OPERATOR'S & MAINTENANCE MANUAL

Model 288

20 MHz Synthesized Function Generator

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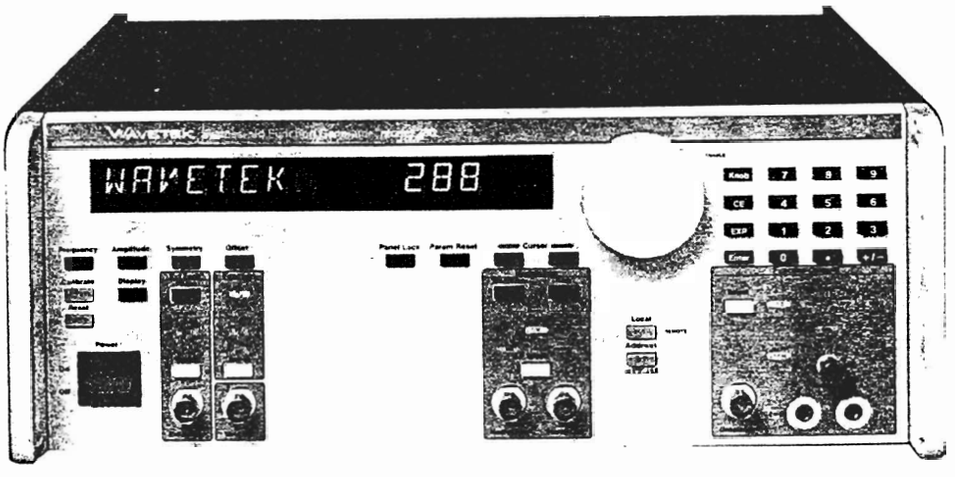


Model 288 20 MHz Synthesized Function Generator

SECTION 1
GENERAL

1.1 INTRODUCTION

The Model 288 Signal Generator is a precision source of sine, triangle, and variable symmetry (ramp and pulse) waveforms for use in the installation and maintenance of radio receivers, transmitters, and other electronic equipment.

- Push button control for easy operation.
- Indicator lights give constant equipment status.
- Large, 16 character (fourteen segments/ character), display for all parameters.
- Programmed interface for remote operation.
- Programmable sine, triangle, square, and dc outputs.
- Variable symmetry provides pulse and ramp waveforms.
- Balanced and unbalanced outputs.
- Built-in calibration and fault analysis programs with extensive self-adjustment.
- Battery backup for saving system setups.

1.1.1 List of Abbreviations

This list identifies abbreviations and descriptions used in this manual that are not contained in MIL-STD-12. For abbreviations used in this manual but not contained in this list refer to MIL-STD-12.

Abbreviation	Term
dBc	dB relative to carrier
dBm	dB relative to 1 milliwatt
fc	carrier frequency
fm	modulating frequency
GPIB	General Purpose Interface Bus
VCF	Voltage Controlled Frequency
VFD	Vacuum Fluorescent Display

1.2 OPTIONS

001: Special 24-pin extender card when used in conjunction with Option 002 permits user access to test points and components on the various circuit cards with or without power being applied.

002: 40-pin Extender Card – Special 40-pin extender card when used in conjunction with Option 001 permits user access to test points and components on the various circuit cards with or without power being applied.

003: Rack Mounting Kit

1.3 SPECIFICATIONS

1.3.1 Waveforms (Functions)

Sine, triangle and square; variable symmetry for pulse and ramp waveforms; and dc.

1.3.2 Operational Modes

Continuous (CW): Synthesized frequency output with selected parameters.

Amplitude Modulation (AM): Same as CW except that maximum amplitude limited to 15 Vp–p (open circuit) and external signal modulates the amplitude of the selected output.

Frequency Modulation (FM and VCF): External input modulates the frequency output.

Sweep Modulation: All symmetrical waveforms swept over 3 decades from Start to Stop frequency (up or down) at programmed rate.

Rate: 100 ms to 100s.

Start/Stop Accuracy: < ± 3%.

Phase Lock: Frequency, stability and purity controlled by external reference. In all modes except FM and Sweep, generator will lock to applied external 20 Hz to 20 MHz sine wave.

Lock Phase Angle: ± 180° (± π radians).

Resolution: 1°.

Accuracy: 50 Hz to 10 MHz, ± (4° + 20 ns).

1.3.3 Waveform Quality

Sine Distortion: Unbalanced output, Total Harmonic Distortion.

2 mHz to 20 Hz: – 40 dB.
20 Hz to 100 kHz: – 46 dB.
100 kHz to 1 MHz: – 40 dB.
1 MHz to 6 MHz: – 34 dB.
6 MHz to 20 MHz: – 26 dB.

Time Symmetry: Programmable from 5% to 95% in 1% steps to 2 MHz, linearly decreasing to 50% fixed at 20 MHz.

Accuracy: < ± (2% + 20 ns). At 50%, < ± (0.1% + 20 ns).

Square Wave Transition Time: < 13 ns, 10% to 90%, full output, from 50Ω source into 50Ω load.

Square Wave Aberrations: Overshoot and ringing < (5% + 20 mV) of p–p amplitude.

Triangle Linearity: From 10% to 90% points:
2 mHz to 100 kHz: ± 1%.
100 kHz to 2 MHz: ± 2%.
2 MHz to 5 MHz: ± 10%.

1.3.4 Frequency

Range: 2 mHz to 20 MHz.
Synthesized: 20 Hz to 20 MHz.
600Ω or Balanced Output: 2 mHz to 1 MHz.
Amplitude Modulation: 0.1 Hz to 20 MHz.

Resolution: 3 1/2 digits (200 to 2000 counts in the display).

Accuracy: Percent of setting:
2 mHz to 20 Hz and FM or Sweep Modes: ± 3%.
20 Hz to 20 MHz: ± 0.05%.

Stability
Within 10 Minutes:
≤ 20 Hz and FM or Sweep Modes: ± 0.1%
> 20 Hz: ±0.001%.
Within 24 Hours:
≤ 20 Hz and FM or Sweep Modes: ± 0.5%
> 20 Hz: ± 0.002%.
Line Voltage Variation:
For ± 10% line variation and ≤ 20 Hz and all frequencies in FM and Sweep Modes: ± 0.1%.
> 20 Hz: ± 0.001%.
Temperature:
≤ 20 Hz and all frequencies in FM and Sweep Modes:
< 100 ppm/°C.
> 20 Hz: < 2 ppm/°C
Output level Variation:
≤ 20 Hz and all frequencies in FM and Sweep Modes:
± 0.1%
> 20 Hz: ± 0.001%.

1.3.5 Amplitude

Range:
Open Circuit: 2 mVp-p to 30 Vp-p.
Impedance Terminated: 1 mVp-p to 15 Vp-p.

Resolution: With no offset:
2 mVp-p to 20 Vp-p Open Circuit, (1 mVp–p to 10 Vp–p Terminated): 3 digits.
To 30 Vp-p (15 Vp-p Terminated): 3 1/2 digits.

Accuracy: % of Setting:

Sine :
To 999 mVp-p: ± 2% + 2 mV.
To 30 Vp-p: ± 2% + 10 mV.
Triangle and Square :
To 999 mVp-p: ± 3% + 4 mV.
To 30 Vp-p: ± 3% + 20 mV.

Flatness: To accuracy percent of setting:
For 100 kHz to 1 MHz: Additional ± 2%.
To 5 MHz: Additional ± 3%.
To 20 MHz: Additional ± 10%.

1.3.6 Offset

Range
± 10V (± 5V terminated).
Resolution
3 digits; may be reduced if both offset and waveform amplitude are programmed.
Accuracy
0.5V to 10V: ± 1% of setting + 20 mV.
1 mV to 500 mV: ± 1% of setting + 5 mV.

1.3.7 Outputs

Sync (Trigger) Output
Pulse at frequency of and in phase with square wave.
Low Level: < 0.4V.
High level: > 1.8V into 50Ω.
10-90% Transition Times: < 13 ns.

Horizontal Output
Ramp indicates sweep position.
Level: Fixed 0V to approx. + 5V (open circuit).
Source Impedance: 600Ω.

Unbalanced Output
Source Impedance:
To 1 MHz: 600Ω ± 1%.
To 20 MHz: 50Ω ± 1% or 75Ω ± 1%.

Balanced Output
Banana jacks for differential output of sine wave; universal binding post for common.
Source Impedance:
To 1 MHz: 135Ω ± 0.5% or 600Ω ± 1%
Output Unbalance:
10 Hz to 1 MHz: < 1% referenced to 1 kHz.

1.3.8 Inputs

External Trigger/Freq In
Input Impedance: 10 kΩ ± 2%.
Range (Sine Wave): 600 mVp-p to 30 Vp-p (into 10 kΩ), 20 Hz to 20 MHz.

Modulation In
Input Impedance: 10 kΩ ± 2%.
Bandwidth: DC to 100 kHz
Max Level: ± 20 Vp-p (into 10 kΩ).
FM Mode: ± 10V gives 1000:1 change. Apply as DC for VCF or AC for FM.
AM Mode: 4 Vp-p into 10 kΩ gives 100% AM.

1.3.9 Displays

Amplitude: V or mV peak-to-peak or peak. For symmetrical waveforms with no offset, displays amplitude in RMS or dBm.
Resolution: 100 to 999 counts or 0.1 dBm.
Offset: V or mV.
Resolution: 100 to 999 counts.
Frequency Including Sweep Start/Stop): mHz, Hz, kHz or MHz.
Resolution: 3 1/2 digits.
Period: sec, ms, µs or ns.
Resolution: 4 digits.
Symmetry: In %.
Resolution: ≥ 10 counts.
Resolution: resolves in 1° (deg) increments, displays radians in 4 digits.
Sweep Time: sec or ms with ≥ 100 counts.

1.3.10 GPIB Programming

Address: 0-30 selectable, battery backed.

Subsets: SH1, AH1, SR1, RL1, PP0, DC1, DT0, C0, T6, L4, TE0,LE0 and E1.

1.3.11 General

MIL-T-28800 Class 5 qualified.
Temperature Range: 0 to +50°C, - 40 to +70°C for storage.
Warm-up Time: 20 minutes for specified operation at 25 ± 10°C ambient temperature.
Humidity: 0 to +25°C at 95% RH, 0 to +40°C at 75% RH, and 0 to 50°C at 45% RH.
Altitude: 3050m (10,000 ft.); non-operating to 12,000m (40,000 ft.).
Vibration: 0.013 in. from 5 to 55 Hz (2g acceleration at 55 Hz).
Shock: Non-operating; 30g, 11 ms half-sine.
Electromagnetic Compatibility: MIL-STD-461A Notice 4 (EL). Emission and susceptibility requirements of CE02, CE04, CS02, CS06, RE02, RE02.1 and RS03.
Dimensions: 35.6 cm (14.00 in.) wide, 13.3 cm (5.219 in.) high and 43.2 cm (17.00 in.) deep.
Weight: Approximately 11.4 kg (25 lb) net; 13.6 kg (30 lb) shipping.
Power: 90 to 108, 108 to 126, 198 to 231, or 216 to 252 Vrms; 48 to 440 Hz; 1 phase; < 60 VA.

1.4 EQUIPMENT SUPPLIED

The Model 288 is supplied with a shielded power cord, spare fuse, and manual.

1.5 EQUIPMENT REQUIRED BUT NOT SUPPLIED

All items required for the Model 288 are supplied.

SECTION 2
PREPARATION

2.1 RECEIVING AND INSPECTING SHIPMENTS

Use the following steps to inspect a shipment of Wavetek equipment.

1. **Inspect the shipment.** Before unpacking the instrument, your receiving clerk should have checked the shipment for missing boxes, inspected each box for damage, and if necessary, have had the driver describe the box damage and list shortages on the delivery bill. If you find unreported shortages or damage, notify the shipper before further unpacking.
2. **After unpacking the boxes.** Save all of the packing material.
3. **Inspect the equipment for damage.** Inspect it carefully, regardless of the condition of the shipping boxes.
4. **If necessary, file a damage claim.** If any damage is found, call the shipper immediately (within 10 days) and start the claim process.
5. **Call Wavetek.** Call Wavetek's Customer Service department (619-279-2200) and tell them that the equipment arrived damaged.

2.2 RETURNING EQUIPMENT FOR REPAIR

Use the following steps when returning Wavetek equipment to Wavetek for repair.

1. **Save the packing material.** Always return the equipment to Wavetek in its original packing material and boxes. If you use inadequate packing material, you will have to pay to repair any shipping damage as carriers will not pay claims on incorrectly packed equipment.
2. **Call Wavetek for a Return Authorization.** Wavetek's customer service representative will ask for the name of the person returning the equipment, telephone number, company name, equipment type, and a description of the problem.

2.3 INITIAL CHECKOUT

2.3.1 Introduction

The following paragraphs provide the information required to prepare, turn-on, and checkout the Model 288 Signal Generator in the local mode. Information required for remote mode is provided in Section 3. Table 2-1 lists maintenance messages and error codes along with the probable cause and corrective action. Numbers shown in parentheses refer to keyed items in figure 2-1.

2.3.2 Preparation for Use

WARNING

The Model 288 Signal Generator is equipped with a three-wire power cable. When connected to a grounded AC power receptacle, this cable grounds the instrument front panel and cabinet. Do not use extension cords or AC adapters without a ground.

1. Verify that the front panel power switch (1) is set to Off .
2. Verify the the voltage selection card (5) on the rear panel matches the line voltage available in your area. Connect the power cable (6) to ac power connector (7) on rear panel.

Table 2-1. Voltage Selection Card Position and Fuse Size.

Input Voltage	Voltage Selection Card	Fuse
90 to 108	100	3/4 amp, Slo-Blo
108 to 126	120	3/4 amp, Slo-Blo
198 to 231	220	3/8 amp, Slo-Blo
216 to 252	240	3/8 amp, Slo-Blo

WARNING

This instrument uses an internal battery that contains 0.2 grams of Lithium. Do not charge or short this battery. A hazard of explosion and or contamination exists.

