ANT-20SE
Advanced Network Tester

O.172 Jitter/Wander
up to 155 Mbit/s

BN 3060/91.30

O.172 Jitter/Wander
up to 622 Mbit/s

BN 3060/91.31

5

O.172 Jitter/Wander
for 2488 Mbit/s Interfaces

BN 3060/91.32

Software Version 7.20

Operating Manual

BN 3060/98.37

Wavetek Wandel Goltermann
Communications Test Solutions

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

Copyrights

Wavetek Wandel Goltermann
Eningen GmbH & Co.
Mühleweg 5, 72800 Eningen u. A.

Author: MDD/TD
Translator: John Nutley

Order no.: BN 3060/98.37
Edition: 02/00.07 (V 7.20)

Previous edition:
01/00.04 (V 7.1)

Subject to change without notice.
Our normal guarantee and delivery terms apply.

Printed in Germany

Contents

Specifications O.172 Jitter / Wander (2488 Mbit/s Interface)

Notes:

Introduction

The Jitter Options BN 3035/90.81 to 90.84 provide the ANT-20SE Advanced Network Tester with compact facilities for generating and measuring jitter. The Jitter Generator and Jitter Analyzer are built in to the ANT-20SE. No additional equipment is required for the measurement.

The Jitter Generator and Jitter Analyzer meet or exceed the requirements of ITU-T recommendation O.172 for demonstrating the jitter specifications for electrical and optical signals up to 622 Mbit/s as stated in ITU-T, Bellcore and ANSI recommendations.

Option BN 3035/90.88 allows generation and analysis of jitter on the 2488 Mbit/s optical interface. More information is found in Sec. 9, Page I-6 and in the Jitter specifications (2488 Mbit/s interface).

Jitter measurements are required

- when installing network elements,
- during troubleshooting, and
- during routine maintenance work.

1 Jitter Generator

PDH/DS1-3 and SDH/SONET output signals at up to 155 Mbit/s are modulated using the Jitter Generator (BN 3035/90.81) in the ANT-20SE.
Option BN 3035/90.83 extends the bit rate range up to 622 Mbit/s.

Jitter is generated by an internal modulation generator that permits sine-wave modulation in the frequency range from 0.1 Hz to 5 MHz.

2 Jitter Analyzer

The ANT-20SE uses the built-in Jitter Analyzer (BN 3035/90.82) to determine the jitter at PDH/DS1-3 and SDH/SONET interfaces at up to 155 Mbit/s.
Option BN 3035/90.84 extends jitter measurement up to a bit rate of 622 Mbit/s.

The Jitter Analyzer includes high-pass and low-pass filters as specified in ITU-T Recommendation O.172. The instantaneous peak jitter values are measured. The maximum jitter amplitude occurring during a measurement interval is also stored. The RMS jitter value can also be measured.

The demodulated jitter signal can be extracted for further processing (e.g. spectrum analysis) from the demodulator output socket [31].

A new type of jitter has become apparent in communications networks with the introduction of SDH / SONET networks. This jitter is caused by pointer operations and by mapping the tributary signals (Combined Jitter).
The ANT-20SE measures this Combined Jitter at the tributary level with high accuracy. This accuracy is achieved by precise conformance to the high-pass filter characteristic defined in ITU-T O.172 and the high tolerance of the jitter analyzer to jitter peaks that are caused by pointer operations.

3 Tolerance to jitter tests

The tolerance to jitter for a system component indicates the maximum jitter amplitude of the data signal at which transmissions are still free of errors. Different amplitudes result at different frequencies.

The tolerance to jitter is an important measurand for acceptance tests, as it indicates how sensitive the system is to any jitter that occurs. The jitter values determined during the acceptance tests can be used as reference values for subsequent in-service measurements. Routine comparisons with these reference values allow early detection of any changes. Components can then be replaced before communications problems occur.

The ANT-20SE includes two automatic test sequences for measuring tolerance to jitter.

Maximum Tolerable Jitter (MTJ measurement)

A pseudo-random bit sequence modulated by a sine-wave signal is used as the test pattern. At a given frequency, the amplitude of the jitter signal is increased using a half-interval progression until errors occur at the output of the device under test.
The output amplitude of the jitter generator at this point is the tolerable input jitter for the device under test. The results are displayed as a graph or as a table.

Fast Maximum Tolerable Jitter (F-MTJ measurement)

The device under test is stressed using pre-set jitter amplitudes and monitored for errors. This method is much faster, as there is no need for a progressive amplitude search. The results are shown in the form of the status messages “OK” or “Failed”.

4 Jitter Transfer Function

The jitter transfer function of a digital communications module indicates the degree to which the input jitter is passed on to the module output. Jitter may be increased or decreased by passage through the module under test.

If the input signal to a communications module is jittered, there will generally be some residual jitter on the output signal.
As the signals pass through the module, the high-frequency jitter is generally suppressed. Low-frequency jitter components normally appear unchanged at the output. It is possible that the input jitter may even be amplified slightly by the module. This can cause problems if several similar components such as regenerators are connected consecutively. Even minimal jitter gain can accumulate to produce high jitter values. The input jitter tolerance for the next module will then be exceeded at a certain point in the line. This will result in a strong increase in the bit error ratio in this module.

The ANT-20SE measures the jitter transfer function selectively. This provides the best possible measurement accuracy as it achieves a high degree of interference suppression.

5 Phase hits

A phase hit is by definition the violation of a certain specified jitter threshold. This event is counted with a counter. The current counter status indicates how many times the phase hit threshold was exceeded since the start of the measurement.

The ANT-20SE jitter analyzer allows separate counting of positive and negative threshold violations (positive count, negative count). The threshold for positive and negative violations can be set separately.

6 Wander Measurement

Slow, periodic and non-periodic phase changes in the frequency range 0 to 10 Hz are known as wander.

Since phase changes may take place at any speed, a reference clock is always required for a wander measurement.

The ANT-20SE can perform wander measurements at all bit rates corresponding to the mainframe configuration. A choice of reference clock frequencies is available: 1.544 MHz, 2.048 MHz, 5 MHz or 10 MHz, or data signals at 1.544 Mbit/s or 2.048 Mbit/s can be used. The “Wander Analyzer” option BN 3035/90.86 is required in addition to the Jitter Analyzer (BN 3035/90.82).

Wander Analyzer: Option BN 3035/90.89

The additional “Wander Analyzer” option BN 3035/90.89 also allows wander characteristics to be measured on 2488 Mbit/s optical interfaces (OC-48/STM-16).
1.544 MHz, 2.048 MHz, 5 MHz or 10 MHz signals can be used as the reference clock.

MTIE/TDEV Analysis: Option BN 3035/95.21

There is also a “MTIE/TDEV Analysis” option (BN 3035/95.21) available for the ANT-20SE. This software is used to calculate and analyze the maximum time interval error (MTIE) and time deviation (TDEV) from wander measurements made using the ANT-20SE.

7 Wander Generator

Using the additional option BN 3035/90.85 (together with option BN 3035/90.81), you can generate sine-wave wander with a frequency between 10 µHz and 10 Hz at amplitudes of up to 200000 UI.

You can also use the wander generator on the 2488 Mbit/s interface with option BN 3035/90.87 (together with options BN 3035/90.81 and BN 3035/90.88).

Maximum Tolerable Wander (MTW)

Automatic measurement of MTW (Maximum Tolerable Wander) is available in connection with the wander generator.

The device under test is subjected to wander at various amplitudes and frequencies and the output signal is monitored for errors, similar to the F-MTJ measurement. The wander amplitudes and frequencies (measurement points) can be selected by the user.

8 Connector panel

8.1 O.172 JITTER ANALYZER/GENERATOR

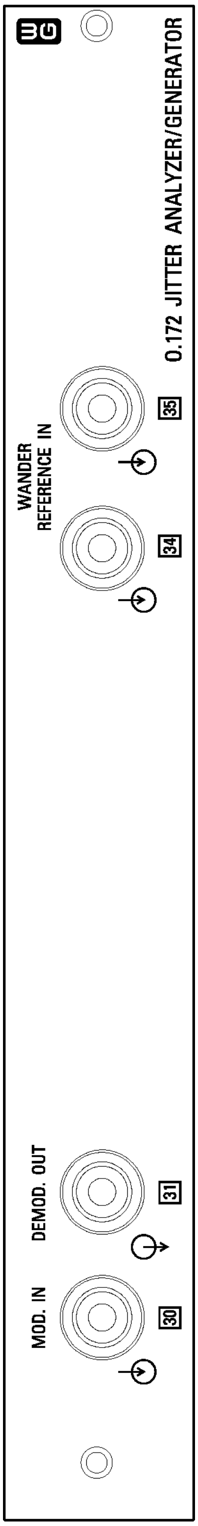


Fig. I-1 O.172 JITTER ANALYZER/GENERATOR connector panel

9 Options BN 3035/90.87, BN 3035/90.88 and BN 3035/90.89

Jitter can be generated and analyzed on the 2488 Mbit/s optical interface with the Jitter Generator/Jitter Analyzer (BN 3035/90.88). You will also need an OC-48/STM-16 Optical Interface (BN 3035/90.50 through BN 3035/90.54 or BN 3035/90.59, or BN 3035/91.53, BN 3035/91.54 or BN 3035/91.59).

The Jitter Generator/Jitter Analyzer meets the requirements of ITU-T Recommendation O.172 for the synchronous digital hierarchy.

9.1 Jitter Generator

Jitter (max. 800 UIpp) is generated by an internal modulation generator which can perform sine-wave modulation from 0.1 Hz to 20 MHz.
An external modulation voltage in the same frequency range can be fed in at connector [50].

9.2 Jitter Analyzer

The jitter measurement range is expanded to 32 UI_{pp}. The demodulated jitter signal is available at connector [51].

9.3 Connector panel: "O.172 JITTER ANALYZER/GENERATOR 2488 Mbit/s" Option BN 3035/90.88

The next figure shows where the "O.172 JITTER ANALYZER/GENERATOR 2488 Mbit/s" is inserted in the ANT-20SE along with the OC-48/STM-16 MODULE.
The two cable connections that are shown between the jitter module and the OC-48/STM-16 module (part of the delivery package) are essential for operation.

The connectors on the cables must not be tightened with a torque greater than 1 Nm (e.g. use torque wrench 74Z-0-0-21 from Suhner).

Note: When the "O.172 JITTER ANALYZER/GENERATOR 2488 Mbit/s" is retrofitted to the ANT-20SE, alignment is necessary to guarantee the measurement accuracy.
The Wavetek Wandel Goltermann Service Center nearest to you will carry out this alignment for you.

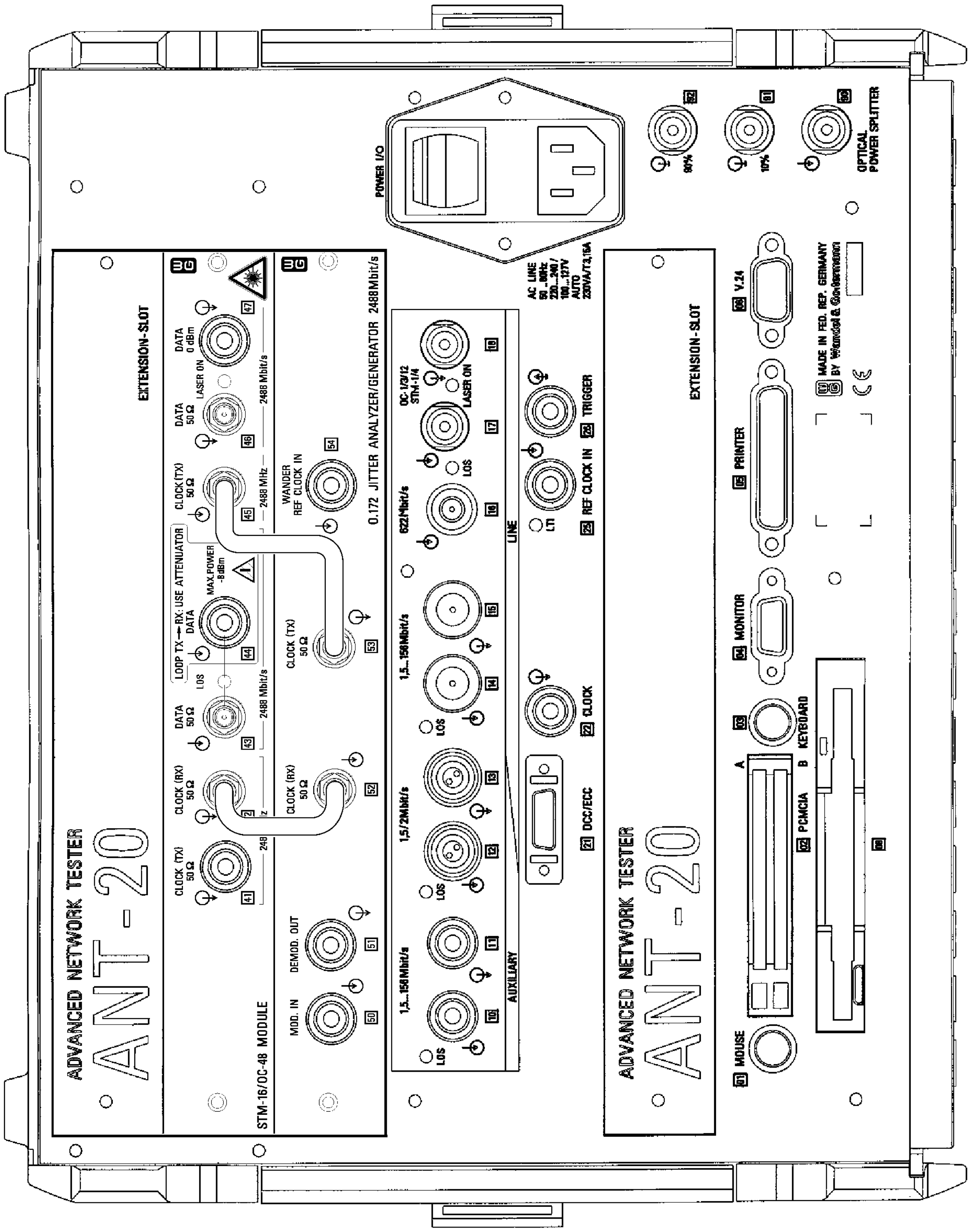


Fig. I-2 ANT-20SE with “O.172 JITTER ANALYZER/GENERATOR 2488 Mbit/s”

Notes:

Operation

1 Main Window: O.172 Jitter Generator/Analyzer general

The “O.172 Jitter Generator/Analyzer” VI is used to generate and measure jitter and wander. Automatic measurements, such as “Maximum Tolerable Jitter” and “Jitter Transfer Function” can be performed. The default setting of the VI also allows phase hit measurements (P-P PH) and RMS jitter measurements (P-P RMS) to be made.

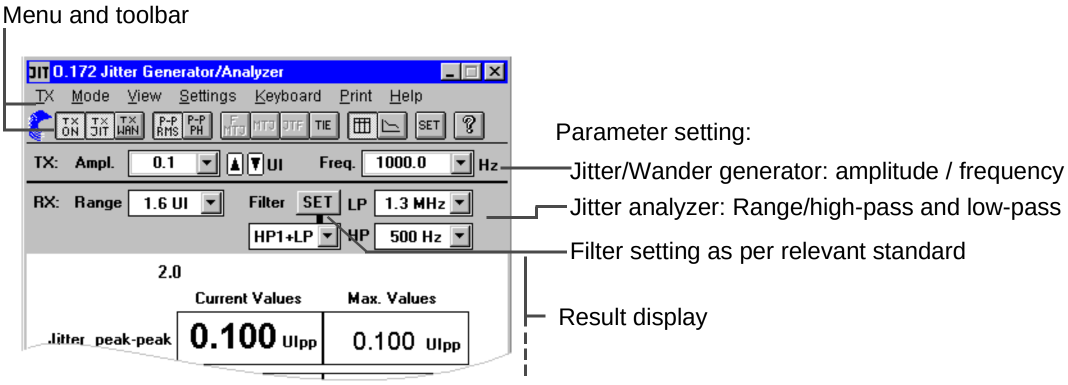


Fig. O-1 “O.172 Jitter Generator/Analyzer” window

Menu	Icon button	Function
TX	TX ON	Generator (Jitter/Wander) on/off
	TX JIT	Generator selection: Jitter
	TX WAN	Generator selection: Wander
Mode	P-P RMS	Measurement of peak to peak jitter (P-P) and RMS jitter (RMS)
	P-P PH	Measurement of peak to peak jitter (P-P) and phase hits (PH)
	F MTJ	FMTJ automatic function (Fast Maximum Tolerable Jitter)
	MTJ MTW	MTJ automatic function (Maximum Tolerable Jitter) MTW automatic function (Maximum Tolerable Wander); only if generator selection = wander
	JTF	JTF automatic function (Jitter Transfer Function)
	TIE	TIE/MTIE wander analysis
View	(table icon)	Results displayed as table
	(graphics icon)	Results displayed as graphics

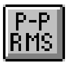
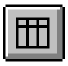
Table O-1 Significance of the menus and icon buttons

Menu	Icon button	Function
Settings		TX and RX parameter settings: • General: Display averaging, modulation source, phase hit thresholds, RMS integration time, TX amplitude step width • FMTJ: Scan frequencies, amplitude • MTJ: Scan frequencies, tolerance mask • MTW: Scan frequencies, amplitudes • JTF: Scan frequencies, amplitude, tolerance mask, calibration mode • Wander: Reference frequency, reference input, wander sample rate, TX amplitude step width
Help		On-line help

Table O-1 Significance of the menus and icon buttons *(continued)*

Note: If you click on one of the displayed results using the left-hand mouse button, an extra result window opens in which the result you clicked on is shown in larger type.
If you click on this extra window using the left-hand mouse button, the window will be enlarged again. You can click several times on the window to enlarge it in several stages. If you click on the window using the right-hand mouse button, the window will reduce in size.

2 Current and maximum jitter values, jitter RMS or phase hits

The “P-P RMS” function (see icon button above) switches the VI to non-automatic measurements which provide the following results:

- Current jitter values; numerical display (see Fig. O-2)
  Current jitter values; graphical display (see Fig. O-4)
- Maximum jitter values
- RMS jitter

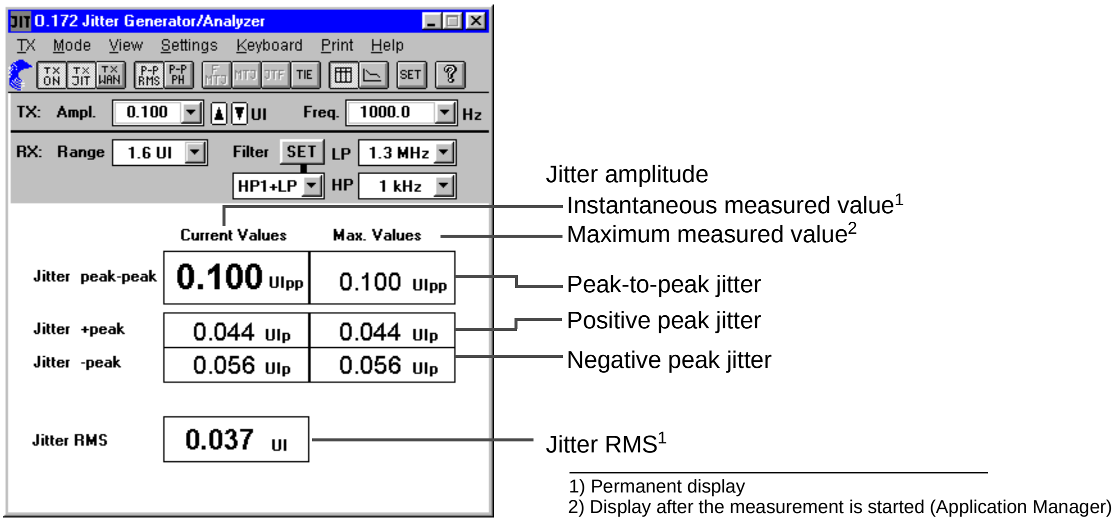
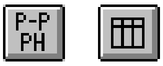


Fig. O-2 Result display for “non-automatic” measurements (numerical display)



The “P-P PH” function (see icon button above) switches the VI to non-automatic measurements which provide the following results:

- Current jitter values; numerical display (see Fig. O-3)
  Current jitter values; graphical display (see Fig. O-4)
- Maximum jitter values
- Number of jitter threshold transgressions (phase hits)

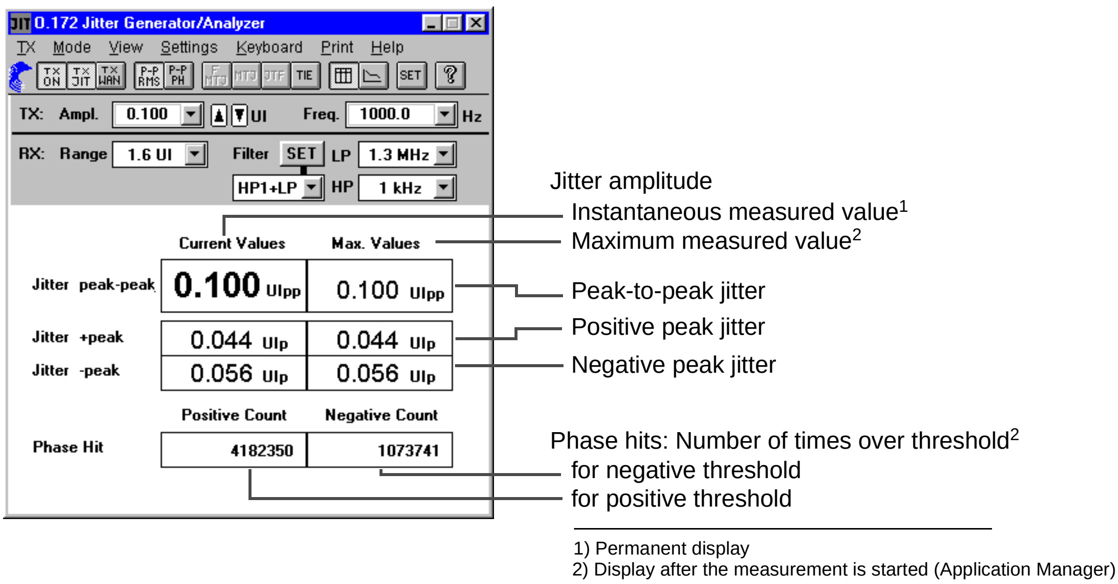
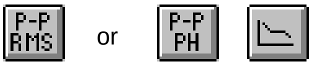


Fig. O-3 Result display for “non-automatic” measurements (numerical display)



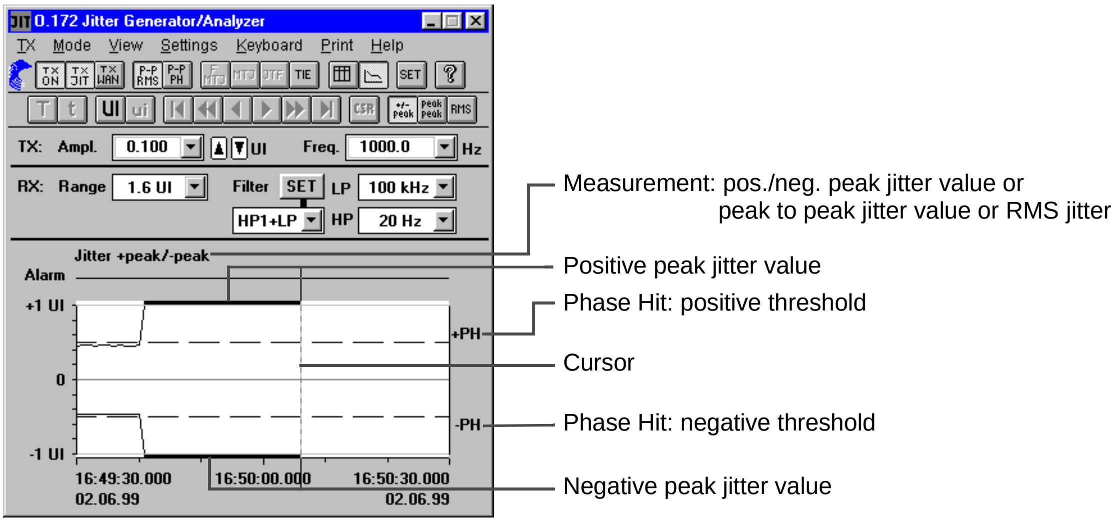


Fig. O-4 Current Values display (graphic display)

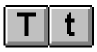
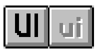
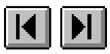
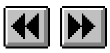
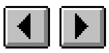
Command in “View” menu	Icon	Function
t-Zoom		Increase / decrease time axis resolution
ui-Zoom		Select display area for Current Values (Diagram)
Cursor - First/Last		Position cursor at start / end of time axis
Cursor - Prev/Next		Move cursor left / right by one page width
Cursor		Move cursor left / right by one measured value
Cursor - Position		Detailed display of jitter amplitude
Diagram Style		Display positive/negative peak jitter value, peak to peak jitter value or RMS jitter value (if P-P RMS is selected)

Table O-2 Meanings of menu commands and icons

3 Clock jitter

3.1 Measuring jitter and wander on clock signals

The ANT-20SE's Jitter Analyzer can measure the jitter and wander on clock signals fed into input [14] (electrical interface) when the following Rx settings have been made in the "Interface" dialog of the "Signal Structure" VI:

1. Code: "CMI" code ("Code" list box). The CMI level specifications of the mainframe now apply to the clock signal to be measured.
2. Sensitivity: "ITU-T" or "PMP" ("Sensitivity" list box), depending on the input level.

