

WIDE RANGE

**BAND PASS FILTER**

MODEL 3103A-4 SERIAL NO. 1278

10 kHz - 3 MHz

**OPERATING AND MAINTENANCE  
MANUAL**



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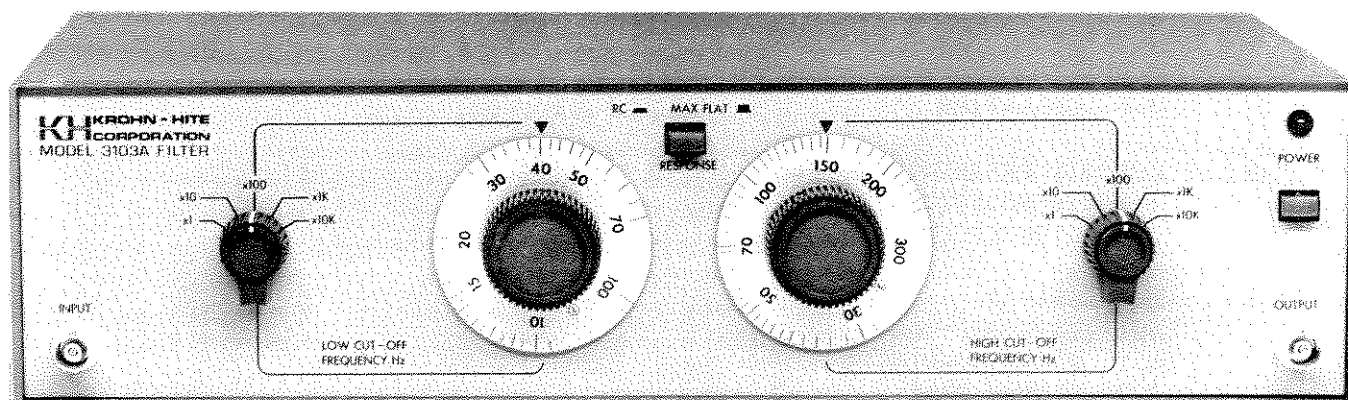


Figure 1. Model 3103A-4

## SECTION 1

## GENERAL DESCRIPTION

## 1.1 INTRODUCTION

The Model 3103A-4, illustrated in Figure 1, is a variable band-pass Filter with a low cutoff frequency range adjustable from 10Hz to 1MHz and a high cutoff range adjustable from 30Hz to 3MHz. The pass-band gain is unity (0dB), with attenuation rate of 18dB per octave outside the passband, and a maximum attenuation of 80dB. Maximum input signal amplitude is 3 volts rms and output hum and noise is less than 100 microvolts.

## 1.2 SPECIFICATIONS

FREQUENCY RANGE: Low cutoff frequency independently adjustable from 10Hz to 1MHz in five bands.

Band	Multiplier	Frequency Hz
1	1	10-100
2	10	100-1K
3	100	1K-10K
4	1K	10K-100K
5	10K	100K-1M

High Cutoff Frequency independently adjustable from 30Hz to 3MHz in five bands.

Band	Multiplier	Frequency Hz
1	1	30-300
2	10	300-3K
3	100	3K-30K
4	1K	30K-300K
5	10K	300K-3M

FREQUENCY DIALS: Separate low cutoff and high cutoff dials are individually calibrated with logarithmic scales reading directly in Hz.

CUTOFF FREQUENCY CALIBRATION ACCURA-

CY: +5% (+ 10% band 5) with RESPONSE switch in MAX FLAT (Butterworth) position; less accurate in RC position. Relative to mid-band level, the Filter output is down 3dB at cutoff in MAX FLAT position, and approximately 11dB in RC position.

BANDWIDTH: Continuously variable within the cutoff frequency limits of 10Hz and 3MHz.

ATTENUATION SLOPE: Nominal 18dB per octave.

MAXIMUM ATTENUATION: Greater than 80dB. See Section 5.2

PASS-BAND GAIN: 0dB  $\pm$  1/2dB.

HUM AND NOISE: Less than 100 microvolts.

FREQUENCY RESPONSE: Standard response is 3rd order Butterworth, maximally flat. A RESPONSE switch converts to simple RC response, optimum for transient-free performance.

## INPUT CHARACTERISTICS:

Maximum Input Amplitude: 3 volts rms, decreasing to 2.5 volts at 3MHz.

Impedance: 100K ohms in parallel with 50pF.

Maximum DC Component: 200 volts.

## OUTPUT CHARACTERISTICS:

Maximum Voltage: 3 volts rms, decreasing to 2.5 volts at 3MHz.

Maximum Current: 10 milliamperes rms

Internal Impedance: Approximately 50 ohms.

FLOATING (ungrounded) OPERATION: A chassis GROUND switch is provided on the rear panel to disconnect signal ground from chassis ground.

Note: For a more in depth definition of specifications, refer to Section 5.2

### 1.3 TERMINALS

On the front and rear panels, one BNC connector for INPUT, one for OUTPUT.

### 1.4 FRONT PANEL CONTROLS:

LOW CUTOFF FREQUENCY dial and multiplier switch.

HIGH CUTOFF FREQUENCY dial and multiplier switch.

RESPONSE switch for MAX FLAT (Butterworth) or RC (Transient-free) mode.

ON/OFF switch.

### 1.5 POWER REQUIREMENTS:

105-125 volts or 210-250 volts, single phase, 50-400 Hz, 15 watts.

### 1.6 DIMENSIONS AND WEIGHTS:

14"/35.6cm wide, 3.5"/9cm high, 8.5"/21.6cm deep, 8lbs./3.6Kgs.

An optional Rack Mounting Kit, (Part No. RK314), is available for installing the Filter into a standard 19" rack.

### 1.7 FILTER CHARACTERISTICS

#### BANDWIDTH ADJUSTMENT

The flexibility of adjustment of bandwidth is illustrated in Figure 2. Band-pass operation in the MAX FLAT (Butterworth) mode for two different bandwidths is illustrated by curves A and B. Curve B shows the

minimum pass-band width obtained by setting the two cutoff frequencies equal. In this condition the pass-band gain is 6dB, and the -3dB cutoff frequencies occur at 0.8 and 1.25 times the mid-band frequency. The minimum pass-band for a 0dB pass-band gain is shown by curve A with the cut-offs set at 0.5 and 2 times the mid-band frequency.

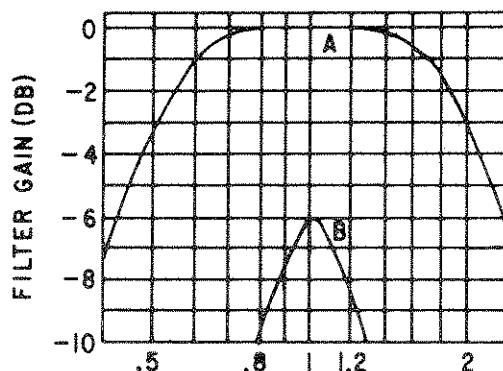


Figure 2. Normalized Filter Response

#### TRANSIENT RESPONSE

The frequency response characteristic of this Filter closely approximates a third order Butterworth with maximal flatness, ideal for filtering in the

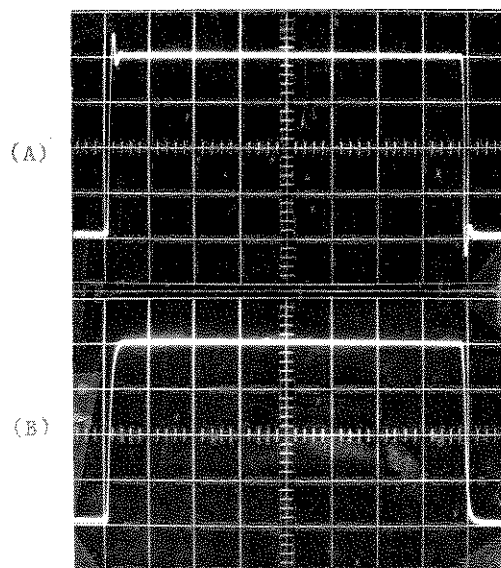


Figure 3. Response to 10kHz Square Wave with Cutoffs at 10Hz and 1MHz. (A) Butterworth (B) RC

frequency domain. For pulse or transient signal filtering, a RESPONSE switch is provided to change the frequency response to the RC mode, optimum for transient-free filtering. Figure 3 shows a comparison of the Filter output response in these modes to a square wave input signal.

