OPERATOR'S & MAINTENANCE MANUAL

Model 288

20 MHz Synthesized Function Generator

WAVETEK

WAVETEK SAN DIEGO, INC.
9045 Balboa Ave., San Diego, CA 92123
P. O. Box 85265, San Diego, CA 92138
Tel 619/279-2200 TWX 910/335-2007

Manual Revision: 1/90
Manual Part Number: 1300-00-0561

SAFETY FIRST

Protect yourself. Follow these precautions:

- Don't touch the outputs of the instrument or any exposed test wire carrying the output signals. This instrument can generate hazardous voltages and currents
- Don't bypass the power cord's ground lead with two-wire extension cords or plug adapters.
- Don't disconnect the green and yellow safety-earth-ground wire that connects the ground lug of the power receptacle to the chassis ground terminal (marked with ⏚ or ⏛)
- Don't hold your eyes extremely close to an RF output for a long time. The normally nonhazardous low-power RF energy generated by the instrument could possibly cause eye injury.
- Don't plug in the power cord until directed to by the installation instructions.
- Don't repair the instrument unless you are a qualified electronics technician and know how to work with hazardous voltages.
- Pay attention to the **WARNING** statements. They point out situations that can cause injury or death.
- Pay attention to the CAUTION statements. They point out situations that can cause equipment damage.

WARNING

This instrument normally contains a lithium battery. Where lithium is prohibited, such as aboard U.S. Navy ships, verify that the lithium battery has been removed.

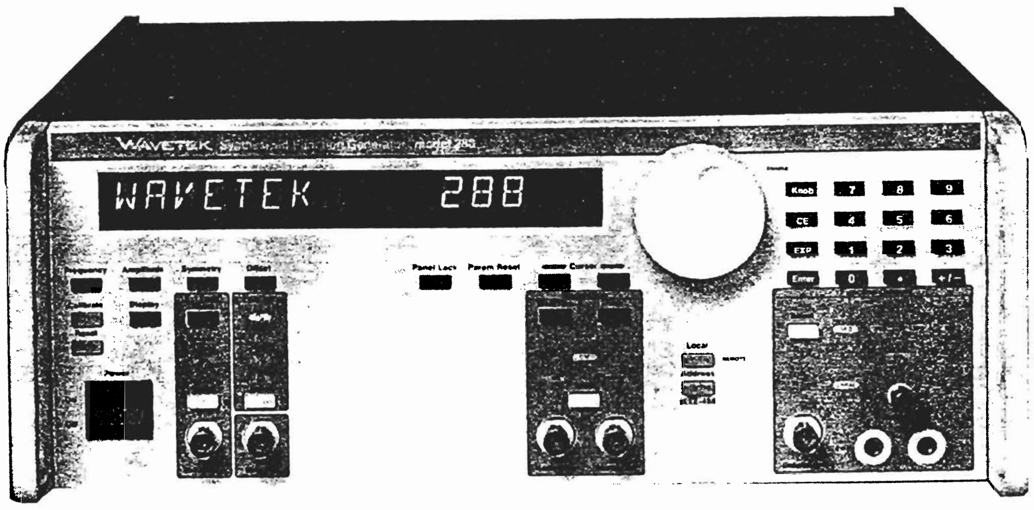
Do not recharge, short circuit, disassemble, or apply heat to the lithium battery. Violating this rule could release potentially harmful lithium. Observe polarity when you replace the battery.

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

ILLUSTRATIONS



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 Hz.
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.

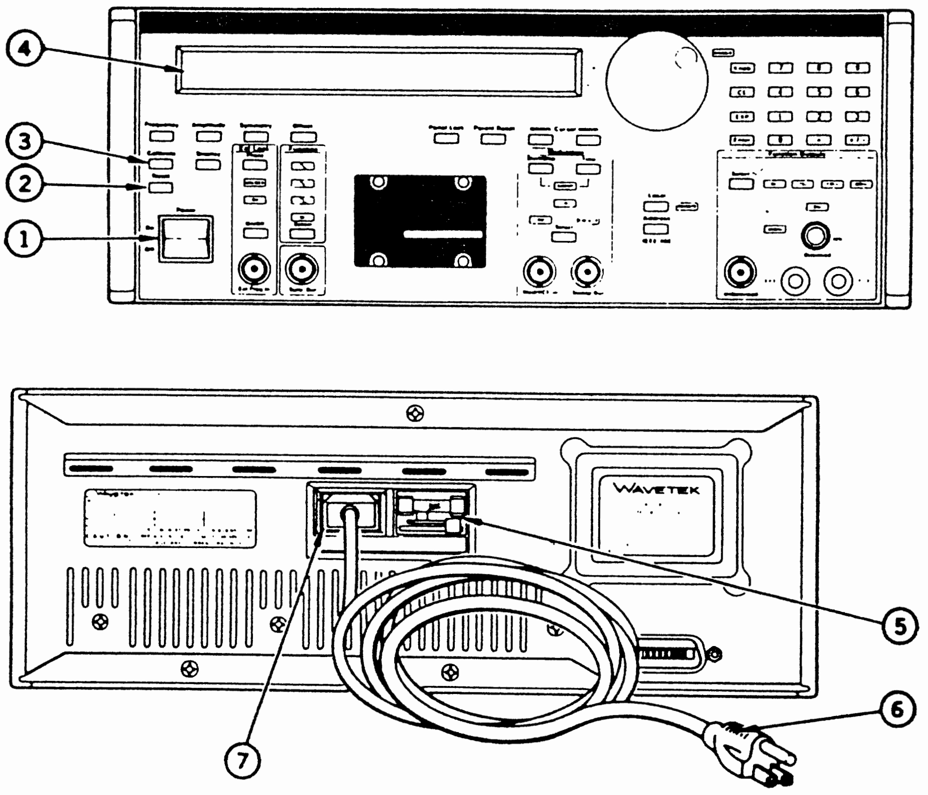


Figure 2-1. Equipment Setup

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.

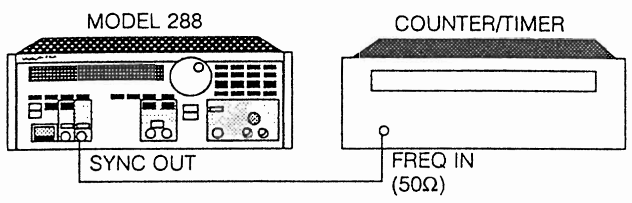


Figure 2-2. Frequency Measurement Setup

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 unlocked 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.

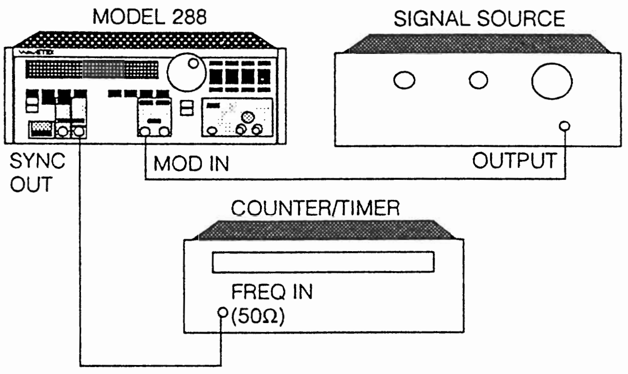


Figure 2-3. VC/FM Setup

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.

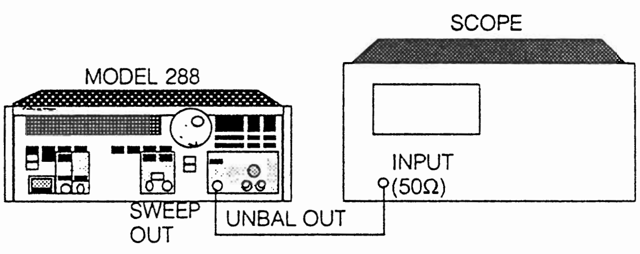


Figure 2-4. Waveforms/Sweep Verification

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.

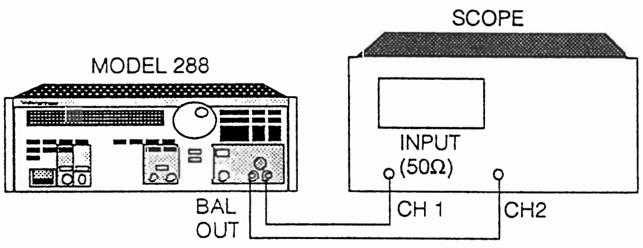


Figure 2-5. Balanced Output Verification

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.

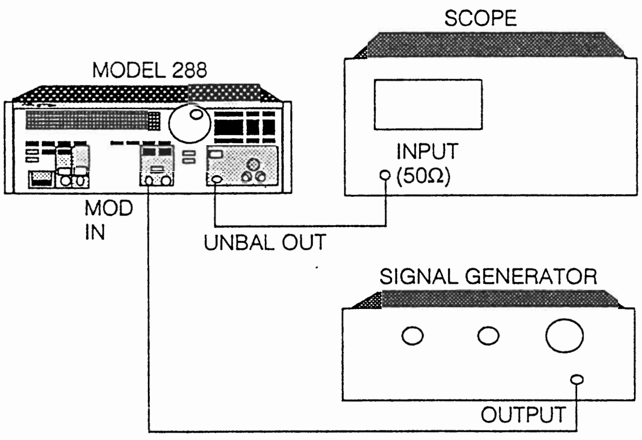


Figure 2-6 AM Verification

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.

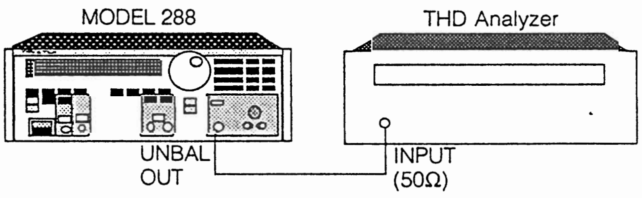


Figure 2-7. Sine Purity Measurement

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.

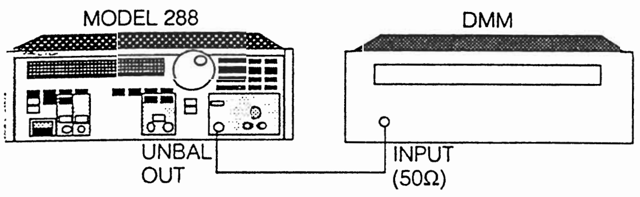


Figure 2-8. Amplitude Accuracy

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.

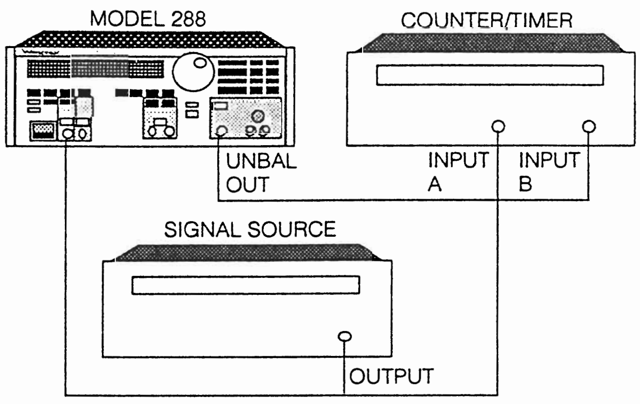


Figure 2-9. Phase Angle Measurement

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.

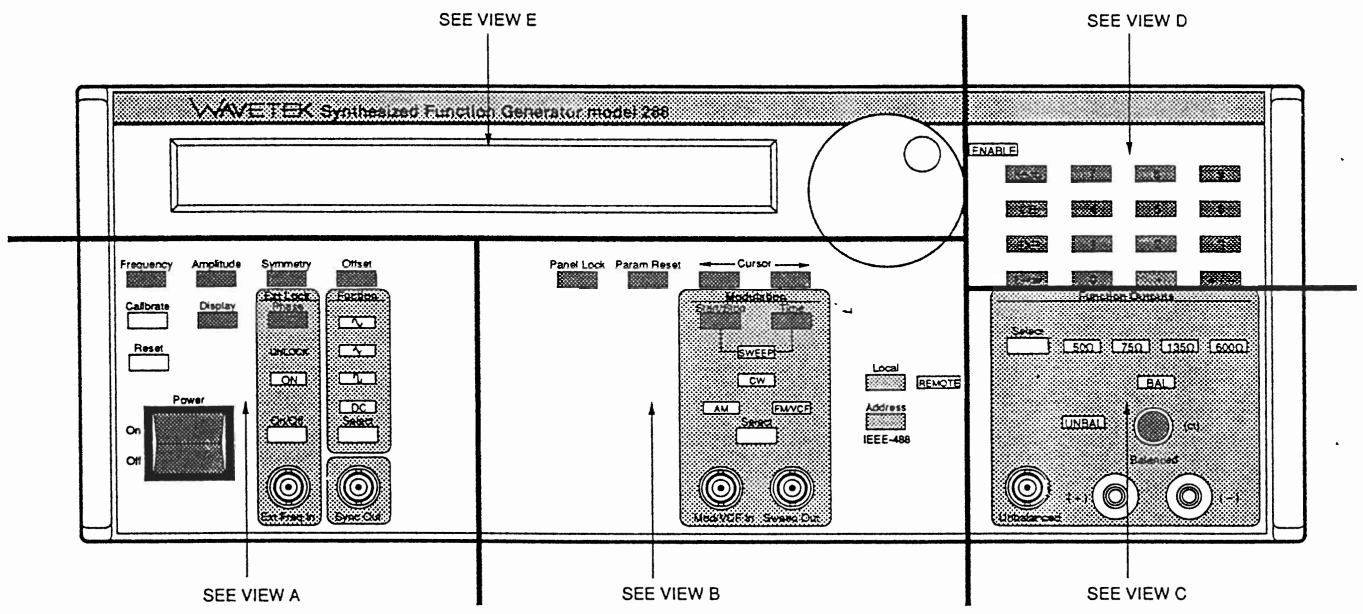
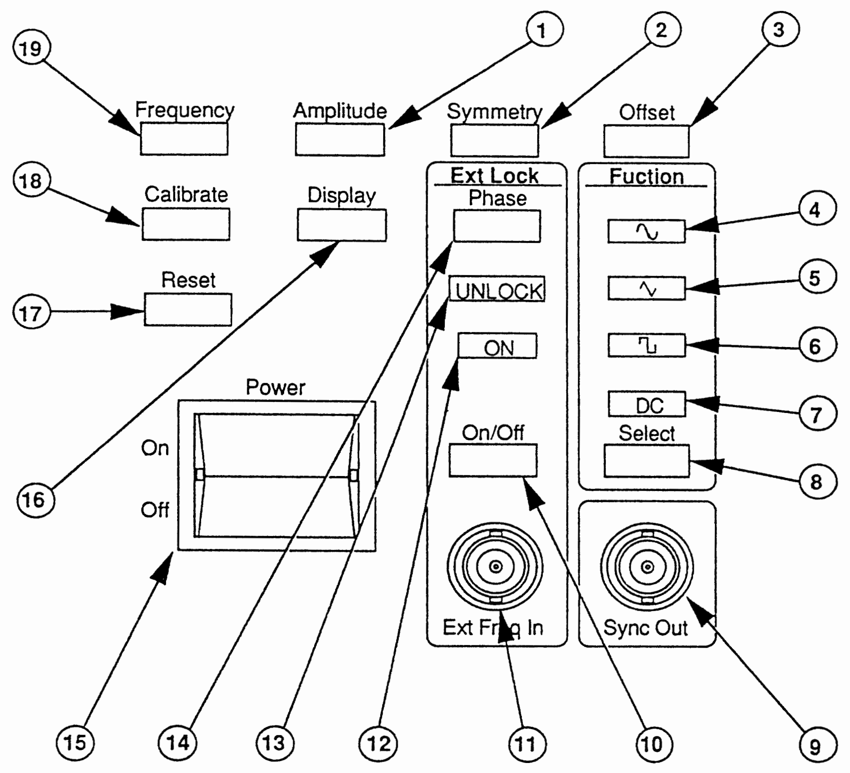


Figure 3-1. Operator's Controls, Indicators and Connectors (front view).

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



VIEW A

Key	Control, Indicator or Connector	Function
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)

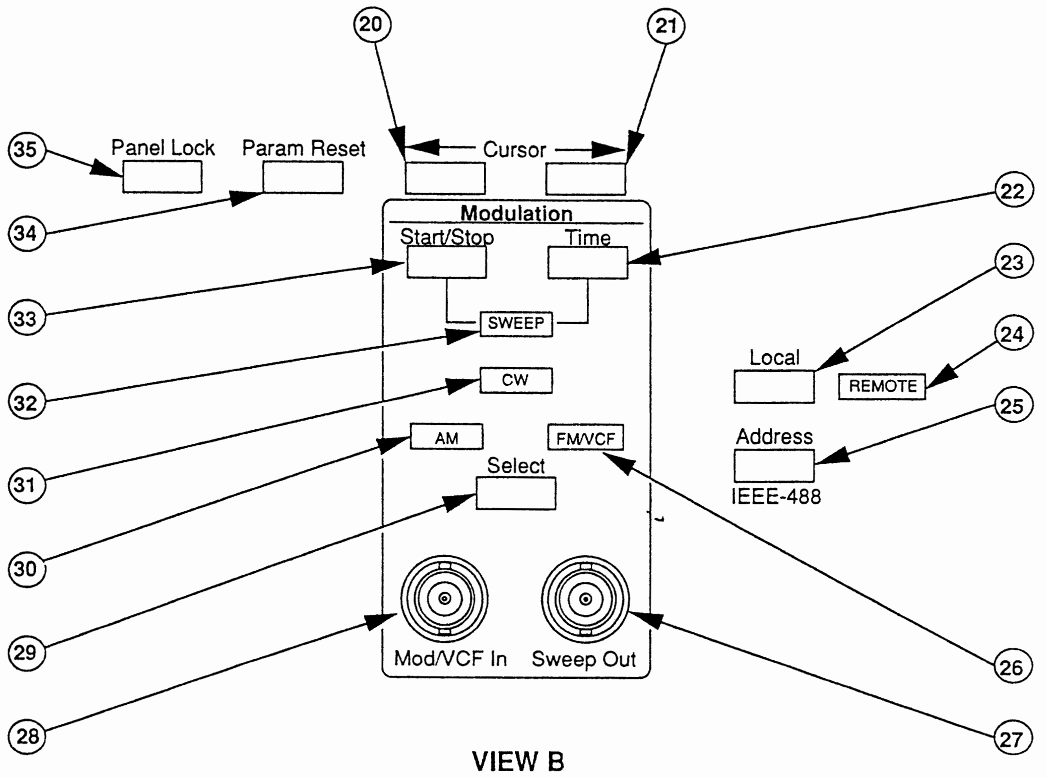
Key	Control, Indicator or Connector	Function
3	Offset key	Used to display and enter DC offset value from +5.000 to –5.000V. In DC function, controls signal output polarity and level. In sine, triangle, and square functions it controls reference level of output waveform. Press to display the present value. 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

Key	Control, Indicator or Connector	Function
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)

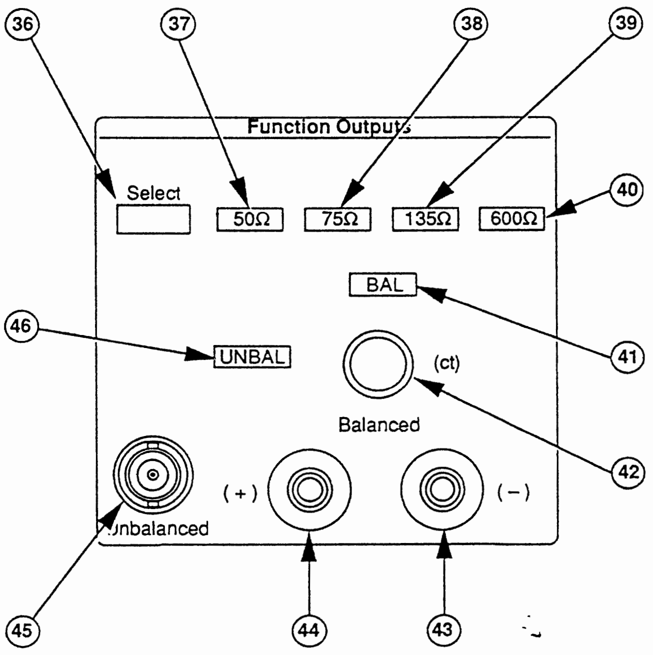
Key	Control, Indicator or Connector	Function
21	Cursor —> key	Used to change display setting. Moves selectable digit to right through all possible display combinations. Press key until desired digit flashes, then use control Knob to change value. **Restrictions:** Not used for Display, Phase, Symmetry, 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.



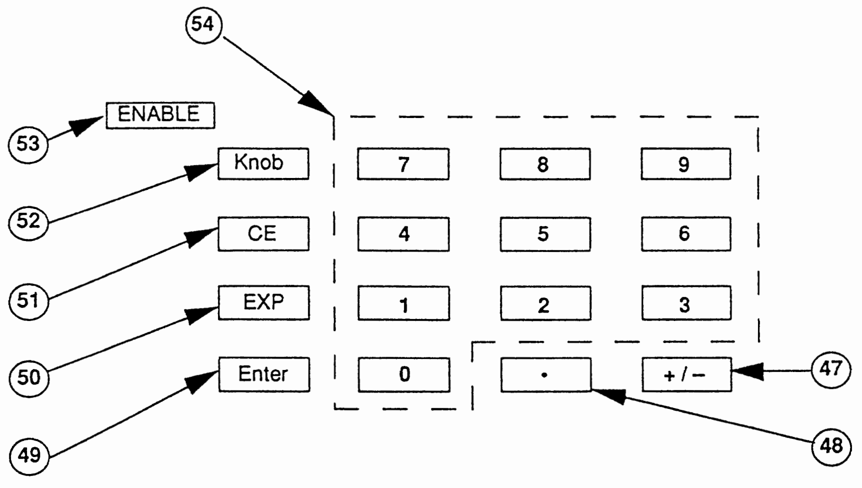
VIEW C

Key	Control, Indicator or Connector	Function
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)

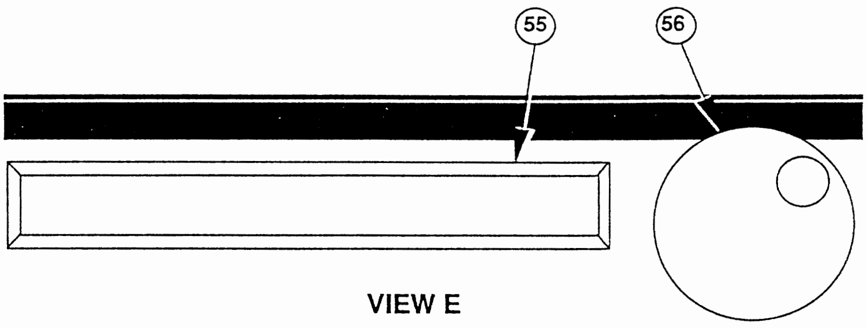


VIEW D

Key	Control, Indicator or Connector	Function
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

Key	Control, Indicator or Connector	Function
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.

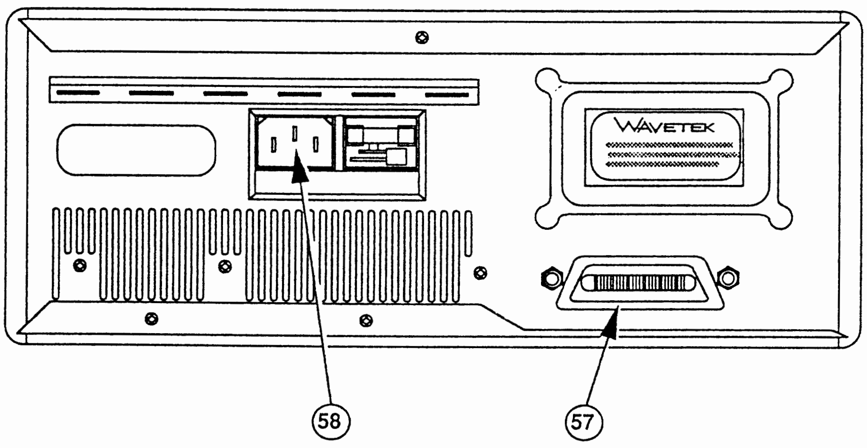


Figure 3-2. Operator's Controls, Indicators, and Connectors (rear view).

