Model 2030

Multifunction Waveform Synthesizer

The Model 2030 Multifunction Waveform Synthesizer is a high-performance, easy-to-use instrument that provides an unprecedented functionality and waveform fidelity at a very affordable price. With a large interactive graphic display, 50 MHz data point output rate, and an endless selection and combination of functions, it can address a wide range of applications in any situation that requires high precision, flexibility, and speed.

Incorporating GPIB control and a floating analog output, the 2030 meets the most stringent requirements of automated test systems, including tests where programmability and precisely generated signals, such as sine waves, pulses, arbitrary functions, random noise, combinations of functions, and modulations, are essential for successful testing.

By using a proprietary combination of digital signal processing and innovative state-of-the-art, high-speed analog techniques, this synthesizer offers a degree of waveform accuracy, stability, and resolution not previously achieved in any single synthesizer instrument. For example, harmonic distortion of the sine wave output is typically –80 dB ($\leq$ 100 kHz), with an output amplitude flatness better than $\pm$ 0.1 dB, increasing to only 0.3 dB at 20 MHz.

The range of standard functions and features extends to phase, FM, and multimode AM modulation modes and includes many advanced features such as linear and logarithmic sweeping and sinx/x modulations. All standard functions, including noise and glitch, can be summed to achieve the desired custom output.

A library of additional waveforms includes Fast Rise Square Wave, Sin^3x, Sinx/x, Glitch, RC Low Pass and RC High Pass. For highly specialized functions, the unit will accept data files through its IEEE-488 interface. The deep dual memory capacity of over 250,000 data points with high-speed output (20 ns/point) makes this instrument an ideal signal source for bench, laboratory, and manufacturing test environments.

FEATURES

- ❏ High-Speed 50 MS/s Output
- ❏ Deep Dual 250k-point Memory
- ❏ High Purity Digitally Synthesized Output
- ❏ Isolated Output for High Noise Immunity
- ❏ Exceptional Amplitude Flatness – within 0.3 dB at 20 MHz
- ❏ Frequency Resolution of 0.1 ppm
- ❏ Easy-to-Use Interactive Graphic Interface
- ❏ Menu of a Wide Variety of Outputs
- ❏ Modulated Outputs
- ❏ Built-in Waveform Library
- ❏ Customized Waveform Capability
- ❏ Multi-unit Precise Synchronization for Production Test Flexibility
- ❏ Reliable Low-power Design
- ❏ Standard GPIB and ARB Software Download

APPLICATIONS

- ❏ Acoustics and Speech Analysis
- ❏ Electromechanical
- ❏ Geophysics
- ❏ Medical Research
- ❏ Digital Communications
- ❏ ATE
- ❏ Sonar Simulation
- ❏ Dynamic LCD Testing

ANALOGIC®
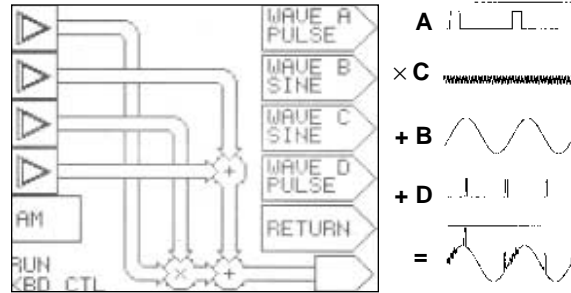*The World Resource for Precision Signal Technology*

Fast, Easy Operation

With the 2030, generating precision waveforms is easier than ever. From simple menus, you can readily select either standard functions and modulations, or a host of functions from a built-in library. Frequency and other parameters are instantly set with a single, large control knob that gives the instrument a real-time "analog feel." Specific values are keyed-in directly. More than 50 complete waveform setups can be stored internally by name, for immediate output when needed.

Flow diagram represents modulator, carrier and waveforms added to obtain the output shown.

Exact bandwidth of the sinx/x modulated burst is menu-selectable.

Producing even complex, custom waveforms is no problem with the graphic display and soft keys. An interactive flow diagram enables the user to sum and modulate different standard functions as desired. In the example
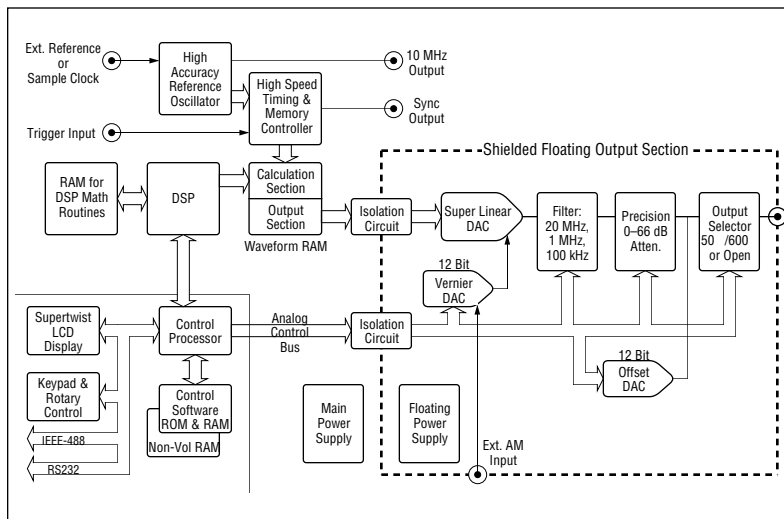
shown, Wave **A** (top input of diagram) modulates Carrier **C**; then **B** and **D** are added. Desired noise levels may be added before or after modulation. In fact, an endless variety of signal combinations are at the operator's fingertips.

Precision and Versatility

Because of its enormous flexibility in waveform generation and its excellent signal quality, the 2030 Waveform Synthesizer is virtually immune to obsolescence.

In production test, for example, where changes and upgrades to manufactured product often call for expensive new test equipment, the 2030 will be a viable signal source through many years of product change. Should new types of modulation or more accurate signals be required, the synthesizer is ready.

The synthesizer's floating analog output to ensures immunity to noise problems encountered in system test set ups. It also offers triggered start, stop, or windowing, and generates counted waveform bursts that either stop at the end of a complete cycle or stop and hold the current level. A high-stability frequency reference is standard. Multiple-unit synchronization is provided through common clocking or by locking frequencies with an external reference.

The Model 2030 Block Diagram.

Applications

The applications illustrated are samples of what the versatile 2030 Synthesizer can do.

Clocking Source for ATE

Ideal for general production test, the 2030 also provides accurate and flexible clocking for a variety of devices such as timing circuits, multiplexers, DACs, ADCs, and memories. A fast 15 ns pulse rise time drives clock-sensitive CMOS memories. Over 50 user test signals can be stored in the unit.

Digital Communications

Testing modern communications products, such as modems, requires various special signals and modulations. The 2030 produces many of these, including phase shift keying and frequency shift keying, over a wide range of frequency and modulation rates. Menus allow fast, precise setup to industry-standard test specifications. To test jitter immunity, a specified phase modulation rate and maximum phase angle are entered.

Sonar Simulation

The 2030 tests the detection capability of a phased sonar array without the expense of field recording by simulating a target using 3 primary tones plus noise. The noise amplitude and spectral line spacing may be altered to mask some of the tones. Non-sinusoidal tones are simulated with square, triangle, or modulated signals.
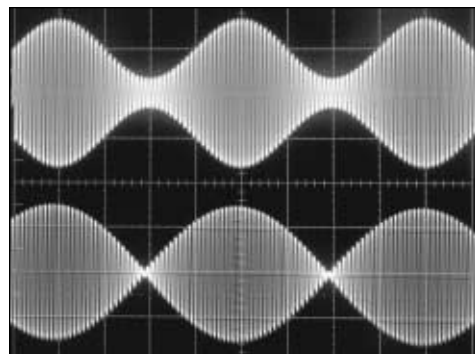
Dynamic LCD Testing

LCD displays require pulsed AC drive for fastest response. The 2030 provides full control of pulse modulation, enabling detailed study of LCD characteristics.
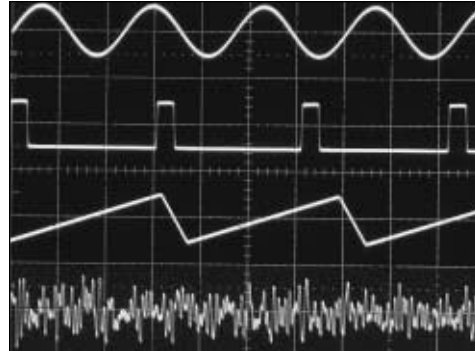
The full selection of standard functions includes programmable noise.
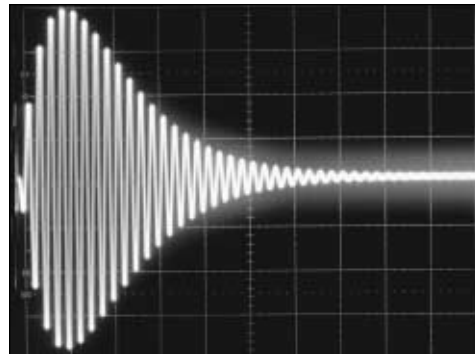
The exponential decay envelope simulates a drum beat or an RF loran burst.

Standard AM and suppressed carrier are generated with high accuracy.

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SPECIFICATIONS

FREQUENCY RANGE
DC - 50 MHz Data point rate. See individual functions for specific frequency ranges.

FUNCTIONS
Standard (Sine, square, triangle, pulse, ramp up/down, random noise, DC, glitch)
Modulations and Sweeps
Combined Waveforms
Arbitrary Waveforms
Waveform Library

OUTPUT

Source Impedance
50Ω/600Ω ±1%

Amplitude Range
5 mV to 10V p-p
10 mV to 20V p-p with no load

Amplitude Resolution
0.1% of output voltage within each of 11 cascaded auto-switching 2:1 attenuator ranges

Amplitude Accuracy
±1%, absolute
0.2%, relative, typ.

Offset Range
±5V in 1.25 mV steps
±10V with no load

Offset Accuracy
±1% ±200 µV (20 to 30°C)
±34 µV/°C

Frequency Stability
±2 ppm, 0° to 50°C
±2 ppm/yr

Frequency Resolution
1 ppm +1 mHz max.

Relative Frequency Accuracy
< 0.2 ppm

Noise
100 µV RMS DC to 10 MHz Typ.

Jitter
0.005% waveform period +100 ps RMS for sine, 0.05% +100 ps RMS for other waveforms

Protection
±15V

TRIGGER

Source
Manual., external, bus

Modes
Free run, counted burst, gated, start, stop, start/stop

SINE WAVE

Frequency Range
0.001 Hz to 20 MHz

Amplitude Flatness
±0.1 dB DC to 100 kHz
±0.2 dB 100 kHz to 1 MHz
±0.3 dB 1 MHz to 20 MHz

Harmonics + Spurious
–70 dBc 1 mHz to 20 kHz
–65 dBc 20 kHz to 100 kHz
–55 dBc 100 kHz to 1 MHz
–25 dBc 1 MHz to 20 MHz

Phase Range
±360° in 0.1° increments

Phase Accuracy
±1.0° DC to 100 kHz

TRIANGLE AND RAMP

Frequency Range
0.001 Hz to 2 MHz

Nonlinearity 10% - 90%
±0.05% up to 10 kHz
±0.5% 10 kHz up to 1 MHz

Ringing
< 0.1% up to 10 kHz
< 0.2% 10k to 1 MHz

Triangle Symmetry
User adjustable from 5% to 95% in 0.1% steps, with 0.1% accuracy

Triangle Delay Range
±360° in 0.1° steps

SQUARE AND PULSE

Frequency Range
0.001 Hz to 5 MHz

Pulse Polarity
Positive with zero volt baseline

Duty Cycle
Adjustable from 5% to 95% in 0.1% steps, with 0.1% accuracy

Delay Range
±1 waveform period in steps of 0.1 µs to 0.1 ms, depending on the frequency selected

Rise Time
15 ns DC to 1.47 Hz
10 µs 1.47 Hz to 1 kHz
1 µs 1 kHz to 10 kHz
50 ns 10 kHz to 5 MHz
15 ns in Fast Square

Overshoot and Ringing
< 0.1% up to 10 kHz
< 0.2% 10k to 1 MHz

NOISE FUNCTION

Amplitude Range
1 mV to 1.8V RMS-steps of 1 µV /1 mV(no load)

Noise Spectral Distribution
Pseudo random with the ability to set number of spectral lines

MODULATION AND SWEEPS
Modulation Types
AM DSB, DSB SC, AM SSB, SSB SC, FM, FM, Expon. Decay, Sinx/x

Carrier Range
0.001 Hz to 20 MHz

Modulation Rate
0.001 Hz to Carrier frequency in steps of <0.4% (<0.1 ppm with reduced carrier resolution)

Modulation Span–(within 20 MHz bandwidth)
AM: 0.0% to 200.0%
FM: lesser of ±carrier/2 or ±2 MHz
ΦM: ±7200 degrees

Envelope Distortion
AM: <1%

Exponential Decay Envelope
$t^2 e^{-at}$ envelope defined by peak time, duration

Sinx/x Envelope
Defined by bandwidth, repetition rate

External Modulation
0 to 40% AM

Sweeps
Linear and log, phase continuous

COMBINED WAVEFORMS
Up to 4 standard functions can be summed or used in modulation including glitch

Carrier
Any standard function

Modulator
Summation of up to 3 standard functions

Modulation Type
AM, FM, or ΦM

Post-modulation Summation
Up to 2 standard functions

ARBITRARY WAVEFORMS

Waveform Length
2k to 256k points

WAVEFORM LIBRARY
Fast Square, sin^3x, sinx/x, RC lowpass/high-pass filtered square wave
Additional libraries are being developed.

GENERAL

Non-volatile Memory
Over 50 instrument set ups

Rear Panel Inputs
Trigger, Ext. Clock/Reference, Modulation (AM)

Rear Panel Outputs
Function, 10 MHz Reference, Sync/Marker

Interfaces
RS-232 and IEEE-488

Operating Temperature
0 to 50°C

Power
< 30W, 100/120/220/240 VAC, 50/60 Hz

DIMENSIONS
8.5" x 5.2" x 16.9" (WxHxD)
216 x 132 x 429 mm

Weight
13 lb (6 kg)

CALL (978) 977-3000

Model 2030

Multifunction
Waveform Synthesizer

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The World Resource
for Precision Signal Technology

Proprietary Statement

The information contained in this publication is derived in part from proprietary and patent data of the Analogic Corporation. This information has been prepared for the express purpose of assisting operating and maintenance personnel in the efficient use of the instrument described herein. Publication of this information does not convey any rights to reproduce it or to use it for any purpose other than in connection with the installation, operation, and maintenance of the equipment described herein.

P/N 82-5081
Revision 2
June 25, 1993

Safety Precautions

The following safety precautions should be observed while operating this instrument. Failure to comply with these precautions violates safety standards of design, manufacture and intended use of this product. Analogic Corporation assumes no liability for the customer's failure to comply with these requirements.

USE PROPER GROUNDING

A three-conductor power cord is supplied with this instrument. To minimize the hazard of shock, the instrument chassis and cabinet should be connected to electrical ground. The power cable should be either plugged into an approved, three-wire, grounded electrical outlet or used with a three-to-two-wire adapter with the ground (green) wire solidly connected to a good electrical ground at the power outlet.

DO NOT OPEN THE CABINET FOR ANY REASON

Hazardous high voltages are present inside the cabinet of this instrument. Making contact with any such voltage levels could cause injury or even death. Servicing should be performed only by qualified personnel.

OBSERVE ANY SPECIAL SYMBOLS MARKED ON THE EQUIPMENT

⚠ Refer to the Instruction Manual: The instrument is marked with this symbol when the user is required to refer to the manual for special operating instructions that may prevent any hazard or damage to the instrument.

OBSERVE ALL WARNINGS, CAUTIONS AND NOTES

The operating instructions in this user's manual include special notes, cautions and warnings pertaining to the use of this instrument. Be sure to pay special attention to the following items:

WARNING: Describes a condition or action that is considered hazardous to the user, such as working around high voltages that can cause serious injury.

CAUTION: Describes a condition or action that may damage the instrument, such as applying input voltages that exceed the limitations of the instrument.

NOTE: Describes other essential information that should be brought to the user's attention, such as operating features that would otherwise be overlooked.

Warranty

Analogic warrants only to the original purchaser that this product, as purchased from Analogic or an Analogic distributor or dealer, will conform to the written specifications for a period of one year from the date of purchase. If the product fails to conform to these warranties, Analogic, as its sole and exclusive liability hereunder, will repair or replace the product and/or its components within a reasonable period of time if the product is returned to Analogic's facility at Peabody, MA, within the warranty period as expressed above. These warranties are made upon the express condition that:

a. The purchaser promptly notify Analogic in writing of any non-conformity with the above warranty including a detailed explanation of the alleged deficiencies.
b. The product is returned to Analogic at the buyer's expense only after obtaining the proper authorization from Analogic.
c. When the product is returned for repair, a copy of the original bill of sale or invoice is sent with the product .
d. Analogic will not be liable for any incidental or consequential damages.
e. In the opinion of Analogic upon inspection, the product has not been misused, altered, or damaged due to abnormal handling and/or operation.
f. Repairs to the product and/or its components have not been made by anyone other than Analogic or one of its authorized repair agents.
g. The product has not been modified, altered, or changed in any manner by anyone other than Analogic or one of its authorized repair agents.

THIS WARRANTY EXCLUDES ALL OTHER WARRANTIES, WHETHER EXPRESSED OR IMPLIED, ORAL OR WRITTEN, INCLUDING WITHOUT LIMITATION WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR A PARTICULAR PURPOSE.

No term, condition, understanding or agreement purporting to modify the terms of this warranty shall have any legal effect unless made in writing and signed by an authorized officer of Analogic and the purchaser.

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6   Applications

7   Specifications

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1.1   *ABOUT THIS MANUAL*

This manual describes the installation and operation of the Model 2030 Multifunction Waveform Synthesizer. The information is organized into the following sections:

Section 1, *Introduction*, describes the scope of this manual and the instrument. It also provides information on seeking technical assistance and arranging customer service.

Section 2, *Getting Started*, describes unpacking and setting up the instrument. Provides a step-by-step start-up procedure for the first-time user, explaining all basic operating conventions.

Section 3, *Local Operation*, explains how to generate waveforms using the menu-driven operation of this instrument.

Section 4, *Remote Operation*, covers remote communications with the 2030 using the RS-232 or IEEE-488 interface.

Section 5, *IEEE-bus and Arbitrary Waves*, describes additional remote control functions using the GPIB and arbitrary waveform generation.

Section 6, *Applications*, Suggests various ways of using the instrument and describes some special methods and techniques.

Section 7, *Specifications*, Lists detailed specifications of the instrument.

1.2   *PRODUCT DESCRIPTION*

The 2030 is a versatile 20-MHz Multifunction Waveform Synthesizer capable of generating a wide variety of waveforms with exceptionally low distortion and high accuracy. Here is a summary of its functions and features:

Functions

- ❏ STANDARD WAVES: Sine, Square, Triangle, Pulse, Ramp Up/Down, DC Level, and Pseudo-Random Noise.

- ❏ MODULATED WAVES: Amplitude Modulation (AM), Frequency Modulation (FM), Phase Modulation, External AM, Exponential Decay, Linear and Logarithmic Sweep and sin X/X.

- ❏ COMBINED WAVES: Sum and product combinations of up to four standard functions.

- ❏ SPECIAL WAVES: Miscellaneous special-purpose waveforms.

- ❏ ARBITRARY WAVES: Pre-calculated waveforms received from an external source via the built-in IEEE-488 bus.

Features

❏ Interactive graphics user interface for ease of operation.

❏ Menu-driven operation of standard and specialized functions with additive noise.

❏ Customized waveforms by combining and modulating standard functions.

❏ Versatile triggering and gating capabilities.

❏ RS232 interface and IEEE-488 (GPIB) instrumentation bus for remote operation.

❏ Isolated output for high noise immunity.

❏ Exceptional amplitude flatness, within 0.3 dB at 20 MHz.

❏ Frequency resolution of 0.1 ppm.

❏ Deep dual 250K data point memory.

1.3 SERVICE AND TECHNICAL SUPPORT

If the instrument you have received fails to operate upon arrival, contact your dealer or the Measurement and Control Division (MCD) Order Entry service at Analogic in Peabody, MA 01960 to arrange for an exchange. Upon contacting MCD Order Entry, you will be given a Return Material Authorization (RMA) number.

To arrange for an exchange:

Call MCD Order Entry   (508) 977-3000, X3871   FAX (508) 532-6097

To get technical assistance with your particular application:

Call MCD Applications Engineering (508) 977-3000   FAX (508) 531-1266

To arrange for service, contact Analogic's Customer Service Office:

Telephone: (508) 977-3000   Repairs: X3617   Parts: X3614

When contacting Customer Service, please have the following information available:

❏ Model number

❏ Serial number

❏ Purchase order number

❏ Quantity being returned

❏ A detailed description of the malfunction,

❏ Customer's "Bill To" and "Ship To" address.

When you call, the Service Coordinator will give you a customer service order number (CSO), the warranty status of the units being returned, and the repair charge, if any. The CSO number is your authorization number. Please write this number on your purchase order and shipping label.

Send authorized returns to Analogic Corporation, 8 Centennial Drive, Peabody, MA 01960, Attn: Receiving Dock B.

After the material has been returned, you will receive an acknowledgment copy of the CSO which will be marked with the scheduled return date.

2.1   INTRODUCTION

This section is written for the first-time user. It includes unpacking instructions, a detailed description of the front and rear panels, bench-top installation instructions and an initial checkout procedure. The initial checkout procedure is designed to familiarize you with basic operating conventions.