#### CUTOFF RESPONSE

The attenuation characteristics of the Filter are shown in Figure 4. With the RESPONSE switch in the MAX FLAT (Butterworth) mode, the gain, as shown by the solid curve, is virtually flat until the -3dB cutoff

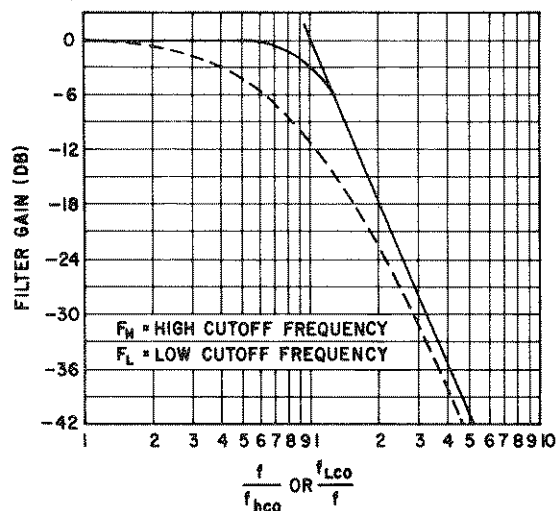


Figure 4. Normalized Attenuation Characteristics

frequency. At approximately two times the cutoff frequency, the attenuation rate coincides with the 18dB per octave straight line asymptote. In the RC mode, optimum for transient-free filtering, the dotted line shows that the gain is down approximately 11dB at cutoff and reaches 18dB per octave attenuation rate at ten times the cutoff frequen-

cy. Beyond this frequency the filter attenuation rate and maximum attenuation, in either mode, are identical.

#### PHASE RESPONSE

Due to the high-pass and low-pass sections of the Filter, the phase angle at any frequency is the sum of the angles. Figure 5 gives the phase characteristics for either section in degrees lead (+) or lag (-), as a function of the ratio of the operating frequency ( $f$ ) to low cutoff frequency ( $f_{lco}$ ) or high cutoff frequency ( $f_{hco}$ ). The solid curve is for the MAX FLAT (Butterworth) mode and the dotted curve is for the RC mode.

Example:

Determine the phase shift through the filter, in the MAX FLAT (Butterworth) mode with the low cutoff ( $f_{lco}$ ) at 200Hz, the high cutoff ( $f_{hco}$ ) at 600Hz and an input frequency ( $f$ ) at 300Hz.

Phase shift due to low cutoff ( $f_L$ )

$$\frac{f}{f_L} = \frac{300}{200} = 1.5$$

from Figure 5;  $1.5 = +80^\circ$

Phase shift due to high cutoff ( $f_H$ )

$$\frac{f}{f_H} = \frac{300}{600} = .5$$

from Figure 5;  $.5 = -60^\circ$

Total phase shift

$$= +80^\circ - 60^\circ = +20^\circ$$

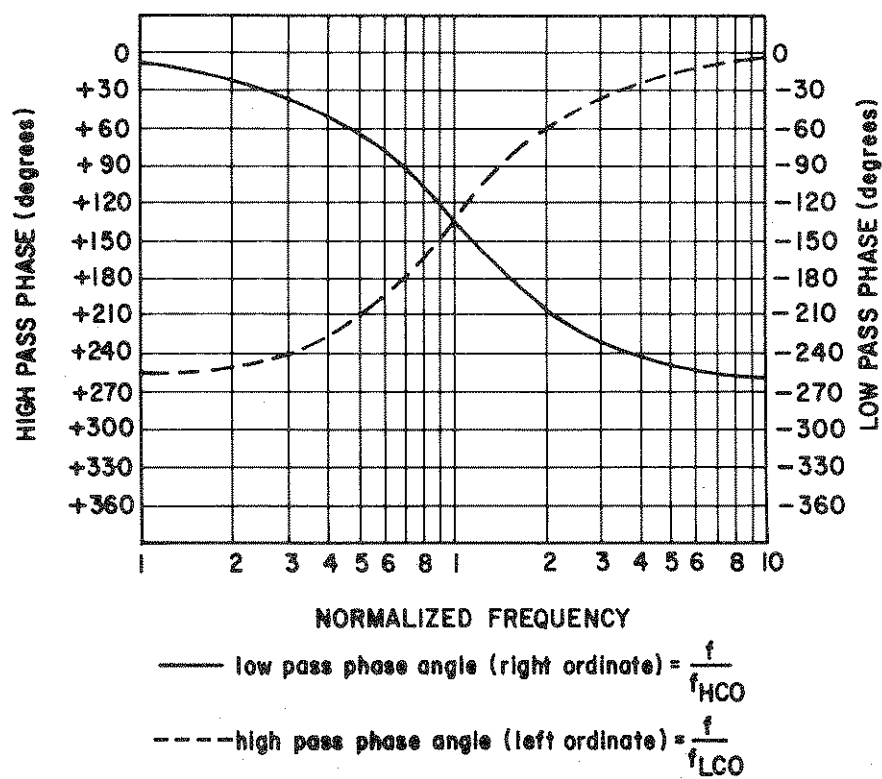


Figure 5. Normalized Phase Characteristics

## SECTION 2

## OPERATION

## 2.1 INTRODUCTION

As shown in the Simplified Schematic Diagram, Figure 6, the Filter consists of an input amplifier, a variable low-pass section (HIGH CUTOFF FREQUENCY), and a variable high-pass section (LOW CUTOFF FREQUENCY) connected in series. Both cutoff frequencies are tuned capacitively in decade steps by the band multiplier switch, and continuously within each decade by the frequency dial which varies four cascaded resistor-filter elements. A RESPONSE switch, S1, selects the desired filter characteristics.

## 2.2 TERMINALS

BNC coaxial connectors are provided on the front panel and on the rear panel for both INPUT and OUTPUT connections.

## 2.3 FRONT PANEL CONTROLS

The front panel of the Filter includes two dials and associated multiplier switches used to set cutoff frequencies; a power ON/OFF switch with indicator light; a RESPONSE switch for MAX FLAT or RC mode; two BNC coaxial connectors, one for the INPUT signal and one for the OUTPUT signal.

Each frequency dial is calibrated with a logarithmic scale reading directly in Hz. The left dial (LOW CUTOFF FREQUENCY) and the band multiplier switch select the low cutoff frequency. The right dial (HIGH CUTOFF FREQUENCY) and the multiplier switch select the high cutoff frequency.

The LOW CUTOFF FREQUENCY multiplier

switch has five positions, covering the frequency ranges as follows:

Band	Multiplier	Frequency Hz
1	1	10-100
2	10	100-1K
3	100	1K-10K
4	1K	10K-100K
5	10K	100K-1M

The HIGH CUTOFF FREQUENCY multiplier switch has five positions, covering the frequency ranges as follows:

Band	Multiplier	Frequency Hz
1	1	30-300
2	10	300-3K
3	100	3K-30K
4	1K	30K-300K
5	10K	300K-3M

## 2.4 LINE VOLTAGE AND FUSES

The Filter is powered from an ac line voltage of either 105-125 volts, with a 1/8A slow blow fuse, or 210-250 volts, with a 1/16A slow blow fuse, single phase, 50-400Hz. Use the LINE selector switch on the rear panel to select the proper mode of operation.