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.

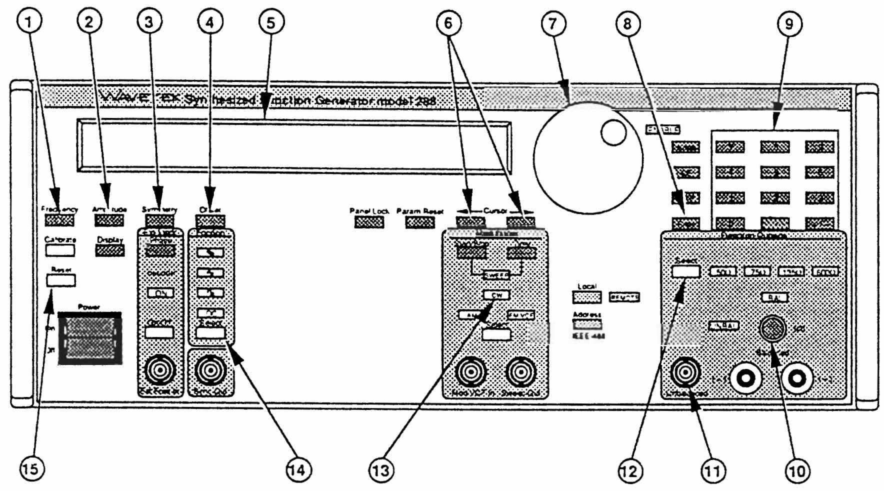


Figure 3-3. Continuous Wave Operation Control Setup

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.

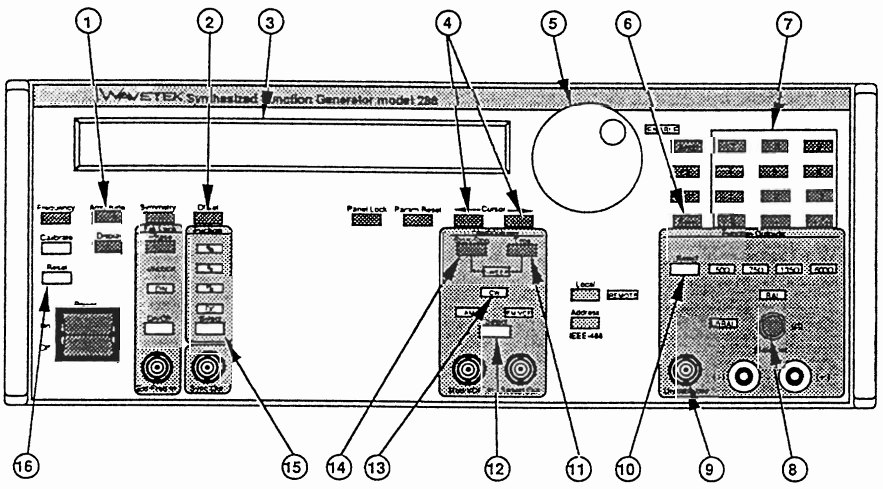


Figure 3-4. Sweep Modulation Operation Control Setup

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.

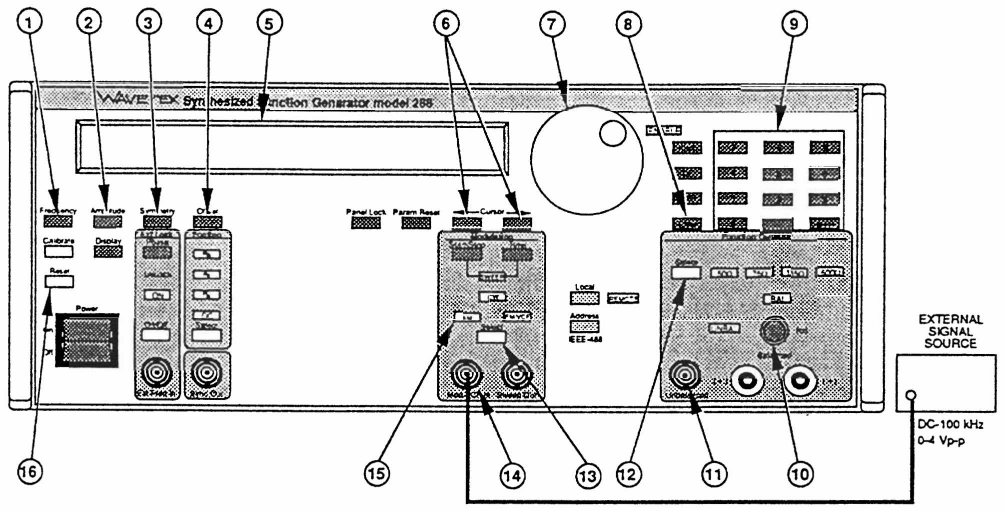


Figure 3-5. Amplitude Modulation Operation Control Setup

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.

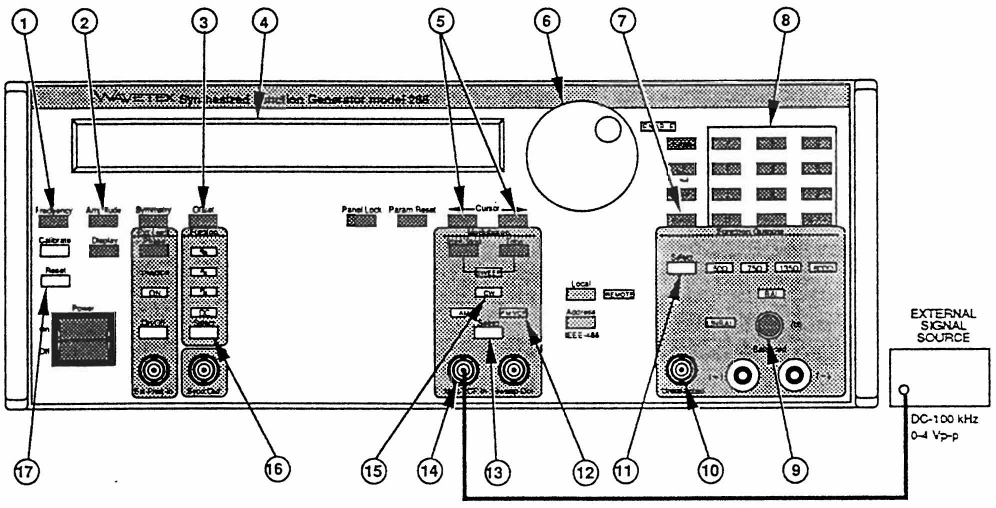


Figure 3-6. Frequency Modulation Operation Control Setup

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).

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.

Connect the external DC source DC level to MOD/VCF IN connector (14).

0. Set the dc signal source to the calculated level (step 4) from –5 to +5V.

1. 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.

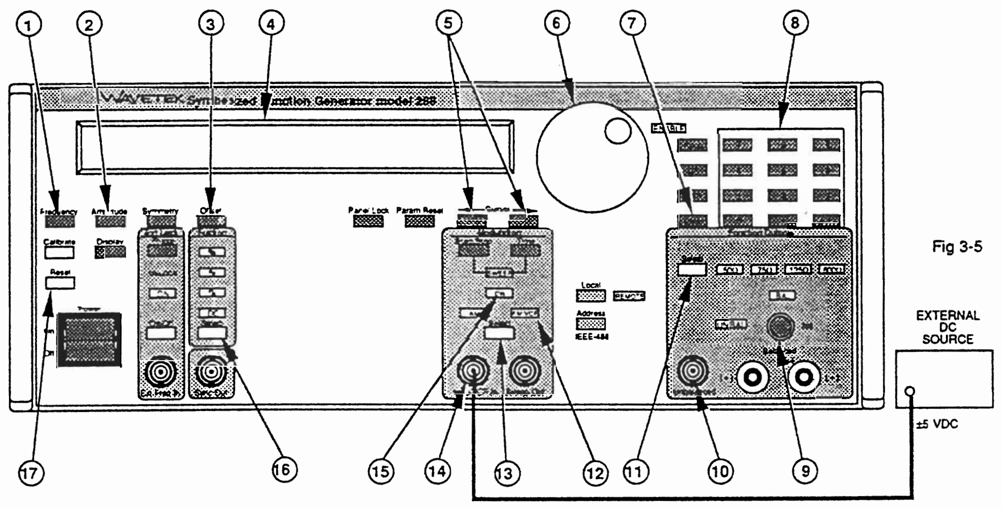


Figure 3-7. VCF Operation Control Setup

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.

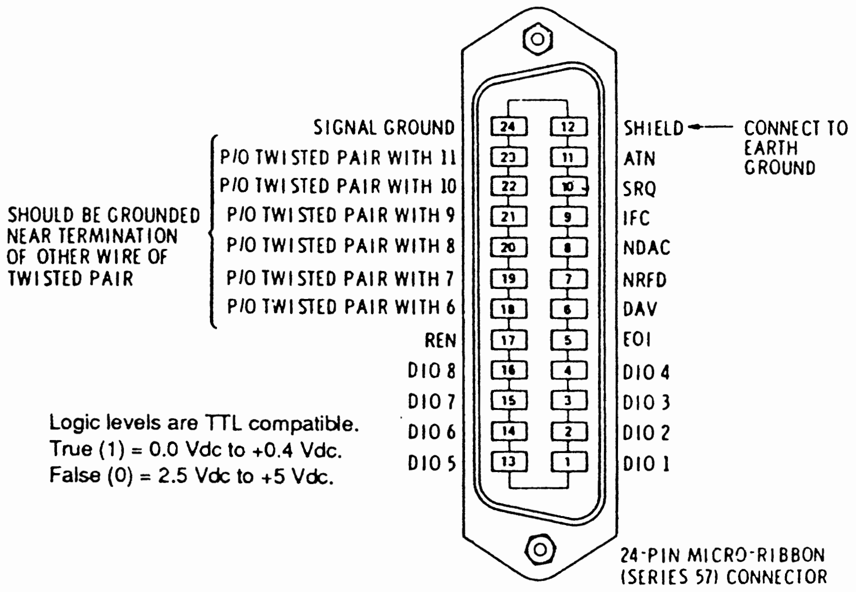


Figure 3-8. GPIB Wiring Connector Pin Out

..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).

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.

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

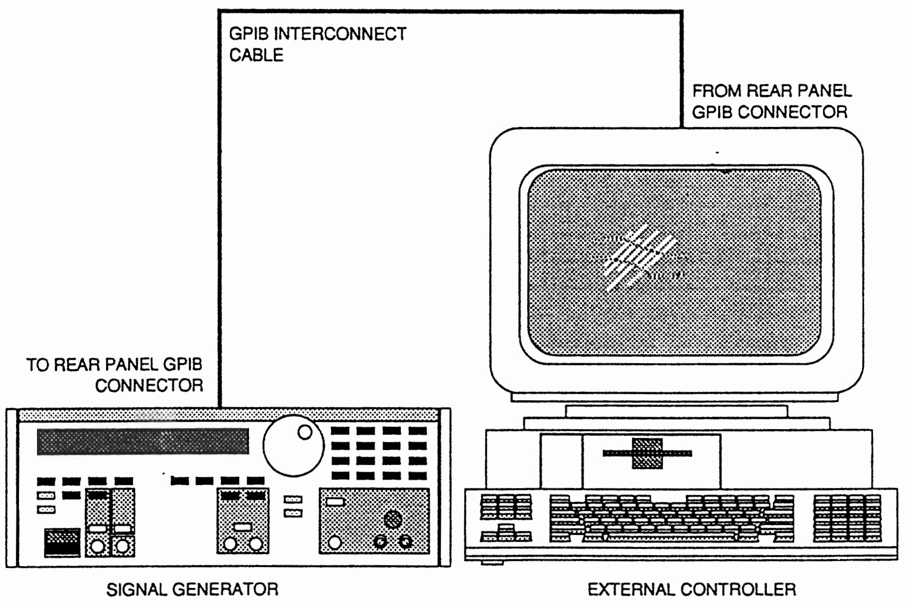


Figure 3-9. GPIB Interconnect Wiring

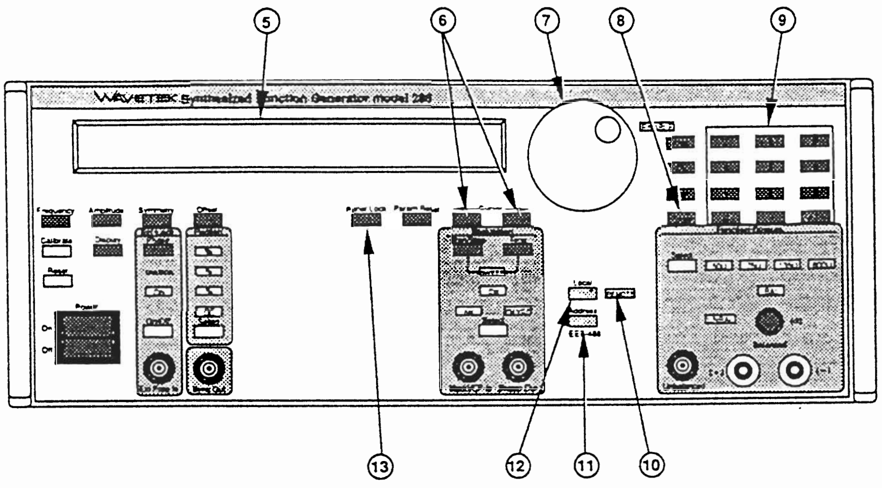


Figure 3-10. GPIB Operation Control Setup

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 set ting.
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 (AUTO-CALIBRATE).

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	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	Range/Value 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$*255 characters.	Dimension String to 255
110	WRITE @709:"HELP?" address 09.	Write HELP to port 7,
120	READ @709:A$	Read the String
130	IF A$="0" THEN 170 170	If string is "0" jump to
132	PRINTER IS @704 dress 04.	Printer is at port 7, a d -
140	PRINT A$	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

000 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.

Version? Command

The Version? command makes the Model 288 return the software version of the Model 288 EPROM as a string of characters. Version? requires a program to make the instrument 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
0	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
0	PRINT VERSION$	Print string to screen
0	END	End program

Running the above program will produce the following display:

WVTK 288 (VX.XX)

In this display, x gives the version number.

.3.5 Service Requests

The following paragraphs discuss the concepts of service requests, describes the commands associated with them, and then lists the service request messages that the 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?

The Model 288 service request tells the controller that the Model 288 wants attention. The Model 288 makes the request 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.

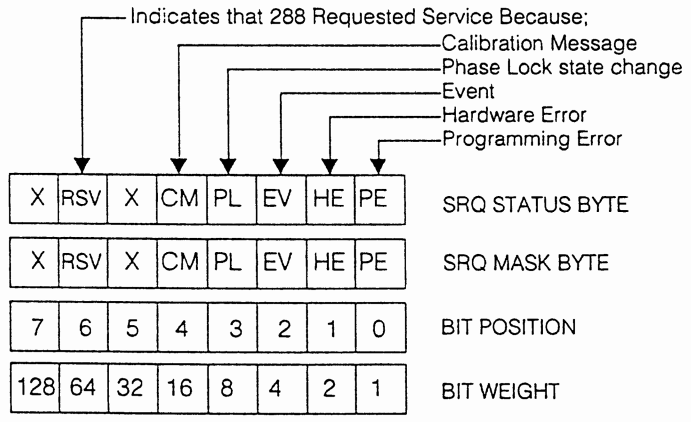


Figure 3-11 Model 288 Status Byte and SRQ Mask

·asing

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

:.3.7 GPIB Keys

·ddress Key

'he address key enables entry of an alternate GPIB ddress using the front panel controls. The GPIB bus :ddress identifies the Model 288 to the instrument con-·oller. Press the address key to display the current GPIB :ddress on the display. Key in a new address using the ıumeric keypad or the control knob and then press Exe-:ute.

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	This means that autocalibration was completed. COMPLETE/
/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.

SECTION 4
CIRCUIT DESCRIPTION

4.1 THE MODEL 288

The Model 288, a 20 MHz synthesized function generator, operates with synthesizer accuracy (<0.02%) over the 20 Hz to 20 MHz range, CW or AM only. Between 2mHz to 20 Hz and in FM or sweep, the unit operates as a standard function generator with <3% accuracy. A separate generator sweeps the generator's frequency up to three decades between a start frequency and a stop frequency (up or down). The Model 288 to an external source and allows the Model 288's output phase (relative to the external source) to be varied ±180°.

The Model 288 consists of six separate assemblies as shown in figure the Instrument Schematic (0004-00-0510): motherboard, front panel, function generator, phase lock loop, output, and rear panel. The motherboard links all the assemblies within the Model 288. Plus it receives, input data from the front panel, processes that data into commands and control lines, and distributes the commands and control lines to the other assemblies. The motherboard also route data from the assemblies back to the front panel. The front panel contains the operator interface: keypad for parameter selection and value entry; control knob for value entry; the display for output signal information, operator messages, and error codes; and LEDs for front panel annunciation. The function generator produces the generator's two basic waveforms: square and sine. In addition, the function generator controls the units frequency and symmetry control. The phase lock assembly locks the function generator to an internal reference for frequency synthesis or locks the function generator to an external source for variable phase operation. Also, the phase lock assembly contains the convertor for triangle to sine conversion and the X-Y multiplier for amplitude modulation. The output assembly selects, amplifies, and attenuates the waveform. The rear panel assembly contains the units power input connector, power transformer, and fuse.

Signal Flow

Signal flow through the Model 288's assemblies depends upon the function and mode selected. The signal originates on the function generator assembly (see figure 4-1) which produces the basic waveforms: tri-

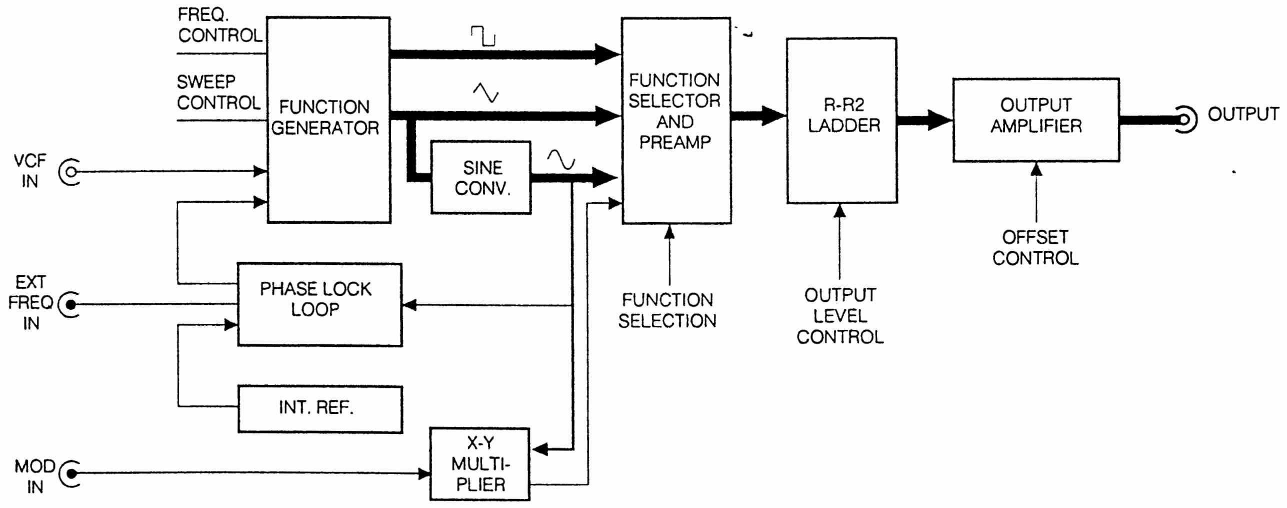


Figure 4-1. Model 388 Signal Flow

ngle and square. The motherboard routes both wave-ɔrms to the function selector on the output assembly. ˈhe triangle also runs to the sine convertor located on ɿe phase lock assembly. The motherboard routes the ;ine wave to the function selector. The output signal ·om the function selector flows through the output .ircuits to the output connectors. The sine wave also a ;rives the X-Y multiplier whose output is routed to the ɹnction selector just like the triangle, square and sine /aves.

ı the synthesized mode, the phase lock loop, refer-·nced to an internal frequency standard, controls the .tabilizes the frequency of the function generator. The ame phase lock loop, using an external reference ·equency, locks the Model 288 to an external source.

;ontrol

\ll control inputs originate from either the front panel ‹eypad or a GPIB controller. The microprocessor circuit ɔn the motherboard processes this input data and ıroduces the control lines for the Model 288's circuits. :ach plug-in board (function generator, phase lock ɔop, and output) contains input registers that decode he control data.

⁴.2 DETAILED CIRCUIT DESCRIPTION

.2.1 Motherboard Assembly

ɿe mother board (see schematic 0103-00-3000) pro-ıdes overall control, interconnection and signal rout-ng, dc voltages, internal reference frequency signals, and remote operation in the Model 288. The mother ɔoard sends and receives all data and control signals to and from the assemblies. All input and output connec-ors located on the rear panel, except the input power ɔonnector, connect through the mother board. Connec-ors for the plug-in assemblies are staggered to prevent ıccidental insertion into incorrect positions.

ˈhe mother board contains:

- Microprocessor Circuit
- GPIB Interface Circuit
- Frequency Synthesizer Circuit.
- Internal Calibration Network Circuit
- DAC/Sample and Hold Network Circuit
- Secondary Input/Output Network Circuit
- Relay Driver Network Circuit.
- Balanced Output Attenuator Network and Impedance Control Circuit
- Unbalanced Output Attenuator Network and Impedance Control Circuit
- Power Supplies Circuit

4.2.1.1 Microprocessor Circuit

The microprocessor circuit (schematic 0103-00-3000 sheet 3) receives input data from the front panel keyboard and control knob, or GPIB interface, processes the data, and provides data and control lines for internal operation. The microprocessor circuit consist of a microprocessor, a processor support controller, and memory (RAM and ROM). There are no test points or adjustments in this circuit.

The microprocessor (Motorola MC6803) controls the microprocessor circuit and provides 16-bit data memory location addresses. The microprocessor performs computations as defined by the operating system instructions in memory (ROM) and provides the 8-bit output for the memory (RAM) and GPIB interface Circuit.

The processor support controller U7 converts the microprocessor data and the instrument feedback data into control signals, quiet address (QA) buses, and quiet data (QD) buses.

The Memory is both RAM and ROM. RAM (8K), a nonvolatile memory, stores the calibration values generated at each calibration, and any other values required for current operation. A RAM backup battery (BT-1) prevents the loss of data when power is turned off. ROM (16K), programmed at the factory, contains the operating system instructions. Maintenance Calibration switch (SW1) used in conjunction with the front panel keyboard allows performance of several maintenance functions. A flashing Life Light verifies microprocessor sequencing.

4.2.1.2 GPIB Interface Circuit

The GPIB interface circuit (schematic 0103-00-3000 sheet 10) allows remote operation of the Model 288 using an external IEEE-488 compatible controller. All functions except power and GPIB address are programmable using the interface. The GPIB circuit consist of a GPIB controller and two transceivers. This circuit contain no test points or adjustments.

The GPIB controller (Motorola MC68488) functions as a traffic controller, permitting data to flow in either direction when the correct control information is received. The 'handshaking' routine will ensure neither the signal generator nor the remote controller will send data faster than the other can use. The controller has internal registers where control, data, and address words are loaded and stored until needed or requested. The controller bus connects to the microprocessor circuit address bus A0-A2. The identification address of an instrument is determined by five bits in the controller address register. The default address (09) automatically loads into the controller from RAM at turn-on. A new address must be entered using the front panel keypad.

The transceivers permit bidirectional flow. They have sufficient input sensitivity to minimize false signals and sufficient drive current to minimize signal loss.

4.2.1.3 Frequency Synthesizer Circuit

The frequency synthesizer (schematic 0103-00-3000 sheet 4) supplies the internal reference frequency for the signal generator. The frequency generated corresponds to the front panel frequency setting. However, it does not operate below 20 Hz. This circuit has two test points located under the shield. TP5 is the loop control voltage. TP17 is the synthesizer output (SYNTH). There are no adjustments in this circuit.