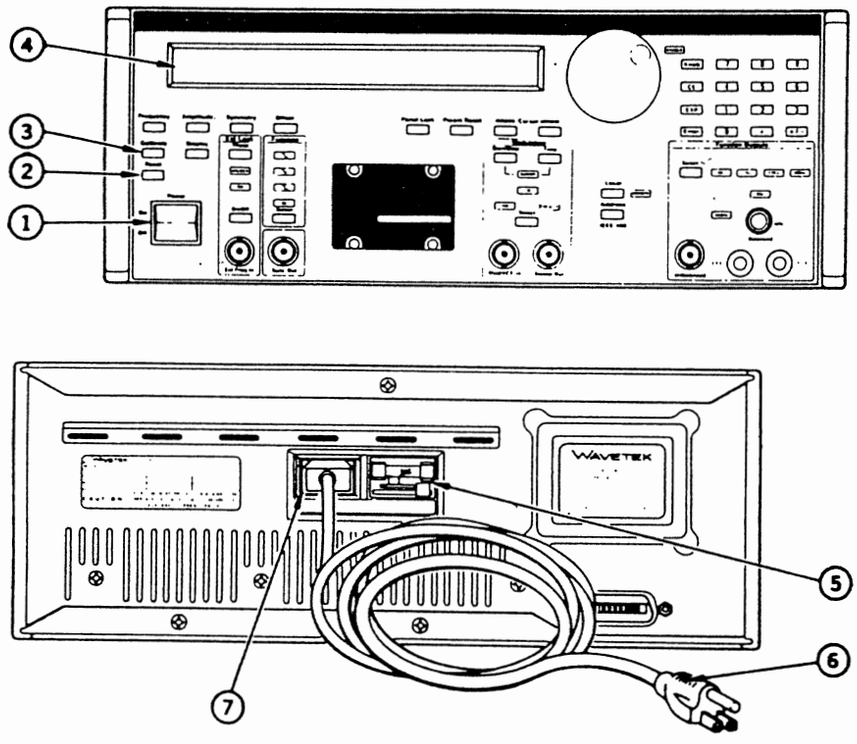


Figure 2-1. Equipment Setup

2.3.3 Turn-on and Initial Checkout Procedure

1. Verify that only the power cable (6) is connected to the Model 288. All other cables should be disconnected.
2. Set the Power On/Off switch (1) from Off to On. Verify that the Model 288 display (4) indicates "WAVETEK 288".

NOTE

If a maintenance message or error code is shown in display, refer to table 2-2 for probable cause and corrective action.

3. Press the Reset key (2). Verify that the following front panel conditions exist:

Display:	RESET (VX.XX)
Function:	Sine indicator ON
Modulation:	CW indicator ON
Function Outputs:	50Ω and UNBAL indicators ON
All other displays and indicators:	Off
Frequency:	FREQ 1 KHZ, PER 1 MILLISEC*
Amplitude:	AMPL 5VPP, AMPL 2.5VP, AMPL 1.77VRMS, AMPL 18DBM
Display:	INTENSITY 16*
Symmetry:	SYMM 50 PCT*
Phase:	PHASE 0 DEG/PHASE 0 RAD*
Offset:	DCOFF 0 VDC*
Start/Stop:	START 2 HZ/STOP 2 KHZ*
Time:	SWPTIME 1 SEC, SWPRATE 1 HZ*
Address:	ADDRS 00 to 30*

* Default value. Press key to display value(s).

4. Allow the Model 288 Signal Generator 20 minutes of warm-up time.

NOTE

- *Whenever the power cable has been disconnected, or the power switch has been in the Off position, the Model 288 requires a 20 minute waiting/warm-up period before the Calibrate key can be selected. If the Calibrate key is selected before 20 minutes, the display will indicate "WAIT XX.XX MIN" to show the time remaining.*

- *The Calibrate key performs only a 20 second self-check, and does not replace standard maintenance calibration.*

5. Press the Calibrate key (3). Verify that the display (4) indicates "CALIBRATING".
6. Wait approximately 20 seconds. Verify that the display (4) indicates "AUTOCALIBRATED".
7. If all above conditions are correct, the signal generator is ready for operation. If indication is incorrect, notify your maintenance department or return the instrument to Wavetek for repair.

2.3.4 Maintenance Messages and Error Codes

Some internal circuit failures cause maintenance messages or error codes to appear in the display. See table 2-2 for a list of possible maintenance messages/error codes and probable cause.

Table 2-2. Maintenance Messages and Error Codes.

Display	Probable Cause	Corrective Action
Err xxxxxxxxx	Improper self-check/unit	Press Calibrate key. If identical failure error is displayed, refer to section 6 (Troubleshooting Procedure). If a different error displayed, press the Calibrate key again. If "AUTO-CALIBRATED" is displayed, the unit is operational.
Low batt x.xxx v	Internal battery voltage low.	Unit is available for immediate operation. Replace the battery.
Cal Required	Internal battery dead.	Unit has lost it's calibration data but can be used after performing and passing AutoCal. Instrument may not meet all specifications.

2.3.5 Performance Verification

Performance verification tests the operation of every selectable parameter and input/output connector and to verify correct operation within each major specification. This verification is necessary only when there is a problem that is not identified by the AutoCal tests. All data obtained during the performance verification should be permanently recorded for future reference. The Performance Verification Form in Appendix A can be used as a master to generate additional copies as needed. Perform initial checkout procedures shown in paragraphs 2.3.2 and 2.3.3 prior to starting the performance verification.

Required Test Equipment - Table 5-2 lists the test equipment required to perform the performance verification procedure. Always keep test equipment interconnecting cables as short as possible.

Table 5-2. Required Test Equipment

Test Equipment	Recommended Model
Scope	Tektronix 2465 or equivalent.
THD Analyzer	Hewlett Packard 8903B or equivalent.
Digital Multimeter (DMM)	Not Critical
Signal Generator (Signal Source)	Not Critical

Frequency Range

1. Reset the Model 288
2. Connect the Model 288 and test equipment as shown in figure 2-2.

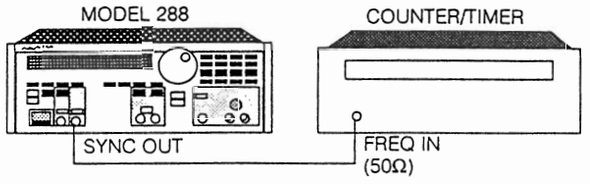


Figure 2-2. Frequency Measurement Setup

3. Program frequency to the top frequency of each of the top six decade frequency ranges and check synthesized frequency accuracy per the table in recorded data: RECORD.
4. Select FM Mode and repeat step 3 testing the uniocked frequency accuracy on all 10 ranges: RECORD.

Frequency Resolution

1. Reset the Model 288
2. Connect the Model 288 and test equipment as shown in figure 2-2.
3. Vary the synthesized frequency in steps over the 1999 Hz to 222 Hz frequency range per Appendix A - Performance Verification Form and measure the frequency resolution: RECORD.

Symmetry

1. Reset the Model 288
2. Connect the Model 288 and test equipment as shown in figure 2-2.
3. Program time symmetry in steps per Appendix A - Performance Verification Form and measure symmetry accuracy: RECORD.

VCF/FM

1. Reset the Model 288
2. Connect the Model 288 and test equipment as shown in figure 2-3.
3. Program the signal source for 0 Volts dc output. Program the Model 288 for FM mode and measure the 1kHz ± 3% frequency: RECORD.

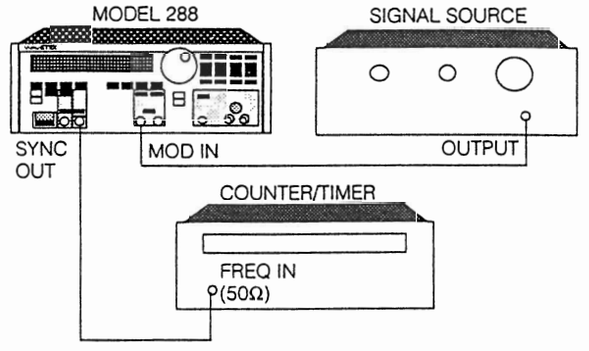


Figure 2-3. VC/FM Setup

4. Program the signal source for +5 Volts dc output into 10 kΩ load. Verify frequency is 2kHz ± 5% ([± 3% unlocked accuracy] + [±2% uncertainty of 10 kΩ input impedance]): RECORD.

Waveforms and Sweep

1. Reset the Model 288
2. Connect the Model 288 and test equipment as shown in figure 2-4.

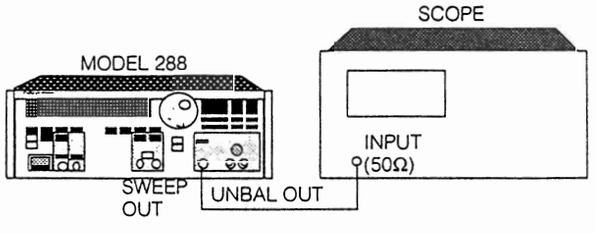


Figure 2-4. Waveforms/Sweep Verification

3. Program the Model 288 through the sine, triangle, square and dc functions while observing them for normal appearance on the scope: yes/no RECORD.
4. Program the Model 288 to start sweeping and observe a normal 100 Hz to 10 kHz, 1 second sweep: yes/no RECORD.
5. Remove the cable at Unbal Out and connect it to Sweep Out and observe the 1 second sweep ramp (600Ω impedance): yes/no RECORD.

Pulse

1. Reset the Model 288
2. Connect the Model 288 and test equipment as shown in figure 2-4. Verify 50Ω source into 50Ω feed-thru termination.
3. Program the Model 288 for 10 MHz square wave and measure rise time, fall time, positive-going transition peak-to-peak aberration in percent and negative-going transition peak-to-peak aberration in percent: RECORD.
4. Disconnect the cable at Unbal Out and connect it to the Sync (trigger) Out. Measure peak-to-peak amplitude, rise time and fall time: RECORD.

Outputs

1. Reset the Model 288
2. Connect the Model 288 and test equipment as shown in figure 2-4.
3. With the Unbal out connected to the scope, program the Model 288 for 50Ω, 75Ω and 600Ω output impedance and verify normal waveform appearance and amplitude into matched feed-thru terminations: yes/no RECORD.
4. Connect the Model 288 and test equipment as shown in figure 2-5.

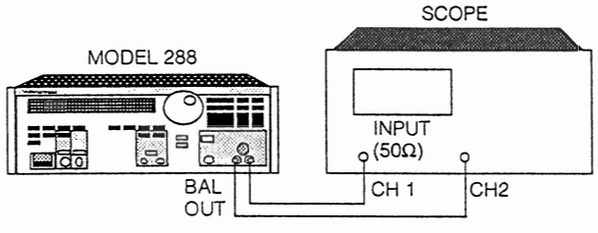


Figure 2-5. Balanced Output Verification

5. Sync the scope internally from channel 1 only, place a 135Ω load resistor across the Bal Out terminals and program the Model 288 for 135Ω balanced output. Observe channel 1 and 2 sine waves 180° out of phase on the scope and each at 1/2 the amplitude of the Unbal Out sine wave of step 3: yes/no RECORD.
6. Change the loading resistor and the Model 288 source impedance to 600Ω. Observe same scope display as in the previous step: yes/no RECORD.

Amplitude Modulation

1. Reset the Model 288
2. Connect the Model 288 and test equipment as shown in figure 2-6.

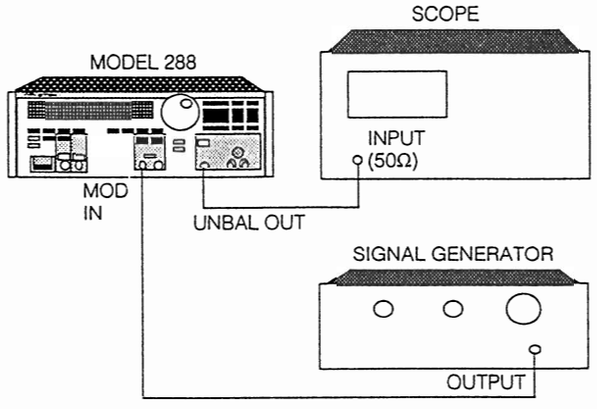


Figure 2-6 AM Verification

3. Program the signal generator for a 1kHz, 2Vp-p open circuit sine wave and the Model 288 for 100 kHz, AM mode. Observe a normal amplitude modulation of approximately 50% on the scope: yes/no RECORD.

Sine Wave Purity

1. Reset the Model 288
2. Connect the Model 288 and test equipment as shown in figure 2-7.

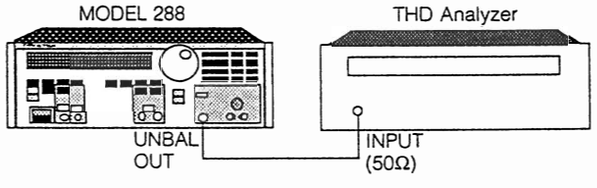


Figure 2-7. Sine Purity Measurement

3. Measure the sine total harmonic distortion in dB: RECORD.

Amplitude Accuracy

1. Reset the Model 288
2. Connect the Model 288 and test equipment as shown in figure 2-8.

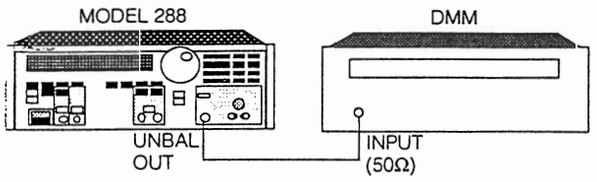


Figure 2-8. Amplitude Accuracy

3. Program the Model 288 sine amplitude to the unattenuated amplitude values per Appendix A - Performance Verification Form. Measure the true rms amplitude at each step: RECORD.
4. Repeat step 3 for the square wave: RECORD.
5. Repeat step 3 for the triangle wave: RECORD.

DC Output and Attenuator Accuracy

1. Reset the Model 288
2. Connect the Model 288 and test equipment as shown in figure 2-8.
3. Program the Model 288 dc offset to the attenuated values per Appendix A - Performance Verification Form. Measure the dc voltage at each step: RECORD.

External Lock

1. Reset the Model 288
2. Connect the Model 288 and test equipment as shown in figure 2-9.
3. Measure the 1kHz frequency of the Model 288: RECORD.
4. Program the signal source for a 1010 Hz, 5Vp-p sine wave. Program the Model 288 to externally lock and measure the frequency of both the signal generator and the Model 288: RECORD.
5. Program the Model 288 locking phase angle between ±180° per Appendix A - Performance Verification Form. Measure the phase angle at each step: RECORD.

Front Panel

Observe the display and annunciators while manually operating the various keys and check for normal appearance and operation: yes/no RECORD.

