Model 5302

Lock-In Amplifier

Instruction Manual

221490-A-MNL-F

FCC Notice

This equipment generates, uses, and can radiate radio-frequency energy and, if not installed and used in accordance with this manual, may cause interference to radio communications. As temporarily permitted by regulation, operation of this equipment in a residential area is likely to cause interference, in which case the user at his own facility will be required to take whatever measures may be required to correct the interference.

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The EG&G PARC Model 5302.....

represents a major advance in lockin technology with its wide frequency range, outstanding performance and unequalled range of facilities.

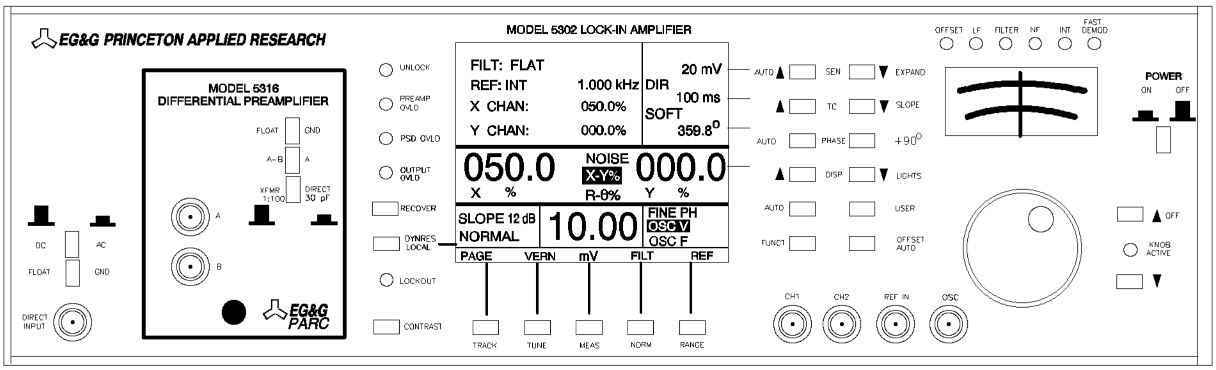


Figure 1-1. MODEL 5302 LOCK-IN AMPLIFIER

Key specifications and benefits:

- **Frequency range:** 1 mHz to 1 MHz
- **Frequency synthesizer** for accuracy and amplitude stability.
- **Instant phase lock**
- **Phase adjustment** to within 1 m°
- **Programmable steep skirt, variable Q filter** - Bandpass, Low Pass, High Pass, Notch, Flat
- **Harmonic Modes** in reference circuit including: 1F, 2F, 3F, 4F, 5F, 6F and 7F.
- **Exponential, Triangular and Rectangular averaging**
- **Compatible modular Preamplifier capability**
- **Curve storage** to 10000 points
- **Methods storage** to 15 methods
- **Full range of auto modes**
- **Standard GPIB and RS232 interfaces**

2.1 Introduction

Installation of the Model 5302 in the laboratory or on the production line is very simple. The power consumption of the Model 5302 is 390 watts. The instrument incorporates forced-air ventilation and can be operated on almost any laboratory bench or, alternatively, rack mounted at the user's convenience. With an ambient operating temperature range of 0°C to 50°C, it is highly tolerant to environmental variables, needing only to be protected from exposure to corrosive agents or adverse weather conditions.

2.2 Rack Mounting

Rack mounting brackets are provided with the Model 5302. These brackets are a special version of the aluminum extrusions that mount on each side of the instrument immediately behind the panel. To install the rack-mounting brackets, remove the original extrusions, each of which is secured by two screws, and, using the same screws, mount the extrusions having the integral rack-mounting brackets.

2.3 Inspection

Newly received apparatus should be inspected for shipping damage. If any is noted, immediately notify EG&G PARC and file a claim with the carrier. The shipping container should be saved for inspection by the carrier.

2.4 Power Cord Plug

For user and equipment safety, it is important that the input power connections be properly made. If the plug provided is not compatible with the available power sockets, the plug or the power cord should be replaced with one of approved type and compatible design.

If the plug is replaced, be sure to retain the original polarity. The wires in the supplied power cord are color-coded for this purpose. Whatever the actual plug configuration, the black wire should be the line or active conductor (also called live or hot), the white wire should be neutral, and the green wire should be earth ground.

2.5 Power Voltage Selection and Line Fuse

Before plugging in the power cord, ensure that the apparatus is set to the voltage of the ac power supply.

A detailed discussion of how to check and, if necessary, change the power-voltage setting follows.

CAUTION! The apparatus described in this manual may be damaged if it is set for operation from 110 V and turned on with 220 V ac applied to the power input.

The Model 5302 can operate from one of four different power-voltage ranges, 90-110 V, 110-130 V, 210-230 V, and 230-260 V, 50-60 Hz. Range changeover is made by repositioning a plug-in circuit card internal to the rear-panel power input assembly. Instruments are ordinarily shipped ready for operation from 110-130 V ac, unless destined for an area known to use a line voltage in the 220-260 V range. If this is the case, they are shipped configured for operation from the higher range.

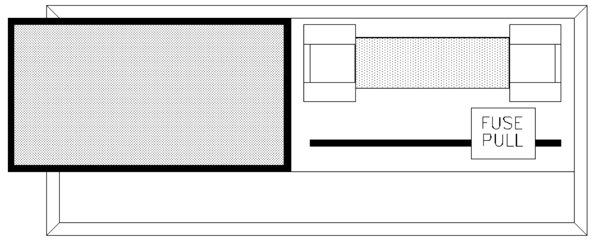


Figure 2-1. POWER INPUT ASSEMBLY

If necessary, changeover from one range to another can be accomplished in the field, as follows. Observing the instrument from the rear, note the clear-plastic door immediately adjacent to the power cord connector (Figure 2-1). When the power cord is disconnected from the rear-panel connector, the plastic door is free to slide to the left, giving access to the fuse and to the voltage selector circuit card. The selector card is located at the lower edge of the fuse compartment. A number printed on the upper surface of the selector card is visible without removing the card. This number, which is somewhat obstructed by the fuse, indicates the selected nominal line voltage. There are four numbers on the card, but only one is visible. In other words, the card can be inserted in one of four different positions, and a different number can be read in each. Table 2-1 indicates the actual line voltage range for each number.

If the number showing is incorrect for the prevailing line voltage, the card will have to be repositioned, as follows.

VISIBLE #	VOLTAGE RANGE
100	90-110 V
120	110-130 V
220	210-230 V
240	230-260 V

Table 2-1. RANGE VS CARD POSITION

The first step is to remove the fuse. When the lever labeled FUSE PULL is rotated out and towards the left, the fuse will lift so that it can be easily removed. At the front center of the circuit card is a small hole that serves as a convenient pry point. A small screwdriver or other tool can be used as an aid in removing the board. With the board removed, four numbers become visible: 100, 120, 220, and 240. Orient the board until the required number (Table 2-1) will be visible when the board is inserted. Then insert the board into its connector. The selected number should be the only one that shows. Ensure that the board is securely seated in its connector. Next check the fuse rating. For operation from a nominal line voltage of 120 V, use a slow-blow fuse rated at 3 A (voltage rating 250 V or higher). For operation from a nominal line voltage of 220 V, use a slow-blow fuse rated at 1.5 A (voltage rating of 250 V or higher). When the proper fuse has been installed, slide the plastic door back over the fuse compartment so that the power cord can be reconnected. Ensure that only fuses with the required current rating and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders are prohibited.

2.6 Preamp Cover

The Model 5302 is supplied with a preamp cover. This cover must be installed whenever the 5302 is operated *without* a plug-in preamplifier. This cover provides shielding that is essential for proper operation when using the Model 5302's DIRECT input. To install the cover, position it so that the attached card is in line with the guides. Then push it back until the connector at the edge of the card mates with the internal connector. Last, rotate the cover's locking knob clockwise to secure the card to the panel. For maximum safety of the internal circuitry, the cover should only be installed or removed with the power **OFF**.

3.1 Introduction

The following procedure checks the performance of the Model 5302. In general, this procedure should be performed after inspecting the instrument for obvious shipping damage (any damage noted must be reported to the carrier and to EG&G PARC; take care to save the shipping container for inspection by the carrier). Note that the procedure that follows is not intended to demonstrate that the instrument meets specifications; but rather to simply show that it has arrived in good working order.

The checkout procedure is extremely simple. You set the internal oscillator to provide a 10 mV, 1 kHz signal and then measure this signal with the 5302. This operation is very much like an actual measurement. You have to make and verify the setup in much the same way, and check the status of some conditions that could cause the measurement to go wrong. This simple exercise is good practice for the real measurements you will subsequently make.

Each instrument receives a careful checkout before leaving the factory. If no shipping damage has occurred, your instrument should perform within the limits of the specifications. If any problems are encountered in carrying out these checks, contact the factory or the nearest authorized factory representative for assistance.

3.2 Setup

1. Ensure that the Model 5302 is set to the line voltage of the power source (See Chapter 2, *INSTALLATION*, for details).

2. With the POWER switch set to OFF, plug the line cord into an appropriate source of power.

3. Turn on the power (pushbutton near right edge of front panel).

   Note: Operation of the Model 5302 centers on its display and on the adjacent pushbutton keys and indicators. An underlying assumption to this text is that you are in the process of performing these checks on an actual unit and so have the front panel of the instrument to refer to. Figure 3-1, a reproduction of this area of the panel, is provided as a convenient reference if you are reading this text while not looking at an actual unit.

4. Note the status of the yellow **LOCKOUT** indicator (to the left of the bottom edge of the display). If it is lighted, it means that the front panel is locked out, which will have to be reversed before you can proceed.

   Local/Remote selection is a FUNCTION toggle, and so is controlled by the green **FUNCT** key (lower right of the display), and one other key, in this case the **DYNRES/LOCAL** key, located just above the **LOCKOUT** indicator. Thus, the required action if **LOCKOUT** is lighted is to momentarily press **FUNCT** and then **DYNRES/LOCAL**. The indicator should immediately extinguish, meaning that the panel is no longer locked out and that you can proceed.

5. Select **OSC F**, as follows, so that the frequency of the internal oscillator can be set.

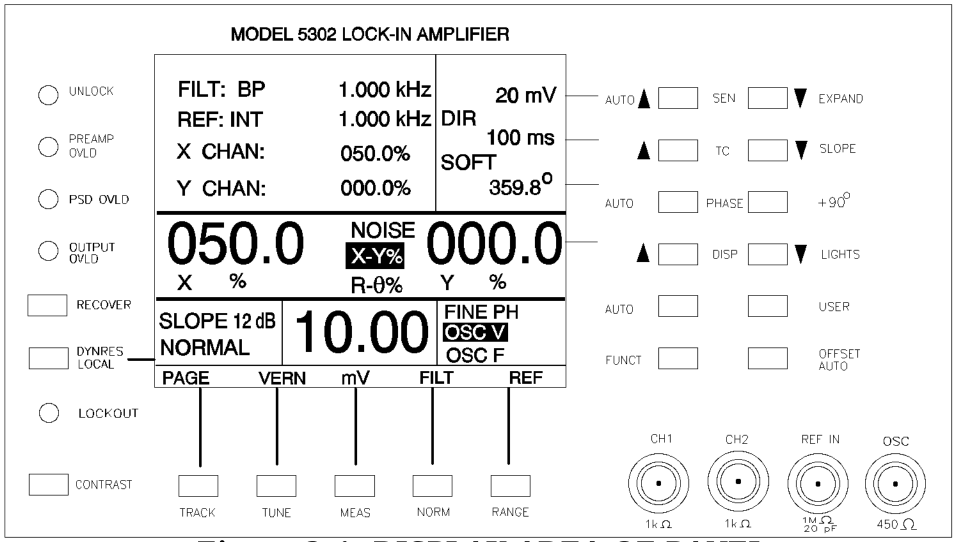


Figure 3-1. DISPLAY AREA OF PANEL

In making this selection, you will have to be concerned with the display's lower-right window, and with the two pushbutton keys and indicator light immediately to the right of the parameter setting knob (large knurled knob towards the right edge of the panel). The two buttons determine which three parameters are displayed in the window. In effect, you can think of the parameter list as being printed on a horizontal barrel which can be rotated on its axis by means of the keys so that they determine which three parameters are displayed. Of the three, the one in the center (displayed in inverse video) is the one selected.

Note that, if the **KNOB ACTIVE** light is extinguished, pressing either knob key once simply lights the indicator (which must be lighted for the knob to function). Subsequent presses will rotate the barrel behind the display window and so change the parameter selection. In any case, using the keys to the right of the setting knob, rotate the barrel so that **OSC F** is the selected parameter. Of the three parameters listed, **OSC F** will be in the middle and in inverse video.

6. Set the oscillator frequency to **1.000 kHz**, as indicated by the large numeric display immediately to the left of the parameter selection barrel. You do this by rotating the parameter setting knob (Figure 3-2) until the desired indication is obtained.

   The numeric indication will be **1.000** and **kHz** will appear beneath the number. Note that the knob has an automatic speed shift so that, if it is turned slowly, a parameter can be set with great precision. If the knob is rotated quickly, it shifts into a higher gear in which the parameter change for a given angle of rotation is greatly increased.

   Again, the **KNOB ACTIVE** indicator must be lit for the parameter setting knob to be functional. As previously explained, if the light is out, press either knob key once to activate the knob and light the indicator. There is a timeout on the knob so that, if it is unused for an extended time, it deactivates automatically.

7. Select **OSC V** so that the output amplitude of the internal oscillator can be set. You do this using the lower-right window of the display and the two keys to the right of the setting knob as previously described.

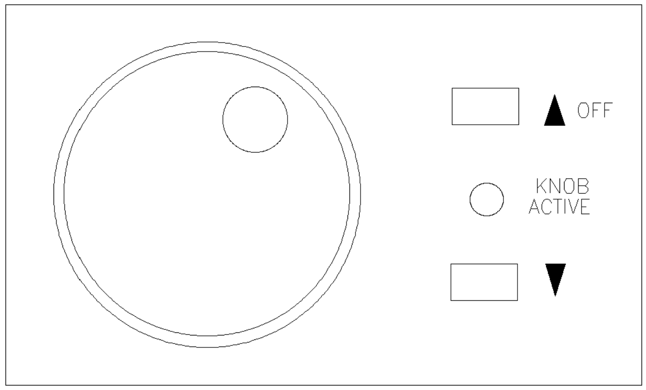


Figure 3-2. PARAMETER SETTING KNOB AND PARAMETER SELECTION KEYS

8. Using the parameter setting knob, set the oscillator output to **10.0 mV**. The numeric display will show **10.0** and **mV** will be indicated beneath the number.

9. Place the instrument in the **INT** reference mode. This is done using the rightmost of the five keys located directly beneath the display. The softkey identifier immediately above the key identifies it as **REF**. The reference mode selected is indicated in the upper left window of the display (second item). Each time the **REF** key is pressed, the reference mode changes, the selection sequence being **EXT**, **INT**, **TTL**. Press the **REF** key until **INT** shows in the window. The reference channel frequency (1.000 kHz) will also be displayed just to the right of the **INT** display legend. Note that selecting the Internal Reference mode also lights the **INT** indicator light, located above the analog meter.

10. Set the Sensitivity to **20 mV**. Doing so requires that you use one of the two columns of keys to the right of the display. The top key in each column affects the sensitivity. The one to the left (↑) selects a higher value of full-scale sensitivity (less sensitive), while the one to the right, (↓), selects a lower value of full-scale sensitivity (more sensitive). The range selected is indicated in the display directly to the left of the **SEN** keys.

11. Set the Time Constant to **100 ms**. It is selected by the two **TC** keys, the next pair of keys below the **SEN** keys. The value selected is indicated directly to the left in the display.

12. Select the **BP** filter mode. The filter mode selection is indicated in the upper left-hand corner of the display. You make the selection using the **FILT** softkey, the second key from the right beneath the display.

13. Set the Dynamic Reserve Mode to **HI STAB**. This is done using the **DYNRES/LOCAL** key (to the left and towards the bottom edge of the display). The reserve mode setting is indicated in the display directly to the right of the key.

14. Set the Slope to **12 dB** Exponential. The Slope indication is located directly above the Reserve indication, and should read **SLOPE 12 dB**. Any other message means that the Slope selection will have to be changed. This is done using the FUNCT key and the **TC** ↓ key. Each time the FUNCT key is pressed and then

the **TC** ↓ key, the slope indication will change. The sequence may need to be repeated several times before **SLOPE 12 dB** is displayed.

15. Set the Reference Phase to 0º. To do this, begin by pressing either of the two keys to the right of the parameter setting knob as many times as are necessary to make **PHASE** the selected parameter as indicated at the lower right of the display. **PHASE** will be in inverse video. Then adjust the parameter setting knob for a phase value of **000.0** as indicated at the lower center of the display.

16. Look at the **VERN** indication, located directly above the second key from the left of the five keys beneath the display. If it is in inverse video, the sensitivity vernier is active, not desirable for these checks, and it will have to be toggled to the calibrated sensitivity state. Simply press the key directly beneath **VERN**. This will establish the calibrated sensitivity mode and normal video display of the word **VERN**.

17. Select the **X-Y%** measurement mode. This is accomplished using the **DISP** ↑ and ↓ keys to the right of the display. You will note that there is a selection "barrel" at the center of the display to the left of these keys. Three display modes are listed, and the center one is selected as indicated by inverse video. The **DISP** keys rotate the barrel to select the **X-Y%** display mode.

18. If the lockin is not equipped with a modular preamplifier, connect a BNC cable from the front-panel **OSC** connector to the **DIRECT INPUT** connector at the lower left corner of the front panel. Then, using the pushbuttons located above the connector, select **AC** and **FLOAT** (upper button latched, lower button released). *If a preamplifier is not present, the preamplifier cover must be installed. See 2.6 PREAMP COVER*, in Chapter 2.

    If the lockin is equipped with a modular voltage preamplifier, such as the Model 5316, then you have the option of connecting to the **DIRECT INPUT** or to the preamplifier input. For the purposes of these checks, use the preamplifier input. Some preamplifiers give you the option of single-ended or differential operation, direct or transformer coupled, and **FLOAT** or **GND**, all selected by pushbuttons on the front-panel of the preamplifier. Use **DIRECT** (non-transformer), **A** (single-ended), and **FLOAT** (shell of input connector returned to ground through a resistor).

    It is important to keep in mind that the 5302 takes as its signal source either the front-panel **DIRECT INPUT** connector or the Preamplifier, if one is installed. One of these two signal sources is selected at all times and the Model 5302 will only accept signals from the selected source. If **DIRECT INPUT** has been selected, the word **DIR** will appear in the upper-right display area. If the preamplifier has been selected, the word **PRE** will appear there. The selection is made via the SIGNAL SETUP screen, as follows. ***Attempting to make a measurement with the input signal connected to the unselected input is probably the commonest cause of apparent instrument malfunction.***

    a. From the Main Page, press the **PAGE** softkey (left-most of the five keys beneath the display). This will bring up the LARGE DISPLAY screen (large type display of the outputs).

    b. Press the **SETUP** softkey (second key from left beneath display). This will take you to the SETUP MENU page, which lists a number of functions that can be selected using the ↑ and ↓ and SELECT softkeys (left-most three keys beneath the display).

c. Using the select arrow softkeys, select **SIGNAL CHANNEL**, that is, make **SIGNAL CHANNEL** the item displayed in inverse video. Then press the **SELECT** softkey, which will bring up the SIGNAL CHANNEL screen.

d. Select **SIGNAL SOURCE** and press the **SELECT** softkey again, which will bring up the SIGNAL SOURCE screen.

e. To make the input selection as indicated by the position of the inverse video bar, use the two right-most keys beneath the display, that is, the keys to the left and right of **ADJ.** Select **PREAMP** if the signal is being applied to the modular preamplifier and **DIRECT** if it is being applied to the DIRECT INPUT connector.

f. Press the **MAIN** softkey (top right of display) to return to the MAIN page (operating display).

19. As a last step in the setup, note the lights above the analog meter. Only **INT** and **FILTER** should be lighted. If any other is lighted, its status will need to be reversed before proceeding. All but **OFFSET** should have been extinguished by setup steps taken prior to this point. If **OFFSET** is lighted, it means that the offset is enabled. To disable it, press the **OFFSET** key. This is the key at the bottom of the second column of keys to the right of the display.

20. The line filter should be off. To check its status, go to the SETUP MENU screen (press **PAGE** and then **SETUP**). Then select **SIGNAL CHANNEL**. When that menu appears, select **LINE NOTCH**, which will bring up the LINE NOTCH screen. Using the **SELECT** and **ADJUST** keys, establish the OFF state for both filters. Then press **MAIN** to return to the MAIN page display.

3.3 The Result

The setup should now be complete and the MAIN page should be displayed. If a setup screen is displayed, return to the MAIN page with the **MAIN** softkey. The X and Y output levels should be indicated in the center band of the display. The X indication should be 50% and the Y indication 0%.

Note, however, that the results could vary a little from those indicated. The X output indication might be slightly high or low, depending on how the various errors are distributed, and a Y output of zero will occur only if the instrument phase calibration is absolutely perfect.

This completes the initial checks. If the indicated results were obtained, the user can be reasonably sure that the unit has not incurred any hidden damage in shipment and is in good working order.

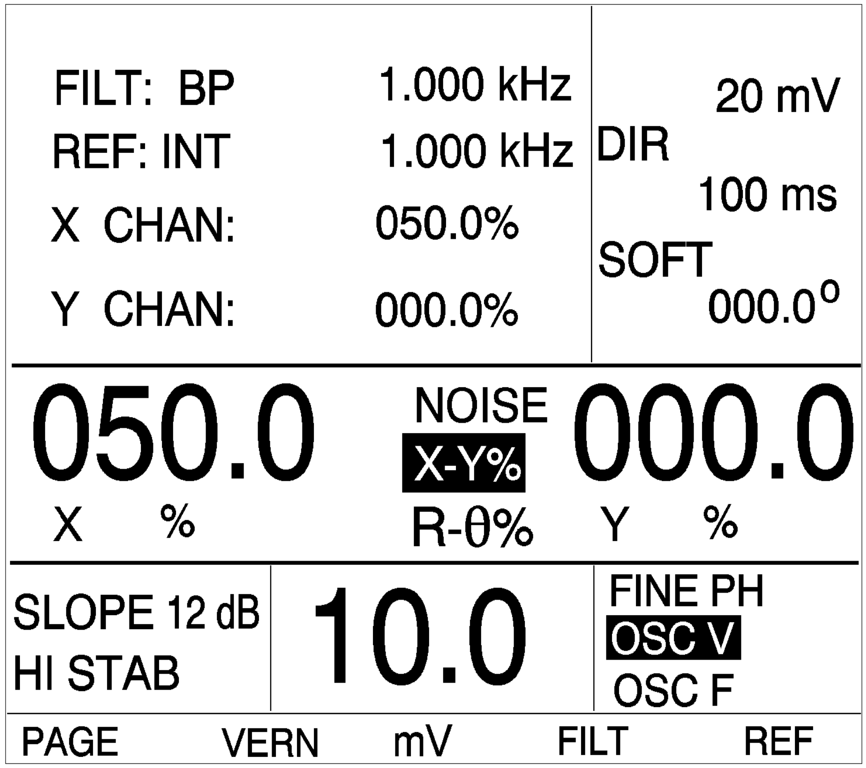


Figure 3-3. MAIN PAGE SCREEN AFTER SETUP

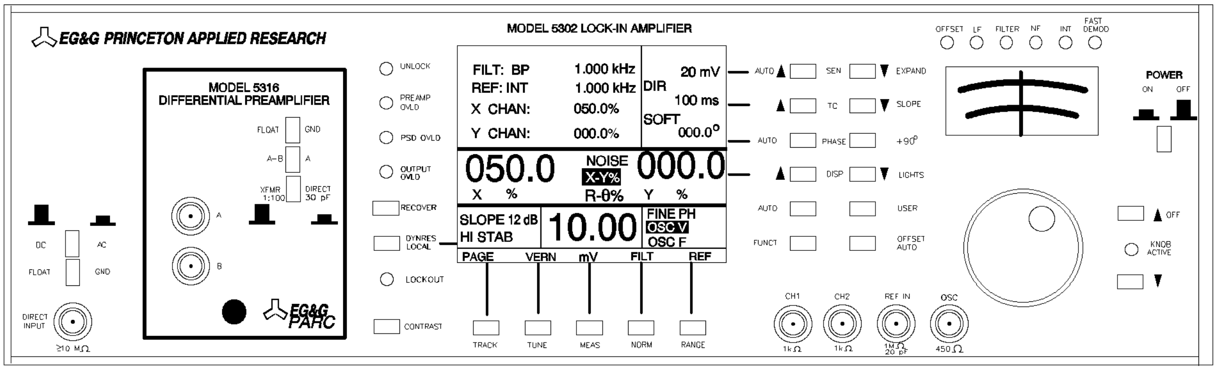


Figure 4-1. MODEL 5302 LOCK-IN AMPLIFIER

4.1 Introduction

This chapter of the manual describes the front panel with emphasis on operating considerations. When operating the 5302 from the front panel as opposed to controlling it from a remote computer via the IEEE-488 or RS232 Interface, your focus will primarily be on the display and on the associated pushbutton keys and setting knob. For this reason, much of the detail in this chapter deals with these items. Nevertheless, other features such as connectors, switches, and indicators are discussed as well.

4.2 The Display

4.2.01 Introduction

The Model 5302 features a back-lit liquid crystal display that works in conjunction with associated pushbutton keys and parameter setting knob to enable you to monitor measurement results as well as set the instrument's operation.

The display information is organized into pages. On any given page, some of the keys are defined as "softkeys" having functions defined on an adjacent part of the screen.

On power-up, the MAIN page (Figure 4-2) appears. The MAIN page is the primary operating screen. From there, pressing the PAGE softkey causes the LARGE DISPLAY page (Figure 4-3) to appear. This page features display of the two output quantities (selected from the MAIN page) in large numbers that can be read from across a room. From the LARGE DISPLAY page, you can use the SETUP softkey to advance to the SETUP MENU page (Figure 4-4). This gives access to the Setup screens, each of which facilitates setting up, configuring, or monitoring the status of some part of the 5302's operation. On completing a task that required accessing a Setup screen, you can return directly to the MAIN page with a single press of the MAIN softkey. Alternatively, you can press the PREV softkey to retrace your path one step at a time back through the selection tree.

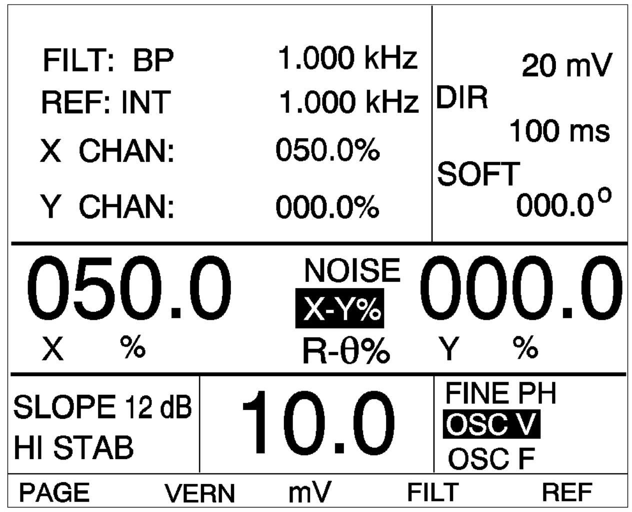


Figure 4-2. DISPLAY MAIN PAGE

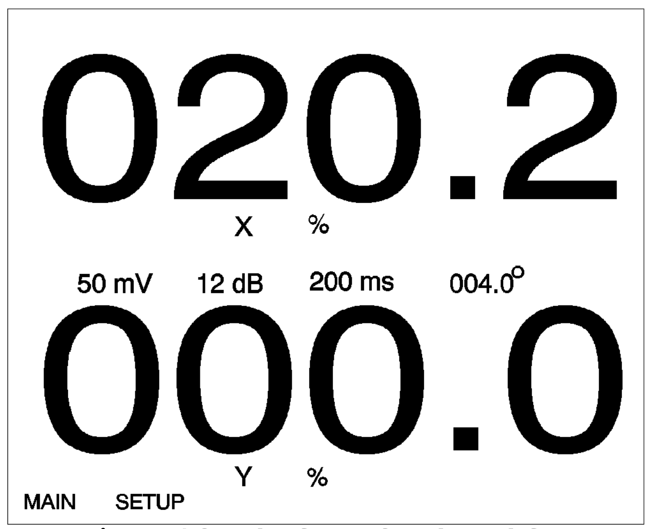


Figure 4-3. LARGE DISPLAY PAGE

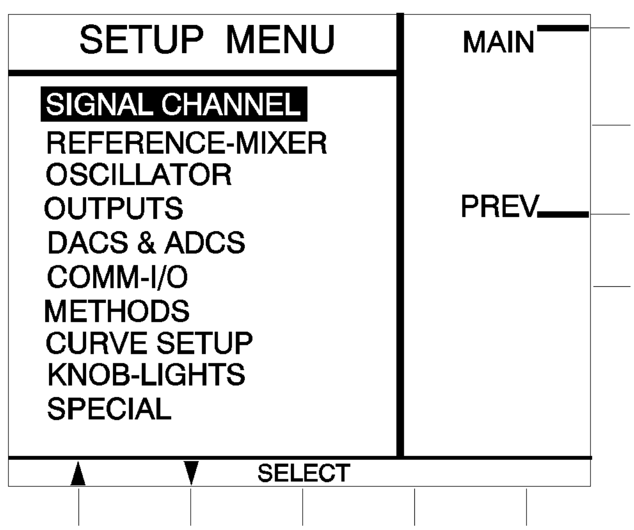


Figure 4-4. SETUP MENU PAGE

4.2.02 MAIN Page - general features

This page is displayed at power-up. In addition to indicating the output levels, it allows you to monitor and set most of the instrument parameters. The screen is divided into clearly delineated functional regions.

On this page there are five softkey functions defined on the lowest line of the display. The associated keys, located below the display, are also used to call some of the Auto-functions (Section 4.4.04) and have corresponding legends printed on the panel.

There follows a discussion of the items displayed in each area and the associated operating instructions.

4.2.03 MAIN Page - Upper Left (Figure 4-5)

Four parameters are always displayed. They are:

FILT: This line refers to the main signal-channel filter (Sections 6.2.06, 6.2.08). If the filter is in the Normal configuration, the filter mode and, except in the FLAT mode, filter frequency appear on this line.

If the Special configuration is active, the word SPECIAL appears instead of the mode and frequency.

FILT: FLAT	
REF: INT	1.000 kHz
X CHAN:	050.0%
Y CHAN:	000.0%

Figure 4-5. UPPER-LEFT AREA OF MAIN PAGE

In the Normal configuration, if the low-frequency mode is not active (LF status light not on), the Filter Mode may be selected by using the FILT key, the second key from the right of the keys beneath the display. The choices are:

FLAT: filter not in use
NOTCH: bandstop
LP: lowpass
BP: bandpass
HP: highpass.

Alternatively the NORMAL FILTER screen or the FLT command may be used.

If the low-frequency mode is active (LF status light on) while the MAIN page is displayed, operation of the FILT key results in the automatic selection of the Special configuration, with parameter values that implement an anti-aliasing filter suitable for the low-frequency demodulation system.

Whenever the SPECIAL legend is showing, operation of the FILT key brings up the NORMAL FILTER setup screen.

In the Normal configuration, the filter's resonance frequency can be set by the parameter-setting knob (Section 4.2.07), the NORMAL FILTER setup screen, the FF command, or automatically by the Auto-Tune of Auto-Track functions (Section 4.4).

In the Special configuration, the filter can be set up by means of the FILTER 1 and FILTER 2 setup screens or the commands listed in Section 6.2.08.

REF: When the reference channel is locked, the Reference Source mode (the options are INT, EXT, TTL) and the reference frequency are displayed on the second line. The word UNLOCKED appears instead of the frequency when the reference channel is unlocked.

Details of the reference source modes INT, EXT, and TTL are given in Section 6.3.01. The mode is selected by the use of the REF softkey (Section 4.4), the REFERENCE SOURCE screen, or the IE command.

X CHAN: This line shows the output of the x channel in % of full scale. It is always displayed, regardless of the mode or information being displayed in the center area. If the center display selection is X-Y%, the x channel value and the output value displayed at the left in the center area will be the same. Note that, if the OFFSET indicator is lit, the x offset will influence the displayed value.

Y CHAN: This line shows the output of the y channel in % of full scale. It is always displayed, regardless of the mode or information being displayed in the center area. If the center display selection is X-Y%, the y channel value and the output value displayed at the right in the center area will be the same. Note that, if the OFFSET indicator is lit, the y offset will influence the displayed value.

4.2.04 MAIN Page - Upper Right (Figure 4-6)

Three parameters are displayed as follows.

SENSITIVITY: The selected Sensitivity range is displayed at the upper right and is always present. You can set the sensitivity manually using the adjacent SEN ↑ and ↓ keys, or automatically by initiating an Auto-Sensitivity cycle (press AUTO and then the SEN ↑ key).

Full-scale sensitivities down to 100 nV can be selected in preamplifier operation (not including transformer gain) and down to 1 µV in DIRECT INPUT operation, except in the FAST mode (Time Constant < 20 ms) where the most sensitive setting is 100 µV, and in DC coupled operation where the most sensitive setting is 10 mV.

Note that, in the Auto-Range state, established by pressing AUTO and then RANGE, the word AUTO is continuously displayed to the left of the indicated sensitivity. Similarly, if the sensitivity vernier is active (VERN softkey pressed or Auto-Normalize performed), the word VERN is continuously displayed beneath the indicated sensitivity.

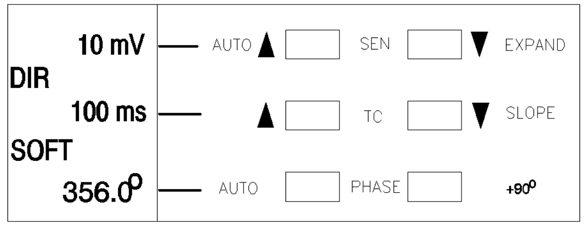


Figure 4-6. UPPER RIGHT DISPLAY AREA

OUTPUT TIME CONSTANT: The time constant of the output filters (Sections 6.4.07 - 6.4.10) is displayed below the sensitivity. The available values are 20 ms to 1000 s in a 2-5-10 sequence, and also the FAST mode time-constants 10 ms, 1 ms, 100 µs, and MIN. The FAST mode time constant settings are marked by the prefix F before the indicated value.

In FAST operation, the analog outputs appear at the rear-panel FAST OUT X and Y outputs.

The output time-constant is set by means of the adjacent TC ↑ and ↓ keys, the TIME CONSTANT screen, or the XTC command.

PHASE: The Reference Phase (Section 6.3.05) is displayed below the time-constant. The value lies in the range ±180.0 and can be set either by the setting knob in conjunction with the left PHASE key, by the PHASE SETUP screen, or the use of the P command; alternatively the Auto-Phase function (Section 6.8.01) may be used if appropriate.

The right PHASE key (+90° key) can be used to increment the reference phase setting by 90.0° at any time.

DIR or PRE: To the left and midway between the sensitivity and time-constant indications will appear either DIR (indicates that the selected Signal Source is the DIRECT INPUT connector) or PRE (indicates that the selected Signal Source is a modular preamplifier). These options can be selected from the SIGNAL SOURCE screen. See Section 6.2.02 for information on the signal source options.

SOFT or HARD: To the left and midway between the time-constant and phase indications will appear SOFT (phase control by mathematically rotating the demodulation axes) or HARD (phase control by shifting the phase of the PSD drive signals). These options can be selected from the PHASE SETUP screen. See Section 6.3.05 for information about phase control modes.

AUTO: Appears to the left of the sensitivity indication during Auto-function operation.

EX: Appears to the left of the sensitivity indication when EXPAND is active. The EXPAND function is toggled by the FUNCT,SEN ↓ sequence (Section 4.4) or set with the EX command.

VERN: Appears directly below the sensitivity indication when the Sensitivity Vernier is activated; this also causes the corresponding soft-key identifier (on the lowest line of the display) to appear in inverse video. When the vernier is active, the SEN ↑ and ↓ keys can be used to adjust the sensitivity over a range of 90% to 400% of the full-scale value indicated at the top of the display. The effect of this adjustment is the same as adjusting the VERN parameter with the setting knob. Note that selecting VERN limits the display mode selections to X-Y% or R-θ%. To leave the Vernier mode and re-establish calibrated sensitivity operation, press the VERN key again.

4.2.05 MAIN Page - Center (Output Display) (Figure 4-7)
This area is used to select the measurement mode and to display the output values. The area is divided into three sections, with the mode selection barrel in the center and with the two output value displays to the right and left respectively. The barrel is rotated by the DISP ↑ and ↓ keys to the right of the display such that three selections appear in the window at any time with the center one selected (selection indicated by inverse video). The name of the output being displayed and the units are indicated beneath the large-type indications. The mode selections are:

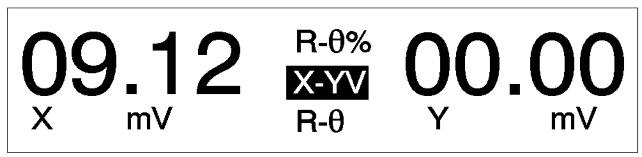


Figure 4-7. CENTER DISPLAY AREA

X-Y%
The x and y demodulator outputs are displayed as a percentage of full scale; x to the left and y to the right. When the phase is adjusted for maximum x output, a full-scale sinusoidal input will give +10 V at the CH1 output, full-scale deflection of the analog meter, and an indicated X output of 100%.

R-θ%
Magnitude is displayed to the left in percent of full-scale and Signal Phase to the right in degrees. The Magnitude output is provided at the CH1 connector (full scale is 10 V) and indicated on the analog meter. The Signal Phase output is provided at the CH2 output connector. The phase transfer function is 50 mV per degree, which gives ±9 V at ±180.0°. There is a discontinuity at 180°, that is, the output jumps from +9 V to -9 V as the phase passes through 180°.

X-YV
This is the same as the X-Y% display except that the x and y demodulator outputs are displayed in voltage units referred to the input (nV, µV, mV, or V, as indicated beneath the displayed values).

R-θ
This is the same as the R-θ% display except that the Magnitude output is displayed in voltage units referred to the input (nV, µV, mV, or V, as indicated beneath the displayed values).

RATIO
The display shows the ratio of the demodulator x channel output to the voltage applied to the rear-panel ADC 1 connector. The ratio is displayed on the analog meter and provided at the CH1 output connector, full scale being a ratio of ±10. The Magnitude output is provided at the CH2 connector, full scale being 10 V.

LRATIO
The display shows the logarithm (base 10) of the ratio of the demodulator x channel output to the voltage applied to the rear-panel ADC 1 connector. The display range is -1.999 to +1.999. The function is also provided at the analog meter, where the log ratio range is ±1 decade and at the CH1 connector (±10 V for ±1 decade). The Magnitude output is provided at the CH2 connector, full scale being 10 V.

θ-R
The difference between this and the R-θ display is that Signal Phase and Magnitude are interchanged: Signal Phase is displayed to the left in degrees, and Magnitude is to the right in voltage units referred to the input. The Signal Phase output is displayed on the analog meter and provided at the CH1 output connector, and the Magnitude output is provided at the CH2 connector.

NOISE
In making a noise measurement, the Model 5302 provides a measure of the root-mean-square value either of the output x of the x channel, or, when the Subtract Mean option has been selected, of (x - (mean value of x)). Before making a noise measurement, it is first necessary to make the appropriate selections from the NOISE Setup screen or with the use of the NNBUF command. For information about noise measurements, see Section 6.4.16.

4.2.06 MAIN Page - Lower Left (Figure 4-8)
The lower left window displays the Slope and Dynamic Reserve Mode settings.

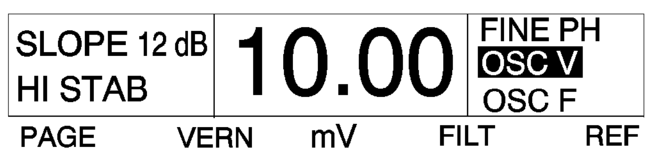


Figure 4-8. LOWER AREA AND SOFT-KEY BAR

SLOPE: This refers to the characteristics of the output low-pass filter (Section 6.4.08). Changing the slope value is a Function key operation - press the FUNCT key and then the SLOPE key (identically the ↓TC key). Four different display messages could appear: 6 dB (first order, exponential weighting), 12 dB (second order, exponential weighting), 6 □ (rectangular weighting), and 12 Δ (triangular weighting).

DYNRES: The Dynamic Reserve Mode is selected with the adjacent key, the choices being NORMAL, HI RES 1 (High Reserve Option 1), HI RES 2 (High Reserve Option 2), HI STAB (High Stability), and MIN (minimum).

The MIN reserve setting is automatically established with a FAST time constant setting (timeconstant 10 ms or shorter). The most sensitive input ranges are not available with minimum reserve.

Information concerning dynamic reserve is provided in Section 6.7.

4.2.07 MAIN Page - Lower Right (Setting Knob Functions)

The barrel window to the lower right always lists three parameters with the center one selected as indicated by inverse video. The barrel is rotated using the ↑ and ↓ keys to the right of the setting knob.

The setting knob is used to set the parameter values. The value in effect for the selected parameter is indicated in the center window in large type. The units are indicated beneath the parameter value indication. In the case of a few parameters (OSC V, OSC F, and FILT F), the key beneath the units legend increments the parameter value in decade steps.

The KNOB ACTIVE indicator to the right of the setting knob must be lighted for the knob to work. If the indicator is not lighted (knob inactive), simply press either of the keys to the right of the setting knob. This will turn on the indicator and activate the knob. Once the KNOB ACTIVE indicator is lighted, pressing either key will rotate the display barrel upwards or downwards according to which key was pressed and so change the selected parameter.

Further information about the setting knob is given in Section 4.8.

The following are the lower area parameters displayed in the right-hand barrel window and set with the setting knob:

OSC V: Allows you to set the output level of the internal sinusoid oscillator from 5 mV to 5 V rms. The units are indicated beneath the value display and the setting knob is used to set the level. The key beneath the units legend increments the output level in decade steps with foldover from the highest to the lowest. Note that setting the oscillator level from the MAIN page is equivalent to setting it from the OSCILLATOR screen.

OSC F: Allows you to set the frequency of the internal oscillator from 1 mHz to 1 MHz. The units are indicated beneath the value display and the setting knob is used to set the frequency. The key beneath the units legend increments the frequency in decade steps with foldover from the highest range to the lowest. Note that setting the oscillator frequency from the MAIN page is equivalent to setting it from the OSCILLATOR screen).

X OFS: Allows you to set the x channel offset up to ±3.0 x f.s (±30 times with expand on). The units (%FS) are indicated beneath the displayed value and the setting knob sets the offset level. The OFFSET key, located immediately to the left of the setting knob, enables and disables the offsets.

When offsets are enabled, the OFFSET indicator lights and the set level of offset is applied to either or both channels as dictated by the offset state selected via the OFFSET STATE screen.

Y OFS: Allows you to set the y channel offset up to ±3.0 x full scale. The units (%FS) are indicated beneath the displayed value and the setting knob sets the offset level. The OFFSET key, located immediately to the left of the setting knob, enables and disables the offsets.

When offsets are enabled, the OFFSET indicator lights and the set level of offset is applied to either or both channels as dictated by the offset state selected via the OFFSET STATE screen.

DAC1: Allows you to set the dc voltage at the rear-panel DAC1 connector over a range of ±12.5 V with 1 mV resolution. The units (Volts) are indicated beneath the value display and the setting knob is used to set the level. Note that setting a DAC from the MAIN page is equivalent to setting it from the DACS screen.

DAC2: Allows you to set the dc voltage at the rear-panel DAC2 connector over a range of ±12.5 V with 1 mV resolution. The units (Volts) are indicated beneath the value display and the setting knob is used to set the level. Note that setting a DAC from the MAIN page is equivalent to setting from the DACS screen.

FILT F: Allows you to set the resonance frequency of the main signal-channel filter (Section 6.2.08) over a range of 2 Hz to 1.25 MHz. The units are indicated beneath the value display and the setting knob sets the frequency. The key beneath the units legend increments the frequency in decade steps with foldover from the highest to lowest range.

VERN: Allows you to set the gain vernier over a range of 90% to 400% of full scale. Vernier operation is established by pressing the VERN softkey, and when it is in effect the gain is adjusted by the factor indicated. For example, if the selected Sensitivity were 100 mV with a vernier factor of 200%, a signal of 50 mV would give full-scale output.

When the vernier is active, the word VERN appears in the upper right area of the display, and the word VERN at the bottom of the display is in inverse video.

PHASE: Allows you to set the phase shift applied to the reference. The units (degrees) are indicated beneath the displayed value and the setting knob is used to change the phase over a range of ±180°.

FINE PH: Allows you to fine adjust the phase shift applied to the reference. The units (millidegrees) are indicated beneath the displayed value and the setting knob is used to change the phase over a range of ±1.000°.

4.2.08 MAIN Page - Soft-key Bar (Figure 4-8)
Located at the lower edge of the display is the soft-key bar, which contains the identifiers that indicate the softkey function for the current screen. The function of each of these keys on the MAIN Page is described in detail in Section 4.4. The interaction of these and other keys with the various Setup screens is described in Chapter 7.

