ERRATA
FOR
INSTRUCTION MANUAL
MODELS 452 & 852
DUAL HI/LO FILTERS
DATED 10/86

Make the following changes to the manual:

Page 1-3, Paragraph 1-4, following "Frequency Range" table:
Add "NOTE: Specifications apply for cutoff frequency dial settings from 0.10 to 10.1010".

Page 1-4, Paragraph 1-4, Maximum Stopband Attenuation:
Replace "90 dB" with:
"80 dB minimum ($f_{in} \leq$ 400 kHz, 1K and 10K multiplier ranges)
70 dB minimum ($f_{in} \leq$ 300 kHz, 100 and 10 multiplier ranges)".

Page 1-6, Paragraph 1-5, following "Frequency Range" table (bottom of page):
Add "NOTE: Specifications apply for cutoff frequency dial settings from 0.10 to 10.1010".

Page 1-7, Paragraph 1-5, Maximum Stopband Attenuation:
Replace "90 dB" with:
"80 dB minimum ($f_{in} \leq$ 400 kHz, 1K and 10K multiplier ranges)
70 dB minimum ($f_{in} \leq$ 300 kHz, 100 and 10 multiplier ranges)".

Page 4-12, Table 4.5, Specification:
Replace "90 dB" with "80 dB" (two locations).

Page 4-15, Table 4.5, Specification:
Replace "90 dB" with "80 dB" (two locations).

Page 5-5, Parts List 004-0930:
Change "R4" to "R4, R38*".
Change "R12, R20, R25, R32, R38*" to "R12, R20, R25, R32."

Drawing 03-004-0930:
Change R38 from 1K to 4.7K.

INSTRUCTION MANUAL

MODELS 452 AND 852
DUAL HI/LO FILTERS

WAVETEK

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Manual Revision: 10/86

WARRANTY

Wavetek warrants that all products manufactured by Wavetek conform to published Wavetek specifications and are free from defects in materials and workmanship for a period of one (1) year from the date of delivery when used under normal operating conditions and within the service conditions for which they were furnished.

The obligation of Wavetek arising from a Warranty claim shall be limited to repairing, or at its option, replacing without charge, any product which in Wavetek's sole opinion proves to be defective within the scope of the Warranty. In the event Wavetek is not able to modify, repair or replace non-conforming defective parts or components to a condition as warrantied within a reasonable time after receipt thereof, Buyers shall be credited for their value at the original purchase. price.

Wavetek must be notified in writing of the defect or nonconformity within the Warranty period and the affected product returned to Wavetek's factory or to an authorized service center within (30) days after discovery of such defect or nonconformity.

For product warranties requiring return to Wavetek, products must be returned to a service facility designated by Wavetek. Buyer shall prepay shipping charges, taxes, duties and insurance for products returned to Wavetek for warranty service. Except for products returned to Buyer from another country, Wavetek shall pay for return of products to Buyer.

Wavetek shall have no responsibility hereunder for any defect or damage caused by improper storage, improper installation, unauthorized modification, misuse, neglect, inadequate maintenance, accident or for any product which has been repaired or altered by anyone other than Wavetek or its authorized representative and not in accordance with instructions furnished by Wavetek.

Exclusion of Other Warranties

The Warranty described above is Buyer's sole and exclusive remedy and no other warranty, whether written or oral, is expressed or implied. Wavetek specifically disclaims the implied warranties of merchantability and fitness for a particular purpose. No statement, representation, agreement, or understanding, oral or written, made by an agent, distributor, representative, or employee of Wavetek, which is not contained in the foregoing Warranty will be binding upon Wavetek, unless made in writing and executed by an authorized Wavetek employee. Under no circumstances shall Wavetek be liable for any direct, indirect, special, incidental, or consequential damages, expenses, losses or delays (including loss of profits) based on contract, tort, or any other legal theory.

SAFETY

This instrument is wired for earth grounding via the facility power wiring. Do not bypass earth grounding with two wire extension cords, plug adapters, etc.

BEFORE PLUGGING IN the instrument, comply with installation instructions.

MAINTENANCE may require power on with the instrument covers removed. This should be done only by qualified personnel aware of the electrical hazards.

The instrument power receptacle is connected to the instrument safety earth terminal with a green/yellow wire. Do not alter this connection. (Reference: ⏚ or ⚠ stamped inside the rear panel near the safety earth terminal.)

WARNING notes call attention to possible injury or death hazards in subsequent operations.

CAUTION notes call attention to possible equipment damage in subsequent operations.

SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION

The Models 452 and 852 are versatile dual-channel filters consisting of two identical channels in a common cabinet. Each filter channel has separate input/output terminals, offers high pass and low pass functions, 0 dB and 20 dB gain, Butterworth and Linear Phase responses and 3-digit resolution for cutoff frequency selection.

Individual channels may be readily interconnected for series or parallel operation, resulting in bandpass (or doubled rolloff) and band reject functions respectively.

Each filter channel provides switch selectable Flat Amplitude (Butterworth) response and Flat Delay (Linear Phase) response.

The Butterworth filter has maximally-flat amplitude response suitable for frequency-domain applications. Its cutoff frequency (fc) is defined as the frequency at which the amplitude response is down 3 dB.

The Linear Phase filter approximates a constant time delay for frequencies below its cutoff frequency. This filter is suitable for time-domain applications because of its inherent ability to pass transient waveforms with a very small amount of distortion and overshoot.

Models 452 and 852 are electrically and mechanically similar, covering the cutoff frequency range of 0.1 Hz to 111 KHz. Rolloff of the Model 452 is 24 dB/octave/channel, Model 852 is 48 dB/octave/channel. Factory-installed Option -01 extends cutoff frequency range and resolution on both models to 0.01 Hz.

Frequency-determining passive elements of the filters consist of stable precision metal film resistors and close tolerance polycarbonate or mica film capacitors. The active elements are FET-input IC operational amplifiers which provide highly stable gain, and very low noise and distortion. This combination of active and passive elements produces a filter having high cutoff frequency accuracy and resettability, and excellent temperature and long term stability. Another result of precise control of frequency-determining elements is close amplitude and phase match between channels.

1-2. DESCRIPTION

ELECTRICAL. Models 452 and 852 operate from either 115 or 230 volts ac, 50-500 Hz, and consume less than 5 watts of power. A rear-panel slide switch selects the nominal line voltage. The case of the instrument is grounded through the power cord, but signal ground can be isolated from power ground (through a 0.01 uf capacitor) via a rear-panel slide switch.

Cutoff frequency of each channel is selected via three 11-position (0-10) switches and a 4-position multiplier switch. The two pilot lights also serve as cutoff frequency decimal point indicators. Passband Gain of 0 dB or 20 dB may be selected for each channel. High Pass or Low Pass mode is individually selectable for each channel, as well as Flat Amplitude or Flat Delay response.

MECHANICAL. The instrument cabinet is 3.5 inches high by 17 inches wide (19 inches wide including rack mounts). It is 13 inches deep and weighs 10 pounds (Model 452) or 12 pounds (Model 852).

The power switch, operating controls, and input and output terminals are located on the front panel. The rear panel contains duplicate (parallel) input and output terminals for each channel, power connector, the fuse holder, the 115/230 Vac line selector switch, and a switch to disconnect signal ground from the power ground.

In its standard configuration the instrument is supplied in a cabinet suitable for table-top use, with feet and tiltstand. A rack-mount configuration is also available (See Options).

1-3. OPTIONS

The following options are available for both models:

Option -01:	Extends low frequency range and resolution to 0.01 Hz.
Option -02:	Provides 600-ohm nominal output impedance instead of 50 ohms.
Option -03:	The instrument is shipped from the factory in a rack-mount configuration without feet and tiltstand.
Option -04:	A field-installable conversion kit, supplied in addition to the standard configuration. It enables the user to convert the instrument to rack-mount configuration.

1-4. SPECIFICATIONS, MODEL 452 & 452-01

FUNCTIONS

Each Channel:	Low Pass (DC Coupled) with 24 dB/oct rolloff High Pass with 24 dB/oct rolloff
Two Channels connected in series:	
Identical cutoff frequencies	Low Pass with 48 dB/oct rolloff
Identical cutoff frequencies	High Pass with 48 dB/oct rolloff
One channel High Pass, one channel Low Pass	Band Pass with 24 dB/oct rolloffs
Two channels connected in parallel:	Band Reject: Broadband with 24 dB/oct rolloff, or Sharp Notch Response

CUTOFF FREQUENCY RANGE & RESOLUTION

Frequency Settings: Three 11-position switches (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10) and a four-position (x10, x100, x1K, x10K) multiplier switch. Option -01 adds a fifth position (x1) to the multiplier switch.

Frequency Range:

	Multiplier	Frequency (Hz)	Resolution (Hz)
With Option -01	x1	0.01-11.1	0.01
	x10	0.1-111	0.1
	x100	1-1.11K	1
	x1K	10-11.1K	10
	x10K	100-111K	100

FLAT AMPLITUDE (BUTTERWORTH) RESPONSE

Passband Gain:

Low Pass: 0 dB/20 dB, ± 0.25 dB.
High Pass: 0 dB/20 dB, ± 0.25 dB, (±0.5 dB in x 10K Multiplier position); - 3dB at approximately 2 MHz.

Band Pass: Depends on separation of cutoff frequencies. If separation is more than two octaves, the Low Pass & High Pass specifications apply. If Low Pass & High Pass cutoffs are identical, an insertion loss of approx. 6 dB is produced; the 3 dB bandwidth extends from 0.8 f_c to 1.25 f_c and is equal to 0.45 f_c.
Band Reject & Sharp Notch: An insertion loss of approximately 6 dB is produced.

FLAT AMPLITUDE (BUTTERWORTH) RESPONSE - continued

Cutoff Frequency Accuracy:	± 2%
Attenuation at Cutoff:	3 dB
Stopband Attenuation Rate (Rolloff):	24 dB/octave, nominal
Maximum Stopband Attenuation:	90 dB
Stability of Cutoff Frequency (Typical):	± 200 ppm/°C
Phase Match between Channels (Typical):	1° or 1%, whichever is greater

FLAT DELAY RESPONSE

Low Pass Delay (Typical):	$\frac{1}{2 f_c}$ seconds
Attenuation at Cutoff:	Approx. 9 dB
Stability of Delay (Typical):	± 200 ppm/°C
Phase Match between Channels (Typical):	1° or 1%, whichever is greater

INPUT CHARACTERISTICS

Circuit:	Single-ended, diode-protected
Impedance:	1 Megohm shunted by 50 pF
Full-scale Signal at 0 dB Gain:	± 10 Volts (7.1 V rms) DC to 300 KHz, decreasing to ± 4 Volts (2.8 V rms) at 1 MHz (Divide these by 10 at 20 dB Gain).
Absolute max. Input:	± 100 Volts
Max. DC component:	High Pass: ± 100 Volts, 0 dB gain, ± 10 Volts, 20 dB gain

OUTPUT CHARACTERISTICS

Circuit:	Single-ended, short-circuit protected, may be d-c isolated from power ground by rear panel switch
Impedance:	50 ohms, nominal
Full-Scale Signal:	± 10 Volts (7.1 V rms) DC to 300 KHz, decreasing to ± 4 Volts (2.8 V rms) at 1 MHz ($R_L \geqq 5K$),± 15 mA max. current
Broadband Noise at either Gain Setting:	100 microvolts rms max. for 100 KHz detector bandwidth
Harmonic Components: Input f = 1 KHz	90 dB below full-scale signal
A-C Line-related Spurious Components:	110 dB below full-scale signal *
DC Offset at 25° C:	Within ±2.5 millivolts at any f_c setting
Drift vs. Temperature:	100 microvolts/°C typ, 500 microvolts/°C max.
Drift vs. Time (Typical):	100 microvolts/week

TYPICAL EQUIVALENT INPUT NOISE SPECTRAL DENSITY

At f = 10 Hz	100 nanovolts/$\sqrt{Hz}$
f = 100 Hz	60 nanovolts/$\sqrt{Hz}$
f ≧ 1 KHz	20 nanovolts/$\sqrt{Hz}$

GENERAL

Power Requirements:	115/230 Vac ± 10%, 50-500 Hz, 5 watts
Operating Temperature:	0°C to + 50°C
Storage Temperature:	-20°C to + 70°C
Connectors:	BNC's on front & rear panel
Floating Operation:	Slide switch on rear panel to disconnect circuit ground from power ground.

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* Derate specification by 6 dB for Model 452-01 when operating in its optional range (x1)

GENERAL - continued

Size:	3-1/2" H x 17" W x 13" D (8.9 cm x 43.2 cm x 33 cm)
Weight:	10 lbs. (4.5 Kg) Net, 14 lbs. (6.5 Kg) Shipping
Configuration:	Bench-Top, convertible to rack-mount
Accessories supplied:	2 Instruction Manuals

1-5. SPECIFICATIONS, MODEL 852 & 852-01

FUNCTIONS

Each Channel:	Low Pass (DC Coupled) with 48 dB/oct rolloff High Pass with 48 dB/oct rolloff
Two Channels connected in series:	
(Identical cutoff frequencies)	Low Pass with 96 dB/oct rolloff
(Identical cutoff frequencies)	High Pass with 96 dB/oct rolloff
(One channel High Pass, one channel Low Pass)	Band Pass with 48 dB/oct rolloff
Two channels connected in parallel:	Band Reject with 48 dB/oct rolloff

CUTOFF FREQUENCY RANGE & RESOLUTION

Frequency Settings: Three 11-position switches (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10) and a four-position (x10, x100, x1K, x10K) multiplier switch. Option -01 adds a fifth posotion (x1) to the multiplier switch.

Frequency Range:

	Multiplier	Frequency (Hz)	Resolution (Hz)
With Option -01	x1	0.01-11.1	0.01
	x10	0.1-111	0.1
	x100	1-1.11K	1
	x1K	10-11.1K	10
	x10K	100-111K	100

FLAT AMPLITUDE (BUTTERWORTH) RESPONSE

Passband Gain:	Low Pass: 0 dB/20 dB, ± 0.5 dB. High Pass: 0 dB/20 dB, ± 0.5 dB, (± 1 dB in x 10K Multiplier position); - 3 dB at approximately 1 MHz. Band Pass: Depends on separation of cutoff frequencies. If separation is more than two octaves, the Low Pass & High Pass specifications apply. If Low Pass & High Pass cutoffs are identical, an insertion loss of approx. 6 dB is produced; the 3 dB bandwidth extends from 0.9 f_c to 1.12 f_c and is equal to 0.22 f_c. Band Reject: An insertion loss of approximately 6 dB is produced.
Cutoff Frequency Accuracy:	± 2%
Attenuation at Cutoff:	3 dB
Stopband Attenuation Rate (Rolloff):	48 dB/octave, nominal
Maximum Stopband Attenuation:	90 dB
Stability of Cutoff Frequency (Typical):	± 200 ppm/°C
Phase Match between Channels (Typical):	2° or 2%, whichever is greater

FLAT DELAY RESPONSE

Low Pass Delay (Typical):	$\frac{1}{f_c}$ seconds
Attenuation at Cutoff:	Approx. 17 dB
Stability of Delay (Typical):	± 200 ppm/°C
Phase Match between Channels (Typical):	2° or 2%, whichever is greater

INPUT CHARACTERISTICS

Circuit:	Single-ended, diode-protected
Impedance:	1 Megohm shunted by 50 pF in 0 dB Gain, shunted by 75 pF in 20 dB Gain

INPUT CHARACTERISTICS - continued

Full-Scale Signal at 0 dB Gain:	± 10 Volts (7.1 V rms) DC to 300 KHz, decreasing to ± 4 Volts (2.8 V rms) at 1 MHz (Divide these by 10 at 20 dB Gain).
Absolute max. Input:	± 100 Volts
Max. DC component:	High Pass: ± 100 Volts, 0 dB gain, ± 10 Volts, 20 dB gain

OUTPUT CHARACTERISTICS

Circuit:	Single-ended, short-circuit protected, may be d-c isolated from power ground by rear panel switch
Impedance:	50 ohms, nominal
Full-Scale Signal:	± 10 Volts (7.1 V rms) DC to 300 KHz, decreasing to ± 4 Volts (2.8 V rms) at 1 MHz ($R_L \geqq 5$ K), ± 15 mA max. current
Broadband Noise at either Gain Setting:	200 microvolts rms max. for 100 KHz detector bandwidth
Harmonic Components: Input f = 1 KHz	80 dB below full-scale signal
A-C Line-related Spurious Components:	100 dB below full-scale signal *
DC Offset at 25°C:	Within ± 2.5 millivolts at any f_c setting
Drift vs. Temperature:	300 microvolts/°C typ, 1.5 millivolts/°C max.
Drift vs. Time (Typical):	500 microvolts/week

TYPICAL EQUIVALENT INPUT NOISE SPECTRAL DENSITY

At f = 10 Hz	250 nanovolts/ $\sqrt{Hz}$
f = 100 Hz	100 nanovolts/ $\sqrt{Hz}$
f ≧ 1 KHz	40 nanovolts/ $\sqrt{Hz}$

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* Derate specification by 6 dB for Model 852-01 when operating in its optional range (x1)

GENERAL

Power Requirements:	115/230 VAC ± 10%, 50-500 Hz, 5 watts
Operating Temperature:	0° C to + 50°C
Storage Temperature:	-20°C to + 70°C
Connectors:	BNC's on front & rear panel
Floating Operation:	Slide switch on rear panel to disconnect circuit ground from power ground.
Size:	3 1/2" H x 17" W x 13" D (8.9 cm x 43.2 cm x 33 cm)
Weight:	12 lbs. (5.5 Kg) Net, 15 lbs. (7 Kg) Shipping
Configuration:	Bench-Top, convertible to rack-mount
Accessories supplied:	1 Instruction Manual

SECTION II

OPERATION

2-1. INTRODUCTION

The instrument is electrically operational as shipped from the factory. The following paragraphs describe inspection, power requirements, interconnection, and operation.

2-2. INSPECTION

This instrument was carefully inspected and tested prior to shipment. It was operated for a number of hours to reduce the probability of early failure. After unpacking the unit, inspect it carefully for shipping damage. Check especially for broken controls and connectors, and dented or scratched cabinet parts. Should the instrument show any signs of damage, file a claim with the carrier immediately. Preserve the carton and packing materials; they will be required by the carrier.

It is recommended that conformance to specifications be verified upon receipt. In case of discrepancies, refer to the warranty at the beginning of this manual.

2-3. INSTALLATION AND POWER REQUIREMENTS

Models 452 and 852 are designed for table-top operation or installation in a standard 19-inch RETMA rack. Ambient temperature within the rack must not exceed +50°C while the instrument is operating. Other paragraphs in this section describe connections and switch settings which should be made before the unit is installed.

Installation

To convert the instrument for mounting into a standard 19 inch wide rack, the following procedure should be followed. (Refer to Figure 2-0).

1. Unplug instrument from AC power source.
2. Stand instrument on one side.
3. Align rack mount bracket with raised edge of instrument as shown.
4. Holes on rack mount bracket should correspond to pem nut holes just underneath black trim strip. Use a pointed object to pierce the black trim strip at the pem nut holes.
5. Use lock washers and metal screws provided to secure rack mount bracket.
6. Repeat for other side bracket.

   CAUTION: Rack mount brackets are to prevent the instrument from sliding when mounted in a rack. They are not intended to support the weight of the instrument and should never be used for lifting or carrying.

Instrument is now ready for rack installation.

