

Model 3380 Series

Tunable Active Filter

Operating Manual

0.1Hz to 200kHz

48dB/Octave Slope

Butterworth and Bessel Response

Low-Pass, High-Pass, Band-Pass, Band-Reject

Model 3381 - Single Channel

Model 3382 - Dual Channel

Model 3384 - Four Channel



KH KROHN-HITE
CORPORATION

Model 3380 Series

0.1Hz to 200kHz (0.005Hz Optional)
1, 2 or 4 Channels, 48dB/Octave Slope
Low-Pass/High-Pass, Butterworth/Bessel Filter

Operating Manual

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SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Krohn-Hite Model 3380 Filter Series (3381, 3382 and 3384) are one, two or four channel filters providing a tunable frequency range from 0.1Hz to 200kHz; and with the 002 option, the range is extended to 0.005Hz. The frequency response characteristic is selectable to either maximally flat (Butterworth) for clean filtering in the frequency domain, or linear phase (Bessel) to provide superior filtering of pulse or complex signals.

Each channel of the 3380 Series is a selectable low-pass or high-pass, 8-pole filter providing an input gain of up to 50dB and an output gain of up to 20dB, selectable in 0.1dB steps. The 3380 Series will accept input signals of $\pm 10V$ peak at 0dB gain and has selectable ac or dc coupling. Memory is available for storing set-ups of the instrument which can be recalled later with a simple command. The following pages are the specifications of the Model 3380 Series Filters.

1.2 SPECIFICATIONS

1.2.1 Functions (Each Channel)

Low-pass filter, high-pass filter; 2 or 4 channel models, one or two channel(s) of band-pass or band-reject via external connections.

1.2.2 Number of Channels

Model	Channels
3381	1
3382	2
3384	4

1.2.3 Filter Characteristics

Type: Selectable 8-pole Butterworth or 8-pole Bessel.

Attenuation: 48dB/octave.

Tunable Frequency Range f_c : 0.1Hz to 200kHz; (option 002, 0.005Hz).

Frequency Resolution: 3 digits, $^3 1Hz f_c$; 0.001Hz, $< 1Hz f_c$.

Cutoff Frequency Accuracy: $\pm 3\%$.

Relative Gain at f_c : $-3.01dB$, Butterworth; $-12.59dB$, Bessel.

Passband Gain: ± 0.2 dB.

High-Pass Bandwidth (0dB Gain): >2 MHz.

Stopband Attenuation: >100 dB.

Maximum Input: ± 10 V peak at 0dB gain, reduced in proportion to gain setting.

Pre-Filter Gain: 0dB, 10dB, 20dB, 30dB, 40dB, 50dB, ± 0.2 dB.

Post-Filter Gain: 0dB to 20dB selectable in 0.1dB steps, ± 0.2 dB.

Wideband Noise (2MHz bandwidth detector): 0dB gain, $<400\mu$ Vrms; Max input gain, $<5\mu$ Vrms RTI; Max. gain $<25\mu$ Vrms RTI.

Harmonic Distortion (1V output): -60 dB (0.1%) to 10kHz; -50 dB (0.3%) to 200kHz..

Input: Differential or single-ended.

CMRR: >60 dB to 10kHz; >50 dB to 100kHz.

Sensitivity: 3mV peak with 70dB total gain for 10V peak output.

Impedance: 1 megohm in parallel with 25pf.

Coupling: ac (0.16Hz) or dc.

Maximum DC Component: ± 100 V in ac coupled mode.

Output:

Maximum Voltage (open circuit): ± 10 V peak.

Maximum Current: ± 80 mA peak.

Impedance: 50 ohms.

DC Offset: Adjustable to zero volts.

1.2.4 General

Crosstalk Between Channels: -80 dB for fsig ≤ 200 kHz, -70 dB for fsig > 200 kHz with input source ≤ 50 ohms.

Memory: 9 stored set-ups (0 - 8).

Self-Test Diagnostics: MPU checks unit upon power-up. Display indicates failure mode.

Displays: 7 segment, green, LED; 0.3" high.

Operating Temperature: 0° C to 50° C.

