SOLID STATE

VARIABLE FILTER

MODEL 3750 SERIAL NO.__

OPERATING AND MAINTENANCE MANUAL

KROHN-HITE CORPORATION

AVON INDUSTRIAL PARK / BODWELL STREET / AVON, MASS. 02322

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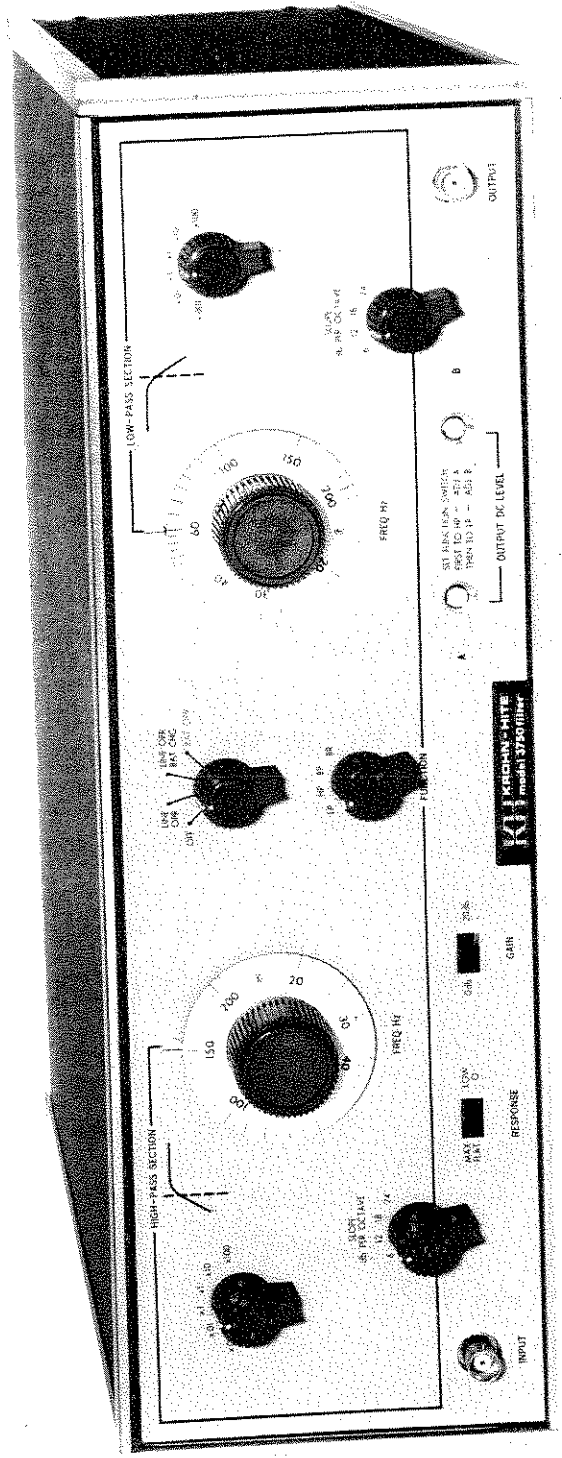


Figure 1. Model 3750 Filter

SECTION 1
GENERAL DESCRIPTION

1.1 INTRODUCTION

The Model 3750 is a variable electronic filter that covers the frequency range from 0.02 Hz to 20 kHz, and operates in any one of four functional modes; high-pass, low-pass, band-pass or band-reject. The mode of operation is selected by means of a front panel FUNCTION switch. The pass-band gain is unity (0db) or 10 (20db), as selected by a front panel GAIN switch, with attenuation slopes of 6, 12, 18 or 24 db per octave, as selected by 2 front panel SLOPE switches.

The cut-off frequencies of both the high-pass and the low-pass sections are independently adjustable from 0.02 Hz to 20 kHz. Operation in the band-pass or band-reject modes permits passage or rejection of any band of frequencies between these limits. In the low-pass and band-reject modes, the filter is direct coupled, passing all frequencies from DC to the selected cut-off frequency of the low-pass section. In the high-pass and band-reject modes, the upper 3 db point is at approximately 1 MHz for 0 db gain, and approximately 200 kHz for 20 db gain.

An optional battery kit (Part No. BK-375), consisting of four (4) rechargeable nickel-cadmium batteries, plus associated hardware, may be added at any time.

In addition, an optional rack-mounting kit (Part No. RK-519), is available for installing the 3750 in a standard 19" rack spacing.

1.2 GENERAL SPECIFICATIONS

Function

Low-pass, high-pass, band-pass, band-reject.

Frequency Range

Continuous coverage from 0.02 Hz to 20 kHz for both cut-off frequencies, independently. Frequency range is covered by separately calibrated dials and six-decade band switches. Center frequency and width of pass-band in band-pass mode are continuously adjustable over the entire frequency range.

BAND	MULTIPLIER	FREQUENCY (Hz)
1	x.001	.02 - 0.2
2	x.01	0.2 - 2.0
3	x.1	2.0 - 20
4	x1	20 - 200
5	x10	200 - 2,000
6	x100	2,000 - 20,000

Cut-Off Frequency Calibration Accuracy

± 5%(±10% band 6 and below .05 Hz) in the 24 db slope position with RESPONSE switch in the MAX FLAT (Butterworth) position; less accurate in LOW O and other slope positions. Relative to mid-band level, the filter output is down 3 db at cutoff in the MAX FLAT position. In the LOW O position, the output is down approximately 11 db with 24 db slope; 9 db with 18, 7 db with 12 and 3 db with 6 db slope.

Bandwidth

Band-Pass Mode: Continuously variable within the cutoff frequency limits of 0.02 Hz and 20 kHz. For minimum bandwidth the high-pass and low-pass cutoff frequencies are set equal. This produces an insertion loss of 6 db, with the -3 db points at 0.8 and 1.25 times the midband frequency.

Band-Reject Mode: Continuously variable within the cutoff frequency limits of 0.02 Hz and 20 kHz or sharp null at any frequency between 0.04 Hz and 10 kHz. The low-pass band extends to dc. The high-pass band has its upper 3 db point at approximately 1 megahertz for 0 db gain and approximately 200 kHz for 20 dB gain. The null is sharper than that of a balanced parallel T filter, and is obtained by setting the high-pass cutoff to approximately twice the desired null frequency, and the low-pass cutoff to approximately half the desired null frequency.

High-Pass Mode: Continuously variable, with cutoff frequency adjustable from 0.02 Hz to 20 kHz. The upper 3 db point is at approximately 1 megahertz for 0 db gain and approximately 200 kHz for 20 db gain.

Low-Pass Mode: Continuously variable, with cutoff frequency adjustable from 0.02 Hz to 20 kHz. The pass band extends to dc at the low end.

Attenuation Slope

Each cutoff independently adjustable to 6, 12, 18, or 24 db per octave.

Maximum Attenuation

Greater than 80 db for 24 db per octave position.

Response Characteristics

Choice of Butterworth (maximum flat response) for frequency domain operation and Low Q (damped response) for transient-free time domain operation, selected by means of a front panel switch.

Pass-Band Gain (selected by front panel control)

0 ±1 db or 20 ±1 db.

Input Characteristics

Maximum Voltage: ±15 volts peak in the 0 db gain position. ±1.5 volts peak in the 20 db gain position to 50 kHz.

Maximum DC Component: 100 volts in BAND-PASS and HIGH-PASS modes. In LOW-PASS and BAND-REJECT modes, the combined ac and dc voltage should not exceed 15 volts peak for 0 db gain or 1.5 volts peak for 20 db gain.

Impedance: 10 megohms in parallel with 200 pf.

Output Characteristics

MAX VOLTAGE: 15 volts peak.

MAX CURRENT: 3 ma. peak.

INTERNAL IMPEDANCE: approximately 50 ohms.

Hum and Noise

500 μv rms in the 0 db gain position, 500μv rms (700 μvrms in the band reject mode) in the 20 db gain position, for a detector bandwidth of 100 kHz.

Output DC Level Stability

±1 millivolt per hour, ±5 millivolts per degree C.

Operating Temperature Range

-10°C to 45°C

Power Requirements

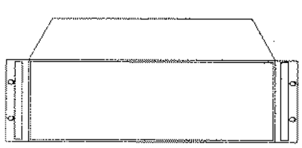
105-125 or 210-250 volts, single phase, 50-400 Hz. 10 watts. (Hum is increased a factor of two for 400 Hz operation).