4.3 Signal input

The Model 5302 gives you the option of operating with or without a plug-in preamplifier (Section 6.2.02). If no preamplifier is installed, the preamp cover must be mounted as described in Section 2.6. Then the input signal must be applied to the

DIRECT INPUT connector (see Figure 4-9) and the coupling parameters selected by the associated keys. If a preamplifier is installed, then you have the option of using either the direct or preamplifier inputs.

You select the active signal source, DIRECT or PREAMP, from the Signal Source screen or with the PREAMP command. If preamplifier operation is selected, then the input characteristics such as impedance and frequency response will be those of the preamplifier.

See Section 6.2.01 for information about the frequency modes. Note that the preamplifier, if in use, may be the primary factor determining the actual low frequency limits obtained.

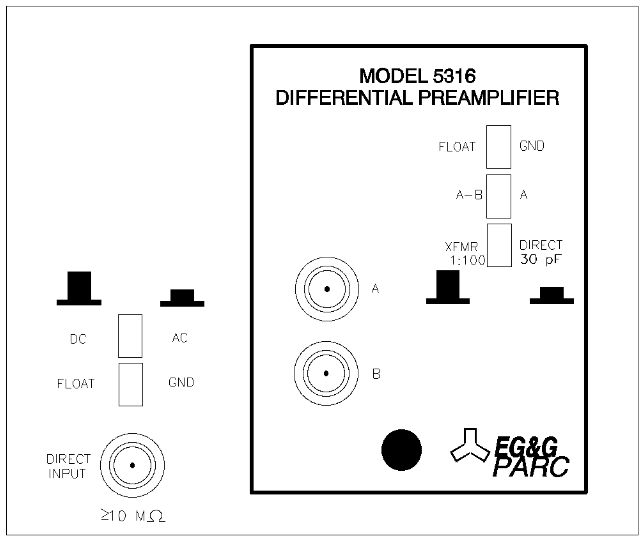


Figure 4-9. SIGNAL INPUT

The following paragraphs describe the individual Signal Input panel features. See Section 6.2.02 for further details.

DC/AC key: With DIRECT INPUT selected, this key determines whether the signal will be ac or dc coupled. As indicated on the panel, the latched position selects AC coupling and the released position selects DC coupling.

Selecting DC coupling eliminates low-frequency phase shifts. Note that the full-scale sensitivity only extends down to 10 mV in this mode.

FLOAT/GND key: In Direct input mode operation, this key determines whether the outer shell of the DIRECT INPUT connector is returned directly to ground or, alternatively, is returned to ground through a 1 kΩ resistor for improved ground-loop suppression. The latched position directly grounds the connector’s shell; the released position inserts the 1 kΩ resistor.

DIRECT INPUT: This BNC connector is the signal input when a modular preamplifier is not in use (Section 6.2.02). Selection of this input connector is from the SIGNAL SOURCE screen or by the use of the PREAMP command.

The input impedance depends on the frequency mode (Section 6.2.01). In

NORMAL and LOW 1, it is 10 MΩ in parallel with 25 pF. In LOW 2, it is 100 MΩ in parallel with 25 pF.

PREAMPLIFIER: When operating with a modular preamplifier, use the preamplifier's connector(s) and mode keys.

4.4 Display-related Keys

4.4.01 Introduction

The following paragraphs describe the keys grouped around the display, starting at the upper right of the display and working around the display in a clockwise direction. These descriptions assume that the MAIN page is current; most of the keys will be nonfunctional or have a different *softkey* function on the Setup screens.

4.4.02 Key List - main part

This Section includes all display-related keys except the softkeys and the AUTO key.

SEN keys:

There are two SEN keys, SEN ↑ and SEN ↓/EXPAND. SEN ↑ increases the displayed full-scale sensitivity value (Section 6.2.03) and SEN ↓ decreases it, in a 1-2-5 sequence.
Sensitivities down to 100 nV can be selected in preamplifier operation (not including transformer gain) and down to 1 µV in DIRECT INPUT operation, except in the FAST mode (Time Constant < 20 ms) where the most sensitive setting is 100 µV, and in DC coupled operation where the most sensitive setting is 10 mV.

Pressing the FUNCT key and then the SEN ↓/EXPAND key toggles the EXPAND function, which causes the x channel output to be multiplied by 10. When the EXPAND function is active, EX appears in the upper-right window of the MAIN page.

TC keys:

There are two TC keys. TC ↑ increases the time-constant setting of the output filters (Sections 6.4.07-10) and TC ↓/SLOPE key decreases it. The available values are 20 ms to 1000 s in a 1-2-5 sequence, and also the FAST mode time-constants 10 ms, 1 ms, 100 µV, and MIN. When a FAST time-constant is selected, the 5302 automatically enters the MIN dynamic-reserve mode, and the demodulator outputs are connected to the rear-panel FAST OUT X and Y output connectors.

The output filter slope selection is incremented by pressing the FUNCT key followed by the TC ↓/SLOPE key. The choices are 6 dB (first order, exponential weighting), 12 dB (second order, exponential weighting), 6 □ (rectangular weighting), and 12 Δ (triangular weighting). See Section 6.4.08, 6.4.10 for additional information.

PHASE keys:

There are two PHASE keys. Pressing the left one directly selects reference phase as the parameter to be adjusted by the parameter setting knob. The lower right window of the MAIN page will show PHASE as the selected parameter and the current value of the reference phase will be displayed in large type. The setting knob can now be used to set the reference phase to any desired value.

The right PHASE key (+90°) increments the reference phase by 90° each time it is pressed.

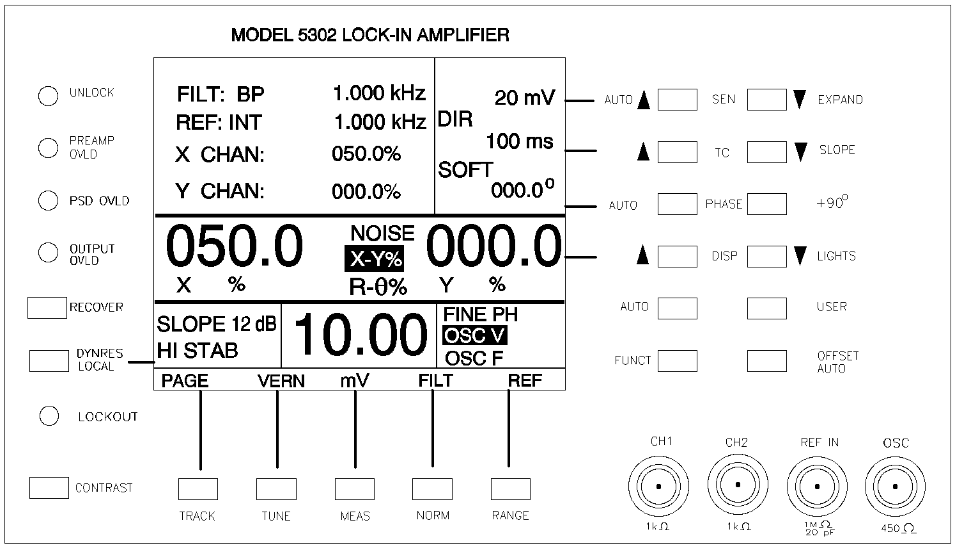


Figure 4-10. DISPLAY RELATED KEYS AND INDICATORS

DISP keys:

There are two DISP keys, DISP ↑ and DISP ↓/LIGHTS. Their primary function is to rotate the MAIN Page output display barrel and so make the output display selection. See the earlier discussion of the center display area for descriptions of the various output display choices.

Press the FUNCT key and then the DISP ↓/LIGHTS key to reverse the lights-control status. In one state the panel lights and display backlight work normally. In the other state they are blanked, convenient for making measurements that, of necessity, must be made in a completely darkened room. Note that the LIGHTS screen provides independent on/off control of the front-panel and display lights. The lights must be placed in the ON state via the LIGHTS screen for the front-panel LIGHTS facility to be operational.

USER key:

This key allows you step through a pre-programmed series of screens. Each press of the USER key causes the next screen in the sequence to appear. This can be very useful in measurements that require frequent resetting of parameters not available at the MAIN Menu. The ability to go directly to each required screen in this way can greatly enhance operational convenience.

The USER-key sequence is programmed using the FUNCT key and USER key together as explained under *User Key Program* in Section 4.4.04.

FUNCT key:

When momentarily pressed, this key changes the function of a two-function key to its secondary function, shown in green letters on the panel underneath the key. The keys having secondary functions controlled by FUNCTION include: SEN ↓/EXPAND, TC ↓/SLOPE, DISP ↓/LIGHTS, and DYNRES/LOCAL, which are all explained in this chapter under the heading of the primary function.

Also, pressing the FUNCT key twice in succession has the same effect as applying the GPIB remote message SELECTED DEVICE CLEAR (SDC). Applying SDC in this manner is one way of halting the data stream that results from the KNOB 2 or OUTFF 1 commands.

Thirdly, the FUNCTION key is involved in the USER key program (Section 4.2.03).

OFFSET/AUTO key:

Operated alone, this key enables or disables both the x and the y offset.
When offsets are enabled, the OFFSET indicator lights and the set level of offset is applied to either or both channels as dictated by the offset state selected via the OFFSET STATE screen.

Operated in conjunction with the AUTO key, the key causes an Auto-Offset operation to occur, as described in Section 6.8.06.

↑/OFF and ↓ keys:

The primary function of these keys, located to the right of the setting knob, is to control the operation of the parameter setting knob as described in Sections 4.2.07 and 4.8.

Press the FUNCT key and then ↑/OFF to deactivate the knob. The KNOB ACTIVE light to the right of the knob extinguishes when the knob is deactivated. Note that there is also a timeout, set from the KNOB screen, that deactivates the knob automatically if it has not been touched for a set period of time.

CONTRAST key:

Allows the user to adjust the display contrast for optimum viewing for the existing lighting conditions and viewing angle. To set the contrast, press *and hold in* the CONTRAST key, and while so doing, slowly rotate the setting knob for optimum.

DYNRES/LOCAL key:

The primary function of this key is to select the Dynamic Reserve setting (Section 6.7). The choices are NORMAL, HI RES 1 (High Reserve Option 1), HI RES 2 (High Reserve Option 2), HI STAB (High Stability), and MIN (minimum).

Press the FUNCT key and then the DYNRES/LOCAL key to toggle the Local Lockout state. In the locked-out state (LOCKOUT indicator beneath the DYNRES/LOCAL key lighted) the only key that remains functional is the DYNRES/LOCAL key. *Note that the rear-panel GPIB and RS232 ports are always active and, independent of the local-lockout state, can always be used to control the 5302.*

RECOVER key:

Although functionally not a display-related key, RECOVER is grouped with the other display keys and so is discussed here. In low frequency operation, pressing this key provides a short time-constant discharge path for the input coupling capacitors.

4.4.03 Softkeys

These keys, located at the lower edge of the display, in addition to initiating auto-functions as previously described, have soft functions determined by the display. A discussion of each of these keys follows.

PAGE: Advances to the LARGE DISPLAY page.

VERN: Establishes the non-calibrated Sensitivity mode, in which the sensitivity can be set to values intermediate to the preset ranges. When the vernier is active, the corresponding soft-key identifier is in inverse video and the word VERN appears beneath the sensitivity indication at the upper right of the display. The SEN ↑ and ↓ keys can then be used to adjust the sensitivity over a range of 90% to 400% of the selected sensitivity. The effect of this adjustment is the same as adjusting the VERN parameter with the setting knob. Note that selecting VERN limits the display mode selections to X-Y% or R-θ%. To leave the Vernier mode and re-establish calibrated sensitivity operation, press the VERN key again.

Example: If the 10 mV sensitivity range were in effect when VERN was activated, the SEN ↑ and ↓ keys could be used to set the sensitivity to any value from 9 mV to 40 mV (90% to 400%).

(units): The soft-key label for this key is the units in which the value directly above are being displayed. This key increments the value of certain parameters (OSC F, OSC V, and FILT F) in decade steps when they have been selected to be monitored and/or set. This capability greatly facilitates changing the parameter setting over a wide range.

FILT: This key selects the main signal-channel filter mode (Section 6.2.08).

REF: This key selects the reference channel source mode (Section 6.3.01), displayed in the upper left window. Selection of the Internal mode causes the INT indicator above the analog meter to light. When the reference channel is unlocked, not only does the UNLOCK indicator light, but the word UNLOCKED is displayed in lieu of the reference frequency indication.

4.4.04 AUTO key

The AUTO key initiates an auto-function operation. In each case, you first press AUTO momentarily, and then one other key. While the auto-function is in progress, an identifying message is flashed at the location of the X CHAN and Y CHAN legends. The various auto-functions are as follows.

Auto-Sensitivity: Press AUTO and then SEN ↑. This causes an Auto-Sensitivity operation to occur, as described in Section 6.8.03.

Auto-Phase: Press AUTO and then the left PHASE key. This causes an Auto-Phase operation to occur, as described in Section 6.8.05.

Auto-Offset: Press AUTO and then OFFSET. This causes an Auto-Offset operation to occur, as described in Section 6.8.06.

Auto-Track: Press AUTO and then TRACK (beneath the display). This causes the main signal-channel filter to enter the Filter Track mode, as described in Section 6.8.07. You can turn Filter Track off by pressing AUTO and then TRACK again.

Auto-Tune: Press AUTO and then TUNE (beneath the display). This causes an Auto-Tune operation to occur, as described in Section 6.8.07.

Auto-Measure: Press AUTO and then MEAS (beneath the display). This causes an Auto-Measure operation to occur, as described in Section 6.8.08.

Auto-Normalize: Press AUTO and then the NORM key (beneath the display). This causes an Auto-Normalize operation to occur, as described in Section 6.8.04.

Auto-Range: Press AUTO and then RANGE (rightmost of the five keys beneath the display). This causes the Auto-Range status to be toggled between 0 and 1, as described in Section 6.8.02.

4.4.05 USER key program

The USER key allows you to access, in sequence, as many as eight different pre-selected screens. Each press of the USER key causes the next screen in the sequence to appear. This can be very useful in measurements that require frequent resetting of parameters not available at the MAIN page.

Programming the sequence is quite straightforward and is done with the FUNCT key and USER key used together as follows.

a. Twice, press FUNCT and then USER (four key presses in all). This will clear the User key program sequence. (The sequence can also be cleared by the use of the USER KEY ERASE screen).

b. Press FUNCT and then USER. This places the instrument in the User key program mode. ***Note:*** *Nothing happens visibly when this is done.*

c. Using the screen access keys in the normal manner, step through the screens until the first screen in the sequence to be programmed is displayed. *Do not return to the MAIN page during this process. If you do, you will leave the User key programming sequence.*

d. Press FUNCT and then USER, thus executing inclusion of the displayed screen into the sequence.

e. Repeat steps "c" and "d" for each screen to be included, up to a maximum of eight. On completing step "d" for the last screen, return to the MAIN page, which will exit the User key programming sequence.

You can now access each of the screens in the programmed sequence by repeatedly pressing the USER key. Note that the User key sequence program can be cleared at any time by twice pressing FUNCT and then USER.

The User key sequence can also be programmed via the GPIB or RS232 port with the USER command.

4.5 Red (warning) indicator lights

Each of these four indicators, if lighted, warns of an error condition that needs to be corrected to assure valid measurements. A brief description of each follows.

OUTPUT OVLD: This indicator lights when the instantaneous output of either demodulator channel goes outside the range of ±120% of full scale. Note that the indicated output may or may not be outside this range, depending on the waveform which is causing the overload. All overloads must be corrected before exact measurements can be made. An overload can always be removed by increasing the full-scale sensitivity, but this is usually a last resort. You may try one or more of the following remedies to treat output overload: increasing the time-constant and/or slope of the output filter, changing the mode of the signal-channel filter, inserting the line-frequency notch filter, turning off the output expand function, or adjusting the output offset values.

PSD OVLD: This indicator lights when the demodulator is driven beyond full scale at its input. Appropriate remedial actions include increasing the dynamic reserve mode, changing the mode of the signal-channel filter, or inserting the line-frequency notch filter.

PREAMP OVLD: Indicates an overload ahead of the main signal-channel filter. Remedies include increasing the dynamic reserve mode and inserting the line-frequency notch filter.

UNLOCK: Indicates that the reference channel is not locked. In the External reference mode, this would ordinarily mean that a suitable reference signal has not been connected. Also, bear in mind that it may take some time to establish reference lock at low frequencies.

4.6 Output connectors

Below and just to the left of the setting knob are a set of four BNC connectors. One is the REF IN connector, discussed in Subsection 4.7. The other three, CH1, CH2 and OSC, are output connectors. A brief description of each follows.

CH1 and CH2: These are the principal analog outputs (output impedance 1 kΩ). The signals provided at each varies according to the selected Display Mode, as listed in Section 4.2.05.

Display modes X-Y% and X-YV:

CH1: The demodulator X channel output, scaled to ±10V full scale.

CH2: The demodulator Y channel output, scaled to ±10V full scale.

Display mode NOISE

CH1: The noise output (Section 6.4.16) scaled to +10V full scale.

CH2: The Magnitude output (Section 6.4.03) scaled to +10V full scale.

Display mode LRATIO

CH1: The logarithm of the ratio of the demodulator X channel output to the voltage applied to the rear-panel ADC 1 connector. The range is ±1 decade, corresponding to ±10 V at the CH1 connector.

CH2: The Magnitude output (Section 6.4.03) scaled to +10V full scale.

Display mode RATIO

CH1: The ratio of the demodulator X channel output to the voltage applied to the rear-panel ADC 1 connector. The maximum ratio that can be displayed is 10:1, which gives ±10 V at the CH1 connector.

CH2: The Magnitude output (Section 6.4.03) scaled to +10V full scale.

Display mode R-θ and R-θ%

CH1: The Magnitude output (Section 6.4.03) scaled to +10V full scale.

CH2: The Signal Phase output (Section 6.4.03) scaled to 50 mV/degree. There is a discontinuity at 180°, that is, the output jumps from +9 V to -9 V as the phase passes through 180°.

Display mode θ-R

CH1: As CH2 in the R-θ mode. Note that the phase can be read directly from the analog panel meter.

CH2: As CH1 in the R-θ mode.

2. **OSC:** The output of the internal oscillator is provided at this connector. The output impedance is 450 Ω, yielding a 10:1 attenuation if terminated in 50 Ω. The amplitude can be set from 5 mV to 5 V rms, and the frequency range extends from 1 mHz to 1 MHz.

   Note that when a cable is attached to this connector, its capacitance will attenuate the output and shift its phase at higher frequencies. This effect is greatly reduced by the use of a 50 Ω terminator.

   The amplitude and frequency can be set from the MAIN page or from the OSCILLATOR setup screen or by the use of the OA and OF commands.

4.7 REF IN connector

There are two reference input connectors for external reference mode operation, TTL REF IN (rear panel, TTL compatible) and REF IN (front panel, input impedance 1 MΩ in parallel with 30 pF).

The standard inputs at the REF IN connector are a squarewave of amplitude 100 mV or greater, or a sinusoid of frequency 1 Hz - 1 MHz and amplitude 1 V rms or more. Reference inputs of less than the standard values can be used at the expense of increased phase noise.

Further details are given in Section 6.3.01.

4.8 Setting knob

This is the large knurled knob located beneath the analog display. Except for those few parameters that are directly settable with keys, such as Input Sensitivity and Time Constant, the knob sets the value of all parameters. A given parameter could be settable from more than one screen. However, the basic operating parameters can all be set from the MAIN page with the setting knob. The value of the selected parameter is displayed in large type towards the bottom of the MAIN page display.

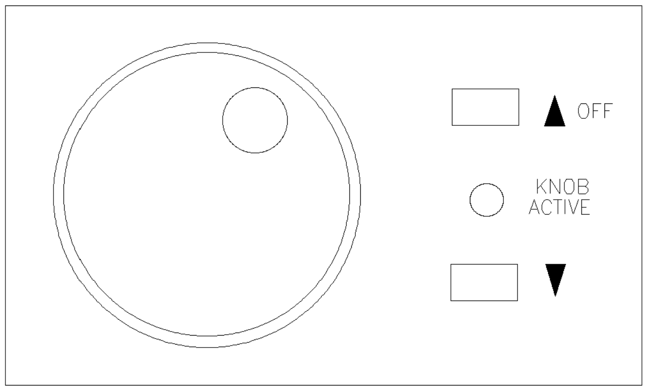


Figure 4-11. PARAMETER SETTING KNOB AND PARAMETER SELECTION KEYS

Note that the setting knob must be active as indicated by the green light directly to its right. Only when this indicator is lighted is the setting knob functional. When the light is out, pressing either of the associated selection keys will light it. So long as the indicator is lighted, pressing either key *rotates* the parameter selection barrel, the direction depending on which key is pressed.

The light can be extinguished and the setting knob rendered inactive by pressing the FUNCT key and then OFF, uppermost of the two keys to the right of the setting knob. You may wish to do this after setting one or more parameters to remove any possibility of disturbing the settings accidentally. The active state also times out and eventually extinguishes if there is no parameter changing activity for an extended period of time.

For convenience in setting a value with precision while still being able to span a large range quickly, the setting knob employs an electronic "gear shift". If the knob is turned slowly, the low gear is in effect, allowing the last place of the parameter value to be easily set. If the knob is turned quickly, it automatically "shifts gears", and the rate of change of the parameter for the same degree of knob rotation dramatically increases, allowing a large range to be quickly spanned. Once the setting is somewhere near the desired value, simply rotate the knob slowly to restore "low gear" operation so that the exact value can be set. The "speeded up" rate of parameter change as a function of knob speed can be independently set for each parameter using the KNOBGEAR setup screens.

The default knobgear and timeout parameters that govern the behavior of the setting knob are set via the KNOB screen.

4.9 Analog meter

The analog meter, located directly above the setting knob, always presents an analog indication of the output at the CH1 connector (Section 4.6) with full scale representing 10V. Scales having full-range values of ±1.0, ±2, ±5, and ±180° are provided for user reading convenience.

4.10 Yellow (status) lights

There is a row of six indicator lights above the analog meter. A brief description of each follows.

1. **OFFSET:** Indicates that offset has been enabled by the OFFSET key, the OFEN command, or the Auto-Offset operation.

2. **LF:** Low Frequency Mode indicator (Section 6.2.01).

3. **FILTER:** Indicates that the Normal filter, *or* the Special filter *or* the line notch filter is selected.

4. **NF:** Indicates that the demodulator is being driven at a harmonic of the reference frequency. Harmonics as high as the eighth can be selected from the REFERENCE HARMONICS screen or the FNF command.

5. **INT:** Indicates that the lockin is operating in the Internal Reference mode.

6. **FAST DEMOD:** Indicates that the FAST output filters (Section 6.4.09) are in operation.

4.11 POWER switch

This switch interrupts both sides of the ac power to the primary of the power transformer. As indicated on the panel, the power is off when the switch is released and on when it is latched.

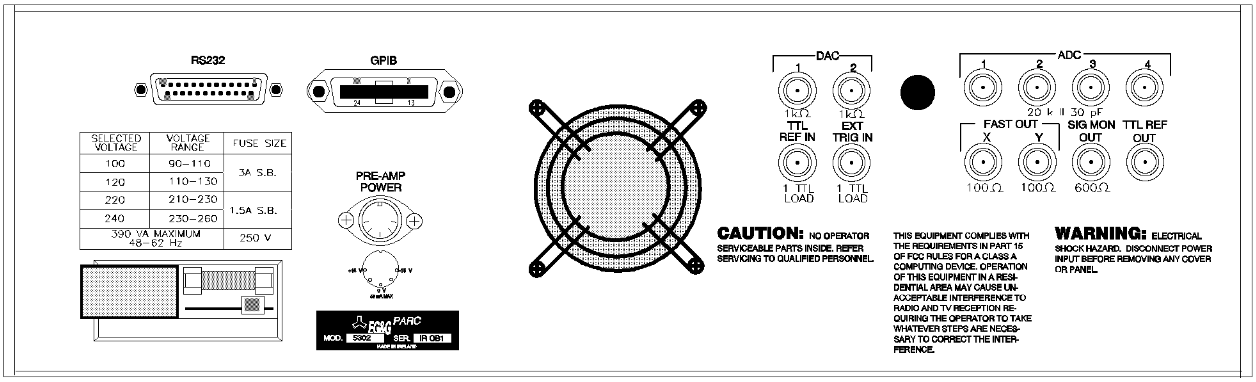


Figure 5-1. MODEL 5302 BACK PANEL

RS232 connector

The RS232 interface connector provides the serial communications capability. The details of the pinout are provided in Appendix C.

GPIB connector

The GPIB interface conforms to the IEEE-488 1978 Instrument Bus Standard. The standard defines all voltage and current levels, connector specifications, timing, and handshake requirements. Pinout details are provided in Appendix C.

PRE-AMP POWER connector

The Model 5302 can operate with an optional preamplifier powered via a cable that extends between the preamplifier and the PREAMP POWER connector. Pinout details are provided on the rear panel and in Appendix C.

Power input assembly

The Power Input Assembly is located at the lower left corner of the rear panel. Power and Line Voltage considerations are discussed in Chapter 2.

TTL REF IN connector

This BNC connector allows the reference channel to be driven from TTL sources. TTL compatible pulse inputs not acceptable to the front-panel reference connector can be applied. See Section 6.3.01 for further information.

EXT TRIG IN connector

This TTL compatible input is provided for external triggering in the External Trigger mode in Fast mode operation (Section 6.4.14). *Take care to distinguish between the EXT reference mode (5302 reference channel driven from signal applied to front-panel REF IN connector) and the External Trigger Mode (A/D conversions of output and ADC inputs controlled by a TTL compatible signal applied to EXT TRIG IN connector).*

ADC IN connectors

There are four ADC Inputs. Each can accept voltages in the range of ±12.5 V to be digitized and stored in memory. The input impedance is 20 kΩ in parallel with 30 pF. In Fast mode operation, a number of different Conversion (trigger) modes are provided (Section 6.4.14). They can be set from the front panel via the ADC Trigger

Mode screen, or by means of the **TRIG** command.

When not in Fast mode operation, the ADCs are always triggered asynchonously at 25 Hz.

Stored input values can be read later from the ADC screen or by means of the **ADC** command. In Ratio or Log Ratio operation, the x demodulator output is divided by the ADC 1 voltage.

DAC connectors

These connectors provide the outputs of two DACs (Digital-to-Analog Converters). The DAC output levels can be set by the DAC1 and DAC2 commands, or from the DACS screen. Full-scale output is ±12.5 V, corresponding to a command operand range of ±12,500. The output impedance is 1 kΩ.

SIG MON OUT connector

The output of the signal channel ahead of the demodulator is provided at this connector. The effect of the signal channel filters (line filters as well as the main filter) will be in evidence. The output impedance is 600 Ω.

The amplitude will depend on the full-scale sensitivity setting and on the dynamic reserve in effect.

In **LOW 1** and **LOW 2** reference operation, the observed signal will be modulated with a 100 Hz square wave.

TTL REF OUT connector

A TTL compatible signal synchronous with the reference is provided at this connector in the NORMAL frequency mode.

FAST OUT connectors

This pair of connectors, labeled **X** and **Y**, provide the demodulator X and Y channel outputs *when the output time constant is <20 ms, that is, when it is 10 ms, 1 ms, 100 µs, or MIN*. At higher time constant settings the FAST OUT outputs have no significance. The output impedance at these connectors is 100 Ω. For further details see Section 6.4.09.

6.1 System description

The Model 5302 Lock-In Amplifier consists of five functional blocks:

1. Signal Channel.
   The signal channel performs linear processing on the signal input, its output being connected to the signal input port of the demodulator.

2. Reference Channel.
   When the analog demodulator is in use, the reference channel generates switching waveforms which enable the demodulator to implement the required demodulation functions. When the digital demodulator is in use, the reference channel operates in software and generates the required demodulation functions as numeric sequences. The reference channel obtains its timing information from the reference input voltage or from the internal oscillator.

3. Demodulator (including output filters).
   The essential action of the demodulator is equivalent to multiplying the output of the signal channel by functions called the x and y demodulation functions, and operating on the results with low-pass filters (the output filters) to give the x and y outputs of the lockin. The action is implemented in hardware or software or a combination of both.

4. Internal Oscillator.
   The internal oscillator is a major convenience feature which usually avoids the necessity of using an external oscillator to generate the signal. Additionally, some performance specifications are improved by the use of the internal oscillator in the Internal Reference mode.

5. Auxiliary I/O.
   The auxiliary I/O consists of four analog-to-digital converters and two digital-to-analog converters which are externally connected and operate independently of the lockin itself but take advantage of the display and communication facilities of the lockin.

In this chapter, a description is given of the structure and operation of each of these blocks in turn. Two additional sections contain a discussion of dynamic reserve, and a description of the auto functions.

Where references are made to commands, front-panel keys or front-panel screens, further details may be found in Chapters 9, 4, and 7 respectively.

6.2 Signal channel

6.2.01 General description of signal channel; frequency modes.

The Signal Input voltage or current contains the signal to be measured (the 'required signal') generally accompanied by unwanted additive voltages or currents known as 'noise'. The signal channel performs linear processing (amplification, filtering, and squarewave modulation) on the signal input, its output being connected to the signal input port of the demodulator.

There are three frequency modes: NORMAL covers 1 Hz - 1 MHz, and the two low-frequency modes LOW 1 and LOW 2 cover 10 mHz - 20 Hz (ac coupling timeconstant 50 s) and 1 mHz - 20 Hz (ac coupling time-constant 500 s) respectively except when DC coupling has been selected from the front panel in which case LOW 1 and LOW 2 are identical and both go down to 1 mHz. Note that in DC coupled operation, full-scale sensitivity values below 10 mV are not available.

The reason for having the LOW 1 mode is to avoid the possible inconvenience of the long recovery time associated with a time-constant of 500 s when used at frequencies where it is not needed. Where it is more important to have the lowest possible phase shift, LOW 1 is not used.

When either LOW 1 or LOW 2 is in operation, the front-panel LF status light is activated.

The NORMAL, LOW 1, LOW 2 options are selected from the LOW FREQUENCY screen or with the use of the LOWF command. Also, when the internal reference source mode is in operation the lockin changes automatically from NORMAL to LOW 1 when the reference frequency drops below 1.0 Hz, and from LOW 1 or LOW 2 to NORMAL when the reference frequency increases above 20 Hz.

The signal channel hardware incorporates the input stage, the signal-channel filters (Section 6.2.06), and some further gain stages distributed at appropriate points in the circuit. There is also a 100 Hz chopper (squarewave modulator) which operates in LOW 1 and LOW 2.

The output of the signal channel is accessible at the SIG MON connector at the front panel. The connection is through a resistor of 600 Ω, so standard coaxial cables (typical capacitance of the order of 100 pF) may cause the SIG MON output to show some additional attenuation and phase shift at higher frequencies. Note that in LOW 1 and LOW 2 the SIG MON output is squarewave modulated at 100 Hz.

The temperature coefficient of gain of the signal channel is specified as ±200 ppm/degree, caused by temperature variations in the values of the resistors that determine the gain.

6.2.02 Signal Input.

The SIGNAL SOURCE screen and the PREAMP command select between the front-panel DIRECT INPUT connector and a modular preamplifier plugged into the front panel.

With DIRECT INPUT selected, the input impedance is 10 MΩ (or 100 MΩ when in the LOW 2 frequency mode) paralleled by 25 pF and the instrument is in the voltage measurement mode. The outer shell can either be grounded (FLOAT-GROUND key latched) or floated off ground by 1000 Ω (FLOAT/GROUND key released).

The Coupling key provides either ac coupling (DC-AC key latched) or dc coupling (DC-AC key released). Selecting DC coupling eliminates low-frequency phase shifts. However, the full-scale sensitivity only extends down to 10 mV in this mode.

Alternatively, operation with a preamplifier may be advantageous in that the instrument's performance may be better tailored to the measurement requirement. According to the preamplifier used, the Model 5302 may attain greater sensitivity, differential as well as single-ended input operation, transformer coupling for optimum noise performance when working from a low source impedance, or current measurement operation. See Appendix D for additional information about the available preamplifiers.

Note that only one signal source, either the DIRECT input connector or a modular preamplifier can be selected at any time. The alternate signal source remains inactive.

Also note that, whenever the Model 5302 is operated without a preamplifier, the preamplifier cover supplied with the instrument must be mounted. This cover provides shielding essential for proper operation when using the DIRECT input. To install the cover, simply position it so that the attached card is in line with the guides. Then push it back until the connector at the edge of the card mates with the internal connector. Last, rotate the cover's locking knob clockwise to secure the card to the panel. For maximum safety of the internal circuitry, the cover should only be installed or removed with the power OFF.

6.2.03 Full-scale Sensitivity

The overall gain of the instrument is varied by adjusting the full-scale sensitivity value. The full-scale sensitivity can be set by the front-panel SENSITIVITY keys, the SEN command, or automatically by the Auto-Sensitivity function.

Additionally, if the Vernier mode has been set, the sensitivity can be changed continuously over a range of 90% to 400% of the indicated value. The Vernier mode is controlled by means of the front-panel VERN key and setting knob, or by the G command.

The full-scale sensitivity is defined with reference to the situation where the reference frequency is in the midband region and with the main filter and the line notch filter not in use. In this situation the full-scale voltage sensitivity is the rms value of the input voltage, assumed sinusoidal at the reference frequency, required to give an output with full-scale magnitude. (The magnitude of the output is defined as the square root of the sum of the square of the x channel output and the square of the y channel output). Note that the higher the full-scale sensitivity value, the less sensitive is the instrument.

If a current-mode preamplifier is in use, a corresponding definition applies to the full-scale current sensitivity. See the preamplifier manual for operating instructions and performance specifications.

The lockin output is displayed on the front panel either in terms of the values of the x channel and y channel outputs, or in terms of magnitude and signal phase (Section 6.4.02) abbreviated in some locations to R-θ. The outputs are optionally expressed as a percentage of full-scale output (indicated by the % symbol) or in appropriate voltage or current units referred to the input.

When for example X-Y% has been selected at the display, an in-phase sinusoidal input voltage of say 1.0 mV will give rise to an output reading of 100% on the 1 mV range, 50% on the 2 mV range, etc. Thus the displayed signal level varies with the choice of full-scale sensitivity, as does the deflection of the analog meter which indicates the actual voltage output of the x channel of the demodulator (or the square root of the sum of the square of the x-channel output and the square of the y-channel output, if R-θ% has been selected). The deflection of the analog meter also indicates the analog voltage at the CH1 output socket.

When X-Y or R-θ has been selected for display, an in-phase sinusoidal input voltage of say 1.0 mV will give rise to an output reading of 1 mV on the 1 mV range, 1 mV also on the 2 mV range, etc. (Note that the analog meter gives the same deflection as when a %FS mode is selected). In this situation some care must be taken to avoid carrying out a measurement with an unduly large value of full-scale sensitivity, i.e. with the demodulator output at an unduly small fraction of full scale, with corresponding loss of accuracy and resolution.

In many lock-in applications there is no requirement for a direct indication of voltage and a % of full scale measurement mode is often to be preferred.

6.2.04 Signal-channel monitor

The gain of the signal channel is determined by an algorithm which distributes the required overall gain between the signal channel and the output filters, taking into account the selected dynamic reserve mode. Because of the operation of this algorithm, the gain of the signal channel as seen at the SIG MON connector does not increase in a regular way as the full-scale sensitivity value is reduced, and this fact should be taken into account when using the SIG MON output to monitor lock-in operation or to implement a stand-alone tuned amplifier.

The impedance of the SIG MON output is 600Ω and in conjunction with a typical cable capacitance of say 100 pF is likely to give rise to noticeable phase shifts and attenuation at the upper end of the frequency range unless a terminating resistor is used.

6.2.05 Signal-channel overload and distortion

There are three overload detectors in the signal channel, at the following locations in the circuit:

1. before the line frequency notch filter;

2. before the main filter;

3. at the output - the same point as accessed by the SIG MON connector.

The output of detector #1 is connected to the PREAMP OVLD indicator. Note that, in spite of its name, this indicator shows input overload whether or not a modular preamplifier is in use. Detector #1 also controls the assertion of bit 4 in the status byte and bit 6 of the overload byte (Section 8.7). Overloads indicated at this location are removed by increasing the full-scale sensitivity value or by increasing the value of the dynamic reserve mode selection.

The outputs of detectors #2 and #3 are connected to the PSD OVLD indicator. They also cause the assertion of bit 4 in the status byte and bit 5 of the overload byte (Section 8.7). Overloads indicated at this location are removed by increasing the full-scale sensitivity value, by increasing the value of the dynamic reserve mode selection, or by introducing one or more of the signal-channel filters.

In measurements where a low level of harmonic distortion is to be measured in the prescence of a much higher level of the fundamental, it may be important to ensure that the harmonic distortion of the signal channel itself should be as low as possible. In this situation the following recommendations are made:

1. Select the HI RES dynamic reserve mode;

2. Set the main filter to highpass, normal mode, tuned to the frequency of the harmonic that is to be measured;

3. By adjustment of the input amplitude or the full-scale sensitivity value, ensure that the input signal level is a relatively small fraction (say 20 percent) of the level required to operate the PREAMP OVLD or PSD OVLD indicators.

6.2.06 Signal-channel filters: general description

In order to discuss these filters we need to define four types of frequency response: lowpass, highpass, bandpass, and notch (otherwise known as bandstop). Each type of frequency response contains two parameters f_0 (resonance frequency or notch frequency) and Q (Qfactor).

The names are fairly self-explanatory: the lowpass cuts off at frequencies above f_0, the bandpass cuts off at frequencies both above and below f_0, and the bandstop cuts off in the region of f_0. The name 'notch' has become attached to the bandstop function because of the shape of the graph of filter gain against frequency. The Qfactor determines the sharpness of the cutoff.

The appropriate formulae and some further discussion are given in Section 6.2.09, but it is not necessary to read Section 6.2.09 to understand what follows.
Filters which implement the formulae are often referred to as second-order sections: second-order because they are quadratic in F and sections because they are used as building blocks in the creation of more complicated filters. Commonly this is done by cascading the sections, that is connecting the output of the first section to the input of the second, etc.

The 5302 has two signal-channel filters, the line-frequency notch filter consisting of two cascaded notch sections, and the main filter consisting of two second-order sections which can be switched between various modes of operation. The main filter is tunable in the range 2.0 Hz to 1.0 MHz, i.e. the value of f_0 is variable over this range. All filter sections are under front-panel or command control, and can be switched out when not required. The front-panel FILTER status light is activated when the line-frequency notch filter or the main filter is in operation.

6.2.07 Line frequency notch filter

This has two cascaded second-order sections, both operating in the Notch mode with Q = 1. The first section has the value of the notch frequency f_0 factory set to 60 or 50 Hz, depending on the country of destination, and the second section has the value of the notch frequency f_0 factory set to double that of the first section.

The filter is equipped with switches that can disable either or both of the sections, under the control of the LINE NOTCH screen and the LF command.

To calculate the gain and phase characteristic of this filter, refer to Section 6.2.09. Note that the Qfactor is only equal to 1, which implies that the filter has the disadvantage of giving substantial attenuation at frequencies well removed from the notch frequency. For example, in the case of a notch at 60 Hz the gain at 37 Hz and 97 Hz is only about 0.3.

The reason for using such a low Qfactor is that line frequencies vary with time by typically ±1 percent, and a filter with a narrower notch (higher Qfactor) would not give satisfactory attenuation over a range of this size. The chosen Qfactor of 1 gives better than 34 dB attenuation over a frequency variation of ±1 percent.

6.2.08 Main filter

This filter has two cascaded second-order sections, each of which can be set to operate in FLAT, BANDPASS, LOWPASS, HIGHPASS, or NOTCH mode. In any mode, the filter is characterized by two adjustable parameters f_0 (resonance frequency or notch frequency) and Q (Qfactor).

There are two filter configurations, Normal and Special. In the Normal configuration the two sections are set to have the same value of resonance frequency in the range 2 Hz to 1 MHz and to have a Qfactor of 2. In the Special configuration the resonance frequencies of the two sections are independently adjusted and the Qfactor of the first section can be set to one of the values 0.7, 2, or 10, the Qfactor of the second section being always 2. In this mode, because of the optional higher Qfactor, the first section is provided with a facility for fine tuning (FILTER 1 TRIM (SPECIAL) screen or FILTFINE command).

In the LOW 1 and LOW 2 frequency modes the main filter is constrained to be either in the FLAT mode or in the Special configuration with parameter values that implement an anti-alias filter suitable for the low-frequency demodulation system. This system is entirely digital and fully frequency-selective so that it does not require signal-channel filters to reject reference harmonics; however, it is not capable of the very high values of dynamic reserve that can be obtained under suitable conditions by the use of the main filter. Note that the filter 1 fine-tune parameter returns to zero when special filter is not active and not FLAT.

Caution: The Normal filter configuration, in conjunction with the Walsh demodulator, is designed to give the best results in almost all experimental situations. Do not use the Special filter configuration unless you have some specific reason for doing so.

The main filter is controlled from the FILT key, the setting knob, the front-panel screens FILTER CONFIG, NORMAL FILTER, SPECIAL FILTER, FILTER 1 (SPECIAL), FILTER 1 TRIM (SPECIAL), FILTER 2 (SPECIAL) and the filter commands FF, FILTFINE, FLT, FQ, SFF1, SFF2, SM1, SM2, and SPEF.

When the filter mode has been selected to BANDPASS, LOWPASS or HIGHPASS, the usual way of tuning the filter (i.e. adjusting f_0) is with the Auto-Tune or Filter Track functions implemented with the front-panel keys or by use of the ATS or ATC commands.

The Auto-Tune operation gives the most accurate and reproducible setting of the filters, and also updates the gain and phase correction parameters in the signal and reference channels.

The Filter Track function performs the same operations, but when in the external reference modes will only carry them out after it has detected a change of at least 2 percent in the applied reference frequency. Therefore, if the most accurate and reproducible settings are required, the Auto-Tune function should be called after every intentional change in reference frequency when in the external reference modes. It is advantageous to do this even in the FLAT filter mode, although in this case the required operations can be done slightly faster with the LOCK command.

The standard operating condition of this instrument is with the main filter in the Normal configuration and the BANDPASS mode. Use of the FLAT mode should normally be avoided where the full-scale sensitivity is less than 100 µV.

The FLAT filter mode operates in conjunction with the square-wave demodulator mode, which is automatically switched in when the FLAT filter mode is selected. In this situation all the Fourier components of the signal are required to contribute to the output, not just the fundamental. This mode of operation gives a slight theoretical advantage (1 dB in the signal/noise ratio) when the signal is a squarewave and the noise is assumed to be white, although in practice this advantage is usually difficult to demonstrate. However, the FLAT mode may show an advantage in the case where the actual area of the signal cycle is to be measured, for instance where the signal is a sequence of pulses with well-defined area but variable pulse shape. There are also advantages in terms of gain accuracy and phase accuracy especially in swept-frequency measurements.

6.2.09 Second-order frequency-response functions

In the following formulae, the responses of four standard types of second-order section to a sinusoid of frequency f are expressed in terms of the normalized frequency variable F and the Qfactor of the filter. F is defined as f/f_0 where f_0 is the resonance frequency (or notch frequency) of the filter. For comparison, a response called Flat (signifying filter not present) is also given.

With j signifying the square root of -1, the frequency-response function H of each section is given by the formulae:

Flat: $H = 1$
Bandpass: $H = (jF/Q)/((1 - F^2) + jF/Q)$
Lowpass: $H = (1/Q)/((1 - F^2) + jF/Q)$
Highpass: $H = (-F^2/Q)/((1 - F^2) + jF/Q)$
Notch: $H = (1 - F^2)/((1 - F^2) + jF/Q)$

For any given value of signal frequency, the gain (ratio of output amplitude to input amplitude) is equal to the magnitude of the complex quantity H and the phase angle between output and input is equal to the angle of H. To obtain the response of the whole filter, multiply the gains of the sections and add the phase angles.

6.3 Reference channel

6.3.01 Reference outputs and inputs

In the NORMAL frequency mode the reference channel generates switching waveforms which enable the demodulator hardware to implement the required demodulation functions. In the LOW 1 and LOW 2 modes the reference channel operates in software and generates the required demodulation functions as numerical sequences.

There are three reference source modes, internal (INT), external analog (EXT) and external TTL (TTL), one of which is selected by means of the REF SOURCE screen or the IE command. In the external modes the reference channel obtains its timing information from the reference input voltage; alternatively, in the internal mode the timing information is obtained from the internal oscillator. Internal reference operation is indicated by the front-panel INT status light.

The standard EXT reference inputs are a squarewave of amplitude 100 mV or greater, or a sinusoid of frequency 1 Hz - 1 MHz and amplitude 1 V rms or greater, connected to the REF IN socket on the front panel. Reference inputs of less than the standard values can be used at the expense of increased phase noise.

The TTL reference input is a TTL-compatible pulse sequence connected to the TTL REF IN socket on the rear panel. The reference channel triggers on every positive-going transition and sequences of narrow pulses (not acceptable to the external analog input) can be used.

In order to obtain the best accuracy and reproducibility in the external reference modes, the auto-tune function or the LOCK command should be executed after any change in reference frequency (Section 6.3.06).

To achieve the fastest possible reference lock at low frequencies in the external reference modes, it is advisable to start by establishing internal mode operation at the intended frequency, and then switch to external operation.