Tip: Use an external attenuator if the signal level is greater than 1 V_{pp}. Various alarms may be indicated in this operating mode depending on the setting (Framed, Unfram.; SDH, SONET). With the exception of "LOS", these are of no significance for clock jitter measurements and can be ignored.

3.2 Generating clock jitter and clock wander on

The ANT-20SE's Jitter Generator can generate clock jitter and clock wander (from output [15]) at PDH / DS1-3 bit rates if certain settings are made in the "Signal Structure" VI.

Settings in the "Edit Signal Structure - TX (RX)" dialog

1. Set the TX bit rate to PDH or DS1, DS2 or DS3.
2. Select "unframed".
3. Select the "DW" test pattern.
4. Set the test pattern to "All Zeros".

Settings in the "Interface" dialog

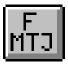
⇒ Select "CMI" line code.

The CMI level specifications apply to the output clock signal.

Tip: Use an external attenuator if you require a clock signal of <1 V_{pp}.

4 Maximum Tolerable Jitter

4.1 Fast MTJ measurements



Using the “Fast-MTJ” function (see icon button), switch to the fast measurement of tolerance to jitter. When a Fast-MTJ measurement is being made, jitter signals (combinations of jitter frequencies and jitter amplitudes) which lie on the limit curves specified by the ITU-T are generated. When the bit rate is changed, the pair of values is automatically set to its default value. You can edit these values in the “FMTJ-Settings” dialog box.

Furthermore, you can set the frequency and amplitude separately in an extended “Scan Frequency/Amplitude” box (double click any field). The frequencies can be entered in any order. When they are entered, the values are checked to determine if they are well-defined - if not they are rejected.

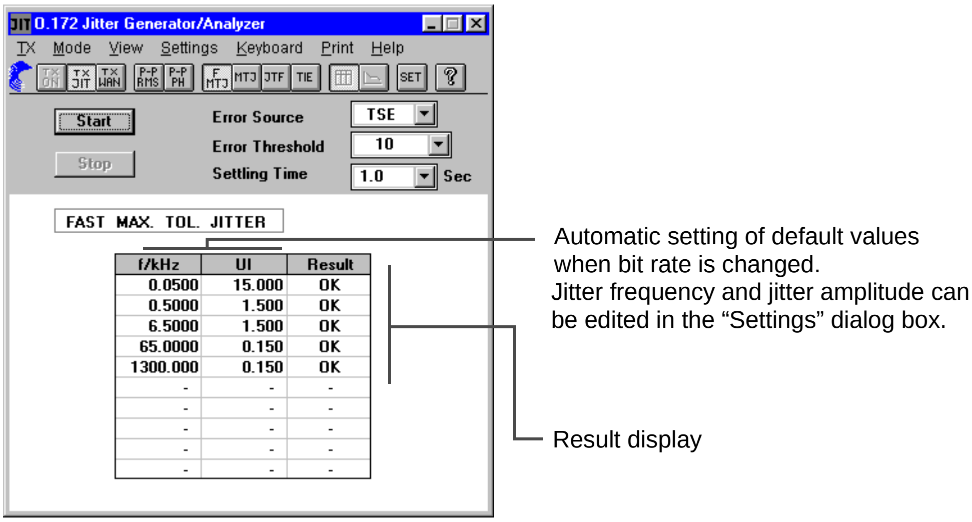
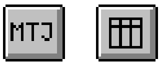


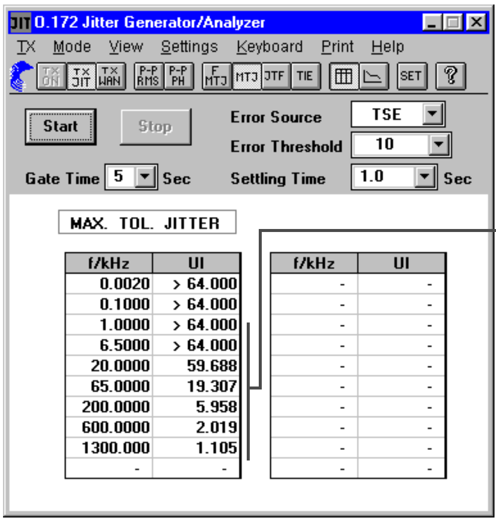
Fig. O-5 Result display for “Fast Maximum Tolerable Jitter”

4.2 MTJ measurements

Using the “MTJ” function, switch to tolerance to jitter measurement. When a sine-wave modulation signal and a pseudorandom sequence are used as the test pattern, at a given frequency, the amplitude of the jitter signal is increased using a half-interval progression until errors occur at the DUT output. The amplitude set on the jitter generator is now the tolerable input jitter for the DUT. As well as 20 selectable jitter frequencies and an adjustable error threshold, the settling time of the DUT can also be taken into account.

The results are displayed as a graph or as a table.



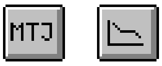


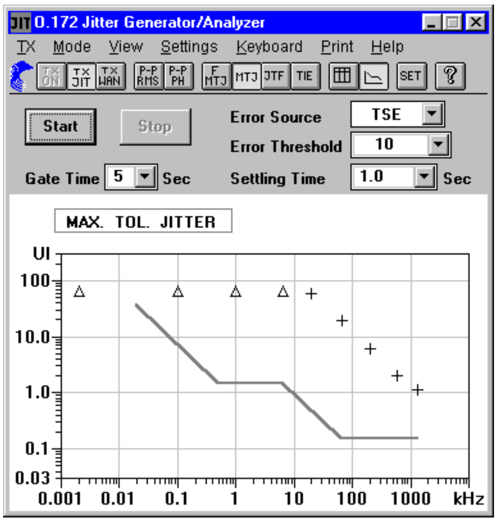
Result display:
Valid measured values

> 64.000 tolerable jitter greater than max. test value

! Tolerable jitter outside tolerance mask

Fig. O-6 Table of results





Result display:
+ Valid measured values
Δ Tolerable jitter greater than max. test value

Fig. O-7 Graphical result display (diagram)

The standard tolerance mask is displayed with the graph. A “Default” key sets the standard values for the jitter measurement frequency for the various bit rates.

4.3 Difference between MTJ and F-MTJ measurements

In a MTJ measurement, the result is a value in UI for each jitter frequency setting. This indicates the actual tolerance to jitter of the device under test. By contrast, jitter signals consisting of jitter frequency and jitter amplitude combinations are generated in a F-MTJ measurement. These values are lying along the limit curves specified by ITU-T.

Example

In a F-MTJ measurement, only the jitter frequencies f1, f2, f3, f4 and f5 and the corresponding jitter amplitudes A1, A2 and A3 are set.

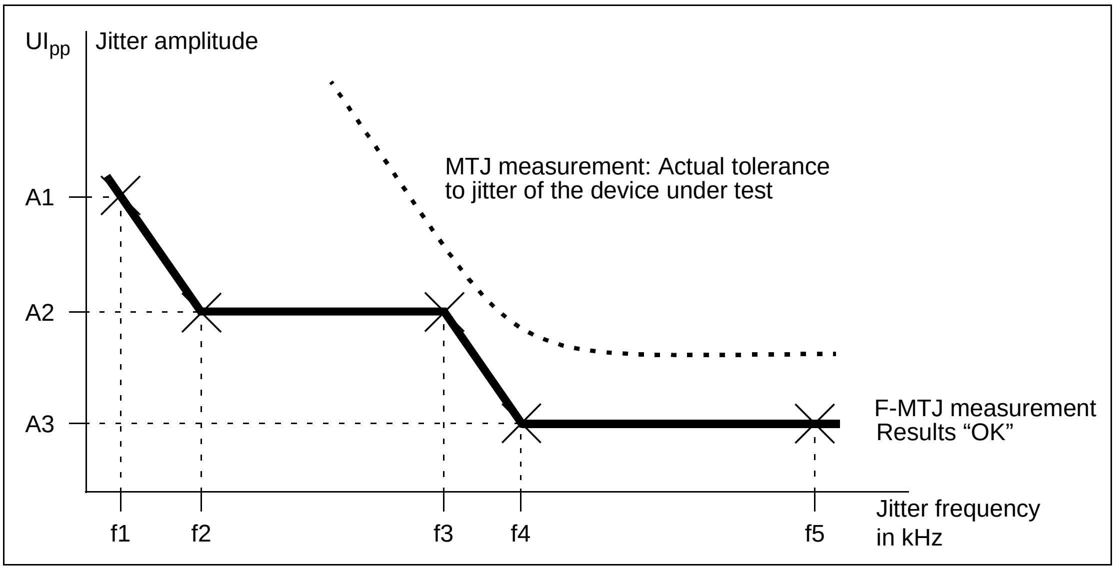


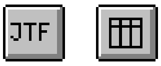
Fig. O-8 Difference between MTJ and F-MTJ measurements

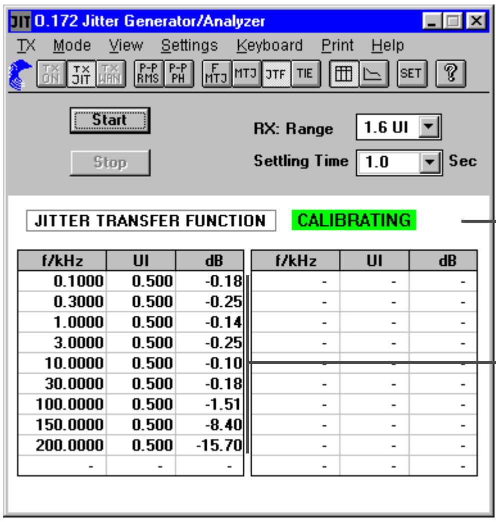
Basically, you can enter up to 10 jitter frequency and jitter amplitude combinations.

5 Jitter Transfer Function

“JTF” activates the jitter transfer function (JTF) measurement. The jitter transfer function is measured by applying a jitter signal of known amplitude at various frequencies to the input of the device under test and measuring the jitter transferred to the output. A selective filter is used for the measurement so that interference signals are effectively suppressed.

The results are displayed as a graph or as a table. The standard tolerance mask is displayed with the graph. A “Default” key sets the standard values for the jitter measurement frequency and amplitude for the various bit rates.



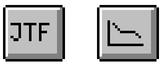


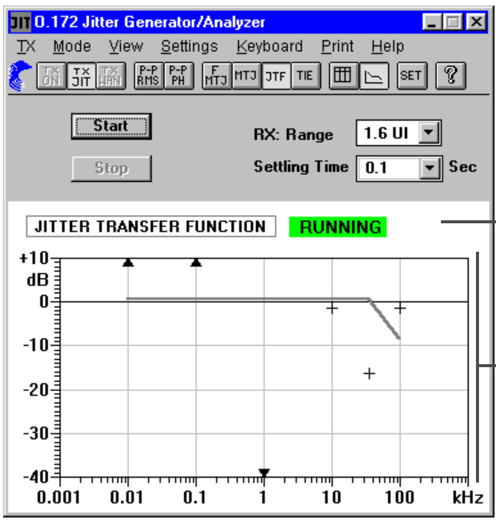
f/kHz	UI	dB	f/kHz	UI	dB
0.1000	0.500	-0.18	-	-	-
0.3000	0.500	-0.25	-	-	-
1.0000	0.500	-0.14	-	-	-
3.0000	0.500	-0.25	-	-	-
10.0000	0.500	-0.10	-	-	-
30.0000	0.500	-0.18	-	-	-
100.0000	0.500	-1.51	-	-	-
150.0000	0.500	-8.40	-	-	-
200.0000	0.500	-15.70	-	-	-
-	-	-	-	-	-

Status display:
“CALIBRATING” (during calibration)
“RUNNING” (during measurement of the DUT)

Result display:
Measured values
! Results outside the tolerance limits

Fig. O-9 “Table” - results are displayed as a table





Status display:
“CALIBRATING” (during calibration)
“RUNNING” (during measurement of the DUT)

Status display on completion of measurement:
“Variable Amplitude” or “Fixed Ampl.: ... UI”

Result display:
+ Measured values

▼ or ▲ measured value is outside the diagram

Fig. O-10 “Diagram” - results are displayed as graphics

Jitter Transfer Function

The jitter analyzer measures the jitter amplitude at the output of the device under test (DUT) resulting from different jitter amplitudes and frequencies applied to the input. The jitter gain or loss is calculated from the logarithmic ratio of output to input jitter amplitude.

The jitter transfer function is defined as follows:

Jitter transfer function	$H(f_j) = 20 \log \frac{\text{Output jitter}}{\text{Input jitter}}$

A maximum of 20 different jitter frequencies can be selected for making the jitter transfer function measurement. A jitter amplitude can also be specified for each jitter frequency.

Calibration measurement

A calibration measurement is required for maximum JTF measurement accuracy. This measurement can be made before each individual JTF measurement (recommended) or the result can be saved and used for several measurements.

The calibration measurement is made without the device under test, i.e. by directly connecting the generator to the receiver. The temporary results (dB) for the calibration measurement appear as soon as the “OK” key is pressed.

Once the measurement has been completed (Calibration measurement done ...), the device under test is inserted between the generator and the receiver and calibration is confirmed by pressing the “OK” key. The result display now shows the values for the device under test.

If you want to use a stored calibration measurement, insert the device under test before starting the measurement.

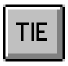
Note: For maximum measurement accuracy, the ANT-20SE should be allowed to warm up for at least 30 minutes before making a calibration measurement or a JTF measurement. It is also a good idea to keep the ambient conditions as constant as possible between the calibration measurement and the JTF measurement on the device under test. Also refer to the information given in the “Specifications” section.

Transfer results of MTJ measurement

This function allows you to use the results of a previous MTJ measurement (frequency and amplitude) as measurement points for the JTF measurement. The MTJ results are automatically matched to the permissible ranges (measurement and frequency) of the jitter meter.

This function ensures that the DUT is not stressed with excessive jitter amplitudes during the JTF measurement, which might result in errors or alarms being generated.

6 Wander Measurements (TIE/MTIE)



Activate wander measurements with the “TIE” function. Slow periodic and non-periodic phase changes in the range 0 to 10 Hz are referred to as “Wander” or “Maximum Time Interval Error”. Wander measurements always need a reference clock as the phase changes may take an indeterminately long time.

The instrument can perform wander measurements at all bit rates permitted by the configuration of the basic unit. Clocks with the rates 1.544 MHz, 2.048 MHz, 5 MHz or 10 MHz can be used as the reference. It is also possible to use data signals with bit rates of 1.544 Mbit/s or 2.048 Mbit/s as reference signals.

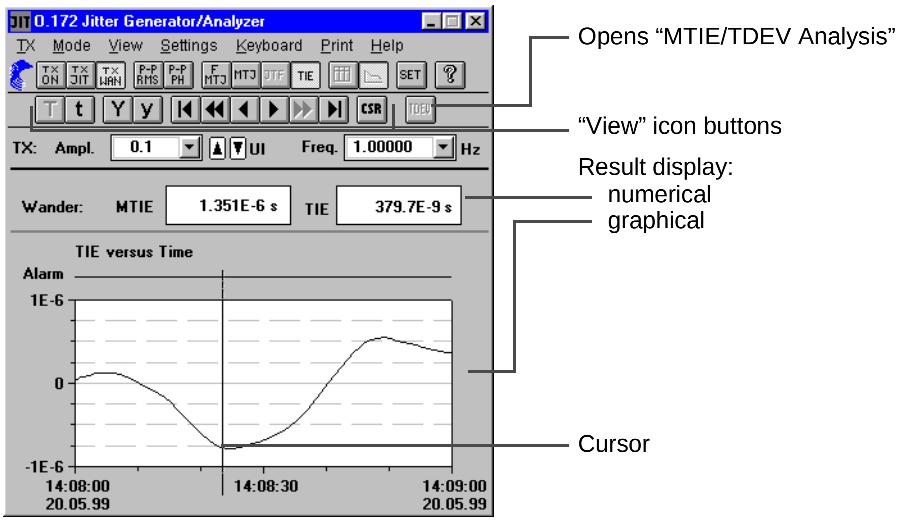


Fig. O-11 Result display for “TIE”

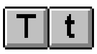
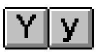
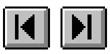
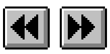
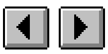
Commands in “View” menu	Icon button	Function
t-Zoom		Change the resolution of the time axis
y-Zoom		Change the resolution of the y axis
Cursor - First/Last		Place cursor at the start/end of the time axis
Cursor - Prev/Next		Move cursor a screen width to the right/left
Cursor		Move cursor a measurement value to the left/right
Cursor - Position		Detailed display of the TIE measurement result
MTIE/TDEV Analysis		Opens MTIE/TDEV Analysis (Option BN 3035/95.21)

Table O-3 Significance of the menus and icon buttons

6.1 Measurands Time Interval Error (TIE) and Maximum Time Interval Error (MTIE)

The measurands are TIE (**T**ime **I**nterval **E**rror) and MTIE (**M**aximum **T**ime **I**nterval **E**rror).

The analog phase vs. time function is determined using a selectable sampling rate to which appropriate low-pass filters are coupled.

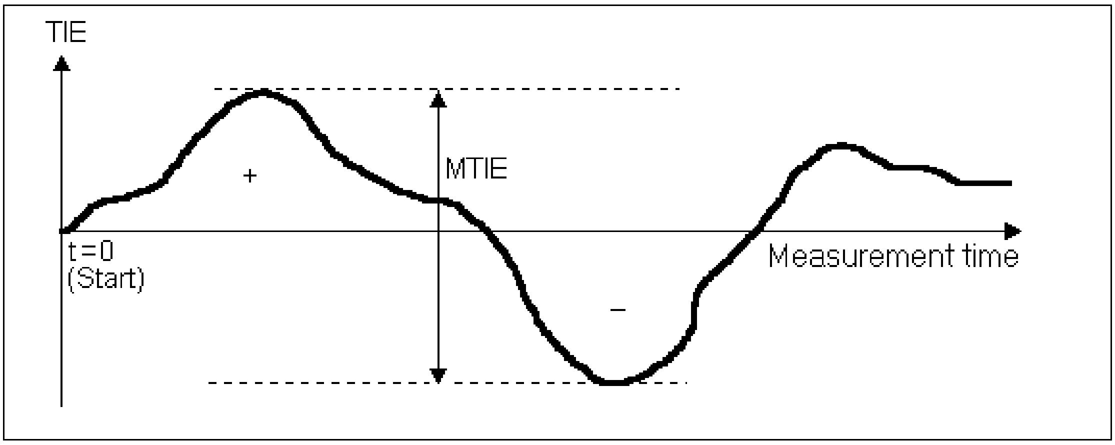


Fig. O-12 Example: Wander measurement versus measurement time

The following sampling rates / filter combinations can be selected:

Sampling rate	Low-pass filter (-3dB cutoff frequency)	Estimated ANT-20SE hard disk space required for the measurement
1/s	0.1 Hz	approx. 58 kB/h
30/s	10 Hz	approx. 1.65 MB/h
60/s	20 Hz	approx. 3.3 MB/h
300/s	100 Hz	approx. 16.5 MB/h

Table O-4 Selectable sample rates/filter combinations

The current values of TIE and MTIE are shown numerically.
TIE is also recorded versus time and displayed graphically (corresponding to the selected sampling rate).

TIE and MTIE are both set to “0” at the start of a measurement.
If the ANT-20SE re-synchronizes after a loss of synchronization caused by a reference clock dropout or an AC line power failure, TIE and MTIE are reset to “0” again. The measured values are saved in the file “WANDMSEC.BIN” on the hard disk of the ANT-20SE.

Note: Before starting a long-term wander measurement, check the available space on the hard disk. The ANT-20SE software calculates the estimated space required using the gate time and sample rate that you selected (see Tab. O-4). If the remaining space is insufficient, a warning message will be displayed.

6.2 Using a data signal as reference at 2488 Mbit/s

If a reference clock source for network synchronization is not available at the point of measurement, but there is a data signal (2 Mbit/s or 1.5 Mbit/s) available, you can make a 2488 Mbit/s wander measurement as follows:

Do the following:

1. Link socket [26] to socket [54].
2. Select the wander reference frequency “2048 kHz” in the “Wander Settings” window.
3. Select the “Input/Output …” command in the “Trigger” menu of the “Signal Structure” window.
   The “Trigger Input/Output [26]” window opens.
4. Select “Ref. Clock (2048 kHz) Output” in the list box.
5. Switch to “Trigger On”.
6. Click on “OK”.
7. Select the “Settings …” command in the “Interface” menu of the “Signal Structure” window.
   The “Interface” window opens.
8. Select “Ext. Data 2M/E1 [25]” or “Ext. Data 1.5/DS1 [25]” in the “Clock Source” list box in the “TX Interface” section of the window.
9. Click on “OK”.
10. Start the wander measurement in the “Application Manager”.
    – or –
    Press key “F5” MEASUREMENT START.

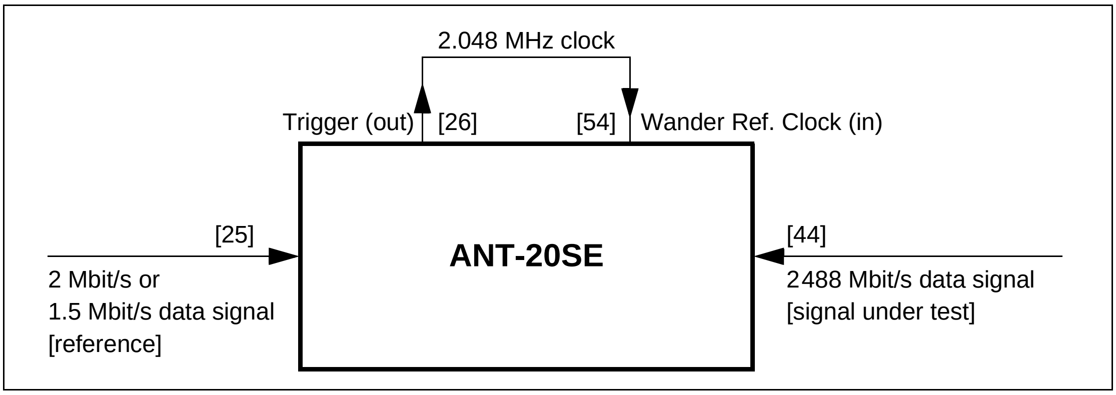
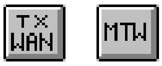


Fig. O-13 Wander measurement using a 2 Mbit/s or 1.5 Mbit/s data signal as reference

Tip: In this mode, the ANT-20SE’s generator is synchronized to the supplied reference signal on socket [25].
As part of this test application, note also the “Specifications”, section “REF CLOCK IN [25]” of the basic instrument.

7 Maximum Tolerable Wander



The MTW (Maximum Tolerable Wander) function activates measurement of maximum tolerable wander.

Note: The MTW function can only be activated if you first set the generator to wander (TX WAN).
The generator must be set back to jitter (TX JIT) if you want to use other automatic jitter measurement functions (MTJ, F-MTJ, JTF) after making a MTW measurement.

Wander signals (combinations of wander frequencies and amplitudes) are generated for the MTW measurement. They correspond to the limit curves for wander specified by various recommendations. These different combinations of amplitude and frequency are set one after the other during the measurement. The received signal is monitored for errors and alarms. depending on the response, the result output will be either “OK” or “Failed”.

The pairs of values are set to their default values automatically when you change the bit rate. You can edit these values in the “MTW Settings” dialog.

The frequency and amplitude values can be set separately in an extended “Scan Frequency/ Amplitude” dialog by double-clicking on any field. The frequency values can be entered in any order. The values are checked when they are entered and will be rejected if they are not permissible.

