9% can be set in steps of 0.1%.

0.1% error ratio: 1 out of every 1000 CRC check words is errored by inverting bit 2 (C_2).

Insertion of CRC errors in this way enables the PCM-4 to be used for testing the CRC error monitoring performance of 2 048 kbit/s digital transmission systems.

Frame synchronisation is lost when more than 913 submultiframes out of 1000 are found to contain errors (i.e. word error ratio of > 91.3%). This value is preset for the receive section of the PCM-4 before delivery, but can be changed by using the DIL switches on the CRC control board if required (see also 3.6.2.1).

3.6.7 PARAMETER LIST 7: PCM ENCODING



Parameter 711 (*)

TX ENCODING LAW A

The code words from the digital signal generator are encoded according to tables 1a and 1b of CCITT Rec. G.711 in symmetrical binary code with inversion of bits 2, 4, 6 and 8 (A-law).

Parameter 721 (*)

RX ENCODING LAW A

Decoding of the code words received by the digital receiver is also according to the A-law.

Parameter 712

TX ENCODING LAW MU

The code words from the digital signal generator are encoded according to tables 2a and 2b of CCITT Rec. G.711 in symmetrical binary code with inversion of bits 2 through 8 (μ-law).

Parameter 722

RX ENCODING LAW MU

Decoding of the code words received by the digital receiver is also according to the μ-law.

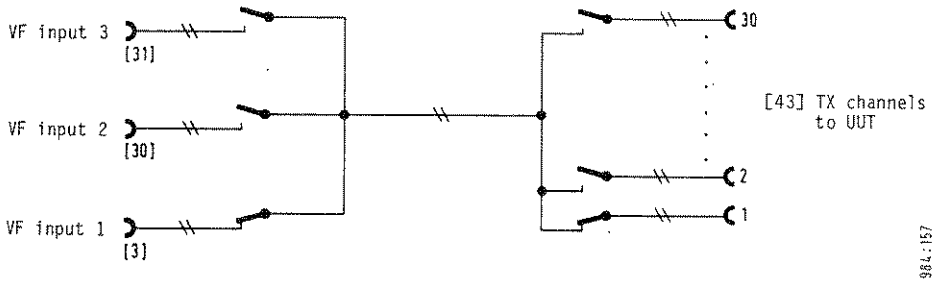
3.6.8 PARAMETER LIST 8: SCANNER PARAMETERS

```
PARAM.8      # SCANNER PARAMETER #

## (11)  VF-INPUT NO.    1
   (12)                  2
   (13)                  3
   (14)                  1+2

## (21)  VF-OUTPUT NO.   1
   (22)                  2
   (23)                  3

                                  RTN

SELECT NO. ENTER OR RTN
```

The MU-30 test point scanner can be controlled by the PCM-4 via the <IEC 625>/IEEE 488 bus. Parameters in list 8 control the switching on and off of the balanced voice frequency (VF) inputs and outputs of the test point scanner.

The analog or digital (64 kbit/s) send signal from the PCM-4 is fed in to the MU-30 via one of the following balanced inputs:

Parameter 811 (*)	VF-INPUT NO. 1 Input [3] (MU-30 front panel).
Parameter 812	VF-INPUT NO. 2 Input [30] (MU-30 back panel).
Parameter 813	VF-INPUT NO. 3 Input [31] (MU-30 back panel).
Parameter 814	VF-INPUT NO. 1 + 2 Inputs [3] (front panel) and [30] (back panel)



Simplified representation of TX signal paths in the MU-30. Input 1 is shown switched through (parameter 811) to TX channel 1 (by pressing /TX CHAN/.

The analog or digital (64 kbit/s) signal is fed to the receiver of the PCM-4 via the following balanced VF outputs of the MU-30:

Parameter 821 (*)

VF-OUTPUT NO. 1

Output [8] (MU-30 front panel).

Parameter 822

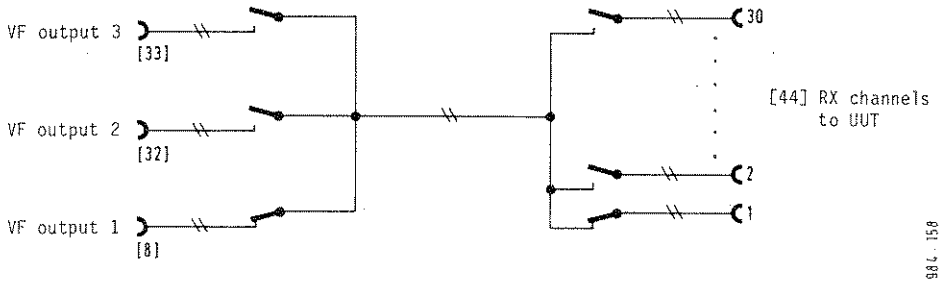
VF-OUTPUT NO. 2

Output [32] (MU-30 back panel).

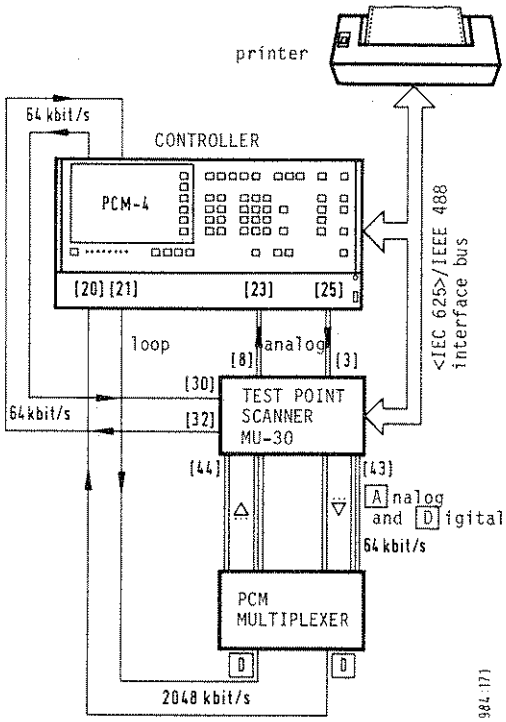
Parameter 823

VF-OUTPUT NO. 3

Output [33] (MU-30 back panel).



Simplified representation of RX signal paths in the MU-30. Output 1 is shown switched through (parameter 821) to RX channel 1 (by pressing /RX CHAN/.



Possible PCM-4 configurations for a sequence:

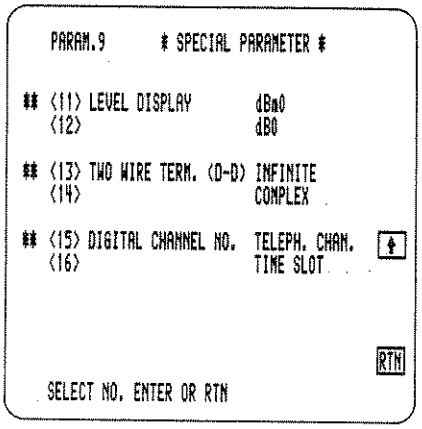
4-wire ports:

A-D = analog TX, RX 2 048 kbit/s (param. 811)
D-A = TX 2 048 kbit/s, RX analog (param. 821)
A-A = analog TX, analog RX with 2 048 kbit/s loop through PCM-4 (param. 121, 811 and 821).

64 kbit/s ports:

D-D = TX 64 kbit/s, RX 2 048 kbit/s (param. 812)
D-D = TX 2 048 kbit/s, RX 64 kbit/s (param. 822)
D-D = TX 64 kbit/s, RX 64 kbit/s with 2 048 kbit/s loop through PCM-4 (param. 121, 812 and 822).

3.6.9 PARAMETER LIST 9: SPECIAL PARAMETERS



Display units for send and receive levels as shown on the results pages.

Parameter 911 (*)

LEVEL DISPLAY dBm0

Parameter 912

LEVEL DISPLAY dB0

Note: In submode lists A2 and A3, the level is still given in dBm0 even if parameter 912 has been selected. This only occurs for these two lists. Calculations and display of results are, however, in dBm0 for parameter 911, and dB0 for parameter 912.

Parameter 913 (*)

TWO WIRE TERM. (D-D) INFINITE

The 2-wire input/output [24] is open circuit in the [D-D] measurement mode.

Parameter 914

TWO WIRE TERM. (D-D) COMPLEX

The 2-wire input/output [24] is terminated with a complex impedance (910 Ω in parallel with 39 nF; not the same as CPLX [13] and CPLX [15]) in [D-D] measurement mode for the measurement of hybrid loss.

Parameter 915 (*)

DIGITAL CHANNEL NO. TELEPH. CHAN.

The digital channels are counted as telephone channels from 1 to 30. The description CHAN. is displayed on the results page. If /SEND CHAN/, /RECV CHAN/ or /BOTH CHAN/ is pressed, the telephone channels 1 to 30 can be selected. Parameter 915 can only be used in conjunction with parameters 211, 212, 221 or 222.

Parameter 916

DIGITAL CHANNEL NO. TIME SLOT

The digital channels are counted as timeslots. The description TS appears on the results page. The numbering of the timeslots is fixed for parameters 213, 223, 214 and 224. The digital channels can be counted as timeslots with parameters 211, 212, 221 and 222.

Parameter 2xx	Counted as timeslots	Corresponding to telephone channels
211, 212, 221, 222	01 - 15	01 - 15
	17 - 31	16 - 30

If /SEND CHAN/, /RCVR CHAN/ or /BOTH CHAN/ is pressed, the timeslot required can be selected.

```
PARAM.9      # SPECIAL PARAMETER #

   (21)  MEAS. NOT POSSIBLE HALT
## (22)                    MARK AND CONT.

## (23)  TOLERANCE MASK     ON
   (24)                    OFF

   (25)  TOLERANCE MASK SET 1                 [↕]

   (26)  OUT OF TOLERANCE   HALT
## (27)                    MARK AND CONT.    [↓]

                                              [RTN]

SELECT NO. ENTER OR RTN
```

Parameter 921

MEAS. NOT POSSIBLE HALT

If the measurement conditions are such that a measurement is impossible or only partially possible, the PCM-4 will stop. Under the heading RESULT on the left-hand side of the screen, the symbol <> will appear. This symbol also appears on the numerical results display in place of a result value.

In [A-A] or [D-A] measurement configuration, the following criteria will cause a measurement to be aborted:

- Autoranging is unsuccesful after:
  - more than 13 attempts to reduce the sensitivity in steps of 6 dB,
  - more than 4 attempts to increase the sensitivity,
  - more than 10 alternations of the input attenuator setting.
- The signal to be measured has a d.c. component which has not decayed sufficiently even after an extended waiting period before the measurement.
- The evaluation processor signals that a non-allowable measurement mode has been selected.
- The evaluation processor signals that the result has a d.c. component only.
- Digital measurements are not synchronised.
- The result of the internal reference measurement is not within the expected range ($\pm$ 1 dB) in modes A2, B1 and B2.
- The wideband result in modes A5 and A9 (S) is < -80 dB.
- An error has occurred in one measurement in a sequence of measurements.

Parameter 922 (*)

MEAS. NOT POSSIBLE MARK AND CONT

This parameter is selected if it is undesirable to stop measurements as described under parameter 921. The symbol <> appears on the screen under "RESULT" and also in the graphics display instead of a result value. A further attempt to make the required measurement is made immediately.

Example of use:

Measurements across all channels using the MU-30 test point scanner. In this way it is easy to determine in which channels measurements are impossible.

Parameter 923 (*)

TOLERANCE MASK ON

Parameter 923 causes a tolerance mask to be superimposed on some results displays.

Parameter 924

TOLERANCE MASK OFF

Parameter 924 negates parameter 923.

Parameter 925

TOLERANCE MASK SET 1 (*) TO 9

A selection of 9 different user-specified tolerance masks for the same combination of mode/running parameters/configuration is available under parameter 925.

If the standard tolerance mask EPROM is supplied, the CCITT tolerance masks for G.712 (A-A full channel) and G.714 (D-A and A-D half channel) for 4 wire port measurements are available under TOLERANCE MASK SET 1.

For measurements on two-wire ports, the tolerance masks specified by CCITT G.713 are provided in TOLERANCE MASK SET 2. For settings which do not apply to two-wire ports, the tolerance masks are identical to those available in TOLERANCE MASK SET 1 (for more details, refer to Appendix D).

Parameter 926

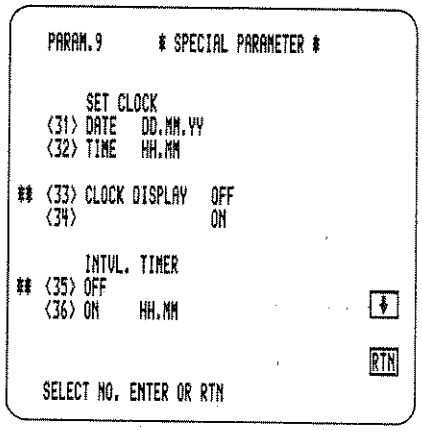
OUT OF TOLERANCE HALT

If the result lies outside the tolerance limits, the measurement sequence in progress will be halted. To restart, press /START/ key.

Parameter 927 (*)

OUT OF TOLERANCE MARK AND CONT.

If the result lies outside the tolerance limits, the measurement sequence in progress continues, and the out-of-tolerance result is shown under the heading RESULT on the graphics display as a numerical value. On the numerical display, the result is marked with *.



Parameter 931

SET CLOCK DATE DD.MM.YY

Date information is entered as follows:
* select parameter 931,
* enter date in DD.MM.YY format
* press /ENTER/.
  If an illegal entry is made, the enter line will show ??.??.??

Parameter 932

SET CLOCK TIME HH.MM

Time information is entered as follows:
* select parameter 932,
* enter time in HH.MM format
* press /ENTER/.
  If an illegal entry is made, the enter line will show ??.??

Parameter 933 (*)

CLOCK DISPLAY OFF

Parameter 934

CLOCK DISPLAY ON

Date and time information is shown in the upper right-hand corner of screen display. This information is not printed out by the graphics plotter.

Parameter 935 (*), 936

Switching the interval timer off (parameter 935) and on (parameter 936).

The TIMER is used to start a measurement at a predetermined time and to repeat it at set intervals, each measurement being preceded by a calibration.

Parameter 935 (*)

INTVL. TIMER OFF

When the timer is switched off, calibration occurs:

- at switch-on,
- 20 minutes after switch-on,
- and every 2 hours thereafter (if a menu page is displayed, the PCM-4 does not autocalibrate until a results page has been called up),
- when called up via the IEC bus.

During calibration, the internal relays will be heard switching. The keys of the PCM-4 are disabled.

Parameter 936

INTVL. TIMER ON

After selecting parameter 936, the interval data is entered in the form HH.MM. If an illegal entry is made, the enter line will show ??.??. The timer is started by pressing the /RTN/ softkey.

Example:

If 00.10 is entered, the measurement will start automatically 10 minutes after the results page is called up by pressing RTN. The autocal routine is run immediately before the measurement starts, and takes about 15 seconds to complete. The process is repeated cyclically, and can only be stopped by pressing RESET or by setting parameter 935 (TIMER OFF).

NOTE ABOUT CALIBRATION:

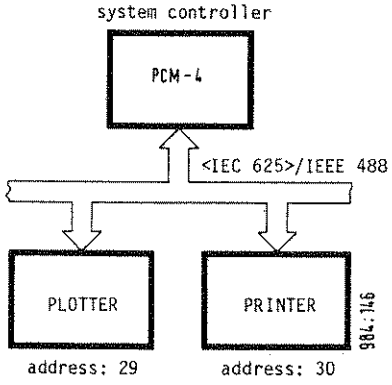
During SWP/S or SWP/R measurements, the sweep in progress is not interrupted in order to carry out a calibration. A calibration triggered by the internal timer can only be carried out after the last result of a sweep measurement has been stored. In MAN/S or MAN/R modes, the current measurement will be completed and the result stored before the calibration takes place.

INVTL. TIMER ON 00.00

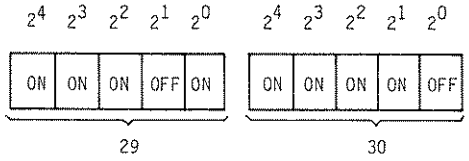
When the setting 00.00 is made for the timer, the PCM-4 runs the autocal routine immediately and repeats this at intervals of 24 hours. It is possible to make bit error rate measurements at any time during this period without the measurement being interrupted by calibration.

3.6.10 PARAMETER LIST 0: PRINTER/PLOTTER

```
PARAM.0      * PRINTER / PLOTTER *

    -PLOT-
## (1) MAN  RESULTS (LINKED & COND.)
   (2)      RESULTS (LINKED)

    -PRINT-
   (3) MAN  RESULTS


   (6) AUTO ALL
   (7)      IF OUT OF TOL.
   (8)      ALL          & TOL. LIM.
   (9)      IF OUT OF TOL. & TOL. LIM.   RTN

   SELECT NO. ENTER OR RTN
```



The PCM-4 must be set as system controller (SC) if the measurement results are to be output on a printer or plotter. This is done by setting the switch on the back panel of the <IEC 625>/IEEE 488 interface board (option) to position SC "ON" (also see section 4). The plotter must be set to address 29 and the printer to address 30.



If "listen always" and "SRQ" switches are provided on the printer, these should be set to OFF.

Plotter requirement:

- hp graphics language
- IEC 625/IEEE 488 bus compatible
- addressable

Recommended type: e.g. hp 7470

Printer requirements:

- IEC 625/IEEE 488 bus compatible
- addressable
- standard ASCII character set
- at least 80 characters/line

Recommended types: hp 2225 Thinkjet
Siemens PT 88
Epson FX-80

NOTE: The printer or plotter must be switched on before the PCM-4 is switched on.

Parameter 01

-PLOT-
MAN RESULTS (LINKED & FRAMED)

When the /PRINT/PLOT/ key is pressed, the complete contents of the graphic or numeric screen display will be plotted out, even if a measurement has not yet been made.

NOTE: The plotter follows the same sequence when producing hard copy as was followed during the building up of the screen picture. The plotter pen will therefore jump from point to point on the paper. The date and time display are not printed out by the plotter as the area of paper on the plot is already occupied by the graph scales and would render the date/time information illegible anyway.

Parameter 02

-PLOT-
MAN RESULTS (LINKED)
It is normal to select parameter 01 first, as parameter 02 only causes the set of results produced by the last sweep measurement to be plotted out and joined up when /PRINT/PLOT/ is pressed. This setting is therefore intended for use where several measurements are made under identical conditions and the results traces are to be overlaid for the purposes of comparison, for example.

Parameter 03

-PRINT-
MAN RESULTS
When a measurement run has been completed, pressing /PRINT/PLOT/ causes the results to be printed out in the form of a table by the printer. As well as date and time information, the heading includes details of the more important settings made for the measurement. Notes about the special symbols which may also appear in the RESULT column are found in section 3.5.1.

Parameter 06

-PRINT-
AUTO ALL
The AUTO ALL setting causes all results for each successive measurement to be printed out by the printer. If a change is made in the measurement mode or the configuration, this causes the printer to print a complete heading before listing the new set of results. Notes about the special symbols which may appear in the RESULT column are found in section 3.5.1.

NOTE: The speed of measurement is considerably influenced by the printing out of all of the results. To save time the printing out of results which are out of tolerance is recommended (parameters 07 and 09).

Parameter 07

-PRINT-
AUTO IF OUT OF TOL.
This setting causes all results which lie outside the tolerance limits to be printed out with the symbol * (see section 3.5.1). If the measurement mode or the configuration is altered, the complete headings for the new measurement will be printed out automatically.

Parameter 08

-PRINT-
AUTO ALL & TOL. LIM.
This setting causes all results, together with their upper and lower limit values, to be printed out automatically. If the measurement mode or the configuration is altered, this causes the printer to print out a complete heading for the new measurement before the results and tolerances are printed out.
Notes about the special symbols which may appear in the RESULT column are found in section 3.5.1.

NOTE: Choice of this parameter slows down the measurement rate of the PCM-4 considerably. It is therefore a good idea to print out the out of tolerance results (parameters 07 and 09) if a complete listing is not required.

Parameter 09

-PRINT-
AUTO IF OUT OF TOL. & LIM.
This setting causes all results which lie outside the tolerance limits to be printed out with the symbol * (see section 3.5.1), together with the corresponding tolerance limits. This takes place automatically. If the measurement mode or the configuration is altered, this causes the printer to print out a complete heading for the new measurement before the results and tolerances are printed out.

3.7 MODE LIST A MEASUREMENTS

All MODE LIST A measurements are described in this section, either as groups or individually.

The digital and analog send signals, together with the receive filter, are set automatically to the requirements of the selected measurement.

List "A" measurements include:

- level measurements
- overall loss
- variation of gain with frequency
- variation of level with frequency
- total distortion
- idle channel noise
- crosstalk
- out of band measurements
- harmonic- or IM distortion

These measurements determine either absolute or referred levels.

X axis parameters:

- frequency
- level
- channel number

All half- and full channel measurements can be made on multiplexers without having to alter any connections, simply by pressing the softkey which corresponds to the measurement configuration required. The diagrams which follow show the four configurations that can be selected in this manner:

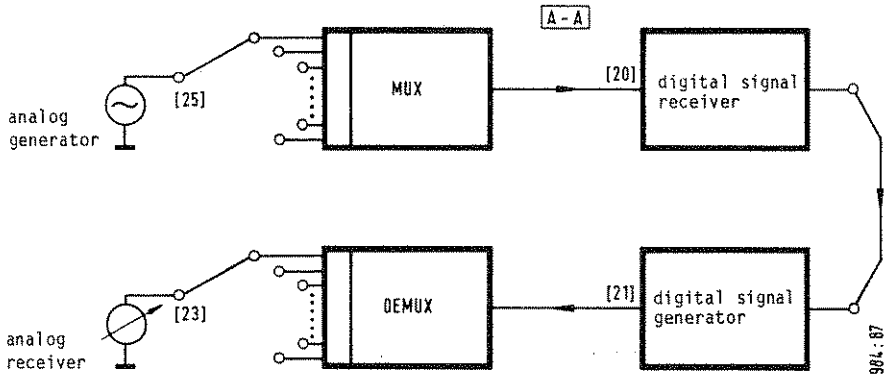


Figure 3-9 Analog-analog measurement

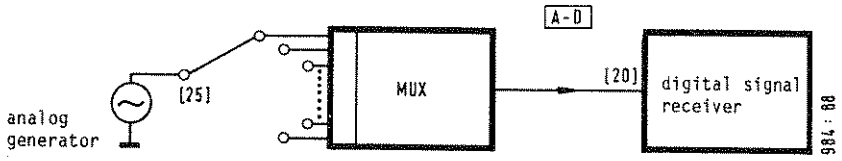


Figure 3-10 Analog-digital measurement

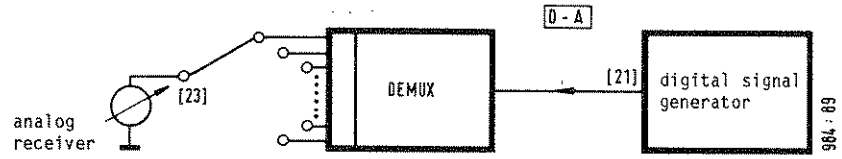


Figure 3-11 Digital-analog measurement

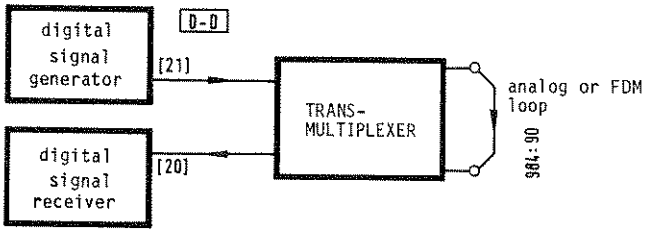


Figure 3-12 Digital-digital measurement

Note regarding the A-A measurement configuration

After the A-A configuration has been selected, an internal loop must be formed on the digital side. The loops can be made using parameter 121 or 122 and opened using parameter 123. If the loop is made using parameter 121 or 122, the clock settings for the digital generator (parameter 331 to 333) will have no effect, as the clock signal in such cases is always derived from the receiver signal (as with parameter 334).

Parameter 121 and parameter 111 (2 048 kbit/s / 2 048 kbit/s):

The digital loop is on the 2 048 kbit/s level. Received frames are looped from receiver to generator without alteration. The generator (parameter 3xx) and receiver (parameter 4xx) line codes must be the same.

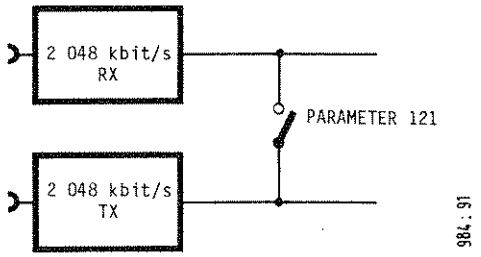


Figure 3-13 Internal 2 048 kbit/s loop

Parameter 122 and parameter 111 (2 048 kbit/s / 2 048 kbit/s):

Here, the digital loop is at the 64 kbit/s level. Channel switching is possible; the information in one of the received frames can be transferred to another channel of the output signal. The send- and receive line codes can differ.

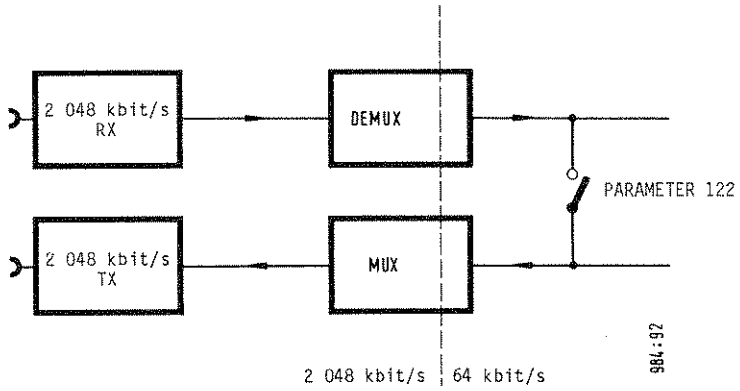


Figure 3-14 Internal 2 048 (64) kbit/s loop

Parameter 123

This parameter is selected when /GENRL RESET/ is pressed. The internal digital loop output is opened and the 2 048 kbit/s output signal can be used as an auxiliary signal. The settings for the digital generator clock (parameters 331 to 334) are fully operational.

Parameters 124 and 112 (64 kbit/s / 64 kbit/s):

The 64 kbit/s signal together with the 64 kHz and 8 kHz clock signals are fed from the interface input to the output via an internal digital loop. When the loop is closed, the status of the 64 kbit/s data stream is displayed on the 8 green LEDs below the display screen. The loop cannot be closed if a codirectional interface to CCITT G.703 is used (e.g. BN 984/00.01 or 984/00.02).

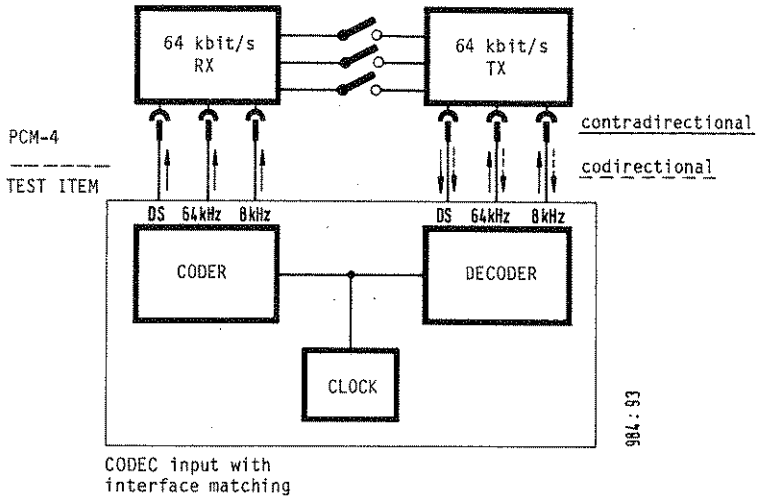


Figure 3-15 Internal 64 kbit/s loop

3.7.1 MODE A1x: LEVEL MEASUREMENTS

Absolute level measurement.

The received level is measured directly and the result displayed. The signal can be from the PCM-4s analog generator or from another analog source. Using this mode, it is possible to rapidly get an overall view of what happens to the signal level as it passes through the system.

X axis parameters:

- frequency
- level
- channel

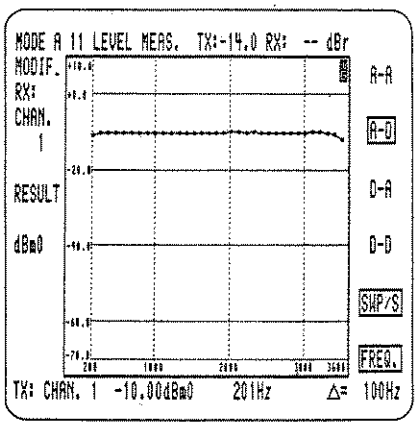


Figure 3-16 Level measurement vs frequency

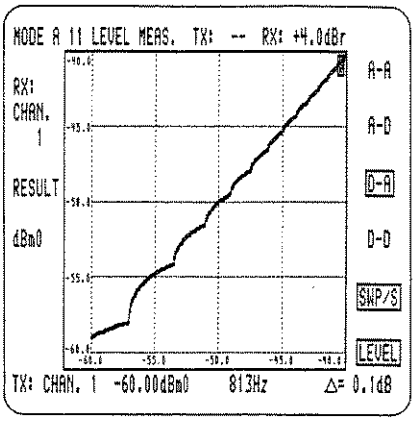


Figure 3-17 A11: level measurement vs. level

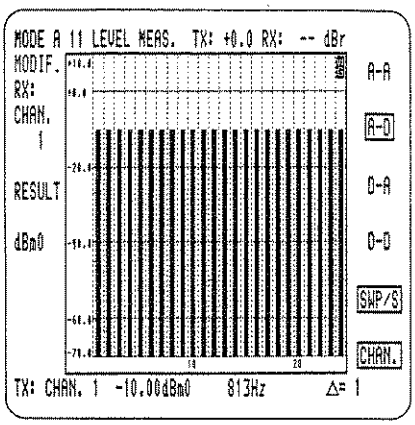


Figure 3-18 A11: level measurement vs. channel number

Mode A11 to A14	A-A	A-D	D-A	D-D	change via
Analog generator	X	X	OFF	OFF	VAR.MODE 1
Analog aux. generator	OFF	OFF	OFF	OFF	VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code	idling code	X	X	VAR.MODE 2
Analog receiver	X		X		
Digital receiver		X		X	
Receive filter and send signals	set using submodes				VAR.MODE 3

Table 3-2 Operational status of generator and receiver as referred to the measurement configuration in modes A11 to A14

Submode	Filter
A11	SINE WAVE 200 Hz ... 4 kHz
A12	SINE WAVE 20 Hz ... 4 kHz
A13	SINE WAVE 20 Hz ... 72 kHz
A14	NOISE 350 Hz ... 550 Hz

Table 3-3 List of submodes A11 to A14

A11 to A13		
Configuration	Run mode	Run parameter
A-A CFØ,	SWP/S MSØ,	FREQ XP1,
A-D CF1,	SWP/R MS1,	LEVEL XP2,
D-A CF2,	MAN/S MS2,	CHAN. XPØ,
D-D CF3,	MAN/R MS3,	

Table 3-4 Softkey program words in measurement modes A11 to A13

A14		
Configuration	Run mode	Run parameter
A-A CFØ,	SWP/S MSØ,	CHAN. XPØ,
A-D CF1,	SWP/R MS1,	LEVEL XP1,
D-A CF2,	MAN/S MS2,	
D-D CF3,	MAN/R MS3,	

Table 3-5 Softkey program words in measurement mode A14

3.7.2 MODE A2x: OVERALL LOSS

Referred level measurement (level difference using reference loop in A-A mode).

Two signal paths are used between the analog generator and receiver for this measurement:

- via an internal loop
- externally via the test object

Method of measurement:

- the receiver and generator of the PCM-4 are connected together via the internal loop and the relative generator level transmitted to the receiver;
- the level is measured directly in the receiver;

- the loop is opened;
- the second measurement is made via the test object, taking account the original relative level;
- the level difference is calculated and displayed.

In this way, the intrinsic attenuation characteristics of the generator and receiver do not influence the result.

NOTE: if the output impedance $R_{out} \approx 0\ \Omega$ is fitted instead of R_{out} = complex, then measurements of analog-analog overall loss will be impossible in modes A21, A22, A23 and A24 if this output impedance is selected.

X axis parameters:

- frequency
- level
- channels

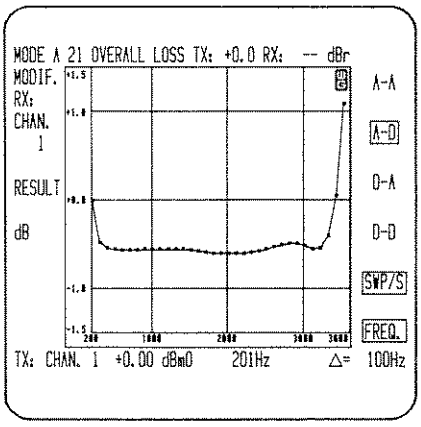


Figure 3-19 A21: overall loss vs. frequency

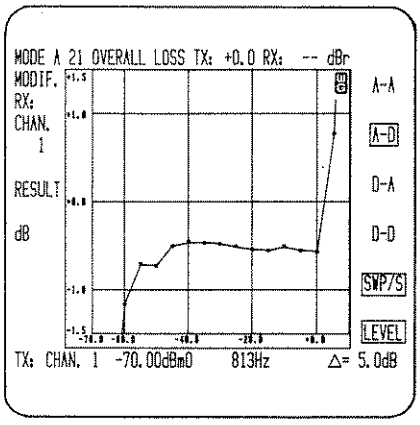


Figure 3-20 A21: overall loss vs. level

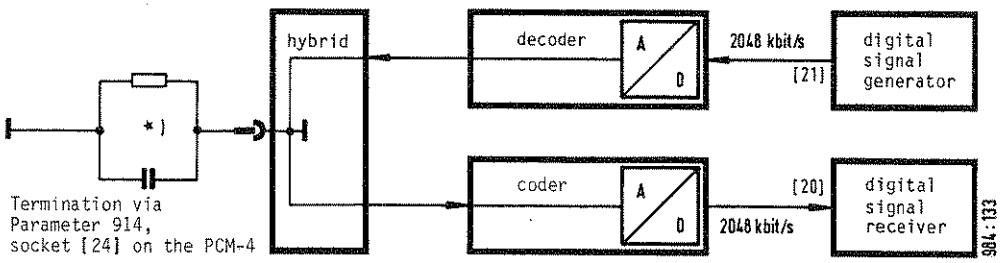


Figure 3-21a Test setup for measurement of hybrid return loss in MODE A21 to A24

Note: Relative levels cannot be set in D-D mode, so remember to take the relative coder/decoder levels into account when calculating the results.

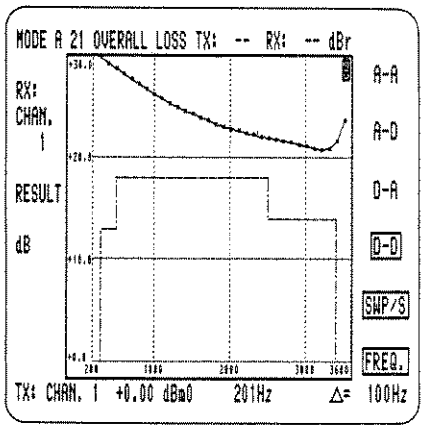


Figure 3-21b Graphics display of hybrid return loss versus frequency

Mode A21 to A24	A-A	A-D	D-A	D-D	change via
Analog generator	X	X	OFF	OFF	VAR.MODE 1
Analog aux. generator	OFF	OFF	OFF	OFF	VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code	idling code	X	X	VAR.MODE 2
Analog receiver	X		X		
Digital receiver		X		X	
Receive filter and send signals	set with submodes				VAR.MODE 3

Table 3-6 Operational status of generator and receiver as referred to the measurement configuration in modes A21 to A24

Submode	Preferred frequency and level
A21	FREQUENCY 813 Hz LEVEL 0dBm0
A22	FREQUENCY 813 Hz LEVEL -10 dBm0
A23	FREQUENCY 1014 Hz LEVEL 0 dBm0
A24	FREQUENCY 1014 Hz LEVEL -10 dBm0

Table 3-7 List of submodes A21 to A24

*) Standard impedance 910 Ω 39 nF can be altered in the factory on request.

A21 to A24		
Configuration	Run mode	Run parameter
A-A CFØ, A-D CF1, D-A CF2, D-D CF3,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	CHAN. XPØ, FREQ. XP1, LEVEL XP2,

Table 3-8 Softkey program words in measurement modes A21 to A24

3.7.2.1 MODE A25: Echo return loss (ERL)

Due to the finite hybrid return loss of the system, a proportion of the signal flows from the output port back to the hybrid circuit on the input side of the system. Both the phase and magnitude of this echo signal add to the original signal in the hybrid circuit. The phase angle depends, among other things, on the signal propagation time in the system. The magnitude depends on the hybrid loss a_F and on the insertion loss of the 4 wire circuit a_E. The higher the ERL, the weaker the echo signal will be.

$$ERL = a_{E1} + a_{E2} + a_F$$

The insertion loss a_E is the sum of the individual losses a_B:

$$a_{E1} = a_{B1} + a_{B2} \qquad a_{E2} = a_{B3} + a_{B4}$$

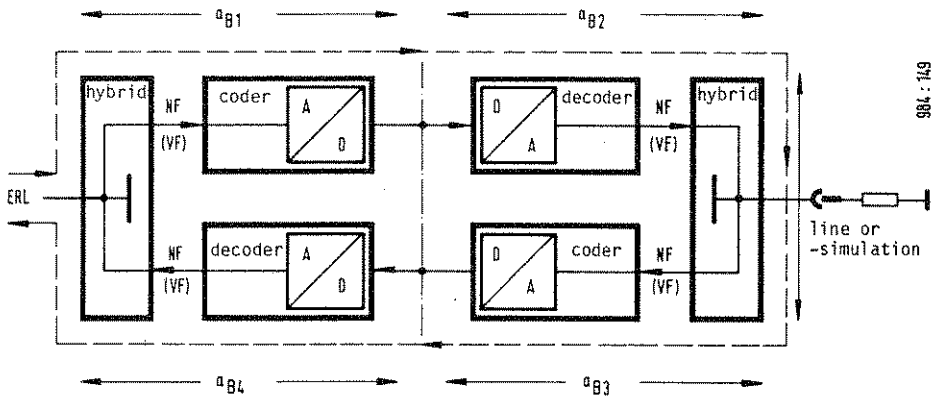


Figure 3-22 Echo signal in a 4-wire circuit

If access to the 4-wire interface is available, ERL can be measured directly by the PCM-4 in A-A mode. ERL cannot be measured at the 2-wire interface in A-A mode, but can be calculated by adding the results of the A-D and D-A measurements together.

1) A-D result gives $a_{B1} + a_{B2} + a_F + a_{B3}$

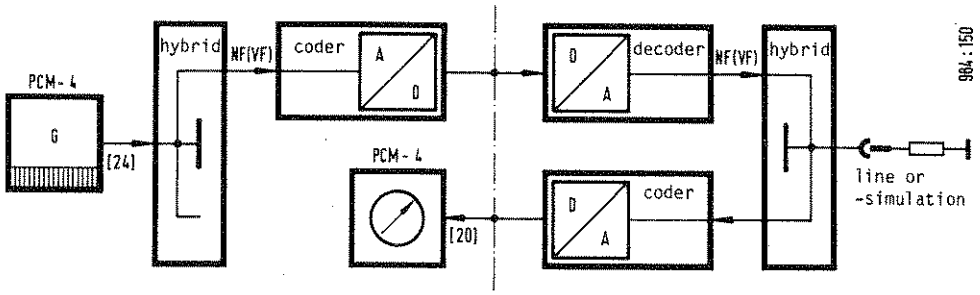


Figure 3-23 A-D measurement configuration for determining ERL in mixed 2-wire/4-wire systems

2) D-A result gives a_{B4}

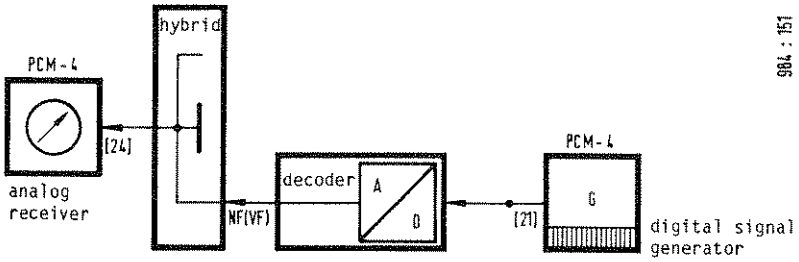


Figure 3-24 D-A measurement configuration for determining ERL in mixed 2-wire/4-wire systems

3) Addition of A-D and D-A results to give ERL

$$ERL = a_{B1} + a_{B2} + a_F + a_{B3} + a_{B4}$$

The result shown by the PCM-4 is the difference between the transmitted and the received levels. The generator signal is a band-limited quasi-stochastic noise signal (560 to 1965 Hz).

3.7.2.2 MODE A26 and A27: Singing return loss (SRL)

An audible whistle or "singing" is heard if the 4-wire circuit starts to oscillate at the critical frequency. This occurs if the system layout is not optimised and the difference between the losses and gains in the 4-wire circuit approaches zero. The singing return loss (SRL) is given by:

$$SRL = a_B + a_{F1} + a_{F2}$$

The singing point occurs when SRL $\leq$ 0.

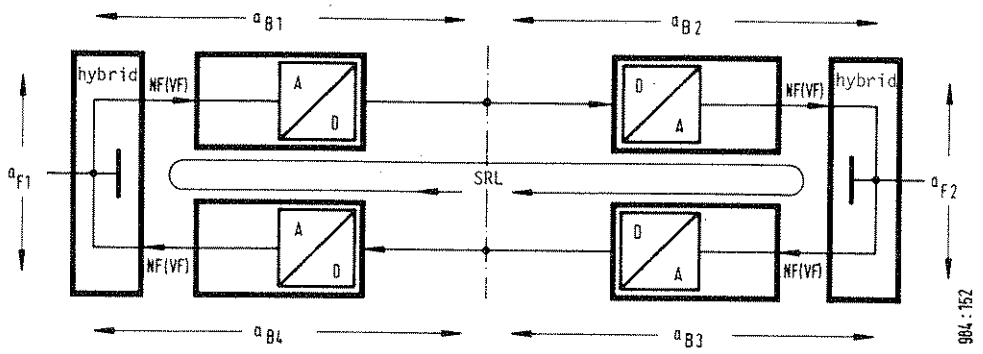


Figure 3-25 SRL in a 4-wire circuit

Two different noise signals are available from the PCM-4 for the measurement of SRL:

SRL LO (260 to 500 Hz) in MODE A26

SRL HI (2200 to 3400 Hz) in MODE A27

Experience has shown that the critical frequency lies within one of these ranges, so that MODE A26 or MODE A27 can be used to determine the singing point, i.e. when the SRL has the worst value. The columns shown in the graphics display will indicate the limit value of 0 dB or a negative value for SRL. The result indicated by the PCM-4 is the difference between the transmitted and the received levels.

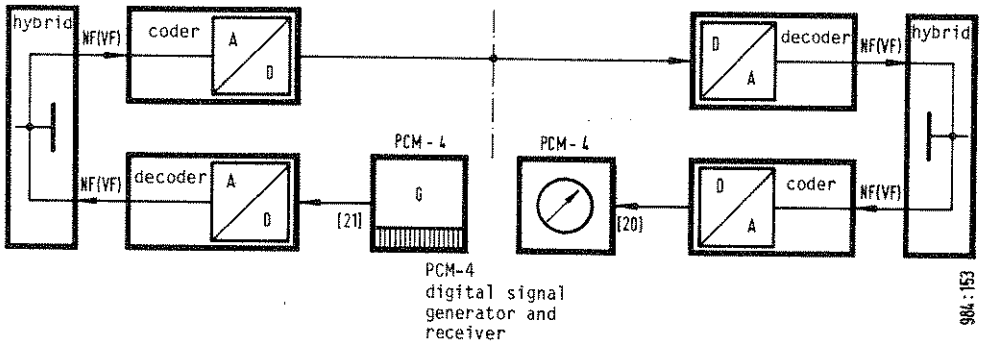


Figure 3-26 D-D measurement configuration for determining SRL in a 4-wire circuit

3.7.3 MODE A3x: VARIATION OF GAIN WITH FREQUENCY

Referred level measurement (difference level, reference frequency).
Generally, this measurement is carried out at constant level.

- Level measurement at a reference frequency (e.g. 813 Hz in mode A31). The frequency value can be altered via VAR.MODE 611.
- Measurement of level values at fixed frequencies between 20 Hz and 4000 Hz with a maximum resolution of 10 Hz. To avoid interference with the subharmonics of the 8 kHz sampling frequency, the actual frequencies differ slightly from the nominal values; for example, 402 Hz is used instead of 400 Hz (see section 3.1 under /FREQ./).
- Calculation of difference. The difference value is displayed.

In MAN/S mode, two measurements are always made:
- the reference measurement, which is immediately followed by
- the level measurement at the frequency pre-set as a parameter.

In MAN/R, SWP/S and SWP/R modes, the reference measurement is only made once, at the start of the measurement run.

X axis parameters:
- frequency
- channels

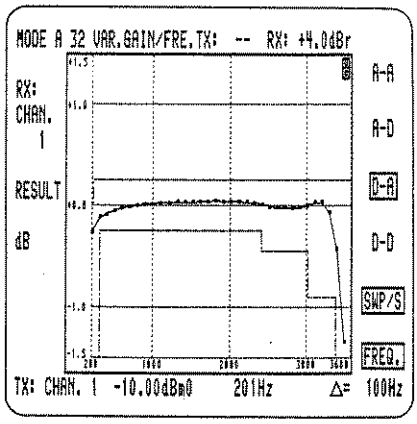


Figure 3-27 A32: frequency response measurement

Note: If the range is extended to 4 kHz, the filter attenuation of 3 dB at 4.3 kHz must be taken into account. If a generator frequency of 23.7 kHz is used, the image frequencies produced by the test filter lie at around 4.3 kHz and will be shown as out-of-band spurious signals with a level of 3 dB less than their true value.

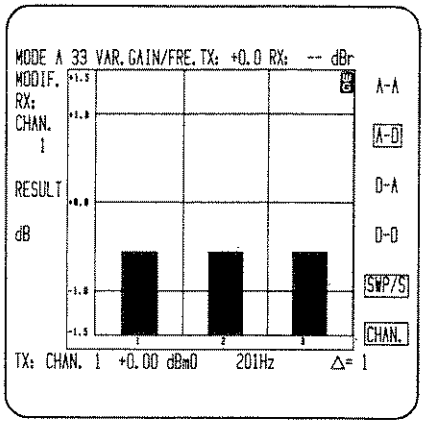


Figure 3-28 A33: frequency response vs. channel for 3 channels

Mode A31 to A38	A-A	A-D	D-A	D-D	change via
Analog generator	X	X	OFF	OFF	VAR.MODE 1
Analog aux. generator	OFF	OFF	OFF	OFF	VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code	idling code	X	X	VAR.MODE 2
Analog receiver	X		X		
Digital receiver		X		X	
Receive filter and send signals	set with submodes				VAR.MODE 3

Table 3-9 Operational status of receiver and generator referred to the measurement configuration in modes A31 to A38

Submode	Filter, reference frequency and preferred level
A31	200 Hz ... 4 kHz REF. FREQ. 813 Hz LEVEL 0 dBm0
A32	200 Hz ... 4 kHz REF. FREQ. 813 Hz LEVEL -10 dBm0
A33	200 Hz ... 4 kHz REF. FREQ. 1014 Hz LEVEL 0 dBm0
A34	200 Hz ... 4 kHz REF. FREQ. 1014 Hz LEVEL -10 dBm0
A35	20 Hz ... 4 kHz REF. FREQ. 813 Hz LEVEL 0 dBm0
A36	20 Hz ... 4 kHz REF. FREQ. 813 Hz LEVEL -10 dBm0
A37	20 Hz ... 4 kHz REF. FREQ. 1014 Hz LEVEL 0 dBm0
A38	20 Hz ... 4 kHz REF. FREQ. 1014 Hz LEVEL -10 dBm0

Table 3-10 List of submodes A31 to A38

A31 to A38		
Configuration	Run mode	Run parameter
A-A CFØ, A-D CF1, D-A CF2, D-D CF3,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	FREQ XP1, CHAN. XPØ,

Table 3-11 Softkey words in measurement modes A31 to A38

3.7.4 MODE A4x: VARIATION OF GAIN WITH LEVEL

Referred level measurement (difference level, reference frequency).
This measurement is carried out at constant frequency.

- Measurement of level with a reference level input (e.g. -10 dBm0 in mode A41). The reference value can be altered using VAR MODE 621.
- Measurement of the level at a frequency of 813 Hz with an input level which can be varied between -60 dBm0 and +3 dBm0, with a maximum resolution of 0.1 dB. Using this measurement it is possible to establish that the compressor and expander characteristics together yield a linear transfer function.
- Calculation of difference. The difference value is displayed.

In MAN/S mode, two measurements are always made:
- the reference measurement, immediately followed by
- the level measurement with the input level as pre-set by parameter.

In MAN/R, SWP/S and SWP/R modes, the reference measurement is only made once, at the start of the measurement run.

X axis parameters:
- level
- channel

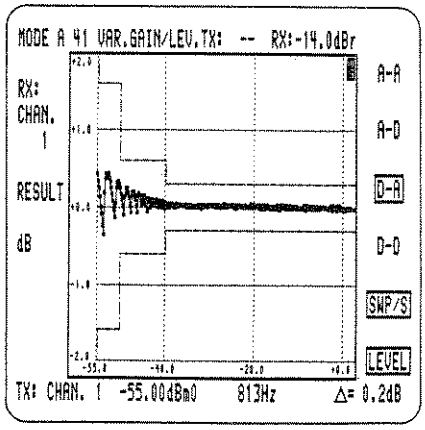


Figure 3-29 A41: linearity measurement

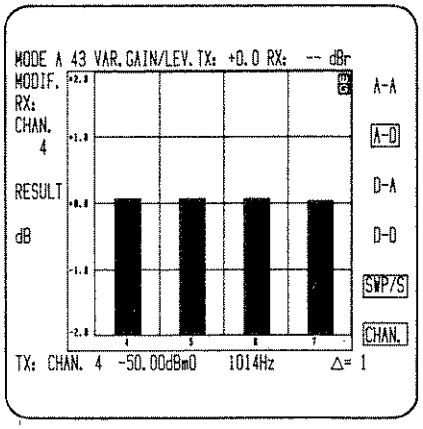


Figure 3-30 A43: linearity measurement vs. channel for four channels

Mode A41 to A46	A-A	A-D	D-A	D-D	change via
Analog generator	X	X	OFF	OFF	VAR.MODE 1
Analog aux. generator	OFF	OFF	OFF	OFF	VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code	idling code	X	X	VAR.MODE 2
Analog receiver	X		X		
Digital receiver		X		X	
Receive filter and send signals	set with submodes				VAR.MODE 3

Table 3-12 Operational status of generator and receiver referred to the measurement configuration in modes A41 to A46

Submode	Preferred frequency, filter
A41	SINE WAVE 813 Hz SELECTIVE
A42	SINE WAVE 813 Hz 200 Hz ... 4 kHz
A43	SINE WAVE 1014 Hz SELECTIVE
A44	SINE WAVE 1014 Hz 200 Hz ... 4 kHz
A45	NOISE RECV.: 350 Hz ... 550 Hz
A46	NOISE RECV.: 200 Hz ... 4 kHz

Table 3-13 List of submodes A41 to A46

A41 to A46		
Configuration	Run mode	Run parameter
A-A CFØ, A-D CF1, D-A CF2, D-D CF3,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	LEVEL XP1, CHAN. XPØ,

Table 3-14 Softkey program words in modes A41 to A46

3.7.5 MODE A5x: TOTAL DISTORTION INCLUDING QUANTISING DISTORTION

Quantising distortion is caused by the method of converting the sampled value of the LF signal into binary coded signals which describe discrete amplitude values. The final resolution of these steps results in a distortion which manifests itself as noise.

Quantising- and harmonic distortions are measured with either a sinusoidal signal or a band-limited noise signal between the channel inputs and outputs, as recommended by CCITT Recs. G.712, G.713 and G.714. The power spectrum of the noise signal lies within the range 350 Hz to 550 Hz. The level difference between the quantising noise and the test signal is determined on the receive side.

X axis paramters:

- level
- channel

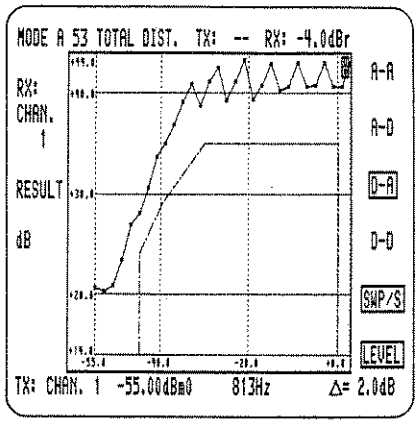


Figure 3-31 A53: total distortion measurement

Mode A51 to A57	A-A	A-D	D-A	D-D	change via
Analog generator	X	X	OFF	OFF	VAR.MODE 1
Analog aux. generator	OFF	OFF	OFF	OFF	VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code	idling code	X	X	VAR.MODE 2
Analog receiver	X		X		
Digital receiver		X		X	
Receive filter and send signals	set with submodes				VAR.MODE 3

Table 3-15 Operational status of receiver and generator referred to measurement configuration in modes A51 to A57

Submode	Preferred frequency, filter
A51	NOISE 350 Hz ... 550 Hz CCITT 0.131
A52	SINE WAVE 422 Hz CCITT 0.131
A53	SINE WAVE 813 Hz PSOPH. CCITT 0.131
A54	SINE WAVE 813 Hz 300 Hz ... 3350 Hz
A55	SINE WAVE 1014 Hz PSOPH.
A56	SINE WAVE 1014 Hz C-MESS. CCITT 0.132
A57	SINE WAVE 1014 Hz 300 Hz ... 3350 Hz

Table 3-16 List of submodes A51 to A57

A51 to A57		
Configuration	Run mode	Run parameter
A-A CFØ, A-D CF1, D-A CF2, D-D CF3,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	LEVEL XP1, CHAN. XPØ,

Table 3-17 Softkey program words in modes A51 to A57

3.7.6 MODE A6x: IDLE CHANNEL NOISE MEASUREMENT

Absolute level measurement

The idle channel noise is usually measured psophometrically or C-message weighted. Idle channel noise is caused by the more or less random switching of the minimum quantizing interval.

X axis parameter:

- channel

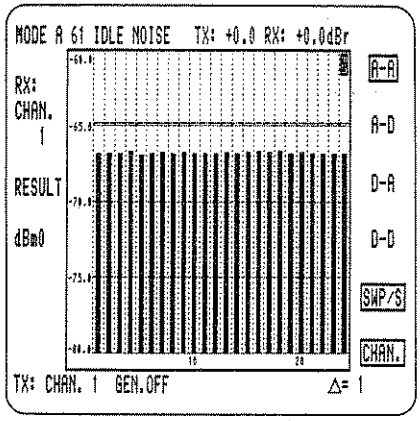


Figure 3-32 A61: idle channel noise vs. channel

Mode A61 to A63

Analog side:
Generator is off, noise is measured in correctly terminated empty channel.

Digital side:

The digital generator outputs the idling code signal +000 or the periodically/randomly alternating digital word +000/-000.

Mode A61 to A63	A-A	A-D	D-A	D-D	change via
Analog generator	OFF	OFF	OFF	OFF	VAR.MODE 1
Analog aux. generator	OFF	OFF	OFF	OFF	VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code	idling code	idling code	idling code	VAR.MODE 2
Analog receiver	X		X		
Digital receiver		X		X	
Receive filter and send signals	set with submode				VAR.MODE 3

Table 3-18 Operational status of receiver and generator referred to the measurement configuration in modes A61 to A63

Submode	Filter
A61 A62 A63	PSOPH. C-MESSAGE 300 Hz ... 3350 Hz

Table 3-19 List of submodes A61 to A63

Modes A64 to A66

Idle channel noise measurement on CODEC modules having integral filters (e.g. S-C filter). An auxiliary signal at 2 kHz is transmitted for this purpose. This signal is a subharmonic of the sampling frequency, and activates the CODEC without generating any quantizing noise in the transmission frequency range. The auxiliary signal is suppressed in the receiver with a suitable stop-band filter, so that just the channel noise is measured at the filter.

Mode A64 to A66	A-A	A-D	D-A	D-D	change via
Analog generator	X	X	OFF	OFF	VAR.MODE 1
Analog aux. generator	OFF	OFF	OFF	OFF	VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code	idling code	X	X	VAR.MODE 2
Analog receiver	X		X		
Digital receiver		X		X	
Receive filter and send signals	set with submodes				VAR.MODE 3

Table 3-20 Operational status of generator and receiver referred to the measurement configuration in modes A64 to A66

Submode	Auxiliary signal, filter
A64	NOISE W. 2 kHz TONE, PSOPH.
A65	NOISE W. 2 kHz TONE, C-MESS.
A66	NOISE W. 2 kHz TONE, 300 Hz ... 3350 Hz

Table 3-21 List of submodes A64 to A66

A61 to A66		
Configuration	Run mode	Run parameter
A-A CFØ, A-D CF1, D-A CF2, D-D CF3,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	CHAN. XPØ,

Table 3-22 Softkey program words in modes A61 to A66

3.7.7 MODE A7x: CROSSTALK

Absolute level measurement

X axis parameter:

- channel

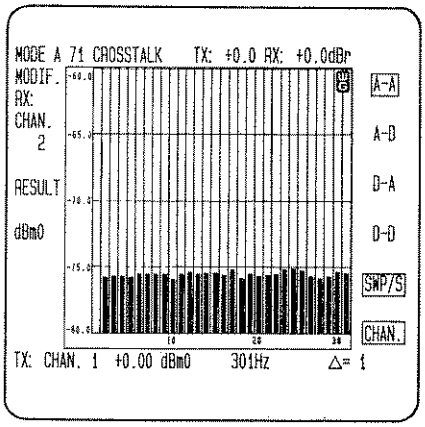


Figure 3-33 A71: crosstalk vs. channel number

MU-30 test point scanner and auxiliary signal

If an MU-30 is connected to the analog inputs and outputs, it is possible to make measurements in all channels in rapid sequence. The MU-30 is particularly useful when making crosstalk measurements, as an auxiliary signal is required in addition to the TX signal. The auxiliary signal is available from output [31] of the PCM-4 and is defined using VAR. MODE 152 to 154. The signal is input to the MU-30 which inserts it into all idle channels. This causes the coder to assume a defined state, so that the results are independent of the more or less random zero point of the coder.

3.7.7.1 Near-end crosstalk measurements using an analog test signal

A-A The analog generator feeds a signal into one of the 30 channels on the analog side of the system. The signal is sinusoidal. All other channels are occupied by the auxiliary signal.

The analog receiver then measures the selective level of each channel in turn to determine the analog receive side near-end crosstalk. The digital receiver is occupied with the idling signal of the digital signal generator.

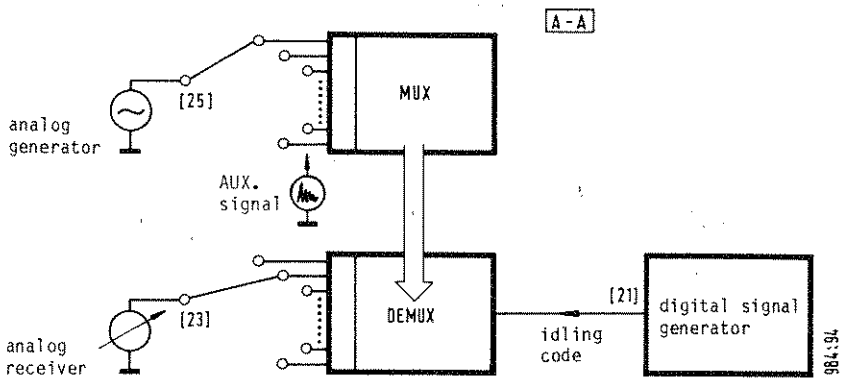


Figure 3-34 Measurement of near-end crosstalk with an analog test signal

3.7.7.2 Far-end crosstalk measurements using an analog test signal

A-D The analog signal generator feeds a sinusoidal test signal into one of the 30 channels on the analog side of the system. The other channels are occupied with an auxiliary signal.

The digital receiver of the PCM-4 measures the far-end crosstalk level on the digital RX side in the remaining 29 channels, one after the other.

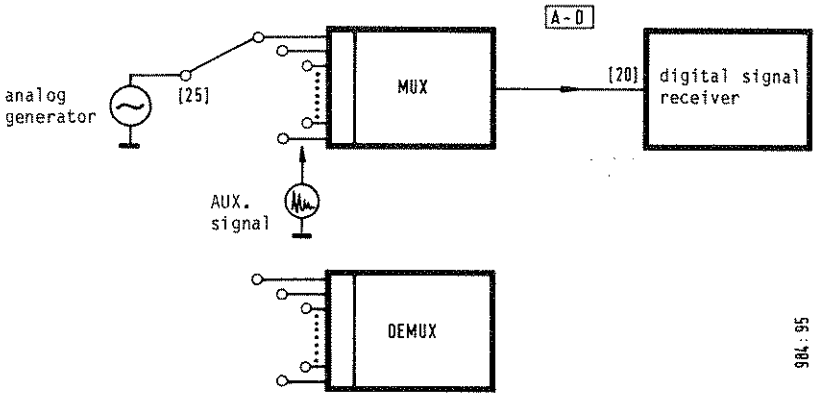


Figure 3-35 Measurement of far-end crosstalk using an analog test signal

3.7.7.3 Measurement of near-end crosstalk using a digital test signal

D-D The digital generator feeds one of the 30 channels on the digital side of the system. The PCM signal level is 0 dBm0. The other channels are occupied by the idling code word. The analog send channels are occupied with an auxiliary signal.

The digital receiver measures the near-end crosstalk on the digital receive side in the remaining 29 channels one after the other.

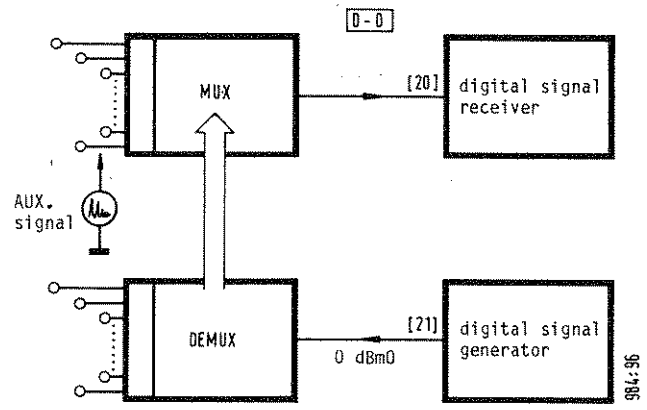


Figure 3-36 Measurement of near-end crosstalk using a digital test signal

3.7.7.4 Measurement of far-end crosstalk using a digital test signal

D-A The digital generator feeds one of the 30 channels on the digital side of the system. All the other channels are occupied with the idling code signal.

The analog receiver measures the far-end crosstalk in the remaining 29 channels on the analog side one after the other.

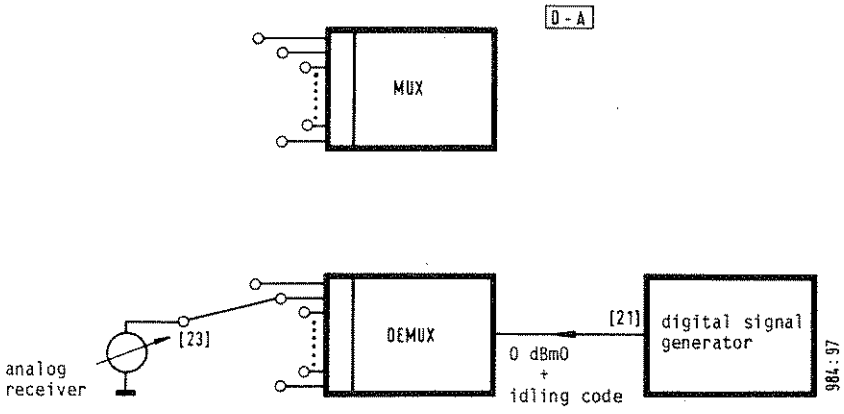


Figure 3-37 Measurement of far-end crosstalk using a digital test signal

3.7.7.5 Sidetone measurement

- A-A measurement

The crosstalk between an analog send channel in the multiplexer and the same receive channel in the demultiplexer is known as sidetone.

The decoder is maintained in a defined state for this measurement by means of an idling code word with fixed sign, to ensure that the sidetone result is not influenced.

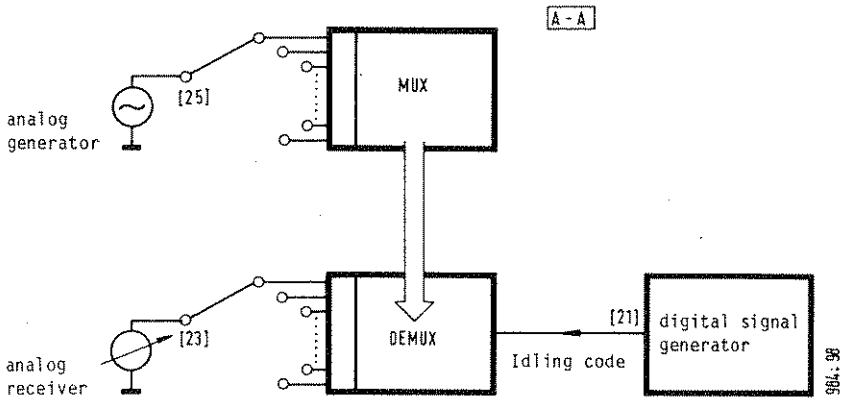


Figure 3-38 Analog-analog sidetone measurement

- D-D measurement

The crosstalk from a digital send channel to the identical digital receive channel is measured. This is done by feeding a PCM signal with level 0 dBm0 to the demultiplexer and measuring the sidetone at the output of the multiplexer with a digital receiver.

The analog channel send side is activated with an auxiliary signal.

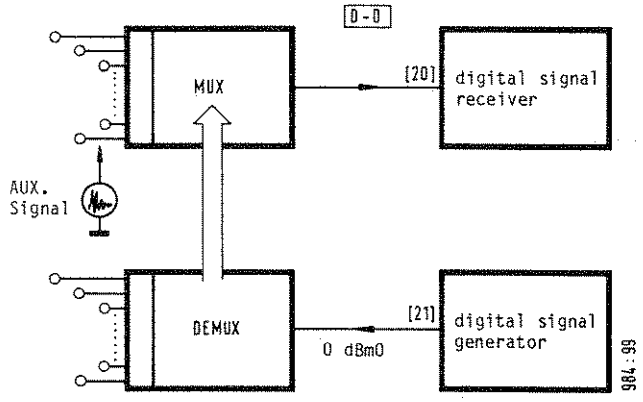


Figure 3-39 Digital-digital sidetone measurement

Mode A71 to A79	A-A	A-D	D-A	D-D	change via
Analog generator	X	X	OFF	OFF	VAR.MODE 1
Analog aux. generator	X	X	X	X	VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code	idling code	X	X	VAR.MODE 2
Analog receiver	X		X		
Digital receiver		X		X	
Receive filter and send signals	set with submode				VAR.MODE 3

Table 3-23 Operational status of generator and receiver referred to the measurement configuration in modes A71 to A79

Submode	Auxiliary signal, filter
A71	DIFFERENT CHANNELS FREQ. 301 Hz SELECT
A72	FREQ. 813 Hz SELECT
A73	FREQ. 1014 Hz SELECT
A74	FREQ. 3343 Hz SELECT
A75	CONV. TEL/PSOPH.
A76	SAME CHANNEL FREQ. 301 Hz SELECT
A77	FREQ. 813 Hz SELECT
A78	FREQ. 1014 Hz SELECT
A79	FREQ. 3343 Hz SELECT

Table 3-24 List of submodes A71 to A79

A71 to A79		
Configuration	Run mode	Run parameter
A-A CFØ, A-D CF1, D-A CF2, D-D CF3,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	CHAN. XPØ,

Table 3-25 Softkey program words for modes A71 to A79

3.7.8 MODE A8x: OUT OF BAND MEASUREMENTS

If an analog signal with frequency in the range 0 to f_m is scanned at a scanning frequency of f_A, the result is a line spectrum n x f_A with sidebands n x $f_A \pm f_m$. Overlapping of the sidebands can only be prevented if $f_m \leq f_A/2$. For this reason, frequencies $f_m > f_A/2$ are filtered out using a low pass filter.

The frequencies outside the passband may possibly cause interference as the band-limiting low-pass filter has finite attenuation and the frequencies do not fulfill the condition $f_m \leq f_A/2$.

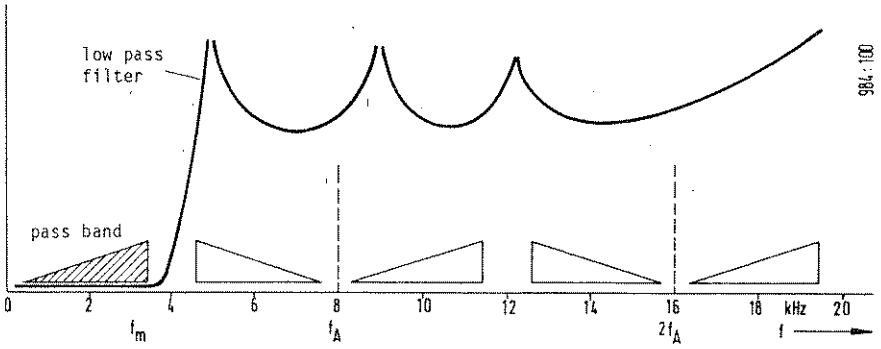


Figure 3-40 Out of band signals

A81 To check the influence of these out of band signals, a signal in the range 4.6 to 72 kHz at a level of -25 dBm0 is fed to the analog input of the multiplexer. The resulting level in the corresponding receive channel is measured, and should be at least 25 dB down on the TX level. This also indirectly tests the stop band attenuation of the low pass filter with respect to out of band signals at the multiplexer input.

The -50 dBm0 tolerance mask refers to the -25 dBm0 TX signal level as specified by CCITT Recs. G.712, 713 and 714.

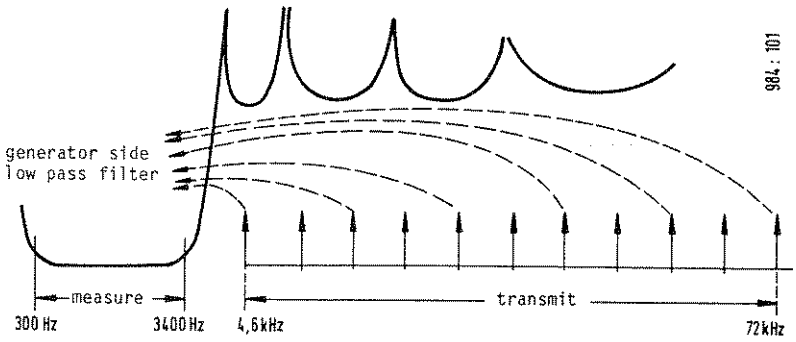


Figure 3-41 Out of band noise signals

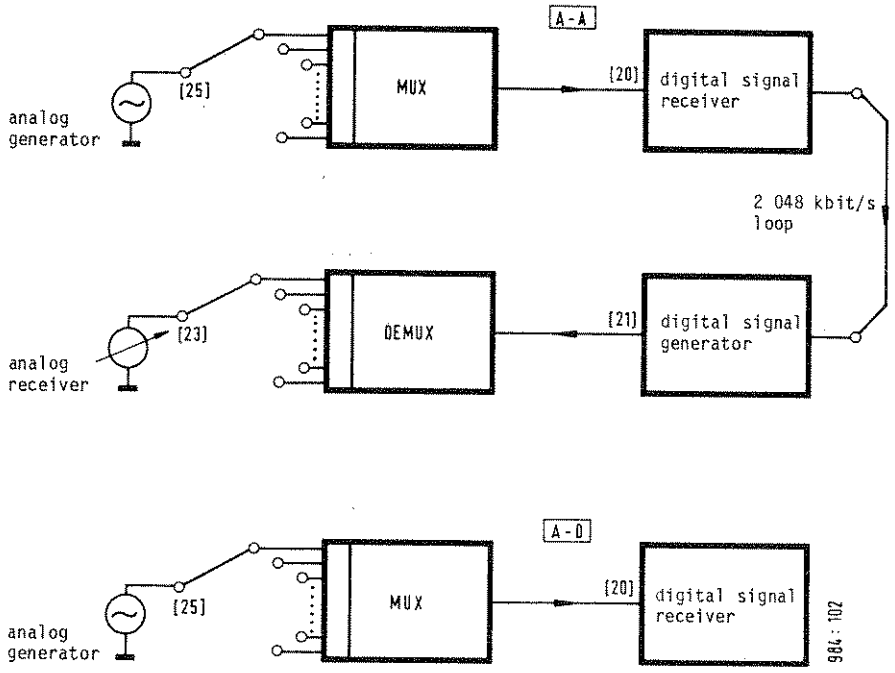


Figure 3-42 A-A or D-D measurement of out of band noise signals

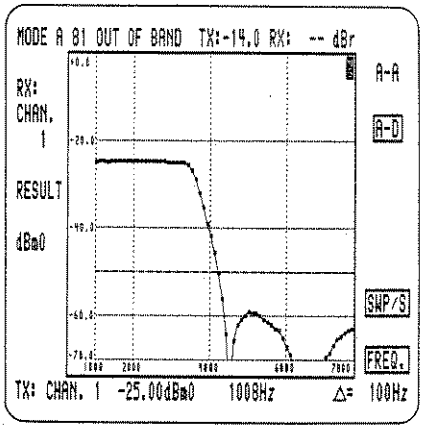


Figure 3-43 Attenuation characteristic, multiplexer input low pass filter

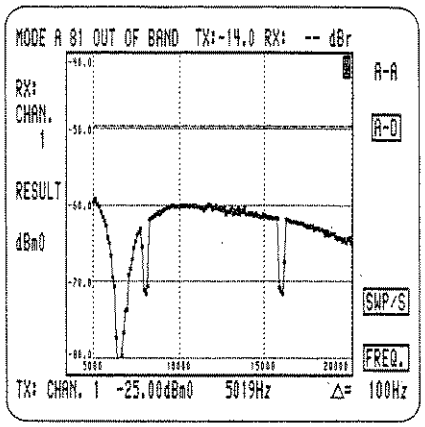


Figure 3-44 A81: out of band measurement (expanded display)

Note:

When the frequency is more than half the 8 kHz sampling frequency, large amounts of breakthrough are observed where the signal frequency is a multiple of 8 kHz. Less pronounced breakthrough occurs at frequencies of 12 kHz + n x 8 kHz. These breakthroughs are a function of the system itself, and are not a property of the PCM-4 or the item under test.