## CAUTION

The covers should not be removed when the filter is connected to an ac power source because of the potentially dangerous voltages that exist within the unit.

## 2.5 OPERATION

To operate the Filter, proceed as follows:

- a. Select proper ac line as described in Section 2.4.

b. Make appropriate connections to the INPUT and OUTPUT connectors of the Filter. The input voltage should not exceed 3 volts rms.

c. Set cutoff frequencies by means of the band multiplier switches and the frequency dials. The minimum pass-band is obtained by setting the HIGH CUTOFF FREQUENCY equal to the LOW CUTOFF FREQUENCY. (Refer to Section 1.7)

#### NOTE

The left multiplier switch and frequency dial are used to select the LOW CUTOFF FREQUENCY, and the right multiplier switch and frequency dial are used to select the HIGH CUTOFF FREQUENCY.

d. Push power switch on.

e. For normal Filter operation the FLOATING/CHASSIS GROUND switch, located on the rear panel, should be in the CHASSIS position. If the Filter is used in a system where ground loops make ungrounded or floating operation essential, this switch should be in the FLOATING position.

f. When filtering consists principally of separating frequency components of a signal, (frequency domain), the RESPONSE switch, should be in the MAX FLAT position. If the Filter is used to separate pulse type signals from noise, (time domain), this switch should be in the RC position.

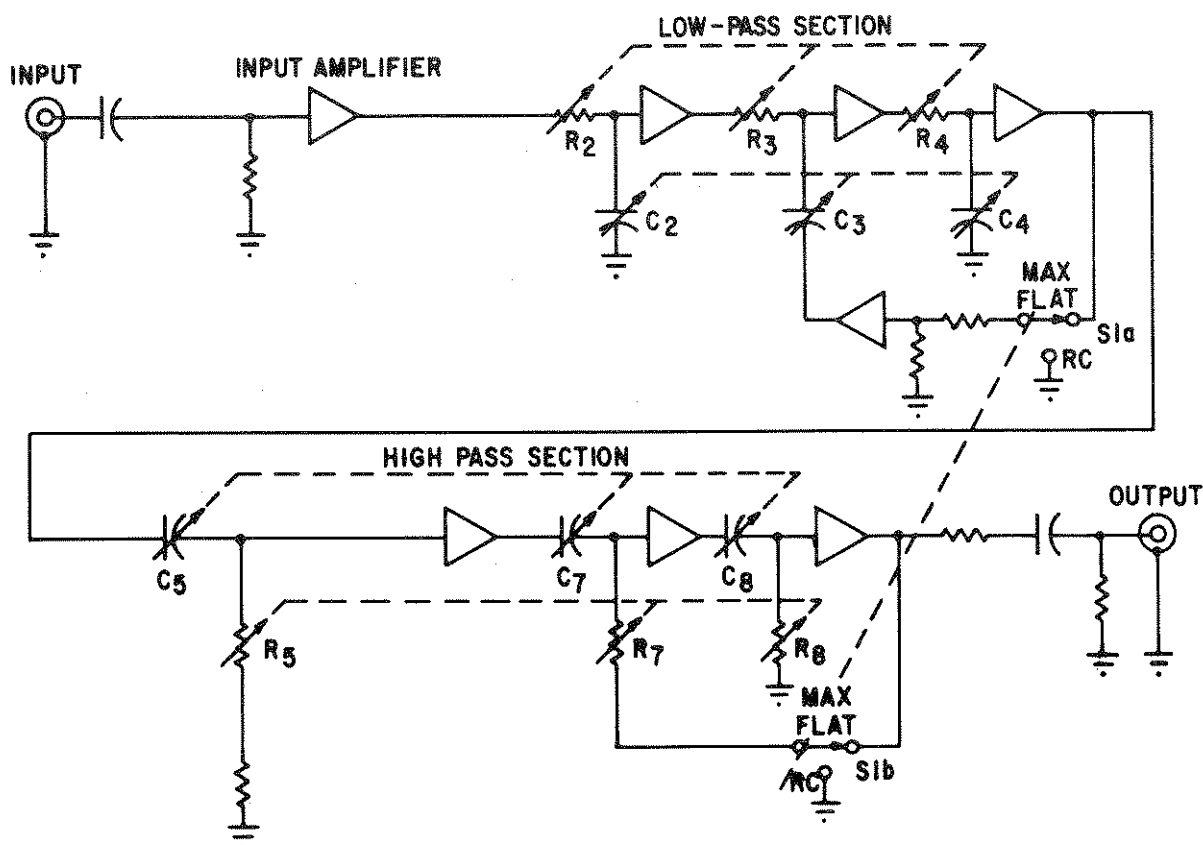


Figure 6. Simplified Schematic Diagram

## SECTION 3

## CIRCUIT DESCRIPTION

## 3.1 INTRODUCTION

As shown in the Simplified Schematic Diagram, Figure 6, the Filter consists of an input amplifier for input isolation. A three-pole low-pass filter section (HIGH CUTOFF FREQUENCY) with three RC filter networks adjustable by means of a ganged potentiometer assembly and band switch. A three-pole high-pass filter section (LOW CUTOFF FREQUENCY) with three filter networks and a similar ganged potentiometer assembly and band switch. Both cutoff frequencies are tuned capacitively in decade steps by the band switch, and continuously within each decade by the potentiometer assembly.

The Schematic of the Filter, Figure 8, is located at the rear of this manual.

## 3.2 CIRCUIT DESCRIPTION

## INPUT AMPLIFIER

The signal input is capacitor coupled to the input amplifier, consisting of emitter followers Q201 and Q202, via current limiting resistors R201 and R202, which in conjunction with clamping diodes, CR201 and CR202 prevent damage in the event of excessive input signal. The input amplifier isolates the input and provides the low impedance source necessary to drive the first RC filter network.

## LOW-PASS SECTION

The Low-Pass Section consists of a single RC filter network and a two-pole RC filter network. The networks are adjusted for the proper response to provide a Butterworth char-

acteristic when cascaded.

All RC filter networks are isolated from each other by a buffer amplifier which consists of two emitter followers. The emitter followers, Q205 and Q206, isolate the output of the single RC network from the input of the two-pole RC network.

The desired response characteristic of the two-pole filter is effected by feeding back a portion of the output of the two-pole filter network, via the attenuator consisting of R247, R248 and P206. Q212 is an emitter follower to prevent loading of this attenuator. An amplifier, consisting of Q210 and Q211, is used to isolate the low pass section from the high pass section, and also provide the additional gain required on band 5 of the high pass section.

## HIGH-PASS SECTION

The High Pass Section also consists of a single RC network and a two-pole RC filter network, each adjusted for the proper response to give a Butterworth characteristic when cascaded.

As in the low pass section, emitter followers are used to isolate all the RC filter networks. Q303 and Q304 act as a buffer amplifier between the output of the single RC network and input of the two-pole RC network. This amplifier also provides the gain, adjusted by P302, necessary to compensate for losses in the filter. R236, R237 and P305 set the gain of the two-pole network to achieve the desired frequency response. Q308 and Q309 are buffer followers to provide isolation from the output.

This amplifier also provides the gain

necessary to compensate for the loss through the filter. The feedback attenuator network consisting of R317 and R318 is used to obtain the desired response characteristic for the first two-pole filter and, similarly, R327 and P305 modify the response of the second two-pole filter. Q308 and Q309 are buffer followers to provide isolation from the output.