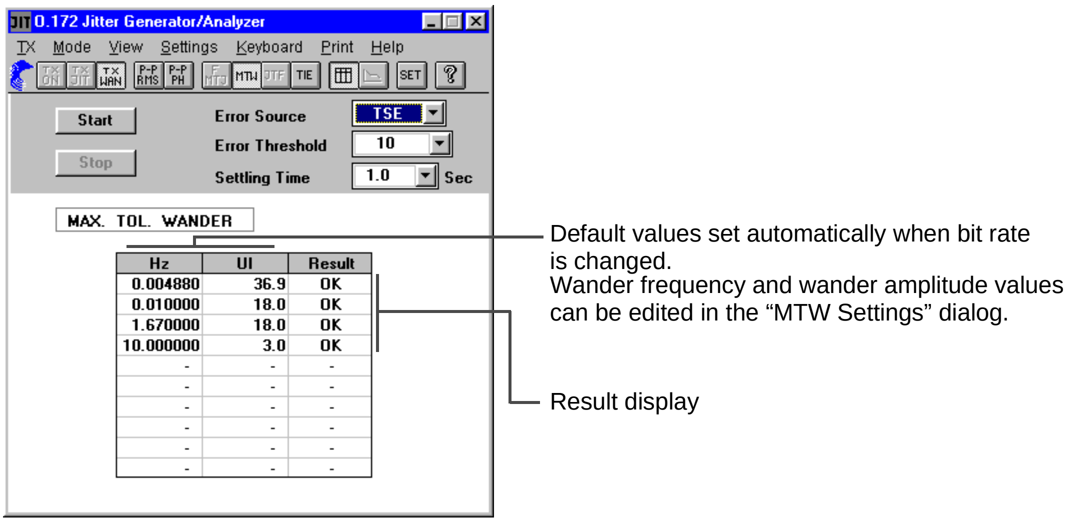


Fig. O-14 MTW result display

Applications

1 Maximum Tolerable Jitter (MTJ)

To G.823, G.825, G.958, O.172

1.1 Test setup and description

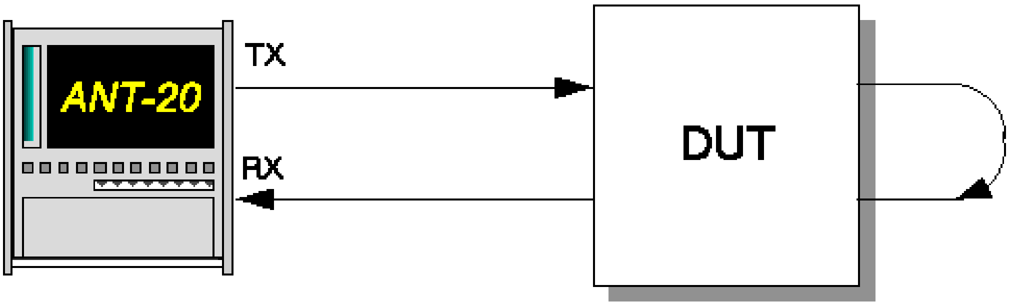


Fig. A-1 MTJ measurements setup

Interfaces

- electrical balanced Rx : [12] Tx : [13]
- electrical unbalanced Rx : [14] Tx : [15]
- optical 52, 155, 622 Mbit/s Rx : [17] Tx : [18]
- optical 2.5 Gbit/s Rx : [44] Tx : [47]

The measurement is used to check the maximum tolerable jitter of the electrical and optical line and tributary inputs.

When a sine-wave modulation signal is used with a pseudorandom sequence as the test pattern, at a given frequency, the amplitude of the jitter signals is increased using a half-interval progression until errors occur at the output of the device under test.

1.2 Application settings

VIs required

- Signal Structure
- O.172 Jitter Generator/Analyzer

1. Add the VIs required to the list of VIs used in the Application Manager.
   The Application Manager should include at least the following instruments (see Fig. A-2).
2. Click on the “JIT” button to open the window for the O.172 Jitter Generator/Analyzer.

Fig. A-2 Minibar (Application Manager) after selecting the VIs

1.3 Measurement

Settings

✓ The O.172 Jitter Generator/Analyzer window must already be open.

1. Select the “MTJ” command in the “Mode” menu.
   – or –
   Click on the corresponding button in the toolbar.
2. Select the error source (e.g. TSE, Test Sequence Error) in the “Error Source” list field (currently only bit errors are available).
3. Enter the error threshold in the “Error Threshold” field. The error threshold provides a decision criterion for the search algorithm.
4. In the “Settling Time” field, enter a delay for each measurement that allows the DUT to settle before the measurement is made.
5. Enter the gate time in the “Gate Time” box.
6. In the “Settings” menu select the “MTJ ...” item.
   – or –
   Click on the “SET” symbol.
   The “Settings” dialog box is opened.

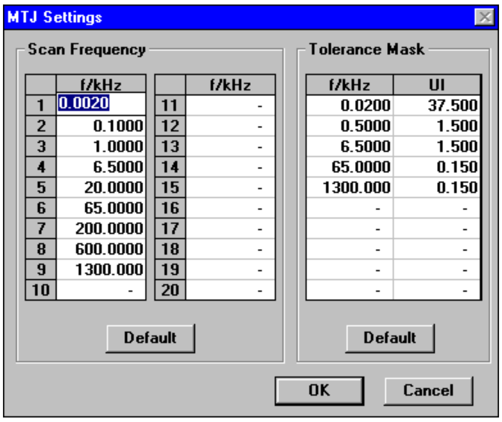


Fig. A-3 “MTJ Settings” dialog

In the box, you will find the measurement frequencies for the MTJ measurement and the characteristic data for the tolerance mask.

7. If necessary select your own scan frequencies and modify the tolerance mask values.
8. Confirm the input with “OK”.
   The “Settings” dialog box is closed.
9. Start the measurement with “Start”. The measurement stops automatically, but can be halted at any time by clicking on “Stop”.

Analysis

When an MTJ measurement is made, the default values for the scan frequencies and the tolerance mask are set in the “MTJ Settings” window according to the bit rate. The default values are changed automatically when the bit rate is changed.

There are two windows for displaying results (see Fig. A-4).

Table format

- Measurement results are displayed in the table under “UI”.
- Measurement results where the tolerable jitter of the DUT is greater than the maximum amplitude that can be set on the jitter generator, are indicated by a “>” (e.g. >64 UI).
- Measurement results which are below the tolerance mask are marked with an “!” in the table.

Graphics format

- Measurement results are marked with a “+” on the graphics.
- Measurement results where the tolerable jitter of the DUT is greater than the maximum amplitude that can be set on the jitter generator are marked with “Δ” on the graphics (instead of the “+”).

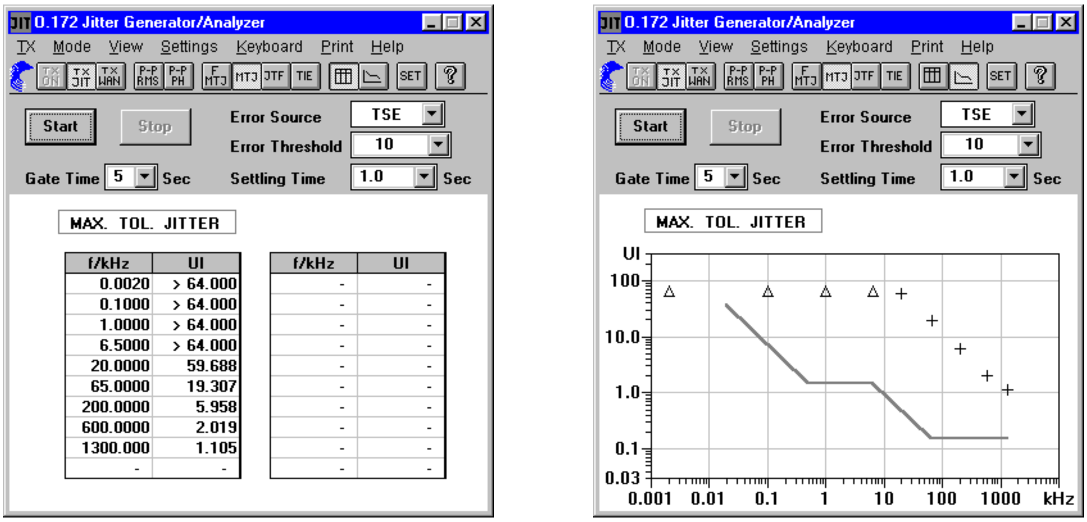


Fig. A-4 MTJ measurements: Results displayed as a table (left) and graphics (right)

2 Fast Maximum Tolerable Jitter (F-MTJ)

2.1 Test setup and description

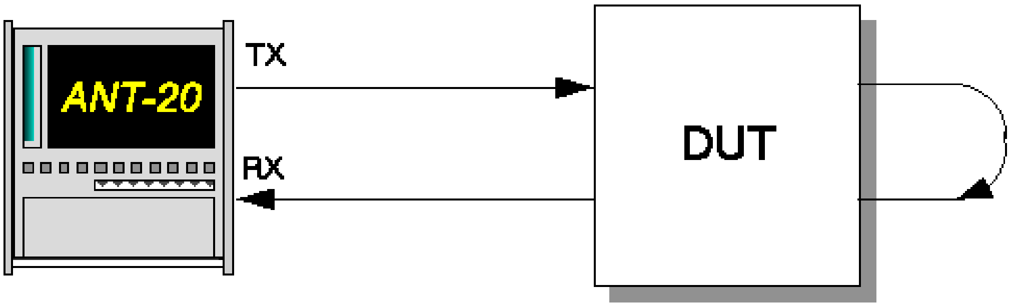


Fig. A-5 Fast MTJ measurements setup

Interfaces

• electrical balanced	Rx : [12]	Tx : [13]
• electrical unbalanced	Rx : [14]	Tx : [15]
• optical 52, 155, 622 Mbit/s	Rx : [17]	Tx : [18]
• optical 2.5 Gbit/s	Rx : [44]	Tx : [47]

With a Fast MTJ measurement, given combinations of jitter frequencies and jitter amplitudes which lie on the limit curves stipulated by ANSI are set on the jitter generator.

Each measurement point is classified as “OK” or “Failed”. This indicates whether the DUT meets the limit curve or not.

2.2 Application setting

VIs required

- Signal Structure
- O.172 Jitter Generator/Analyzer

1. Add the VIs required to the list of VIs used on the Application Manager.
   The Application Manager should include at least the following instruments (see Fig. A-6).
2. Click on the “JIT” button to open the window for the O.172 Jitter Generator/Analyzer.

Fig. A-6 Minibar (Application Manager) after selecting the VIs

2.3 Measurement

Settings

✓ The “O.172 Jitter Generator/Analyzer” window has already been opened.

1. Select the “Fast MTJ” command in the “Mode” menu.
   – or –
   Click on the corresponding button in the tool bar.
2. Select the error source (e.g. TSE, Test Sequence Error) from the “Error Source” list box.
3. In the “Error Threshold” box, enter the error threshold above which a device under test is to be considered as having “Failed” the test.
   An error threshold cannot be entered if an alarm is selected from the “Error Source” list box.
4. In the “Settling Time” box, enter a settling time for each measurement to allow the d.u.t to settle.
5. Select “MTJ ...” in the “Settings” menu.
   – or –
   Click on the “SET” icon.
   The “Settings” dialog opens.

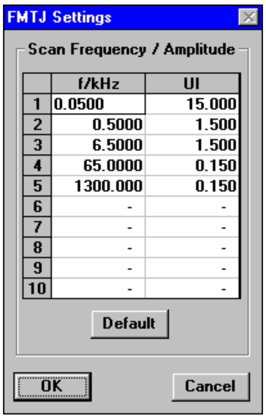


Fig. A-7 “FMTJ Settings” dialog

6. If required, select individual frequency and amplitude combinations to be used for performing the measurement.
7. Confirm your entries by clicking “OK”.
   The “Settings” dialog closes.

8. Click “Start” to start the measurement. The measurement stops automatically on completion or when you click on “Stop”.

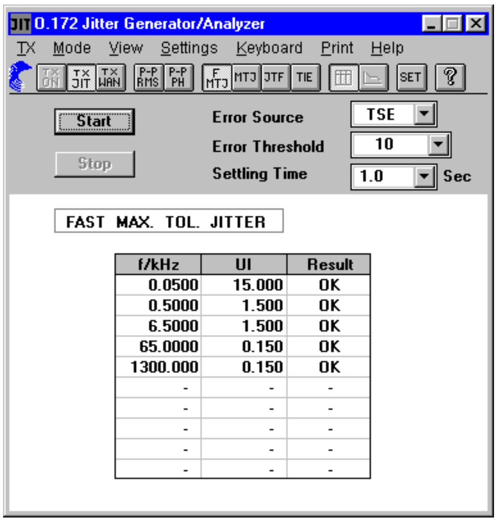


Fig. A-8 Fast MTJ measurements window

Analysis

- The table (see Fig. A-8) contains combinations of jitter frequencies and jitter amplitudes or default values specified by the user. Starting with the smallest frequency, they are set when the measurement is started.
- After the delay set with “Settling Time”, a check is made to determine if there are any alarms or errors in the input signal.
- According to the result, each setting is classified as “OK” or “Failed”.
- The measurement stops automatically when the last measurement point has been completed or by clicking on “Stop”.

3 Jitter Transfer Function (JTF)

To G.958, G.823, O.172

3.1 Test setup and description

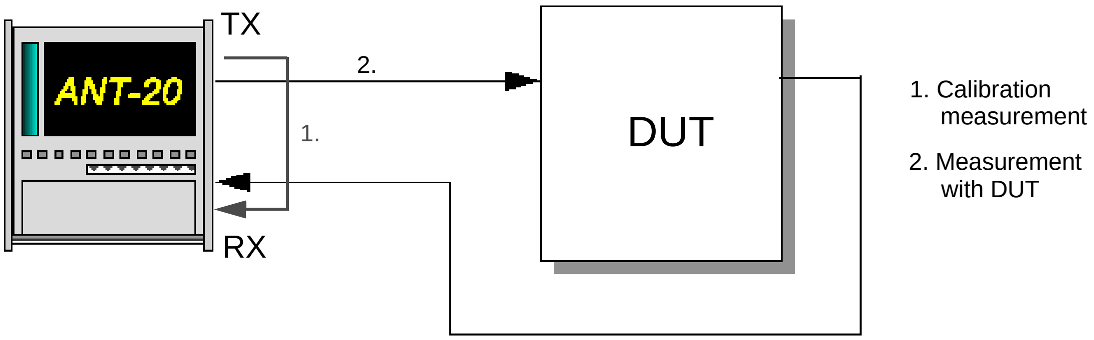


Fig. A-9 Jitter transfer function measurements setup

Interfaces

electrical balanced	Rx : [12]	Tx : [13]
electrical unbalanced	Rx : [14]	Tx : [15]
optical 52, 155, 622 Mbit/s	Rx : [17]	Tx : [18]
optical 2.5 Gbit/s	Rx : [44]	Tx : [47]

Jitter transfer function measurements are of particular importance when dealing with regenerative repeaters. Checks are carried out to demonstrate that the jitter gain of a regenerative repeater is below a predefined value. If this is not the case, “jitter runaway” occurs after several regenerative repeaters.
The jitter transfer function (JTF) is measured by applying a signal whose jitter is constant over frequency to the DUT. The jitter amplitude is selected so that the DUT can handle it at high frequencies.
The Jitter Analyzer measures the resulting jitter amplitude at the output of the DUT at various TX jitter frequencies. The log of the ratio gives the jitter gain or attenuation.

Tip: For maximum measurement accuracy, it is a good idea to make a calibration measurement before every JTF measurement (see Fig. A-9).

3.2 Application setting

VIs required

- Signal Structure
- O.172 Jitter Generator/Analyzer

1. Add the VIs required to the list of VIs used in the Application Manager.
   The Application Manager should include at least the following instruments (see Fig. A-10).
2. Click on the “JIT” button to open the window for the O.172 Jitter Generator/Analyzer.

Fig. A-10 Minibar (Application Manager) after selecting the VIs

3.3 Measurement

Settings

✓ The “O.172 Jitter Generator/Analyzer” window has been opened already.

1. In the “Mode” menu, select the “JTF” command.
   – or –
   Click on the corresponding button in the tool bar.
2. Select the appropriate range (1.6 UI or 20 UI; the range is pre-set for STM-16/OC-48) in the “RX: Range” box.
3. Enter an appropriate delay time for the various measurements in the “Settling Time” field, so that the measurement starts after the DUT has settled.

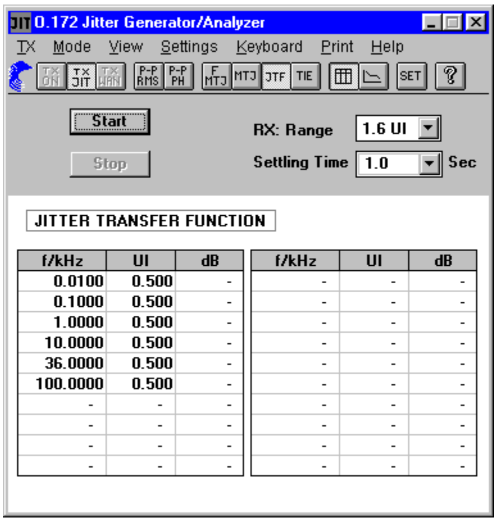


Fig. A-11 “O.172 Jitter Generator/Analyzer” window for JTF measurements

Dialog “JTF Settings”

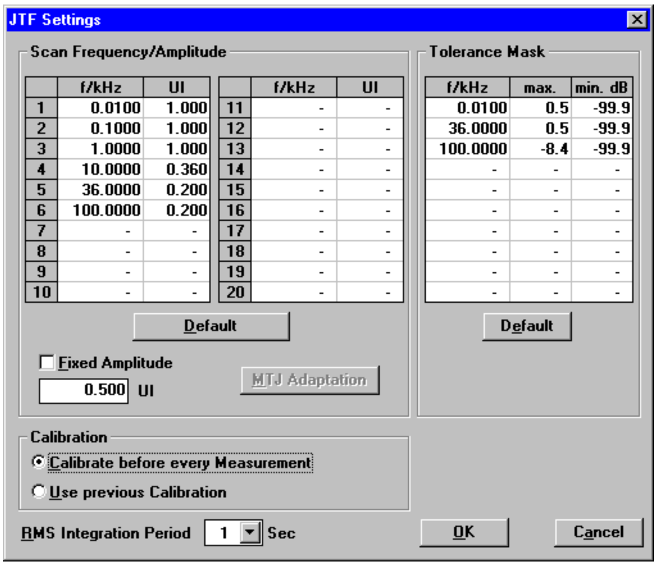


Fig. A-12 Dialog “JTF Settings”

The measurement frequencies for the JTF measurement and the specifications for the tolerance mask are found here.

1. Select “JTF ...” in the “Settings” menu.
   – or –
   Click on the “SET” icon.
   The “JTF Settings” dialog opens.
2. If required, select individual scan frequencies and amplitudes, as well as altered tolerance mask values.
3. If you want the measurement to be performed using a constant amplitude for all scan frequencies, check the “Fixed Amplitude” check box and enter the required amplitude in the box below it.
4. If you want to use the results of a previous MTJ measurement for the scan frequencies and amplitudes, click on the “MTJ Adaptation” button. The MTJ results are then automatically matched to the permissible ranges (measurement and frequency) of the jitter meter. If there are no MTJ results available, the button is grayed out.
5. Select whether you want to perform a calibration measurement before every JTF measurement or to use a single calibration measurement (stored internally). For maximum measurement accuracy, it is a good idea to make a calibration measurement before every JTF measurement
6. Click “Start” to start the measurement. The measurement stops automatically when finished or when you click “Stop”.

Analysis

The measurement results are displayed in three different windows. The default values for the scan frequencies and the tolerance masks in the “JTF-Settings” window are set in the window with the table display (see Fig. A-13).

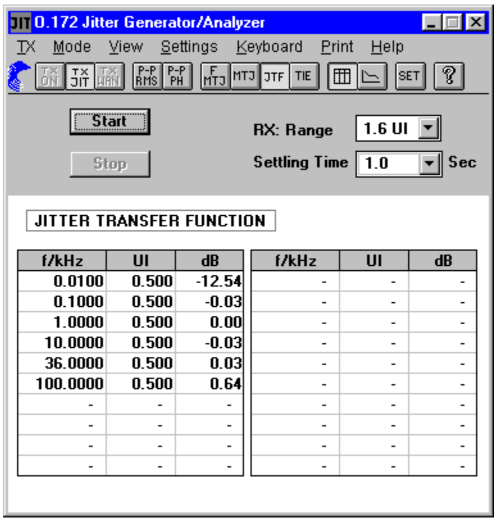


Fig. A-13 JTF measurements: results displayed as tables

- The default values depend on the bit rate and change automatically when the bit rate is changed.
- Measurement results are displayed in the table under “dB”.
- Measurement results in the table that are outside the tolerance mask(s) are marked with an “!”.

There are two graphics windows. The right window has the higher y-axis resolution. On the graph, the measurement values are marked with a “+”.

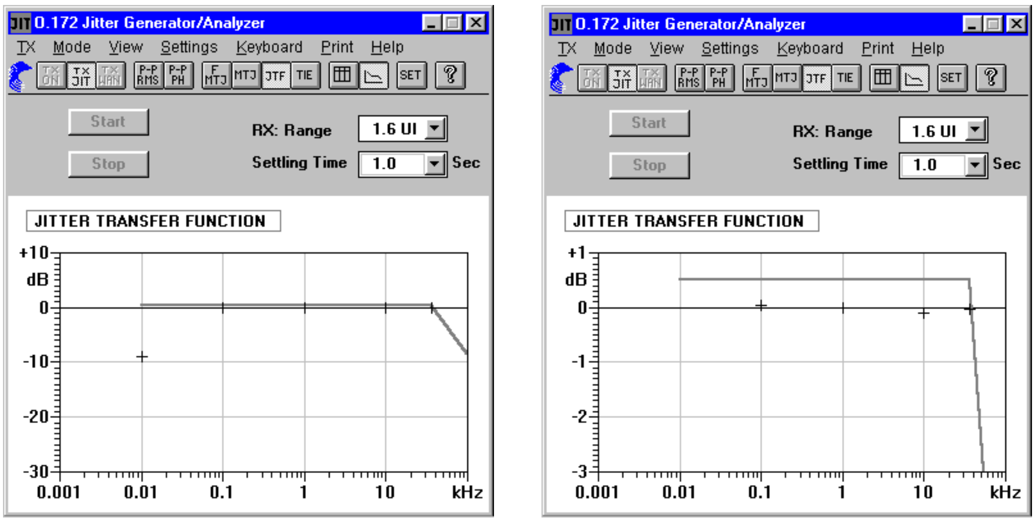


Fig. A-14 JTF measurements: result graphics with various resolutions

4 Phase Hit Measurement

4.1 Test setup and description

Fig. A-15 Phase hit measurement setup

Interfaces

electrical balanced	Rx: [12]
electrical unbalanced	Rx: [14]
optical 52, 155, 622 Mbit/s	Rx: [17]
optical 2.5 Gbit/s	Rx: [44]

Phase hits occur when a specific jitter threshold is exceeded. Events of this kind are recorded using a counter. The current counter reading indicates how often the phase hit threshold has been exceeded since the measurement was started.

Positive counts and negative counts can be made mutually with the ANT-20SE Jitter Analyzer.

4.2 Application setting

VIs required

- Signal Structure
- O.172 Jitter Generator/Analyzer

1. Add the VIs required to the list of VIs used in the Application Manager.
   The Application Manager should at least include the following instruments (see Fig. A-16).
2. Click on the "JIT" button to open the "O.172 Jitter Generator/Analyzer" window.

Fig. A-16 Minibar (Application Manager) after selecting the VIs

4.3 Measurement

Settings

1. In the “Mode” menu select the “PP+PH” command.
   – or –
   Click on the corresponding button in the toolbar.
   The O.172 Jitter Generator/Analyzer” window opens.

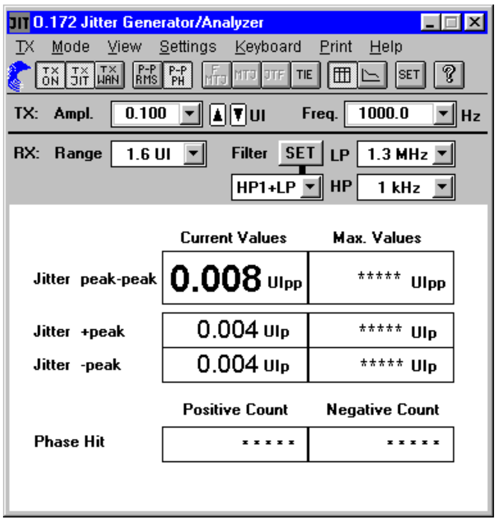


Fig. A-17 “O.172 Jitter Generator/Analyzer” window when the auto function is turned off

2. In the “Settings” menu click on the “General ...” command.
   – or –
   Click on the corresponding button in the tool bar.
   The “Jitter-General Settings” window opens.

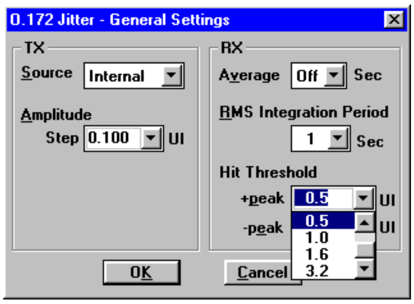
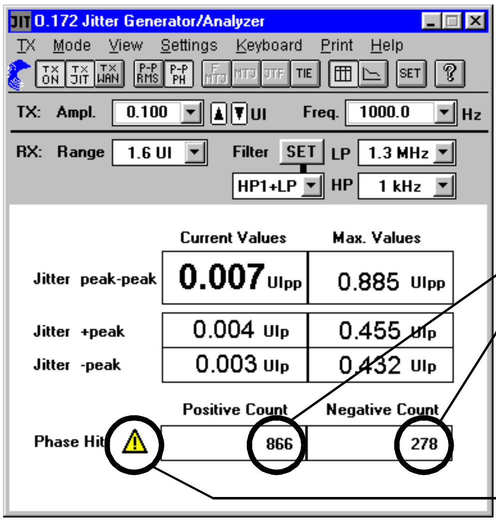


Fig. A-18 “Jitter - General Settings” dialog box

3. Enter the threshold values you want under “Hit Threshold” using the list fields.
4. Confirm with “OK”.
5. Start the measurement by
   – pressing function key F5 or
   – clicking on the “green traffic signal” icon in the Application Manager.

Input to the “Hit Threshold” can be made with the normal keyboard or with the “virtual” keyboard window.

Analysis



Current display of counted threshold transgressions

A phase hit measurement will be interrupted when synchronization or the AC line supply fails. The counters are stopped during the interruption. Counting continues as soon as the instrument re-synchronizes after the interruption.
The yellow warning label indicates that the measurement was interrupted.

