Model 3900

1Hz to 99kHz, GPIB Programmable
2-Channel Low-Pass Tunable Active Filter

KROHN-HITE CORPORATION

Operating Manual

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1Hz to 99KHz
Dual Channel, Low-Pass Elliptical Programmable Filter

MODEL 3900

SERIAL NO. _____

OPERATING AND MAINTENANCE

MANUAL

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SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Krohn-Hite Model 3900 programmable, dual channel elliptical filter/voltage gain amplifier is one of a family of new programmable filters from Krohn-Hite. As an elliptical filter, the Model 3900 has two independent low-pass filter channels that have a tunable cutoff frequency range from 1Hz to 99kHz and a rolloff rate of 115dB/octave.

Each filter section has a minimum stopband attenuation of >80dB and a passband ripple of typically 0.22dB. The 3900 provides either a single-ended or differential input with a common mode rejection of >60dB. Input gains up to 40dB in 10dB steps and output gains to 20dB are also provided. The 3900 will accept input signals of ±10V peak at 0dB gain and has selectable ac or dc coupling. The filter is IEEE-488 Bus programmable and is complimented with non-volatile memory for the storage of up to 99 front panel set-ups. Overload detectors are standard and assist the user in detecting excessive input signals or incorrect gain settings.

The 3900 is also a programmable voltage gain amplifier for applications that require a low noise amplifier. The amplifier has a bandwidth of 1MHz and gains to 60dB, selectable in 10dB steps, and a wideband noise of <100μV.

Typical applications for the Model 3900 are: anti-aliasing in digital signal processing, separating specific bandwidths of information, enhancing signal-to-noise ratio, low noise pre-amplification and many more.

1.2 SPECIFICATIONS

FUNCTION

Two independent, low-pass filter channels or voltage gain amplifiers.

FILTER MODE (Each Channel)

Type: 7-pole, 6-zero elliptical.

Attenuation: 115dB/octave.

Passband Ripple: 0.22dB theoretical, 0.4dB max.

Tunable Frequency Range f_c: 1Hz to 99kHz.

Frequency Control: Keyboard entry or increment, decrement keys.

Relative Gain at f_c: –0.22dB at 1.01f_c nominal.

Cutoff Frequency Accuracy: ±2%.

Stopband Attenuation: >80dB.

Stopband Frequency (f_s): 1.7f_c.

Insertion Loss: 0dB ±0.1dB.

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

Post-Filter Gain: 0dB, 10dB, 20dB ±0.2dB.

Input Coupling: ac or dc.

Bandwidth: dc coupled, dc to f_c; ac coupled, 0.32Hz to f_c.

Wideband Noise (RFI, 2MHz bandwidth detector): min. gain, 1kHz cutoff, <400μV, 99kHz cutoff, <1mV; Max. gain, <20μV.

Harmonic Distortion: –80dB at 1kHz.

Intermodulation Distortion: –80dB below full scale volts at 70kHz and 90kHz input frequency.

Spurious Components: –80dB below full scale with input source <50 ohms.

DC Stability: Typically ±10μV/°C.

Crosstalk Between Channels: –85dB below full scale with input source <50 ohms.

AMPLIFIER MODE (Each Channel)

Bandwidth: dc coupled, min. gain, dc to >1MHz, max. gain, 400kHz; ac coupled, min gain, 0.32Hz to >1MHz, max gain >400kHz.

Insertion Loss: 0dB ±0.05dB.

Gain: 10dB to 60dB in 10dB steps ±0.2dB.

Input: Differential or single-ended + (in phase), –(inverted).

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

    Sensitivity: 10mV peak with 60dB total gain for 10V peak output.

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

    Impedance: 1 megohm in parallel with 100pf.

    Coupling: ac or dc.

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

Output:

> **Maximum Voltage (o.c.):** 7Vrms to 200kHz; 3Vrms to 500kHz; 1Vrms to 1MHz.
>
> **Impedance:** 50 ohms.
>
> **DC Offset:** Adjustable to zero volts.
>
> **Harmonic Distortion (1V input):** –80dB (0.01%) to 10kHz, –60dB (0.1%) to 100kHz.
>
> **Wideband Noise (refered to input, 2MHz BW detector):** min. gain 150μV; max. gain, 25μV.
>
> **DC Stability (RFI):** Typically ±10μV/°C.
>
> **Crosstalk Between Channels:** >85dB below full scale with input source <50 ohms.

