User Manual

SONY
Tektronix

AFG2020
Synthesized Arbitrary Function Generator

070-8659-02

CE

Printed in Japan.

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EC Declaration of Conformity

We

Tektronix Holland N.V.
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declare under sole responsibility that the

AFG2020 Synthesized Arbitrary Function Generator instruments

meets the intent of Directive 89/336/EEC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Communities:

EN 55011	Class A Radiated and Conducted Emissions
EN 50081-1 Emissions:	
EN 60555-2	AC Power Line Harmonic Emissions
EN 50082-1 Immunity:	
IEC 801-2	Electrostatic Discharge Immunity
IEC 801-3	RF Electromagnetic Field Immunity
IEC 801-4	Electrical Fast Transient/Burst Immunity

Welcome

This is the user manual for the AFG2020 Synthesized Arbitrary Function Generator.

Section 1 Getting Started covers the features of the AFG2020, installation, and start up procedures. Before switching on the power, pay particular attention in the start up section to the procedure and the precautions. When using the AFG2020 for the first time, read this section carefully to learn about the basic operation methods. The Tutorial will help you learn how to use many instrument features in common tasks.

Section 2 Operating Basics covers general front panel operations and gives a basic operation example in *Outputting Predefined Waveforms.* This section will help you learn about all the front panel controls.

Section 3 Reference describes the front and rear panel features and summaries operating concepts. It also explains the menu functions in detail. This section exposes detailed operating information to help you effectively use this instrument.

The appendices cover the options, accessories, performance characteristics, performance verification procedure, edit waveform library, and various miscellaneous subjects, including initial settings and repackaging for shipment.

Related Manuals

Other documentation for the instrument includes:

- The AFG2020 Programmer Manual (Tektronix part number 070–8660–01) describes how to control the AFG2020 with a computer through the GPIB interface. This manual is a standard accessory.
- The AFG2020 Service Manual (Tektronix part number 070–8661–01) provides information to maintain and service the AFG2020 and provides the theory of operations at the module level, performance verification, adjustment procedures, maintenance and etc. And it contains the mechanical parts list. This manual is an optional accessory.

Conventions

In sections 1 through 3, you will find various procedures that contain steps of instructions for you to perform. To keep those instructions clear and consistent, this manual uses the following conventions:

- Names of front panel controls and menus appear in the same case (initial capitals, all uppercase, etc.) in the manual as is used on the signal generator front panel and menus. Front panel names are all upper case letters, for example, **MODE MENU**, **CH 1**, etc.
- Instruction steps are numbered. The number is omitted if there is only one step.

Contents

Getting Started

Operating Basics

Reference

Appendices

Glossary

Index

Change Information

List of Figures

List of Tables

Operator's Safety Summary

Please take a moment to review these safety precautions. They are provided for your protection and to prevent damage to the function generator. This safety information applies to all operators and service personnel.

Symbols and Terms

These two terms appear in manuals:

- CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.
- WARNING statements identify conditions or practices that could result in personal injury or loss of life.

These two terms appear on equipment:

- *CAUTION* indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.
- *DANGER* indicates a personal injury hazard immediately accessible as one reads the marking.

This symbol appears in manuals:

Static-Sensitive Devices

This symbol indicates where applicable cautionary or other information is to be found.

These symbols appear on equipment:

DANGER
High Voltage

Protective ground (earth) terminal

ATTENTION
Refer to manual

Specific Precautions

Observe all of these precautions to ensure your personal safety and to prevent damage to either the function generator or equipment connected to it.

Power Source

The function generator is intended to operate from a power source that will not apply more than 250 V_{RMS} between the supply conductors or between either supply conductor and ground. A protective ground connection, through the grounding conductor in the power cord, is essential for safe system operation.

Grounding the Function Generator

The function generator is grounded through the power cord. To avoid electric shock, plug the power cord into a properly wired receptacle where earth ground has been verified by a qualified service person. Do this before making connections to the input or output terminals of the function generator.

Without the protective ground connection, all parts of the function generator are potential shock hazards. This includes knobs and controls that may appear to be insulators.

Use the Proper Power Cord

Use only the power cord and connector specified for your product. Use only a power cord that is in good condition.

Use the Proper Fuse

To avoid fire hazard, use only the fuse specified in the parts list for your product, matched by type, voltage rating, and current rating.

Do Not Remove Covers or Panels

To avoid personal injury, do not operate the function generator without the panels or covers.

Take Antistatic Precautions

Wear an antistatic grounding wrist strap when working with the input connectors on the function generator.

Do Not Operate in Explosive Atmospheres

The function generator provides no explosion protection from static discharges or arcing components. Do not operate the function generator in an atmosphere of explosive gases.

Getting Started

Overview

This section explains the features of the AFG2020, initial inspection, and start up procedures. Also, the tutorial describes many common operating tasks.

Product Description

The AFG2020 is a portable function waveform generator equipped with waveform generator functions, sweep functions, modulation functions, and a variety of arbitrary waveform editing functions.

This waveform generator provides these major features:

- 5 types of standard function waveforms
- 32 types of custom waveforms (arbitrary waveforms)

This instrument has independent 12-bit × 1K word waveform memory for each channel, 250 MS/s high-speed D/A conversion, and direct digital synthesis (DDS). Also, the waveform output is terminated with 50 Ω for a maximum output of ±5 V (10 V_{p-p}).

In synthesizer on mode, the maximum frequency is 100 MHz for sine waveforms and 2.5 MHz for function waveforms and arbitrary waveforms.

In synthesizer off mode, the maximum frequency is 50 MHz for square waveforms and 31.2 MHz for other waveforms.

When Option 02 is added, two waveforms can be output at the same time.

For sine waves, the output signal frequency can be swept from 1 Hz to 100 MHz; for other waveforms, from 1 Hz to 2.5 MHz.

There are three types of analog modulation functions — AM, FM, and Offset. There are two types of digital modulation functions — phase shift keying (PSK) and frequency shift keying (FSK). Also, when a digital modulation function is used, sequences of up to 2048 steps can be assembled that combine the amplitude, offset, frequency, phase, and other output conditions.

The waveform editor comprises a wide variety of editing functions, so custom (arbitrary) waveforms can be easily made. The waveform editor can express the waveform data in either of two display formats: graphic or table. In the graphic display mode, the waveform editor has functions for mathematically combining the waveform data in the buffer with the waveform being created.

The menu system has a hierarchical structure. Main menus are selected with the six front panel menu buttons and the TRIGGER MODE button. Menu functions are selected and set from the bottom menus and the side menus that are displayed on the screen when a main menu is selected. The screen displays use graphics and icons to clearly present the data to you.

The AFG2020 contains nonvolatile RAM to store the waveform data created with the AFG2020, including the instrument settings.

Also, a GPIB interface is standard. This instrument can be controlled through this interface and can be combined with other measurement instruments and computers in a wide range of applications.

Initial Inspection

Before unpacking the AFG2020 from its shipping carton, inspect it for external damage. If the carton is damaged, notify the carrier.

Remove the AFG2020 from its package and check that it has not been damaged in transit. Verify that the package contains all the accessories. For the list of the accessories, see *Appendix A: Options and Accessories*.

This instrument passed thorough electrical and mechanical inspections before being shipped from the factory. However, this instrument has both startup and extended self-diagnostics tests that check for proper operation. If a detailed performance verification is desired, refer to *Appendix C: Performance Verification Procedure*. Refer to the optional AFG2020 Service manual for adjustment procedures. If there is any damage or breakdown of this instrument, contact our nearest representative.

NOTE

Store the carton and packing material in case it becomes necessary to repack this instrument.

Start Up

Installation

Before you begin, refer to the *Operator's Safety Summary* at the front of this manual for power source, grounding, and other safety information.

Before switching on the power for this instrument, check that it has been installed correctly. Install it according to the procedure below, then connect to the power source.

☐ **Step 1:** Check that you have the proper power source. The AFG2020 operates within the following power supply voltage ranges:

Line Voltage Range	90 V – 250 V
Line Frequency	48 Hz – 440 Hz (90 V – 127 V)
	48 Hz – 63 Hz (127 V – 250 V)
Maximum Power	300 W

⚠ ☐ **Step 2:** Remove the fuse from the fuse holder on the rear panel and check the fuse. Make sure it is the proper type and rating.

WARNING

Always unplug the power cord from the socket before checking the line fuse to avoid electrical shock.

To remove the fuse, turn the fuse–holder cap counterclockwise with a screwdriver while pushing it in. Pull the cap (with the attached fuse inside) out of the fuse holder. The same fuse is used for both 115 V and 230 V systems. See Figure 1-1 for the fuse location.

One of two fuse types is installed in the instrument, depending upon the power cord option. Table 1-1 provides the available types and ratings.

Table 1-1: Fuse Type and Rating

Power Cord Option	Fuse Type	Fuse Part Number	Fuse Cap Part Number
Standard, A3, A4, A5	0.25 inch x 1.25 inch (UL 198G,3AG): 6A FAST, 250 V	159–0239–00	200–2264–00
A1, A2	5 mm x 20 mm (IEC 127):5A (T), 250 V	159–0210–00	200–2265–00

NOTE

The second fuse listed in the table above (part number 159–0210–00) is approved under the IEC standards. This fuse is used in equipment sold in the European market.

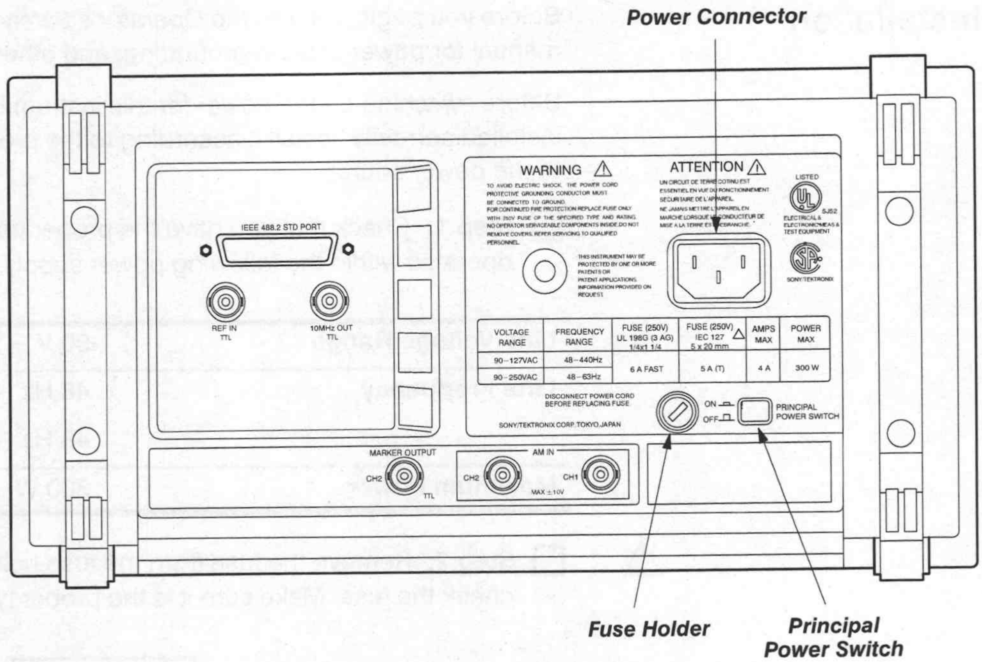


Figure 1-1: Rear Panel Controls Used in Start Up

☐ **Step 3:** Connect the proper power cord from the rear panel power connector (see Figure 1-1) to the power system.

CAUTION

Instruments are shipped with a power cord appropriate for use with normal 115 V power systems. If the AFG2020 is to be used with 230 V power the power cord must be replaced with one appropriate for the power source used. See Figure 1-2 on page 1-5 for the available power cord types.

The AFG2020 uses single-phase power, so a detachable three-wire power cord with a three-contact plug is provided to connect both the power source and protective ground.

WARNING

The power source must not apply more than 250 V_{RMS} between the supply conductors or between either supply conductor and ground. Exceeding this rated operating voltage can result in equipment failure and potential fire or shock hazards.

For electrical shock protection, insert the power plug into a power source outlet that has a properly grounded protective-ground contact.

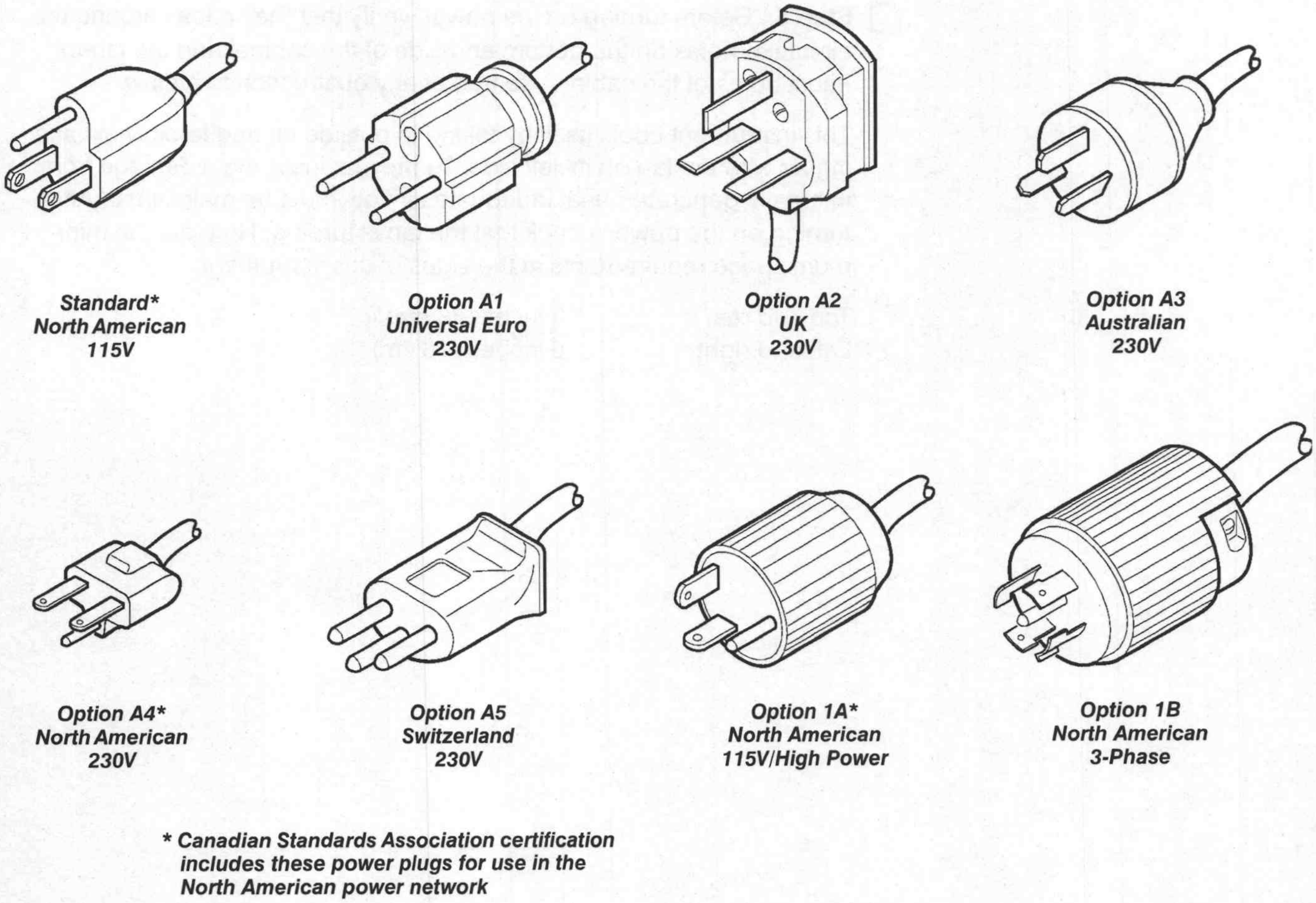


Figure 1-2: Optional Power Cords

☐ **Step 4:** Check that the operating environment is appropriate.

The AFG2020 operates normally at ambient temperatures from 0° C to +50° C. If the AFG2020 has been stored at temperatures outside this range, let the chassis reach operating temperature before switching on the power. For the environmental characteristics, see *Appendix B: Performance Characteristics*.

NOTE

Install this instrument on a flat, sturdy desk or table. If you are installing this instrument in the dedicated rack, refer to the instruction sheet that comes with the rack mounting kit.

☐ **Step 5:** Before turning on the power, verify that the spaces around the air-intake holes on the bottom and side of the cabinet and the fan-exhaust holes of the cabinet are free of any obstruction to airflow.

This instrument cools itself by taking in outside air and forcibly exhausting air with the fan on its left side. To prevent instrument damage from internally generated heat, adequate air flow must be maintained. After turning on the power, check that the fan is turning. Here are the minimum space requirements at the sides of this instrument.

Top and rear	3 inches (8 cm)
Left and right	6 inches (16 cm)

Power On

☐ **Step 6:** Press the PRINCIPAL POWER SWITCH on the rear panel of this instrument to switch on the principal power. Power is applied to this instrument's standby circuits. See Figure 1-1 on page 1-4 for the switch location.

☐ **Step 7:** Press the ON/STBY switch on the front panel to switch on the power for the instrument. See Figure 1-3 for the switch location.

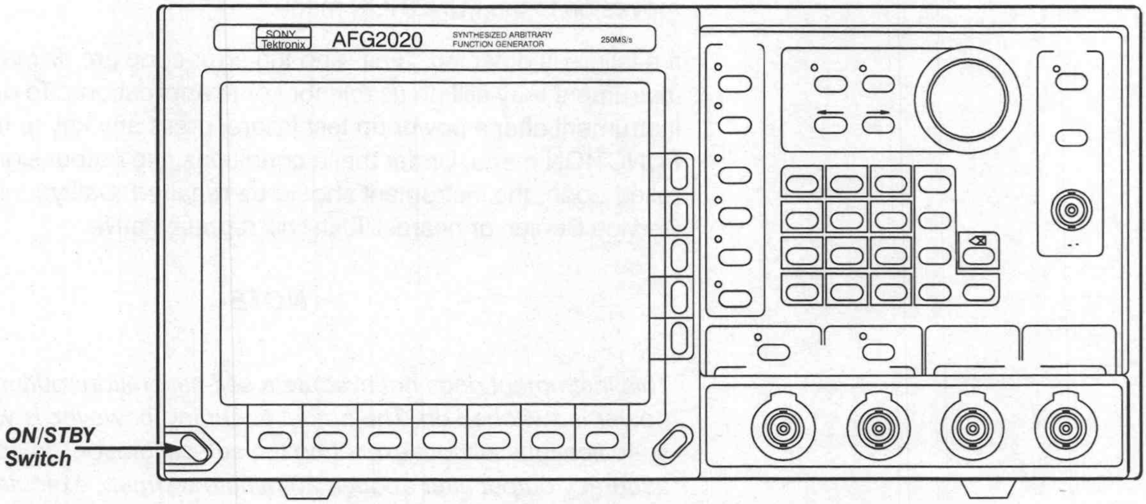


Figure 1-3: Front Panel Control Used in Start Up

This instrument must be warmed up for at least 20 minutes to operate with the specified precision.

Once the instrument is installed, it is typical to leave the principal power switch on. The ON/STBY button is then used as the power switch.

NOTE

With the PRINCIPLE POWER SWITCH on, if you switch it off, then immediately on again, the power is immediately available. In this case, these is no need to press the front panel ON/STBY switch. In fact, the AFG2020 stores the state of the ON/STBY switch so that when the PRINCIPLE POWER SWITCH is turned on, the last ON/STBY condition is implemented.

Start-Up Diagnostics

☐ **Step 8:** Check the start-up diagnostics results.

At power on, the instrument automatically performs a set of start-up diagnostic tests. This process executes the diagnostics carried out from the UTILITY menu to check whether the instrument is operating normally.

The startup diagnostics take about 35 seconds. If no faults are encountered, "Pass" is displayed for each diagnostic item and the system moves on to the FUNCTION menu.

If a failure is detected, "Fail" and the error code are displayed. The instrument may still be usable for some applications. To operate the instrument after a power-up test failure, press any key to move on to the FUNCTION menu. Under these conditions, the output signal cannot be relied upon; the instrument should be repaired. Call your local Tektronix Service Center, or nearest Tektronix representative.

NOTE

This instrument does not execute a self-calibration routine when the power is switched on. The output accuracy, however, is within the specifications without executing the self-calibration. To assure high accuracy output after about a 20-minute warmup, execute the DC calibration with the instrument in an ambient temperature of +20° C to +30° C.

For details on how to execute DC calibration, see the example of operation in this section or the explanation of the Calibration item in the *UTILITY Menu* in Section 3.

Power Off

☐ **Step 9:** Press the ON/STBY switch to put the AFG2020 onto standby.

NOTE

The AFG2020 instrument settings are not automatically stored at power down. To store instrument settings for the next power up, use the NV RAM function in the UTILITY menu before powering down.

Tutorial

Nine examples comprise the tutorial to demonstrate the primary tasks and basic operations for the AFG2020:

- Example 1: Saving and Recalling Settings
- Example 2: Selecting Arbitrary and Function Waveforms
- Example 3: Setting Output Parameters
- Example 4: Setting Trigger Conditions
- Example 5: Setting Standard Sweep
- Example 6: Setting Multiple Sweep
- Example 7: Setting Analog Modulation
- Example 8: Setting Digital Modulation
- Example 9: Setting Synchronized Parallel Operation

These operation examples are not intended to give you a complete inventory of every feature and function of this instrument. Rather, the examples are to give you quick insight, so that you can easily explore those features that are of interest to you.

Refer to *Section 2, Operating Basics*, for general descriptions of the front panel menu and control operations, or refer to *Section 3, Reference*, for more detailed descriptions of instrument features.

Certain parts of these examples require test equipment having these minimum specifications:

- One signal generator, 10 MHz bandwidth, 5 V_{p-p} output amplitude
- Five coaxial cables, BNC connectors, 50 Ω impedance

NOTE

These examples show the procedures for setting up various functions with this instrument when it has Option 02 (CH2 output) installed. If Option 02 is not installed, there is no channel switching or display.

Example 1: Saving and Recalling Settings

When the AFG2020 power is switched off, the current settings are not saved automatically, so the next time the power is switched on, the instrument goes into its initial state. Thus, this example shows you how to save settings into nonvolatile memory to make it easier to reset this instrument when similar settings are desired for other test suites. You will learn to save, recall, and initialize AFG2020 settings.

Save Settings

To save the settings using the UTILITY menu, perform the following steps:

☐ **Step 1:** Use the FUNCTION, OUTPUT, and other menus to configure the settings to any condition you desire. If you choose, you can glance at Examples 2 and 3 to see what kinds of parameters can be set. Otherwise, just pick a few at random.

☐ **Step 2:** Press the UTILITY button in the MENU column on the front panel.

☐ **Step 3:** Select the bottom menu NV RAM item (see Figure 1-4).

☐ **Step 4:** Move the reverse video display cursor with the general purpose knob to select the file number into which settings will be saved.

The file number can be selected from 1 through 32.

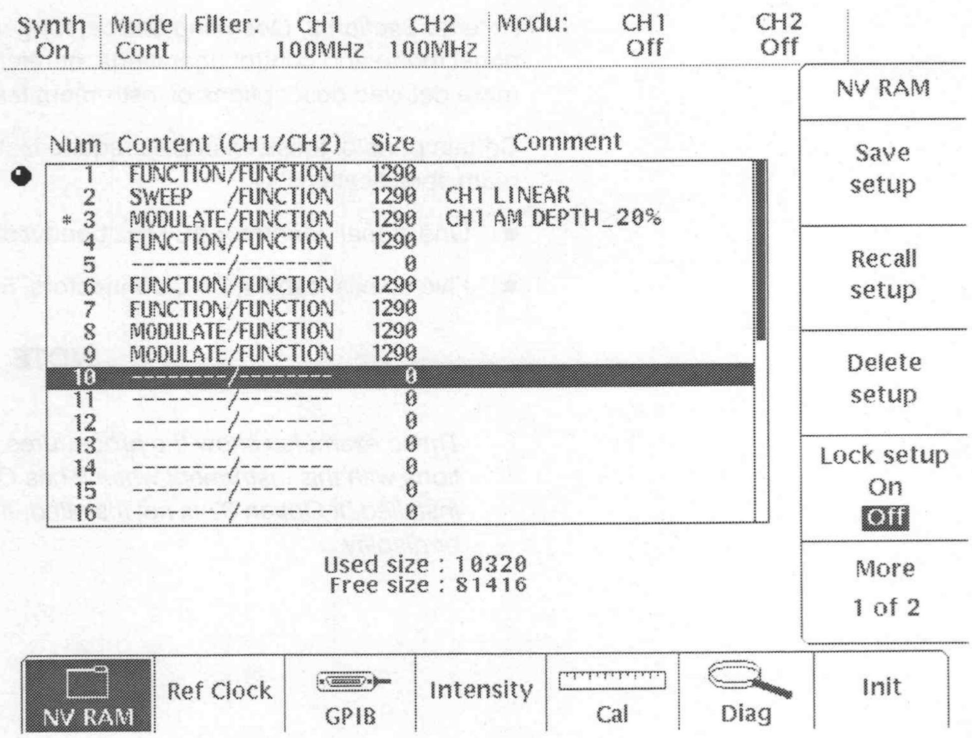


Figure 1-4: NV RAM Menu

☐ **Step 5:** Press the side menu Save setup button to save the current settings.

NOTE

You cannot save the settings into a file that contains previously stored settings. You have to empty that file with the Delete setup button before you can save the new settings into it.

An asterisk (*) is displayed to the left of the file number of locked files. Settings can be deleted if the lock is cleared by pressing the Lock setup key.

☐ **Step 6:** Change some of the settings in the FUNCTION, OUTPUT, or other menus that you set before. This prepares you to see the effect of recalling settings in the next procedure.

Recall Settings

To recall settings saved to NV RAM, perform the following steps:

☐ **Step 1:** Press the UTILITY button in the MENU column on the front panel.

☐ **Step 2:** Select the bottom menu NV RAM item.

☐ **Step 3:** Move the reversed video display cursor with the general purpose knob to select the file number in which the desired settings are stored.

☐ **Step 4:** Press the side menu Recall setup button to reset the instrument with the desired settings. The system then displays the OUTPUT menu.

The AFG2020 settings can be loaded sequentially by pressing the Recall and step key for each file to be loaded from a set of files that are grouped. Grouped files are sets of files that are delimited in the table by files that have no stored settings. Files 1 to 4 in Figure 1-4 are one group of files and files 6 to 9 are another group.

☐ **Step 5:** Press the More 1 of 2 key on the side menu to display the second page of the side menu.

☐ **Step 6:** Use the general purpose knob to scroll the reversed video display cursor through the display to select a file number from the desired group.

☐ **Step 7:** Press the Recall and step key. When the Recall and step key is pressed, the contents of the selected file are setup in the AFG2020 and the reversed video display cursor moves to the next file number. Screen display remains at the NV RAM menu and the OUTPUT menu is not switched.

☐ **Step 8:** Press the Recall and step key to recall the next file. Each time the Recall and step key is pressed the contents of the file shown reversed are setup in the AFG2020 and the reversed video display cursor moves to the next file number.

After the file with the largest number in a group has been loaded into the AFG2020, the reversed video display cursor moves to the file with the smallest file number in the group.

☐ **Step 9:** To change groups, use the general purpose knob to scroll the reversed video display cursor and select a file from a different group.

Initialize Settings

The Initial settings are the same settings to be setup when the power is switched on (see *Initial Settings* in *Appendix E* for details on the contents of the initial settings). These initial settings can also be recalled by selecting Secure, which also deletes the data in arbitrary waveform memory and setting memory (NV RAM).

To initialize the instrument to its initial settings, perform the following steps:

☐ **Step 1:** Press the UTILITY button in the MENU column on the front panel.

☐ **Step 2:** Select the bottom menu Init item (see Figure 1-5).

The AFG2020 displays a message indicating that O.K. resets the AFG2020 to the power on state, and that Secure deletes the data in arbitrary waveform memory and setting memory as well as recalling the initial settings.

☐ **Step 3:** If you want to keep the data in memory, press the O.K. key on the side menu. Otherwise, perform step 4. The initial settings are recalled and the display switches to the FUNCTION menu screen display.

If the Cancel key is pressed, the message will be erased from the screen and the menu items will return to the state where nothing has been selected.

If the Secure key is pressed, the message will switch to one that warns that all data will be deleted.

☐ **Step 4:** If you want to delete the contents in memory, press the Secure key and then the O.K. key on the side menu. The contents of memory are deleted and the initial settings are recalled, then the display switches to the FUNCTION menu screen display.

If the Cancel key is pressed, the message will be erased from the screen and the menu items will return to the state where nothing has been selected.

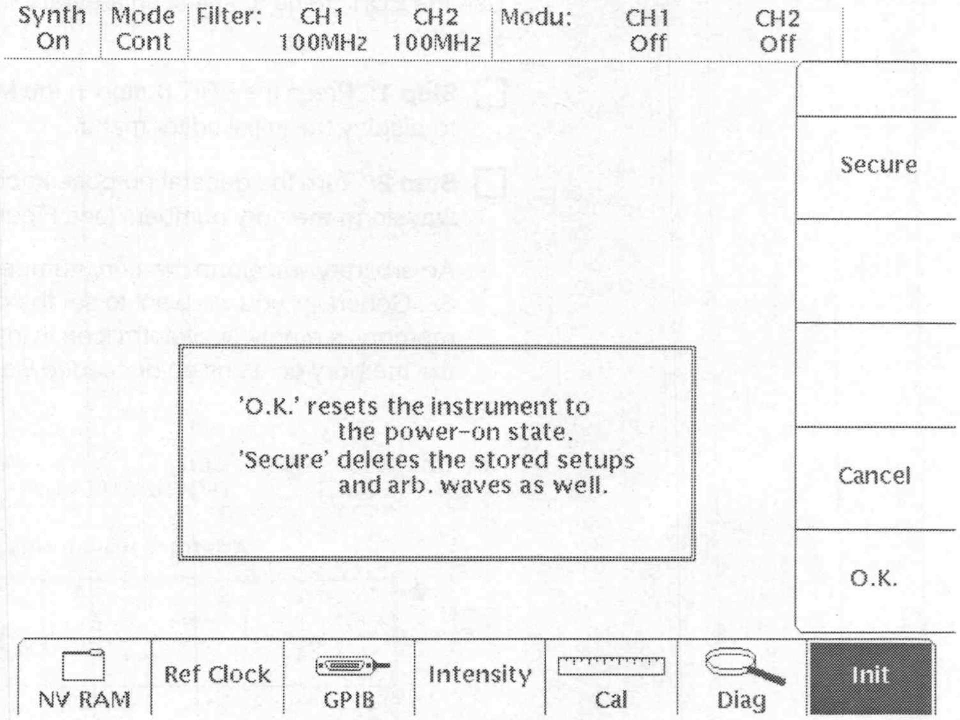


Figure 1-5: Init Menu

Example 2: Selecting Arbitrary and Function Waveforms

In this example, you will learn to save a library function waveform into arbitrary waveform memory, select the waveform as the CH1 waveform, and select an exponential curve (pulse width 30%) pulse for the CH2 waveform.

Use the EDIT menu to select an arbitrary waveform by performing these steps:

☐ **Step 1:** Press the EDIT button in the MENU column on the front panel to display the initial editor menu.

☐ **Step 2:** Turn the general purpose knob to select 7 from the arbitrary waveform memory numbers (see Figure 1-6).

An arbitrary waveform memory number can be selected from 1 through 32. Generally, you will want to set the cursor on a number for which the memory is empty (waveform icon is just a horizontal line) or for which the memory contains an unneeded waveform.

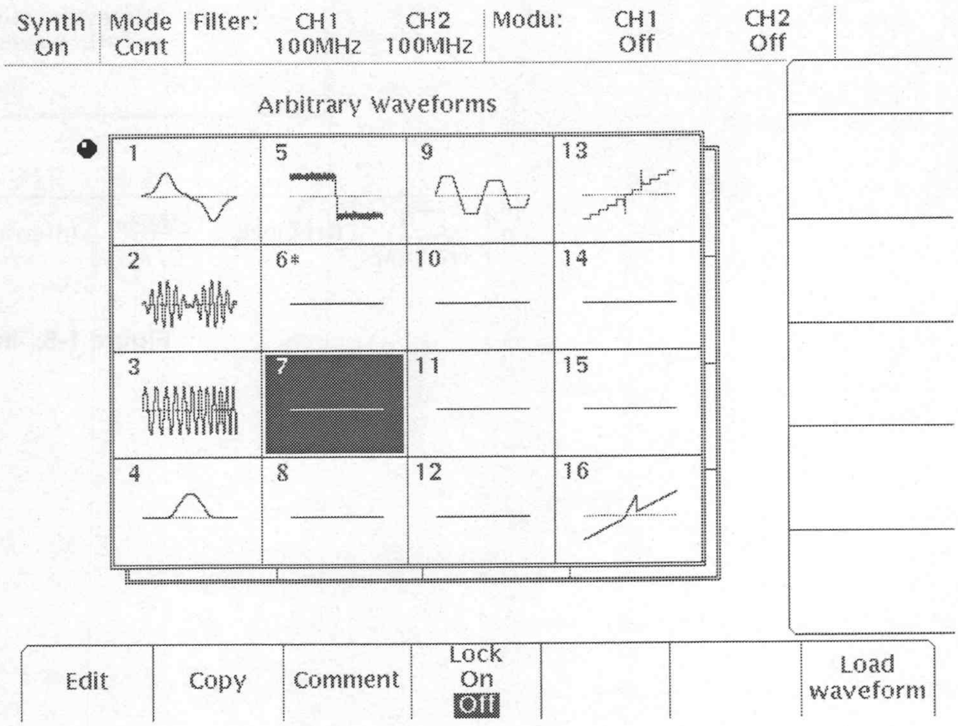


Figure 1-6: Initial Editor Menu

☐ **Step 3:** Press the bottom menu Edit button, then press the bottom menu Library button. The menu for selecting library functions is displayed on the CRT screen (see Figure 1-7).

An asterisk (*) is displayed to the right of the file number of locked files. The waveform can be edited if the lock is cleared by pressing the Lock key.

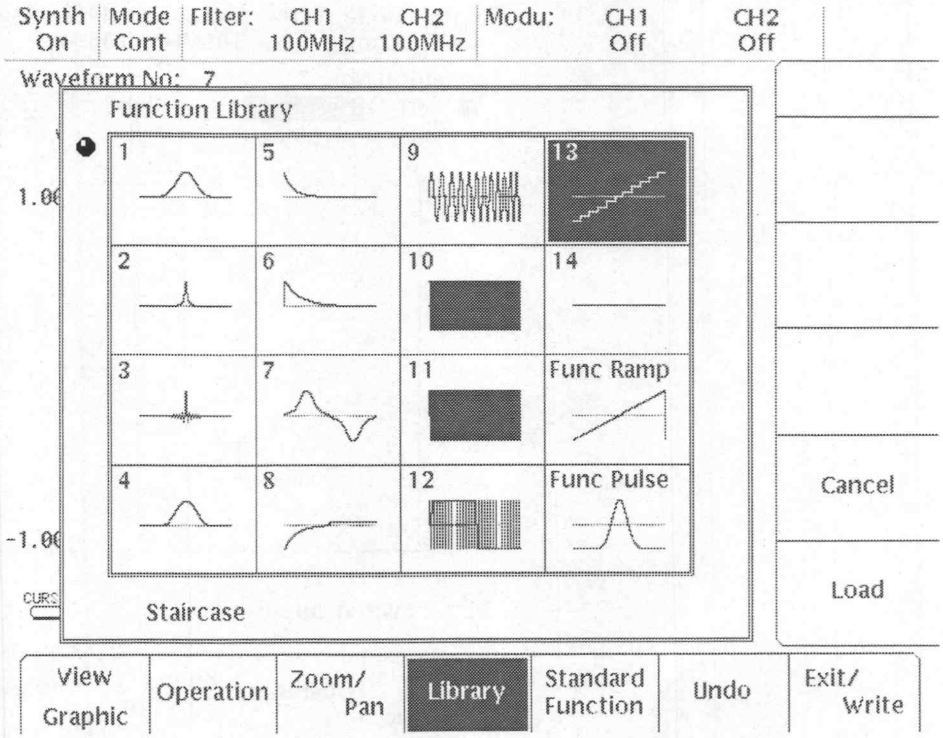


Figure 1-7: Library Menu

☐ **Step 4:** Turn the general purpose knob to select the stair waveform of number 13.

☐ **Step 5:** Press the side menu Load button. The CRT screen switches to a display of the stair waveform in the editor graphical area.

☐ **Step 6:** Press the bottom menu Exit/Write button, then press the side menu Write and Exit button (see Figure 1-8). The CRT screen switches to the initial editor screen and the stair waveform icon is now displayed at number 7.

So far, you have saved a library stair waveform as an arbitrary waveform in Wave #7.

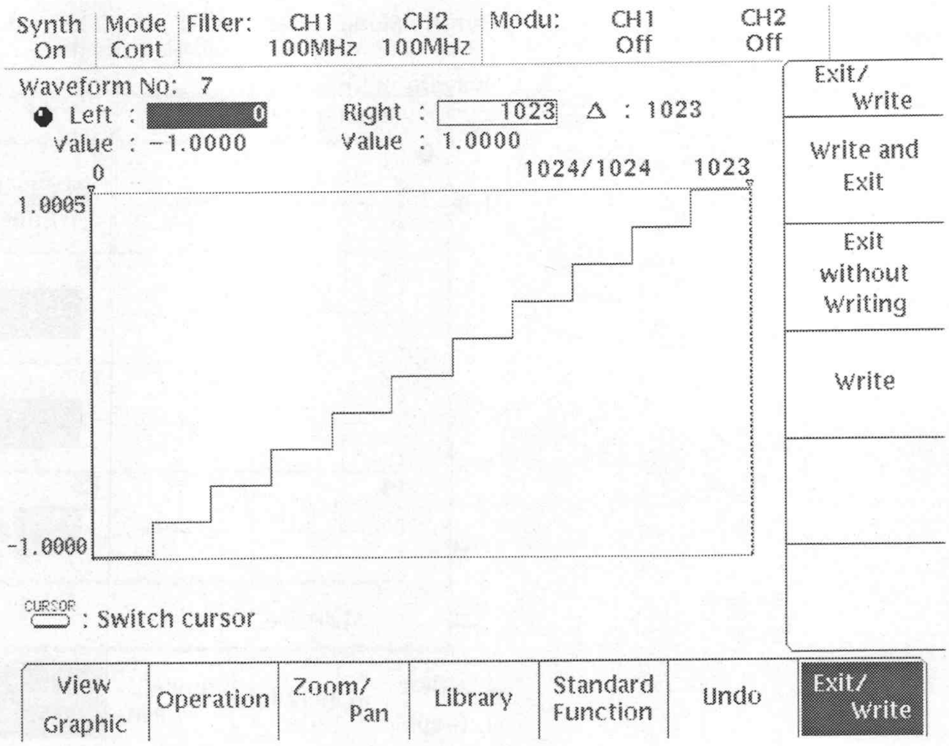


Figure 1-8: Exit/Write Menu

Now, use the FUNCTION menu to assign the waveform to CH1 by performing these steps:

☐ **Step 7:** Press the FUNCTION button on the front panel MENU column.

☐ **Step 8:** Press the bottom menu Channel button to set the reverse video display portion to the CH1 side.

☐ **Step 9:** Press the bottom menu Arbitrary button, then press the side menu More button. Wave #5 through Wave #8 are displayed on the side menu, More 2 of 8 (see Figure 1-9).

☐ **Step 10:** Press the side menu Wave #7 button. The stair waveform is drawn in the CH1 graphical area on the CRT screen.

It will still be possible to select waveforms even if the following procedure is performed instead of steps 9 and 10.

a. Press the Arbitrary key on the bottom menu to display the arbitrary waveform list.

b. Use the general purpose knob to move the reversed video display cursor to item number 7 in the arbitrary waveform list.

c. Press the Arbitrary key once again. The stair waveform will be displayed in the CH1 graphical area.

With these operations, you have now saved the stair waveform into the CH1 waveform memory.

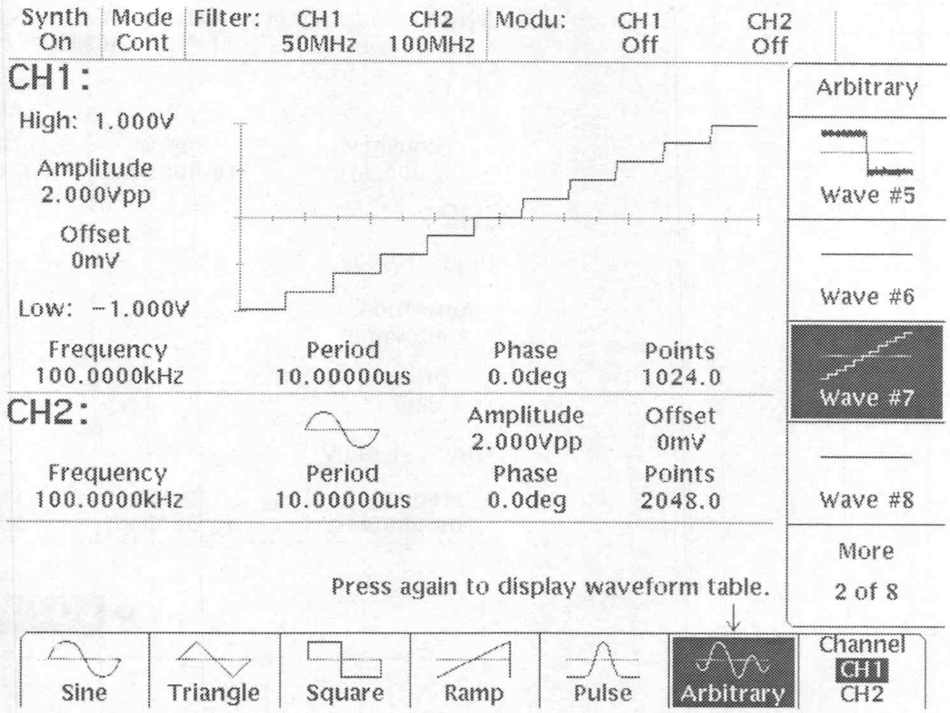


Figure 1-9: Setting the Stair Waveform into CH1 Waveform Memory

Now, assign a pulse waveform to CH2 by performing these steps:

☐ **Step 11:** Press the bottom menu Channel button to set the reverse video display portion to the CH2 side.

☐ **Step 12:** Press the bottom menu Pulse button. A pulse wave is drawn in the CH2 graphical area on the CRT screen.

☐ **Step 13:** Press the side menu Edge Type button, then use either the general purpose knob or the Edge Type button to select Exponent. The pulse waveform on the CRT screen is redrawn as a pulse waveform with an exponential curve.

☐ **Step 14:** Press the side menu Width button, then use the numeric keys or general purpose knob to change the pulse width to 30% (see Figure 1-10). The pulse waveform on the CRT screen is changed to the new pulse width.

NOTE

When changing the value with the general purpose knob, the digit over the underscore in the numeric input column is changed with each detent change of the knob. The position of the underscore is moved with the front panel left (←) or right ( ) arrow buttons.

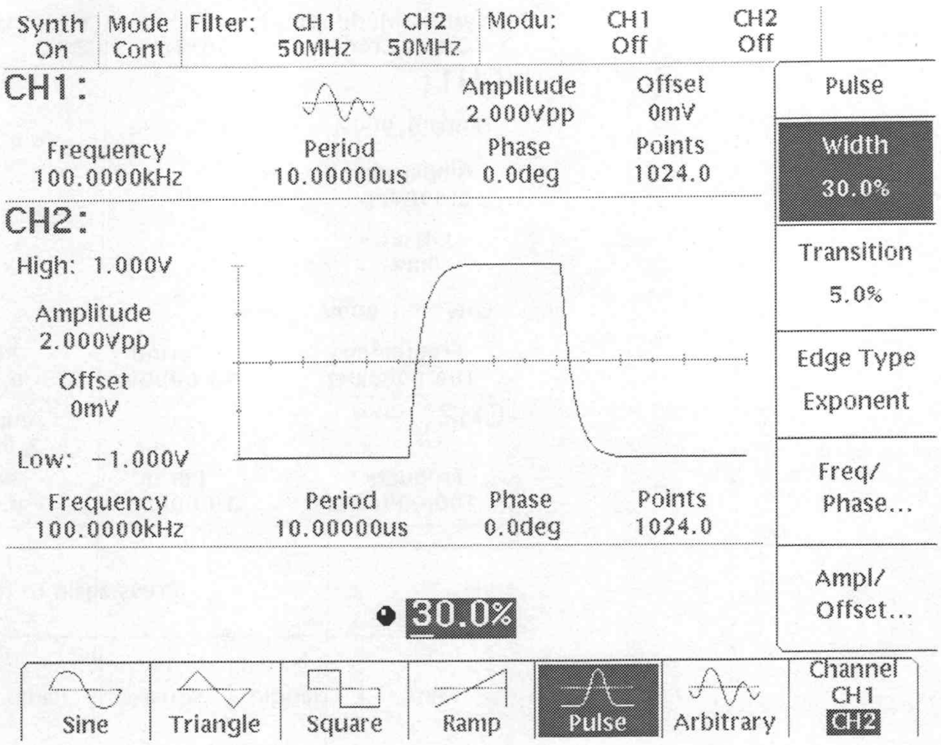


Figure 1-10: Setting a Pulse Waveform into CH2 Waveform Memory

In the operations up till now, you have specified an exponential function waveform with 30% pulse width for the CH2 waveform memory.

Example 3: Setting Output Parameters

In this example, you will change the CH1 waveform frequency to 2 MHz, the amplitude to 1 $V_{p\text{-}p}$, and the offset to 0.6 V. In addition, you will set the voltage range to 2 $V_{p\text{-}p}$ and set the synthesizer mode to off. This procedure requires you to initialize settings using the Init function in the Utility menu.

Use the OUTPUT menu to set various waveform parameters of the CH1 and CH2 waveforms by performing these steps:

☐ **Step 1:** Initialize the settings to their default conditions using the Init function in the Utility menu, as described in Example 1.

☐ **Step 2:** Press the OUTPUT button in the MENU column on the front panel.

☐ **Step 3:** Check that the bottom menu Freq/Phase column and the side menu Frequency column are displayed in reverse video.

☐ **Step 4:** Set the frequency to 2.000 000 0 MHz (see Figure 1-11) using the numeric keys or the general purpose knob.

NOTE

When changing the value with the general purpose knob, the digit over the underscore in the numeric input column is changed with each detent change of the knob. The position of the underscore is moved with the front panel left (←) or right ( ) arrow buttons.

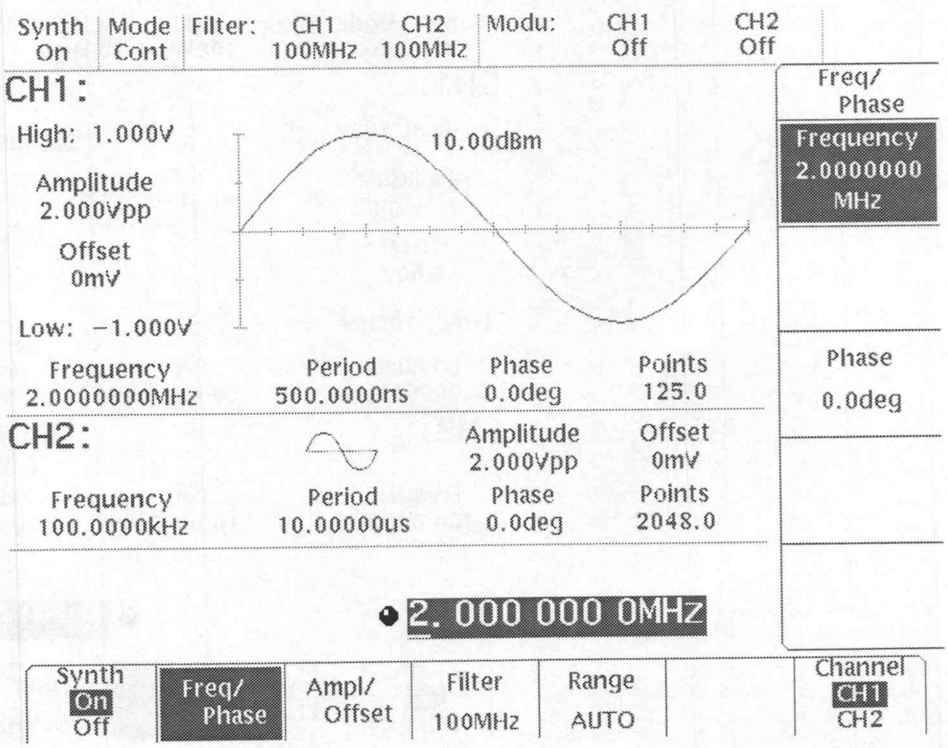


Figure 1-11: Frequency Setting

☐ **Step 5:** Press the bottom menu Ampl/Offset button. Check that the side menu Amplitude column is displayed in reverse video.

☐ **Step 6:** Set the amplitude to 1.000 $V_{p\text{-}p}$ using the numeric keys or the general purpose knob.

☐ **Step 7:** Press the side menu Offset button (see Figure 1-12).

☐ **Step 8:** Set the offset to 0.60 V (see Figure 1-12) using the numeric keys or general purpose knob.

NOTE

Because this procedure sets the output signal high level to +1.100 V, the auto range function automatically changes the range from the 2 $V_{p\text{-}p}$ range to the 10 $V_{p\text{-}p}$ range with the x5 amp inserted. However, the Range menu label still displays AUTO.

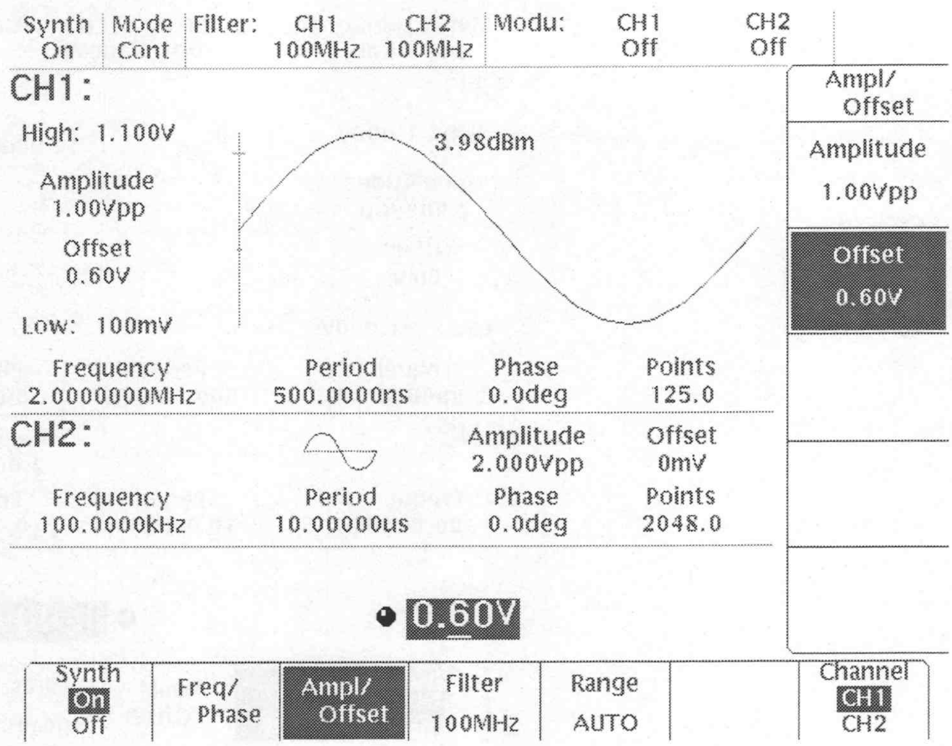


Figure 1-12: Amplitude/Offset Setting

Thus far, you have learned to set an amplitude of 1.00 $V_{p\text{-}p}$, an offset of 0.60 V, and a frequency of 2.000 000 0 MHz for the signal output in Synthesizer On Mode. Next you will select parameters for an output signal on CH2.

☐ **Step 9:** Press the bottom menu Range button, then select the side menu 2 $V_{p\text{-}p}$ range. Since the output signal peak level is restricted to ±1.000 V, the offset value is automatically changed to 500 mV.

☐ **Step 10:** Press the bottom menu Synth button to set the reverse video display portion to the Off position. The synthesizer mode is set to the same mode for CH1 and CH2.

☐ **Step 11:** Press the bottom menu Freq/Phase button (see Figure 1-13). In synthesizer off mode, the side menu Phase item is deleted and the frequency value is displayed with three digits.

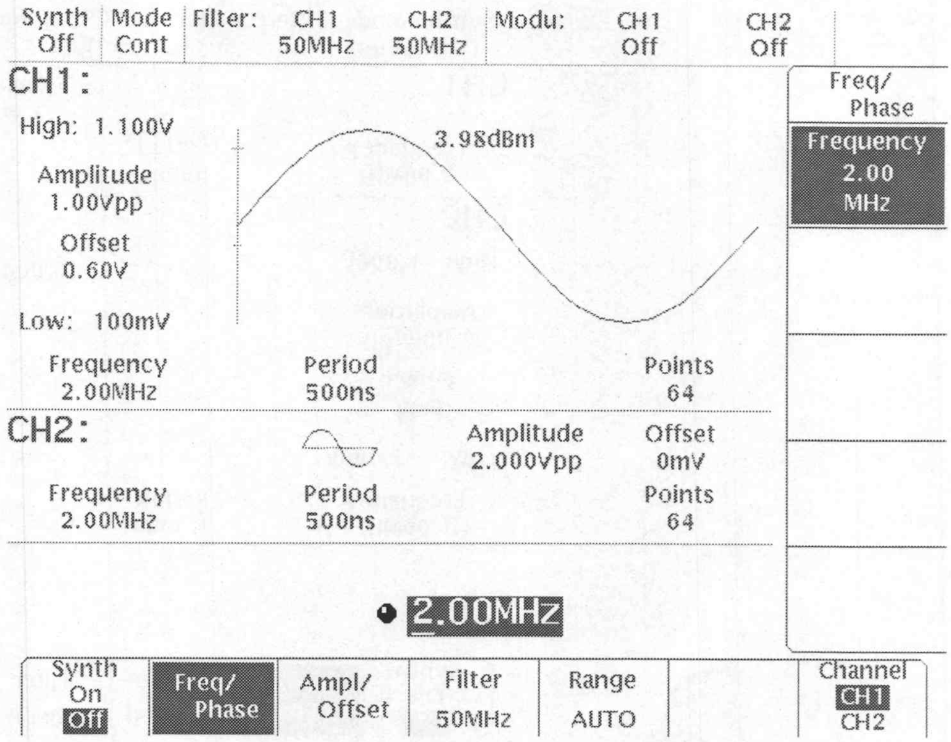


Figure 1-13: CH1 Display in Synthesizer Off Mode

☐ **Step 12:** Press the bottom menu Channel button, then set the reverse video display portion to the CH2 position.

☐ **Step 13:** Check that the side menu Frequency column is displayed in reverse video, then use the Frequency button or the general purpose knob to set the frequency to CH1/2 (see Figure 1-14).

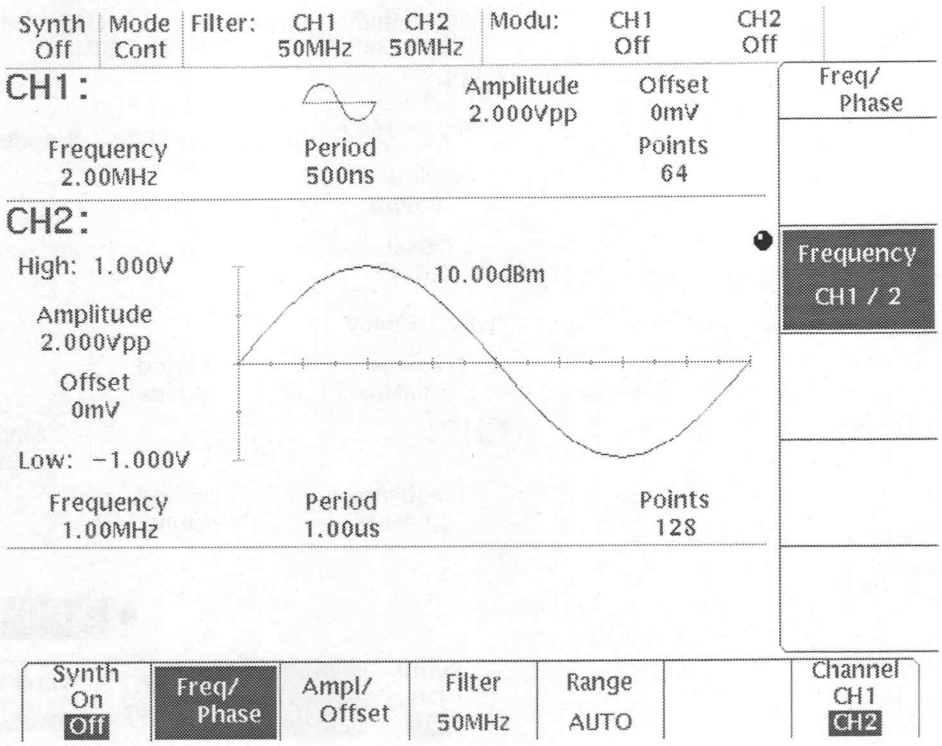


Figure 1-14: CH2 Display in Synthesizer Off Mode

Thus far, you have learned to set an amplitude of 1.000 $V_{p\text{-}p}$, an offset of 500 mV, and a frequency of 2.00 MHz for CH1 signal output in Synthesizer Off Mode. Also, you have set an amplitude of 2.000 $V_{p\text{-}p}$, an offset of 0 mV, and a frequency of 1.00 MHz for CH2 signal output in Synthesizer Off Mode.

Example 4: Setting Trigger Conditions

In this example, you will learn to set the Trigger Mode to Gate and Time Burst. You will also control the waveform output with an external gate signal and an internal source. You will need to connect an external signal source to generate the external trigger.

Use the MODE menu to select a trigger mode and set its parameters by performing these steps:

☐ **Step 1:** Press the MODE button in the TRIGGER column on the front panel.

☐ **Step 2:** Press the bottom menu Gate button. In gate mode, the signal is output while the gate signal is true.

☐ **Step 3:** Press the side menu Source button repeatedly to select External (see Figure 1-15). You can also select the trigger source with the general purpose knob.

☐ **Step 4:** Press the side menu Slope button to select the polarity. For + polarity, the signal is output when the gate signal level is high.

☐ **Step 5:** Press the Level button.

☐ **Step 6:** Set the external gate signal level using the numeric keys or the general purpose knob.

NOTE

When changing the value with the general purpose knob, the digit over the underscore in the numeric input column is changed with each detent change of the knob. The position of the underscore is moved with the front panel left (←) or right ( ) arrow buttons.

☐ **Step 7:** Connect an appropriate external gate signal source to the INPUT connector on the front panel of this instrument. Make sure it meets the parameters set in the Gate side menu. While the gate signal is valid, the signal waveform is output continuously from the waveform output connector for each channel.

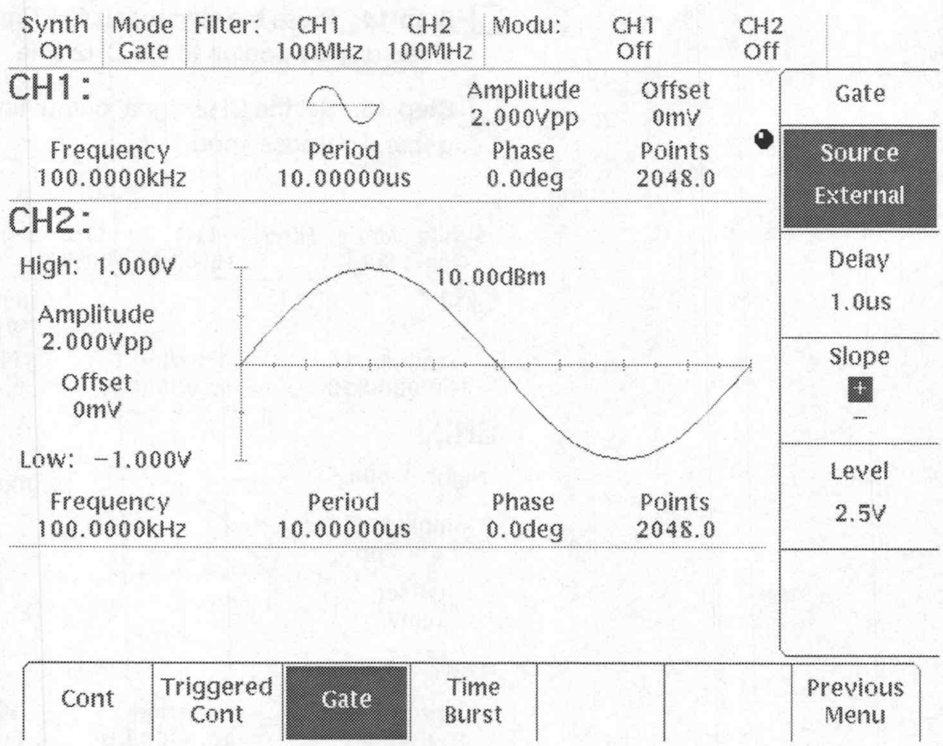


Figure 1-15: Setting Up External Source in Gate Mode

Now, set the Trigger Mode to Time Burst and control the waveform output with an internal trigger signal.

☐ **Step 8:** Press the bottom menu Time Burst button. In time burst mode, the signal is output for the duration set with the Time side menu.

☐ **Step 9:** Press the side menu Source button repeatedly to select Internal (see Figure 1-16). You can also select the trigger source with the general purpose knob.

☐ **Step 10:** Press the side menu Trigger Period button.

☐ **Step 11:** Set the internal trigger repetition period using the numeric keys or the general purpose knob. The internal trigger period is set to the same value for CH1 and CH2.

☐ **Step 12:** Press the side menu CH Time button. Check that the CH1 side is displayed in reverse video.

☐ **Step 13:** Set the CH1 signal output time using the numeric keys or the general purpose knob.

☐ **Step 14:** Press the side menu CH Time button to switch the reverse video display portion to the CH2 side.

☐ **Step 15:** Set the CH2 signal output time using the numeric keys or the general purpose knob.

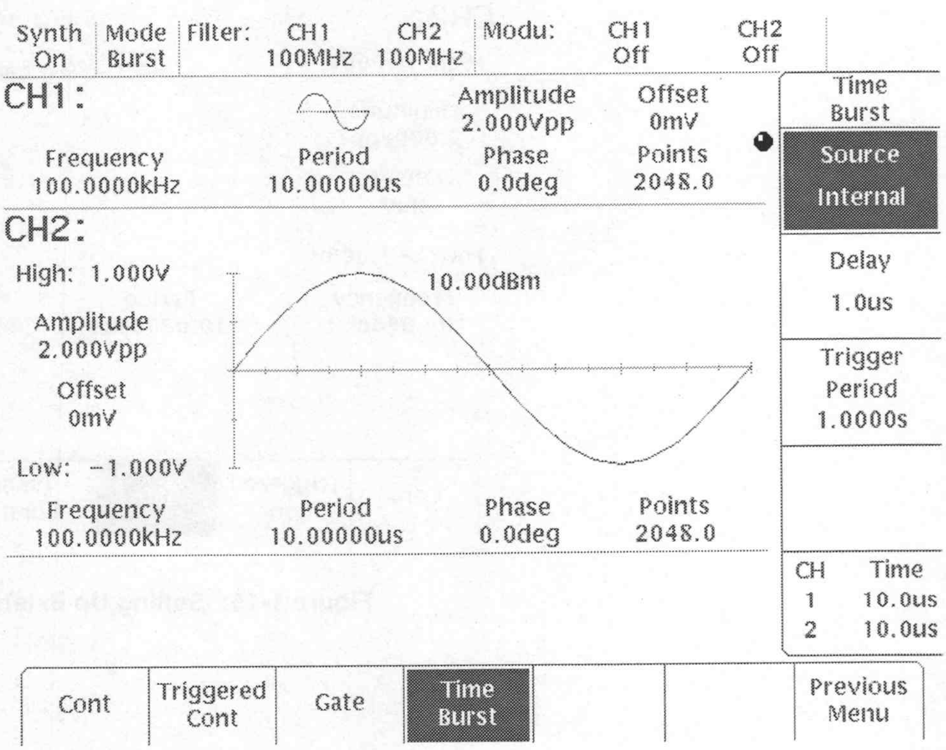


Figure 1-16: Setting Up Internal Source in Time Burst Mode

The ranges for the trigger period, the delay, and the channel signal output time influence each other under the conditions given in the equation below. When the sweep function or the modulation function (except for AM modulated with an external signal or CH1 signal) is On, the CH Time setting is ignored and one sweep repetition or one modulation signal repetition or one sequence is output.

Trigger Period > Delay + Time + 2.5 μsec.

Example 5: Setting Standard Sweep Parameters

In this example, you will learn to set sweep for the CH1 waveform signal. The sweep is set with a Sweep frequency from 1 MHz to 2 MHz in 10 kHz steps, a Dwell Time Sweep of 100.0 μsec, and a Dwell Time Return of 1 μsec. Also, a marker is set at the center of the sweep.

Additionally, if you have Option 02 (CH2) installed, steps are included to show you how to synchronize a ramp output from CH2 with the CH1 frequency sweep.

Use the SWEEP menu to set sweep parameters by performing these steps:

☐ **Step 1:** Initialize the settings to their default conditions using the Init function in the Utility menu, as described in Example 1.

☐ **Step 2:** Press the SWEEP button in the MENU column on the front panel.

☐ **Step 3:** Press the bottom menu Channel button to set the reverse video display portion to the CH1 side.

☐ **Step 4:** Press the bottom menu Dwell Time button.

☐ **Step 5:** Check that the side menu Sweep column is displayed in reverse video.

☐ **Step 6:** Set the dwell time per step to 100.0 μs (see Figure 1-17) using the numeric keys or the general purpose knob.

NOTE

When changing the value with the general purpose knob, the digit over the underscore in the numeric input column is changed with each detent change of the knob. The position of the underscore is moved with the front panel left (←) or right ( ) arrow buttons.

☐ **Step 7:** Press the side menu Return button.

☐ **Step 8:** Set the dwell time per step to 1.0 μs using the numeric keys or the general purpose knob.

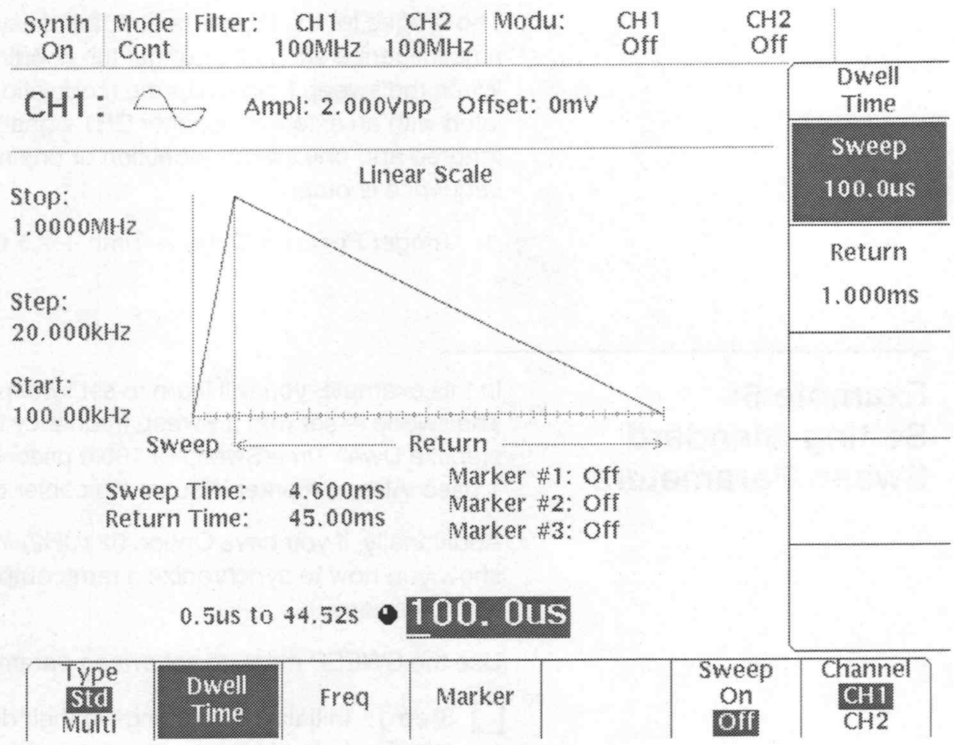


Figure 1-17: Dwell Time Menu

☐ **Step 9:** Press the bottom menu Freq button, then check that the side menu START column is displayed in reverse video (see Figure 1-18).

☐ **Step 10:** Set the sweep start frequency to 1.0000 MHz using the numeric keys or the general purpose knob.

☐ **Step 11:** Press the side menu Stop button.

☐ **Step 12:** Set the sweep end frequency to 2.0000 MHz using the numeric keys or the general purpose knob.

☐ **Step 13:** Check that the reverse video display portion is set to Linear label in the Spacing column of the side menu.

☐ **Step 14:** Press the side menu Step button.

☐ **Step 15:** Set the sweep step frequency to 10.000 kHz (see Figure 1-18) using the numeric keys or the general purpose knob.

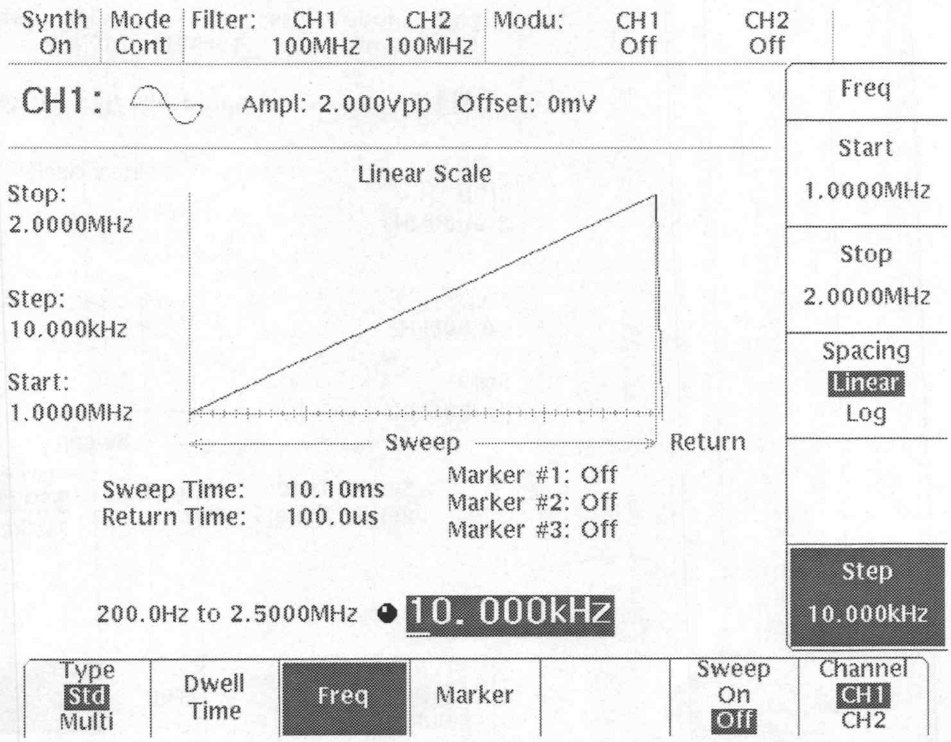


Figure 1-18: Freq Menu

Thus far, you have set a linear sweep from 1 MHz to 2 MHz in 101 steps of 10 kHz each and with a return from 2 MHz to 1 MHz in 100 steps of 10 kHz each. The sweep time is 10.10 msec. (100 μs × 101) and the return time is 100.0 msec. (1 μs × 100).

Now, select a marker pulse and set its parameters.

- ☐ **Step 16:** Press the bottom menu Marker button.
- ☐ **Step 17:** Press the side menu Selected Marker # button to select Marker #2, either by repeatedly pressing the Selected Marker # button or by turning the general purpose knob (see Figure 1-19).
- ☐ **Step 18:** Press the side menu State button to set the reverse video display portion to the On side.
- ☐ **Step 19:** Press the side menu Frequency button.
- ☐ **Step 20:** Set the marker position to a frequency value of 1.500 MHz using the numeric keys or the general purpose knob.
- ☐ **Step 21:** Press the side menu Time button.
- ☐ **Step 22:** Set the marker time to 1.000 ms using the numeric keys or the general purpose knob (see Figure 1-20).

  These marker settings cause the sweep to stop for 1 ms when the sweep frequency reaches 1.5 MHz; then it starts the sweep again.

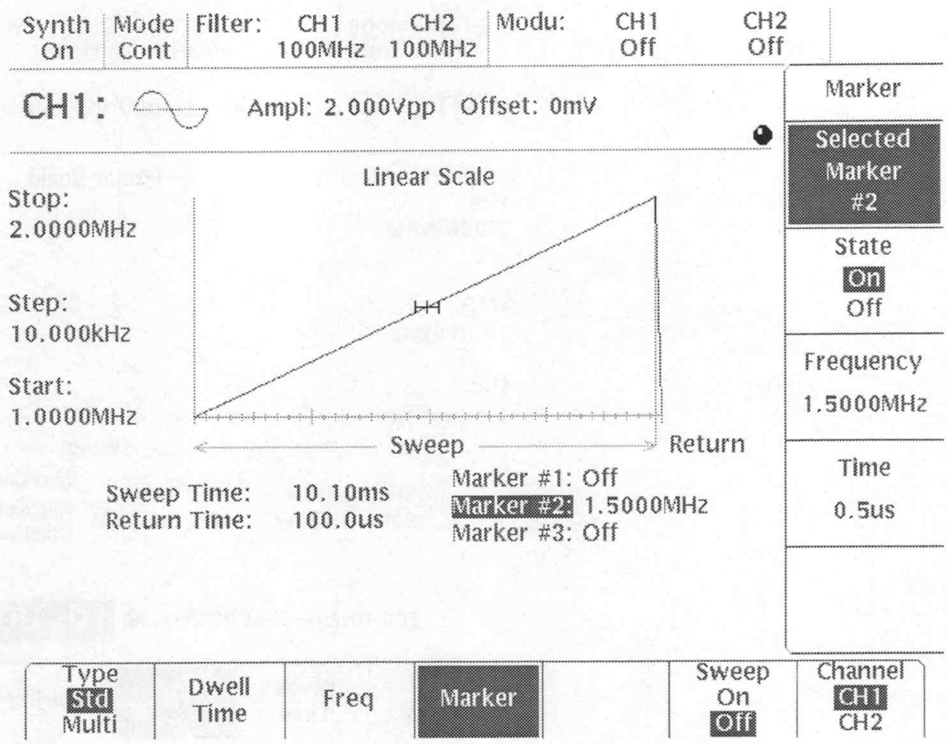


Figure 1-19: Marker Setting

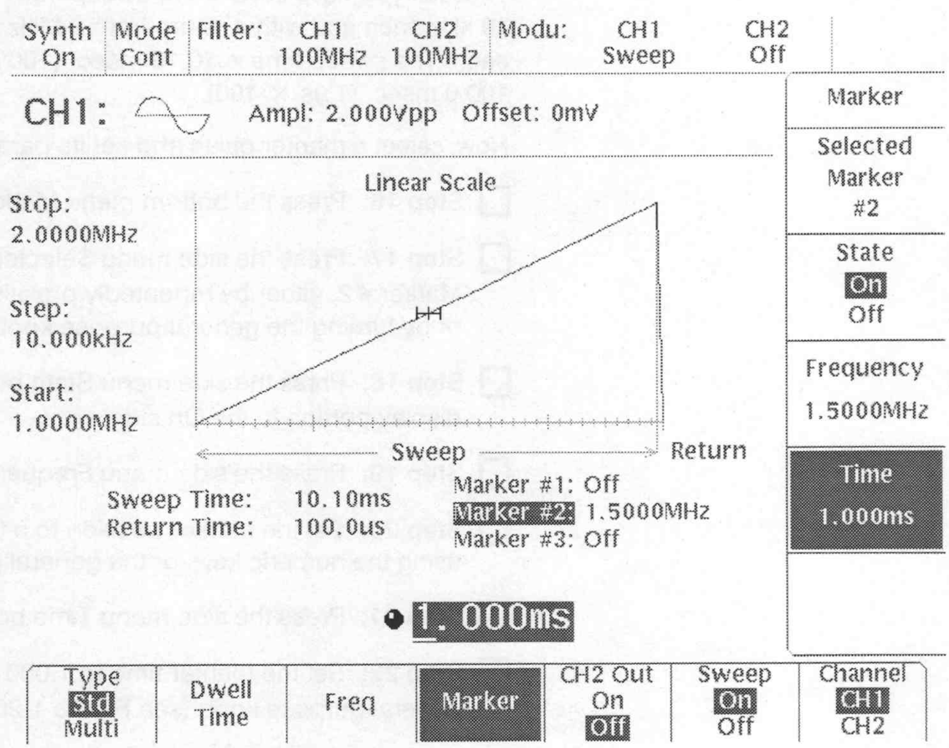


Figure 1-20: Setting the Sweep Function On

☐ **Step 23:** Press the bottom menu Sweep button to set the reverse video display portion to the On side. The frequency sweep output is obtained for the CH1 waveform.

If you have Option 02 is installed, perform the following steps to synchronize a ramp waveform from the CH2 output connector with the CH1 sweep.

☐ **Step 24:** When the CH1 sweep function is set On, the CH2 Out On/Off item is added to the bottom menu (see Figure 1-20). Press the CH2 Out button to switch the reverse video display portion to the On side.

The ramp signal at the CH2 connector begins at −1.000 V, which corresponds to the start frequency at CH1. The ramp signal ends at +1.000 V, which corresponds to the stop frequency at CH1. When a Marker is turned On, the marker signal is added to the ramp. This causes the ramp voltage to remain constant at the point corresponding to the marker frequency for the duration of time specified for the marker.

Example 6: Setting Multiple Sweep

This example presents the procedure for applying multi-sweep to the CH1 waveform signal. Multi-sweep is a technique in which several types of sweep with differing parameters are programmed (with up to 16 steps). Then the individual sweeps are output sequentially according to the program.

☐ **Step 1:** Press the SWEEP button in the MENU column on the front panel.

☐ **Step 2:** Press the Channel button on the bottom menu to set the reverse video display to the CH1 side.

☐ **Step 3:** Press the Type button on the bottom menu switch to multi-sweep.

A table for programming multi-sweep will be displayed on the screen. The side menu is used for editing the table. Parameter values are set using the cursor and the numeric keys.

A reverse video display cursor and a box cursor, which surrounds numbers with a square frame, are displayed in the table. Only one line of sweep parameters are setup as defaults.

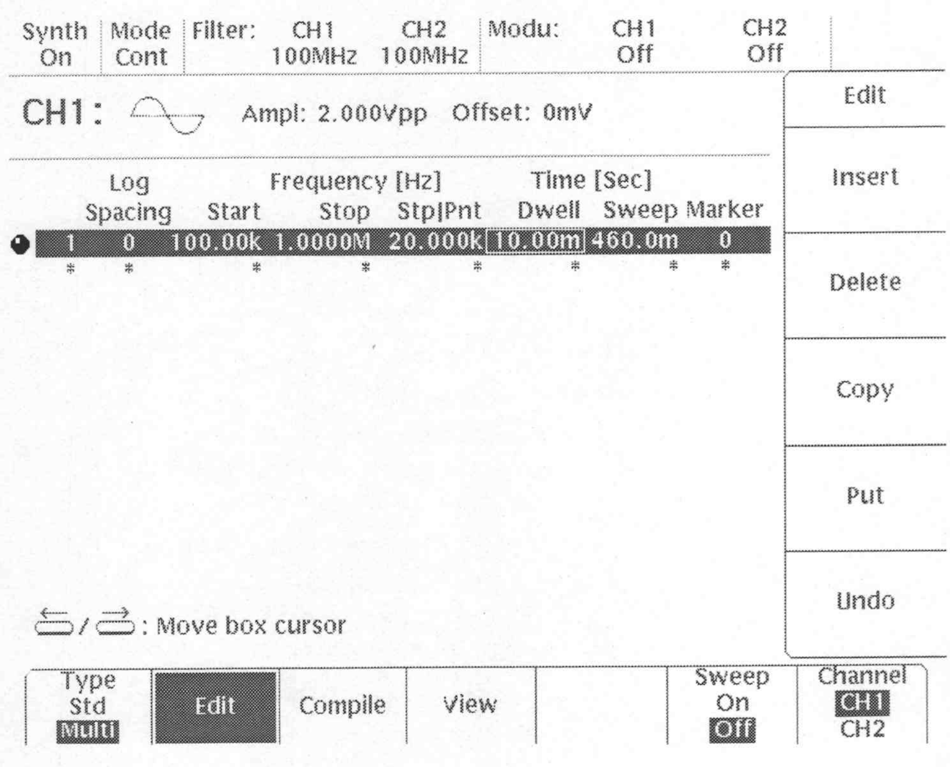


Figure 1-21: Multiple Sweep Menu

☐ **Step 4:** Press the Insert key on the side menu to add a single sweep line.

The new line will be inserted at the line immediately preceding the reverse video display cursor.

☐ **Step 5:** Move the reverse video display cursor to the first sweep line using the general purpose knob.

☐ **Step 6:** Move the box cursor to the Dwell column in the table using the arrow keys.

The box cursor will move quickly if an arrow key is held down.

☐ **Step 7:** Press the 2 and ENTER keys, in that order, on the front panel numeric keys to insert 2.000 m in the Dwell column. Instead of using ENTER key, the kHz/ms/mV key can be used to achieve the same result.

The frequency of the actual sweep waveform changes in steps. The Dwell parameter expresses the time spent at each step.

The ENTER key confirms the prior unit when only the value of the number, and not the units, is to be changed.

Press the Undo key on the side menu to return to the prior value after a new value has been entered and confirmed.

☐ **Step 8:** Move the box cursor to the Marker column in the table by pressing the right arrow key.

☐ **Step 9:** Enter 1 in the Marker column using the numeric keys on the front panel.

The marker settings are 1 for on and 0 for off. The entry is confirmed as soon as the numeric key is pressed without the use of the ENTER key.

When the Marker column is set to 1, a high level TTL signal will be output from the marker output connector during the period that the corresponding sweep is output.

☐ **Step 10:** Move the reverse video display cursor in the table to the second sweep line using the general purpose knob.

You can also move the reverse video display cursor in the table using the arrow keys. If the box cursor is in the Marker column, pressing the right arrow key will move the reverse video display cursor to the next row. If the box cursor is in the Log Spacing column, pressing the left arrow key will move the reverse video display cursor to the previous row.

☐ **Step 11:** Move the box cursor to the Stp|Pnt column using the arrow keys.

☐ **Step 12:** Press the 5 and ENTER keys, in that order, on the front panel numeric keys to insert 5.0000 k in the Stp|Pnt column. The kHz/ms/mV key can be used to confirm the prior unit.

The frequency of the actual sweep waveform changes in steps. The Stp|Pnt parameter expresses the size of the frequency change for each step in a linear sweep.

☐ **Step 13:** Move the box cursor to the Dwell column using the arrow keys.

☐ **Step 14:** Press the 1 and ENTER keys, in that order, on the front panel numeric keys to insert 1.000 m in the Dwell column.

☐ **Step 15:** Press the Copy key on the side menu. When the Copy key is pressed, the data from the line indicated by the reverse video display cursor is copied to a buffer. This operation does not change the screen display.

Once the copy operation has been performed, the contents of the buffer can be inserted or written over existing data using the Insert or Put keys.

☐ **Step 16:** Use the general purpose knob to move the reverse video display cursor to a line that has an asterisk displayed.

☐ **Step 17:** Press the Insert key to add another sweep line. The copied data will be inserted as the third line.

☐ **Step 18:** Move the box cursor to the Log Spacing column using the arrow keys.

☐ **Step 19:** Enter 1 in the Log Spacing column using the numeric keys on the front panel.

The spacing settings are 1 for logarithmic sweep and 0 for linear sweep. The entry is confirmed as soon as the numeric key is pressed without the use of the ENTER key.

☐ **Step 20:** Move the box cursor to the Stp|Pnt column using the arrow keys.

☐ **Step 21:** Press the 2, 0, 0, and ENTER keys, in that order, on the front panel numeric keys to insert 200 in the Stp|Pnt column.

The frequency of the actual sweep waveform changes in steps. The Stp|Pnt parameter specifies the number of steps per decade (a frequency range where the frequency changes by a factor of 10 or 1/10) for a logarithmic sweep.

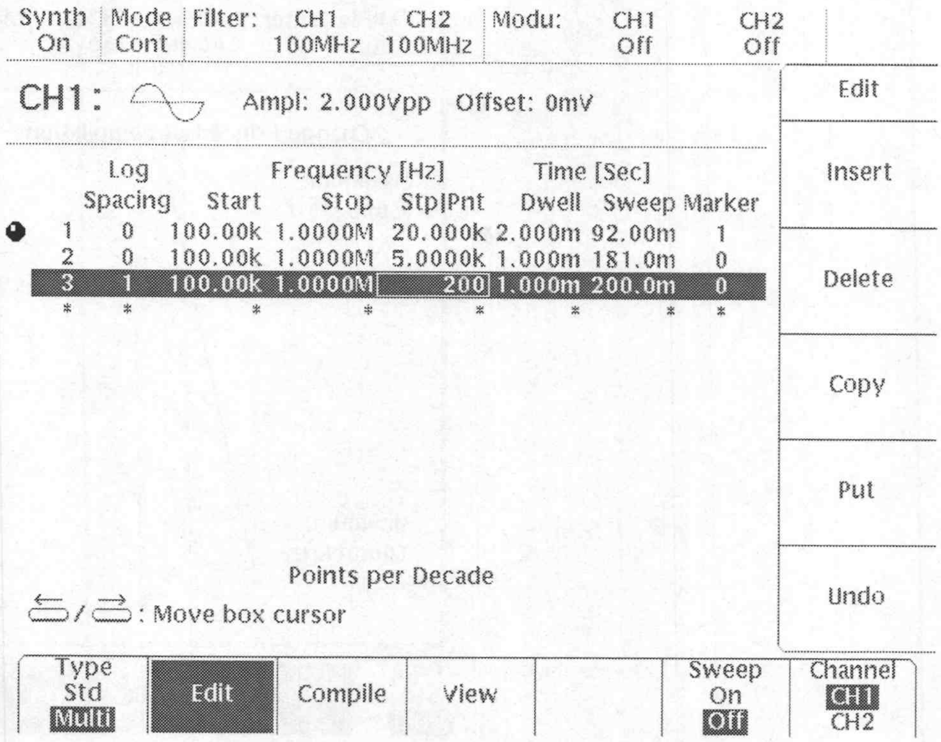


Figure 1-22: Screen Display for Setting the Parameter Values

☐ **Step 22:** Press the View key on the bottom menu. The View key allows the multi-sweep to be verified graphically (see Figure 1-23).