Optional Battery Kit

Part No. BK-375; consists of four (4) rechargeable, nickel-cadmium batteries, plus associated hardware. Batteries will operate for eight (8) hours without recharging.

Optional Rack-Mounting Kit

Part No. RK-519; permits installation of the 3750 into a standard, 19" rack spacing.



SECTION 2
OPERATION

2.1 INTRODUCTION

The filter is thoroughly checked and carefully adjusted before shipment to insure that it meets all stated specifications. The filter is shipped complete, and after unpacking, is ready to be used.

Unpack the filter carefully and inspect it for damage that may have occurred during shipment. Check the case for damage and check for loose sub-assemblies and parts. Check all controls and adjustments for freedom of operation. The recommended operating procedure is given below.

2.2 POWER REQUIREMENTS

The filter can be operated from an AC power source of either 105-125 volts 50-400 Hz, or 210-250 volts, 50-400 Hz by use of the 115/230V LINE switch, located on the rear panel. When 105-125 volt operation is selected, the filter uses a 0.3 ampere slow-blow fuse. When 210-250 volt operation is required, a 0.15-ampere fuse is used. When the optional battery kit is installed, the filter may be operated for 8 hours without recharging.

2.3 OPERATING PRECAUTIONS

Observe the following limitations on the filter input signal:

MAXIMUM INPUT AMPLITUDE: ±15 volts peak with GAIN switch in 0 db position ±1.5 volts peak with GAIN switch in 20 db position. Above 50 kHz the allowable input signal decreases at the rate of 6 db per octave, reaching approximately ±.7 volt peak at 1 MHz with 20 db gain.

MAXIMUM DC COMPONENT: ±100 volts, in band-pass and high-pass modes. In low-pass and band-reject modes, the combined peak ac input voltage and dc input voltage should not exceed 15 volts peak for 0 db gain or 1.5 volts peak for 20 db gain.

The following limitations apply to the Filter output signal:

MAXIMUM VOLTAGE:	±15 volts peak.
MAXIMUM CURRENT:	3 ma. peak.
INTERNAL IMPEDANCE:	Approximately 50 ohms.

2.4 OPERATION (Figure 2-1)

2.4.1 Make appropriate power connections as described in Paragraph 2.2.

2.4.2 Make appropriate connections to the INPUT and OUTPUT terminals of the filter. A chassis ground terminal is provided on the rear panel for connection to system ground. If the filter is to be used where ground currents may be a problem, it may be advantageous to switch the GROUND switch to the FLTG position. However, because of the possibility of noise being picked up by capacity coupling to high impedance circuits, signal ground is usually connected to system ground.

2.4.3 Select correct GAIN setting for the signal level in use. Note that while the maximum input signal in the 20 db position is ±1.5 volts peak and the maximum input in 0 db is ±15 volts peak, the maximum output signal in both cases is ±15 volts peak. Observe the precautions of Paragraph 2.3 with regard to maximum input signal amplitude within the tuning range and also the maximum amplitude-versus-frequency limitation for frequencies above the tuning range.

2.4.4 Turn the FUNCTION switch to the desired mode of operation.

2.4.5 Set both HIGH and LOW pass slope switches to desired attenuation.

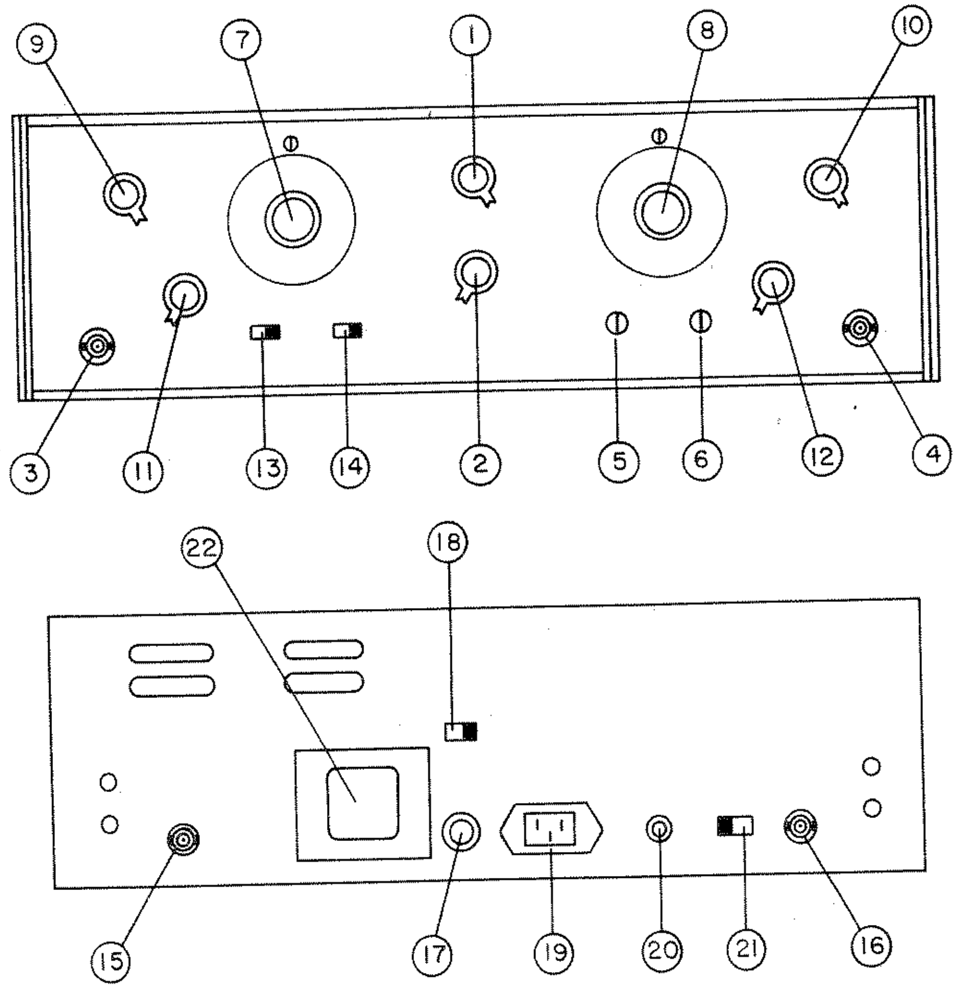
2.4.6 Set desired cutoff frequencies by means of the frequency selection dials and switches.

2.4.7 Set the POWER switch to the appropriate position.

2.5 SPECIAL FUNCTIONS

2.5.1 Pass Band Response

The flexibility of adjustment of bandwidth is illustrated in Figure 2-2; Low Pass, High Pass, and Band-pass operation in the MAXimally FLAT or Butterworth mode are illustrated by curves A, B, and C. Curve C shows the variation available in the slope selection feature, and the minimum bandwidth, obtained by setting the two cutoff frequencies equal. In this condition the insertion loss is 6 db, and the 3 db



1 POWER SWITCH
2 FUNCTION SWITCH
3 FRONT INPUT (BNC)
4 FRONT OUTPUT (BNC)
5 OUTPUT DC LEVEL ADJ (HIGH PASS)
6 OUTPUT DC LEVEL ADJ (LOW PASS)
7 FREQUENCY DIAL (HIGH PASS)
8 FREQUENCY DIAL (LOW PASS)
9 MULTIPLIER SWITCH (HIGH PASS)
10 MULTIPLIER SWITCH (LOW PASS)
11 SLOPE SWITCH (HIGH PASS)
12 SLOPE SWITCH (LOW PASS)
13 RESPONSE SWITCH
14 GAIN SWITCH
15 REAR OUTPUT (BNC)
16 REAR INPUT (BNC)
17 FUSE
18 115V/230V LINE SWITCH
19 AC POWER RECEPTACLE
20 CHASSIS GROUND CONN. (BINDING POS
21 GROUND SWITCH
22 POWER TRANSFORMER