Mode A81	A-A	A-D			change via
Analog generator	X	X			VAR.MODE 1
Analog aux. generator	OFF	OFF			VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code	idling code			VAR.MODE 2
Analog receiver	X	X			
Digital receiver		X			
Receive filter and send signals	set with submode				VAR.MODE 3

Table 3-26 Operational status of generator and receiver referred to the measurement configuration in mode A81

Submode	Generator signal, filter
A81	SEND 4.6 ... 72 kHz/RECV 0.2 ... 4 kHz

Table 3-27 Submode A81

A81		
Configuration	Run mode	Run parameter
A-A CFØ, A-D CF1,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	FREQ XP1, CHAN. XPØ,

Table 3-28 Softkey program words in mode A81

A82 In the opposite direction, a signal between 300 Hz and 3.4 kHz at a level of 0 dBm0 is fed into the analog input of the multiplexer and the out of band noise level is measured in the receive channel in the range 4.6 to 128 kHz. This noise may occur due to the finite attenuation of the low pass filter at the demultiplexer input. It should be at least 25 dB down on the TX level. The tolerance mask at -25 dBm0 refers to the TX level of 0 dBm0 specified by CCITT Recs. G.712, 713 and 714.

Either analog-analog or digital-analog measurements are made.

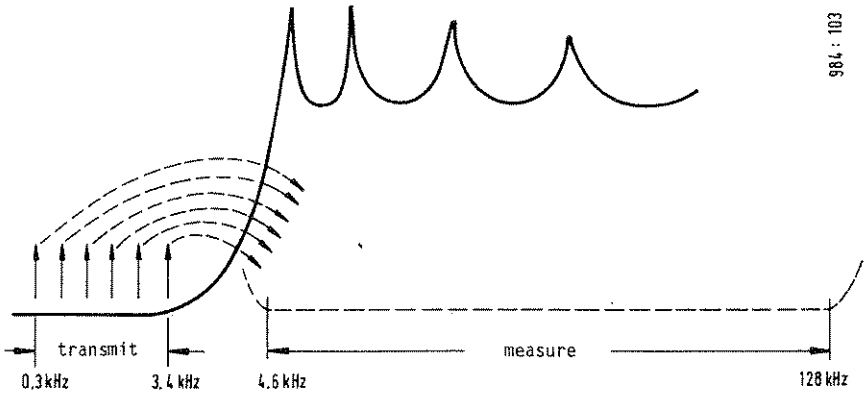


Figure 3-45 Out of band noise level

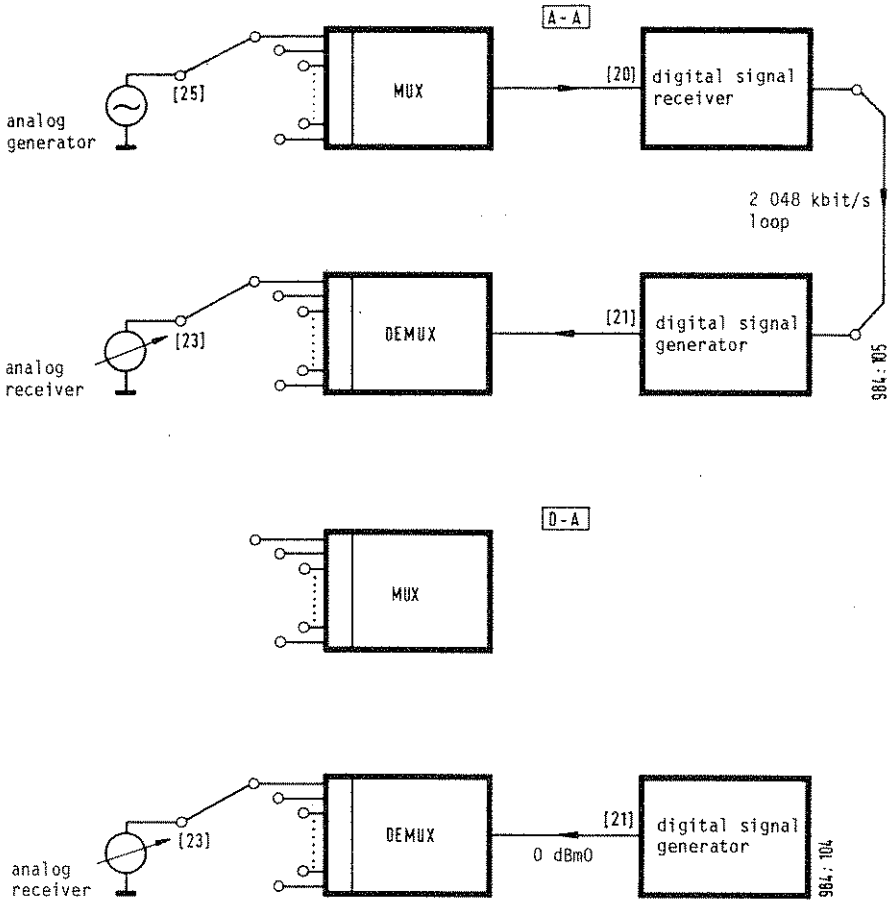


Figure 3-46 A-A or D-A measurement of noise levels in the stop band

Mode A82	A-A		D-A		change via
Analog generator	X		OFF		VAR.MODE 1
Analog aux. generator	OFF		OFF		VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code		X		VAR.MODE 2
Analog receiver	X		X		
Digital receiver					
Receive filter and send signals	set with submode				VAR.MODE 3

Table 3-29 Operational status of generator and receiver referred to the measurement configuration in mode A82

Submode	Auxiliary signal, filter
A82	SEND 0.1 ... 4 kHz/RECV 4.6 ... 128 kHz

Table 3-30 Submode A82

A82		
Configuration	Run mode	Run parameter
A-A CFØ, D-A CF2,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	FREQ XP1, CHAN. XPØ,

Table 3-31 Softkey program words in mode A82

A83 Out of band noise is measured in the range 4.6 to 128 kHz with no signal present at the LF input to the multiplexer. The noise level should be less than -65 dBm0.

The upper limit of 128 kHz has been chosen so that interference caused by the clock frequency used by many codecs (2 x 64 kHz) can also be measured.

Mode A83	A-A		D-A		change via
Analog generator	OFF		OFF		VAR.MODE 1
Analog aux. generator	OFF		OFF		VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code		idling code		VAR.MODE 2
Analog receiver	X		X		
Digital receiver					
Receive filter and send signals	set with submode				VAR.MODE 3

Table 3-32 Operational status of generator and receiver referred to the measurement configuration in mode A83

Submode	Auxiliary signal, filter
A83	SENDER OFF/RECV 0.2 ... 4 kHz

Table 3-33 Submode A83

A83		
Configuration	Run mode	Run parameter
A-A CFØ, D-A CF2,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	CHAN. XPØ,

Table 3-34 Softkey program words in mode A83

3.7.9 HARMONIC- AND INTERMODULATION DISTORTION

The non-linearities which occur in transmission systems, such as compression and limiting, give rise to intermodulation products and harmonics which lie within the speech band and which therefore interfere with the speech signal.

3.7.9.1 MODE A91 and A92: harmonic distortion

MODE A91 measures the second order harmonic distortion a_{k2} as the difference between the levels of the selectively received generator signal with frequency f_1 = 1004 Hz and the selectively received second harmonic $2f_1$. The receive filter for the second harmonic has a passband of 2000 to 2028 Hz.

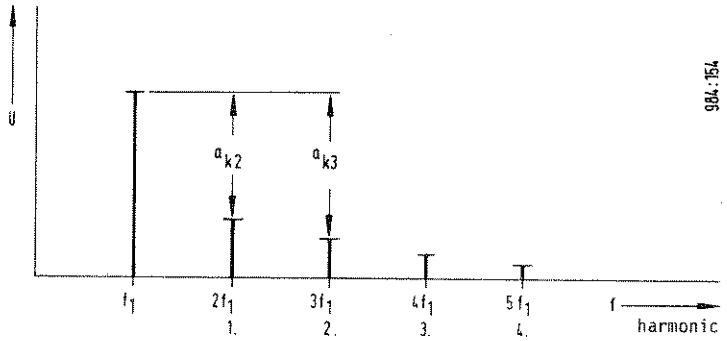


Figure 3-47 Frequency spectrum for harmonic distortion

MODE A92 measures the third order harmonic distortion a_{k3} as the difference between the levels of the selectively received generator signal with frequency f_1 = 1004 Hz and the selectively received third harmonic $3f_1$. The receive filter for the third harmonic has a passband of 3000 to 3042 Hz.

3.7.9.2 MODE A93 and A94: intermodulation distortion

Intermodulation distortion is the occurrence of sum- and difference frequencies as a result of non-linearities in the characteristic of the transmission system, resulting in the distortion of the original waveform.

The linearity of a channel can be tested using the 4-tone method. The 4-tone signal used consists of four signals of equal amplitude arranged as pairs A and B:

A ≅ 857 Hz and 862 Hz

B ≅ 1373 Hz and 1388 Hz

The non-linearities in the system result in the production of intermodulation products of these four frequencies. The second order products consist of four difference frequencies, B-A, and four sum frequencies, B+A, which lie within the speech band at 520 Hz and 2240 Hz respectively. The third order products within the speech band are six frequencies 2B-A at about 1900 Hz.

MODE A93

The 2nd. order intermodulation products B-A and B+A are measured selectively and the average level calculated. The difference between this level and the wideband level of the 4-tone signal is displayed in dB.

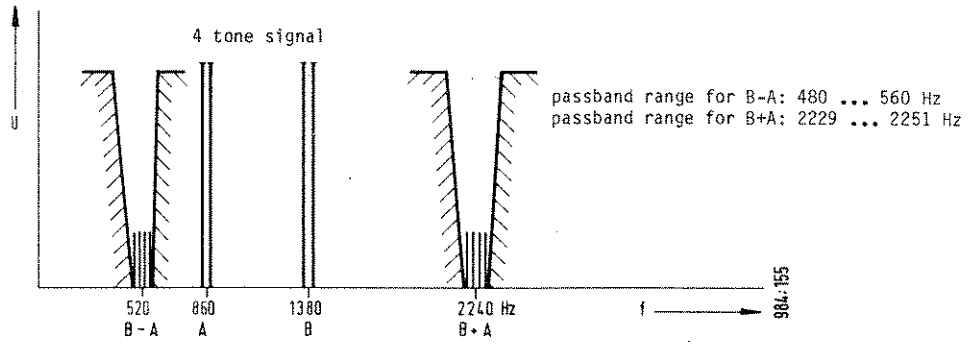


Figure 3-48 Frequency spectrum of 2nd. order intermodulation products in the speech band

MODE A94

The 3rd. order intermodulation product 2B-A is measured selectively and the difference between this level and the wideband level of the 4-tone signal is calculated and displayed in dB.

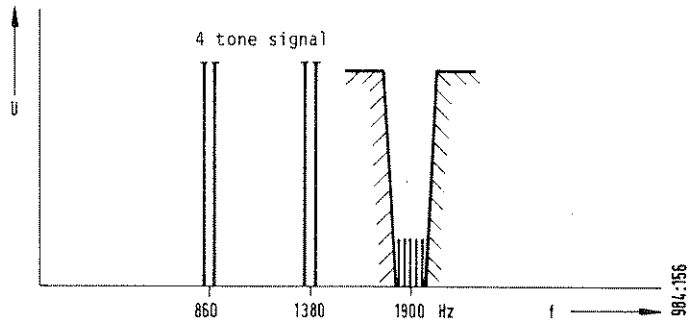


Figure 3-49 Frequency spectrum of 3rd. order intermodulation products in the speech band

3.8 MODE LIST B MEASUREMENTS

All MODE LIST B measurements are described in the following section, either as groups or individually.

The digital and analog send signals, together with the receiver filter, are set automatically to the requirements of the selected measurement. These values can be altered via the VAR.MODE list (see 3.9).

List "B" measurements include:

- return loss
- longitudinal conversion loss
- longitudinal conversion transfer loss
- peak code value
- group delay
- signalling distortion
- interference from signalling
- error measurements

Measurements of return loss, LCL and LCTL are only possible if the measuring bridge option (BN 984/00.12) is fitted.

3.8.1 MODE B1x: RETURN LOSS

To ensure matching to a given characteristic impedance, it is necessary to measure the return loss of cables, instruments and modules.

The return loss:

$$a_r = 20 \log \left| \frac{Z_X + Z_o}{Z_X - Z_o} \right| \quad \text{dB}$$

expresses the degree of matching between the input and output impedances, Z_X and the characteristic impedance, Z_o.

The following standard characteristic impedances are fitted to the PCM-4:
600 Ω, 850 Ω (or 900 Ω with BN 984/00.10 bridge) and a complex impedance (220 Ω in series with 820 Ω in parallel with 115 nF); this impedance can be modified ex-works if required.

The complex impedance is used for return loss measurements on 2-wire subscriber connection modules. The input impedance of the 2-wire input is complex, due to the line simulation circuit used in the hybrid circuit.

If the MU-30 test point scanner is used, the test object should be connected to one of the three connectors [23], [24] or [25]:

- [23] selected as RX by softkey and /4-wire/ key
- [24] selected as RX or TX by softkey and /RX/TX/ key
- [25] selected as TX by softkey and /4-wire/ key.

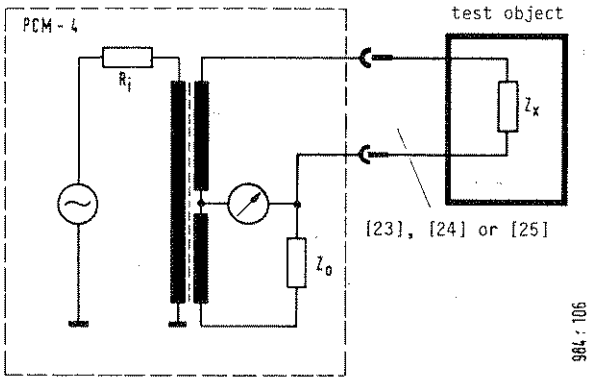


Figure 3-50 Measurement of return loss

The loss measured with the circuit shown in figure 3-50 is 6 dB higher than the actual return loss. This difference is taken into account by the calibration process, however, so that the actual return loss is displayed. Since any additional impedances between the bridge input and the device under test (Z_x) will also be compensated for, it is important that Z_x is connected directly to one of the bridge inputs.

3.8.2 MODE B2x: LONGITUDINAL CONVERSION LOSS

Measurement of longitudinal conversion loss is the measurement of the attenuation error caused by the apparent impedances between the two balanced input wires (a and b) and ground (c). The bridge is configured so that points a and c as well as b and c form arms of the bridge.

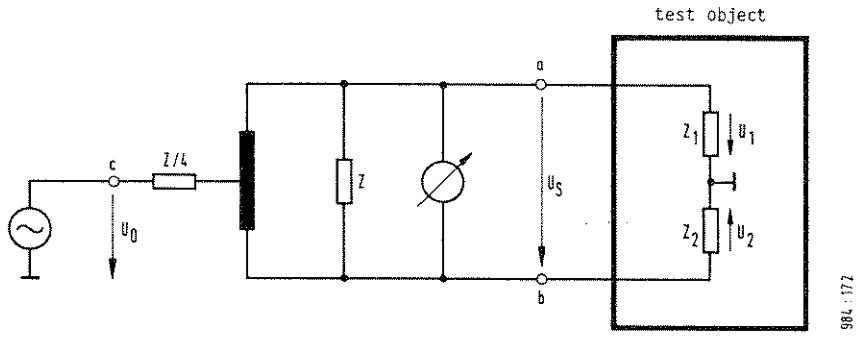


Figure 3-51 Longitudinal conversion loss measurement as per CCITT Rec. O.121

In this measuring configuration, a centre-tapped coil is fed from a source impedance of Z/4. An impedance of Z is connected in parallel with the coil.

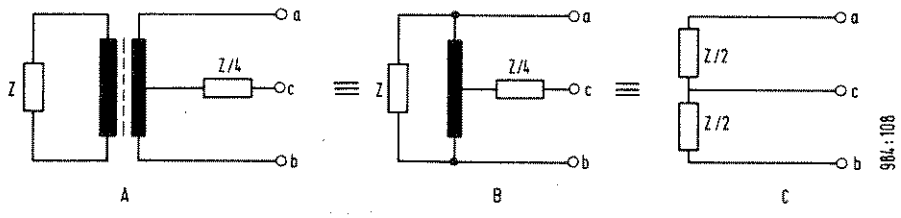


Figure 3-52 Electrical correspondence between centre-tapped coil configuration and centre-tapped resistors

If Z_1 and Z_2 are both $\frac{Z}{2}$, then $|U_1| = |U_2|$ and hence $U_s = 0$.
If an additional impedance Z_a is present between b and c, the voltage U_s between a and b is $|U_1| - |U_2|$.
The LCL is then given by

$$LCL = 20 \log \left(\frac{3}{2} + \frac{4\ Z_a}{Z}\right) = 20 \log \left|\frac{U_o}{U_s}\right|$$

The following reference impedances (Z) are provided in the PCM-4:
600 Ω, 850 Ω (or 900 Ω with bridge BN 984/00.10).

B1, B2		
Configuration	Run mode	Run parameter
TX LPØ, RX LP1,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	FREQ XP1, CHAN. XPØ,

Table 3-35 Softkey program words in modes B1 and B2

3.8.3 MODE B3x: LONGITUDINAL CONVERSION TRANSFER LOSS (LCTL)

In analog-analog measurement of LCTL, the influence of unbalance of the send side on the unbalance of the receive side is determined (input to output unbalance).
The test configuration shows the forced symmetrical feed to the two-port network and a similar termination on the receive side. Under normal circumstances, switch S1 is closed so that Z/4 is in circuit.

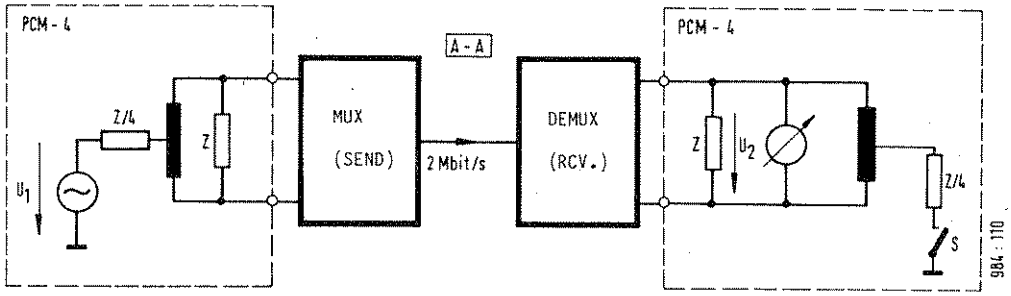


Figure 3-53 Measurement of LCTL [A-A]

The LCTL is given by:

$$a_B = 20 \log \left| \frac{U_1}{U_2} \right| \text{ dB}$$

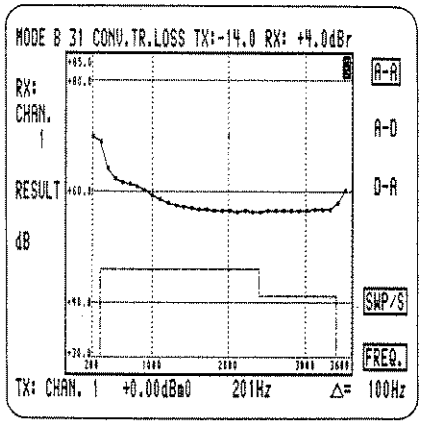


Figure 3-54 B31: LCTL measurement

For the measurement of LCTL on the send side of a multiplexer, (analog to digital measurement) the test object is fed in the same way as before. A PCM word analyser on the digital side is used as the measuring instrument.

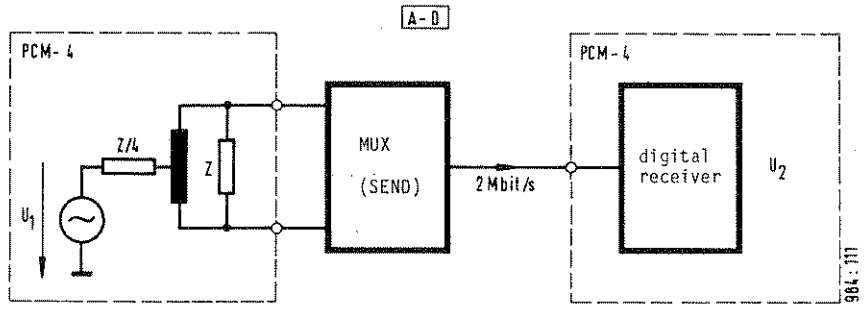


Figure 3-55 Measurement of LCTL [A-D]

For the measurement of LCTL on the receive side of a multiplexer (digital to analog measurement), the PCM side of the test item is fed with a digital signal from the digital generator. The two port network is terminated on the receive side with the forced symmetrical circuit.

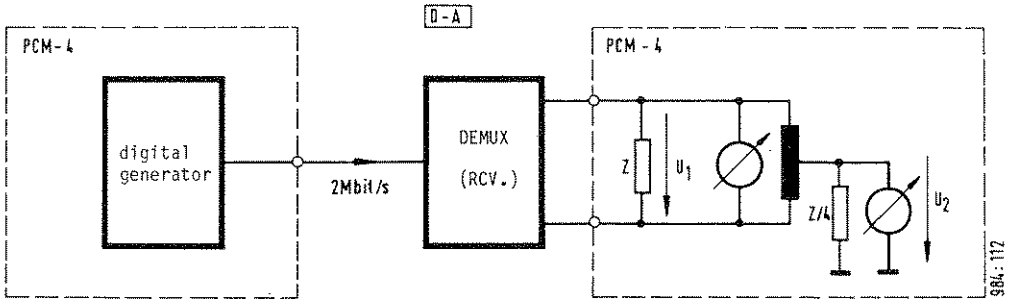


Figure 3-56 Measurement of LCTL [D-A]

Here, the LCTL is given by:

$$a_B = 20 \log \left| \frac{U_1}{U_2} \right| \text{dB}$$

Mode B31 and B32	A-A	A-D	D-A		change via
Analog generator	X	X	OFF		VAR.MODE 1
Analog aux. generator	OFF	OFF	OFF		VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code	idling code	idling code		VAR.MODE 2
Analog receiver	X		X		
Digital receiver		X			
Receive filter and send signals	set with submode				VAR.MODE 3

Table 3-36 Operational status of generator and receiver referred to the measurement configuration in modes B31 and B32

Submode	Impedance
B31	REF. IMPEDANCE 600 OHM
B32	REF. IMPED. 850/900 OHM OR OPT.

Table 3-37 List of submodes B31 and B32

B31 and B32		
Configuration	Run mode	Run parameter
A-A CFØ, A-D CF1, D-A CF2,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	FREQ XP1, CHAN. XPØ,

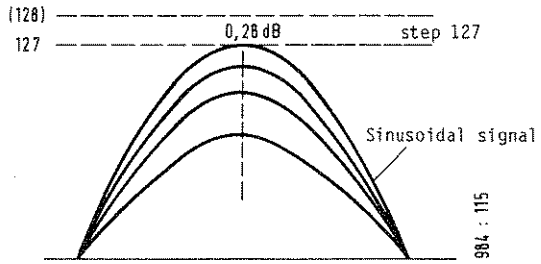
Table 3-38 Softkey program words in modes B31 and B32

3.8.4 MODE B4x: DETERMINATION OF CODER OVERLOAD CAPACITY

Due to the finite number of amplitude levels available, limiting in PCM systems is severe. If the send level is increased beyond the overload limit, all sampled values with an absolute value greater than the decision threshold value will be output as fixed values on the receive side.

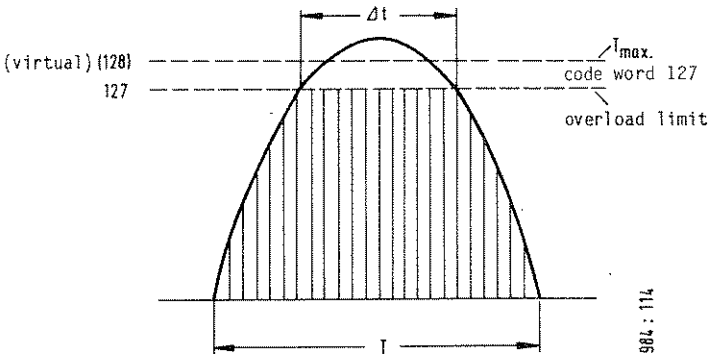
When testing PCM coders, this overload limit is a very important factor. The presently-used method for determining coder overload capacity uses a sinusoidal signal, the amplitude of which is successively increased until the peak amplitude of the signal just reaches the maximum decision threshold value (e.g. 127). This occurs when the display of the maximum code word at the digital signal receiver changes from 126 to 127. The limit value of the overload lies 0.28 dB above this level (i.e. the width of step 127).

In the PCM-4, coder overload capacity is determined by applying a defined overload to the coder. The digital receiver counts the number of +127 or -127 codewords occuring within the measurement period, and the processor calculates the overload capacity from these figures.



Normal method: stepwise increase in coder drive signal level unit peak code of 127 is reached

Figure 3-57 Determining the overload capacity of a coder



Method used in PCM-4: system is overloaded with a defined signal level

Δt = no. of words with code 127;

T = number of code words per half-period.

Calculation of the virtual overlaod capacity T_{max} from the number of words with code 127.

Figure 3-58 Determining the overload capacity of a coder

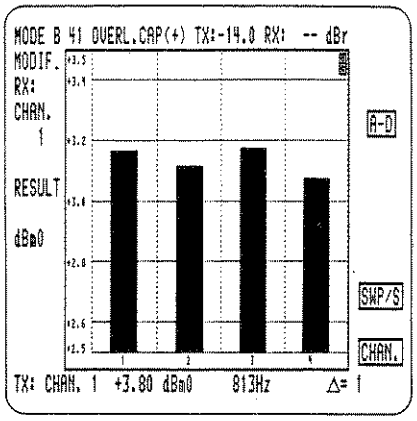


Figure 3-59 B41: measurement of overload capacity as a function of channel number

Mode B41 to B44		A-D			change via
Analog generator		X			VAR.MODE 1
Analog aux. generator		OFF			VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)		idling code			VAR.MODE 2
Analog receiver					
Digital receiver		X			
Receive filter and send signals	set with submode				VAR.MODE 3

Table 3-39 Operational status of generator and receiver referred to the measurement configuration in modes B41 to B44

Submode	Frequency
B41	OVERLOAD CAPACITY W. POS. PEAK CODE 813 Hz
B42	W. NEG. PEAK CODE 813 Hz
B43	OVERLOAD CAPACITY W. POS. PEAK CODE 1014 Hz
B44	W. NEG. PEAK CODE 1014 Hz

Table 3-40 List of submodes B41 to B44

B41 to B44		
Configuration	Run mode	Run parameter
A-D CF1,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	CHAN. XPØ,

Table 3-41 Softkey program words in modes B41 to B44

MODE B45: PEAK LOAD CAPACITY

This measurement enables measurement of the peak-peak value of a PCM signal. The maximum positive and negative code words are determined in a single measurement. The coder offset can also be determined manually with a small drive signal using this measurement mode.

The difference between the maximum positive and negative values is determined and the deviation from zero gives the coder offset expressed in terms of full code words (see also under B46).

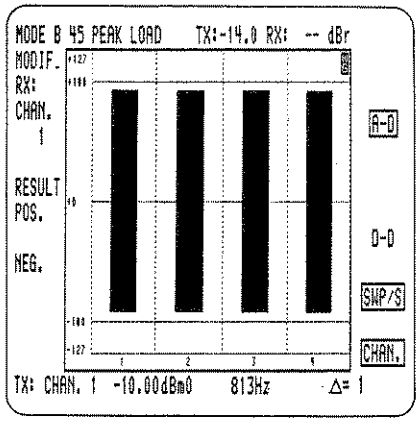


Figure 3-60 Measurement of pk-pk value of a PCM signal as a function of channel number for 10 channels

MODE B46: CODER OFFSET

The coder offset is determined as follows:

- the individual code words are expanded to linear 16 bit code words,
- the linear average value over a given time period is calculated,
- the average value is companded (μ- or A-law),
- the result is displayed.

Due to the computing method used, it is possible to display the coder offset in terms of fractions of a code word, so that a trend in the offset can be spotted more easily.

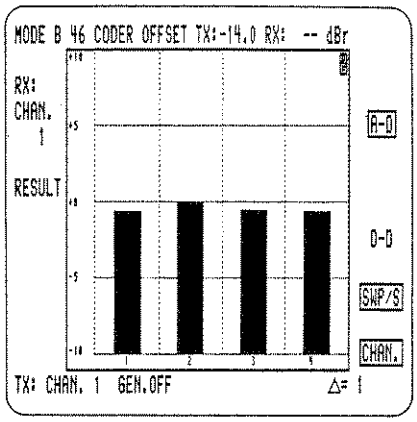


Figure 3-61 B46: measurement of coder offset as a function of channel number

Mode B45, B46		A-D		D-D	change via
Analog generator		X		OFF	VAR.MODE 1
Analog aux. generator		OFF		OFF	VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)		idling code		X	VAR.MODE 2
Analog receiver					
Digital receiver		X		X	
Receive filter and send signals	set with submode				VAR.MODE 3

Table 3-42 Operational status of generator and receiver referred to the measurement configuration in modes B45 and B46

Submode	
B45	PEAK LOAD
B46	CODER OFFSET

Table 3-43 List of submodes B45 and B46

B45, B46		
Configuration	Run mode	Run parameter
A-D CF1, D-D CF3,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	CHAN. XPØ,

Table 3-44 Softkey program words in modes B45 and B46

3.8.5 MODE B5x: GROUP DELAY

Group delay is caused by phase distortion which the signal undergoes along the transmission path. In PCM systems, the band-limiting low-pass filter in the multiplexer and the demodulator low-pass filter in the demultiplexer are the main sources of such phase distortion.

Group delay is measured in the PCM-4 by means of a so-called loop measurement. The test object is fed with an amplitude modulated carrier signal (combination signal) and the group delay referred to a reference pulse is calculated from the receive side signal.

Test frequencies:
292, 500, 604, 1000, 1792, 2604, 2791 and 3396 Hz.

Modulation frequencies:
41.66 Hz ± 0.1 % or 83.33 Hz ± 0.1 %

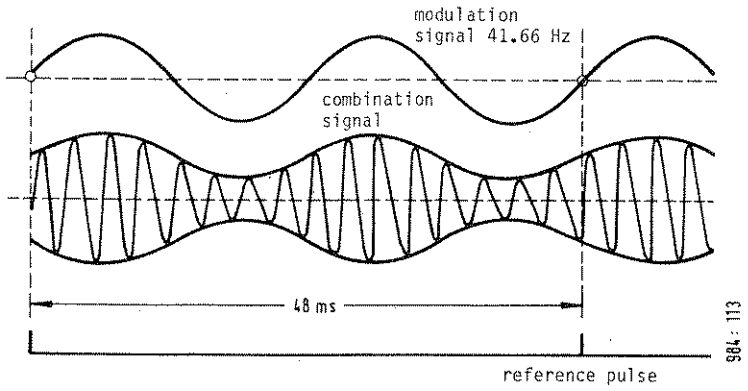


Figure 3-62 Group delay measurement test signal

MODE B51: ABSOLUTE GROUP DELAY

Absolute group delay is measured at eight fixed frequencies using the combination signal. If the signal passes through a test object with non-linear phase response, the modulation frequency (envelope) will be phase-shifted with respect to the send side modulation signal. This phase shift corresponds to the absolute group delay at the given carrier frequency.

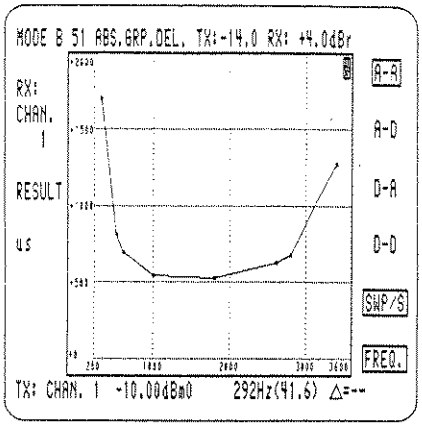


Figure 3-63 B51: measurement of absolute group delay

B51		
Configuration	Run mode	Run parameter
A-A CF0, A-D CF1, D-A CF2, D-D CF3,	SWP/S MS0, SWP/R MS1, MAN/S MS2, MAN/R MS3,	FREQ XP1, LEVEL XP2, CHAN. XP0,

Table 3-45 Softkey program words in mode B51

MODE B52: GROUP DELAY DISTORTION

The group delay distortion is measured at eight fixed frequencies and referred to the absolute group delay at 1792 Hz. Group delay distortion thus corresponds to the difference between the absolute group delay at the test frequency and the reference frequency.
Any one of the eight frequencies can be set as reference frequency using VAR. MODE 611.
The PCM-4 carries out two measurements in sequence and calculates the result.
Group delay distortion only occurs if the phase response of the test object is non linear with respect to frequency.

Mode B51 and B52	A-A	A-D	D-A	D-D	change via
Analog generator	X	X	X	OFF	VAR.MODE 1
Analog aux. generator	OFF	OFF	OFF	OFF	VAR.MODE 1
Digital generator (2 048 or 64 kbit/s)	idling code	idling code	X	X	VAR.MODE 2
Analog receiver	X		X		
Digital receiver		X		X	
Receive filter and send signals	set with submode				VAR.MODE 3

Table 3-46 Operational status of generator and receiver referred to the measurement configuration in modes B51 and B52

Submode	
B51 B52	ABSOLUTE GROUP DELAY GROUP DELAY DISTORTION V. FREQ.

Table 3-47 List of submodes B51 and B52

B52		
Configuration	Run mode	Run parameter
A-A CF0, A-D CF1, D-A CF2, D-D CF3,	SWP/S MS0, SWP/R MS1, MAN/S MS2, MAN/R MS3,	FREQ XP1, CHAN. XP0,

Table 3-48 Softkey program words in mode B52

ABSOLUTE GROUP DELAY Mode B53 / GROUP DELAY DISTORTION Mode B54

Modes B53 and B54 correspond to modes B51 and B52 using a modulation frequency of 83.33 Hz.

3.8.6 MODE B6x: SIGNALLING DISTORTION

The signalling information in PCM systems with channel-associated signalling is sampled every 2 ms and transmitted. The 2 ms sampling time corresponds to the duration of the signalling pulse frame. If four signalling channels, each running at 500 bit/s are formed, the theoretical maximum sampling distortion is ± 2 ms per channel, calculated from the pulse frame duration. A further distortion occurs in the send- and receive side signalling processor equipment, due to the response times of the relays used for switching.

The resultant signalling distortion can therefore be of the order of several milliseconds. This is not critical in the case of status signals, but the dialing signal tolerances can be exceeded if (worst case) all the tolerances of the individual equipments (dial switch, relay, selector) add together.

For this reason, it is necessary that the signalling distortion is measured.

For this measurement, signalling pulses are simulated by feeding a 10 Hz or 20 Hz rectangular signal with variable duty cycle onto the M line (S2 in), see also section 3.9.7.

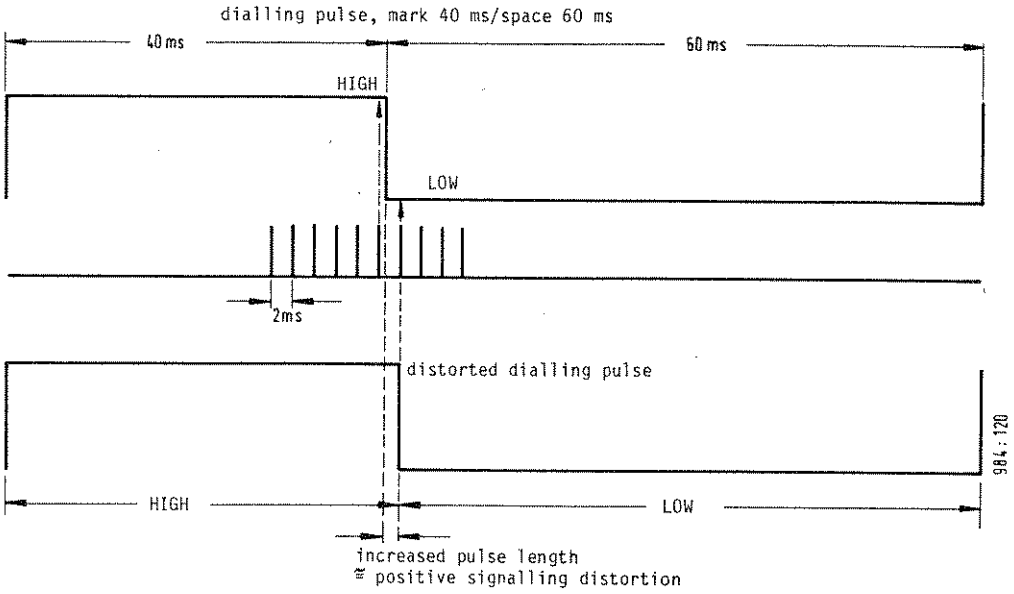


Figure 3-64 Signalling distortion caused by sampling at 2 ms intervals

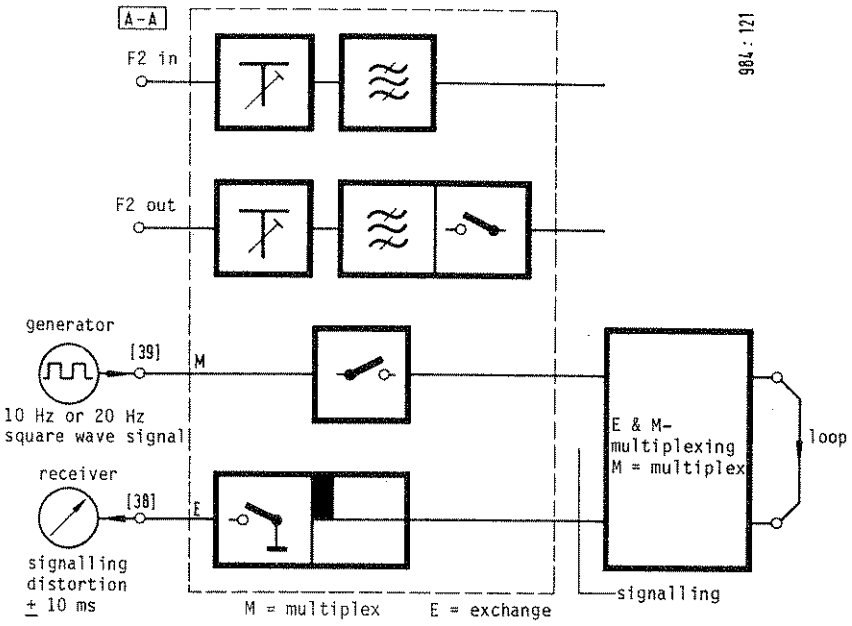


Figure 3-65 Measurement of signalling distortion

The internal impedance of the generator (electronic switch) has the following values: mark < 30 Ω, space > 20 kΩ.

On the receive side, the signalling distortion receiver measures the duty cycle deviation of the signal compared to the reference, averaged over 10 or 20 periods, and displays the result in milliseconds.

The PCM-4 signalling receiver [38] is connected to the E-wire (S2 out) of the system. The receiver input impedance is 750 Ω and is connected internally to -15 V d.c. The input must be connected to earth via the driving switch.

The receiver monitors the closing and opening impedances of the switch in addition to the signalling distortion. The closing impedance must be < 300 Ω; the opening impedance > 20 kΩ otherwise Z will be displayed next to the value 0.0.

The measurement range is ± 10 ms with a resolution of 0.1 ms.

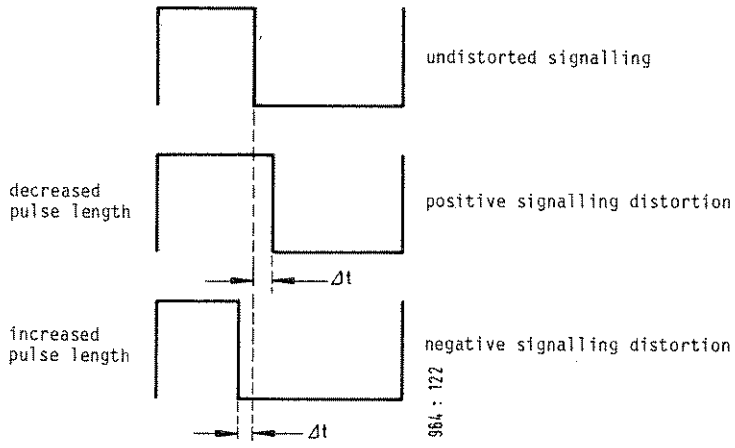


Figure 3-66 Distorted signalling pulses

B61 to B69		
Configuration	Run mode	Run parameter
A-A CFØ, A-D CF1, D-A CF2, D-D CF3,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	CHAN. XPØ,

Table 3-49 Softkey program words in modes B61 to B69

3.8.7 MODE B7x: INTERFERENCE FROM SIGNALLING

In order to determine what effect the signalling has upon the quality of the received analog signal, an analog signal of 10 Hz or 20 Hz is fed into the signalling input of the mulitplexer. At the output of the demultiplexer, the resultant noise signal in the telephone channel is weighted psophometrically and measured by the receiver.

A check is made to see if spikes or dialling noise in the signalling channel exceed the idle channel signal.

The measurement is analog-analog.

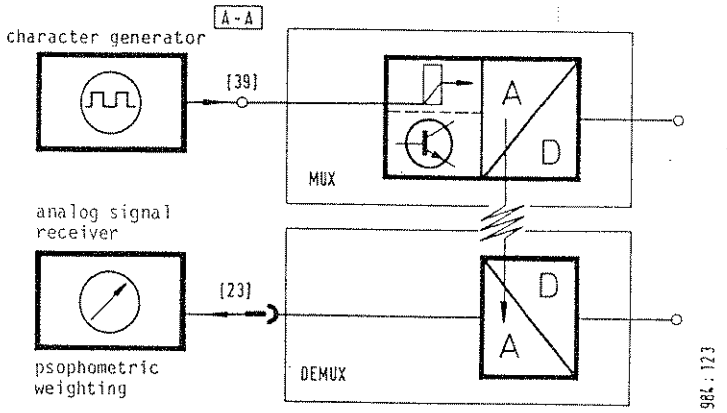


Figure 3-67 Measurement of noise voltage at the demultiplexer analog output

To determine the effects of digital signalling, the digital generator of the PCM-4 provides a 10 Hz squarewave to represent the b signalling bit in the selected channel. The digital receiver measures the crosstalk (psophometrically weighted) in the multiplexer telephone channels (D-D configuration). It is also possible to select signalling bits a, c or d under VAR. MODE 7xx. The duty cycle and frequency of the analog or digital signalling can also be altered.

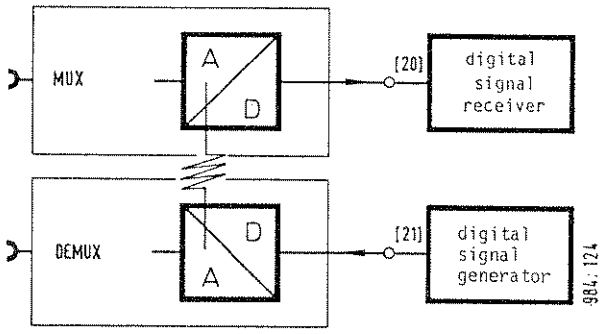


Figure 3-68 Measurement of noise signal at the digital multiplexer output

B71 to B79		
Configuration	Run mode .	Run parameter
A-A CFØ, A-D CF1, D-A CF2, D-D CF3,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	CHAN. XPØ,

Table 3-50 Softkey program words in modes B71 to B79

3.8.8 MODE B8x: ERROR MEASUREMENTS

All error measurements are carried out over a presettable measurement period.

This measurement period is set as follows:

* press /Δ/;
  the input and display field for hours appears in reverse field characters
* enter the number of hours (max. 99)
* press /ENTER/:
  the next field (minutes) will be displayed in reverse field characters minutes and seconds are entered in the same way as hours.

Every time /Δ/ is pressed, the display jumps back to hours.

Δ max. = 99h 59m 59s.

MODE B81: frame alignment signal errors

Possible measurements:

- FAS bit error rate
- FAS word error rate
- MFAS word error rate
- CRC error rate (with parameter 232)

X axis parameter:

- up to 50 test intervals as histogramm
- test interval for each channel

Normally, the PCM line is disconnected and bit error measurement are then made to determine the transmission quality.
If the line is actually in operation it is possible to assess the transmission quality of the line by measuring the FAS bit error rate with a monitor connected via a high impedance connection.

The test interval is preset to 10 s.

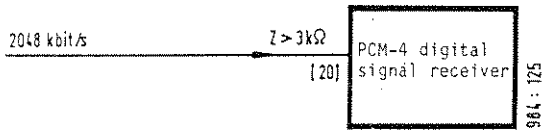


Figure 3-69 FAS error measurement with Z_{in} > 3 kΩ

B81		
Configuration	Run mode	X parameter
FAS/B ET0, FAS/W ET1, MFRM ET2, CRC ET3,	SWP/S MS0, SWP/R MS1, MAN/S MS2,	HISTG XP0, CHAN XP1,

Table 3-51 Softkey program words in mode B81

B82 Measurement of bit- or word error rates in the telephone channel
B83 Counting of telephone channel bit- or word errors
B84 Counting of error free or errored seconds in test interval (in %)
X axis parameters:
- up to 50 test intervals as histogramm
- test interval for each channel.

The measurements determine bit- and octet errors in the 64 kbit/s telephone channel. Four different configurations are possible, these being set with parameters 111 to 114.

TX	RX	Parameter
2 Mbit/s	2 Mbit/s	111
64 kbit/s	64 kbit/s	112
64 kbit/s	2 Mbit/s	113
2 Mbit/s	64 kbit/s	114

Parameter 334 (clock from receiver) must be selected for measurements on codirectional cards (64 k / 2 M) since the demultiplexer and the PCM-4 have separate clocks and would therefore not be synchronous.

The test patterns can be selected via softkey 1. The following:
- pseudorandom sequence 2^9-1 (PRS9)
- pseudorandom sequence 2^{11}-1 (PRS11)
- 8 bit word (WORD)

are available.

Setting the 8 bit word:
* select WORD with softkey 1;
  on the screen next to softkey 2 the message SET/W is displayed
* press softkey 2;
  the input and display field for the 8 bit word at the bottom of the screen is displayed in reverse field characters
* enter an 8 bit sequence using the /1/ and /0/ keys
* press /ENTER/

The 8 bit word can also be altered via VAR.MODE 263.

Display of results:

Measurement	Graphical	Numerical
B82 Error rate in 64 kbit/s channel	Bit or octet, selection via softkey 4	Bit or ocetet simultaneously
B83 Error counting in 64 kbit/s channel	Bit or octet, selection via softkey 4	Bit and octet simultaneously
B84 Error-free seconds in 64 kbit/s channel	Error free of errored selection via softkey 4	Error free and errored simultaneously

If softkey 3 is pressed, single errors can be inserted manually to check the test connection.
All results are updated together, the results being displayed under RESULT on the left hand side of the screen and updated every 0.5 to 2 seconds. At the end of the measurement period, the results of the measurement are displayed in the graphical and numerical display fields.
The measurement interval is preset to 10 seconds.

Loss of results due to synchronisation loss

If the chosen test interval is long it is possible that the measurement result will be lost if synchronisation is lost even momentarily. This risk can be reduced if the test intervals are as short as possible and the maximum number of 50 intervals per sweep is set.

Printout

The results are output on a printer connected to the IEC bus. If synchronisation is lost during a test interval, this is indicated by the words NO SYNC. on the printout. The duration of the synchronisation loss can be determined from the number of test intervals not indicated by NO SYNC. and the length of the test interval; e.g. if the test interval = 1 minute, the start time = 23:00, and the number of synchronised intervals is 32, then sync. loss occurred between 23:32 and 23:33.

Note:

Up to 70 intervals in MODE B81 and 140 intervals in MODES B82 to 84 can be displayed on a single numerical results page in SWP/R mode even if a printer is not connected. NO SYNC. intervals are similarly indicated. The shorter the interval chosen, the more exact the determination of the time when sync. loss occurred.

Avoiding calibration interrupts during measurements

To ensure that the autocal routine does not operate during the course of a measurement, set the TIMER using parameter 936 (see 3.6.9) to 00.00 if the measurement is to start immediately. This ensures that the next autocal will not occur for 24 hours. If the start of the measurement is to be delayed, then the difference between the actual time and the desired start time must be entered using parameter 936. The PCM-4 then autocalibrates immediately before making the measurement, and repeats calibration after the time set with parameter 936 has elapsed.

B82, B83		
Configuration	Run mode	Run parameter
PRS9 EFØ, PRS11 EF1, WORD EF2, B bbbbbbbb, ERROR ER, BIT EGØ, OCT EG1,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	HISTG XP1, CHAN. XPØ,

Table 3-52 Softkey program words in modes B82 and B83

B84		
Configuration	Run mode	Run parameter
PRS9 EFØ, PRS11 EF1, WORD EF2, B bbbbbbbb, ERROR ER, EFS EMØ, ES EM1,	SWP/S MSØ, SWP/R MS1, MAN/S MS2, MAN/R MS3,	HISTG XP1, CHAN. XPØ,

Table 3-53 Softkey program words in mode B84

3.8.9 MODE B9x: SPECIAL MEASUREMENTS

MODE B91: display of words in the PCM frame

The function of this measurement mode is comparable to that of the 8 LEDs below the display screen. The words in the PCM frame are sequentially checked and displayed on the screen in binary code. The PCM words can be called up via the <IEC 625> bus in mode B91, which is not the case with the 8 LEDs.

Display of:

- FAS
- FAS
- words in selected channel
- MFAS
- MFAS
- signalling record

B91		
Configuration	Run mode	Run parameter
A-D CF1, D-D CF3,	MAN/R MS3, MAN/S MS2,	

Table 3-54 Softkey program words in mode B91

MODE B92: multiplex/demultiplex operation

For detailed information, refer to section 5.1 which describes the 64 kbit/s interfaces.
This mode is not intended for making measurements with the PCM-4, but it does allow access to the 64 kbit/s signal of a telephone channel. An external 64 kbit/s signal can be fed into a chosen channel of the 2 Mbit/s digital send signal via the 64 kbit/s input (option). The 64 kbit/s signal in the chosen channel of the 2 Mbit/s received signal is available at the 64 kbit/s output (option). Channel selection is via the /RECV CHAN/, /SEND CHAN/ or /BOTH CHAN/ keys. Timeslot 16 can selected if parameters 213 and 223 are set previously, and timeslots 0 and 16 can be selected if parameters 214 and 224 have been set.
Parameter 334 (clock from receiver) must be selected for measurements on codirectional cards (64 k / 2 M) since the demultiplexer and the PCM-4 have separate clocks and would therefore not be synchronous.
MUX/DEMUX operation is only possible if

- the 64 kbit/s interface option is fitted, otherwise an error message is displayed:

64kbit/s INTERFACES NOT PRESENT

- parameter 111 or 116 has been selected, otherwise an error message is displayed:

MUX/DEMUX OPERATION NOT POSSIBLE SELECT PARAM. NO. 111 OR 116

- parameter 212 or 222 has not been selected, otherwise an error message is displayed:

64kbit/s INTERFACES NOT AVAILABLE

MUX/DEMUX operation with parameter 111

If parameter 111 is selected in mode B92, parameters 121 to 123 can also be selected, but have no effect, as the 2 Mbit/s loop is always open in mode B92.

Input interface mode	Clock generation via parameters	Remarks
codirectional	no choice available	
contradirectional	parameter 331 - 334	

MUX/DEMUX operation with parameter 116

Input interface mode	Clock generation via parameter	Remarks
codirectional		error: codirectional operation not possible with parameter 116
contradirectional	no choice available	

3.9 V A R . M O D E

The parameters in the VAR.MODE list are set automatically when a measurement mode is selected, and are marked with **. To match the PCM-4 exactly to a given test item, however, it is possible to modify the VAR. MODE parameters set by the PCM-4.

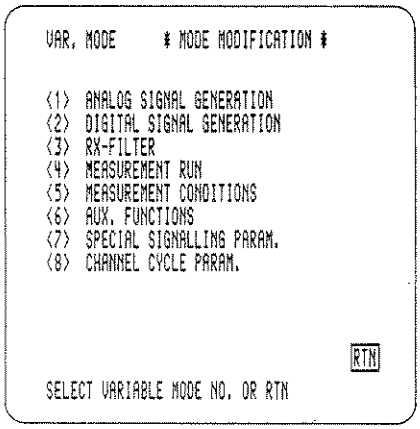
Note:

A plausibility check of any alterations is not made. Meaningless results will be obtained if implausible changes are made.

A change in the VAR. MODE parameter is indicated by the word MODIF in the upper left corner of the results page display.

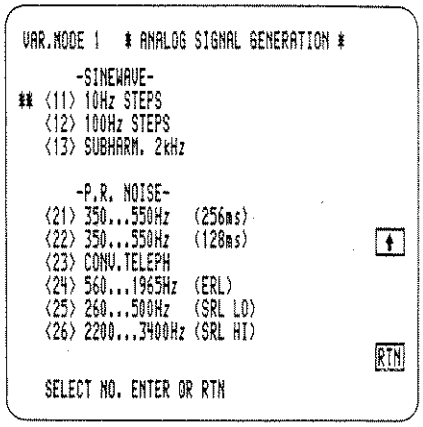
Note:

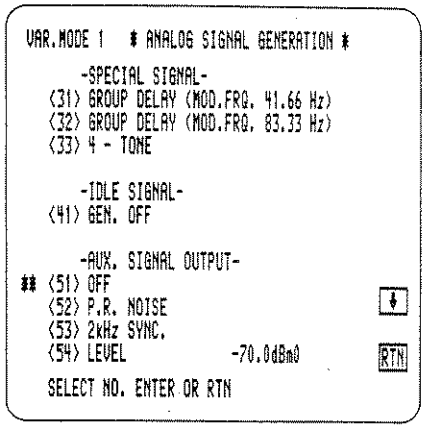
If MODE LIST A or MODE LIST B is selected, the altered parameters in the VAR. MODE list are automatically reset to their standard values. To retain the altered settings, store them as a setup in the non-volatile memory of the PCM-4 (see 3.4).



The VAR.MODE list can only be displayed if a measurement mode has already been selected and a results page is displayed. The list is shown when /VAR.MODE/ is pressed.

3.9.1 VAR.MODE 1xx: ANALOG SIGNAL GENERATION

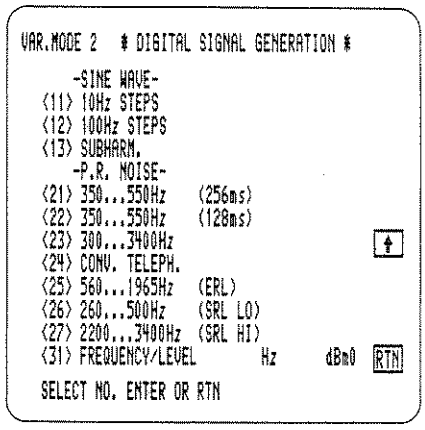


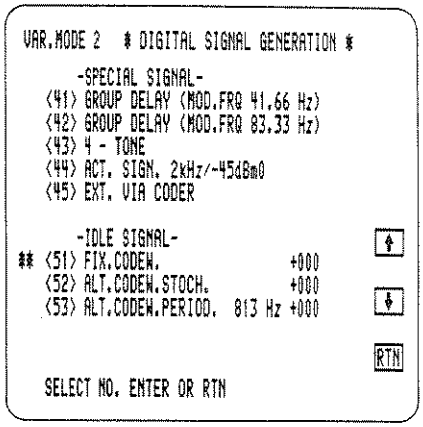


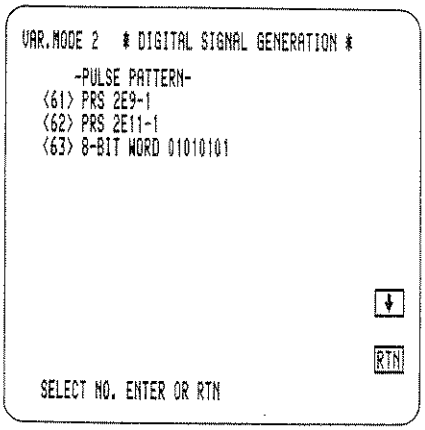
All possible generator signals are shown. In A-A or A-D modes, the generator transmits the signal which is determined by the mode chosen. The signal in use is marked with ** on one of the two VAR.MODE list 1 pages. In these measurement configurations, the digital generator outputs the idling code word +000. By selecting another parameter in the VAR.MODE list 2, this signal can be altered. Only the send signal of the generator operating in the foreground will be shown on the results page, however (in this case, analog).

The analog auxiliary signal outputs [30] and [31] can be switched on or off using VAR. MODE 151 to 153. The output level can be set via VAR. MODE 154.

3.9.2 VAR. MODE 2xx: DIGITAL SIGNAL GENERATION







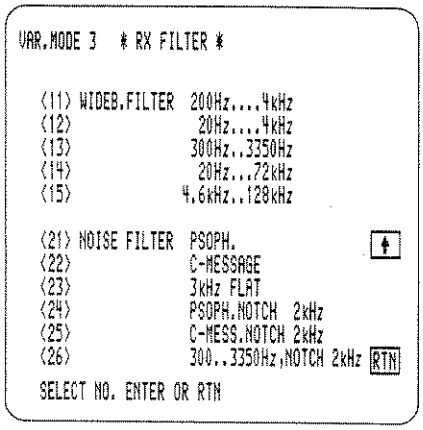
All possible digital generator signals are shown. In D-A or D-D modes, the generator transmits the signal which is determined by the mode chosen. The signal in use is marked with ** on one of the 3 VAR. MODE list 2 pages. In these measurenent configurations, the analog generator is switched off by VAR. MODE 141. It can, however, generate another signal chosen from the VAR. MODE list 1 which cannot be influenced by external factors (standard values). Only the send signal of the generator operating in the foreground will be shown on the results page (here, digital). The analog auxiliary output can also be used via VAR. MODE 151 to 154 (see 3.9.1 above).

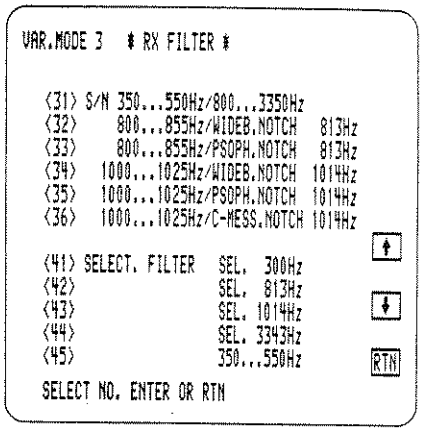
The line

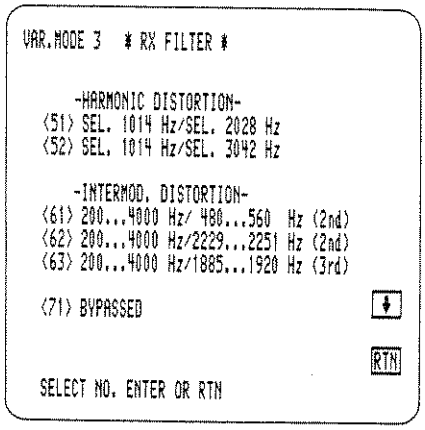
<31> FREQUENCY/LEVEL Hz dBm0

only appears on the first page of VAR. MODE 2 when A-A or A-D configuration is set. This allows you to set frequency and level for an auxiliary signal if <31> is chosen, depending on the VAR. MODE 2 settings.

3.9.3 VAR. MODE 3xx: RX FILTER

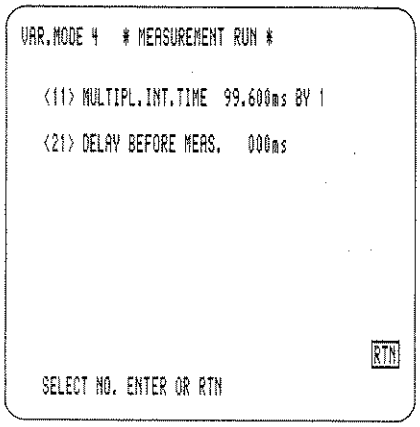






Note: Since certain receive filters (e.g. 20 Hz to 72 kHz) are fixed because of the evaluation method used in a given mode, free choice of filters for each mode is restricted.

3.9.4 VAR. MODE 4xx: MEASUREMENT RUN



Integration time (VAR. MODE 411)

To keep the natural fluctuation in the results to a reasonably small value, each measurement mode has an integration time assigned to it. The integration time can be displayed in VAR. MODE list 4; it comprises a basic time and a multiplier. A value between 1 and 9 can be chosen for the multiplier using VAR. MODE 411.

If large fluctuations in the signal due to external factors are present, an increase in the integration time will reduce the scatter of the results but will increase the measurement time.

In certain cases, the integration time can also be decreased.
Example:

Interference due to lines or nearby systems is not usually a problem when measuring the quantising distortion of a codec module. Any interference is basically caused by the codec itself, and quite often the effects are minimal fluctuations, so that the results are highly reproducible. If quantizing distortion is measured using a noise signal (MODE A51), the basic integration time is fixed at 256 ms and the multiplier is 2, given an integration time of 512 ms. Setting the multiplier to 1 will shorten the measurement time, but a possible increase in the variation of the measured values must be reckoned with.

Pre-measurement delay time (VAR. MODE 421)

Some test objects have relatively long settling times, for example if the oscillator is badly synchronised or if the connection is via several converters. In order that the measurement is not affected by this factor, a delay can be set before each measurement using VAR. MODE 421. The delay can be set between 0 and 900 ms in steps of 100 ms.

3.9.5 VAR. MODE 5xx: MEASUREMENT CONDITIONS

```
VAR.MODE 5   * MEASUREMENT CONDITIONS *

   <11> EXPECTED RX LEVEL TX LEVEL
   <12>                   FIXED   -11.0dBm0
** <13> PRE-MEASUREMENT

   <21> LOWER RANGE LIMIT         -95.0dBm

** <31> RANGING  AUTO
   <32>          OFF
   <33>          WIDE BAND/LOW DIST.



                                        RTN

   SELECT NO. ENTER OR RTN
```

To reduce the activity of the attenuator switching circuits and the measurement time, it is possible to enter an expected value for the received signal level in VAR. MODE 5, so that the attenuators can be preset to the right level.

<11> EXPECTED RX LEVEL TX LEVEL

Here, the expected receive level is the same as the generator level; the attenuators are set accordingly.

<12> EXPECTED RX LEVEL FIXED -11.0 dBm0

If the receive signal levels lie within a fixed range, this value can be entered to set the attenuator circuits. For an expected level of -11 dBm0, the attenuator is set to a 6 dB range of -8 to -14 dBm0, for example.

<13> PRE MEASUREMENT

The correct attenuator setting is determined after the start of the measurement by means of a preliminary measurement. For each subsequent measurement, the attenuator setting determined by the preceding measurement is used as the expected level.

<21> LOWER RANGE LIMIT -95.0 dBm

The lower range limit can be extended if, for example, levels which lie below the nominal range limit are to be measured. The characteristic data however may not always be valid.

<31> RANGING AUTO

The auto ranging circuit ensures that the correct attenuator setting is made automatically.

<32> RANGING OFF

If the auto ranging circuit is off, the full dynamic range of the A-D converter can be exploited, reducing the activity of the attenuator switching circuits. This, in turn, means that the measurement times are reduced, but the signal to noise ratio is worsened and the accuracy of the measurement therefore suffers.

<33> RANGING WIDEBAND/LOW DIST.

Out-of-band or in-band interference (such as mains hum) can lead to saturation of the input amplifier if the receive signal level is low, i.e. the attenuator is set to a sensitive range. This makes measurements impossible.

If VAR. MODE 533 is switched in, interference signal levels are determined by a wideband measurement (20 Hz to 128 kHz) and the attenuators set accordingly. This avoids saturating the amplifier, but results in a longer measurement time.

3.9.6 VAR. MODE 6xx: AUXILIARY FUNCTIONS

```
VAR.MODE 6   * AUX. FUNCTIONS *

   <11> REF.FREQ.MODE A3/B52/B54:  813Hz

   <21> REF.LEVEL MODE A4 :       -10.0dBm0

** <31> CHAN. DISPLAY WITHOUT SCANNER   YES
   <32>                                NO

** <41> MEAS. BRIDGE 1/2  OUTPUT 1
   <42>                   OUTPUT 2 (BAL)
   <43>                   OUTPUT 2 (UNBAL)
** <51> MEAS. BRIDGE 2    S-Z/4 OPEN
   <52>                   S-Z/4 CLOSED       RTN

   SELECT NO, ENTER OR RTN
```

<11> REF. FREQ. MODE A3/B52/B54: 813 Hz

The measurement of gain vs. frequency response (MODE A3) is referred to the value at 813 Hz or 1014 Hz. Any frequency between 20/200 Hz and 4 kHz can be set for MODE A3 using VAR. MODE 611.

The group delay distortion measurement (MODE B52 or B54) is referred to the value at 1792 Hz. VAR. MODE 611 can be used to set one of the following test tones as reference for MODE B52 or B54:

292, 500, 604, 1000, 1792, 2604, 2792 and 3396 Hz.

<21> REF. LEVEL MODE A4: -10 dBm0

The variation of gain with input level measurement (MODE A4) is referred to a level of -10 dBm0. Any level between 0.0 and -50.0 dBm0 can be set as reference for MODE A4 using VAR. MODE 621.

<31> CHAN. DISPLAY WITHOUT SCANNER YES

<32> NO

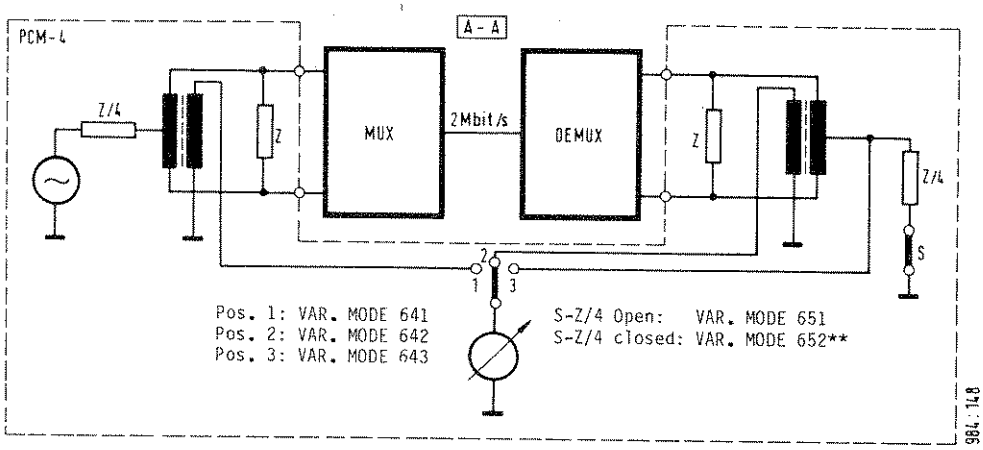
To perform rapid sequential measurements on all channels of an analog interface, a test point scanner is essential. If a test point scanner is not used, the CHANNEL parameter can be disabled using VAR. MODE 632 for A-A, A-D and D-A configurations. The result will be a single measurement in the selected RX/TX channel, shown as a bar on the display. The display for the normal 30 channel sweep measurement is blanked.

```
    <41> MEAS-BRIDGE 1/2 OUPUT 1
**  <42>                 OUPUT 2 (BAL.)
    <43>                 OUPUT 2 (UNBAL.)
    <51> MEAS-BRIDGE 2 S-Z/4 OPEN
**  <52>               2 S-Z/4 CLOSED
```

In MODE 83, A-A configuration, different test setups can be used with the bridge circuits. The basic settings VAR. MODE 642 and 652 are for longitudinal conversion transfer loss (LCTL) measurements. The setup corresponds to that depicted in figure 3 of CCITT Rec. O.121.

The LCTL is displayed by selecting VAR. MODE 641.

The test setup for VAR. MODE 643 and 652 is for determining the transverse conversion transfer loss (TCTL). It corresponds to figure 4 of CCITT Rec. O.121.



3.9.7 VAR. MODE 7xx: SPECIAL SIGNALLING PARAMETERS

```
VAR.MODE 7   * SPECIAL SIGNALLING PARAM. *

   (11) DUTY CYCLE IN %  50

** (21) SIGNALLING FREQUENCY 10Hz
   (22)                    20Hz

   (31) SIGNALLING ON BIT a
** (32)              BIT b
   (33)              BIT c
   (34)              BIT d

                                    RTN

   SELECT NO, ENTER OR RTN
```

<11> DUTY CYCLE IN %

A signalling duty cycle of 10, 20, 30, 40, 50, 60, 70, 80 or 90 % can be selected under MODE B6 and B7. The duty cycle can be set in finer steps using VAR. MODE 711:

- in steps of 1% for A-A and A-D measurements
- in steps of 2% for D-A and D-D measurements with 10 Hz signalling frequency.
- in steps of 4% for D-A and D-D measurements with 20 Hz signalling frequency.

At a signalling frequency of 20 Hz, the input values are rounded up to 12, 20, 32, 40, 52, 60, 72, 80 and 92%, due to the 2 ms frame structure of the multiframe.

<21> SIGNALLING FREQUENCY 10 Hz

<22> 20 Hz

The signalling frequency in MODE B6 and B7 can be switched to 20 Hz with VAR. MODE 722.

<32> SIGNALLING ON BIT a

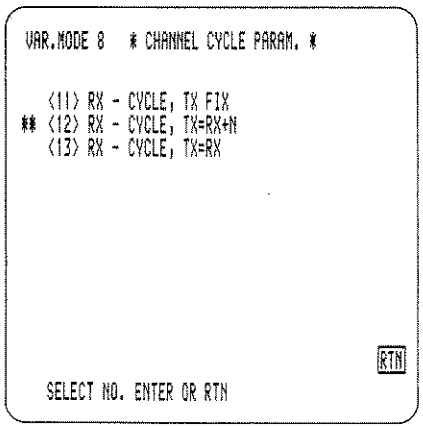
<32> BIT b

<33> BIT c

<34> BIT d

The signalling bit to be simulated/evaluated in A-D, D-A and D-D configurations in MODE B6 and B7 can be set using VAR. MODE 731 to 734.

3.9.8 VAR. MODE 8xx: CHANNEL CYCLE PARAMETERS



<11> RX-CYCLE, TX FIX

VAR. NMODE 811 should be set for making crosstalk measurements in MODE A7 or B7. Only the RX channels are swept. Identical settings for RX and TX channel number are impossible.

<12> RX-CYCLE, TX = RX+N

Both TX and RX channels are swept. The difference in channel numbers between the RX channel and the TX channel is N.

<13> RX-CYCLE, TX = RX

The TX and RX channels are swept with TX channel number = RX channel number. The TX CHAN and RX CHAN keys are disabled. The TX+RX CHAN key can be used to set the channel number from which the sweep is to start.

4 REMOTE CONTROL

4.1 INTRODUCTION

The PCM-4 PCM channel measuring set is a microprocessor-controlled instrument and all its functions can be controlled from a desk-top computer or process controller.

In order to do this, the instrument is fitted with a remote-control board conforming to DIN IEC 625 and IEEE 488 standards (byte-serial bit-parallel interface system). This differs from the commonly used IEEE 488/78 or HP-IB systems only in the type of connector used; as regards the electrical properties, it is identical. With this system, up to 15 instruments can be linked together very easily to form a flexible, powerful measurement system.

When you choose a controller, various factors such as implemented IEC bus functions (see 4.2.4), speed characteristics, programming facilities, memory capacity, etc. have to be carefully considered if you want an efficient test system.

All devices are connected in parallel with the interface system (referred to as the "IEC bus" from now on). The test system is controlled by a computer, the controller.

All the instruments connected to the IEC bus can, depending on type, either transmit (= Talker) or receive (= Listener) data. However, only one Talker may put data on the bus at any one time, and only one computer (controller) may be used to run the system. All information on the bus is transmitted in ISO-7 bit code (ASCII code).

This remote control information contains some examples of programs for setting up and interrogating the PCM-4, so that the programmer can gain experience in the programming of our measuring instruments. A knowledge of BASIC will be of help in understanding the programs. A good working knowledge of the manual operating procedure for the instrument and of the general characteristics of the IEC bus system (see "Interface-Bus <IEC 625>" brochure, order no. 6390/00.39), will also help in the programming procedure.

Wandel & Goltermann also supply complete "turnkey" systems, which eliminate the need for the user to be involved with the mechanical and electrical properties of the instruments or with the techniques used in programming the various functions.

4.2 INSTRUMENT SETUP

The system is set up by fitting the interface boards into the controller (e.g. HP-85) and the PCM-4, and setting the addresses before connecting the instruments together. All the procedures and settings are dealt with in the following sections.

4.2.1 IEC 625 REMOTE CONTROL BUS INTERFACE BOARD, (BN 958/24)

The IEC bus board BN 958/24 must be fitted before the instrument can be operated in an automated system. The board is easily retrofitted, as it is simply plugged into the slot exposed by removing the cover plate on the back panel of the instrument.

Before the board is inserted, check that the solder links on the board correspond to fig. 4-1, and that the CLR switch is correctly set.