#### RC/BUTTERWORTH RESPONSE

To provide minimum overshoot to fast rise pulses, S202 is used to disconnect the feedback to the second two-pole filters of both the low-pass and high-pass sections.

#### POWER SUPPLIES

The Power Supplies deliver a plus 10 and minus 10 volts regulated volt-

age. It consists of a bridge rectifier CR101, CR104, CR105 and CR106 and filter capacitors C101 and C102 to provide the necessary unregulated dc voltage. The minus 10 volts regulated supply is a typical series type regulator, using a zener reference, Z101, and amplifiers Q108 and Q105 which drive a series regulator Q106. To prevent damage when short circuits of the regulated voltage occur, a current limiting circuit consisting of Q102 and R103 turns off the minus 10 volts supply if the current in R103 exceeds a predetermined value. The plus 10 volts supply uses the minus 10 volts as a reference. A divider network consisting of R113 and R114 sets the proper voltage level for the amplifiers Q107 and Q104, which drive the series regulator Q103. Q101 and R102 limit the current in the plus 10 volts supply.



1. When ordering parts, please specify the following:
- Instrument model number and serial number.
  - Schematic reference.
  - Manufacturer's part number.
2. Any engineering modifications will be found at the rear of this manual.
3. The part numbers listed are either the actual parts used or direct replacements.

CAPACITORS					RESISTORS				
SCHEM. REF.	DESCRIPTION			MFR.	PART NUMBER	SCHEM. REF.	DESCRIPTION		
C101	500uF		25V	SP	TT501N025	R112	1K	10%	1/2W
C102	500uF		25V	SP	TT501N025	R113	8.66K	1%	1/4W
C103	.01uF	10%	100V	CD	WMD1S1	R114	10K	1%	1/4W
C104	.01uF	10%	100V	CD	WMD1S1	R115	TRIM		1/4W
C105	1uF	+80-20%	100V	AVX	5C023105D8250B3	R116	1K	5%	1/2W
C106	100uF		25V	SP	30D107G025DD4	R117	1K	10%	1/2W
C107	100uF		25V	SP	30D107G025DD4	R118	25K	POT	1/2W
C108	100uF		25V	SP	30D107G025DD4	R119	1K	10%	1/2W
C109	.02uF	20%	500V	SP	C023A501J203M	R120	27	10%	1/4W
C110	1000pF	20%	500V	SP	C023B501E102M	R121	1K	10%	1/4W
C201	1uF	10%	200V	TRW	X663F-11	R122	47	10%	1/4W
C207	1uF	+1-3%	200V	TRW	X663F-9	R123	5.1K	5%	1/4W
C208	.1uF	+1-3%	200V	TRW	X663F-5	R124	330	10%	1/4W
C209	.01uF	+1-3%	200V	TRW	X663F-1	R201	1K	10%	1/2W
C210	940pF	1%	500V	KGN	DM19C941F	R202	1K	10%	1/4W
C211	85pF	10%	500V	KGN	DM15C850K	R203	100K	10%	1/4W
C212	1uF	+80-20%	100V	AVX	5C023105D8250B3	R204	470	10%	1/4W
C213	1uF	+1-3%	200V	TRW	X663F-9	P205	100	POT	1/2W
C214	.1uF	+1-3%	200V	TRW	X663F-5	R205	470	10%	1/4W
C215	.01uF	+1-3%	200V	TRW	X663F-1	P206	5K	POT	1/2W
C216	900pF	1%	500V	KGN	DM19C901F	R206	3K	5%	1/2W
C218	.32uF	+1-3%	200V	TRW	X663F-7	R207	47	10%	1/4W
C219	.032uF	+1-3%	200V	TRW	X663F-3	R208	470	5%	1/2W
C220	.0032uF	1%	300V	KGN	DM19C322F	R210A	10K	POT	1/2W
C221	295pF	1%	500V	KGN	DM19C295F	R210B	10K	10%	1/4W
C223	10-60pF	TRIMMER		STT	10STRIKO06N1500	R217A	500	POT	1/2W
C224	680pF	10%	500V	KGN	DM19C681K	R217B	130	10%	1/4W
C225	39pF	10%	500V	KGN	DM15C390J	R219	470	10%	1/4W
C226	1uF	+80-20%	100V	AVX	5C023105D8250B3	R220	100	10%	1/4W
C227	50uF		25V	SP	30D506G025CC4	R221	470	10%	1/4W
C231	18pF	5%	500V	KGN	DM15C180J	R222	8.2K	5%	1/4W
C232	10pF	10%	500V	QC	TYPE QC	R223	1.5K	5%	1/2W
C301	270pF	1%	500V	KGN	DM19C271F	R224	47	10%	1/4W
C302	3.2uF	+1-3%	50V	TRW	X663F-12	R230A	1K	POT	1/2W
C303	.32uF	+1-3%	200V	TRW	X663F-7	R230B	240	5%	1/4W
C304	.032uF	+1-3%	200V	TRW	X663F-3	R231A	25K	POT	1/2W
C305	.003uF	1%	300V	KGN	DM19C302F	R231B	7.5K	5%	1/4W
C311	.22uF	20%	100V	AVX	8131-100-651-224M	R232	100	10%	1/4W
C312	1uF	+1-3%	200V	TRW	X663F-9	R233	100	10%	1/4W
C313	.1uF	+1-3%	200V	TRW	X663F-5	R234	220	10%	1/4W
C314	.01uF	+1-3%	200V	TRW	X663F-1	R235	4.3K	5%	1/4W
C315	.001uF	1%	500V	KGN	DM19C102F	R236	47	10%	1/4W
C316	82pF	5%	500V	KGN	DM15C820J	R237	470	5%	1/2W
C317	10-60pF	TRIMMER		STT	10STRIKO06N1500	R238A	1K	POT	1/2W
C318	150pF	10%	500V	KGN	DM15C151K	R238B	240	5%	1/4W
C319	10-60pF	TRIMMER		STT	10STRIKO06N1500	R239A	25K	POT	1/2W
C320	3.2uF	+1-3%	50V	TRW	X663F-12	R239B	7.5K	5%	1/4W
C321	.32uF	+1-3%	200V	TRW	X663F-7	R240	1K	10%	1/4W
C322	.032uF	+1-3%	200V	TRW	X663F-3	R241	510	5%	1/2W
C323	2850pF	1%	300V	KGN	DM19C2850F	R242	470	10%	1/4W
C325	10-60pF	TRIMMER		STT	10STRIKO06N1500	R243	220	10%	1/4W
C326	.22uF	20%	100V	AVX	8131-100-651-224M	R244	270	5%	1W
C327	500uF		25V	SP	TT501N025	R245	27	10%	1/4W
C328	150pF	10%	500V	KGN	DM15C151K	R246	470	10%	1/4W
C330	33pF	5%	500V	KGN	DM15C330J	R247	910	5%	1/4W
RESISTORS						R248	1.2K	10%	1/4W
SCHEM. REF.	DESCRIPTION			MFR.	PART NUMBER	R249	1K	5%	1/2W
R102	1.5	3%	1W	KRL	P-1AW1-1R5H	R250	100	10%	1/4W
R103	1.5	3%	1W	KRL	P-1AW1-1R5H	R253	2K	5%	1/4W
R104	1K	5%	1/4W	AB	CB1025	P302	5K	POT	1/2W
R105	45	3%	5W	KRL	P-5W1-45RH	R303A	10K	POT	1/2W
R106	1K	5%	1/4W	AB	CB1025	R303B	7.5K	5%	1/4W
R107	45	3%	5W	KRL	P-5W1-45RH	P305	200	POT	1/2W
R108	10K	5%	1/4W	AB	CB1035	R309	1K	10%	1/4W
R109	51	5%	1/2W	AB	EB5105	R310A	500	POT	1/2W
R110	15	10%	1/4W	AB	CB1501	R310B	10	10%	1/4W
R111	10K	5%	1/4W	AB	CB1035	R312	390	10%	1/4W
R112	1K	10%	1/2W	AB	EB1021	R313	470	10%	1/4W
R113	8.66K	1%	1/4W	PRP	8.66KGPI/4-T100	R314	390	10%	1/4W
R114	10K	1%	1/4W	PRP	10KGPI/4-T100	R315	1.5K	10%	1/4W
R115	TRIM		1/4W	AB	EB1025				
R116	1K	5%	1/2W	AB	EB1025				
R117	1K	10%	1/2W	AB	EB1021				
R118	25K	POT	1/2W	BKM	72PMR25K				
R119	1K	10%	1/2W	AB	EB1021				
R120	27	10%	1/4W	AB	CB2701				
R121	1K	10%	1/4W	AB	CB1021				
R122	47	10%	1/4W	AB	CB4701				
R123	5.1K	5%	1/4W	AB	CB5125				
R124	330	10%	1/4W	AB	CB3311				
R201	1K	10%	1/2W	AB	EB1021				
R202	1K	10%	1/4W	AB	CB1021				
R203	100K	10%	1/4W	AB	CB1041				
R204	470	10%	1/4W	AB	CB4711				
P205	100	POT	1/2W	BKM	72PMR100				
R205	470	10%	1/4W	AB	CB4711				
P206	5K	POT	1/2W	BKM	72PMR5K				
R206	3K	5%	1/2W	AB	EB3025				
R207	47	10%	1/4W	AB	CB4701				
R208	470	5%	1/2W	AB	EB4715				
R210A	10K	POT	1/2W	BKM	72PMR10K				
R210B	10K	10%	1/4W	AB	CB1031				
R217A	500	POT	1/2W	BKM	72PMR500				
R217B	130	10%	1/4W	AB	CB1311				
R219	470	10%	1/4W	AB	CB4711				
R220	100	10%	1/4W	AB	CB1011				
R221	470	10%	1/4W	AB	CB4711				
R222	8.2K	5%	1/4W	AB	CB8225				
R223	1.5K	5%	1/2W	AB	EB1525				
R224	47	10%	1/4W	AB	CB4701				
R230A	1K	POT	1/2W	BKM	72PMR1K				
R230B	240	5%	1/4W	AB	CB2415				
R231A	25K	POT	1/2W	BKM	72PMR25K				
R231B	7.5K	5%	1/4W	AB	CB7525				
R232	100	10%	1/4W	AB	CB1011				
R233	100	10%	1/4W	AB	CB1011				
R234	220	10%	1/4W	AB	CB2211				
R235	4.3K	5%	1/4W	AB	CB4325				
R236	47	10%	1/4W	AB	CB4701				
R237	470	5%	1/2W	AB	EB4715				
R238A	1K	POT	1/2W	BKM	72PMR1K				
R238B	240	5%	1/4W	AB	CB2415				
R239A	25K	POT	1/2W	BKM	72PMR25K				
R239B	7.5K	5%	1/4W	AB	CB7525				
R240	1K	10%	1/4W	AB	CB1021				
R241	510	5%	1/2W	AB	EB5115				
R242	470	10%	1/4W	AB	CB4711				
R243	220	10%	1/4W	AB	CB2211				
R244	270	5%	1W	AB	GB2715				
R245	27	10%	1/4W	AB	CB2701				
R246	470	10%	1/4W	AB	CB4711				
R247	910	5%	1/4W	AB	CB9115				
R248	1.2K	10%	1/4W	AB	CB1221				
R249	1K	5%	1/2W	AB	EB1025				
R250	100	10%	1/4W	AB	CB1011				
R253	2K	5%	1/4W	AB	CB2025				
P302	5K	POT	1/2W	BKM	72PMR5K				
R303A	10K	POT	1/2W	BKM	72PMR10K				
R303B	7.5K	5%	1/4W	AB	CB7525				
P305	200	POT	1/2W	BKM	72PMR200				
R309	1K	10%	1/4W	AB	CB1021				
R310A	500	POT	1/2W	BKM	72PMR500				
R310B	10	10%	1/4W	AB	CB1001				
R312	390	10%	1/4W	AB	CB3911				
R313	470	10%	1/4W	AB	CB4711				
R314	390	10%	1/4W	AB	CB3911				
R315	1.5K	10%	1/4W	AB	CB1521				