Figure 2-1. Front and Rear Panels

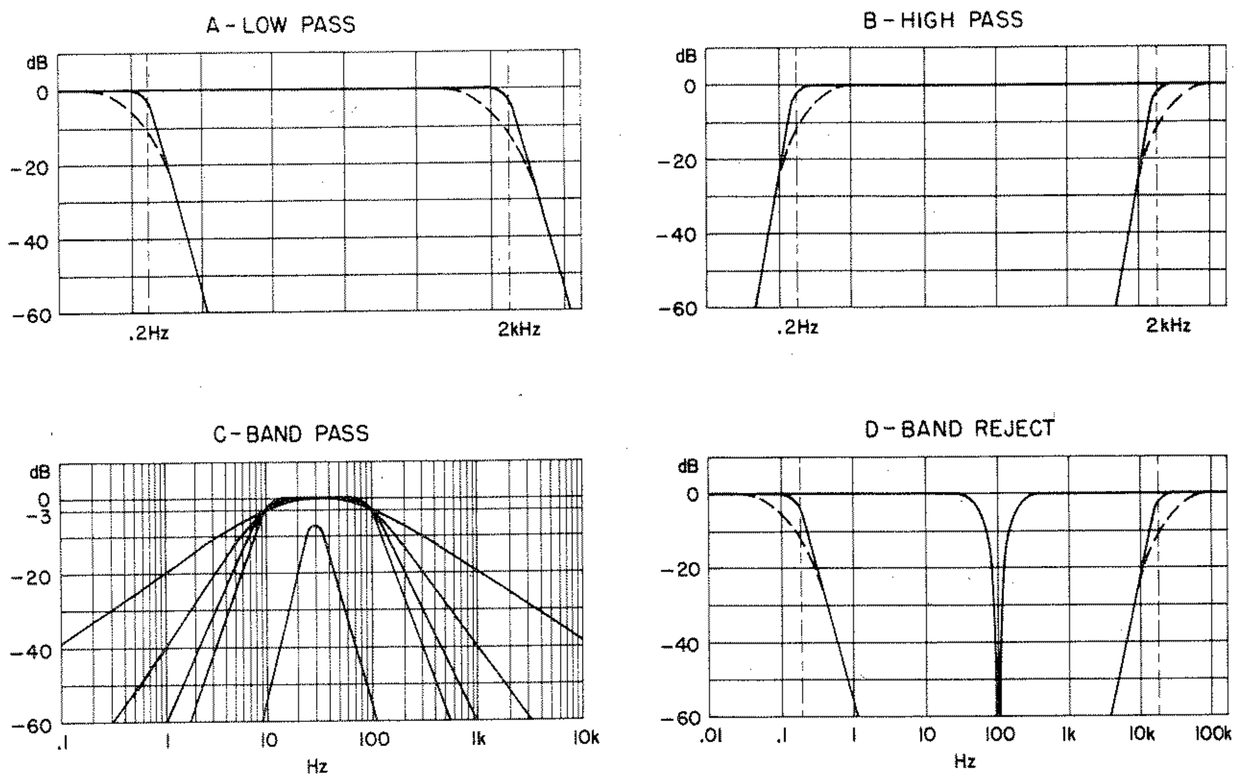


Figure 2-2. Pass Band Response: A-Low Pass, B-High Pass, C-Band Pass, D-Band Reject

cutoff frequencies occur at 0.8 and 1.25 times the mid-band frequency. The minimum pass-band for less than 1% insertion loss is obtained with the cutoffs set at 0.5 and 2 times the mid-band frequency.

The attenuation characteristics of the filter with -24 dB/octave attenuation are shown in Figure 2-2, curves A and B. With the response switch in the MAXimally FLAT or Butterworth mode, the gain, as shown by the solid curve, is virtually flat until the -3 dB cutoff frequency. At approximately two times the cutoff frequency the attenuation rate coincides with the 24 dB per octave straight line asymptote. In the LOW Q mode, optimum for transient-free filtering, the dotted line shows that the gain is down approximately 12 dB at cutoff and reaches 24 dB per octave attenuation rate at five times the cutoff frequency. Beyond this frequency the filter attenuation rate and maximum attenuation in both modes are identical.

Figure 2-2, curve D, shows the band reject characteristics of the filter. A sharp null can be obtained by setting the low-pass cutoff to half the desired rejection frequency, and the high-pass cutoff to twice the frequency, and adjusting the dials for minimum response.

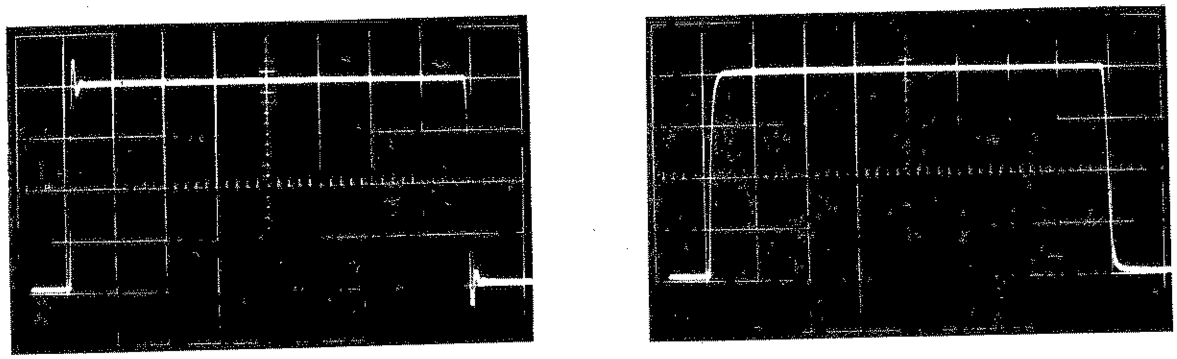


Figure 2-3. Square Wave Response Characteristics

2.5.2 Square Wave Response

The frequency response characteristic of this Filter is a fourth order Butterworth function ideal for filtering in the frequency domain. For pulse or transient signal filtering, a response switch is provided to change the frequency response to Low (optimum for transient-free filtering. Figure 2-3 shows a comparison of the filter output response in these modes to a square wave input signal.

2.5.3 Phase Response

The phase shift through a band-pass filter at any frequency is the sum of the angl due to the high-pass and low-pass sections of the filter. Figure 2-4 gives the phase characteristics for both high- and low-pass sections, at the selected attenu tion slopes. The ordinates are in degrees phase shift, negative for the low pass section and positive for the high pass section. The abcissa is the ratio of input frequency to cutoff (f/f_{LCO} or f/f_{HCO}.)

Example:

Determine the phase shift through the filter with the high pass (f_{LCO}) at 200 Hz, and the low pass (f_{HCO}) at 600 Hz, and an input frequency (f) of 300 Hz, at 18 dB/octave attenuation.