IMPORTANT INSTRUCTIONS FOR HANDLING THE IEC BUS BOARD TO AVOID DAMAGE TO THE CIRCUITS:

It is important to remember that the circuits used in the instrument can be damaged by static charges. As it is possible that you may be at a higher electrical potential than the instrument, it is important to observe the following procedure before handling circuit boards or making adjustments inside the instrument:

- Switch the instrument off using the on/off switch, but do not disconnect the instrument from the a.c. mains. This ensures that the chassis of the instrument remains at earth potential.
- Discharge any static charge you may be carrying by touching an exposed metal part of the instrument (such as may be revealed when the blanking plate on the instrument is removed).
- The IEC bus board is supplied in conductive packaging. Do not remove the board from the packaging until you are ready to fit it into the instrument.
- Always carry the IEC bus board in the conductive packaging and never directly in the hand.
- If you leave your workstation for any reason, remember to discharge any possible static charge you may be carrying before resuming work on the instrument.

Notes about the "CLR" switch:

If the IFC command is intended to apply to the instrument as well as the interface, the CLR switch must be set to ON. In this case, the IFC command will also cause a DEVICE CLEAR and GOTO LOCAL command to be issued. Any previously stored settings will be retained.

Interface board, BN 958/24 (IEEE connector)

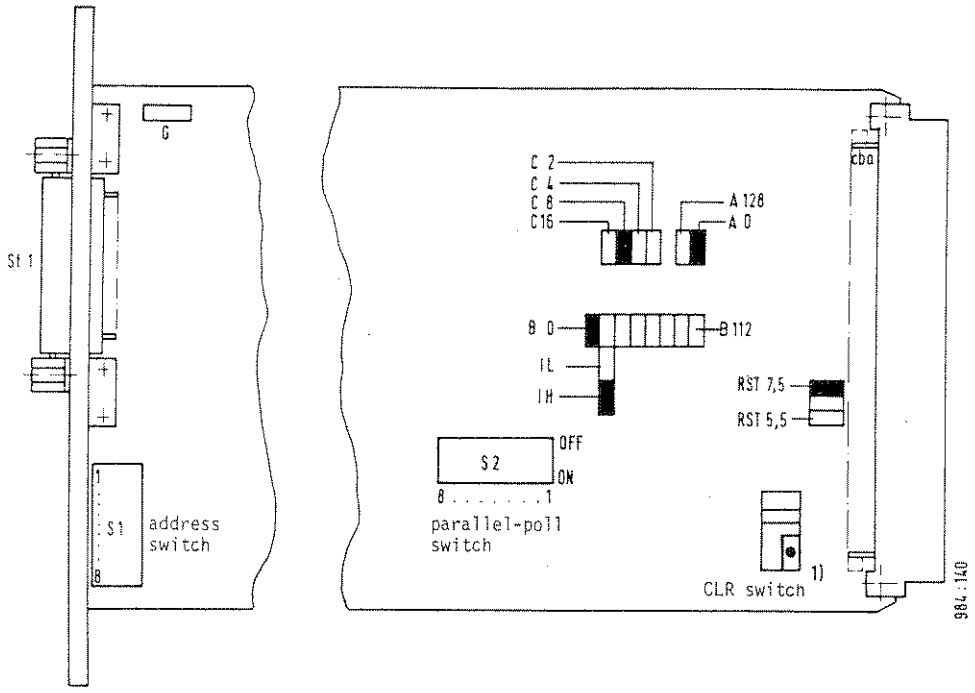
This board is fitted with a 24 way Amphenol type connector to IEEE 488 specifications. Pin connections are as shown in fig. 4-5 (right).

Important note:

Controllers having integral disc drives, such as the HP 9816, may cause "system booting" errors if the disc drive and the PCM-4 share the same IEC bus controller interface. This will only occur if the CLR switch is ON, and if the interface controller and the PCM-4 are switched on simultaneously. Due to a time-out condition, the controller repeatedly sends an IFC signal, which prevents it from loading the BASIC operating system from the disc.

The problem can be solved by either:

- Setting the CLR switch to OFF, which means that a selected device clear command or SDC (CLEAR 7Ø2) must be sent after each IFC is issued by the PCM-4.
- switching on the PCM-4 at least 15 seconds after the controller (time relay) if the CLR switch is ON, or
- fitting a second IEC bus controller interface (option) for the measuring instruments, and choosing another select code.



1) Clear switch "OFF"

Figure 4-1 IEC bus board BN 958/24 for PCM-4, showing positions of wire links, address switch, CLR switch and parallel-poll switch.

4.2.1.1 Instrument address

Each instrument in the system must have a unique address so that the controller can talk/listen to each instrument. The address for the PCM-4 is set with the instrument switched off using S 1 on the interface board. The address is set to 2 in the factory.

Example: setting up address 10 (decimal) = 01010 (binary)

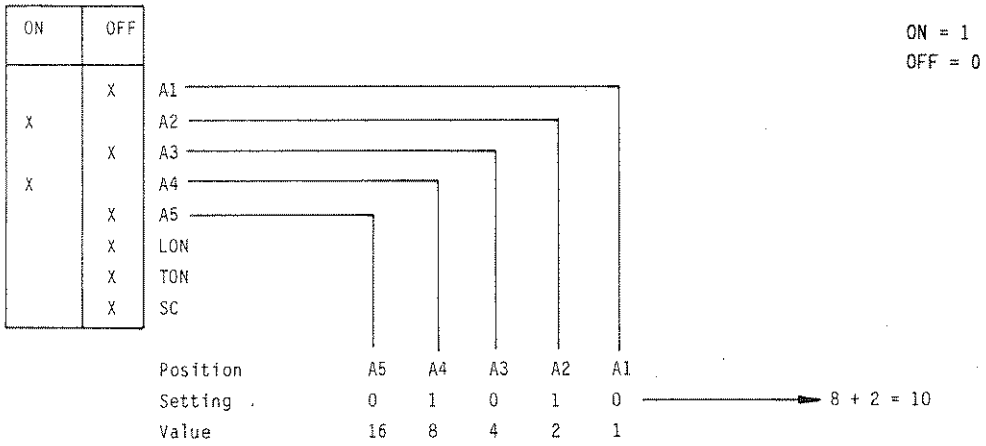


Figure 4-2 Setting up the instrument address

It is very important to ensure that no two instruments in the same system have the same address[1)] or the address of the controller (e.g. 21 for hp controllers). A maximum of 31 addresses are available between 0 and 30, one of which is used by the interface. Address no. 31 is used for resetting the listener function (UNLISTEN). However, no more than 15 instruments can be connected together to form a system. Switches 6 to 8 should initially be set to the OFF position.

4.2.1.2 LON, TON and SC switch functions

LON, TON

The listen only (LON) and talk only (TON) interface functions allow a minimal system configuration to be set up which does not require a controller.

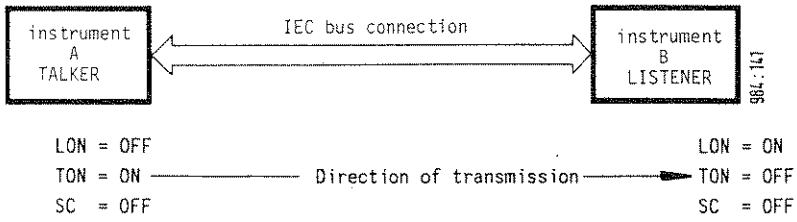


Figure 4-3a Minimal configuration for a test system

In this special operating mode, any instrument addresses which may have been set are ignored, and so it is not necessary to ensure that the addresses are set correctly with respect to each other.

1) When an interface is used

This minimal system is always specially designed for a particular application. It is not possible for the devices to exchange data as data can only flow in one direction; for this reason:

INSTRUMENTS MADE BY WANDEL & GOLTERMANN
DO NOT USE THIS FUNCTION

SC

Usually the system control function is the sole responsibility of the controller, however as test systems become more and more complex some kind of "distributed intelligence" is essential. The SC (system controller) function recommended by DIN <IEC 625> is available in our instruments to give users a facility of this kind.
The SC switch is located on the address switch of the interface board.
Test procedures can be simplified if a test instrument can act as a system controller. As this function can be switched on or off by the controller, the user can exploit his system in a way that would not be possible if he only had the LON/TON function at his disposal.
Figures 4-3b and 4-3c show the difference between systems with and without additional controllers.
In contrast to the LON/TON function, the instrument addresses for the peripherals must be assigned defined values. Instruments made by Wandel & Goltermann assign address 29 to the plotter and 30 to the printer. These addresses should be assigned to the instruments concerned; follow the instructions given in their operating manuals.

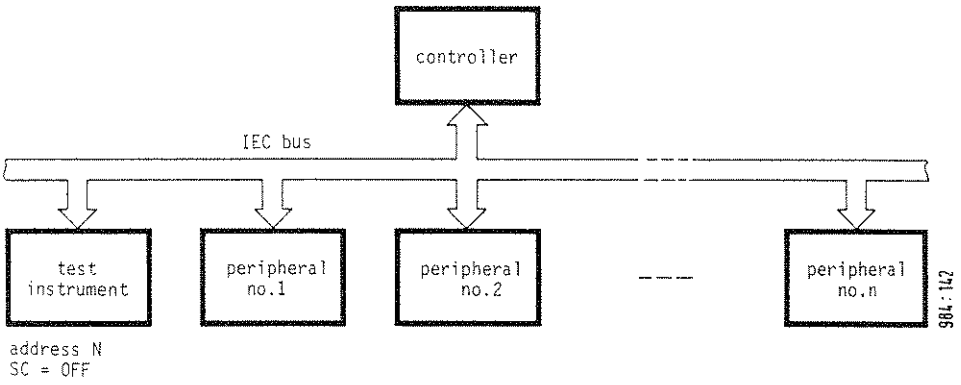


Figure 4-3b Test system configuration: with controller

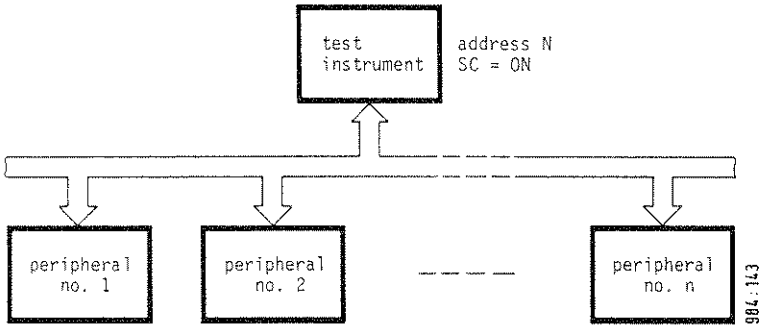


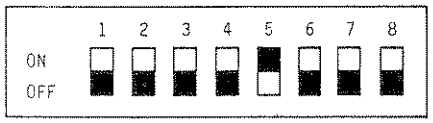
Figure 4-3c Test system configuration: without controller

If the PCM-4 is run with SC = ON, it performs the functions of a controller (cf. 4.2.1.5). The control function is, however, only tailored to specific types of instrument. In the case of the PCM-4, the instruments are: a plotter, a printer and up to two MU-30 test point scanners, BN 923/11 (see 4.3.5).
The control programs are stored permanently in EPROMs, and cannot be altered by the user, in contrast to the programs of a normal controller.

4.2.1.3 Setting the parallel poll

The parallel poll function which is implemented on the IEC bus board BN 958/24 enables the instrument to put a status bit onto one of the lines DIO 1 ... DIO 8 in response to a parallel poll from the controller, without first needing to be addressed as talker.
This allows the simultaneous identification of up to eight instruments connected to the bus which may have sent a SRQ (service request) to the controller. The data line which will be used by the instrument in the event of a parallel poll is set using S 2 with the instrument switched off (see fig. 4-1).

Example: Parallel poll response on DIO 5



Parallel poll switch S 2

Only position 5 is switched on. The status of the data lines is interpreted as a binary pattern and read in as $2^{(5-1)} = 16$ as a control variable.

Figure 4-4 Setting the parallel poll switch

Once the address and (if required) the parallel poll function have been set, the bus board can be fitted into the slot in the back panel and fixed in place with two screws,[1] (see 4.2.1). The instrument can then be connected into the bus system using the IEC bus cable, as detailed in section 4.4.1.4.

Note: Some controllers (such as HP 9816) automatically make a parallel poll each time the main memory is addressed. If the PCM-4 and the main memory share the same line for the parallel poll reply, this may lead to problems.
Remedy: Change the parallel poll setting of the PCM-4. If this is not possible due to the fact that all the lines are in use or the main memory setting is not known, all the switches of the parallel poll switch should be set to off. If the controller then issues a parallel poll, the main memory will reply with its parallel poll bit. For the HP 9816, the addresses and parallel poll bits are assigned as given in the table overleaf:

1) These screws must be fixed tightly; good earth connections will help to eliminate interference on the IEC bus system.

HP-IB address	PPOLL bit	DIO line
0	7	8
1	6	7
2	5	6
3	4	5
4	3	4
5	2	3
6	1	2
7	0	1

4.2.1.4 Bus connections

The IEC bus board is fitted with a 24 way connector; connections are as shown in fig. 4-5. Cables in various lengths are available to connect the instrument to the system (K 420 = 1.2 m or K 421 = 2.0 m). The maximum cable run between instruments must not exceed 4 metres.

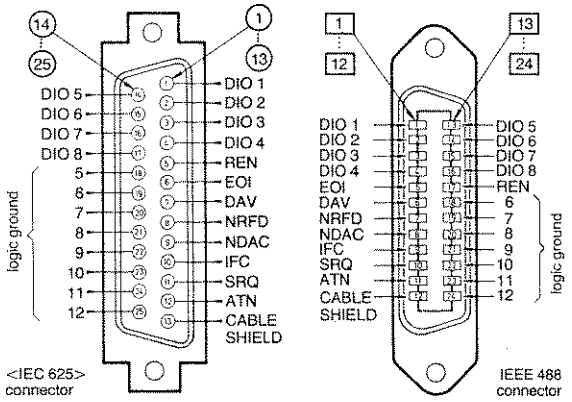


Figure 4-5 Pin connections for the IEC bus connector of the PCM-4

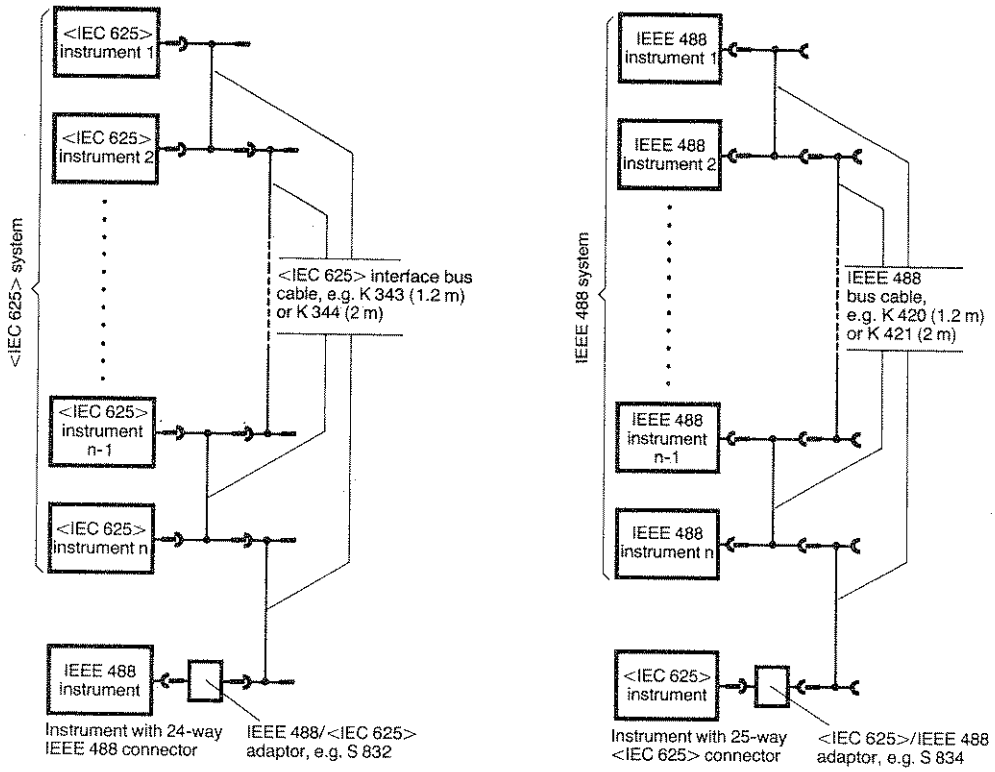


Figure 4-6 Connecting IEC and IEEE systems together

Up to 15 instruments can be connected to the same bus; the maximum length of the complete bus must not exceed 20 metres (see DIN <IEC 625>, Part 1 Section 31.1, p. 66 and Section 39, p. 71).

The length of the bus can be increased if 2- or 4-wire interface couplers or modems are used.

4.2.1.5 PCM-4 interface functions

Table 4-1 shows the interface functions (corresponding to the DIN IEC 625 standard) which have been implemented for the PCM-4. A more detailed description of the interface functions and the abbreviations used is given in the <IEC 625> Interface Bus brochure (Order no. 0853/00.80).

Function	Comments
SH 1 Source Handshake	Full implementation
AH 1 Acceptor Handshake	Full implementation
T 6 Talker	All functions except TON (Talk only), see 4.2.1.2
L 4 Listener	All functions except LON (Listen only), see 4.2.1.2
SR 1 Service Request	Full implementation
RL 1 Remote/Local	Full implementation. Manual operation blocked by LLO command
PP 2 Parallel poll	Function activated with switch
DC 1 Device Clear	Full implementation
DT 1 Device Trigger	Full implementation
C 1	System control function, SC = ON
C 2	Sends IFC and starts operating, SC = ON
C 3	Sends REN, SC = ON
C 4	Responds to SRQ, SC = ON
C 5	- Transmits interface data, releases control, - assumes control, synchronous/synchronous control, - parallel poll
C 11	Assumes control, releases control, transmits interface data, synchronous control, SC = ON

Table 4-1 List of implemented interface functions (cf. DIN <IEC 625>, part 1)

Controller interface functions

The use of the HP computer recommended by us will guarantee problem-free operation of the IEC bus system and simple, rapid programming of our remote controlled instruments.

Other computers can, of course, be used for this purpose if they are fitted with the IEC bus interface. However, it must first be ascertained whether the computer in question can handle all of the necessary controller functions (see table 4-2). This information will be found in the computer handbook or can be obtained directly from the manufacturer. Controllers which do not have the specification recommended in the table below may not be suitable for the system.

Function	Description
SH 1 Source Handshake	Full implementation
AH 1 Acceptor Handshake	Full implementation
T 6 Talker	All functions with the exception of TON
L 4 Listener	All functions with the exception of LON
SR 1 Service Request	Full implementation
DC 1 Device Clear	Full implementation
DT 1 Device Trigger	Full implementation
C 1 Controller	System control function
C 2 Controller	Send IFC
C 3 Controller	Send REN
C 4 Controller	React to SRQ
and	
C 5 Controller	Assume control or release control, synchronous control, request control, transmit interface data, parallel poll
or	
C 7 Controller	as for C 5 without PPOLL
or	
C 9 Controller	as for C 5 without request control
or	
C 11 Controller	as for C 5 without PPOLL and request control
E 1	Open collector line driver

cf. DIN <IEC 625> Part 1

Table 4-2 Interface functions recommended for the control computer (controller)

4.2.2 TEST SYSTEM CONFIGURATION

4.2.2.1 Small automatic measuring system

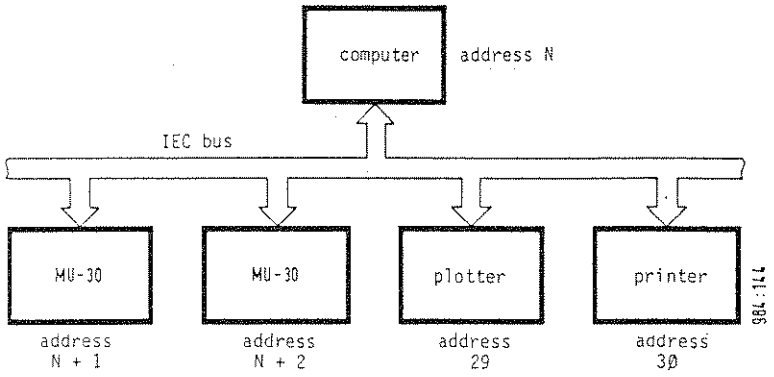


Figure 4-7 Small automatic measuring system; instrument addresses

The PCM-4 is capable of controlling the instruments needed for a complete measuring system via the IEEE 488 bus system, i.e. MU-30 Test Point Scanner, BN 823/11, an external plotter (using HPGL graphics language), and a printer.
For this purpose, the "SC" switch on the back of the <IEC 625> board, BN 958/24, should be set to "ON".
The plotter IEC bus address must be set to 29, and the printer IEC bus address must be set to 30.
The address for the MU-30 is dependent on the address of the PCM-4. To control the MU-30, the PCM-4 adds 1 or 2 to its own address; hence, the first MU-30 address should be set to that of the PCM-4 + 1, and the second MU-30 address should be set to that of the PCM-4 + 2.

Printer and plotter specifications

Printer specification:
PCM-4 output sequences
- standard ASCII characters with the exclusion of characters (35), (36), (64), (91) to (96), (123) to (127) (decimal codes)
- 79 characters per line
- 62 lines per page
- EOL sequence <CR> <LF>
- EOP sequence <FF>

General requirements:
- IEC bus
- 80 characters per line
- page length 11" or 12"
- standard ASCII character set

IEC bus requirements:
- AH 1 Acceptor handshake: full implementation
- L2 Listener function: basic version

Recommended types:
- HP 2225 ThinkJet
- Epson FX-80
- Siemens PT 88

Plotter specification:

General requirements:
- IEC bus
- HPGL graphics language

IEC bus requirements:
- AH 1 Acceptor handshake, full implementation
- SH1 Source handshake, full implementation
- L2 Listener function, basic version
- T2 Talker function, basic version with serial poll

Recommended instrument:
- HP 7470 A graphics plotter

4.2.2.2 Using the PCM-4 with an external controller

Normally, all instruments on the IEC bus will be controlled from one computer. The "SC" (System Controller) switch should therefore be set to "OFF".

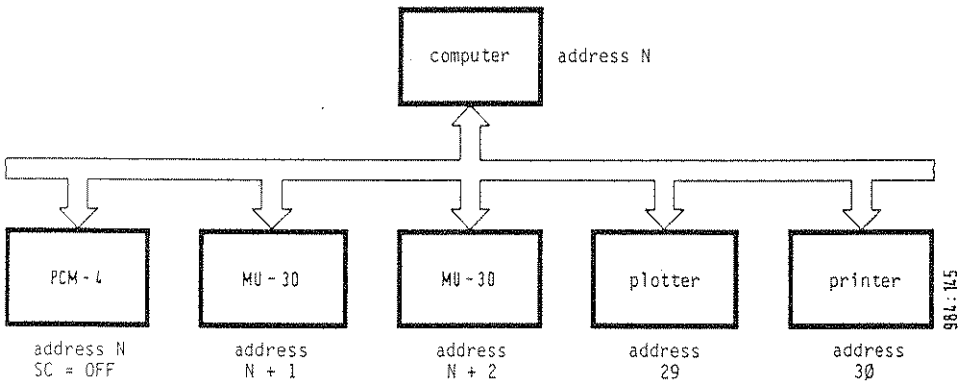


Figure 4-8 PCM-4 and other IEC bus controlled instruments configured for computer control

Using the non-controller mode, (program word ZZ ...) the computer can be used to system control the PCM-4, the latter directly controlling the MU-30 Test Point Scanner and the IEC bus plotter or printer. It follows, therefore, that a program segment for passing control over to the PCM-4 must be available in the control computer. The instrument addresses must be set in the same way as shown for the small automatic measuring system, or as shown in figure 4-8.

When the PCM-4 is switched off, the controller function is automatically cleared.

4.3 P R O G R A M M I N G

Most of the programming examples given are suitable for the HP 85 computer. Some examples are also given for HP 9816 or IBM PC with interface board and "PLUS 5ØØ" software from KEITHLEY. The type of computer for which the example is suitable is given alongside the program. The following input/output format is generally used:

```
OUTPUT 7 Ø 2   USING " # , K"; " MA11,"
```

Select code
HP-IB interface

IEC bus address

Output format
(#: suppress CR LF , see p. 4-17;
K: compact output format)

4.3.1 INITIAL PROGRAM EXAMPLE

Example: measuring the level of a 1 kHz signal. A HP 85 computer is used as controller.

* Connect the controller to the remote control board of the PCM-4 using the IEC cable,
* set the address switch on the remote control board to 2,
* set the SC switch on the remote control board to OFF,
* switch on the PCM-4,
* connect socket [25] (analog generator) to socket [23] (analog receiver).

The following BASIC commands can now be entered one at a time and executed by pressing /EXECUTE/.

Interface clear (IFC) and initialise PCM-4 (SDC) if CLR switch on IEC board is ON	ABORTIO 7	Sets up defined output state REMOTE LED does not light up
Remote enable (REN) and intialise PCM-4 (SDC)	CLEAR 7Ø2	REMOTE LED lights up
Preliminary setting	OUTPUT 7Ø2; "XXØØØ3,"	Defines EOT character and SRQ requirements
Set measurement mode	OUTPUT 7Ø2; "MA11, MS2,"	Results page for mode A11 in MAN/S mode is displayed
Set generator frequency 1ØØ4 Hz	OUTPUT 7Ø2; "FA1ØØ4,"	
Start measurement	TRIGGER 7Ø2	START LED lights briefly
Call up result	ENTER 7Ø2; E$	Result is read into string variable "E$"
Display result	PRINT E$	

Table 4-3 Initial programming example

4.3.2 PRINCIPLES OF PROGRAMMING

The example given in 4.3.1 is intended to give those users unfamiliar with the programming of our instruments an insight into the way the instrument reacts to the various BASIC statements given from the controller (HP-85). Depending on the use, the controller will automatically address the instrument as LISTENER (receiving data from the controller) or TALKER (transmitting data to the controller).

4.3.2.1 Preparation

Before program data can be transmitted to the instrument, the interface must be cleared (IFC) and remote control enabled (REN).

HP 85 command:

```
ABORTIO 7
```

IBM PC command:

```
CALL IBSIC(GPIBØ%)
```

The command ABORTIO 7 clears the interface (IFC), setting up a defined set of output conditions on the bus. If the CLR switch on the interface board is ON (see 4.2.1) the PCM-4 is reset to its basic setting at the same time (see 4.3). Any previously stored settings will be retained.

If the CLR switch is OFF, the IEC bus command SDC resets the addressed instrument to its specific output settings. This also ensures that no function is set that may lead to erroneous operation of the test sequence. The HP-85 controller initiates this command with the statement

```
CLEAR 702
```

By calling up the address of the instrument (Ø2), it is addressed as LISTENER, and all keys on the front panel, with the exeception of the LOCAL key, are then disabled.

Remote control of the instrument can also be initiated from the control computer with the REN command in conjunction with addressing as LISTENER, e.g. with the statement

```
REMOTE 702
```

The LOCAL key can be rendered inoperative to guard against accidental operation if the LLO command follows the REMOTE 7Ø2 command. This is done by programming

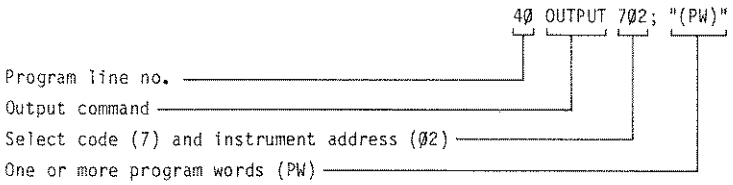
```
LOCAL LOCKOUT 7
```

The LLO command is cleared and manual control is restored with the GTL command (see also IEC bus brochure), which is effected by the statement

```
LOCAL 702
```

4.3.2.2 Setting up the instrument using program words

Once the instrument has been set up by clearing the interface, resetting to the basic settings (see table 4-18) and remote enable, the instrument can be programmed with statements of the form (using HP 85 as controller):



The program words (PW) consist of a HEADER followed by the main numerical part and are always concluded with a comma. Each PW corresponds to a specific function of the instrument. All the program words are listed in logical order in table 4-11, and described in alphabetical order in section 4.4.2.

It is possible to put several PWs into the character string for setting the instrument. For example, the following could be input:

```
OUTPUT 702 USING; "#, K" "XXØ1Ø3, YY121, XQ1,MA71, MS2,"
```

Each PW is executed in order of entry (left to right), in this case starting with the setting of the interface mode ("XX ...,").

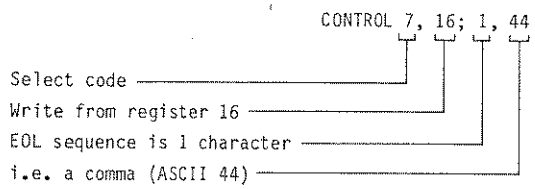
NOTES about the comma:

Every PW must end with a comma. If this is not done and, for example, the following is programmed:

```
(a)  4Ø OUTPUT 7Ø2; "TMØ, LA1Ø"          comma missing
       :
     7Ø OUTPUT 7Ø2; "FA36ØØ,"            or
(b)  7Ø OUTPUT 7Ø2; "TMØ, LA1Ø FA36ØØ,"  comma missing
```

then in both cases, the PW "LA1Ø" will not be executed until the computer encounters the next comma, i.e. after the PW "FA36ØØ," (in line 7Ø). However, the frequency of 3600 Hz will not be set!

Errors of type (a) can be avoided by programming the HP-85 EOL (end of line) sequence to automatically include a comma. This is done by writing the statement to alter IEC bus registers 16 and 17 of the HP-85:



The normal EOL sequence of CR and LF which may be required by other instruments is restored by:

```
CONTROL 7, 16; 2, 13, 10
```

There is no corresponding corrective measure that can be taken to avoid errors of type (b).

PWs must be entered in the same order as manual commands.

Example 1: HP 9816, HP 85

```
OUTPUT 7Ø2 USING "#,K"; "MA 11, CF2, MS2, XP1,"
```

Example 2: IBM PC

```
WRT$ = "MA11, CF2, MS2, XP1,"
CALL IBWRT (PCM4%, WRT$)
```

Output instruction
Instrument address (defined at start of program)
String containing PW

Notes on processing the programming data:

Only capital letters, the numbers Ø to 9 and the signs "+", "-", "k" and "," are recognised by the instrument; any other symbols in the character string will be ignored.

4.3.2.3 Reducing the transmission time of programming data

A character string of a multiple of 21 characters is always output by the HP-85 to the instrument for transmitting programming words. If the PW "JØ,", (i.e. a short string) is entered as the statement

```
8Ø OUTPUT 7Ø1 ; "JØ,"
```

the string will be extended automatically to 21 characters with spaces. This results in a relatively long transmission time of about 50 ms. In general, it is preferable that the commands be executed in the shortest possible time.

The output of spaces is suppressed by the use of the K format command; the time required for the example is reduced by

$$(21-3)\ \ 0.82\ \text{ms} + 1\ \text{ms} = 15.4\ \text{ms},$$

resulting in a time of 33.5 ms for execution of the command statement:

```
8Ø OUTPUT 7Ø1 USING "K" ; "JØ,"
```

If the commands which are automatically sent when the OUTPUT command is entered are written out in full, the transmission time can also be reduced:

```
(a)                          SEND 7 ; MTA   UNL LISTEN 1 DATA "JØ," or

(b)                          SEND 7 ; CMD "U?!" DATA "JØ,"
Select code ---------------------'
IEC bus command (ATN = 1) --------------'
My talk address (HP-85) 21 -------------------'           - CHR$ (21 + 64) = "U"
Unlisten ---------------------------------------'
Listen address group (PCM-4) Ø1 -----------------'        - CHR$ (Ø1 + 32) = "!"
Programming data (ATN = Ø, false): -------------------'
```

Execution time, example (a): 15.1 ms
example (b): 12.5 ms

The examples show that the greater part of the execution time consists of the time taken by the controller to decode the BASIC commands.

The CR and LF characters are not required by the PCM-4[1] and can therefore be suppressed by using "#,". This shortens the execution time by a further 2 ms.

```
Example:                  OUTPUT 7Ø2 USING "#,K"; "MA11,"

Suppression of CR and LF ----------------'
Compact format ----------------------------'
```

1) Exception: see 4.3.6.4 b)

4.3.2.4 Abbreviation of program words

Some of the program words can be abbreviated by omitting the sign or any zeros in the main (numerical) part of the PW. Of course, the PW code and the final comma cannot be changed. If no sign is entered, the instrument assumes that the value is positive. The sign must always be entered if the value is negative. Leading zeros and trailing can also be omitted.

Example: LA+32.ØØ, = LA32,
LA+Ø9.5, = LA9.5,

The following PWs can be abbreviated:

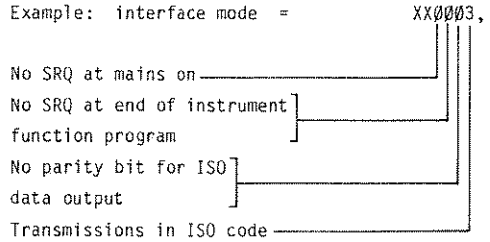
Channel setting	CB, CR or CT
Level setting	LA, LI, LE, RR, RS or VxxxL
Frequency setting	FA or FI
Scaling	XL, XU YL or YU

Other program words can be abbreviated if only a part of the main section of the PW is to be altered. The following PWs fall into this category:

- Interface mode, XXbbddd,
- Controller mode, YYbddddddddd,
- Non-controller mode, ZZbbbb,
- Data output mode DMd[ddddd],

If a change is to be made in the main part of these program words, it is sufficient to enter the parts of the PW up to and including the character to be changed. Any remaining characters which are not to be altered can be omitted.

Example: interface mode = XXØØØ3,



A SRQ at mains on is required:

New PW:	XX1ØØ3,
abbreviated PW:	XX1,

4.3.2.5 Speeding up measurements and settings

The measurement and setting up times can be reduced by applying the following measures:

- Switch off the VDU display (SCØ)
- Use overlapping input/output mode (TM1)
- Use variable mode settings such as:
  - enter expected level,
  - switch off autoranging,
  - reduce the integration time (see 3.9.4)
- Store complete setups and recall these as required
- Switch off the tolerance masks.

These measures are a compromise between measurement accuracy, display facilities and speed, and these factors should be borne in mind by the programmer.

Example program for HP 9816:

```
10    ! Example : speed up Measurement
20    ! ------------------------------
30    !
40    ! Use : VAR MODE 511 (RX LEVEL = TX LEVEL)
50    !
60    P4=705
70    CLEAR P4
80    ON INTR 7 GOTO 210
90    OUTPUT P4 USING "#,K";"XX0103,DM0,"
100   SET TIME 0
101   DATA 4
102   DATA -60,-40,-20,0
110   !
120   ! Main program
130   OUTPUT P4 USING "#,K";"MA11,XP2,MS2,V511,"
140   !
141   RESTORE
143   READ Number
144   FOR I=1 TO Number
145   READ L
146   OUTPUT P4 USING "#,2A,K,A";"LA",L,","
147   !
150   TRIGGER P4
160   T1=TIMEDATE
170   !
180   ENABLE INTR 7;2
190 Wait:   GOTO Wait
200   !
210   T2=TIMEDATE
220   STATUS 7,1;S1
230   ENTER P4 USING "#,K";L1
240   PRINT USING Form_1;"Input: ",L,"dBm0","Result: ",L1,"dBm0"
250   PRINT USING Form_2;"Measurement time: ",T2-T1,"s"
251   NEXT I
252 Form_1:   IMAGE 8A,X,4D,X,4A,4X,8A,2X,SDD.DD,2X,4A
253 Form_2:   IMAGE 18A,X,Z.DDD,X,A
260   END
```

By selecting VAR.MODE 511 (line 130 ..., V511,") the measurement time has been reduced; the receiver expects the level to be the same as the generator level, so no preliminary measurement is made to determine the attenuator setting.

The measurement time is:

390 ms if VAR.MODE 511 is not selected, or

150 ms if VAR.MODE 511 is selected.

Note, however, that for the first measurement, the attenuator will be set during the measurement, so that this measurement will take longer than any subsequent measurements, unless the attenuator has previously been set to the right value.

4.3.2.6 Non-overlapping inputs and outputs (TM0)

As soon as the PW is received by the PCM-4, the relevant setting is made. Program word START triggers the measurement; the result is stored in an output buffer and can be read out via the IEC bus by the controller (see figure 4-9). If a PW is entered during a measurement, the measurement will be interrupted and the program word executed immediately.

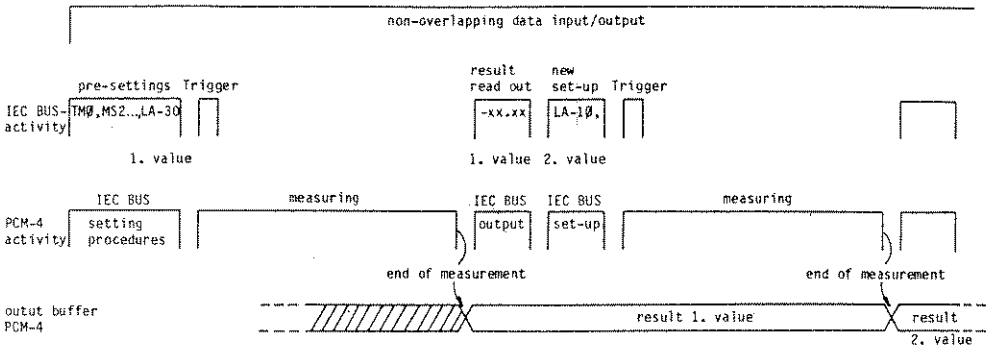
4.3.2.7 Overlapping inputs and outputs (TM1)

Trigger mode TM1, overlapping inputs and outputs, is only intended for us in MAN/S mode

The program words for which overlapped input is possible (marked with *** in section 4.4.2) do not interrupt a measurement which is in progress. These PWs are only executed after a TRIGGER or START command (see figure 4-10). All other PWs are unaffected by TM1, so that these will still interrupt a measurement when entered. For this reason, trigger mode TM1 should only be set for a single sequence of measurements, all the preliminary instrument settings being carried out in trigger mode TMØ. Otherwise, if the preliminary settings contain a PW for which overlapping input is possible, this will not be set until after the START command is given in trigger mode TM1.

Procedure:

Preliminary settings	Trigger mode "TMØ" recommended
TM1	Trigger mode "TM1" set; PWs which can be overlapped are stored in the input buffer of the PCM-4 but not executed
First measurement:	
TRIGGER or START	- PWs executed - measurement started - next settings transferred to input buffer
Second measurement:	
TRIGGER or START	- next settings executed, - 2nd. measurement started - transfer of result of first measurement to output buffer; result can be read out with ENTER command - next settings transferred to input buffer
Final measurement:	
TRIGGER or START	- final settings executed, - final measurement started, - transfer of result of penultimate measurement to output buffer; result can be read out with ENTER command
TMØ	- transfer of final result to output buffer; result can be read out with ENTER command

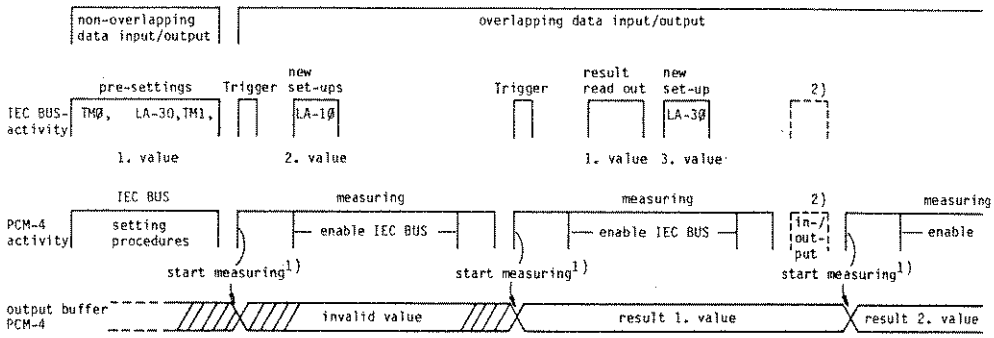


With status non-overlapped data input/output (trigger mode "continuous" TM0) the measurement result will be stored in the PCM-4's internal output buffer at the end of a measurement. It can then be read out via the IEC-Bus.

The measurement can be started by the programming word "START," or by trigger command.

The end of the measurement can be displayed by SRQ.

Figure 4-9 Non-overlapped data input/output timing in MAN/S mode



1) With status overlapped data input/output (trigger mode "single" TM1) the measuring result will be transferred to the internal PCM-4 output buffer at the beginning of a measurement (started by trigger command) and can then be read out via the IEC Bus.

2) With status overlapped data input/output (TM1), in addition a data exchange via the IEC Bus can take place when a measurement is being carried out. If the transmission takes longer than the release time during the measurement, the transmission will be interrupted by the PCM-4 and after the end of the measurement it will be automatically continued.
The end of the measurement can be displayed by SRQ.

Figure 4-10 Overlapping data input/output timing in MAN/S mode

4.3.3 STATUS BYTE AND SERVICE REQUEST

A wait period must be provided between the computer triggering a measurement and the calling up of the result to allow the instruments time to settle, and also for calibration and settings to be made. An incorrect result will be obtained if the ENTER command follows immediately after the TRIGGER command in the control program. The four different methods of providing this wait period are outlined below for a HP 9816 controller.

1a) Use of the WAIT statement

If the level change is small and the settling time is roughly constant and known (e.g. less than 800 ms) then the statement

```
WAIT 800
```

will suffice to make the controller wait until the measurement has finished. Other controllers may need to be programmed with a FOR ... NEXT loop delay.

If large variations in level are expected, so that the instrument may need to calibrate itself, then the wait period is likely to vary considerably between measurements, and some kind of automatic recognition of the end of a measurement is necessary. This can be done by repeated interrogation of the BUSY bit in the status byte or of the SRQ (STATUS REQUEST) line, or with a SRQ interrupt from the controller.

Example:

```
10   ! Example: Program 1
20   ! ------------------
30   P4=702 ------------------------------------ IFC and REN; HP-IB select code 7, PCM-4
                                                  address Ø2
40   CLEAR P4 ---------------------------------- setting interface mode XX and data mode DM
50   !
60   OUTPUT P4 USING "#,K";"XX0003,DM0,"
70   !
80   !
90   OUTPUT P4 USING "#,K";"MA11,MS52,FA1004," - set measurement mode
100  !
110  TRIGGER P4
120  !
130  WAIT .4 ----------------------------------- wait 400 ms
140  !
150  ENTER P4 USING "#,K";L1 -------------------- call up level
160  DISP "Level L1/dBmØ = ";L1
170  END
```

1b) Serial poll

The instrument responds to a serial poll from the controller by sending the status byte (see 4.4.4); the controller evaluates the BUSY bit (normally bit 4 with weighting $2^4 = 16$). A SRQ is not necessary.

The command in HP-85 BASIC is:

```
23Ø  S = SPOLL (7Ø2) ------------------------- serial poll of instrument with address Ø2
24Ø  IF  BIT (S,4) THEN 23Ø ------------------ if measurement not ended, go to 23Ø
```

For the IBM-PC, the command is:

```
59Ø  CALL IBRSP (PCM4%, SPR%) ---------------- SPR% contains PCM-4 status byte
6ØØ  IF (SPR% AND 16) <>Ø THEN 59Ø
```

This loop will operate until the BUSY bit (true = 1) which is set by the TRIGGER command is reset at the end of the measurement (false = 0).

Other bits present in the status byte can be used for signalling errors or incorrect evaluation; their meanings and coding are described in 4.4.4.

If this continuous serial poll (SPOLL approx. every 15 ms using the HP-85) leads to corruption of sensitive level measurements or interference on other instruments, this effect can be tempered by inserting a WAIT period greater than 50 ms.

Example:

```
10   ! Example: Program 2
20   ! ------------------
30   P4=702
40   CLEAR P4
50   !
60   OUTPUT P4 USING "#,K";"XX0003,DM0,"
70   !
80   !
90   OUTPUT P4 USING "#,K";"MA11,MS52,FA1004,"
100  !
110  TRIGGER P4
120  !
130  S=SPOLL(P4)          ---- instrument status byte poll
140  IF BIT(S,4) THEN 130 ---- BUSY bit evaluation; when BUSY = true, repeat poll
150  !
160  ENTER P4 USING "#,K";L1
170  DISP "Level L1/dBm0 =";L1
180  END
```

1c) Repetitive SRQ interrogation

If there is no continuous data traffic on the IEC bus, the third possibility for determining the end of the measurement is by repeated interrogation of the IEC bus control lines, particularly the SRQ line of the controller interface (see 1c, 3.3.1 for example using HP-85):

```
230 STATUS 7, 7; Q                    IEC control line interrogation
240  IF NOT BIT (Q,5) THEN 230        Evaluation of RQS bit; if no SRQ then repeat
```

The instrument must previously be programmed to issue a SRQ at the end of a measurement; this is done when setting up the instrument with the PW "XX01000,". Lines 230 and 240 are repeated until the RQS bit in status register 2 (IEC bus control lines) is set.

Example:

```
10   ! Example: Program 3
20   ! ------------------
30   P4=702
40   CLEAR P4
50   !
60   OUTPUT P4 USING "#,K";"XX0003,DM0,"  ---- XX: instrument outputs SRQ at end of measurement
70   !
80   !
90   OUTPUT P4 USING "#,K";"MA11,MS52,FA1004,"
100  !
110  TRIGGER P4
120  !
130  STATUS 7,7;C          ---- poll of IEC bus control lines
140  IF NOT BIT(C,10) THEN 130 ---- SRQ evaluation; if SRQ = false, repeat poll
150  !
160  ENTER P4 USING "#,K";L1 ---- call up level
170  DISP "Level L1/dBm0 =";L1
180  END
```

1d) SRQ Interrupt recognition

Apart from continuous polling of the IEC bus control lines at the controller interface, some controllers can be programmed to jump to a particular point in the program on receipt of a SRQ with statements such as ON INTERRUPT GOTO ... or ON SRQ GOSUB ...; whilst waiting for the SRQ to occur, the controller can be carrying out calculations, etc.

If several instruments are connected to the IEC bus, any of which may send out a SRQ in the same period of time, a serial poll of all instruments must also be made to determine which of the instruments has issued a SRQ at the end of a measurement; such instruments will have the RQS bit set (bit 7 = 1) and the BUSY bit will be reset (Bit 5 = 0).

Instead of a serial poll, a parallel poll of all the instruments (up to a max. of 8) can be used to determine this more rapidly.

The command for this in HP-85 BASIC is:

A = PPOLL (7)

The variable, A, is the value of the individual bits on lines DIO 1 to DIO 8. If, for example, the status bits DIO 1 and DIO 3 are set, A = 5 ($2^0 + 2^2$). The instrument thus identified will then be serial polled to determine the reason for the SRQ from the status byte.

Example:

```
10   ! Example: Program 4
20   ! ------------------
30   P4=702
40   CLEAR P4
50   ON INTR 7 GOTO 160
60   OUTPUT P4 USING "#,K";"XX0003,DM0,"
70   !
80   !
90   OUTPUT P4 USING "#,K";"MA11,MS52,FA1004,"
100  !
110  TRIGGER P4
120  !
130  ENABLE INTR 7;2
140 Wait:    GOTO Wait
150  !
160  STATUS 7,1;S1
170  ENTER P4 USING "#,K";L1
180  DISP "Level L1/dBm0 =";L1
190  END
```

when SRQ = true, call up level result
XX: instrument outputs SRQ at end of measurement

respond to SRQ interrupt only
HP 9816 waits for SRQ interrupt (end of measurement)

HP 9816 interrupt register must be cleared

If an IBM PC, fitted with a KEITHLEY interface and PLUS 500 software, is used, a special command can be used to cause the computer to wait for the SRQ signal. When the SRQ bit is detected in the interface status register, the program will continue on the following lines:

```
541 MASKE%=&H80Ø                          wait until SRQ line on IEC bus is active
542 CALL IBWAIT(PCM4%,MASKE%)
```

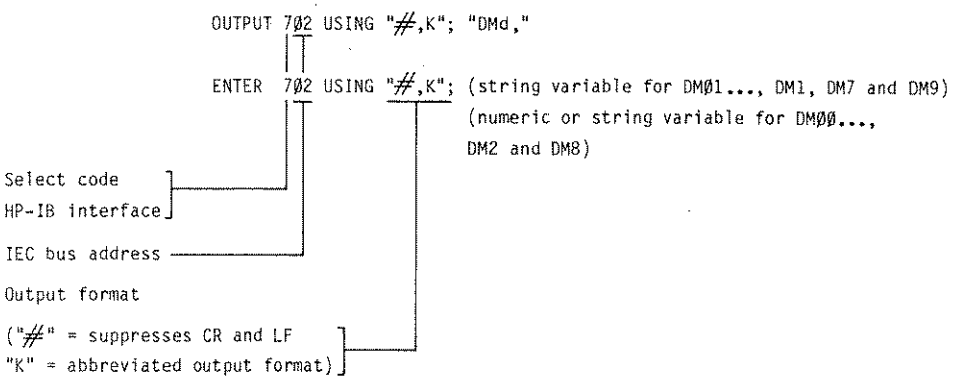
Note: see section 4.3.9 for details of interrupt routine

4.3.4 DATA OUTPUT

In data mode "DMd," the controller can call up the following data from the PCM-4:

- measurement results DMØ or DM1
- PCM-30 status DM2
- date and time DM7
- system status DM8
- error messages DM9

For this, the PCM-4 must be addressed as TALKER. The necessary command in HP basic is:



The output is always in ISO 7 bit code. The output format is determined by the interface mode which has been programmed (XXbbddd) and the data output mode (DMd).

NOTE: Transfer of the result to the output buffer is dependent on the trigger mode (TMb) when data output mode DM0 is selected (see 4.3.2.6 and 4.3.2.7.)

In data output modes DM1 to DM9, the data is output to the output buffer immediately after the OUTPUT... command is received.

The number of partial results per measurement is dependent on the measurement mode in data output mode DM0 and DM1 (see table 4-4).

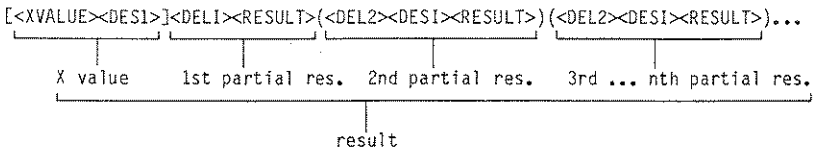
Mode	Number of partial res.	1st. partial result	2nd. part. result	3rd. part. result	4th part. result	5th part. result	6th part. result
A11-A14	1	Ø.Ø1 dB(m)Ø					
A21-A27	1	Ø.Ø1 dB					
A31-A38	1	Ø.Ø1 dB					
A41-A46	1	Ø.Ø1 dB					
A51-A57	1	Ø.Ø1 dB					
A61-A66	1	Ø.Ø1 dB(m)Ø					
A71-A79	1	Ø.Ø1 dB(m)Ø					
A81-A83	1	Ø.Ø1 dB(m)Ø					
A91-A94	1	Ø.Ø1 dB					
B11-B13	1	Ø.Ø1 dB					
B21-B22	1	Ø.Ø1 dB					
B31-B32	1	Ø.Ø1 dB					
B41-B44	1	Ø.Ø1 dB(m)Ø					
B45	2	1 CW (POS)	1 CW (NEG)				
B46	1	Ø.1 CW					
B51-B52	1	1 µs					
B61-B69	1	Ø.1 ms					
B71-B79	1	Ø.Ø1 dB(m)Ø					
B81	4	1 (FAS/B)	1 (FAS/W)	1 (MFRM)	1 (CRC)		
B82-B83	2	1E-9 (BIT)	1E-9 (OCT)				
B84	2	Ø.Ø1% (EFS)	Ø.Ø1% (ES)				
B91	6	FAS	NFAS	SEL.CH	MFAS	NMFAS	SIGN.W
B92	No data output						

Table 4-4 Number of partial results and measurement result units

4.3.4.1 Data output mode DMØ

In data output mode "DMØ", each data output string contains the results of a single measurement:

Output format:



<DESI>: = <DESI1> / <DESI2> / <DESI3> / <DESI4>
<DESI1>: = - (ASCII-space)
<DESI2>: = - / * / Z / > / < / S / ! / ?
<DESI3>: = - / T / Z / H / L / S / O / X
<DESI4>: = R <n> <DEL2>
<n> : = Ø / 1 / 2 / 3 / 4 / 5 / 6 / 7
<DESI> : = , / ; / :
<DESI> : = , / ; / :
<DESI> : = , / ; / :

Results designator:

DESI2	DESI3	DESI4	Meaning
_	_	0	Result in range
*	T	1	Result out of tolerance range
Z	Z	2	Input/output impedance out of tolerance (B 6x)
>	H	3	Overrange
<	L	4	Underrange
S	S	5	No synchronisation (PCM-30 receiver)
!	O	6	Analog input overdriven
?	X	7	Measurement not possible

Table 4-5 Explanation of DESI and DEL (see also DM... in 4.4.2)

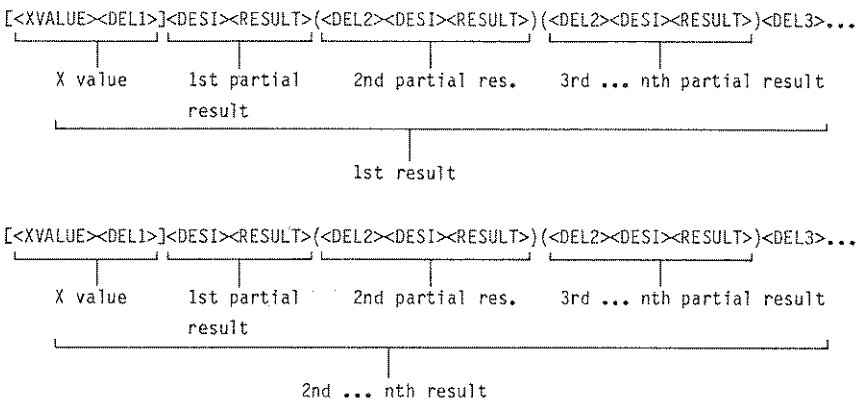
XVALUE and DEL1 are only output in DMd1dddd
DEL1 is between the X value and the result
DEL2 is placed between the partial results and between the designator and the result in DMdd3ddd (type 4 designator, numerical designator).

DEL3 has no meaning in DMØ data output mode.
Example: (MODE A11, result designator indicates out of tolerance)
DMØØØØØØ -3.Ø4
DMØØ1ØØØ *-3.Ø4
DMØØ2ØØØ T-3.Ø4
DMØØ3ØØØ R1,-3.Ø4
DMØ1Ø2ØØ 3ØØ1: -3.Ø4
DMØ132ØØ 3ØØ1:R1,-3.Ø4

4.3.4.2 Data output mode DM1

In data output mode DM1, a data string is output which contains all the results of the sequence of measurements.

Output format:



For explanation of DEL and DESI, see table 4-5

XVALUE and DEL1 are only output in DMd1ddd

DEL1 is placed between the X value and the result.

DEL2 is placed between the parital results and between the designator and the result in DMdd3ddd (designator 4, numerical designator).

DEL3 is placed between a result and the subsequent X VALUE or the next partial result if no XVALUE is output.

Example:

```
DM1ØØØØØ    +Ø.ØØ, -Ø.Ø7, -Ø.48, -3.Ø4,
DM1Ø3ØØ2    RØ, +Ø.ØØ: RØ, -Ø.Ø7: RØ, -Ø.48: R1, -3.Ø4,
DM113ØØØ    1ØØ4, RØ, +Ø.ØØ, 1496, RØ, -Ø.Ø7, 1997, RØ, -Ø.48, 3ØØ1, R1, -3.Ø4,
DM113ØØ1    1ØØ4, RØ, +Ø.ØØ; 1496, RØ, -Ø.Ø7; 1997, RØ, -Ø.48; 3ØØ1, R1, -3.Ø4;
DM1132Ø1    1ØØ4: RØ, +Ø.ØØ; 1496: RØ, -Ø.Ø7; 1997: RØ, -Ø.48; 3ØØ1: R1, -3.Ø4;
```

NOTE:

After the DM1 program word, either two commas or a comma and LF should be entered (i.e. DM1dddddd,, or DM1dddddd,LF) so as to extend the transmission time. The PCM-4 requires this extra time in order to reset the results stack pointer to the first result. If this is not done, the first result may not be correctly transmitted.

4.3.4.3 Data output mode DM2

In data output mode DM2, the status of the PCM-30 receiver is given as a number between 0 and 255. If this number is converted to binary, the individual status bits can be determined. The current status byte is transferred to the output buffer following:

- programming data output mode DM2, or
- after reading out the PCM-30 status byte from the output buffer.

This makes it possible to set up a loop in the program so that the status byte can be monitored ONLINE.

4.3.4.4 Data output mode DM7

In data output mode DM7, the date and time are output as a data string.

The format is: DD.MMM.YY HH:MM

4.3.4.5 Data output mode DM8

In data output mode DM8, the PCM-4 system status is output. If data is lost, bit 1 is set (at the moment, only bit 1 is used). Data loss occurs when:

- the battery is faulty,
- the CPU board is removed,
- /CLR/ is pressed when the instrument is being switched on.

4.3.4.6 Data output mode DM9

In data output mode DM9, the error messages can be called up and output (see 4.3.7, 4.3.8 and 4.4.2).

4.3.5 SMALL AUTOMATED TEST SYSTEM

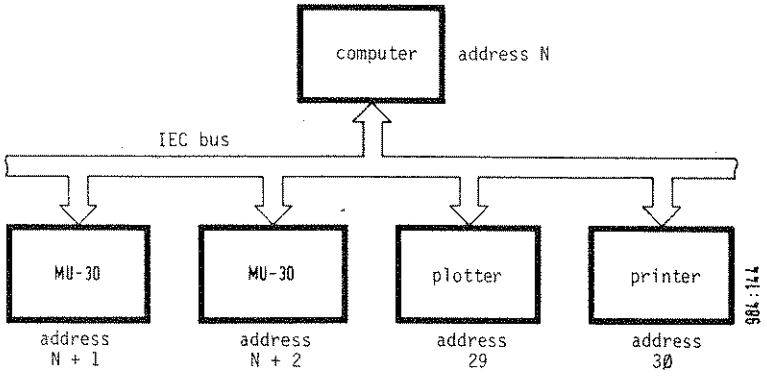


Figure 4-11 PCM-4 as system controller

In the setup shown in figure 4-11, the PCM-4 acts as system controller for the following:

- Test point scanner no. 1
- Test point scanner no. 2
- Plotter
- Printer

Setting up procedure:

* Switch off the PCM-4
* Set the SC switch on the interface board to ON
* Set the instrument addressesas follows:
  - MU-30 test point scanner no. 1 to N + 1
  - MU-30 test point scanner no. 2 to N + 2
  - Plotter to 29
  - Printer to 30
* Switch on the peripherals and then
* Switch on the PCM-4

  After the switch-on self-test of the PCM-4 is completed, all the peripherals which are switched on and correctly addressed will be initialised and switched to remote operation by the PCM-4.

When a measurement mode is selected for the first time after switching the PCM-4 on, the screen display for the chosen measurement mode will not be displayed until the PCM-4 has switched both MU-30s to remote operation. If only one MU-30 is connected, the delay will be initialisation time for the MU-30 plus a TIMEOUT for the second MU-30. If no MU-30s are connected, the delay will be twice the TIMEOUT.

4.3.6 USING THE PCM-4 WITH AN EXTERNAL SYSTEM CONTROLLER (COMPUTER)

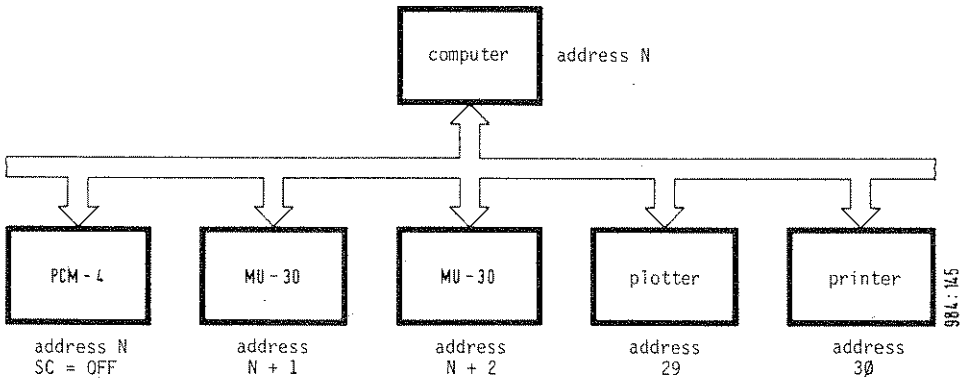


Figure 4-12 PCM-4 with computer as system controller

Here, the computer acts as system controller for the following:

- PCM-4
- Test point scanner no. 1
- Test point scanner no. 2
- Plotter
- Printer

Setting up procedure:

* Set the SC switch on the IEC interface of the computer to ON
* Set the SC switch on the IEC interface of the PCM-4 to OFF
* Set the following instrument addresses:
  - PCM-4 to N
  - MU-30 no. 1 to N + 1
  - MU-30 no. 2 to N + 2
  - Plotter to 29
  - Printer to 30

Two different control methods can be used:

1) The computer controls the peripherals directly, or
2) the computer releases control to the PCM-4 by means of the IEC bus command. This effects a considerable reduction in software requirements, but the following programming techniques must be observed in order that the complex IEC bus data exchange process functions correctly.

4.3.6.1 Control function

If control of a particular instrument is released by means of PW ZZbbbb, the PCM-4 takes over the control function and controls the peripheral instrument if the following IEC bus commands are issued:

- Measurement mode setting — MA, MB
- Configuration — CF
- Channel setting — CB, CR, CT, CS
- X axis scaling — XL, XU
- Running parameter setting (X parameter) — XP
- Recall — RM
- Var. mode — V
- Non controller mode — ZZ
- Trigger mode — TM
- Loss parameter setting — LP

4.3.6.2 Control function operation

- The PCM-4 sets bit 7 of the status byte to request controller function.
- If the controller mode YYlddddddddd has already been programmed, the PCM-4 sets the RQS (bit 6 of the status byte) and activates the SRQ line.
- The system controller (here: computer) recognises the controller function request and transfers control (CA) to the PCM-4 with PASS CONTROL.
- When CA is received by the PCM-4, it controls the IEC bus and can thus set the peripherals.
- After this, the PCM-4 returns the CA function to the computer.
- The computer cannot have access to the IEC bus when the CA function is transferred to the PCM-4.

It is thus possible for the PCM-4 to control peripheral instruments in local mode without having to alter the instrument set-up, if an external control computer is used.

For this, a program module which enables control of the transfer of the control function to the PCM-4 on request must be fitted in the control computer.

Before the system controller transfers CA to the PCM-4, the peripherals to be controlled (MU-30, plotter, printer must first of all be switched to remote operation. This normally occurs at the start of the program with the command:

REMOTE N (where N is the address of the peripheral)
or
CLEAR N

NOTE:

If the controller mask (YY) and the non-controller mask (ZZ) are transferred in remote operation, the PCM-4 will also request CA in LOCAL mode each time a command for control of peripherals is received. If YY1ddddddddd is programmed (SRQ for request of controller function) the CA request is triggered by the SRQ line.

N.B.:

In LOCAL mode,
- none of the controls are disabled
- TALKER, PARALLEL-POLL, and SERVICE REQUEST functions are active
- LISTENER, SERVICE CLEAR and SERVICE TRIGGER functions are inactive.

4.3.6.3 Initial accessing of the MU-30 by the PCM-4

The initial accessing of the MU-30 by the PCM-4 occurs after:
- mains on,
- /GENRL. RESET/ is pressed
- an IFC command if the CLR link is fitted or the CLR switch on the IEC bus board is ON,
- an SDC or DCL command

The initial accessing proceeds as follows:

1)	CA request	- request MU-30 status -	CA returned
2)	CA request	- basic setting -	CA returned
3)	CA request	- channel setting -	CA returned

The interrupt control must answer the three CA requests with CA transfer (PASS CONTROL).

The initial accessing of the MU-30 takes place at the same time as the non-controller mask is transferred (ZZ1...), i.e. the channel numbers already set in the PCM-4 are set in the MU-30 as soon as the controller function is released.

4.3.6.4 Transfer of controller function

> If no controller mode (ZZ1...) is transferred (also controller mode YY1...), all commands for setting peripheral instruments must come at the end of an output command, so that the control computer can transfer control to the PCM-4 immediately.
> This is necessary, as an OUTPUT command cannot be INTERRUPTed.

The PCM-4 requires a certain period of time in order to prepare for control of the peripheral instruments. It is therefore necessary that subsequent lines of the program do not begin before the CA transfer or return is completed, if the controller has SRQ interrupt recognition. To make sure that the controller waits when a PCM-4 peripheral command has been issued until the PCM-4 is ready, the following methods can be used:

a) After the transmission of the last OUTPUT command, two commas instead of one are sent. The second comma is not accepted by the PCM-4 immediately, and so transfer of bus commands is blocked. During this time, the PCM-4 can process the data already transmitted and activate the SRQ line to request CA. After this, the handshake procedure accepts the second comma, which does not in itself cause any instrument functions to be triggered.

NOTE: The OUTPUT command described above transmits the commands in compact format with LF and CR suppressed.

EXAMPLE:
```
10  ┐
.   │ Controller mode YY... and
.   } non-controller mode ZZ... transmitted
80  ┘
90    OUTPUT 702 USING "#,K";"CB19,,"
100   TRIGGER 702
```

b) Some controllers do not wait until the handshake cycle for the peripherals, which occurs after the last character is transferred, has ended. The next program line is thus already in the process of being interpreted. This means that a SRQ from the PCM-4 is not recognised until this interpretation is completed, so that the PCM-4 does not receive the CA command. If the next program line contains an OUTPUT or a TRIGGER command, the PCM-4 receives a further setting instruction instead. This means that the MU-30 is not set by the PCM-4, and the error bit in the status byte is set. The error message output will be:

E1 **/0003 = input disabled by present instrument status

REMEDY: Transmit two commas ",," or
transmit CR and LF as delimiter or
transmit 1 comma and either LF or CR.

```
EXAMPLE:  10 ⎫
          :  ⎪ Controller mode YY... and
          :  ⎬ non-controller mode ZZ... transmitted
          80 ⎭
          100   OUTPUT 702 USING "K";"CB19,"      ! CR + LF
or        100   OUTPUT 702 USING "#,K";"CB19,,"   ! 2 commas
          110   TRIGGER 702
```

You will need to check how the controller that you are using reacts, and use the most suitable method. You can put as many commas at the end of the program word as you like, as all controllers will accept this, but the object is to keep the transmission times as short as possible (see 4.3.2.3).

NOTE: We recommend that the non-controller mask ZZ1... is transferred immediately prior to the final channel setting command.

Example:

```
1ØØ OUTPUT 7Ø2 "#,K"; "XXØ1Ø3, XQ1, TMØ, MA11, CF1, XL3ØØØ, CT2Ø, ZZ1ØØØ,,"
                                        └─┬─┘ └┬┘ └──┬──┘ └─┬─┘ └──┬──┘
MU-30 not yet accessed ───────────────────┴────┴─────┴──────┘      │
Initial accessing of MU-30,  ⎫                                     │
channel setting of PCM-4     ⎬ ────────────────────────────────────┘
set in MU-30 at the same line.⎭
```

4.3.7 ERROR TRANSMISSION

If an error occurs during the course of the program run, bit 6 in the PCM-4 status byte is set. Data output mode DM9 can be used to read out the type of error. For this, the program run needs to be halted, the error analysed and the appropriate action taken to correct the error before processing.

4.3.7.1 Program interrupt on error

We will assume that an interrupt routine has been included in the program, for example:

```
500 ON INTR GOSUB 800
.....
800 OUTPUT 702 ; "DM9,,"
810 ENTER 702 , E$
820 OUTPUT 702 ; "DM*,,"          (DM* = reset data output mode which was set
830 PRINT E$                      prior to DM9)
840 RETURN
```

Whether the program halts when an error occurs, or the error message is overwritten, depends on PW "XQb" (SRQ on error).

XQØ No SRQ on error. The error message is stored, and the program is not interrupted. If a further error occurs, the first error message will be overwritten.

XQ1 SRQ on error. The error message is stored. If a further error occurs, the first error message is not overwritten, i.e. several error messages will be concatenated into a string. The program is halted and the interrupt routine runs. The error(s) are displayed (see 4.4.2). The error bit (bit 6 in the status byte) is only reset by a serial poll (SPOLL), by DCL, SDC and IFC.

NOTE: An SRQ does not only occur when an error occurs, but also when the PCM-4 requests AC, for example when an MU-30 is to be controlled (control bit D7 = true). For this reason, it is additionally necessary to read out bits D5 and D7 so that the necessary branch in the interrupt routine can be made.

4.3.8 ERROR MESSAGES

If bit 5 of the status byte = true, then an error has occured. The error message can be output using data output mode DM9, and has the format:

EX-KK/nnnn

E = ERROR

X = error number is formed from bits 1 (XNØ), 2 (XN1) and 3 (XN2) of the status byte.

X	XN2	XN1	XNØ	Error
Ø	Ø	Ø	Ø	no error
1	Ø	Ø	1	input error
2	Ø	1	Ø	meas. run error
3	Ø	1	1	IEC bus error
4	1	Ø	Ø	MU-30 no. 1 error
5	1	Ø	1	MU-30 no. 2 error
6	1	1	Ø	PLOTTER error
7	1	1	1	PRINTER error

Table 4-6 Error numbers

KK = error designation, indicates the type of error which has occured

KK	designation
--	no error
**	measurement error
??	unidentified word code
XY	XY input error

Table 4-7 Error designations

nnnn = number of error shown under "X"

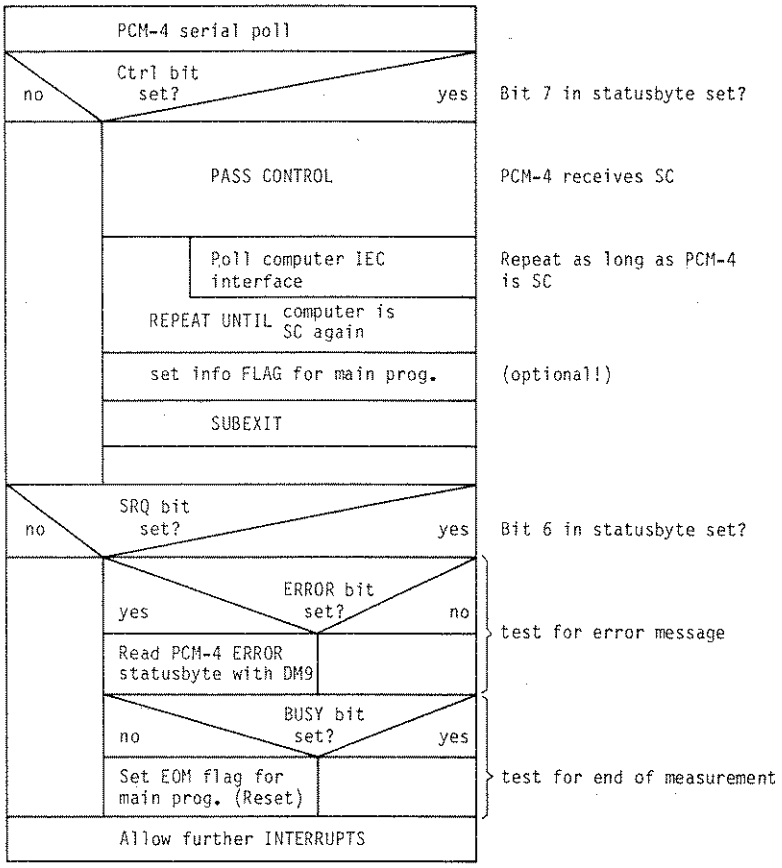
nnnn	Meaning
1	Undefined word code
2	Incorrect integer value entered
3	Input disabled by present instrument status
4	Measurement interrupted by input
5	Measurement impossible, error (missing option, etc.)
10	Setup no. not used
11	Setup no. already used
12	Stack overflow: incorrect initialisation of PCM-4
13	Memory full: no new setups can be stored
14	No sequence entries available
20	Y-Error: Upper Value < Lower Value
21	Y-Error: Range too small
22	X-Error: Upper Value < Lower Value
23	X-Error: Range too small
24	X-Error: Frame Conflict
101	Measuring Bridge not present
102	64 kbit Input not present
103	64 kbit Output not present
104	64 kbit Interfaces not present
105	64 kbit Input not available
106	64 kbit Output not available
107	Digital Loop not possible
108	Line Codes TX/RX different
109	Frame Type TS16 Ext. not possible
110	120 OHM Balanced not possible
111	Dig. Config./Frame Param. incompatible Select Param. No. 111 & 231
112	Measurement not possible/Select Param. No. 116
113	Mux/Demux Operation not possible Select Param. No. 111 or 116
114	Mux/Demux Operation not possible
115	Mux/Demux Operation not possible Select DIL-Switch on 64 kbit Input to Contradir.
116	Telephone Channel not possible
117	64 kbit Interfaces not available
118	Measurement not possible/Select correct Config./Frame
118	Measurement not possible/Select Param. 111, 113 or 116/221, 222 or 223
119	Mux/Demux operation not possible/no rx frame
125	CRC-4 Multiframe not possible/Select Frame Type G.704
126	CRC-4 Error not possible /Select Param. 232
134	Hardware Incompatible

Table 4-8 Input errors, X = 1

4.3.9 COMPLETE INTERRUPT ROUTINE

This is an interrupt routine suitable for allowing the computer to temporarily release control of the IEC bus to the PCM-4.

A suitable name for the routine: SUB INTERRUPT



Note: See program example 4.5.2 DEMO 3A, lines 2080 to 2690.

nnnn	Meaning
1	Stop on measurement not possible (Param. 921)

Table 4-9 Measurement run error X = 2

nnnn	Meaning
1	Controller address missing Send control word YY... from computer to PCM-4!

Table 4-10 IEC error X = 3

4.4 PROGRAM WORDS

4.4.1 OVERVIEW

Table 4-11 contains all the program words (instrument input data). Each program word (PW) consists of a code letter, the main section (decimal number, + or -), and a terminating character (,).

Once the code for the program word for setting the instrument functions has been determined from table 4-11, the program word can easily be formed with the help of the alphabetically arranged list of program word codes in section 4.4.2.

The program word codes are chosen as far as possible to serve as mnemonics for the functions they define (e.g. SM = Store Mode).