Fig. A-19 Phase hit measurement

5 Wander Generator

The Wander Generator is used to make manually tolerance to wander measurements conforming to ITU-T G.823, G.824, G.825, O.172 and ETSI EN302084.

5.1 Test setup and description

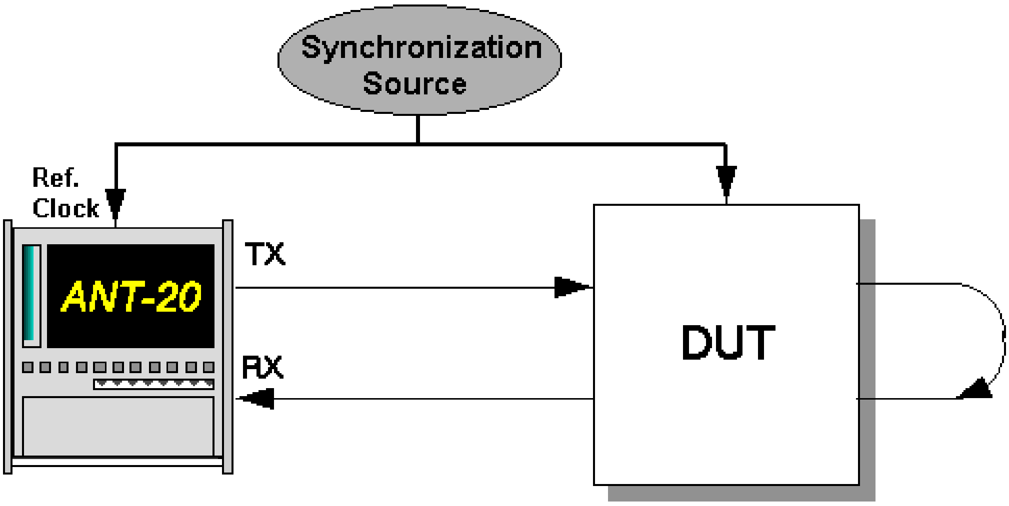


Fig. A-20 Test setup for tolerance to wander measurements

Interfaces

• electrical balanced	Rx : [12]	Tx : [13]
• electrical unbalanced	Rx : [14]	Tx : [15]
• optical 52, 155, 622 Mbit/s	Rx : [17]	Tx : [18]
• optical 2,5 Gbit/s	Rx : [44]	Tx : [47]
• Ref Clock in	[25]	Generator synchronization input; clock or data signal (2 Mbit/s or 1.5 Mbit/s)

5.2 Application setting

VIs required

- Signal Structure
- O.172 Jitter Generator/Analyzer
- Anomaly/Defect Analyzer

1. Add the VIs required to the list of VIs used in the Application Manager.
   The Application Manager should at least include the following instruments (see Fig. A-21).
2. Click on the “JIT” button to open the “O.172 Jitter Generator/Analyzer” window.
3. Click on the button to the right of the “JIT” button to open the “Anomaly/Defect Analyzer” window

Fig. A-21 Minibar (Application Manager) after VI selection

5.3 Measurement

Settings

✓ The “O.172 Jitter Generator/Analyzer” window is already open.

1. Select the “Settings ...” command from the “Interface” menu in the “Signal Structure” window.
   The “Interface” dialog opens.

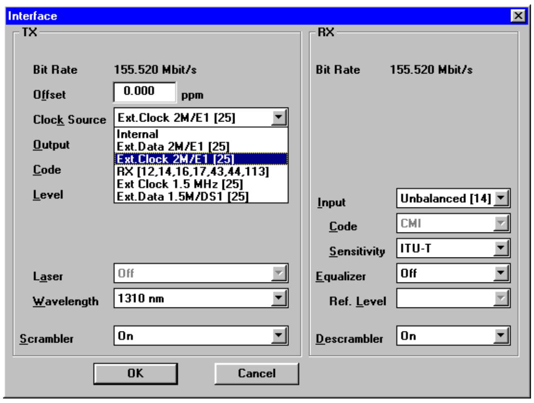


Fig. A-22 “Interface” dialog

2. Select the clock source corresponding to the clock frequency at input [25] on the TX side from the “Clock Source” list box.
3. Select the “Wander” command from the “TX” menu in the “O.172 Jitter Generator/Analyzer” window.
4. Set the TX amplitude and frequency according to the tolerance masks of the appropriate standard.
5. Select the “On” command from the “TX” menu.

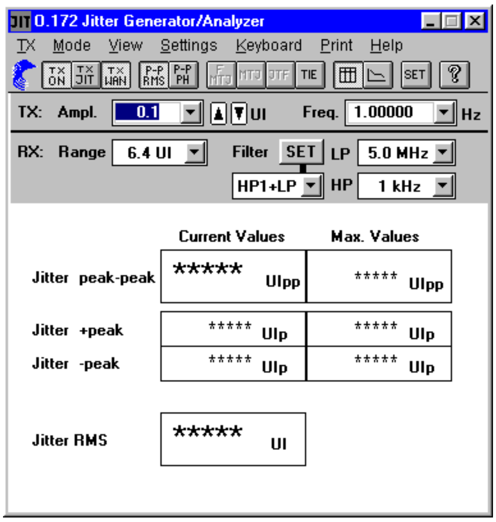


Fig. A-23 “O.172 Jitter Generator/Analyzer” window with wander generator activated

6. In the Application Manager, select the “Settings ...” command from the “Measurement” menu.
   The “Measurement Settings” dialog opens.

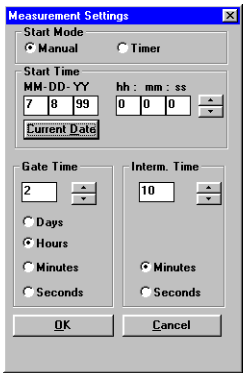
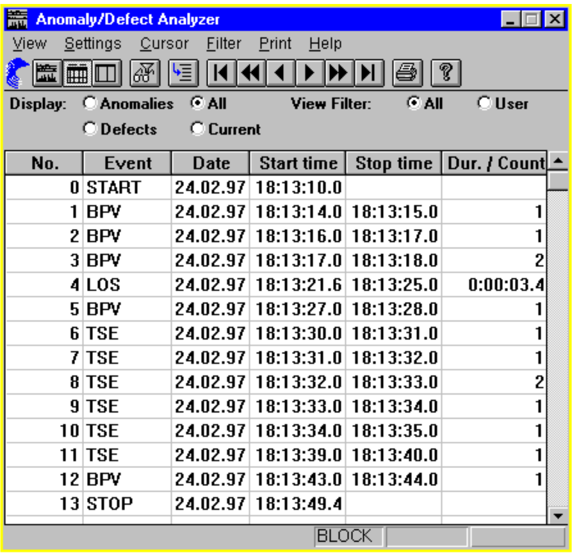


Fig. A-24 “Measurement Settings” dialog

7. Enter the gate time required.
   When setting the gate time, remember that the period time can be very long, depending on the wander frequency that you selected. Select the gate time such that it corresponds to at least one wander modulation period $\left(\triangleq \frac{1}{f_{mod}}\right)$.
8. Start the measurement
   – by pressing function key F5, or
   – by clicking the “green traffic signal” icon in the Application Manager.

Analysis

The “Anomaly/Defect Analyzer” window indicates the wander frequency or wander amplitude above which errors or alarms occur.



No.	Event	Date	Start time	Stop time	Dur. / Count
0	START	24.02.97	18:13:10.0		
1	BPV	24.02.97	18:13:14.0	18:13:15.0	1
2	BPV	24.02.97	18:13:16.0	18:13:17.0	1
3	BPV	24.02.97	18:13:17.0	18:13:18.0	2
4	LOS	24.02.97	18:13:21.6	18:13:25.0	0:00:03.4
5	BPV	24.02.97	18:13:27.0	18:13:28.0	1
6	TSE	24.02.97	18:13:30.0	18:13:31.0	1
7	TSE	24.02.97	18:13:31.0	18:13:32.0	1
8	TSE	24.02.97	18:13:32.0	18:13:33.0	2
9	TSE	24.02.97	18:13:33.0	18:13:34.0	1
10	TSE	24.02.97	18:13:34.0	18:13:35.0	1
11	TSE	24.02.97	18:13:39.0	18:13:40.0	1
12	BPV	24.02.97	18:13:43.0	18:13:44.0	1
13	STOP	24.02.97	18:13:49.4		

Fig. A-25 “Anomaly/Defect Analyzer” window

6 Wander Analysis to 2.5 Gbit/s

To G.811, G.812, G.813, G.823, G.824, G.825, O.172

6.1 Test setup and description

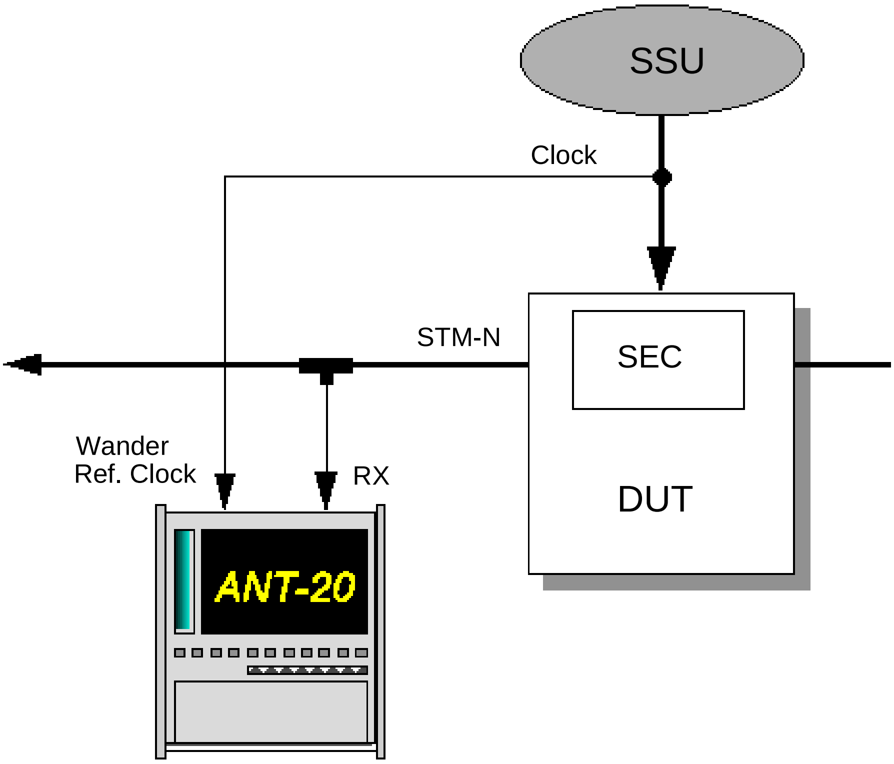


Fig. A-26 Wander measurements setup

Interfaces

• electrical balanced	Rx : [12]
• electrical unbalanced	Rx : [14]
• optical 52, 155, 622 Mbit/s	Rx : [17]
• optical 2.5 Gbit/s	Rx : [44]
• wander ref clock in	[35] (to 622 Mbit/s)
	[54] (2.5 Gbit/s)

Every SDH network element can make use of an internal clock (SEC-SDH Equipment Clock). This clock source is synchronized by means of an SSU (Synchronization Supply Unit) via a 2.048 MHz clock line. To check the quality of the internal clock source, the clock stability of the reference source (SSU) is compared with that of the transmitted data signal. The difference is referred to as wander.

The ANT-20SE can be used to perform measurements on all interfaces of the instrument.

6.2 Application setting

VIs required

- Signal Structure
- O.172 Jitter Generator/Analyzer

1. Add the VIs required to the list of VIs used in the Application Manager.
   The Application Manager should at least include the following instruments (see Fig. A-27).
2. Click on the “JIT” button to open the window for the “O.172 Jitter Generator/Analyzer”.

Fig. A-27 Minibar (Application Manager) after selecting the VIs

6.3 Measurement

Settings

1. In the “Mode” menu select “TIE”.
   – or –
   Click on the “Wander” button in the toolbar.
   The wander display appears in the “O.172 Jitter Generator/Analyzer” window.

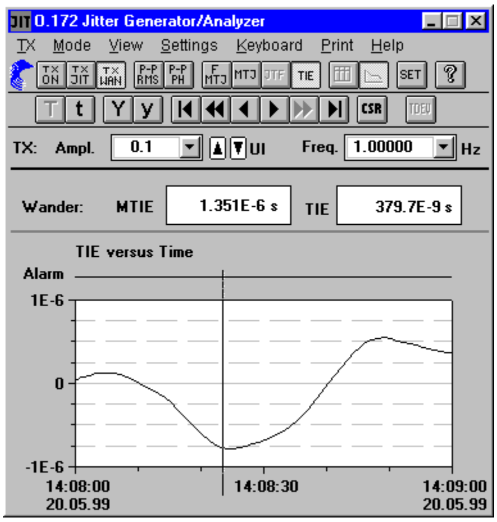


Fig. A-28 “O.172 Jitter Generator/Analyzer” window with wander display

2. In the “Settings” menu select “Wander ...”
   – or –
   Click on the “SET” icon in the toolbar.
   Set the reference clock frequency in this window.

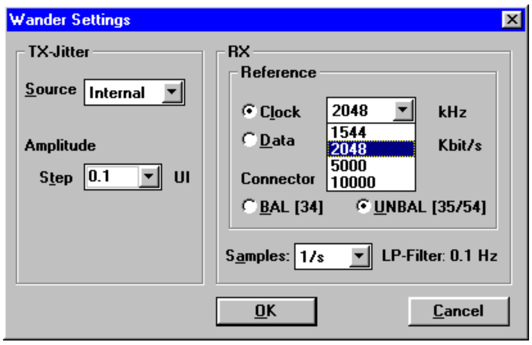


Fig. A-29 “Wander Settings” dialog

3. In the “Wander Settings” dialog, set the frequency or bit rate (not for 2488 Mbit/s) of the reference signal.
4. Select the reference signal input required (BAL [34] or UNBAL [35]) (not for 2488 Mbit/s).
5. Select the sample rate required. The low-pass filter is set automatically.
6. Click “OK” to confirm.
7. Start the measurement by
   – pressing function key F5 or
   – clicking on the “green traffic signal” icon in the Application Manager.

Wander analysis

Wander analysis involves measurements that take a particularly long time. Measurement intervals up to 99 days can be set on the ANT-20SE.

The measured values are displayed in the “O.172 Jitter Generator/Analyzer” window as a graph of the TIE values and numerically in the MTIE and TIE fields above.

⇒ Click on the “CSR” button in the toolbar.
The “Cursor Position” window then opens. This gives you an overview of the current values on the curve which is being recorded.

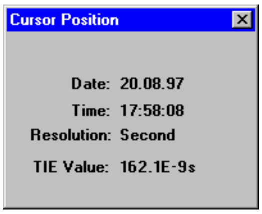


Fig. A-30 “Cursor Position” window

Storing results

1. Select the “Export ...” command in the “Print” menu.
   The “Save as” dialog box is opened.
2. Select the target directory, under the current file shall be stored and set the “CSV” format.
3. Click on “Ok” to start exporting.

Analysis for MTIE and TDEV (BN 3035/95.21)

The “MTIE/TDEV Analysis” software (option BN 3035/95.21) is available for precise time-domain analysis of MTIE and TDEV. The program can be started from the “O.172 Jitter Generator/Analyzer” or separately from the ANT-20SE software. The program evaluates TIE values that were measured using an ANT-20SE. The evaluations follow the recommendations set out in ETSI ETS 300462, EN 302084, ITU-T G.811, G.812, G.813 and ANSI T1.101, and include the masks for the various signal sources.

Starting the “MTIE/TDEV Analysis” program from the “O.172 Jitter Generator/Analyzer”

1. Click on the “TDEV” button in the “O.172 Jitter Generator/Analyzer” (wander side) window. The program starts and the TIE data from the previous measurement (stored in the file “WANDMSEC.BIN”) are loaded automatically.
   The TIE data are displayed in the graphics box of the “TIE analysis” window.
2. Click on the “MTIE/TDEV ...” button.
   The “MTIE analysis” window opens (see Fig. A-31).
3. Click on the “Analysis” button in this window.
   The values are calculated and displayed.

Starting the “MTIE/TDEV Analysis” program from the Windows 95 Start menu

1. Click on the appropriate item in the Windows 95 “Start” menu.
   The program starts.
2. Click on the “Load” button.
   The “Load data file” dialog opens.
3. Select the “WANDMSEC.BIN” file from the “C:\ANT-20SE\RESULTS” directory
   – or –
   select a previously exported CSV format file.
   The TIE data are displayed in the graphics box of the “TIE analysis” window.
4. Click on the “MTIE/TDEV ...” button.
   The “MTIE analysis” window opens (see Fig. A-31).
5. Click on the “Analysis” button in this window.
   The values are calculated and displayed.

Possible evaluations

- The check boxes at the lower left of the “MTIE analysis” window are used to select the values that you want to display.
- You can limit the number of measurement points to be displayed by entering a range in the “Analysis range” text boxes.
- You can select different tolerance masks from the “Masks” list box. These can be used to give you a quick impression of whether the measured values meet the tolerance requirements or not.
- The displayed graph can be printed out (“Print” button) and exported (“Export” menu).

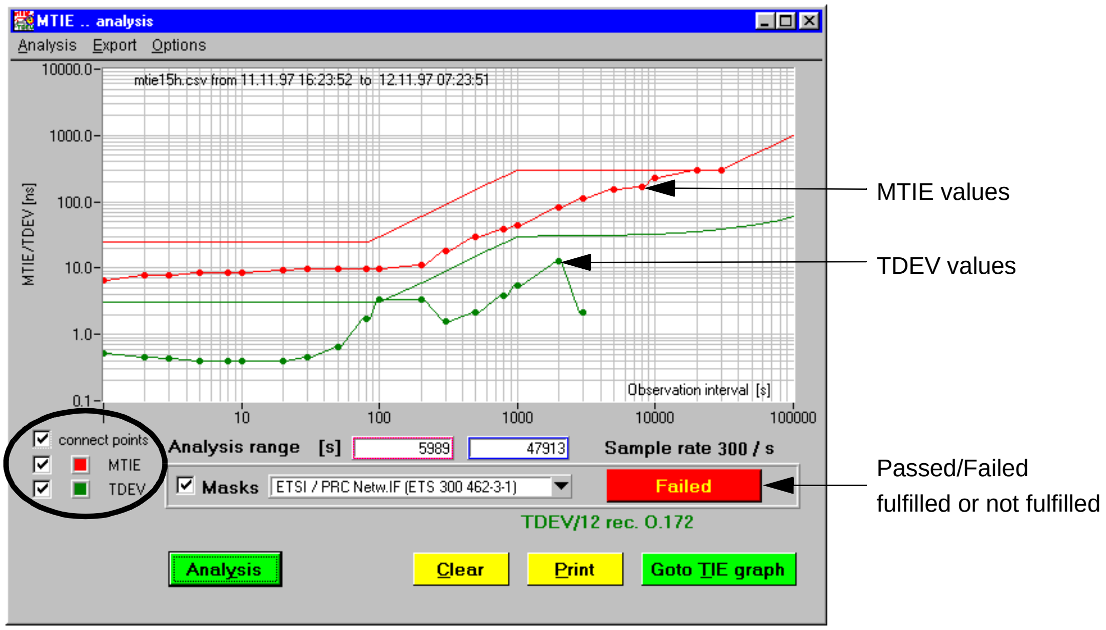


Fig. A-31 MTIE and TDEV analysis

7 Maximum Tolerable Wander (MTW)

The Maximum Tolerable Wander (MTW) function is used to perform automatic measurements of wander tolerance conforming to ITU-T G.823, G.824, G.825 and O.172 and ETSI EN302084.

7.1 Test setup and description

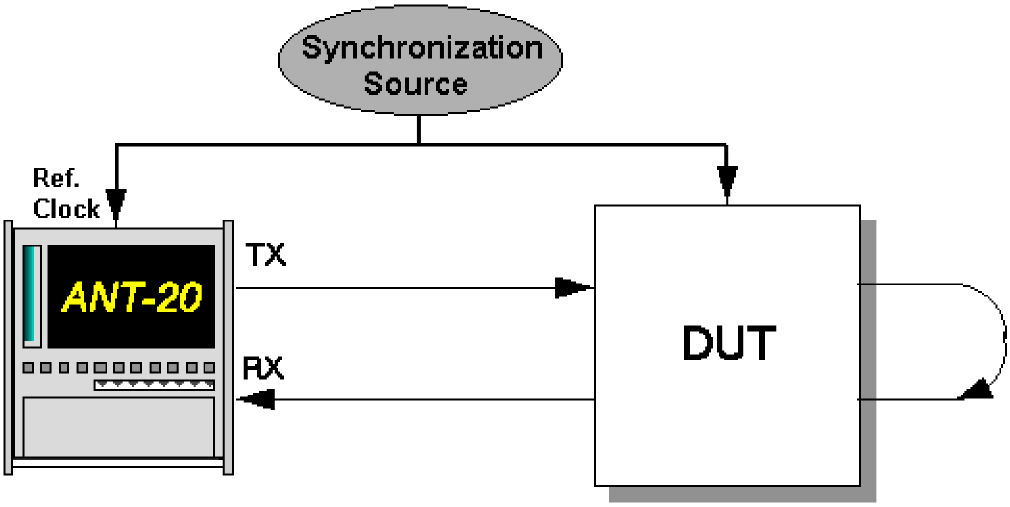


Fig. A-32 Test setup for measuring maximum tolerable wander

Interfaces

• electrical balanced	Rx : [12]	Tx : [13]
• electrical unbalanced	Rx : [14]	Tx : [15]
• optical 52, 155, 622 Mbit/s	Rx : [17]	Tx : [18]
• optical 2.5 Gbit/s	Rx : [44]	Tx : [47]
• Ref Clock in	[25]	Generator synchronization input; clock or data signal (2 Mbit/s or 1.5 Mbit/s)

7.2 Application settings

VIs required

- Signal Structure
- O.172 Jitter Generator/Analyzer

1. Add the VIs required to the list of VIs used in the Application Manager. The Application Manager should include at least the following instruments (see Fig. A-33).
2. Click on the “JIT” button to open the window for the O.172 Jitter Generator/Analyzer.

Fig. A-33 Minibar (Application Manager) after selecting the VIs

7.3 Measurement

Settings

✓ The “O.172 Jitter Generator/Analyzer” window must already be open.

Settings in the “Interface” dialog of the “Signal Structure” window

1. Select the “Settings ...” command from the “Interface” menu in the “Signal Structure” window.
   The “Interface” dialog opens.

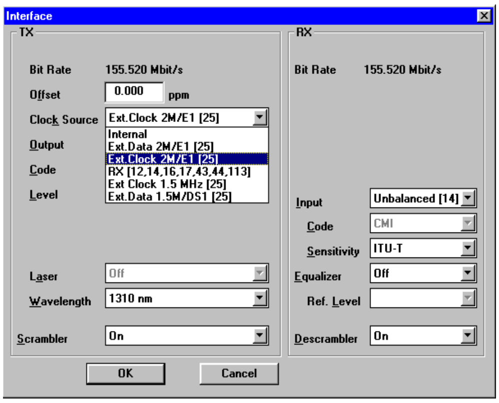


Fig. A-34 “Interface” dialog

2. Select the clock source corresponding to the clock frequency at input [25] from the “Clock Source” list box on the TX side of the box.

Settings in the “O.172 Jitter Generator/Analyzer” window

1. Select the “Wander” command from the “TX” menu in the “O.172 Jitter Generator/Analyzer” window
   – or –
   click on the “TX WAN” icon in the toolbar.
2. Select the “MTW” command from the “Mode” menu
   – or –
   click on the “MTW” icon in the toolbar.

Note: The MTW function can only be activated if you first set the generator to wander (TX WAN).
The generator must be set back to jitter (TX JIT) if you want to use other automatic jitter measurement functions (MTJ, F-MTJ, JTF) after making a MTW measurement.

3. Select the error source (e.g. TSE, Test Sequence Error) in the “Error Source” list box.
4. In the “Error Threshold” box, enter the error threshold above which the result will be assessed as “Failed”.
   An error threshold cannot be entered if an alarm was selected in the “Error Source” box.
5. In the “Settling Time” box, enter the delay between individual measurement points.
6. Select the “MTW” command from the “Settings” menu
   – or –
   click on the “SET” icon in the toolbar.

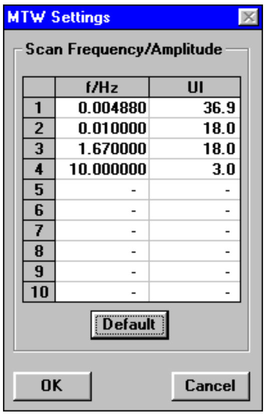


Fig. A-35 “MTW Settings” dialog

7. If required, select your own combinations of frequency and amplitude to be used for the measurement.
8. Click “OK” to confirm your entries.
   The “MTW Settings” dialog closes.
9. Click “Start” to start the measurement. The measurement stops automatically after all measurement points have been tested. It can also be stopped at any time by clicking on “Stop”.

Note: The measurement times may be very long due to the frequency settings.