GENERAL

Phase Match Between Channels: 1° typical, 2° max from dc to 0.8f$_c$; 2° typical, 4° max from 0.8f$_c$ to f$_c$.

Amplitude Match Between Channels: ±0.1dB max from dc to 0.8fc; ±0.2dB max from 0.8f$_c$ to f$_c$.

Memory: 99 selectable groups; memory is non-volatile battery-backed CMOS.

Overload Modes: Three selectable modes; non-latching, latching, that maintains the overload display until it is cleared; and no indications.

Overload Indicators: LEDs for input and output. Gain display flashes when overload occurs on displayed channel.

Input Indicators: Green LEDs to indicate active input BNC.

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

Displays: 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 and E1.

Operating Temperature: 0°C to 50°C.

Isolation to Chassis: ±100Vdc.

Storage Temperature: –20°C to 70°C.

Input/Output Connectors: BNC, front and rear.

Power Requirements: 90-132/180-264 volts ac, 50Hz-400Hz, 40 watts.

Dimensions and Weights: 3½" (9cm) high, 8½" (21.8cm) wide, 18" (46.2cm) deep; 12 lbs (5.4kg) net, 14 lbs (6.3kg) shipping.

Accessories: 3-terminal line cord; operating and maintenance manual.

OPTIONS

Rack Mounting Kit: Part no. RK-37, permits installation of the Model 3900 into a standard 19" rack spacing.

Specifications apply at 25°C ±5°C.

Specifications subject to change without notice.

SECTION 2

OPERATION

2.1 INTRODUCTION

The Model 3900 is a dual, low-pass, elliptical filter covering the frequency range from 1Hz to 99kHz. All filter parameters are programmable via the front panel keyboard controls or remotely over the IEEE-488 (GPIB) bus.

The filter has two modes of operation: filter mode and amplifier mode. Each mode will be explained in detail in this section.

2.2 TURN-ON PROCEDURE

The Model 3900 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 3900 is to be programmed remotely, connect the bus cable to the rear panel connector of the 3900.

After reading the Self-Test feature, described next, turn on the Model 3900.

2.3 SELF TEST

When the Model 3900 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 3900 will return to the last set-up prior to turning the unit off. The Model 3900 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 paramter 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, "el." (Elliptical).

[MODE]   When pressed, DISPLAY indicates the mode of operation for the channel displayed. "GAin" for amplifier mode, "L.P. - 1." for low-pass mode.

[RECLL]   When preceeded 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 [RCLL] key again will recall the entire instrument set-up from memory location "09".

              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.

2-1

[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 both 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.

Overload
Detection   When [SHIFT][MODE] is first pressed, the DISPLAY will indicate the overload mode currently selected. Pressing a number from [1] to [3] then [SHIFT][MODE] will select the following overload conditions:

[1][SHIFT][MODE] will select no overload indication.

[2][SHIFT][MODE] will select the non-latching mode. The unit will monitor all channels and display the first channel to have an overload.

[3][SHIFT][MODE] will select the latching mode. In this mode, the unit will maintain the overload display until it is cleared.

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 the [SHIFT] key followed by the [TYPE] key will display the input coupling, indicating "AC" or "dC", and will alternate between the two.

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] followed by the [MEGA] key (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. 3.7).

[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 3900 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 alternates the channel settings.

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 both 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 10dB. The two digit DISPLAY will indicate either 0dB, 10dB 20dB, 30dB or 40dB.

2.4.6 Output Gain (Post Filter)

Up [Δ] and down [∇] OUTPUT GAIN SET controls increase or decrease the output amplifier by 10dB. The two digit DISPLAY will indicate either 0dB, 10dB or 20dB.

2.4.7 Digit Select/Increment and Decrement

When the [SHIFT] key is pressed, followed by the DIGIT SELECT [Δ] or [∇] keys, the DISPLAY will intensify the first or second digit. Pressing the [SHIFT] followed by the [Δ] or [∇] key again, will intensify the next digit or will turn the DIGIT SELECT off. Pressing the [Δ] or [∇] keys will then increment or decrement the intensified digit.