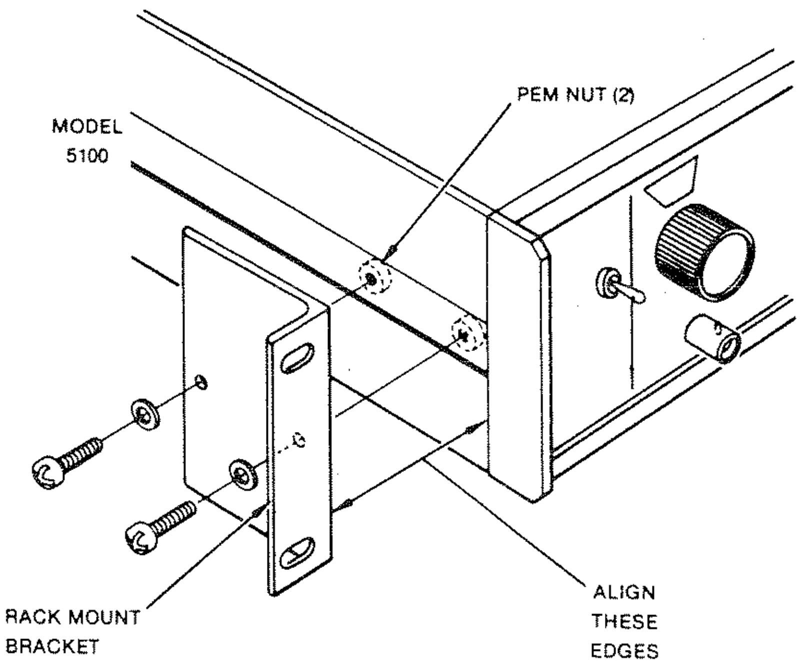

Figure 2-0. Installing Rack Mount Bracket

CAUTION

Always ensure that the 115/230 volt switch is set for the nominal line voltage and that a fuse of the proper rating is installed in the instrument. If the switch is set incorrectly or a fuse of the wrong rating is used, the instrument may be damaged or fail to operate.

Power
The instrument will operate from either 115 or 230 volts ac, 50-500 Hz. Converstion for line voltage is performed with a slide switch mounted on the rear panel (see Figure 2-1). The unit is shipped with the switch set for 115 volts. To change the setting, insert a small-blade screwdriver in the switch slot and move switch to expose 115 for 115 Vac operation, or 230 for 230 Vac operation.

The instrument is shipped with a 1/4-amp slow-blow fuse for 115-volt or 230-volt operation.

WARNING

In keeping with standard safety practice, the case of the instrument is grounded through the power cord. If the instrument must be connected to a two-wire receptacle, use a parallel-ground adapter and connect the short lead to ground.

2-4. CONTROLS AND INDICATORS

Controls and indicators are shown in Figure 2-1 and described in Table 2-1. The descriptions in Table 2-1 and the following paragraphs are not intended to be complete operating instructions, but only general information applying to all modes of operation. Paragraphs 2-5, through 2-10 describe filter settings, interconnection, and typical operating procedures.

Table 2-1. Controls and Indicators

NUMBER	DESCRIPTION
1	On Switch: The switch is moved to the on position to supply power to the instrument
-	Controls and Indicators numbered 2 through 11 pertain to Channel 1:
2	First significant digit of Cutoff Frequency setting, 0 - 10 positions, continuous rotation
3	A light-emitting diode (LED) indicates that power is on and also serves as a decimal point indicator for the Cutoff Frequency setting

Table 2-1. Controls and Indicators (Continued)

NUMBER	DESCRIPTION
4	Second significant digit of Cutoff Frequency setting, 0 - 10 positions, continuous rotation
5	Third significant digit of Cutoff Frequency setting, 0 - 10 positions, continuous rotation
6	Decimal Multiplier of Cutoff Frequency setting, 4 or 5 positions, depending on option
7	Low Pass (In) or High Pass (Out) selector switch
8	Output BNC Connector
9	Flat Delay (In) or Flat Amplitude (Out) selector switch
10	20 dB Gain (In) or 0 dB Gain (Out) selector switch
11	Input BNC Connector
-	Channel 2 Controls and Indicators are identical to those of Channel 1
12	Channel 2 Output BNC Connector
13	Channel 2 Input BNC Connector
14	Fuseholder for 1/4 Amp slow-blow fuse for either 115 V or 230 V operation
15	115/230 V line voltage selector switch
16	Two position switch: connects signal ground to power (and chassis) ground, or floats signal ground
17	Channel 1 Output BNC Connector
18	Channel 1 Input BNC Connector
19	3-wire power cord

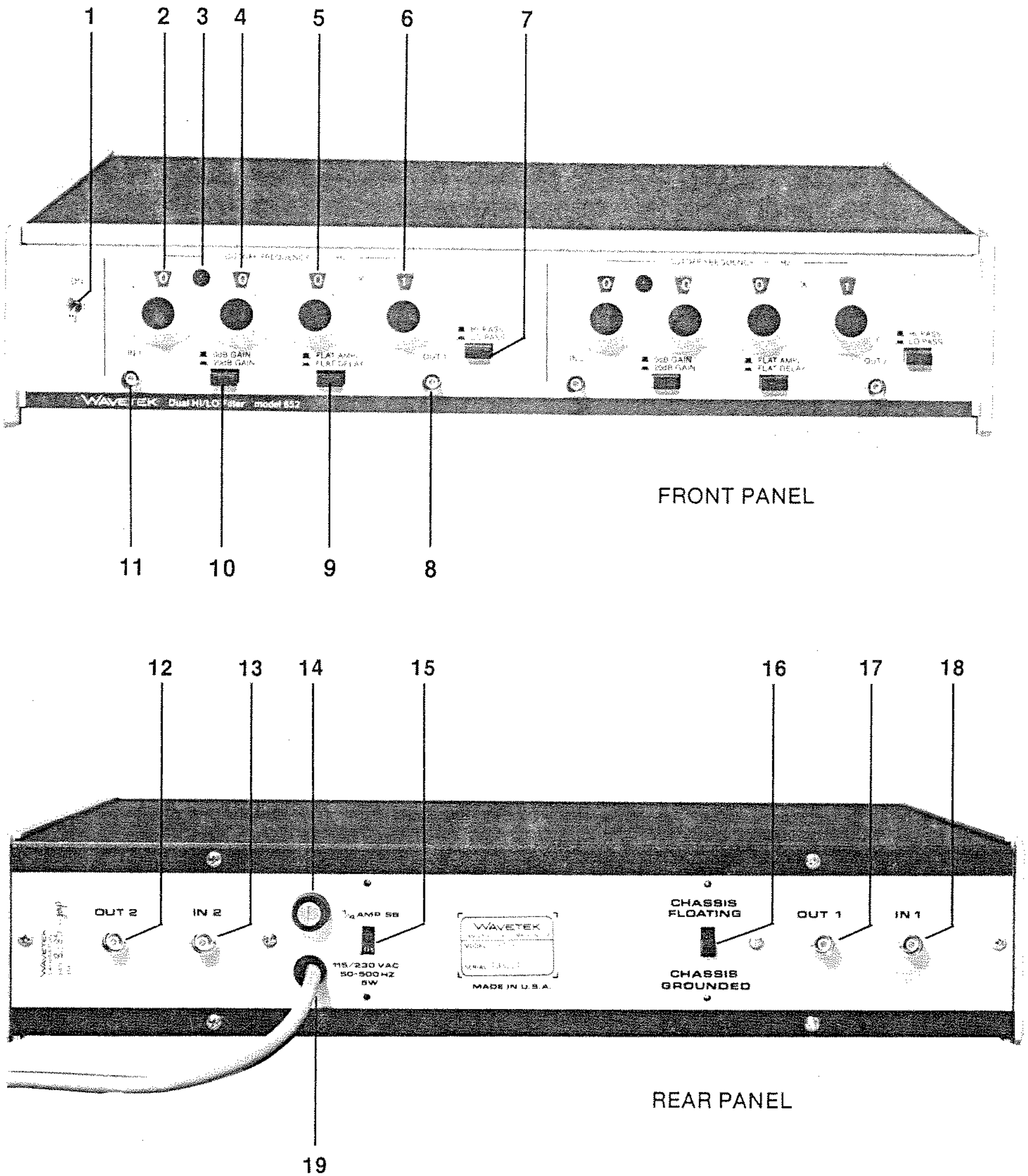

Figure 2-1. Controls and Indicators

2-5. INPUT SIGNAL

The maximum input signal amplitude (at 0 dB Gain) is specified as ±10 Volts (7.1 V rms) up to a frequency of 300 KHz. This is the signal amplitude which can be handled linearly by the instrument. Above 300 KHz the input signal handling capability is reduced as shown in Fig. 2-2. The reduction is due to Slew-Rate* limitations of the Operational Amplifiers employed in the instrument.

When 20 dB Gain is employed, the maximum input signal amplitude is ±1.0 Volt (0.71 V rms) up to 300 KHz.

CAUTION

Input signals in excess of ±100 V in either Gain setting may damage the instrument.

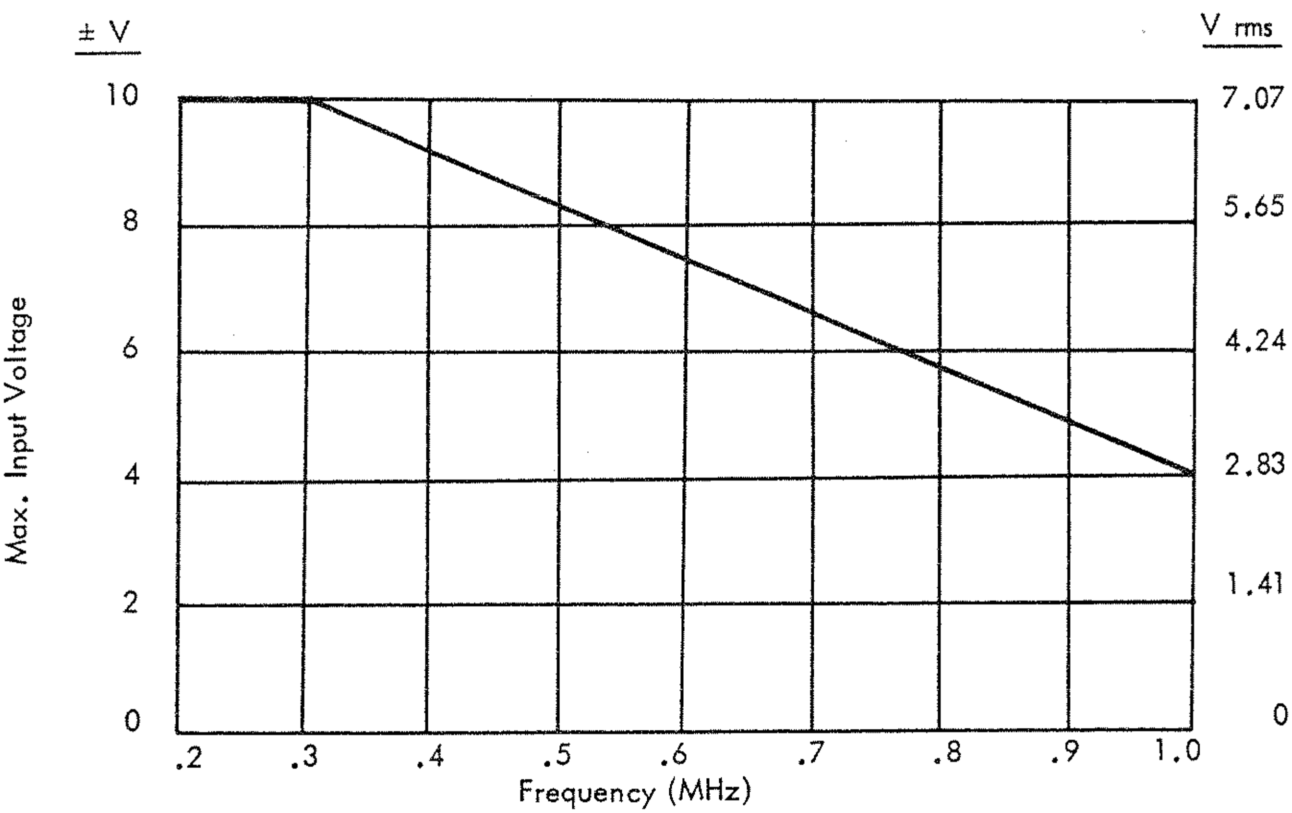

Fig. 2-2 Full-Scale Input Signal vs. Frequency

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* The term "Slew-Rate" refers to the ability of an Operational Amplifier to follow fast changes in input signal and it is usually expressed in volts/usec.

2-6. TYPICAL OPERATING PROCEDURES

a. Low-Pass or High-Pass Filter

The operating mode of each channel of the instrument is selected with the HI PASS/LO PASS switch. The position of this switch determines whether the channel is operating as a Low Pass (IN) or High Pass (OUT) filter.

In the Low Pass mode of operation the passband of the filter extends from DC to the cutoff frequency which is defined by the settings of the three CUTOFF FREQUENCY dials and the MULTIPLIER. In the High Pass mode of operation the passband extends from the cutoff frequency setting to the upper 3-dB point of the instrument (approximately 2 MHz for Model 452 and 1 MHz for Model 852).

b. Response Selection

The desired type of response for each channel is selected with the FLAT AMPL/ FLAT DELAY switch. The position of this switch determines whether the response of the channel is a Butterworth response (OUT) or Linear Phase response (IN).

The Butterworth characteristic provides a maximally flat amplitude response which is 3 dB down at the cutoff frequency. Beyond the cutoff frequency the amplitude response rolls off at a rate of 24 dB/octave (80 dB/decade) for the Model 452 and 48 dB/octave (160 dB/decade) for the Model 852.

The Low-Pass or High-Pass Butterworth response for either model may be determined by scaling the normalized plots given in Figures 2-3, 2-4, 2-5 and 2-6. To determine the frequency response for a particular Cutoff Frequency setting, the normalized scale on these plots should be multiplied by the cutoff frequency. For example, if the cutoff frequency is set to 500 Hz Low-Pass, then "1" on the normalized scale represents 500 Hz, "2" represents 1000 Hz and ".5" represents 250 Hz.

The Flat Delay characteristic provides a response which is useful for filtering squarewave or pulsed waveforms with minimum overshoot and ringing. While this response is available in either Low-Pass or High-Pass modes of operation, its primary usefulness is in Low-Pass mode.

Normalized Delay characteristics are given in Figures 2-7, 2-8, 2-9 and 2-10. For comparison, these figures include Phase and Delay characteristics for the Butterworth response.

The procedure for determining the Phase or Delay response for a particular Cut-off Frequency from the normalized plots is the same as outlined for the amplitude response. The actual Delay in seconds is equal to the value obtained from the plot divided by the value of cutoff frequency.

c. Gain Selection

The passband gain of each channel is selected with the 0 dB GAIN/20 dB GAIN Switch. The position of this switch determines whether the channel is operating with 0 dB Gain (OUT), or 20 dB Gain (IN).

The 20 dB Gain position is useful when filtering low-level signals. Since output noise of the filter is independent of the gain position, a 20 dB effective improvement in dynamic range is achieved.

d. Band-Pass Filter

The two channels of the instrument, one in High-Pass and the other in Low-Pass mode, may be cascaded as shown in Fig. 2-11 to provide Band-Pass operation. Flat Amplitude (Butterworth) response should be utilized in both channels.

When channels are cascaded for Band-Pass operation, the input signal should be connected to the High-Pass channel (IN 1), and the output of this channel (OUT 1) should be connected to the input of the Low-Pass channel (IN 2). The output signal is available at OUT 2.

The passband in this configuration extends from the High-Pass Cutoff Frequency to the Low-Pass Cutoff Frequency setting. Maximum passband gain of 40 dB is available. If only 20 dB gain is desired, channel 1 should be set to 20 dB gain and channel 2 should be set to 0 dB gain.

CAUTION

> Reversing the gain settings will increase the output noise of this configuration, because channel 2 will amplify the output noise of channel 1.

The overall response of this configuration may be determined by combining the normalized plots given in Figures 2-3 through 2-6.

The narrowest Band-Pass is obtained by setting High-Pass and Low-Pass Cutoff Frequencies to the same value f_o. In this case an insertion loss of approximately 6 dB is produced at f_o. For the Model 452, the 3-dB bandwidth extends from 0.8 f_o to 1.25 f_o and is equal to 0.45 f_o. This corresponds to a Q of 2.2. For the Model 852, the 3-dB bandwidth extends from 0.9 f_o to 1.12 f_o and is equal to 0.22 f_o. This corresponds to a Q of 4.5. In this mode of operation, both instruments operate as constant - Q, or constant % - Bandwidth filters.

e. Band-Reject Filter

The two channels of the instrument, one in High-Pass and the other in Low-Pass mode, may be connected in parallel, as shown in Fig. 2-11 to provide Band-Reject operation. Flat Amplitude response should be utilized in both channels.

The input signal should be connected to both inputs (IN 1 and IN 2). The outputs (OUT 1 and OUT 2) should be summed through 1 K, 1% resistors. The output signal is available at the common point of these resistors. This connection produces a passband insertion loss of 6 dB.

CAUTION

Both channels must be set to the same gain setting. If they are both set to 0 dB gain, the output will be 6 dB below the input level in the passband. If they are both set to 20 dB gain, the output will be 14 dB above the input level in the passband.

The rejection band in this configuration extends from the Low-Pass Cutoff Frequency to the High-Pass Cutoff Frequency. Again, the overall response may be determined by combining the normalized plots given in Figures 2-3 through 2-6.

f. Sharp-Notch Filter (Model 452 only)

The Sharp-Notch response shown in Fig. 2-12 is a special case of Band-Reject operation of Model 452. Input signal, channel connections, etc. should be made as described under Band-Reject filtering.

To obtain a notch (or null) at a desired frequency f_o, the High-Pass Cutoff Frequency is set to 1.75 f_o and the Low-Pass Cutoff Frequency is set to 0.57 f_o. For optimum rejection the High-Pass and Low-Pass settings should be alternatively adjusted, starting with the least significant digits.

CAUTION

While the maximum rejection obtainable in this mode of operation approaches the noise floor of the instrument, the maximum measurable rejection may be limited by the harmonic content of the input sinewave. In this mode of operation, it is thus possible to use the instrument for distortion analysis.

g. Low Pass or High Pass Filter with Doubled Rolloff

The two channels of the instrument may be cascaded as shown in Fig. 2-11. The Cutoff Frequencies of both channels are set to the same value and both channels are set to either High Pass, or Low Pass. Flat Amplitude response is utilized in both channels. Signal and channel connections are made as described under Band-Pass Filter and gain settings should also be made in accordance with the instructions given under Band-Pass Filter.

The overall response of this configuration may be determined by combining the normalized plots given in Figures 2-3 through 2-6. The Response at the Cutoff Frequency will now be 6 dB down and Rolloff will be 48 dB/octave for Model 452 and 96 dB/octave for Model 852.

2-7. OUTPUT SIGNAL

Full-scale output signal is specified as ± 10 Volts and ± 15 mA, max. Above 300 KHz, the output signal will follow the reduction in input signal shown in Fig. 2-2, provided the current required by the load connected to the instrument does not exceed the maximum value of ± 15 mA. Heavy capacitive loads can easily exceed this current at high frequencies. For example, 25 feet of RG-58 cable is equivalent to a capacitance of 750 pf, which requires ± 15 mA current at 300 KHz.

2-8. CUTOFF FREQUENCY OVERRANGE

The unmarked position between 0 and 10 on the Cutoff Frequency dials is an active position corresponding to the digit 11. If all Cutoff Frequency dials are set to this position a maximum setting of 122.1 (110 + 11 + 1.1) is available.

This position provides a 10% overrange relative to the specified maximum setting of 111.

2-9. MINIMUM CUTOFF FREQUENCY SETTING

The minimum valid setting of the Cutoff Frequency dials is 0.01. The setting 0.00 is not valid.

2-10 CUTOFF FREQUENCY RESOLUTION

The Cutoff Frequency dials should always be set for maximum resolution. For example, a cutoff frequency of 500 Hz may be set as 5.00x100, 0.50x1K, or 0.05x10K. Of the above choices, 5.00x100 is the proper setting.