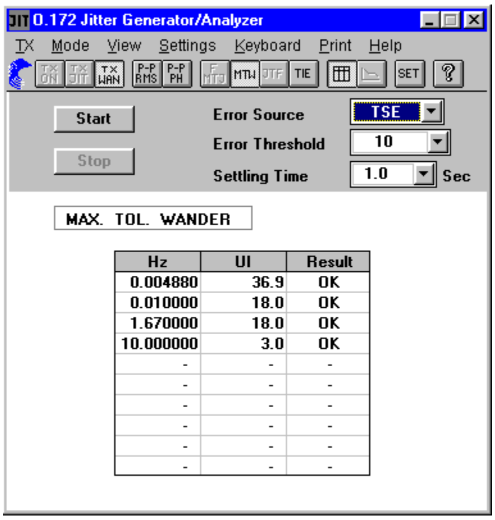


Fig. A-36 “O.172 Jitter Generator/Analyzer” window for MTW measurements

Analysis

- The table (see Fig. A-36) contains combinations pre-selected by the user or the default values for wander frequencies and wander amplitudes. These are set one after the other in the order they are entered in the table when the measurement is started.
- After the “Settling Time” has elapsed, the output signal of the ANT-20SE is modulated for one period of the current frequency and the input signal is monitored for the presence of alarms or errors.
- Depending on the result, each setting will be indicated as “OK” or “Failed”.
- The measurement stops automatically when the last measurement point has been tested. It can also be stopped at any time by clicking on “Stop”.

Specifications O.172 Jitter / Wander up to 622 Mbit/s

These Specifications apply to the following Options:

- 3035/90.81 O.172 Jitter Generator
- 3035/90.82 O.172 Jitter Analyzer
- 3035/90.83 O.172 Jitter Generator Extension up to 622 Mbit/s
- 3035/90.84 O.172 Jitter Analyzer Extension up to 622 Mbit/s
- 3035/90.85 O.172 Wander Generator
- 3035/90.86 O.172 Wander Analyzer

Numbers enclosed in square brackets […] correspond to numbers printed on the instrument.

Calibrated specifications are indicated by ***.

Standards

Jitter and wander is generated and analyzed in accordance with the following standards:

- ITU-T G.823, G.824, G.825, O.172
- Bellcore GR-253, GR-499
- ANSI T1.101, T1.102, T1.105.03

1 Jitter Generator

Meets or exceeds the requirements of ITU-T O.172.

1.1 Bit rates

As fitted to the mainframe instrument.

Bit rates . . . . 1544 kbit/s, 2048 kbit/s, 6312 kbit/s, 8448 kbit/s, 34368 kbit/s, 44736 kbit/s, 51840 kbit/s, 139264 kbit/s, 155520 kbit/s, 622080 kbit/s

Modulation source . . . . internal or external

Jitter modulation signal . . . . sine wave

1.2 Internal modulation source

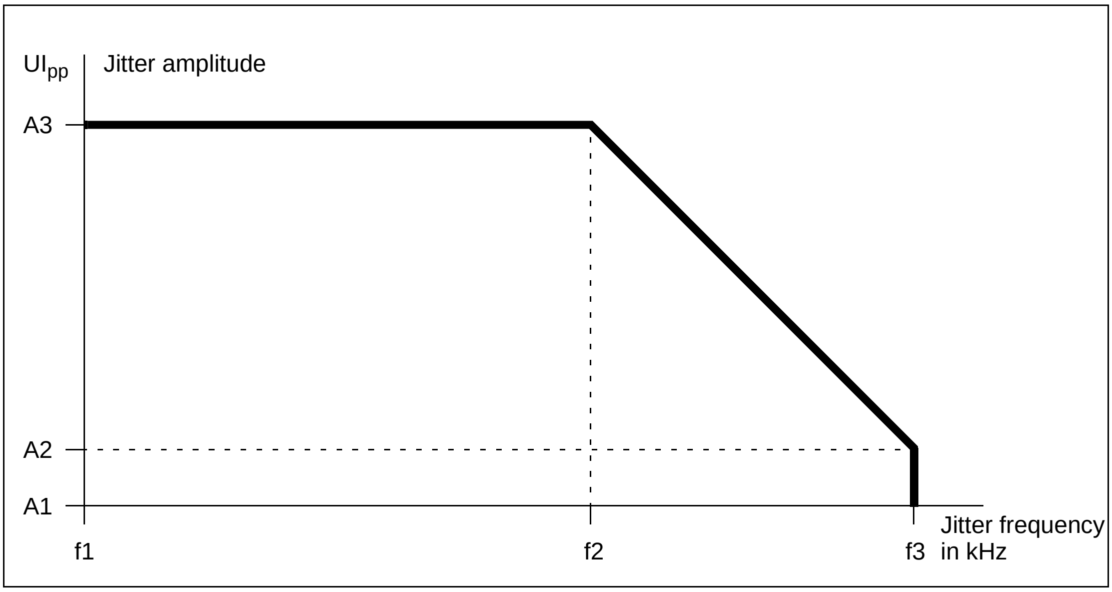


Fig. S-1 Jitter amplitude versus jitter frequency

Bit rate in kHz	A1 in UIpp	A2 in UIpp	A3 in UIpp	f1 in Hz	f2 in kHz	f3 in kHz
1544	0.002	0.5	64	0.1	0.625	80
2048	0.002	0.5	64	0.1	1.56	200
6312	0.002	0.5	64	0.1	0.94	120
8448	0.002	0.5	64	0.1	6.25	800
34368	0.002	0.5	64	0.1	27	3500
44736	0.002	0.5	64	0.1	35	4500
51840	0.002	0.5	64	0.1	27	3500
139264	0.002	0.5	64	0.1	39	5000
155520	0.002	0.5	64	0.1	39	5000
622080	0.008	1.0	256	0.1	20	5000

Table S-1 Jitter amplitude and jitter frequency at various system bit rates

Settling time for changes in amplitude . . . . <2 seconds

Changes in modulation frequency or amplitude are without phase hits.

Jitter frequency setting step width
0.1 Hz to 1 MHz . . . . 0.1 Hz
above 1 MHz . . . . .1 Hz
Jitter amplitude setting step width . . . . .0.001 UI

1.3 External modulation voltage input [30]

Socket . . . . .BNC

Input impedance. . . . . .75 Ω

Frequency range . . . . 0 Hz to 5 MHz

Nominal input voltage range. . . . . .0 to 2.0 V_{pp} (8.2 dBm)
Corresponding jitter amplitude (at 2.0 V_{pp}) . . . . variable

Maximum permitted input level. . . . . 4.0 V_{pp} (14.2 dBm)

If the external modulation voltage exceeds 2.0 V_{pp} this will be indicated by the message:
Warning: External [30] Modulation Exceeded!

Note: To achieve maximum accuracy, it is recommended that as high an input voltage as possible is used (maximum 2.0 V pp) and that the amplitude be set to the desired value. At very low input voltages and very large amplitude settings, accuracy will be reduced and intrinsic jitter increased.

1.4 Error limits

The error limits conform to or are better than the requirements of ITU-T O.172.

1.4.1 Amplitude error ***

Amplitude error describes the deviation from the set amplitude for sine wave modulation.

Maximum deviation . . . .±Q% of set value ± 0.02 UI_{pp}

Q (variable error) is taken from the following table:

Bit rate in k/bits	**Q (variable error) in %**	**Frequency range in kHz**
1544	8	0.002 to 40
2048	8	0.01 to 100
6312	8	0.002 to 60
8448	8	0.02 to 400
34368	8	0.1 to 500
	12	500 to 800
44736	8	0.002 to 400
51840	8	0.3 to 400
139264	8	0.1 to 500
	12	500 to 2000
	15	2000 to 3500
155520	8	0.5 to 500
	12	500 to 1300
622080	8	1 to 500
	12	500 to 2000
	15	2000 to 5000
Q = 12% below the stated ranges or Q = 15% above the stated ranges		

Table S-2 Q for various bit rates and modulation frequencies

1.4.2 Intrinsic jitter

The intrinsic jitter indicates the maximum output jitter of the ANT-20SE for a jitter amplitude setting of 0 UI. A bandwidth between the filters HP1 and LP (see Tab. S-7, Page S-8) is assumed.

Bit rate in kbit/s	Intrinsic jitter in UI
up to 155520	0.005
622080	0.04

Table S-3 Intrinsic jitter

1.4.3 Modulation frequency

Modulation frequency accuracy . . . . ±0.1%

2 Jitter Analyzer

Meets or exceeds the requirements of ITU-T O.172

2.1 Bit rates

As fitted to the mainframe instrument.

Bit rates . . . . 1544 kbit/s, 2048 kbit/s, 6312 kbit/s, 8448 kbit/s, 34368 kbit/s, 44736 kbit/s, 51840 kbit/s, 139264 kbit/s, 155520 kbit/s, 622080 kbit/s

permissible offset. . . . . ±100 ppm

Receive line codes . . . . .as fitted to the mainframe instrument

Tip: It is recommended that cables not longer than 10 m are used for jitter and wander measurements. Longer cables can cause pattern jitter due to frequency-dependent loss characteristics, which would reduce measurement accuracy.

2.2 Jitter measurement range

Range 1
up to 155 Mbit/s. . . . . 0 to 1.6 UI_{pp}
at 622 Mbit/s . . . . 0 to 6.4 UI_{pp}

Range 2
up to 155 Mbit/s. . . . . .0 to 20 UI_{pp}
at 622 Mbit/s . . . . .0 to 80 UI_{pp}

Range 3
up to 155 Mbit/s. . . . . .0 to 200 UI_{pp}
at 622 Mbit/s . . . . .0 to 800 UI_{pp}

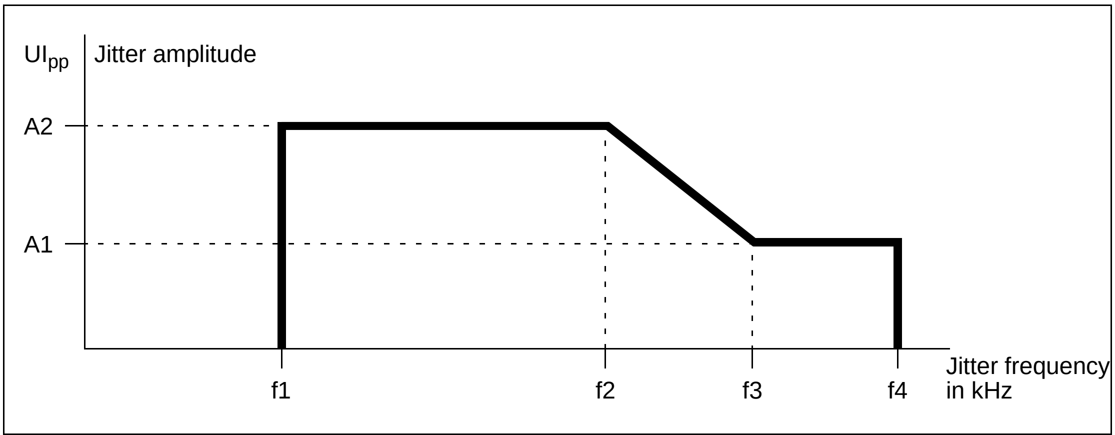


Fig. S-2 Jitter measurement range

Jitter measurement range 1.6 UI or 6.4 UI

Bit rate in kbit/s	A2 (UI)	A1 (UI)	f1 (Hz)	f2 (Hz)	f3 (Hz)	f4 (Hz)
1544	1.6	0.5	0.1	12.5 k	40 k	-
2048	1.6	0.5	0.1	31.25 k	100 k	-
6312	1.6	1	0.1	37.5 k	60 k	-
8448	1.6	0.5	0.1	62.5 k	200 k	400 k
34368	1.6	0.5	0.1	62.5 k	200 k	800 k
44736	1.6	0.5	0.1	62.5 k	200 k	400 k
51840	1.6	0.25	0.1	62.5 k	400 k	-
139264	1.6	0.5	0.1	62.5 k	200 k	3500 k
155520	1.6	0.2	0.1	62.5 k	500 k	1300 k
622080	6.4	0.2	0.1	62.5 k	2000 k	5000 k

Table S-4 Jitter measurement range 1.6 UI or 6.4 UI versus bit rate

Jitter measurement range 20 UI or 80 UI

Bit rate in kbit/s	A2 (UI)	A1 (UI)	f1 (Hz)	f2 (Hz)	f3 (Hz)	f4 (Hz)
1544	20	0.5	0.1	1 k	40 k	-
2048	20	0.5	0.1	2.5 k	100 k	-
6312	20	1	0.1	3 k	60 k	-
8448	20	0.5	0.1	5 k	200 k	400 k
34368	20	0.5	0.1	5 k	200 k	800 k
44736	20	0.5	0.1	5 k	200 k	400 k
51840	20	0.25	0.1	5 k	400 k	-
139264	20	0.5	0.1	5 k	200 k	3500 k
155520	20	0.2	0.1	5 k	500 k	1300 k
622080	80	0.2	0.1	5 k	2000 k	5000 k

Table S-5 Jitter measurement range 20 UI or 80 UI versus bit rate

Jitter measurement range 200 UI or 800 UI

Bit rate in kbit/s	A2 (UI)	A1 (UI)	f1 (Hz)	f2 (Hz)	f3 (Hz)	f4 (Hz)
up to 155520	200	20	0.1	100	1 k	-
622080	800	80	0.1	100	1 k	-

Table S-6 Jitter measurement range 200 UI or 800 UI versus bit rate

Note: The stated measurement ranges apply for electrical signals with nominal line code (CMI, HDB-3, B3ZS, B8ZS) or clock.

2.3 Weighting filters to ITU-T O.172

The following filter settings are possible, depending on the bit rate setting:

High-pass filter (in Hz)[1] 0.1; 2; 4; 10; 20; 40; 100; 200; 400; 500; 700
1 k; 3 k; 8 k; 10 k; 12 k; 18 k; 20 k; 30 k; 65 k; 80 k; 250 k

High-pass filter characteristic . . . . 1st order (to ITU-T O.172)

Low-pass filter (in Hz) . . . . .1 k[2]; 40 k; 60 k; 100 k; 400 k; 800 k; 1300 k; 3500 k; 5000 k

Low-pass filter characteristic . . . . 3rd order Butterworth (to ITU-T O.172)

1 High pass filters between 0.1 Hz and 10 Hz only can be set for the 200 UI and 800 Ui measurement ranges.
2 The 1 kHz low-pass filter is only available for measurement ranges 200 UI and 800 UI (no other low-pass filter is available for these ranges). Filter characteristic: 4th order.

Filter properties
-3 dB cutoff frequency tolerance . . . .$f_C \pm 10\%$
Second high-pass filter pole . . . .≤0.1 Hz
Maximum attenuation . . . . at least 60 dB

Preferred filter settings to ITU-T:

Bit rate in kbit/s	HP1 + LP		HP2 + LP	
	High-pass in kHz	Low-pass in kHz	High-pass in kHz	Low-pass in kHz
1544	0.01	40	8	40
2048	0.02	100	18	100
6312	0.01	60	3	60
8448	0.02	400	3	400
34368	0.1	800	10	800
44736	0.01	400	30	400
51840	0.1	400	20	400
139264	0.2	3500	10	3500
155520	0.5	1300	65	1300
622080	1	5000	250	5000

Table S-7 ITU-T filter settings

Note: If 0.1 Hz, 2 Hz or 4 Hz is set as the high-pass filter, up to three minutes may elapse after switching on the cold instrument before valid results are delivered by the jitter analyzer. This does not apply if an already warmed-up instrument is switched on again.

2.4 Demodulator output [31]

Socket . . . . BNC

Output impedance . . . . 75 Ω

Output voltage (terminated with 75 Ω):

Bit rate (in kbit/s)	Range		
	1.6 UI or 6.4 UI	**20 UI or 80 UI**	**200 UI or 800 UI**
up to 155520	1 V/UI	0.1 V/UI	0.01 V/UI
622080	0.25 V/UI	0.025 V/UI	0.0025 V/UI

Table S-8 Output voltages at output [31]

2.5 Result display

The positive and negative jitter amplitudes are measured.

Current Values

The current values are displayed continuously or shown as a graph.

Jitter peak-peak . . . . peak to peak jitter value

Jitter +peak. . . . . positive peak jitter value

Jitter -peak . . . . negative peak jitter value

Current Values display averaging (selectable). . . . . off, 1, 2, 3, 4, 5 seconds

Display resolution (current value)
in range 1 . . . . 0.001 UI_{pp}
in range 2 . . . . 0.01 UI_{pp}
in range 3 . . . . 0.1 UI_{pp}

Display range 1 (graphic display)
Jitter peak-peak . . . . 1.6 UI_{pp} or 6.4 UI_{pp} (622 Mbit/s)
Jitter +peak/-peak. . . . . ±0.8 UI_p or ±3.2 UI_p (622 Mbit/s)

Display range 2 (graphic display)
Jitter peak-peak . . . . 20 UI_{pp} or 80 UI_{pp} (622 Mbit/s)
Jitter +peak/-peak. . . . . ±10 UI_p or ±40 UI_p (622 Mbit/s)

Display range 3 (graphic display)
Jitter peak-peak . . . . 200 UI_{pp} or 800 UI_{pp} (622 Mbit/s)
Jitter +peak/-peak. . . . . ±100 UI_p or ±400 UI_p (622 Mbit/s)

Max. Values

The maximum value is only displayed if a measurement was started in the “Application Manager”.

Jitter peak-peak . . . . peak to peak jitter value in measurement interval

Jitter +peak . . . . positive peak jitter value in measurement interval

Jitter -peak . . . . negative peak jitter value in measurement interval

Display resolution
in range 1. . . . . .0.001 UI_{pp}
in range 2. . . . . .0.01 UI_{pp}
in range 3. . . . . .0.1 UI_{pp}

2.6 Error limits for displayed jitter

The error limits for displayed jitter meet or are better than the requirements of ITU-T Recommendation O.172.

The stated error limits apply under the following conditions:

- Electrical signals: Nominal input level to ITU-T G.703 without line distortion nominal line code (CMI, HDB-3, B3ZS, B8ZS) or clock
- Optical signals: Optical level in the range -10 dBm to -12 dBm (scrambled NRZ)
- Structured signals (pseudo-random sequences or framed signals) or clock
- Sine wave modulation
- Standard filter HP1 + LP or HP2 + LP as per Sec. 2.3, Page S-8, Table S-5

The overall measurement error is made up from the following partial errors (additive):

- Measurement error at reference frequency (see Sec. 2.6.1, Page S-11)
- Frequency response error (see Sec. 2.6.2, Page S-12)
- Deviation of filter frequency response from nominal curve (see Sec. 2.3, Page S-8)

2.6.1 Measurement accuracy

The stated measurement accuracy applies under the following conditions:

- Reference frequency: 100 kHz (SDH) or 1 kHz (PDH)
- The stated measurement error applies without restriction to the smaller measurement range, for values >0.8 UI (or >3.2 UI at 622 Mbit/s) in the medium measurement range and for values >10 UI (or 40 UI at 622 Mbit/s) in the larger measurement range.

Maximum measurement error***
(excluding frequency response error). . . . . ±5% of measured value ± W

The value W (fixed error) is taken from the following tables:

Bit rate in kbit/s	Structured signals or pseudo-random bit sequences (PRBS)			
	Filter HP1 + LP	Filter HP2 + LP	HP 2 Hz + LP	HP 0.1 Hz + LP
	W in UI	W in UI	W in UI	W in UI
1544	0.03	0.02[1]	0.05	0.07[2]
2048	0.03	0.02[1]	0.05	0.07[2]
6312	0.03	0.02[1]	0.05	0.07[2]
8448	0.03	0.02[1]	0.05	0.07[2]
34368	0.035	0.025[1]	0.07	0.1[2]
44736	0.035	0.025[1]	0.07	0.1[2]
51840	0.035	0.025	0.07	0.1[2]
139264	0.035	0.025[1]	0.07	0.2[2]
155520	0.05	0.025[1]	0.07	0.2[2]
622080	0.07	0.05[1]	0.1	0.5[2]

1 Demonstrated without modulation
2 After warming up the instrument for ≥30 min, only demonstrated with signal sources having high clock stability

Table S-9 W (fixed error) for structured signals or pseudo-random bit sequences

Bit rate in kbit/s	Clock signals			
	Filter HP1 + LP	Filter HP2 + LP	HP 2 Hz + LP	HP 0.1 Hz + LP
	W in UI	W in UI	W in UI	W in UI
1544	0.015	0.01[1]	0.05	0.07[2]
2048	0.015	0.01[1]	0.05	0.07[2]
6312	0.015	0.01[1]	0.05	0.07[2]

1 Demonstrated without modulation
2 After warming up the instrument for ≥30 min, only demonstrated with signal sources having high clock stability
3 Clock signals cannot be measured at the optical interfaces

Table S-10 W (fixed error) for clock signals

Bit rate in kbit/s	Clock signals			
	Filter HP1 + LP	Filter HP2 + LP	HP 2 Hz + LP	HP 0.1 Hz + LP
	W in UI	W in UI	W in UI	W in UI
8448	0.015	0.01[1]	0.05	0.07[2]
34368	0.025	0.02[1]	0.07	0.1[2]
44736	0.025	0.02[1]	0.07	0.1[2]
51840[3]	0.025	0.02	0.07	0.1[2]
139264	0.025	0.02[1]	0.07	0.2[2]
155520[3]	0.025	0.02[1]	0.07	0.2[2]

1 Demonstrated without modulation
2 After warming up the instrument for ≥30 min, only demonstrated with signal sources having high clock stability
3 Clock signals cannot be measured at the optical interfaces

Table S-10 W (fixed error) for clock signals *(continued)*

Additional error for
attenuated electrical signals . . . . typically ≤0.03 UI
line-distorted electrical signals. . . . . typically ≤0.05 UI
optical signals with levels >-10 dBm or <-12 dBm. . . . . typically ≤0.05 UI

2.6.2 Frequency response error***

The following frequency response error can occur in addition to the measurement error at frequencies that are not equal to the reference frequency:

Frequency response error for SDH-/SONET-signals . . . . .as per ITU-T O.172, Table 10

Reference frequency . . . . 100 kHz

Bit rate in kbit/s	Additional error	Frequency range[1] in kHz
51840	±2%	0.1 to 400
155520	±2%	0.5 to 300
	±3%	300 to 1000
	±5%	1000 to 1300
622080	±2%	1 to 300
	±3%	300 to 1000
	±5%	1000 to 3000
	±10%	3000 to 5000

1 Below the stated frequency range, the error which applies there is continued

Table S-11 Frequency response error for SDH-/SONET-signals

Frequency response error for PDH / tributary signals . . . . as per ITU-T O.171, Table 6

Reference frequency . . . . 1 kHz

Bit rate in kbit/s	Additional error	Frequency range[1] in kHz
1544	±4%	0.01 to 1
	±2%	1 to 40
2048	±2%	0.02 to 100
6312	±4%	0.01 to 1
	±2%	1 to 60
8448	±2%	0.02 to 300
	±3%	300 to 400
34368	±2%	0.1 to 300
	±3%	300 to 800
44736	±4%	0.01 to 0.2
	±2%	0.2 to 300
	±3%	300 to 400
139264	±2%	0.2 to 300
	±3%	300 to 1000
	±5%	1000 to 3000
	±10%	3000 to 3500

1 Below the stated frequency range, the error which applies there is continued

Table S-12 Frequency response error for PDH / tributary signals

2.7 Input phase tolerance when measuring pointer jitter

The following table shows jitter amplitude and frequency combinations that can be measured without degradation in the 1.6 UI range using the specified high-pass filter (or above). It is assumed that the jitter is sine wave modulation conforming to ITU-T O.172, Section 9.2.4, Table 6 (representing worst-case pointer jitter).

Bit rate in kbit/s	HP filter (Hz)	Amplitude in UI	Frequency in Hz
1544	≥10	20	0.5
2048	≥20	40	0.5
6312	≥10	20	0.5
8448	≥20	40	0.5
34368	≥100	25	5
44736	≥10	20	0.5
139264	≥200	80	1.5

Table S-13 Input phase tolerance when measuring pointer jitter

2.8 RMS jitter

Range and resolution up to 155 Mbit/s

	1.6 UI range (peak - peak)	**20 UI range (peak - peak)**	**200 UI range (peak - peak)**
RMS jitter range	0 to 0.8 UI	0 to 10 UI	0 to 100 UI
Resolution	0.001 UI	0.01 UI	0.1 UI

Table S-14 Range and resolution up to 155 Mbit/s

Range and resolution at 622 Mbit/s

	6.4 UI range (peak - peak)	**80 UI range (peak - peak)**	**800 UI range (peak - peak)**
RMS jitter range	0 to 3.2 UI	0 to 40 UI	0 to 400 UI
Resolution	0.001 UI	0.01 UI	0.1 UI

Table S-15 Range and resolution at 622 Mbit/s

Measurement accuracy

Valid for all bit rates if the 12 kHz RMS filter is used with nominal signals.

1.6 UI or 6.4 UI range. . . . .±5% of measured value ± 0.01 UI
20 UI / 200 UI or 80 UI / 800 UI range . . . .±5% of measured value ± 0.1 UI

Integration time. . . . . .1, 2, 5, 10, 20, 40, 80 seconds (selectable)

Default setting. . . . . 1 second

3 Tolerance to jitter measurement

3.1 Fast Maximum Tolerable Jitter (F-MTJ)

Only possible if option BN 3035/90.81 is fitted.