In this example, three sweep types are combined in a multiple sweep. Since the marker is set for the first sweep, it is displayed at a higher intensity. A linear sweep is displayed as a straight line and a logarithmic sweep as a curved line.

☐ **Step 23:** Press either the Continue button on the side menu or the Edit button on the bottom menu to return to table edit mode.

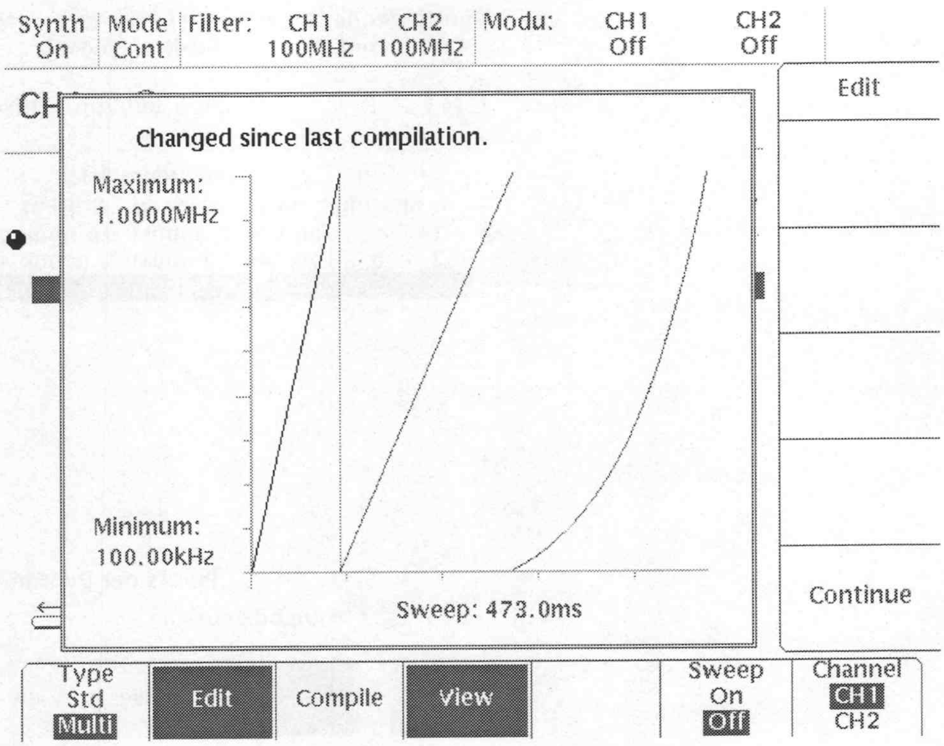


Figure 1-23: Screen Display for Selecting the View Menu

- [ ] **Step 24:** Press the Compile button on the bottom menu to compile the input data.

- [ ] **Step 25:** Press the Sweep button on the bottom menu to switch the reverse video display to the On item. The CH1 signal sweep output can now be acquired.

Example 7: Setting Analog Modulation

In this example, you will learn to set AM modulation for a CH1 waveform with a 1 MHz carrier signal, a 0.8V amplitude, and a modulation of 25% depth by a 10 kHz sine wave.

Use the OUTPUT and MODULATE menus to create an AM signal at the CH1 Output connector by performing the following steps:

☐ **Step 1:** Initialize the settings to their default conditions using the Init function in the Utility menu, as described in Example 1.

☐ **Step 2:** Press the OUTPUT button in the MENU column on the front panel.

☐ **Step 3:** Check that the reverse video display portion is on the CH1 side in the bottom menu Channel column (see Figure 1-24).

☐ **Step 4:** Check that the bottom menu Freq/Phase column and the side menu Frequency column are displayed in reverse video. Then, set the frequency to 1 MHz using the numeric keys or the general purpose knob.

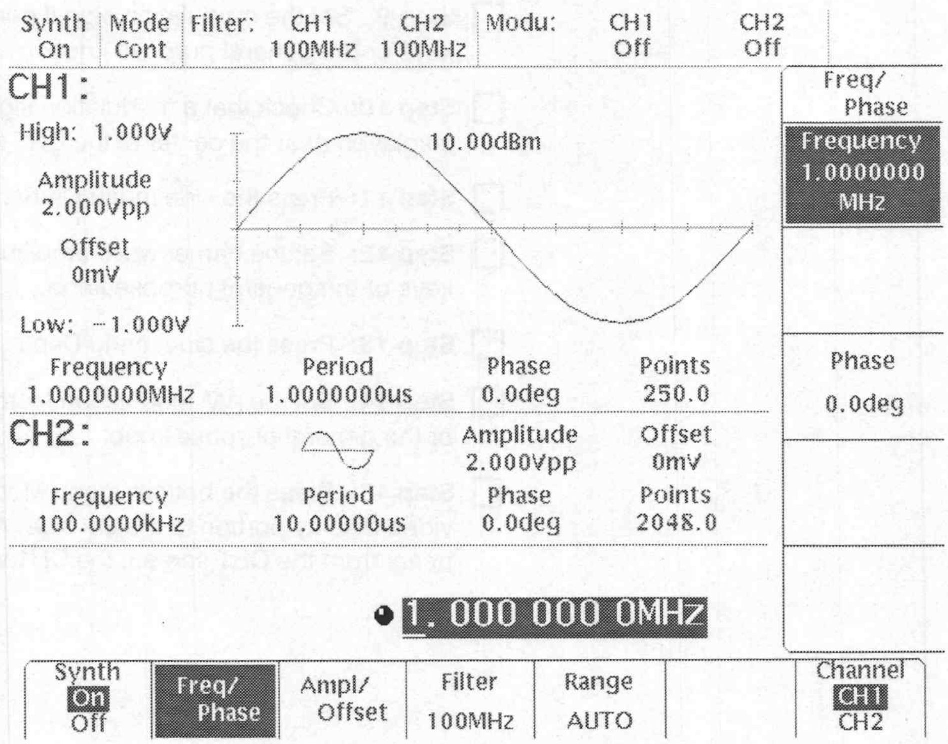


Figure 1-24: Setting Carrier Wave Frequency

NOTE

When changing the value with the general purpose knob, the digit over the underscore in the numeric input column is changed with each detent change of the knob. The position of the underscore is moved with the front panel left (←) or right ( ) arrow buttons.

☐ **Step 5:** Press the MODULATE button in the MENU column on the front panel.

☐ **Step 6:** Verify that the AM label is displayed in the bottom menu Type column, and the Sine label is displayed in the bottom menu Signal column.

If different labels are displayed, correct the selections with the corresponding menus.

☐ **Step 7:** Press the bottom menu Params button (see Figure 1-25).

☐ **Step 8:** Press the side menu Signal Period button.

☐ **Step 9:** Set the modulation signal period to 100 μs using the numeric keys or the general purpose knob.

☐ **Step 10:** Check that a modulation signal frequency of 10.00 kHz is displayed near the center of the CRT screen.

☐ **Step 11:** Press the side menu Carrier Amplitude button.

☐ **Step 12:** Set the carrier wave amplitude to 800 mV_{p-p} using the numeric keys or the general purpose knob.

☐ **Step 13:** Press the side menu Depth button.

☐ **Step 14:** Set the AM modulation factor to 25% using the numeric keys or the general purpose knob.

☐ **Step 15:** Press the bottom menu Modulate button to set the reverse video display portion to the On side. After the busy clock icon disappears from the CRT screen, the CH1 waveform AM output is obtained.

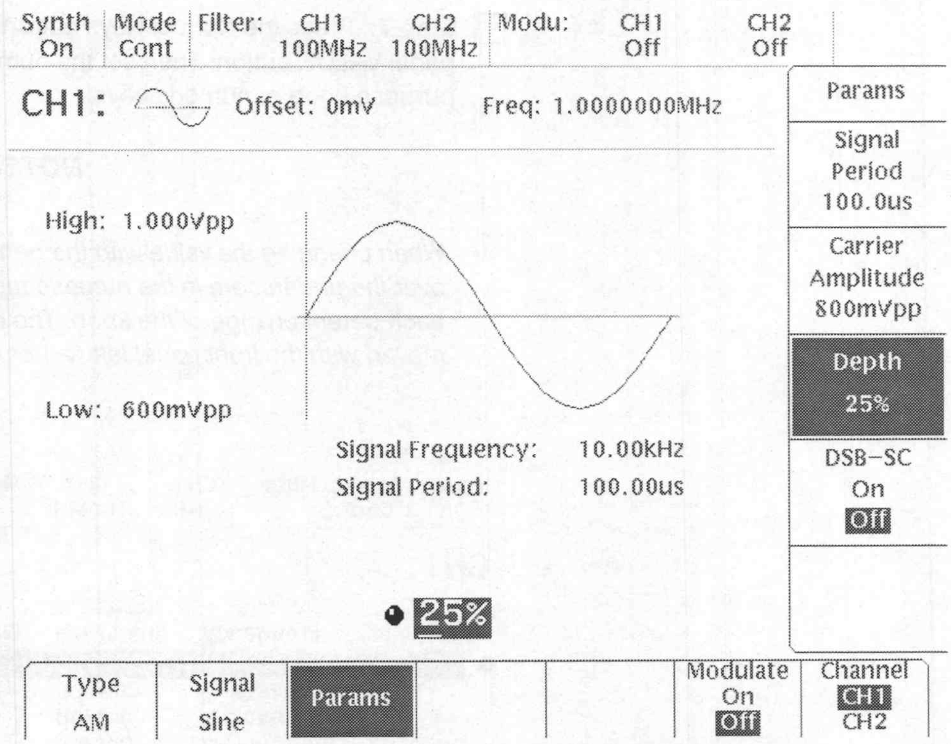


Figure 1-25: AM Parameter Setting

Example 8: Setting Digital Modulation

In this example, you will learn to set digital modulation for a CH1 waveform. This includes frequency shift keying functions for selecting the number of keys and setting their modulation deviation parameters and for creating the key sequence with a data length of eight bits.

Use the MODULATE menu to set digital modulation parameters by performing these steps:

☐ **Step 1:** Initialize the settings to their default conditions using the Init function in the Utility menu, as described in Example 1.

☐ **Step 2:** Press the MODULATE button in the MENU column on the front panel.

☐ **Step 3:** Press the Channel button in the bottom menu to set the reverse video display portion to the CH1 side.

☐ **Step 4:** Press the bottom menu Type button.

☐ **Step 5:** Press the FSK button in the side menu to select FSK modulation. The FSK label is displayed in the bottom menu Type column.

☐ **Step 6:** Press the Key button in the bottom menu to display the table for setting the modulation deviation parameters for the keys (see Figure 1-26).

☐ **Step 7:** Press the Num of Keys button in the side menu, or the front panel VALUE button. Then set the number of keys to 4 using the general purpose knob or numeric keys.

NOTE

When changing the value with the general purpose knob, the digit over the underscore in the numeric input column is changed with each detent change of the knob. The position of the underscore is moved with the front panel left (←) or right ( ) arrow buttons.

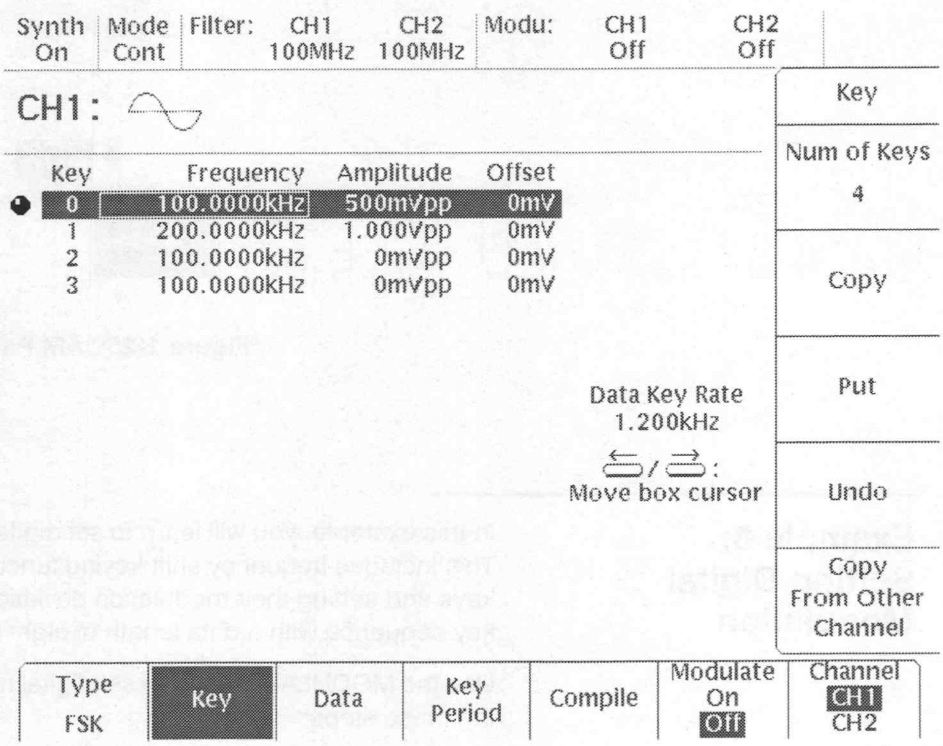


Figure 1-26: Key Menu

☐ **Step 8:** Press the CURSOR button to allocate the function of moving the reverse video display cursor to the general purpose knob again.

☐ **Step 9:** Turn the general purpose knob to scroll the reverse video display cursor within the table and select the Key 0 row.

☐ **Step 10:** Use the arrow buttons to move the frame cursor to the Frequency parameter.

☐ **Step 11:** Use the front panel numeric keys to input the numeric value into the table. Then press a unit key or the ENTER key to enter the numeric value.

☐ **Step 12:** Use the arrow buttons to move the frame cursor to the Amplitude parameter. Then enter the input value with the method given in step 11.

☐ **Step 13:** Repeatedly press the right arrow button, or use the general purpose knob, to move the reverse video display cursor to the next Key number.

☐ **Step 14:** Repeat steps 10–13 to input the deviation parameter for up to Key 3.

So far, you have set the desired frequency and amplitude to the individual Key number from 0 to 3.

☐ **Step 15:** Press the Data button in the bottom menu to display the Data table for setting the key sequence (see Figure 1-27).

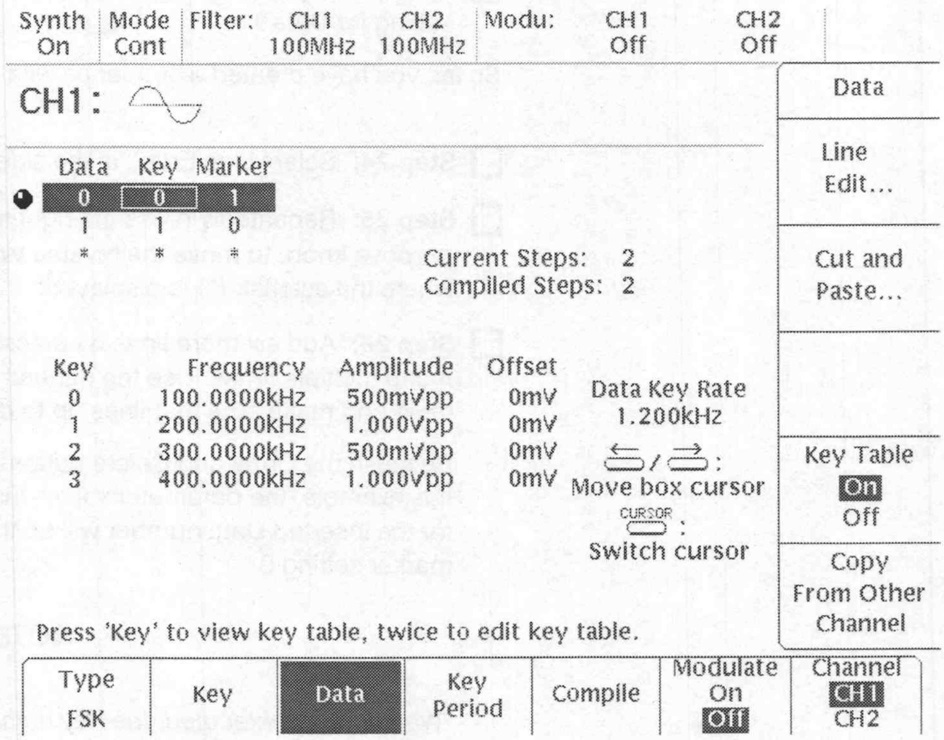


Figure 1-27: Data Menu

☐ **Step 16:** Press the Key Table button on the side menu to switch the reverse video display to the On item. The deviation parameter table defined using the key (bottom) menu will be added to the display. This table will be referred to when inputting the key number in step 20.

☐ **Step 17:** Press the Data button on the bottom menu once again to move the knob icon from the Key table to the Data table.

☐ **Step 18:** Turn the general purpose knob to scroll the reverse video display cursor within the table and select the Data 0 row.

☐ **Step 19:** Use the arrow buttons to move the frame cursor to the Key parameter column in the table.

☐ **Step 20:** Use the front panel numeric keys to input any Key number from 0 to 3. Then press the ENTER key to enter the input number.

☐ **Step 21:** Use the arrow buttons to move the frame cursor to the Marker parameter. If a marker is needed for the Data number, enter 1 into the Marker parameter column with the numeric keys. If the marker is not needed, enter 0.

☐ **Step 22:** Repeatedly press the right arrow button, or use the general purpose knob, to move the reverse video display cursor to the next Data number.

☐ **Step 23:** Repeat Steps 19–22 to enter the Key number and Marker setting for Data 1.

So far, you have created a sequence with a data length of two.

☐ **Step 24:** Select Line Edit... in the side menu.

☐ **Step 25:** Repeatedly press the right arrow button, or use the general purpose knob, to move the reverse video display cursor to the row where the asterisk (*) is displayed.

☐ **Step 26:** Add six more lines by pressing the Insert button in the side menu multiple times. Use the general purpose knob to scroll the data table and make sure that lines up to data number 7 have been added.

Because the Copy and Delete buttons have not been pressed during this example, the parameter values inserted to the parameter columns for the inserted Data number will be the data for key number 0 and marker setting 0.

NOTE

When copy is executed, the Key number and Marker setting data at the reverse video display cursor is stored into the copy buffer. Then pressing the Insert button causes the contents of the copy buffer to be inserted at the Data number displayed in reverse video.

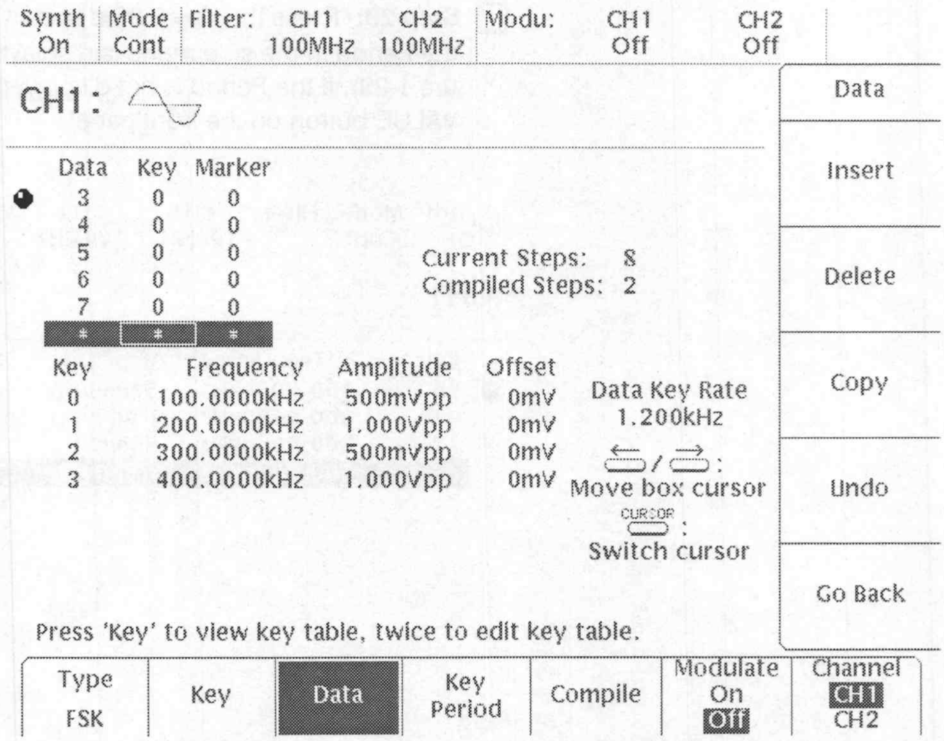


Figure 1-28: Sub Menu of Line Edit...

☐ **Step 27:** If too many lines were added, use the general purpose knob to move the reverse video display cursor to data number 8. Then use the Delete key to delete the excess lines.

NOTE

If unnecessary Data numbers are displayed, repeatedly press the arrow button or use the general purpose knob to move the reverse video display cursor to that Data number line. Then press the Delete button in the side menu to delete the Data number. Whenever executing the Delete operation, the length of the sequence is reduced by one line.

☐ **Step 28:** Repeat Steps 19–22 to input the parameter values for Data numbers up to 7.

Thus far, you have created a sequence of 8 data items for Keys 0 to 3.

☐ **Step 29:** Press the Key Period button on the bottom menu. Check that the Period in the side menu is displayed in reverse video (see Figure 1-29). If the Period is not displayed in reverse video, press the VALUE button on the front panel.

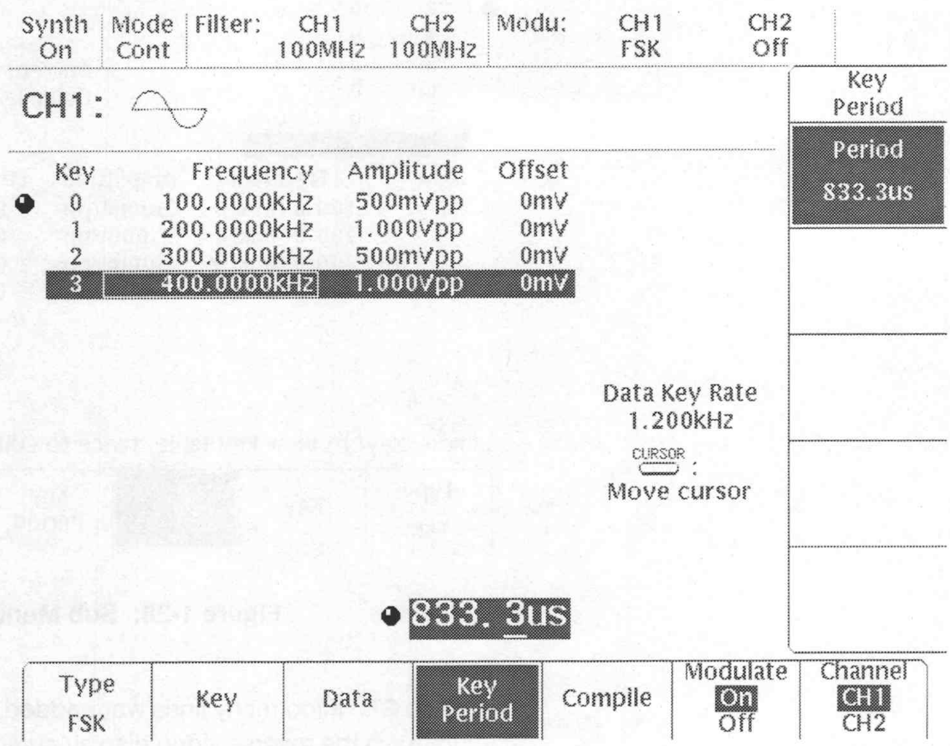


Figure 1-29: Key Period Menu

☐ **Step 30:** Set the period for changing keys using the numeric keys or general purpose knob.

The value of Data Key Rate, the reciprocal number of Key Period, is also displayed on the CRT screen.

☐ **Step 31:** Press the Compile button in the bottom menu to compile the settings you have input during this procedure.

☐ **Step 32:** Press the Modulate button in the bottom menu to set the reverse video display portion to On. When the busy clock icon on the CRT screen disappears, the FSK modulation of CH1 waveform is obtained.

Example 9: Setting Synchronized Parallel Operation

To get accurate output timing from each AFG2020 in a multiple, parallel configuration, connect the AFG2020s as shown in Figure 1-30. This example shows the connections among three AFG2020s. Instrument A is the master unit and instruments B and C are slave units. In this example, you will learn to make the menu settings necessary to operate this configuration. You will need an external trigger source for this example.

☐ **Step 1:** Connect the 10MHz OUT clock signal from A to REF IN on B. Connect the 10MHz OUT clock signal from B to REF IN on C. See Figure 1-30.

NOTE

A 50 Ω BNC cable has a delay of 5 ns per meter. Connect the clock signals with as short cable as possible.

☐ **Step 2:** Connect the SYNC output from A to the INPUT connector (external trigger input) on B. Connect the SYNC output from B to the INPUT connector on C. See Figure 1-30.

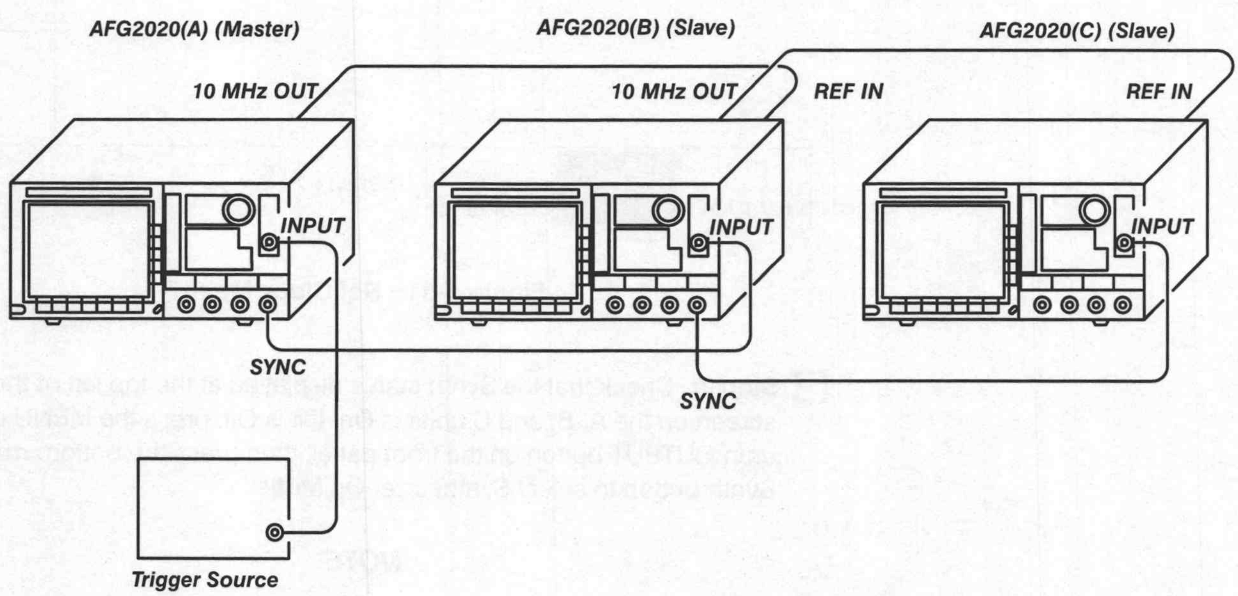


Figure 1-30: Example of Connections for Parallel Operation

☐ **Step 3:** Check that the EXT CLK icon is not displayed on the upper right of the A (master unit) CRT screen.

When this icon is displayed, the clock source is External. You must switch the clock source to Internal for this procedure. Use the method described in steps 4–6, but select Internal (not External) from the side menu of the A unit.

☐ **Step 4:** Press the UTILITY button in the MENU column of the B unit.

☐ **Step 5:** Press the bottom menu Ref Clock button (see Figure 1-31).

☐ **Step 6:** Press the External button in the side menu to set the B unit Ref clock (clock source) to External.

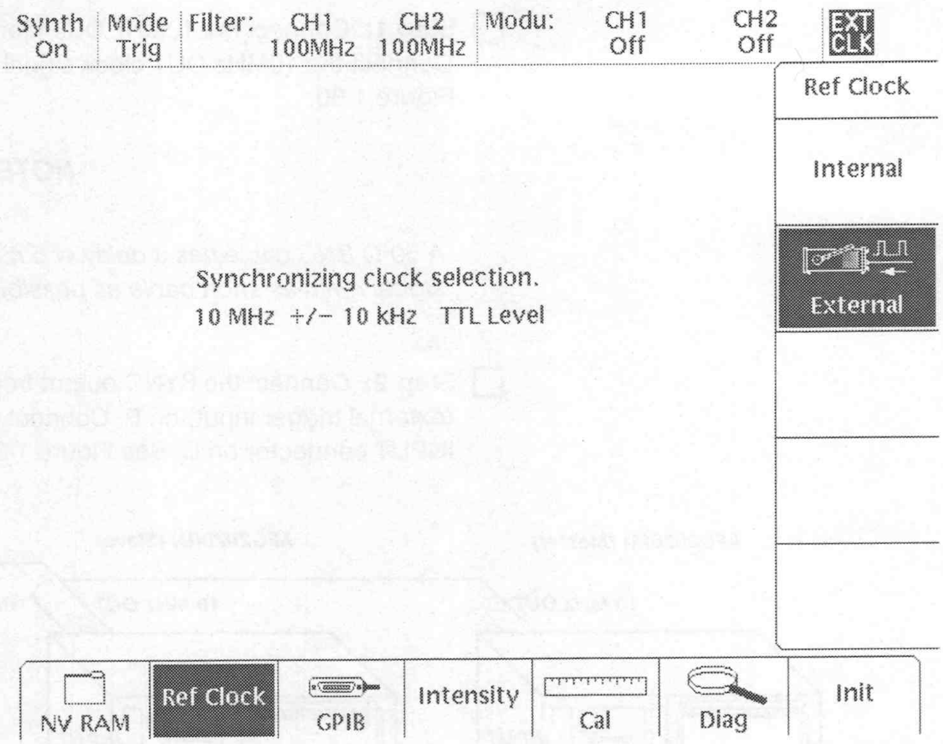


Figure 1-31: Ref Clock Menu

☐ **Step 7:** Check that the Synth status displayed at the top left of the CRT screen on the A, B, and C units is On. If it is Off, press the MENU column OUTPUT button on the front panel, then press the bottom menu Synth button to select Synthesizer On Mode.

NOTE

Synchronized operations are only valid in Synthesizer On Mode. In Synthesizer Off Mode, there is no synchronization because the internal clock for reading out waveform data is not fixed at 250 MHz.

☐ **Step 8:** In the same manner as in steps 4–6, set the C unit Ref Clock (clock source) to External.

☐ **Step 9:** Press the MODE button in the TRIGGER column of the A unit front panel.

☐ **Step 10:** Press the Triggered Cont button in the bottom menu (see Figure 1-32).

☐ **Step 11:** After pressing the side menu Source button of the A unit, press the Source button again, or use the general purpose knob to set the trigger source to External.

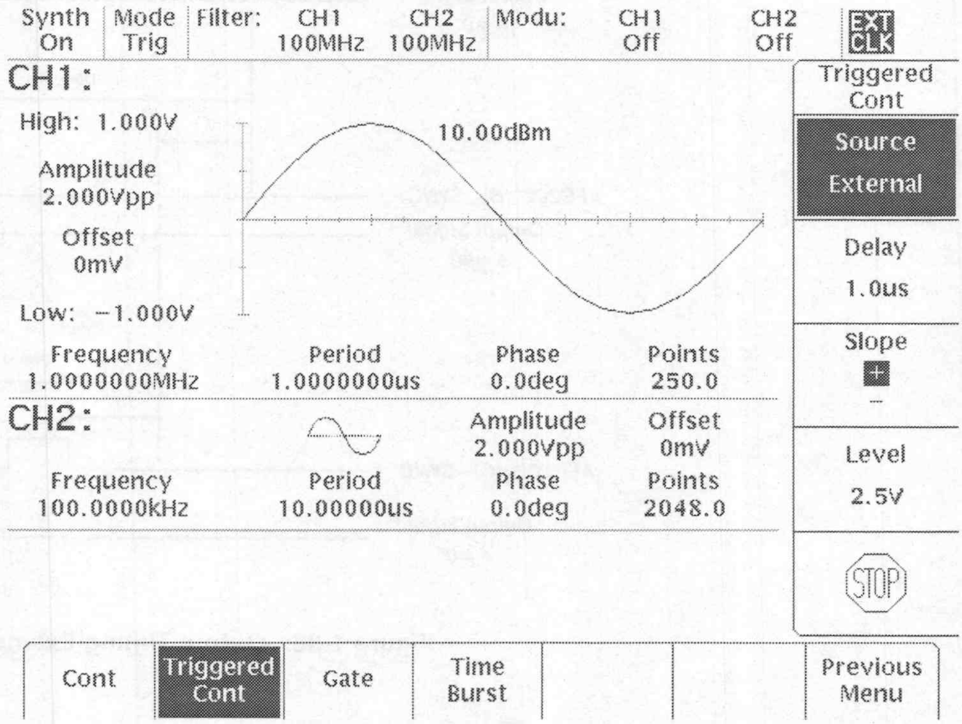


Figure 1-32: Triggered Cont Mode Menu

☐ **Step 12:** Using the same procedure as in steps 9–11, set the trigger source for the B and C units to External.

☐ **Step 13:** Connect an appropriate trigger signal source to the INPUT connector of the A unit.

☐ **Step 14:** Set the trigger slope and level for the A, B, and C units with the side menu.

☐ **Step 15:** Adjust the delay time for the A, B, and C units to set the desired start timing of output from each unit.

☐ **Step 16:** Apply a trigger signal to the A unit. The A, B, and C units will start synchronized operation.

Figure 1-33 shows the same output timing for the three units with a given external trigger applied to unit A.

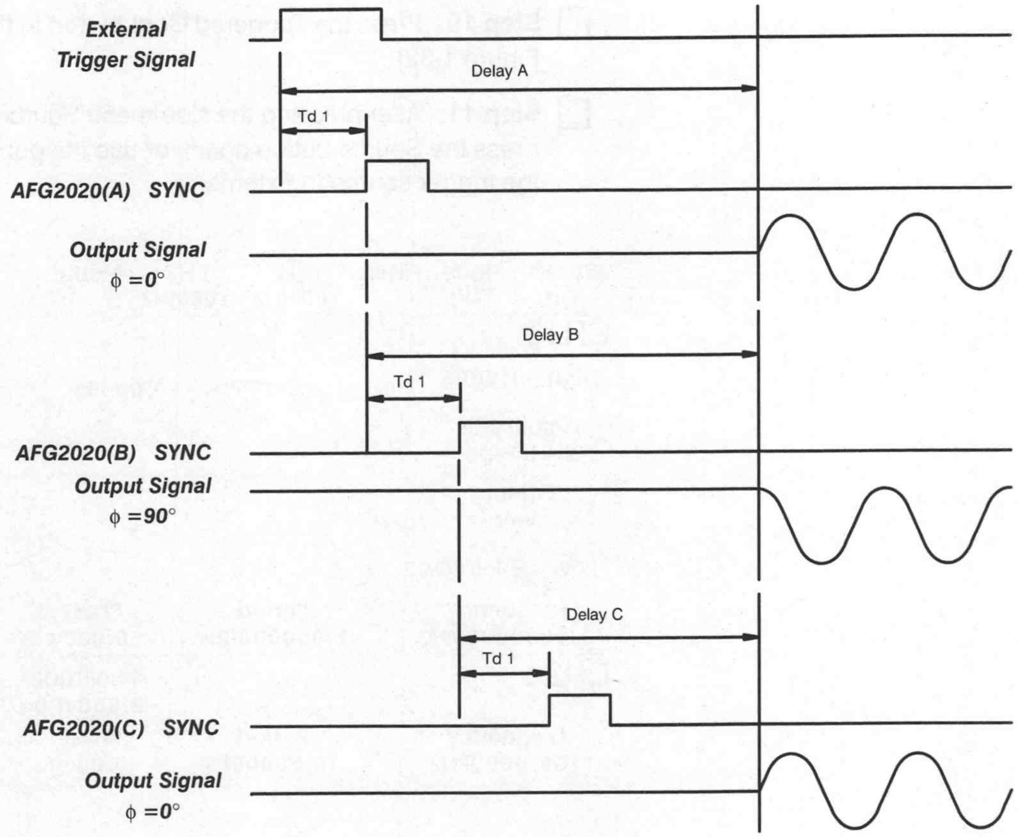


Figure 1-33: Output Timing Example for Parallel Operation

☐ **Step 17:** Press the STOP button in the side menu to stop the signal output.

Operating Basics

Basic Menu Operation

This section begins by describing the general menu operations. The menu operation description is followed by how to use the front panel general purpose knob and numeric keys to make selections and enter data.

Menu Operation

The AFG2020 settings and operations are carried out through a menu system. The main menus are accessed by pressing the corresponding MENU button (FUNCTION, OUTPUT, SWEEP, MODULATE, EDIT, UTILITY) or by pressing the TRIGGER MODE button. Each of the main menu buttons has an indicator on the left. While a main menu is selected, its indicator is lit.

The bottom menu items are displayed along the bottom of the CRT screen and the side menu items along the right side. Menu items on the CRT screen are selected by pressing the corresponding CRT bezel buttons. There are seven bottom bezel buttons along the bottom menu items and five side bezel buttons along the side menu items.

When one of the bottom menu items is selected, its column is turned to reverse video display and the selection items and numeric items are displayed on the side menu. Some bottom menu columns include a label (name of side menu item) selected with the side menu.

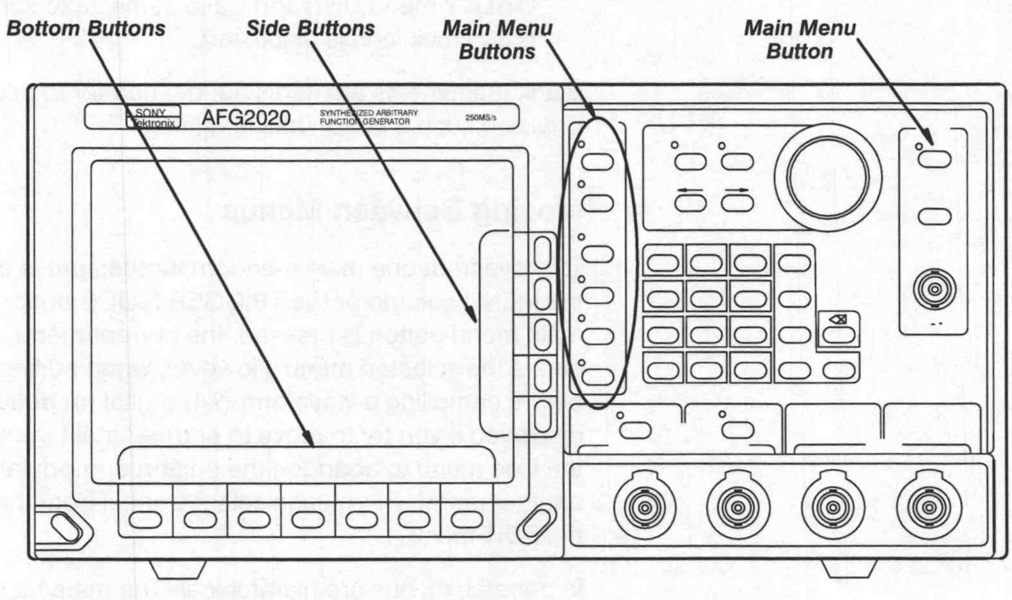


Figure 2-1: Menu Button Locations

There are three types of menu items: selection items, numeric items, and execution items.

1. **Selection Items** — Here are the three ways to select a menu selection item.
   - Press the desired bottom or side menu item button (example: the Filter side menu item in the OUTPUT menu).
   - For two selection options displayed within a menu item, press the corresponding bottom or side menu button to toggle between selections (example: the Channel bottom menu item in the FUNCTION menu).
   - For multiple selection options, either numeric or selection items, rotate the general purpose knob or repeatedly press the corresponding menu item button to cycle through the available settings. In this case, the general purpose knob icon is displayed at the top left of the menu item to indicate you can use the general purpose knob to make selections (example: Selected Marker # item of the Marker side menu in the SWEEP menu).
2. **Numeric Items** — For menu items that require numeric input, press the desired numeric keys or rotate the general purpose knob to change the value (see *Numeric Input Methods* in this section).
3. **Execution items** — Press the menu item button to immediately execute the function. More, Undo, Compile and many EDIT menu items are execution items. In general, execution times are short and the menu item is displayed in reverse video. However, some items, such as the UTILITY menu Diag and Calib items, take some time. In such cases, the busy clock icon is displayed.

Blank menu items are items not defined for the currently selected menu. Pressing such a button has no effect.

Moving Between Menus

To move from one main menu to another, press the corresponding button in the MENU column or the TRIGGER MODE button on the front panel. When a main menu button is pressed, the current menu is ended and the system enters the selected menu. However, when editing in the EDIT menu or before compiling a waveform with digital modulation, a warning message is displayed if you try to move to another main menu. You can select O.K. from the side menu to abandon the editing or modulation data and move to another menu. Or you can select Cancel from the side menu to remain in the EDIT menu.

In general, menus are hierarchical. The main menus are the highest level menus—next are the bottom menus—then the side menus. Some of the side menu items for the EDIT and FUNCTION menus have even lower level menus displayed. Such menus are termed sub-menus.

In general, you move the system to an upper level menu by pressing a main menu button and move to a lower level menu by pressing a bottom or side menu button. However, to return from a current side menu (sub-menu) to the side menu before it, you need to press the Go Back button. The front panel CLEAR MENU button removes the comment input menu and the library menu. It also is used to exit the Interactive diagnostic menu in the UTILITY menu.

Characteristics of the General Purpose Knob and Knob Control Buttons

The general purpose knob is assigned various functions by the different menus. It can control numeric input, cursor movement, selection of characters and items in tables. The knob control buttons are the left and right arrow buttons, the CURSOR button, and the VALUE button. These buttons are used to select the bottom digit of numeric values changed with the general purpose knob and to change the allocation of general purpose knob functions.

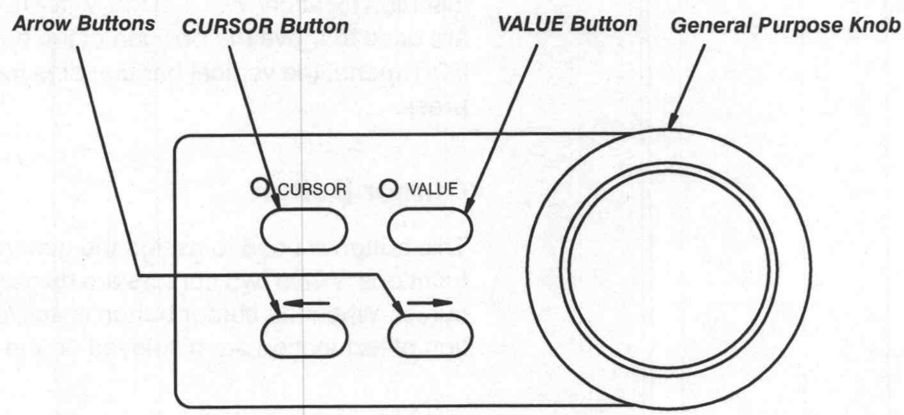


Figure 2-2: General Purpose Knob and Knob Control Buttons

General Purpose Knob

A number of items can be controlled with the general purpose knob. When the general purpose knob is valid, the general purpose knob icon is displayed at high intensity on the screen near the item that can be controlled. CURSOR or VALUE indicators on the front panel light up depending on functions allocated to the general purpose knob. Here are explanations of the main functions of the general purpose knob.

- **Numeric input:** The general purpose knob is used to specify values for the numeric item displayed in reverse video. Turning the general purpose knob clockwise increases the numeric value and turning the general purpose knob counter-clockwise decreases it. The numeric value cannot be changed past the parameter setting range.

- **Item and character selection:** Various tables are displayed for the MODULATE, EDIT, and UTILITY menus. The general purpose knob is used to move the reversed video section or asterisk within the table and thus select an item or character.
- **Cursor movement:** The general purpose knob can move the point cursor and line cursor in waveform graphics.

Arrow Buttons

The left (←) and right (→) arrow buttons are used to move the underscore (horizontal bar cursor) in the input column when a numeric menu item is selected. For details, see *Numeric Input with the General Purpose Knob* in this section.

The ← and → buttons are also used to move the cursor. In this case, the arrow button icon and an explanation of the functions allocated to the buttons are displayed on the screen. For example, in the menu for character input, these buttons are used to move the bar cursor that indicates the insertion location. While in the MODULATE and EDIT menus, these buttons are used to move the position of the box cursor in the table. Also, in the EDIT menu, the vertical bar cursor is moved one point for each arrow button press.

Cursor Button

This button is used to assign the general purpose knob to cursor movement functions. When two cursors are displayed, this button selects the active cursor. When the cursor button is active, the CURSOR icon and an explanation of its function are displayed on the screen.

Value Button

This button is used to assign the general purpose knob to numeric input functions. In the character input menu, the Value button selects the character highlighted in reverse video for insertion into the text being entered. In graphic editing using the Draw function of the EDIT menu, this button combined with the general purpose knob is used to move the point cursor. When the Value button is active, the VALUE icon and an explanation its function are displayed on the screen.

Characteristics of Numeric Input Keys

The keys used for numeric input are the numeric keys (0–9, ".", "–"), the unit keys (ns, MHz/µs, kHz/ms/mV, Hz/sec/V), delete key, and ENTER key.

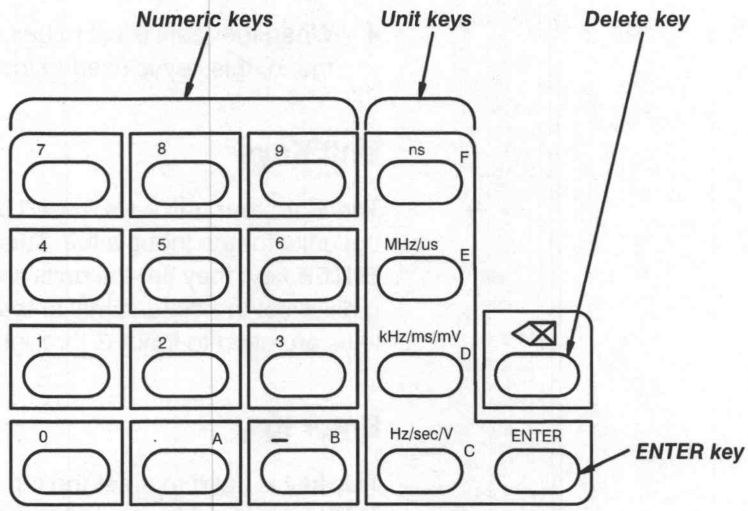


Figure 2-3: Numeric Input Keys

Numeric Keys

These keys — numbers (0–9), decimal points, and minus sign — are used for numeric input. When a numeric menu item is selected, pressing one of the numeric keys puts the system into numeric input mode. The numeric input mode presents the menu item numeric selection in reverse video, located toward the bottom center of the screen, just above the bottom menu items. When the first numeric key is pressed, the numeric selection changes from its initial value to the character just input. After inputting the entire numeric value, press the ENTER key to enter the value. Once entered, the numeric value and units are displayed in the menu item. This new value also changes the related parameter displayed in the status area at the top of the screen and in the channel field on the screen.

"–" Key Characteristics

- The "–" key indicates a minus sign, that is, a negative value (not subtraction).
- Pressing the "–" key over and over toggles the numeric value input between minus and plus. The + sign is not displayed for positive sign.
- For parameters which only take positive values, the "–" key is ignored and cannot be input.
- When the radix is set to hexadecimal in the table display mode of EDIT menu, this key is used to input B.

"." Key Characteristics

- After the "." key has been pressed once, pressing it again has no effect.
- For parameters that take only integer values, the "." key is ignored.
- When the radix is set to hexadecimal in the table display mode of EDIT menu, this key is used to input A.

Unit Keys

There are four unit keys: ns, MHz/μs, kHz/ms/mV, and Hz/sec/V. They set the units for the input value. These keys also have the same function as the ENTER key; they set the units and end input at the same time. When the radix is set to hexadecimal in the table display mode of EDIT menu, these keys are used to input C through F.

Enter Key

This key is used to enter the input value and complete the numeric input. This key is used for items not requiring unit (% or number of times) or for entering numeric values with the same units as for before the system went into numeric input mode.

Delete Key

This key is used for correcting input data. Pressing this key repeatedly deletes the most recent data input (from the right end towards the left).

Numeric Input Methods

There are two methods to change the value of numeric items in the menu: input with the numeric keys and input with the general purpose knob. When a numeric item is selected, the input area (a square frame) is displayed in reverse video near the bottom of the CRT screen, above the bottom menu items. Also, the general purpose knob icon is displayed at the upper left of the input frame. In this frame, the currently set value is displayed with larger than normal numbers. In addition, the VALUE indicator on the front panel lights up to show that numeric input is possible. When a non-numeric menu item is selected, the input frame disappears from the CRT screen. Here are explanations of the features of the numeric keys and the numeric input methods.

Numeric Input with Numeric Keys

Here is the procedure for specifying numeric values using the front panel numeric keys, ENTER key, and unit keys.

☐ **Step 1:** Press the key for the parameter (numeric item in a menu) to be changed.

☐ **Step 2:** Use the numeric keys to input the new value.

☐ **Step 3:** Press a unit key or the ENTER key.

Here are explanations of the features for inputting numeric values using the numeric keys.

Pressing the ENTER key has no effect before the system goes into numeric input mode. However, the unit keys are exceptions. Pressing one of the unit keys before the system goes into numeric input mode changes the unit without changing the numeric value. For example, if 10 Hz is displayed in reversed video, pressing the kHz/ms/mV key changes the display to 10 kHz.

To enter the input value, press the appropriate unit key or ENTER key. Pressing any unit key for an item without units or pressing an inappropriate unit key does not enter the input.

While inputting numbers, if you press any key other than the numeric input keys before pressing the ENTER key or unit key, the input numeric value is canceled and the system returns to the value it had before input. Turning the general purpose knob also cancels the numeric input value.

If you attempt to change to a value outside the available range for a parameter, the value is not changed and the input column returns to the value it had before input mode. In this case, an error message is displayed above the input column.

Even if the numeric value is within the available range, if you attempt to enter a numeric value with more than the valid number of digits, the numeric value is rounded off. For input items that can only take discrete values (not a continuous range of valid input), the input value is rounded to the nearest of the valid discrete values.

Examples for Numeric Input — Here is example using the output amplitude parameter in the OUTPUT menu. The starting value is 456 mV_{p-p} and is to be changed to 123 mV_{p-p}. Pressing the "1", "2", "3", and ENTER keys, in that order, changes the input column value shown in Table 2-1.

Table 2-1: Example 1 for Numeric Value Input

Input Key	Numeric Value Column	Numeric Value Status
	456 mV_{p-p}	Before input
1	1	During input
2	12	
3	123	
ENTER	123 mV_{p-p}	Entered

Here is an example using the Offset parameter. The value is to be changed from 0mV to −30 mV. When the − key is pressed, at any time, it inputs the minus sign. Pressing the ".", "0", "3", "−", and Hz/sec/V keys, in that order, changes the input column value as shown in Table 2-2.

Table 2-2: Example 2 for Numeric Value Input

Input Key	Numeric Value Column	Numeric Value Status
	0 mV	Before input
.	.	During input
0	.0	
3	.03	
—	−.03	
Hz/sec/V	−30 mV	Entered

Pressing the keys in the order "−", "3", "0", kHz/ms/mV also changes the value to −30 mV.

Numeric Input With the General Purpose Knob

The general purpose knob and the ← and → buttons can be used to select items displayed in reverse video. When the general purpose knob is used to change a numeric value, there is no need to press the ENTER key or unit key on the front panel. The numeric input value is entered automatically, even without your pressing the ENTER key or unit key.

General Purpose Knob — You can use the general purpose knob to increase or decrease the value of the underscored digit in the numeric value frame displayed in reverse video. Turning the general purpose knob counter-clockwise decreases the value and turning the general purpose knob clock-wise increases the value. The value cannot be increased or decreased outside of the valid range for the parameter. When attempting to change a value outside the range, an error message is displayed above the numeric input frame.

← and → Buttons — When a numeric item is selected, an underscore (horizontal bar cursor) appears under one of the digits in the numeric value input frame. The general purpose knob can change the value of this digit and those to its left. The position of the underscore is changed with the front panel ← and → buttons. Each time these buttons are pressed, underscore moves left or right by one digit. When the cursor has reached the most significant digit or the least significant digit within the range that can be input, pressing the button again has no effect.

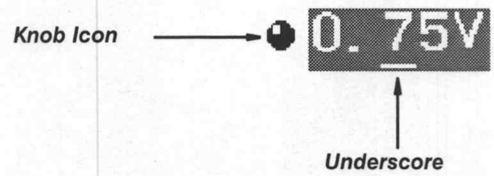


Figure 2-4: Knob Icon and Underscore

Here is how to change a value using the general purpose knob.

- ☐ **Step 1:** Press the button for the parameter (menu item) you want to change.
- ☐ **Step 2:** Press ← or → buttons to specify the least significant digit to be changed.
- ☐ **Step 3:** Turn the general purpose knob to change the value.

Example of Numeric Input — This example shows how the offset value changes in the OUTPUT menu. Initially, the Range is set to AUTO. If the value in numeric input column is 2.75 V and the underscore is under the 2, turning the general purpose knob counter-clockwise decreases the value in 1 V increments, as shown below.

2.75 V
1.75 V
0.75 V
−0.25 V
−1.25 V
−2.25 V

This example shows how the frequency value changes in the OUTPUT menu. If the value in the numeric input column is 2.34 MHz and the underscore is under the 3, pressing the left arrow button twice moves the underscore.

2.34 MHz
2.34 MHz
02.34 MHz

In the example below, turning the general purpose knob clockwise changes the value. The maximum value for this parameter is 31.2 MHz. There are three significant digits.

02.34 MHz
12.3 MHz
22.3 MHz
22.3 MHz

When the values of the upper digits from the underscore reach the maximum allowable value for the parameter, turning the general purpose knob further clockwise has no effect. In the case above, the underscored 2 is not raised to 3, and an error message is displayed even if the knob is turned.

Outputting Predefined Waveforms

This operation example is intended to show you how to use the menu system described earlier, in practice, while demonstating the task of outputting waveforms. Details about the menus used in the following examples are provided in *Section 3, Reference*.

This example assumes Option 02 (CH2 output) is installed. If Option 02 is not installed, there is no channel switching or display.

Procedures for outputting waveforms generally follow this sequence:

1. A waveform to be output is selected in the FUNCTION menu.
2. Output parameters are set in the OUTPUT menu.
3. Trigger condition are set in the TRIGGER MODE menu.
4. The channel switch is switched On on the front panel.

Operation Example

This example will have you turn on the power switch, calibrate the instrument, and set the instrument to output a function sine waveform using the continuous trigger mode.

☐ **Step 1:** Switch on the power for this instrument with the procedure given in *Start Up* in Section 1. Then let this instrument warm up for 20 minutes.

Steps 2 through 5 are a procedure for calibration. Normally, the output precision meets the specifications without calibration. But to assure precise output, after the warmup is complete, calibrate this instrument with the ambient temperature at +20° C through +30° C.

☐ **Step 2:** Press the UTILITY button in the MENU column on the front panel.

☐ **Step 3:** Press the bottom menu Cal button to display the calibration menu.

☐ **Step 4:** Use the general purpose knob or press the side menu Select button to select DC calibration (see Figure 2-5). The selection can be verified with the Select column label and the position of the asterisk in the table.

☐ **Step 5:** Press the side menu Execute button to start the calibration. During calibration, the busy clock icon is displayed on the top right of the CRT screen.

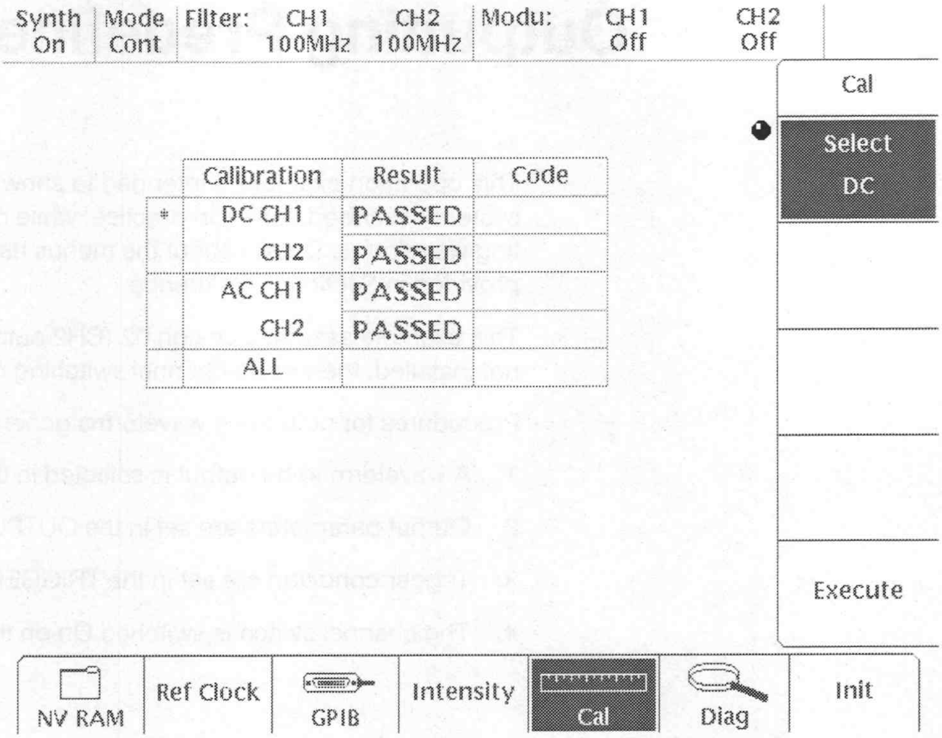


Figure 2-5: DC Cal Selection

☐ **Step 6:** Press the FUNCTION button in the MENU column on the front panel to display the FUNCTION menu (see Figure 2-6).

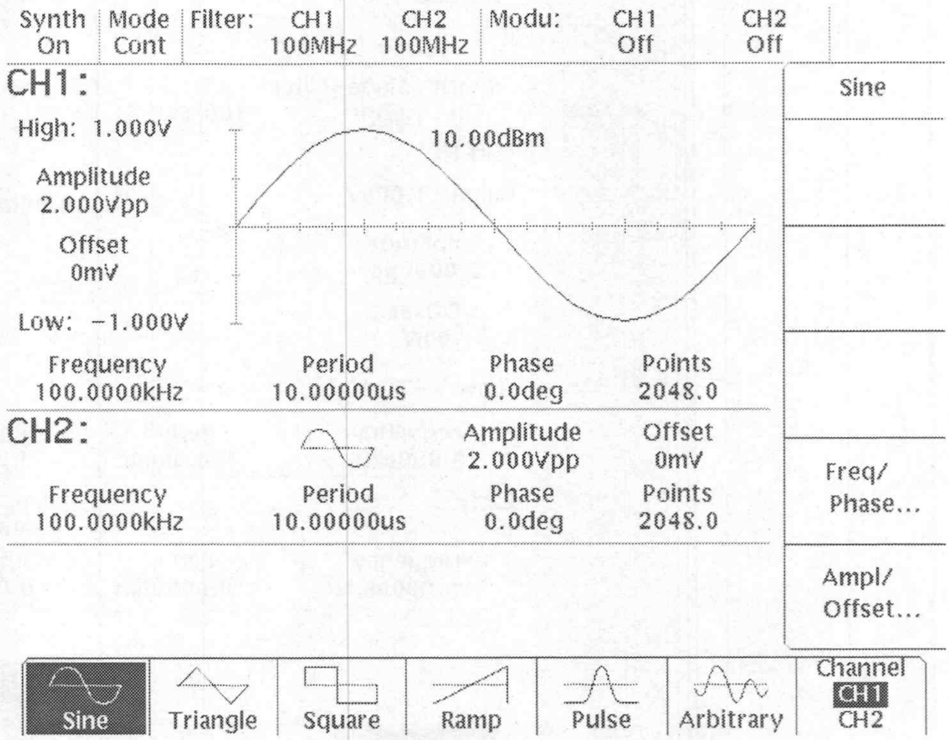


Figure 2-6: FUNCTION Menu

☐ **Step 7:** Check that the reverse video display in the bottom menu Channel column is on the CH1 label. If Option 02 is not installed, there is no Channel menu.

☐ **Step 8:** Check that the bottom menu Sine item is displayed in reverse video.

Standard function waveforms other than sine can also be selected.

☐ **Step 9:** Check that Cont is displayed under the Mode label in the status column at the top edge of the screen. Cont is the mode in which the waveform is output continuously.

☐ **Step 10:** Press the side menu Freq/Phase... button. The sub-menu for changing the frequency and phase is displayed.

☐ **Step 11:** Check that the sub-menu Frequency item is displayed in reverse video. Then use the general purpose knob or numeric keys to set the frequency to 10.0000 kHz (see Figure 2-7). The phase stays at 0°.

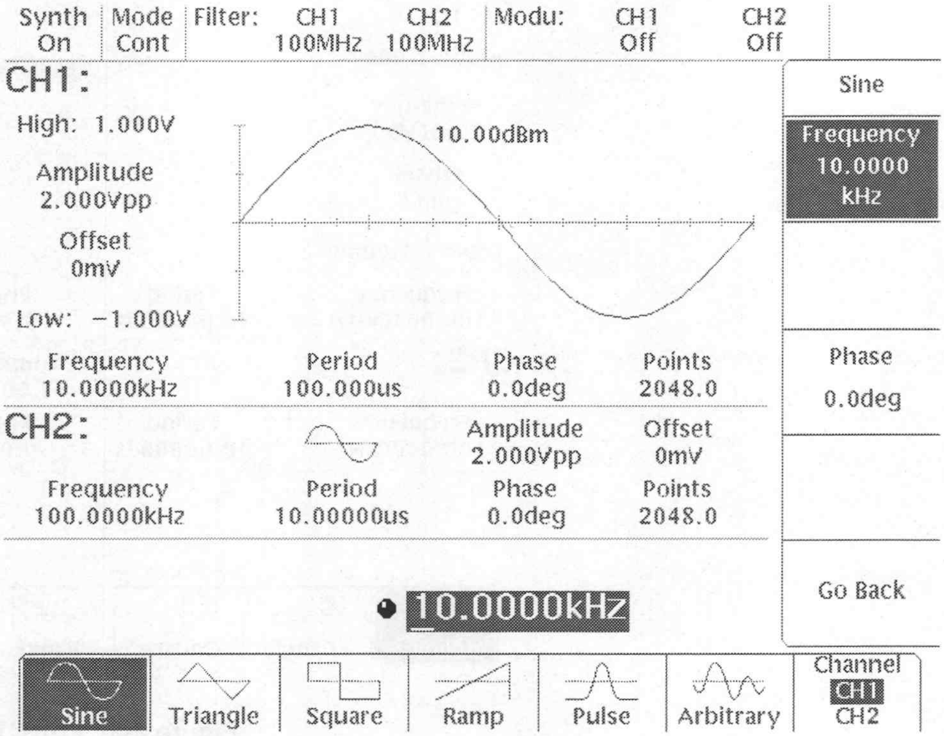


Figure 2-7: Frequency Setting

☐ **Step 12:** Press the sub-menu Go Back button to exit the sub-menu.

☐ **Step 13:** Press the side menu Ampl/Offset... button (see Figure 2-8). The sub-menu for changing the amplitude and offset is displayed.

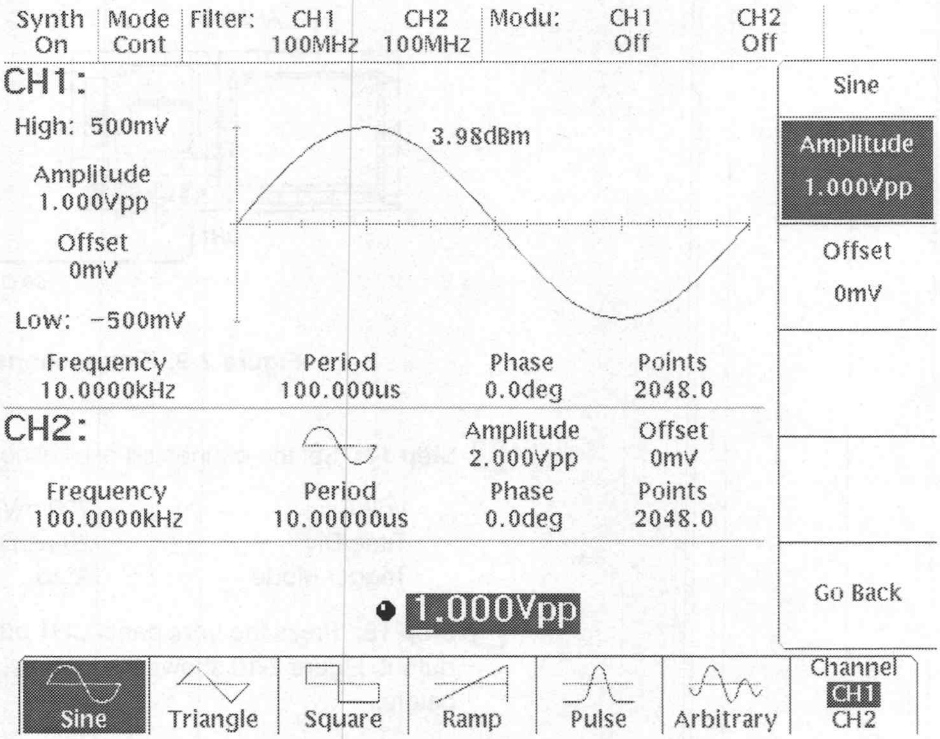


Figure 2-8: Amplitude Setting

☐ **Step 14:** Check that the sub-menu Amplitude item is displayed in reverse video. Then use the general purpose knob or numeric keys to set the amplitude to 1.000 $V_{p\text{-}p}$. The offset stays at 0 mV.

☐ **Step 15:** Press the sub-menu Go Back button to exit the sub-menu.

☐ **Step 16:** Connect the AFG2020 and an oscilloscope with a 50 Ω cable and 50 Ω terminator as shown in Figure 2-9.

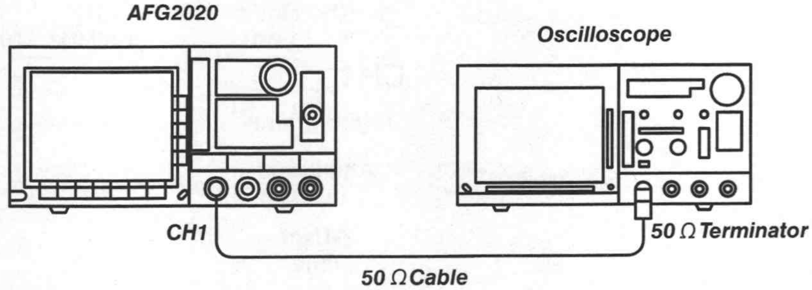


Figure 2-9: Connections for the Example

☐ **Step 17:** Set the connected oscilloscope as follows.

Volt/Div	200 mV/Div
Time/Div	20 µs/Div
Trigger Mode	Auto

☐ **Step 18:** Press the front panel CH1 button to switch on the waveform output. Figure 2-10 shows the channel output On/Off buttons and indicators.

When the channel output is on, the On/Off indicator is lit up. This operation actually outputs the specified waveform from the CH1 connector so it can be observed on the oscilloscope screen.

When the frequency, amplitude, and offset are changed with the procedure in steps 10–14, the output signal changes accordingly in real time.

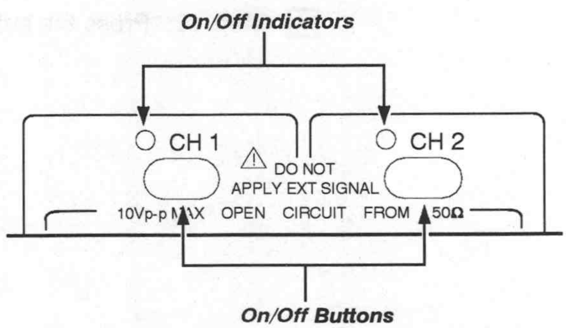


Figure 2-10: Channel Output On/Off Buttons and Indicators

Reference

Overview

This section begins by describing the AFG2020 controls, connectors, and indicators. Then it explains the CRT display status areas. After the status area descriptions, the major functional operating concepts are described.

The remainder of this section describes the details of the following main menus:

- FUNCTION Menu
- OUTPUT Menu
- TRIGGER MODE Menu
- SWEEP Menu
- MODULATE Menu
- EDIT Menu
- UTILITY Menu

Note that the EDIT menu description later in this section includes many details about basic AFG2020 operations, besides EDIT menu features. General menu operations are described in *Section 2, Operating Basics*.

Front and Rear Panels

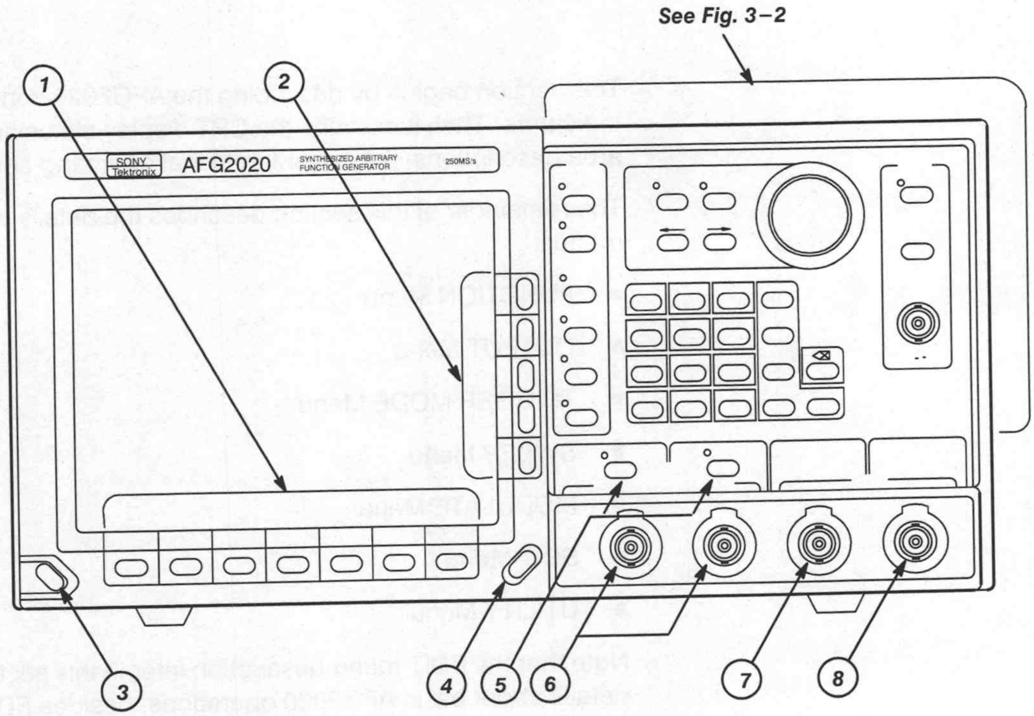


Figure 3-1: Front Panel (Overall Diagram)

(1) Bottom Bezel Buttons

These buttons select items displayed at the bottom of the CRT screen. The display of the bottom menu changes when a main menu button (in the MENU column or in the TRIGGER column on the front panel) is pressed.

(2) Side Bezel Buttons

These buttons select items displayed at the right side of the CRT screen. The display of the side menu usually changes when one of the bottom buttons is pressed (except for menu items that are immediately executed).

(3) ON/STBY Switch

This switch changes instrument power between the ON and STANDBY states. After the rear panel PRINCIPAL POWER SWITCH is turned on to supply power to the standby circuit, pressing the ON/STBY switch supplies power to the rest of the instrument. Pressing this switch again puts the instrument in standby.

NOTE

With the power on, if the rear panel PRINCIPLE POWER SWITCH is turned off, the state of the ON/STBY switch is stored in AFG2020 memory. Thus, the next time the PRINCIPLE POWER SWITCH is turned on, the instrument returns to the ON/STBY state last stored. However, the ON/STBY state can be changed even when the PRINCIPLE POWER SWITCH is off.

(4) CLEAR MENU Button

This button cancels the numeric data being input. During execution of the UTILITY menu Interactive diagnostics, this button is used to exit the menu. This button also deselects the comment input menu and the EDIT library menu, and it erases the message surrounded by the frame.

(5) CH1 and CH2 Buttons and Indicators

These buttons switch channel output on/off. When on, the indicator lights up and the signal is output from the BNC connector of the selected channel. When off, the indicator goes off and the output is cut off. If conditions for generating the trigger or gate signal are not met, no signal is output, even though the channel is turned on.

The CH2 switch is only valid when Option 02 (CH2 output) is installed. For an instrument without CH2 output, pressing the CH2 switch displays an error message.

(6) Waveform Output Connector

The waveform for CH1 is output from the left connector and the waveform for CH2 is output from the right connector. The maximum output is ±5 V with 50 Ω termination. The CH2 output connector is installed with Option 02.

CAUTION

Do not apply an external voltage to the AFG2020 output connectors. If the load has a DC voltage, connect it through an appropriate coupling capacitor.

CAUTION

AM modulation with an external signal or CH1 signal can produce output signal voltages beyond the range ±10 V (for open circuit), depending on the signal. This could damage output load circuitry.

(7) CH1 MARKER Output Connector

The TTL-level CH1 marker signal is output from this connector. The output resistance is 51 Ω. A protection circuit guards against shorts and erroneous input of up to ±5 V (DC + peak AC). The marker signal is output when the Modulate function is On and when both the Sweep function and the markers are on.

(8) CH1 SYNC Output Connector

When the waveform output is triggered, a TTL level SYNC signal is output from this connector. The output resistance is 51 Ω. A protection circuit guards against shorts and erroneous input of up to ±5 V (DC + peak AC).

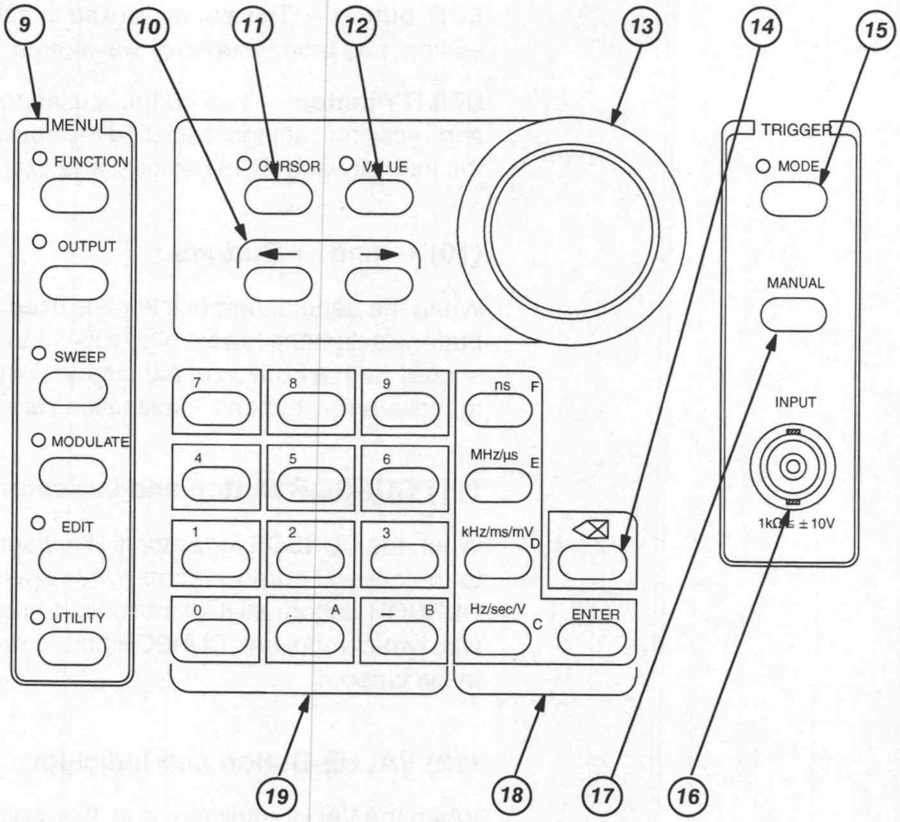


Figure 3-2: Front Panel Right Side

(9) MENU Buttons and Indicators

There are six MENU buttons for selecting this instrument's main menus: FUNCTION, OUTPUT, SWEEP, MODULATE, EDIT, and UTILITY. Pressing one of these MENU buttons lights up the corresponding indicator and displays the corresponding bottom menu and side menu. These menus are each described in detail later in this section.

FUNCTION button — This button is used to call the FUNCTION menu for selecting the waveform type (sine wave, standard waveform, arbitrary waveform, etc.).

OUTPUT button — This button is used to call the OUTPUT menu for setting the output parameters (amplitude, frequency, etc.).

SWEEP button — This button is used to call the SWEEP menu for setting the frequency sweep for the output signal.

MODULATE button — This button is used to call the MODULATE menu to set modulation parameters. There are three types of analog modulation: AM, Offset, and FM — and two types of digital modulation: PSK and FSK.

EDIT button — This button is used to call the EDIT menu for creating, editing, and storing arbitrary waveforms.

UTILITY button — This button is used to call the UTILITY menu for storing and recalling settings, selecting the source of the Reference Clock, selecting the Intensity and GPIB settings, and executing diagnostics and calibration.

(10) ← and → Buttons

When the general purpose knob is used to change numeric values, these buttons select the lowest digit subject to change. This lowest digit is underscored (with a horizontal bar cursor). When special functions are allocated to these arrow buttons, explanations are displayed on the CRT screen.

(11) CURSOR Button and Indicator

When the CURSOR indicator is lit, cursor movement functions are assigned to the general purpose knob. When special functions are assigned to the CURSOR button, an explanation is displayed on the CRT screen. For menus with two cursors, the CURSOR button switches the active cursor between these cursors.

(12) VALUE Button and Indicator

When the VALUE indicator is lit, this indicates that the general purpose knob is assigned to the numeric input function or to select a function. A numeric value can be input for the selected item with the numeric keys or the general purpose knob. Also, selection can be done with the general purpose knob. When special functions are assigned to the VALUE button, an explanation is displayed on the CRT screen.

(13) General Purpose Knob

Movement of cursors (line cursor, reverse video cursor, etc.), numeric input, and other functions are allocated to the general purpose knob. For numeric input, turning the general purpose knob changes the value sequentially. The knob icon is displayed on the CRT screen near the item that can be controlled with the general purpose knob.

(14) Delete Key

The Delete key is used when correcting input data. the Delete key removes one character at a time from the right end of the input data.

(15) MODE Button

This button selects the TRIGGER MODE menu. Pressing the MODE button lights up the indicator. This menu is used to set the trigger mode and trigger parameters such as the source and delay time.

(16) INPUT Connector

This connector is for inputting the external trigger signal or gate signal. This connector allows external signal that have a frequency of DC to 10 MHz, and a maximum input voltage of ± 10 V (DC + Peak AC). This connector provide with a voltage sensitivity of 0.2 $V_{p\text{-}p}$ and an input impedance of 1 kΩ.

(17) MANUAL Button

This button causes a trigger event if Manual triggering is selected and the trigger mode is set to Cont, Triggered Cont, or Time Burst. When Gate mode is selected, the waveform is output as long as this button is depressed.

(18) Unit and ENTER Keys

The unit keys enter the numeric value and its units. In the waveform editor, these keys can also be used to input C–F. The ENTER key enters the numeric value.

(19) Numeric Keys

These keys input numeric data. After a numeric value is input, pressing a unit key or the ENTER key enters it. In the waveform editor, the "." and "–" keys can also be used to input A and B.

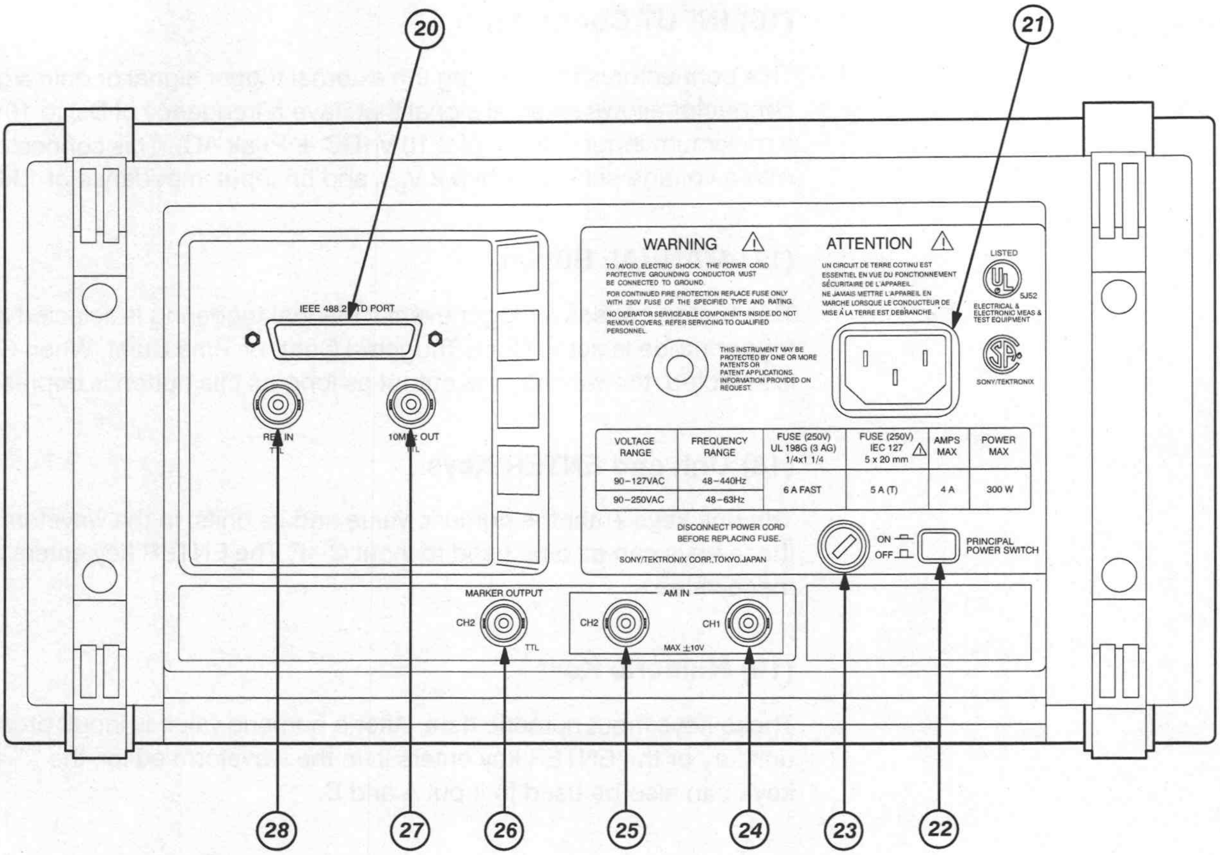


Figure 3-3: Rear Panel

(20) IEEE STD 488.2 Connector

This is a 24-pin GPIB connector for remote control by computer through an IEEE488.2 standard parallel interface.

(21) Power Connector

The AC power cord is connected to this connector.

(22) PRINCIPAL POWER Switch

This switch switches the power supply circuit between STANDBY and OFF. When starting up this instrument, switch the PRINCIPAL POWER switch to STANDBY, then press the front panel ON/STBY switch.

NOTE

With the power on, if the rear panel PRINCIPLE POWER SWITCH is turned off, the state of the ON/STBY switch is stored in AFG2020 memory. Thus, the next time the PRINCIPLE POWER SWITCH is turned on, the instrument returns to the ON/STBY state last stored.

(23) Fuse Holder

This holder contains the AC-power-source fuse. A 6 A, 250 V, fast-blow type fuse is used. The same fuse is used for 110 V and 220 V systems,

(24) AM INPUT CH1 Connector

This connector is for inputting an external signal that modulates CH1 waveform with amplitude modulation. This connector allows an external signal that has a frequency of DC to 100 kHz and a maximum input voltage of ±10 V (DC + Peak AC). The input impedance is 10 kΩ.

(25) AM INPUT CH2 Connector (Option 02)

This connector is for inputting an external signal that modulates CH2 waveform with amplitude modulation. The characteristics are the same as for callout 24, above.

(26) MARKER OUTPUT CH2 Connector (Option 02)

The TTL-level CH2 marker signal is output from this connector. The output resistance is 51 Ω. A protection circuit guards against shorts and erroneous input of up to ±5 V (DC + peak AC). The marker signal is output when the Modulate function is On and when both the Sweep function and markers are on.

(27) 10MHz OUT Connector

A TTL-level 10 MHz clock is output from this connector. The output resistance is 51 Ω. A protection circuit guards against shorts and erroneous input of up to ±5 V (DC + peak AC).

(28) REF IN Connector

This connector is used to input a TTL signal with a frequency of 100 MHz ±10 kHz, an input impedance of 10 kΩ, and a maximum input voltage of within 0 V to 5 V. This input is used as an external clock reference to allow this instrument to be synchronized with the 10 MHz clock of another AFG2020 to obtain concurrent signal output. The clock source is switched between internal and external using the UTILITY menu.

CRT Display

Figure 3-4 shows the screen display status and menu areas. The callouts are described following the figure.