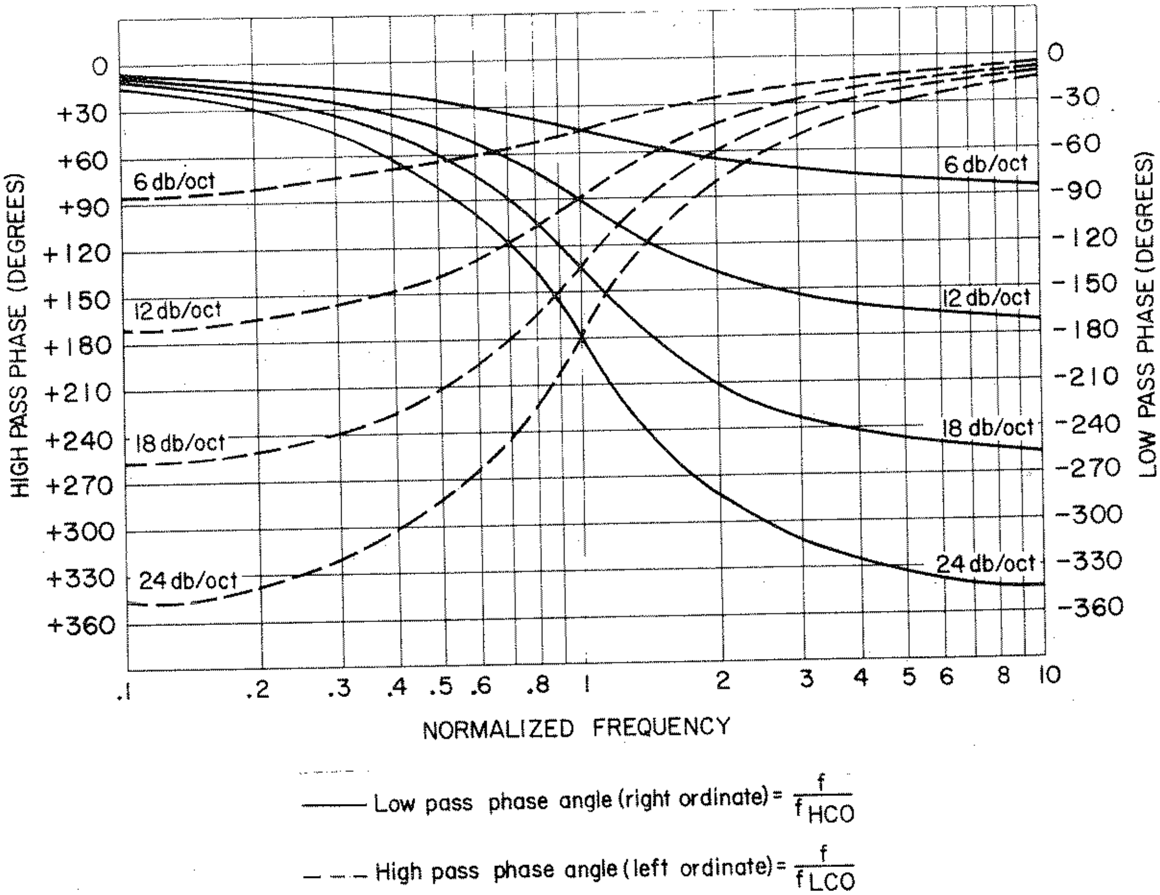


Figure 2-4. Phase Response

1) Phase shift due to low pass

$$\frac{f}{f_{HCO}} = \frac{300}{600} = 0.5$$

from figure 2-7, phase shift is -60°

2) Phase shift due to high pass

$$\frac{f}{f_{LCO}} = \frac{300}{200} = 1.5$$

from figure 2-7, phase shift is +80°

3) Total phase shift = -60° + 80° = +20°

Phase shift through a band-reject filter requires vector addition of the signal components passed by the two filter sections, and is difficult to calculate. In actual cases it is much more easily determined by measurement of the relative phase angle of the resultant output signal.

2.6 INSTALLATION OF BATTERY KIT (Part No. BK-375)

2.6.1 Material Required

Item	Quantity	Part Number
Battery	4	Y5043
Bracket	2	FA2815-B
Wafer	4	A2830-B
Wafer	2	A2831-A
Disc, Fiberglass	6	-----
Liner, Kraft Paper	2	-----
Nut, KEP, 6-32	12	-----
Screw, 6-32 x 3/8 PPN	4	-----
Screw, 6-32 x 3/8 SEMS	4	-----
Tube	2	FB2833-1-B
Screw, 6-32 x 1/2 PPN	4	-----

2.6.2 Procedure

2.6.2.1 There are two battery holders, one for the +22 volt supply and one for the -22 volt supply. Except for the polarity of the battery connections, the assembly procedure is the same for both. Refer to illustration, Figure 2-5.

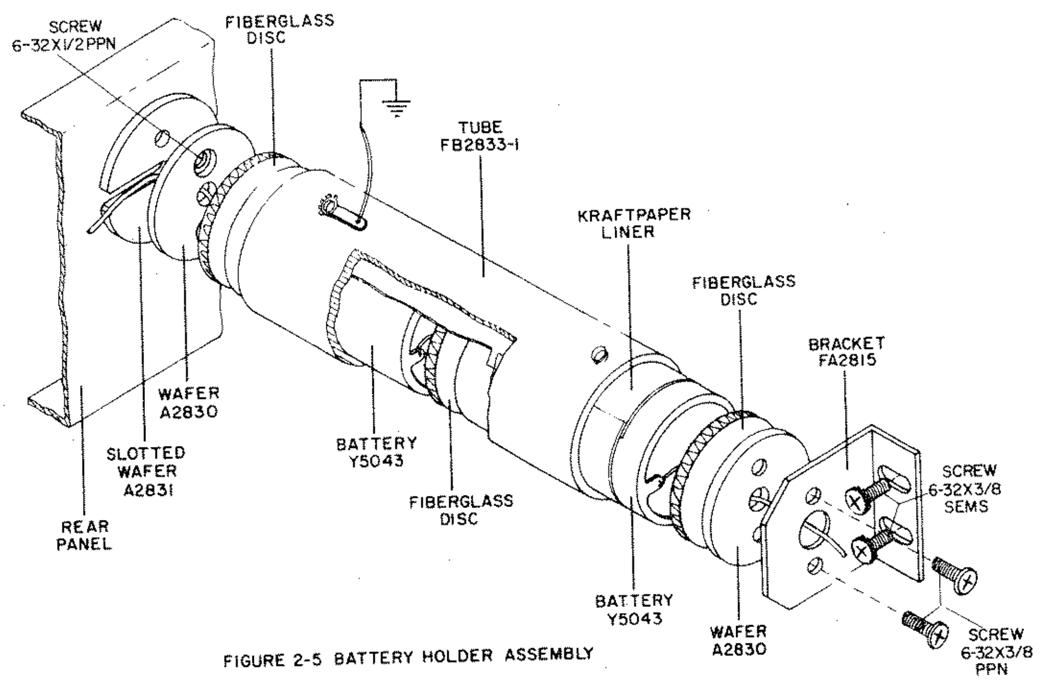


FIGURE 2-5 BATTERY HOLDER ASSEMBLY

Figure 2-5. Installation of Battery Holders

2.6.2.2 First connect 2 batteries in series (+ to -) with a 1-inch length of AWG24 stranded hookup wire. Then solder a 13-inch length of red-insulated wire to the remaining positive terminal, and a 11-inch length of black-insulated wire to the remaining negative terminal. Repeat for the other 2 batteries.

2.6.2.3 Assemble the battery holders in the order shown in the illustration, starting at the inside of the rear panel. The negative lead of the left hand batteries and the positive lead of the right hand batteries should be toward the rear panel. Thread wire through the fiberglass disc, through the center holes in the A2830-B wafer, and through the slot in the slotted wafer. Place a fiberglass disc between batteries. The battery lead toward the front should be threaded around the fiberglass disc, and through the center holes in the wafer and bracket. After the batteries are in place, trim the wires.

2.6.2.4 Connect the positive lead of the left hand battery assembly to the front end of R602 on the power switch, and connect the negative lead to terminal 5 on the power supply board.

2.6.2.5 Connect the negative lead of the right hand battery to the front end of R603 on the power switch, and connect the positive lead to terminal 6 on the power supply board.

2.6.2.6 Before using the filter with batteries alone, charge the batteries for 4 hours with the POWER switch in the LINE OPR BAT CHG position.