RESISTORS						INDUCTORS					
SCHEM. REF.	DESCRIPTION			MFR.	PART NUMBER	SCHEM. REF.	DESCRIPTION		MFR.	PART NUMBER	
R316	470	5%	1/2W	AB	EB4715	L201	220uHY	10%	2W	DEL	3500-16
R318	232	1%	1/4W	PRP	232GP1/4-T100						
R319	3.9K	5%	1/4W	AB	CB3925						
R320	1K	10%	1/4W	AB	CB1021						
R321	100	10%	1/4W	AB	CB1011						
						SEMICONDUCTORS					
SCHEM. REF.	DESCRIPTION			MFR.	PART NUMBER	SCHEM. REF.	DESCRIPTION		MFR.	PART NUMBER	
R322	470	10%	1/4W	AB	CB4711	Q101	TRANSISTOR, PNP		MOT	2N2907	
R323	4.3K	5%	1/4W	AB	CB4325	Q102	TRANSISTOR, NPN		TI	TIS97	
R324A	1K	POT	1/2W	BKM	72PMR1K	Q103	TRANSISTOR, PNP		MOT	2N4234	
R324B	4.7K	10%	1/4W	AB	CB4721	Q104	TRANSISTOR, NPN		TI	TIS97	
R325A	25K	POT	1/2W	BKM	72PMR25K	Q105	TRANSISTOR, PNP		MOT	2N2907	
R325B	10	10%	1/4W	AB	CB1001	Q106	TRANSISTOR, NPN		NS	2N5189	
R327	620	5%	1/2W	AB	EB6215	Q107	TRANSISTOR, NPN		TI	TIS97	
R328	1K	10%	1/4W	AB	CB1021	Q108	TRANSISTOR, PNP		MOT	2N2907	
R329	47	10%	1/4W	AB	CB4701	Q201	TRANSISTOR, NPN		TI	TIS97	
R330	430	5%	1/2W	AB	EB4315	Q202	TRANSISTOR, PNP		MOT	2N2907	
R331	47	10%	1/4W	AB	CB4701	Q204	TRANSISTOR, PNP		MOT	2N2907	
R332	2M	5%	1/4W	AB	CB2055	Q205	TRANSISTOR, NPN		TI	TIS97	
R333	100	10%	1/4W	AB	CB1011	Q208	TRANSISTOR, NPN		TI	TIS97	
R334	1K	10%	1/4W	AB	CB1021	Q209	TRANSISTOR, PNP		MOT	2N2907	
R335	470	10%	1/4W	AB	CB4711	Q210	TRANSISTOR, NPN		MOT	MPS6515	
R336	4.3K	5%	1/4W	AB	CB4325	Q211	TRANSISTOR, PNP		MOT	2N2907	
R337A	1K	POT	1/2W	BKM	72PMR1K	Q212	TRANSISTOR, NPN		TI	TIS97	
R337B	10	10%	1/4W	AB	CB1001	Q303	TRANSISTOR, NPN		TI	TIS97	
R338A	25K	POT	1/2W	BKM	72PMR25K	Q304	TRANSISTOR, PNP		MOT	2N2907	
R338B	10K	10%	1/4W	AB	CB1031	Q305	TRANSISTOR, NPN		TI	TIS97	
R339	390	5%	1/2W	AB	EB3915	Q306	TRANSISTOR, PNP		MOT	2N2907	
R340	47	10%	1/4W	AB	CB4701	Q307	TRANSISTOR, PNP		MOT	2N2907	
R341	10	10%	1/4W	AB	CB1001	Q308	TRANSISTOR, NPN		TI	TIS97	
R342	51	5%	1/2W	AB	EB5105	Q309	TRANSISTOR, PNP		MOT	2N2907	
R343	10K	10%	1/4W	AB	CB1031						
R344	10	10%	1/4W	AB	CB1001						
DIODES						MISC.					
SCHEM. REF.	DESCRIPTION			MFR.	PART NUMBER	SCHEM. REF.	DESCRIPTION		MFR.	PART NUMBER	
CR101	DIODE, RECTIFIER			AS	1N4002	S101	PUSHBUTTON SWITCH, POWER		KH	B3386	
CR102	DIODE, SWITCHING			APD	1N4149	S102	SLIDE SWITCH, GROUND		CW	GF123	
CR103	DIODE, SWITCHING			APD	1N4149	S103	SLIDE SWITCH, 115V - 230V		SWC	46256LFR	
CR104	DIODE, RECTIFIER			AS	1N4002	S201	ROTARY SWITCH, MULT, HCO		KH	B4038	
CR105	DIODE, RECTIFIER			AS	1N4002	S202	PUSHBUTTON SWITCH, RES.		KH	B3386	
CR106	DIODE, RECTIFIER			AS	1N4002	S301	ROTARY SWITCH, MULT, LCO		KH	B4038	
CR107	DIODE, RECTIFIER			AS	1N4002	F101	FUSE 1/8A - 115V 1/16A - 230V		BUS BUS	MDL-1/8A MDL-1/16A	
CR201	DIODE, SWITCHING			APD	1N4149	J101	RECEPTACLE		SWC	EAC-301	
CR202	DIODE, SWITCHING			APD	1N4149	T101	TRANSFORMER		KH	B2290	
Z101	DIODE, ZENER, 10V			APD	1N961B	DS100	INDICATOR LED		DL	559-0101-003	