The reference channel can operate in the F mode or one of the NF modes (with N in the range 2 - 8), selected from the REF HARMONICS screen or with the F2F or FNF commands. NF operation is indicated by the front-panel NF status light.

In the F mode, which is the normal operating mode and is automatically selected at power-up, the reference frequency is the fundamental frequency of the reference input. In an NF mode, where N has a value of 2 to 8, the reference frequency is exactly N times the fundamental frequency of the reference input.

6.3.02 Reference unlock indicator

The message **UNLOCKED** appears in the upper left window of the display when no suitable reference voltage is being applied to the appropriate connector. When a suitable reference is applied, this message disappears.

6.3.03 Reference frequency meter

The Reference Frequency Meter is connected directly to the reference input circuit and operates in one of two modes. Above 2 kHz the unit counts the number of reference cycles in a period of 0.5 s, and below 2 kHz it goes into the Period mode and counts the number of cycles of a 4 MHz clock in one reference period, the result subsequently being divided into 4000000 to give the frequency. At 2 kHz both methods give a resolution of 1 part in 2000, and at other frequencies the preferred method gives a better resolution than 1 in 2000. Above 2 kHz the time for a measurement is always 0.5 s, and below 2 kHz the time is inversely proportional to the reference frequency and has its greatest value of 1000 s when the reference frequency has its lowest specified value of 1 mHz.

Although these details about the method of operation do not need to be known when the instrument is manually operated, they are of importance in the design of control programs where it is necessary to know the time that elapses between a change in the reference frequency and the availability of an accurate measure of it.

6.3.04 Reference acquisition

In the INT reference mode, acquisition is instantaneous because the software that generates the internal oscillator output also generates the output of the reference channel. In the EXT or TTL modes, acquisition below 100 Hz is entirely digital and takes the shortest possible time - that is, the time elapsed before the occurrence of two reference edges at the new frequency. This is at least 1, at most 2 reference cycles with a mean value of 1.5 reference cycles. Above 100 Hz, depending on the exact value of the change that has taken place in the reference frequency, a new measurement of reference frequency may be required; if so, this requires at least 0.5, at most 1.0, and on average 0.75 second. To this must be added the settling time of the phase-lock loops, say 0.1 second.

6.3.05 Reference phase and the phase shifter; phase noise

If the reference input is a sinusoid applied to the REF IN socket, the reference phase is defined as the phase of the x demodulation function with respect to the reference input.

This means that when the reference phase is zero and the input to the demodulator is a full-scale sinusoid in phase with the reference input sinusoid, the x output of the demodulator gives a full-scale positive value and the y output is zero.

The circuits connected to the REF IN socket actually detect a positive-going crossing of the mean value of the applied reference voltage. Therefore when the reference input is not sinusoidal, its effective phase is the phase of a sinusoid with positive-going zero crossing at the same point in time, and accordingly the reference phase is defined with respect to this waveform. Similarly, the effective phase of a reference input to the TTL REF IN socket is that of a sinusoid with positive-going zero crossing at the same point in time.

The reference phase is adjusted to its required value (see below) by the use of the phase shifter, which is implemented either by reference-channel hardware (Hard Phase mode) or by vector rotation implemented in software in the demodulator (Soft Phase mode). See Section 6.4.01 for more details about the phase shifters.

In either mode, the phase shifter is accessed from the front panel or by the P command or with the use of the Auto-Phase function. From the panel the phase can be incremented, optionally with the use of the PHASE SETUP screen, in steps of 100 millidegrees (phase parameter) or 1 millidegree (fine phase parameter) with the setting knob, or in quadrants with the 90º key.

In the Soft Phase mode the adjustment can be done very fast, the response time being independent of the output time constant. This mode also gives low phase noise (see below), high resolution, and seamless increments. Except when the required signal is not a sinusoid and the signal-channel filters are not in use,, the Soft Phase mode is more accurate than Hard Phase. Soft Phase is not available when the output time constant is less than 20 ms.

The correct method of setting the phase shifter depends on the type of measurement being performed. A case of particular interest is the signed-scalar measurement, where the aim is to measure the amplitude and sign of a signal which is of fixed frequency and whose phase with respect to the reference input does not vary apart from reversals of phase corresponding to changes in the sign of the signal. In this signed scalar measurement the phase shifter must be set, after removal of any zero errors (Section 6.8.04), to maximize the x or the y output of the demodulator. This is the only method that will give correct operation as the output signal passes through zero, and is also the best method to be used in an unsigned scalar measurement where any significant amount of noise is present.

There is inevitably some timing error between the required value of the reference phase and the phase of the actual waveform generated by the reference channel. This error, which has random and deterministic components, is called ’phase noise’. To a first-order approximation, phase noise does not affect the magnitude output, nor the x output when the phase shifter has been set to maximize the x output as discussed above. However, measurements of signal phase, or of y output where the x output has been maximized, are strongly affected by phase noise.

The Model 5302 offers a very low level of phase noise when the Soft Phase option has been selected; this is especially true in the internal reference mode, where the demodulation functions are generated directly by the oscillator without the intervention of a phase-lock loop or equivalent processing. Phase noise is also very low in the LOW 1 and LOW 2 frequency modes.

6.3.06 System updates and reference frequency changes

Both the signal channel and the reference channel contain parameters the required values of which are dependent on the reference frequency. These include the setting of the main filter when it is in use.

In the internal reference mode, these parameters are updated automatically every time the user makes a change in the reference frequency, however small. In the external reference modes the processor uses the reference frequency meter to monitor the reference frequency supplied by the user, and updates the parameters when a change of two percent has been detected.

All the parameters are also updated when the Auto-Tune operation is performed. Therefore if the most accurate and reproducible settings are required, the Auto-Tune function should be called after every intentional change in reference frequency when in the external reference modes. It is advantageous to do this even in the FLAT filter mode, although in this case the required operations can be done slightly faster with the LOCK command. Note that sufficient time must be allowed for the frequency meter to give a fully accurate value.

6.3.07 Reference monitor

The output of the reference channel can be monitored at the TTL REF OUT rear-panel socket. This output is TTL compatible, and monitors correct reference channel operation but does not necessarily show the correct phase relationship with the SIG MON output in that under some conditions it shows phase reversal.

The impedance of the TTL REF output is 600Ω and, in conjunction with a typical cable capacitance of say 100 pF, gives rise to severe pulse distortion at higher frequencies unless a terminating resistor is used.

6.3.08 Beats and the choice of reference frequency

It is mentioned elsewhere (Sections 6.4.02, 6.4.04, 6.4.05) that output errors (beats and/or offsets) may occur as a result of deterministic noise with frequency close to a harmonic of the reference frequency. Also (Section 6.4.15) beats may occur between the reference frequency and the sampling frequency and its harmonics.

The most damaging effect of beats occurs when the beat frequency is very low, so that the existence of beats is not apparent to the user and the effect is the same as a static output error. In critical measurements where the reference frequency can easily be changed, it is common practice to test for slow beats by making small changes to the reference freqeuncy to increase the frequency of any slow beats and thus make the effect more easily visible. When a beat has been identified, its frequency is increased (usually by changing the reference frequency) until it is high enough to be eliminated by the output filter.

Where the beats involve the sample frequency, the same procedure can be carried out with the use of the SAMPLE command or the front-panel controls to adjust the system sample rate (Section 6.4.15).

6.4 Demodulator including output filters

6.4.01 General description of demodulator

The essential action of the demodulator (implemented by hardware, software or a combination of both) is to multiply the output of the signal channel by functions called the x and y demodulation functions, and to operate on the results with low-pass filters (the output filters) to give the x and y outputs of the lockin. The demodulation functions are periodic at the reference frequency, and the y demodulation function is the x demodulation function delayed by a quarter of a reference cycle.

The 5302 implements an analog demodulator with two alternative configurations (squarewave and Walsh, Section 6.4.04) and two alternative methods of phase control (Hard Phase and Soft Phase). There is also a fully digital demodulator that is used in the LOW 1 and LOW 2 frequency modes, preceded by an analog squarewave demodulator operating at 100 Hz, synchronously with the signal-channel chopper (Section 6.2.01). The output filters are implemented by a combination of analog and digital techniques.

The analog demodulator has two channels, each incorporating a set of switches, an analog low-pass filter, and an analog-to-digital converter. The switches are operated by waveforms generated by the reference channel, and can be set either to the squarewave or the Walsh configuration (Section 6.4.04). There are two alternative methods of implementing the phase-shift function which adjusts the reference phase (Section 6.3.05). In Hard Phase, one of the hardware channels is committed to the x demodulation channel and the other to the y channel, phase adjustment being done by an analog phase-shifter in the reference channel. In Soft Phase, the required x and y demodulation functions are implemented with the aid of software, the waveforms generated by the reference channel having a fixed phase relationship with the reference input and the x and y outputs being obtained as linear combinations of the outputs of the two analog-to-digital converters.

The lockin output is displayed on the front panel either in terms of the values of the x channel and y channel outputs, or in terms of magnitude and signal phase (Section 6.4.02) abbreviated in some locations to R-θ. The values are optionally displayed as a percentage of full-scale output (indicated by the % symbol) or in appropriate voltage or current units referred to the input. The type of output display is selected by the use of the DISP key.

The analog outputs, and the values sent as command responses, are always scaled as a percentage of full scale.

6.4.02 Operation of the demodulator

The operational effect of the demodulator can be seen by considering its response to a signal sinusoid of amplitude V_{sp} and frequency f_s. The demodulation function may be a sinusoid at the reference frequency f_r, or if non-sinusoidal may be expressed as the sum of sinusoids at the reference frequency and its odd harmonics. For each sinusoidal constituent of the demodulation function, at frequency say f_d and amplitude V_{dp}, the multiplication generates a product of two sinusoids which can be expressed (using a standard trigonometrical formula) as the sum of two sinusoids at the sum and difference frequencies $(f_s + f_d)$ and $(f_s - f_d)$, with amplitude equal to $(V_{sp}V_{dp}/2)$. Except where $f_s = f_d$, these are time-varying voltages which become attenuated to a greater or less extent by the output filters. In the case $f_s = f_d$, the difference term is at zero frequency and causes the output of the demodulator to have a dc component (mean value) equal to:

$$(V_{sp}V_{dp}\cos(\alpha)/2)$$

where α is the phase difference between the signal-channel sinusoid and the relevant sinusoidal constituent of the demodulation function. Note that the sum frequency $2f_s$ is present with amplitude $(V_{sp}V_{dp}/2)$.

We now apply these results to four different forms of the voltage $V_1(t)$ applied by the signal channel to the signal input port of the demodulator:

1. Required Signal
   If $V_1(t)$ contains a sinusoid $V_s(t)$ (the required signal) at the reference frequency f_r, but does not contain sinusoids at harmonics of the reference frequency, the x channel of the demodulator gives a mean output V_{xmean} proportional to the component of $V_s(t)$ which is in phase with the x demodulation function and the Y channel of the demodulator gives a mean output V_{ymean} proportional to the component of $V_s(t)$ which is in phase with the y demodulation function - that is, in quadrature with the x demodulation function. These are the required outputs of the system: in order to make use of them it is normally necessary to reduce the effect of the accompanying sum-frequency ac voltages (the largest is typically at $2f_r$) by setting the time constant of the output filters to a value greater than $1/f_r$. Note that a time constant much greater than this value may be required in order to reduce the effects of random and deterministic noise.

   When the output filters are set to a sufficiently long time constant, the demodulator outputs are constant levels $V_x = V_{xmean}$ and $V_y = V_{ymean}$. The function $(V_x^2 + V_y^2)^{½}$ is dependent only on the amplitude of the required signal $V_s(t)$ (i.e. it is not dependent on the phase of $V_s(t)$ with respect to the reference input) and is computed by the processor in the lockin and made available as the *magnitude output*. The phase angle between $V_s(t)$ and the x demodulation function is equal to the angle of the complex quantity $(V_x + jV_y)$, where j is the square root of -1; it is also computed by the processor by means of a fast arctan algorithm, and made available as the *signal phase output*. The use of the magnitude and signal phase outputs is discussed in Section 6.4.03.

2. Harmonic Responses
   If $V_1(t)$ contains a sinusoid at a harmonic of the reference frequency corresponding to a harmonic constituent of the demodulation functions, this will make its own contribution to the mean value of the x and y outputs. This effect is called a harmonic response and is usually (but not always) unwanted. Harmonic responses can be reduced to negligible levels by the use of signal-channel filters and/or by suitable demodulator design.

3. Random Noise
   If $V_1(t)$ contains an unwanted randomly varying voltage (random noise), this will give rise to random noise at the x and y outputs. If the noise process has an approximately flat spectrum (white noise) the root-mean-square value of the output noise is inversely proportional to the square root of the time constant of the output filters.

4. Deterministic Noise
   If $V_1(t)$ contains an unwanted sinusoid (deterministic noise or interference) of frequency f_i which is not a harmonic of the reference frequency, the x and y outputs will contain sinusoids at frequencies $(f_i \pm nf_r)$ where the relevant values of the integer n depend on the form of the demodulation function. If the interference frequency f_i is close to a harmonic of the reference frequency, the demodulator output may contain responses at difference frequencies which are low enough to cause slow oscillations at the output in spite of the action of the lowpass filter; this effect is often referred to as *beats* between the unwanted signal and the reference harmonic (Section 6.3.08).

6.4.03 Use of Magnitude and Signal Phase outputs

The magnitude and signal phase outputs, as defined in Section 6.4.02, are used in cases where phase is to be measured, or alternatively where the magnitude is to be measured under conditions of uncertain or varying phase.

One case of varying phase is that in which the reference input is not derived from the same source as that which generates the signal, and is therefore not exactly at the same frequency. In this case, if the input signal is a sinusoid of constant amplitude, the x and y demodulator outputs show slow sinusoidal variations at the difference frequency, and the magnitude output remains steady.

However, the magnitude output has disadvantages where noise is present at the outputs of the demodulator. When the required signal outputs (i.e. the mean values of the demodulator outputs) are less than the noise, the outputs take both positive and negative values but the magnitude algorithm gives only positive values: this effect, sometimes called noise rectification, gives rise to a zero error which in the case of a Gaussian process has a mean value equal to 0.751 multiplied by the combined root-mean-square (rms) value of the x and y demodulator noise. Note that unlike other forms of zero error (Section 6.4.11) this is not a constant quantity which can be subtracted from all readings, because when the square root of the sum of the squares of the required outputs becomes greater than the total rms noise the error due to this mechanism disappears.

A second type of signal-dependent error in the mean of the magnitude output occurs as a result of the inherent non-linearity of the magnitude algorithm: this error is always positive and its value, expressed as a fraction of the signal level, is half the ratio of the mean-square value of the noise to the square of the signal.

These considerations lead to the conclusion that when the magnitude output is being used, the time constants of the demodulator should be set to give the required signal/noise ratio at the x and y demodulator outputs; improving the signal/noise ratio by averaging the magnitude output itself is not to be recommended.

For analogous reasons, the magnitude function also shows signal-dependent errors when zero offsets are present in the demodulator. For this reason, it is essential to reduce zero offsets to an insignificant level (usually by the use of the auto-offset function) when the magnitude output is to be used.

Note that the majority of lock-in applications are scalar measurements, where the phase between the required signal and the reference voltage is constant apart from possible phase reversals corresponding to changes in the sign of the quantity being measured. In this situation the lock-in amplifier is used in the normal x-y mode, with the phase shifter adjusted to maximize the x output and to bring the y output to zero. (Refer to Section 6.7.03 for further information on the correct use of the Auto-Phase functions for this purpose, and Section 6.3.05 for further information about the phase shifter.)

6.4.04 Squarewave and Walsh demodulators

Squarewave demodulator operation is available in the 5302 by the use of the FLAT filter option, which also disables the signal-channel filters.

With the squarewave demodulator, the outputs of the reference channel are squarewaves at the fundamental frequency of the reference input voltage, with a phase difference of 90 degrees between the channels. The multiplying element consists of a reversing switch under the control of the squarewave generated by the reference channel. In practice this reversing switch consists of a two-way switch which causes the signal path to be connected alternately to the output of the signal channel and the output of an inverting amplifier (i.e. an amplifier with transfer function approximately equal to -1) the input of which is connected to the output of the signal channel. Functionally, this arrangement acts as an analog multiplier which multiplies the output of the signal channel with a demodulation function consisting of a reference-derived squarewave having the two values 1 and -1. The Fourier analysis of this waveform consists of the fundamental and all odd harmonics, the amplitude of the nth harmonic being proportional to 1/n. (Note that the fundamental is regarded as the first harmonic.)

It follows from the discussion of Section 6.4.02 that the squarewave demodulator gives a steady-state output resulting from any Fourier component of the signal channel output which is at the fundamental frequency of the reference input voltage or any of its odd harmonics, with the gain being inversely proportional to the harmonic number. Also, interfering signal voltages at frequencies near the odd-harmonic frequencies can cause damaging beats at the output.

The squarewave demodulator is simple to implement and (because the multiplication is performed only by switches) is capable of excellent performance at low cost. However, in the majority of experimental situations the odd-harmonic responses of the squarewave demodulator are undesirable in that they implement ’windows’ in the frequency domain through which interfering voltages at or near odd harmonics of the reference frequency can cause output errors, in the form of static offsets or of low-frequency beats (Section 6.4.02).

In principle, the problem can be solved by the use of the fundamental-only demodulator. In this system, the outputs of the reference channel are sinusoids at the fundamental frequency of the reference input voltage, with a phase difference of 90 degrees between the channels. The multiplier itself is simply a standard analog multiplier (i.e. one which accepts continuously variable voltages at both its inputs) with one input connected to the output of the reference channel and the other to the output of the signal channel. Therefore the demodulation function is a sinusoid and there are no responses to reference harmonics other than the first.

In practice, there are severe problems both in implementing an analog multiplier of sufficiently good performance (in terms of frequency response, offsets and linearity) and also in constructing a reference channel to generate the required reference-derived sinusoids with sufficient purity over the frequency range required in general-purpose lockins. Therefore, the most common way of removing harmonic responses has been with the aid of signal-channel filters which reduce the amplitude of the offending components of the signal before they reach the demodulator.

A general-purpose lockin is normally equipped with signal-channel filters for quite a different reason, which is to increase the dynamic range by attenuating high-level interfering signals which would otherwise force the signal-channel gain to be reduced in order to prevent overloading. The preferred Qfactor, particularly for filters under microprocessor control, is not more than 2 in order to avoid excessive phase errors, but even a fourth-order filter with Q=2 does not give sufficient rejection of reference harmonics.

What is required is a demodulator which like the squarewave demodulator implements its demodulation function with switches, but which has better harmonic rejection. An obvious solution is to use more switches, and a set of scaling resistors, to implement a demodulation function which is intermediate between a squarewave and a sinusoid. The required coefficients can be calculated by the application of Walsh analysis, which is the counterpart of Fourier analysis in the domain of switching functions.

The 5302 features an 8-interval switching demodulator which multiplies the signal by a Walsh-function approximation to a sinusoid. A special feature of this demodulation function is that it contains no harmonics below the seventh, and in conjunction with a properly designed filter (the fourth-order filter with Q = 2, which is the Normal configuration of the main filter) gives an outstandingly good performance in most signal-recovery situations.

The Walsh demodulator is automatically switched in whenever the main filter is in use in the Normal configuration, in a mode other than FLAT, provided that the output time constant is set to a value greater than 10 ms.

When the main filter is switched to the FLAT mode, the configuration of the demodulator automatically changes to the squarewave type.

6.4.05 Digital demodulator

The digital demodulator consists of a delta-sigma converter the output of which is multiplied by sine and cosine values generated by special-purpose software clocked at 4 MHz and triggered by each incoming reference edge. The lowpass filtering is entirely digital and is synchronous with the reference frequency so that optimum smoothing is achieved.

6.4.06 Effective Demodulator Gain and dynamic reserve

The *effective demodulator gain* is defined for either channel in relation to the situation where the input voltage is a reference-frequency sinusoid in phase with the demodulation function, and the output time-constant is sufficiently long to ensure that the output is a constant value. Then the effective demodulator gain EDG is defined as the ratio of the output value, expressed as a fraction of full scale, to the peak value of the input sinusoid, expressed as a fraction of the input overload level.

It follows from the above definition that the system can deal, without overload, with noise voltages greater than the full-scale required signal voltage by a factor (EDG - 1). This factor is the demodulator dynamic reserve.

When an increase in the dynamic reserve is implemented by the software, the gain of the signal channel is reduced in order to reduce the signal level at the demodulator input. Correspondingly, the gain of the demodulator is increased to keep the overall sensitivity the same. If an analog demodulator is in use the dc gain of the output filters is increased, otherwise the required gain change is implemented in software.

6.4.07 Function of output filters

The time variation of the output of the lockin is required to represent the time variation of the magnitude and phase of the required input signal. The function of the output filter is to reduce the level of spurious (i.e. unwanted, non-information bearing) time variations, commonly referred to as output noise which may be random or deterministic in nature.

One inevitable source of deterministic output noise results from the shape of the waveform of the required signal. For example, the familiar rectified sinusoid waveform with mean value 1.00 varies from zero to ($\pi/2$) twice in each cycle. A second-order filter with time constant equal to the period of the sinusoid will reduce the time variation to about ±0.02, and a filter with three times this time constant will leave a time variation less than ±0.002. Where the residual fluctuation is less than 1 least significant bit of the output converter, a noise-free input sinusoid gives rise to a noise-free digital output. However, where additive noise (random or deterministic) is present, the output time constant will normally be increased to a value which reflects a compromise between output noise and response time. Note that for rejection of deterministic noise the second-order output filter is greatly superior to the first-order filter for equivalent response time.

In the LOW 1 and LOW 2 frequency modes the filter is synchronous, i.e. the time constant is automatically set to be an integer number of reference cycles. The time constant is not less than 1 s and not less than the selected value. Triangular weighting is recommended in these modes.

Synchronous filtering has the major advantage of removing deterministic output noise resulting from the waveform of the required signal while keeping the response time as short as possible.

If the noise process is random with an approximately flat spectrum (white noise) the root-mean-square value of the output noise is inversely proportional to the square root of the time constant of the output filters. The greater the time constant, the narrower is the overall measurement bandwidth and the greater the improvement in the output signal/noise ratio. This improvement is obtained at the expense of increased response time.

6.4.08 General description of output filters

The output filters are implemented both by analog and digital techniques and are of types classified as "exponential 6 dB/octave", "exponential 12 dB/octave", "rectangular" and "triangular". This terminology has sometimes been found confusing and the following explanation may be helpful.

In traditional audio terminology, a first-order low-pass filter is described as having "a roll-off (or slope) of 6 dB per octave" because, in the high-frequency limit, its gain is inversely proportional to frequency (6 dB is approximately a factor of 2 in amplitude and an octave is a factor of 2 in frequency); similarly a second-order lowpass filter is described as having "a roll-off (or slope) of 12 dB per octave". These terms have become part of the accepted terminology relating to lock-in output filters and are used in the Model 5302, in which, for example, the front-panel designation of the order of the output filters reads SLOPE 6 dB or SLOPE 12 dB.

The terms "exponential", "rectangular", "triangular" refer to the shape of the weighting function of the output filter. (In the case of these time-invariant filters, the weighting function has the same shape as the impulse-response function with time reversal.) The 6 dB/octave exponential function is that given by a single-stage resistor-capacitor circuit. A rectangular weighting function requires a delay line and an integrator for implementation in analog form, but in digital form requires only a simple sliding average; its frequency response goes as sin(x)/x where x is defined as ($\pi \cdot$ frequency $\cdot$ time-constant), and the envelope of this function has a slope of 6 dB/octave.

The 12 dB/octave filters (exponential or triangular) can be constructed from two equal 6 dB/octave (exponential or rectangular) filters in cascade. For engineering reasons, the four filter functions are not implemented exactly in the 5302; however, for most purposes the filters will be indistinguishable from the ideal models.

The 5302 has two alternative output filters in each channel, the fast output filter used with time constants less than 20 ms and the main output filter for longer time constants.

The time constant of the output filters is controlled from the Main page of the front-panel display, the TIME CONSTANT screen, and the XTC command. When a time constant of less than 20 ms is selected, the fast output filter is automatically activated.

The order of the output filters and (in the case of the main output filter) the type of weighting function are controlled from the Main page of the front-panel display, the SLOPE/AVERAGING screen and the XDB command.

6.4.09 The fast output filters

These are conventional analog filters implemented with resistors, capacitors and operational amplifiers. Each filter has two identical first-order lowpass stages, one of which can be switched out, so is used optionally as a first-order filter or as a second-order filter with two equal time constants. The available time constants are 1000 µs, 100 µs, 10 µs and MIN (minimum), which is less than 1 µs. Operation of the fast output filters, and availability of their analog outputs at the rear panel, are indicated by the front-panel FAST DEMOD status light.

The most sensitive input ranges (less than 100 µV full scale) are not available when the fast output filters are in use.

The parameters of the fast output filters are optimized for fast time-domain measurements and correspondingly the gain is set to slightly greater than unity, giving a dynamic reserve of about 0.5 dB, displayed on the Main page as MIN. Also the full-scale output is set to 9.4 V rather than 10.0 V to provide additional headroom with low time-constant values.

The analog outputs of the fast output filters are available at the FAST OUT X, Y sockets on the rear panel, and are also sampled by an internal sampling converter having various trigger modes (Section 6.4.13).

6.4.10 Main output filter

This filter is implemented by a combination of analog and digital techniques and allows the selection of time constants in the range 20 ms to 1000 s in a 1-2-5 sequence, with 6 dB/octave or 12 dB/octave slope. Rectangular and triangular weighting functions are available with time constants above 50 ms, or exponential weighting functions at all time constants (Section 6.4.08).

The 6 dB/octave filters are not satisfactory for most purposes because they do not give good rejection of non-random interfering signals which can cause aliasing problems with the analog-to-digital converters. However, the 6 dB/octave exponential filter finds use where the lock-in amplifier is incorporated in a feedback control loop, and the rectangular filter is sometimes preferred in spectroscopic applications where it gives the least possible distortion of spectral lines.

For ultimate signal-recovery performance, the 12 dB/octave exponential filter is the best. Where the noise level is not too high, the triangular filter is to be preferred because of its rapid response (100% in two time constants) to a change in the input signal.

In the LOW 1 and LOW 2 frequency modes the filter is synchronous, i.e. the time constant is automatically set to be an integer number of reference cycles. The time constant is not less than 1 s and not less than the selected value. Triangular weighting is recommended in these modes.

Synchronous filtering has the major advantage of removing deterministic output noise resulting from the waveform of the required signal (Section 6.4.07) while keeping the response time as short as possible.

6.4.11 Zero errors and crosstalk

Even when the input to the signal channel is nominally zero, the x-channel and y-channel outputs of the demodulator may show non-zero values. This phenomenon is called zero error and is usually caused by unwanted coupling or crosstalk between the signal channel and the reference channel, either in the external connections or possibly (in the most sensitive ranges and at the highest reference frequencies) in the instrument itself. Zero errors may also be caused by the effects of changing ambient temperature on the demodulator hardware although these are usually negligible in the case of modern designs such as the Model 5302. The values of any zero errors are usually dependent on the reference frequency.

The problems of crosstalk in the external circuit (i.e. the hardware which is generating the signal and the reference) are illustrated by the following numerical example. Suppose that the signal source impedance is 1 kΩ, and the reference is 1 V rms at 100 kHz. Then a stray capacitance of only 0.001 pF between the reference source and the lockin input terminal would give an offset corresponding to 600 nV at the input - more than full scale on the 3 most sensitive ranges!

Unless they are large enough to cause overload, zero errors do not give rise to any malfunction in the demodulator, simply acting as additive errors which can be measured under zero-signal conditions and subsequently subtracted from the x and y outputs. However, the magnitude and signal phase outputs, being non-linear functions of the input, operate incorrectly when zero errors are present and it is essential when using these outputs to reduce the x and y zero errors to a small fraction of full scale.

Correction of zero errors in the 5302 is done with the X Offset and Y Offset facilities, which can be accessed in four ways:

1. from the OFFSETS screen;

2. from the front-panel OFFSET key and setting knob;

3. by means of the XOF and YOF commands in conjunction with the OFEN command;

4. by means of the Auto-Offset function (Section 6.7.04).

Operation of the X Offset and/or Y Offset facilities is indicated by the front-panel OFFSET status light.

6.4.12 Output overload detectors

There are hardware overload detectors at the x and y outputs of the analog demodulators.

The outputs of these detectors drive the front-panel OUTPUT OVLD led indicator. They also cause the assertion of bit 4 in the serial poll status byte and bits 3 and/or 4 in the N status byte. (See discussion of ST and N commands in Chapter 9.)

If overload occurs at either of these points with less than 120 percent full-scale showing at either the X or the Y outputs, the overload can be removed by increasing the time constant of the output filters or possibly by increasing the value of the dynamic reserve mode or by making use of the signal-channel filters.

The same indicator and bits are activated when the x-channel or y-channel outputs exceed 120 percent of full scale, when either the analog or the digital demodulators are in use. This type of overload can be removed by increasing the full-scale sensitivity value.

6.4.13 Output converters and system sample rate

In the low-frequency ranges LOW 1 and LOW 2, signal samples are generated from the outputs of x and y delta-sigma converters at a 100 Hz rate and the software generates output samples at the same rate.

In the Normal frequency range (i.e. when not in a low-frequency range) and when the time-constant is more than 10 ms the demodulator outputs are sampled with the same delta-sigma converters at a rate (the system sample rate) in the range 50-100 Hz selected from the front panel by means of the SAMPLE RATE screen or by the SAMPLE command. The external ADC inputs are sampled at the same rate.

The outputs of the fast output filter are digitized by a successive-approximation converter (see below).

An inherent problem with any sampling system is the possibility of aliasing with interfering signals. To avoid problems of intermodulation with harmonics of the supply line frequency the sample rate is factory set to 100 Hz for delivery to countries with 60 Hz line frequency, and to 83 Hz for delivery to countries with 50 Hz line frequency. In some situations where high-level interfering signals at other frequencies are causing beats or offsets, the problem can be eliminated by adjustment of the system sample rate. For further information about beats, refer to Section 6.3.08.

6.4.14 Successive-approximation converter and Trigger Modes

The outputs of the fast output filter (time-constant less than 20 ms) are digitized by a successive-approximation converter with 16-bit resolution, which also converts the ADC inputs.

The converter has various trigger modes (Ref/Ext/Async/Ratio/8F) selected by means of the ADC TRIGGER MODE screen or the TRIG command.

The trigger modes operate as follows. Note that they are applicable only when the output time-constant is 10 ms or less.

Reference: triggers synchronously with the reference frequency. The maximum conversion rate is nominally once every 5 ms. **Use of this mode gives unpredictable results when the reference frequency exceeds 200 Hz.** On any given trigger, the output and one of the four ADC inputs is converted.

External: triggers on each positive going transition detected at the rear-panel ADC EXT TRIG IN connector, which is TTL compatible. If an applied trigger occurs too soon for the conversion time of 10 ms, it will be ignored. On any given trigger, the output and all four of the ADC Inputs are converted.

Asynchronous: triggers asynchronously at the system sample rate (Section 6.4.13). On any given trigger, the output and one of the four ADC inputs is converted. This is the default trigger mode.

Ratio: triggering is synchronous with the reference. The output and the ADC Input 1 (only) are converted, and the maximum trigger rate is 200 Hz. **Use of this mode gives unpredictable results when the reference frequency exceeds 200 Hz.**

8F Mode: at reference frequencies below 20 Hz, triggering is synchronous with the reference and there are eight triggers per reference period. On any given trigger, the output and one of the four ADC Inputs is converted, so that any given ADC Input is converted once every four trigger cycles (twice per reference cycle). The eight output readings are averaged and it is this average value that is used as the converter output. At higher reference frequencies, the lockin automatically transfers to the Asynchronous mode, but 8F triggering will be automatically restored if the frequency is subsequently dropped to less than 20 Hz.

6.4.15 Choice of trigger mode

The sampling converter is sometimes used in situations where the random noise level is low and the output time constant is less than, or not much greater than, the reciprocal of the reference frequency. In this situation the following points may be taken into account:

1. the Async Trigger mode gives a noisy output which includes beats between the reference frequency and the sampling frequency or its harmonics. This effect is greatly reduced by using the 12 dB/octave slope option rather than 6 dB/octave.

2. The Ref Trigger mode does not give rise to extra noise, but the measured value

of the signal depends on the phase setting in a way that may be unexpected. This results from the fact that there is not more than one sample in each reference cycle, occurring always at the same point in the cycle.

3. If the reference frequency is between 1 Hz and 20 Hz, the 8F Trigger mode usually gives good results.

6.4.16 Noise Measurements

In making a noise measurement, the Model 5302 provides a measure of the root-mean-square value either of the output x of the x channel, or of (x - (mean value of x)) (when the Subtract Mean option has been selected).

Because of dynamic range requirements, the quantity actually measured is the mean value of the modulus of x or of (x - (mean value of x)). The result is presented with a scaling factor which gives the correct root-mean-square value if the amplitude distribution is sinusoidal. For the more likely case of a Gaussian distribution, the correct root-mean-square value is obtained by multiplying the reported noise value by a correction factor 1.1986.

In the averaging process, two circular noise buffers of length N are used. The value of N, and also the SUBTRACT MEAN option, are set from the NOISE screen or the NNBUF command. One buffer contains values of x averaged over 100 samples, and the mean of the contents of this buffer is used if necessary as the mean value of x. The second buffer contains values of the modulus of x, or alternatively values of the modulus of (x - (mean value of x)), in both cases averaged over 100 samples. The Model 5302 reports the mean of the second noise buffer’s contents as the measured noise, and this is updated at intervals of 100 samples.

The measured noise is itself a time-varying quantity, and the length N of the Noise Buffers is chosen to give an acceptable level of fluctuation in the measured noise. If the samples of x are independent random quantities then the root-mean-square value of the fluctuation is inversely proportional to the square root of (100N) and a typical value of N is 10 giving about 3 percent fluctuation.
If the correlation time of the noise process being measured is greater than the sample time then a correspondingly higher value of N is required. The noise bandwidth will not be less than the equivalent noise bandwidth (ENBW) of the output filters, and not less than the bandwidth of the main filter in the signal channel.

With exponential averaging selected, the ENBW of the output filters is either 1/4TC (6 dB/octave rolloff selected) or 1/8TC (12 dB/octave rolloff selected) where TC is the selected time-constant.

If the purpose of the measurement is to find the spectral density of a broadband random noise source, and assuming that the low- frequency ranges are not in use, the output time-constant should typically be set to 10 ms or 1 ms. The BANDPASS filter option should normally be used so that the spectral density is measured at a well-defined frequency, i.e. the reference frequency; the use of this filter is also important in reducing the effect of interfering signals, but at lower reference frequencies it may have a significant effect on the overall noise bandwidth. When setting the reference frequency, the power line frequency and its harmonics should be avoided, and a useful precaution is to experiment with small changes in the reference frequency to ensure that the measurement is not being affected by an external interfering signal causing a spurious peak to occur in the measured noise spectrum.

Note that the settling time of the measured noise output, after a change in the instrument settings or a change in the mean value of x, is N sample periods.

Because of possible inaccuracies in calculated values of noise bandwidth, the user is strongly recommended to calibrate spectral density measurements by the use of a resistor connected to the input as a noise voltage source. For measurements at frequencies up to a few kHz a value of 100 kΩ is commonly used, giving 40.7 nV/√Hz at 300 K. At higher frequencies the input capacitance of the lockin makes it desirable to use a lower resistor value, but in this case the voltage noise of the lockin must be taken into account.

Note that the above method of calibration is only appropriate to those instruments which, like the 5302, have JFET input stages.

6.5 Internal Oscillator

6.5.01 General description

The internal oscillator is based on a quartz-controlled frequency synthesizer. The synthesizer writes a sequence of addresses into a ROM containing sinusoid values which are written into a DAC. From 1 mHz to 20 kHz a 16-bit DAC is used to generate the output, and from 20 kHz to 1 MHz a fast 7-bit DAC is used. The DAC outputs are processed with switchable fourth-order Butterworth filters giving harmonic distortion of less than 0.2% in the lower (16-bit) range and less than 1.0% in the upper (8-bit) range.

6.5.02 Frequency control

The frequency synthesizer consists essentially of an 8 MHz clock with stability ±30ppm/°C, two frequency dividers giving minimum resolution of 0.1%, and a phase-locked loop with switchable loop filters.

The frequency is set in the range 1 mHz - 1 MHz by means of the front-panel setting knob, optionally using the OSCILLATOR screen, or the OF command.

6.5.03 Amplitude control

The amplitude is controlled by a 12-bit multiplying digital-to-analog converter cascaded with a switchable 20 dB attenuator to give a lower range of 5 - 500 mV with 2.0 mV resolution, and an upper range of 500 - 5000 mV with 20 mV resolution. Monotonicity is not guaranteed at the range change.

The amplitude is set with the front-panel setting knob, optionally using the OSCILLATOR screen, or with the OA command.

6.6 Auxiliary I/O

6.6.01 DAC outputs

The voltages at the DAC1 and DAC2 connectors can be set with the front-panel keys and setting knob, optionally using the DACS screen, or alternatively by the use of the

DAC command.

Full-scale output is ±12.5 V, corresponding to a command parameter of ±12500 and a resolution of about 15 bits. In the default trigger mode (asynchronous, selected as Trigger Mode 2) the update rate is one sixth of the system sample rate. For further details of the update rate, see Section 6.4.13.

6.6.02 ADC inputs

The four analog-to-digital converter inputs are the ADC1 through ADC4 sockets on the rear panel. They allow input voltages in the range ±12.5 V to be digitized in the range ±12500 corresponding to a resolution of about 15 bits. The converter values may be read from the ADCS screen or by the use of the ADC command. In the default trigger mode (asynchronous, selected as Trigger Mode 2) the update rate is one quarter of the system sample rate. For further details of the update options, see Section 6.4.13.

6.7 Dynamic Reserve

6.7.01 Definition of Dynamic Reserve

The dynamic reserve is defined as the factor by which input noise voltages may exceed the full-scale sensitivity value without causing overload. Note that a noise voltage may be random or may be periodic at some fixed frequency; in the latter case it is often referred to as an interfering signal.

Obviously the dynamic reserve value is limited by the full-scale sensitivity setting: for example, a lock-in amplifier could well show a reserve value of 1000 (60 dB) at a full-scale sensitivity setting of 1 mV (implying the capability of handling 1 V noise) but would not be able to maintain this value of reserve at a full-scale sensitivity setting of 1 V because this would require the capability of handling 1000 V noise.

There are two mechanisms by which dynamic reserve is achieved, demodulator reserve and filter reserve. These are discussed below.

6.7.02 Demodulator reserve

The demodulator reserve is equal to (EDG - 1) where EDG is the effective demodulator gain defined in Section 6.4.06.

The demodulator gain is set by internal software according to the dynamic reserve mode selection in relation to other control parameters, particularly sensitivity.

The dynamic reserve mode is selected with the front-panel keys or with the DR command. The choices are HI STAB, NORMAL, HI RES 1, and HI RES 2 and the highest value of the demodulator dynamic reserve is 80 dB available under HI RES 2 for full-scale sensitivity 100 µV and below. The HI STAB mode gives 20 dB demodulator reserve for full-scale sensitivity 10 µV and above. The dynamic reserve mode selection also adjusts the signal-channel gain distribution for low noise or for high filter reserve as appropriate.

Note that when the software increases the demodulator gain it must correspondingly reduce the gain of the signal channel to keep the overall sensitivity the same.

The HI RES options may cause increased demodulator noise and signal-channel noise, and reduced output stability. In most typical measurement situations a dynamic reserve of 20 dB is adequate and the use of HI STAB is recommended. The NORMAL mode, giving 40 dB demodulator reserve for full-scale sensitivity 10 mV and below, will handle very high noise levels (noise voltage 100 times the signal voltage) and the HI RES modes are needed only in exceptional cases.

6.7.03 Filter reserve

One of the functions of the signal-channel filters is to provide dynamic reserve by reducing the amplitude of interfering signals. (The other function is to reject reference harmonics as discussed in Section 6.4.)

The success of this operation depends on the frequency of the interfering signal being well outside the passband of the filter. This is very often the case, because the passband occupies only a tiny fraction of the total frequency range; however, when a serious interfering signal does occur in the passband, it is sometimes possible to change the frequency of the measurement (for instance, by changing the chopper speed in the case of an optical measurement).

Note that the action of the filter does not improve the dynamic reserve unless there is amplification in the signal channel following the filter. If such gain is not present, an interfering signal of peak value equal to the overload level at the input of the filter would not cause overload whether attenuated by the filter or not. It follows from these considerations that the greatest improvement in the reserve that the filter can provide is equal to the value of the voltage gain in the signal channel following the signal-channel filter. This value is called the filter reserve.

In many experimental situations where the signal-channel filter is used for reserve improvement, the amount of available filter reserve is not the limiting factor.

In practice, tunable fourth-order active filters show substantially higher levels of random noise than simple amplifying stages, and if this is to be made insignificant compared with the preamplifier noise then there must be sufficient voltage gain in the signal channel in front of the filter.

Therefore the distribution of the total signal-channel gain involves a tradeoff: gain in front of the filter improves the noise while gain after the filter improves the filter reserve. In the 5302 the gain-distribution algorithm takes this into account and provides the lowest noise in the HISTAB option and the best reserve in the HIRES2 option, with NORMAL coming somewhere in between. This matches the effects of the demodulator gain selections that are made in these options.

At lower values of full-scale sensitivity the system provides substantial filter reserve even in the HISTAB option and the first choice for normal experimental situations should be HISTAB in conjunction with the BANDPASS or LOWPASS filter modes.

6.7.04 Specification of Dynamic Reserve

It is often assumed that the specification of the maximum dynamic reserve of a lockin is the criterion by which its ultimate signal-recovery performance can be judged.

However, the dynamic reserve figure by itself does not define the actual performance of the instrument. In fact, any demodulator design in the world is capable of having its dynamic reserve increased to any desired value by the simple process of attaching a dc amplifier to the output (if analog) or multiplying the output by some number (if digital). By this means both the dynamic reserve and the output errors are increased in the same proportion.

It follows that if we want to specify the signal-recovery performance of a lockin we must specify the output errors at a stated value of dynamic reserve. In the existing lock-in marketplace it is conventionally assumed that the main error is the temperature coefficient of zero offset, and a typical performance specification might be "500 ppm/degree zero drift at 60 dB reserve".

A warning should be given here about lockins that use digital multipliers as demodulators. In the case of these units, while the temperature coefficients are exceedingly low, the main errors are due to limited resolution and to differential non-linearity, and the above type of specification based on temperature coefficients is meaningless.

6.8 Auto functions

6.8.01 Introduction

The Auto functions are groups of control operations which can be executed by means of a single command or two key presses. The Auto functions allow easier, faster operation in most applications; however, direct manual operation or special-purpose control programs may give better results in particular applications.

During several of the Auto functions, decisions are made on the basis of output readings made at a particular moment. Where this is the case, it is important for the output time constant set by the user to be long enough to reduce the output noise to a sufficiently low level so that valid decisions can be made; also, sufficient time must be allowed for the output to settle.

All auto-functions may be called from the front panel with two keypresses, the red AUTO key followed by the key marked in red for the required function.

6.8.02 Auto-Range

The Auto-Range status (0 or 1) is set from the front panel keys or by means of the AR command with parameter 0 or 1; alternatively its state may be changed by the execution of the ASC command.

If the x and y outputs are being displayed, a single Auto-Range operation consists of increasing the full-scale sensitivity range if either output exceeds 80% of full scale, or reducing the range if both are below 30% of full scale. If the x and y outputs are not being displayed, the same procedure is carried out in relation to the magnitude output.

When the Auto-Range status is equal to 1, autorange operations are continually executed with an interval of four times the output time-constant.

6.8.03 Auto-Sensitivity

This function is called from the front panel keys or by means of the AS command.

It initiates one Auto-Sensitivity cycle in which a sensitivity range is selected that provides at least 30% but not more than 80% of full-scale output.

An Auto-Sensitivity cycle is a limited sequence of Auto-Range operations (see above). After the Auto-Sensitivity function is called, Auto-Range operations continue to be made at an interval of four time-constants, until the required criterion is met.

In the presence of noise, or an input signal of time-varying magnitude or phase, it may be a long time before the Auto-Sensitivity sequence comes to an end, and the resulting setting may not be what is really required.

6.8.04 Auto-Normalize

This function is called from the front-panel keys or by the ANR command.

It switches off the gain vernier, then performs an Auto-Sensitivity cycle. It then switches the gain vernier back on and sets its value so that the magnitude output has a full-scale value.

6.8.05 Auto-Phase

The Auto-Phase function is called from the front panel keys or by means of the AQN command.

In an Auto-Phase operation the value of the signal phase (Section 6.4.02) is computed and an appropriate phase shift is then introduced into the reference channel (by means of digital switching in the reference channel in conjunction with a suitable voltage applied to the analog phase shifter) so as to bring the value of the signal phase to zero. The intended result is to null the output of the y channel while maximizing the output of the x channel.

Any small residual phase can normally be removed by calling Auto-Phase for a second time after a suitable delay to allow the outputs to settle.

The Auto-Phase facility is normally used with a clean signal which is known to be of the required phase. It usually gives very good results provided that the x and y channel outputs are steady when the procedure is called.

