INSTRUCTION MANUAL

MODEL 164
30 MHz
SWEEP GENERATOR

WAVETEK®

WAVETEK SAN DIEGO, INC.

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

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WARRANTY

Wavetek warrants that all products manufactured by Wavetek conform to published Wavetek specifications and are free from defects in materials and workmanship for a period of one (1) year from the date of delivery when used under normal operating conditions and within the service conditions for which they were furnished.

The obligation of Wavetek arising from a Warranty claim shall be limited to repairing, or at its option, replacing without charge, any product which in Wavetek's sole opinion proves to be defective within the scope of the Warranty. In the event Wavetek is not able to modify, repair or replace non-conforming defective parts or components to a condition as warrantied within a reasonable time after receipt thereof, Buyers shall be credited for their value at the original purchase price.

Wavetek must be notified in writing of the defect or nonconformity within the Warranty period and the affected product returned to Wavetek's factory or to an authorized service center within (30) days after discovery of such defect or nonconformity.

For product warranties requiring return to Wavetek, products must be returned to a service facility designated by Wavetek. Buyer shall prepay shipping charges, taxes, duties and insurance for products returned to Wavetek for warranty service. Except for products returned to Buyer from another country, Wavetek shall pay for return of products to Buyer.

Wavetek shall have no responsibility hereunder for any defect or damage caused by improper storage, improper installation, unauthorized modification, misuse, neglect, inadequate maintenance, accident or for any product which has been repaired or altered by anyone other than Wavetek or its authorized representative and not in accordance with instructions furnished by Wavetek.

Exclusion of Other Warranties

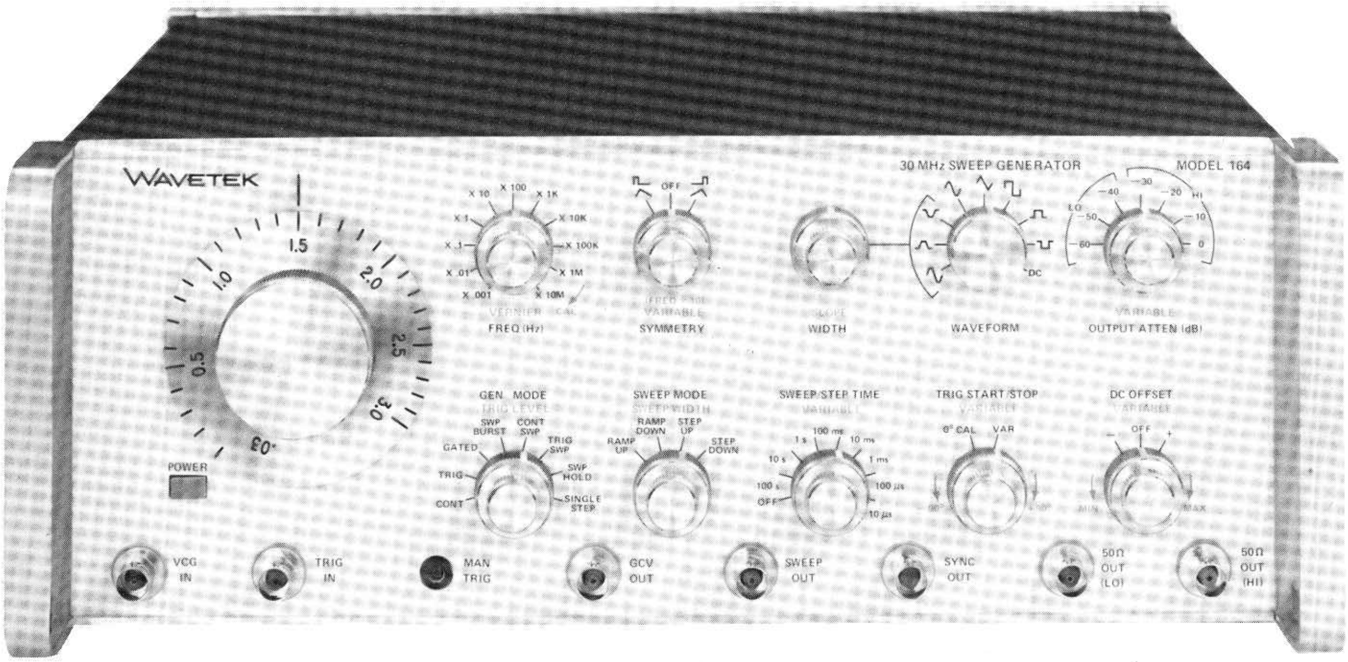
The Warranty described above is Buyer's sole and exclusive remedy and no other warranty, whether written or oral, is expressed or implied. Wavetek specifically disclaims the implied warranties of merchantability and fitness for a particular purpose. No statement, representation, agreement, or understanding, oral or written, made by an agent, distributor, representative, or employee of Wavetek, which is not contained in the foregoing Warranty will be binding upon Wavetek, unless made in writing and executed by an authorized Wavetek employee. **Under no circumstances shall Wavetek be liable for any direct, indirect, special, incidental, or consequential damages, expenses, losses or delays (including loss of profits) based on contract, tort, or any other legal theory.**