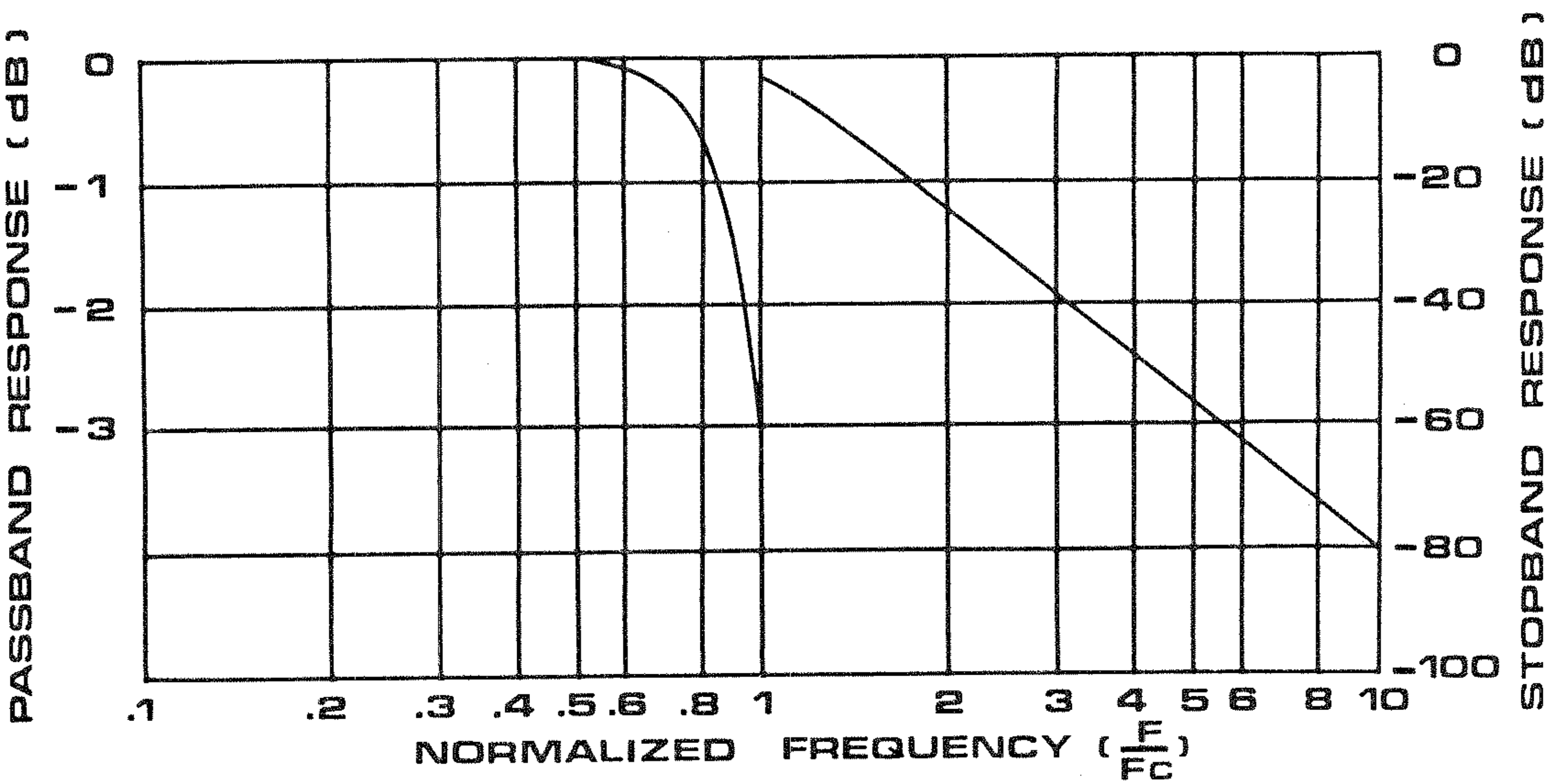


Fig. 2-3 452 Flat Ampl. Response - Lo Pass

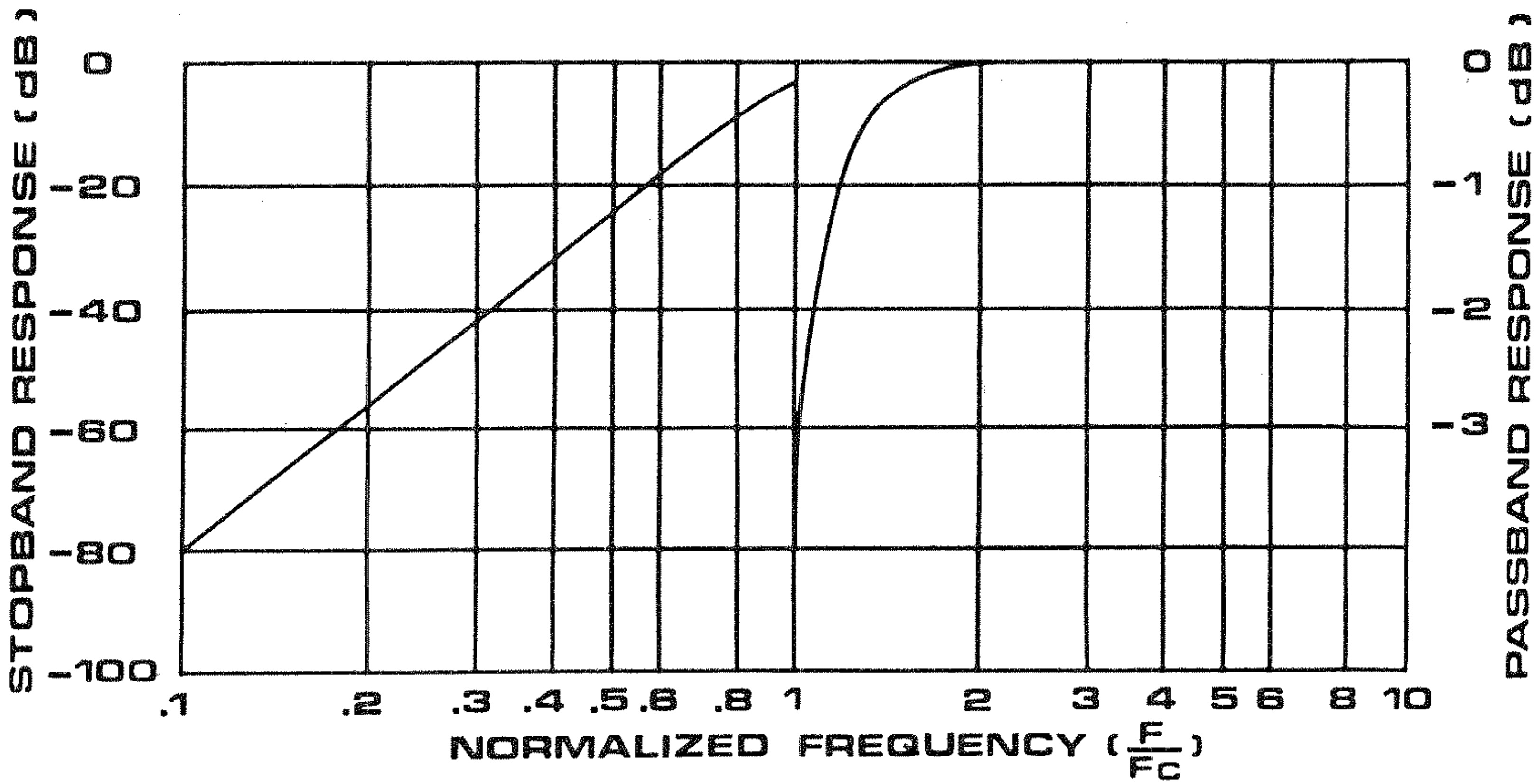


Fig. 2-4 452 Flat Ampl. Response - Hi Pass

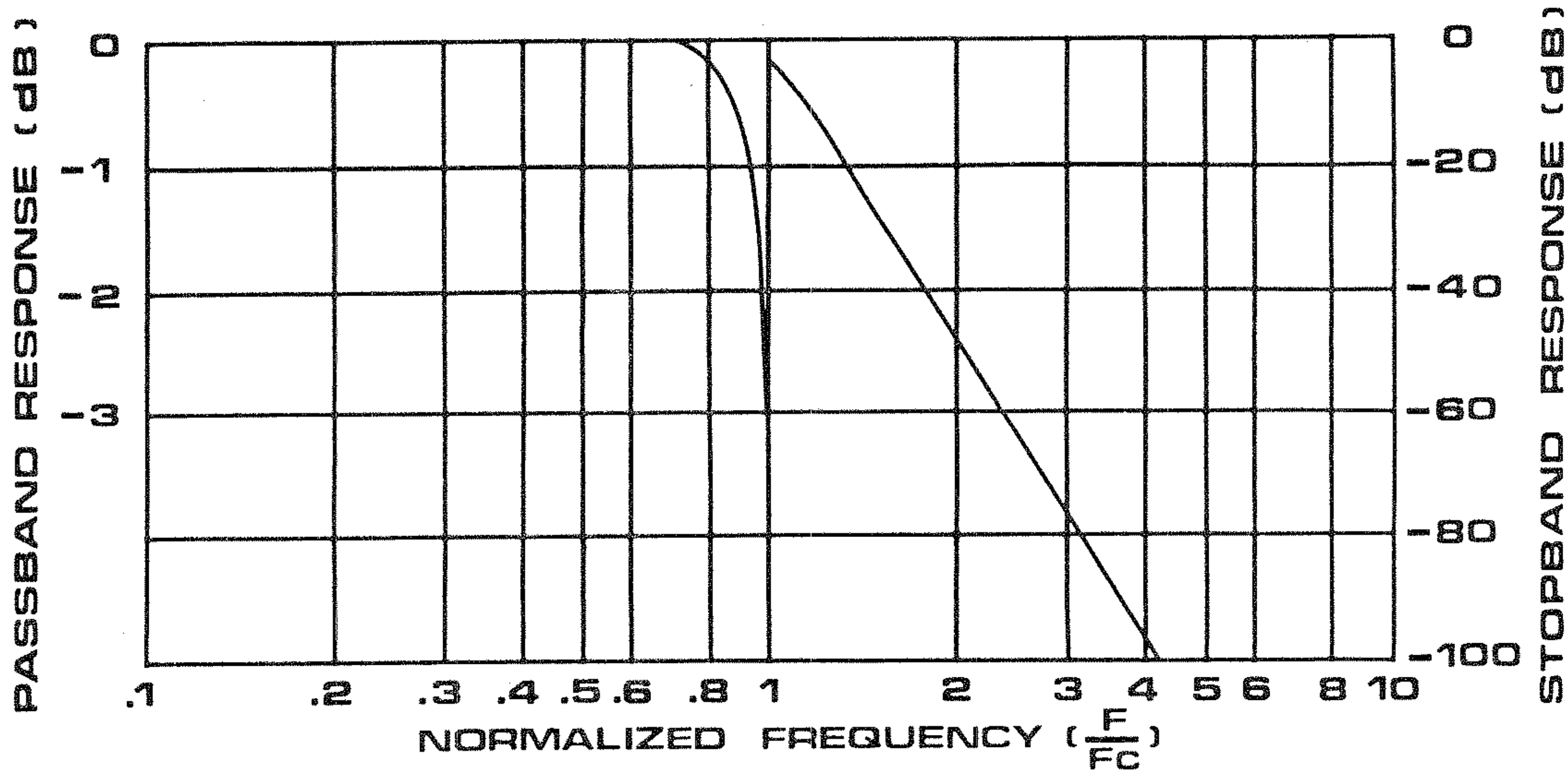


Fig. 2-5 852 Flat Ampl. Response - Lo Pass

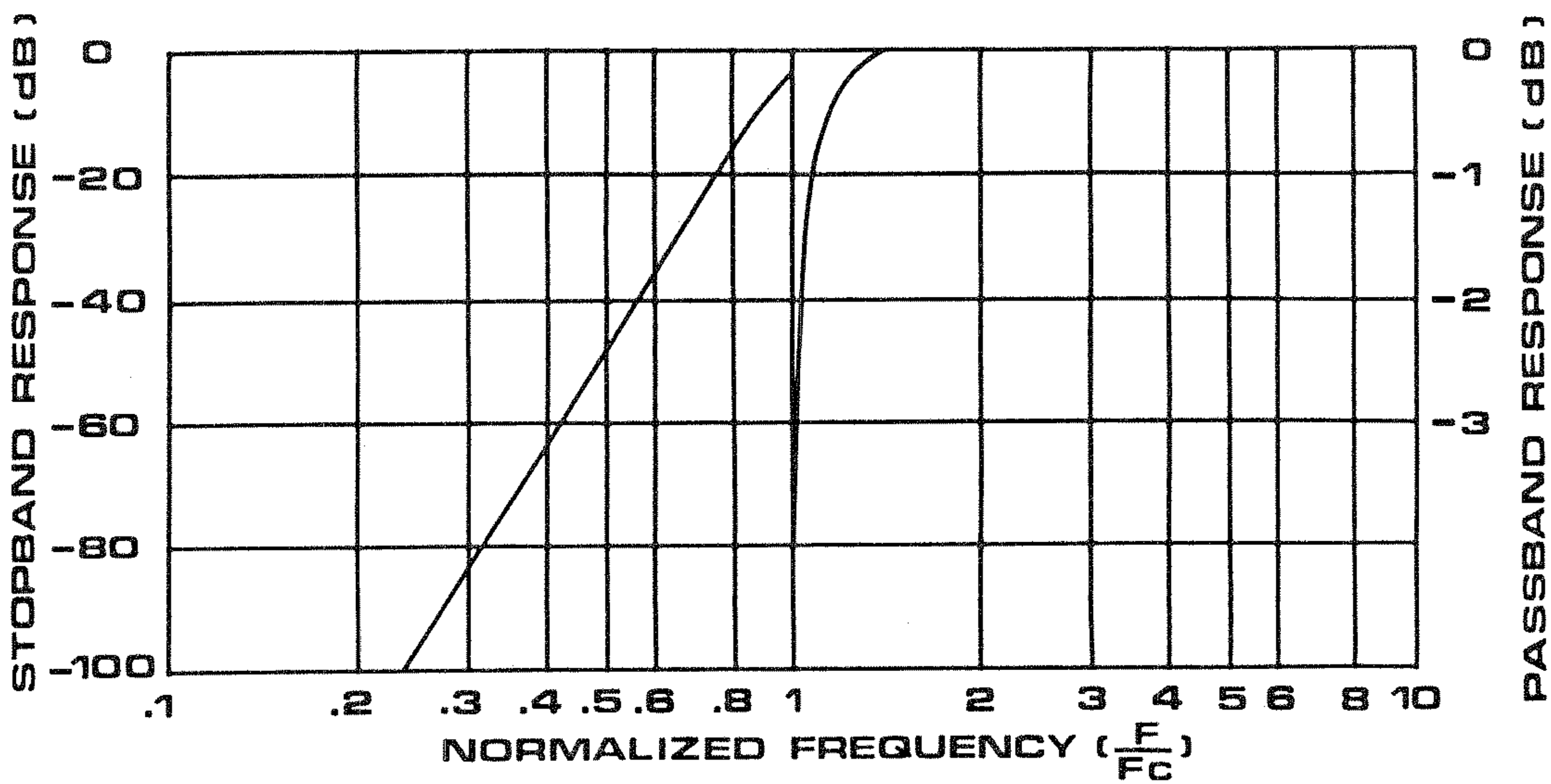


Fig. 2-6 852 Flat Ampl. Response - Hi Pass

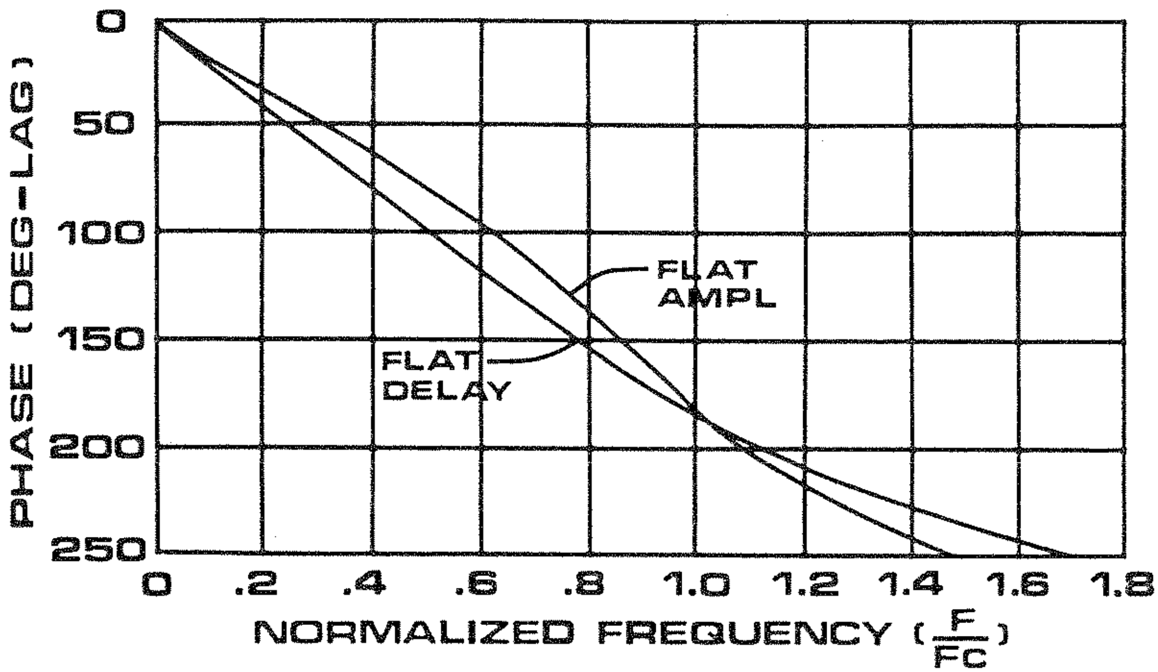


Fig. 2-7 452 Phase Response - Lo Pass

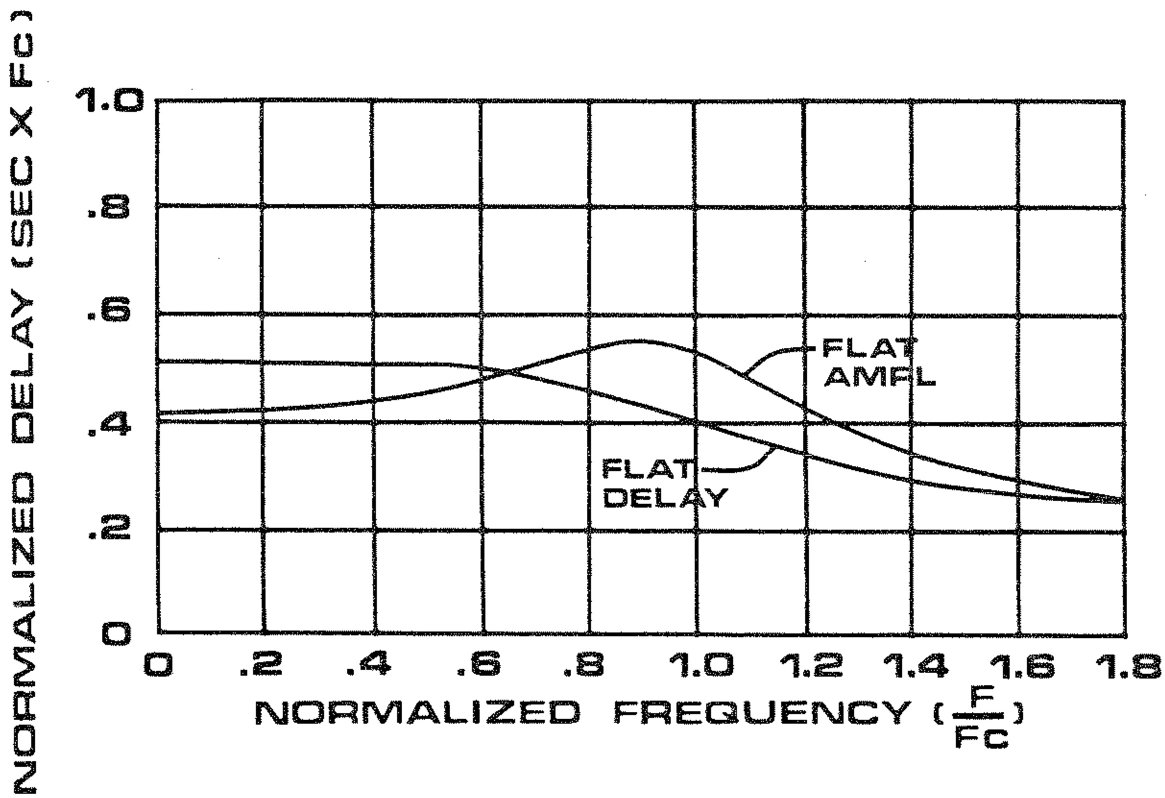


Fig. 2-8 452 Delay Response - Lo Pass

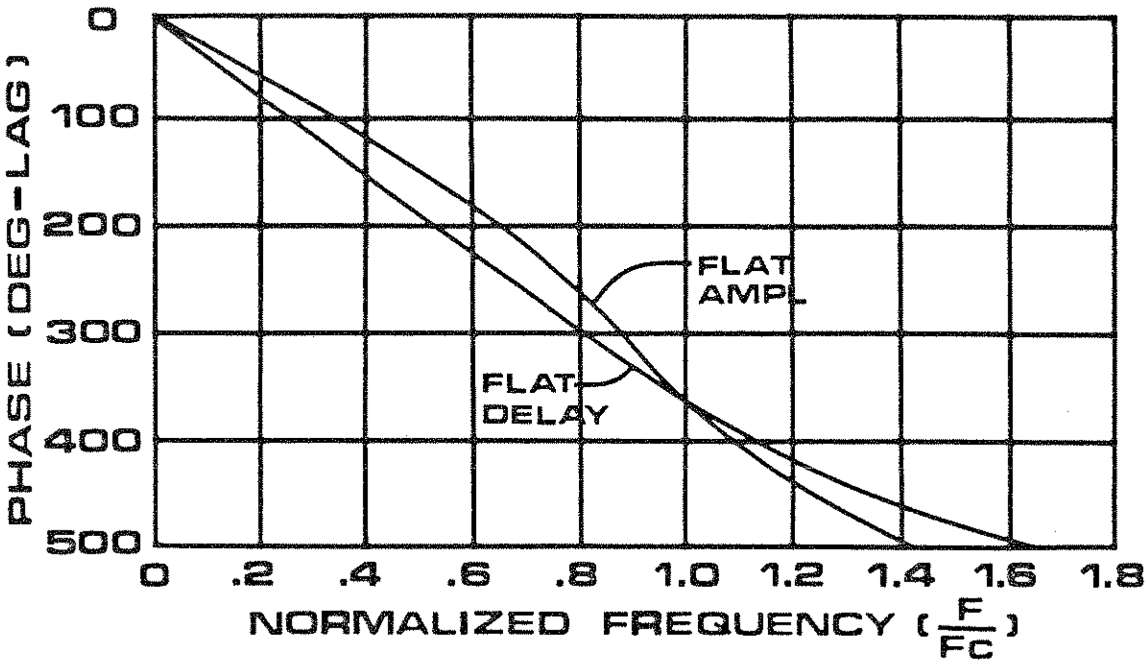


Fig. 2-9 852 Phase Response - Lo Pass

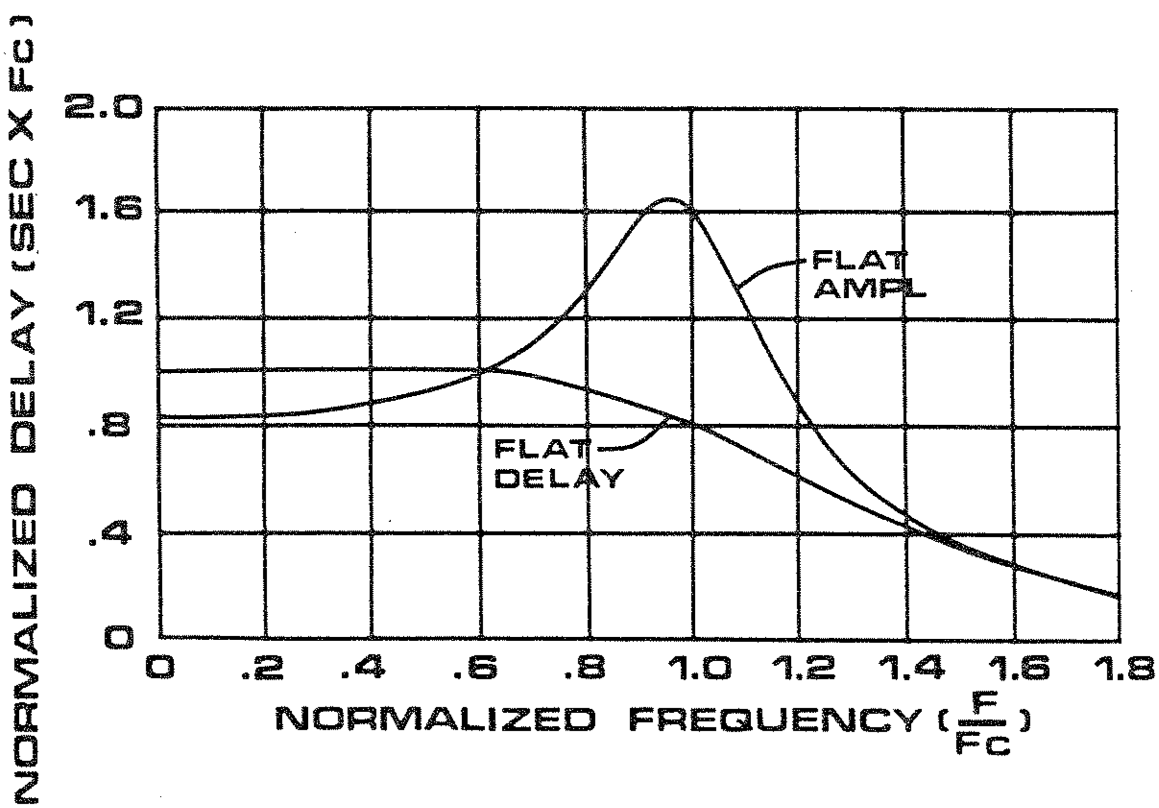
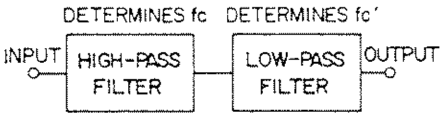
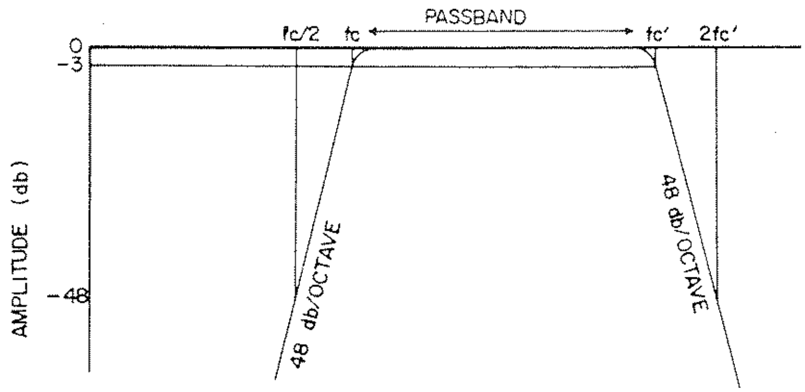
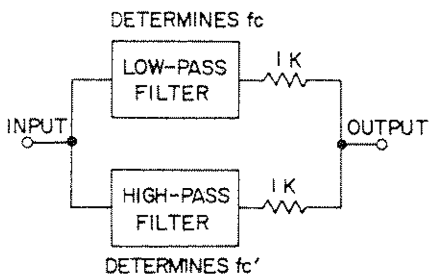


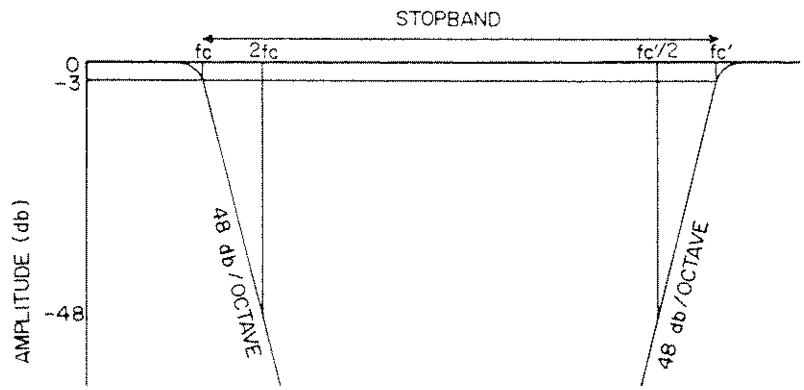
Fig. 2-10 852 Delay Response - Lo Pass



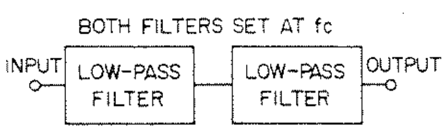


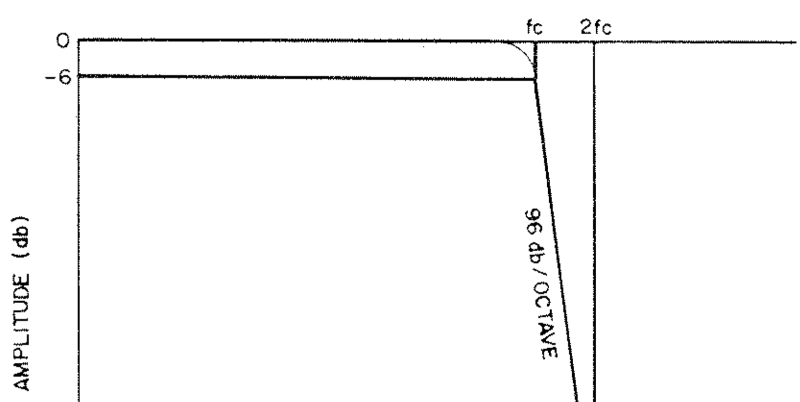
Band-Pass Filter





Band-Reject Filter





Low-Pass Filter with Doubled Rolloff

Fig. 2-11 Interconnection of Filter Channels
(Model 852 Rolloff shown)

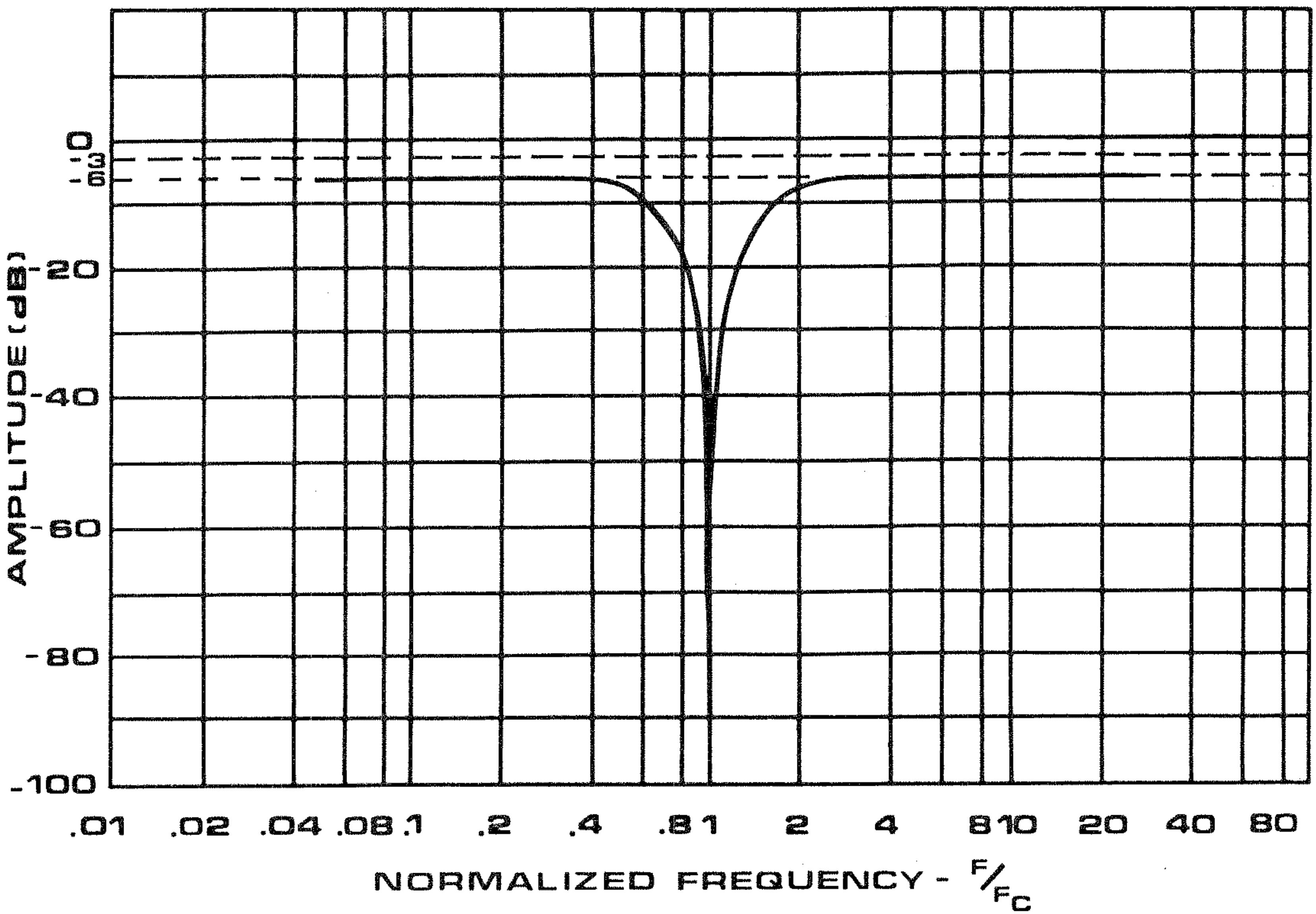


Fig. 2-12 452 Sharp Notch Response

SECTION III

PRINCIPLES OF OPERATION

3-1. INTRODUCTION

This section describes the basic principles of operation of Models 452 and 852 Dual Hi/Lo Filters. Fig. 3-1 is a Block Diagram of Model 452 and Fig. 3-2 is a Block Diagram of Model 852.

3-2. MODEL 452

The input signal of Channel 1 is applied through a 0 dB/20 dB Input Attenuator, which controls the two available gain positions, and is followed by a high input impedance buffer amplifier. The Input Attenuator provides a constant 1 Megohm input resistance in either position. The output of the Buffer amplifier is applied to a cascade of two "2nd-Order Prototypes". A "2nd-Order Prototype" is an active RC, 2nd-order (12 dB/octave) filter section which is used as a building block to synthesize higher-order filters. The gains of these stages at dc and at cutoff are as follows:

	Gain at dc	Gain at fc
Input Attenuator	0.0 dB/ - 20.0 dB	0.0 dB/ - 20.0 dB
Input Buffer	+11.8 dB	+11.8 dB
1st Prototype	+ 1.2 dB	- 4.1 dB
2nd Prototype	+ 7.0 dB	+ 9.3 dB
Overall (OUT/IN)	+20.0 dB/0.0 dB	+17.0 dB/ - 3.0 dB

Cutoff Frequency control is obtained by changing the resistors of the filter stages in 8 - 4 - 2 - 1 BCD steps. The capacitors are changed in decade steps and Option -01 adds an extra set of capacitors to extend the cutoff frequency coverage.