If a zero error is present, it must be nulled with an Auto-Offset operation before the signal is applied and Auto-Phase executed. If the error is due to crosstalk (Section 6.4.11) the Auto-Phase, while actually setting the correct phase, will not give a zero value of signal phase. The final step is to remove the signal and execute another Auto-Offset operation. This is a powerful method of removing the effect of crosstalk which is not generally in the same phase as the required signal.

6.8.06 Auto-offset

The Auto-Offset function is called from the front panel keys or by means of the AXO command.

In an Auto-Offset operation the X Offset and Y Offset functions are turned on and are automatically set to the values required to give zero values at both the X and the Y outputs. Any small residual values can normally be removed by calling Auto-Offset for a second time after a suitable delay to allow the outputs to settle.

The primary use of the Auto-Offset is to cancel out zero errors which are usually caused by unwanted coupling or crosstalk between the signal channel and the reference channel, either in the external connections or possibly under some conditions in the instrument itself (Section 6.4.11).

Note that if a zero error is present, the Auto-Offset function should be executed before any execution of Auto-Phase.

6.8.07 Auto-Tune and Filter Track

The Auto-Tune and Filter Track functions are called from the front panel keys or by means of the ATS and ATC commands. The Filter Track function is alternatively referred to as Auto-Track.

When the filter mode has been set to BANDPASS, HIGHPASS or LOWPASS, the usual way of tuning the filter is with the Auto-Tune or Filter-Track functions implemented from the front panel keys or by use of the ATS or ATC commands, which set the maximum-response frequency of the filter to equal the reference frequency. Alternatively the FF command may be used to set f_0 to any value in its range.

The Auto-Tune operation gives the most accurate and reproducible setting of the filters, and also updates the gain and phase correction parameters in the signal and reference channels.

Filter Track operation performs the same operations, but when in the external reference modes, will only carry them out after it has detected a change of at least 2 percent in the applied reference frequency. Therefore if the most accurate and reproducible settings are required, the Auto-Tune function should be called after every intentional change in reference frequency when in the external reference modes. It is advantageous to do this even in the FLAT filter mode, although in this case the required operations can be done slightly faster with the LOCK command.

6.8.08 Auto-Measure

The Auto-Measure function is called from the front panel keys or by means of the ASM command. It causes the following control functions to be executed:

The output time constant is set to 100 ms; the filter slope is set to 12 dB/ octave; the output expand is switched off; the reference f/2f option is set to f; the dynamic reserve option is set to normal; the x-offset and y-offset functions are switched off; the main filter is set to BANDPASS; the line notch filters are switched off; the Filter-Track function is switched off; the panel indicators and displays are switched on; the trigger mode is set to 8; the display is set to XY%FS; an Auto-Tune operation is executed; Auto-Phase and Auto-Sensitivity operations are executed.

The Auto-Measure function is intended to give a quick setting of the instrument which will be approximately correct in typical simple measurement situations. For optimum results in any given situation, it may be convenient to start with Auto-Measure and to make subsequent modifications to the setup.

The Auto-Measure function is most often used as a rescue operation to bring the instrument into a well-defined state when it is giving unexpected results. The length of the above list demonstrates that one or more items can easily be overlooked. When using the Auto-Measure function in this way, the user should remember that the function has no control over the preamplifier keys. If the instrument unexpectedly gives no output, check that the proper signal source has been selected.

7.1 Introduction

This chapter illustrates and discusses the setup screens, which are presented *in alphabetical order beginning on the following page*. The underlying assumption is that you are viewing a screen on the instrument and wish to obtain more information about it. Each screen's title appears at the top of the screen. Descriptions include information on how to access each screen, the screen's purpose, and on the mechanics of using it. For the sake of convenience and completeness, the Main page and Large Display pages, although not setup screens, are included as well.

7.2 Overview

As previously described, the Model 5302 display uses an outer loop of three different screens, the Main page, the Large Display page, and the SETUP MENU page. The Main page, displayed at powerup, is the primary operating screen and is used as described in the preceding chapters. The Large Display page, accessed by pressing the Page softkey from the Main page, provides a very large, easily read presentation of the output signal levels, together with critical operating parameter values. Pressing the Setup softkey on the Large Display page takes you to the SETUP MENU page, from which the more than sixty setup screens can be accessed. On most of these screens, there are ↑ and ↓ softkeys used to make the operating selection by controlling the position of the inverse video bar, and a Select softkey used to execute the selection. If the parameter selection in question requires further delineation, either by selection or setting a value, the screen will be provided with Adjust softkeys (rightmost softkeys beneath display; the word ADJUST appears on the display just above and between these two keys on screens that require their use). These keys are used as ↑ and ↓ keys to set a value or select one from a displayed range with inverse video used to mark the selection.

In those instances where the value is to be set as opposed to being selected, you have the option of using the Adjust Softkeys or the Parameter Setting knob. In most instances, unless the change to be made is very small, it will prove more convenient to use the Setting Knob.

To return to the Main page from any other screen you need only press the MAIN softkey. Similarly, pressing the PREV key will back you up one screen. Pressing it repeatedly will back you through the sequence of screens used to reach any location. In those cases where all of the decisions for a function cannot be listed on a single screen, the screen is provided with a NEXT softkey. Pressing it takes you to a continuation screen for the function in question. In those cases where a screen's function includes initiating an activity, such as starting curve acquisition, the screen is provided with an EXEC (Execute) softkey.

Movement through the decision tree is extremely simple, with the options open to you always clearly indicated and each executable by a single keystroke. Each screen allows you to make choices or set parameter values appropriate to the screen's function.

ADCS (PG 1 of 2)

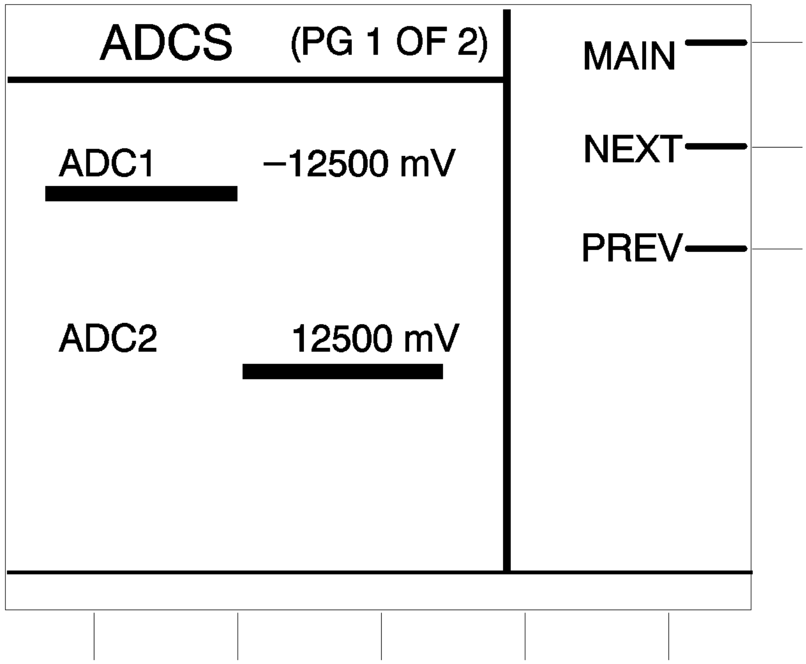


Figure 7-1. ADCS 1 & 2 SCREEN

How accessed Select ADCS from the DACS & ADCS screen, accessed from the SETUP MENU page.

Purpose Allows the outputs of ADCs 1 and 2 to be monitored. *The companion screen, ADCS (PG 2 OF 2), accessed via the NEXT key from this screen, provides the same function for ADCs 3 and 4.* A voltage applied to either ADC 1 or ADC 2 is converted to a digital value (range ±12,500) that can be monitored from this screen. Voltages applied to either connector are sampled, held, and digitized when the converters are triggered. In FAST mode operation, a number of different conversion (trigger) modes are provided, as described in the discussion of the ADC Trigger Modes screen (pg 7-4). Note that the RATIO and LOG RATIO functions arecomputed by comparing the voltage applied to ADC1 with that at the CH1 connector.

How used The ADC1 and ADC2 levels are indicated as soon as the screen is displayed. The range is ±12,500. Also, a bar graph is provided beneath the indicated value for each ADC, with the length of the bar corresponding to the value. If the value is negative, the bar extends to the left. If positive, it extends to the right. The zero position of the bar graph is beneath and just to the left of the numeric value.

Pressing MAIN returns you to the MAIN page. PREV returns you to the DACS & ADCS screen. NEXT brings up the ADCS (PG 2 OF 2) screen.

ADCS (PG 2 of 2)

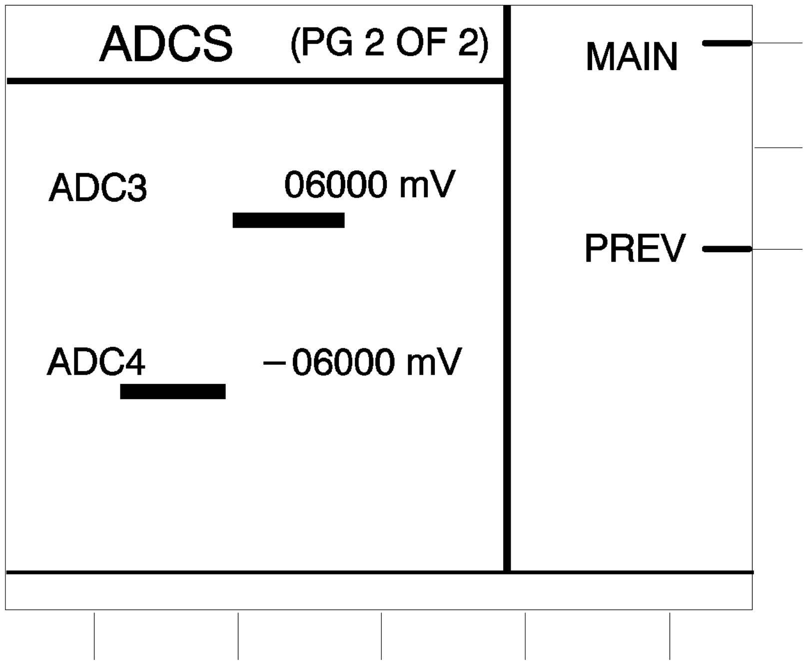


Figure 7-2. ADCS 3 & 4 SCREEN

How accessed

Press the NEXT softkey from the ADCS (PG 1 OF 2) screen, accessed from the DACS & ADCS page.

Purpose

Allows the outputs of ADCs 3 and 4 to be monitored. The companion screen, ADCS (PG 1 OF 2), accessed by selecting ADCS on the DACS & ADCS screen or PREV key on this screen, provides the same function for ADCs 1 and 2. A voltage applied to either ADC 3 or ADC 4 is converted to a digital value (range ±12,500) that can be monitored from this screen. Voltages applied to either connector are sampled, held and digitized when the converters are triggered. In FAST mode operation, a number of different conversion (trigger) modes are provided, as described in the discussion of the ADC Trigger Modes screen (pg 7-4).

How used

The ADC3 and ADC4 levels are indicated as soon as the screen is displayed. The range is ±12,500. Also, a bar graph is provided beneath the indicated value for each ADC, with the length of the bar corresponding to the value. If the value is negative, the bar extends to the left. If positive, it extends to the right. The zero position of the bar graph is beneath and just to the left of the numeric value.

Pressing MAIN returns you to the MAIN page. PREV returns you to the ADCS (PG 1 OF 2) screen.

ADC TRIGGER MODES

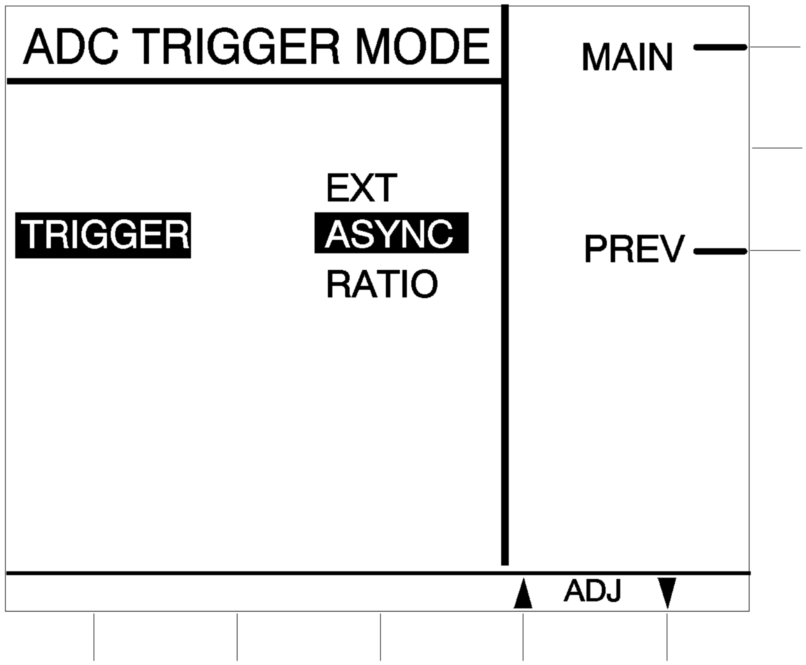


Figure 7-3. ADC TRIGGER MODES SCREEN

How accessed Select ADC TRIGGER MODES on either the Reference-Mixer setup screen, accessed from the SETUP MENU page, or from the DACS & ADCS page, accessed from the SETUP MENU page.

Purpose In Fast mode operation (output time constant less than 20 ms), allows selection of one of the five trigger modes that control the conversion mode of the sampling analog-to-digital converter which is attached to the rear-panel FAST OUT X and Y outputs. Because the same converter is used for the rear-panel ADC inputs, the selected conversion code also determines the handling of these inputs.

Details of the trigger modes are given in Section 6.4.14.

How used Use the softkeys to either side of ADJUST to make the Trigger mode selection as indicated by the inverse video bar. Pressing the MAIN key returns you to the Main page. PREV returns you either the DACS & ADCS screen or to the Reference-Mixer screen, whichever was the previous screen.

COMM-I/O

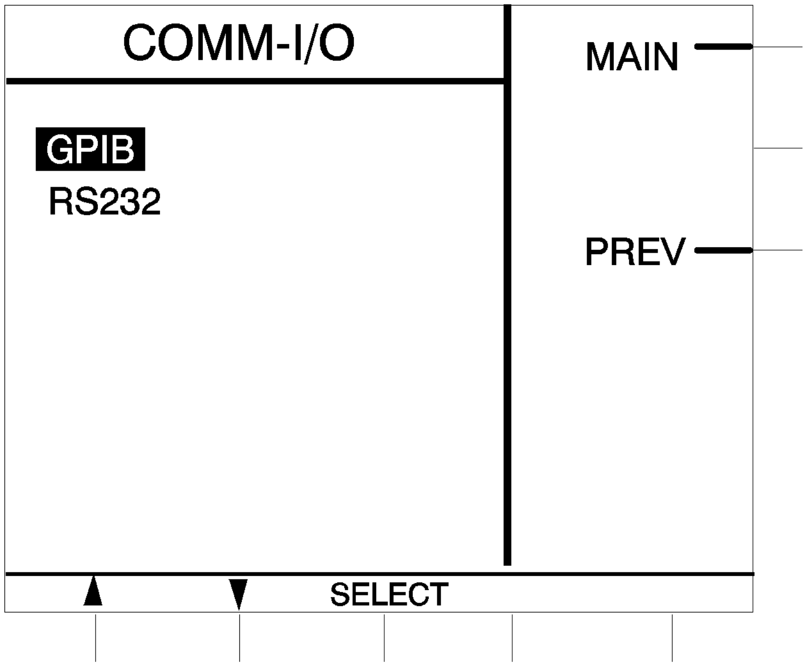


Figure 7-4. COMM-I/O SCREEN

How accessed Select COMM-I/O from the SETUP MENU page, accessed from the Large Display page.

Purpose Gives access to the GPIB setup screen and to the first of the two RS232 setup screens.

How used Use the ↑ or ↓ softkeys to position the inverse video bar over your selection, GPIB or RS232. Then press SELECT.

Pressing MAIN returns you to the Main page. PREV returns you to the SETUP MENU page.

CURVE SETUP

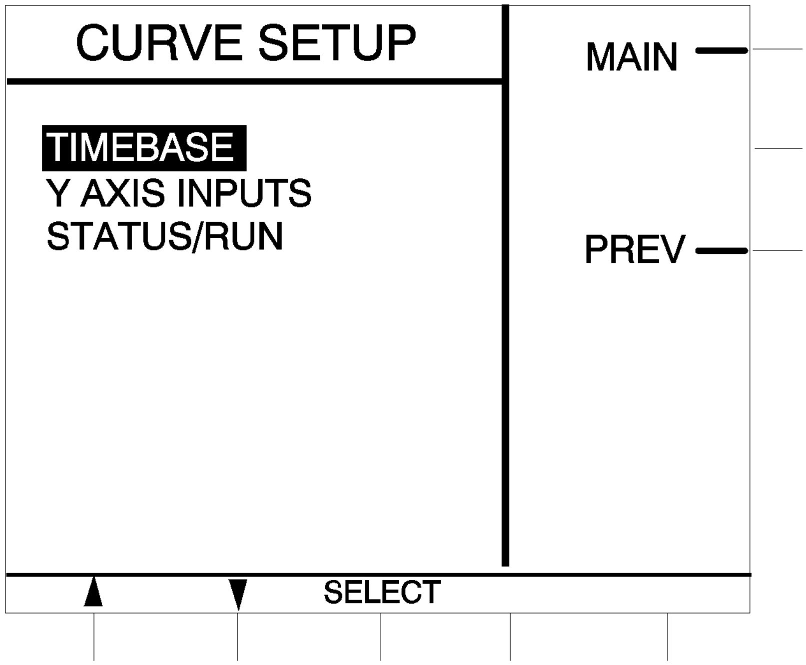


Figure 7-5. CURVE SETUP SCREEN

How accessed Select CURVE SETUP on the SETUP MENU page, accessed from the Large Display page.

Purpose Allows you to select any one of the three screens that control and execute the curve setup and acquisition.

How used Use the ↑ and ↓ softkeys to select either TIMEBASE, Y AXIS INPUTS, or CURVE STATUS/RUN. Then press SELECT to bring up the selected screen. Separate descriptions are provided for each.

Pressing MAIN returns you to the Main page. PREV returns you to the SETUP MENU page.

CURVE STATUS/RUN

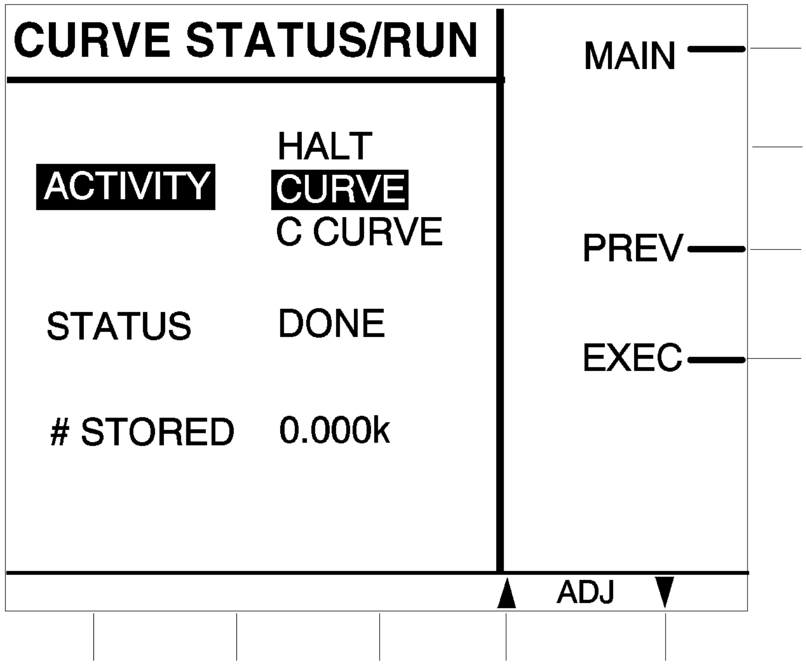


Figure 7-6. CURVE STATUS/RUN SCREEN

How accessed Select STATUS/RUN from the Curve setup screen, accessed from the SETUP MENU screen.

Purpose Allows you to setup, monitor, and control taking a curve in which the readings from some specified number of measurements are stored in memory.

How used The STATUS and # STORED indications provide essential operating information. The Adjust softkeys are used to select the desired curve activity. In each case, the selected activity begins when the EXEC key is pressed. The choices are:

CURVE: Upon execution, curve acquisition begins and continues until the specified points have been taken (Status indication changes from CURVE to DONE to mark completion of acquisition) or until HALT is executed (status immediately changes from CURVE to DONE). Each curve taken overwrites previously taken data.

C CURVE: This is the Continuous Curve mode. It is similar to CURVE except that the number of points specified defines a shift register. When the register is filled (number of points specified taken), data continues to be taken, but the old data is shifted out and lost point-by-point as the new data values are loaded. Thus the memory always contains the N most recent values, where N is the number of points specified.

HALT: Upon execution, stops curve acquisition and resets the point counter to the first point.

P/C (Pause/Continue): When EXEC is pressed, data acquisition stops but the point number is retained. Pressing EXEC again causes data acquisition to continue from that point until the specified number of points have been taken.

The curve acquisition status is reported in the Status line. A status indication of CURVE means that data acquisition is in progress. An indication of DONE means that the specified number of points has been taken or that curve acquisition was HALTed. An indication of PAUSED (C) indicates that P/C has been invoked and that data acquisition will resume when EXEC is pressed again. The number of points stored are indicated on the # STORED line.

Pressing MAIN returns you to the Main page. PREV returns you to the Curve setup screen. EXE initiates the selected action.

DACS

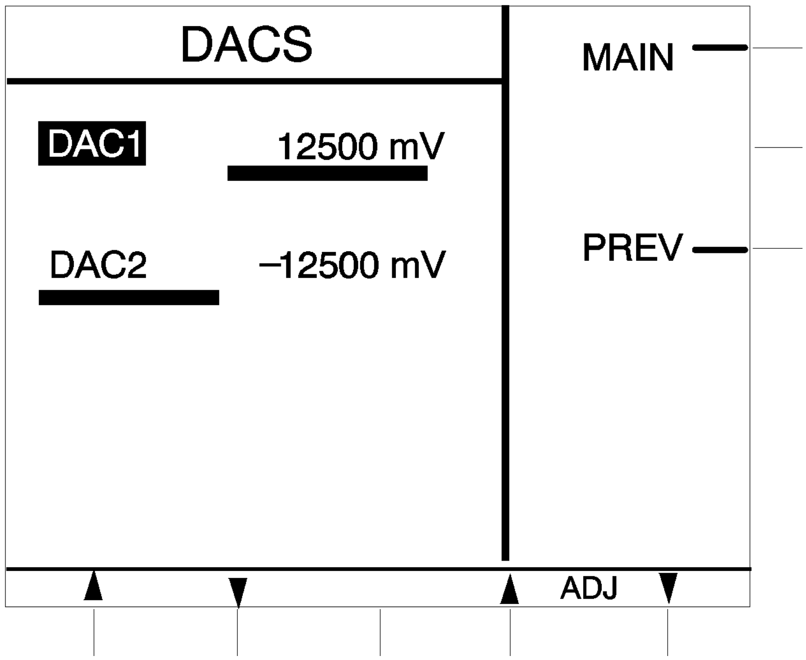


Figure 7-7. DACS SCREEN

How accessed Select DACS from the DACS & ADCS screen, accessed from the SETUP MENU page.

Purpose Allows you to independently set the dc voltage provided at the two rear-panel DAC connectors.

How used There are two rear-panel DAC connectors, DAC1 and DAC2. Using the ↑ and ↓ softkeys, select DAC1 to set the voltage at the DAC1 connector, or DAC2 to set the voltage at the DAC2 connector. The range is ±12,500 mV. Once the DAC of choice has been selected, use either the ADJUST softkeys (keys to either side of ADJUST) or the setting knob to set the output level.

A bar graph is provided beneath the indicated value for each DAC, with the length of the bar corresponding to the value. If the value is negative, the bar extends to the left. If positive, it extends to the right. The zero position of the bar graph is beneath and just to the left of the numeric value.

Pressing MAIN returns you to the Main page. PREV returns you to the DACS & ADCS page.

DACS & ADCS

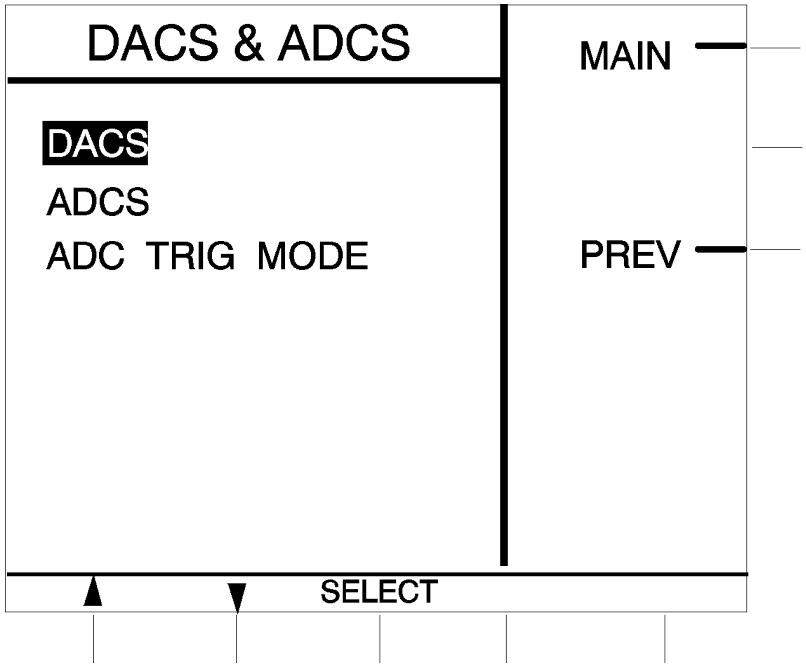


Figure 7-8. DACS & ADCS SCREEN

How accessed Select DACS & ADCS from the SETUP MENU page, accessed from the Large Display page.

Purpose Allows you to access the DACs screen, the ADCs screens, or the ADC Trigger Mode screen.

How used Use the ↑ and ↓ softkeys to select either DACS, ADCS, or ADC TRIG MODE as indicated by the position of the inverse-video bar. Then press SELECT. Pressing MAIN returns you to the Main page. Press PREV to return to the SETUP MENU page.

DACS 1 & 2 (knob-gear)

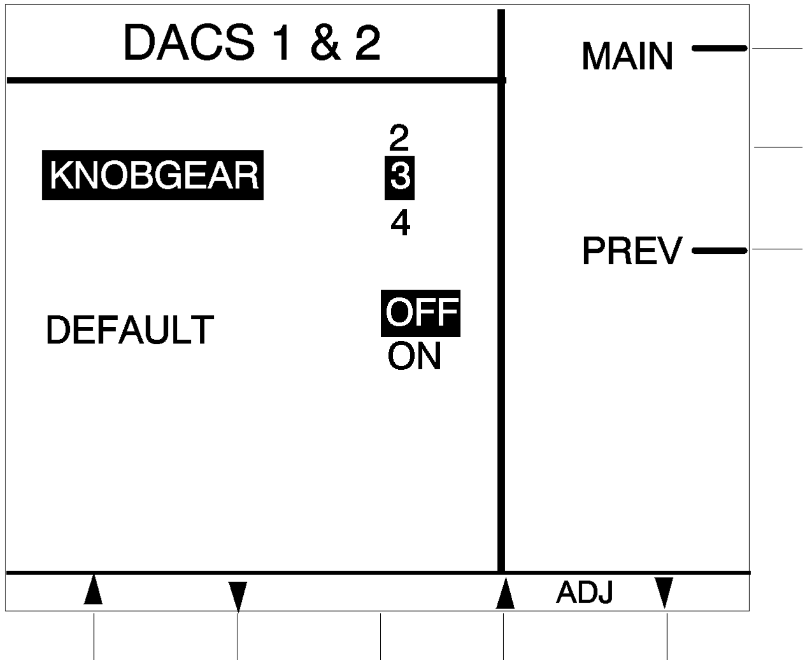


Figure 7-9. DACS 1 & 2 KNOB-GEAR SCREEN

How accessed Select DACS 1 & 2 from the Knobgear screen, accessed from the Knob screen by pressing NEXT.

Purpose Allows you to set the DACS 1 & 2 speedup gear ratio and to select whether the speedup ratio for DACS 1 & 2 will be the default value set via the Knob screen or the value set locally via this screen.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, DEFAULT ON/OFF or KNOBGEAR. Then use the ADJUST softkeys to set the Default ON/OFF status or the local speedup ratio, as appropriate.

Pressing MAIN returns you to the Main page. PREV returns you to the Knobgear screen.

FILT - F (knob-gear)

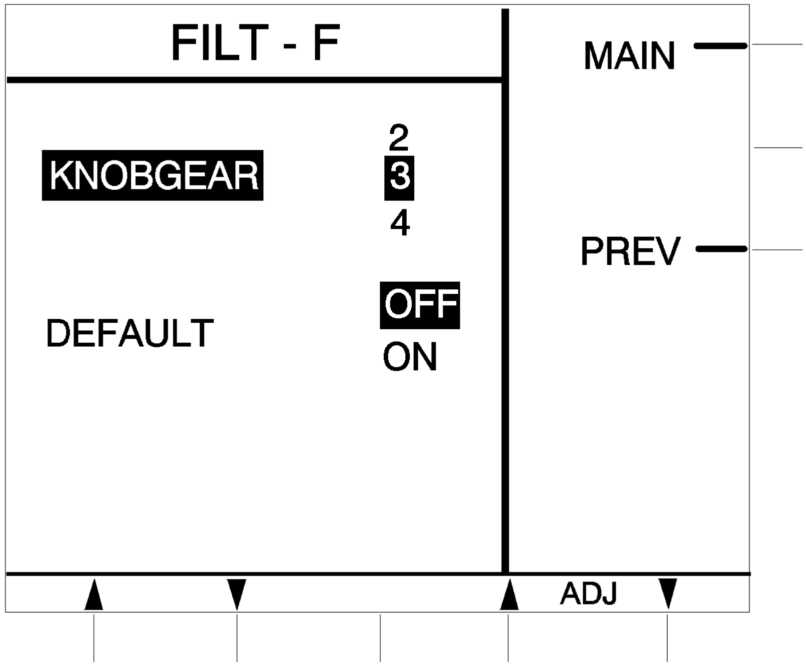


Figure 7-10. FILT - F KNOB-GEAR SCREEN

How accessed Select FILT-F from the Knobgear screen, accessed from the Knob screen by pressing NEXT.

Purpose Allows you to set the FILT-F speedup knob-gear ratio and to select whether the speedup ratio for FILT-F will be the default value set via the Knob screen or the value set locally via this screen.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, DEFAULT ON/OFF or KNOBGEAR. Then use the ADJUST softkeys to set the Default ON/OFF status or the local speedup ratio, as appropriate.

Pressing MAIN returns you to the MAIN page. PREV returns you to the Knobgear screen.

FILTER 1 (SPECIAL)

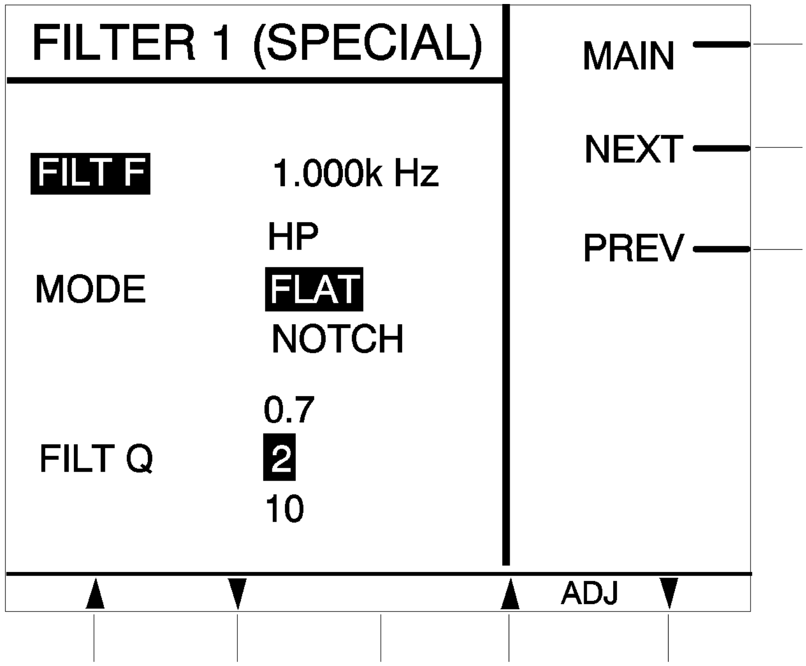


Figure 7-11. FILTER 1 (SPECIAL)

How accessed Select FILTER 1 from the SPECIAL FILTER screen, accessed from the Signal Channel screen.

Purpose Allows you to set the characteristics of the first section of the main signal-channel filter (Section 6.2.08) when in the Special configuration. Parameters that can be set include resonance frequency, mode, and Qfactor. In addition the NEXT softkey allows you to access the FILTER 1 TRIM (SPECIAL) screen that allows you to fine-trim the frequency setting.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, FILT F, MODE, or FILT Q. The mode and Qfactor are set with the ADJUST softkeys, and the resonance frequency can be adjusted with either the setting knob or the ADJUST keys.

Pressing MAIN returns you to the Main page. PREV returns you to the Special Filter screen. NEXT takes you the second FILTER 1 screen, used to fine-trim the frequency setting.

FILTER 1 TRIM (SPECIAL)

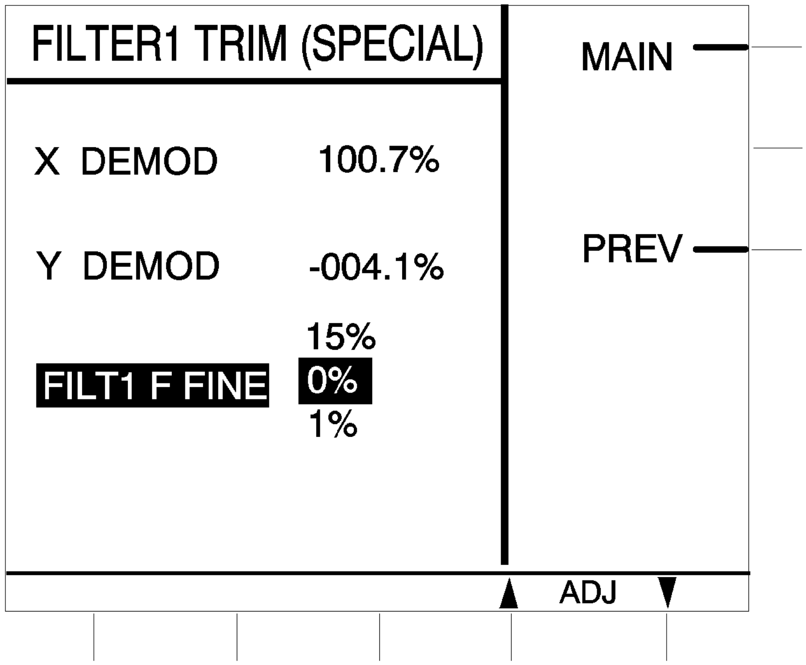


Figure 7-12. FILTER 1 TRIM (SPECIAL) SCREEN

How accessed Select FILTER 1 TRIM from the Special Filter screen, accessed from the Signal Channel screen. Alternatively, press the NEXT softkey on the FILTER 1 (SPECIAL) screen.

Purpose Allows you to fine-trim the resonance frequency setting of the first section of the main signal-channel filter (Section 6.2.08) when in the Special configuration. The X and Y DEMOD output levels are displayed to facilitate the frequency setting process.

How used Use the ADJUST softkeys to incrementally fine tune the frequency. Observe the DEMOD output levels to facilitate the setting process.

Pressing MAIN returns you to the Main page. PREV returns you to the Special Filter screen.

FILTER 2 (SPECIAL)

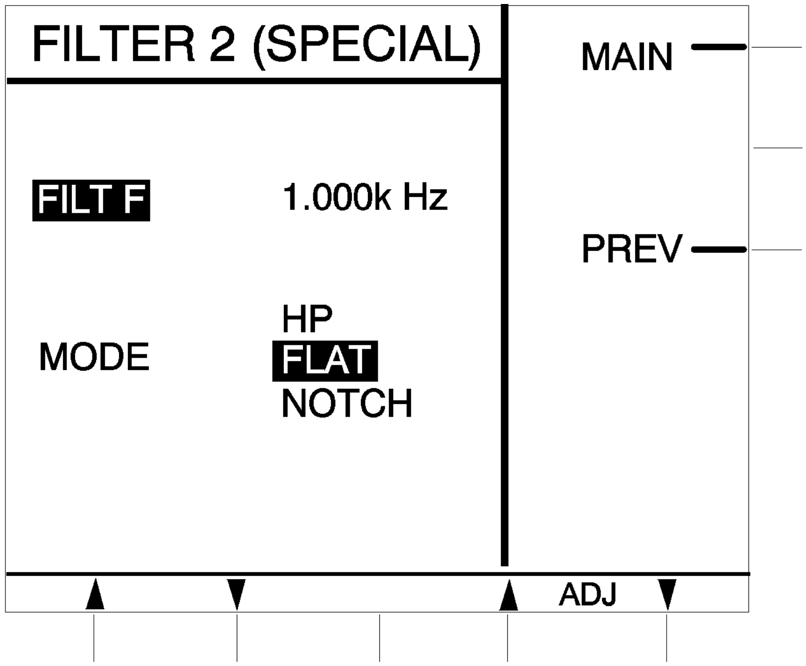


Figure 7-13. FILTER 2 (SPECIAL) SCREEN

How accessed Select FILTER 2 from the Special Filter screen, accessed from the SIGNAL CHANNEL screen.

Purpose Allows you to set the resonance frequency and mode of the second section of the main signal-channel filter (Section 6.2.08) when in the Special configuration.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, FILT F or MODE. The mode is set with the ADJUST softkeys, and the resonance frequency can be adjusted with either the setting knob or the ADJUST softkeys.

Pressing MAIN returns you to the MAIN page. PREV returns you to the SPECIAL FILTER screen.

FILTER CONFIGURATION

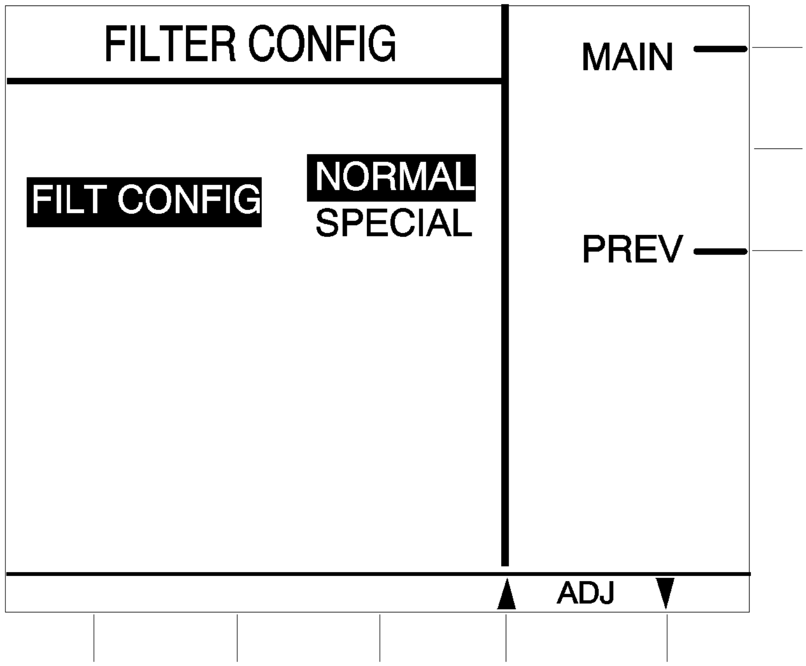


Figure 7-14. FILTER CONFIGURATION

How accessed Select FILTER CONFIG from the SPECIAL FILTER screen, accessed from the SIGNAL CHANNEL screen.

Purpose Allows you to select between the Normal and Special configurations of the main signal-channel filter (Section 6.2.08).

How used Use the ADJUST softkeys to select NORMAL or SPECIAL.

Pressing MAIN returns you to the MAIN page. PREV returns you to the SPECIAL FILTER screen.

Note: The Filter Configuration selection can also be made from the NORMAL FILTER screen. The two ways of making the selection are completely equivalent.

FINE PHASE (knob-gear)

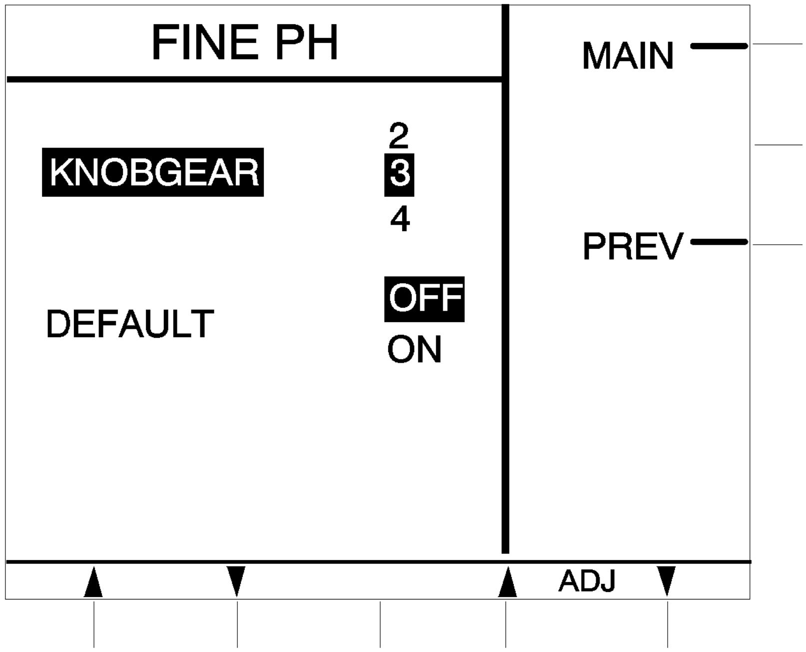


Figure 7-15. FINE PHASE (knob-gear) SCREEN

How accessed Select FINE PH from the KNOBGEAR screen, accessed from the KNOB screen via the NEXT key.

Purpose Allows you to set the local speedup knob-gear ratio. Additionally allows you to select DEFAULT ON or OFF. If OFF is selected, the locally set ratio will apply for the FINE-PHASE adjustment. If ON is selected, the DEFAULT value set via the KNOB screen will apply.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, DEFAULT ON/OFF or KNOBGEAR. Then use the ADJUST softkeys to set the Default ON/OFF status or local speedup ratio, as appropriate.

Pressing MAIN returns you to the MAIN page. PREV returns you to the KNOBGEAR screen.

FIRMWARE VERSION

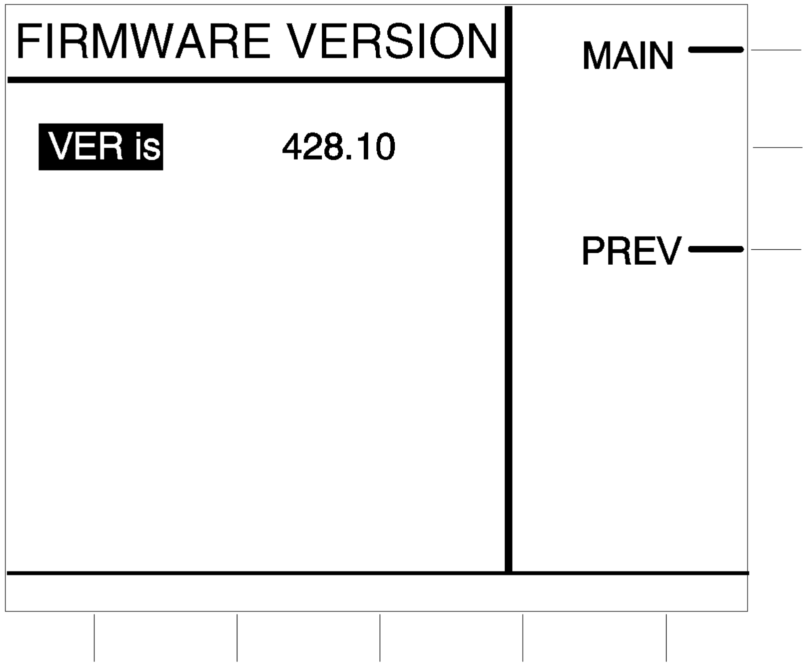


Figure 7-16. SPECIAL VERSION SCREEN

How accessed Select FIRMWARE VERSION from the SPECIAL screen, accessed from the SETUP MENU screen.

Purpose Displays the firmware version.

How used Pressing MAIN returns you to the MAIN page. PREV returns you to the SPECIAL screen.