NOTE: *The intensified digit will only increment or decrement within the resolution in that band.*

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 3900 rear panel consists of the following: four input and two output BNC connectors and dc level adjustments, a fuse holder, GPIB bus connector and an ac receptacle.

2.5.2 BNC Connectors and Indicators

2.5.2.1 Input Connectors

The Model 3900 has four input BNC connectors on both the front and rear panels. The inputs are labeled on the front panel CH1+, CH1–, CH2+ and CH2–; the rear panel is simply labeled – and +.

Note: A slide switch is provided on the rear panel for selecting the INPUT BNC connector desired. The selections are +, DIFF and –. The + is a non-inverting input, the – input is inverting and DIFF is for differential operation.

2.5.2.2 Output Connectors

The Model 3900 has two output BNC connectors on both the front and rear panels.

2.5.2.3 Indicators

Four LED indicators are provided on the front panel to indicate which input is active. A slide switch located on the rear panel selects the desired input.

2.5.3 DC Level Adj (Rear Panel)

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

There are two DC LEVEL potentiometers located on the rear panel of the Model 3900. They are for adjusting the DC level at the output BNC connector.

2.5.4 Power

Receptacle: Standard 3 pin.

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

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 3900 is a filter with two identical channels that can function independently. Each channel is a low-pass filter with 115dB/octave rolloff or a voltage gain amplifier with 60dB of gain.

2.6.2 Amplitude Response

Each channel of the Model 3900 has a rolloff rate of 115dB/octave. The amplitude response characteristics of each channel are shown in Figure 2.1.
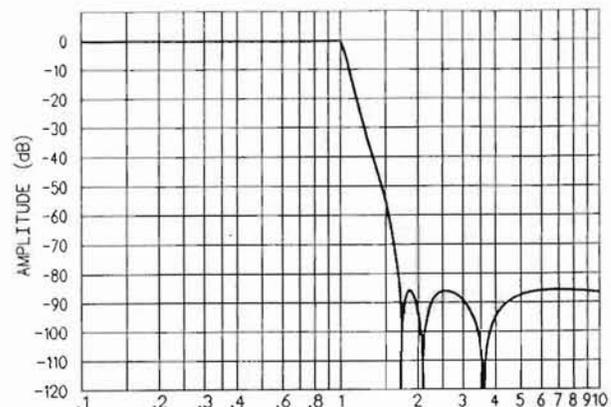
Figure 2.1 Amplitude Response

2.6.3 Phase Response

Phase characteristics of the Model 3900 is shown is Figure 2.2. The filter provides output phase relative to the input over a 10:1 frequency range.
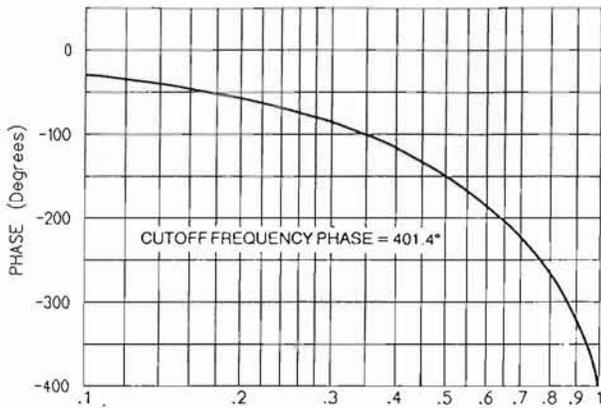
Figure 2.2 Phase Response

When the input frequency of the filter is less than 4/10 the cutoff frequency, the phase response is practically linear and can be calculated by using the formula $\theta = -293.17 \times f/f_c$, which is referred to as the zero frequency phase response. At a frequency 1/10 the cutoff, the phase shift would be -29.317 degrees and -2.9317 degrees at 1/100 of the cutoff frequency (not shown).