The frequency synthesizer circuit consists of a phase lock loop, voltage controlled oscillator, divide by two circuit, and a counter/divider. The output from a 10 MHz crystal controlled reference is multiplied and divided by three numbers computed by the microprocessor circuit. The three numbers are a serial data stream of 64 bits: 14 bits divide the reference, 14 bits divide the variable, and 36 bits divide the VCO to the desired frequency. All are under software control and respond to the front panel frequency settings.

4.2.1.4 Internal Calibration Network Circuit

During the measurement portion of the auto calibration cycle, the internal calibration network (schematic 0103-00-3000 sheet 2) measures five analog voltages. FGTST and FGTST100 voltages monitor the function generator condition. THD, +PK, and –PK voltages monitor the output assembly status. VLOOP monitors the phase lock loop assembly status. The microprocessor circuit monitors the digital equivalent of these voltage, and if any are incorrect, they are corrected by applying an analog calibration voltage from the DAC/sample and hold network circuit.

A sixth voltage, the RAM backup battery (DVMBAT), is tested during the power on sequence. If the voltage tests low, the microprocessor circuit causes the display to show "LOW BATT". If the battery tests dead, the Microprocessor circuit causes the display to show "CAL REQUIRED". There are no test points or adjustments in this circuit (TP1 is not used).

4.2.1.5 DAC/Sample and Hold Network Circuit

The DAC/sample and hold network circuit (schematic 0103-00-3000 sheet 5) supplies the control voltages for the signal generator. The DAC/Sample and Hold Network Circuit consists of a digital to analog converter and a demultiplexer. TP7 connects to the sample and hold digital/analog output. There are no adjustments in this circuit.

The digital to analog circuit (DAC) converts the binary data from the microprocessor circuit into one of eight control levels in the form of a stepped waveform.

The Demultiplexer converts the stepped waveform containing the eight control levels from the DAC into eight separate analog control voltages. Four control voltages, VOFSET, VPHASE, VSLEN, and VFREQ respond to the front panel settings. The other four control voltages VSINCAL, VAMCAL, VCGZERO, and VTRIBAL respond to calibration data from the microprocessor circuit.

During the measurement portion of the auto calibration cycle, SHCLK clocks the serial data (SHDATA) into the (DAC). From this data, the eight analog calibration voltages (–5V and +5V) are produced which slightly changes the normal outputs of the eight circuits during the calibration portion of the auto calibration cycle which changes the circuit output to correct the signal output to the internal frequency and voltage standards. The DAC sample and hold network circuit and the internal calibration network circuit work together to alternately measure and adjust a circuit. The serial data is stored in RAM until the next auto calibration cycle. If the analog calibration voltage cannot change the measured voltage enough to bring it into limits, the microprocessor circuit will generate an error message to be displayed. This error refers to the affected circuit.

4.2.1.6 Secondary Input/Output Network Circuit

The secondary input/output network (schematic 0103-00-3000 sheet 6) conditions and routes the Ext Freq In signal to phase lock loop's reference frequency input. This circuit squares the input signal and compensates the signal for any nonsymmetry . It also routes the Sync Out square wave from the function generator assembly through this circuit's 50Ω driver to the front panel connector. This circuit also routes the Mod/VCF In signal directly to the phase lock loop assembly and function generator assembly. While The Sweep Out is routed to the front panel from the function generator assembly.

To test the external frequency input circuit, an external signal must be connected to the Ext Freq In connector. All test points and components are located under the shield. TP9 is the limited external frequency input. TP10 is the buffered external frequency. There are no adjustments in this circuit.

.2.1.7 Relay Driver Network Circuit.

ıe relay driver network circuit (schematic 0103-00-
:0 sheet 7) controls the relays used in the balanced .d unbalanced output attenuator network and imped-ıce control circuits. Microprocessor data lines drive 's circuit. There are no test points or adjustments in this rcuit.

.2.1.8 Balanced Output Attenuator Net-ork and Impedance Control Circuit

ıis circuit (schematic 0103-00-3000 sheet 7) routes ɹtput signals to BAL output connectors. The relays in ıis circuit are driven by the relay driver network circuit. ıutput signals (BOUT1 and BOUT2) from the output ssembly are selected and routed through a –40 dB tenuator as required by the amplitude setting at the ont panel. The desired impedance of 135Ω or 600Ω is elected, and the signal is routed to the front panel BAL onnectors. There are no test points or adjustments in ıis circuit.

.2.1.9 Unbalanced Output Attenuator etwork and Impedance Control Circuit

ıis circuit (schematic 0103-00-3000 sheet 7) routes ɹtput signals to UNBAL output connector The relays in ıis circuit are driven by the relay driver network circuit. ıutput signal (UBOUT) from the output assembly are elected and routed through a –40 dB attenuator as equired by the amplitude setting at the front panel. The esired impedance of 50Ω, 75Ω or 600Ω is selected, nd the signal is routed to the front panel UNBAL onnector. There are no test points or adjustments in ıis circuit.

.2.1.10 Power Supplies Circuit

hese circuits provides the ac and dc operating volt-s for all circuits in the signal generator. The power plies circuit consist of a +5V power supply, ±12V er supply, ±22V power supply, and VFD ac filament ply.

5V Power Supply. This circuit (schematic 0103-00-000 sheet 8)supplies the +5 Vdc for the TTL logic and lay circuits in the signal generator. Remove the jumper MP6 to isolate the +5V supply from the circuits .

12V Power Supplies. This circuit (schematic 0103-00-000 sheet 8) supplies the positive and negative 12 Vdc r the signal generator. These power supplies are ghly regulated by a precision voltage reference source, REF, which is also used by the internal calibration etwork. Remove the jumper JMP4 to isolate the +12V upply, and remove the jumper JMP5 to isolate the –12V upply.

±22V Power Supplies. This circuit (schematic 0103-00-3000 sheet 9) supplies the positive and negative 22V used in the signal generator. The +12V supply provides a reference voltage for the positive 22V supply. This power supply cannot be isolated.

VFD AC Filament Supply. An unregulated ac voltage (schematic 0103-00-3000 sheet 9) approximately 8 Vrms supplies current to the display characters in the Vacuum Fluorescent Display .

These power supplies have five test points:

JMP4 is the +12 Vdc output.
JMP5 is the –12 Vdc Output.
JMP6 is the +5 Vdc output.
TP14 is the +22 Vdc output.
TP15 is the –22 Vdc output.
There are no adjustments in these circuits.

4.2.2 Front Panel

The front panel provides operator interface to the signal generator. It allows the operator to input commands, and provides the operator with a display showing output signal parameters and equipment status. This assembly contains the following circuits:

Control Knob Circuit.
Display
Keyboard Circuit
Light Emitting Diode Circuit.

4.2.2.1 Control Knob

The control knob (SW1 - schematic 0103-00-3001 sheet 1) rotates continuously in both directions. Knob values depend on the function, mode, and range selected. Two output lines, RKA and RKB, are pulsed at TTL logic levels as the knob is rotated. The microprocessor circuit on the motherboard counts the pulses to determine the amount of change. The microprocessor circuit detects the knob's direction by comparing the TTL logic level of the signals and detecting the first one to change to a new level. For clockwise rotation, RKA will change first, and for counterclockwise rotation, RKB will change first. The microprocessor circuit determines when the rotation has reached the end of the range selected, in either direction. If there is a further range in the direction the knob is turning, the range will automatically change. If the range is at the limit, the limit value will be displayed.

4.2.2.2 Display

The front panel display (schematic 0103-00-3001 sheet 1) receives its data via the quiet data bus QD5-7. The display controller/driver (U1) receives a serial word of eight bits on the DISPDATA line. DSPCLK clocks each bit, most significant bit (MSB) first. The serial word may be either a display character or a control word, the MSB determines which. The 64 possible combinations of the remaining seven bits display standard ASCII upper case characters or control various functions and addresses. This display information drives the florescent display. The display controller/driver will retain only the most recent data received.

The display circuit is supplied by its own +15 Vdc regulator (VR1) which uses the +22V for its input. The florescent display filament receives its power from the 9Vac supply. Both voltages originate from the power supply on the motherboard.

4.2.2.3 Keyboard Circuit

The keyboard circuit (schematic 0103-00-3001 sheet 2) consists of 48 push buttons in a eight–column, six–row matrix. The control signal FPREG latches the quiet data bus QD0-2 lines into the decoder. The decoder selects one of the six rows and applies +5 Vdc. If any key is pressed on that row, the +5V will appear on one of the keyboard bus lines P10-P17. The microprocessor circuit on the motherboard determines which key has been pushed by analyzing the position of the decoder when detecting +5V on a column (keyboard bus lines P10-P17).

4.2.2.4 LED Circuit

The LED circuit (schematic 0103-00-3001 sheets 2 and 3) consists of 18 LED's that indicate the mode and function selected. The control signal FPS permits quiet address bus QA0 and QA1 to select one of the four least significant outputs of the decoder. Control signals CLOCK0 and CLOCK 1 of the decoder sequentially strobes an 8-bit number from quiet data bus (QD0-7) into both latches. Each bit (QD0-7) entered into the latches will turn on the LED indicator related to that bit. Control signal FPREG illuminates the UNLK LED and ON/OFF LED in the same way. Once the LED is set, it remains on until a change occurs. Pressing a key associated with a LED will latch new data. The previous LED will turn off and the new one will turn on.

The Power On/Off switch connects the line voltage to the transformer located in the rear panel. The CT (center tap) connector provides a neutral connection for the balanced output connectors.

4.2.3 Function Generator

The function generator produces the Model 288's square and triangle waveforms. The triangle drives the sine converter on the the phase lock loop assembly. The unit routes the triangle and square waves to the output assembly for selection and amplification. The function generator's input registers decodes digital control signals from the microprocessor circuit for use in selecting and maintaining frequency, symmetry, sweep, and modulation. The VCF In (frequency modulation) allows an external signal to control the frequency of the function generator. The function generator also provides the Sync Out and Sweep Out signals. The function generator includes the following circuits:

Voltage Controlled Generator (VCG) Summing Amplifier
Sweep Generator
Symmetry Control
VCG Current Sources
High Frequency Compensation
Comparator
Frequency Range Switches
Capacitance Multiplier
Triangle Buffer
Auto Calibration

4.2.3.1 VCG Summing Amplifier

The voltage controlled generator, VCG, (schematic 0103-00-3004 sheet 2) produces a voltage that is the negative sum of its input control voltages. The input control voltages can consist of up to five analog signals:

Fixed frequency set point (VFREQ) originating from the motherboard's DAC/sample and hold network.

Calibration voltage (VCGZERO) generated by the DAC/ sample and hold network on the motherboard.

Feedback control (VLOOP) supplied by the phase lock loop filter on the phase lock loop assembly.

Sweep voltage (SWEEP) generated by the sweep generator (if selected).

Modulating signal (MOD IN) originating at the VCF In connector and routed from the secondary input/output network on the motherboard (if selected).

These control voltages summed by the amplifier provide an accurate dc voltage (VSUM), test point TP2, for symmetry control and auto calibration circuit. There are no adjustments in this circuit.

4.2.3.2 Sweep Generator

The sweep generator (schematic 0103-00-3004 sheet 2) produces the sweep voltage (0 to -8V) for the function generator. In addition, the sweep generator supplies the sweep output ramp to the Sweep Out connector. The operator, via the front panel, sets the sweep start and stop frequency, as well as, the sweep time. The microprocessor circuit interpret and routes the data to the sweep generator The microprocessor circuit determines the correct data (byte) to set the sweep generator DAC to produce a voltage that sets the function generator to the start frequency. Then the microprocessor steps DAC, in turn the function generator, to the stop frequency at a rate dependent on the sweep time. At the stop frequency, the microprocessor resets the sweep generator to the start frequency. Another portion of the sweep generator's DAC produces a ramp proportional to the sweep frequency. A calibration voltage (VSLEN) from the DAC/sample and hold circuit provides a correction voltage to the sweep DAC. The voltage (VSLEN) is generated when the internal calibration circuit, during the auto cal cycle reads the sweep output and makes corrections to the sweep generator. The microprocessor circuit stores the correction value as VSLEN which provides the reference voltage for the sweep generator DAC.

4.2.3.3 Symmetry Control

The symmetry control (schematic 0103-00-3004 sheet 3) provides control of the generated waveform's symmetry. VCG summing amplifiers divide the signal VSUM into two signals. One signal controls the one half of the waveform; the other signal controls the other half or the waveform. If the symmetry setting remains at 50% (symmetrical waveform), each signal receives the same amplification. As the symmetry setting changes from 50%, in either direction, one signal receives greater amplification and the other receives less amplification. Control lines QD0-7 from the microprocessor circuit control the outputs from the DAC which in turn set the gain of the VCG amplifiers. The two symmetry control outputs (+FCV and –FCV) drive the VCG current source and high frequency compensation circuit. The auto cal circuit also receives inputs from these two lines. This circuit has two test points: TP3 monitors the positive function control voltage (+FCV) and TP4 monitors the negative function control voltage (–FCV). There are no adjustments in this circuit.

4.2.3.4 VCG Current Sources

The VCG current sources (schematic 0103-00-3004 sheet 4) converts the +FCV and –FCV voltages from the symmetry control into two currents (ISWITCH+ and ISWITCH–) for use by the comparator circuit. The positive current (ISWITCH+) flows into the comparator, and the negative current (ISWITCH–) flows from the comparator. At 50% the current flow is equal flow to and from the comparator. However, if the symmetry setting is not 50%, the current flow will be unsymmetrical.

This circuit has four test points. TP5 is the VCG current sources positive reference voltage. TP8 is the VCG current sources negative reference voltage. TP6 is the positive integrator voltage source current flow into the comparator circuit. TP7 is the negative integrator voltage source current flow out of the comparator circuit. There are no adjustments in this circuit.

4.2.3.5 High Frequency Compensation

The high frequency compensation circuit (schematic 0103-00-3004 sheet 4) offsets any internal circuit time delays in the function generator circuit on the 200 kHz to 2MHz and 2MHz to 20 MHz frequency ranges. At higher frequencies, the time it takes to control or calculate the shape of the waveform, as well as the rise and fall times, and levels takes a measurable part of the time required by the waveform. A calculated value (+COMP and –COMP) compensates for the time delay by slightly altering the +FCV and –FCV signals from the symmetry control circuit at the comparator. The +COMP and –COMP output signal drives auto calibration circuit. There are no test points or adjustments in this circuit.

4.2.3.6 Comparator

The comparator circuit (schematic 0103-00-3004 sheet 7) combines the input signal representing the frequency set point (+COMP and –COMP), and compares it with the actual triangle waveform being generated by the current flows (+VI and –VI). As the output triangle reaches the positive peak set point, the comparator switches the output signal (SQWAVE) to a negative level. When the triangle reaches the negative peak, SQWAVE switches to a positive value. SQWAVE is used as the source square output waveform, and SYNC OUT signal. The switching SQWAVE signal alternately permits the current from the VCG Current Sources Circuit to flow into then out of the Comparator Circuit current sense point (TRINODE). This carefully controlled alternating current flow is sensed in the Triangle Buffer Circuit as a triangle wave (TRIOUT). During the control part of the auto calibration cycle, VTRIBAL is adjusted to the necessary voltage to insure a symmetrical triangle signal is measured by the measurement part of the auto calibration cycle. This circuit has two test points. TP13 is reference square wave, or the level the triangle must reach in order to switch. TP14 is the switched square wave. TP15 is the Square Wave output. There are no adjustments in this circuit.

4.2.3.7 Frequency Range Switches

The frequency range switches (schematic 0103-00-3004 sheet 5) selects the four switchable range capacitors for the Model 288's five upper ranges. The microprocessor circuit via the function generator's data latches selects the capacitors. On the 20 MHz range, the capacitance consists of approximately 50 pF (15 pF plus stray capacitance) permanently connected to the input of the triangle buffer (TRINODE). For the 2MHz range the microprocessor circuit adds 440 pF in parallel with the existing 50 pF (≈500 pF total). For the 200 kHz range, the microprocessor circuit adds to 0.0047 μF in parallel with 440 pF (≈0.005 μF total). For the 20 kHz range, the microprocessor adds 0.047 μF in parallel with 0.0047 μF (≈0.05 μF total). For the 2kHz range, the microprocessor adds 0.47 μF in parallel with 0.047 μF (≈0.5 μF total). On the 200 Hz range and below, the capacitance multiplier (paragraph 4.2.3.8) selects the range "capacitors".

When the Model 288 produces an unsymmetrical waveform, the frequency range divides by 10. The microprocessor circuit automatic compensates for this by programming the next higher range.

4.2.3.8 Capacitance Multiplier

Lower frequencies require larger capacitors that often fail to maintain the precise value over time needed for accurate frequencies. To eliminate the need for large capacitors, the Model 288 uses a capacitance multiplier (schematic 0103-00-3004 sheet 6) which controls the current at the TRINODE point. When the VCG current source supplies current (+VI) to the comparator, the capacitance multiplier draws a portion of the current from the TRINODE point. When the VCG current source draws current (–VI) from the comparator, the capacitance multiplier adds current to the TRINODE point.

This effectively decreases the amount of current to the range capacitor, which decreases the time it takes for the capacitor to charge to the comparator sense point; making the frequency lower. Microprocessor circuit data lines, routed through the function generator's data latches, select the capacitance multiplier's control line. TP11 is the capacitance multiplier output. There are no adjustments in this circuit.

4.2.3.9 Triangle Buffer

The triangle buffer (schematic 0103-00-3004 sheet 6) amplifies the triangle generated by charging and discharging the range capacitor. The buffer output (TRIOUT) drives the comparator sense point, the waveform selector on the output assembly, and the sine convertor on the phase lock loop assembly.

The auto cal circuit measure the triangle balance (TRIBAL) relative to the triangle buffer's ground (TRICOM) and produces a triangle balance voltage (VTRIBAL) that adjusts the comparator. The Model 288 stores the triangle balance voltage in the microprocessor circuit. The stored value changes only during the auto cal cycle.

4.2.3.10 Auto Calibration

The function generator's auto calibration circuit (schematic 0103-00-3004 sheet 4) selects and buffers six key points on the function generator assembly during the auto cal cycle. The circuit's output (FGTST) drives the units internal calibration network on the motherboard. In addition, another circuit amplifies the FGTST by +100 and route it to the internal calibration network. There are no test points or adjustments in this circuit.

4.2.4 Phase Lock Loop Assembly

The phase lock loop assembly contains three blocks: the phase lock loop itself, the sine convertor, and the AM modulator. The phase lock loop selects and locks triangle or square wave signal to internal or external reference. The sine convertor transforms the triangle into the sine wave. The AM modulator controls the amplitude modulation of the sine wave signal. All the control lines for this assembly originate from the microprocessor circuit and transfer through the assembly data latches.

4.2.4.1 Phase Lock Loop

Phase lock loop circuit consists of the sine-Z-cross circuit, the source selector circuit, the phase comparator circuit, the phase comparator circuit, the charge pump circuit, and the lock loop filter circuit.

Sine-Zero-Crossing Detector

The sine zero crossing detector (schematic 0103-00-3003 sheet 2) converts the sine wave (SIN 3) from the sine buffer into a square wave As the sine wave passes through its zero crossing point, the output from the crossing detector changes its dc level, thus producing the square wave. This square wave drives the source selector for the phase comparator. All test points and components are located under the shield. TP1 is the sine wave zero crossing output. There are no adjustments in this circuit.

Source Selector

The source selector circuit (schematic 0103-00-3003 sheet 2) selects the reference frequency source for the phase comparator. The source selector selects from two reference frequency sources:SYNTH the internal frequency synthesizer or BXFREQ the external reference source from the Ext Freq In connector. The selector also selects one of the two available variable frequency waveforms: SQWAVE (square wave) and SIN3 (sine wave). When using the internal frequency reference, the comparator receives the square wave as the variable frequency waveform. When using the external frequency reference, the comparator uses the zero-crossed square wave as the variable frequency (triangle and sine wave functions) or square wave (square wave function). The front panel circuit through the microprocessor circuit controls the signal selection and routing. All components are located under the shield. TP2 is the buffered external reference frequency (external signal must be connected to EXT FREQ IN). TP3 is the frequency synthesizer output. There are no adjustments in this circuit.

Phase Comparator

The phase comparator circuit (schematic 0103-00-3003 sheet 2) compares the reference frequency signal and the variable frequency signal and produces an output based on positive edge arrival times of each selected signal. The comparator generates three output conditions on the output lines VLAGR and VLEADR.

1. The reference signal and generated waveform arrive at the same time.
2. The reference signal leads the generated waveform.
3. The reference signal lags the generated waveform.

VLAGR and VLEADR drives the charge pump. All components are located under the shield. There are no test points or adjustments in this circuit.

Charge Pump

The charge pump circuit (schematic 0103-00-3003 sheet 3) controls the current flow to and from the lock-loop filter. The two output line from the phase comparator (VLAGR and VLEADR) regulates the charge pumps current flow. Current flow represents the difference between the selected reference frequency signal and the variable frequency signal which is set from the front panel. The current pulses briefly during the positive edge comparison and then stops. The time difference between the input signals VLAGR and VLEADR determine the amount of current pumped to the lock-loop filter The arrival order of the input signal VLAGR and VLEADR determine the direction of the current flow. If the signals arrive at the same time, no current is pumped to the lock-loop filter. All test points and components are located under the shield. TP7 is the variable lag reference. TP8 is the variable lead reference. There are no adjustments in this circuit.

Lock-Loop Filter

The lock-loop filter circuit (schematic 0103-00-3003 sheet 3) converts the current flow from the charge pump into an error voltage (VLOOP) for the function generator's VCG summing amplifier. The filter smooths the pulsing current flow into a voltage that is the average of the current pulses. The error voltage is positive when the average current is flowing from the filter and negative when the average current is flowing into the circuit. The error voltage VLOOP gradually changes the VCG summing amplifier's output signal (VSUM) changing generators frequency closer the reference frequency.

Under certain conditions the microprocessor circuit disconnects the VLOOP error signal from the VCG summing amplifier. If the reference to variable frequency difference is too great which generates an even greater error in the opposite direction the microprocessor circuit turns on the UNLOCK indicator at the front panel and disconnects the VLOOP signal. When FM or Sweep modulation is selected at the front panel, the VLOOP signal is disconnected, but the UNLOCK indicator is not turned on.

The microprocessor circuit varies the characteristics of the lock-loop filter characteristics based on the selected frequency. During the auto cal cycle, the internal calibration network produces a correction voltage VPHASE.that fine tunes the lock-loop filter. TP9 is the phase lock loop error voltage. There are no adjustments in this circuit.

4.2.4.2 Sine Convertor

The sine convertor consists of three circuits: the variable supply, the sine convertor itself, and the sine buffer.

Variable Supply

The variable supply (schematic 0103-00-3003 sheet 5) produces an isolated ±12V used only by the sine converter. To provide minimum sine distortion, the internal calibration network on the motherboard measures the sine distortion and produces a correction voltage VSINCAL which fine tunes the sine convertor by adjusting the variable supply. There are no test points in this circuit. R97 provides course adjustment of the variable supply.

Sine Converter

The sine convertor (schematic 0103-00-3003 sheet 4) transforms the triangle (TRIOUT from the sine buffer) into a sine wave. The sine convertor uses the logarithmic response characteristics of the ten matched diodes to approximate a sine wave current output SINCO. TP13 is the sine wave converter output. R33 adjusts the input level of the sine converter.

Sine Buffer

The sine buffer (schematic 0103-00-3003 sheet 4) converts the sine current supplied by the sine converter into two sine wave signals (SIN1 and SIN3). Signal SIN1 drives the function selector on the output assembly, and provides the carrier for the X-Y multiplier (AM). Signal SIN3 is routed to the phase lock-loop's sine zero-crossing Circuit. TP10 monitors the sine wave buffered output. R64 adjusts signal dc level. R208 adjusts sine wave amplitude.

4.2.4.3 Amplitude Modulator

The amplitude modulator consists of two circuits: the X-Y multiplier and the AM buffer.

X-Y Multiplier Circuit.