GPIB

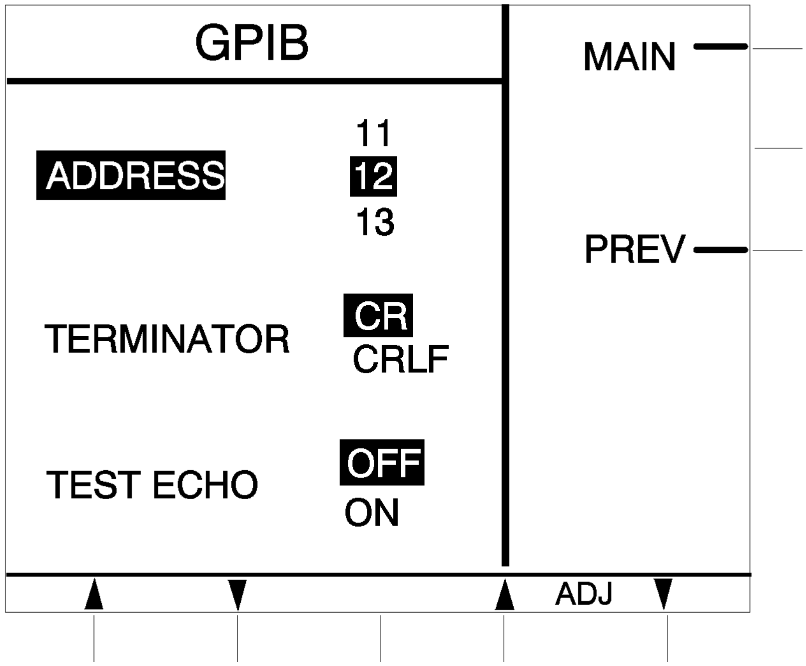


Figure 7-17. GPIB SCREEN

How accessed Select GPIB from the COMM-I/O screen, accessed from the SETUP MENU page.

Purpose Allows you to set the GPIB communications parameters. These are three, ADDRESS, TERMINATOR, and TEST ECHO.

Address: the address is the numeric identifier assigned to the Model 5302 to distinguish it from other devices on the bus (Section 8.3). Addresses from 0 to 30 can be selected. The host computer must use the address assigned to the Model 5302 to communicate with it.

Terminator: the output (response) terminator is the sequence of characters that the Model 5302 adds to the end of responses to commands. If the parameters have been set from the GPIB screen or the GP command, it is CR in GPIB communications and CRLF in RS232 communications. The AT command allows either sequence to be set as either terminator.

The input (command) terminator is the sequence appended by the computer to the end of a command line. This may be either CR or CRLF, and it is necessary for the instrument to be told which terminator to expect. Note that the input terminator can be independently selected for the GPIB and RS232 ports.

Test Echo: the third parameter is provided for convenient program development. When ON, every transmission to or from the GPIB port is echoed to the RS232 port, facilitating monitoring with a separate terminal. Do not confuse this echo function with the RS232 echo function selectable from the RS232 screen. The RS232 echo applies to RS232 communications only.

How used Using the ↑ and ↓ softkeys, position the inverse video bar over the parameter to be adjusted.

Pressing MAIN returns you to the MAIN page. PREV returns you to the COMM-I/O screen.

KNOB

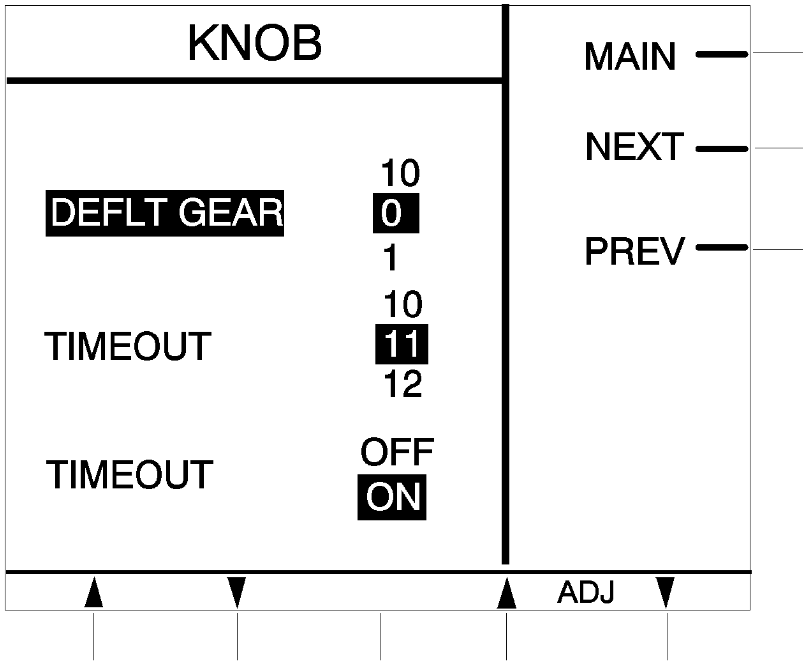


Figure 7-18. KNOB SCREEN

How accessed Select KNOB on the KNOB-LIGHTS screen, accessed from the SETUP MENU page.

Purpose Allows you to set the Default (globally active) Gear-Speedup ratio, the Timeout ON/OFF status, and the Timeout Duration. DEFAULT GEAR refers to the rate of change per knob-turn of a parameter at a rapid knob-turn rate relative to the rate of change obtained when turning the knob slowly. In addition to the globally active speedup knob-gear ratio, the speedup ratio can be set independently for each parameter via the KNOBGEAR screen, accessed by pressing the NEXT softkey.

Timeout ON/OFF determines whether the setting knob will remain active indefinitely or time out and become inactive after the set interval expires. Timeout-Interval simply sets the timeout interval in effect when the Timeout ON/OFF status is ON. *Note that TIMEOUT is always global, that is, it cannot be separately set for each parameter.*

How used Use the ↑ and ↓ softkeys to make your selection. Then use the ADJUST softkeys to set the value or status, as appropriate.

Pressing MAIN returns you to the MAIN page. PREV returns you to the KNOB-LIGHTS screen. NEXT takes you to the KNOBGEAR page, used to access the individual local knob-gear pages.

KNOB-LIGHTS

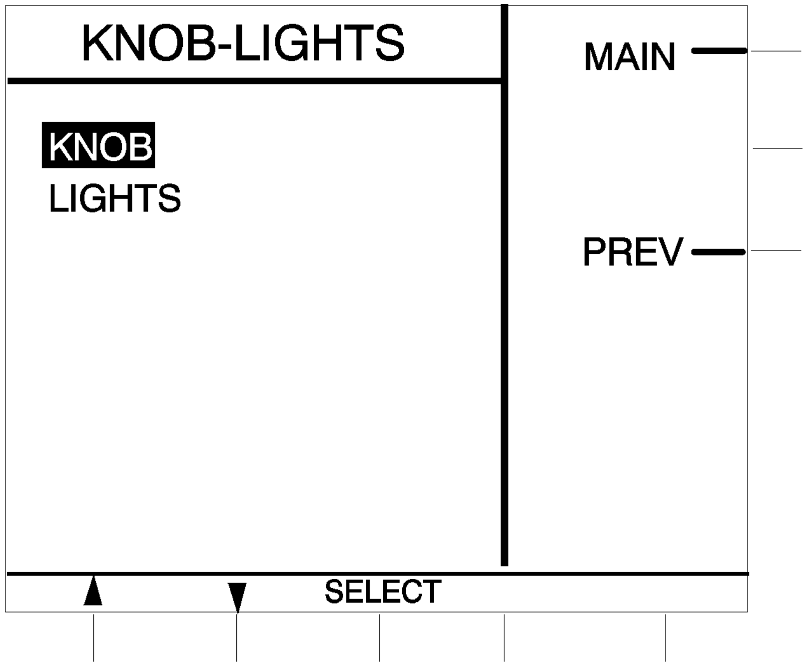


Figure 7-19. KNOB-LIGHTS SCREEN

How accessed Select KNOB-LIGHTS from the SETUP MENU page, accessed from the LARGE DISPLAY page.

Purpose Allows you to access the KNOB and LIGHTS screens.

How used Use the ↑ and ↓ softkeys to select the screen you wish to access. Then press SELECT.

Pressing MAIN returns you to the MAIN menu. PREV returns you to the SETUP MENU page.

KNOBGEAR

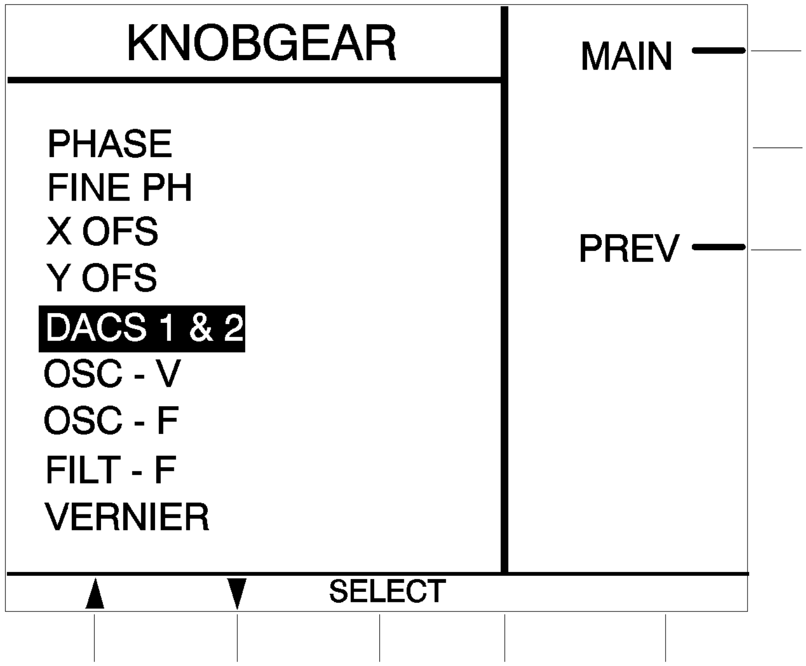


Figure 7-20. KNOBGEAR SCREEN

How accessed Press the NEXT softkey from the KNOB screen, accessed from the KNOB-LIGHTS screen.

Purpose Allows you to select the various individual local knob-ratio setting screens. The choices include **Phase**, **Fine Phase**, **X Offset**, **Y Offset**, **DACS 1 & 2**, **Oscillator Volts**, **Oscillator Frequency**, **Filter Frequency**, and **Vernier**.

How used Use the ↑ and ↓ softkeys to select the desired local knob-ratio setting screen. Then press the SELECT softkey.

Pressing MAIN returns you to the MAIN page. PREV returns you to the KNOB screen.

LARGE DISPLAY SCREEN

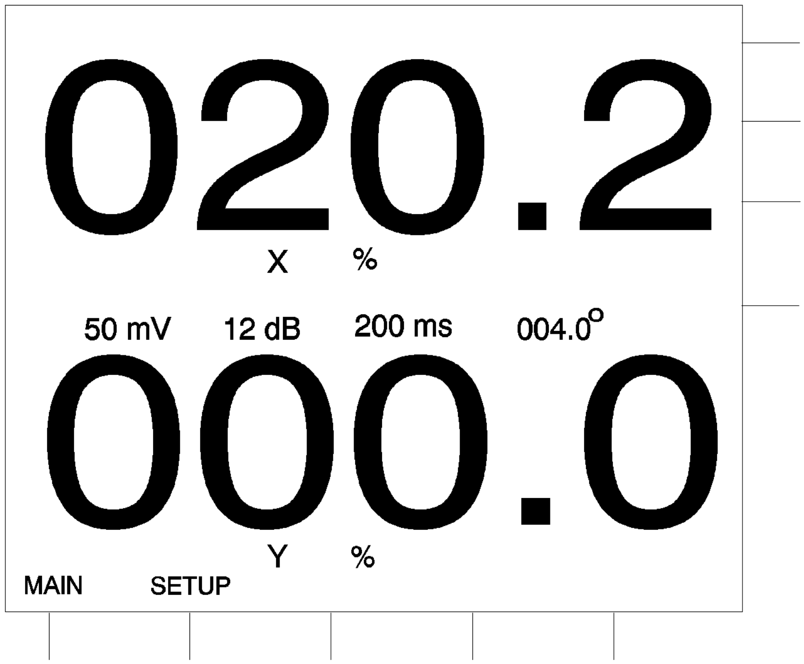


Figure 7-21. LARGE DISPLAY SCREEN

How accessed Select PAGE from the MAIN MENU screen.

Purpose Provides a very large, highly readable display of the outputs selected for display at the MAIN menu. Additionally indicates some critical parameters (Sensitivity, Output Time Constant, Slope, and Phase).

How used Press MAIN to return to the MAIN page display. Press SETUP to access the SETUP MENU screen.

LIGHTS

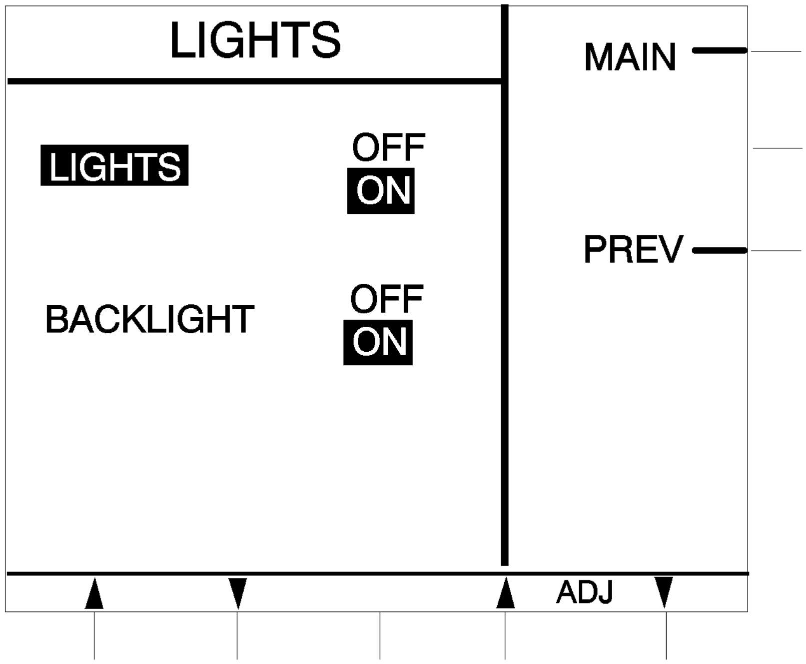


Figure 7-22. LIGHTS SCREEN

How accessed — Select LIGHTS from the KNOB-LIGHTS screen, accessed from the SETUP MENU page.

Purpose — Gives you control over the ON/OFF status of the panel lights and display backlight. Note that ON must be selected for the front-panel FUNCT LIGHTS facility to work.

How used — Using the ↑ and ↓ keys, select either LIGHTS or BACKLIGHT, as indicated by the position of the inverse-video bar. Then use the softkeys to either side of ADJUST to set the desired ON/OFF state.

Pressing MAIN returns you to the MAIN menu. PREV returns you to the KNOB-LIGHTS screen.

LINE NOTCH FILTER

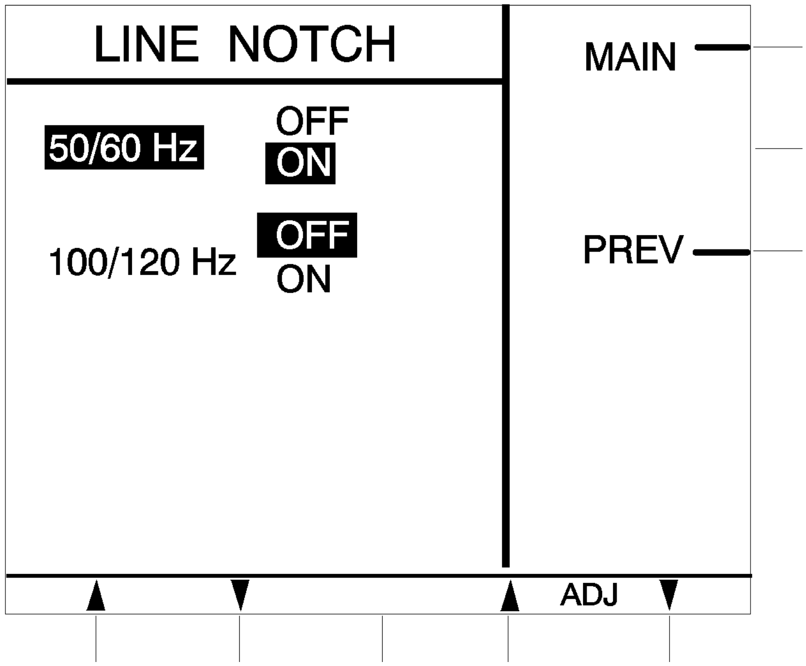


Figure 7-23. LINE NOTCH FILTER SCREEN

How accessed Select LINE NOTCH on the SIGNAL CHANNEL screen, accessed from the SETUP MENU screen.

Purpose Gives you ON/OFF control over the line-frequency notch filter (Section 6.2.07). Either section, or both sections, can be selected; the first operates at 50/60 Hz, the second at 100/120 Hz. At a ±1% stopband, each filter's response is more than 34 dB down.

How used The ↑ and ↓ softkeys select the filter section. The ADJUST softkeys set the ON/OFF state of the selected section.

Pressing MAIN will return you to the MAIN menu. PREVIOUS will return you to the SIGNAL page.

LOW FREQUENCY

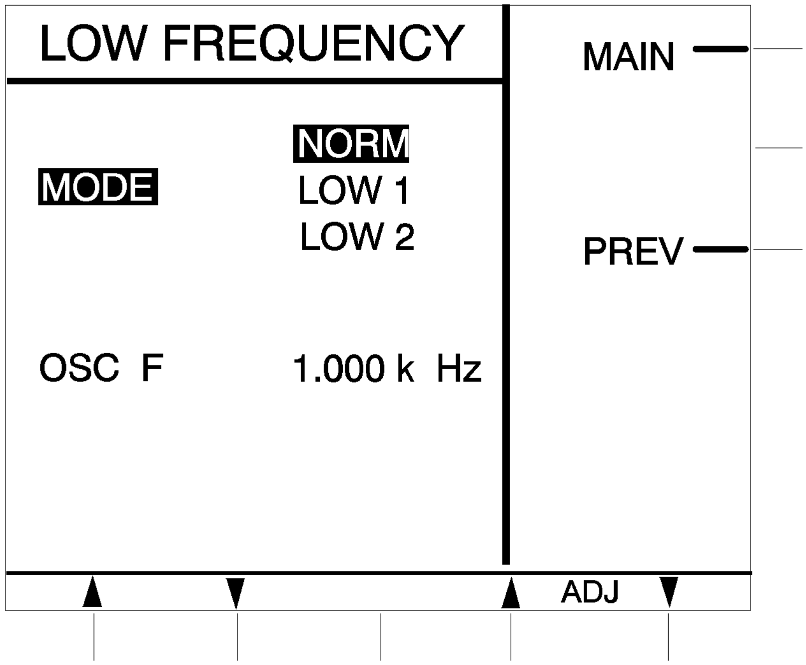


Figure 7-24. LOW FREQUENCY SCREEN

How accessed Select LOW FREQUENCY on the REFERENCE-MIXER screen, accessed from the SETUP MENU page.

Purpose Allows you to select the frequency mode (Section 6.2.01) to NORMAL, LOW 1, or LOW 2, and to set the frequency of the internal oscillator.

How used Use the ↑ or ↓ key to select MODE or OSC F as desired. For MODE, use the ADJUST softkeys to make your selection as indicated by the position of the inverse video bar. For OSC F use either the ADJUST keys or the Tuning Knob to set the frequency to the desired value.

Pressing MAIN returns you to the MAIN page. PREV returns you to the REFERENCE-MIXER screen.

MAIN MENU

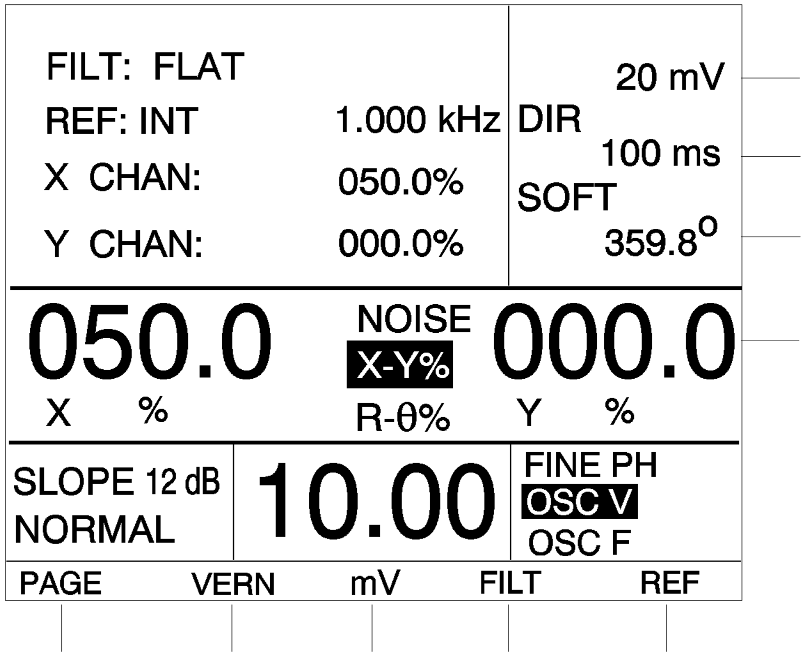


Figure 7-25. MAIN MENU

How accessed Displayed at power-up. Also, press MAIN softkey from any other screen.

Purpose All the basic parameters can be set and the instrument operated from this menu. Additionally the screen gives access to the LARGE DISPLAY screen by pressing the PAGE softkey. From there you can reach the SETUP MENU page by pressing SETUP.

How used Chapter 4 discusses use of the MAIN page in detail.

METHODS PAGE

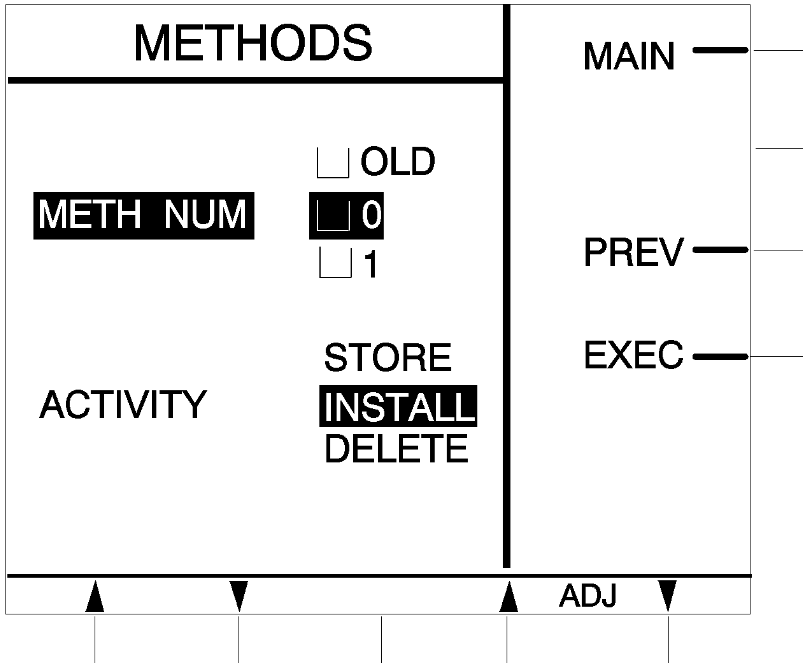


Figure 7-26. METHODS PAGE

How accessed Select METHODS from the SETUP MENU screen, accessed from the LARGE DISPLAY screen.

Purpose Allows you to store up to 15 different methods and to recall any one of them to re-establish the parameters in effect when a particular measurement or set of measurements was taken. *Note: The METH command allows an unlimited number of methods to be stored by the host computer and recalled at will.*

How used Use the ↑ and ↓ softkeys to select either METH NUMBER (Method Number) or ACTIVITY. Then use the ADJUST softkeys to select the method number or activity to be performed. The activity selected is then initiated by use of the EXEC softkey.

Method Number: Any one of 15 different methods, 0 through 14, can be selected. Each stored method consists of a series of codes representing all of the parameter values in effect when the method was *stored*. When a previously stored method is *installed*, those parameter values are re-established.

The memory locations at which these methods are stored can be thought of as *buckets*, and, in fact, a bucket symbol appears on the display adjacent to the identifier for each method. When a method is stored at a given location, the is shown *filled*, allowing you to determine each location's status at a glance. A previously stored method can be *deleted* at any time. When this is done, the associated bucket *empties* to indicate that the location is available again.

In addition to Methods 0 through 14, there are two others, DEFault and OLD. The default method is always available (it cannot be deleted) and so can be restored at any time. The OLD method is a copy of the method in effect when a new method is installed. In other words, if you install a method, the one previously in effect is copied to OLD. Each time a new method is installed, it overwrites the method previously stored in OLD. Note that

OLD cannot be deleted. It can only be overwritten.

Activity: There are three activity choices, STORE, INSTALL, and DELETE. The selected activity is performed as previously described when the EXEC softkey is pressed.

Pressing MAIN returns you to the MAIN page. PREV returns you to the SETUP MENU screen.

NOISE

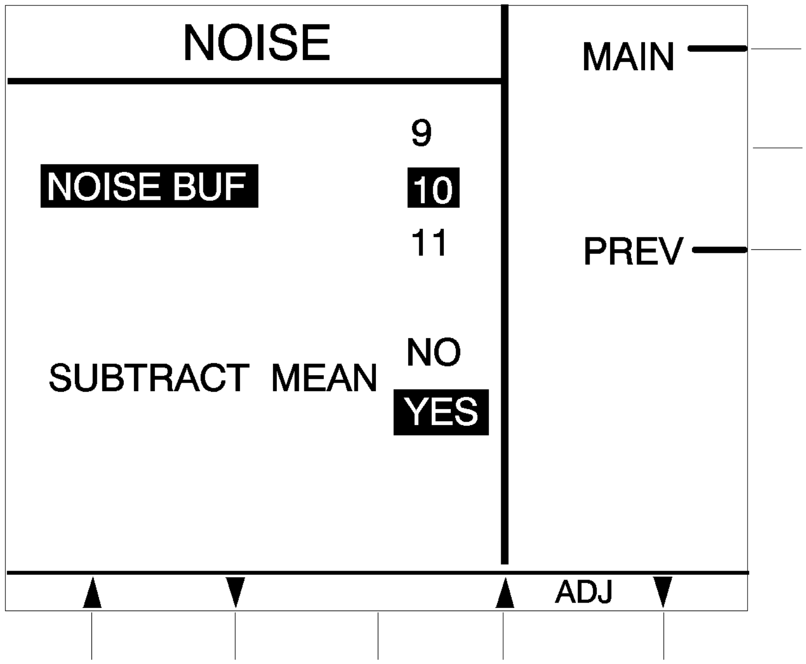


Figure 7-27. NOISE SCREEN

How accessed Press NOISE on the OUTPUTS screen, accessed from the SETUP MENU page.

Purpose Allows the noise measurement parameters to be set. See Section 6.4.16 for details about noise measurements.

How used Use the ↑ and ↓ keys to select either NOISE BUF or SUBTRACT MEAN. Then use the keys on either side of ADJUST to set the Buffer Length or the desired YES/NO status, as appropriate. When the desired settings are established, press **MAIN** to return to the Main Page screen.

NORMAL FILTER

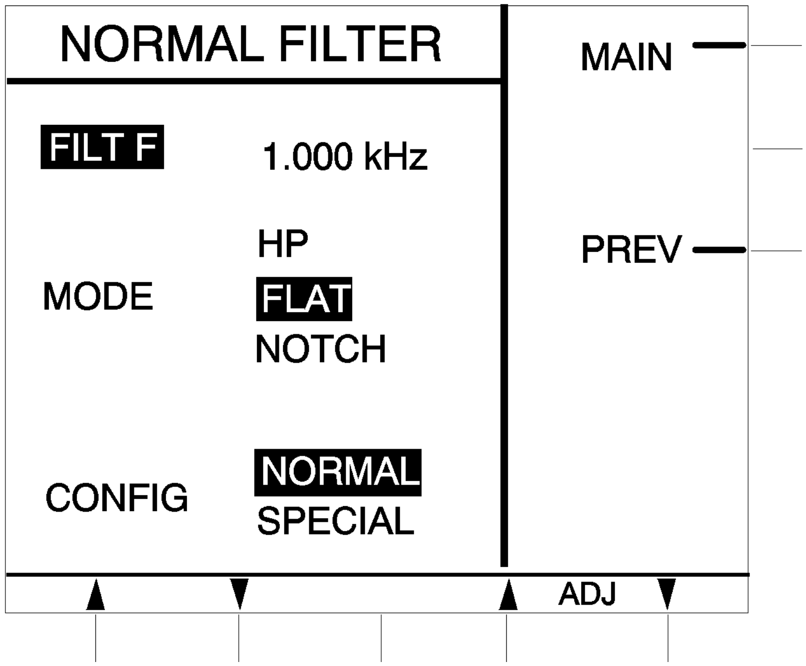


Figure 7-28. NORMAL FILTER SCREEN

How accessed Select NORMAL FILTER from the SIGNAL CHANNEL screen, accessed from the SETUP MENU screen.

Purpose Allows you to select whether the NORMAL or SPECIAL filter configuration (Section 6.2.08) will be in effect, and additionally to set the FILTER FREQUENCY and MODE in the Normal configuration.

How used Use the ↑ and ↓ softkeys to select FILT F, MODE, or CONFIG, as appropriate. If FILT F is selected, either the ADJUST softkeys or the Setting knob can be used to set the frequency. Unless the adjustment to be made is very small, the Setting knob is the better choice. In the case of MODE and CONFIG, the selection is made with the ADJUST softkeys.

Pressing MAIN returns you to the MAIN page. PREV returns you to the SIGNAL CHANNEL screen.

OFFSETS

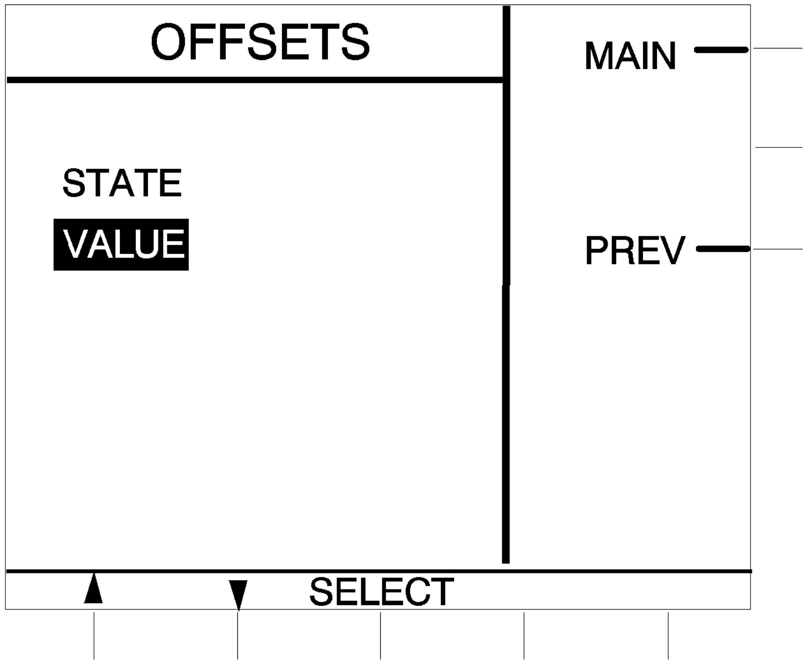


Figure 7-29. OFFSETS SCREEN

How accessed Select OFFSETS from the OUTPUTS screen, accessed from the SETUP MENU screen.

Purpose Allows you to access the OFFSET STATE and OFFSET VALUE screens.

How used Use the ↑ and ↓ softkeys to select the screen to be accessed, STATE or VALUE.

Pressing MAIN returns you to the MAIN page. PREV returns you to the OUTPUTS screen (returns to SETUP MENU screen in early units).

OFFSET STATE

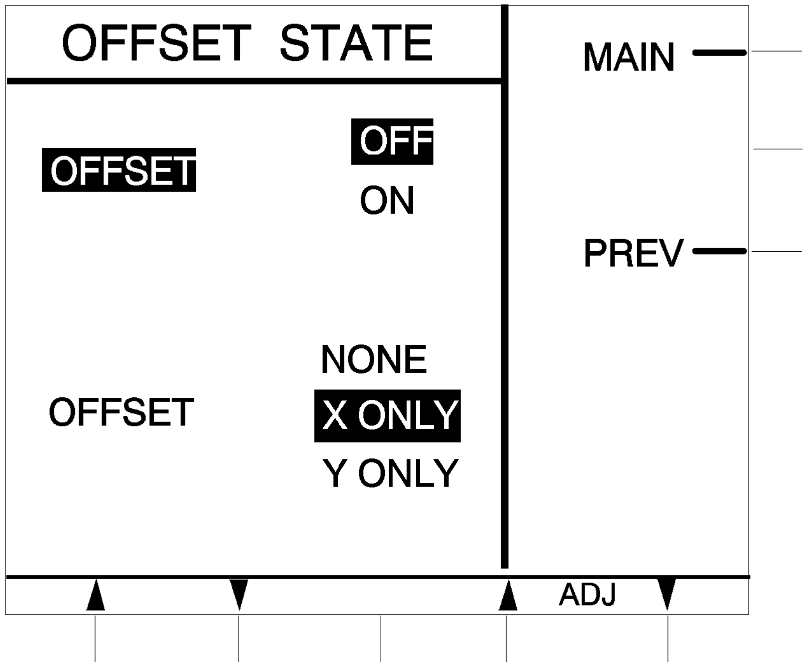


Figure 7-30. OFFSET STATE

How accessed Select STATE from the OFFSETS screen, accessed from the OUTPUTS screen.

Purpose Allows you to disable or enable the X and Y Offset facility with the options OFF/ON. The OFF selection can also be made with the front-panel OFFSET key or the OFEN command. Subject to being enabled, the offset is applied according to the options X ONLY, Y ONLY, or X AND Y.

A NONE selection has an equivalent effect to OFF except that the offsets cannot be reapplied by the use of the OFFSET key. X ONLY and Y ONLY cannot be selected in the Soft Phase mode.

How used Use the ↑ and ↓ softkeys to make the parameter selection. Then use the ADJUST softkeys to set the desired state in each case.

Pressing MAIN returns you to the MAIN page. PREV returns you to the OFFSETS screen.

OFFSET VALUE

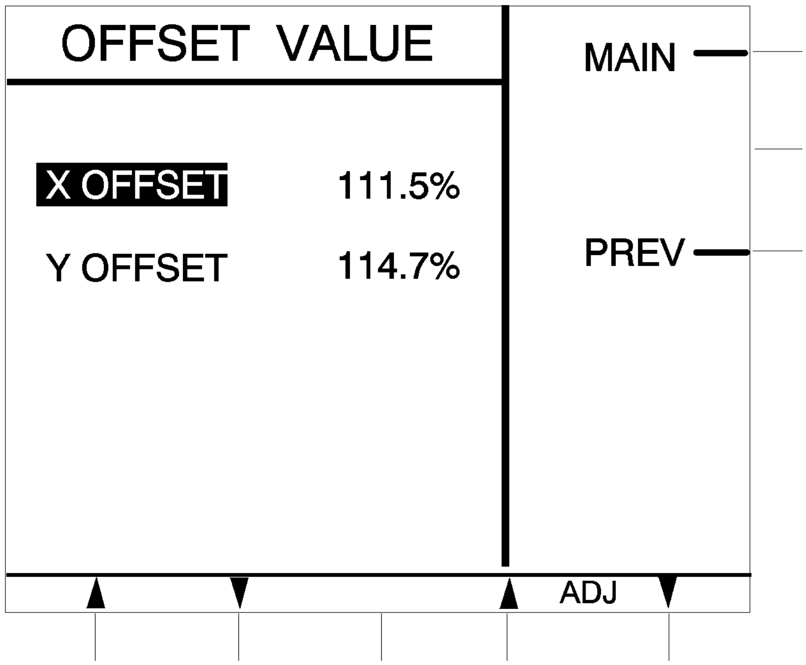


Figure 7-31. OFFSET SCREEN

How accessed Select VALUE from the OFFSETS screen, accessed from the OUTPUTS screen.

Purpose Allows the offset value to be separately set for each channel. The range is ±300% of f.s. Note that the decision of whether the offset will be applied to one channel, the other channel, or both, is made via the OFFSET STATE screen, also accessed from the OFFSETS screen.

How used Use the ↑ and ↓ softkeys to select either X OFFSET, or Y OFFSET, as desired. Then set the value for the selected parameter using the ADJUST softkeys or the Parameter Setting knob.

Pressing MAIN returns you to the MAIN page. Press PREV to return to the OFFSETS screen.

OSC-F (knob-gear)

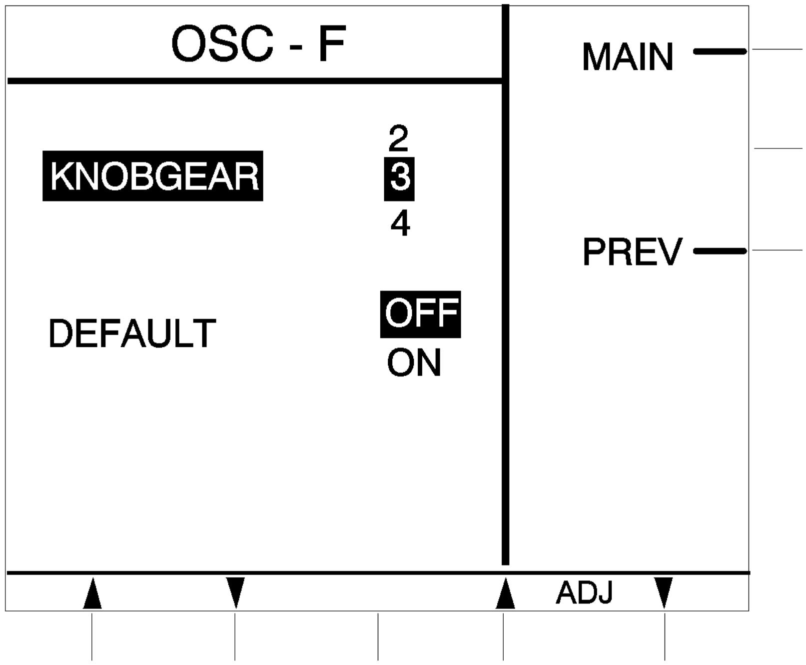


Figure 7-32. OSC - F KNOB-GEAR SCREEN

How accessed Select OSC-F from the KNOBGEAR screen, accessed from the KNOB screen via the NEXT softkey.

Purpose Allows you to select whether the speedup knob-gear ratio for OSC-F will be the locally set value or the default value. It additionally allows you to set the OSC-F speedup ratio value that will be in effect if local (DEFAULT OFF) is selected.

How used Use the ↑ and ↓ softkeys to select DEFAULT ON/OFF or KNOBGEAR. Then use the ADJUST softkeys to set the DEFAULT ON/OFF status or speedup ratio, as required.

Pressing MAIN returns you to the MAIN page. PREV returns you to the KNOBGEAR screen.

OSC-V (knob-gear)

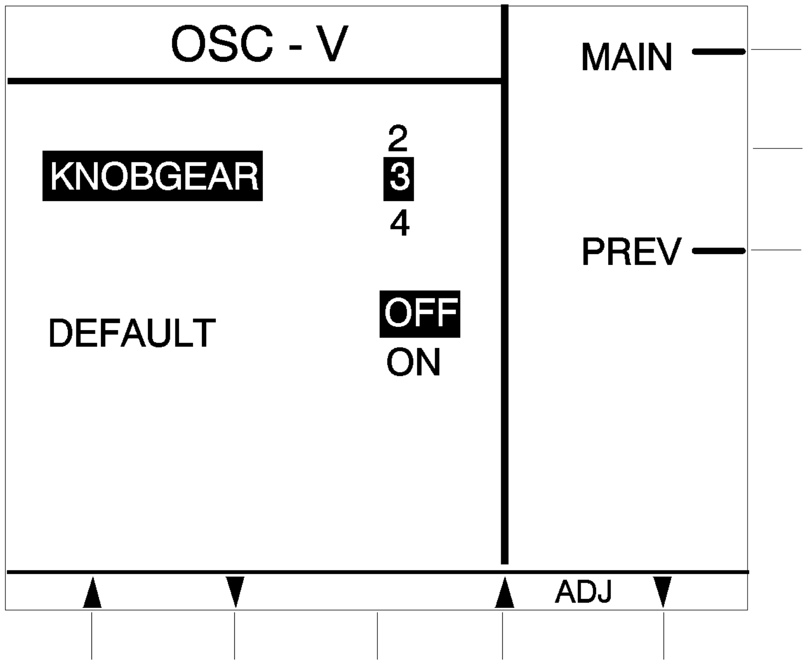


Figure 7-33. OSC - V KNOB-GEAR SCREEN

How accessed Select OSC-V from the KNOBGEAR screen, accessed from the KNOB screen via the NEXT softkey.

Purpose Allows you to select whether the speedup knob-gear ratio for OSC-V will be the locally set value or the default value. It additionally allows you to set the OSC-V speedup Knob-Gear ratio value that will be in effect if local (DEFAULT OFF) is selected.

How used Use the ↑ and ↓ softkeys to select DEFAULT ON/OFF or KNOBGEAR. Then use the ADJUST softkeys to set the DEFAULT ON/OFF status or knob-gear speedup ratio, as appropriate.

Pressing MAIN returns you to the MAIN page. PREV returns you to the KNOBGEAR screen.

OSCILLATOR

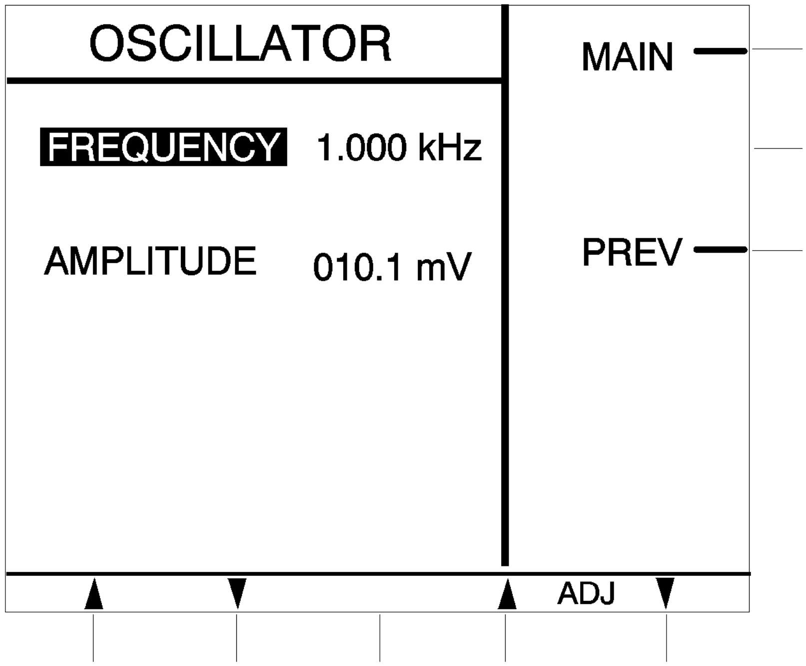


Figure 7-34. OSCILLATOR SCREEN

How accessed Select OSCILLATOR from the SETUP MENU page, accessed from the LARGE DISPLAY page.

Purpose Allows you to set the frequency and amplitude of the internal oscillator.

How used The ↑ and ↓ softkeys select the parameter to be set, either FREQUENCY or AMPLITUDE. The value for the selected parameter is then set using the ADJUST softkeys or the Parameter Setting Knob.

Pressing MAIN returns you to the MAIN page. PREV returns you to the SETUP MENU page.

OUTPUTS

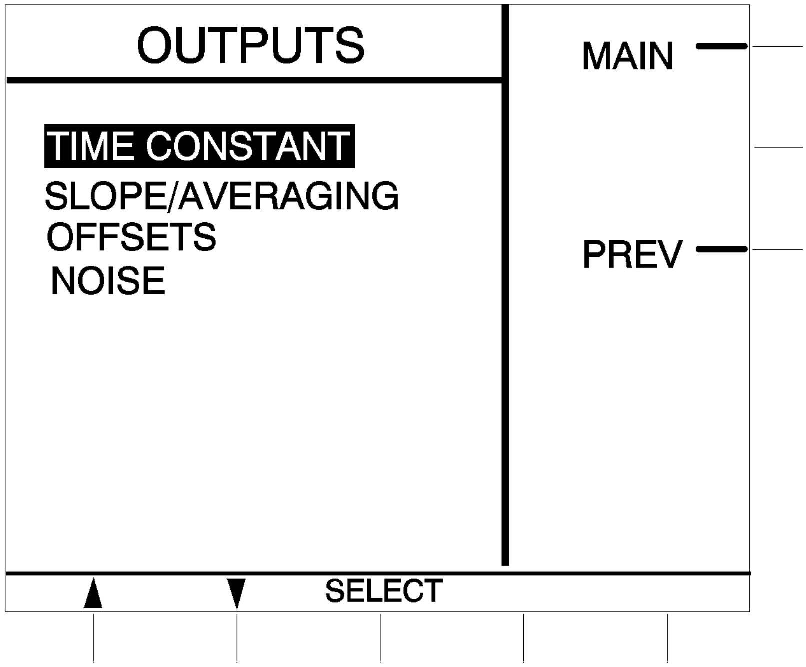


Figure 7-35. OUTPUTS SCREEN

How accessed Select OUTPUT-DISPLAY from the SETUP MENU page, accessed from the LARGE DISPLAY page.