Once the measurement is started, selectable jitter amplitude and jitter frequency combinations are set. The result for each combination (test point) is then indicated either as “OK” (no alarms or bit errors) or “Failed” (alarms or bit errors).

Error source selectable from:
SDH . . . . TSE (Test Sequence Error, bit error), Code, B1, B2, B3, MS-REI, MS-RDI, HP-REI, HP-RDI, LP-REI, LP-RDI

SONET . . . . TSE (Test Sequence Error, bit error), Code, B1, B2, B3, REI-L, REI-P, REI-V, RDI-L, RDI-P, RDI-V

Error threshold . . . . 0 to 999999

Delay (recovery time) . . . . 0.1 to 999 s

Selectable jitter frequencies (scan frequencies) and
jitter amplitudes . . . . see Tab. S-1, Page S-3

Display . . . . table of values

Default settings

Bit rate in kbit/s	f1 / A1 in kHz/UI	f2 / A2 in kHz/UI	f3 / A3 in kHz/UI	f4 / A4 in kHz/UI	f5 / A5 in kHz/UI	f6 / A6 in kHz/UI
1544	0.01/5	0.1/5	0.5/5	2/0.7	8/0.1	40/0.1
2048	-	0.002/15	0.02/1.5	2.4/1.5	18/0.2	100/0.2
6312	0.01/5	0.1/5	0.9/5	2/0.61	4/0.1	20/0.1
8448	-	0.002/15	0.02/1.5	0.4/1.5	3/0.2	400/0.2
34368	-	0.01/15	0.1/1.5	1/1.5	10/0.15	800/0.15
44736	0.01/5	0.1/5	2.3/5	15/0.52	60/0.1	300/0.1
51840	0.01/15	0.03/15	0.3/1.5	2/1.5	20/0.15	400/0.15
139264	-	0.02/15	0.2/1.5	0.5/1.5	10/0.075	3500/0.075
155520	-	0.05/15	0.5/1.5	6.5/1.5	65/0.15	1300/0.15
622080	-	0.1/15	1/1.5	25/1.5	250/0.15	5000/0.15

Table S-16 Jitter frequency and jitter amplitude settings for Fast-MTJ measurement

The default values in the table represent the corner values for the limit curves specified in ITU-T Recommendations G.823 and G.825 or Bellcore GR-499.

3.2 Maximum Tolerable Jitter (MTJ)

Only possible if option BN 3035/90.81 is fitted.

Once the measurement is started, the jitter amplitude of the digital signal is altered until the bit error meter detects that a pre-set threshold has been exceeded. The maximum tolerable jitter value that will be shown is one search step less than the value causing the threshold violation.

Error source, selectable from:
SDH . . . . TSE (Test Sequence Error, bit error), Code, B1, B2, B3, MS-REI, MS-RDI, HP-REI, HP-RDI, LP-REI, LP-RDI

SONET . . . . TSE (Test Sequence Error, bit error), Code, B1, B2, B3, REI-L, REI-P, REI-V, RDI-L, RDI-P, RDI-V

Error threshold . . . . 0 to 999999

Delay (recovery time) . . . . 0.1 to 999 s

Gate time . . . . 1 to 60 s

The jitter frequencies (scan frequencies) can be user defined as a group of up to 20 freely programmable frequencies in the range from 0.1 Hz to 5 MHz (depending on bit rate).

Display . . . . table of values or log vs. log graph

Tolerance masks can also be displayed.

Default scan frequencies

Bit rate in kbit/s	f1 in kHz	f2 in kHz	f3 in kHz	f4 in kHz	f5 in kHz	f6 in kHz	f7 in kHz	f8 in kHz	f9 in kHz
1544	0.002	0.01	0.04	0.1	0.4	1	4	10	40
2048	0.002	0.02	0.2	0.8	2.4	8	18	50	100
6312	0.002	0.01	0.04	0.1	0.4	1	4	20	60
8448	0.002	0.02	0.4	1	3	10	40	100	400
34368	0.002	0.1	1	4	10	40	100	300	800
44736	0.002	0.01	0.1	0.6	3	10	30	100	400
51840	0.002	0.01	0.03	0.3	2	8	20	100	400
139264	0.002	0.1	1	10	40	100	400	1000	3500
155520	0.002	0.1	1	6.5	20	65	200	600	1300
622080	0.002	0.1	1	10	100	400	1000	2000	5000

Table S-17 Default scan frequencies

Default tolerance masks

Bit rate in kbit/s	f1 / A1 in kHz/UI	f2/A2 in kHz/UI	f3 / A3 in kHz/UI	f4 / A4 in kHz/UI	f5 / A5 in kHz/UI	f6 / A6 in kHz/UI
1544	-	-	0.01/5	0.5/5	8/0.1	40/0.1
2048	-	0.002/15	0.02/1.5	2.4 /1.5	18/0.2	100/0.2
6312	-	-	0.01/5	0.9/5	4/0.1	20/0.1
8448	-	0.002/15	0.02/1.5	0.4/1.5	3/0.2	400/0.2
34368	-	0.003/50	0.1/1.5	1/1.5	10/0.15	800/0.15
44736	-	-	0.01/5	2.3/5	60/0.1	300/0.1
51840	0.01/15	0.03/15	0.3/1.5	2/1.5	20/0.15	400/0.15
139264	-	0.005/60	0.2/1.5	0.5/1.5	10/0.075	3500/0.075
155520	-	0.0193/39	0.5/1.5	6.5/1.5	65/0.15	1300/0.15
622080	-	0.0096/156	1/1.5	25/1.5	250/0.15	5000/0.15

Table S-18 Default tolerance masks

4 Jitter Transfer Function

4.1 Jitter Transfer Function measurement

Only possible if options BN 3035/90.81 **and** BN 3035/90.82 are fitted.

Once the measurement is started, a user-defined amplitude is set at each of the pre-selected jitter frequencies in turn. The Jitter Analyzer determines the jitter transferred by the device under test. The jitter is measured selectively, i.e. using a band-pass filter that is tuned to the modulation frequency. This ensures that interference frequencies outside the pass band of the filter do not affect the result.

The jitter transfer function is calculated from the logarithmic ratio of output jitter to input jitter on a point by point basis:

Jitter transfer function: $H(f_j) = 20 \log \frac{\text{output jitter}}{\text{input jitter}}$

Maximum measurement accuracy is achieved by means of a calibration measurement which can either be performed before every measurement (recommended) or stored for future use. The intrinsic error of the analyzer is determined at every selected scan frequency during a loop measurement (TX linked to RX). This intrinsic error correction is then applied to the results for the device under test as they are measured.

TX jitter settings . . . . .see Sec. 1, Page S-2

Measurement range . . . . .1.6 UI_{pp} or 20 UI_{pp} (switchable)
or 6.4 UI_{pp} or 80 UI_{pp} at 622 Mbit/s

Delay (recovery time) . . . . 0.1 to 999 s

Filter bandwidth (-3 dB) . . . . 10 Hz

The jitter frequencies (scan frequencies) can be user defined as a group of up to 20 freely programmable frequencies in the range from 10 Hz to 5 MHz (depending on bit rate).

Display . . . . .table of values or graph with logarithmic frequency axis

Tolerance masks can also be displayed.

Default scan frequencies and amplitudes

Bit rate in kbit/s	f1/Ampl. (kHz/UI)	f2/Ampl. (kHz/UI)	f3/Ampl. (kHz/UI)	f4/Ampl. (kHz/UI)	f5/Ampl. (kHz/UI)	f6/Ampl. (kHz/UI)	f7/Ampl. (kHz/UI)	f8/Ampl. (kHz/UI)	relevante Normen
1544	0.01/1	0.035/1	0.1/1	0.35/1	1/1	2.5/0.51	15/0.1	-	Bellcore GR-499
2048	0.01/1	0.1/1	1/1	10/0.36	36/0.2	100/0.2	-	-	ITU-T G.823
6312	0.01/1	0.035/1	0.1/1	0.5/1	1/1	2.5/0.34	15/0.1	-	Bellcore GR-499
8448	0.01/1	0.1/1	0.4/1	1/0.6	10/0.2	100/0.2	400/0.2	-	ITU-T G.823
34368	0.01/1	0.1/1	0.3/1	1/1	3/0.5	10/0.15	100/0.15	800/0.15	ITU-T G.823
44736	0.01/1	0.1/1	1/1	4/1	15/0.52	-	-	-	Bellcore GR-499
51840	0.01/1	0.1/1	1/1	10/0.3	40/0.15	100/0.15	400/0.15	-	Bellcore GR-253
139264	0.01/1	0.1/1	0.5/1	1/0.75	5/0.15	-	-	-	ITU-T G.823
155520	0.1/1	1/1	10/0.975	130/0.15	500/0.15	1300/0.15	-	-	ITU-T G.825, Bellcore GR-253
622080	0.1/1	1/1	10/1	100/0.375	500/0.15	1000/0.15	5000/0.15	-	ITU-T G.825, Bellcore GR-253

Table S-19 Default scan frequencies and amplitudes

The default scan frequencies and amplitudes correspond to or are below the maximum tolerable jitter limit curves specified in the relevant standards. This ensures that the JTF measurement is not performed using unacceptably high levels of jitter.

Default tolerance masks

Bit rate in kbit/s	f1/max. dB in kHz/in dB	f2/max. dB in kHz/in dB	f3/max. dB in kHz/in dB	f4/max. dB in kHz/in dB	Applicable standards
1544	0.01/0.1	0.35/0.1	2.5/-34	15/-49.5	Bellcore GR-499
2048	0.01/0.5	36/0.5	100/-8.4	-	ITU-T G.735, G.736, G.737, G.738, G.739
6312	0.01/0.1	0.5/0.1	2.5/-28	15/-43.5	Bellcore GR-499
8448	0.01/0.5	0.1/0.5	1/-19.5	400/-19.5	ITU-T G.751
34368	0.01/0.5	0.3/0.5	3/-19.5	800/-19.5	ITU-T G.751
44736	0.01/0.1	1/0.1	15/-23.4	-	Bellcore GR-499
51840	0.01/0.1	40/0.1	400/-19.9	-	ANSI T1.105.03, Bellcore GR-253
139264	0.01/0.5	0.5/0.5	5/-19.5	-	-
155520	0.01/0.1	130/0.1	1300/-19.9	-	ITU-T G.958, ANSI T1.105.03, Bellcore GR-253
622080	0.01/0.1	500/0.1	5000/-19.9	-	ITU-T G.958, ANSI T1.105.03, Bellcore GR-253

Table S-20 Default tolerance masks

The default lower tolerance mask limit (min. dB) is always -99.9 dB and is not visible in the graph display.

4.2 Measurement error (typical)

The total error F_{total} is made up from the partial errors F1 + F2 + F3.

F1 and F2 depend on the transmitted jitter amplitude (F1) and on the measured jitter amplitude (F2). They can be read off from the diagrams below.
F3 depends on the measured jitter loss D (in dB) and on a bit rate-dependent constant k up to a maximum value,

where: $\mathbf{F3 = D \cdot k}$

Note: The value of F3 can never exceed $F3_{MAX}$.

Bit rate	k	$F3_{MAX}$
≤ 140 Mbit/s	0.035	0.5 dB
155 Mbit/s	0.05	1 dB
622 Mbit/s	0.1	3 dB

Table S-21 Factor k and the maximum value $F3_{MAX}$ as a function of bit rate

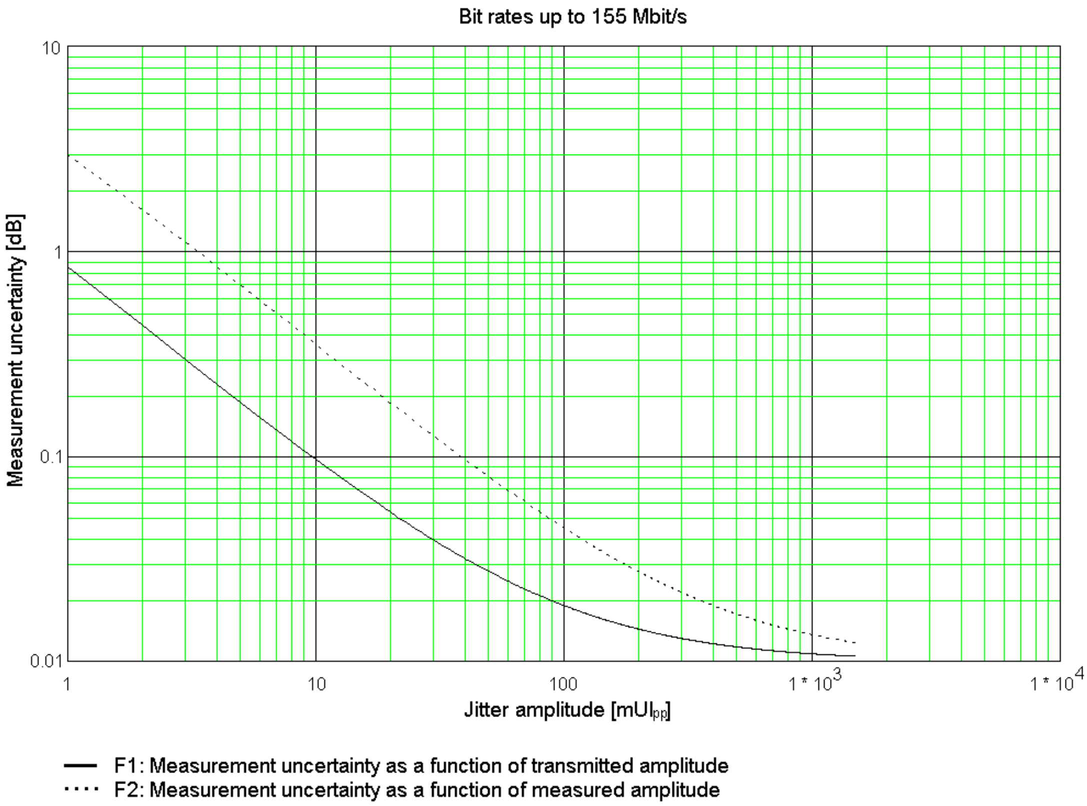


Fig. S-3 Measurement uncertainty for bit rates up to 155 Mbit/s

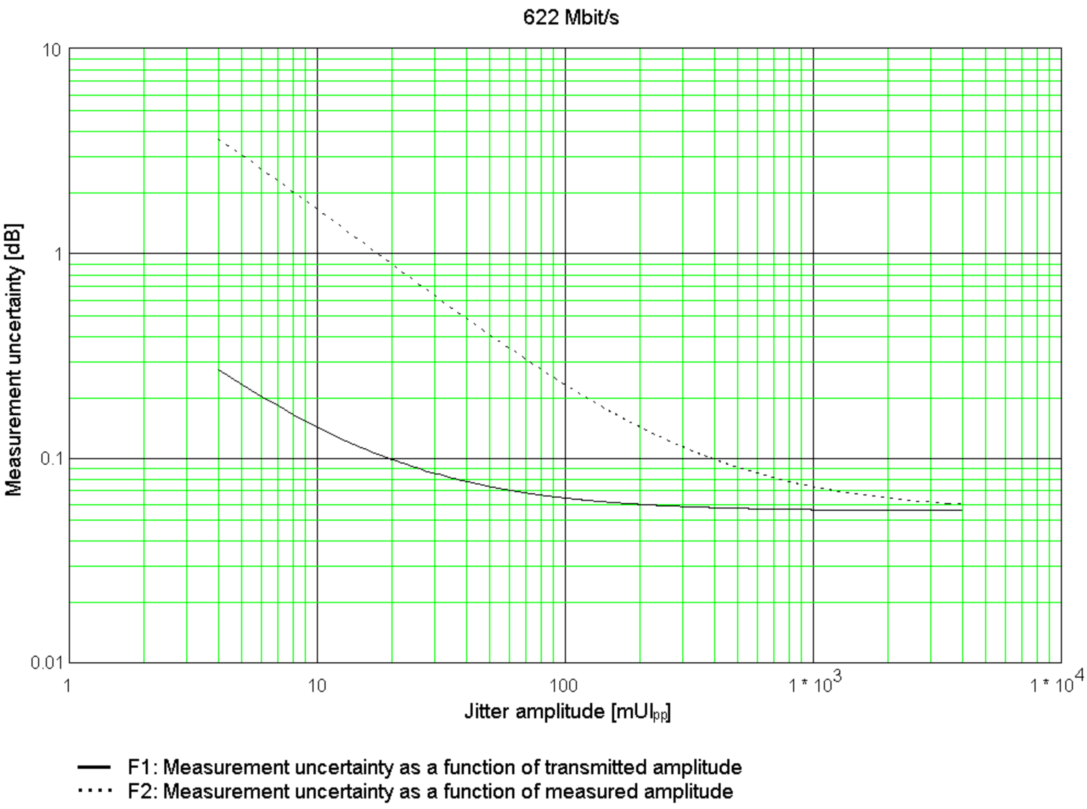


Fig. S-4 Measurement uncertainty for 622 Mbit/s

All data applies under the following conditions:

- Nominal level and standard line code
- Temperature: 20 °C to 26 °C
- Integration time: 5 s
- Settling time: 1 s
- Complete instrument warm-up time: 30 minutes
  The relevant optical bit rate (155 Mbit/s and 622 Mbit/s) must also have been activated for at least five minutes.
- Calibration immediately before the measurement
- Jitter amplitude on the jitter meter and measurement range:

up to 155 Mbit/s:	1 mUI to 1.5 UI	1.6 UI range
at 622 Mbit/s:	4 mUI to 4 UI	6.4 UI range

Example

A jitter transfer of -21 dB is measured at a bit rate of 34 Mbit/s and a transmitted amplitude of 1000 mUI_{pp}.

To calculate the total error, errors F1 and F2 are taken from Fig. S-3. Error F3 is calculated using the relationship given above (k is taken from Table S-21).

F1 = 0.011 dB (from Fig. S-3)

The jitter transfer function

$$H(f_j) = 20 \log \frac{\text{measured jitter}}{\text{transmitted jitter}} = 20 \log \frac{x}{1000\ \text{mUI}} = -21\ \text{dB}$$

gives a measured jitter of approximately 90 mUI.

This value can be used to read the value of F2 from Fig. S-3.

F2 = 0.05 dB (from Fig. S-3)

$$F3 = 21\ \text{dB} \cdot 0.035 = 0.735\ \text{dB}$$

F3 is greater than $F3_{MAX}$ in Table S-21 (0.5 dB). The value $F3_{MAX}$ = 0.5 dB is therefore substituted for F3.

$\mathbf{F_{total}}$ = 0.011 dB + 0.05 dB + 0.5 dB **= 0.561 dB**

(0.011 dB = F1, 0.05 dB = F2, 0.5 dB = F3)

5 Phase hits

An event is counted if the demodulated jitter signal violates a pre-set positive or negative threshold value. Positive and negative events are counted by separate counters. The counter value indicates the number of times the positive and negative thresholds were violated during the measurement.

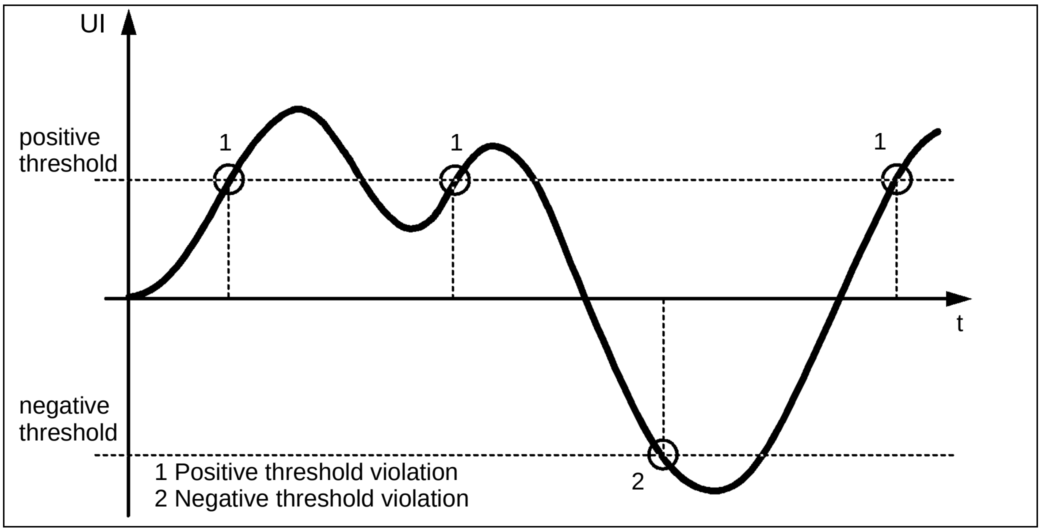


Table S-22 Example: Demodulated jitter signal (jitter vs. time function)

Display

- Number of times positive threshold was violated
- Number of times negative threshold was violated

Threshold settings (positive and negative)

Bit rates up to 155 Mbit/s	1.6 UI range	20 UI range	200 UI range
Range of values	0.1 UI to 0.8 UI	0.1 UI to 10 UI	1 to 100 UI
Step width	0.1 UI	0.1 UI	1 UI

Table S-23 Range of values and step width up to 155 Mbit/s

Bit rate 622 Mbit/s	6.4 UI range	80 UI range	800 UI range
Range of values	0.1 to 3.2 UI	0.1 to 40 UI	1 to 400 UI
Step width	0.1 UI	0.1 UI	1 UI

Table S-24 Range of values and step width for 622 Mbit/s

Alarms

Alarms . . . . LOS (Loss of Signal), LTI (Loss of Timing Information) and AC line power failure

The counters are stopped during an alarm. The count resumes when the alarm is cleared and the gate time has not yet elapsed completely. The occurrence of an alarm is indicated by a yellow warming sign in front of the result. The warning sign is cleared when a new measurement is started.

Maximum count frequency . . . . approx. 10 kHz (sine wave), approx. 25 kHz (square wave)

Threshold setting error limits . . . .±5% of threshold value, plus jitter meter error

6 Wander Generator

Only possible if options BN 3035/90.81 **and** BN 3035/90.85 are fitted.

6.1 Bit rates

As fitted to the mainframe instrument.

Bit rates . . . . 1544 kbit/s, 2048 kbit/s, 6312 kbit/s, 8448 kbit/s, 34368 kbit/s, 44736 kbit/s, 51840 kbit/s, 139264 kbit/s, 155520 kbit/s, 622080 kbit/s

Wander modulation shape. . . . . sine wave

Frequency range . . . . 10 µHz to 10 Hz

Wander frequency setting step width . . . . 1 µHz

Amplitude range . . . . 0.1 UI to 200000 UI

Wander amplitude setting step width. . . . . 0.1 UI

6.2 Wander amplitude and wander frequency

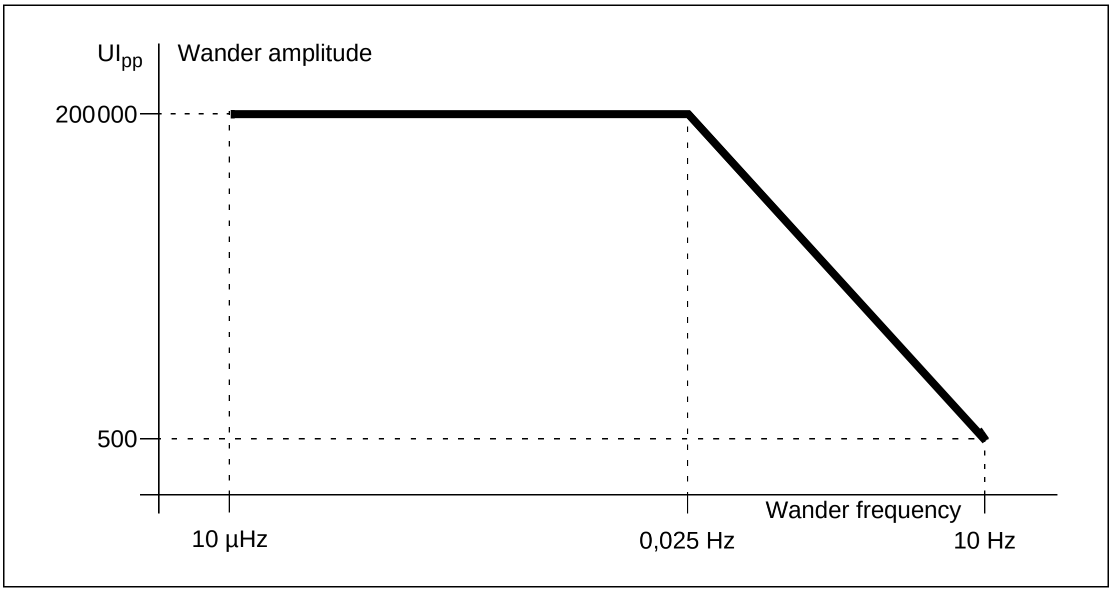


Fig. S-5 Maximum wander amplitude as a function of wander frequency

6.3 Error limits

6.3.1 Amplitude error

Amplitude error describes the deviation from the set amplitude for sine wave modulation.

Maximum deviation . . . . ±8% of set value ± 0.02 UI_{pp}

6.3.2 Intrinsic jitter / wander

The intrinsic jitter / wander indicates the maximum output jitter / wander of the ANT-20SE for a jitter / wander amplitude setting of 0 UI. A bandwidth between the filters HP1 and LP (see Tab. S-7, Page S-8) is assumed.