The X-Y multiplier (schematic 0103-00-3003 sheet 5) is a transconductance amplifier that produces differential currents that drive the AM buffer. The sine buffer from the sine convertor provides the multiplier's carrier (X) input SIN1. The external Mod In signal supplies the circuit's modulation (Y) input MOD IN. During the auto cal cycle, the Model 288's internal calibration network measures the +PK and -PK signals (peak detector on the output board). The microprocessor circuits stores a correction value based on the measurement. During the control cycle, the DAC/sample and hold circuit converts the value into a voltage VAMCAL that fine tunes the X-Y multiplier. There are no test points in this circuit. R102 provides course adjustment of the sine wave input. R108 provides course adjustment of the modulation signal input.

AM Buffer

The AM buffer (schematic 0103-00-3003 sheet 5) is a differential amplifier that combines the two signals from the X-Y multiplier into one symmetrical around zero signal. The voltage level is compatible with the other signals selected at the output assembly. TP12 monitors the AM buffer output. R125 provides dc level offset adjustment.

4.2.5 Output Assembly

This assembly contains circuits that select the waveform, set the output level of the waveform, and provide waveform amplification. All waveforms can be dc offset Waveform selection, amplitude, and dc offset are set from the front panel and processed by the microprocessor circuit. The assembly input registers read the data from the microprocessor circuit and routes the control lines to the circuits. This assembly contains the following circuits:

Function Selector.
Preamplifier.
R-R2 Ladder.
Power Amplifier.
–20dB Attenuator.
Balanced Drivers.
Peak Detector.

4.2.5.1 Function Selector

The function selector (schematic 0103-00-3002 sheet 2) selects and routes either the square wave, triangle wave, sine wave, or amplitude modulated signal to the preamplifier. The triangle wave TRIOUT from the function generator assembly, sine wave SIN1 from the phase lock loop assembly, and amplitude modulated signal AMSIG form the phase lock loop assembly are unchanged. But, the square wave SQWAVE from the function generator assembly is shaped, and its amplitude set to the same level as the other signals. The output level from the function selector for all waveforms is 2Vp-p. The front panel selections, processed by the microprocessor circuit, select and route the waveforms to the preamplifier. TP1 is the shaped square wave input. There are no adjustments in this circuit.

4.2.5.2 Preamplifier

This circuit (schematic 0103-00-3002 sheet 2) amplifies the selected 2Vp-p waveform (square wave, triangle wave, sine wave, and amplitude modulation signal) from the function selector to a 6Vp-p signal (PREAMP) which drives both the R-R2 Ladder and the Peak Detector . TP2 is the preamplifier output. C22 adjusts frequency peaking.

4.2.5.3 R-R2 Ladder

The R-R2 ladder digital binary attenuator (schematic 0103-00-3002 sheet 2) provides 0 to 20 dB of variable attenuation of the output from the preamplifier. With the exception of the first step of attenuation, each selected step doubles the attenuation of the previous step. Attenuation depends on the front panel selections and microprocessor circuit processing. There are no test points or adjustments in this circuit.

4.2.5.4 Power Amplifier

The power amplifier, a fixed gain, wide-band inverting amplifier with a push-pull complimentary symmetry output stage, (schematic 0103-00-3002 sheet 2) provides the gain and drive needed for the balanced and unbalanced outputs and –20 dB attenuator. The amplifier receives its input (PA IN) from the R-R2 ladder. Another input, VOFST, supplies the dc offset level. VOFST also allows the internal calibration network through auto cal to correct for amplifier aging and temperature effects. Two diodes, CR29 and CR30, protects the four output transistor that drive the output.

4.2.5.5 –20 dB Attenuator

The –20 dB attenuator circuit (schematic 0103-00-3002 sheet 6) reduces the power amplifier PA OUT level by either 0dB or –20 dB. The microprocessor circuit selects the attenuator based on the output level selected via the front panel. This attenuator together with the R-R2 ladder and the –40 dB attenuator on the balanced and unbalanced network sets the output level. There are no test points or adjustments in this circuit.

4.2.5.6 Unbalanced and Balanced Drivers

This circuit (schematic 0103-00-3002 sheet 6) routes the signal from the –20 dB attenuator to either the unbalanced output, UBOUT, or the balanced drivers. TP6 is the negative balance driver output. TP7 is the positive balance driver output. There are no adjustments in this circuit. The unbalanced signal is routed to the unbalanced output attenuator network and impedance control circuits on the A2 Motherboard unchanged as (UBOUT). The unbalanced signal (UNBAL OUT) is routed through two complimentary drivers which produces two 180° out signals, BOUT1 and BOUT2. Both signals drive the peak detector and balanced output attenuator network and impedance control circuits on the motherboard.

4.2.5.6 Peak Detector

During the auto cal cycle, the peak detector circuit (schematic 0103-00-3002 sheet 7) processes four signal lines generated on the output assembly. The peak detector circuit consists of the input selector and its positive and negative peak detectors, as well as a harmonic distortion notch filter.

For ac measurements the input selector routes one of the four inputs to the peak detector: preamplifier output PREAMP, balanced driver outputs BOUT 1 and BOUT2 , and power amplifier output PAOUT. The peak detector senses the positive and negative value and produces a dc equivalent value for the internal calibration network. For dc measurements the input selector chooses one of the four inputs and routes it directly to the +PK The sine wave from PREAMP drives the harmonic distortion notch filter whose output voltage, THD, represents the sine's distortion content. The voltage THD corrects for minor distortions in the sine convertor circuit

TP8 is the total harmonic distortion notch filter output. TP9 is the positive peak detector output (not measurable). TP10 is the negative peak detector output (not measurable). There are no adjustments in this circuit.

4.2.6 Rear Panel

This assembly (refer to the instrument schematic 0004-00-0510) provides the operator with line power connection, voltage selection facilities, fuse protection, and GPIB connection. The selected input line voltage of 100/120/220/240 Vac is converted to ≈8 Vac, ≈32 Vac, and ≈52 Vac for use by the individual power supply circuits located on the A2 Motherboard Assembly. ≈9 Vac is provided to the Front Panel Assembly for display power. Front Panel Assembly provides On/Off switching.

SECTION 5
CALIBRATION PROCEDURE

5.1 CALIBRATION

This section contains the Model 288's calibration procedures (paragraph 5.2).

Wavetek maintains a factory repair department for those customers not possessing the necessary personnel or test equipment to calibrate or repair the instrument. Before returning the instrument, contact the Customer Service Department by calling or writing:

Wavetek San Diego, Inc.
9045 Balboa Ave.
San Diego, CA 92123
Telephone: (619) 279-2200
TWX: (910) 335-2007

The Model 288 provides the user with two calibration methods: Auto Cal and Calibrate.

5.1.1 Auto Cal

Auto Cal (automatic calibration) provides a quick method of calibrating the Model 288 without using external test equipment. Auto Cal does not require opening the instrument or making adjustments. Use Auto Cal when Model 288 accuracy is critical, long term instrument storage, following drastic changes in the environment, or when the operator believes Auto Cal is necessary. Paragraph 5.3.1 describes the Auto Cal procedure.

5.1.2 Calibrate

The calibrate mode provides a more extensive method of calibrating the Model 288 using external test equipment. Calibrate does require opening the instrument and making adjustments. Use Calibrate when the Model 288 displays "CAL REQUIRED" or "FAILED AUTO CAL", when the Model 288 has been repaired or fails the Performance Verification procedure (Paragraph 2.), or when routine calibration is scheduled. Paragraph 5.3.2 describes the Calibrate procedure.

5.2 AUTO CAL PROCEDURE

To Auto Cal the Model 288, perform the following steps. Auto Cal requires no external test equipment, in fact, nothing must be connected to the input connectors otherwise the Auto Cal circuitry could miscalibrate the instrument. Also, disconnect all outputs from the instrument otherwise the sudden changes in the instrument's output waveforms could damage external equipment.

1. Turn on the Model 288 and allow it to warm up for 20 minutes. Pressing the Calibrate key prior to the 20 minute warm up time displays the count-down time to Auto Cal. The instrument automatically Auto Cals after the 20 minute count down. However, pressing any other key during the count down aborts Auto Cal and returns the instrument to normal operation.

   Remember to remove all input and output connections to the Model 288 before pressing Auto Cal.

2. Press the Calibrate key and allow the unit time to complete the Auto Cal. When completed successfully, the Model 288 displays AUTOCALIBRATED and the unit returns to its last setting. If the Auto Cal fails the Model 288 displays an error message which identifies the parameter - ERR (Keyword). If this occurs occasionally, try to Calibrate the unit again. Note the error keywords and report the errors when the unit is returned for scheduled maintenance.

5.3 CALIBRATE PROCEDURE

To calibrate the Model 288 perform the following steps. This procedure contains five separate steps which the Model 288 guides you through. If a specific step needs adjustment, use the cursor key to advance to the desired step.

Table 5-1. Recommended Test Equipment

Test Equipment	Recommended Model
Scope	Tektronix 2465 or equiv.
Distortion Analyzer	Hewlett Packard 8903B or equiv.
Digital Voltmeter	Not Critical
Function Generator	Not Critical
Phase Meter (optional)	Hewlett Packard 5335A or Hewlett Packard 3575A

NOTE

Use rear panel for all ground connections unless otherwise specified.

All indications and waveforms are referenced to chassis ground unless otherwise specified.

STEP 1 Initial Setup

1. Remove five top cover screws.

NOTE

Keep the top shield and top cover in place during the procedures except when necessary to make an internal adjustment.

2. Perform the turn-on procedures as shown in paragraph 2.3.3..

WARNING

Dangerous voltages are present with the covers removed. Where maintenance can be performed without power applied, the power should be removed. Battery voltage is present even with AC power cable removed.

3. Slide the top cover back. Press and hold down the internal calibration switch S1 (figure 5-1) while pressing the front panel CALIBRATE key.
4. Verify the Model 288 display indicates WVTK SN XXXXXXX or WVTK SN 0. Press the front panel —> CURSOR key.
5. Verify the Model 288 display flashes CALIBRATING then indicates USER SN XXXX or USER SN 0.

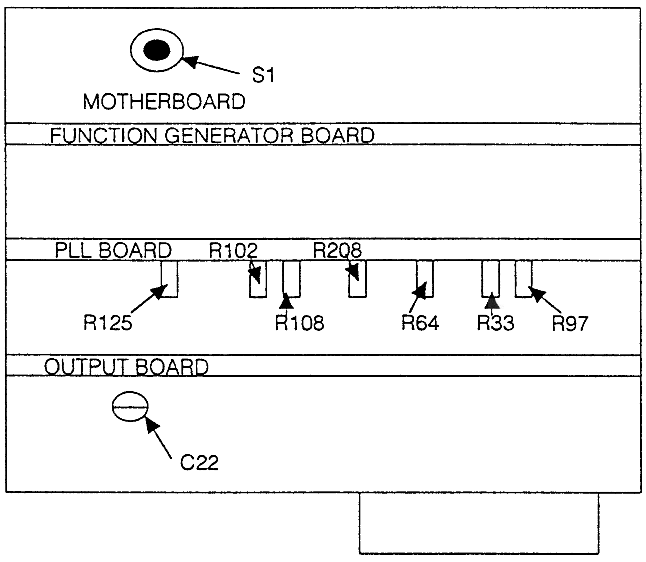


Figure 5-1. Calibration Location

STEP 2 Adjust Square Wave

Before performing any adjustment procedure, the initial setup (Step 1 of this procedure) must be completed.

1. Verify that the Model 288 display indicates USER SN XXXX or USER SN 0.
2. Verify that the Model 288 display flashes CALIBRATING then indicates PEAKING C22.
3. Connect the test equipment as shown in figure 5-2.

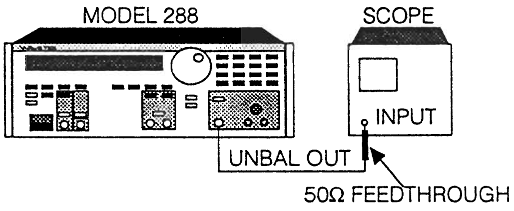


Figure 5-2. Square Wave Adjust Setup

4. Set the scope controls to display the Model 288 output. Verify that the scope displays peak-to-peak aberrations are greater than 3% and less than 5%.

   If incorrect, adjust C22 (figure 5-1) until the reading is within specified limits.

5. On the Model 288,

   Press the –> Cursor key. Verify the display flashes CALIBRATING then indicates R33, 97, 64 VSINE XX .

STEP 3 Adjust Sine Wave.

1. Connect the test equipment as shown in figure 5-3.

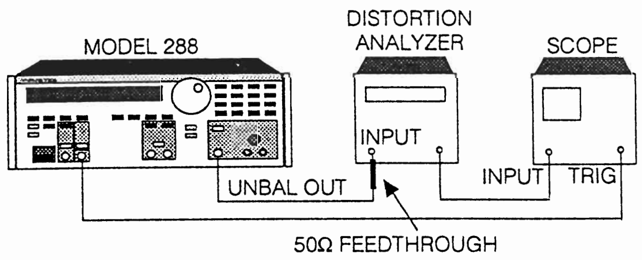


Figure 5-3. Sine Wave Adjust Setup

2. Set the distortion analyzer controls to display the Model 288 output signal Total Harmonic Distortion (THD) in dB.

3. On the Model 288, slowly adjust the Front Panel Knob (figure 5-1) until the THD as displayed on the distortion analyzer is minimum. Verify that reading is ≤ – 50 dB at 10 kHz.

   If correct, proceed to STEP 3 Adjust Amplitude.

4. If incorrect, set the scope controls to display the distortion analyzer output.

   Adjust R33 (figure 5-1) until waveform peaks are clearly visible in the residue.

   Adjust R97 until waveform peaks are symmetrical, one above the average value of the residue signal and one below.

5. Adjust R33 until the peaks disappear back into the residue.

6. Observe the overall ripple in the residue in the are of the waveform zero crossings as displayed on the scope. Turn the Model 288 Front Panel Control Knob CW until the waveform peaks are clearly visible in the residue and repeat step 6.

   If the overall ripple has decreased, continue the procedure always turning the Model 288 Front Panel Knob CW.

   If the overall ripple has increased, continue the procedure always turning the Model 288 Front Panel Knob CCW.

7. Repeat steps 5 and 6 until:

   The amplitude of the overall ripple in the residue signal is minimum as displayed on the scope.

   The THD as measured on the distortion analyzer is ≤ – 50 dB.

8. Disconnect the test equipment.

9. Connect the digital multimeter + lead to TP10 and – lead to TP11. Verify that the digital multimeter displays <1 mVdc.

   If incorrect, adjust R64 until the reading is within specified limits.

10. On the Model 288, press the –> Cursor key. Verify the display flashes CALIBRATING then indicates SIN AMP R208.

STEP 4 Adjust Amplitude

1. Connect the test equipment as shown in figure 5-4.

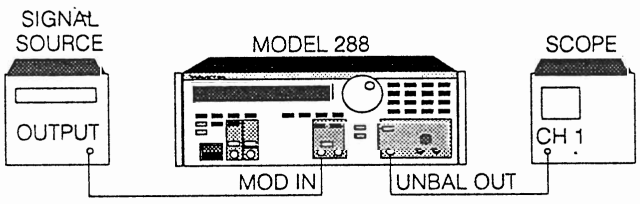


Figure 5-4. Adjust Amplitude Setup

2. Verify that the digital voltmeter reads 7.071 Vrms ±100 mVrms.

- If incorrect, adjust R208 (figure 5-1) until reading is within specified limits.

3. On the Model 288,

Press the —> CURSOR key.

Verify that the display indicates CALIBRATING for approximately 5 seconds.

Verify that the display indicates ADJ AM POTS.

STEP 5 Adjust Amplitude Modulation

1. Connect the test equipment as shown in figure 5-5.

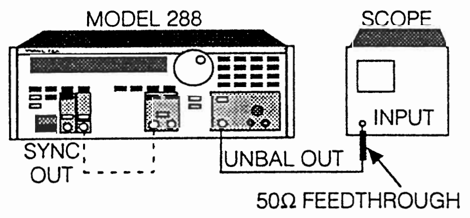


Figure 5-5. Adjust AM Setup

2. Set the scope controls to display the Model 288 output. Verify the scope displays carrier null with <50 mVp-p AC ripple and <5 mVdc offset.

   If carrier null is incorrect, adjust R108 (figure 5-1) for minimum indication..

   If DC offset is incorrect, adjust R125 until reading is within specified limits.

3. On the Model 288,

   Press the —> CURSOR key.

   Verify that the display flashes CALIBRATING for approximately 1 second. then displays AM MOD NULL.

   Connect a jumper between A7TP11 and TP13.

4. Connect a 50Ω BNC cable between the Sync Out and the Mod/VCF In connectors

5. Verify that the scope displays carrier null with <20 mVp-p AC ripple.

   If incorrect, adjust R102 for minimum indication

6. On the Model 288,

   Press the —> Cursor key.

   Verify that the display indicates CALIBRATING for approximately 5 seconds.then displays PHASE 0 XX,XXX

STEP 6 Adjust Phase

1. Connect the test equipment as shown in figure 5-6.

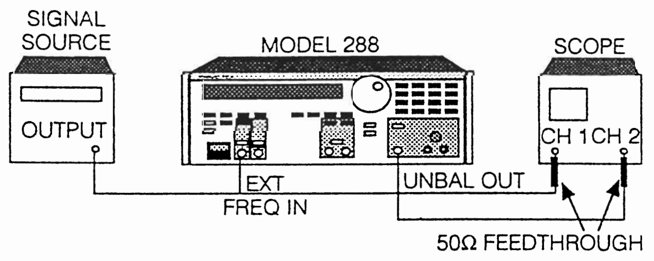


Figure 5-6. Adjust Phase Setup

2. Set the signal source controls as follows:

   Set Function to Sine.

   Frequency to 2kHz.

   Output Level to 5V p-p.

3. Set the scope controls as follows:

   Trigger to channel 1.

   Channel 1 and 2 vertical controls so that settings are identical, and waveforms are displayed.

   Channel 1 and 2 horizontal controls so that settings are identical, and waveforms are displayed.

   Adjust the controls to accurately superimpose both waveforms.

   Select channel 2 Invert.

   Select 1 and 2 Add.

4. On the Model 288,

   Adjust the Front Panel Knob to null the added waveform on the scope display.

   Press the —> CURSOR key.

   Verify that the display flashes CALIBRATING for approximately 1 second.

   Verify that the display indicates PHASE +180 XX,XXX.

5. Set the scope controls as follows:

   Set Channels 1 and 2 Add to Off.

Channel 1 and 2 vertical controls so settings are identical, and waveforms are displayed.

Channel 1 and 2 horizontal controls so settings are identical, and waveforms are displayed.

Adjust the controls to accurately superimpose both waveforms.

Select channel 2 normal (non-invert).

Set Channels 1 and

6. On the Model 288,

   Adjust the Front Panel Knob to null (minimum displayed signal) the added waveform on the scope display.

   Press the —> CURSOR key.

   Verify that the display flashes CALIBRATING for approximately 1 second then displays PHASE –180 XX,XXX.

   Adjust the Front Panel Knob to null (minimum displayed signal) the added waveform on the scope display.

7. On the Model 288,

   Press the —> CURSOR key.

   Verify that the display flashes CALIBRATING for approximately 1 second then displays SQ PHASE 0 XX,XXX.

8. Set the Signal Source controls as follows:

   Function to Square.

   Frequency to 2kHz.

   Output Level to 5V p-p.

9. Set the scope controls as follows:

   Trigger on channel 1.

   Channel 1 and 2 vertical controls so settings are identical, and waveforms are displayed.

   Channel 1 and 2 horizontal controls so settings are identical. and waveforms are displayed.

   Adjust controls to accurately superimpose both waveforms.

   Select channel 2 Invert.

   Select 1 and 2 Add.

10. On the Model 288,

    Adjust the Front Panel Knob to null the added waveform on the scope display.

    Press the CALIBRATE key.

    Verify that the display indicates CALIBRATION OFF.

11. Remove the power and disconnect the test equipment. Install top cover .

SECTION 6
TROUBLESHOOTING

6.1 INTRODUCTION

This section provides a method of troubleshooting the Model 288 to the circuit level. The Model 288 uses several "tools" in addition to conventional operating failures, such as blown fuses and nonoperating functions. The Model 288 produces error messages which this section uses to guide you to a probable faulty block. Also, the Model 288's performance verification procedure (paragraph 2.3.5) tests the units operating parameters. If the unit fails any one the the performance verification tests, proceed to the manual calibration procedure (section 5).

6.2 FACTORY REPAIR

Wavetek maintains a factory repair department for those customers not possessing the necessary personnel or test equipment to maintain the instrument. If an instrument is returned to the factory for calibration or repair, a detailed description of the specific problem should be attached to minimize turnaround time.

6.3 BEFORE STARTING

No troubleshooting guide can possibly cover all the potential problems, the aim of this this section is to guide you to a figure that represents each of the Model 288's assemblies. These figures contain information about unit setup and test conditions for test point on the assembly. Also, it is necessary to become familiarize with the instrument by reviewing the function description and the detailed circuit description (section 4) in conjunction wit the schematics (section 7). Successful troubleshooting depends upon understanding the circuit operation within each function block as well as the block relationships.

6.3.1 Inspection

Before before beginning the troubleshooting procedure, use the following inspection procedures to locate obvious malfunctions with the Model 288.

1. Inspect all external surfaces of Model 288 for physical damage, breakage, loose or dirty contacts, and missing components.
2. Remove top cover, shield, and bottom cover to access components.

WARNING

The Model 288 contains high voltages. After power is removed, discharge capacitors to ground before working inside the instrument to prevent electrical shock.

CAUTION

Do not disconnect or remove any board assemblies in the Model 288 unless the instrument is unplugged. Some board assemblies contain devices that can be damaged if the board is removed with the power on. Several components, including MOS devices, can be damaged by electrostatic discharge. Use conductive foam and grounding straps when servicing is required around sensitive components. Use care when unplugging IC's from high-grip sockets.

3. Inspect printed circuit board surfaces for discoloration, cracks, breaks, and warping.
4. Inspect printed circuit board conductors for breaks, cracks, cuts, erosion, or looseness.
5. Inspect all assemblies for burnt or loose components.
6. Inspect all chassis-mounted components for looseness, breakage, loose contacts or conductors.
7. Inspect the Model 288 for disconnected, broken, cut, loose, or frayed cables or wires.

6.4 TROUBLESHOOTING

This troubleshooting procedure relies on the the Model 288's error messages and performance verification failures. If during the normal operation the Model 288 fails, note the conditions and consult this table for the closest possible problem.

Table 6-1 lists the Models 288's error messages and references the recommended troubleshooting figure or igures. Table 6-2 lists the items from the performance verification procedure and the recommended trouleshooting figures.