Purpose Allows you to access the TIME CONSTANT, AVERAGING MODE/SLOPE, OFFSET, and NOISE screens.

How used Using the ↑ and ↓ soft-keys, position the inverse-video bar over your selection. Then press SELECT.

Pressing MAIN returns you to the MAIN page. Press PREV to return to the SETUP MENU page.

PHASE (knobgear)

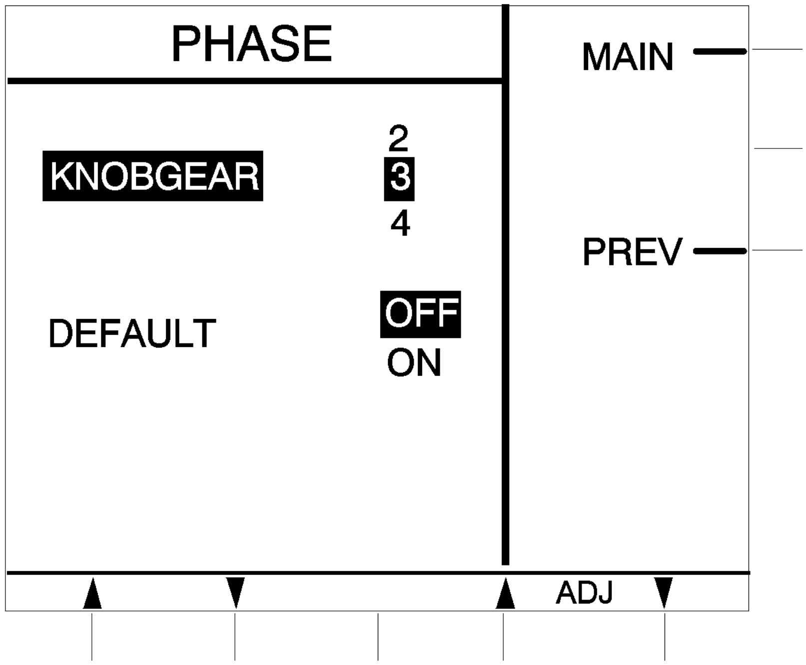


Figure 7-36. PHASE KNOBGEAR SCREEN

How accessed Select PHASE from the KNOBGEAR screen, accessed from the KNOB screen via the NEXT softkey.

Purpose Allows you to select whether the speedup knob-gear ratio for adjusting PHASE will be the locally set value or the default value. It additionally allows you to set the PHASE speedup knob-gear ratio value that will be in effect if local control (DEFAULT OFF) is selected.

How used Use the ↑ and ↓ softkeys to select DEFAULT ON/OFF or KNOBGEAR. Then use the ADJUST softkeys to set the DEFAULT ON/OFF status or knob-gear speedup ratio, as appropriate.

Pressing MAIN returns you to the MAIN page. PREV returns you to the KNOBGEAR screen.

PHASE SETUP

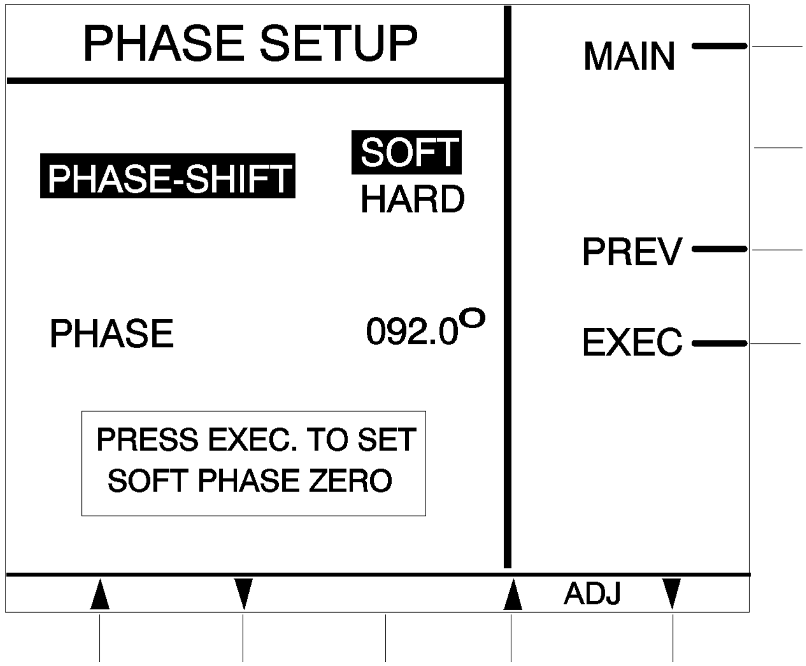


Figure 7-37. PHASE SETUP SCREEN

How accessed Select PHASE on the REFERENCE-MIXER screen, accessed from the SETUP MENU page.

Purpose Allows you to select either the SOFT or HARD phase-control mode, and to set the reference phase (Section 6.3.05).

How used Use the ↑ and ↓ softkeys to select PHASE-SHIFT or PHASE. Then use the ADJUST softkeys to select the parameter setting. The Parameter Setting knob can also be used to set the phase, and in fact, unless the change is quite small, its use will prove the easier technique.

MAIN returns you to the Main Page and PREVIOUS returns you to the REF-MIXER screen. Pressing the EXEC softkey establishes soft-phase operation and sets the soft-phase zero; the phase reading will be set to zero without a change occurring in the actual phase offset. Subsequent phase readings are made with respect to this point.

REFERENCE HARMONICS

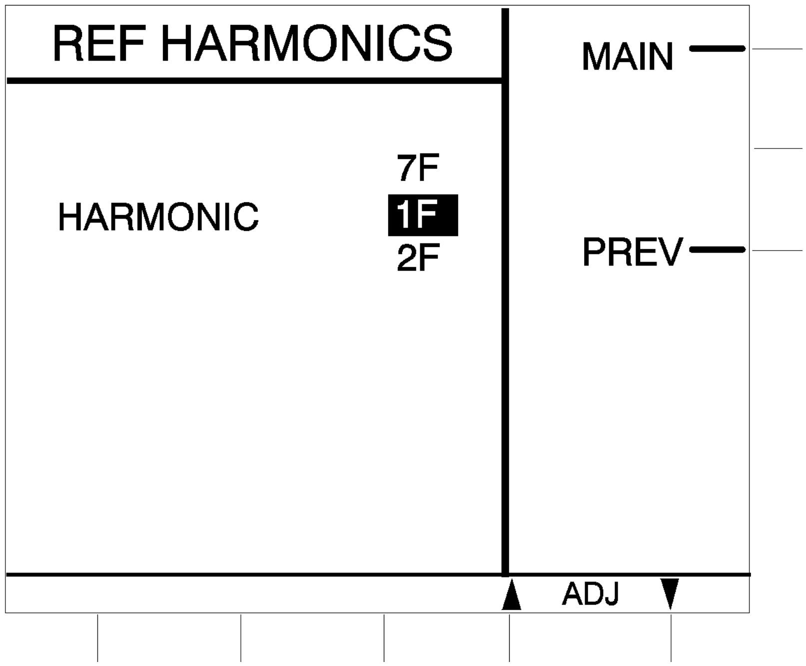


Figure 7-38. REFERENCE HARMONICS SCREEN

How accessed Select REF HARMONICS on the REFERENCE-MIXER screen, accessed from the SETUP MENU page.

Purpose Selects the NF modes of the reference channel (Section 6.3.01).

How used Use the ADJUST softkeys to select the desired harmonic as indicated by the inverse video bar.

Pressing MAIN returns you to the MAIN page. PREVIOUS returns you to the REFERENCE-MIXER screen.

REFERENCE-MIXER

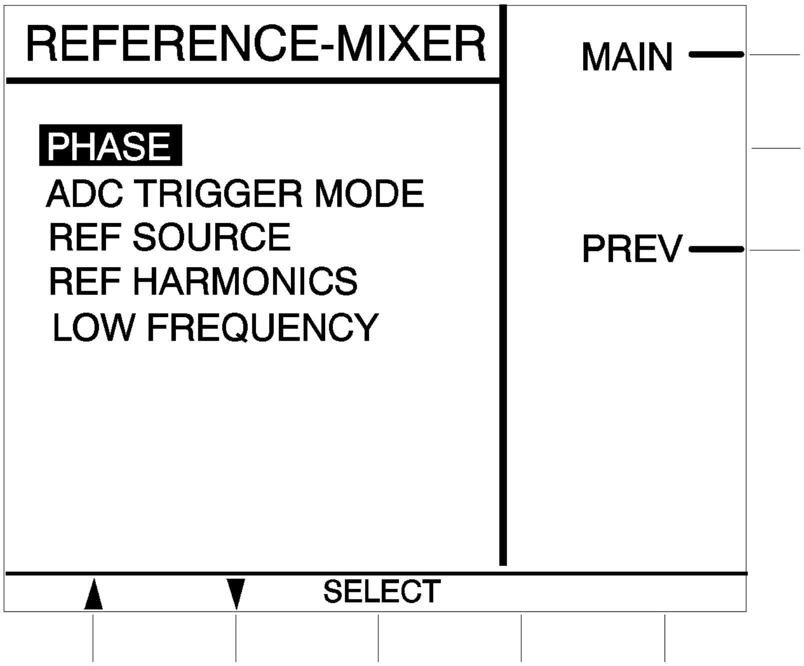


Figure 7-39. REFERENCE-MIXER SCREEN

How accessed Select REFERENCE MIXER on the SETUP MENU page, accessed from the LARGE DISPLAY page.

Purpose Gives you access to the **PHASE**, **ADC TRIGGER MODES**, **REF SOURCE**, **REF HARMONICS**, and **LOW FREQUENCY** screens.

How used Use the ↑ and ↓ softkeys to position the reverse-video bar over your selection. Then press the SELECT key.

Pressing MAIN returns you to the MAIN page. PREVIOUS returns you to the SETUP MENU page.

REFERENCE SOURCE

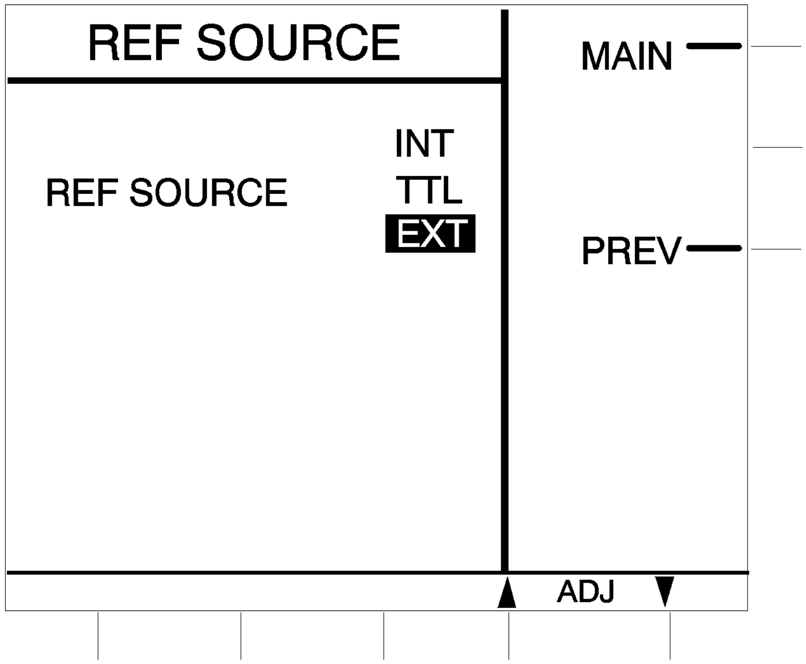


Figure 7-40. REFERENCE SOURCE SCREEN

How accessed Select REF SOURCE from the REFERENCE-MIXER screen, accessed from the SETUP MENU page.

Purpose Allows you to select the reference source mode (Section 6.3.01).

How used Use the ADJUST softkeys to set the position of the inverse video bar and so select the reference source mode.

Pressing MAIN returns you to the MAIN page. PREVIOUS returns you to the REFERENCE-MIXER screen.

RS232 (PG 1 OF 2)

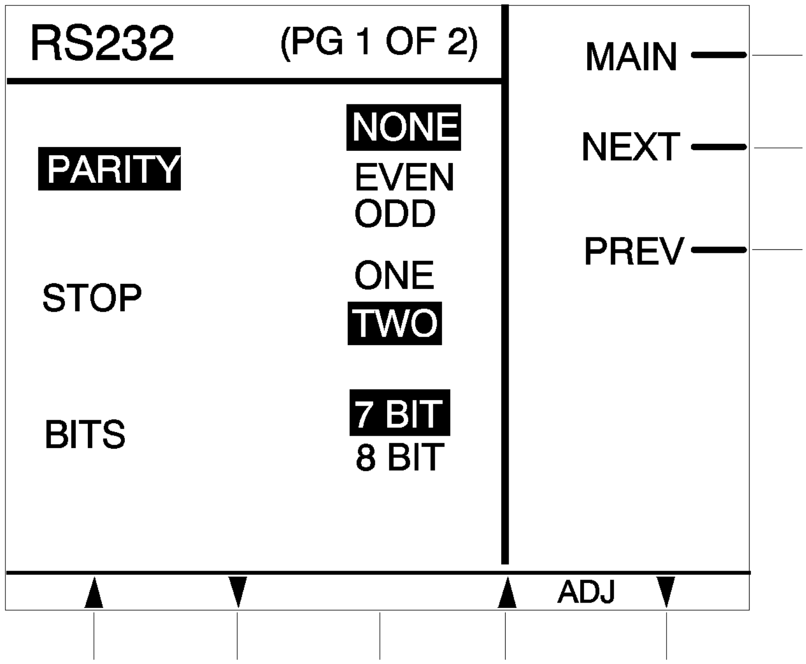


Figure 7-41. RS232 SCREEN (PG 1 of 2)

How accessed Select RS232 from the COMM-I/O screen, accessed from the SETUP MENU page.

Purpose Allows the RS232 communications parameters PARITY, number of STOP bits, and number of data BITS to be set. Additionally provides the means for accessing RS232 screen 2, used to set the RS232 parameters BAUD rate, TERMINATOR selection, and RS232 ECHO.

The PARITY, STOP, BITS, and BAUD selections must be the same for both the Model 5302 and the host computer or terminal. The usual settings are EVEN,ONE,7 BIT.

How used Use the ↑ and ↓ softkeys to select the parameter to be set. Then use the softkeys to either side of ADJUST to make the value selection.

Pressing MAIN returns you to the MAIN page. PREV takes you back to the COMM-I/O screen, and NEXT takes you to the second RS232 screen.

RS232 (PG 2 OF 2)

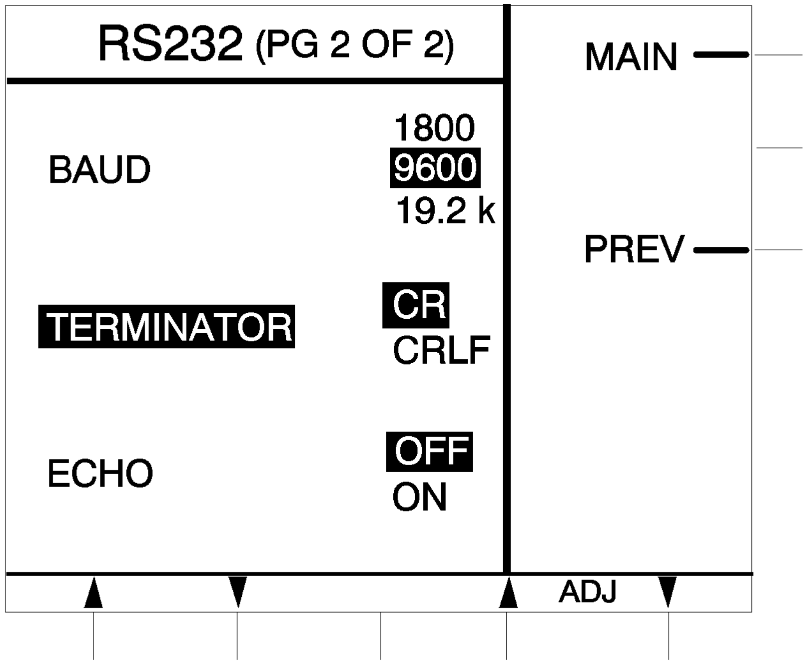


Figure 7-42. RS232 SCREEN (PG 2 of 2)

How accessed Select NEXT from the RS232 (PG 1 OF 2) screen, accessed from the COMM-I/O screen.

Purpose Allows the RS232 communications parameters BAUD rate, TERMINATOR, and ECHO to be set. The BAUD selections must be the same for both the Model 5302 and the host computer or terminal.

Baud: This is the data transmission rate. Thirteen different rates from 75 baud to 19.2 kbaud are provided. The usual setting is 9600 for use with a terminal or a computer having a fast serial interface, or 1200 for use with a computer having a slow serial interface.

Terminator: this option sets the input (command) terminator, which is the sequence appended by the computer to the end of a command line. This may be either CR or CRLF, and it is necessary for the instrument to be told which terminator to expect. Note that the input terminator can be independently selected for the GPIB and RS232 ports.

If the input terminator is set from this screen, the output (response) terminator is automatically set to CRLF for RS232 communications. The AT command allows this to be changed if necessary.

Echo: When ECHO is ON, the RS232 echo (Section 8.4) is enabled. The normal setting is ON.
Do not confuse this echo function with the TEST ECHO function selectable at the GPIB screen. The TEST ECHO echoes all GPIB communications to the RS232 port and is provided primarily as a convenience in program development.

How used Use the ↑ and ↓ softkeys to select the parameter to be set. Then use the softkeys to either side of ADJUST to make the value selection.

Pressing MAIN returns you to the MAIN page. PREV takes you back to the RS232 (PG

1 of 2) screen.

SAMPLE RATE

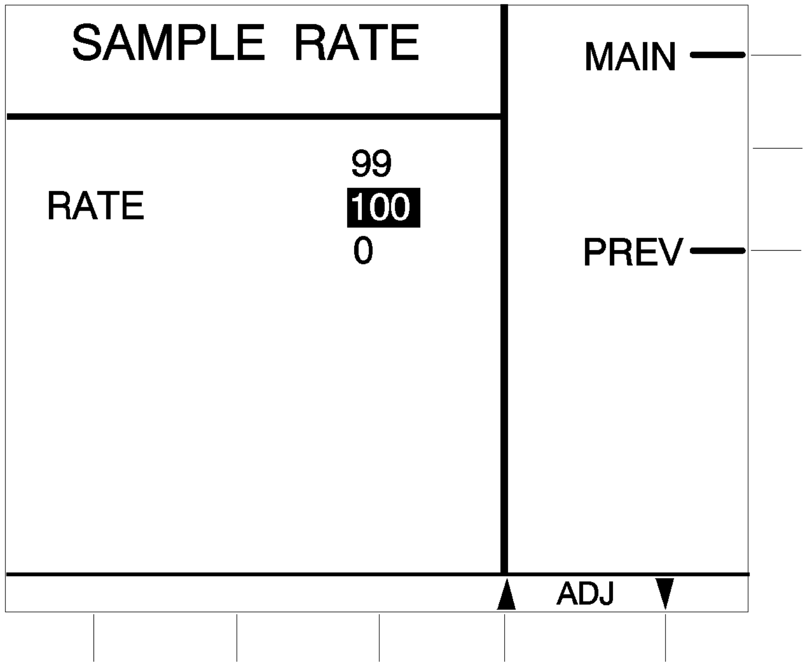


Figure 7-43. SAMPLE RATE SCREEN

How accessed Select SAMPLE RATE on the SPECIAL screen, accessed from the SETUP MENU page.

Purpose Allows the system sample rate (Section 6.4.13), normally 100 Hz, to be adjusted to a lower value (range is 50 Hz to 100 Hz). In areas served by 50 Hz power, operating stability may be improved by setting the sample rate to a frequency that is not a multiple of the power line frequency.

How used Press ↑ and/or ↓ ADJ softkeys so that the desired frequency shows in reverse video. Then pressing MAIN to return to the MAIN menu or PREV to return to the SETUP MENU page.

SETUP MENU

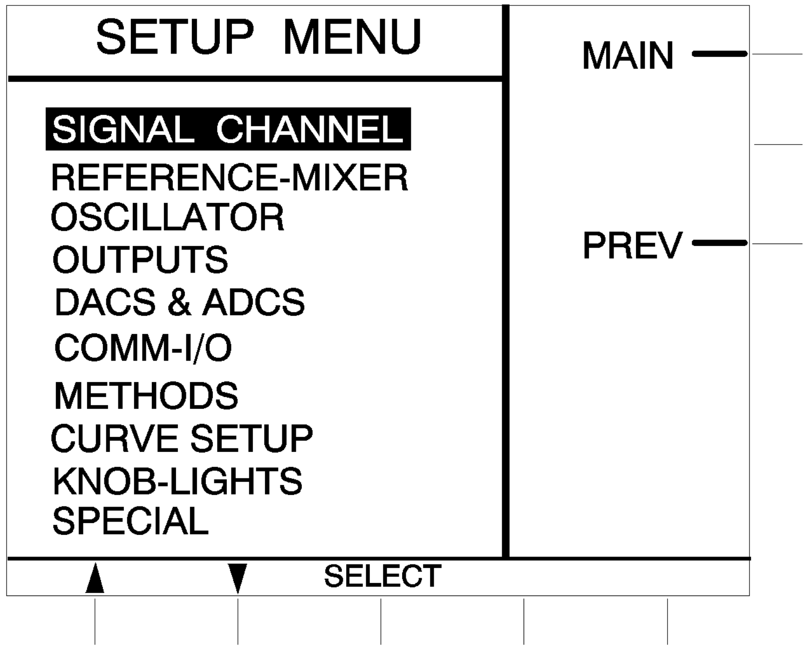


Figure 7-44. SETUP MENU

How accessed Press the SETUP key on the LARGE DISPLAY page.

Purpose Provides means for accessing the Setup Screens. A brief description of each selection follows.

Signal Channel: Allows you to select the signal source, either a separate preamplifier or the 5302's Direct Input connector. Also allows you to make the line filter selections, and to access the screens used to set the Normal and Special filter screens.

Reference Mixer: Allows you to select the Phase Setup screen, the Reference Trigger mode screen, the Reference Source (INT, EXT, TTL) selection screen, the Reference Harmonic screen, and the Low Frequency mode select screen.

Oscillator: Allows you to set the frequency and amplitude of the internal oscillator.

Outputs: Allows you to make the Time Constant, Averager Mode/Slope, Offset, and Noise mode selections.

DACS & ADCS: Allows you to read the outputs of the four ADCs, and to set the outputs of the two DACs.

Comm-I/O: Allows you to set the GPIB Address, as well as select the Terminator (CR or CRLF) and Test Echo ON/OFF status. Additionally allows you to set the RS232 parameters, Parity (NONE/ODD/EVEN), Number of STOP bits, Number of Data bits, Baud Rate, and Terminator. Additionally allows the RS232 echo function to be turned ON or OFF.

Methods: Allows up to fifteen different methods to be stored. A stored method can be recalled and re-installed when needed.

Curve Setup: Allows you to set the number of curve points and to set the memory location of the first curve point.

Knob-Lights: Allows you to set the knob parameters, Knob-Gear and Timeout. *Timeout can be ON or OFF and is always global; Knob-Gear can be global (default) or locally set for each affected parameter.* Additionally allows you to set the ON/OFF state of the panel lights and display backlight.

Special: Allows the firmware version to be read. Additionally provides the User Key and Sample Rate functions.

How used

Press ↑ and/or ↓ softkeys to make the selection. Then press SELECT softkey. The selected screen will be displayed.

Pressing MAIN will return you to the MAIN menu. PREV returns you to the LARGE DISPLAY page.

SIGNAL CHANNEL

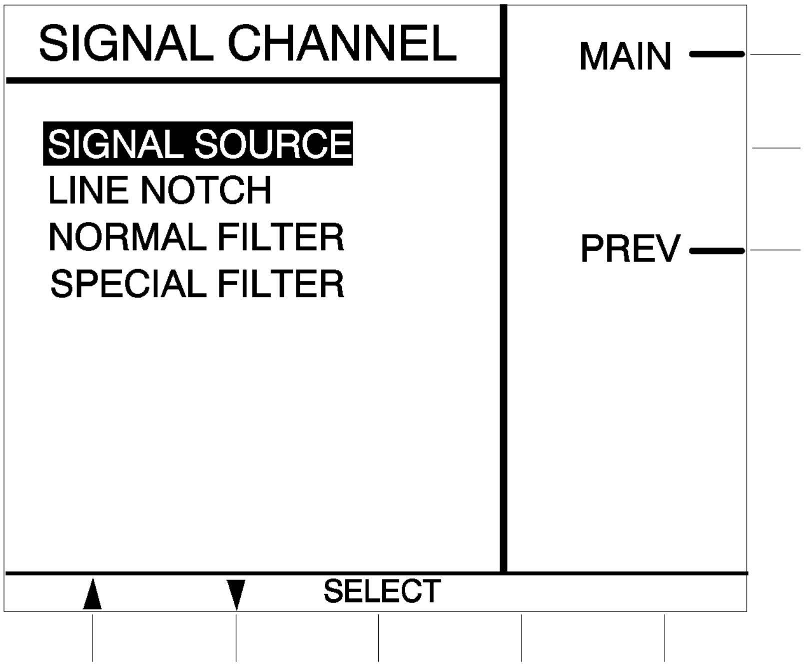


Figure 7-45. SIGNAL SCREEN

How accessed Select SIGNAL CHANNEL on the SETUP MENU page, accessed from the LARGE DISPLAY page.

Purpose Provides access to **SIGNAL SOURCE**, **LINE NOTCH**, **NORMAL FILTER** and **SPECIAL FILTER** screens.

How used Press ↑ and/or ↓ softkeys as required to position reverse-video bar on desired selection. Then press SELECT softkey. The selected screen will be displayed.

Pressing MAIN will return you to the MAIN menu. PREVIOUS will return you to the SETUP MENU page.

SIGNAL SOURCE

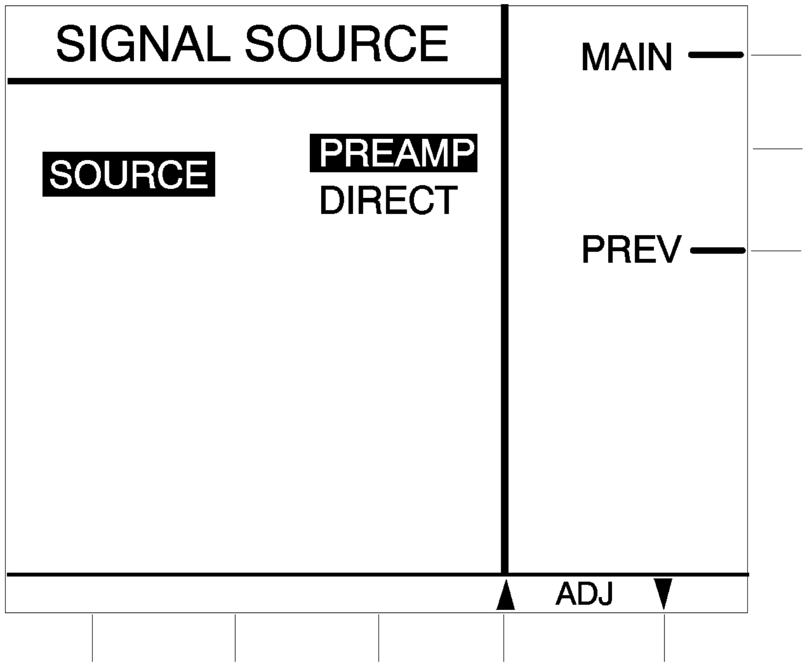


Figure 7-46. SIGNAL SOURCE SCREEN

How accessed Select SIGNAL SOURCE on the SIGNAL CHANNEL screen, accessed from the SETUP MENU page.

Purpose Allows you to select either the PREAMP or DIRECT input (Section 6.2.02). If PREAMP is selected, you must have a plug-in preamplifier and the input signal must be applied to its input. If DIRECT is selected, the input signal must be applied to the front-panel DIRECT INPUT connector.

How used Use the ADJUST softkeys to position the reverse-video bar over your selection.

Pressing MAIN will return you to the MAIN menu. PREVIOUS will return you to the SIGNAL page.

SLOPE/AVERAGING

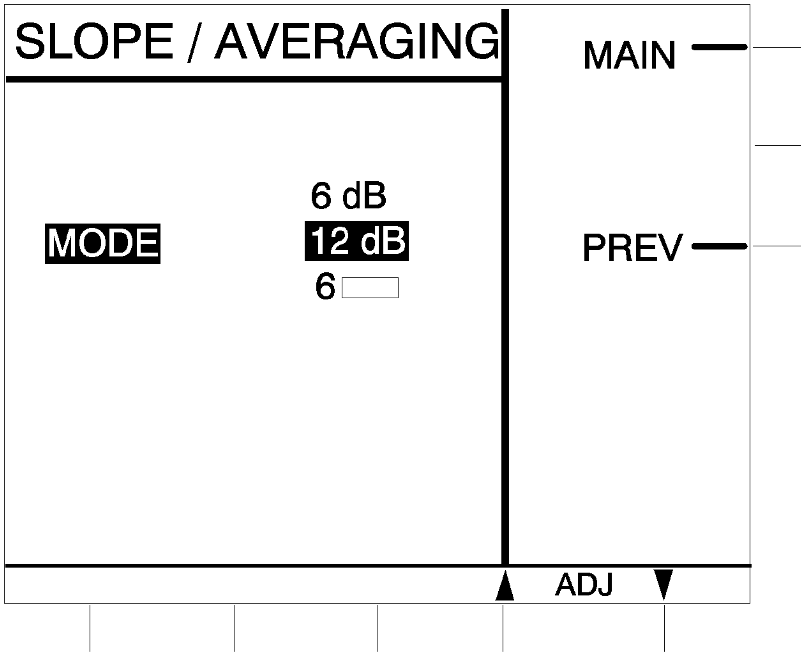


Figure 7-47. SLOPE/AVERAGING SCREEN

How accessed Select SLOPE/AVERAGING from the OUTPUTS screen, accessed from the SETUP MENU screen.

Purpose Allows you to select the output filter characteristics (Sections 6.4.08, 6.4.10). Four choices are provided, 6 dB/octave exponential, 12 dB/octave Δ (triangular), 6 dB/octave □ (rectangular), and 12 dB/octave exponential. The terms exponential, rectangular, and triangular refer to the shape of the weighting function. The preferred output filter modes are 12 dB/octave, exponential or triangular. Of these, the triangular mode gives the best output processing, but, for a given response time, the exponential mode will handle a higher level of interference at frequencies near the reference. The 6 dB/octave rectangular mode may be preferred where the interference is low. The 6 dB/octave exponential mode should be used where the 5302 is incorporated into a feedback loop. Note that the rectangular and and triangular weighting functions are not available at time constants of 50 ms or lower. However, if either has been selected, the unit automatically returns to the previous slope on setting the time constant above 50 ms.

How used Use the ADJUST softkeys to select the desired output filter slope/configuration. The inverse-video bar position is fixed and the ADJUST softkeys simply scroll the available values. The center selection (inverse video) is always selected.

Pressing MAIN returns you to the MAIN page. PREV returns you to the OUTPUTS screen.

SPECIAL

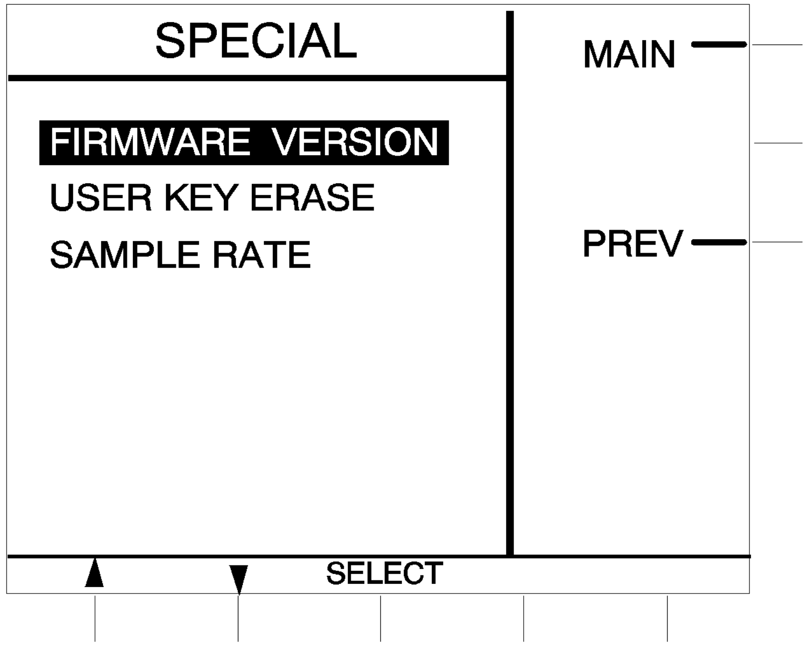


Figure 7-48. SPECIAL SCREEN

How accessed Select SPECIAL from the SETUP MENU page, accessed from the LARGE DISPLAY page.

Purpose Allows you to access the **FIRMWARE VERSION**, **USER KEY ERASE**, and **SAMPLE RATE** screens.

How used Use the ↑ and ↓ keys to select either FIRMWARE VERSION, USER KEY ERASE, or SAMPLE RATE. Then press the SELECT softkey.

MAIN returns you to the MAIN MENU. PREV returns you to the SETUP MENU screen.

SPECIAL FILTER

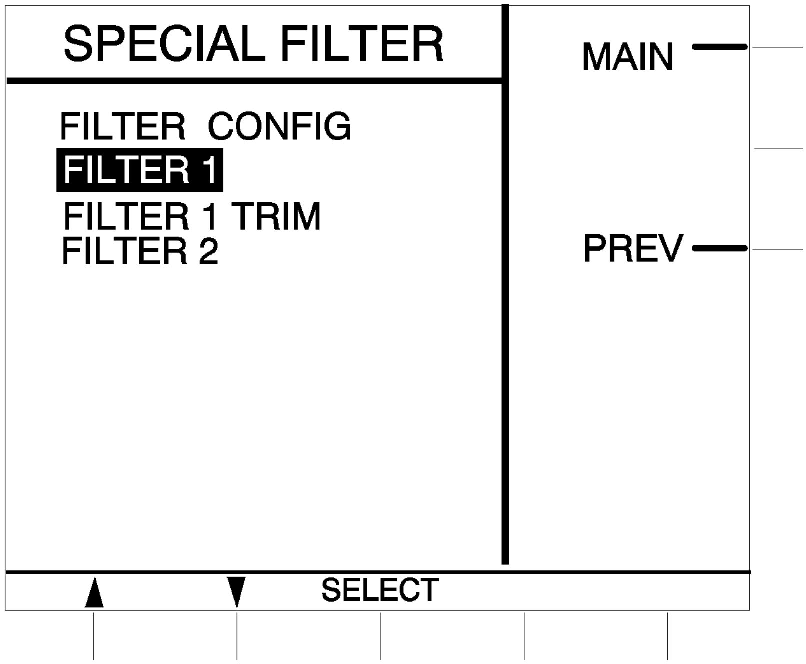


Figure 7-49. SPECIAL FILTER SCREEN

How accessed Select SPECIAL FILTER from the SIGNAL CHANNEL screen, accessed from the SETUP MENU screen.

Purpose Allows you to select four other screens as follows.

1. **FILTER CONFIG:** used to select between the Normal and the Special configurations of the main signal-channel filter (Section 6.2.08).

2. **FILTER 1 (SPECIAL):** used to set the resonance frequency, mode, and Qfactor of section 1 when in the Special configuration.

3. **FILTER 1 TRIM (SPECIAL):** used to fine-adjust the frequency setting of section 1 when in the Special configuration.

4. **FILTER 2 (SPECIAL):** used to set the resonance frequency and mode of section 2 when in the Special configuration.

How used Use the ↑ and ↓ softkeys to select the screen to be accessed. Then press the SELECT softkey.

Pressing MAIN returns you to the MAIN page. PREV returns you to the SIGNAL CHANNEL screen.

TIME CONSTANT

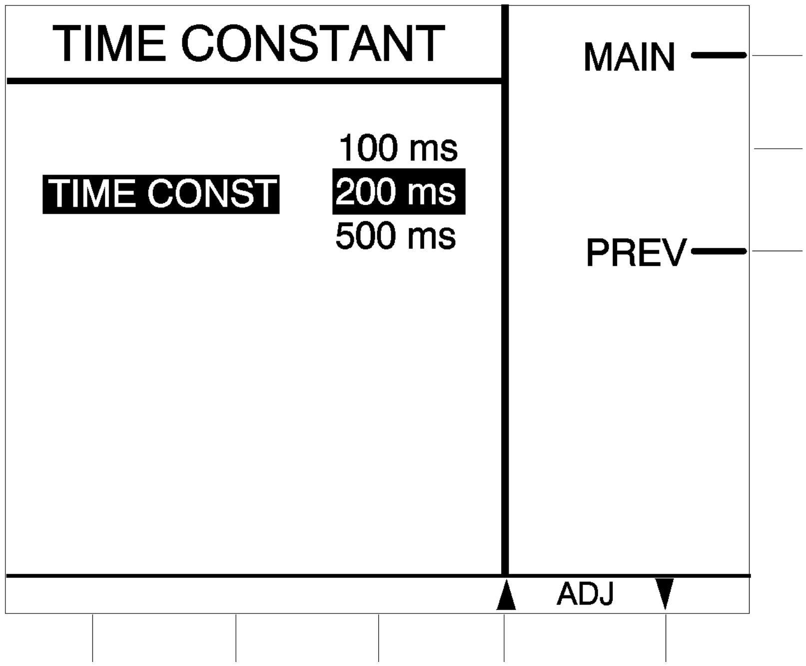


Figure 7-50. TIME CONSTANT SCREEN

How accessed Select TIME CONSTANT from the OUTPUTS screen, accessed from the SETUP MENU page.

Purpose Used to set the value of the time constant of the output filters (Sections 6.4.07, 6.4.09, 6.4.10).

Note that the values below 20 ms, that is, 10 ms, 1 ms, 100 µs, and MIN are the Fast Mode time constant settings, as marked by the prefix F before the indicated value at the front panel. In Fast Mode operation, the FAST OUT X and Y Outputs are provided at the rear panel.

How used Use the ADJUST softkeys to select the desired time constant.

Pressing MAIN returns you to the MAIN page. Press PREV to return to the OUTPUTS screen.

TIMEBASE

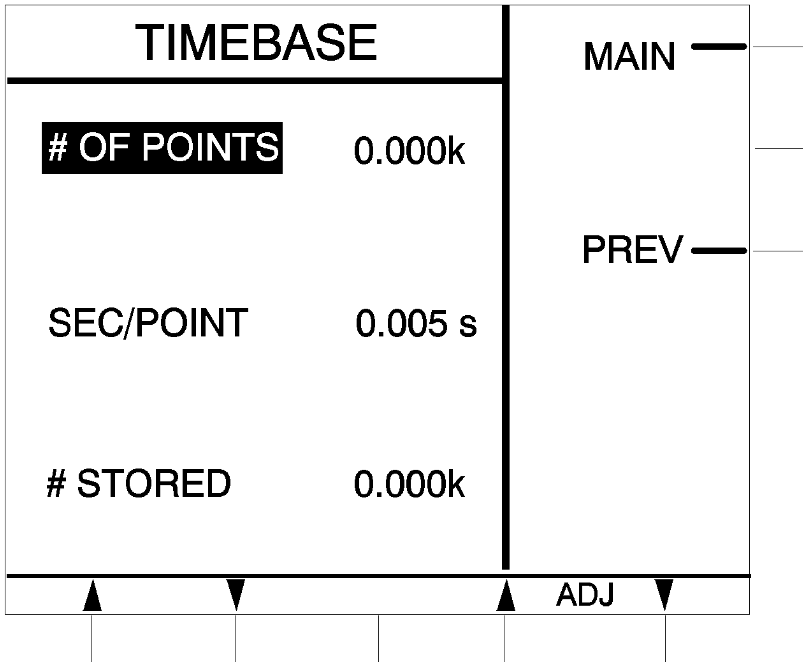


Figure 7-51. TIMEBASE SCREEN

How accessed Select TIMEBASE from the CURVE SETUP screen, accessed from the SETUP MENU screen.

Purpose Allows you to set the **Number of Points** and the **Seconds per Point** parameters for Curve Acquisition. Additionally indicates the number of points stored.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, # OF POINTS or SEC/POINT. Then use the ADJUST softkeys or the Parameter Setting KNOB to set the desired value.

Pressing MAIN returns you to the MAIN page. PREV returns you to the CURVE SETUP screen.

USER KEY ERASE

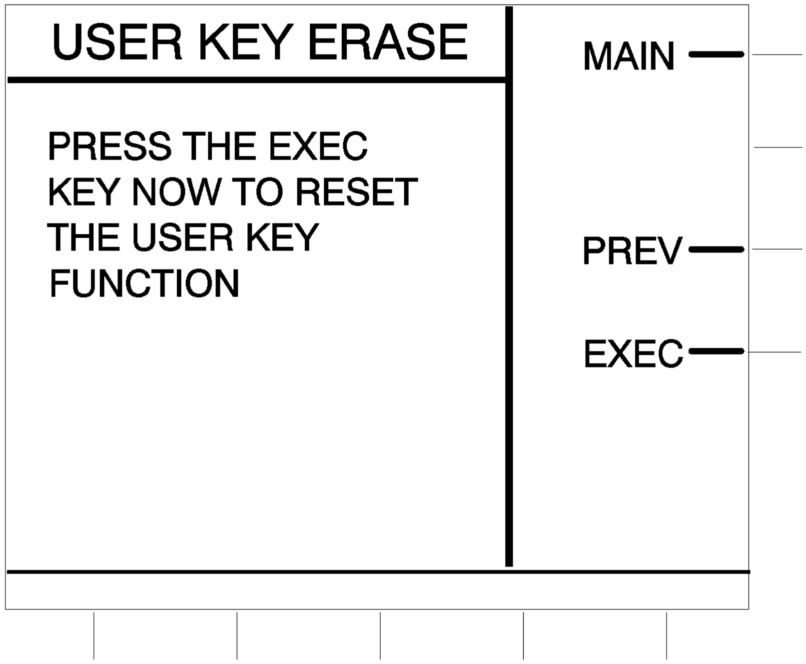


Figure 7-52. USER KEY ERASE SCREEN

How accessed Select USER KEY ERASE from the SPECIAL screen, accessed from the SETUP MENU screen.

Purpose Provides a means for clearing the USER KEY sequence. It can also be cleared by twice keying FUNCT and then USER, or by applying the USER 0 command as discussed in Chapter 9.

How used Simply press the EXEC key to reset the User Key Function.

Pressing MAIN returns you to the MAIN page. PREV returns you to the SPECIAL screen.

VERNIER (knobgear)

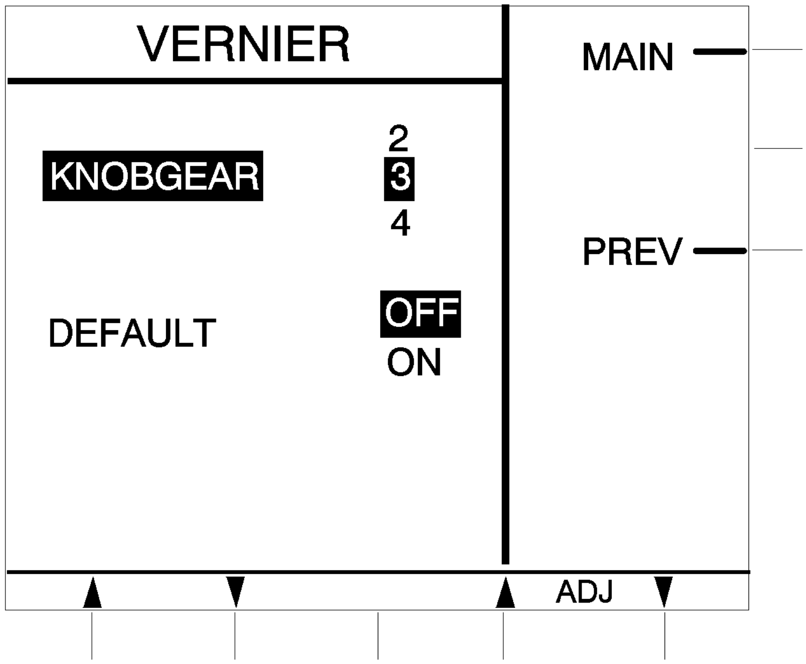


Figure 7-53. VERNIER KNOBGEAR SCREEN

How accessed Select VERNIER from the KNOBGEAR screen, accessed from the KNOB screen via the NEXT softkey.

Purpose Allows you to select whether the speedup knob-gear ratio for adjusting the Sensitivity VERNIER will be the locally or globally set value. It additionally allows you to set the VERNIER speedup ratio that will be in effect if local control (DEFAULT OFF) is selected.

How used Use the ↑ and ↓ softkeys to select DEFAULT ON/OFF or KNOBGEAR. Then use the ADJUST softkeys to set the DEFAULT ON/OFF status or knob-gear speedup ratio, as appropriate.

Pressing MAIN returns you to the MAIN page. PREV returns you to the KNOBGEAR screen.