## SECTION 4

### MAINTENANCE

#### WARNING

This procedure should be performed by qualified personnel only. If the covers must be removed, it is strongly recommended that extra precautions be taken in working with exposed circuitry, and that insulated probes and tools be used.

SHUT THE POWER SWITCH OFF AND DISCONNECT THE LINE CORD FROM THE POWER SOURCE BEFORE REPAIRING OR REPLACING COMPONENTS.

#### 4.1 INTRODUCTION

If the Filter is not functioning properly and requires service, the following procedure may help in locating the source of trouble. Access to the Filter is accomplished easily by removing the two screws on each side of the cover. (On rack units, the lower screw on the rack adapters, and the screw towards the rear on each side.)

The layout of components, test points, and adjustments is included on the Schematic, Figure 8, which is located at the rear of the manual. Various check points are shown on the Schematic and labeled on the PC board.

Many malfunctions may be found by visual inspection. Make a quick check of the unit for such things as broken wires, burnt or loose components, or similar conditions which could be a cause of malfunction. Any trouble-shooting of the Filter will be simplified if there is an understanding of the operation of the circuit. See Section 3, Circuit Description.

#### 4.2 POWER SUPPLY

A fuse, F101, (1/8A for 115V or 1/16A for 230V operation), located on the rear panel, is provided to protect the filter from internal

short circuits. The rating of this fuse was selected for proper protection of the filter, and it should be replaced with one of the same type and rating.

If the Filter is not working properly, the two power supplies should be checked first. If the plus or minus 10 volts supplies appear to be correct, within 5%, refer to the Signal Tracing Procedure Section 4.3.

If the minus 10 volts supply is out of tolerance, R118 should be adjusted.

If the minus 10 volts supply is correct, and the plus 10 volts supply is out of tolerance, R113 or R114 may be defective.

Two regulated supplies are used to provide plus 10 volts and minus 10 volts with respect to chassis ground. The minus 10 volts supply uses a zener, Z101, as its reference, while the plus 10 volts supply uses the minus supply as its reference. This should be kept in mind when doing any work on the supply, since an error in the minus will be reflected in the plus. Both supplies are provided with current limiting circuits that will shut down the supply when excessive current is being drawn from it. Because of this, an apparent power supply malfunction may be caused by an overload elsewhere in the Filter.

If the supply does not appear to be working properly, the resulting error signal should be traced through the regulator loop to find the faulty component. Correct voltages for various points in the supply are shown on the Schematic, Figure 8. As an example of the method of trouble-shooting, let us assume that the minus 10 volts supply is low. This should make the base of Q108 more positive than normal, while making its collector more negative. The base of Q106 should then be more positive than normal and the collector more negative, thus correcting the output of the supply. If a faulty component is present in the regulating loop this corrective action would be blocked. That component would then be found at the point in the loop where the action was blocked. The plus supply uses approximately the same type of circuit, therefore, the same basic method of trouble-shooting may be used there as well.

#### 4.3 SIGNAL TRACING PROCEDURE

If the power supplies appear to be correct, but the Filter is not working, the following procedure should locate the area of malfunction:

Set both the low and high cutoff frequencies to 300Hz. Connect a 300Hz, 1 volt rms sine wave signal to the input terminals. If the test signal does not appear correctly at the output, the area of the malfunction may be localized by determining where in the Filter the signal first deviates from normal.

Figure 7 shows various test points with their correct signal levels. If a test point is found whose signal level differs appreciably from the correct value, the circuitry immediately preceding that test point should be checked. Trace the signal

through the entire Filter, and they should be checked in the order given. The range determining capacitors associated with the band multiplier switches S201 and S301 are specially selected for close capacitance tolerance. All capacitor values fall within  $\pm 5\%$  of the specified value, but in order to maintain accurate frequency calibration over the entire dial range and also between decade ranges, the capacitors are matched within  $\pm 2\%$  of each other and generally within  $\pm 2\%$  in decade ratios.

The values of capacitance used on the two higher bands are selected to compensate for stray capacitance and are therefore not completely in decade ratios of those used on the lower bands.

For replacement purposes, a capacitor within  $\pm 1\%$  of the specified value can be used with negligible effect on the overall calibration accuracy. If more than one capacitor on a particular range is to be changed, it is recommended that several other capacitors on the switch be carefully measured on a capacitance bridge to de-

LOW CUTOFF FREQUENCY: 300Hz  
HIGH CUTOFF FREQUENCY: 300Hz  
RESPONSE Switch: MAX FLAT  
INPUT: 1 Volt rms, 300Hz Sine Wave

Test Point	Correct Signal Level, RMS Volts
INPUT	1.0
1	0.9
3	0.7
5	0.5
7	0.7
9	0.6
11	0.5
13	0.5
15	0.6
OUTPUT	0.5

Figure 7. Test Point Voltages

termine the average percentage deviation from the nominal value. Any capacitors, except those used on the two highest frequency ranges, may be measured to determine this tolerance.

Replacement can then be made with capacitors of the exact value, and calibration will not be impaired.

Each of the variable resistance elements consists of three potentiometers ganged together with a gear assembly. Each potentiometer has series and shunt trims to insure proper tracking. The trims and the angular orientation of the potentiometers are adjusted at the factory. If it becomes necessary to change one of these potentiometers in the field, it should be replaced only with a unit supplied by the factory. The angular orientation should then be adjusted following the procedure supplied with the parts.