All control and signal lines, as well as voltages, are outed though the Motherboard; see figure 6-1. Check e Microprocessor circuit by verifying the flashing Life ght, if not check the supplies to the circuit. Also, nove all boards

sing the Troubleshooting Figures

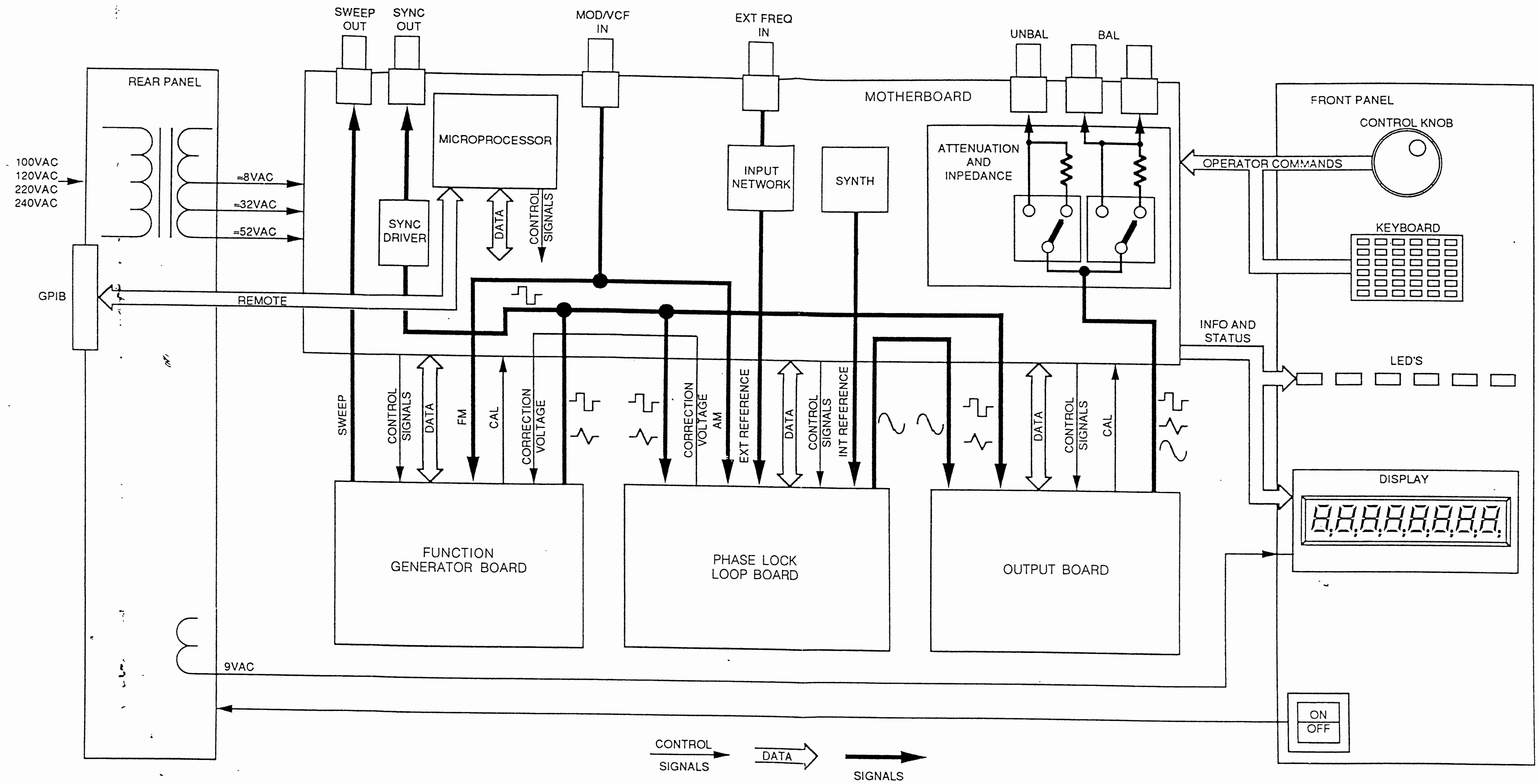
ne troubleshooting figures contains test setup instructions and test point data. Use these figures by checking the output test points first, usually the right side of the block diagram, and proceeding by step back through the circuits. Once the suspected circuit has been isolated, use the appropriate assembly drawing, schematic, and parts list to aid in isolating the faulty component. Remember, the circuit description, section 4, provides a functional and detailed description of the circuit.

Table 6-1. Error Messages

Error Message	Troubleshoot
VCGZERO VFREQ VFREQOS SPOSVCGOFF SNEGVCGOFF VTRIBAL SYMM50PCT POSVCGOFF SWPLENGTH SCALE TOFR7 TOFR6 TOFR5 TOFR4 TOFR3 COMP9+ COMP8+	Function Generator - Figure 6-7 Motherboard - Figures 6-1, 6-3, and 6-8 Front Panel - Figure 6-2
FINDNOTCH OFSTZERO OFSTGAIN BALOFFST SINEAMPL TRIAMPL SQURAMPL BALAMPL VSINCAL VAMCAL	Phase Lock Board - Figure 6-6 Output Board - Figure 6-4 Motherboard - Figures 6-1, 6-3, and 6-8

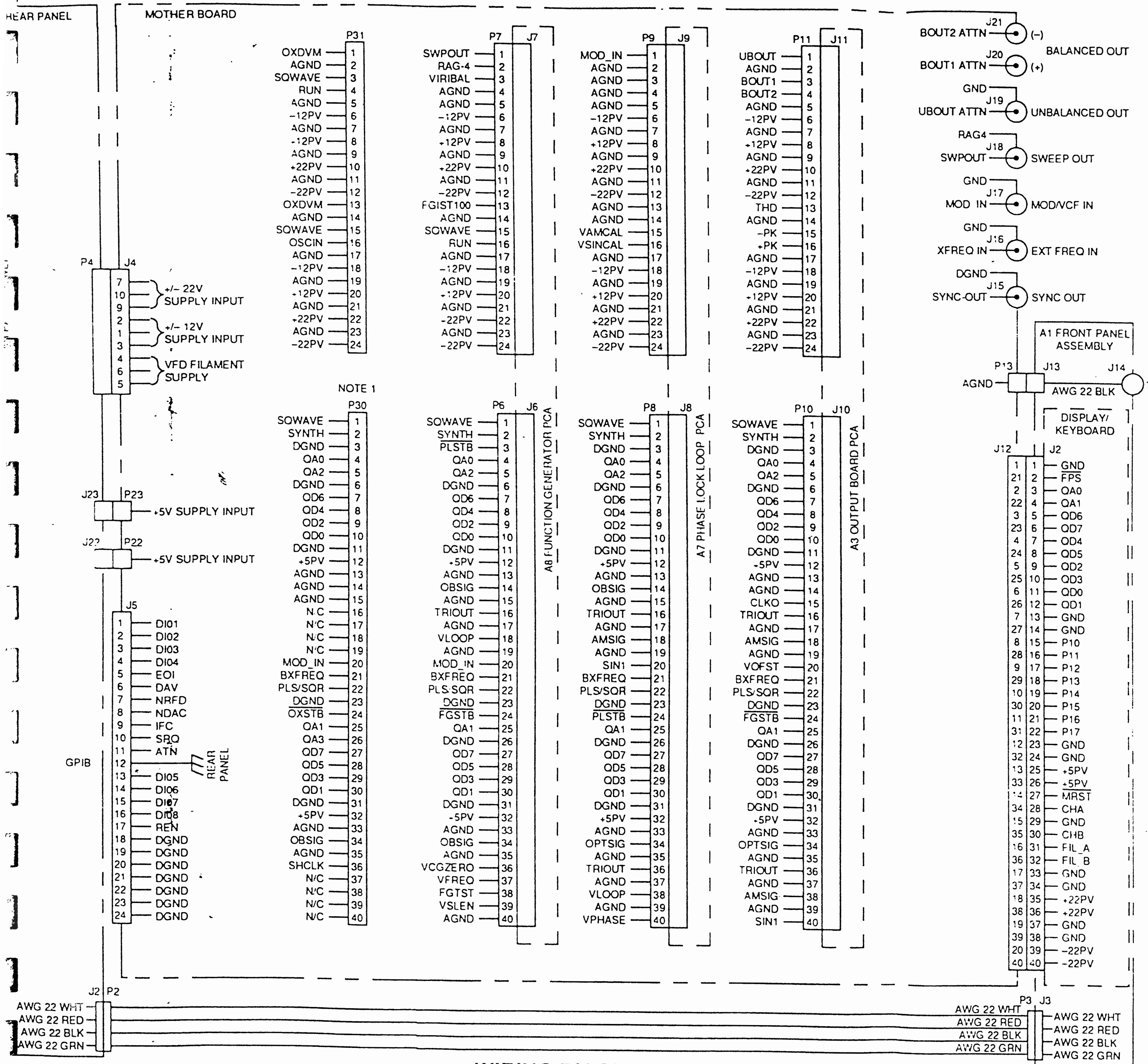
Table 6-2. Performance Verification Failures

Test Failure	Troubleshoot
Frequency Range Frequency Resolution Symmetry VCF/FM Operation	Function Generator - Figure 6-7 Motherboard - Figure 6-1, 6-3, and 6-8 Front Panel - Figure 6-2 Phase Lock Board (Synth.) Figure 6-6
Waveform and Sweep Pulse Characteristics Output Verification AM Verification Sine Wave Purity Amplitude Accuracy DC Offset/Attenuator External Lock	Output Board - Figure 6-4 Phase Lock Board - Figure 6-6 Function Generator - Figure 6-7 Motherboard - 6-1, 6-3, and 6-8



BLOCK DIAGRAM

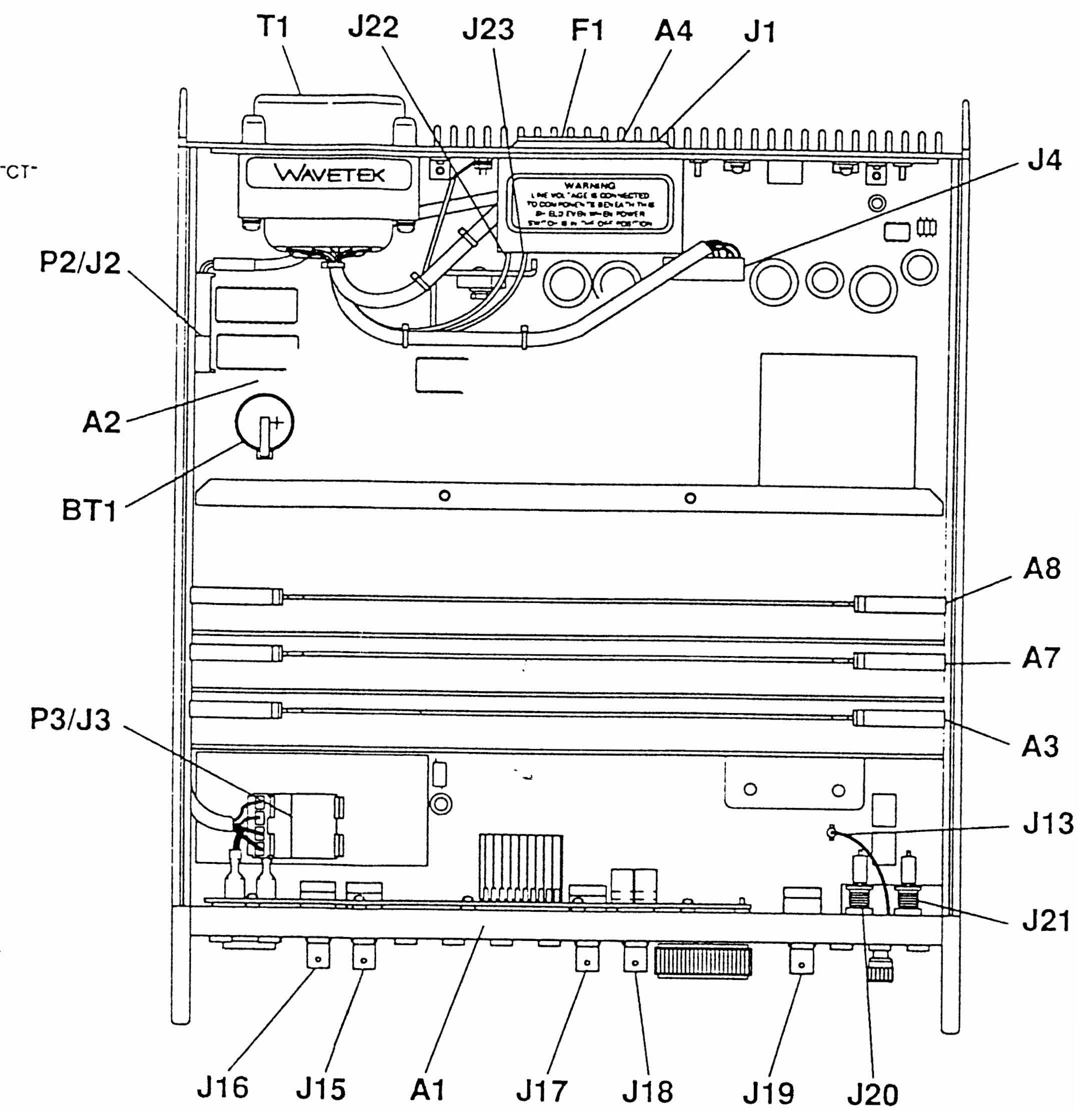
Figure 6-1. Instrument (Sheet 1 of 2).



WIRING DIAGRAM

NOTES:

1. P30 AND P31 NOT USED. INFORMATION PROVIDED FOR TROUBLESHOOTING PURPOSES ONLY.



ASSEMBLY AND CABLE LOCATOR – TOP VIEW

Figure 6-1. Instrument (Sheet 2 of 2).

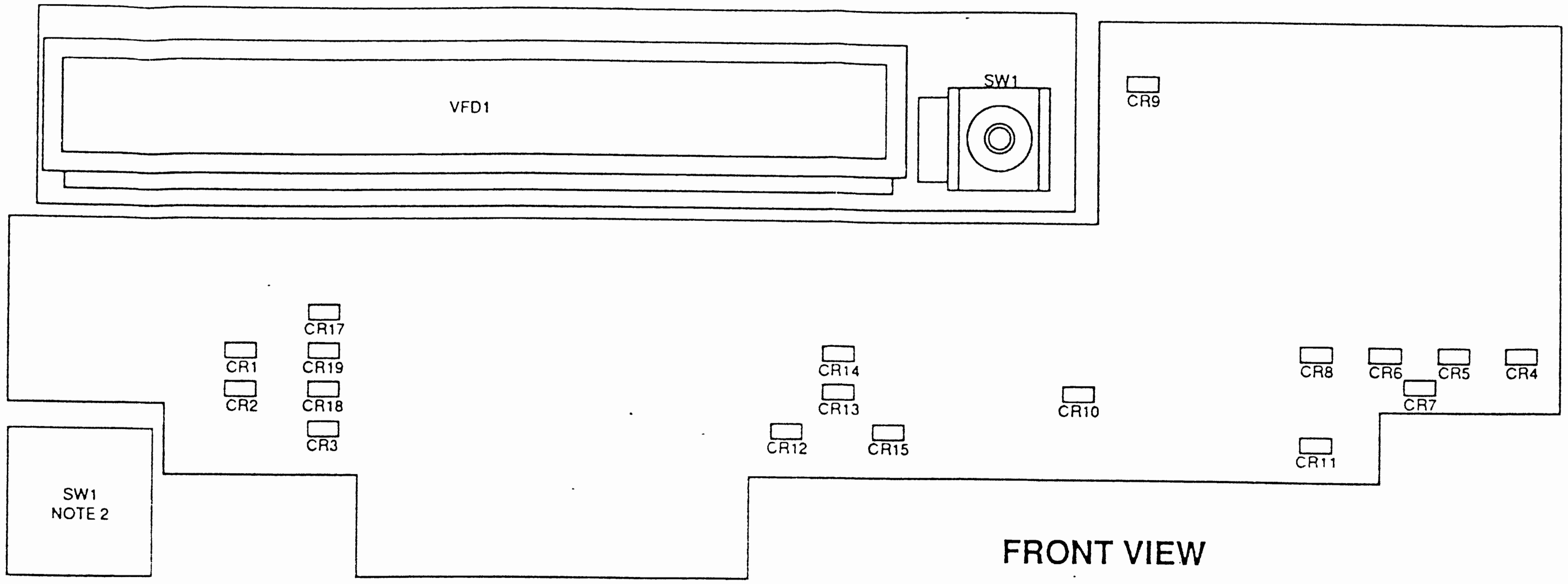
NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   RESISTANCE IS IN Ω (METAL FILM 1/8W,±1%)
   CAPACITANCE IS IN µF
   INDUCTANCE IS IN µH

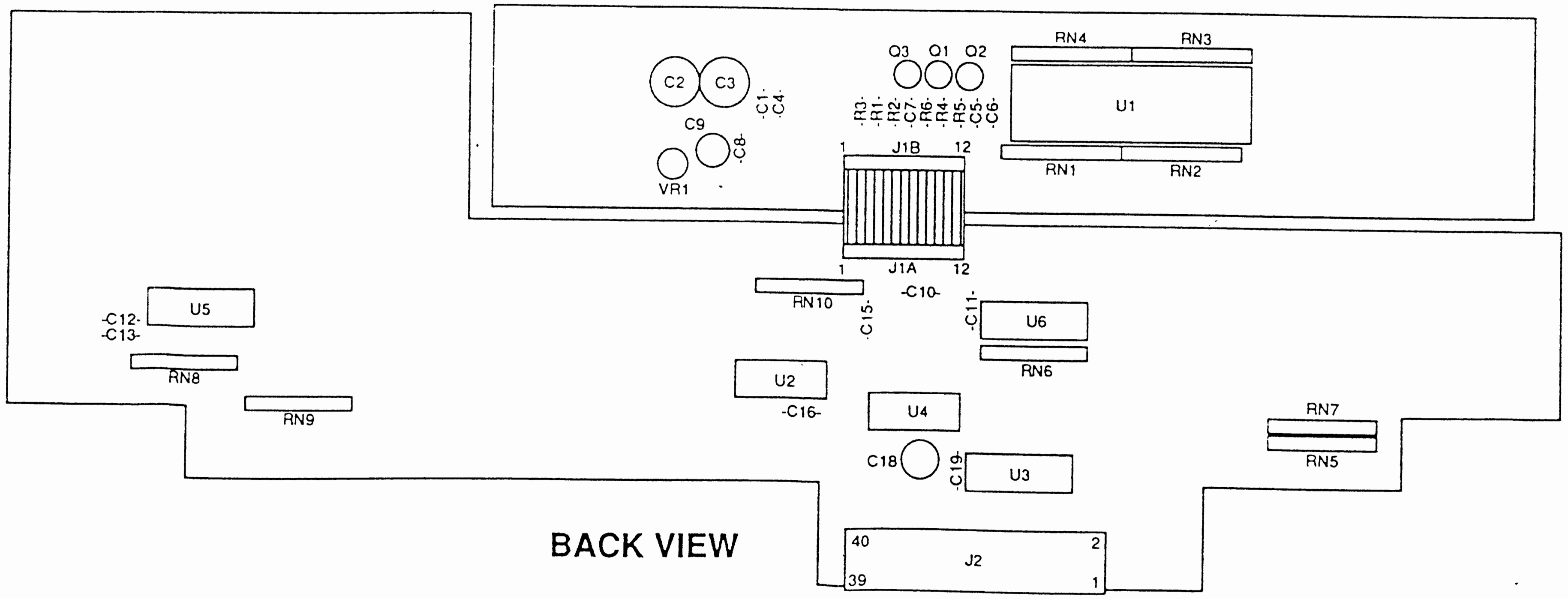
2. UNLESS OTHERWISE SPECIFIED, INITIAL SETUP FOR VOLTAGES AND WAVEFORMS IS:

   SET POWER TO ON.
   PRESS RESET KEY.
   WAIT 20 MINUTES.
   PRESS CALIBRATE KEY.
   VERIFY DISPLAY SHOWS AUTOCALIBRATED.

3. UNLESS OTHERWISE SPECIFIED, ALL VOLTAGE READINGS AND WAVEFORMS TAKEN WITH RESPECT TO CHASSIS GROUND.



FRONT VIEW



BACK VIEW

Figure 6-2. Front Panel (Sheet 1 of 2).

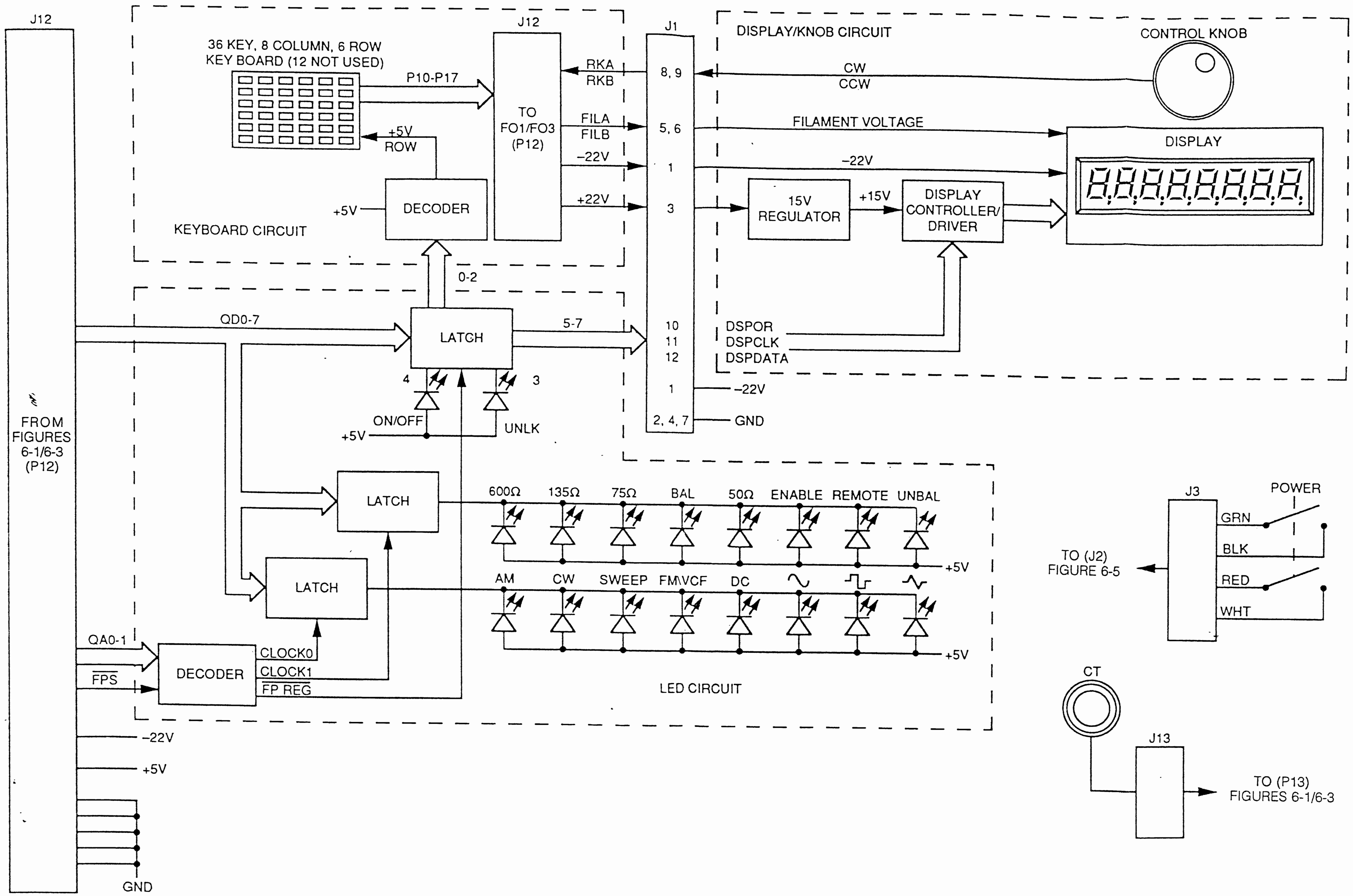


Figure 6-2. Front Panel (Sheet 2 of 2).

NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   RESISTANCE IS IN Ω (METAL FILM 1/8W,±1%)
   CAPACITANCE IS IN µF
   INDUCTANCE IS IN µH

2. UNLESS OTHERWISE SPECIFIED, INITIAL SETUP FOR VOLTAGES AND WAVEFORMS IS:

   SET POWER TO ON.
   PRESS RESET KEY.
   WAIT 20 MINUTES.
   PRESS CALIBRATE KEY.
   VERIFY DISPLAY SHOWS AUTOCALIBRATED.

3. UNLESS OTHERWISE SPECIFIED, ALL VOLTAGE READINGS AND WAVEFORMS TAKEN WITH RESPECT TO CHASSIS GROUND.

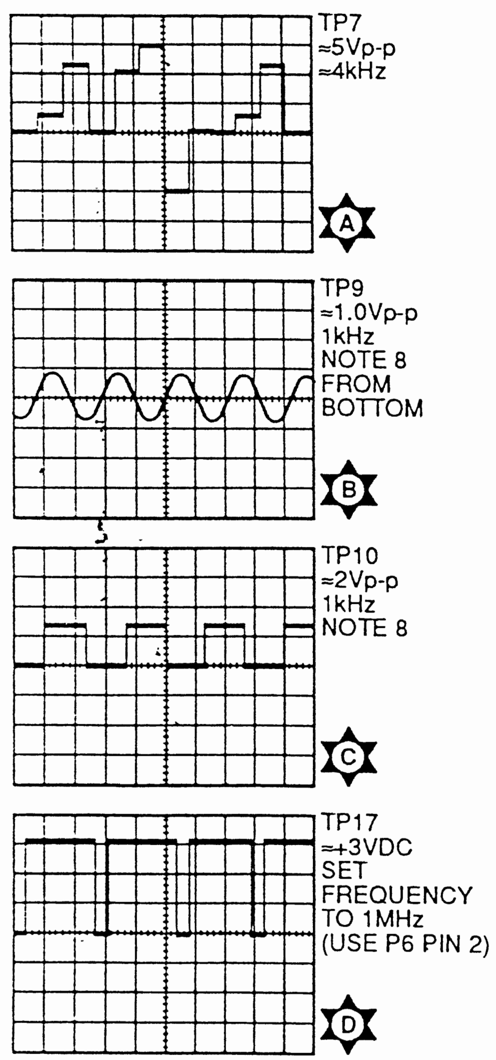
4. NOT FUNCTIONAL — TP1.