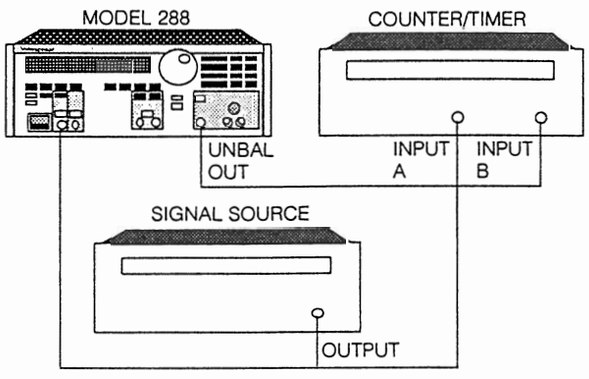


Figure 2-9. Phase Angle Measurement

2.4 PREVENTIVE MAINTENANCE

2.4.1 General

To be sure that your equipment is always ready for operation, you must perform scheduled preventive maintenance. When you are doing any PM or routine checks, keep in mind the WARNINGS and CAUTIONS about electrical shock and bodily harm.

2.4.2. PM Procedures.

No tools or equipment are required for operator preventive maintenance. Cleaning materials required are soap, water, and rags.

PM is limited to routine checks as follows:

- Cleaning
- Dusting
- Wiping
- Checking for frayed cables
- Storing items not in use
- Covering unused receptacles

Perform these routine checks anytime you see they must be done.

SECTION 3
OPERATION

3.1 USE AND FUNCTION OF EACH CONTROL

Paragraphs 3.1.1 and 3.1.2 describe all of the operator "Controls, Indicators, and Connectors" for the Model 288 signal generator.

3.1.1 Front Panel Controls, Indicators, and Connectors.

Due to the large number of controls and indicators on the front panel, it is necessary to separate the front panel into five different sections. Figure 3-1 shows the location of each section of the front panel (called views) used in table 3-1.

Table 3-1 shows each section (views A thru E) of the front panel as an enlarged view immediately followed by the description of the controls, indicators, and connectors for that view.

The rear panel (paragraph 3.1.2) is shown in figure 3-2 and described in table 3-2.

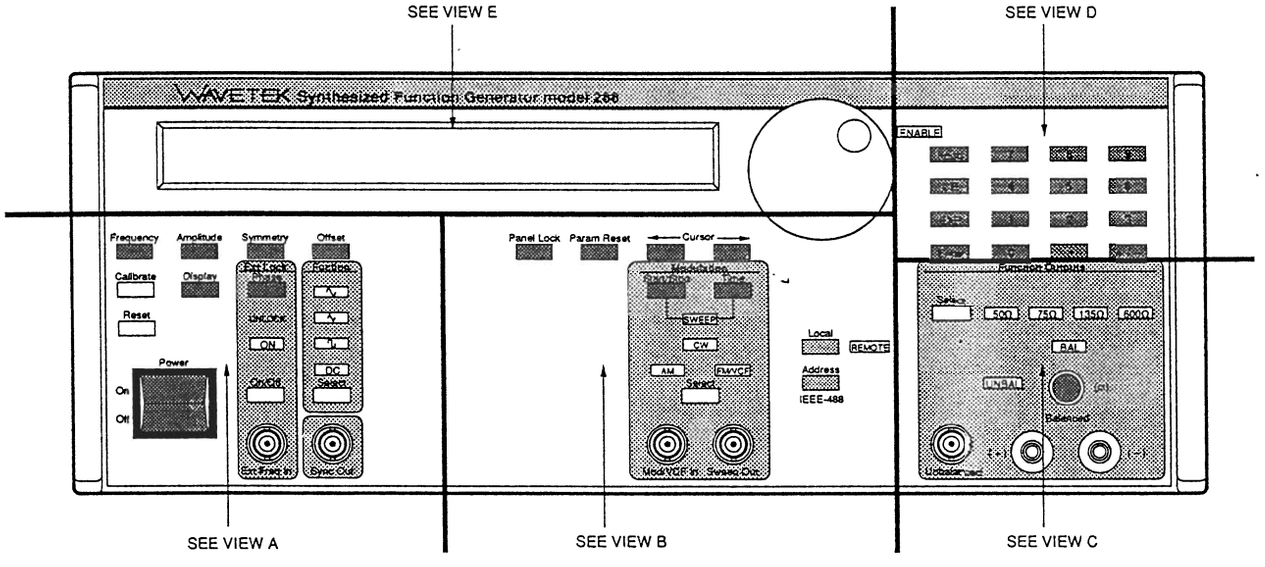
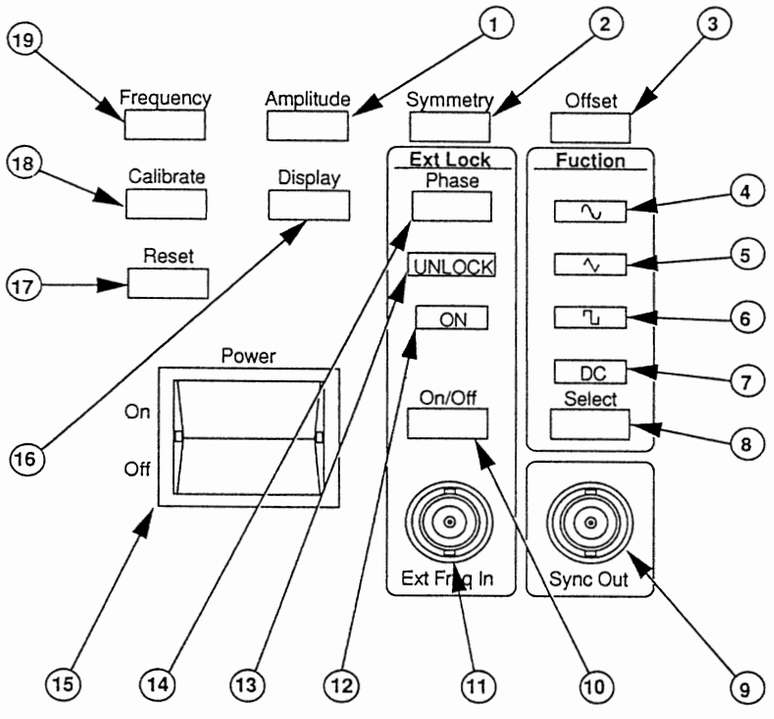


Figure 3-1. Operator's Controls, Indicators and Connectors (front view).

Table 3-1. Front Panel Controls, Indicators, and Connectors

Key	Control, Indicator or Connector	Function



VIEW A

1	Amplitude key	Used to display and enter output amplitude. Displayed units in Vpp, Vp, Vrms, or dBm. To enter a new value, press key until desired units are displayed. Use Cursor keys and control Knob or Numeric and Enter keys to enter a new value. All units reflect new value. Range is from 0.001 to 15.0 Vpp, 0.0005 to 7.5 Vp, 0.0004 to 5.3 Vrms, and –56.0 dBm to +27.5 dBm. Defaults to 5 Vpp. Restrictions: If the DC Offset is not 0 Vdc or symmetry not 50%, can select only units of Vpp and Vp with decreased range.
2	Symmetry key	Used to display and enter output waveform symmetry from 5% to 95%. Press to display the present value. Use the control Knob or the Numeric and Enter keys to enter a new value in 1% increments. Defaults to 50%. Restrictions: Fixed at 50% when either BAL, FM/VCF, or Sweep is selected. Linearly increases (from 5%) and decreases (from 95%) at frequencies above 2 MHz to 50% at 20 MHz.

Table 3-1. Front Panel Controls, Indicators, and Connectors (Continued)

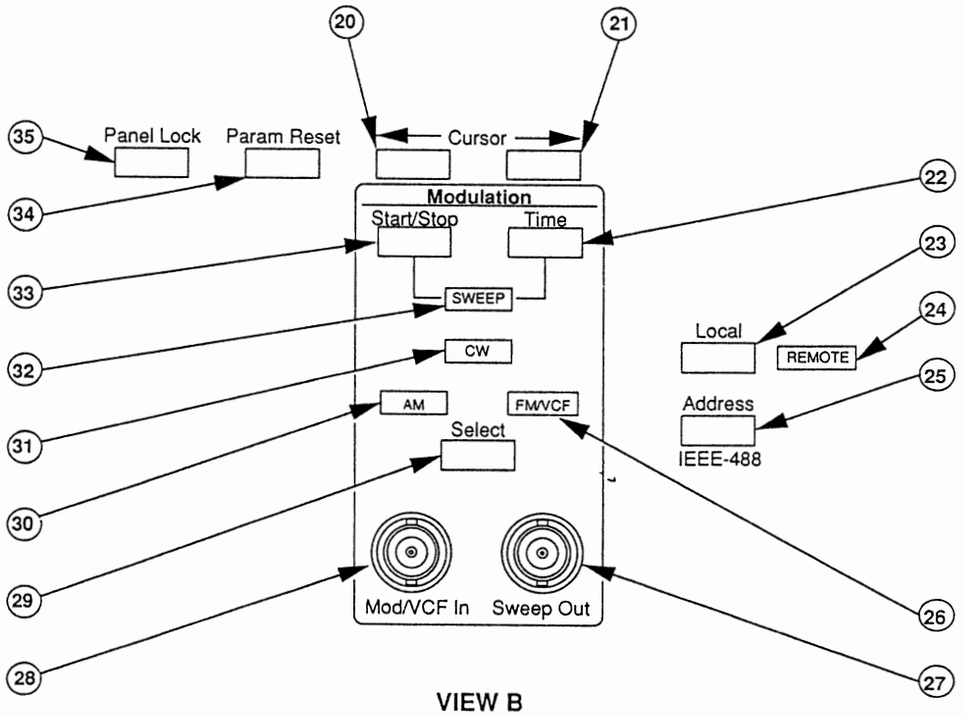
Key	Control, Indicator or Connector	Function
3	Offset key	Used to display and enter DC offset value from +5.000 to –5.000V. In DC function, controls signal output polarity and level. In sine, triangle, and square functions it controls reference level of output waveform. Press to display the present value. Use the Cursor keys and control Knob or the Numeric and Enter keys to enter a new value. Defaults to 0 Vdc. **Restrictions:** Fixed at 0 Vdc when BAL selected. When Sweep, CW, and FM/VCF are selected, range limited at amplitudes ≥ 5 Vdc. When AM is selected, range limited at amplitudes ≥ 2.5 Vdc.
4	∿ (Sine) indicator	When ON, indicates that Sine function is active. Provides an operator defined sine waveform from Unbalanced or Balanced output connectors. To activate, press the Function Select key until the indicator lights. **Restrictions:** Locked in when BAL and/or AM selected.
5	∧ (Triangle) indicator	When ON, indicates that Triangle function is active. Provides an operator defined triangle waveform from Unbalanced connector. To activate, press the Function Select key until indicator lights. **Restrictions:** Locked out when BAL and/or AM selected.
6	⊓ (Square) indicator	When ON, indicates that Square function is active. Provides an operator defined square waveform from Unbalanced connector. To activate, press the Function Select key until indicator lights. **Restrictions:** Locked out when BAL and/or AM selected.
7	DC indicator	When ON, indicates that DC function is active. Provides an operator defined dc voltage level from Unbalanced connector. To activate, press the Function Select key until indicator lights. **Restrictions:** Locked out when BAL, AM, and/or phase lock ON is selected.
8	Function Select key	Used to select Sine, Triangle, Square, or DC function. Press until the desired indicator lights. **Restrictions:** See Sine, Triangle, Square, and DC indicators.
9	Sync Out connector	BNC female connector with capacity of driving 50Ω. Provides a 1.0 to 2.5 Vpp TTL pulse at output waveform frequency. Signal is used when synchronizing the signal generator to any external equipment. Signal symmetry is same as square wave. Signal is "in phase" with square wave but leads sine and triangle waveforms by 90°. **Restrictions:** Signal not present in DC function.

Table 3-1. Front Panel Controls, Indicators, and Connectors (Continued)

Key	Control, Indicator or Connector	Function
10	Ext Lock On/Off key	Used to select the external reference frequency signal connected to the Ext Freq In connector. OFF activates internal frequency reference signal. ON deactivates internal frequency reference and an external signal must be used. Press for on (Ext Lock ON indicator on), press for off (Ext Lock ON indicator off). **Restrictions:** Locked out when frequency < 20 Hz, and when DC, Sweep, and/or FM/VCF is selected.
11	Ext Freq In connector	BNC female connector with 10kΩ input impedance accepts 20 Hz to 20 MHz sine wave at from 600 mVrms to 30 Vpp signal. Frequency must be set to Model 288 output frequency ± 3%. Used to connect an external frequency reference to the Model 288 for increased accuracy and stability.
12	Ext Lock On indicator	When ON, indicates that signal connected to Ext Freq In connector is to be used for reference frequency. Does not indicate signal is present at Ext Freq In connector. See Ext Lock ON/OFF key description for further explanation.
13	UNLOCK indicator	When flashing, indicates a problem with internal or external frequency reference signal, causing the signal generator output frequency to be inaccurate. Normally off. When ON continuously, indicates that current instrument set-up does not allow locking to a frequency reference.
14	Phase key	Used to display and enter the output signal phase. Phase relationship compared to an external signal connected to the Ext Freq In connector. Displayed units are in +/– degrees or in + /– radians. To enter a new value, press the key until desired units are displayed. Use Cursor keys and control Knob or the Numeric and Enter keys to enter a new value. Both units reflect new value. Range from +180° to –180° or +3.14 to –3.14 radians. Defaults to 0°.
15	Power switch	Used to set voltage to Model 288 on or off. ON when button rocked up, OFF when button rocked down.
16	Display key	Used to show and adjust the intensity of the display from 00 to 31. 31 is brightest setting. Press to display the present value. Use control Knob or the Numeric and Enter keys to enter a new value. Defaults to 16.
17	Reset key	Used to set the Model 288 parameters to the default condition (para 2-6). The GPIB address remains unchanged. Press to activate.
18	Calibrate key	Used to perform the Model 288 Self-test and Auto-Calibration. Performs a 20 second functional check and fine tune of certain internal circuits. The display will indicate "CALIBRATING" during the Self-test, and "AUTOCALIBRATED" after a successful Self-test. Press to activate. **Restrictions:** Requires 20 minute warm-up each time power is applied.

Table 3-1. Front Panel Controls, Indicators, and Connectors (Continued)

Key	Control, Indicator or Connector	Function
19	Frequency key	Used to display and enter output frequency/period. Displayed frequency units in MHz, kHz, Hz, and mHz. Displayed period units in SEC and ms. To enter a new value, press key until desired units are displayed. Use the Cursor keys and control Knob or the Numeric and Enter keys to enter a new value in Hz or SEC. Both units reflect new value. Range is from 0.002 Hz to 20.00 MHz or 500.0 SEC to 0.00005 ms. Defaults to 1.000 kHz. **Restrictions:** Frequencies > 2 MHz are limited when symmetry is not 50%. Frequencies < 20 Hz are locked out when phase lock ON is selected. Frequencies > 1 MHz locked out when BAL, 135Ω, and/or 600Ω is selected. Frequencies < 0.1 Hz locked out when AM selected.



