

Model 3940/3944

**Programmable (IEEE-488) Filter
3Hz to 2MHz
LP, HP, BP, BR**



Operating and Maintenance Manual

**KH KROHN-HITE
CORPORATION**

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3Hz TO 2MHz

**Butterworth/Bessel
Low-Pass/High-Pass/Band-Pass/Band-Reject
Programmable Filter**

**MODELS
3940 and 3944**

SERIAL NO. _____

**OPERATING AND
MAINTENANCE MANUAL**



北京泰瑞恩商贸有限公司

Beijing Torion Trading Co.Ltd.

www.torion.cn

电话: 13801253818

sales@torion.cn

传真: 010-84067150



15 Jonathan Drive, Unit 4. Brockton, MA 02301-5566

Tel: (508) 580-1660; Fax: (508) 583-8989

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MODEL 3940 MULTICHANNEL FILTER

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Model 3940 (two channels) and the Model 3944 (4 channels) are Butterworth/Bessel Filters with identical channels covering a tunable frequency range from 3Hz to 2MHz. Each channel can function independently with either low-pass or high-pass functions at 24dB/octave attenuation, or channels can be connected in series externally in the same mode to provide 48dB/octave (Model 3940) to 96dB/octave (Model 3944) attenuation. One channel of band-pass or band-reject operation (Model 3940) or two channels (Model 3944) are also available.

Either maximally flat (Butterworth) response or linear phase (Bessel) response for pulse signal filtering is selectable. Both input and output amplifiers provide either 0dB or 20dB of gain per channel.

The filter is controlled by the front panel keyboard or over the IEEE-488 bus. Provided are LED displays and indicators for input and output gain, cutoff frequency, channel selection and remote operation. Non-volatile, battery-backed, CMOS memory permits storing and recalling of 99 selectable groups of front panel settings. Storing and recalling group settings is accomplished with a single command. Self-testing of the digital circuitry occurs upon power-up.

1.2 SPECIFICATIONS

1.2.1 FILTER CHARACTERISTICS

Functions:

Model 3940: Two independent channels of low-pass, high-pass or by-pass; one channel of band-pass or band-reject.

Model 3944: Four independent channels of low-pass, high-pass or by-pass; two channels of band-pass or band-reject.

Type: 4-pole Butterworth (maximally flat) or Bessel (linear phase) per channel.

Frequency Range (f_c): 3Hz to 2MHz.

Frequency Resolution: 1Hz from 3Hz to 1kHz; 10Hz up to 2kHz; 100Hz up to 100kHz; 1kHz up to 1MHz; 10kHz up to 2MHz.

Frequency Accuracy (f_c): $\pm 2\%$ or least significant digit (which ever is greater) 20Hz to 500kHz; $\pm 5\%$ to 2MHz.

Relative Gain at f_c : Butterworth, -3dB; Bessel, -7.5dB.

Bandwidth: dc to f_c , dc coupled; 0.2Hz to f_c , ac coupled (low-pass); f_c to 10MHz (high-pass).

Attenuation: 24dB/octave per channel.

Stopband Attenuation: >80dB.

Insertion Loss (0dB Input/Output gain): ± 0.5 dB to 2MHz.

1.2.2 INPUT

Gain (pre-filter): 0dB or 20dB \pm 0.2dB.

Coupling: as (high-pass and band-pass, ac or dc, low-pass and band-reject).

Impedance: 1 megohm in parallel with <100pf.

Maximum Signal (at 0dB gain): \pm 4.5V peak at f_c <1MHz; \pm 4V peak at 2MHz.

Maximum DC Components: \pm 200V in ac coupled mode.

1.2.3 OUTPUT

Gain (post-filter): 0dB or 20dB \pm 0.2dB.

Impedance: 50 ohms.

Maximum Current: \pm 25mA.

Distortion: -80dB at 1kHz at 1Vrms.

Noise (RTI): <200 μ V with 2MHz band width detector.

DC Offset: Adjustable to 0V.

DC Drift: \pm 1mV/ $^{\circ}$ C.

Phase Match Between Channels: 1 $^{\circ}$ to 500kHz f_c (Bessel only); 2 $^{\circ}$ to 1MHz; 3 $^{\circ}$ to 2MHz (max difference between any two channels).

1.2.4 GENERAL

Memory: 99 selectable groups of all filter characteristics; memory is non-volatile battery-backed CMOS.

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

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

Remote Programming: IEEE-488/1978 GPIB interface. Subsets: SH1, AH1, T6, L4, SR1, RL1, PP1, DC1, DT0, C0, E1.

Operating Temperature: 0 $^{\circ}$ C to 50 $^{\circ}$ C.

Isolation to Chassis: \pm 200V dc.

Storage Temperature: -20 $^{\circ}$ to 70 $^{\circ}$ C.

Input/Output Connectors: BNC, front and rear.

Power Requirements: 90-132/180-264 volts ac, 50Hz-400Hz, 25 watts (Model 3940) and 40 watts (Model 3944).

Dimensions: 3 ½" (9cm) high, 8 ½" (21.8cm) wide, 18" (46.2cm) deep.

Weights: 12 lbs. (5.4kg) net; 14 lbs. (6.3kg) shipping.

Accessories: 6 foot, 3 terminal line cord; operating and maintenance manual.

1.2.5 OPTIONS

Rack Mount Kit: Part NO. RK-37, permits installation of the Model 3940 or the 3944 into a standard 19" rack spacing.

Specifications apply at 25°C ±5°C.

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SECTION 2 OPERATION

2.1 INTRODUCTION

The Model 3940/3944 is a filter covering the frequency range from 3Hz to 2MHz. All filter parameters are programmable via the front panel keyboard controls or remotely over the IEEE-488 (GPIB) bus.

The filter has five modes of operation: high-pass, low-pass, band-pass, band-reject, and by-pass. Each mode will be explained in detail in this section.

2.2 TURN-ON PROCEDURE

The Model 3940/3944 line voltage range has been preset for either 115V or 230V operation. To change this setting, remove the bottom cover to expose the line switch. Be sure to change the fuse to the proper rating for the line switch setting selected.

Make certain the POWER switch on the front panel is off.

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

If the Model 3940/3944 is to be programmed remotely, connect the bus cable to the rear panel connector of the 3940/3944.

After reading the Self-Test feature, described next, turn on the Model 3940/3944.

2.3 SELF TEST

When the Model 3940/3944 is turned on, the microprocessor performs a self-test routine whereby the entire RAM and ROM operation is verified. During the test, the front panel LEDs and DISPLAYS will light sequentially. If there is a malfunction on the microprocessor board, such as a defective RAM or ROM, the sequence will stop and the word “bad” will appear in the DISPLAY followed by a number 1, 2 or 3. Refer to Section 6, Maintenance, to find which RAM or ROM is defective.

When the self-test program is complete, the Model 3940/3944 will return to the last set-up prior to turning the unit off. The Model 3940/3944 is now ready to be programmed for operation.

2.4 FRONT PANEL CONTROLS AND DISPLAY

2.4.1 Data Keys and Display

Data entry keyboard controls [0] to [9] and [.] set the numeric value of the parameter selected. To enter 1.5kHz press the [1][.][5] keys and the parameter key [KILO] and [FREQ]. The cutoff frequency will be indicated in the DISPLAY.

2.4.2 Parameter and Control Keys

[KILO]	When pressed, multiplies the numeric value of the keyboard entry by 10^3 .
[MEGA]	When pressed, multiplies the numeric value of the keyboard entry by 10^6 .
[FREQ]	When pressed, enters and/or displays frequency in Hertz.