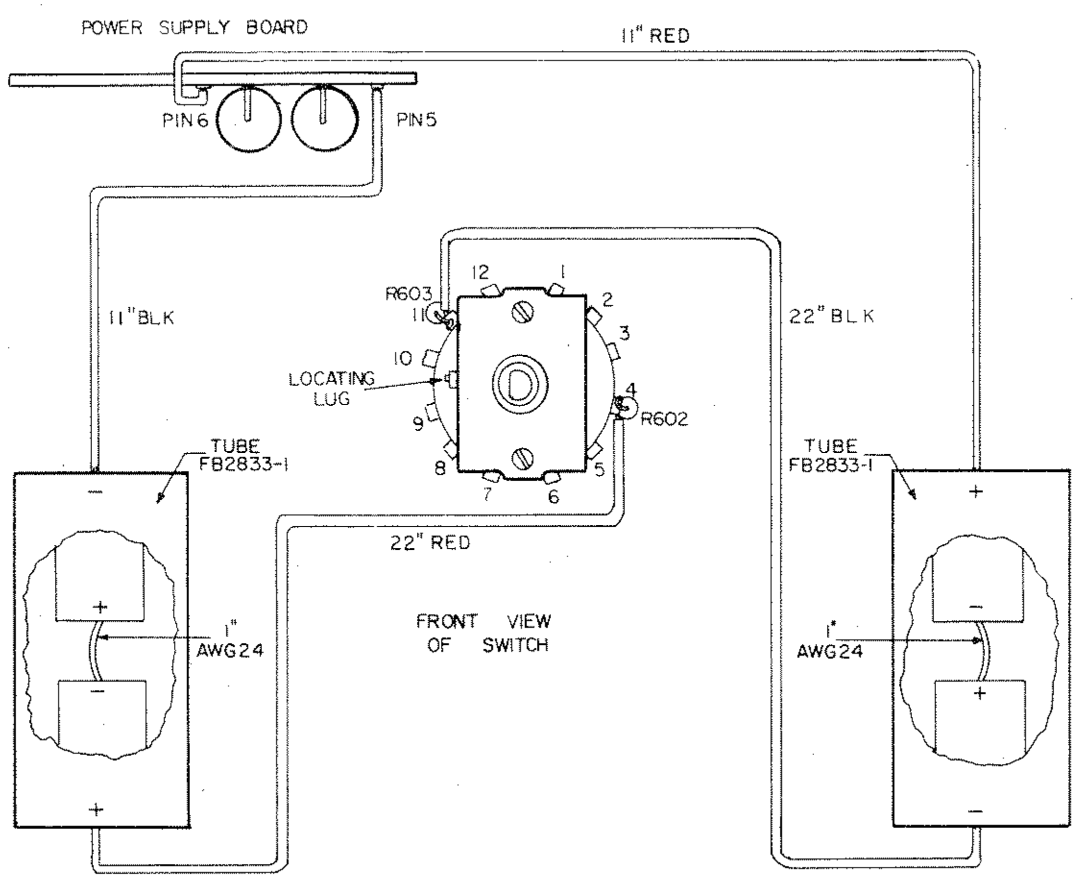


Figure 2-6. Battery Wiring Diagram

SECTION 3
INCOMING ACCEPTANCE AND INSPECTION

3.1 INTRODUCTION

The following procedure should be used to verify the filter operation within spec fications for incoming inspection and periodic specification checks. Tests must made with all covers in place. If the instrument is not operating within specific tions refer to Section 5 and 6 before attempting any detailed maintenance. Befo testing, follow the initial setup and operating procedures given in Section 2.

3.2 TEST EQUIPMENT REQUIRED

The following test equipment is required to perform these tests:

a. High impedance digital voltmeter capable of measurements from 1 milliv to 20 volts, Fluke Model 8000A or equal.

b. A-C voltmeter capable of measurements from 100 microvolts to 10 volts rms. Ballantine Model 314A, or equal.

c. Oscilloscope DC to 5 MHz, 10 mv/cm sensitivity.

d. Oscillator: 0.2 Hz to 1 MHz; with frequency accuracy better than 3%; dis tion, hum noise, less than 0.05%; frequency response ±.05 dB (Krohn-Hite Model 4100A or equal).

3.3 TEST PROCEDURE AND CONDITIONS

Table 3-1 gives the conditions and setup for testing the various filter characteristics. Unless otherwise specified in the table, the RESPONSE switch is in the MAX FLAT position, and the output load is greater than 1000 ohms. In the tabl voltages are rms unless otherwise specified. To check operation of units equip with batteries, conduct any of the performance tests in table 3-1 with the POWE switch in the BAT OPR position. If dc level cannot be zeroed with the unit in battery operation, or if unit does not provide full signal voltage, charge the batteries for 16 hours and recheck.

NOTE

Because the accuracy of a-c voltmeters is greatly reduced at frequencies below 10 Hz, it is necessary to use an oscilloscope in making some of the measurements required by this test procedure. It is recommended that the oscilloscope be set up to show 1 volt p-p as 20 divisions on the graticule. The -3 dB points (given as 0.63 to 0.77 vrms in the text) then become 12 to 16 divisions peak to peak.

Table 3-1. Acceptance Check out Procedure

Test	Function	HP	LP	Input Freq.	Voltage At Testpoint
1. Low Pass Operation	LP	-	200 x 100	10 kHz	1 volt at output
	Measure input voltage. Limits are .9 to 1.1 volts. Change osc. to 20 kHz. Output should read .6 to .8 volt. Switch LP to 200 x 10 and osc. to 2 kHz. Switch LP to 200 x 1 and osc. to 200 Hz. Switch LP to 200 x .1 and osc. to 20 Hz. Switch LP to 200 x .01 and osc. to 2 Hz. Switch LP to 200 x .001 and osc. to 0.2 Hz. With 1 volt output reference, output should read .63 to .77 volt at all cutoff settings.				
2. High Pass Operation	HP	200 x .001	-	10 Hz	1 volt at output
	Measure input voltage. Limits are .9 to 1.1 volt. Change osc. to 0.2 Hz. Output should read .63 to .77 volt. Change HP to 200 x .01 and osc. to 2 Hz. Change HP to 200 x .1 and osc. to 20 Hz. Change HP to 200 x 1 and osc. to 200 Hz. Change HP to 200 x 10 and osc. to 2 kHz. With 1 volt output reference output should read .63 to .77 volt at all cutoff settings. Change HP to 200 x 100 and osc. to 20 kHz. Output should read .6 to .8 volt.				
3. Band Pass	BP	20 x 1	200 x 10	1 kHz	1 volt at output
Attenuation Slope 3a)	Change the osc. to 20 Hz. Output should be .63 to .77 volt. Change osc. to 10 Hz and HP SLOPE switch to 6 dB/octave. Output should read .35 to .55 volt. Change SLOPE switch to 12 dB/octave. Output should read .15 to .4 volt. Change SLOPE switch to 18 dB/octave. Output should read .06 to .25 volt. Change SLOPE switch to 24 dB/octave. Output should read between 45 and 85 millivolts.				
3b)	Change the osc. to 2 kHz. Output should read .63 to .77 volt. Change osc. to 4 kHz and LP SLOPE switch to 6 dB/octave. Output should read .35 to .55 volt. Change SLOPE switch to 12 dB/octave. Output should read .15 to .4 volt. Change SLOPE switch to 18 dB/octave. Output should be .06 to .25 volt. Change SLOPE switch to 24 dB/octave. Output should read 45 to 85 millivolts.				

Table 3-1 (contd.) Acceptance Check out Procedure

Test	Function	HP	LP	Input Freq.	Voltage At Testpoint
4. 20 dB gain	BP	20 x 1	200 x 10	1 kHz	0.1 volt at input
	Switch GAIN switch to 20 dB. Output should read 0.9 to 1.1 volt. Set GAIN switch to 0 dB.				
5. Band Reject Operation	BR	200 x 10	20 x 1	10 Hz	1 volt at output
	Switch osc. to 20 Hz. Output should read .63 to .77 volt. Switch osc. to 200 Hz. Output should be less than 1 millivolt. Switch osc. to 2 kHz. Output should be .63 to .77 volt. Change osc. to 4 kHz. Output should be .9 to 1.1 volts.				
6. Maximum Signal Voltage	BP	60 x .1	60 x 100	600 Hz	1 volt at input
	Connect oscilloscope to output. Increase osc. amplitude to a point just below clipping on the output. Input voltage should be greater tha 11 volts. Return osc. amplitude to zero, and switch GAIN to 20 dB. Increase osc. amplitude to a point just below clipping on the output. Input voltage should be greater than 1.1 volt.				
7. Impedance	BP	20 x 1	200 x 100	2 kHz	0.1 volt at output
	Shunt output with 50 ohm resistor. Voltage at output should drop to 0.05 ± .01 volt.				
8. Hum and Noise	BP	20 x 1	200 x 100	--	
	Short input. Output voltage should be less than 500 microvolts.				

SECTION 4
CIRCUIT DESCRIPTION

4.1 GENERAL

The Krohn-Hite Model 3750 Filter consists of an Input Amplifier, a Low Pass Section, a High Pass Section, an Output Amplifier, and a Power Supply. The switching of the various filter functions is shown in figure 4-1. In the Low Pass (LP) mode, the signal is applied to the Input Amplifier, through the Low Pass Section to the Output Amplifier. In the High Pass (HP) mode, the signal is applied to the Input Amplifier, through the High Pass Section to the Output Amplifier. In the Band Pass (BP) mode, the LP and HP sections are connected in series. In the Band Reject (BR) mode, the LP and HP sections are connected in parallel, and their outputs are added at the input to the Output Amplifier.

The GAIN switch operates on the input amplifier only, by controlling a 10:1 attenuator in the feedback loop.

The passband controls for the high - and low - pass sections tune the 4 - pole RC networks. Frequency ranges are determined by the capacitors, switched in decades by means of the multiplier controls on the front panel. The resistances are ganged potentiometers, and are continuously variable within a given range by means of the FREQ Hz dials.