CONTENTS

SAFETY FIRST

Protect yourself. Follow these precautions:

- Don't touch the outputs of the instrument or any exposed test wiring 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 adaptors.
- 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.



Model 164 30 MHz Sweep Generator

SECTION 1
INTRODUCTION

1.1 PURPOSE OF THE EQUIPMENT

The Model 164 Sweep Generator offers an extended waveform versatility plus a frequency range that spans twelve decades, from 30 μHz (9.2 hours per cycle) to 30 MHz.

The waveforms available are sine, square, triangle, trapezoidal and positive and negative rectangular and trapezoidal pulse, each with variable amplitude, dc offset and symmetry.

The trapezoidal waveform rise and fall times may be varied by means of independent slope, width and symmetry controls. Different rise times and fall times, both controllable, may be selected to suit your testing or triggering requirements.

The Model 164 employs a main generator, which can be triggered, gated or swept by an external signal. In addition, it has a ramp/step generator. The latter is used to sweep, sweep burst or step the frequency of the main generator. Frequency sweeping and stepping may be up or down. Steps may be automatically sequenced or triggered.

1.2 SPECIFICATIONS

1.2.1 Waveforms

Eight selectable waveforms, sine , triangle , square , positive pulse , negative pulse , trapezoid , positive trapezoid , and negative trapezoid , plus variable DC output. Symmetry of all waveform outputs is continuously adjustable from 1:19 to 19:1. Varying symmetry provides variable duty-cycle pulses, sawtooth or unsymmetrical trapezoidal waveforms. Separate sync output included.

Sweep generator ramp and steps for continuous or discrete-step sweep; up or down sweeping. The swept signal may be triggered, gated, single stepped or swept-and-held. Main generator frequency may be swept as much as 1000:1.

1.2.2 Operating Frequency Range

Frequency selectable from 0.00003 Hz to 30 MHz in the following ranges.

X 0.001	0.00003 Hz to 0.003 Hz
X 0.01	0.0003 Hz to 0.03 Hz
X 0.1	0.003 Hz to 0.3 Hz
X 1	0.03 Hz to 3 Hz
X 10	0.3 Hz to 30 Hz
X 100	0.3 Hz to 300 Hz
X 1K	3 Hz to 3 kHz
X 10K	30 Hz to 30 kHz
X 100K	300 Hz to 300 kHz
X 1 MHz	3 kHz to 3 MHz
X 10 MHz	30 kHz to 30 MHz

NOTE

When SYMMETRY control is used, indicated frequency is divided by a factor of approximately 10.

1.2.3 Sweep/Step Range

Sweep/step time is selectable from 10 μs to 100 s in the following ranges:

100 s to 10 s	0.01 Hz to 0.1 Hz
10 s to 1 s	0.1 Hz to 1 Hz
1 s to 100 ms	1 Hz to 10 Hz
100 ms to 10 ms	10 Hz to 100 Hz
10 ms to 1 ms	100 Hz to 1 kHz
1 ms to 100 μs	1 kHz to 10 kHz
100 μs to 10 μs	10 kHz to 100 kHz

1.2.4 Outputs

Main Output

Maximum output of sine, triangle, square and trapezoidal waveforms is 20 V p-p into open circuit and 10 V p-p into 50Ω load. Positive and negative trapezoids and pulses are 10 V peak into open circuit and 5 V peak into 50Ω. DC voltage is adjustable between ±10 volts, 50Ω source impedance. Output peak current is 100 mA minimum for all waveforms and DC. Precision output allows from 0 dB to −60 dB attenuation in 10 dB steps with a 20 dB vernier; maximum overall attenuation is −80 dB. High level 0 to

−50 dB and low level −40 to −80 dB outputs give optimum performance.