2.6.4 Group Delay

Group delay[1], 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.
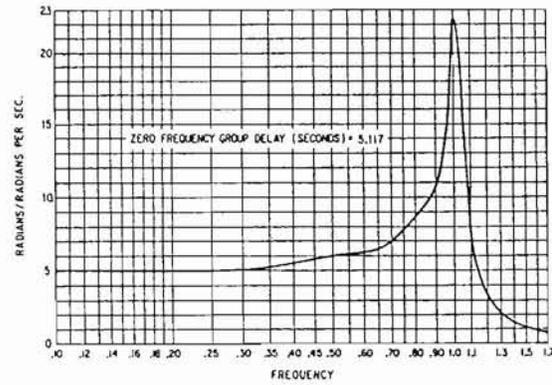
Figure 2.3 Group Delay

In numeric terms, the zero frequency phase slope is $-293.17°/Hz$ when normalized for a cutoff frequency of 1Hz. This will be 2π times greater in °/Hz for a cutoff of 1 radian/sec or $-1842°/Hz$. Dividing by 360 converts °/Hz to radians/radians-per-sec yields a group delay time of 5.12s.

2.6.5 Transient Response

The normalized response for a unit step voltage applied to the input of the Model 3900 is shown in Figure 2.4. A delay time in seconds for the output of the filter to reach 50% of its input voltage is determined by the formula $0.869/f_c$. With a cutoff frequency f_c of 1Hz, the delay time at point A on the response curve is 0.869 seconds. Since the delay time is inversely proportional to frequency, the delay time for f_c of 10Hz would be 1/10 that of 1Hz or 0.0869 seconds.
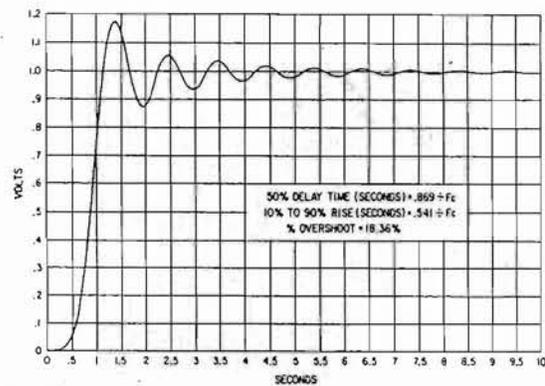
Figure 2.4 Normalized Unit Step Response

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

The time for the output voltage of the filter to increase from 10% to 90% of its input voltage is determined by the formula $0.541/f_c$ or 0.541 seconds for a normalized frequency of 1Hz. The inverse relationship reduces the time delay proportionally at higher cutoff frequencies.

The normalized impulse response of the Model 3900 is shown in Figure 2.5. An impulse will produce a damped sinewave whose maximum amplitude overshoot will be 30% of the input pulse amplitude, and the damped sinewave will approach zero amplitude in approximately 10 cycles.
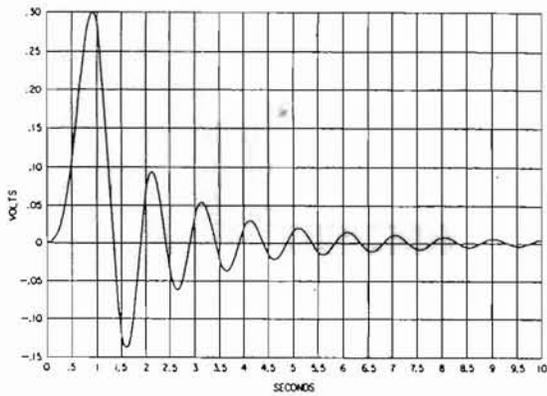
Figure 2.5 Normalized Impulse Response

SECTION 3

IEEE-488 STD (GPIB) PROGRAMMING

3.1 INTRODUCTION

The Model 3900 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 3900 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 3900 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.