2.2   UNPACKING INSTRUCTIONS

Remove the instrument from the shipping carton and check that you have received the following accessories:

- 110/120 Vac Line Cord (Domestic) or 220 Vac Line Cord (Export)
- 0.5A Fuse (Domestic) or 0.25A Fuse (Export)
- BNC/BNC Cable
- 50Ω Terminator
- Hardware User's Manual

Thoroughly inspect the instrument for physical damage. If you detect any damage, file a claim with your carrier immediately. A carrier's report is required for settlement of all damage-in-shipment claims. Be sure to save the shipping carton and packing materials.

2.3   FRONT PANEL CONTROLS

The front panel layout is given in Figure 2-1. The front panel consists of a display screen, user interface controls and an output connector.

The display is a bright, easy-to-read liquid crystal display (LCD) with adjustable contrast and brightness levels. The display and the front panel pushbutton keys provide the user interface for operating this menu-driven instrument.

The front panel keys are grouped by function. Software-defined function keys (Softkeys) are aligned with the right and left vertical borders of the display so that they can easily be associated with a displayed function definition. The group of labeled dedicated function keys under the display always perform their assigned set-up or control function. A standard numeric keypad is included on the right-hand side of the panel for direct entry of parameter values. The right/left arrow keys and the Rotary Encoder are used for scrolling through menu selections and changing parameter values.

The BNC connector in the lower right-hand corner is the main signal output and is electrically connected to the output connector on the rear panel. This is a standard BNC connector.

2.4   INPUT/OUTPUT CONNECTIONS

Except for the main signal output connector on the front panel, all I/O connections are on the rear panel as described in Figure 2-2. Except for the IEEE-488 and RS232 interface, all connections are BNC connectors. The power input module, which contains the ac line fuses, can be configured for various ac input voltages. To change the line voltage configuration, see Section 2.5.

Softkeys
Software-defined function keys which select or activate the function displayed on the screen. Some functions call up a submenu of parameters to set up before performing the function.

Move Left / Delete Key
When a selected parameter has a numeric value, this key moves the cursor one position to the left in this numeric field. The Rotary Encoder increases or decreases the numeric value starting at the cursor position. For submenus and parameters that have a pre-defined list of selections, this key steps through the list in bottom-to-top order. When entering a numeric value from the keypad, this key performs a delete function which erases the last digit entered.

Rotary Encoder
A multi-purpose control used in conjunction with displayed information called up by a softkey. For example, it can increase or decrease any numeric parameter value, or scroll through a pre-defined list of parameter selections.

Display Screen
A liquid crystal display (LCD) with adjustable contrast and backlight levels is the user interface to the instrument's software operation (Waveform Menu is shown).

Move Right Key
When a selected parameter has a numeric value, this key moves the cursor one position to the right in this numeric field. The cursor indicates which digit is selected and subject to change by rotating the Rotary Encoder. For submenus and parameters that have a pre-defined list of selections, this key steps through the list in top-to-bottom order.

ANALOGIC.■ —— 2030 MULTIFUNCTION WAVEFORM SYNTHESIZER

STANDARD WAVE

MODULATED WAVE

COMBINED WAVE

SPECIAL WAVES

RETURN

STOP
KBD CTL

DEL
◄ ►

1 2 3
4 5 6
7 8 9
. 0 +/−

Numeric Keypad
For entering specific parameter values.

Power ON/OFF
A two-position pushbutton switch. Push in for ON, push in again to release for OFF.

ON OFF

TRIG WAVE OUT CLK DIR
MAN I/O STAT DISP R/S

FLOATING OUTPUT
⚠ 42VMAX

50 / 600

Main Signal Output Connector (BNC)
Electrically connected to the rear panel OUTPUT connector. User-programmable output impedance of 50 or 600 ohms.
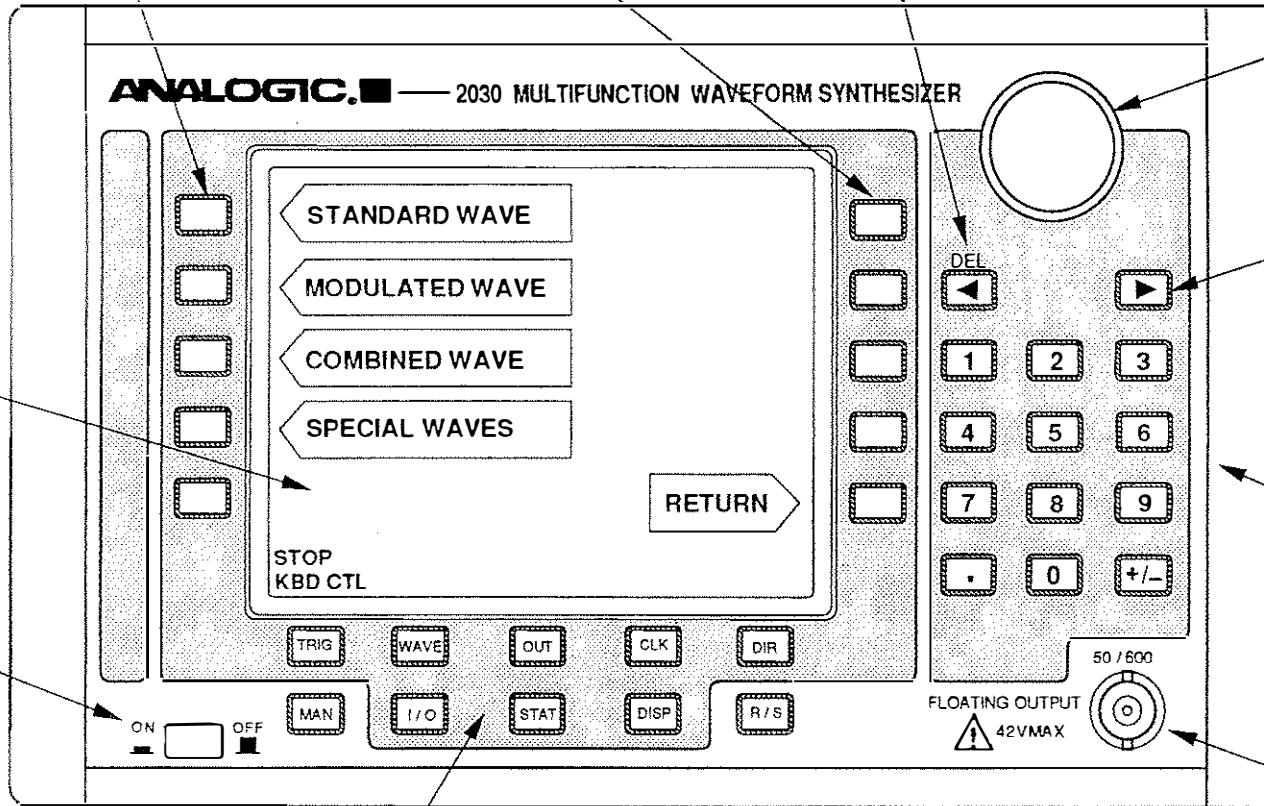
Dedicated Function Keys

TRIG
Calls up the Trigger Set-Up Menu (Trigger Type, Trigger Source, Trigger Level and Gate Type).

WAVE
Calls up the Waveform Menu (Standard, Combined, Modulated and Special Waves).

OUT
Calls up the Output Menu (50 or 600 ohm output impedance).

CLK
Calls up the Clock Source Menu (External Clock, Internal Clock or External Reference).

DIR
Calls up a list of all established waveform files.

MAN
Generates a manual trigger pulse.

I/O
Calls up the I/O Control Menu (Keyboard, GPIB and RS232).

STAT
Displays a summary of 2030 set-up.

DISP
Calls up the Display Menu (Contrast, Backlight and Display Units).

R/S
Starts and Stops the output of the generator.

Figure 2-1. Front Panel Controls and Indicators

EXTERNAL AM INPUT
External amplitude modulation input allows you to directly modulate a carrier with an external signal – floating BNC connector, 10 k input impedance, 10% modulation/volt of input allowed, maximum safe input range is ± 30 volts.

OUTPUT
Main signal output electrically connected to the front panel signal output – floating BNC type connector, 50 or 600 ohm user-programmable output impedance, overload protected, chassis isolated.

EXT TRIGGER INPUT
Trigger input signal – BNC chassis grounded connector, 10 K input impedance, –3V to + 3V input level range.
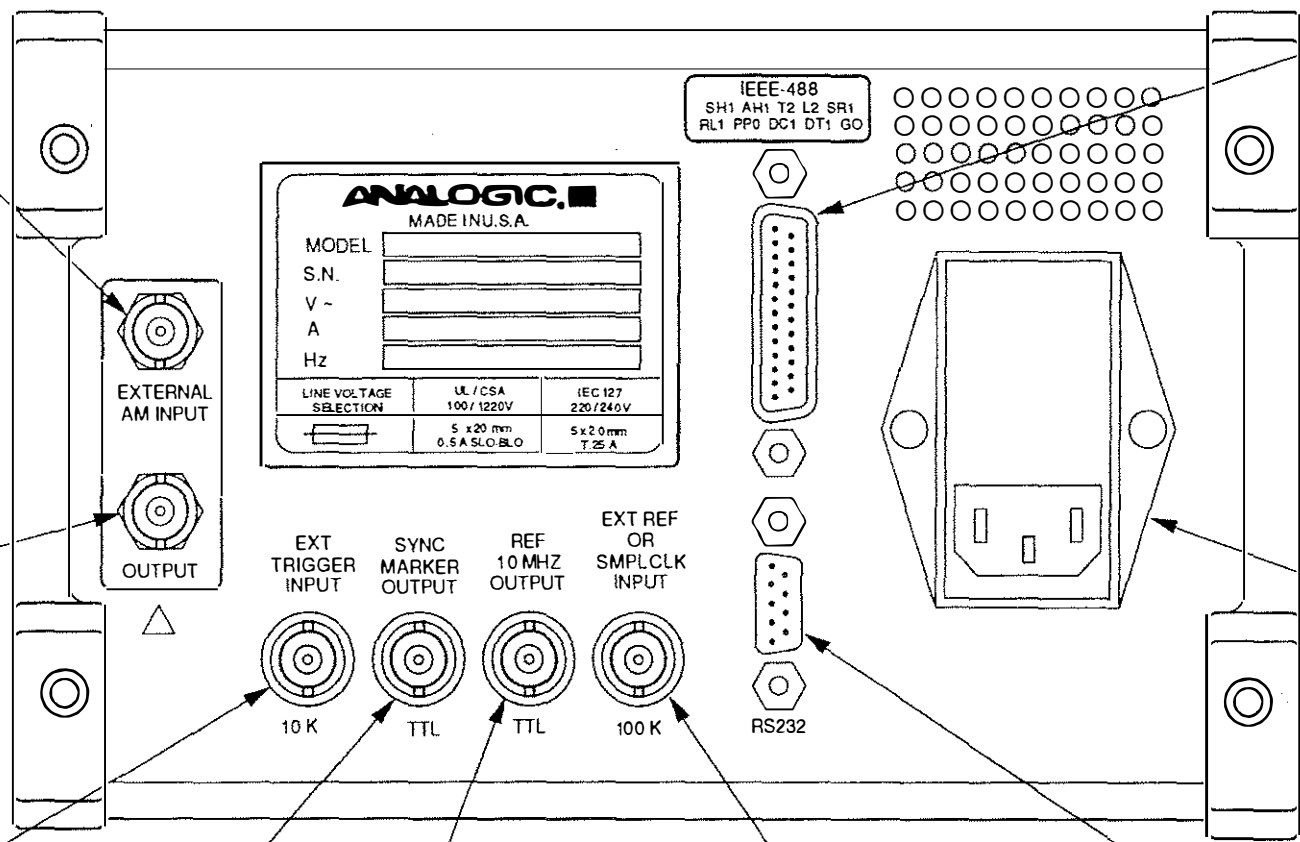
SYNC / MARKER OUTPUT
Sync/Marker output signal provides external equipment with synchronization information about the output waveform – BNC chassis grounded connector, 3 V to .1 V signal output into 50 ohms, short-circuit protected.

REF 10 MHZ OUTPUT
BNC connector for a 10-MHz reference clock output with TTL logic levels.

EXT REF OR SMPL CLK INPUT
An external clock input, user-selectable as a system reference oscillator or an external sample clock for the D/A converter – chassis grounded, input level range of 3 V to 0.3 V, 100K input impedance in parallel with 30 pf. As a reference oscillator input, the allowed frequency range is 1 to 16 MHz in 1-MHz steps. As an external sample clock, frequency input can be up to 25 MHz.

RS232
Standard RS232 Interface, user-selectable by front-panel control. [Transmission Characteristics: 8 data bits, 1 stop bit, no parity; 300, 600, 1200, 2400, 4800 or 9600 baud.]

Pin 2: Input   Pin 3: Output   Pin 5: Gnd

IEEE-488 (2030A Only)
General Purpose Interface Bus (GPIB), user-selectable by front-panel control. Hardware/software capabilities listed in the label above the connector are defined by IEEE standards.

POWER INPUT MODULE
AC power input module configurable for 100, 120, 220 or 240 Vac input. Contains ac line fuses.

IEEE-488
SH1 AH1 T2 L2 SR1
RL1 PP0 DC1 DT1 GO

ANALOGIC.
MADE IN U.S.A.
MODEL
S.N.
V ~
A
Hz

LINE VOLTAGE SELECTION	UL / CSA 100 / 1220V	IEC 127 220 / 240V
	5 x 20 mm 0.5 A SLO-BLO	5 x 20 mm T.25 A

EXTERNAL AM INPUT

OUTPUT

EXT TRIGGER INPUT   SYNC MARKER OUTPUT   REF 10 MHZ OUTPUT   EXT REF OR SMPL CLK INPUT

10 K   TTL   TTL   100 K   RS232

2.5   *INPUT LINE VOLTAGE CONFIGURATION*

This instrument can be configured to operate on line voltages of 100, 120, 220 or 240 Vac by changing the position of the voltage selection wheel in the power input module on the rear panel. If you need to change the voltage selection, follow the procedure below and refer to Figure 2-3.

<u>CAUTION</u>:   *Connecting this instrument to a line voltage other than the selected voltage may destroy the line fuses. When replacing fuses, always use a direct replacement.*

(1)   Remove the line cord from the power input module.

(2)   Using a blade screw driver, pry open the cover of the input power module.

(3)   Remove the voltage selection wheel from inside the power input module.

(4)   Rotate the voltage selection wheel and place it back into the module so that the correct voltage appears in the window when the cover is closed.

(5)   Check the two line fuses for the correct rating. See the note in Figure 2-3.

(6)   Plug the line cord into the power input module.

NOTE: When changing input voltage, check fuses:
For 100/120 Vac – 5 x 20mm, 0.5A, SLO-BLO (UL/CSA).
For 220/240 Vac – 5 x 20mm, T.25A (IEC).
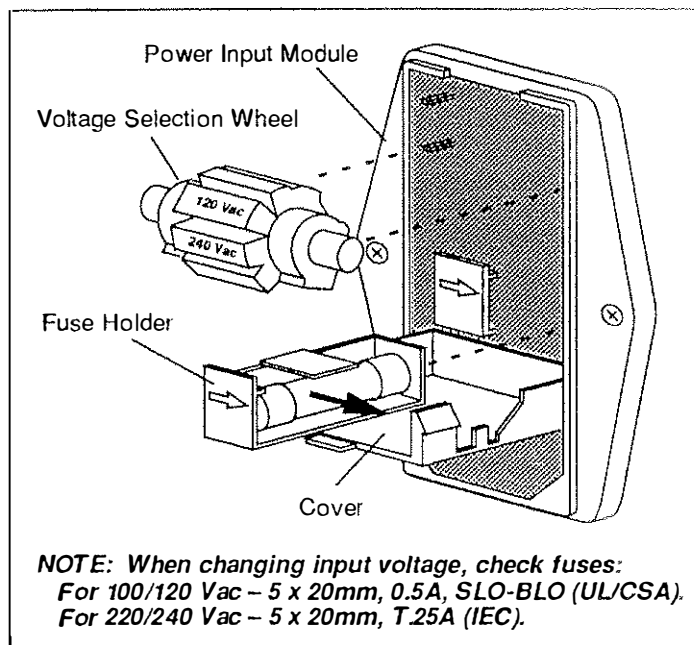
Figure 2-3. Power Input Module

2.6   *BENCH-TOP INSTALLATION*

For bench top use, this instrument is equipped with front and rear feet on the bottom panel. A locking bail is also included to raise the front of the instrument for a more convenient viewing angle. To use the bail, lift the front of the instrument and pull the bail down into its locking position.

2.7 INITIAL CHECKOUT PROCEDURE

This procedure is designed to guide you through the first few minutes of operation. It describes all the basic operating conventions of the instrument.

Step 1: Making Power Connections

— Confirm that the power input module on the rear panel is set for the correct ac line voltage. If the line voltage selection is incorrect and needs to be changed, refer to Section 2.5.

— Connect one end of the line cord to the power input module and the other end to the ac power source.

Step 2: Applying Line Power

NOTE: If no image appears on the display screen after power is on, press the DISP function key and then the top left-hand softkey. Rotate the Rotary Encoder clockwise to increase the display contrast.

— Set the ON/OFF pushbutton switch to the ON position. During power-up, the instrument performs a self test. At the beginning of the process, a software revision number is displayed briefly. Make note of this number. This information will be useful if you should ever detect a problem and require service or technical assistance.

— When the power-on process is complete, the waveform menu in Figure 2-4 is displayed. If not, press the WAVE key. Note the labels in the lower left-hand corner: STOP means the main signal output is inactive; KBD CTL means that the instrument is under local (front panel) control.
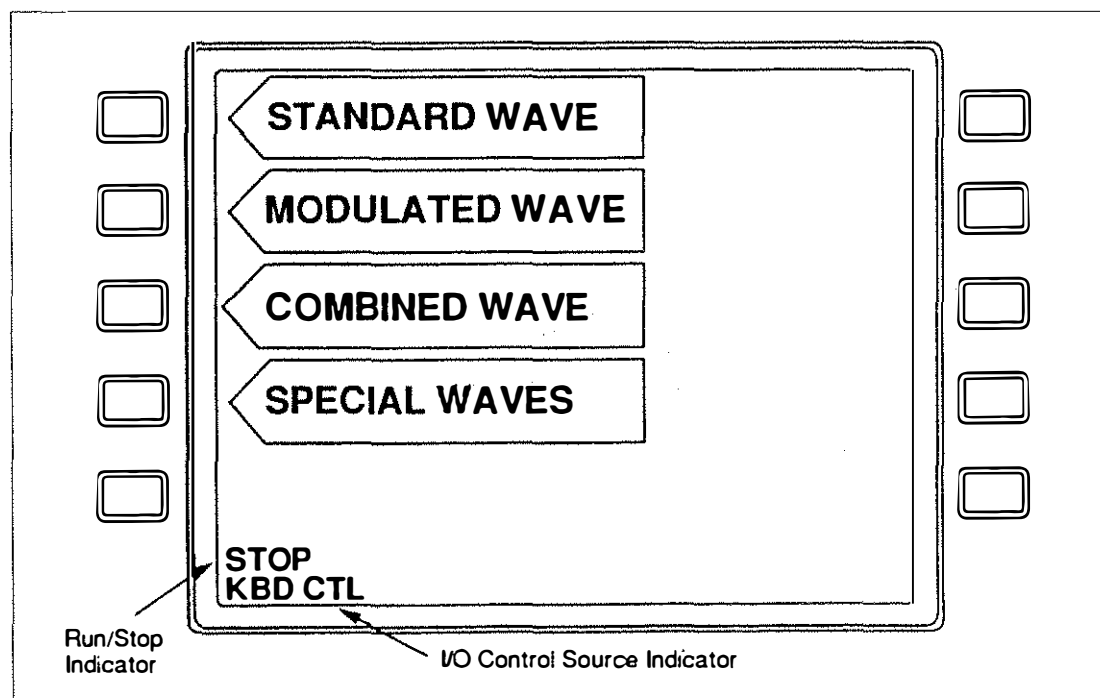
Figure 2-4. WAVE Menu Display

Step 3: Adjusting Display Contrast and Backlight

- Press DISP and see Figure 2-5.

- Press CONTRAST. Note that a solid bar or selection indicator appears on the softkey function pointer. Adjust the screen contrast with the Rotary Encoder: clockwise to increase contrast, counter-clockwise to decrease.

- Press BACKLIGHT. Just as with CONTRAST, use the Rotary Encoder to adjust the light level: clockwise increases , counter-clockwise decreases.

- Ignore INPUT FORMAT for now, it is described in detail in Section 3.

Step 4: Using the RETURN Softkey

- Press the RETURN softkey. Note that the display returns to the WAVE menu.

- The operating software has nested menus and RETURN enables you to step back one level at a time until you reach the WAVE menu. For example, select STANDARD WAVE from the WAVE menu and press the NOISE softkey. This steps you into the menu structure by two levels. Now, press RETURN twice (allow a slight delay between presses) and note that the display steps back to the WAVE menu.
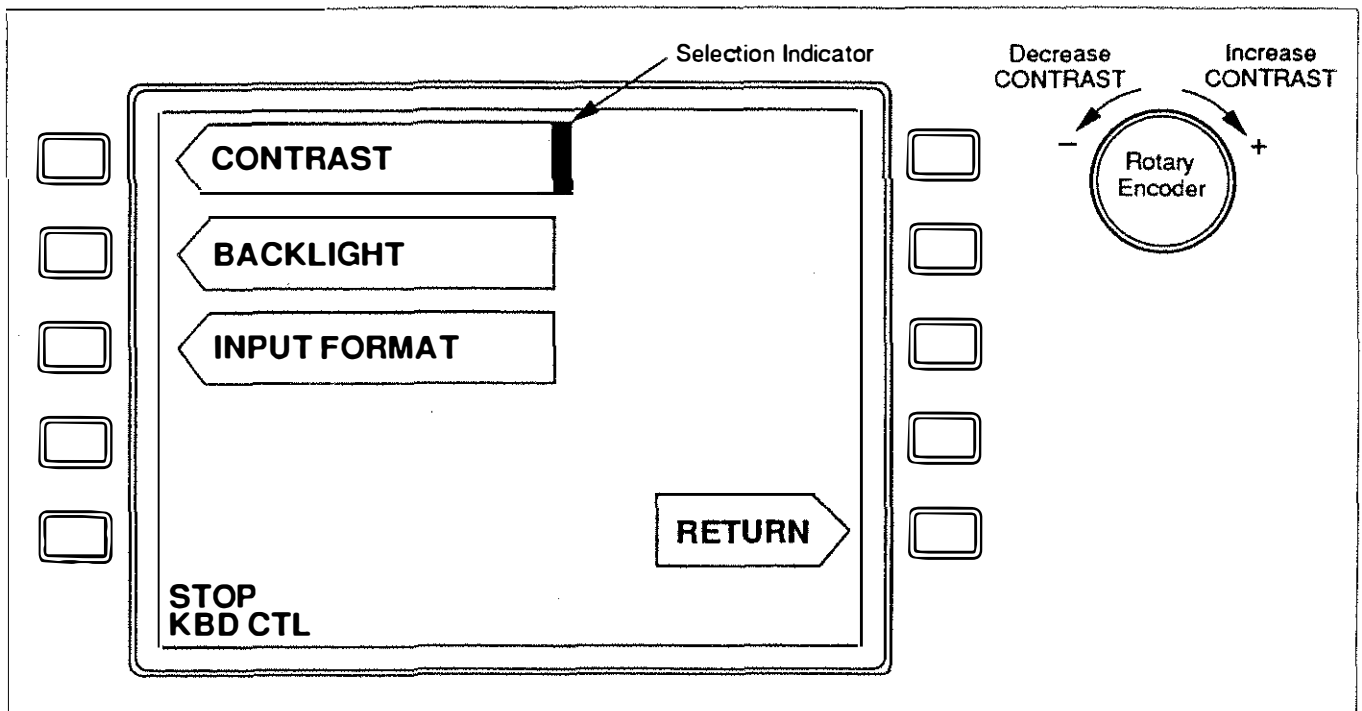
Figure 2-5. DISP Function Screen

Step 5: Setting Up a Waveform

- Press STANDARD WAVE from the WAVE menu. This calls up the submenu of standard waveform functions shown in Figure 2-6.

- Note the information box at the top of the display which tells you the last wave type entered.

- Note the cursor to the left of the submenu. To select a wave type, place the cursor next to the wave type name and press ENTER. This action calls up the parameter set-up display for the chosen wave type. For example, if you selected SINE, the parameter set-up display would look like Figure 2-7.
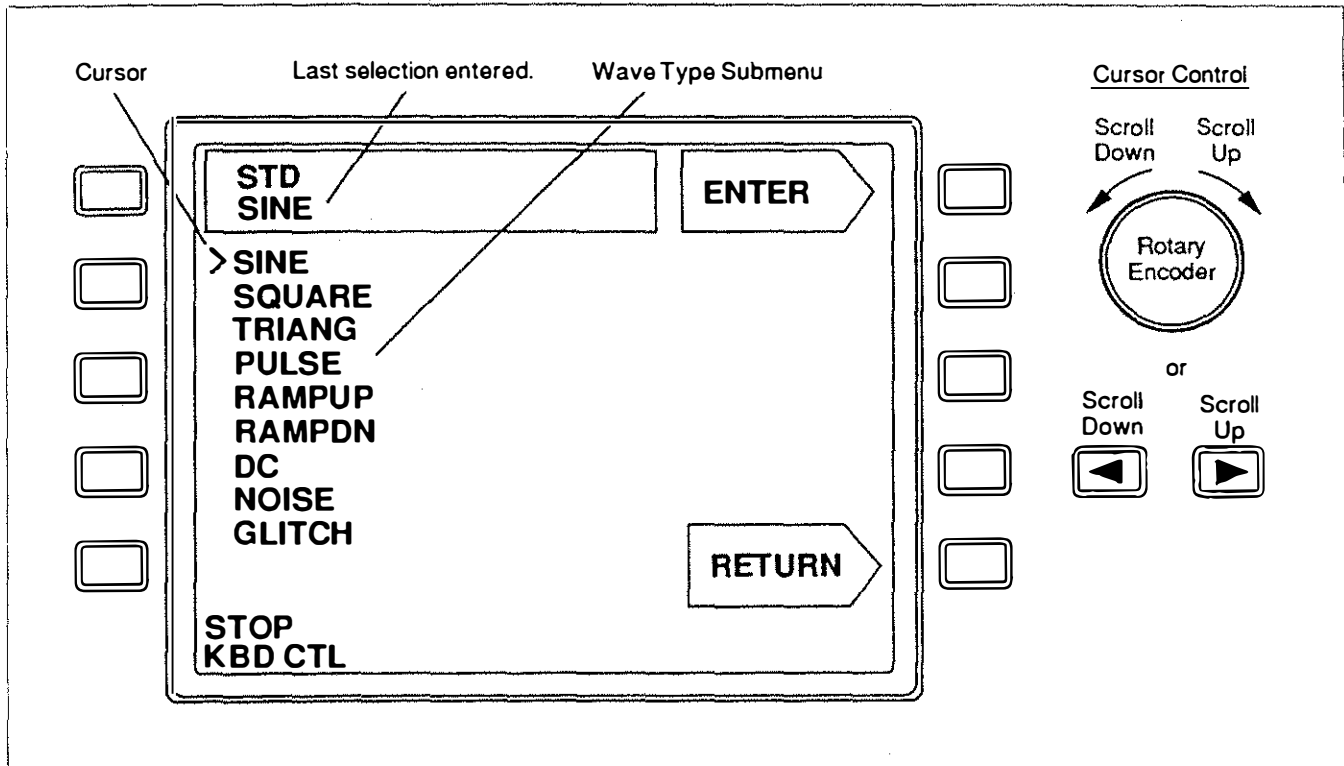
Figure 2-6. STANDARD WAVE Function Submenu

NOTE: The upper right-hand box in the display (Figure 2-7) is a read-only field controlled by the internal program. This is not a Softkey pointer. Pressing the Softkey adjacent to this box has no effect. Other displays may also have one of these boxes which are for displaying information only.

—   Press FREQUENCY. Note the cursor under the right-most digit of the frequency value — the cursor selects the digit to be changed.

—   Using the Left/Right Move keys, try moving the cursor left and right.

—   Select a digit with the cursor and try changing its value using the Rotary Encoder: clockwise to increment, counter-clockwise to decrement. Using this method, set FRE-QUENCY = 1 kHz.

—   Press AMPLITUDE and set it to 2.525 V.

—   Press PHASE and set it to 90 DEG.

—   Press OFFSET and set it to 10 mV.

—   Press Noise. Set it ON with an AMPLITUDE of 1 mV.
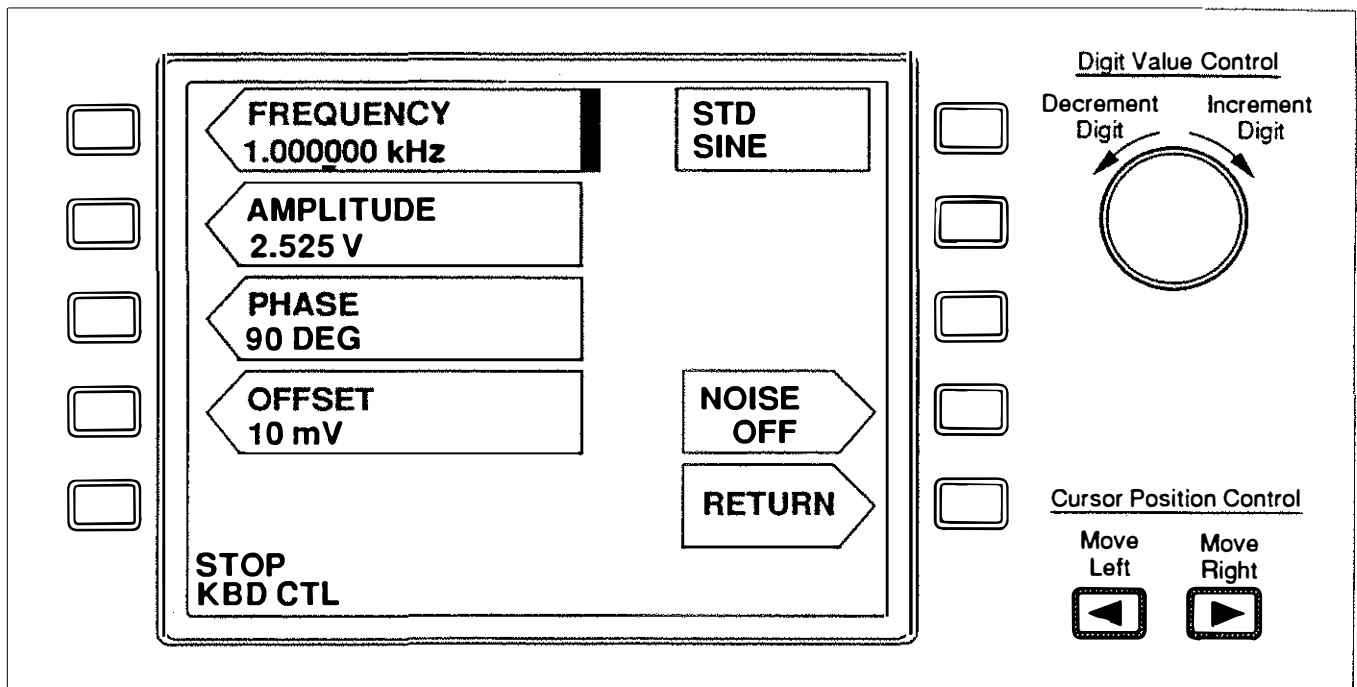
Figure 2-7. Parameter Set-Up Display Example (SINE)

Step 6: Direct Entry of Parameter Values

— Press AMPLITUDE in the STANDARD WAVE set-up display. Rather than change the numerical value as before, try direct numerical entry. See Figure 2-8.

NOTE: During direct numerical entry, the Left Move key performs a delete function. Pressing DEL clears the numeric entry one digit at a time from right to left.

— On the Keypad, press [4] [decimal point] [5]. Amplitude should now read "4.5" on the display with no units.

— Units pointers "mV" and "V" appear under the wave type submenu. Press "V" for volts. Note that the amplitude now reads "4.500 V." The value is entered into memory when the units Softkey is pressed.

— Press R/S. The output is now activated with a Sine wave having the following characteristics:

```
FREQUENCY = 1 kHz
AMPLITUDE = 4.5 V
PHASE = 90 DEG
OFFSET = 10 mV
NOISE AMPLITUDE = 1 mV
```

NOTE: The voltages entered for AMPLITUDE, OFFSET and NOISE AMPLITUDE are the actual values generated at the output under open-circuit conditions only. When the output is terminated, the actual voltage is less than what was entered. See Section 3.4 for more information.
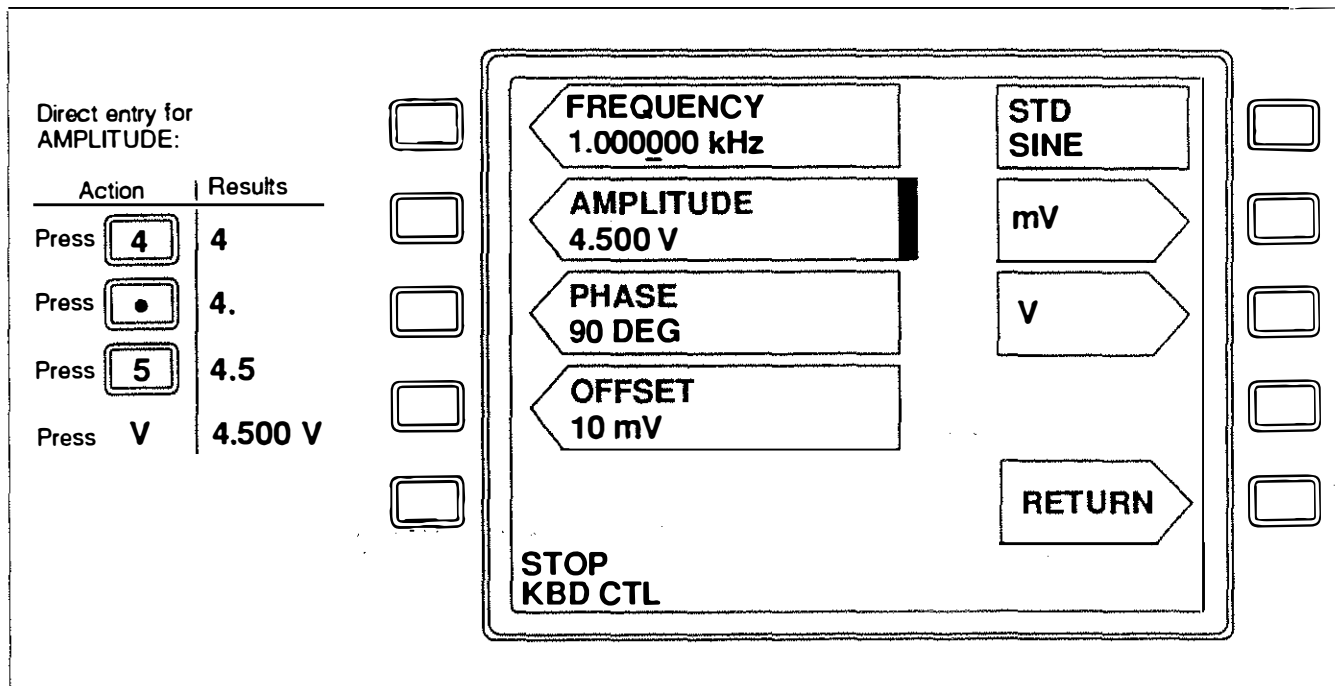
Figure 2-8. Parameter Entry Display Example

Step 7: Checking the Setup Status (STAT)

- Press the STAT function key. The display should look like the example in Figure 2-9.
- This display contains a set-up summary. The PREV (previous) and NEXT Softkey controls enables you to page through this information.
- Press RETURN to go back to the previous function screen or menu.

Step 8: Experiment

At this point, try changing some of the waveform parameters. Note that if you change to another category of waveform functions, such as MODULATED WAVE, the output stops and R/S must be pressed again to activate it. For information on using the other waveform functions and common control functions, see Section 3.

```
WAVE TYPE              STANDARD
WAVE SHAPE             SINE
FREQUENCY             1.000000kHz
AMPLITUDE            4.500 V
OFFSET
       10.0 mV
NOISE AMPL                    PREV
       1.0 mV
NOISE REP RATE
      10.00 Hz                NEXT
ADDITIVE NOISE
       NOISE ON             RETURN

STOP
KBD CTL
```
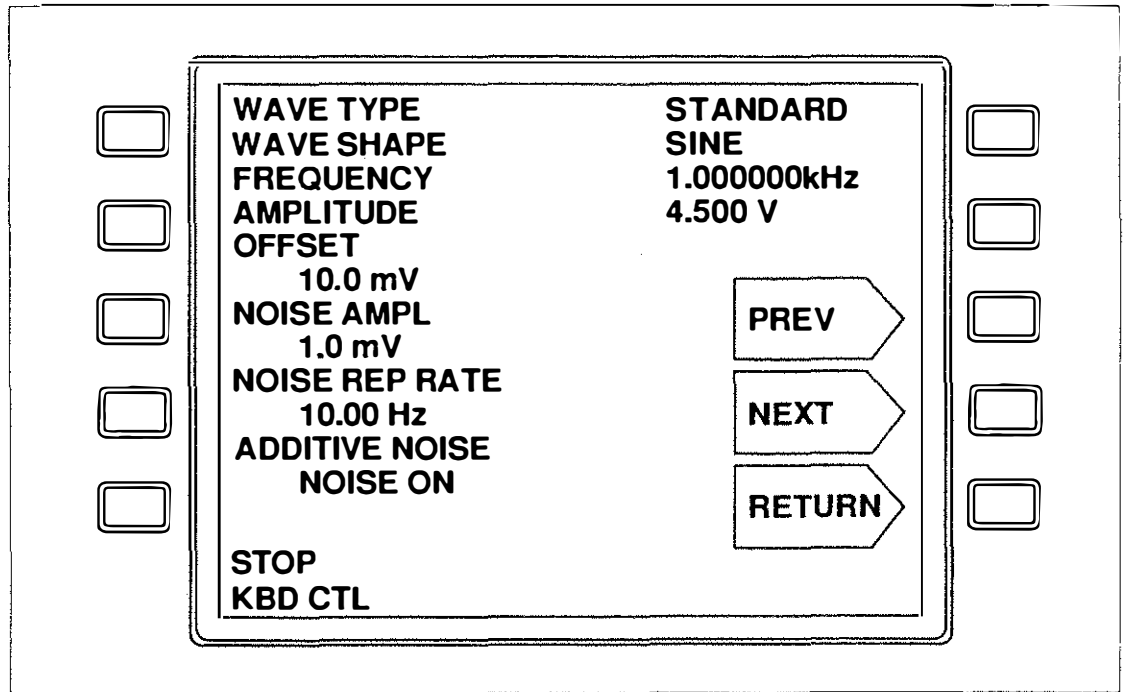
Figure 2-9. Sample STAT Display

3.1   *INTRODUCTION*

This section covers local operation, that is operating the instrument from the front panel. The instructions presented here use the terminology and operating conventions explained in Section 2. If you are not familiar with the operating conventions of this instrument, it is recommended that you read Section 2 before proceeding any further. Remote control is covered in Sections 4 and 5.

3.2   *SUMMARY OF FUNCTIONS*

All functions of the instrument are microprocessor-controlled by a built-in software program (firmware). The firmware is responsible for the instrument's graphics user interface (GUI) explained in the getting started procedures in Section 2. The following paragraphs describe operation of the instrument from the front panel.

3.2.1   *Waveform Functions*

The waveform functions are accessed via the WAVE key as illustrated in Figure 3-1. The set-up display for each category of waveform functions is called up by pressing its associated Softkey. The set-up displays for the STANDARD WAVE and MODULATED WAVE functions include a submenu of choices. After a wave type is selected, the display shows you the parameters to enter for generating that particular wave. The COMBINED WAVE function allows you to combine up to four waveforms from the STANDARD WAVE submenu. The SPECIAL WAVES function provides miscellaneous special purpose waveforms such as the Fast Square wave (FSQR) which is described later.
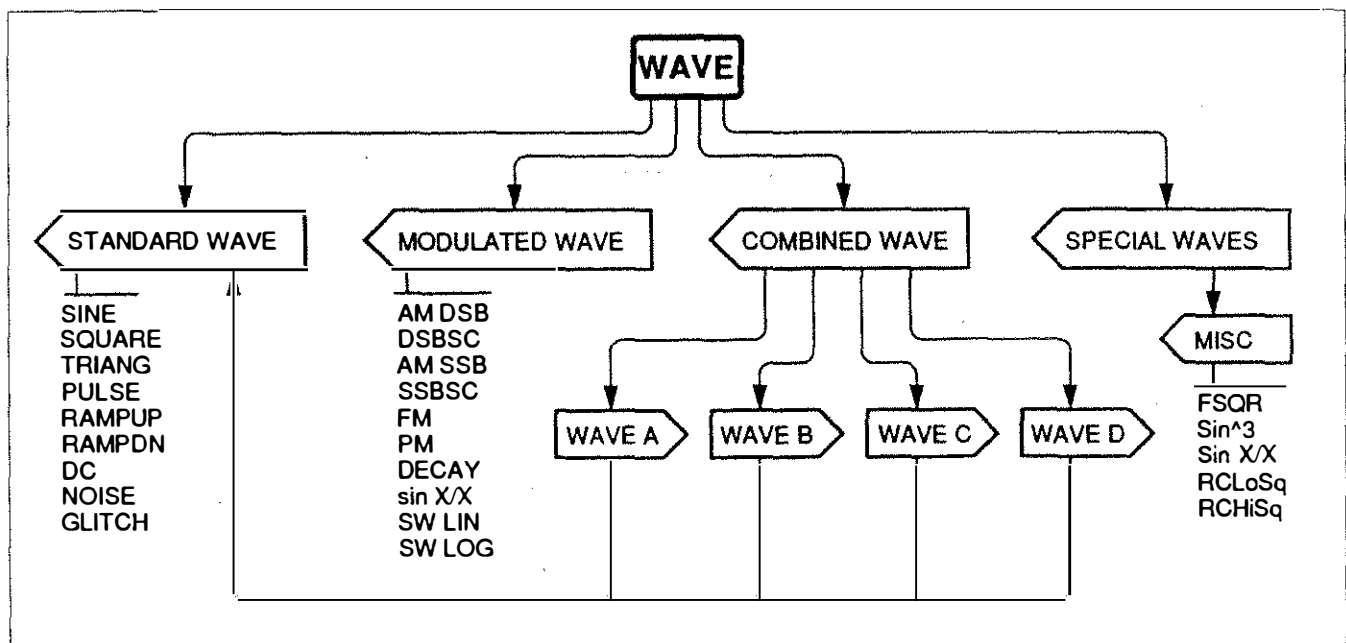
Figure 3-1. WAVE Menu Functions

3.2.2   Common Control Functions

The TRIG, OUT, CLK, DIR, MAN, I/O, DISP and R/S dedicated function keys perform common control functions (See Figure 3-2). Each of these functions are described in more detail later on in this section.