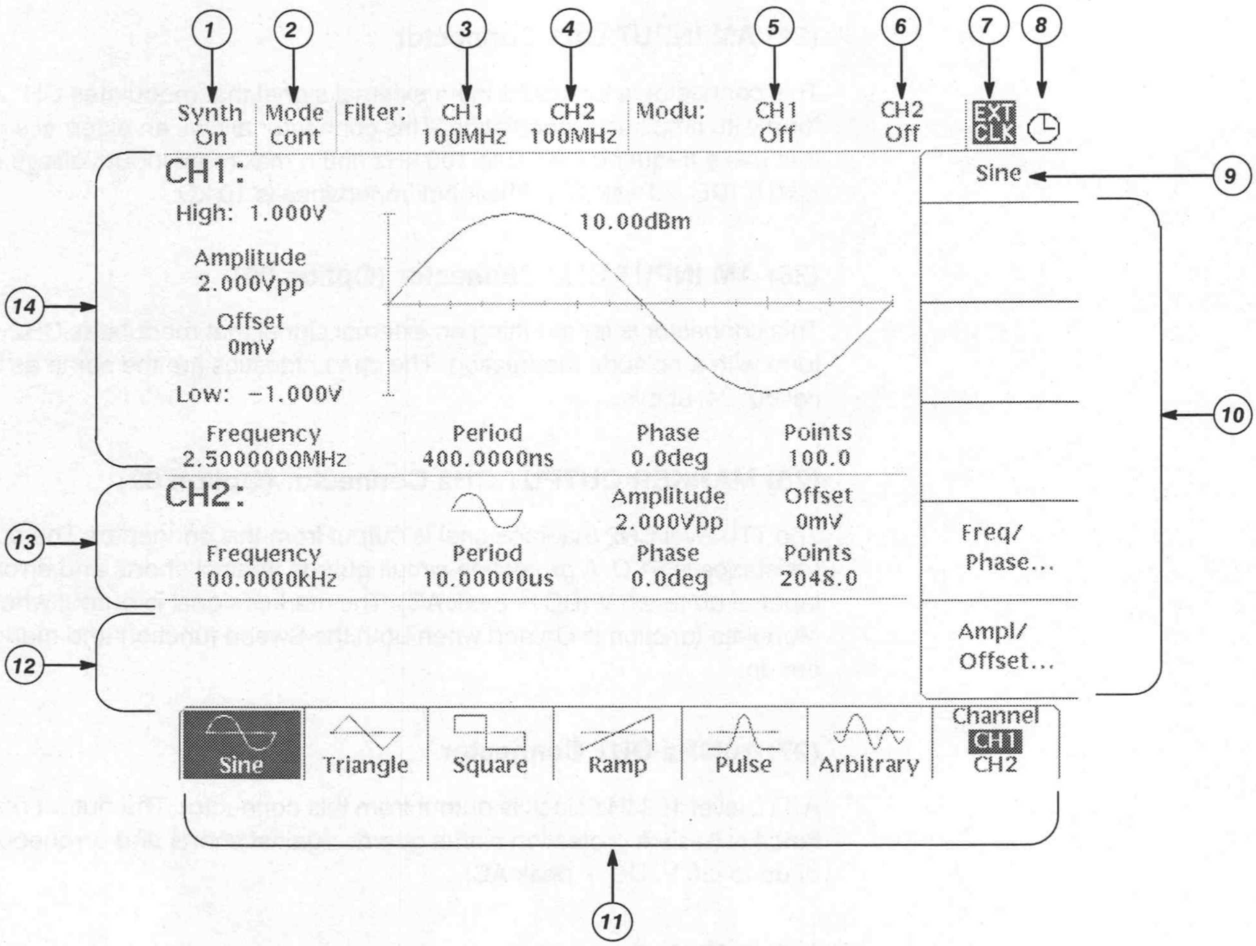


Figure 3-4: CRT Screen Display

(1) Synthesizer Mode Status Area

This area displays the mode for reading out waveform memory data. Synth On indicates DDS mode and Synth Off indicates that the frequency of the data readout clock is variable (refer to *Functional Operating Concepts* later in this section for details).

(2) Trigger Mode Status Area

This area shows the mode selected with the TRIGGER MODE menu. Mode labels are Cont, Triggered Cont, Gate, and Time Burst.

(3) CH1 Filter Status Area

This area displays the type of CH1 filter currently selected. There are three displays: 100MHz, 50MHz, and Full Pass.

(4) CH2 Filter Status Area (Option 02)

This area displays the type of CH2 filter currently selected. The type of filter displays are same as for CH1.

(5) CH1 Status Area

This area shows the setting for the CH1 modulation function or sweep function.

Modulation function setting status — When the modulation function is off, "off" is displayed under the channel label. When the modulation function is on, the selected modulation type — AM, Offset, FM, PSK, or FSK — is displayed under the channel label.

Sweep function setting status — When the sweep function is off, "off" is displayed under the channel label. When the sweep function is on, "Sweep" is displayed under the channel label. When a ramp waveform synchronized with the CH1 sweep is output from the CH2 connector, "Sweep > Sync. Volts" is displayed under the CH1 and CH2 label. This status is displayed when Sweep is set to On and then CH2 Out is set to On with the CH1 bottom menu.

(6) CH2 Status Area (Option 02)

This area shows the setting for the CH2 modulation function or sweep function. The contents of the display are the same as for CH1.

(7) Reference Clock Source Display Area

When the source for the clock signal controlling the signal generation circuit is set to External, the EXT CLK icon is displayed in reverse video in this area. If an appropriate external signal is not input, the EXT CLK icon blinks.

(8) Busy Clock Icon Display Area

When an execution menu item is being executed or when time is required to change the settings, the clock icon is displayed in this area.

(9) Bottom Menu Item Display Area

This area shows the label for the item selected in the bottom menu.

(10) Side Menu

When an item is selected from the bottom menu, the corresponding side menu is displayed at the right side of the screen.

(11) Bottom Menu

When one of the buttons in the MENU column or MODE button in the TRIGGER column is pressed, the corresponding menu is displayed at the bottom of the CRT screen.

(12) Numeric Input and Message Field

When a numeric menu item is selected, the numeric input frame is displayed toward the bottom center of this field (not shown). Also, if an out of range value is entered, a message is displayed above the numeric input frame.

(13) CH2 Field (Option 02 only)

CH2 parameters set in OUTPUT menu are displayed. When CH2 is selected as the current channel, this field becomes bigger than CH1 and the waveform graph and parameters are displayed. When CH2 is not the current channel, this field becomes smaller and an waveform icon is displayed, instead of the waveform graph. The icon indicates the type of the waveform previously assigned to this nonselected channel.

(14) CH1 Field

When CH1 is selected as the current channel, this field becomes bigger than CH2 and the waveform graph and parameters are displayed. When CH1 is not the current channel, this field becomes smaller and an waveform icon is displayed, instead of the waveform graph. The icon indicates the type of the waveform previously assigned to this nonselected channel.

Functional Operating Concepts

It is useful to understand the basic functions of the AFG2020 in order to effectively operate this instrument. This section explains the basic principles of waveform generation, post processing for analog waveforms, trigger timing, and uses for the auxiliary connectors.

Basic Principles of Waveform Generation

The AFG2020 reads waveform data stored in high-speed RAM and converts this data into an analog waveform using a D/A converter to generate various waveforms. Two modes can be used for this conversion, as appropriate:

1. Synthesizer On Mode—the read out clock is not synchronized with the output waveform. Synthesizer On Mode is called DDS (Direct Digital Synthesis).
2. Synthesizer Off Mode—the read out clock is synchronized with the waveform output.

The table below shows the features of both modes.

Table 3-1: Characteristics of Synthesizer Mode

	Synthesizer On Mode (DDS)	Synthesizer Off Mode
Clock	250 MHz constant	250–125 MHz (VCO) frequency divided by 2^n
Clock and output waveform	Asynchronized	Synchronized
Output frequency change	High speed (FM, PSK, FSK modulation, SWEEP output possible)	Low speed (PLL response time)
CH2 frequency	Can be set independently	Restricted to power of 2 submultiples of CH1
Frequency resolution	0.5 Hz	1.0%–0.1% of output frequency
Phase adjust-ment	Function	No function

Synthesizer On Mode: DDS Configuration

The DDS is a type of synthesizer that can synthesize waveforms with a variety of frequencies from a single reference frequency. However, in this case, the Nyquist Theorem must be observed.

Figure 3-5 shows the configuration of the DDS. The phase accumulator works in the central role in the DDS. The figure shows how the phase accumulator generates the RAM address, reads out the data from RAM at the specified address, converts the data with the D/A converter, and finally outputs the analog waveform.

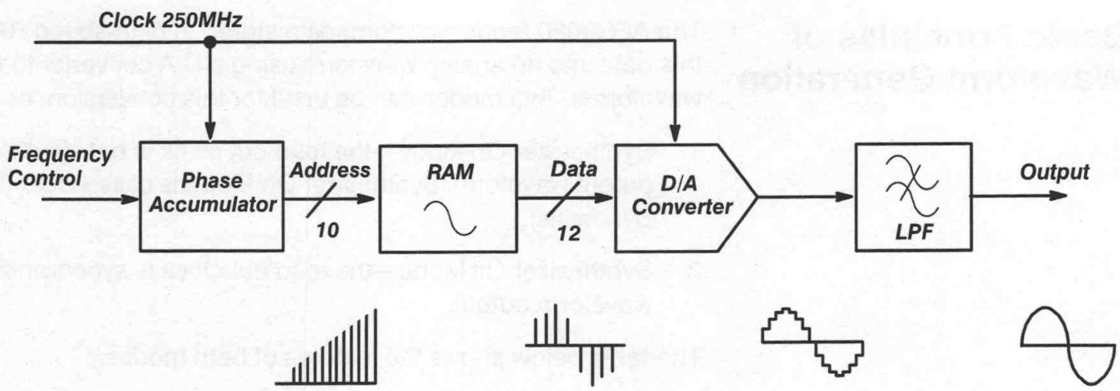


Figure 3-5: DDS Configuration

Phase Accumulator — Figure 3-6 shows the configuration of the phase accumulator. The operation of the phase accumulator is extremely simple: the value of the input register is added to the output register for each clock cycle. This operation is repeated over and over. For example, if the input register value is 1, the output register value is incremented by 1 each clock cycle: 0, 1, 2, 3, ... Similarly, if the value of the input register is 2, the output register value is: 0, 2, 4, 6, ... This input register is called the delta phase register. It expresses the amount by which the phase of the waveform has advanced during one clock cycle. The output register gives the current phase of the waveform.

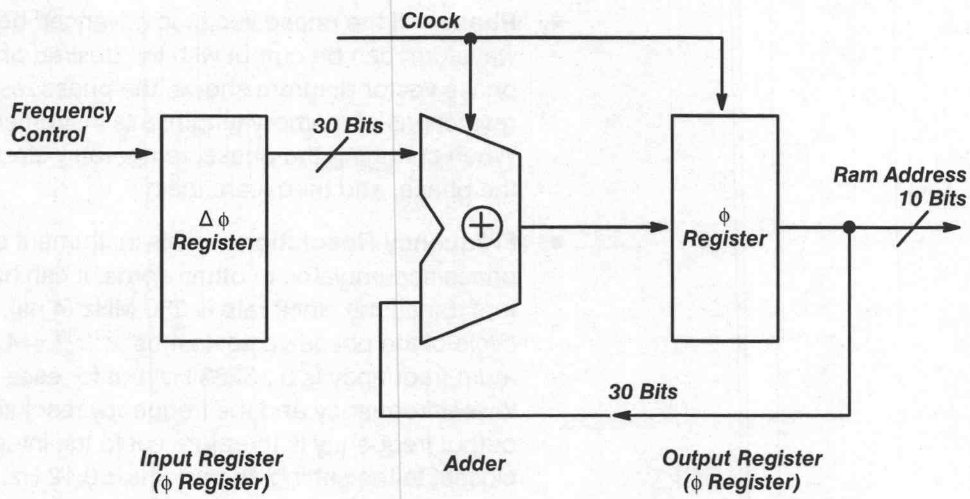


Figure 3-6: Configuration of the Phase Accumulator

Phase Vector — The value of the output register in the phase accumulator can be expressed with phase vectors, as shown in Figure 3-7. This figure shows what happens when 3 is set in the delta phase register. When 1 is specified, all the phase vector points are rotated and the slowest frequency waveform is generated.

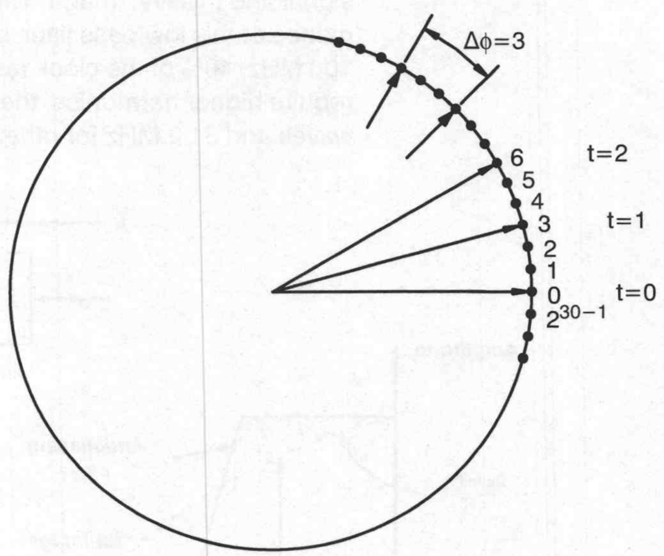


Figure 3-7: Phase Vector of the Output Register

- **Phase**— If the phase vector is advanced before starting the output, the waveform can be output with the desired phase. As the Figure 3-7 phase vector diagram shows, the phase resolution is $360/2^{30}$. But due to restrictions of memory length, this instrument has a resolution of 0.1°. When changing the phase, temporarily stop the waveform output, set the phase, and then start again.
- **Frequency Resolution** — This instrument deals with 30-bit data in its phase accumulator. In other words, it can handle 2^{30} = 1G phase vectors. Since the clock rate is 250 MHz (4 ns), the time required for one cycle of the phase vector is 4 ns × 2^{30} = 4.2950 seconds. The minimum frequency is 0.23283 Hz, but for ease of use, this system sets the lowest frequency and the frequency resolution to 0.5 Hz. Since the output frequency is therefore set to the integer multiple of 0.23283 Hz closest to the setting, the error is ±0.12 Hz.

Maximum Frequency — According to the Nyquist theorem, sine waves can be generated with frequencies of up to 50% of the clock rate, but in actual practice, there are hardware restrictions. Figure 3-8 shows the spectrum for sine waveform generation.

The image frequency is generated by the sampling effect of the D/A converter. The figure shows how the image frequency changes when a sine waveform with a frequency of f_0 is generated and this frequency is changed from low to high. When f_0 approaches $f_c/2$, the first image frequency gradually approaches the signal frequency. A low pass filter is required to separate the signal and this first image. The maximum frequency depends on the performance of this low pass filter. In this instrument, the maximum frequency is 100 MHz, 40% of the clock rate. Also, since nonsine waveforms always require higher harmonics, the maximum frequency is 50 MHz for square waves and 31.2 MHz for other types of waveforms.

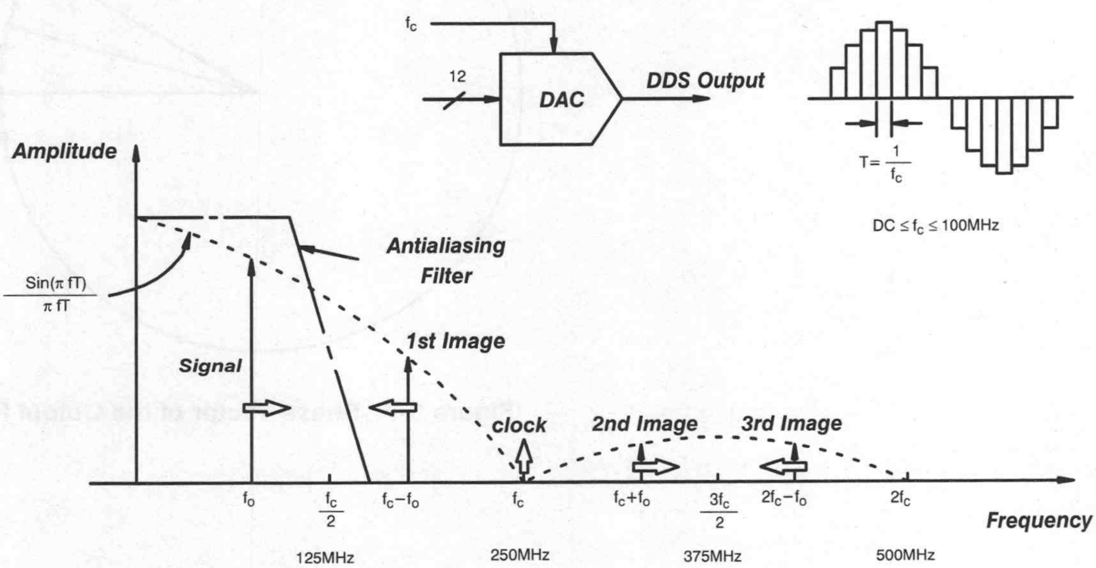


Figure 3-8: Output Spectrum

Aliasing — When a signal composed with higher harmonics is output at high speed with direct digital synthesis (DDS), the waveform differs from what is expected, as shown in Figure 3-9. This figure shows the aliasing for 13.33 points per cycle. For a sine wave, the solid line is the D/A converter output, the sine wave is reproduced by the low pass filter, and no aliasing occurs. However, for a square wave, the waveform is generated as a solid line in the figure whose duty cycle differs from what is expected. Also, for impulse waves, the pulse is not generated at the second cycle. For this reason, DDS mode has a one clock cycle uncertainty.

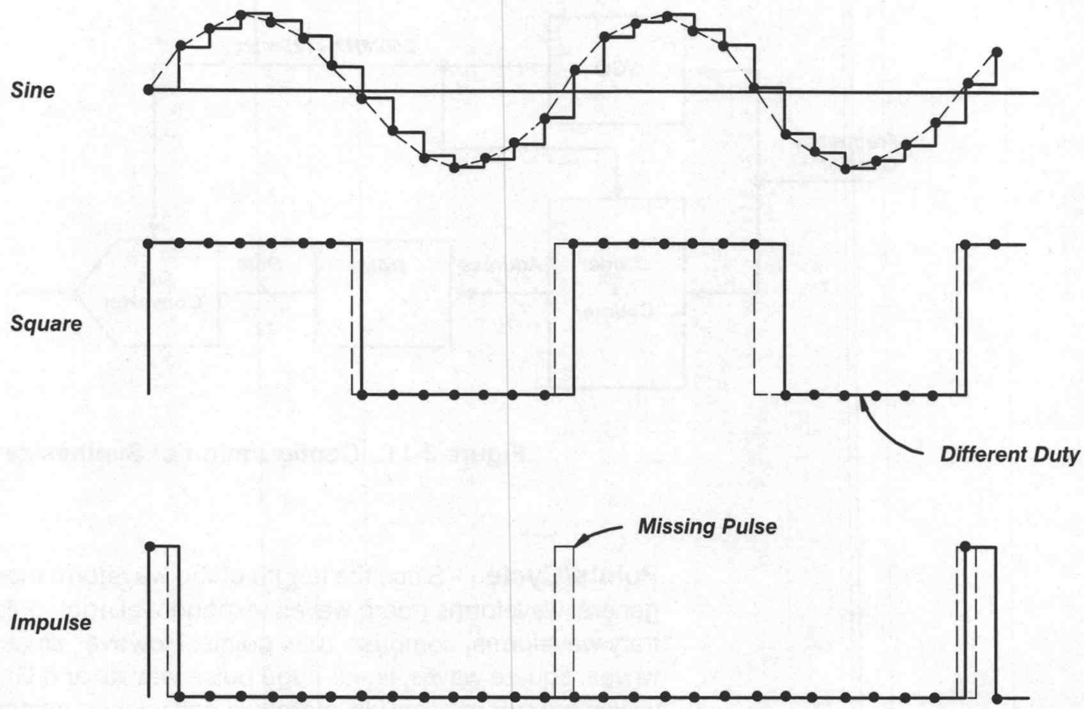


Figure 3-9: Aliasing Example 1

When a number of cycles of a sine wave are written into RAM as an arbitrary waveform, aliasing can occur, depending on the number of sample points, as shown in Figure 3-10.

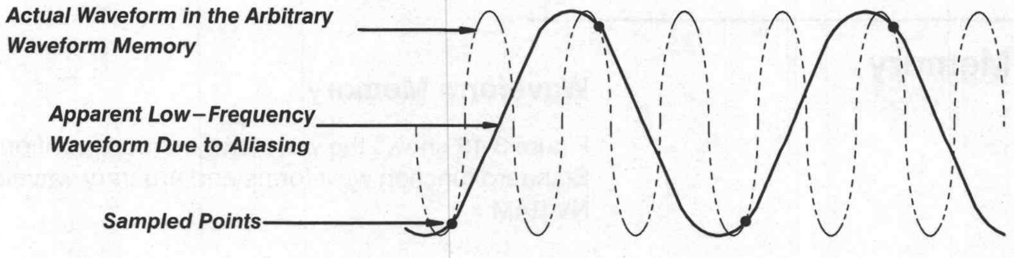


Figure 3-10: Aliasing Example 2

Synthesizer Off Mode — In this mode, the clock is made with a variable frequency oscillator and frequency divider. Therefore, the clock and the output signal are synchronized and this mode does not have the uncertainty found in the clock in Synthesizer On Mode. However, since the output frequency is determined with a VCO (voltage controlled oscillator), the frequency value is changed much slower than in Synthesizer On Mode. Therefore, the sweep function and the functions such as FM, PSK, and FSK modulation that have to change the frequency at high speed cannot be used in Synthesizer Off Mode. Figure 3-11 shows the configuration of Synthesizer Off Mode.

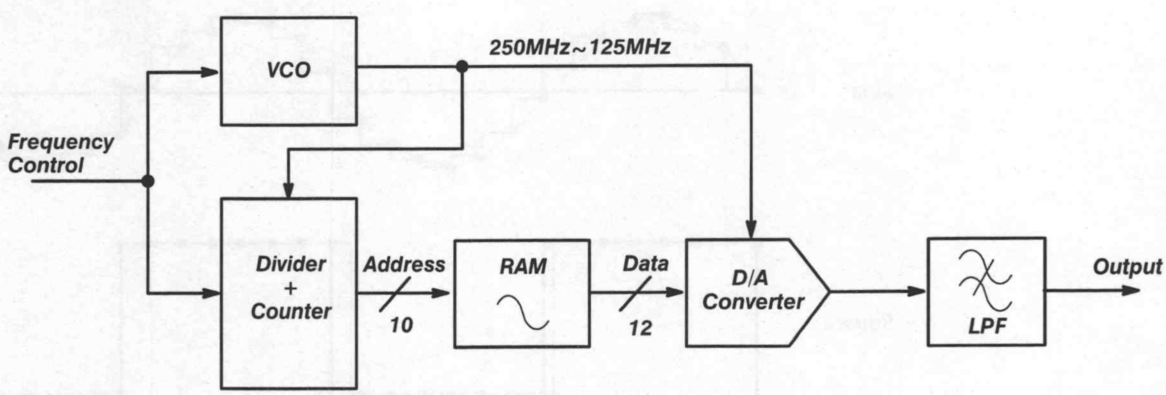


Figure 3-11: Configuration of Synthesizer Off Mode

Points/Cycle — Since the length of the waveform memory is 1024 points, general waveforms (ramp waves, exponential edge pulse waves, and arbitrary waveforms) comprise 1024 points. However, since sine waves, triangle waves, square waves, linear edge pulse waves, and Gaussian edge pulse waves are symmetrical waveforms, a half cycle is written into waveform memory and this is read out reciprocally to give the equivalent of 2048 points. The equivalent length of 2048 points data is available only in synthesizer on mode. The maximum frequency that reads out all 2048 points is 122.070 kHz, and the maximum frequency that reads out all 1024 points is 244.140 kHz. If a sine wave is generated at 100 MHz, the wave is composed with 2.5 points/cycle.

Memory

Waveform Memory

Figure 3-12 shows the waveform memory configuration and data flow. Standard function waveforms and arbitrary waveforms are stored in the NV-RAM.

Load 1 — When a waveform is selected with the FUNCTION menu, the waveform data is loaded from the NV-RAM to the waveform memory for CH1 or CH2. This is the operation for outputting one of the predefined waveforms.

Load 2 — This operation is mainly for saving a waveform into arbitrary waveform NV-RAM or reading a waveform out of arbitrary waveform NV-RAM. The data flows are classified as follows.

- From within the EDIT menu, an arbitrary waveform in the NV-RAM, a ramp wave, or a pulse wave is read into the edit buffer memory. After being edited, the waveform is loaded into arbitrary waveform NV-RAM memory.
- The Load Waveform menu in the EDIT menu or a computer is used to transfer waveforms between the arbitrary waveform NV-RAM and an external device via the GPIB interface.
- The Copy function in the EDIT menu is used to transfer waveforms between arbitrary waveform memories.

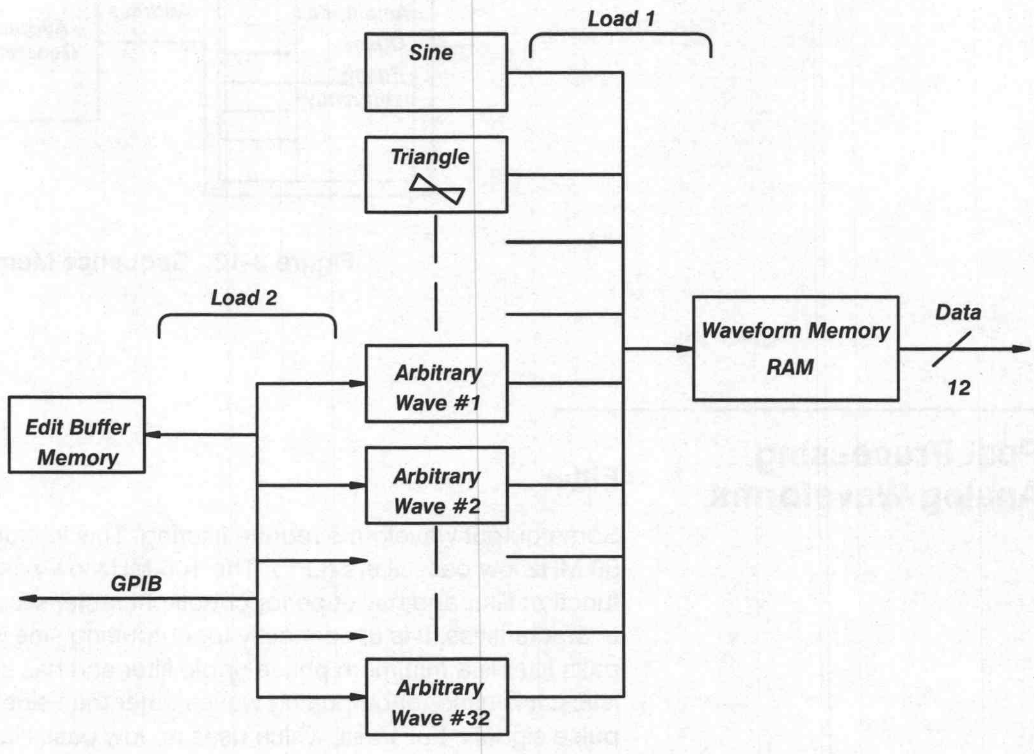


Figure 3-12: Waveform Memory Configuration

Sequence Memory

In addition to its waveform memory, this instrument has sequence memory for storing frequency, phase, amplitude, and offset values. The sweep and modulation functions are also programmed into this sequence memory and operate by reading out their values. This memory works with a 10 MHz (0.1 ms.) clock. Sequence memory has a marker output function. In analog modulation, the markers are set automatically, and in sweep and digital modulation, the markers are programmable.

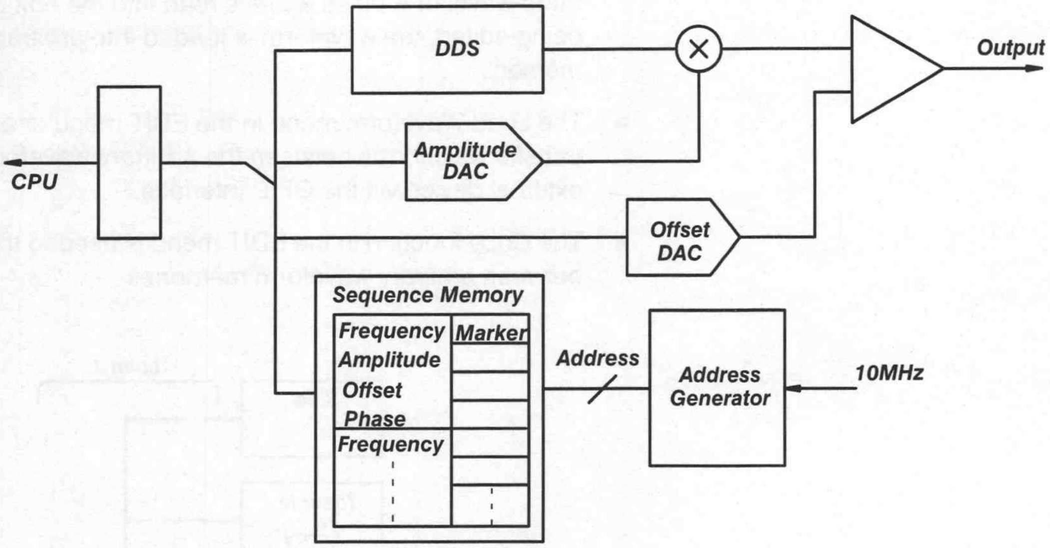


Figure 3-13: Sequence Memory

Post Processing Analog Waveforms

Filter

Some output waveforms require filtering. This instrument has 100 MHz and 50 MHz low pass filters (LPF). The 100 MHz low pass filter is an elliptic function filter and has superior cut-off characteristics, but inferior phase characteristics. It is used mostly for outputting sine waves. The 50 MHz low pass filter is a minimum phase ripple filter and has superior phase characteristics. It is used for outputting waves other than sine waves. For fast-rising pulse signals, Full Pass, which uses no low pass filter, may be selected.

Amplitude

As Figure 3-14 shows, the amplitude is varied by multiplying the analog value from the amplitude D/A converter and the output from the waveform D/A converter with an analog multiplier.

Offset

The offset is varied by adding the output from the offset D/A converter to the output amplifier.

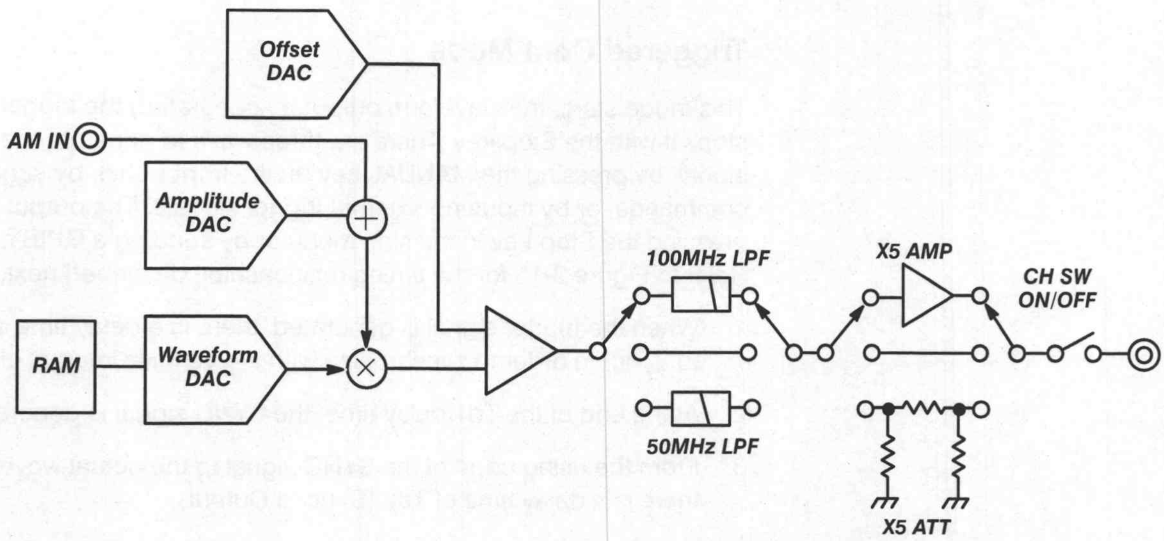


Figure 3-14: Amplitude and Offset Control

Range

The output circuit has a X5 amplifier, a pass-through circuit, and a X5 attenuator. They are used to switch the range. The maximum output for the 2 V_{p-p} (pass-through) range is usually $\pm$1.0 V with 50 Ω termination. The exception is AM modulation with a modulation signal source from external or CH1. The sum of the amplitude peak voltage and the offset voltage must be within the maximum output. The lower the amplitude, the greater the range for the offset. The opposite is also true. The maximum output for the 10 V_{p-p} range is 5 times the 2 V_{p-p} range and the maximum output for the 0.4 V_{p-p} range is one fifth of the 2 V_{p-p} range with 50 Ω termination.

The Auto Range function automatically selects the X5 amplifier (10 V_{p-p}), through (2 V_{p-p}), or X5 attenuator (0.4 V_{p-p}) according to the amplitude and offset values. The X5 amplifier is connected when the sum of the amplitude peak voltage and the offset voltage exceeds $\pm$1.000 V. The X5 attenuator is connected when this sum is within $\pm$200.0 mV. In normal usage, Auto Range is convenient. However, the instrument will switch relays on/off automatically in order to select a range with a good S/N ratio. When this is not desirable, use a fixed range.

Trigger Timing

The trigger circuit is controlled by a 10 MHz clock. There is some propagation delay from the generation of the trigger signal to the generation of the SYNC. Also, there is some delay from the time you press the Stop key, or the end of the gate signal, until output actually stops.

Triggered Cont Mode

This mode starts the waveform output by generating the trigger signal and stops it with the Stop key. There are three ways to generate the trigger signal: by pressing the MANUAL key on the front panel, by sending GPIB commands, or by inputting external trigger signals. The output is stopped by pressing the Stop key in the side menu or by sending a GPIB command. Refer to Figure 3-15 for the timing relationships described next.

1. When the trigger signal is generated, there is a delay time Td1 (Ext Input to Sync) in order to synchronize with the 10 MHz internal clock.
2. At the end of the Td1 delay time, the SYNC signal is generated.
3. From the rising edge of the SYNC signal to the actual waveform output, there is a delay time of Td2 (Sync to Output).
4. The value displayed on the Delay menu is Td1 + Td2. When the Delay value is changed in Synthesizer On Mode, it is actually that the Td2 time is changed. In Synthesizer Off Mode, the Td1 time is varied. The programmable delay can be freely set within the range from 0.7 μs to 100.0 s with the Delay menu.
5. At the end of the delay Td2, the waveform output starts. The starting voltage for the output signal is determined by the waveform phase, amplitude, and offset.
6. The waveform is outputting until STOP becomes valid.
7. When STOP becomes valid, after a fixed delay Td3 (Gate end to Output) of about 0.2 μs, the system enters the Tpr (Phase Recovery Time).
8. The phase recovery time is about 2.5 μs. During this period, the CPU stops the D/A converter and the phase returns to its origin. When the phase has returned to the origin, preparations are complete for receiving the next trigger signal.

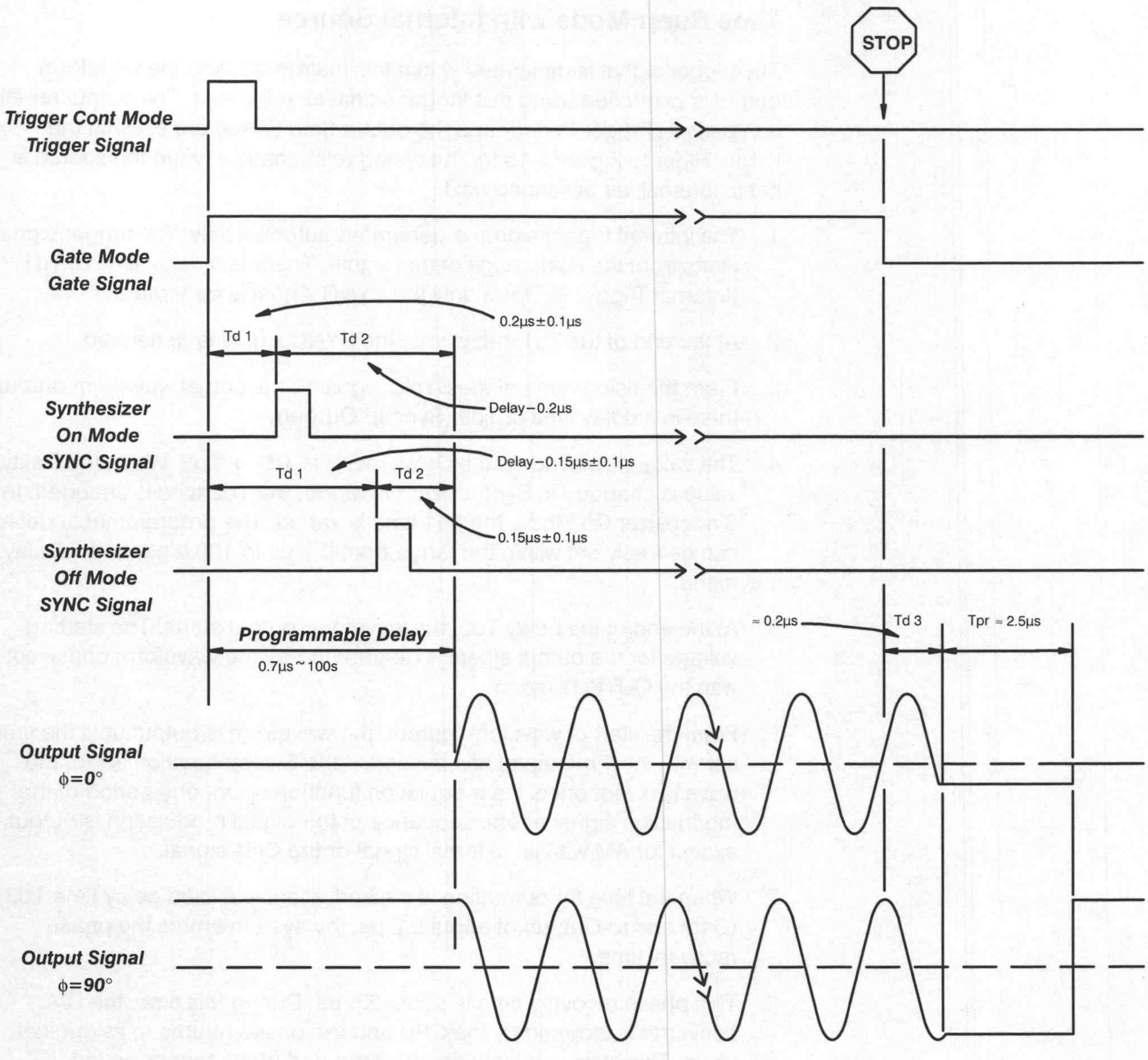


Figure 3-15: Timing of Triggered Cont/Gate Mode

Gate Mode

While the gate signal is present, the waveform output is continued. There are three ways to generate the gate signal: by holding down the front panel MANUAL key, sending the GPIB command, or inputting an external gate signal. The output frame is stopped when the MANUAL key is released, GPIB stop command is sent, or the external gate signal goes False. The timing relations of the Gate Mode is same as for Triggered Cont Mode.

Time Burst Mode with Internal Source

The trigger signal is generated within this instrument and the waveform output is controlled using this trigger signal as reference. The output repetition period (Trigger Period) and the output time (Time) are set with the menu. Refer to Figure 3-16 for the timing relationships when the source is set to Internal, as described next.

1. The internal trigger signal is generated automatically. The trigger signal starts from the rising edge of this signal. There is a delay time of Td1 (Internal Trigger to Sync) until the SYNC signal is generated.
2. At the end of the Td1 delay time, the SYNC signal is generated.
3. From the rising edge of the SYNC signal to the actual waveform output, there is a delay time of Td2 (Sync to Output).
4. The value displayed on the Delay menu is Td1 + Td2. When the Delay value is changed in Synthesizer On Mode, the Td2 time is changed. In Synthesizer Off Mode, the Td1 time is varied. The programmable delay can be freely set within the range from 0.7 μs to 100.0 s with the Delay menu.
5. At the end of the delay Td2, the waveform output starts. The starting voltage for the output signal is determined by the waveform phase set with the OUTPUT menu.
6. From the start of waveform output, the waveform is output until the time set with the Time menu has passed. If the Sweep function is On, the wave is swept once. If a modulation function is On, one period of the modulation signal or one sequence of the digital modulation is output, except for AM with an external signal or the CH1 signal.
7. When the time for outputting is passed, there is a fixed delay time Td3 (Gate end to Output) of about 0.2 μs, the system enters the phase recovery time.
8. This phase recovery time is about 2.5 μs. During this time, the D/A converter is stopped by the CPU and the phase returns to its original value. This state is maintained until the end of the trigger period.
9. When the trigger period ends, an internal trigger signal is immediately and automatically generated and the next trigger period starts.

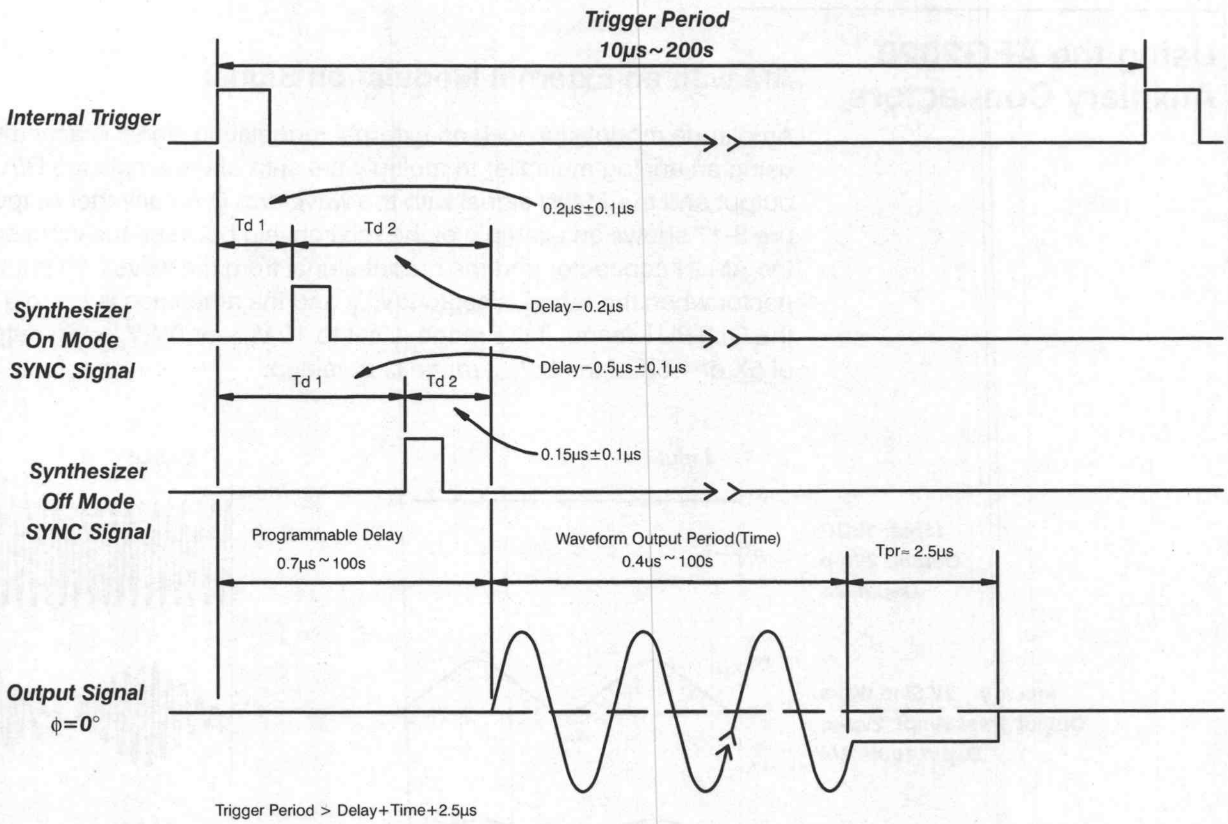


Figure 3-16: Timing of Time Burst Mode with Internal Source

Using the AFG2020 Auxiliary Connectors

AM with an External Modulation Signal

Amplitude modulation with an external modulation signal is accomplished by using an analog multiplier to multiply the sum of the amplitude D/A converter output and the AM IN signal with the waveform D/A converter output. Figure 3-17 shows an example of the relationship between the input signal from the AM IN connector and the output signal from the waveform output connector when the range is set to 2 V_{p-p} and the amplitude is set to 0 V_{p-p} in the OUTPUT menu. If the range is set to 10 V_{p-p} or 0.4 V_{p-p}, an output signal of 5X or 1/5X of the 2 V_{p-p} range is obtained.

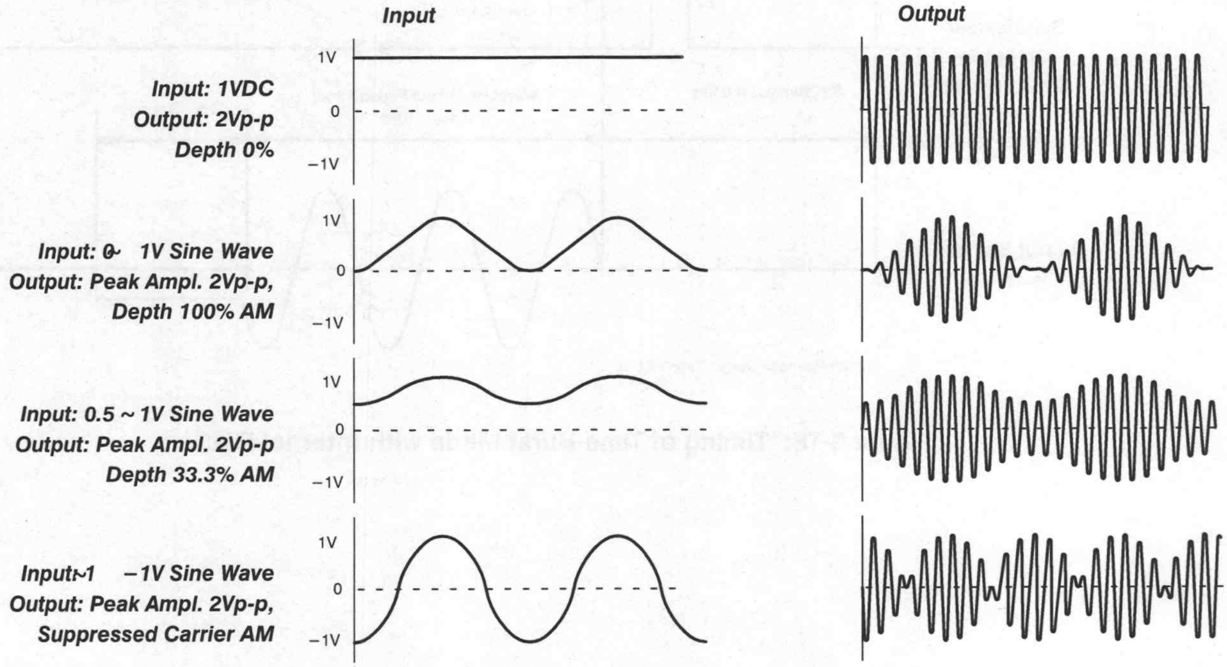


Figure 3-17: AM Output for External Modulation Input

Reference Clock

When operating some AFG2020s in parallel, the 10MHz clocks that control the trigger circuits are generated with their phases unrelated to each other. When the trigger is obtained by simply inputting an external trigger signal in parallel to each instrument, since the SYNC signal is output synchronized with the clock, there is a variation of up to 0.1 µs (the period of a 10 MHz clock) in the SYNC output timing of each instrument. In measurements that would be affected by such variation, the clocks of the AFG2020s operating in parallel must be synchronized.

Synchronization operations are only valid in Synthesizer On Mode. The AFG2020's 10MHZ OUT signal (reference clock) and REF IN connector can be used to obtain accurate clock synchronization. On the other hand, in Synthesizer Off Mode, there is no synchronization because the internal clock is not fixed at 250 MHz.

For details on synchronizing signal outputs, see *Example 9: Setting Synchronized Parallel Operation* in the Section 1 tutorial.

Impedance Matching

The AFG2020 is designed to operate at 50 Ω. When terminated with exactly 50 Ω, the AFG2020 provides its specified performance. If it is terminated with another value of impedance, there is mismatching and reflection from the load, and this causes ringing and overshoot in the pulse wave. In addition, sine waves do not have the correct frequency characteristics.

The following explanation shows how to connect a load to the AFG2020.

- When connecting a matched system with cables, use 50 Ω cables (see Figure 3-18).

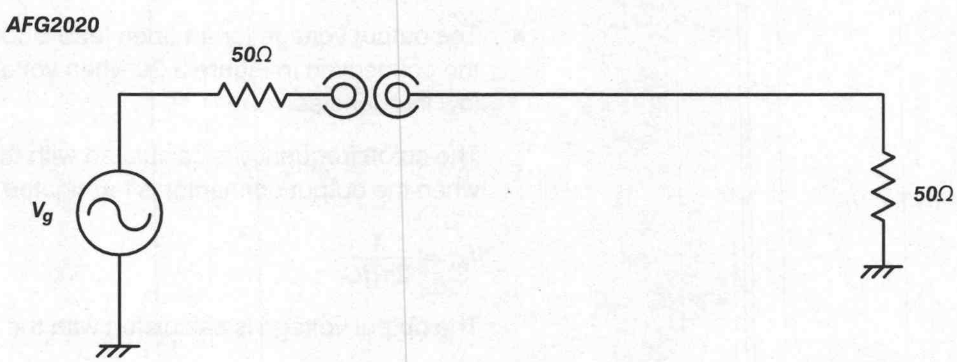


Figure 3-18: Connection for Matched System

- When measuring the waveform with a high-impedance oscilloscope, terminate the oscilloscope input connector with a 50 Ω terminator. Compared to a 50 Ω input oscilloscope, the waveform is disrupted by the internal inductance and capacitance shown in Figure 3-19.

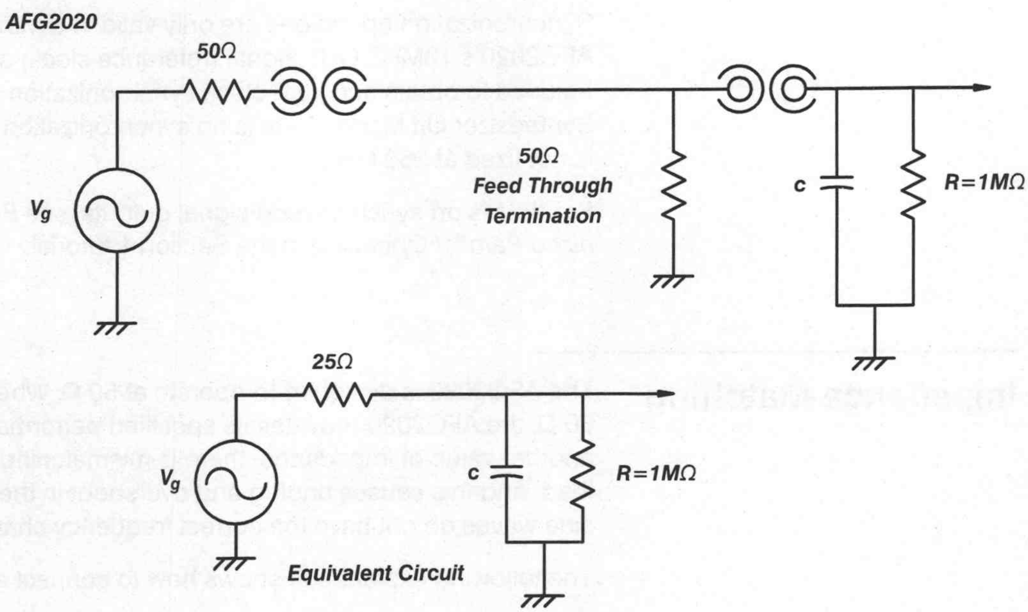


Figure 3-19: Connection for High-impedance Oscilloscope

- The output voltage for an open load is 2X that for 50 Ω termination. Use the connection in Figure 3-20 when voltage output is needed at relatively low frequencies.

  The cutoff frequency is calculated with the following equation. R is 25 Ω when the output connector is terminated with 50 Ω.

  $$f_{co} = \frac{1}{2\pi RC}$$

  The output voltage is calculated with the following equation.

  $$V_c = \frac{V_g}{\sqrt{1 + (\frac{f}{fco})^2}}$$

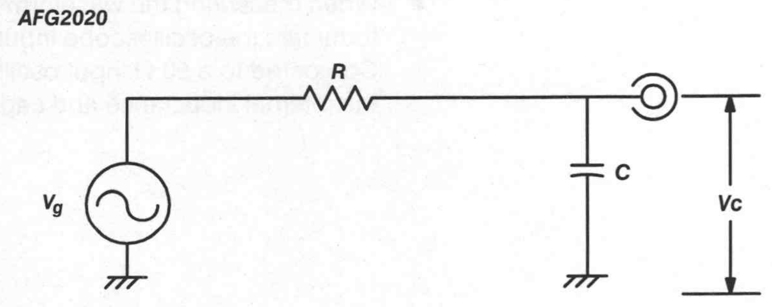


Figure 3-20: Connection to Open Load

- When using this instrument with a load impedance other than 50 Ω, connect the minimum attenuation impedance matching network shown in Figure 3-21 between the load and this instrument.

  The relationship between R1 and R2 and Z1 and Z2 is as follows.

  $$R1 = \sqrt{Z2(Z2 - Z1)}$$

  $$R2 = Z1\sqrt{\frac{Z2}{Z2 - Z1}}$$

  When Z1 is equal to 50 Ω, and Z2 is equal to 75 Ω

  R1 = 43.30 Ω

  R2 = 86.60 Ω

  In this case, the voltage attenuation ratio is as follows.

  A1 = E1/E2 = (R1/Z2) + 1 = 1.58

  This makes output voltage E2 equal to 1/1.58 of E1.

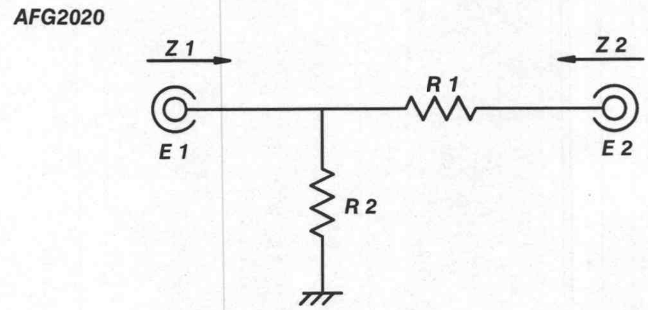


Figure 3-21: Network Connection

Function Menu

Press the FUNCTION button in the MENU column on the front panel to select various standard function waveforms and arbitrary waveforms from waveform memory (12 bits × 1024 points). Refer to Figure 3-22 for the FUNCTION menu structure. The bottom menu items displayed for waveforms are Sine, Triangle, Square, Ramp, Pulse, and Arbitrary. The Channel item in the FUNCTION bottom menu is used to select the current channel. If Option 02 (CH2 output) is not installed, Channel item and items related to CH2 are not displayed.

When one of the standard function waveforms is selected from the bottom menu in the FUNCTION menu, the waveform is displayed on the screen in the graphical area for the current channel. Also, a side menu is displayed to allow you to change output parameters (for example, Frequency or Amplitude). For ramp and pulse waves, side menu items are added for selecting waveform parameters (Rise, Width, Transition, etc.). Each parameter can be changed by pressing its side button, then using the general purpose knob or numeric keys to enter the required data. The waveform graph changes to reflect these parameter changes.

When the Arbitrary bottom button is selected, the side menu is displayed for selecting one of 32 arbitrary waveforms. This side menu has four pages. When one of these arbitrary waveforms is selected, it is displayed on the screen in the graphical area for the current channel. Pressing the More button in the side menu displays the next page of the side menu.

Various parameter values that can be changed with the OUTPUT menu are displayed for CH1 and CH2 on the screen. These parameters include the Amplitude, High, Low, Offset, Frequency, Phase, Points (number of points per 1 cycle of output), and other parameters. In the field for the channel not currently selected, a small waveform icon is displayed above the Period parameter to indicate the type of waveform selected for this channel.

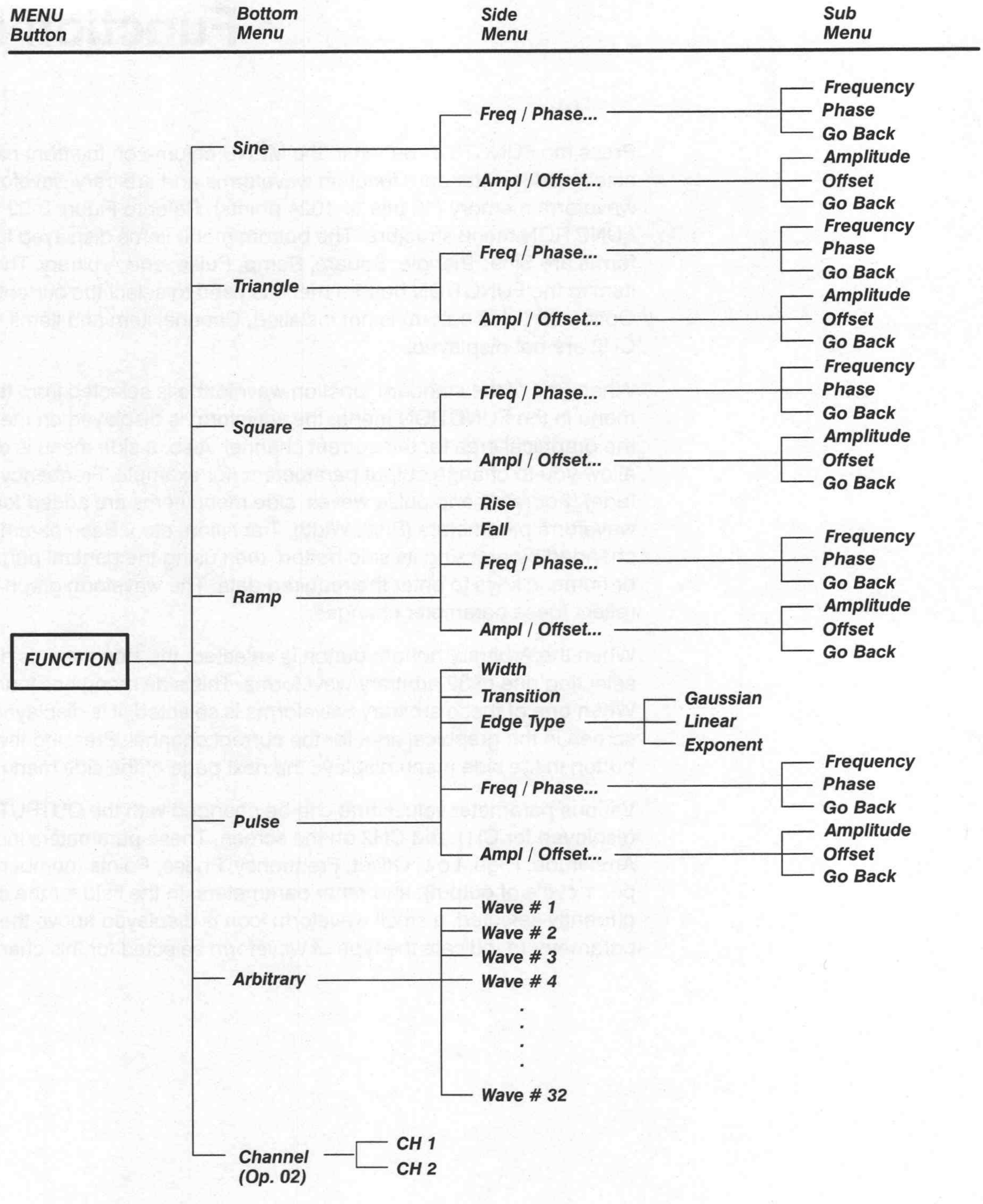


Figure 3-22: FUNCTION Menu Structure

Function Menu Display

Figure 3-23 shows the general display for the Function menu. The descriptions for the feature callouts follow this figure.

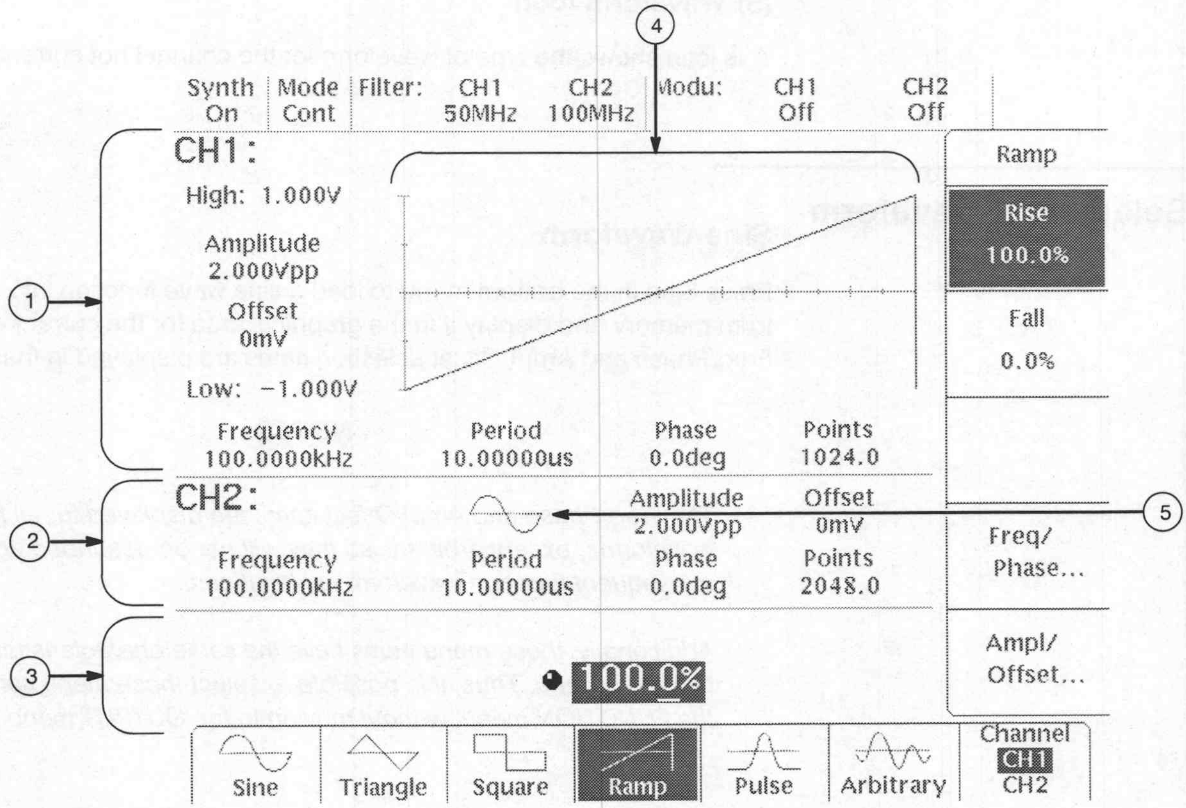


Figure 3-23: Screen Display of FUNCTION Menu

(1) CH1 Field

When CH1 is selected as the current channel, this field becomes larger than CH2 and the waveform graph and parameters are displayed. When CH1 is not the current channel, this field becomes smaller and an waveform icon is displayed, instead of the waveform graph. The icon indicates the type of the waveform previously assigned to this nonselected channel.

(2) CH2 Field (Option 02)

CH2 parameters set in OUTPUT menu are displayed. The feature of CH2 field is same as CH1.

(3) Numeric Input and Message Field

The numeric input frame is displayed by selecting a numeric item. If an out of range value is entered, a message is displayed above the numeric input frame.

(4) Graphical Area

The waveform for the current channel is displayed as a graph in this area.

(5) Waveform Icon

This icon shows the type of waveform for the channel not currently selected.

Selecting a Waveform

Sine Waveform

Press Sine in the bottom menu to load a sine wave function into the waveform memory and display it in the graphical area for the current channel. Freq/Phase and Ampl/Offset selection items are displayed in the side menu.

NOTES

The Freq/Phase and Ampl/Offset items are displayed for all function waveforms, except arbitrary, so they will not be described again in subsequent function waveform explanations.

Additionally, these menu items have the same characteristics in the OUTPUT menu. Thus, it is possible to select these menu items in the FUNCTION menu, without moving to the OUTPUT menu.

Frequency/Phase — When this button is pressed, another side menu for changing the frequency and phase is displayed. However, the phase item is only displayed for synthesizer on mode (when Synth On is selected with the OUTPUT menu). Pressing the Go Back button returns the display from the sub menu to the side menu. See same menu item in the OUTPUT menu later in this section for more detail.

Amplitude/Offset — When this button is pressed, another side menu for changing the amplitude and offset is displayed. Pressing the Go Back button returns the display from the sub menu to the side menu. See the same menu item in the OUTPUT menu later in this section for more detail.

Triangle Waveform

Press Triangle in the bottom menu to load a triangle waveform into the waveform memory and display it in the graphical area for the current channel. The Freq/Phase and Ampl/Offset items are, again, displayed in the side menu.

Square Wave

Press Square in the bottom menu to load a square wave into the waveform memory and display it in the graphical area for the current channel. Again, the Freq/Phase and Ampl/Offset items are displayed in the side menu.

Ramp Waveform

Press Ramp to load a ramp waveform into the waveform memory and display it in the graphical area for the current channel. The side menu has Rise, Fall, Freq/Phase, and Ampl/Offset items displayed.

Rise/Fall — Use these menu items to set the Rise or Fall time for the ramp function in terms of ratio (percent) of the cycle. The sum of these ratios adds up to 100%. Therefore, changing percentage for a parameter cause changing percentage for another parameter. The adjustable range is from 0.0% to 100.0% for both Rise and Fall.

NOTE

Setting a value of 0% for Rise or Fall would mean an ideal waveform in the RAM memory. However the actual waveform output is restricted by characteristics of the chosen filter and this instrument's amplifier.

Pulse Waveform

Press Pulse to load a pulse waveform into the waveform memory and display it in the graphical area for the current channel. The side menu has Width, Transition, Edge Type, Freq/Phase, and Ampl/Offset items displayed.

Width Setting — This item sets the pulse width (half-width) for the pulse wave function in units of ratio (percentage) of the one cycle. This parameter can be set within the range from 1% to 99% of the cycle.

Transition Setting — This item sets the rise and fall time for the square wave in units of ratio (percentage) of the one cycle. The rise and fall are set to the same value.

The transition time is the time width during which the amplitude is between 10% and 90%. This parameter can be set within the range from 0% to 35% of the pulse width.

The pulse width and transition setting range affect each other. For example, when the pulse width is 40%, the maximum value for the transition is $40.0\% \times 0.35 = 14.0\%$. When the transition is 14.0%, if an attempt is made to make the pulse width less than 40%, the pulse width does not change. You must change the transition to a smaller value, then change the pulse width.

Edge Type Selection — One of three edges — Gaussian, Linear, or Exponent — can be selected for the rising and falling edge of a pulse wave function. The selection is made by turning the general purpose knob or by repeatedly pressing the Edge Type button (see Figure 3-24).

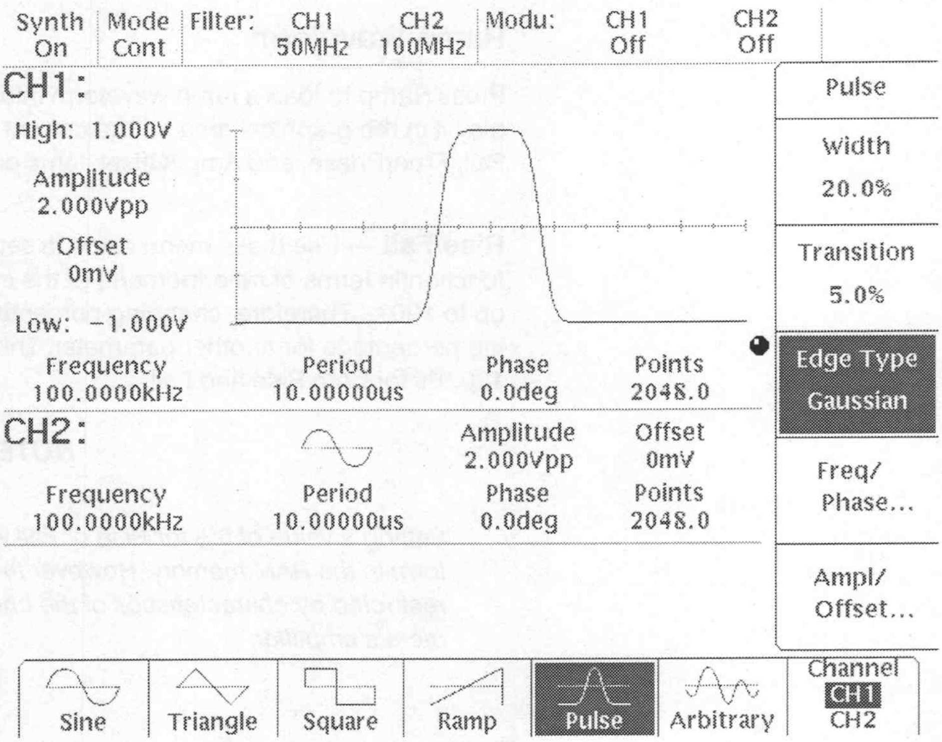


Figure 3-24: Pulse Waveform Display

Arbitrary Waveform

Press Arbitrary in the bottom menu to access up to 32 arbitrary waveforms items in its side menu.

If the Arbitrary button is pressed again, an arbitrary waveform table divided into 16 items and covering two pages will be displayed. One of the arbitrary waveforms can be selected by using the general purpose knob to move the reverse video display cursor. If the Arbitrary key is pressed once again, the display will switch to the FUNCTION menu.

Arbitrary waveforms are first created with the EDIT menu and stored into Wave #1 through Wave #32 of the arbitrary waveform memory. However, external waveform data can also be down-loaded into arbitrary waveform memory through the GPIB interface.

The side menu for Arbitrary has eight pages. To change the page, press the More button.

Figure 3-25 shows the CRT screen display example when an arbitrary waveform is selected. The current channel is CH1.

NOTE

The frequency value on the screen indicates the repetition frequency that occurs when the waveform memory represents one waveform cycle. However, when outputting a multi-cycle arbitrary waveform, the frequency displayed will differ from the actual frequency of the output signal.

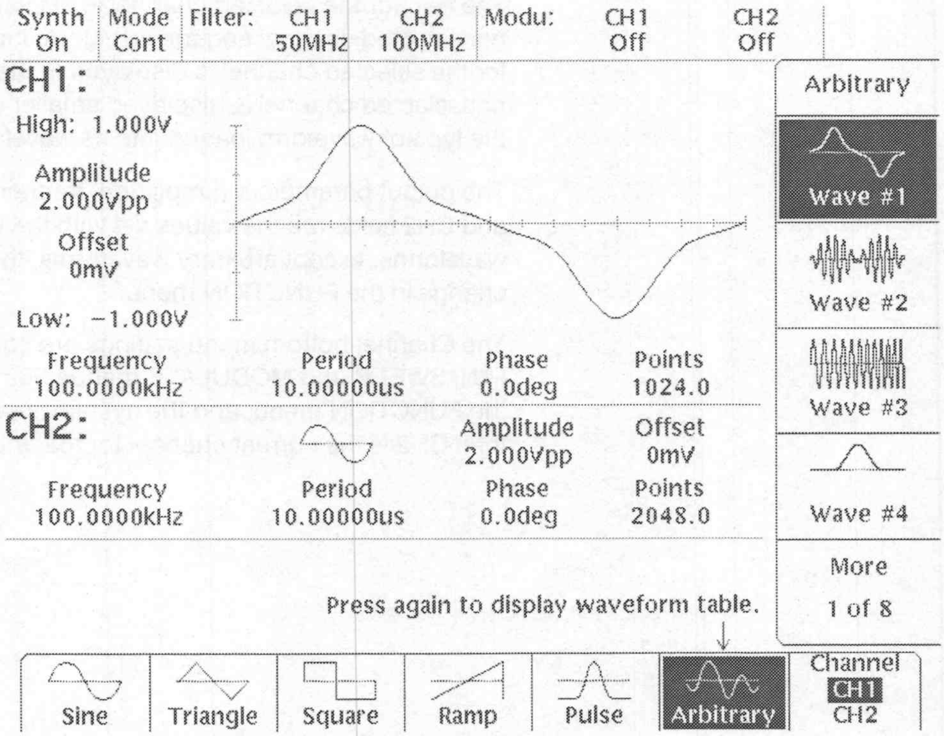


Figure 3-25: Arbitrary Waveform Display

Wave #1 through Wave #32—The Wave # selection item contains a copy of the waveform stored into the corresponding arbitrary waveform memory. When no waveform is stored, since DC is the initial setting, a straight line is displayed as the icon.

When one of the Wave # buttons is pressed, the corresponding arbitrary waveform is loaded into the waveform memory for the current channel.

When an arbitrary waveform is selected in synthesizer off mode (Synth Off selected with the OUTPUT menu), the Clock Rate is displayed in the CH1 parameter display area.

Selecting the Output Channel

If Option 02 is installed, the Channel menu item is displayed. The bottom menu Channel column has CH1 and CH2 labels, one of them is displayed in reverse video. Pressing this button switches the reverse video display and selects the current channel.

The Channel item of the FUNCTION menu selects which channel is affected when function waveforms and arbitrary waveforms are loaded into the waveform memory and parameters are changed.

The field for the selected channel is displayed larger than the field for the nonselected channel and the waveform loaded into the waveform memory for the selected channel is displayed in the graphical area. The field for the nonselected channel is displayed smaller and an icon is displayed indicating the type of waveform loaded into its waveform memory.

The output parameters (amplitude, frequency, etc.) displayed in the CH1 and CH2 fields are the values set with the OUTPUT menu. For all function waveforms, except arbitrary waveforms, the output parameter can also be change in the FUNCTION menu.

The Channel bottom menu settings are common to the FUNCTION, OUTPUT, SWEEP, and MODULATE menus. For example, if CH2 is selected with the FUNCTION menu, and the system is switched to the OUTPUT menu, then CH2 is the current channel for that menu too.

Output Menu

Press the OUTPUT button on the front panel in the MENU column to set the output parameters for the selected waveform on the current channel. Refer to Figure 3-26 for the Output menu structure. The bottom menu displays the Synth On/Off, Frequency/Phase, Amplitude/ Offset, Filter, Range, and Channel selection items.

When one of the items (other than Synth and Channel) is selected from the bottom menu, a corresponding side menu for the output parameter is displayed at the right side of the screen. Use the side buttons and the general purpose knob or numeric keys to change these parameters. Parameters can be set separately for CH1 and CH2.

Except for the specific bottom menu and side menus, the OUTPUT menu display is the same as for the FUNCTION or TRIGGER MODE menus (refer to these menu descriptions in this section for details). The parameter values of amplitude, output offset, frequency, phase, and points (number of points per output cycle) are displayed for CH1 and CH2. When the parameter values are changed, the parameter displayed in the current channel field changes too. A waveform graph is displayed to show the waveform loaded into the waveform memory for the current channel and a waveform type icon is displayed for the non-current channel. If Option 02 (CH2 output) is not installed, channel item and items related to CH2 are not displayed.

The signal output can be switched on or off anytime with the channel switch above the output connector on the front panel.

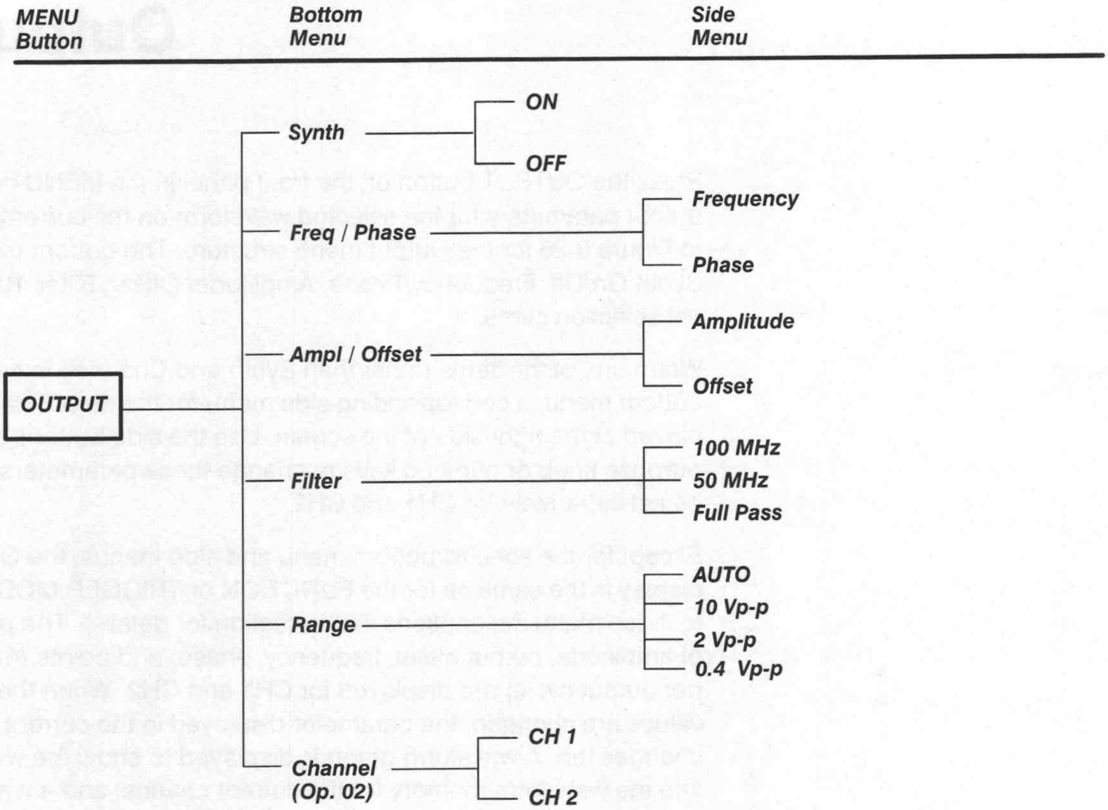


Figure 3-26: OUTPUT Menu Structure

Selecting Output Parameters

Synthesizer Mode

The Synth bottom menu has the On and Off labels in the column. One of which is displayed in the reverse video. Each time the Synth button is pressed, the reverse video display is toggled to the other label and the synthesizer mode is selected accordingly. The Synthesizer On/Off mode is the same for CH1 and CH2.

The synthesizer on mode reads out the waveform with the Direct Digital Synthesis (DDS) method (refer to *Basic Principles of Waveform Generation*, earlier in this section, for details). The synthesizer off mode varies the read out clock frequency as it reads out the waveform.

Use the following criteria to select Synthesizer On mode:

- Low-speed waveform output and smooth waveforms such as sine waves
- Sine wave output up to frequencies of 100 MHz, and wave shapes other than sine waves up to 2.5 MHz
- High-resolution of frequency and phase for waveform outputs
- The frequency for CH1 and CH2 can be set independently
- Modulation menu FM, FSK, and PSK modulation and SWEEP menu selectable
- Parallel operation of multiple AFG2020s and waveform output with output timing for each instrument accurately synchronized

Use the following criteria to select Synthesizer Off mode:

- High-speed pulse waveform output
- Pulse waves with frequencies up to 50 MHz and non-pulse waves with frequencies up to 31.2 MHz (the frequency of CH2 must be an integer multiple of ½ the CH1 frequency, for example 1/2, 1/4, 1/8...)

Frequency and Phase

Press the Freq/Phase button in the bottom menu to display the side menu for changing the frequency and phase of the output signal for the current channel (see Figure 3-27). However, the Phase item is only displayed when the synthesizer on mode is selected.

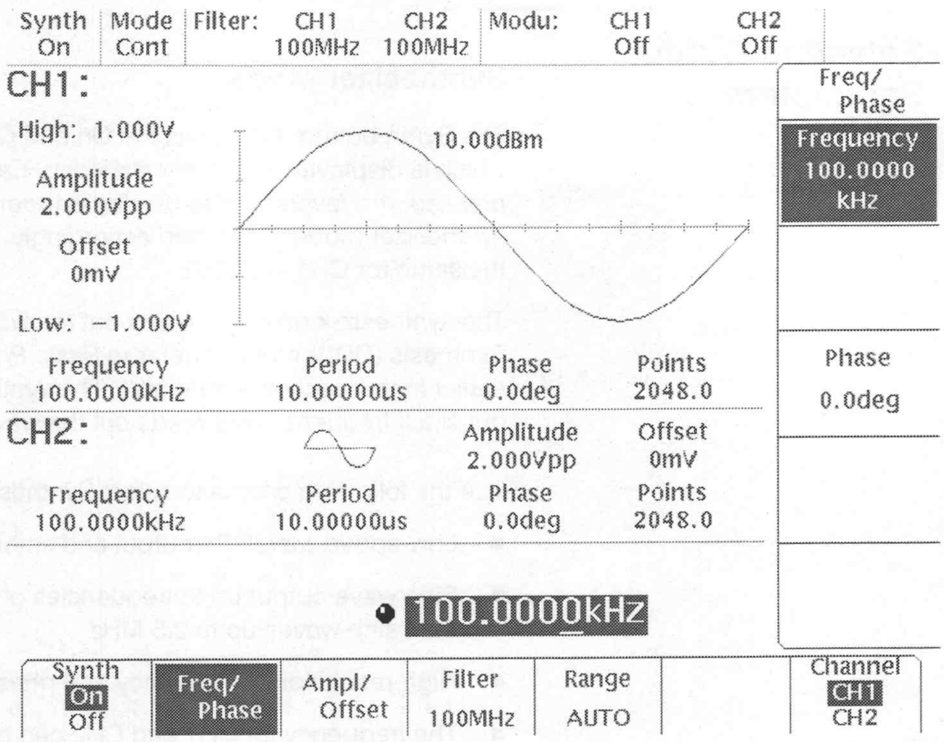


Figure 3-27: Frequency/Phase Menu

The side menu contains the following items.

Frequency — This menu is used to adjust the frequency for the output signal. In Synthesizer Off mode, the frequency for CH2 must be an integer multiple of ½ the CH1 frequency (for example 1/2, 1/4, 1/8...). The setting range depends on the synthesizer mode and the type of waveform selected.

When Synthesizer On mode is selected, for symmetrical waveforms (other than arbitrary waveforms and pulse waveforms with exponential edges), the waveform data for a half cycle is written into waveform memory and that data is read out normal and inverted to generate one repetition of the waveform. Thus the data count appears to be 2048 points, double the waveform memory length.

The Points value displayed on the CRT screen shows the number of waveform data sample points read out at the frequency set with the menu (see Table 3-2). To read out 2048 points of data, the output signal frequency must be set no greater than 122.070 kHz.

NOTE

When outputting an arbitrary waveform comprising multiple cycles, the number of sample points must observe the Nyquist theorem so that no aliasing occurs.

Table 3-2: Adjustable Range of Frequency and Number of Points

Type of Waveform	Synthesizer On Mode		Synthesizer Off Mode	
	Frequency	Point	Frequency	Point
Sine	0.5 Hz to 100 MHz	2048 to 2.5	0.5 Hz to 31.2 MHz	1024 to 8
Triangle	0.5 Hz to 2.5 MHz	2048 to 100	0.5 Hz to 31.2 MHz	1024 to 8
Square	0.5 Hz to 2.5 MHz	2048 to 100	0.5 Hz to 50 MHz	1024 to 4
Ramp	0.5 Hz to 2.5 MHz	1024 to 100	0.5 Hz to 31.2 MHz	1024 to 8
Exponent Pulse	0.5 Hz to 2.5 MHz	1024 to 100	0.5 Hz to 31.2 MHz	1024 to 8
Other Pulse	0.5 Hz to 2.5 MHz	2048 to 100	0.5 Hz to 31.2 MHz	1024 to 8
Arbitrary	0.5 Hz to 2.5 MHz	1024 to 100	0.5 Hz to 31.2 MHz	1024 to 8

For Synthesizer On mode, the frequency resolution is 0.5 Hz and the frequency setting is an integer multiple of this resolution.

NOTE

When CH1 and CH2 are set to a frequency that is an integer multiple of the base frequency resolution, the output from the two channels can be out of synchronization by as much as 0.12 Hz.

For synthesizer off mode, the frequency resolution is 0.1% to 1.0% of the output frequency and the setting value of frequency is displayed with three significant digits. For more detail, see the *Electrical Characteristics*, *Frequency/Phase*, in *Appendix B*.

Phase — This menu is displayed only in the Synthesizer On mode and is used to adjust the output signal phase. This function determines the phase difference relative to the reference point of phase 0 degrees. The range for setting this parameter is $-360°$ to $+360°$. The resolution is $0.1°$.

If the phase is shifted in the minus direction, the graph axis on the screen moves to the left. If the phase is shifted in the plus direction, the graph axis on the screen moves to the right. After the passage of the delay time from the generation of trigger signal, the waveform is output from the point where it intersects the vertical axis on the graph. The delay time is set with the TRIGGER MODE menu.

NOTE

When the frequency and phase are changed, the output is temporarily interrupted to align the output start phase.

Amplitude and Offset

Press Ampl/Offset in the bottom menu to change the output signal amplitude and offset values for the current channel. The side menu contains the items below.

Amplitude — These functions are used to adjust the amplitude of the output signal. An amplitude value with a minus sign reverses the polarity of the waveform.

When a sine wave is selected, the sine wave amplitude value is added to the top of the waveform graph with units of dBm. 0 dBm is the value that supplies 1 mW of power for 50 Ω termination.

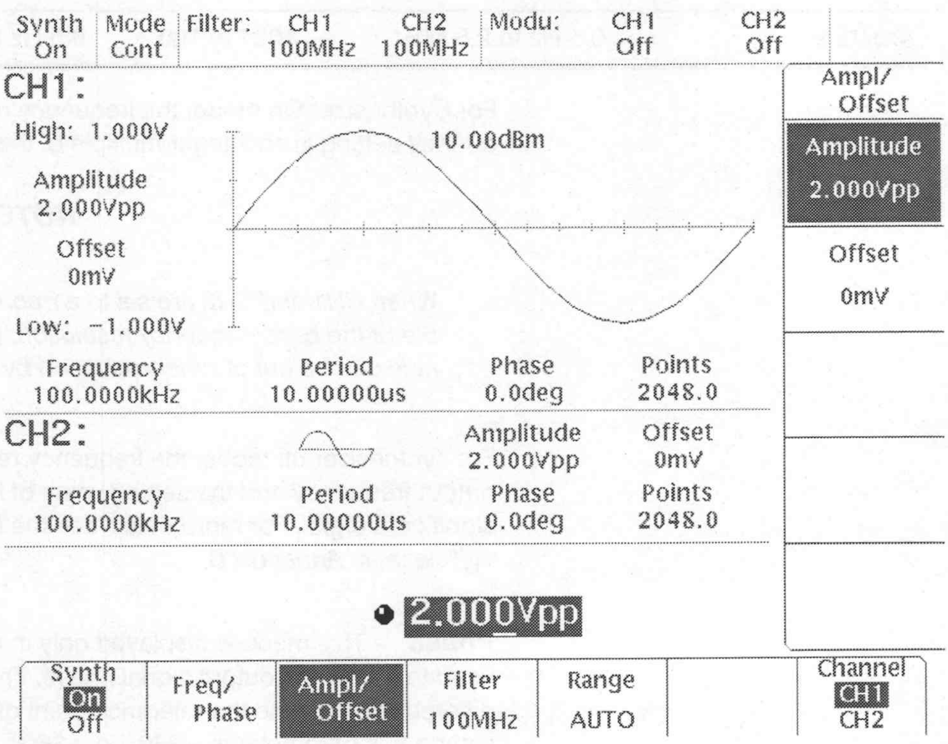


Figure 3-28: Ampl/Offset Menu

The High and Low values displayed on the CRT screen are the peak levels of the output signal when the Offset and Amplitude are set. When the amplitude is changed, the High and Low values change. When the amplitude is shown in negative (polarity are inverted), the inequality relationship between High and Low values are reversed (High < Low).