Isolation to Chassis: ± 200 Vdc.

Input/Output Connectors: BNC.

Power: 3381, 9 watts; 3382, 16 watts; 3384, 30 watts.

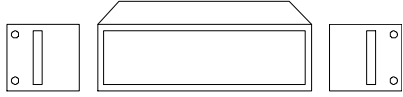
Dimensions and Weights: $3\frac{1}{2}$ " (9cm) high, 14" (35.56cm) wide, $12\frac{1}{2}$ " (31.75cm) deep; 7 lbs (3.18kg) net, 9 lbs (4.09kg) shipping.

1.2.5 Options

002: extends low end cutoff to 0.005Hz.

BK-330: Battery Option, up to 8 hours of operation, rechargeable NiCad batteries (factory installation).

Rack Mount Kit: Part No. RK-314, permits installation of the Model 3380 Series into a standard 19" rack spacing.



Extended 1 Year Warranty: Part No. EX3380.

Specifications apply at 25°C, $\pm 5^\circ\text{C}$.

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SECTION 2 OPERATION

2.1 INTRODUCTION

The Model 3381, 3382 and 3384 Filters are one, two or four channel filters respectively, providing a tunable frequency range of 0.1Hz to 200kHz (0.005Hz with option 002).

Each channel is selectable low-pass or high-pass, 8-pole with input gain from 0dB to 50dB, selectable in 10dB steps; and output gain from 0dB to 20dB, selectable in 0.1dB steps.

The input signal can be ±10V peak at 0dB gain and has selectable ac or dc coupling. Memory is available for storing set-ups of the front panel settings which can be recalled later with a keystroke entry.

Each mode of operation will be explained in this section.

2.2 TURN-ON PROCEDURE

The Model 3380 line voltage range has been preset for either 115V or 230V, Norm, line voltage. When making any changes to the line connections, remove the power cord.

To change the Norm/Low line setting, remove the top cover to expose the Norm/Low line switch located near the rear panel, under the back shield.

To achieve access to the 120V/240V connections, remove the bottom cover and change the connections to the desired

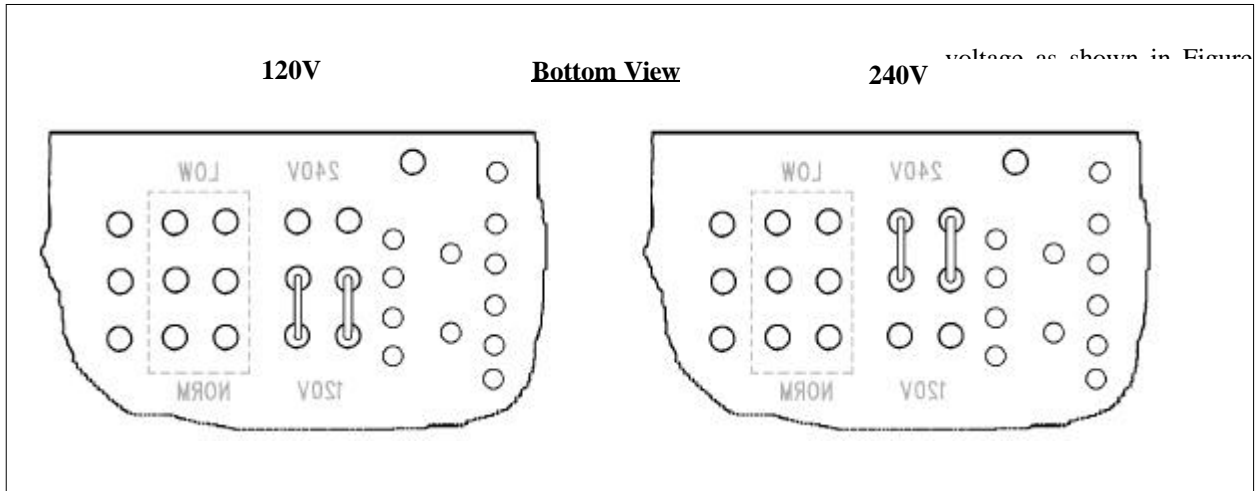


Figure 2.1 Jumper Settings for 120V/240V Operation



Model 3382 Filters

Note: On early models, a 120V/240V switch was provided next to the Norm/Low line switch.