#### 4.4 TUNING CIRCUITS

If signal tracing shows one of the tuning circuits to be faulty, it should be determined if the trouble is in the resistive or capacitive ele-

ment. If there is trouble in a capacitive element, it will show up only on a particular multiplier band. If there is a problem in a resistive element, the trouble will be of a general nature and will show up on all multiplier bands. For replacement purposes, a capacitor within  $\pm 1\%$  of the specified value can be used with negligible effect on the overall calibration accuracy. The values of capacitors used on the two higher bands are selected to compensate for stray capacitance and, therefore, are not completely in decade ratios of those used on the lower bands.

Each of the variable resistance elements consists of three potentiometers ganged together with a gear assembly. Each potentiometer has series and shunt trims to insure proper tracking. The trims and the angular orientation of the potentiometers are adjusted at the factory. If it becomes necessary to change one of these potentiometers, do not attempt to replace the defective potentiometer, instead notify our Factory Service Department and they will provide you with the necessary information regarding repair or recalibration.

## SECTION 5

## CALIBRATION

## WARNING

This procedure should be performed by qualified personnel only. If the covers must be removed, it is strongly recommended that extra precautions be taken in working with exposed circuitry, and that insulated probes and tools be used.

## 5.1 INTRODUCTION

The following procedure is provided for the calibration of the Filter. The steps outlined, follow closely the operations which are performed on the Filter by our Final Test Department. Strict adherence to this procedure should restore the Filter to its original specifications. If any difficulties are encountered, refer to Section 4, Maintenance. Please consult our Factory Service Department for any question which are not covered in this procedure.

## 5.2 SPECIFICATIONS

## CUTOFF FREQUENCY CALIBRATION

The high and low cutoff frequencies, as defined below, should be within  $\pm 5\%$ , ( $\pm 10\%$  band 5), of the corresponding dial reading, KROHN-HITE Filters are calibrated to conform to passive Filter terminology. The cutoff frequency in the MAX FLAT (Butterworth) mode is the frequency at which the gain of the Filter is 3dB down from the gain at the middle of the pass-band. This pass-band varies with separation of the cutoff frequencies as shown in Figure 2. In the RC transient-free mode, this cutoff frequency gain is approximately 11dB down.

## PASS-BAND GAIN

The Filter output voltage, under open circuit conditions, will be within  $\pm 1/2$ dB of the input voltage for all frequencies within the pass-

band.

To determine the pass-band gain accurately, the high and low cutoff frequencies must be separated by a factor of at least four, and the measuring frequency must be the geometric mean of these frequencies.

## ATTENUATION SLOPE

A typical attenuation curve is shown in Figure 4. At the cutoff frequency, in the MAX FLAT (Butterworth) mode, the slope is approximately 9dB per octave, and at the 9dB point the slope has essentially reached its nominal value of 18dB per octave. The slope of the straight portion of the curve may vary slightly from 18dB per octave at certain frequencies because of cross-coupling effects.

## MAXIMUM ATTENUATION

This Filter has a maximum attenuation specification of 80dB which applies over most of the frequency range. At the high frequency end, this attenuation is reduced due to unavoidable cross-coupling between input and output.

## OUTPUT IMPEDANCE

The Filter will operate into any load impedance providing the maximum output voltage and current specification is not exceeded. For a matched load impedance of 50 ohms, the pass-band gain will be approximately 6dB. Lower values of load resistance will not damage the filter but will increase

the distortion.

Higher values of external load may be used with no sacrifice in performance and correspondingly, lower pass-band gain. In KROHN-HITE Filters, there is no requirement for the load impedance to match the output impedance.

#### INTERNALLY GENERATED HUM AND NOISE

The internally generated hum and noise measurement is based on the use of a Ballantine Model 310 Voltmeter or equivalent. The measurement is made with the input connector shorted, and with no other external signal connections to the Filter, and with the voltmeter leads shielded.

#### DISTORTION

Filter distortion is a function of several variables and is difficult to specify exactly. In general, if the Filter is operated within its ratings, distortion products introduced by the Filter and not present in the input signal will not exceed 0.5%. In most cases distortion will be considerably less than 0.5%.

#### 5.3 TEST EQUIPMENT REQUIRED

a. Oscillator - capable of supplying at least 3 volts rms from 10Hz to 10MHz with frequency calibration better than  $\pm 1\%$ , distortion less than 0.1% and frequency response within  $\pm 0.2$ dB.

b. AC Meter - frequency response, 10Hz to 10MHz; full scale sensitivity from 10mV to 10 volts rms; dB scale; input capacitance should be less than 20pF.

c. Oscilloscope - having direct coupled horizontal and vertical amplifiers with equal phase characteristics to at least 20kHz and vertical sensi-

tivity of 10mV per division.

d. DC Voltmeter - 15 volts dc full scale.

e. Variable Auto-Transformer - to adjust line voltage.

f. AC Voltmeter - to measure line voltage.

#### 5.4 POWER SUPPLIES

With the Filter operating at 115 or 230 volts line, whichever is applicable, check the plus and minus 10 volts supplies with respect to chassis ground. The FLOATING/CHASSIS grounding switch, located on the rear panel, should be in the CHASSIS position.

If the minus 10 volts supply is out of tolerance R118 should be adjusted.

If the minus 10 volts supply is correct and the plus 10 volts supply is out of tolerance, R113 or R114 may be defective.

#### 5.5 CALIBRATION PROCEDURE

The following procedure must be used in the sequence given in order to have the controls in the proper positions. Throughout the procedure, low cutoff is abbreviated LCO and high cutoff is abbreviated HCO. Note that LOW CUTOFF dial and multiplier refers to the left frequency dial and band multiplier switch, and the HIGH CUTOFF and multiplier refers to the right frequency dial and band multiplier switch. For all steps, the ac input line voltage should be at 115 or 230 volts, whichever is applicable.

The layout of components, test points, and adjustments is shown on the schematic, Figure 8.

In the event the Filter does not meet

the correct tolerance as specified in each step of the calibration procedure, refer to Section 4, Maintenance.

1. LCO dial slope calibration at 30.

Set: LCO dial: 30  
LCO Multiplier: X10  
HCO dial: 300  
HCO Multiplier: X10K  
Input signal: 1 volt rms at 150Hz.

Switch LCO frequency multiplier to the X1 position. Connect AC Meter to Filter output. Adjust oscillator output until AC Meter indicates exactly 20dB. Return LCO frequency multiplier to X10. With RESPONSE switch in the MAX FLAT position adjust LCO dial for -18dB reading on the AC Meter. If necessary, loosen LCO dial screws and set dial to 30.

2. LCO dial gain calibration at 300.

Set: HCO dial: 300  
HCO Multiplier: X10K  
Input signal: 1 volt rms at 300HZ.

Switch LCO frequency multiplier to X1. Connect AC Meter to Filter output. Adjust oscillator output until AC Meter indicates exactly 20dB. Return LCO frequency multiplier to X10 position. Adjust P305 until AC Meter indicates 17dB. If P305 requires adjustment, recheck 20dB reference level.

3. LCO dial gain calibration at 10.

Set: LCO dial: 10  
HCO dial: 300  
HCO Multiplier: X10K

Input signal: 1 volt rms at 100Hz

Switch LCO frequency multiplier to X1. Adjust oscillator output until AC Meter indicates exactly 20dB. Return LCO frequency multiplier to X10. Adjust LCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 9.5 to 10.5.

4. LCO dial gain calibration at 100.

Set: LCO dial: 100  
HCO dial: 300  
HCO Multiplier: X10K  
Input signal: 1 volt rms at 1kHz

Switch LCO frequency multiplier to X1. Adjust oscillator output until AC Meter indicates exactly 20dB. Return LCO frequency multiplier to X10. Adjust LCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 95 to 105.