The following equation expresses the amplitude in terms of the High and Low values.

$$\text{Amplitude} = \text{High} - \text{Low}$$

The following equations express the High and Low values in terms of the amplitude and offset.

$$\text{High} = \text{Offset} + \text{Amplitude } (V_{p\text{-}p})/2$$

$$\text{Low} = \text{Offset} - \text{Amplitude } (V_{p\text{-}p})/2$$

The setting range for the amplitude varies with the offset value and selected Range (see the Range menu item). This is because the High or Low value must be set within the selected Range. The smaller the offset, the greater the setting range for the amplitude.

NOTE

The amplitude expresses the 12-bit full-scale value for the vertical axis. When outputting arbitrary waveforms that do not take up the full scale, the actual amplitude of the output waveform differs from the displayed amplitude value.

Offset — This menu is used to adjust the output signal offset. When the Offset is changed in the minus direction, the axis of the graph displayed on the CRT screen moves up. When the Offset is changed in the plus direction, the axis of the graph displayed on the CRT screen moves down.

The High and Low values are the peak levels of the output signal when the Offset and Amplitude are set. When the offset is changed, the High and Low values change.

The following equation expresses the offset in terms of the High and Low values.

$$\text{Offset} = (\text{High} - \text{Low})/2$$

The range through which the offset can be set varies with the amplitude values and the setting of the Range menu (see the Range menu).

The setting range for the offset varies with the amplitude value and selected Range (see the Range menu item). This is because the High or Low value must be set within the selected Range. The smaller the amplitude, the greater the setting range for the offset.

Filter

Press Filter in the bottom menu to select the Full Pass filter (no filter) or either of two low pass filters. The side menu contains the items below.

100 MHz, 50 MHz, Full Pass — The image frequency is generated by the sampling effect during D/A conversion. The low pass filter is needed to remove the image frequency component from the signal.

The 100 MHz (Brick Wall) filter is an elliptical function low pass filter. Its attenuation characteristic is within 1 dB maximum at 100 MHz and −40 dB at 125 MHz. This filter has a superior cutoff characteristic, but an inferior phase characteristic, so it is mainly used for outputting sine waves.

The 50 MHz (Linear Phase) low pass filter has an attenuation of −3 dB at 50 MHz. It has a good phase characteristic, so it is used for outputting signals other than sine waves.

The Full Pass item does not connect a filter at all. It is selected for outputting impulse waves and square waves with fast rising edges.

NOTE

When a sine wave is selected, the initial filter and the filters that can be selected depend on whether the Synthesizer mode is On or Off (see Table 3-3).

Table 3-3: Initial Filter and Selectable Filter

Type of Waveform	Synthesizer On Mode			Synthesizer Off Mode		
	100 MHz	50 MHz	Full Pass	100 MHz	50 MHz	Full Pass
Sine	@	X	0	X	@	0
Triangle	X	@	0	X	@	0
Square	X	0	@	X	0	@
Ramp	X	@	0	X	@	0
Pulse	X	@	0	X	@	0
Arbitrary	0	@	0	0	@	0

@: Initial Setting   O: Selectable   X: Non-Selectable

Range

Press Range in the bottom menu to select the output signal voltage range. The side menu contains the items below.

AUTO — When AUTO range is set, the voltage range is selected automatically according to the output signal amplitude and offset settings. If any other range is selected, the amplitude and the offset are restricted to the selected fixed value of Range.

10 V_{p-p}, 2 V_{p-p}, 0.4 V_{p-p} — The selectable fixed ranges give the maximum voltage value for the sum of the offset and half the peak to peak amplitude within the setting range shown in Table 3-4. Therefore, increasing the amplitude narrows the range for the offset and increasing the offset narrows the range for the amplitude.

Table 3-4: Setting Range

Range	Setting Range	Remark
AUTO	±5.000 V	Range switched automatically
10 V_{p-p}	±5.000 V	X5 amplifier inserted
2 V_{p-p}	±1.000 V	Pass through
0.4 V_{p-p}	±0.200 V	X5 attenuator inserted

The 2 V_{p-p} range of pass through is the basic range. The 10 V_{p-p} range connects a X5 amplifier and the 0.4 V_{p-p} range connects a X5 attenuator, so the setting range for amplitude and offset becomes X5 or 1/5. The voltage precision depends on the range. For details on the precision, see "Amplitude/Offset" in *Appendix B, Performance Characteristics*.

In normal usage, AUTO range is convenient, but when using the CH1 signal or external signal as the modulation signal for AM, the range should not be set to AUTO, because when the amplitude and offset are set with the menu and the range corresponding to these values is selected automatically, the desired voltage output may not be obtained.

For example, suppose the amplitude is set to 1 V_{p-p} with the menu, and the AM modulation signal is an external signal having a 1 V_{p-p} amplitude and 0.5 V offset. If AUTO range is selected, the 2 V_{p-p} range is automatically selected. Now, since the output is set to exceed 2 V_{p-p}, the modulated signal is clamped and distorted.

For another example, suppose the range is set to the fixed 2 V_{p-p} range (instead of AUTO), amplitude is set to 0 V_{p-p} with the menu, and AM modulation is used with the same external signal described above. Now the AM modulated signal has a 100% modulation factor, and the carrier wave has a 1 V_{p-p} amplitude. In this example, if the range changes to 10 V_{p-p} or 0.4 V_{p-p}, the output signal is 5X or 1/5X, respectively, of that for the 2 V_{p-p} range.

For details on AM modulation using an external signal or a CH1 signal as the modulation signal, see *Selecting Modulation Type* later in this section.

Selecting the Output Channel

When Option 02 (CH2 output) is installed, the Channel menu is displayed. The channel bottom menu has the CH1 and CH2 labels in its column, one of which is displayed in reverse video. Pressing the channel button toggles the reversed video display between CH1 and CH2 to select the current channel.

The channel item determines which channel the output parameters are set for in the OUTPUT menu.

The Channel bottom menu settings are common to the FUNCTION, OUTPUT, SWEEP, and MODULATE menus. The screen display is the same as for the FUNCTION menu, except for specific menu items.

Trigger Mode Menu

Press the TRIGGER MODE button on the front panel to set up the signal output trigger mode. Refer to Figure 3-29 for the Trigger Mode menu structure. The bottom menu displays the Cont (continuous), Triggered Cont, Gate, and Time Burst selection items.

The Cont mode continuously outputs the signal without a trigger or gate signal. Triggered Cont mode starts the signal output when the trigger event occurs and stops the output when the STOP button is pressed. Gate mode only outputs the signal while the gate signal exists. Time Burst mode starts signal output with a trigger signal and outputs the signal for the specified time duration. When modulation or sweep output are carried out in Time Burst mode, for each trigger signal, one sweep is executed, or one cycle of an analog modulation signal, or one sequence of digital modulation. For details on the start and stop timing of the output signal, see *Trigger Timing* earlier in *Section 3, Functional Operating Concepts*.

When a bottom menu item is selected, a corresponding side menu for selecting the trigger mode parameters is displayed at the right side of the screen, except for Cont, in which case there is no side menu.

The top-most column in the side menu is for the trigger source selection. Selecting the trigger source changes the display of other parameter items below in the side menu. Refer to the menu structure figure on the next page to see the lower level functions. These parameters can be changed using the side buttons and the general purpose knob or numeric keys.

Setting the Source, Delay, Slope, and Level in the side menu is common to Triggered Cont, Gate, and Time Burst modes. Thus, if some parameters are set up in one trigger mode, when another trigger mode is selected, those parameters remain the same. For example, if the Delay for External Source in Triggered Cont mode is set to 10 μs, the delay is set to 10 μs for all trigger modes and all sources.

The screen in TRIGGER MODE is the same one displayed when the FUNCTION or OUTPUT menus are selected.

The TRIGGER MODE menu does not have the channel menu for selecting the current output channel. However, the Time values in the Time Burst mode can be set separately for CH1 and CH2. The starting and stopping of the output signal is controlled by the same source in the same mode for both CH1 and CH2. If Option 02 (CH2 output) is not installed, the items related to CH2 are not displayed and menu items and parameters are displayed without channel distinction.

Trigger Mode Menu

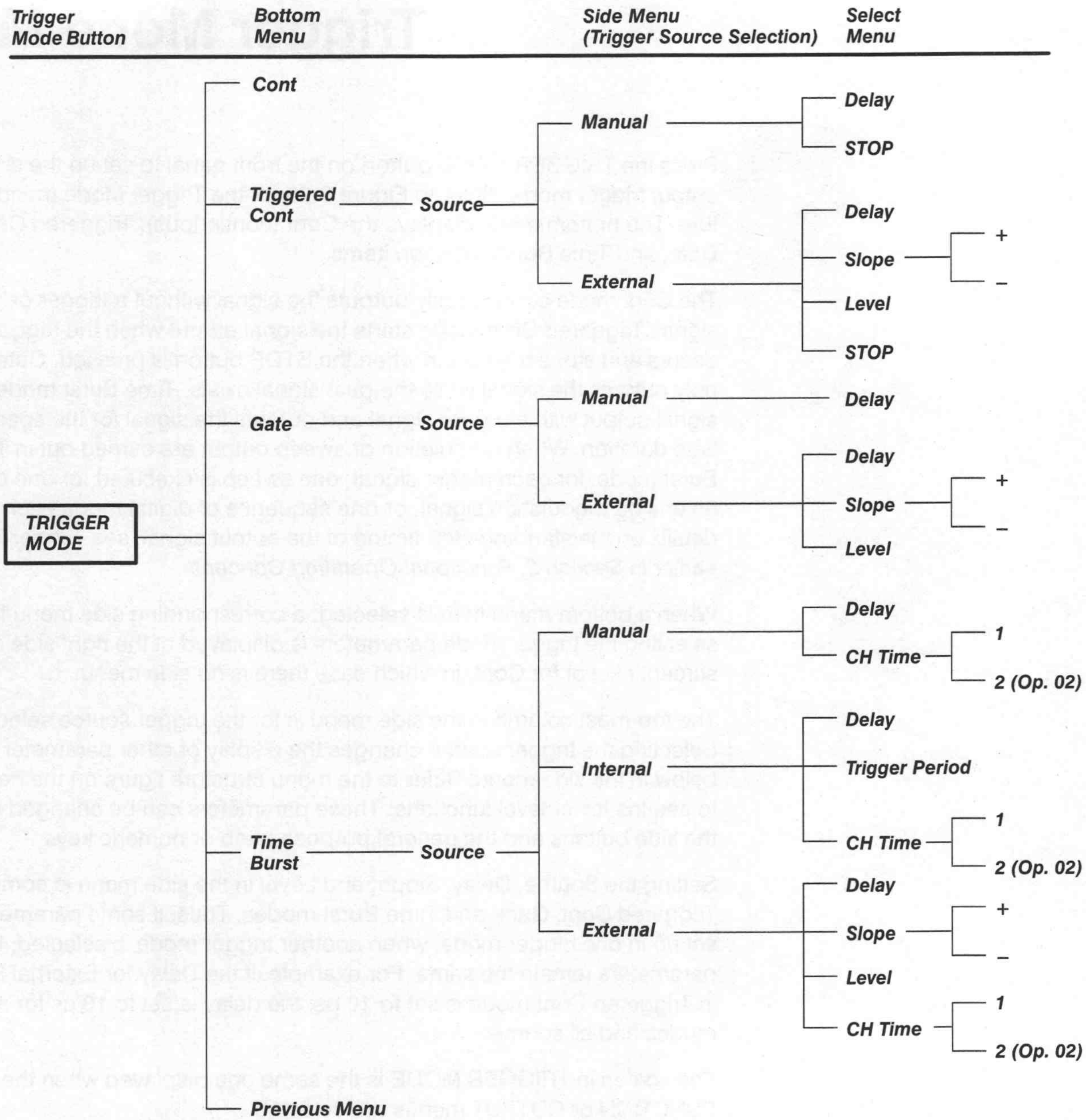


Figure 3-29: TRIGGER MODE Menu Structure

Selecting the Trigger Mode

Cont

Select Cont in the bottom menu to continuously output a waveform without a trigger or gate signal. When the MODULATE or SWEEP function is set to On, a modulated signal or a frequency sweep signal is continuously output.

Triggered Cont

Select Triggered Cont in the bottom menu to output the waveform, including all modulation and sweep waveforms, at the first occurrence of a trigger. The signal output continues until the side menu STOP button is pressed.

The trigger circuit is synchronized with the AFG2020 internal 10 MHz clock. From recognition of a trigger signal until the generation of the SYNC signal, there is a delay time of Td1 for synchronizing with the instrument's internal 10 MHz clock. Also, from the SYNC signal generation to the actual start of output, there is a delay time of Td2 (see Figure 3-15 earlier in this section).

The programmable delay that can be changed with the menu is the sum of Td1 and Td2. In Synthesizer Off mode (Synth Off on the OUTPUT menu), if the programmable delay is changed, the Td1 delay time changes. In Synthesizer On mode (Synth On on the OUTPUT menu), if the programmable delay is changed, the Td2 delay time changes.

From the moment the STOP button is pressed until the waveform output stops, there is a time delay, Td3, about 0.2 μs for CPU processing and for synchronizing with the 10 MHz clock. Furthermore, there is 2.5 μs of phase recovery time. At the end of the phase recovery time, the phase returns to its original phase, and the next trigger can be received. See *Trigger Timing* earlier in *Section 3, Functional Operating Concepts*, for more detail.

To accurately set the output timing for parallel operation of multiple AFG2020s, use rear panel REF IN and 10 MHz OUT connector signals to control output start/stop in the Triggered Cont mode.

Gate

Select Gate in the bottom menu to control the waveform output using gate signals. The start of the gate signal triggers waveform output and the end of the gate signal stops the output. Thus, the waveform is output as long as the gate signal is present.

The timing delays for starting and stopping the output with gate signals is the same as for Triggered Cont.

Time Burst

Select Time Burst in the bottom menu to set waveform output to start when a trigger signal occurs. The output will continue for a specified time duration. When modulation or sweep output is carried out in Time Burst mode, the time set with the Time side menu item is ignored. For each trigger signal, one sweep, or one cycle of an analog modulation signal (except CH1 AM and EXT AM), or one sequence of digital modulation is executed.

Selecting the Trigger Source

Press the Source button in the side menu to select the trigger source (see Figure 3-30). Each time this button is pressed, the source label in the side menu column moves to the next setting in the order: External, Manual, Internal, External ... You can also use the general purpose knob to change the source. Note that Internal is only selectable in Time Burst mode.

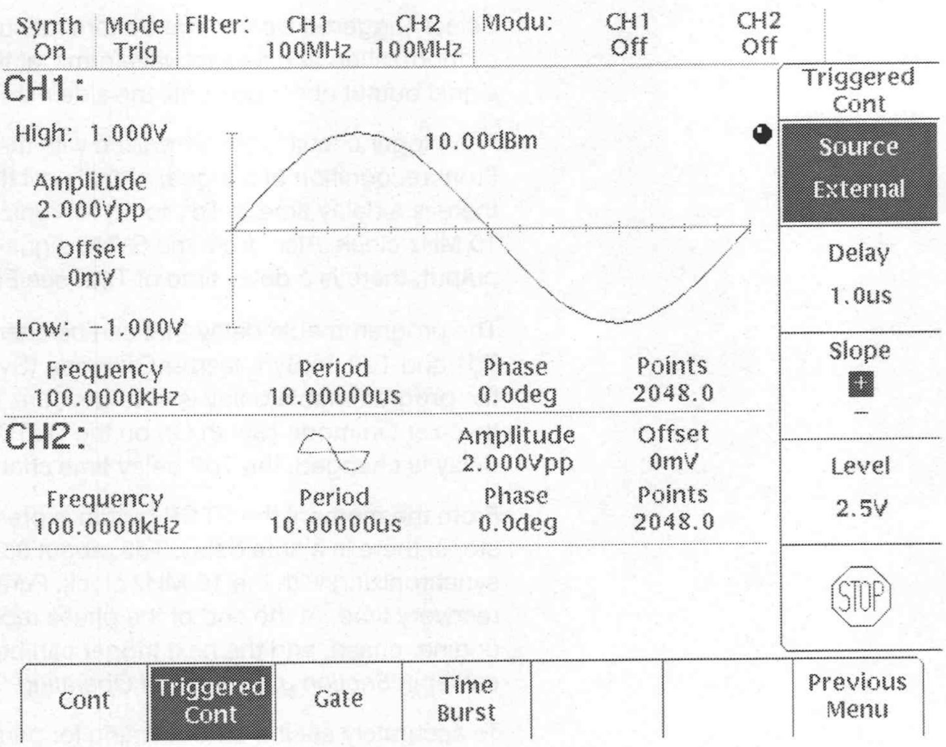


Figure 3-30: Menu Display in Triggered Cont Mode with External Source

External

The trigger or gate source signal is input from the TRIGGER INPUT connector on the front panel. The input signal frequency range is DC–10 MHz, and the maximum input voltage is ±10 V (DC + Peak AC). The trigger point on the external signal is set using the level and slope menus. When the gate mode is selected, the signal is only output during the period in which the gate signal is present.

Manual

In Triggered Cont mode, the trigger is generated when the front panel MANUAL button is pressed and is output until the STOP button is pressed in the side menu. In Gated mode, the waveform is output only while the MANUAL button is being pressed on the front panel.

Internal

The trigger signal is generated within the AFG2020. Internal triggering can only be set for Time Burst mode. The repetition period is set with the Trigger Period menu item. The time for which the signal is actually output is set with the Time menu item.

Setting Trigger Parameters

Delay

Use this item to adjust the time from the generation of the trigger or gate signal to the start of output. The setting range is from 0.7 μs to 100 s. The Delay item is displayed for all trigger sources.

NOTE

The programmable delay is the sum of Td1 and Td2 (see Figure 3-15 earlier in this section). Td1 is the time from the generation of the trigger signal to the generation of the SYNC signal. Td2 is the time from the SYNC signal generation to the actual start of output. In Synthesizer Off mode (Synth Off on the OUTPUT menu), if the programmable delay is changed, the Td1 delay time changes. In Synthesizer On mode (Synth On on the OUTPUT menu), if the programmable delay is changed, the Td2 delay time changes. Attention is needed for SYNC output timing.

Slope

The Slope item is displayed when External is set as the source. Each time the Slope button is pressed, the reverse video display switches between + and –. This item sets the trigger slope to either the rising or the falling edge of the external signal.

When Triggered Cont or Time Burst modes are selected, for a + slope, the trigger is generated at the rising slope of the external signal. For a – slope, the trigger is generated at the falling slope of the external signal.

When Gate mode is selected, for + slope, a signal is output during the high level of the external signal. For a – slope, a signal is output during the low level of the external signal.

Level

Use this item to set the level at which the trigger is generated between the positive and negative peaks of the external signal. The setting range is from +9.9 V to –9.9 V. The Level item is displayed when the source is set to External.

Stop

After the waveform output is triggered in Triggered Cont mode, this item is used to stop the waveform output. When the STOP button is pressed, the waveform output stops after about 0.2 μs required for CPU processing and Synchronizing with 10 MHz clock. There is also 2.5 μs of Tpr (phase recovery time). At the end of the Tpr, the phase returns to its original phase, and the next trigger can be received (see Figure 3-15 earlier in this section).

In Time Burst mode, the Time items is displayed in the side menu. If the source is set to Internal, the Trigger Period item is added to the side menu.

Trigger Period

Use this item to adjust the repetition period of the internal trigger signal. This trigger period is the time from the rising edge of the trigger signal to the next rising edge of the trigger signal. Each time the internal trigger signal is generated, the waveform output is triggered.

The setting range is from 10 μs to 100 s. However, there is a restriction:

Trigger Period > Delay + Time + 2.5 μs

Delay: Programmable Delay Time

Time: Signal Output Time

If Delay or Time is increased, the Trigger Period is changed automatically with the upper restriction.

CH Time

The channel output duration time is only selectable in Time Burst mode and is used to set the Time value for CH1 or CH2 (see Figure 3-31). The Time value is the time during which the waveform signal is actually output.

Each time the CH Time button is pressed, the reverse video display switches between CH1 and CH2 time value. The Time can be set independently for each channel. When Option 02 (CH2 output) is not installed, there is no switching between CH1 and CH2.

The setting range is from 0.4 μs to 100 s. However, there is a restriction:

Time < Trigger Period − Delay − 2.5 μs

Trigger Period: Repetition Period of Internal Trigger signal

Delay: Programmable Delay Time

When the modulate function or sweep function is On, except CH1 AM and EXT AM, the time value set with the Time side menu item is ignored. Instead, a modulated signal is output for one cycle of an analog modulation signal, or one sequence of digital modulation, or one sweep sequence is output.

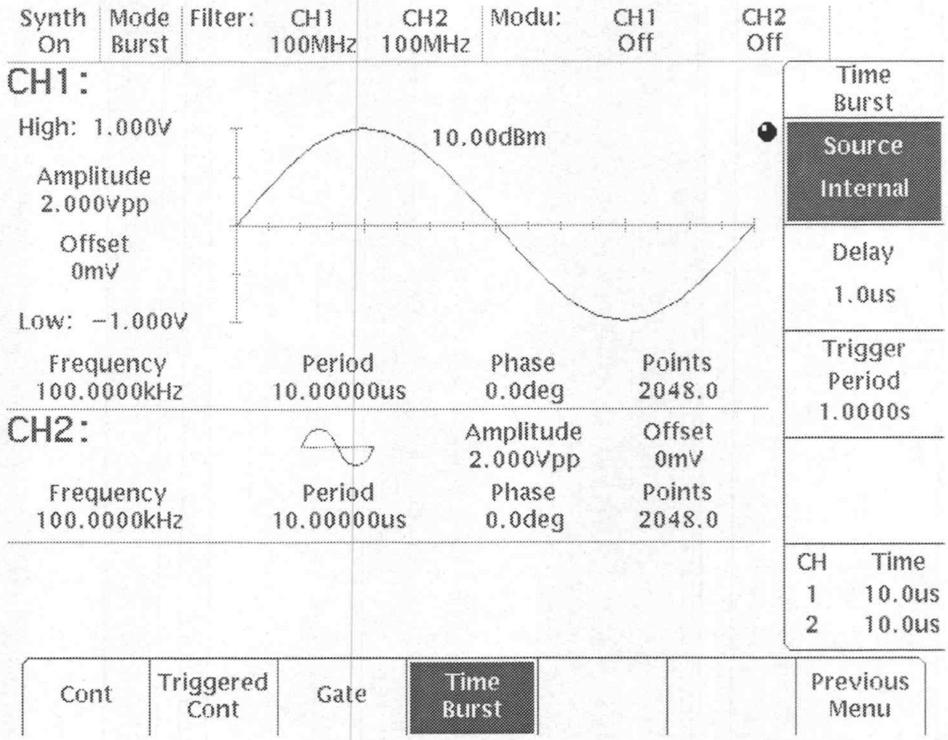


Figure 3-31: Menu Displayed in Time Burst Mode with Internal Source

Return to the Previous Menu

Press Previous Menu at the right side of the bottom menu to return the system to the menu displayed before selecting the TRIGGER MODE main menu.

Sweep Menu

Press the SWEEP button on the front panel to change the settings for sweeping the frequency of the output signal. Refer to Figure 3-32 for the Sweep menu structure. The sweep function varies the frequency linearly or logarithmically. Therefore, the frequency parameter set with the OUTPUT menu is ignored. The bottom menu items include the Type, Dwell time, Frequency, Marker, CH2 out, Sweep, and Channel.

When Synthesizer Off Mode is set to OFF (with the OUTPUT menu) and the front panel MENU column SWEEP button is pressed, a message is displayed that the SWEEP main menu cannot be selected with the Synthesizer OFF. After pressing the side menu Continue button or the CLEAR MENU button on the front panel to erase the message, select Synth On with the OUTPUT menu. Then press the SWEEP button to enter the SWEEP menu.

The Type button in the bottom menu can be used to select either standard sweep or multiple sweep.

- **Standard Sweep**—When Timing, Freq, or Marker is selected from the bottom menu, the item is displayed in reverse video. At the same time, the side menu for selecting the related sweep parameters is displayed on the right side of the screen. The parameters can be changed using the side buttons and the general purpose knob, or numeric keys.

  The sweep display waveform is a sawtooth wave with frequency along the vertical axis and time along the horizontal axis. When the Timing parameter is changed, the displayed sweep waveform also changes. The parameters can be set to sweep from low to high frequencies, or in the reverse direction. When the marker is On, + marks on the sweep waveform display indicate the marker position.

- **Multiple Sweep**—Multiple sweep is a technique in which several types of sweeps with differing parameters are programmed (with up to 16 steps). The individual sweeps are then executed sequentially. A table for programming multi–sweeps is displayed on the screen. The parameters in this table can be selected and their values changed using the arrow keys, the general purpose knob, and the numeric keys. The edit (bottom) menu is used to edit this table.

Sweep waveforms having different parameters can be set for CH1 and CH2. Thus, the sweep signals with different parameters can be output concurrently from the two channels. If Option 02 (CH2 output) is not installed, the Channel item and the items related to CH2 are not displayed.

Even when the modulate function is On, the sweep function can be turned on. This turns off the modulate function in order to obtain sweep output. Also, while the Sweep function is on, you can select waveforms with the FUNCTION menu and change output parameters with the OUTPUT menu.

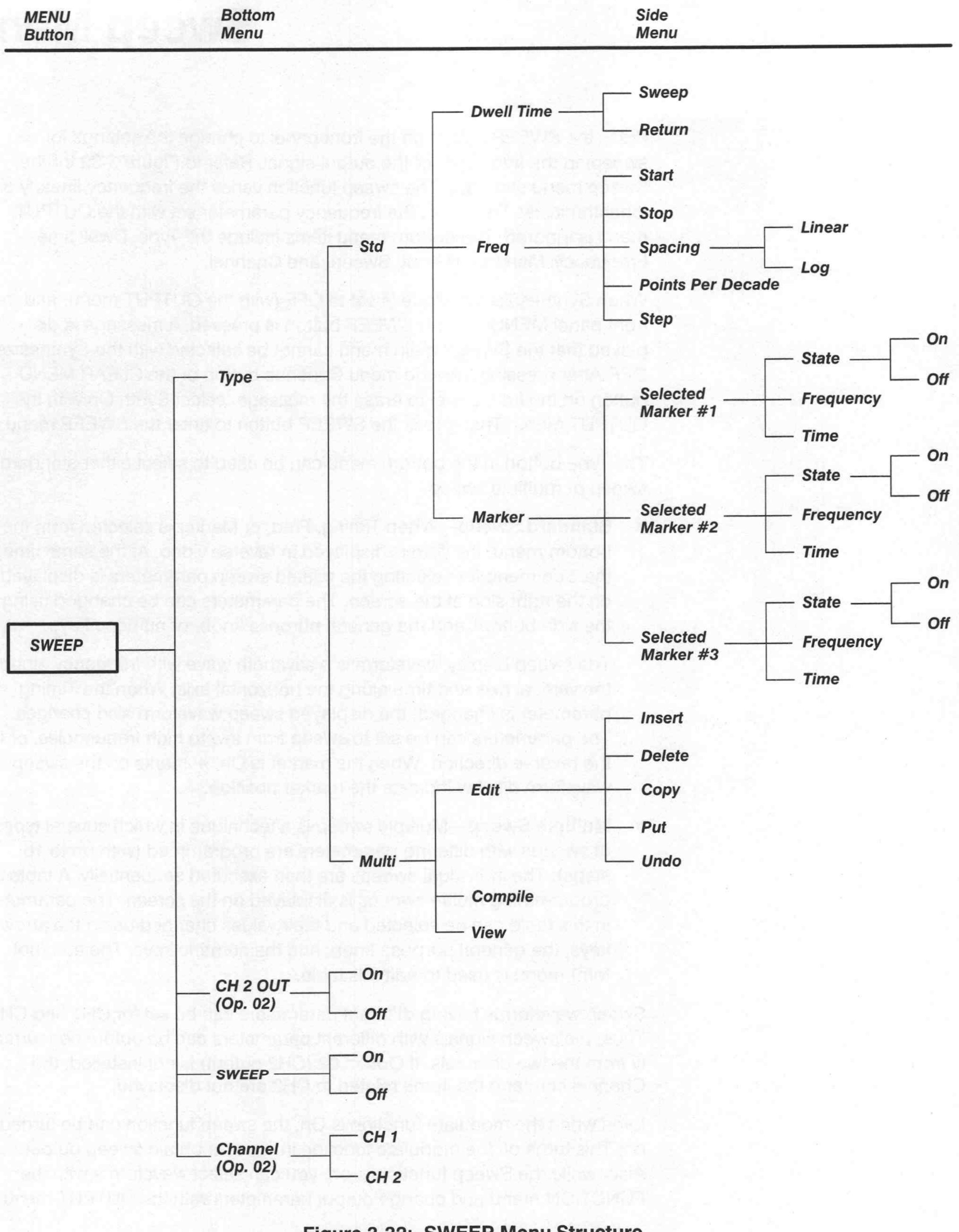


Figure 3-32: SWEEP Menu Structure

Standard Sweep Menu Display

Figure 3-33 shows the general display for the Standard Sweep menu. The descriptions for the feature callouts follow the figure.

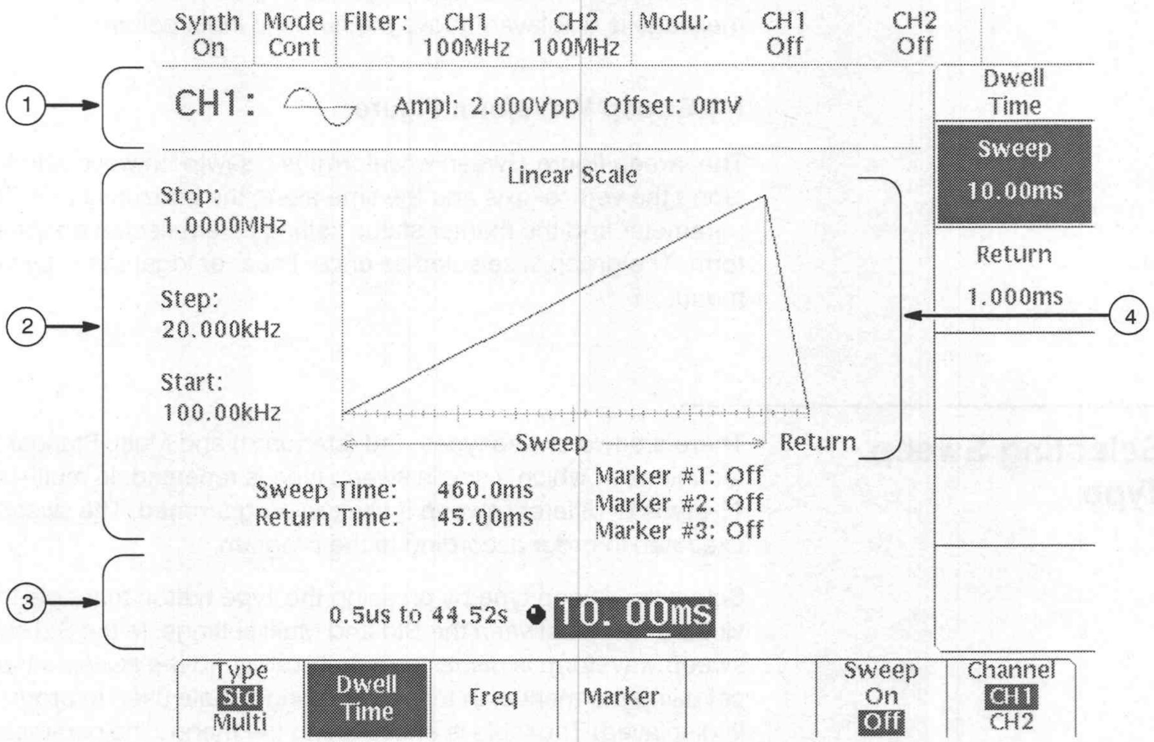


Figure 3-33: Screen Display for Std SWEEP Menu

(1) Current Channel Status

The current channel number, an icon indicating the type of waveform set in waveform memory, and the values for the amplitude and frequency parameters set with the OUTPUT menu are displayed in this area. When Sweep is switched to On, the frequency parameter is removed.

(2) Sweep Parameters

The Start frequency and Stop frequency are displayed at the left side of the sweep waveform figure. At the bottom of the figure, the Sweep Time, Return Time, and Marker #1–#3 parameter values are displayed. When the marker parameter is Off, Off is displayed. But when the Marker parameter is on, the marker frequency is displayed to indicate its position on the sweep waveform.

(3) Numeric Input and Message Field

When a numeric item is selected in a side menu, the numeric input column is displayed, and the current valid range is displayed for some parameters. If an attempt is made to input a numeric value that exceeds the valid range, a message is displayed above the numeric input column.

(4) Sweep Waveform Figure

The sweep figure (sweep waveform) is a sawtooth wave with the frequency along the vertical axis and the time along the horizontal axis. The Timing parameter and the marker status settings are reflected on the sweep waveform. The graph is selected as either linear or logarithmic by the Spacing menu.

Selecting Sweep Type

There are two sweep types: Std (standard) and Multi. Standard sweep is a technique in which a single sweep type is repeated. In multi–sweep, up to 16 steps of different sweep types are programmed. The sweeps are then executed in order according to the program.

Select the sweep type by pressing the Type button to toggle the reverse video display between the Std and Multi settings. In the Std setting the sweep waveform is displayed graphically, and the sweep parameters can be set using the menus. In the Multi setting a table used to program the sweep is displayed. The table is edited using the menu. The parameter values are set using the cursors and the numeric keys.

Setting Standard Sweep Parameters

The sweep parameters are Sweep and Return for the Dwell Time item and Start, Stop, Step, and Points per Decade for the Freq item. When parameter items are selected, the current valid range of the parameter is displayed at the bottom left of the CRT screen. In addition to the limits on the range inherent in each parameter, there are also the following conditions.

$$0 \le \text{Points} \le 5000$$
$$\text{Sweep\_Time} + \text{Return\_Time} \le 2048.0\text{ s}$$

Here is the relationship among the sweep parameters

$$\text{Sweep\_Time} = \text{Dwell\_Time\_Sweep} \times (\text{Points} + 1)$$
$$\text{Return\_Time} = \text{Dwell\_Time\_Return} \times \text{Points}$$

For linear sweep, the Points value is the integer rounded off from the expression $|\text{Start} - \text{Stop}|\ /\ \text{Step}$.

The actual sweep waveform has its frequency changed in steps. Figure 3-34 is an example of a 5-point sweep waveform.

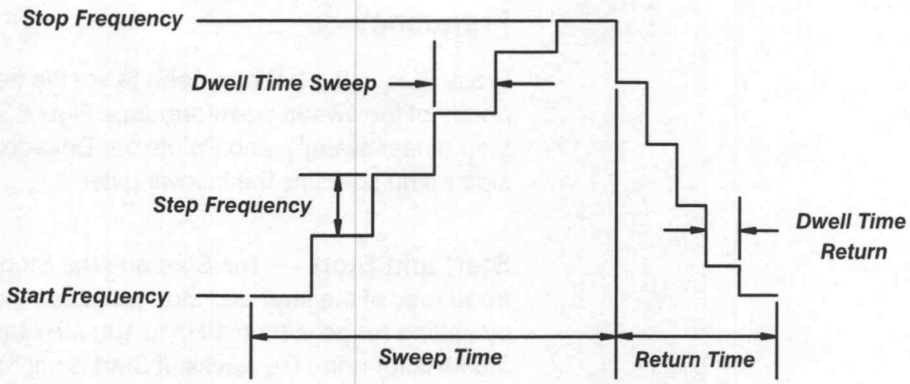


Figure 3-34: Example of Std Sweep Waveform

Dwell Time

The sweep waveform has its frequency changed in steps. Press Dwell to adjust the length of time per step (point) of the sweep waveform. When Dwell Time is selected from the bottom menu, the side menu is displayed to set the time duration of sweep time per step and the return time per step. The side menu contains the following items.

Sweep — The Sweep item can adjust the duration time for one point during the sweep changing from the start frequency to the stop frequency. The setting range is from 0.5 μs to 100 s. The Sweep Time value displayed on the CRT screen expresses the sweep waveform rise time (see the Sweep section in Figure 3-33) and is the product of the Sweep item value and the number of points + 1. Even if a marker is set, the marker time is not included.

Return — The Return item can adjust the duration the sweep takes for each point to return from the stop frequency to the start frequency. The setting range is from 0.5 μs to 100 s. The Return Time value displayed on the CRT screen expresses the sweep waveform fall time (Return section in the graph) and is the product of the Return item value and the number of points.

The sweep signal is output during the return time, too, for a reciprocal sweep. When Log is selected in the Spacing menu, the signal is swept logarithmically, both for the sweep and return times.

Frequency

Press Freq in the bottom menu to set the frequency for the start and stop points of the sweep waveform (see Figure 3-35). Spacing, frequency per step (linear sweep), and Points per Decade (log sweep) can also be set. The side menu contains the following items:

Start and Stop — The Start and the Stop items are used to adjust the frequency of the start and stop points on the sweep waveform. The frequency setting range is from 1 Hz to 100 MHz for sine waves and from 1 Hz to 2.5 MHz for non-sine waves. If Start is set higher than Stop, the frequency sweeps from the higher frequency to the lower.

The setting range for the frequency is also restricted by the Step frequency with linear sweep, or by the number of Points per Decade with log sweep. Up to 5000 steps in frequency are available in linear sweep. Thus the smallest Step frequency is limited to the following quantity.

$$\frac{\textit{upper sweep frequency limit} - \textit{lower sweep frequency limit}}{5000}$$

In log sweep, Points per Decade ranges from 10 to 1000 in a 1-2-5 sequence. For frequencies less than or equal to 10 Hz, the limit is 10. For frequencies from 10 Hz to 100 Hz, the limit is 100. For frequencies above 100 Hz, 1000 Points per Decade are available.

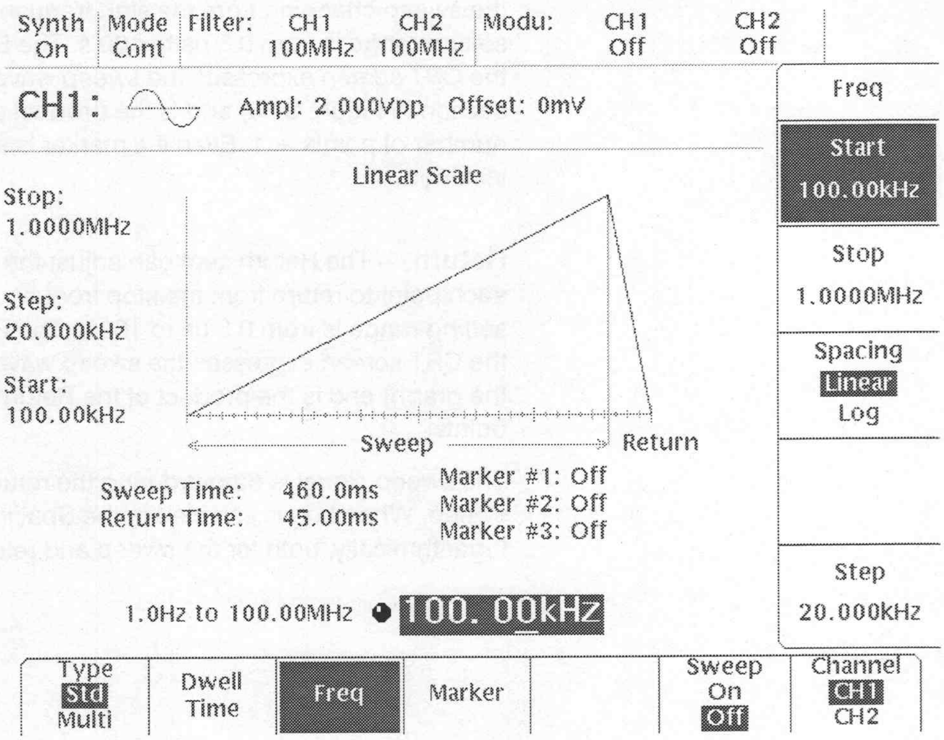


Figure 3-35: Display for the Freq Menu

Spacing — When the Spacing side menu button is pressed, the reverse video display in the Spacing column is switched between Linear and Log. The rate of change for sweep frequency can be either Linear or Log.

The sweep output frequency is varied in steps. When Linear is selected, the frequency is varied by a fixed amount (Step frequency) for each step. When Log is selected, the frequency is changed logarithmically for each step.

Step — When Linear Spacing is selected, the Step item is displayed. Use the Step item to adjust the value of the frequency for each step. Up to 5000 steps in frequency are available between the Start and Stop frequency. The step size must be set so that the 5000 step limit is not exceeded.

When Log is selected as the Spacing, the Points Per Decade item is displayed. This item indicates the number of steps it takes for the frequency to change to 10X (or 1/10X). When the Points per Decade button is pressed, the general purpose knob icon is displayed at high intensity in the upper left of this column. The Points Per Decade parameter can be set from 10 to 1000 in steps of 1-2-5 by turning the general purpose knob or by repeatedly pressing the Points Per Decade button.

Marker

Press Marker in the bottom menu to set up to three reference points on the sweep waveform. When the sweep reaches a marker position, the change of sweep frequency is stopped for the time duration set with the Time item in the Marker menu. The On/Off, frequency, and Time parameters can be set independently for each marker.

The side menu has four items: Selected Marker #, State On/Off, Frequency, and Time.

Selected Marker #1 to #3 — When the Selected Marker # item is selected, the general purpose knob icon is displayed at high intensity at the top left of the side menu column (see Figure 3-36). There are two ways to select one of the three markers. The general purpose knob can be used to cycle the selection through the numbers from 1 to 3. A marker can be selected by pressing the Selected Marker # button repeatedly. The parameters for the selected marker are displayed under the Selected Marker # item in the side menu.

State — This item is used to switch the marker On/Off. When the marker is On, a + sign is displayed at the marker position on the sweep waveform. Also, vertical lines are added on both sides of the + sign for the selected marker. When a marker is off, its marker symbol is not displayed.

If changing the Start or Stop of sweep parameter causes the marker position (frequency value) to be out of the sweep range, that marker is automatically switched off. If you switch that marker on, using the side menu, the marker frequency takes on the value of the limit it previously exceeded.

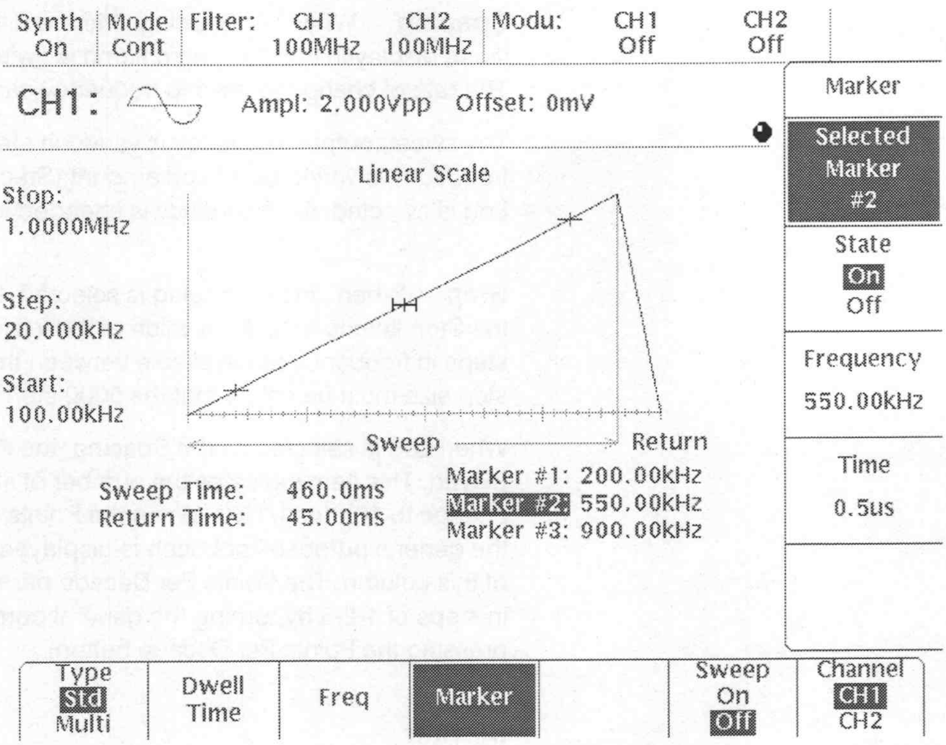


Figure 3-36: Display for the Marker Menu

Frequency — This function sets the frequency of the marker. The range setting is between the Start and Stop frequencies. The markers are placed in order 1, 2, 3 from left to right on the sweep waveform. If a marker is given a frequency placing it beyond the next marker on the left or right, the next marker is given the same frequency as the marker being set.

If the marker frequency is out of range because of changing the Start or Stop frequency of the sweep, or because of attempting to change the value with general purpose knob, an error message is displayed.

Below the sweep diagram on the screen, the frequencies indicating the marker positions are shown for markers that are on; Off is displayed for markers that are off.

Time — This item is used to set the marker Pause time. The setting range is from 0.5 µs to 100 s. When the sweep reaches the marker position, the sweep frequency is held constant for this time, then the sweep resumes. The marker time is not included in the sweep time.

CH2 Out

If Option 02 is installed, and when CH1 is selected as the current channel and the sweep function is on, CH2 Out item is displayed in the bottom menu. CH2 Out is used to turn on or off the output of a ramp waveform synchronized with the CH1 sweep waveform.

At the bottom menu CH2 Out column, the On or Off label is displayed. Each time this button is pressed, the reverse video display portion is toggled between On and Off. When it is set to On, the channel bottom menu item is removed and the current channel cannot be changed. When the sweep function is set to off, the CH2 Out function automatically goes off.

The CH2 Out function generates a signal with the Start frequency represented by −1.000 V and the Stop frequency represented by +1.000 V. For linear sweep, a signal is output proportional to the frequency. And for log sweep, a signal is output proportion to the log of the frequency. The CH2 Out signal is a waveform combining the CH1 sweep waveform, displayed on the screen, and the markers. Since the frequency is held constant at the marker position on the sweep waveform, the voltage is also held constant on the CH2 Output signal for the marker time duration.

Sweep On/Off

Press the Sweep button in the bottom menu to toggle the sweep function on and off. The reverse video display thus toggles between On and Off. The sweep is switched on and off independently for each channel by selecting the current channel.

If the modulation is on, as selected in the MODULATE menu, when the sweep is switched on, the modulation is switch off and the sweep output is obtained. While the Sweep function is on, you can select waveforms with the FUNCTION menu and change output parameters with the OUTPUT menu. When the sweep function is on, if you select the OUTPUT menu, the bottom menu synthesizer and frequency items are not displayed.

Selecting the Output Channel

The Channel menu is displayed when Option 02 (CH2 output) is installed. The CH1 and CH2 labels are displayed in the bottom menu Channel column. Each time this button is pressed, the reverse video display toggles between these two labels and the channel with the reverse video display is selected as the current channel.

When a channel is selected, the status, sweep waveform graph, and the parameters set with the SWEEP menu (start frequency, stop frequency, sweep time, return time, marker frequencies, etc.) are displayed for the selected channel.

The Channel bottom menu is common to the FUNCTION, OUTPUT, SWEEP, and MODULATE menus.

Multiple Sweep Menu Display

Figure 3-37 shows the general display when multiple sweep is selected. The descriptions for the feature callouts follow the figure.

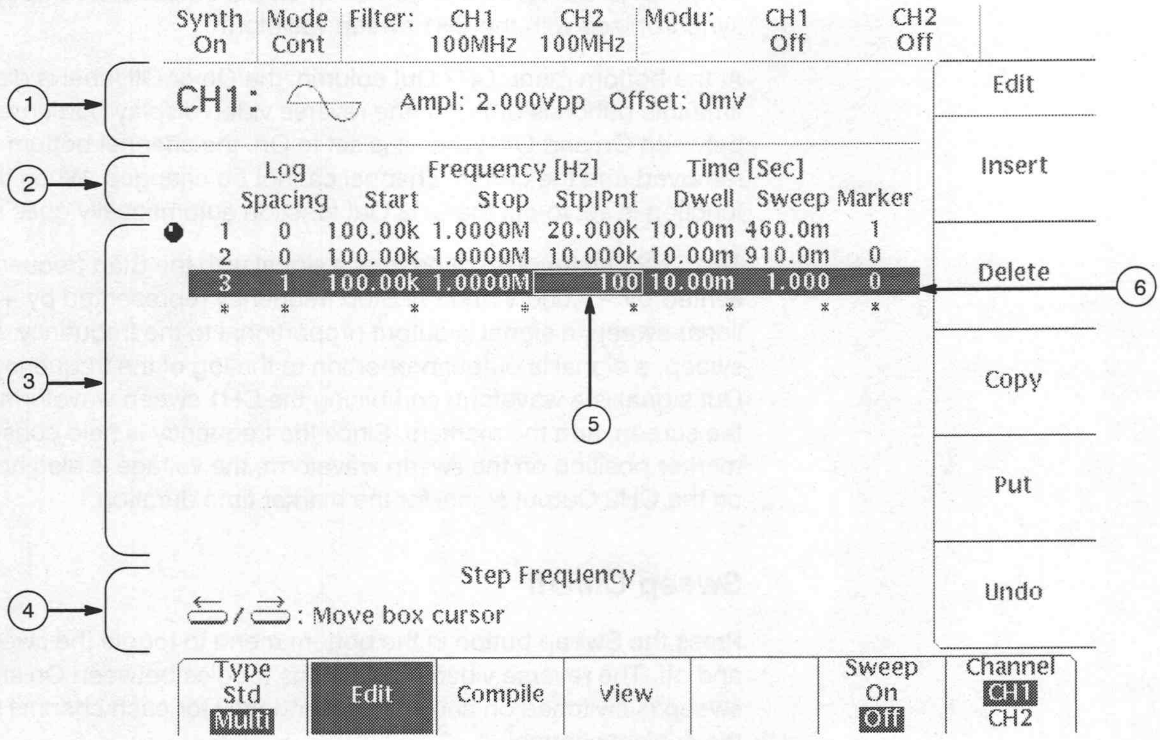


Figure 3-37: Screen Display for Multi SWEEP Menu

(1) Current Channel Status

The current channel number, an icon indicating the type of waveform set in the waveform memory, and the values for the amplitude and offset parameters set with the OUTPUT menu are displayed in this area.

(2) Sweep Parameters

The following item columns appear in the multiple sweep table: Log Spacing, Frequency (Start, Stop, Step/Point), Dwell times (Dwell, Sweep), and Marker. There is no return time setting in the multiple sweep parameters.

Sweep parameters (other than Marker) for standard and multiple sweep function the same way. Refer to the following sweep parameter descriptions:

Log Spacing — A value of 1 selects a logarithmic sweep and a value of 0 selects a linear sweep.

Start — Specifies the sweep start frequency.

Stop — Specifies the sweep stop frequency.

Stp | Pnt — When logarithmic sweep is selected, specifies the number of points per decade (a frequency range where the frequency changes by a factor of 10 or 1/10).

When a linear sweep is selected, specifies the frequency for a single step within the sweep.

Dwell — Specifies the sweep time per step (point).

Sweep — Specifies the time (sweep time) during which the sweep moves from the start frequency to the stop frequency. Since the sweep time is calculated from the Stp | Pnt and Dwell settings, its value cannot be set directly.

Marker — The marker setting is 1 for on and 0 for off. The marker on/off setting can be specified for each sweep. The marker output is output as a TTL-level signal from the MARKER output connector.

(3) Display Area for Multiple Sweep Steps

The sweep parameter values for each step are displayed. Up to 13 lines can be displayed at the same time. Additional steps can be reached by scrolling with the general purpose knob.

(4) Key Operations and Other Information

Provides descriptions of the functions assigned to the ← and → keys on the front panel, and information about the sweep parameter selected by box cursor.

(5) Box Cursor

A frame cursor that can only be moved with the arrow keys is displayed within the reverse video display cursor. It indicates the currently selected sweep parameter.

(6) Reverse Video Cursor

The reverse video display cursor can be moved using the general purpose knob or the arrow keys. The reverse video display cursor indicates the currently selected step in the display.

Setting Multiple Sweep Parameters

When Multiple Sweep is selected using the Type button in the bottom menu, a table for programming the sweep is displayed. Only one line of sweep parameters is setup in that table for default setting.

Up to 16 steps of different sweep types can be programmed. The table is edited using the Edit menu, and the parameter values are set using the cursors and the numeric keys.

Changing Parameter Values in a Multi-Sweep Table

The following procedure describes how to change parameters in a table that has multiple lines of multi-sweep parameters already setup. A reverse video display cursor containing a box cursor will be displayed in the table.

Perform the following steps to enter data into the multi-sweep table:

☐ **Step 1:** Move the reverse video display cursor to the program step to be changed using the general purpose knob.

☐ **Step 2:** Move the box cursor to the parameter to be changed using the arrow keys.

Check that the CURSOR indicator on the front panel is lit. If it is not lit, press the CURSOR button.

If the box cursor is at the end of the line, an attempt to move it out of the line using the arrow keys will automatically move the reverse video display cursor to the previous or next line.

☐ **Step 3:** Input the value for the parameter using the numeric keys.

During numeric input, the box cursor will be converted to a block cursor (frame cursor with black level background). When the numeric value is confirmed, the box cursor will be restored.

When the box cursor is moved to either the Log Spacing or Marker column, it will be converted to a block cursor. Using the numeric keys, enter a 1 for the log sweep setting or a 0 for the linear sweep setting. Enter a 1 to specify marker output or a 0 to disable marker output. Both of these parameters are automatically confirmed without pressing the ENTER key.

☐ **Step 4:** Confirm numeric values by pressing an appropriate units key or by pressing the ENTER key.

Use the ENTER key when only the value of the number, and not the units, is to be changed.

Both the Log Spacing and Marker parameters are automatically confirmed without pressing the ENTER key.

Press the Undo key on the side menu to return to the prior value after a new value has been entered and confirmed.

☐ **Step 5:** Repeat steps 1–4 to set each required parameter value.

☐ **Step 6:** Press the View button on the bottom menu to graphically verify the multiple sweep.

Press either the Continue button on the side menu or the Edit button on the bottom menu to return to table edit mode.

☐ **Step 7:** Compile the input data by pressing the Compile button on the bottom menu.

Edit Function

When Edit has been selected in the bottom menu, Insert, Delete, Copy, Put, and Undo are displayed on the side menu and the multiple sweep steps can be edited.

Each side menu item is described below:

Insert — If Copy has not been executed, a parameter line with default values is inserted above the reverse video display cursor. The line numbers following the inserted line are incremented.

After a Copy operation has been executed, the Insert operation inserts the contents of the copy buffer above the reverse video display cursor. The line numbers following the inserted line are incremented.

Up to 16 lines can be specified. Line numbers start from 1. Up to 13 lines can be displayed at the same time on the screen. If there are more than 13 lines, the window can be changed by scrolling using the general purpose knob.

Delete — The delete key deletes the line indicated by the reverse video display cursor and rewrites the line numbers of the following lines in order. If a line is deleted accidentally, the previous state can be recovered by pressing the Undo button immediately after the delete operation.

Copy — The Copy operation copies the data for the line indicated by the reverse video display cursor into the buffer.

The contents of the copy buffer are cleared by the following operations:

- Exiting the multiple sweep menu
- Executing the Compile function
- Turning on the sweep output (the Sweep item in the bottom menu is set to On)

Put — The Put operation overwrites the sweep parameter values stored in the copy buffer on the line indicated by the reverse video display cursor.

If the Put button is pressed when the copy buffer is empty, a message indicating that the copy buffer is empty will be displayed, and the Continue side menu will appear. The screen will return to the previous state if either Continue or the CLEAR MENU button is pressed.

Undo — This function cancels the most recent Input, Delete, Put, or data input operation. When this button is pressed, the previous data are restored in the table. Pressing this button again cancels the Undo operation (executes the cancel operation again).

NOTE

If you press the Put button more than one time, pressing the Undo button will not restore the previous data.

If the Undo button is pressed before any Insert, Delete, Put, or data input is executed, a message is displayed indicating that there is no previous action and the Continue item is displayed in the side menu. Press the Continue button or the CLEAR MENU button to return to the previous screen.

Compiling a Sequence

After entering the sweep parameters and editing lines in the multi-sweep table, the Compile button is pressed to compile the data.

If you try to change the sweep type, channel, or main menu before the Compile button is pressed, a message is displayed that the uncompiled data will be lost by this change. If the O.K. button is pressed, the uncompiled numeric values and settings are lost and the system switches to the selected menu. If the Cancel or CLEAR MENU button is pressed, the system returns to the previous screen.

NOTE

If sweep output is turned on (if the Sweep item in the bottom menu is set to on) before the Compile button is pressed, any uncompiled values and edits will be lost with no message displayed.

Graphic Display for Multiple Sweep

When the View button in the bottom menu is pressed, the AFG2020 graphically displays the contents of the multi-sweep table (see Figure 3-38). The maximum and minimum sweep frequencies are displayed on the vertical axis and the time to execute one sequence of the multiple sweep is displayed on the horizontal axis. Sweeps for which the marker is set are displayed intensified. Note that a log sweep is displayed as a curved line.

To return to the table display, press the Edit button in the bottom menu.

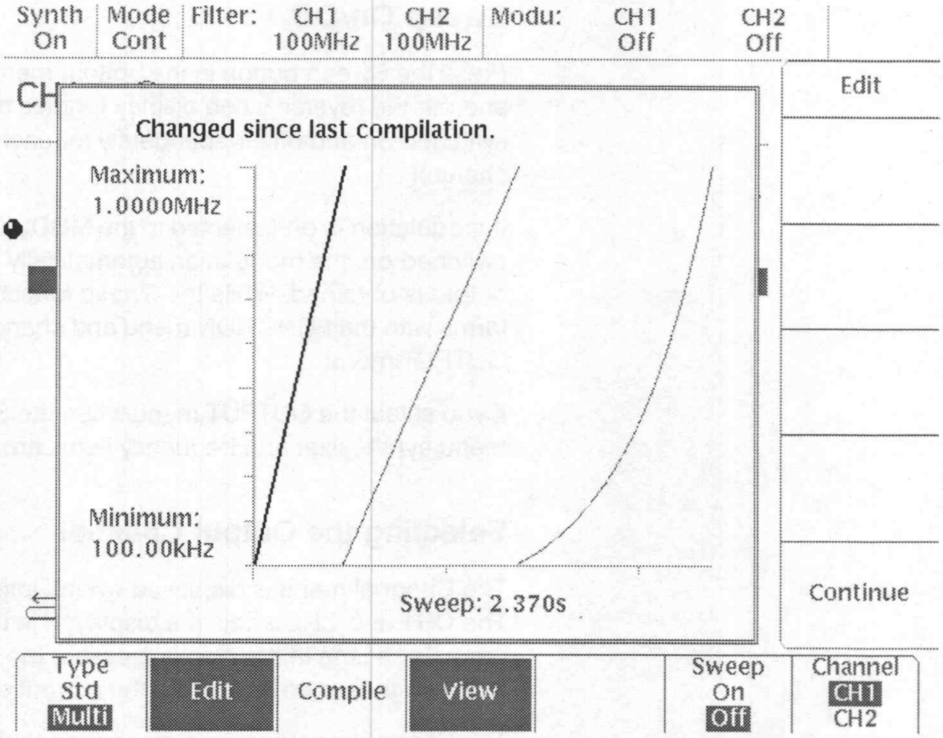


Figure 3-38: Screen Display when View Item is Selected

CH2 Out

If Option 02 is installed, CH1 is selected as the current channel, and the sweep function is on, the CH2 Out item is displayed in the bottom menu. CH2 Out is used to turn on or off the output of a ramp waveform synchronized with the CH1 sweep waveform.

The On and Off label is displayed at the bottom menu CH2 Out column. Each time this button is pressed, the reverse video display portion is toggled between On and Off. When the CH2 Out function is set to On, the channel bottom menu item is removed and the current channel cannot be changed. When the sweep function is set to off, the CH2 Out function automatically goes off.

The CH2 Out function generates a signal with the minimum frequency represented by −1.000 V and the maximum frequency represented by +1.000 V. For linear sweep, a signal is output in proportion to the frequency. For log sweep, a signal is output in proportion to the log of the frequency.

Sweep On/Off

Press the Sweep button in the bottom menu to toggle the sweep function on and off; the reverse video display toggles between On and Off. The sweep is switched on and off independently for each channel by selecting the current channel.

If modulation is on (selected in the MODULATE menu) when the sweep is switched on, the modulation automatically switches off and the sweep output is obtained. While the Sweep function is on, you can select waveforms with the FUNCTION menu and change output parameters with the OUTPUT menu.

If you select the OUTPUT menu when the Sweep function is on, the bottom menu synthesizer and frequency items are not displayed.

Selecting the Output Channel

The Channel menu is displayed when Option 02 (CH2 output) is installed. The CH1 and CH2 labels are displayed in the bottom menu Channel column. Each time this button is pressed, the reverse video display toggles between these two labels and the current channel can be selected.

The Channel bottom menu is common to the FUNCTION, OUTPUT, SWEEP, and MODULATE menus.

Modulate Menu

Press the MODULATE button in MENU column on the front panel to set the modulation parameters for the current channel output signal. Refer to Figure 3-39 for the Modulate menu structure.

When you enter the MODULATE menu, first select the modulation type. The Type column contains a label that indicates the current type selected. The two primary categories of modulation include analog modulation (AM, Offset, FM) and digital modulation (PSK and FSK). The specific types of modulation include: AM, Offset, FM, PSK, and FSK. Each type has different bottom menu items.

The AFG2020 analog modulation is controlled digitally. In this manual, the term of analog modulation means a modulation method in which the carrier wave is modulated continuously by parameter variance.

FM, PSK, and FSK modulation can only be selected when the clock mode is set to Synth On in the OUTPUT menu. When the clock mode is set to Synth Off (in effect, arbitrary waveform generation mode), the FM, PSK, and FSK labels are not displayed in the side menu.

When one of the MODULATE menu items is selected by the bottom button (except Modulate or Channel), the column for that menu item is displayed in reverse video and the related side menu items are displayed on the right side of the screen. Selection or parameter values for the menus are changed using the menu buttons and general purpose knob or numeric keys.

Information about the carrier wave is displayed in the status area for the current output channel. Information includes the current channel number, an icon indicating the type of waveform set in waveform memory, and the output parameters set with the OUTPUT menu. Different types of output parameters are displayed, depending on the type of modulation selected.

The CH1 marker signal is output from the CH1 MARKER connector on the front panel and the CH2 marker signal is output from MARKER OUTPUT CH2 connector on the rear panel. When analog modulation is selected, the marker can not be switched on and off, and the marker is generated at the start of every cycle of the modulation waveform. For digital modulation, the marker can also be switched on and off.

Different modulation parameters can be set for the CH1 and CH2 waveforms by changing the current channel. If Option 02 (CH2 output) is not installed, the Channel item and items related to CH2 are not displayed.

If the sweep (SWEEP menu) is on, when modulation is switched on, the sweep is switched off and the modulated signal is output. While the modulation function is on, you can select waveforms with the FUNCTION menu and change output parameters with the OUTPUT menu.

Modulate Menu

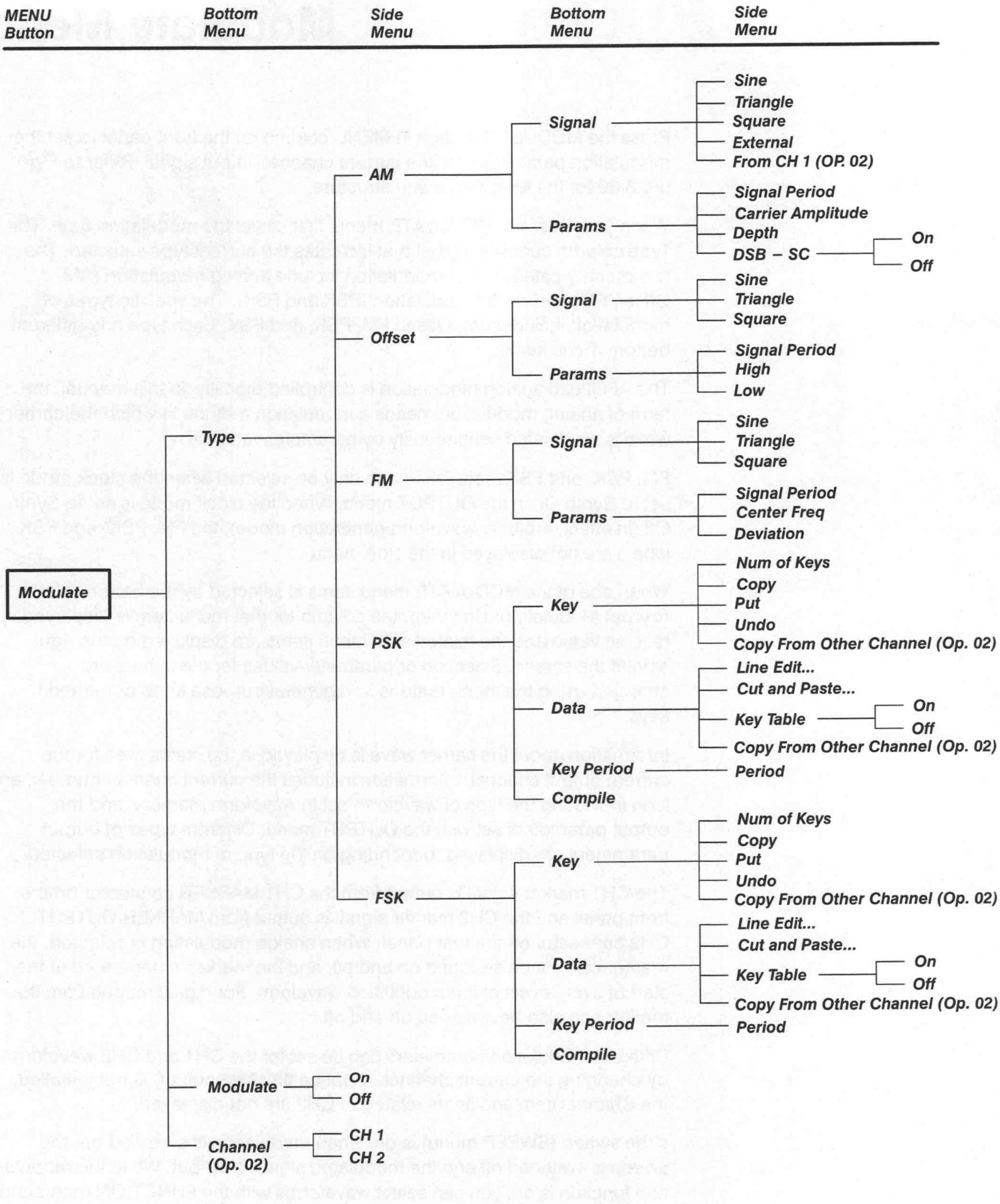


Figure 3-39: MODULATE Menu Structure

Modulate Menu Display

Figure 3-40 shows the general display for the Modulate menu. The descriptions for the feature callouts follow the figure.

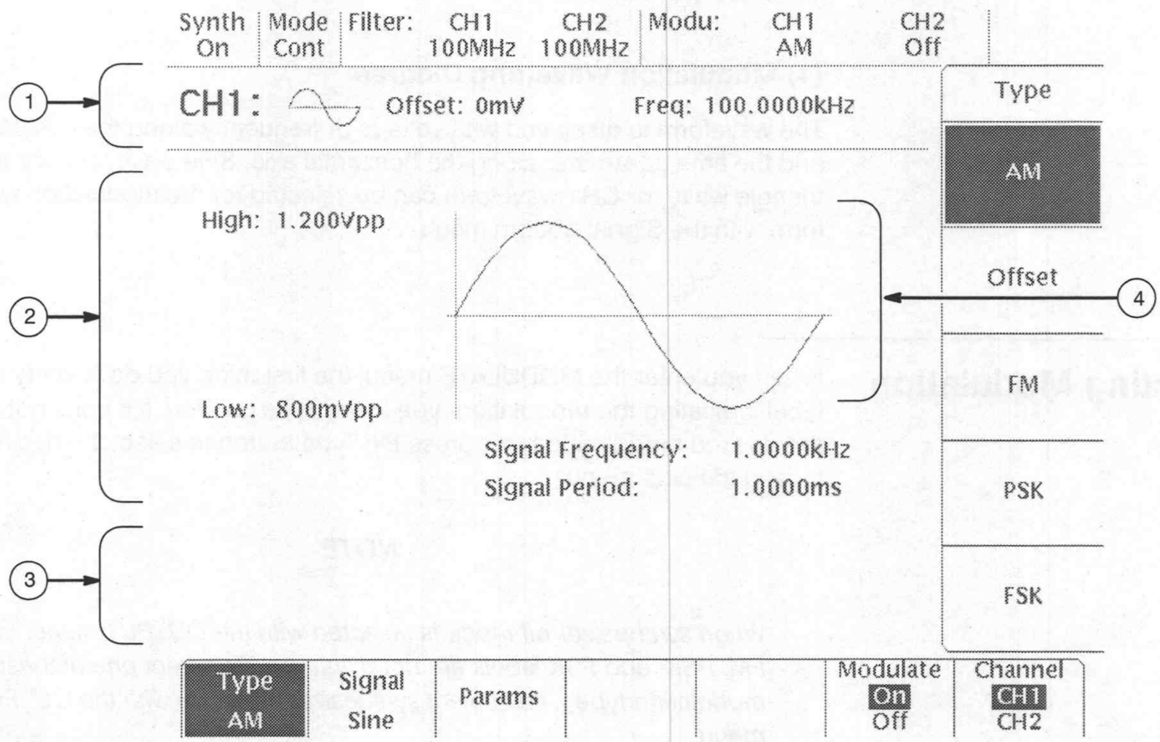


Figure 3-40: Screen Display for Analog Modulation

(1) Current Channel Status

Information about the signal that is to be the carrier wave is displayed in this area. The current channel number, an icon that shows the type of waveform set in the waveform memory, and the amplitude, offset, and frequency parameters are displayed in this area.

(2) Modulation Waveform Parameters

When the modulation waveform is a sine wave, square wave, or triangle wave, the Signal frequency and Signal Period parameter values are displayed. When the modulation wave is the CH1 waveform, the CH1 Frequency and CH1 Period parameter values are displayed. High and Low give the maximum and minimum values of peak level for the modulation waveform, respectively. Depending on the modulation type, the voltage or frequency is displayed for High and Low.

(3) Numeric Input and Message Display Field

The numeric input column is displayed by selecting a numeric item. When an out of range numeric value is input, a message is displayed above the numeric input column.

(4) Modulation Waveform Diagram

The waveform is displayed with voltage or frequency along the vertical axis and the time parameter along the horizontal axis. Sine wave, square wave, triangle wave, or CH1 waveform can be selected for the modulation waveform with the Signal bottom menu.

Selecting Modulation Type

When you enter the MODULATE menu, the first thing you do is verify the label indicating the modulation type in the Type column. If it does not show the desired modulation type, press the Type button to select the desired type in the side menu.

NOTE

When synthesizer off mode is selected with the OUTPUT menu, the FM, PSK, and FSK labels are not displayed. To select one of these modulation types, first select synthesizer on mode with the OUTPUT menu.

The analog modulation types are amplitude modulation (AM), offset level modulation (Offset), and frequency modulation (FM). When an analog modulation type is selected, the modulation waveform figure and parameters are displayed on the screen. The bottom menu items of Signal, Params, Modulate, and Channel are displayed to the right of the Type item.

The digital modulation types are phase shift keying (PSK) modulation and frequency shift keying (FSK) modulation. When a digital modulation is selected, the data needed for modulation is displayed in a table. The bottom menu of Key, Data, Key Period, Compile, Modulate, and Channel are displayed to the right of the Type item.

Analog Modulation

Selecting a Signal

Use the Signal item to select the modulation signal type. There are five types of modulation signals (see Figure 3-41). The External item is only displayed for AM modulation. Also, the From CH1 item is displayed only when the current channel is CH2 and the modulation type is AM.

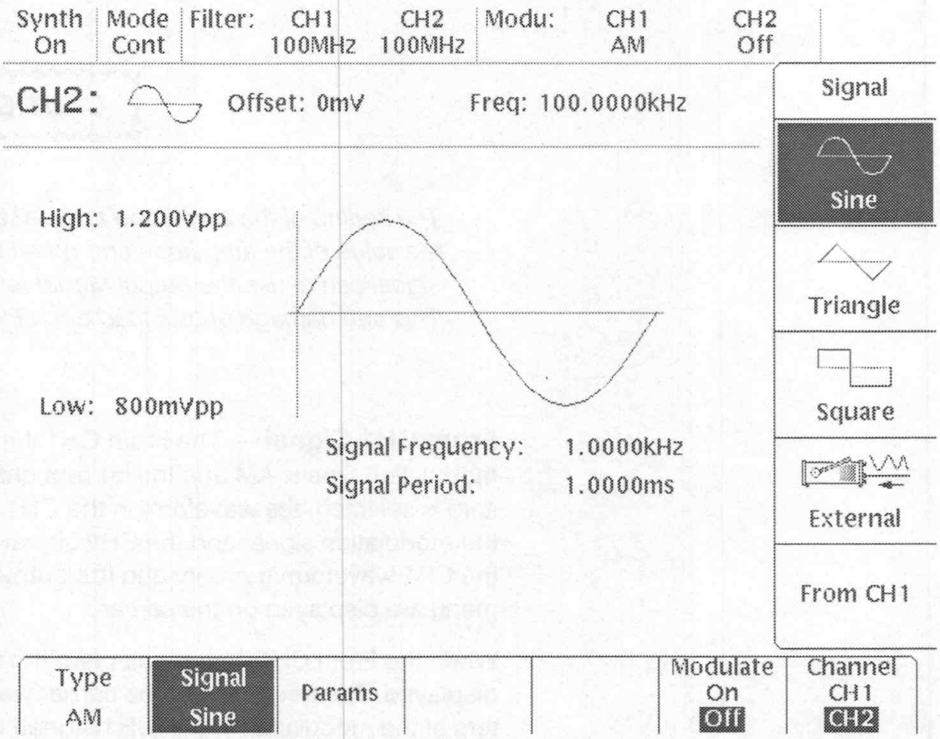


Figure 3-41: Signal Menu Display

Sine, Square, and Triangle — A sine wave, square wave, or triangle wave can be selected as the modulation signal waveform. The selected waveform is drawn in the graphical area.

External Signal — This item is only displayed when the modulation type is AM. When External is selected, the message "using external modulation signal" is displayed instead of the waveform figure, and the signal connected to the AM IN connector on the rear panel is selected as the modulation signal.

The effective voltage range for external modulation signals is ±1 V. While the external modulation is in process, the OUTPUT menu amplitude and offset can be changed. For details, see *Using the AFG2020 Auxiliary Connectors* in the *Functional Operating Concepts* part of *Section 3.*

NOTE

When the External item is selected, Range must be set to the appropriate range, other than AUTO. Even when using the same level of modulation signal for CH1, if you switch the range from 2 V_{p-p} to 10 V_{p-p} or 0.4 V_{p-p} in the OUTPUT menu, the amplitude of the modulation signal is either five times or a fifth of the output amplitude at the 2 V_{p-p} range.

CAUTION

The setting of the amplitude and offset in the OUTPUT menu and the value of the amplitude and offset for the external modulation signal can cause the output signal to exceed ±10 V (open circuit). This can damage output load circuitry.

From CH1 Signal — The From CH1 item is displayed only when the modulation type is AM and the current channel is CH2. When the From CH1 item is selected, the waveform in the CH1 waveform memory is selected as the modulation signal and the CH2 signal is AM modulated. The waveform in the CH1 waveform memory and the output parameters set in the OUTPUT menu are displayed on the screen.

When the From CH1 item is selected, the Params bottom menu items is not displayed. The frequency of the carrier wave (CH2 signal) and the parameters of the modulation wave (CH1 signal) can be changed with the OUTPUT menu.

NOTES

When using the CH1 signal as the modulation wave, terminate the CH1 output connector with 50 Ω. When the CH1 output is switched off, it is terminated internally with 50 Ω.

When the From CH1 item is selected, Range must be set to an appropriate range other than AUTO. Even when using the same level of modulation signal for CH1, if you switch the range from 2 V_{p-p} to 10 V_{p-p} or 0.4 V_{p-p} in the OUTPUT menu, the amplitude of modulation signal is either five times or a fifth of the output amplitude at the 2 V_{p-p} range.

CAUTION

The CH1 and CH2 amplitude and offset settings can cause the output signal to exceed ±10 V (open circuit). This can damage output load circuitry.

Setting Parameters

When Sine, Square, or Triangle are selected with the Signal menu, the Params item is displayed in the bottom menu. Press the Params button to display the side menu to set the modulation parameters (see Figure 3-42).

As shown below, the actual parameter items displayed in the side menu change with the modulation type selected:

AM modulation: Signal Period, Carrier Amplitude, Depth, DSB-SC

Offset modulation: Signal Period, High, Low

FM modulation: Signal Period, Center Frequency, Deviation

The AM carrier amplitude and the FM carrier center frequency are changed with Params menu. Other carrier wave parameters (amplitude offset, frequency, and phase) are changed with the OUTPUT menu.

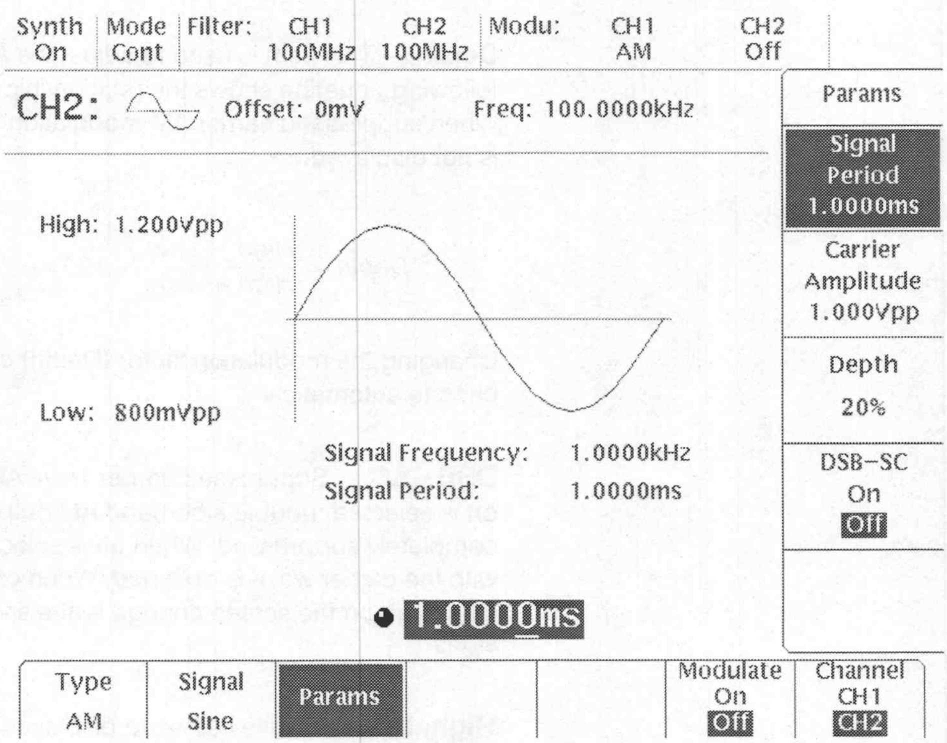


Figure 3-42: Params Menu Display

Here are explanations of all the possible side menu items.

Signal Period — This item is used to set time parameters for the modulation signal when Sine, Square, or Triangle is selected with the signal menu. When the Signal Period button is pressed, the period of modulation signal can be set. The setting range for the period is from 10 μs to 1 s for AM, offset, and FM modulation. The Signal Period and Signal Frequency values are displayed below the graph of the modulation waveform on the CRT screen.

Carrier Amplitude — This item is used to adjust the AM carrier wave amplitude. When the amplitude is changed, the High and Low values are changed automatically according to the modulation factor. When a negative amplitude is set, the carrier wave polarity is inverted. When suppressed carrier AM modulation is not set (DSB-SC is off), the relationship among Carrier Amplitude, High, and Low is given by the equation below.

$$\text{Carrier Amplitude} = (\text{High} + \text{Low})/2$$

NOTE

If carrier amplitude is less than the value of the Range, the S/N ratio is lower. In this case, select the appropriate Range in the OUTPUT menu.

Depth — This item is used to adjust the AM modulation factor (Depth). The following equation shows the relationship with the High and Low values. When suppressed carrier AM modulation is set (DSB-SC on), the Depth item is not displayed.

$$Depth = \frac{High - Low}{High + Low} \times 100\%$$

Changing the modulation factor (Depth) causes the High and Low values to change automatically.

DSB−SC — Suppressed carrier wave AM can be switched on or off. When on is selected, double side-band AM output is obtained with the carrier wave completely suppressed. When off is selected, double side-band AM output with the carrier wave is obtained. When on is selected, the High and Low displayed on the screen change to the same absolute values with opposite signs.

High, Low — These items are displayed for offset modulation. They set the peak voltages for the modulation signal. The High value must be greater than the Low value.

Center Frequency — This item is used to adjust the FM carrier wave center frequency. When the frequency is changed, the High and Low values are automatically changed while holding the Deviation constant. The setting range is from 0.5 Hz to 100 MHz when a sine wave is selected with the FUNCTION menu and from 0.5 Hz to 2.5 MHz when a waveform other than a sine wave is selected. However, the range is narrowed by the amount set with Deviation.

Deviation — This item is used to adjust frequency deviation of FM modulation. When the frequency deviation is changed, the High and Low values are automatically centered on the carrier wave frequency. The following equation shows the relationship among the Deviation and High and Low.

Deviation = (High – Low) / 2

Modulate On/Off

Press the Modulate button in the bottom menu to switch between modulation on and modulation off; the reverse video display toggles between On and Off. When On is selected, the modulation is carried out for the current channel waveform. When either the modulation function or the sweep function is switched On, the other is automatically switched Off. Even while the Modulation function is on, you can select waveforms with the FUNCTION menu and change output parameters with the OUTPUT menu.

NOTES

When changing from the MODULATE menu to the OUTPUT menu, depending on the type of modulation selected and whether modulation is set on or off, some OUTPUT bottom menu items may not be displayed in the OUTPUT menu.

The modulation signal is made based on a 10 MHz (0.1 μs) clock. On the other hand, the carrier wave frequency is an integer multiple of the DDS 0.23283 Hz. Therefore the carrier wave and the modulation signal are not synchronized.

Selecting the Output Channel

The Channel menu is displayed when Option 02 (CH2 output) is installed. The Channel column contains CH1 and CH2 labels with the selected current channel displayed in reverse video. Press the Channel button to toggle between CH1 and CH2.

When a channel is selected, the carrier wave status, graph of modulation waveform, and parameters (frequency, period, High, Low, etc.) are displayed for the selected channel. These parameters are only displayed if an analog modulation type is selected. The Channel bottom menu settings are common to the FUNCTION, OUTPUT, SWEEP, and MODULATE menus.

Digital Modulation

Figure 3-43 shows the general display when digital modulation (PSK or FSK) is selected. The descriptions for the feature callouts follow the figure.

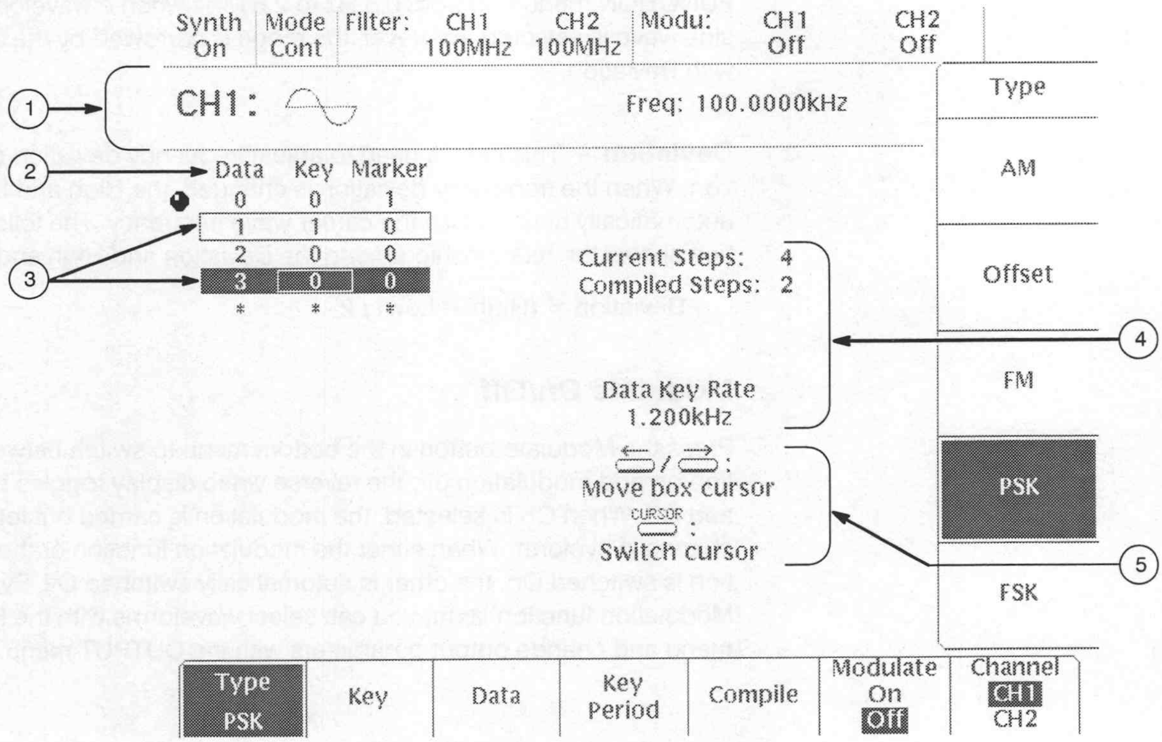


Figure 3-43: Digital Modulation Screen Display

(1) Current Channel Status

Information about the signal that is to be the carrier wave is displayed in this area. The current channel number, an icon that show the type of waveform set in the waveform memory, and the amplitude, offset, and frequency parameters are displayed in this area.

(2) Data Parameter

The items displayed are Data, Key, and Marker.