Bit rate in kbit/s	**Intrinsic jitter / wander in UI**
up to 155520	0.005
622080	0.04

Table S-25 Intrinsic jitter / wander

6.3.3 Modulation frequency

Modulation frequency accuracy . . . . ±0.1%

6.4 Synchronization

In Wander Generator mode, the generator of the ANT-20SE is normally synchronized to an external source. The appropriate reference signal should be fed into socket [25]. Refer to the “Specifications” for the mainframe instrument.

7 Wander Measurement

Only possible if options BN 3035/90.82 **and** BN 3035/90.86 are fitted.

7.1 Bit rates

As fitted to the mainframe instrument.

Bit rates . . . . 1544 kbit/s, 2048 kbit/s, 6312 kbit/s, 8448 kbit/s, 34368 kbit/s, 44736 kbit/s, 51840 kbit/s, 139264 kbit/s, 155520 kbit/s, 622080 kbit/s

7.2 Reference input [34]/[35]

Tip: Wander measurements can only be performed using an external reference signal! This signal must conform with the clock frequencies or bit rates and input levels specified below.

Permissible offset . . . . ±100 ppm

Wander transmission bandwidth . . . . 0 to 100 Hz

Sockets . . . . Bantam [34] and BNC [35]

Monitoring . . . . LTI (Loss of Timing Information)

Socket [34]

Input impedance . . . . 110 Ω, balanced

Permitted input level
Clock signal . . . . 0.65 V_{pp} to 6.5 V_{pp}
Data signal (HDB-3, B8ZS) . . . . ±3 V ± 10%

Reference frequencies
Clock signal . . . . 1.544 MHz; 2.048 MHz
Data signal (HDB-3, B8ZS) . . . . 1.544 Mbit/s; 2.048 Mbit/s

Socket [35]

Input impedance . . . . 75 Ω, unbalanced

Permitted input level
Clock signal . . . . 0.5 V_{pp} to 5 V_{pp}
Data signal (HDB-3, B8ZS) . . . . ±2.37 V ± 10%

Reference frequencies
Clock signal . . . . 1.544 MHz; 2.048 MHz; 5 MHz; 10 MHz
Data signal (HDB-3, B8ZS) . . . . 1.544 Mbit/s; 2.048 Mbit/s

7.3 Measurement range

Wander amplitude range . . . . $\pm 1 \times 10^6$ s

Maximum permitted phase change rate
Sample rate 1/s . . . . 1000 UI/s for all bitrates
Sample rate ≥ 30/s . . . . 5000 UI/s for bitrates <45 Mbit/s
20000 UI/s for bitrates ≥45 Mbit/s

The upper limit of the wander frequency range is set by a first-order low-pass filter. The low-pass filter is selected automatically to correspond with the selected sample rate.

Sample rate	Low-pass filter/f_C
1/s	0.1 Hz
30/s	10 Hz
60/s	20 Hz
300/s	100 Hz

Table S-26 Low-pass filters for various sample rates

Low-pass filter

Filter characteristic . . . . first order low-pass

Measurement bandwidth . . . . 0 Hz to f_C

-3 dB cutoff frequency deviation . . . . f_C ± 10%

Maximum attenuation . . . . at least 30 dB

Pass-band ripple in the range 1 Hz to 10 Hz
(referred to the attenuation at 0.1 Hz) . . . . <±0.2 dB

7.4 Result display

Result displayed in seconds
TIE (instantaneous value) . . . . numerically and graphically
MTIE (maximum difference) . . . . numerically

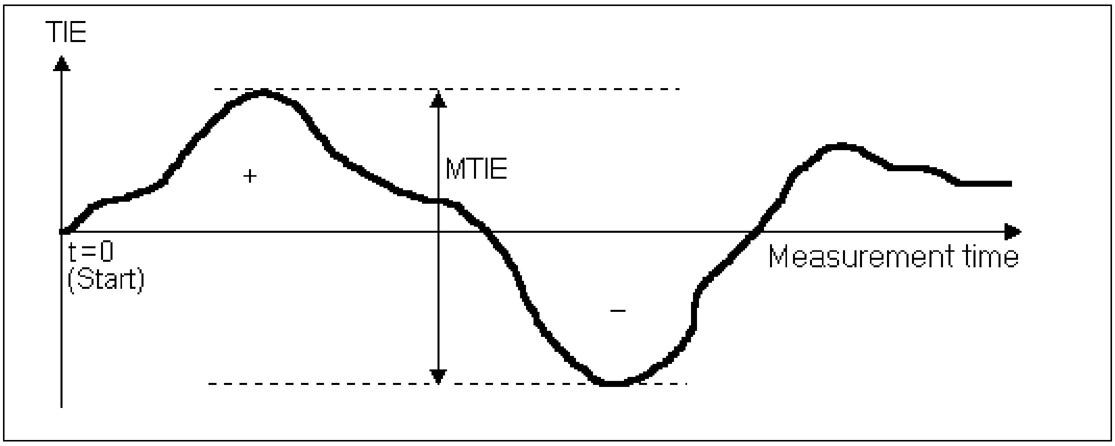


Fig. S-6 Example: Wander measurement versus measurement time

7.5 Accuracy***

The specified measurement error applies after a warm-up period of at least 30 minutes for the ANT-20SE and a maximum change in ambient temperature of 5 K.

Overall TIE error for each TIE measurement
for an observation interval τ . . . . <±5% of TIE value ± Z_0

Z_0 is taken from the following table:

Z_0 (τ)/ns	**Observation interval τ/s**
2.5 + 0.0275 τ	$0.05 \le \tau \le 1000$
29 + 0.001 τ	$\tau > 1000$

Table S-27 Error Z_0

7.6 Memory requirements

Before starting a long-term wander measurement, check the available hard disk space. The ANT-20SE software calculates the expected hard disk space requirements from the selected gate time and sample rate. A warning message is displayed if there is insufficient space.

Sample rate	Memory requirements
1/s	approx. 58 kB/h
30/s	approx. 1.65 MB/h
60/s	approx. 3.3 MB/h
300/s	approx. 16.5 MB/h

Table S-28 Memory requirements versus sample rate

8 Measurement of Maximum Tolerable Wander

only possible with options BN 3035/90.81 **and** BN 3035/90.85

8.1 Maximum Tolerable Wander (MTW)

Note: The ANT-20SE's generator is normally synchronized externally in MTW mode. This is done by connecting an appropriate reference signal to socket [25]. Refer to the "Specifications" of the mainframe for details.
An appropriate message will be displayed when the MTW measurement is started if the internal clock source is used for a MTW measurement.

Variable combinations of wander amplitudes and wander frequencies are set once the measurement is started. The output signal is modulated for one period of the wander frequency for each combination of values. The measurement point is then marked as "OK" (no alarms or bit errors detected) or "Failed" (alarms or bit errors detected).

Error source, selectable
SDH . . . . TSE (Test Sequence Error, bit error), Code, B1, B2, B3, MS-REI, MS-RDI, HP-REI, HP-RDI, LP-REI, LP-RDI
SONET . . . . TSE (Test Sequence Error, bit error), Code, B1, B2, B3, REI-L, REI-P, REI-V, RDI-L, RDI-P, RDI-V

Error threshold . . . . 0 to 999999

Settling time (wait between measurements) . . . . .0.1 to 999 s

Settable values of wander frequency
(scan frequency) and wander amplitude . . . . .see Fig. S-5, Page S-26

Display . . . . table of values

Default settings

Bit rate in kbit/s	f1 / A1 in Hz/UI	f2 / A2 in Hz/UI	f3 / A3 in Hz/UI	f4 / A4 in Hz/UI	f5 / A5 in Hz/UI	f6 / A6 in Hz/UI	Relevant standards
1544	0.014/17	0.16/15	0.16/15	0.19/13	3.9/13	10/5	ITU-T G.824
2048	0.00488/36.9	0.01/18	1.67/18	10/3	-	-	ITU-T G.823
6312	0.01/24.4	0.03/18.9	0.1/14.4	03/11.2	1/8.5	10/5	ITU-T G.824
8448	-	-	-	-	-	-	-
34368	0.01/137.5	0.032/137.5	0.13/34.4	4.4/34.4	10/15.1	-	ITU-T G.823
44736	0.01/120.7	0.03/96.1	0.1/81	0.3/73.2	1.675/65.7	10/11	ITU-T G.824
51840	0.016/103.7	0.05/33.2	0.13/13	10/13	-	-	ITU-T G.813 (Option 1)
139264	0.01/557	0.032/557	0.13/139.3	2.2/139.3	10/30.6	-	ITU-T G.823
155520	0.016/311	0.05/99.5	0.13/38.9	10/38.9	-	-	ITU-T G.813 (Option 1)
622080	0.016/1244	0.5/398	0.13/155.5	10/155.5	-	-	ITU-T G.813 (Option 1)

Table S-29 Settings for wander frequency and wander amplitude for MTW measurements

Note: The masks specified in the standards quoted generally start at lower frequencies (e.g. 12 µHz). These lower wander frequencies result in very long measurement times. They have therefore been omitted in order to reduce measurement times. You can alter the appropriate default settings if you want to make measurements at these lower frequencies.

Notes:

Specifications O.172 Jitter / Wander (2488 Mbit/s Interface)

These Specifications apply to the following options:

- BN 3035/90.88 Jitter Generator / Jitter Analyzer
- BN 3035/90.87 Wander Generator
- BN 3035/90.89 Wander Analyzer

Numbers enclosed in square brackets […] correspond to numbers printed on the instrument.

Calibrated specifications are indicated by ***.

Standards

Jitter is generated and jitter and wander are analyzed in accordance with the following standards:

- ITU-T G.825, O.172
- Bellcore GR-253
- ANSI T1.101, T1.105.03

1 Jitter Generator

Meets or exceeds the requirements of ITU-T O.172

1.1 Bit rate

Bit rate . . . . 2488320 kbit/s

Maximum offset (Jitter Generator/Analyzer active) . . . . ±50 ppm

Modulation source . . . . internal or external

Jitter modulation signal . . . . sine wave

1.2 Internal modulation source

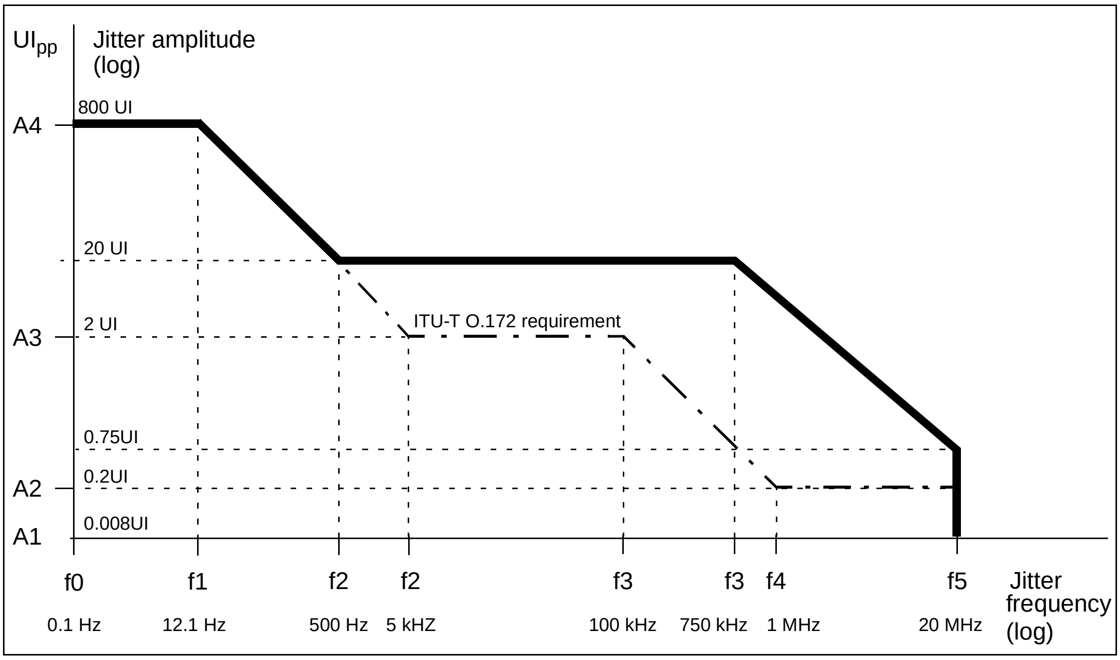


Fig. S-7 Jitter amplitude versus jitter frequency

	Amplitude in UIpp				Frequency in kHz					
Bit rate in kHz	**A1**	**A2**	**A3**	**A4**	**f0**	**f1**	**f2/f2**	**f3/f3**	**f4**	**f5**
ANT-20SE	0.008	0.75	20	800	0.0001	0.0121	0.5	750	-	20000
ITU-T O.172	-	0.2	2	800	0.000125	0.0121	5	100	1000	20000

Table S-30 Jitter amplitude and jitter frequency

Settling time for changes in amplitude . . . . <2 seconds

Changes in modulation frequency or amplitude are without phase hits.

Jitter frequency setting step width
0.1 Hz to 1 MHz . . . . 0.1 Hz
above 1 MHz . . . . 1 Hz

Jitter amplitude setting step width . . . . 0.001 UI

1.3 External modulation voltage input [50]

Socket . . . . BNC

Input impedance . . . . 75 Ω

Frequency range . . . . 0.1 Hz to 20 MHz

Nominal input voltage range . . . . 0 to 2.0 V_{pp} (8.2 dBm)

Corresponding jitter amplitude (at 2.0 V_{pp}) . . . . variable

Maximum permitted input level . . . . 4.0 V_{pp} (14.2 dBm)

1.4 Error limits

The error limits conform to or are better than the requirements of ITU-T O.172.

1.4.1 Amplitude error***

Amplitude error describes the deviation from the set amplitude for sine wave modulation.

Maximum deviation . . . . ±Q% of set value ± 0.02 UI_{pp}

Q (variable error) is taken from the following table:

Q (variable error) in %	Frequency range in kHz
8	5 to 500
12	500 to 2000
15	2000 to 20000
Q = 12% below the stated ranges	

Table S-31 Q for various modulation frequencies

1.4.2 Intrinsic jitter

The intrinsic jitter indicates the maximum output jitter of the ANT-20SE for a jitter amplitude setting of 0 UI. A bandwidth between the filters HP1 and LP (see Tab. S-33, Page S-40) is assumed.

Intrinsic jitter . . . . 0.04 UI

1.4.3 Modulation frequency

Modulation frequency accuracy. . . . . ±0.1%

2 Jitter Analyzer

Meets or exceeds the requirements of ITU-T O.172

2.1 Bit rate

Same as bit rate of STM-16 / OC-48 Module

Bit rate . . . . .2488320 kbit/s

Permitted offset . . . .±20 ppm

RX line code . . . . NRZ (optical)

2.2 Jitter measurement range

Range 1 . . . . 0 to 2 UI_{pp}

Range 2 . . . . 0 to 32 UI_{pp}

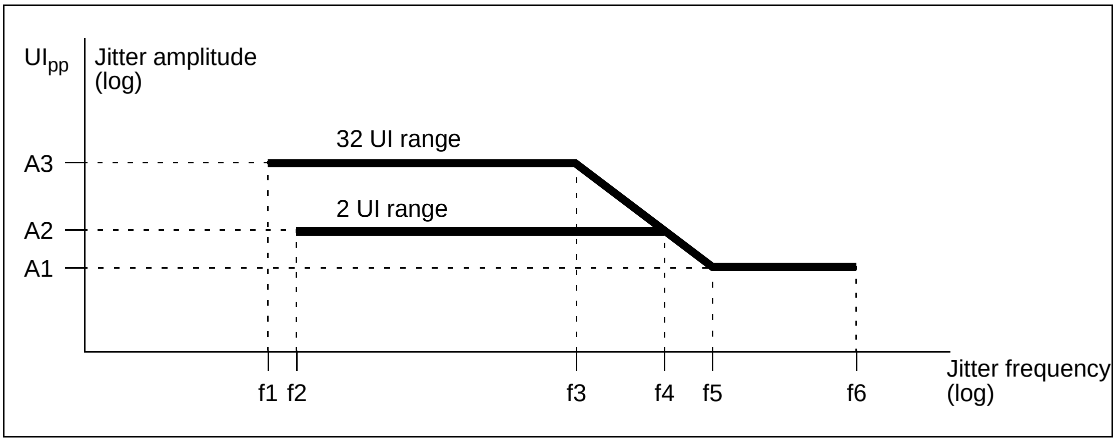


Fig. S-8 Jitter measurement range

Amplitude in UI_{pp}			**Frequency in kHz**					
A1	**A2**	**A3**	**f1**	**f2**	**f3**	**f4**	**f5**	**f6**
0.2	2	32	5 (0.01)	5 (0.08)	6.25	100	1000	20000
f1 = 10 Hz with 5 or 12 kHz high-pass filter deactivated f2 = approx. 80 Hz with 5 or 12 kHz high-pass filter deactivated								

Table S-32 Jitter measurement range

2.3 Weighting filters to ITU-T O.172

High-pass filters . . . . 5 kHz, 12 kHz and 1000 kHz

High-pass filter characteristic . . . . 1st order (to ITU-T O.172)

Low-pass filter . . . . 20000 kHz
Low-pass filter characteristic . . . . 3rd order Butterworth (to ITU-T O.172)

Filter properties
-3 dB cutoff frequency tolerance . . . . $f_C \pm 10\%$
Maximum attenuation . . . . at least 60 dB

Default filter settings to ITU-T O.172 (standard filters):

HP1 + LP		**HP2 + LP**	
High-pass in kHz	**Low-pass in kHz**	**High-pass in kHz**	**Low-pass in kHz**
5	20000	1000	20000

Table S-33 ITU-T filter settings

Frequency range without high-pass filter (lower -3 dB cutoff point):

Range 1 (2 UI_{pp}) . . . . 80 Hz

Range 2 (32 UI_{pp}) . . . . 10 Hz

2.4 Demodulator output [51]

Socket . . . . BNC

Output impedance . . . . 75 Ω

Output voltage (terminated with 75 Ω)
Range 1 (2 UI_{pp}) 1V/UI
Range 2 (32 UI_{pp}) . . . . 62.5 mV/UI

2.5 Result display

The positive and negative jitter amplitudes are measured.

Current Values

The current values are displayed continuously or shown as a graph.

Jitter peak-peak . . . . .peak to peak jitter value

Jitter +peak. . . . . positive peak jitter value

Jitter -peak . . . . .negative peak jitter value

Current Values display averaging (selectable). off, 1, 2, 3, 4, 5 seconds

Display resolution (current value)
in range 1 (2 UI_{pp}) . . . . 0.001 UI_{pp}
in range 2 (32 UI_{pp}) . . . . 0.01 UI_{pp}

Display range 1 (graphical display)
Jitter peak-peak . . . . .2 UI_{pp}
Jitter +peak/-peak. . . . . ±1 UI_p

Display range 2 (graphical display)
Jitter peak-peak . . . . .32 UI_{pp}
Jitter +peak/-peak. . . . . ±16 UI_p

Max. Values

The maximum value is only displayed if a measurement was started in the “Application Manager”.

Jitter peak-peak . . . . peak to peak jitter value in measurement interval

Jitter +peak. . . . . .positive peak jitter value in measurement interval

Jitter -peak . . . . negative peak jitter value in measurement interval

Display resolution
in range 1 (2 UI_{pp}) . . . . 0.001 UI_{pp}
in range 2 (32 UI_{pp}) . . . . 0.01 UI_{pp}

2.6 Error limits for displayed jitter

The error limits for displayed jitter meet the requirements of ITU-T Recommendation O.172.

The stated error limits apply under the following conditions:

- Optical level in the range -10 dBm to -12 dBm (scrambled NRZ)
- Structured signals (framed signals to ITU-T O.172)
- Sine wave modulation
- Standard filters HP1 + LP or HP2 + LP as per Sec. 2.3, Page S-40, Table S-33

The overall measurement error is made up from the following partial errors (additive):

- Measurement error at reference frequency (see Sec. 2.6.1, Page S-42)
- Frequency response error (see Sec. 2.6.2, Page S-43)
- Deviation of filter frequency response from nominal curve (see Sec. 2.3, Page S-40)

2.6.1 Measurement accuracy

The stated measurement accuracy applies under the following conditions:

- Reference frequency: 100 kHz
- The stated measurement error applies without restriction to the smaller measurement range and for values >1 UI in the larger measurement range.

Maximum measurement error***
(excluding frequency response error) . . . . ±5% of measured value ± W

The value W (fixed error) is taken from the following table:

Filter HP1 + LP	Filter HP2 + LP	HP 80 Hz + LP	HP 10 Hz + LP
W in UI	**W in UI**	**W in UI**	**W in UI**
0.1	0.05[1]	0.2	0.3
1 demonstrated without modulation			

Table S-34 W (fixed error)

Additional error for
optical signals with levels >-10 dBm or <-12 dBm. . . . . typically ≤0.05 UI

2.6.2 Frequency response error***

The following frequency response error can occur in addition to the measurement error at frequencies that are not equal to the reference frequency:

Frequency response error . . . . .to ITU-T O.172, Table 10

Reference frequency . . . . 100 kHz

Additional error	Frequency range[1] in kHz
±2%	1 to 300
±3%	300 to 1000
±5%	1000 to 3000
±10%	3000 to 10000
±15%	10000 to 20000

1 Below the stated frequency range, the error which applies there is continued

Table S-35 Frequency response error

The specified frequency response error applies for a jitter amplitude of 0.15 UI_{pp} and an ambient temperature range of +23 ±10 °C.

2.7 RMS jitter

Range and resolution

	2 UI range (peak - peak)	32 UI range (peak - peak)
RMS range	0 to 1 UI	0 to 16 UI
Resolution	0.001 UI	0.01 UI

Table S-36 Range and resolution

Measurement accuracy

Valid if the 12 kHz RMS filter is used with nominal signals.

2 UI range. . . . .±5% of measured value ± 0.01 UI
32 UI range. . . . .±5% of measured value ± 0.1 UI

Integration time. . . . . .1, 2, 5, 10, 20, 40, 80 seconds (selectable)

Default setting. . . . . 1 second

2.8 Phase hits

An event is counted if the demodulated jitter signal violates a pre-set positive or negative threshold value. Positive and negative events are counted by separate counters. The counter value indicates the number of times the positive and negative thresholds were violated during the measurement.

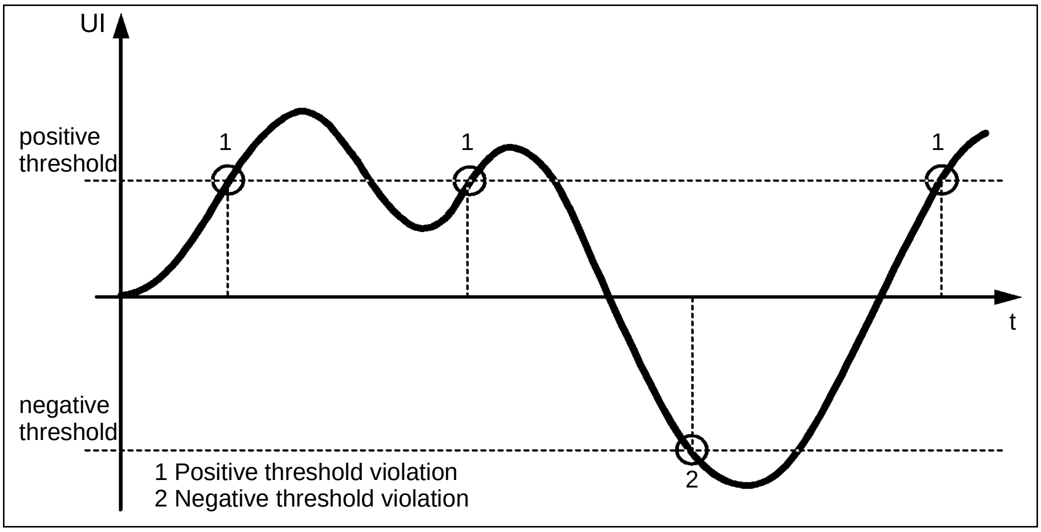


Fig. S-9 Example: Demodulated jitter signal (jitter vs. time function)

Display

- Number of times positive threshold was violated
- Number of times negative threshold was violated

Threshold settings (positive and negative)

Range of values in range 1 (2 UI_{pp}) . . . . 0.1 UI_p to 1 UI_p
Step width . . . . 0.1 UI_p
Range of values in range 2 (32 UI_{pp}) . . . . 0.1UI_p to 16 UI_p
Step width . . . . 0.1 UI_p

Alarms

Alarms . . . . LTI (Loss of Timing Information) and AC line power failure

The counters are stopped during an alarm. The count resumes when the alarm is cleared and the gate time has not yet elapsed completely. The occurrence of an alarm is indicated by a yellow warming sign in front of the result. The warning sign is cleared when a new measurement is started.

Maximum count frequency . . . . approx. 20 kHz (sine wave)

Threshold setting error limits . . . . ±5% of threshold value, plus jitter meter error

3 Tolerance to jitter measurement

3.1 Fast Maximum Tolerable Jitter (F-MTJ)

Once the measurement is started, selectable jitter amplitude and jitter frequency combinations are set. The result for each combination (test point) is then indicated either as “OK” (no alarms or bit errors) or “Failed” (alarms or bit errors).