The output signal is available after the 2nd prototype through a 50-ohm (or, optionally, 600-ohm) resistor. The output of the buffer amplifier is available at Test Point TP - 1; the output of the 1st prototype at TP - 2.

Channel 2 is identical to Channel 1. Both channels are powered from one main power supply, through separate ± 15 V dc dual-tracking regulators.

3-3. MODEL 852

The input signal of Channel 1 is applied through a 0 dB/20 dB Input Attenuator, which controls the two available gain positions, and is followed by a high input impedance buffer amplifier. The Input Attenuator provides a constant 1 Megohm resistance in either position. The output of the Buffer amplifier is applied to a cascade of four "2nd-Order Prototypes". A "2nd-Order Prototype" is an active RC, 2nd-order (12 dB/octave) filter section which is used as a building block to synthesize higher-order filters. The gains of these stages at dc and at cutoff are as follows:

	Gain at dc	Gain at fc
Input Attenuator	0.0 dB/ - 20.0 dB	0.0 dB/ - 20.0 dB
Input Buffer	+3.4 dB	+3.4 dB
1st Prototype	+0.3 dB	-5.5 dB
2nd Prototype	+2.5 dB	-1.9 dB
3rd Prototype	+5.5 dB	+4.6 dB
4th Prototype	+8.3 dB	+16.5 dB
Overall (OUT/IN)	+20.0 dB/0.0 dB	+17.0 dB/ -3.0 dB

Cutoff Frequency control is obtained by changing the resistors of the filter in 8 - 4 - 2 - 1 BCD steps. The capacitors are changed in decade steps and Option -01 adds an extra set of capacitors to extend the cutoff frequency coverage.

The output signal is available after the 4th prototype through a 50-ohm (or, optionally, 600-ohm) resistor. The output of the buffer amplifier is available at Test Point TP - 1; the output of the 1st prototype at TP - 2; the output of the 2nd prototype at TP - 3; and the output of the 3rd prototype at TP -4.

Channel 2 is identical to Channel 1. Both channels are powered from one main power supply, through separate ± 15 V dc dual-tracking regulators.

3-4. 2nd - ORDER PROTOTYPE

Figure 3-3 is a simplified from of the low-pass 2nd-order prototype. The high-pass prototype is identical to the circuit of Figure 3-3 except that the position of resistors R and capacitors C is interchanged. In both Models the interchange is effected by the Hi Pass/Lo Pass switch.

The amplitude response of this circuit is shown in Fig. 3-4.