Sync Output
Approximately 0 to +4 V into open circuit, 50Ω source impedance. Rise and fall times are typically 10 ns into 50Ω load. Sync is a square waveform during symmetrical outputs, rectangular waveform when SYMMETRY control is ON.

Sweep Output
SWEEP OUT connector provides a 0 to +5 V positive ramp from a 600Ω impedance source when SWEEP MODE is RAMP UP or RAMP DOWN, or 0 to +5 V stair step waveform in 10 equal steps when SWEEP MODE is STEP UP or STEP DOWN.

GCV Output
GCV OUT connector provides voltage proportional to main generator frequency from a 600Ω impedance source.

1.2.5 DC Offset

Front panel controlled between ± 9.4 Vdc into open circuit, + 5 Vdc into 50Ω load. Peak voltage output (signal peak plus dc offset) is limited to ± 9.4V into open circuit, ± 4.7V into 50Ω load. DC offset and output waveform are attenuated proportionately by the attenuator.

1.2.6 Sweep Modes

Ramp Up
Main generator sweeps linearly from frequency set on front panel to a higher frequency determined by SWEEP WIDTH control at a rate set by SWEEP/STEP TIME control, then returns immediately to start frequency.

Ramp Down
Same as RAMP UP except frequency decreases.

Step Up
Same as RAMP UP except main generator frequency steps up in 10 equal steps.

Step Down
Same as RAMP UP except main generator frequency steps down in 10 equal steps.

1.2.7 Main Generator Operational Modes

Continuous
Operating as a standard VCG (voltage controlled generator), frequency output is determined by front panel control settings in conjunction with external control voltage at VCG IN.

NOTE

Sweep width control performance is limited on 10 μs sweep range.

Triggered
Only one complete cycle of output appears at 50Ω OUT connector for each pulse applied to TRIG IN connector (or press of MAN TRIG switch).

Gated
Same as triggered mode except that output oscillations continue for duration of gating signal applied to TRIG IN connector.

Continuous Sweep
Main generator is repeatedly swept in one of the four sweep modes with start and stop frequencies set by the front panel controls.

NOTE

Sweep width control performance is limited on 10 μs sweep range.

Triggered Sweep
Main generator oscillates at the frequency set on the front panel. When triggered, it makes one sweep in the selected sweep mode and then returns to the start frequency.

Sweep Hold
Same as triggered sweep except output frequency can be held at final sweep frequency after sweep.

Sweep Burst
Main generator output is a gated swept frequency for the duration of the gate. Between gate signals, output is a dc level.

Single Step
Main generator steps to next one of eleven frequency levels when triggered; eleventh trigger returns output to start frequency.

1.2.8 Voltage Controlled Generator

VCG Control Range
Up to 1000:1 frequency change with external voltage input. Upper frequency is limited to maximum of selected range. Required external signal for full voltage control is 0 to 5 V with input impedance of 5 kΩ.

VCG Slew Rate
2% of range per μs.

VCG Linearity
0.0003 Hz to 3 MHz . . . . ±0.5% of range

1.2.9 Triggered Generator

Trigger Input
Trigger pulse is 1 V p-p to ±50 V; input impedance is 10 kΩ, 33 pF; minimum pulse width is 25 ns; maximum repetition rate is 20 MHz.

Start/Stop Point Adjustment
Triggered-signal start/stop point is adjustable:
To 3 MHz . . . . Approximately −90° to +90°
3 MHz to 30 MHz . . . . Approximately −90° to 0°

1.2.10 Horizontal Precision

Dial Accuracy for Symmetrical Waveforms*
0.0003 Hz to 300 kHz . ±(1% of setting +1% of full scale)
300 kHz to 30 MHz . . ±(3% of setting +2% of full scale)

Frequency Vernier
Electronic frequency vernier precision frequency adjustment is approximately 1% of range.