(3) Line Cursors and Box Cursor

Three cursors are displayed:

- The line cursor, displayed in reverse video, can be moved using the general purpose knob or the arrow keys
- The inactive box–shaped line cursor
- The box cursor, which can be moved within the reverse video cursor only by the arrow keys (the general purpose knob cannot be used)

(4) Information for Digital Modulation

The Key switching speed, the current sequence step count, and the step count for the compiled sequence are displayed.

(5) Button Operations

This area shows how the functions are allocated to the control buttons (←, →, and CURSOR in this case) on the front panel.

Entering Numeric Data in the Key and Data Tables

When digital modulation (PSK or FSK) is selected, the data necessary for modulation is displayed in a table. With the CURSOR button selected, the cursor can be moved, and numeric values can be input to the table at the cursor position.

There are two types of tables: a data table and a key table. When Type or Data is selected from the bottom menu, a data table is displayed to input a key sequence. Use this data table to set markers and input key numbers for each data number. One repetition of the sequence starts with Data number 0 and ends with the last data number defined.

When Key or Key Period is selected from the bottom menu, a key table is displayed to input deviation parameters. Use this key table to input the frequency, phase, amplitude, and offset values for each key number.

There are two line cursors within the data table. When pressed, the CURSOR key alternately selects which line cursor is displayed as the reverse video display cursor. There is only one line cursor in the Key table. The cursor is always displayed as a reverse video display cursor. There is also a box cursor which has a rectangular shape and surrounds numeric values within a reverse video display cursor.

To enter data into data or key tables, perform the following steps:

☐ **Step 1:** Display the data table or the key table.

To set a key sequence, select Type or Data from the bottom menu to display the data table. To input deviation parameters for keys, select Key or Key Period from the bottom menu to display the key table.

☐ **Step 2:** Check that the CURSOR indicator on the front panel is lit. If it is not lit, press the CURSOR button.

☐ **Step 3:** Use the general purpose knob to move the reverse video display cursor to the row of the desired Data number or Key number.

☐ **Step 4:** Use the arrow button to move the box cursor to the desired parameter column.

When the box cursor is at the end of the row, moving it further to the outside automatically moves the reverse video display cursor to the next or the previous number row.

☐ **Step 5:** Use the numeric keys to input the numeric value.

During numeric input, the box cursor changes into a block cursor (frame cursor with black level background). When you enter the numeric value, the cursor returns to a box cursor.

If you move the box cursor to the marker column, it automatically changes into a block cursor. Press the 1 key to set a marker; press the 0 key if you do not want to set a marker. This setting is entered automatically; you do not press the ENTER key.

☐ **Step 6:** Use the appropriate unit key or the ENTER key to enter the numeric value.

Use the appropriate unit key for the frequency, amplitude, and offset. Use the ENTER key for the phase and key number.

☐ **Step 7:** Repeat steps 3–6 to set the values for the necessary parameters.

☐ **Step 8:** Press the bottom menu Compile button to compile the data input into the table.

If you try to enter a Key number not found in the key table into the data table, when you press the Compile button, the data are not compiled. A message to this effect is displayed. Press the side menu Continue button or press the front panel CLEAR MENU button to remove the message and return to the previous display. Then set the data correctly.

The explanations of the Key, Data, Key Period, Compile, Modulate, and Channel items displayed in the bottom menu are described next.

Setting Key Deviation Parameters

Use Key to specify the deviation parameters for the modulation key in PSK or FSK modulation (see Figure 3-44). Besides setting deviation parameters, use this item to determine how many keys to use, to change key numbers, and to copy the deviation parameters on a cursor row and put them in another key. When Key is selected, the table used to input the values of the deviation parameters, the explanations of the control buttons, and the side menu are displayed on the screen. The deviation parameters in the table are the Phase, Amplitude, and Offset for PSK modulation and Frequency, Amplitude, and Offset for FSK modulation.

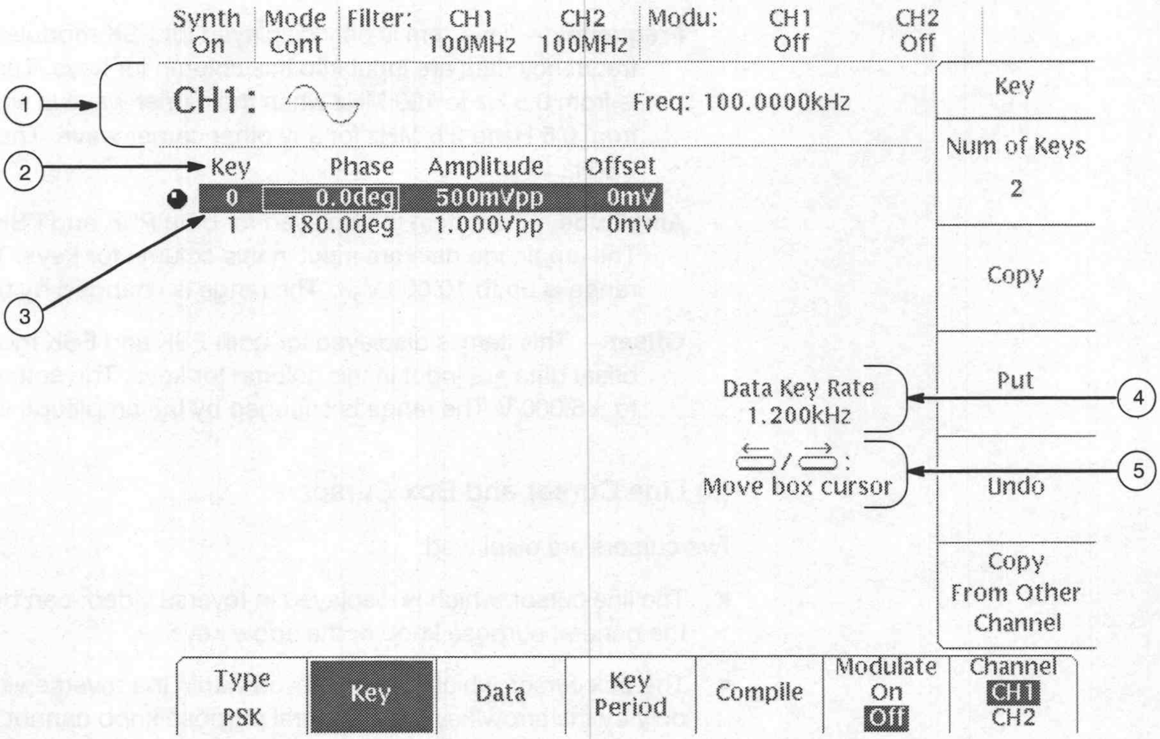


Figure 3-44: Key Menu Screen Display

(1) Current Channel Status

Information about the signal that is to be the carrier wave is displayed in this area. The current channel number, an icon that shows the type of waveform set in the waveform memory, and the amplitude, offset, or frequency parameters (whichever are applicable) are displayed in this area.

(2) Key Parameters

The items displayed are Key number, Phase (PSK Modulation) Amplitude, and Offset. Frequency is displayed instead of Phase in FSK Modulation.

Here are explanations of the deviation parameters in the key table.

Phase — This item is displayed for PSK modulation and phase data are input into this column for keys. The setting range is from $-360°$ to $+360°$.

NOTE

PSK modulation uses a differential technique. For example, if 90° is defined for the key, the phase is increased 90° when that key is selected.

Frequency — This item is only displayed for FSK modulation. The frequency data are input into this column for keys. The setting range is from 0.5 Hz to 100 MHz when the carrier wave is sine wave and from 0.5 Hz to 2.5 MHz for any other carrier wave. The resolution is 0.5 Hz.

Amplitude — This item is displayed for both PSK and FSK modulation. The amplitude data are input in this column for keys. The setting range is up to 10.000 $V_{p\text{-}p}$. The range is changed by the offset value.

Offset — This item is displayed for both PSK and FSK modulation. The offset data are input in this column for keys. The setting range is up to ±5.000 V. The range is changed by the amplitude value.

(3) Line Cursor and Box Cursor

Two cursors are displayed:

- The line cursor, which is displayed in reverse video, can be moved using the general purpose knob or the arrow keys
- The box cursor, which can be moved within the reverse video cursor only by the arrow keys (the general purpose knob cannot be used)

(4) Information for Digital Modulation

The Data Key Rate (key switching speed) are displayed.

(5) Button Operations

This area shows how the functions are allocated to the ← and → buttons, and the CURSOR button, on the front panel.

The descriptions of the side menu items follow.

Num of Keys — This item is used to set the number of keys. The range is two to 256. The key numbers start from 0. The screen can display up to 13 keys at one time. When there are more keys than 13, use the general purpose knob to scroll through the table.

Copy — This item is used to copy into the buffer the value of the three deviation parameters at the Key number row indicated with the reverse video cursor.

Put — This item is used to put the deviation parameters stored in the buffer onto the row of the key number specified with the reverse video cursor.

If the Put button is pressed when the buffer is empty, a message indicating that the copy or cut is not executed yet is displayed, and the Continue item is displayed in the side menu. Press the Continue button or the CLEAR MENU button to return to the previous screen.

Undo — This function cancels the most recent put or data input operation. When this button is pressed, the previous data are restored in the table. Pressing this button again cancels the Undo operation (it executes the Put operation or inputs the data again).

NOTE

If you press the Put button more than once, pressing the Undo button will not restore the previous data.

If the Undo button is pressed before any Put or data input is executed, a message is displayed indicating that there is no previous action and the Continue item is displayed in the side menu. Press the Continue button or the CLEAR MENU button to return to the previous screen.

Copy From Other Channel — If Option 02 is installed, this menu item is displayed in the side menu. This operation copies the Key table from the other channel and replaces the Key table for the currently displayed channel with the data other channel. If the current channel's modulation is PSK, then the PSK modulation Key table is copied. If the current channel's modulation is FSK, then the FSK modulation Key table is copied.

Creating a Data Key Sequence

Use Data to input key numbers and marker setting data into the data table, to create the data key sequence, and to change the data key sequence length (see Figure 3-45). When Data is pressed, the table to input the key numbers and marker status, explanations of the knob control buttons, and side menu are displayed on the screen. The sequence parameters in the data table are Key and Marker. Except for the side menu, the screen display is the same as for Figure 3-43.

From two to 2048 data items can be set. Data numbers start from 0. Up to 16 data items can be displayed at one time on the screen (if the key table is not displayed). If there are more than 16 data items, the window can be changed by scrolling the table using the general purpose knob.

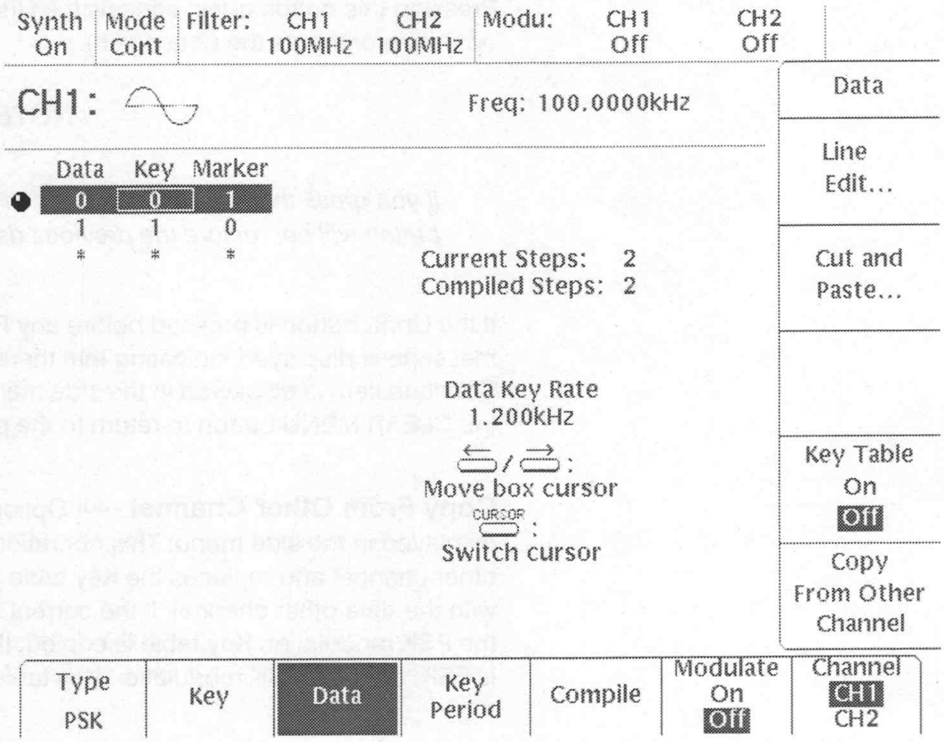


Figure 3-45: Data Menu Display

Here are explanations for the sequence parameters in the data table.

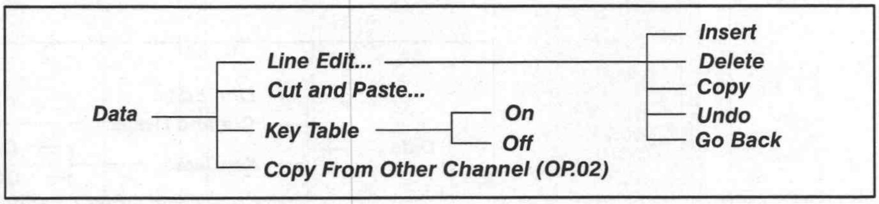
Key — A Key number can be allocated to the Data number displayed in reverse video in the table. Keys are arranged to create a desired modulation sequence. Frequency (for FSK modulation), phase (for PSK modulation), amplitude, and offset are set for a key beforehand, using the Key item in the bottom menu.

Marker — Marker status can be set On or Off for the Data number displayed in reverse video in the table. Input 1 to set the marker On and input 0 to set the marker Off. Shift keying modulation (PSK or FSK) executes sequentially from Data number 0. When the sequence reaches the position where the marker is On, the marker signal is output from the current channel marker output connector.

The descriptions of the side menu and sub menu items follow.

Line Edit... — This editing function allows data table lines to be edited in single line units with functions such as insert, delete, and copy.

The "..." in the menu item indicates that there is another sub-menu. The Line Edit... menu has the following menu configuration:



Insert — If Copy has not been executed, this item inserts the data of key number 0 and marker setting 0 into the data number displayed in reverse video. Data numbers after the reverse video are renumbered.

If Copy has been executed, this item inserts the contents of the copy buffer to the data number displayed in reverse video. Data numbers after the reverse video are renumbered.

Delete — This item is used to delete the data line whose number is displayed in reverse video. The removed data are saved temporarily in the buffer memory. After deleting the data line, all subsequent data line numbers are decreased by 1 to fill in the resulting gap.

Copy — The marker setting and key number data highlighted in reverse video is stored into the buffer.

Undo — This function cancel the most recent Insert or Delete operation. When this button is pressed, the previous data are restored in the table. Pressing this button again cancel the Undo operation, so it executes the Insert or Delete.

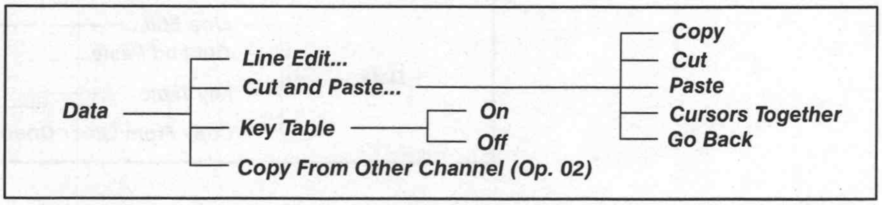
If the Undo button is pressed before Insert or Delete is executed, a message is displayed indicating that there is no previous action and the Continue item is displayed in the side menu. Press Continue button or the CLEAR MENU button to return to the previous screen.

Go Back — This function is used to exit from the sub-menu and return to the original side menu.

Cut and Paste... — This table editing function allows a range of data table lines to be specified with the two line cursors and then copied or cut, and for data to be pasted into the table at the line specified by the reverse video display cursor (including that line).

The line cursor displayed in reverse video switches back and forth between the two line cursors in the data table each time the CURSOR key is pressed. The reverse video display cursor can be moved using the general purpose knob.

The "..." in the menu item indicates that there is a further sub-menu. The Cut and Paste... menu has the following menu configuration:



Copy — This function copies the key number and marker setting data from the lines between (and including) the two line cursors into the buffer.

Cut — This function cuts the key number and marker setting data from the lines between (and including) the two line cursors and reorders the data items following the cut data. The contents of the cut data is stored in the buffer.

Paste — This function pastes the contents of the buffer at the location of the reverse video display cursor (including the cursor location). The data items following the pasted data are reordered.

Up to 2048 data items can be specified. If this range is exceeded by repeating the paste operation, a message indicating that pasting is not possible will be displayed.

The paste operation cannot be performed if no copy or cut operation has been performed, since the buffer will be empty. In this case a message indicating that Copy or Cut is not executed yet will be displayed.

Cursors Together — Moves the box-shaped line cursor (the non-reversed line cursor) to the position of the reverse video display cursor. The two cursors will overlap after this operation has been executed.

Go Back — This function is used to exit from the sub-menu and return to the original side menu. The contents of the buffer is erased on exit from the sub-menu.

Key Table On/Off — When the Key Table item in the side menu is turned on while editing a data table, the key table is displayed under the data table. This allows the key table contents to be referenced on the same screen and for the parameters in both tables to be changed.

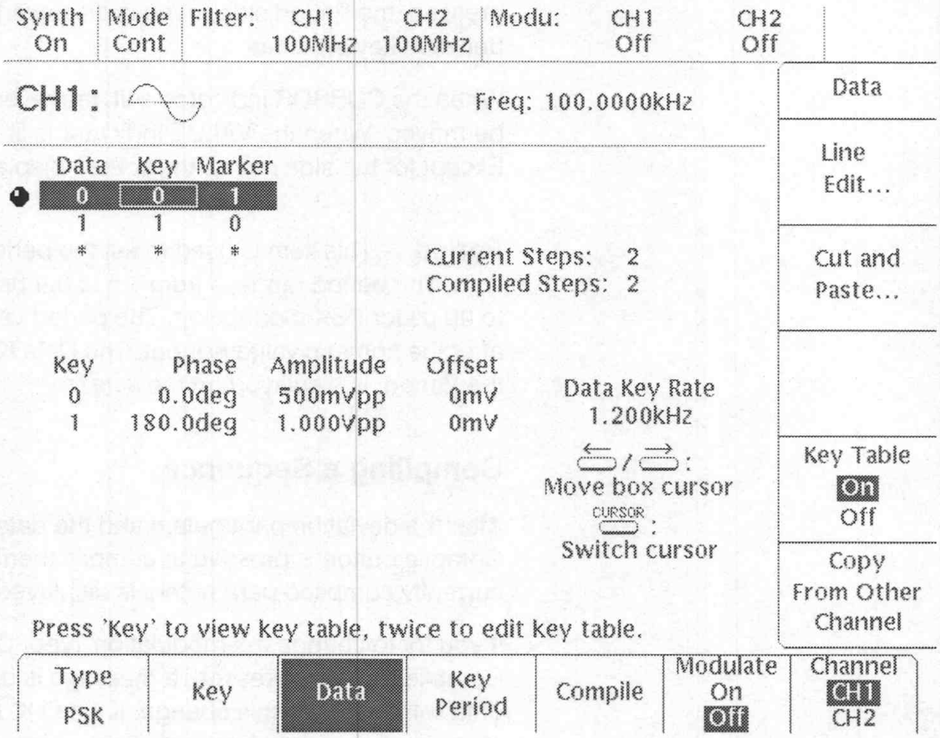


Figure 3-46: Display when the Key Table is Set to On

When the line cursor is in the data table, the line cursor can be moved to the key table by pressing the Key button on the bottom menu. Similarly, when the line cursor is in the key table, it can be moved to the data table by pressing the Data button on the bottom menu.

If the Key button is pressed once again while the line cursor is in the key table, the menu will switch to the key table editing menu.

Copy From Other Channel — The AFG2020 displays the Copy From Other Channel menu if option 02 (CH2 output) is installed.

This operation copies the Data table from the other channel and replaces the Data table for the currently displayed channel with the copied data. If the current channel's modulation is PSK, then the PSK modulation Data table is copied. Similarly, if the current channel's modulation is FSK, then the FSK modulation Data table is copied.

Setting the Key Period

In shift keying modulation, a key is switched periodically from one item to the next in the sequence. When the Key Period button in the bottom menu is pressed, the Period side menu is displayed to change the length of time between key switches.

When the CURSOR indicator is lit, the reverse video cursor in the table can be moved. When the VALUE indicator is lit, Key Period can be changed. Except for the side menu, the screen display is the same as in Figure 3-43.

Period — This item is used to set the period for switching keys in units of time. The period range is from 1 s to 0.4 μs for FSK modulation and from 1 s to 20 μs for PSK modulation. The period value does not require compiling after the numeric value is input. The Data Key Rate, which is the inverse of the Period, is displayed on the screen.

Compiling a Sequence

After the deviation parameters and the data key sequence are set, the Compile button is pressed to compile them. The number of steps for the currently compiled parameters is displayed on the screen.

If you try to change the modulation Type, Channel, or main menu before the Compile button is pressed, a message is displayed that the uncompiled data will be lost by this change. If the O.K. button is pressed, the uncompiled numeric values and settings are lost and the system switches to the selected menu. If the Cancel or CLEAR MENU button is pressed, the message goes out and the system returns to the previous screen.

Modulate On/Off

When the Modulate button is pressed in the bottom menu, the reverse video display is toggled between On and Off and the digital modulation is switched On or Off. This is the same as the Modulate On/Off function for analog modulation.

NOTES

The modulation signal is made based on a 10 MHz (0.1 μs) clock. On the other hand, the carrier wave frequency is an integer multiple of the DDS 0.23283 Hz. Therefore the carrier wave and the modulation signal are not synchronized.

PSK modulation changes require 800 ns (200 clocks) to complete. During this period, the D/A converter stops.

In PSK modulation, in order to cancel out the cumulative phase error for each step, a cancellation step is automatically added at the end of the sequence.

Selecting the Output Channel

Channel menu is displayed when Option 02 (CH2 output) is installed. CH1 and CH2 labels are displayed in the Channel column of the bottom menu. Each time this button is pressed, the reverse video display toggles between these two labels and the current channel can be selected. This is the same as the Channel function for the analog modulation. When a channel is selected, the table and menu items are displayed for the selected channel if digital modulation is selected.

Edit Menu

Press the EDIT menu button in the MENU column to create and edit waveforms. Refer to Figure 3-47 for the Edit menu structure. The initial menu displayed contains two tables of up to 32 arbitrary waveforms currently saved in 32 memory locations. The rough figures enable you to identify what types of arbitrary waveform are saved to which waveform number. If no arbitrary waveform is saved in a particular memory location, a 0-level DC waveform is initialized and a horizontal line is drawn as the rough figure.

When the Edit item is selected in the bottom menu, a graphic display waveform editor is automatically displayed. The graphic display shows the waveform with the point count along the horizontal axis and the level values along the vertical axis. It has many waveform editing functions; such as the Standard Function which overwrites standard function waveforms at desired waveform edit area, and the Library item which can select special function waveforms. In addition, the Zoom/Pan item expands the waveform in the waveform edit area to enable more precise data editing. Alternately, you can select the table display format to edit the state of each waveform point in memory. After editing, waveforms are saved into one of the arbitrary waveform memory locations, #1 through #32.

The Load Waveform item downloads waveform data into arbitrary waveform memory over the GPIB interface without using an intermediate computer. This data can be one of the following formats:

- Waveform data acquired from a Tektronix digital oscilloscope in the TDS series, 2400 series, 2200 series, or 11K series
- Waveform data from a DSA series digitizing analyzer, a RTD710 digitizer, an AWG series waveform generator, or an AFG2020 waveform generator.

The AFG2020 also supports direct waveform transfers from equipment from many other manufacturers.

You can use the FUNCTION menu to recall a desired waveform into the current channel waveform memory for editing.

To immediately output a waveform while in the EDIT menu, set the appropriate trigger conditions and output parameters beforehand. Then save the edited waveform into the same waveform number as the arbitrary waveform memory selected with the FUNCTION menu. This makes it possible to output the waveform with the operations in the EDIT menu. Output is possible in the same way even when the sweep or modulation function is on.

When Exit is selected from the bottom menu, the exit menu is displayed and the edited waveform can be saved. When the editor is ended, the system returns to the initial menu.

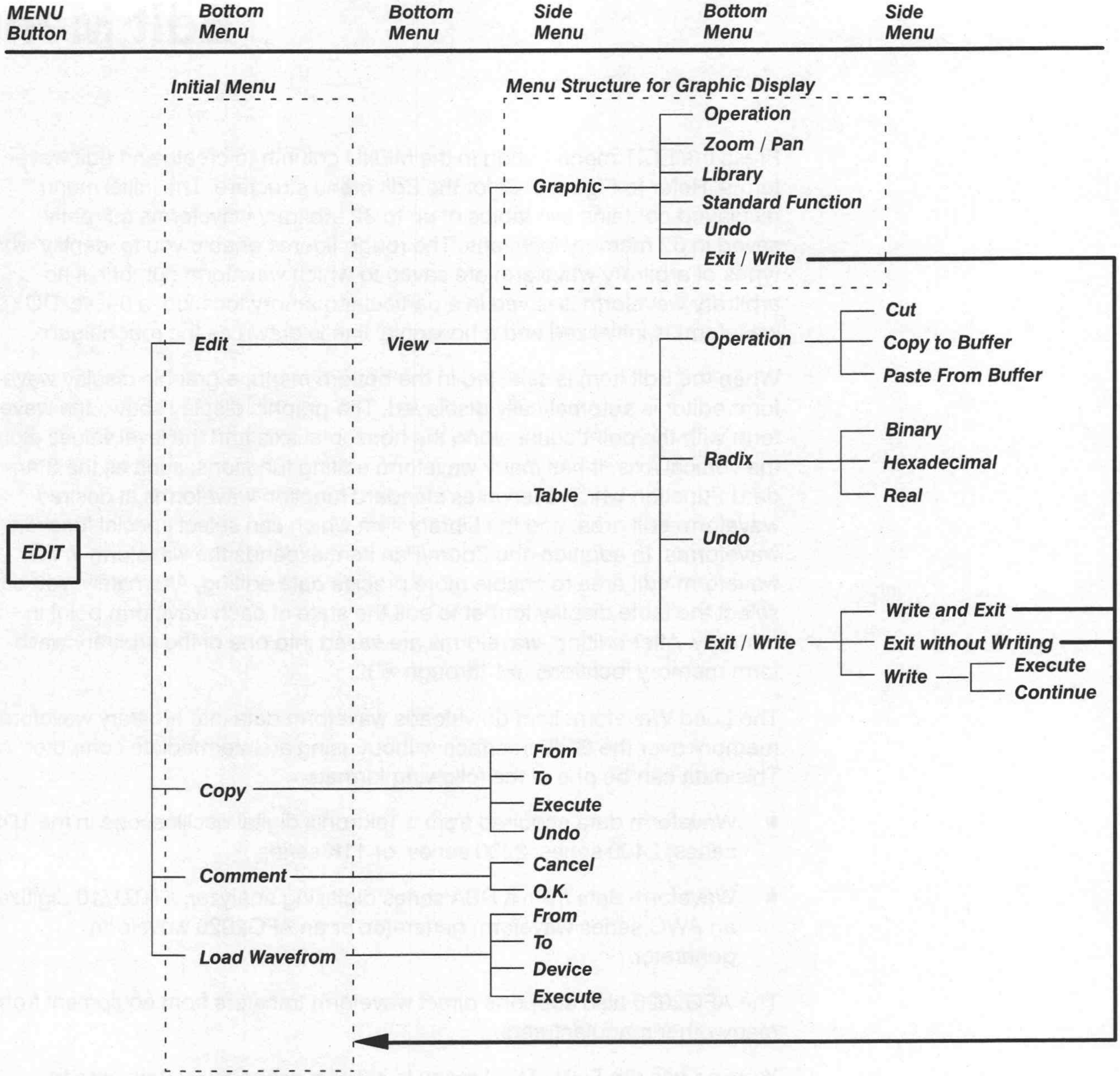


Figure 3-47: EDIT Menu Structure

Initial Menu

Press the EDIT button in the MENU column to display the initial menu. This menu is used as the base menu for creating and editing the waveform.

The initial menu has the Edit, Copy, Comment, and Load Waveform items. These items are described after the display description.

CRT Display

Figure 3-48 shows the EDIT initial menu. The descriptions for the feature callouts follow this figure.

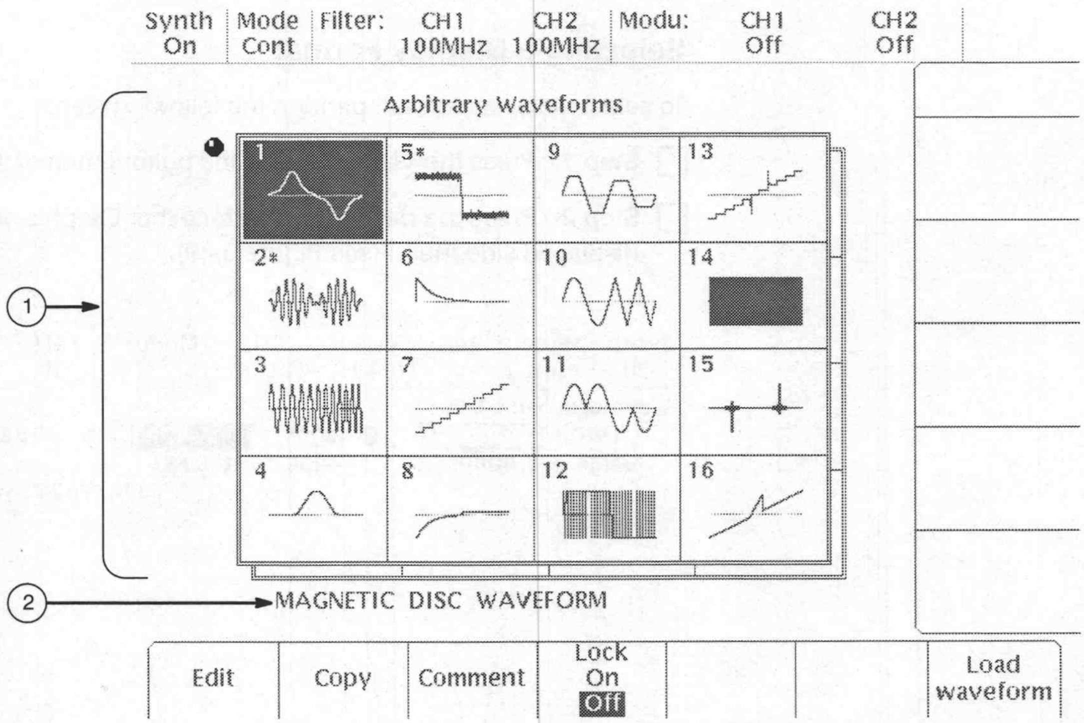


Figure 3-48: EDIT Initial Menu

(1) Arbitrary Waveform Table

Up to 32 arbitrary waveforms can be saved. The waveform number is selected with the general purpose knob. The numbered box for the selected waveform is displayed in reverse video. An asterisk in the numbered box indicates that the file is locked.

(2) Comment Display

The characters input with the comment menu are displayed. When the waveform number selection is changed, the comment for the newly selected waveform number is displayed.

Entering the Waveform Editor

To enter the waveform editor, perform the following steps:

☐ **Step 1:** Press the EDIT menu button in the MENU column.

☐ **Step 2:** Press the Edit button in the bottom menu of the initial menu.

When the Edit button is pressed in the bottom menu, the display on the CRT screen switches from the initial menu to the graphic display edit menu. In addition to the graphic waveform data display, there is also table display. The edit menus for each display format are explained in "Graphic Display Editing" and "Table Display Editing" later in this section.

Selecting a Display Format

To select a display format, perform the following steps:

☐ **Step 1:** Press the View button in the bottom men of the Edit menu.

☐ **Step 2:** Press the desired button for either Graphic or Table from the displayed side menu (see Figure 3-49).

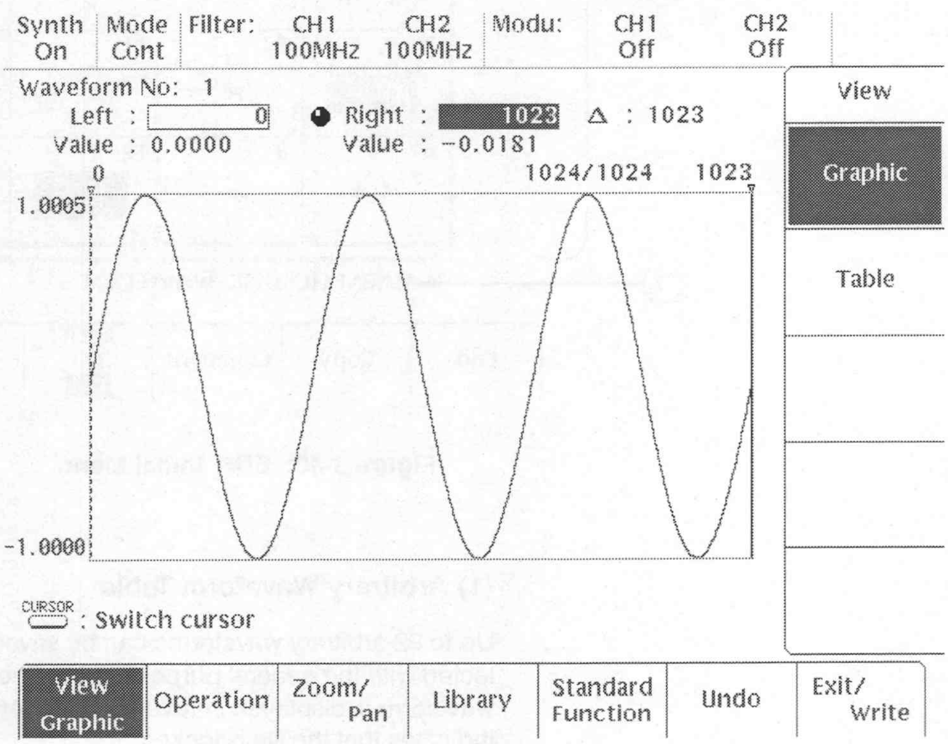


Figure 3-49: View Menu Display

Here are explanations for the side menu items of the View menu.

Graphic — Graphic display has several items, such as: Operation, which has many editing functions; Standard Function, which can create standard function waveforms; and Library, which is prepared for special functions. A waveform can be drawn and edited freely in the waveform edit area on the screen. Editing in this display format is described later in this section.

Table — Table displays the waveform data in a numerical table. By selecting the Radix menu, 12-bit data for the vertical axis can be edited in binary, hexadecimal, or real number notation. Editing in this display format is described later in this section.

Copying a Waveform

To copy a waveform, perform the following steps:

☐ **Step 1:** Press the bottom menu Copy button in the editor initial menu.

☐ **Step 2:** Press the side menu From button, turn the general purpose knob and move the reverse video cursor to a waveform number for copy source.

☐ **Step 3:** Press the side menu To button. Then turn the general purpose knob to move the reverse video cursor to a waveform number for copy destination.

☐ **Step 4:** If the destination file is locked, press the bottom menu Lock button to unlock the file. The reverse video portion in the Lock bottom menu item moves to the off position.

☐ **Step 5:** Press the side menu Execute button to execute the copy.

Use the bottom menu Copy item to select a waveform to be copied from among those in the 32 memory partitions and copy it to the desired waveform number. This item is used to reorganize arbitrary waveforms by changing the waveform numbers or to provide a base waveform for editing.

Here are explanations for the side menu items of the Copy menu.

From — This item is used to select a waveform number for copy source. Use the general purpose knob to move the reverse video display cursor to the waveform number for the copy source.

To — This item is used to select a waveform number for copy destination. Use the general purpose knob to move the reverse video display cursor to the waveform number for copy destination.

Execute — Press the Execute button to copy the waveform data. Even if a comment has been annotated to the source, it is not copied. If the copy destination already has a comment, that comment is deleted.

Copy can not be executed to a destination that is a locked file. If the Execute button is pressed before the destination file is unlocked, a message is displayed in the side menu indicating that the waveform is locked. Press the Continue button or the CLEAR MENU button to return to the previous screen.

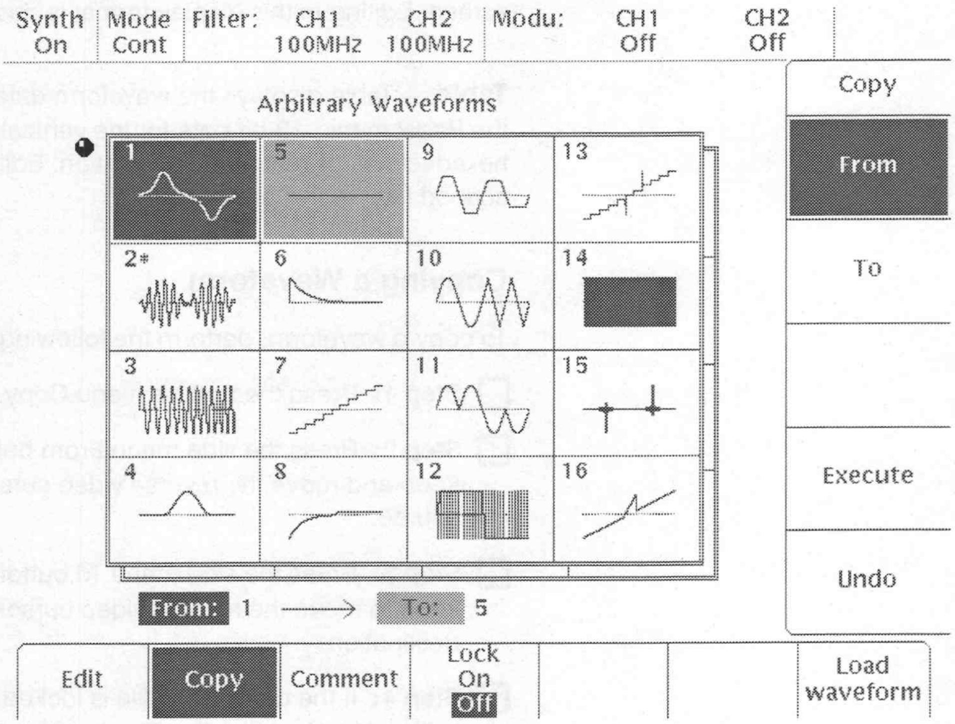


Figure 3-50: Copy Menu Display

Undo — This function cancels the most recent execution of copy and returns to the status it had before copy. When the Undo button is pressed in succession, executing copy and canceling copy are carried out alternately. If the Execute button has been pressed in succession, pressing the Undo button has no effect.

Inputting Waveform Comments

The comment item is used to annotate comments to the selected waveform number. The comment for the waveform number displayed in reverse video is displayed below the arbitrary waveform table.

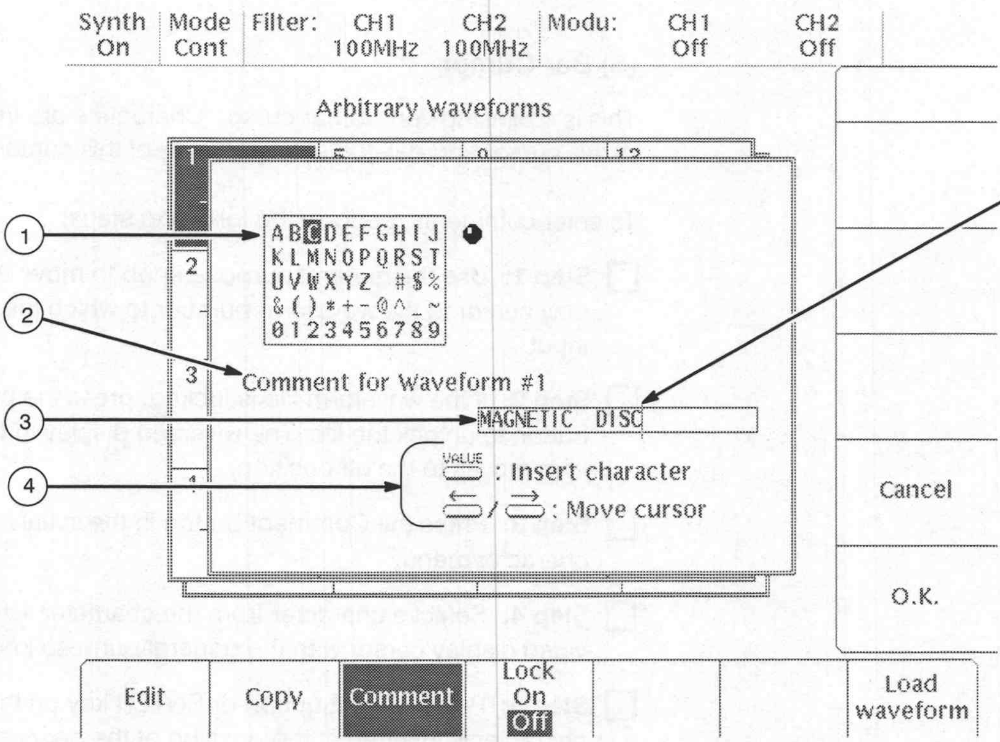


Figure 3-51: Comment Input Menu Display

(1) Character Menu

A list of the characters that can be used is displayed and one of them is displayed in reverse video. Characters are selected by using the general purpose knob to move the reverse video cursor.

(2) Comment Waveform Number

This line identifies the waveform number the comment refers to. In the UTILITY menu, a file number is displayed instead of a waveform number.

(3) Comment Input Column

This column is for inputting a comment of up to 24 characters. The vertical bar cursor blinks at the position for character input.

(4) Button Operations

- **VALUE/ENTER:** VALUE button and ENTER button on the front panel are used to input the selected character at the position of the cursor.
- **← / → :** Left arrow and right arrow buttons on the front panel are used to move the cursor.

(5) Bar Cursor

This is a blinking vertical bar cursor. Characters are inserted at the right side of this cursor and deleted at the left side of this cursor.

To enter comments, perform the following steps:

☐ **Step 1:** Use the general purpose knob to move the reverse video display cursor to the waveform number to which the comment is to be input.

☐ **Step 2:** If the waveform file is locked, press the bottom menu Lock button to unlock the file. The reversed display in the Lock bottom menu item moves to the off position.

☐ **Step 3:** Press the Comment button in the initial menu to display the character menu.

☐ **Step 4:** Select a character from the character list by moving the reverse video display cursor with the general purpose knob.

☐ **Step 5:** Press VALUE button or ENTER key on the front panel. The character is inserted at the position of the bar cursor blinking in the character input column.

Numbers, decimal points, and minus signs can also be input with the numeric keys. In this case, there is no need to press the VALUE button.

Characters are deleted with delete button on the front panel. the character just before the cursor is deleted. The bar cursor can be moved by pressing arrow button on the front panel.

☐ **Step 6:** Repeat Steps 4 and 5 to write the complete comment.

☐ **Step 7:** Press the side menu O.K. button. The display of the comment input menu goes out and the comment just input is displayed under the arbitrary waveform registration table. Note that pressing the ENTER key effects the function like the O.K. button.

When the side menu O.K. button is pressed, if the waveform already has a comment, that old comment is replaced with the new comment.

If you do not want to enter the comment, press the side menu Cancel button. The character menu goes out and the comment is not written.

If you want to delete the comment just entered, select Comment from the bottom menu. Then delete each character in the input column and press O.K. The comment for the waveform number is now deleted.

Lock or Unlock Waveform Files

The Lock item is used to lock or unlock waveform files. It is possible to prevent the comment from being changed and the file data from being over-written by locking a file.

When a file is locked, an asterisk (*) indicating the locked state is displayed to the right of the waveform number. If you attempt to change the comment or to over-write the file contents (by executing an Edit, Copy, or Load Waveform) the message “Waveform is locked” will be displayed in the message area. Press the Continue button on the side menu to return to the original screen.

To lock or unlock a waveform, perform the following steps:

- ☐ **Step 1:** Select the file to be locked from the waveform file list on the initial menu using the general purpose knob.
- ☐ **Step 2:** Press the Lock button on the bottom menu. The selected file will be locked and On in the Lock label will be highlighted by a reversed display. An asterisk (*) will be displayed to the right of the waveform number in the file list to indicate the locked state.
- ☐ **Step 3:** To release the lock on a file, use the method of step 1 to select the file and press the Lock button. This will switch the reversed display to the Off item.

Loading Waveforms from Other Instruments

This operation downloads waveform data into an arbitrary waveform memory location from supported equipment, including digital storage oscilloscopes, digitizers, and other waveform generators. This download is performed directly over the GPIB interface without the use of an intermediate computer.

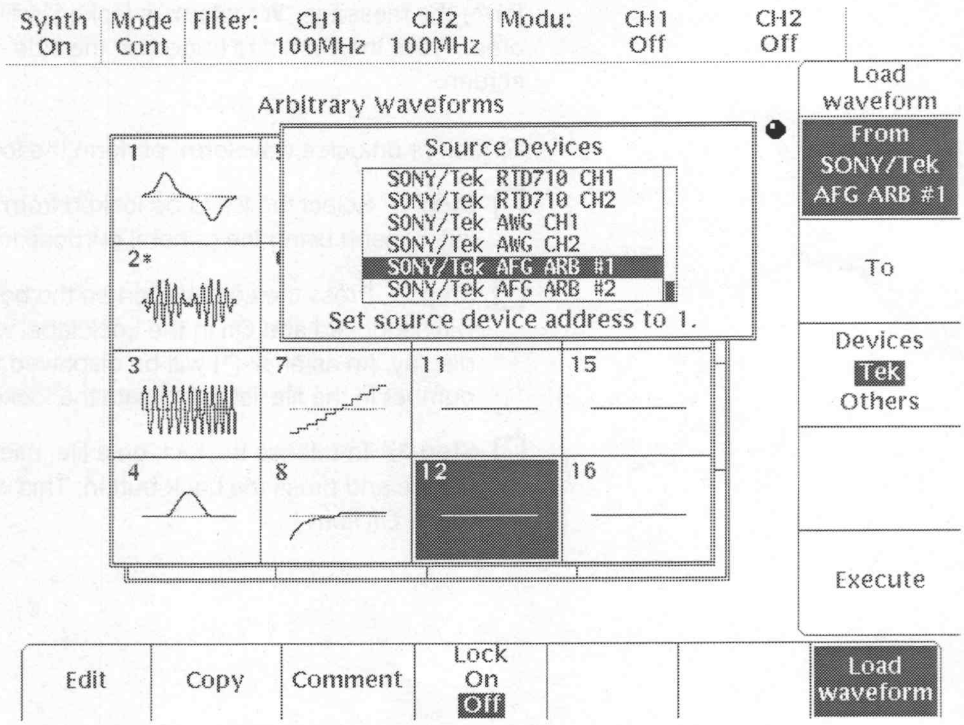


Figure 3-52: Load Waveform Menu Display

To load a waveform, perform the following steps:

☐ **Step 1:** Create waveform data to be transferred on a data source instrument.

☐ **Step 2:** Connect the data source instrument to the AFG2020 with a GPIB cable.

☐ **Step 3:** Set the GPIB address of the waveform data source instrument to 1.

☐ **Step 4:** Press the Load Waveform button to display the download menu (see Figure 3-52).

☐ **Step 5:** Press the From button on the side menu, then select the source device by either turning the general purpose knob or by pressing the From button multiple times.

To select equipment from another manufacturer, press the Device button on the side menu to select Others. Then use the general purpose knob (or press the From key multiple times) to select the source unit.

☐ **Step 6:** Press the side menu To button, then turn the general purpose knob to move the reverse video display cursor to the waveform number for the download destination. If the download destination waveform file is locked, press the Lock key on the bottom menu to release the lock.

☐ **Step 7:** Press the Execute button on the side menu to execute the download operation.

If there was data already stored in the load destination memory, the old data will be replaced with new data. If waveform data is larger than 1024 points in the source, the first 1024 points data will be stored in the destination memory.

NOTE

Contact your Tektronix sales representative if a waveform transfer from another manufacturer's product cannot be performed due to version incompatibilities or other problems.

Here are explanations of side menu items in the Load Waveform menu.

From — This item is used to select the source device and waveform memory name for the waveform data. Use the general purpose knob or the From button to select the desired source.

Table 3-5 lists the supported equipment and waveform memory names.

Table 3-5: Supported Devices for Direct Transfer

Company Name	Instruments and Memory name
Tektronix	TDS Series Digital Storage Oscilloscope CH1, CH2, CH3, CH4 REF1, REF2, REF3, REF4
	2400 Series Digital Storage Oscilloscope CH1, CH2 REF1, REF2, REF3, REF4
	2200 Series Digital Storage Oscilloscope CH1, CH2 REF1, REF2, REF3, REF4
	11K Series Digital Storage Oscilloscope WFM1, WFM2, WFM3, WFM4 ST01, ST02, ST03, ST04
	DSA Series Digitizing Analyzer WFM1, WFM2, WFM3, WFM4 ST01, ST02, ST03, ST04

Table 3-5: Supported Devices for Direct Transfer (Cont.)

Company Name	Instruments and Memory name
Sony Tektronix	RTD710 Series Waveform Digitizer CH1, CH2
	AWG2000 Series Arbitrary Waveform Generator CH1, CH2
	AFG2020 Arbitrary Function Generator ARB#1, ARB#2
Hewlett Packard	54600 Series Digital Storage Oscilloscope CH1, CH2, CH3, CH4
	54600 Series Digital Storage Oscilloscope CH1, CH2 MEM1, MEM2, MEM3, MEM4
LeCroy	9300 Series Digital Storage Oscilloscope CH1, CH2, CH3, CH4 MEM1, MEM2, MEM3, MEM4
Yokogawa	DL1000 Series Digital Storage Oscilloscope CH1, CH2, CH3, CH4 M1, M2, M3, M4

To — This item is used to select the load destination waveform number. Use the general purpose knob to move the reverse video display cursor in the table to the waveform number of the load destination.

Device Tek/Others — This function selects whether the waveform data source device is to be selected from a list of Tektronix products (Tek) or from a list of products from other manufacturers (Others).

When From in the side menu is highlighted by a reversed display, a list of supported source equipment is displayed. The equipment displayed in the list can be switched between Tektronix products and products of other manufacturers using the side menu Device selection.

Execute — Pressing the Execute button executes the waveform data download operation.

A waveform file is downloaded to the AFG2020 from any equipment for which direct waveform transfer is supported.

Selecting a Waveform to Edit

To edit a waveform, select the waveform to be edited with the initial menu and enter the edit menu. The selected waveform is drawn in the waveform edit area on the screen and can be edited. A simple way to create a new waveform is to select a base waveform in the waveform edit area. Then edit that base waveform into the desired waveform.

There are two methods to select a base waveform. One method is to select a waveform from those in arbitrary waveform memory, if waveforms exist. The other method is to press the bottom menu Edit button to enter the edit menu. Then select a waveform from the standard functions or the library.

If no such base waveform is needed, either select a waveform number in the initial menu for which no waveform is registered or select DC from standard functions in the edit menu.

NOTE

When ending editing, to leave the base waveform in arbitrary waveform memory unchanged, copy it before entering the editor menu. Even if you do not copy it, you can use the Write item of the Exit menu to select an arbitrary waveform number and store the edited waveform to that waveform number.

To select the edit waveform from arbitrary waveform memory, perform the following steps:

☐ **Step 1:** Display the editor initial menu.

The editor initial menu is displayed when EDIT button is pressed in the MENU column on the front panel or Exit is executed from the Edit menu.

☐ **Step 2:** Turn the general purpose knob to set the reverse video display cursor on a base waveform number.

☐ **Step 3:** When the bottom menu Edit button is pressed, the CRT screen display is switched to the edit menu and the selected waveform is drawn in the waveform edit area. Also, the number for the waveform being edited is displayed at the top left of the CRT screen.

To select edit waveform from the Standard Functions in Edit bottom menu, perform the following steps:

☐ **Step 1:** Select the Edit bottom menu in the initial menu. The edit menu is displayed.

☐ **Step 2:** Turn the general purpose knob to set the left vertical cursor at left end of the waveform edit region (Points 0).

☐ **Step 3:** Press the CURSOR button on the front panel to change allocation of active cursor.

☐ **Step 4:** Turn the general purpose knob to set the right vertical cursor at right end of the waveform edit region (Points 1023).

☐ **Step 5:** Press the Standard Function button in the bottom menu. The menu items that is used to select a standard function or to set function parameters are displayed in the side menu.

☐ **Step 6:** Select the desired standard function pressing the Function Type button in the side menu or using general purpose knob.

☐ **Step 7:** Set standard function waveform parameter such as Cycles, Amplitude, and Offset pressing the parameter button and then using general purpose knob or numeric buttons.

☐ **Step 8:** Press the side menu Execute button to write the selected standard function waveform into the waveform edit area. The area where standard function is drawn is between the left and right vertical bar cursors.

To select the edit waveform from the Library, perform the following steps:

☐ **Step 1:** Select the Edit bottom menu in the initial menu. The edit menu is displayed.

☐ **Step 2:** Press the bottom menu Library button to display the menu for selecting a waveform from the function library.

☐ **Step 3:** Use the general purpose knob to move the reverse video display cursor to the desired function waveform column.

☐ **Step 4:** Press the side menu Load button. The library menu goes out and the selected function waveform is written into the waveform edit area.

Graphic Display Editing

Figure 3-53 shows the many waveform editor graphic display features.

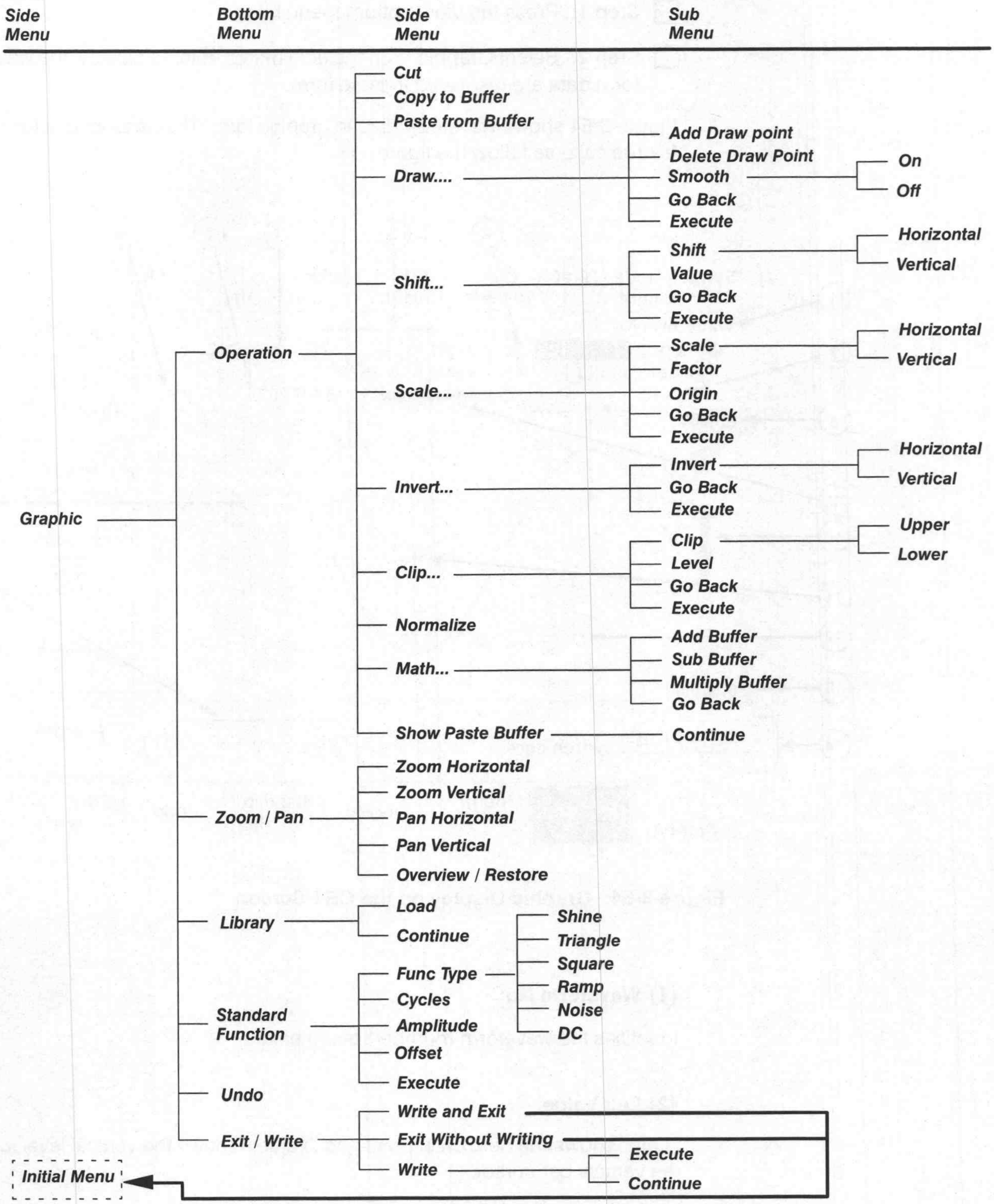


Figure 3-53: Waveform Editor Graphic Display Menu Structure

Entering the Graphic Display

To choose the graphic display of the Edit menu, perform the following steps:

☐ **Step 1:** Press the View bottom menu button.

☐ **Step 2:** Select Graphic from the side menu. In table display, the waveform data are displayed in table form.

Figure 3-54 shows waveform data in graphic form. The descriptions for feature callouts follow the figure.

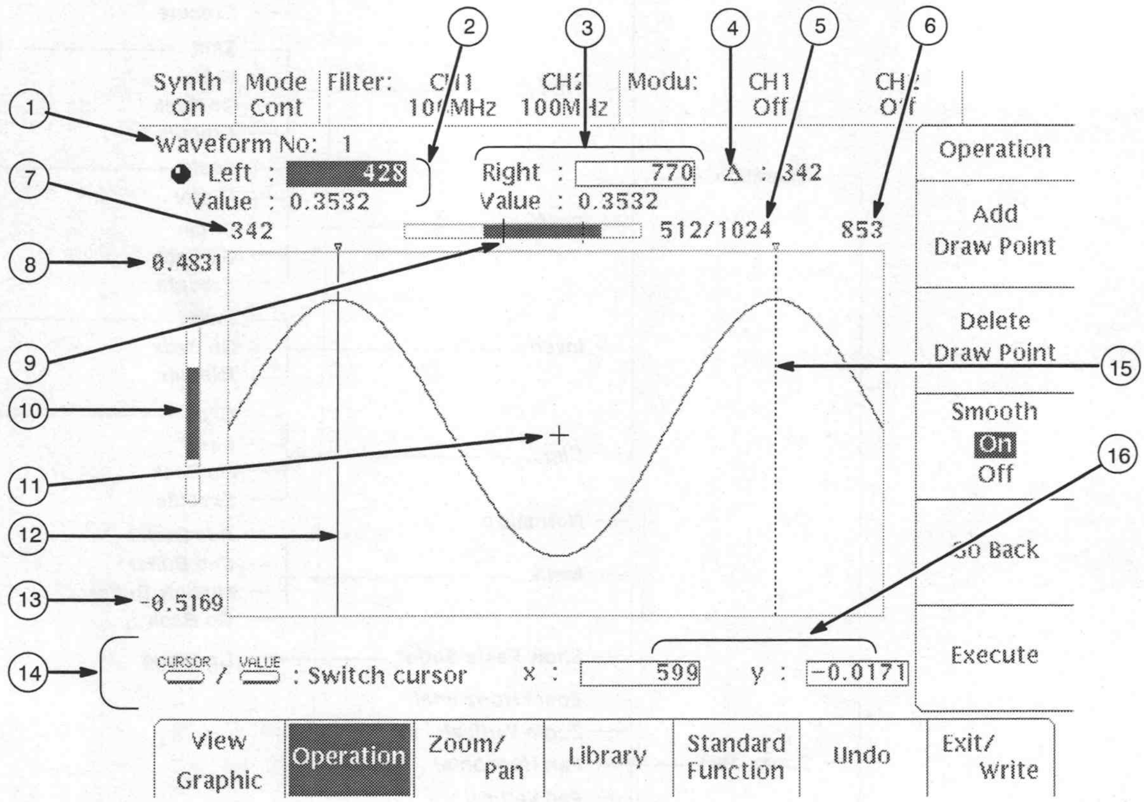


Figure 3-54: Graphic Display on the CRT Screen

(1) Waveform No:

Identifies the waveform (number) being edited.

(2) Left Value

"Left:" shows the horizontal point and "Value:" shows the vertical level for the left vertical bar cursor.

The cursor whose horizontal point value is displayed in reverse video can be moved with the general purpose knob, arrow buttons, or numeric keys. This cursor is called the active vertical bar cursor.

(3) Right Value

"Right:" shows the horizontal point and "Value:" shows the vertical level for the right vertical bar cursor.

(4) Δ (Delta)

Shows the differential number of horizontal points between the left and right vertical bar cursors.

(5) Waveform Point Data Readout

Shows the number of waveform points displayed on the screen and the total number of waveform points.

(6) Right Waveform Point

Shows the right end point value for the waveform data displayed on the screen.

(7) Left Waveform Point

Shows the left end point value for the waveform data displayed on the screen.

(8) Top Waveform Level

Shows the top level (highest amplitude) for the waveform data displayed on the screen.

(9) Horizontal Scroll Indicator

When the display is magnified horizontally with Zoom/Pan menu, this indicator is displayed to show where the waveform in the drawing area is relative to the entire waveform. The portion of the waveform displayed on the screen is shown in reverse video.

(10) Vertical Scroll Indicator

When the display is magnified vertically with Zoom/Pan menu, this indicator is displayed to show where the drawing area is relative to the vertical axis. The portion of the waveform displayed on the screen is shown in reverse video.

(11) Point Cursor

This cursor appears when Draw... item is selected from the Operation side menu and is used to determine the drawing point. When this cursor is active (movable state), an arrow is displayed to show the direction in which it can be moved by the general purpose knob.

(12) Left Vertical Bar Cursor

If this cursor is active, The cursor is displayed with solid line. If nonactive, the cursor is displayed with broken line.

(13) Bottom Waveform Level

Shows the bottom level (lowest amplitude) for the waveform data displayed on the screen.

(14) Button Operations

This area shows how the front panel knob buttons operate in this menu.

CURSOR: Switch Cursor — Pressing the CURSOR button toggles the active vertical bar cursor between left and right.

CURSOR/VALUE: Switch Cursor — Pressing the CURSOR button toggles the active vertical bar cursor between left and right. Pressing the VALUE button switches the direction along which the point cursor can move between the X and Y axes.

(15) Right Vertical Bar Cursor

If active state, its displayed with solid line. If nonactive, its displayed with broken lines.

(16) X-Y Coordinates

Shows the X-Y coordinates for the point cursor explained in item 11. If X or Y coordinates are displayed in reverse video, the point cursor can be moved in that direction.

Editing Operations

When the Operation item is selected in the bottom menu, the waveform data can be edited. The side menu has 11 items, Cut, Copy to Buffer, Paste From Buffer, Draw..., Shift..., Scale..., Invert.., Clip..., Normalize, Math..., and Show Paste Buffer for selecting editing functions.

The Cut, Copy To Buffer, Paste From Buffer functions work on the waveform data area between the vertical bar cursors. They can cut data or copy it to the paste buffer. Also, the contents of the paste buffer can be pasted to the position of the active cursor in the waveform edit area.

The "..." after some item labels indicates that those items have menus below the side menu. These lower level side menus are called sub-menus. To return from such a sub-menu to its original side menu, press the Go Back button.

Pressing the Operation bottom button gives the display shown in Figure 3-55. The side menu has three pages. You can move to the next page by selecting the More item. The Operation menu is used to carry out editing operations on the area between the left and right vertical bar cursors.

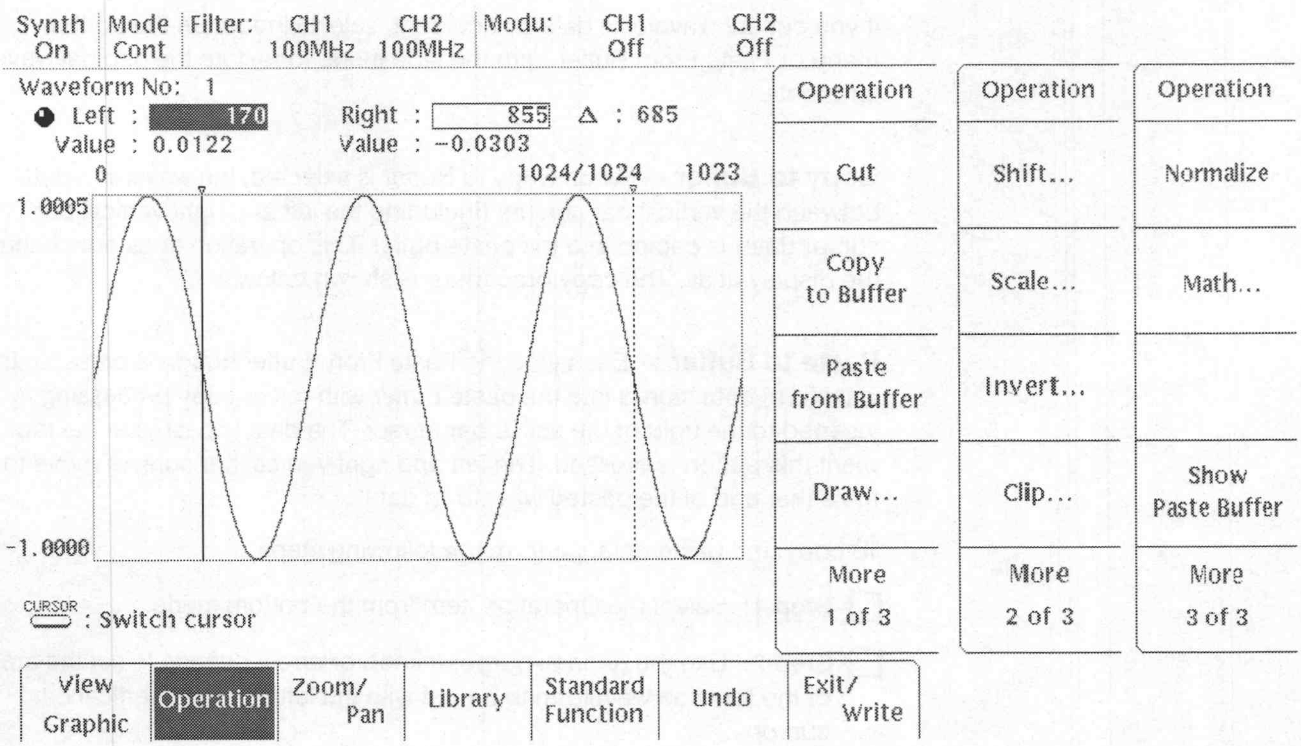


Figure 3-55: Display When Operation is Selected

The descriptions of the side menu items follow.

Cut — At the moment the Cut button is pressed, the waveform data between the vertical bar cursors (including the left and right vertical bar cursor data) is cut out. The cut waveform data goes into the paste buffer.

Waveform data located after the cut out area is shifted to the left to fill in the cut out area and the data value of the final point is automatically filled in from the end of the waveform to the last.

To cut data, perform the following steps:

☐ **Step 1:** Select Operation item from the bottom menu.

☐ **Step 2:** Use the general purpose knob or arrow buttons to set the area of the function waveform to be cut with the left and right vertical bar cursors.

Press the CURSOR button on the front panel to change the active cursor between left and right. The arrow buttons move the cursor one point at a time. When the numeric keys are used, the cursor moves directly to the point position with that value.

☐ **Step 3:** Press the Cut button from the displayed side menu to execute the cut.

If you cut out waveform data by accident, select Undo from the bottom menu or Paste From Buffer from the side menu to restore the original waveform data.

Copy to Buffer — When Copy to Buffer is selected, the waveform data between the vertical bar cursors (including the left and right vertical bar cursor data) is copied into the paste buffer. This operation does not change the display at all. The copy procedure is shown below.

Paste to Buffer — Each time the Paste From Buffer button is pressed, the waveform data stored into the paste buffer with cut or copy processing is inserted to the right of the active bar cursor. The data is pasted at the moment this button is pressed. The left and right vertical bar cursors move to the either end of the pasted waveform data.

To copy and paste data, perform the following steps:

☐ **Step 1:** Select the Operation item from the bottom menu.

☐ **Step 2:** Use the general purpose knob or arrow buttons to set the area of the function waveform to be cut with the left and right vertical bar cursors.

Press the CURSOR button on the front panel to change the active cursor between left and right. The arrow buttons move the cursor one point at a time. When the numeric keys are used, the cursor moves directly to the point position with that value.

☐ **Step 3:** Press the Copy to Buffer button from the displayed side menu to execute the copy.

☐ **Step 4:** Use the general purpose knob or arrow buttons to specify the active vertical bar cursor position where the buffer data is pasted.

☐ **Step 5:** Press the Paste From Buffer button displayed in the side menu to execute the pasting. The waveform data in the buffer is inserted at the position of the active bar cursor. Any waveform data extruded from the waveform area is lost.

Draw... — This item is used to create an arbitrary waveform by placing points between the left and right vertical bar cursors and connecting those points. Immediately after Draw... is selected, the point cursor is placed midway between the vertical bar cursors at the center of the vertical axis.

The point cursor is moved by using the general purpose knob or arrow buttons after pressing VALUE button. The direction of point cursor movement is toggled between the X-axis and the Y-axis direction each time the VALUE button is pressed.

When the Draw... item is selected, the sub-menu is started for arbitrary waveform creation and the menu display is as shown in Figure 3-56.

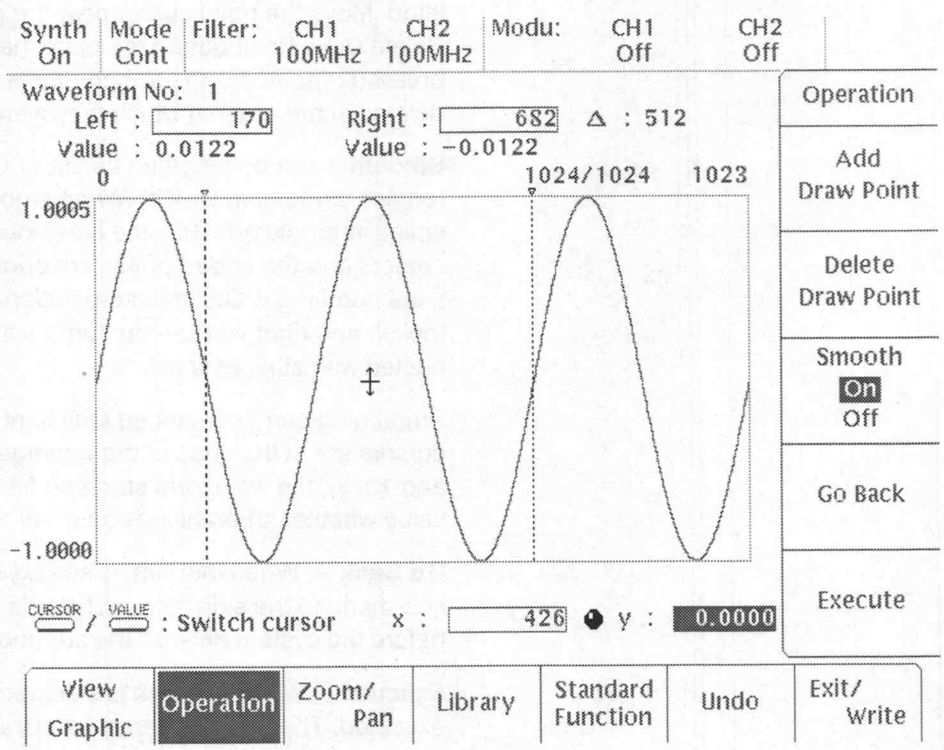


Figure 3-56: Menu Display When Draw... is Selected

When Draw... is selected from the side menu, the sub-menu containing Add Draw Point, Delete Draw Point, Smooth, Go Back, and Execute is displayed.

Here are the functions of these items.

Add Draw Point — When the point cursor is placed between the vertical bar cursor and the Add Draw Point button is pressed, the point is written. The X-Y coordinate for the current position of the point cursor is displayed at the bottom right of the CRT screen. Write any number of points to draw the arbitrary waveform.

NOTES

Points can be placed outside the left and right vertical bar cursors. However, such points are not drawn when Execute is pressed.

You cannot set multiple points above the same horizontal position. If you try to do so, the system asks you if you want to change the level to the new point. Select O.K. to change the level, or select Cancel to cancel the new point placement.

Delete Draw Point — Points added with Add Draw Point can be deleted. Move the point cursor near the point to be deleted, then press the Delete Draw Point button to delete the point. If the Delete Point button is pressed repeatedly, the added points closest to the point cursor are deleted in the order in which they were placed.

Smooth — Smoothing can be On or Off. Pressing the Smooth button toggles smoothing On/Off. When smoothing is On, the waveform data is spline interpolated. Thus the curve outside the left and right vertical bar cursors and the added points are connected with a smooth curve. When the smoothing is Off, the interpolation is linear. Thus the curve outside the left and right vertical bar cursors and the added points are connected with straight lines.

Smoothing can be switched On/Off at any time. When the vertical bar cursors are at the ends of the waveform being edited (horizontal points 0 and 1023), the waveform start and finish are given the same vertical value whether smoothing is on or off.

Go Back — When this item is selected, the system returns from the sub-menu to the side menu. The side menu that was being displayed before the system entered the sub-menu is displayed again.

Execute — When this item is selected, the selected function is executed. The points entered with Draw... are connected with curves or straight lines and this new waveform replaces the old one.

NOTE

The Go Back and Execute items appear not only in the Draw... sub-menu but also in the Shift..., Scale..., Invert..., and Clip... sub-menus, where they have the same functions as in the Draw... sub-menu.

Arbitrary waveforms are drawn by moving the point cursor between the vertical bar cursors and adding any number of points. To create a waveform using Draw..., perform the following steps:

☐ **Step 1:** Select Operation from the bottom menu, then select the Draw... item from the side menu displayed.

☐ **Step 2:** Press the front panel CURSOR button for moving the vertical bar cursors. Use the general purpose knob or arrow buttons to move the left and right vertical bar cursors to waveform area for drawing. The left and right vertical bar cursors are selected with the CURSOR button.

☐ **Step 3:** Press the front panel VALUE button for moving the point cursor. Use the general purpose knob or arrow buttons to move the point cursor to the location where you want to add a point. Each time the front panel VALUE button is pressed, the direction of movement for the point cursor switches between horizontal (X) and vertical (Y). The coordinates for the point cursor position are displayed at the bottom right of the CRT display.

When moving the point cursor vertically with the general purpose knob, if the display magnification ratio is low, the amount of change per detent of the knob is greater. To set the location value more precisely, either input the values directly with the numeric keys or use the Zoom/Pan function described later in this section. Use the Zoom/Pan function to expand in the vertical direction and reduce the amount of change per detent of the knob.

☐ **Step 4:** After positioning the point cursor, press the Add Draw Point button to enter this point on the screen.

☐ **Step 5:** Repeat steps 3 and 4 to add as many points as desired. Entered points are shown as X marker on the screen.

☐ **Step 6:** To delete a point added with the Add Draw Point button, move the point cursor near the point to be deleted. Then press the Delete Draw Point button.

NOTE

Deleted points can not be recovered with Undo. Reenter the point if accidentally deleted.

☐ **Step 7:** When the insertion of points between the vertical bar cursors is complete, press the Smooth button to select spline interpolation.

☐ **Step 8:** Press the Execute button from the sub-menu. The curve outside the left and right vertical bar cursors and the added points are connected with a smooth curve. Figure 3-57 shows the waveform between the vertical bar cursors has been spline interpolated.

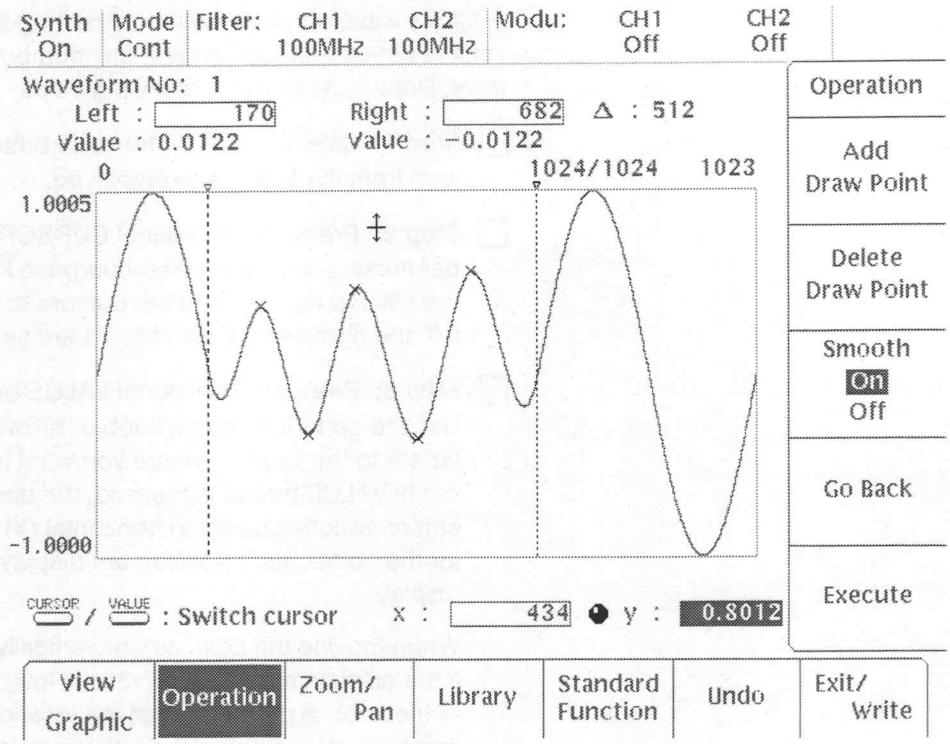


Figure 3-57: Spline Interpolated Waveform Display

☐ **Step 9:** To return to the original waveform, select Undo from the bottom menu.

☐ **Step 10:** To change the interpolation after executing draw, switch the Smooth state to Off and select Execute again. The curve outside the left and right vertical bar cursors and the added points are connected with straight lines.

The waveform can be changed even after executing draw. For instance, add points or delete points, move the vertical bar cursor, and change the Smooth state; then press the Execute button to redraw the waveform.

Even if there are points added outside of the drawing area, only the curve between left and right vertical bar cursors changes.

At this point, if you leave the waveform editor and reenter, the drawn points outside the bar cursors have been erased.

NOTE

Even if the Undo button operation in step 9 is skipped, the waveform can be drawn. In this case, the original waveform data (the data before the Execute button was pressed) between the vertical bar cursors is lost.

☐ **Step 11:** Select the Go Back button from the sub-menu. The display returns to the previous side menu that was displayed just before you entered the Draw... sub-menu.

Shift... — The Shift function shifts waveform data in the area specified with the vertical bar cursors in a vertical or horizontal direction by the specified number of points. When Shift... is selected, the sub-menu of shift operations is called up and the menu shown in Figure 3-58 is displayed.

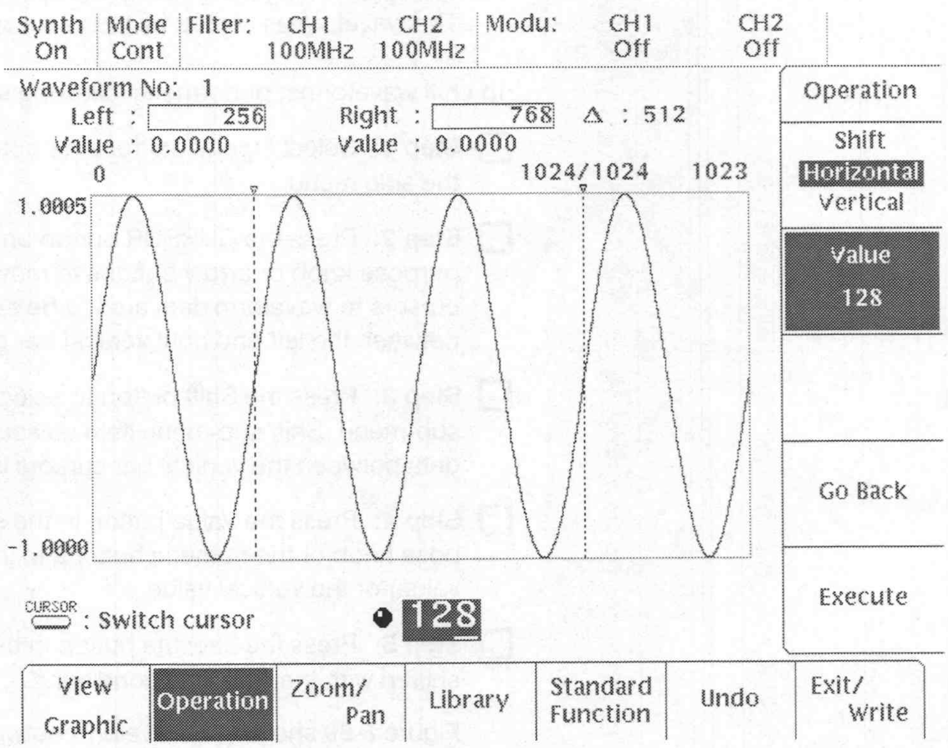


Figure 3-58: Shift... Menu Display

Here are explanations of Shift... sub-menu items.

Shift — This item is used to select the direction in which waveform data between the vertical bar cursors is shifted. The selections are Vertical and Horizontal. Each time Shift side menu button is pressed, the reverse video display toggles between Horizontal and Vertical.

Horizontal shift — the shift can be set in units of one point, within the range ±1024. When the shift value is positive, the waveform is circularly shifted to the right. When the shift value is negative, the waveform is circularly shifted to the left. Data shifted out from between the vertical bar cursors by this shifting is reinserted at the opposite side.

Vertical shift — the waveform can be shifted vertically within the vertical axis full scale. A positive shift moves the waveform up, a negative shift down. However, any points shifted beyond the vertical full scale are clipped.

Value — This item is used to set the amount by which the waveform is shifted. This shift value is input with the numeric buttons or the general purpose knob.

Go Back — When this item is selected, the system returns from the sub-menu to the side menu. The side menu that was being displayed before the system entered the sub-menu is displayed again.

Execute — When this item is selected, the shift function is executed. The waveform is shifted by the value specified with Value.

To shift waveforms, perform the following steps:

☐ **Step 1:** Select Operation from the bottom menu, then select Shift... from the side menu.

☐ **Step 2:** Press the CURSOR button on the front panel. Use the general purpose knob or arrow buttons to move the left and right vertical bar cursors to waveform data area to be shifted. The active cursor is toggled between the left and right vertical bar cursors with CURSOR button.

☐ **Step 3:** Press the Shift button to select Horizontal or Vertical in the sub-menu. Shift sub-menu item selects the direction in which waveform data between the vertical bar cursors is to be shifted.

☐ **Step 4:** Press the Value button in the sub-menu. Use the general purpose knob or the numeric buttons to input the shift amount (horizontal value) or the vertical value.

☐ **Step 5:** Press the Execute button in the sub-menu. The waveform is shifted with the specified conditions.

Figure 3-59 shows the waveform between the vertical bar cursors shifted right 128 points.

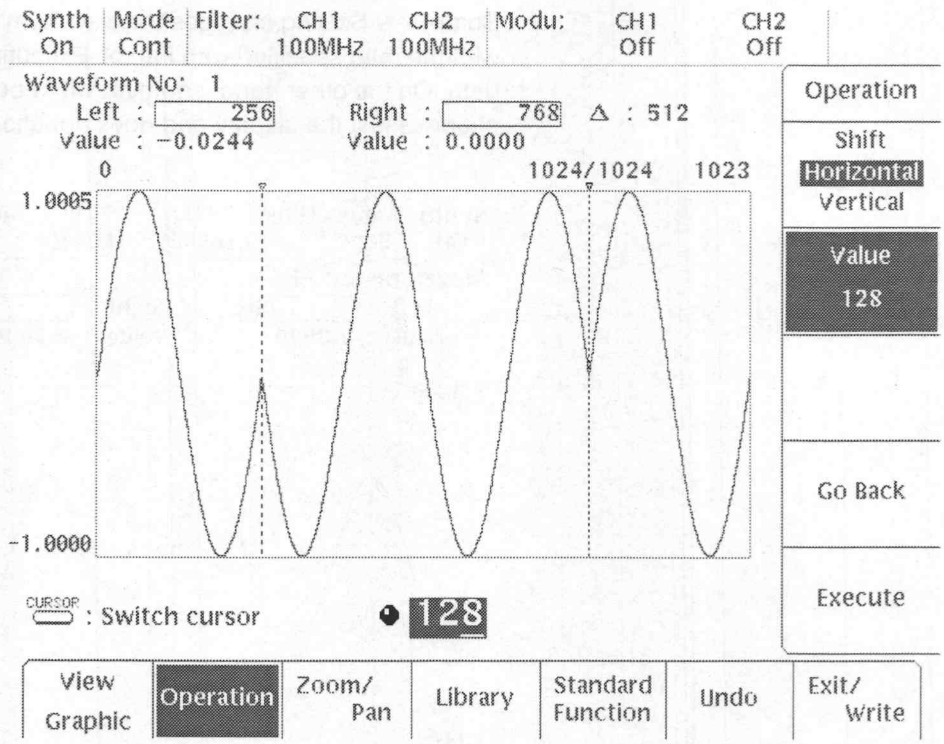


Figure 3-59: Horizontally Shifted Display

☐ **Step 6:** Select Go Back item from the sub-menu. The system returns from Shift... sub-menu to the previous side menu.

Scale... — Scaling changes the waveform data between vertical bar cursors with the ratio specified with Factor. Executing scaling changes the waveform data. On the other hand, zooming with Zoom/ Pan from the bottom menu changes just the display and does not affect the waveform data itself.