	Pin	Pin	
DIO1	1	13	DIO5
DIO2	2	14	DIO6
DIO3	3	15	DIO7
DIO4	4	16	DIO8
EOI	5	17	REN
DAV	6	18	GND (TW PAIR W/DAV)
NRFD	7	19	GND (TW PAIR W/NRFD)
NDAC	8	20	GND (TW PAIR W/NDAC)
IFC	9	21	GND (TW PAIR W/IFC)
SRQ	10	22	GND (TW PAIR W/SRQ)
ATN	11	23	GND (TW PAIR W/ATN)
SHIELD	12	24	SIGNAL GROUND
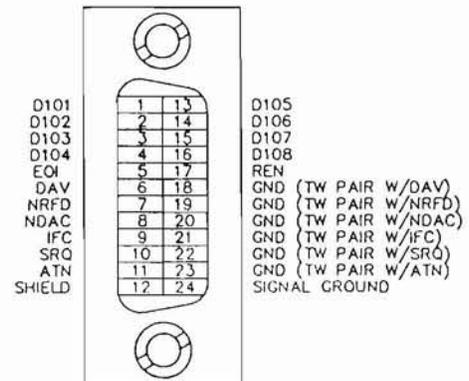
Figure 3.1 Rear Panel GPIB Connector

3.3 ASCII DATA COMMANDS

3.3.1 Format

The Model 3900 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 contain (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 3900 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 (Hex 0A) or carriage return (Hex 0D) or by sending the end-or-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 3900 GPIB COMMANDS

Command Desired	Allowable Character String	
Input Gain	IG	set input gain
	IU	increase input gain (up)
	ID	decrease input gain (down)
Frequency	F	frequency
	H	frequency (Hz)
	K	kilo (10^3 multiplier)
	ME	Mega (10^6 multiplier)
Channel	CH	set channel
	CU	next channel (up)
	CD	previous channel (down)
Output Gain	OG	set output gain
	OU	increase output gain (up)
	OD	decrease output gain (down)
Type	TY1	Elliptical
Mode	M1	Low-Pass
	M2	Gain
Coupling	AC	ac coupled
	D	dc coupled
Store	ST	store
Recall	R	recall
All Channel	AL	all channel mode
	B	NOT all channel mode
Misc.	CE	clear entry
	OV	overflow (1, 2, 3)
	Q	reports board model number(s) (see Section 3.5.4)
	SRQON	GPIB service request on
	SRQOF	GPIB service request off
	V	report model number and software version (see Section 3.5.3)

Alphabetical Listing of Model 3900 GPIB Commands

Character String	Command
AC	ac coupled
AL	all channel mode
B	NOT all channel mode
CD	channel down
CE	clear entry
CH	channel # n
CU	channel up
D	dc coupled
F	frequency
H	frequency (Hz)
ID	input gain down
IG	input gain
IU	input gain up
K	kilo
M1	Low-Pass mode
M2	Gain mode
ME	Mega (10^6 multiplier)
OD	output gain down
OG	output gain
OU	output gain up
OV	overflow mode
Q	report board model number(s) (see Section 3.5.4)
R	recall
SRQON	GPIB service request on
SRQOF	GPIB service request off
ST	store
T1Elliptical Type	Elliptical Type
V	report model number and software version (see Section 3.5.3)

3.3.4 Examples

3.3.4.1 Example 1

To set both 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 150ьHZ[†]
            or 150F
            or .15K
            or F150
            or H150
            or HZ150
            or K0.15
            or 1.5E2HZ
            or F1.5E2

3.3.4.3 Example 3

To read back the settings of channel 2 (see Section 3.5.1):

Data sent *to* filter: CH2

Data received *from* filter[†]: 10ь2.000E + 3ь02ь00bAC❀

Interpretation: 10dB input gain
                  2kHz cutoff frequency
                  channel #2
                  0dB output gain
                  ac coupled

                  all channel mode (indicated by the "❀")

---

†   ь 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 recieve data.
Unlisten	UNL	Disables unit from recieving data.
My talk Address	MTA	Designates unit to send 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 = Elliptical; Mode = Low-Pass; Cutoff Frequency = 1kHz; Coupling = ac. Clears current settings for all channels. It does not clear set-ups 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 3900 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 un-listens 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 3900 to be configured is unit #5, and we want it to respond with a "1" when an error exists:

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 exists.
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 3900 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 bit 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 3900 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 3900 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" command, the next line of data read from the Model 3900 will be as follows:

KROHN-HITE 3900, 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™, Borland Turbo C and National Instruments IBIC.