PW code	Function
A	RX octet display setting
B	Graphics mode functions
CA CB CF CR CS CT	Calibration request Send- and receive channel setting Configuration setting Receive channel setting Channel step setting Transmit channel setting
DM	Data output mode
EF EG EI EM ER ET	Error rate setting Graphics mode setting Error measurement interval setting Error measurement mode setting Error insertion Error type setting
FA FI FS	Absolute frequency setting Frequency increment setting Frequency step setting
GN	Graphic/numeric mode switchover
J	4-wire and TX/RX interface setting
LA LE LI LS LP	Absolute level setting Expected level setting Level increment setting Loss parameter setting Level step setting
MA MB MS	Mode A setting Mode B setting Measurement run setting
P	General parameter setting

Table 4-11 List of all program words

PW code	Function
RM	RECALL mode
RR	Relative receiver level setting
RS	Relative send level setting
SC	Screen control
SM	STORE mode
SQ	SEQUENCE mode
START	START measurement run
STOP	STOP measurement run
TM	Trigger mode setting
V	Var. mode parameter setting
XL	X scale setting
XP	Running parameter (X parameter) setting
XQ	SRQ request on error
XU	X scale setting
XX	Interface mode
YL	Y scale setting
YU	Y scale setting
YY	Controller mode
ZI	Input impedance setting
ZO	Output impedance setting
ZZ	Non controller mode

Table 4-11 List of all program words (continued)

4.4.2 ALPHABETICAL LIST OF PCM-4 PROGRAM WORDS

All the PW codes are listed in this section, from which (with the aid of the corresponding list of permissible settings - example, see figure 4-13) the program words can be formed. The heading of each table shows the meaning of the PW code.

The tables are set out as follows:

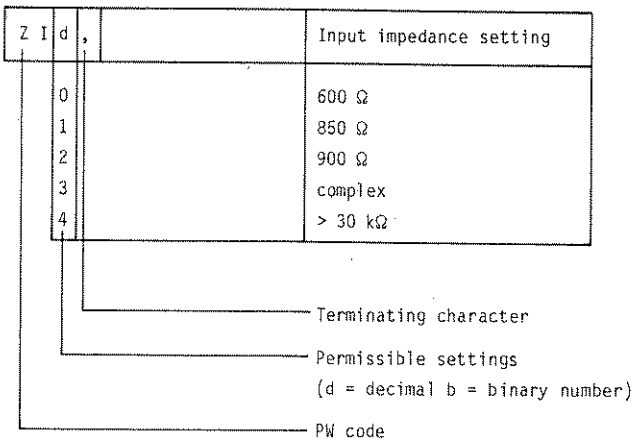


Figure 4-13 Example of a program word table

The SYNTAX given in the tables must be adhered to. An exception to this rule are numerical inputs; inputs in exponent form are also accepted.

Leading and trailing zeros need not be entered.

Example:
Frequency input (Hz):
"FA Ø1ØØØ.ØØ,"
"FA 1ØØØ," } is the same as

Units (e.g. dB, %, etc.) should not be entered. Similarly, the data sent by the PCM-4 to the controller will have no units specified.

If incorrect or illegal input data is received:
The setting commands are checked for correct syntax. Incorrect or incomplete program words are not accepted by the instrument and the settings remain unchanged. A corresponding error message may be displayed. Input values which are above or below the limit values for the instrument will result in the upper or lower limit value being set.

A

A d ,	RX octet display setting	
1	TELEPH. CHANNEL	BIT 1 ... 8
2	FRAME ALIGNMENT SIGN.	BIT 1 ... 8
3	NOT FRM. ALIGNMENT SIGN.	BIT 1 ... 8
4	MULTIFR. ALIGNMENT SIGN. NOT MULTIFR. ALIGN. SIGN.	BIT 1 ... 4 BIT 5 ... 8
5	SIGNALLING CHANNEL TX RX	BIT 1 ... 4 BIT 5 ... 8
6	DISPLAY OFF	

B

B d ,	Graphics mode functions
0	CLEAR
1	LINK
2	PRINT/PLOT
3	NUM

CA

C A ,	Calibration request
	Request calibration cycle before next measurement. Calibration cycle request stored and executed a) after end of measurement cycle or sweep in MAN/R or SWP/R modes b) before the next measurement in MAN/S or SWP/S modes

*****CB**

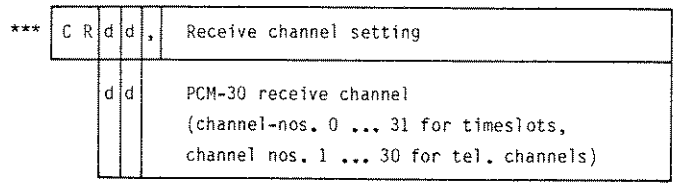
*** C B d d ,	Send- and receive channel setting
d d	PCM-30 send and receive channel (Channel nos. 0 ... 31 for timeslots, channel nos. 1 ... 30 for tel. channels)

CF

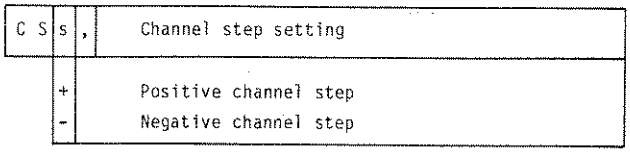
C F d ,	Configuration setting
0	AA
1	AD
2	DA
3	DD

*** Overlapping input possible in single trigger mode.

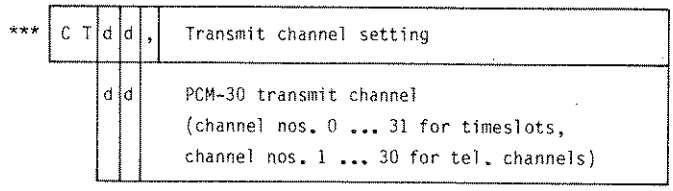
***CR



CS



***CT



*** Overlapping input possible in single trigger mode

D M	d	[	d	d	d	d	d	]	,	Data output mode
										Output
	Ø									Single result
	1									List of results
	2									PCM-30 digital receiver status
	7									Date and time
	8									PCM-4 system instrument status
	9									Error message
										X value output 1)
			Ø							Off
			1							On
										Result designator 1)
				Ø						Designator 1 (see designator)
				1						Designator 2 (symbol designator)
				2						Designator 3 (character designator)
				3						Designator 4 (numeral designator)
										Output delimiter 1 (DELIM1) 1)
					Ø					, (comma)
					1					; (semicolon)
					2					: (colon)
										Output delimiter 2 (DELIM2) 1)
						Ø				, (comma)
						1				; (semicolon)
						2				: (colon)
										Output delimiter 3 (DELIM3) 1)
							Ø			, (comma)
							1			; (semicolon)
							2			: (colon)

1) For single result or list of results outputs.

Data output DMØ..., DM1...,
To designate results, any of the 4 following character sets can be selected:

<DESI1>: = (ASCII-space)
<DESI2>: = / * / Z / > / < / S / ! / ?
<DESI3>: = / T / Z / H / L / S / O / X
<DESI4>: = R <n> <DEL2> (n = Ø ... 7)

The individual symbols have the following meanings:

DESI2	DESI3	DESI4	Meaning
_		0	Result in range
*	T	1	Result out of tolerance range
Z	Z	2	Input/Output impedance out of tolerance (B 6x)
>	H	3	Overrange
<	L	4	Underrange
S	S	5	No synchronisation (PCM-30 receiver)
!	0	6	Analog input overdriven
?	X	7	Measurement not possible

Table 4-12 Result designator meanings

See 4.3.4 for more details on data output and examples

Mode	Number of partial res.	1st. partial result	2nd. part. result	3rd. part. result	4th part. result	5th part. result	6th part. result
A11-A14	1	Ø.Ø1 dB(m)Ø					
A21-A27	1	Ø.Ø1 dB					
A31-A38	1	Ø.Ø1 dB					
A41-A46	1	Ø.Ø1 dB					
A51-A57	1	Ø.Ø1 dB					
A61-A66	1	Ø.Ø1 dB(m)Ø					
A71-A79	1	Ø.Ø1 dB(m)Ø					
A81-A83	1	Ø.Ø1 dB(m)Ø					
A91-A94	1	Ø.Ø1 dB					
B11-B13	1	Ø.Ø1 dB					
B21-B22	1	Ø.Ø1 dB					
B31-B32	1	Ø.Ø1 dB					
B41-B44	1	Ø.Ø1 dB(m)Ø					
B45	2	1 CW (POS)	1 CW (NEG)				
B46	1	Ø.1 CW					
B51-B52	1	1 µs					
B61-B69	1	Ø.1 ms					
B71-B79	1	Ø.Ø1 dB(m)Ø					
B81	4	1 (FAS/B)	1 (FAS/W)	1 (MFRM)	1 (CRC)		
B82-B83	2	1E-9 (BIT)	1E-9 (OCT)				
B84	2	Ø.Ø1% (EFS)	Ø.Ø1% (ES)				
B91	6	FAS	NFAS	SEL.CH	MFAS	NMFAS	SIGN.W
B92	No data output						

Table 4-13 Number of partial results and measurement result units

D M 2 ,	Data output mode
	PCM-30 digital receiver mode

Data is output in the form "nnn" (0 ... 255).
Meaning of output data:

128	64	32	16	8	4	2	1
NO STAT	NO SIGN	AIS	NO FRM	NO EX. F	NO MFRM	-	-

NO STAT = 1: PCM-30 Status = 128 Status not available at present

D M 7 ,	Data output mode
	Date and time

Date and time output in following format:
DD.MMM.YY HH.MM
e.g. " 7.MAR.86 9.33"

D M 8 ,	Data output mode
	PCM-4 system status

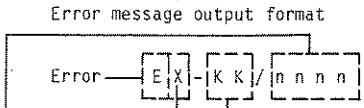
Data is output in the form "nnn" (0 ... 255).
Meaning of output data:

128	64	32	16	8	4	2	1
-	-	-	-	-	-	-	D.LOST

D.LOST: Data lost because: 1. battery faulty
2. CPU missing
3. /CLR/ pressed at switch-on

D M 9 ,	Data output mode
	Error message

Error message output format



X	Error
0	No error
1	Input error
2	Measurement run error
3	IEC bus error
4	MU-30 error instrument no. 1
5	MU-30 error, instrument no. 2
6	PLOTTER error
7	PRINTER error

KK	Identifier
--	No error
**	Measurement error
??	Unidentifiable word code
XY	XY input error

Table 4-14 Error numbers

Error numbers with X = 1 are input errors

nnnn	Meaning
1	Undefined word code
2	Incorrect integer value entered
3	Input disabled by present instrument status
4	Measurement interrupted by input
5	Measurement not possible due to error (missing option, etc.)
10	Setup no. not used
11	Setup no. already used
12	Stack overflow: PCM-4 incorrect initialised
13	Memory full: no new setups can be stored
14	No sequence entries available
20	Y-Error: Upper Value < Lower Value
21	Y-Error: Range too small
22	X-Error: Upper Value < Lower Value
23	X-Error: Range too small
24	X-Error: Frame Conflict
101	Measuring Bridge not present
102	64 kbit Input not present
103	64 kbit Output not present
104	64 kbit Interfaces not present
105	64 kbit Input not available
106	64 kbit Output not available

Table 4-15 Input errors (error no. 1)

nnnn	Meaning
107	Digital Loop not possible
108	Line Codes TX/RX different
109	Frame Type TS16 Ext. not possible
110	120 OHM Balanced not possible
111	Dig. Config./Frame Param. incompatible Select Param. No. 111 & 231
112	Measurement not possible/Select Param. No. 116
113	Mux/Demux Operation not possible Select Param. No. 111 or 116
114	Mux/Demux Operation not possible
115	Mux/Demux Operation not possible Select DIL-Switch on 64 kbit Input to Contradir.
116	Telephone Channel not possible
117	64 kbit Interfaces not available
118	Measurement not possible/Select correct Config./Frame
118	Measurement not possible/Select Param. 111, 113 or 116/221, 222 or 223
119	Mux/Demux operation not possible/no rx frame
125	CRC-4 Multiframe not possible/Select Frame Type G.704
126	CRC-4 Error not possible /Select Param. 232
134	Hardware Incompatible

Table 4-15 Input errors (error number 1) (continued)

X = 2 Run errors

nnnn	Meaning
1	Stop when measurement not possible (Param. 921)

Table 4-16 Run errors (error number 2)

X = 3 IEC bus error

nnnn	Meaning
1	Controller address missing Transmit YY... to PCM-4 from computer!

Table 4-17 IEC bus errors (error number 3)

EF

E F	d	,	Error rate setting
			Mode MB82 - Mode MB84 :
	0		PRS9 2 9-1
	1		PRS11 2 11-1
	2	B bbbbbbbb	WORD or VAR. MOD
			V 263 B bbbbbbbb,.

EG

E G	d	,	Graphics mode setting
			Mode MB82 - Mode MB83 :
	0		BIT
	1		OCT

EI

E I	h h : m m : s s	,	Error measurement interval setting
			Mode MB81 - Mode MB84 :
	h h		Hours
	m m		Minutes
	s s		Seconds

EM

E M	d	,	Error measurement mode setting
			Mode MB84 :
	0		EFS
	1		ES

ER

E R	,	Error insertion
E R	[ROR] ,	Mode MB82 - Mode MB84 :

ET

E T	d	,	Error type setting
			Mode MB81 :
	0		FAS B
	1		FAS W
	2		MFRM
	3		CRC

***FA

*** F A d d d d d , [d.ddk] Absolute frequency setting

d d d d d d	Frequency value [Hz]
d d . d d k	Frequency value [kHz]

FI

F I d d d d d , [d.ddk] Frequency increment setting

d d d d d d	Frequency increment value [Hz]
d d . d d k	Frequency increment value [kHz]

FS

F S s ,

Frequency step setting

+	Positive frequency step
-	Negative frequency step

GN

G N d ,

Graphic/numeric mode switchover

0	Numeric mode
1	Graphic mode

J

J b ,

4-wire and TX/RX interface setting

0	TX/RX interface
1	4 wire

***LA

*** L A s d d . d d ,

Absolute level setting

s d d . d d	Level value

LE

L E s d d . d d ,

Expected level setting

s d d . d d	Expexted receive level value (Level as per V512Lsdd.dd)

*** Overlapping input possible in single trigger mode

LI

L I s d d . d d ,		Level increment setting
s d d . d d		Level increment value

LP

L P d ,		Loss parameter selection setting
0		Softkey function for TX
1		MB11-13, MB21, 22 RX

LS

L S s ,		Level step setting
+		Positive level step
-		Negative level step

MA

M A d d ,		Mode A setting
d d		Mode no.

MB

M B d d ,		Mode B setting
d d		Mode no.

MS

M S d ,		Measurement run setting
0		Sweep single
1		Sweep repetitive
2		Manual single
3		Manual repetitive

P

P d d d [. . .] ,	General parameter setting
d d d ,	(1) no further parameter
d d d B b b b b ,	(2) 4 bit parameter
d d d B b b b b b b b b ,	(3) 8 bit parameter
d d d T h h . m m ,	(4) time parameter
d d d D d d . m m . y y ,	(5) date Parameter
d d d X x x . x ,	(6) percent parameter
d d d R d ,	(7) range parameter
	(2): P514, P515, P518
	(3): P512, P513, P516
	(4): P932, P936
	(5): P931
	(6): P629
	(7): P925

RM

R M d d [CFd] ,	RECALL mode
d d	Setup nos. 0 to 40, 50 (sequence)
0	Optional configuration AA
1	AD
2	DA
3	DD

RR

R R s d d . d d ,	Relative receiver level setting
s d d . d d	Level (-19.90 to +9.90 dB)

RS

R S s d d . d d ,	Relative send level setting
s d d . d d	Level (-19.90 to +9.90 dB)

SC

S C b ,	Screen control
0	Screen off
1	on

SM

S M [s] d d ,	STORE mode
- d d	Clear setups (-99: all)*
s d d	Setup nos. 0 to 40

* -50 also possible via IEC bus

SQ

S Q [s] d d N n n ,	Sequence mode
- d d	Clear sequence -50
d d	Setup nos. 0 ... 40
n n	Channel steps 1 ... 32

STA/STO

START/STOP	Measurement run
START, [STA,]	START
STOP, [STO,]	STOP

TM

T M d ,	Trigger mode setting
0	Continuous trigger mode
1	Single trigger mode

V

V ddd [...] ,	Var. mode parameter setting	
ddd ,		(1) no further parameter
ddd B	bbbbbbbb,	(2) 8 bit parameter
ddd W	sddd,	(3) code word parameter
ddd D	dd,	(4) duty cycle parameter
ddd F	ddddd, [..dd.ddk,]	(5) frequency parameter
ddd L	sdd.dd,	(6) level parameter
ddd R	d,	(7) range parameter
		(2) V263
		(3) V251, V252, V253
		(4) V711
		(5) V231, V253, V611
		(6) V154, V231, V512, V521, V621
		(7) V411, V421

XL

X L d d d d d d ,	X scale setting
	Lower limit, X scale
s d d . d d	Level [Hz]
d d d d d	Frequency [Hz]
d d . d d k	Frequency [kHz]
d d	Channel

XP

X P	d	,	Running parameter XP setting

Mode MA14, MA4x, MA5x, :

configuration	AA AD DA	DD
0	CHAN * *	CHAN
1	LEVEL	LEVEL

Mode MB81

configuration	DD
0	HISTO

Mode MB82 - MB84 :

configuration	DD
0	CHAN * *
1	HISTO

Modes MA11 - MA15, MA21 - MA24,
MAB51, MAB53 :

configuration	AA AD DA	DD
0	CHAN * *	CHAN
1	FREQ	FREQ
2	LEVEL	LEVEL

Modes MA3x, MA81, MA82, MB31,
MB32, MB52, MB54 :

configuration	AA AD DA	DD
0	CHAN * *	CHAN
1	FREQ	FREQ

Modes MA25 - MA27, MA6x, MA7x, MA83,
MA9x, MB4x, MB6x, MB7x :

configuration	AA AD DA	DD
0	CHAN * *	CHAN

XQ

X Q	b	,	SRQ request on error
	Ø		SRQ request when ERR = 1 no
	1		(ERR = bit 6/status register) yes

XU

X U	d	d	d	d	d	d	,	X scale setting
	s	d	d	.	d	d		Upper limit, X scale
	d	d	d	d	d			Level
	d	d	.	d	d	k		Frequency
	d	d						Channel
	d	d						Histogram

* * In Var. Mode 632, measurements versus channel are not possible.

XX

X X	b	b	d	d	d	,	Interface mode	
	0						SRQ at POWER ON	no
	1							yes
		0					SRQ at end of instrument	no
		1					function program	yes
			0				Parity bit, data output in ISO code No parity bit	
			1				Odd parity bit generation	
			2				Even parity bit generation	
				0			EOT character, ISO code No EOT character	
				1			"END" on last data byte	
				2			"END" and "ISO 7-bit character LF"	
				3			"ISO 7-bit character LF"	
					0		EOT character, non ISO code No EOT character	
					1		"END" on last data byte	
					2		"END" and "ISO 7-bit character LF"	

YL

Y L	d	d	d	d	d	d	,	Y scale setting	
	s	d	d	.	d	d		Lower limit, Y scale dB, dB[m]0	
	s	d	d	d				CW	(B45 - B46)
	d	d	d	d	d			µs	(B51 - B54)
	d	d						ms	(B61 - B69)
	d							1E+d	(B81, B83)
	d							1E-d	(B82)

YU

Y U	d	d	d	d	d	d	,	Y scale setting	
	s	d	d	.	d	d		Upper limit, Y scale dB, dB[m]0	
	s	d	d	d				CW	(B45 - B46)
	d	d	d	d	d			µs	(B51 - B54)
	d	d						ms	(B61 - B69)
	d							1E+d	(B81, B83)
	d							1E-d	(B82)

YY

Y Y	b	d	d	d	d	d	d	d	d	,	Controller mode	
	Ø										SRQ for request of controller function	no
	1											yes
		d	d								Talker address of external controller	(0 ... 31)
				d	d						Second talker address of external controller	(0 ... 31)
						d	d				Listener address of external controller	(0 ... 31)
								d	d		Second listener address of external controller	(0 ... 31)

ZI

Z I	d	,	Input impedance setting
	0		600 Ω
	1		850 Ω
	2		900 Ω
	3		complex
	4		> 30 kΩ

ZO

Z O	d	,	Output impedance setting
	0		600 Ω
	1		850 Ω
	2		900 Ω
	3		complex

ZZ

Z Z	b	b	b	b	,	Non-controller mode	
	Ø					Enable control of 1st. MU-30 by PCM-4	no
	1						yes
		0				Enable control of 2nd. MU-30 by PCM-4	no
		1					yes
			0			Enable control of PLOTTER by PCM-4	no
			1				yes
				0		Enable control of PRINTER by PCM-4	no
				1			yes

4.4.3 BASIC INSTRUMENT SETTINGS

- Switch S 3 set to ON
  IFC or SDC commands from the control computer reset the PCM-4 and the interface (corresponds to pressing /GENRL RESET/ in manual operation).
- Switch S 3 set to OFF
  IFC command from the controller resets the interface only. To reset the PCM-4 as well, an SDC command is required.

Function (control)	Setting corresponds to IEC program word
Mode	Mode selection page 1
SRQ mask:	X Q Ø
Interface mode:	X X Ø Ø Ø 1 1
Controller mode:	Y Y Ø 3 1 3 1
Non controller mode:	Z Z Ø Ø Ø Ø
Trigger mode:	T M Ø
Data output mode:	D M Ø
Screen control	S C 1
Digital Word Displ. off [11]	A 6
Both Channels Ø1 [5]	C B 1
Graphic mode [2]	G N 1
4-wire interface [14]	I 1
Gen. Parameter [1]	P 1 1 1 P 1 2 3 P 2 1 1 P 2 2 1 P 3 1 1 P 3 2 1 P 3 3 1 P 4 1 1 P 4 2 1 P 5 1 1 P 5 2 1 P 6 1 1 P 7 1 1 P 7 2 1 P 8 1 1 P 8 2 1 P 9 1 1 P 9 1 3 P 9 1 5
Rel. Level Recv. [8]	R R Ø
Rel. Level Send [8]	R S Ø
RX-Impedance [13]	Z I Ø
TX-Impedance [15]	Z O Ø
Operation	on "Selected Device Clear" (SDC): Remote on "Interface Clear" (IFC): Local

Table 4-18 Basic setting of the PCM-4 after reset

4.4.4 STATUS BYTE

The instrument issues a status byte onto the IEC bus in response to a serial poll. The status byte gives information as to the current operational status of the instrument, the bits being assigned the meanings shown in table 4-19.

DIO 8 Bit 7	DIO 7 Bit 6	DIO 6 Bit 5	DIO 5 Bit 4	DIO 4 Bit 3	DIO 3 Bit 2	DIO 2 Bit 1	DIO 1 Bit 0
Control	RQS	Error	Busy	Power On	XN2	XN1	XNØ
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Table 4-19 Status byte meaning

DIO 8: Control

Control transfer request
DIO 8 = 1 indicates that the PCM-4 has requested control from the controller.

DIO 7: RQS

Service request
DIO 7 = 1 indicates that the instrument has issued an SRQ.

DIO 6: ERROR

Error identifier
DIO 6 = 1 indicates that the PCM-4 has detected an error. The type of error is given by bits DIO 3 to DIO 1 (error number). DIO 6 (ERROR) and DIO 3 to DIO 1 (XN) are all reset by a serial poll or by DCL, SDC and IFC.

DIO 5: Busy

Measurement in progress
DIO 5 = 1 indicates that a measurement is in progress.

DIO 4: Power On

DIO 4 = 1 indicates that a power supply failure has occurred. It is not possible to call up the status byte information if the power supply is down. DIO 4 is cleared by the reset functions DCL and SDC.

DIO 3 to DIO 1: Error numbers (0 to 7), see also 4.3.4.6, 4.3.5 and 4.4.2 (DM9)

XN2	XN1	XN0	Error
0	0	0	No error
0	0	1	Input error
0	1	0	Measurement run error
0	1	1	IEC bus error
1	0	0	MU-30 no. 1 error
1	0	1	MU-30 no. 2 error
1	1	0	PLOTTER error
1	1	1	PRINTER error

4.5 EXAMPLE PROGRAMS

4.5.1 DEMO 2A ON HP 9816: TRANSFER CONTROL FROM COMPUTER TO PCM-4

```
10    ! ************************************************************************!
20    ! HP9816-COMPUTER                                      WANDEL & GOLTERMANN !
30    !                                                                        !
40    ! DEMOPROGRAM  NO 2A                "DEMO2A"                04-02-86  !
50    !                                                                        !
60    !                                                                        !
70    ! ************************************************************************!
80    !
90    ! PCM4 controls the Scanner MU30
100   ! The Controller passes the STATUS "Active Controller" to the device PCM4
110   !
120   COM /Io/ @Pcm4
130   COM /Stat/ Dm$[6],INTEGER S_p,Measure_flag,Cont_trans_flag
140   DIM E$[300]
150   !
160   LOADSUB Interrupt FROM "DEMO3A"   ! See DEMO3A
170   !
180   N=702
190   ASSIGN @Pcm4 TO N
200   ASSIGN @Mu30 TO N+1
210   STATUS 7,1;S1                     ! Clear the Interrupt-Register.
220   !
230   CLEAR @Pcm4
240   CLEAR @Mu30                 ! First Initialization of the Scanner.
250   !
260   ! Definition of the Interface-Interrupt
270   ! -------------------------------------
280   ON INTR 7 CALL Interrupt          ! IF an Interrupt occurs THEN CALL Int.
290   ENABLE INTR 7;2                   ! Enable HP-IB SRQ Interrupt.
300   !
310   ! Initialization
320   ! --------------
330   OUTPUT @Pcm4 USING "#,K";"XX0103,YY121,XQ1,TM0,MA71,ZZ1,,"
340   Dm$="111210"
350   !
360   ! Measurement
370   ! -----------
380   OUTPUT @Pcm4 USING "#,K";"CR25,," ! >>>>> 2. Comma suspends transfer
390                                     ! of the next OUTPUT-statement
400                                     ! to allow the program to 'pass Control
410                                     ! if required.
420   Measure_flag=1
430   TRIGGER @Pcm4                     ! Start measurement
440   !
450   REPEAT                            ! Wait until end of Measurement
460   UNTIL Measure_flag=0
470   !
480   WAIT .12                              ! WAIT until Results are
490                                         ! stored in PCM4-memory.
500                                         ! Only Series B and C
510                                         !
520   OUTPUT @Pcm4 USING "#,K";"DM",Dm$,","  !
530                                         ! 2. Comma to suspend transfer
540                                         ! of following ENTER-statement
550                                         ! until internal pointers of
560                                         ! PCM4 are adjusted.
570   ENTER @Pcm4 USING "#,K";E$
580   !
590   !
600   PRINT CHR$(12)                        ! Clear Screen
610   PRINT "RESULTS:"
620   PRINT E$                              ! Display results
630   !
640   END
```

4.5.2 DEMO 3A ON HP 9816: OPTIMISING MEASUREMENT RATE

```
10    ! ********************************************************************* !
20    ! HP9816-Computer                                    WANDEL & GOLTERMANN  !
30    !                                                                       !
40    ! DEMOPROGRAM  NO 3A                  "DEMO3A"          04-02-86       !
50    !                                                                       !
60    !                                                                       !
70    ! ********************************************************************* !
80    !
90    !
100   ! This program shows some methods to achieve maximum speed of
110   ! measurement. The used methods are:
120   ! - to switch off the Display and Tolerance-masks
130   ! - overlapped Datatransfer
140   ! - to switch off the Automatic Ranging
150   ! - to send an Expected Level
160   ! - to store the Measurement-Modes for further use in the STORE-MODE-List
170   !
180   ! The Subprogram "Interrupt" is a common program with following functions:
190   ! - Transfer of the Controller-Active Status to the PCM4
200   ! - Test of the SRQ-Statusbit, Error-Statusbit and Busy-Statusbit.
210   ! - The ERROR-Status-Byte is read and displayed on the screen.
220   !
230   ! The Subprogram "Recr_exp" is a common program for measurement-cycle
240   ! control using the TM1 Mode (overlapped input/output).
250   !
260   ! With the Interface-Mode (XX....) the PCM4 is forced to send an Interrupt
270   ! when  a measurement is finished.
280   !
290   !
300   OPTION BASE 1
310   COM /Io/ @Pcm4
320   COM /Stat/ Dm$[6],INTEGER S_p,Measure_flag,Cont_trans_flag
330   DIM Setup$[80]
340   REAL Test_rpar(20),Explev(20),Result1(20),Result2(20),Result3(20),Result4(
20)
350   INTEGER N
360   !
370   !
380   ASSIGN @Pcm4 TO 702
390   STATUS 7,1;S1                                  ! Clear the Interrupt-Register
400   PRINTER IS 1
410   CLEAR @Pcm4                                    ! Device Clear
420   !
430   !
440   !
450   ! Definition of the Interface-Interrupt
460   ! -------------------------------------
470   ON INTR 7 CALL Interrupt                        ! IF an SRQ-Interrupt occurs
480   ENABLE INTR 7;2                                 ! THEN CALL Subprogram
490   !                                               ! "Interrupt".
500   !
510   !
520   !
530   ! Setup  List
540   ! -----------
550 Test1:    DATA "MA11,V512L-40,V532,V343,MS2,FA1014,P924,"  ! Mode-Setup
560 Xp1:      DATA LA,6                                ! Meas. vs Level (TX:"LA")
570           DATA -60,-50,-40,-30,-20,-10             !
580 Ep1:      DATA -40,-40,-40,-10,-10,-10             ! Expected RX-Level
590   !
600 Test2:    DATA "MA51,V512L-20,V532,MS2,XP1,CF2,LA-50,P924,"
610 Xp2:      DATA LA,6                                !
620           DATA -50,-40,-30,-20,-15,-10             !
630 Ep2:      DATA 20,30,37,37,37,37                   !
640   !
```

```
660   ! Setup PCM-4
670   ! ------------
680   !
690   Dm$="003000"            ! Datamode
700   OUTPUT @Pcm4 USING "#,K";"XX0103,XQ1,TMO,SCO,DM",Dm$,","
710   !                       ! This Initialization must  be sent in the TMO-Mode.
720   !                       ! To speed up the measurement, the DISPLAY is
730   !                       ! switched off.
740   !                       ! XQ1 = Enable SRQ-Interrupt
750   !
760   RESTORE Test1
770   READ Setup$,Xp$,N,First_rpar
780   RESTORE Ep1
790   READ First_explev
800   Store_mode(1,N,Setup$,Xp$,First_rpar,First_explev)
810   !
820   RESTORE Test2
830   READ Setup$,Xp$,N,First_rpar
840   RESTORE Ep2
850   READ First_explev
860   Store_mode(2,N,Setup$,Xp$,First_rpar,First_explev)
870   !
880   !
890   !
900   ! ============================================================================
910   !
920   ! Measurement
930   ! -----------
940   !
950   PRINT "STATUS: Running"
960   !
970   RESTORE Xp1
980   READ Xp$,N
990   REDIM Test_rpar(N),Explev(N)
1000  READ Test_rpar(*),Explev(*)
1010  Recr_exp(1,N,1,Xp$,Test_rpar(*),Explev(*),Result1(*))
1020  !
1030  !
1040  !
1050  RESTORE Xp2
1060  READ Xp$,N
1070  REDIM Test_rpar(N),Explev(N)
1080  READ Test_rpar(*),Explev(*)
1090  Recr_exp(2,N,1,Xp$,Test_rpar(*),Explev(*),Result1(*))
1100  !
1110  PRINT "STATUS: Stopped"
1120  PRINT
1130  !
1140  END
1150  !
1160  !
1170  ! ============================================================================
1180  !
1190  !
1200  SUB Recr_exp(INTEGER Setup_nr,Steps,N_res,Xp$,REAL Rpar(*),Explev(*),Res1(
*),OPTIONAL REAL Res2(*),Res3(*),Res4(*))
1210  !
1220  ! Setup_nr  : Nr. of Setup to use("RMnn,")
1230  ! Steps     : # of Measurements
1240  ! N_res     : # of Subresults (1 .. 4)
1250  ! Xp$       : Sweep-Parameter for remote-control of PCM-4 (eg. "LA")
1260  ! Rpar      : Array of Sweep-Parameters
1270  ! Explev    : Array of Expected RX-Level assigned to Sweep-Parameters
1280  ! Res.      : Array for Subresult n (1 .. 4)
1290  !
```

```
1300  COM /Io/ @Pcm4
1310  COM /Stat/ Dm$[6],INTEGER S_p,Measure_flag,Cont_trans_flag
1320  !
1330  I=1
1340  !
1350  IF Steps=1 THEN
1360    OUTPUT @Pcm4 USING "#,K";"RM",Setup_nr,","      ! Recall of the stored
1370    TRIGGER @Pcm4                                   ! Mode.
1380    GOSUB Wait_meas_end
1390    GOSUB Read_result
1400  ELSE
1410    OUTPUT @Pcm4 USING "#,K";"TM1,"                 ! To speed up the
1420    OUTPUT @Pcm4 USING "#,K";"RM",Setup_nr,","      ! measurement, the
1430    TRIGGER @Pcm4                                   ! Overlapped input/
1440    Last_explev=Explev(1)                           ! output-Datatransfer
1450    REPEAT
1460      OUTPUT @Pcm4 USING "#,K";Xp$,Rpar(I+1),","    ! is used [TM1].
1470      El=Explev(I+1)
1480      IF El<>Last_explev THEN
1490        OUTPUT @Pcm4 USING "#,K";"LE",El,","       ! Expected Level:
1500        Last_explev=El              ! While adressing the PCM4 in the
1510      END IF                        ! TM1-Mode, the used Operation-Code
1520      !                             ! is "LE". Set the pointer to V512
1530      !                             ! during TM0-Mode ( s. SUB Store_mode )
1540      !
1550      GOSUB Wait_meas_end
1560      !
1570      TRIGGER @Pcm4
1580      GOSUB Read_result
1590      I=I+1
1600    UNTIL I=Steps
1610    GOSUB Wait_meas_end
1620    OUTPUT @Pcm4 USING "#,K";"TM0,"                 ! Datatransfermode TM0 before
1630    GOSUB Read_result                               ! reading the last result
1640  END IF
1650  SUBEXIT
1660  !
1670  ! ---------------------------------------------------------------------------
1680 Wait_meas_end:                                     !
1690  Measure_flag=1
1700  REPEAT                                            ! Wait until End of Measurement
1710  !
1720  UNTIL Measure_flag=0
1730  RETURN
1740  !
1750  ! ---------------------------------------------------------------------------
1760 Read_result:                                       !
1770  !
1780  ! In some Measurement-Modes the PCM4 sends 2 (3 or 4) results. This
1790  ! subprogram  reads such subresults.
1800  !
1810 Read_res: IMAGE  #,4(A,D,K)
1820  ON N_res GOSUB Read1,Read2,Read3,Read4
1830  RETURN
1840  !
1850 Read1: ENTER @Pcm4 USING Read_res;A$,K1,Res1(I)
1860  RETURN
1870 Read2: ENTER @Pcm4 USING Read_res;A$,K1,Res1(I),A$,K2,Res2(I)
1880  RETURN
1890 Read3: ENTER @Pcm4 USING Read_res;A$,K1,Res1(I),A$,K2,Res2(I),A$,K3,Res3(I)
1900  RETURN                                            !
1910 Read4: ENTER @Pcm4 USING Read_res;A$,K1,Res1(I),A$,K2,A$,Res2(I),A$,K3,Res3
(I),A$,K4,Res4(I)
1920  RETURN
1930  !
1940  SUBEND
```

```
1960  ! ------------------------------------------------------------------------
1970  ! This Subprogram stores the Measurement-Modes in the "STORE-MODE-List".
1980  ! The pointer of the Expected Level is set to V512 .
1990  ! Before storing the  Mode, the List-Adress is erased.
2000  !
2010  SUB Store_mode(INTEGER Rm_nr,N,Rm$,Xp$,Par1,Explev1)
2020  COM /Io/ @Pcm4                          !
2030  OUTPUT @Pcm4 USING "#,K";Rm$,",",Xp$,Par1,",V512L",Explev1,","
2040  OUTPUT @Pcm4 USING "#,K";"SM-",Rm_nr,",SM",Rm_nr,","
2050  SUBEND
2060  ! ------------------------------------------------------------------------
2070  !
2080  SUB Interrupt        ! ================= General Interruptroutine =====
2090  !
2100  COM /Io/ @Pcm4
2110  COM /Stat/ Dm$[6],INTEGER S_p,Measure_flag,Cont_trans_flag
2120  !
2130  STATUS 7,1;S1                           ! Clear the Interrupt-Register
2140  S_p=SPOLL(@Pcm4)                        ! Clear Status _Register of PCM4
2150  !
2160  ! Testing the CONTROLLER-ACTIVE-DEMAND of the PCM4
2170  IF BIT(S_p,7) THEN                      ! Not used in Program DEMO3A
2180     !
2190     ! Transfer of the CONTROLLER ACTIVE-Status
2200     PASS CONTROL @Pcm4                   ! Transfer of the Act.-Controller-
2210                                          ! Status to the Interface (PCM4).
2220                                          !
2230     ENABLE INTR 7;-32768                 ! HP-IB Interrupt enabled only for
2240                                          ! internal actions of HP9816.
2250                                          ! This Interrupt will not be passed
2260                                          ! to User-Program-Layer.
2270                                          ! Don't think about. DO IT!
2280                                          !
2290     REPEAT                               ! Wait until Active Controller-
2300       STATUS 7,4;Statcon                 ! State (PCM4 passes Active Control
2310     UNTIL BIT(Statcon,15)                ! to HP9816).
2320     Cont_trans_flag=1                    ! Flag: Active Controller changed.
2330     ENABLE INTR 7;2                      ! Re-enable HP-IB SRQ Interrupt.
2340     SUBEXIT
2350  END IF
2360  !
2370  !
2380  ! Testing the SRQ-Status
2390  IF BIT(S_p,6) THEN                      !
2400  !
2410  !  Testing the ERROR-Status
2420     IF BIT(S_p,5) THEN
2430        !
2440        ! Reading the ERROR-Statusbyte
2450        PRINT CHR$(12)
2460        PRINT
2470        PRINT USING "K";CHR$(130)&" SRQ-ERROR "&CHR$(128)
2480        OUTPUT @Pcm4 USING "#,K";"DM9,,"  !
2490        ENTER @Pcm4 USING "#,K";Errorstr$
2500        OUTPUT @Pcm4 USING "#,K";"DM",Dm$,",,"!Datamode corresponds
2510        PRINT                                 !to the main program.
2520        PRINT " Error-Status : ",Errorstr$
2530        PRINT
2540        PRINT " Program stopped -->  Analyse the Error-Status-Byte,  please"
2550        PRINT
2560        PRINT " Continue with key ""CONTINUE"""
2570        PAUSE                             ! Program is stopped
2580        SUBEXIT
2590     END IF
2600     !
2610     !
2620     ! Testing the BUSY-Status
2630     IF NOT BIT(S_p,4) THEN Measure_flag=0 ! IF Busy THEN return.
2640     !                                     ! Flag signals the end of
2650     !                                     ! measurement.
2660  END IF
2670  !
2680  ENABLE INTR 7;2                         ! Re-enable HP-IB  SRQ Interrupt.
2690  SUBEND
```

4.5.3 IEC 11A ON HP 85: TRANSFER CONTROL FROM COMPUTER TO PCM-4

```
100 ! ************************ !
110 ! HP85              06-02-86 !
120 !                            !
130 !                            !
140 !                            !
150 !    PROGRAM  "IEC11A"       !
160 !                            !
170 !    Test program for        !
180 ! PCM-4  IEC bus operation   !
190 !                            !
200 !          MA11              !
210 ! Run parameter CHANNEL      !
220 ! MU30 controlled by PCM-4   !
230 !                            !
240 ! Wait for end of measure-   !
250 ! ment with interrupt        !
260 ! Results output together    !
270 ! in one data string (due    !
280 ! to MU-30 control by PCM-4!
290 !                            !
300 ! ************************ !
310 !
320 OPTION BASE 1
330 PRINTER IS 2 !
340 DIM R$[1000]
350 IOBUFFER R$
360 DIM E9$[10]
370 INTEGER C,M,N,S0,S1,S5
380 INTEGER T0,T1
390 !
400 ! Interface initialisation
410 ! ------------------------
420 N=702 ! Adress of PCM-4
430 !
440 CLEAR N
450 CLEAR N+1 ! Primary initialisation, MU-30 scanner
460 !
470 !
480 OUTPUT N USING "#,K" ; "X01,YY121," ! Enable CA
490 !
500 !
510 ON INTR 7 GOSUB 1160
520 ENABLE INTR 7;8 ! Enable SRQ
530 !
540 !
550 ! Start measurement
560 ! ------------------
570 CLEAR
580 DISP "STATUS: Running"
590 !
600 ! Set measurement mode
610 ! ----------------------
620 !
630 ! ZZ mask to enable PCM-4 to control MU-30 transferred at end
640 ! Thereafter, (Series A-D) a selective channel setting is required
650 OUTPUT N USING "#,K" ; "XX0102,YY121,X01,TM0,MA71,ZZ1,,"
660 !
670 OUTPUT N USING "#,K" ; "CR25,,"
680 !
690 !
700 ! Start of measurement cycle
710 M=1 ! Reset end of measurement flag
720 TRIGGER N
730 !
740 !
```

```
750 !
760 !
770 ! Wait for end of last measurement
780 !
790 GOSUB 1600
800 !
810 !
820 !
830 ! Reading-in of results
840 !
850 WAIT 120 ! Wait until data in output buffer (series B+C)
860 OUTPUT N ;"DM110000,," ! Write DM1... command before enter
870 !
880 TRANSFER N TO R$ FHS ; EOI
890 !
900 ! End of measurement
910 ! ------------------
920 !
930 PRINT "TEST NO 11A"
940 PRINT
950 !
960 DISP "STATUS: Stopped"
970 !
980 !
990 !
1000 ! Output of results read in
1010 ! ---------------------------
1020 PRINT " CHAN     RESULT "
1030 PRINT "-------------------"
1040 !
1050 STATUS R$,0 ; T0,T1 ! Check of buffer contents
1060 IF T0=T1 THEN 1100 ! EOT character ignored and not printed
1070 PRINT USING "X,DD,7X,SZZ.DD" ; X,R
1080 GOTO 1050
1090 !
1100 LOCAL N
1110 END
1120 !
1130 !
1140 !
1150 !
1160 ! Interrupt routine
1170 ! ------------------
1180 !
1190 S0=SPOLL(N) ! Status PCM4  (PCM4 interrupt, controller transfer,
1200 !           ! end of measurement, error)
1210 WAIT 1 !    ! HP85 internal Wait
1220 STATUS 7,1 ; S1 ! Reset interrupt flag on the controller
1230 IF BIT(S0,7)=0 THEN 1320
1240 !
1250 ! Control transfer
1260 PASS CONTROL N
1270 STATUS 7,5 ; S5 ! Poll of controller active status
1280 IF BIT(S5,5)=0 THEN 1270
1290 C=1 ! Flag: Controller active changed
1300 GOTO 1550
1310 !
1320 ! SRQ status poll
1330 IF BIT(S0,6)=0 THEN GOTO 1550
1340 !
1350 !
1360 ! Error status poll
1370 IF BIT(S0,5)=0 THEN GOTO 1520
1380 !
1390 !
1400 CLEAR
```

```
1410 DISP "SOR-ERROR"
1420 OUTPUT N USING "#,K" ; "DM9,," ! Data output mode: Error status data string
1430 ENTER N USING "#,K" ; E9$ !    ! Reading the error status data string
1440 DISP "FEHLER:",E9$
1450 PRINT "FEHLER:",E9$
1460 OUTPUT N USING "#,K" ; "DM110002," ! Datamode is the same as in the
1470 DISP !                             ! main program
1480 DISP "Continue with CONT"
1490 PAUSE
1500 GOTO 1550
1510 !
1520 ! Busy status poll
1530 IF BIT(S0,4)=0 THEN M=0 ! Recognise EOM and set flag
1540 !
1550 ENABLE INTR 7;8 ! Enable SRQ interrupt
1560 RETURN
1570 !
1580 !
1590 !
1600 ! Subroutine: Wait for end of measurement
1610 !
1620 IF M=1 THEN GOTO 1620
1630 RETURN
```

4.5.4 SETUPS ON HP 9816: INPUT/OUTPUT OF SETUPS TO/FROM DISKETTE

```
10      ! "SETUPS_E"
20      ! ************************************************************************
30      ! HP 9816                                                  22 Apr 1987   11:30
40      ! ************************************************************************
50      !
60      ! This program stores/recalls the setup memory of the PCM-4 to/from
70      ! diskette.
80      !
90      ! NOTE: Data is transferred in ASCII code, i.e., 2 ASCII HEX characters
100     !       per byte (e.g. "E0")
110     !
120     ! The ASCII characters in this example are not packed before storing on
130     ! diskette, so twice as much memory space will be required as usual.
140     !
150     ! PCM-4 SETUP memory          start address:  EB20H
160     !                             length.......:  4584  bytes
170     !
180     !-------------------------------------------------------------------------
190     !
200     ! Definitions
210     Printer=730
220     Ff$=CHR$(12)                           ! Form Feed
230     Cr$=CHR$(13)                           ! Carriage Return
240     !
250     ! Buffer
260     INTEGER Blocks
270     Blocks=36
280     DIM Buffer$[9216]
290     !
300     ! ----------------------------------------------------------------------------
310     !
320     !
330     ! Input control commands
340     !-------------------------
350 Start:                                     !
360     PRINT CHR$(12)
370     PRINT "                  P C M - 4   Setup  Store/Load  Utility"
380     PRINT "                  ------------------------------------------"
390     PRINT
400     PRINT
410     PRINT "      This program SAVEs or LOADs all 40 setups"
420     PRINT "      to or from a disk-file."
430     PRINT
440     PRINT
450     PRINT "       PCM-4 Addr. ?"
460     PRINT
470     PRINT "       Filename : ?"
480     PRINT "       Function : ?"
490     !
500     REPEAT
510       DISP "Input PCM-4 IEC bus address (default = 2) ";
520       N=99
530       INPUT N
540       IF N=99 THEN N=2
550     UNTIL N>=0 AND N<=30
560     PRINT TABXY(18,10);N
570     ASSIGN @Pcm4 TO 700+N
580     !
```

```
590     REPEAT
600       DISP "Input Filename: ";
610       INPUT Filename$
620       IF LEN(Filename$)=0 THEN BEEP 800,.5
630     UNTIL LEN(Filename$)>0
640     PRINT TABXY(18,12),Filename$
650     !
660     REPEAT
670       DISP "Input function L=LOAD or S=SAVE: ";
680       INPUT Function$
690       IF Function$="l" OR Function$="L" THEN Function$="LOAD"
700       IF Function$="s" OR Function$="S" THEN Function$="SAVE"
710     IF NOT (Function$="LOAD" OR Function$="SAVE") THEN BEEP 800,.5
720     UNTIL Function$="LOAD" OR Function$="SAVE"
730     PRINT TABXY(18,13),Function$
740     !
750     !
760     !-------------------------------------------------------------------------
770     !
780     ! Main program
790     !
800     IF Function$="SAVE" THEN                ! SAVE
810        DISP "STATUS: Reading PCM-4 setups"
820        OUTPUT @Pcm4 USING "7A";"R:EB20,"
830        ENTER @Pcm4 USING "#,9168A";Buffer$
840        LOCAL @Pcm4
850        !
860        DISP "STATUS: Saving setups into file ";Filename$
870        ON ERROR GOTO Create_error
880        CREATE BDAT Filename$,Blocks         ! Create new file
890        ASSIGN @File TO Filename$            ! Open file
900        OUTPUT @File;Buffer$                 ! Transfer
910        ASSIGN @File TO *                    ! Close file
920     ELSE                                    ! LOAD
930        DISP "STATUS: Loading setups from file ";Filename$
940        ASSIGN @File TO Filename$
950        ENTER @File;Buffer$
960        !
970        DISP "STATUS: Storing PCM-4 setups"
980        OUTPUT @Pcm4 USING "#,7A,9168A,A";"W:EB20.",Buffer$,","
990        LOCAL @Pcm4
1000       ASSIGN @File TO *
1010    END IF
1020    !
1030    DISP "STATUS: Ready"
1040    STOP
1050    !
1060    !-------------------------------------------------------------------------
1070    !
1080  Create_error:                             !
1090    BEEP 800,.5
1100    PRINT
1110    PRINT
1120    PRINT "File '";Filename$;"' already exists. Program aborted!"
1130    !
1140    !
1150    END
```

5 OPTIONS, ACCESSORIES

5.1 64 kbit/s INTERFACES

Five different types of 64 kbit/s interface are available for the PCM-4 as options:

- Codirectional 64 kbit/s input BN 0984/00.01
  codirectional 64 kbit/s output BN 0984/00.02

  This interface has characteristics to CCITT Recommendation G.703.

- Contradirectional 64 kbit/s input BN 0984/00.03
  contradirectional 64 kbit/s output BN 0984/00.04

  This interface has characteristics to CCITT Recommendation G.703.

- Serial 64 kbit/s TTL input BN 0984/00.05
  serial 64 kbit/s TTL output BN 0984/00.06

  Input and output are switchable between codirectional and contradirectional signal flow.

- Parallel 64 kbit/s TTL input BN 0984/00.07
  parallel 64 kbit/s TTL output BN 0984/00.08

  Input with codirectional signal flow only.
  Output switchable between codirectional and contradirectional signal flow.

- 64 kbit/s V.11 interface BN 0984/00.09

  Input/output via 15-pin connector to CCITT Recommendation X.24 or ISO 4903.

Fitting the interface

There are two slots on the back panel of the PCM-4 for the 64 kbit/s input and output modules. The 64 kbit/s input module is fitted in the left-hand slot, the 64 kbit/s output module in the right-hand slot.

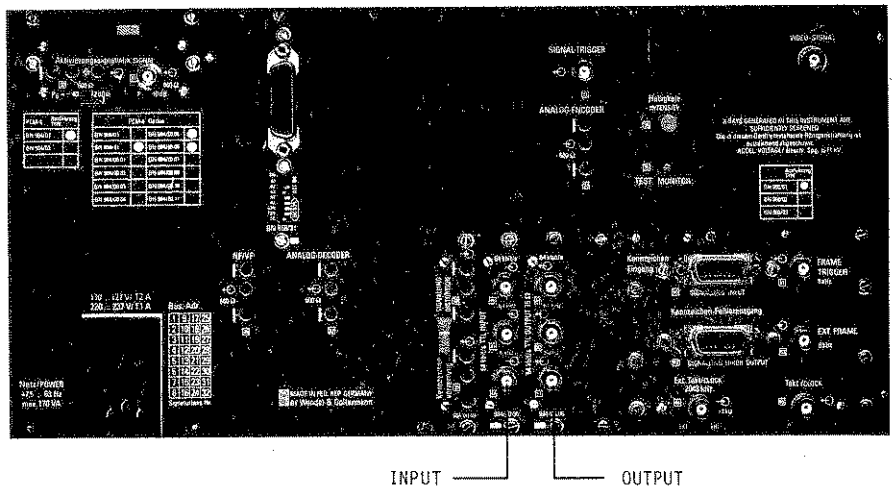


Figure 5-1 Fitting the 64 kbit/s interface

NOTE:

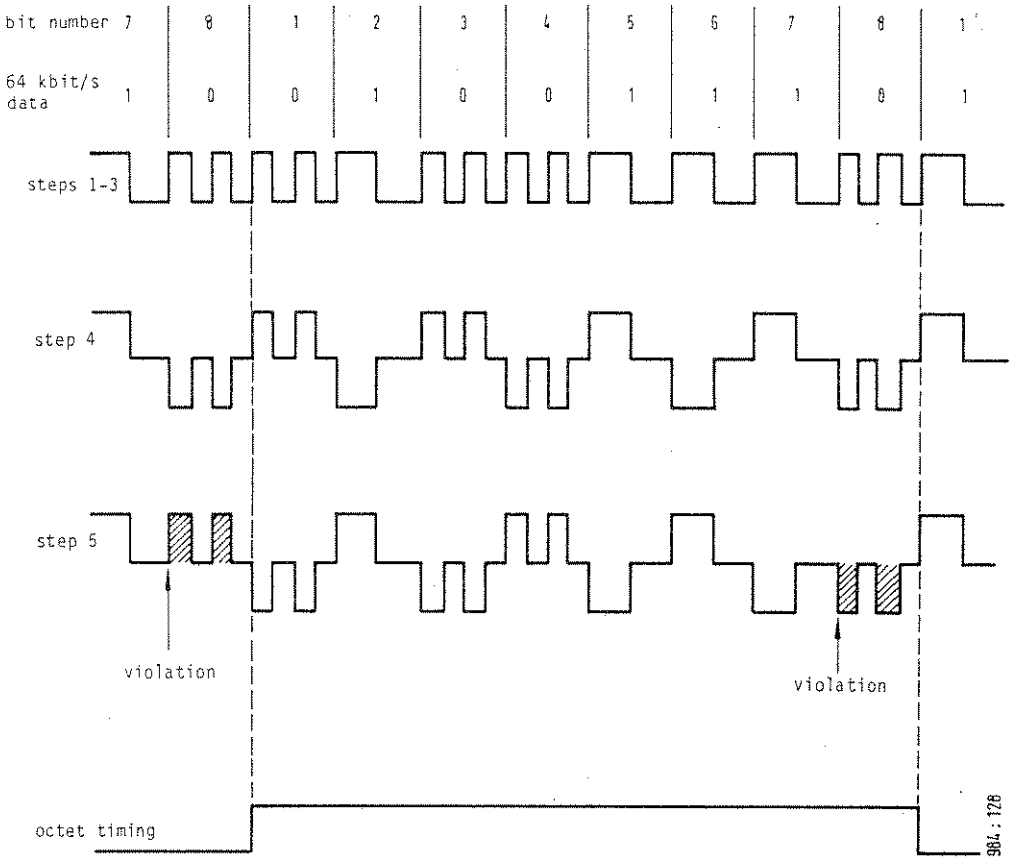
The analog noise signal is generated digitally in the PCM-4. This requires an 8 kHz clock, which is derived from the 64 kbit/s interface in the two cases defined below. It must always be provided if an analog noise signal is selected as the output signal on the analog side.

1) A 64 kbit/s output is set for contradirectional operation and selected via parameter 112 or 113.
2) The 64 kbit/s output is set for codirectional operation in a digital-digital configuration via parameter 112 or 113, and parameter 334 (CLOCK FROM RECEIVER) has also been selected.

5.1.1 CODIRECTIONAL 64 kbit/s INTERFACE TO CCITT G.703

With this interface, a combination signal is transmitted in both directions via one balanced line each at a modulation rate of 256 kbaud. This signal contains not only the 64 kbit/s data signal, but also the 64 kHz and 8 kHz clock information in encoded form. The interface can only be operated with a codirectional signal flow.

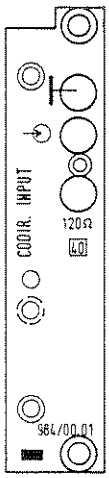
Step 1 A 64 kbit/s bit period is divided into four unit intervals.
Step 2 A binary one is coded a s a block of the following four bits: 1100
Step 3 A binary zero is coded as a block of the following four bits: 1010
Step 4 The binary signal is converted into a three-level signal by alternating the polarity of consecutive blocks
Step 5 The alternation in polarity of the blocks is violated every 8th block. The violation block marks the last bit in an octet.



Code conversion to CCITT Rec. G./03
Section 1.2.1
Figure 4/G.703

Figure 5-2 Coding rule for the codirectional signal

5.1.1.1 Codirectional 64 kbit/s input BN 0984/00.01



256 kbaud input

NB: Parameter 124 (64 kbit/s loop at A-A) cannot be selected with the codirectional 64 kbit/s input.

Receiver operation with parameter 112 or 114

If this parameter is selected, the 64 kbit/s input operates as a digital receiver. The 64 kbit/s signal received can be used for all digital measurements selectable under MODE.

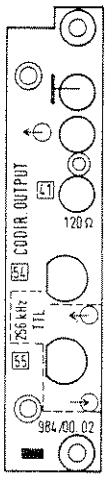
MUX operation with parameter 212 or MODE B92

If parameter 212 or MODE B92 is selected, the 64 kbit/s input operates as a multiplexer in conjunction with parameter 111. Parameter 212 injects an external digital signal into time slot 16, or into the selected time slot in MODE B92.
In this mode, the 2048 kHz output clock of the PCM-4 is derived from the 8 kHz component of the 256 kbaud input signal by a PLL circuit.

NB: MUX operation via the codirectional 64 kbit/s input in conjunction with parameter 116 (2 Mbit/s tandem operation) is not possible.

The demultiplexer and the PCM-4 have separate clock sources which are not synchronized. Parameter 334 (clock from receiver) must be selected for codirectional 64 k / 2 M measurements to prevent bit slips.

5.1.1.2 Codirectional 64 kbit/s output BN 0984/00.02



256 kbaud output

256 kHz unjittered clock output

256 kHz jittered clock input

NB: Parameter 124 (64 kbit/s loop at A-A) cannot be selected with the codirectional 64 kbit/s output.

Generator operation with parameter 112 or 113

If this parameter is selected, the 64 kbit/s output operates as a digital generator. All digital signals selectable under MODE and VAR. MODE can be output.

Note: The jitter tolerance of devices under test with codirectional 64 kbit/s interface can be determined with parameter 112 in MODE B83 if the 256 kbaud output signal is given a defined jitter. To do this, the 256 kHz clock can be be passed from output [54] via a jitter modulator and the clock signal jittered in this way then fed to input [55].

DEMUX operation with parameter 222 or MODE B92

If parameter 222 or MODE B92 is selected, the 64 kbit/s output operates as a demultiplexer in conjunction with parameter 111. Parameter 222 outputs the digital signal from time slot 16, or the digital signal from the selected time slot in MODE B92.

NB: DEMUX operation via the codirectional 64 kbit/s input in conjunction with parameter 116 (2 Mbit/s tandem operation) is not possible.

5.1.2 Contradirectional 64 kbit/s interface to CCITT G.703

This interface has two separate balanced lines each for the output and input directions. One line carries the AMI-coded 64 kbit/s data, while the other carries the AMI 1/2-coded 64 kbit/s clock and the 8 kHz octet information in the form of a bipolar violation (see fig. 5-3).

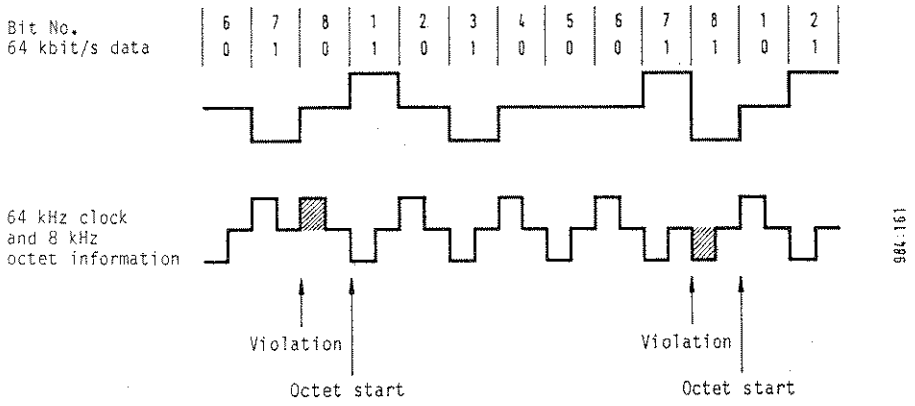


Figure 5-3 Signal shape of the contradirectional 64 kbit/s interface to CCITT G.703, Figure 7

In accordance with Figure 3 of CCITT Recommendation G.703 (see Fig. 5-4), a contradirectional interface carries the clock information (of both data transmission directions) in the direction of the data terminal (Office Terminal Service Side).

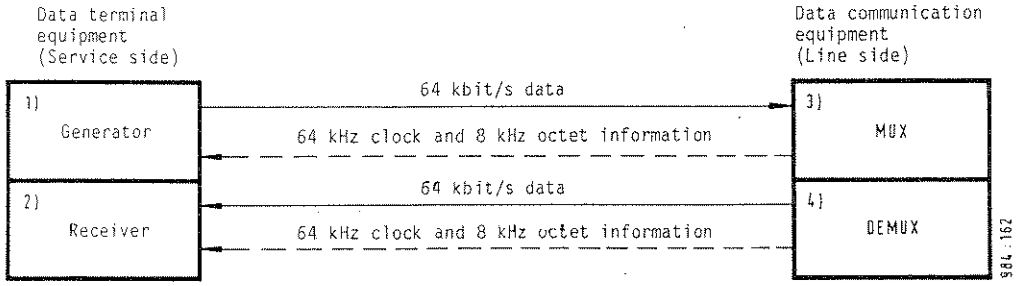
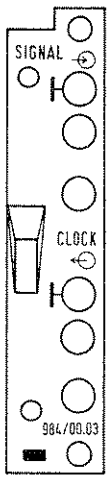


Figure 5-4 Contradirectional interface to CCITT G.703, Figure 3

1) Contradirectional 64 kbit/s output of the PCM-4 operating as a 64-kbit/s generator (parameter 112 or 113)
2) Contradirectional 64-kbit/s input of the PCM-4 operating as a 64-kbit/s receiver (parameter 112 or 114).
3) Contradirectional 64-kbit/s input of the PCM-4 operating as a multiplexer (parameter 212 or MODE B92)
4) Contradirectional 64-kbit/s output of the PCM-4 operating as a demultiplexer (parameter 222 or MODE B92).

5.1.2.1 Contradirectional 64 kbit/s input BN 0984/00.03



64 kbit/s data input

64 kHz clock and 8 kHz octet information.
Input when operating as 64 kbit/s receiver, output when operating as multiplexer

Receiver operation with parameter 112 or 114

If this parameter is selected, the 64 kbit/s input operates as a digital receiver. The 64 kbit/s signal received can be used for all digital measurements selectable under MODE.

In conjunction with the contradirectional 64 kbit/s output, the 64 kbit/s loop can be closed internally in the A-A configuration by selecting parameter 124.

Note: Signal flow of digital signal and clock as per item 2, fig. 5-4.

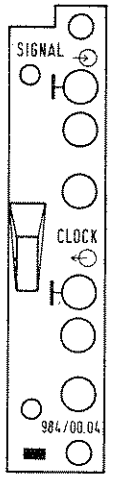
MUX operation with parameter 212 or MODE B92

If parameter 212 or MODE B92 is selected, the 64 kbit/s input operates as a multiplexer in conjunction with parameter 111. Parameter 212 injects an external 64 kbit/s signal into time slot 16, or into the selected transmission channel in MODE B92.

MUX operation is possible in MODE B92 via the contradirectional 64 kbit/s input in conjunction with parameter 116 (2 Mbit/s tandem operation).

Note: Signal flow of digital signal and clock as per item 3, fig. 5-4.

5.1.2.2 Contradirectional 64 kbit/s output BN 0984/00.04



64 kbit/s data output

64 kHz clock and 8 kHz octet information
Input when operating as 64 kbit/s receiver, output when operating as demultiplexer

Generator operation with parameter 112 or 113

If this parameter is selected, the 64 kbit/s output operates as a digital generator. All digital signals selectable under MODE and VAR. MODE can be output.
In conjunction with the contradirectional 64 kbit/s input, the 64 kbit/s loop can be closed internally in the A-A configuration by selecting parameter 124.

Note: Signal flow of digital signal and clock as per item 1, fig. 5-4.

DEMUX operation with parameter 222 or MODE B92

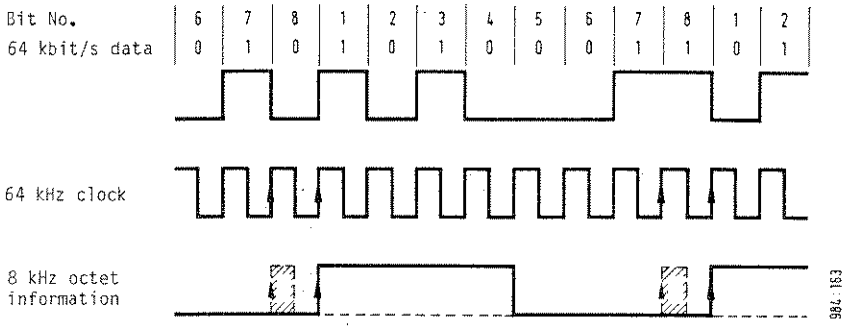
If parameter 222 or MODE B92 is selected, the 64 kbit/s output operates as a demultiplexer in conjunction with parameter 111. Parameter 222 outputs the 64 kbit/s signal from time slot 16, or from the selected receive channel in MODE B92.

DEMUX operation is only possible in MODE B92 via the contradirectional 64 kbit/s output in conjunction with parameter 116 (2 Mbit/s tandem operation).

Note: Signal flow of digital signal and clock as per item 4, fig. 5-4.

5.1.3 SERIAL 64 kbit/s TTL INTERFACE

This interface has three separate coaxial lines each with TTL signals for the output and input directions. One line carries the NRZ-coded 64 kbit/s data. The other lines carry the 64 kHz clock and the 8 kHz octet information (see Fig. 5-5).



1) Phase relationship between 8 kHz octet information and 64 kbit/s data can be switched over for contradirectional companion signals (64 kHz clock and 8 kHz octet information)

Figure 5-5 TTL signals of the serial 64 kbit/s interface

Codirectional or contradirectional signal direction of companion signals

The signal direction of the 64 kHz clock and 8 kHz octet information can be switched from co-directional to contradirectional on the individual 64 kbit/s plug-in cards.

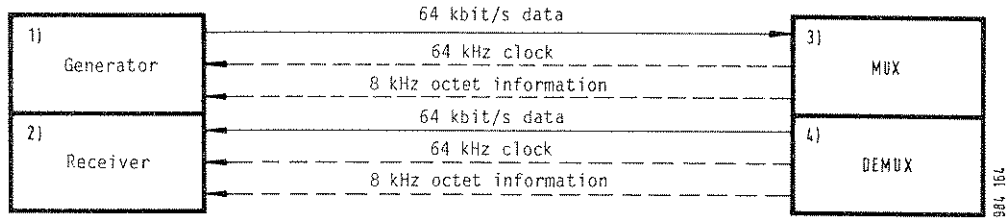


Figure 5-6 Serial 64 kbit/s interface of the PCM-4 in contradirectional setup

1) Serial 64 kbit/s output of the PCM-4 operating as a 64 kbit/s generator (parameter 112 or 113) with contradirectional companion signals.

   The positive edge of the 8 kHz octet information marks the start of bit 1 or bit 8 of the PCM octet in the 64 kbit/s data (switchable).

2) Serial 64 kbit/s input of the PCM-4 operating as a 64 kbit/s receiver (parameter 112 or 114) with codirectional companion signals.

   The positive edge of the 8 kHz octet information must mark the start of bit 1 of a received PCM octet in the 64 kbit/s data.

3) Serial 64 kbit/s input of the PCM-4 operating as a multiplexer (parameter 212 or MODE B92) with contradirectional companion signals.

   The positive edge of the 8 kHz octet information marks bit 1 of a received PCM octet in the 64 kbit/s data. The duty cycle of the 8 kHz signal is 0.5 (pulse duty factor 1:1).

   Switchable:
   The positive edge of the 8 kHz octet information marks bit 8 of a received PCM octet in the 64 kbit/s data. The 8 kHz signal is a pulse of 7.8 µs duration.

   NB: The maximum permissible delay of bit 1 or bit 8 in relation to the positive edge of the 8 kHz signal is 7 µs.

4) Serial 64 kbit/s output of the PCM-4 operating as a demultiplexer (parameter 222 or MODE B92).

   The positive edge of the 8 kHz octet information marks the start of bit 1 of the PCM octet in the 64 kbit/s data.

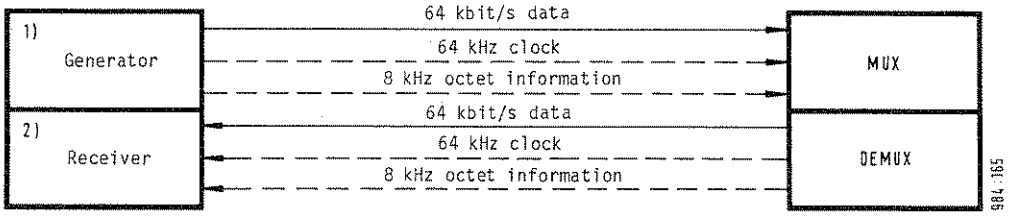


Figure 5-7 Serial 64 kbit/s interface of the PCM-4 in codirectional setup

1) Serial 64 kbit/s output of the PCM-4 operating as a 64 kbit/s generator (parameter 112 or 113) with codirectional companion signals.

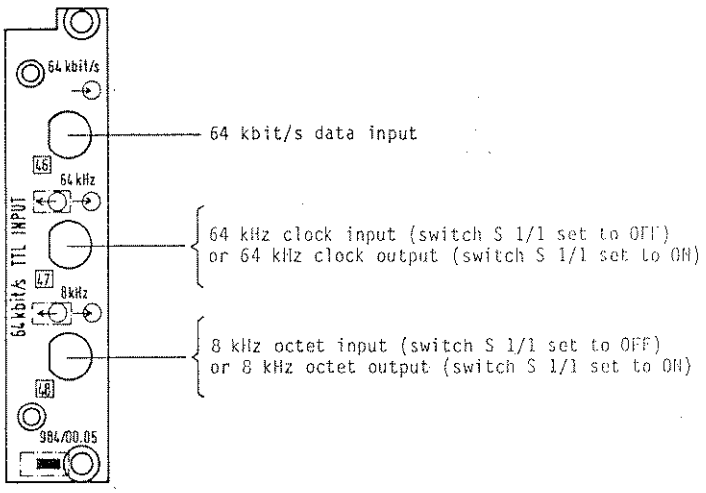
2) See fig. 5-6, item 2.

3) Serial 64 kbit/s input of the PCM-4 operating as a multiplexer (parameter 212 or MODE B92) with codirectional companion signals. The 2048 kHz output clock of the PCM-4 is derived from the 8 kHz signal with a PLL circuit.

   The positive edge of the 8 kHz signal must mark the start of bit 1 of a received PCM octet in the 64 kbit/s data.

4) See fig. 5-6, item 4.

5.1.3.1 Serial 64 kbit/s TTL input BN 0984/00.05



Receiver operation with parameter 112 or 114

If this parameter is selected, the 64 kbit/s input operates as a digital receiver. All digital measurements selectable under MODE are possible with the 64 kbit/s signal received.

In conjunction with the serial 64 kbit/s TTL output, the 64 kbit/s loop can be closed internally in the A-A configuration by selecting parameter 124.

NB: Switch settings for receiver operation (see fig. 5-6, item 2, and fig. 5-7, item 2):

Switch S 1/1 set to OFF = codirectional
Switch S 1/4 set to OFF = 8 kHz, bit 1

MUX operation with parameter 212 or MODE B92

If parameter 212 or MODE B92 is selected, the 64 kbit/s input operates as a multiplexer in conjunction with parameter 111. Parameter 212 injects an external 64 kbit/s signal into time slot 16, or into the selected output channel in MODE B92.

In conjunction with parameter 116 (2 Mbit/s tandem operation), MUX operation in MODE B92 is only possible with contradirectional companion signals (see Fig. 5-6, Item 3).

NB: Switch settings for MUX operation with contradirectional companion signals (see fig. 5.6, item 3):

Switch S 1/1 set to ON = contradirectional

Switch S 1/3 set to OFF = 64 kHz clock as asymmetrical TTL signal
or
Switch S 1/3 set to ON = 64 kHz clock as signal symmetrical about zero

Switch S 1/4 set to OFF = 8 kHz, bit 1
or
Switch S 1/4 set to ON = 8 kHz, bit 8

NB: Switch settings for MUX operation with codirectional companion signals (see Fig. 5-7, Item 3):

Switch S 1/1 set to OFF = codirectional
Switch S 1/4 set to OFF = 8 kHz, bit 1

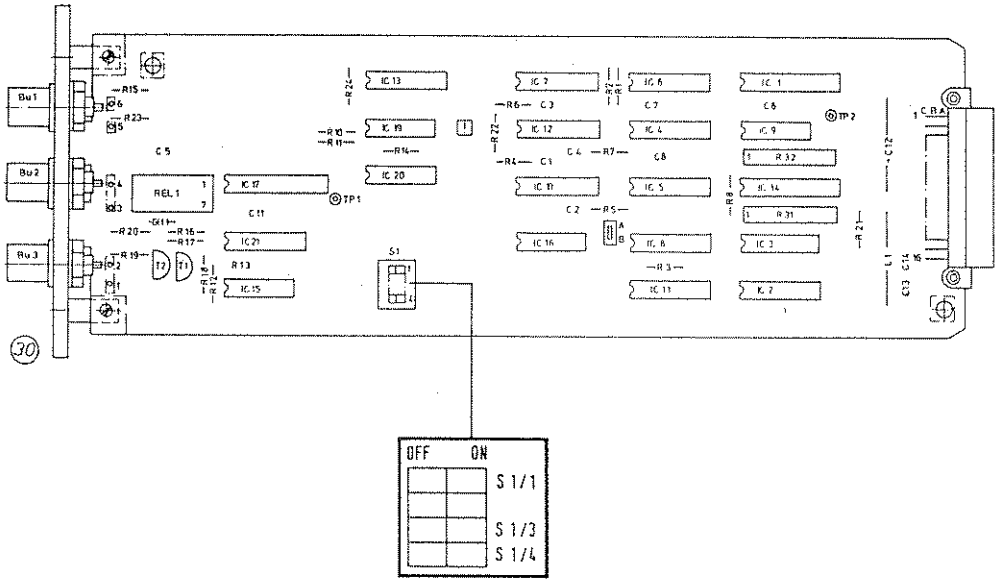
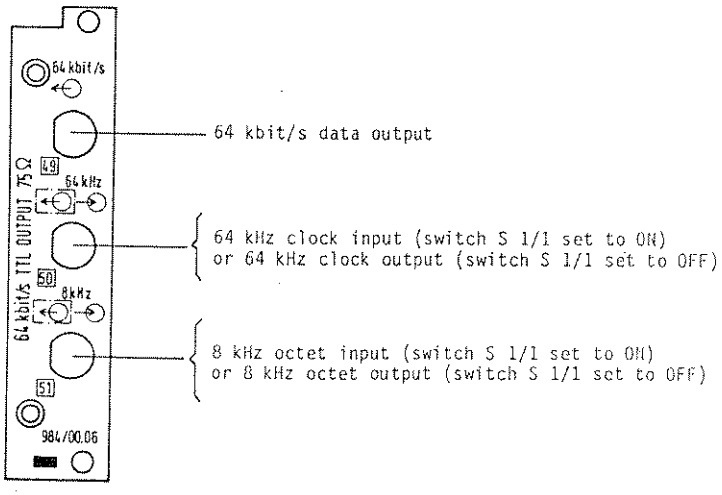


Figure 5-8 Switch S 1 on serial 64 kbit/s TTL input

5.1.3.2 Serial 64 kbit/s TTL output BN 0984/00.06



Generator operation with parameter 112 or 113

If this parameter is selected, the 64 kbit/s output operates as a digital generator. All digital signals selectable under MODE amd VAR. MODE can be output.