3.3   I/O CONTROL SOURCE

As described in Section 2, the instrument's firmware provides four modes for controlling the instrument's functions. The four modes are accessed via the I/O function key. Pressing the I/O key calls up the Command Device Submenu shown in Figure 3-3 which allows you to select a source of control. When switching to exclusive GPIB or RS232 control, all front panel keys are disabled except for the I/O key. When transfering control between Local and Remote, any waveform running will continue to run.
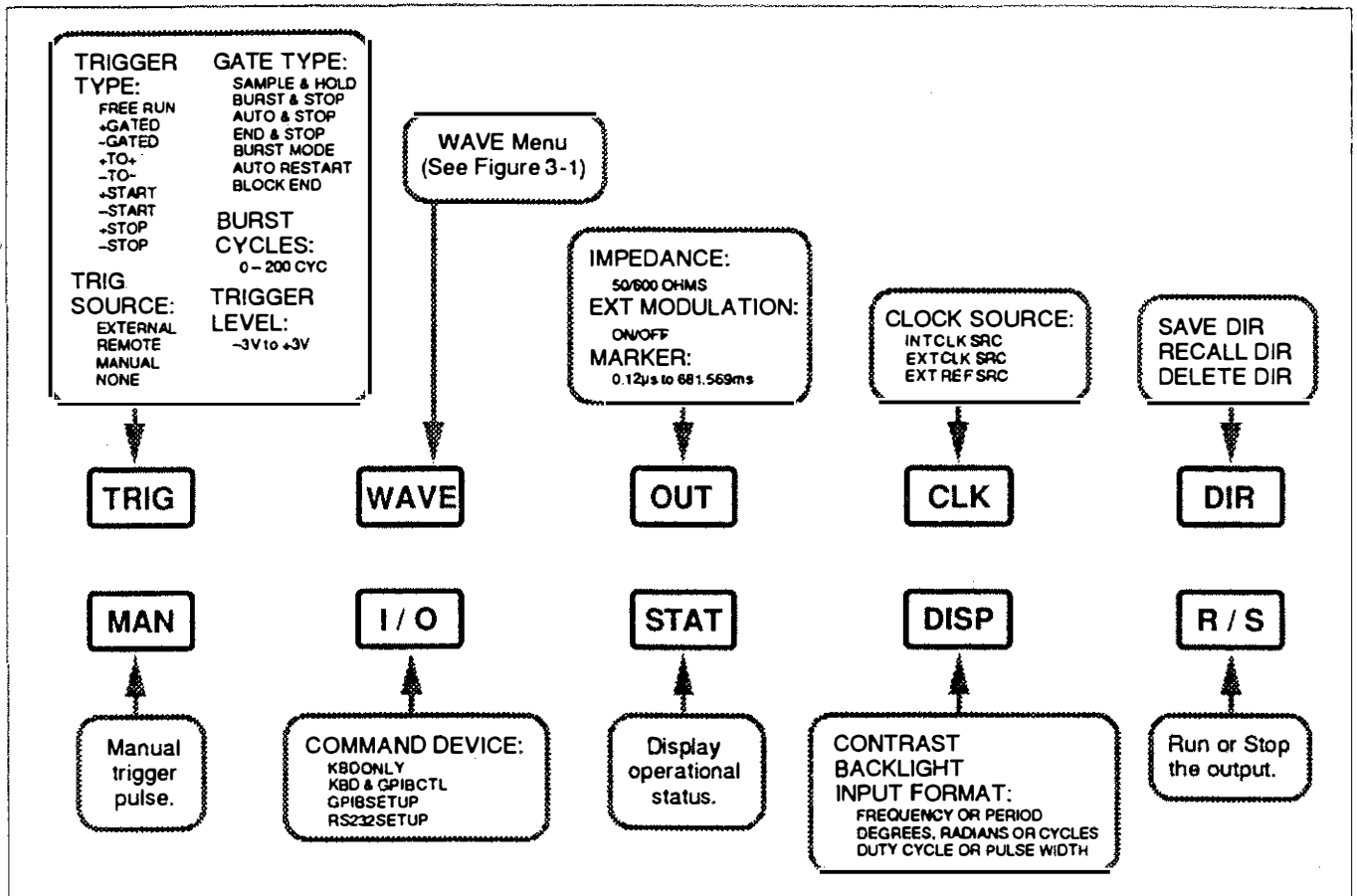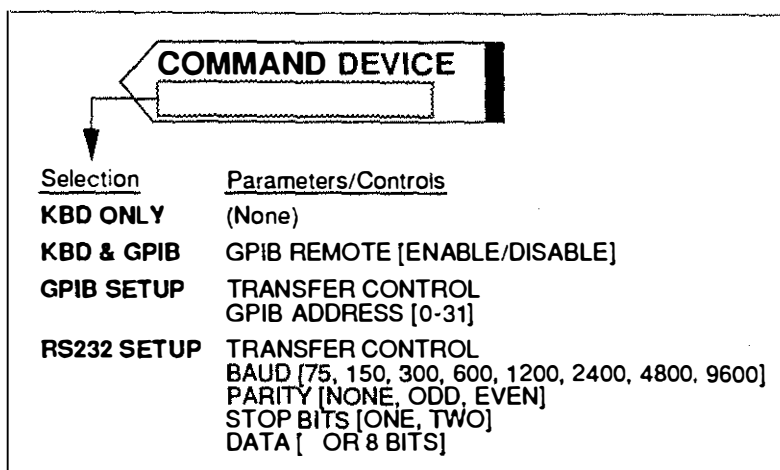
Figure 3-2. Common Control Functions

Figure 3-3. I/O Control Source Menu

3.3.1 *Exclusive Front Panel Control*

Exclusive front panel control is achieved by setting the CONTROL DEVICE to KBD ONLY. When under exclusive GPIB or RS232 control, front panel control can be regained by pressing the I/O key.

3.3.2 *Front Panel Control With GPIB Access*

Setting the COMMAND DEVICE to KBD & GPIB CTL enables a shared control between the front panel keys and the GPIB bus. In this mode, GPIB communication can be enabled or disabled by changing the setting of GPIB REMOTE.

3.3.3 *Exclusive GPIB Control*

Exclusive GPIB control is achieved by setting COMMAND DEVICE to GPIB SETUP. This calls up a display which requests a GPIB address and then allows you to manually transfer control of the instrument to the GPIB bus by pressing the TRANSFER CONTROL Softkey. If power is switched off while in this mode, the instrument will resume operating in this mode when power is switched back on again. To return to KBD ONLY control, press the I/O function key.

3.3.4 *Exclusive RS232 Control*

For exclusive RS232 control, set COMMAND DEVICE to RS232 SETUP. This calls up a display of all RS232 characteristics to be set up. Set all displayed parameters to the appropriate value and press the TRANSFER CTL Softkey to switch control of the instrument to the RS232 bus. If power is switched off while in this mode, the instrument will resume operating in this mode when power is switched back on again. To return to KBD ONLY control, press the I/O function key again.

3.4 MAIN SIGNAL OUTPUT CONTROL

The main signal output is affected by several factors: the common controls accessed via the OUT KEY, the R/S key, and output termination.

3.4.1 OUT Control Functions

Pressing the OUT key calls up the display of functions shown in Figure 3-4.

IMPEDANCE is the output impedance of the main signal output which can be set to 50 or 600 ohms.

EXT MODULATION switches the EXTERNAL AM INPUT port on the rear panel ON or OFF.

The MARKER function controls the SYNC MARKER OUTPUT on the rear panel and can be set to a value within the range of 0.12 μS to 618.992 mS. The SYNC MARKER output signal comprises two separate pieces of information. The rising edge of this signal is the SYNC and defines zero-time or the beginning of the waveform. The falling edge of this signal is the MARKER and is set to your specifications.

The information box labeled FILTER (a read-only field) indicates the setting of the recon-struction filters in the output circuit.

3.4.2 Run/Stop Control

Pressing the R/S function key activates the output. While in the RUN state, wave parameters can be changed and incorporated into the output being generated. However, switching to another waveform function, such as from STANDARD WAVE to MODULATED WAVE, deactivates the output. To activate the new waveform output, press R/S again.
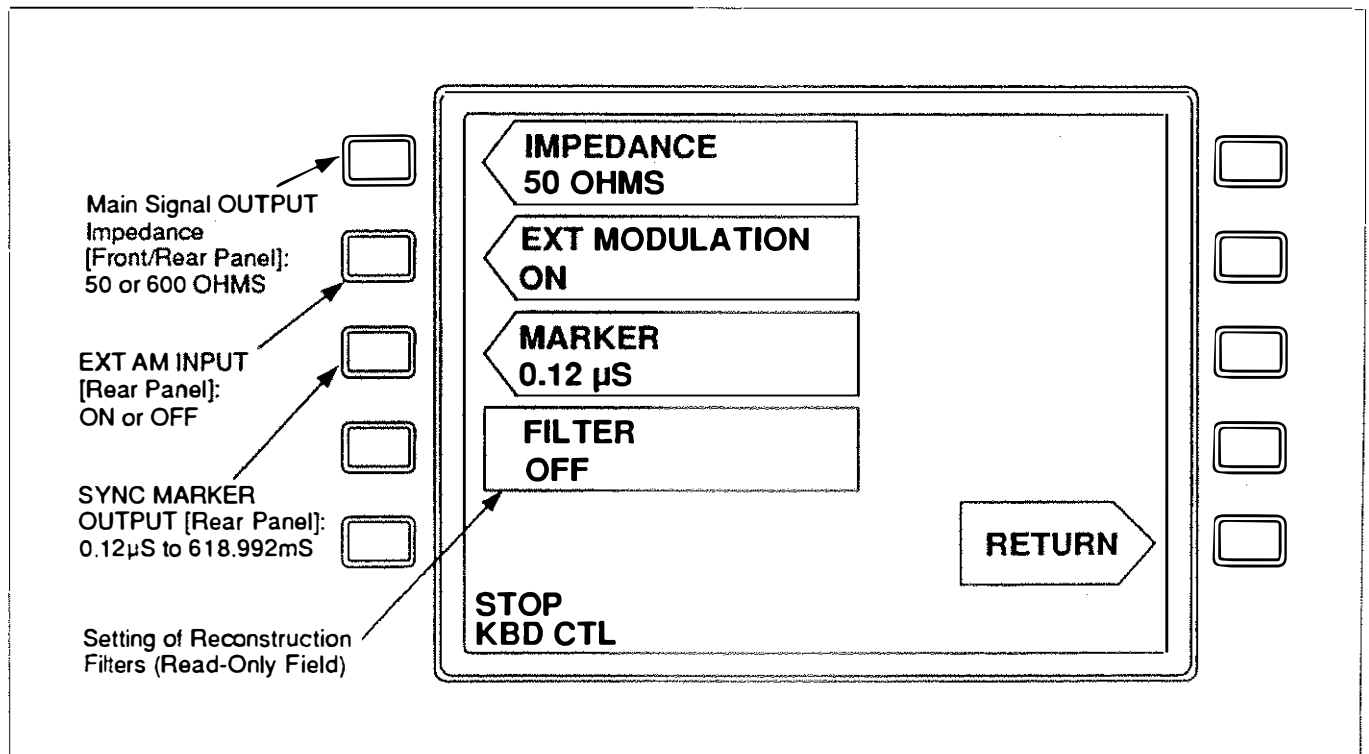
Figure 3-4. OUT Set-Up Display

3.4.3   Output Characteristics

The voltage values set up for waveform amplitude, dc offset and noise amplitude are the actual voltages produced at the output under *open circuit conditions only*. Waveform amplitude is specified in peak volts, open circuit. Noise is specified as volts rms, open circuit.

When a load is connected to the output, the actual waveform amplitude and dc offset are reduced. The amount of reduction depends upon the output impedance of the instrument and the input impedance of the load. Figure 3-5 shows a simplified schematic of the instrument's output stage. As you can see, applying a load impedance to the output creates a voltage divider with the series output resistance (50 or 600 ohms) of the instrument. Therefore, if IMPEDANCE is set to 50 ohms and the sine wave in Figure 3-6 is fed into a 50-ohm load, the actual voltage levels measured at the output should be approximately half the voltage levels entered via the front panel. One way to define AMPLITUDE values is to assume peak values when the output is open circuit or connected to a high impedance load and peak-to-peak values when properly terminated.

NOTE: **When entering voltage levels, be careful that the combination of waveform amplitude, dc offset voltage and noise amplitude does not exceed the ± 10-volt output limitation of the instrument. If this should occur, the output may be clipped without warning from the instrument.**
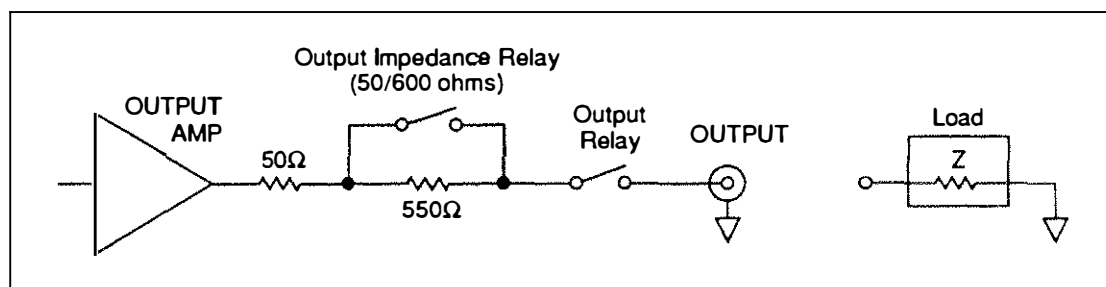
Figure 3-5. Output Stage Simplified Schematic
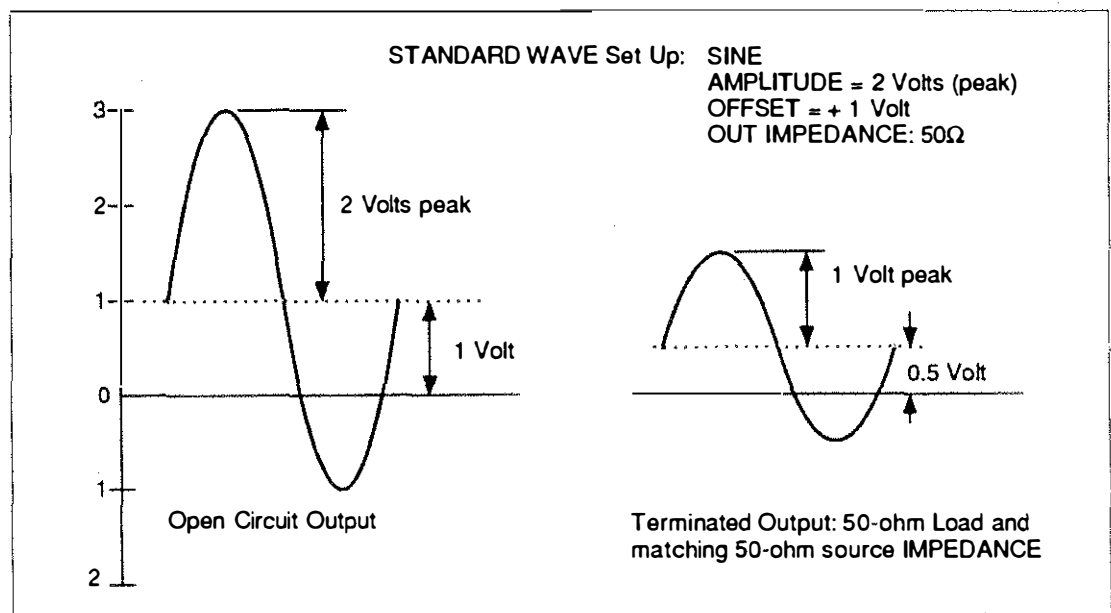
Figure 3-6. Load/No-Load Output Characteristic

3.5   CLOCK SOURCE CONTROL

The rear panel has an external TTL-level (100 kΩ input impedance) clock input (EXT REF OR SAMPL CLK INPUT). You can designate this external input as the system reference oscillator signal or external sample clock using the CLK function key. Figure 3-7 describes the CLK set-up display.

Selection	Function
INT CLK SRC	Selects an internal clock for the system sample clock.
EXT CLK SRC	Designates the rear panel EXT REF OR SAMPL CLK INPUT as an external sample clock input. External frequency can be up to 25 MHz.
EXT REF SRC	Designates the rear panel EXT REF OR SAMPL CLK INPUT as an external reference oscillator input. External frequency can be any multiple of 1 MHz from 1 to 16 MHz. The externally applied frequency must be within ± 20 ppm of a precise multiple to guarantee lock-in. This is used to phase lock multiple units together.

CLOCK SOURCE

SAMPLE RATE
384.615 KHz

384.615 kHz,
5 MHz or 50 MHz,
depending upon
selected frequency
range.

RETURN

STOP
KBD CTL

Figure 3-7. CLK Function Selections

3.6   TRIGGER CONTROL

Setting up the trigger characteristics includes selecting a trigger type, a gate type, number of burst cycles, a trigger source, and a trigger voltage level. Pressing the TRIG key calls up the set-up display shown in Figure 3-8; the submenu selections are shown on the left-hand side of the figure. Figure 3-9 describes each trigger type and Figure 3-10 demonstrates how each GATE type affects the waveform output.

NOTE: *The ability of the instrument to switch from one waveform type to another (e.g., from SINE to SQUARE) is affected by TRIGGER TYPE. Switch waveforms only while in FREE RUN. Be sure to set up WAVE first and TRIGGER TYPE and GATE TYPE last.*

FREE RUN is the only TRIGGER TYPE available for frequencies of 1.47 Hz or less.

When GATE TYPE = BURST & STOP or BURST MODE, TRIGGER TYPEs +START, –START, +STOP AND – STOP are not available.

BURST & STOP and BURST MODE gate types are only available for STANDARD WAVES at frequencies above 1.47 Hz.

The time period between trigger pulses must be long enough to allow one complete reading of the waveform output memory before the next trigger pulse occurs. This time period is dependent upon the sample rate and is equal to (262144 ÷ SAMPLE RATE) + 50 microseconds. For example, if the sample rate is 50MHz, the time between trigger pulses must be no less than (262144 ÷ 50MHz) + 50 μS = 5.293mS.
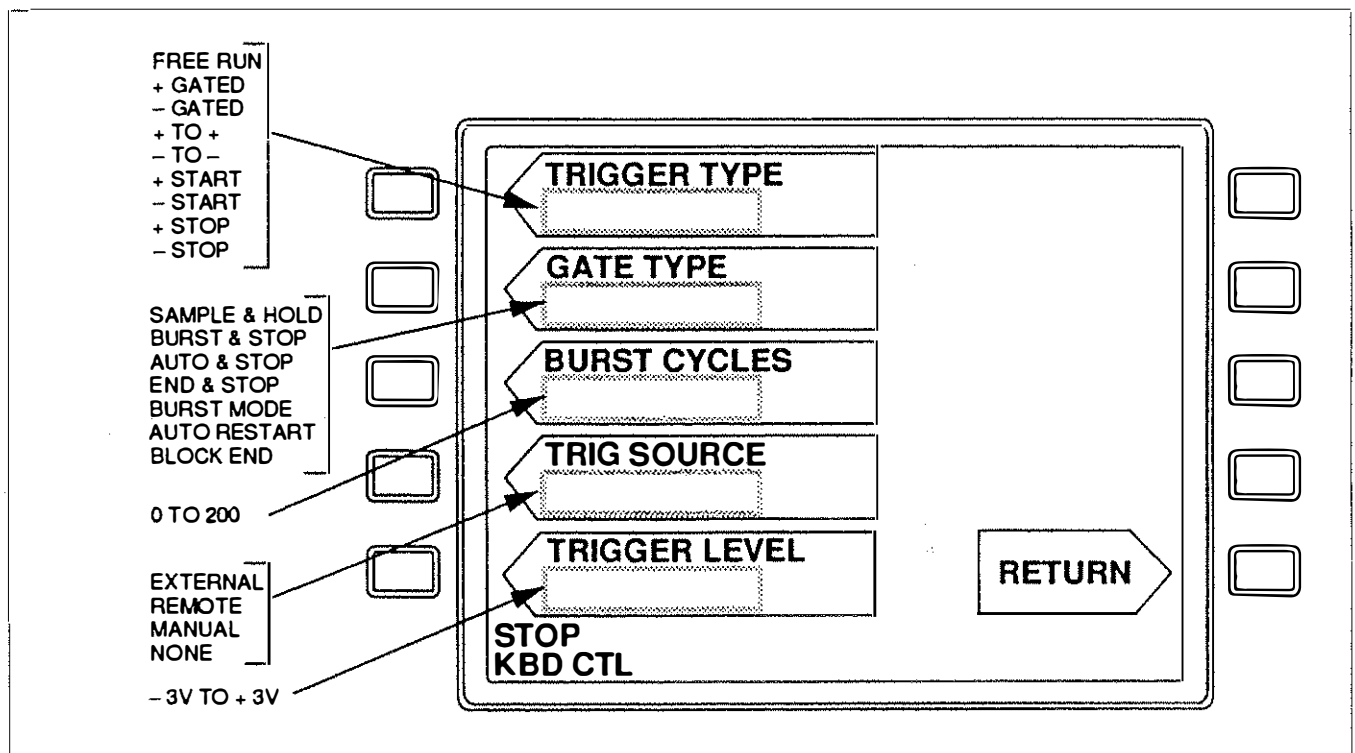
Figure 3-8. TRIG Set-Up Display