VIEW B

20	<— Cursor key	Used to change display setting. Moves selectable digit to left through all possible display combinations. Press key until desired digit flashes, then use the control Knob to change value. **Restrictions:** Not used for Display, Phase, Symmetry, and Address keys.

Table 3-1. Front Panel Controls, Indicators, and Connectors (Continued)

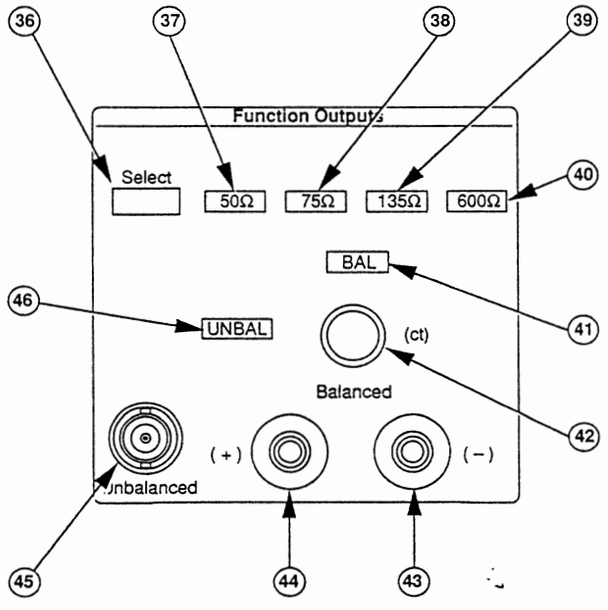
Key	Control, Indicator or Connector	Function
21	Cursor —> key	Used to change display setting. Moves selectable digit to right through all possible display combinations. Press key until desired digit flashes, then use control Knob to change value. **Restrictions:** Not used for Display, Phase, Symmetry, and Address keys.
22	Time key	Used to display and enter the time or rate for one complete sweep. Only used during sweep modulation. Displayed units are in SEC or Hz. To enter a new value, press key until desired units are displayed. Use the Cursor keys and control Knob or the Numeric and Enter keys to enter a new value. Both units reflect new value. Range is from 0.1 to 100 SEC or 10 to 0.01 Hz. Defaults to 1 SEC.
23	Local key	Used to return the Model 288 to front panel control from the remote (GPIB) mode. Front panel displays "GOTO LOCAL". Press to activate. **Restrictions:** Will not select if Local Lockout set by external Controller during remote operation.
24	REMOTE indicator	When ON, indicates that Model 288 is in remote (GPIB) operation using the external Controller. Instrument settings can be queried but not changed.
25	Address key	Used to display and enter IEEE-488 (GPIB) address from 00 to 30. Press to display present value. Use control Knob or the Numeric and Enter keys to enter a new value. Defaults to 09 when (34) is pressed. **Restrictions:** Will not select if Local Lockout is set by an external Controller during remote operation.
26	FM/VCF indicator	When ON, indicates that FM/VCF modulation mode is active. Provides an operator defined frequency modulated waveform from Unbalanced or Balanced output connectors. An external signal source connected to MOD/VCF IN connector is required for FM/VCF operation. External signal amplitude of 0 to 10 Vpp controls deviation. External signal frequency of DC to 100 kHz controls rate. To activate, press Modulation Select key until indicator lights. **Restrictions:** Locked out when symmetry not 50% and/or when Phase Lock ON is selected.
27	Sweep Out connector	BNC female connector with 600Ω output impedance. Provides a 0 to +5V or +5 to 0V linear ramp voltage from start to stop frequency at sweep time selected. Signal is used for sweeping an external signal source. **Restrictions:** Signal only present during sweep modulation mode.
28	Mod/VCF In connector	BNC female connector with 10kΩ input impedance. Used to connect an externally supplied DC to 100 kHz signal for modulation of Unbalanced and Balanced output signals. Maximum signal input is 20 Vpp. Input amplitude controls AM depth and FM/VCF deviation. Input frequency controls AM and FM/VCF modulation rate.

Table 3-1. Front Panel Controls, Indicators, and Connectors (Continued)

Key	Control, Indicator or Connector	Function
29	Modulation Select key	Used to select Sweep, CW, AM, or FM/VCF modulation. Press until desired indicator lights. **Restrictions:** See Sweep, CW, AM, or FM/VCF indicators.
30	AM indicator	When ON, indicates that AM modulation mode is active. Provides an operator defined amplitude modulated waveform from Unbalanced or Balanced output connectors. An external signal source connected to MOD/VCF IN connector is required for AM operation. External signal amplitude of 0 to 4 Vpp controls depth. A 4 Vpp provides 100% depth. External signal frequency of DC to 100 kHz controls rate. To activate, press Modulation Select key until indicator lights. **Restrictions:** Locked out when the Triangle, Square, or DC function is selected, frequency is set to < 0.1 Hz, and/or the sum of amplitude (Vpp) and Offset (Vdc) exceeds 7.5.
31	CW indicator	When ON, indicates that CW modulation mode is active. Provides an operator defined continuous waveform from Unbalanced or Balanced output connectors. To activate, press Modulation Select key until indicator lights. Defaults to CW. **Restrictions:** Locked in when Triangle, Square, Ext Lock ON. Amplitude, and/or symmetry selections lock out sweep, AM, and FM/VCF modes.
32	SWEEP indicator	When ON, indicates that sweep modulation mode is active. Provides an operator defined swept waveform from Unbalanced or Balanced output connectors. To activate, press Modulation Select key until indicator lights and "SWEEP RUN" is shown on display. **Restrictions:** Locked out when symmetry not 50%, when Ext Lock ON selected, and/or when the combination of Start/Stop frequencies exceed range limits.
33	Start/Stop key	Used to display and enter the start and stop frequencies for sweep modulation mode. Displayed units in mHz, Hz, kHz, and MHz. Press for start frequency, and again for stop frequency. If Sweep indicator is on, pressing again will cause swept output (display indicates "SWEEP RUN"). To enter a new value, press key until desired parameter is displayed. Use the Cursor keys/control Knob or the Numeric and Enter keys to enter a new value. Range from 2 mHz to 20 MHz. Defaults are 2.0 Hz start and 2 kHz stop. **Restrictions:** If sweep is selected while entering start and stop frequencies, it will automatically change value entered first to provide sweep within acceptable range limits.
34	Param Reset key	Used to reset only parameter currently shown in the display to default value. Does not change non-displayed parameters. Press to activate.

Table 3-1. Front Panel Controls, Indicators, and Connectors (Continued)

Key	Control, Indicator or Connector	Function
35	Panel Lock key	Used to disable all front panel key selections, except the Power switch. Does not affect signals at output connectors. Press to activate, press again to deactivate. Display indicates "PANEL LOCKED" or "PANEL UNLOCKED" to show status. **Restrictions:** If panel is locked when power is set to OFF, it will remain locked when power is set to ON; however, the display will not indicate locked status.



VIEW C

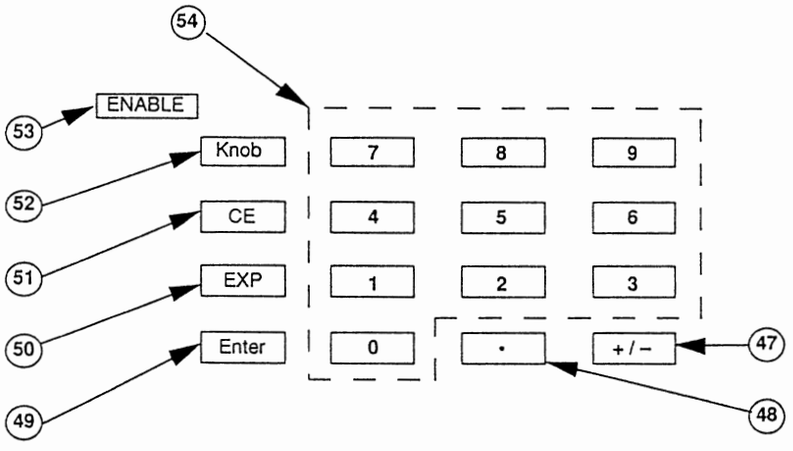
36	Function Outputs Select key	Used to select desired output impedance (50Ω, 75Ω, 135Ω, or 600Ω) and output connector (UNBAL or BAL) combination. Press until desired indicators light. **Restrictions:** See 50Ω, 75Ω, 135Ω, 600Ω, UNBAL, or BAL indicators.
37	50Ω indicator	When ON, indicates 50Ω output impedance. Select to match 50Ω load impedance. Provides an signal output with 50Ω impedance at the Unbalanced output connector. To activate, press Function Outputs Select key until 50Ω and UNBAL indicators light. Defaults to 50Ω UNBAL.
38	75Ω indicator	When ON, indicates 75Ω output impedance. Select to match 75Ω load impedance. Provides a signal output with 75Ω impedance at the Unbalanced output connector. To activate, press Function Outputs Select key until 75Ω and UNBAL indicators light.

Table 3-1. Front Panel Controls, Indicators, and Connectors (Continued)

Key	Control, Indicator or Connector	Function
39	135Ω indicator	When ON, indicates 135Ω output impedance. Select to match 135Ω load impedance. Provides signal output with 135Ω impedance at the Balanced output connector. To activate, press Function Outputs Select key until 135Ω and BAL indicators light. **Restrictions:** Locked out for frequencies greater than 1 MHz. See BAL indicator for further restrictions.
40	600Ω indicator	When ON, indicates 600Ω output impedance. Select to match 600Ω load impedance. Provides signal output with 600Ω impedance at the Unbalanced or Balanced output connectors. To activate, press Function Outputs Select key until 600Ω and BAL, or 600Ω and UNBAL indicators light. **Restrictions:** Locked out for frequencies greater than 1 MHz. See BAL indicator for further restrictions.
41	BAL indicator	When ON, indicates that Balanced output connectors are providing an operator defined balanced output signal. Impedance is selectable for 135Ω or 600Ω. To activate, press Function Outputs Select key until 135Ω and BAL, or 600Ω and BAL indicators light. **Restrictions:** Locked out for frequencies greater than 1 MHz, for Triangle, Square, or DC functions, for Offset other than 0 Vdc, and/or symmetry other than 50%.
42	Balanced (ct) terminal	Captive screw binding post used as neutral center tap with Balanced (–) and Balanced (+) jacks.
43	Balanced (–) jack	Female banana jack with 135Ω or 600Ω output impedance. Provides a balanced output from 2 mHz to 1 MHz when used as negative signal lead with Balanced (+) jacks. Selected when BAL indicator on.
44	Balanced (+) jack	Female banana jack with 135Ω or 600Ω output impedance. Provides a balanced output from 2 mHz to 1 MHz when used as positive signal lead with Balanced (–) jacks. Selected when BAL indicator on.
45	Unbalanced connector	BNC female connector with 50Ω, 75Ω, or 600Ω output impedance. Provides an unbalanced output from 2 mHz to 20 MHz (2 mHz to 1 MHz for 600Ω). Selected when UNBAL indicator on.
46	UNBAL indicator	When on, indicates Unbalanced output connector is providing an operator defined unbalanced output signal. Impedance is selectable from 50Ω, 75Ω, or 600Ω. To activate, press Function Outputs Select key until 50Ω and UNBAL, 75Ω and UNBAL, or 600Ω and UNBAL indicators light. Defaults to 50Ω UNBAL. **Restrictions:**600Ω UNBAL locked out for frequencies greater than 1 MHz.

Table 3-1. Front Panel Controls, Indicators, and Connectors (Continued)

Key	Control, Indicator or Connector	Function

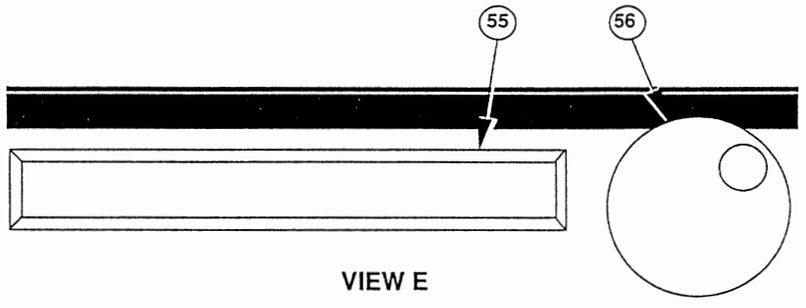


VIEW D

47	+/- key	Used to enter a positive or negative sign for numeric data entry. Used for standard and exponent entry. Blank indicates positive, – indicates negative. Press to change sign.
48	. (DECIMAL) key	Used to enter a decimal point for numeric data entry.
49	Enter key	Used to terminate entries from the Numeric keypad. Pressing after numeric data entry transfers the display contents to MODEL 288 internal circuits. All values entered not within specifications are disregarded. Values exceeding resolution are rounded or entered to nearest allowable value.
50	EXP key	Used to enter an exponent digit. To enter an exponent, use Numeric keypad to enter prefix, press EXP key, then exponent value using Numeric key 0 to 9. Exponent can be entered as a negative by pressing +/– key.
51	CE key	Used to clear a numeric entry error when using the Numeric keys. Unwanted data must be cleared before pressing Enter key. Press once to clear display of numeric entry.
52	Control Knob key	Used to enable or disable the control Knob. When ON, selecting appropriate parameter key activates control Knob (ENABLE indicator ON). When OFF, control Knob is deactivated (ENABLE indicator remains OFF). Press for ON, press again for OFF. Defaults to ON.
53	ENABLE indicator	When ON, indicates that control Knob will change value in the display. Press the Knob key to activate. Restrictions: ENABLE indicator will light only when selecting a parameter that can use the control Knob as input.

Table 3-1. Front Panel Controls, Indicators, and Connectors (Continued)

Key	Control, Indicator or Connector	Function
54	NUMERIC keypad (0 — 9)	Used to enter a 0, 1, 2, 3, 4, 5, 6, 7, 8, or 9 for numeric data entry. Used with +/–, DECIMAL, Enter, EXP, and CE keys to enter data. Press desired digit.



VIEW E

55	DISPLAY	Indicates all output signal information, entry information, operator messages, and error codes. Variable brightness 16-digit alphanumeric display with decimal point and minus sign.
56	Control KNOB	Used to change numeric value of flashing digit as selected by Cursor keys. CW rotation increases value, CCW rotation decreases value. Active when ENABLE indicator is ON.