In conjunction with the serial 64 kbit/s input, the 64 kbit/s loop can be closed internally in the A-A configuration by selecting parameter 124.

NB: Switch settings for generator operation with contradirectional companion signals (see fig. 5-6, item 1):

Switch S 1/1 set to ON = contradirectional
Switch S 1/4 set to OFF = 8 kHz, bit 1
or
Switch S 1/4 set to ON = 8 kHz, bit 8

NB: Switch settings for generator operation with codirectional companion signals (see fig. 5-7, item 1):

Switch S 1/1 set to OFF = codirectional
Switch S 1/4 set to OFF = 8 kHz, bit 1

DEMUX operation with parameter 222 or MODE B92

If parameter 222 or MODE B92 is selected, the 64 kbit/s output operates as a demultiplexer in conjunction with parameter 111. Parameter 222 outputs the 64 kbit/s signal from time slot 16, or from the selected time slot in MODE B92.

NB: Switch settings for DEMUX operation with codirectional companion signals (see fig. 5-6, item 4, and fig. 5-7, item 4):

Switch S 1/1 set to OFF = codirectional
Switch S 1/4 set to OFF = 8 kHz, bit 1

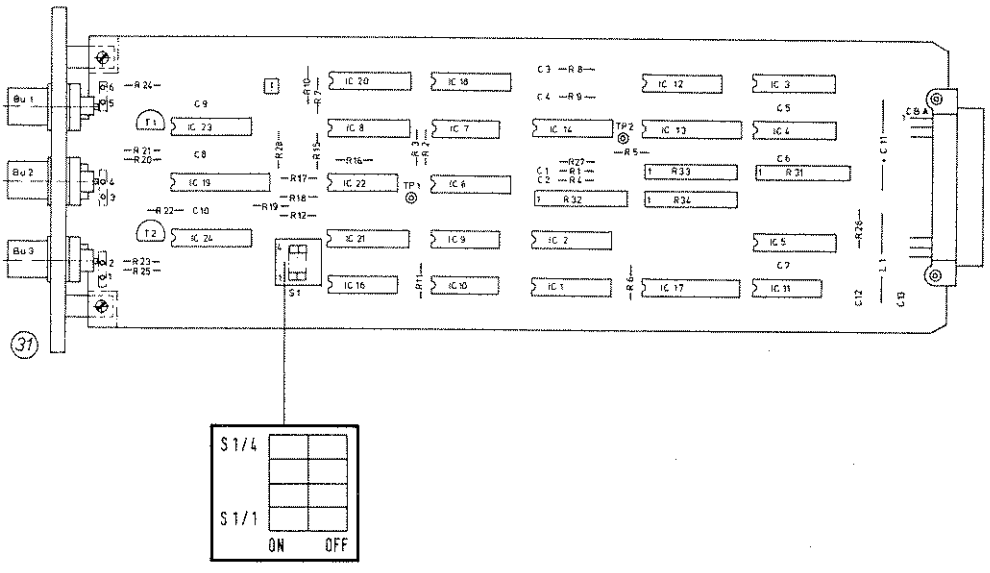


Figure 5-9 Switch S 1 on serial 64 kbit/s TTL output

5.1.4 PARALLEL 64 kbit/s TTL INTERFACE

This interface has one 24-pin Amphenol socket each for the output and input directions, each of which carries 8 data lines for bits 1 ... 8 of a PCM octet (8x8 kbit/s = 64 kbit/s). The octet structure of the data is marked by a codirectional or contradirectional 8 kHz signal (see fig. 5-10). The signals have TTL levels.

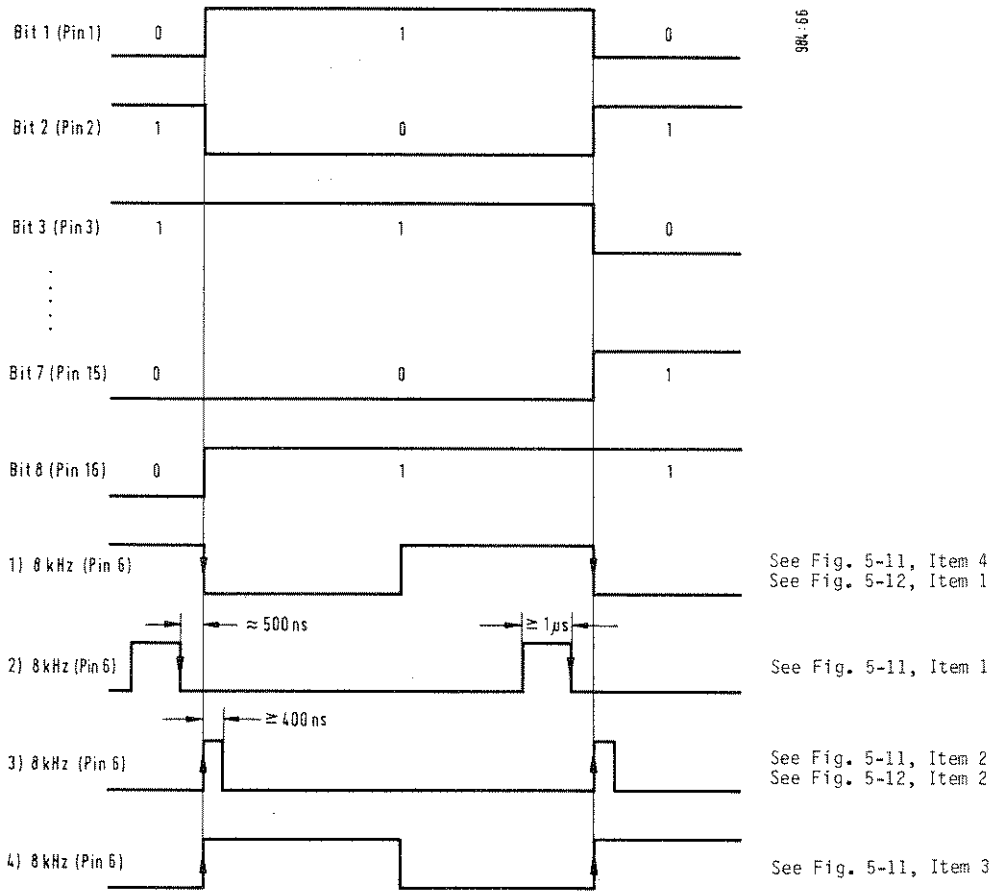


Figure 5-10 TTL signals of the parallel 64 kbit/s interface

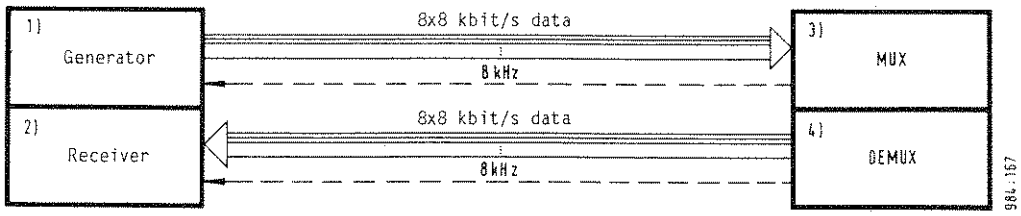


Figure 5-11 Parallel 64 kbit/s interface of the PCM-4 in contradirectional setup

1) Parallel 64 kbit/s output of the PCM-4 operating as a 64 kbit/s generator (parameter 112 or 113) with contradirectional 8 kHz signal. The data at the octet output change approx. 500 ns after the negative edge of the 8 kHz input signal. The minimum HIGH or LOW pulse duration of the 8 kHz signal is 1 µs (see fig. 5-10, item 2).

2) Parallel 64 kbit/s input of the PCM-4 operating as a 64 kbit/s receiver (parameter 112 or 114) with codirectional 8 kHz signal. The data at the octet input must be valid at the positive edge of the codirectional 8 kHz input signal. The minimum HIGH or LOW pulse duration of the 8 kHz signal is 400 ns (see fig. 5-10, item 3).

   If the 64 kbit/s DEMUX signal of a 24-channel PCM system is received with Channel Associated Signalling (CAS 7 5/6), Pin 9 (SF = Signalling Frame) must have a LOW signal for the duration of the signalling frames. This means that Bit 8 is recognized as a signalling bit and not evaluated by the PCM-4.

3) Parallel 64 kbit/s input of the PCM-4 operating as a multiplexer (parameter 212 or MODE B92) with contradirectional 8 kHz signal. The data present at the octet input must be valid at the positive edge of the contradirectional 8 kHz output signal (see fig. 5-10, item 4).

4) Parallel 64 kbit/s output of the PCM-4 operating as a demultiplexer (parameter 222 or MODE B92). The data at the octet output change with the negative edge of the codirectional 8 kHz output signal (see fig. 5-10, item 1).

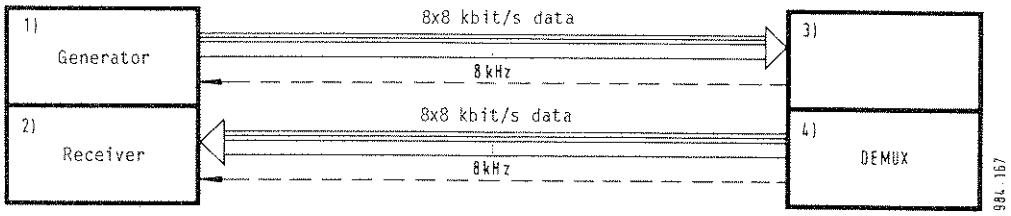


Figure 5-12 Parallel 64 kbit/s interface of the PCM-4 in codirectional setup

1) Parallel 64 kbit/s output of the PCM-4 operating as a 64 kbit/s generator (parameter 112 or 113) with codirectional 8 kHz signal. The data at the octet output change with the negative edge of the 8 kHz output signal (see fig. 5-10, item 1).

2) See fig. 5-11, item 2.

3) The parallel 64 kbit/s input of the PCM-4 cannot operate in MUX mode with a codirectional 8 kHz signal. If parameter 212 or MODE B92 is selected, the system automatically switches to a contradirectional 8 kHz output signal.

4) See fig. 5-11, item 4.

5.1.4.1 Parallel 64 kbit/s TTL input BN 0984/00.07

Pin assignment of the 24-pin Amphenol socket

1 Bit 1
2 Bit 2
3 Bit 3
4 Bit 4
5 Not used
6 8 kHz input (codirectional)
8 kHz output (contradirectional)
7 Ground
8 Ground
9 SF (see Fig. 5-11, Item 2)
10 Ground
11 Ground
12 Ground
13 Bit 5
14 Bit 6
15 Bit 7
16 Bit 8
17 to 24 Ground

Receiver operation with parameter 112 or 114

If this parameter is selected, the 64 kbit/s input operates as a digital receiver. All digital measurements selectable under MODE are possible with the received 64 kbit/s signal. In conjunction with the parallel 64 kbit/s TTL output, the 64 kbit/s loop can be closed internally in the A-A configuration by selecting parameter 124.

NB: Fig. 5-10, item 3, and fig. 5-11, item 2.

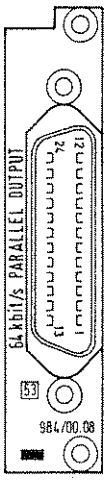
MUX operation with parameter 212 or MODE B92

If parameter 212 or MODE B92 is selected, the 64 kbit/s input operates as a multiplexer in conjunction with parameter 111. Parameter 212 injects an external 64 kbit/s signal into time slot 16, or into the selected output channel in MODE B92.

NB: Fig. 5-12, item 3.

MUX operation is possible in MODE B92 in conjunction with parameter 116 (2 Mbit/s tandem operation).

5.1.4.2 Parallel 64 kbit/s TTL output BN 0984/00.08



Pin assignments of the 24-pin Amphenol socket

1 Bit 1
2 Bit 2
3 Bit 3
4 Bit 4
5 Not used
6 8 kHz output (codirectional)
8 kHz input (contradirectional)
7 Ground
8 Ground
9 Not used
10 Ground
11 Ground
12 Ground
13 Bit 5
14 Bit 6
15 Bit 7
16 Bit 8
17 to 24 Ground

Generator operation with parameter 112 or 113

If this parameter is selected, the 64 kbit/s output operates as a digital generator. All digital signals selectable under MODE and VAR. MODE can be output. In conjunction with the parallel 64 kbit/s input, the 64 kbit/s loop can be closed internally in the A-A configuration by selecting parameter 124.

NB: Switch setting for generator operation with contradirectional 8 kHz signal (see fig. 5-11, item 1):

Switch S 1/1 set to ON = contradirectional

NB: Switch setting for generator operation with codirectional 8 kHz signal (see fig. 5-12, item 1):

Switch S 1/1 set to OFF = codirectional

DEMUX operation with parameter 222 or MODE B92

If parameter 222 or MODE B92 is selected, the 64 kbit/s output operates as a demultiplexer in conjunction with parameter 111. Parameter 222 outputs the 64 kbit/s signal from time slot 16, or from the selected receive channel in MODE B92.

DEMUX operation is possible in MODE B92 in conjunction with parameter 116 (2 Mbit/s tandem operation).

NB: DEMUX operation is only possible with codirectional 8 kHz signal (see fig. 5-11, item 2):

Switch S 1/1 set to OFF = codirectional

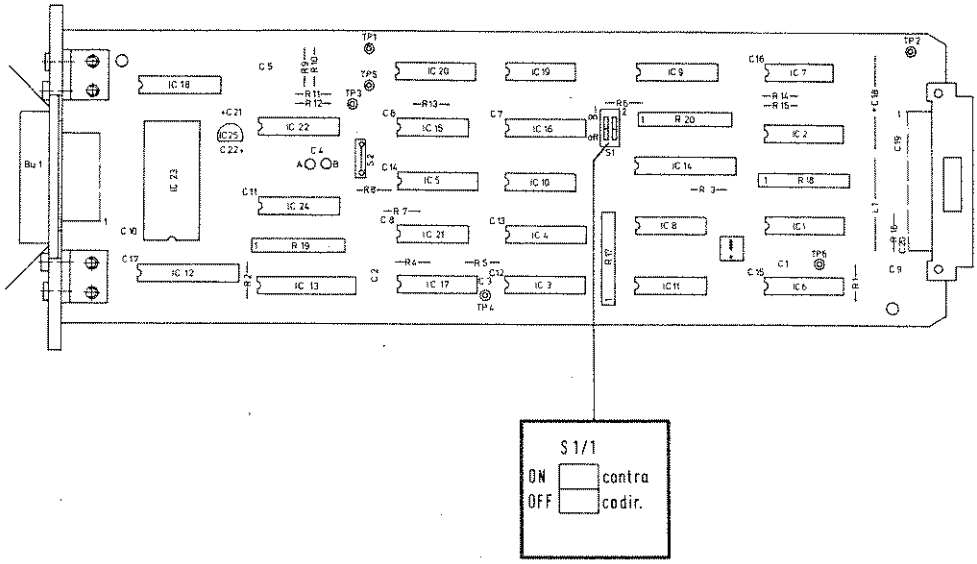


Figure 5-13 Switch S 1 on parallel 64 kbit/s output

5.1.5 64 kbit/s V.11 INTERFACE BN 0984/00.09

This interface has a 15-pin socket to CCITT X.24 or ISO 4903 to carry the symmetrical 64 kbit/s output and input signal, as well as the balanced clock and control lines with electrical characteristics to CCITT Recommendation V.11 or X.27.

NB: The 64 kbit/s V.11 interface comprises two modules. The plug-in card with the 15-pin socket is fitted in the right-hand slot of the two slots provided for the 64 kbit/s interfaces.

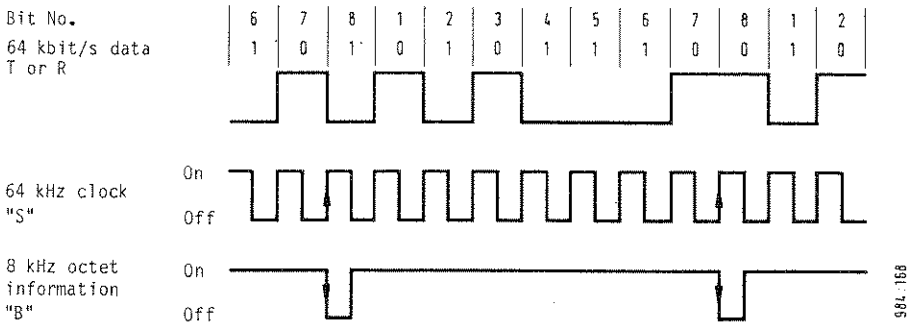


Figure 5-14 Symmetrical TTL signals of the 64 kbit/s V.11 interface

Voltage assignments at the inputs

	Differential input voltage	
	< -200 mV	> +200 mV
T and R	1	0
S, B, C and I	OUT	IN

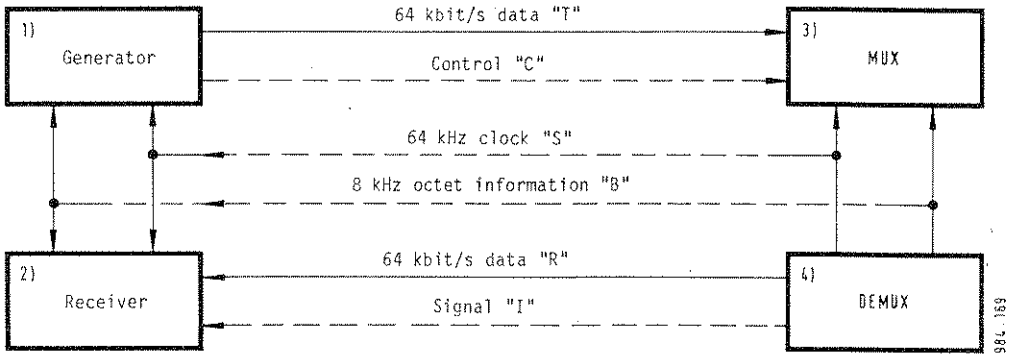


Figure 5-15 Signal flow at the 64 kbit/s V.11 interface of the PCM-4

1) Generator operation with parameter 112 or 113 (see fig. 5-15, item 1)

If this parameter is selected, the 64 kbit/s output operates as a digital generator. All digital signals selectable under MODE and VAR. MODE can be output. If parameter 124 is selected, the 64 kbit/s signal received on line "R" can be internally looped to line "T" in the A-A configuration.

NB: The logic state of line "C" (Control) can be set on the interface card (with socket) at DIL switch S 1/2. The ON state (HIGH level) of line "C" is the preferred setting, this being obtained by setting switch S 1/2 to the ON position.

2) Receiver operation with parameter 112 or 114 (see fig. 5-15, item 2)

If this parameter is selected, the 64 kbit/s input operates as a digital receiver. All digital measurements selectable under MODE are possible using the 64 kbit/s signal received. If parameter 124 is selected, the 64 kbit/s signal received on line "R" can be internally looped to line "T" in the A-A configuration.

NB: The state of line "I" (Signal) is not evaluated.

3) MUX operation with parameter 212 or MODE B92 (see fig. 5-15, item 3)

If parameter 212 or MODE B92 is selected, the 64 kbit/s input operates as a multiplexer in conjunction with parameter 111. Parameter 212 injects an external 64 kbit/s signal into time slot 16, or into the selected output channel in MODE B92.

NB: The texts appearing on the screen after selecting MODE B92 in conjunction with parameter 111 or 116 are not valid.

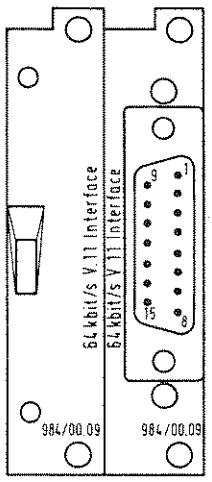
NB: The state of line "C" (Control) is not evaluated.

4) DEMUX operation with parameter 222 or MODE B92 (see fig. 5-15, item 4)

If parameter 222 or MODE B92 is selected, the 64 kbit/s output operates as a demultiplexer in conjunction with parameter 111. Parameter 222 outputs the 64 kbit/s signal from time slot 16, or from the selected receive channel in MODE B92.

NB: The texts appearing on the screen after selecting MODE B92 in conjunction with parameter 111 or 116 are not valid.

NB: The logic state of line "I" (Signal) can be set on the interface card (with socket) at DIL switch S 1/1. The ON state (HIGH level) of line "I" is the preferred setting, this being obtained by setting switch S 1/1 to the ON position.



Pin assignments of the 15-pin socket to CCITT X.24 or ISO 4903

1	-	Shield (for shielded cable)
2	T (A)	64 kbit/s output data
9	T (B)	
3	C (A)	Control
10	C (B)	
4	R (A)	64 kbit/s receive data
11	R (B)	
5	I (A)	Signal
12	I (B)	
6	S (A)	64 kHz clock
13	S (B)	
7	B (A)	8 kHz octet information
14	B (B)	
8	G	Ground (0 V)

5.2 RETURN LOSS AND LONGITUDINAL CONVERSION LOSS MEASURING BRIDGE

600/900 Ω measuring bridge, BN 984/00.10
600/850 Ω measuring bridge, BN 984/00.11
The measuring bridge must be fitted in the PCM-4 for measurements B1x, B2x and B3x.

Fitting

After removing the top cover plate of the PCM-4, the return loss and longitudinal conversion loss measuring bridge can be slotted into the guide rails behind the front panel.

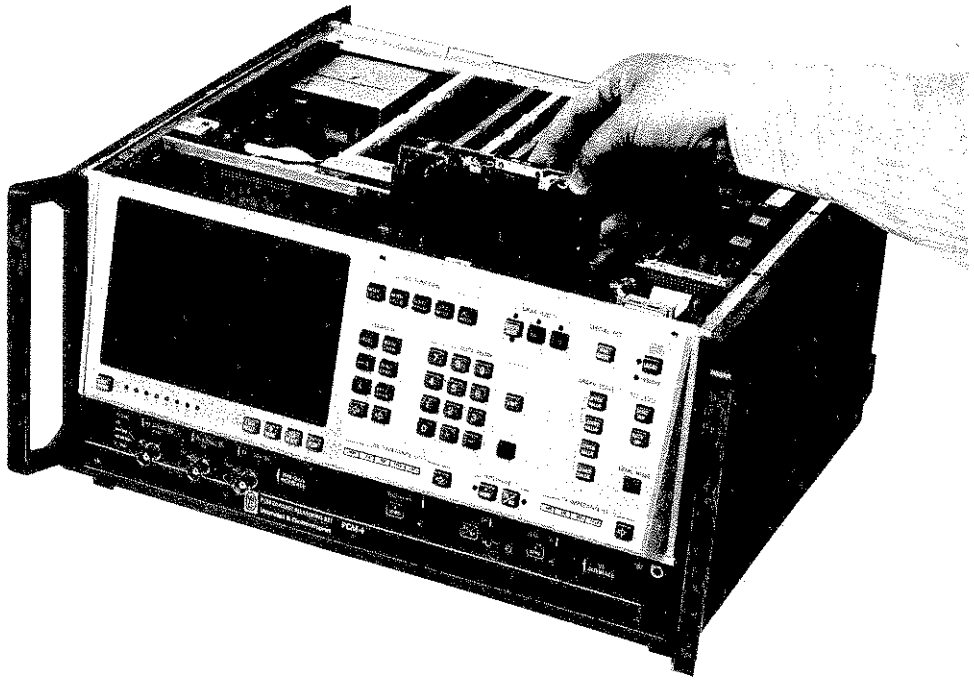


Figure 5-16 Fitting the return loss and longitudinal conversion loss bridge

In MODE B13, the return loss is measured using a complex impedance. In the standard version, the measuring bridge is supplied with 220 Ω in series with 820 Ω//115 nF. The complex impedance can be modified by the manufacturer on request.

5.2.1 BRIDGE IMPEDANCE ADDITION BN 984/00.16

Additional reference impedances for measuring return loss are provided by the optional bridge impedance addition BN 984/00.16. A pcb is factory-equipped with the impedances specified by the customer (maximum 4 impedances in complex configuration) and mounted on the bridge.

Note: To upgrade with a BN 984/00.16 impedance addition, the bridge BN 984/00.11 must be returned to the factory.

The bridge with the added pcb is inserted in the guide rails shown in figure 5-16 after removing the top cover of the PCM-4.

Note: The IEC/IEEE bus is used to toggle the additional impedances. The standard impedances (600, 850 or 900 Ohm and complex) can also be addressed by menu in modes B11, B12 and B13.

For impedances with magnitudes of less than 200 Ω, the following applies:

Mode	Power level referred to	Error limit in result range 30 to 36 dB	36 to 40 dB
B11	600 Ω	± 1.8 dB	± 2.5 dB
B12, B13	900 Ω	± 1.8 dB	± 2.5 dB

A programming word is assigned to each additional impedance. A sticker showing the programming word assignent of the customer-specific impedances is located on the PCM-4 back panel and the bridge transformer.
The programming word for switching the additional impedances must be input twice (see example). The first measurement determines a set return loss of 20 dB with a standard mismatched impedance (factor 1.222 of the selected additional impedance). During the second measurement, the additional impedance is activated as a test standard. The difference between the two measurements is used to form the result.

Programming word: "O@54.80": turn on additional impedance 1
"O@54.90": turn on additional impedance 2
"O@54.AO": turn on additional impedance 3
"O@54.BO": turn on additional impedance 4
"O@54.FO": turn off additional impedance 1, 2, 3 or 4 ("RESET" for additional impedance)

Example: IEC/IEEE bus program for the hp 9816 computer

```
10 N=702                                        ! IEC address PCM-4
12 !
15 OUTPUT N USING "#,K";"MB11,MSO,FA1004,"      ! PCM-4 parameter
20 OUTPUT N USING "#,K";"O@54.90,"               ! Add. imp. 2
30 OUTPUT N USING "#,K";"O@54.90,"              ! Second output
40 !
50 TRIGGER N                                    ! Start
60 !
```

5.2.1.1 Return loss measurements with external blocking capacitance

When making measurements on energized systems, d.c. blocking is necessary between the test object and the PCM-4 analog input and output. The plug-in PCMZ-4 (BN 984/00.13) handles this task.
In the a- and b-wires, 100 µF capacitors block the d.c. voltage.
However, when measuring return loss with the PCMZ-4 installed, problems occur because the blocking capacitors in the bridge test branch add to the impedance of the test object.

Frequently, this causes the return loss tolerances to be exceeded at low frequencies. The PCM-4 test result is correct, but is interpreted incorrectly due to the added blocking capacitance. To remedy this problem, a compensation capacitance must be added in the bridge reference branch.

Due to space limitations, this capacitance must be housed on the additional bridge pcb.

a) Return loss measurements with standard impedances
   If return loss measurements are to be made with the standard impedances, they must be present on the additional pcb. The additional impedance chosen with the programming word is in series with the compensation capacitance in the bridge reference branch.

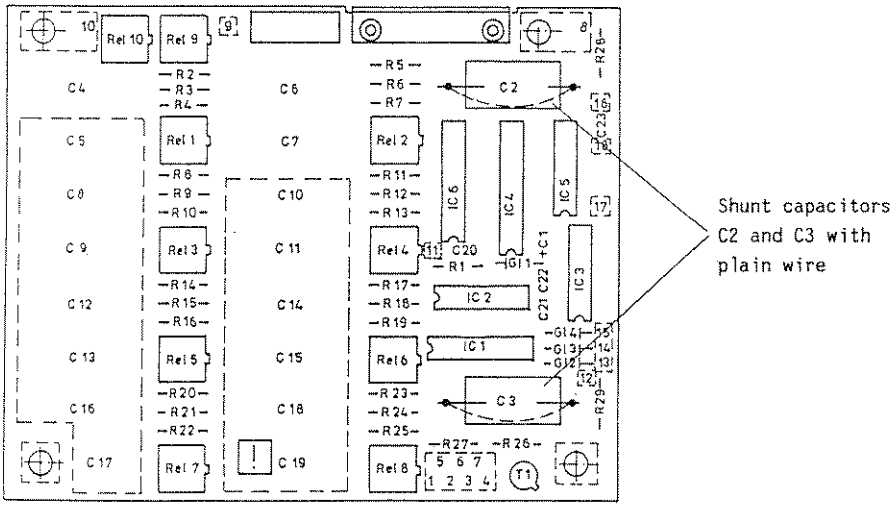
b) Return loss measurements with additional impedances
   When one of the four additional impedances is selected, the compensation capacitance is alreay included in the bridge reference branch.

5.2.1.2 Return loss measurements without external blocking capacitance

For each additional impedance selected, the appropriate compensation capacitance of the PCMZ-4 blocking capacitor is connected in series on the additional pcb. If the PCMZ-4 is not used or the blocking capacitor in the PCMZ-4 is shunted by a slide switch, then the compensation capacitance must also be shunted.

The simulated blocking capacitance for a return loss measurement without external blocking capacitor is shunted out as follows:

a) Bridge impedance addition BN 984/00.16 from series A to series D

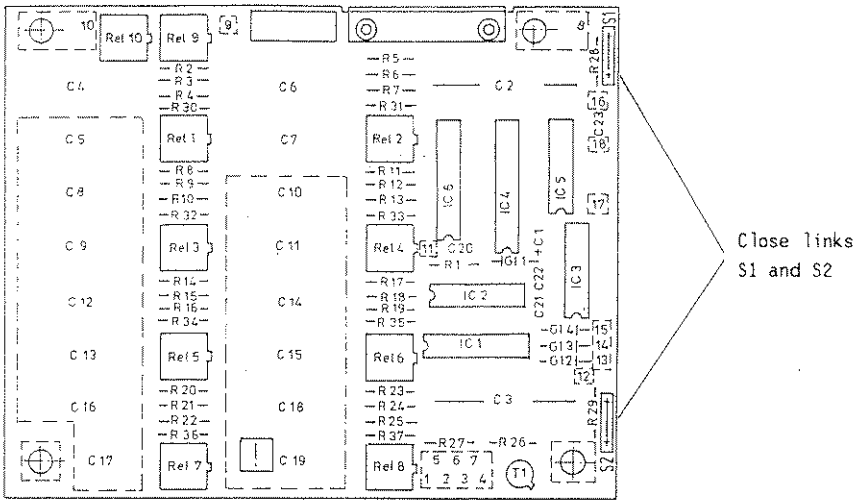


29

Figure 5-16a Additional bridge impedance board BN 984/00.15 (series A to D)

Shunt capacitors C2 and C3 on the board using plain wire (see figure 5.16a)

b) Bridge impedance addition BN 984/00.16 from series E onwards



(29)

Figure 5-16b Additional bridge impedance board BN 984/00.15 (from series E)

Close the two links S1 and S2 on the board.

5.3 D C L O O P - H O L D I N G C I R C U I T GH-1, BN 0984/00.12

The DC loop-holding circuit has a DC-free output and allows the loop current to be maintained when test instruments are connected to telephone equipment.
The connections are balanced and floating.

Fitting
The DC loop-holding circuit GH-1 is connected to the other equipment via CF cables.

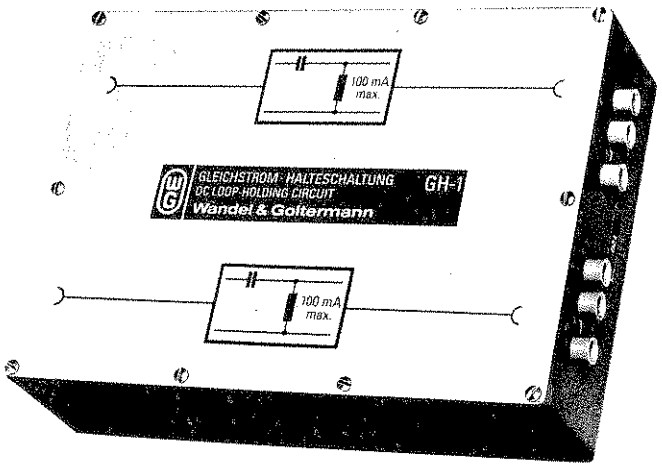


Figure 5-17 DC loop-holding circuit GH-1

NB: The high inductance (> 1000 H) simulated by the GH-1, together with the terminating impedance and the existing loop-holding current source, yields a network with a very low cut-off frequency (< 1 Hz). Consequently, longer settling times occur, particularly in conjunction with switching operations relating to the test point selector MU-30, and these must be taken into account by means of a delay before the measurement is carried out. This delay is obtained via the setting (0 ... 900 ms) in VAR. MODE 421.

5.4 DC DECOUPLING UNIT PCMZ-4, BN 0984/00.13

If the DC decoupling unit PCMZ-4 is installed, the a and b wires of the analog signal generator and receiver, as well as the two-wire output and input can each be capacitively decoupled by means of one 47 µF capacitor each.

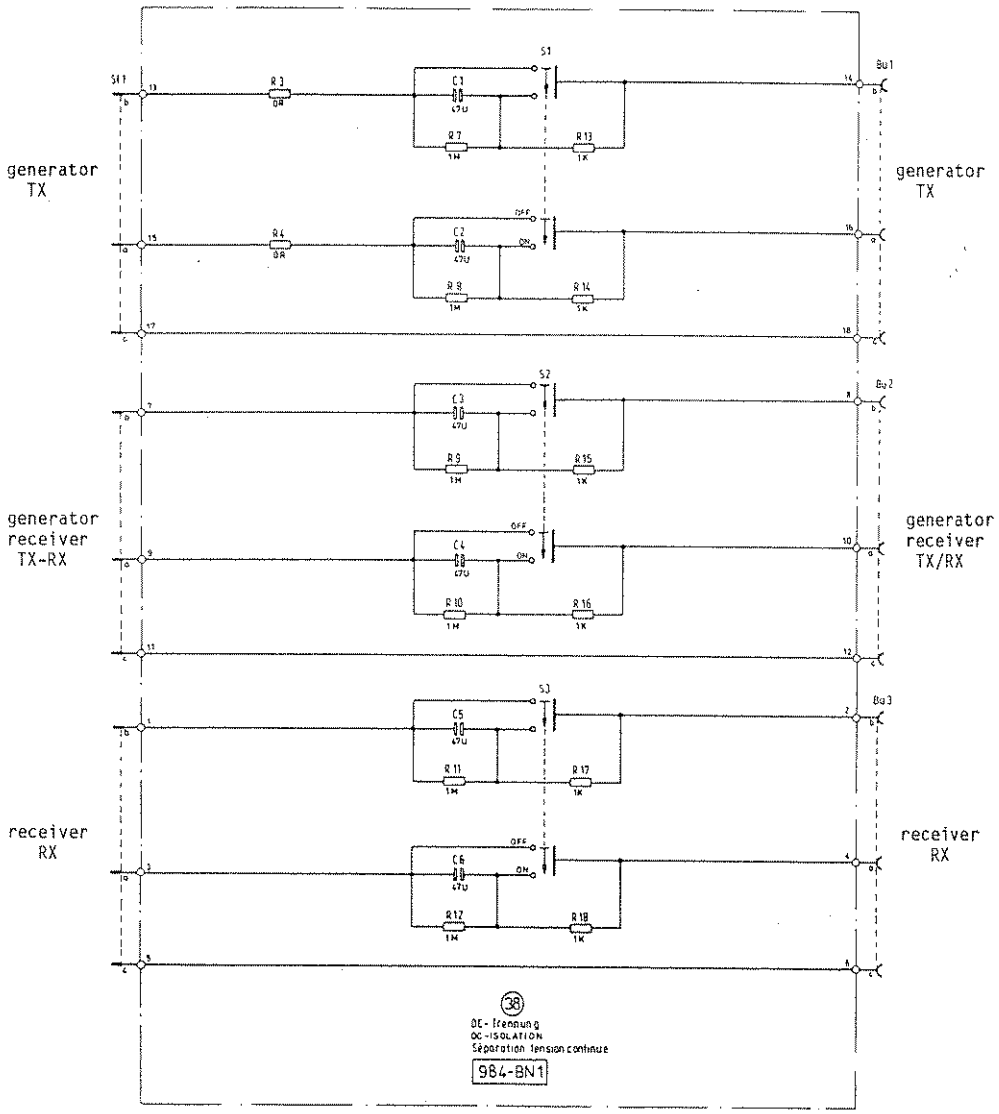


Figure 5-18 Circuit diagram of the capacitive decoupling unit

The decoupling capacitors can be switched on and off via the slide switches on the front panel of the DC decoupling unit.

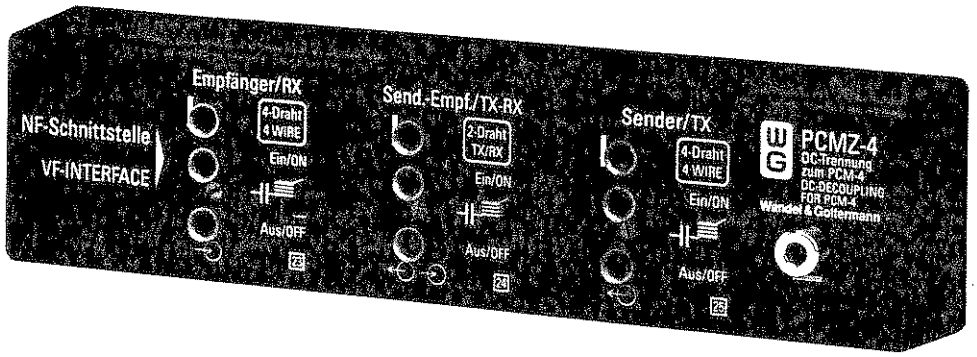


Figure 5-19 DC decoupling unit PCMZ-4

Fitting

The DC decoupling unit PCMZ-4 is plugged into the analog inputs and outputs [23], [24] and [25] of the PCM-4. The instrument is then ready for use immediately.

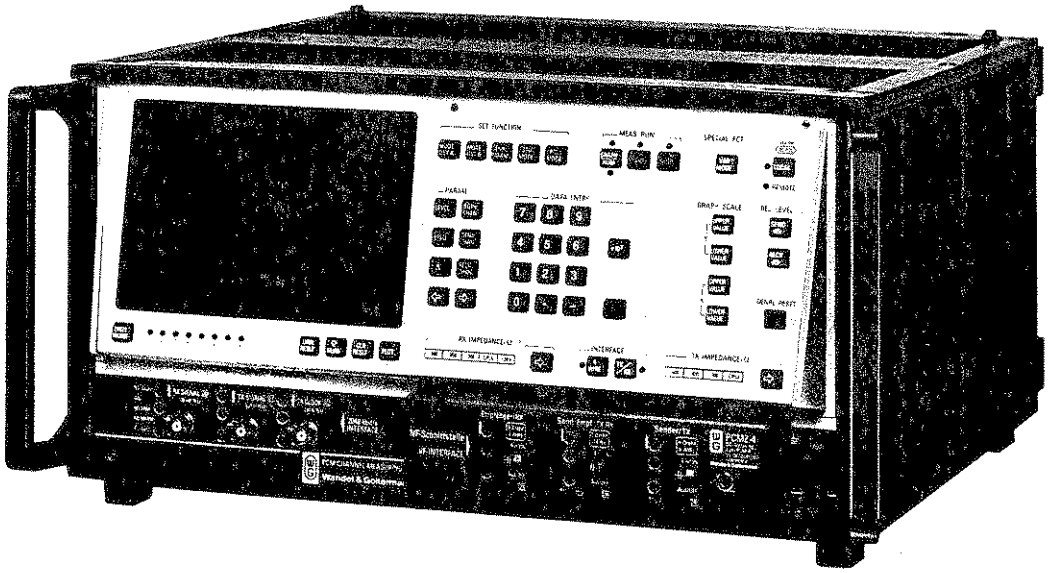


Figure 5-20 PCM-4 with DC decoupling unit PCMZ-4

5.5 120 kHz LOW-PASS FILTER BN 0984/00.14

Spurious out-of-band signals can cause overdriving of the input amplifiers in the analog receiver of the PCM-4 if the smaller signal level received results in selection of an excessively sensitive divider range. This makes measurement impossible. If VAR. MODE 533 is activated, spurious signals are detected by a preliminary wideband measurement (20 Hz ... 128 kHz) and the divider range is then selected on the basis of the spurious signal. This means that measurement is again possible, although a longer measuring time must be taken into account.

Certain digital transmission systems generate spurious out-of-band signals if the level is too high, e.g. at 256 kHz. Selection of VAR. MODE 533 will not detect such spurious signals, since they are beyond the receiving range of the PCM-4.

Installation of a 120 kHz low-pass filter upstream of the input transformer of the analog signal receiver is the only way to suppress spurious out-of-band signals above 120 kHz. This low-pass filter can be installed by the manufacturer as an option and has the Order No. BN 0984/00.14.

The filter yields the following attenuation values:

0.2 ... 3.97 kHz	$\pm$ 0.03 dB
4 ... 10.0 kHz	$\pm$ 0.10 dB
10 ... 72.0 kHz	$\pm$ 0.25 dB
Atten. peak at 256 kHz	$\pm$ 5.0 kHz with a > 40 dB
Sidetone suppression	$\geq$ 18 dB

NB: Installation of the 120 kHz low-pass filter automatically results in different technical data. Refer to the corresponding notes in sections 1.5, 1.27.1, 1.27.3 and 1.27.8.

5.6 IEC BUS CARD, BN 0958/24

Remote control, see section 4 of the Operating Manual.

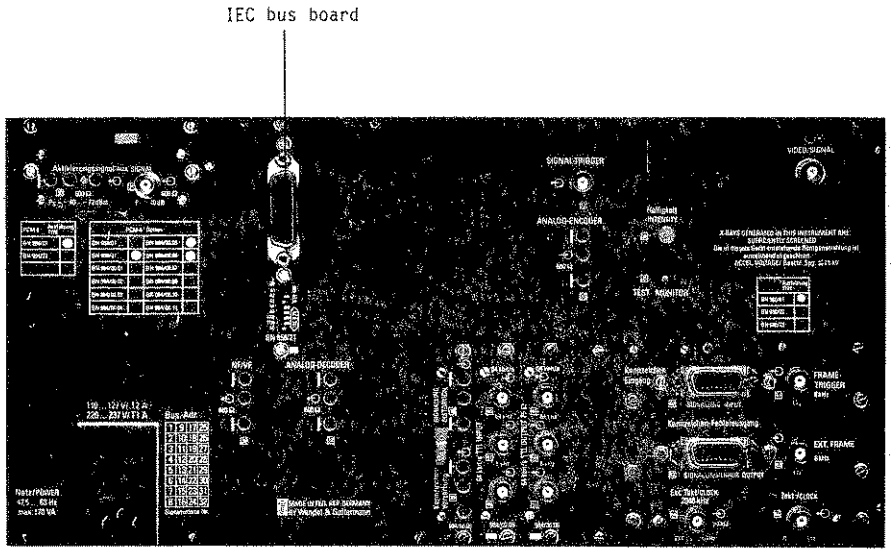


Figure 5-21 Fitting the IEC bus card

APPENDIX A: INSTRUMENT DESIGN

Preface:

As the PCM-4 is an extremely complex instrument, only the more important functional groups are described in this appendix with the aid of a simple block diagram. The detailed circuit description is found in the service manual.

Analog signal generator

The analog signals are derived from binary coded signal samples stored in ROM. For example, a total of 1999 samples are stored for forming sinusoidal signals. The ROM addresses are scanned at a frequency of 20.0653 kHz. If all of the stored samples are used to form the signal, the output frequency is 20.0653 kHz divided by 1999, i.e. 10.0377 Hz. This basic frequency cannot, however, be selected; frequencies which are integer multiples of the basic frequency are produced by combining every nth sample: e.g. every 2nd sample for 20.075 Hz or every 3rd sample for 30.113 Hz, and so on. The digital samples are then converted in a D-A converter and the resultant waveform is smoothed by a low pass filter. The signal passes through attenuators and finally through the floating output stage.

The receiver measurement rate is synchronised to the period of the basic frequency, i.e. 99.625 ms (for sine signals); during this period, all of the stored samples are read out once, irrespective of the selected output frequency. In this way, the same number of samples are evaluated each time, leading to highly reproducible results with very short measurement times. The number of samples and the scanning frequency are chosen so as to avoid the subharmonics of the 8 kHz clock frequency.

The ROM also contains noise signals, four-tone signals, group delay test signals and so on, all stored in digital form.

Digital signal generator

The digital signal generator provides code wort sequences which correspond to coded analog signals. The code words are not generated on-line, but are stored in ROM.

An encoded sinusoidal signal is produced, for example, by scanning 797 signal samples at a rate of 8 kHz, the scan being repeated every 99.625 ms. The signal samples are stored in logarithmic form as 14 bit words, so that any level can be reproduced by simple addition or subtraction. A simple conversion to 8 bit code words (A-low or μ-law) follows, and the resultant digital signals are practically the same as those which would be output from an ideal coder fed with an ideal sine wave signal.

The ROM also contains digitally encoded samples of noise signals, idle channel signals and pulse patterns for bit error measurements, among others.

The digital signals produced in this way can either be output from a 64 kbit/s output, or inserted into standard PCM frames. The 64 kbit/s and 2 048 kbit/s interfaces are to CCITT Recommendation G.703.

Analog receiver

Attenuator and amplifier stages are used for level matching. A control circuit with high bandwidth monitors the signal and prevents the amplifiers from being overdriven. A sample and hold circuit, followed by an A-D converter converts the signal into 16 bit digital form. Depending on the frequency and the selected measurement mode, the signal is processed in one of three different ways:

- In-band signals are limited to 4 kHz to avoid overlap effects. The sampling rate is 8 or 10 kHz.
- Out-of-band signals pass through a 130 kHz low-pass filter. Sampling does not take place at regular intervals, but is stochastic, the sampling frequency varying between 2.5 and 10 kHz. This avoids the large errors which would result if too few samples were taken.
- A third signal path limits the signal bandwidth to between 4.6 kHz and 130 kHz. The a.c. signal is rectified, and the d.c. level corresponding to the true r.m.s. value of the signal is continuously converted into 16 bit digital form.

Signal processing takes place in a digital filter and evaluation processor. The digital filter is a fast arithmetic processor, capable of realising more than 50 different filter characteristics. It consists of a 16 by 16 bit multiplier and a coefficient register. The stored coefficients determine the filter characteristics; they are altered according to the type of operation required. Fast buffers store the intermediate results, the final results being determined in the evaluation processor which is a 16 bit microprocessor.

Digital receiver

The input circuit is followed by a code converter circuit, which changes the HDB3 or AMI code of the input signal into NRZ code. A frame demultiplexer than extracts the contents of the required channel from the 2 048 kbit/s signal. The serial data stream is converted to parallel form and then fed to the A-law or μ-law decoder, which outputs the signals as expanded linear code words. The 16 bit code words which result are then fed to the digital filter.

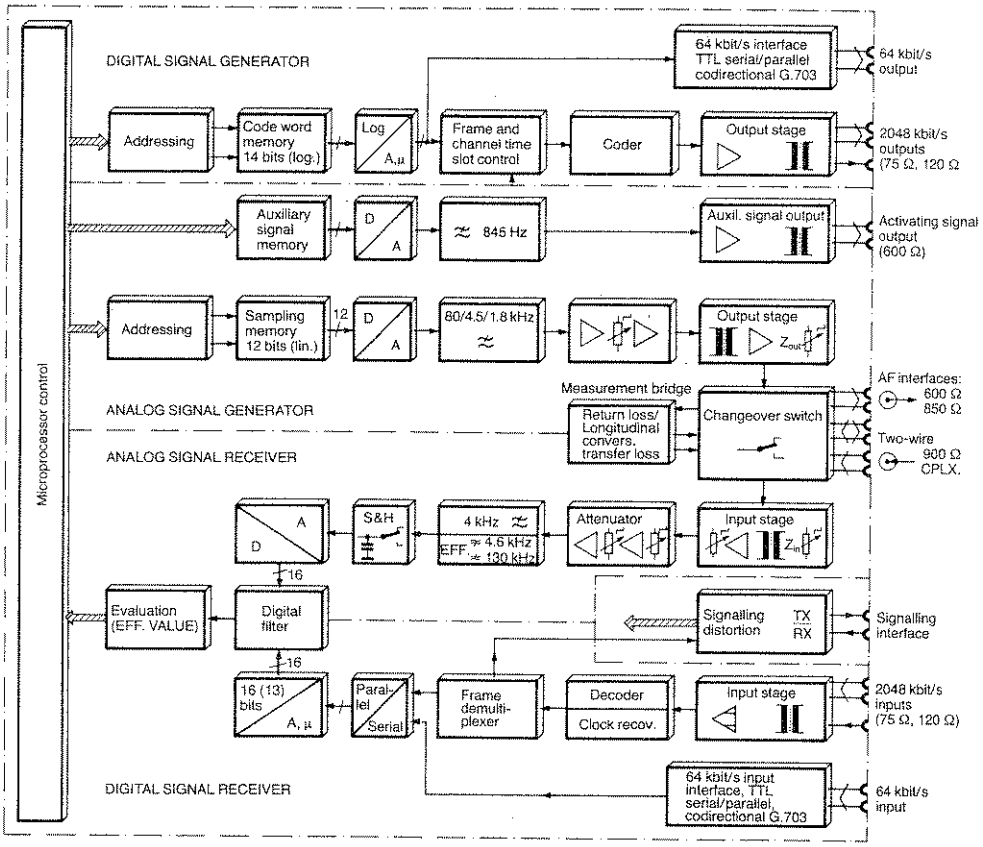


Figure A-1 PCM-4 block diagram

APPENDIX B

B.1 ERROR SIGNALS ON SELF TEST AND CALIBRATION

The various audible and visible error signals which may occur during the self test of the PCM-4 are described in this section. Any errors which are detected are signalled in such a way as to make their location accurately known. Three possible signals are used:

1. Audible signals from the built-in beeper are possible at all times. The location of the fault is signalled by the type of signal (i.e. the frequency, duration and number of output tones). Audible signals are given if a fault occurs on the:
   - CPU I board (master)
   - CPU II board (display)
   - CPU III board (meas. flow.)
   - coupling board I
   - coupling board II

2. If all the above modules are free of faults, visible signals from the LEDs on the front panel may indicate other faults, i.e.:
   - CPU II RAM/ROM test error
   - coupling board I RAM/ROM test error
   - screen control board test error

3. If all the above are free of faults, any other possible errors are signalled by means of clear text messages on the screen. The following errors are signalled:
   - CPU III RAM/ROM test error
   - evaluation circuit RAM/ROM test error
   - calibration error
   - keyboard poll error (contacts closed?)

If the error list appears on the screen, a fault has occurred during calibration, and the instrument is disabled (see footnote 1 and figures B-1 and B-2).

The diagram at the end of this manual shows all the possible error messages which can occur during the self test and calibration routines.

---

1) It is possible to operate the instrument under limited conditions by omitting the calibration sequence. This is done by pressing /9/ when switching the instrument on, the effect being that:
   - the instrument does not self-calibrate,
   - the error list is not displayed,
   - standard values are entered in place of the values which would normally result from calibration,
   - the result may differ from the nominal values.

Meaning of error messages:

"X" appears in the display when:

- $\Delta a \geq \pm 1$ dB for attenuators and amplifiers
- $\Delta a \geq \pm 2$ dB for basic attenuations
- offset is $\geq$ 100 digits

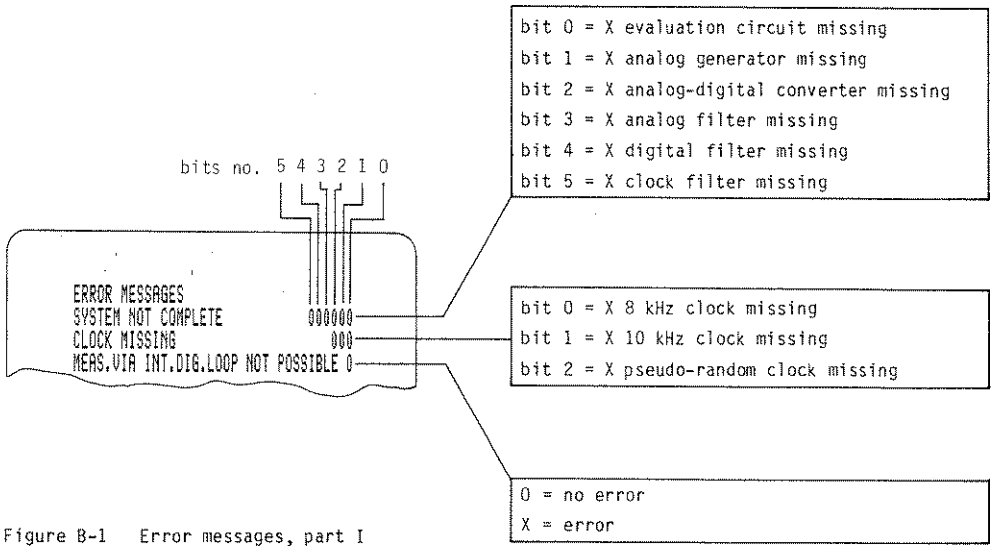
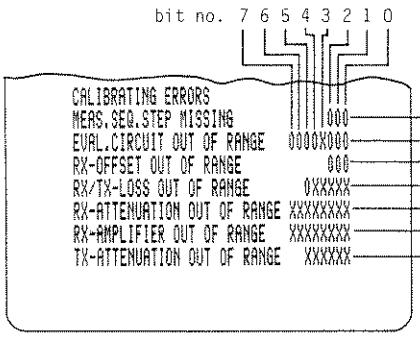


Figure B-1 Error messages, part I



bit 0 = X no pre-measurement
bit 1 = X no main measurement
bit 2 = X hardware overload

bit 0 = X no mode
bit 1 = X dc component
bit 2 = X input overload
bit 3 = X level too high
bit 4 = X level too low
bit 5 = X eval. processor overload
bit 6 = X no offset adjustment
bit 7 = X range overload

bit 0 = X offset in band
bit 1 = X offset out of band
bit 2 = X offset 72 kHz

bit 0 = X receiver base attenuation in band
bit 1 = X receiver base atten. out of band
bit 2 = X receiver base attenuation 72 kHz
bit 3 = X generator base attenuation in band
bit 4 = X generator base attenuation noise
bit 5 = X generator base atten. out of band

bit 0 = X interm. atten. 1 06 dB
bit 1 = X interm. atten. 1 12 dB
bit 2 = X interm. atten. 1 18 dB
bit 3 = X interm. atten. 1 24 dB
bit 4 = X interm. atten. 2 06 dB
bit 5 = X interm. atten. 2 12 dB
bit 6 = X interm. atten. 2 18 dB
bit 7 = X interm. atten. 2 24 dB

bit 0 = X input attenuator 18 dB
bit 1 = X input amplifier 12 dB
bit 2 = X input amplifier 24 dB
bit 3 = X interm. ampl. 1 06 dB
bit 4 = X interm. ampl. 1 12 dB
bit 5 = X interm. ampl. 1 18 dB
bit 6 = X interm. ampl. 2 06 dB
bit 7 = X interm. ampl. 2 30 dB

bit 0 = X gener. atten. 42 dB
bit 1 = X gener. atten. 30 dB
bit 2 = X gener. atten. 24 dB
bit 3 = X gener. atten. 18 dB
bit 4 = X gener. atten. 12 dB
bit 5 = X gener. atten. 06 dB

Figure B-2 Error messages, part II (calibration)

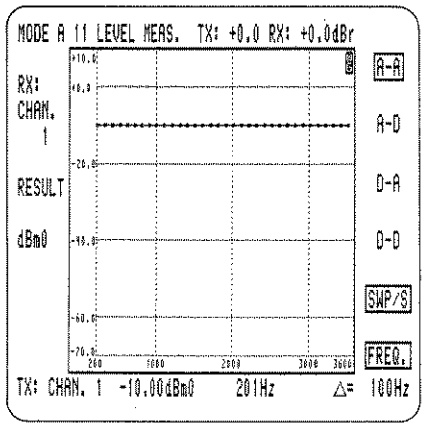
B.2 PCM-4 F U N C T I O N C H E C K

Press /CLR RESLT/ at the same time as switching the instrument on. Hold the /CLR RESLT/ key down until the first BEEP is heard.
The instrument now performs a self test (see 2.4). If this is completed successfully MODE LIST A will be displayed on the screen. If an error is detected during the self test, the error list will be displayed (see previous section).

Analog test

* Connect the analog generator output [25] to the analog receiver input [23]
* Perform the following sequence of keystrokes: /MODE A/, /1/, /1/, /ENTER/, /START/

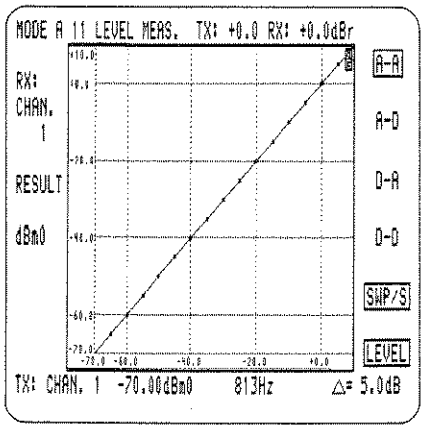
The following result should then be displayed on the screen:



The result curve is horizontal line at -10 dB

* Now press softkey 6 (labelling changes from FREQ. to LEVEL) and then /START/

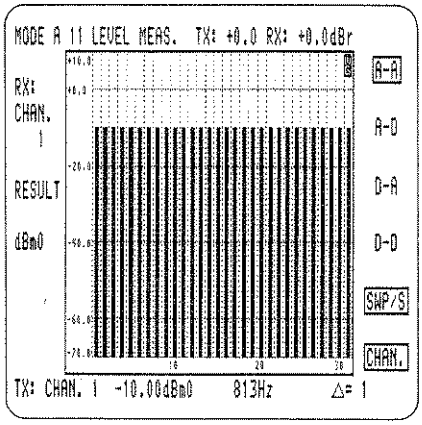
The following result should then be displayed on the screen:



The result curve is a diagonal straight line with slope = 1.

* Now press softkey 6 (labelling changes from LEVEL to CHAN.) and then /START/

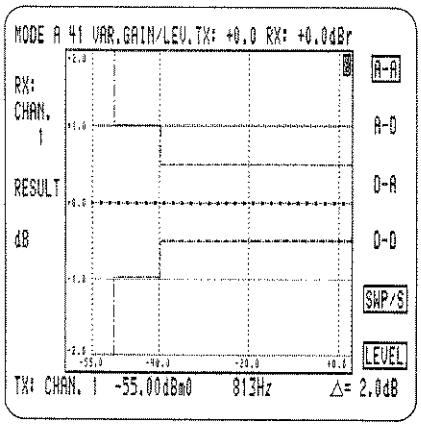
The following result should then be displayed on the screen:



The display shows vertical columns each corresponding to a level of -10 dB.

* Now perform the following sequence of keystrokes /MODE A/, /4/, /1/, /ENTER/, /START/

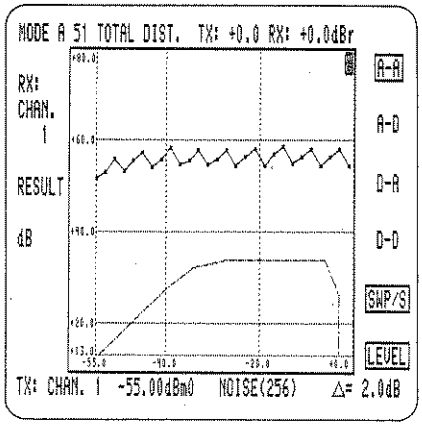
The following result should then be displayed on the screen:



The result curve must be a straight line corresponding to 0 dB.

* Now perform the following sequence of keystrokes: /MODE A/, /5/, /1/, /ENTER/, /Y-UPPER VALUE/, /8/, /0/, /ENTER/, /RTN/ (Softkey 6), /START/

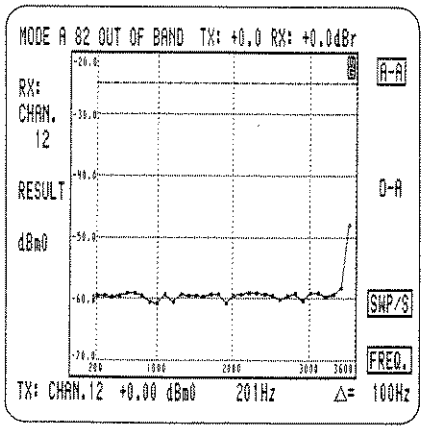
The following result should then be displayed on the screen:



the sawtooth curve should lie within the limits +50 dB to +65 dB.

* Now perform the following sequence of keystrokes: /MODE A/, /8/, /2/, /ENTER/, /Y-LOWER VALUE/, /7/, /0/, /ENTER/, /RTN/, (Softkey 6), /START/

The following result should then be displayed on the screen:

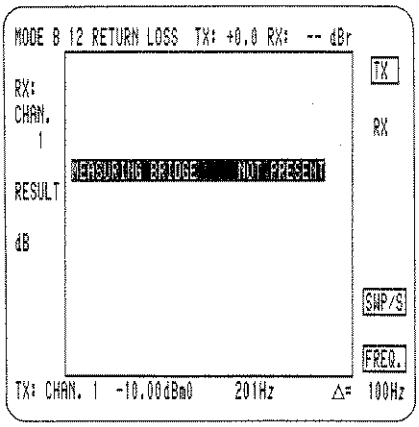


The result curve should be within the range -70 dB to -60 dB between 200 and 3400 Hz.

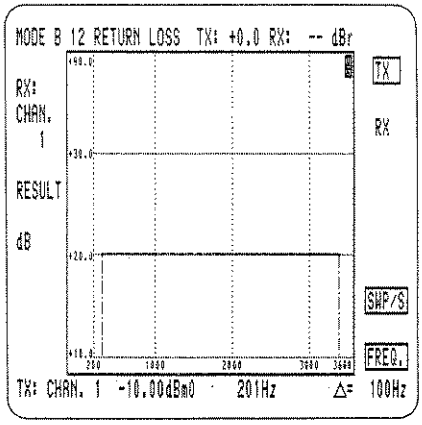
Measuring bridge test

* Disconnect the analog generator and receiver from each other.
* Perform the following sequence of keystrokes: /MODE B/, /1/, /2/, /ENTER/

If the measuring bridge is not fitted, the following error message will be displayed:



If the measuring bridge is fitted, the screen display will be:

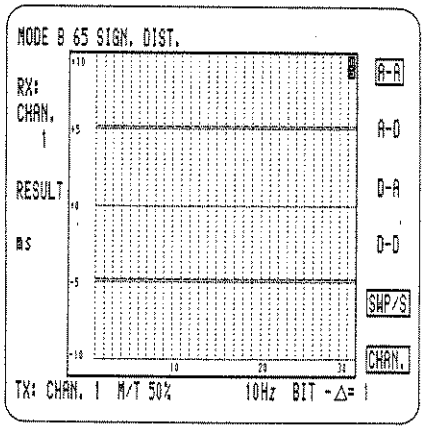


On the left-hand side, under RESULT, the value 0.00 dB should be shown.

A-A signalling distortion test

* Make sure that sockets [38] and [39] are not connected together, and then perform the following sequence of keystrokes: /MODE B/, /6/, /5/, /ENTER/, /START/.

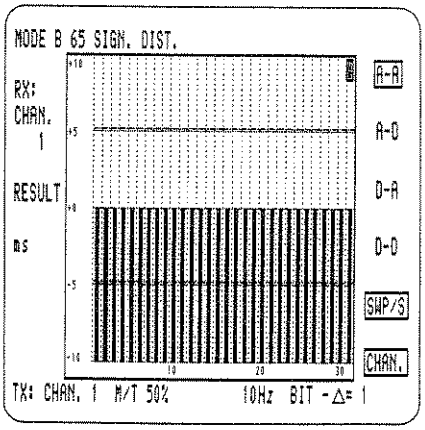
The following should then appear on the screen:



On the left-hand side under RESULT, the symbol <> should be shown (measurement not possible).

* Now connect sockets [38] and [39] together.

The screen display should then be:



The display shows vertical columns, each of which shows a distortion of 0.

Digital test

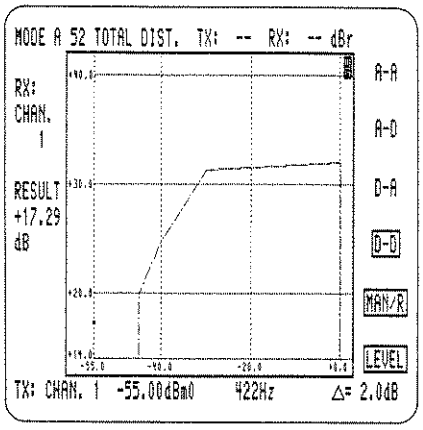
Disconnect all connections made for the analog test.

* Connect the digital generator output (CF connector [21]) to the digital receiver input (CF connector [20])

Test 1

* Perform the following sequence of keystrokes: /GENRL RESET/, /MODE A/, /5/, /2/, /ENTER/
* Using the softkeys, set the following parameters:
  - softkey 4 D-D
  - softkey 5 MAN/R
* Now press /START/

The following should be displayed on the screen:



On the left-hand side, under RESULT, the value +17.29 dB should be shown.*

Test 2

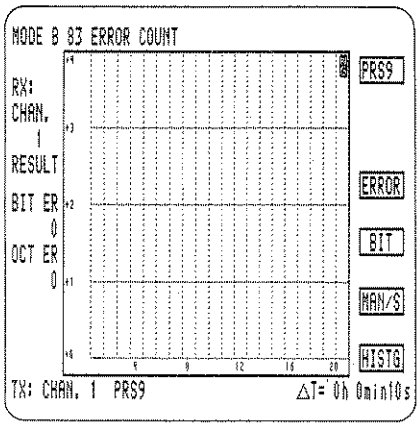
* Perform the following sequence of keystrokes: /GENRL RESET/, /MODE B/, /8/, /3/, /ENTER/
* Using the /Δ/ key, set the time interval to 10 s,
* Using the softkeys, set the following parameters:
  - softkey 1 PRS 9
  - softkey 5 MAN/S
* Now press /START/

The green START LED should light for 10 seconds

---

* The result is +17.31 dB for PCM-4s of series A to D if latest sortware has not been retro-fitted.

The following should be displayed on the screen:



On the left-hand side, under RESULT, the information BIT ER = 0 and OCT ER = 0 should be displayed.

Appendix C: Options, Accessories, Maintenance

Appendix C: Options, Accessories, Maintenance

C.1 Instrument designation

When making enquiries or ordering options or accessories, the following information is required in addition to the type number of the instrument (PCM-4):

- The **series index** and the **serial number**
  e.g. C 0034; this information is found on the front panel below the instrument type number
- The **version**
  e.g. BN 123/01. This information is found in the table printed on the back panel
- The **options** fitted
  e.g. BN 123/00.03 or BN 958/24. This information is also found in the table on the back panel.

A further table next to the mains voltage selector shows the address of the <IEC 625> interface, if this is fitted.

C.2 Accessory compartment

A small compartment is fitted on the back panel of the instrument; the lid opens to the left (figure C-1). It contains the following items:

- **Card puller**
  for removing the lids of screening cans and extracting the p.c.boards. For service purpose only.
- **Hex (allen) key**
  for the instrument cover screws.
- **Spanner**
  for the Versacon®9 connector system.
- **Two spare fuses**
  for the mains voltage set ex-works.

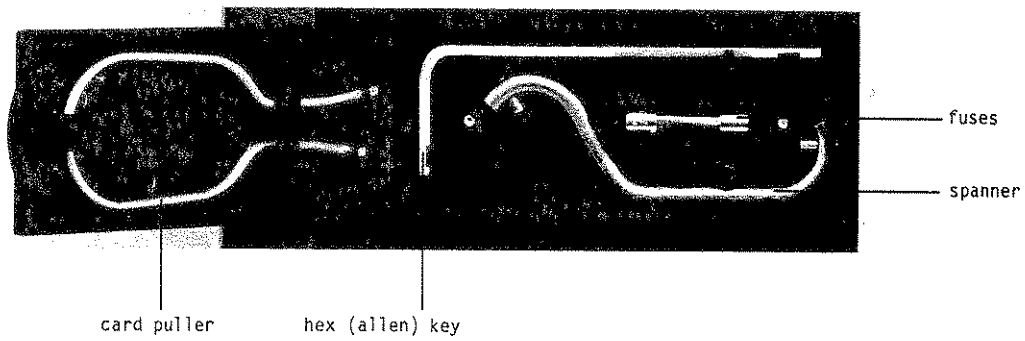


Figure C-1 Accessory compartment

C.3 Changing the versacon inserts

Coaxial inputs and outputs are fitted ex-works with BNC type connectors. These can be replaced by any other type of connector in the Versacon®9 system (figure C-2) by using the spanner provided.

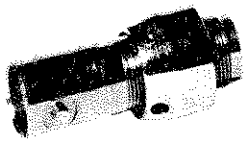


Figure C-2 Versacon®9 inserts

To remove the connector:

* Turn the locknut anti-clockwise with the spanner
* Undo the locknut completely
* Remove the insert, using the spanner if necessary.

To fit the connector:

* Screw the locknut onto the insert as far as it will go
* Screw the insert into the basic connector on the instrument
* Tighten the locknut with the aid of the spanner

C.4 Changing the fuse

A faulty fuse is indicated if the instrument does not operate and the mains cable and voltage are OK. Check this by

- disconnecting the instrument from the mains
- checking that the mains voltage and the voltage set with the selector are the same
- removing the fuse from the holder (use a coin or broad tipped screwdriver to undo the cover)
- checking the continuity of the fuse.

Replacement fuses are provided for the mains voltage set ex-works; they are found in the accessory compartment on the back panel. If the instrument still does not work, contact the service dept.

C.5 Data back-up battery

Three batteries are fitted in the instrument power supply for powering the instrument setup memory (STO. MODE, RCL. MODE). The batteries are trickle charged when the instrument is switched on, and they cannot be damaged by overcharging.

If the instrument is used continuously for 24 hours, the battery charge will be sufficient to retain the data for up to one month at normal room temperature. At higher temperatures, the batteries self-discharge at a faster rate, so the data retention time will be reduced.

The battery manufacturer recommends a lower limit of +5°C for the charging temperature. This is also the lower range limit for operating temperature of the PCM-4, and should always be observed.

C.6 Cleaning the instrument

Do not use solvents or household cleaning agents for cleaning the instrument. Solvents may attack the paint finish and lettering on the panels, and some cleaning agents may damage the lettering and leave shiny marks on the instrument panels. Use a cloth moistened with warm water to which a little washing-up liquid has been added. Ensure that water does not get inside the instrument, and dry off the panels with a clean cloth.

The VDU screen surface should be cleaning with a damp cloth, to avoid scratches and static buildup. Trichlorotrifluoroethane (TCTF) can also be used; it is non-flammable, non-toxic and practically odourless. We recommend the use of this substance for removing greasy marks.

C.7 Removing batteries

Before opening the instrument, you must pull out the power plug and disconnect any other voltage sources.

Remove the top of the enclosure by undoing the six hexagonal screws and remove the left side. The instrument can now be lifted vertically out of the enclosure. The power supply is left in the enclosure.

The batteries are at the front of the power supply (see Fig. C-3) and can be taken out when the restraint (bend open) is released.

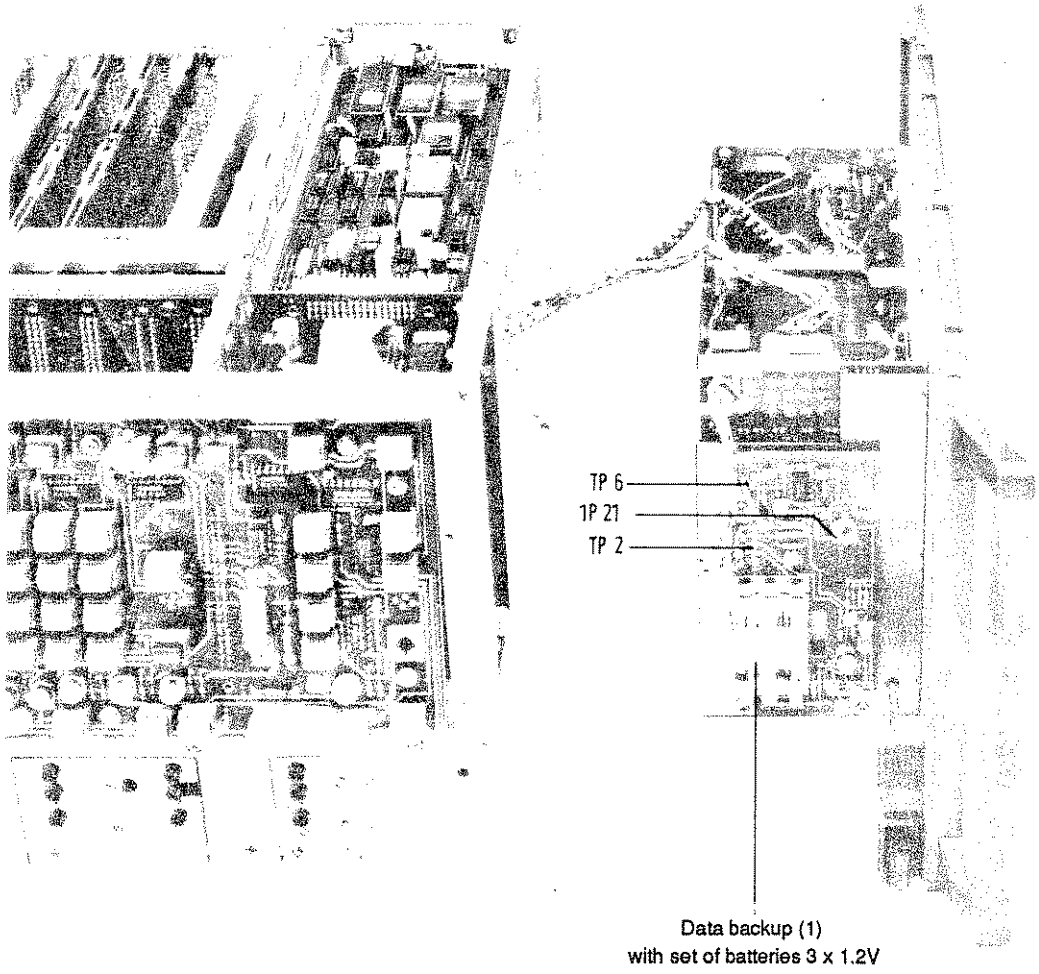


Figure C-3 Position of batteries in instrument

Appendix D: User-specific tolerance masks

Appendix D: User-specific tolerance masks

D.1 Tolerance mask structure in the PCM-4 from series AK onwards

Parameter 925 (1 ... 9) of the PCM-4 offers a selection of up to 9 tolerance masks for each operating mode, i.e. without changing the measurement mode, running parameter or configuration. The tolerance values of the masks are defined by the user on the forms enclosed in this Appendix and assigned to the operating modes in lists Nos. 1 to 9.