Time Symmetry*
0.0003 Hz to 30 Hz . . . . ±1.0%
30 Hz to 300 kHz . . . . ±0.5%

1.2.11 Vertical Precision

Amplitude Change with Frequency (Sine)
Less than:
- 0.1 dB to 300 kHz
- 0.2 dB to 3 MHz
- 2.5 dB to 30 MHz

Step Attenuator Accuracy
±0.5 dB per 10 dB step.

Stability*
Short term . . . . ±0.05% for 10 minutes
Long term . . . . ±0.25% for 24 hours
Percentages apply to amplitude, frequency, and dc offset.

Amplitude Symmetry
All symmetrical waveforms are symmetrical about ground within ±1% of amplitude range up to 3 MHz (e.g. within ±100 mV with output attenuator at 0 dB).

1.2.12 Purity*

Sine Wave Distortion
10 Hz to 100 kHz . . . Less than 0.5% (typically 0.25%)
0.0003 Hz to 300 kHz . . . . Less than 1.0%
To 30 MHz . . . . All harmonics at least 26 dB down

Triangle Linearity
0.0003 Hz to 300 kHz . . . . Greater than 99%

Square Wave Rise and Fall Time
Less than 12 ns (typically 8 ns) when terminated into 50Ω load.

Square Wave Total Aberrations
Less than 5%.

Trapezoidal Rise and Fall Time
Ratio of period to rise or fall time is continuously variable from 2:1 (triangle) to greater than 100:1 and limited to 12 ns (maximum) rise and fall time.

1.2.13 Environmental

Temperature
All specifications listed are for 23°C ± 5°C. For operation from 0°C to 55°C, specifications including horizontal precision, amplitude symmetry, and sine wave distortion are derated by a factor of 2.

1.2.14 Mechanical

Dimensions
14½ in./36.8 cm wide; 5¼ in./13.3 cm high; 13½ in./34.3 cm deep.

Weight
13 lb/5.9 kg net; 20 lb/9 kg shipping.

Power
90 to 110 V, 105 to 125 V, 180 to 220 V or 210 to 250 V; 50 to 400 Hz; less than 50 watts.

NOTE

Specifications apply from 10 to 100% of a selected frequency range.

*SYMMETRY control OFF.

SECTION 2
INSTALLATION AND OPERATION

2.1 MECHANICAL INSTALLATION

After unpacking the instrument, visually inspect all external parts for possible damage to knobs, connectors, surface areas, etc. If damage is discovered, file a claim with the carrier who transported the unit. The shipping container and packing material should be saved in case reshipment is required.

2.2 ELECTRICAL INSTALLATION

2.2.1 Power Connection

Connect the ac line cord to the mating connector at the rear of the unit.

NOTE

Unless otherwise specified at the time of purchase, this instrument was shipped from the factory with the power transformer connected for operation on a 105 - 125 Vac line supply and with a 1/2 amp line fuse.

Conversion for 90 to 110 V, 180 to 220 V or 210 to 250 V operation requires resetting two switches on the inside of the rear panel. To reset the switches, unscrew the four captive screws securing the rear panel, and remove the rear panel. Set the two switches and select the fuse for the ac line voltage according to the following table.

AC Line Voltage	Switch A	Switch B	Fuse (SB)
90 - 110	115	LO	½ amp
105 - 125	115	HI	½ amp
180 - 220	230	LO	¼ amp
210 - 250	230	HI	¼ amp

2.2.2 Signal Connections

Use 50Ω shielded cables equipped with female BNC connectors to distribute all signals when connecting this instrument to associated equipment.

The two main outputs, 50Ω OUT (LO) and 50Ω OUT (HI), should be terminated with 50Ω load when used for optimum performancd.

2.3 OPERATING CONTROLS

The operating controls and electrical connections for the Model 164 are shown in Figure 2-1. The listing below discusses each control and its function.

1. **POWER Switch** – Power is on when this pushbutton switch is in, and off when extended.

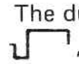
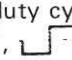
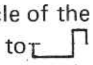
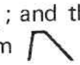
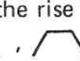
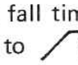
2. **Frequency Index** – The scribe line indicates the frequency dial setting. The index is illuminated when the unit is on.

3. **Frequency Dial** – The main frequency control. The setting on this dial multiplied by the frequency range setting is the basic output frequency of the generator. (The FREQ (Hz) VERNIER, the SYMMETRY control and VCG IN also affect the generator frequency.)

4. **FREQ (Hz) Range** – This 11 position switch selects the generator frequency range, which, when multiplied by the frequency dial setting, determines the basic output frequency of the generator.

5. **FREQ (Hz) VERNIER Control** – This control allows precision control over the output frequency. A complete turn of this vernier is equivalent to approximately one half of the smallest division on the main frequency dial. When in the full clockwise position (CAL), the settings on the main dial will be accurate.

6. **SYMMETRY Control** – The large knob selects a right-hand or left-hand waveform time-symmetry. The small VARIABLE knob varies the waveform time-symmetry up to 19:1 or 1:19. When these controls are used, the frequency range is divided by approximately 10.

   The duty cycle of the square wave can be varied from ,  to ; the slope of the triangle from ,  to ; and the rise to fall time ratio of the trapezoid from ,  to . See

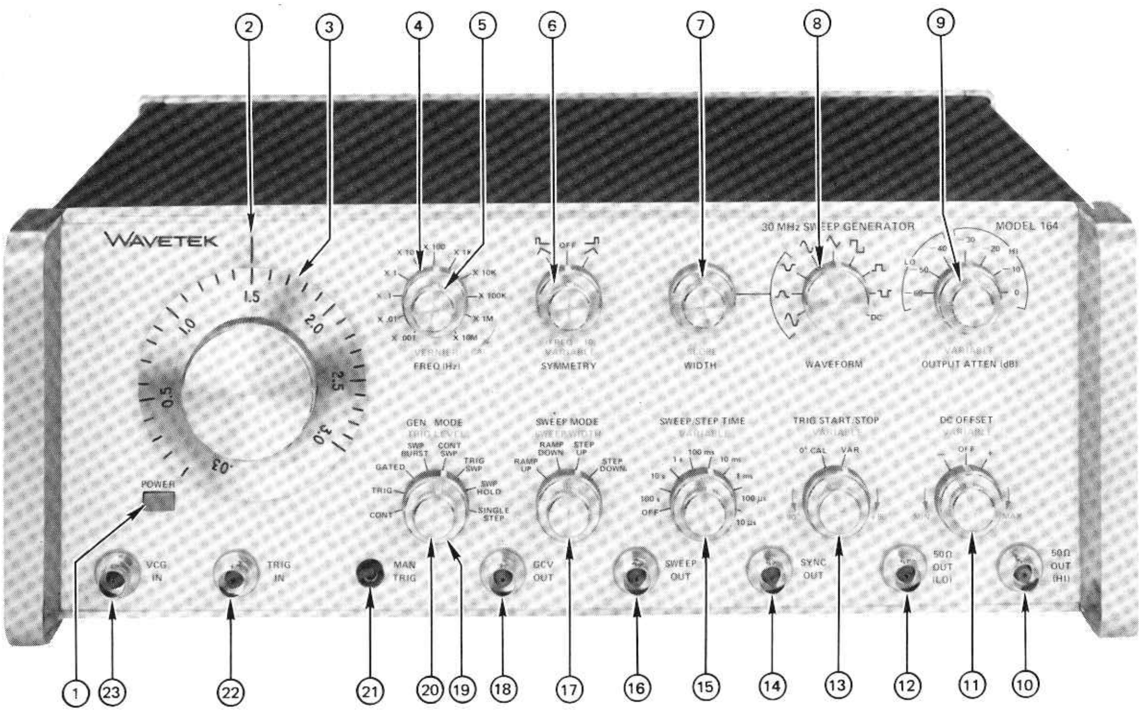


Figure 2-1. Operating Controls and Electrical Connections, Front Panel

Figure 2-2 for the sync signal relationship.