3.1.2 Rear Panel Controls, Indicators, and Connectors.

This paragraph provides information on the location, description, and use of the rear panel controls, indicators, and connectors. Refer to figure 3-2 for the location of the rear panel controls, indicators, and connectors. Table 3-2 provides the description and use of the rear panel controls, indicators, and connectors.

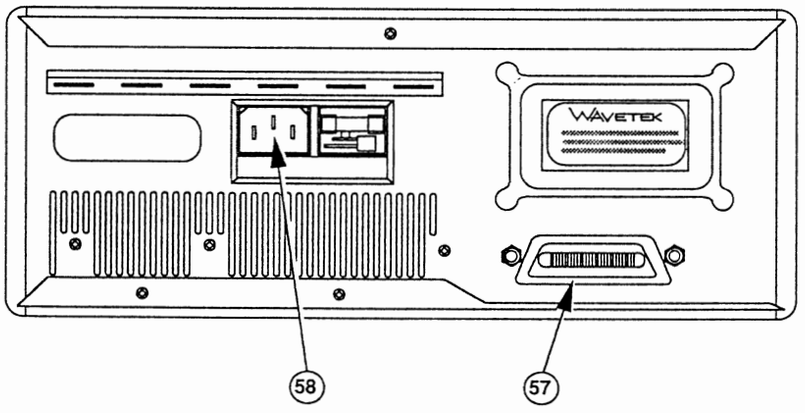


Figure 3-2. Operator's Controls, Indicators, and Connectors (rear view).

Table 3-2. Rear Panel Controls, Indicators, and Connectors

ey	Control, Indicator, or Connector	Function
57	GPIB connector	Used to connect an external Controller to Model 288 during remote operation. Connector has 24 pins and threaded posts conforming to IEEE-488 1978.
58	INPUT POWER connector	Used as ac power input connector for Model 288. Also contains the line fuse and voltage selection facilities. Voltage selection is from 100/120/ 220/240 Vac. Number visible in window indicates nominal line voltage for which the Model 288 is set to operate. Power input connector accepts female end of power cable (supplied). Protective grounding conductor connects the Model 288 through this connector. Line power fuse is 0.75 amp, 250V for 100/120 Vac and 0.375 amp, 250V for 220/240 Vac operation.

3.2 NORMAL OPERATION

This section provides the information required to set up and operate the Model 288 signal generator. Operation of the signal generator is divided into sections: continuous wave, sweep modulation, amplitude modulation, frequency modulation, voltage controlled frequency, and GPIB operation.

Operation of signal generator is provided in paragraphs 3.2.2 thru 3.2.7. Refer to tables 3-1 and 3-2 for use and description of the front and rear panel controls, connectors, and indicators. Table 2-2 lists all operator errors along with the probable cause.

3.2.1 Start Up

Refer to section 2, paragraph 2.3.3, for turn-on procedures

3.2.2 Continuous Wave (CW)

Perform the following steps (using figure 3-3) to provide continuous wave output signal from 2 mHz to 20 MHz at from 1 mVpp to 15 Vpp.

1. Press the Reset key (15). Verify that CW indicator (13) is on.
2. Select desired output waveform (sine, triangle, square, or dc) using the Function Select key (14).
3. Press the following keys and then enter desired value. Use the Cursor keys (6) and control Knob (7), or the Numeric keypad (9) and Enter key (8). Entry will appear in the display (5).
   - Press the Frequency key (1) and enter desired output frequency (Hz) or period (SEC).
   - Press the Amplitude key (2) and enter desired output amplitude in Vpp, Vp, Vrms, or dBm.
   - Press the Symmetry key (3) and enter desired output waveform symmetry in percent.
   - Press the Offset key (4). If Sine, Triangle, or Square is selected (14), enter desired output waveform reference level in volts dc. If dc is selected (14), enter desired dc output level in volts dc.
4. Select desired output impedance (50Ω, 75Ω, 135Ω, or 600Ω) and connector (BAL or UNBAL) using Function Outputs Select key (12) to match load termination.

NOTE

- *When connecting the Model 288 output connector to a load, use a cable with the correct impedance for the output selected.*
- *Balanced ct connector is internally connected to the shield of all the other Model 288 BNC connectors. When connecting to external equipment, whose connector shields are at chassis ground, a ground loop will be formed that will adversely affect the Balanced output signal.*

5. Connect the selected output Balanced (10) or Unbalanced (11) connector to load.

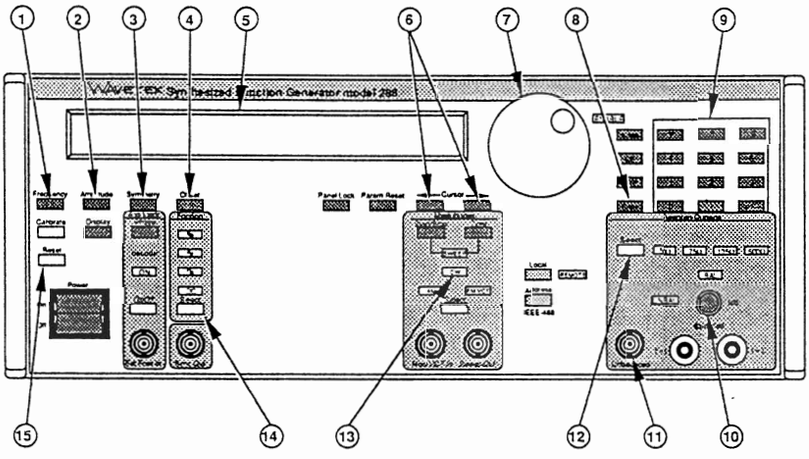


Figure 3-3. Continuous Wave Operation Control Setup

3.2.3 Sweep Modulation

Perform the following steps (using figure 3-4) to provide a swept output signal from 0.002 Hz to 20 MHz at 1 mVpp to 15 Vpp with sweep rate from 0.1 to 100 seconds.

1. Press the Reset key (16). Select Sweep indicator (13) using the Modulation Select key (12).
2. Select the desired output waveform (Sine, Triangle, Square, or DC) using Function Select key (15).
3. Press the following keys and then enter desired value. Use the Cursor keys (4) and control Knob (5), or the Numeric keypad (7) and Enter key (6). Entry will appear in the display (3).
   - Press the Time key (11) and enter the desired sweep time in SEC or Hz.
   - Press Start/Stop key (14) until "START X HZ" is displayed and enter desired sweep start frequency in Hz.
   - Press the Start/Stop key (14) until "STOP X KHZ" is displayed and enter the desired sweep stop frequency in Hz

   NOTE

   If the entered start and/or stop frequency exceeds the Model 288 sweep limits, one parameter will be adjusted. Press the Start/Stop key (14) as required to verify entered frequencies.

   - *Press the Amplitude key (1) and enter desired swept output amplitude in Vpp, Vp, Vrms, or dBm.*
   - *Press the Offset key (2). If Sine, Triangle, or Square selected (15), enter desired swept output waveform reference level in volts dc. If dc selected (15), enter desired dc output level in volts dc.*
4. Select the desired output impedance (50Ω, 75Ω, 135Ω, or 600Ω) and connector (BAL or UNBAL) using Function Outputs Select key (10) to match load termination.

   NOTE

   - *When connecting the Model 288 output connector to the load, use cable with correct impedance for the output selected.*
   - *Balanced ct connector is internally connected to the shield of all the other Model 288 BNC connectors. When connecting to external equipment, whose connector shields are at chassis ground, a ground loop will be formed that will adversely affect the Balanced output signal.*
5. Press Start/Stop key (14) until "SWEEP RUN" is displayed.
6. Connect the selected output Balanced (8) or Unbalanced (9) connector to load.

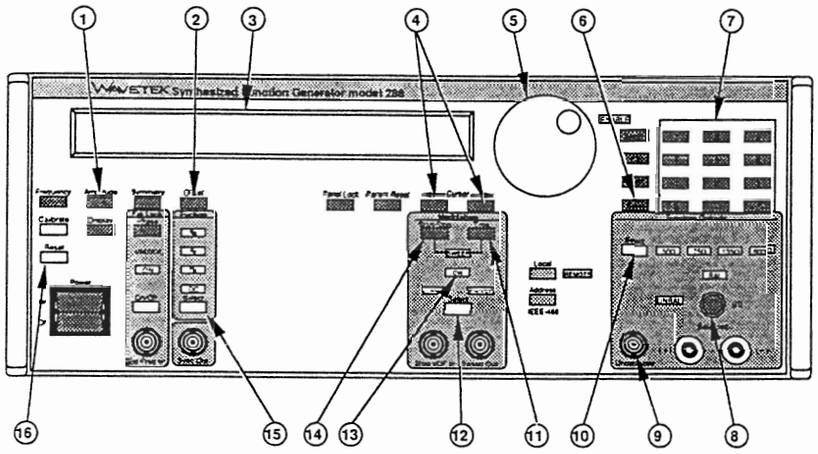


Figure 3-4. Sweep Modulation Operation Control Setup

3.2.4 Amplitude Modulation (AM)

Perform the following steps (using figure 3-5) to provide an amplitude modulated output signal from 0.1 Hz to 20 MHz at 1 mVpp to 7.5 Vpp with modulation rate from DC to 100 kHz and modulation depth from 0 to 100%.

1. Press the Reset key (16). Select AM indicator (15) using the Modulation Select key (13).
2. Press the following keys and then enter desired value. Use the Cursor keys (6) and control Knob (7), or the Numeric keypad (9) and Enter key (8). Entry will appear in the display (5).
   - Press the Frequency key (1) and enter desired output carrier frequency (Hz) or period (SEC).
   - Press the Amplitude key (2) and enter desired output carrier amplitude in Vpp, Vp, Vrms, or dBm.
   - Press the Symmetry key (3) and enter desired output carrier waveform symmetry in percent.
   - Press the Offset key (4) and enter desired output carrier waveform reference level in volts DC.
3. Connect the external signal source sine wave to the MOD/VCF IN connector (14).
4. Set the external signal source to desired frequency from DC to 100 kHz. This is the rate at which the Model 288 will modulate the output signal.
5. Set the external signal source to desired amplitude from 0 to 4 Vpp. This is the depth at which the Model 288 will modulate the output signal. Modulation depth is directly proportional to the input signal amplitude.

   Example: A 4 Vpp input provides 100% depth, 2 Vpp input provides 50% depth, etc.
6. Select the desired output impedance (50Ω, 75Ω, 135Ω, or 600Ω) and connector (BAL or UNBAL) using Function Outputs Select key (12) to match load termination.

   NOTE

   - *When connecting Signal Generator output connector to the load, use cable with correct impedance for the output selected.*
   - *Balanced ct connector is internally connected to the shield of all the other Model 288 BNC connectors. When connecting to external equipment, whose connector shields are at chassis ground, a ground loop will be formed that will adversely affect the Balanced output signal.*
7. Connect selected output Balanced (10) or Unbalanced (11) connector to load.

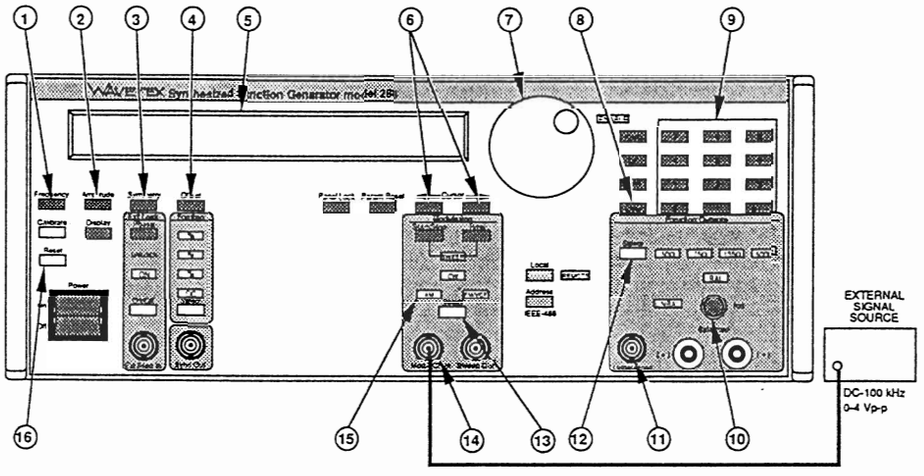


Figure 3-5. Amplitude Modulation Operation Control Setup

3.2.5 Frequency Modulation (FM)

Perform the following steps (using figure 3-6) to provide a frequency modulated output signal from 0.002 Hz to 20 MHz at 1 mVpp to 15 Vpp with modulation rate from DC to 100 kHz and deviation as specified below.

1. Press Reset key (17). Verify CW indicator (15) is on.
2. Calculate and record upper and lower modulation limit frequencies required as follows:

UPPER LIMIT = CTRF + PEAK DEVIATION
LOWER LIMIT = CTRF – PEAK DEVIATION

where: UPPER LIMIT is upper modulation limit required
LOWER LIMIT is lower modulation limit required
CTRF is desired center frequency
PEAK DEVIATION is desired positive OR negative deviation

Example: Desired Center Frequency = 200 kHz
Peak Deviation = ± 25 kHz

Upper Limit = 200 kHz + 25 kHz = 225 kHz
Lower Limit = 200 kHz – 25 kHz =175 kHz

3. Using table 3-3, find and record the range number that contains the calculated upper limit (step 2). Verify calculated lower limit (step 2) is within limits of table for range selected.

Example: Upper limit of 225 kHz is range number 8. Calculated lower limit within range (range 8 lower limit 2.0 kHz and calculated lower limit 175 kHz).

CAUTION

Exceeding lower limit will cause output signal distortion.

4. Calculate and record the external source amplitude (Vpp) as follows:

OUT AMP = P-P DEVIATION ÷ DEVIATION PER V

where: OUT AMP is external source amplitude (Vpp)
P-P DEVIATION is desired positive AND negative deviation
DEVIATION PER V from table above using range number recorded in step 3

Example: P-P Deviation = 50 kHz (+ and – 25 kHz)
Deviation per volt = 200 kHz (from table, range 8)
Output Amplitude = 50 kHz ÷ 200 kHz = 0.25 Vpp

5. Press the Frequency key (1) and enter calculated upper limit frequency (step 2) in Hz. Use either Cursor keys (5) and control Knob (6), or the Numeric keypad (8) and Enter key (7). Entry will appear in the display (4).