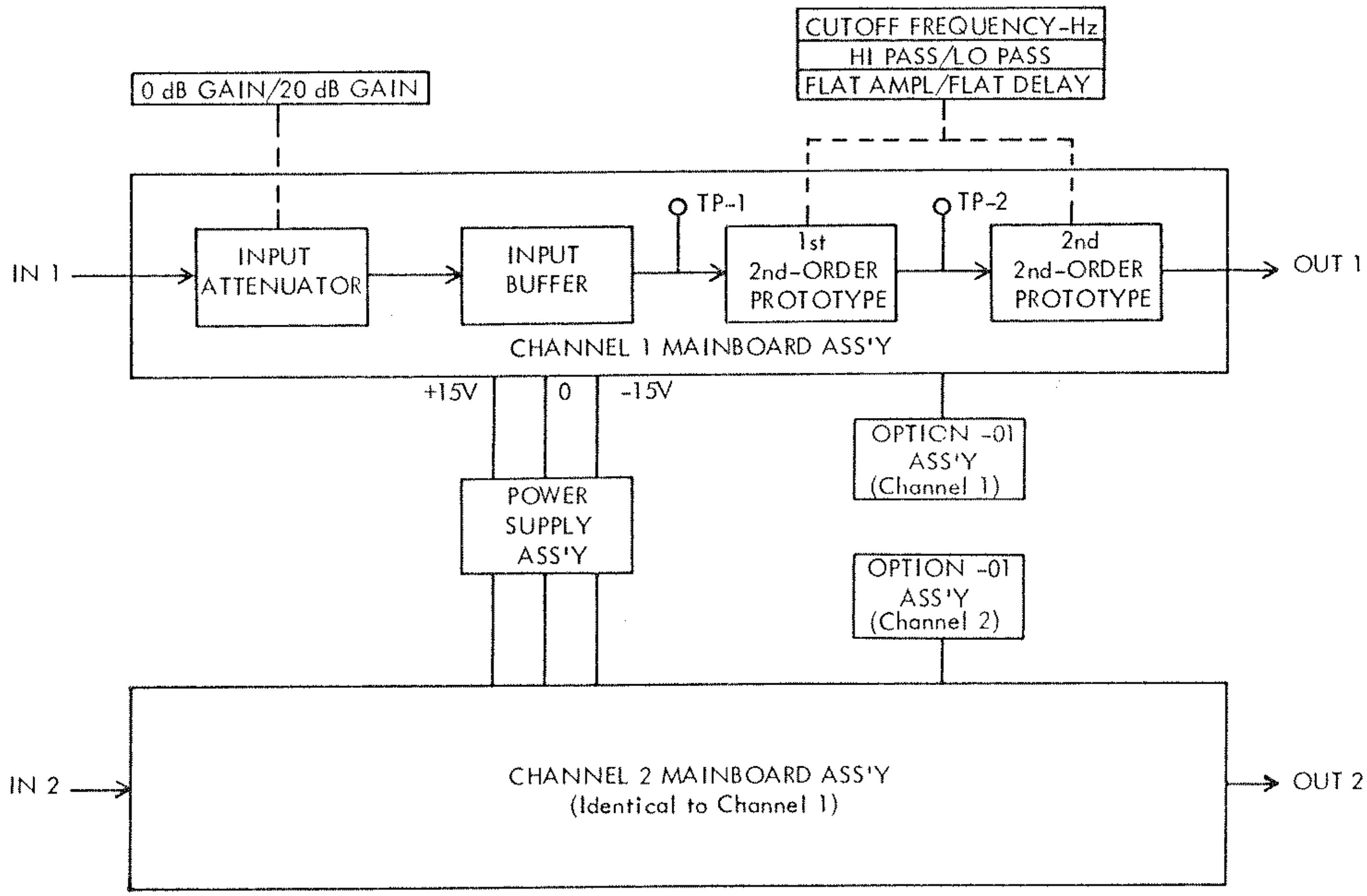


Fig. 3-1. Model 452 Block Diagram

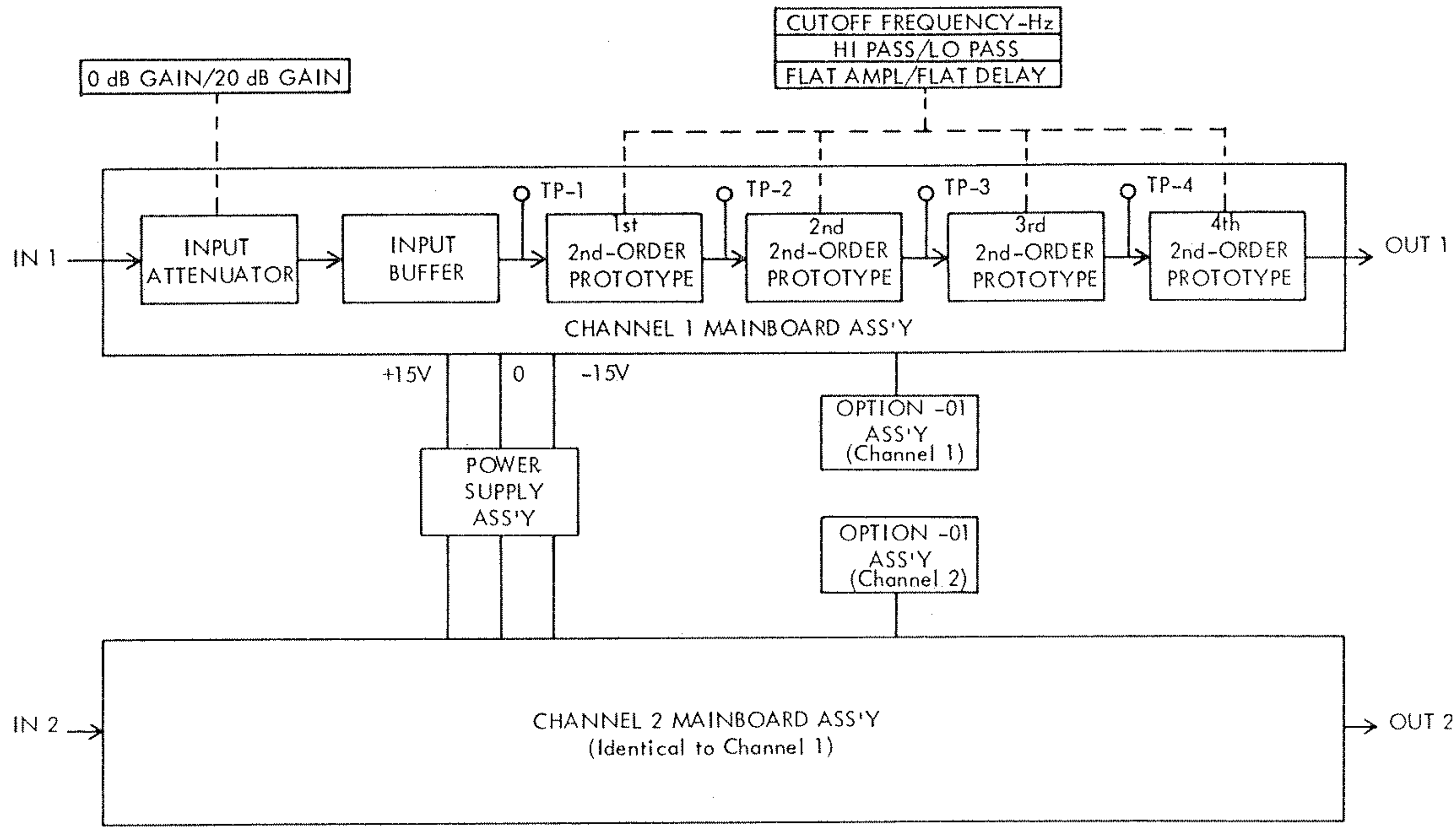


Fig. 3-2. Model 852 Block Diagram

It is seen that the response of the circuit may be altered in the vicinity of the cutoff frequency by changing the value of damping β . The damping is a function of the gain of the operational amplifier which, in turn, is determined by the ratio of resistors R1 and R2.

Likewise, the overall response of a cascade of such prototype sections may be tailored by appropriate selection of damping and the desired higher-order filter may thus be synthesized.

In the Model 452, a fourth order Flat-Amplitude, or Butterworth filter (per channel) is synthesized in this manner, while an eighth-order Butterworth filter is synthesized in the Model 852. The Flat-Delay response is obtained in either model by appropriate changes in the damping of the prototype sections.

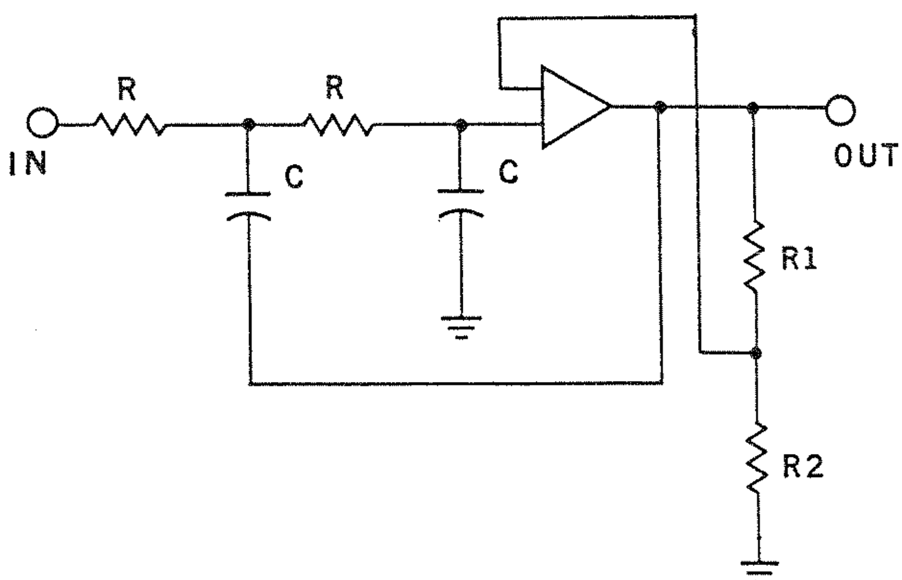


Fig. 3-3. 2nd Order Low-Pass Prototype

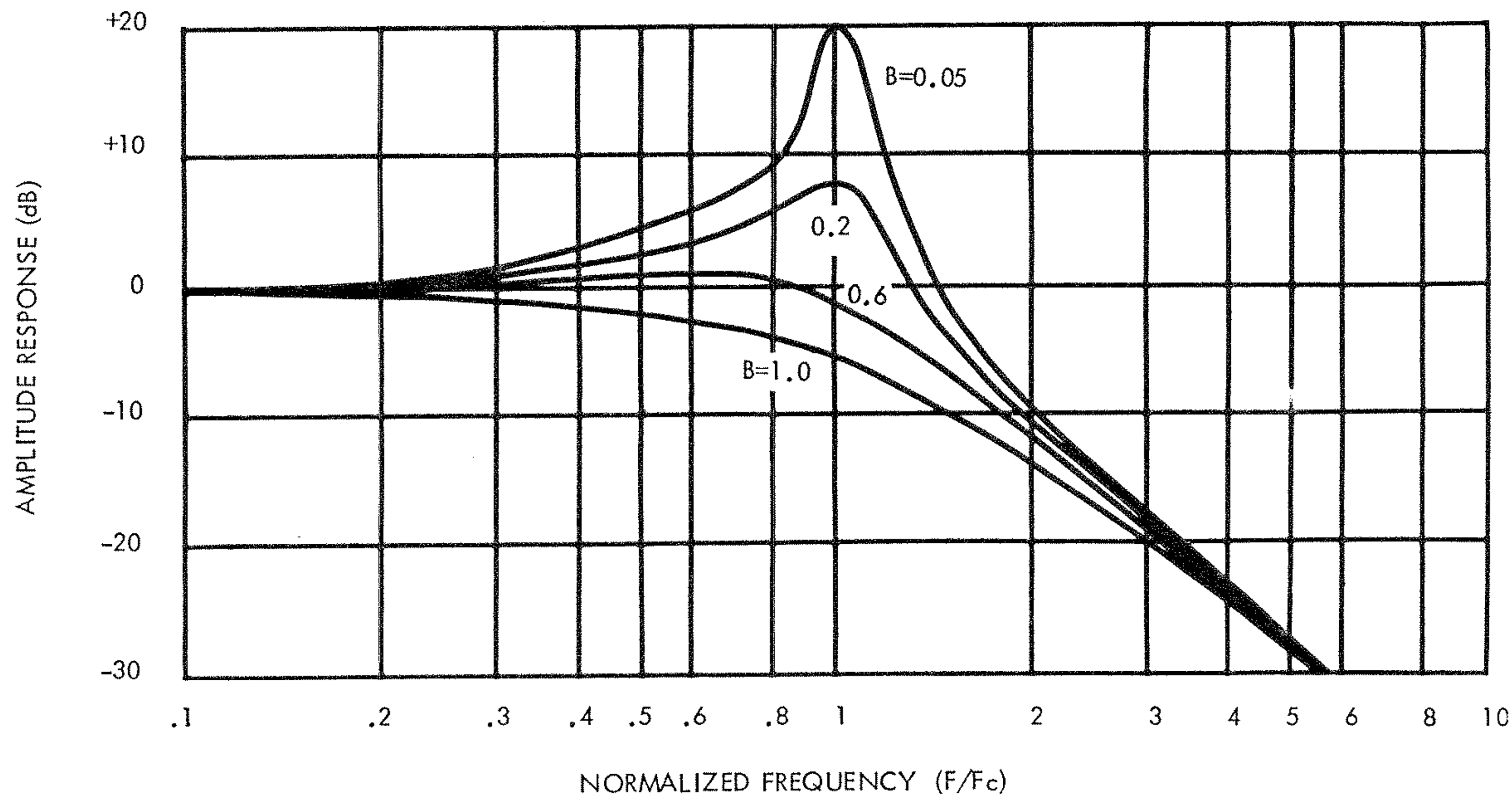


Fig. 3-4. Response of 2nd order Low-Pass Prototype for various values of damping B

SECTION IV

MAINTENANCE

4-1. INTRODUCTION

This section describes recommended test procedures to verify that the instrument meets its performance specifications. In addition, adjustment procedures are described, so that an instrument may be calibrated to meet its specifications. Troubleshooting and repair procedures are also included.

4-2. RECOMMENDED TEST EQUIPMENT

The recommended test equipment and its use is listed below:

Description (Feature)	Model	Tests
Oscilloscope	Tektronix 475	Waveform viewing
Digital Multimeter (100 uV dc resolution)	Keithley 168	DC Offset
AC Voltmeter (1% accuracy)	HP 400FL	Passband Gain, Cutoff Frequency Accuracy
RMS Voltmeter (True RMS)	Ballantine 3620A	Broadband Noise
Frequency Synthesizer (> -70 dB harmonics at 1 KHz)	Wavetek 5100	Passband Gain, Cutoff Frequency Accuracy, Max. Stopband Attenuation, Harmonic Components
Band-Pass Filter (24 dB/oct rolloff, 40 dB Gain)	Wavetek 452	Broadband Noise
Spectrum Analyzer (20 Hz - 300 KHz)	HP 141T Display 8556A LF Section 8552B IF Section	Max. Stopband Attenuation
Spectrum Analyzer (5 Hz - 50 KHz)	HP 3580A	Harmonic Components, AC Line-related Spurious

Description (Feature)	Model	Tests
Gain/Phase Meter (1 Hz - 13 MHz)	HP 3575A	Adjustments
50 - ohm Termination	-	-
5 K load resistor	-	-
1 KHz Notch Filter	Assemble as shown below	Harmonic Components

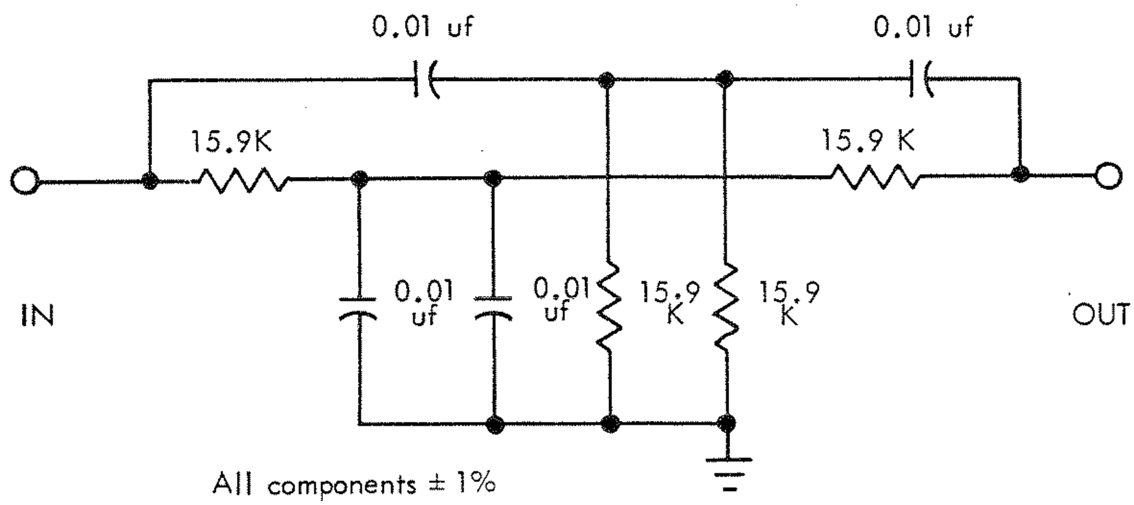
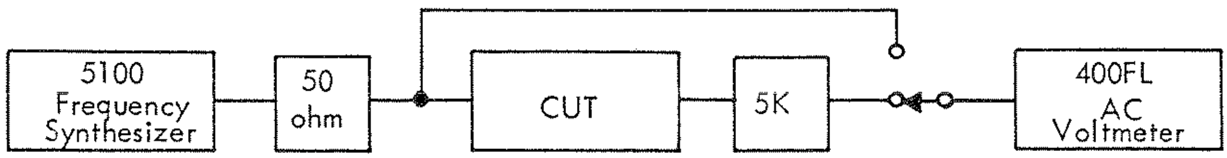


Fig. 4-1. 1 KHz Notch Filter

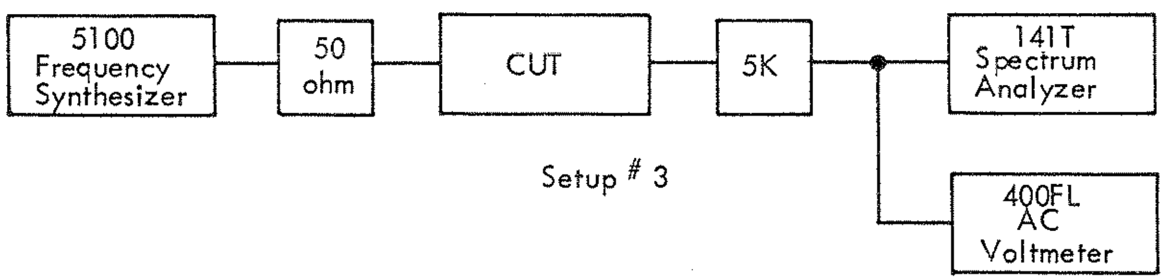
WARNING

The specifications of these instruments cannot be verified, unless the recommended equipment (or equal) is utilized in test. In particular, Function Generators cannot be used in place of the recommended signal source. Function Generators produce high harmonics in their output waveform and will cause considerable errors in certain tests requiring the use of a signal source.

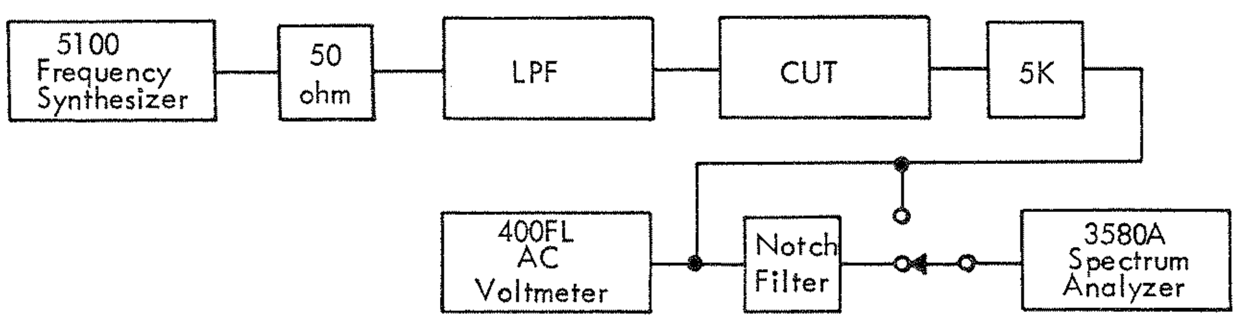


Setup # 1

Setup # 2



Setup # 3



Setup # 4

Fig. 4.2. Performance Test Setups

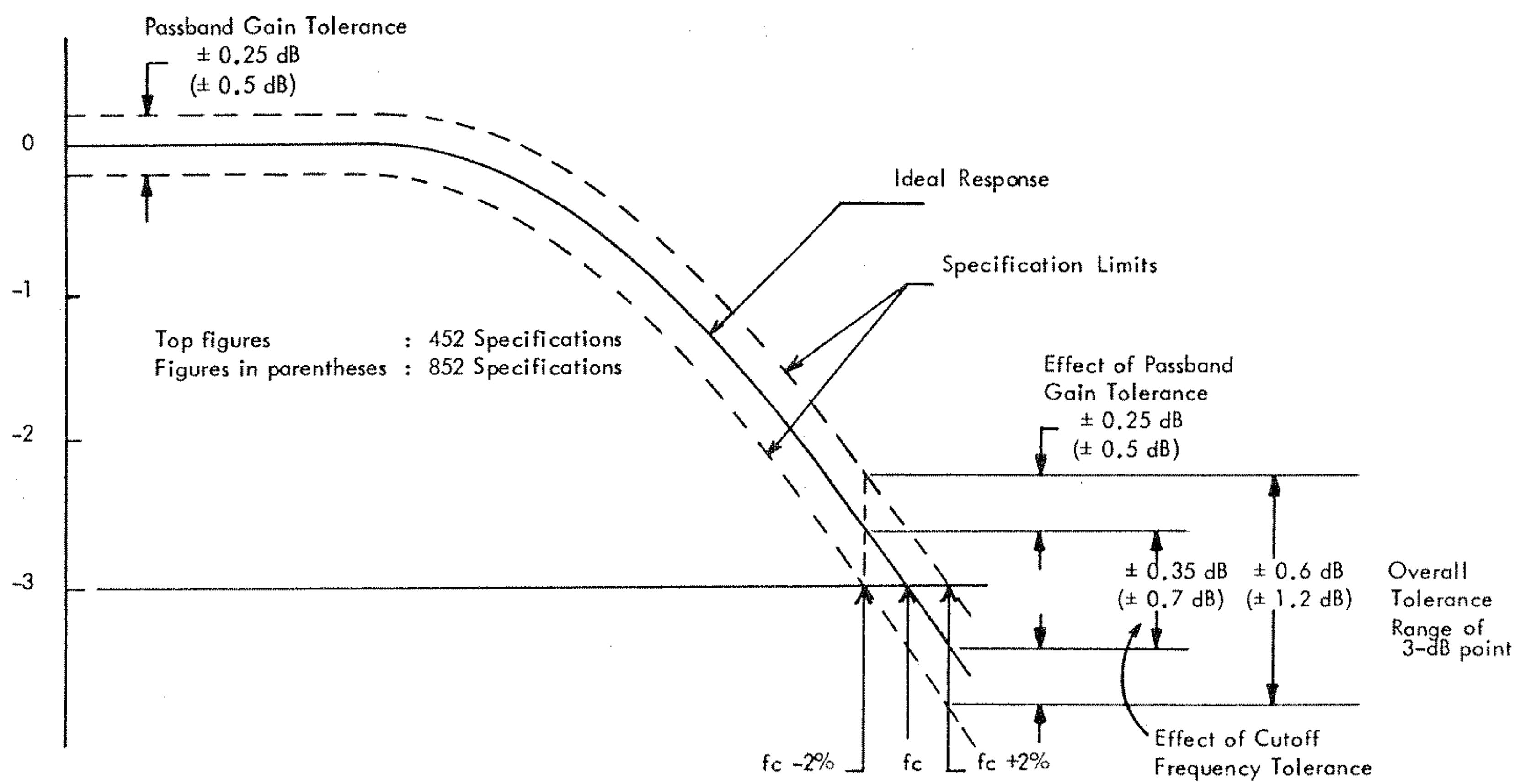


Fig. 4-3. Passband Gain & Cutoff Frequency Tolerances

4-3. PERFORMANCE TESTS

The following Performance Tests are procedures which can be used to verify that the instrument is operating properly and meets the specifications listed below. All specifications apply to Butterworth (Flat Ampl.) response and all Performance Tests are performed with the Flat Ampl./Flat Delay switch in the Flat Ampl. position.