120V 240V Jumper	Norm Low Line Switch	Input Voltage Range (rms)	Install Fuse		
			Model 3381	Model 3382	Model 3384
120V	Norm	108-132	.15A	1/4A	1/2A
	Low	90-110			
240V	Norm	216-264	.1A	1/8A	1/4A
	Low	180-220			

Power Consumption (watts)			
120V/240V Jumper	Model 3381	Model 3382	Model 3384
120V	8	14	26
	9	16	30
240V	8	14	26
	9	16	30

Set the 120V/240V and Norm/Low line switch and jumpers as needed according to the table above.

Be sure to change the fuse to the proper rating for the line switch setting selected. Replace the cover.

Plug the line cord into the unit, then the ac outlet.

After reading the Self-Test feature, described next, turn on the Model 3380.

2.3 SELF TEST

When the Model 3380 is turned on, the microprocessor performs a self-test routine whereby the entire RAM and ROM operation is verified. If there is a malfunction, such as a defective RAM or ROM, the word “bad” will appear in the DISPLAY followed by a number 1 or 2. “bad 1” indicates U16, microprocessor is defective and a “bad 2” indicates U17, EPROM is defective.

When the self-test program has completed, the Model 3380 will return to the setup stored in storage location 0. The Model 3380 is now ready for operation.

2.4 OPERATION

2.4.1 Front Panel Controls and Display

2.4.1.1 Channel Selection (Models 3382 and 3384 only)

The up [Δ] control key below the CHANNEL display increments the channel number. The various displays and indicators on the front panel (cutoff frequency, gains, etc.) pertain to the channel indicated by this display.

2.4.1.2 Setting Cutoff Frequency

Data entry keys [0] to [9], [.] , [KILO] and [MEGA] set the numeric value of the cutoff frequency desired. To select 1.5kHz, press the [1][.][5] data keys and parameter keys [KILO] and [FREQ]. The cutoff frequency for the channel selected will be indicated in Hertz on the four digit DISPLAY (when [ALL CH] mode is selected, the frequency will be changed on all channels). The KILO and FREQ keys will be lit.

2.4.1.3 Digit Select/Frequency Increment and Decrement

When the [SHIFT] key is pressed, followed by the DIGIT SELECT [Δ] or [∇] keys, the FREQUENCY DISPLAY will intensify a digit. Pressing the [SHIFT] followed by the [Δ] or [∇] key again, will intensify the next digit or will turn the DIGIT SELECT off. The [Δ] will move the intensified digit to the left and the [∇] will move the intensified digit to the right (direction is labeled in red to the left of keys).

Pressing the [Δ] or [∇] keys will then increment or decrement the intensified frequency digit.

2.4.1.4 Setting Input Gain (Pre-Filter)

Up [Δ] and down [∇] INPUT GAIN SET controls increase or decrease the input amplifier by 10dB. The two digit DISPLAY will indicate either 0dB, 10dB 20dB, 30dB, 40dB or 50dB. May also be set by entering gain desired directly on the keypad and pressing either the [Δ] or [∇] gain key.

2.4.1.5 Setting Output Gain (Post Filter)

Up [Δ] and down [∇] OUTPUT GAIN SET controls increase or decrease the output amplifier by 0.1dB steps from 0dB to 20.0dB. For gains <10dB, 0.1dB resolution is displayed. For gains >10dB, only 1dB resolution is displayed; however, the up [Δ] and down [∇] keys continue to increment and decrement the gain by 0.1dB. The full 3-digit resolution may be seen in the middle display by pressing [SHIFT] the [Δ] or [∇] key under the output gain display. Also for gains >10dB, the decimal point is off for whole dB's (10, 11, 12, etc.) but on for fractional (10.1 – 10.9, 11.1 – 11.9, etc.). Gain may also be set by entering gain desired directly on the keypad and pressing either the [Δ] or [∇] gain key.

2.4.1.6 Butterworth or Bessel Selection – [TYPE]

When [TYPE] is pressed once, DISPLAY indicates the present filter type, “bu.” (Butterworth) and “bES.” (Bessel). When pressed again, the type will change (i.e. if the type was “bES.”, the change will be to “bu.”)

2.4.1.7 Low-Pass and High-Pass Operation – [MODE]

When [MODE] is pressed once, DISPLAY indicates the present filter type, “h.P.” (high-pass) and “L.P.” (low-pass). When pressed again, the type will change (if the type was “L.P.”, the change will be to “h.P.”).

2.4.1.8 Variable Band-Pass Operation (Models 3382 and 3384 only)

To obtain Band-Pass operation with 48dB per octave attenuation proceed as follows:

Set channel 1 to high-pass mode (this will control the low cutoff frequency). Set channel 2 to low-pass (this will control the high cutoff frequency). Connect the input signal to channel 1 input, connect the channel 1 output to the channel 2 input and connect the load to the channel 2 output. For the Model 3384, the same can be done with channels 3 and 4 respectively.

The minimum pass-band is obtained by setting the high cutoff frequency equal to the low cutoff frequency. In this condition the insertion loss is nominally 6dB (in the Butterworth mode) and the -3 dB cutoff frequencies occur at 0.8 and 1.25 times the mid-band frequency. Insertion loss may be made-up by setting output gains to +6dB.

2.4.1.9 Variable Band-Reject Operation (Models 3382 and 3384 only)

To obtain Band-Reject or Notch operation, proceed as follows:

Connect the two channels in parallel by connecting the input signal to the input of each channel simultaneously. The output from both channels should be added through two equal external resistors in series with each output. The junction of these resistors becomes the output of the filter. It is recommended that the resistors be approximately 1k ohms and of the carbon or metal film type if the filter is used at higher frequencies. If the two resistors are not equal, the gain on one side of the notch will be different than the gain of the other. Insertion loss may be made-up by setting output gains to +6dB.

Set channel 1 for low-pass and channel 2 for high-pass, and adjust the cutoff of each channel for the maximum rejection. The ideal notch occurs when setting the low cutoff (low-pass) to 0.5 and the high cutoff (high-pass) to 1.5 notch. Insertion loss may be made-up by setting output gains to +6dB.

Caution: Do not exceed specified voltage at terminals.

2.4.1.10 AC/DC Coupling

Pressing the [SHIFT] key, followed by the [TYPE] key, will display the present input coupling, indicating “AC” or “DC”. Press [SHIFT] [TYPE] again to toggle between AC and DC.

2.4.1.11 Differential/Single-Ended Input

LED indicators are provided on the front panel to indicate which input(s) is (are) active. Pressing [SHIFT] and then the [+ONLY] key under the Input Gain Display will select single-ended input mode, only the LED beside the +Input of the selected channel will be lit. Pressing [SHIFT] and then the [DIFF] key, will select the differential input mode and both LEDs beside the selected channel will be lit.

2.4.1.12 Storing a Filter Setup – [STORE]

There are 9 storage locations for storing front panel filter setups. The locations are numbered 0 through 8. When [SHIFT] [RECLL][STORE] is first pressed, the DISPLAY indicates the number of the next memory location available. For example, the DISPLAY will indicate the following: “n=05”. Pressing [RECLL] again will store the entire filter set-up into that memory location. If another memory location is desired, enter that location on the keyboard and then press [SHIFT] [RECLL]. When [SHIFT] [RECLL] is preceded by a number (0-8), the 3380 will store the current filter set-up into the memory location selected.

When [SHIFT] [RECLL] is pressed to indicate the next memory location only, pressing the clear entry key [CE] will restore the DISPLAY to the cutoff frequency setting. The filter settings stored in memory location 0 is automatically recalled at turn-on.

2.4.1.13 Recalling a Filter Setup – [RECLL]

When [RECLL] is preceded by a number, it will recall the filter set-up which was stored in the memory location selected. Selectable locations are 0 to 8.

When first pressed, the DISPLAY indicates the number of the memory location to be recalled. For example, the DISPLAY will indicate the following: “n=05”. Pressing the [RECLL] key again will recall the entire filter set-up from memory location “05”.

When pressed to indicate the memory location to be recalled only, pressing the [CE] (clear entry key) will restore the DISPLAY to the cutoff frequency setting.

Memory location 0 is automatically recalled at turn-on.

2.4.1.14 Clear Entry Key – [CE]

When entering a numeric value in the keyboard, but not specifying a parameter, pressing the clear entry key will restore the DISPLAY to the current cutoff frequency setting.

When a numeric value and its parameter has been entered and the numeric value is then changed, pressing the [CE] key will restore DISPLAY to the previous value of that parameter. Pressing the [CE] key continuously will toggle between the previous keypad entry and the present entry.

When either the [STORE] or [RECALL] key is pressed, the next memory location will be indicated on the DISPLAY. Pressing the [CE] key will restore DISPLAY to the current cutoff frequency setting.

2.4.1.15 All Channel Mode – [ALL CH] (Models 3382 and 3384)

When [ALL CH] is pressed, the LED in the [ALL CH] key will light; and when frequency, input/output gain, type, mode, +only or diff input, and/or coupling is entered or changed, the new setting will be entered in all channels of the filter.

2.5 REAR PANEL DC LEVEL ADJ.

The Model 3380 rear panel has 2, 4 or 8 output dc level adjustments. The following procedure is for adjusting the output dc level to zero volts for any channel.

2.5.1 DC Level Adj. (Rear Panel) HP

Set the filter to HP at 1.1kHz. Adjust HP for 0V at filter output.

2.5.2 DC Level Adj (Rear Panel) Out

At any frequency setting, the output dc level may be adjusted to zero volts for each channel with the rear panel, screwdriver adjust, output dc level control.

2.6 FILTER CHARACTERISTICS

2.6.1 Amplitude Response

Each channel of the Model 3380 can operate in either the low-pass or high-pass mode at 48dB/octave attenuation and provide either maximally flat (Butterworth) amplitude response or linear phase (Bessel) operation. Comparative amplitude response characteristics in both modes are shown in Figure 2.2A and 2.2B.

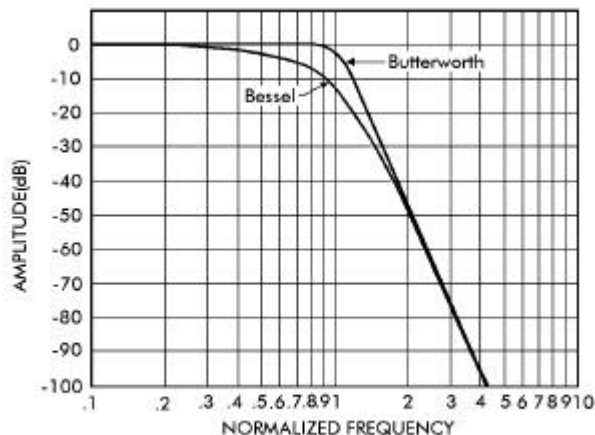


Figure 2.2A Low-Pass Amplitude Response

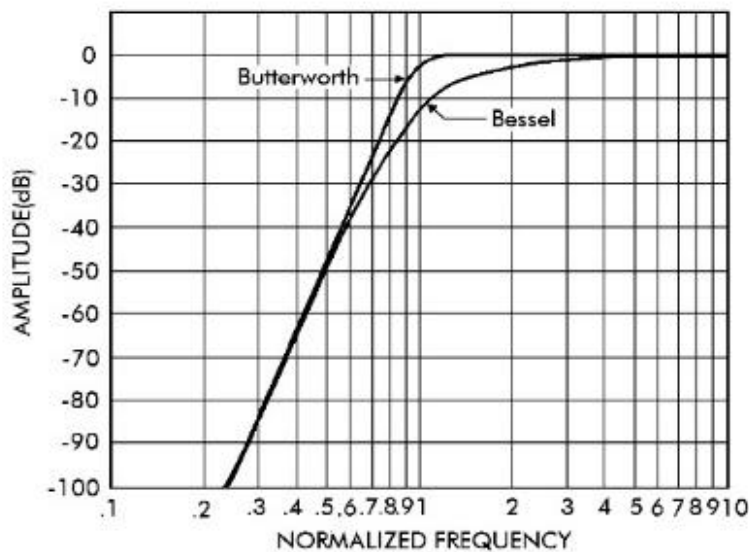


Figure 2.2B High-Pass Amplitude Response

2.6.2 Phase Response

Phase characteristics of the Model 3380 is shown in Figure 2.3. The graph of the filter response provides output phase relative to the input over a 10:1 frequency range.

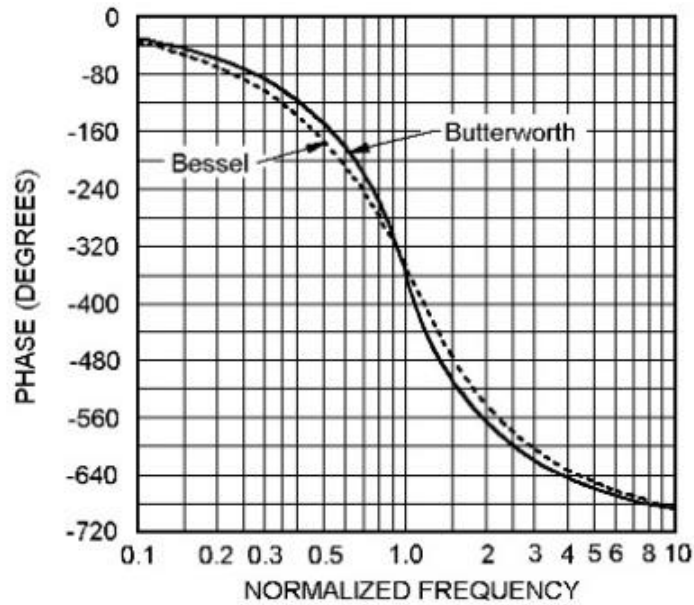


Figure 2.3 Phase Response

2.6.3 Group Delay

Group delay¹, shown in Figure 2.4, on opposite page, is defined as the derivative of radian phase with respect to radian frequency, which is the slope of the phase curve. A flat group delay is considered a linear phase response which corresponds to a constant slope of the phase curve. With linear phase response, the distortion of complex data signals will be minimized because their various frequency components, due to constant time delay, will not shift relative phase.

In numeric terms, the zero frequency phase slope is $-293.7^\circ/\text{Hz}$ for Butterworth and $-351.9^\circ/\text{Hz}$ for Bessel, when normalized for a cutoff frequency of 1Hz. This will be 2π times greater in $^\circ/\text{Hz}$ for a cutoff of 1 radian/sec or $-1845^\circ/\text{Hz}$ and $-2211^\circ/\text{Hz}$ respectively. Dividing by 360 converts $^\circ/\text{Hz}$ to radians/radians-per-sec yields a group delay time of 5.13s for Butterworth and 6.14s for Bessel.

[1] *IEEE Standard Dictionary of Electrical and Electronic Terms*, Institute of Electrical and Electronic Engineers, IEEE-STD 100-1977, Second Edition, 1977, page 296. , shown in Figur , shown in Figur

2.6.4 Transient Response

The normalized response for a unit step voltage applied to the input of the Model 3380 operating in the low-pass mode with both Butterworth and Bessel response is shown in Figure 2.5, on page 2-12.

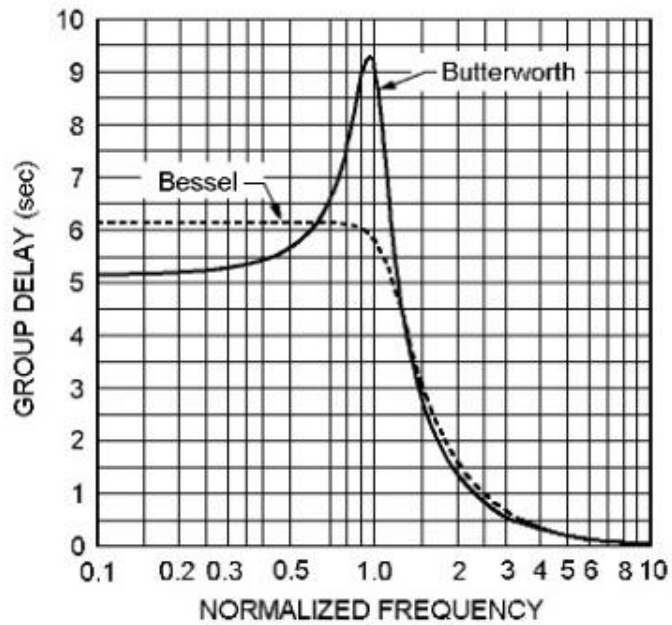


Figure 2.4 Group Delay

SECTION 3

INCOMING ACCEPTANCE

3.1 INTRODUCTION

The following procedure should be used to verify that the Model 3380 filter is operating within specifications. These checks may be used for incoming acceptance and periodic performance checks. Tests must be made with all covers in place and operating for a minimum of 30 minutes to reach operating temperature. If the unit is not operating within specifications, refer to Calibration Section of the Maintenance Manual before attempting any detailed maintenance. Before testing, follow the initial set-up and operating procedure in Section 2.

3.2 TEST EQUIPMENT REQUIRED

The test equipment below is required to perform the following tests:

- a. Low Distortion RC Oscillator: Krohn-Hite Model 4400A or equivalent.
- b. RC Oscillator: 10Hz to 10MHz, frequency response of ± 0.025 dB from 10Hz to 500kHz. Krohn-Hite Model 4300B or equivalent.
- c. AC Voltmeter: capable of measuring 100 μ V to 10Vrms, 10MHz bandwidth, Fluke Model 8920A or equivalent.
- d. Frequency Counter.
- e. Distortion Analyzer: Krohn-Hite Model 6900B or equivalent.

If the [ALL CHAN] key is not lit, press the [ALL CHAN] key to turn on ALL CHANNEL mode. Perform each test on channel 1, then repeat it on channel 2.

3.3 CUTOFF FREQUENCY ACCURACY

Place BNC tees on the oscillator's output and the filter's '+' input and set the filter's input to '+ only' (press [SHIFT] [Δ input gain]).

Connect the frequency counter to the oscillator, the oscillator to the filter '+' input, and the AC meter to the filter input.

Set the filter to butterworth with the 'TYPE' key, lowpass with the 'MODE' key, 0dB input gain, 0dB output gain and 5kHz with the 'FREQ' key. Set the oscillator to 5kHz, 1VRMS. Set the meter to read 0dB (*dB* and *REL* mode on the Fluke 8920). Connect the meter to the filter output; adjust the oscillator frequency to get -3.01dB. The frequency on the counter should be 5kHz \pm 3%. Change the filter to highpass, adjust the oscillator frequency for -3.01dB; the counter should read 5kHz \pm 3%. Change the filter to lowpass mode, bessell type. Adjust the oscillator frequency for -12.6dB; the frequency on the counter should be 5kHz \pm 3%. Change the filter to highpass, adjust the oscillator frequency for -12.6dB; the counter should read 5kHz \pm 3%.

Repeat the entire above procedure for 50Hz, 500Hz, 50kHz and 200kHz. It is important to re-reference the voltmeter at each new frequency since the amplitude of the generator may change with changes in frequency.

3.4 STOPBAND ATTENUATION

Accurate stopband attenuation measurements require some simple precautions because of low level signals. The filter should be shielded with the top and bottom covers in place. BNC cable only should be used between oscillator, filter and voltmeter, and no other instruments should be connected.

Set the oscillator to 7Vrms, 20kHz and connect it to the '+' INPUT with the filter set to a cutoff frequency of 1kHz and 0dB of Input and Output gain. Connect the OUTPUT through a 6kHz passive high-pass filter, as shown in Figure 3.1, to the ac voltmeter. (Fluke 8920 should have 'low range enable' pressed in).

Set the filter to low-pass mode. The filter OUTPUT should be <700 μ Vrms (-80dB).