Error source selectable from:
SDH . . . . TSE (Test Sequence Error, bit error), B1, B2, B3, MS-REI, MS-RDI, HP-REI, HP-RDI, LP-REI, LP-RDI
SONET . . . . TSE (Test Sequence Error, bit error), B1, B2, B3, REI-L, REI-P, REI-V, RDI-L, RDI-P, RDI-V

Error threshold . . . . 0 to 999999

Delay (recovery time) . . . . 0.1 to 999 s

Selectable jitter frequencies (scan frequencies)
and jitter amplitudes . . . . see Tab. S-30, Page S-36

Display . . . . table of values

Default settings

f1 / A1 in kHz/UI_{pp}	**f2 / A2 in kHz/UI_{pp}**	**f3 / A3 in kHz/UI_{pp}**	**f4 / A4 in kHz/UI_{pp}**	**f5 / A5 in kHz/UI_{pp}**
0.012/622	5/1.5	100/1.5	1000/0.15	20000/0.15

Table S-37 Jitter frequency and jitter amplitude settings for Fast-MTJ measurement

The default values in the table represent the corner values of the limit curve specified in ITU-T Recommendation G.825.

3.2 Maximum Tolerable Jitter (MTJ)

Once the measurement is started, the jitter amplitude of the digital signal is altered until the bit error meter detects that a pre-set threshold has been exceeded. The maximum tolerable jitter value that will be shown is one search step less than the value causing the threshold violation.

Error source selectable from:
SDH . . . . TSE (Test Sequence Error, bit error), B1, B2, B3, MS-REI, MS-RDI, HP-REI, HP-RDI, LP-REI, LP-RDI
SONET . . . . TSE (Test Sequence Error, bit error), B1, B2, B3, REI-L, REI-P, REI-V, RDI-L, RDI-P, RDI-V

Error threshold . . . . 0 to 999999

Delay (recovery time) . . . . .0.1 to 999 s

Gate time . . . . 1 to 60 s

The jitter frequencies (scan frequencies) can be user defined as a group of up to 20 freely programmable frequencies in the range from 0.1 Hz to 20 MHz.

Display . . . . .table of values or log vs. log graph

Tolerance masks can also be displayed.

Default scan frequencies

f1 in kHz	f2 in kHz	f3 in kHz	f4 in kHz	f5 in kHz	f6 in kHz	f7 in kHz	f8 in kHz	f9 in kHz	f10 in kHz
0.012	0.1	1	5	20	100	500	1000	5000	20000

Table S-38 Default scan frequencies

Default tolerance mask

f1 / A1 in kHz/UI_{pp}	f2/A2 in kHz/UI_{pp}	f3 / A3 in kHz/UI_{pp}	f4 / A4 in kHz/UI_{pp}	f5 / A5 in kHz/UI_{pp}
0.0121/622	5/1.5	100/1.5	1000/0.15	20000/0.15

Table S-39 Default tolerance mask

4 Jitter Transfer Function

4.1 Jitter Transfer Function measurement

Once the measurement is started, a user-defined amplitude is set at each of the pre-selected jitter frequencies in turn. The Jitter Analyzer determines the jitter transferred by the device under test. The jitter is measured selectively, i.e. using a band-pass filter that is tuned to the modulation frequency. This ensures that interference frequencies outside the pass band of the filter do not affect the result.

The jitter transfer function is calculated from the logarithmic ratio of output jitter to input jitter on a point by point basis:

Jitter transfer function: $$H(f_j) = 20 \log \frac{\text{output jitter}}{\text{input jitter}}$$

Maximum measurement accuracy is achieved by means of a calibration measurement which can either be performed before every measurement (recommended) or stored for future use. The intrinsic error of the analyzer is determined at every selected scan frequency during a loop measurement (TX linked to RX). This intrinsic error correction is then applied to the results for the device under test as they are measured.

TX jitter settings . . . . .see Sec. 1, Page S-36

Measurement range, fixed . . . . 32 UI for f <1 kHz,
4 UI for f ≥1 kHz

Delay (recovery time) . . . . 0.1 to 999 s

Filter bandwidth (-3 dB) . . . . 10 Hz

The jitter frequencies (scan frequencies) can be user defined as a group of up to 20 freely programmable frequencies in the range from 10 Hz to 20 MHz.

Display . . . . table of values or log vs. log graph

Tolerance masks can also be displayed.

Default scan frequencies and amplitudes as per ITU-T G.825 and Bellcore GR-253

f1/Ampl. (kHz/UI)	**f2/Ampl. (kHz/UI)**	**f3/Ampl. (kHz/UI)**	**f4/Ampl. (kHz/UI)**	**f5/Ampl. (kHz/UI)**	**f6/Ampl. (kHz/UI)**	**f7/Ampl. (kHz/UI)**	**f8/Ampl. (kHz/UI)**
0.1/15	1/3.0	10/1.5	100/1.5	500/0.3	2000/0.15	5000/0.15	20000/0.15

Table S-40 Default scan frequencies and amplitudes

The default scan frequencies and amplitudes correspond to or are below the maximum tolerable jitter limit curves specified in the relevant standards. This ensures that the JTF measurement is not performed using unacceptably high levels of jitter.

Default tolerance mask as per ITU-T G.958, Bellcore GR-253 and ANSI T1.105.03

Frequency in kHz	f1 = 0.01	f2 = 2000	f3 = 20000
Maximum level in dB	0.1	0.1	-19.9
Minimum level in dB	-99.9	-99.9	-99.9

The default lower tolerance mask limit (min. dB) is always -99.9 dB and is not visible in the graph display.

4.2 Measurement error (typical)

The total error F_{total} is made up from the partial errors F1 + F2 + F3.

F1 and F2 depend on the transmitted jitter amplitude (F1) and on the measured jitter amplitude (F2). They can be read off from the diagrams below.
F3 depends on the measured jitter loss D (in dB) and on a bit rate-dependent constant k up to a maximum value,

where: $\mathbf{F3 = D \cdot k}$

Note: The value of F3 can never exceed $F3_{MAX}$.

k	**$F3_{MAX}$**
0.1	2 dB

Table S-41 Factor k and the maximum value $F3_{MAX}$

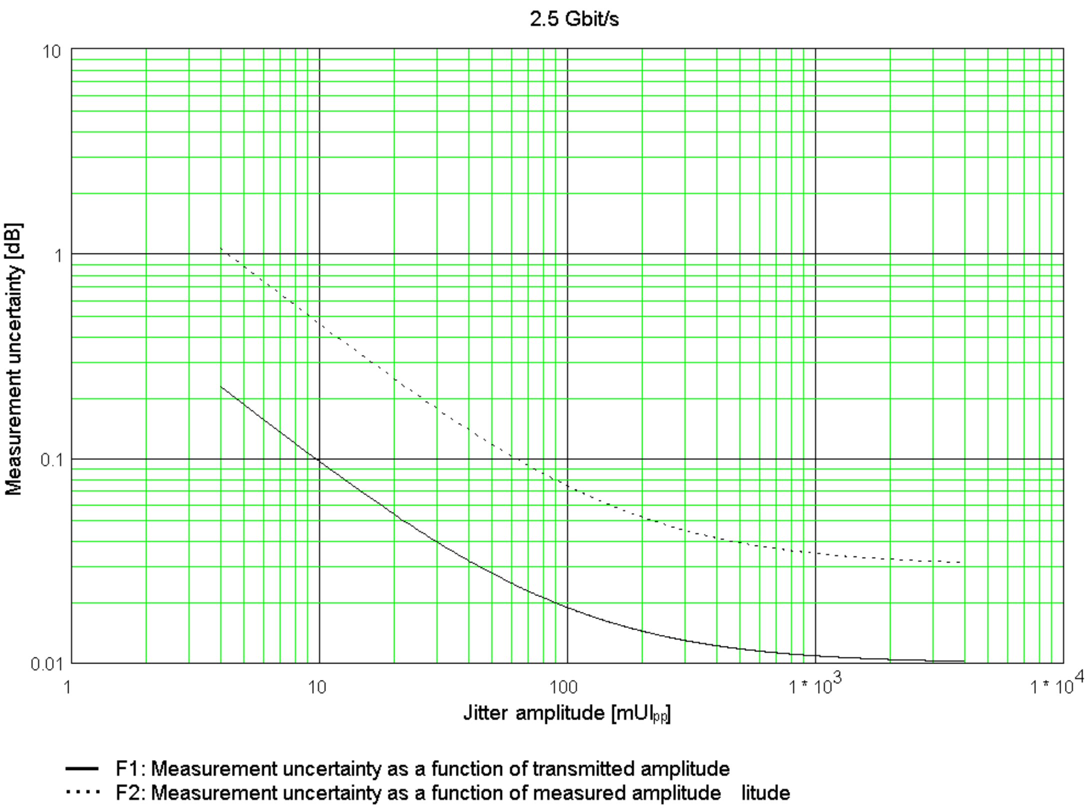


Fig. S-10 Measurement uncertainty at 2.5 Gbit/s

All data applies under the following conditions:

- Nominal optical level
- Temperature: 20 °C to 26 °C
- Integration time: 5 s
- Settling time: 1 s
- Complete instrument warm-up time: 30 minutes
  The relevant optical bit rate (STM-16) must also have been activated for at least five minutes.
- Calibration immediately before the measurement
- Jitter amplitude on jitter meter: 4 mUI to 4 UI
- Frequency range: 1 kHz to 20 MHz

Example

A jitter transfer of -21 dB is measured at a transmitted amplitude of 1000 mUI_{pp}.

To calculate the total error, errors F1 and F2 are taken from Fig. S-10. Error F3 is calculated using the relationship given above (k is taken from Table S-41).

F1 = 0.011 dB (from Fig. S-10)

The jitter transfer function

$$H(f_j) = 20 \log \frac{\text{measured jitter}}{\text{transmitted jitter}} = 20 \log \frac{x}{1000 \text{ mUI}} = -21 \text{ dB}$$

gives a measured jitter of approximately 90 mUI.

This value can be used to read the value of F2 from Fig. S-10.

F2 = 0.08 dB (from Fig. S-10)

$$F3 = 21 \text{ dB} \cdot 0.1 = 2.1 \text{ dB}$$

F3 is greater than $F3_{MAX}$ in Table S-41 (2.0 dB). The value $F3_{MAX}$ = 2.0 dB is therefore substituted for F3.

$\mathbf{F_{total}}$ = 0.011 dB + 0.08 dB + 2.0 dB **= 2.091 dB**

(0.011 dB = F1, 0.08 dB = F2, 2.0 dB = F3)

5 Wander Generator

Only possible if options BN 3035/90.88 **and** BN 3035/90.87 **and** BN 3035/90.81 are fitted.

5.1 Bit rate

Bit rate . . . . 2488320 kbit/s

Wander modulation shape. . . . . sine wave

Frequency range . . . . 10 µHz to 10 Hz

Wander frequency setting step width . . . . 1 µHz

Amplitude range . . . . 0.1 UI to 200000 UI

Wander amplitude setting step width. . . . . 0.1 UI

5.2 Wander amplitude, wander frequency and clock offset

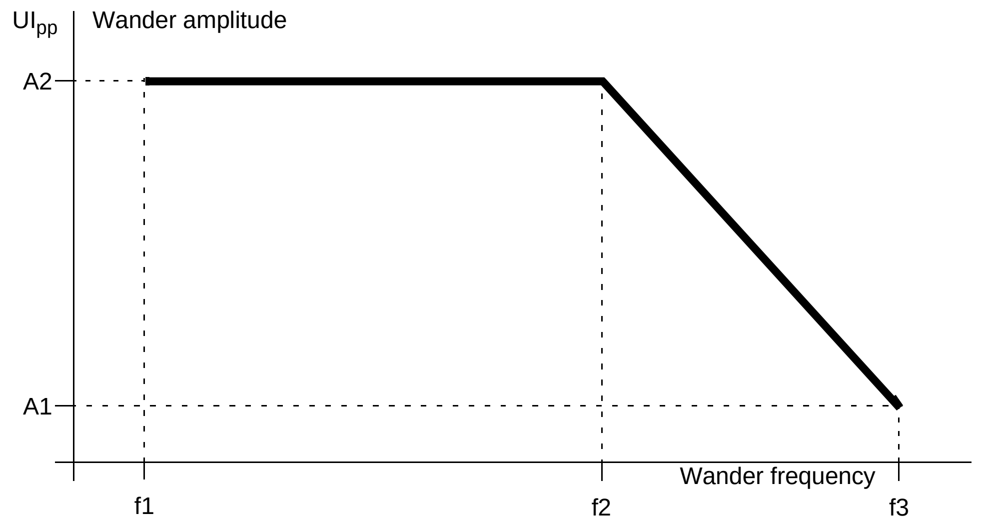


Fig. S-11 Maximum wander amplitude as a function of the wander frequency with the parameter of clock offset

Clock offset	**A1 in UI**	**A2 in UI**	**f1 in µHz**	**f2 in Hz**	**f3 in Hz**
0 ppm	2340	200000	10	0.117	10
50 ppm	390	200000	10	0.0195	10

Table S-42 Maximum wander amplitude as a function of the wander frequency with the parameter of clock offset

The maximum values for the amplitude / frequency combinations that can be set depend on the clock offset.

At a given modulation frequency, the maximum settable amplitude is the value 200000 UI or the value calculated from the following equation, whichever is the smaller:

$$A_{max} = \frac{23400 - 390 \times \Delta f}{f_{mod}}$$

A_{max} = maximum settable amplitude in UI

Δf = magnitude of clock offset in ppm

f_{mod} = modulation frequency in Hz

5.3 Error limits

5.3.1 Amplitude error

Amplitude error describes the deviation from the set amplitude for sine wave modulation.

Maximum deviation . . . . ±8% of set value ± 0.02 UI_{pp}

5.3.2 Intrinsic jitter / wander

The intrinsic jitter / wander indicates the maximum output jitter / wander of the ANT-20SE for a jitter / wander amplitude setting of 0 UI. A bandwidth between the filters HP1 and LP (see Tab. S-33, Page S-40) is assumed.

Intrinsic jitter / wander . . . . 0.04 UI

5.3.3 Modulation frequency

Modulation frequency accuracy . . . . ±0.1%

5.4 Synchronization

In Wander Generator mode, the generator of the ANT-20SE is normally synchronized to an external source. The appropriate reference signal should be fed into socket [25]. Refer to the “Specifications” for the mainframe instrument.

6 Wander Measurement

Only possible if options BN 3035/90.88 **and** BN 3035/90.89 are fitted.

6.1 Reference clock [54]

Tip: Wander measurements can only be performed using an external reference signal. This signal must conform with the clock frequencies and input levels specified below.

Socket . . . . BNC

Input impedance . . . . 75 Ω

Clock frequencies . . . . .1.544; 2.048; 5; 10 MHz

Permitted input level . . . . .0.5 to 5 V_{pp}

Monitoring . . . . LTI (Loss of Timing Information)

6.2 Measurement range

Wander amplitude range . . . . ±1 x 10^6 s

Maximum permitted phase change rate
Sample rate 1/s . . . . 1000 UI/s
Sample rate ≥ 30/s . . . . 10000 UI/s

The upper limit of the wander frequency range is set by a first-order low-pass filter. The low-pass filter is selected automatically to correspond with the selected sample rate.

Sample rate	**Low-pass filter/f_C**
1/s	0.1 Hz
30/s	10 Hz
60/s	20 Hz
300/s	100 Hz

Table S-43 Low-pass filters for various sample rates

Low-pass filter

Filter characteristic . . . . 1st order low-pass filter

Measurement bandwidth . . . . 0 Hz to f_{LIM}

Deviation in -3 dB cutoff frequency. . . . . f_{LIM} ± 10%

Maximum attenuation . . . . .at least 30 dB

1 Hz to 10 Hz passband ripple
(referred to attenuation at 0.1 Hz) . . . . <±0.2 dB

6.3 Result display

Result displayed in seconds
TIE (instantaneous value) . . . . numerically and graphically
MTIE (maximum difference) . . . . numerically

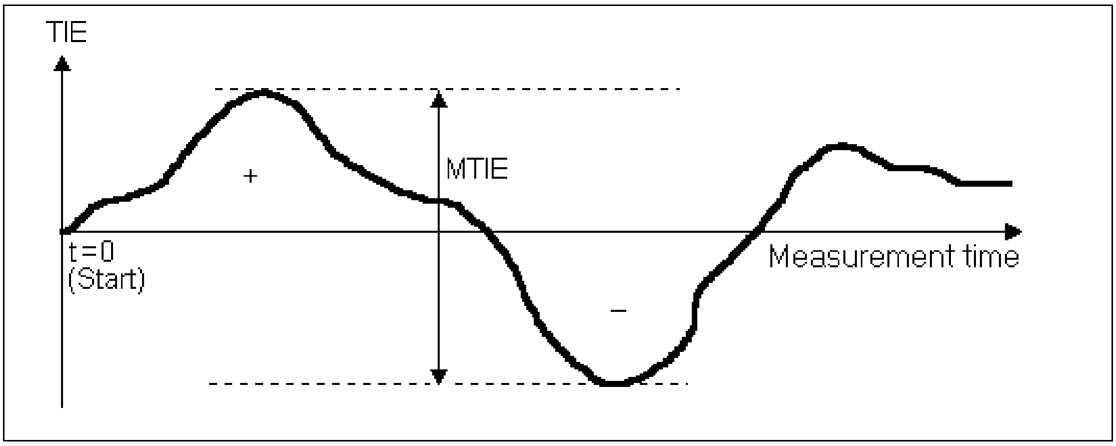


Fig. S-12 Example: Wander measurement versus measurement time

6.4 Accuracy

The specified measurement error applies after a warm-up period of at least 30 minutes for the ANT-20SE and a maximum change in ambient temperature of 5 K.

Overall TIE error for each TIE measurement
for an observation interval τ. . . . . <±5% of measured TIE value ± Z_0

Z_0 is taken from the following table:

Z_0 (τ)/ns	Observation interval τ/s
2.5 + 0.0275 τ	0.05 ≤ τ ≤ 1000
29 + 0.001 τ	τ > 1000

Table S-44 Error Z_0

6.5 Memory requirements

Before starting a long-term wander measurement, check the available hard disk space. The ANT-20SE software calculates the expected hard disk space requirements from the selected gate time and sample rate. A warning message is displayed if there is insufficient space.

Sample rate	Memory requirements
1/s	approx. 58 kB/h
30/s	approx. 1.65 MB/h
60/s	approx. 3.3 MB/h
300/s	approx. 16.5 MB/h

Table S-45 Memory requirements versus sample rate

7 Measurement of Maximum Tolerable Wander

only possible with options BN 3035/90.88 **and** BN 3035/90.87 **and** BN 3035/90.81

7.1 Maximum Tolerable Wander (MTW)

Note: The ANT-20SE's generator is normally synchronized externally in MTW mode. This is done by connecting an appropriate reference signal to socket [25]. Refer to the "Specifications" of the mainframe for details.
An appropriate message will be displayed when the MTW measurement is started if the internal clock source is used for a MTW measurement.

Variable combinations of wander amplitudes and wander frequencies are set once the measurement is started. The output signal is modulated for one period of the wander frequency for each combination of values. The measurement point is then marked as "OK" (no alarms or bit errors detected) or "Failed" (alarms or bit errors detected).

Error source, selectable
SDH . . . . TSE (Test Sequence Error, bit error), B1, B2, B3, MS-REI, MS-RDI, HP-REI, HP-RDI, LP-REI, LP-RDI
SONET . . . . TSE (Test Sequence Error, bit error), B1, B2, B3, REI-L, REI-P, REI-V, RDI-L, RDI-P, RDI-V

Error threshold . . . . 0 to 999999

Settling time (wait between measurements). . . . . 0.1 to 999 s

Settable values of wander frequency
(scan frequency) and wander amplitude . . . . see Tab. S-42, Page S-50

Display . . . . table of values

Default settings

Bit rate in kbit/s	f1 / A1 in Hz/UI	f2 / A2 in Hz/UI	f3 / A3 in Hz/UI	f4 / A4 in Hz/UI	f5 / A5 in Hz/UI	f6 / A6 in Hz/UI	Relevant standards
2488320	0.016/4977	0.05/1593	0.13/622	10/622	-	-	ITU-T G.813 (Option 1)

Table S-46 Settings for wander frequency and wander amplitude for MTW measurements

Note: The masks specified in the standards quoted generally start at lower frequencies (e.g. 12 µHz). These lower wander frequencies result in very long measurement times. They have therefore been omitted in order to reduce measurement times. You can alter the appropriate default settings if you want to make measurements at these lower frequencies.

8 Note for ANT-20SE users

The following hardware and software bundles have been formed for the ANT-20SE.

Assignments of modules and software ANT-20SE – ANT-20/ANT-20E:

	Module / Software	BN number ANT-20SE	Equivalent BN number
ANT-20SE Mainframe	Mainframe, SDH	3060/01	3035/41 or 3035/21 + 3035/92.15 + 3035/93.11 + 3035/90.01
	Mainframe, SONET	3060/02	3035/42 or 3035/22 + 3035/92.15 + 3035/93.11 + 3035/90.10
	Extended SDH Testing	3060/90.01	3035/90.02, 3035/90.03, 3035/90.04, 3035/90.05, 3035/90.06, 3035/90.15
	Extended SONET Testing	3060/90.02	3035/90.11, 3035/90.12, 3035/90.13, 3035/90.03, 3035/90.15
	Add SONET (SONET expansion for SDH mainframe)	3060/90.03	3035/90.10, 3035/90.11, 3035/90.12, 3035/90.13, 3035/90.34
	Add SDH (SDH expansion for SONET mainframe)	3060/90.04	3035/90.01, 3035/90.02, 3035/90.04, 3035/90.05, 3035/90.06, 3035/90.33
	Drop&Insert (Through mode, Block&Replace)	3060/90.10	3035/90.20
	PDH MUX/DEMUX (64/140)	3060/90.11	3035/90.30
	M13 MUX/DEMUX	3060/90.12	3035/90.32
Optics STM-1/4, OC-1/3/12	STM-1, OC-1/3 1310 nm	3060/91.01	3035/90.43 + 2 Adapters
	STM-1, OC-1/3 1310 nm & 1550 nm	3060/91.02	3035/90.45 + 2 Adapters
	STM-1/4, OC-1/3/12 1310 nm	3060/91.11	3035/90.46 + 2 Adapters
	STM-1/4, OC-1/3/12 1310 nm & 1550 nm	3060/91.12	3035/90.48 + 2 Adapters
	Optical power splitter	3060/91.05	3035/90.49 + 3 Adapters
	OC-12c BULK	3060/90.90	3035/90.90
	OC-12c Virtual concatenation	3060/90.92	3035/90.92

Table O-47 Assignments of modules and software

	Module / Software	BN number ANT-20SE	Equivalent BN number
Optics STM-16, OC-48	STM-16, OC-48 1550 nm	3060/91.50	3035/91.53 + 2 Adapters
	STM-16, OC-48 1310 nm	3060/91.51	3035/91.54 + 2 Adapters
	STM-16, OC-48 1310 nm & 1550 nm	3060/91.52	3035/91.59 + 2 Adapters
	STM-16, OC-48 15... nm, special	3060/91.53	3035/90.38 + 2 Adapters
	OC-48c BULK	3060/90.93	3035/90.93
	Package: STM-0/1/4/16 1310 nm + Concatenation	3060/90.55	3035/90.46, 3035/91.54, 3035/90.90, 3035/90.93, + 4 Adapters
	Package: STM-0/1/4/16 1550 nm + Concatenation	3060/90.56	3035/90.47, 3035/91.53, 3035/90.90, 3035/90.93, + 4 Adapters
	Package: STM-0/1/4/16 1310 nm & 1550 nm + Concatenation	3060/90.57	3035/90.48, 3035/91.59, 3035/90.90, 3035/90.93, + 4 Adapters
	Package: STM-0/1/4 1310 nm STM-16 1550 nm + Concatenation	3060/90.58	3035/90.46, 3035/91.53, 3035/90.90, 3035/90.93, + 4 Adapters
Jitter O.172	Package: O.172 Jitter/Wander up to 155 Mbit/s	3060/91.30	3035/90.81, 3035/90.85, 3035/90.82, 3035/90.86
	Package: O.172 Jitter/Wander up to 622 Mbit/s	3060/91.31	3035/91.31
	Package: O.172 Jitter/Wander up to 2488 Mbit/s	3060/91.32	3035/91.32
	MTIE/TDEV Analysis Part of 3060/91.30 to 91.32	-	3035/95.21
ATM	ATM Basic	3060/90.50	3035/90.70
	ATM Comprehensive	3060/90.51	3035/91.80
	Add ATM SDH	3060/90.52	3035/90.72, 3035/90.74, 3035/90.75, 3035/90.77, 3035/90.33
	Add ATM SONET	3060/90.53	3035/90.71, 3035/90.73, 3035/90.76, 3035/90.34,
	OC-12c ATM Testing	3060/90.91	3035/90.91
Accessories	Remote control, V.24	3035/91.01	
	Remote control, GPIB	3035/92.10	
	Remote Operation Modem	3035/95.30	
	Remote Operation LAN/PCMCIA	3035/95.31	
	PDH/SDH NEXT Expert	3035/95.40	
	Test Sequencer	3035/95.90	
	LabWindows/CVI drivers	3035/95.99	
	Calibration report	3035/94.01	
	Transport case	3035/92.03	

Table O-47 Assignments of modules and software

Notes:

Index

Notes: