WAVETEK

OPERATION &
MAINTENANCE MANUAL

Model 98
1 MHz Audio Frequency Generator

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1 MHz Audio Frequency Generator

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Manual Revision C, 2/93
Manual Part Number 1006-00-0667
Instrument Part Number 1000-00-0667

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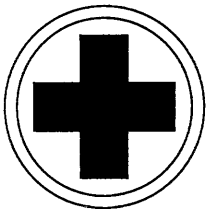
SAFETY FIRST



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

The commercial 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 and replaced with a 1F capacitor to maintain short term RAM backup.

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.

⚠ This symbol on the front panel indicates that this output terminal is a floating output terminal. It is not directly connected to safety ground nor does it have protection devices preventing the user from floating this output to dangerous voltage levels. Use extreem caution when connecting this output to devices not operating at SELV potentials.

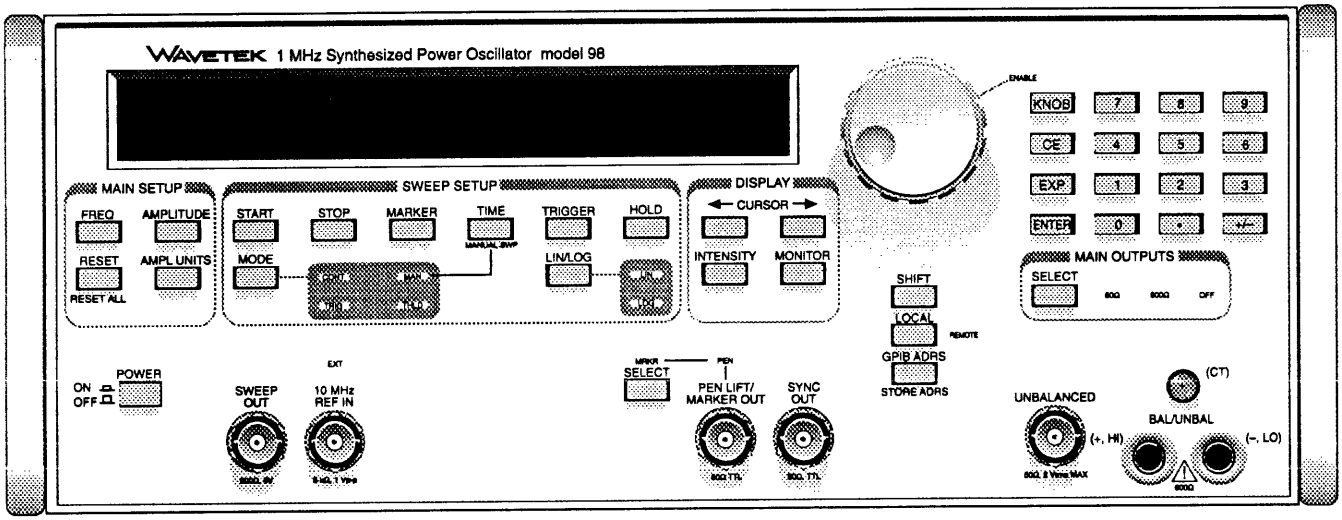


Figure 1-1. Model 98 1 MHz Synthesized Power Oscillator

SECTION 1
GENERAL

1.1 INTRODUCTION

The Model 98 1 MHz Synthesized Power Oscillator is a precision source of low distortion and frequency accurate sine waves for use in the installation and maintenance of audio test equipment and other general purpose electronic equipment.

1.1.1 Equipment Description

- Low distortion (<0.02% THD typical) sine wave.
- Up to 10 Vrms 600Ω balanced or 5Vrms 50Ω unbalanced.
- 1 μHz to 1.1 MHz frequency range.
- Programmed interface for remote operation.
- 8 digits of frequency resolution.
- Versatile Sweep Modes.
- Simplified user interface.
- High reliability and low Maintenance.

1.1.2 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
VFD	Vacuum Fluorescent Display

1.2 OPTIONS

001: Handles and Rack Adapter – This option consists of a pair of handles (standard on some units) and rack adapters. Rack adapters allow mounting of the unit in a standard 19 inch equipment cabnet.

1.3 SPECIFICATIONS

1.3.1 Waveforms

Low distortion sine wave at the 50Ω unbalanced or 600Ω balanced main output. TTL level signal in phase with the sine at the Sync Output.

1.3.2 Operational Modes

Operates in continuous (cw) and frequency sweep modes. In continuous mode the waveforms are generated continuously and supplied to the selected output. Waveforms are output at programmed frequency and amplitude. In the sweep modes (see the next paragraph) the instantaneous frequency is linearily or logrithmically programmed between start and stop frequencies at the selected sweep rate.

1.3.2.1 Frequency Sweep Modes

The SWEEP OUT and the PEN LIFT/MARKER OUT BNCs are active with a Sweep Mode selected, and inactive at other times. The selected output, 50Ω UNBALANCED or 600Ω BAL/UNBAL, and the SYNC OUT waveforms are swept.

Sweep Modes:

Off (O or 0):

No sweep mode selected. Generator operates in continuous (cw) mode with constant frequency.

Continuous (C or 1):

Continuously sweeps from programmed start frequency to programmed stop frequency, immediately resets to start frequency and begins a new sweep. Repeats continuously at the specified sweep time.

Continuous with Reverse (CR or 2):

Continuously sweeps from start frequency to stop frequency, and then sweeps back to start frequency. Repeats continuously at the specified sweep time.

Triggered (T or 3):

Programmed start frequency is generated continuously until the Model 98 receives a trigger (front panel TRIGGER key or GPIB TRigger sweep command), which will initiate one sweep to the programmed stop frequency then an immediate reset to the start frequency.

Triggered with Reverse (TR or 4):

Programmed start frequency is generated continuously until a trigger signal is received, which will initiate one sweep from the start frequency to the stop frequency. The generator then immedately sweeps back to the start frequency and holds for another trigger.

Triggered Hold (THLD or 5):

Programmed start frequency is generated continuously until a trigger signal is received, which will initiate one sweep from the start frequency to the stop frequency. The generator holds at the stop frequency until receipt of a second trigger which sets it immediately back to the start frequency, where it holds for another trigger cycle.

Triggered Hold with Reverse (THLDR or 6):

Programmed start frequency is generated continuously until a trigger signal is received, which will initiate one sweep from the start frequency to the stop frequency. The generator holds at the stop frequency until receipt of a second trigger which sweeps it back to the start frequency, where it holds for another trigger cycle.

Manual (M or 7):

Output frequency is set between start and stop frequencies by programming the Sweep Index (SI) from 0000 to 1023. Frequency at each point is displayed and may be queried. With the aid of the SWEEP OUT voltage, used for precisely setting up sweep characteristics.

Start/Stop Frequencies (STA/STO):
Independently programmable sweep limits, may be set from 1 Hz to 1.1 MHz with 5 digit resolution (accuracy is determined by cw frequency accuracy). When Stop Frequency is set higher than Start Frequency, the generator sweeps upward from start to stop. When Start Frequency is set higher than Stop Frequency, the generator sweeps downward from start to stop.

Start and stop settings may be alternately defined by center (CN) and span (SP) settings. Center must be greater than 1/2 of the span. Center frequency can be set from 1 Hz to 1 MHz with 4 digit resolution. Span can be set from -1 MHz to +1 MHz with 4 digit resolution. A positive span results in upward sweeping, a negative span results in downward sweeping.

Hold/Resume (HLD/RSM):
Front panel key or GPIB command stops the sweep at present value for display of frequency. Resumes sweeping from this point.

Sweep Function (SF):
Frequency sweep characteristic (spacing) programmable as either linear or logarithmic (LIN/LOG).

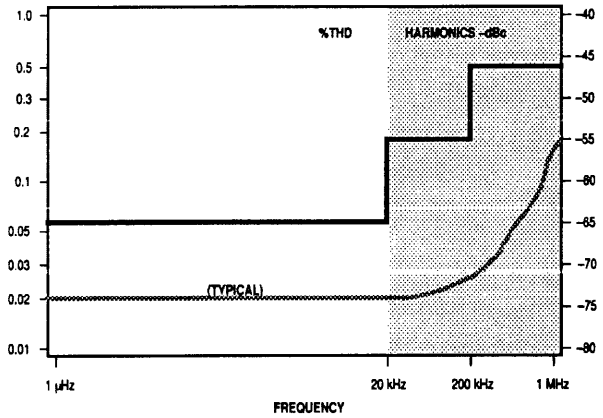
Sweep Time (ST):
The duration of one swept transition between start/stop frequencies, programmed from 30 ms to 1000 s.

Flyback Time:
1 ms.

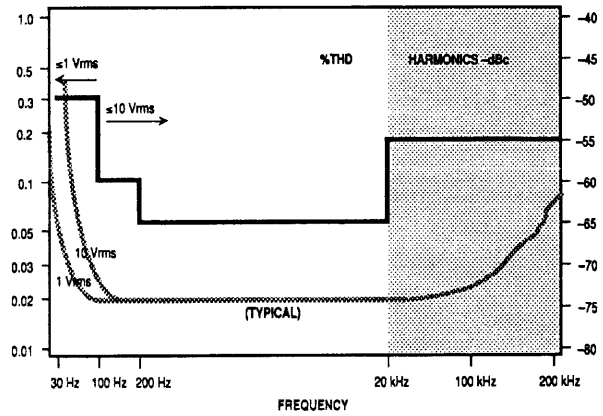
Resolution:
1 point/ms, 1024 points per sweep maximum.

1.3.3 Sine Wave Purity

50Ω Unbalanced output, 50 mVrms to 5 Vrms:



600Ω Bal/Unbal output, 100 mVrms to 10 Vrms:



1.3.4 Frequency

Range:

50Ω Output: 1 μHz to 1.1 MHz.
600Ω Output: 30 Hz to 200 kHz.

Resolution: 8 digits limited by 1 μHz.

Accuracy:

±30 ppm (limited by 20 nHz)

Stability

Internal reference:
±25 ppm accuracy specification applies to all operating conditions.
External reference:
Accuracy and stability determined by external source.

1.3.5 Amplitude

50Ω Unbalanced Output:

Range: 15 mVpp to 15 Vpp into 50Ω (30 mVpp to 30 Vpp open circuit).
Resolution: 4 digits (Vpp).
Accuracy (1 kHz): ±(1% of setting + 1 mVpp).
Flatness (relative to 1 kHz):
≤100 kHz: ±0.3 dB
≤1 MHz ±1.0 dB
≤1.1 MHz ±1.5 dB

600Ω Bal/Unbal Output:

Range: 30 mVpp to 30 Vpp into 600Ω (60 mVpp to 60 Vpp open circuit).
Resolution: 4 digits (Vpp).
Accuracy (1 kHz): ±(5% of setting + 5 mVpp).
Flatness (relative to 1 kHz):
≤100 kHz: ±1 dB
≤200 kHz +1, –4 dB

NOTE

When using the 600Ω output as an Unbalanced (single-ended) output, connect signal common to the "LO" terminal and use the "HI" terminal as the 600Ω Unbalanced output.

1.3.6 Outputs

Sync Output

TTL compatible square output at programmed frequency and in phase with the sine function at the main output.

Frequency: 1 μHz to 1.1 MHz.
Amplitude: TTL high, >2.0 V into ≥50Ω; TTL low <0.4 V into ≥50Ω.
Rise/Fall time: < 50 ns.
Protection: Short circuit to ground

50Ω Unbalanced Output

Main output, selectable as source of sine waveform at selected frequency and amplitude. Not concurrently available with 600Ω Bal/Unbal Output.

Frequency: 1 μHz to 1.1 MHz
Amplitude: 15 mVpp to 15 Vpp (5.3 mVrms to 5.3 Vrms) into 50Ω load.
Impedance: 50Ω ± 1%
Protection: Momentarily protected to ±15Vdc.

600Ω Balanced/Unbalanced Output

Main output, selectable as source of sine waveform at selected frequency and amplitude. Transformer-coupled output terminals, not referenced to signal common (present on BNC input/output connectors). Not concurrently available with 50Ω Unbalanced Output.

Frequency: 30 Hz to 200 kHz
Amplitude: 15 mVpp to 30 Vpp (10.6 mVrms to 10.6 Vrms) into 600Ω load.
Impedance: 600Ω ± 1% (1 kHz, bal/unbal)
Connectors: "banana" jack for "+" and "–" terminals; universal binding post for "C.T."
Isolation: Protected to ±500 Vdc.

Sweep Output:

Linear 0 V to +5 V (open circuit) ramp signal occurring during a frequency sweep. Instantaneous value of ramp voltage indicates percent time completion of frequency sweep.

Ramp Period: 30 ms to 1000 s.
Amplitude: 0 V ± 25 mV at start of sweep, increasing to +5 V ± 250 mV at sweep stop.
Source Impedance: 600 Ω.
Protection: Output protected to ±15 V inputs.

Pen Lift/Marker Output:

TTL levels output, selectable as a Pen Lift or as a Frequency Marker. Pen lift is true (high) during the 1 ms retrace (flyback) period for use as a recorder pen lift or X-Y display retrace blanking input. The Frequency Marker is set to any 5 digit frequency value. With Marker selected, the Pen Lift/Marker output goes high for 1 ms as the sweep frequency passes through the set Marker Frequency (or at the bottom or top of the sweep range if the Marker Frequency is outside the sweep frequency).

Frequency:	30 ms to 1000s (once per sweep)
Amplitude:	TTL high, >2.0 V into ≥50Ω; TTL low <0.4 V into ≥50Ω.
Rise/Fall time:	< 50 ns.
Protection:	Short circuit to ground

1.3.7 Input

External Reference In

Accepts sine wave or TTL compatible square external reference signal, ac coupled input. Automatically detects and switches to a valid external reference of 10 MHz ±5%. Programmed frequencies are correct with a 10 MHz external reference.

Minimum input:	1 Vpp
Maximum input:	30 Vpp
Impedance:	> 1 kΩ
Protection:	± 50 Vdc

1.3.8 Display

16 digit Vacuum Florescent Display (VFD) with 14 segment alpha-numeric characters and 11 mm character height. Display brightness is adjustable with front panel INTENSITY key. All selectable parameters display the parameter name, the numeric value and the unit. The display is also used for GPIB messages and various utilities.

1.3.9 GPIB Programming

IEEE-488.1 -1978 GPIB interface is provided with the standard unit.

Address: 0-30 selectable, EEPROM backed up.
Subsets: SH1, AH1, SR1, RL1, PP0, DC1, DT0, C0, T6, L4, TE0,LE0 and E1.

1.3.10 General

MIL-T-28800 Class 5 qualified.

Temperature Range: 0 to +50°C operating, - 40 to +71°C for storage.

Warm-up Time: 20 minutes for specified operation at 0 to +50°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; 40g, 11 ms half-sine.

Electromagnetic Compatibility: MIL-STD-461 emission and susceptibility requirements of CE02, CE04, CS02, CS06, RE02, RE02.1 and RS03.

Safety: Conforms to Type Testing requirements of IEC-348.

Reliability: MTBF >5000 hours.

Calibration Interval: No periodic requirement.

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 6.8 kg (15 lb) net; 11.4 kg (25lb) shipping.

Power: 90 to 108, 108 to 126, 198 to 231, or 216 to 252 Vrms; 48 to 440 Hz; 1 phase; < 30 VA.

1.4 EQUIPMENT SUPPLIED

The Model 98 is supplied with a shielded power cord and manual.

1.5 EQUIPMENT REQUIRED BUT NOT SUPPLIED

All items required for the Model 98 are supplied.

SECTION 2
PREPARATION/INSTALLATION

2.1 RECEIVING AND INSPECTION

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 information required to prepare, turn-on, and checkout the Model 98 Signal Generator in the local (front panel) mode. Information required for remote (GPIB) 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 98 Signal Generator is equipped with a three-wire power cable. When connected to a grounded AC power receptacle, this cable grounds the chassis. Do not use extension cords or AC adapters without a ground.

1. Verify that the power switch (1) is set to OFF.
2. Verify the the voltage selection card (23) on the rear panel matches the line voltage used to operate the unit. Connect the power cable (24) to ac power connector (25) on rear panel.

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

Input Voltage	Voltage Selection Card	Fuse
90 to 108	100	1/2 amp, Slo-Blo
108 to 126	120	1/2 amp, Slo-Blo
198 to 231	220	1/4 amp, Slo-Blo
216 to 252	240	1/4 amp, Slo-Blo

WARNING

The entry module (25) has a sliding window which requires that the power cord (24) be removed before the fuse or selector card (23) may be accessed.

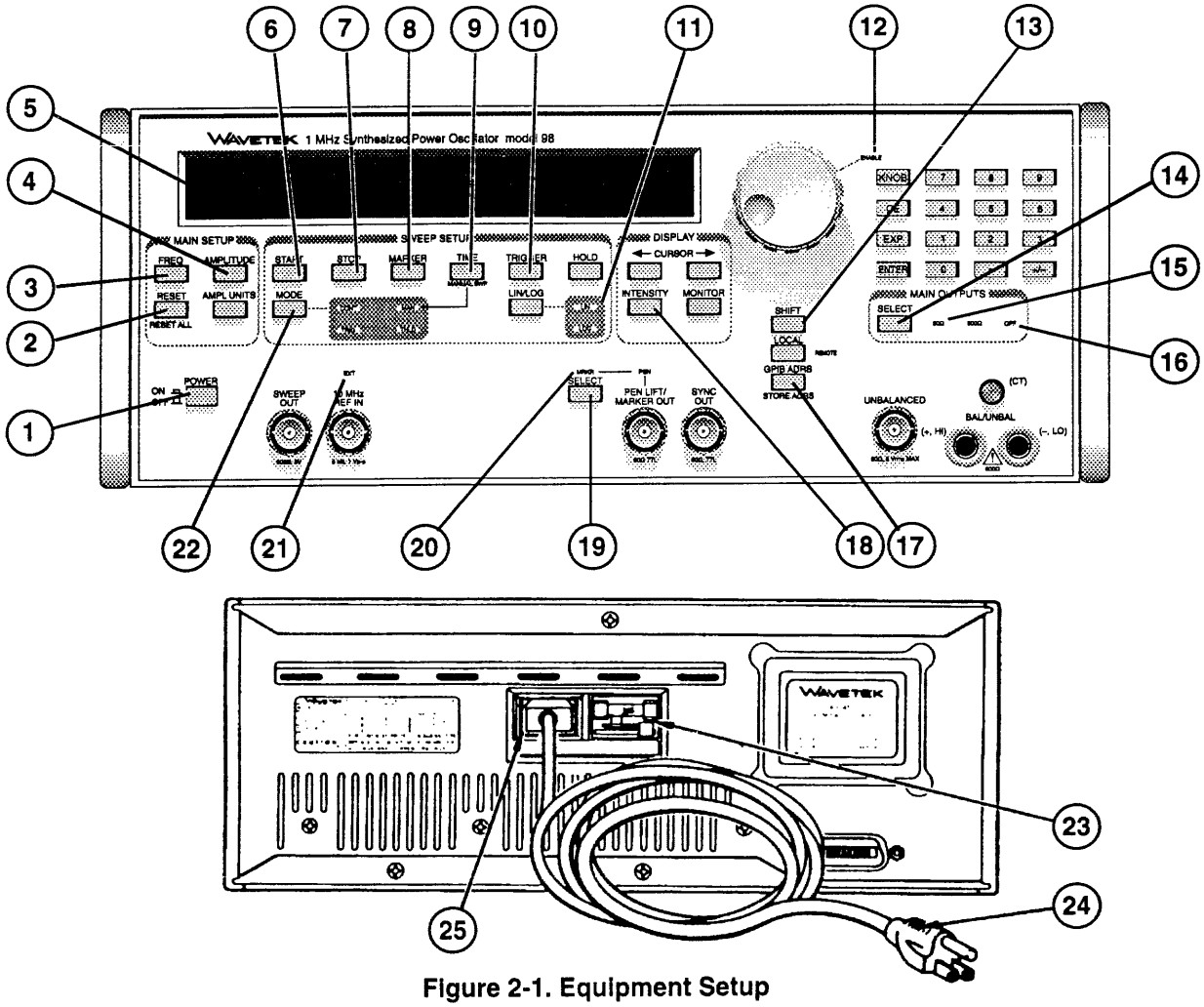


Figure 2-1. Equipment Setup

2.3.3 Turn-on and Initial Checkout Procedure

1. Verify that only the power cable (24) is connected to the Model 98. All other cables should be disconnected.
2. Set the Power On/Off switch (1) from Off to On. Verify that the Model 98 display (5) indicates "WAVETEK MODEL 98".

NOTE

If the turn-on message does not appear in the display as indicated above, and it is not simply replaced with a programming eror message from the last time the unit was operated, verify the power connections are made correctly per the previous paragraph. If the problem persists, consult the final step of this procedure.

3. Press the SHIFT (13) and then the RESET key (2). Verify that the following front panel conditions exist:

DISPLAY (5):	-- RESET ALL --
outputs OFF (16):	indicator illuminated
knob ENABLE (12):	indicator illuminated
sweep LIN (11):	indicator illuminated
select MRKR (20)	indicator illuminated
(All others):	Off

Press each of the following keys and verify RESET ALL parameter values as indicated:

FREQUENCY (3):	FR 1 KHZ
AMPLITUDE (4):	One of the following:
	AMPL 1 VRMS
	AMPL 2.828 VPP
	AMPL 1.414 VPK
	AMPL 13 DBM

START (6)	START 1 KHZ
STOP (7)	STOP 10 KHZ
MARKER (8)	MRKR 5 KHZ
TIME (9)	SWP TM 1 S
INTENSITY (18):	INTENSITY 25
GPIB ADRS (17):	GPIB ADRS 00 to 30
MODE (22)	SWP OFF

4. Allow the Model 98 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 98 requires a 20 minute warm-up period for specified operation.

5. Press the MAIN OUTPUTS SELECT key (14) once and verify that the 50Ω indicator is on and the display (5) reads OUTPUT ON (50). Connect the 50Ω UNBALANCED output to the oscilloscope listed in Table 2-2 using a 50Ω BNC cable and termination. Observe two cycles of sine waveform when the oscilloscope is set for 0.2 msec/div horizontal and 1 V/div vertical. Verify amplitude is approximately 3 divisions peak to peak (1 Vrms).
6. Remove the cable at the model 98's 50Ω Output and connect it to the SYNC OUT connector. Observe two cycles of square wave on the oscilloscope.
7. Move the cable from the oscilloscope to the counter/timer listed in Table 2-2. Verify that the SYNC OUT frequency is 1.000 kHz.
8. Connect another cable from the counter/timer Ref Out (10 MHz) to the Model 98's 10 MHz Ref In connector. Verify that the external reference EXT (21) indicator illuminates, and that the counter/timer continues to display 1.000 kHz.
9. Remove the cables from the counter/timer. Reconnect the UNBALANCED output to the oscilloscope and verify the 1 kHz sine. Press the SWEEP SETUP MODE key (22) twice to advance to the first sweep mode, SWP CONT-RST. The CONT indicator illuminates, and the scope should show a continuously sweeping waveform. In the RESET ALL settings, the waveform is sweeping upward from the 1 kHz START frequency to the 10 kHz STOP frequency with a 1s swep TIME.
10. Press the MODE key (22) twice more to advance the sweep mode to SWP TRIG-RST. The sweep TRIG indicator should illuminate. The scope should display a 1 kHz fixed frequency sine wave. Press the TRIGGER key to produce one sweep to the STOP frequency and reset to the START frequency. Display should indicate SWEEP TRIGGERED.
11. Connect the SWEEP OUT BNC to the scope, no 50Ω load, 2V/DIV vertical. Observe 0 Vdc. Press the TRIGGER key (10) and observe that the sweep output ramps up to approximately +5V and returns to 0 Vdc.
12. Reset the sweep MODE (22) to SWP CONT-RST and set the sweep TIME (9) to 0.05 s (50 ms). Set the scope horizontal for 5 ms/DIV and adjust the triggering for a stable sweep ramp waveform.
13. Connect the PEN LIFT/MARKER BNC to the other channel of the scope, no termination, 2V/DIV vertical. Use "CHOP" vertical mode to display both traces. Check for accurate marker positioning by setting the START frequency (6) to 1 Hz. Observe a frequency marker pulse approximately 1 ms wide at the center of the 1 Hz to 10 kHz sweep.
14. Press the pen lift/marker SELECT key (19) and observe that the PEN indicator illuminates and the marker switches to a pen lift signal at the scope display. Set the horizontal to 10 ms/DIV and then turn on the X10 magnifier to verify the approximate 1 ms pulse occurs during the ramp flyback or "retrace" time.
15. Set up the equipment per step 5 and verify the two cycles of sine waves on the scope. Set the sweep MODE (22) to SWP CONT-RST, sweep TIME (9) to 1 s, and LIN/LOG to LOG SWEEP. Note the difference in the sweep charactersitic. Note that the CONT, LOG, PEN, ENABLE, and 50Ω indicators are now on (as opposed to the configuration after the RESET ALL). Turn the unit off and wait a few moments. Turn the unit back on. The scope display and the front panel indicators should be the same as when the unit was turned off, except that the display now reads WAVETEK MODEL 98.
16. If all above conditions are correct, the signal generator is ready for operation. If an indication is incorrect, notify your maintenance department or contact Wavetek's Customer Service department (see paragraph 2.1).

2.3.4 Performance Verification

Performance verification tests the operation of every selectable parameter and input/output connector. It also verifies correct operation within each major specification. This verification is performed as desired or at

scheduled maintenance to determine if the unit requires adjustment or further maintenance procedures to meet specifications. 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 2-2 lists the test equipment required to perform the performance verification procedure. Always keep test equipment interconnecting cables as short as possible.

Table 2-2. Required Test Equipment

Test Equipment	Recommended Model/Critical Specification
Counter/Timer	Hewlett Packard 5334A or equivalent. 10 MHz Ref Out, ≥8 digits.
Scope	Tektronix 2465 or equivalent. Not critical.
THD Analyzer	Hewlett Packard 8903B or equivalent. 100 kHz BW.
Digital Voltmeter (DVM)	Fluke 8922A or equivalent. True rms, dBm, relative, 50Ω and 600Ω, ≥600 kHz BW.
Signal Generator (Signal Source)	Wavetek 90 or equivalent. Not critical.
Terminations	50Ω, 0.1%, ≥3W 600Ω, 0.1%, ≥1W
Coax cables	2 BNC to BNC male , 50Ω impedance, 3 ft.
Adapter	Dual "banana" plug to BNC female, 0.75" centers.

Frequency Range, Accuracy, Resolution

1. Reset the Model 98.
2. Connect the Model 98 and test equipment as shown in figure 2-2.
3. Temporarily disconnect the cable at the Model 98 10 MHz REF IN connector. Program FREQUENCY to 1 MHz and check synthesized frequency accuracy for ±25 ppm per the table in recorded data: RECORD.

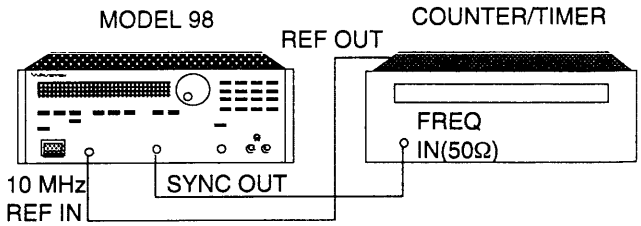


Figure 2-2. Frequency Measurement Setup

4. Reconnect the external reference to the unit. Check that the counter/timer now indicates 1 MHz ±1 count: yes/no: RECORD.

NOTE

Step 3 of this procedure is sufficient to verify frequency synthesizer accuracy. Referencing the Model 98 to the counter/timer's 10 MHz reference will cause all subsequent frequency measurements, which are concerned only with verifying range and resolution, to agree exactly (plus or minus a small counter uncertainty).

5. Program FREQUENCY to the values given in the table and verify that all programmed digits of resolution are generated: yes/no: RECORD.

50Ω Amplitude Range/Accuracy

1. Reset the Model 98.
2. Connect the Model 98 and test equipment as shown in figure 2-3.

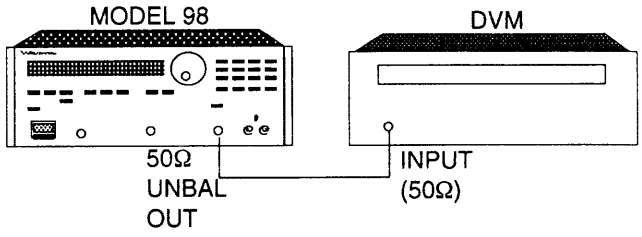


Figure 2-3. 50Ω Amplitude Measurement Setup

3. Verify accurate 50Ω termination per Table 2-2. Set the DVM to measure ac Vrms, auto range, no filter, 50Ω (no buttons pressed). Press Model 98 MAIN

OUTPUTS SELECT button once and verify 50Ω indicator is on. Press the AMPL UNITS button as necessary to display AMPLITUDE parameter value in VRMS and MVRMS. Program AMPLITUDE for 5 Vrms and check amplitude accuracy per the table of recorded data: RECORD.

4. Press the DVM's "AC/AC + DC" button to include the dc component of the signal in the measurement. Subtract the AC measurement value taken from the previous step from the AC + DC value of this step: RECORD.

NOTE

If this verification procedure is being run as scheduled maintenance, check that the measurements taken in the above two steps do not exceed 80% of their specified upper or lower limit. If this value is exceeded, first verify 50Ω termination accuracy is within the value specified in Table 2-2. If the Model 98 requires adjustment, refer to the Adjustment Procedure given in the Maintenance Section of this manual.

5. Release the DVM's "AC/AC + DC" button and program AMPLITUDE to the table values and verify amplitude range and accuracy: RECORD.

50Ω Amplitude Flatness

1. Reset the Model 98.
2. Connect the Model 98 and test equipment as shown in figure 2-3.
3. Verify accurate 50Ω termination per Table 2-2. Set the DVM to measure dBm, auto range, no filter, 50Ω. Press Model 98 MAIN OUTPUTS SELECT button once and verify 50Ω indicator is on. Press the AMPL UNITS button as necessary to display AMPLITUDE parameter value in VRMS and MVRMS. Program AMPLITUDE for 5 Vrms and verify approximately +27 dBm. Press dBm REL button on the DVM and verify 0.00 dB (relative): yes/no: RECORD.
4. Program the model 98's FREQUENCY to 100 kHz and measure amplitude change in dB: RECORD.
5. Program the model 98's FREQUENCY to 600 kHz and measure amplitude change in dB: RECORD.

600Ω Amplitude Range/Accuracy

1. Reset the Model 98.
2. Connect the Model 98 and test equipment as shown in figure 2-4.

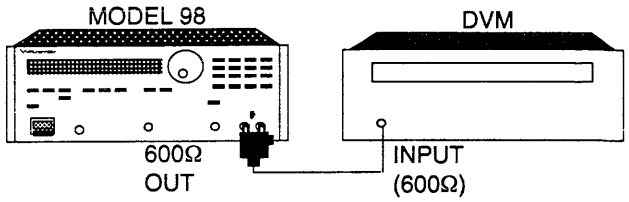


Figure 2-4. 600Ω Amplitude Measurement Setup

3. The connection from the Model 98 600Ω OUTPUT to the DVM can be made unbalanced as follows:
   a) Connect a dual banana to female BNC adapter to the 600Ω banana jack outputs. Be sure to connect the ground side to the "LO" terminal and the signal side to the "HI" terminal.
   b) Connect a BNC cable to the adapter, keeping it a short as test equipment placement will allow (≤3 feet).
   c) Terminate the cable with an accurate 600Ω termination at the DVM input.
4. Verify accurate 600Ω termination per Table 2-2. Set the DVM to measure ac Vrms, auto range, no filter, 600Ω (no buttons pressed). Press Model 98 MAIN OUTPUTS SELECT button twice and verify 600Ω indicator is on. Press the AMPL UNITS button as necessary to display AMPLITUDE parameter value in VRMS and MVRMS. Program AMPLITUDE for 10 Vrms and check amplitude accuracy per the table of recorded data: RECORD.
5. Program AMPLITUDE to the table values and verify amplitude range and accuracy: RECORD.

600Ω Amplitude Flatness

1. Reset the Model 98.
2. Connect the Model 98 and test equipment as shown in figure 2-4, following the instructions in step 3 of the previous test.
3. Verify accurate 600Ω termination per Table 2-2. Set the DVM to measure dBm, auto range, no filter, 600Ω. Press Model 98 MAIN OUTPUTS SELECT button twice and verify 600Ω indicator is on. Press the AMPL UNITS button as necessary to display AMPLITUDE parameter value in VRMS and MVRMS.

Program AMPLITUDE for 10 Vrms and verify approximately +22.2 dBm. Press dBm REL button on the DVM and verify 0.00 dB (relative): yes/no: RECORD.

4. Program the model 98's FREQUENCY to 100 kHz and measure amplitude change in dB: RECORD.
5. Program the model 98's FREQUENCY to 200 kHz and measure amplitude change in dB: RECORD.

Sine Wave Purity

1. Reset the Model 98.
2. Connect the test equipment as shown in figure 2-5.

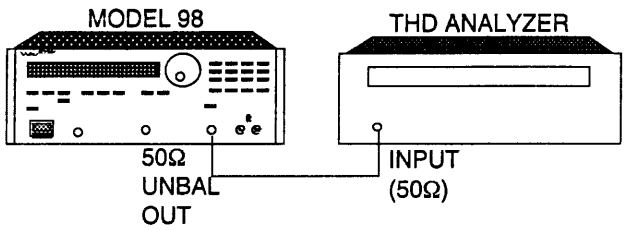


Figure 2-5. THD Measurement

3. Set the THD analyzer to measure distortion in dB. Press the Model 98 MAIN OUTPUT SELECT button once and verify 50Ω indicator is on. Measure distortion in dB: RECORD.
4. Program FREQUENCY to 10 kHz and measure distortion in dB: RECORD.
5. Program FREQUENCY to 100 kHz and measure distortion in dB: RECORD.

Sweep Output Amplitude Accuracy

1. Reset the Model 98. Connect the Model 98 SWEEP OUT BNC to the DVM using the 600Ω load.
2. Set Sweep Mode to Manual and set the sweep index to 0000. Measure sweep out voltage: RECORD.
3. Set the sweep index to 1023 and measure the sweep out voltage: RECORD.

Sync Output

1. Reset the Model 98.
2. Connect the Model 98 and test equipment as shown in figure 2-6.
3. Program the Model 98's FREQUENCY to 600 kHz and observe three cycles of TTL level square wave on the oscilloscope (50 Ω terminated) when the oscilloscope is set for 0.5 μs/div horizontal and 0.5 V/div vertical: yes/no: RECORD.

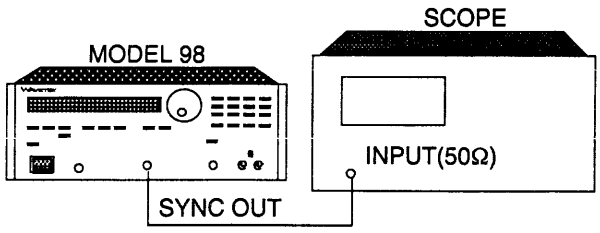


Figure 2-6 SYNC OUT Verification

4. Measure the waveform's upper level, lower level, and transition times: RECORD.

Reference Input

1. Reset the Model 98.
2. Connect the Model 98 and test equipment as shown in figure 2-7.

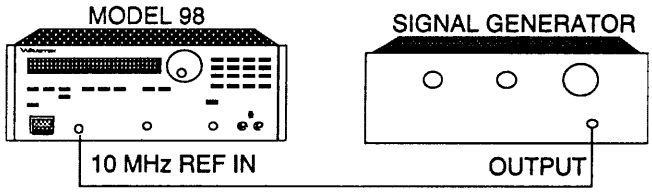


Figure 2-7. Reference Input Verification

3. Program the external generator for a 600 mVp-p, 7 MHz sine wave. Terminate the external signal with 50Ω. Verify that the Model 98's EXTREFERENCE indicator is off: yes/no: RECORD.
4. Program the external generator's frequency upward in increments of 0.1 MHz until the Model 98 EXT REFERENCE indicator illuminates: RECORD lower threshold frequency.
5. Continue to program the external generator's frequency upward in increments of 0.1 MHz until the Model 98 EXT REFERENCE indicator turns off. Then decrement the external generator's frequency back down until the EXT REFERENCE indicator illuminates again: RECORD upper threshold frequency.

Front Panel

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

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 98 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 six 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 F) 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.

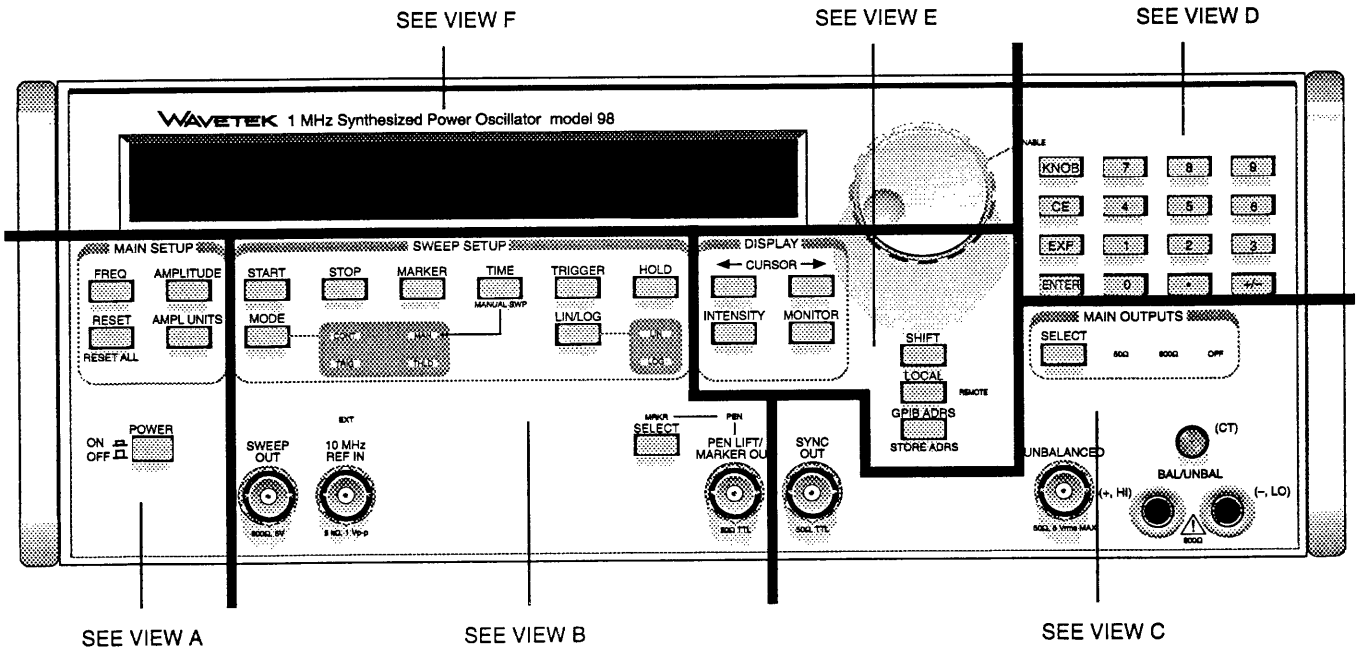
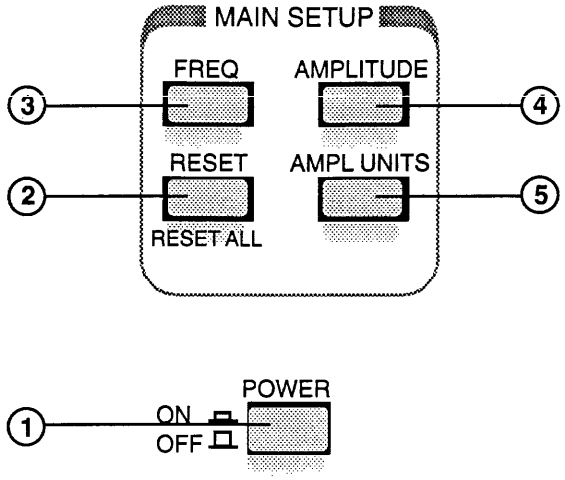


Figure 3-1. Operator's Controls, Indicators and Connectors (front view).



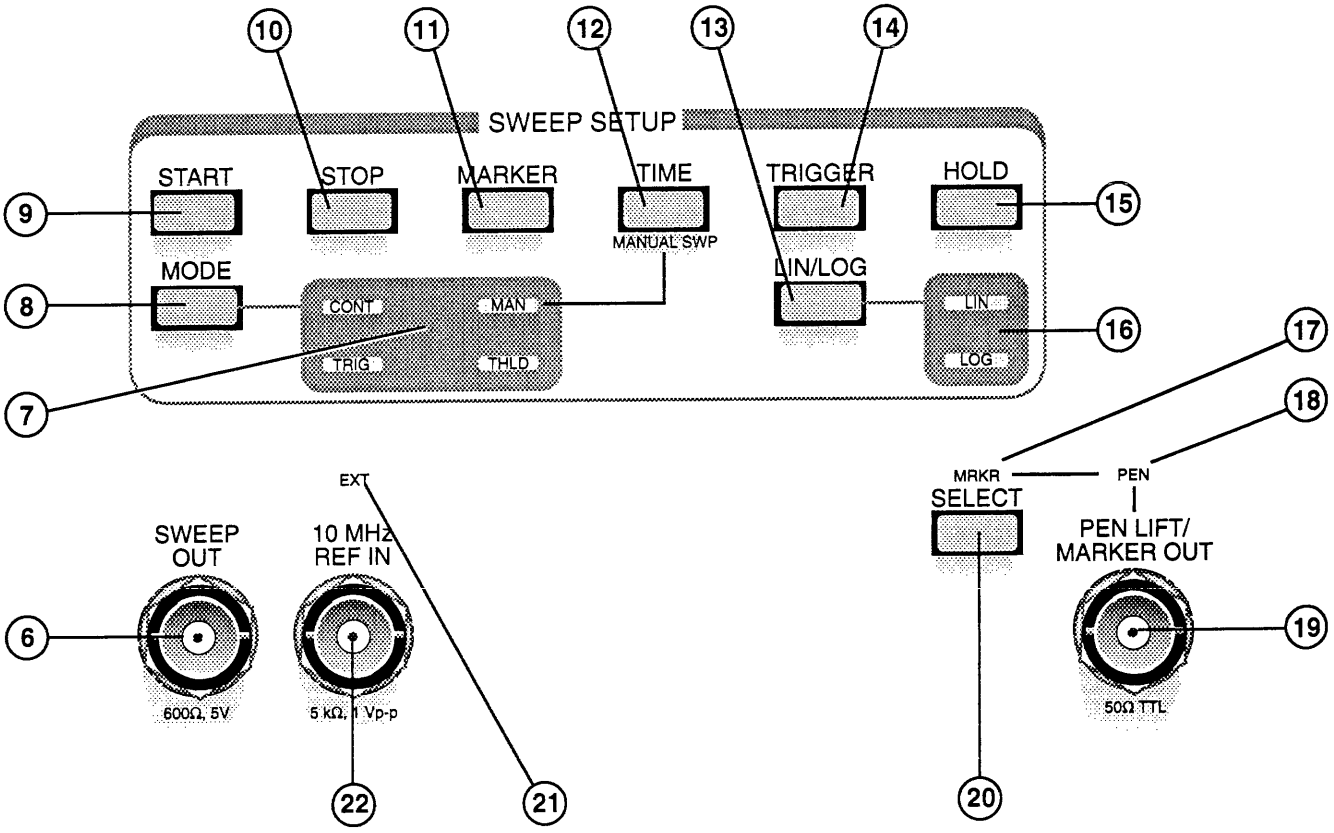
VIEW A

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

Key	Control, Indicator or Connector	Function
1	Power switch	This switch turns the Model 98's power on or off. ON when button pressed in, OFF when button released. At power on, the Model 98 first performs a Self-Test of its digital frequency synthesis and waveform generation circuits. It then presets its setup parameters to the same state as it was when last turned off (except that DISPLAY intensity defaults to 25). *NOTE: For units supplied with capacitor back up of RAM memory in place of the Lithium battery, retention of settings during power off is limited to approximately 5 days. After this time the Model 98 will power up with its default settings (see RESET defaults, paragraph 2.3.3).*
2	Reset key	Used to set the Model 98 parameters to the default condition (para 2.3.3). The GPIB address and the Amplitude Units preference remains unchanged. Press SHIFT and then RESET to reset the entire front panel setup (RESET ALL). Press RESET to send only the currently selected parameter to its default value.
3	Frequency key	Used to display and enter output frequency. Displayed frequency units in µHz, mHz, Hz, kHz and MHz. To enter a new value, press key and observe current value in display. Use the Cursor keys and control Knob or the Numeric and Enter keys to enter a new value in Hz. Range is from 1 µHz to 1 MHz. Resolution is 8 digits (limited by 1 µHz). Defaults to 1 kHz. **Restrictions:** 600Ω BAL/UNBAL output is restricted to 30 Hz to 200 kHz.

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

Key	Control, Indicator or Connector	Function
4	Amplitude key	Used to display and enter output amplitude. Displayed units in Vpp, Vpk, Vrms, or dBm. To enter a new value, press key and observe current value in display. Use Cursor keys and control Knob or Numeric and Enter keys to enter a new value. All units reflect new value. Range is from 15 mVp-p to 30.00 Vpp, 7.5 mVp to 15 Vp, 5.3 mVrms to 10.6 Vrms, or –37.3 dBm to +27.5 dBm. Resolution is 4 digits. Defaults to 1 Vrms. **Restrictions**: Maximum amplitude value for the 50Ω UNBALANCED output is 15.00 Vp-p, 7.5 Vp, 5.3 Vrms, or +27.5 dBm.
5	Amplitude units key	Used to change the displayed unit of the AMPLITUDE parameter. Each press of the AMPL UNITS key advances the selected unit from Vrms to dBm (referenced to selected output impedance) to Vpk to Vpp. Unchanged by a RESET or by cycling the power (see note under item 1).



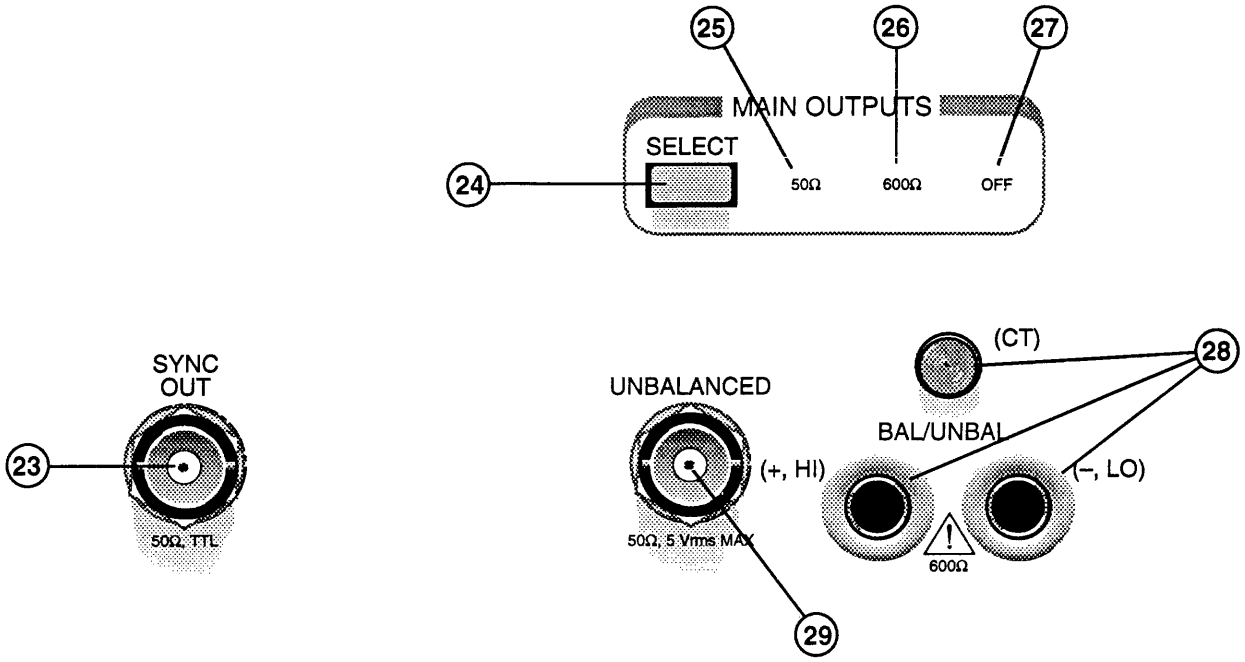
VIEW B

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

Key	Control, Indicator or Connector	Function
6	Sweep Out connector	BNC female connector with 600Ω output impedance, supplies a linear 0 V to +5V (open circuit) proportional sweep voltage when Sweep Mode is enabled.
7	Sweep mode indicators	Four LED indicators used to indicate present Sweep Mode (8) selection. When sweep is *Off*, no indicator is on. When sweep is *Continuous* or *Continuous with Reverse*, the CONT indicator is lit. When sweep is *Triggered* or *Triggered with Reverse*, the TRIG indicator is lit. When sweep is *Triggered Hold* or *Triggered Hold with Reverse*, the THLD indicator is lit. When sweep is *Manual*, the MAN indicator is lit. When the MAN indicator is on, the TIME (12) key is reassigned to control MANUAL SWP frequency.
8	Sweep Mode key	Used to set the mode of operation of the Model 98's internal frequency sweep generator. To change the sweep mode, press the key and observe the present mode in the display. Set the desired mode using the MODE key (8) to advance the mode setting once per press, the knob to "scroll" forward or backward through the list of modes, or the numeric keyboard to enter the mode number (0 through 7). Mode indicators (7) also indicate the type of sweep mode selected. An *Off* mode (default mode) disables the sweep generator, selecting continuous (cw) operation.
9	Start frequency key	Used to set the start frequency of a frequency sweep. Use the Cursor keys and control knob or the numeric keys and Enter key to enter a new value in Hz. Can be set to any frequency value from 1 Hz to 1.1 MHz with 5 digits of resolution. Defaults to 1 kHz. **Restrictions:** 600Ω BAL/UNBAL output is restricted to 30 Hz to 200 kHz.
10	Stop frequency key	Used to set the stop frequency of a frequency sweep. Use the Cursor keys and control knob or the numeric keys and Enter key to enter a new value in Hz. Can be set to any frequency value from 1 Hz to 1.1 MHz with 5 digits of resolution. Defaults to 10 kHz. **Restrictions:** 600Ω BAL/UNBAL output is restricted to 30 Hz to 200 kHz.
11	Marker frequency key	Used to set the marker frequency within a frequency sweep. Use the Cursor keys and control knob or the numeric keys and Enter key to enter a new value in Hz. Can be set to any frequency value from 1 Hz to 1.1 MHz (usually between the Start (9) Stop (10) frequencies) with 5 digits of resolution. Controls the position of the Marker Output (19). Defaults to 5 kHz. **Restrictions:** 600Ω BAL/UNBAL output is restricted to 30 Hz to 200 kHz.
12	Sweep Time key	Used to set the repetition rate of a frequency sweep. Use the Cursor keys and control knob or the numeric keys and Enter key to enter a new value in seconds. Can be set to any value from 30 ms to 1000 s with 4 digits (limited by 1 ms) of resolution. Controls the period of the waveform at the Sweep Out (6). Defaults to 1 second. Additionally, if *Manual* Sweep Mode is selected (the MAN indicator (7) is on), this key is used to enable "manual" control of the sweep frequency. When Manual Sweep is enabled, the display shows a four digit value from

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

Key	Control, Indicator or Connector	Function
		0000 to 1023 and a corresponding frequency. The 1024 possible frequency settings are the same frequencies used in a sweep between Start and Stop frequency settings. May be used in conjunction with the Sweep Out (6) to locate a precise frequency of interest in a swept response.
13	Lin/Log key	Used to select between a linear (LIN) or logarithmic (LOG) Sweep Function. Toggles between functions each time the key is pressed. Sweep function indicators (16) display current selection. Sweep Out (6) is linear regardless of setting, LOG effects only the way frequency is programmed between its Start (9) and Stop (10) settings. Defaults to LIN.
14	Sweep Trigger key	Used to manually initiate a single sweep (a frequency change from Start to Stop, or Stop to Start, at a controlled rate) when one of the triggered sweep modes is selected. A triggered mode is selected if the TRIG or THLD indicator (7) is on.
15	Sweep Hold key	Used to manually stop or resume a sweep at an instantaneous frequency. Toggles between Hold and "run". When the Hold key is pressed the first time to stop the sweep, the display goes into the frequency Monitor mode (see 41) and remains there until another key displaying a parameter value is pressed.
16	LIN/LOG indicators	Indicate present sweep function selection using the LIN/LOG key (13). Default setting is Linear.
17	Sweep Marker indicator	When on, indicates that the PEN LIFT/MARKER OUT (19) output is a frequency marker pulse occuring at the same time that the swept frequency passes through the Marker frequency (11) setting. Selected by the SELECT key (20). Default setting is Marker.
18	Sweep Pen Lift indicator	When on, indicates that the PEN LIFT/MARKER OUT (19) output is a pen lift pulse occuring during the retrace time (flyback) of the sweep. Selected by the SELECT key (20). Default setting is Marker.
19	Pen Lift/Marker connector	BNC female connector capable of driving TTL levels into a 50Ω termination. Outputs an approximate 1 ms positive pulse when the sweep resets (retrace or flyback time) if the PEN indicator (18) is on, or when the instantaneous sweep frequency passes through the preset Marker frequency (11) if the MRKR indicator (17) is on.
20	Pen Lift/Marker Select key	Used to toggle the Pen/Lift Marker output (19) between a Pen Lift and a Marker output. PEN and MRKR indicators (17 and 18) indicate current selection. Default setting is Marker.
21	External reference indicator	Indicator comes on automatically when an external signal with the proper characteristics is applied to the 10 MHz REF IN BNC (22). When on, indicates that the Model 98's frequency synthesizer is referenced with the external signal.
22	Reference input connector	BNC female connector with ≥ 1 kΩ input impedance, accepts external signal to reference the Model 98's frequency synthesizer. The external signal is ac coupled and must be 10 MHz ± 500 kHz, ≥ 600 mVp-p.



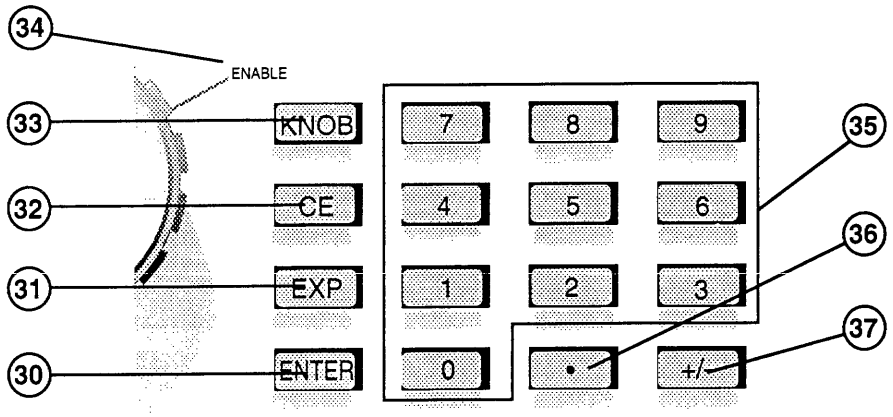
VIEW C

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

Key	Control, Indicator or Connector	Function
23	Sync Out connector	BNC female connector with capacity of driving 50Ω. Provides a 2 Vpp TTL pulse at output waveform frequency. Signal is used when synchronizing the signal generator to any external equipment.
24	Outputs Select key	Used to select desired output impedance (50Ω or 600Ω) and output connector (BNC or banana jack). Also used to turn the output off. Press until desired indicator (25, 26 or 27) lights. Selected output remains selected when power is cycled. Defaults to OFF with the RESET ALL. **Restrictions:** See 50Ω, 600Ω, or OFF indicators.
25	50Ω output indicator	When ON, indicates 50Ω output impedance. Select to match 50Ω load impedance. Provides a signal output with 50Ω impedance at the Unbalanced output BNC connector. To activate, press Function Outputs Select key (24) until 50Ω indicator lights. **Restrictions:** Amplitude will limit at 15 Vp-p when 50Ω is selected.
26	600Ω output indicator	When ON, indicates 600Ω output impedance. Select to match 600Ω load impedance. Provides a signal output with 600Ω impedance at the Balanced/Unbalanced banana jack output connector. To activate, press Function Outputs Select key (24) until 600Ω indicator lights.

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

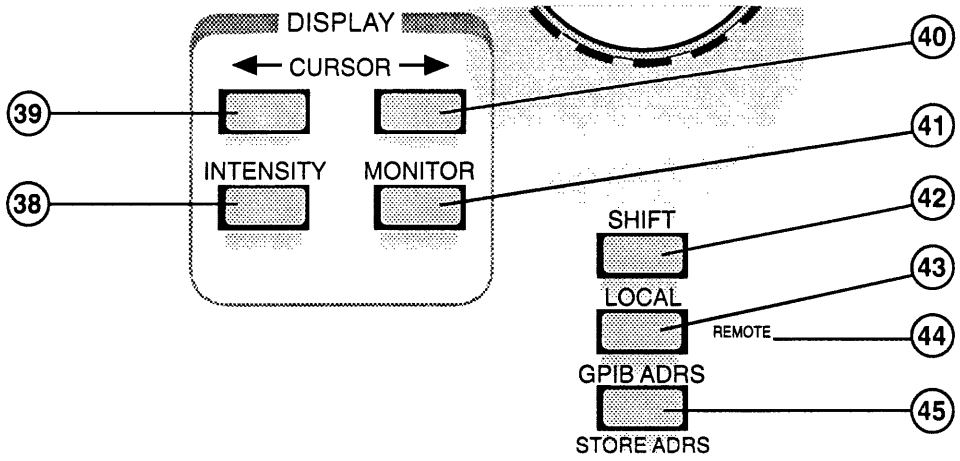
Key	Control, Indicator or Connector	Function
		Restrictions: Frequency will limit to values between 30 Hz and 200 kHz when 600Ω is selected.
27	Outputs off indicator	When on, indicates both outputs are off. 50Ω source impedance is assumed when displaying selected amplitude in dBm. To activate, press Main Outputs Select key (24) until OFF indicator lights.
28	600Ω output jacks	Pair of female banana jacks with 300Ω (one side of a balanced 600Ω) output impedance. Provides a balanced or unbalanced output from 30 Hz to 600 kHz. Selected when 600Ω indicator on. See section 3.2 for output configurations. "CT" terminal is captive screw binding post used as neutral center tap with (–,LO) and (+,HI) jacks when used as a balanced output. When used as an unbalanced output the "CT" is not used, the (–,LO) jack is grounded, and the unbalanced signal is taken from the (+,HI) jack. **Restrictions:** 600Ω output limited to frequencies between 30 Hz and 200 kHz. When selected with frequency outside of that range, the output is selected, frequency is put into the limit, and an error message is generated.
29	Unbalanced connector	BNC female connector with 50Ω output impedance. Provides an unbalanced output from 1 µHz to 1.1 MHz. Selected when 50Ω indicator on. See section 3.2 for output configurations. **Restrictions:** 50Ω output limited to amplitudes less than 15 Vp-p. When selected with frequency outside of that range, the output is selected, frequency is put into the limit, and an error message is generated.



VIEW D

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

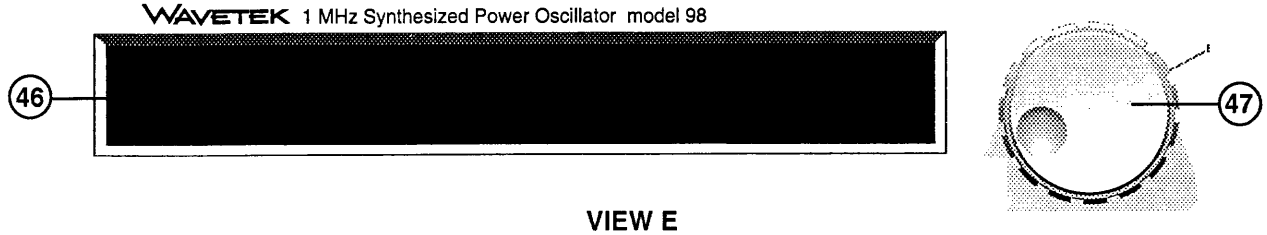
Key	Control, Indicator or Connector	Function
30	Enter key	Used to terminate entries from the Numeric keypad. Pressing after numeric data entry transfers the display contents to MODEL 98 internal circuits. Out of range values are not executed. Values exceeding resolution are rounded or entered to nearest allowable value.
31	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.
32	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. Press twice to restore old value.
33	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.
34	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.
35	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.
36	. (DECIMAL) key	Used to enter a decimal point for numeric data entry.
37	+/- key	Used to enter a positive or negative sign for numeric data entry. Used for mantissa and exponent entry. Blank indicates positive, – indicates negative. Press to change sign.



VIEW E

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

Key	Control, Indicator or Connector	Function
38	Display Intensity 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 25 following a RESET, not changed by cycling power.
39	⇐ 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 and Address keys.
40	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 and Address keys.
41	Sweep Monitor key	Used to continuously display the instantaneous frequency during a sweep. Press to activate. Press any other key to deactivate.
42	Shift key	Used to select an alternate key function. When Shift is pressed, the display reads "SHIFT", and pressing another key will activate that key's secondary function (see (2) and (45)). Cancel the Shift function by pressing the Shift key again while "SHIFT" is displayed.
43	Local key	Used to return the Model 98 to front panel control from the remote (GPIB) mode. Front panel displays "LOCAL" and REMOTE indicator turns off. **Restrictions:** Will not select if Local Lockout (LLO) set by external Controller during remote operation.
44	REMOTE indicator	When ON, indicates that Model 98 is in remote (GPIB) operation using the external Controller. Instrument settings can be queried but not changed.
45	GPIB 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. Press Shift and then GPIB ADRS to set to a new power-up default. **Restrictions:** Will not select if Local Lockout is set by an external Controller during remote operation.



VIEW E

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

Key	Control, Indicator or Connector	Function
46	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.
47	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.

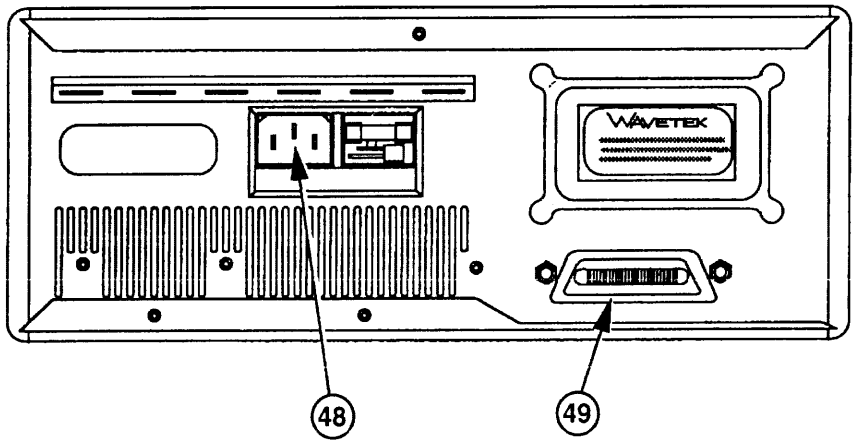


Figure 3-2. Operator's Controls, Indicators, and Connectors (rear view).

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

Key	Control, Indicator, or Connector	Function
48	GPIB connector	Used to connect an external Controller to Model 98 during remote operation. Connector has 24 pins and threaded posts conforming to IEEE-488.1 - 1978.
49	INPUT POWER connector	Used as ac power input connector for Model 98. 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 98 is set to operate. Power input connector accepts female end of power cable (supplied). Protective grounding conductor connects the Model 98 through this connector. Line power fuse is 0.5 amp, 250V for 100/120 Vac and 0.25 amp, 250V for 220/240 Vac operation.

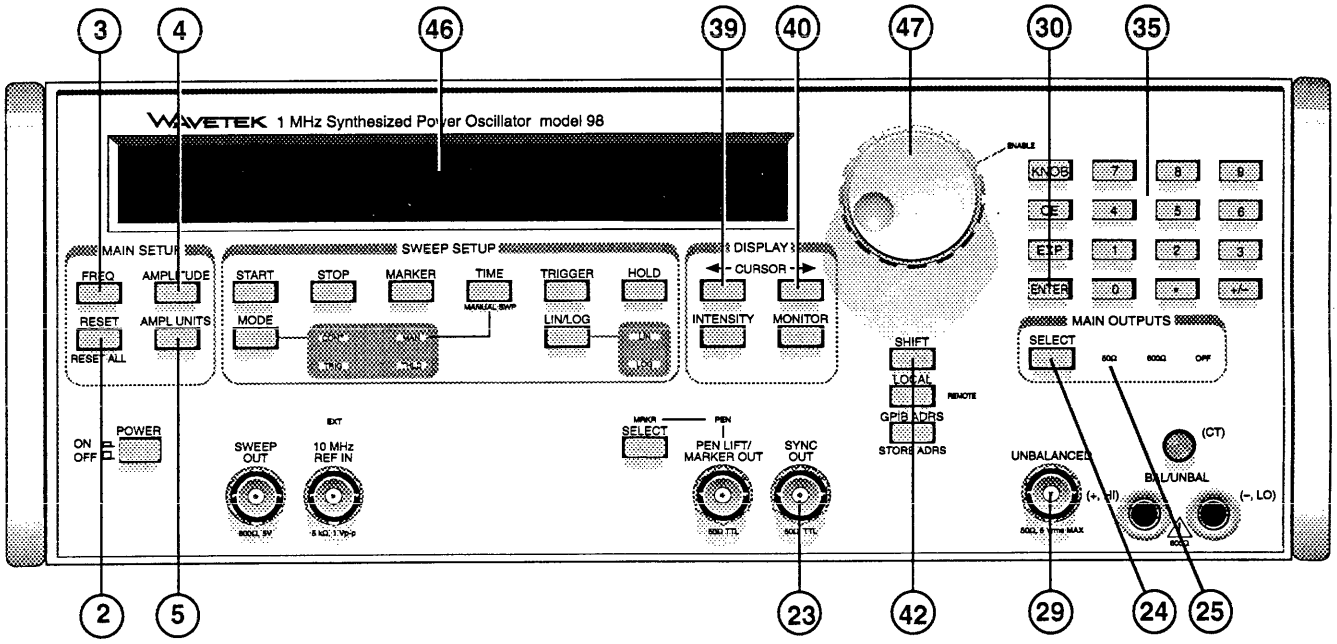


Figure 3-3. 50Ω Operation Control Setup

3.2 NORMAL OPERATION

This section provides the information required to set up and operate the Model 98 synthesized power oscillator. Operation of the signal generator is divided into sections: 50Ω unbalanced operation, 600Ω unbalanced operation, 600Ω balanced operation, operation with an external reference, internal sweep generator operation and GPIB operation.

Operation of the power oscillator 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.

3.2.1 Start Up

Refer to section 2, paragraph 2.3.3, for turn-on proce dures.

3.2.2 50Ω Unbalanced Operation

Perform the following steps (using figure 3-3) to provide a 50Ω sinewave output signal from 1 μHz to 1 MHz at 15 mVpp to 15 Vpp.

1. Press the Shift (42) and then the Reset key (2).
2. Select the 50Ω output by pressing the SELECT key (24) until the 50Ω indicator (25) is on.
3. Press the following keys and then enter desired value. Use the Cursor keys (39 and 40) and control Knob (47), or the Numeric keypad (35) and Enter key (30). Entry will appear in the display (46).
   - Press the Frequency key (3) and enter desired output frequency (Hz).
   - Press the Amplitude Units key (5) until the displayed value of amplitude is in your preferred amplitude unit of Vpp, Vp, Vrms, or dBm.
   - Press the Amplitude key (4) and enter desired output amplitude in Vpp, Vp, Vrms, or dBm.

   NOTE

   When connecting the Model 98 output connector to a load, use a cable with the correct impedance for the output selected.
4. Connect the 50Ω output (29) connector to the load.
5. Connect the SYNC OUT (23) connector as TTL clock signal or equipment synchronization signal.

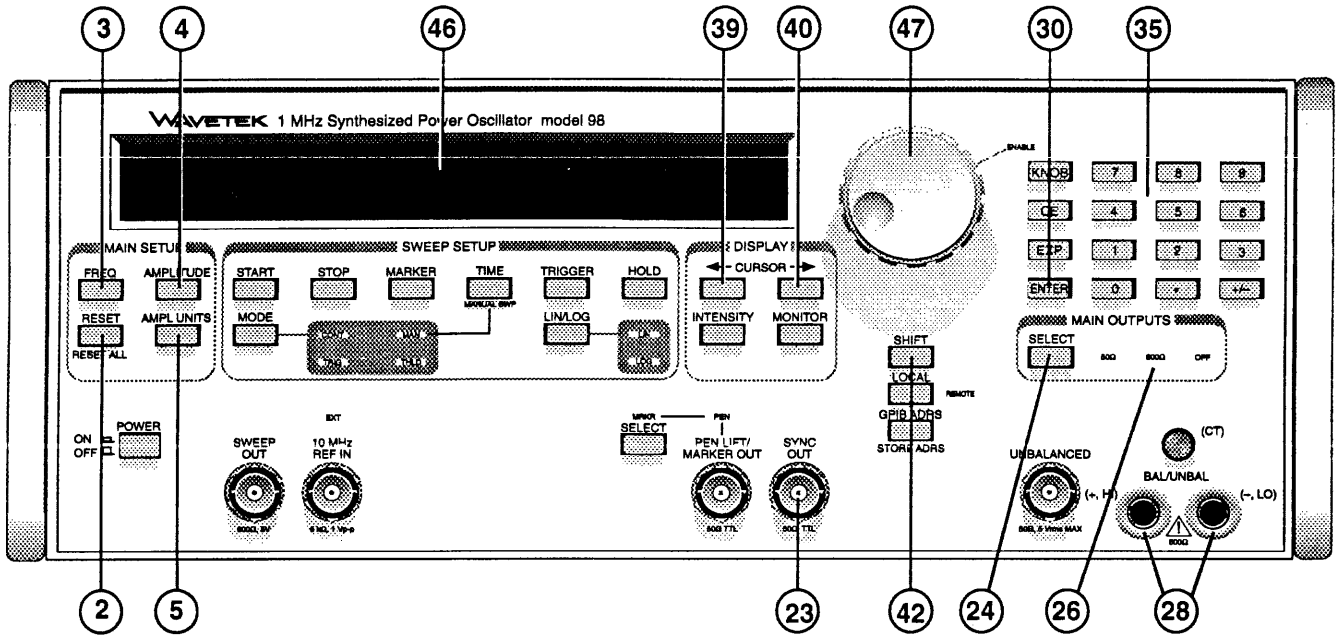


Figure 3-4. 600Ω Unbalanced Operation Control Setup.

3.2.3 600Ω Unbalanced Operation

Perform the following steps (using figure 3-4) to provide a 600Ω unbalanced sinewave output signal from 30 Hz to 200 kHz at from 30 mVpp to 30 Vpp.

1. Press the Shift (42) Reset key (2).
2. Select the 600Ω output by pressing the SELECT key (24) until the 600Ω indicator (26) is on.
3. Press the following keys and then enter desired value. Use the Cursor keys (39 and 40) and control Knob (47), or the Numeric keypad (35) and Enter key (30). Entry will appear in the display (46).
   - Press the Frequency key (3) and enter desired output frequency (Hz).
   - Press the Amplitude Units key (5) until the displayed value of amplitude is in your preferred amplitude unit of Vpp, Vp, Vrms, or dBm.
   - Press the Amplitude key (4) and enter desired output amplitude in Vpp, Vp, Vrms, or dBm.

NOTE

When connecting the Model 98 output connector to a load, use a cable with the correct impedance for the output selected. For 600Ω high impedance outputs, use twisted pair or very short lengths of off-impedance BNC coax cable or loss of amplitude bandwidth will occur.

4. Connect the 600Ω output (28) connector to load. If using BNC coax, use a dual banana to BNC adapter, and verify that the "ground" side of the adapter is connected to the "LO" and not the "HI" side of the 600Ω output or loss of amplitude bandwidth will result. See Figure 3-5 for correct connections.
5. Connect the SYNC OUT (23) connector as TTL clock signal or equipment synchronization signal.

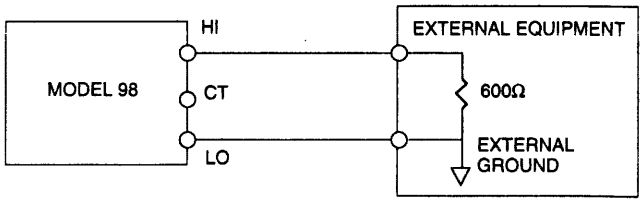


Figure 3-5. 600Ω Unbalanced Connections

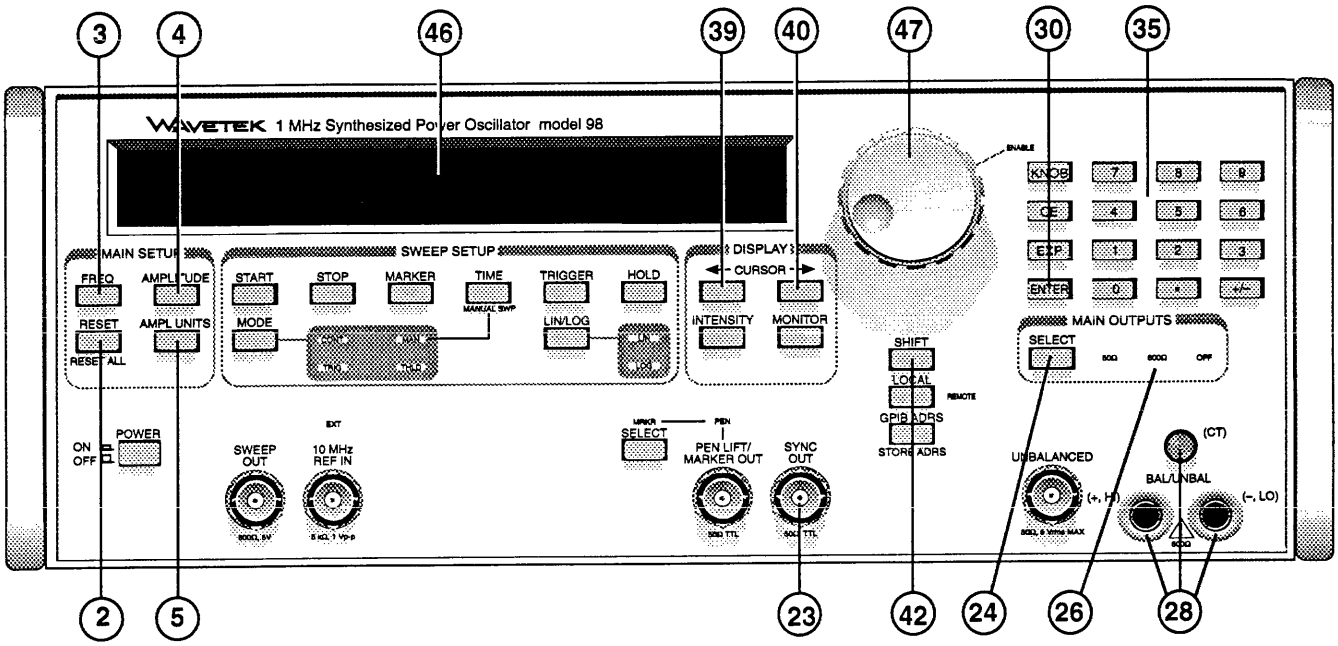


Figure 3-6. 600Ω Balanced Operation Control Setup

3.2.4 600Ω Balanced Operation

Perform the following steps (using figure 3-6) to provide a 600Ω balanced sinewave output signal from 30 Hz to 200 kHz at from 30 mVpp to 30 Vpp.

1. Press the Shift (42) and then the Reset key (2).
2. Select the 600Ω output by pressing the SELECT key (24) until the 600Ω indicator (26) is on.
3. Press the following keys and then enter desired value. Use the Cursor keys (39 and 40) and control Knob (47), or the Numeric keypad (35) and Enter key (30). Entry will appear in the display (46).
   - Press the Frequency key (3) and enter desired output frequency (Hz).
   - Press the Amplitude Units key (5) until the displayed value of amplitude is in your preferred amplitude unit of Vpp, Vp, Vrms, or dBm.
   - Press the Amplitude key (4) and enter desired output amplitude in Vpp, Vp, Vrms, or dBm.

NOTE

When connecting the Model 98 output connector to a load, use a cable with the correct impedance for the output selected. For 600Ω high impedance outputs, use twisted pair or very short lengths of off-impedance BNC coax cable or loss of amplitude bandwidth will occur.

4. Connect the 600Ω output (28) connector to load. Connect the center tap, CT (28) to the signal common of the equipment providing the load to the balanced outputs. See Figure 3-7 for correct connections.
5. Connect the SYNC OUT (23) connector as TTL clock signal or equipment synchronization signal.

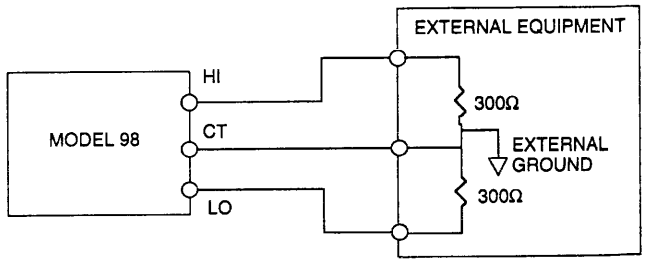


Figure 3-7. 600Ω Balanced Connections

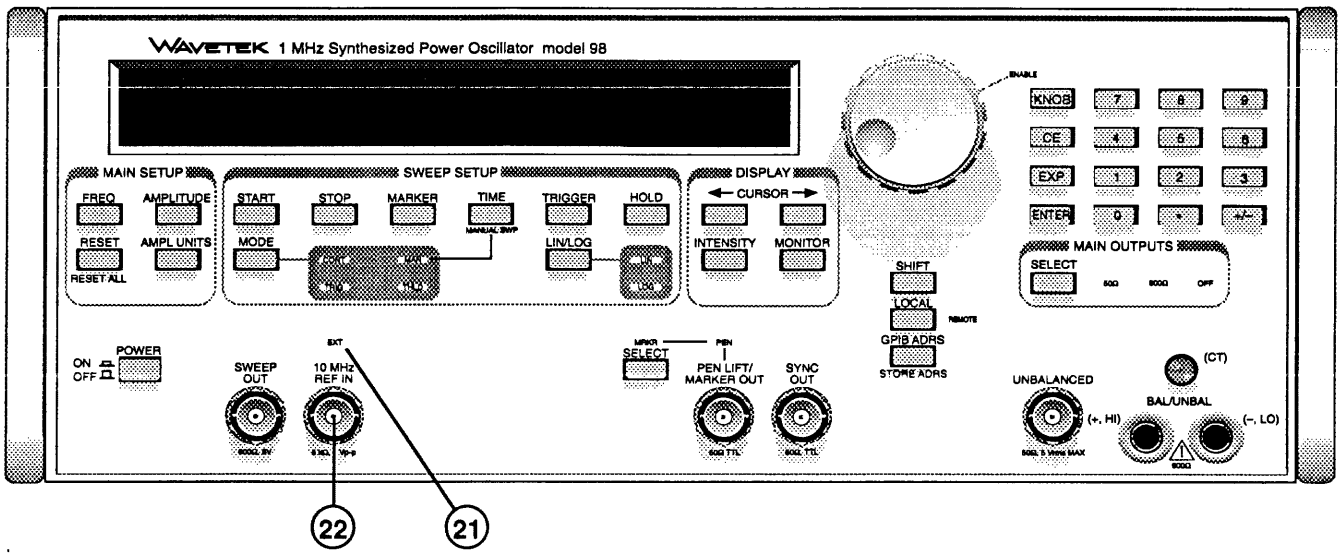


Figure 3-8. External Reference Operation Control Setup

3.2.5 External Reference Operation

Perform the following steps (using figure 3-8) to operate the Model 98 using an external signal to provide a 10 MHz frequency reference to the generator's frequency synthesis circuits.

1. First set up the Model 98 to operate as a source of 50Ω unbalanced (paragraph 3.2.2), 600Ω unbalanced (paragraph 3.2.3), or 600Ω balanced (paragraph 3.2.4) sine wave output.
2. Note that the EXT reference indicator (21) is off.
3. Obtain an appropriate frequency reference with a frequency output of 10 MHz and an amplitude between 600 mVp-p and 30 Vp-p. Typical sources of reference frequencies include WWV Converters and high-end frequency counters.
4. Connect the frequency reference source to the 10 MHz REF IN BNC connector (22) using BNC coax cable and appropriate terminator.
5. Note that the EXT reference indicator (21) is on.
6. Operate the unit normally as if it were using its internal reference.

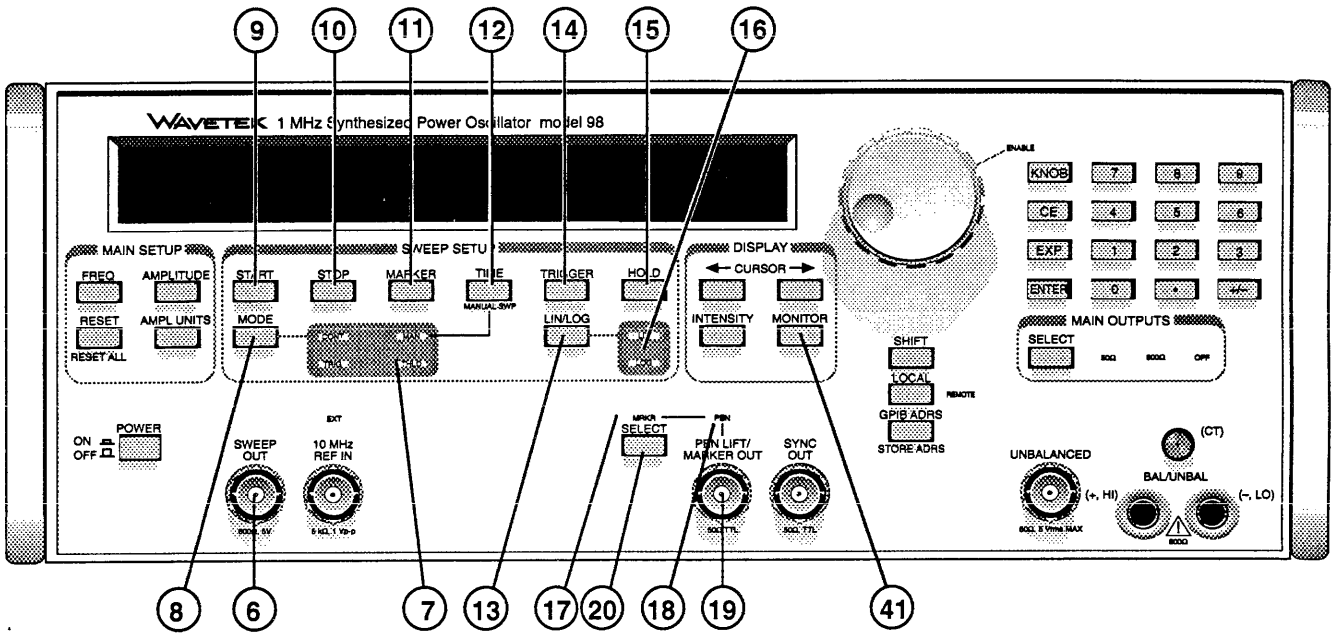


Figure 3-9. Internal Sweep Generator Operation Control Setup

3.2.6 Internal Sweep Generator Operation

Perform the following steps (using figure 3-9) to operate the Model 98 using the internal sweep generator to control the oscillator's frequency.

1. First set up the Model 98 to operate as a continuous (cw) source of 50Ω unbalanced (paragraph 3.2.2), 600Ω unbalanced (paragraph 3.2.3), or 600Ω balanced (paragraph 3.2.4) sine wave output.
2. Note that the Sweep Mode (8) is Off and that none of the sweep mode indicators (7) are on.
3. Use Figure 3-10 to select a Sweep Mode. In the figure, the ramps represent the instantaneous value of oscillator frequency and the horizontal axis is time. Sweep Start frequency (9) is assumed to be set below Sweep Stop frequency (10), but this does not need to be the case. Therefore in this figure, the bottom of a ramp is the start, and the top of a ramp is the stop. The time of one ramp transition, either up or down, is the Sweep Time (12). An abrupt transition is a RESET, or ramp flyback time, and this is less than 1 ms.
4. After selecting a mode from the figure, set the generator to that Sweep Mode (8). Note that the appropriate Mode indicator (7) is on. The generator is now sweeping if a continuous mode is selected. Press the Trigger key (14) to initiate a sweep in a triggered mode. Connect the selected 50Ω or 600Ω output to an oscilloscope. The SWEEP OUT BNC (6) can then be used as an external trigger, second channel input triggering source, or as a X-axis input (X-Y horizontal mode) so that the frequency sweep can be synchronized and displayed on the scope. The default settings will result in a sweep between 1 kHz and 10 kHz at a 1 second rate. Modify the Start (9), Stop (10) and Time (12) settings as desired.
5. Using the LIN/LOG key (13), select either linear or logarithmic sweep function. The selection will turn on either the LIN or LOG indicator (16).
6. The sweep generator should now be set up with the desired sweep. The remaining controls and modes are used to locate features in the swept response of the unit or circuit under test and read out the frequency at the point of interest. For very slow sweep times, the Sweep Hold (15), frequency Monitor (41), and the Manual Sweep Mode (8) are most useful. For faster sweeps, the Sweep Marker (19) will be used.
7. To operate the frequency Monitor (41), set sweep time to a very slow sweep and press the key. The display will read out instantaneous frequency with a rapid update time. Trigger a sweep or allow it to run continuously, and observe the swept response as the display reads out the frequencies being covered.

8. For a better readout at a point of interest, press Hold (15) when the sweep is at a feature of interest. The sweep is held, and the display indicates the frequency being held at. Press the key again to resume sweeping.

9. To manually scroll back and forth frequencies being covered by the current sweep setup, select Manual Sweep Mode (8). The display reads out a number between 0000 and 1023, which corresponds to the 1024 frequency points being selected for each sweep. Therefore, this 4 digit number is a linear indication of position within a sweep. Use the numeric keypad to set a 4 digit number that positions the sweep in the general area of interest, and then use the control knob to fine set points of interest within the sweep.

10. For a fast sweep, such as filter adjustments, use the marker system. Press the Marker Select key (20) to turn on the MRKR indicator (17). The PEN LIFT/MARKER OUT BNC (19) can be connected to the scope's alternate vertical channel or the chart recorder marker channel pen as a timing pulse. The marker generates a 1 ms positive pulse as the sweep passes through the Marker Frequency (11) setting. The marker can also be used to drive the Z-axis input of most oscilloscopes (use varying load resistance values to fine-tune intensity modulation) to provide an intensity spot at the marker frequency. Depending upon the scope, this will be either an intensified or de-intensified spot.

11. The PEN LIFT/MARKER OUT BNC (19) also can provide a Pen Lift (or retrace blanking) pulse. Press the Marker Select key (20) to turn on the PEN indicator (18). When using a chart recorder operating an oscilloscope in the X-Y mode, this pulse can be used to prevent retrace. Connect it to the Z-axis input of the scope or the pen lift input of the recorder.

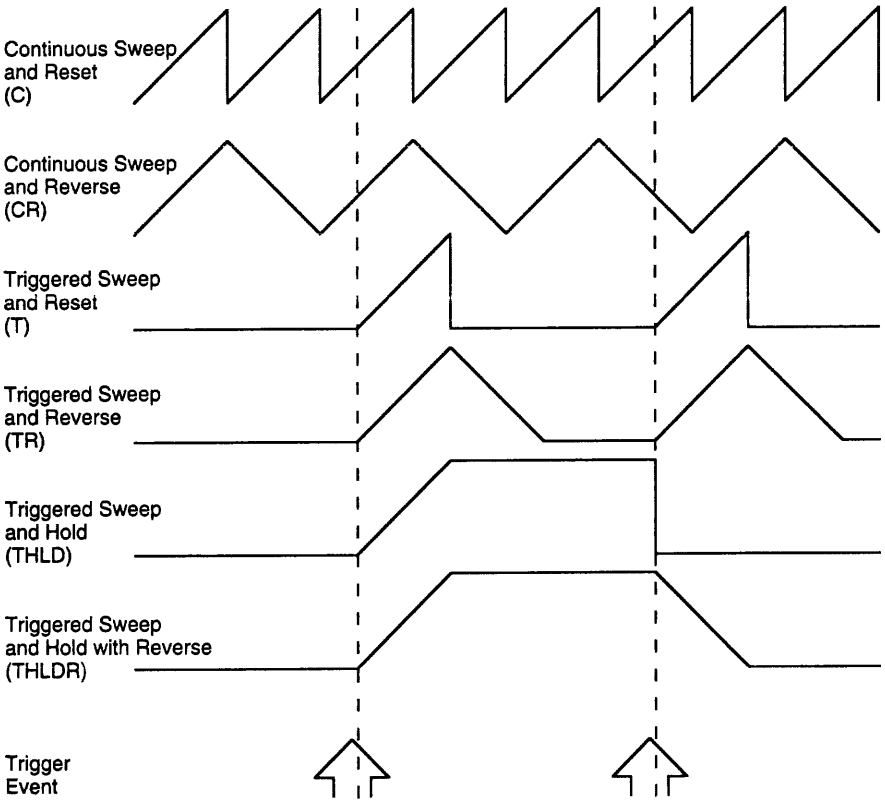


Figure 3-10. Sweep Mode Characteristics.

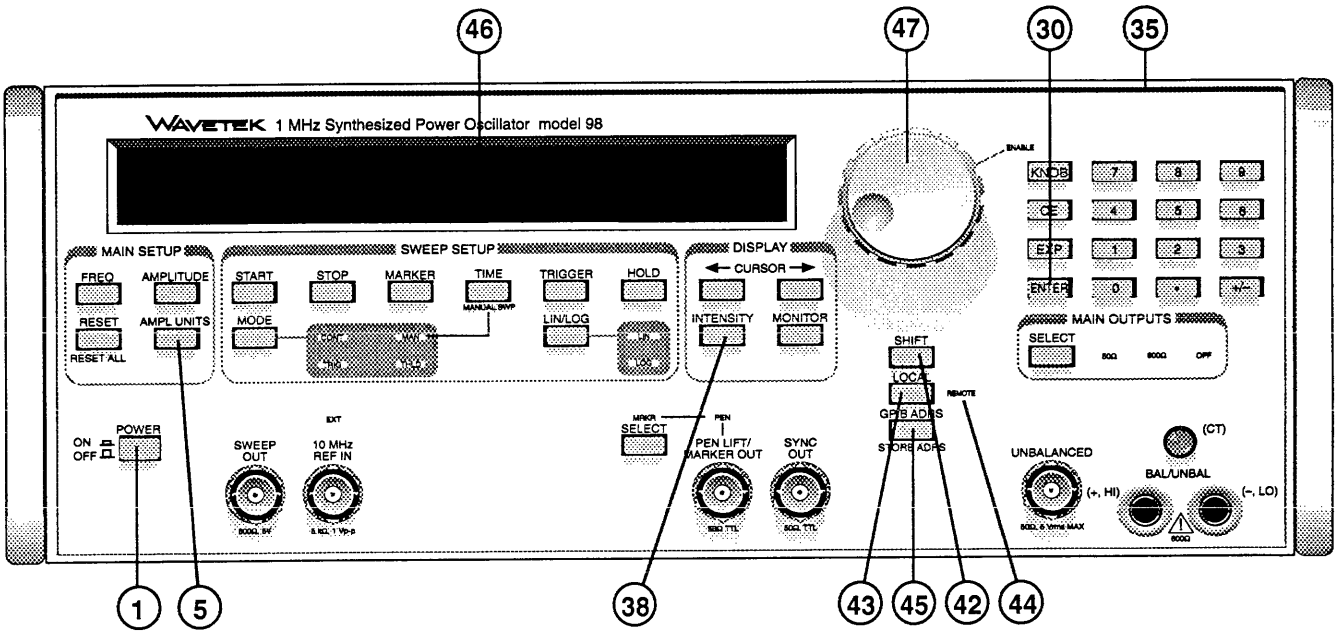


Figure 3-11. GPIB Operation Control Setup.

3.2.6 GPIB (Remote) Operation

This following paragraphs describe the Model 98 remote operation (GPIB) procedures using an external controller. GPIB Digital Interface conforms to IEEE 488.1 1978 subsets SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, CO, and E1.

Remote operation of the Model 98 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 (1), Display Intensity (38), Amplitude Units (5), Local key (43), and GPIB Address key (45). Refer as necessary to Section 2 for descriptions of controls, indicators, and connectors, and individual operating procedures (paragraphs 3.2.2 thru 3.2.5). GPIB connector wiring data is shown in figures 3-12 and 3-13.

Perform the following steps (using figure 3-11) for remote operation of the Model 98 signal generator.

1. Connect the equipment as shown below.

   NOTE

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

2. Perform Model 98 turn-on procedure (refer to paragraph 2.2.3).

3. On oscillator front panel:

   - Press the Local key (43), verify that the display (46) indicates "LOCAL", and that the REMOTE indicator (44) is out.
   - Press the GPIB Address key (45) and enter desired address from 00 to 30. Use the control Knob (47), or the Numeric keypad (35) and Enter key (30) to select an address. Entry will appear in the display (46). When the desired address is displayed, press SHIFT (42) and then GPIB ADRS (STORE ADRS) (45) to enter the new address into non-volatile memory. Factory default address is 09. Once set, this address will not change until reset to another address.

4. Send a command (examples: REMOTE 709 or OUTPUT 709 ; "FR 123,EX") to send the unit to Remote. Commands are programmed using an external Controller and GPIB commands listed in table 3-6. Do not send the LLO (Local Lock-Out) at this time.

5. Verify that the REMOTE indicator (44) is on and a normal message is in the display (46) for the last parameter sent.

6. Press the LOCAL key (43) and verify that the REMOTE indicator (44) goes off.

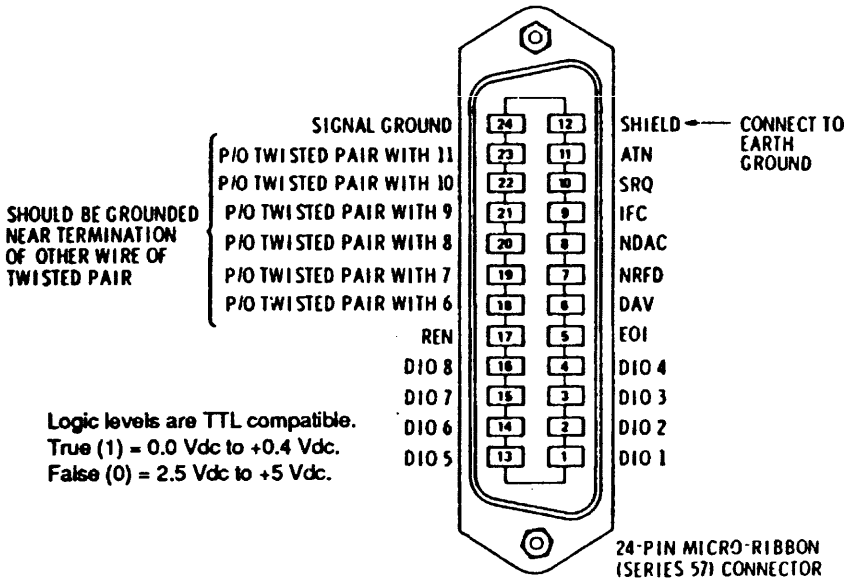


Figure 3-12. GPIB Wiring Connector Pin Out

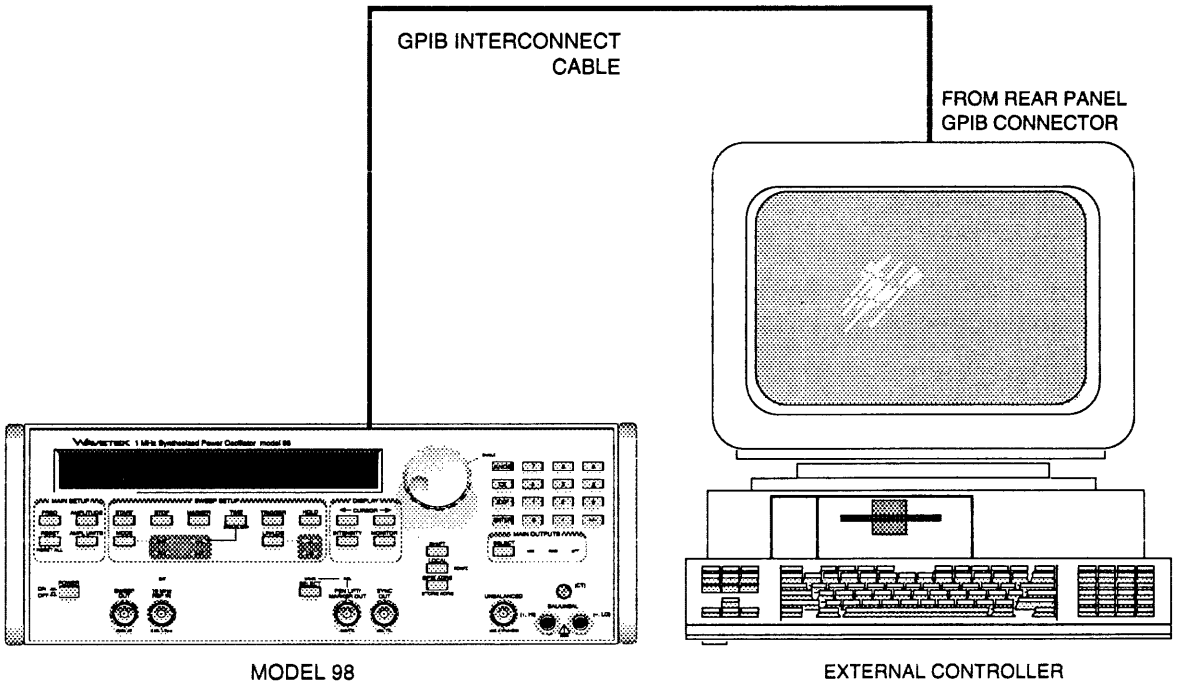


Figure 3-13. GPIB Interconnect Wiring

3.3 GPIB COMMAND STRUCTURE

3.3.1 Introduction

This paragraph tells how to control the Model 98 remotely over the GPIB bus and is divided into the following topics:

Model 98 Commands.

Universal and Addressed Commands.

Detailed Command Descriptions.

Service Requests.

Displaying Messages.

GPIB Keys.

3.3.2 Model 98 Commands

The following is a discussion of the Model 98 commands and the rules that must be followed to apply them.

Commands Types

Command Syntax

Command List

3.3.2.1 Command Types

The Model 98 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 98 will display that parameter's current value. Replacing the numerical value with a "?" (query) will make the Model 98 display and send the current value to the controller as a string of characters. Do not send an Execute command after a query command. See "terminators" for more information.

Parameter Commands

Parameter commands specify a particular numerical value within a continuous range of values. The values may 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 2 kHz
`AMPLITUDE 3;`	Sets the amplitude at 3 Vp-p

Enumerated Commands

Enumerated commands provide a list of distinct choices. Either the name or numerical value can be used (see example).

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:

`Output 1`
or
`Output Unbalanced` } Selects the 50Ω output.

Direct Commands

Direct commands make the Model 98 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 98 parameters
`EXECUTE:`	Executes preceding commands in string.

Query Commands

Query commands tell the Model 98 to send information to the controller.

The Model 98 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 98 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 98 to send (rather than receive) the information. Certain other headers appear only in query commands. See Query Commands in paragraph 3.3.2.2, 98 Command Syntax for a sample query program.

Parameter Header Examples:

`FREQUENCY?"`	Returns current frequency.
`AMPLITUDE?"`	Returns current amplitude.

Enumerated Header Example:

`OUTPUTSELECT?"`	Returns current output type.

Query Header Examples:

`MAINPARAMETERS?"`	Returns current setup.
`SRQ?"`	Returns current SRQ buffer.
`STATUSBYTE?"`	Returns status byte.

3.3.2.2 98 Command Syntax

Commands sent by an instrument controller to the Model 98 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 particular model of Instrumentation Controller) works as follows:

`WRITE @ 709:"FR 2E4;O 1;AM 50E-3;FR;EX"`

`FR 2E4`	Sets the frequency to 20 kHz.
`O 1`	Selects unbal 50Ω as the output.
`AM 50E-3`	Sets the amplitude to 50 mVp-p.
`FR`	Tells the Model 98 to display the frequency menu.
`EX`	Makes the Model 98 convert all these commands to a signal output.

How Does the 98 Process Commands?

The 256-character listen buffer receives the commands from the controller. If the buffer fills up or the GPIB transmission becomes idle, it will 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 98 receives an Execute or GET.

The listen buffer accepts all commands regardless of syntax errors. When the Model 98 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. An askerisk is placed in the SRQ buffer immediately after the unrecognized command. 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 98 ignores it.

Separators

A separator is used to punctuate multiple commands in a single command string. Although the Model 98 recognizes semicolons (;), commas (,) and spaces as separators , commas or semicolons greatly simplify debugging. When the controller sends the Model 98 more than one command in a string, the individual commands should have commas or semicolons (;) inserted between them as separators. When using spaces, the Model 98 will copy (and ignore) all commands after the first defective command into the SRQ buffer. With commas or semicolons, the Model 98 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;O 1;FR;EX"
```

Message: `SRQ = /PE:0 FR2E4*/`

Without Semicolons:

```
Write @ 709:"FR2E4 O 1 FR;EX"
```

Message: `SRQ = /PE:0 FR2E4* O 1 FR EX/`

Terminators

A terminator is intended to tell the receiving instrument that it has reached the end of the command string. When addressed as a Listener, the Model 98 handles separators and terminators the same. Any of the common termination characters likely to be sent by a Controller (CR, LF, or EIO in any order) are recognized by the Model 98. When addressed as a Talker, the Model 98 sends the LF and pulses the EOI low after the end of a query response.

Minimum Uniqueness

The Model 98 will interpret the following 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 output select command (`O 1`, `OUTSEL U`, and `OUTPUTSELECT UNBALANCED50`) demonstrates the use of numbers and descriptive character strings in the argument of enumerated commands.

```
Write @ 709:"FR 2E4;O 1;FR;EX" (1)

Write @ 709:
   "FREQ 2E4;OUTSEL U;FREQ;EXEC" (2)

Write @ 709:
   "FREQUENCY 2E4;OUTPUTSELECT UNBALANCED50
   ;FREQUENCY;EXECUTE" (3)
```

Query Commands

Query commands (such as FR?) make the Model 98 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 sample program requests the data, accepts it, and writes it to the particular Instrumentation Controller's screen.

Program Statements	Explanation
`10 CLEAR`	Clear screen
`20 WRITE @ 709:"FR?"`	Write command to Model 98 (port 7, address 09).
`30 DIM STRING$*25`	Dimension string.
`40 READ @709:STRING$`	Read returning string
`50 PRINT STRING$`	Print string to screen
`60 END`	End program

3.3.2.3 98 Command List

Table 3-6 uses the following format to list and briefly describe the complete Model 98 GPIB command set. See the detailed command descriptions part or the corresponding menu key description for more information.

Command	Range/String	Function
`FRequency`	`1E-6 TO 1.1E6`	Sets the frequency.
`FRequency?`	`FREQUENCY n`	Returns frequency n.
`Outputselect`	`0 to 3`	Selects a channel output waveform.

Command Column

1) Lists commands alphabetically by their full names.
2) Indicates minimum uniqueness with capital 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

Capital letters (Outputselect) indicate the minimum letter combination required by the Model 98. Use just the caps (O), a longer abbreviation that contains all the caps (OUTSEL), or the entire command (OUTPUTSELECT).

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 3-3. Model 98 Command Syntax

Typical Command Line: `WRITE @709:"FR 2E4;O 1;FR;EX"`

`WRITE @ 709`	Varies depending on the controller. This particular format used throughout this manual tells the controller to send the command string out port 7 (the GPIB port) to the Model 98 (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 "separators" and "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 `0.005` as `5E-3`.
`FR` `FREQUENCY`	Use the minimum uniqueness version (`FR`), a longer version that contains the minimum uniqueness letters (`FR`), or the full version (`FREQUENCY`) of each `FREQUENCY` command in

Table 3-3. Model 98 Command Syntax

Typical Command Line: `WRITE @709:"FR 2E4;O 1;FR;EX"`

Syntax	Explanation
	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.
`O 1` `O U`	Enumerated commands that select a function (such as `O, OUTPUTSELECT`) allow the output to be selected by either number (1) or by name (`U`), (unbalanced 50Ω output). Table 3-6 lists the enumerated commands and their arguments.
`;CMD;`	Drop the numerical value of a parameter command to make the Model 98 display that parameter. For example, `;AM;` will display the amplitude. Use this feature in step-by-step operation to follow and verify program operation.
`EX"`	Place an Execute command at the end of a command string to make the Model 98 put the commands into effect. The Model 98 will accept commands and put them in the pending setup registers, but it will not generate their output until an `EX` command is sent. `EX` also puts the Model 98 in the "listen for more commands" mode; therefore, do not put `EX` after a query (?) command as it will prevent the Model 98 from returning the answer.
`?`	Replace the numerical value of a parameter command with a `"?"` to make the Model 98 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 98 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 `EX` after a `?` command.

Table 3-4. Model 98 Command Set

Command	Abbreviation	Range/Value Min	Range/Value Max	Description
`AMplitude`	`AM`	`15E-3`	`30`	Set Amplitude in Vpp
`AMplitude?`	`AM?`			Request current Amplitude setting (Vpp)
`CeNterfrequency`	`CN`	`0`	`1E6`	Set center frequency of a sweep
`CeNterfrequency?`	`CN?`			Request current center frequency
`DBm`	`DB`	`-43.3`	`27.5`	Set amplitude in dBm
`DBm?`	`DB?`			Request current amplitude (dBm)
`EXecute`	`EX`			Execute previous commands
`FRequency`	`FR`	`1`	`1.1E6`	Set Frequency in Hz
`FRequency?`	`FR?`			Request current Frequency setting (Hz)
`Help?`	`H?`			Request this Command list
`HoLD`	`HLD`			Stop the sweep

Table 3-4. Model 98 Command Set (Continued)

Command	Abbreviation	Range/Value Min	Range/Value Max	Description
MainParameters?	MP?			Request current main parameters
MoNitorFreq?	MNF?			Request instantaneous sweep frequency
Outputselect	O	0	2	Set Output type
Off	O	0		Set Output off
Unbalanced50	U	1		Set Output to 50Ω Unbalanced
Balunbal600	B	2		Set Output to 600Ω Bal/unbal
Outputselect?	O?			Request current Output type
PaRameterreset	PR			Reset currently selected parameter
Reset	R			Reset parameters except GPIB address, Display Intensity, and Amplitude Units
ReSuMe	RSM			Restart a held sweep
STArtfrequency	STA	1	1.1E6	Set sweep start frequency
STArtfrequency?	STA?			Request current sweep start frequency
STOpfrequency	STO	1	1.1E6	Set sweep stop frequency
STOpfrequency?	STO?			Request current sweep stop frequency
SweepTime	ST	30E-3	1E3	Set sweep time
SweepTime?	ST?			Request current sweep time
SweepFunc	SF	0	1	Set sweep linear or log function
LINear	LIN	0		Set sweep to linear
LOGarithmic	LOG	1		Set sweep to logarithmic
SweepFunc?	SF?			Request current sweep function
SweepMode	SM	0	7	Set sweep mode
Off	O	0		Set sweep mode off (cw)
Continuous	C	1		Set continuous sweep mode
ContwithRev	CR	2		Set continuous with reverse sweep
Triggered	T	3		Set triggered sweep mode
TrigwithRev	TR	4		Set triggered with reverse sweep
TrigHoLD	THLD	5		Set triggered hold sweep mode
TrigHoLDwithRev	THLDR	6		Set triggered hold with reverse sweep
Manual	M	7		Set manual sweep mode
SweepMode?	SM?			Request current sweep mode
SweepIndex	SI	0	1023	Set manual sweep index
SweepIndex?	SI?			Request current manual sweep index
SELect	SEL	0	1	Set sweep marker or pen lift output
Marker	M	0		Set output to marker
Penlift	P	1		Set output to pen lift
SELect?	SEL?			Request current marker or pen lift selection

Table 3-4. Model 98 Command Set (Continued)

Command	Abbreviation	Range/Value Min	Range/Value Max	Description
SETSTaRt	SETSTR			Set manual sweep, index = 0000
SETSToP	SETSTP			Set manual sweep, index = 1023
SrQMask	SQM	0	255	Set Service Request Mask value
SrQMask?	SQM?			Request current SRQ Mask value
SRQ?	SRQ?			Request current SRQ buffer contents
STatusByte?	STB?			Request current serial poll Status Byte value
SPanfrequency	SP	-1E6	1E6	Set sweep frequency span
SPanfrequency?	SP?			Request current sweep frequency span
TRiggersweep	TR			Triggers a single sweep
Version?	V?			Request software version number
VoltsPeaktoPeak	VPP	15E-3	30	Set amplitude in Vpp
VoltsPeaktoPeak?	VPP?			Request current amplitude in Vpp
VoltsPeaK	VPK	7.5E-3	15	Set amplitude in Vpk
VoltsPeaK?	VPK?			Request current amplitude in Vpk
VoltsRMs	VRM	5.3E-3	10.6	Set amplitude in Vrms
VoltsRMs?	VRM?			Request current amplitude in Vrms

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 98 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 98 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 98 GPIB commands that perform functions not controlled by the front panel and also the GPIB universal and addressed commands recognized by the Model 98. 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?	98	HELP?
LLO	Universal	Local Lock Out
MP?	98	Main Parameters?
SRQ?	98	Service Request?
SQM	98	Service Request Mask
SQM?	98	Service Request Mask?
STB?	98	Status Byte?
V?	98	Version?

GPIB Control

The Model 98 limits the operator's use of the front panel with two levels of increasing restrictions as shown in table 3-7.

The Model 98 switches to GPIB control when the instrument controller asserts the GPIB REN (remote enable) line and sends the Model 98 its listen address. The particular 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 98 will remain under the GPIB control until the operator presses the Local key.

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 98 front panel as described in table 3-7 For a particular Instrumentation 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 98 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 particular Instrumentation 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 98 does not require that it be followed with another command.

GET Command

The Group Execute Trigger command, GET, executes and triggers whatever trigger function is set up within the instrument. All instruments on the bus recognize the GPIB addressed GET command. However, GET can also be sent to just one instrument at a time. The Model 98 performs an EXECUTE immediately on receipt of the GET command, and if in a triggered sweep mode, it initiates a single sweep.

Table 3-5. 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

HELP? Command

The HELP? command makes the Model 98 return a list of the Model 98'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 sample program requests the list, accepts it, and sends it to a printer connected to the GPIB bus. Table 3-6 provides the same information as the list this program prints.

Sample HELP Print Program

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

MainParameters? Command

The MP? command makes the Model 98 return the current setting of the Model 98's main parameters as a string to the controller. The controller can save this string, then send it back to the Model 98 at a later time to restore the parameters to their previous values.

DCL Command

The DCL command resets the Model 98 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). To reset everything on the bus, use DCL @7, 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 98 resets itself immediately when it receives either command.

Reset Command

The Reset command resets the Model 98 to default conditions (paragraph 2.3.3).

Version? Query

The Version? query makes the Model 98 return the software version of the Model 98 EPROM as a string of characters. Version? requires a program to make the instrument controller use the returned string. The following sample program requests the version, accepts it, and writes it to the controller's screen.

Sample Version? Print Program

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

Running the above program will produce the following display:

```
WVTK 98 (VX.XX)
```

In this display, **x.xx** gives the version number.

3.3.5 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 98 generates. The Model 98 can set the SRQ line whenever a programming error occurs or an event is completed.

SRQ CONCEPTS

What Does the Service Request Tell the Controller?

The Model 98 service request tells the controller that the Model 98 wants attention. The Model 98 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 perform a serial poll and 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 98 uses three of the eight bits in its status byte. One tells the controller if the Model 98 requested service. The others indicate the type or types of messages (programming error or event complete) that the Model 98 wants to send. Figure 3-14 shows the format of the Model 98 status byte. If the controller wants to know the specific message within the category, it must read the Model 98's SRQ buffer using the SRQ? query.

What Does the SRQ Buffer Tell the Controller?

The Model 98 SRQ buffer stores the programming error and event complete 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 `SQM` command makes the Model 98 selectively ignore one or more of the two types of conditions that make it produce service requests. For example, if programming errors were masked out, the Model 98 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 and EV messages. The SRQ mask is reset to SRQ mask #1 (programming error only) on power on. It is not changed by `"RESET"`

SRQMask? Command

The `SQM?` command makes the Model 98 return the current mask setting to the controller. The Model 98 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 98 to send the mask, then tells the controller how to receive and process the returning string.

STatusByte? Command

The `STB?` command makes the Model 98 send its current status byte to the controller over the GPIB bus. The Model 98 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 98. To use `STatusByte?`, write a program that first asks the Model 98 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 98 send the contents of the SRQ buffer to the controller over the GPIB bus. The Model 98 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 98 to send the SRQ buffer messages, then tells the controller how to receive and process them.

SRQ MESSAGES

SRQ Message Format

The Model 98 puts messages in the SRQ buffer in this general format:

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

Slashes (/) enclose each message. PE identifies a programming error message and EV an event complete message. "n" identifies a type of message within the class. 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 and table 3-9 lists all the SRQ event error messages.

3.3.6 Displaying Messages

The Model 98 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 98 accepts either single or double quotes as string delimiters, the controller in our examples interprets the double quotes as its own program string delimiters. This restricts use to the single quotes for Model 98 display strings when using the particular controller used throughout this manual. Other controllers might reverse this situation.

Message Size

The screen will allow a maximum message size of 16 characters. The Model 98 will ignore any characters beyond these limits.

Erasing

Press any menu key or send another GPIB command string to return to normal Model 98 displays. To erase the previous message, send a new message.

Table 3-6. SRQ Programming Error Messages

Command	Description
/PE:0 < defective command string > * <rest of command string up to separator>	The Model 98 did not recognize the command it received. The < defective command string > is the unrecognized portion of the command string.
/PE:1 < parameter header >: LIMIT ERROR/	This is a limit error. An attempt was made to set a parameter to a value outside of its maximum range. The < parameter header > is the maximum header string, e.g. "FREQUENCY".
/PE:2:CONFLICT < param# >: < param name >	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# > < param name >** 1 FREQ>200KHZ IN 600OHM 2 FREQ<30HZ IN 600OHM 3 START>200KHZ IN 600OHM 4 START<30HZ IN 600OHM 5 STOP>200KHZ IN 600OHM 6 STOP<30HZ IN 600OHM 7 AMPL>15VPP IN 50OHM

Table 3-7. SRQ Event Complete Error Messages

Command	Description
/EV:1 EXECUTE COMPLETE/	This means that execute was complete. After an execute command, the Model 98 will send either this service request or a PE:2 (assuming both PE and EV SRQ's are enabled by the SRQ mask).

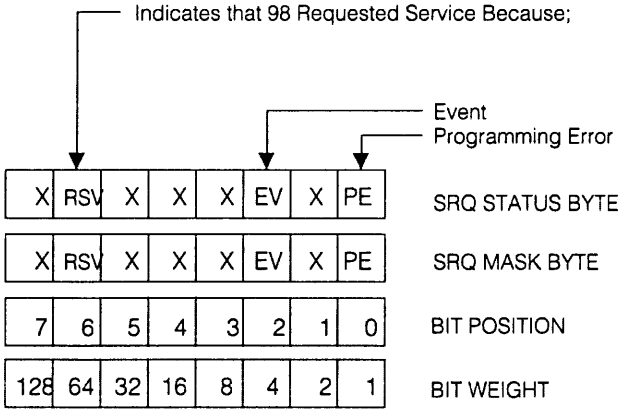


Figure 3-14. Model 98 Status Byte and SRQ Mask

SECTION 4
CIRCUIT DESCRIPTION

4.1 THE MODEL 98

The Model 98, a 1 MHz synthesized power oscillator, operates with synthesizer accuracy (±25 ppm) and resolution (8 digits) over the 1 μHz to 1.1 MHz range. The two waveform outputs are a low distortion (<0.03%) sine wave and a TTL square synchronization signal. The sine wave can appear at a BNC (unbalanced) at a 50Ω source impedance or at a transformer-coupled banana jack output (balanced or unbalanced) at a 600Ω source impedance. Amplitude is selectable from 15 mVp-p to 15 Vp-p at the 50Ω output or as 15 mVp-p to 30 Vp-p at the 600Ω output.

The Model 98 consists of three separate assemblies as shown in figure 4-1 and the Instrument Schematic (0004-00-0667): motherboard, front panel, and rear panel. The motherboard links all the assemblies within the Model 98. Additionally, 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 routes 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 waveform generator produces the generator's two basic waveforms: square and sine. The output circuits buffer, amplify and attenuate the waveform. The rear panel assembly contains the unit's power input connector, power transformer, and fuse.

Signal Flow

Signal flow through the Model 98's assemblies originates in the waveform generation circuits on the motherboard (see figure 4-1). The motherboard routes both

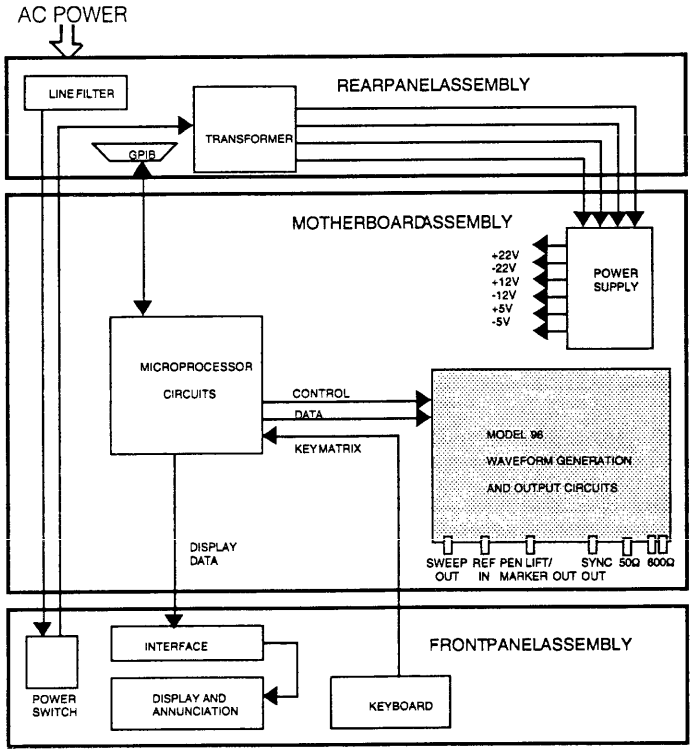


Figure 4-1. Model 98 Signal Flow

waveforms through various amplitude control, buffer, output, and attenuation circuits to the Sync Out (TTL square) and the 50Ω and 600Ω Main Outputs (sine).

Figure 4-3, the detailed motherboard block diagram, shows these circuit blocks and details signal flow between them.

Control

All control inputs originate from either the front panel keypad or a GPIB controller. The microprocessor circuit on the motherboard processes this input data and produces the control lines for the Model 98's circuits.

4.2 DETAILED CIRCUIT DESCRIPTION

4.2.1 Motherboard Assembly

The mother board (see Figure 4-3 and schematic 1104-00-3498) provides overall control, interconnection and signal routing, power supply voltages, internal reference frequency signals, and remote operation, and the waveform generation and output conditioning circuits in the Model 98. The mother board sends and receives all data and control signals to and from the circuits. All input and output connectors located on the front and rear panels, except the input power connector, connect through the mother board.

The mother board contains:

- Microprocessor Circuit
- GPIB Interface Circuit
- Control Registers
- Fine Amplitude Control
- Reference Clock
- Address Generator Circuit.
- Waveform Memory
- Waveform DAC
- Preamplifier
- 1 MHz Low Pass Filter
- Coarse Amplitude Control Circuit
- Output Amplifier and Attenuator
- 50Ω Attenuator and On/Off Control
- 600Ω Balanced Output Driver
- Sync Output Conditioning and Buffer
- Power Supplies Circuit
- Sweep Out and Marker Drivers

4.2.1.1 Microprocessor Circuit

The microprocessor circuit (schematic 1104-00-3498 sheet 2) 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 U2 (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. 10 MHz crystal Y2 provides a frequency signal from which the microprocessor creates all timing signals. DS1 is a "life light" LED which flashes to indicate normal operation of the microprocessor and its internal busses. U1 is an integrated reset generator used to detect power-up and power-down and provide a master RESET signal. U3 is a EPROM which contains the unit's firmware. U4 is an 8K X 8 RAM which has associated battery back-up components. When these components and Lithium battery are not used, the RAM receives short-term memory retention voltage from C154. U6 is an EEPROM, providing 256 bits of additional non-volatile memory. The P10 to P17 inputs to the microprocessor are connected to the scanned key matrix columns on the Display/Keyboard printed circuit assembly.

The microprocessor design is made very simple through the use of an ASIC LSI device, U5, the Processor Support Chip (PSC288). All other necessary functions of an 8-bit microprocessor system not mentioned in the above paragraph are contained in the PSC. These functions include separation of the multiplexed Address and Data busses, address mapping, external (quiet) address and data busses, parallel-to-serial conversion, I/O selection and strobes, interrupts, frequency and voltage measurement interfaces, and encoder knob decoding. The PSC device is socketed to facilitate maintenance.

4.2.1.2 GPIB Interface Circuit

The GPIB interface circuit (schematic 1104-00-3498 sheet 3) allows remote operation of the Model 98 using an external IEEE-488 compatible controller. All functions except power, display intensity, amplitude units 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 automatically loads into the controller from EEPROM 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 Control Registers

The control registers (schematic 1104-00-3498 sheet 4) consist of U10, U11, and U12. U10 is a 3-line binary to eight-line decimal decoder/demultiplexer. The outputs are normally high, except when an enable input is strobed low the output corresponding to the binary code of the ABC inputs is also strobed low. U11 and U12, the data registers, are octal D-type flip/flops. To change one of the data lines at the right of the schematic, the processor sets quiet address lines QA0-QA2 to select the data register driving that line, sets the quiet data bus to the pattern of the new data that will appear at this data register's outputs, and then strobes the REG-STB\ line. The data registers hold their outputs constant until they are clocked by U10.

4.2.1.4 Fine Amplitude Control

This circuit can be seen on sheet 7 of schematic 1104-00-3498. Serial data from the PSC is applied to the Fine Amplitude Control block which fine adjusts the dc reference voltage to the Waveform Digital to Analog Converter (DAC). This circuit can be seen in the lower half of sheet 7 of the schematic. The waveform DAC, U21, operates best when "REF-" is -1 Vdc and an amplitude control voltage more positive than -1 Vdc is applied through a current setting resistor so that approximately 600 μA flows into "REF+". The junction of R36 and R37 determines a +1 Vdc reference voltage. This is inverted by U26B to -1 Vdc which is applied to "REF-", pin 19, of U21. The output of U26A is made to vary from approximately +5 Vdc to +3.5 Vdc. This puts approximately +6 Vdc to +4.5 Vdc across the series combination of R42, R43, and R24 to the "REF+" input, which causes reference current to vary from 600 μA to 450 μA. This keeps the waveform DAC between full scale and 75% of full scale. Fine amplitude control is set between these values when serial data is applied to another DAC, U25, producing a positive fine amplitude control voltage at VOUT, pin 9. This voltage is summed into U26A, which drives the "REF+" terminal. The waveform DAC generates a 40 mA full scale output with a 600 μA reference current and maximum digital word, for a 1 Vp-p analog output across 25Ω.

4.2.1.5 Reference Clock

The Reference Clock circuit (sheet 5 of 1104-00-3498) selects either the internal or external 10 MHz reference frequency. The selected reference is scaled, buffered and distributed to the waveform generation circuits. The circuit is shown in page 5 of the Model 98 schematics. The internal 10 MHz reference is Y2, and it normally passes through U15D and C and U16 (divide by 2) to U17 for buffering and distribution to various clocked logic devices. The external 10 MHz may be applied to the 10 MHz REF IN BNC. Signals input to IN1A pin of U14 are ac-coupled, zero-crossed, and converted to a TTL level square by the comparator. U14's output is connected to U15B and through a passive filter network to the IN2A input of U14. The filter (R18, L1, C17, and R19) passes signals that are 10 MHz ±10%. CR8 and C18 peak detect any signals that pass through the filter. When a 10 MHz signal is present at the OUT1 pin of U14, the peak detector charges enough to make IN2A greater than IN2B. Then REFSENSE, which is normally high, goes low. When REFSENSE is high, the internal 10 MHz is inhibited at U15D and the external 10 MHz passes through U15B and C. REFSENSE is periodically read by the microprocessor, and LED annunciation keeps the user informed whether the internal or external reference is selected.

4.2.1.6 Address Generator

The Direct Digital Synthesis (DDS) waveform generation circuits include the Address Generator, the Waveform Memory, and the Waveform DAC. The Address Generator (U18 on sheet 6 of schematic 1104-00-3498) is a Wavetek proprietary CMOS ASIC device with a part number of "PA4800". It generates addresses for the waveform memory through a technique known as "Phase Accumulation". Figure 4-2 below illustrates the Phase Accumulator:

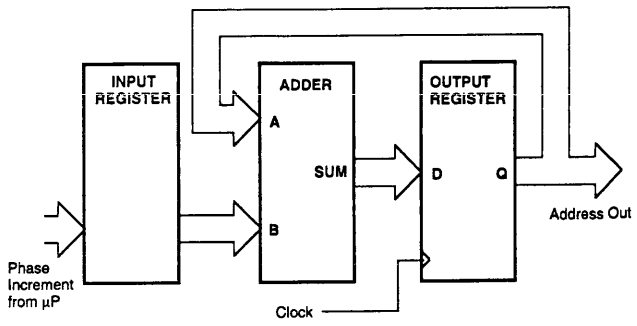


Figure 4-2. Phase Accumulator Block Diagram.

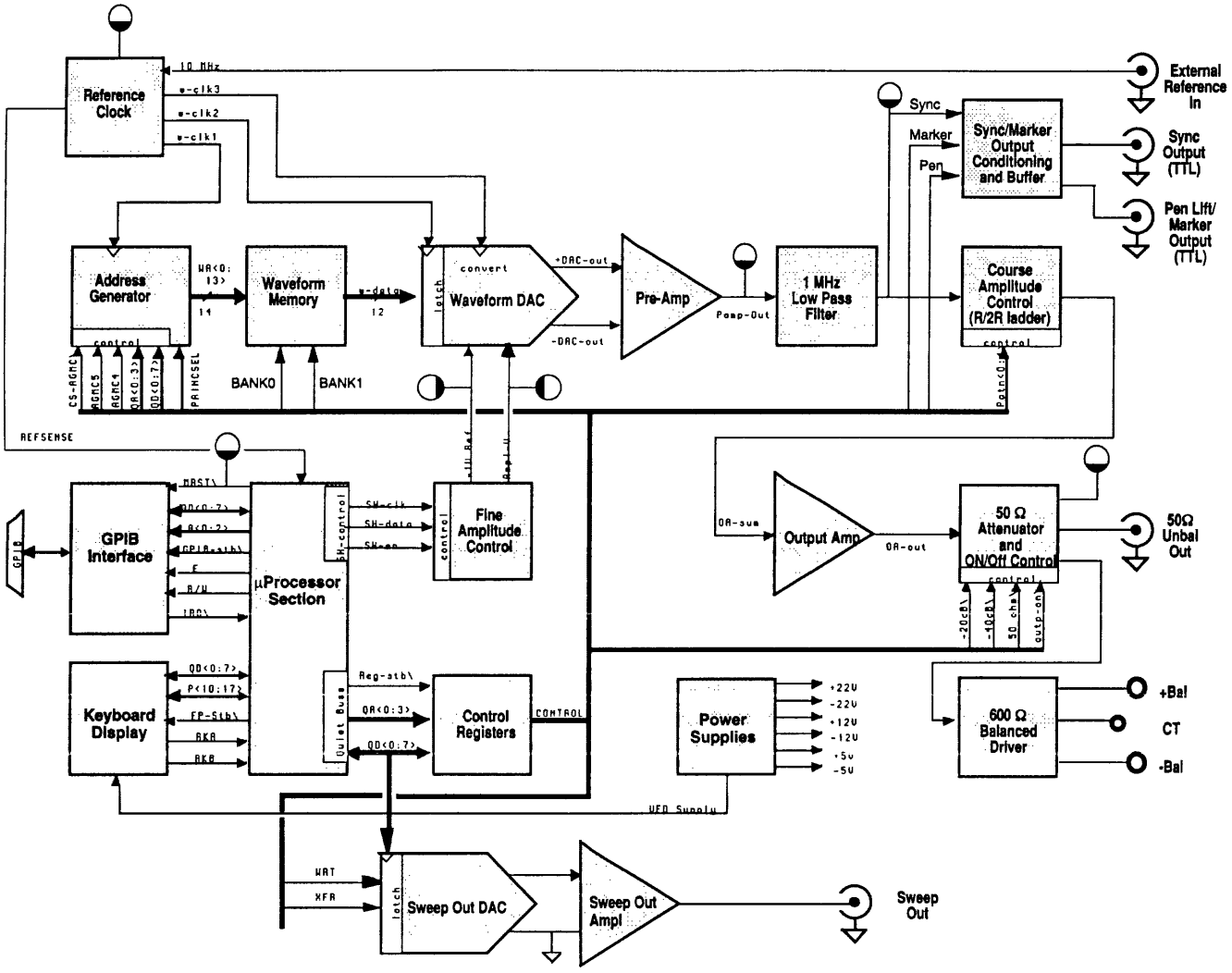


Figure 4-3. Model 98 Detailed Block Diagram.

Based on the programmed frequency, the microprocessor calculates a phase increment value and applies it to the Input Register of the PA4800. This phase increment value is applied to the B input of the adder and held constant until frequency is changed. The sum of the A and B inputs is applied to the Output Register D input, and on a clock edge, is transferred to the Q output as an address. The address is also sent back to the Adder's A input where it will be summed with the phase increment on the next clock edge. Therefore, the Address value can be seen to be the output of an adder/accumulator (totalizer), where the value of the address increases by the value of the phase increment once per clock cycle. The Address value starts off at a low value and increases by a fixed value on each tick of the time clock. When the Address overflows the adder, its values goes back to a low value. The value of the phase increment depends upon the clock frequency and the maximum size of the adder, and when calculated properly, overflows at a rate equal to the programmed frequency. If this Address were connected directly to a DAC, the analog output would be a positive-going ramp at the programmed frequency. The PA4800 has a 48 bit adder, so overflow occurs when 2^{48} is exceeded, and extremely small differences in frequency can be expressed (1 part in 2^{48}).

4.2.1.7 Waveform Memory.

The Address is applied to a Waveform Memory (U19/20 on sheet 6 of schematic 1104-00-3498) before being applied to the DAC. The memory is a PROM programmed with a sinewave look-up table, as shown in Figure 4-4:

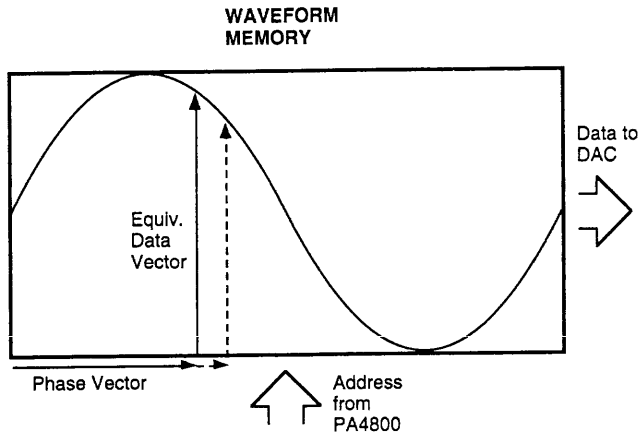


Figure 4-4. Waveform Memory.

The figure represents Address value as a quantity that is increasing from left to right, while the sinewave data value increases from bottom to top. A particular address value can be represented as a phase vector (the solid horizontal arrow), which corresponds to a particular amplitude data vector (the solid vertical arrow). The next clock cycle adds 1 phase increment (the dashed horizontal line), which generates a new amplitude vector (the dashed vertical line). Because of the equal time and phase spacing between amplitude vectors, any series of vectors will generate sinewaves.

4.2.1.8 Waveform DAC

The DAC (U21 on sheet 7 of the 1104-00-3498 schematic) converts digital amplitude values into an analog signal. The 40 mA full-scale output currents develop a 1 Vp-p differential voltage signals across R25 and R27. The instantaneous digital value at the DB1 through DB12 inputs determines the instantaneous current at the DAC+ output, with the complementary current at the DAC- output. The digital inputs are the Waveform Memory data outputs, resynchronized to the clock signal by data registers U22 and U23.

4.2.1.9 Preamplifier

The output conditioning circuits consist of the Preamplifier, the 1 MHz Low Pass Filter, the Coarse Amplitude Control, the Output Amplifier, the 50Ω Attenuator and On/Off Control, and the 600Ω Balanced Output Driver blocks. The differential voltage signals at R25 and R27 are amplified and buffered by differential amplifier U24 (sheet 7 of 1104-00-3498) into a bipolar sinewave. U24 is a commercial high-bandwidth OP AMP.

4.2.1.10 1 MHz Low Pass Filter

One of the more important advantages of the phase accumulator DDS technique is that the clock frequency, and therefore the frequency of the DAC steps on the sinewave output of the Preamplifier, is a single fixed frequency. This allows a single low pass filter to be placed in the output conditioning chain just above the highest sinewave frequency of interest and well below the clock frequency, so that DAC steps are removed from the sinewaves. This filter is shown on sheet 8 of the 1104-00-3498 schematic as U28 and U29. This circuit arrangement provides a 6 pole, active low pass filter.

4.2.1.11 Coarse Amplitude Control Circuit

The sine waveform is nearly fixed in amplitude up to the output of U29; except for a small amount of fine amplitude control provided by the DAC reference. The sum of Fine and Coarse Amplitude Control provides continuous control over a 10:1 range. Two decades of fixed attenuation following the Output Amplifier, along with this 10:1 control, provide a total 1000:1 continuous

amplitude control of the final sinewave output. The coarse control is provide by a 5-bit R-2R ladder network, which results in 1/32 amplitude steps. The fine control fills in between these steps. The R-2R ladder network is shown on sheet 8 of the 1104-00-3498 schematics. The voltage signal at the output of U29 is converted into a current as it passes through the R-2R ladder network (R64 to R79) to the current summing junction of the Output Amplifier. The relays, K1 through K5, control how much current is switched to the summing junction and how much is switched to ground in 32 binary weighted steps.

4.2.1.12 Output Amplifier

The Output amplifier summing junction, OA-SUM, is shown in sheet 9 of the 1104-00-3498 schematics. The OP AMP U30 provides low frequency gain and offset stability for the amplifier. High frequency gain is provided by Q8 and Q12. The output is "push-pull", with Q10/Q11 providing the "push" and Q14/Q15 providing the "pull". Q9 and Q13 are connected as cross-over distortion diodes.

4.2.1.13 50Ω Attenuator and On/Off Control

Also on sheet 9 of 1104-00-3498, the Output Amplifier's 50Ω source impedance is provided by R111/R112. Resistors R113/R114 and R117/R118 provide a -20 dB (10:1) voltage divider with 50Ω source impedance, under control of K6. Resistors R115/R116 and R119/R120 provide a -40 dB (100:1) voltage divider with 50Ω source impedance, under control of K7. K8 selects whether the output is at the 50Ω BNC or at the 600Ω banana jacks. K9 is used to turn the output on or off. The POE\ signal controlling the base of Q16 insures that K6 through K9 are in a known state (dropped out) during turn-on and turn-off, so that the output does not make unexpected amplitude transitions while the power supplies and microprocessor are in unknown states.

4.2.1.14 600Ω Balanced Output Driver

Shown on sheet 9 of 1104-00-3498, the 600Ω output is driven from a 2:1 step-up signal transformer, T2. C70 through C72 ac-couple the 50Ω output to the primary of the transformer. The transformer is quadfilar, with the primaries in parallel and the secondaries in series to provide the 2:1 step-up. The 50Ω source impedance in the primary is reflected into the secondary as 200Ω (the step-up ratio squared). R127 and R128 provide the remainder of the 600Ω source impedance. The transformer has a 30 Hz to 200 kHz bandwidth.

4.2.1.15 Sync Output Conditioning and Buffer

The sync out circuits are shown on the top of sheet 8 of the 1104-00-3498 schematics. The DAC output sine wave, buffered to a nearly constant amplitide voltage signal by the Preamplifier and Low Pass Filter, is applied to a zero-crossing detector, U27, at TP7. The output of comparator IC U27 is a TTL level square wave which is high when the sine is positive of ground and low when the sine is negative of ground. Q5 is a buffer which provides the necessary output current drive for the SYNC OUT connector.

4.2.1.16 Sweep Out and Marker Drivers

The sweep out drivers is shown on the top of sheet 4 of the 1104-00-3498 schematics. To sweep the oscillator frequency, software sets up a table of 1024 phase increments in RAM, corresponding to the 1024 frequencies that will be programmed in succession to complete a sweep. The indexing function that reads values form the sweep table essentially counts from 0000 to 1023. This function also generates the data to produce a linear sweep control voltage at the Sweep Out BNC. Sweep control data is applied to U35 DAC at its DB0-DB9 inputs. QA0 controls latching of high-order vs low-order data. The WR and XFER control signal latch the data. A -5V reference is applied through R170. The current output at IOUT1 is buffered by op-amp U36A and applied to the SWEEP OUT BNC.

The marker and pen lift output driver is shown on the top of sheet 8 of the 1104-00-3498 schematics. The marker and pen lift driver is one-half of the sync out driver. Along with sweep frequencies, the states of the marker or pen lift outputs is maintained in the sweep data table. The PEN or the MARKER value, as appropriate, is latched through the control register U12 and applied to the SYNC OUTPUT BUFFER U38. U38 drives J14, the PEN LIFT/MARKER OUT BNC through the same passive conditioning network as used in the SYNC OUT.

4.2.1.17 Power Supplies Circuit

These circuits provides the ac and dc operating voltages for all circuits in the signal generator. The power supplies circuit consist of a +5V power supply, ±12V power supply, ±22V power supply, and VFD ac filament supply. The supplies are linear and transformer isolated. The primary circuit can be seen schematically in the Instrument Schematic 1004-00-0667. The rear panel mounted line entry module, Corcom 6J1, is shown with integral line entry connector, fuse, voltage selection switch, and line filter. The front panel mounted POWER switch interrupts both poles of the line. The rear panel mounted power transformer, T1, has its secondaries connected to J2, J10 and J11.

The secondary connectors route to mating connectors on the Mother Board printed circuit assemblies, where the power supply circuits rectify and regulate the secondary voltages.

+5V Power Supply. This circuit (schematic 1104-00-3498 sheet 10) supplies the +5 Vdc for the TTL logic and relay circuits in the oscillator. Remove the jumper JMP1 to isolate the +5V supply from the circuits.

The +5 V regulator is a discrete implementation of a low drop-out, series-pass voltage regulator. The full-wave rectified, unregulated voltage from the +5 V secondary is applied to the emitter of the series pass device Q20. The darlington connected pair, Q19 and Q20, control load current to the +5 Vdc output. Regulation is provided by the differential amplifier, Q17 and Q18, controlling the base current (and thus the collector current) of the darlington pair. The regulated output voltage is sensed at the base of Q18. The voltage reference is sensed at the base of Q17. If output voltage begins to rise, current in Q18 begins to increase and current in Q17 begins to decrease. This reduces base current drive in Q19/20, decreasing output current and cancelling the original error signal. CR23 shunts the discharge current of C96 around Q20 at turn-off.

±12V Power Supplies. This circuit (schematic 1104-00-3498 sheet 10) supplies the positive and negative 12 Vdc for the oscillator. These power supplies are highly regulated by a precision voltage reference source, VREF, which is also used by the internal calibration network. Remove the jumper R152 to isolate the +12V supply, and remove the jumper R153 to isolate the –12V supply.

U32 provides a highly accurate and stable +10 Vdc. OP AMP U31A compares the voltage reference to the +12V regulated output and controls the voltage at the ADJ terminal of regulator VR1 to keep the output at +12 Vdc. VR1 is the series pass device for the power supply, and it maintains a voltage of 1.2 Vdc from the OUT terminal to the ADJ terminal. A full-wave rectified, unregulated output of the ±12V secondary is applied to the IN terminal of VR1. The 1.2 Vdc between the terminals of VR1 is developed across R130 in series with R131. Since +12V supply current passes through R130, the voltage across them is a direct indication of load current. The voltage across R131 will be 1.2 Vdc minus the instantaneous voltage across R130. If a fault condition occurs to circuitry powered from +12 V, the load current may increase so that the entire 1.2 Vdc is dropped across R130. The load current may not increase further because VR1 will shift from a voltage regulation mode to a current limit mode and allow the output voltage to drop while maintaining a maximum current output determined by the ratio of 1.2 Vdc to the value of R130. This current limiting effect reduces maximum current supplied under fault conditions to a safe level. CR14 shunts the discharge current from C89 around VR1 at turn-off.

The -12 V regulator is a mirror image of the +12 V regulator and operates identically, except that the voltage reference is the +12 V supply rather than the +10 V reference. OP AMP U31B compares the junction of equal-valued resistors R140 and R141 with ground and regulates the voltage at the ADJ terminal of VR2 to make the -12 Vdc output a mirror image of the +12 V output.

-5V Power Supply. This circuit (schematic 1104-00-3498 sheet 10) supplies the -5 Vdc for the waveform DAC circuit in the oscillator. No jumper is provided isolate the -5V supply from the circuits. VR3 is a integrated circuit three-terminal regulator operating off the -12V supply. The output voltage is determined by the ratio of R150 and R151. CR24 protects VR3 from the turn-off discharge of C100.

±22V Power Supplies. This circuit (schematic 1104-00-3498 sheet 11) supplies the positive and negative 22V used in the oscillator. VREF provides a reference voltage for the positive 22V supply. Lift R163 to isolate the +22V supply. Lift R166 to isolate the -22V supply. The ±22 V regulators on sheet 9 are identical to the ±12 V regulators, except for the resistor values that set the magnitudes of regulated output voltage and the current limit.

VFD AC Filament Supply. An unregulated ac voltage (schematic 1104-00-3498 sheet 1) approximately 8 Vrms supplies current to the display characters in the Vacuum Fluorescent Display. The VFD device (essentially a multi-grid, multi-plate electron tube) requires a 30 Vdc plate to cathode potential. Additionally, the filaments are common with the cathode, requiring that the cathode voltage have 8 Vrms impressed on it. A center-tapped 8 Vrms transformer secondary provides the cathode/filament voltages, FILA and FILB. The center-tap is referenced to -15 Vdc, through CR1 and CR2 to the -22 Vdc. The +15 Vdc plate voltage is provided on the front panel printed circuit board by regulating down the +22 Vdc supply voltage. These power supplies have five test points:

TP9 is the +12 Vdc output.
TP10 is the –12 Vdc Output.
TP11 is the +5 Vdc output.
TP12 is the -5Vdc output.
TP13 is the +22 Vdc output.
TP14 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 0103-00-3322 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 PSC-288 device on the motherboard counts the pulses to determine the amount of change. The PSC-288 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 0103-00-3322 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 input data is converted into 16 segment data at U1-pins 2 through 17 (drives the 16 grids to define one particular character in a scan), and a scan sequence at U1-pins 23 to 40 which scans through the 16 characters in the display (sequentially provides +15 Vdc to one of 16 plates). 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 8 Vac supply. Both voltages originate from the power supply on the motherboard.

4.2.2.3 Keyboard Circuit

The keyboard circuit (schematic 0103-00-3322 sheet 2) consists of 48 push buttons in a eight–column, six–row matrix. Referring to sheet 2, each time FPREG\ is strobed, the quiet data bus is latched into data register U3. The outputs at pins 12, 13 and 14 are the clocked serial data and reset for the display driver discussed in the previous paragraph. The outputs at pins 17, 18, and 19 are programmed to provide a binary count, advancing on the FPREG\ strobe. This binary sequence is applied to a binary to decimal converter, U2. The output of U2 scans the key matrix rows. The microprocessor monitors the key matrix columns, P10 through P-17. The columns are normally pulled low, but if a key is held down while its row is being scanned, that column will pulse high on each scan. The microprocessor will then be able to decode the row and column data and determine which key is pressed.

4.2.2.4 LED Circuit

The LED circuit (schematic 0103-00-3322 sheets 2 and 3) consists of 18 LED's that indicate the mode and function selected. Referring to sheet 3, a typical digital interface between the microprocessor and a group of circuits on a printed circuit card is illustrated in U4 through U7 (and U3 on the previous page). The microprocessor sets the data bus, QD <0:7>, to the value it wants to send. Then it sets QA0 through QA1 to select Y0, Y1, Y2 or Y3 output of U4, depending on which data register U3, U5, U6, or U7 that it wishes to update with the new data byte. Then it sends the FPS\ signal to strobe the front panel. This strobe is passed to the selected data register and the new data byte is latched in to control its associated circuitry. The three data registers on sheet 3 control the front panel's LED annunciation. 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 Rear Panel

This assembly (refer to the instrument schematic 1004-00-0667) 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 Motherboard Assembly. ~8 Vac is provided to the Front Panel Assembly for display power. Front Panel Assembly provides On/Off switching.

SECTION 5
MAINTENANCE

5.1 PREVENTIVE MAINTENANCE

5.1.1 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.

5.1.2. 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 any time you see they must be done.

5.2 FACTORY SERVICE

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
FAX: (619) 565-9558

5.3 DISASSEMBLY, REASSEMBLY, REMOVAL AND REPLACEMENT

The Model 98 contains three major assemblies: 1) the rear panel, 2) the front panel, and 3) the mother board. The mother board and a printed circuit sub-assembly inside the front panel assembly contain component parts. Access to the mother board for inspection or alignment requires only top cover removal. Mother board components other than power supply pass devices require bottom cover removal. Rear panel removal is also required to replace power supply pass devices. Access to front panel components requires removal and then dissassembly of the front panel. All disassembly/reassembly procedures may be accomplished with a minimum of common hand tools.

WARNING

Dangerous voltages are present with the covers removed. Where maintenance can be performed without power applied, the power should be removed.

5.3.1 Disassembly Instructions

Top Cover Removal:

1. Remove the two screws from the top/center of the cover attaching the cover to the shield.
2. Remove one screw from the back/center of the cover attaching the cover to the rear panel.
3. Slide the top cover straight back and off.

Bottom Cover Removal:

1. Remove the one screw from the bottom/center of the cover attaching the cover to the motherboard.
2. Remove two screws from the back of the cover attaching the cover to the rear panel.
3. Slide the bottom cover straight back and off.

Front Panel Removal:

1. Cover removal is not necessary. Remove the three panel nuts from the front panel BNCs.
2. Remove the two screws at the front of each side panel (in the side panel, *not* in the handle/brackets).
3. Pull the front panel forward an inch to disconnect the front panel/motherboard connector.

WARNING

Dangerous voltages may be present in the next step. Verify that the power cord has been removed to avoid severe safety hazard.

4. Disconnect and detach the two in-line connectors which supply line voltage to the POWER switch.
5. Disconnect the CT wire from the lug on the motherboard.
6. Remove the front panel asembly for further disassembly.

Rear Panel Removal:

1. Remove the top and bottom covers.
2. Remove the three screws along the bottom of the heat sink fins.
3. Remove the two jack screws in the GPIB connector.

WARNING

Dangerous voltages may be present in the next step. Verify that the power cord has been removed to avoid severe safety hazard.

4. Disconnect and detach the two in-line connectors which supply line voltage to the POWER switch.
5. Disconnect the transformer secondary connectors at J2, J10, and J11 on the motherboard.
6. Remove the two screws at the rear of each side panel.
6. Remove the rear panel asembly for further disassembly.

Display/Keyboard Removal:

1. Remove the front panel assembly.
2. Remove the seven self-tapping screws along the border of the small VFD printed circuit board.
3. Fold the VFD board back on its ribbon cable and remove the self-tapping screw on the keyboard under the ribbon cable. Remove the remaining 14 self-tapping screws from the keyboard.
4. Remove the Display/Keyboard.

Motherboard Removal:

1. Remove covers and front panel assembly.
2. Perform steps 2, 3, and 5 of the Rear Panel Removal procedure.
3. Remove two screws holding the shield to the side panels.
4 Remove connector P6 at the 600Ω signal transformer mounting bracket from J6 on the motherboard.
5. Remove the three screws under the motherboard holding the shield to the motherboard.
6. Remove the shield.
7. Pull the motherboard out the front of the unit.

5.3.2 Reassembly Instructions

For reassembly, reverse the steps given for removal. After reassembling the Model 98, check out the unit by performing the Turn-on and Initial Checkout Procedure given in paragraph 2.3.3 of this manual.

5.3.3 Removal and Replacement

Motherboard Component Replacement:

1. Remove top and bottom covers.
2. Set the unit on a side panel so that components can be located from one side and desoldered from the other.

Motherboard Pass Device Replacement:

1. Remove motherboard.
2. Replace the power supply pass devices connected to the rear heat sink bracket.

Keyboard/Display Component Replacement:

1. Remove front panel assembly.
2. Remove Display/Keyboard.
3. Pull the conductive rubber keypad away from the area where components are to be replaced.
4. Replace components.

5.4 CALIBRATION AND ALIGNMENT

For scheduled calibration and maintenance of the Model 98, perform the Performance Verification Procedure of paragraph 2.3.4. If the NOTE following step 4 of the Verification Procedure indicates that the Model 98 requires adjustment, perform the Alignment Procedure of this section. If the Verification Procedure was completed sucessfully, the unit requires no further maintenance.

5.4.1 Alignment Procedure

Table 5-1. Recommended Test Equipment

Test Equipment	Recommended Model
Digital Multimeter	Fluke 8050A or equiv.
50Ω termination	0.1%, ≥ 3 W
Coax cable	RG-58, 3 feet

NOTE

Adjustment tolerances given in the Alignment Procedure are not instrument specifications. Specifications are given in Section 1 and in the limits given for the Performance Verification Procedure in Appendix A.

STEP 1 Initial Setup

1. Remove three top cover screws.

NOTE

Keep the 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.

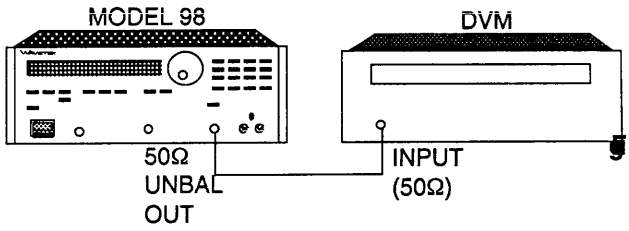
WARNING

Dangerous voltages are present with the covers removed. Where maintenance can be performed without power applied, the power should be removed.

3. Slide the top cover back to make adjustments as necessary in the following steps. Keep the cover in place except when making the adjustment.
5. Allow the unit 1 hour warmup.

STEP 2 Adjust Full Scale Amplitude

1. Connect the test equipment as shown in figure 5-1. Refer to figure 5-2 for adjustment locations.
2. Press the SHIFT then the RESET key. Press Main Output SELECT key until the 50Ω indicator is on.
3. Press the AMPL UNITS key until the display shows amplitude in VPP. Press AMPLITUDE, 15, ENTER and verify unit is set for 15 VPP at the 50Ω output..
4. Set the DVM to read ac volts, true rms, 50Ω ± 0.1% termination.
5. Adjust R42 for 5.303 Vrms ± 2 mVrms.



5-1. Full Scale Adjust Setup

STEP 3 Adjust DC Offset

1. Set the DVM to read dc volts (20 mV range). Press AMPLITUDE, 1.51, ENTER and verify unit is set for 1.51 VPP at the 50Ω output.
2. Adjust R85 for 0.000 Vdc ± 1 mVdc.
3. Press AMPLITUDE, 1.5, ENTER and verify unit is set for 1.5 VPP at the 50Ω output.
4. Adjust R174 for 0.000 Vdc ± 1 mVdc.
5. Repeat steps 1 through 4.

STEP 4 Verify Calibration

1. Complete the Performance Verification Procedure (paragraph 2.3.4).
2. If Performance Verification Procedure is successful, disconnect equipment and reinstall top cover. If a performance problem exists which is not corrected by this alignment procedure, go to Troubleshooting, the next paragraph of this section.

THIS COMPLETES THE ALIGNMENT PROCEDURE

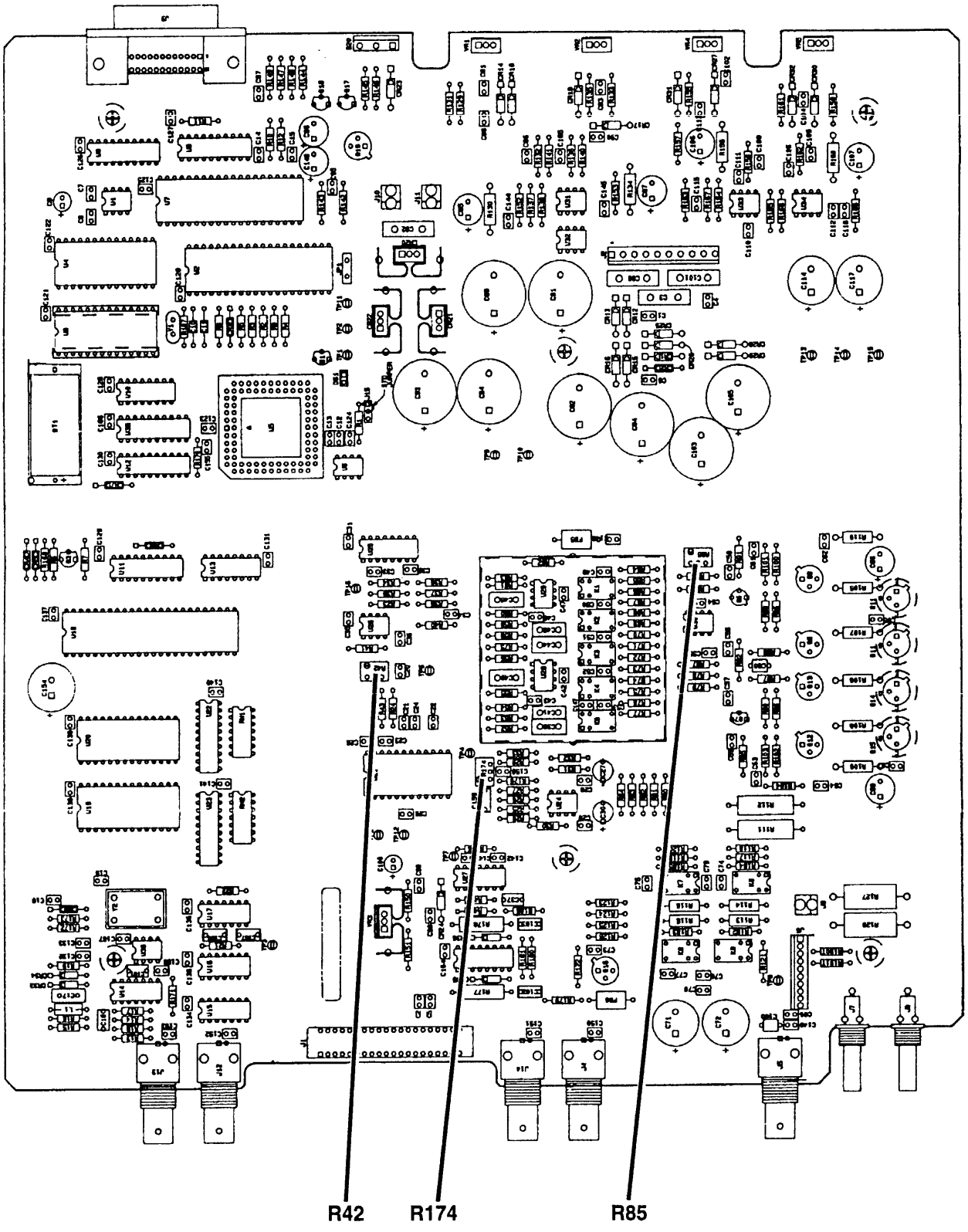


Figure 5-2. Calibration Location

5.5 TROUBLESHOOTING

This section provides a method of troubleshooting the Model 98 to the circuit level. A troubleshooting symptom table is used for fault isolation and direction to specific troubleshooting procedures. The Model 98's performance verification procedure (paragraph 2.3.4) tests the units operating parameters, and as such, it provides symptoms (failed steps) for the table. If the unit fails amplitude or offset performance verification tests, first perform the adjustment procedure (paragraph 5.4) before attempting to troubleshoot.

5.5.1 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.

5.5.2 Before Starting

No troubleshooting guide can possibly cover all the potential problems. The aim of this this section is to guide you to a small functional circuit. Also, it is necessary to become familiar with the instrument by reviewing the functional description and the detailed circuit description (section 4) in conjunction with the schematics (section 6). Successful troubleshooting depends upon understanding the circuit operation within each function block as well as the block relationships.

5.5.3 Inspection

Before before beginning the troubleshooting procedure, use the following inspection procedures to locate obvious malfunctions with the Model 98.

1. Inspect all external surfaces of Model 98 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 98 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 98 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 98 for disconnected, broken, cut, loose, or frayed cables or wires.

5.5.4 Troubleshooting Procedure

This troubleshooting procedure relies on easily recognized failure symptoms and performance verification failures. If during the normal operation the Model 98 fails, note the conditions and consult this table for the closest possible problem.

Table 5-1 lists common failure symptoms and references the recommended troubleshooting procedure or procedures. Table 5-2 lists the items from the performance verification procedure and the recommended troubleshooting procedures.

Table 5-1. Common Failure Symptoms

Symptom	Troubleshooting Paragraph
Fuse blown, panel blank	5.5.4.1, 5.5.4.2
No power on message	5.5.4.1, 5.5.4.3
Random diplay/indicators	5.5.4.1, 5.5.4.3
Missing display segments	5.5.4.14
Keyboard or knob problem	5.5.4.3, 5.5.4.13, 5.5.4.14
Power-on memory loss	5.5.4.3
Outputs missing	5.5.4.1, 5.5.4.3, 5.5.4.4, 5.5.4.6 5.5.4.7, 5.5.4.8 5.5.4.9, 5.5.4.10 5.5.4.11, 5.5.4.12
GPIB problem	5.5.4.3
Amplitude control problem	5.5.4.4, 5.5.4.7, 5.5.4.10
Sweep Out problem	5.5.4.4
Sync or Pen/Marker problem	5.5.4.11
Main Out distortion, clipping	5.5.4.8, 5.5.4.9, 5.5.4.12
Ext Reference problem	5.5.4.5
Sine waveshape breaks up	5.5.4.6
DC offset at 50Ω out	5.5.4.12

Table 5-2. Performance Verification Failures

Test Step Failure	Troubleshooting Paragraph
Freq Range, Res, Acc	
step 3, 4, 5	5.5.4.5
50Ω Amplitude	
step 3	5.5.4.4, 5.5.4.7, 5.5.4.10
step 4	5.5.4.8, 5.5.4.12
step 5	5.5.4.7, 5.5.4.10, 5.5.4.12
50Ω Flatness	
step 4, 5	5.5.4.9
600Ω Amplitude	
step 4, 5	5.5.4.12
600Ω Flatness	
step 4, 5	5.5.4.12
Sine Wave Purity	
step 3, 4, 5	5.5.4.6, 5.5.4.8, 5.5.4.9, 5.5.4.12
Sweep Out	
step 2, 3	5.5.4.4
Sync Out	
step 3, 4	5.5.4.11
Ref In	
step 3, 4, 5	5.5.4.5

5.5.4.1 Power Supply Verification

It is always a good idea to verify the regulated power supply voltages before starting any other troubleshooting procedures. To verify the model 98's supplies, proceed as follows:

1. Connect the power cord to the line. Power on the model 98. Set up a DVM for DCV, 200V range. A DVM called out earlier in this manual, or the Fluke 8050A, will suffice for troubleshooting. Obtain a test cable for the DVM, a "mini-hook" style ball clip is a good choice for the test points used in the Model 98.

2. The power supply circuits are on the motherboard behind the shield. Connect the ground lead of the DVM to TP14 and connect the input lead as indicated to verify the following:

TP9	+12 Vdc ± 0.2 Vdc
TP10	-12 Vdc ± 0.2 Vdc
TP13	+22 Vdc ± 0.5 Vdc
TP15	-22 Vdc ± 0.5 Vdc

   Move the input lead to the cathode or CR1 and verify approximately -16 Vdc negative supply for the VFD.

   Move the ground lead to TP2 and verify the following:

TP11	+5 Vdc ± 0.2 Vdc

   Move the ground lead to TP5 (up in the front, center of the motherboard) and verify the following:

TP12	-5 Vdc ± 0.2 Vdc

   Move the input lead to check at pin 1 of U1 (the LSI device) *on the display board* and verify +15 Vdc ± 0.5 Vdc positive supply for the VFD.

If the above power supplies are good, skip over the next paragraph and use the tables or the remaining troubleshooting paragraphs to fault isolate and repair the unit. If there is one or more faulty supplies, proceed to the next paragraph to troubleshoot.

5.5.4.2 Power Supply Troubleshooting

1. Verify that the power line matches one of the voltage and frequency ranges specified for the Model 98 in Table 2-1. Verify that the voltage selector card (see Figure 2-1) is set properly (the voltage which can be read through the "window" is the mid-point of the selected range). Verify that the line cord is connected.

2. If the unit shows no signs of powering up when the line switch is on, check the fuse per paragraph 2.3.2. Replace only with fuse of same voltage and current rating per Table 2-1. If the unit has LED indicators, but the display is dark, press SHIFT and then RESET to reset the display intensity. If the intensity had been set very low, the display should now read "--RESET ALL--".

3. Verify that the connectors P2/J2 and P3/J3 to the power switch are mated. Verify transformer secondary wiring connectors are properly mated to the motherboard connectors J2, J10 and J11.

4. Check the unregulated dc voltage inputs to the power supply regulators as follows:

   Obtain a DVM and test cable per the previous paragraph. Connect the ground lead of the DVM to TP14 and connect the input lead as indicated to verify the following:

Cathode CR12/13	+20 Vdc ± 12%
Anode CR15/16	-20 Vdc ± 12%
Cathode CR25/26	+35 Vdc ± 12%
Anode CR28/29	-35 Vdc ± 12%

   Move the ground lead to TP2 and verify the following:

Cathode CR23	+10.8 Vdc ± 12%

   The voltages given are nominal, the percent variation accounts for allowable line voltage variation plus component variations.

5. If the unregulated inputs are normal, check the +10 Vdc voltage reference in the +12 Vdc regulator. Connect the DVM common to TP14 and check U32 pin 6 for +10.00 Vdc. Do not continue with the following steps until the +10V reference is good.

6. The -12V supply is referenced from the +12V supply, which is referenced from the +10V reference. Likewise, the -22V supply is referenced from the +22V supply, which is referenced from the +10V reference. The +5V supply is also referenced from the +10V reference. If the +10V reference is good, perform the power supply verification of the previous paragraph and record the various voltage readings.

7. If the +12V and +22V supplies are good proceed to the next step. Otherwise, troubleshoot either supply as follows. The components named will refer to the +12V supply. When troubleshooting the +22V supply, use the parts and readings called out in parenthesis. Isolate the supply from its load by lifting one side of jumper R152 (R163). If the supply

is now good, faulty components on the motherboard which are connected to the supply are loading it down. Troubleshoot by lifting and then replacing components until the power supply is good with only the components in faulty area lifted. If the power supply is still bad with the jumper lifted, troubleshoot the regulator. Check the voltage at pin 2 of U31A (U33). It should be +10V, but in a faulty supply it should be off in the same direction that the supply is off. If so, the op-amp should be saturated to its supply voltage in the opposite direction. If not, the op-amp is probably bad. If the op-amp is good, then regulator VR1 (VR4) or one of its associated components is probably bad. When the supply is repaired, replace all lifted components/jumpers.

8. If the -12V and -22V supplies are good proceed to the next step. Otherwise, troubleshoot either supply as follows. The components named will refer to the -12V supply. When troubleshooting the -22V, use the parts and readings called out in parenthesis. Isolate the supply from its load by lifting one side of jumper R153 (R166). If the supply is now good, faulty components on the motherboard which are connected to the supply are loading it down. Troubleshoot by lifting and then replacing components until the power supply is good with only the components in faulty area lifted. If the power supply is still bad with the jumper lifted, troubleshoot the regulator. Check the voltage at pin 6 (2) of U31B (U34). It should be 0V, but in a faulty supply it should be off in the same direction that the supply is off. If so, the op-amp should be saturated to its supply voltage in the opposite direction. If not, the op-amp is probably bad. If the op-amp is good, then regulator VR2 (VR5) or one of its associated components is probably bad. When the supply is repaired, replace all lifted components/jumpers.

9. If the +5V supply is good proceed to the next step. Otherwise, isolate the supply from its load by lifting jumper JP1. If the supply is now good, faulty components on the motherboard which are connected to the supply are loading it down. Troubleshoot by lifting and then replacing components until the power supply is good with only the components in faulty area lifted. If the power supply is still bad with the jumper lifted, troubleshoot the regulator. Check the voltage at the bases of Q17 and Q18 for +2.5V. The voltage at Q18 base should be off in the same direction that the supply voltage is off. If the supply is high, Q17 should be off and its collector voltage should be near the unregulated voltage value. If the supply is low, Q17 should be saturated, and its colector voltage should be approximately half the output voltage. If incorrect, check Q127/Q18. If correct check Q19/Q20. When the supply is repaired, replace all lifted components/jumpers.

10. If the -5V supply is good, proceed to the next step. If it is bad, either the regulator VR3 and associated circuitry is bad, or if the -5V is low in value, U21 may be loading it down.

11. If the VFD negative supply is bad, check CR1/CR2 on the motherboard.

12. If the VFD positive supply is bad, check VR1 on the display/keyboard.

5.5.4.3 Microprocessor/GPIB

After verifying power supplies, check the operation of the microprocessor system. With power on, check behind the shield for a flashing "life light" DS1.

When flashing, this indicates that the microprocessor U2 is processing code. For this to happen, the reset generator U1, clock Y2, ROM U3, RAM U4, EEPROM U6, PSC288 U5, and associated components shown on sheet 2 of the motherboard schematic are functioning. All "internal" busses (those connected to U2) are functional. However, "external" busses, QA0:3 and QD0:7, driven by the PSC288 can be faulty. Additionally, the strobes and control lines for the GPIB, control registers, sweep ramp generator, and the AGMC U18 could still be faulty with a flashing "life light".

If the 'Life Light" is not flashing, proceed as follows:

1. Obtain an oscilloscope and X10 probe. Connect the probe from TP2 (common) to TP1 MRST\. Cycle power to the unit and observe the reset line. It should stay low for a second after turning on the power, and then go high. If not, check U1 and associated circuitry.

2. Verify a 5 MHz clock at U2 pin 3. If not, go to paragraph 5.5.4.5.

3. Verify that the 6803 microprocessor receives Mode 2 initialization during the power up reset period. Connect the probe to pin 8 of U2 while cycling power. In the second before the MRST\ goes high, pin 8 should be low, and then be replaced by its operational signal. Connect the probe to pin 8 of U2 while cycling power. In the second before the MRST\ goes high, pin 9 should be high, and then be replaced by its operational signal. Pin 10 should be low.

4. Verify U2 interrupt lines, pins 4 and 5, are high.

5. The following are U2 pins which are or may be driven by U2, and will normally have TTL level

activity on them. Verify each line and ensure that it is not "stuck" high or low. If any are "stuck", U2 may have a faulty driver, or another device in the microprocessor system connected to the "stuck" lines may be loading them.

pin 40	E clock
pin 39	AS
pins 22-29	A8-A15
pins 30-37	AD0-AD7
pin 38	R/W

5. The following are U5 pins which are or may be driven by U5, and will normally have TTL level activity on them. Verify each line and ensure that it is not "stuck" high or low. If any are "stuck", U5 may have a faulty driver, or another device in the microprocessor system connected to the "stuck" lines may be loading them.

pin 78	ROM
pin 79	RAM
pin 77	WE
pin 2-6, 81-83	A0-A7

6. Replace U2, U3, U4 or U5 as indicated by troubleshooting for "stuck" lines. U5 is socketed.

If the "Life Light" is flashing, but the unit does not respond or operate, verify that the "external" control signal and busses from the microprocessor system are operating, as follows:

1. The following are U5 pins which are or may be driven by U5, and will normally have TTL level activity on them. Verify each line and ensure that it is not "stuck" high or low. If any are "stuck", U5 may have a faulty driver, or another device connected to the "stuck" lines may be loading them. U5 is socketed.

pin 80	GPIB
pin 7	FPSTB\
pin 8	REG-STB\
pin 9	CS-AGMC\
pins 12-15	QA0-QA3
pins 16-25	QD0-QD7
pin 29	SEN
pin 30	SDAT
pin 31	SCK
pin 36	SHCLK
pin 37	SHDATA
pin 38	SHEN
pin 39	RKA
pin 40	RKB
pin 53	FOUT
pin 62	IRQ
pin 11	PRST

2. The first four strobe lines are very important. Without GPIB, the processor will not read or write to the GPIB port. Without FPST\, the processor will not write to the front panel. Without REG-STB\, the processor cannot write to the Control Registers and control the oscillator circuits. Without CS-AGMC, the processor cannot control the phase accumulator DDS chip. They should have periodic activity at all times.
3. QA0-QA3 and QD0-QD7 are the "quiet" address and data bus, respectively. These are the processor's address and data bus with "internal" bus transactions removed. They should be busy at all times.
4. The SEN, SDATA, and SCLK line operate the EEPROM U6. This should be looked at if the unit does not store its GPIB address.
5. The SHCLK, SHDATA, and SHEN lines are the serial data to the Fine Amplitude Control DAC. Look for activity as amplitude is changed.
6. The IRQ, RKA, and RKB lines should be active when the front panel control knob is activated.
7. The FOUT line allows the microprocessor to use its timing input to verify the sync, marker, and pen lift outputs. The PSC288 selectes one of the three inputs, divides it by 2^n, and outputs the FOUT signal to the 6803 TIN input. Look for the sync frequency (1 kHz default) after a RESET ALL.
8. The PRST\ output keeps the output off while power is cycling. It should be low afer power up to allow the outputs to come on.

To troubleshoot the GPIB, first ensure that the "Life Light" is flashing and the PSC288 has activity at its outputs (especially the GPIB strobe). Then set up the unit according to paragraph 3.2.6. Repeatedly send the unit a GPIB command, using a looping program in the controller. Verify that the GPIB Address is set right. Use a GPIB Bus Monitor, or check each of the I/O lines at the transceivers U8 and U9 with a probe. If the transceivers are good, U7 is probably at fault.

5.5.4.4 Control Registers and Sweep Ramp Generator

These circuits are located on sheet 4 of the motherboard schematic. Troubleshoot as follows:

1. Preset the unit with a RESET ALL, and then change the Sweep Mode to CONT-RST to ensure that the registers are being written to. Verify U10 pin 5, REG-STB\, has an approximate 0.5 µs negative pulse occuring at a 1 ms rate. If not, return to the previous troubleshooting paragraph.
2. Observe pulses at U10 pins 15, 13 and 12. Press the AMPLITUDE key and hold the probe on U10 pin 14. Spin the control knob rapidly and observe pulses at pin 14, too. If not, U10 is faulty.
3. Press parameter RESET to set amplitude back to default. Look at U11 pins 19 through 12 and observe the following bit pattern:

   pin 19 low
   pin 18 high
   pin 17 high
   pin 16 low
   pin 15 low
   pin 14 high
   pin 13 high
   pin 12 high

   If incorrect, U11 is probably faulty. Verify the same bit pattern at U13's outputs.
4. With Sweep Mode at CONT-RST, look at the output pins of U12:

   pin 19 high
   pin 18 low
   pin 17 low
   pin 16 1 kHz square
   pin 15 high
   pin 14 low
   pin 13 high
   pin 12 high

   If incorrect, U12 is probably faulty.
5. Check the SWEEP OUT BNC for a 0V to +5V ramp occuring at a 1s rate. If missing, troubleshoot the U35/U36A circuitry.

5.5.4.5 Reference Clock

These circuits are located on sheet 5 of the motherboard schematic. Troubleshoot as follows:

1. Press SHIFT and then RESET. Ground the scope probe to TP5 at the front, center of the motherboard. Verify U16B pin 9 has a 5 MHz square. Otherwise look at Y2 and U16.
2. Verify 5 MHz also at TP3. If good, skip to step 4. If not, check U15 pin 2 for a low and pins 3 and 12 for a high. If pin 2 is low, U15 is faulty. If pin 2 is high, the problem is in the U14 circuitry. Troubleshoot U14 in the next step.
3. Verify the following U14 pin voltages with a DVM:

pin 1	+10 mV
pin2	+100 mV
pin 11	+100 mV
pin 12	0V

   Also verify TTL high at pin 4 and a TTL low at pin 9. If any of the above readings is incorrect, troubleshoot the U14 circuitry. If pin 9 is high, verify that L1 is not open.

10. Connect an external 10 MHz reference >600 mVp-p to the 10 MHZ REF IN BNC. Verify U14 pin 4 is 10 MHz and pin 9 is high.

5.5.4.6 AGMC and Waveform Memory

These circuits are located on sheet 6 of the motherboard schematic. Troubleshoot as follows:

1. Press SHIFT and then RESET. Set Sweep Mode to CONT-RST. Verify CS-AGMC\ pulses low every 1 ms at pin 18 of U18. If not, go back to paragraph 5.5.4.3.
2. Verify PAINCSEL is a 1 ms square at pin 19 of U18. Also, AGMC4 and AGMC5 at pins 16 and 17 are low. If not, go back to paragraph 5.5.4.4.
3. Verify a 5 MHz clock at U18 pin 24. If not, go back to paragraph 5.5.4.5.
4. Verify QA0-3 and QD0-7 inputs. If not active, go back to paragraph 5.5.4.3.
5. WA0-12 outputs. WA12, pin 26, should be the 1 kHz to 10 kHz swept frequency programmed into the unit. Going down the pins to WA0, the frequency should increase at each step. If not, U18 is probably bad.
6. Check WD4 through WD15 at the outputs of the waveform memory. The patterns and frequencies

at these outputs will not be quantifiable. However, they should all show activity. Replace U19 or U20 if an output line is missing. When the Waveform DAC and Pre-Amp block is operational, the waveform can be observed, and if it has deviations from a clean sine wave, check the sine ROMs U19/U20 and the output registers U22/U23 again. By syncronizing the scope to the Pre-Amp output on CH1, and studying the various bit patterns of each line on CH2, a line with bad data will correspond to the abberations in the sine.

5.5.4.7 Fine Amplitude Control

These circuits are located on sheet 7 of the motherboard schematic. Troubleshoot as follows:

1. Press SHIFT and then RESET. Monitor U26A pin 3, VOUT, as amplitude is varied between 1.50 and 1.51 VPP. The DVM should indicate a voltage variance between +2.46Vdc and +3.05Vdc. If good, go on to step 2. If not, verify that the SHCLK, SHDATA, and SHEN lines show activity as AMPLITUDE is varied. If bad, go back to paragraph 5.5.4.3. If the serial lines vary, but the voltage is not right, U25 is probably bad.
2. Check TP16 with the DVM for -1.0 Vdc. If bad, check the U26B circuitry.
3. Check TP6 for approximately +1.5 Vdc with AMPLITUDE at 1.51 VPP, and for approximately +2.1 Vdc with AMPLITUDE at 1.50 VPP. If bad, check U26A and R42 adjustment.

5.5.4.8 Waveform DAC and Pre-Amp

These circuits are located on sheet 7 of the motherboard schematic. Troubleshoot as follows:

1. Verify 5 MHz clock at U22/U23 pin 11 and at U21 pin 16. If missing, return to paragraph 5.5.4.5.
2. Verify data activity at the input pins of U22/U23. If missing, return to paragraph 5.5.4.6.
3. Verify data activity at DB1-12 output pins of U22/U23. If a line or lines are missing, change the associated data register.
4. Verify -5 Vdc at U21 pin 18.
5. Check U21 pins 19 and 20 for -1.0 Vdc. If bad, and the TP6 and TP16 readings of the previous paragraph are good, then U21 is bad.
6. Check U21 pins 6 and 7 for an approximate 0V to -1V, 1 kHz sine wave. If missing, U21 is probably bad. If offset or distorted, U24 could be the cause.
7. Check TP4 for a 5 Vp-p, 1 kHz sine wave. If missing or distorted, U24 is probably bad.

5.5.4.9 Low Pass Filter

These circuits are located on sheet 8 of the motherboard schematic. Troubleshoot as follows:

1. Press the SHIFT and then the RESET keys. Verify the 5 Vp-p, 1 kHz sine wave at TP4 per the previous paragraph.
2. Check TP7 for the same waveform as in step 1. If bad or missing, isolate between U28 and U29 by checking at their output pins 6. Repair the filter section so that the waveform at TP7 is 5 Vp-p.
3. Press SHIFT and then "9". The display should read "FILTER TEST". Observe the envelope of the swept signal. The low end of the sweep should have an amplitude of 5 Vp-p, and the high end should be rolled-off by the filter.

5.5.4.10 Coarse Amplitude Control

These circuits are located on sheet 8 of the motherboard schematic. Troubleshoot as follows:

1. Press SHIFT and then RESET. Verify the 5 Vp-p signal at TP7 of the previous paragraph.
2. Verify U30 pin 2 is 0 Vdc. If not, skip to paragraph 5.5.4.12.
3. Press AMPLITUDE rotate the control knob and verify that the relays periodically "click" as the control varies. If not, return to paragraph 5.5.4.4.
4. A problem with this area should be limited to a bad relay or an off-value precision resistor. A bad relay will show up as an irregular amplitude step. With the Output AMplifier operational, monitor the output on a scope as the AMPLITUDE value is slowly rotated from 1.51 Vp-p to 15 Vp-p. Look for a smooth increase in amplitude. If an amplitude irregularity is found, locate which control line, PATN0\ through PATN4\, occurs at the same time as the bad step. Then replace the relay associated with that control line.
5. An off-value resistor can cause the same sort of amplitude irregularity, but generally less noticable. In this case, track the amplitude up from 1.51 Vp-p to 15 Vp-p and record values using a DVM. If there is a curvature to the data, power the unit down and lift one side of each of the 1k, 0.1% resistors. Measure the resistors with a DMM and replace any out of tolerance resistors.

5.5.4.11 Sync/Marker Output

These circuits are located on sheet 8 of the motherboard schematic. Troubleshoot as follows:

1. Press SHIFT and then RESET. Verify the 5 Vp-p signal at TP7 per paragraph 5.5.4.9. Check U27 pin 4 for a 1 kHz TTL signal. If missing, U27 is probably bad.
2. Check the SYNC OUT BNC for a 1 kHz, TTL signal. If bad or missing, change U38.
3. Change Sweep Mode to CONT-RST and Sweep Time to 0.03 s. Verify that U38 pin 10 is high and pin 12 is a 1 ms positive pulse occuring every 30 ms. If incorrect, U12 is probably bad.
4. Change Pen Lift/Marker Select to "PEN". Verify that U38 pin 12 is high and pin 10 is a 1 ms positive pulse occuring every 30 ms. If incorrect, U12 is probably bad.
5. Check the PEN LIFT/MARKER OUT BNC for a TTL level 1 ms pulse occuring every 30 ms. If bad or missing, change U38.

5.5.4.12 Output Amplifier and Attenuator

These circuits are located on sheet 9 of the motherboard schematic. Troubleshoot as follows:

1. Press SHIFT and then RESET. Verify the 5 Vp-p signal at TP7 per paragraph 5.5.4.9. If the output amplifier is good, U30 pin 2 will be at 0 Vdc, and the right-hand side of R111/R112 will be an approximate 6 Vp-p sine wave with no appreciable dc offset. Troubleshoot a bad amplifier as follows.
2. Check the emitters of Q6/Q7 for approximately ± 18 Vdc. If bad, check the Q6/Q7 transistors and their biasing resistors.
3. Check the emitters of Q8/Q12 for approximately ± 19 Vdc. If bad, check Q8, Q9, Q12, and Q13.
4. Verify that the voltage at the collector of Q8, Q9, Q12, and Q13 (the "can" is the collector) corresponds roughly to the output voltage at R111/R112. If not, check the output transistors Q10, Q11, Q14, and Q15. Note that the transistor pairs are in parallel and the only way to be sure is to remove them.
5. If the output is saturated, U30 pin 2 should be pulled away from 0 Vdc in the same direction. If U30's output is not saturated to its supply in the opposite direction, then U30 is bad.
6. If the output amplifier is good, and the the 50Ω output is bad, check K6, K7 and K8.
7. If the 50Ω output is good, select the 600Ω output and verify a 1 Vrms sine wave. If bad or missing, check C71, C72, P6, T2, R127 and R128.

5.5.4.13 Keyboard

These circuits are located on sheet 2 of the Display/Keyboard schematic. Troubleshoot as follows:

1. Check U4 (display/keyboard, stand the unit up on its handles) pin 4 for negative pulses occuring at irregular intervals of approximately 50 µs. If missing, go back to paragraph 5.5.4.3 (FPSTB\). Then check U2 pin 11 for negative pulses occuring every 0.25 ms. If bad or missing, U4 is probably bad.
2. Check U2 pins 9, 10, and 11 for negative pulses occuring every 20 ms. If missing, U3 is probably bad.
3. Check U2 pins 13, 14, 15, 12, 1, and 5 for positive "pulses" ocuring at 20 ms intervals. The fall times will have a large time constant. If bad or missing, replace U2.
4. If the keyboard is still not functional, substitute another model 98 front panel to verify that the problem is in the keyboard printed circuit board. Alternatively, the keyboard could be removed, and the keypad cleaned and the pcb key "targets" cleaned and burnished.

5.5.4.14 Display and Annunciators

These circuits are located on sheets 1 and 3 of the Display/Keyboard schematic. Troubleshoot as follows:

1. The LED annunciators on sheet 3 are controlled by U4 (already checked) and registers U5, U6 and U7. If individual LEDs are not turning on when they should, the LED is probably bad. Test this by looking for a low at the LED cathode when it should be turned on. If the low is present, the LED is bad. If the low is missing, the data register supplying the control signal is bad. If a group of LEDs don't turn on, relate them to a register (U5, U6, or U7) and verify that the register is getting a clock from U4. If so, then the register is probably bad.
2. The components on sheet 1 relate to the display and the control knob. SW1 is the control knob. If the knob is not working, first inspect it for mechanical breakage. If the knob appears unbroken, check that the two wiper voltages pulse up and down as the knob is rotated. If so, the knob may be good and U6 on the motherboard (see paragraph 5.5.4.3) may be faulty.

3. Verify +15V supply at pin 1 of U1.
4. Check the display for data input as follows. Locate the Q1, Q2, Q3 near the top edge of the display board. Press the Sweep Mode key. Note that when the control knob is rotated back and forth, the display is updated. Monitor the collector of each transistor as the knob is rotated. Observe 15V positive pulses as the kob is rotated. If not, troubleshoot Q1, Q2, Q3, the ribbon cable, and U3 on the keyboard.
5. Observe the row of connector pins along the bottom edge of the display board (under the ribbon cable between the display and keyboard). This is the VFD connector. The first and last pins of the VFD connector have the filament supplies. Verify approximately 12 Vp-p line frequency riding on -16 Vdc on both these connector pins.
6. Observe each of the output pins going from U1 to the VFD with a scope probe. Vary display message as necessary to activate each line. The active signal is positive pulses going from -22 V to +15 V. If these lines cannot be made active, then U1 is bad.
7. If the display is still blank or has missing elements, the VFD is bad.

SECTION 6
PARTS LISTS AND SCHEMATICS

6.1 DRAWINGS

The following assembly drawings, schematics, and parts lists are arranged in order shown below.

6.1 .1 Assembly Drawings

All of the mechanical assembly drawings are show in this section. These drawings contain enough detail and clarity to assist the repair technician in the disassembly and reassembly of the Model 98. The parts lists for each assembly drawing immediately follow that drawing.

6.1.2. Schematics

All of the schematics for the Model 98 are shown in this section. Schematic drawings containing a proprietary message may not be copied for resale or use in any other publication nor for any use other than the repair and maintenance of the instrument associated with this manual.

6.1.3 Parts Lists

The parts lists for each individual board or assembly are shown immediately following that board or assembly. The parts lists contain Wavetek and manufacturers parts information. All manufacturers are listed by a Wavetek code designation. To convert the Wavetek code to a manufacturers name and address or FSCM, refer to table 6-1, Wavetek Code to FSCM and Manufacturers Name and Address.

6.2 ADDENDA

Under Wavetek's product improvement program, the latest electronic designs and circuits are incorporated into each Wavetek instrument as quickly as development and testing permits. Because of the time needed to compose and print instruction manuals, it is not always possible to include the most recent changes in the initial printing. Whenever this occurs, addendum pages are prepared to summarize the changes made and are inserted immediately inside the rear cover. If no such pages exist, the manual is correct as printed.

6.3 ORDERING PARTS

When ordering spare parts, please specify the part number, circuit reference, board, serial number of the unit, and, if applicable, the function performed.

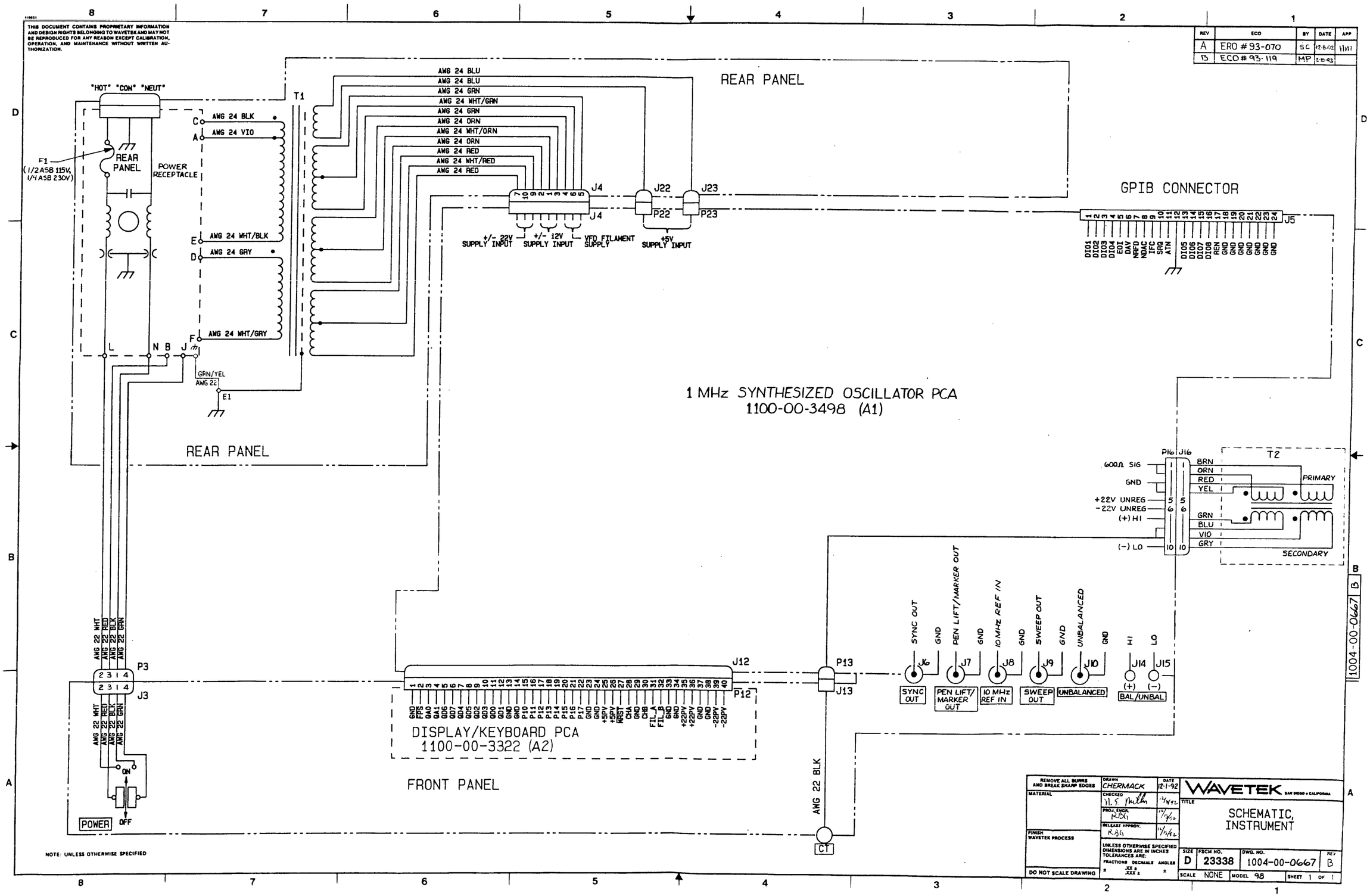
The number etched into a PC board is the board part number. The assembly (PC board and components on the board) part number is stamped on the board.

DRAWING	DRAWING NUMBER
Instrument Schematic	1004-00-0667
Instrument Assembly	1001-00-0667
Instrument Parts List	1000-00-0667
1 MHz Synthesized Oscillator Board Schematic	1104-00-3498
1 MHz Synthesized Oscillator Board Assembly	1101-00-3498
1 MHz Synthesized Oscillator Board Parts List	1100-00-3498
Display / Keyboard Schematic	1104-00-3322
Display / Keyboard Assembly	1101-00-3322
Display / Keyboard Parts List	1100-00-3322

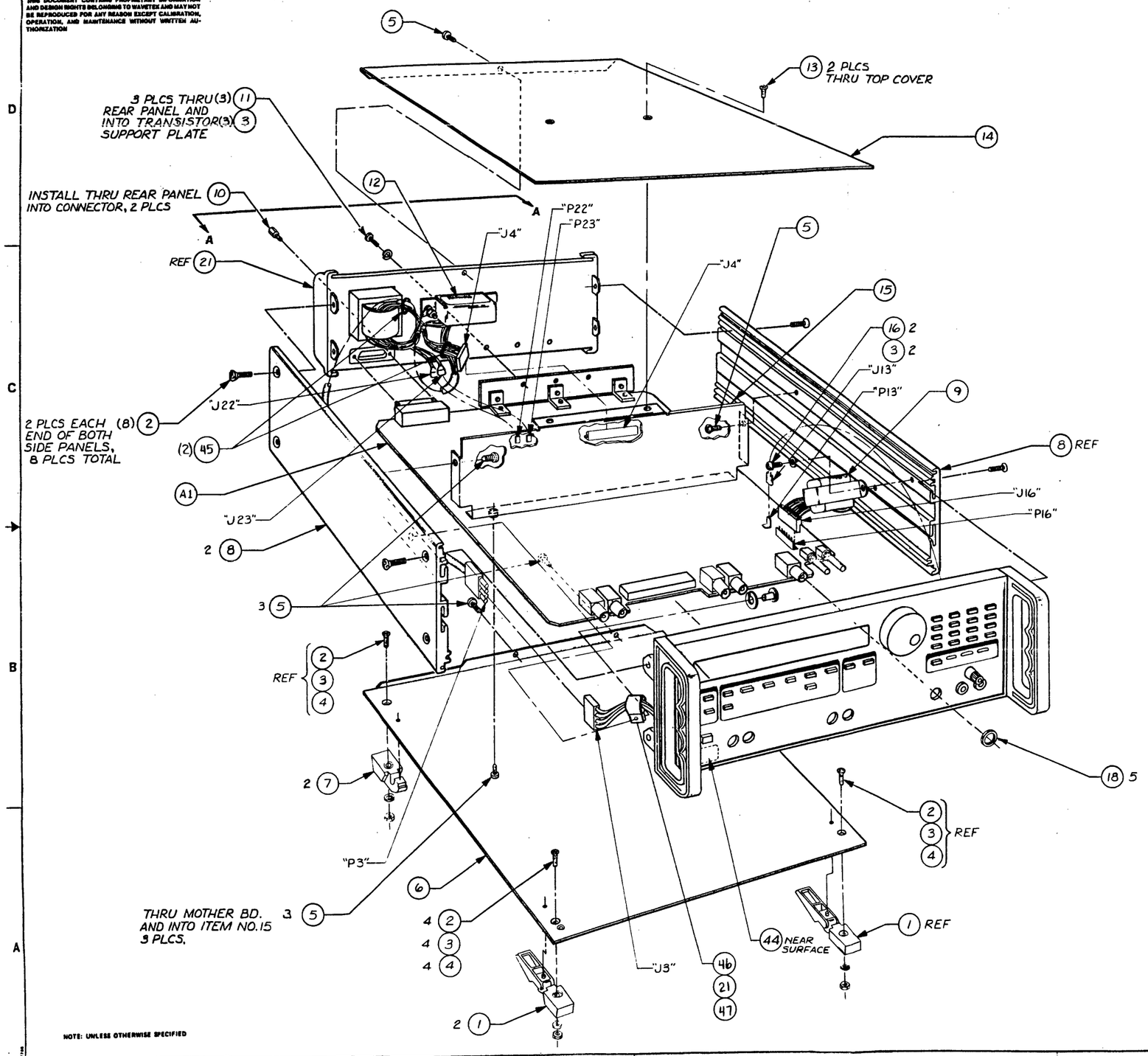
Table 6-1. Wavetek Code to FSCM (Cage Code) and Manufacturers Name and Address.

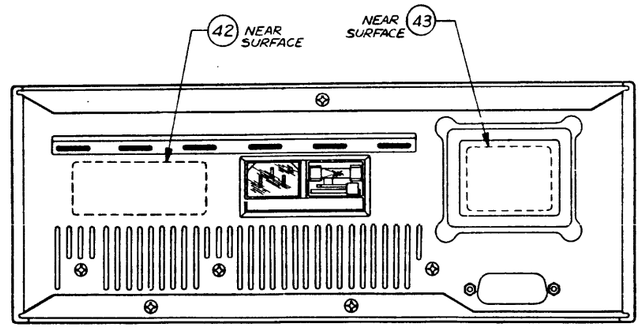
Wavetek	Manufacturer	Cage Code	Address	City	State	Zip
AAVID	Aavid Engineering Inc.	30161	1 Kool Path, PO Box 400	Laconia	NH	03247
AB	Allen Bradley	01121	1201 South 2nd st.	Milwaukee	WI	53204
AMP	AMP Incorporated	00779	2800 Fulling Mill	Middletown	PA	17057
APTRN	3M Co.-Electronic Products Div. (formerly Aprtronics)	53387	3M Austin Center	Austin	TX	78769
ARCO	Arco Electronics Inc.	24652	2325 E. Michigan Rd.	Shelbyville	IN	46176
AROMT	Aromat Corp.	61529	629 Central Ave.	New Providence	NJ	07974
AVX	AVX Ceramics	96095	Seneca Ave.	Olean	NY	14760
BECK	Beckman Instmts Inc.	73138	4200 Bonita Pl.	Fullerton	CA	92635
BIVAR	Bivar Inc.	32559	4 Thomas St	Irvine	CA	92718
BOURN	Bourns Inc.	80294	1200 Columbia Ave, Bldg. C	Riverside	CA	92507
BURND	Burndy	09922	Richards Ave	Norwalk	CT	06856
BURR	Burr-Brown Corp.	13919	6730 S Tuscon Blvd.	Tuscon	AZ	85734
CAMBN	Interconnection Products (formerly Cambion Division)	71279	2601 S. Garnsey St.	Santa Ana	CA	92707
COML/CMRCL	Commercial fastener hardware	N/A	N/A	N/A	N/A	N/A
COMPO	AVX Tantalum Corporation (formerly Corning/Components Corp.)	17554	69 Landry St.	Biddeford	ME	04005
CONCD	Concord Electronics	18310	30 Great Jones St	New York	NY	10012
CORNG	Corning Electronics	24546	550 High St.	Bradford	PA	16701
CRL	Centralab (Div. of North American Philips)	71590	Hwy 20, PO Box 858	Ft. Dodge	IA	50501
DLVAN	Delevan	99800	270 Quaker Rd.	East Aurora	NY	14057
ELAN	"Elantec, Inc."	64762	1996 Tarob Ct.	Milpitas	CA	95035
EMHRT	Pop Fasteners (formerly USM Corp. Div. of Emhart Industries)	07707	510 River Rd.	Shelton	CT	68100
EXEL	Exel Microelectronics	66419	2150 Commerce Dr.	San Jose	CA	95131
FAIR	Fairchild	07263	464 Ellis St.	Mountain View	CA	94042
FARITE	Fair-Rite	34899	1 Commercial Row	Wallkill	NY	12589
FASTX	Fastex Div. of Illinois Tool Works	02768	195 Algonquin Rd.	Des Plaines	IL	60016
FOX	Fox Electronics	61429	6225 Presidential Ct.	Fort Meyer	FL	33905
FUJI	Fujitsu America Inc.	3R731	2945 Oakmead Village Ct.	Santa Clara	CA	95051
HP	Hewlett Packard	28480	3000 Hanover St.	Palo Alto	CA	94304
IERC	International Electronics Research Corp	98978	135 W Magnolia St, POBox 7704	Burbank	CA	91502
KEMET	Kemet Electronics Corp.	31433	2835 Kemet Way	Simpsonville	SC	29681
LESIG	Accurate Rubber Products - Div. of Lear Siegler	08065	4370 Jutland Dr.	San Diego	CA	92117
LINTE	Linear Technology	64155	1630 McCarthy Blvd.	Milpitas	CA	95035
LITE	Lite-on and Vision Inc.	0RW67	17779-8 Main St.	Irvine	CA	92714
LITFU	Littlefuse	75915	800 Northwest Hwy.	Des Plaines	IL	60016
MEPCO	Mepco/Electra (N.A. Philips Corporation)	19701	60 Flounders Blvd.	El Paso	TX	79906
MOT	Motorola	04713	5005 E McDowell Rd.	Phoenix	AZ	85008
NAT/NSC	National Semiconductor	27014	2900 Semiconductor Dr.	Santa Clara	CA	95051
NEC	NEC Electronics	4T165	401 Ellis St	Mountain View	CA	94039
NIC	NIC Components Corp.	0EHX1	6000 New Horizons Blvd	North Amityville	NY	11701
PANAS	Panasonic Co.	54473	One Panasonic Way	Secaucus	NJ	07094
PHLIP	North American Philips Corporation	59821	7158 Merchant Ave.	EL Paso	TX	79915
ROHM	R-ohm Corp.	57668	16931 Milliken Ave	Irvine	CA	92713
RCA	Harris Corp.	34371	200 Palm Bay Blvd., POBox 883	Melbourne	FL	32902
ROCK	Rockwell/Ferrocom	34576	4311 Jamboree Rd.	New Port Beach	CA	92660
SCHRF	Schroff Inc.	62559	170 Commerce Dr.	Warwick	RI	02886
SESTM	Seastrom Mfg. Co. Inc.	86928	701 Sonoro Ave.	Glendale	CA	91201
SGS	SGS	66958	1000 E. Bell Rd.	Phoenix	AZ	85022
SIG	Signetics	18324	811 E Arques	Sunnyvale	CA	94086
SMITH	Kukla Smith - H.H. Smith Div.	83330	1913 Atlantic Dr.	Manaquan	NJ	08736
SONY	Sony	8V413	1 Sony Dr.	Park Ridge	NJ	07656
SPRAG	Sprague Electronics	56289	61 Split Brook Rd., Ste. 305	Nashua	NH	03060
STKPL	Stackpole	78488	201 Stackpole St.	St. Mary	PA	15857
SUPER	Supertex Inc.	59640	1225 Bordeaux Dr.	Sunnyvale	CA	94086
TI	Texas Instruments	01295	13500 N Central Expressway	Dallas	TX	75265
TRW	TRW	01281	14520 Aviation Blvd.	Lawndale	CA	90260
UNCON	United Chemi-Con	62643	9806 Higgins St	Rosemont	IL	60018
WAKE	EG&G Wakefield	05820	60 Audobon Rd.	Wakefield	MA	01880
WVTK	Wavetek Corp. - Instruments Division	23338	9045 Balboa Ave.	San Diego	CA	92123

REV	ECO	BY	DATE	APP
A	ERO #93-070	SC	12-8-92	
B	ECO #93-119	MP	2-10-93	



REV	ECO	BY	DATE	APP
A	ERO 93-070	[illegible]	[illegible]	[illegible]
B	ECO#93-119	MF	2-16-94	





VIEW A-A

⚠1 1/2 A SLOW BLOW FUSE IS INSTALLED IN REAR PANEL FOR 100V/120V APPLICATION.
1/4 A SLOW BLOW FUSE IS SUPPLIED WITH UNIT FOR 220V/240V APPLICATION.

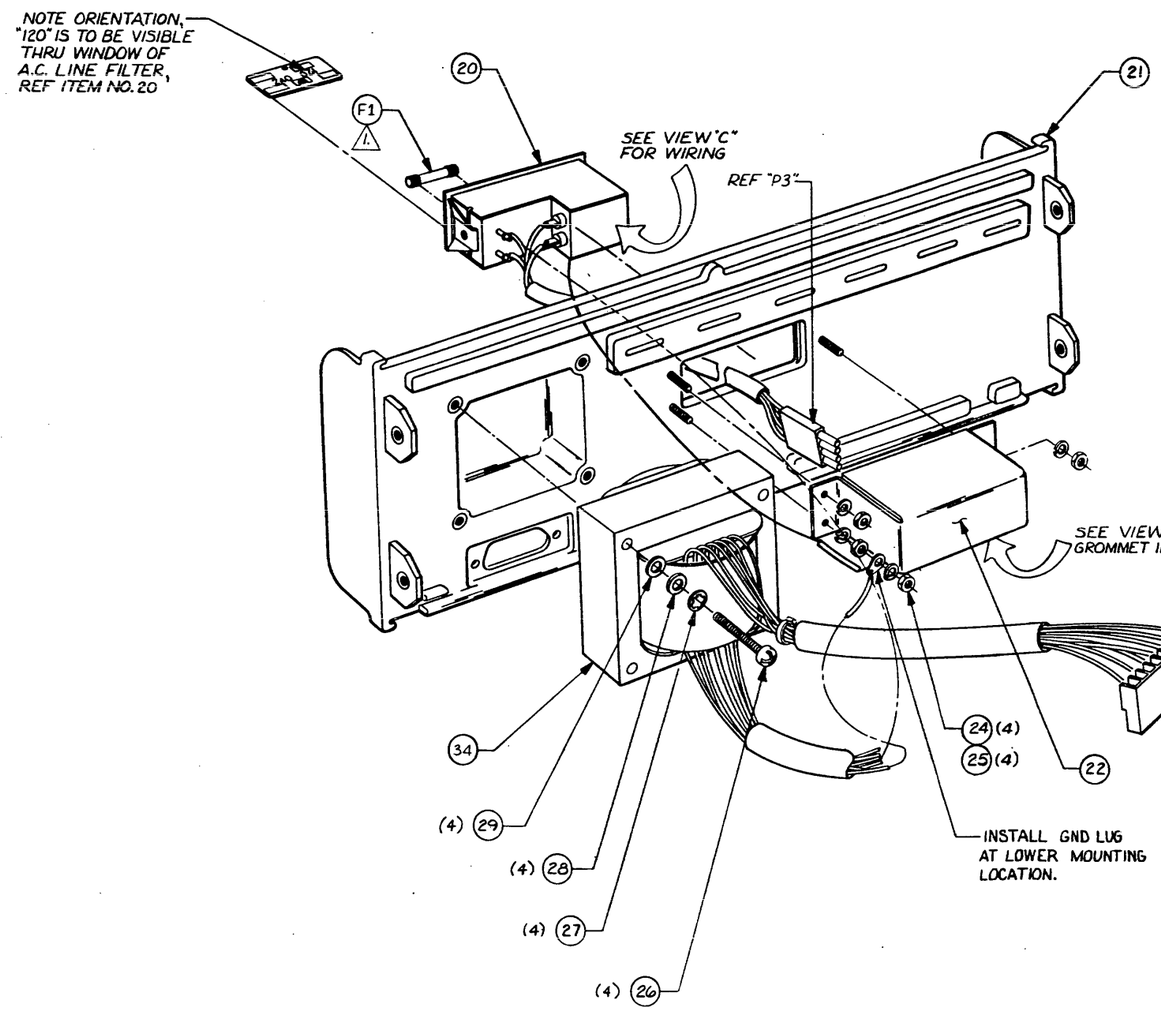
NOTES: UNLESS OTHERWISE SPECIFIED. SEE SEPARATE PARTS LIST.

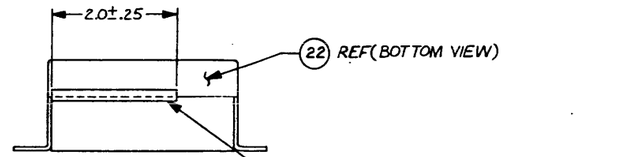
NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN A SMITH/ CHERMACK	DATE 4-16-93	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED M. S. Mth	12/11/93	TITLE ASSEMBLY, INSTRUMENT (1 MHz POWER OSCILLATOR)
	PROJ. ENGR. RBL	1/5/93	
FINISH WAVETEK PROCESS	RELEASE APPROV RBL	1/6/94	
DO NOT SCALE DRAWING	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ± XX ± .XXX ± °		SIZE D · FSCM NO. 23338 · DWG. NO. 1001-00-0667 · REV B · SCALE NONE · MODEL 98 · SHEET 1 OF 4

1001-00-0667 B

REV	ECO	BY	DATE	APP

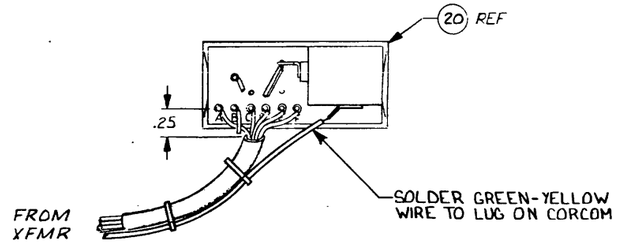




VIEW "B"

WIRE LIST

XFMR WIRE COLOR	LINE FILTER TERM. MARKING
VIOLET	A
BLACK	C
GRAY	D
WHT/BLK	E
WHT/GRAY	F



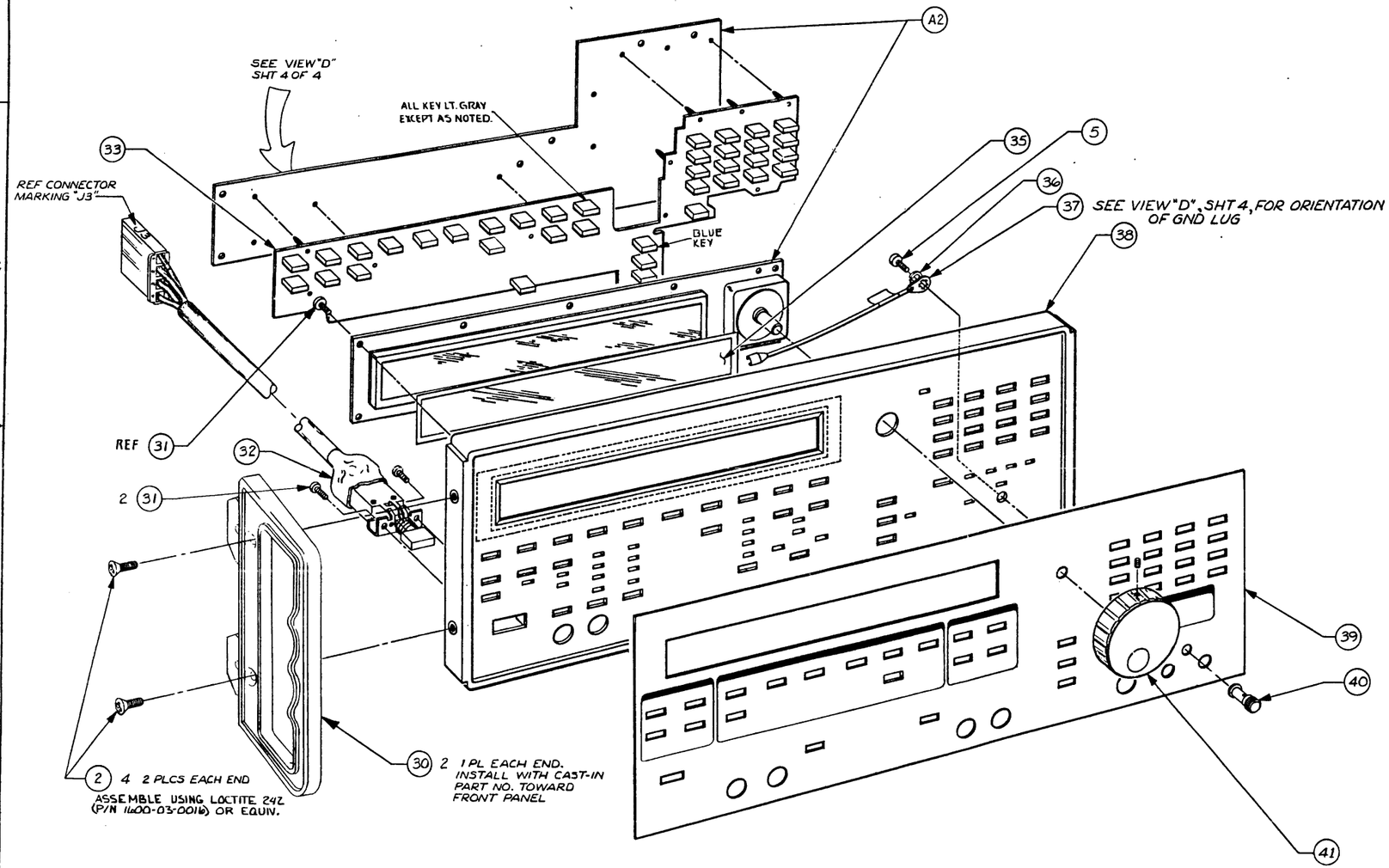
VIEW "C"
XFMR WIRE HOOKUP

1001-00-0667 B

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN CHERMACK	DATE 11-11-92	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED		TITLE ASSEMBLY INSTRUMENT (1 MHz POWER OSCILLATOR)
	PROJ. ENGR.		
	RELEASE APPROV.		
FINISH WAVETEK PROCESS	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES .XX ± .XXX ± ±		SIZE D · FSCM NO. 23338 · DWG. NO. 1001-00-0667 · REV B
DO NOT SCALE DRAWING			SCALE · MODEL 98 · SHEET 2 OF 4

REV	ECO	BY	DATE	APP

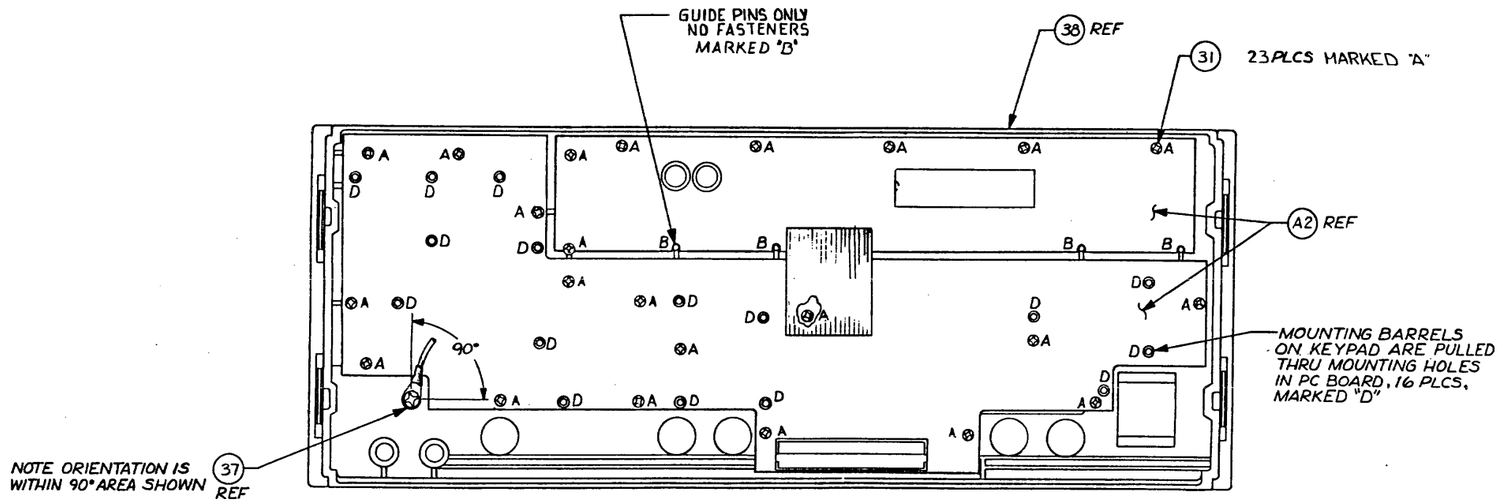


NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN SC/MS	DATE 4-89z	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL —	CHECKED		TITLE: ASSEMBLY, INSTRUMENT (1 MHz POWER OSCILLATOR)
	PROJ. ENGR.		
FINISH WAVETEK PROCESS —	APPROV.		SIZE D · FSCM NO. 23338 · DWG. NO. 1001-00-0667 · REV B
DO NOT SCALE DRAWING	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± / DECIMALS .XX ± .XXX ± / ANGLES ±		SCALE NONE · MODEL 98 · SHEET 3 OF 4

1001-00-0667 B

REV	ECO	BY	DATE	APP



VIEW "D"
(PC BOARD TO FRONT PANEL INSTALLATION)

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN CHERMACK	DATE 11-11-92	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED		TITLE: ASSEMBLY INSTRUMENT (1 MHz POWER OSCILLATOR)
	PROJ. ENGR.		
FINISH WAVETEK PROCESS	RELEASE APPROV.		
DO NOT SCALE DRAWING	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES XX ± XXX ±		SIZE D · FSCM NO. 23338 · DWG. NO. 1001-00-0667 · REV B · SCALE · MODEL 98 · SHEET 4 OF 4

1001-00-0667 B

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
REF	A/D 1MHz SYNTHESIZED POWER OSCILLATOR	1001-00-0667	WVTK	1001-00-0667	1
REF	ATS MODEL 98	1002-00-0667	WVTK	1002-00-0667	1
REF	INSTRUMENT SCHEMATIC MODEL 98	1004-00-0667	WVTK	1004-00-0667	1
REF	MODEL 98 OPERATION & MAINTENANCE MANUAL	1006-00-0667	WVTK	1006-00-0667	1
REF	MODEL 98 CALIBRATION PROCEDURE	1008-00-0667	WVTK	1008-00-0667	1
42	INSTRUMENT LABEL	1009-00-0667	WVTK	1009-00-0667	1
A2	PCA, DISPLAY/ KEYBOARD	1100-00-3322	WVTK	1100-00-3322	1
A1	PCA, 1MHz SYNTHESIZED OSCILLATOR	1100-00-3498	WVTK	1100-00-3498	1
41	ENCODER KNOB ASSY REF: A/D 1201-00-3380	1200-00-3380	WVTK	1200-00-3380	1
32	CABLE ASSY, AC SWITCH AND CABLE	1200-00-3391	WVTK	1200-00-3391	1
9	AUDIO XFMR ASSY-98	1200-00-3487	WVTK	1200-00-3487	1
20	LINE FILTER CABLE ASSY	1200-00-3508	WVTK	1200-00-3508	1

WAVETEK PARTS LIST	TITLE MODEL 98 1MHz SYNTHESIZED POWER OSCILLATOR	ASSEMBLY NO. 1000-00-0667 PAGE 1	REV B

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/P
34	TRANSFORMER ASSEMBLY	1204-00-3009	WVTK	1204-00-3009	1
J13	WIRE ASSY	1207-00-3010	WVTK	1207-00-3010	1
12	LABEL, CAUTION	859-1400	WVTK	1400-01-1400	1
21	PANEL, REAR, PAINTED	1400-02-3242	WVTK	1400-02-3242	1
30	HANDLE, PTD	1400-02-3252	WVTK	1400-02-3252	2
22	SHIELD, AC CONN	1400-02-3463	WVTK	1400-02-3463	1
8	SIDE PANEL	1400-02-3472	WVTK	1400-02-3472	2
35	WINDOW, DISPLAY	1400-02-5073	WVTK	1400-02-5073	1
38	FRONT PANEL MOLDED	1400-02-5087	WVTK	1400-02-5087	1
39	OVERLAY, FRONT PANEL	1400-02-5151	WVTK	1400-02-5151	1
33	KEYPAD, MODIFIED	1400-02-5152	WVTK	1400-02-5152	1
15	SHIELD SUPPORT	1400-02-5154	WVTK	1400-02-5154	1
14	COVER, TOP	1400-02-5248	WVTK	1400-02-5248	1
6	COVER, BOTTOM	1400-02-5280	WVTK	1400-02-5280	1
43	LABEL, WARRANTY	1400-02-5282	WVTK	1400-02-5282	1
44	LABEL, CALIBRATION	1400-02-5283	WVTK	1400-02-5283	1
40	LUG, GROUNDING	159	SMITH	2100-04-0043	1

WAVETEK PARTS LIST	TITLE	ASSEMBLY NO.	REV
	MODEL 98 1MHz SYNTHESIZED POWER OSCILLATOR	1000-00-0667	B
		PAGE 2	

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
10	HARDWARE KIT, GPIB CONN	554808-1	AMP	2100-07-0024	1
F1	FUSE, 1/2A, 250V	313.500	LITFU	2400-05-0010	1
45	TY-WRAP	TY-523M	TB	2800-00-0006	2
46	CABLE CLAMP	E-3	RICH	2800-00-0009	1
7	FOOT	10603-026	SCHRF	2800-08-0020	2
1	FOOT WITH TIP-UP	10603-025	SCHRF	2800-08-0021	2
24	NUT, HEX, 4-40	MS35649-244	COML	2800-14-4100	4
18	NUT, HEX, 1/2-28	1-329631-2	AMP	2800-16-0025	5
4	NUT, HEX, 8-32, 3/32 THK, .25 FLT, MINI, SS	2800-16-8106	CMCRL	2800-16-8106	4
5	SCREW, 6-32X1/4, PHP, Z NYLOK PELLET	6-32 X 1/4	CMRCL	2800-23-6104	9
29	WASHER, #8 FIBER BIN 470	#8 FIBER WASHER	CMRCL	2800-28-8000	4
3	LOCKWASHER, #8 SPLIT RING, SS	#8SRLW	CMRCL	2800-42-8000	11
25	WASHER, LOCK REG, S/S #4	MS 35338-135	CMRCL	2800-45-4000	4

WAVETEK PARTS LIST	TITLE: MODEL 98 1MHz SYNTHESIZED POWER OSCILLATOR	ASSEMBLY NO. 1000-00-0667	REV B
		PAGE 3	

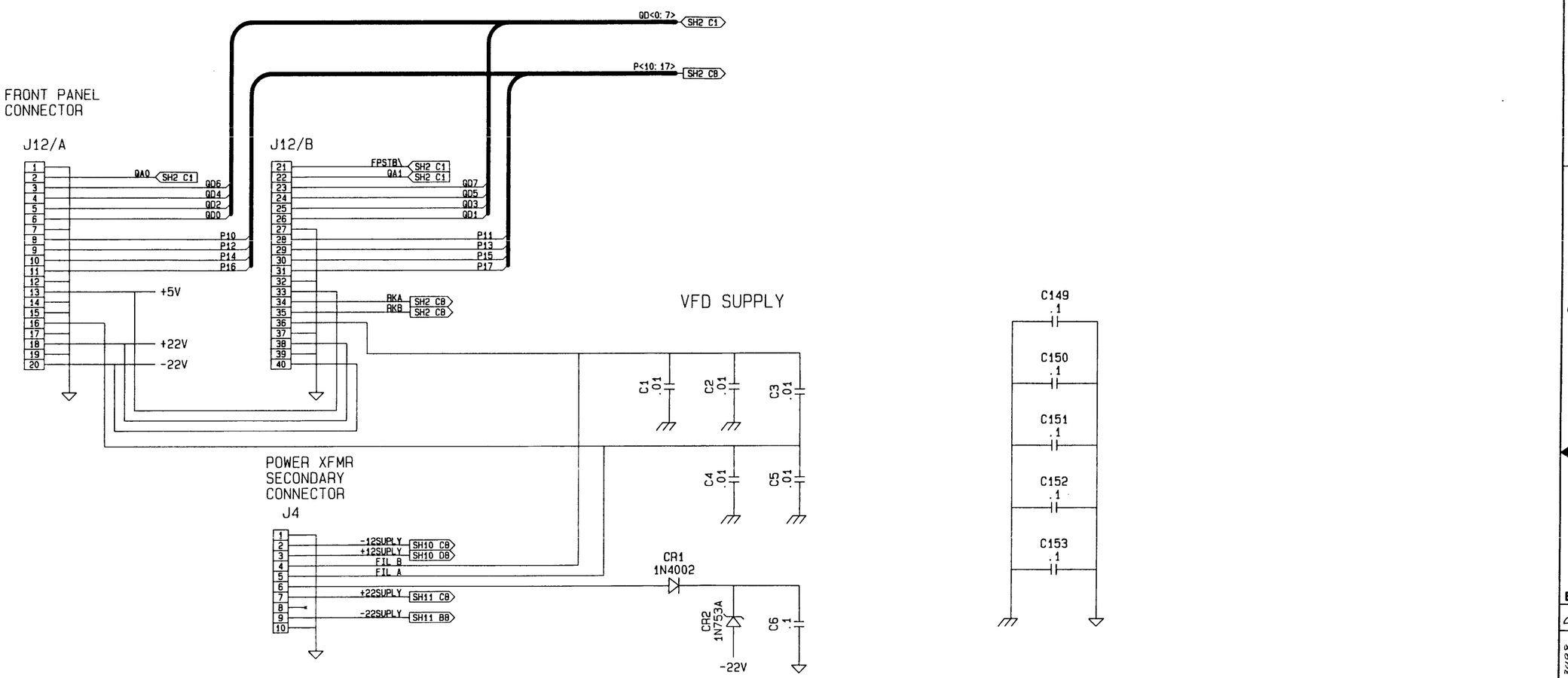
REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/P
36	WASHER, LOCK, REG S/S #6	MS 35338-136	CMRCL	2800-45-6000	1
47	WASHER, FLAT, SS, #6 LARGE OUTLINE	AN 960C6	CMRCL	2800-46-6001	1
28	WASHER, #8, FLT, SS, THK .050, ID .174, OD .375	2800-46-8000	CMRCL	2800-46-8000	4
11	SCREW PLPS PAN M/S 18-8 S/S 8-32X1/2	SCREW PH 8-32X1/2	CMRCL	2800-48-8108	3
26	SCREW, 8-32 X 1 5/8, UNCZA, PHLP, PH, SS	2800-48-8126	CMRCL	2800-48-8126	4
16	SCREW, BINDER HD, 8-32 x 1/4, SLOTED ZINC-PLATED	8-32 x 1/4	CMRCL	2800-54-0217	2
27	WASHER, #8, INT TOOTH, LOCK, SS	2800-56-0002	CMRCL	2800-56-0002	4
31	SCREW, 2 X 5/16, TYPE B, THD FORM, PH, SS	2800-57-2905	CMRCL	2800-57-2905	25
21	SCREW, PH, 6-32 X 5/16, PHLPS, NYLOK, SS	2800-59-6105	CMRCL	2800-59-6105	6
13	SCREW, 6-32/3/8, FH, PHL PS, 100DEG, SS, NYLOK, PA TCH	2800-60-6106	CMRCL	2800-60-6106	2
2	SCREW, 8-32X7/16, 100DE	2800-60-8107	CMRCL	2800-60-8107	16

WAVETEK PARTS LIST	TITLE	ASSEMBLY NO.	REV
	MODEL 98 1MHz SYNTHESIZED POWER OSCILLATOR	1000-00-0667	B

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
	G FH PHLPS, SS. NYLOK				
23	EXTRU, RUBBER, U CHNL, 1/16 INSIDE, 1/8 OUTSIDE	924	LESIG	3200-06-0079	2
NONE	PWR CORD, SHIELDED	6001-80-0009	WVTK	6001-80-0009	1

WAVETEK PARTS LIST	TITLE MODEL 98 1MHz SYNTHESIZED POWER OSCILLATOR	ASSEMBLY NO. 1000-00-0667 PAGE 5	REV B

REV	ECO	BY	DATE	APP
A	ERO # 93-070	MP	12-15-92	
B	ECO # 93-108	MP	1-26-93	
C	ECO # 93-119	MP	2-3-93	
D	ECO # 93-127	MP	2-12-93	



7. BANK0 + BANK1 CONTROL LINES ARE ALWAYS INITIALIZED "HIGH" WHEN CONNECTED TO A 2764 EPROM.

6. T SUFFIX ON REFERENCE DESIGNATOR INDICATES NOMINAL VALUE.

5. ELECTRICAL COMPONENT REFERENCE DESIGNATION STATUS:
   A. LAST USED: C171, CR38, DS3, BT1, FB6, J15, K9, L1, P23, R188, RN2, Q20, VR5, TP16, U38.
   B. NOT USED: C38, 76, 119; CR9-11; DS2; FB1-4; J1-3, 11, 13; P1-12, 14-21; R7, 20, 21, 35, 44, 47-49, 50, 51, 93, 99, 139, 154; Q2, 4, 5; U37

4. REMOVED

3. CAPACITORS VALUED IN MICROFARADS (uF) WITH CERAMIC COMPOSITION; POLARIZED CAPACITORS WITH ALUMINUM ELECTROLYTIC COMPOSITION.

2. RESISTORS VALUED IN OHMS, 1/8W, 1%.

1. FOR INSTRUMENT INTERCONNECTION, SEE INSTRUMENT SCHEMATIC, 1004-00-3498.

NOTE: UNLESS OTHERWISE SPECIFIED

CAD JOB #: B078C

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN N. MILLER	DATE 11/2/92
MATERIAL	CHECKED M. Peterson	12/1/92
	PROJ. ENGR. R.B.C.	12/1/92
	RELEASE APPROV. R.B.C.	12/1/92
FINISH WAVETEK PROCESS	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ± XX ± XXX ± °	
DO NOT SCALE DRAWING		

WAVETEK SAN DIEGO, CALIFORNIA

TITLE: A1 SCHEMATIC, 1 MHz SYNTHESIZED OSCILLATOR BOARD

SIZE	FSCM NO.	DWG. NO.	REV
D	23338	1104-00-3498	D

SCALE | MODEL 98 | SHEET 1 OF 11

1104-00-3498 D

REV	ECO	BY	DATE	APP

MICROPROCESSOR

U1 TL7705 — VCC, SENSE, RESIN, CT, GND, RESET, RESET, REF; C7 .1, C8 22-25V, C9 .1

U2 6803 — XTAL, EXTAL, RESET, E, R/W, AS, AD0 P30 … AD7 P37, P20 TIN, P21 TOUT, P22 SCLK, P23 RX, P24 TX, A8 P40 … A15 P47, NMI, IRQ

U3 27256 — VPP, CE, OE

U4 SR8K8 — CS1, CS2, OE, WE

U5 PSC288 — MAST, E, R/W, AS, IRQ, PRST, GPIB, AOM, RAM, WE, STB0–STB3, QA0–QA3, QD0–QD7, SHSEL0–SHSEL3, SHSELM, SHCLK, SHDATA, SHEN, SEN, SDAT, SCK, DVMHB, DVMLB, DVM5–DVM0, DVMRUN, DVMRDY, FOUT, F0–F2, RKA, RKB

U6 XL93CL66 — DI, CS, SK, DO

P11 — OPTION, STANDARD (XP11)

DS1 LTL-3231A; DS3 3231A; Q1 2N3904; Q3 VN0106N3; CR3, CR5 HP2811

R1 274, R2 49.9K, R3 10K, R4 10K, R5 10K, R6 2.21K, R8 10K, R9 10K, R169 49.9, R187 0, R188 332, C154 1F, C12 .01, C13 .01, C120 .1, C121 .1, C122 .1, C123 .1, C124 .1

TP1 MAST\, TP2 +5V

	U2	U3	U4	U5	U6
	6803	27256	SR8K8	PSC288	XL93CL06
+5V	7, 21	28	---	1, 22, 43, 65	8
GND	1	14	14	23, 44, 64, 84	5
CAP	C120	C121	C122	C123	C124

NOTE UNLESS OTHERWISE SPECIFIED

CAD JOB #: B078C

REMOVE ALL BURRS AND BREAK SHARP EDGES — MATERIAL — FINISH: WAVETEK PROCESS — DO NOT SCALE DRAWING

DRAWN N. MILLER 11/2/92 — CHECKED — PROJ ENGR — RELEASE APPROV.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES .XX ±.02 .XXX ±.005

WAVETEK SAN DIEGO, CALIFORNIA

TITLE: A1 SCHEMATIC, 1 MHz SYNTHESIZED OSCILLATOR BOARD

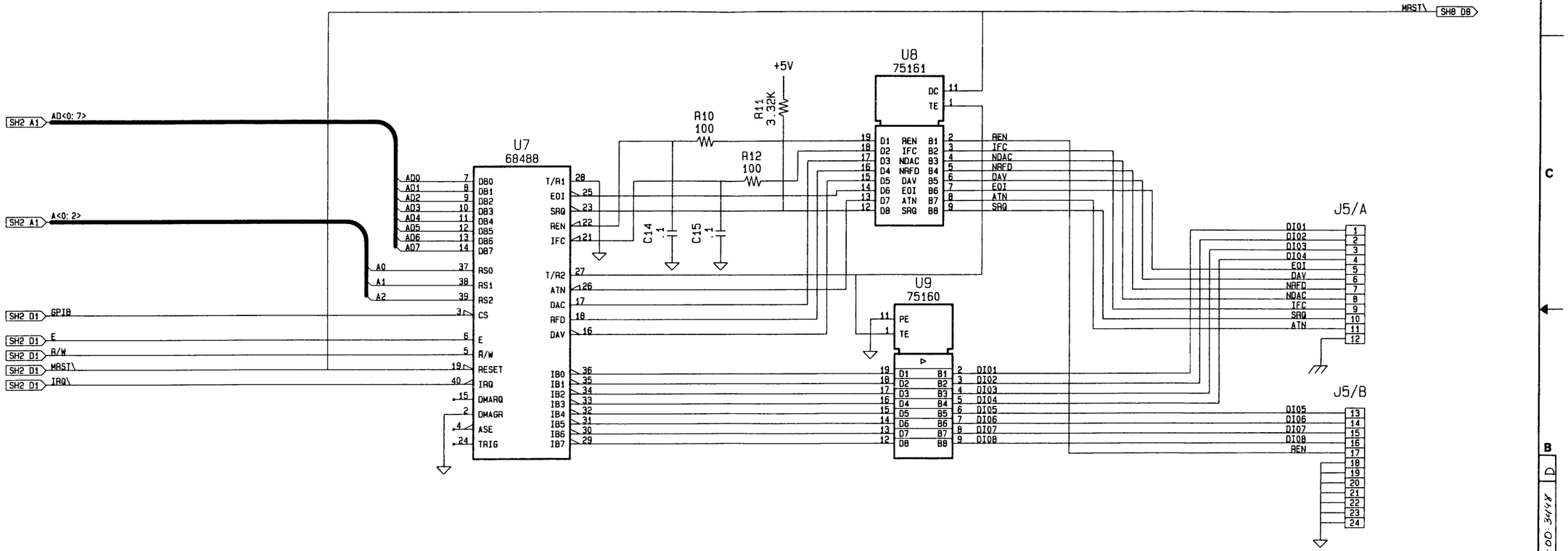
SIZE	FSCM NO.	DWG. NO.	REV
D	23338	1104-00-3498	D

SCALE — MODEL 18 — SHEET 2 OF 3

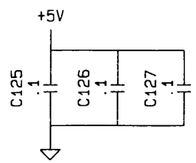
1104-00-3498 D

REV	ECO	BY	DATE	APP

GPIB INTERFACE



	U7	U8	U9
	68488	75161	75160
+5V	20	20	20
GND	1	10	10
CAP	C125	C126	C127



NOTE UNLESS OTHERWISE SPECIFIED

CAD JOB #: B078C

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN N. MILLER	DATE 11/2/92	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED		TITLE: A1 SCHEMATIC, 1 MHz SYNTHESIZED OSCILLATOR BOARD
	PROJ. ENGR.		
FINISH WAVETEK PROCESS	RELEASE APPROV.		
DO NOT SCALE DRAWING	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±		SIZE D · FSCM NO. 23338 · DWG. NO. 1104-00-3498 · REV D · SCALE · MODEL 98 · SHEET 3 OF 11

1104-00-3498 D

REV	ECO	BY	DATE	APP

SWEEP RAMP GENERATOR

SH2 C1 QA0

SH2 C1 QD<0:7>

+12V C166 .1

C155 .1

R170 100 -5V

DAC1006 U35

CS WR XFER B1/B2 GND VCC IOUT2 IOUT1 VREF (LSB) DB0 DB1 DB2 DB3 DB4 DB5 DB6 DB7 DB8 DB9 RFB

QD0 QD1 QD2 QD3 QD4 QD5 QD6 QD7

C161 .01

+12V C167 .1

U36/A 34082A

C168 .1 -12V

+5V CR33 1N5282

CR34 1N5282 -5V

R171 604

J9 SWEEP

CONTROL REGISTERS

U10 74LS138

SH2 C1 QA1

SH2 C1 QA2

SH2 C1 REG-STB\

A B C G1 G2A G2B EN Y0 Y1 Y2 Y3 Y4 Y5 Y6 Y7

+5V

U11 74ALS574

CLK OC

QD0 QD1 QD2 QD3 QD4 QD5 QD6 QD7

+5V CR6 1N5282

U13 ULN2003

PATN0\ SH8 A8
PATN1\ SH8 A8
PATN2\ SH8 A8
PATN3\ SH8 A8
PATN4\ SH8 A8
-20DB\ SH9 A8
-40DB\ SH9 A8

OUTP-ON\ SH9 A8

U12 74ALS574

CLK OC

QD0 QD1 QD2 QD3 QD4 QD5 QD6 QD7

+5V CR7 1N5282

500HM SH9 A8
AGMC4 SH6 B8
AGMC5 SH6 B8
PAINCSEL SH6 C8
PENLIFT SH8 C8
MARKER SH8 C8
BANK0 SH6 B8
BANK1 SH6 B8

1104-00-3498

UNUSED GATES:

U36/B 34082B

	U10	U11	U12	U13
	74LS138	74ALS574	74ALS574	ULN2003
+5V	16	20	20	9
GND	8	10	10	8
CAP	C128	C129	C130	C131

+5V C128 .1 C129 .1 C130 .1 C131 .1

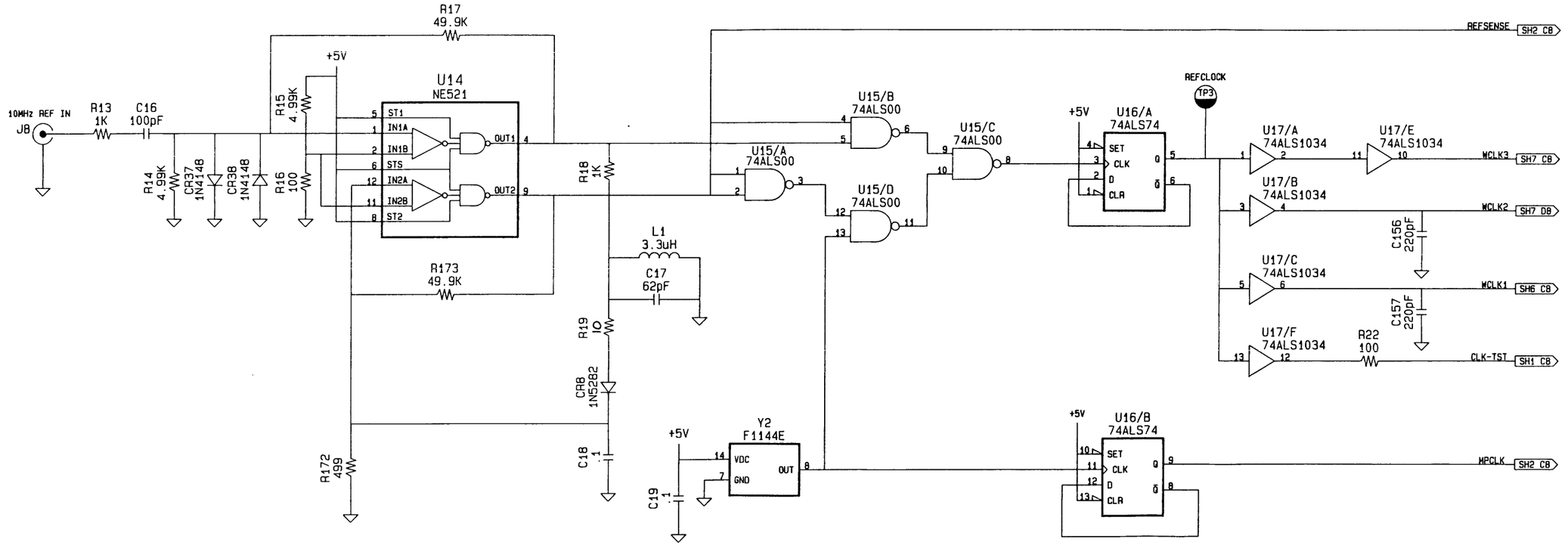
NOTE: UNLESS OTHERWISE SPECIFIED

CAD JOB #: B078C

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN N. MILLER	DATE 11/2/92	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED		TITLE: A1 SCHEMATIC, 1 MHz SYNTHESIZED OSCILLATOR BOARD
	PROJ. ENGR		
FINISH WAVETEK PROCESS	RELEASE APPROV.		
DO NOT SCALE DRAWING	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ± .XX ± .XXX ± °		SIZE D · FSCM NO. 23338 · DWG. NO. 1104-00-3498 · REV D · SCALE · MODEL 98 · SHEET 4 OF 11

REV	ECO	BY	DATE	APP

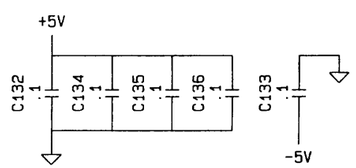
REFERENCE CLOCK



UNUSED GATES:

U17/D 1034

	U14	U15	U16	U17
	NE521	74ALS00	74ALS74	74ALS1034
+5V	14	14	14	14
GND	7	7	7	7
-5V	13			
CAP	C132, C133	C134	C135	C136



NOTE UNLESS OTHERWISE SPECIFIED

CAD JOB #: B078C

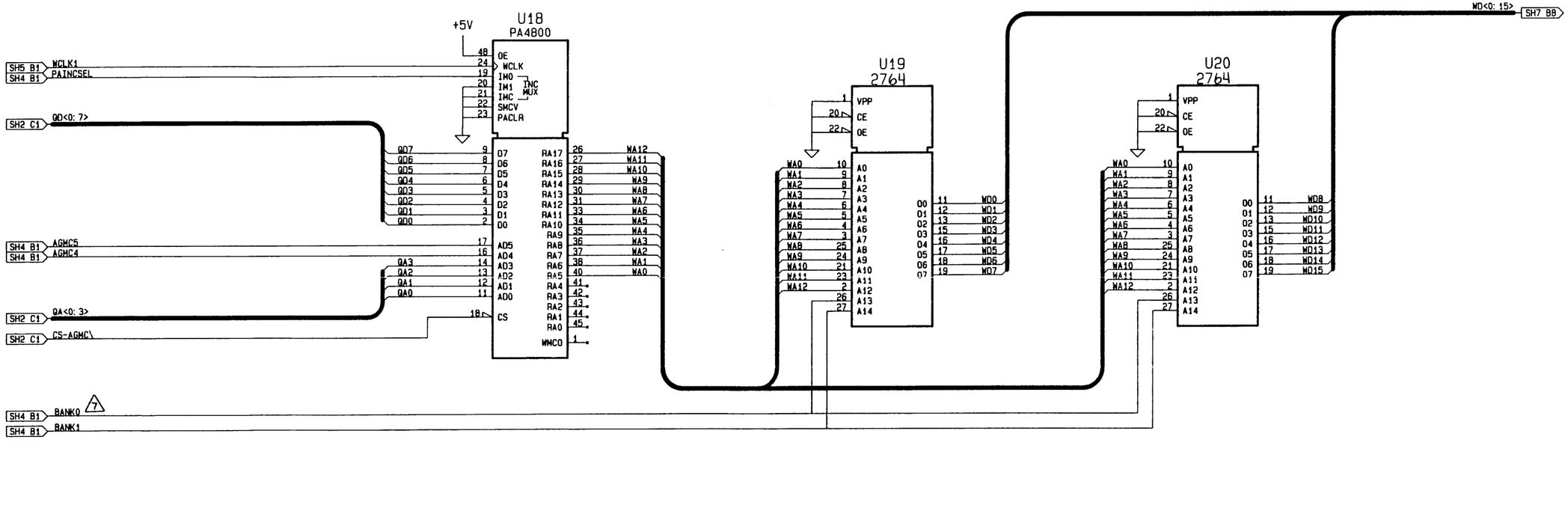
REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN R. MILLER	DATE 11/15/92	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED		TITLE A1 SCHEMATIC, 1 MHz SYNTHESIZED OSCILLATOR BOARD
	PROJ. ENGR.		
FINISH WAVETEK PROCESS	RELEASE APPROV.		
DO NOT SCALE DRAWING	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES XX ± XXX ± ±		SIZE D · FSCM NO. 23338 · DWG. NO. 1104-00-3498 · REV D · SCALE · MODEL 98 · SHEET 5 OF 11

1104-00-3498 D

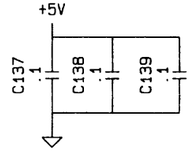
REV	ECO	BY	DATE	APP

ADDRESS GENERATOR / MODE CONTROL

WAVEFORM MEMORY



	U18	U19	U20
	PA4800	27C64	27C64
+5V	10, 25, 47	28	28
GND	15, 32, 39, 46	14	14
CAP	C137	C138	C139



NOTE UNLESS OTHERWISE SPECIFIED

CAD JOB #: B078C

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN N. MILLER	DATE 11/2/82	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED		TITLE: A1 SCHEMATIC, 1 MHz SYNTHESIZED OSCILLATOR BOARD
FINISH WAVETEK PROCESS	PROJ. ENGR.		
	RELEASE APPROV.		
DO NOT SCALE DRAWING	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±		SIZE D; FSCM NO. 23338; DWG. NO. 1104-00-3498; REV D; SCALE; MODEL 98; SHEET 6 OF 11

1104-00-3498

REV	ECO	BY	DATE	APP

WAVEFORM DAC

PRE-AMP

-1V REF

FINE AMPLITUDE CONTROL

SH5 C1 WCLK2

SH5 C1 WCLK3

SH6 C1 WD<0:15>

SH2 C1 SHCLK

SH2 C1 SHDATA

SH2 C1 SHEN

PAMP-OUT SH8 B8

+/-3V TP4

COMMON TP5

-1V REF TP16

AMPL CONTROL TP6

FULL SCALE AMPL ADJUST

	U22	U23
	74ALS574	74ALS574
+5V	20	20
GND	10	10
CAP	C140	C141

NOTE UNLESS OTHERWISE SPECIFIED

CAD JOB #: B078C

REMOVE ALL BURRS AND BREAK SHARP EDGES | MATERIAL | FINISH WAVETEK PROCESS | DO NOT SCALE DRAWING

DRAWN N. MILLER 11/2/92 | CHECKED | PROJ. ENGR. | RELEASE APPROV.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES .XX ±, .XXX ±, ±

WAVETEK SAN DIEGO, CALIFORNIA

TITLE: A1 SCHEMATIC, 1 MHz SYNTHESIZED OSCILLATOR BOARD

SIZE D | FSCM NO. 23338 | DWG. NO. 1104-00-3498 | REV D

SCALE | MODEL 98 | SHEET 7 OF 11

1104-00-3498 D

REV	ECO	BY	DATE	APP

SYNC OUTPUT CONDITIONING AND BUFFER

SH3 C8 MRST\

R45 2.49K

R46 24.9K

FILT TP7

+5V

U27 NE521

ST1, IN1A, IN1B, STS, IN2A, IN2B, ST2, OUT1, OUT2

R176 2.49K

C37 33pF

U38 75121

1A 1B 1C 1D 1E 1F 2A 2B 2C 2D 2E 2F 1Y 2Y

CR35 1N5282

CR36 1N5282

R179 10

J6 SYNC OUT

R177 49.9

C162 220pF

R180 1K

SYNC-TST SH2 C8

R181 10

J7 PEN LIFT/ MARKER OUT

R178 49.9

C163 220pF

R186 1K

LIFTTEST SH2 C8

SH4 B1 PENLIFT

SH4 B1 MARKER

1MHz LOW PASS FILTER

SH7 C1 PAMP-OUT

R52 750

R53 750

R54 750

R55 750

R56 1K

R57 750

R58 750

R59 750

R60 750

R61 1K

R62 33.2

R63 2.49K

C40 270pF-5%-MICA

C41 30pF-5%-MICA

C42 .1

C43 .1

C44 240pF-5%-MICA

C45 270pF-5%-MICA

C46 30pF-5%-MICA

C47 .1

C48 .1

C39 240pF-5%-MICA

U28 EL2020

U29 EL2020

V+ DISAB BL2 BL1 V-

+12V

-12V

COARSE AMPLITUDE CONTROL (R/2R LADDER)

K1 HD1E-DC5V

K2 HD1E-DC5V

K3 HD1E-DC5V

K4 HD1E-DC5V

K5 HD1E-DC5V

R64 1K-.1%

R65 1K-.1%

R66 1K-.1%

R67 1K-.1%

R68 1K-.1%

R69 1K-.1%

R70 1K-.1%

R71 1K-.1%

R72 1K-.1%

R73 1K-.1%

R74 1K-.1%

R75 1K-.1%

R76 1K-.1%

R77 1K-.1%

R78 1K-.1%

R79 1K-.1%

OA-SUM SH9 C8

+5V

FB5

C146 .1

C147 .1

K1/A HD1E-DC5V

K2/A HD1E-DC5V

K3/A HD1E-DC5V

K4/A HD1E-DC5V

K5/A HD1E-DC5V

C49 .1

C50 .1

C51 .1

C52 .1

C53 .1

R80 10

R81 10

R82 10

R83 10

R84 10

SH4 C1 PATN0\

SH4 C1 PATN1\

SH4 B1 PATN2\

SH4 B1 PATN3\

SH4 B1 PATN4\

	U27	U38
	NE521	75121
+5V	14	16
GND	7	8
-5V	13	
CAP	C142, C143	C164

C164 .1

C142 .1

C143 .1

-5V

NOTE UNLESS OTHERWISE SPECIFIED

CAD JOB #: B078C

REMOVE ALL BURRS AND BREAK SHARP EDGES

MATERIAL

Finish WAVETEK PROCESS

DO NOT SCALE DRAWING

DRAWN N. MILLER DATE 11/2/92

CHECKED

PROJ. ENGR.

RELEASE APPROV.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ± .XX ± .XXX ± ±

WAVETEK SAN DIEGO, CALIFORNIA

TITLE

A1 SCHEMATIC, 1 MHz SYNTHESIZED OSCILLATOR BOARD

SIZE	FSCM NO.	DWG. NO.	REV
D	23338	1104-00-3498	D

SCALE — MODEL 98 SHEET 8 OF 11

1104-00-3498

REV	ECO	BY	DATE	APP

OUTPUT AMP

50 OHM ATTENUATOR AND ON/OFF CONTROL

600 OHM BALANCED OUTPUT DRIVER

NOTE UNLESS OTHERWISE SPECIFIED

CAD JOB #: B078C

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN N. MILLER	DATE 11/2/92	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED		TITLE: A1 SCHEMATIC, 1 MHz SYNTHESIZED OSCILLATOR BOARD
	PROJ. ENGR.		
FINISH WAVETEK PROCESS	RELEASE APPROV.		
DO NOT SCALE DRAWING	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ± XX ± XXX ±	SCALE	SIZE D · FSCM NO. 23338 · DWG. NO. 1104-00-3498 · REV D · MODEL 98 · SHEET 4 OF 11

REV	ECO	BY	DATE	APP

+/- 12V POWER SUPPLIES

SH1 B6 +12SUPLY

SH1 B6 -12SUPLY

CR14 1N4002
CR12 1N4002
CR13 1N4002
CR15 1N4002
CR16 1N4002
CR17 1N4002
CR18 1N4002
CR19 1N4002

VR1 LM317T (IN, OUT, ADJ)
VR2 LM337T (ADJ, IN, OUT)

R130 3.9-1/2W
R131 392
R132 3.92K
R133 3.92K
R134 3.9-1/2W
R135 392
R136 3.92K
R129 3.92K

C80 .01
C81 .1
C82 4700-25V
C83 .1
C84 4700-25V
C85 100-35V
C86 .1
C87 100-35V
C165 .1
C144 .1
C145 .1

U31/A 34082A
U31/B 34082B
R137 2K
R138 10K
+10VREF

U32 LT1021 (IN, OUT, GND, TRIM)
+10VREF

+12V TP9
R152 0 +12V
R141 7.5K
C88 .1
C89 4700-25V

-12V TP10
R153 0 -12V
R140 7.5K
C90 .1
C91 4700-25V

+5V POWER SUPPLY

P22
P23
C92 .01

CR20/A MBR1535
CR20/B MBR1535
CR21 MBR1535
CR22 MBR1535

C93 6800-16V
C94 6800-16V
R146 40.2
R145 165

Q20 TIP-36
Q19 2N2905A
CR23 1N4002

+5V TP11
JP1 +5V

C96 1000-16V
R149 499
C97 .1
R147 1K
R148 1K

+10VREF R142 3.01K
Q17 2N3904
Q18 2N3904
R143 1K
C95 .1
C148 47-20V TANT
R144 182

-5V POWER SUPPLY

HEATSINK
CR24 1N4002
VR3 LM337T (IN, OUT, ADJ)

-12V
-5V TP12
-5V

C98 .1
R150 121
C99 .1
C100 100-16V
R151 365

NOTE UNLESS OTHERWISE SPECIFIED

CAD JOB #: B078C

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DO NOT SCALE DRAWING

DRAWN N. MILLER 11/2/82
CHECKED
PROJ. ENGR.
RELEASE APPROV.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS DECIMALS ANGLES
± .XX ± .XXX ±

WAVETEK SAN DIEGO, CALIFORNIA

TITLE
A1 SCHEMATIC, 1 MHz SYNTHESIZED OSCILLATOR BOARD

SIZE D | FSCM NO. 23338 | DWG. NO. 1104-00-3498 | REV D
SCALE | MODEL 98 | SHEET 10 OF 11

REV	ECO	BY	DATE	APP

+/- 22V POWER SUPPLIES

+22UNREG SH9 B1

SH1 B6 +22SUPLY

CR27 1N4002

R156 4.7-1/2W

C106 100-35V

VR4 LM317T (IN, OUT, ADJ)

CR25 1N4005

CR26 1N4005

C102 .1

C103 3300-50V

R155 3.92K

R157 499

C111 .1

CR31 1N4002

R158 3.92K

C108 .1

C109 .1

U33 34081 (V+, V-, N1, N2)

+10VREF

R164 12.1K

R165 7.5K

C113 .1

C114 1000-50V

+22V TP13

R163 0

+22V

C115 .01

TP14

C101 .01

CR28 1N4005

CR29 1N4005

CR32 1N4002

R162 3.92K

C104 .1

C105 3300-50V

R159 3.92K

C107 100-35V

R161 499

ADJ IN OUT LM337T VR5

R160 4.7-1/2W

CR30 1N4002

U34 34081 (V+, V-, N1, N2)

C110 .1

R167 10K

C112 .1

R168 7.5K

C116 .1

C117 1000-50V

-22V TP15

R166 0

C118 .01

-22V

SH1 B6 -22SUPLY

-22UNREG SH9 B1

NOTE UNLESS OTHERWISE SPECIFIED

CAD JOB #: B078C

REMOVE ALL BURRS AND BREAK SHARP EDGES

MATERIAL

FINISH WAVETEK PROCESS

DO NOT SCALE DRAWING

DRAWN N. MILLER 11/2/9

CHECKED

PROJ. ENGR.

RELEASE APPROV.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES XX ± .XXX ±

WAVETEK SAN DIEGO, CALIFORNIA

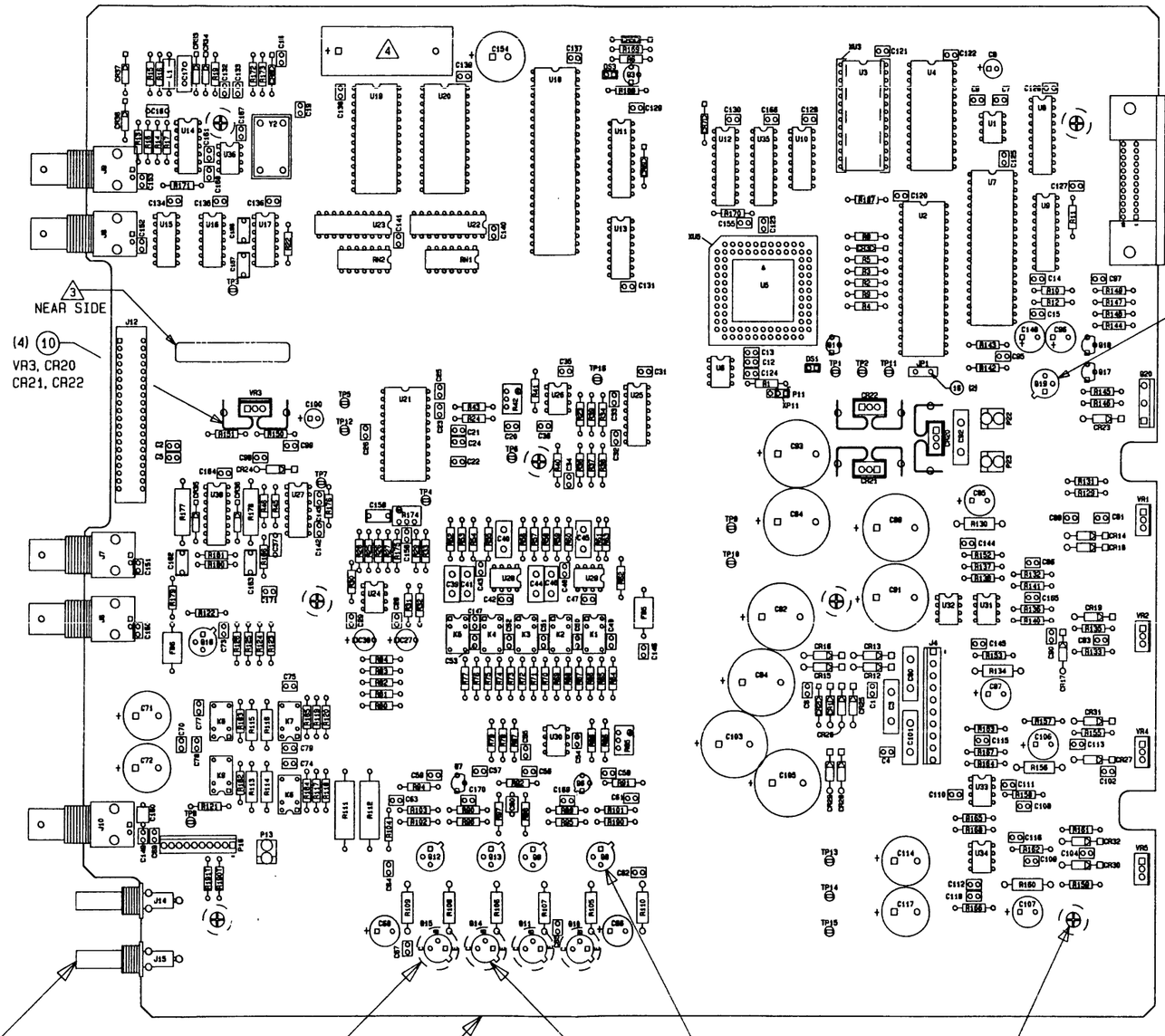
TITLE: A1 SCHEMATIC, 1 MHz SYNTHESIZED OSCILLATOR BOARD

SIZE D | FSCM NO. 23338 | DWG. NO. 1104-00-3498 | REV D

SCALE | MODEL 98 | SHEET 11 OF 11

1104-00-3498 D

REV	ECO	BY	DATE	APP
A	ERO 93-070	SC	12/15/92	RBM
B	ECO# 93-099	MP	1-21-93	MP
C	ECO# 93-127	MP	2-12-93	MP



4. THIS IS A SECOND SOURCE (WAVETEK P/N 1500-30-1001) FOOTPRINT FOR C154.

3. MARK ASSY WITH PART NUMBER, REVISION LEVEL, DATE CODE AND SEQUENCE NUMBER (OPTIONAL) IN APPORXIMATE AREA SHOWN.

2. ASSEMBLE PER WAVETEK WORKMANSHIP STANDARDS.

1. SEE 1104-00-3498 FOR SCHEMATIC.

NOTE: UNLESS OTHERWISE SPECIFIED

CAD JOB #: B078C

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
Finish WAVETEK PROCESS
DO NOT SCALE DRAWING

		DATE
DRAWN	N. MILLER	12/4/92
CHECKED		12/10/92
PROJ. ENGR.	RBM	12/14/92
RELEASE APPROV.	RBM	12/14/92

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±

WAVETEK SAN DIEGO, CALIFORNIA

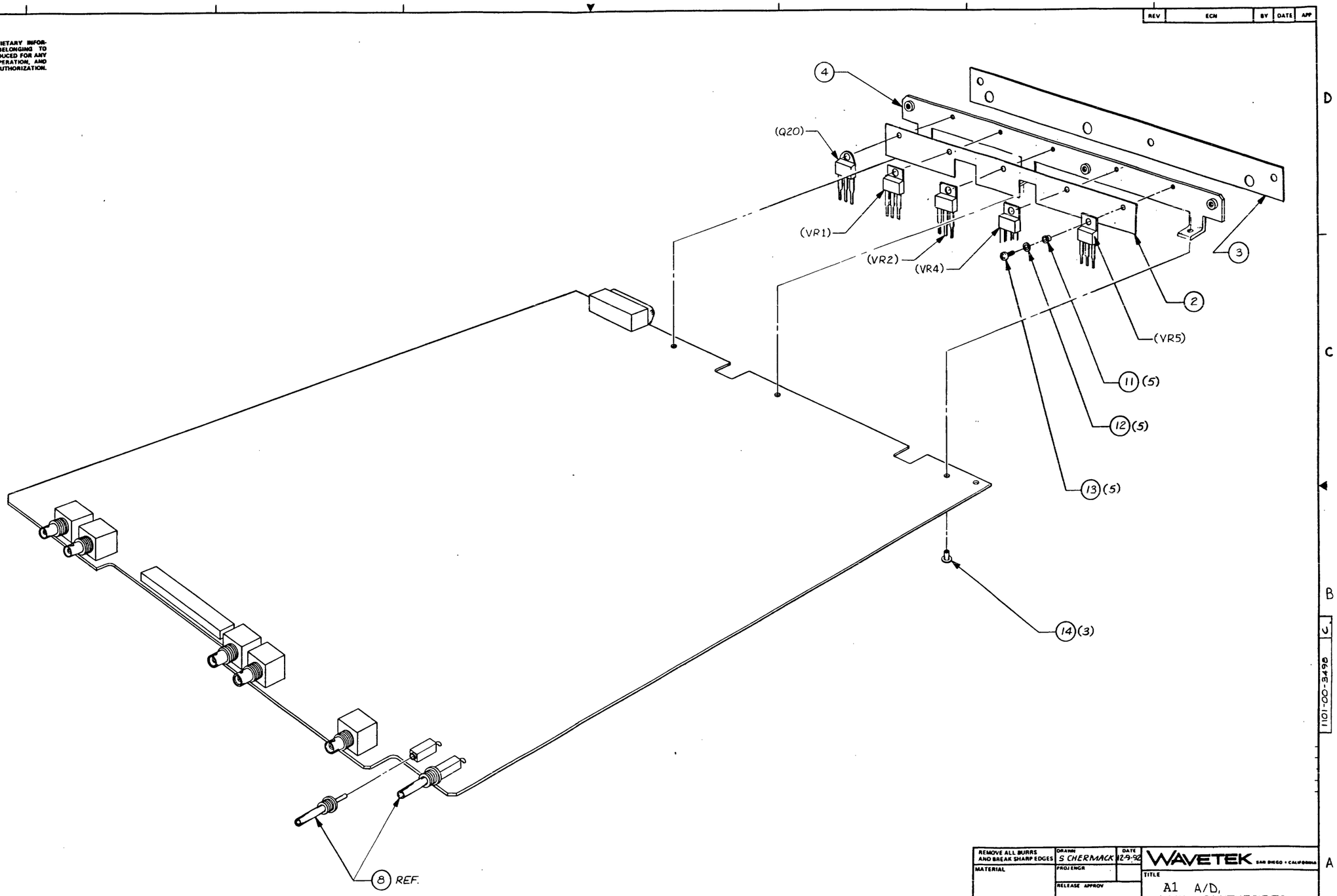
TITLE
A1 A/D,
1MHz SYNTHESIZED
OSCILLATOR BOARD

SIZE	FSCM NO.	DWG. NO.	REV
D	23338	1101-00-3498	C

SCALE 1.5/1 | MODEL 98 | SHEET 1 OF 2

1101-00-3498 C

REV	ECN	BY	DATE	APP



NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN S CHERMACK	DATE 12-9-92	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR		TITLE A1 A/D, 1 MHz SYNTHESIZED OSCILLATOR BOARD
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1° XX ± .030		
	DO NOT SCALE DWG		MODEL NO. 98 / DWG NO. 1101-00-3498 / REV C
	SCALE NONE		CODE IDENT 23338 / SHEET 2 OF 2

1101-00-3498 C

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
REF	A/D, 1MHz SYNTHESIZED OSCILLATOR BOARD	1101-00-3498	WVTK	1101-00-3498	1
REF	SCHEMATIC, 1MHz SYNTHESIZED OSCILLATOR BOARD	1104-00-3498	WVTK	1104-00-3498	1
CR2	SL ZR 6.2V 5% 400MW (1N753A)	1N753A	ROHM	131.9620	1
2	THERMAL GASKET-REAR PANEL-A	1400-02-4400	WVTK	1400-02-4400	1
3	THERMAL GASKET-REAR PANEL-B	1400-02-4410	WVTK	1400-02-4410	1
4	SUPPPORT PLATE, TRANSISTOR	1400-02-5007	WVTK	1400-02-5007	1
C16	CAP,CER,100PF,1KV	DD-101 LONG LEAD	CRL	1500-01-0101	1
C1 C115 C118 C12 C13 C161 C169 C170 C2 C22 C23 C24 C25 C26 C4 C5	CAP,CER,.01MF,+-10%,50V,X7R,.1"LS	SR155C103KAA	AVX	1500-01-0307	16
C101 C3 C80 C92	CAP,CER,.01MF,1KV	GAP-103	CRL	1500-01-0309	4
C102 C104 C108 C109 C110 C111 C112 C113 C116 C120 C121 C122 C123 C124 C125 C126 C127 C128 C129 C130 C131 C132 C133 C134 C135 C136 C137 C138 C139 C14	CAP,CER,.1 MF,50V,X7R,+-10%,.1" LS	SR205C104KAA	AVX	1500-01-0415	105

WAVETEK PARTS LIST	TITLE A1 PCA, 1MHz SYNTHESIZED OSCILLATOR	ASSEMBLY NO. 1100-00-3498 PAGE 1	REV E

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/P
C140 C141 C142 C143 C144 C145 C146 C147 C149 C15 C150 C151 C152 C153 C155 C158 C164 C165 C166 C167 C168 C171 C18 C19 C20 C21 C28 C29 C31 C32 C33 C34 C35 C36 C42 C43 C47 C48 C49 C50 C51 C52 C53 C54 C55 C56 C57 C58 C59 C6 C61 C62 C63 C64 C65 C67 C69 C7 C70 C73 C74 C75 C77 C78 C79 C81 C83 C86 C88 C9 C90 C95 C97 C98 C99					
C160	CAP, CER, 15PF, 1KV	D150K20S2LNAAAL	PHLIP	1500-01-5011	1
C60	CAP, CER DISK, 1. 5PF, 1KV, TEMP COMP	NCD1. 5PF1KVK750-CR	NIC	1500-01-5507	1
C156 C157 C159 C162 C163	CAP, CER, 220PF, 1KV	D221K20Z5FNAAEM	PHLIP	1500-02-2111	5
C37	CAP, CER DISK, 33PF, 1KV, 10%	5GAQ33	SPRAG	1500-03-3001	1
C39 C44	CAP, MICA, 240PF, 500V	DM15-241J	ARCO	1500-12-4100	2
C40 C45	CAP, MICA, 270PF, 500V	DM15-271J	ARCO	1500-12-7100	2
C41 C46	CAP, MICA, 30PF, 500V, RA DIAL	DM15-300J	ARCO	1500-13-0000	2
C17	CAP, MICA, 62PF, 500V	DM15-620J	ARCO	1500-16-2000	1

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/P
C154	CAP, ELECT, GOLD TYPE, 1 FD, 5.5VDC, .2 LS ROUND BODY	EEC-F5F5U105	PANAS	1500-30-1000	1
C106 C107 C66 C68 C85 C87	CAP, ELECT, 100MF, 35V RADIAL LEAD, SP .20	NRE101M35V10X12.5(OBS)	NIC	1500-31-0102	6
C100	CAP, ELEC, 100 MF, 16V, RAD, .1 LS	NRE101M16V6.3X11	NIC	1500-31-0111	1
C114 C117	CAP, ELECT, 1000MF/50V RADIAL LEAD, SP .30	NRE102M50V16X25	NIC	1500-31-0203	2
C96	CAP, ELECT, 1000MF/16V RADIAL LEAD, SP .20	1500-31-0214	WVTK	1500-31-0211	1
C8	CAP, ELECT, 22MF, 25V, RADIAL	SRA25VB22RM6X7LL	UNCON	1500-32-2002	1
C71 C72	CAP, ELECT, 2200MF, 25V RADIAL LEAD	ECEA1EV222S	PANAS	1500-32-2202	2
C103 C105	CAP, ELECT, 3300MF, 50V RADIAL LEAD, SP .40	NRE 3300/50	NIC	1500-33-3202	2
C82 C84 C89 C91	CAP, ELECT, 4700MF/25V RADIAL LEAD, SP .50	NRSA472M25V18X36	NIC	1500-34-7202	4
C93 C94	CAP, ELECT, 16V, 6800 uF, RAD, 0.4 LS	NRE682M16V22X41	NIC	1500-36-8201	2
C148	CAP, TANT, 47MF, 20V	196D476X9020PE4(OBS)	SPRAG	1500-74-7601	1

WAVETEK PARTS LIST	TITLE A1 PCA, 1MHz SYNTHESIZED OSCILLATOR	ASSEMBLY NO. 1100-00-3498 PAGE 3	REV E

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/P1
C27 C30	CAP, TANT, 6.8MF, 50V	T354J685M050AS	KEMET	1500-76-8503	2
1	PCB, LOW DISTORTION SINE WAVE OSCILLATOR REF: SPEC 0008-00-0455 REV E	1700-00-3498	WVTK	1700-00-3498	1
L1	CHOKE, 3.3MH, 10%	1537-24	DLVAN	1800-00-0006	1
J10 J6 J7 J8 J9	CONN, BNC(PC)	227161-1	AMP	2100-01-0019	5
J4	CONN, HEADER	1-640386-0	AMP	2100-02-0079	1
P16	CONN, HEADER, 10 PIN	1-640456-0	AMP	2100-02-0133	1
J14 J15	PC JACK	09-9094-1-04	CONCD	2100-02-0190	2
P11	CONN, HEADER, 3 PIN	929834-01-03	APTRN	2100-02-0196	1
XP11	JUMPER, FEMALE, 2 POSITION, 0.1 SPACE	929950-00	APTRN	2100-02-0213	1
J12	CONN, HEADER, 40 PIN, RECPT, 2X20, .1 CTR PCMT	1-0102585-2(REF ONLY)	AMP	2100-02-0256	1
J5	CONN, RECP, GPIB, 24POS, .125 TAIL, RT ANG, PC MT	488-2R4-24BM32K9	BURND	2100-02-0259	1
XU3	SOCKET, IC, 28 PIN	DILB28P-108T	BURND	2100-03-0081	1
XU5	SOCKET, 84	821573-1	AMP	2100-03-0094	1

WAVETEK PARTS LIST	TITLE A1 PCA, 1MHz SYNTHESIZED OSCILLATOR	ASSEMBLY NO. 1100-00-3498	REV E
		PAGE 4	

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
	PIN, PLCC, THRU HOLE				
16	JACK, CLSD ENTRY, PCB TYPE, PRES MNT, 0.040 PIN	450-3752-01-06-00	CAMB	2100-03-0096	2
P13 P22 P23	TERMINAL TAB (FASTON)	62747-1	AMP	2100-04-0038	3
TP14 TP2 TP5	TEST POINT, BLK, PC	TP-104-01-00	COMPO	2100-04-0054	3
TP1 TP10 TP11 TP12 TP13 TP15 TP16 TP3 TP4 TP6 TP7 TP8 TP9	TEST POINT, RED, PC	TP-104-01-02	COMPO	2100-04-0055	13
8	CONN PIN, INSERT	2100-05-0061	WVTK	2100-05-0061	2
Y2	OSCILLATOR, 10MHZ, TTL	F1144H-10MHZ	FOX	2300-99-0036	1
5	TRANSIPAD	503-075	BIVAR	2800-11-0003	4
6	TRANSIPAD	531-218	BIVAR	2800-11-0004	6
9	HEATSINK	209	WAKE	2800-11-0008	2
11	WASHER	5607-150	SESTM	2800-11-0015	5
10	HEATSINK, TO-220, CLIP-ON	574902B033	AAVID	2800-11-0040	4
7	HEATSINK, TO-5 PKG	7-120BA	IERC	2800-11-0042	4
14	RIVET, 1/8 BODY DIA, 1/8-3/16 GRIP SS	SSD43SSBS	EMHRT	2800-12-0055	3

WAVETEK PARTS LIST	TITLE A1 PCA, 1MHz SYNTHESIZED OSCILLATOR	ASSEMBLY NO. 1100-00-3498 PAGE 5	REV E

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/P
15	HOLE PLUG, BINDER HEAD, NTRAL NYLON	207-120241-03-0101	FASTX	2800-35-0009	7
12	WASHER, LOCK REG, S/S #4	MS 35338-135	CMRCL	2800-45-4000	5
13	SCREW PLPS PAN M/S 18-8 S/S 4-40X1/4	MS 51957-13	CMRCL	2800-48-4104	5
JP1	JUMPER	461-2871-01-03-10	CAMBN	3000-00-0034	1
FB5 FB6	BALUN CORE, FERRITE, 680 OHMS	2943666671	FARIT	3100-00-0017	2
K1 K2 K3 K4 K5 K6 K7 K8 K9	RELAY, 1 FORMC, 5V, .312H, .296W	HD1E-M-DC5V	AROMT	4500-00-0034	9
R174 R85	POT, TOP TRIM, 20T, 100K	68WR100K	BECK	4609-90-0001	2
R42	POT, TOP TRIM, 20T, 1K	68WR1K	BECK	4609-90-0005	1
R109 R110	RES, C, 1/2W, 5%, 10	RC-1/2-10J	STKPL	4700-25-0100	2
R130 R134	RES, C, 1/2W, 5%, 3.9	RC-1/2-3R9J	STKPL	4700-25-0399	2
R156 R160	RES, C, 1/2W, 5%, 4.7	RC-1/2-4R7J	STKPL	4700-25-0479	2
R105 R106 R107 R108	RES, C, 1/2W, 5%, 8.2	RC-1/2-8R2J	STKPL	4700-25-0829	4
R64 R65 R66 R67 R68 R69 R70 R71 R72 R73 R74 R75 R76 R77 R78 R79	RES, MF, 1/8W, .1%, 1K	RN55E-1001B	MEPCO	4701-02-1001	16

WAVETEK PARTS LIST	TITLE A1 PCA, 1MHz SYNTHESIZED OSCILLATOR	ASSEMBLY NO. 1100-00-3498	REV E
		PAGE 6	

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R38 R39 R40 R41	RES, MFLM, 1/8W, 0.1%, 20K	RN55E2002B	MEPCO	4701-02-2002	4
R10 R12 R16 R170 R22	RES, MF, 1/8W, 1%, 100	RN55D-1000F	TRW	4701-03-1000	5
R121 R13 R143 R147 R148 R180 R186 R33 R37 R56 R61	RES, MF, 1/8W, 1%, 1K	RN55D-1001F	TRW	4701-03-1001	12
R138 R167 R3 R34 R4 R5 R8 R9	RES, MF, 1/8W, 1%, 10K	RN55D-1002F	TRW	4701-03-1002	8
R175	RES, MF, 1/8W, 1%, 100K	RN55D-1003F	TRW	4701-03-1003	1
R101 R103 R123 R124 R125 R126 R179 R181 R19 R80 R81 R82 R83 R84	RES, MF, 1/8W, 1%, 10	5043ED10R100F	MEPCO	4701-03-1009	14
R36	RES, MF, 1/8W, 1%, 11K	RN55D-1102F	TRW	4701-03-1102	1
R100 R102 R117 R118 R119 R120 R150	RES, MF, 1/8W, 1%, 121	RN55D-1210F	TRW	4701-03-1210	7
R164	RES, MF, 1/8W, 1%, 12.1K	RN55D-1212F	TRW	4701-03-1212	1
R29 R30	RES, MF, 1/8W, 1%, 1.5K	RN55D-1501F	TRW	4701-03-1501	2
R98	RES, MF, 1/8W, 1%, 15	RN55D-15R0F	TRW	4701-03-1509	1
R145	RES, MF, 1/8W, 1%, 165	RN55D-1650F	TRW	4701-03-1650	1
R144 R190T R191T	RES, MF, 1/8W, 1%, 182	RN55D-1820F	TRW	4701-03-1820	3

WAVETEK PARTS LIST	TITLE A1 PCA, 1MHz SYNTHESIZED OSCILLATOR	ASSEMBLY NO. 1100-00-3498 PAGE 7	REV E

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/P
R104	RES, MF, 1/8W, 1%, 19.1K	RN55D-1912F	TRW	4701-03-1912	1
R137 R89 R90 R95 R96	RES, MF, 1/8W, 1%, 2K	RN55D-2001F	TRW	4701-03-2001	5
R6	RES, MF, 1/8W, 1%, 2.21K	RN55D-2211F	TRW	4701-03-2211	1
R32	RES, MF, 1/8W, 1%, 249	RN55D-2490F	TRW	4701-03-2490	1
R176 R45 R63 R87 R88 R91 R94	RES, MF, 1/8W, 1%, 2.49K	RN55D-2491F	TRW	4701-03-2491	7
R46 R92	RES, MF, 1/8W, 1%, 24.9K	RN55D-2492F	TRW	4701-03-2492	2
R25 R27	RES, MF, 1/8W, 1%, 24.9	RN55D-24R9F	TRW	4701-03-2499	2
R1	RES, MF, 1/8W, 1%, 274	RN55D-2740F	TRW	4701-03-2740	1
R142	RES, MF, 1/8W, 1%, 3.01K	RN55D-3011F	TRW	4701-03-3011	1
R188	RES, MF, 1/8W, 1%, 332	RN55D-3320F	TRW	4701-03-3320	1
R11	RES, MF, 1/8W, 1%, 3.32K	RN55D-3321F	TRW	4701-03-3321	1
R31 R62	RES, MF, 1/8W, 1%, 33.2	RN55D-33R2F	TRW	4701-03-3329	2
R151	RES, MF RN55D 365 OHM 1%	5043ED365R0F	MEPCO	4701-03-3650	1
R131 R135	RES, MF, 1/8W, 1%, 392	RN55D-3920F	TRW	4701-03-3920	2
R129 R132 R133 R136 R155 R158 R159 R162	RES, MF, 1/8W, 1%, 3.92K	RN55D-3921F	TRW	4701-03-3921	8

WAVETEK PARTS LIST	TITLE A1 PCA, 1MHz SYNTHESIZED OSCILLATOR	ASSEMBLY NO. 1100-00-3498 PAGE 8	REV E

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R43	RES, MF, 1/8W, 1%, 4.02K	RN55D-4021F	TRW	4701-03-4021	1
R146	RES, MF, 1/8W, 1%, 40.2	RN55D-40R2F	TRW	4701-03-4029	1
R26 R28	RES, MF, 1/8W, 1%, 475	5033RD4750F	MEPCO	4701-03-4750	2
R122 R149 R157 R161 R172	RES, MF, 1/8, 1%, 499	RN55D-4990F	TRW	4701-03-4990	5
R14 R15 R24 R97	RES, MF, 1/8W, 1%, 4.99K	RN55D-4991F	TRW	4701-03-4991	4
R17 R173 R182 R183 R2	RES, MF, 1/8W, 1%, 49.9K	RN55D-4992F	TRW	4701-03-4992	5
R86	RES, MF, 1/8W, 1%, 499K	RN55D-4993F	TRW	4701-03-4993	1
R169	RES, MF, 1/8W, 1%, 49.9	RN55D-49R9F	CORNG	4701-03-4999	1
R171	RES, MF, 1/8W, 1%, 604	RN55D-6040F	TRW	4701-03-6040	1
R184 R185	RES, MF, 1/8W, 1%, 681	RN55D-6810F	TRW	4701-03-6810	2
R52 R53 R54 R55 R57 R58 R59 R60	RES, MF, 1/8W, 1%, 750	RN55D-7500F	TRW	4701-03-7500	8
R140 R141 R165 R168	RES, MF, 1/8W, 1%, 7.5K	RN55D-7501F	TRW	4701-03-7501	4
R23	RES, MF, 1/8W, 1%, 9.76K	RN55D-9761F	TRW	4701-03-9761	1
R113 R114 R115 R116	RES, MF, 1/4W, 1%, 909	RN60D9090F	TRW	4701-13-9090	4
R177 R178	RES, MF, 1/2W, 1%, 49.9	RN65D-49R9F	TRW	4701-23-4999	2
R111 R112	RES, MF, 1W, 1%, 100	RN70D-1000F	TRW	4701-33-1000	2

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/P
RN1 RN2	RES NETWORK 39 OHM 14PIN DIP ISOL	314B390	AB	4770-00-0026	2
R152 R153 R163 R166 R187	RES, 0 OHM JUMPER	JP02T68G	ROHM	4799-00-0087	5
CR33 CR34 CR35 CR36 CR6 CR7 CR8	DIODE, HIGH CONDUCTANCE, ULTRA FAST	1N5282	FAIR	4801-01-5282	7
CR1 CR12 CR13 CR14 CR15 CR16 CR17 CR18 CR19 CR23 CR24 CR27 CR30 CR31 CR32	DIODE, 1N4002 GEN PURPOSE RECT. 100V, 1A	1N4002	FAIR	4801-02-0001	15
CR25 CR26 CR28 CR29	DIODE 1N4005 GENERAL PURPOSE, RECTIFIER, 600 V, 1A	1N4005	MOT	4806-01-4005	4
CR20 CR21 CR22	RECT, SCHOT BARRIER, CNTR-TAP, 15A, 35V	MBR1535CT	MOT	4806-01-5350	3
CR37 CR38	DIODE, SWITCHING, GP, 100V, 200MA	1N4148	NSC	4807-02-6666	2
CR3 CR5	DIODE 5082-2811 SCHOTTKY, 15V, 20MA	5082-2811	HP	4809-02-2811	2
DS1 DS3	LED, GREEN, RECT BAR	LTL-3231A	LITE	4899-00-0057	2
Q10 Q11 Q12 Q9	TRANS 2N2219A NPN GENERAL PURPOSE TO-5	2N2219A	NSC	4901-02-2191	4
Q6	TRANS, SILICON, PLANAR,	2N2369A	MOT	4901-02-3691	1

WAVETEK PARTS LIST	TITLE A1 PCA, 1MHz SYNTHESIZED OSCILLATOR	ASSEMBLY NO. 1100-00-3498 PAGE 10	REV E

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
	EPITAXIAL, NPN, TO-18				
Q13 Q14 Q15 Q16 Q19 Q8	TRANS 2N2905A PNP GENERAL PURPOSE TO-5	2N2905A	NSC	4901-02-9051	6
Q1 Q17 Q18	TRANS 2N3904 NPN GENERAL PURPOSE TO-92	2N3904	FAIR	4901-03-9040	3
Q7	TRANS 2N5771 PNP SWITCH TO-92	2N5771	NSC	4901-05-7710	1
Q20	TRANS	TIP-36	TI	4902-00-0360	1
Q3	TRANS, FET N CHANNEL	VN0106N3	SUPER	4902-01-0600	1
U25	DAC, SERIAL INP, 16 BIT, MONO	PCM56P	BURR	7000-00-5600	1
VR1 VR4	VOLT REGULATOR, 3 TERMINAL ADJUSTABLE POS	LM317T	NSC	7000-03-1700	2
VR2 VR3 VR5	VOLT REGULATOR	LM337T	NSC	7000-03-3700	3
U30	OP-AMP	LF356N	NSC	7000-03-5600	1
U14 U27	COMPARATOR, DUAL DIFFERENTIAL, SENSE AMP	NE521N	SIG	7000-05-2100	2
U35	DAC	DAC1006LCN	NAT	7000-10-0600	1
U32	VOLTAGE REFERENCE,	LT1021CCN8-10	LINTE	7000-10-2101	1

WAVETEK
PARTS LIST

TITLE A1
PCA, 1MHz SYNTHESIZED OSCILLATOR

ASSEMBLY NO. 1100-00-3498

REV E

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REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/P
	10V, 8 PIN DIP				
U13	DARLINGTON ARRAYS, HIGH VOLTAGE, HIGH CURRENT	ULN2003A	SPRAG	7000-20-0300	1
U24 U28 U29	OP, AMP CURRENT FEEDBACK, 50mhz	EL2020CN	ELAN	7000-20-2000	3
U1	RESET GEN	TL7705ACP	TI	7000-77-0501	1
U33 U34	OP AMP, HI SLEW RTE, WIDEBND, JFET, STD	MC34081P	MOT	7003-40-8100	2
U26 U31 U36	OP AMP, HI SLEW RTE, WIDEBND, JFET DUAL	MC34082P	MOT	7003-40-8200	3
U38	DRIVER, DUAL LINE	SN75121N	TI	7007-51-2100	1
U21	DAC, 12 BIT, 20MHZ	TDC1012N7-C2	TRW	8000-10-1200	1
U4	SRAM, 8KX8, 120NS, CMOS	CXK5864BP-12L	SONY	8000-62-6400	1
U2	MICROPROCESSOR, 8BIT	EF6803P	SGS	8000-68-0300	1
U15	GATE, NAND, QUAD 2-INP, TTL	SN74LS00N	TI	8000-74-0010	1
U16	FLIP-FLOP, DUAL D, POS EDGE TRIG W/CLR/PRES	SN74ALS74N	TI	8000-74-7403	1
U7	ADPT, GPIB INTERFACE	MC68488P	MOT	8006-84-8800	1

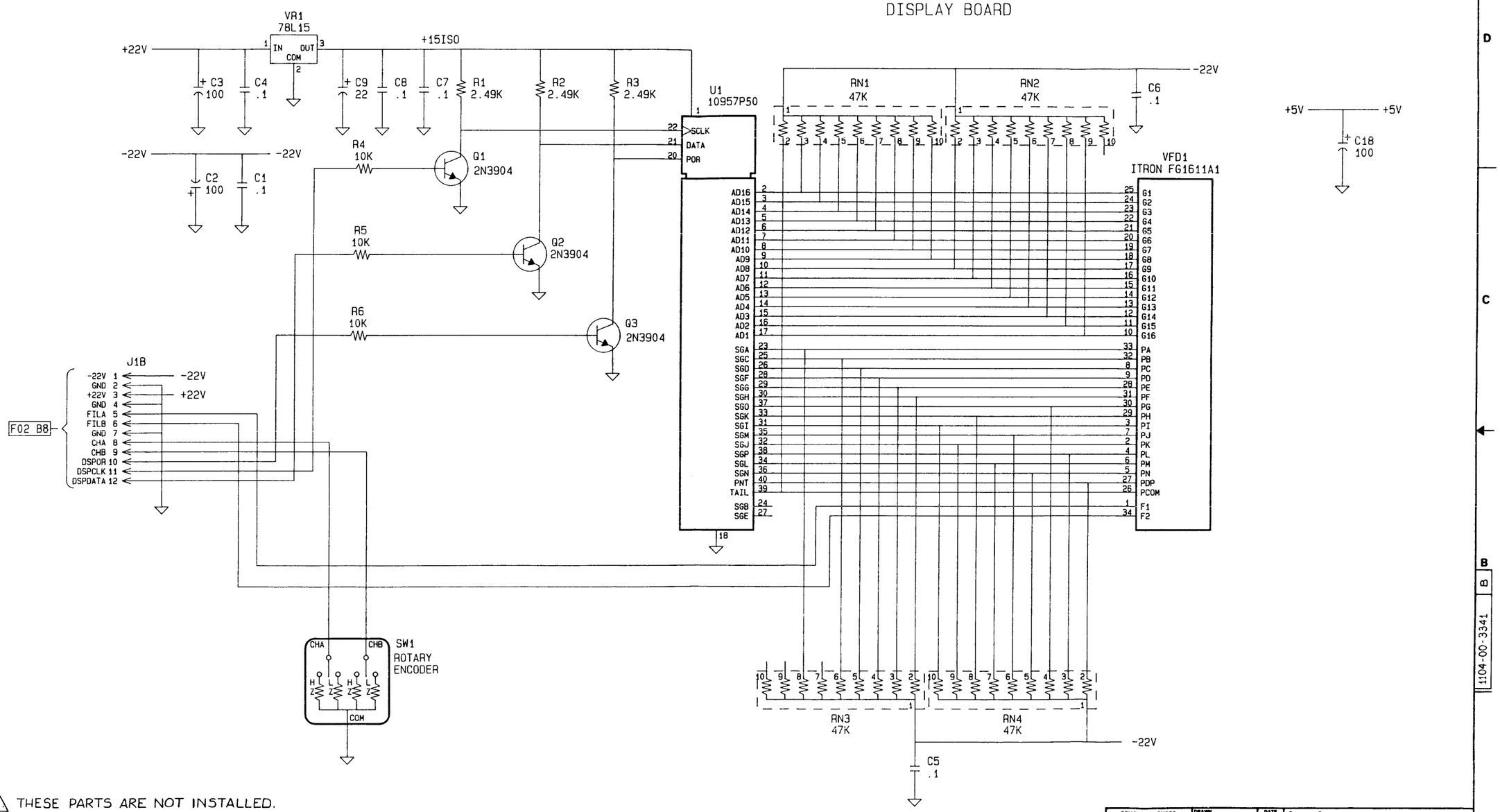
WAVETEK PARTS LIST	TITLE A1 PCA, 1MHz SYNTHESIZED OSCILLATOR	ASSEMBLY NO. 1100-00-3498 PAGE 12	REV E

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
U17	DRIVER, HEX, NON-INV	SN74ALS1034N	TI	8007-41-0340	1
U10	DECODER, 1-8 LINE, TTL	74LS138	TI	8007-41-3810	1
U11 U12 U22 U23	FLIP-FLOP, OCTAL D	SN74ALS574N	TI	8007-45-7450	4
U9	XCVR, OSC BUS, TTL	75160	TI	8007-51-6000	1
U8	TRANSCEIVER, OCT BUS, TTL	SN75161BN	TI	8007-51-6100	1
U6	EEPROM, SERIAL, 4096 BIT	XL93C66P	EXEL	8009-36-6000	1
U19	PROG EPROM, USES 1 EA 8002-76-4001 FOR MODEL 98, V1.0, REF U19	8600-00-0795	WVTK	8600-00-0795	1
U20	PROG EPROM, USES 1 8002-76-4001 FOR MODEL 98 V1.0, REF U20	8600-00-0796	WVTK	8600-00-0796	1
U3	PROG EPROM. USES 1 EA. 8002-72-5600 FOR MODEL 98 REF U3 V1.2	8600-00-0798	WVTK	8600-00-0798	1
U18	GA, PHASE ACCUMULATOR-CUSTOM	8700-00-0001	WVTK	8700-00-0001	1
U5	GATE ARRAY, 84 PIN, PSC288	8700-00-0003	WVTK	8700-00-0003	1

WAVETEK PARTS LIST	TITLE A1 PCA, 1MHz SYNTHESIZED OSCILLATOR	ASSEMBLY NO. 1100-00-3498 PAGE 13	REV E

REV	ECO	BY	DATE	APP
B	ECO 93-0067	SC	12292	

DISPLAY BOARD



4. THESE PARTS ARE NOT INSTALLED.

3. FOR INSTRUMENT INTERCONNECTION, SEE INSTRUMENT SCHEMATIC.

2. ALL CAPACITORS ARE IN MICROFARADS (uF).

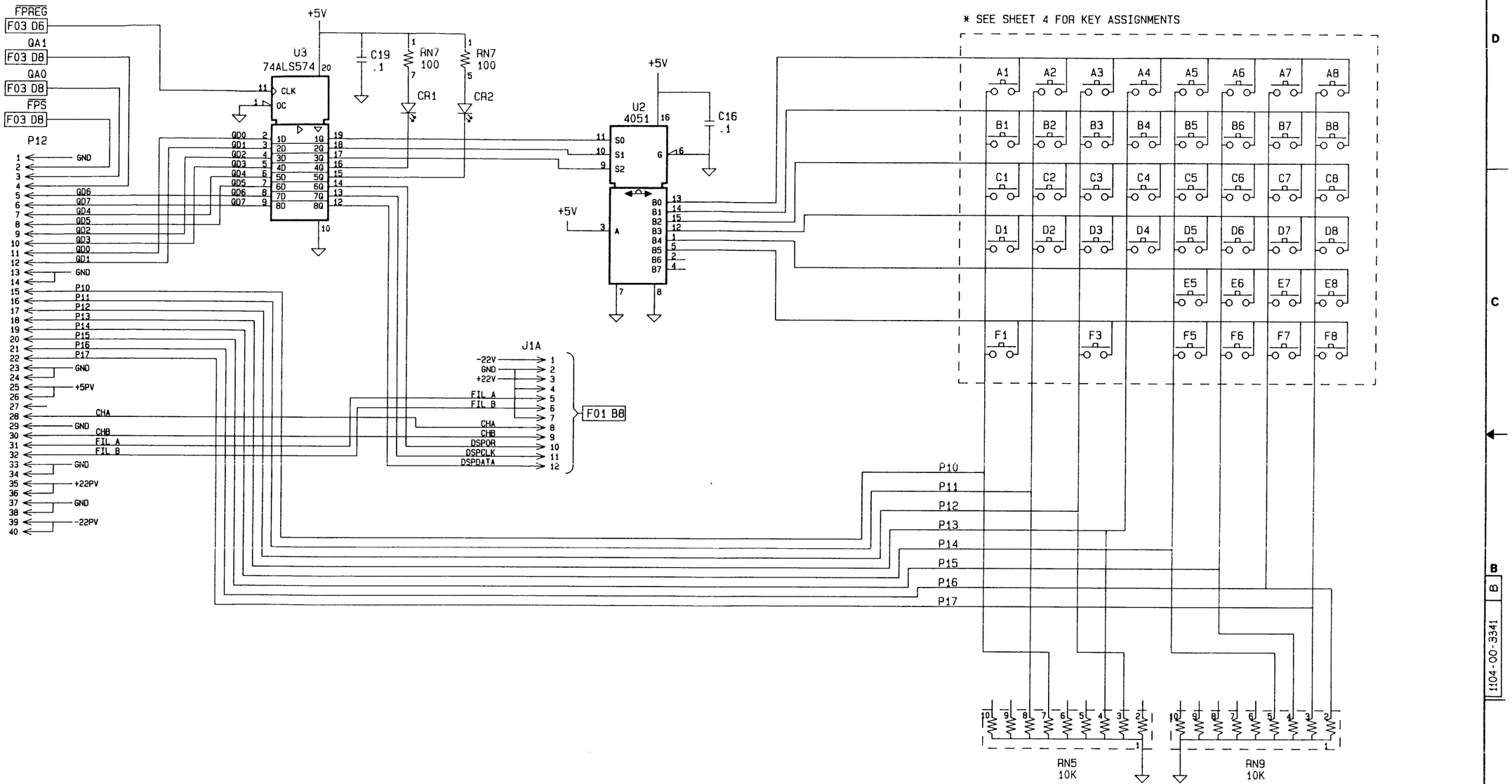
1. ALL RESISTORS ARE IN OHMS, 1/8W, 1%, MF.

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN A. TALMADGE	DATE 7-11-90	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED	7-26-90	TITLE: A2 SCHEMATIC, DISPLAY/KEYBOARD
	PROJ. ENGR.	7/26/90	
FINISH: WAVETEK PROCESS	RELEASE APPROV.	7/26/90	
DO NOT SCALE DRAWING	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES .XX ± .XXX ± °		SIZE D · FSCM NO. 23338 · DWG. NO. 1104-00-3322 · REV C · SCALE NONE · MODEL 90 SERIES · SHEET 1 OF 4

1104-00-3341 B

REV	ECO	BY	DATE	APP



NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN A. TALMADGE	DATE 7-11-90	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED	7-16-90	TITLE: A2 SCHEMATIC, DISPLAY/KEYBOARD
FINISH WAVETEK PROCESS	PROJ. ENGR.	7/24/90	
	RELEASE APPROV.	7/25/90	
DO NOT SCALE DRAWING	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ± DECIMALS .XX ± .XXX ± ANGLES ±		SIZE D · FSCM NO. 23338 · DWG. NO. 1104-00-3322 · REV C · SCALE NONE · MODEL 90 SERIES · SHEET 2 OF 4

1104-00-3341 B

REV	ECO	BY	DATE	APP

U4 74ALS138
U5 74ALS574
U6 74ALS574
U7 74ALS574

* SEE SHEET 4 FOR LED ASSIGNMENTS

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN A. TALMADGE	DATE 7-11-90	WAVETEK SAN DIEGO, CALIFORNIA	
MATERIAL	CHECKED	7-26-90	TITLE A2 SCHEMATIC, DISPLAY/KEYBOARD	
FINISH WAVETEK PROCESS	PROJ. ENGR.	7/24/90		
	RELEASE APPROV.	7/24/90		
DO NOT SCALE DRAWING	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES ± XX ± XXX ± ±		SIZE D	FSCM NO. 23338
			DWG. NO. 1104-00-3322	REV C
			SCALE NONE	MODEL 90 SERIES SHEET 3 OF 4

REV	ECO	BY	DATE	APP

LED ASSIGNMENTS

	90	95	91	98
CR1	UNLOCK	UNLOCK	UNLOCK	—
CR2	EXT	EXT	EXT	—
CR3	—	DC	DC	EXT
CR4	600	600	600	—
CR5	135	135	135	OFF
CR6	75	75	75	600
CR7	BAL	BAL	BAL	—
CR8	50	50	50	50
CR9	ENABLE	ENABLE	ENABLE	ENABLE
CR10	REMOTE	REMOTE	REMOTE	REMOTE
CR11	HV OPT	—	—	—
CR12	AM	AM	AM	PEN
CR13	FM	FM	FM	—
CR14	SWEEP	SWEEP	SWEEP	—
CR15	SCM	SCM	SCM	—
CR17	—	~	~	CONT
CR18	—	⊓	⊓	—
CR19	—	∿	∿	TRIG
CR20	TRIG	TRIG	TRIG	LOG
CR21	GATE	GATE	GATE	—
CR22	CONT	CONT	CONT	LIN
CR23	BURST	BURST	BURST	MARK
CR24	DC	ARB4	EW	—
CR25	⊓	ARB3	⊓⊓	—
CR26	∿	ARB2	_⊓_	THOLD
CR27	~	ARB1	⊓___	MAN

KEY ASSIGNMENTS-MODEL 90

	1	2	3	4	5	6	7	8
A	AMPL	FREQ		SYMM	1	0	7	4
B	OFFSET	DISPLAY		SOURCE	2	.	8	5
C	STORE	RESET	PHASE	FUNCTION	3	+/-	9	6
D	→		←	BURST CNT	EXP	ENTER	KNOB	CE
E					CMD RECALL	ON/OFF	LOCAL	SHIFT
F	MAN TRIG		SWEEP MODE			MODE	TRIG FREQ	TIME

KEY ASSIGNMENTS-MODEL 95

	1	2	3	4	5	6	7	8
A	AMPL	FREQ	SYNC ADDR	FILTER	1	0	7	4
B	OFFSET	Z-AXIS	CURSORS	PHASE	2	.	8	5
C	STORE	RESET	ADDRESS	FUNCTION	3	+/-	9	6
D	EDIT	SOURCE	DATA	BURST CNT	EXP	ENTER	KNOB	CE
E					CMD RECALL	ON/OFF	LOCAL	SHIFT
F	MAN TRIG		SWEEP MODE			MODE	TRIG FREQ	TIME

KEY ASSIGNMENTS-MODEL 91

	1	2	3	4	5	6	7	8
A	AMPL	FREQ/PER	SYNC	WIDTH	1	0	7	4
B	OFFSET	DISPLAY	LOWER LVL	PHASE	2	.	8	5
C	STORE	RESET	DELAY	FUNCTION	3	+/-	9	6
D	PULSE	LOCK SOURCE	UPPER LVL	TRIG SETUP	EXP	ENTER	KNOB	CE
E					CMD RECALL	ON/OFF	LOCAL	SHIFT
F	MAN TRIG		SWEEP MODE			MODE	TRIG FREQ	TIME

KEY ASSIGNMENTS-MODEL 98

	1	2	3	4	5	6	7	8
A	AMPL	FREQ		STOP	1	0	7	4
B	START	RESET	LIN/LOG	MODE	2	.	8	5
C	AMPL UNITS		MARKER		3	+/-	9	6
D	TRIGGER		TIME	HOLD	EXP	ENTER	KNOB	CE
E					GPIB ADRS	SELECT (MAIN OUT)	LOCAL	SHIFT
F	←		INTENSITY			SELECT (MARK OUT)	→	MONITOR

NOTE UNLESS OTHERWISE SPECIFIED

CAD JOB #: B068B

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN M. PETERSON	DATE 3/4/93	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	CHECKED		TITLE A2 SCHEMATIC, DISPLAY/KEYBOARD
	PROJ. ENGR		
	RELEASE APPROV		
FINISH WAVETEK PROCESS	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES .XX ± .XXX ± ±		SIZE D | FSCM NO. 23338 | DWG. NO. 1104-00-3322 | REV C
DO NOT SCALE DRAWING			SCALE — | MODEL 90 SER 95 | SHEET 4 OF 4

1104-00-3322

REV	ECN	BY	DATE	APP
A	ERO#90-462	ST	7-11-90	
B	ECO 93-067	SC	12-2-92	

NOTES:

1. COMPONENTS MOUNTED ON COMPONENT SIDE OF PCB SHOWN ON SHEET 1, COMPONENTS MOUNTED ON SOLDER SIDE OF PCB SHOWN ON SHEET 2.

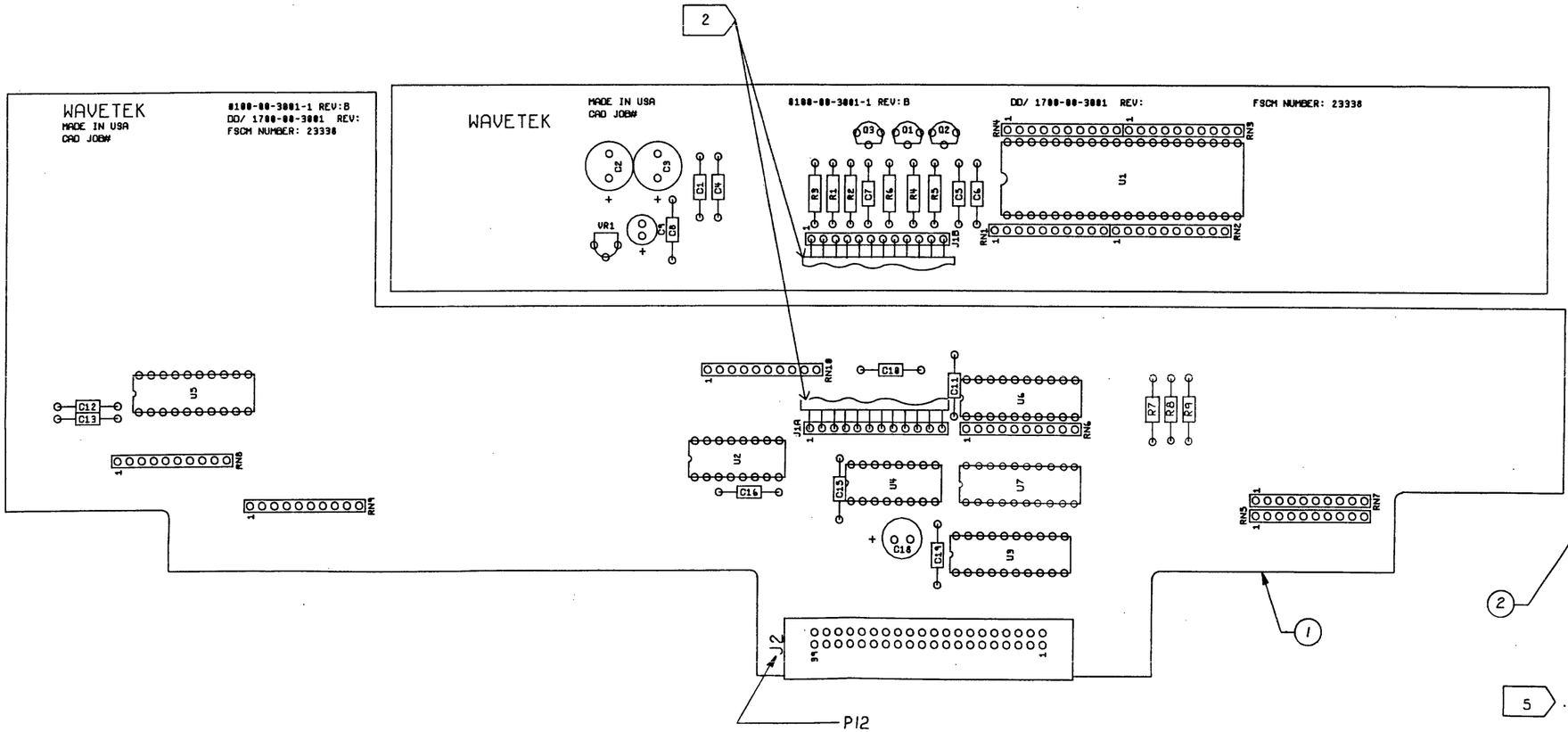
2 RIBBON CABLE IS INSTALLED BETWEEN J1A ON LOWER KEYBOARD PCB AND J1B ON UPPER DISPLAY PCB.

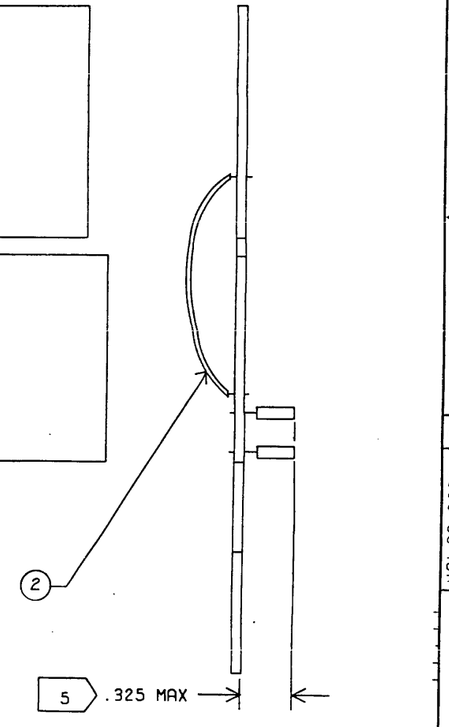
3 LEADS OF COMPONENTS MOUNTED ON COMPONENT SIDE OF PCB OPPOSITE DISPLAY (VFD1), MUST HAVE LEADS TRIMMED TO WITHIN .050 OF PCB SURFACE.

4 MOUNTING OF DISPLAY (VFD1):

A. INSTALL AND SOLDER COMPONENTS ON COMPONENT SIDE OF PCB.
B. TRIM LEADS OF COMPONENT ON UPPER BOARD PER NOTE 3.
C. ATTACH DISPLAY CUSHION (ITEM NO.3) TO DISPLAY, POSITIONING CUSHION SO THAT IT DOES NOT OVERLAP DISPLAY.
D. PLACE DISPLAY (VFD1) WITH ATTACHED CUSHION ON SOLDER SIDE OF PCB MAKING SURE THAT THE SURFACE OF THE CUSHION IS FLUSH TO THE PCB SURFACE.
PINS OF COMPONENTS ON OPPOSITE SIDE OF PCB WILL PIERCE THE CUSHION.
E. ALLOW DISPLAY (VFD1 ON COMPONENT SIDE) TO SELF-LEVEL BEFORE SOLDERING THE PINS OF DISPLAY.

5 LEDS (CR1 THRU CR27) MAY BE MOUNTED FLUSH TO PCB.





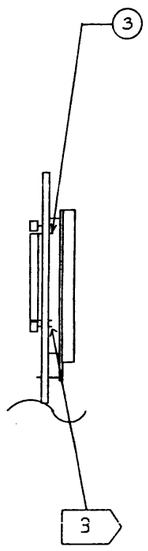
SEE SEPARATE PARTS LIST

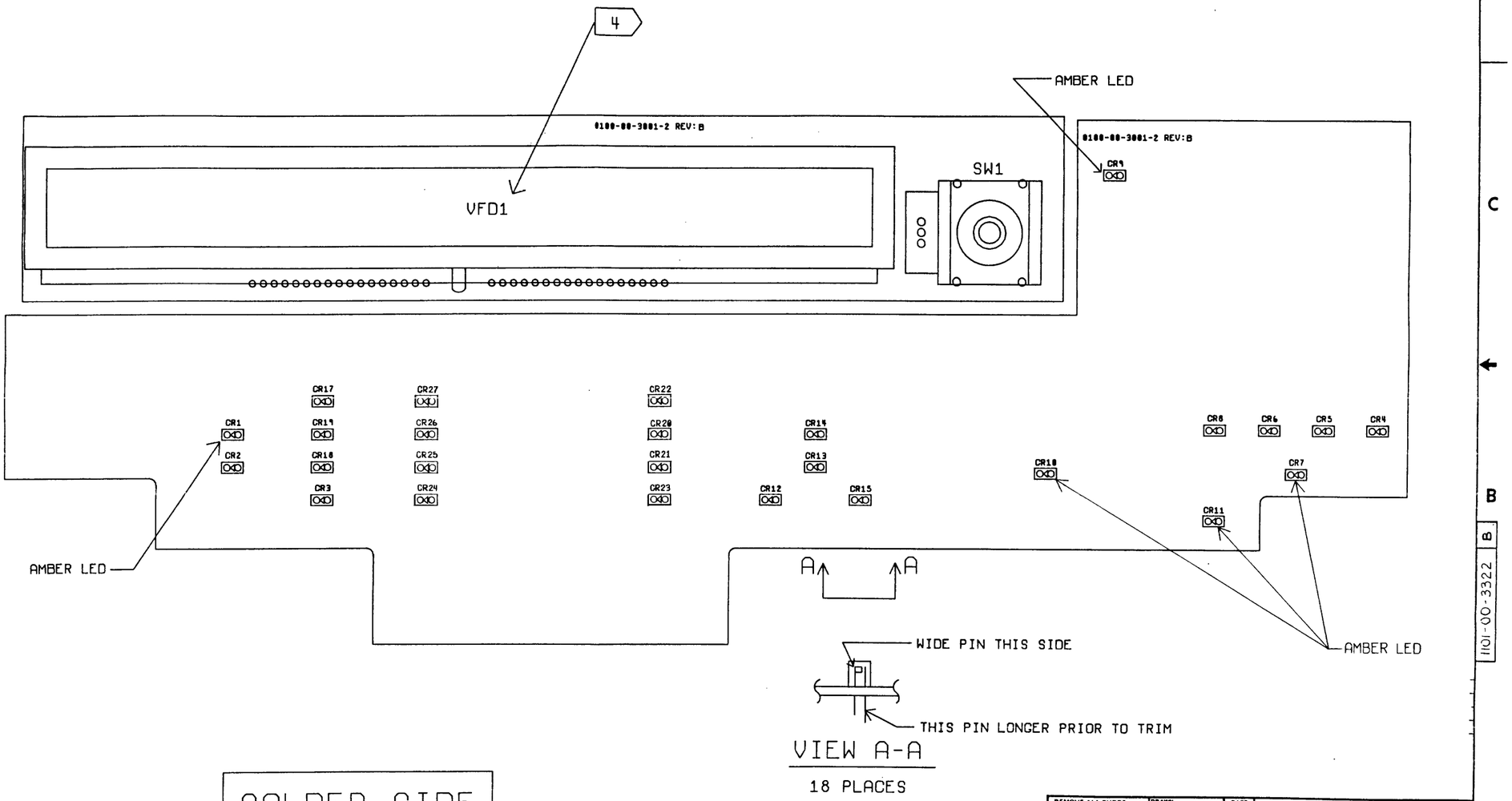
NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN A. TALMADGE	DATE 7-1-90	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR J. McCosh	7/1/90	TITLE: A2 PCB ASSEMBLY - DISPLAY/KEYBOARD
	RELEASE APPROV	7/4/90	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 ANGLES ±1° .XX ±.030		
	DO NOT SCALE DWG	MODEL NO. 90 SERIES	DWG NO. 1101-00-3322 REV B
	SCALE NONE	CODE IDENT 23338	SHEET 1 OF 2

1101-00-3322 B

REV	ECN	BY	DATE	APP





VIEW A-A

18 PLACES

SOLDER SIDE

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN A. TALMADGE	DATE 7-1-90	WAVETEK SAN DIEGO, CALIFORNIA
MATERIAL	PROJ ENGR J. McCann	7/1/90	TITLE A2 PCB ASSEMBLY - DISPLAY/KEYBOARD
FINISH WAVETEK PROCESS	RELEASE JM	APPROV 7/1/90	
	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 ANGLES ±1° .XX ±.030		
	DO NOT SCALE DWG	MODEL NO. 90 SERIES	DWG NO. 1101-00-3322 REV. B
	SCALE NONE	CODE IDENT 23338	SHEET 2 OF 2

1101-00-3322 B

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
REF	A/D, DISPLAY/ KEYBOARD	1101-00-3322	WVTK	1101-00-3322	1
REF	S/D DISPLAY, KEYBOARD	1104-00-3322	WVTK	1104-00-3322	1
3	CUSHION, DISPLAY	1400-02-3510	WVTK	1400-02-3510	1
C1 C10 C11 C12 C13 C15 C16 C19 C4 C5 C6 C7 C8	CAP, CER, MON, .1MF, 50V, AXIAL	CAC03Z5U104Z050A	CORNG	1500-01-0405	13
C18 C2 C3	CAP, ELECT, 100MF, 35V RADIAL LEAD, SP .20	NRE101M35V10X12.5(OBS)	NIC	1500-31-0102	3
C9	CAP, ELECT, 22MF, 25V, RA DIAL	SRA25VB22RM6X7LL	UNCON	1500-32-2002	1
1	PCB, DISPLAY/KEYBOARD REF: SPEC 0008-00-0455 REV E	1700-00-3001	WVTK	1700-00-3001	1
P12	CONN, HEADER, 40 PIN, PCB MT, .1 CTR, 2X20, SHRD	1-102692-3	AMP	2100-02-0258	1
VFD1	DISPLAY, VAC, FLOUR	FIP16A11R	NEC	2400-03-0019	1
R7 R8 R9	RES, MF, 1/8W, 1%, 100	RN55D-1000F	TRW	4701-03-1000	3
R4 R5 R6	RES, MF, 1/8W, 1%, 10K	RN55D-1002F	TRW	4701-03-1002	3
R1 R2 R3	RES, MF, 1/8W, 1%, 2.49K	RN55D-2491F	TRW	4701-03-2491	3
RN5 RN6 RN9	RES NETWORK 10K 2%	4310R-101-103	BOURN	4770-00-0008	3

WAVETEK PARTS LIST	TITLE A2 PCA, DISPLAY/ KEYBOARD	ASSEMBLY NO. 1100-00-3322	REV D
		PAGE 1	

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/P
	10PIN SIP BUSS				
RN1 RN2 RN3 RN4	RES NETWORK 47K 2% 10PIN SIP BUSS	4310R-101-473	BOURN	4770-00-0030	4
RN10 RN7 RN8	RES NETWORK 10PIN SIP 100 OHM BUSS	4310R-101-101	BOURN	4770-00-0054	3
CR1 CR10 CR11 CR7 CR9	LED, AMBER, RECT BAR	LTL-3251A	LITE	4899-00-0056	5
CR12 CR13 CR14 CR15 CR17 CR18 CR19 CR2 CR20 CR21 CR22 CR23 CR24 CR25 CR26 CR27 CR3 CR4 CR5 CR6 CR8	LED, GREEN, RECT BAR	LTL-3231A	LITE	4899-00-0057	21
Q1 Q2 Q3	TRANS 2N3904 NPN GENERAL PURPOSE TO-92	2N3904	FAIR	4901-03-9040	3
SW1	ENCODER, ROTARY, MADE FROM 5104-00-0027	5109-00-0001	WVTK	5109-00-0001	1
2	CABLE, FLEX, JMP, ASSY	1-86943-1	AMP	6001-60-0017	1
VR1	VOLT REGULATOR, POSITIVE	78L15	TI	7000-78-1501	1
U2	MUX/DEMUX, ANALOG	CD4051BE	RCA	8000-40-5100	1
U1	CONTROLLER, ALPH NUM DISP, 40V	10957P-50	ROCK	8001-09-5700	1
U4	DECODER/DEMUX, 3 TO 8 LINE	SN74ALS138N	TI	8007-41-3800	1

WAVETEK PARTS LIST	TITLE A2 PCA, DISPLAY/ KEYBOARD	ASSEMBLY NO. 1100-00-3322	REV D
		PAGE 2	

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PI
U3 U5 U6 U7	FLIP-FLOP, OCTAL D	SN74ALS574N	TI	8007-45-7450	4

WAVETEK PARTS LIST	TITLE A2 PCA, DISPLAY/ KEYBOARD	ASSEMBLY NO. 1100-00-3322 PAGE 3	REV D

APPENDIX A
PERFORMANCE VERIFICATION FORM

Date _____ Technician _____ Serial No _____

Frequency Range, Accuracy, Resolution

	Measured value	Specified value
Step 3: Accuracy		
1 MHz	_____ MHz	1 MHz ± 25 Hz
Step 4: External Ref		
1 MHz	_____ yes/no	1 MHz ± 1 count
Step 5: Range, Resolution		
888.888 kHz	_____ yes/no	888.888 kHz ± 1 count
444.444 kHz	_____ yes/no	444.444 kHz ± 1 count
444.445 kHz	_____ yes/no	444.445 kHz ± 1 count

50Ω Amplitude Range/Accuracy

	Measured value	Specified value
Step 3: Full Scale Accury.		
5 Vrms	_____ Vrms	4.949 to 5.051 Vrms
Step 4 Residual Offset:		
5 Vrms	_____ mVrms	< ±10 mVrms
Step 5: Range/Accuracy		
2 Vrms	_____ Vrms	1.979 to 2.021 Vrms
1 Vrms	_____ Vrms	0.989 to 1.011 Vrms
500 mVrms	_____ mVrms	494 to 506 mVrms
200 mVrms	_____ mVrms	197 to 203 mVrms
100 mVrms	_____ mVrms	98 to 102 mVrms
50 mVrms	_____ mVrms	48.5 to 51.5 mVrms
20 mVrms	_____ mVrms	18.8 to 21.2 mVrms
10 mVrms	_____ mVrms	8.9 to 11.1 mVrms

50Ω Amplitude Flatness

	Measured value	Specified value
Step 3:		
1 kHz	_____yes/no	0.00 dB (rel)
Step 4:		
100 kHz	_____ dB	< ± 0.2 dB (rel)
Step 5:		
600 kHz	_____ dB	< ± 0.5 dB (rel)

600Ω Amplitude Range/Accuracy

	Measured value	Specified value
Step 4: Full Scale Accury.		
10 Vrms	_____ Vrms	9.495 to 10.505 Vrms
Step 5: Range/Accuracy		
5 Vrms	_____ Vrms	4.745 to 5.255 Vrms
1 Vrms	_____ Vrms	0.945 to 1.055 Vrms

600Ω Amplitude Flatness

	Measured value	Specified value
Step 3:		
1 kHz	_____yes/no	0.00 dB (rel)
Step 4:		
100 kHz	_____ dB	< ± 1dB (rel)
Step 5:		
200 kHz	_____ dB	< +1, –4 dB (rel)

Sine Wave Purity

	Measured value	Specified value
Step 3:		
THD at 1 kHz (30 kHz filter on)	_____ dB	≤ – 70 dB (0.03%)
Step 4:		
THD at 10 kHz (80 kHz filter on)	_____ dB	≤ – 70 dB (0.03%)
Step 5:		
THD at 100 kHz (no filter)	_____ dB	≤ – 60 dB (0.1%)

Sweep Output Amplitude Accuracy

	Measured value	Specified value
Step 2:		
Vout at index 0000, 600Ω	_____ mVdc	0 ± 25 mVdc
Step 3:		
Vout at index 1023, 600Ω	_____ Vdc	2.5 ± 0.25 Vdc

Sync Output

	Measured value	Specified value
Step 3:		
600 kHz	_____ yes/no	3 cycles TTL square
Step 4:		
Upper Level	_____ V	> 2.0 V
Lower Level	_____ V	< 0.4 V
Rise Time	_____ ns	< 50 ns
Fall Time	_____ ns	< 50 ns

Reference Input

	Measured value	Specified value
Step 3: Internal Reference 600 mVp-p, 7 MHz	_____ yes/no	EXT indicator off
Step 4 External Reference lower threshold	_____ MHz	EXT on, 7.0 to 9.8 MHz
Step 5 External Reference upper threshold	_____ MHz	EXT on, 10.2 to 13.0 MHz

Front Panel

	Measured value	Specified value
Step 1: Test controls and displays Test operation	_____ yes/no	operational