- [TYPE]** When pressed, DISPLAY indicates the 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.”). When in band-pass or band-reject mode, the type will be changed on the two channels simultaneously.
- [MODE]** When pressed, DISPLAY indicates the mode of operation for the channel displayed. “bYP.” for by-pass, “L.P.” for low-pass, “h.P.” for high-pass, “b.P.” for band-pass and “b.r.” for band-reject.
- When pressed again, the MODE will change to the next in the order explained above.
- [RECLL]** When preceded by a number, it will recall the entire instrument set-up from the memory location selected.
- When first pressed, the DISPLAY indicates the number of the next memory location to be recalled. For example, the DISPLAY will indicate the following: “n=09”. Pressing the [RECLL] key again will recall the entire instrument set-up of from the next memory location.
- When pressed to indicate the next memory location to be recalled only, pressing the [CE] (clear entry key) will restore the DISPLAY to the cutoff frequency setting.
- [ALL CH]** When frequency, input/output gain, type, mode or coupling are entered or changed, and the LED in the [ALL CH] key is lit, the new setting will be entered in all channels of the filter.
- [SHIFT]** The [SHIFT] key in conjunction with other keys (keys with red lettering under them) provide additional filter characteristics, and permits front panel entry of the type of GPIB line termination and address.
- Store** When [SHIFT] [RECLL] is first pressed, the DISPLAY indicates the number of the next memory location available. For example, the DISPLAY will indicate the following: “n=09”. Pressing [RECLL] again will store the entire instrument 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 (0-98), the filter will store the entire instrument set-up into the memory location selected. The maximum number of memory groups is 99.
- 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.
- AC/DC Coupling** Pressing [SHIFT] key followed by the [TYPE] key will display the input coupling, indicating “AC” or “dC”, and will alternate between the two when in the low-pass, band-reject and by-pass modes. High-pass and band-pass modes will indicate “AC” only.

GPIB Address When the [SHIFT] key followed by the [MEGA] key are pressed, the DISPLAY will indicate the existing GPIB address setting. To select a different address setting, enter the address number in the data keys from [0] to [30] and press the [SHIFT] and [MEGA] keys (see Section 3.2.1 for GPIB addressing information).

GPIB Line Termination When the [SHIFT] key followed by the [ALL CH] key are pressed, the DISPLAY will indicate the existing GPIB Line Termination Code sequence. To select a different one, enter a number from [0] to [4] and press [SHIFT] [ALL CH] keys (see Section 3.2.1 for line termination information).

Software Version When the [SHIFT] key followed by the [KILO] key are pressed, the DISPLAY will indicate the software version installed (i.e. 3.5).

[CE] When entering a numeric value in the keyboard, but not specifying a parameter, pressing the clear entry key will function as an error correction procedure and restore 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.

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.

If the Model 3940/3944 is operating via the IEEE-488 bus (the front panel REMOTE LED is “on”), pressing the [CE] key will return unit to LOCAL operation.

2.4.3 Channel Selection

The up [Δ] control key below the CHANNEL display cycles through the channel settings. When held, channels will cycle through all channels continuously.

2.4.4 Cutoff Frequency

Data entry keyboard controls [0] to [9] and [.] 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. Also see 2.4.7.

2.4.5 Input Gain (Pre-Filter)

Up [Δ] and down [▽] INPUT GAIN SET controls increase or decrease the input amplifier by 20dB. The two digit DISPLAY will indicate either 0dB or 20dB.

2.4.6 Output Gain (Post Filter)

Up [Δ] and down [▽] OUTPUT GAIN SET controls increase or decrease the output amplifier by 20dB. The two digit DISPLAY will indicate either 0dB or 20dB.

2.4.7 Digit Select/Increment and Decrement

When the [SHIFT] key is pressed, followed by either the [Δ] or the [▽] keys under FREQ beside the INPUT BNC connectors, the DISPLAY will intensify either the least or the most significant digit. Pressing the [Δ] or [▽] keys will then increment or decrement the intensified desired digit.

Pressing [SHIFT] and either [Δ] or the [▽] keys again will intensify the next digit in the DISPLAY. the [Δ] key 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).

2.4.8 Key Click Feature On/Off

When the [SHIFT] key is pressed, followed by the [Δ] key under the CHANNEL display, the key click feature will either toggle on or off.

2.5 REAR PANEL CONTROLS AND CONNECTORS

2.5.1 Introduction

Model 3940/3944 rear panel consists of the following: two input and output (Model 3940), four input and output (Model 3944) BNC connectors and dc level adjustments, a fuse holder, GPIB bus connector and an ac receptacle.

2.5.2 BNC Connectors

There are two input and output (Model 3940), four input and output (Model 3944) BNC connectors. Each connector (1 or 2; 1.1, 1.2, 2.1 and 2.2) is an independent filter channel when set-up in the low-pass or high-pass mode. In the band-pass and band-reject modes, the input and output connectors are configured as in paragraph 2.6.2.1 and 2.6.2.2.

2.5.3 DC Level Adj

Proper procedure for adjusting input and output dc levels can be found in the Calibration section of this manual.

2.5.4 Power

Receptacle: Standard 3 pin.

Fuse: 3/16 amp slow-blow for 120V operation; 1/4 amp slow-blow for 230V operation. To change this setting, refer to section 2.2 on page 2-1.

2.5.5 GPIB Connector

Standard IEEE-488 interface. Subsets are SH1, AH1, T6, L4, SR1, RL1, PP1, DC1, DT0, C0 and E1.

2.6 FILTER OPERATION

2.6.1 Introduction

The Model 3940/3944 is a Multichannel filter with four (two in Model 3940) identical channels that can function independently. Each channel can operate in either the low-pass mode or high-pass mode and provide 24dB/octave attenuation, or channels 1.1/1.2 or 2.1/2.2 (channels 1 and 2 in Model 3940) can be set to the same mode and connected in series, *externally*, to obtain 48dB/octave attenuation. The interconnection of two channels by front panel data key entry, will provide band-pass or band-reject (null) operation and no external connections are needed.

2.6.2 Variable Band-Pass and Band-Reject Operation

2.6.2.1 Band-Pass

Variable band-pass response is obtained by applying the input signal to channel 1.1 or 2.1. Set the filter to the band-pass mode by pressing the [MODE] key until "b.P." appears in the display. Enter the desired low-cutoff (high-pass) frequency, then set the filter to channel 1.2 or 2.2 and enter the desired high-cutoff (low-pass) frequency. The band-pass response will appear at the output BNC connector of channel 1.1 and 1.2 or 2.1 or 2.2 simultaneously. (The Model 3940 selectable channels are 1 and 2).

2.6.2.2 Band-Reject

Variable band-reject response is obtained by applying the signal to channel 1.1 or 2.1. Set the filter to the band-reject mode by pressing the [MODE] key until "b.r." appears in the display. Enter the desired low-cutoff (high-pass) frequency into channel 1.1 or 2.1, then set the filter to channel 1.2 or 2.2 and enter the desired high-cutoff (low-pass) frequency. A null can be obtained by setting the low cutoff frequency to approximately 0.58 of the desired null frequency, the high cutoff frequency to approximately 1.7 of the null frequency. Fine tuning of both cutoff frequencies can be accomplished by varying the cutoff frequency using the increment/decrement feature of the DIGIT SELECT

described in paragraph 2.4.7. The resolution of the Model 3940/3944 will limit the extent of the null.

2.6.3 Amplitude Response

Each channel of the Model 3940/3944 can operate in either the low-pass or high-pass mode at 24dB/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 2.1A and 2.1B.

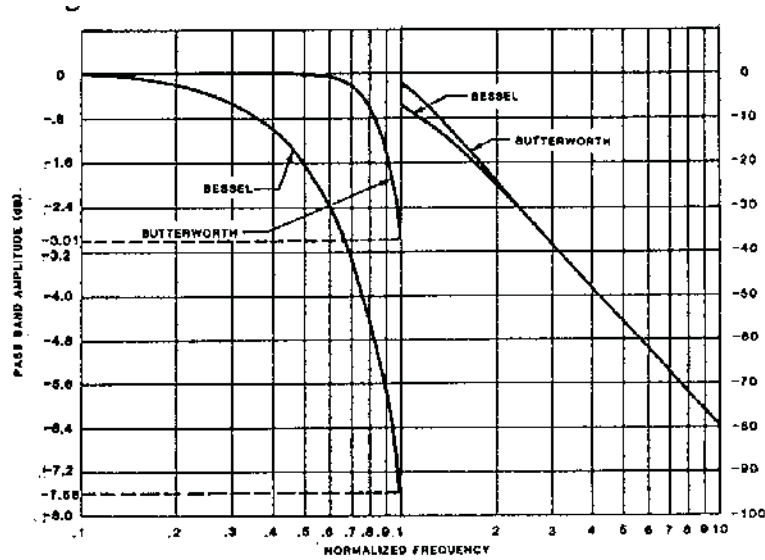


Figure 2.1A Low-Pass Amplitude Response

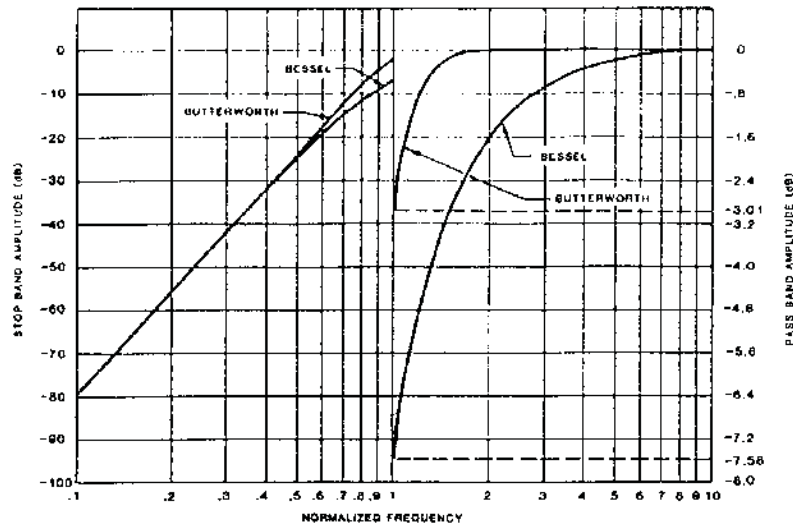


Figure 2.1B High-Pass Amplitude Response

2.6.4 Phase Response

Phase characteristics of Model 3940/3944 are shown in Figure 2.2. It provides output phase relative to the input with the filter operating in the low-pass mode with Butterworth and Bessel response.

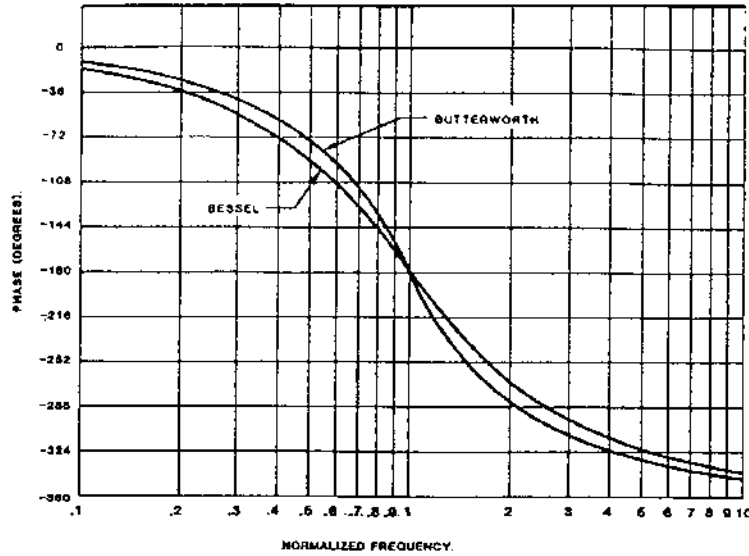


Figure 2.2 Phase Response

2.6.5 Group Delay

Group delay¹, shown in Figure 2.3, 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 a constant time delay, will not shift relative phase.

In numeric terms, the zero frequency phase slope is $-149.7^\circ/\text{Hz}$ for Butterworth and $-183.4^\circ/\text{Hz}$ 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 940.7Hz and $-1152.4^\circ/\text{Hz}$ respectively. Dividing by 360 converts $^\circ/\text{Hz}$ to radians/radians-per-sec yields a group delay time of 2.61s for Butterworth and 3.20s for Bessel.

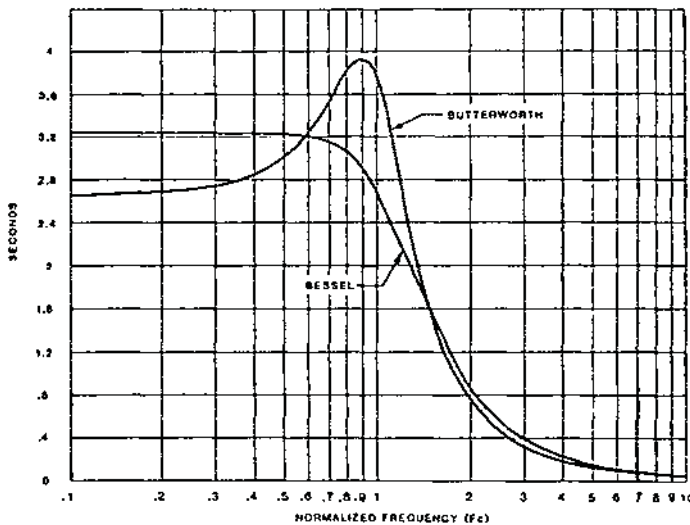


Figure 2.3 Group Delay

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

2.6.6 Transient Response

The normalized response for a unit step voltage applied to the input of the Model 3940/3944 operating in the low-pass mode with both Butterworth and Bessel response is shown in Figure 2.4.

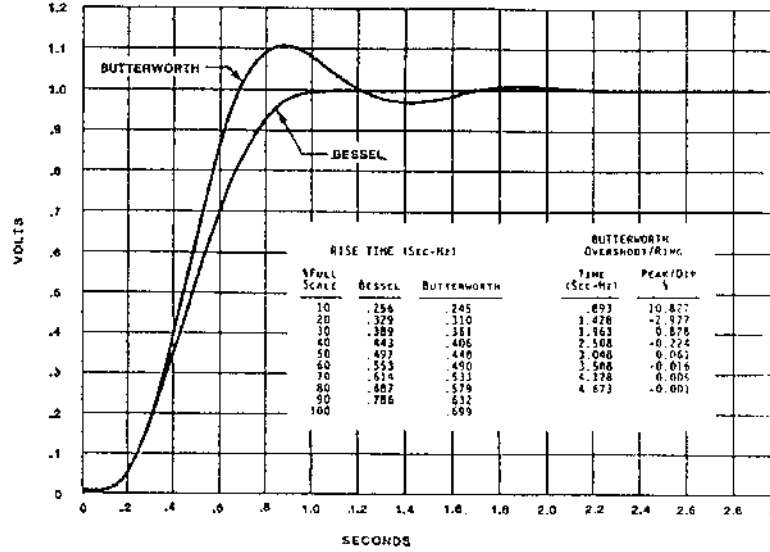


Figure 2.4 Transient Response

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SECTION 3 IEEE-488 STD (GPIB) PROGRAMMING

3.1 INTRODUCTION

The Model 3940/3944 remote programming interface accepts both ASCII data commands and IEEE-488 standard commands (ATN true) for control of the unit.

In presenting the information required to program the Model 3940/3944 via the IEEE-488 STD bus, this manual presupposes a user knowledge of both ASCII data and IEEE-488 bus commands.

3.2 PRELIMINARY PROGRAMMING INFORMATION

3.2.1 GPIB Primary Bus Address

The GPIB primary address and software line-termination-character-sequence (LTCS) selection is set via the front panel keyboard as listed in Tables 3.1 and 3.2. These two parameters are stored in non-volatile memory and will be remembered indefinitely, even when the power to the unit is removed. They do not need to be reentered each time the unit is turned on.

The LTCS affects the GPIB in the TALKER mode only (data output from the 3940/3944 to the GPIB). After the printable characters have been sent, non-printable characters, such as carriage return (CR) and line feed (LF), are often required to achieve the desired results in various computers. Table 3.2 lists the various key sequences with the LTCS it selects.

SETTING AND DISPLAYING THE GPIB PRIMARY ADDRESS

Function	Keyboard Entry
a. To set a primary address from 0 to 30	[X][SHIFT][MEGA]
b. To display the primary address	[SHIFT][MEGA]

Table 3.1

LINE-TERMINATION-CHARACTER-SEQUENCE

Line-Termination-Character-Sequence	Keyboard Entry
a. None (EOI only)	[0][SHIFT][ALL CH]
b. Carriage return (with EOI)	[1][SHIFT][ALL CH]
c. Line Feed (with EOI)	[2][SHIFT][ALL CH]
d. Carriage return followed by line feed (with EOI)	[3][SHIFT][ALL CH]
e. Line feed followed by carriage return (with EOI)	[4][SHIFT][ALL CH]
f. Display present LTCS	[SHIFT][ALL CH]

Table 3.2

3.2.2 IEEE-488 Bus Interface Programming Connector

The rear panel programming connector, labeled “IEEE-488 PORT” (Figure 3.1), is the standard bus interface connector as specified in the IEEE-488 STD.

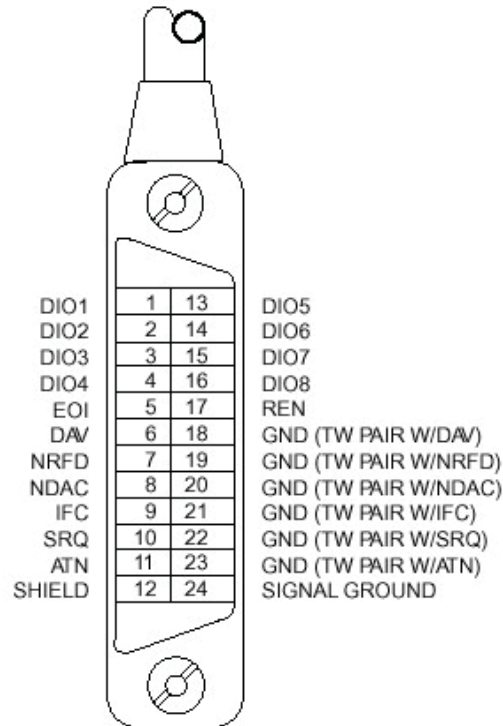


Figure 3.1 Rear Panel GPIB Connector

3.3 ASCII DATA COMMANDS

3.3.1 Format

The Model 3940/3944 employs free-format software commands, allowing the user to program a specific function in several different ways. See Section 3.3.3.

3.3.2 Types of Data Commands

- a. Commands fall into two types: Those involving numeric parameters and those that do not.

Commands which involve numeric data contains (3) types of fields:

1. Numeric: Numeric fields may be floating point or scientific notation.

1	=	1.0
1.0	=	1.0
2.7E3	=	2.7×10^3
-2E3	=	-2×10^3
2E-3	=	2×10^{-3}

2. Multiplier: “KILO”, “MEGA”
3. Parameter: Parameter (frequency, gain, channel, etc.) is included in Section 3.3.3.

- b. Delimiters which may separate commands are the following: (; : / \ .)

- c. Two consecutive character strings (i.e. parameter and multiplier) must have a space between them or they will be treated as one string.
- d. The Model 3940/3944 uses an internal 32 character buffer for command processing. A line may be composed of multiple commands, separated by delimiters mentioned above. No commands are executed until the line is terminated with a line feed ASCII character (Hex0A) or carriage return (hex0D) or by sending the end-of-identify (EOI) command with the last character.

3.3.3 Table of ASCII Commands

In this Section there are characters that are underlined and characters that are **NOT** underlined. The characters that are underlined **MUST** be sent for the command to be recognized properly. Any additional characters may be sent once all the underlined letters are sent. Commands are case sensitive; upper case characters **MUST** be used.

MODEL 3944 GPIB COMMANDS

Command Desired	Allowable Character String
Input Gain	<u>I</u> G set input gain <u>I</u> <u>U</u> increase input gain (up) <u>I</u> <u>D</u> decrease input gain (down)
Frequency	<u>F</u> frequency <u>H</u> frequency (Hz) <u>K</u> kilo (10 ³ multiplier) <u>ME</u> Mega (10 ⁶ multiplier)
Channel	<u>CH</u> set channel <u>CU</u> next channel (up) <u>CD</u> previous channel (down)
Output Gain	<u>OG</u> set output gain <u>OU</u> increase output gain (up) <u>OD</u> decrease output gain (down)
Type	<u>TY1</u> Butterworth <u>TY2</u> Bessel
Mode	<u>M1</u> Low-Pass <u>M2</u> High-Pass <u>M3</u> Band-Pass <u>M4</u> Band-Reject <u>M5</u> By-Pass
Coupling	<u>AC</u> ac coupled <u>D</u> dc coupled
Store	<u>ST</u> store
Recall	<u>R</u> recall
All Channel	<u>AL</u> all channel mode <u>B</u> NOT all channel mode
Misc.	<u>CE</u> clear entry <u>O</u> <u>V</u> overload (1, 2, 3) <u>Q</u> reports board model number(s) (see Section 3.5.4) <u>SRQON</u> GPIB service request on <u>SRQOF</u> GPIB service request off <u>V</u> report model number and software version (see Section 3.5.3)

Alphabetical Listing of Model 3944 GPIB Commands

Character String	Command
<u>A</u> C	ac coupled
<u>A</u> L	all channel mode
<u>B</u>	NOT all channel mode
<u>C</u> D	channel down
<u>C</u> E	clear entry
<u>C</u> H	channel # n
<u>C</u> U	channel up
<u>D</u>	dc coupled
<u>F</u>	frequency
<u>H</u>	frequency (Hz)
<u>I</u> D	input gain down
<u>I</u> G	input gain
<u>I</u> U	input gain up
<u>K</u>	kilo
<u>M</u> 1	Low-Pass mode
<u>M</u> 2	High-Pass mode
<u>M</u> 3	Band-Pass mode
<u>M</u> 4	Band-Reject mode
<u>M</u> 5	By-Pass mode
<u>M</u> E	Mega (10^6 multiplier)
<u>O</u> D	output gain down
<u>O</u> G	output gain
<u>O</u> U	output gain up
<u>O</u> V	overload
<u>Q</u>	report board model number(s) (see Section 3.5.4)
<u>R</u>	recall
<u>S</u> RQON	GPIB service request on
<u>S</u> RQOF	GPIB service request off
<u>S</u> T	store
<u>T</u> 1	Butterworth type
<u>T</u> 2	Bessel type
<u>V</u>	report model number and software version (see Section 3.5.3)

3.3.4 Examples

3.3.4.1 Example 1

To set all channels to 10dB input gain, 2kHz, 0dB output gain: AL;10IG;2K;0OG<LF>

NOTE: It is only necessary to send those parameters that change, all others remain unaffected.

3.3.4.2 Example 2

To change frequency to 150Hz:

150H	or	150bHZ
	or	150F
	or	.15K
	or	F150
	or	H150
	or	HZ150
	or	K0.15
	or	1.5E2HZ
	or	F1.5E2
	or	etc.

3.3.4.3 Example 3

To read back the settings of channel 2.2 (see Section 3.5.1):

Data sent to filter: CH2.2

Data received from filter : 10b2.000E + 3b02.2b00bAC*

Interpretation: 10dB input gain
 2kHz cutoff frequency
 channel #2.2
 0dB output gain
 ac coupled
 all channel mode (indicated by the "**")

b represents a space

3.4 IEEE-488 STANDARD COMMANDS

These commands are sent with ATN true as described in the standard.

3.4.1 Multi-Line Messages

IEEE-488 Command	Mnemonic	Result
My listen address	MLA	Enables unit to receive data.
Unlisten	UNL	Disables unit from receiving data.
My talk address	MTA	Designates unit to sent data.
Untalk	UNT	Disables unit from sending data.
Local lockout	LLO	Disables return-to-local key (CE key) on front panel such that when in remote mode, keyboard cannot be activated by pressing a front panel key.
Go to local	GTL	Puts unit into local control mode such that front panel keyboard is activated.
Device clear	DCL	When the device clear command is sent, the following parameters are changed regardless of their existing settings: Input Gain = 0dB; Output Gain = 0dB; Response = Butterworth; Mode = Low-Pass; Cutoff Frequency = 100kHz; Coupling = ac. Clears current settings for all channels. It does not clear setups stored with [STORE] key. It does not change interface bus parameters and flags, such as: addresses, SRQ ON/OFF, parallel poll bit selected, etc.
Selected device clear	SDC	Performs same functions as device clear (DCL) except only if unit is addressed.

DISCUSSION: (See Section 2.8 and Figure 10 of the IEEE-488 Interface Standard). Note that there are (4) possible states; local, remote, local-with-lockout, and remote-with-lockout. Front panel control is considered to be local while control from the system controller is considered to be remote. Selection of local or local-with-lockout and remote or remote-with-lockout is done several ways. When the unit is addressed to talk (MTA) or listen (MLA), it will enter into remote. When GO-TO-LOCAL (GTL) is sent, it enters into local mode or local-with-lockout mode.

Also, if lockout mode is not invoked by the controller (local lockout command LLO), pressing the [CE] key when the remote LED is on will return control to the keyboard.

NOTE: The lockout mode is not related to whether control is local or remote, only whether control can be returned to local by the [CE] key.

Lockout mode (local-with-lockout and remote-with-lockout versus local and remote) is controlled by the controller. Sending the local lockout command (LLO) selects the local-with-lockout and remote-with-lockout pair versus remote and local without lockout out. Lockout can only be canceled by the controller placing the remote enable line false.

3.4.2 Polling Commands

The IEEE standard provides two methods of determining the status of the devices in the system; namely serial poll and parallel poll. The parallel poll produces up to 8 bits of status from up to 8 different units simultaneously. A parallel poll is very fast but provides limited information. The serial poll provides 7 bits of status from one unit at a time.

3.4.2.1 Parallel Polling

The model 3940/3944 provides for software configuring of which bit and with which polarity the unit should respond. This bit is “true” when an error condition exists. (“ERR” displayed on the panel). Configuring needs to be done only once or anytime the software desires to change the configuration. The commands related to parallel poll are as follows:

For sample sequences, see section 6.5.4 of the IEEE-488 standard.

IEEE-488 Command	Mnemonic	Result
Configure	PPC	Places unit into a state where it expects parallel poll enable and disable commands to establish which bits should be set or selected in response to a parallel poll.
Unconfigure	PPU	Removes unit from PPC state (UNL does the same, but also unlistens device).
Enable	PPE	When unit is in PPC state, it indicates which bit and which polarity the device should respond. Hex codes 60-67 selects bits 0-7 respectively to be set to 0 for a true error response. Since logic 0 is HI on open collector lines, this provides a logical “OR” of all units designated to respond with a given line. Hex codes 68-6F selects bits 0-7 respectively to be set to 1 for a true (error) response. This can provide logical NAND of all units designated to respond, with a given line.
Disable	PPD	Clears any configuration previously entered. This is valid only when unit is in PPC state.

Example: If the Model 3940/3944 to be configured is unit #5, and we want it to respond with a “1” when an error exits:

IEEE-488 Command	Result
MLA 5	Addresses unit to be configured.
PPC	Places unit into parallel poll configured mode.
PPE 8	Configures bit #0 (Lo 3 bits of command) to respond with a “1” (8’s bit) when an error exits.
UNL	Unlistens unit.

For additional sample sequences, see Section 6.5.4 of the Standard.

3.4.2.2 Service Request and Serial Polling

The IEEE-488 standard provides serial polling as a method of determining which unit caused a service request. When serial poll enable (SPE) is sent, the system enters into serial poll state. When a unit is addressed to talk, a single status byte will be sent. The hex 40 bit in this byte is true if that unit is requesting service. The remaining bits are used to provide status information. The Model 3940/3944 service request capability is enabled or disabled with the SRQON and SRQOFF commands (see Section 3.3.3). The unit turns on with service request disabled. This is an extension of the standard.

IEEE-488 Command	Mnemonic	Result
Enable	SPE	Unit enters serial poll when a unit is addressed to talk. It will send one status byte in which the hex 40 bit is true if the unit is requesting service.
Disable	SPD	Unit exists serial poll state.

3.4.2.3 Serial Responses

The chart below lists the error numbers, in decimal notation, resulting a command error either from the bus or not from the bus.

The serial responses are:

1. No error: 0.
2. Error (error numbers in decimal notation); See the chart below.

Note: that if SRQ is “ON” and the command which caused the error came from the bus, not the front panel, then the 64 bits will be set in the serial poll response, indicating that this unit requires service.

Error #	Description
1	Input gain too high or too low.
2	Frequency too high.
3	Frequency too low.
4	Channel # too high.
5	Channel # too low.
6	Output gain too high or too low.
7	Store page # too high.
8	Recall page # too high.
9	Type # invalid.
10	Mode # invalid.

3.4.3 Uniline Messages

IEEE-488 Command	Mnemonic	Result
End	END	Sent with last byte of data. A line of data may either be terminated by a line feed character or by this command.
Identify	IDY	This command, issued by the controller, causes a parallel, response which was previously configured by the PPC, PPD, PPE and PPU commands.
Request service	RQS	Generated in response to an error when a command came from the bus, and service request is enabled by the SRQON command.
Remote enable	REN	When true, allows the 3940/3944 to respond to remote messages. When this line goes false, the unit will go to local-with-lockout state, activating the front panel.
Interface clear	IFC	Un-addresses all units and clears all special states.

3.5 TALKER FORMAT

The Talker Software allows an IEEE-488 (GPIB) controller to interrogate the Model 3940/3944 and read back over the bus it's settings (gain, frequency, etc.).

Four different types of data can be sent over the bus: Normally parameter information is returned unless an "OS", "Q" or "V" command is sent to the unit.

3.5.1 Parameter Information Format

1. Two (2) digits of input gain.
 - 1a. space
2. Four (4) digits plus decimal of frequency or other alpha.
3. If frequency is displayed:
 - E+0 if both kilo and mega LEDs are off.
 - E+3 if kilo LED is on.
 - E+6 if mega LED is on.
 - otherwise 3 spaces.
- 3a. space
4. Two (2) digits, a decimal and one digit of channel #
 - 4a. space
5. Two (2) digits of output gain.
 - 5a. space
6. "AC" if ac coupled
"DC" if dc coupled
7. "*" if all channel mode, otherwise a space (see Section 3.3.4.3 for example)

3.5.2 Model Number and Software Version Format

After sending the "V" commands, the next line of data read from the Model 3940/3944 will be as follows:

KROHN-HITE 3940 or 3944, V3.5

The version number will reflect the revision level of the firmware in the instrument.

This data is returned only once per command; after that it returns to talking what the front panel display is showing.

3.6 PROGRAMMING EXAMPLES

The following are programming examples in Microsoft® Quick Basic™ and Borland Turbo C.