3.6.1 Example 1 – Microsoft Quick Basic

```
'  Microsoft (R) Quick Basic (tm) program for the Krohn-Hite Model 3900
'
'     *   Enter this program from DOS by typing: QB 3900 /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]
'
'———— Initialize National Instruments Interface Board ————
'
'$INCLUDE: 'QBDECL.BAS'
  CLS
  CALL IBFIND("GPIB0", BRD0%): 'initialize access to the board
  CALL IBFIND("DEV1", D3900%): 'init access to the instrument, assumes addr 1!
  CALL IBTMO(D3900%, 10): ' set timeout to 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(D3900%, "500HZ;0IG;0OG;DC;F"): IF IBSTA%  <0 THEN GOTO gpiberr

' allocate a buffer (define a string long enough to hold the response)
' and read the meter
  Buf$ = SPACE$(40): CALL IBRD(D3900%, Buf$): IF IBSTA%  <0 THEN GOTO gpiberr

'Shorten the 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(D3900%, "333HZ;20IG;20OG;AC;F"): IF IBSTA%  <0 THEN GOTO gpiberr
  Buf$ = SPACE$(40): CALL IBRD(D3900%, Buf$): IF IBSTA%  <0 THEN GOTO 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(D3900%, 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 3900 multichannel
 *     filter using the NI-488
 *  Should work with Microsoft C also.
 */
*/==============================================================================
 *
 *  This sample program sends and receives data from a Krohn-Hite model 3900
 *
 *     *  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     <stdib.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 3900...\n");
```

```
        printf("\n");

/*
 *  Assign a unique identifier (a 'handle') to the K-H 3900 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 3900 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 3900 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 3900.
 *  If the error bit ERR is set in IBSTA, call GPIBERR with an error message.
 */
       ibwrt (GpibDev,"500HZ;0IG;00G;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 3900.  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 3900 setting
 */
       ibwrt (GpibDev,"333HZ;2OIG;200G;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 3900 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 { int bit; char *msg;} ibstaMsg[16]=
    { {ERR,   " ERR"},
      {TIMO,  " TIMO"},
      {END,   " END"},
      {SRQI,  " SRQI"},
      {RQS,   " RQS"},
      {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 byte 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 of
 *   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 interpertation
 */
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 with 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 3900 to GPIB address 1:

Press 1[SECOND FUNCTION][MEGA]

Set the talker to only send EOI:

Press 1[SECOND FUNCTION][ALL CHAN]

Prompt	Command You Type	Comments
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 3900 Programmable 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 on the Model 3900 in the filter mode 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 procedures given in Section 2 of this manual.

4.2 TEST EQUIPMENT REQUIRED

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

a. RC Oscillator, with a frequency range of .01Hz to 1MHz. Krohn-Hite Model 4100A or equivalent.

b. RC Oscillator, with a frequency range of 10Hz to 10MHz. Frequency response of ±0.025dB from 10Hz to 500kHz. Krohn-Hite Model 4200B/4300B or equivalent.

c. Oscilloscope, bandwidth of DC to 50MHz, vertical input sensitivity of 5mV/cm, Tektronix 465 or equivalent.

d. DC Voltmeter (DVM), capable of measuring 1mV to 20V, Fluke Model 8000A or equivalent.

e. AC Voltmeter, capable of measuring 100μV to 10Vrms, Fluke Model 8920A or equivalent.

f. Frequency Counter.

4.3 PRE-FILTER, POST-FILTER AND UNITY GAIN ACCURACY

Set all filters to a cutoff frequency of 900Hz with 0dB Input and Output gain and apply 50mVrms at 100Hz to INPUT of each filter module. Monitor the OUTPUT with an ac voltmeter. Should be 50mV ±1mV.