	Specification	
Parameter	Model 452	Model 852
Passband Gain Accuracy	0 ±0.25 dB, 20 ±0.25 dB (±0.5 dB, HP, x10K)	0 ±0.5 dB, 20 ±0.5 dB (±1dB, HP, x10K)
Cutoff Frequency Calibration Accuracy	±2%	±2%
DC Offset	0±2.5 mV dc	0 ±2.5 mV dc
Broadband Noise	100 uV rms, max.	200 uV rms, max.
Maximum Stopband Attenuation*	90 dB	90 dB
Harmonic Components*	-90 dB	-80 dB
AC Line-related Spurious Components*	-110 dB	-100 dB

* relative to full-scale signal of 7.1 V rms (+17 dBV)

a. Passband Gain Accuracy (See Fig. 4-3)

Connect equipment as shown in Setup #1. Set Frequency Synthesizer output to 0.71 V rms and measure passband gain of the Channel Under Test (CUT) for the settings shown in Table 4.1.

b. Cutoff Frequency Calibration Accuracy (See Fig. 4-3)

With the equipment connected as shown in Setup #1, set CUT gain to 0 dB and the Frequency Synthesizer output to 0.0 dBV. At each Cutoff Frequency setting shown in Table 4.2 set the Synthesizer frequency equal to the Cutoff Frequency setting.

The ± 2% specification on Cutoff Frequency Calibration Accuracy is met if the output level falls within the tolerance limits shown in Fig. 4-3, namely:

Model 452 : -3dBV ± 0.6 dB
(-3dBV ± 0.85dB, in x 10K, HP)

Model 852 : -3dBV ± 1.2dB
(-3dBV ± 1.7dB, in x 10K, HP)

c. DC Offset

Connect a short across the input connector of the Channel Under Test (CUT) and the DC Multimeter across the output connector. Allow at least 10 minutes for the instrument to warm up under its own power and measure the DC Offset for the settings shown in Table 4.3.

d. Broadband Noise

Connect equipment as shown in Setup #2. Connect a short across the input connector of the Channel Under Test and set the Ground/Float switch on the rear panel to the Float position. Turn off all unused equipment in the vicinity of the test area and disconnect it from the instrument under test.

Connect the 452 Post Filter/Amplifier as a Band-Pass filter with the following settings:

CH 1: 0.01 x 10 Cutoff Frequency
Hi Pass
20 dB Gain
Flat Ampl.

CH 2: 10.00 x 10K Cutoff Frequency
Lo Pass
20 dB Gain
Flat Ampl.

With the above settings, the 452 Post Filter/Amplifier provides 40 dB of gain and establishes a noise measurement bandwidth of 0.1 Hz to 100 KHz. (A noise bandwidth of 100 KHz is, for all practical purposes, equal to the 3-dB bandwidth of a 4th-order filter.)

Measure noise with the 3620A RMS Voltmeter for the CUT settings shown in Table 4.4. Output Broadband Noise of the CUT is calculated as follows:

$$\text{Output Noise} = \frac{1}{100} \times \text{Voltmeter Reading}$$

e. <u>Maximum Stopband Attenuation</u>

Connect equipment as shown in Setup # 3 and set the Channel Under Test as follows:

1.00 x 10 K Cutoff Frequency
Hi Pass
20 dB Gain
Flat Ampl.

Set the 5100 Frequency Synthesizer to 100 KHz and increase its output amplitude until CUT output is equal to full-scale signal of 7.1 V rms (+17 dBV).

Set the 141T Spectrum Analyzer controls as follows:

Input Level	:	-10 dBV
Bandwidth	:	300 Hz
Scan Width	:	2 KHz/div
Scan Time	:	50 msec
Log Ref Level	:	Adjust for full-scale Display after tuning analyzer to 100 KHz

Set the CUT and input frequency to the values shown in Table 4.5. In each case, tune the Spectrum Analyzer to the input frequency and increase Input Level control setting to -60 dBV. Read the amplitude of the signal displayed on the screen. The Maximum Stopband Attenuation with respect to full-scale signal is calculated as follows:

$$A = (50\text{ dB} + \text{Display dB})$$

f. Harmonic Components

Because of the extremely low distortion of these instruments, a special measurement procedure must be employed. The arrangement shown in Setup # 4 is recommended. Here, the unused channel of the instrument is employed as a Low-Pass Filter to reduce the harmonic components of the 5100 Frequency Synthesizer to levels of -100 dB or less. The output of the Channel Under Test (CUT) is viewed on the 3580 A Spectrum Analyzer directly, or through a passive Notch Filter centered on the measurement frequency. For the values shown, the Notch Filter will attenuate the fundamental (1 KHz) by at least 50 dB, while the 2nd harmonic is attenuated 10 dB and the 3rd harmonic 6 dB.

Set the Synthesizer frequency to 1.000 KHz and the Low Pass Filter to a Cutoff Frequency of 1.00 x 1 K, 0 dB Gain, Flat Ampl. response. Set the Channel Under Test as follows:

1.00 x 10 Cutoff Frequency
Hi Pass
20 dB Gain
Flat Ampl.

Increase Synthesizer amplitude until full-scale signal of 7.1 V rms (+ 17 dBV) appears at the output of the CUT.

Connect the 3580 A Spectrum Analyzer to the output of the CUT and set its controls as follows:

Bandwidth	:	30 Hz
Freq. Span	:	.5 KHz/div
Sweep Time	:	1 sec/div
Display	:	LOG, 10 dB
Input Sensitivity	:	+ 10 dBV
Input Sensitivity Vernier	:	Adjust to obtain full-scale (0 dB) Display at 1 KHz.
Amplitude Ref Level	:	Normal

Connect the Spectrum Analyzer to the output of the Notch Filter and increase Input Sensitivity to -30 dBV. Read the amplitude of each harmonic component displayed on the screen. Harmonic Components at the output of the CUT with respect to full-scale signal are calculated as follows:

2nd Harmonic = -(40 dB + 2nd Harm. Display dB) + 10 dB
3rd Harmonic = -(40 dB + 3rd Harm. Display dB) + 6 dB
4th Harmonic = -(40 dB + 4th Harm. Display dB) + 4 dB

g. A-C Line-related Spurious Components

Connect a short across the input connector of the Channel Under Test and the 3580A Spectrum Analyzer to the output connector. Set the Ground/Float switch on the rear panel to the Float position and turn off all other equipment in the vicinity of the test area. Disconnect all other equipment from the instrument under test.

Set the Channel Under Test as follows:

10.00 x 10 K Cutoff Frequency
Lo Pass
0 dB Gain
Flat Ampl.

Set the 3580A Spectrum Analyzer controls as follows:

Input Sensitivity	:	-30 dBV
Input Sensitivity Vernier	:	CAL
Bandwidth	:	3 Hz
Freq. Span	:	20 Hz/div
Sweep Time:	:	5 sec/div
Display	:	LOG, 10 dB
Amplitude Ref Level	:	Normal

Obtain a complete sweep on the analyzer screen and measure the amplitude of the Display at line frequency and multiples (x2, x3) of the line frequency. Line-related spurious components at the output of the CUT with respect to full-scale signal (+ 17 dBV) are calculated as follows:

Spurious = - (47 dB + Display dB)

PERFORMANCE TEST RESULTS

Wavetek Model 452 Option- Test By________________

Dual Hi/Lo Filter Date________________

Serial Number________________

Channel 1 | 2

Table 4.1. Passband Gain Accuracy

Cutoff Frequency	Mode	Gain	Input Frequency	Passband Gain Specification	Measured	
10.00 x 1K	LP	0 dB	1 KHz	0 ± .25 dB		
10.00 x 1K	LP	20 dB	1 KHz	20 ± .25 dB		
1.00 x 1K	HP	0 dB	10 KHz	0 ± .25 dB		
1.00 x 1K	HP	20 dB	10 KHz	20 ± .25 dB		
1.00 x 10K	HP	0 dB	100 KHz	0 ± .5 dB		
1.00 x 10K	HP	20 dB	100 KHz	20 ± .5 dB		

Table 4.2. Cutoff Frequency Calibration Accuracy

Cutoff Frequency	Mode	Input Frequency	Output level Specification Limits	Measured	
10.00 x 10K	LP	100.0 KHz	-2.40 dBV to -3.60 dBV		
10.00 x 10K	HP	100.0 KHz	-2.15 dBV to -3.85 dBV		
1.00 x 10K	LP	10.0 KHz	-2.40 dBV to -3.60 dBV		
1.00 x 10K	HP	10.0 KHz	-2.15 dBV to -3.85 dBV		
10.00 x 1K	LP	10.0 KHz	-2.40 dBV to -3.60 dBV		
10.00 x 1K	HP	10.0 KHz	-2.40 dBV to -3.60 dBV		
10.00 x 100	LP	1.0 KHz	-2.40 dBV to -3.60 dBV		
10.00 x 100	HP	1.0 KHz	-2.40 dBV to -3.60 dBV		
10.00 x 10	LP	100 Hz	-2.40 dBV to -3.60 dBV		
10.00 x 10	HP	100 Hz	-2.40 dBV to -3.60 dBV		
Option-01:					
10.00 x 1	LP	10 Hz	-2.40 dBV to -3.60 dBV		
10.00 x 1	HP	10 Hz	-2.40 dBV to -3.60 dBV		

Table 4.2. Cutoff Frequency Calibration Accuracy - continued

Cutoff Frequency	Mode	Input Frequency	Output level Specification limits	Measured
10.00 x 1K	LP	10.00 KHz	-2.40 dBV to -3.60 dBV	
9.00 x 1K	LP	9.00 KHz	-2.40 dBV to -3.60 dBV	
8.00 x 1K	LP	8.00 KHz	-2.40 dBV to -3.60 dBV	
7.00 x 1K	LP	7.00 KHz	-2.40 dBV to -3.60 dBV	
6.00 x 1K	LP	6.00 KHz	-2.40 dBV to -3.60 dBV	
5.00 x 1K	LP	5.00 KHz	-2.40 dBV to -3.60 dBV	
4.00 x 1K	LP	4.00 KHz	-2.40 dBV to -3.60 dBV	
3.00 x 1K	LP	3.00 KHz	-2.40 dBV to -3.60 dBV	
2.00 x 1K	LP	2.00 KHz	-2.40 dBV to -3.60 dBV	
1.00 x 1K	LP	1.00 KHz	-2.40 dBV to -3.60 dBV	
1.00 x 1K*	LP	1.00 KHz	-2.40 dBV to -3.60 dBV	
0.90 x 1K	LP	900 Hz	-2.40 dBV to -3.60 dBV	
0.80 x 1K	LP	800 Hz	-2.40 dBV to -3.60 dBV	
0.70 x 1K	LP	700 Hz	-2.40 dBV to -3.60 dBV	
0.60 x 1K	LP	600 Hz	-2.40 dBV to -3.60 dBV	
0.50 x 1K	LP	500 Hz	-2.40 dBV to -3.60 dBV	
0.40 x 1K	LP	400 Hz	-2.40 dBV to -3.60 dBV	
0.30 x 1K	LP	300 Hz	-2.40 dBV to -3.60 dBV	
0.20 x 1K	LP	200 Hz	-2.40 dBV to -3.60 dBV	
0.10 x 1K	LP	100 Hz	-2.40 dBV to -3.60 dBV	
0.10 x 1K*	LP	100 Hz	-2.40 dBV to -3.60 dBV	
0.09 x 1K	LP	90 Hz	-2.40 dBV to -3.60 dBV	
0.08 x 1K	LP	80 Hz	-2.40 dBV to -3.60 dBV	
0.07 x 1K	LP	70 Hz	-2.40 dBV to -3.60 dBV	
0.06 x 1K	LP	60 Hz	-2.40 dBV to -3.60 dBV	
0.05 x 1K	LP	50 Hz	-2.40 dBV to -3.60 dBV	
0.04 x 1K	LP	40 Hz	-2.40 dBV to -3.60 dBV	
0.03 x 1K	LP	30 Hz	-2.40 dBV to -3.60 dBV	
0.02 x 1K	LP	20 Hz	-2.40 dBV to -3.60 dBV	
0.01 x 1K	LP	10 Hz	-2.40 dBV to -3.60 dBV	

* Use the "10" of the next lower digit to obtain this setting.

Table 4.3. D.C. Offset

Cutoff Frequency	Mode	Gain	Specification	Measured
10.00 x 10K	LP	0 dB	± 2.5mV dc	
10.00 x 10K	LP	20 dB	± 2.5 mV dc	
0.01 x 10	HP	0 dB	± 2.5 mV dc	
0.01 x 10	HP	20 dB	± 2.5 mV dc	

Table 4.4. Broadband Noise

Cutoff Frequency	Mode	Gain	Specification	Measured
10.00 x 10K	LP	0 dB	100 uV rms, max	
10.00 x 10K	LP	20 dB	100 uV rms, max	
0.01 x 10	HP	0 dB	100 uV rms, max	
0.01 x 10	HP	20 dB	100 uV rms, max	

Table 4.5. Maximum Stopband Attenuation

Cutoff Frequency	Mode	Input Frequency	Specification	Measured
1.00 x 10K	LP	200 KHz	90 dB	
10.00 x 10K	HP	5 KHz	90 dB	

Table 4.6. Harmonic Components

	Specification	Measured
2nd Harmonic	-90 dB	
3rd Harmonic	-90 dB	
4th Harmonic	-90 dB	

Table 4.7. Line-Related Spurious Components

	Specification	Measured
Line Frequency	-110 dB	
2 x Line Frequency	-110 dB	
3 x Line Frequency	-110 dB	

PERFORMANCE TEST RESULTS

Wavetek Model 852 Option- Test By________________

Dual Hi/Lo Filter Date________________

Serial Number________________

Channel 1 | 2

Table 4.1. Passband Gain Accuracy

Cutoff Frequency	Mode	Gain	Input Frequency	Passband Gain Specification	Passband Gain Measured	
10.00 x 1K	LP	0 dB	1 KHz	0 ± .5 dB		
10.00 x 1K	LP	20 dB	1 KHz	20 ± .5 dB		
1.00 x 1K	HP	0 dB	10 KHz	0 ± .5 dB		
1.00 x 1K	HP	20 dB	10 KHz	20 ± .5 dB		
1.00 x 10K	HP	0 dB	100 KHz	0 ± 1 dB		
1.00 x 10K	HP	20 dB	100 KHz	20 ± 1 dB		

Table 4.2. Cutoff Frequency Calibration Accuracy

Cutoff Frequency	Mode	Input Frequency	Output level Specification Limits	Measured	
10.00 x 10K	LP	100.0 KHz	-1.8 dBV to -4.2 dBV		
10.00 x 10K	HP	100.0 KHz	-1.3 dBV to -4.7 dBV		
1.00 x 10K	LP	10.0 KHz	-1.8 dBV to -4.2 dBV		
1.00 x 10K	HP	10.0 KHz	-1.3 dBV to -4.7 dBV		
10.00 x 1K	LP	10.0 KHz	-1.8 dBV to -4.2 dBV		
10.00 x 1K	HP	10.0 KHz	-1.8 dBV to -4.2 dBV		
10.00 x 100	LP	1.0 KHz	-1.8 dBV to -4.2 dBV		
10.00 x 100	HP	1.0 KHz	-1.8 dBV to -4.2 dBV		
10.00 x 10	LP	100 Hz	-1.8 dBV to -4.2 dBV		
10.00 x 10	HP	100 Hz	-1.8 dBV to -4.2 dBV		

Option -01:

10.00 x 1	LP	10 Hz	-1.8 dBV to -4.2 dBV		
10.00 x 1	HP	10 Hz	-1.8 dBV to -4.2 dBV		

Table 4.2. Cutoff Frequency Calibration Accuracy - continued

Cutoff Frequency	Mode	Input Frequency	Output level Specification Limits	Measured
10.00 x 1K	LP	10.00 KHz	-1.8 dBV to -4.2 dBV	
9.00 x 1K	LP	9.00 KHz	-1.8 dBV to -4.2 dBV	
8.00 x 1K	LP	8.00 KHz	-1.8 dBV to -4.2 dBV	
7.00 x 1K	LP	7.00 KHz	-1.8 dBV to -4.2 dBV	
6.00 x 1K	LP	6.00 KHz	-1.8 dBV to -4.2 dBV	
5.00 x 1K	LP	5.00 KHz	-1.8 dBV to -4.2 dBV	
4.00 x 1K	LP	4.00 KHz	-1.8 dBV to -4.2 dBV	
3.00 x 1K	LP	3.00 KHz	-1.8 dBV to -4.2 dBV	
2.00 x 1K	LP	2.00 KHz	-1.8 dBV to -4.2 dBV	
1.00 x 1K	LP	1.00 KHz	-1.8 dBV to -4.2 dBV	
1.00 x 1K*	LP	1.00 KHz	-1.8 dBV to -4.2 dBV	
0.90 x 1K	LP	900 Hz	-1.8 dBV to -4.2 dBV	
0.80 x 1K	LP	800 Hz	-1.8 dBV to -4.2 dBV	
0.70 x 1K	LP	700 Hz	-1.8 dBV to -4.2 dBV	
0.60 x 1K	LP	600 Hz	-1.8 dBV to -4.2 dBV	
0.50 x 1K	LP	500 Hz	-1.8 dBV to -4.2 dBV	
0.40 x 1K	LP	400 Hz	-1.8 dBV to -4.2 dBV	
0.30 x 1K	LP	300 Hz	-1.8 dBV to -4.2 dBV	
0.20 x 1K	LP	200 Hz	-1.8 dBV to -4.2 dBV	
0.10 x 1K	LP	100 Hz	-1.8 dBV to -4.2 dBV	
0.10 x 1K*	LP	100 Hz	-1.8 dBV to -4.2 dBV	
0.09 x 1K	LP	90 Hz	-1.8 dBV to -4.2 dBV	
0.08 x 1K	LP	80 Hz	-1.8 dBV to -4.2 dBV	
0.07 x 1K	LP	70 Hz	-1.8 dBV to -4.2 dBV	
0.06 x 1K	LP	60 Hz	-1.8 dBV to -4.2 dBV	
0.05 x 1K	LP	50 Hz	-1.8 dBV to -4.2 dBV	
0.04 x 1K	LP	40 Hz	-1.8 dBV to -4.2 dBV	
0.03 x 1K	LP	30 Hz	-1.8 dBV to -4.2 dBV	
0.02 x 1K	LP	20 Hz	-1.8 dBV to -4.2 dBV	
0.01 x 1K	LP	10 Hz	-1.8 dBV to -4.2 dBV	

* Use the "10" of the next lower digit to obtain this setting.