FREE RUN The simplest mode of operation. TRIG IN is ignored and the Output Gate is always ON (high) to produce an output.	TRIG IN — Level = Don't Care Output Gate — Always ON (High)
+GATED The Output Gate goes ON at every rising edge of TRIG IN and goes OFF at every falling edge of TRIG IN.	TRIG IN Output Gate — ON ... ON
–GATED The Output Gate goes ON at every falling edge of TRIG IN and goes OFF at every rising edge of TRIG IN.	TRIG IN Output Gate — ON ... ON ... ON
+ TO + On each rising edge of TRIG IN, the state of the Output Gate toggles.	TRIG IN Output Gate — ON
– TO – On each falling edge of TRIG IN, the state of the Output Gate toggles.	TRIG IN Output Gate — ON
+START On first rising edge of TRIG IN, the Output Gate goes ON and stays on, ignoring any further changes in TRIG IN.	TRIG IN Output Gate — ON
–START On first falling edge of TRIG IN, the Output Gate goes ON and stays on, ignoring any further changes in TRIG IN.	TRIG IN Output Gate — ON
+STOP On first rising edge of TRIG IN, the Output Gate goes OFF and stays off, ignoring any further changes in TRIG IN.	TRIG IN Output Gate — OFF
–STOP On first falling edge of TRIG IN, the Output Gate goes OFF and stays off, ignoring any further changes in TRIG IN.	TRIG IN Output Gate — ON ... OFF

Figure 3-9. TRIGGER TYPE and Output Gating
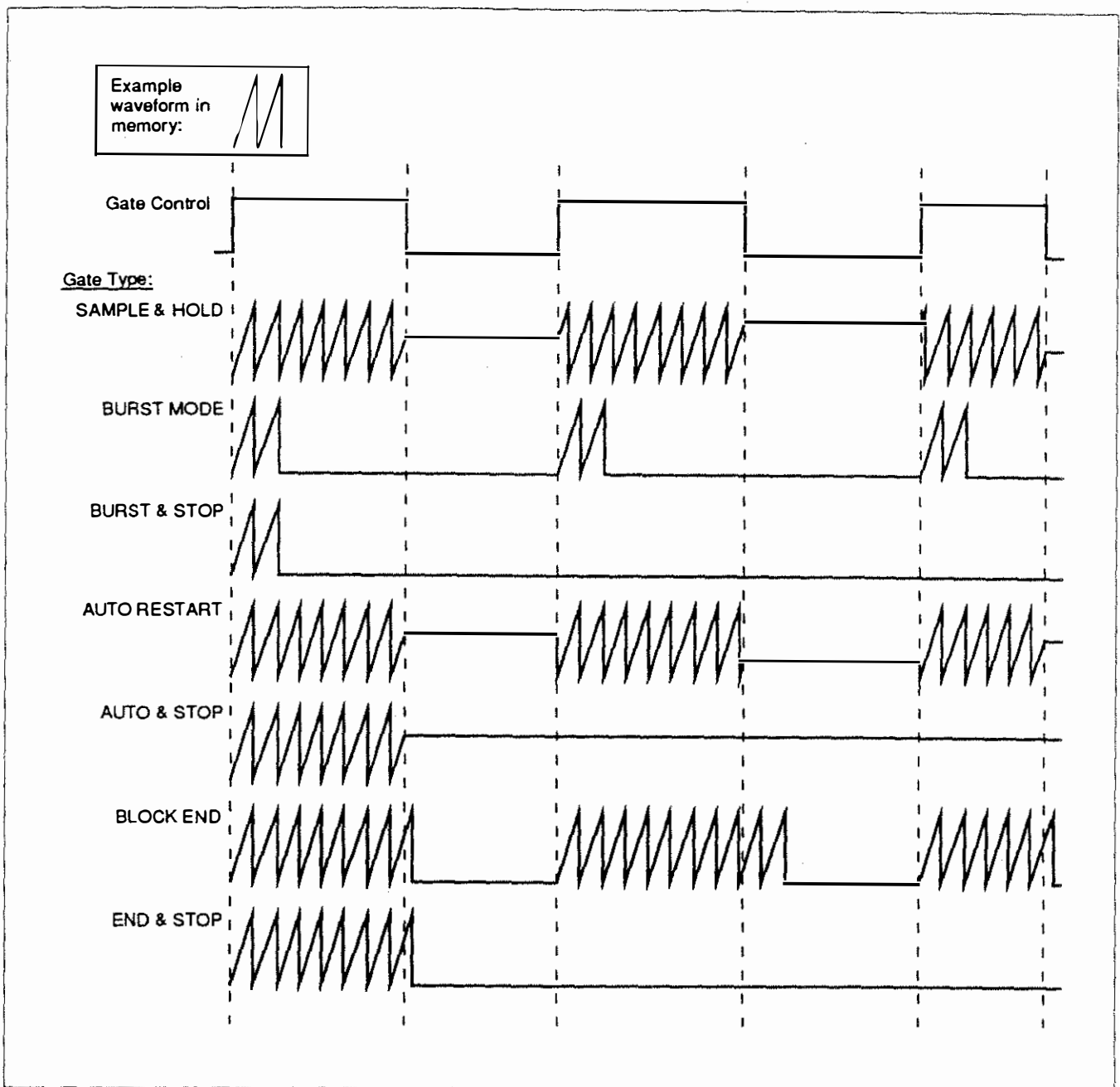
Figure 3-10. Waveform Output vs. GATE TYPE

3.7 STANDARD WAVE MENU

The Standard Wave Submenu provides the standard waves listed in Table 3-1. Some wave types have expanded features such as symmetry, dc offset and additive pseudo-random noise.

3.7.1 Setting up a Standard Wave

(1) Press WAVE.

(2) Press STANDARD WAVE. The submenu in Figure 3-11 should appear on the screen.

(3) Using the Rotary Encoder or the Right/Left Move keys, move the cursor to the chosen wave type.

(4) Press ENTER. The parameter set-up display should appear on the screen.

Figure 3-11. STANDARD WAVE Display

(5) Refer to Table 3-1 and set up the parameters as required.

(6) Press R/S to activate the output.

Table 3-1. STANDARD WAVE Set-Up Parameters

	SINE	SQUARE & PULSE	TRIANG	RAMPUP & RAMPDN	DC
FREQUENCY	0.001Hz to 20MHz	0.001Hz	to	5MHz	—
AMPLITUDE	5mV	to	10V		—
PHASE	−359.9 to +359.9 DEG	—	—	—	
OFFSET	−10V	to	+10V		—
DUTY CYCLE	—	5 to 95% *	—	—	—
DELAY TIME	—	0 to 999.722S	—	—	—
SYMMETRY	—	—	5 to 95% *	—	—
DC LEVEL	—	—	—	—	−10V to +10V
NOISE:	—	—	—	—	—
RMS NOISE	1mV	to	1.879V		—
OFFSET	−10V	to	+10V		—
LINE SPACING	1.47Hz	to	24.41406		—
GLITCH:	—	—	—	—	—
RISE TIME	0.02µs	to	340.13ms		—
TOP WIDTH	0	to	340.13ms		—
FALL TIME	0.02µs	to	340.13ms		—
POLARITY	Positive	or	Negative		—

* Limited by the minimum rise time of 50nS.

3.7.2 Using the GLITCH Function

The GLITCH function enables you to combine a glitch or spike with another wave type. To use the GLITCH function, do the following:

(1) From the COMBINED WAVES setup display, select GLITCH for one of the waves.

(2) In the parameter setup display (Figure 3-12), select the following:

FREQUENCY: 2.94 Hz to 5.0 MHz
AMPLITUDE: 5.0 mV to 10 V
PHASE: −359.9 to +359.9 DEG
POLARITY: Positive/Negative

(3) Press the SHAPE Softkey to define the actual shape of the glitch (Figure 3-13).
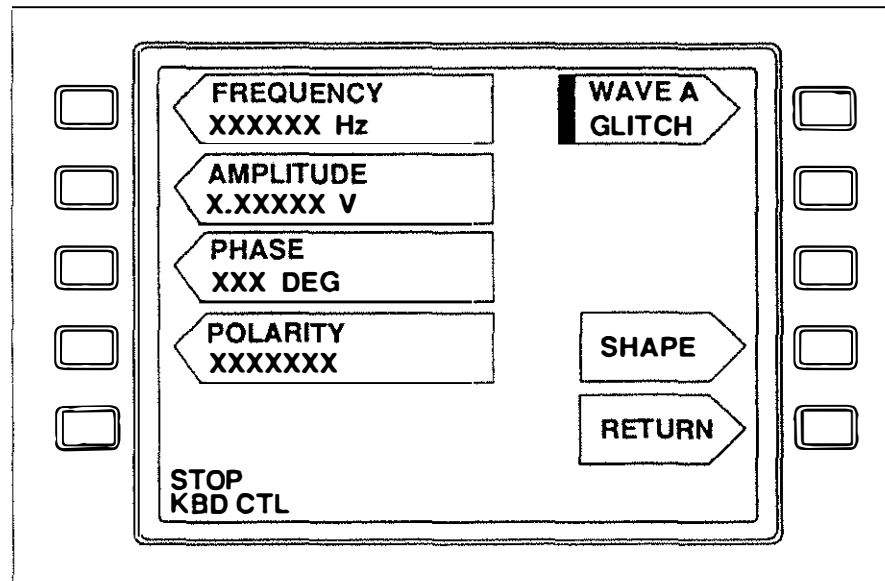
Figure 3-12. GLITCH Waveform Parameters Menu
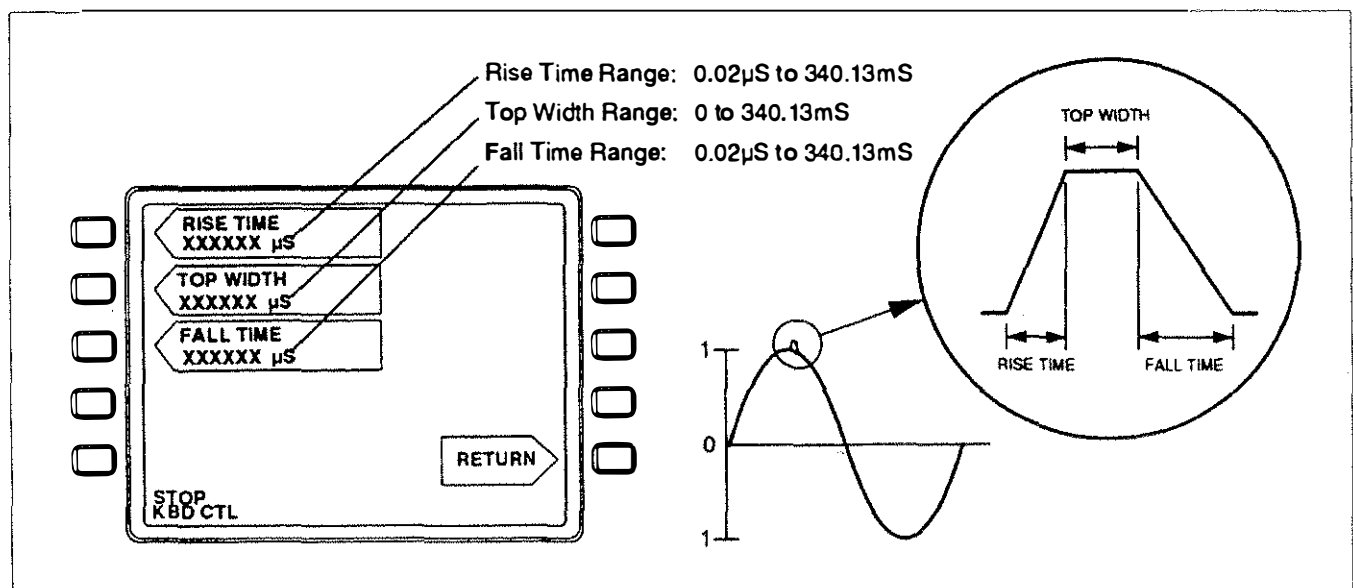
Figure 3-13. GLITCH SHAPE Submenu

3-11

3.8 MODULATED WAVE MENU

The Modulated Wave submenu provides modulation functions including multimode AM, FM, PM and external modulation modes. Advanced functions include linear and logarithmic sweeping, sin X/X envelope modulation and exponential envelope functions.

3.8.1 Setting Up a Modulated Waveform

To set up a Modulated Wave type, follow these steps:

(1)   Press WAVE.

(2)   Press MODULATED WAVE. The submenu shown in Figure 3-14 should appear on the screen.

(3)   Using the Rotary Encoder or the Right/Left Move keys, move the cursor to the chosen wave type.

(4)   Press ENTER. The parameter set-up display should appear on the screen.

(5)   Refer to Table 3-2 and set up the parameters as required.
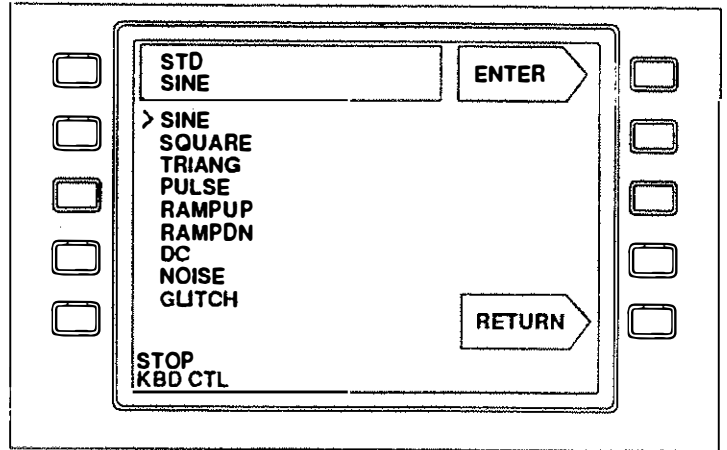
(6)   Press R/S to activate the output.
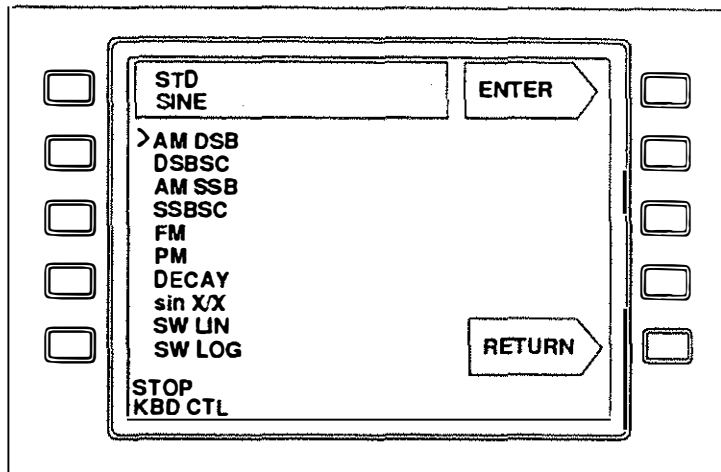
Figure 3-14. MODULATED WAVE Display

Table 3-2. MODULATED WAVE Set-Up Parameters

	AM DSB, AMSSB, and PM	DSBSC and SSBSC	FM and PM	DECAY	sin X/X	SW LIN and SW LOG
CARRIER FREQUENCY	1.47Hz	to	20MHz			—
AMPLITUDE	5mV	to	10V			
MOD FREQUENCY	1.470Hz	to	20MHz *	—	—	—
MOD INDEX	0 TO 200%	—	—	—	—	—
OFFSET	–10	to	+10V		—	–10V to +10V
MAX FREQ DEV	—	—	1.470Hz to 20MHz	—	—	—
PEAK TIME	—	—	—	0.64 to 199.20µS	—	—
DURATION	—	—	—	40.96µS to 5.24mS	—	40.96µS to 5.24mS
BANDWIDTH	—	—	—	—	1.47Hz to 20MHz *	—
LINE SPACING	—	—	—	—	1.47Hz to 24.4kHz *	—
PHASE	—	—	—	—	0 to 359 Deg	—
START FREQ	—	—	—	—	—	1.47Hz to 20MHz *
STOP FREQ	—	—	—	—	—	1.47Hz to 20MHz *

* Depending on Carrier Frequency.

3.8.2 Using the Sweep Function LONG Submenu

Sweep functions SW LIN and SW LOG include a "LONG" submenu for setting up longer sweeps than those provided by the normal parameter set. To use the LONG Submenu parameters, do the following:

(1)   Select either SW LIN or SW LOG from the MODULATED WAVES menu. The submenu shown in Figure 3-15 should appear on the screen. This is the NORMAL parameter submenu.

(2)   Press the LONG Softkey. The LONG submenu shown in Figure 3-16 should appear on the screen. Notice that the OFFSET parameter changes to SAMPLE RATE and the LONG Softkey changes to NORMAL. Set up the parameters as follows:

AMPLITUDE = 5mV to 10V
START FREQ = 1.47Hz to 20MHz (Max. value limited by SAMPLE RATE)
STOP FREQ = 1.47Hz to 20MHz (Max. value limited by SAMPLE RATE)
DURATION = 819.2µS to 3435.921S (Dependent upon SAMPLE RATE)
SAMPLE RATE =76.295Hz to 2.5MHz

(3)   Press NORMAL to return to the normal parameter submenu for SW LIN or SW LOG.
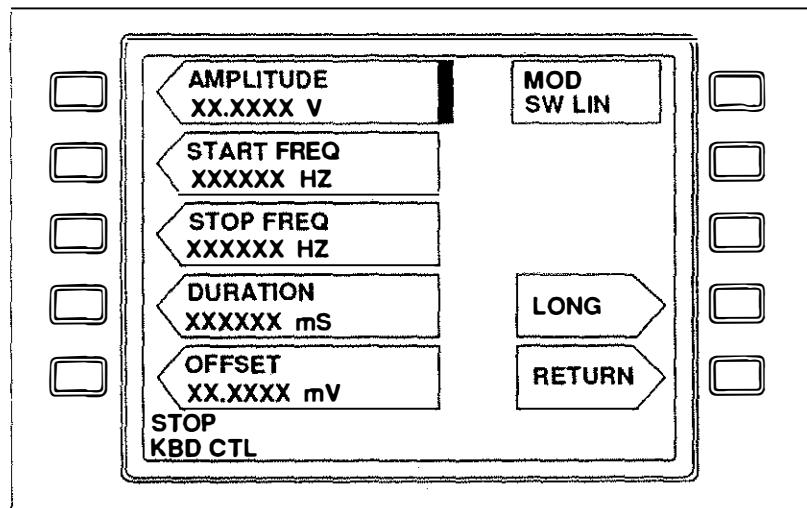
Figure 3-15. NORMAL Parameter Setup for SW LIN and SW LOG
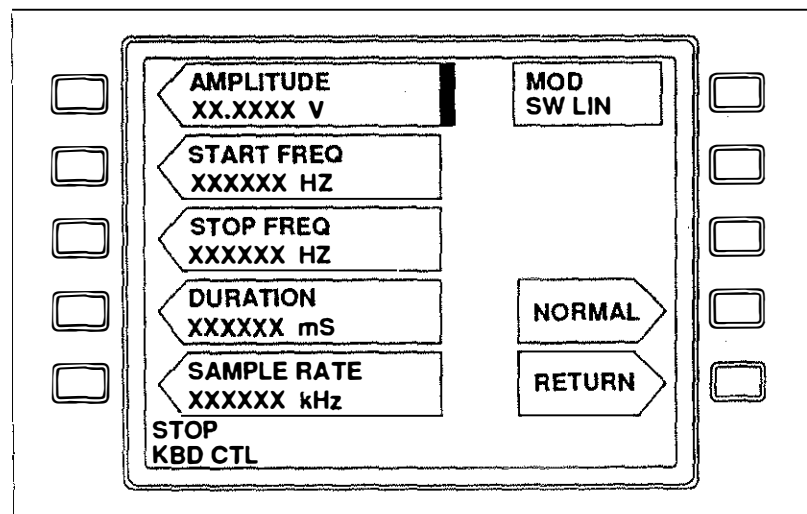
Figure 3-16. LONG Submenu Parameters

3.9   COMBINED WAVES MENU

The COMBINED WAVES Menu provides sum and product combinations of up to four standard functions. Up to four waveforms (each generated by a standard function) may be added together or modulation of a carrier wave may be performed. A carrier can be any type of waveform listed in the STANDARD FUNCTION Submenu. A modulator can be a summation of up to three standard functions using a modulation method of AM, FM or PM. Within the COMBINED WAVES function, AM is always applied as Double Side-Band, Suppressed Carrier AM. Any post-modulation summation can be included using one or two standard functions.

To view the set-up display (Figure 3-17), press WAVE and select COMBINED WAVES.