X OFFSET (knobgear)

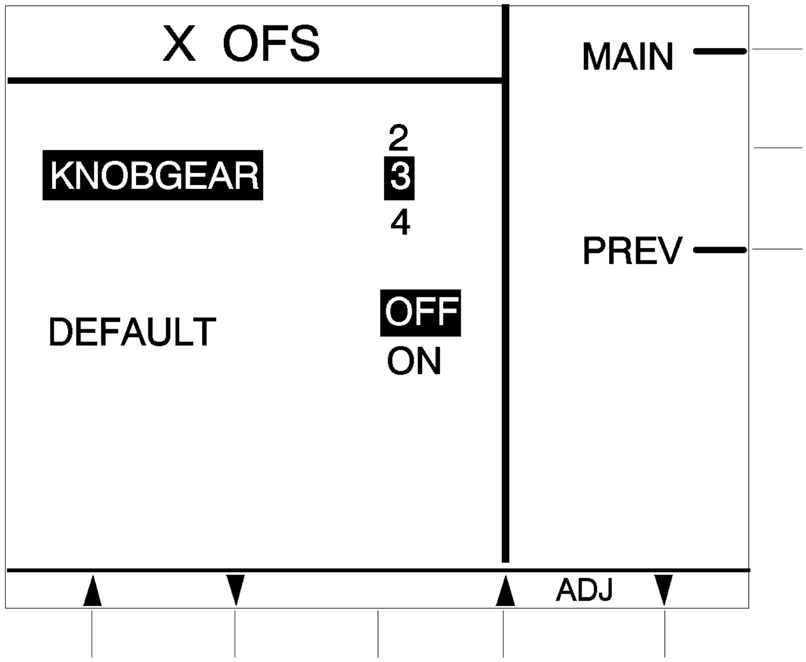


Figure 7-54. X OFFSET KNOBGEAR SCREEN

How accessed Select X OFFSET from the KNOBGEAR screen, accessed from the KNOB screen via the NEXT softkey.

Purpose Allows you to select whether the speedup knob-gear ratio for adjusting X OFFSET will be the locally set value or the default value. It additionally allows you to set the X OFFSET speedup knob-gear ratio value that will be in effect if local control (DEFAULT OFF) is selected.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, DEFAULT ON/OFF or KNOBGEAR. Then use the ADJUST softkeys to set the DEFAULT ON/OFF status or knob-gear speedup ratio, as appropriate.

Pressing MAIN returns you to the MAIN page. PREV returns you to the KNOBGEAR screen.

Y AXIS INPUTS 1

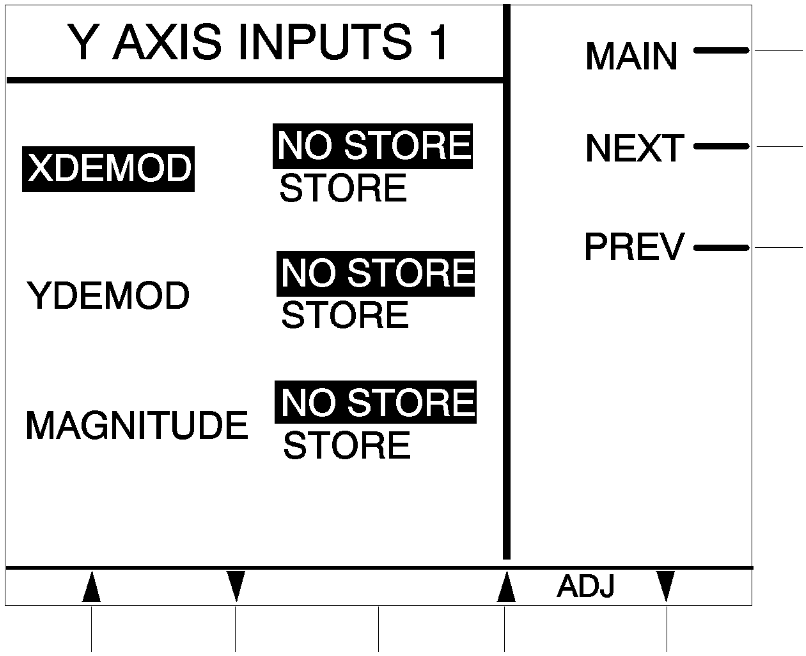


Figure 7-55. Y AXIS INPUTS 1 SCREEN

How accessed Select Y AXIS INPUTS from the CURVE SETUP screen, accessed from the SETUP MENU screen.

Purpose There is a series of Y AXIS INPUTS screens. Each lists three parameters and gives you means of deciding whether those parameters will be included in a Curve Acquisition. Since the amount of available memory is limited, the more parameters that are included, the smaller will be the number of points that can be taken. The three parameters for the Y AXIS INPUTS 1 screen are XDEMOD, YDEMOD, and MAGNITUDE.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, XDEMOD, YDEMOD, or MAGNITUDE. Then use the ADJUST softkeys to set status of each. If STORE is selected, the parameter will be included in the curve. If NO STORE is selected, the parameter will not be included.

Pressing NEXT will advance you to the Y AXIS INPUTS 2 screen. Pressing MAIN returns you to the MAIN page. PREV returns you to the CURVE SETUP screen.

Y AXIS INPUTS 2

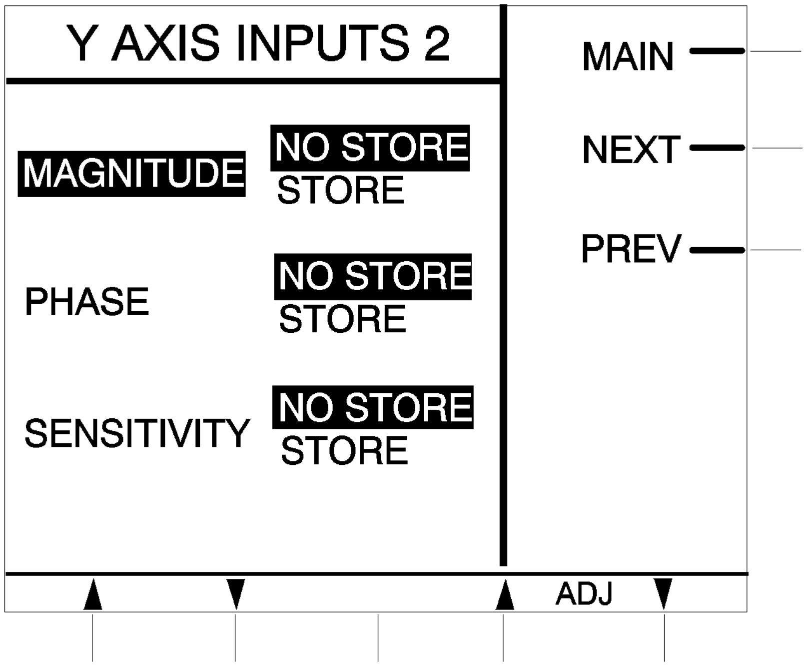


Figure 7-56. Y AXIS INPUTS 2 SCREEN

How accessed Press the NEXT softkey on the Y AXIS INPUTS 1 screen, accessed from the CURVE SETUP screen.

Purpose There is a series of Y AXIS INPUTS screens. Each lists three parameters and gives you means of deciding whether those parameters will be included in a Curve Acquisition. Since the amount of available memory is limited, the more parameters that are included the smaller will be the number of points that can be taken. The three parameters for the Y AXIS INPUTS 2 screen are MAGNITUDE, PHASE, and SENSITIVITY.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, MAGNITUDE, PHASE, or SENSITIVITY. Then use the ADJUST softkeys to set status of each. If STORE is selected, the parameter will be included in the curve. If NO STORE is selected, the parameter will not be included.

Pressing NEXT will advance you to the Y AXIS INPUTS 3 screen. Pressing MAIN returns you to the MAIN page. PREV returns you to the Y AXIS INPUTS 1 screen.

Y AXIS INPUTS 3

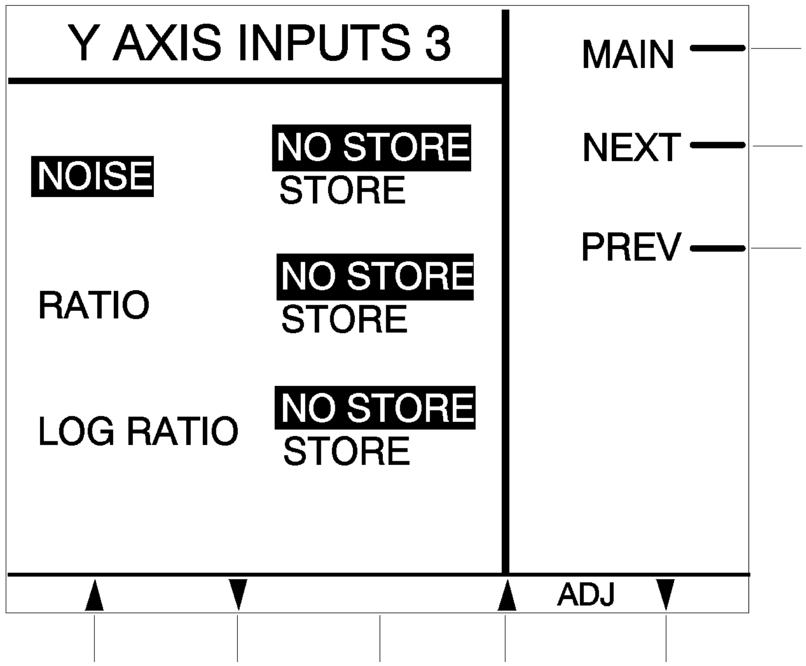


Figure 7-57. Y AXIS INPUTS 3 SCREEN

How accessed Press the NEXT softkey on the Y AXIS INPUTS 2 screen, accessed from the Y AXIS INPUTS 1 screen.

Purpose There is a series of Y AXIS INPUTS screens. Each lists three parameters and gives you means of deciding whether those parameters will be included in a Curve Acquisition. Since the amount of available memory is limited, the more parameters that are included the smaller will be the number of points that can be taken. The three parameters for the Y AXIS INPUTS 3 screen are NOISE, RATIO, and LOG RATIO.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, NOISE, RATIO, or LOG RATIO. Then use the ADJUST softkeys to set status of each. If STORE is selected, the parameter will be included in the curve. If NO STORE is selected, the parameter will not be included.

Pressing NEXT will advance you to the Y AXIS INPUTS 4 screen. Pressing MAIN returns you to the MAIN page. PREV returns you to the Y AXIS INPUTS 2 screen.

Y AXIS INPUTS 4

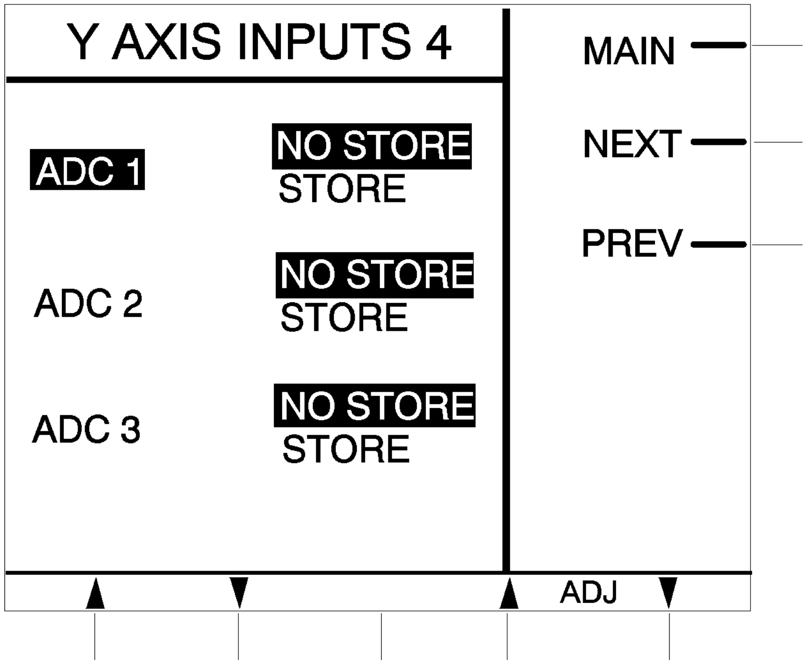


Figure 7-58. Y AXIS INPUTS 4 SCREEN

How accessed Press the NEXT softkey on the Y AXIS INPUTS 3 screen, accessed from the Y AXIS INPUTS 2 screen.

Purpose There is a series of Y AXIS INPUTS screens. Each lists three parameters and gives you means of deciding whether those parameters will be included in a Curve Acquisition. Since the amount of available memory is limited, the more parameters that are included the smaller will be the number of points that can be taken. The three parameters for the Y AXIS INPUTS 4 screen are ADC 1, ADC 2, and ADC 3.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, ADC 1, ADC 2, or ADC 3. Then use the ADJUST softkeys to set status of each. If STORE is selected, the parameter will be included in the curve. If NO STORE is selected, the parameter will not be included.

Pressing NEXT will advance you to the Y AXIS INPUTS 5 screen. Pressing MAIN returns you to the MAIN page. PREV returns you to the Y AXIS INPUTS 3 screen.

Y AXIS INPUTS 5

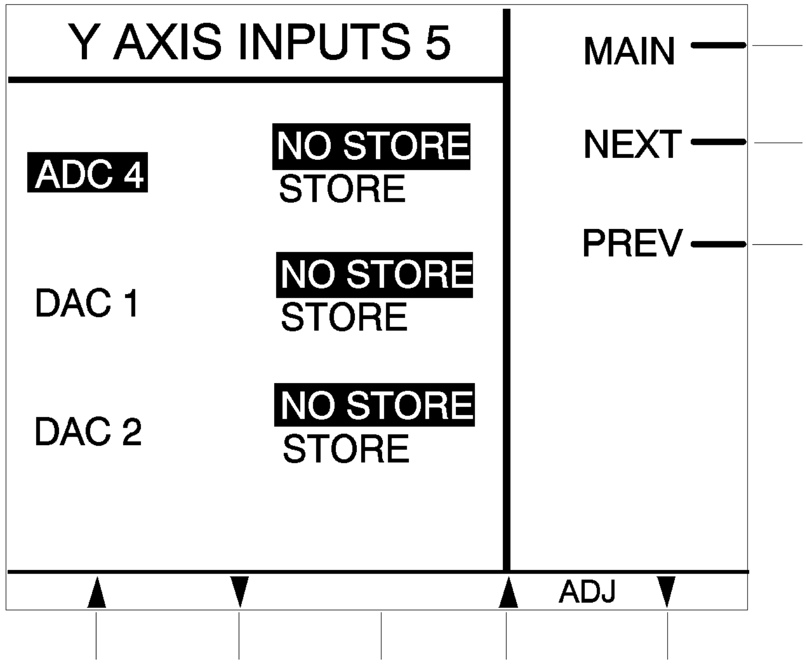


Figure 7-59. Y AXIS INPUTS 5 SCREEN

How accessed Press the NEXT softkey on the Y AXIS INPUTS 4 screen, accessed from the Y AXIS INPUTS 3 screen.

Purpose There is a series of Y AXIS INPUTS screens. Each lists three parameters and gives you means of deciding whether those parameters will be included in a Curve Acquisition. Since the amount of available memory is limited, the more parameters that are included the smaller will be the number of points that can be taken. The three parameters for the Y AXIS INPUTS 5 screen are ADC 4, DAC 1, and DAC 2.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, ADC 4, DAC 1, or DAC 2. Then use the ADJUST softkeys to set status of each. If STORE is selected, the parameter will be included in the curve. If NO STORE is selected, the parameter will not be included.

Pressing NEXT will advance you to the Y AXIS INPUTS 6 screen. Pressing MAIN returns you to the MAIN page. PREV returns you to the Y AXIS INPUTS 4 screen.

Y AXIS INPUTS 6

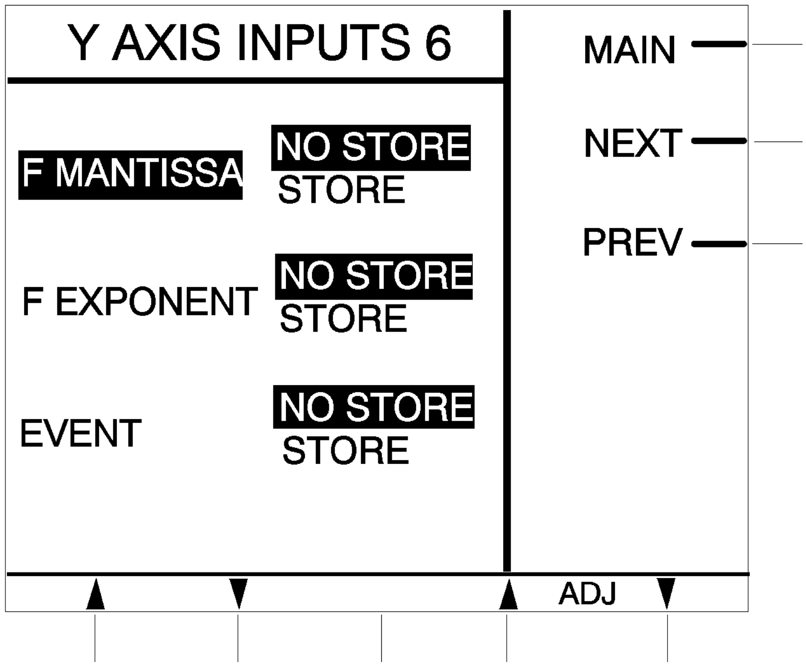


Figure 7-60. Y AXIS INPUTS 6 SCREEN

How accessed Press the NEXT softkey on the Y AXIS INPUTS 5 screen, accessed from the Y AXIS INPUTS 4 screen.

Purpose There is a series of Y AXIS INPUTS screens. Each lists three parameters and gives you means of deciding whether those parameters will be included in a Curve Acquisition. Since the amount of available memory is limited, the more parameters that are included the smaller will be the number of points that can be taken. The three parameters for the Y AXIS INPUTS 6 screen are F MANTISSA, F EXPONENT, and EVENT.

How used Use the ↑ and ↓ softkeys to select the parameter to be set, F MANTISSA, F EXPONENT, or EVENT. Then use the ADJUST softkeys to set status of each. If STORE is selected, the parameter will be included in the curve. If NO STORE is selected, the parameter will not be included.

Pressing NEXT will advance you to the CURVE SETUP screen. Pressing MAIN returns you to the MAIN page. PREV returns you to the Y AXIS INPUTS 5 screen.

Y OFFSET (knobgear)

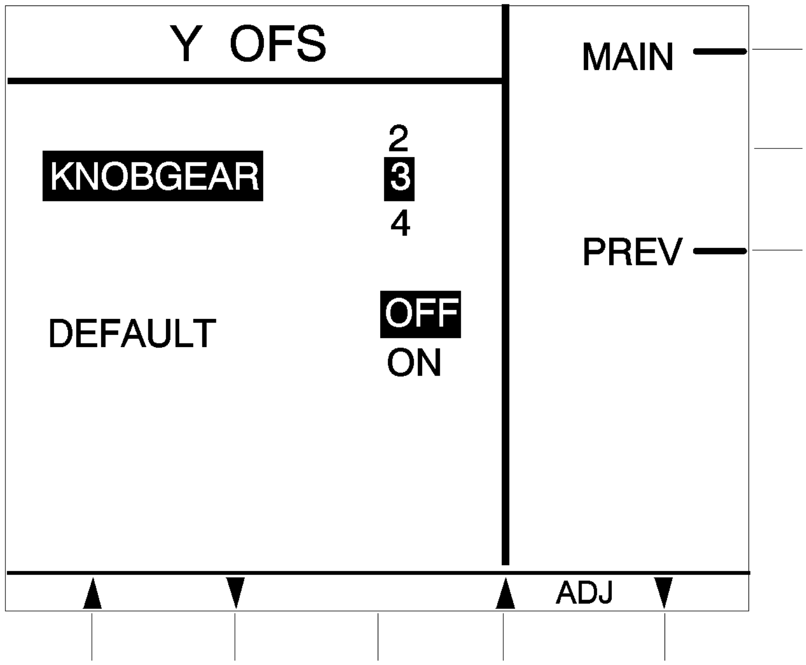


Figure 7-61. Y OFFSET KNOBGEAR SCREEN

How accessed Select Y OFFSET from the KNOBGEAR screen, accessed from the KNOB screen via the NEXT softkey.

Purpose Allows you to select whether the speedup knob-gear ratio when adjusting Y OFFSET will be the locally set value or the default value. It additionally allows you to set the Y OFFSET speedup knob-gear ratio that will be in effect if local control (DEFAULT OFF) is selected.

How used Use the ↑ and ↓ softkeys to select DEFAULT ON/OFF or KNOBGEAR. Then use the ADJUST softkeys to set the DEFAULT ON/OFF status or knob-gear speedup ratio, as appropriate.

Pressing MAIN returns you to the MAIN page. PREV returns you to the KNOBGEAR screen.

8.1 Introduction

The RS232 and IEEE488 (also known as GPIB for General Purpose Interface Bus) ports are designed to provide communications between the Model 5302 and a computer. In this chapter, the operation of the communications interface is described. Where references are made to commands, front-panel keys or front-panel screens, further details may be found in Chapters 9, 4 and 7 respectively.

The communication activity consists of the computer sending commands to the 5302, and the 5302 responding either by sending back some data or by changing one of its control settings. The commands and data responses are encoded in standard ASCII format.

The two ports cannot be used simultaneously, but when a command has been completed, the Model 5302 will accept a command at either port. Also when the test echo facility has been activated from the front panel (GPIB screen) or by the use of the GP command, all output from the computer to the GPIB can be moni-tored by a terminal attached to the RS232 connector.

Although the interface is primarily intended to enable the lockin to be operated by a computer program specially written for the application, it also finds application in the *direct mode* or *terminal mode*. In this mode the user enters commands on a keyboard and reads the results on a video screen.

The simplest way to establish the terminal mode is to connect a standard terminal, or a terminal emulator, to the RS232 port. A terminal emulator is a computer running special-purpose software that makes it act as a terminal. The lockin sends a convenient prompt character when ready for a command, and is normally set (from the RS232 screen) to echo each character that is received (Section 8.4).

Note: powerful terminal programs such as PROCOMM® (registered trademark of Datastorm Corporation) are available commercially at very reasonable cost. On the other hand, a simple terminal program with minimal facilities can be written in a few lines of BASIC code (Section B.1).

8.2 The RS232 interface - general features

The RS232 interface in the 5302 is implemented with three wires: one carries digital transmissions from the computer to the lockin, the second carries digital transmissions from the lockin to the computer, and the third is the Logic Ground to which both signals are referred. The logic levels are ±12 V referred to Logic Ground, and the connecting wires can be of low-cost general-purpose cable.

The main advantages of the RS232 interface are:

1. that it communicates with the serial port which is present as a standard equipment on nearly all computers, using leads and connectors which are available from suppliers of computer accessories or can be constructed at minimal cost in the user’s workshop; and

2. that it requires no more software support than is normally supplied with the

computer, for example Microsoft's GWBASIC or QUICKBASIC. **Note:** Microsoft®, GWBASIC® and QUICKBASIC® are registered trademarks of Microsoft Corporation.

Unless special external hardware is present, each serial port will support one 5302 or one alternative instrument, so that the total number of instruments is equal to the number of serial ports supported by the computer. In the case of the types of computer known as PC-compatible, one or two serial ports are supplied as standard.

Each 7-bit ASCII character is normally encoded in 10 bits, and the rate of data transfer depends on the number of bits per second sent over the interface, usually called the baud rate. In the 5302 the baud rate can be set to a range of different values up to 19200, corresponding to a byte in just over one half millisecond.

8.3 The GPIB - general features

The GPIB is a parallel digital interface with 8 bidirectional data lines, and 8 further lines which implement additional control and communication functions. Communication is through 24-wire cables (including 8 ground connections) with special-purpose connectors which are constructed in such a way that they can be stacked on top of one another to enable numerous instruments to be connected in parallel. By means of internal hardware or software switches, each instrument is set to a different address on the bus, usually a number in the range 1 to 30.

A most important aspect of the GPIB is that its operation is defined in minute detail by the IEEE488 standard, usually implemented by highly complicated special-purpose semiconductor devices that are present in each instrument and communicate with the instrument's microprocessor. The existence of this standard greatly simplifies the problem of programming the bus controller (i.e., the computer) to implement complex measurement and test systems involving the interaction of numerous instruments.

The operation of the GPIB requires the computer to be equipped with special-purpose hardware (usually in the form of a plug-in card) and associated software which enable it to act as a bus controller. The control program is written in a high-level language, usually BASIC or C, containing additional subroutines implemented by software supplied by the manufacturer of the interface card.

Because of the parallel nature of the GPIB and its very effective use of the control lines including the implementation of a 3-wire handshake, comparatively high data rates are possible, up to a few hundred thousand bytes/second. In typical setups the data rate of the GPIB itself is not the factor that limits the rate of operation of the control program.

8.4 Handshaking and echoes

The GPIB interface includes three lines (*DAV,*NRFD,*NDAC) which are used to implement a three-wire handshake ensuring that the transmitter does not send a byte until the receiver has read the previous one, and that the receiver reads the data lines only when they contain a valid byte.

In the 5302 the arrival of a byte at the RS232 input port causes an interrupt to be sent to the communications processor, which immediately reads the input byte into a large (2048 byte) command buffer. This process takes much less time than does the transfer of the next byte over the serial interface, so no provision for handshaking is required for data transfers to the lockin.

Normally the communications routines implemented by the computer will also be interrupt-driven and incorporate a sufficiently large data buffer; where this is not the case, or where some outside factors slow down the rate at which serial input can be handled, it may be necessary to reduce the baud rate below the standard value of 9600.

The RS232 ECHO option, which can be enabled from the RS232 screen or the RS command, causes the lockin immediately to send back to the computer a copy of each byte that it receives. This is a major convenience when a terminal is being used, also in the development of control programs based on the RS232 interface. The RS232 echo facility may also be used to monitor data integrity while control programs are being run, provided that the time penalty is acceptable. The RS232 echo is in the enabled state when the 5302 leaves the factory.

8.5 Terminators

In order for communications to be successfully established between the lockin and the computer, it is essential that each transmission (i.e., command or command response) is terminated in a way which is recognizable by the computer and the lockin as signifying the end of that transmission.

In the 5302 there are two input and output termination options for GPIB and RS232 communications, selected from the front panel (GPIB and RS232 screens) or by means of the AT and GP commands. The options are the <CR> byte (ASCII 13) or the <CR,LF> sequence (ASCII 13 followed by ASCII 10).

8.6 Command format, delimiters and compound commands

The formats of the simple commands listed in Chapter 9 are **CMDNAME** or **CMDNAME [n_1]** or **CMDNAME [n_1 n_2]** where **CMDNAME** is an alphanumeric word which defines the command, and n_1, n_2 are optional numeric parameters separated by spaces.

Any given **CMDNAME** may be allowed to have two parameters or one or none, as specified in Chapter 9. Where one or more parameters are allowed, the command may also be sent without any parameter in which case the response consists of a transmission of the current values of the parameter(s). As stated in Section 8.5, commands must be correctly terminated.

Any response transmissions consist of one or two numbers followed by a response terminator. Where the response of the lockin consists of two numbers in succession, they are separated by a byte called a delimiter. This delimiter can be any printing ASCII character and is selected by the use of the DD command.

A compound command consists of two or more simple commands separated by semicolons (ASCII 59) and terminated by a single command terminator. If any of the responses involve data transmissions, each one is followed by an output terminator.

8.7 Status bytes and prompts

An important feature of the IEEE488 standard is the serial poll operation by which a special byte, the status byte, may be read at any time from any instrument on the bus. This contains information which must be urgently conveyed from the instrument to the controller.

The function of the individual bits in the status byte is instrument dependent, apart from bit 6 (the request service bit) whose function is defined by the standard.

In the 5302, bits 0 and 7 signify command complete and data available respectively. The use of these bits can lead to a useful simplification of the control program by providing a response subroutine which is the same for all commands, whether or not they send a response over the bus. The principle is that after any command is sent, serial poll operations are repeatedly executed. After each operation bit 0 is tested; if this is found to be negated then bit 7 is tested, and if this is asserted then a read operation is performed. Serial poll operations continue until the lockin asserts bit 0 to indicate that the command-response sequence is complete. This method deals successfully with compound commands.

In RS232 communications, comparatively rapid access to the status byte is provided by the prompt character which is sent by the lockin at the same time as bit 0, the command complete bit, becomes asserted in the status byte. This character is sent out by the lockin after each command response (whether or not the response includes a transmission over the interface) to indicate that the response is finished and the instrument is ready for a new command. The prompt takes one of two forms. If the command contained an error (either in syntax or by a command parameter being out of range) or alternatively if an overload or reference unlock is currently being reported by the front-panel indicators, the prompt is **?** (ASCII 63). Otherwise the prompt is ***** (ASCII 42).

These error conditions correspond to the assertion of bits 1,2,3 or 4 in the status byte. When the **?** prompt is received by the computer, the usual procedure is to issue the ST command in order to discover which type of fault exists and to take appropriate action.

The prompts are a rapid way of checking on the instrument status and enable a convenient keyboard control system to be set up simply by attaching a standard terminal (or a simple computer-based terminal emulator) to the RS232 port. Where the prompt is not required it can be suppressed by setting the noprompt bit, bit 5 in the RS232 parameter byte. The default (power up) state of this bit is zero.

Because of the limited number of bits in the status byte, it can indicate that an overload exists but cannot give more detail. An auxiliary byte, the overload byte returned by the N command, gives details of the location of the overload.

A summary of the bit assignments in the status byte and the overload byte is given below.

	Status Byte	**Overload Byte**
bit 0	command complete	not used
bit 1	invalid command	not used
bit 2	command param error	not used
bit 3	reference unlock	X or Y overload
bit 4	overload	X or Y overload
bit 5	ext trig detected	PSD overload
bit 6	SRQ asserted	preamplifier overload
bit 7	data available	reference unlock

8.8 Service requests

The interface defined by the IEEE-488 standard includes a line (pin 10 on the connector) called the SRQ (service request) line which is used by the instrument to signal to the controller that urgent attention is required. At the same time that the instrument asserts the SRQ line, it also asserts bit 6 in the serial poll byte. The controller responds by executing a serial poll of all the instruments on the bus in turn and testing bit 6 of the serial poll byte in order to discover which instrument was responsible for asserting the SRQ line. The serial poll byte of that instrument is then further tested in order to discover the reason for the service request and to take appropriate action.

In the 5302 the assertion of the SRQ line is under the control of a byte called the **SRQ mask byte** which can be set by the user with the MSK command. If any bit in the serial poll byte becomes asserted, and the corresponding bit in the mask byte has a non-zero value, the SRQ line is automatically asserted. If the value of the mask byte is zero, the SRQ line is never asserted.

9.1 Command format, delimiters and compound commands

The standard syntax of each of the commands listed in this chapter has one of three forms:

CMDNAME terminator
CMDNAME [n] terminator
CMDNAME [n_1 n_2] terminator

where CMDNAME is an alphanumeric string that defines the command, and n, n_1, n_2 are integer parameters separated by spaces. [n] means that n is optional, and [n_1 n_2] means that n_1 is optional and if present must be followed by n_2. Upper-case and lower-case characters are equivalent. Terminator bytes are defined in Section 8.6.

Where the command syntax includes one or two optional parameters and the command is sent without any parameter, the response consists of a transmission of the current values of the parameter(s).

Any response transmission consists of one or two numbers followed by a response terminator. Where the response consists of two numbers in succession, they are separated by a delimiter (Section 8.6).

A compound command consists of two or more listed commands separated by semicolons (ASCII 59) and terminated by a single command terminator. If any of the responses involve data transmissions, each one is followed by a response terminator. The maximum length of a compound command is 80 characters.

In the case of RS232 communications, the response terminator (or the last response terminator in the case of a compound command) is followed by a prompt character, either ***** or **?** as explained in Section 8.7.

In the event of a command error or parameter error, the lock-in sets bit 1 or bit 2 in the status byte and, in the case of RS232 communications, sends a **?** prompt. If a correct command followed by meaningless characters is sent, the lockin will implement the correct part of the command but will give an error for the bad part.

9.2 Command Descriptions

AA **(abandon auto)**
Terminates Auto-Sensitivity, Auto-Normalize and Auto-Measure operations.

ADC1, ADC2, ADC3, ADC4
(analog to digital converter 1,2,3,4)
Cause the lockin to respond with a numeric value in the range ±12500 representing the value in mV of the voltage applied to one of the rear-panel ADC sockets.

ANR **(Auto-Normalize)**
Causes an Auto-Normalize operation to be executed (Section 6.8.04).

AQN **(Auto-Quadrature Null)**
Causes an Auto-Phase operation to be executed (Section 6.8.05).

AR [n] **(Auto-Range)**
Sets the Auto-Range status (Section 6.8.02). Allowed values are 0 (Auto-Range OFF) and 1 (Auto-Range ON).

AS **(Auto-Sensitivity)**
Causes an Auto-Sensitivity operation to be executed (Section 6.8.03).

ASC **(Auto-Range toggle)**
Changes the Auto-Range status (Section 6.8.02).

ASM **(Auto-Signal Measure)**
Causes an Auto-Measure operation to be executed (Section 6.8.08).

AT [n] **(all terminator)**
Provides an alternative way of reading and setting the communication terminators to those provided by the GP command and by the Setup screens. Both the input (command) and output (response) terminators can be set separately for GPIB and RS232 communications.

The parameter n is a decimal number in the range 0 to 15, equivalent to a 4-bit binary number in which each bit represents <CR> (ASCII 13) when negated or <CR,LF> (ASCII 13 followed by ASCII 10) when asserted. The assignment of the bits is given in the following table.

bit number	terminator
0	RS232 input terminator
1	RS232 output terminator
2	GPIB input terminator
3	GPIB output terminator

ATC [n] **(Auto-Tune continuous)**
Allowed values of n are 0 and 1. When n is equal to 1, the lock-in enters the Filter-Track mode (Section 6.8.07).

ATS **(Auto-Tune single)**
Causes an Auto-Tune operation to be executed (Section 6.8.07).

AXO **(Auto xy Offset)**
Causes an Auto-Offset operation to be executed (Section 6.8.06).

BD [n] **(binary dump)**
Has the same effect as the DC command except that the output format is 16-bit signed binary.

CBD [n] **(curve buffer define)**
Defines which curves are to be stored when subsequent TD (take data) or TDC (take data continuously) commands are issued. Up to 17 curves (data types) may be taken, as designated by the CBD parameter.

The CBD parameter is an unsigned decimal number equivalent to a 17-bit binary word. When a given bit is negated, the corresponding data type is not selected for storage. When a bit is a asserted, the corresponding data type is selected for storage. The bit weighting and range information for each data type are as shown in the table below.

bit	decimal value	parameter range
0	1	X Output (±10000 f.s.)
1	2	Y Output (±10000 f.s.)
2	4	Magnitude (10000 f.s.)
3	8	Phase (±18000 = ±180°)
4	16	Sensitivity (0 to 21)
5	32	ADC1 (±10000 = ±10.0 V)
6	64	ADC2 " "
7	128	ADC3 " "
8	256	ADC4 " "
9	512	DAC1 " "
10	1024	DAC2 " "
11	2048	Noise (10000 f.s.)
12	4096	Ratio (±10000 f.s.)
13	8192	Log Ratio (-3000 to +2000)
14	16384	Last value given to EVENT command
15	32768	Reference Frequency bits 15 to 0 (mHz)
16	65536	Reference Frequency bits 31 to 16 (mHz)

10000 points are available for data storage, shared equally between the designated curves. For example, if all 17 curves are stored, then the maximum number of storage points for each curve is 10000/17. The LEN command sets the actual curve length, which must be no longer than 10000 divided by the number of curves designated by the CBD parameter. If more curves are requested than can be stored with the current buffer length, the buffer length will be automatically reduced. Its actual length at any time can be monitored by sending the LEN command without a parameter.

Note that the CBD command directly determines the allowable parameters for the BD, DC, HC, and HX commands. It also interacts with the LEN command and affects the values reported by the M command.

D1 [n]

(display 1)
The value of n determines the knob display selection according to the following table:

value of n	selection
0	PHASE
1	FINE PHASE
2	OSC V
3	OSC F
4	X OFS
5	Y OFS
6	DAC 1
7	DAC 2
8	FILT F
9	VERN

D2 [n]

(display 2)
The value of n determines the main display selection according to the following table:

value of n	selection
0	X-Y%
1	X-YV
2	R-θ
3	R-θ%
4	NOISE
5	θ-R
6	LOG RATIO
7	RATIO

DAC1 [n], DAC2 [n]

(digital to analog converter 1,2)
Causes a voltage equal to n mV, in the range -12500 to 12500, to be output at one of the rear-panel DAC sockets.

DC [n]

(dump curve)
Causes a stored curve to be dumped via the GPIB or RS232 port in unsigned 16-bit decimal format. One curve at a time may be dumped. The value of n must be the decimal equivalent of one of the bit numbers asserted in the most recently executed CBD command. See the discussion of the CBD command, also the BD, HD, and HX commands.

Example: Suppose CBD 5 has been executed, in which case bits 0 and 2 would be asserted, causing the X and Magnitude outputs to be stored. DC 0 then would cause the X output data to be dumped. DC 2 would cause the Magnitude data to be dumped.

The Curve Dump operation is different from a normal Read operation, and is intended for use with special-purpose controller software.

In the case of IEEE488 communications, the controller subroutine to read the responses to the "CD" and "HD" commands needs to set the EOS byte to decimal 13, and to put the interface into the ’terminate read on EOS' mode. The required values can now be read in a FOR loop of length equal to the value set in the "LEN" command. The responses to the "BD" and "HX" commands have no delimiters but are of fixed length so that they can easily be read into a buffer of appropriate length, usually 2 bytes for "BD" and 4 bytes for "HX". Each read will terminate when the buffer is full.

Note that the serial poll status byte is not used in these procedures, and is set to a fixed value of 129. In order to clear the status byte, a dummy command (normally the null command <cr>) is sent to the instrument at the end of the dump operation.

The unsigned decimal format requires that if the returned value exceeds 32768, the number 65536 must be subtracted if normal signed decimal format is required.

DD [n] **(define delimiter)**
The value of n, in the range of 0 to 127, determines the ASCII value of the character sent by the lockin to separate the two numeric values in a two-value response (Section 8.6).

DEFMETH **(default method)**
Causes the lockin to respond with the values that define the default method. The output format is a sequence of approximately forty decimal numbers that can take values from 0 to 255 inclusive, separated by the delimiter set up by the DD command.

Note: *This command is one of a set of nine commands that controls the Methods Function. The full set includes the following commands: METH, DEFMETH, EMPTY, STORE, INST, INSTDEF, UNINST, OLDMETH and DEL. Users are advised to read and understand the descriptions of all these commands before using any of them.*

DEL [n] **(delete method)**
Deletes the method specified by n (range 0 to 14). Afterwards, regardless of the initial state, the specified method is empty.

Note: *This command is one of a set of nine commands that controls the Methods Function. The full set includes the following commands: METH, DEFMETH, EMPTY, STORE, INST, INSTDEF, UNINST, OLDMETH and DEL. Users are advised to read and understand the descriptions of all these commands before using any of them.*

DISP [n] **(display period)**
The value of n, in the range of 1 to 8, sets the display update period.

DR [n] **(dynamic reserve mode)**
The value of n sets the dynamic reserve mode (Section 6.7) according to the following table.

value of n	dynamic reserve mode
0	MIN
1	HI STAB
2	NORM
3	HI RES 1
4	HI RES 2

EMPTY [n]

(method empty)
Causes the lockin to respond with 0 if there is a method stored for the number specified by n (range 0 to 14), else 1.

Note: *This command is one of a set of nine commands that controls the Methods Function. The full set includes the following commands: METH, DEFMETH, EMPTY, STORE, INST, INSTDEF, UNINST, OLDMETH and DEL. Users are advised to read and understand the descriptions of all these commands before using any of them.*

EVENT [n]

(event)
The value of n sets the event variable, range 0 to 32767. This variable is stored as one of the stored curve options (bit 14 of the CBD command), and can be used as a marker indicating the time when experimental parameters were changed.

EX [n]

(expand x)
Allowed values of n are 0 and 1. When n is 1, the lockin enters the Expand X mode in which the gain of the x demodulator channel is increased by a factor 10.

F2F [n]

(F, 2F reference modes)
Allowed values of n are 0 and 1. When n is equal to 1, the lockin enters the 2F mode in which the reference channel operates at exactly twice the frequency of the reference input or the internal oscillator.

FF [n_1 n_2]

(filter frequency)
The values of n_1 and n_2 set the resonance frequency of the main filter when in the Normal configuration, according to the following table.

value of n_1	**value of n_2**	**frequency range**
2000 to 20000	0	2 Hz to 20 Hz
2000 to 20000	1	20 Hz to 200 Hz
2000 to 20000	2	200 Hz to 2 kHz
2000 to 20000	3	2 kHz to 20 kHz
2000 to 20000	4	20 kHz to 200 kHz
2000 to 12500	5	200 kHz to 1.25MHz

When the filter is in the NOTCH mode, the notch frequency changes only in response to every fifth increment in the value of the parameter n_1. If this does not provide sufficient resolution, it may be necessary to use the Special configuration selected by the command SPEF 1.

FILTFINE [n]

(filter fine)
The value of n provides fine control of the resonance frequency of the first section of the main filter when in the Special filter configuration, according to the following table.

value of n	FILT1FFINE
0	-8%
1	-7%
2	-6%
3	-5%
4	-4%
5	-3%
6	-2%
7	-1%
8	0%
9	1%
10	2%
11	3%
12	4%
13	5%
14	6%
15	7%

FLT [n]

(filter function)
The value of n sets the mode of the main filter when in the Normal configuration, according to the following table:

value of n	filter function
0	FLAT
1	NOTCH
2	LOW-PASS
3	BAND-PASS
4	HI-PASS

FNF [n]

(reference harmonic mode)
The value of n sets the reference channel to one of the NF modes, or restores it to the default F mode (Section 6.3.01), according to the following table:

value of n	harmonic mode
1	F
2	2F
3	3F
4	4F
5	5F
6	6F
7	7F

FQ [n]

(filter Q)
The value of n sets the Qfactor of the first section of the main filter (Section 6.2.08) when in the Special configuration, according to the following table.

value of n	Q
0	0.7
1	2
2	10 (ranges 0-4) 2 (range 5)

FRQ **(frequency)**

If the lockin is in the EXT or TTL reference source modes, the FRQ command causes the lockin to respond with 0 if the reference channel is unlocked, otherwise with the reference input frequency in milliHertz.
If the lockin is in the INT reference source mode, it responds with the frequency of the internal oscillator in milliHertz.

G [n_1 [n_2]] **(gain)**

Controls the gain vernier function. When n_1 is 0, the gain vernier is OFF. When n_1 is 1, the gain vernier is ON. The value of n_2 directly sets the vernier gain, in the range 900 to 4000. 1000 sets the gain at 100% of the calibrated sensitivity.
Note: *n_1 can be sent without n_2.*

GP [n_1 n_2] **(GPIB parameters)**

n_1 is the GPIB device address, with a range of 0 to 30.

n_2 sets the input (command) terminator according to the following table.

value of n	settings
0	<CR>, Test Echo OFF
1	<CR>, Test Echo ON
2	<CR,LF>, Test Echo OFF
3	<CR,LF>, Test Echo ON

When the Test Echo is ON, every character transmitted or received via the GPIB port is echoed to the RS232 port. **This facility is provided solely as an aid to program development and should not be enabled during normal operation of the instrument.**

After the parameters have been set by the GP command, the output (response) terminator is <CR> in GPIB communications and <CR,LF> in RS232 communications. The AT command allows further adjustment of the output terminator.

HC **(halt curve)**

Halts curve acquisition in progress. It is effective during both single (data acquisition initiated by TD command) and continuous (data acquisition initiated by TDC command) curve acquisitions. The curve may be restarted by means of the TD or TDC command, as appropriate.

HD [n] **(hexadecimal curve dump 1)**

Has the same effect as the DC command except that the output format is 16-bit hexadecimal words terminated by <CR>.

HX [n] **(hexadecimal curve dump 2)**

Has the same effect as the DC command except that the output format is unterminated 16-bit hexadecimal words.
There may be single trailing <CR> or <LF> at the end of the sequence.

ID **(identification)**

Causes the lockin to respond with the number 5302.

IE [n]

(internal/external)
The value of n specifies the reference source mode (Section 6.3.01) according to the following table:

value of n	mode
0	INTERNAL
1	TTL rear panel
2	EXTERNAL

INST [n]

(install method)
Causes method number n (with n in the range 0 to 14) to be installed.

Note: *This command is one of a set of nine commands that controls the Methods Function. The full set includes the following commands: METH, DEFMETH, EMPTY, STORE, INST, INSTDEF, UNINST, OLDMETH, and DEL. Users are advised to read and understand the descriptions of all these commands before using any of them.*

INSTDEF

(install default)
Causes the Default Method to be installed.