3.6.1 Example 1 – Microsoft Quick Basic

```
' Microsoft® Quick Basic™ program for the Krohn-Hite Model 39XX
'
' * Enter this program from DOS by typing: QB 39XX /LQBIB.QLB
' (the /L switch means tells Quick Basic to load a library)
'
' * Set the instrument to GPIB address 1:
' Press 1 [SECOND FUNCTION] [MEGA]
'
' * Set the instrument for no carriage return or line feed (EOI only):
' Press 0 [SECOND FUNCTION] [ALL CHAN]
'
' _____ Initialized National Instruments Interface Board _____
'
'$INCLUDE: 'QBDECL.BAS'
CLS
CALL IBFIND("GPIB0", BRD0%): 'initialize access to the board
CALL IBFIND("DIV1", D39XX%): 'init access to the instrument, assumes addr 1!
```

```

CALL IBTMO(D39XX%, 10): ' set timeout at 300mS
'
' _____ Send/receive the data _____
'
' Set to 500 Hz (500Hz), 0dB input gain (0IG), 0db output gain (0OG),
' DC coupled, re-display the frequency (F) so it will be read over the bus.
'
CALL IBWRT(D39XX%, "500HZ;0IG;0OG;DC;F"): IF IBSTA% <0 THEN GOT0 gpiberr

' allocate a buffer (define a string long enough to hold the response)
' and read the meter
Buf$ = SPACE$(40): CALL IBRD(D39XX%, Buf$): IF IBSTA% <0 THEN GOTO gpiberr

' Shorten buffer to the # of characters actually received and print it
Buf$ = LEFT$(Buf$, IBCNT%)
PRINT "Read: "; Buf$
' Send UNLISTEN(?), UNTALK(_) so the bus will be in an idle state
CALL IBCMD(BRD0%, "?_"): IF IBSTA% <0 THEN GOTO gpiberr
'
' Set to 333 Hz, 20dB input gain (20IG), 20dB output gain (20OG), AC coupled,
' and again display frequency in the main display window.
'
CALL IBWRT(D39XX%, "333HZ;20IG;20OG;AC;F"): IF IBSTA% <0 THEN GO TO gpiberr
Buf$ = SPACE$(40): CALL IBRD(D39XX%, Buf$): IF IBSTA% <0 THEN GO TO GPIBERR
Buf$ = LEFT$(Buf$, IBCNT%)
PRINT "Read: "; Buf$
CALL IBCMD(BRD0%, "?_"): IF IBSTA% <0 THEN GOTO gpiberr
'
' _____ Cleanup and End _____
'
cleanup:
CALL IBONL(BRD0%, 0): 'Release the board file handle
CALL IBONL(D39XX%, 0): 'Release the instrument file handle
END

GPIBERR:
PRINT "IBSTA%="; HEX$(IBSTA%); ", IBERR%="; IBERR%: GOTO cleanup

```

3.6.2 Example 2 – Borland Turbo C

```

/*
 * Borland Turbo C Example Program for the Krohn-Hite Model 39XX multichannel
 * filter using the NI-488
 * Should work with Microsoft C also.
 */
*/=====
*
* This sample program sends and receives data from a Krohn-Hite model 39XX
*
* * In the Borland IDE, place "MCIB.OBJ" in your project list
*
* * Set the instrument to GPIB address 1:
* Press [1] [SECOND FUNCTION] [MEGA]
*
* * Set the instrument for no carriage return or line feed (EOI only):
* Press [0] [SECOND FUNCTION] [ALL CHAN]
*
* This program assumes the name of the device at address 1 hasn't been
* changed in IBCONFIG (it's still called DEV1, which is the default).
*

```

```

*   The status variables IBSTA, IBERR, and IBCNT are defined in DECL.H.
*   Each bit of IBSTA and each value of IBERR are defined in DECL.H as
*   a mnemonic constant for easy recognition in application programs. In
*   this example, these mnemonic definitions are logically ANDed with the
*   variable IBSTA to determine if a particular bit has been set. The mnemonic
*   definitions are equated with the variable IBERR to determine the error
*   code.
*
*   The function GPIBERR is called when a NI-488 function fails. The
*   error message is printed along with the status variables IBSTA, IBERR,
*   and IBCNT.
*
*   The NI-488 function IBONL is called from the main body of the program or
*   from the function GPIBERR. When the second parameter of the function
*   IBONL is zero, the software and hardware are disabled.
*   Execution of this program is terminated after the call to the function
*   IBONL to disable the software and hardware.
*
*   The function EXIT is used to terminate this program within the function
*   GPIBERR. The exit status is set to 1 to indicate an error has occurred.
*
*/=====
*/

#include <stdio.h>
#include <stdlib.h>
#include <string.h>

/*   DECL.H contains constants, declarations, and function prototypes. */

#include "decl.h"
#define DEVNUM "dev1" /* Set instrument to GPIB address 1 */

/*   GPIBERR is an error function that is called when a NI-488 function fails. */
void gpiberr(char *msg);

char      rd[255];          /* read data buffer */
int       GpibDev, GpibBoard; /* device handles */

void main() {

    printf("\nSending data to the Krohn-Hite model 39xx...\n");
    printf("\n");
/*
*   Assign a unique identifier (a 'handle') to the K-H 39XX and store it in the
*   variable GpibDev. If GpibDev is less than zero, call GPIBERR with an error
*   message.
*/
    GpibDev = ibfind (DEVNUM);
    if (GpibDev ,0) gpiberr("ibfind Error");

/*
*   Assign a handle to the GPIB board so we can use IBCMD to send board
*   level commands such as UNL and UNT.
*/

```

```

*/
    GpibBoard = ibfind ("gpib0");
    if (GpibBoard <0) gpiberr("ibfind Error");
/*
*   Clear the K-H 39XX to its default state. The settings vary depending on the
*   type of board in each channel. These settings are listed in the GPIB
*   section of the manual for each filter board (not the 39XX manual).
*   If the error bit ERR is set in IBSTA, call GPIBERR with an error message.
*/
    ibclr (GpibDev);
    if (ibsta & ERR) gpiberr("ibclr Error");

/*
*   Write a string out to the K-H 39XX.
*   If the error bit ERR is set in IBSTA, call GPIBERR with an error message.
*/
    ibwrt (GpibDev, "500HZ;0IG; 0OG;DC;F", 18L); /* the 'F' displays the frequency so when*/
    if (ibsta & ERR) gpiberr ("ibwrt Error"); /* we read the unit we'll see the freq */

/*
*   Read the K-H 39XX. If the error bit ERR is set in IBSTA, call GPIBERR with
*   an error message.
*/
    ibrd (GpibDev, rd, 30L);
    if (ibsta & ERR) gpiberr ("ibrd Error");

    /* Append the null character to mark the end of the data*/
    rd[ibcnt] = '\0'; /* do this BEFORE calling ibcmd because ibcnt will be */
    printf("Read: %s\n", rd);          /* changed by any 'ib' calls. */

    ibcmd(GpibBoard,"?_",2L); /* send unt, unl */
    if (ibsta & ERR) gpiberr("ibcmd Error");

/*
*   Change the K-H 39XX setting
*/
    ibwrt (GpibDev, "333HZ;20IG;20OG;AC;F", 20L); /* the 'F' displays the frequency so when */
    if (ibsta & ERR) gpiberr("ibwrt Error"); /* we read the unit we'll see the freq */

/*
*   Read the K-H 39XX again like before.
*/
    ibrd (GpibDev,rd,30L);
    if (ibsta & ERR) gpiberr("ibrd Error");

    rd[ibcnt] = '\0';
    printf("Read: %s\n", rd);

    ibcmd(GpibBoard,"?_",2L); /* send unt, unl */
    if (ibsta & ERR) gpiberr("ibcmd Error");

/*   Call the ibonl function to disable the hardware and software. */
    ibonl (GpibDev, 0); /* Release the device handle */
    ibonl (GpibBoard, 0); /* Release the board handle */