5. GROUND — TP2, TP6, TP8, TP11 AND TP16.

6. NOT USED — TP4, TP12, AND TP13.

7. SIGNAL MEASURED WITH 1kHz AT 1Vp-p SINE WAVE SIGNAL. CONNECTO TO EXTERNAL FREQUENCY INPUT. SELECT EXTERNAL LOCK ON INDICATOR TO ON.

8. * DENOTES CONTROL SIGNAL.



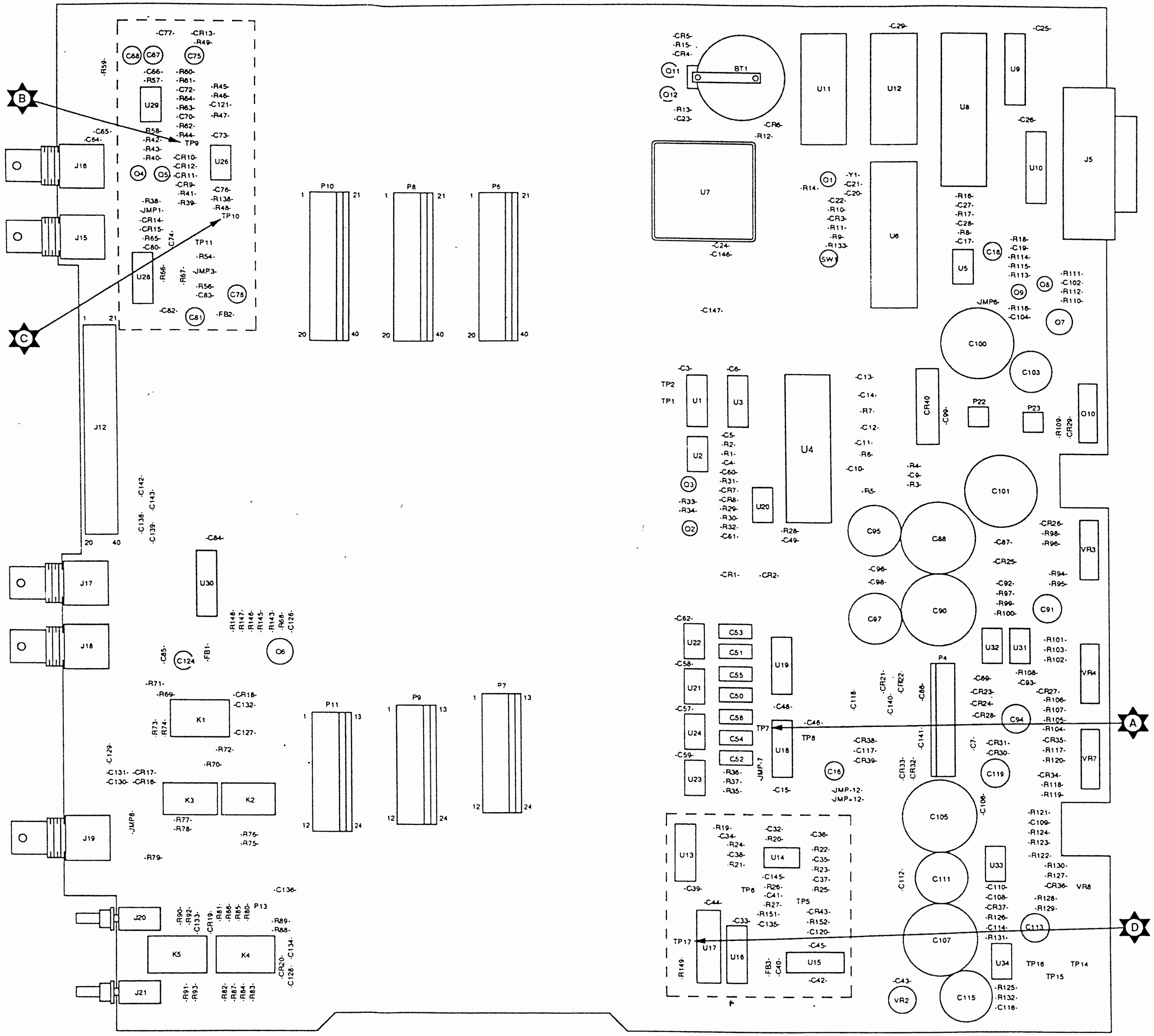


Figure 6-3. Motherboard (Sheet 1 of 2).

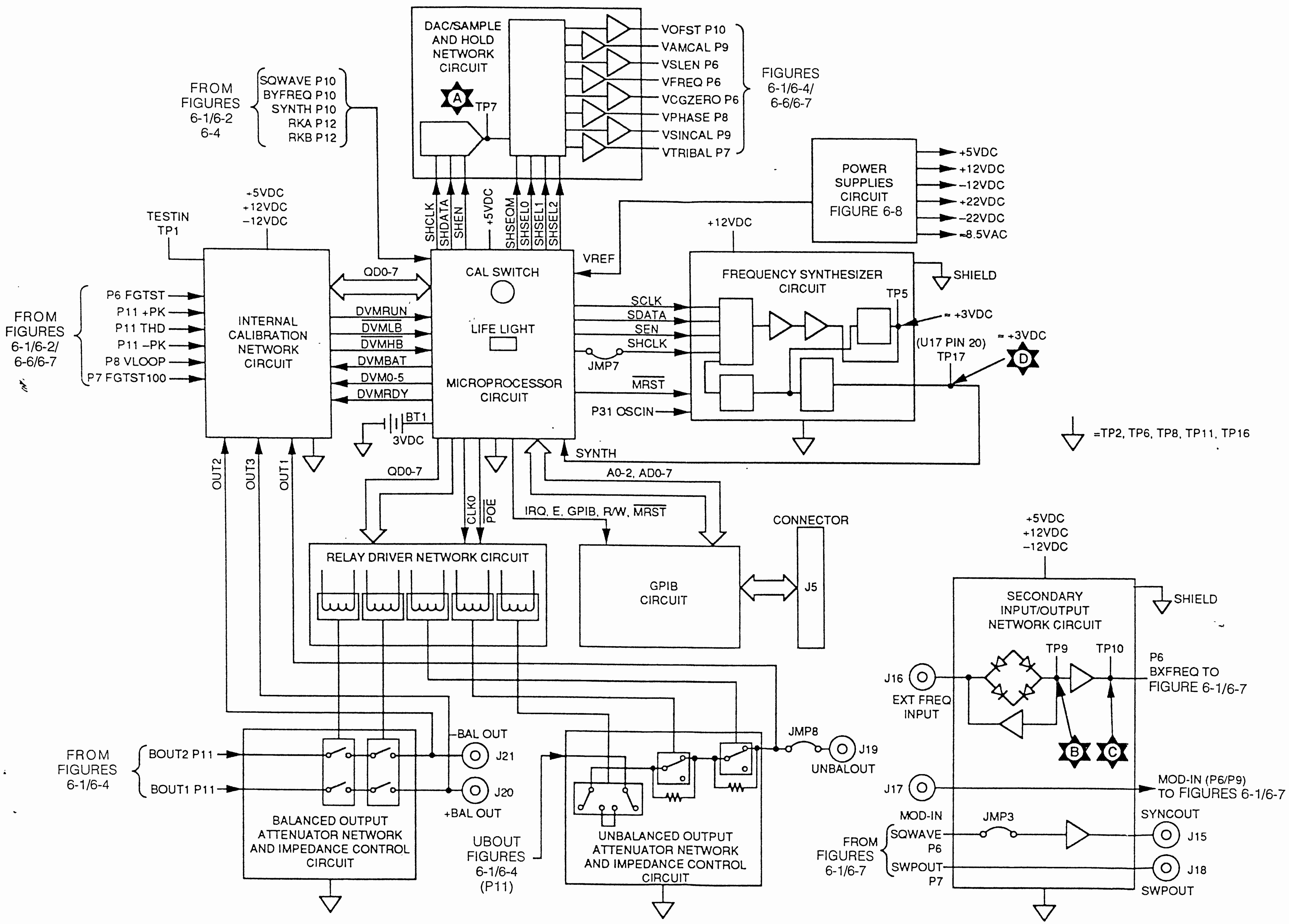


Figure 6-3. Motherboard (Sheet 2 of 2).

NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   RESISTANCE IS IN Ω (METAL FILM 1/8W,±1%)
   CAPACITANCE IS IN μF
   INDUCTANCE IS IN μH

2. UNLESS OTHERWISE SPECIFIED, INITIAL SETUP FOR VOLTAGES AND WAVEFORMS IS:

   SET POWER TO ON.
   PRESS RESET KEY.
   WAIT 20 MINUTES.
   PRESS CALIBRATE KEY.
   VERIFY DISPLAY SHOWS AUTOCALIBRATED.

3. UNLESS OTHERWISE SPECIFIED, ALL VOLTAGE READINGS AND WAVEFORMS TAKEN WITH RESPECT TO ANALOG/DIGITAL GROUND.

4. ANALOG GROUND — TP3 AND TP5.

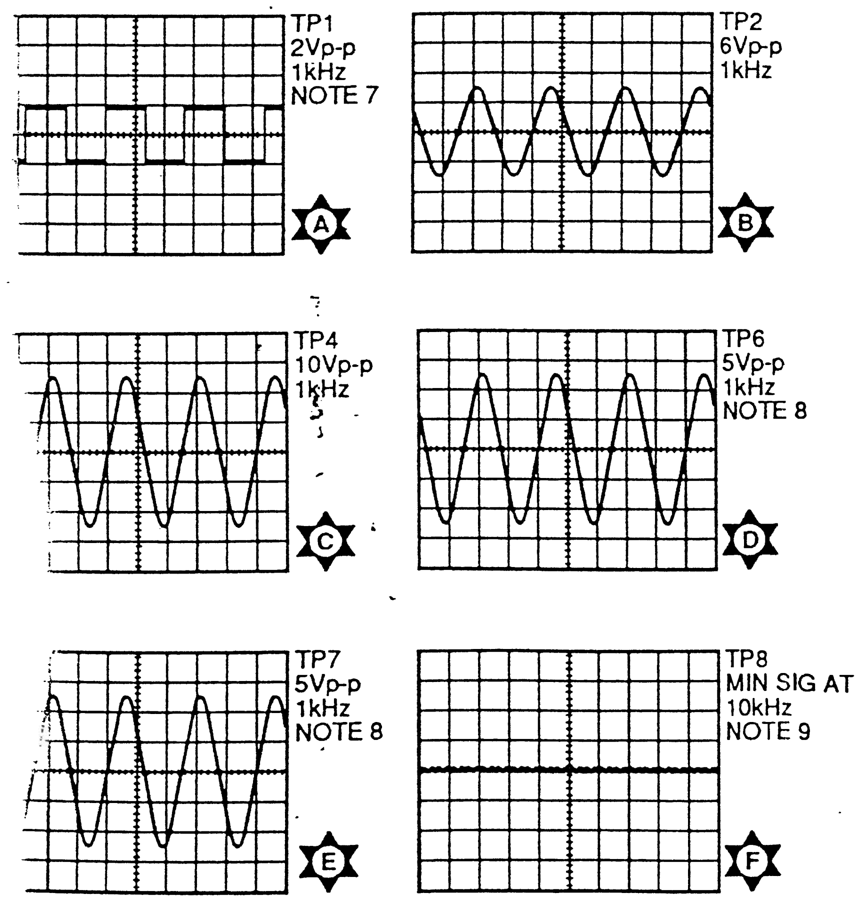
5. NOT MEASURABLE — TP 9 AND TP10.

6. SIGNAL MEASURED WITH FUNCTION SET TO SQUARE.

7. SIGNAL MEASURED WITH OUTPUT SET TO 600Ω.

8. SIGNAL MEASURED WITH FREQUENCY AT =10KHz TUNE TO MINIMUM SIGNAL.

9. * DENOTES CONTROL SIGNAL.



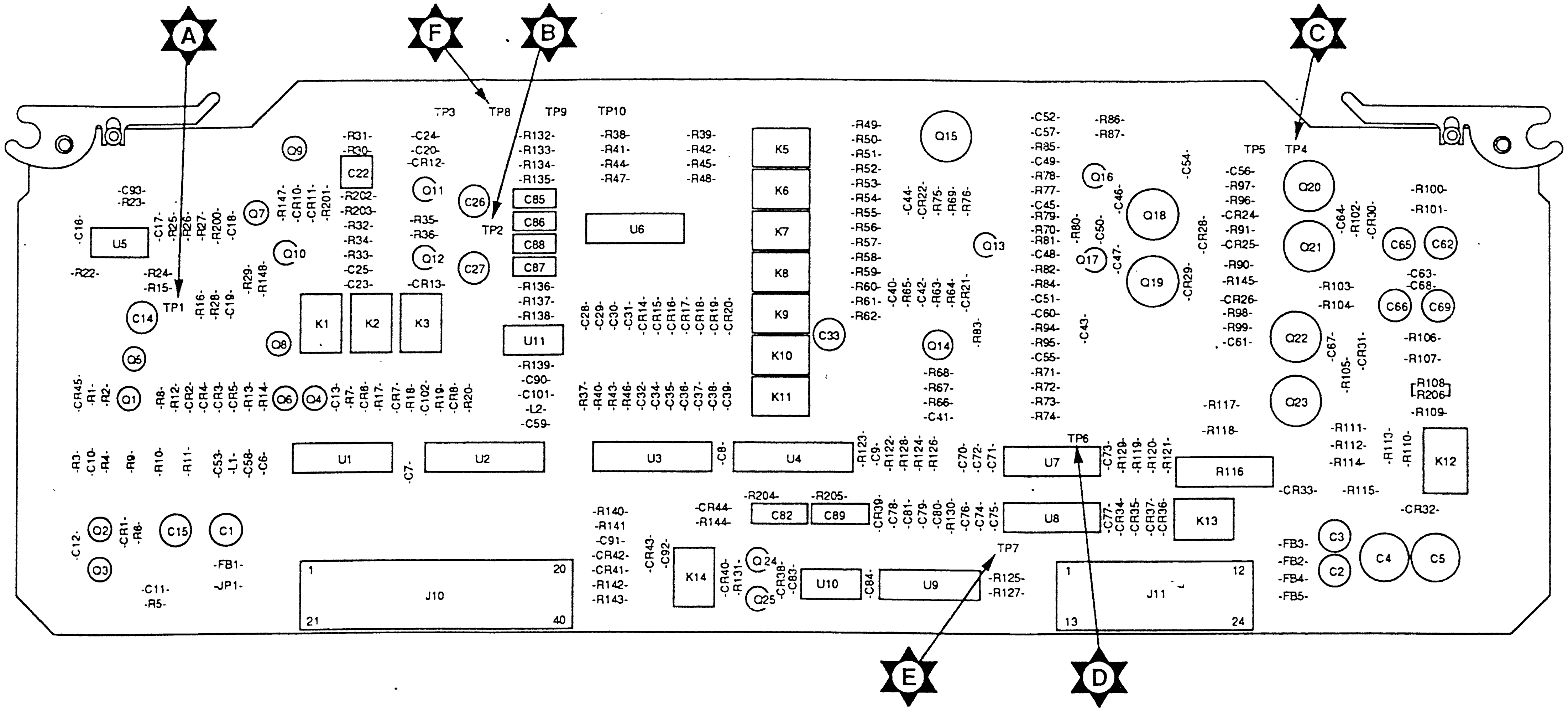


Figure 6-4. Output Board (Sheet 1 of 2).

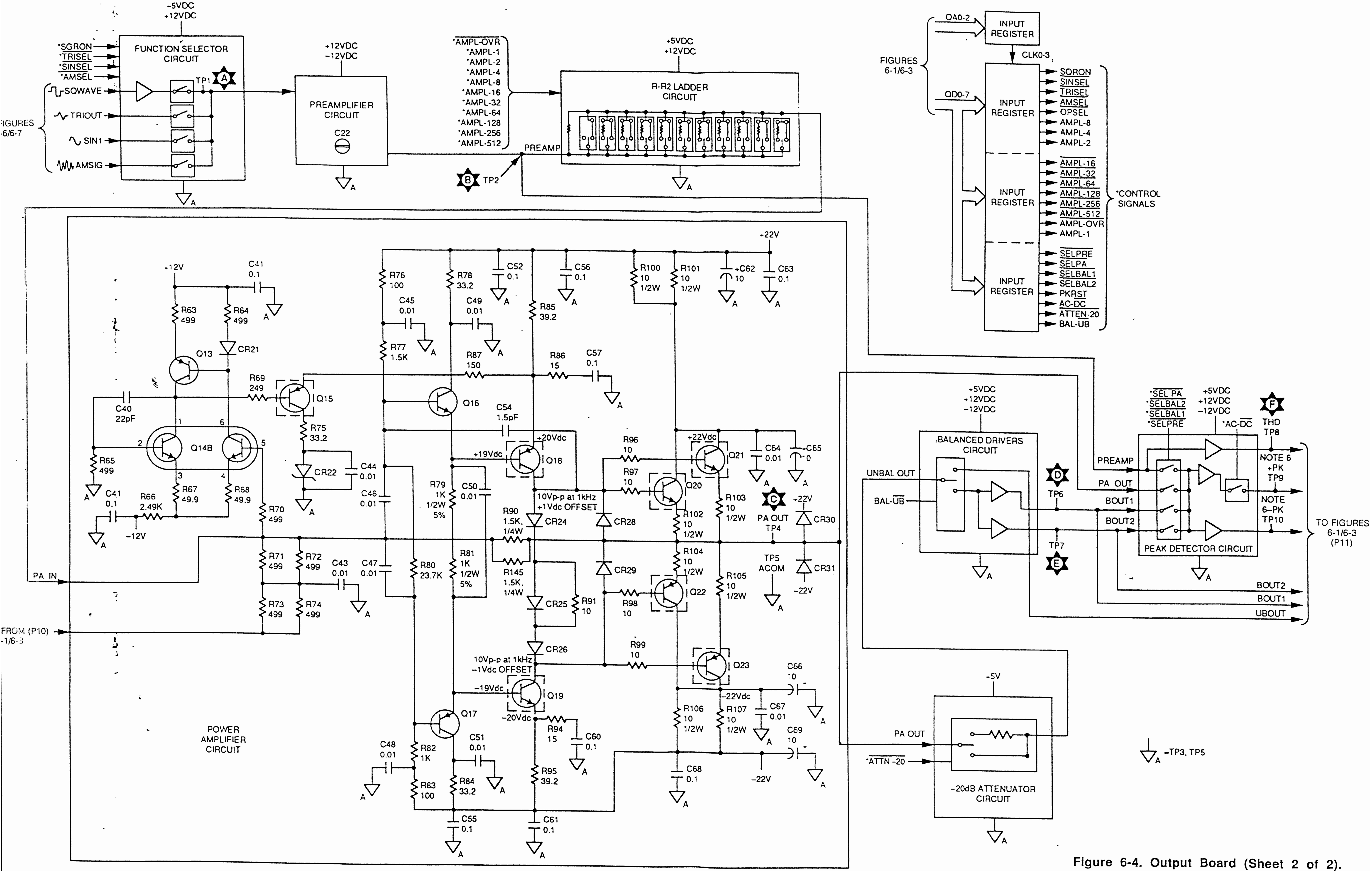


Figure 6-4. Output Board (Sheet 2 of 2).

)TES:

UNLESS OTHERWISE SPECIFIED:
RESISTANCE IS IN Ω (METAL FILM 1/8W,±1%)
CAPACITANCE IS IN μF
INDUCTANCE IS IN μH

UNLESS OTHERWISE SPECIFIED, INITIAL SETUP FOR VOLTAGES AND WAVEFORMS IS:

SET POWER TO ON.
PRESS RESET KEY.
WAIT 20 MINUTES.
PRESS CALIBRATE KEY.
VERIFY DISPLAY SHOWS AUTOCALIBRATED.

)NLESS OTHERWISE SPECIFIED, ALL VOLTAGE EADINGS AND WAVEFORMS TAKEN WITH ESPECT TO CHASSIS GROUND.

)0 VAC = A-B, C-D, E-F.

?0 VAC = E-F, B-C-D

:0 VAC = A-B, D-E

:0 VAC = B-C, D-E

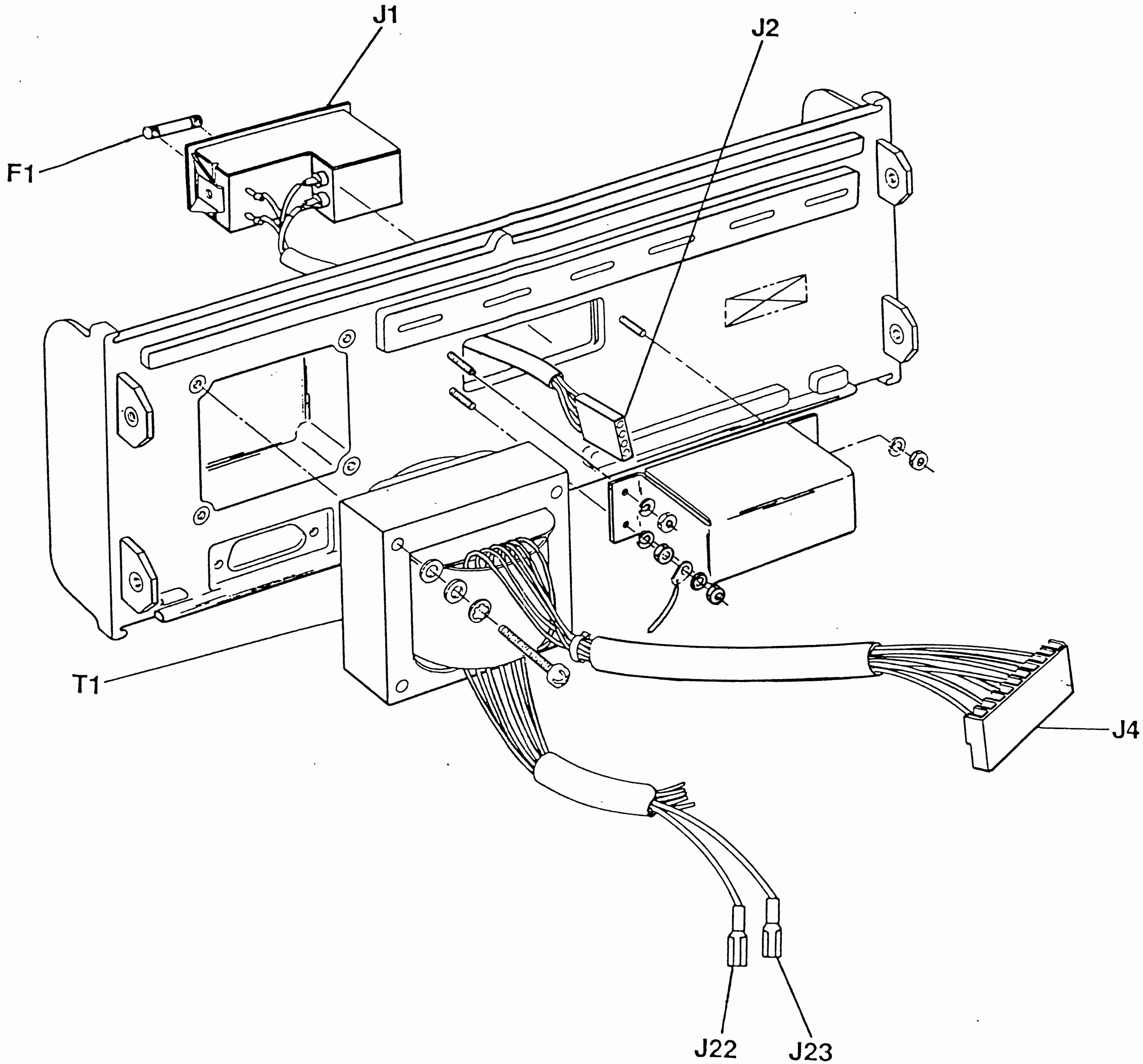


Figure 6-5. Rear Panel Assembly (Sheet 1 of 2).