Example: With the following settings on the PCM-4
PARAMETER 925 No. 3
Measurement mode: A 52
Configuration: A-D
Running parameter: LEVEL

the tolerance mask of Operating Mode List No. 3 assigned to the operating mode (A 52/LEVEL/A-D) is displayed on the graphic screen display.

The PCM-4 is fitted with a standard tolerance mask EPROM where Operating Mode List Nos. 1 to 7 provide tolerance masks in accordance with CCITT Blue Book Recommendations G.712 ("full-channel" A-A) and G.714 ("half-channel" A-D and D-A) for measurements on 4-wire interfaces. Masks complying with CCITT Recommendation G.792 are assigned for (D-D) measurements on transmultiplexers.

If measurements are to be made on 2-wire interfaces, Operating Mode List No. 2 can be called up by setting PARAMETER 925 No. 2. This list takes account of the operating modes for which the CCITT assigns masks for 2-wire interfaces in Recommendation G.713 and G.715.

Tolerance masks for measuring the transmission characteristics of 2-wire analog interfaces to Q.552 are assigned to Operating Mode Lists Nos. 3 to 5.

Tolerance masks to Q.553 for measurements on 4-wire analog interfaces are located in the Operating Mode Lists Nos. 6 and 7.

The table on pages D-7 to D-18 in this Appendix documents Operating Mode List Nos. 1 to 7. This table shows which mask is assigned to which operating mode. FORM 3 documents 113 stored tolerance masks (Nos. 1 to 113), showing a graphic representation and the numerical coordinates of the upper and lower tolerance limits.

In addition to List Nos. 1 to 7 defined here, the user-specified masks can be assigned to the operating modes on FORM 2 (original copy enclosed in this Appendix) as Lists Nos. 7 to 9 or overwritten on lists which are already assigned. All the data of a user mask can be listed on FORM 4.

Form 1: For entering important instrument data

Form 2: For listing the operating modes with the associated tolerance masks; Operating Mode Lists Nos. 1 to 9 are possible. Lists Nos. 1 to 7 are offered.
No. 1 contains the CCITT masks G.714/G.792;
No. 2 contains the CCITT masks G.713/G.715;
No. 3 contains the CCITT masks Q.552 Z and C_2 interface, speech wired;
No. 4 contains the CCITT masks Q.552 C_2 interface, separate wired;
No. 5 contains the CCITT masks Q.552 Z and C_2 interface;
No. 6 contains the CCITT masks Q.553 speech wired;
No. 7 contains the CCITT masks Q.553 separate wired
If, for example, four masks are to be assigned to the same operating mode, these must be kept on four separate lists.

Form 3: Offers 113 masks assigned to Operating Mode Lists No. 1 to 9.
Each mask can be changed by the user on FORM 3 (retaining the same mask number) and, for example, also assigned to Operating Mode Lists Nos. 1 to 9.

Form 4: User-specified masks can be defined. Each mask is identified by its own mask number.
(FORM 4, enclosed on the last page of this Appendix as a blank original for copying, is also available in a 50-sheet block under Order No. BN 0984/00.79).

Each user-specified mask will be displayed on the graphics display of the PCM-4 when the appropriate settings are made. If a numerical display is selected, all results lying beyond the user-specified tolerance mask are marked "*" on the display.
PARAMETER 08 can be used to print out all the user-specified tolerance mask values and measurement results on a printer connected via the IEC/IEEE bus. PARAMETER 09 causes only the results lying beyond the tolerance mask to be printed out, together with the associated tolerance values.

D.1.1 Ordering user-specified tolerance masks

After receipt of the completed forms at the factory, the tolerance masks are stored in an EPROM.

Mask EPROMs must be ordered under Order No.

BN 0984/00.35 "Tolerance masks submitted to user specification".

If orders are to be handled smoothly, it is also essential to send the completed forms to:

Wandel & Goltermann & Co
Abt. Disposition
Postfach 1262
D-7412 Eningen u.A.
Federal Republic of Germany

The PCM-4 can be fitted with the EPROM containing the user-specified tolerance masks either before or after delivery. Appendix D.3 describes the procedure for installation of the EPROM in the PCM-4 by the user.

NB:
If the order for a PCM-4 does not quote the Order No. BN 0984/00.35 or contains only the ordering information but no completed forms, the standard EPROM with the CCITT masks of Operating Mode Lists Nos. 1 and 2 will be fitted in the PCM-4.

D.1.2 Retrofitting the PCM-4 with the series AK mask structure

PCM-4 of series A...F

Instruments of these series can only have the series K mask structure described in Appendix D.1 if the software has already been updated and the software version of the PCM-4 has the following identifications in MODE A01:

Software identification	Instrument version
984-0093.210	BN 984/01
984-0094.222	BN 984/02
984-0095.218	BN 984/03

PCM-4 units with these software identifications are prepared for accepting the user-specified mask EPROMs.

If software identifications with lower numbers appear, or if no identification can be obtained at all in MODE A01, the PCM-4 software must be updated. Depending on instrument version, the software update to the latest status can be ordered under the following numbers:

Order No.	Instrument version
BN 984/00.41	BN 984/01
BN 984/00.42	BN 984/02 and BN 984/05
BN 984/00.43	BN 984/03

PCM-4 of series G to AK

Instruments of these series are prepared for accommodating the user-specified mask EPROM.

D.2 How to complete forms 1 to 4

(1) Name

You can enter up to 6 ASCII characters here to identify your tolerance mask EPROM. When the tolerance mask EPROM is fitted, this name will be displayed on the screen of the PCM-4, along with the software version, after pressing the keys /MODE A/ + /0/ + /1/ + /ENTER/.

(2) Page No.

Number each page consecutively in this field. Note that Form 3 is printed on both sides. Enter the **same** number on both sides of the form in field (2). Form 1 is used as a cover page and is thus given the page No. 1. The entries in field (2) make it easier to keep the sheets in order.

Company stamp, date and signature
should always be included on the cover (Form 1).

D.2.1 Form 1

(3) No. of pages

The number of pages is entered here and must match the page No. in field (2) of the last form. This is helpful if ever a page is mislaid.

(4) Serial number

If the PCM-4 has yet to be delivered, this number will be entered at the factory.
If you already have your PCM-4, enter the serial number here. It consists of one letter and a four-figure number and can be found near the bottom of the front panel.

(5) Version

If the PCM-4 has yet to be delivered, the entries relating to the PCM-4 version and the installed options are completed at the factory. Otherwise, put a tick in the boxes which correspond to those marked with a sticker on the back of your PCM-4.

(6) Software version

If the PCM-4 has yet to be delivered, the software version data are entered at the factory. If you already have your PCM-4, press the keys /MODE A/ + /0/ + /1/ + /ENTER/. The software version information is then displayed on the screen. Please enter it in the field provided.

NB: See the notes in section D.1.2.

D.2.2 Form 2

Operating modes which are to be assigned a tolerance mask are defined in the Operating Mode List by entering the measurement mode, running parameter and configuration. Each operating mode may be assigned up to 9 different tolerance masks in Operating Mode Lists Nos. 1 to 9 (to be entered under (3)).

Operating Mode Lists Nos. 1 and 2 are provided. They contain masks Nos. 1 to 7 and can either be adopted unchanged or modified by the user. These masks are documented on Form 3.

There are various ways of retaining Operating Mode Lists Nos. 1 to 9 in the EPROM with user-specified tolerance masks. Form 2 can be used as an original for copying in this case. No. 1 to No. 9 are entered in field (3).

Possible ways of retaining Operating Mode List Nos. 1 to 9 in the mask EPROM:

a) without changes
Nothing need be entered in columns (4), (5), (6), (7) and (8), as lists Nos. 1 to 7 are to be stored in the EPROM unchanged.

b) with deletions
If the operating modes in lists Nos. 1 to 7 are not to be assigned masks, the entries for the operating mode in question must be copied into columns (4), (5), (6), (7) and (8). A horizontal bar is used to indicate that the information is intended for deletion.

c) with changed masks
Changes to masks Nos. 1 to 113 can be made on Form 3 without changing the mask number. The changed mask is assigned to the same operating modes in List Nos. 1 to 7 with the same identification (mask number). Consequently, no entries need be made in columns (4), (5), (6), (7) and (8) on Form 2.

d) with new masks
New masks can be drafted by the user on Form 4. The numbering of new masks should start with No. 114.
The new mask is assigned to an operating mode in list Nos. 1 to 9 by making entries relating to the corresponding operating mode in columns (4), (5), (6) and (7). Column (8) contains the new mask number.

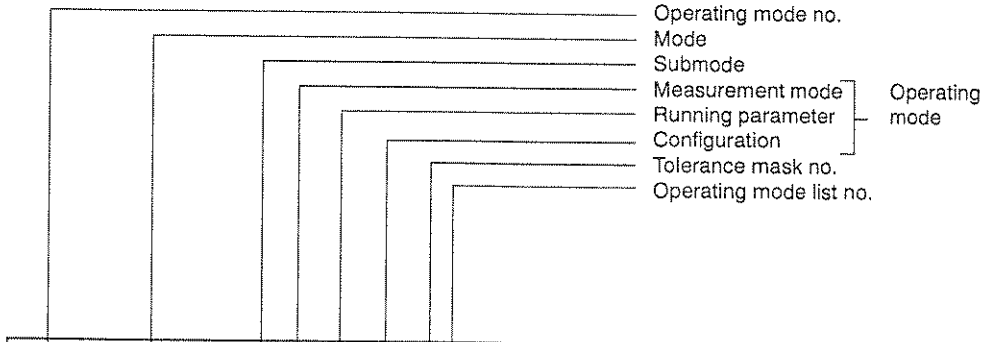
e) with additional operating modes
Operating modes not included in the table on pages D-7 to D-18 can be added on Form 2 as a supplement to list 1 to 7. Columns (5), (6) and (7) identify the additional operating mode, while column (8) shows the mask number. Column (4) can be left blank.

Exception:
Operating modes presenting more than one result cannot be assigned a mask.
This affects operating modes with the mesurement mode:

B45	Peak code word
B81	Frame error measurement
B82	Error frequency
B83	Error counting
B84	Error-free seconds

NB: Each operating mode may only appear once per list. If an operating mode is to be assigned more than two different masks, Lists No. 8 and 9 must be used.

NB: In contrast to Lists No. 1 to 7, every operating mode assigned a mask must be entered in Lists No. 8 and 9 on Form 2. If an operating mode is not listed, no mask can appear on the screen after selecting the corresponding operating mode on the PCM-4 and PARAMETER 925 TOLERANCE SELECTION 8 and 9.



				4–wire			2–wire		
			1	G.712	G.714	G.792	2	G.713	
1	Overall loss	A21/FRE/DD	3			11.1/9*	40	11/9	17
2		A21/CHA/AA	1	16			41	15	
3	813 Hz/0dBm0	A21/CHA/AD	2		4		42	–	
4		A21/CHA/DA	2		4		42	–	
5	Overall loss	A22/FRE/DD	3			11.1/9*	40	11/9	1
6									

			4-wire				2-wire			Q.552 Z-,C_2 interface		Q.552 C_2 interface		Q.552 Z-,C_2 interface		Q.553			
			1	G.712	G.714	G.792	2	G.713	G.715	3	speech wired	4	separate wired	5		6	speech wired	7	separate wired
1	*Overall loss*	A21/FRE/DD	3	-	-	11.1/9*	40	11/9	17.1/11	-		-		-		-		-	
2		A21/CHA/AA	1	16	-	-	41	15	-	-		-		-		-		-	
3	*813 Hz/ 0 dBm0*	A21/CHA/AD	2	-	4	-	42	-	3	-		-		-		-		-	
4		A21/CHA/DA	2	-	4	-	42	-	3	-		-		-		-		-	
5	*Overall loss*	A22/FRE/DD	3	-	-	11.1/9*	40	11/9	17.1/11	-		-		-		-		-	
6		A22/CHA/AA	1	16	-	-	41	15	-	-		-		-		-		-	
7	*813 Hz/-10 dBm0*	A22/CHA/AD	2	-	4	-	42	-	3	-		-		-		-		-	
8		A22/CHA/DA	2	-	4	-	42	-	3	-		-		-		-		-	
9	*Overall loss*	A23/FRE/DD	3	-	-	11.1/9*	40	11/9	17.1/11	72	3.1.8.1/11	72	3.1.8.1/11	-		-		-	
10		A23/CHA/AA	1	16	-	-	41	15	-	-		-		-		-		-	
11	*1014 Hz/0 dBm0*	A23/CHA/AD	2	-	4	-	42	-	3	71	3.1.1.2	71	3.1.1.2	91	3.1.8.2	94	3.1.1.2	94	3.1.1.2
12		A23/CHA/DA	2	-	4	-	42	-	3	71	3.1.1.2	71	3.1.1.2	91	3.1.8.2	94	3.1.1.2	94	3.1.1.2
13	*Overall loss*	A24/FRE/DD	3	-	-	11.1/9*	40	11/9	17.1/11	72	3.1.8.1/11	72	3.1.8.1/11	-		-		-	
14		A24/CHA/AA	1	16	-	-	41	15	-	-		-		-		-		-	
15	*1014 Hz/-10 dBm0*	A24/CHA/AD	2	-	4	-	42	-	3	71	3.1.1.2	71	3.1.1.2	91	3.1.8.2	94	3.1.1.2	94	3.1.1.2
16		A24/CHA/DA	2	-	4	-	42	-	3	71	3.1.1.2	71	3.1.1.2	91	3.1.8.2	94	3.1.1.2	94	3.1.1.2
17	*Variation of gain*	A31/FRE/AA	4	1/1	-	-	43	1/1	-	-		-		-		-		-	
18	*with frequency*	A31/FRE/AD	5	-	7/2	-	44	-	7/2	-		-		-		-		-	
19	*200 Hz...4 kHz/*	A31/FRE/DA	5	-	7/2	-	44	-	7/2	-		-		-		-		-	
20	*813 Hz/0 dBm0*	A31/FRE/DD	6	-	-	7/2	-			-		-		-		-		-	

* G.713

			4-wire				2-wire			Q.552 Z-,C_2 interface		Q.552 C_2 interface		Q.552 Z-,C_2 interface		Q.553			
			1	G.712	G.714	G.792	2	G.713	G.715	3	speech wired	4	separate wired	5		6	speech wired	7	separate wired
21	*Variation of gain*	A32/FRE/AA	4	1/1	-	-	43	1/1	-	-		-		-		-		-	
22	*with frequency*	A32/FRE/AD	5	-	7/2	-	44	-	7/2	-		-		-		-		-	
23	*200 Hz...4 kHz/*	A32/FRE/DA	5	-	7/2	-	44	-	7/2	-		-		-		-		-	
24	*813 Hz/-10 dBm0*	A32/FRE/DD	6	-	-	7/2	-			-		-		-		-		-	
25	*Variation of gain*	A33/FRE/AA	4	1/1	-	-	43	1/1	-	-		-		-		-		-	
26	*with frequency*	A33/FRE/AD	5	-	7/2	-	44	-	7/2	73	3.1.1.5/6a	73	3.1.1.5/6a	-		95	3.1.1.5/4a	95	3.1.1.5/4a
27	*200 Hz...4 kHz/*	A33/FRE/DA	5	-	7/2	-	44	-	7/2	74	3.1.1.5/6b	74	3.1.1.5/6b	-		96	3.1.1.5/4b	96	3.1.1.5/4b
28	*1014 Hz/0 dBm0*	A33/FRE/DD	6	-	-	7/2	-			-		-		-		-		-	
29	*Variation of gain*	A34/FRE/AA	4	1/1	-	-	43	1/1	-	-		-		-		-		-	
30	*with frequency*	A34/FRE/AD	5	-	7/2	-	44	-	7/2	73	3.1.1.5/6a	73	3.1.1.5/6a	-		95	3.1.1.5/4a	95	3.1.1.5/4a
31	*200 Hz...4 kHz/*	A34/FRE/DA	5	-	7/2	-	44	-	7/2	74	3.1.1.5/6b	74	3.1.1.5/6b	-		96	3.1.1.5/4b	96	3.1.1.5/4b
32	*1014 Hz/-10 dBm0*	A34/FRE/DD	6	-	-	7/2	-			-		-		-		-		-	
33	*Variation of gain*	A35/FRE/AA	4	1/1	-	-	43	1/1	-	-		-		-		-		-	
34	*with frequency*	A35/FRE/AD	5	-	7/2	-	44	-	7/2	-		-		-		-		-	
35	*20 Hz...4 kHz/*	A35/FRE/DA	5	-	7/2	-	44	-	7/2	-		-		-		-		-	
36	*813 Hz/0 dBm0*	A35/FRE/DD	6	-	-	7/2	-			-		-		-		-		-	
37	*Variation of gain*	A36/FRE/AA	4	1/1	-	-	43	1/1	-	-		-		-		-		-	
38	*with frequency*	A36/FRE/AD	5	-	7/2	-	44	-	7/2	-		-		-		-		-	
39	*20 Hz...4 kHz/*	A36/FRE/DA	5	-	7/2	-	44	-	7/2	-		-		-		-		-	
40	*813 Hz/-10 dBm0*	A36/FRE/DD	6	-	-	7/2	-			-		-		-		-		-	
41	*Variation of gain*	A37/FRE/AA	4	1/1	-	-	43	1/1	-	-		-		-		-		-	
42	*with frequency*	A37/FRE/AD	5	-	7/2	-	44	-	7/2	73	3.1.1.5/6a	73	3.1.1.5/6a	-		95	3.1.1.5/4a	95	3.1.1.5/4a
43	*20 Hz...4 kHz/*	A37/FRE/DA	5	-	7/2	-	44	-	7/2	74	3.1.1.5/6b	74	3.1.1.5/6b	-		96	3.1.1.5/4b	96	3.1.1.5/4b
44	*1014 Hz/0 dBm0*	A37/FRE/DD	6	-	-	7/2	-			-		-		-		-		-	

			4-wire				2-wire			Q.552 Z-,C_2 interface		Q.552 C_2 interface		Q.552 Z-,C_2 interface		Q.553			
			1	G.712	G.714	G.792	2	G.713	G.715	3	speech wired	4	separate wired	5		6	speech wired	7	separate wired
45	*Variation of gain*	A38/FRE/AA	4	1/1	-	-	43	1/1	-	-		-		-		-		-	
46	*with frequency*	A38/FRE/AD	5	-	7/2	-	44	-	7/2	73	3.1.1.5/6a	73	3.1.1.5/6a	-		95	3.1.1.5/4a	95	3.1.1.5/4a
47	*20 Hz...4 kHz/*	A38/FRE/DA	5	-	7/2	-	44	-	7/2	74	3.1.1.5/6b	74	3.1.1.5/6b	-		96	3.1.1.5/4b	96	3.1.1.5/4b
48	*1014 Hz/-10 dBm0*	A38/FRE/DD	6	-	-	7/2	-			-		-		-		-		-	
49	*Variation of gain*	A41/LEV/AA	7	10/7c	-	-	-			-		-		-		-		-	
50	*with level*	A41/LEV/AD	8	-	15.3/7	-	45	9/7c	-	-		-		-		-		-	
51	*SINE 813 Hz*	A41/LEV/DA	8	-	15.4/7	-	45	9/7c	-	-		-		-		-		-	
52	*SELECTIVE*	A41/LEV/DD	7	-	-	13/6	-			-		-		-		-		-	
53	*Variation of gain*	A42/LEV/AA	7	10/7c	-	-	-			-		-		-		-		-	
54	*with level*	A42/LEV/AD	8	-	15.3/7	-	45	9/7c	-	-		-		-		-		-	
55	*SINE 813 Hz*	A42/LEV/DA	8	-	15.4/7	-	45	9/7c	-	-		-		-		-		-	
56	*200 Hz...4 kHz*	A42/LEV/DD	7	-	-	13/6	-			-		-		-		-		-	
57	*Variation of gain*	A43/LEV/AA	7	10/7c	-	-	-			-		-		-		-		-	
58	*with level*	A43/LEV/AD	8	-	15.3/7	-	45	9/7c	-	75	3.1.1.4/5	75	3.1.1.4/5	-		97	3.1.1.4/3	97	3.3.1.4/3
59	*SINE 1014 Hz*	A43/LEV/DA	8	-	15.4/7	-	45	9/7c	-	75	3.1.1.4/5	75	3.1.1.4/5	-		97	3.1.1.4/3	97	3.3.1.4/3
60	*SELECTIVE*	A43/LEV/DD	7	-	-	13/6	-			-		-		-		-		-	
61	*Variation of gain*	A44/LEV/AA	7	10/7c	-	-	-			-		-		-		-		-	
62	*with level*	A44/LEV/AD	8	-	15.3/7	-	45	9/7c	-	75	3.1.1.4/5	75	3.1.1.4/5	-		97	3.1.1.4/3	97	3.3.1.4/3
63	*SINE 1014 Hz*	A44/LEV/DA	8	-	15.4/7	-	45	9/7c	-	75	3.1.1.4/5	75	3.1.1.4/5	-		97	3.1.1.4/3	97	3.3.1.4/3
64	*200 Hz...4 kHz*	A44/LEV/DD	7	-	-	13/6	-			-		-		-		-		-	
65	*Variation of gain*	A45/LEV/AA	9	10/7a	-	-	46	9/7a	-	-		-		-		-		-	
66	*with level*	A45/LEV/AD	10	-	15.1/6a	-	47	-	15.1/6a	-		-		-		-		-	
67	*NOISE RECV.*	A45/LEV/DA	10	-	15.2/6a	-	47	-	15.2/6a	-		-		-		-		-	
68	*350 Hz...550 Hz*	A45/LEV/DD	9	10/7a	-	-	-			-		-		-		-		-	

			4-wire				2-wire			Q.552 Z-,C_2 interface		Q.552 C_2 interface		Q.552 Z-,C_2 interface		Q.553			
			1	G.712	G.714	G.792	2	G.713	G.715	3	speech wired	4	separate wired	5		6	speech wired	7	separate wired
69	*Variation of gain*	A46/LEV/AA	9	10/7a	-	-	46	9/7a	-	-		-		-		-		-	
70	*with level*	A46/LEV/AD	10	-	15.1/6a	-	47	-	15.1/6a	-		-		-		-		-	
71	*NOISE RECV.*	A46/LEV/DA	10	-	15.2/6a	-	47	-	15.2/6a	-		-		-		-		-	
72	*200 Hz...4 kHz*	A46/LEV/DD	9	10/7a	-	-	-			-		-		-		-		-	
73	*Total distortion*	A51/LEV/AA	11	8/5	-	-	48	7/5	-	-		-		-		-		-	
74	*NOISE*	A51/LEV/AD	12	-	14.1/4a	-	49	-	14.1/4a	-		-		-		-		-	
75	*350 Hz...550 Hz*	A51/LEV/DA	13	-	14.2/4b	-	50	-	14.2/4b	-		-		-		-		-	
76	*CCITT O.131*	A51/LEV/DD	14	-	-	11/4b	-			-		-		-		-		-	
77	*Total distortion*	A52/LEV/AA	15	8/6	-	-	51	7/6	-	-		-		-		-		-	
78	*SINE*	A52/LEV/AD	16	-	14.3/5	-	52	-	14.3/5	-		-		-		-		-	
79	*422 Hz*	A52/LEV/DA	16	-	14.4/5	-	52	-	14.4/5	-		-		-		-		-	
80	*CCITT O.131*	A52/LEV/DD	17	-	-	11/5b	-			-		-		-		-		-	
81	*Total distortion*	A53/LEV/AA	15	8/6	-	-	51	7/6	-	-		-		-		-		-	
82	*SINE*	A53/LEV/AD	16	-	14.3/5	-	52	-	14.3/5	-		-		-		-		-	
83	*813 Hz PSOPH.*	A53/LEV/DA	16	-	14.4/5	-	52	-	14.4/5	-		-		-		-		-	
84	*CCITT O.131*	A53/LEV/DD	17	-	-	11/5b	-			-		-		-		-		-	
85	*Total distortion*	A54/LEV/AA	-				-			-		-		-		-		-	
86	*SINE*	A54/LEV/AD	-				-			-		-		-		-		-	
87	*813 Hz*	A54/LEV/DA	-				-			-		-		-		-		-	
88	*300 Hz...3350 Hz*	A54/LEV/DD	-				-			-		-		-		-		-	
89	*Total distortion*	A55/LEV/AA	15	8/6	-	-	51	7/6	-	-		-		-		-		-	
90	*SINE*	A55/LEV/AD	16	-	14.3/5	-	52	-	14.3/5	76	3.2.3/14	88	3.2.3/13	92	3.3.3/15a	98	3.1.5/11	111	3.1.5/10
91	*1014 Hz PSOPH.*	A55/LEV/DA	16	-	14.4/5	-	52	-	14.4/5	76	3.2.3/14	88	3.2.3/13	93	3.3.3/15b	98	3.1.5/11	111	3.1.5/10
92		A55/LEV/DD	17	-	-	11/5b	-			-		-		-		-		-	

			4-wire				2-wire			Q.552 Z-,C_2 interface		Q.552 C_2 interface		Q.552 Z-,C_2 interface		Q.553			
			1	G.712	G.714	G.792	2	G.713	G.715	3	speech wired	4	separate wired	5		6	speech wired	7	separate wired
93	*Total distortion*	A56/LEV/AA	15	8/6	-	-	51	7/6	-	-		-		-		-		-	
94	*SINE*	A56/LEV/AD	16	-	14.3/5	-	52	-	14.3/5	76	3.2.3/14	88	3.2.3/13	92	3.3.3/15a	98	3.1.5/11	111	3.1.5/10
95	*1014 Hz C-BEW.*	A56/LEV/DA	16	-	14.4/5	-	52	-	14.4/5	76	3.2.3/14	88	3.2.3/13	93	3.3.3/15b	98	3.1.5/11	111	3.1.5/10
96	*CCITT O.132*	A56/LEV/DD	17	-	-	11/5b	-			-		-		-		-		-	
97	*Total distortion*	A57/LEV/AA	-				-			-		-		-		-		-	
98	*SINE*	A57/LEV/AD	-				-			-		-		-		-		-	
99	*1014 Hz.*	A57/LEV/DA	-				-			-		-		-		-		-	
100	*300 Hz...3350 Hz*	A57/LEV/DD	-				-			-		-		-		-		-	
101	*Idle channel noise*	A61/CHA/AA	18	4.1	-	-	53	4.1	-	-		-		-		-		-	
102		A61/CHA/AD	19	-	9	-	54	-	9	77	3.2.2.1.2	89	3.2.2.1.2	-		99	3.1.3.1.	112	3.1.3.1
103	*PSOPH.*	A61/CHA/DA	20	-	10	-	55	-	10	78	3.2.2.1.1	90	3.2.2.1.1	-		100	3.1.3.1	113	3.1.3.1
104		A61/CHA/DD	18	-	-	9.1	-			-		-		-		-		-	
105	*Idle channel noise*	A62/CHA/AA	18	4.1	-	-	53	4.1	-	-		-		-		-		-	
106		A62/CHA/AD	19	-	9	-	54	-	9	77	3.2.2.1.2	89	3.2.2.1.2	-		99	3.1.3.1.	112	3.1.3.1
107	*C WEIGHTED*	A62/CHA/DA	20	-	10	-	55	-	10	78	3.2.2.1.1	90	3.2.2.1.1	-		100	3.1.3.1	113	3.1.3.1
108		A62/CHA/DD	18	-	-	9.1	-			-		-		-		-		-	
109	*Idle channel noise*	A63/CHA/AA	-				-			-		-		-		-		-	
110		A63/CHA/AD	-				-			-		-		-		-		-	
111	*300 Hz...3350 Hz*	A63/CHA/DA	-				-			-		-		-		-		-	
112		A63/CHA/DD	-				-			-		-		-		-		-	
113	*Idle channel noise*	A64/CHA/AA	18	4.1	-	-	53	4.1	-	-		-		-		-		-	
114		A64/CHA/AD	19	-	9	-	54	-	9	77	3.2.2.1.2	89	3.2.2.1.2	-		99	3.1.3.1.	112	3.1.3.1
115	*NOISE w. 2 kHz*	A64/CHA/DA	20	-	10	-	55	-	10	78	3.2.2.1.1	90	3.2.2.1.1	-		100	3.1.3.1	113	3.1.3.1
116	*TONE, PSOPH.*	A64/CHA/DD	18	-	-	9.1	-			-		-		-		-		-	

			4-wire				2-wire			Q.552 Z-,C_2 interface		Q.552 C_2 interface		Q.552 Z-,C_2 interface		Q.553			
			1	G.712	G.714	G.792	2	G.713	G.715	3	speech wired	4	separate wired	5		6	speech wired	7	separate wired
117	*Idle channel noise*	A65/CHA/AA	18	4.1	-	-	53	4.1	-	-		-		-		-		-	
118		A65/CHA/AD	19	-	9	-	54	-	9	77	3.2.2.1.2	89	3.2.2.1.2	-		99	3.1.3.1.	112	3.1.3.1
119	*NOISE w. 2 kHz*	A65/CHA/DA	20	-	10	-	55	-	10	78	3.2.2.1.1	90	3.2.2.1.1	-		100	3.1.3.1	113	3.1.3.1
120	*TONE, C MESS.*	A65/CHA/DD	18	-	-	9.1	-			-		-		-		-		-	
121	*Idle channel noise*	A66/CHA/AA	-				-			-		-		-		-		-	
122		A66/CHA/AD	-				-			-		-		-		-		-	
123	*300 Hz...3350 Hz*	A66/CHA/DA	-				-			-		-		-		-		-	
124		A66/CHA/DD	-				-			-		-		-		-		-	
125	*Crosstalk*	A71/CHA/AA	21	-	16.2/8	-	56	-	16.2/8	79	3.1.4.1/8	79	3.1.4.1/8	-		101	3.1.4.1.1/6	101	3.1.4.1.1/6
126		A71/CHA/AD	22	-	16.2/8	-	57	-	16.2/8	80	3.1.4.1/8	80	3.1.4.1/8	-		102	3.1.4.1.1/6	102	3.1.4.1.1/6
127	*Different channels*	A71/CHA/DA	21	-	16.4/10	-	56	-	16.3/9	79	3.1.4.2/9	79	3.1.4.2/9	-		101	3.1.4.2.1/8	101	3.1.4.2.1/8
128	*301 Hz SELECTIVE*	A71/CHA/DD	22	-	16.4/10	-	57	-	16.3/9	80	3.1.4.2/9	80	3.1.4.2/9	-		102	3.1.4.2.1/8	102	3.1.4.2.1/8
129	*Crosstalk*	A72/CHA/AA	21	-	16.2/8	-	56	-	16.2/8	79	3.1.4.1/8	79	3.1.4.1/8	-		101	3.1.4.1.1/6	101	3.1.4.1.1/6
130		A72/CHA/AD	22	-	16.2/8	-	57	-	16.2/8	80	3.1.4.1/8	80	3.1.4.1/8	-		102	3.1.4.1.1/6	102	3.1.4.1.1/6
131	*Different channels*	A72/CHA/DA	21	-	16.4/10	-	56	-	16.3/9	79	3.1.4.2/9	79	3.1.4.2/9	-		101	3.1.4.2.1/8	101	3.1.4.2.1/8
132	*813 Hz SELECTIVE*	A72/CHA/DD	22	-	16.4/10	-	57	-	16.3/9	80	3.1.4.2/9	80	3.1.4.2/9	-		102	3.1.4.2.1/8	102	3.1.4.2.1/8
133	*Crosstalk*	A73/CHA/AA	21	-	16.2/8	-	56	-	16.2/8	79	3.1.4.1/8	79	3.1.4.1/8	-		101	3.1.4.1.1/6	101	3.1.4.1.1/6
134		A73/CHA/AD	22	-	16.2/8	-	57	-	16.2/8	80	3.1.4.1/8	80	3.1.4.1/8	-		102	3.1.4.1.1/6	102	3.1.4.1.1/6
135	*Different channels*	A73/CHA/DA	21	-	16.4/10	-	56	-	16.3/9	79	3.1.4.2/9	79	3.1.4.2/9	-		101	3.1.4.2.1/8	101	3.1.4.2.1/8
136	*1014 Hz SELECTIVE*	A73/CHA/DD	22	-	16.4/10	-	57	-	16.3/9	80	3.1.4.2/9	80	3.1.4.2/9	-		102	3.1.4.2.1/8	102	3.1.4.2.1/8
137	*Crosstalk*	A74/CHA/AA	21	-	16.2/8	-	56	-	16.2/8	79	3.1.4.1/8	79	3.1.4.1/8	-		101	3.1.4.1.1/6	101	3.1.4.1.1/6
138		A74/CHA/AD	22	-	16.2/8	-	57	-	16.2/8	80	3.1.4.1/8	80	3.1.4.1/8	-		102	3.1.4.1.1/6	102	3.1.4.1.1/6
139	*Different channels*	A74/CHA/DA	21	-	16.4/10	-	56	-	16.3/9	79	3.1.4.2/9	79	3.1.4.2/9	-		101	3.1.4.2.1/8	101	3.1.4.2.1/8
140	*3343 Hz SELECTIVE*	A74/CHA/DD	22	-	16.4/10	-	57	-	16.3/9	80	3.1.4.2/9	80	3.1.4.2/9	-		102	3.1.4.2.1/8	102	3.1.4.2.1/8

			4-wire				2-wire			Q.552 Z-,C_2 interface		Q.552 C_2 interface		Q.552 Z-,C_2 interface		Q.553			
			1	G.712	G.714	G.792	2	G.713	G.715	3	speech wired	4	separate wired	5		6	speech wired	7	separate wired
141 142 143 144	*Crosstalk* *NOISE*	A75/CHA/AA A75/CHA/AD A75/CHA/DA A75/CHA/DD	23 23 23 23	* * * *	- - - -	14.2 14.2 14.2 14.2	56 57 56 57	- - - -	16.2/8 16.2/8 16.3/9 16.3/9	- - - -		- - - -		- - - -		- - - -		- - - -	
145 148	*Crosstalk* *Same channel* *301 Hz SELECTIVE*	A76/CHA/AA A76/CHA/DD	24 24	- -	16.3/9 16.5/11	-	-			-		-		-		103 104	3.1.4.1.2/7 3.1.4.2.2/9	103 104	3.1.4.1.2/7 3.1.4.2.2/9
149 152	*Crosstalk* *Same channel* *813 Hz SELECTIVE*	A77/CHA/AA A77/CHA/DD	24 24	- -	16.3/9 16.5/11	-	-			-		-		-		103 104	3.1.4.1.2/7 3.1.4.2.2/9	103 104	3.1.4.1.2/7 3.1.4.2.2/9
153 156	*Crosstalk* *Same channel* *1014 Hz SELECTIVE*	A78/CHA/AA A78/CHA/DD	24 24	- -	16.3/9 16.5/11	-	-			-		-		-		103 104	3.1.4.1.2/7 3.1.4.2.2/9	103 104	3.1.4.1.2/7 3.1.4.2.2/9
157 160	*Crosstalk* *Same channel* *3343 Hz SELECTIVE*	A79/CHA/AA A79/CHA/DD	24 24	- -	16.3/9 16.5/11	-	-			-		-		-		103 104	3.1.4.1.2/7 3.1.4.2.2/9	103 104	3.1.4.1.2/7 3.1.4.2.2/9
161 162 163 164	*Out of band* *measurements* *TX 4.6...72 kHz* *RX 0.2...4 kHz*	A81/FRE/AA A81/FRE/AD A81/CHA/AA A81/CHA/AD	25 25 25 25	5.1 5.1 5.1 5.1	- 11.1 - 11.1	-	58 58 58 58	5.1 5.1 5.1 5.1	- 11.1 - 11.1	- 81 - 81	- 3.1.6.1 - 3.1.6.1	- 81 - 81	- 3.1.6.1 - 3.1.6.1	- - - -		- 105 - 105	- 3.1.6.1 - 3.1.6.1	- 105 - 105	- 3.1.6.1 - 3.1.6.1

Note: measurement modes 161 to 259 are **not** included in the PCM-5.

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* Crosstalk caused by noise signal: values under study.

			4-wire				2-wire			Q.552 Z-,C_2 interface		Q.552 C_2 interface		Q.552 Z-,C_2 interface		Q.553			
			1	G.712	G.714	G.792	2	G.713	G.715	3	speech wired	4	separate wired	5		6	speech wired	7	separate wired
165	*Out of band*	A82/FRE/AA	26	6.1	-	-	59	6	-	-		-		-		-		-	
166	*measurements*	A82/FRE/DA	26	-	12.1	-	59	-	12	82	3.1.7.1	82	3.1.7.1	-		106	3.1.7.1	106	3.1.7.1
167	*TX 0.1...4 kHz*	A82/CHA/AA	26	6.1	-	-	59	6	-	-		-		-		-		-	
168	*RX 4.6...128 kHz*	A82/CHA/DA	26	-	12.1	-	59	-	12	82	3.1.7.1	82	3.1.7.1	-		106	3.1.7.1	106	3.1.7.1
171	*Out of band*	A83/CHA/AA	27	4.2	-	-	60	4.2	-	-		-		-		-		-	
172	*measurements TX OFF RX 4.6...128 kHz*	A83/CHA/DA	27	4.2	13	9.3	60	4.2	13	83	3.1.3	83	3.1.3	-		107	3.1.3.4	107	3.1.3.4
173	*Return*	B11/FRE/TX	28	3.2	5	-	61	3.2	4.2	84	2.1.1.2/1	84	2.1.1.2/1	-		108	2.1.1.2	108	2.1.1.2
174	*loss*	B11/FRE/RX	28	3.2	5	-	61	3.2	4.2	84	2.1.1.2/1	84	2.1.1.2/1	-		108	2.1.1.2	108	2.1.1.2
175	*Return*	B12/FRE/TX	-				61	3.2	4.2	84	2.1.1.2/1	84	2.1.1.2/1	-		108	2.1.1.2	108	2.1.1.2
176	*loss*	B12/FRE/RX	-				61	3.2	4.2	84	2.1.1.2/1	84	2.1.1.2/1	-		108	2.1.1.2	108	2.1.1.2
177	*Return*	B13/FRE/TX	-				61	3.2	4.2	84	2.1.1.2/1	84	2.1.1.2/1	-		108	2.1.1.2	108	2.1.1.2
178	*loss*	B13/FRE/RX	-				61	3.2	4.2	84	2.1.1.2/1	84	2.1.1.2/1	-		108	2.1.1.2	108	2.1.1.2
179	*Longitudinal*	B21/FRE/TX	29	3.3/3	6/1	-	62	3.3/3	5/1	85	2.1.2/2	85	2.1.2/2	-		109	2.1.2/1	109	2.1.2/1
180	*conversion loss*	B21/FRE/RX	29	3.3/3	6/1	-	62	3.3/3	5/1	85	2.1.2/2	85	2.1.2/2	-		109	2.1.2/1	109	2.1.2/1
181	*Longitudinal*	B22/FRE/TX	29	3.3/3	6/1	-	62	3.3/3	5/1	85	2.1.2/2	85	2.1.2/2	-		109	2.1.2/1	109	2.1.2/1
182	*conversion loss*	B22/FRE/RX	29	3.3/3	6/1	-	62	3.3/3	5/1	85	2.1.2/2	85	2.1.2/2	-		109	2.1.2/1	109	2.1.2/1
183	*Longitudinal conv.*	B31/FRE/AA	29	3.3/3	6/1	-	63	3.3/3	5/1	-		-		-		-		-	
184	*transfer loss*	B31/FRE/AD	29	3.3/3	6/1	-	63	3.3/3	5/1	-		-		-		-		-	
185	*600 OHM*	B31/FRE/DA	29	3.3/3	6/1	-	63	3.3/3	5/1										

Note: measurement modes 161 to 259 are **not** included in the PCM-5.

			4-wire				2-wire			Q.552 Z-,C_2 interface		Q.552 C_2 interface		Q.552 Z-,C_2 interface		Q.553			
			1	G.712	G.714	G.792	2	G.713	G.715	3	speech wired	4	separate wired	5		6	speech wired	7	separate wired
186	*Longitudinal conv.*	B32/FRE/AA	29	3.3/3	6/1	-	63		5/1	-		-		-		-		-	
187	*transfer loss*	B32/FRE/AD	29	3.3/3	6/1	-	63		5/1	-		-		-		-		-	
188	*850/900 OHM/OPT.*	B32/FRE/DA	29	3.3/3	6/1	-	63		5/1	-		-		-		-		-	
189	*Group delay*	B51/CHA/AA	30	2.1	-	-	64	2.1	-	-		-		-		-		-	
190		B51/CHA/AD	31	-	8.1.1	-	65	-	8.1.1	-		-		-		-		-	
191	*absolute*	B51/CHA/DA	32	-	8.1.2	-	66	-	8.1.2	-		-		-		-		-	
192		B51/CHA/DD	33	-	-	8.1	-			-		-		-		-		-	
193	*Group delay*	B52/FRE/AA	34	2.2/2	-	-	67	2.2/2	-	-		-		-		-		-	
194		B52/FRE/AD	35	-	8.2/3	-	68	-	8.2/3	86	3.1.2.2/7	86	3.1.2.2/7	-		110	3.1.2.2/5	110	3.1.2.2/5
195	*Group delay-*	B52/FRE/DA	36	-	8.2/3	-	69	-	8.2/3	87	3.1.2.2/7	87	3.1.2.2/7	-		110	3.1.2.2/5	110	3.1.2.2/5
196	*distortion*	B52/FRE/DD	37	-	-	8.2/3	-			-		-		-		-		-	
197	*Signalling*	B61/CHA/AA	-				-			-		-		-		-		-	
198	*distortion*	B61/CHA/AD	-				-			-		-		-		-		-	
199		B61/CHA/DA	-				-			-		-		-		-		-	
200	*Signalling*	B62/CHA/AA	-				-			-		-		-		-		-	
201	*distortion*	B62/CHA/AD	-				-			-		-		-		-		-	
202		B62/CHA/DA	-				-			-		-		-		-		-	
203	*Signalling*	B63/CHA/AA	-				-			-		-		-		-		-	
204	*distortion*	B63/CHA/AD	-				-			-		-		-		-		-	
205		B63/CHA/DA	-				-			-		-		-		-		-	

Note: measurement modes 161 to 259 are **not** included in the PCM-5.

			4-wire				2-wire			Q.552 Z-,C_2 interface		Q.552 C_2 interface		Q.552 Z-,C_2 interface		Q.553			
			1	G.712	G.714	G.792	2	G.713	G.715	3	speech wired	4	separate wired	5		6	speech wired	7	separate wired
206	*Signalling*	B64/CHA/AA	-				-			-		-		-		-		-	
207	*distortion*	B64/CHA/AD	-				-			-		-		-		-		-	
208		B64/CHA/DA	-				-			-		-		-		-		-	
209	*Signalling*	B65/CHA/AA	-				-			-		-		-		-		-	
210	*distortion*	B65/CHA/AD	-				-			-		-		-		-		-	
211		B65/CHA/DA	-				-			-		-		-		-		-	
212	*Signalling*	B66/CHA/AA	-				-			-		-		-		-		-	
213	*distortion*	B66/CHA/AD	-				-			-		-		-		-		-	
214		B66/CHA/DA	-				-			-		-		-		-		-	
215	*Signalling*	B67/CHA/AA	-				-			-		-		-		-		-	
216	*distortion*	B67/CHA/AD	-				-			-		-		-		-		-	
217		B67/CHA/DA	-				-			-		-		-		-		-	
218	*Signalling*	B68/CHA/AA	-				-			-		-		-		-		-	
219	*distortion*	B68/CHA/AD	-				-			-		-		-		-		-	
220		B68/CHA/DA	-				-			-		-		-		-		-	
221	*Signalling*	B69/CHA/AA	-				-			-		-		-		-		-	
222	*distortion*	B69/CHA/AD	-				-			-		-		-		-		-	
223		B69/CHA/DA	-				-			-		-		-		-		-	
224	*Signalling*	B71/CHA/AA	38	13	-	-	-			-		-		-		-		-	
225	*crosstalk*	B71/CHA/AD	39	-	18	-	70	12	-	-		-		-		-		-	
226		B71/CHA/DA	39	-	18	-	70	12	-	-		-		-		-		-	
227		B71/CHA/DD	-				-			-		-		-		-		-	

Note: measurement modes 161 to 259 are **not** included in the PCM-5.

			4-wire				*2-wire*			*Q.552* Z-,C_2 *interface*		*Q.552* C_2 *interface*		*Q.552* Z-,C_2 *interface*		*Q.553*			
			1	G.712	G.714	G.792	2	G.713	G.715	3	speech wired	4	separate wired	5		6	speech wired	7	separate wired
228	*Signalling*	B72/CHA/AA	38	13	-	-	-			-		-		-		-		-	
229	*crosstalk*	B72/CHA/AD	39	-	18	-	70	12	-	-		-		-		-		-	
230		B72/CHA/DA	39		18	-	70	12	-	-		-		-		-		-	
231		B72/CHA/DD	-				-			-		-		-		-		-	
232	*Signalling*	B73/CHA/AA	38	13	-	-	-			-		-		-		-		-	
233	*crosstalk*	B73/CHA/AD	39	-	18	-	70	12	-	-		-		-		-		-	
234		B73/CHA/DA	39	-	18	-	70	12	-	-		-		-		-		-	
235		B73/CHA/DD	-				-			-		-		-		-		-	
236	*Signalling*	B74/CHA/AA	38	13	-	-	-			-		-		-		-		-	
237	*crosstalk*	B74/CHA/AD	39	-	18	-	70	12	-	-		-		-		-		-	
238		B74/CHA/DA	39	-	18	-	70	12	-	-		-		-		-		-	
239		B74/CHA/DD	-				-			-		-		-		-		-	
240	*Signalling*	B75/CHA/AA	38	13	-	-	-			-		-		-		-		-	
241	*crosstalk*	B75/CHA/AD	39	-	18	-	70	12	-	-		-		-		-		-	
242		B75/CHA/DA	39	-	18	-	70	12	-	-		-		-		-		-	
243		B75/CHA/DD	-				-			-		-		-		-		-	
244	*Signalling*	B76/CHA/AA	38	13	-	-	-			-		-		-		-		-	
245	*crosstalk*	B76/CHA/AD	39	-	18	-	70	12	-	-		-		-		-		-	
246		B76/CHA/DA	39	-	18	-	70	12	-	-		-		-		-		-	
247		B76/CHA/DD	-				-			-		-		-		-		-	
248	*Signalling*	B77/CHA/AA	38	13	-	-	-			-		-		-		-		-	
249	*crosstalk*	B77/CHA/AD	39	-	18	-	70	12	-	-		-		-		-		-	
250		B77/CHA/DA	39	-	18	-	70	12	-	-		-		-		-		-	
251		B77/CHA/DD	-				-			-		-		-		-		-	

Note: measurement modes 161 to 259 are **not** included in the PCM-5.

			4-wire				2-wire			Q.552 Z-,C_2 interface		Q.552 C_2 interface		Q.552 Z-,C_2 interface		Q.553			
			1	G.712	G.714	G.792	2	G.713	G.715	3	speech wired	4	separate wired	5		6	speech wired	7	separate wired
252	*Signalling*	B78/CHA/AA	38	13	-	-	-			-		-		-		-		-	
253	*crosstalk*	B78/CHA/AD	39	-	18	-	70	12	-	-		-		-		-		-	
254		B78/CHA/DA	39	-	18	-	70	12	-	-		-		-		-		-	
255		B78/CHA/DD	-				-			-		-		-		-		-	
256	*Signalling*	B79/CHA/AA	38	13	-	-	-			-		-		-		-		-	
257	*crosstalk*	B79/CHA/AD	39	-	18	-	70	12	-	-		-		-		-		-	
258		B79/CHA/DA	39	-	18	-	70	12	-	-		-		-		-		-	
259		B79/CHA/DD	-				-			-		-		-		-		-	

Note: measurement modes 161 to 259 are **not** included in the PCM-5.

D.2.3 Form 3

Tolerance masks No. 1 to 113 can be changed on Form 3 without changing the mask number.

Form 3

- identifies each mask with a MASK NO. 1 to 113
- lists the operating modes to which the mask is assigned in Operating Mode Lists No. 1 and 2
- shows the graphic representation of the tolerance mask
- lists the numerical X and Y tolerance values of each corner point separately for the lower and upper tolerance limit

D.2.3.1 Changing an X or Y value

The changed X or Y value of a corner point is entered in column (3) (see example in fig. D-1).

D.2.3.2 Deleting a corner point

The line referring to the corner point in question is crossed out (see example in fig. D-1).

D.2.3.3 Adding a corner point

A new corner point must be added by entering the X and Y values in column (3) of a new line.

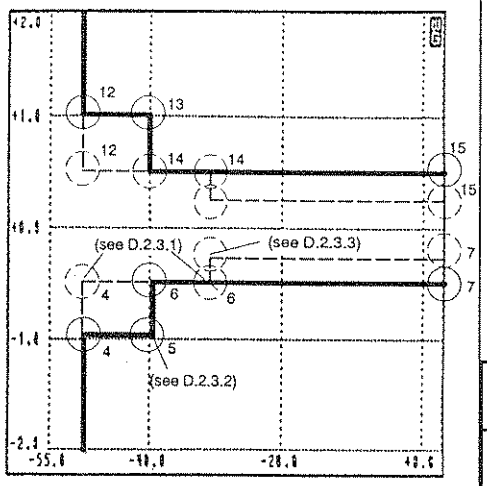
Since the new corner point lies between corner points which have already been defined, it is assigned the same number as the preceding corner point.

See example in fig. D-1:
The added corner point for the lower limit with the X value -30.00 and the Y value -.40 is assigned the corner point number 6, since the corner point lies between corner points No. 6 and No. 7.

PCM–4/PCM–5 tolerance masks | **mask no. 7** | **Form 3**

Bv. no.

To CCITT Rec. G.712/10 figure 7c



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, sifgnature

name ①

page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		Liste no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
49		49															
52		52															
53		53															
56		56															
57		57															
60		60															
61		61															
64		64															

Units: X in dB <0, m0>] Y in [dB]

corner point no.	lowe limit				corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		–99.99		9	–55.00		30.00	
2	–55.00		–3.00		10	–55.00		3.00	
3	–50.00		–3.00		11	–50.00		3.00	
4	–50.00		–1.00	-.50	12	–50.00		1.00	.50
~~5~~	~~–40.00~~		~~–1.00~~	—	~~13~~	~~–40.00~~		~~1.00~~	—
6	–40.00	-30.00	–.50		14	–40.00		.50	
7	3.00		–.50	-.40	15	3.00	-30.00	.50	.40
8	3.00	-30.00	–99.99		16	3.00		30.00	
6				-.40	14		-30.00		.40

——— = old mask
– – – = new mask

Fig. D-1 Example of changing a tolerance mask

D.2.4 Form 4

User-specified tolerance masks can be defined on photocopies of Form 4.

Form 4 is also available in a 50-sheet block under Order No. BN 978/00.79.

(3) Each mask is identified by its own mask number. The masks are numbered consecutively, starting with No. 114.

(4) The mask is identified as being a straight line or a linear approximation by putting an X in the appropriate box.

(5) The mask can only be assigned to operating modes with identical units for the running parameter (X axis) and measuring result (Y axis).

(6) The X and Y values of the lower and upper tolerance limit are assigned to 1 of up to 24 corner point numbers (see example in fig. D-2). Drawing the mask on graph paper gives greater clarity.

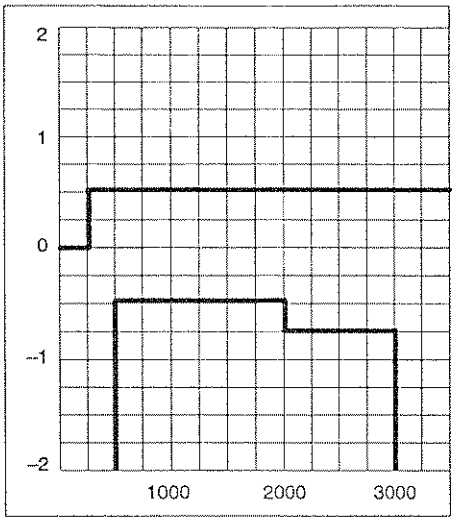
PCM–4/PCM–5 tolerance masks | **mask no.** | **Form 4**

Bv. no.

Type of mask ④

line ☐

linear approximation ☒



Complete this form if you want to procedure a completely new tolerance mask.
Only fill in the sections outlined in heavy type.

① name
② page number
③ number of tolerance masks
④ type of mask (linear or piecewise lineart approximation)
⑤ units for (X and Y)
⑥ tolerance values for (X and Y)
⑦ official stamp, date, signature

name ①

page no. ②

⑤ Units X in [Hz] Y in [dB <0, m0>]

Units: dB <0, m0> Hz, ms, µs, %

corner point no.	lower limit ⑥ X value	lower limit ⑥ Y value	corner point no.	upper limit ⑥ X value	upper limit ⑥ Y value
1	500	–99.99	7	10	0.00
2	500	–.50	8	250	0.00
3	2000	–.50	9	250	.50
4	2000	–.75	10	4000	.50
5	3000	–.75	11	4000	0.00
6	3000	–.99.99	12	5000	0.00

Figure D-2 Example of creating a new tolerance mask

D.3 Fitting the EPROM with user-specified tolerance masks

The EPROM is supplied in an electrically conductive wrapper (black film). It should be left in this wrapper until immediately prior to installation. Please pay special attention to the safety precautions marked "!" in the instructions below in order to prevent damaging CMOS components.

1. Switch off the PCM-4 at the mains ON/OFF switch. Leave the plug in the mains socket so that the instrument remains earthed.
2. Remove the rear panel of the PCM-4 as indicated in fig. D-3.
   If you have a PCM-4 of Series A or B, you must also remove the "64 kbit/s input" interface board or the dummy plate.
3. Grasp the top part of the yellow board extractor "984 CPU-2A/2" between thumb and index finger. Pull sharply downwards to release the board from its connector.
4. Due to static charges, you may have a higher potential than the instrument.
   To equalize the potentials, briefly touch a bare metal part of the PCM-4.
5. Use the yellow board extractor to remove the board from the PCM-4, holding it at the edges in one hand. Do not touch the components!
6. If you do not have a conductive foam mat large enough for the board, it can be placed on the PCM-4 with the component side facing upwards.
7. Fig. D-4 shows the EPROM slot.
   Carefully extract the EPROM already fitted from its connector. A small screwdriver can be inserted from the edge of the board to lever the EPROM out of the connector.
8. Briefly touch a bare metal part of the PCM-4. Take the new EPROM out of the black film and remove the conductive foam mat.
9. Now make sure that the EPROM is the right way round. The EPROM notch should point towards the edge of the board. Place the EPROM onto the connector and make sure that the pins fit correctly.
10. If you are sure that no pin can be bent, press the EPROM into the connector. Check that it is level with the other EPROMs.
11. The board can now be pushed back into its mount. Use enough force to make sure that it is fully home.
    The board is correctly located when the yellow board extractor rights itself again.
12. Fix the back panel onto the rear of the PCM-4 again and switch the instrument on at the mains ON/OFF switch.

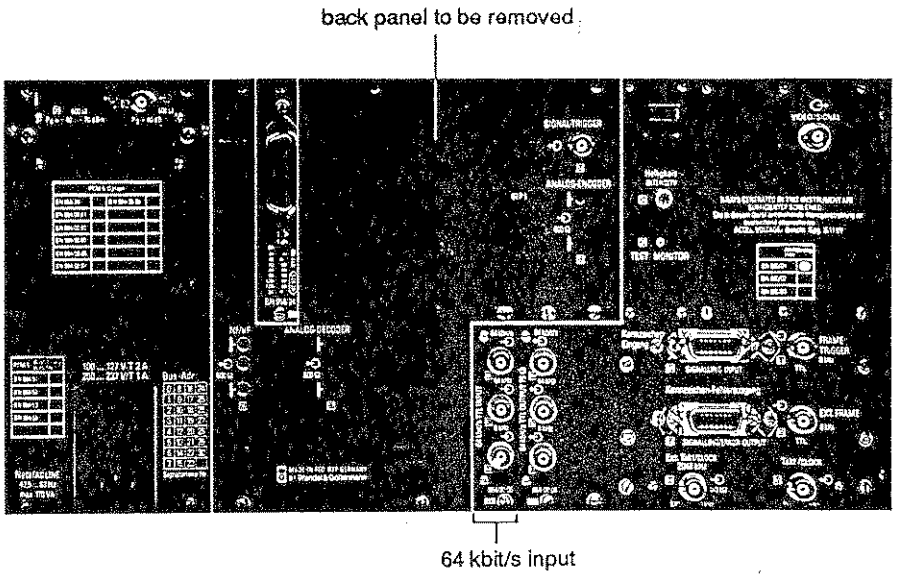


Figure D-3 Rear view of the PCM-4

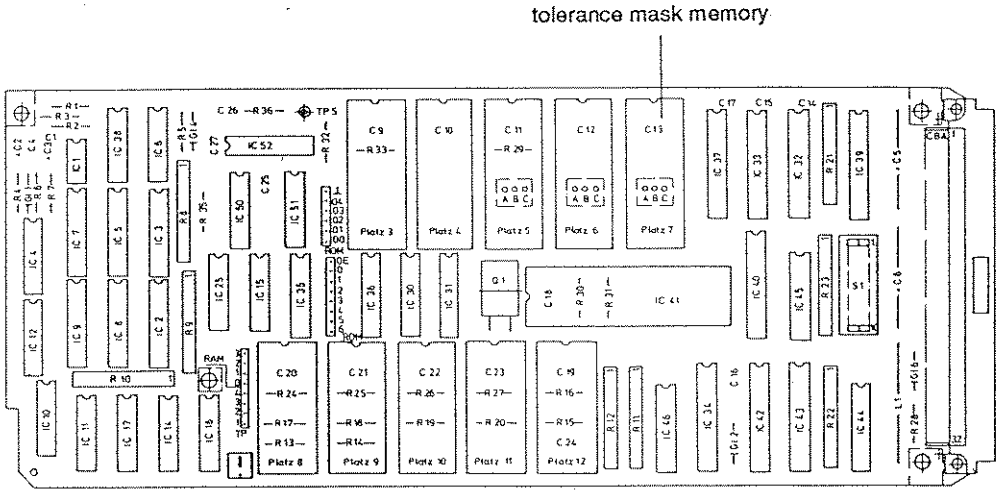


Figure D-4 CPU 2A/2

PCM–4/PCM–5 tolerance masks

Instrument details

Form 1

Bv. no.

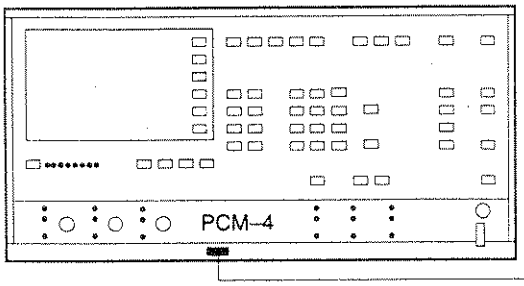
AB. no.

name ①

page no. ②

Complete this form and use it as page 1
Only fill in the sectiopns outlined in heavy type

① name
② page no.
③ mode list no. (1 to 9)
④ operating mode no.
⑤ measurement mode (e.g. A53)
⑥ X or running parameter (e.g. FRE)
⑦ configuration (e.g. AD)
⑧ number of applicable tolerance mask
⑨ official stamp, date, signature

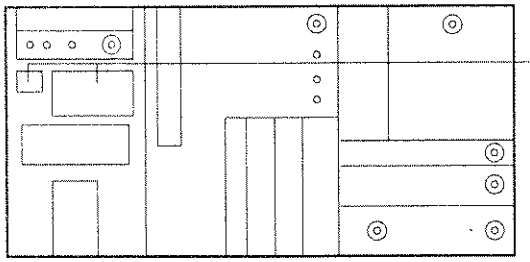


Serieal no. ③	No. of shetts ④

⑤

PCM–4		Ausführung/Version		PCM–5 Ausführung/ Version	
BN 984/01		BN 984/04		BN 984/51	
BN 984/02		BN 984/05		BN 984/52	
BN 984/03		BN 984/06		BN 984/53	

PCM–4/PCM–5 Option					
BN 958/24		BN 984/00.06		BN 984/00.14	
BN 984/00.01		BN 984/00.07		BN 984/00.16	
BN 984/00.02		BN 984/00.08		BN 984/00.31	
BN 984/00.03		BN 984/00.09		BN 984/00.32	
BN 984/00.04		BN 984/00.10		BN 984/00.33	
BN 984/00.05		BN 984/00.11		BN 984/00.34	



⑥

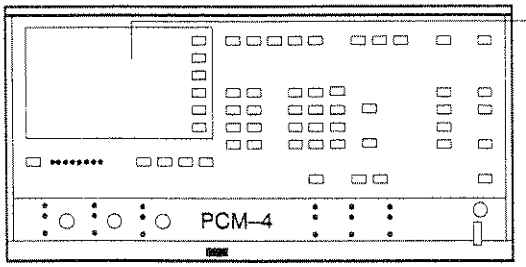
PCM–4 EPROMS tolerance masks to	
CCITT Red book (2 list occupied, 7 free)	
CCITT Blue book (7 list occupied, 2 free)	
User specification (see following forms 3 and 4	

⑦

MODE A 01 * SOFTWARE *

VERSION: 0984-___.___

CPU-2/1 (MASTER) REV.: ___.___
CPU-2/2 (DISPLAY) REV.: ___.___
CPU-2/3 (MEAS.) REV.: ___.___
EVAL. CIRCUIT REV.: ___.___
COUPLING CARD 1 REV.: ___.___
TOLERANCE SET REV.: ___.___



⑧ official stamp date signature

PCM–4/PCM–5 tolerance masks

mode list no. ③ [ ]

Form 2

Bv. no.

name
①

page no.
②

① name
② page no.
③ mode list no.
(1 to 9)
④ operating mode no.
⑤ measurement mode (e.g. A53)
⑥ X or running parameter (e.g. FRE)
⑦ configuration (e.g. AD)
⑧ number of applicable tolerance mask
⑨ official stamp, date, signature

④ operating mode no.	⑤ measure–ment mode	⑥ X or running param.	⑦ configu–ration	⑧ mask no.	④ operating mode no.	⑤ measure–ment mode	⑥ X or running param.	⑦ configu–ration	⑧ mask no.

⑨ official stamp | date | signature

PCM–4/PCM–5 tolerance masks

Mask no. 1

Form 3

Bv.–No.

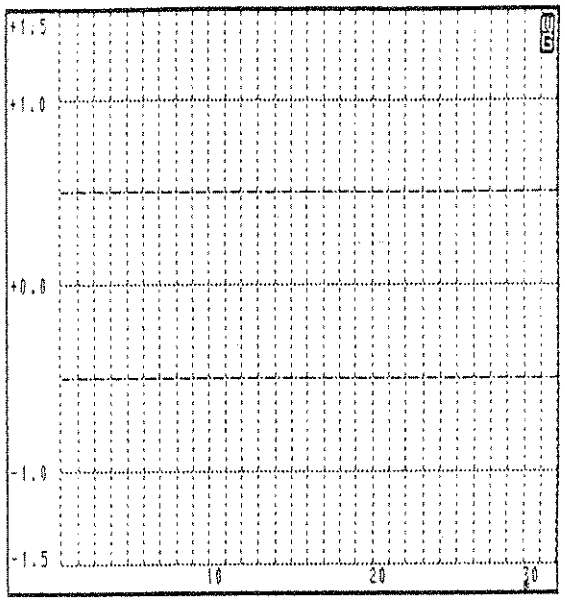
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
2								
6								
10								
14								

Units: X in [ ] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	– –		–.50		2	– –	–.50		

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 2

Form 3

Bv.–No.

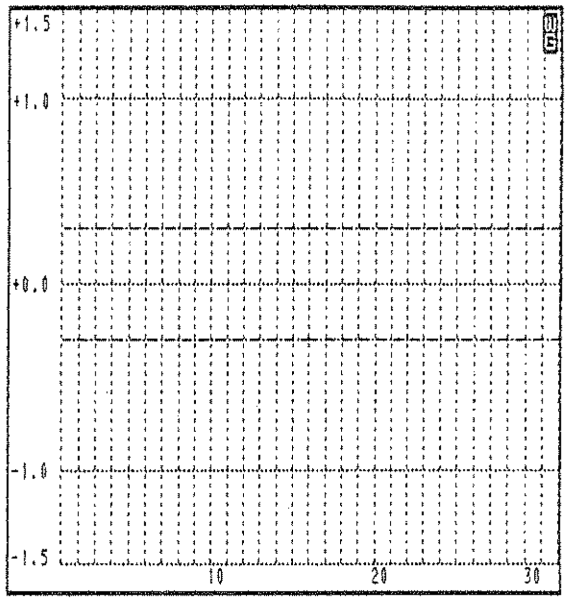
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
3																	
4																	
7																	
8																	
11																	
12																	
15																	
16																	

Units: X in [ ] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
					2	--		.30	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 3

Form 3

Bv.–No.

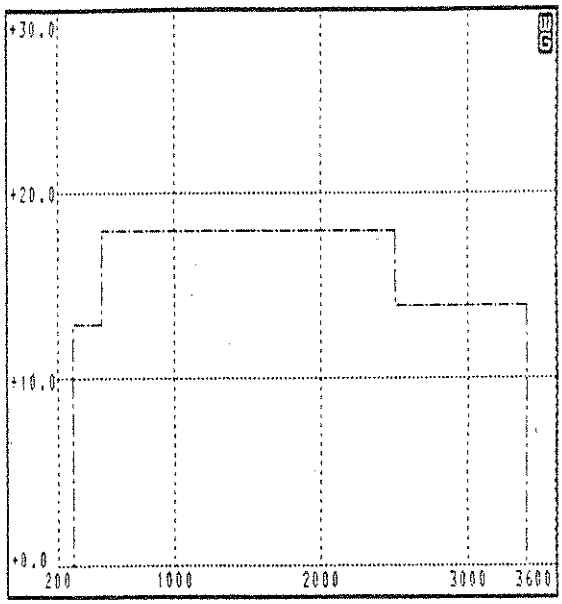
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
1																	
5																	
9																	
13																	

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00	– –	–99.99			– –		– –	
2	300.00		13.00			– –		– –	
3	500.00		13.00			– –		– –	
4	500.00		18.00			– –		– –	
5	2500.00		18.00			– –		– –	
6	2500.00		14.00			– –		– –	
7	3400.00		14.00			– –		– –	
8	3400.00		–99.99			– –		– –	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 4

Form 3

Bv.–No.

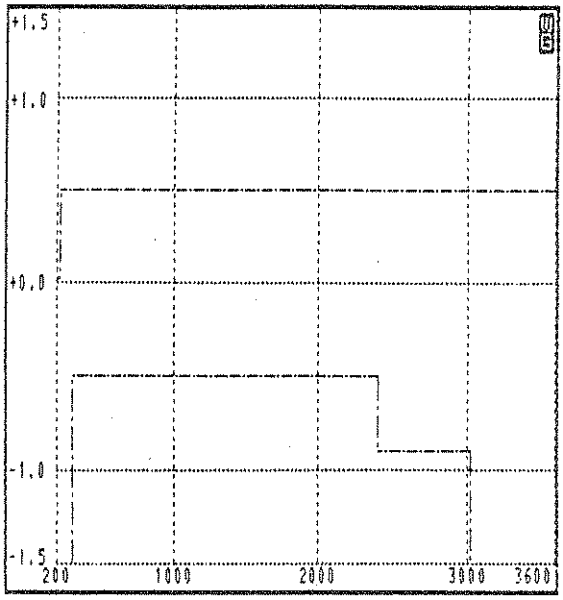
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	
17	
21	
25	
29	
33	
37	
41	
45	

List no. 2	

List no. 3	

List no. 4	

List no. 5	

List no. 6	

List no. 7	

List no. 8	

List no. 9	

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		-99.99		9	10.00		0.00	
2	300.00		-.50		10	200.00		0.00	
3	2400.00		-.50		11	200.00		.50	
4	2400.00		-.90		12	3600.00		.50	
5	3000.00		-.90		13	3600.00		0.00	
6	3000.00		-1.80		14	5000.00		0.00	
7	3400.00		-1.80			--		--	
8	3400.00		-99.99			--		--	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 5

Form 3

Bv.–No.

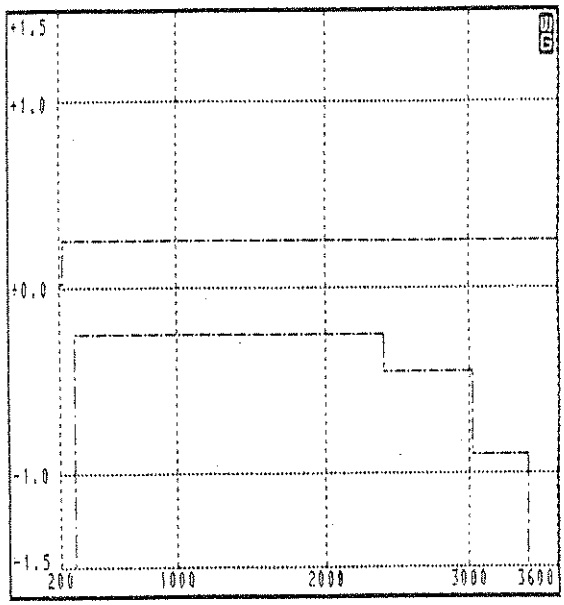
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	
18	35
19	38
22	39
23	42
26	43
27	46
30	47
31	
34	

List no. 2	

List no. 3	

List no. 4	

List no. 5	

List no. 6	

List no. 7	

List no. 8	

List no. 9	

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		-99.99		9	10.00		0.00	
2	300.00		-.25		10	200.00		0.00	
3	2400.00		-.25		11	200.00		.25	
4	2400.00		-.45		12	3600.00		.25	
5	3000.00		-.45		13	3600.00		0.00	
6	3000.00		-.90		14	5000.00		0.00	
7	3400.00		-.90			--		--	
8	3400.00		-99.99			--		--	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 6

Form 3

Bv.–No.

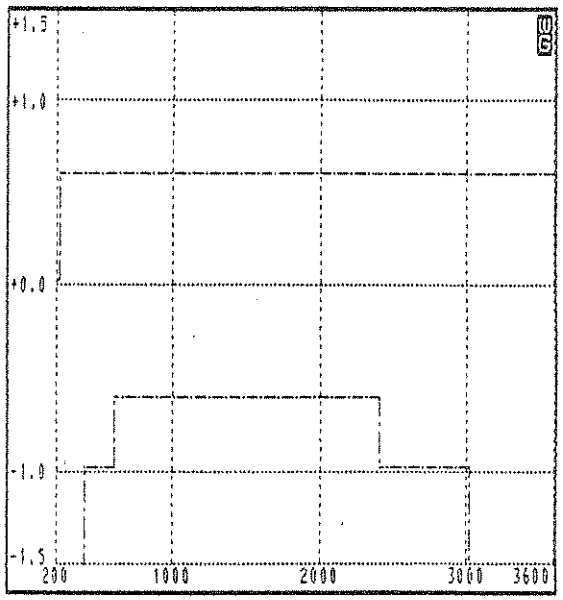
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	
20	
24	
28	
32	
36	
40	
44	
48	

List no. 2	

List no. 3	

List no. 4	

List no. 5	

List no. 6	

List no. 7	

List no. 8	

List no. 9	

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		–99.99		13	10.00		0.00	
2	300.00		–1.70		14	200.00		0.00	
3	400.00		–1.70		15	200.00		.60	
4	400.00		–1.00		16	3600.00		.60	
5	600.00		–1.00		17	3600.00		0.00	
6	600.00		–.60		18	5000.00		0.00	
7	2400.00		–.60			– –		– –	
8	2400.00		–1.00			– –		– –	
9	3000.00		–1.00			– –		– –	
10	3000.00		–2.40			– –		– –	
11	3400.00		–2.40			– –		– –	
12	3400.00		–99.99			– –		– –	

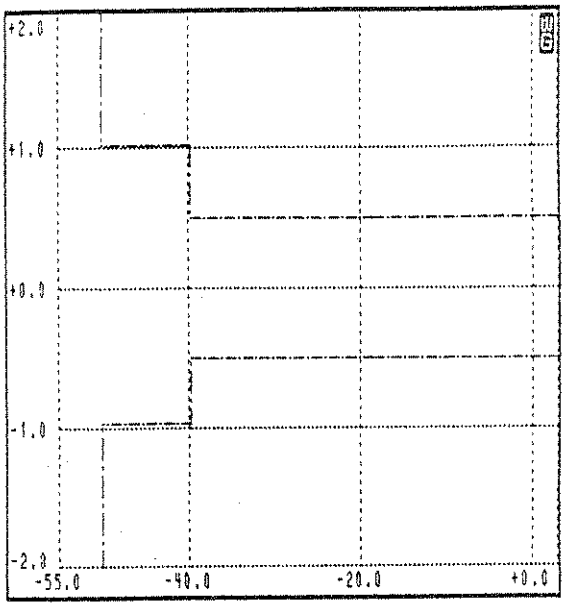
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 7

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
49																	
52																	
53																	
56																	
57																	
60																	
61																	
64																	

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		–99.99		9	–55.00		30.00	
2	–55.00		–3.00		10	–55.00		3.00	
3	–50.00		–3.00		11	–50.00		3.00	
4	–50.00		–1.00		12	–50.00		1.00	
5	–40.00		–1.00		13	–40.00		1.00	
6	–40.00		–.50		14	–40.00		.50	
7	3.00		–.50		15	3.00		.50	
8	3.00		–99.99		16	3.00		30.00	

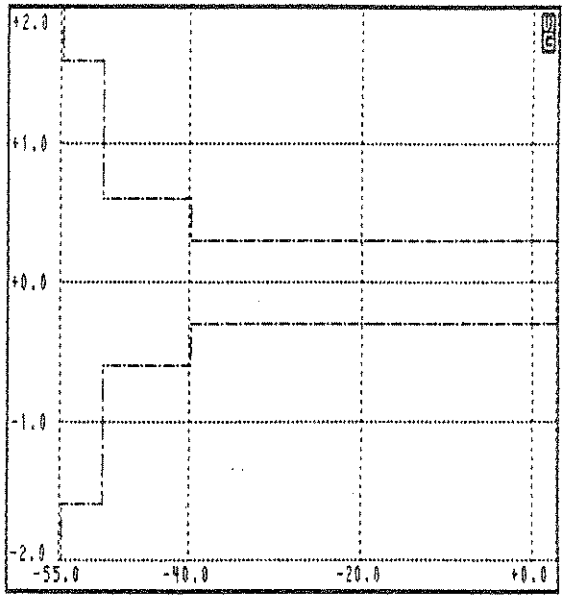
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 8

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
50																	
51																	
54																	
55																	
58																	
59																	
62																	
63																	

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		–99.99		9	–55.00		30.00	
2	–55.00		–1.60		10	–55.00		1.60	
3	–50.00		–1.60		11	–50.00		1.60	
4	–50.00		–.60		12	–50.00		.60	
5	–40.00		–.60		13	–40.00		.60	
6	–40.00		–.30		14	–40.00		.30	
7	3.00		–.30		15	3.00		.30	
8	3.00		–99.99		16	3.00		30.00	

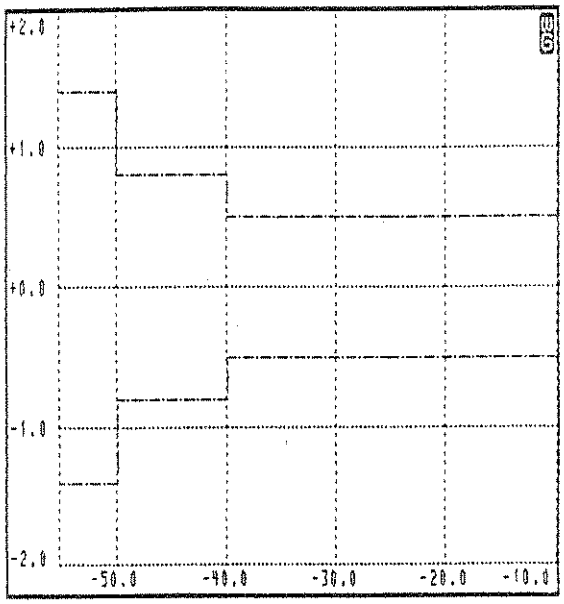
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 9

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
65																	
68																	
69																	
72																	

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		–1.40		8	–55.00		1.40	
2	–50.00		–1.40		9	–50.00		1.40	
3	–50.00		–.80		10	–50.00		.80	
4	–40.00		–.80		11	–40.00		.80	
5	–40.00		–.50		12	–40–00		.50	
6	–10.00		–.50		13	–10.00		.50	
7	–10.00		–99.99		14	–10.00		30.0	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 10

Form 3

Bv.–No.