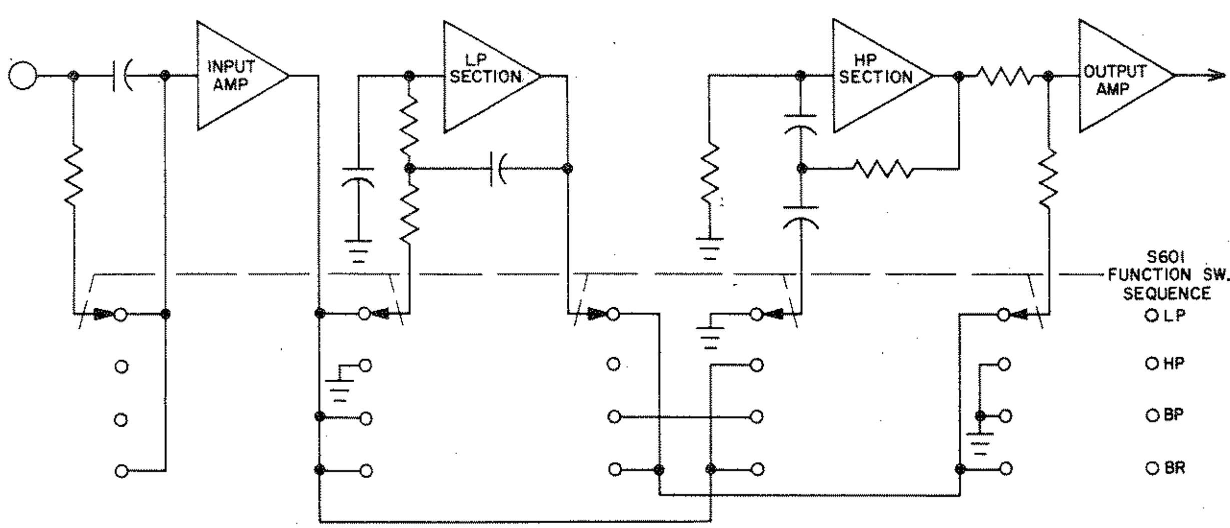


Figure 4-1. Model 3750 Function Selection Diagram

The SLOPE switches vary the attenuation slope of each section by switching the potentiometers and their associated capacitors into or out of the coupling and feedback networks. Figure 4-2 illustrates this action. The networks designated A, B, C, etc. are the cutoff frequency controls. For a slope of 6 dB per octave, networks F (Low Pass) and B (High Pass) are the only ones that are used in the RC circuits. (Notice, however, that the capacitor of network A is in series with the capacitor for network B in the 6 and 18 dB positions).

For an attenuation slope of 24 dB per octave, all four networks are used in each section. Table 4-1 shows which networks are used for each attenuation slope.

The RESPONSE switch is used to select a Butterworth (MAX FLAT) or an RC (LOW Q) response by changing the feedback characteristics of the LP and HP output stages.

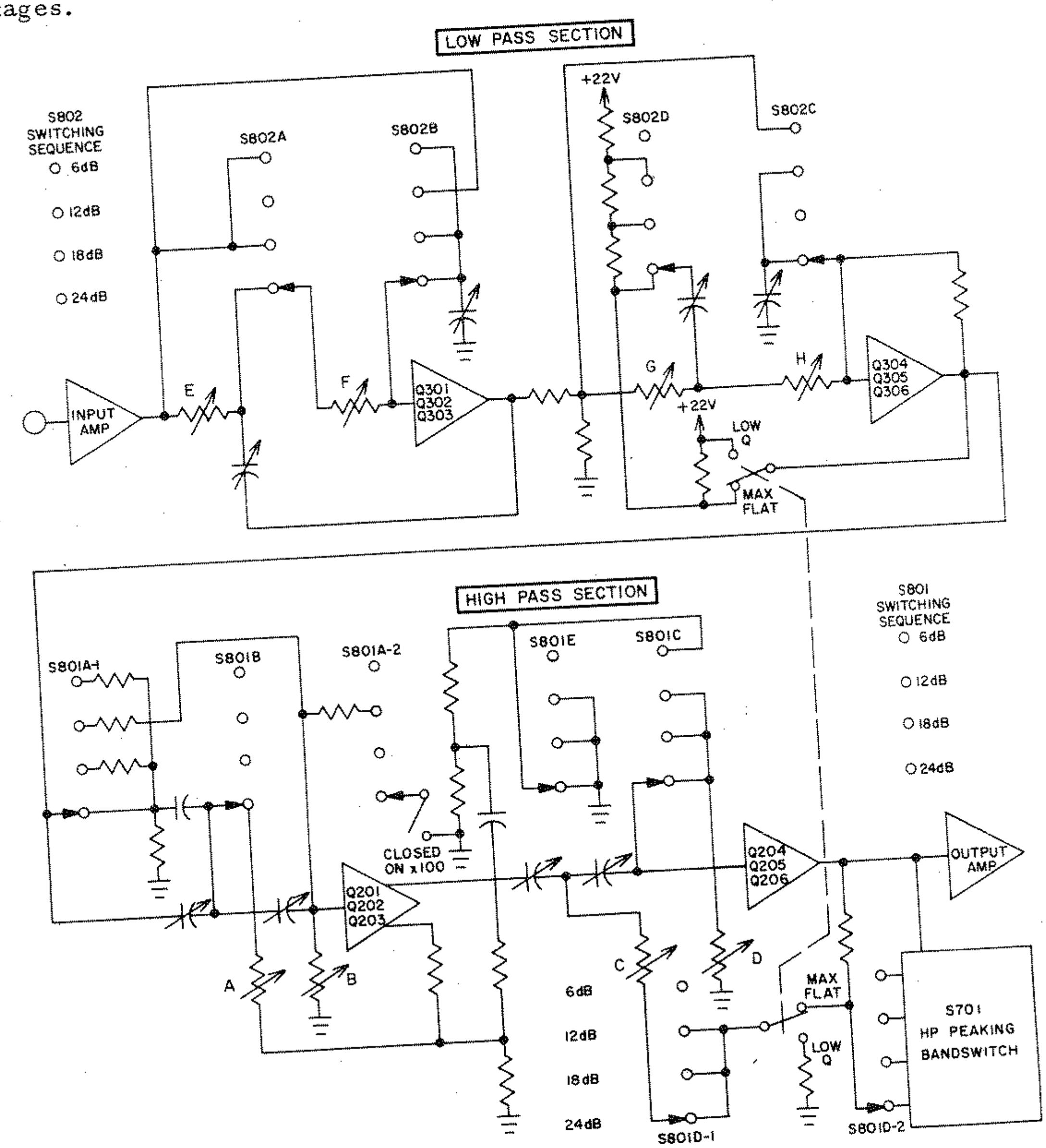


Figure 4-2. Model 3750 Slope Selection Diagram

Table 4-1. Attenuation Slope Selection

Attenuation Slope (dB/octave)	Network In Use (ref Figure 4-2)							
	High Pass				Low Pass			
6	--	B	--	--	--	F	--	--
12	--	--	C	D	--	--	G	H
18	--	B	C	D	--	F	G	H
24	A	B	C	D	E	F	G	H

The various electronic circuits are described in detail in the following paragraphs.

4.2 INPUT AMPLIFIER

The input signal is resistance coupled to the input amplifier in the LP and BR modes, and capacitance-coupled in the HP and 3BP modes. The balanced output of O101 drives the bases of Q102 and Q103, which provide a low impedance signal for the RC networks. Broadbanding is accomplished by R102, R103, and C103 at the input, and R106, R107 and C105 in the feedback loop. R113 and C106 are used to prevent oscillation. The GAIN switch serves to shunt R115 with R110 (20 dB gain) or to ground R110 (0 dB gain), varying negative feedback in a 10-to-1 ratio.

4.3 LOW PASS SECTION

The low-pass section consists of two similar two-pole stages to form a quadratic amplifier. (The term quadratic is used here because the transfer function of the section is a quadratic equation). It can be seen from the schematic that while the two stages are similar in circuit arrangement, they differ in polarity; i. e., Q301, Q302, and Q303 are PNP, NPN, and PNP transistors respectively, while Q304, Q305, and Q306 are NPN, PNP, and NPN respectively. This arrangement has the effect of cancelling nonlinearities in transitor characteristics and compensating for drift due to temperature changes.