6. Select FM/VCF indicator (12) using the Modulation Select key (13).
7. Select the desired output waveform (Sine, Triangle, Square, or DC) using function Select key (16).
8. Press the following keys and then enter desired value. Use either Cursor keys (5) and control Knob (6), or the Numeric keypad (8) and Enter key (7). Entry will appear in the display (4).
   - Press the Frequency key (1) and enter center frequency used in calculation (step 2) in Hz.
   - Press the Amplitude key (2) and enter desired output carrier amplitude in Vpp, Vp, Vrms, or dBm.
   - Press the Offset key (3). If Sine, Triangle, or Square selected (16), enter desired output carrier waveform reference level in volts dc. If dc selected (16), enter desired dc output level in volts DC.
9. Connect the external signal source sine wave to MOD/VCF IN connector (14).
10. Set the external signal source to desired frequency from DC to 100 kHz. This is the rate at which the Model 288 will modulate the output signal.
11. Set the external signal source to calculated amplitude (step 4) from 0 to 10Vpp. This is the deviation at which the Model 288 will modulate the output signal.
12. Select desired output impedance (50Ω, 75Ω, 135Ω, or 600Ω) and connector (BAL,or UNBAL) using Function Outputs Select key (11) to match load termination.

NOTE

- *When connecting Signal Generator output connector to the load, use cable with correct impedance for the output selected.*
- *Balanced ct connector is internally connected to the shield of all the other Model 288 BNC connectors. When connecting to external equipment, whose connector shields are at chassis ground, a ground loop will be formed that will adversely affect the Balanced output signal.*

13. Connect selected output Balanced (9) or Unbalanced (10) connector to load.

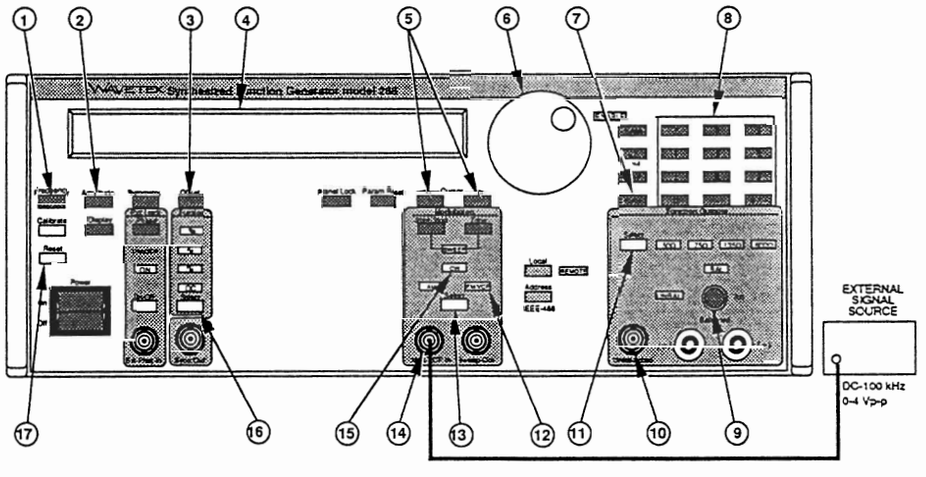


Figure 3-6. Frequency Modulation Operation Control Setup

Table 3-3. Frequency Modulation Range Information.

Range Number	Modulation Upper Limit Range	Modulation Lower Limit	Deviation per Volt
0	20 mHz to 2 mHz	2 mHz	2 mHz
1	200 mHz to 20.1 mHz	2 mHz	20 mHz
2	2 Hz to 201 mHz	2 mHz	200 mHz
3	20 Hz to 2.01 Hz	20 mHz	2 Hz
4	200 Hz to 20.1 Hz	200 mHz	20 Hz
5	2 kHz to 201 Hz	2 Hz	200 Hz
6	20 kHz to 2.01 kHz	20 Hz	2 kHz
7	200 kHz to 20.1 kHz	200 Hz	20 kHz
8	2.0 MHz to 201 kHz	2.0 kHz	200 kHz
9	20 MHz to 2.01 MHz	20 kHz	2 MHz

3.2.6 Voltage Controlled Frequency (VCF)

Perform the following steps (using figure 3-7) to provide a voltage controlled frequency output signal from 0.002 Hz to 20 MHz at 1 mVpp to 15 Vpp.

1. Press Reset key (17). Verify CW indicator (15) is on.
2. Calculate and record upper and lower frequency limits required as follows:

UPPER LIMIT = INT + FREQ CHG
LOWER LIMIT = INT – FREQ CHG

where: UPPER LIMIT is upper frequency limit required
LOWER LIMIT is lower frequency limit required
INT is desired initial frequency
FREQ CHG is desired positive or negative frequency change

Example: Desired Initial Frequency = 200kHz, Frequency Change = (+25kHz) and (–10 kHz)

Upper Limit = 200 kHz + 25 kHz = 225 kHz
Lower Limit = 200 kHz – 10 kHz =190 kHz

3. Using table 3-4, find and record the range number that contains the calculated upper limit (step 2). Verify calculated lower limit (step 2) is within limits of table for range selected.

Example: Upper limit of 225 kHz is range number 8. Calculated lower limit within range (range 8 lower limit 2.0 kHz and calculated lower limit 190 kHz).

NOTE

Exceeding lower limit will cause output signal distortion.

4. Calculate and record the external DC source level (Vdc) as follows:

OUT VOLT = FREQ CHG ÷ CHG PER V

where: OUT VOLT is external source voltage (+ or – Vdc)
FREQ CHG is desired positive or negative frequency change
CHG PER V from table above using range number recorded in step 3.

Example: Frequency Change = + 25 kHz and – 10 kHz
Change per volt = 200 kHz (from table, range 8)

Output Voltage = + 25 kHz ÷ 200 kHz = + 0.125V
and
Output Voltage = – 10 kHz ÷ 200 kHz = – 0.05V.

5. Press the Frequency key (1) and enter calculated upper limit frequency (step 2) in Hz. Use either Cursor keys (5) and control Knob (6), or the Numeric keypad (8) and Enter key (7). Entry will appear in the display (4).
6. Select FM/VCF indicator (12) using Modulation Select key (13).
7. Select desired output waveform (Sine, Triangle, Square, or DC) using function Select key (16).

8. Press the following keys and then enter desired value. Use the Cursor keys (5) and control Knob (6), or the Numeric keypad (8) and Enter key (7). Entry will appear in the display (4).
   - Press Frequency key (1) and enter initial frequency used in calculation (step 2) in Hz.
   - Press Amplitude key (2) and enter desired output amplitude in Vpp, Vp, Vrms, or dBm.
   - Press Offset key (3). If Sine, Triangle, or Square selected (16), enter desired output waveform reference level in volts dc. If dc selected (16), enter desired dc output level in volts DC.
9. Connect the external DC source DC level to MOD/VCF IN connector (14).
10. Set the dc signal source to the calculated level (step 4) from –5 to +5V.
11. Select desired output impedance (50Ω, 75Ω, 135Ω, or 600Ω) and connector (BAL/UNBAL) using Function Outputs Select key (11) to match load termination.

NOTE

- *When connecting the Model 288 output connector to the load, use cable with correct impedance for the output selected.*
- *Balanced ct connector is internally connected to the shield of all the other Model 288 BNC connectors. When connecting to external equipment, whose connector shields are at chassis ground, a ground loop will be formed that will adversely affect the Balanced output signal.*

12. Connect selected output Balanced (9) or Unbalanced (10) connector to load.

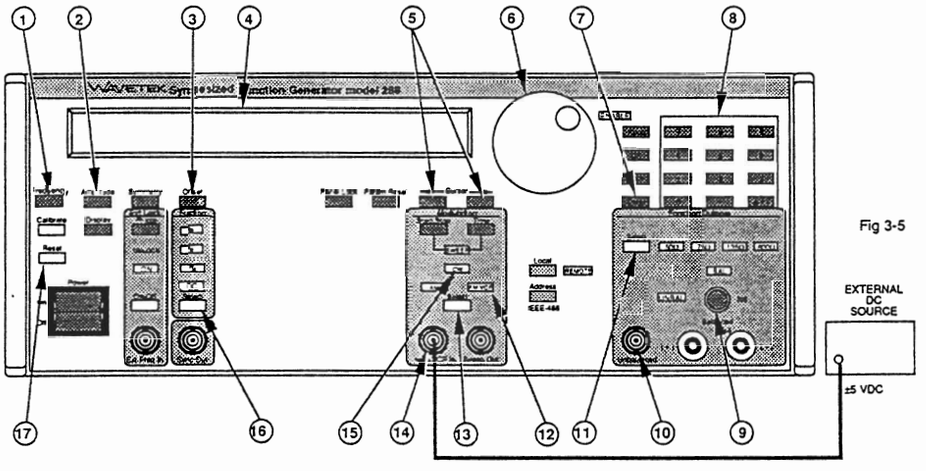


Fig 3-5

Figure 3-7. VCF Operation Control Setup

Table 3-4. Voltage Controlled Frequency Range Information.

Range Number	Upper Limit Range	Lower Limit	Change per Volt
0	20 mHz to 2 mHz	2 mHz	2 mHz
1	200 mHz to 20.1 mHz	2 mHz	20 mHz
2	2 Hz to 201 mHz	2 mHz	200 mHz
3	20 Hz to 2.01 Hz	20 mHz	2 Hz
4	200 Hz to 20.1 Hz	200 mHz	20 Hz
5	2 kHz to 201 Hz	2 Hz	200 Hz
6	20 kHz to 2.01 kHz	20 Hz	2 kHz
7	200 kHz to 20.1 kHz	200 Hz	20 kHz
8	2.0 MHz to 201 kHz	2.0 kHz	200 kHz
9	20 MHz to 2.01 MHz	20 kHz	2 MHz

3.2.7 GPIB (Remote) Operation

This following paragraphs describe the Model 288 remote operation (GPIB) procedures using an external controller. GPIB Digital Interface conforms to IEEE 488 1978 subsets SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, CO, and E1.

Remote operation of the Model 288 is very similar to local operation, except that the commands are entered and received using an external Controller, and not by pressing keys and observing the display and indicators on the front panel. The GPIB connector permits remote control of all functions except Power switch, Local key, and Address key. Refer as necessary to Section 2 for descriptions of controls, indicators, and connectors, and individual operating procedures (paragraphs 3.2.2 thru 3.2.7). GPIB connector wiring data is shown in figure 3-8.

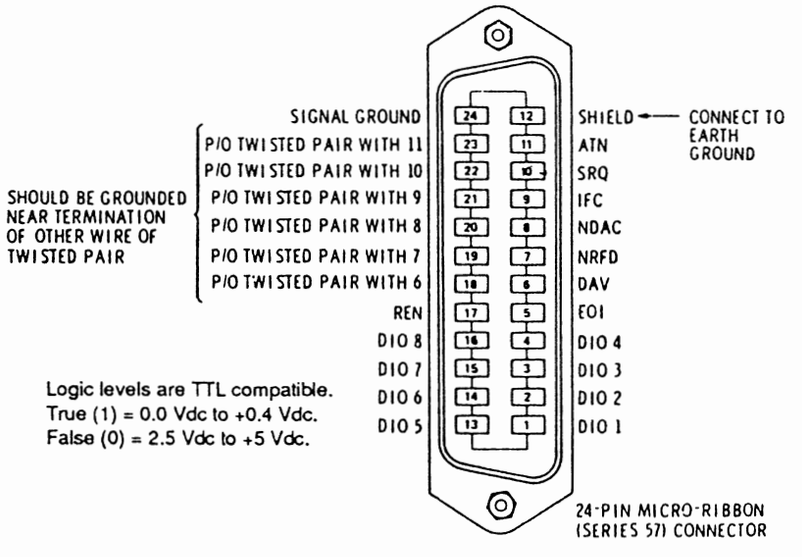


Figure 3-8. GPIB Wiring Connector Pin Out

rform the following steps (using figure 3-9) for remote eration of the Model 288 signal generator.

Connect the equipment as shown below.

NOTE

Keep GPIB interconnect cable length below 2 meters (6.6 feet)

Perform Model 288 turn-on procedure (refer to paragraph 2.2.3).

3. On Signal Generator front panel:

   - Press the Local key (8), verify that the display (1) indicates "GOTO LOCAL", and that the REMOTE indicator (6) is out.
   - Press the Address key (7) and enter desired address from 00 to 30. Use the control Knob (3), or the Numeric keypad (5) and Enter key (4). Entry will appear in the display (1). Default address is 09.

4. Operator commands are programmed using an external Controller and GPIB commands listed in table 3-6

3.3 GPIB COMMAND STRUCTURE

3.3.1 Introduction

This paragraph tells how to control the Model 288 remotely over the GPIB bus and is divided into the following topics:

Model 288 Commands.

Universal and Addressed Commands.

Detailed Command Descriptions.

Service Requests.

Displaying Messages.

GPIB Keys.

3.3.2 Model 288 Commands

The following is a discussion of the Model 288 commands and the rules that must be followed to apply them.

Commands Types

Command Syntax

Command List

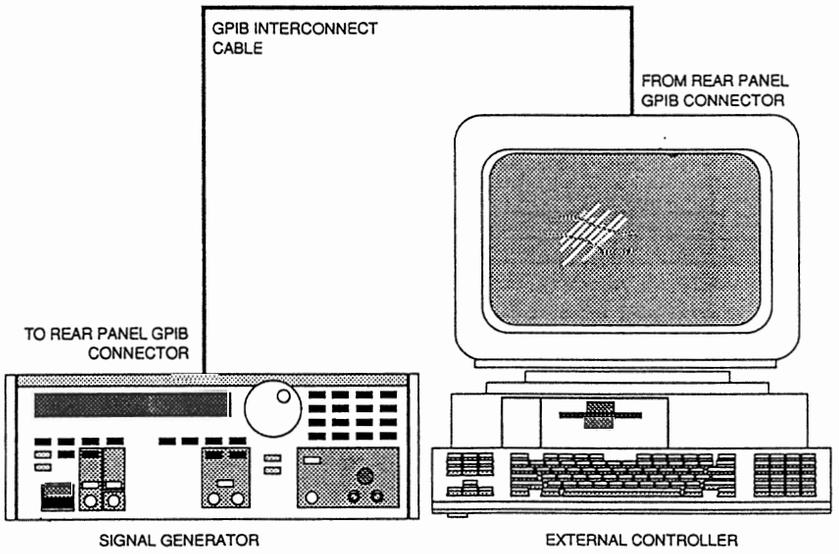


Figure 3-9. GPIB Interconnect Wiring

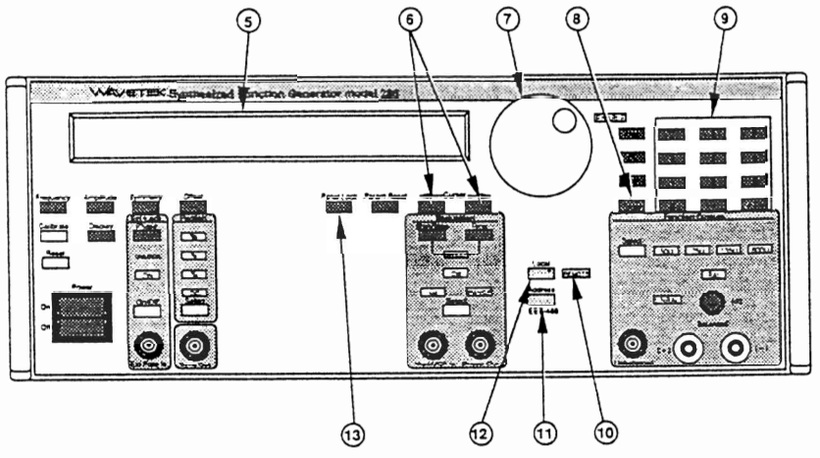


Figure 3-10. GPIB Operation Control Setup

3.3.2.1 Command Types

The Model 288 has four types of commands: parameter, enumerated, direct, and query.