Set gain of pre-filter (input) to 10dB, 20dB, 30dB and 40dB. Fluke on the OUTPUT of the filter should be within ±0.2dB of all four pre-filter gain settings.

Set gain of pre-filter and post-filter to 0dB and apply a 0.7Vrms signal to the INPUT of the filter. Monitor the OUTPUT of the filter with an ac voltmeter and record the OUTPUT voltage. Set gain of post-filter (output) to 10dB and 20dB. Fluke on the OUTPUT of the filters should be within ±0.2dB of both post-filter gain settings.

4.4 PASSBAND GAIN AND DISTORTION TESTS

To verify that the filter is functioning correctly in the passband, set both filter channels to a cutoff frequency of 900Hz and pre-filter and post-filter amplifier gain to 0dB (unity gain). Apply a 7Vrms signal at 50Hz to the INPUT of each filter channel and monitor the OUTPUT of each with a scope, ac voltmeter and a distortion analyzer. The OUTPUT should be within ±0.2dB of the INPUT and the distortion should be <0.1%.

CAUTION: *If the distortion is excessive, verify that the distortion of the oscillator being used is <0.1%.*

4.4.1 Low Bands Ripple Response
(FIGURE 4.1)

Connect oscillator at 3Vrms at 50Hz to INPUT of filter. Set front panel channel indicator to the channel of the filter under test. Set filter to 900Hz cutoff frequency with 0dB of INPUT and OUTPUT gain. Monitor OUTPUT of filter with ac voltmeter. Record OUTPUT voltage. Set filter to 90Hz cutoff frequency.

Check the response of the three peaks at 42.9Hz, 73.9Hz and 89.1Hz. Check the response of the three valleys at 22.3Hz, 60.3Hz and 83.4Hz. The adjacent peak-to-valley ripple should not exceed 0.4dB. If necessary, refer to Section 5, Calibration.

4.4.2 High Band Ripple Response

Connect oscillator at 3Vrms at 100Hz to INPUT of filter. Set front panel channel indicator to the channel of the filter under test. Set the filter to 10kHz cutoff frequency with 0dB Input and Output gain. Monitor OUTPUT of filter with ac voltmeter. Record OUTPUT voltage

Check the response of the three peaks at 4.7kHz, 8.2kHz and 9.9kHz. Check the response of the three valleys at 2.4kHz, 6.8kHz and 9.2kHz. The adjacent peak-to-valley ripple should not exceed 0.4dB. If necessary, refer to Section 5, Calibration.

NOTE: *Check the accuracy of the ac voltmeter at low frequencies. If necessary, compare the OUTPUT with the INPUT to eliminate any error.*

4.5 STOPBAND ATTENUATION

4.5.1 Band 1

Set filter to 10Hz with 0dB Input and 20dB Output gain, dc coupling. Set oscillator to 17.5Hz at 7Vrms. Connect scope to OUTPUT. Signal should be less than 20mV p-p. Set oscillator to 18.7Hz, 25.9Hz and 70Hz. Signal should be less than 20mV p-p.

4.5.2 Band 2

Same as Band 1 setting the filter to 100Hz and oscillator to 175Hz, 187Hz, 259Hz and 700Hz.

4.5.3 Band 4

Same as Band 1 setting the filter to 10kHz and oscillator to 17.5kHz, 18.7kHz, 25.9kHz and 70.0kHz.

4.6 CUTOFF FREQUENCY ACCURACY

Connect oscillator at 3Vrms at 42.9Hz to INPUT. Set filter to 90Hz with 0dB Input and Output gain. Monitor OUTPUT with ac voltmeter. Record voltage at Output. Adjust input frequency near 90.9Hz to obtain –0.22dB. Frequency should be between 89.12Hz and 92.7Hz.

Set filter and oscillator to 100Hz - adjust oscillator frequency for –0.22dB. Frequency should read between 99Hz and 103Hz.

Set filter and oscillator to 10kHz - adjust oscillator frequency for –0.22dB. Frequency should read between 9.9kHz and 10.3kHz.

4.7 NOISE MEASUREMENTS
(use 2MHz limited detector)

Short the INPUT of the filter. Connect ac voltmeter to the OUTPUT of filter. Set filter to 1kHz with 0dB Input and Output gain. OUTPUT should be less than 0.4mV. Set filter to 99kHz with 0dB Input and Output gain. OUTPUT should be less than 1mV.

Set filter to 99kHz with 40dB Input and 20dB Output gain. OUTPUT should be less than 20mV.

Set to GAIN mode with 0dB Input and 0dB Output gain. Output should be less than 150μV. Set Input gain to 40dB and Output gain to 20dB. Output should be less than 25mV.


Figure 4.1 Normalized Ripple Response