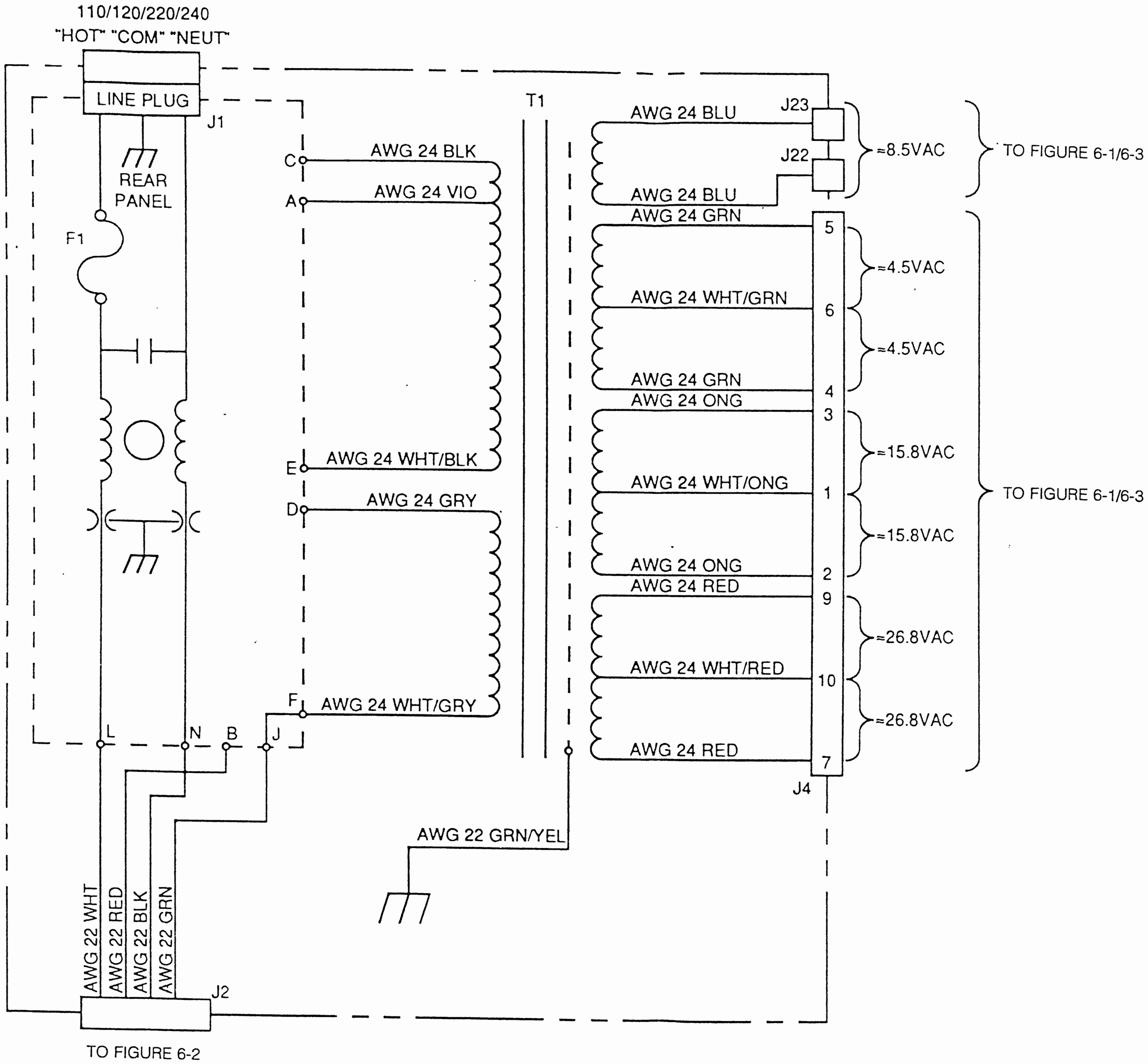


Figure 6-5. Rear Panel Assembly (Sheet 2 of 2).

NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   RESISTANCE IS IN Ω (METAL FILM 1/8W,±1%)
   CAPACITANCE IS IN µF
   INDUCTANCE IS IN µH

2. UNLESS OTHERWISE SPECIFIED, INITIAL SETUP FOR VOLTAGES AND WAVEFORMS IS:

   SET POWER TO ON.
   PRESS RESET KEY.
   WAIT 20 MINUTES.
   PRESS CALIBRATE KEY.
   VERIFY DISPLAY SHOWS AUTOCALIBRATED.

3. UNLESS OTHERWISE SPECIFIED, ALL VOLTAGE READINGS AND WAVEFORMS TAKEN WITH RESPECT TO ANALOG/DIGITAL GROUND.

4. DIGITAL GROUND — TP4.

5. ANALOG GROUND — TP11.

6. NOT USED — TP5 AND TP6.

7. SIGNAL MEASURED WITH 1kHz AT 1 Vp-p SINE WAVE SIGNAL. CONNECT TO EXTERNAL FREQUENCY INPUT. SELECT EXTERNAL LOCK ON INDICATOR TO ON.

8. SIGNAL MEASURED WITH EXTERNAL LOCK ON INDICATOR TO ON WITHOUT SIGNAL CONNECTED TO EXTERNAL FREQUENCY INPUT.

9. * DENOTES CONTROL SIGNAL.

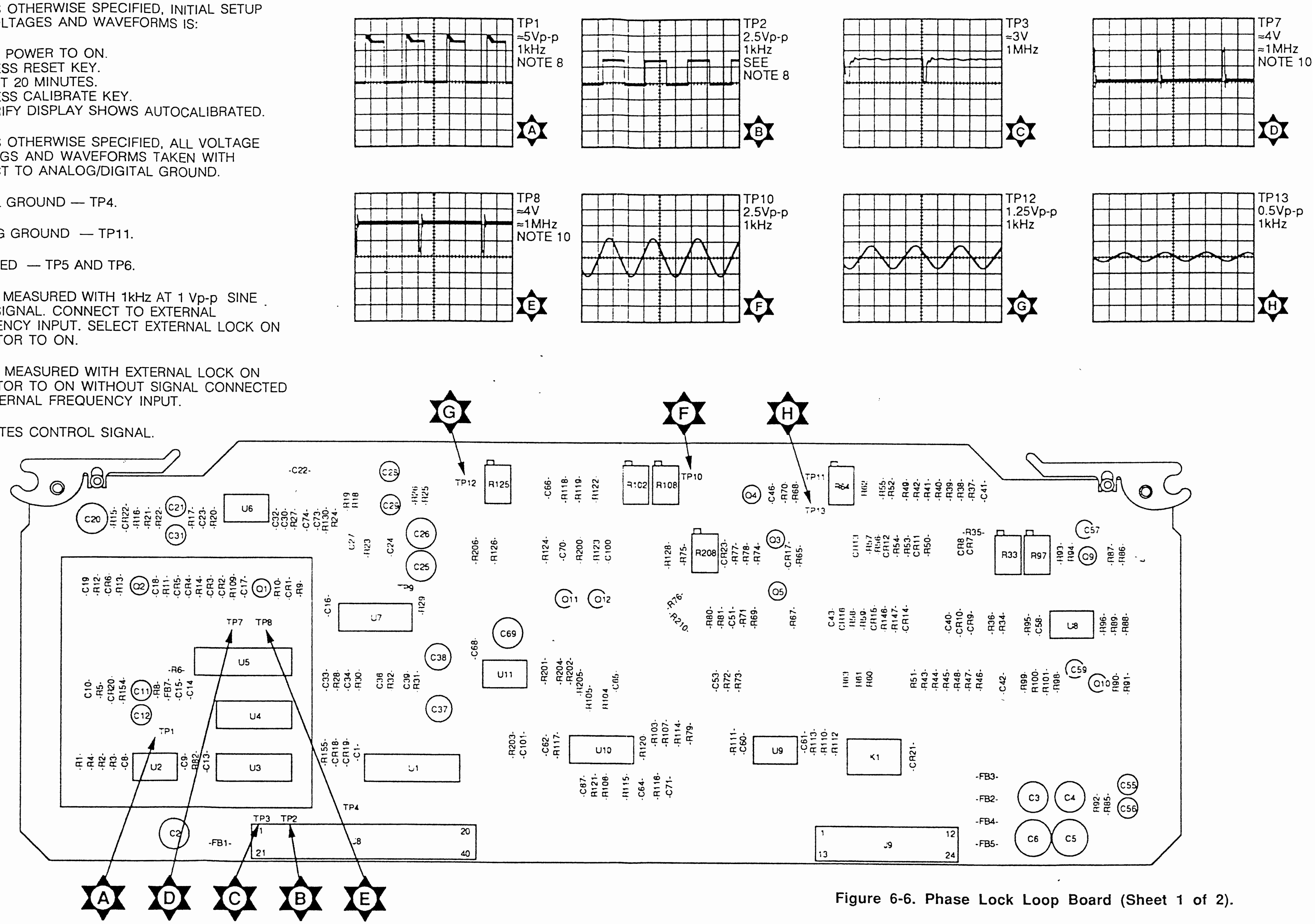


Figure 6-6. Phase Lock Loop Board (Sheet 1 of 2).

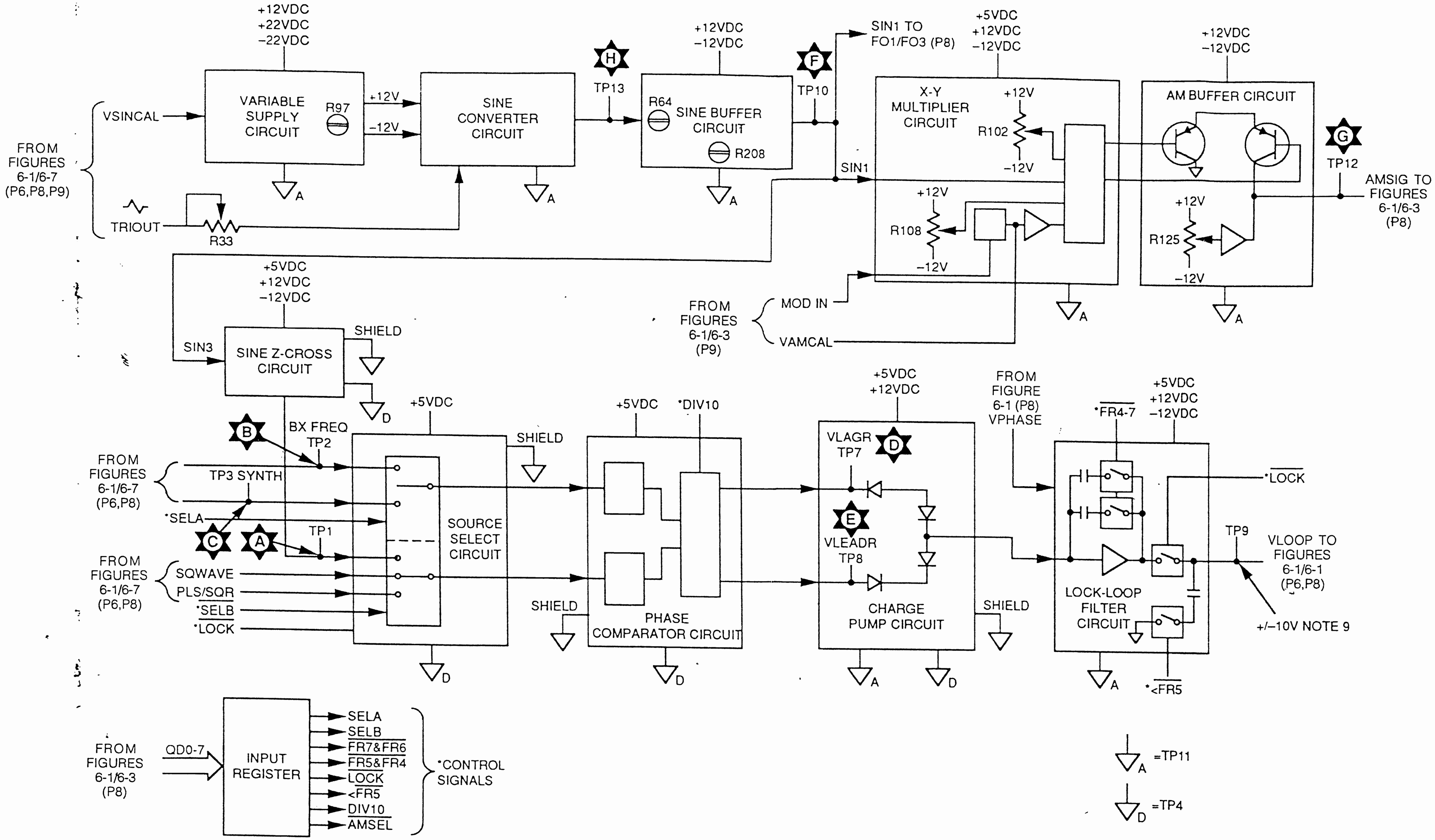


Figure 6-6. Phase Lock Loop Board (Sheet 2 of 2).

NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   RESISTANCE IS IN Ω (METAL FILM 1/8W,±1%)
   CAPACITANCE IS IN μF
   INDUCTANCE IS IN μH

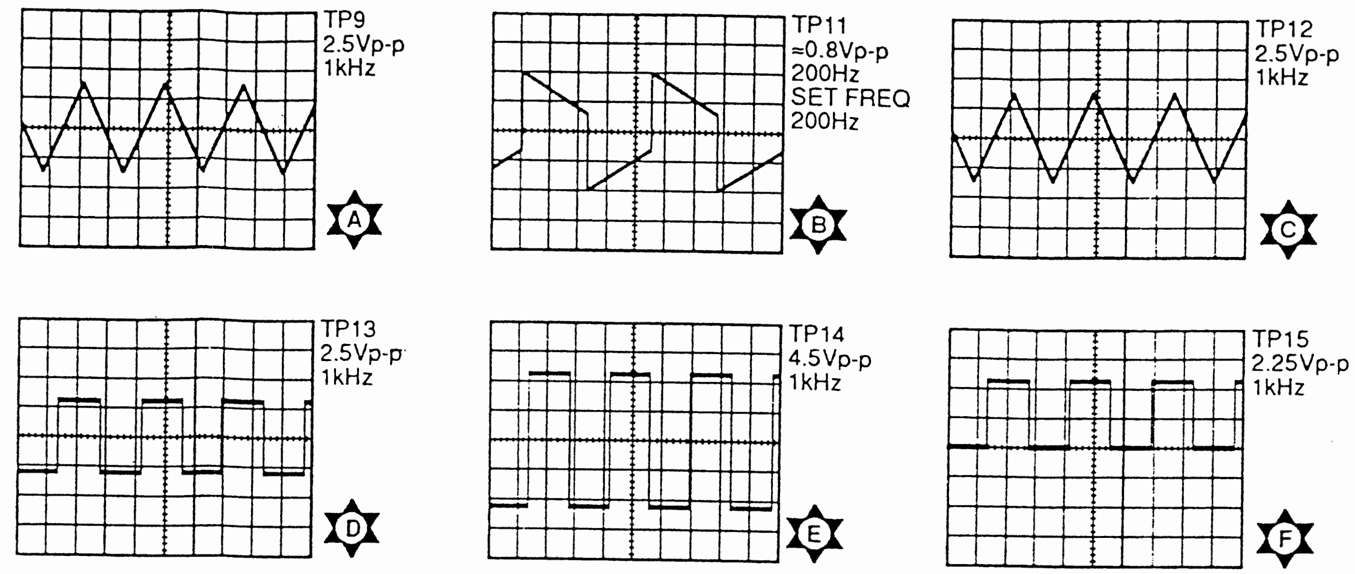
2. UNLESS OTHERWISE SPECIFIED, INITIAL SETUP FOR VOLTAGES AND WAVEFORMS:

   SET POWER TO ON.
   PRESS RESET KEY.
   WAIT 20 MINUTES.
   PRESS CALIBRATE KEY.
   VERIFY DISPLAY SHOWS AUTOCALIBRATED.

3. UNLESS OTHERWISE SPECIFIED, ALL VOLTAGE READINGS AND WAVEFORMS TAKEN WITH RESPECT TO ANALOG GROUND.

4. ANALOG GROUND — TP1, TP10, AND TP16.

5. * DENOTES CONTROL SIGNAL.



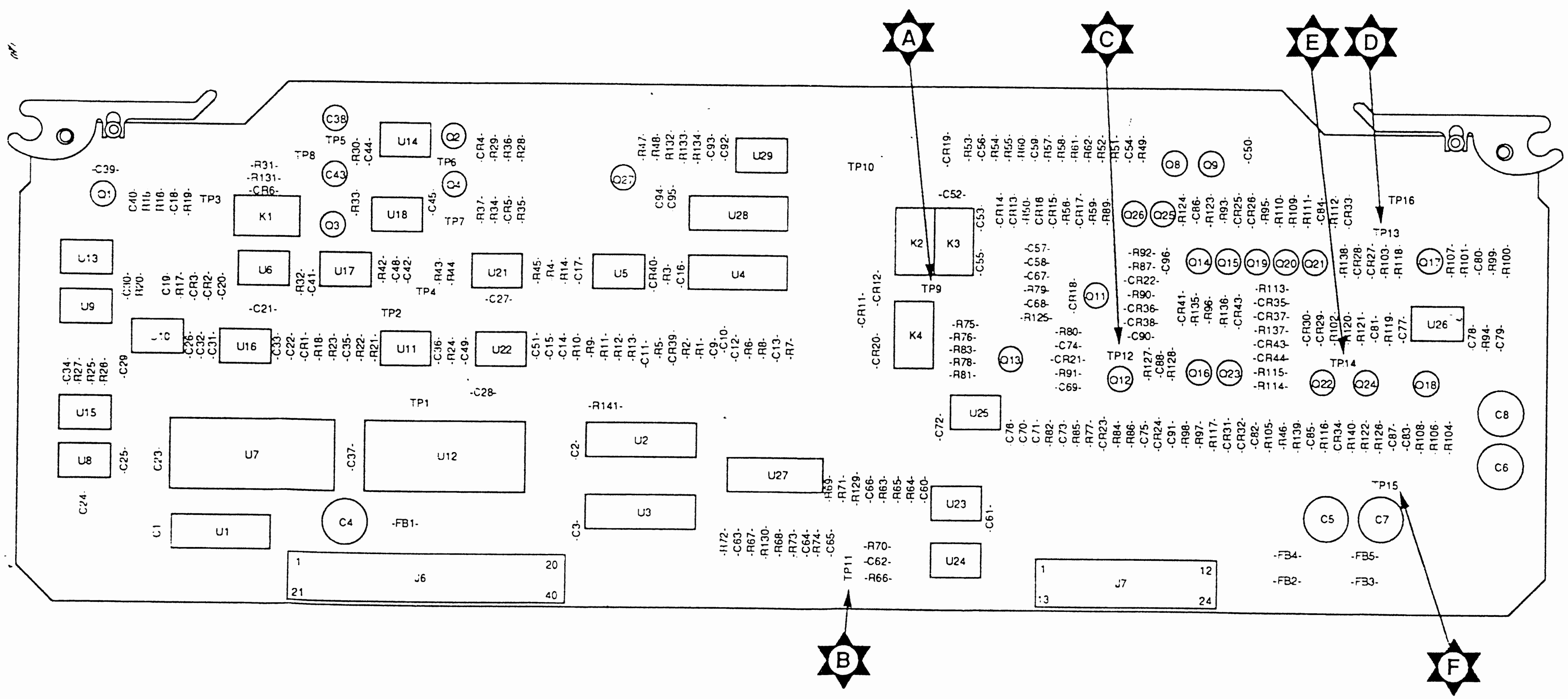


Figure 6-7. Function Generator (Sheet 1 of 2).