The following text discusses each type of command separately. The examples terminate the commands with semicolons (;) or closing quotes ("). The controller may send just the command name without a value and the 288 will display that parameter's current value. Replacing the numerical value with a "?" (query) will make the Model 288 display and send the current value to the controller as a string of characters. Do not send an Execute command after a query command, the string will not be sent because the Execute command has put the Model 288 in a "listen for more commands" mode. See "terminators" for more information.

Parameter Commands

Parameter commands specify a particular numerical value within a continuous range of values. The values should use exponential (E) notation.

Format: <header>SPACE<value>TERMINATION

The header specifies the parameter and the value specifies the numerical value. Table 3-6 lists the parameter commands and their allowable value ranges.

Example:

FREQUENCY 2E3;	Sets the frequency at 2kHz
PHASE 87;	Sets the phase at 87°
SWEEPTIME 2.3;	Sets the second sweep time at 2.3

Enumerated Commands

Enumerated commands provide a list of distinct choices. Either the name or numerical value can be used (AM may be sent by sending either "MA;E" or "M1;E").

Format: <header>SPACE<argument>TERMINATION

The header specifies the parameter and the argument specifies the choice. A number or a descriptive character string can be used for the argument. Table 3-6 lists the enumerated commands and their arguments.

Example:

FUNC 2 or FUNC SQUARE	Selects the square output function.

Direct Commands

Direct commands make the Model 288 perform an immediate action.

Format: <header>TERMINATION

The header specifies the action. Direct commands have no value or argument. Table 3-6 lists all the direct commands.

Examples:

RESET:	Resets 288 parameters
TRIGGER:	Triggers waveform or sweep
EXECUTE:	Executes preceding commands in string.

Query Commands

Query commands tell the Model 288 to send information to the controller.

The Model 288 will not send the information when it receives the command, but will wait until the controller subsequently addresses it as a talker. Query commands can be sent only one at a time. If two or more are sent in a query string, the Model 288 will respond only to the last one.

Format: <header> <?>TERMINATION

The header specifies the type of information. Because all parameter command headers (and most enumerated command headers) can also serve as query headers, the question mark tells the Model 288 to send (rather than receive) the information. Certain other headers appear only in query commands. See Query Commands in paragraph 3.3.2.2, 288 Command Syntax for a sample query program.

Parameter Header Examples:

FREQUENCY?"	Returns current frequency.
PHASE?"	Returns current phase.

Enumerated Header Examples:

FUNCTION?"	Returns current output wave form.
OUTPUT?"	Returns current output setting.

Query Header Examples:

MAINPARAMETERS?"	Returns current output waveform.
SRQ?"	Returns current output setting.
STATUSBYTE?"	Returns status byte.

3.3.2.2 288 Command Syntax

Commands sent by an instrument controller to the Model 288 must follow the syntax given in table 3-5. The following text discusses command operation, command processing, semicolons, minimum uniqueness, and ? commands.

Command String Operation

The command string at the top of the table (written to run on a Wavetek Model 6000 Instrumentation Controller) works as follows:

WRITE @ 709:"FR 2E4;OU 1;FU SQ;FR;E"

FR 2E4 Sets the frequency to 20 kHz.

OU 1 Selects unbal 75Ω as the output configuration of channel 1.

FU SQ Selects a square waveform.

FR Tells the Model 288 to display the frequency menu.

E Makes the Model 288 convert all these commands to a signal output.

How Does the 288 Process Commands?

The 256-character listen buffer receives the commands from the instrument controller. If it fills up before receiving an Execute command, it will stop accepting commands, distribute its contents to the next-setup registers, then again accept commands. The commands in the next-setup registers will not take effect until the Model 288 receives an Execute.

The listen buffer accepts all commands regardless of syntax errors. When the Model 288 processes the commands in the listen buffer, it copies the defective commands over into the SRQ buffer and labels them with PE:0 to indicate defective syntax. The parameters and functions that the defective commands would have changed retain their previous values. If a command appears in the SRQ buffer, the Model 288 ignores it.

Terminators

A terminator tells the Model 288 that it has reached the end of the current command. Although the Model 288 recognizes both semicolons (;) and spaces as terminators, semicolons greatly simplify debugging. When the controller sends the Model 288 more than one command in a string, the individual commands should have semicolons (;) inserted between them as terminators. When using spaces, the Model 288 will copy (and ignore) all commands after the first defective command into the SRQ buffer. With semicolons, the Model 288 will accept all good commands and put only the defective ones in the SRQ buffer. Consider these two examples with and without semicolons (the defective command FR2E4 should read FR 2E4):

With Semicolons

Write @ 709:"FR2E4;OU 1;FN SQ;FR;E"

Message: SRQ = /PE:0 FR2E4*/

Without Semicolons

Write @ 709:"FR2E4 OU 1 FN SQ FR;E"

Message: SRQ = /PE:0 FR2E4* CH 1 OT 1 FN RM FR E/

Minimum Uniqueness

The Model 288 will interpret the following three command lines exactly the same. String 1 uses the minimum character set each command requires, string 2 uses longer abbreviations that contain each command's minimum character set, while string 3 completely spells out each command./ The expansion of the function command (FN 3, FUNC DC, and FUNCTION DC) demonstrates the use of numbers and descriptive character strings in the argument of enumerated commands.

Write @ 709:

"FR 2E4;OU 1;FN 3;FR;E" (**1**)

Write @ 709:

"FREQ 2E4;OUTP 1;FUNC SQR;FREQ ;EXEC" (**2**)

Write @ 709:

"FREQUENCY 2E4;OUTPUT 1;FUNCTION SQUARE ;FREQUENCY;EXECUTE" (**3**)

Query Commands

Query commands (such as FR?) make the Model 288 return the current setting of the parameter as a string of characters and require a program to make the controller use the returned data. The following Wavetek 6000 program requests the data, accepts it, and writes it to the 6000's screen.

Program Statements	Explanation
10 CLEAR	Clear screen
20 WRITE @ 709:"FR?"	Write command to Model 288 (port 7, address 09)
30 DIM STRING$*25	Dimension string to 25 characters
40 READ @709:STRING$	Read returning string
50 PRINT STRING$	Print string to screen
60 END	End program

3.3.2.3 288 Command List

Table 3-6 uses the following format to list and briefly describe the complete Model 288 GPIB command set. See the detailed command descriptions part or the corresponding menu key description for more information about each command.

Command	Range/String	Function
FRequency	2E-3 to 20E6	Sets the genera-tor frequency.
FRequency?	FREQUENCY n	Returns generator frequency n.
FUnction	0 to 3	Selects a channel output waveform.

Command Column

1) Lists commands alphabetically by their full names
2) Indicates minimum uniqueness with capitol letters
3) Indents command arguments

Range/String Column

1) Gives the value range for each parameter command.
2) Gives the argument number range for each enumerated command.
3) Lists the arguments (names and numbers) for each enumerated command.
4) Gives the string returned in response to each query command.

Function Column

1) States briefly the function of each command.
2) Uses an asterisk (*) to indicate further explanation in the detailed command description section.

Minimum Uniqueness

Capitol letters (AutoCalibrate) indicate the minimum letter combination required by the Model 288. Use just the caps (AC), a longer abbreviation that contains all the caps (AUTOCAL), or the entire command (AUTOCALIBRATE).

Other Sources of this Data

The HELP? command provides less complete forms of the data given in table 3-6. HELP? sends a list of all the commands, arguments, and ranges to the GPIB controller.

Table 3-5. Model 288 Command Syntax

Typical Command Line: WRITE @709:"FR 2E4;OU 1;FN SQ;FR;E"

Syntax	Explanation
RITE @709	Varies depending on the controller. This format, for the Wavetek 6000, tells the controller to send the command string out port 7 (the GPIB port) to the Model 288 (at address 09 on the GPIB bus).
"__" or '__'	Enclose the command string in quotes. Either single or double quotes can serve as string delimiters.
;	Separate commands with semicolons. See "terminators" in the text for the reasons for this requirement.
E	Use exponent notation to avoid entering long strings of zeros. For example, enter 20000 as 2E4 and 0.0005 as 5E-4.
FR	Use the minimum uniqueness version (FR), a longer version that contains the
FREQUENCY	minimum uniqueness letters (FREQ), or the full version (FREQUENCY) of each FREQUENCY command in programming. Table 3-6 spells out the commands and indicates the minimum uniqueness with capital letter (FRequency). The text gives examples of full, partial, and minimum uniqueness command strings.
FU 2	
FU SQ	Enumerated commands that select a function (such as FU, select channel output FU SQ waveform) allow the function to be selected by either number (3) or by name (SQ), (square waveform). Table 3-6 lists the enumerated commands and their arguments.
;CMD;	Drop the numerical value of a parameter command to make the Model 288 display that parameter. For example, ;A; will display the amplitude. Use this feature in step-by-step operation to follow and verify program operation.
E"	Place an Execute command at the end of a command string to make the Model 288 put the commands into effect. The Model 288 will accept commands and put them in the pending setup registers, but it will not generate their output until an E command is sent. E also puts the Model 288 in the "listen for more commands" mode; therefore, do not put E after a query (?) command as it will prevent the Model 288 from returning the answer.
?	Replace the numerical value of a parameter command with a ? to make the Model 288 return the current setting of that parameter as a string of characters. Table 3-6 lists the query commands and shows the format of the returning strings. Query commands also make the Model Model 288 display the menu of the requested parameter. The text gives a short program that makes the controller accept and display the returning information. Do not use E after a ? command.

Table 3-6. Model 288 Command Set

Command	Abbreviation	Range/Value Min	Range/Value Max	Description
Amplitude	A	1E-3	15	Set Amplitude
Amplitude?	A?			Request current Amplitude setting
AutoCalibrate	AC			Start Auto-Calibrate
Execute	E			Execute previous commands
FRequency	FR	2E-3	20E6	Set Frequency
FRequency?	FR?			Request current Frequency setting
FUnction	FU	0	3	Set Function
DC	D	3		Set dc Function
SIne	SI	0		Set Sine Function
SQuare	SQ	2		Set Square Function
Triangle	T	1		Set Triangle Function
FUnction?	FU?			Request current Function setting
Help?	H?			Request this Command list
Modulation mode	M	0	5	Set Modulation mode
Am	A	1		Set to AM modulation mode
Cw	C	0		Set to CW modulation mode
Fm	F	2		Set to FM/VCF Modulation mode
Sweep	S	5		Set to Sweep Modulation mode
SweepStArt	SSA	3		Set to Sweep start
SweepStOp	SSO	4		Set to Sweep stop
Modulation mode?	M?			Request current Modulation type
MaiNParameters?	MNP?			Request current main parameters
OFfset	OF	-5	5	Set Offset voltage
OFfset?	OF?			Request current Offset value
OUtputtype	OU	0	4	Set Output type
Balanced 135	B1	4		Set Output to 135Ω Balanced
Balanced 600	B6	3		Set Output to 600Ω Balanced
Unbalanced 50	U5	0		Set Output to 50Ω Unbalanced
Unbalanced 75	U7	1		Set Output to 75Ω Unbalanced
Unbalanced 600	U6	2		Set Output to 600Ω Unbalanced
OUtputtype?	OU?			Request current Output type
PhaseLock	PL	0	1	Set Phase lock source
External	E	1		Set Phase lock source to external
Internal	I	0		Set Phase lock source to internal
PhaseLock?	PL?			Request current Phase lock source
Phase	P	-180	180	Set phase against external source
Phase?	P?			Request current phase value
PANellock	PAN	0	1	Set Panel lock
ON	ON	1		Set Panel to locked
OFf	OFF	0		Set Panel to unlocked
PARameterreset	PAR			Reset previously transmitted parameter
RAngelock	RA	0	1	Set Range lock
ON	ON	1		Locks generator in the current range
OFf	OFF	0		Sets Range to normal
Reset	R			Reset parameters except GPIB address
SYmmetry	SY	5	95	Set Symmetry value
SYmmetry?	SY?			Request current Symmetry value
SWeepStArtfreq	SWSA	2E-3	20E6	Set Sweep start frequency
SWeepStArtfreq?	SWSA?			Request current Sweep start frequency

Table 3-6. Model 288 Command Set (Continued)

Command	Abbreviation	Range/Value Min	Max	Description
SWeepStOpfreq	SWSO	2E-3	20E6	Set Sweep stop frequency
SWeepStOpfreq?	SWSO?			Request current Sweep stop frequency
SWeepTime	SWT	100E-3	100	Set Sweep time
SWeepTime?	SWT?			Request current Sweep time value
SRQMask	SRQM	0	255	Set Service Request Mask value
SRQMask?	SRQM?			Request current SRQ Mask value
SRQ?	SRQ?			Request current SRQ value
STatusByte?	STB?			Request current Status Byte value
SErialnumbers?	SE?			Request instrument serial numbers
STARTCALibration	STARTCAL			Initiate instrument Auto-Cal
Talkmode	T	0	10	Set instrument to send a value
Version?	V?			Request software version number

3.3.3 Universal and Addressed Commands

Universal and addressed (U/A) commands make most GPIB instruments perform generally accepted standard functions. Usually, universal commands control all the instruments on the GPIB bus, while addressed commands control individual instruments at specific addresses on the bus. The Model 288 accepts the following U/A commands:

Command	Type	Function
DCL	Universal	Device Clear
GET	Addressed	Group execute trigger
GTL	Addressed	Go to local
LLO	Universal	Local lock out command
SDC	Addressed	Selected device clear

Paragraph 3.3.4 (detailed command descriptions) discusses these U/A commands and selected Model 288 commands in detail.