5. Unity gain adjustment at 5kHz.

Set: LCO dial: 70  
LCO multiplier: X1  
HCO dial: 45  
HCO Multiplier: X10K  
Input signal: 1 volt rms at 5kHz

With AC Meter, compare ac signal on input Filter with ac signal on output. If necessary, adjust P302 for unity gain.

6. X10K band calibration.

Set: LCO dial: 10  
LCO multiplier: X100  
HCO dial: 300  
HCO Multiplier: X10K  
Input signal: 0.5 volts rms at 1MHz

a. Switch LCO multiplier to X10K. Adjust P205 for minimum change, less than 0.3dB, in output amplitude when switching LCO multiplier from X100 to X10K.

b. Change input frequency to 50kHz. Switch LCO multiplier to X100. Adjust oscillator amplitude until AC Meter indicates exactly 0.1 volts, 20dB on output of Filter. Switch LCO multiplier to X10K. If necessary, adjust C317 until AC Meter indicates output of Filter is down 18dB and repeat part a.

c. Change input frequency to 100kHz. Switch LCO multiplier to X1K. Adjust oscillator amplitude until AC Meter indicates exactly 0.1 volts, 20dB on output of Filter. Switch LCO multiplier to X10K. Adjust LCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 9.0 to 11.0. If off, dial reading high, increase C319 and decrease C317. If dial reading is low, decrease C319 and increase C317. Repeat parts a and b respectively.

d. Set LCO dial to 100. Set output frequency to 1MHz. Switch LCO multiplier to X1K. Adjust oscillator amplitude until AC Meter indicates exactly 0.1 volts, 20dB on output of Filter. Switch LCO multiplier to X10K. Adjust C325 until AC Meter indicates 17dB.

e. Set LCO dial to 30. Set input frequency to 300kHz. Switch LCO multiplier to X1K. Adjust oscillator amplitude until AC Meter indicates exactly 0.1 volts, 20dB on output on Filter. Set LCO multiplier to

X10K. Adjust LCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 27.0 to 33.0. If out of tolerance, divide the error between 10 and 100 on the dial.

7. LCO dial gain calibration at 30 on all bands.

Set: LCO dial: 30  
LCO multiplier: X1  
HCO dial: 300  
HCO multiplier: X10K  
Input signal: 0.1 volts rms with the frequency as noted.

a. X1 calibration:

Connect AC Meter to Filter output. Set oscillator frequency to 300Hz. Adjust oscillator output until AC Meter indicates exactly 20dB. Change frequency to 30Hz. Adjust LCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 28.5 to 31.5.

b. X100 calibration:

Set: LCO dial: 30  
LCO multiplier: X10  
Input signal: 1 volt rms at 3kHz

Adjust oscillator output until AC Meter indicates exactly 20dB. Set LCO frequency multiplier to X100. Adjust LCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 28.5 to 31.5.

c. X1K calibration:

Set: LCO dial: 30  
HCO dial: 100  
Input signal: 1 volt rms at 30kHz

Adjust oscillator output until AC Meter indicates exactly

20dB. Set LCO frequency multiplier to X1K. Adjust LCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 28.5 to 31.5.

8. HCO dial calibration at 90.

Set: LCO dial: 90  
LCO multiplier: X1  
HCO dial: 90  
HCO multiplier: X100  
Input signal: 0.1 volts rms at 1.8kHz

Switch HCO frequency multiplier to X100. Adjust oscillator output until AC Meter indicates exactly 20dB. Return HCO frequency multiplier to X10. With the RESPONSE switch in the MAX FLAT position, adjust HCO dial for a -18dB reading on the AC Meter. If necessary, loosen HCO dial screws and set dial to 90.

9. HCO dial gain calibration at 90.

Set: LCO dial: 10  
LCO multiplier: X1  
HCO dial: 90  
HCO multiplier: X10  
Input signal: 0.1 volts rms at 900Hz.

Switch HCO frequency multiplier to X100 and adjust oscillator output until AC Meter indicates exactly 20dB. Return HCO frequency multiplier to X10. Adjust P206 until AC Meter indicates 17dB.

10. HCO dial gain calibration at 30.

Set: LCO dial: 10  
LCO multiplier: X1  
HCO dial: 30  
Input signal: 0.1 volts rms at 300Hz

Switch HCO frequency multiplier to X100 and adjust oscillator output until AC Meter indicates exactly 20dB. Return HCO frequency multiplier to X10. Adjust HCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 28.5 to 31.5.

11. HCO dial calibration at 300.

Set: LCO dial: 10  
LCO multiplier: X1  
HCO dial: 300  
Input signal: 0.1 volts rms at 3kHz

Switch HCO frequency multiplier to X100 and adjust oscillator until AC Meter indicates exactly 20dB. Return HCO frequency multiplier to X10. Adjust HCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 28.5 to 31.5.

12. X10K band calibration:

Set: LCO dial: 10  
LCO multiplier: X1  
HCO dial: 30  
HCO multiplier: X10K  
Input signal: 0.1 volts rms at 30kHz

Adjust oscillator output until AC Meter indicates exactly 20dB. Change oscillator frequency to 300kHz. Adjust C223 until AC Meter indicates 17dB. Set filter dial to 300 and oscillator to 3MHz. Adjust C230 until AC Meter indicates 17dB. Check 90 on the dial with the oscillator set at 900kHz. It may be necessary to divide the error by re-adjusting C223 and C230.

13. HCO dial gain calibration at 90 on all bands.

Set: LCO dial: 10

LCO multiplier: X1

HCO dial: 90

Input signal: 0.1 volts rms at 90kHz.

a. X1K band calibration:

Adjust oscillator output until AC Meter indicates exactly 20dB. Switch HCO multiplier to X1K. Adjust HCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 85.5 to 94.5.

b. X100 band calibration:

Set: Input signal: 0.1 volts rms at 9kHz

Adjust oscillator output until AC Meter indicates exactly 20 dB. Switch HCO multiplier to X100. Adjust HCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 85.5 to 94.5.

c. X1 band calibration:

Set: HCO multiplier: X10  
Input signal: 0.1 volt rms at 90Hz

Adjust oscillator output until AC Meter indicates exactly 20dB. Switch HCO multiplier to X1. Adjust HCO dial until AC Meter indicates 17dB. Tolerance is a dial setting from 85.5 to 94.5.

14. Maximum attenuation at 50kHz.

Set: LCO dial: 100  
LCO multiplier: X10K  
HCO dial: 30  
HCO multiplier: X10K  
Input signal: 3 volts rms at 50kHz

Output signal should be below 500 microvolts.

15. Maximum attenuation at 3MHz.

Set: LCO dial: 10  
LCO multiplier: X100  
HCO dial: 30  
Input signal: 1 volt rms at 3MHz

Output signal should be below 5.0 millivolts.

16. Maximum input voltage.

Set: LCO dial: 100  
LCO multiplier: X1  
HCO dial: 300  
HCO multiplier: X10K  
Input signal: 3 volts at 300kHz

Check that output signal is not distorted.

17. Output impedance.

Set: LCO dial: 100  
LCO multiplier: X1  
HCO dial: 300  
HCO multiplier: X10K  
Input signal: 1 volt rms at 1kHz

Connect 50 ohm resistor to Filter output. Output signal should decrease to approximately 0.5 volts. Remove 50 ohm resistor.

18. Hum and noise.

Set: LCO dial: 10  
LCO multiplier: X1  
HCO dial: 300  
HCO multiplier: X10K  
Input signal: 0

Remove oscillator. Connect AC Meter only to Filter output and a shorting jumper across the input connector. Replace all covers. Output signal level should be below 150 microvolts. Caution! If output level is greater than 150 microvolts,

monitor output to be sure  
excessive output is not due to  
radio or television station  
interference.