```

```

    exit(0); /* exit with no error */
} /* main */

/*=====
*
*                               Function GPIBERR
*
*   This function will notify you that a NI-488 function failed by
*   printing an error message. The status variable IBSTA will also be
*   printed in hexadecimal along with the mnemonic meaning of the bit position.
*   The status variable IBERR will be printed in decimal along with the
*   mnemonic meaning of the decimal value. The status variable IBCNT will
*   be printed in decimal.
*
*   The NI-488 function IBONL is called to disable the hardware and software.
*
*   The EXIT function will terminate this program.
*=====
*/

void gpiberr(char *msg) {
    Unsigned int I;
    /* Table of ibsta (interface board status word) bit positions and
    corresponding messages */
    static struct { in bit; char *msg;} ibstaMsg [16]=
    { {ERR, " ERR"},
      {TIMO, " TIMO"},
      {END, " END"},
      {SRQI, "SRQI"},
      {RQS, "RQD"},
      {SPOLL, "SPOLL"},
      {EVENT, " EVENT"},
      {CMPL, " CMPL"},
      {LOK, " LOK"},
      {REM, " REM"},
      {CIC, " CIC"},
      {ATN, " ATN"},
      {TACS, " TACS"},
      {LACS, " LACS"},
      {DTAS, " DTAS"},
      {DCAS, " DCAS"} };

    /* Table of iberr error messages */
    static struct { int val; char *msg;} iberrMsg[15]=

    { { EDVR, " EDVR <DOS Error>\n"},
      { ECIC, " ECIC <Not CIC>\n"},
      { ENOL, " ENOL <No Listener>\n"},
      { EADR, " EADR <Address error>\n"},
      { EARG, " EARG <Invalid argument>\n"},
      { ESAC, " ESAC <Not Sys Ctrlr>\n"},
      { EABO, " EABO <Op. aborted>\n"},
      { ENEB, " ENEB <No GPIB board>\n"},
      { EOIP, " EOIP <Async I/O in prg>\n"},
      { ECAP, " ECAP <No capability>\n"},
      { EFSO, " EFSO <File sys> error\n"},
      { EBUS, " EBUS <Command error>\n"},
      { ESTB, " ESTB <Status bye lost>\n"},
      { ESRQ, " ESRQ <SRQ stuck on >\n"},
      { ETAB, " ETAB <Table Overflow>\n"};

```



```
printf ("%s\n:", msg); /* Print the application supplied context message. */

/*
 *   The ibsta variable provides the primary information about the cause o
 *   the error: print it's value and mnemonic for each bit set.
 */
printf ("ibsta = &H%X <", ibsta);
for (i=0; i<=15; i++)
    { if (ibsta & ibstaMsg[i].bit) printf ("%s", ibstaMsg[i].msg); };
printf (" .\n");

/*
 *   Print the iberr value and interpretation
 */
printf ("iberr = %d, iberr);
for (i=0; i<=14; i++)
    { if (iberr==iberrMsg[i].val) printf ("%s", iberrMsg[i].msg); };

/*
 *   Print ibcnt in decimal
 */
printf ("ibcnt = %d\n", ibcnt);
printf ("\n");

/*   put the board and device offline */
ibonl (GpibDev, 0); /* Release the device handle (/
ibonl (GpibBoard, 0); /* Release the board handle */

exit (1); /* exit the status=1 to indicate error */
}
```

3.6.3 Example 3 – National Instruments IBIC Preparation:

Your c:\config.sys file must have the following line in it:

device=c:\488\gpib.com

After you add this line, you must re-boot (reset) your computer for the driver to be loaded. For purposes of this demo, set the Krohn-Hite Model 3940/3944 to GPIB address 1:

Press 1 [SECOND FUNCTION][MEGA]

Set the talker to only send EOI:

Press 1 [SECOND FUNCTION][ALL CHAN}

<u>Prompt</u>	<u>Command You Type</u>	<u>Comments</u>
C:\488>.....	ibic.....	From the DOS command line, enter the IBIC program.
:.....	ibfind gpib0.....	Initialize the program to access the board.
gpib0:.....	ibfind dev1.....	Initialize the program to access the device at GPIB address 1.
dev1:.....	ibwrt "5.1K".....	Set the unit to 5.1kHz.
dev1:.....	ibrd 50.....	Read the unit (50 characters is adequate).
dev1:.....	set gpib0.....	The ibrd command does not unaddress the unit; it must be done manually: select the board so you can do a board level command.
gpib0:.....	ibcmd "?_".....	Send "unlisten (UNL)" which is "?" and "untalk (UNT)" which is "_" (underscore).
dev1:.....	ibwrt "AL;0IG;0OG;1TY;1MO;DC".....	Set: all channel mode (AL), 0dB input gain (0IG), 0dB output gain (0OG), type 1 (Butterworth), mode 1 (low-pass), DC coupling.
dev1:.....	ibwrt "B;CH1;1K;CH2;2K;CH3;5K".....	Set: all channel mode off (B), channel 1 to 1kHz cutoff, channel 2 to 2kHz cutoff and channel 3 to 5kHz.
dev1:.....	e.....	Exit IBIC
c:\488>		

SECTION 4

INCOMING ACCEPTANCE

4.1 INTRODUCTION

The following procedure should be used to verify that the Model 3940/3944 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 time of ½ hour to reach thermal equilibrium. If not operating within specifications refer to Section 5, Calibration, before attempting any detailed maintenance. Before testing, follow the initial set-up and operating procedure in Section 2.

4.2 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 4200B/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.

4.3 FILTER CHARACTERISTICS

4.3.1 Low Pass/High Pass Response

The Model 3940/3944 two/four independent channels in either the low-pass, high-pass or by-pass mode; or one/two channels in the band-pass or band-reject mode. Either Butterworth (maximally flat) or Bessel (linear phase) response is selectable.

Set the filter cutoff frequency to 1kHz in the low-pass mode “L.P.” with Butterworth response “bu.” and with 0dB Input and Output gain. Apply 1Vrms at 100Hz to the INPUT of the channel. These settings can be entered into all channels simultaneously by pressing the [ALL CHAN] key (so its LED is on) prior to entering the above settings. When this LED is off, these settings will be entered only in the channel indicated in the CHANNEL display.

Monitor the OUTPUT of the filter with an ac voltmeter referenced to 0dB. Set the oscillator frequency to 1kHz. The OUTPUT voltage should be approximately –3dB. Set the frequency to 2kHz. The OUTPUT voltage should be approximately –24dB. Set the filter to Bessel response “bES” and repeat the above. The OUTPUT voltage should be approximately –7.6dB and –25.4dB respectively.

Set the filter cutoff frequency to 1kHz in high-pass mode “h.P.” with Butterworth response and with 0dB Input and Output gain. Apply 1Vrms at 10kHz to the INPUT of the filter. Monitor the OUTPUT of the filter with an ac voltmeter referenced to 0dB. Set the oscillator frequency to 1kHz. The OUTPUT voltage should be approximately –3dB. Set the frequency to 500Hz. The OUTPUT voltage should be approximately –24dB. Set the filter to Bessel response and repeat the above. The OUTPUT voltage should be approximately –7.6dB and –25.4dB respectively.

In the by-pass mode “bYP.” the INPUT is connected directly to the OUTPUT. Monitor the INPUT and OUTPUT to verify this mode of operation.

4.3.2 Cutoff Frequency Accuracy

Connect the oscillator at 1Vrms at 50Hz to the INPUT of the filter set to Butterworth response. Set the cutoff frequency to 1kHz and adjust its frequency so the OUTPUT voltage is -3dB . The oscillator frequency should be within $\pm 2\%$ of the cutoff frequency of 1kHz. Repeat above at a filter cutoff frequency of 100kHz, 500kHz and 1MHz. The tolerance should be within $\pm 2\%$ at 100kHz and 500kHz, and $\pm 5\%$ at 1MHz.