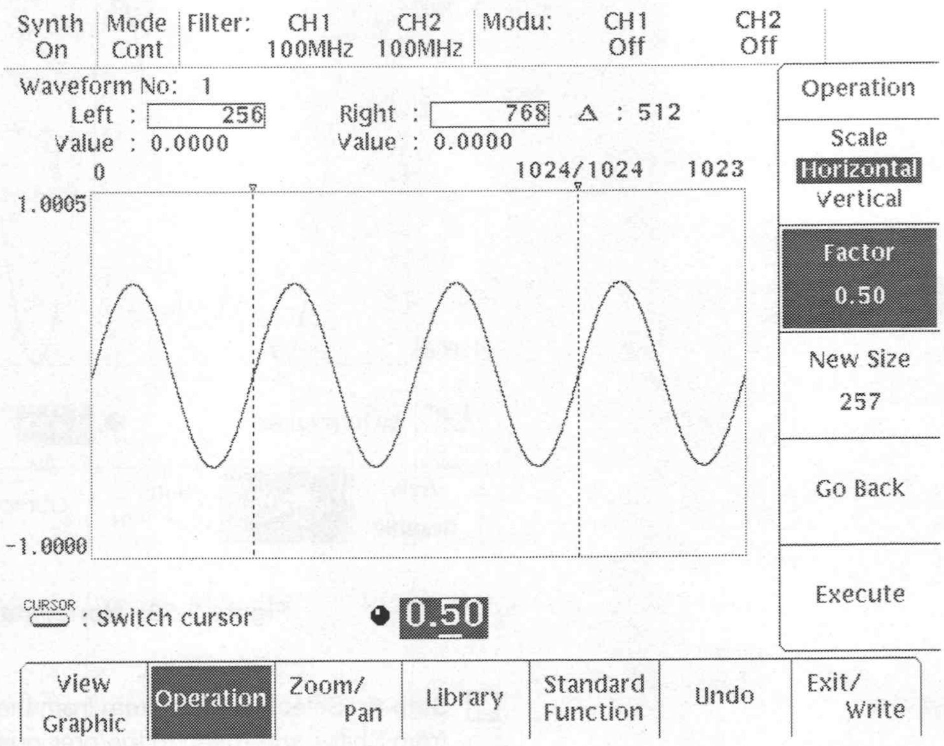


Figure 3-60: Scale Menu Display

When Scale... is selected from the side menu, a sub-menu containing Scale, Factor, Origin or New Size, Go Back, and Execute is displayed. Here are explanations of Scale... sub-menu items.

Scale — This item determines the direction in which the waveform data between the vertical bar cursors is scaled. Each time the Scale side button is pressed, the selection toggles between Horizontal and Vertical. When Vertical is selected, the Origin item is added to the sub-menu and the waveform data is scaled vertically using the Origin horizontal line as the reference. When Horizontal scaling is selected, the New Size item is displayed in the sub-menu, instead of the Origin item.

Horizontal — the waveform data between the vertical bar cursors is scaled horizontally from the left vertical bar cursor toward the right side. The factor can be set in the range ±100.00. A negative factor scales the waveform with reversing left and right.

When scaling with a factor whose absolute value is less than 1.00 (for example, from −0.99 to +0.99), the waveform between the vertical bar cursors is reduced horizontally. Since the waveform has 1024 points, the data value at the final point (1023rd point) of the waveform before reduction are added to the end of the waveform. If the factor is greater than 1.00 or less than −1.00, the waveform between vertical bar cursors is expanded horizontally and the data that overflows beyond the vertical bar cursors is lost.

New Size — When Horizontal is selected with Scale item in the sub-menu, the New Size item is displayed in the sub menu. This value shows how many data points there will be between the vertical bar cursors after horizontal scaling. The point count includes the points on the left and right vertical bar cursors.

When the value of New Size is changed, the value of Factor is automatically changed according to the equation below. However the value is rounded off. The Δ value displayed on the screen is the difference of horizontal point value between the left and right vertical bar cursors.

Factor = New Size / (Δ + 1)

Vertical — the waveform data between the vertical bar cursors is scaled vertically centering on the origin. The range for the factor is ±100.00. A negative factor inverts the polarity of the waveform between the vertical bar cursors.

When scaling with a factor whose absolute value is less than 1.00 (for example, from −0.99 to +0.99), the waveform between the vertical bar cursors is reduced vertically.

If the factor is greater than 1.00 or less than −1.00, the waveform between the vertical bar cursors is expanded vertically. Any waveform data that scaling pushes out beyond the vertical full scale is clipped.

Origin — When Vertical is selected with Scale item in the sub-menu, the Origin item is displayed in the sub menu and the horizontal broken line that is the reference line for scaling is displayed on the screen.

This item is used to set the reference level anywhere within the full scale. It is set with the numeric buttons or the general purpose knob. The waveform data is scaled vertically centered on the Origin

Factor — This item determines the ratio with which the waveform data between the vertical bar cursors is scaled. This factor is input using numeric buttons or general purpose knob.

Go Back — When this item is selected, the system returns from the sub-menu to the side menu.

Execute — When this item is selected, the scale function is executed in the area specified with the vertical bar cursors.

To scale waveforms, perform the following steps:

☐ **Step 1:** Select Operation from the bottom menu. Then select Scale... from the side menu.

☐ **Step 2:** Press the CURSOR button on the front panel. Use the general purpose knob or arrow buttons to move the left and right vertical bar cursors to the waveform data area to be scaled.

☐ **Step 3:** Press the Scale button to select Horizontal or Vertical in the sub-menu. The Scale sub-menu item sets the direction in which the data between the vertical bar cursors is to be scaled.

When Vertical is selected, the Origin item is added to the side menu.

☐ **Step 4:** ***This step is only used for vertical scaling.*** Select Origin from the side menu. Use the general purpose knob or numeric keys to set the reference level that is displayed on the screen as a horizontal broken line. The waveform will be reduced or expanded, centered on the origin line.

☐ **Step 5:** Press the Factor item in the sub-menu. Use the numeric keys or general purpose knob to input the scaling factor or reduction ratio.

☐ **Step 6:** Press the Execute button in the sub-menu. The waveform is scaled with the specified conditions.

Figure 3-61 shows the waveform between the vertical bar cursors expanded to 1.5X of the Figure 3-60 waveform, vertically centered on the reference line. Figure 3-62 shows the waveform reduced horizontally to 1/2 of the Figure 3-60 waveform.

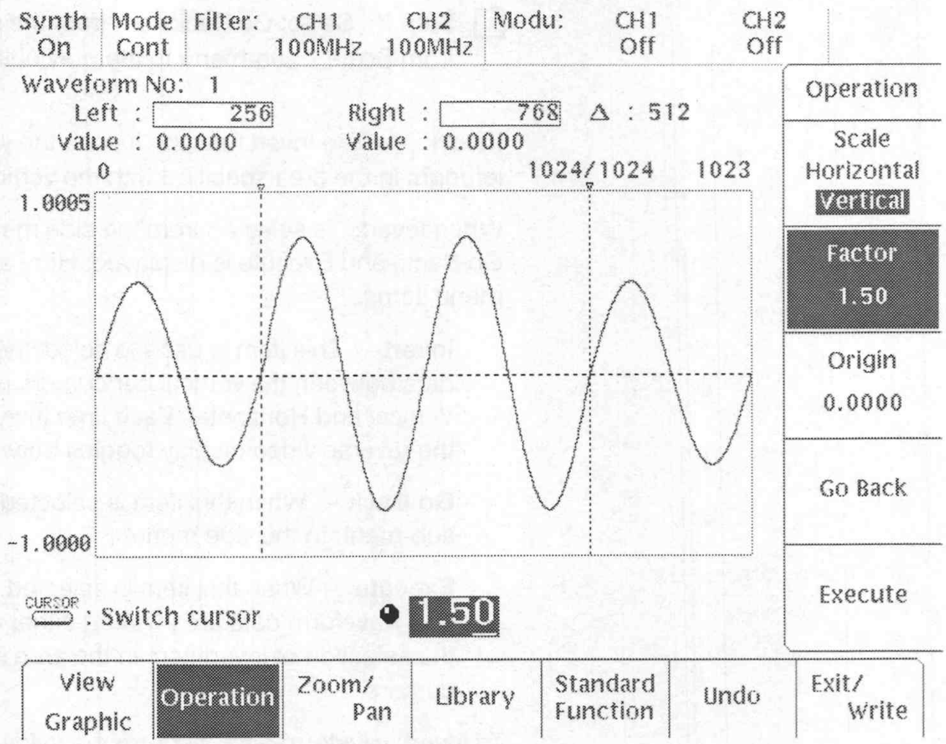


Figure 3-61: 1.5X Vertically Expanded Display

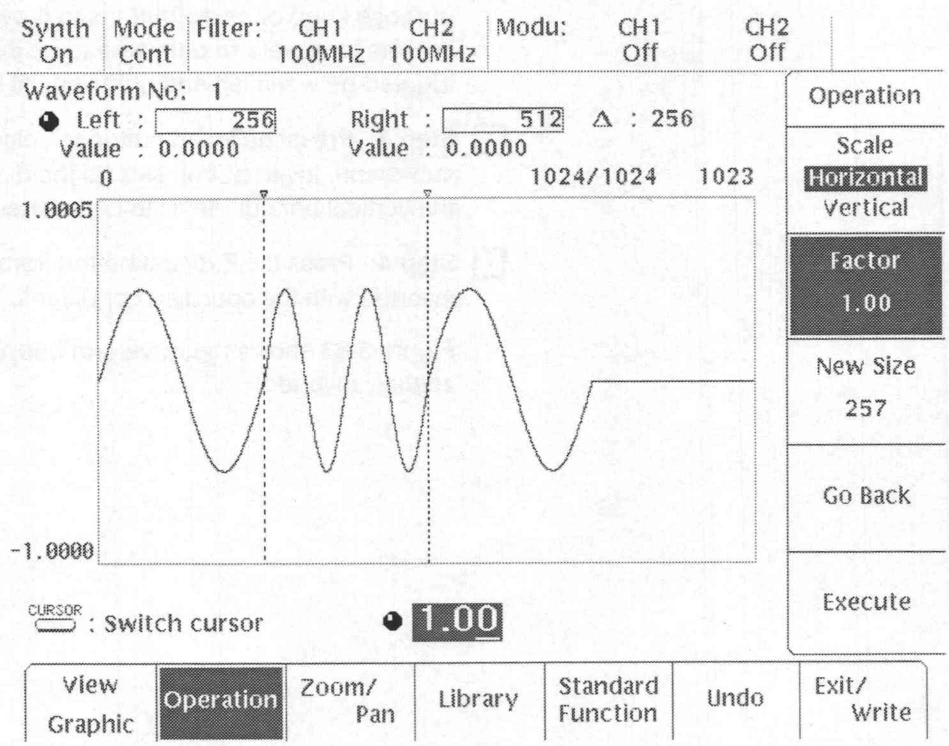


Figure 3-62: 1/2X Horizontally Reduced Display

☐ **Step 7:** Select Go Back item from the sub-menu. The system returns from Scale... sub-menu to the previous side menu.

Invert... — The Invert function inverts the waveform data either up/down or left/right in the area specified with the vertical bar cursors.

When Invert... is selected from the side menu, a sub-menu containing Invert, Go Back, and Execute is displayed. Here are explanations of Invert... sub-menu items.

Invert — This item is used to select the direction in which waveform data between the vertical bar cursors is inverted. The selections are Vertical and Horizontal. Each time Invert side menu button is pressed, the reverse video display toggles between Horizontal and Vertical.

Go Back — When this item is selected, the system returns from the sub-menu to the side menu.

Execute — When this item is selected, the Invert function is executed. The waveform data are inverted either up/down or left/right according to the selection of Invert item in the area specified with the vertical bar cursors.

To invert waveform data, perform the following steps:

☐ **Step 1:** Select Operation from the bottom menu, then select Invert... from the side menu.

☐ **Step 2:** Press the CURSOR button on the front panel. Use the general purpose knob or arrow buttons to move the left and right vertical bar cursors to waveform data area to be inverted. The active cursor is toggled between left and right vertical bar cursors with CURSOR button.

☐ **Step 3:** Press the Invert button to select Horizontal or Vertical in the sub-menu. Invert button selects the direction in which the data between the vertical bar cursors is to be inverted.

☐ **Step 4:** Press the Execute button from the sub-menu. The waveform is inverted with the specified conditions.

Figure 3-63 shows the waveform between the vertical bar cursors horizontally inverted.

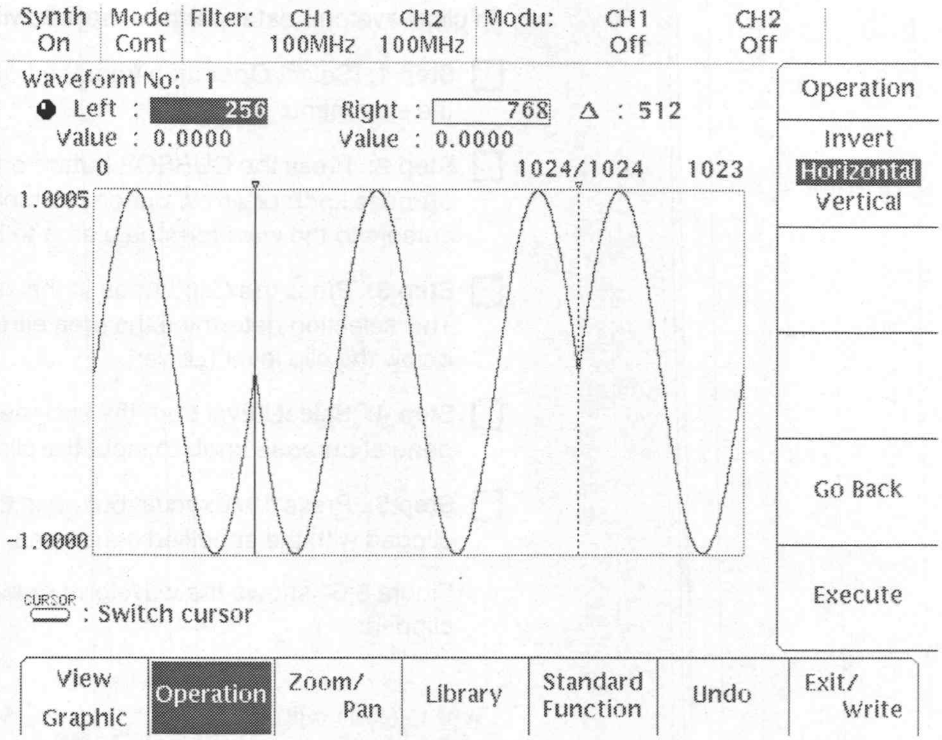


Figure 3-63: Horizontally Inverted Display

☐ **Step 5:** Select Go Back item from the sub-menu. The system returns from the Invert... sub-menu to the side menu.

Clip... — The Clip function clips any waveform data between the vertical bar cursors that is above or below the set level. When Clip... is selected, a broken horizontal line appears to show the clip level.

When Clip... is selected from the side menu, a sub-menu containing Clip, Level, Go Back, and Execute is displayed. Here are explanations of Clip... sub-menu items.

Clip — This item selects the area to be clipped off the waveform data between the vertical bar cursors. Either Upper or Lower can be selected. Each time the Clip side button is pressed, the selection toggles between Upper and Lower.

Level — This item selects the clip level. The level is input with the general purpose knob or the numeric buttons. Turning the general purpose knob raises or lowers the horizontal line showing the clip level on the screen.

Go Back — When this item is selected, the system returns from the sub-menu to the side menu.

Execute — When this item is selected, the clip function is executed in the area specified with the vertical bar cursors.

To clip waveform data, perform the following steps:

☐ **Step 1:** Select Operation from the bottom menu, then select Clip... from the side menu.

☐ **Step 2:** Press the CURSOR button on the front panel. Use the general purpose knob or arrow buttons to move the left and right vertical bar cursors to the waveform data area to be clipped.

☐ **Step 3:** Press the Clip button in the sub-menu to select Upper or Lower. This selection determine the area either above the clip level (Upper) or below the clip level (Lower).

☐ **Step 4:** Select Level from the sub-menu. Use the numeric keys or general purpose knob to input the clip level.

☐ **Step 5:** Press the Execute button in the sub-menu. The waveform is clipped with the specified conditions.

Figure 3-64 shows the waveform between the vertical bar cursors clipped.

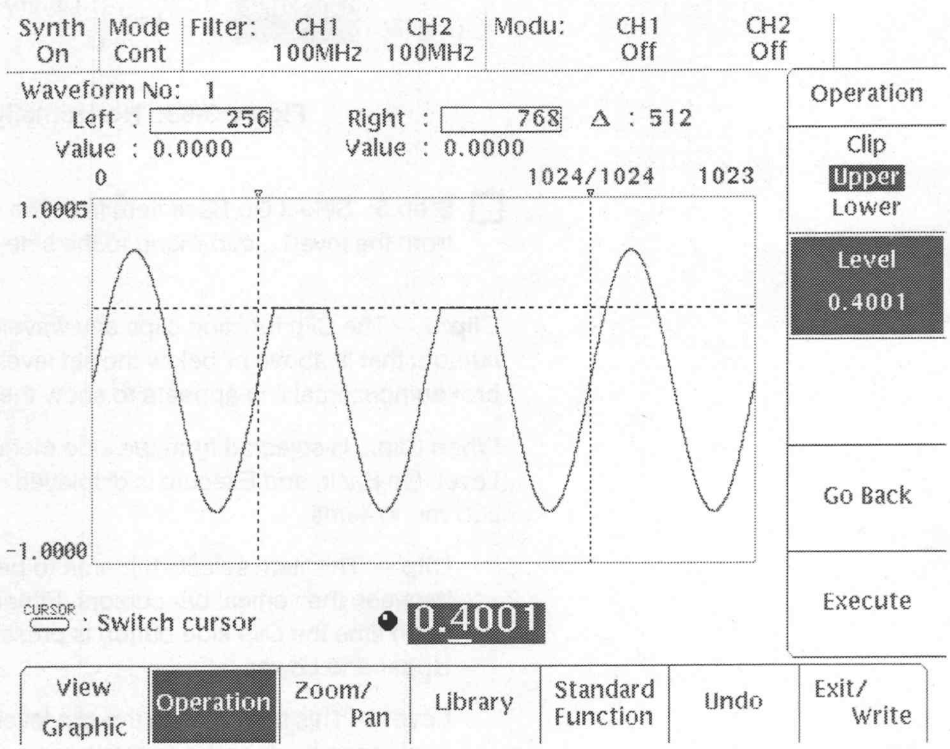


Figure 3-64: Display of Waveform Clipped Above Clip Level

☐ **Step 6:** Press sub-menu Go Back button. The system returns from Clip... sub-menu to the previous side menu.

Normalize — The Normalize item can be selected from the side menu displayed when the Operation bottom button is pressed.

The data is normalized at the moment this item is selected. This function normalizes the waveform data between the vertical bar cursors. The data is scaled with regard to the center of the vertical axis so that the waveform maximum or minimum value is at the top or bottom of full scale. The Normalize item has no sub-menu.

To normalize waveforms, perform the following steps:

☐ **Step 1:** Select Operation from the bottom menu.

☐ **Step 2:** Press the CURSOR button on the front panel. Use the general purpose knob or arrow buttons to move the left and right vertical bar cursors to the waveform data area to be normalize.

☐ **Step 3:** Press the side menu Normalize button to normalize the data.

Figure 3-65 shows the waveform between the vertical bar cursors is normalized.

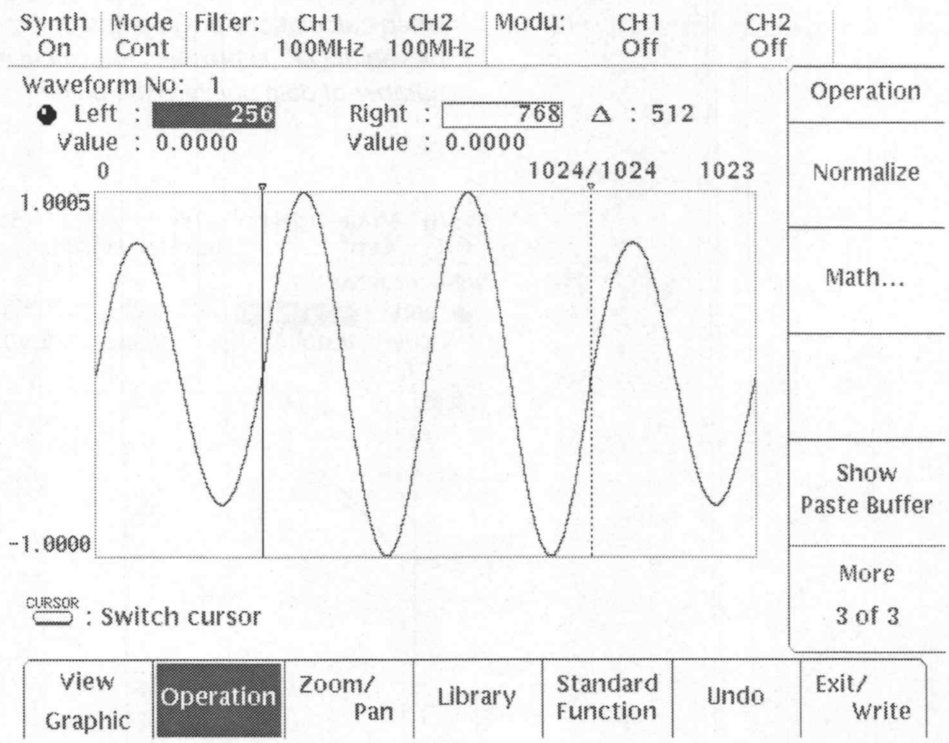


Figure 3-65: Normalized Waveform Display

Math... — The Math function performs calculations with the waveform currently being edited and other waveform data in the buffer. Figure 3-66 shows the menu displayed when Math... is selected.

When the Math... item is selected from the side menu, a sub-menu is displayed containing Add Buffer, Sub Buffer, Multiply Buffer, and Go Back items. Here are explanations of the sub-menu items.

Add Buffer — Addition with the waveform data in the buffer

Sub Buffer — Subtraction with the waveform data in the buffer

Multiply Buffer — Multiplication with the waveform data in the buffer

All these operations operate on the buffer waveform data and the waveform data between left and right vertical bar cursors. The result of the operation is displayed between the vertical bar cursors on the screen.

NOTE

If the number of waveform points in the buffer is less than the number of points between the left and right vertical bar cursors, when calculations are attempted, a message to this affect is displayed. If O.K. is pressed, the calculation is carried out for just the number of data points in the buffer.

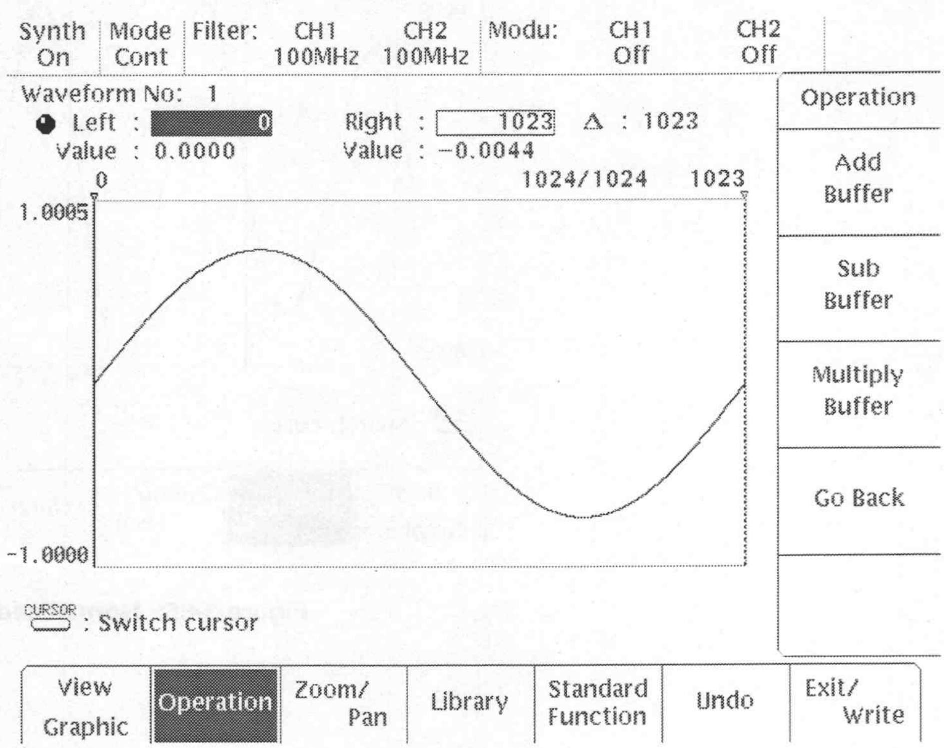


Figure 3-66: Menu Display When Math... is Selected

To perform math operations with waveforms, perform the following steps:

☐ **Step 1:** Using Operation menu, create waveform in the waveform edit area which is to be written into the buffer.

☐ **Step 2:** Press Cursor button on the front panel. Use the general purpose knob or arrow buttons to specify the waveform data area to be written into the buffer with the left and right vertical bar cursors.

☐ **Step 3:** Press the side menu Cut or Copy To Buffer button to write the waveform data into the buffer.

☐ **Step 4:** Using the Operation menu, create the other waveform for the operation in the waveform edit area.

☐ **Step 5:** Press CURSOR button on the front panel. Use the general purpose knob or arrow buttons to specify the waveform data area for the mathematical operation.

☐ **Step 6:** Press Math side menu button in Operation menu to display the Math... sub-menu (see Figure 3-67).

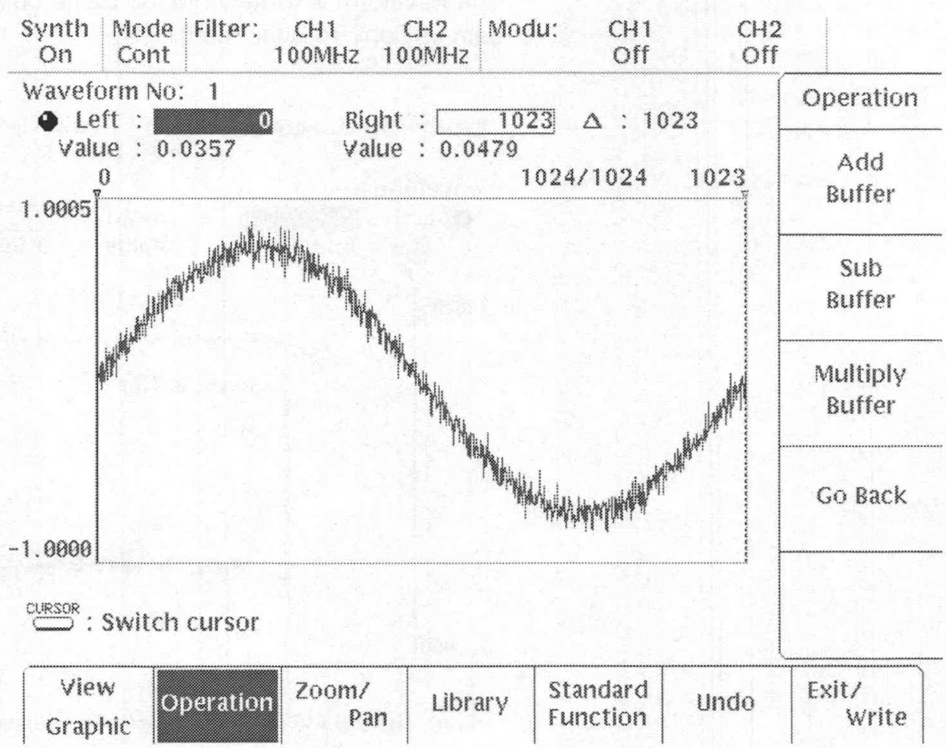


Figure 3-67: Waveform Display for Mathematical Operation

☐ **Step 7:** Press one of the mathematical operation buttons (Add Buffer, Sub Buffer, or Multiply Buffer) in the sub-menu. The corresponding mathematical operation is carried out on the waveform data in the buffer and the waveform data between left and right vertical bar cursors. The resulting waveform is displayed between the left and right vertical bar cursors.

Figure 3-67 shows the result of adding the sine wave in Figure 3-66 to the noise in Figure 3-68.

☐ **Step 8:** Press the Go Back button to return from the Math... sub-menu to the previous side menu.

Show Paste Buffer — The Show Paste Buffer item can be selected from the side menu displayed when the Operation bottom button is pressed.

This item displays the waveform data in the paste buffer (see Figure 3-68). This item is used to verify the contents of the buffer when using the Math menu. Pressing the Continue button or the Clear Menu button removes the buffer waveform from the display.

The waveform is written into the paste buffer with the Operation menu Cut item or Copy To Buffer item.

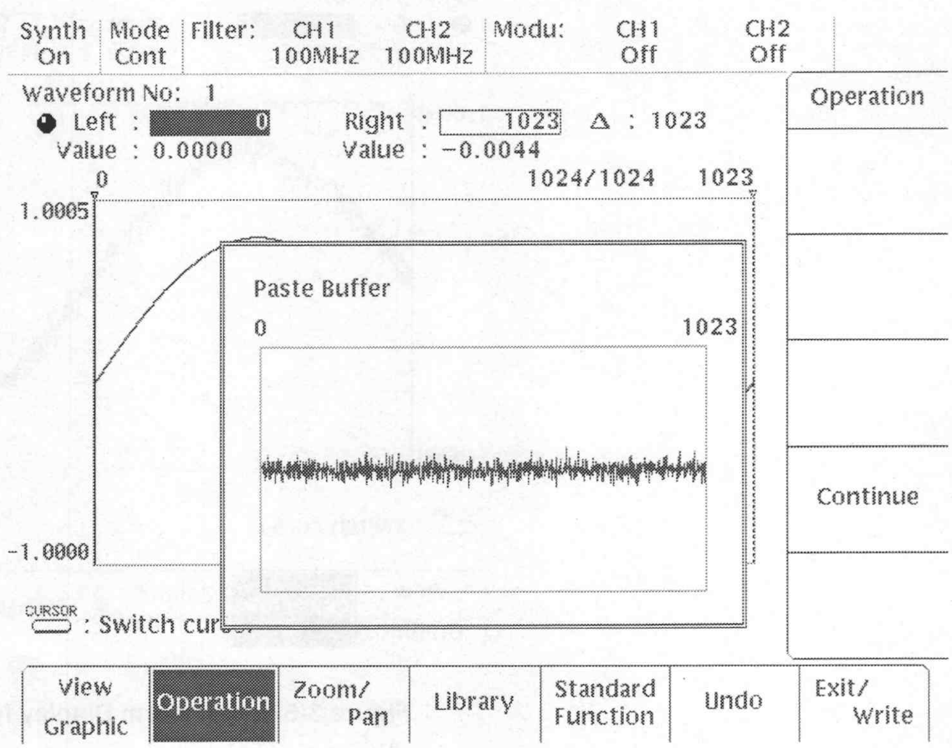


Figure 3-68: Paste Buffer Waveform Display

Waveform Zoom/Pan Functions

When Zoom/Pan is selected, the waveform being edited can be zoomed or panned. Here are explanations of the operations using the side menu items displayed when Zoom/Pan is selected.

Zoom Horizontal — When the Zoom Horizontal item is selected, the waveform being edited can be magnified horizontally. This does not change the waveform data itself, just the display.

Horizontal zooming is determined by the magnification ratio displayed under the Zoom Horizontal label. The magnification ratio can be set in steps of 1-2-5 within the range X1 to X200 using the general purpose knob or by repeatedly pressing the Zoom Horizontal button. The magnification is carried out with the active vertical bar cursor as center. When the waveform is magnified horizontally, the horizontal scroll indicator appears above the waveform display. This indicator displays the area currently displayed on the screen with reverse video display. Figure 3-69 shows a waveform display magnified to X2 horizontally using the zoom function.

The number of pixels horizontally in the waveform display area is 448. If 1024 points are displayed on the screen, when you use the general purpose knob to move the vertical bar cursor, it moves 2 or 3 points at one click. If you use the numeric buttons or arrow buttons, the vertical bar cursor can be moved one point at a time even when there are more than 448 points in the waveform display area.

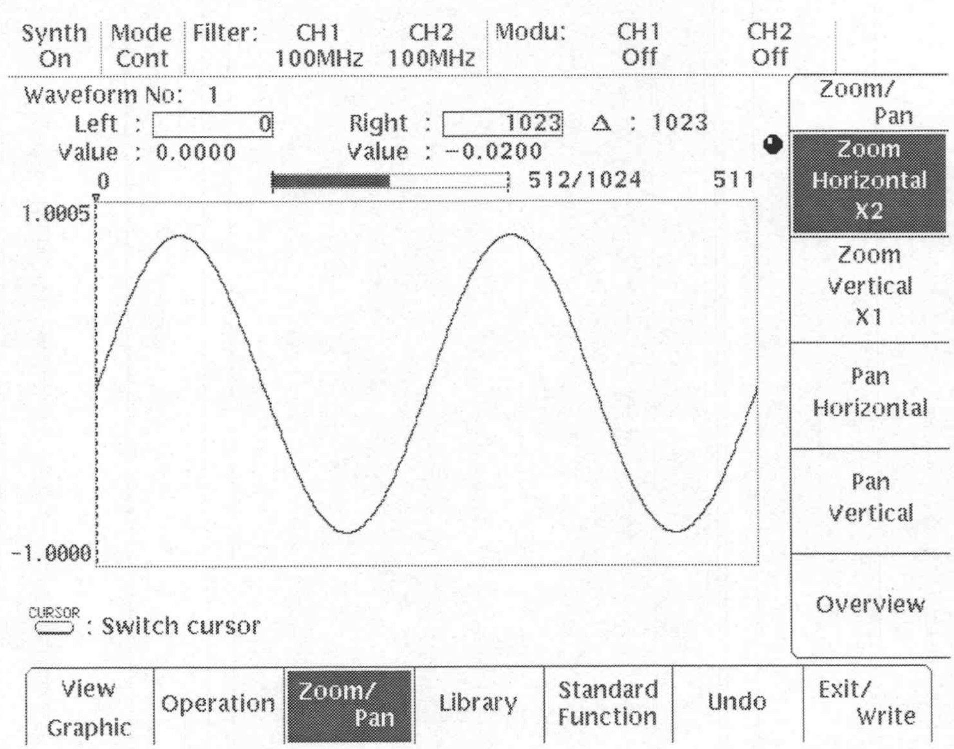


Figure 3-69: Waveform Display Magnified to X2 Horizontally

Zoom Vertical — When the Zoom Vertical item is selected, the waveform being edited can be magnified vertically. This does not change the waveform data itself, just the display.

Vertical zooming is determined by the magnification ratio displayed under the Zoom Vertical label. The magnification ratio can be set in steps of 1-2-5 within the range X1 to X200 using the general purpose knob or by repeatedly pressing the Zoom Vertical button. The magnification is carried out with the center of the vertical axis as the reference line. When the waveform is magnified vertically, the vertical scroll indicator appears to the left of the waveform display. This indicator displays the area currently displayed on the screen in reverse video.

Pan Horizontal, Pan Vertical — When Pan Horizontal or Pan Vertical is selected, you can view an entire waveform magnified (X2 or more) vertically or horizontally by scrolling through it with the general purpose knob to move the waveform display window. The waveform currently displayed on the CRT is the area displayed in reverse video by the horizontal or vertical scroll indicator.

Overview/Restore — When the Overview item is selected, the display switches from that magnified horizontally/vertically with the Zoom item to the X1 display, and the overall waveform is displayed. Also the Overview label changes to Restore. Selecting Restore switches the display back to the original magnification ratio and changes Restore label to Overview.

Function Waveform Library

When Library is selected from the bottom menu, a menu is displayed for selecting a waveform from among the various function waveforms in the library (see Figure 3-70). The selected waveform is drawn in the waveform edit area with 1024 points on the CRT screen. The function waveforms shown in the table below are contained in the library. For details on these functions, see *Edit Library* in *Appendix D*.

Table 3-6: Function Waveforms in Library Menu

Waveform Number	Function
#1	Gaussian Pulse
#2	Lorentz Pulse
#3	Sin(X)/X Pulse
#4	Sin(X)*Sin(X) Pulse (Sine Squared Pulse)
#5	Exponential Pulse
#6	Double Exponential Pulse
#7	Magnetic Disk Waveform
#8	Transient Voltage Test Signal
#9	Chirp Signal
#10	Random Signal (NRZ)
#11	Random Signal (RZ)
#12	Pulse Wide Modulated Signal
#13	Step Waveform
#14	(Blank)
#15	Ramp Waveform in FUNCTION menu
#16	Pulse Waveform in FUNCTION menu

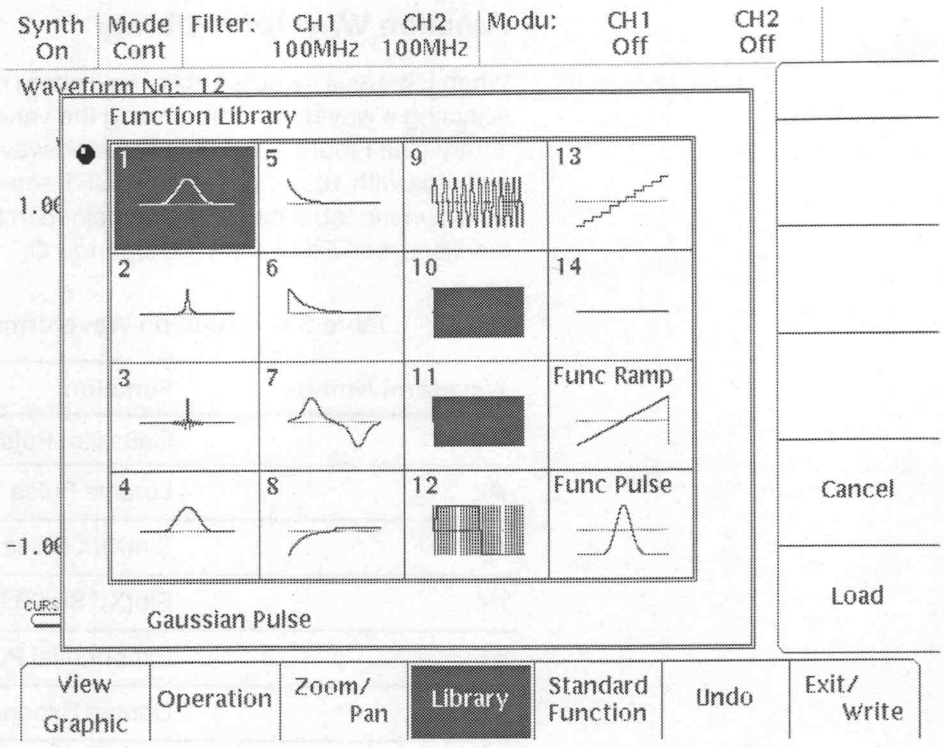


Figure 3-70: Function Library Display

To select a waveform from the function Library, perform the following steps:

☐ **Step 1:** Press the Library button from the bottom menu to display the menu for selecting a waveform from the function library.

☐ **Step 2:** Use the general purpose knob to move the reverse video display cursor to the desired waveform box.

☐ **Step 3:** Press the side menu Load button. This erases the library menu and draws the selected function waveform in the waveform edit area. To undo a load operation, press the Undo button in the bottom menu (see *Cancelling Menu Function Execution* later in this section).

The side menu items descriptions follow.

Load — When Load is executed, the selected function waveform is drawn in the full waveform edit area (horizontal points 0 through 1023).

Cancel — The Cancel button is used to return from the library menu to the edit menu without selecting a function. The waveform edit area returns to the waveform it had before the Library button was pressed and editing can continue on the waveform.

Using a Standard Function

When the Standard Function item is selected, a standard function waveform can be written between vertical bar cursors (see Figure 3-71). The function waveforms are sine waves, triangle waves, square waves, ramp waves, noise, and DC. For each function waveform, the cycle, amplitude, and offset parameters can be set. However, Noise has amplitude and offset parameters, and DC has only an offset parameter.

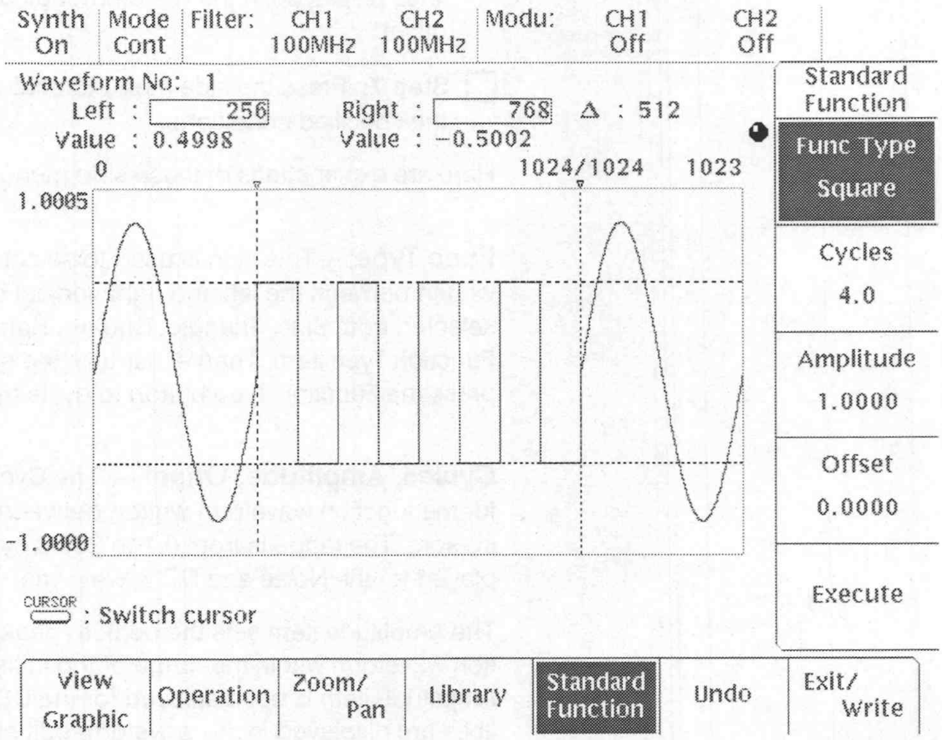


Figure 3-71: Standard Function Waveform Display

To select a function library waveform, perform the following steps:

- ☐ **Step 1:** Press the Standard Function button from the bottom menu to display the menu for setting a waveform.
- ☐ **Step 2:** The name of the currently selected function is displayed under the Func Type label in its column. Repeatedly press the Func Type button or turn the general purpose knob to select the desired function.
- ☐ **Step 3:** Press the CURSOR button on the front panel. Use the general purpose knob or arrow buttons to move the left and right vertical bar cursors to the waveform data area where the function is to be written.
- ☐ **Step 4:** Select the side menu Cycles item. Use the numeric keys or the general purpose knob to set the repetition count for the waveform to be written between the left and right vertical bar cursors.

☐ **Step 5:** Select Amplitude from the side menu. Use the numeric buttons or the general purpose knob to set the amplitude for the waveform to be written between the left and right vertical bar cursors. Two broken horizontal lines are displayed in the waveform edit area to show the amplitude.

☐ **Step 6:** Select Offset from the side menu. Use the numeric buttons or the general purpose knob to set the offset for the waveform to be written between the left and right vertical bar cursors. The two broken horizontal lines displayed in the waveform edit area move up or down with the offset.

☐ **Step 7:** Press the side menu Execute button to write the waveform with the specified conditions.

Here are explanations of these side menu items.

Func Type — This item is used to select the type of function waveform written between the left and right vertical bar cursors. The function type is selected from Sine, Triangle, Square, Ramp, Noise, or DC by pressing the Function Type item. Then either turn the general purpose knob or repeatedly press the Function Type button to cycle through to the desired selection.

Cycles, Amplitude, Offset — The Cycles item sets the number of cycles for the function waveform written between the left and right vertical bar cursors. The range is from 0.1 to 256.0 cycles. The Cycles item is not displayed for the Noise and DC waveforms.

The Amplitude item sets the peak to peak amplitude for the selected function waveform within the range of the full scale for the vertical axis. The Amplitude item is not displayed for the DC waveform. Two dotted horizontal lines are displayed in the waveform edit area to show the amplitude.

The Offset item sets the offset for the selected function waveform within the range of the full scale for the vertical axis. The two dotted horizontal lines displayed in the waveform edit area are moved up and down by the offset. If the dotted horizontal line cursor showing the amplitude range is moved outside the waveform display area, the function waveform is written with clipping.

Execute — This item writes the standard function waveform between left and right vertical bar cursors and between the upper and lower horizontal cursors.

Cancelling Menu Function Execution

Selecting the bottom menu Undo item cancels the editing carried out and restores the status before the function was executed. Pressing the Undo button again undoes the Undo function, so it restores the status created by execution items. This Undo item has the same function in the graphic display waveform editor and the table display editor.

Exiting the Waveform Editor

When Exit/Write is selected from the bottom menu, a side menu is displayed for saving the edited waveform data and returning to the editor initial menu. This item has the same function in both the graphic display waveform editor and the table display waveform editor. Select the Exit/Write item to display the side menu shown in Figure 3-72.

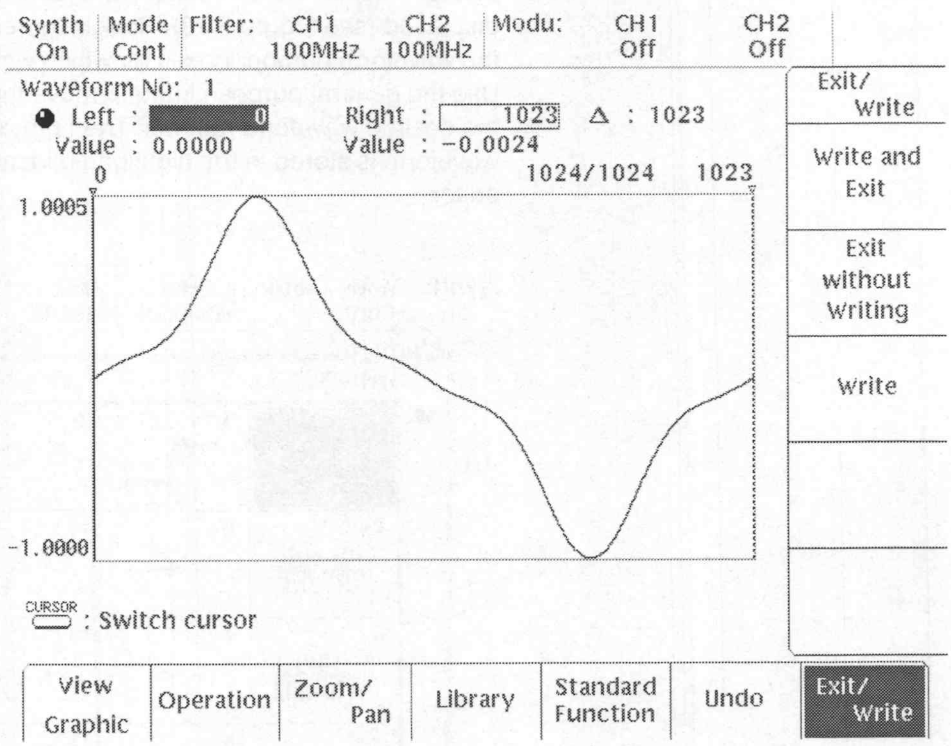


Figure 3-72: Exit/Write Menu Display

When Exit/Write is selected from the bottom menu, a side menu containing Write and Exit, Exit Without Writing, and Write is displayed. Here is an explanation of these items.

Write and Exit — Selecting this item saves the newly created or edited waveform data into the waveform number displayed as “Waveform No:” near the upper left corner on the screen, then returns the system to the initial menu.

NOTE

The waveform number displayed as "Waveform No:" is the number selected with the edit initial menu. If you want to recheck the waveform at this waveform number before saving or to save to a different waveform number, select the Write side menu item.

Exit Without Writing — When this item is selected, the system returns to the initial menu without saving the created or edited waveform into internal memory. In this case, a message asking you if it is O.K. to erase the created data is displayed on the screen. Reply either O.K. to throw out the data or Cancel to return to the editor again.

Write — When Write is selected, a table for saving the arbitrary waveform is displayed (see Figure 3-73). Rough figures for the waveform are displayed in the waveform number boxes for which waveforms have already been stored. Use the general purpose knob to move the reverse video display cursor to the desired waveform number. Then press the Execute button. The edited waveform is stored in the highlighted location, and the system returns to the editor.

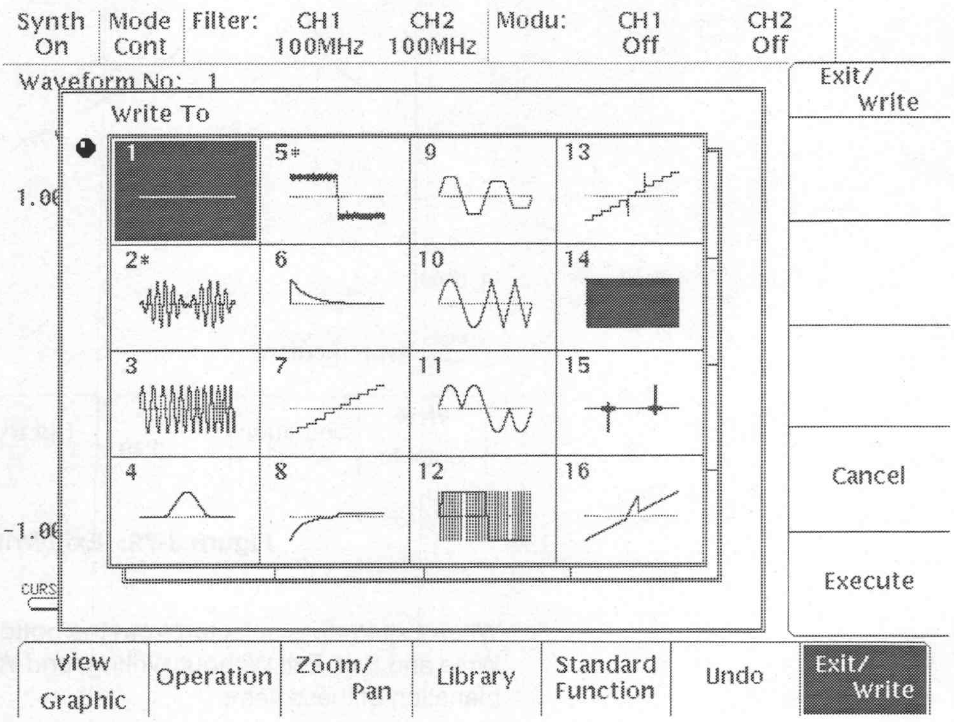


Figure 3-73: Write Side Menu Display

The following sub-menu items are displayed when Write is selected from the side menu.

Execute — This item writes the edited waveform data into the internal memory for the waveform number at which the cursor is displayed in reverse video and returns the system to the editor.

Cancel — This item is used to return to the editor without writing the data into memory.

Table Display Editing

Figure 3-74 shows the many waveform editor table display features.

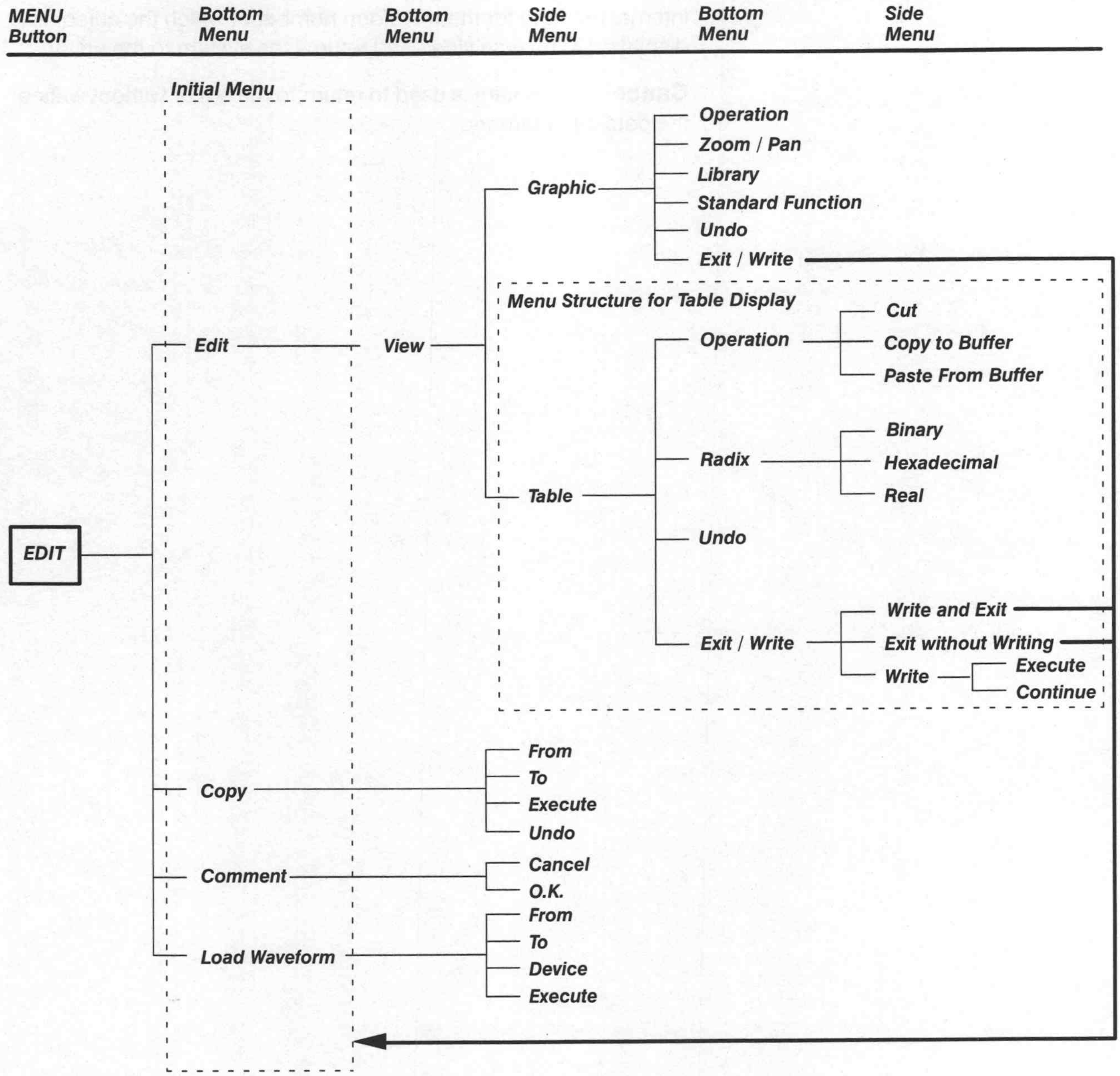


Figure 3-74: Waveform Editor Table Display Menu Structure

Entering the Table Display

To choose the table display of the Edit menu, perform the following steps:

☐ **Step 1:** Press the View bottom menu button.

☐ **Step 2:** Select Table from the side menu. In table display, the waveform data are displayed in table form.

Figure 3-75 shows waveform data in table form. The descriptions for feature callouts follow the figure.

In the table display, use the Radix menu item to choose to display the 12-bit waveform data in binary, hexadecimal, or real number notation.

This section shows the table display waveform editor using a binary radix.

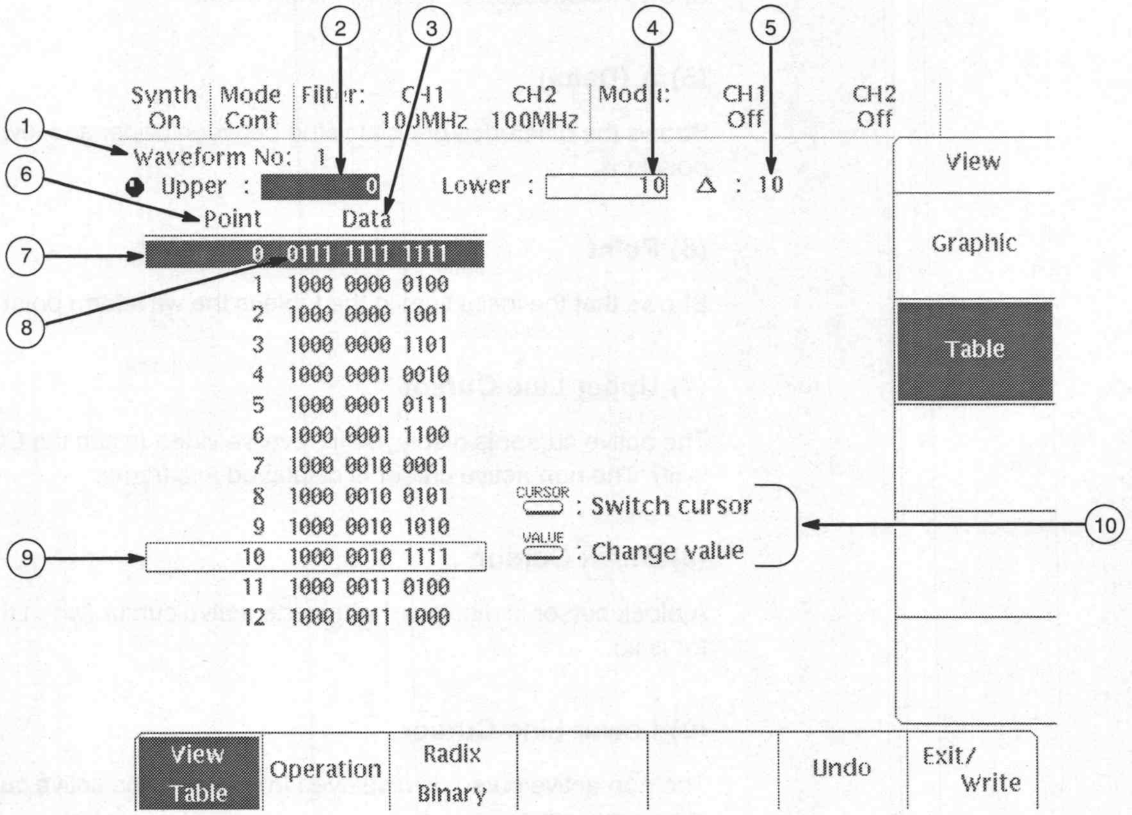


Figure 3-75: Table Display with a Binary Radix

(1) Waveform No:

Shows the waveform number being edited.

(2) Upper

Shows the position of the upper line cursor. When the value is displayed in reverse video, it shows this cursor can be moved. The position can be changed with the general purpose knob, arrow buttons, or the numeric keys.

(3) Data

Shows that the second item in the table is the waveform data for the waveform point. When the base is binary, the data is displayed with 12 digits, with the left end being the most significant bit.

(4) Lower

Shows the location of the lower line cursor.

(5) Δ (Delta)

Shows the difference of point value between upper and lower line cursor positions.

(6) Point

Shows that the initial item in the table is the waveform point number.

(7) Upper Line Cursor

The active cursor is displayed in reverse video (when the CURSOR indicator is lit). The non-active cursor is displayed in a frame.

(8) Block Cursor

A block cursor is displayed within the active cursor (when the VALUE indicator is lit).

(9) Lower Line Cursor

The non-active cursor is displayed in a frame. The active cursor is displayed in reverse video.

(10) Button Operations

This area shows how the front panel knob buttons operate in this menu.

CURSOR: Switch Cursor — Pressing the CURSOR button toggles the active vertical bar cursor between upper and lower.

CURSOR: Move Cursor — Pressing the CURSOR button allocates the line cursor movement function to the general purpose knob.

VALUE: Change value — When the VALUE button is pressed, a numeric value can be input at the block cursor position.

← / → : Move Block Cursor — Pressing an arrow button moves the block cursor left or right.

Using the Front Panel Controls

Numeric input and cursor operations vary, depending on whether the CURSOR button or the VALUE button is selected.

When the CURSOR indicator is on:

- Movement functions for the line cursor displayed in reverse video are assigned to the general purpose knob and the arrow buttons.
- Pressing the CURSOR button toggles the active cursor between upper and lower.

When the VALUE indicator is on:

- Movement functions for the block cursor in the active cursor are assigned to the arrow buttons.

  If the block cursor is at the left end (MSB) of the waveform data, pressing the ← button moves the reverse video display cursor to the previous data point and moves the block cursor to the right end (LSB) of that data point.

  If the block cursor is at the right end (LSB) of the waveform data, pressing the → button or inputting a numeric value with buttons moves the reverse video display cursor to the next data point and moves the block cursor to the left end (MSB) of that data point.

- Numeric values can be input at the position of the block cursor.

  Data can be input with the general purpose knob or the numeric keys. When data is input with the numeric keys or the unit keys, the block cursor moves to the right. When the number base is hexadecimal (16), the decimal point is assigned to the number A, the minus sign to the number B, and the unit keys to the numbers C–F.

Input Example

This example shows how to use the front panel buttons to set the number base to binary.

☐ **Step 1:** Press the bottom menu Radix button, then select binary from the side menu displayed.

☐ **Step 2:** Press the CURSOR button on the front panel. The function for moving the line cursor is allocated to the general purpose knob and the arrow buttons.

☐ **Step 3:** Use the general purpose knob or arrow buttons to move the active line cursor to the data point to be changed.

☐ **Step 4:** Press the VALUE button on the front panel. The numeric input functions is allocated to the general purpose knob and the block cursor movement functions are assigned to the arrow buttons.

☐ **Step 5:** Use the arrow buttons to move the block cursor to the position of the data bit to be changed.

☐ **Step 6:** Use the numeric buttons to input 0 or 1. That numeric value is input at the data bit position and the block cursor automatically moves to the next lower bit.

When using the general purpose knob to change the numeric value, the block cursor does not move automatically. Since the base is binary, no numeric values other than 0 or 1 can be input.

☐ **Step 7:** Repeat steps 5 and 6 to change each data bit to the desired value.

☐ **Step 8:** Repeat steps 2–7 to change the values of all the desired data points.

Editing Operations

When Operation is selected from the bottom menu, a side menu containing the Cut, Copy to Buffer, and Paste from Buffer items is displayed. These functions are used to efficiently edit the waveform data in the area between upper and lower line cursors. Figure 3-76 shows the Operation menu displayed when binary is selected as the number base.

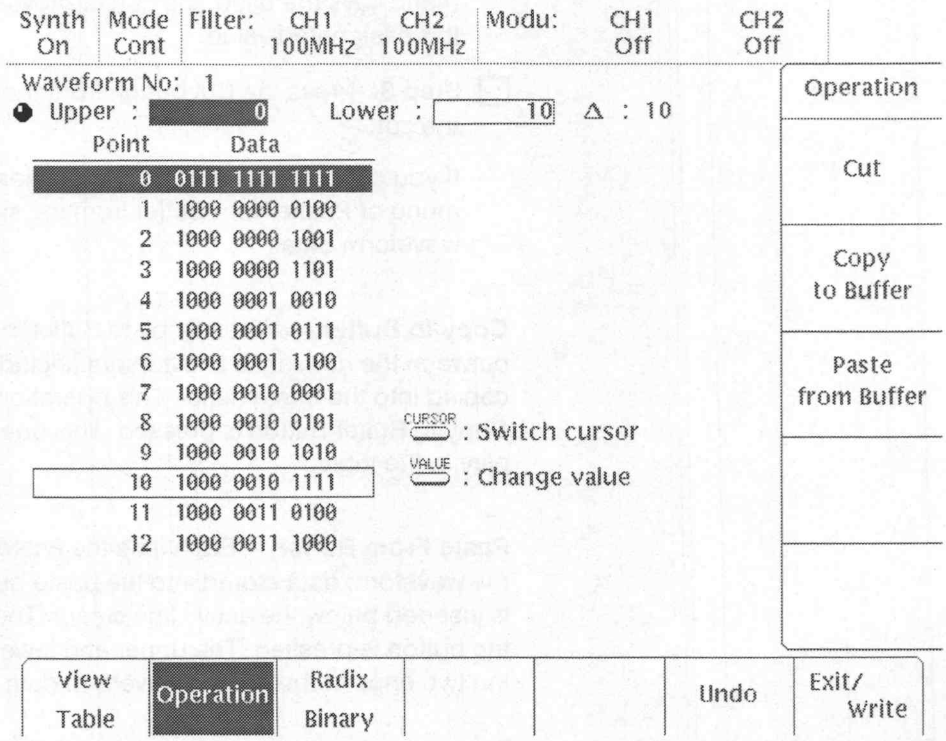


Figure 3-76: Table Display When Operation Selected

The Cut, Copy to Buffer, and Paste from Buffer functions work on the waveform data between upper and lower horizontal line cursors. They can cut this data or copy it to the paste buffer. Also, the contents of the paste buffer can be pasted to the position of the active cursor in the table. These functions are the same as the corresponding ones for the waveform editor graphic display. The descriptions of the side menu items follow.

Cut — At the moment Cut button is pressed, the waveform data between the horizontal bar cursors (including the upper and lower horizontal bar cursor data) is cut out. The cut waveform data goes into the paste buffer.

After the cut, the waveform data located below the cut is shifted up to fill in the cut out area. The waveform data value of the final point is automatically filled in from the end of the waveform data to the last point in memory.

To cut data, perform the following steps:

☐ **Step 1:** Select the Operation item from the bottom menu.

☐ **Step 2:** Use the general purpose knob or arrow buttons to set the area of the waveform data to be cut between the upper and lower horizontal line cursors. The active cursor is toggled with the CURSOR button.

The arrow buttons move the cursor one point at a time. When the numeric keys are used, the cursor moves directly to the point position with the designated value.

☐ **Step 3:** Press the Cut button from the displayed side menu to execute the cut.

If you cut out waveform data by accident, select Undo from the bottom menu or Paste From Buffer from the side menu to restore the original waveform data.

Copy to Buffer — When Copy to Buffer is selected, the waveform data between the horizontal line cursors (including the data under the cursor) is copied into the paste buffer, This operation is processed the moment the Copy to Buffer button is pressed. This operation does not change the display in the table.

Paste From Buffer — Each time the Paste From Buffer button is pressed, the waveform data stored into the paste buffer with the cut or copy functions is inserted below the active line cursor. The data is pasted at the moment the button is pressed. The upper and lower horizontal line cursors move to the two ends of the pasted waveform data.

To copy and paste data, perform the following steps:

☐ **Step 1:** Select the Operation item from the bottom menu.

☐ **Step 2:** Use the general purpose knob or arrow buttons to set the area of the waveform data to be copied between the upper and lower horizontal line cursors. The active cursor is toggled with the CURSOR button.

The arrow buttons move the cursor one point at a time. When the numeric keys are used, the cursor moves directly to the point position with the designated value.

☐ **Step 3:** Press the Copy to Buffer button from the displayed side menu to execute the copy.

☐ **Step 4:** Use the general purpose knob or arrow buttons to specify the active horizontal line cursor position where the buffer data will be pasted.

☐ **Step 5:** Press the Paste From Buffer button displayed in the side menu to execute the pasting. The waveform data is inserted at the position of the active cursor and any waveform data pushed out of the table is lost.

Selecting the Radix

The waveform data can be displayed with binary, hexadecimal, or real numbers. Radix selects a numeric base for the table display waveform data. Figure 3-77 shows the side menu containing Binary, Hexadecimal, and Real items when this item is selected. In this figure, the radix is set to Hexadecimal and the data for each point is displayed in hexadecimal.

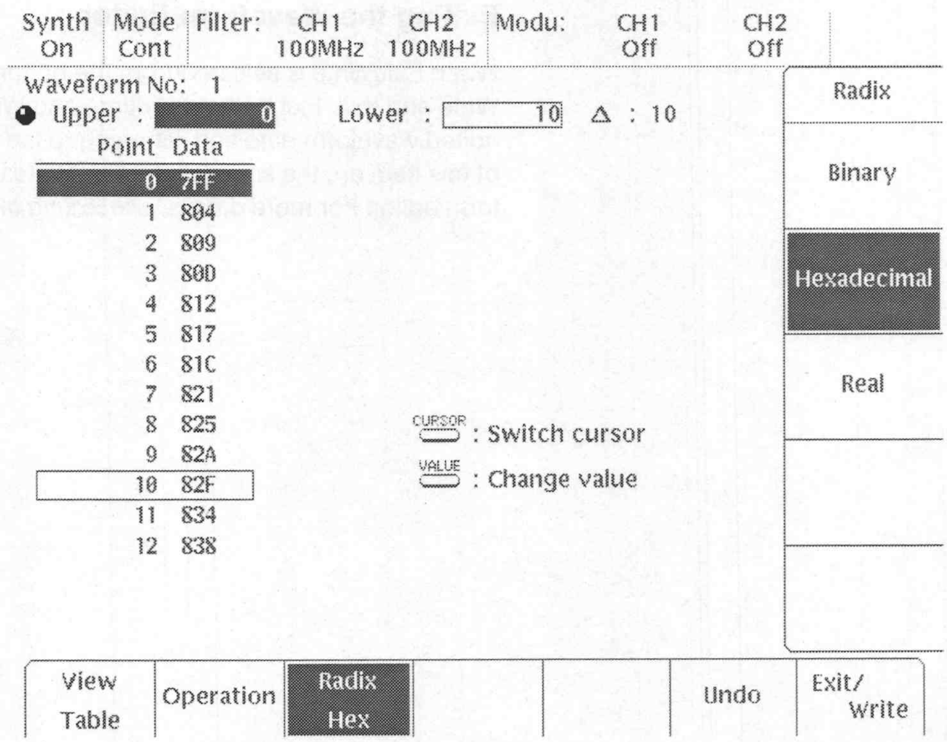


Figure 3-77: Radix Selection Menu

The waveform data can be displayed as Binary, Hexadecimal, or Real. A radix is selected by pressing the corresponding button from the side menu. The description of the side menu items follow.

Binary — 12-bit waveform data is created using 0 or 1.

Hexadecimal — Waveform data is created using 0–9 and A–F . When Hexadecimal is selected, A–F are allocated to numeric keys and unit keys.

Real — Waveform data can be input using numeric keys and the ENTER key for general numeric input. It also can be input with the general purpose knob. Any real number can be input up to the full scale value of the vertical axis. The active cursor moves automatically to the next waveform point.

Inputting a number or character not appropriate to the selected radix has no effect.

Cancelling Menu Function Execution

Selecting the bottom menu Undo item cancels the editing carried out and restores the status before the function was executed. Pressing the Undo button again undoes the Undo function, so it restores the status created by execution items. The function of this item is the same as the Undo item in the waveform editor graphic display.

Exiting the Waveform Editor

When Exit/Write is selected from the bottom menu, a side menu containing Write and Exit, Exit Without Writing, and Write is displayed for saving the edited waveform data and returning to the editor initial menu. The functions of this item are the same as the Exit/Write item in the graphic display waveform editor. For more details, see *Exiting the Waveform Editor* on page 3-139.

Utility Menu

Press the UTILITY button in the MENU column on the front panel to select a utility function from the bottom menu buttons, an appropriate side menu for settings or calibration or diagnostics is displayed at the right side of the screen. Refer to Figure 3-78 for the Utility menu structure. The selections and settings can be changed with the side menu buttons, the general purpose knob, and the numeric keys.

The following items can be set in the Utility menu:

- **Setting Memory (NV RAM)**

  The NV RAM item is the menu for saving and recalling settings for outputting waveforms. Up to 32 settings can be stored in the NV RAM. These setting are the selections and parameter values made with the waveform type (FUNCTION), output parameters (OUTPUT), Sweep (SWEEP), modulation (MODULATE), and trigger mode (MODE) menus. The Save setup item can save all these settings as file numbers. The Recall setup item calls out the settings with the selected file number. The Recall and Step item also calls out the settings of grouped files, one file after another. The NV RAM item also has the Comment for setup item in the side menu.

- **Reference Clock (Ref Clock)**

  The Ref Clock item selects the reference clock source for accurately synchronizing multiple AFG2020s connected in parallel.

- **GPIB configuration (GPIB)**

  The GPIB item sets the GPIB address or selects Off Bus.

- **Intensity**

  The Intensity item sets the screen brightness.

- **Calibration (Cal)**

  The Cal item is the menu for calibration. When attempting calibration, this instrument must be warmed up 20 minutes after power on and calibrated at an ambient temperature between 20° C and 30° C.

- **Diagnosis (Diag)**

  The Diag item is the menu for executing diagnostic tests to see if this instrument is functioning normally or not. If this test finds problem, contact the nearest Tektronix office.

- **Initial settings (Init)**

  The Init item resets the settings to the status they have when the power is switched on. The Secure item executes the power on initial settings and also deletes the data in arbitrary waveform memory and setting memory (NV RAM).

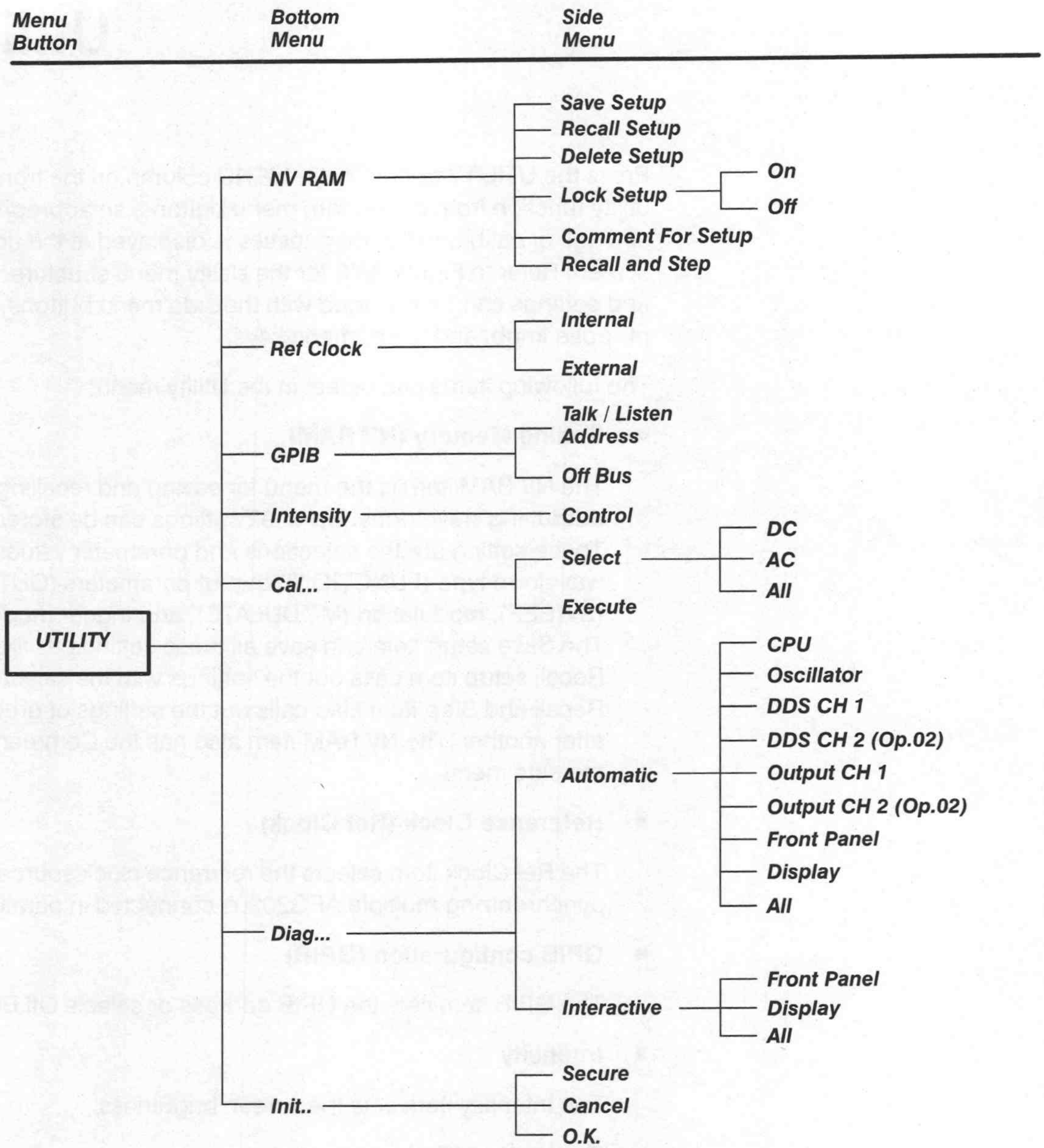


Figure 3-78: UTILITY Menu Structure

Saving Settings

Use NV RAM in the bottom menu to save waveform output settings into nonvolatile memory and call them up from that memory (see Figure 3-79). Up to 32 settings can be stored in the nonvolatile memory. The settings are the items selected and values input with the waveform type (FUNCTION), output parameters (OUTPUT), sweep (SWEEP), modulation (MODULATE), and trigger mode (MODE) menus.

NOTE

The settings just before the power is switched off are not automatically stored. To use the same settings again the next time the power is switched on, save the settings with the NV RAM menu before switching off the power.

The table items are File No, Type (CH1/CH2), Size, and Comment. One of the file Num rows is displayed in reverse video. This reverse video display cursor is moved with the general purpose knob.

Size in the table shows the number of bytes used to save the settings. Used size under the table shows the sum of the number of bytes in the Size column. Free size shows the number of bytes still available for storing settings.

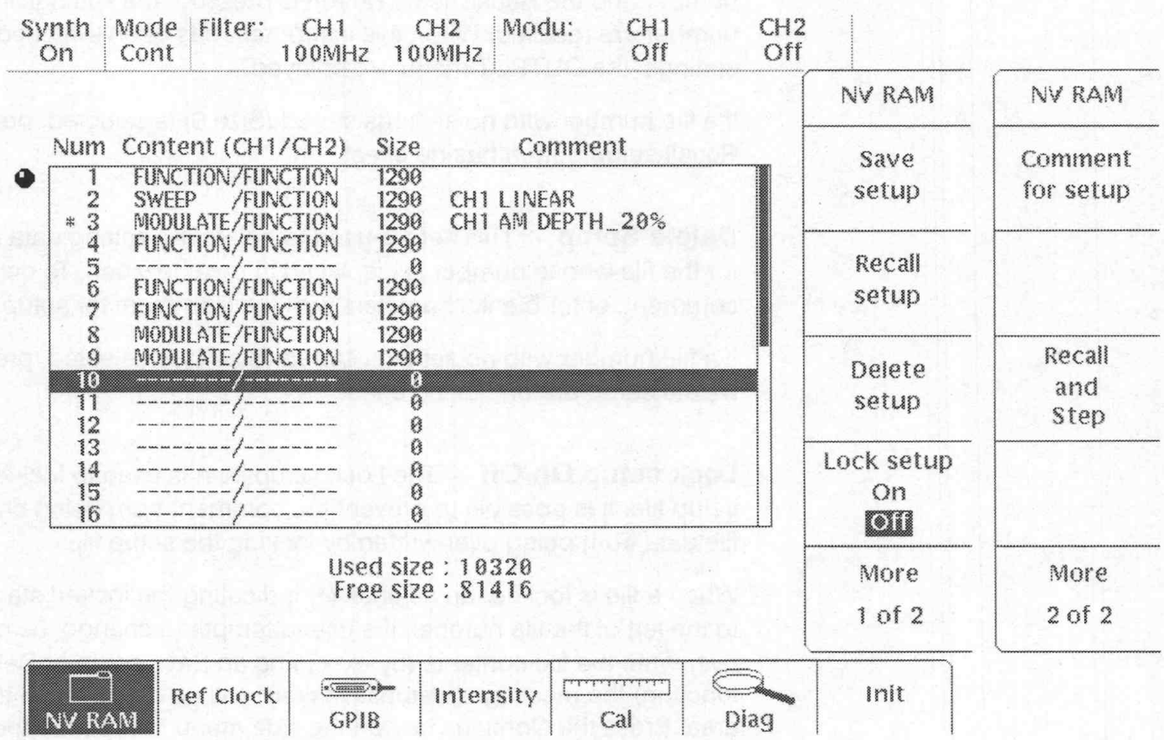


Figure 3-79: NV RAM Menu Display

The side menu has the following items.

Save Setup — When the reverse video display cursor is placed over an empty file number and the Save setup button is pressed, the current settings of this instrument are saved into that file number.

In the Content column of the list, labels are displayed for CH1 and CH2. If sweep function is on, "SWEEP" is displayed. If the modulate function is on, "MODULATE" is displayed. If both the sweep and modulate functions are off, "FUNCTION" is displayed. The Size column shows the number of bytes of memory used for the setting.

If you attempt to recall several files in succession, save these settings as grouped files, which can be recalled by pressing the Recall and Step button in order of file number. The term grouped files refers to a set of files delimited by file numbers that have no settings stored.

If you attempt to save the setup into a file number already containing settings, a message to that effect is displayed. Pressing the Continue button or the front panel CLEAR MENU button removes the message and returns the system to the previous menu display. If you do want to save the setup into that file, first delete the old setup from that file with the Delete setup button, then save the current setup.

Recall Setup — When the reverse video display cursor is placed on a file number and the Recall setup button is pressed, the settings in that file number are recalled. When this instrument has been switched over to those settings, the OUTPUT menu is displayed.

If a file number with no settings stored (Size 0) is selected, pressing the Recall setup button has no effect.

Delete Setup — This item is used to delete the setting data and comment for the file whose number is displayed in reverse video. To delete just the comment, enter blank characters with the Comment for setup menu.

If a file number with no settings stored (Size 0) is selected, pressing the Delete setup button has no effect.

Lock setup On/Off — The Lock setup item is used to lock or unlock the setup file. It is possible to prevent the comment from being changed and the file data from being over-written by locking the setup file.

When a file is locked, an asterisk (*) indicating the locked state is displayed to the left of the file number. If a user attempts to change the comment or to over-write the file contents (by executing an Save setup or Delete setup function) the message "Setup is locked" will be displayed in the message area. Press the Continue key on the side menu to return to the original screen.

☐ **Step 1:** Select the file to be locked from the setup file list on the NV RAM menu using the general purpose knob.

☐ **Step 2:** Press the Lock setup button on the side menu. The selected file will be locked and On in the Lock setup label will be highlighted by a reversed display. An asterisk (*) will be displayed to the left of the waveform number in the file list to indicate the locked state.

☐ **Step 3:** To release the lock on a file, use the method of step 1 to select the locked file and press the Lock setup button. This will switch the reversed display to the Off item.

Comment for Setup — This item is used to input comments into the Comment column displayed in reverse video in the table. When the Comment for setup button is pressed, the comment input menu is displayed. If a file number is selected for which no settings are saved, the comment menu is not displayed. Comments can be input up to 24 characters. For details on the screen display of the comment input menu, see *Inputting Waveform Comments* in the *Edit Menu* description earlier in this section.

☐ **Step 1:** In the NV RAM menu, use the general purpose knob to move the reverse video display cursor to the file number for which the comment is to be input. A setting must already be stored in the selected file number.

☐ **Step 2:** If the waveform is locked, press the Lock setup button on the side menu to switch the reversed display to the Off item.

☐ **Step 3:** Press the Comment for setup button in the side menu to display the comment menu.

☐ **Step 4:** Select a character from the character list by moving the reverse video display cursor with the general purpose knob.

☐ **Step 5:** Press the front panel VALUE button. The character is inserted at the position of the blinking bar cursor in the comment input column.

Numbers, decimal points, and minus signs are input with the numeric keys as well. In this case, there is no need to press the VALUE button.

Characters are deleted with the front panel Delete button. The character just before the bar cursor is deleted. The bar cursor can be moved with the arrow buttons on the front panel.

☐ **Step 6:** Repeat steps 4 and 5 to write the comment.

☐ **Step 7:** Press the side menu O.K. button. The display of the comment input menu goes out and the comment just input is displayed in the Comment column at the position of the cursor in the table.

In the comment menu, the front panel ENTER button has the same function as the O.K. button.

If you do not want to enter the comment, press the side menu Cancel button and the comment is not written.

To delete a comment that has already been entered, select Comment for setup from the menu. Then delete each character in the comment input column and press the O.K. button. This deletes the comment for that file number.

Recall and Step — When the reverse video display cursor is moved to one of the file numbers within a grouped set of files, and the Recall and Step button is pressed, the settings from that file are recalled and the reverse video display cursor moves to the file with the next file number. The settings in the files that have been grouped can be recalled in order by pressing the Recall and Step button again. Unlike the Recall setup function, the system does not move to the OUTPUT menu by pressing the Recall and Step button.

Grouped files are a set of files delimited by file numbers that have no settings stored. (It is assumed that files are delimited before file number 1 and after file number 32) In Figure 3-79 file numbers 1–4, and file numbers 6–9, are grouped. To switch between groups, use the general purpose knob to move the reverse video display cursor to a file in other group.

Setting the Reference Clock Source

Use Ref Clock in the bottom menu to select a reference clock source to synchronize multiple AFG2020s operating in parallel. When Ref Clock is pressed, the Internal and External side menu items are displayed (see Figure 3-80).

The clock signal to control the signal generation circuit must be synchronized among all the instruments in order to obtain accurate output timing for the signals output from all the instruments. Clock synchronization can be obtained with the 10MHz OUT signal and from the REF IN connector on this instrument. REF IN can also be used to as a clock source to raise the precision of this instrument's clock by using a high-performance external clock. For details on the connections and setting procedure for parallel operation, see *Example 9: Setting Synchronized Parallel Operation* in the *Section 1* tutorial.

Internal, External — When Internal is selected, this instrument's signal generation circuit operates with internal 10 MHz clock. After the 10MHz OUT signal of another AFG2020 or a high-performance clock generator signal is connected to this instrument's REF IN connector, when External is selected, this instrument's signal generation circuit operates with the external clock signal.

When External is selected, the EXT CLK icon is displayed at the top right of the screen. If you have selected External, but have not input an appropriate external clock signal, this EXT CLK icon blinks.

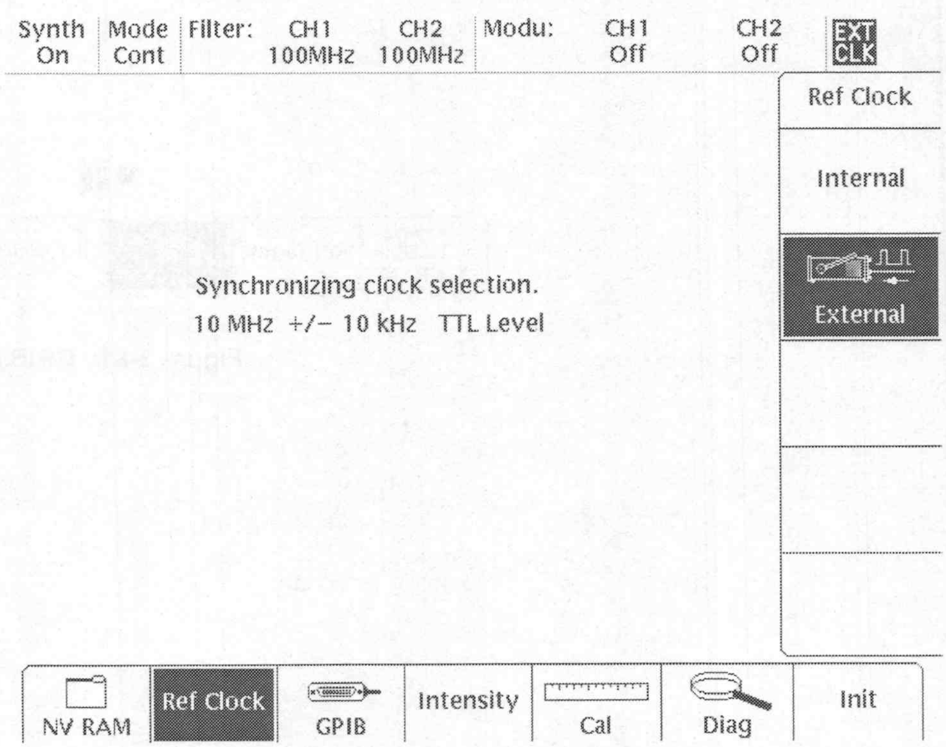


Figure 3-80: Ref Clock Menu Display

GPIB Configuration

This instrument can be remote controlled by a computer via the IEEE STD 488.2–1987 interface. The terminator is LF/EOI. The GPIB item is used to set the GPIB address and the off-bus setting (see Figure 3-81). For more details on GPIB, refer to the Programmer Manual. When GPIB is pressed, the side menu has the following items.