Table 4.3. D.C. Offset

Cutoff Frequency	Mode	Gain	Specification	Measured
10.00 x 10K	LP	0 dB	± 2.5 mV dc	
10.00 x 10K	LP	20 dB	± 2.5 mV dc	
0.01 x 10	HP	0 dB	± 2.5 mV dc	
0.01 x 10	HP	20 dB	± 2.5 mV dc	

Table 4.4. Broadband Noise

Cutoff Frequency	Mode	Gain	Specification	Measured
10.00 x 10K	LP	0 dB	200 uV rms, max	
10.00 x 10K	LP	20 dB	200 uV rms, max	
0.01 x 10	HP	0 dB	200 uV rms, max	
0.01 x 10	HP	20 dB	200 uV rms, max	

Table 4.5. Maximum Stopband Attenuation

Cutoff Frequency	Mode	Input Frequency	Specification	Measured
1.00 x 10K	LP	200 KHz	90 dB	
10.00 x 10K	HP	5 KHz	90 dB	

Table 4.6. Harmonic Components

	Specification	Measured
2nd Harmonic	-80 dB	
3rd Harmonic	-80 dB	
4th Harmonic	-80 dB	

Table 4.7. Line-Related Spurious Components

	Specification	Measured
Line Frequency	-100 dB	
2 x Line Frequency	-100 dB	
3 x Line Frequency	-100 dB	

4-4. ADJUSTMENTS*

a. DC Offset Adjustment

This adjustment may be performed if the output dc level is determined to be out of specification. The adjustment should be performed after allowing at least 10 minutes for the instrument to warm up under power. Connect a short across the input connector of the instrument and the DC Multimeter across the output connector. Perform the adjustments shown below:

Cutoff Freq.	Mode	Gain	Response	Adjustment and 452 : Vo	Output V 852 : Vo
10.00 x 1K	Hi Pass	20 dB	Flat Ampl.	R23 : ±2.5 mV	R27 : ± 2.5 mV
0.01 x 1K	Lo Pass	20 dB	Flat Ampl.	R8 : ±2.5 mV	R8 : ± 2.5 mV

b. Attenuator Response Adjustment

This adjustment may be performed if the response at 100 KHz in high-pass mode and 0 dB gain is out of specification. Connect the Frequency Synthesizer to the input of the instrument and the Gain/Phase Meter betwen input and output. Use the following settings:

Input Frequency	:	100 KHz / 1 KHz
Amplitude	:	1.0 V rms
Filter Settings	:	5.00 x 10
		Hi Pass
		0 dB Gain
		Flat Ampl.

Model 452: Adjust C1 to obtain same gain at 100 KHz as at 1 KHz (within ± 0.25 dB)

Model 852: Adjust C1 to obtain same gain at 100 KHz as at 1 KHz (within ± 0.5 dB)

c. Gain Adjustment

This adjustment may be performed if the passband gain, or the attenuation at the cutoff frequency is determined to be out of specification. Connect the 5100 Frequency Synthesizer to the input of the instrument and the 400FL AC Voltmeter to the appropriate points indicated below. Proceed as follows:

---

* The Frequency Synthesizer should be terminated with 50 ohms and the Filter Channel under adjustment should be terminated with 5K.

Model 452

1. Set filter settings as follows:
   5.00 x 100
   Lo Pass
   0 dB Gain
   Flat Amplitude
2. Set input frequency to 500 Hz. Connect the AC Voltmeter to TP-1 and adjust input amplitude to obtain a reading of -10.0 dBV.
3. Move the AC Voltmeter to TP-2 and verify a reading of -14.1 dBV (± 0.1 dB).
4. Move the AC Voltmeter to OUT and adjust R19 to obtain a reading of -4.8 dBV.
5. Change filter setting to 5.00 x 1K and adjust R11 to obtain a reading of -1.8 dBV at OUT.

Model 852

1. Set filter settings as follows:
   5.00 x 100
   Lo Pass
   0 dB Gain
   Flat Amplitude
2. Set input frequency to 500 Hz. Connect the AC Voltmeter to TP-1 and adjust input amplitude to obtain a reading of -10.0 dBV.
3. Move the AC Voltmeter to TP-2 and verify a reading of -15.5 dBV (± 0.1 dB).
4. Move the AC Voltmeter to TP-3 and adjust R19 to obtain a reading of -17.4 dBV.
5. Move the AC Voltmeter to TP-4 and adjust R24 to obtain a reading of -12.8 dBV.
6. Move the AC Voltmeter to OUT and adjust R31 to obtain a reading of +3.6 dBV.
7. Change filter setting to 5.00 x 1K and adjust R11 to obtain a reading of +6.6 dBV at OUT.

d. High Frequency (x 10K) Cutoff Adjustment

This adjustment may be performed if cutoff frequency in the x 10K position is determined to be out of specification, while other positions are within specification. It should also be performed if the Gain adjustment described above has been performed. Connect the Frequency Synthesizer to the input of the instrument and the Gain/Phase meter to the appropriate points shown below. Use the following settings

	A	B	C
Input Frequency :	50.0 KHz	100.0 KHz	50.0 KHz
Amplitude :	1.0 V rms	1.0 V rms	1.0 V rms
Filter Settings :	5.00 x 10K	1.00 x 10K	5.00 x 10K
	Lo Pass	Hi Pass	Hi Pass
	0 dB Gain	0 dB Gain	0 dB Gain
	Flat Amplitude	Flat Amplitude	Flat Amplitude

Model 452: Perform the following adjustments:

Gain/Phase meter connected between:	TP-1 & TP-2	TP-2 & OUT	IN & OUT
A - Alternately adjust:	C29 & C34	C39 & C44	C39 & C44
to obtain Gain (dB):	-4.1 ± 0.2	+9.3 ± 0.2	-3.0 ± 0.2
and Phase (deg):	90 ± 1	90 ± 3	180 ± 4
B - Adjust:			R16
to obtain Gain (dB):			0.0 + 0.1
C - Adjust:			R21
to obtain Gain (dB):			-3.0 ± 0.0

Model 852: Perform the following adjustments:

Gain/Phase meter connected between:	TP-1 & TP-2	TP-2 & TP-3	TP-3 & TP-4	TP-4 & OUT	IN & OUT
A - Alternately Adjust:	C29 & C34	C39 & C44	C49 & C54	C59 & C64	C59 & C64
to obtain Gain (dB):	-5.5 ± 0.2	-1.9 ± 0.2	+4.6 ± 0.2	+16.5 ± 0.2	-3.0 ± 0.5
& Phase (deg):	90 ± 1	90 ± 1	90 ± 2	90 ± 6	180 ± 8
B - Adjust:					R16
to obtain Gain (dB):					0 + 0.2
C - Adjust:					R33
to obtain Gain (dB):					-3.0 ± 0.0

4-5. TROUBLESHOOTING PROCEDURES

a. 1st Level Troubleshooting

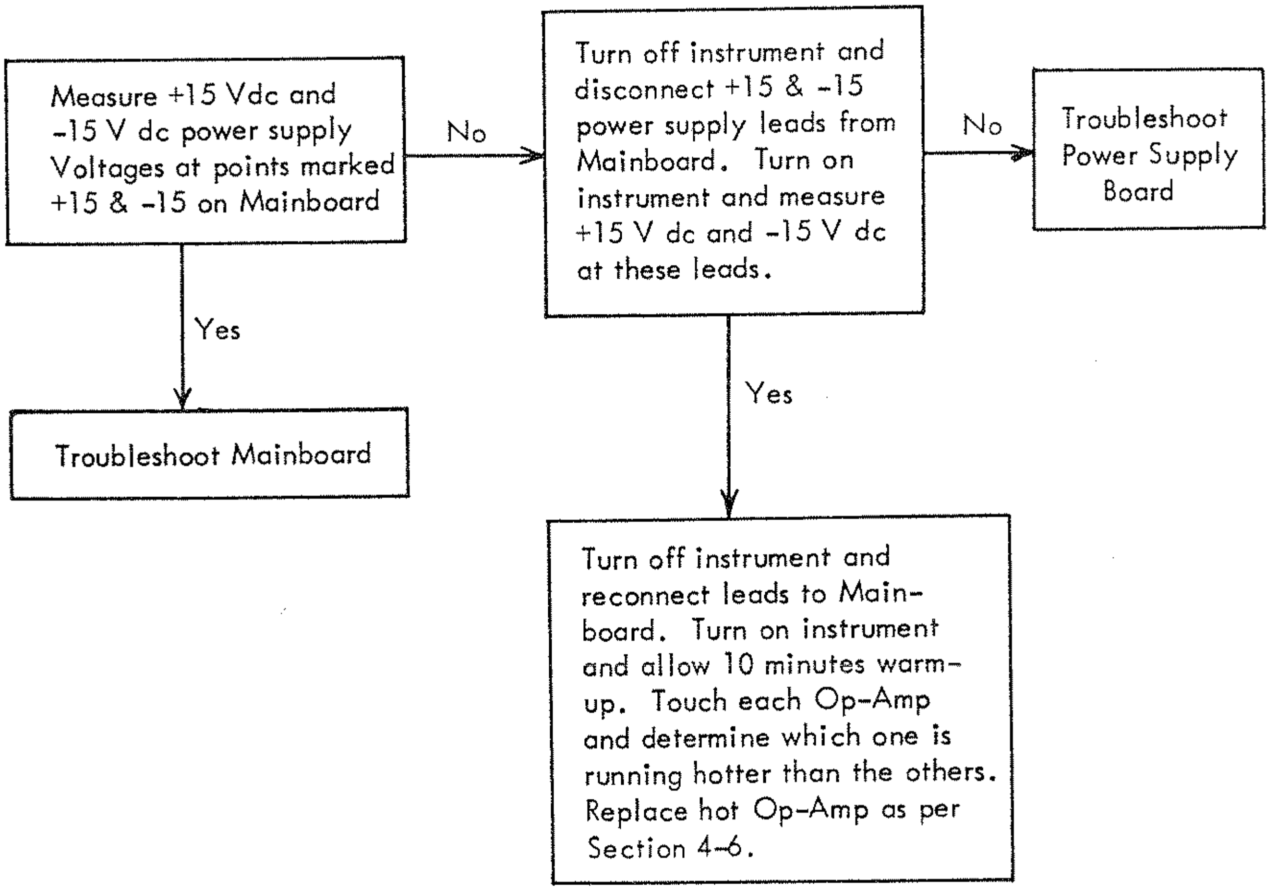
If both LED indicators fail to operate when the power switch is in the ON position:

1. Make certain that line power is available to the instrument.
2. Check that the 115/230 volt switch is in proper position for the available line voltage.
3. Check the fuse and replace, if defective.
4. With the power switch in the ON position check continuity of the power cord with an ohmmeter.
5. Check proper functioning of the Floating Operation switch by verifying a short/open between the third wire of the power cord and the shell of one of the BNC connectors.

If one LED indicator is on and the other is off, troubleshoot the Power Supply board (see 3rd Level Troubleshooting).

b. 2nd Level Troubleshooting

1. If both indicators are on but the instrument fails to operate, remove the hardware that secures the top and bottom covers to the rear panel; slide back and remove top and bottom covers.
2. Perform the procedure in the order given in the 2nd Level Troubleshooting Tree. Voltages (±0.25 Volts) given in this Tree are measured with respect to ground using a Digital Multimeter (See Section 4-2 for Recommended Test Equipment).



2nd Level Troubleshooting Tree

c. <u>3rd Level Troubleshooting : Power Supply Board</u>

1. To gain access to the Power Supply board, proceed as follows:

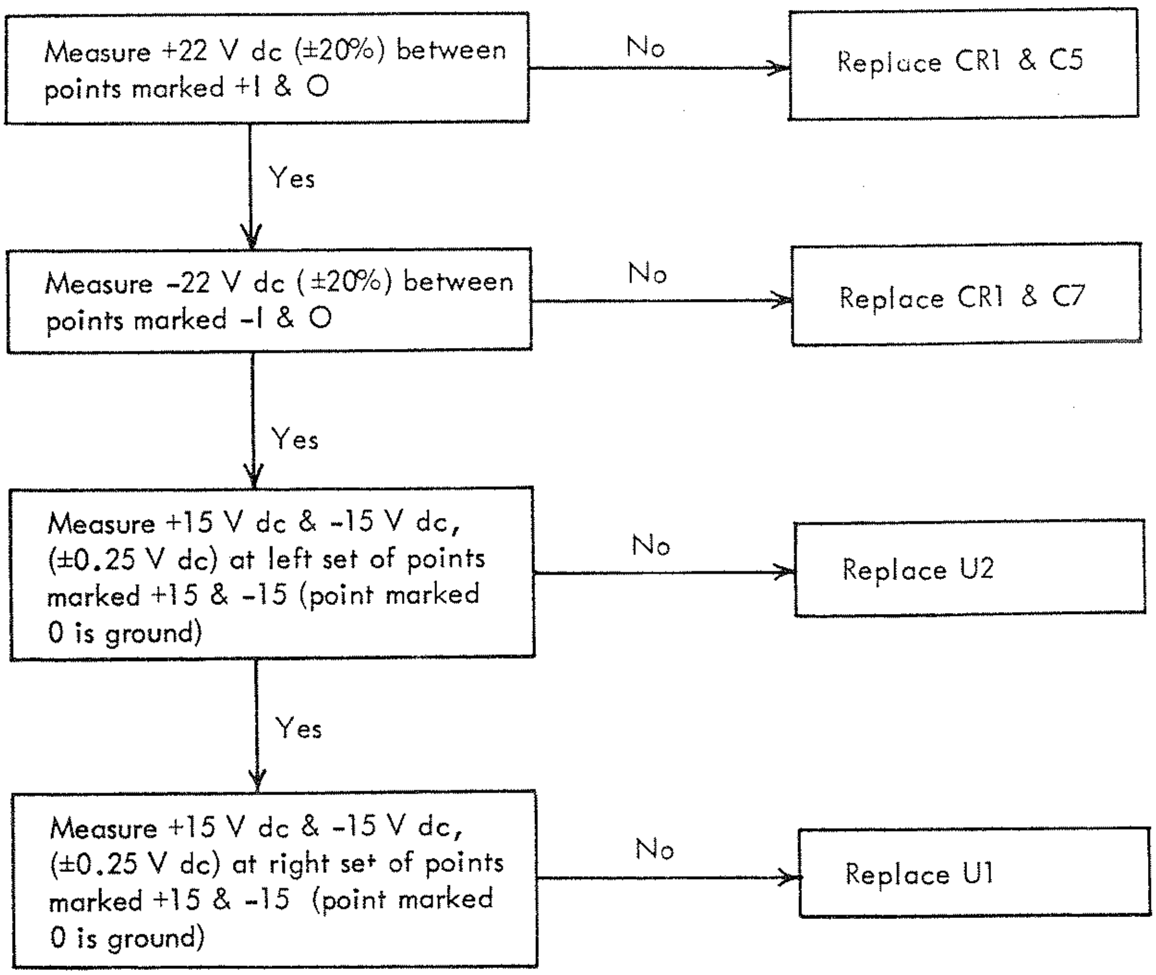
   a. Remove the two screws which fasten the Rear Panel to the Side Frames and pull back the Rear Panel.

   b. Remove the two screws which fasten the Power Supply Shield Box to the Rear Panel and move the Shield Box forward.

   c. Remove the four screws which fasten the Power Supply board to the Rear Panel standoffs. Disconnect Power Supply leads from Mainboards and move Power Supply board out of the Shield Box.

2. Perform the procedure in the order given in the 3rd Level Troubleshooting Tree. Voltages given in this Tree are measured with respect to ground using a Digital Multimter (See Section 4-2. for Recommended Test Equipment).

3. Repair as per Section 4-6, and replace by reversing the previous procedure.



3rd Level Troubleshooting Tree: Power Supply board

d. <u>4th Level Troubleshooting: Mainboard</u>

1. Set filter channel controls as follows:
   5.00 x 1K
   Lo Pass
   0 dB Gain
   Flat Amplitude

2. Apply input signal at 500 Hz and adjust its amplitude to 0.0 dBV.

3. Perform the procedure in the order given in the 4th Level Troubleshooting Tree. Voltages (±0.2 dB) given in this Tree are measured with respect to ground using an AC Voltmeter (See Section 4-2. for Recommended Test Equipment).

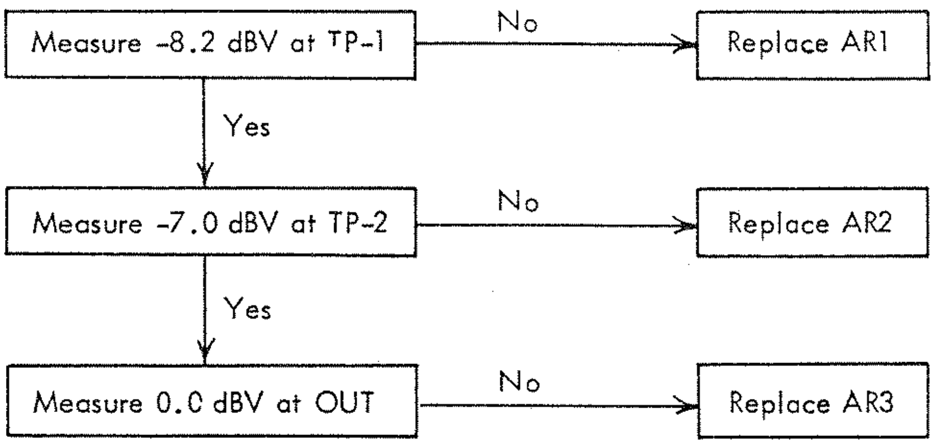
4. If replacement of any component is required, access to the bottom of the Mainboard is either readily available, or, if behind one of the Support Bars, it may be made available as follows:

   a. Remove the three screws from each Mainboard that fasten them to the Support Bar.

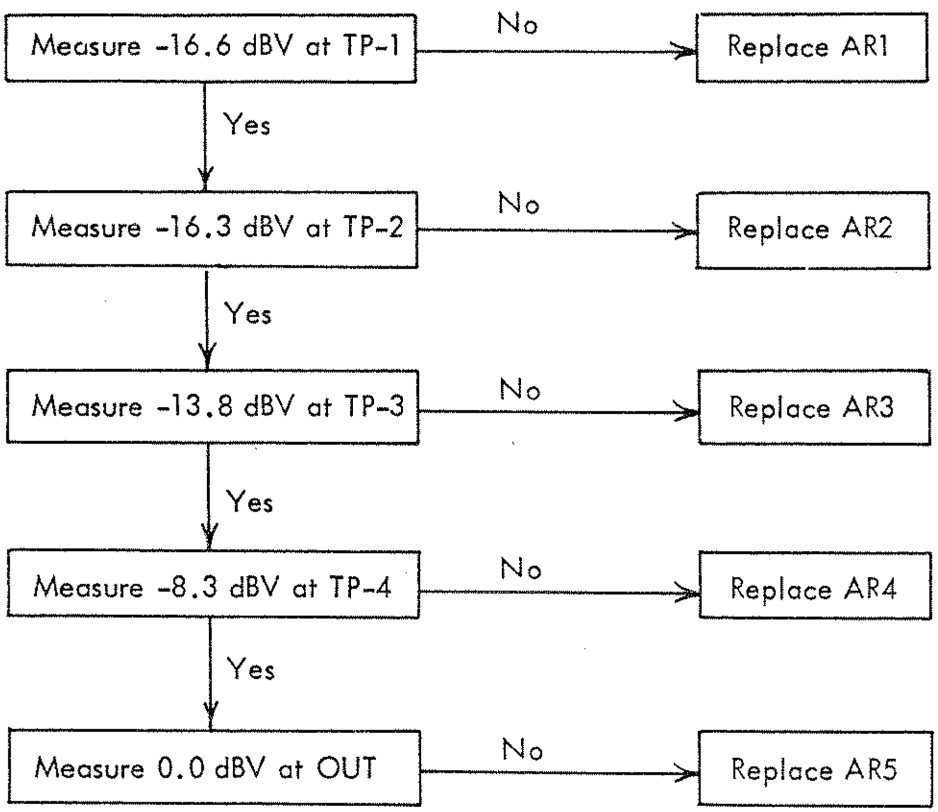
   b. Remove all fastening nuts from the Shield Board (between channels) and lift Shield Board supporting lugs out of the holes in Support Bars.

   c. Remove the two screws which fasten the Support Bar to the Side Frames. Lift Mainboards slightly and slide Support Bar forwards (or backwards) to expose desired area on bottom of Mainboard.

   d. Repair as per Section 4-6. and replace by reversing the above procedure.