The input transistor of each stage is designed for very low current drain (R305 and R321 are 39 megohms) so as not to load the RC networks. RC networks are used in both stages for negative feedback and loop stabilization. The RESPONSE switch in combination with the slope switch, provides for selection of RC or Butterworth response by modifying feedback.

4.4 HIGH PASS SECTION

The high pass section consists of two stages; the first stage is single ended, and utilizes a buffer amplifier (Q202) in the feedback loop. On the two higher bands the gain of the loop is adjusted by means of P201. RC's are used extensively in this stage to provide wide bandpass and compensate for stray capacitance.

The second stage (Q204, Q205, Q206) is similar to the input amplifier but the functions here are (a) to drive the peaking circuits for slope control, (b) to prov for selection of an RC or Butterworth response, and (c) to provide a low-imped source for the following sections.

4.5 OUTPUT AMPLIFIER

The outputs of the low-pass and high-pass sections are added in the BR mode at input of the output amplifier. Potentiometer P401 is used to equalize the HP an LP signals, which are applied to the base of Q401, and clamped at the same dc level as the output by the action of Q404. Q401 and Q402 are emitter-coupled a drive the constant current output stage, Q403 and Q404. Network R412-C404 pr vides negative feedback to the input. R410 and C403 are used to prevent oscilla and C403 is a bypass capacitor for resistor R406.

4.6 POWER SUPPLY

The power supply furnishes two regulated voltages of + 22 and -22 volts. The b teries, or rectifiers CR602 thru CR605 and filter capacitors C501 and C506, pr vide the unregulated dc voltages. Both supplies are of the typical series type. + 22 volt supply is the master supply using Zener-connected Q504 as a referenc and amplifiers Q502 and Q503 to drive the series regulator Q501. Short circuit protection is provided by the series resistor R502 which cuts off Q502 via diode CR501. The -22 volt supply is slaved to the + 22 volt supply. A divider networ consisting of R524 and R525 sets the proper voltage level for amplifiers Q509 a Q506, which drive the series regulator Q505. Short circuit protection is provic by R514 and diode CR503. To insure starting, a Zener Z501 provides a negativ voltage for the regulating amplifiers. Diode CR504 is normally conducting and mits Z501 to function when required. When power switch S602 is in the LINE O BAT CHG position, diodes CR601 and CR606 charge the batteries through curre limiting resistors R602 and R603.

SECTION 5
MAINTENANCE

5.1 INTRODUCTION

If the Model 3750 is not functioning properly and requires service, follow this procedure to locate the source of trouble. To obtain access to the interior of the filter, remove the screw centered at the rear of each cover; sliding off the side covers will unlock the top and bottom covers.

The general layout of major components, test points, screwdriver controls and adjustments is shown in Figure 5-1. A detailed component layout for the printed circuit card is included with the schematic diagram at the end of this book. Various check points and voltages are shown on the schematic diagram and are also marked on the printed circuit card.

First make a visual inspection; check the unit for such things as broken wires, burnt or loose components, or similar conditions which could cause trouble. Any troubleshooting of the filter will be greatly simplified if you understand the operation of the circuit. Before attempting detailed troubleshooting refer to Circuit Description Section 4.

5.2 POWER SUPPLY

The Power Supply consists of two separate regulated supplies of +22 and -22 volts dc. The +22 is used as a reference supply for the -22 and this fact should be kept in mind when doing any work on the supply, as a malfunction in the +22 will be reflected in the -22. If the supplies do not seem to be working properly, the +22 should be checked first. The two supplies have current limiting circuits which will shut down the supply if excessive current is being drawn from it. For this reason an apparent malfunction in the supply could be caused by an overload in one of the other circuits, e.g., a collector to emitter short in one of the output transistors will overload the power supply.

Nominal voltages for various points in the supplies are given in the schematic. If a malfunction occurs, the error signal thus developed should be traced through the circuit to find the faulty component. Let us suppose, for example, that the +22 was lower than normal. This would produce an error signal which would make both the base and emitter of Q503 more negative than normal. Because the base moves less than the emitter, the total result is a lowering of the collector from its normal value. The base of Q502 should then be more negative than normal and the collector

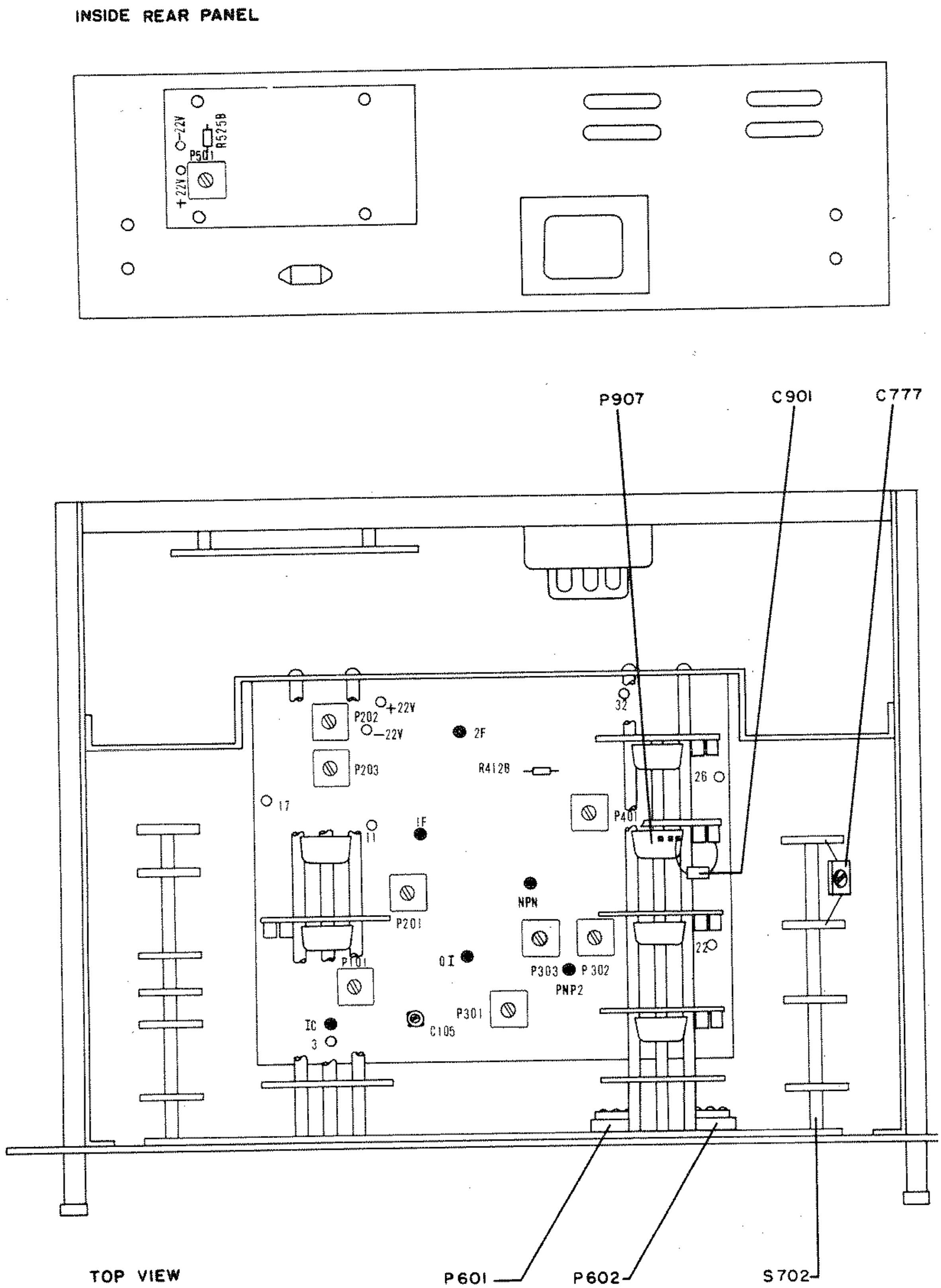


Figure 5-1. Trims and Adjustments

more positive. This will raise the base of series regulator transistor Q501 and finally should correct the output level. Had there been a defective component somewhere in the circuit, this correcting action would have been blocked. The same basic method of troubleshooting may also be used in the -22 volt supply.