The combined function is defined by graphically creating a network of signal paths on the display screen. The Softkeys on the right call up set-up displays for the four standard functions. The Softkeys on the left are signal path controls which enable you to graphically create the network that represents the combined function that you want. If you choose to simulate a modulated carrier signal, the bottom Softkey on the left allows you to select the type of modulation. If no modulation is performed, the Modulation Type indicator reads "NONE."
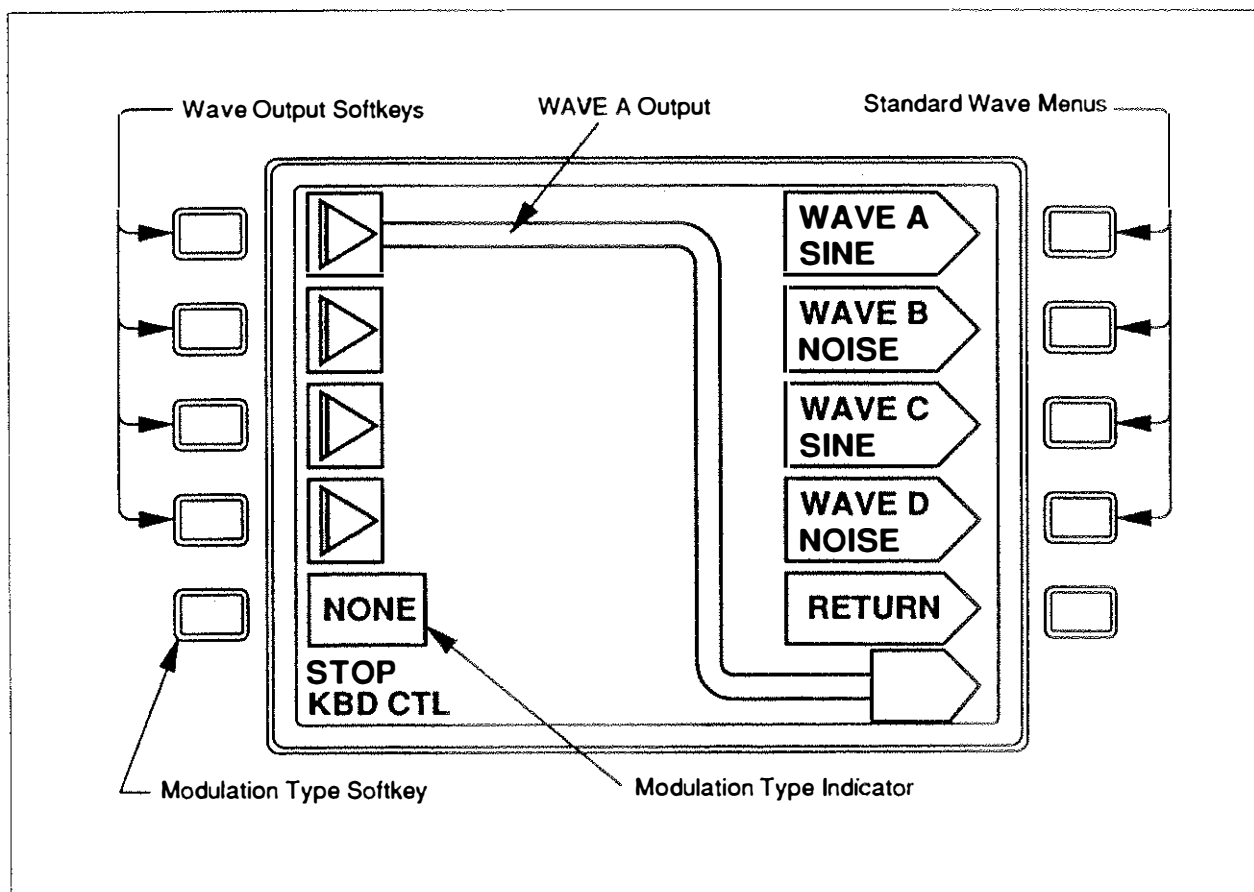
Figure 3-17. COMBINED WAVES Set-Up Display

3.9.1   Setting Up Standard Functions

To set up any of the four standard functions, press the Softkey for WAVE A, B, C or D. You should see a set-up display similar to the one shown in Figure 3-18.

Pressing the top right Softkey enables the Standard Function Submenu. Once enabled, rotating the Rotary Encoder scrolls through the list of standard functions. To select a function, rotate the Rotary Encoder until the function you want appears on the display. After selecting a function, the set-up parameters for that function are displayed on the left-hand side of the display. These parameters can be set up as instructed in Section 2. Pressing RETURN takes you back to the combined wave set-up display.

When setting up an FM or PM modulator, an additional set-up parameter of FREQ DEV (frequency deviation) or MOD INDEX (Modulation Index) is included in the set-up display.

3.9.2   Frequency Limitations

The instrument's operating program handles the four waveforms according to a hierarchical order where WAVE A is at the top of the hierarchy and B, C and D establish the second, third and fourth levels.

The highest-level waveform used determines the internal sample clock. Therefore, the frequency used for the highest level waveform limits the allowed frequency range for waveforms set up on any of the lower levels. For example, if the frequency of WAVE A is set to 5 kHz, the frequency selected for B, C, or D must have a common denominator with 5 kHz. Likewise, If WAVE B is the highest level used and its frequency is 1 kHz, the frequency selected for C or D must have a common denominator with 1 kHz. The actual frequency allowed can best be determined by spinning the Rotary Encoder and observing which frequencies are valid.
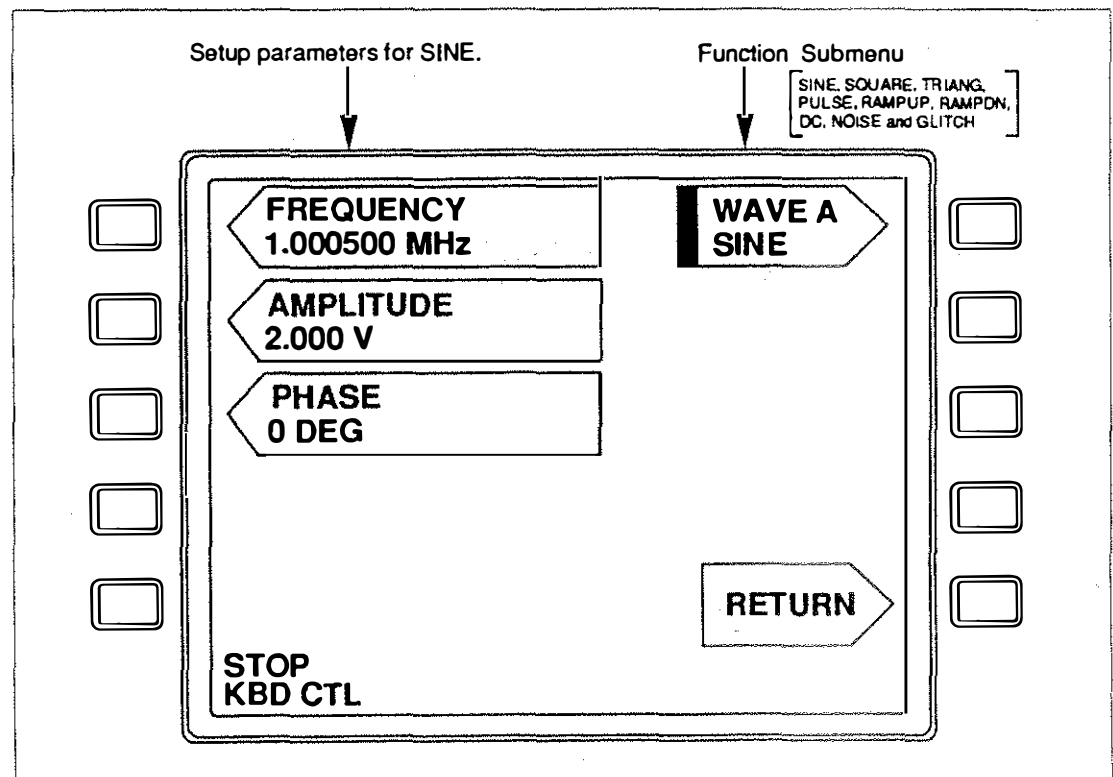
Figure 3-18. Standard Function Set-Up Display

3.9.3   Selecting Modulation Type

The Modulation Type control selects the modulation method for combining the designated modulator with the carrier. Pressing this Softkey steps through the available selections: AM, FM, PM. The type appearing in the box is applied to the combined function.

3.9.4   Defining a Combined Output

The combined output is defined by placing signal paths in the appropriate positions on the display as shown in Figure 3-19. Signal paths can be positioned in one of three columns by pressing the signal path Softkey. Pressing the applicable Softkey moves the signal path from one column to the next in a cyclical fashion, always moving from left to right across the screen.

When defining a combined function, follow these guidelines:

(1)   Functions to be summed should always be placed in columns 1 or 3.

(2)   A modulating signal should always be placed in Column 1.

(3)   A carrier should always be placed in Column 2.

See Section 3.9.5 for a combined output example.
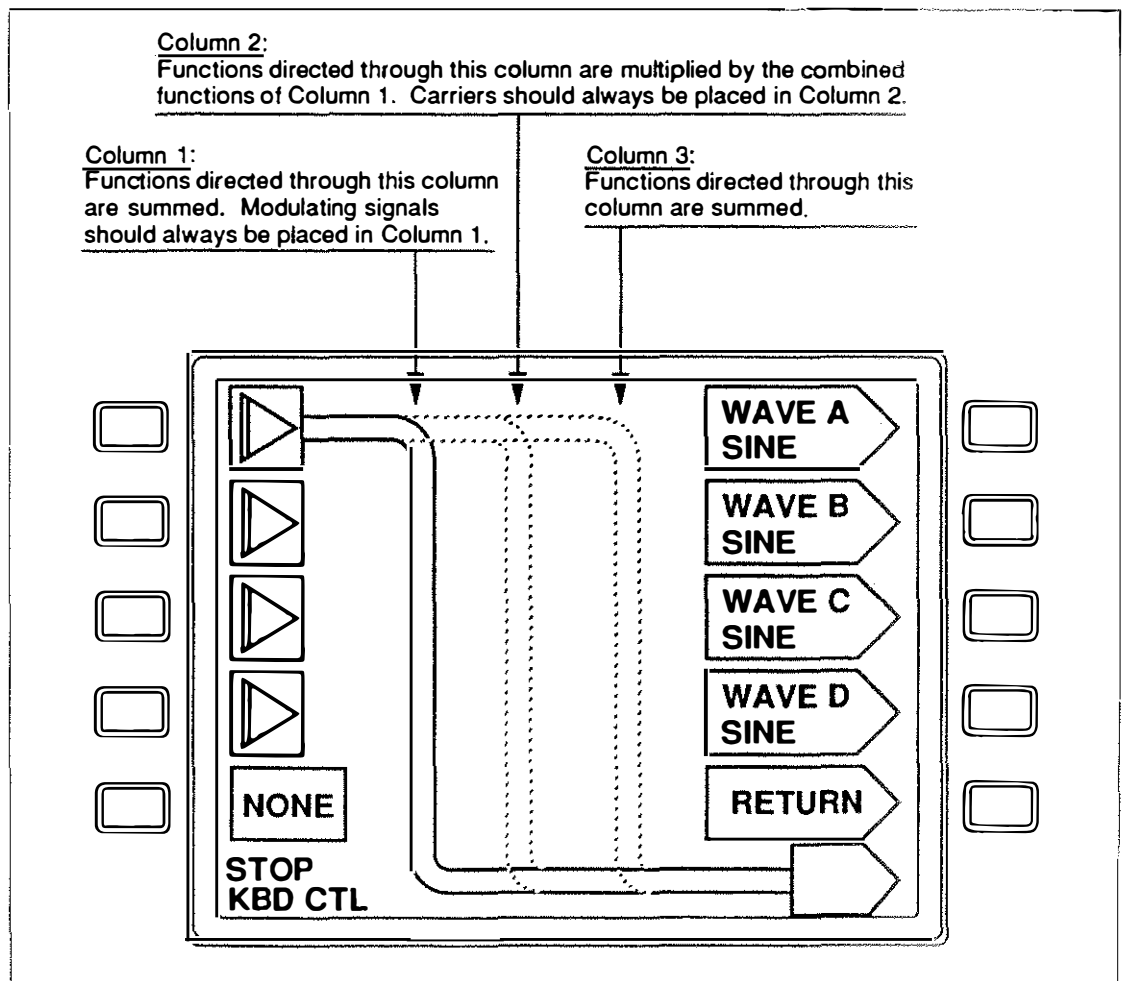
Figure 3-19. Signal Path Positioning

3.9.5 Combined Waves Example

This example simulates the output of an AM radio IF stage. The output is a 455-kHz carrier modulated with an 1.2-kHz audio tone. The set-up display for this combined function is shown in Figure 3-20.

To set up this combined function, do the following:

(1) Press WAVE and select the COMBINED WAVES function.

(2) Using the signal path controls, create the signal network: Place WAVE A in Column 2, WAVE B in Column 1, WAVE C in Column 1 and WAVE D in Column 3.

(3) Select AM for the modulation method.

(4) Press WAVE A and set up the following parameters. Press RETURN when done.

WAVE A = SINE
FREQUENCY = 455 kHz
AMPLITUDE = 1 V

(5) Press WAVE B and set up the following parameters. Press RETURN when done.

WAVE B = SINE
FREQUENCY = 1.2 kHz (Note that the nearest available frequency is 1.153846 kHz.)
AMPLITUDE = 1 V

(6) Press WAVE C and set up the following parameters. Press RETURN when done.

WAVE C = DC
DC LEVEL = 1 V

(7) Press WAVE D and set up the following parameters. Press RETURN when done.

WAVE D = NOISE
RMS NOISE = 5 mV

(8) Press R/S to activate the output.
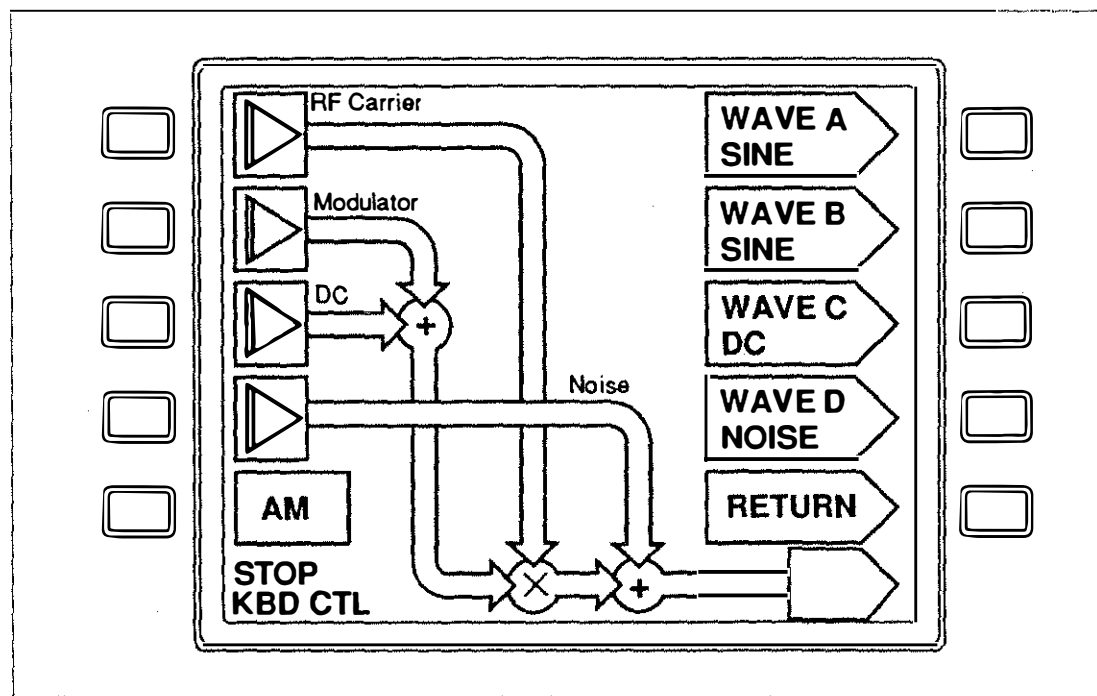
Figure 3-20. COMBINED WAVES Example

3.10   SPECIAL WAVES MENU

The Special Waves Menu provides miscellaneous special-purpose waveforms. From the WAVE menu, press the SPECIAL WAVES Softkey to display the submenu of waveforms shown in Figure 3-21.

To set up one of these waveforms, follow these steps:

(1)   Press WAVE.

(2)   Press SPECIAL WAVES. The MISC submenu (Figure 3-21) should appear.

(3)   Using the Rotary Encoder or the Right/Left Move keys, select a wave type.

(4)   Press ENTER. The appropriate parameter set-up display should appear on the screen.

(5)   Refer to Table 3-3 and set up the required parameters.

(6)   Press R/S to activate the output.
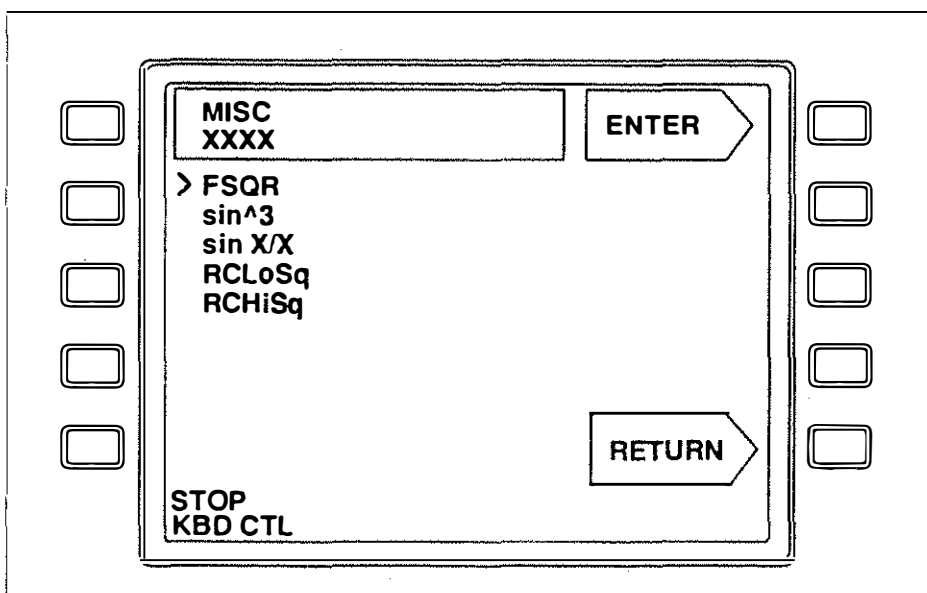
Figure 3-21. MISC Waveform Submenu

Table 3-3. Setup Parameters for MISC Waveforms

	FSQR	sin^3	sin X/X	RCLoSq & RCHISq
HIGH TIME	0.02µS to 4.99mS	—	—	—
PERIOD	0.04µS to 5.0mS	—	—	—
AMPLITUDE	5.0mV	to	10V	
OFFSET	0 to	10V	—	−10V to +10V
FREQUENCY	—	1.47Hz to 2.5MHz	—	1.47Hz to 2.5MHz
PHASE	—	−359.9 to +359.9 DEG	—	—
BANDWIDTH	—	—	1.47Hz to 20MHz	—
LINE SPACING	—	—	1.47Hz to 24.41kHz	—
DELAY TIME	—	—	—	0 to 680.1mS
R * C	—	—	—	4.0nS to 6803mS

3.11   SAVING, RECALLING OR DELETING INSTRUMENT SET-UPS

Any waveform setup can be saved to internal memory storage and recalled at another time. The DIR function key provides access to SAVE, RECALL and DELETE functions.

3.11.1   Saving Set-Ups

(1)   Set up and run the wave function.

(2)   Press DIR and select SAVE DIR from the directory menu.

(3)   Name the file: Press SAVE SETUP AS. Using the Left/Right Move keys and the Rotary Encoder, spell a name using up to 13 alphanumeric characters.

(4)   Press ENTER. "DONE" flashes on the screen to indicate a successful operation.

3.11.2   Recalling Set-Ups

(1)   Press DIR and select RECALL DIR from the directory menu.

(2)   Press RECALL DIR and select a file from the list with the cursor using the Right/Left Move keys.

(3)   Press ENTER. "DONE" flashes on the screen to indicate a successful operation.

NOTE: DEFAULT has a special meaning. It may be used to set the instrument to a factory-defined setting.

3.11.3   Deleting Set-Ups

(1)   Press DIR and select DELETE DIR from the directory menu.

(2)   Press DELETE DIR and select a file from the list with the cursor using the Right/Left Move keys.

(3)   Press ENTER. "DONE" flashes on the screen after the file name is removed from the list.

NOTE: DEFAULT can not be deleted.

4.1 INTRODUCTION

This instrument can be operated remotely using either the RS232 or IEEE-488 (GPIB) interface. To transfer control between Local and Remote, see Section 3.3 for a description of the I/O key functions. For more information on using the GPIB interface, see Section 5.

Figure 4-1 provides a summary of the commands described in this section. The command set is organized into five groups. Below the title of each group you will find a section reference.

MAINFRAME COMMON COMMANDS (Section 4.3)	
TRIG:TYPE	Trigger Type
TRIG:TSRC	Trigger Source
TRIG:LEV	Trigger Level
TRIG:GATE	Gate Type
BURST:CYCLES	Burst Count
WAVE	Waveform Category
OUTPUT	Run/Stop Output
OUT:IMP	Output Impedance
MARKER	Marker Time
EXT:MOD	External Modulation
OUT:FLT	Output Filter
CLK:CSRC	Clock Source
CLK:RATE	Output Sample Rate
CLK:REF	Ext. Ref. Clock
DIR:SAVE	Save Directory
DIR:RECALL	Recall Directory
DIR:DELETE	Delete Directory
DIR:NAME	Name Directory
DIR:FIRST	First Dir. Index
DIR:NEXT	Next Dir. Index
DIR:FREE	Empty Directory Index
LOCAL	Front Panel Control
ECHO	RS232 Echo
DISP:CNTRST	Display Contrast
DISP:BCKLT	Display Backlight
TABLE	Upload Instrument Setup
UPLOAD	Upload Arbitrary Data

STANDARD WAVE (WAVE=STD) (Section 4.4)	
SHAPE	Wave shape
FREQ	Frequency
AMP	Amplitude
DLY	Delay
PHS	Phase
OFF	Offset
SYM	Symmetry
DUTY	Duty Cycle
LEV	DC Level
NOI:MODE	Noise Mode
NOI:NAMP	Noise Amplitude
NOI:LINES	Line Spacing
GLIT:RISE	Glitch Rise Time
GLIT:FALL	Glitch Fall Time
GLIT:TOP	Glitch Top Width
POLARITY	Polarity

MODULATED WAVES (WAVE=MOD) (Section 4.5)	
MSHAPE	Wave shape
BW	Bandwidth
CAMP	Carrier Amplitude
CFREQ	Carrier Frequency
MDEV	Modulation Deviation
MFREQ	Modulation Frequency
MINDX	Modulation Index
MPERCENT	Modulation Percent
OFF	Offset
AMP	Peak Amplitude
PKT	Peak Time
REP	Repetition Rate
STRFREQ	Start Frequency
STPFREQ	Stop Frequency
DURATION	Duration
LONGSWEEP	Long Sweeps Enable
LONGSAMPLE	Long Sweep Sample Rate

COMBINED WAVES (WAVE=COMB) (Section 4.6)	
DEFINE	Combined Output
CMB:TYPE	Modulation Type
WAVEn:AMP	Amplitude
WAVEn:FREQ	Frequency
WAVEn:LEV	DC Level
WAVEn:DEV	Freq. Deviation
WAVEn:INDX	Mod. Index
WAVEn:SHAPE	Wave Shape
WAVEn:SYM	Symmetry
WAVEn:GLIT:RISE	Glitch Rise Time
WAVEn:GLIT:FALL	Glitch Fall Time
WAVEn:GLIT:TOP	Glitch Top Width
POLARITY	Polarity

SPECIAL WAVES (WAVE=SPECIAL) (Section 4.7)	
SSHAPE	Wave Shape
FSQU	Fast Square Wave
FSQ:REP	Fast Square Repeat Time
FSQ:HIGH	Fast Square High Time
AMP	Amplitude
OFF	DC Offset
RCTCONST	RC Time Constant

Figure 4-1. Command Summary

4.1.1   Connecting to the RS232 Interface

The RS232 interface included with this instrument requires only a three-wire connection with pins 2 and 3 reversed.