Talk/Listen Address — Use the general purpose knob or the numeric keys to set the Talk/Listen Address for this instrument. The GPIB address can be set from 0 to 30.

Off Bus — Off Bus disconnects this instrument from the bus.

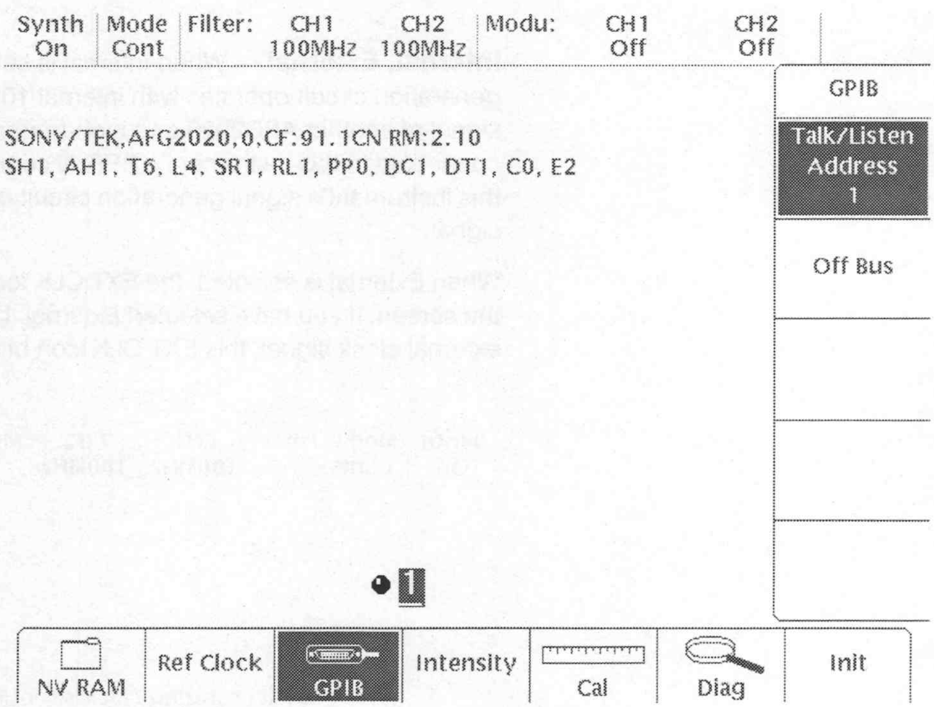


Figure 3-81: GPIB Menu Display

Display Intensity

When Intensity is selected from the bottom menu, the intensity of the screen display can be adjusted (see Figure 3-82). The side menu contains the Control item.

Control — The intensity can be adjusted between 20% and 100%, in steps of 1%. High intensity, medium intensity, and low intensity square and line are displayed on the CRT screen. Use this display as a criterion for adjusting the intensity.

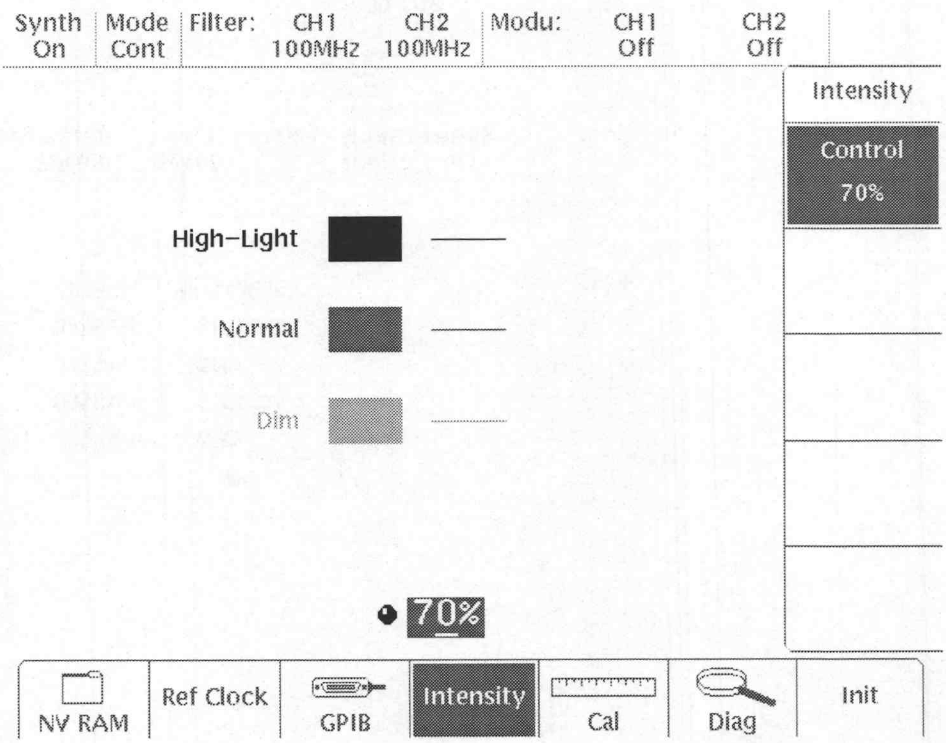


Figure 3-82: Intensity Menu Display

Selecting Calibration

Use Calibration to calibrate the output circuit. A table showing the calibration selection status and the results is displayed on the screen (see Figure 3-83). If the calibration ends normally, PASSED is displayed; if the calibration ends abnormally, FAILED and an error code are displayed.

NOTE

Before calibration, warm up this instrument for at least 20 minutes, and execute calibration at ambient temperature between 20° C and 30° C.

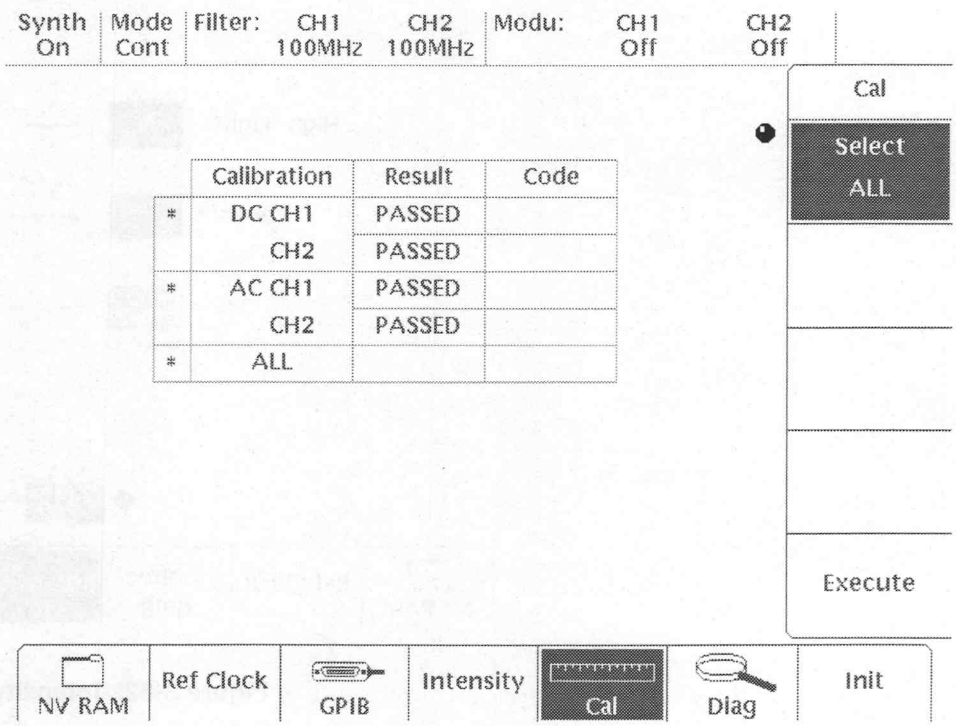


Figure 3-83: Display After Calibration

Select — When Cal is selected from the bottom menu, the Select item in the side menu is displayed in reverse video. Turn the general purpose knob or press the Select button to select the calibration item. The calibration items are DC calibration, AC calibration, and ALL. When one is selected, an asterisk is displayed in the first column of the table and the label for the selected item is also displayed in the Select column.

Here are explanations of the items in the table.

Item selection column — Asterisks (*) are displayed in the first column of the table. This column shows the calibration item selected.

Calibration — Calibration items are displayed in this column.

DC — Low-frequency amplitude and DC offset accuracy are calibrated for the output circuit.

AC — High-frequency amplitude accuracy are calibrated for the output circuit. Since the amplitude is calibrated at every 100 kHz from 100 kHz to 100 MHz, AC calibration takes about 90 seconds per channel. This item is not needed unless the backup battery in this instrument has been removed or replaced.

All — DC calibration and AC calibration are both executed.

Result — The results of the calibration for each item are displayed in this column. If the calibration ends normally, PASSED is displayed; if the calibration ends abnormally, FAILED is displayed.

Code — When the calibration can not end normally, the error code is displayed in this column.

Execute — When Execute is pressed, the selected calibration item is executed. During calibration, the busy clock icon is displayed. If the calibration ends normally, PASSED is displayed; if the calibration ends abnormally, for example due to circuit trouble, FAILED and an error code are displayed.

Selecting Diagnostics

Diagnostics check the functions of this instrument. When Diag is selected, a table of the test items is displayed (see Figure 3-84). When these diagnostics are carried out, the results and error number are entered into the table.

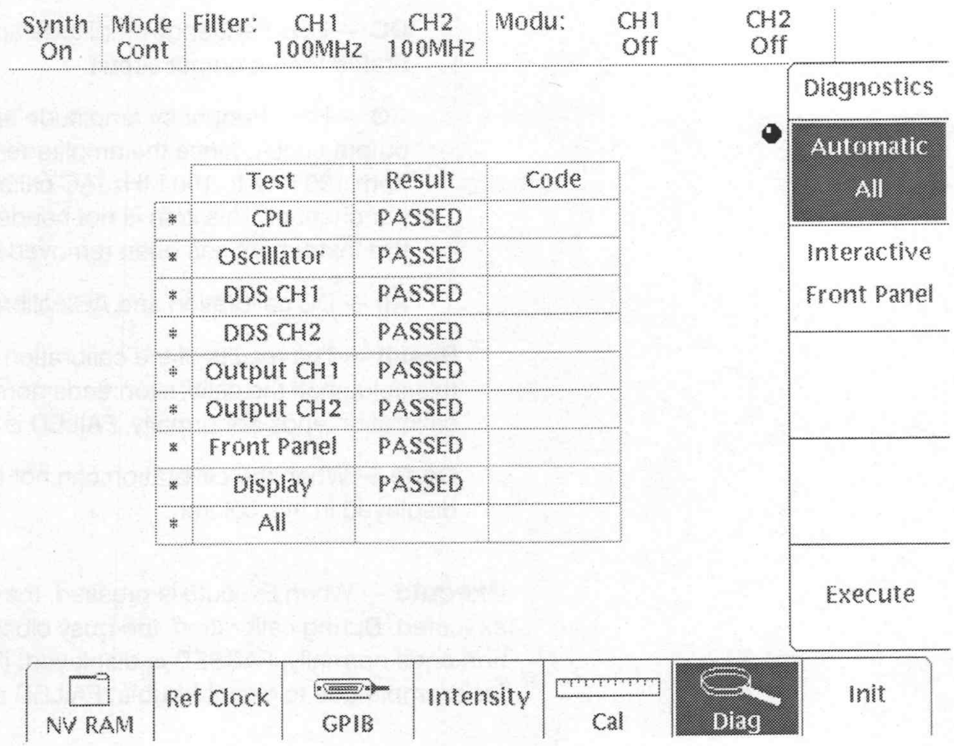


Figure 3-84: Diag Menu Display

Here are explanations of the items in the table.

Item selection column — Asterisks are displayed in the first column of the table to indicate the test items selected.

Test — This column gives the block name for the hardware diagnosed. When Automatic is selected with the side menu, the test items are divided into the following blocks.

CPU	Diagnostics of control section around CPU
Oscillator	Diagnostics of PLL and other interface functions.
DDS #1	Diagnostic of CH1 waveform RAM, sequence RAM, and other interface functions.
DDS #2	Diagnostic of CH2 waveform RAM, sequence RAM, and other interface functions.
Output #1	Diagnostics of CH1 amplitude, offset, and other output functions.

Output #2	Diagnostics of CH2 amplitude, offset, and other output functions.
Front Panel	Check button for make or break on the front panel.
Display	Check of hardware for screen display.
All	Diagnose each test item successively.

Result — The result of the test for each item is displayed in this column. If the test ends normally, PASSED is displayed; if the test ends abnormally, FAILED is displayed.

Code — When the test can not end normally, the error code is displayed in this column.

Automatic — When the general purpose knob is turned, the asterisk in the first column of the table moves and the test item can be selected. The label for the selected test item is displayed in the side menu Automatic column. To execute all the items consecutively, select All.

Interactive Diagnostic Selection — The Front Panel and Display items displayed in the Test column of the table are a menu for the operator to make judgments while viewing the screen. Here are explanations of the test items.

Front Panel — This item is used to check buttons for make or break on the front panel. Pressing the Execute button displays a diagram of the AFG2020's front panel on the screen. If only the ON/STBY switch is displayed in reverse video, the initial button status is normal. While you press a front panel button, its button icon is displayed in reverse video and you can check the making/breaking. Turning the general purpose knob turns the general purpose knob icon dots. Pressing the CLEAR MENU button at the bottom right of the bezel twice, the system goes out of the front panel diagnostic mode.

Display — This mode is for visually checking the quality of the CRT screen display. Each time any button other than CLEAR MENU is pressed, the entire CRT screen changes among a screen with high intensity, medium intensity, and low intensity, lattice pattern, dot pattern, etc. These displays allow you to check the phosphor uniformity, the geometry (distortion and linearity), and the quality of focus. Pressing the CLEAR MENU button at the bottom right of the bezel, the system goes out of the Display diagnostic mode.

All — First the display is set up for the Display diagnostics, then when you leave this display by pressing the CLEAR MENU button, the display is set up for the front panel diagnostics.

Execute — The diagnostics for the selected test items are executed. When All is selected with the Automatic item, for an instrument without CH2 (standard instrument configuration), the diagnostics take about 80 seconds. During the diagnostics, the busy clock icon is displayed.

Initial Settings

This function sets the AFG2020 to the initial setting state that occurs when power is first applied (see Figure 3-85). For a list of the initial settings, see *Initial Settings* in *Appendix E*.

When the Init button is pressed, the AFG2020 will display the side menu and a message indicating O.K. and Secure menu descriptions on the screen.

Power on initial settings can also be recalled by executing Secure function, which also deletes the data in arbitrary waveform memory and setting memory (NV RAM).

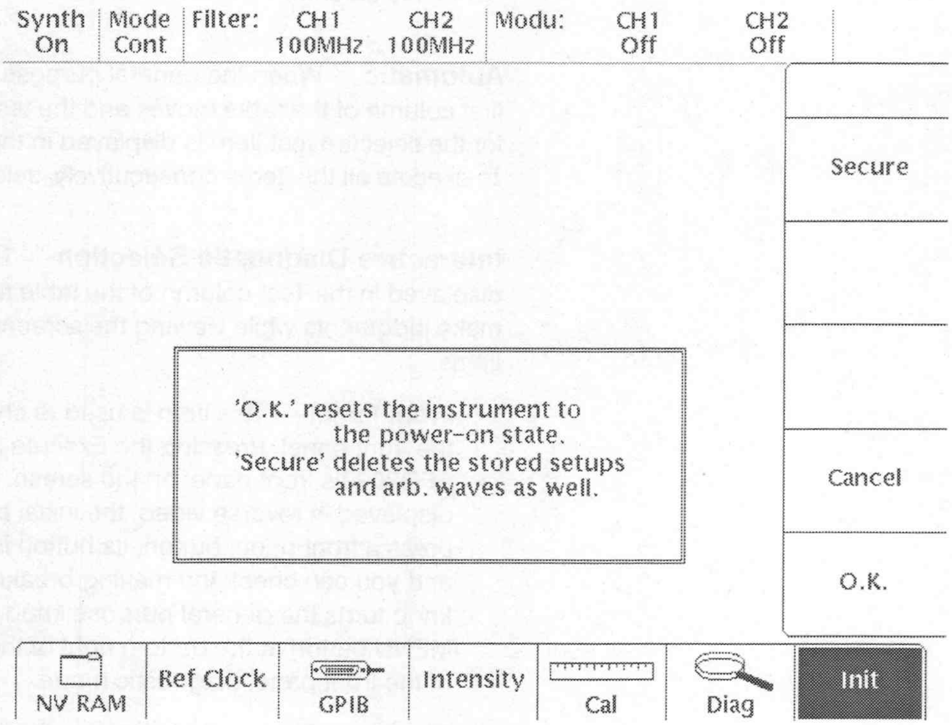


Figure 3-85: Initial Menu Display

Secure —This function deletes the contents of both arbitrary waveform memory and non-volatile memory (NV RAM), and at the same time resets the AFG2020 to the initial setting state that occurs when it is first turned on.

When the Secure button is pressed, the Secure item disappears from the side menu. A message indicating that all data will be deleted is then displayed on the screen.

O.K. — If Secure is not selected (the Secure item is displayed in the side menu) pressing the O.K. button will execute the initialization operation. When that operation completes, the FUNCTION menu will be displayed. A busy clock icon will be displayed while the operation is executing.

If Secure is selected (the Secure item is not displayed in the side menu) pressing the O.K. button will delete the contents of memory and execute the initialization operation. When that operation completes, the FUNCTION menu will be displayed. A busy clock icon will be displayed while the operation is executing.

Cancel — If the Cancel button is pressed, the screen display returns to the UTILITY menu with nothing selected in the bottom menu.

Appendices

Appendix A: Options and Accessories

This section contains a general description of available AFG2020 options, standard accessories, and optional accessories.

Options

The following options are available with the AFG2020.

Option 02

Adds a second output channel to the AFG2020.

Option 1R (Rack Mount)

AFG2020 is shipped in a configuration that permits easy installation into a 19 inch wide equipment rack. Also, an optional rack mount kit (part number 016−1166−00) may be ordered to convert the standard AFG2020 to a rackmounted instrument.

Instructions for rackmounting AFG2020 are shipped with the rackmount kit or the option 1R.

Rack mounted instruments include holes in their front panels for mounting connectors. You can route the signals found on the rear-panel connectors to the front-panel connectors you install in these holes. You must provide the cables and connectors to implement the through-panel access. However, you can order them separately as catalog items from Tektronix, Inc.

Option B1

Adds a Service manual.

Power Cord Options

Instruments are shipped with the detachable power-cord option ordered by the customer. Descriptive information about the international power-cord options is provided in *Section 1*. The following power cords are available for this instrument.

Option Name	Description	Part Number
Option A1	Universal Europe, 220V/6A	161−0104−06
Option A2	United Kingdom, 240V/6A	161−0104−07

Option Name	Description	Part Number
Option A3	Australia, 240V/6A	161–0104–05
Option A4	North America, 240V/10A	161–0104–08
Option A5	Switzerland, 220V/6A	161–0167–00

Accessories

Standard Accessories

The following standard accessories are provided with this instrument.

Quantity	Description	Part Number
1	User Manual	070–8659–01
1	Programmer Manual	070–8660–01
1	GPIB Programming Examples Disk, 3.5-inch	063–1381–~~00~~01
1	Power Cable	061–0230–01

Optional Accessories

The following optional accessories are recommended for use with the AFG2020.

Quantity	Description	Part Number
1	Service Manual	070–8661–01
1	GPIB Cable	012–0991–00
1	50 Ω BNC Cable	012–1342–00
1	50 Ω BNC Terminator	011–0049–01
1	Front Cover	200–3232–00
1	C9 Camera Adapter	016–1154–00
1	Accessory Pouch	016–1159–00
1	Test Lead	103–0275–00
1 1	Fuse (6A, fast-blow, UL198G, 3AG) Fuse Cap	159–0239–00 200–2264–00
1 1	Fuse (5A, fast-blow, IEC127) Fuse Cap	159–0210–00 200–2265–00

Appendix B: Performance Characteristics

This subsection describes the conditions required for the AFG2020 to operate to specified characteristics.

Performance Conditions

The electrical characteristics are valid under the following conditions:

- The instrument must have been calibrated at an ambient temperature between +20° C and +30° C.
- Allow 20 minutes warmup time for operation to specified accuracy.
- The instrument must be in an environment with limits that are described in *Environmental Characteristics* on page 4-21.

Any conditions unique to a particular characteristic are expressly stated as part of the characteristic.

The electrical and environment performance limits and their related validation procedures comprise a complete statement of the electrical and environmental performance of the calibrated instrument.

Electrical characteristic limits in the *Performance Requirements* column are verified by completing the test listed in the *Performance Check* column. Items listed in the *Supplemental Information* column are not verified in the manual; they are either explanatory notes or performance characteristics for which no limits are specified.

The electrical performance is specified for signals at the AFG2020 output terminals.

Electrical Characteristics

Table 4-1: Electrical Characteristics

Characteristic	Performance Requirement	Supplemental Information	Performance Test
	Frequency/Phase		
Synthesizer On Mode			
Clock	250 MHz		
Frequency	10 digits		Output Frequency Accuracy Check on page 4-31.
Range	0.5 Hz to 100.00 MHz (Sine) 0.5 Hz to 2.5 MHz (Other)		
Resolution	0.5 Hz		
Increment		0.232830 Hz (250 MHz/2^{30})	
Accuracy	±(Reference Oscillator Accuracy +0.12 Hz)		
Period	Same digit as Frequency 2.0 to 10.00000000 ns		
Points/Cycle	5 digits 250 MHz/f @ f< 100 MHz up to 1024 or 2048		
Phase	4 digits		
Range	±360°		
Resolution	0.1°	The resolution is effective when the waveform has no frequency components more than clock/2 such as sine.	
Jitter		1 clock (4 ns) uncertainty for the waveform which has abrupt edge such as Square.	
Synthesizer Off Mode			
Frequency	3 digits		Output Frequency Accuracy Check on page 4-32.
Range	0.5 Hz to 50.0 MHz (Square) 0.5 Hz to 31.2 MHz (Other)	Refer to *Frequency Parameters*	
Accuracy	±0.1%		
Period	Same digit as Frequency 2.00 s to 40.0 ns		
Points/Cycle	5 digits		
Clock Rate	512 Hz to 250 MHz	Frequency (Points/cycle)	

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement			Supplemental Information	Performance Test
Frequency/Phase (Cont.)					
Frequency Parameters	**No.**	**Range**	**Resolution**	**Points/Cycle**	
	1	0.500Hz ~ 0.931Hz	1mHz	1024	
	2	0.932Hz ~ 1.86Hz	1mHz/10mHz	1024	
	3	1.87Hz ~ 3.72Hz	10mHz	1024	
	4	3.73Hz ~ 7.45Hz	10mHz	1024	
	5	7.46Hz ~ 14.9Hz	10mHz/0.1Hz	1024	
	6	15.0Hz ~ 29.8Hz	0.1Hz	1024	
	7	29.9Hz ~ 59.6Hz	0.1Hz	1024	
	8	59.7Hz ~ 119Hz	0.1Hz/1Hz	1024	
	9	120Hz ~ 238Hz	1Hz	1024	
	10	239Hz ~ 476Hz	1Hz	1024	
	11	477Hz ~ 953Hz	1Hz	1024	
	12	954Hz ~ 1.90kHz	1Hz/10Hz	1024	
	13	1.91kHz ~ 3.81kHz	10Hz	1024	
	14	3.82kHz ~ 7.62kHz	10Hz	1024	
	15	7.63kHz ~ 15.2kHz	10Hz/0.1kHz	1024	
	16	15.3kHz ~ 30.5kHz	0.1kHz	1024	
	17	30.6kHz ~ 61.0kHz	0.1kHz	1024	
	18	61.1kHz ~ 122kHz	0.1kHz/1kHz	1024	
	19	123kHz ~ 244kHz	1kHz	1024	
	20	245kHz ~ 488kHz	1kHz	512	
	21	489kHz ~ 976kHz	1kHz	256	
	22	977kHz ~ 1.95MHz	1kHz/10kHz	128	
	23	1.96MHz ~ 3.90MHz	10kHz	64	
	24	3.91MHz ~ 7.81MHz	10kHz	32	
	25	7.82MHz ~ 15.6MHz	10kHz/0.1MHz	16	
	26	15.7MHz ~ 31.2MHz	0.1MHz	8	
	27	31.3MHz ~ 50.0MHz	0.1MHz	4	
Amplitude/Offset					
Range	0.4 V_{p-p}, 2 V_{p-p}, 10 V_{p-p}, Auto				
Amplitude	4 digits				
Resolution	10 mV_{p-p} at 10 V_{p-p} Range 2 mV_{p-p} at 2 V_{p-p} Range 1 mV_{p-p} at 0.4 V_{p-p} Range				
Max. Amplitude	10 V_{p-p} into 50 Ω 20 V_{p-p} into open circuit			Offset 0 V	

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
Amplitude/Offset (Cont.)			
DC Accuracy		With 0.1% 50 Ω terminator, Waveform Data 1.00 and −1.00, Offset 0 V, Just after CAL	Amplitude Accuracy Check on page 4-34
Range			
0.4 V_{p-p}	±(1.0% of setting +1 mV_{p-p})		
2.0 V_{p-p}	±(1.0% of setting+5 mV_{p-p})		
10 V_{p-p}	±(2.5% of setting+50 mV_{p-p})		
Stability		±400 ppm/°C	
Linearity		±1.0% at 2 V_{p-p} 100 kHz ±2.0% at 10 V_{p-p} 100 kHz Measured from 10% to 90% of Staircase (10 step) waveform.	
Offset	4 digits		
Resolution	10 mV at 10 V_{p-p} Range 2 mV at 2 V_{p-p} Range 1 mV at 0.4 V_{p-p} Range		
Max. Offset	±5 V into 50 Ω	Amplitude 0 V_{p-p} ±10 V into open circuit Offset reduced by attenuator	
Accuracy		With 0.1% 50 Ω terminator, Waveform Data 0, Amplitude 0 V_{p-p}, Just after CAL	Offset Accuracy Check on page 4-37
Range			
0.4 V_{p-p}	±(1.0% of setting +1 mV)		
2.0 V_{p-p}	±(1.0% of setting+5 mV)		
10 V_{p-p}	±(2.5% of setting+50 mV)		
0 V Stability		±3.0 mV/°C 10 V_{p-p} ±0.6 mV/°C 2 V_{p-p} ±0.12 mV/°C 0.4 V_{p-p}	
Noise Floor			
Range			
0.4 V_{p-p}	−128 dBm/Hz (@10 MHz)	Amplitude 0 V_{p-p} Offset 0 V Waveform Data 7FF	
2 V_{p-p}	−114 dBm/Hz		
10 V_{p-p}	−100 dBm/Hz		

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement			Supplemental Information		Performance Test
Waveform Characteristics						
Sine						
Maximum Points	2048			1024 (Synthesizer Off Mode)		
SSB Phase Noise	−90 dBc/Hz (Synthesizer On Mode) −80 dBc/Hz (Synthesizer Off Mode)			10 MHz, 2 V_{p-p} at 10 kHz offset		
Harmonics						
Synthesizer On Mode with 100 MHz LPF						
Range	**f<100 kHz**	**1 MHz**	**10 MHz**	**100 MHz**		
10 V_{p-p}	−40 dBc	−40 dBc	−35 dBc	−25 dBc		
2 V_{p-p}, 0.4 V_{p-p}	−55 dBc	−55 dBc	−40 dBc	−40 dBc		
Synthesizer Off Mode with 50 MHz LPF						
Range	**f<100 kHz**	**1 MHz**	**10 MHz**	**31.2 MHz**		
10 V_{p-p}	−40 dBc	−40 dBc	−35 dBc	−35 dBc		
2 V_{p-p}, 0.4 V_{p-p}	−55 dBc	−55 dBc	−40 dBc	−40 dBc		
Spurious	See *Mode* or −70 dBm			Including harmonics greater than 5^{th}.		
Mode	**f<50 kHz**	**500 kHz**	**5 MHz**	**31.2 MHz**	**50 MHz**	**100 MHz**
Synthesizer On Mode with 100 MHz LPF	−60 dBc	−55 dBc	−45 dBc	−40 dBc	−40 dBc	−30 dBc
Synthesizer Off Mode with 50 MHz LPF	−55 dBc	−55 dBc	−45 dBc	−35 dBc	—	—

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement		Supplemental Information		Performance Test
Waveform Characteristics (Cont.)					
Amplitude					
Flatness	Referenced to 100 kHz		Measured with an RF Power Meter including its RSS error 0.22 dB. Max error is 0.43 dB.		Flatness Check (High Frequency) on page 4-40 Flatness Check (Low Frequency on page 4-45
Synthesizer On Mode with 100 MHz LPF					
Range	**100 kHz<f<50 MHz**		**f<100 MHz**		
10 V_{p-p}	±0.5 dB		±1.0 dB		
2 V_{p-p}, 0.4 V_{p-p}	±0.5 dB		±0.5 dB		
Synthesizer Off Mode with 50 MHz LPF					
Range	**100 kHz<f<10 MHz**		**f<31.2 MHz**		
ALL	±1.0 dB		±3.0 dB		
Accuracy					
Range					
0.4 V_{p-p}	DC accuracy ±3.0% + Flatness				
2.0 V_{p-p}	Same for the 0.4 V_{p-p} Range				
10 V_{p-p}	DC accuracy ±5.0% + Flatness				
Power	4 digit, up to 23.98 dBm				
Square					
Maximum Points	2048		1024 (Synthesizer Off Mode)		
Amplitude					
Flatness	Referenced to 1 kHz				
Filter	**≤100 kHz**	**≤2.5 MHz**	**≤15.6 MHz**	**≤50 MHz**	
50 MHz LPF	±2.0%	±5.0%	±5.0%	−30%	
Full Pass	±2.0%	±5.0%	±5.0%	±10%	
Accuracy	DC accuracy ±2% + Flatness				
Rise/Fall time	Within 9.0 ns Within 4.0 ns		At 1 MHz With 50 MHz LPF With Full Pass		Rise and Fall Time Check on page 4-50

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement		Supplemental Information		Performance Test
Waveform Characteristics (Cont.)					
Aberrations			At 1 MHz		Aberrations Check on page 4-47
Range					
$2\ V_{p\text{-}p}$, $0.4\ V_{p\text{-}p}$	Within 5 % +2 $mV_{p\text{-}p}$ Within 7 % +2 $mV_{p\text{-}p}$		With 50 MHz LPF With Full Pass		
$10\ V_{p\text{-}p}$ (>$1.0\ V_{p\text{-}p}$)	Within 7 % +10 $mV_{p\text{-}p}$ Within 12 % +10 $mV_{p\text{-}p}$		With 50 MHz LPF With Full Pass		
Triangle					
Maximum Points	2048		1024 (Synthesizer Off Mode)		
Amplitude					
Flatness	Referenced to 1 kHz				
Filter	**≤ 100 kHz**	**≤ 2.5 MHz**	**≤ 15.6 MHz**	**≤ 31.2 MHz**	
50 MHz LPF	±2.0%	−7.0%	−20%	−40%	
Accuracy	DC accuracy ±4.0% + Flatness				
Ramp					
Maximum Points	1024				
Timing	Rise, Fall 4digits 0% to 100.0% of Period				
Amplitude					
Flatness	Referenced to 1 kHz		With rise 90%, fall 10% waveform		
Filter	**≤ 100 kHz**	**≤ 2.5 MHz**	**≤ 15.6 MHz**	**≤ 31.2 MHz**	
50 MHz LPF	±2.0%	−8.0%	−25%	−45%	
Accuracy	DC accuracy ±4.0% + Flatness				
Pulse					
Maximum Points					
Gaussian	2048		1024 (Synthesizer Off Mode)		
Exponential	1024				
Linear	2048		1024 (Synthesizer Off Mode)		
Pulse Width	1.0% to 99.0% of Period				
Transition	0% to 35.0% of Pulse width				

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement		Supplemental Information	Performance Test
Waveform Characteristics (Cont.)				
Amplitude				
Accuracy	DC accuracy ±2% + flatness			
Flatness	Referenced to 1 kHz		With Gaussian, Width 50%, Transition 10% waveform	
Filter	**≤100 kHz**	**≤2.5 MHz**	**≤15.6 MHz**	**≤31.2 MHz**
50 MHz LPF	±2.0%	±5.0%	±5.0%	−20%
Arbitrary				
Maximum Points	Any periodic waveform described with 12 bits and 1024 points.			
Numbers of Waveforms	32			
Sweep				
Sweep Type	Standard, Multiple			
Spacing	Linear, Log			
Frequency	5 digits			
Start, Stop	1.0 Hz to 100 MHz (Sine) 1.0 Hz to 2.5 MHz (other)			
Step (Linear)	Within (Stop −Start), 5 digits			
Points/decade (Log)	10 to 1000 1−2−5 sequence 1.0 Hz to 10 Hz ≤10 10 Hz to 100 Hz ≤100 100 Hz to 1 kHz ≤1000 1 kHz to 100 MHz ≤1000			
Timing	4 digits			
Sweep Dwell	0.5 μs to 100 s			
Return Dwell	0.5 μs to 100 s		Except Multiple-Sweep	
Standard Sweep Marker				
Number	3			
Frequency	Between Start and Stop			
Time	0.5 μs to 100 s			
Multiple-Sweep Marker	Positive TTL level Pulse		Only Auxiliary Output	

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
Sweep (Cont.)			
Points			
Sweep	2 to 5001		
Return	1 to 5000	Except Multiple-Sweep	
Standard Sweep Max Period	2048 s ≤ Sweep + Return Time	Without Marker	
CH2 Sweep Out	±1 V out put into 50 Ω Start −1.00 V Stop +1.00 V	 Linear proportional to f Log proportional to log f	
Modulation			
Amplitude Modulation			
Modulation Signal	Sine, Square, Triangle, External, CH1		
Sine, Square, Triangle			
Modulation Parameter			
Amplitude	4 digits $-10.00\ V_{p-p}$ to $+10.00\ V_{p-p}$		Internal AM Modulation Check on page 4-52
Depth	3 digits 0 to 100%	$Depth = \frac{High - Low}{High + Low}\%$	
DSB−SC	On/Off		
Modulation Rate			
Period	10 µs to 1 s, every 0.2 ms		
Accuracy	±0.1%		
Rise time	Within 2 µs	$-10\ V_{p-p}$ to $10\ V_{p-p}$ Calculated bandwidth 175kHz	
AM Distortion		1% at 10 kHz Rate 50% AM, $1\ V_{p-p}$	
AM Noise	Within 1% of Range		
External, CH1		$1\ V_{p-p}$ typical causes 100% Modulation at half amplitude of each Range	External AM Modulation Check on page 4-65
Rise time	Within 2 µs		

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
	Modulation (Cont.)		
Offset Modulation			Offset Modulation Check on page 4-55
Modulation Parameter			
High, Low	4 digits −5.000 to 5.000 V		
Modulation Signal	Sine, Square, Triangle		
Modulation Rate			
Period	10 μs to 1 s, every 0.2 μs		
Accuracy	±0.1%		
Modulation Noise	Within 1% of Range		
Rise time	Within 2 μs	−5 V to 5 V Calculated bandwidth 175 kHz	
Frequency Modulation			
Center Frequency	9 digits		
Deviation	6 digits	$Depth = \frac{High - Low}{2}$	
Modulation Signal	Sine, Square, Triangle		
Modulation Rate			
Period	10 μs to 1 s every 0.2 μs		
Accuracy	±0.1%		

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
	Modulation (Cont.)		
Frequency Shift Keying (FSK)			
Method	Continuous Phase FSK	Carrier signal is asynchronous with modulation rate.	
Key			
Numbers of Key	2 to 256		
Frequency	≤ 100 MHz (sine) or 2.5 MHz (other)		
Amplitude	Within 10 $V_{p\text{-}p}$		
Offset	Within ±5 V		
Data			
Numbers of Data	2 to 2,048		
Frequency Transition			
Time	4 ns		
Data Rate	1 to 2,500,000		
Period	1 s to 0.4 µs, every 0.1 µs		
Phase Shift Keying (PSK)			
Method	Refer to Figure 4-1	Carrier signal is asynchronous with modulation rate.	

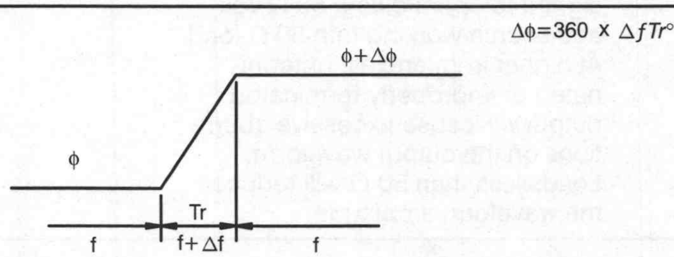


Figure 4-1: Phase Change

Key			
Numbers of Key	2 to 256		
Phase	Within ±360.0 degrees		
Amplitude	Within 10 $V_{p\text{-}p}$		
Offset	Within ±5 V		

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
Modulation (Cont.)			
Data			
Numbers of Data	2 to 2,048		
Phase Transition		Refer to Figure 4-1	
Time Tr	800 ns (200 Clocks)	In this time the DAC is disabled.	
Phase accuracy		Within ±67.0 micro-degree ($360*200/2^{30}$) calculated for 1 step	
Data Rate	1 to 50,000		
Period	1 s to 20 µs, every 0.1 µs		
Reference Oscillator			
Type	TCXO		
Nominal Frequency	10 MHz		
Accuracy	±1 ppm (0° C ~ 50° C)	±10 Hz	
Stability	±1ppm/year (20° C ~ 30° C)		
Main Output			
Output Source Resistance	50 Ω The output of the AFG2020 is designed to operate as a 50 Ω voltage source working into 50 Ω load. At higher frequencies, unterminated or improperly terminated output will cause excessive aberrations on the output waveform. Loads less than 50 Ω will reduce the waveform amplitude.		
VSWR		0.4 V_{p-p} range — 1.1 2 V_{p-p} range — 2.0 10 V_{p-p} range — 2.5 with 100 MHz LPF	
Reverse Power Protection	If there is a DC voltage across the output load, use a coupling capacitor in series with the load. The time constant of the coupling capacitor and load must be long enough to maintain pulse flatness. *Do not apply external signal into the output!*	Up to 0.4 W	

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
Main Output (Cont.)			
Low Pass Filters			
100 MHz Brick Wall		Within 1 dB to 100 MHz less than −40 dB 125 MHz 1 dB to 1 GHz	
50 MHz Linear Phase		−3 dB ±0.5 dB at 50 MHz	
Auxiliary Outputs			
Sync Output	Positive TTL level pulse		SYNC Output Check on page 4-57
Resistance	From 51 Ω nominal		
Level		2.8 V< V(Hi) < 5.0 V −0.1 V< V(Lo) < 0.2 V into 1 MΩ	
Pulse width		400 ns minimum	
Protection		Protected against short circuit and up to ±5 VDC + peak AC accidental input.	
Marker Output	Positive TTL level pulse		Marker Output Check on page 4-59
Resistance	From 51 Ω nominal		
Level		2.8 V< V(Hi) < 5.0 V −0.1 V< V(Lo) 0.2 V into 1 MΩ	
Pulse width		100 ns minimum	
Protection		Protected against short circuit and up to ±5 VDC + peak AC accidental input.	
10 MHz Output	TTL level square wave		10 MHz Output Check on page 4-61
Resistance	From 51 Ω nominal		
Level		2.8 V< V(Hi) < 5.0 V −0.1 V < V(Lo) < 0.2 V into 1 MΩ	
Duty		50% to 75%	
Protection		Protected against short circuit and up to ±5 VDC + peak AC accidental input.	

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
Auxiliary Inputs			
Trigger/Gate Input			External Trigger Level Accuracy Check on page 4-67
Sensitivity	200 mV_{p-p} minimum DC to 10MHz		
Minimum width	30 ns, 200 mV_{p-p} amplitude		
Width Impedance	1 kΩ ±5%		
Maximum Input	≤ ±10 VDC plus peak AC		
Threshold			
Range	±9.90 V		
Resolution	0.1 V		
Accuracy	±10% ±100 mV		
Polarity Selection	Positive slope for Arming and Time Burst, and positive true for Gate. Negative slope for Arming and Time Burst, and negative true for Gate.		
AM Input		1 V_{p-p} typical causes 100% modulation at half amplitude of each range	
Impedance	10 kΩ ±5%		
Maximum Input	≤ ±10 VDC plus peak AC		
REF IN	TTL compatible	2.4 V< V(HI) <5.0 V 0.0 V< V(L0) <0.1 V	REF IN Clock Check on page 4-62
Range	10 MHz ±10 kHz		
Impedance	10 kΩ ±5%		
Maximum Input	0 V ≤ Input ≤ +5 V		
Operating Modes			
Continuous	Generates the waveform continuously.		
Start	Output quiescent until triggered by an external, GPIB or manual trigger, after the predefined delay generates continuously and stops by STOP command or GPIB command.		

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
Operating Modes (Cont.)			
Gate	Output quiescent until triggered by an external, GPIB or manual; the predefined delay generates waveform for the duration of the gated signal.		
Time Burst	Output quiescent until triggered by an external, GPIB, internal or manual; after the predefined delay generates waveform for the predefined time. When Sweep or Modulate is on, generates one sequence.		Internal Time Burst Check on page 4-72
Trigger delay	0.7 µs to 100.00 s, 5 digits		
Accuracy	±(0.1 µs + 0.01%) ±(0.2 µs + 0.01%)	Synthesizer On Mode Synthesizer Off Mode	
Time	0.4 µs to 100 s, 3 digits		
Accuracy	±0.1 µs		
Internal Trigger Period	10 µs to 200 s > Delay + Time + 2.5 µs, 3 digits		
Accuracy	±1%		
Trigger Delay			
Synthesizer On Mode			
Trigger Delay			
Ext Input to Output	Td1+Td2	Refer to Figure 4-2	
Ext Input to Sync (Td1)		0.2 µs ±0.1 µs	External Trigger Delay Check on page 4-74
Sync to Output (Td2)		Predefined Delay −0.2 µs	
Gate end to Output (Td3)		0.2 µs typical	
Phase Recovery time (Tpr)		2.5 µs typical	

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
Trigger Delay (Cont.)			

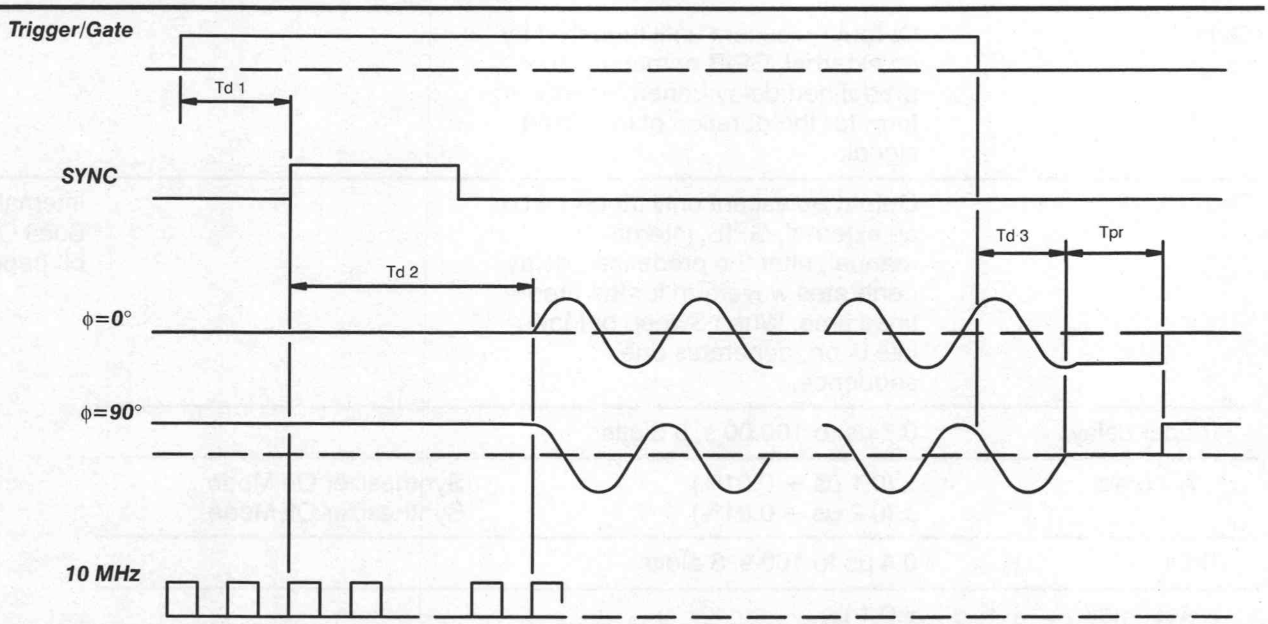


Figure 4-2: Trigger Delay (Synthesizer On Mode)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
Synthesizer Off Mode			
Trigger Delay			
Ext Input to Output	Td1 + Td2	Refer to Figure 4-3	
Ext Input to Sync (Td1)		Predefined Delay −0.15 μs ±0.1 μs	External Trigger Delay Check on page 4-74
Sync to Output (Td2)		0.15 μs ±0.1 μs	
Gate end to Output (Td3)		0.2 μs typical	
Phase recovery time (Tpr)		2.5 μs typical	

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
Trigger Delay (Cont.)			

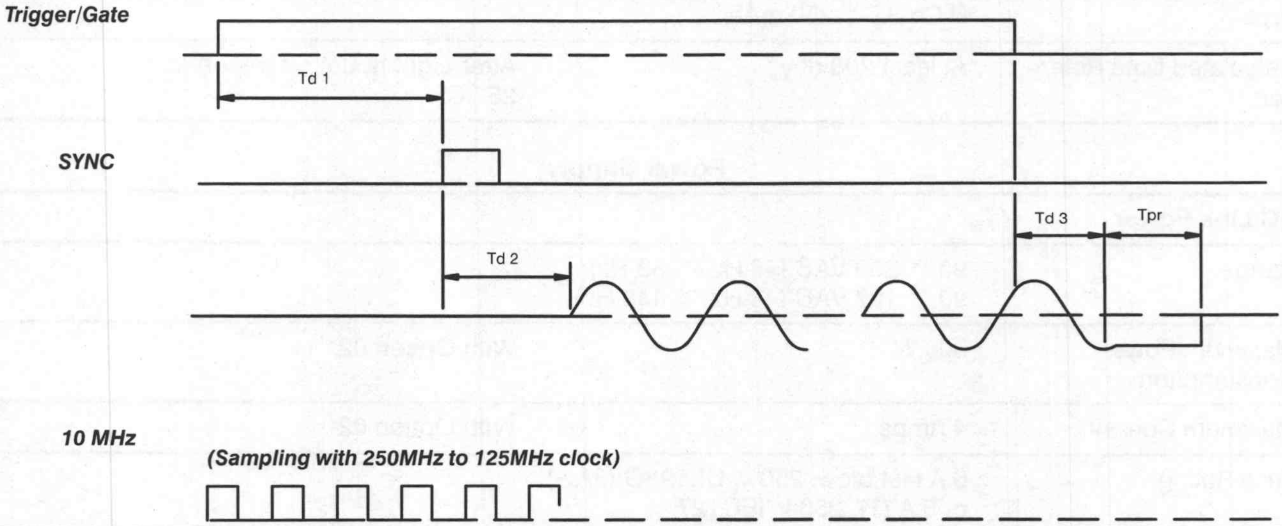


Figure 4-3: Trigger Delay (Synthesizer Off Mode)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
Second Channel (Synthesizer On Mode) (Option 02)			
Skew	Within 2.0 ns	Sine, 100 MHz, 0°, 2.0 $V_{p\text{-}p}$ with 100 MHz LPF	Dual Channel Synchronization Check on page 4-78
Cross talk		−60 dBc Sine, 2.0 $V_{p\text{-}p}$ with 100 MHz LPF	
Phase Accuracy		Sine, 2.0 $V_{p\text{-}p}$ with 100 MHz LPF Other waveform Within ±(4 ns + 0.35°) at 2.0 $V_{p\text{-}p}$ with 50 MHz LPF	

Frequency	**50 Hz≤ ~ ≤100 kHz**	**~ ≤1 MHz**	**~ ≤10 MHz**	**~ ≤100 MHz**
Accuracy	±0.1 deg.	±0.5 deg.	±1 deg.	±2 deg.

Characteristic	Performance Requirement	Supplemental Information	Performance Test
Display			
CRT			
Type		Electromagnetic deflection	
Phosphor		P4	
Screen Size		17.8 cm (7 in.) diagonal, 640 × 480 pixels	

Table 4-1: Electrical Characteristics (Cont.)

Characteristic	Performance Requirement	Supplemental Information	Performance Test
	Battery		
Type	NiCd 3.6 V 250 mAh		
Calculated Data Retention	At least 200 days	After eight hours operation at 25° C.	
	Power Supply		
AC Line Power			
Range	90 ~ 250 VAC (48 Hz ~ 63 Hz) 90 ~ 127 VAC (48 Hz ~ 440 Hz)		
Maximum Power Consumption	300 W	With Option 02	
Maximum Current	4 Amps	With Option 02	
Fuse Rating	6 A fast blow, 250 V, UL198G (3AG) or 5 A (T), 250 V, IEC127		

Mechanical Characteristics

Table 4-2: Mechanical Characteristics

Characteristics	Description
Net Weight	
Standard	9.0 kg (19.84 lb.)
Option 02	9.5 kg (20.94 lb.)
Height (with feet)	164 mm (6.4 in.)
Width (with handle)	362 mm (14.3 in.)
Depth	
With Front Cover Installed	491 mm (19.25 in.)
With Handle Extended	576 mm (22.2 in.)

Environmental Characteristics

Table 4-3: Environmental Characteristics

Characteristics	Performance Requirement
Temperature	
Operating	0° C to +50° C
Non-operating	−20° C to +60° C Possible loss of nonvolatile memory data below −20° C. Meets MIL-T-28800C, Class 5.
Humidity	
Operating and Non-operating	Five cycles (120 hours) with equipment tested at 90−95% relative humidity. Tested non-operating at 30° C to 60° C and operating at 50° C. Meets MIL-T-28800C, Class 5.
Altitude	
Operating	To 4.5 km (15,000 feet) Maximum operating temperature decreases 1° C each 1,000 feet above 5,000 feet.
Non-operating	To 15 km (50,000 feet)
Operating and Non-operating	Meets MIL-T-28800C, Class 5.
Vibration	
operating	15 minutes sweep along each of three major axes at a total displacement of 0.015 inch p-p with frequency varied from 10 Hz to 55 Hz. Hold 10 minutes at each major resonance, or if no major resonance present, hold 10 minutes at 55 Hz. Meets MIL-T-28800C, Class 5.
Shock	
Non-operating	30 G, half sine, 11 ms duration, three shocks per axis in each direction for a total of 18 shocks. Meets MIL-T-28800C, Class 5.

Table 4-3: Environmental Characteristics (Cont.)

Characteristics	Performance Requirement
Electromagnetic Compatibility	
Emissions	
Enclosure	EN 55011 Class A limits for radiated emissions
AC Mains	EN 55011 Class A limits for conducted emissions EN 60555-2 Power line harmonics
Immunity	
Enclosure	IEC 801-3 RF electromagnetic field, 10 V/m, 27 MHz to 500 MHz (up to 200 mV_{p-p} noise may be output in this test.) IEC 801-2 ESD 8 kV
AC Mains	IEC 801-4, 4 kV_{p-p}, 5/50 ns, T_r/T_h, 5 kHz

Appendix C: Performance Verification

Before Verification

This subsection describes the verification procedures in this section, indicates when to use the procedures, and gives conventions used in their structure. The procedures in this section are:

- Self Tests
- Performance Tests

Preparation

These procedures verify the AFG2020 Synthesized Arbitrary Function Generator functionality. Choose the procedure that best suits your need:

- To quickly confirm that the AFG2020 functions and is adjusted properly, do the procedures under *Self Tests*, which begin on page 4-24.

  Advantages: These procedures are short, require no external equipment, and perform extensive functional and accuracy testing. Use them to quickly determine if the AFG2020 is suitable for putting into service, such as when it is first received.

- For a more extensive confirmation of performance, do the *Self Tests* just referenced; then do the *Performance Tests*, beginning on page 4-28.

  Advantages: These procedures involve direct checking of warranted specifications. They require more time and suitable test equipment (see *Equipment Required* on page 4-29).

Before starting any of these procedures, read *Section 1, Getting Started*, and *Section 2, Operating Basics* of this manual. These sections describe the power-on procedure, and the AFG2020 front-panel controls and menu system.

Conventions

Throughout the procedures in this section, the following conventions apply:

- Each test procedure uses the following general format:
  - Title of Test
  - Equipment Required
  - Prerequisites
  - Procedure

- Each procedure consists of as many steps, substeps, and subparts as required to do the test. Steps, substeps, and subparts are sequenced as follows:

  1. First Step

     a. First Substep

        - First Subpart

        - Second Subpart

     b. Second Substep

  2. Second Step

- Instructions for menu selection follow this format: **FRONT PANEL BUTTON Main Menu Button Side Menu Button**. For example, "Press **UTILITY Init O.K.**"

- Where instructed to use a front-panel button, key, or knob, or select from the MENU column, or from a bottom or side menu, the name of the item appears in boldface type: "push **FUNCTION**, " or "select **Ramp** in the bottom menu."

Self Tests

This subsection describes how to use AFG2020 internal self-test routines. No equipment is required to do these procedures. The self tests include these internal routines:

- Diagnostics

  This self-test procedure uses internal routines to verify that the AFG2020 functions, and passes the internal circuit tests.

- Calibration

  The second procedure checks the AFG2020 internal calibration constants and changes them if needed.

Diagnostics

The AFG2020 internal diagnostic routines check AFG2020 characteristics in the circuitry indicated by the menu shown in Figure 4-4.

The AFG2020 automatically performs the internal diagnostics at power-on; you can also run the internal diagnostics using the menu selections described in this procedure. The difference between these two methods of initiating diagnostics is that the menu method does more detailed memory checking than the power-on method.

Equipment Required: None.

Prerequisites: The AFG2020 must have been calibrated at an ambient temperature between +20° C and +30° C and must be operating at an ambient temperature between 0° C and +50° C. Power on the AFG2020 and allow a 20-minute warmup period before doing this procedure.

Procedure:

1. *Verify that internal diagnostics pass:* Do the following substeps to verify passing internal diagnostics.

   a. *Display the diagnostics menu and select all tests*: Push **UTILITY** **Diag** **Automatic All**. See the menu in Figure 4-4.

   The list on the left shows the tests available for Diagnostics. In addition to selecting all of the tests shown for Diagnostics, you can select only the test(s) you want to run using the general purpose knob. In Figure 4-4, the symbol (*) to the left of a test name indicates that test is currently selected.

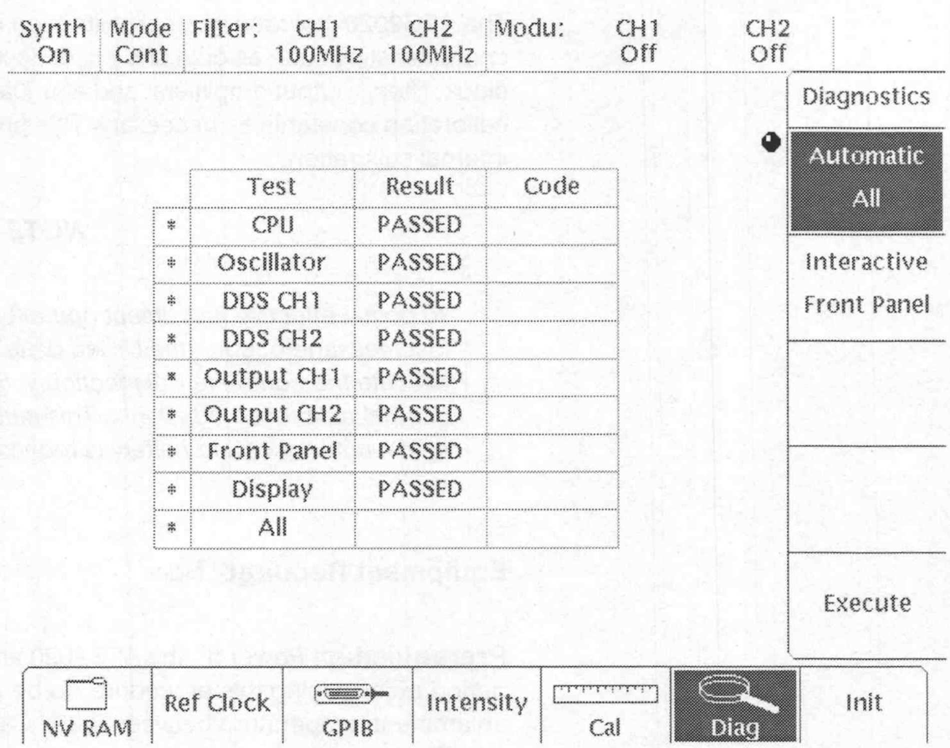


Figure 4-4: Display of the Diagnostics Menu

   b. *Run the diagnostics*: Select **Execute** from the side menu. This executes all the AFG2020 diagnostics automatically.

c. *Wait*: The internal diagnostics do an extensive verification of AFG2020 functions. This verification takes about 35 seconds for a single-channel AFG2020. While it progresses, the screen displays the clock icon. When finished, the resulting status appears on the screen.

d. *Confirm that no failures are found*: Verify that no failures are reported on-screen. If the diagnostics displays FAIL as the result of any test, contact your nearest Tektronix representative.

2. *Return to regular service*: Push a button (other than UTILITY) in the MENU column to exit the Diag menu.

NOTE

The interactive tests on the Diag menu is for manufacturing use at the factory.

Calibration

The AFG2020 includes internal calibration routines that check electrical characteristics such as gain and offset accuracy (DC and AC), trigger level, clock, filters, output amplifiers, and attenuation. They also adjust internal calibration constants as necessary. This procedure describes how to do the internal calibration.

NOTE

To obtain effective instrument operation when a Calibration Data lost message occurs (the NiCad battery is discharged), you must execute the complete Cal function in the Utility menu to restore all internal calibration constants. This must be done for each power-up cycle, until the NiCad battery is recharged or replaced.

Equipment Required: None.

Prerequisites: Power on the AFG2020 and allow a 20-minute warmup period before doing this procedure. To be valid, calibration must be done at an ambient temperature between +20° C and +30° C.

Procedure:

1. *Verify that internal calibration routines pass:* Do the following substeps to verify that internal calibration routines run successfully.

   a. *Display the calibration menu and select all routines*: Push **UTILITY** ▸ **Cal** ▸ **Select All**. See the menu in Figure 4-5.

The list on the left shows the calibration routines available for Cal. In addition to selecting all of the calibrations shown, you can select only the calibration routine you want to run using the general purpose knob. In Figure 4-5, the symbol (*) to the left of a calibration name indicates that calibration is selected.

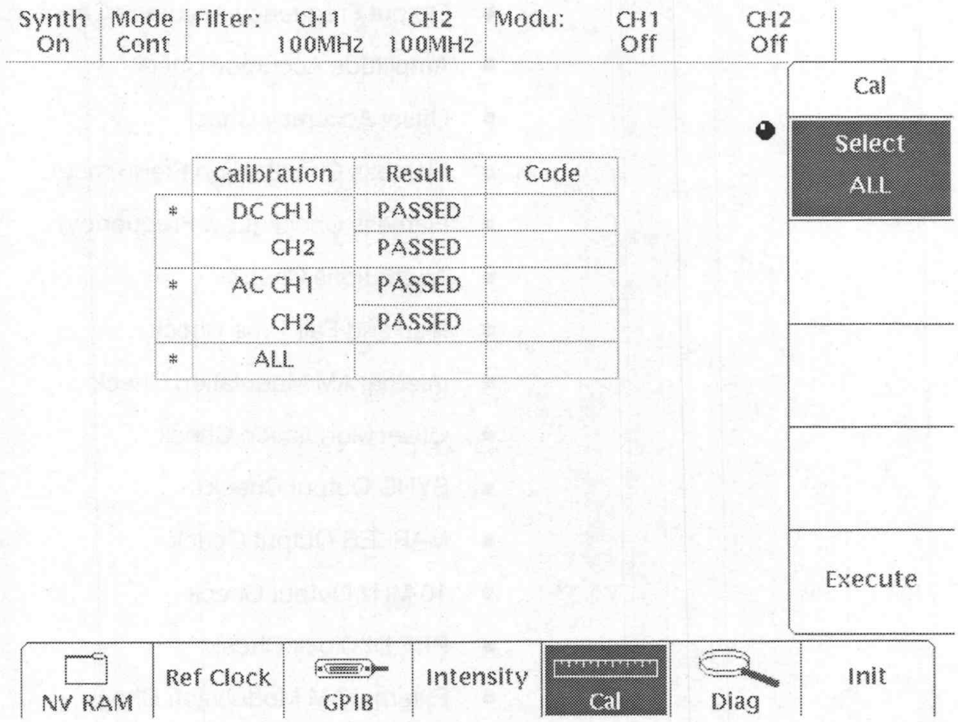


Figure 4-5: Display of the Calibration Menu

b. *Run the calibration routine*: Select **Execute** from the side menu. This executes the selected AFG2020 calibration routine(s).

c. *Wait*: The internal calibration does an exhaustive verification of proper AFG2020 function and adjusts internal calibration constants as necessary. This verification takes about 100 seconds. While it progresses, the clock icon appears on screen. When finished, the resulting status will appear on the screen.

d. *Confirm that no failures are found*: Verify that no failures are reported on-screen. If the calibration displays FAIL as the result, contact your nearest Tektronix representative.

2. *Return to regular service*: Push any button (other than UTILITY) in the MENU column to exit the Cal menu.

Performance Tests

This subsection contains a series of tests for checking that the AFG2020 Synthesized Arbitrary Function Generator performs as warranted.

The tests are presented in the following order:

- Output Frequency Accuracy Check (Synthesizer On)
- Output Frequency Accuracy Check (Synthesizer Off)
- Amplitude Accuracy Check
- Offset Accuracy Check
- Flatness Check (High Frequency)
- Flatness Check (Low Frequency)
- Aberrations Check
- Rise and Fall Time Check
- Internal AM Modulation Check
- Offset Modulation Check
- SYNC Output Check
- MARKER Output Check
- 10 MHz Output Check
- REF IN Clock Check
- External AM Modulation Check
- External Trigger Level Accuracy Check
- Internal Time Burst Check
- External Trigger Delay Check
- Dual Channel Synchronization Check (Option 02 Only)

These procedures extend the confidence level provided by the internal diagnostic and calibration routines in the preceding subsection, *Self Tests*.

Prerequisites

The tests in this subsection comprise an extensive confirmation of AFG2020 performance and functionality, when the following requirements are met:

- You must have successfully run the calibration routines described in the subsection, *Self Tests*, with the AFG2020 operating at an ambient temperature between +20° C and +30° C.
- The AFG2020 must have been operating for a warm-up period of at least 20 minutes and must be operating at an ambient temperature between 0° C and +50° C.

Related Information — Read *Before Verification* beginning on page 4-23. Also, if you are not familiar with operating the AFG2020, read *Section 1, Getting Started*, and *Section 2, Operating Basics*, before doing any of these procedures.

Equipment Required — The equipment listed in Table 4-4 is required to check the performance of the AFG2020.

Table 4-4: Test Equipment

Description	Minimum Requirements	Example	Purpose
Termination, 2 ea.	Impedance: 50 Ω, 0.1% Connectors: BNC	Tektronix P/N 011−0129−00	Signal termination
X10 Attenuator	Connectors: BNC 10:1	Tektronix P/N 011−0059−02	Check flatness
Adapter	Connectors: BNC female-to-dual banana	Tektronix P/N 103−0090−00	Signal interconnection
Adapter	Connectors: BNC TEE Type	Tektronix P/N 103−0030−00	Signal interconnection
Adapter	Connectors: BNC (male) to N (female)	Tektronix P/N 103−0058−00	Signal interconnection
BNC Cable, 3 ea.	Impedance 50 Ω Connectors: BNC Length: 1 m (43 in.)	Tektronix P/N 012−0057−01	Signal interconnection
Oscilloscope	Bandwidth: >250 MHz	Tektronix TDS500 Series Digitizing Oscilloscope or 2400 Series Digitizing Oscilloscope	Check output signals
Frequency Counter	Frequency range: 10 Hz to 100 MHz	Tektronix DC 5010 Programmable Universal Counter/Timer* or HP5386A Opt. 4	Check frequency
RF Power Meter	Frequency range: 100 kHz to 100 MHz	HP437B+HP8482A or Anritsu ML4803A+MA4601A	Check flatness
Digital Multimeter	Voltage range: 0.05 V to 5 V Accuracy: ±0.1%	Fluke 8842A	Check voltages
Function Generator	Output voltage: −5 V to 5 V Frequency: 20 MHz	Tektronix FG5010*	Trigger threshold level minimum pulse width External AM frequency response sensitivity External clock

* **Requires a TM 5000 Series Power Module Mainframe**

Performance Check Waveform

Some of the performance tests require special arbitrary waveforms for generating AFG2020 output. Use the following procedure to create the arbitrary waveforms before doing the performance tests. In the tests, these waveforms are called Test Waveform 1, Test Waveform 2, and Test Waveform 3.

Creating Test Waveform 1

This waveform is a 0 VDC signal with a 0.0000 VDC offset.

1. *Display the menu:* Press the **EDIT** button in the MENU column on the front panel.
2. *Select the memory location to edit:* Turn the general purpose knob to highlight a memory location to edit. If you select a memory location containing an unneeded waveform, the new waveform will overwrite and destroy the unneeded waveform. An icon that appears as a straight line at the midpoint is a memory location that is empty. Note which memory location you select for later reference.
3. *Change to the waveform editor:* Press **EDIT** in the bottom menu.
4. *Select the source of the new waveform:* Press **Standard Function**.
5. *Select the type of new waveform:* Press **Func Type xxxx** repeatedly or turn the general purpose knob until the text under Func Type changes to **DC**.
6. *Set the offset:* If the offset setting under Offset in the side menu is 0.0000, skip this step.
   a. *Select parameter:* Press **OFFSET** in the side menu.
   b. *Set offset:* Turn the general purpose knob (or push the numeric and decimal keys and ENTER) to change the offset to 0.0000.
7. *Create the new waveform:* Press **Execute**.
8. *Write the new waveform into the memory location:* Press **Exit/ Write** **Write and Exit**. The new waveform appears as a straight line at the baseline, in the previously selected memory location.

Creating Test Waveform 2

This waveform is a 0 VDC signal with a +1.0000 offset.

9. Repeat steps 2–8 to create the waveform in *another arbitrary waveform memory location*, except set the offset to 1.0000 VDC. The new waveform appears as a straight line elevated above the baseline in the selected memory location.

Creating Test Waveform 3

This waveform is a 0 VDC signal with a −1.0000 offset.

10. Repeat steps 2 through 8 to create the waveform in *another arbitrary waveform memory location*, except set the offset to −1.0000 VDC. The new waveform appears as a straight line below the baseline in the selected memory location.
11. Push a MENU button other than EDIT to exit.

Output Frequency Accuracy Check (Synthesizer On)

This procedure checks the frequency accuracy at 100 MHz and 2.5 MHz with the synthesizer turned on.

Electrical Characteristic Checked:

Output frequency range and accuracy, and reference oscillator accuracy (see page 4-4).

Equipment Required: A coaxial cable, a termination, and a frequency counter.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*
   a. *Hook up the counter:* Connect the AFG2020 CH1 output connector through the coaxial cable and termination to the channel A input connector on the counter (see Figure 4-6).

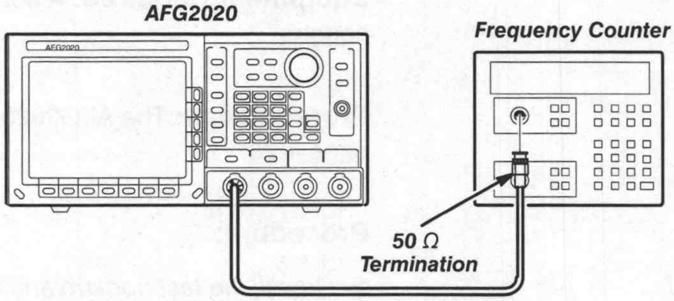


Figure 4-6: Connections for Checking Output Frequency Accuracy (Synthesizer On)

b. *Set the counter controls:*

Function:	Frequency A

2. *Set the AFG2020 controls:*

a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

b. *Change the AFG2020 controls:*

- Push **OUTPUT**.
- Press the numeric and units keys to select an output frequency of 100 MHz.
- Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Check against limits:* Check that the counter reading is between 99.999900 MHz and 100.000100 MHz.

4. *Change the AFG2020 controls:* Press the numeric and units keys to select an output frequency of 2.5 MHz.

5. *Check against limits:* Check that the counter reading is between 2.49999738 MHz and 2.50000262 MHz.

6. *End procedure:* Disconnect all connections to the AFG2020.

Output Frequency Accuracy Check (Synthesizer Off)

This procedure checks the frequency accuracy at 7.81 MHz and 7.82 MHz with the synthesizer turned off.

Electrical Characteristic Checked:

Output frequency accuracy (see page 4-4).

Equipment Required: A coaxial cable, a termination, and a frequency counter.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

a. *Hook up the counter:* Connect the AFG2020 CH1 output connector through the coaxial cable and termination to the channel A input connector on the counter (see Figure 4-7).

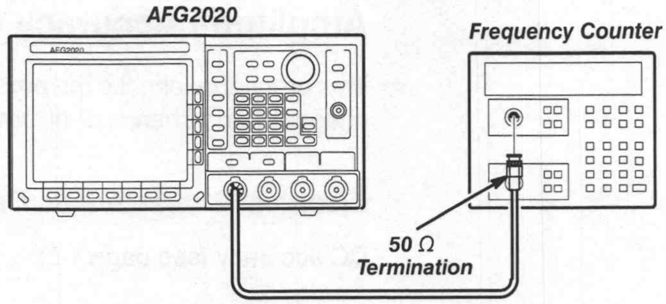


Figure 4-7: Connections for Checking Output Frequency Accuracy (Synthesizer Off)

b. *Set the counter controls:*

Function:	Frequency A

2. *Set the AFG2020 controls:*

a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

b. *Change the AFG2020 controls:*

- Push **Square** **OUTPUT** **Synth** to highlight **Off**.
- Press the numeric and units keys to select an output frequency of 7.81 MHz.
- Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Check against limits:* Check that the counter reads between 7.80219 MHz and 7.81781 MHz.

4. *Change the AFG2020 controls:* Press the numeric and units keys to select an output frequency of 7.82 MHz.

5. *Check against limits:* Check that the counter reads between 7.81218 MHz and 7.82782 MHz.

6. *End procedure:* Disconnect all connections to the AFG2020.

Amplitude Accuracy Check

This procedure checks the amplitude accuracy at three amplitude ranges for channel 1 and channel 2 (if Option 02 is installed).

Electrical Characteristic Checked:

DC accuracy (see page 4-6).

Equipment Required: A coaxial cable, a termination, a dual banana adapter, and a digital multimeter (DMM).

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

   a. *Hook up the DMM:* Connect the AFG2020 CH1 output connector through the coaxial cable, termination, and dual banana adapter to the DMM input connector (see Figure 4-8).

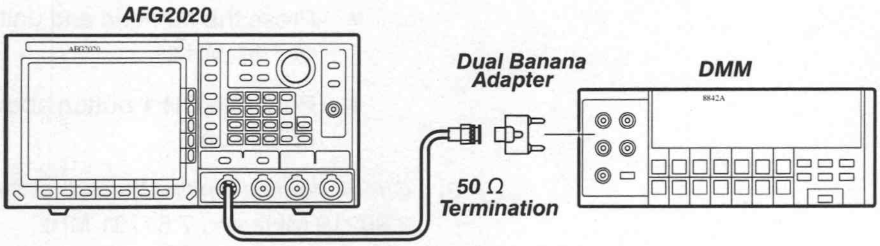


Figure 4-8: Connections for Checking Amplitude Accuracy

   b. *Set the DMM controls:*

Mode:	VDC
Range	Auto

2. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

   b. *Change the AFG2020 controls:*

   - Push **OUTPUT** **Range** **2 $V_{p\text{-}p}$**.
   - Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Check against limits for the 2V_{p-p} range:* Check that the AFG2020 amplitude is within limits:

   a. *Set AFG2020 controls:*

      - Push **Ampl/Offset**.
      - Press the numeric and units keys to select the first amplitude setting in Table 4-5.

   b. *Select the test waveform for output:* Push **FUNCTION** ➞ **Arbitrary**. Then push **Wave #x** for the memory location containing Test Waveform 3.

   c. *Note the Vneg reading:* Write down the DMM reading.

   d. *Select the test waveform for output:* Push **Wave #x** for the memory location containing Test Waveform 2.

   e. *Note the Vpos reading:* Write down the DMM reading.

   f. *Calculate Vout, using the formula:*

      Vout = Vpos − Vneg

      For example, if Vpos is 1 VDC and Vneg is −1 VDC, Vout is +2 VDC.

   g. *Check calculation against limits:* Check that Vout is within the range listed in Table 4-5 for the amplitude setting.

   h. *Change AFG2020 controls:* Push **OUTPUT**.

   i. *Check other settings:* Repeat steps a (numeric input only) through h for each amplitude setting in Table 4-5.

Table 4-5: Amplitude Accuracy in the 2 V_{p-p} Range

Amplitude Setting (V_{p-p})	Amplitude Vout Range (V_{p-p})
+2.0	+1.975 to +2.025
+1.0	+0.985 to +1.015
+0.5	+0.490 to +0.510
+0.2	+0.193 to +0.207
+0.1	+0.094 to +0.106
+0.0	−0.005 to +0.005
−0.1	−0.094 to −0.106
−0.2	−0.193 to −0.207
−0.5	−0.490 to −0.510
−1.0	−0.985 to −1.015
−2.0	−1.975 to −2.025

4. *Check against limits for the 0.4V_{p-p} range:*

   a. *Change AFG2020 controls:* Push **Range** ➞ **0.4 V_{p-p}**.

   b. *Check other settings:* Repeat step 3, using the amplitude settings and amplitude Vout ranges listed in Table 4-6.

Table 4-6: Amplitude Accuracy in the 0.4 V_{p-p} Range

Amplitude Setting (V_{p-p})	Amplitude Vout Range (V_{p-p})
+0.4	+0.395 to +0.405
+0.2	+0.197 to +0.203
+0.1	+0.098 to +0.102
+0.0	−0.001 to +0.001
−0.1	−0.098 to −0.102
−0.2	−0.197 to −0.203
−0.4	−0.395 to −0.405

5. *Check against limits for the 10 V_{p-p} range:*

   a. *Change AFG2020 controls:* Push **Range** **10 V_{p-p}**.

   b. *Check other settings:* Repeat step 3, using the amplitude settings and amplitude Vout ranges listed in Table 4-7.

Table 4-7: Amplitude Accuracy in the 10 V_{p-p} Range

Amplitude Setting (V_{p-p})	Amplitude Vout Range (V_{p-p})
+10.0	+9.700 to +10.300
+5.0	+4.825 to +5.175
+2.0	+1.900 to +2.100
+1.0	+0.925 to +1.075
+0.0	−0.050 to +0.050
−1.0	−0.925 to −1.075
−2.0	−1.900 to −2.100
−5.0	−4.825 to −5.175
−10.0	−9.700 to −10.300

6. *Check channel 2:* If Option 02 is installed in the AFG2020, check the CH2 output signal amplitude using the following procedure.

   a. *Change connections:* Move the cable from the AFG2020 CH 1 connector to the CH 2 connector.

   b. *Check other settings:* Repeat steps 2 through 5, except after initializing the AFG2020, push **Channel** to highlight CH2. This allows you to set the parameters for channel 2.

7. *End procedure:* Disconnect all connections to the AFG2020.

Offset Accuracy Check

This procedure checks the offset accuracy at three amplitude ranges for channel 1 and channel 2 (if Option 02 is installed).

Electrical Characteristic Checked:

Offset accuracy on all fixed ranges (see page 4-6).

Equipment Required: A coaxial cable, a termination, a dual banana adapter, and a digital multimeter (DMM).

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*
   a. *Hook up the DMM:* Connect the AFG2020 CH1 output connector through the coaxial cable, termination, and dual banana adapter to the DMM input connector (see Figure 4-9).

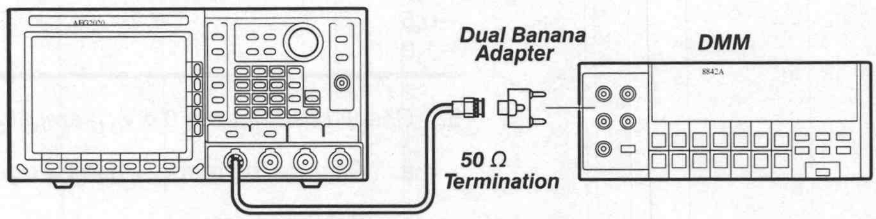


Figure 4-9: Connections for Checking Offset Accuracy

   b. *Set the DMM controls:*

Mode:	VDC
Range	Auto

2. *Set the AFG2020 controls:*
   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**
   b. *Change the AFG2020 controls:*
      - Push **OUTPUT** **Range** **2 V_{p-p}** **Ampl/Offset**.
      - Press the numeric and units keys to select an amplitude of 0 mV_{p-p}.
      - Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Select the test waveform for output:* Push **FUNCTION** **Arbitrary.** Then push **Wave #x** for the memory location containing Test Waveform 1.

4. *Check offset for the 2 V_{p-p} amplitude range:*

   a. *Set the offset:*

      - Push **OUTPUT** **Offset**.
      - Press the numeric and units keys to select the first offset setting in Table 4-8.

   b. *Check the reading:* Check that the DMM reading is within the output voltage range listed in Table 4-8 for the offset setting.

   c. *Check other settings:* Repeat substeps a and b for the other offset settings in Table 4-8.

Table 4-8: Offset Accuracy in the 2 V_{p-p} Range

Offset Setting (V)	Output Voltage Range (V)
+1.0	+0.985 to +1.015
+0.5	+0.490 to +0.510
+0.2	+0.193 to +0.207
+0.1	+0.094 to +0.106
0.0	−0.005 to +0.005
−0.1	−0.094 to −0.106
−0.2	−0.193 to −0.207
−0.5	−0.490 to −0.510
−1.0	−0.985 to −1.015

5. *Check offset for the 0.4 V_{p-p} amplitude range:*

   a. *Change the range:* Push **Range** **0.4 V_{p-p}**.

   b. *Set the offset:*

      - Push **Ampl/Offset**.
      - Press the numeric and units keys to select the first offset setting in Table 4-9.

   c. *Check the reading:* Check that the DMM reading is within the output voltage range listed in Table 4-9 for the offset setting.

   d. *Check other settings:* Repeat substeps b and c for the other offset settings in Table 4-9.

Table 4-9: Offset Accuracy in the 0.4 V_{p-p} Range

Offset Setting (V)	Output Voltage Range (V)
+0.2	+0.197 to +0.203
+0.1	+0.098 to +0.102
0.0	−0.001 to +0.001
−0.1	−0.098 to −0.102
−0.2	−0.197 to −0.203

6. *Check offset for the 10 V_{p-p} amplitude range:*

   a. *Change the range:* Push **Range** **10 V_{p-p}**.

   b. *Set the offset:*

      - Push **Ampl/Offset**.
      - Press the numeric and units keys to select the first offset setting in Table 4-10.

   c. *Check the reading:* Check that the DMM reading is within the output voltage range listed in Table 4-10 for the offset setting.

   d. *Check other settings:* Repeat substeps b and c for the other offset settings in Table 4-10.

Table 4-10: Offset Accuracy in the 10 V_{p-p} Range

Offset Setting (V)	Output Voltage Range (V)
+5.0	+4.825 to +5.175
+2.0	+1.900 to +2.100
+1.0	+0.925 to +1.075
0.0	−0.050 to +0.050
−1.0	−0.925 to −1.075
−2.0	−1.900 to −2.100
−5.0	−4.825 to −5.175

7. If Option 02 is installed, check the CH2 offset:

   a. *Change connections:* Move the cable from the AFG2020 CH 1 connector to the CH 2 connector.

   b. *Check limits:* Repeat steps 2 through 6, except after initializing the AFG2020, push **Channel** to highlight CH2. This allows you to set the parameters for channel 2.

8. *End procedure:* Disconnect all connections to the AFG2020.

Flatness Check (High Frequency)

This procedure checks signal flatness for various ranges and frequencies. Also checks flatness for channel 2 (if Option 02 is installed).

Electrical Characteristic Checked:

Sine amplitude flatness with the synthesizer on and off, at frequencies from 100 kHz to 100 MHz on all fixed ranges (see page 4-8).

Equipment Required: A coaxial cable, an attenuator, a BNC-to-N adapter, and a power meter.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Calibrate the power meter:*

   a. *Hook up the power meter:* Connect the sensor head and cable to the power meter for calibration. Figure 4-10 shows an example of this connection.

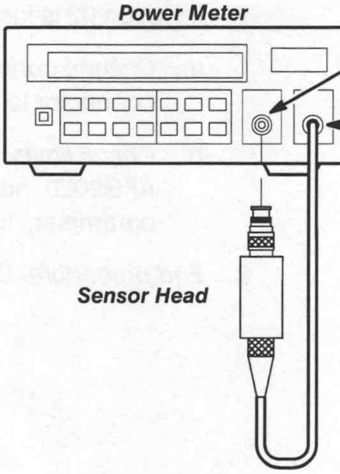


Figure 4-10: Connections for Calibrating Power Meter

   b. *ZERO adjustment:* Zero the sensor head to the power meter.

   c. *Calibrate the power meter to the sensor head:* Enter into the power meter memory the calibration factor for the sensor head you are using, for measurements at 100 kHz.

   d. *Change connections:* Disconnect the sensor head from the POWER REF connector.

2. *Install the test hookup and set test equipment controls:*

   a. *Hook up the power meter:* See Figure 4-11.

   - Connect the AFG2020 CH1 output connector to an attenuator.
   - Connect the sensor head of the power meter through the BNC-to-N adapter to the the other side of the attenuator.

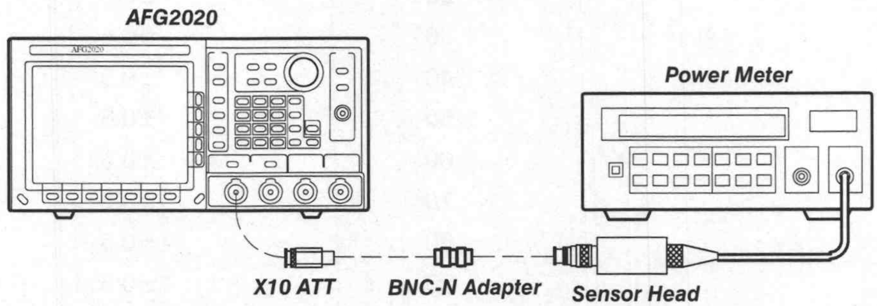


Figure 4-11: Connections for Checking Flatness (High Frequency)

3. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

   b. *Change the AFG2020 controls:*

   - Push **OUTPUT**.
   - Press the numeric and units keys to select a frequency of 100 kHz; it might already be 100 kHz.
   - Push **Range** **2 $V_{p\text{-}p}$**.
   - Push the **CH 1** button above the CH 1 output connector so the LED is on.

4. *Check limits on the 2 $V_{p\text{-}p}$ range:*

   a. *Check reading:* Check that the power meter reads within −10 dBm ±0.8 dBm.

   b. *Change power meter controls:* Set the power meter to make relative dBm measurements (hint: press REL).

   c. *Change AFG2020 controls:*

   - Push **Freq/Phase**.
   - Press the numeric and units keys to select the first frequency listed in Table 4-11.

   d. *Check limits:* Check that the power meter reading is within the limits listed in Table 4-11 for the AFG2020 frequency and range settings.

   e. *Check other settings:* Repeat substeps c and d for the other frequency settings in Table 4-11.

Table 4-11: Flatness Accuracy

AFG2020 Frequency Setting (MHz)	Power Range (dB)	
	2 V_{p-p} and 0.4 V_{p-p} Range	10 V_{p-p} Range
1	±0.5	±0.5
10	±0.5	±0.5
20	±0.5	±0.5
30	±0.5	±0.5
40	±0.5	±0.5
50	±0.5	±0.5
60	±0.5	±1.0
70	±0.5	±1.0
80	±0.5	±1.0
90	±0.5	±1.0
100	±0.5	±1.0

5. *Check limits on the 0.4 V_{p-p} range:*

   - Push **Range** ▶ **0.4 V_{p-p}** ▶ **Freq/Phase**.
   - Press the numeric and units keys to select a frequency of 100 kHz.

   a. *Change power meter controls:* Set the power meter to make measurements in dBm (hint: press REL).

   b. *Check reading:* Check that the power meter reads within −23.98 dBm ±1.0 dBm.

   c. *Change power meter controls:* Set the power meter to make relative dBm measurements (hint: press REL).

   d. *Change AFG2020 controls:* Press the numeric and units keys to select the first frequency listed in Table 4-11.

   e. *Check limits:* Check that the power meter reading is within the limits listed in Table 4-11 for the AFG2020 frequency and range settings.

   f. *Check other settings:* Repeat substeps d and e for the other frequency settings in Table 4-11.

6. *Check limits on the 10 V_{p-p} range:*

   a. *Change AFG2020 controls:*

   - Push **Range** ▶ **10 V_{p-p}** ▶ **Freq/Phase**.
   - Press the numeric and units keys to select a frequency of 100 kHz.
   - Press **Ampl/Offset**.
   - Press the numeric and units keys to select an amplitude of 10 V.

b. *Change power meter controls:* Set the power meter to make measurements in dBm (hint: press REL).

c. *Check reading:* Check that the power meter reads within 3.98 dBm ±1.0 dBm.

d. *Change power meter controls:* Set the power meter to make relative dBm measurements (hint: press REL).

e. *Change AFG2020 controls:* Press the numeric and units keys to select the first frequency listed in Table 4-11.

f. *Check limits:* Check that the power meter reading is within the limits listed in Table 4-11 for the AFG2020 frequency and range settings.

g. *Check other settings:* Repeat substeps e and f for the other frequency settings in Table 4-11, changing the power meter calibration factor as necessary.