If it becomes necessary to replace the reference zener Q504 the voltage of the +22 supply will have to be readjusted. This may be done by adjusting P501, so the supply is +22 ±1 volt. If the -22 supply exceeds -22 ±1 volt, change the fixed trim resistor R525B in parallel with R525A (do not disturb 525A).

5.3 SIGNAL TRACING ANALYSIS

If the power supplies appear to be correct but the Model 3750 is not working, the following signal tracing analysis should help locate the area of malfunction. Set the function switch to BP; set the RESPONSE switch to MAX FLAT position. Set both the low and high cutoff frequencies to 200 Hz Attenuation slope to 24 db per octave. Connect a 200 Hz 5-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.

Table 5-1 shows various test points with their correct signal levels for band pass operation. If a test point is found whose signal level differs appreciably from the correct value, the circuitry immediately preceding that test point should be carefully checked.

Table 5-1. Test Point vs Signal Voltage

Function: Band Pass
Input: 200 Hz, 5 volts rms
HP and LP Settings: 200 x 1
Response: LOW Q
Gain: 0 dB
Slope: 24 dB/octave

Test Point	Voltage (rms)
3	5.0
OI	2.7
11	0.40
1F	0.47
17	0.22
2F	0.28
22	1.4
PNP	1.4
26	0.35
NPN	0.73
32	0.40

5.4 TUNING CIRCUITS

If signal tracing shows one of the tuning circuits to be faulty, it should be deter- mined if the trouble is in the resistive or capacitive elements. If the trouble is a capacitive element the malfunction will appear only on that position. If there a problem in a resistive element, the trouble will be of a general nature and wil show up on all multiplier bands.

The value of capacitance used on the highest band are selected to compensate fo stray capacitance and are therefore, not completely in decade ratios of those us on the lower bands.

Each of the variable resistance elements consists of four potentiometers gangec together with a gear assembly. Each potentiometer has series and shunt trims insure proper tracking. The trims and the angular orientation of the potentio- meters are carefully adjusted at the factory. If it becomes necessary to chang one of these potentiometers in the field, it should be replaced only with a unit s plied by the factory complete with proper trims. The angular orientation shoul then be carefully adjusted following the procedure supplied with the parts.

SECTION 6

CALIBRATION AND ADJUSTMENT

6.1 INTRODUCTION

Before making adjustments follow the procedure in Section 3 to determine if performance is within limits. The following procedure is provided for the adjustment and calibration of the filter in the field, and adherence to this procedure should restore the filter to its original specifications. If any difficulties are encountered, please refer to Maintenance, Section 5. If any question arises which is not covered by this procedure, please contact our factory service department. The locations of major components and trims are shown in Figure 5-1. The test points are marked on the PC board.

Access to the interior of the Model 3750 is gained by removing the screw centered at the rear of each cover; sliding off the side covers will unlock the top and bottom covers.

6.2 TEST EQUIPMENT REQUIRED

The following test equipment is required to perform these tests.

a. High impedance digital voltmeter capable of measurements from 1 millivolt to 20 volts, Fluke Model 8000A or equal.

b. A-C voltmeter capable of measurements from 100 microvolts to 10 volts rms, Ballantine Model 314A, or equal.

c. Oscilloscope DC to 5 MHz, 10 mv/cm sensitivity.

d. Oscillator; 0.01 Hz to 1 MHz; with frequency accuracy better than 3%; distortion, hum, and noise less than 0.05%; frequency response ±.05 dB (Krohn-Hite Model 4100A or equal).

6.3 DC LEVEL ADJUSTMENTS

6.3.1 Positive Voltage

Connect the d-c voltmeter between ground and the +22V terminal at the left rear of the PC board. Limits are +21 to +22 volts. If out, adjust P501.

6.3.2 Negative Voltage

Connect the d-c voltmeter between ground and the -22V test point on the PC board Limits are -21 to -22 volts. If out, trim R525. If trim is necessary, check and adjust the +22 volt level.

6.3.3 Amplifier Output

Short the filter input, set the FUNCTION switch to LP and the GAIN switch to 20 d Measure the d-c level at test point OI. Limits are -10 to + 10 millivolts. If out, adjust P101.

6.3.4 HP Mode Output Level

With input shorted, set FUNCTION switch to HP. Measure level at filter output. Limits are 0 to ±10 millivolts. If out, adjust P601 (pot A on front panel).

6.3.5 Slope vs Output Level

6.3.5.1 With the input shorted, set FUNCTION switch to LP and LP dial to 200 x 100. Set LP SLOPE to 6 dB. Output level should be 0 to ±10 millivolts. If out adjust P602 (pot B on front panel).

6.3.5.2 Set LP dial to 20 x 100. Switch LP slope from 6 to 18 dB/octave. Adjus P303 for same level at 18 dB as at 6 dB.

6.3.5.3 Switch LP slope to 12 dB, and then to 24 dB/octave. Adjust P301 for sar level at 24 dB as at 12 dB.

6.3.5.4 Repeat 6.3.5.1---pot B on front panel.

6.3.6 Calibration Procedure

The calibration procedure, which should be conducted only after the d-c levels ha been set, is given in Table 6-1. In the table the initial setup is given in tabular fc at the beginning of each test, and then follows a sequence of steps. It is importan that the sequence be followed in order. Nominal oscillator output voltage at the beginning of all tests is 1 volt rms. Amplitude is then adjusted at the test point given. Unless otherwise specified, the GAIN switch is in the 0 dB position, the SLOPE switches are set for 24 dB/octave, the RESPONSE switch is on MAX FLA and the output load is greater than 1000 ohms.

Table 6-1. Calibration Procedure

Test	Function	HP Section	LP Section	Input Freq.	Voltage at Testpoint
1. LP vs HP Gain	LP	20 x 1	20 x 100	90 Hz	1 vrms at input
	Connect acvm to output. Switch FUNCTION from LP to HP. Output should change less than ±.02 vrms. If off adjust P401.				
2. Unity Gain	HP	20 x .001	--	90 Hz	1 vrms at input
	Connect acvm to output. Limits are 1 ± .1 vrms. If off trim R412.				
3. Frequency Response	HP	20 x .01	--	100 Hz	1 vrms at output
3a)	Switch osc. to 1 KHz, 10 KHz, and 100 KHz. Output voltage should change less than ±.03 vrms as switch is operated. Adjust C105 for minimum change.				
	HP	60 x 1	--	60 KHz	1 vrms at output
3b)	Switch HP to x 10 and x 100. Output should be .95 to 1.05 vrms. If off, adjust P201 while switch is in x 100 position.				
	HP	60 x .1	--	60 Hz	1 vrms at input
3c)	Connect acvm to output. Limits are .90 to 1.1 vrms. Switch HP to 60 x 1, and adjust HP dial to 0.7 vrms. Switch osc. to 600 Hz, and HP multiplier to X10. Output should be 0.63 to 0.77 vrms. Switch osc. to 6 KHz, and HP Multiplier to X100. Output should read 0.54 to 0.86 vrms. If off, adjust P203 with HP switch in X100 position.				
4. HP Dial Set	HP	60 x 1	--	60 Hz	1 vrms at input
	Connect oscilloscope vertical input to test point 2F, and horizontal input to test point 01. Adjust HP dial to close the ellipse. Dial should read 58 to 62. If off, loosen dial set screws and set to 60. Tighten set screws.				
5. HP Gain Calibration	HP	60 x .1	--	60 Hz	1 vrms at 2F
	Switch HP multiplier to X1. Voltage at test point 2F should be 0.7 ±0.07 vrms. If off, adjust P202.				
6. LP Dial Set	LP	20 x .001	60 x 1	60 Hz	1 vrms at output
	Oscilloscope horizontal input to test point 01, and vertical input to filter output. Adjust LP dial to close the ellipse. Dial should read 58 to 62. If off, loosen set screws and set dial to 60. Tighten set screws.				
7. LP Gain Calibration	LP	--	60 x 10	60 Hz	1 vrms at output
	Switch LP multiplier to X1. Output should be 0.7 ±0.07 vrms. If off, adjust P302.				
8. LP X 100 Calibration	LP	--	20 x 100	200 Hz	1 vrms at input
8a)	Switch osc. to 2 KHz. Output should be 0.7 ± 0.14 vrms. If off, adjust C777.				
8b)	Set LP to 200 x 100, and osc. for 2 KHz, 1 vrms at output. Switch osc. to 20 KHz. Output should be 0.7 ± 0.14 vrms. If off, adjust C901.				