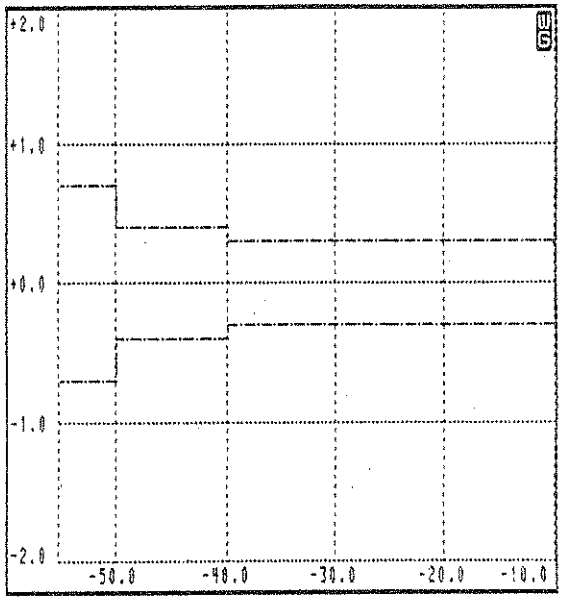
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
66																	
67																	
70																	
71																	

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		–99.99		9	–55.00		30.00	
2	–55.00		–.70		10	–55.00		.70	
3	–50.00		–.70		11	–50.00		.70	
4	–50.00		–.40		12	–50.00		.40	
5	–40.00		–.40		13	–40.00		.40	
6	–40.00		–.30		14	–40.00		.30	
7	–10.00		–.30		15	–10.00		.30	
8	–10.00		–99.99		16	–10.00		30.00	

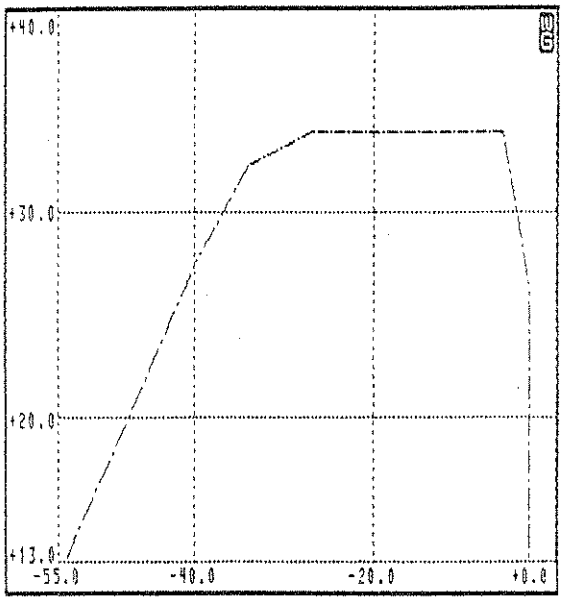
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 11

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
73								

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		0.00			– –		– –	
2	–55.00		12.60			– –		– –	
3	–40.00		27.60			– –		– –	
4	–34.00		32.20			– –		– –	
5	–27.00		33.90			– –		– –	
6	–6.00		33.90			– –		– –	
7	–3.00		26.30			– –		– –	
8	–3.00		0.00			– –		– –	

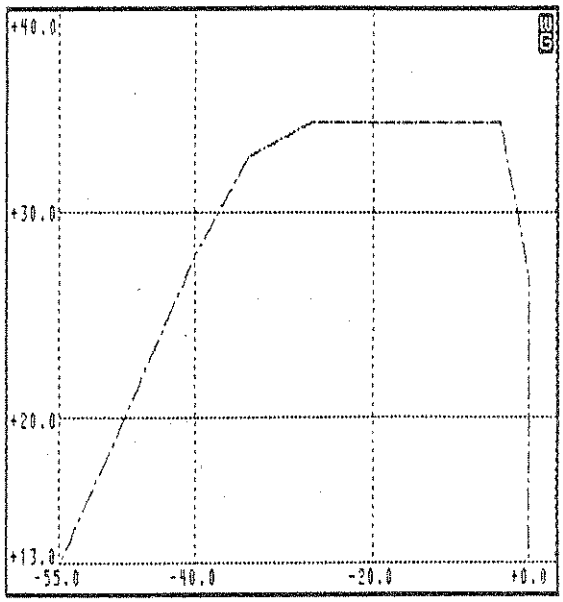
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 12

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
74																	

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		0.00			– –		– –	
2	–55.00		13.10			– –		– –	
3	–40.00		28.10			– –		– –	
4	–34.00		32.70			– –		– –	
5	–27.00		34.40			– –		– –	
6	–6.00		34.40			– –		– –	
7	–3.00		26.80			– –		– –	
8	–3.00		0.00			– –		– –	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 13

Form 3

Bv.–No.

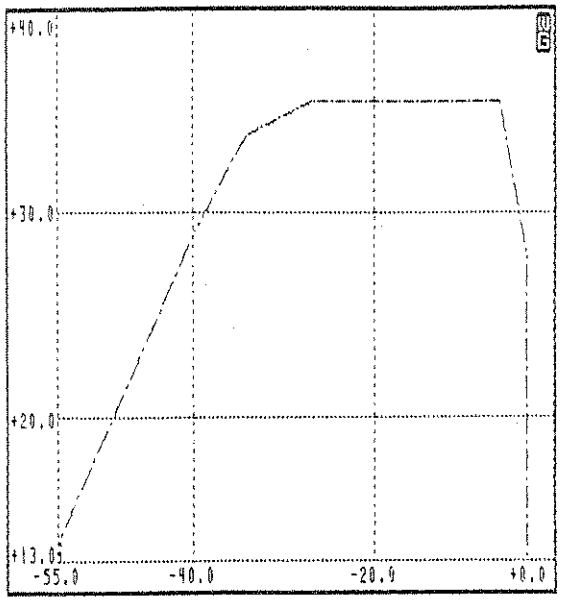
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
75								

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		0.00			– –		– –	
2	–55.00		14.10			– –		– –	
3	–40.00		29.10			– –		– –	
4	–34.00		33.70			– –		– –	
5	–27.00		35.40			– –		– –	
6	–6.00		35.40			– –		– –	
7	–3.00		27.80			– –		– –	
8	–3.00		0.00			– –		– –	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 14

Form 3

Bv.–No.

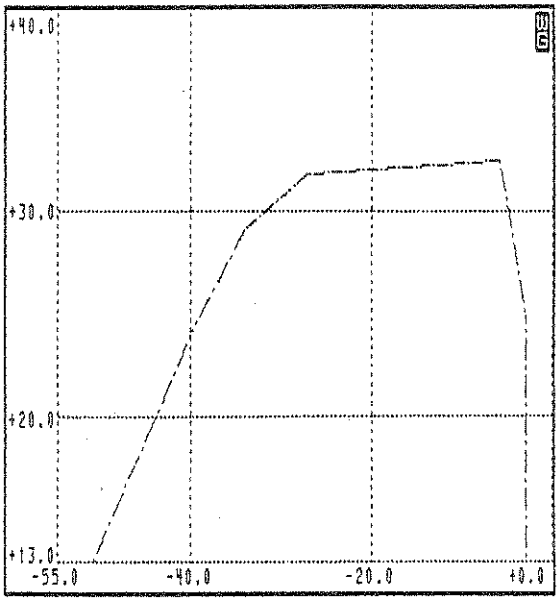
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
76								

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		0.00			– –		– –	
2	–55.00		9.20			– –		– –	
3	–40.00		24.20			– –		– –	
4	–34.00		29.10			– –		– –	
5	–27.00		31.80			– –		– –	
6	–6.00		32.50			– –		– –	
7	–3.00		24.90			– –		– –	
8	–3.00		0.00			– –		– –	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 15

Form 3

Bv.–No.

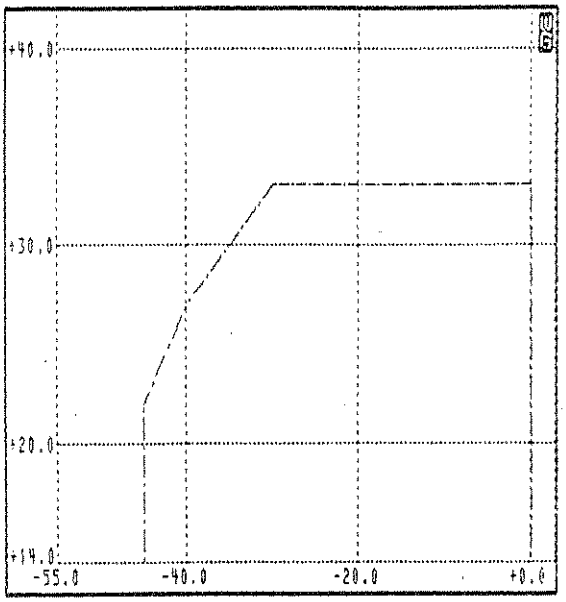
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
77																	
81																	
89																	
93																	

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–45.00		0.00			– –		– –	
2	–45.00		22.00			– –		– –	
3	–40.00		27.00			– –		– –	
4	–30.00		33.00			– –		– –	
5	0.00		33.00			– –		– –	
6	0.00		0.00			– –		– –	

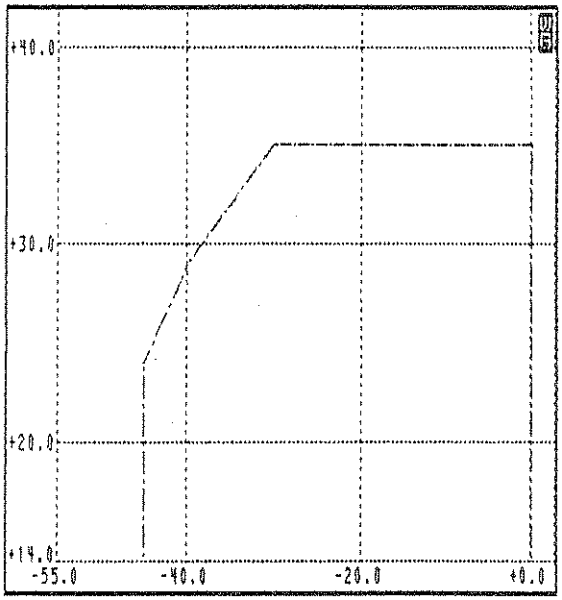
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 16

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
78																	
79																	
82																	
83																	
90																	
91																	
94																	
95																	

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–45.00		0.00			– –		– –	
2	–45.00		24.00			– –		– –	
3	–40.00		29.00			– –		– –	
4	–30.00		35.00			– –		– –	
5	0.00		35.00			– –		– –	
6	0.00		0.00			– –		– –	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 17

Form 3

Bv.–No.

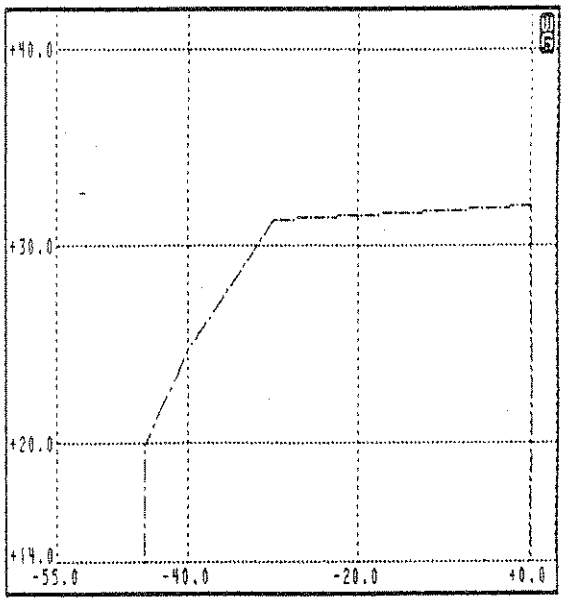
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

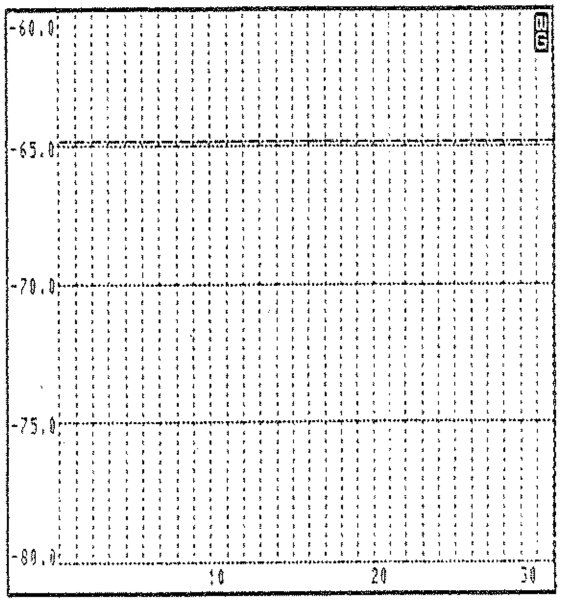
List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
80																	
84																	
92																	
96																	

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–45.00		0.00			— —		— —	
2	–45.00		19.90			— —		— —	
3	–40.00		24.90			— —		— —	
4	–30.00		31.30			— —		— —	
5	0.00		32.00			— —		— —	
6	0.00		0.00			— —		— —	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks	Mask no. 18	Form 3
		Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
101																	
104																	
105																	
108																	
113																	
116																	
117																	
120																	

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		-65.00	

④ official stamp	date	signature

PCM–4/PCM–5 tolerance masks

Mask no. 19

Form 3

Bv.–No.

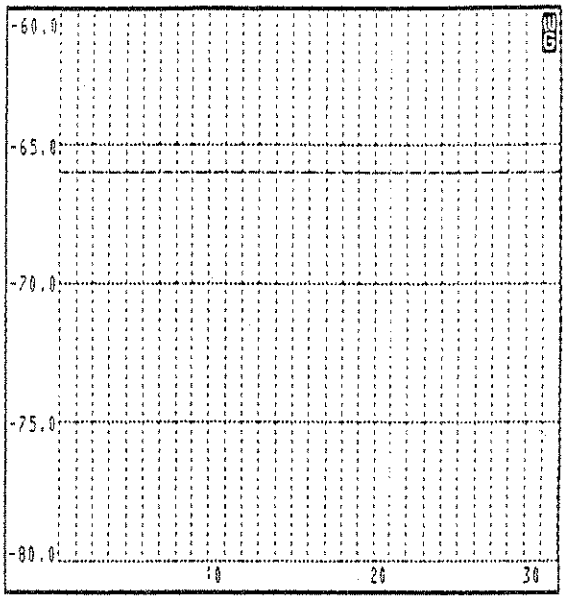
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
102								
106								
114								
118								

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–66.00	

④ official stamp

date

signature

PCM–4/PCM–5 tolerance masks

Mask no. 20

Form 3

Bv.–No.

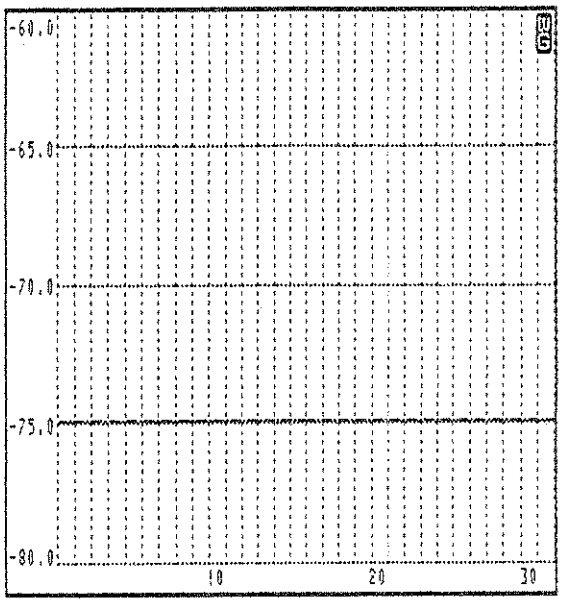
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
103								
107								
115								
119								

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–75.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 21

Form 3

Bv.–No.

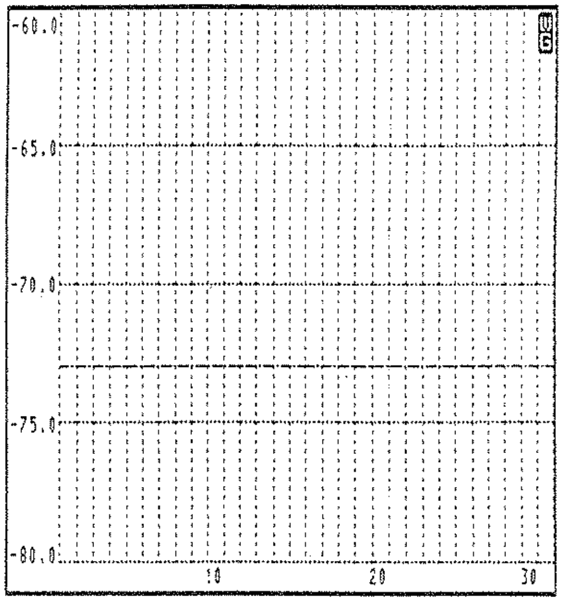
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
125																	
127																	
129																	
131																	
133																	
135																	
137																	
139																	

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–73.00	

④ official stamp — date — signature

PCM–4/PCM–5 tolerance masks

Mask no. 22

Form 3

Bv.–No.

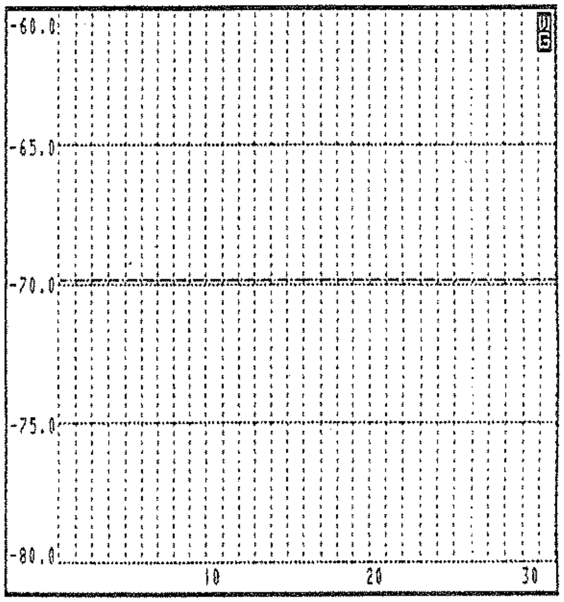
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
126																	
128																	
130																	
132																	
134																	
136																	
138																	
140																	

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–70.00	

④ official stamp date signature

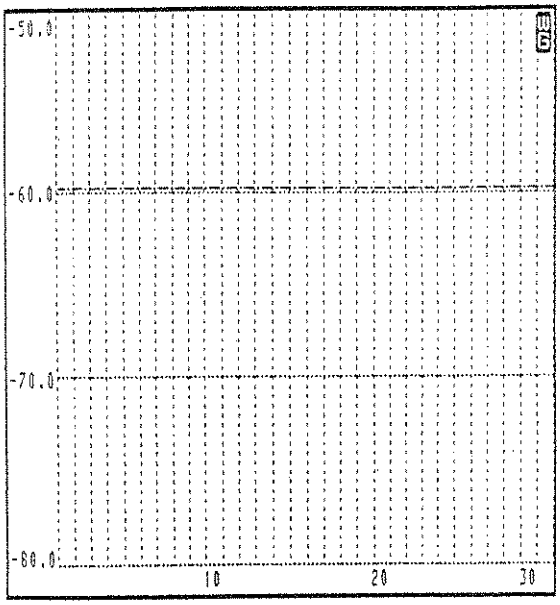
PCM–4/PCM–5 tolerance masks

Mask no. 23

Form 3

Bv.–No.

To CCITT Rec. G.712/14.2



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
141																	
142																	
143																	
144																	

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–60.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. **24**

Form 3

Bv.–No.

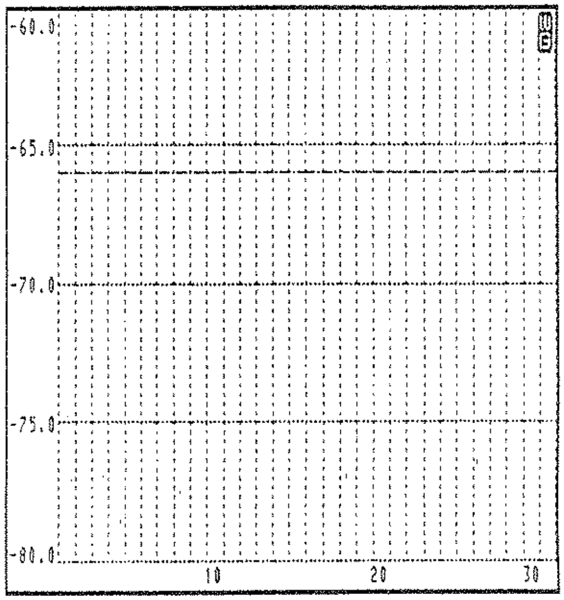
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
145																	
148																	
149																	
152																	
153																	
156																	
157																	
160																	

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		-66.00	

④ official stamp

date

signature

PCM-4/PCM-5 tolerance masks

Mask no. 25

Form 3

Bv.–No.

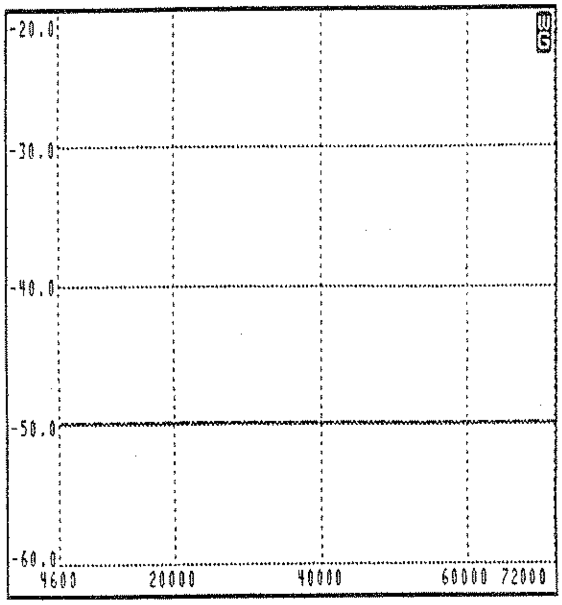
Complete this form if the tolerance mask shown opposite is to be changed or extended.
<u>Only fill in the sections outlined in heavy type.</u>

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
161								
162								
163								
164								

Units: X in [Hz] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–50.00	

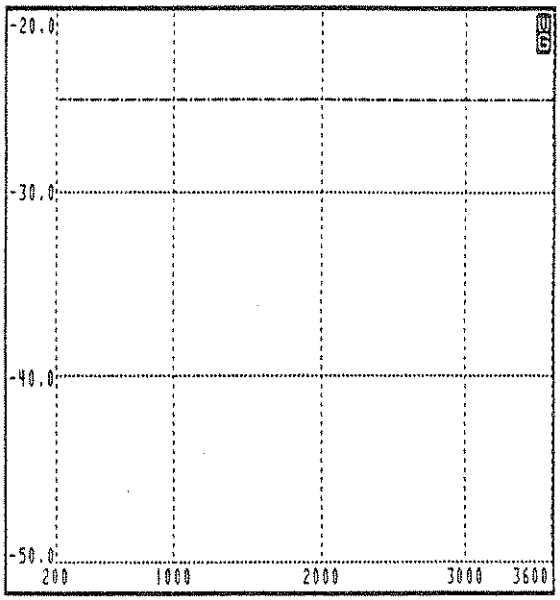
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 26

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
165																	
166																	
167																	
168																	

Units: X in [Hz] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	--		-25.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 27

Form 3

Bv.–No.

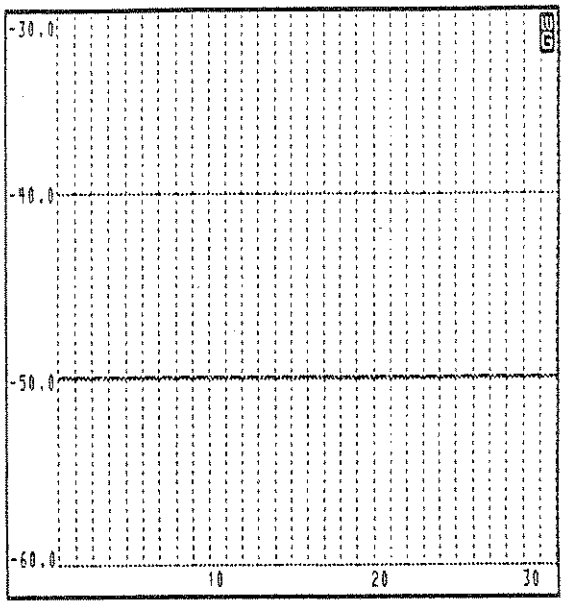
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
171								
172								

Units: X in [Hz] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	--		-50.00	

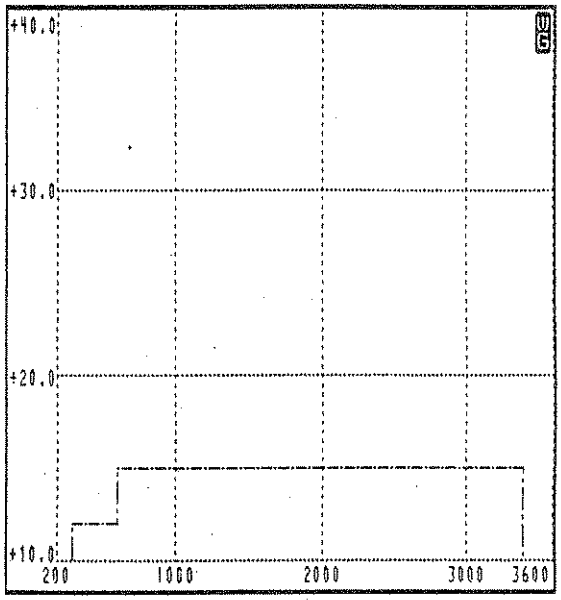
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 28

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
173																	
174																	

Units: X in [Hz] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		0.00			– –		– –	
2	300.00		20.00			– –		– –	
3	3400.00		20.00			– –		– –	
4	3400.00		0.00			– –		– –	

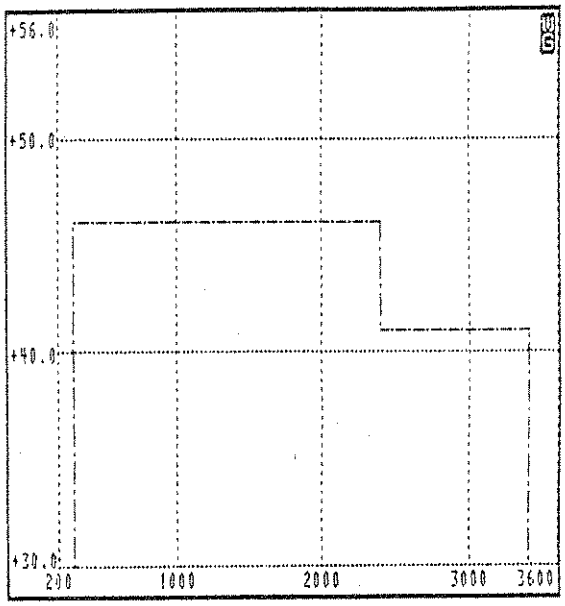
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 29

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
179	188																
180																	
181																	
182																	
183																	
184																	
185																	
186																	
187																	

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		0.00			--		--	
2	300.00		46.00			--		--	
3	2400.00		46.00			--		--	
4	2400.00		41.00			--		--	
5	3400.00		41.00			--		--	
6	3400.00		0.00			--		--	

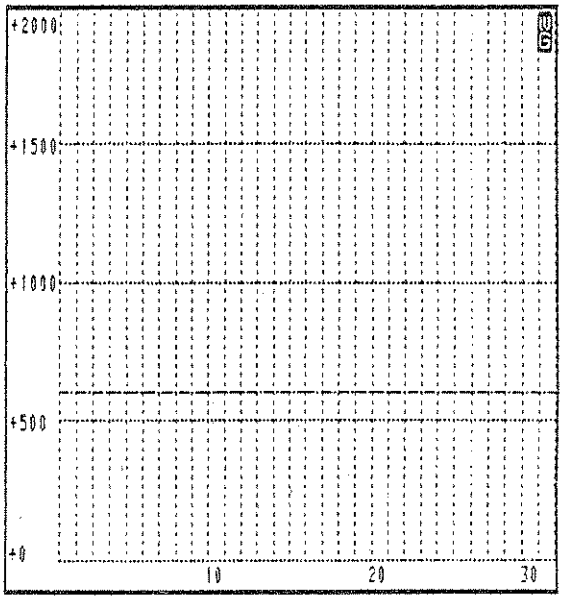
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 30

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
189								

Units: X in [ ] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		600.00	

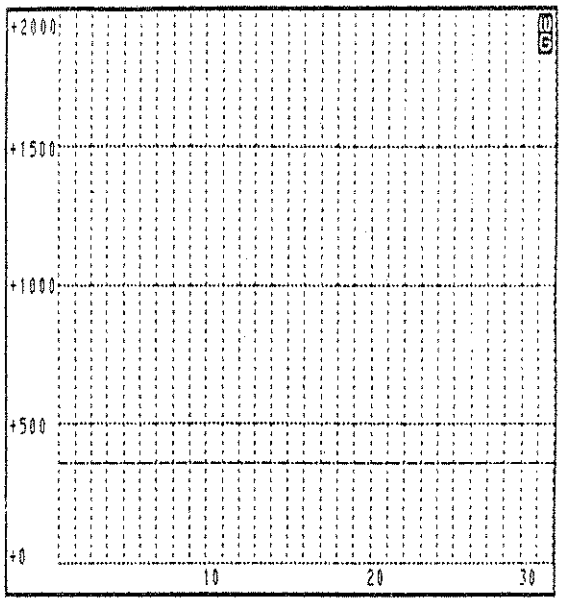
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 31

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
190																	

Units: X in [ ] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		360.00	

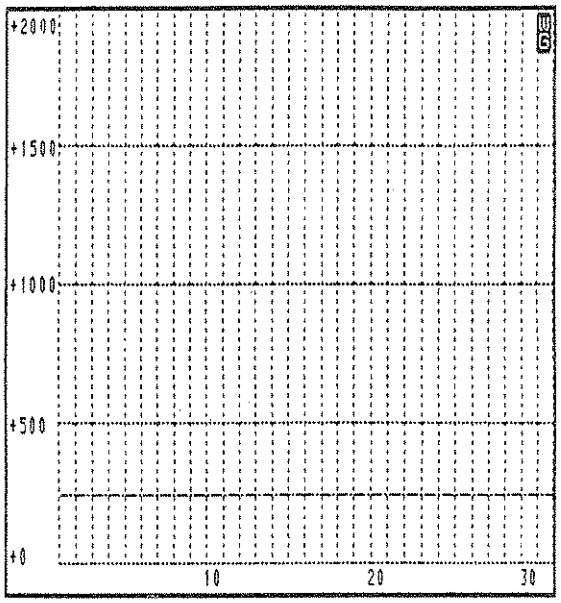
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 32

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
191								

Units: X in [ ] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		240.00	

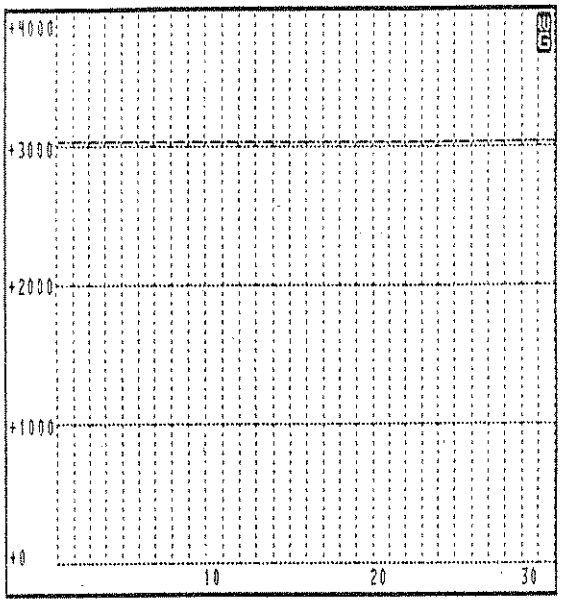
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 33

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
192								

Units: X in [ ] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		3000.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 34

Form 3

Bv.–No.

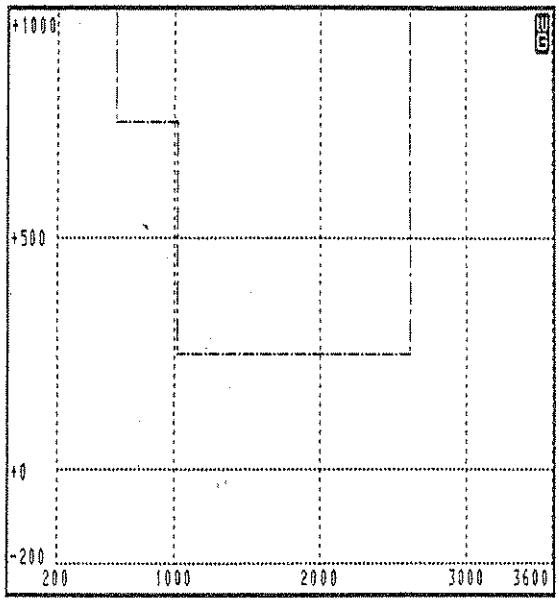
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
193								

Units: X in [Hz] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	500.00		10000.00	
	– –		– –		2	500.00		1500.00	
	– –		– –		3	600.00		1500.00	
	– –		– –		4	600.00		750.00	
	– –		– –		5	1000.00		750.00	
	– –		– –		6	1000.00		250.00	
	– –		– –		7	2610.00		250.00	
	– –		– –		8	2610.00		1500.00	
	– –		– –		9	2800.00		1500.00	
	– –		– –		10	2800.00		10000.00	

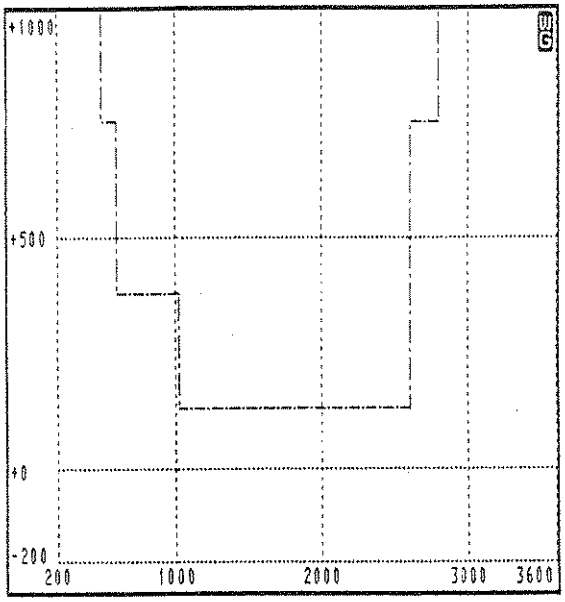
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 35

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
194								

Units: X in [Hz] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	500.00		10000.00	
	--		--		2	500.00		750.00	
	--		--		3	600.00		750.00	
	--		--		4	600.00		380.00	
	--		--		5	1000.00		380.00	
	--		--		6	1000.00		130.00	
	--		--		7	2610.00		130.00	
	--		--		8	2610.00		750.00	
	--		--		9	2800.00		750.00	
	--		--		10	2800.00		10000.00	

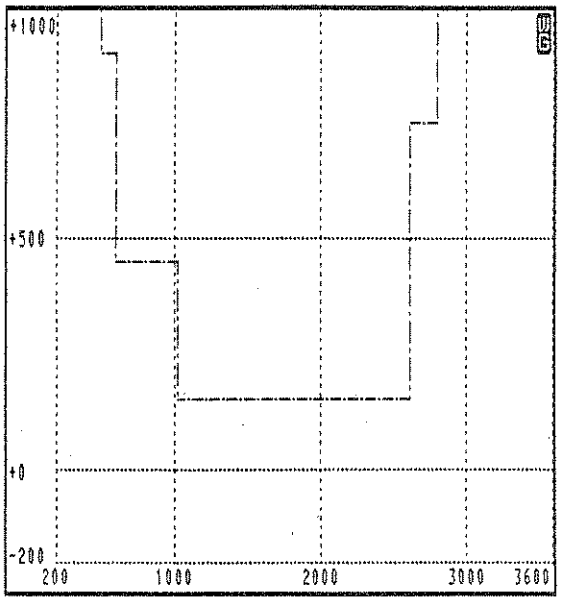
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 36

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
195								

Units: X in [Hz] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	500.00		10000.00	
	– –		– –		2	500.00		750.00	
	– –		– –		3	600.00		750.00	
	– –		– –		4	600.00		380.00	
	– –		– –		5	1000.00		380.00	
	– –		– –		6	1000.00		130.00	
	– –		– –		7	2610.00		130.00	
	– –		– –		8	2610.00		750.00	
	– –		– –		9	2800.00		750.00	
	– –		– –		10	2800.00		10000.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 37

Form 3

Bv.–No.

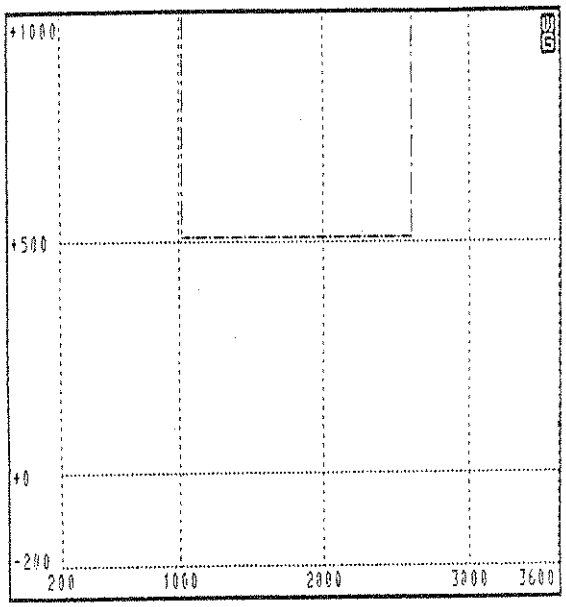
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
196								

Units: X in [Hz] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	500.00		10000.00	
	--		--		2	500.00		2000.00	
	--		--		3	600.00		2000.00	
	--		--		4	600.00		1500.00	
	--		--		5	1000.00		1500.00	
	--		--		6	1000.00		500.00	
	--		--		7	2610.00		500.00	
	--		--		8	2610.00		2000.00	
	--		--		9	2800.00		2000.00	
	--		--		10	2800.00		10000.00	

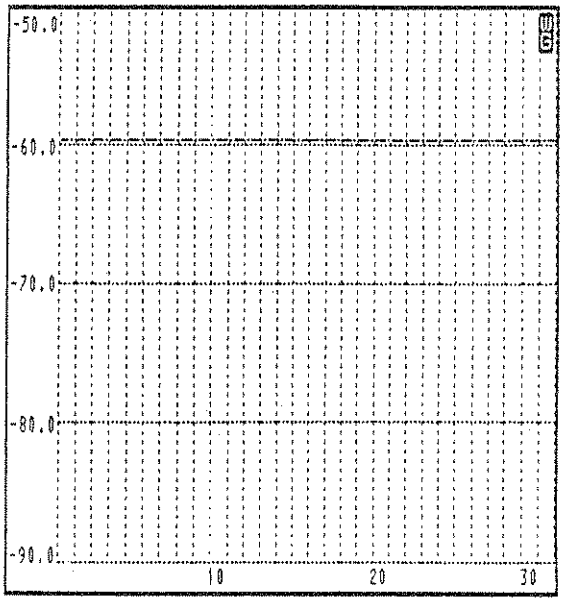
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 38

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
224																	
228																	
232																	
236																	
240																	
244																	
248																	
252																	
256																	

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–60.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 39

Form 3

Bv.–No.

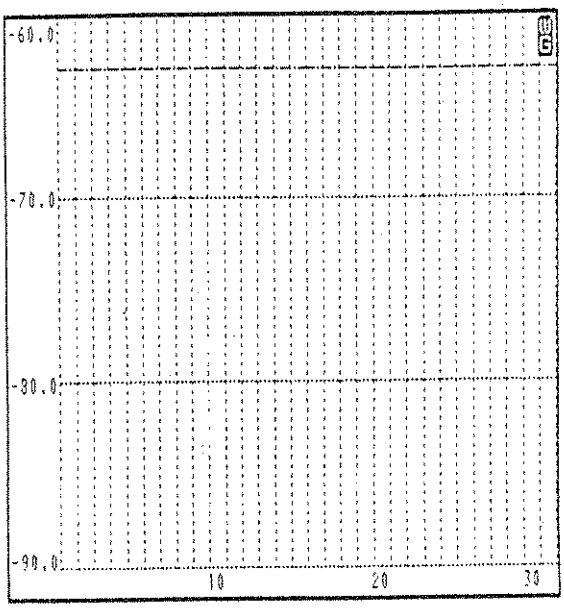
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
225	242																
226	245																
229	246																
230	249																
233	250																
234	253																
237	254																
238	257																
241	258																

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		-63.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 40

Form 3

Bv.–No.

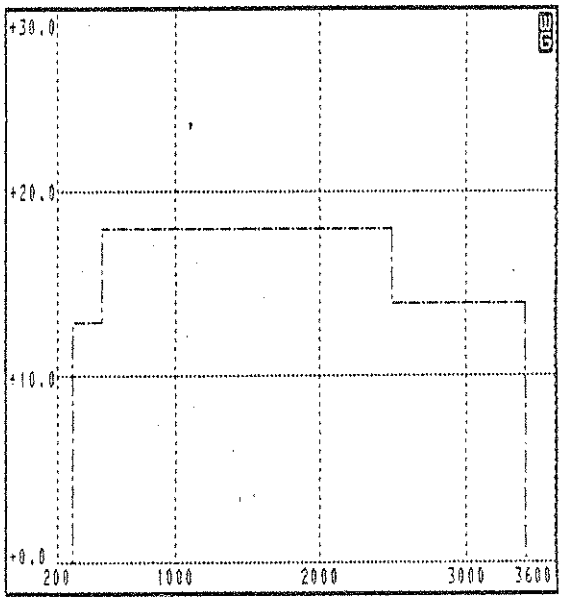
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	1							
	5							
	9							
	13							

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		–99.99			– –		– –	
2	300.00		13.00			– –		– –	
3	500.00		13.00			– –		– –	
4	500.00		18.00			– –		– –	
5	2500.00		18.00			– –		– –	
6	2500.00		14.00			– –		– –	
7	3400.00		14.00			– –		– –	
8	3400.00		–99.99			– –		– –	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 41

Form 3

Bv.–No.

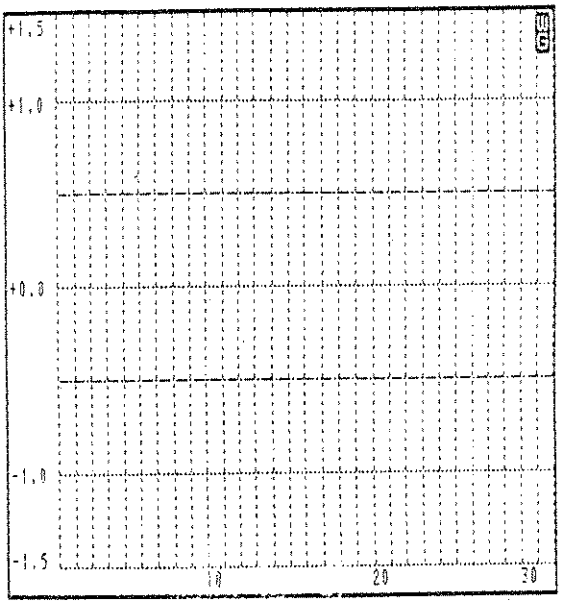
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	2							
	6							
	10							
	14							

Units: X in [ ] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	– –		–.60		2	– –		.60	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 42

Form 3

Bv.–No.

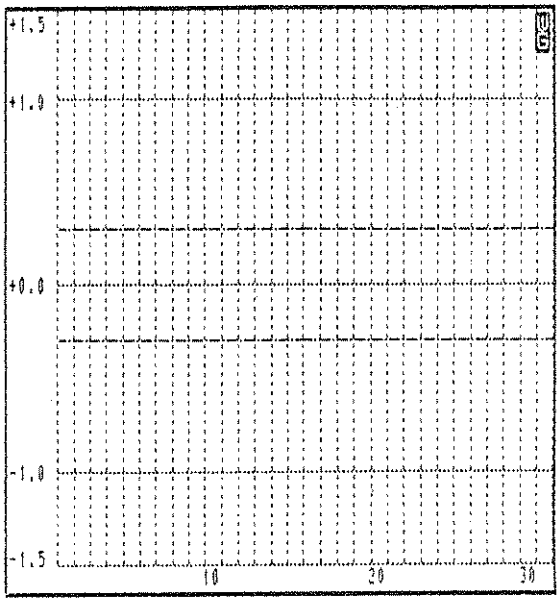
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	3							
	4							
	7							
	8							
	11							
	12							
	15							
	16							

Units: X in [ ] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	– –		–.30		2	– –		.30	

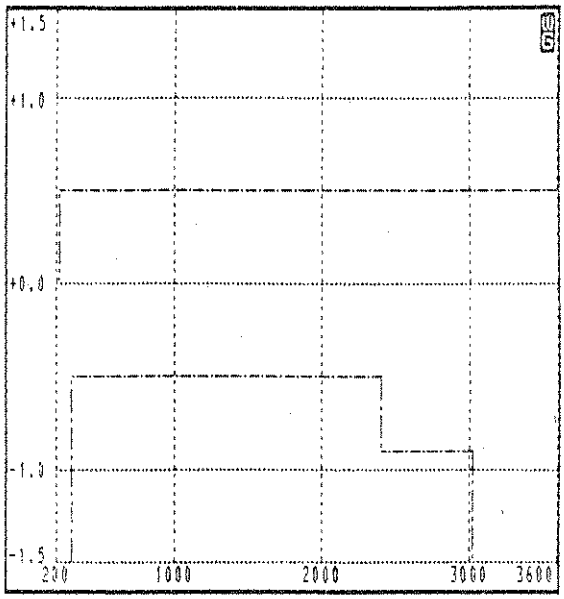
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 43

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
		17															
		21															
		25															
		29															
		33															
		37															
		41															
		45															

Units: X In [Hz] Y In [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		–99.99		13	10.00		0.00	
2	300.00		–2.00		14	200.00		0.00	
3	400.00		–2.00		15	200.00		.60	
4	400.00		–1.50		16	3600.00		.60	
5	600.00		–1.50		17	3600.00		0.00	
6	600.00		–.70		18	5000.00		0.00	
7	2400.00		–.70						
8	2400.00		–1.10						
9	3000.00		–1.10						
10	3000.00		–3.00						
11	3400.00		–3.00						
12	3400.00		–99.99						

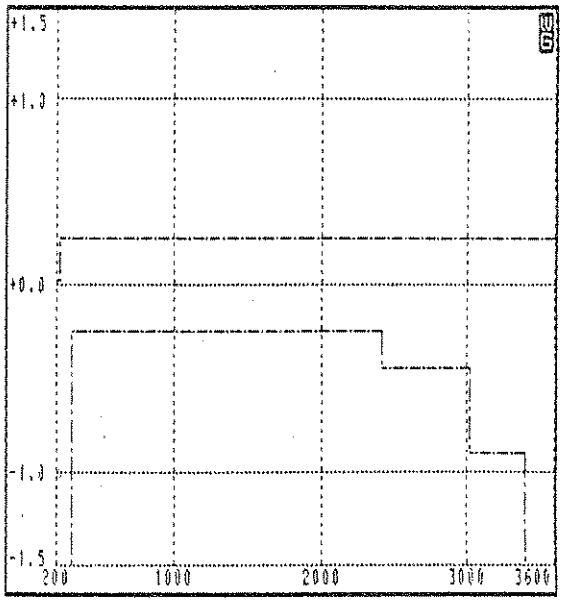
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 44

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
		18	35														
		19	38														
		22	39														
		23	42														
		26	43														
		27	46														
		30	47														
		31															
		34															

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		9–99.99		13	10.00		0.00	
2	300.00		–1.00		14	200.00		0.00	
3	400.00		–1.00		15	200.00		.30	
4	400.00		–.75		16	3600.00		.30	
5	600.00		–.75		17	3600.00		0.00	
6	600.00		–.35		18	5000.00		0.00	
7	2400.00		–.35						
8	2400.00		–.55						
9	3000.00		–.55						
10	3000.00		–1.50						
11	3400.00		–1.50						
12	3400.00		–99.99						

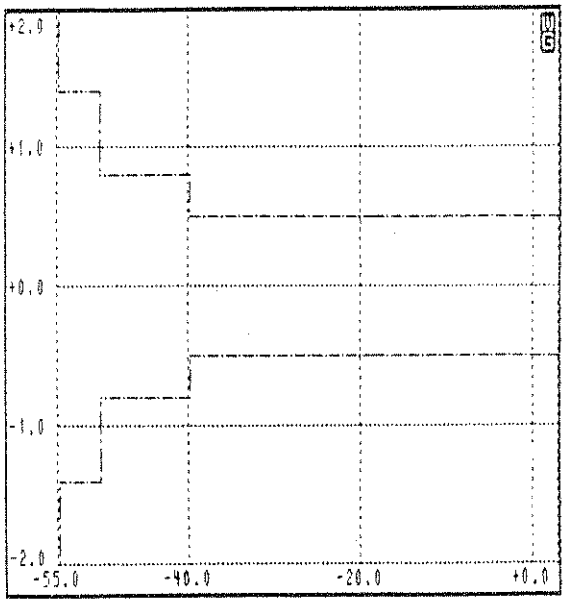
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 45

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	50							
	51							
	54							
	55							
	58							
	59							
	62							
	63							

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		–99.99		9	–55.00		30.00	
2	–55.00		–1.40		10	–55.00		1.40	
3	–50.00		–1.40		11	–55.00		1.40	
4	–50.00		–0.80		12	–50.00		+0.80	
5	–40.00		–0.80		13	–40.00		+0.80	
6	–40.00		–0.50		14	–40.00		+0.50	
7	3.00		–0.50		15	3.00		+0.50	
8	3.00		–99.99		16	3.00		30.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 46

Form 3

Bv.–No.

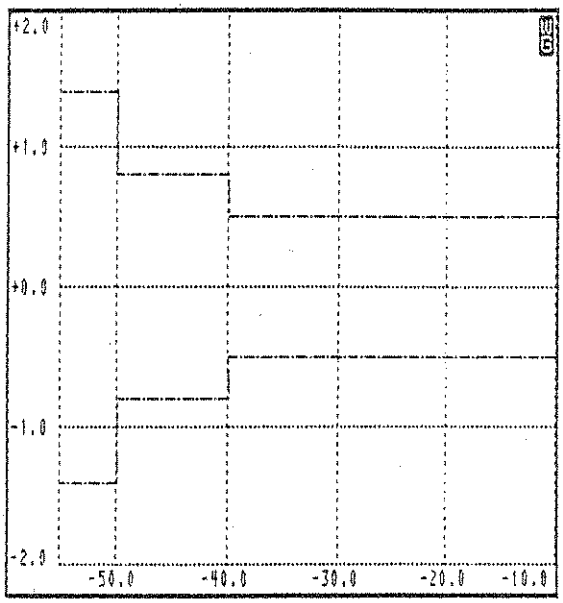
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	65							
	69							

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		–1.40		8	–55.00		1.40	
2	–50.00		–1.40		9	–50.00		1.40	
3	–50.00		–.80		10	–50.00		.80	
4	–40.00		–.80		11	–40.00		.80	
5	–40.00		–.50		12	–40.00		.50	
6	–10.00		–.50		13	–10.00		.50	
7	–10.00		–99.99		14	–10.00		30.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 47

Form 3

Bv.–No.

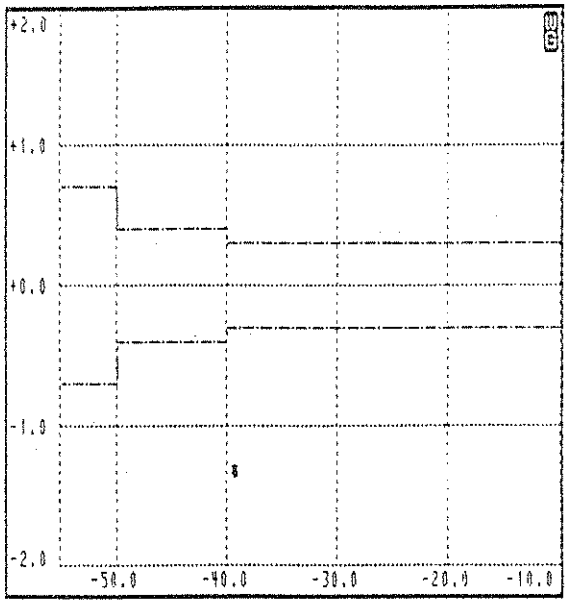
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	66							
	67							
	70							
	71							

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		–.70		8	–55.00		.70	
2	–50.00		–.70		9	–50.00		.70	
3	–50.00		–.40		10	–50.00		.40	
4	–40.00		–.40		11	–40.00		.40	
5	–40.00		–.30		12	–40.00		.30	
6	–10.00		–.30		13	–10.00		.30	
7	–10.00		–99.99		14	–10.00		30.00	

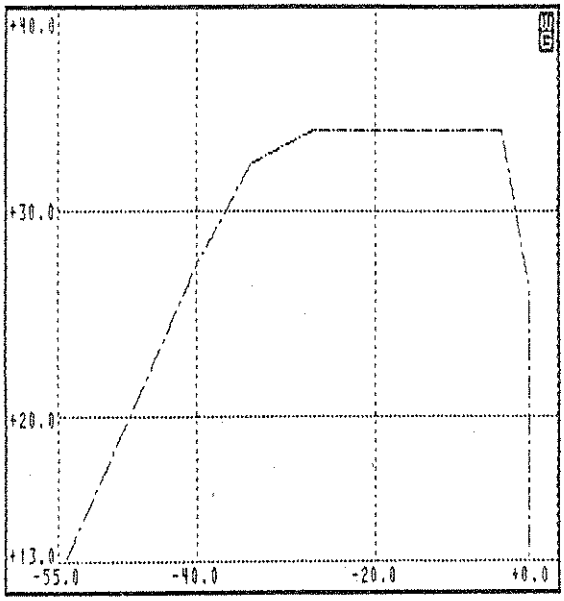
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 48

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
		73															

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		0.00			– –		– –	
2	–55.00		11.10			– –		– –	
3	–40.00		26.10			– –		– –	
4	–34.00		30.70			– –		– –	
5	–27.00		32.40			– –		– –	
6	–6.00		32.40			– –		– –	
7	–3.00		24.80			– –		– –	
8	–3.00		0.00			– –		– –	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 49

Form 3

Bv.–No.

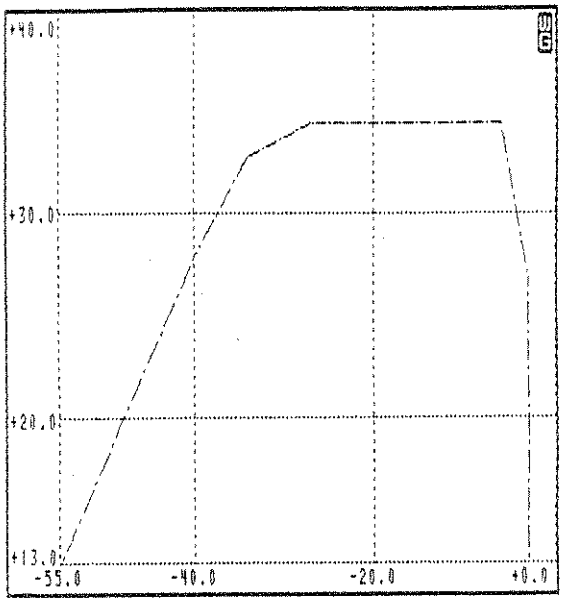
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	74							

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		0.00			– –		– –	
2	–55.00		12.40			– –		– –	
3	–40.00		27.40			– –		– –	
4	–34.00		32.00			– –		– –	
5	–27.00		33.70			– –		– –	
6	–6.00		33.70			– –		– –	
7	–3.00		26.10			– –		– –	
8	–3.00		0.00			– –		– –	

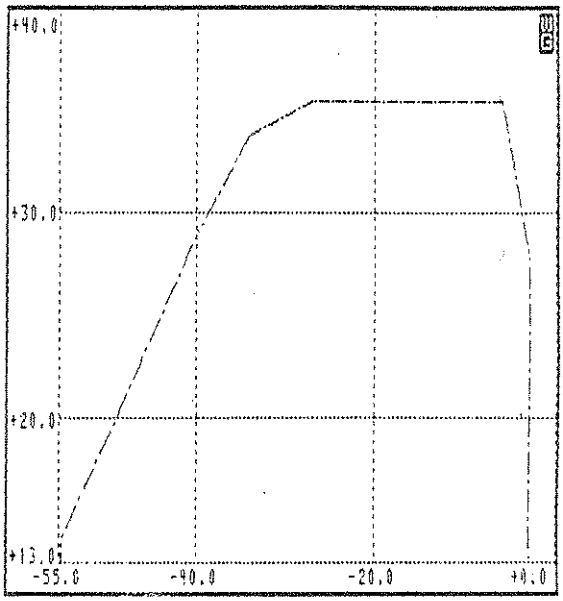
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 50

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	75							

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		0.00			– –		– –	
2	–55.00		13.40			– –		– –	
3	–40.00		28.40			– –		– –	
4	–34.00		33.00			– –		– –	
5	–27.00		34.70			– –		– –	
6	–6.00		34.70			– –		– –	
7	–3.00		27.10			– –		– –	
8	–3.00		0.00			– –		– –	

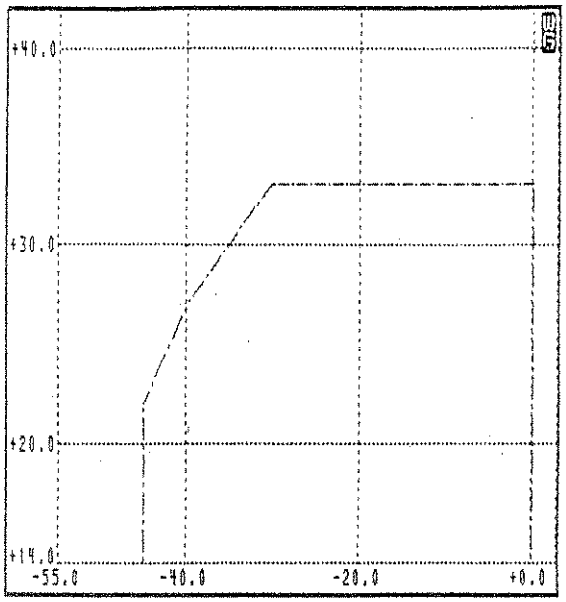
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 51

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	77							
	81							
	89							
	93							

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–45.00		0.00			– –		– –	
2	–45.00		22.00			– –		– –	
3	–40.00		27.00			– –		– –	
4	–30.00		33.00			– –		– –	
5	0.00		33.00			– –		– –	
6	0.00		0.00			– –		– –	

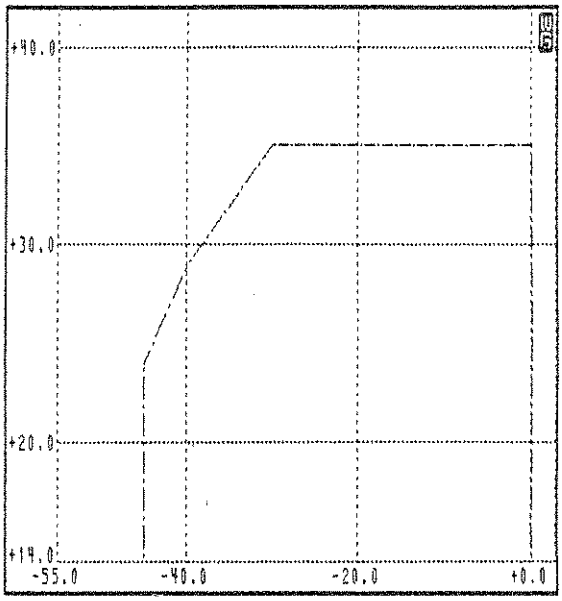
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 52

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
		78															
		79															
		82															
		83															
		90															
		91															
		94															
		95															

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–45.00		0.00			– –		– –	
2	–45.00		24.00			– –		– –	
3	–40.00		29.00			– –		– –	
4	–30.00		35.00			– –		– –	
5	0.00		35.00			– –		– –	
6	0.00		0.00			– –		– –	

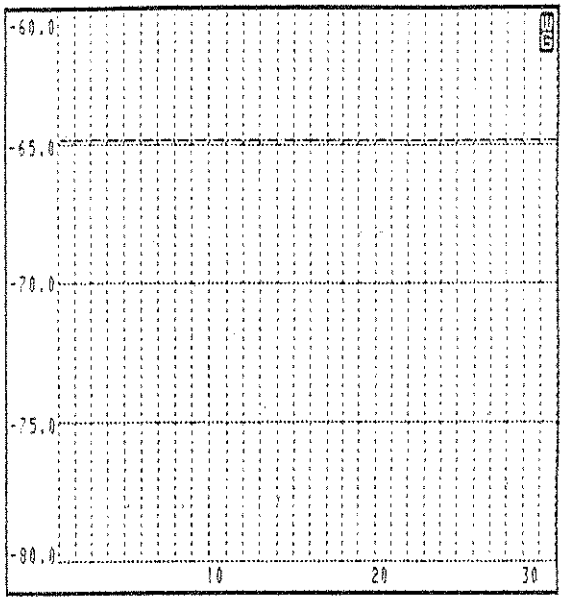
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 53

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	101							
	105							
	113							
	117							

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–65.00	

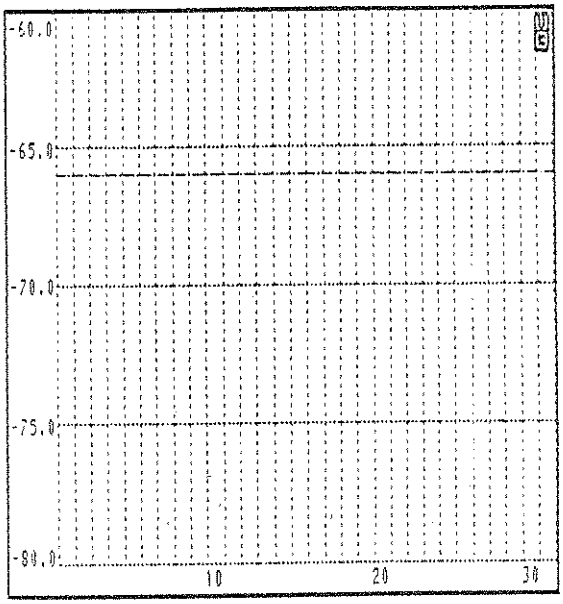
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 54

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	102							
	106							
	114							
	118							

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		-66.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 55

Form 3

Bv.–No.

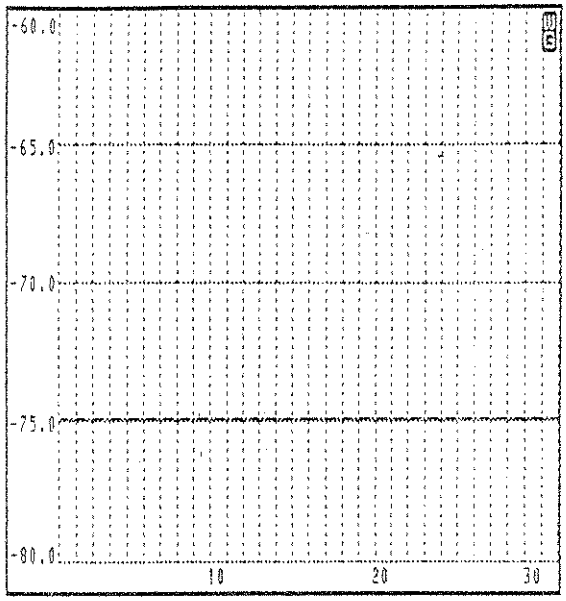
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	103							
	107							
	115							
	119							

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–75.00	

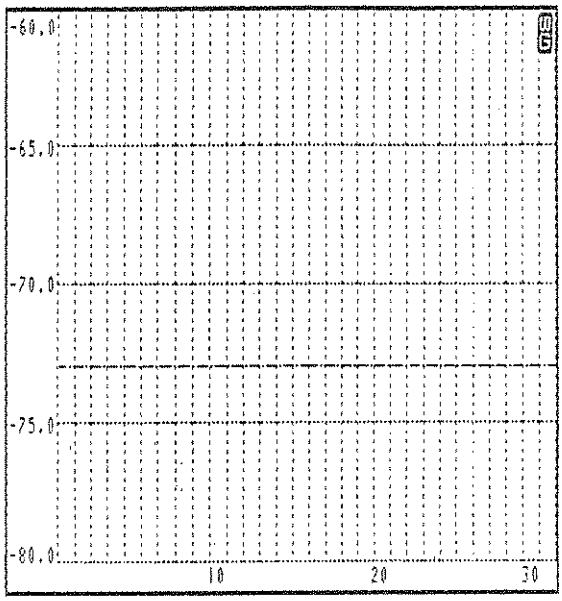
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 56

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
		125	143														
		127															
		129															
		131															
		133															
		135															
		137															
		139															
		141															

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–73.00	

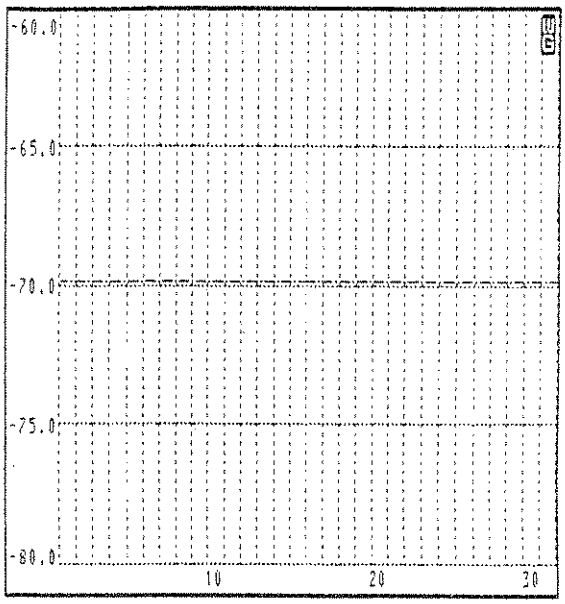
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 57

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
		126	144														
		128															
		130															
		132															
		134															
		136															
		138															
		140															
		142															

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	--		-70.00	

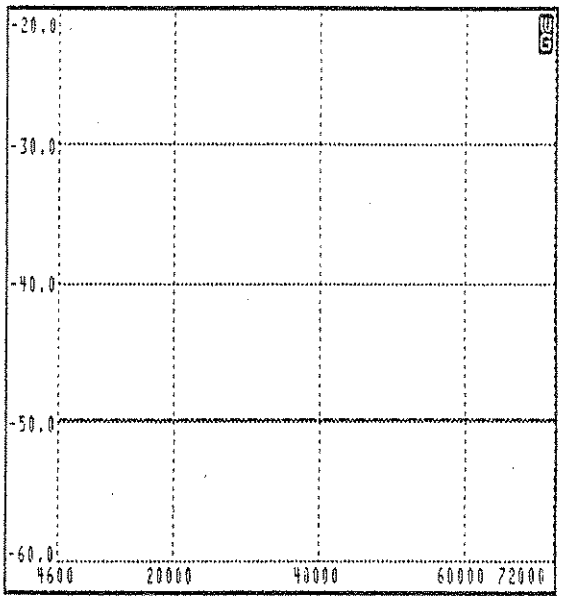
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 58

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	161							
	162							
	163							
	164							

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –			– –		–50.00	

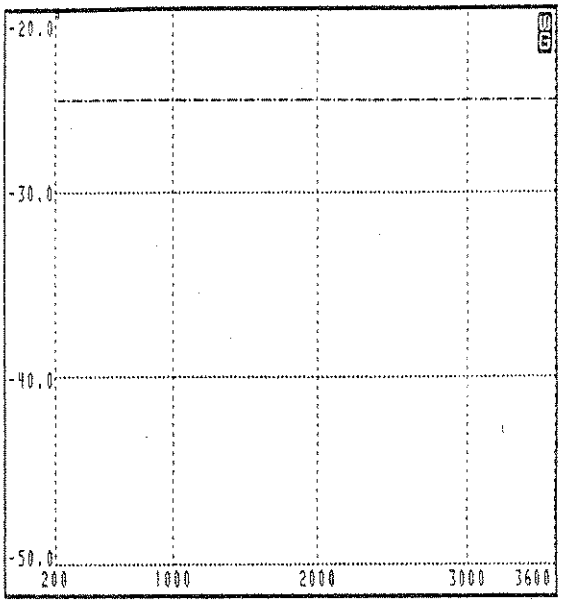
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 59

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	165							
	166							
	167							
	168							

Units: X in [Hz] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–25.00	

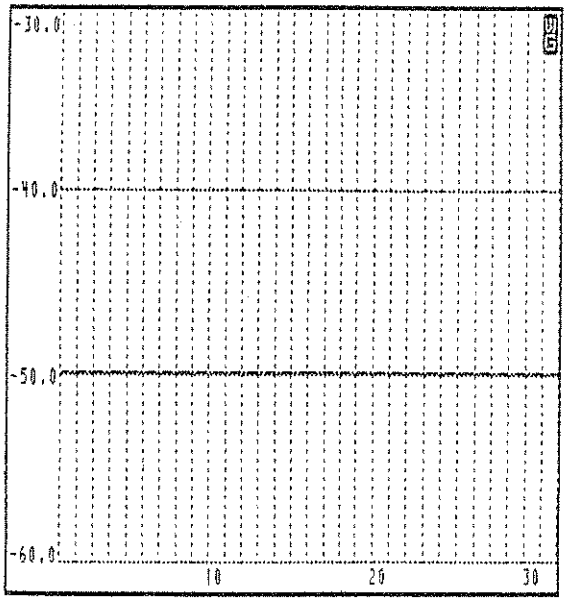
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 60

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	171							
	172							

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–50.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 61

Form 3

Bv.–No.