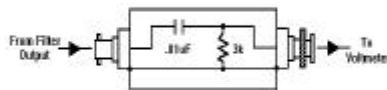


Figure 3.1 Passive 6kHz High-Pass Filter

3.5 PRE-FILTER AND POST-FILTER GAIN ACCURACY

With a BNC tee, connect both the oscillator and the AC meter to the filter '+' Input. Set the filter to 10kHz, low-pass. With the meter in volts mode, set the oscillator to 1kHz, and about 700mVrms. Set the meter to read 0dB (*dB* and *REL* mode on the Fluke 8920). Connect the meter to the filter output. Set the input gain to 10dB, the meter should read 9.8 to 10.2dB. Set the input gain to 20dB, the meter should read 19.8 to 20.2dB. Set the input gain to 0dB, set the output gain to 1dB by pressing '1' and either of the output gain arrows. The meter should read 0.8 to 1.2dB. Set the output gain to 2dB to 20dB in 1dB steps, checking the meter for \pm 0.2dB accuracy. Set the output gain to 0dB.

Connect the meter to the filter '+' Input and set it to volts mode. Set the oscillator to about 70mVrms. Set the meter to read 0dB (*dB* and *REL* mode on the Fluke 8920). Connect the meter to the filter output. Set the input gain to 30dB, the meter should read 29.8 to 30.2dB. Set the input gain to 40dB, the meter should read 39.8 to 40.2dB.

Connect the meter to the filter input and set it to volts mode. Set the oscillator to about 25mVrms. Set the meter to read 0dB (*dB* and *REL* mode on the Fluke 8920). Connect the meter to the filter output. Set the input gain to 50dB, the meter should read 49.8 to 50.2dB. It is important that the generator be low noise; passive BNC attenuators produce the best results, placed at the filter input.

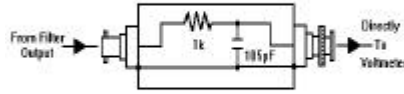


Figure 3.2 Passive 2MHz Low-Pass Filter

3.6 NOISE CHECK

Short the '+' inputs of both filter channels and set the channel being tested to 0dB input gain, 0dB output gain, lowpass (mode key), butterworth (type key), DC coupled (press shift then type, if display shows 'AC' press shift type again; display will show 'DC'). Connect a 2MHz lowpass, passive filter, shown in Fig 3.2, to the ac voltmeter and, using a short coax BNC cable, connect it to the model 3380's output. Set the filter to 5kHz. Voltmeter reading should be 400 μ V or less. Set the filter to highpass (mode key). Voltmeter reading should be 400 μ V or less. Set the filter to 50kHz, lowpass. Voltmeter reading should be 400 μ V or less. Set the filter to highpass. Voltmeter reading should be 400 μ V or less. Set input gain to 50dB and output gain to 20dB (press 20 and either of the output gain arrows). Voltmeter should read 80mV or less.

3.7 COMMON MODE REJECTION

Set the filter to low-pass, 20kHz cutoff and differential input by pressing the shift key, then the DIFF key under the INPUT GAIN display. Set the generator to 10kHz at 7Vrms. Connect the generator to the + and - inputs simultaneously. Connect the ac voltmeter to the filter output. Reading should be <7mVrms. Set the filter to 200kHz and generator to 100kHz. AC voltmeter should read <25mVrms.

3.8 DISTORTION AND MAXIMUM SIGNAL CHECKS

Set the filter to a cutoff frequency of 1kHz in the low-pass mode with 0dB of Input and Output gain. Connect a low distortion oscillator to the INPUT and apply a 1Vrms signal at 1kHz.

CAUTION

If the distortion is excessive, verify that the distortion of the oscillator being used is <0.005%.

Monitor the OUTPUT of the filter with a distortion analyzer. The reading should be <0.1%.

Connect a 50 ohm terminator to the OUTPUT of the filter. Distortion should be <0.1%. Remove the terminator.

Disconnect oscillator and distortion analyzer.

3.9 AC/DC COUPLING CHECK

Apply a 1Vdc signal to the INPUT of the filter. Set the filter to low-pass mode with 0dB Input and Output gain.

In the DC COUPLED mode, the OUTPUT of the filter should be approximately 1Vdc and approximately 0Vdc in the AC COUPLED mode.