Note: *This command is one of a set of nine commands that controls the Methods Function. The full set includes the following commands: METH, DEFMETH, EMPTY, STORE, INST, INSTDEF, UNINST, OLDMETH and DEL.* The default values installed by INSTDEF are as follows:

SENSITIVITY	1 V
DYNAMIC RESERVE	HI STAB
TIME CONSTANT	100 ms
SLOPE	12 dB/OCT; EXPONENTIAL
OSCILLATOR FREQUENCY	1.000 kHz
OSCILLATOR AMPLITUDE	V range; no mantissa
REF MODE	INTERNAL
SIGNAL INPUT	DIRECT
PHASE	0.00^{o}
FILTER FREQUENCY	1.000 kHz
FILTER MODE	FLAT
X-OFFSET	1,0 (reflects command XOF 1 0)
Y-OFFSET	1,0 (reflects command YOF 1 0)
SPEC FILT 1	1.00 kHz
SPEC FILT 2	1.00 kHz
SPEC FILT 1 MODE	FLAT
SPEC FILT 2 MODE	FLAT
GPIB ADDRESS	12; No Test Echo
RS232	9600 baud
MAIN DISPLAY	R-θ%
LOWER BARREL	PHASE
VERNIER GAIN	0,1000 (reflects command G 0 1000)
DAC1	0.00 V
DAC2	0.00 V
LINE NOTCH FILTERS	OFF
LIGHTS/BACKLIGHT	BOTH ON

KEY [n]

(key)
Sent without a parameter, causes the lockin to respond with the number of the last front-panel key pressed since the last KEY command with no parameter (0 means no key pressed). Sent with a parameter, simulates pressing of the front-panel key number n.
The list of key numbers is given in the following table.

value of n	key
8	RECOVER key
7	DRES key
6	CONTRAST key - push
100	CONTRAST key - release
5	AUTO TRACK/PAGE key
4	AUTO TUNE key
3	AUTO MEAS key
2	AUTO NORM key
1	AUTO RANGE key
17	SEN ↑ key
25	SEN ↓ key
16	TC ↑ key
24	TC ↓ key
15	PHASE key
23	+90° key
14	DISP ↑ key
22	DISP ↓ key
13	AUTO key
12	FUNCTION key
21	USER key
11	OFFSET key
26	KNOB ↑ key
27	KNOB ↓ key

KNOB [n]

(knob)
The value of n determines the knob mode, allowed values being 0, 1, and 2. The significance of each value is as follows.

The value 0 signifies the normal mode of operation in which the knob alters the variable on the knob display on the main page or some other variable on the setup pages.

In modes 1 and 2, the lockin outputs the knob position and the knob has no other effect.

In mode 1, in addition to setting the knob mode, the lockin outputs the number of counts on the knob since the last KNOB 1 command. *This will always be zero the first time a KNOB 1 command is given after a KNOB 0.*

In mode 2, a rapid continuous output stream is generated with each output value giving the number of counts that the knob has moved since the previous output value. Each value transmitted is followed by the terminator established by the AT or GP command, and EOI is not asserted after each value.

Note: *If operating under program control, be sure the controlling program can handle a data stream of this nature before using this command.*

The method used to turn the stream off depends on whether one is using RS232 or GPIB communications. The command KNOB 0 applied via either the GPIB or RS232 port will terminate the data stream. In the case of the GPIB, it is also possible to terminate the data stream by applying the remote message SELECTED DEVICE CLEAR (SDC). SDC can be applied via the interface or generated internally by pressing the FUNCT key twice.

LEN [n]

(length)
The value of n determines the curve buffer length in effect for data acquisition. The maximum allowed value depends on the last value given to the CBD command, and a parameter error results if the value given is too large. For this reason, if the number of points is to be increased and the number of curves to be plotted is to be reduced using the CBD command, then the CBD command should be issued first.

LF [n]

(line filter)
The value of n sets the line notch filter selection according to the following table.

value of n	notch filter mode
0	OFF
1	enable 100 or 120 Hz filter
2	enable 50 or 60 Hz filter
3	enable both filters

LOCK

(system lock)
Updates all frequency-dependent gain and phase correction parameters in the signal and reference channels (Section 6.3.06).

LOWF [n]

(low frequency)
The value of n determines the frequency mode (Section 6.2.01) according to the following table.

value of n	mode
0	NORMAL
1	LOW 1
2	LOW 2

Note: If DC coupling is selected at the front panel, coupling is dc to eliminate low-frequency phase shift.

LR

(log ratio)
Causes the lockin to respond with a number in the range -3000 to +2000 representing 1000 times the $\log_{10}$ of the ratio of the value that would be returned by the X command to the value that would be returned by the ADC1 command.

LTS [n]

(lights)
Sets the status of the front-panel lights. Allowed values are 0 and 1. When n = 0, all lights are OFF. When n = 1, lights function normally.

M **(curve status)**

Causes the lockin to respond with four values that provide information concerning data acquisition, as follows.

First value, Curve Acquisition Status: a number in the range 0 to 7, defined by the following table.

value	significance
0	No curve activity in progress.
1	Acquisition via TD command in progress.
2	Acquisition via TDC command in progress.
3	Curve dump in progress.

In addition, assertion of bit 2 (decimal values 4-7) indicates that activity has been halted with an HC command or paused from the front panel using the CURVE STATUS/RUN page.

Second value, Number of Sweeps Acquired: this number is incremented each time a TD is completed and each time a full cycle is completed on a TDC acquisition. It is zeroed by the NC command and also whenever a CBD or LEN command is applied without parameters.

Third value, Status Byte: the same as the response to the ST command. The number returned is the decimal equivalent of the status byte (Section 8.7) and refers to the previously applied command.

Fourth value, Number of Points Acquired: this number is incremented each time a point is taken. It is zeroed by the NC command and whenever CBD or LEN is applied without parameters.

MAG **(magnitude)**

Causes the lockin to respond with the value of the signal magnitude (Section 6.4.03) in the range 0 to 12000, full scale being 10000.

METH n [seq] **(method)**

In the format METH n, causes the lockin to respond with the sequence of integers that define the method specified by n (range 0 to 14), or gives a parameter error if the method is empty.

The METH command may optionally include a numeric sequence after the parameter n. This sequence must be identical with a sequence derived from a METH or STORE command and (provided that method n is empty) will be assigned to method n. By means of this facility, any number of preset methods can easily be maintained on a computer disk.

The output format is a sequence of approximately forty decimal numbers that can take values from 0 to 255 inclusive, separated by the delimiter set up by the DD command.

Note: *This command is one of a set of nine commands that controls the Methods Function. The full set includes the following commands: METH, DEFMETH, EMPTY, STORE, INST, INSTDEF, UNINST, OLDMETH, and DEL. Users are advised to read and understand the descriptions of all these commands before using any of them.*

MP **(magnitude-phase)**
Equivalent to the compound command MAG;PHA.

MSK [n] **(mask)**
The value of n sets the SRQ mask byte (Section 8.8) in the range of 0 to 255.

N **(nstatus)**
Causes the lockin to respond with the overload byte (Section 8.7).

NC **(new curve)**
Initializes the curve storage memory and status variables. All record of previously taken curves is removed.

NN **(noise output)**
Causes the lockin to respond with the noise output value (Section 6.4.16) in the range 0-12000, full scale being 10000.

NNBUF [n_1 n_2] **(noise buffer)**
The value of n_1 sets the length of the noise buffer (Section 6.4.16) in the range 1 to 127.
The value of n_2 (0 or 1) sets the SUBTRACT MEAN option (Section 6.4.16).

OA [n_1 n_2] **(oscillator amplitude)**
The value of n_1 and n_2 set the amplitude of the internal oscillator output according to the following table:

value of n_1	value of n_2	amplitude range
500 to 5000	0	5 mV to 50 mV
250 to 5000	1	25 mV to 500 mV
250 to 5000	2	250 mV to 5000 mV

OF [n_1 n_2] **(oscillator frequency)**
The values of n_1 and n_2 set the frequency of the internal oscillator according to the following table:

value of n_1	value of n_2	frequency range
1000 to 10000	0	1 mHz to 10 mHz
1000 to 10000	1	10 mHz to 100 mHz
1000 to 10000	2	100 mHz to 1 Hz
1000 to 10000	3	1 Hz to 10 Hz
1000 to 10000	4	10 Hz to 100 Hz
1000 to 10000	5	100 Hz to 1 kHz
1000 to 10000	6	1 kHz to 10 kHz
1000 to 10000	7	10 kHz to 100 kHz
1000 to 10000	8	100 kHz to 1 MHz

OFEN [n] **(offset enable)**
Allowed values of n are 0 and 1. When n = 0, the offset function is disabled whatever the status of the XOF and YOF commands. When n = 1, the operation of the XOF and YOF commands is enabled. The Auto-Offset operation sets the OFEN status to 1.

OLDMETH **(old method)**

Whenever a method is installed, the method previously in effect is copied to the Old Method location. The OLDMETH command causes the sequence of numbers that define the old method to be returned. As with METH and DEFMETH, the output format is a sequence of approximately forty decimal numbers with values in the range 0 to 255.

Note: *This command is one of a set of nine commands that controls the Methods Function. The full set includes the following commands: METH, DEFMETH, EMPTY, INST, INSTDEF, STORE, UNINST, OLDMETH, and DEL. Users are advised to read and understand the descriptions of all these commands before using any of them.*

OUTFF [n]

Sent with n = 1, the OUTFF command causes the lockin to output a continuous stream of x and y demodulator output values scaled to ±32000 full scale, at a rate of up to 100 Hz. The x and y values are separated by the delimiter set by the DD command, and terminated with the output terminator set by the GP or AT commands.

The data stream may be stopped by the use of the command OUTFF 0 or by pressing the FUNCT key twice. If GPIB communications are in use, it is also possible to terminate the data stream by applying the remote message SELECTED DEVICE CLEAR (SDC).

If OUTFF is applied without an parameter, the lockin will respond with 0 (output stream not in progress) or 1 (output stream in progress). Note that, if the output stream is in progress, the response will be mixed in with the transmitted output readings.

Note: *If operating under program control, be sure the controlling program can handle a data stream of this nature before using this command.*

P [n_1 n_2] **(reference phase)**

The values of n_1 (quadrant number) and n_2 (angle) set the value of the reference phase in millidegrees according to the following table.

value of n_1	value of n_2	phase range (millidegrees)
0	0 to 100000	0 to 100000
1	0 to 100000	90000 to 190000
2	0 to 100000	180000 to 280000
3	0 to 100000	270000 to 10000

PAGE [n] **(page)**

The value of n determines the currently displayed screen page in the range 0 to 63 as listed in Appendices D and E.

PER **(reference period)**

Causes the lockin to respond with the reference period in milliseconds. It offers advantages over the FRQ command at low frequencies because the ±1 mHz resolution of the FRQ command prohibits precision low-frequency readings.

Note that, at 1 Hz, both the PER and FRQ command return the same value, 1000. Thus, above 1 Hz the FRQ command gives better precision. Below 1 Hz, PER gives better precision.

PHA **(signal phase)**

Causes the lockin to respond with the signal phase (Section 6.4.03) in millidegrees, in the range ±180000 with 100 millidegree resolution.

PHC [n] **(phase correction)**

Allowed values of n are 0 and 1. When n = 1, internal frequency-dependent phase corrections are enabled and are updated under the conditions stated in Section 6.3.06. When n = 0, these phase corrections are disabled.

PHS [n] **(phase hard/soft)**

Allowed values for n are 1 and 0, selecting the Hard Phase mode and the Soft Phase mode respectively (Section 6.3.05).

POINT n_1 [n_2] **(point)**

Reads or sets the screen pointer number, i.e. the number of the currently selected item on any Setup screen page (not the MAIN or LARGE DISPLAY pages), with 0 as the top item.

The first parameter, which specifies the screen page number, is compulsory. The second parameter, which specifies the pointer number, is optional. If the second parameter is absent, the lockin responds with the pointer number. If the second parameter is present, the pointer number is set to its value.

PREAMP [n] **(preamp)**

Allowed values for n are 0 and 1. If n = 0, the DIRECT input is selected. If n = 1, the PREAMP input is selected (Section 6.2.02).

REMOTE [n] **(remote only)**

Allowed values are 0 and 1. When n = 1, the lockin enters the Remote Only mode in which the front-panel control functions are inoperative and the instrument can only be controlled with the RS232 or GPIB interfaces.

RS [n_1 n_2] **(RS232)**

The value of n_1 sets the baud rate of the RS232 interface according to the following table.

value of n_1	baud rate
0	75
1	110
2	134.5
3	150
4	300
5	600
6	1200
7	2000
8	2400
9	4800
10	1800
11	9600
12	19200

The lowest seven bits in n_2 control the other RS232 parameters according to the following table.

bit number	bit negated	bit asserted
0	7 data bits	8 data bits
1	even parity	odd parity
2	1 stop bit	2 stop bits
3	parity enabled	parity disabled
4	echo disabled	echo enabled
5	no effect	parity bit forced low
6	no effect	parity bit forced high

Note: *bits 5 and 6 override lower parity-determining bits.*

RT

(ratio)
Causes the lockin to respond with a number that is 1000 times the ratio of the value that would be returned by the X command to the value that would be returned by the ADC1 command.

SAMPLE [n]

(sample)
The value of n determines the system sample rate (Section 6.4.13) in the range 50 to 100 Hz.

SEN [n]

(sen)
The value of n sets the full-scale sensitivity (Section 6.2.03) according to the following table:

value of n	f.s. sensitivity (rms sinusoid)
0	100 nV
1	200 nV
2	500 nV
3	1 µV
4	2 µV
5	5 µV
6	10 µV
7	20 µV
8	50 µV
9	100 µV
10	200 µV
11	500 µV
12	1 mV
13	2 mV
14	5 mV
15	10 mV
16	20 mV
17	50 mV
18	100 mV
19	200 mV
20	500 mV
21	1 V

Notes:
1. The lowest range available in DIRECT (no preamp) is 3 (1 µV).
2. The lowest range available in FAST (TC < 20 ms) is 6 (10 µV).

SFF1 [n_1 n_2]

(special filter 1 frequency)
The values of n_1 and n_2 set the resonance frequency of the first section of the main filter (Section 6.2.08) when in the Special configuration, according to the following table.

value of n_1	**value of n_2**	**frequency range**
2000 to 20000	0	2 Hz to 20 Hz
2000 to 20000	1	20 Hz to 200 Hz
2000 to 20000	2	200 Hz to 2 kHz
2000 to 20000	3	2 kHz to 20 kHz
2000 to 20000	4	20 kHz to 200 kHz
2000 to 12500	5	200 kHz to 1.25MHz

SFF2 [n_1 n_2]

(special filter 2 frequency)
The values of n_1 and n_2 set the resonance frequency of the second section of the main filter (Section 6.2.08) when in the Special configuration, according to the following table.

value of n_1	**value of n_2**	**frequency range**
2000 to 20000	0	2 Hz to 20 Hz
2000 to 20000	1	20 Hz to 200 Hz
2000 to 20000	2	200 Hz to 2 kHz
2000 to 20000	3	2 kHz to 20 kHz
2000 to 20000	4	20 kHz to 200 kHz
2000 to 12500	5	200 kHz to 1.25MHz

SM1 [n]

(special filter 1 mode)
The value of n sets the filter mode of the first section of the main filter (Section 6.2.08) when in the Special configuration, according to the following table.

value of n	**mode**
0	FLAT
1	NOTCH
2	LOW-PASS
3	BAND-PASS
4	HI-PASS

SM2 [n]

(special filter 2 mode)
The value of n sets the filter mode of the second section of the main filter (Section 6.2.08) when in the Special configuration, according to the following table.

value of n	**mode**
0	FLAT
1	NOTCH
2	LOW-PASS
3	BAND-PASS
4	HI-PASS

SPEF [n]

(special filter)
Allowed values for n are 0 and 1. If n = 0, the Normal configuration of the main filter is selected. If n = 1, the Special configuration is selected.

ST **(status)**
Causes the lockin to respond with the serial poll status byte (Section 8.7).
Note: *This command is not used in GPIB communications, where the status byte is accessed by performing a serial poll.*

STORE n **(store method)**
Causes the lockin to store the current instrument setup under the method number specified by n (range 0 to 14). The location must be empty, otherwise a parameter error results.
Note: *This command is one of a set of nine commands that controls the Methods Function. The full set includes the following commands: METH, DEFMETH, EMPTY, STORE, INST, INSTDEF, UNINST, OLDMETH, and DEL. Users are advised to read and understand the descriptions of all these commands before using any of them.*

STR [n] **(storage interval)**
Sets the time interval between successive points being acquired under the TD or TDC commands. n specifies the time interval in ms with a resolution of 5 ms, input values being rounded up to a multiple of 5. The longest interval that can be specified is about 1000000 s or one point in 12 days.

TD **(take data)**
Initiates data acquisition. Acquisition starts at the current position in the curve buffer and continues at regular intervals (the length of which may be set by the STR command) until the buffer is full.

TDC **(take data continuously)**
Initiates data acquisition. Acquisition starts at the current position in the curve buffer and continues at regular intervals (the length of which may be set by the STR command) until halted by an HC command or paused or halted from the front panel. The buffer is circular in the sense that when it has been filled, current data overwrites earlier points.

TRIG [n] **(trigger)**
The value of n sets the trigger mode of the output converter (Section 6.4.14) according to the following table.

value of n	trigger mode
0	reference
1	external
2	asynchronous
3	ratio
4	8F

Note that TRIG 0 and TRIG 3 are not intended for use with reference frequencies above a few hundred Hz.

UNINST **(uninstall method)**
Cancels the effect of the the last INST command by installing the Old Method (see description of OLDMETH command).

Note: *This command is one of a set of nine commands that controls the Methods Function. The full set includes the following commands: METH, DEFMETH, EMPTY, STORE, INST, INSTDEF, UNINST, OLDMETH, and DEL. Users are advised to read and understand the descriptions of all these commands before using any of them.*

USER [seq]

Sets or reads the numeric sequence representing the screens called by the USER key (Section 4.4.6). The sequence consists of up to 8 screen numbers followed by a zero, up to nine numbers in all.
The USER command without any parameter causes the screen numbers to be output, separated by the delimiter set by the DD command. When the command incorporates a suitable sequence of numbers separated by spaces, the USER key page sequence is set to the given values. The command USER 0 clears the current USER page sequence.

VER

(version)
Causes the lockin to respond with its firmware version number.

X

(x output)
Causes the lockin to respond with the x demodulator output in the range ±12000, full scale being ±10000.

XDB [n]

The value of n sets the slope of the output filters (Section 6.4.08) according to the following table.

value of n	slope
0	6 dB/octave exponential
1	12 dB/octave exponential
2	6 dB rectangular (TC > 50 ms)
3	12 dB triangular (TC > 50 ms)

XOF [n_1 [n_2]]

(x offset)
Allowed values of n_1 are 0 and 1. When n_1 is equal to 0, the X Offset facility (Section 6.4.11) is disabled. When n_1 is equal to 1, the X Offset facility is enabled if the OFEN command state is 1. n_1 can be sent without n_2. In Soft Phase, Y Offset is automatically enabled when X Offset is enabled.

The n_2 range is ±3000, corresponding to the application of ±300% full scale offset at the x output when the X Offset facility is enabled.

XTC [n]

(output time constant)
The value of n sets the time constant of the output filters (Section 6.4.08) according to the following table.

value of n	time constant
0	F MIN
1	F 100 µs
2	F 1 ms
3	F 10 ms
4	20 ms
5	50 ms
6	100 ms
7	200 ms
8	500 ms
9	1 s
10	2 s
11	5 s
12	10 s
13	20 s

14	50 s
15	100 s
16	200 s
17	500 s
18	1000 s

Note: *The F prefix indicates that the FAST MODE is implemented, where the analog outputs are directed to the FAST OUT connectors on the rear panel.*

XY **(x,y outputs)**
Equivalent to the compound command X;Y .

Y **(y output)**
Causes the lockin to respond with the y demodulator output in the range ±12000, full scale being ±10000.

YOF [n_1 [n_2]] **(y offset)**
Allowed values of n_1 are 0 and 1. When n_1 is equal to 0, the Y Offset facility (Section 6.4.11) is disabled. When n_1 is equal to 1, the Y Offset facility is enabled if the OFEN command state is 1. n_1 can be sent without n_2. In Soft Phase, X Offset is automatically enabled when Y Offset is enabled.

The n_2 range is ±3000, corresponding to the application of ±300% full scale offset at the y output when the Y Offset facility is enabled.

	INPUT AMPLIFIER									
Signal Inputs	**DIRECT**	**5316 NORMAL MODE**	**5316 XMFR MODE**	**5317**	**5381**					
					Conversion Gain A/V					
Sensitivity	1 µV - 1 V	100 nV - 1 V	1 nV - 10 mV	100 nV - 1 V	10^{-9}	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}
Frequency Response	1 mHz - 1 MHz	100 mHz - 1 MHz	1 Hz - 50 kHz Dependent On Source Resistance	100 mHz - 1 MHz	1 Hz to 1 kHz	1 Hz to 10 kHz	1 Hz to 50 kHz	1 Hz to 100 kHz	1 Hz to 200 kHz	1 Hz to 200 kHz
Input Impedance	10 MΩ/25 pF	100 MΩ - 15 pF	Transformer Primary Low Impedance	100 MΩ - 15 pF	1 Ω - 50 kΩ DEPENDENT ON CONVERSION GAIN AND FREQUENCY					
Input Noise	25 nV/√Hz @ 1 kHz									
Input Modes	DIFF	SINGLE/DIFF	SINGLE/DIFF	SINGLE/DIFF	SINGLE					
CMRR @ 50/60 Hz	40 dB	100 dB	140 dB	100 dB	NOT APPLICABLE					

Note: All indicated sensitivities are without output expand.

Figure A-1. DIRECT VS. PREAMP INPUT CHARACTERISTICS

A.1 Signal Channel

Frequency range

With DIRECT INPUT selected: 1 mHz to 1MHz in 3 ranges (NORMAL, LOW 1, LOW 2).
With PREAMP selected: frequency range depends on preamplifier type (see table above).

Input impedance

With DIRECT INPUT selected: 10 MΩ in parallel with 30 pF (NORMAL and LOW 1), 100 MΩ in parallel with 30 pF (LOW 2).
With PREAMP selected: input impedance depends on preamplifier type (see table above).

Sensitivity

With DIRECT INPUT selected:

AC coupling, timeconstant > 10 ms: 1 µV to 1 V in 1-2-5 sequence;
timeconstant < 20 ms: 100 µV to 1V in 1-2-5 sequence;

DC coupling: 10 mV to 1 V in 1-2-5 sequence.

With PREAMP selected: sensitivity depends on preamplifier type (see table above).

Preamplifiers

Although the Model 5302 can achieve excellent results in many applications without a preamplifier, we recommend use of one or more of the following plug-in preamplifiers to utilize fully the 5302's capabilities.

5315 Multiplexer	5316 Hi Impedance/Transformer
5317 Hi Impedance	5320 Wide Frequency/Transformer
5381 Current	5383 Remote

Signal-Channel filters

Line Filters:

First and second harmonic notch filters can be switched in to suppress line related pick-up. Notch frequencies are 50 and 100 or 60 and 120 Hz, depending on factory settings.

Main filter:
Frequency range: 2 Hz to 1 MHz.
Normal configuration: 4th order filter in FLAT, BANDPASS, LOWPASS, HIGHPASS, or NOTCH modes; Q = 2.
Special configuration: two 2nd order sections with independent frequency and function control in FLAT, BANDPASS, LOWPASS, HIGHPASS, or NOTCH modes; Q of first filter can be set to 0.7, 2, or 10.

Dynamic Reserve

Up to 125 dB.

A.2 Reference channel

Modes

Internal: waveforms from the internal synthesizer are applied directly to the demodulator. Phase lock is instantaneous and phase noise is lowest. The frequency range is 1 mHz to 1 MHz.

External: below 100 Hz, the digital reference circuit locks to the reference input within one cycle providing very low phase noise. At frequencies above 100 Hz, the analog phase-locked loop provides optimum performance. The frequency range is 1 mHz to 1 MHz. To speed up reference lock at extreme low frequencies use internal mode at the approximate frequency followed by switching to an external reference mode.

Reference Inputs

Analog: the standard inputs at the front-panel REF IN connector are a squarewave of amplitude 100 mV or greater, or a sinusoid of frequency 1 Hz - 1 MHz and amplitude 1 V rms or greater. Reference inputs of less than the standard values can be used at the expense of increased phase noise.

Digital: the rear-panel TTL REF IN connector allows the reference channel to be driven from TTL sources. The reference circuits will always trigger on a positive-going transition. TTL compatible pulse sequences not acceptable to the front-panel reference input can be used.

In order to obtain the best accuracy and reproducibility in the external reference modes, it is advisable to execute the auto-tune function or the LOCK command after any change in reference frequency.

NF - Reference Harmonic Operation

In an NF mode, where N has a value from 2 to 8, the reference frequency is exactly N times the fundamental frequency of the reference input or the internal synthesizer, subject to an upper frequency limit of 1 MHz.

Acquisition Time

This is the time required for the Reference Channel to lock in frequency and phase to the reference input or the internal synthesizer.
External modes: 1 period + 1 second.

Internal mode: 1 period + 1 second in hard phase, instantaneous in soft phase.

Phase shift

Implemented either by reference-channel hardware (Hard Phase) or by vector rotation implemented in software in the demodulator (Soft Phase).

Accuracy: Hard Phase 3°, Soft Phase 1 m°.

Setting Resolution:

Coarse: 0.1°; front-panel knob adjusts phase 360° with 0.1° resolution. Front-panel key adds 90° to the setting with each press.

Fine: 0.001°; After initial phase adjustment in normal mode, FINE PHASE can be used to trim final adjustment. Range is ±1° with 1 m° resolution.

Orthogonality: 0.1°

A.3 Demodulator

Demodulation function

8-step Walsh or squarewave.

Time Constant of Output Filter

1 µs to 1000 s.

Weighting Function of Output Filter

Exponential 6 dB/octave or 12 dB/octave, rectangular (6 dB/octave) or triangular (12 dB/octave).

Digital Outputs

±10000 fs, ±12500 max.

Analog Outputs

CH1, CH2: ±10.0 V fs, 1 kΩ impedance, 1 mV resolution.
FAST OUT X,Y: ± 9.4 V fs ±3%, 100 Ω impedance.

Stability

Normal:	±1 LSB/°C	(typical)
Hi STAB:	±1 LSB/10° C	(typical)
FAST OUT:	±100 µV/°C	

A.4 Oscillator

Type

Quartz Controlled Synthesizer

Frequency Range

1 mHz to 1 MHz

Frequency Stability

±30 ppm/°C

Frequency Setting Resolution

0.1% of frequency (typical)

Output Amplitude and Impedance
5 mV - 5 V rms, 450 Ω

Amplitude Stability
0.02%/ºC (typical)

Amplitude Setting Resolution
Above 0.5 V: 20 mV
Below 0.5 V: 2.0 mV

Harmonic Distortion
0.2% to 20 kHz; < 1% above 20 kHz.

A.5 Auxiliary I/O

ADC Inputs
There are four ADC inputs on the back panel. The digitized outputs can be read from the ADCS screen or with the use of the ADC command.

Range: ±12.5 V, corresponding to ±12500 decimal (resolution 1 mV).

Input Impedance: 20 kΩ in parallel with 30 pF.

DAC Outputs
There are two DAC outputs on the back panel. The inputs are implemented from the DACS screen or with the use of the DAC command.

Range: ±12.5 V, corresponding to ±12500 decimal (resolution 1 mV).

Output Impedance: 1.0 kΩ.

A.6 Curve store memory

Memory Size
10000 points by 16-bit (15 bits + sign) memory can be subdivided into n separate curves (12 max) each of 10000/n points (e.g. four curves each of 2500 points).

Storage Rate
200 points/second (max)

Readout Rate
RS232: 200 points/second (typical)
IEEE: 250 points/second (typical).

A.7 Power requirements

100 - 117 V ac or 200 - 240 V ac (47 - 63 Hz)
390 W.

B Appendix B Demonstration Programs

B.1 Simple terminal emulator

This is a short terminal emulator with minimal facilities, which will run on a PC-compatible computer in a Microsoft GWBASIC or QuickBASIC environment, or can be compiled with a suitable compiler.

```
10 'MINITERM 16-Jan-93
20 CLS: PRINT "Lockin RS232 parameters must be set to 11,16"
30 PRINT "Hit <ESC> key to exit"
40 OPEN "COM1:9600,E,7,1,CS,DS" AS #1
50 '..............................
60 ON ERROR GOTO 180
70 '..............................
100 WHILE (1)
110    B$ = INKEY$
120    IF B$=CHR$(27) THEN CLOSE #1: ON ERROR GOTO 0: END
130    IF B$<>"" THEN PRINT#1, B$;
140    LL% = LOC(1)
150    IF LL%>0 THEN A$ = INPUT$(1,#1): PRINT A$;
160 WEND
170 '..............................
180 PRINT "ERROR NO.";ERR: RESUME
```

B.2 GPIB user interface program

GPCOM.BAS is a user interface program which illustrates the principles of the use of the serial poll status byte to coordinate the command and data transfer.

The program runs under Microsoft GWBASIC or QuickBASIC on a PC-compatible computer fitted with a National Instruments IEEE488 interface card and the GPIB.COM software installed in the CONFIG.SYS file. Note that program lines 100,105 and 110 are from the National Instruments declaration file DECL.BAS, and that the file BIB.M is also supplied by National Instruments. Each software revision has its own version of these files.

The interface needs to be configured by means of the National Instruments program IBCONF.EXE. There is no need to make special provision for terminating read operations because the lockin sends EOI at the end of each response and this will terminate the read. Normally, the options called 'high-speed timing', 'interrupt jumper setting', and 'DMA channel' should all be disabled.

The principles of using the Serial Poll Status Byte to control data transfer, as implemented in the main loop of GPCOM, are recommended for incorporation in the user's own programs.

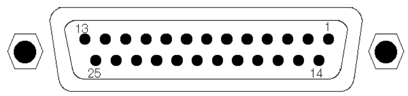
```
10 'GPCOM 17-Jan-93
100 '....the following three lines and BIB.M are supplied by the.......
110 '....manufacturer of the GPIB card, must be correct version........
120 CLEAR,60000!:IBINIT1=60000!:IBINIT2=IBINIT1+3:BLOAD"BIB.M",IBINIT1
130 CALL
IBINIT1(IBFIND,IBTRG,IBCLR,IBPCT,IBSIC,IBLOC,IBPPC,IBBNA,IBONL,IBRSC,IBSRE,IBRSV,IBP
AD,IBSAD,IBIST,IBDMA,IBEOS,IBTMO,IBEOT,IBRDF,IBWRTF,IBTRAP)
140 CALL
```

```
IBINIT2(IBGTS,IBCAC,IBWAIT,IBPOKE,IBWRT,IBWRTA,IBCMD,IBCMDA,IBRD,IBRDA,IBSTOP,IB
RPP,IBRSP,IBDIAG,IBXTRC,IBRDI,IBWRTI,IBRDIA,IBWRTIA,IBSTA%,IBERR%,IBCNT%)
150 '.................................................
160 CLS: PRINT"DEVICE MUST BE SET TO CR TERMINATOR"
170 '....assign access code to interface board........
180 BDNAME$="GPIB0"
190 CALL IBFIND(BDNAME$,GPIB0%)
200 IF GPIB0%<0 THEN PRINT "board assignment error":END
210 '....send INTERFACE CLEAR........................
220 CALL IBSIC(GPIB0%)
230 '....set bus address, assign access code to device..........
240 SUCCESS% = 0
250 WHILE SUCCESS%=0
260   INPUT "BUS ADDRESS ";A%
270   DEVNAME$ = "DEV"+RIGHT$(STR$(A%),LEN(STR$(A%))-1)
280   CALL IBFIND(DEVNAME$,DEV%)                  ' assign access code
290   IF DEV%<0 THEN PRINT "device assignment error": END
300   A$ = CHR$(13): GOSUB 710                  ' test: write <CR> to bus
310   IF IBSTA%>0 THEN SUCCESS% = 1
320   IF (IBSTA%<0 AND IBERR%=2) THEN BEEP: PRINT "NO DEVICE AT THAT ADDRESS"
330 WEND
340 '....send SELECTED DEVICE CLEAR..................
350 CALL IBCLR(DEV%)
360 '....set timeout to 1 second......................
370 V%=11: CALL IBTMO(DEV%,V%)
380 '....set status print flag.......................
410 INPUT "Display status byte y/n "; R$
440 IF R$="Y" OR R$="y" THEN DS% = 1 ELSE DS% = 0
450 '....main loop...................................
460 GOSUB 780                                          ' serial poll, returns S%
470 WHILE 1                                            ' infinite loop
480   WHILE (S% AND 1)=0
490     GOSUB 780                                      ' serial poll, returns S%
500   WEND
510   IF (S% AND 4) THEN PRINT "parameter error"
520   IF (S% AND 2) THEN PRINT "invalid command"
540   INPUT "command (00 to exit) ";A$
550   IF A$="00" THEN END
570   A$ = A$ + CHR$(13)                               ' terminator is <CR>
580   GOSUB 710                                        ' write A$ to bus
590   GOSUB 780                                        ' serial poll, returns S%
600   WHILE (S% AND 1)=0                             ' while command not complete
610     GOSUB 780                                      ' serial poll, returns S%
620     IF DS% THEN PRINT "S%= ";S%
630     IF (S% AND 128) THEN GOSUB 740: PRINT B$;      'read B$ from bus and print
660   WEND
690 WEND
700 '....end of main loop............................
710 '....write string to bus.........................
720 CALL IBWRT(DEV%,A$): RETURN
740 '....read string from bus.........................
750 B$=SPACE$(32)                                      ' clear buffer
760 CALL IBRD(DEV%,B$): RETURN
780 '......serial poll...............................
790 CALL IBRSP(DEV%,S%): RETURN
```

C.1 Introduction

This appendix describes the Model 5302 external connectors with their pinouts and associated signal names. In addition to the BNC connectors described in Chapter 3, the Model 5302 has a five-pin DIN connector (PREAMP POWER), a 25-pin RS232C connector, and a 24-pin GPIB connector located on the rear panel.

C.2 RS232



RS232 Connector

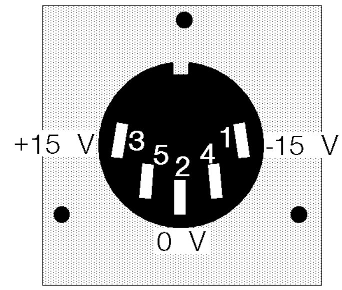
The 5302's RS232 port is configured as a DTE. The lead connecting it to a terminal or a computer (which are also DTE) must connect the Transmit Data pin at each end to the Receive Data pin at the other end. Apart from a connection from Logic Ground at one end to Logic Ground at the other, no other connection is required. The logic levels are ±12 V.

PIN	FUNCTION	COMMENT
1	Earth Ground	Ties the chassis of the Model 5302 to that of the computer. THE USE OF THIS PIN IS OPTIONAL AND IT MAY BE LEFT UNCONNECTED.
2	Transmit Data	This pin must connect to the Receive Data pin on the terminal or computer (normally pin 2 for a 9-pin connector, pin 3 for a 25-pin connector).
3	Receive Data	This pin must connect to the Transmit Data pin on the terminal or computer (normally pin 3 for a 9-pin connector, pin 2 for a 25-pin connector).
4	Request to Send	In the Model 5302, this pin is asserted when the input buffer is not full, that is, when the instrument is ready to receive the next byte. THE USE OF THIS PIN IS OPTIONAL AND IT MAY BE LEFT UNCONNECTED.
5	Clear to Send	To enable the Model 5302 to transmit, the pin is placed at the positive logic level (+3 V to +12 V). To hold off transmission by the Model 5302, the pin must be at the negative logic level (-3 V to -12 V). This pin is returned to +12 V via an internal resistor so that, if pin 5 is left unconnected, the 5302 is allowed unimpeded transmission. THE USE OF THIS PIN IS OPTIONAL AND IT MAY BE LEFT UNCONNECTED.
6, 8-25		Unused
7	Logic Ground	Data signal levels are referred to logic ground. This pin should be connected to logic ground of the terminal or computer (normally pin 5 for a 9-pin connector, pin 7 for a 25-pin connector).

C.3 PREAMP POWER

PIN	FUNCTION
1	-15 V
2	GROUND
3	+15 V

All other pins are unused.
Shell is shield ground.

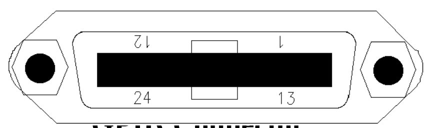


50 mA MAX

Note: Mating connector is SWITCHCRAFT® type 05BL5M or equivalent (EG&G PARC #2102-0171).

PREAMP POWER PINOUT

C.4 GPIB



GPIB Connector

PIN #	FUNCTION
1	DIO1
2	DIO2
3	DIO3
4	DIO4
5	EOI
6	DAV
7	NRFD
8	NDAC
9	IFC
10	SRQ
11	ATN
12	SHIELD
13	DIO5
14	DIO6
15	DIO7
16	DIO8
17	REN
18	GND 6
19	GND 7
20	GND 8
21	GND 9
22	GND 10
23	GND 11
24	LOGIC GROUND

GPIB PINOUT

D.1 Introduction

There is an identifying number associated with each screen. These are the screen or page numbers that are used with the **PAGE** and **USER** commands.

D.2 List in numeric order

00 MAIN MENU
01 LARGE DISPLAY SCREEN
02 SETUP MENU
03 SIGNAL CHANNEL
04 SIGNAL SOURCE
05 LINE NOTCH
06 NORMAL FILTER
07 REFERENCE-MIXER
08 PHASE SETUP
09 ADC TRIGGER MODE
10 REF SOURCE
11 REF HARMONICS
12 OUTPUTS
13 TIME CONSTANT
14 OFFSET VALUE
15 NOISE
16 DACS & ADCS
17 OSCILLATOR
18 COMM-I/O
19 GPIB
20 RS232 (PG 1 OF 2)
21 RS232 (PG 2 OF 2)
22 CURVE SETUP
23 KNOB-LIGHTS
24 KNOB
25 LIGHTS
26 SPECIAL
27 DACS
28 ADCS (PG 1 OF 2)
29 ADCS (PG 2 OF 2)
30 KNOBGEAR
31 PHASE *knobgear*
32 FINE PHASE *knobgear*
33 X OFS *knobgear*
34 Y OFS *knobgear*
35 DACS 1 & 2 *knobgear*
36 OSC - V *knobgear*
37 OSC - F *knobgear*
38 FILT - F *knobgear*
39 LOW FREQUENCY
40 FILTER 1 (SPECIAL)
41 SLOPE/AVERAGING
42 FIRMWARE VERSION
43 VERNIER *knobgear*
44 SPECIAL FILTER

45 FILTER CONFIG
46 FILTER 2 (SPECIAL)
47 FILTER 1 TRIM (SPECIAL)
48 METHODS
49 TIMEBASE
50 YAXIS INPUTS 1
51 YAXIS INPUTS 2
52 YAXIS INPUTS 3
53 YAXIS INPUTS 4
54 YAXIS INPUTS 5
55 YAXIS INPUTS 6
56 CURVE STATUS/RUN
57 EG&G PAGE
58 USER KEY ERASE
59 EG&G PAGE
60 OFFSETS
61 OFFSET STATE
62 ADC TRIGGER MODE
63 SAMPLE RATE

D.3 List in alphabetical order

09 & 62 ADC TRIGGER MODE
28 ADCS (PG 1 OF 2)
29 ADCS (PG 2 OF 2)
18 COMM - I/O
22 CURVE SETUP
36 CURVE STATUS/RUN
27 DACS
16 DACS & ADCS
35 DACS 1 & 2 *knobgear*
57 & 59 EG&G PAGE
38 FILT - F *knobgear*
40 FILTER 1 (SPECIAL)
47 FILTER 1 TRIM (SPECIAL)
46 FILTER 2 (SPECIAL)
45 FILTER CONFIGURATION
32 FINE PHASE *knobgear*
19 GPIB
24 KNOB
30 KNOB GEAR
23 KNOB-LIGHTS
01 LARGE DISPLAY SCREEN
25 LIGHTS
05 LINE NOTCH
39 LOW FREQUENCY
00 MAIN MENU
48 METHODS
15 NOISE
06 NORMAL FILTER
61 OFFSET STATE
14 OFFSET VALUE
60 OFFSETS
37 OSC - F *knobgear*
36 OSC - V *knobgear*
17 OSCILLATOR
12 OUTPUTS

31 PHASE *knobgear*
08 PHASE SETUP
11 REF HARMONICS
10 REF SOURCE
07 REFERENCE-MIXER
20 RS232 (PG 1 OF 2)
21 RS232 (PG 2 OF 2)
63 SAMPLE RATE
02 SETUP MENU
03 SIGNAL CHANNEL
04 SIGNAL SOURCE
41 SLOPE/AVERAGING
26 SPECIAL
44 SPECIAL FILTER
42 SPECIAL VERSION
13 TIME CONSTANT
49 TIMEBASE
58 USER KEY ERASE
43 VERNIER *knobgear*
33 X OFS *knobgear*
50 YAXIS INPUTS 1
51 YAXIS INPUTS 2
52 YAXIS INPUTS 3
53 YAXIS INPUTS 4
54 YAXIS INPUTS 5
55 YAXIS INPUTS 6
34 Y OFS *knobgear*

Menu Structure

Note: Page 57, the EG&G screen, cannot be accessed from the front panel.

```
MAIN MENU
⇓ PAGE                ⇑ MAIN
01 LARGE DISPLAY SCREEN
 ⇓ SETUP
02 SETUP MENU
        03 SIGNAL CHANNEL
            04 SIGNAL SOURCE
            05 LINE NOTCH
            06  NORMAL FILTER
            44 SPECIAL FILTER
                45 FILTER CONFIGURATION
                40 FILTER 1 (SPECIAL)
                47 FILTER 1 TRIM (SPECIAL)
                46 FILTER 2 (SPECIAL)
        07 REFERENCE-MIXER
            08 PHASE SETUP
            09 ADC TRIGGER MODE
            10 REF SOURCE
            11 REF HARMONICS
            39 LOW FREQUENCY
        17 OSCILLATOR
        12 OUTPUTS
            13 TIME CONSTANT
            41 SLOPE/AVERAGING
            60 OFFSETS
                61 OFFSET STATE
                14 OFFSET VALUE
            15 NOISE
        16 DACS & ADCS
            27 DACS              NEXT
            28 ADCS (PG 1 OF 2)  ⇒  29 (PG 2 OF 2)
            09 ADC TRIGGER MODE
        18 COMM - I/O
            19 GPIB               NEXT
            20 RS232 (PG 1 OF 2)  ⇒  21 RS232 (PG 2 OF 2)
        48 METHODS
        22 CURVE SETUP
            49 TIMEBASE
            50 YAXIS INPUTS 1
                    ⇓ NEXT
                51 YAXIS INPUTS 2
                        ⇓ NEXT
                    52 YAXIS INPUTS 3
                            ⇓ NEXT
                        53 YAXIS INPUTS 4
                                ⇓ NEXT
                            54 YAXIS INPUTS 5
                                    ⇓ NEXT
                                55 YAXIS INPUTS 6
            56 CURVE STATUS/RUN
        23 KNOB-LIGHTS
                    NEXT
            24 KNOB  ⇒  30 KNOB GEAR
                                31 PHASE knobgear
                                33 PHASE XOFFSET knobgear
                                34 YOFFSET knobgear
                                35 DACS 1 & 2 knobgear
                                38 FILT - F knobgear
                                36 OSC - V knobgear
                                37 OSC - F knobgear
                                43 VERNIER knobgear
            25 LIGHTS
        26 SPECIAL
            42 SPECIAL VERSION
            58 USER KEY ERASE
            63 SAMPLE RATE
```

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EG&G Instruments Corporation warrants each instrument of its own manufacture to be free of defects in material and workmanship. Obligations under this Warranty shall be limited to replacing, repairing or giving credit for the purchase price, at our option, of any instrument returned, shipment prepaid, to our Service Department for that purpose within **ONE** year of delivery to the original purchaser, provided prior authorization for such return has been given by an authorized representative of EG&G Instruments Corporation.

This Warranty shall not apply to any instrument, which our inspection shall disclose to our satisfaction, to have become defective or unworkable due to abuse, mishandling, misuse, accident, alteration, negligence, improper installation, or other causes beyond our control. This Warranty shall not apply to any instrument or component not manufactured by EG&G Instruments Corporation. When products manufactured by others are included in EG&G Instruments Corporation equipment, the original manufacturer's warranty is extended to EG&G Instruments Corporation's customers.

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A. Contact the Service Department (609-530-1000) or your local representative to discuss the problem. In many cases it will be possible to expedite servicing by localizing the problem to a particular plug-in circuit board.

B. If it is necessary to send any equipment back for service, we need the following information.

1. Model number and serial number.
2. Your name (instrument user).
3. Your address.
4. Address to which the instrument should be returned.
5. Your telephone number and extension.
6. Symptoms (in detail, including control settings).
7. Your purchase order number for repair charges (does not apply to repairs in warranty).
8. Shipping instructions (if you wish to authorize shipment by any method other than normal surface transportation.)

C. **U.S. CUSTOMERS** - Ship the equipment being returned to:

EG&G Instruments
375 Phillips Blvd.
Trenton, NJ 08618

D. **CUSTOMERS OUTSIDE OF U.S.A.** - To avoid delay in customs clearance of equipment being returned, please contact the factory or the nearest factory distributor for complete shipping information.

E. Address correspondence to:

EG&G Instruments
P.O. Box 2565
Princeton, New Jersey 08543-2565

Phone: (609) 530-1000
TELEX: 84-3409
FAX: 883-7259