Model 452



Model 852

4th Level Troubleshooting Tree: Mainboard

4.6 PRINTED CIRCUIT BOARD REPAIR

When replacing integrated circuits or other electronic components soldered to printed-circuit boards, the procedures indicated below should be followed to prevent potential damage to the board.

1. Determine by troubleshooting techniques, which component has failed.

2. Remove the defective component from the board by cutting the pins or leads with a small diagonal clipping tool. (Always remove and replace the entire component.)

3. Apply heat (40-50 W soldering iron) sparingly to each of the cut pins or leads and remove from the board; clean the hole(s) with a toothpick or solder suction tool.

4. Form the tinned leads of the replacement part and insert in the printed circuit holes; solder, then trim leads to extend 1/16-inch beyond the back surface of the board. (Use only 63-37 solder with maximum 1/16 -inch diameter.)

5. When soldering semiconductor devices and all small components, be sure to use a heat sink tool or long-nosed plier connected to the component lead(s) while each is being soldered. Allow the soldered connection to cool before removing the heat sink.

6. Clean all dirt and solder-flux from the printed circuit traces by liberal application of isopropyl alcohol or freon-type solvents.

4-7. POWER SUPPLY REMOVAL

Step 1 - Remove top and bottom covers.

Step 2 - Remove center conductor from all four BNC connectors on the rear panel. Be very careful not to move or bend center conductor. (It is very susceptible to breaking).

Step 3 - The ribbon cable coming out of the power supply shield should be disconnected from the boards it's going to, noting wiring configuration.

Step 4 - Unscrew the 5/16 inch nut to remove the power switch from the front panel.

Step 5 - Unscrew the four cable ties on the side panel.

Step 6 - Using a flat blade screw driver in behind the power supply shield, pry out the black "Hayco" grommet. Cut any cable ties if needed.

Step 7 - Remove the two screws holding the rear panel to side frame and the two screws holding the power supply shield to rear panel and let the panel lay down flat. (If an 01 option is installed, remove the two screws from the right angle bracket to the stand off of the capacitor packs).

Step 8 - Lift the power supply shield up and move it to the side as much as you need to remove the four screws holding the power supply board in.

Step 9 - Unsolder the five wires from the line cord and power switch co-ax cable on the power supply board noting wiring configuration.

Step 10- The power supply board can now be removed for repair or replacement.

SECTION V

REPLACEABLE PARTS LISTS & DIAGRAMS

5-1. INTRODUCTION

This section contains an alphanumeric listing of all replaceable electrical parts used in the instrument. Reference designations applying to the parts list are provided below. Component-location and schematic diagrams are also included.

5-2. ORDERING INFORMATION

To order a replacement part, address inquiry to your Wavetek Representative, or:

Wavetek San Diego, Inc.
9045 Balboa Ave.
San Diego, CA 92123
Phone: (619) 279-2200
TWX: (910) 355-2007

Specify the following information:

1) Model and serial number of instrument
2) Circuit reference designation
3) Wavetek part number
4) Description of part

REFERENCE DESIGNATIONS

A	Assembly	MP	Mechanical Part
AR	Amplifier	P	Plug
B	Motor	Q	Transistor
C	Capacitor	R	Resistor
CR	Diode	S	Switch
DS	Device Indicator	T	Transformer
F	Fuse	U	Microcircuit
FL	Filter	VR	Voltage Regulator
J	Conncector	X	Socket
K	Relay		

ASSEMBLY A1

Power Supply Assembly, Models 452 & 852

P/N 004-0950

Ref. Des.	Description	P/N
C1, C2, C3	C: Fxd cer 0.01 uF +80 -20% 100 V	100-3100
C5, C7	C: Fxd elect 500 uF 50 V	109-7500
C6, C8, C11, C12	C: Fxd tant 0.01 uF 20% 35 V	109-4100
C9, C10, C13, C14	C: Fxd polyester 0.0015 uF 10% 100 V	105-2150
CR1	CR: Sil FWB 50 PIV 1.5 A	130-0140
R1, R2	R: Fxd comp 15K 5% 1/4W	116-3151
R3, R4, R5, R6	R: Fxd comp 10 ohm 5% 1/4W	116-0101
R7, R8	R: Fxd comp 2.2K 5% 1/4W	116-2221
S1	S: Switch Slide DPDT, PC 115/230	342-2203
S2	S: Switch Slide DPDT, PC Mount	342-2202
T1	T: Transformer, Power	177-3012
U1, U2	U: Dual volt reg ±15 V 100 mA	120-0152

ASSEMBLY A2, A3

Mainboard Assembly, Model 452

P/N 004-0960

Ref. Des.	Description	P/N
C1	C: Var mica 2-25pF 175 V	108-0250
C2	C: Fxd mica dipped 100pF 10% 500 V	101-1100
C3, C5, C7, C9, C10, C12, C13	C: Fxd ceram. 0.01uF +80 -20% 30 V	100-3101
C4, C6, C15, C16	C: Fxd tant 1uF 20% 35 V	109-5100
C8	C: Fxd mica dipped 33pF 10% 500 V	101-0330
C11	C: Fxd mica dipped 200pF 10% 500 V	101-1200
C14	C: Fxd mica dipped 47pF 10% 500 V	101-0470
C25, C30, C35, C40	C: Fxd polycarb 1.0uF 1% 100 V	104-5100
C26, C31, C36, C41	C: Fxd polycarb 0.1uF 1% 100 V	104-4100
C27, C32, C37, C42	C: Fxd polycarb 0.01uF 1% 100 V	104-3100
C28, C33, C38, C43	C: Fxd mica dipped 820pF 10% 500 V	101-1820
C29, C34, C39, C44	C: Var mica 24-200pF 175 V	108-1200
CR1, CR4	CR: Zener 6.8 V 10% 400 mW	131-9680
CR2, CR3	CR: Sil low leak 70 PIV 200 mA	132-0457
R1	R: Fxd metflm 900K 1% 1/8W	113-9000
R2, R3	R: Fxd metflm 100K 1% 1/8W	113-1000
R4	R: Fxd comp 2.7K 5% 1/4W	116-2271
R5, R6	R: Fxd comp 10K 5% 1/4W	116-3101
R7, R24	R: Fxd metflm 64.9K 1% 1/8W	112-6490
R8	R: Var cermet 50K 10% 1/2W	118-3501
R9, R13, R17	R: Fxd comp 100 ohm 5% 1/4W	116-1101
R10	R: Fxd metflm 4.32K 1% 1/8W	111-4320
R11, R19	R: Var cermet 50 ohm 10% 1/2W	118-0500
R12	R: Fxd metflm 1.5K 1% 1/8W	111-1500
R14	R: Fxd metflm 154 ohm 1% 1/8W	110-1540
R15, R25	R: Fxd metflm 1.0K 1% 1/8W	111-1000
R16, R21	R: Var cermet 10K 10% 1/2W	118-3101
R20	R: Fxd metflm 2.0K 1% 1/8W	111-2000
R22	R: Fxd comp 47 ohm 5% 1/4W	116-0471
R22 (Option-02)	R: Fxe comp 620 ohm 5% 1/4W	116-1621
R26, R18	R: Fxd metflm 2.49K 1% 1/8W	111-2490
R27 *	R: Fxd comp 1K 5% 1/4W	116-2101
R28 *	R: Fxd comp 33K 5% 1/4W	116-3331
R29 *	R: Fxd comp 47K 5% 1/4W	116-3471
R30 *	R: Fxd comp 6.8K 5% 1/4W	116-2681
R23	R: Var cermet 100K 10% 1/2W	118-4103

* Factory selected value; typical value shown

ASSEMBLY A2, A3 - continued

Mainbaord Assembly, Model 452

P/N 004-0960

Ref. Des.		Description	P/N
R41, R45, R65, R69	R:	Fxd metflm 1.99K 1% 1/8W	111-1990
R42, R46, R66, R70	R:	Fxd metflm 7.96K 1% 1/8W	111-7960
R43, R47, R67, R71	R:	Fxd metflm 15.9K 1% 1/8W	112-1590
R44, R48, R68, R72	R:	Fxd metflm 3.98K 1% 1/8W	111-3980
R49, R53, R73, R77	R:	Fxd metflm 19.9K 1% 1/8W	112-1990
R50, R54, R74, R78	R:	Fxd metflm 79.6K 1% 1/8W	112-7960
R51, R55, R75, R79	R:	Fxd metflm 159K 1% 1/8W	113-1590
R52, R56, R76, R80	R:	Fxd metflm 39.8K 1% 1/8W	112-3980
R57, R61, R81, R85	R:	Fxd metflm 199K 1% 1/8W	113-1990
R58, R62, R82, R86	R:	Fxd metflm 796K 1% 1/8W	113-7960
R59, R63, R83, R87	R:	Fxd metflm 1.59M 1% 1/8W	114-1590
R60, R64, R84, R88	R:	Fxd metflm 398K 1% 1/8W	113-3980
S1, S9	S:	Push button Push/Push DPDT	341-2202
S2, S3, S4	S:	Rotary 4 pole 12 pos BCD Coded	345-4120
S5, S6	S:	Push button Push/Push 8PDT	341-8200
S8	S:	Rotary 7 pole 2-5 pos	343-7051
AR1, AR2	U:	Linear Op-Amp	120-1014
AR3	U:	Linear Op-Amp	120-1021

C17, C18 (Option-01 only)	C:	Fxd mica dipped 100pF 10% 500V	101-1100

ASSEMBLY A4, A5

Option -01 Assembly, Model 452

P/N 004-0980

Ref. Des.	Description	P/N
C1, C2, C3, C4	C: Fxd polycarb 10uF 1% 100V	104-6100

ASSEMBLY A2, A3

Mainboard Assembly, Model 852

P/N 004-0930

Ref. Des.	Description	P/N
C1	C: Var mica 2-25pF 175 V	108-0250
C2, C8, C14	C: Fxd mica dipped 100pF 10% 500 V	101-1100
C3, C5, C7, C9, C10, C12, C13, C15, C16, C18, C19	C: Fxd ceram. 0.01 uF +80 -20% 30 V	100-3101
C4, C6, C21, C22	C: Fxd tant 1uF 20% 35 V	109-5100
C11	C: Fxd mica dipped 500pF 10% 500 V	101-1500
C17	C: Fxd mica dipped 47pF 10% 500 V	101-0470
C20, C23	C: Fxd mica dipped 22pF 10% 500 V	101-0220
C25, C30, C35, C40, C45, C50, C55, C60	C: Fxd polycarb 1.0uF 1% 100 V	104-5100
C26, C31, C36, C41, C46, C51, C56, C61	C: Fxd polycarb 0.1uF 1% 100 V	104-4100
C27, C32, C37, C42, C47, C52, C57, C62	C: Fxd polycarb 0.01uF 1% 100 V	104-3100
C28, C33, C38, C43, C48, C53, C58, C63	C: Fxd mica dipped 820pF 10% 500 V	101-1820
C29, C34, C39, C44, C49, C54, C59, C64	C: Var mica 24-200pF 175 V	108-1200
C67	C: Fxd ceram. 1000pF +80 -20% 1000 V	100-2100
CR1, CR4	CR: Zener 6.8 V 10% 400 mW	131-9680
CR2, CR3	CR: Sil low leak 70 PIV 200 mW	132-0457
R1	R: Fxd metflm 900K 1% 1/8W	113-9000
R2, R3	R: Fxd metflm 100K 1% 1/8W	113-1000
R4	R: Fxd comp 4.7K 5% 1/4W	116-2471
R5, R6	R: Fxd comp 10K 5% 1/4W	116-3101
R9, R13, R17, R22, R29	R: Fxd comp 100 ohm 5% 1/4W	116-1101
R10	R: Fxd metflm 453 ohm 1% 1/8W	110-4530
R11, R19, R24, R31	R: Var cermet 50 ohm 10% 1/2W	118-0500
R12, R20, R25, R32, R38*	R: Fxd metflm 1.0K 1% 1/8W	111-1000

* Factory selected value; typical value shown

ASSEMBLY A2, A3 - continued

Mainboard Assembly, Model 852

P/N 004-0930

Ref. Des.		Description	P/N
R14	R:	Fxd metflm 57.6 ohm 1% 1/8W	119-5760
R15, R35	R:	Fxd metflm 1.5K 1% 1/8W	111-1500
R16	R:	Var cermet 1K 10% 1/2W	118-2102
R18	R:	Fxd metflm 340 ohm 1% 1/8W	110-3400
R23	R:	Fxd metflm 887 ohm 1% 1/8W	110-8870
R27, R8	R:	Var cermet 200K 10% 1/2W	118-4201
R28, R7	R:	Fxd metflm 200K 1% 1/8W	113-2000
R30	R:	Fxd metflm 1.62K 1% 1/8W	111-1620
R33	R:	Var cermet 10K 10% 1/2W	118-3101
R34	R:	Fxd metflm 1.33K 1% 1/8W	111-1330
R36	R:	Fxd comp 47 ohm 5% 1/4W	116-0471
R36 (Option-02)	R:	Fxd comp 620 ohm 5% 1/4W	116-1621
R37 *	R:	Fxd comp 5.6K 5% 1/4W	116-2561
R41, R45, R65, R69, R89, R93, R113, R117	R:	Fxd metflm 1.99K 1% 1/8W	111-1990
R42, R46, F66, F70, R90, R94, R114, F118	R:	Fxd metflm 7.96K 1% 1/8W	111-7960
R43, R47, R67, R71, R91, R95, R115, F119	R:	Fxd metflm 15.9K 1% 1/8W	112-1590
R44, R48, R68, R72, R92, R96, R116, R120	R:	Fxd metflm 3.98K 1% 1/8W	111-3980
R49, R53, R73, R77, R97, R101, R121, R125	R:	Fxd metflm 19.9K 1% 1/8W	112-1990
R50, R54, R74, R78, R98, R102, R122, R126	R:	Fxd metflm 79.6K 1% 1/8W	112-7960
R51, R55, R75, F79, R99, R103, R123, R127	R:	Fxd metflm 159K 1% 1/8W	113-1590
R52, R56, R76, R80, R100, R104, R124, R128	R:	Fxd metflm 39.8K 1% 1/8W	112-3980
R57, R61, R81, R85, R105, R109, R129, R133	R:	Fxd metflm 199K 1% 1/8W	113-1990
R58, R62, R82, R86, R106, R110, R130, R134	R:	Fxd metflm 796K 1% 1/8W	113-7960
R59, R63, R83, R87, R107, R111, R131, R135	R:	Fxd metflm 1.59M 1% 1/4W	114-1590
R60, R64, R84, R86, R108, R112, R132, R136	R:	Fxd metflm 398K 1% 1/8W	113-3980

* Factory selected value; typical value shown

ASSEMBLY A2, A3 - continued

Mainboard Assembly, Model 852

P/N 004-0930

Ref. Des.		Description	P/N
R137*	R:	Fxd comp 330 ohm 5% 1/4W	116-1331
R140*	R:	Fxd comp 3.9K 5% 1/4W	116-2391
R141 *	R:	Fxd comp 2.7K 5% 1/4W	116-2271
S1, S9	S:	Push button Push/Push DPDT	341-2202
S2, S3, S4	S:	Rotary 8pole 12 pos Coded	345-8124
S5, S6, S7	S:	Push button Push/Push 8PDT	341-8200
S8	S:	Rotary 13 pole 2-5 pos	344-3050
AR1, AR2, AR3 AR4, AR5	U:	Linear Op-Amp	120-1007
C65, C66 (Option-01 only)	C:	Fxd mica dipped 100pF 10% 500V	101-1100

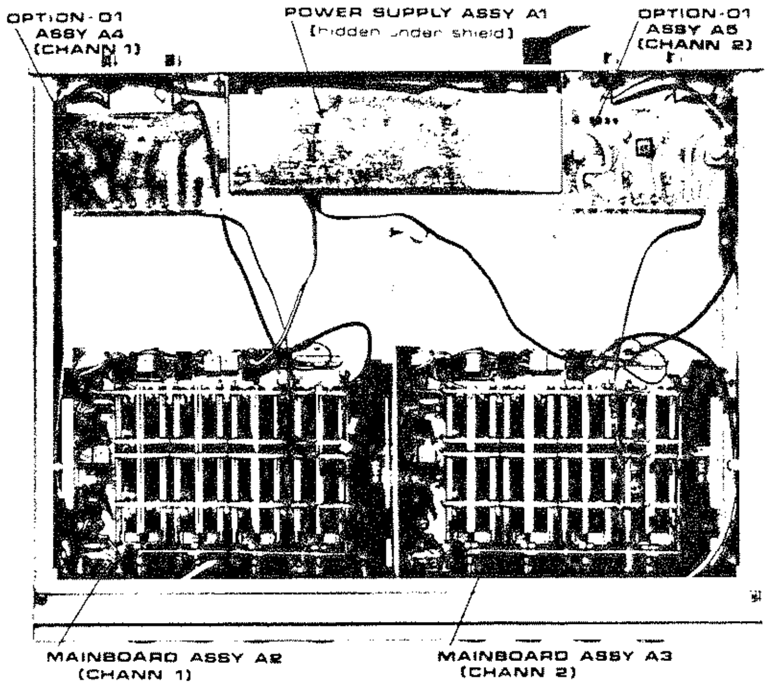
ASSEMBLY A4, A5

Option -01 Assembly, Model 852

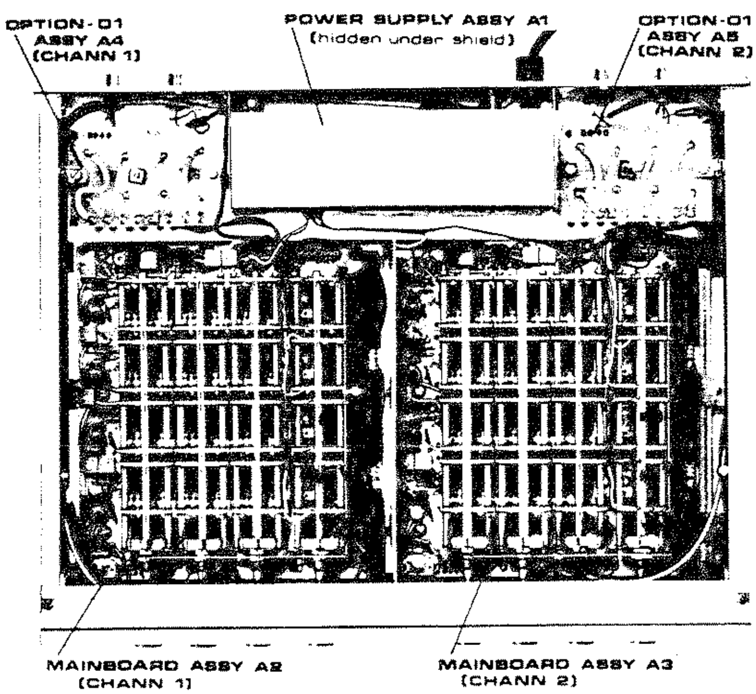
P/N 004-0940

Ref. Des.		Description	P/N
C1, C2, C3, C4, C5, C6, C7, C8	C:	Fxd polycarb 10uF 1% 100V	104-6100

* Factory selected value; typical value shown



Model 452-01



Model 852-01

Fig. 5-1 Assembly Designation