Pin	Signal
2	Input
3	Output
5	Ground

4.1.2   Programming Guidelines

The command set in Figure 4-1 allows you to remotely control the 2030 using the same functions available from the front panel. Note the following guidelines for remote operation.

* Only one waveform function (Standard, Modulated, Combined or Special) can be active at a time. When one waveform function is active you cannot access the parameters of another. However, the mainframe and GPIB common commands can be used while a waveform function is active.

* Waveform setups are saved when switching from one waveform function to another.

* When switching between waveform functions the output is deactivated. Send "OUTPUT=RUN" to reactivate the output for a new waveform function.

* If the instrument is switched off while under remote operation, it will power-up in remote operation when switched on again.

* Commands may be written in a string as long as each command is separated by a semicolon.

4.2   COMMAND ENTRY

Programming commands may be entered in the following format:

COMMAND MNEMONIC=<argument> <suffix> <termination>

where:

<argument> ....is a decimal, an integer, a mnemonic or an ASCII string as specified,

<suffix> ....is either a multiplier in scientific notation or units of measure.

Multipliers:			
	EX 1e18	MA 1e6	N .... 1e −9
	PE 1e15	K 1e3	P .... 1e −12
	T 1e12	M .... 1e −3	F .... 1e −15
	G 1e9	U .... 1e −6	A .... 1e −18

Units:		
	HZ .... Hertz	RAD ...... Radians
	V .... Volts	S .... Seconds
	DEG ..... Degrees	DB .... Decibels

<termination> .... is either a <LF> and/or <EOI> (End or Identify, IEEE-488). If a <CR> is included, it is ignored.

Query commands are entered using a question mark in place of the equal sign:

COMMAND MNEMONIC?<termination>

The response to a query is returned on the next line.

4.3   MAINFRAME COMMON COMMANDS

These commands correspond to the functions performed by the front panel dedicated function keys. All commands may be sent in the query format which returns the selection entered last.

4.3.1   Trigger Commands [TRIG]

Command	Input		Comments
TRIG:TYPE=<Input>	FREE	Free Run	Trigger Type
	+GATED	Positive Gated	
	–GATED	Negative Gated	
	+TO+	Positive-to-Positive	
	–TO–	Negative-to-Negative	
	+START	Positive Start	
	–START	Negative Start	
	+STOP	Positive Stop	
	–STOP	Negative Stop	
TRIG:TSRC=<Input>	EXTER	External Trigger	Trigger Source
	MANUAL	Manual Trigger	
	REMOTE	IEEE-488 GET	
TRIG:TLEV=<Input>	–3 to +3	Voltage Level	External Trigger Level
TRIG:GATE=<Input>	BURST	Burst	Gate Type
	AUTO	Auto-Restart	
	SH	Sample & Hold	
	BLOCK	Block End	
	BURST-STOP	Burst & Stop	
	AUTO-STOP	Auto-Restart & Stop	
	BLOCK-STOP	Block End & Stop	
BURST:CYCLES=<Input>	1 to 200	Cycles	Burst number of cycles.

4.3.2   Wave Functions [WAVE]

Command	Input		Comments
WAVE=<Input>	STD	Standard Wave	Waveform Category Selection
	MOD	Modulated Wave	
	COMB	Combined Waves	
	SPECIAL	Special Waves	
	ARB	Arbitrary	

4.3.3   Output Functions [OUT]

Command	Input	Comments
OUT:IMP=<Input>	50 or 600	Output Impedance: 50 or 600 Ohms
MARKER=<Input>S	120ns to 618.992ms	Marker Time. MARKER? returns value in scientific notation.
EXT:MOD=<Input>	ON or OFF	External Modulation
OUT:FLT=<Input>	OFF	Output Filter Cutoff. Arbitrary (ARB) mode only, see Section 5.4.
	F20M 23MHz	
	F1M 1MHz	
	F100K 100kHz	

4.3.4 *Clock Functions [CLK]*

Command	Input	Comments
CLK:CSRC=<Input>	INTER ....Internal Clock EXTER .... External Clock REF ....Ext. Ref. Clock	System Clock Source
CLK:RATE=<Input>	384.615384615 kHz, 5 MHz or 50 MHz	Output Sample Rate. Only active in ARB mode.
CLK:REF=<Input>	1 to 16 MHz in 1-MHz Steps	External reference clock frequency.

4.3.5 *Directory Functions [DIR]*

Command	Input/Response	Comments
DIR:SAVE=<Input>	ASCII filename (13 char. max.)	Save Directory
DIR:RECALL=<Input>	Directory Index	Recall Directory
DIR:DELETE=<Input>	Directory Index	Delete Directory
DIR:NAME=<Input>	ASCII filename (13 char. max.)	Directory establishes a directory name.
DIR:FIRST?	<Index><Space><Name>	Returns the index of the First directory.
DIR:NEXT?	<Index><Space><Name>	Returns the index of the Next Directory.
DIR:FREE?	<Index>	Returns the index of the next Free Directory.

4.3.6 *Communication Functions [I/O]*

Command	Input	Comments
LOCAL	None	Restores front panel operation.
ECHO=<Input>	ON or OFF	Sets RS232 echo capability on or off.
UPLOAD		Loads external data into output memory. See Section 5.
TABLE?	#nbbbb;xxxx...	Uploads the parameter set-up table to the PC. The data format is as follows:

        TABLE=#nbbbb;xxxxxxxx ...

        n = number of following bytes (represented by "bbbb") before semicolon

        bbbb = number of bytes in data stream including the semicolon

        xxxx... = data stream

        In this example, n = 4.

It is best to store the uploaded data in a file so that it can be downloaded at another time. Note that the command "TABLE=" is embedded into the ASCII string. To download the string back to the 2030, simply send the entire file. When this is done, the output is switched to STOP to protect whatever is connected to the output.

Only a limited amount of time is permitted between downloading data bytes. A counter is set to 0x7FFF and then decrements as the communication port is polled for a data byte. If a byte is not received before the counter expires, an execution error is generated.

4.3.7 *Display Functions [DISP]*

Command	Response	Comments
DISP:CNTRST?	0 to 300 ....Contrast Level	Query only function.
DISP:BCKLT?	0 to 100 ....Backlight Level	Query only function.

4.3.8   Run/Stop Functions [R/S]

Command	Input	Comments
OUTPUT=<Input>	RUN .... Activate Output	Activates or deactivates the output.
	STOP .... Deactivate Output	

4.4   STANDARD WAVE COMMANDS [WAVE=STD]

The Standard Wave Commands are listed below. Before using these commands, be sure to send WAVE=STD. All commands may be sent in the query format which returns the selection entered last.

4.4.1   Waveform Command

Command	Waveform	Parameter Commands (Section 4.4.2)
SHAPE=<Waveform>	SINE .... Sine	FREQ, AMP, PHS, OFF and NOI
	SQU .... Square	FREQ, AMP, OFF DUTY, DLY and NOI
	PULSE .... Pulse	FREQ, AMP, OFF, DUTY, DLY and NOI
	TRI .... Triangle	FREQ, AMP, OFF, SYM, DLY and NOI
	RAMPUP .... LO-to-HI Ramp	FREQ, AMP, OFF, DLY and NOI
	RAMPDN ....HI-to-LO Ramp	FREQ, AMP, OFF, DLY and NOI
	DC .... DC Level	LEV
	NOI.................... Noise	NOI:MODE, NOI:AMP and NOI:LINES
	GLITCH .... Glitch	GLIT:RISE, GLIT:FALL, GLIT:TOP, POLARITY

4.4.2   Waveform Parameter Commands

Command	Input	Comments
FREQ=<Input>Hz	0.001 to 20000000 Hz	Frequency for SINE, SQU, PULSE, TRI, RAMPUP, RAMPDN.
AMP=<Input>V	0.005 to 10 Volts	Amplitude for SINE, SQU, PULSE, TRI, RAMPUP, RAMPDN.
DLY=<Input>S	(±0.997 x FREQ) Sec.	Delay for SQR, TRI, PULSE, RAMPUP, RAMPDN.
PHS=<Input> DEG	−359.9 to +359.9 Deg.	Phase for SINE.
OFF=<Input>V	−10.0 to +10.0 Volts	Offset for SINE, SQR, TRI, PULSE, RAMPUP, RAMPDN.
SYM=<Input>	5.0to 95.0 Percent	Symmetry for TRI.
DUTY=<Input>	5.0 to 95.0 Percent	Duty Cycle for SQR and PULSE.
LEV=<Input>V	−10to +10 Volts	DC level for DC.
NOI:MODE=<Input>	ON or OFF	Noise Mode Enable for SINE, SQU, TRI, PULSE, RAMPUP, RAMPDN.
NOI:NAMP=<Input>V	0.001 to 1.879 Volts	Noise Amplitude for SINE, SQU, TRI, PULSE, RAMPUP, RAMPDN.
NOI:LINES=<Input>Hz	1.47 to 24.41406 Hz	Line spacing of the noise signal for SINE, SQU, TRI, PULSE, RAMPUP, RAMPDN and NOISE.
GLIT:RISE=<Input>S	0.02µS to 340.13mS	Glitch Rise
GLIT:FALL=<Input>S	0.02µS to 340.13mS	Glitch Fall Time
GLIT:TOP=<Input>S	0 to 340.13mS	Glitch Top Width
POLARITY=<Input>	0 = Normal, 1 = Inverted	Polarity

NOTE: *Noise commands "NOI:MODE" and "NOI:AMP" apply only to additive noise. Command "NOI:LINES" applies to any noise output.*

4.5   *MODULATED WAVE COMMANDS [WAVE=MOD]*

Before using the modulated wave commands, be sure to send WAVE=MOD. All these commands can be sent in the query format which returns the last value programmed.

4.5.1   *Modulated Waveforms*

Command	Waveform		Parameter Commands (Section 4.5.2)
MSHAPE=	AM	Amplitude Modulation	CFREQ, CAMP, MFREQ, MINDX, MPERCENT, OFF
<Waveform>	AMDSBSC	AM Dble Sideband Supp. Carrier	CFREQ, CAMP, MFREQ, MINDX, OFF
	AMSSB	AM Single Sideband	CFREQ, CAMP, MFREQ, MINDX, MPERCENT, OFF
	AMSSBSC	AM SSB Suppressed Carrier	CFREQ, CAMP, MFREQ, OFF
	FM	Frequency Modulation	CFREQ, CAMP, MFREQ, MDEV, OFF
	PM	Phase Modulation	CFREQ, CAMP, MFREQ, MINDX, OFF
	EXPD	Exponential Decay	CFREQ, AMP, PKT, DURATION, OFF
	SINX	sin X/X	CFREQ, AMP, BW, REP, PHS
	SWPUP	Linear Sweep Up	AMP, STRFREQ, STPFREQ, DURATION, OFF,LONGSWEEP, LONGSAMPLE
	SWPDN	Linear Sweep Down	Same as for SWPUP.
	SWPLOGUP	Exponential Sweep Up	Same as for SWPUP.
	SWPLOGDN	Exponential Sweep Down	Same as for SWPUP.

4.5.2   *Modulated Waveform Parameter Commands*

Command	Input	Comments
AMP=<Input>V	0.005to 10.00	Peak Amplitude for EXPD, SIN X, SWPUP, SWPDN, SWPLOGUP, SWPLOGDN, SWPEXPUP and SWPEXPDN.
BW=<Input>HZ	1.470 to 20000000	Bandwidth for SIN X
CAMP=<Input>V	0.005to 10.00	Carrier Amplitude for AM, AMDSBSC, AMSSB, AMSSBSC, FM and PM.
CFREQ=<Input>HZ	1.470 to 20000000	Carrier Frequency for AM, AMDSBSC, AMSSB, AMSSBSC, FM, PM EXPD and SIN X.
DURATION=<Input>S	40.96μS to 5.24mS	Wave duration for EXPD, SWPUP, SWPDN, SWPLOGUP and SWPLOGDN.
MDEV=<Input>HZ	1.470 to 20000000	Modulation deviation for FM.
MFREQ=<Input>HZ	1.470 to 20000000	Modulation frequency for AM, AMDSBSC, AMSSB, AMSSBSC, FM and PM.
MINDX=<Input>	0 to 9213	Modulation index for PM.
MPERCENT=<Input>	0.0 to 200.0	Modulation percentage for AM, AMDSBSC, and AMSSB.
OFF=<Input>V	– 10.00 to + 10.00	Offset for AM, AMDSBSC, AMSSB, AMSSBSC, FM, PM, EXPD, SIN X, SWPUP, SWPDN, SWLOGUP and SWPLOGDN.
PHS=<Input>DEG	– 359.9 to 359.9	Phase for SIN X.
PKT=<Input>S	20.5μS to 672mS	Peak time for the EXPD exponential decay envelope to reach its peak value (clock dependent).
REP=<Input>HZ	1.47 Hz min. (Clock + 262144) to 24.414 kHz max. (Clock + 2048)	Repetition rate (line spacing) for SIN X (clock dependent).
STRFREQ=<Input>HZ	1.470 to 20000000	Start frequency for SWPUP, SWPDN, SWPLOGUP and SWPLOGDN.
STPFREQ=<Input>HZ	1.470 to 20000000	Stop frequency for SWPUP, SWPDN, SWPLOGUP and SWPLOGDN.
LONGSWEEP=<Input>	ENABLE...to enable, anyother character to disable.	Longsweep enable. Extends range of DURATION.
LONGSAMPLE=<Input>Hz	76.295 to 2500000 Hz	Sample Rate for longsweep functions.

4.6 COMBINED WAVES COMMANDS [WAVE=COMB]

Before using these commands, send WAVE=COMB. All these commands can be sent in the query format which returns the last value programmed. To define the combined output function, send

DEFINE= (Modulator) * (Carrier) + (Offset)

where the Modulator, Carrier and Offset represent one of the standard waveforms (A), (B), (C) or (D); or a combination of standard waveforms, such as (A+B) or (A+B+C), etc. The parameters for the waveforms are as follows.

Command	Input	Comments
CMB:TYPE=<Input>	AM, FM or PM	Modulation method of combined output.
WAVEn:AMP=<Input>V	0.005 to 10.0	Amplitude for SINE, SQU, TRI, PULSE, RAMPUP & RAMPDN.
WAVEn:FREQ=<Input>HZ	2.94 to 20000000	Frequency of WAVEn.
WAVEn:LEV=<Input>V	−10.0 to +10.0	DC Level of WAVEn.
WAVEn:DEV=<Input>HZ	2.94 to 20000000	FM Frequency Deviation of WAVEn.
WAVEn:INDX=<Input>	0 to 92131	Phase Modulation index for PM.
WAVEn:SHAPE=<Input>	SINE .... Sine	Waveform type for WAVEn.
	SQU .... Square	
	PULSE .... Pulse	
NOTE: n = A, B, C or D	TRI .... Triangle	
	RAMPUP .... LO-to-HI Ramp	
	RAMPDN .... HI-to-LO Ramp	
	DC .... DC level	
	NOISE .... Noise	
WAVEn:PHS=<input>DEG	−359.9 to 359.9	Phase shift for WAVEn (SINE only).
WAVEn:SYM=<Input>	5.0 to 95.0%	Symmetry of TRI wave.
WAVEn:GLIT:RISE=<Input>S	0.02μS to 340.13mS	Glitch Rise Time of WAVEn.
WAVE:GLIT:TOP=<Input>S	0 to 340.13mS	Glitch Top Width of WAVEn.
WAVEn:GLIT:FALL=<Input>S	0.02μS to 340.13mS	Glitch Fall Time of WAVEn.
POLARITY=<Input>	POSITIVE/NEGATIVE	Polarity of Glitch.

4.7 SPECIAL WAVES COMMANDS [WAVE=SPECIAL]

The following commands are for programming the Special Waves functions.

Command	Input	Comments
SSHAPE=<Input>	FSQU .... Fast Square	Special Wave type.
	SIN3 .... sin^3	
	SINXX .... sin X/X	
	RCLOSQ ..... RCLoSq	
	RCHISQ .... RCHiSq	
FSQ:REP=<Input>S	40nS to 5.24288mS	Fast Square repeat time.
FSQ:HIGH=<Input>S	20nS to 5.24286mS	Fast Square high time.
AMP=<Input>V	0.005 to 10.00 Volts	Fast Square amplitude.
OFF=<Input>V	−10.0 to +10.0 Volts	Fast Square dc offset.
RCTCONST	4.0nS to 6803mS	RC Time Constant

4.8   PROGRAMMING EXAMPLES

The following command strings demonstrate how to remotely program this instrument.

4.8.1   Example #1 – Standard Wave

Instrument Setup: Wave Type: Sine wave
Frequency: 6 MHz
Amplitude: 5.0 Volts
Offset: 1.0 Volts
Phase: 180 Degrees

Command String:

WAVE=STD;SHAPE=SINE;FREQ=6MAHZ;AMP=5.0;OFF=1.0;PHS=180;OUTPUT=RUN

4.8.2   Example #2 – Modulated Wave

Instrument Setup: Carrier Wave Type: Sine
Carrier Amplitude: 5.0 Volts
Carrier Frequency: 100kHz
Modulation Frequency: 1kHz
Modulation Percent: 100%
Offset: 1.0 Volts

Command String:

WAVE=MOD;SHAPE=AM;CFREQ=100KHZ;MFREQ=1KHZ;AMP=5.0;MPERCENT=100;
OFF=1.0;OUTPUT=RUN

4.8.3   Example #3 – Combined Waves

Instrument Setup: Combined Output: (WAVE A + WAVE B) × (WAVE C) + (WAVE D)
WAVE A Frequency: 1 kHz
WAVE B Frequency: 2.0 kHz
WAVE C Frequency: 1 MHz

Command String:

WAVE=COMB;DEFINE=(A+B)*(C) + (D)
WAVEA:FREQ=1KHZ;WAVEB:FREQ=2.0KHZ;WAVEC:FREQ=1MAHZ

4.8.4   Example #4 – Queries

The following query examples show the responses that would be returned if the instrument was programmed for the combined output function in Example #3. Note that the reported frequency of WAVE B is not exactly 2.0kHz as programmed. This is because the instrument's operating program rounds off the frequency to the next integer multiple of the carrier wave.

Query Command		Response
WAVEA:FREQ?	→	WAVEA:FREQ=1.000000E+00
WAVEB:FREQ?	→	WAVEB:FREQ=2.01183E+002

5.1 INTRODUCTION

This section describes the implementation of the IEEE-488 Interface Bus (GPIB) and the Arbitrary Waveform capability.

5.2 GPIB INTERFACE

The IEEE-488 interface is user-selectable through front-panel controls. The operation of this interface complies with standards IEEE-488.1-1987 and IEEE-488.2-1988.

5.2.1 IEEE-488 Implemented Capabilities

Code	Name	Comments
SH1	SOURCE HANDSHAKE	Complete capabilities as defined by IEEE-488.1 – 19987.
AH1	ACCEPTOR HANDSHAKE	Complete capabilities as defined by IEEE-488.1 – 19987.
T6	TALKER	Basic Talker, Serial Poll and Unaddress if MLA capabilities.
L4	LISTENER	Basic Listener and Unaddress if MTA capabilities.
SR1	SERVICE REQUEST	Complete capabilities as defined by IEEE-488.1 – 19987.
RL2	REMOTE/LOCAL	Remote/Local capabilities with no local lockout.
PP1	PARALLEL POLL	Parallel poll capability with remote configuration.
DC1	DEVICE CLEAR	Complete capabilities as defined by IEEE-488.1 – 19987.
DT1	DEVICE TRIGGER	Complete capabilities as defined by IEEE-488.1 – 19987.

5.2.2 GPIB Common Control Commands

The GPIB Common Commands begin with an asterisk which distinguishes them from all other function commands. Some commands are queries only.

Command	Input/Response	Comments
*CLS	None	Clears the Status Byte Register.
*ESE<Input>	0 to 255	Sets the Standard Event Status Enable Register. ESE? reads this register.
*ESR?	0 to 255	Returns the contents of the Standard Event Status Register.
*IDN?	Instrument ID	Returns the Manufacturer, Model Number and Revision Number
*IST?	Status Message	Individual Status Query: A summary of the Parallel Poll Enable Register logically ANDed with the combination of the Status Byte Register (bits 0-7) and bits 8-15 set low. Note that bits 8-15 are not used in this device.
*OPC	1=Complete	Sets the Operation Complete Flag in the ESE Register when all pending commands have been completed.
*OPC?	1 =Complete	Returns a 1 after command is complete.
*PRE<Input>	0 to 255	Sets the Parallel Poll Enable Register bits. Note that bits 8 to 15 are not used. *PRE? returns the status of the Parallel Poll Enable Register bits. This register is logically ANDed with the parallel poll register to produce the *IST* signal. The parallel poll register is equivalent to the byte reported by a *STB?. The optional upper 8 bits (8-15) of the parallel poll register are not used.
*SRE<Input>	0-63 or 128-191	Sets the Service Request Enable Register (bit 6 = 0). *SRE? returns the contents.
*STB?	0 to 255	Returns the value of the Status Byte Register. Bit 6 is the Master Summary Status Bit.
*TRG	None	Sends a Trigger pulse if the GPIB port is selected for the trigger source.
*RST	None	Resets the instrument: Recalls the factory default settings and turns the output off.