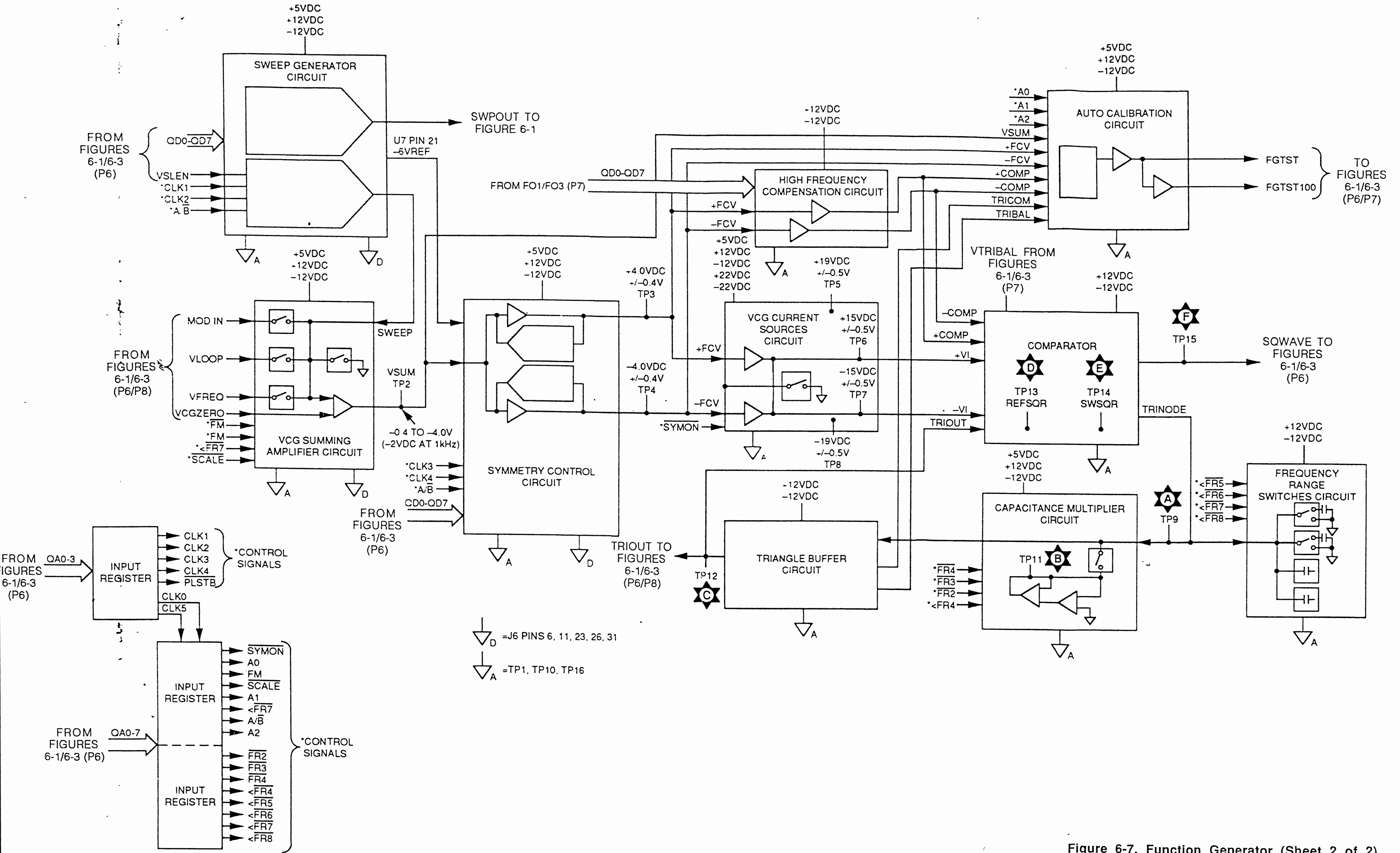
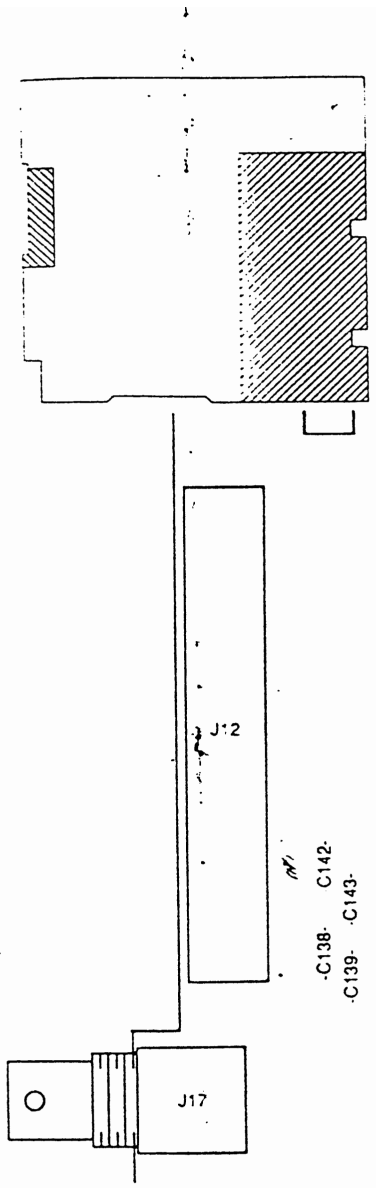
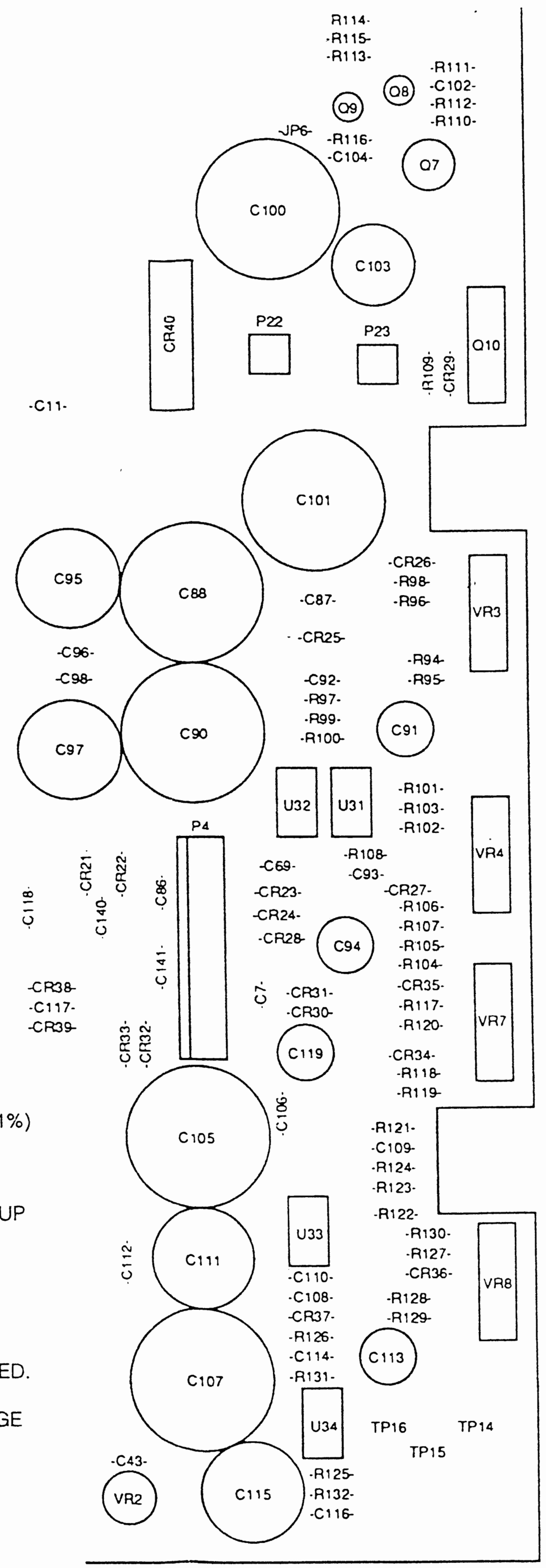


Figure 6-7. Function Generator (Sheet 2 of 2).





TES:

UNLESS OTHERWISE SPECIFIED:
RESISTANCE IS IN Ω (METAL FILM 1/8W,±1%)
CAPACITANCE IS IN µF
INDUCTANCE IS IN µH

UNLESS OTHERWISE SPECIFIED, INITIAL SETUP FOR VOLTAGES AND WAVEFORMS:

SET POWER TO ON.
PRESS RESET KEY.
WAIT 20 MINUTES.
PRESS CALIBRATE KEY.
VERIFY DISPLAY SHOWS AUTOCALIBRATED.

UNLESS OTHERWISE SPECIFIED, ALL VOLTAGE READINGS AND WAVEFORMS TAKEN WITH RESPECT TO ANALOG GROUND.

'/REF SIGNAL TO INTERNAL CALIBRATION 'IETWORK CIRCUIT ON FIGURE 6-3.

+12REF SIGNAL FROM +12V SUPPLY IN FIGURE 6-3.,

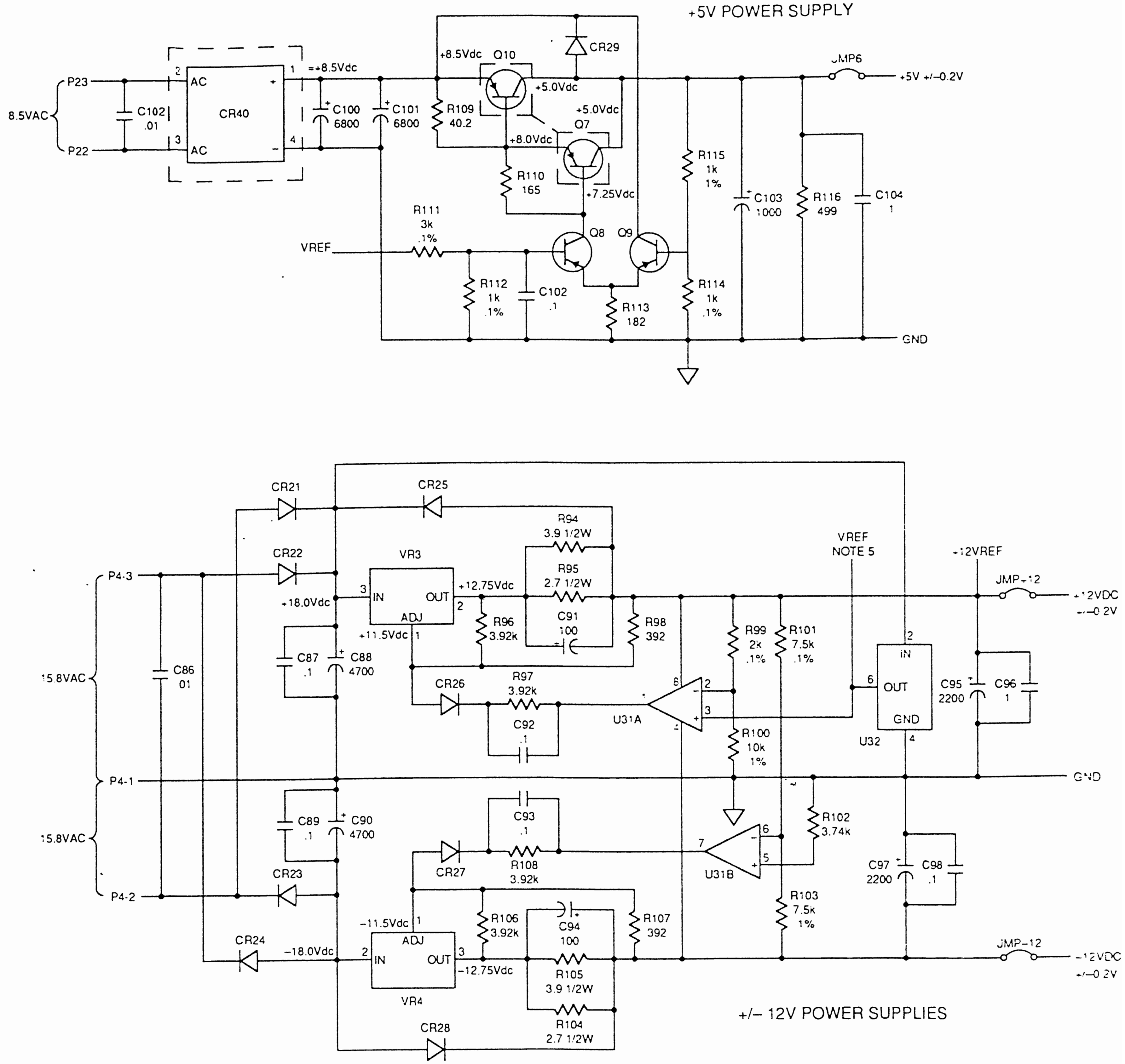


Figure 6-8. Power Supply (Sheet 1 of 2).

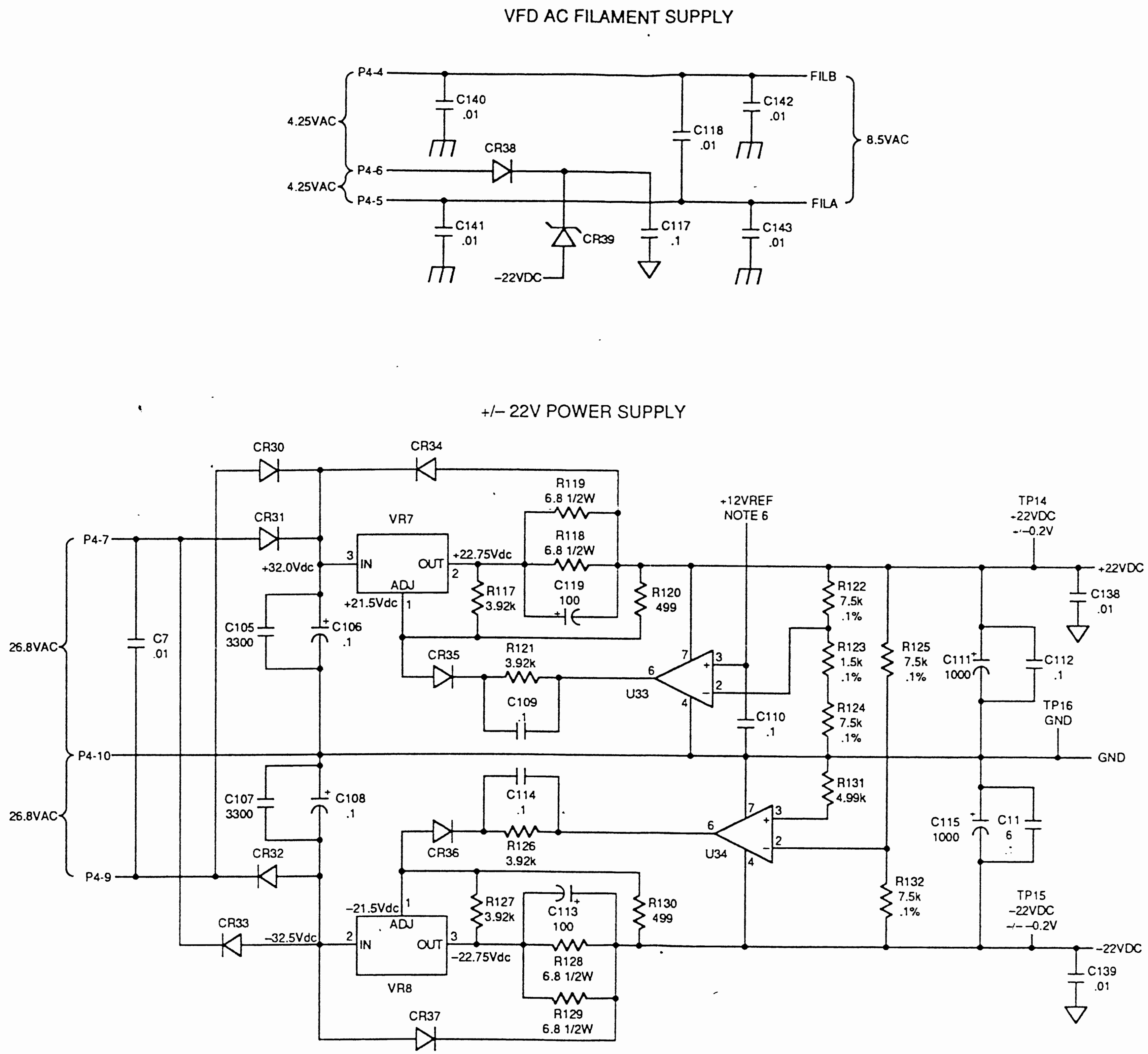
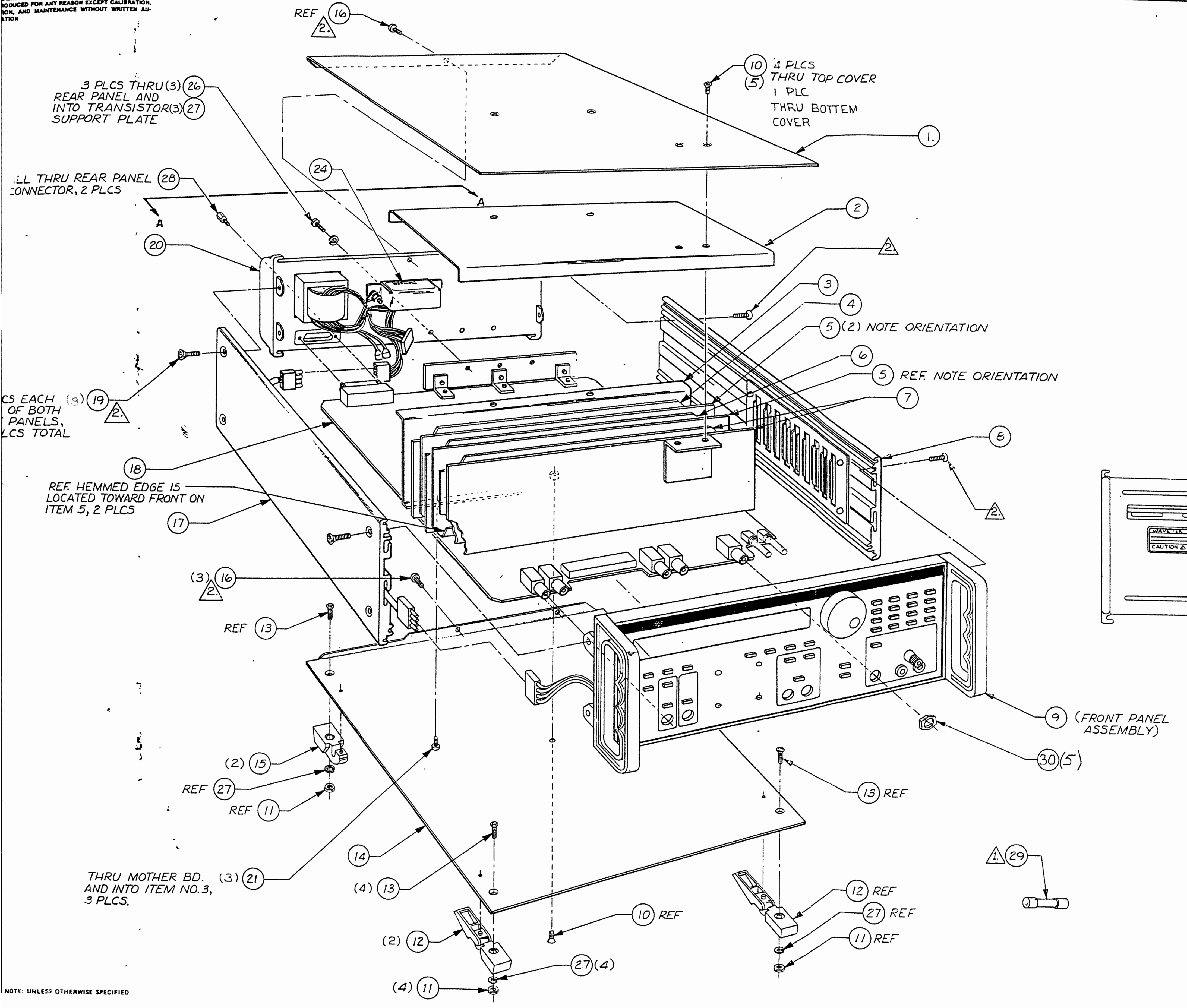
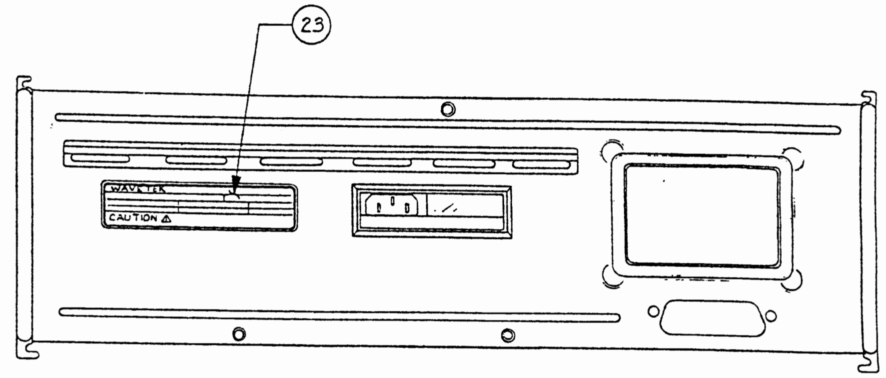


Figure 6-8. Power Supply (Sheet 2 of 2).

DOCUMENT CONTAINS PROPRIETARY INFORMATION AND RIGHTS BELONGING TO WAVETEK AND MAY NOT BE REPRODUCED FOR ANY REASON EXCEPT CALIBRATION, OPERATION, AND MAINTENANCE WITHOUT WRITTEN AUTHORIZATION

REV	ECO	BY	DATE	APP
A	ERO 89-025	MK	11/2/89	





VIEW A-A

2 DO NOT USE LOCTITE (OR EQUIV) ON THESE. SCREWS.

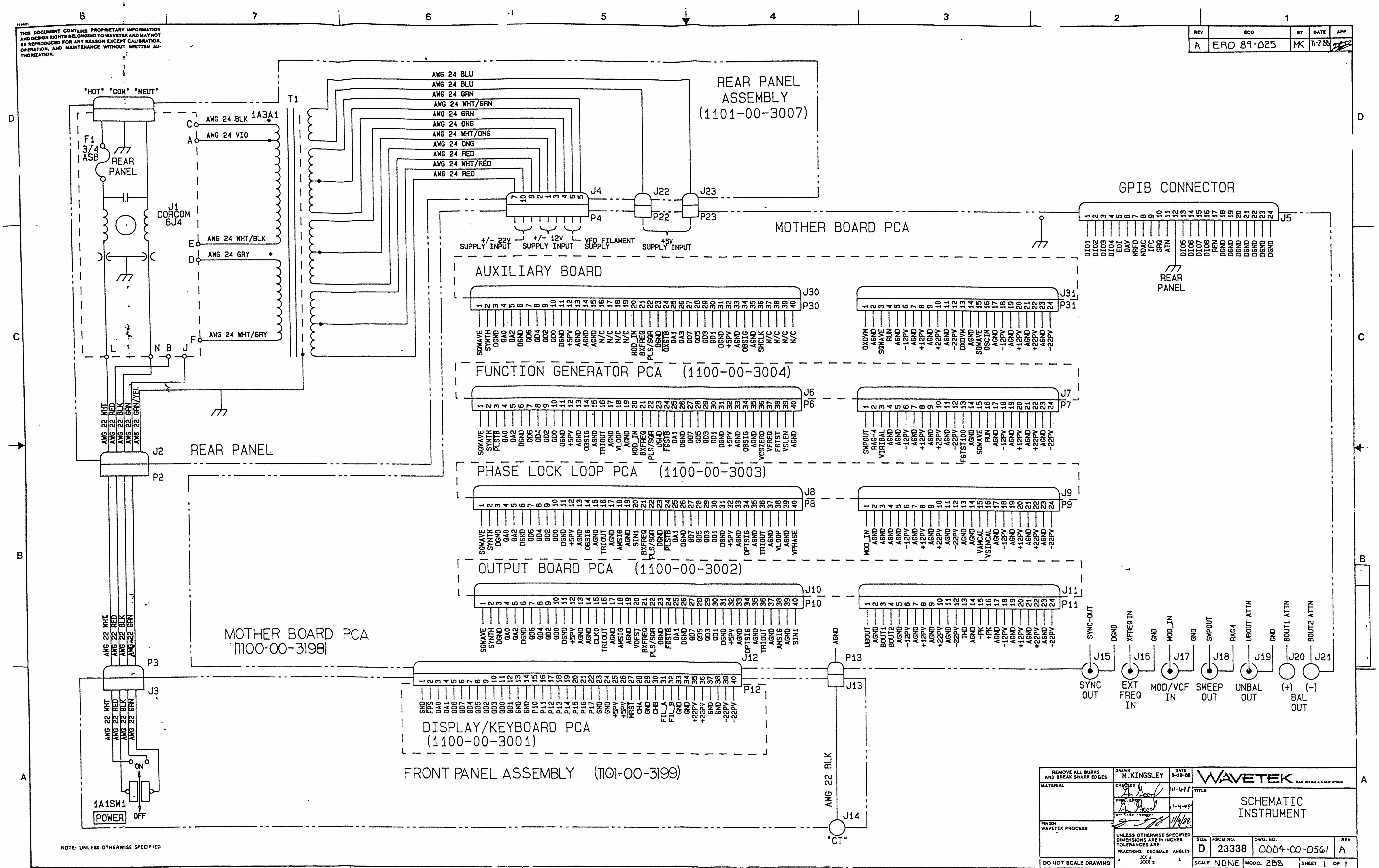
1 3/4 A SLOW BLOW FUSE IS INSTALLED IN REAR PANEL FOR 100V/120V APPLICATION. 3/8A SLOW BLOW FUSE IS SUPPLIED WITH UNIT FOR 220V/240V APPLICATION.

NOTES: UNLESS OTHERWISE SPECIFIED. SEE SEPARATE PARTS LIST.

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN CHERMACK	DATE 2-5-88	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED M. Kingsly	11-4-88	TITLE ASSEMBLY, CHASSIS
	PROJ. ENGR.	11-4-88	
FINISH WAVETEK PROCESS	RELEASE APPROV.	11/4/88	
	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±		SIZE D · FSCM NO. 23338 · DWG. NO. 0002-00-0561 · REV A
DO NOT SCALE DRAWING			SCALE NONE · MODEL 288 · SHEET 1 OF 1

0002-00-0510 | A | B


THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION AND DESIGN RIGHTS BELONGING TO WAVETEK AND MAY NOT BE REPRODUCED FOR ANY REASON EXCEPT CALIBRATION, OPERATION, AND MAINTENANCE WITHOUT WRITTEN AUTHORIZATION.
REAR PANEL ASSEMBLY (1101-00-3007)
GPIB CONNECTOR
MOTHER BOARD PCA
AUXILIARY BOARD
FUNCTION GENERATOR PCA (1100-00-3004)
PHASE LOCK LOOP PCA (1100-00-3003)
OUTPUT BOARD PCA (1100-00-3002)
MOTHER BOARD PCA (1100-00-3198)
DISPLAY/KEYBOARD PCA (1100-00-3001)
FRONT PANEL ASSEMBLY (1101-00-3199)
REAR PANEL
J1 CORCOM 6J4
F1 3/4 ASB
1A1SW1 POWER
SYNC OUT
EXT FREQ IN
MOD/VCF IN
SWEEP OUT
UNBAL OUT
BAL OUT
NOTE: UNLESS OTHERWISE SPECIFIED
REV A ERO 89-025 MK
WAVETEK SAN DIEGO • CALIFORNIA
DRAWN M. KINGSLEY
TITLE SCHEMATIC INSTRUMENT
SIZE D FSCM NO. 23338 DWG. NO. 0004-00-0561 REV A
SCALE NONE MODEL 288 SHEET 1 OF 1
DO NOT SCALE DRAWING