7. *Check flatness with synthesizer mode turned off:*

a. *Change AFG2020 controls:*

- Push **Synth** to highlight Off.
- Push **Range** **2** $V_{p\text{-}p}$ **Freq/Phase**.
- Press the numeric and units keys to select a frequency of 100 kHz.

b. *Change power meter controls:*

- Change the power meter calibration factor for measurements at 100 kHz.
- Set the power meter to make measurements in dBm.

c. *Check reading:* Check that the power meter reads within –10.0 dBm ±1.0 dBm.

d. *Change power meter controls:* Set the power meter to make relative dBm measurements (hint: press REL).

e. *Change AFG2020 controls:*

- Push **Range** **10** $V_{p\text{-}p}$ **Freq/Phase**.
- Press the numeric and units keys to select the first frequency listed in Table 4-12.

f. *Check limits:* Check that the power meter reading is within the limits listed in Table 4-12 for the AFG2020 frequency and range settings.

g. *Check other settings:* Repeat substeps e and f for the other frequency settings in Table 4-12.

Table 4-12: Flatness Accuracy in the 10 V_{p-p} Range

Frequency Setting (MHz)	Power Range (dB)
1	±1.0
10	±1.0
20	±1.0
30	±3.0
31.2	±3.0

8. *Check channel 2 signal flatness with synthesizer mode turned on:* If Option 02 is installed in the AFG2020, check the channel 2 output signal flatness using the following procedure:

   a. *Change connections:* Move the attenuator from the AFG2020 CH 1 connector to the CH 2 connector.

   b. *Check other settings:* Repeat steps 3 through 6, except after initializing the AFG2020, push **Channel** to highlight CH2. This allows you to set the parameters for channel 2.

9. *Check channel 2 signal flatness with synthesizer mode turned off:*

   a. *Change AFG2020 controls:*

      - Push **Synth** to highlight Off.
      - Push **Freq//Phase** **Frequency Same as CH1**.
      - Push **Channel** to highlight CH1.

NOTE

With the synthesizer turned off and the frequency for channel 2 set to Frequency Same as CH1, any changes to the channel 1 frequency also change the channel 2 frequency.

   b. *Check other settings:* Repeat step 7, changing the current channel temporarily to CH2 when changing the range.

10. *End procedure:* Disconnect all connections to the AFG2020.

Flatness Check (Low Frequency)

This procedure checks the flatness of the output waveform at various ranges and frequencies for channel 1 and channel 2 (if Option 02 is installed).

Electrical Characteristic Checked:

Sine amplitude flatness with synthesizer turned on, at frequencies between 50 Hz and 100 kHz on all fixed ranges (see page 4-8).

Equipment Required: A coaxial cable, a termination, a dual banana adapter, and a digital multimeter (DMM).

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

   a. *Hook up the DMM:* Connect the AFG2020 CH1 output connector through the coaxial cable, termination, and dual banana adapter to the DMM input connector (see Figure 4-12).

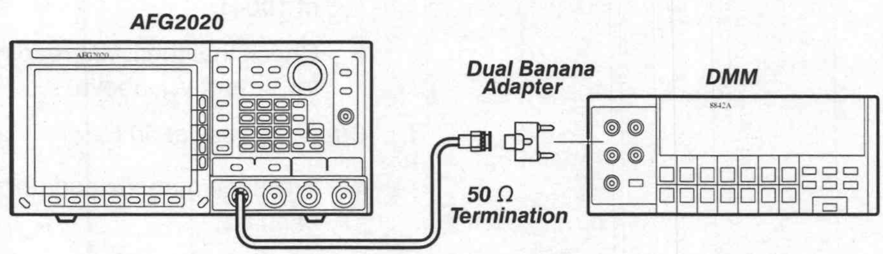


Figure 4-12: Connections for Checking Flatness (Low Frequency)

   b. *Set the DMM controls:*

Mode:	VAC
Range	Auto

2. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

   b. *Change the AFG2020 controls:*

   - Push **OUTPUT** **Range** **2** $V_{p\text{-}p}$ **Freq/Phase**.
   - Press the numeric and units keys to select an output frequency of 100 kHz.
   - Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Check flatness on the 2 V_{p-p} range:*

   a. *Check the DMM reading:* Check that the DMM reading is from 0.68943 V_{RMS} to 0.72478 V_{RMS}. Record the reading.

   b. *Calculate values:* Find the V_L and V_H from the DMM reading value in the substep a using the following formula:

   $$V_L = (\text{DMM ACV}_{RMS}) \times 0.9446$$
   $$V_H = (\text{DMM ACV}_{RMS}) \times 1.0925$$

   c. *Check flatness at 10 kHz:*

   - Press the numeric and units keys to select an output frequency of 10 kHz.
   - Check that the DMM reading is between the values calculated for V_L and V_H, above.

   d. *Check flatness at 1 kHz:*

   - Press the numeric and units keys to select an output frequency of 1 kHz.
   - Check that the DMM reading is between the values calculated for V_L and V_H, above.

   e. *Check flatness at 100 Hz:*

   - Press the numeric and units keys to select an output frequency of 100 Hz.
   - Check that the DMM reading is between the values calculated for V_L and V_H, above.

   f. *Check flatness at 50 Hz:*

   - Press the numeric and units keys to select an output frequency of 50 Hz.
   - Check that the DMM reading is between the values calculated for V_L and V_H, above.

4. *Check flatness on the 0.4 V_{p-p} range:*

   a. *Change the AFG2020 controls:*

   - Push **Range** **0.4 V_{p-p}** **Freq/Phase**.
   - Press the numeric and units keys to select an output frequency of 100 kHz.

   b. *Check the DMM reading:* Check that the DMM reading is 137.886 mV_{RMS} to 144.956 mV_{RMS}. Record the reading.

   c. *Calculate values:* Find the V_L and V_H from the DMM reading value in the substep b using the following formula:

   $$V_L = (\text{DMM ACV}_{RMS}) \times 0.9446$$
   $$V_H = (\text{DMM ACV}_{RMS}) \times 1.0925$$

   d. *Check limits:* Repeat substeps 3c through f, checking that the readings are between the limits calculated in substep 4c.

5. *Check flatness on the 10 V_{p-p} range:*

   a. *Change the AFG2020 controls:*

      - Push **Range** **10 V_{p-p}** **Freq/Phase**.
      - Press the numeric and units keys to select an output frequency of 100 kHz.
      - Push **Ampl/Offset**.
      - Press the numeric and units keys to select an output amplitude of 10 V_{p-p}.
      - Press **Freq/Phase**.

   b. *Check the DMM reading:* Check that the DMM reading is 3.3411 V_{RMS} to 3.7200 V_{RMS}. Record the reading.

   c. *Calculate values:* Find the V_L and V_H from the DMM reading value in the substep b using the following formula:

$$V_L = (\text{DMM ACV}_{RMS}) \text{ X } 0.9446$$
$$V_H = (\text{DMM ACV}_{RMS}) \text{ X } 1.0925$$

   d. *Check limits:* Repeat substeps 3c through f, checking that the readings are between the limits calculated in substep 5c.

6. *If Option 02 is installed, check the CH2 output signal flatness:*

   a. *Change the connections:* Move the cable from the AFG2020 CH1 connector to the CH2 connector.

   b. *Check channel 2 flatness:* Repeat steps 2 through 5, except after initializing the AFG2020, push **Channel** to highlight CH2. This allows you set the parameters for channel 2.

7. *End procedure:* Disconnect all connections to the AFG2020.

Aberrations Check

This procedure checks output signal aberrations on three amplitude ranges using the low pass filter (50 MHz) and the full pass filter (no filtering).

Electrical Characteristic Checked:

Aberration range (see page 4-9).

Equipment Required: A coaxial cable, a termination, an attenuator, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

   a. *Hook up the oscilloscope:* Connect the AFG2020 CH1 output connector through the coaxial cable, attenuator, and termination to the oscilloscope vertical input connector (see Figure 4-13).

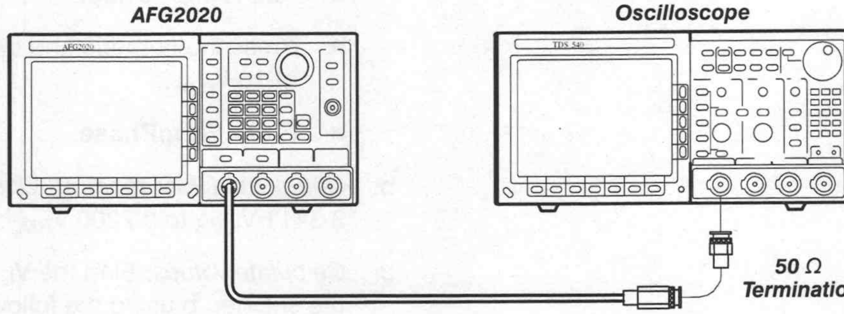


Figure 4-13: Connections for Checking Aberrations on 10 V_{p-p} Range

   b. *Set the oscilloscope controls:*

Vertical	
CH1 coupling	DC
CH1 scale	100 mV/div.
Horizontal	
Sweep	2 ns/div.
Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	0 V
Mode	Auto

2. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY**   **Init**   **O.K.**

   b. *Change the AFG2020 controls:*

   - Push **Square**   **OUTPUT**   **Synth** to highlight Off.
   - Press the numeric and units keys to select an output frequency of 5 MHz.
   - Push **Range**   **10 V_{p-p}**   **Ampl/Offset**.
   - Press the numeric and units keys to select an output amplitude of 10.00 V_{p-p}.
   - Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Check aberrations with full pass filter on 10 V_{p-p} range:* Check that the aberration of the displayed waveform on the test oscilloscope is less than 121 mV_{p-p}.
4. *Check aberrations with 50 MHz filter on 10 V_{p-p} range:*
   a. *Change* AFG2020 *controls:* Push **Filter** **50MHz.**
   b. *Check display:* Check that the aberration of the displayed waveform on the test oscilloscope is less than 71 mV_{p-p}.
5. *Check aberrations with full pass filter on 2 V_{p-p} range:*
   a. *Change AFG2020 controls:*
      - Push **Range** **2 V_{p-p}**.
      - Push **Filter** **Full Pass**.
   b. *Change oscilloscope controls:* Set the vertical scale to 200 mV/div.
   c. *Change AFG2020 connections:* Remove the attenuator and reconnect the coaxial cable to the termination (see Figure 4-14).

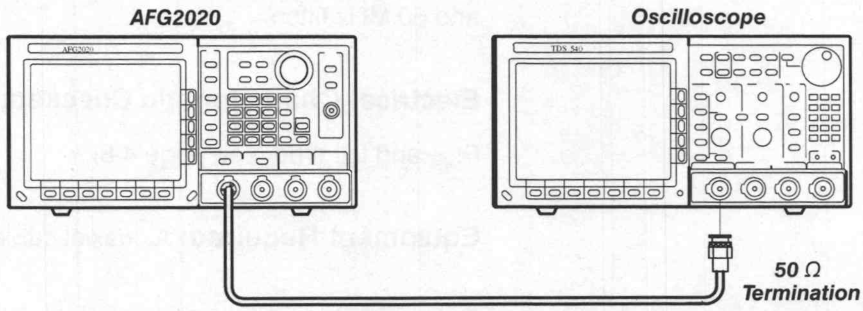


Figure 4-14: Connections for Checking Aberrations on 2 V_{p-p} and 0.4 V_{p-p} Ranges

   d. *Check display:* Check that the aberration of displayed waveform on the test oscilloscope is less than142 mV_{p-p}.
6. *Check aberrations with 50 MHz filter on 2 V_{p-p} range:*
   a. *Change AFG2020 controls:* Push **50 MHz.**
   b. *Check display:* Check that the aberration of displayed waveform on the test oscilloscope is less than102 mV_{p-p}.
7. *Check aberration with full pass filter on 0.4 V_{p-p} range:*
   a. *Change oscilloscope controls:* Set the vertical scale to 50 mV/div.
   b. *Change AFG2020 controls:*
      - Push **Range** **0.4 V_{p-p}**.
      - Push **Filter** **Full Pass**.
   c. *Check display:* Check that the aberration of displayed waveform on the test oscilloscope is less than 30 mV_{p-p}.

8. *Check aberrations with 50 MHz filter on 0.4 V_{p-p} range:*

   a. *Change AFG2020 controls:* Push **50 MHz**.

   b. *Check display:* Check that the aberration of displayed waveform on the test oscilloscope is less than 22 mV_{p-p}.

9. *Check channel 2:* If option 02 is installed in the AFG2020, check the CH2 output signal aberration using the following procedure:

   a. *Change connections:* Move the cable from the AFG2020 CH 1 connector to the CH 2 connector.

   b. *Check limits:* Repeat steps 1b through 8, except after initializing the AFG2020, push **Channel** to highlight CH2. This allows you to set the parameters for channel 2.

10. *End procedure:* Disconnect all connections to the AFG2020.

Rise and Fall Time Check

This procedure checks the output signal rise and fall time using the 100 MHz and 50 MHz filters.

Electrical Characteristic Checked:

Rise and fall time (see page 4-8).

Equipment Required: A coaxial cable, a termination, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

   a. *Hook up the oscilloscope:* Connect the AFG2020 CH1 output connector through the coaxial cable, and termination to the oscilloscope vertical input connector (see Figure 4-15).

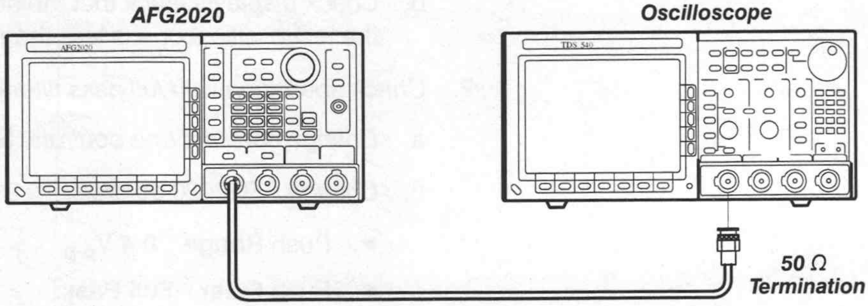


Figure 4-15: Connections for Checking Rise and Fall Time

b. *Set the oscilloscope controls:*

Vertical	
CH1 coupling	DC
CH1 scale	500 mV/div.
Horizontal	
Sweep	2 ns/div.
Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	0 V
Mode	Auto

2. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

   b. *Change the AFG2020 controls:*

      - Push **Square** **OUTPUT** **Synth** to highlight Off.
      - Press the numeric and units keys to select an output frequency of 1 MHz.
      - Push **Range** **2 $V_{p\text{-}p}$**.
      - Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Check limits:* Check that the rise time of displayed waveform on the test oscilloscope is within 4 ns.
4. *Change oscilloscope controls:* Change the trigger slope to Negative.
5. *Check limits:* Check that the fall time of displayed waveform on the test oscilloscope is within 4 ns.
6. *Change AFG2020 controls:* Press **Filter** **50 MHz**.
7. *Check limits:* Check that the fall time of displayed waveform on the test oscilloscope is within 9 ns.
8. *Change oscilloscope controls:* Change the trigger slope to Positive.
9. *Check limits:* Check that the rise time of displayed waveform on the test oscilloscope is within 9 ns.
10. *Check channel 2 rise and fall time:* If Option 02 is installed in the AFG2020, check that the CH2 output signal rise/fall time with following procedure.

    a. *Change connections:* Move the cable from the AFG2020 CH 1 connector to the CH 2 connector.

    b. *Check channel 2 limits:* Repeat steps 1b through 9, except after initializing the AFG2020, push **Channel** to highlight CH2. This allows you to set the parameters for channel 2.

11. *End procedure:* Disconnect all connections to the AFG2020.

Internal AM Modulation Check

This procedure checks the amplitude and rise time of an AM modulated signal for channel 1 and channel 2 (if Option 02 is installed). For Option 02, the procedure also checks channel 2 output when modulated by the channel 1 signal.

Electrical Characteristic Checked:

Amplitude modulation signal, amplitude (see page 4-11).

Equipment Required: A coaxial cable, a termination, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

   a. *Hook up the oscilloscope:* Connect the AFG2020 CH1 output connector through the coaxial cable, and termination to the oscilloscope vertical input connector (see Figure 4-16).

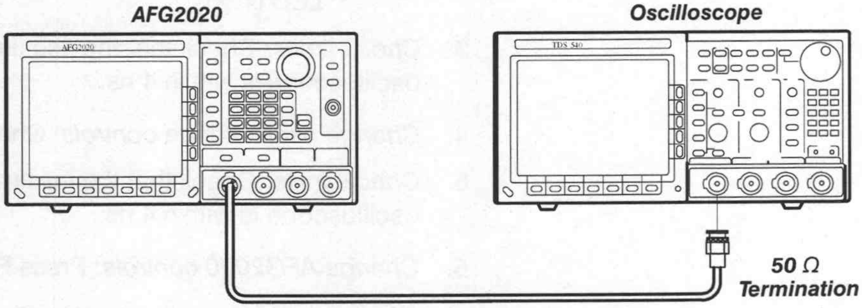


Figure 4-16: Connections for Checking Internal AM Modulation

   b. *Set the oscilloscope controls:*

Vertical	
CH1 coupling	DC
CH1 scale	2 V/div.
Horizontal	
Sweep	100 µs/div.

Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	0 V
Mode	Auto

2. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

   b. *Change the AFG2020 controls:*

   - Push **OUTPUT** **Range** **10 V_{p-p}**.
   - Push **MODULATE** **Signal** **Square** **Params** **DSB−SC** to highlight On.
   - Press **Carrier Amplitude**.
   - Press the numeric and units keys to select a carrier amplitude of 10 V_{p-p}.
   - Push **Modulate** to highlight On.
   - Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Select the test waveform for output:* Push **FUNCTION** **Arbitrary**. Then push **Wave #x** for the memory location containing Test Waveform 2.

4. *Check amplitude limits:* Check that the amplitude of the modulated waveform on the oscilloscope is 10 V_{p-p}.

5. *Change the oscilloscope controls:* Change the horizontal sweep to 1 μs/div.

6. *Check rise time limits:* Check that the rise time of the modulated waveform on the oscilloscope is within 2 μs.

7. *Check channel 2 limits:* If option 02 is installed in the AFG2020, check that the CH2 output amplitude and rise time using following procedure.

   a. *Change connections:* Move the cable from the AFG2020 CH 1 connector to the CH 2 connector.

   b. *Change AFG2020 channel:*

   c. *Check channel 2 limits:* Repeat steps 1b through 6, except after initializing the AFG2020, push **Channel** to highlight CH2. This allows you to set the parameters for channel 2.

8. *Check channel 2 output when modulated by the channel 1 signal:* If option 2 is installed in the AFG2020, do the following steps:

   a. *Change AFG2020 channel:* Push **Channel** to highlight CH1.

   b. *Change AFG2020 controls:*

      - Push **MODULATE** and check to see that Modulate is off.
      - Push **FUNCTION** and check to see that Sine is selected.
      - Push **OUTPUT** **Ampl/Offset**.
      - Press the numeric and units keys to select an amplitude of 1.000 V_{p-p}.
      - Push **Freq/Phase**.
      - Press the numeric and units keys to select a frequency of 400.0 Hz.
      - Push **Range** **2 V_{p-p}**.
      - Check that the LED above the **CH 1** button is off.

   c. *Change AFG2020 channel:* Push **Channel** to highlight CH2.

   d. *Change oscilloscope controls:*

Vertical	
CH1 Scale	500 mV/div.
Horizontal	
Sweep	1 ms/div.
Trigger	
Level	0.5 V

   e. *Change AFG2020 controls:*

      - Push **OUTPUT** **Range** **2 V_{p-p}**.
      - Push **MODULATE** **Signal** **From CH1** **Modulate** to highlight On.
      - Push **OUTPUT** **Ampl/Offset**.
      - Press the numeric and units keys to select an amplitude of 1.000 V_{p-p}.
      - Check that the LED above the **CH 2** button is on.

9. *Select the test waveform for output:* Push **FUNCTION** **Arbitrary**. Then push **Wave #x** for the memory location containing Test Waveform 2.

10. *Check limits:* Check that the amplitude is 1 V_{p-p}, the period is 2.5 ms, and the DC offset is 0.5 V for the displayed waveform on the oscilloscope.

11. *End procedure:* Disconnect all connections to the AFG2020.

Offset Modulation Check

This procedure checks the amplitude and rise time of an offset-modulated signal for channel 1 and channel 2 (if Option 02 is installed).

Electrical Characteristic Checked:

Offset modulation amplitude and rise time (see page 4-12).

Equipment Required: A coaxial cable, a termination, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

   a. *Hook up the oscilloscope:* Connect the AFG2020 CH1 output connector through the coaxial cable, and termination to the oscilloscope vertical input connector (see Figure 4-17).

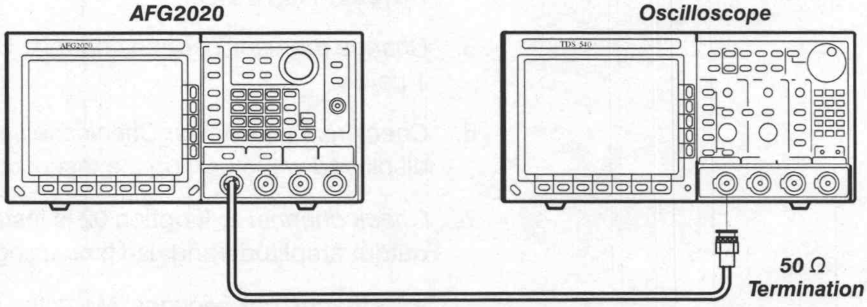


Figure 4-17: Connections for Checking Offset Modulation

   b. *Set the oscilloscope controls:*

Vertical	
CH1 coupling	DC
CH1 scale	2 V/div.
Horizontal	
Sweep	100 µs/div.
Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	0 V
Mode	Auto

2. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

   b. *Change the AFG2020 controls:*

   - Push **OUTPUT** **Range** **10 V_{p-p}** **Ampl/Offset**.
   - Press the numeric and units keys to select an amplitude of 0.00 V_{p-p}.
   - Push **MODULATE** **Offset** **Signal** **Square** **Params** **High**.
   - Press the numeric and units keys to select a setting of 5.00 V.
   - Push **Low**.
   - Press the numeric and units keys to select a setting of −5.00 V.
   - Push **Modulate** to highlight On.
   - Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Select the test waveform for output:* Push **FUNCTION** **Arbitrary**. Then push **Wave #x** for the memory location containing Test Waveform 1.

4. *Check amplitude limits:* Check that the amplitude of the oscilloscope waveform is 10 V_{p-p}.

5. *Change the oscilloscope controls:* Change the horizontal sweep to 1 μs/div.

6. *Check rise time limits: Check rise time limits:* Check that the rise time of displayed waveform on the test oscilloscope is within 2 μs.

7. *Check channel 2:* If option 02 is installed in the AFG2020, check the CH2 output amplitude and rise time using following procedure.

   a. *Change connections:* Move the cable from the AFG2020 CH 1 connector to the CH 2 connector.

   b. *Check channel 2 limits:* Repeat steps 1b through 6, except after initializing the AFG2020, push **Channel** to highlight CH2. This allows you to set the parameters for channel 2.

8. *End procedure:* Disconnect all connections to the AFG2020.

SYNC Output Check

This procedure checks the amplitude and pulse width of the SYNC out signal.

Electrical Characteristic Checked:

Sync output level and pulse width (see page 4-15).

Equipment Required: Two coaxial cables, a termination, a function generator, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*
   a. *Hook up the oscilloscope:* Connect the AFG2020 SYNC output connector through a coaxial cable to the oscilloscope CH1 vertical input connector (see Figure 4-18).
   b. *Hook up the function generator:* Connect the function generator output through a coaxial cable to the AFG2020 TRIGGER INPUT connector.

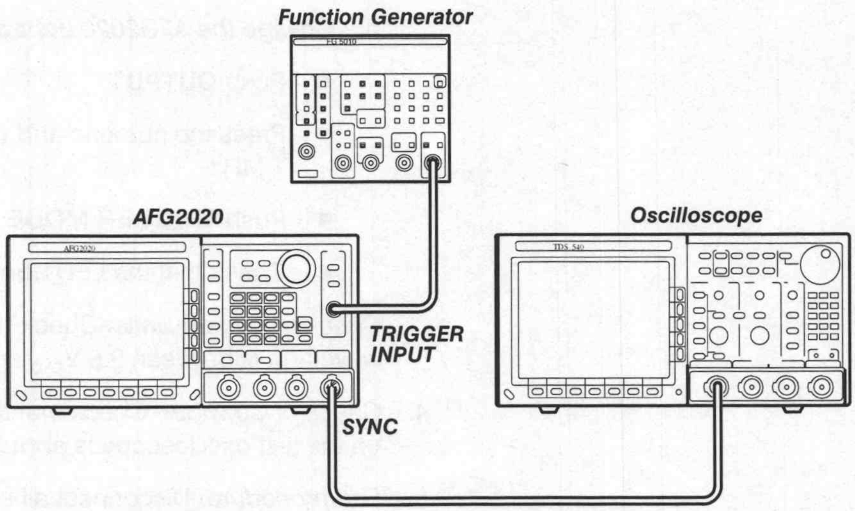


Figure 4-18: Connections for Checking SYNC Output

c. *Set the oscilloscope controls:*

Vertical	
CH1 coupling	DC
CH1 scale	1 V/div.
Horizontal	
Sweep	200 ns/div.
Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	1.0 V
Mode	Auto

d. *Set the function generator controls:*

Function	Square
Mode	Continuous
Parameter	
Frequency	1 kHz
Amplitude	4 V
Offset	2.5 V
Output	On

2. *Set the AFG2020 controls:*

a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

b. *Change the AFG2020 controls:*

- Push **OUTPUT**.
- Press the numeric and units keys to select a frequency of 1 MHz.
- Push **TRIGGER MODE** **Gate** **Source** to highlight External.
- Check that the LED above the **CH 1** button is on.

3. *Check amplitude limits:* Check that the amplitude of the oscilloscope waveform is between 2.8 V_{p-p} and 5 V_{p-p}.

4. *Check pulse width:* Check that the pulse width of displayed waveform on the test oscilloscope is about 400 ns.

5. *End procedure:* Disconnect all connections to the AFG2020.

Marker Output Check

This procedure checks the output amplitude, pulse width, and frequency of the MARKER signal for channel 1 and channel 2 (if Option 02 is installed).

Electrical Characteristic Checked:

Marker output level, pulse width, and frequency (see page 4-15).

Equipment Required: A coaxial cable, a counter, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

   a. *Hook up the oscilloscope:* Connect the AFG2020 CH1 MARKER output connector through a coaxial cable to the oscilloscope vertical input connector (see Figure 4-19).

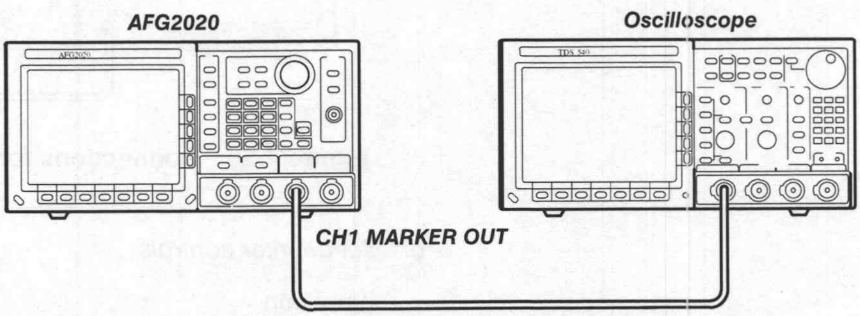


Figure 4-19: Connections for Checking MARKER Output

   b. *Set the oscilloscope controls:*

Vertical	
Ch1 coupling	DC
CH1 scale	1 V/div.
Horizontal	
Sweep	200 ns/div.
Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	1.0 V
Mode	Auto

2. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

   b. *Change the AFG2020 controls:*

      - Push **MODULATE** **FSK** **Key Period**.
      - Press the numeric and units keys to select a setting of 0.4 μs.
      - Press **Modulate** to highlight On.

3. *Check amplitude limits:* Check that the amplitude of the oscilloscope waveform is between 2.8 V_{p-p} and 5 V_{p-p}.

4. *Check pulse width limits:* Check that the pulse width of displayed waveform on the test oscilloscope is about 400 ns.

5. *Check frequency limits:*

   a. *Change connections:* Move the cable from the oscilloscope vertical input to the counter input connector (see Figure 4-20).

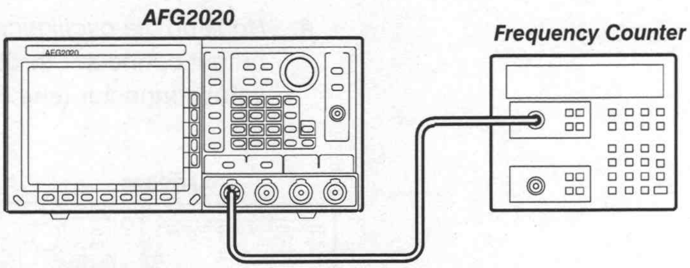


Figure 4-20: Connections for Checking MARKER Output

   b. *Set counter controls:*

Function	Frequency A

   c. *Change AFG2020 controls:*

      - Push **Type** **AM** **Params**.
      - Press the numeric and units keys to select a setting of 10 μs.

   d. *Check frequency limits:* Check that the frequency reading on the counter is within 100 kHz ± 0.1 Hz. Disconnect the cable.

6. *Check channel 2 MARKER signal:* If Option 02 is installed in the AFG2020, check the CH2 MARKER output signal using the following procedure.

   a. *Change connections:* Connect a cable from the CH2 MARKER OUTPUT connector (on rear panel) to the oscilloscope vertical input.

   b. *Check channel 2 limits:* Repeat steps 1b through 6 to check the channel 2 output amplitude, pulse width, and frequency. Except after initializing the AFG2020, push **Channel** to highlight CH2. This allows you to set the parameters for channel 2.

7. *End procedure:* Disconnect all connections to the AFG2020.

10 MHz Output Check

This procedure checks the amplitude and frequency of the signal at the 10 MHz OUT connector on the AFG2020 rear panel.

Electrical Characteristic Checked:

10 MHz level and frequency (see page 4-15).

Equipment Required: A coaxial cable, a counter, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

   a. *Hook up the oscilloscope:* Connect the10 MHz OUT connector on the AFG2020 rear panel through a coaxial cable to the counter input connector (see Figure 4-21).

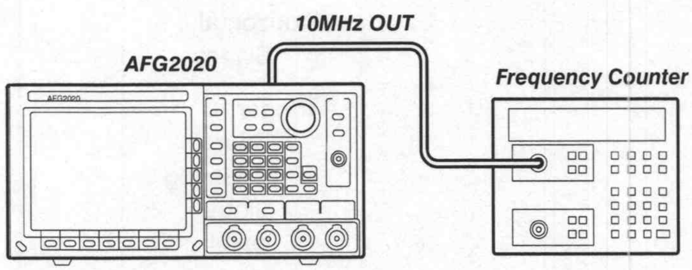


Figure 4-21: Connections for Checking 10 MHz Output Frequency

   b. *Set the counter controls:*

Function	FREQ A

2. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

3. *Check frequency limits:* Check that the counter reading is between 9.99999 MHz and 10.00001 MHz.

4. *Change connections and control settings:*

   a. *Change connections:* Move the coaxial cable from the counter input to the oscilloscope vertical input (see Figure 4-22).

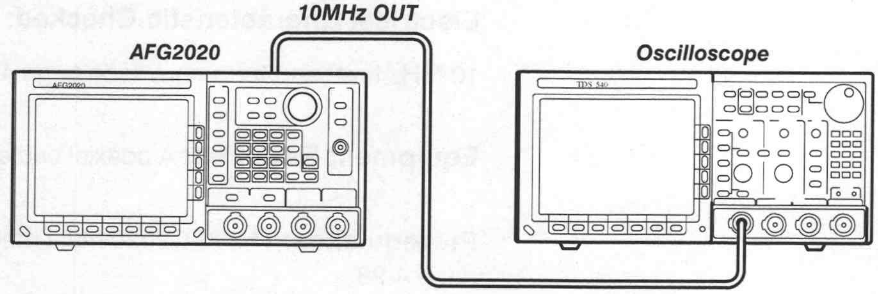


Figure 4-22: Connections for Checking 10 MHz OUT Amplitude

   b. *Set the oscilloscope controls:*

Vertical	
Ch1 coupling	DC
CH1 scale	1 V/div.
Horizontal	
Sweep	200 ns/div.
Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	1.0 V
Mode	Auto

5. *Check amplitude limits:* Check that the amplitude of the waveform displayed on the oscilloscope is from 2.8 $V_{p\text{-}p}$ to 5 $V_{p\text{-}p}$.

6. *End procedure:* Disconnect all connections to the AFG2020.

REF IN Clock Check

This procedure checks the REF IN clock frequency.

Electrical Characteristic Checked:

REF IN range (see page 4-16).

Equipment Required: Two coaxial cables, a termination, a BNC TEE connector, a function generator, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

   a. *Hook up the equipment:* See Figure 4-23.

   - Connect the AFG2020 CH1 connector through a coaxial cable and termination to the oscilloscope CH2 vertical input.
   - Connect the oscilloscope CH1 vertical input through a coaxial cable to one side of the BNC TEE adapter.
   - Connect the function generator output through a coaxial cable to the BNC TEE adapter.
   - Connect the BNC TEE adapter directly to the REF IN connector on the AFG2020 rear panel.

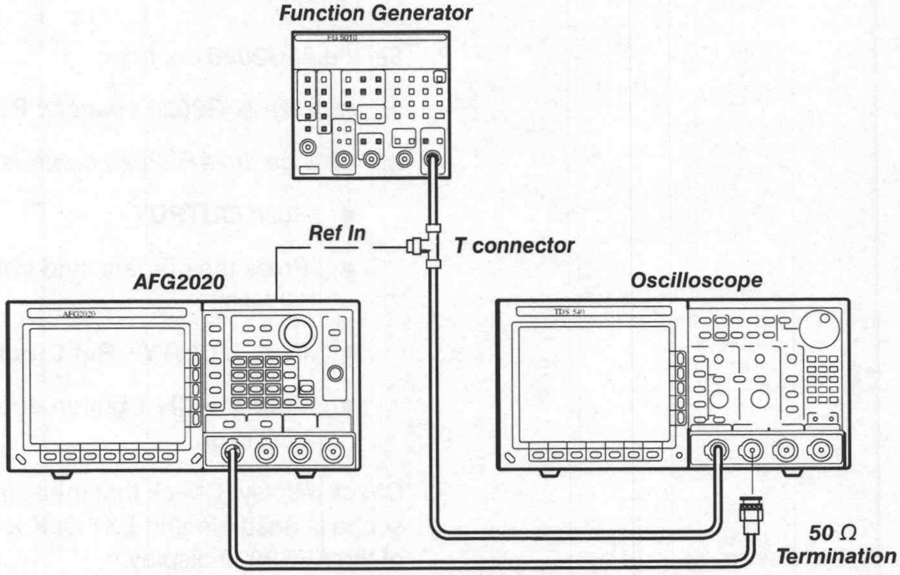


Figure 4-23: Connections for Checking REF IN Clock

   b. *Set the oscilloscope controls:*

Vertical	
CH1 coupling	DC
CH1 scale	2 V/div.
CH2 coupling	DC
CH2 scale	1 V/div.
Horizontal	
Sweep	50 ns/div.

Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	2.0 V
Mode	Auto

c. *Set the function generator controls:*

Function	Square
Mode	Continuous
Parameter	
Frequency	9.99 MHz
Amplitude	5 V
Offset	2.5 V
Output	Off

2. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

   b. *Change the AFG2020 controls:*

      - Push **OUTPUT**.
      - Press the numeric and units keys to select a frequency of 10 MHz.
      - Push **UTILITY** **Ref Clock** **External**.
      - Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Check display:* Check that the sine waveform displayed on the oscilloscope is unstable and EXT CLK icon is blinking in the upper-right corner of the AFG2020 display.
4. *Enable function generator output:* Turn on the function generator output.
5. *Check display:* Check that the sine waveform displayed on the oscilloscope is stable and the EXT CLK icon is lit up on the AFG2020 display and is not blinking.
6. *Change controls:* Change the function generator frequency to 10.01 MHz.
7. *Check display:* Check that the sine waveform displayed on the oscilloscope is stable.
8. *End procedure:* Disconnect all connections to the AFG2020.

External AM Modulation Check

This procedure checks the amplitude and rise time of an AM modulated signal.

Electrical Characteristic Checked:

Amplitude modulation, external (see page 4-11).

Equipment Required: Two coaxial cables, a termination, a function generator, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

   a. *Hook up the equipment:* See Figure 4-24.

      - Connect the AFG2020 CH1 connector through a coaxial cable and termination to the oscilloscope CH1 vertical input.
      - Connect the function generator output through a coaxial cable to the AM IN CH1 connector on the AFG2020 rear panel.

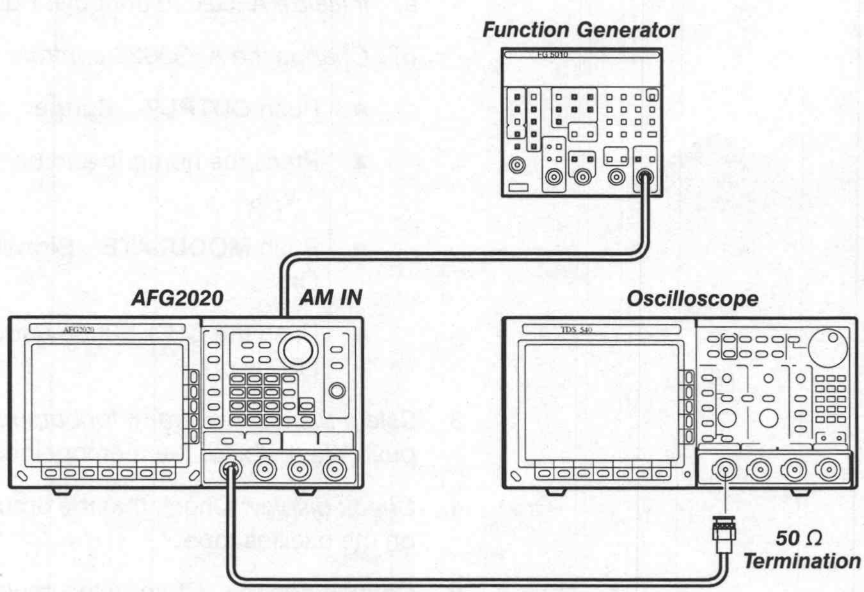


Figure 4-24: Connections for Checking External AM Modulation

b. *Set the oscilloscope controls:*

Vertical	
CH1 coupling	DC
CH1 scale	200 mV/div.
Horizontal	
Sweep	200 µs/div.
Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	0.5 V
Mode	Auto

c. *Set the function generator controls:*

Function	Square
Mode	Continuous
Parameter	
Frequency	1 kHz
Amplitude	1 V
Offset	0 V
Output	On

2. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

   b. *Change the AFG2020 controls:*

   - Push **OUTPUT** **Range** **2 V_{p-p}** **Ampl/Offset**.
   - Press the numeric and units keys to select an amplitude of 1 V_{p-p}.
   - Push **MODULATE** **Signal** **External** **Modulate** to highlight On.
   - Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Select the test waveform for output:* Push **FUNCTION** **Arbitrary**. Then push **Wave #x** for the memory location containing Test Waveform 2.

4. *Check display:* Check that the amplitude of square wave is about 1 V_{p-p} on the oscilloscope.

5. *Change controls:* Change the oscilloscope horizontal scale factor to 0.5 µs/div.

6. *Check display:* Check that the rise time of AM modulated signal on the oscilloscope is within 2 µs.

7. *Check channel 2:* If Option 02 is installed in the AFG2020, check the CH2 output using the following procedure.

   a. *Change connections:*

      - Move the coaxial cable from the CH 1 connector to the CH 2 connector on the AFG2020 front panel.
      - Move the cable from the AM IN CH1 connector to the AM IN CH2 connector on the AFG2020 rear panel.

   b. *Check channel 2 limits:* Repeat steps 1b through 6, except after initializing the AFG2020, push **Channel** to highlight CH2. This allows you to set the parameters for channel 2., turning on the output for channel 2.

8. *End procedure:* Disconnect all connections to the AFG2020.

External Trigger Level Accuracy Check

This procedure checks the accuracy and range of the AFG2020 response to an external trigger.

Electrical Characteristic Checked:

Trigger/gate input sensitivity, minimum width, and accuracy (see page 4-16).

Equipment Required: Three coaxial cables, a BNC TEE adapter, a dual banana adapter, a termination, a digital multimeter (DMM), a function generator, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

   a. *Hook up the equipment:* See Figure 4-25.

      - Connect the AFG2020 CH1 connector through a coaxial cable and termination to the oscilloscope CH1 vertical input.
      - Connect the function generator output through a coaxial cable to the BNC TEE adapter.
      - Connect a coaxial cable from the BNC TEE adapter through a dual banana adapter to the DMM input.
      - Connect the BNC TEE adapter directly to the TRIGGER INPUT connector on the AFG2020 front panel.

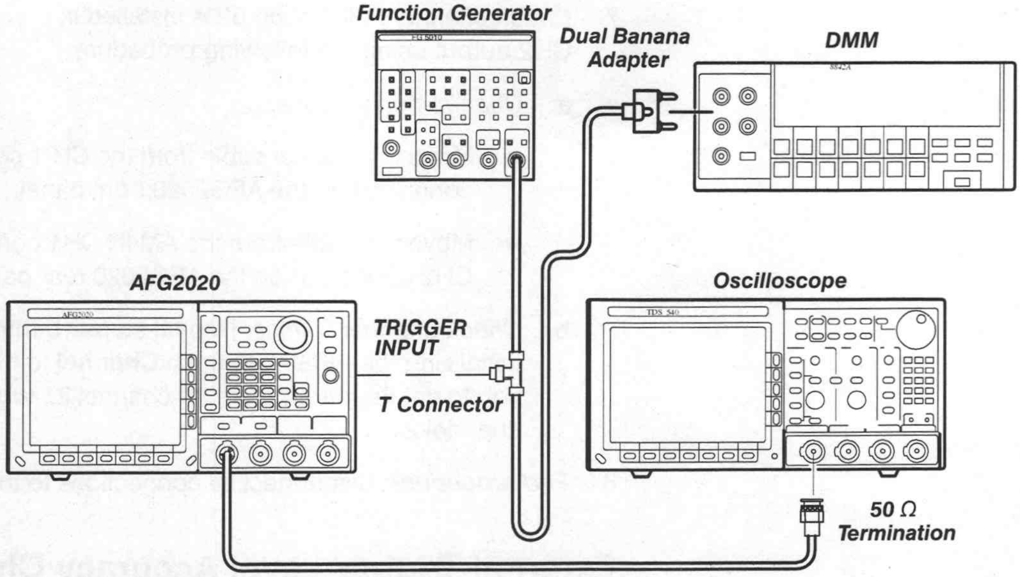


Figure 4-25: Connections for Checking External Trigger Level

b. *Set the oscilloscope controls:*

Vertical	
CH1 coupling	DC
CH1 scale	500 mV/div.
Horizontal	
Sweep	500 μs/div.
Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	0 V
Mode	Auto

c. *Set the function generator controls:*

Function	Square
Mode	Triggered
Parameter	
Frequency	1 kHz
Amplitude	0.0 V
Offset	0.0 V
Output	On

d. *Set the DMM controls:*

Function	VDC
Range	Auto

2. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

   b. *Change the AFG2020 controls:*

      - Push **TRIGGER MODE** **Gate** **Source** to select External.
      - Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Check trigger levels:*

   a. Set AFG2020 trigger level:

      - Push **Level**.
      - Press the numeric and unit keys and press ENTER to select the first trigger level listed in Table 4-13.

   b. *Locate trigger point:* Increment or decrement the function generator offset level to find the trigger point where output starts and stops (or stops and then starts) on the oscilloscope display.

   c. *Check limits:* Check that the DMM reading is within the triggered voltage range listed in Table 4-13 for the selected trigger level. Repeat beginning with substep 3a for the other trigger levels listed in the table.

Table 4-13: Accuracy of the External Trigger Level

AFG2020 Trigger Level (V)	Triggered Voltage Range (V)
0.0	−0.10 to +0.10
+0.5	+0.35 to +0.65
+1.0	+0.80 to +1.20
+2.0	+1.70 to +2.30
+5.0	+4.40 to +5.60
−0.5	−0.35 to −0.65
−1.0	−0.80 to −1.20
−2.0	−1.70 to −2.30
−5.0	−4.40 to −5.60

4. *Check trigger level range:*

   a. *Change AFG2020 controls:* Press the numeric and units keys to select a trigger level of +9.9 V.

   b. *Change function generator controls:*

Parameter	
Amplitude	10.0 V
Offset	4.9 V
Complement	On

   c. *Locate trigger point:* Increment or decrement the function generator offset level to find the trigger point where output starts and stops (or stops and then starts) on the oscilloscope display.

d. *Check limits:* Check that the DMM reading is between 8.81 V and 10.99 V.

e. *Change AFG2020 controls:* Press the numeric and units keys to select −9.9 V.

f. *Change function generator controls:*

Parameter	
Offset	−4.9 V
Complement	Off

g. *Locate trigger point:* Increment or decrement the function generator offset level to find the trigger point where output starts and stops (or stops and then starts) on the oscilloscope display.

h. *Check limits:* Check that the DMM reading is between −8.81 V and −10.99 V.

5. *Check trigger level accuracy on negative slope:*

a. *Change AFG2020 controls:*

- Press the numeric and units keys to select 0.0 V.
- Push **Slope** to highlight − (negative).

b. *Change function generator controls:*

Parameters	
Amplitude	0 V
Offset	0 V

c. *Check negative slope:* Repeat steps 3 and 4 to check that the external trigger level accuracy for the negative slope.

6. *Check trigger STOP control:* The AFG2020 will stop triggering for positive triggered voltage range values.

a. *Change connections:*

- Disconnect the BNC TEE adapter from the AFG2020 TRIGGER INPUT connector.
- Connect the function generator output through a coaxial cable to the AFG2020 TRIGGER INPUT connector (see Figure 4-26).

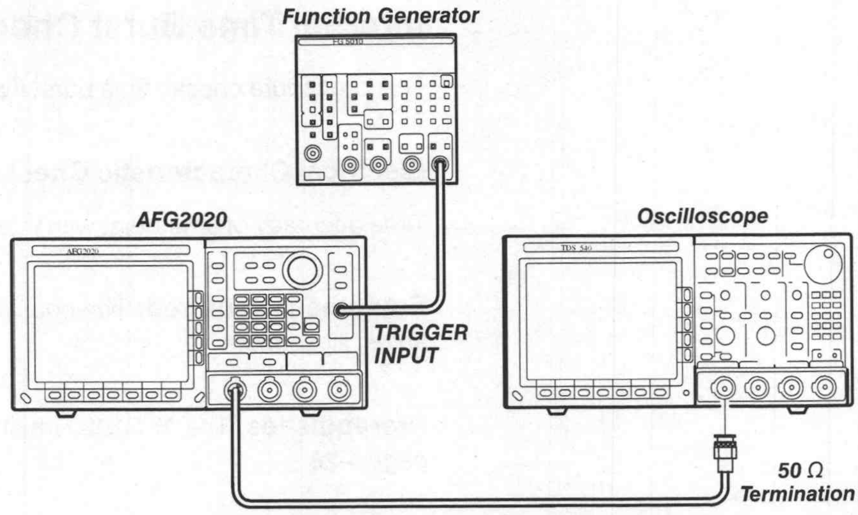


Figure 4-26: Connections for Checking External Trigger Level

b. *Change function generator controls:*

Function	Square
Mode	Triggered
Parameter	
Frequency	10.0 MHz
Symmetry	30%
Amplitude	210 mV
Offset	0.0 V
Output	On

c. *Change AFG2020 controls:*

- Push **Triggered Cont**.
- Push **Slope** +.
- Press the numeric and units keys to select a level of 0.0 V.
- Press **STOP** to stop the output signal.

d. *Check limits:* Press the function generator Manual Trigger key and check that the waveform output simultaneously begins on the oscilloscope display.

7. *End procedure:* Disconnect all connections to the AFG2020.

Internal Time Burst Check

This procedure checks time burst frequency and duration.

Electrical Characteristic Checked:

Time accuracy of time burst with internal trigger (see page 4-17).

Equipment Required: Two coaxial cables, a termination, a counter, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

   a. *Hook up the equipment:* See Figure 4-27.

   - Connect the AFG2020 CH1 connector through a coaxial cable and termination to the oscilloscope CH1 vertical input.
   - Connect the AFG2020 SYNC output through a coaxial cable to the counter input.

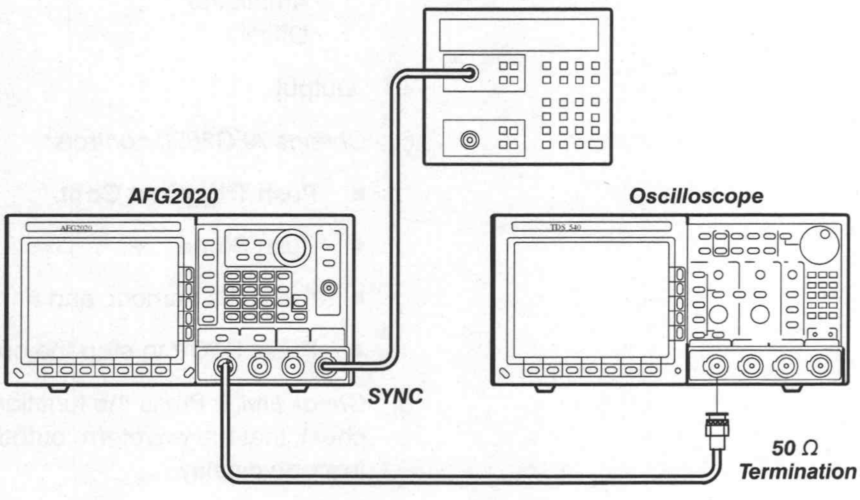


Figure 4-27: Connections for Checking Internal Time Burst

   b. *Set the oscilloscope controls:*

Vertical	
CH1 coupling	DC
CH1 scale	200 mV/div.

Horizontal	
Sweep	200 ns/div.
Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	0 V
Mode	Auto

c. *Set the counter controls:*

Mode	Period

2. *Set the AFG2020 controls:*

a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

b. *Change the AFG2020 controls:*

- Push **Triangle** **OUTPUT**.
- Press the numeric and units keys to select a frequency of 400 kHz.
- Push **TRIGGER MODE** **Time Burst** **Source** to highlight Internal.
- Push **Trigger Period**, and press the numeric and units keys to select 100 μs.
- Push **Time** (or **CH Time**, if Option 02 is installed) to highlight the burst time for CH1, and use the numeric and units keys to select 0.4 μs.
- Push the **CH 1** button above the CH 1 output connector so the LED is on.

c. *Check limits:* Check that the counter reading is 100 μs ±1 μs.

d. *Check display:* Check that the duration of the rising portion of the signal displayed on the oscilloscope is 400 ns ±100 ns.

3. *Check channel 2:* If Option 02 is installed in the AFG2020, check the channel 2 output signal using following procedure:

a. *Change connections:* Move the cable from the AFG2020 CH 1 connector to the CH 2 connector.

b. *Change AFG2020 channel:* Push **OUTPUT** **Channel** to highlight CH2.

c. *Change AFG2020 controls:*

- Push **FUNCTION** **Square**.
- Push **TRIGGER MODE** **Time** (or **CH Time**, if Opt. 02 is installed) to highlight the burst time for CH2 and press the numeric and units keys to select 0.4 µs.
- Push the **CH 2** button above the CH 2 output connector so the LED is on.

d. *Check display:* Check that the duration of the rising portion of the signal displayed on the oscilloscope is within 400 ns ±100 ns.

4. *End procedure:* Disconnect all connections to the AFG2020.

External Trigger Delay Check

This procedure checks the delay time from the external trigger input to the SYNC output (Td1) and from the SYNC output to the waveform output (Td2).

Electrical Characteristic Checked:

Trigger delay: external input to SYNC (Td1) and SYNC to output (Td2) with synthesizer on and off (see page 4-17).

Equipment Required: Three coaxial cables, two terminations, a BNC TEE adapter, a function generator, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

a. *Hook up the equipment:* See Figure 4-28.

- Connect the AFG2020 CH 1 SYNC connector through a coaxial cable and termination to the oscilloscope CH2 vertical input.
- Connect a BNC TEE adapter directly to the AFG2020 TRIGGER INPUT connector.
- Connect the one side of the BNC TEE adapter through a coaxial cable to the function generator output connector.
- Connect the other side of the BNC TEE adapter through a coaxial cable to the oscilloscope CH1 vertical input.

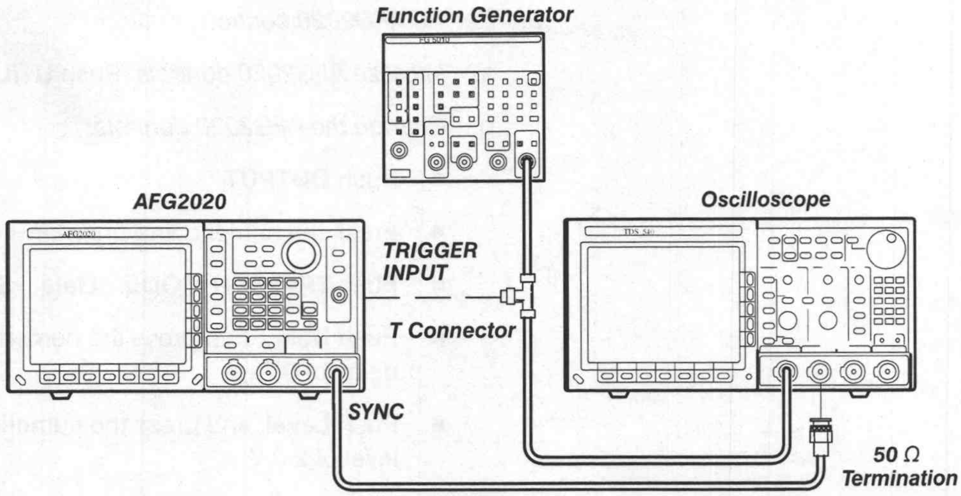


Figure 4-28: Connections for Checking External Trigger Delay Td1

b. *Set the oscilloscope controls:*

Vertical	
CH1 coupling	DC
CH1 scale	1 V/div.
CH2 coupling	DC
CH2 scale	500 mV/div.
Horizontal	
Sweep	100 ns/div.
Trigger position	10%
Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	1 V
Mode	Auto

c. *Set the function generator controls:*

Function	Square
Mode	Continuous
Parameter	
Frequency	10 kHz
Amplitude	4 V
Offset	2.0 V
Output	On

2. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

   b. *Change the AFG2020 controls:*

      - Push **OUTPUT**.
      - Press the numeric and units keys to select 1 MHz.
      - Push **TRIGGER MODE** **Gate** **Source** to highlight External.
      - Push **Delay**, and press the numeric and units keys to select a delay of 0.7 μs.
      - Push **Level**, and press the numeric and units keys to select a level of 2.0 V.
      - Push the **CH 1** button above the CH 1 output connector so the LED is on.

3. *Check trigger delay from external input to SYNC output (Td1):*

   a. *Check limits:* Check that the delay time between the rising edge of the oscilloscope CH1 waveform and the rising edge of the oscilloscope CH2 waveform is 200 ns ±100 ns. The CH2 waveform jitter is about 100 ns.

   b. *Change oscilloscope controls:*

      Trigger
      Slope Negative

   c. *Change AFG2020 controls:* Push **Slope** to select – (Negative).

   d. *Check limits:* Check that the delay time between the falling edge of the oscilloscope CH1 waveform and the rising edge of the oscilloscope CH2 waveform is 200 ns ±100 ns. The CH2 waveform jitter is about 100 ns.

   e. *Change oscilloscope controls:*

      Trigger
      Slope Positive

   f. *Change AFG2020 controls:*

      - Push **OUTPUT** **Synth** to select Off.
      - Push **TRIGGER MODE** **Slope** to select + (positive).

   g. *Check limits:* Check that the delay time between the rising edge of the oscilloscope CH1 waveform and the rising edge of the oscilloscope CH2 waveform is 550 ns ±100 ns. The CH2 waveform jitter is about 100 ns.

   h. *Change connections:* Remove all connections to the AFG2020.

4. *Check trigger delay from SYNC output to waveform output (Td2):*

   a. *Hook up the equipment:* See Figure 4-29.

   - Connect the AFG2020 CH 1 output through a coaxial cable and termination to the oscilloscope CH2 vertical input.
   - Connect the AFG2020 SYNC output through a coaxial cable and termination to the oscilloscope CH1 vertical input.
   - Connect the AFG2020 TRIGGER INPUT through a coaxial cable to the function generator output connector.

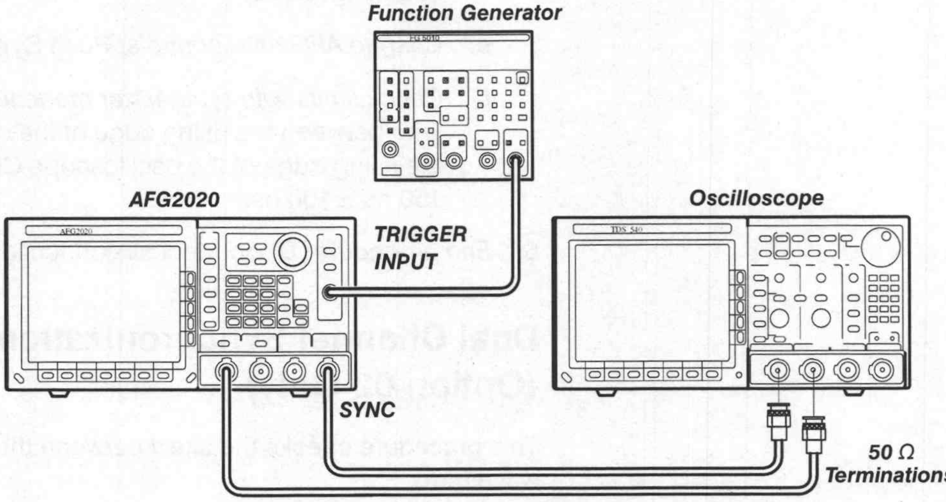


Figure 4-29: Connections for Checking External Trigger Delay Td2

   b. *Check limits with synthesizer mode turned off:* Check that the delay time between the rising edge of the oscilloscope CH1 waveform and the rising edge of the oscilloscope CH2 waveform is 150 ns ±100 ns.

   c. *Change AFG2020 controls:* Push **OUTPUT** **Synth** to select On.

   d. *Check limits with synthesizer mode turned on:* Check that the delay time between the rising edge of the oscilloscope CH1 waveform and the rising edge of the oscilloscope CH2 waveform is 500 ns ±100 ns.

5. *Check channel 2:* If Option 02 is installed in the AFG2020, check the delay time for channel 2 using the following procedure:

   a. *Change connections:* Move the cable from the AFG2020 CH 1 connector to the CH 2 connector.

   b. *Change AFG2020 channel:* Push **Channel** to highlight CH 2

c. *Change AFG2020 controls:*

- Push the **CH 2** button above the CH 2 output connector so the LED is on.
- Push **Ampl/Offset**.
- Press the numeric and units keys to select an amplitude of 1 $V_{p\text{-}p}$.

d. *Check limits with synthesizer mode turned on:* Check that the delay time between the rising edge of the oscilloscope CH1 waveform and the rising edge of the oscilloscope CH2 waveform is within 500 ns ±100 ns.

e. *Change AFG2020 controls:* Push **Synth** to select Off.

f. *Check limits with synthesizer mode turned off:* Check that the delay time between the rising edge of the oscilloscope CH1 waveform and the rising edge of the oscilloscope CH2 waveform is within 150 ns ±100 ns.

6. *End procedure:* Disconnect all connections to the AFG2020.

Dual Channel Synchronization Check (Option 02 Only)

This procedure checks the skew between the channel 1 and channel 2 waveforms.

Electrical Characteristic Checked:

Second channel skew (see page 4-19).

Equipment Required: Two coaxial cables, two terminations, and an oscilloscope.

Prerequisites: The AFG2020 must meet the prerequisites listed on page 4-28.

Procedure:

1. *Install the test hookup and set test equipment controls:*

a. *Hook up the equipment:* See Figure 4-30.

- Connect the AFG2020 CH 1 output connector through a coaxial cable and termination to the oscilloscope CH1 vertical input.
- Connect the AFG2020 CH 2 output connector through a coaxial cable and termination to the oscilloscope CH2 vertical input.

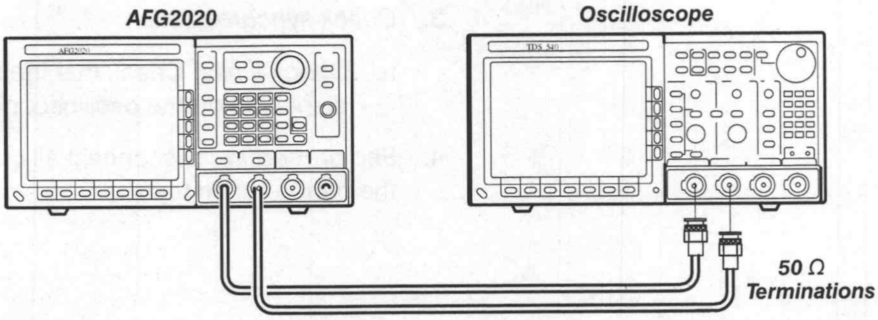


Figure 4-30: Connections for Checking Dual Channel Synchronization

b. *Set the oscilloscope controls:*

Vertical	
CH1 coupling	DC
CH1 scale	1 V/div.
CH2 coupling	DC
CH2 scale	500 mV/div.
Horizontal	
Sweep	1 ns/div.
Trigger position	10%
Trigger	
Source	CH1
Coupling	DC
Slope	Positive
Level	0 V
Mode	Auto

2. *Set the AFG2020 controls:*

   a. *Initialize AFG2020 controls:* Push **UTILITY** **Init** **O.K.**

   b. *Change the AFG2020 controls:*

   - Push **Square** **Freq/Phase**.
   - Press the numeric and units keys to select a frequency of 2.5 MHz.
   - Push **Channel** to highlight CH2.
   - Push **Square** **Freq/Phase**.
   - Press the numeric and units keys to select a frequency of 2.5 MHz.
   - Push the **CH 1** button above the CH 1 output connector so the LED is on.
   - Push the **CH 2** button above the CH 2 output connector so the LED is on.

3. *Check synchronization:*

   a. *Check limits:* Check that the skew between the two waveforms displayed on the oscilloscope is within 2 ns.

4. *End procedure:* Disconnect all connections to the AFG2020. This ends the performance tests.

Appendix D: Sample Waveform Library

The Edit menu has a function waveform Library selection in the bottom menu of the graphic display. See *Function Library* in *Section 3* for details. Here is explanation of the equations in the Library. An i in an equation means an address in the waveform memory, and i takes a value that is 0, 1, 2, ..., 1023. The value of waveforms are normalized within ±1.000.

Gaussian Pulse

The pulse width is 23.486% of the cycle.

Equation:

$$Xi = \frac{i - 512}{512}$$

$$Yi = e(-\, pi \times (2 \times Xi)^2)$$

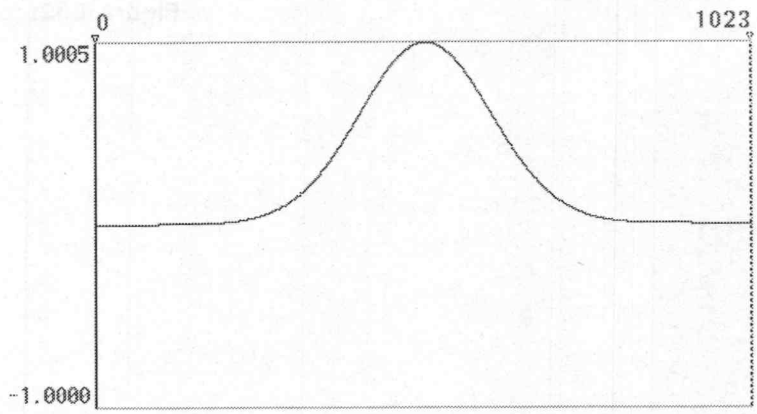


Figure 4-31: Gaussian Pulse – # 1

Lorentz Pulse

The pulse width is 3.125% of the cycle.

Equation:

$$Xi = \frac{i - 512}{512}$$

$$Yi = \frac{1}{(32 \times Xi)^2 + 1}$$

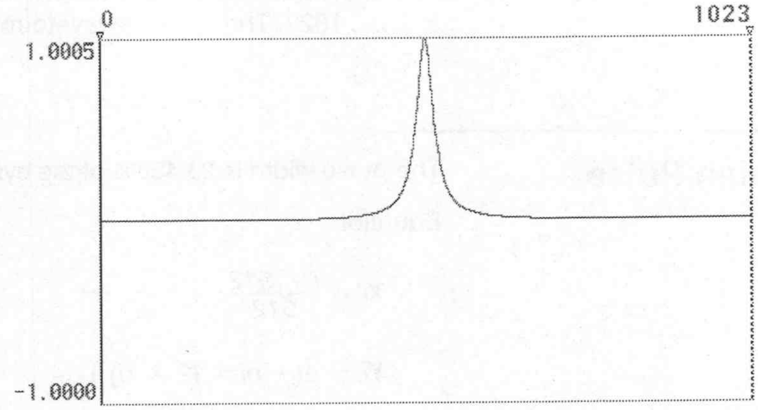


Figure 4-32: Lorentz Pulse – # 2

Sin(X)/X Pulse

This waveform contains 32 cycles.

Equation:

$$Xi = \frac{i - 512}{512}$$

$$Yi = \frac{Sin(32 \times \pi \times Xi)}{32 \times \pi \times Xi}$$

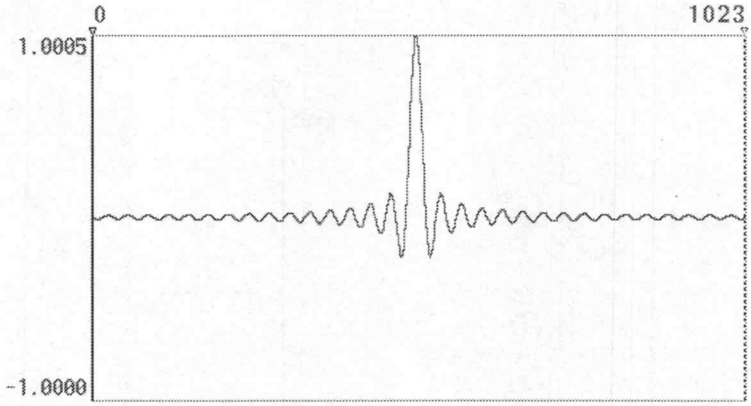


Figure 4-33: Sin(X)/X Pulse – # 3

Sin(X) * Sin(X) (Squared Sine Pulse)

The pulse width is 25% of the cycle.

Equation:

$$Xi = \frac{i - 512}{512}$$

$$Yi = \frac{Cos(2 \times \pi \times Xi)}{2} \quad |Xi| \leq 0.5$$

$$Yi = 0 \qquad\qquad |Xi| \geq 0.5$$

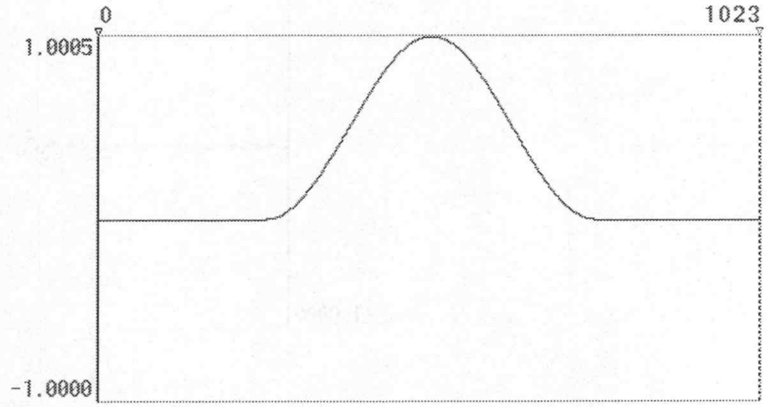


Figure 4-34: Squared Sine Pulse – # 4

Exponential Function Pulse

The half-life is 6.93% of the cycle.

Equation:

$$Xi = \frac{i}{1024}$$

$$Yi = exp\ (-10 \times Xi)$$

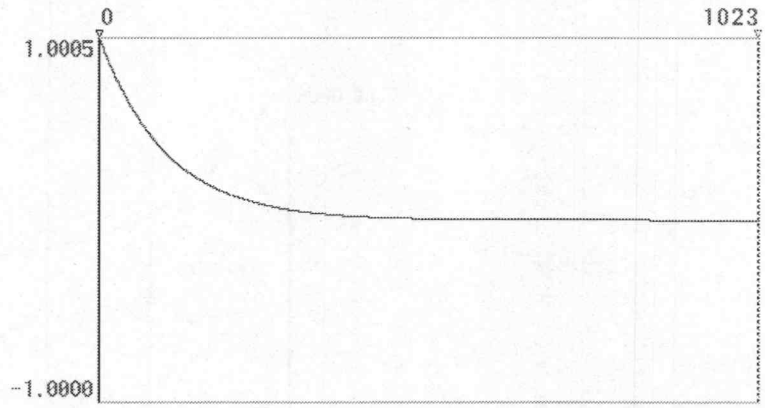


Figure 4-35: Exponential Pulse – # 5

Rising, Falling Exponential Pulse (Double Exponential Pulse)

This is a waveform with a rising peak on the 15th point, and does not converge in 1024 points.

Equation:

$$Xi = \frac{4.588}{15} \times i$$

$$Yi = \frac{1}{0.8905}(exp(-Xi/50) - exp(-Xi/1.2))$$

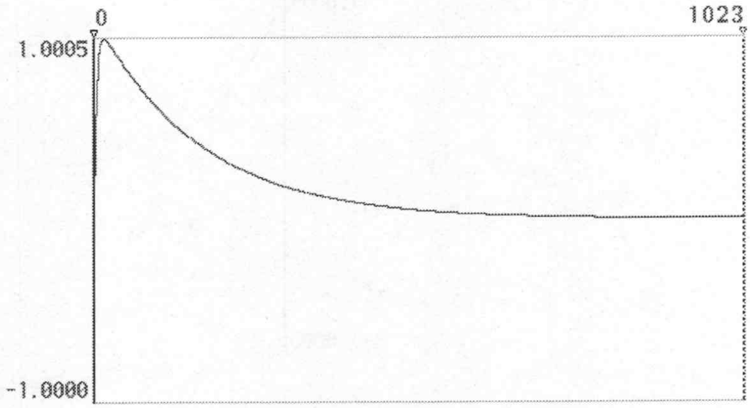


Figure 4-36: Rising and Falling Exponential Pulse – # 6

Electromagnetic Disk Waveform

The repetition frequency includes 3x and 5x high frequency harmonic waves.

Equation:

$$Xi = \frac{i}{1024}$$

$$Yi = \frac{9}{13}\{sin(2 \times \pi \times Xi) - k1 \times \sin(6 \times \pi \times Xi) + k2 \times \sin(10 \times \pi \times Xi)\}$$

$$k1 = \frac{1}{3} \qquad k2 = \frac{1}{9}$$

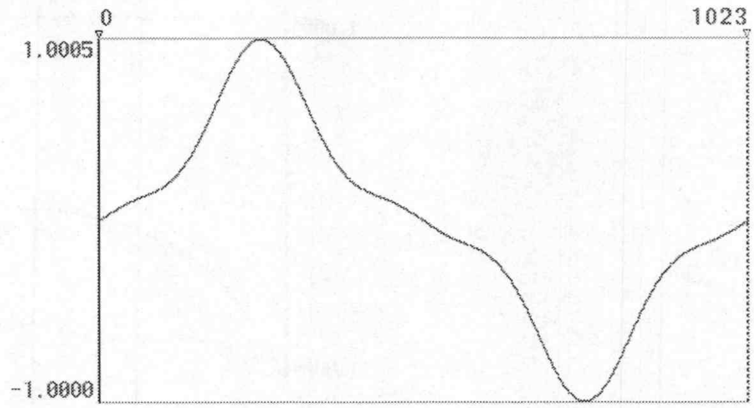


Figure 4-37: Electromagnetic Disk Waveform – # 7

Transient Voltage Test Signal

This is the JASO (Japan Automotive Engineering Society) transient voltage test signal. For actual testing, the signal is passed through a power amp.

Equation:

$$Xi = i$$

$$Yi = -e(-Xi/128.88) - 1 \qquad Xi \leq 511$$

$$Yi = 0.1 \qquad Xi \geq 512$$

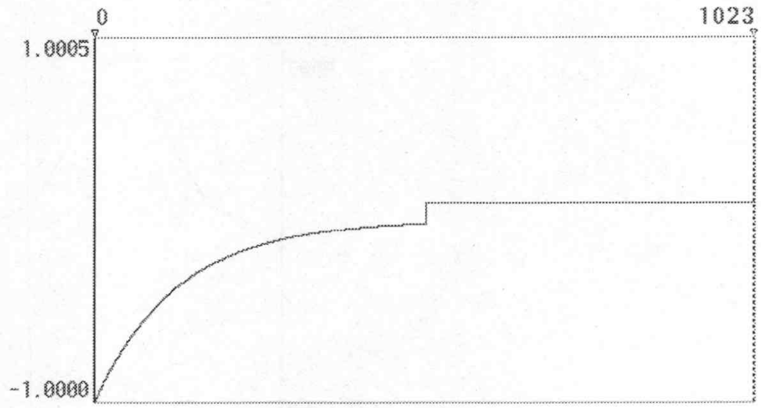


Figure 4-38: Transient Voltage Test Signal – # 8

Chirp Signal

The frequency varies linearly to 2x.

Equation:

$$Xi = \frac{i}{1024}$$

$$Yi = sin(16 \times \pi \times Xi + 8 \times \pi \times Xi \times Xi)$$

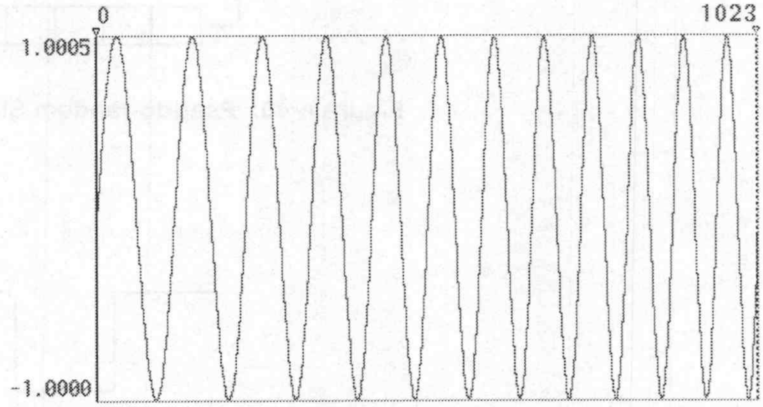


Figure 4-39: Chirp Signal – # 9

NRZ Random Signal

This is a 511 bits m-series pseudo-random signal generated with the shift register shown in Figure 4-40. The shift register bits are initially set to 1 and the data is changed every two samples.

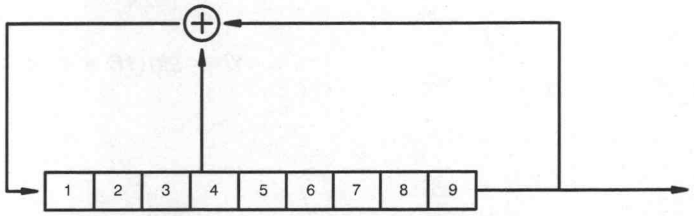


Figure 4-40: Pseudo-random Signals Generated with Shift Register

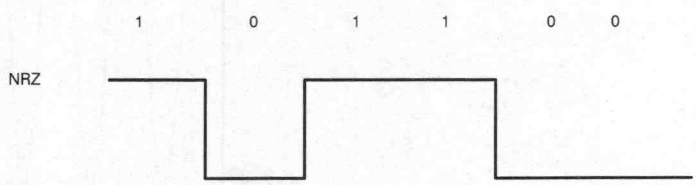


Figure 4-41: NRZ Random Signal – # 10

RZ Random Signal

RZ signals are generated in the same way as NRZ signals, but they always change through electrical zero.

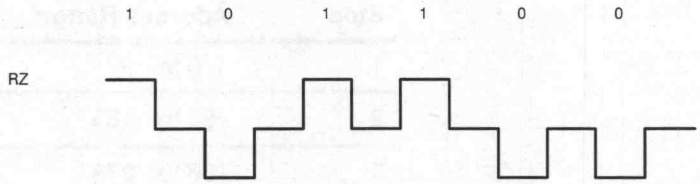


Figure 4-42: RZ Random Signal – # 11

Pulse Modulated Signal

The waveform memory is divided into 32 blocks of 32 points each. The number of points with the +1 level and the number of points with the −1 level are increased or decreased by 2 to vary the pulse width.

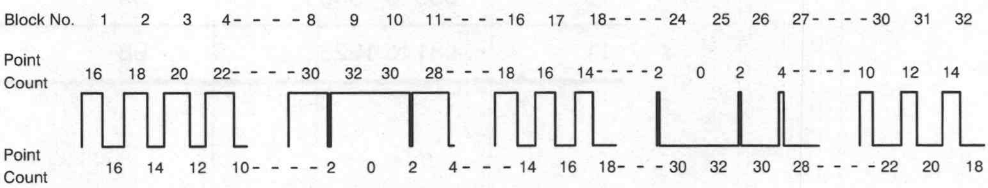


Figure 4-43: Pulse Modulated Signal – # 12

Stair Wave

This is an 11-level stair wave. The address range for each step and its level in hexadecimal are shown in the table below.

Step	Address Range	Number of Points	Level
1	0 to 92	93	000
2	93 to 185	93	199
3	186 to 278	93	333
4	279 to 371	93	4CC
5	372 to 464	93	666
6	465 to 558	94	7FF
7	559 to 651	93	998
8	652 to 744	93	B32
9	745 to 837	93	CCB
10	838 to 930	93	E65
11	931 to 1023	93	FFE

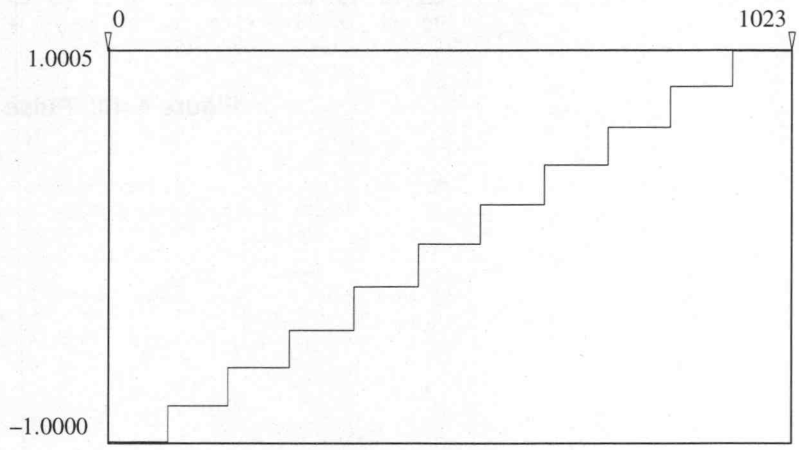


Figure 4-44: Stair Wave – # 13

Vacant

The function waveform library is vacant in waveform # 14.

Function Ramp

When this item is selected in the function library menu, the Ramp function waveform set in the FUNCTION menu is copied into the Edit buffer and displayed in the Edit area on the screen.

Function Pulse

When this item is selected in the function library menu, the Pulse function waveform set in the FUNCTION menu is copied into the Edit buffer and displayed in the Edit area on the screen.

Appendix E: Miscellaneous

This appendix covers the following items.

- Initial settings
- Repackaging for shipment

Initial Settings

The AFG2020 settings can be initialized to certain factory defaults with the Init function in the UTILITY menu (refer to the UTILITY menu description in *Section 3, Reference*, for details). Also, when this instrument is switched on, the same default settings are obtained.

FUNCTION menu:

Waveform copied into waveform memory

Sine		

Ramp waveform parameters

Ramp	Rise	100.0 %
	Fall	0.0 %

Pulse waveform parameters

Pulse	Width	20.0 %
	Transition	5.0 %
	Edge Type	Gaussian

Arbitrary waveform number selection

Arbitrary	Wave #1	

OUTPUT menu:

Synthesizer mode

Synth	On	

Frequency and Phase setting

Freq/Phase	Frequency	100.0000 kHz
	Phase	0.0 deg

Amplitude and Offset setting

Ampl/Offset	Amplitude	2.000 $V_{p\text{-}p}$
	Offset	0.000 V

Filter Setting

Filter	100 MHz	

Range Setting		
Range	AUTO	

TRIGGER MODE menu:

Trigger Mode Selection		
Cont		
Trigger Source Selection		
Source	Manual	
Trigger parameters		
	Delay	1.0 µs
	Slope	+
	Level	2.5 V
	Trigger Period	1.0000 s
	Time	10.0 µs

SWEEP menu:

Sweep Type		
Type	Std	
Dwell Time parameters		
Dwell Time	Sweep	10.00 ms
	Return	1.0 ms
Frequency parameters		
Freq	Start	100.00 kHz
	Stop	1.0000 MHz
	Step (Linear)	20.000 kHz
	Points Per Decade	100
	Spacing	Linear
Currently Selected Marker		
Marker	Selected Marker	#1
Marker parameters		
(Marker #1)	State	Off
	Frequency	100.00 kHz
	Time	0.5 µs
(Marker #2)	State	Off
	Frequency	550.00 kHz
	Time	0.5 µs
(Marker #3)	State	Off
	Frequency	1.0000 MHz
	Time	0.5 µs
State of CH2 Out (Option 02 installed)		
CH2 Out	Off	
State of Sweep function		
Sweep	Off	

Multiple Sweep parameters			
	Number of steps		1 step
	Log Spacing		0
	Frequency	Start	100.00 kHz
		Stop	1.0000 MHz
		Stp|Pnt (Linear)	20.000 kHz
		Stp|Pnt (Log)	100
	Time	Dwell	10.00 ms
	Marker		0

MODULATE menu:

Modulation Type			
	Type	AM	
Modulation signal type			
	Params	Signal	Sine
Modulation signal period			
	Params	Signal Period	1.0000 ms
AM modulation parameters			
	Params	Carrier Amplitude	1.000 V_{p-p}
		Depth	20.0 %
		DSB-SC	Off
OM modulation parameter			
	Params	High	0.50 V
		Low	−0.50 V
FM modulation parameter			
	Params	Center Frequency	1.0000000 MHz
		Deviation	10.0000 kHz
Digital modulation parameter			
	Key	Num of Key	2
		Data	2
		Key Period	833.3 μs
State of Modulate function			
	Modulate	Off	

UTILITY menu:

Ref Clock Source		
	Ref Clock	Internal

State of Channel Switch:

CH1 output	Off
CH2 output	Off

Repackaging For Shipment

If this instrument is shipped by commercial transportation, use the original packaging material. Unpack the instrument carefully from the shipping container to save the carton and packaging material for this purpose.

If the original packaging is unfit for use or is not available, repackage the instrument as follows:

1. Obtain a corrugated cardboard shipping carton having inside dimensions at least six inches greater than the instrument dimensions and having a carton test strength of at least 275 pounds.

2. If the instrument is being shipped to a Tektronix Service Center for repair or calibration, attach a tag to the instrument showing the following:

- Owner of the instrument (with address)
- Name of a person at your firm who may be contacted if additional information is needed
- Complete instrument type and serial number
- Description of the service required

3. Wrap the instrument with polyethylene sheeting or equivalent to protect the outside finish and prevent entry of packing materials into the instrument.

4. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between the carton and the instrument, allowing for three inches of padding on each side (including top and bottom).

5. Seal the carton with shipping tape or with an industrial stapler.

6. Mark the address of the Tektronix Service Center and your return address on the carton in one or more prominent locations.

Glossary

Glossary

ADIFC
The Analog Data Interchange Format Conversion software that converts waveform data received from specified Tektronix measuring instruments so it can be processed by the AFG2020.

AM
The amplitude modulation function whose parameters are selectable in the MODULATE Menu.

ARB
Industry slang that generally refers to instrumentation which converts digital information into an analog waveform. These products are based upon a digital memory array which is clocked out for creation of the output waveform.

Analog modulation
A method in which the carrier wave is modulated continuously by parameter variances defined in the MODULATE Menu.

Arbitrary function generator
A hybrid instrument integrating the features of an arbitrary waveform generator with the full function generator capabilities. It often includes a built-in sweeper.

Arbitrary waveform generator
Essentially a digital-to-analog converter with built-in memory, plus trigger and output mode settings.

Cont
An AFG2020 triggering mode that continuously outputs waveforms.

DDS
Direct Digital Synthesis. A synthesizer design which provides exececllent frequency accuracy, stability, resolution, and agility (ability to change frequency).

Filter
An output parameter that restricts the frequency band. The desired filter is selectable in the OUTPUT Menu.

FM
The frequency modulation function whose parameters are selectable in the MODULATE Menu.

Digital modulation
For the AFG2020, either frequency shift keying or phase shift keying. A data key sequence created in the MODULATE Menu defines a desired modulation pattern to be applied to the waveform in waveform memory (i.e., carrier wave).

General purpose knob
The front panel rotary knob that is used to select items or move the cursor position within the CRT display area.

Internal memory
The AFG2020 internal random access memory.

Key
A step in digital modulation that defines deviation parameters such as phase, frequency, and offset.

Key period
The time between key switches in a data key sequence.

LPF
Low Pass Filter. The AFG2020 has 50 MHz and 100 MHz output filters.

NV Ram
The AFG2020 internal nonvolatile random access memory.

Library
A set of special predefined function waveforms found in the EDIT Menu.

Pan
Allows display of waveform segments across the horizontal time axis of a zoomed waveform in the EDIT Menu.

Sequence program
An assembly of modulation data keys serially ordered to create a desired pattern. See the MODULATE Menu description in *Section 3* for details.

Standard function waveforms
A set of common predefined waveforms such as sine waves, square waves, triangle waves, and ramps. These are found in the EDIT Menu.

VALUE button
The front panel button used in conjunction with the general purpose knob and popup menu windows to select and enter alphanumeric input in the CRT display area.

Sweep
A sawtooth wave with frequency along the vertical axis and time along the horizontal axis. The sweep function varies the frequency either linearly or logarithmically.

Zoom
Magnifies the horizontal time axis display of waveform data, but does not actually change the data in internal waveform memory. See the EDIT Menu description in *Section 3* for details.

Index

Index

Numbers

A

B

C

D

E

F

R

S

T

U

V

W