5.2.3   IEEE-488 Standard Data Structure

As required by the IEEE-488.2-1987 standard, the data structure shown in Figure 5-1 is implemented in the instrument's firmware. A brief description of this data structure follows.

Status Byte Register

The Status Byte Register contains status bits assigned to instrument-related functions and the Request Service (RQS) and Master Summary Status (MSS) messages. This register can be read with a serial poll or a *STB? query command. The register bits are assigned as follows:

Bit	Name	Description
7	CAL	Calculating: 1 = Yes, 0 = No
6	RQS	Request Service; read by Serial Poll method along with bits 0-5 and 7.
	MSS	Master Summary Status: read by *STB? command along with bits 0-5 and 7.
5	ESB	Event Status Bit; indicates whether or not one or more of the enabled IEEE-488.2-defined events have occurred since the last reading or clearing of the Standard Event Status Register. ESB is true when an enabled event in the Standard Event Status Register is set True. Conversely, ESB is False when no enabled events are True.
4	MAV	Message Available; indicates whether or not the Output Queue is empty. Whenever the instrument is ready to accept a request by the controller to output data bytes, MAV is True.
3	ARM	Trigger Arming: 1 = Armed, 0 = Not Armed
2	RUN	Output Control: 1 = Active, 0 = Not Active
1	OVL	Overload: 1 = Output Overloaded, 0 = Not overloaded
0	ARB	Arbitrary Mode

The function of bit 6 is dependent upon the method used. When serial-polled, the instrument returns the 7 status bits plus the RQS message. The status byte with the RQS message is returned to the controller as a single byte. The RQS message indicates if the instrument was sending SRQ True. The STB message portion of the Status Byte Register is read non-destructively. The value of the status byte is not altered by a serial poll.

The *STB? command reads the contents of the Status Byte Register and MSS bit. The response represents the sum of the binary-weighted values of the Status Byte Register bits 0-5 and 7 (weights 1, 2, 4, 8, 16, and 128, respectively and the MSS summary message (weight 64).

Thus, the response to *STB? when considered as a binary value is identical to the response to a serial poll except that the MSS summary message appears in bit 6 in place of the RQS message.

Service Request Enable Register

The Service Request Enable (SRE) Register is written with the *SRE command. A bit value of one indicates an enabled condition, whereas a zero indicates a disabled condition. The instrument always ignores bit 6.

Standard Event Status Register

The Standard Event Status Register has a specific IEEE-defined event assigned to each bit. This register is read by the *ESR? query command. For more information on the function of each bit, refer to the IEEE specification.

Standard Event Status Enable Register

The Standard Event Status Enable Register is written with a *ESE command and read with a *ESE? query. The 8 bits of this register are ANDed with the 8 bits of the Standard Event Status Register and if one of the standard events is detected, the ESB bit is set in the Status Byte Register.
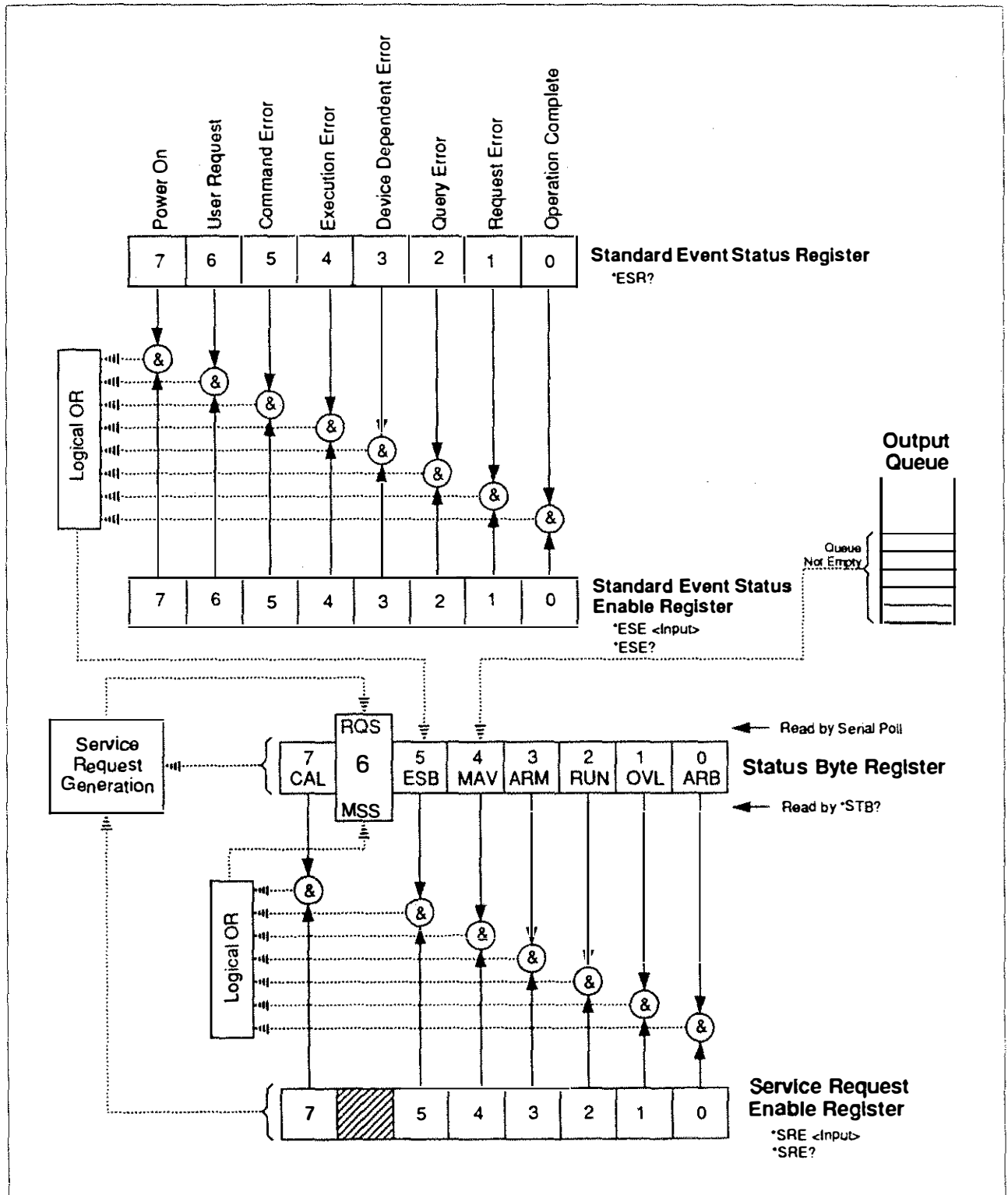
Figure 5-1. GPIB Interface Data Structure

5.3   ARBITRARY WAVES [WAVE=ARB]

The AFS can receive pre-calculated arbitrary waveforms (2K to 256K points) from an external source. Waveform data can be loaded into output memory only via the GPIB interface. The maximum clock rate is 50 Mhz (internal) or 25 MHz (external). The command "WAVE=ARB" places the instrument in the Arbitrary Mode.

5.3.1   Data Transfer Command

The UPLOAD transfers data from an external source and places the data in the output memory of the instrument. The command format is as follows:

> UPLOAD = < *bytes expected*>;
> <#><*n*><*block_size*><*data*>

Where:

UPLOAD .... is the upload command.

<*bytes expected*> .... is the number (decimal) of bytes expected. Must be an even number.

<#> .... is the ASCII pound sign.

<*n*> .... is the number (decimal) of digits in <*block_size*>.

<*block_size*> .... is the data block size (decimal).

<*data*> .... are the data points for the waveform.

NOTE: *The number of bytes is two times the number of data points, since each pair of bytes holds a single unpacked 12-bit sample point. The number of points is restricted to greater than or equal to 2048 points, and not more than 262144 points (256K). The number of bytes is two times these numbers.*

The four LSBs of the 12-bit sample point are located in the four MSBs of the first byte of each pair sent. The eight MSBs of the 12-bit sample are located in the second byte of the pair sent.

The 12-bit sample is sent in two's complement form with 7FF(hex) being the most positive output and 801(hex) being the most negative.

Example: The wave is an 11 point ramp that starts at zero volts and goes up by one DAC code with each sample point. Note that this example does not meet the minimum point requirement.

> UPLOAD=22;
> #3022<byte 1><byte 2> ......<byte 21><byte 22
> byte 1 contains 00h   "LSB's of sample 1"
> byte 2 contains 00h   "MSBs of sample 1"
> byte 3 contains 01h   "LSBs of sample 2"
> byte 4 contains 00h   "MSBs of sample 2"
> byte 5 contains 02h   "LSBs of sample 3"
>   •
>   •
> byte 21 contains 0Ah   "LSBs of sample 11"
> byte 22 contains 00h   "MSBs of sample 11"

When UPLOAD is sent, the instrument reads blocks of arbitrary data until the total number of bytes expected are received, thus terminating the command. Data must be sent in multiple data blocks. Each block must be in the IEEE-488 arbitrary data block format as shown in the next section. Messages are discarded if sent after the UPLOAD command and before the entire data stream is received.

5.3.2 Data Format

Each data block must be in the IEEE-488 arbitrary data block format as follows:

#<n><bytes><data>

Where:

.... is the ASCII number sign.

n .... is the number (non-zero) of characters used to define #bytes.

<bytes> .... is the number of bytes to be transferred. Must be an even number.

<data> .... is the data points of the arbitrary wave.

NOTE: *A line feed <LF> is accepted as a data byte. The EOI terminator may be sent at the end of a block transfer. A host with a small buffer should send multiple data blocks.*

5.3.3 Arbitrary Wave Example #1

This command will upload a total of 4096 bytes in 16 blocks of 256 bytes each.

```
UPLOAD = 4096;  #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
                #3256<data byte 1> ....<data byte 256>
```

5.3.4 Arbitrary Wave Example #2

This command string will upload a total of 4096 bytes from one block of data.

```
UPLOAD = 4096;#44096<data byte 1> .......<data byte 4096>
```

5.3.5 Arbitrary Wave Example #3

The following command string illustrates a typical waveform setup:

WAVE=ARB	Sets mode to Arbitrary Waves.
CLK:RATE=5E6	Sets clock rate to 5MHz.
UPLOAD=<ASCII string>	Sends waveform data to 2030.
OUTPUT=RUN	Activates the output.
OFF=-0.5	Sets offset to -0.5 volts.
AMP=2.2	Sets waveform amplitude to 2.2 volts.
OUT:FLT=F20M	Selects the 20MHz output filter.

6.1   INTRODUCTION

This section presents some typical test applications. Each test example includes a description of the application and a set-up procedure. Before working through any of these examples, the DEFAULT set-up should be retrieved from the non-volatile memory.

To retrieve the DEFAULT set-up, do the following:

(1)   Press DIR and select RECALL DIR.

(2)   Using the arrow keys, select DEFAULT from the submenu and press ENTER.

(3)   Press WAVE to return to the top menu level.

6.2   AM RADIO TEST SIGNAL

AM radios use an intermediate frequency (IF) of 455 kHz to mix with the received RF signal. The mixer output passes through a fixed passband filter which strips off the audio signal. To test a receiver, a 455-kHz carrier wave can be modulated with an audio tone to test the quality of the filter.

To generate a 455-kHz carrier modulated by a 384-Hz audio tone with a 50% modulation index, do the following:

(1)   Press WAVE and select MODULATED WAVE.

(2)   Select AMDSB from the submenu and press ENTER.

(3)   Set CARRIER FREQ = 455 kHz, MOD FREQUENCY = 384 kHz and MOD INDEX = 50%.

(4)   If the output is inactive, press R/S.

6.3   EXTERNAL CLOCKING SOURCE FOR TTL DEVICES

Many low-speed digital devices are controlled by TTL logic. In order to clock a TTL device, the clock signal voltage must meet TTL specifications. This example generates a TTL-level logic signal which alternates between 3.5 Volts and 0.5 Volts. Since most TTL devices have threshold voltages of 0.8 Volts (low) and 2.4 Volts (high), these levels assure state transition on a properly functioning device.

To generate a TTL-level logic signal alternating between 3.5 Volts and 0.5 Volts at 100 kHz, do the following:

(1)   Press WAVE and select STANDARD WAVE.

(2)   Select SQUARE from the submenu and press ENTER.

(3)   Set FREQUENCY = 100 kHz, AMPLITUDE = 1.5 V and OFFSET = 2 V.

(4)   If the output is inactive, press R/S.

NOTE: The voltages given here are correct values for an open-circuit load. If terminated into 50 ohms, the resulting values will be half of what is given in this example.

6.4　GENERATING A HAVERSINE WAVE

A Haversine Wave signal is used in mechanical systems to perform rotating machinery vibration analysis. The general shape is a sine wave but it is offset by a dc voltage and phase shifted.

The mathematical definition of the waveform is $HAV = 1/2 \ (1 - COS \ A)$.

In order to generate a Haversine Wave with an amplitude of 0.5 Volts, a dc offset of 0.5 Volts and a phase shift of – 90 degrees, do the following:

(1)　Press WAVE and select STANDARD WAVE.

(2)　Select SINE from the submenu and press ENTER.

(3)　Set AMPLITUDE = 0.5 V, OFFSET = 0.5 V and PHASE = –90 DEG

(4)　If the output indicator on the display says STOP, press R/S to activate the output.

6.5　SETTING UP A BURST WAVEFORM

Burst waveforms are used to provide a timing reference or clock external devices. The I/O key is used in this example to set up the appropriate parameters to burst out 10 cycles of a sine wave.

(1)　Press WAVE and select STANDARD WAVE.

(2)　Set STD=SINE, FREQUENCY = 1 kHz, AMPLITUDE = 1 V, PHASE = 0.0 DEG, OFFSET = 0.0 V.

(3)　Press TRIG and set TRIGGER TYPE = +GATED, GATE TYPE = BURST MODE, BURST CYCLES = 10 CYC and TRIG SOURCE = MANUAL.

(4)　If the output is inactive, press R/S.

(5)　Press MAN while observing the output on an oscilloscope. Note that an external trigger source could be used also to automate the burst.

6.6　TESTING AN ANALOG FILTER

Linear filters are used in a wide variety of electronics applications and filter performance must be tested to verify design. This section describes only one of the many tests that may be performed. This test example generates a combined signal consisting of three tones that can be fed into a filter to test its ability to pass those frequencies within a passband and reject the out-of-band tones.

To generate a combined output of three tones at 1, 5 and 10 kHz, do the following:

(1)　Press WAVE and select COMBINED WAVES.

(2)　Set up the following waves:

WAVE A:　SINE, FREQUENCY = 1 kHz
WAVE B:　SINE, FREQUENCY = 5 kHz
WAVE C:　SINE, FREQUENCY = 10 kHz

(3)　If the output is inactive, press R/S.

Functions

Standard Waveforms .... Sine, Square, Triangle, Pulse, Ramp Up, Ramp Down, DC, Noise

Modulations and Sweeps .... AM Double Sideband, Double Sideband Suppressed Carrier, AM Single Sideband, Single Sideband Suppressed Carrier, FM, PM, Decay Pulse Envelope, Sin x/x Envelope, Linear Sweep, Log Sweep

Additional Waveforms .... Combined Waveforms, Arbitrary and Special Waveforms

Output

Source Impedance .... 50Ω/600Ω ±1% or open circuit

Amplitude Range & Resolution ...... 5 mV pk to 9.999mV pk in steps of 1μV
10mV pk to 99.99mV pk in steps of 10μV
100mV pk to 999.9mV pk in steps of 100μV
1V pk to 10.000V pk in steps of 1mV

Amplitude Accuracy .... Analog output circuitry error less than ±1% of requested amplitude at 1kHz. Typical relative error 0.05%.

Offset Range & Resolution .... –10.00V to +10.00V in steps of 2.5mV

Offset Accuracy .... 1% ± 200 μV (20 to 30°C) ± 34 μV/°C

Freq. Range & Resolution .... 0.001Hz to 9.999999kHz in steps of 0.001Hz
10kHz to 99.99999kHz in steps of 0.01Hz
100kHz to 999.9999kHz in steps of 0.1Hz
1MHz to 5.000000MHz in steps of 1Hz
Sinewave only: 5MHz to 20MHz in steps of 1Hz

Frequency Stability .... (internal reference) 2ppm, 0 to 50°C, 2ppm/year

Relative Freq. Accuracy .... ±0.2 ppm ratiometric frequency error referred to Internal Reference Oscillator or External Reference Input

Noise .... < 0.2mV rms with 10MHz Bandwidth; < 0.75mV rms with 1000MHz Bandwidth

Jitter.. < 0.005% of waveform period + 100 ps (sine); < 0.05% of waveform period +100 ps (others)

Protection .... Output overloads greater than ±150mA cause opening of output relay. Safe voltage is greater than ±15V on the output connector.

Isolation .... Common Mode voltages to at least 42V can be applied to the output connector.

Trigger

Source .... Manual, External, Bus

Modes.. Free Run, Counted Burst, Gated, Start, Stop, Start/Stop

Sine Wave

Frequency Range .... 0.001 Hz to 20 MHz

Amplitude Flatness......................... ±0.1 dB dc to 100 kHz
±0.2 dB 100 kHz to 1 MHz
±0.3 dB 1 MHz to 20 MHz

Harmonic Distortion .... –70dBc to 20kHz
–65dBc to 100kHz
–55dBc to 1MHz
–25dBc to 20MHz

Phase Range.................................. ±360° in 0.1° increments

Phase Accuracy .... ±1.0° dc to 100 kHz

Triangle and Ramp

Frequency Range .... 0.001 Hz to 5 MHz

Nonlinearity .... ±0.05% @ dc to 10 kHz; ±0.5% @ 10 kHz to 1 MHz; ±2.0% @ 1 MHz to 5 MHz (10% to 90% on waveform)

Ringing .... < 0.1% up to 10 kHz
< 0.2% up to 5 MHz

Triangle Symmetry .... User adjustable from 5% to 95% in 0.1% steps; 50nS min. risetime

Triangle Delay Range .... ± 1 period in steps of 0.1nS to 0.1mS, depending on frequency selected

Square and Pulse

Frequency Range .... 0.001Hz to 5MHz

Pulse Polarity .... Positive with zero volt baseline

Duty Cycle .... Adjustable from 5% to 95% in 0.1% steps (50ns minimum risetime restriction)

Delay Range .... ±1 waveform period in steps of 0.1 ns to 0.1 ms, depending on the frequency selected

Rise Time .... 15ns from .... 0.001Hz to 1.47Hz
10µs from ...... >1.47Hz to 1kHz
1µs from .... >1kHz to 10kHz
50 ns from ...... >10kHz to 5 MHz
16 ns in Fast Square Wave (FSQR) (typ.)

Overshoot and Ringing.................. < 0.1% up to 10kHz; < 0.2% up to 5 MHz

Noise Function

Amplitude Range .... 1 mV to 1.8V rms in steps of 1 µV to 1 mV (no load)

Noise Spectral Distribution .... Pseudo random with the ability to set number of spectral lines.

Amplitude Distribution .... Approaches Gaussian with zero mean, depending on the selected noise record size.

Modulation and Sweeps

Modulation Types .... AM DSB, DSB SC, AM SSB, SSB SC, FM, ΦM, Exponential Decay, Sinx/x

Carrier Range .... 1.470Hz to 20 MHz

Modulation Rate .... 1.470Hz to Carrier Frequency

Modulation Span .... (Within 20-MHz bandwidth)
AM: 0.0% to 200.0%
FM: lesser of ±carrier/2 or ±2 MHz
PM: ±7200 degrees

Envelope Distortion .... AM: <1%

Exponential Decay Envelope .... $t^2 e^{-at}$ envelope defined by peak time, duration

Sinx/x Envelope........................... Defined by bandwidth, repetition rate

External Modulation .... 0 to 40% AM

Sweeps .... Linear and log

Combined Waveforms

Up to 4 standard functions can be summed or used in modulation.

Carrier .... Any standard function

Modulator .... Summation of up to 3 standard functions

Modulation Type .... AM, FM, or PM

Postmodulation Summation .... Up to 2 standard functions

Arbitrary Waveforms

Maximum Clock Rate .... 50MHz, 5MHz, or 384kHz internal; 25 MHz external

Waveform Length .... 2k to 256k points

Waveform Library

Fast Square Wave, sine cubed, sinx/x, RC lowpass/highpass filtered square wave

General

Non-volatile Memory .... Over 50 instrument setups

Battery Type .... Lithium BR2030

Rear Panel Inputs .... Trigger, Ext. Clock/Reference, Ext. Modulation (AM)

Rear Panel Outputs .... Function, 10 MHz Reference, Sync/Marker

Multi-unit Frequency Sync .... Within 0.4 ppm

Interfaces .... RS-232 and IEEE-488

Operating Temperature .... 0 to 50°C

Storage Temperature .... −40 to 70°C

Power .... < 30W, 100/120/220/240 Vac ±15%, 50/60 Hz
Safety Class I to VDE 0411 (IEC348)

Dimensions................................. 216 mm (8.5 in) W; 132 mm (5.2 in) H; 429 mm (16.9 in) D

Weight .... 6 kg (13 lb)

Mechanical Stress .... Shock tested to MIL STD 810D, 40g; Vibration tested to DIN IEC 68-2-6,
5 to 55 Hz (sine) 4g rms, 80 to 300 Hz (random)

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