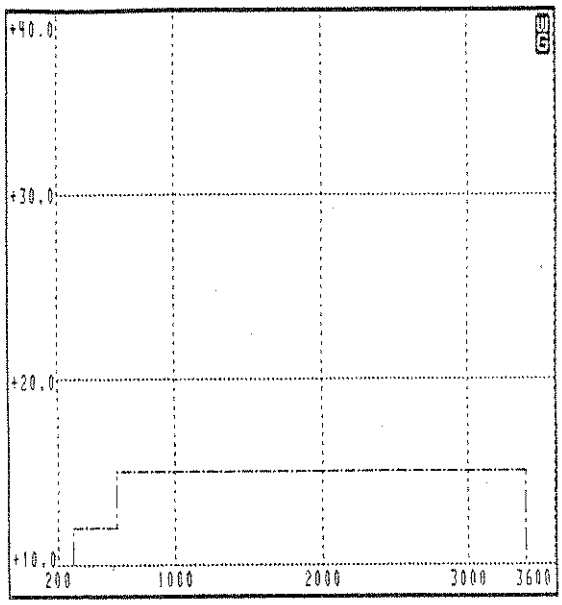
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	173							
	174							
	175							
	176							
	177							
	178							

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		0.00			– –		– –	
2	300.00		12.00			– –		– –	
3	600.00		12.00			– –		– –	
4	600.00		15.00			– –		– –	
5	3400.00		15.00			– –		– –	
6	3400.00		0.00			– –		– –	
7	4000.00		0.00			– –		– –	

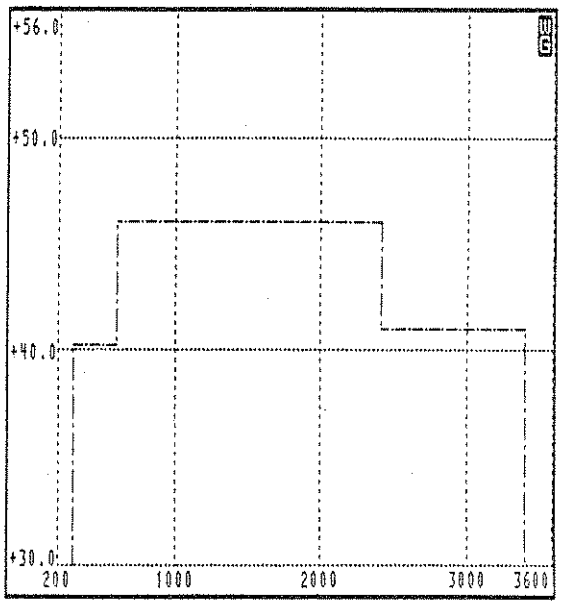
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 62

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	179							
	180							
	181							
	182							

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		0.00			– –		– –	
2	300.00		40.00			– –		– –	
3	600.00		40.00			– –		– –	
4	600.00		46.00			– –		– –	
5	2400.00		46.00			– –		– –	
6	2400.00		41.00			– –		– –	
7	3400.00		41.00			– –		– –	
8	3400.00		0.00			– –		– –	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 63

Form 3

Bv.–No.

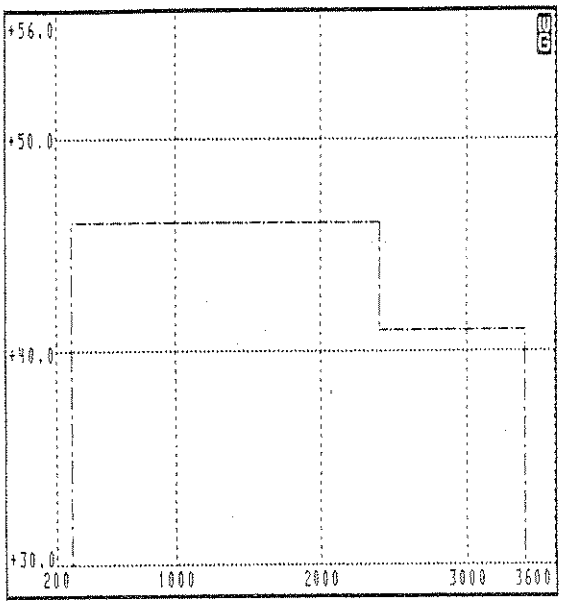
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	183							
	184							
	185							
	186							
	187							
	188							

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		0.00			– –		– –	
2	300.00		40.00			– –		– –	
3	600.00		40.00			– –		– –	
4	600.00		46.00			– –		– –	
5	2400.00		46.00			– –		– –	
6	2400.00		41.00			– –		– –	
7	3400.00		41.00			– –		– –	
8	3400.00		0.00			– –		– –	

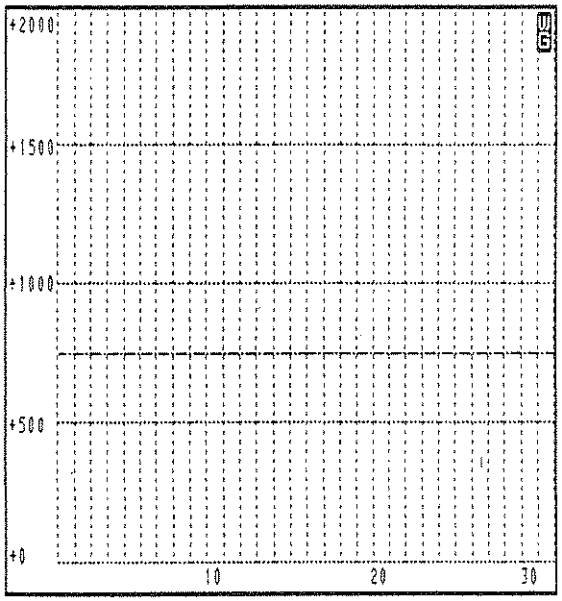
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 64

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	189							

Units: X in [ ] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		750.00	

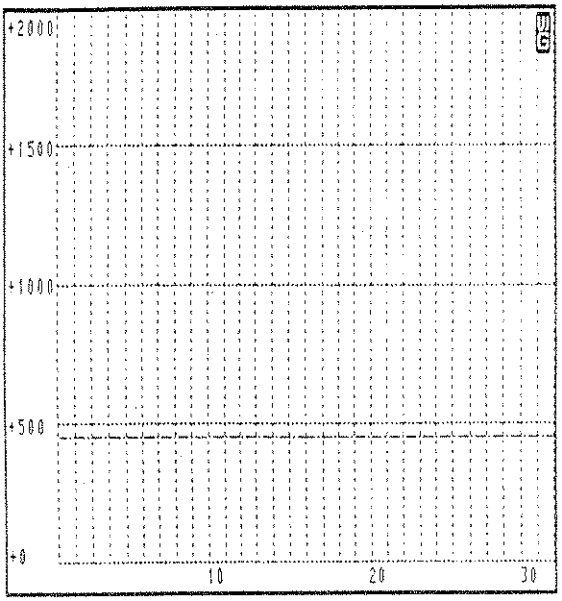
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 65

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9

Units: X in [ ] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		450.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 66

Form 3

Bv.–No.

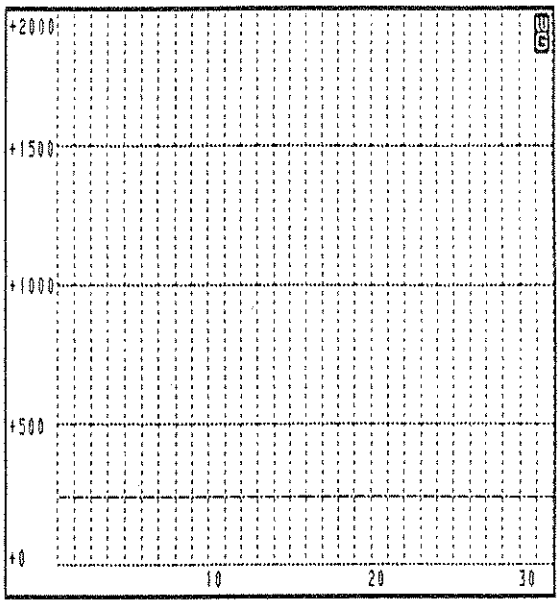
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	191							

Units: X in [ ] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		300.00	

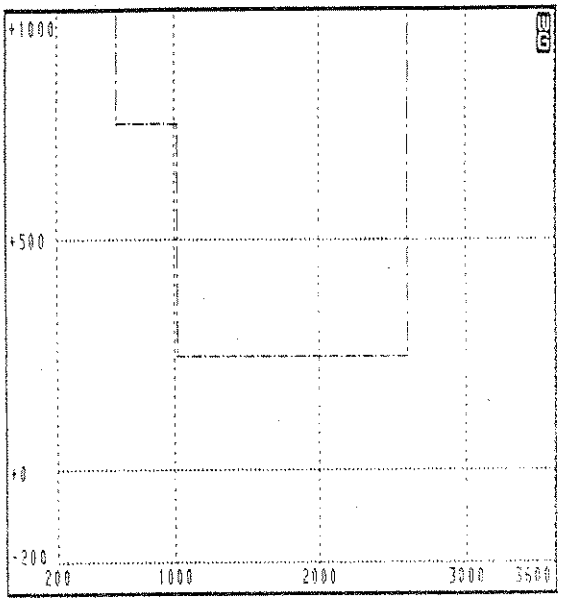
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 67

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

This mask is used in the following operating modes

Name
①

Page no.
②

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	193							

Units: X in [Hz] Y in [MIKROSEK]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	500.00		10000.00	
	--		--		2	500.00		1800.00	
	--		--		3	600.00		1800.00	
	--		--		4	600.00		900.00	
	--		--		5	1000.00		900.00	
	--		--		6	1000.00		300.00	
	--		--		7	2610.00		300.00	
	--		--		8	2610.00		1500.00	
	--		--		9	2800.00		1500.00	
	--		--		10	28000.0		10000.00	

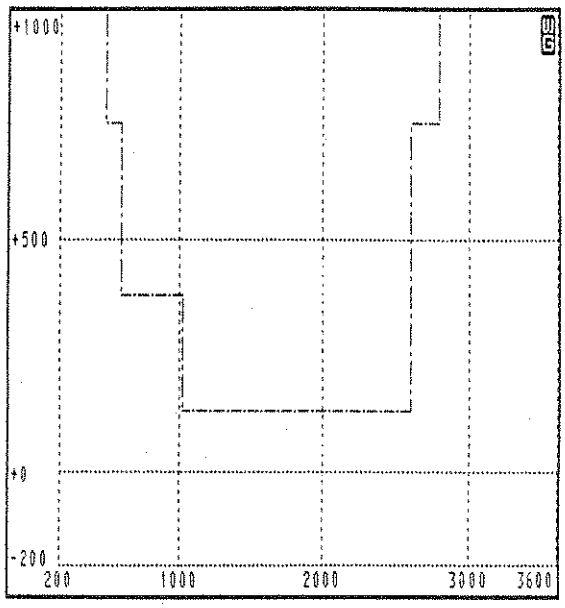
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 68

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	194							

Units: X in [Hz] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	500.00		10000.00	
	– –		– –		2	500.00		900.00	
	– –		– –		3	600.00		900.00	
	– –		– –		4	600.00		450.00	
	– –		– –		5	1000.00		450.00	
	– –		– –		6	1000.00		150.00	
	– –		– –		7	2610.00		150.00	
	– –		– –		8	2610.00		750.00	
	– –		– –		9	2800.00		750.00	
	– –		– –		10	2800.00		10000.00	

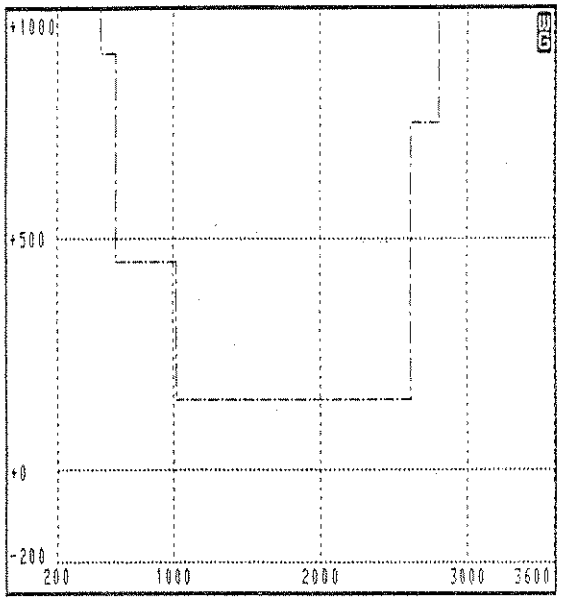
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 69

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
	195							

Units: X in [Hz] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	500.00		10000.00	
	--		--		2	500.00		900.00	
	--		--		3	600.00		900.00	
	--		--		4	600.00		450.00	
	--		--		5	1000.00		450.00	
	--		--		6	1000.00		150.00	
	--		--		7	2610.00		150.00	
	--		--		8	2610.00		750.00	
	--		--		9	2800.00		750.00	
	--		--		10	2800.00		10000.00	

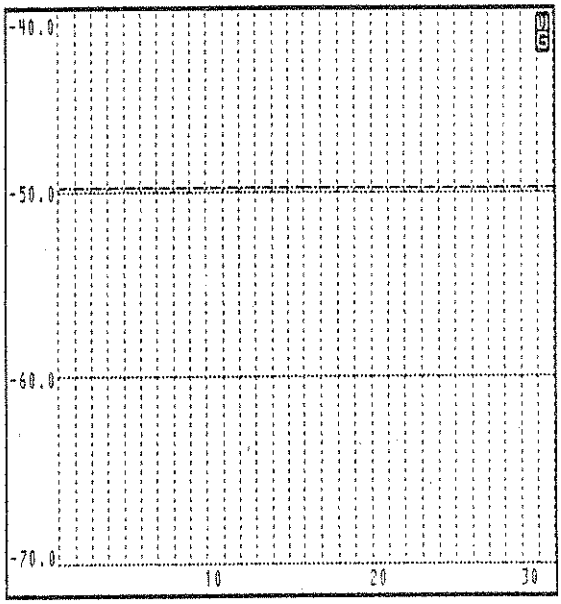
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 70

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
		225	242														
		226	245														
		229	246														
		230	249														
		233	250														
		234	253														
		237	254														
		238	257														
		241	258														

Units: X in [ ] Y in [dB <0, m=>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–50.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 71

Form 3

Bv.–No.

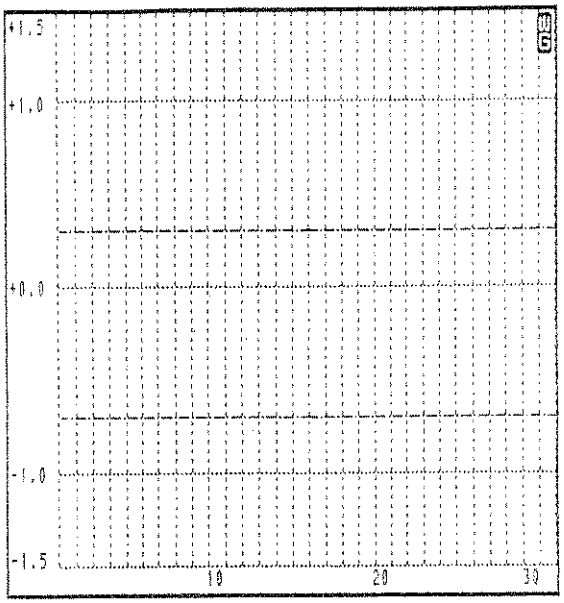
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		11	11					
		12	12					
		15	15					
		16	16					

Units: X in [ ] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	– –		–.70		2	– –		.30	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 72

Form 3

Bv.–No.

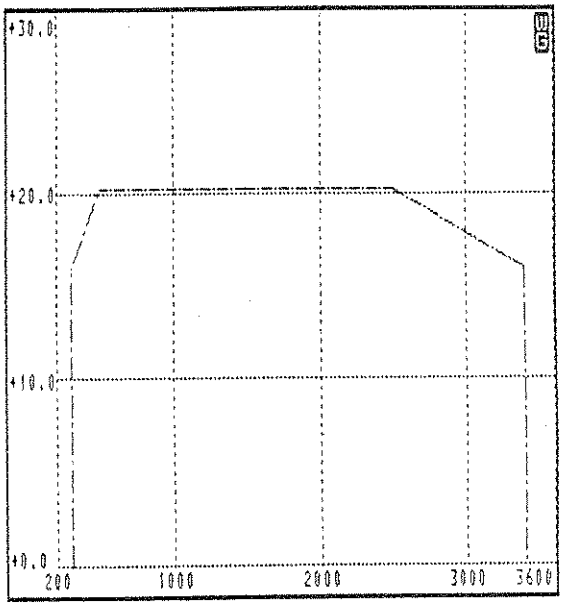
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		9	9					
		13	13					

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00					--		--	
2	300.00					--		--	
3	500.00					--		--	
4	2500.00					--		--	
5	3400.00					--		--	
6	3400.00					--		--	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 73

Form 3

Bv.–No.

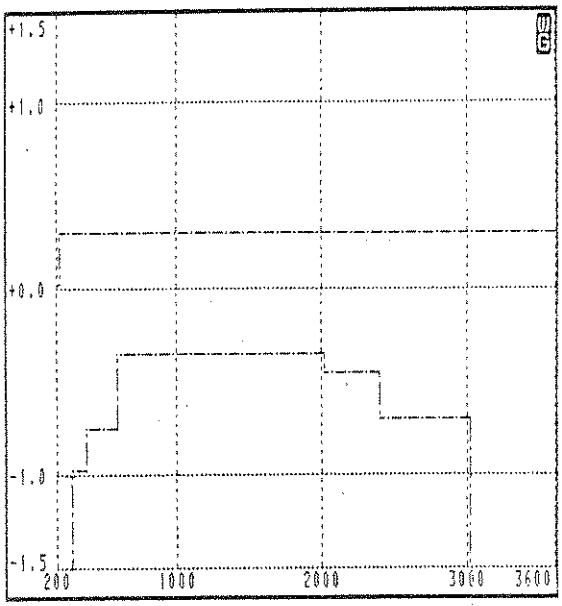
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		26	26					
		30	30					
		42	42					
		46	46					

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		–99.00		15	10.00		0.00	
2	300.00		–1.00		16	200.00		0.00	
3	400.00		–1.00		17	200.00		.30	
4	400.00		–.75		18	3600.00		.30	
5	600.00		–.75		19	3600.00		0.00	
6	600.00		–.35		20	5000.00		0.00	
7	2000.00		–.35						
8	2000.00		–.45						
9	2400.00		–.45						
10	2400.00		–.70						
11	3000.00		–.70						
12	3000.00		–1.70						
13	3400.00		–1.70						
14	3400.00		–99.00						

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 74

Form 3

Bv.–No.

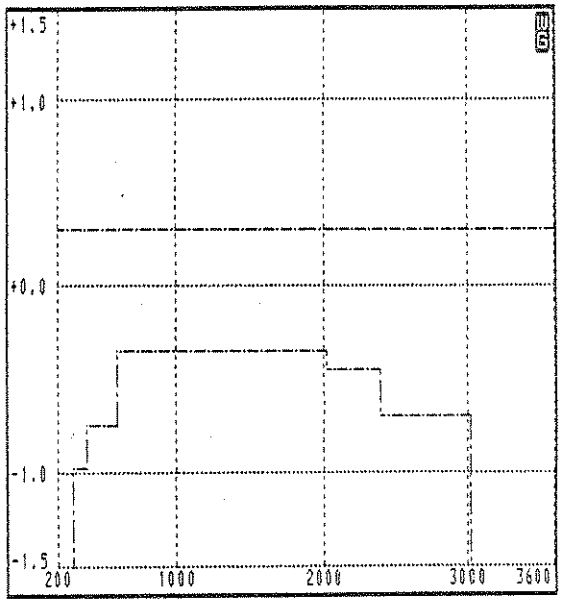
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		27	27					
		31	31					
		43	43					
		47	47					

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		–99.00		15	10.00		.30	
2	300.00		–1.00		16	3600.00		.30	
3	400.00		–1.00		17	3600.00		0.00	
5	600.00		–.75		18	5000.00		0.00	
6	600.00		–.75						
7	2000.00		–.35						
8	2000.00		–.45						
9	2400.00		–.45						
10	2400.00		–.70						
11	3000.00		–.70						
12	3000.00		–1.70						
13	3400.00		–1.70						
14	3400.00		–99.00						

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 75

Form 3

Bv.–No.

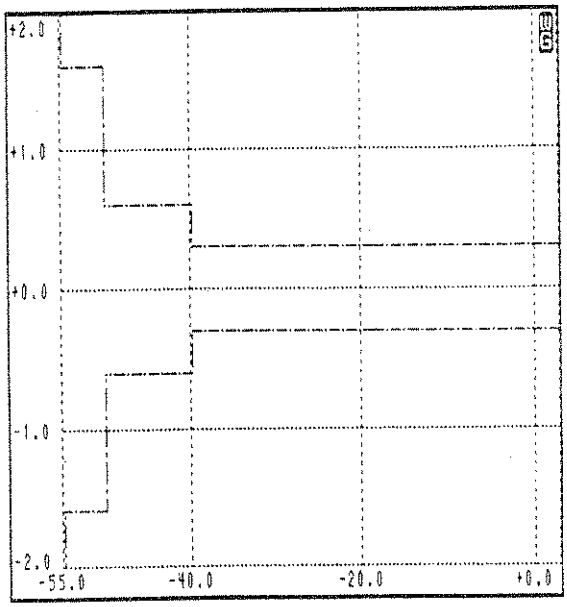
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
			58					
			59					
			62					
			63					

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		–99.99		9	–55.00		30.00	
2	–55.00		–1.60		10	–55.00		1.60	
3	–50.00	–	1.60		11	–50.00		1.60	
4	–50.00		–.60		12	–50.00		.60	
5	–40.00		–.60		13	–40.00		.60	
6	–40.00		–.30		14	–40.00		.30	
7	3.00		–.30		15	3.00		.30	
8	3.00		–99.99		16	3.00		30.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 76

Form 3

Bv.–No.

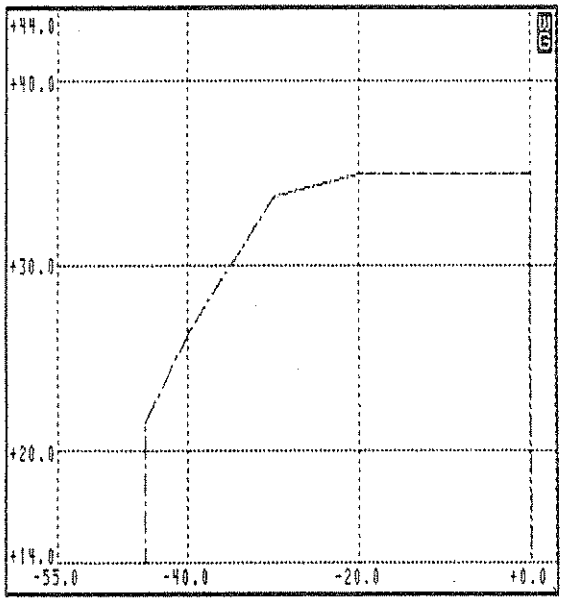
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		90						
		91						
		94						
		95						

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–45.00		0.00			– –		– –	
2	–45.00		21.60			– –		– –	
3	–40.00		26.50			– –		– –	
4	–30.00		33.80			– –		– –	
5	–20.00		35.00			– –		– –	
6	0.00		35.00			– –		– –	
7	0.00		0.00			– –		– –	

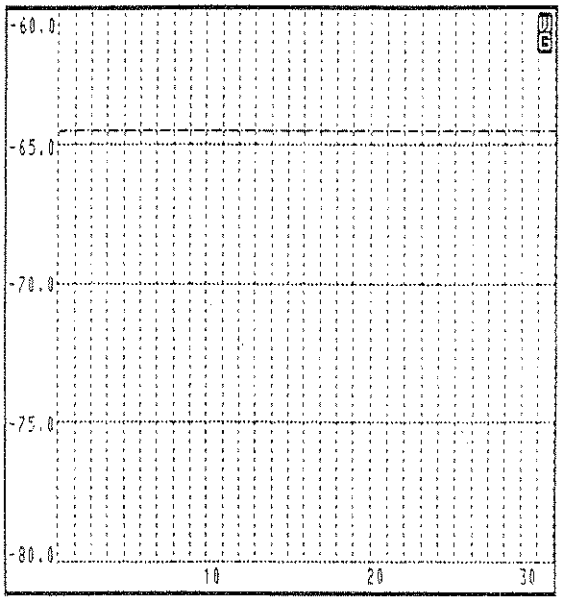
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 77

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		102						
		106						
		114						
		118						

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–64.50	

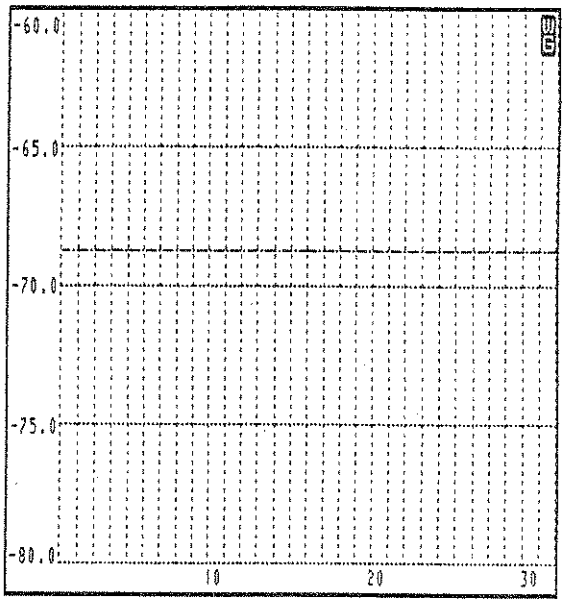
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 78

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		103						
		107						
		115						
		119						

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –				1	– –		–68.80	

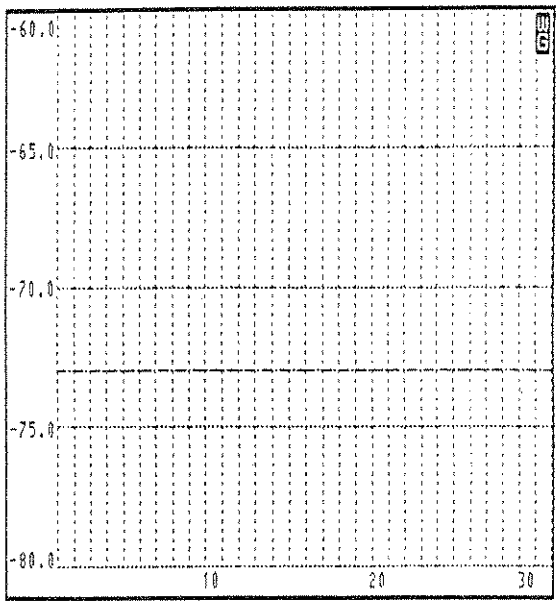
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 79

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		125	125					
		127	127					
		129	129					
		131	131					
		133	133					
		135	135					
		137	137					
		139	139					

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–73.00	

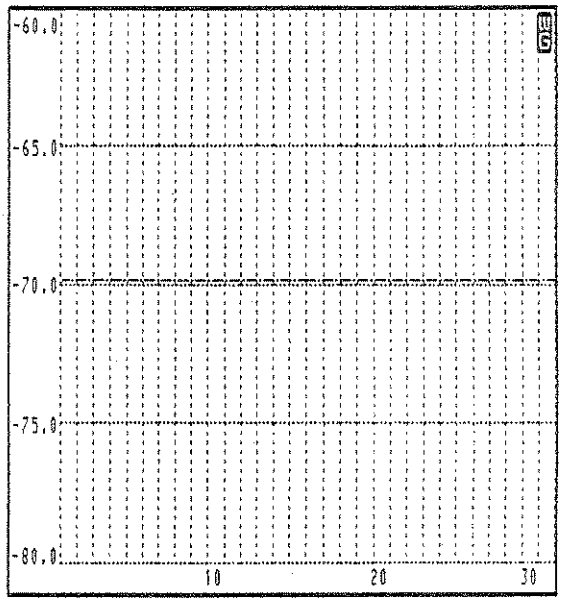
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 80

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
				126		126											
				128		128											
				130		130											
				132		132											
				134		134											
				136		136											
				138		138											
				140		140											

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–70.00	

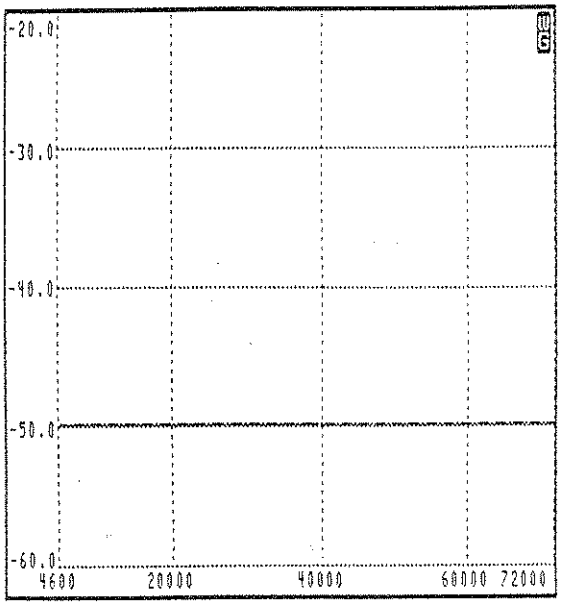
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 81

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		162	162					
		164	164					

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	--		-50.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 82

Form 3

Bv.–No.

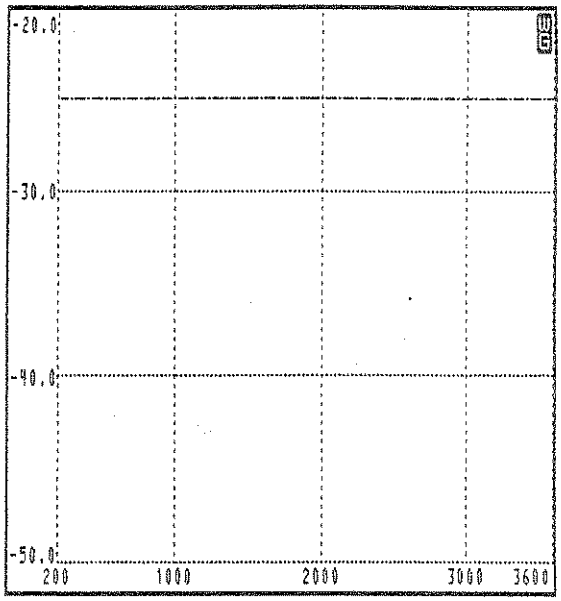
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		166	166					
		168	168					

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–25.00	

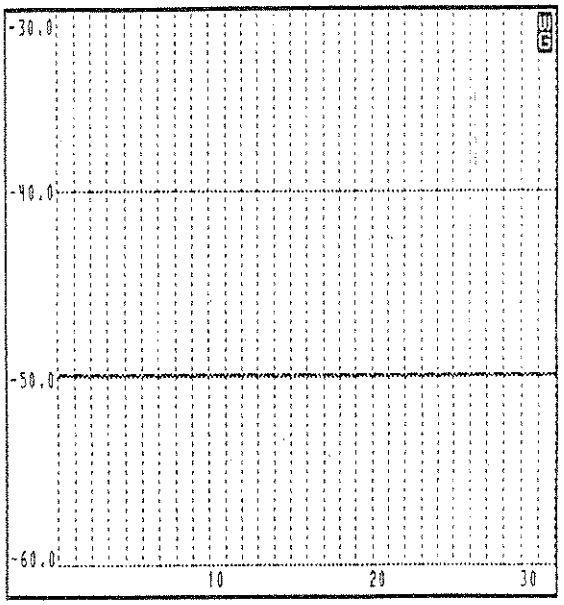
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 83

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		172	172					

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	--		-50.00	

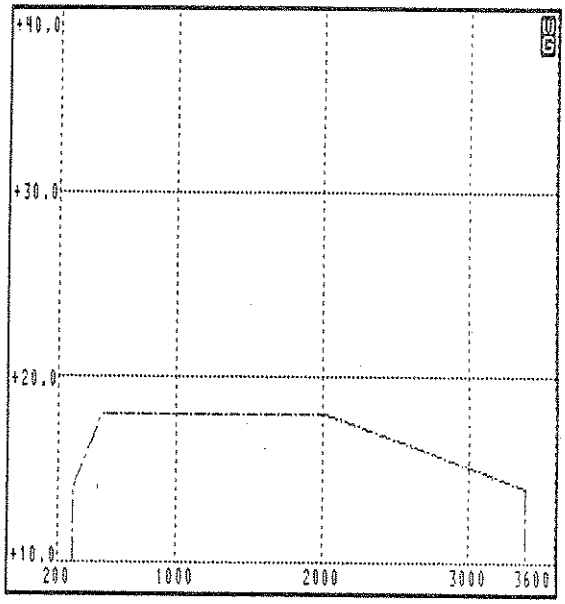
④ official stamp | date | signature

PCM–4/PCM–5 tolerance masks

Mask no. 84

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		173	173					
		174	174					
		175	175					
		176	176					
		177	177					
		178	178					

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		0.00			--		--	
2	300.00		14.00			--		--	
3	500.00		18.00			--		--	
4	2000.00		18.00			--		--	
5	3400.00		14.00			--		--	
6	3400.00		0.00			--		--	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 85

Form 3

Bv.–No.

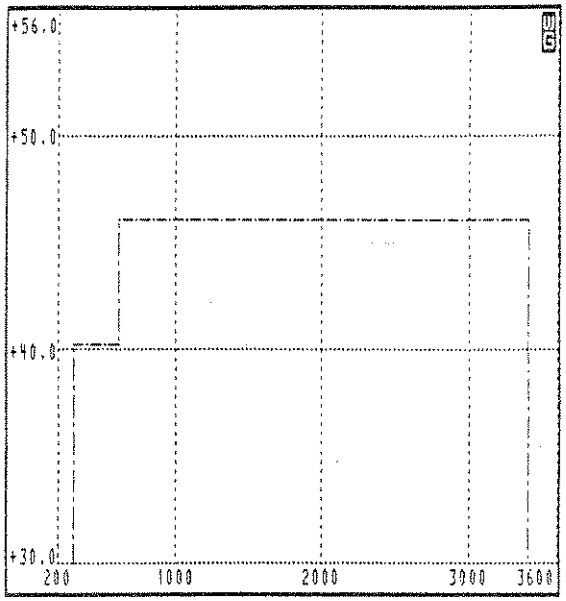
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		179	179					
		180	180					
		181	181					
		182	182					

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		0.00			– –		– –	
2	300.00		40.00			– –		– –	
3	600.00		40.00			– –		– –	
4	600.00		46.00			– –		– –	
5	3400.00		46.00			– –		– –	
6	3400.00		0.00			– –		– –	

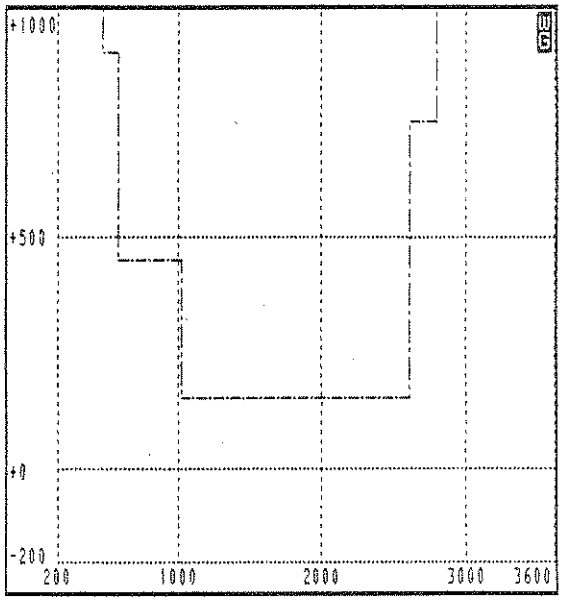
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 86

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		194	194					

Units: X in [Hz] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	500.00		10000.00	
	--		--		2	500.00		900.00	
	--		--		3	600.00		900.00	
	--		--		4	600.00		450.00	
	--		--		5	1000.00		450.00	
	--		--		6	1000.00		150.00	
	--		--		7	2610.00		150.00	
	--		--		8	2610.00		750.00	
	--		--		9	2800.00		750.00	
	--		--		10	2800.00		10000.00	

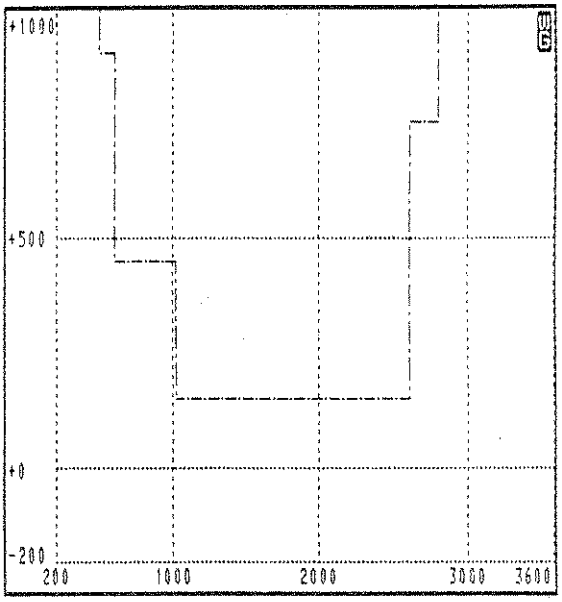
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 87

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
		195	195					

Units: X in [Hz] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	500.00		10000.00	
	– –		– –		2	500.00		900.00	
	– –		– –		3	600.00		900.00	
	– –		– –		4	600.00		450.00	
	– –		– –		5	1000.00		450.00	
	– –		– –		6	1000.00		150.00	
	– –		– –		7	2610.00		150.00	
	– –		– –		8	2610.00		750.00	
	– –		– –		9	2800.00		750.00	
	– –		– –		10	2800.00		10000.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 88

Form 3

Bv.–No.

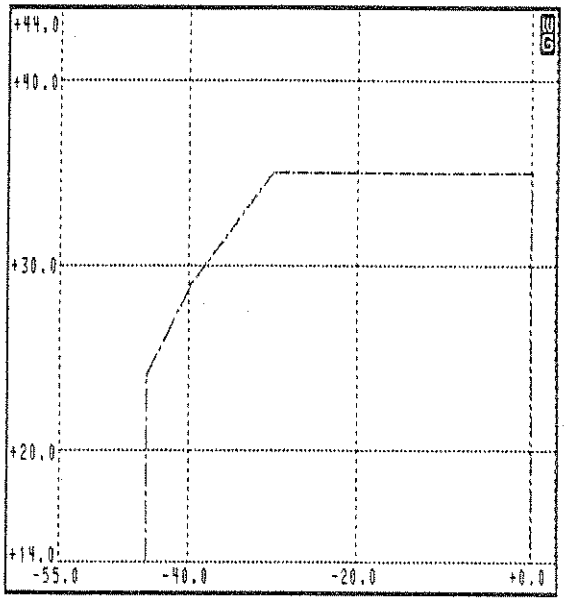
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
			90					
			91					
			94					
			95					

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–45.00		0.00			– –		– –	
2	–45.00		24.00			– –		– –	
3	–40.00		29.00			– –		– –	
4	–30.00		35.00			– –		– –	
5	0.00		35.00			– –		– –	
6	0.00		0.00			– –		– –	

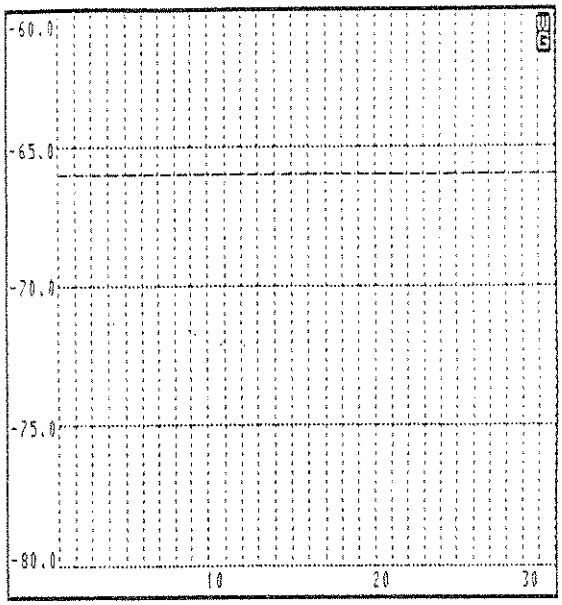
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 89

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
			102					
			106					
			114					
			118					

Units: X in [ ] Y in [dB <C, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	--		-66.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 90

Form 3

Bv.–No.

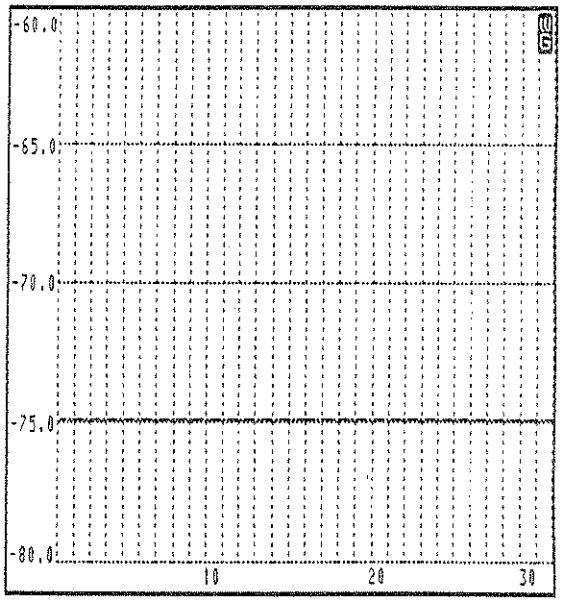
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
			103					
			107					
			115					
			119					

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–75.00	

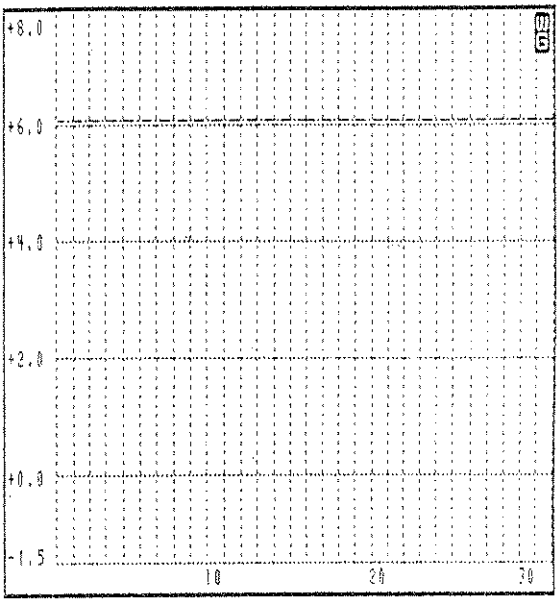
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 91

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
				11				
				12				
				15				
				16				

Units: X in [ ] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	--		6.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 92

Form 3

Bv.–No.

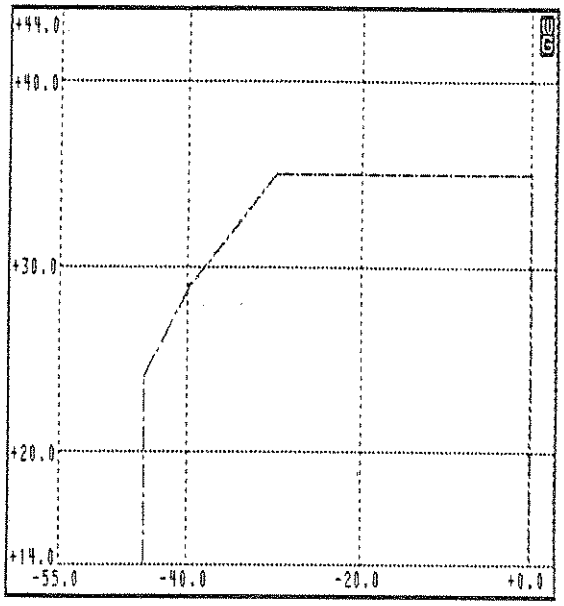
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
				90				
				94				

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–45.00		0.00			– –		– –	
2	–45.00		19.90			– –		– –	
3	–40.00		24.90			– –		– –	
4	–30.00		32.90			– –		– –	
5	–20.00		35.00			– –		– –	
6	0.00		35.00			– –		– –	
7	0.00		0.00			– –		– –	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 93

Form 3

Bv.–No.

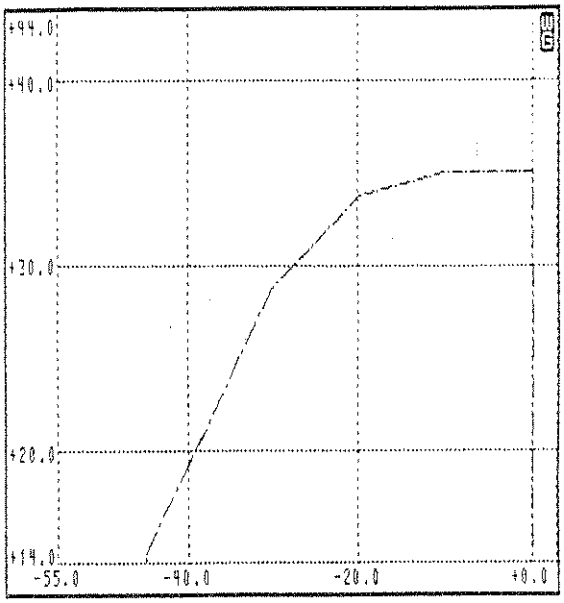
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
				91				
				95				

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–45.00		0.00			– –		– –	
2	–45.00		14.50			– –		– –	
3	–40.00		19.50			– –		– –	
4	–30.00		28.80			– –		– –	
5	–20.00		33.80			– –		– –	
6	–10.00		35.00			– –		– –	
7	0.00		35.00			– –		– –	
8	0.00		0.00			– –		– –	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 94

Form 3

Bv.–No.

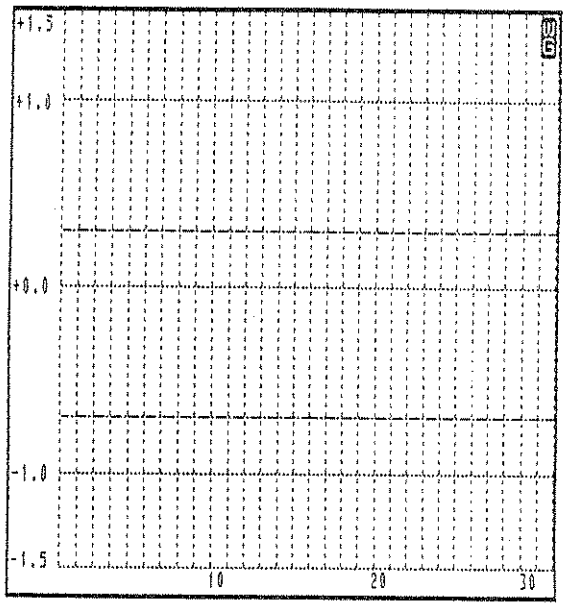
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					11	11		
					12	12		
					15	15		
					16	16		

Units: X in [ ] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	– –		–.70		2	– –		.30	

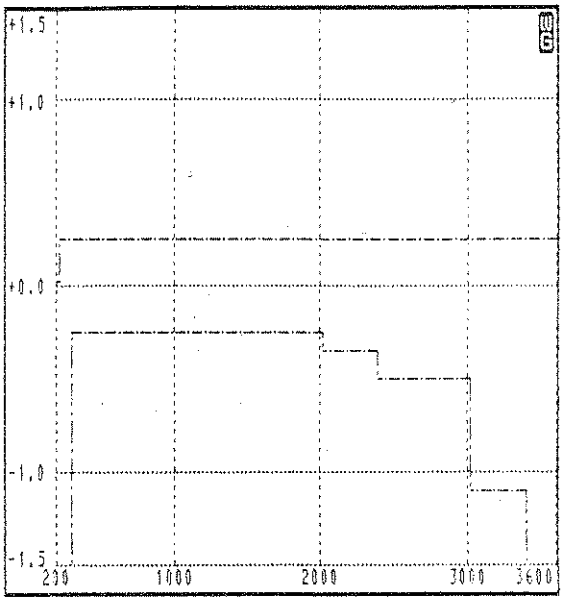
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 95

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1		List no. 2		List no. 3		List no. 4		List no. 5		List no. 6		List no. 7		List no. 8		List no. 9	
										26		26					
										30		30					
										42		42					
										46		46					

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		–99.00		11	10.00		0.00	
2	300.00		–.25		12	200.00		0.00	
3	2000.00		–.25		13	200.00		25	
4	2000.00		–.35		14	3600.00		25	
5	2400.00		–.35		15	3600.00		0.00	
6	2400.00		–.50		16	5000.00		0.00	
7	3000.00		–.50						
8	3000.00		–1.10						
9	3400.00		–1.10						
10	3400.00		–99.00						

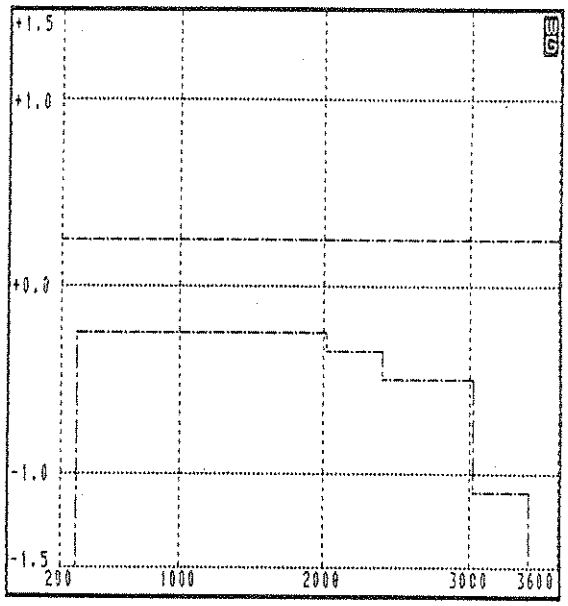
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 96

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					27	27		
					31	31		
					43	43		
					47	47		

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		–99.00		11	10.00		.25	
2	300.00		–.25		12	3600.00		.25	
3	2000.00		–.25		13	3600.00		0.00	
4	2000.00		–.35		14	5000.00		0.00	
5	2400.00		–.35						
6	2400.00		–.50						
7	3000.00		–.50						
8	3000.00		–1.10						
9	3400.00		–1.10						
10	3400.00		–99.00						

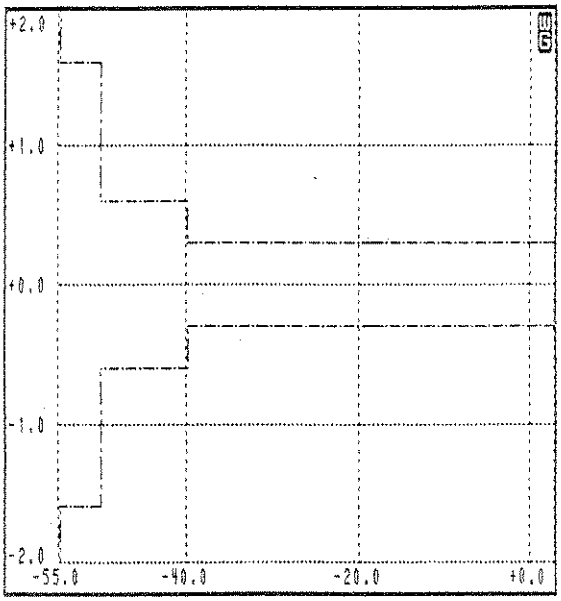
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 97

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					58	58		
					59	59		
					62	62		
					63	63		

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–55.00		–99.99		9	–55.00		30.00	
2	55.00		–1.60		10	–55.00		1.60	
3	–50.00		–1.60		11	–50.00		1.60	
4	–50.00		–.60		12	–50.00		.60	
6	–40.00		–.60		13	–40.00		.60	
6	–40.00		–.30		14	–40.00		.30	
7	3.00		–.30		15	3.00		.30	
8	3.00		–99.99		16	3.00		30.00	

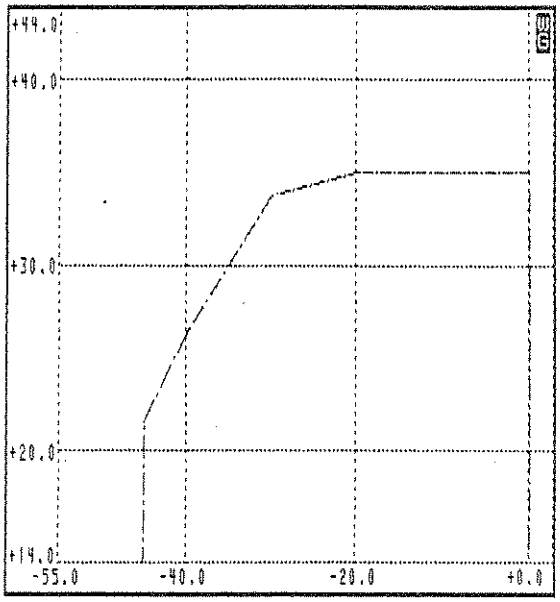
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 98

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					90			
					91			
					94			
					95			

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–45.00		0.00			– –		– –	
2	–45.00		21.50			– –		– –	
3	–40.00		26.50			– –		– –	
4	–30.00		33.80			– –		– –	
5	–20.00		35.00			– –		– –	
6	0.00		35.00			– –		– –	
7	0.00		0.00			– –		– –	

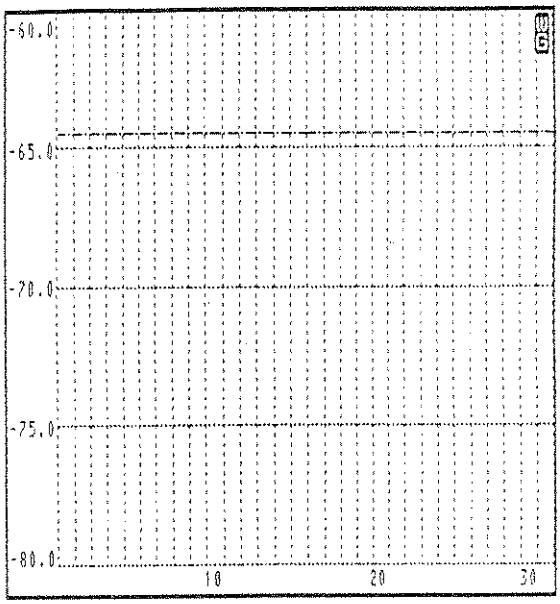
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 99

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					102			
					106			
					114			
					118			

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		-64.50	

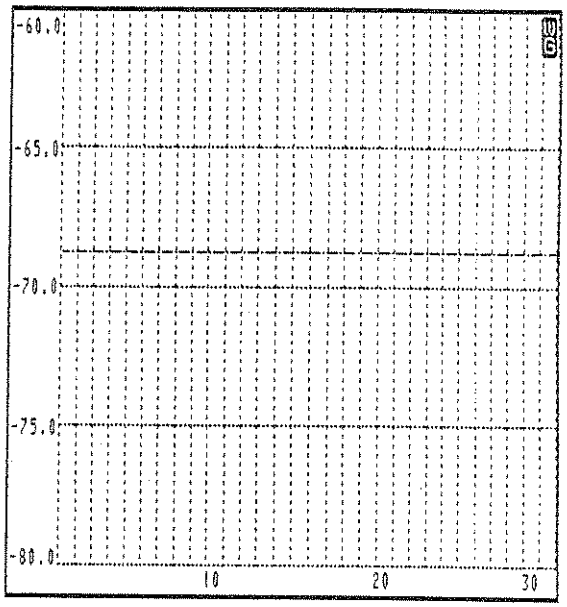
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 100

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					103			
					107			
					115			
					119			

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		-68.80	

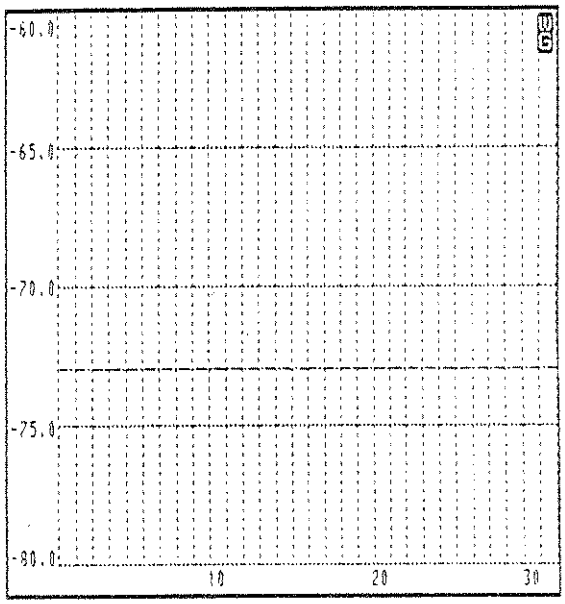
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 101

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					125	125		
					127	127		
					129	129		
					131	131		
					133	133		
					135	135		
					137	137		
					139	139		

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		-73.00	

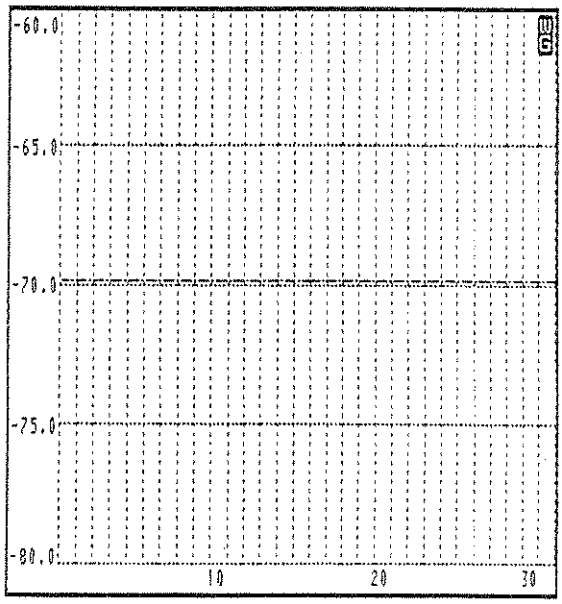
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 102

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					126	126		
					128	128		
					130	130		
					132	132		
					134	134		
					136	136		
					138	138		
					140	140		

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–70.00	

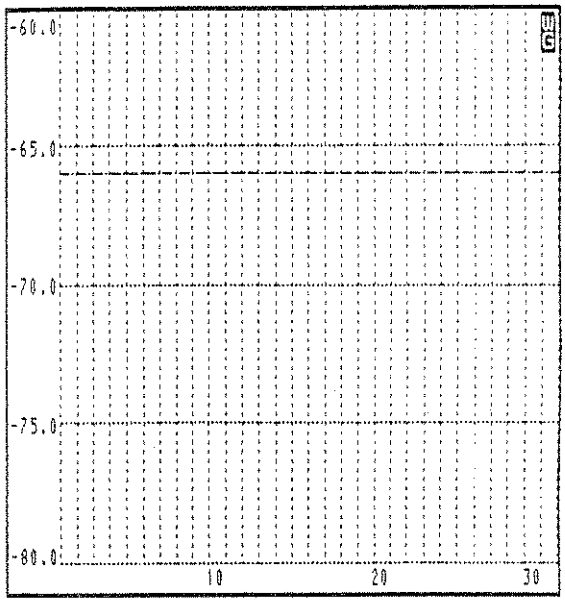
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 103

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					145	145		
					149	149		
					153	153		
					157	157		

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		-66.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 104

Form 3

Bv.–No.

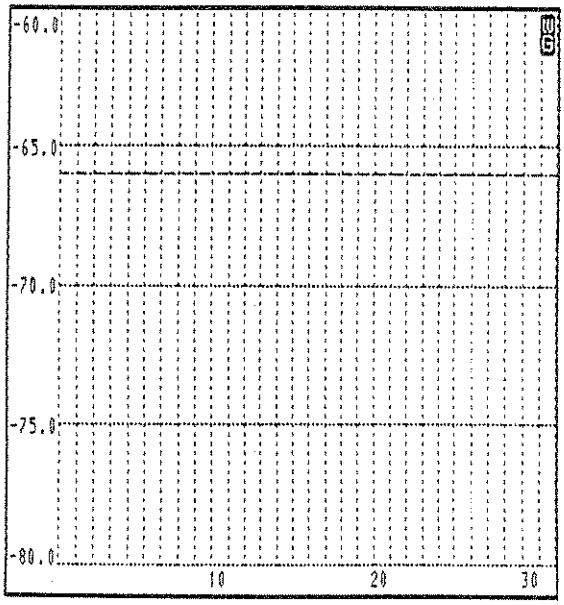
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					148	148		
					152	152		
					156	156		
					160	160		

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		-66.00	

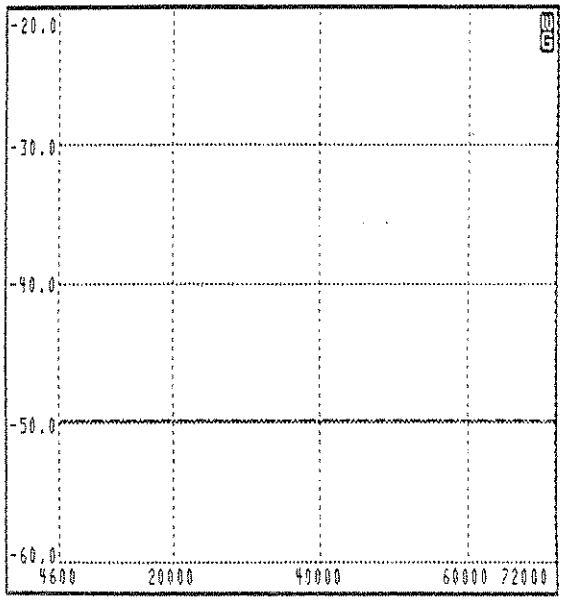
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 105

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					162	162		
					164	164		

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	--		-50.00	

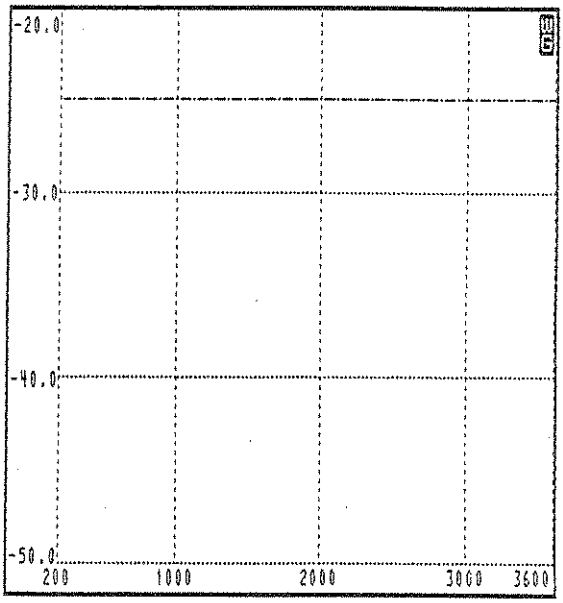
④ official stamp | date | signature

PCM–4/PCM–5 tolerance masks

Mask no. 106

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					166	166		
					168	168		

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	--		-25.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 107

Form 3

Bv.–No.

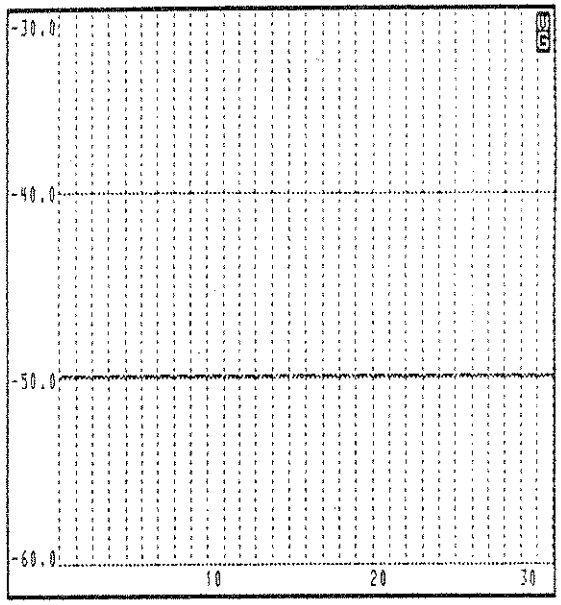
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					172	172		

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	--		--		1	--		-50.00	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 108

Form 3

Bv.–No.

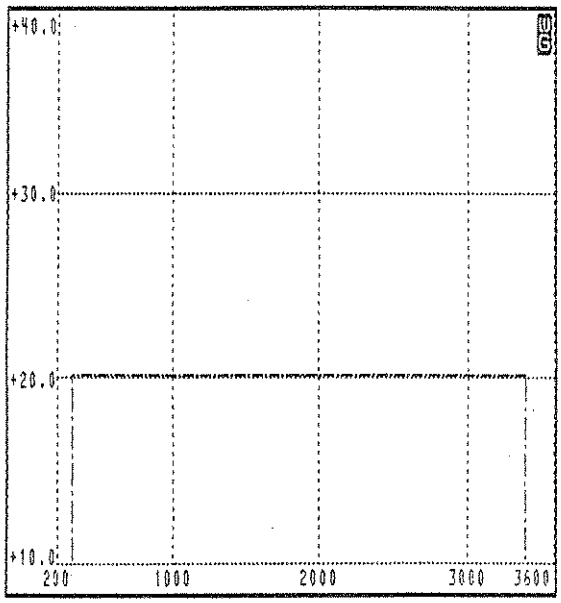
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					173	173		
					174	174		
					175	175		
					176	176		
					177	177		
					178	178		

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		0.00			– –		– –	
2	300.00		20.00			– –		– –	
3	3400.00		20.00			– –		– –	
5	3400.00		0.00			– –		– –	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 109

Form 3

Bv.–No.

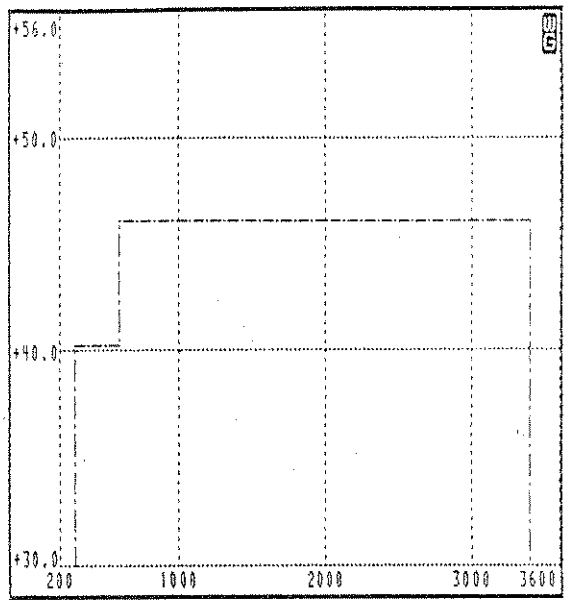
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					179	179		
					180	180		
					181	181		
					182	182		

Units: X in [Hz] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	300.00		0.00			--		--	
2	300.00		40.00			--		--	
3	600.00		40.00			--		--	
4	600.00		46.00			--		--	
5	3400.00		46.00			--		--	
6	3400.00		0.00			--		--	

④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 110

Form 3

Bv.–No.

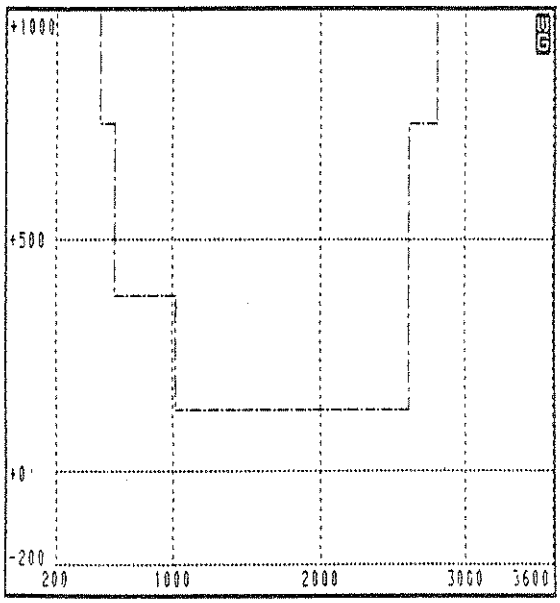
Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature



Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
					194	194		
					195	195		

Units: X in [Hz] Y in [MIKROSEK.]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	500.00		10000.00	
	– –		– –		2	500.00		750.00	
	– –		– –		3	600.00		750.00	
	– –		– –		4	600.00		380.00	
	– –		– –		5	1000.00		380.00	
	– –		– –		6	1000.00		130.00	
	– –		– –		7	2610.00		130.00	
	– –		– –		8	2610.00		750.00	
	– –		– –		9	2800.00		750.00	
	– –		– –		10	2800.00		10000.00	

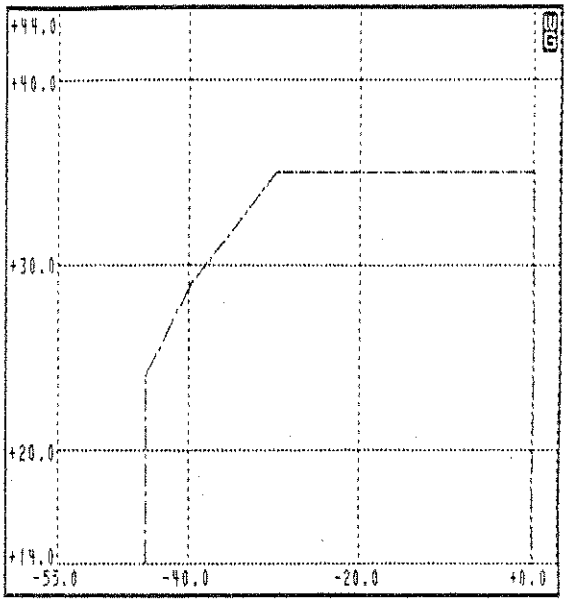
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 111

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
						90		
						91		
						94		
						95		

Units: X in [dB <0, m0>] Y in [dB]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
1	–45.00		0.00			– –		– –	
2	–45.00		24.00			– –		– –	
3	–40.00		29.00			– –		– –	
4	–30.00		35.00			– –		– –	
5	0.00		35.00			– –		– –	
6	0.00		0.00			– –		– –	

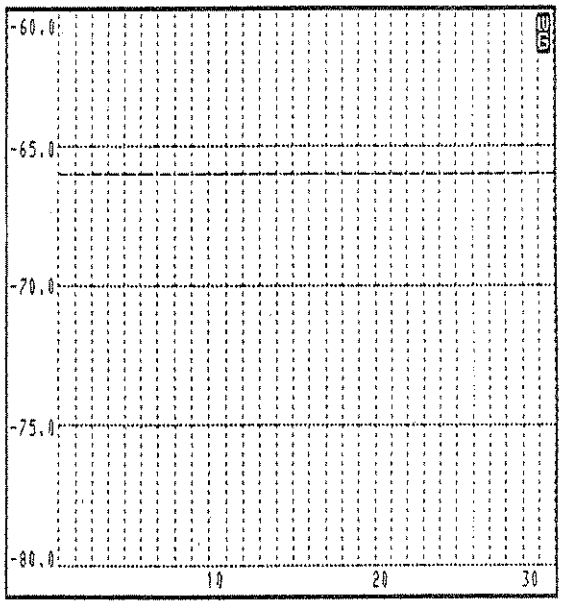
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 112

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number
(same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name
①

Page no.
②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
						102		
						106		
						114		
						118		

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–66.00	

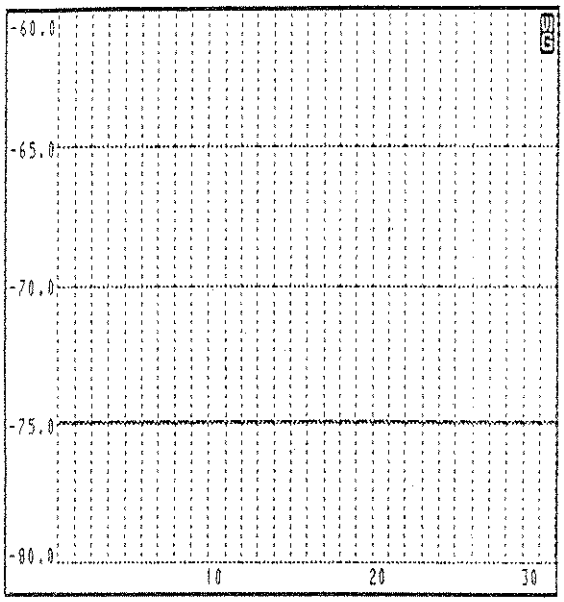
④ official stamp date signature

PCM–4/PCM–5 tolerance masks

Mask no. 113

Form 3

Bv.–No.



Complete this form if the tolerance mask shown opposite is to be changed or extended.
Only fill in the sections outlined in heavy type.

① name

② page number (same number on both sides!)

③ changed corner values

④ official stamp, date, signature

Name ①

Page no. ②

This mask is used in the following operating modes

List no. 1	List no. 2	List no. 3	List no. 4	List no. 5	List no. 6	List no. 7	List no. 8	List no. 9
						103		
						107		
						115		
						119		

Units: X in [ ] Y in [dB <0, m0>]

Corner point no.	lower limit				Corner point no.	upper limit			
	X value		Y value			X value		Y value	
	standard	③ change	standard	③ change		standard	③ change	standard	③ change
	– –		– –		1	– –		–75.00	

④ official stamp date signature

PCM-4/PCM-5 tolerance masks

MASK NO. ③ ☐

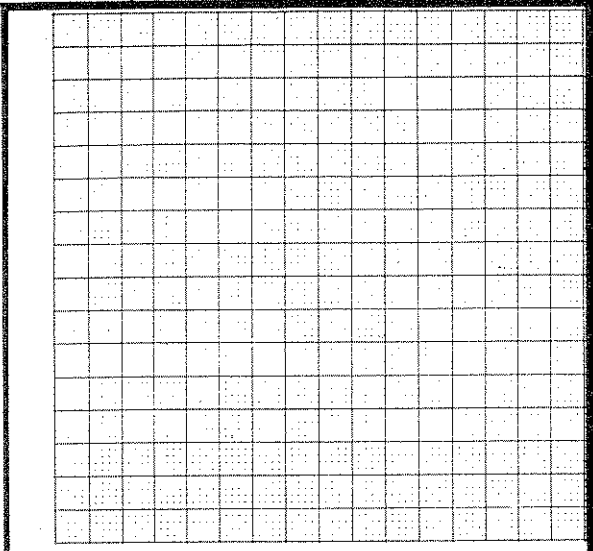
FORM 4

Bv. no.

type of mask ④

line ☐

linear approxi-mation ☐



Complete this form if you want to produce a completely new tolerance mask.
Only fill in the sections outlined in heavy type.

① name
② page no.
③ mask no.
④ type of mask (line or piecewise linear approximation)
⑤ units (for X and Y)
⑥ tolerance values (for X and Y)
⑦ official stamp, date, signature

name ①

page no. ②

⑤ Units X in [ ] Y in [ ]

Units: dB(Ø, mØ) Hz, ms, µs, %

corner point no.	lower limit ⑥ X value	lower limit ⑥ Y value	corner point no.	upper limit ⑥ X value	upper limit ⑥ Y value

⑦ official stamp date signature

Order no. BN 984/00.79

5/1348