Connect the oscillator at 1Vrms at 20kHz to the INPUT of the filter set to a cutoff frequency of 1kHz in the high-pass mode with 0dB Input and Output gain. Monitor the OUTPUT of the filter with a frequency counter and an ac voltmeter, and reference the ac voltmeter to 0dB. Set the oscillator to 1kHz and adjust its frequency so the OUTPUT voltage is -3dB . The oscillator frequency should be within $\pm 2\%$ of the cutoff frequency of 1kHz. Repeat above at a filter cutoff frequency of 100kHz, 500kHz and 1MHz. The tolerance should be within $\pm 2\%$ at 100kHz and 500kHz, and $\pm 5\%$ at 1MHz.

4.3.3 Band-Pass/Band-Reject Response

Variable band-pass response shown in Figure 4.1, is obtained by applying the input signal to channel 1 (or n. on Model 3944) INPUT. Set the CHANNEL display to channel 1 (or a channel n.1 on Model 3944). Set the filter to band-pass mode "b.P.". In the band-pass mode it is necessary that the [ALL CHAN] LED is off.

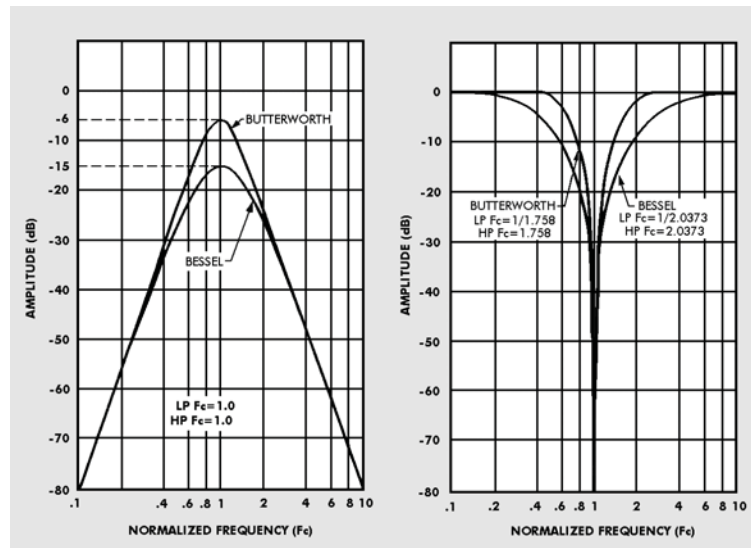


Figure 4.1 Band-Pass and Band-Reject Response

Set the filter to Butterworth response and apply 1Vrms at 10kHz to the INPUT of channel 1/n.1. Set filter to a low cutoff frequency of 1kHz. Set the filter to channel 2/n.2 to a high cutoff frequency of 100kHz.

Monitor the OUTPUT of channel 1/n.1 with an ac voltmeter referenced to 0dB. Set the oscillator frequency to 1kHz and 100kHz. The OUTPUT voltage should be approximately -3dB at these frequencies. Set the oscillator frequency to 500Hz and 200kHz. The OUTPUT voltage should be approximately -24dB at these frequencies.

Variable band-reject response, shown in Figure 4.2, is obtained by applying the input signal to channel 1/n.1 INPUT. Set the filter to the band-reject mode "b.r." and Butterworth response. Apply 1Vrms at 100Hz to the INPUT of channel 1/n.1 and set the low cutoff frequency to 1kHz. Set the filter to channel 2/n.2 and the high cutoff frequency to 100kHz.

Monitor the OUTPUT of channel 1/n.1 with an ac voltmeter referenced to 0dB. Set the oscillator frequency to 1kHz and 100kHz. The OUTPUT voltage should be approximately -3dB at these frequencies. Set the oscillator frequency to 2kHz and 50kHz. The OUTPUT voltage should be -24dB at these frequencies.

4.3.4 Stopband Attenuation

Accurate stopband attenuation measurements require some simple precautions because of low level signals. The filter should be shielded with top and bottom covers of the Model 3940/3944 in place. BNC cables only should be used between oscillator, filter and voltmeter and no other instruments should be connected.

Connect the oscillator at 3Vrms at 20kHz to 1/n.1 INPUT of the filter set to a cutoff frequency of 1kHz with 0dB Input and Output gain. Connect channel 1/n.1 OUTPUT of the filter through a 6kHz passive high-pass filter, as shown in Figure 4.3, to the AC Voltmeter. Set the filter to the low-pass mode. The filter OUTPUT should be $e < 300\mu\text{Vrms}$ (-80dB).

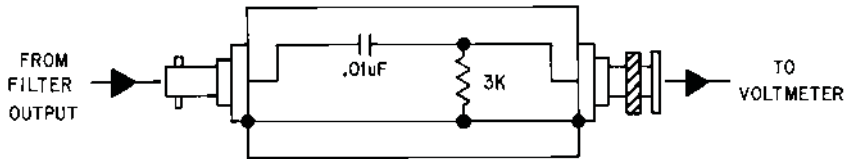


Figure 4.3 High-Pass Filter

4.3.5 Pre-Filter and Post-Filter Gain Accuracy

Set the filter to a cutoff frequency of 1kHz in the low-pass mode with 0dB Input and Output gain and apply 50mVrms at 100Hz to the INPUT.

Monitor the OUTPUT of the filter with an ac voltmeter referenced to 0dB. Set the GAIN of the pre-filter (Input) to 20dB. The OUTPUT of the filter should be a sinewave and within $\pm 0.2\text{dB}$ of the pre-filter gain setting of 20dB. Set the gain of the pre-filter (Input) to zero and the gain of the filter post-filter (Output) to 20dB. The OUTPUT of the filter should be a sinewave and within $\pm 0.2\text{dB}$ of the post-filter gain settings of 20dB.

4.3.6 Noise Check

Short the INPUT of the filter and set it to 0dB Input and Output gain, low-pass mode, Butterworth response at a cutoff frequency of 2MHz. Connect the OUTPUT of the filter using a shielded BNC cable in series with a 2MHz low-pass filter, shown in Figure 4.4 to the AC Voltmeter. Voltmeter reading should be $< 200\mu\text{V}$. The 2MHz low-pass filter should be inserted in a shielded enclosure (Pomona Model 3231 or equivalent) and connected directly to the voltmeter. Nothing else should be connected to the filter and voltmeter.

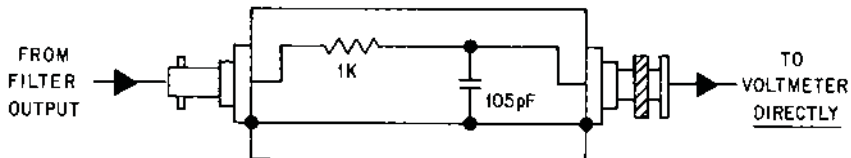


Figure 4.4 Low-Pass Filter

4.3.7 Distortion and Maximum Signal Checks

- a. Set the filter to a cutoff frequency of 25.6kHz in the low-pass mode with 0dB Input and Output gain. Connect a low distortion oscillator to the INPUT and apply 1Vrms at 1kHz. Monitor the OUTPUT of the filter with a distortion analyzer. The distortion should be <0.02%.

CAUTION!

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

- b. Connect a 50 ohm terminator to OUTPUT of the filter. Distortion should be <0.02%. Remove terminator.
- c. Set oscillator to 2.9Vrms. Distortion should be <0.2%.
- d. Set oscillator to 460mVrms and filter Output gain to 20dB. Distortion should be <0.2%. Set filter back to 0dB Output gain.
- e. Set oscillator to 1Vrms and filter to 100Hz in HP mode. Distortion should be <0.2%.
- f. Set oscillator to 2.8Vrms. Distortion should be <0.2%.
- g. Disconnect oscillator and distortion analyzer.

4.3.8 AC/DC Coupling Check

Apply 1Vdc to the Input of the filter in the low-pass mode with 0dB of 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.

Repeat the entire Incoming Acceptance procedure for the remaining channel(s).