U/A Syntax

This manual uses generic names to identify the universal and addressed commands and the functions they perform. Individual controllers will use differently named commands to perform these same functions. See the manual for the controller being used to determine the actual command names and the syntax they require.

3.3.4 Detailed Command Descriptions

The following paragraphs describe in detail the unique Model 288 GPIB commands that perform functions not controlled by the front panel and also the GPIB universal and addressed commands recognized by the Model 288. Use the following list to identify these specialized commands.

Command	Type	Description
DCL	Universal	Device Clear
GET	Address	Group Execute Trigger
GTL	Address	Go To Local
HELP?	288	HELP?
LLO	Universal	Local Lock Out
MNP	288	MaiN Parameters
SDC	Address	Selected Device Clear
SRQ?	288	Service ReQuest?
SRQM	288	Service ReQuest Mask
SRQM?	288	Service ReQuest Mask?
STB?	288	STatus Byte?
V?	288	Version?

GPIB Control

The Model 288 limits the operator's use of the front panel with two levels of increasing restrictions as shown in table 3-7.

The Model 288 switches to GPIB control when the instrument controller asserts the GPIB REN (remote enable) line and sends to the Model 288 its listen address. The Wavetek 6000 instrument controller command string WRITE @709:"– command string –" will automatically perform these two actions. The GPIB control restricts further front panel operation as described in table 3-7. The Model 288 will remain under the GPIB control until the operator presses the Local key.

Table 3-7. Front Panel Restrictions

IF Front Panel Operation is Limited With —» THEN the Operator Can:	Nothing	GPIB Control	LLO Command
See the Screen Display?	Yes	Yes	Yes
Display Parameters?	Yes	Yes	Yes
Take Control Back From the GPIB?	Yes	Yes	No
Change Parameters?	Yes	No	No

LLO Command

All instruments on the bus recognize the universal command LLO; it cannot be directed to just one instrument. LLO restricts operation of the Model 288 front panel as described in table 3-7 For the Wavetek 6000 controller, LLO has the format LLO @7, where 7 specifies the GPIB bus port of the controller.

GTL Command

GTL cancels the LLO command and returns the Model 288 front panel to full operator control. All instruments on the bus recognize the addressed command GTL; however, it must be sent to each instrument individually. The Wavetek 6000 instrument controller uses the LCL command to issue GTL commands. LCL @7 sends GTL commands to all the instruments on the bus, while LCL @709 sends the GTL to just the specified instrument. In these command formats, 7 specifies the GPIB bus port of the controller and 09 specifies the address of a particular instrument on the bus. LCL becomes effective on receipt; the Model 288 does not require that it be followed with another command.

GET Command

The GET command triggers whatever trigger function that is set up within the Model 288. All instruments on the bus recognize the GPIB addressed command GET (group execute trigger); however, it can be sent to just one instrument at a time. For the Wavetek 6000 controller, the TRG command sends the group execute trigger to individual instruments on the GPIB bus. TRG has the format TRG @709, where 7 specifies the GPIB bus port of the controller and 09 the address of a particular instrument on the bus. The Model 288 triggers the selected function immediately on receipt of the TRG command.

HELP? Command

The HELP? command makes the Model 288 return a list of the Model 288's primary and secondary commands and their limits as a string to the controller. HELP? requires that a program be written to make the instrument controller accept and print the returned list. The following Wavetek 6000 program requests the list, accepts it, and sends it to a printer connected to the GPIB bus. To make this program work, set the address switches of the printer to 04. Table 3-6 provides the same information as the list this program prints.

Wavetek 6000 HELP Print Program

```
100  DIM A$*255                  Dimension String to 255
                                 characters.
110  WRITE @709:"HELP?"          Write HELP to port 7,
                                 address 09.
120  READ @709:A$                Read the String
130  IF A$="0" THEN 170          If string is "0" jump to
                                 170
132  PRINTER IS @704             Printer is at port 7, a d -
                                 dress 04.
140  PRINT A$                    Print the list
150  GO TO 120
170  END                         End Program
```

MaiNParameters? Command

The MNP? command makes the Model 288 return the current setting of the Model 288's main parameters as a string to the controller. The controller can save this string, then send it back to the Model 288 at a later time to restore the parameters to their previous values.

DCL and SDC Commands

The DCL and SDC commands reset the Model 288 to the power-up conditions, but leave it in the remote (GPIB controlled) mode. All instruments on the bus recognize the GPIB universal command DCL (device clear). Individual instruments recognize the GPIB addressed command SDC (selected device clear). For the Wavetek

6000 instrumentation controller, the DCL command issues DCL and SDC. To reset everything on the bus, use DCL @&, where 7 specifies the GPIB bus port of the controller. To reset just one instrument, use DCL @709, where 09 specifies the instrument address. The Model 288 resets itself immediately when it receives either command.

Reset Command

The Reset command resets the Model 288 to default conditions.

ersion? Command

he Version? command makes the Model 288 return the oftware version of the Model 288 EPROM as a string of haracters. Version? requires a program to make the nstrument controller use the returned string. The following Wavetek 6000 program requests the version, accepts it, and writes it to the 6000's screen.

'Wavetek 6000 Version? Print Program

'0	CLEAR	Clear screen
20	WRITE @709:"V?" port 7, address 09.	Write VERSION? to
'0	DIM VERSION$*50 50 characters.	Dimension string to
,0	READ @709:VERSION$	Read returning string
50	PRINT VERSION$	Print string to screen
80	END	End program

unning the above program will produce the following isplay:

WVTK 288 (VX.XX)

In this display, x gives the version number.

.3.5 Service Requests

e following paragraphs discuss the concepts of service requests, describes the commands associated with hem, and then lists the service request messages that he Model 288 generates. The Model 288 can set the SRQ line whenever a programming error occurs, a hardware error occurs, an event is completed, Phase lock changes state, or a Calibration message is displayed.

SRQ CONCEPTS

What Does the Service Request Tell the Controller?

ne Model 288 service request tells the controller that the lodel 288 wants attention. The Model 288 makes the equest by asserting the SRQ line of the GPIB bus. Because any instrument on the bus can assert this line, the controller must read the status byte of each instrument in turn to determine which one requested attention.

What Does the Status Byte Tell the Controller?

The Model 288 uses six of the eight bits in its status byte. One tells the controller if the Model 288 requested service. The others indicate the type or types of messages (programming error, hardware error, event , Phase Lock state, or Calibration) that the Model 288 wants to send. Figure 3-11 shows the format of the Model 288 status byte. If the controller wants to know the specific message within the category, it must read the Model 288's SRQ buffer.

What Does the SRQ Buffer Tell the Controller?

The Model 288 SRQ buffer stores the programming error, hardware error, event complete, Phase Lock state, and Calibration messages until the controller can read them. Tables 3-8 thru 3-12 list all of the SRQ messages.

SRQ COMMANDS

The following paragraphs discuss the commands related to the service request mask, the status byte and the service request messages.

SRQMask Command

The SRQM command makes the Model 288 selectively ignore one or more of the three types of conditions that make it produce service requests. For example, if programming errors were masked out, the Model 288 would not load messages for specific programming errors into the SRQ buffers and it would not set the PE and service request bits in the status byte. Figure 3-9 shows the positions and the corresponding decimal mask values required to block out PE, HE, and EV messages. The SRQ mask is reset to SRQmask #1 (programming error only) on power on. It is not changed by "RESET"

SRQMask? Command

The SRQM? command makes the Model 288 return the current mask setting to the controller. The Model 288 sends the SRQ mask setting as the character string SRQMASK#, where # gives the decimal equivalent of the binary mask bits. To use SRQMASK?, write a program that first asks the Model 288 to send the mask, then tells the controller how to receive and process the returning string.

STatusByte? Command

The STB? command makes the Model 288 send its current status byte to the controller over the GPIB bus. The Model 288 sends its status byte as a string of characters with the format STB=##, where ## gives the decimal equivalent of the status byte. STatusByte? reads, **but**

does not reset, the status byte of the Model 288. To use STatusByte?, write a program that first asks the Model 288 to send the status byte, then tells the controller how to receive and process the returning string.

SRQ? Command

The SRQ? command makes the Model 288 send the contents of the SRQ buffer to the controller over the GPIB bus. The Model 288 sends its SRQ buffer contents as a string of characters with the format SRQ = MESSAGES, where MESSAGES represents a string of messages. Reading the SRQ buffer empties it. To use SRQ?, write a program that first asks the Model 288 to send the SRQ buffer messages, then tells the controller how to receive and process them.

SRQ MESSAGES

SRQ Message Format

The Model 288 puts messages in the SRQ buffer in this general format:

SRQ=/PE:n Description//HE:n Description//
EV:n Description/

Slashes (/) enclose each message. PE identifies a programming error message, HE a hardware error message, and EV an event complete message. "n" identifies a specific message within the type. This fixed format header allows a computer to easily parse (decode) the message. "Description" describes the error in English for the benefit of human readers. Table 3-8. lists all the SRQ programming error messages, table 3-9 lists all the SRQ hardware error messages, table 3-10 lists all the SRQ event error messages, table 3-11 lists all the SRQ phase lock state change error messages, and table 3-12 lists all the SRQ Calibration error messages.

3.3.6 Displaying Messages

The Model 288 can accept messages from the GPIB bus and display them on the front panel display. Use this feature to give instructions to an operator or to display information.

Command Format

Send messages in this format:

WRITE @709:" 'TEXT' "

The standard double quotes (") identify the command string. The single quotes (') identify the contents as a message rather than commands. Messages do not require an Execute command.

Although the Model 288 accepts either single or double quotes as string delimiters, the Wavetek 6000 interprets the double quotes as its own program string delimiters. This restricts use to the single quotes for Model 288 display strings when using the Model 6000. Other controllers might reverse this situation.

Message Size

The screen will allow a maximum message size of four line of 16 characters. The Model 288 will ignore any characters beyond these limits.

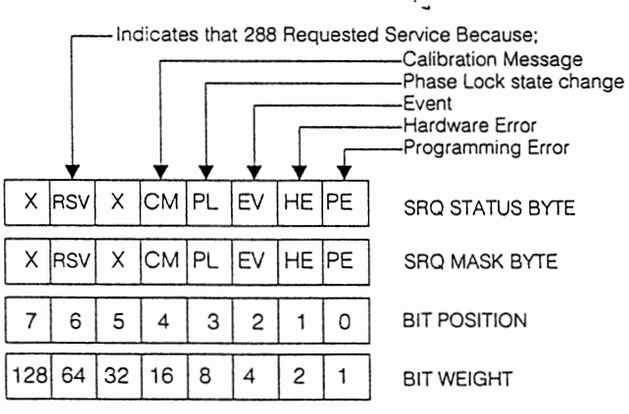


Figure 3-11 Model 288 Status Byte and SRQ Mask

Erasing

ess any menu key or send another GPIB command ring to return to normal Model 288 displays. To erase ..e previous message, send a new message.

3.3.7 GPIB Keys

Address Key

The address key enables entry of an alternate GPIB address using the front panel controls. The GPIB bus address identifies the Model 288 to the instrument controller. Press the address key to display the current GPIB address on the display. Key in a new address using the numeric keypad or the control knob and then press Execute.

Local Key

The Local key switches control of the Model 288 from the GPIB bus to the front panel. Receipt of any GPIB command (if the controller simultaneously asserts the REN line of the GPIB) by the Model 288 disables the front panel to the extent that parameter settings can be read but modes or numbers cannot be changed. Pressing the Local key returns full control to the front panel except when the universal command LLO has been issued by the controller. LLO disables the Local key so that full control cannot be obtained at the front panel.

Table 3-8. SRQ Programming Error Messages

Command	Description
/PE:0 < defective command string > /	The Model 288 did not recognize the command it received. < defective command string > is whatever garbage the Model 288 received over the bus.
/PE:1 < parameter header > /	This is a limit error. An attempt was made to set a parameter to an illegal value. < parameter header > is the maximum header string e.g. "FREQUENCY" or "SWEEPSTOPFREQ".
/PE:2:< param# >:< param# > < param name >-< param name> CONFLICT/	This is a setting conflict error. This service request will occur after an execute command if there are conflicting settings. It will only flag the first conflict that it finds. < param# > and < param name > are redundant and are as follows: **< param# > — < param name >** 1 — FREQUENCY 2 — AMPLITUDE 3 — OFFSET 4 — SYMMETRY 5 — PHASE 6 — FUNCTION 7 — MODULATION 8 — EXTLOCK 9 — OUTPUT 10 — SWP START 11 — SWP STOP 12 — SWP TIME 13 — AMPLITUDE-OFFSET 14 — RANGE LOCK

Table 3-9. SRQ Hardware Error Messages

Command	Description
/HE:0 < cal index >< cal name >	This is a failure to complete and autocal step. AUTOCAL ERROR < cal index > is a number associated with the calibration parameter that failed adjustment. < cal name > is is an archaic name associated with the calibration parameter that failed adjustment..
/HE:1 WAIT < time > MIN/	This means an autocal was attempted before the required 20 minute warm-up. < time > is the time (in minutes) remaining before an autocal can be performed.

Table 3-10. SRQ Event Complete Error Messages

Command	Description
/EV:0 AUTOCALIBRATION COMPLETE/	This means that autocalibration was completed.
/EV:1 EXECUTE COMPLETE	This means that execute was complete. After an execute command, the Model 288 will send either this service request or a PE:2 (assuming both PE and EV SRQ's are enabled by the SRQ mask).

Table 3-11. SRQ Phase Lock State Change Error Messages

Command	Description
/PL:0 PLL UNLOCKED/	This means that the phase lock loop has changed from an unlocked state to a locked state..
/PL:0 PLL LOCKED/	This means that the phase lock loop has changed from a locked state to an unlocked state..

Table 3-12. SRQ Calibration Error Messages

Command	Description
'CM:1:<cal index><cal name>/	This is an information message usually requesting a manual operation. < cal index > is a number associated with the calibration parameter or step that needs attention. < cal name > is anarchic name associated with the calibration parameter or step that needs attention.
/CM:2:< cal index >:< number >	This is an information message having an unchangable number < cal name > / associated with it.
/CM:3:< cal index >:< number>	This is a request for a numeric calibration parameter. < cal name > / < number > is the previous value of this parameter.
/CM:4 CALIBRATION BUTTON	This is sent if an attempt is made to enter the calibration NOT PUSHED/ procedure without the internal calibration enable key pushed.
/CM:5 THANKS I NEEDED THAT! /	This is sent after the completion of the full calibration procedure if the calibration was required because of lost RAM data.