7. **SLOPE/WIDTH Control** – The small knob controls the slope of the trapezoidal waveforms. The large knob controls the time symmetry of the waveform. The setting of these controls does not affect the other waveforms. See Figure 2-2 for the sync signal relationship.

8. **WAVEFORM Selector** – This control selects the waveform that appears at the 50Ω output connector. The waveforms are sine , triangle , square , positive going rectangular pulse , negative going rectangular pulse , trapezoidal , positive going trapezoidal pulse , negative going trapezoidal pulse , and DC voltage.

9. **OUTPUT ATTEN (dB) Control** – The large knob attenuates the 50Ω output from 0 dB (10 V p-p max into 50Ω load) to –60 dB (10 mV p-p into 50Ω) in 10 dB steps. LO and HI indicate the correct output connector to use. The small VARIABLE knob may be used to continuously change the amplitude by approximately 20 dB. Maximum attenuation is –80 dB (1.0 mV p-p into 50Ω). The OUTPUT ATTEN (dB) VARIABLE control is inoperative when DC is selected on the WAVEFORM selector.

10. **50Ω OUT (HI)** – This is the selected waveform

NOTE: VARIABLE SYMMETRY OFF

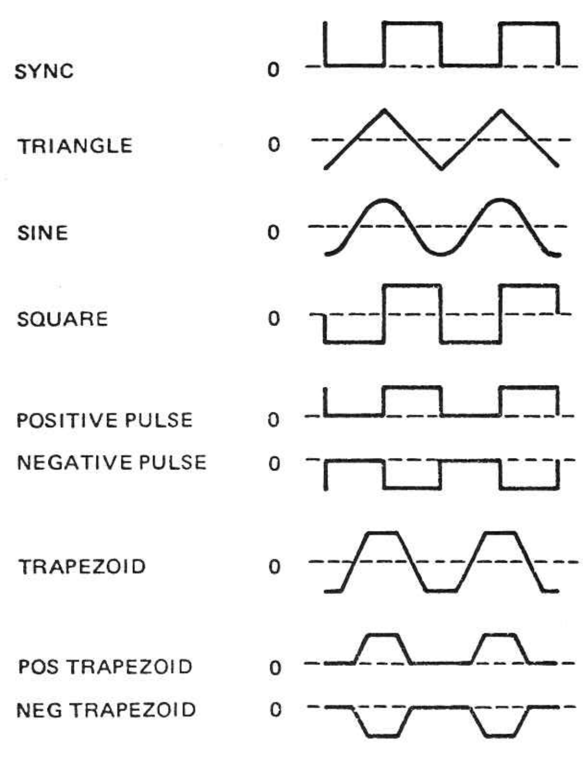


Figure 2-2. Selectable Waveforms and Sync Signal Phase and Polarity Relationships

output for the main generator or a dc voltage when the OUTPUT ATTEN (dB) switch is set 0 to −30 dB. The Model 164 operating into an open circuit provides 20 V p-p maximum, or into a 50Ω load provides a 10 V p-p output for the sine, triangle, square and trapezoidal waveforms; maximum trapezoidal and rectangular pulses are 10 V into an open circuit and 5 V into a 50Ω load.

11. **DC OFFSET Control —** Adjusts dc base line offset above (+) or below (−) signal ground; or, when DC is selected on the WAVEFORM selector, adjusts dc voltage at the 50Ω output. The large knob selects polarity, and the small VARIABLE knob adjusts voltage up to ±9.4 Vdc into an open circuit (±4.7 Vdc into 50Ω load).

    Peak signal output (waveform plus dc offset) is limited to ±9.4 Vdc into an open circuit (±4.7 Vdc into a 50Ω load). (The OUTPUT ATTEN (dB) control affects dc offset as well as waveform amplitude.)

12. **50Ω OUT (LO)** — This is the selected waveform output for the main generator or a dc voltage when the OUTPUT ATTEN (dB) control is set −40 dB to −60 dB.

13. **TRIG START/STOP Control** — The large knob switched to VAR allows the triggered output signal start and stop point to be varied by turning the small knob. For sine and triangle waveforms, the start/stop point may be varied from negative peak voltage to almost positive peak voltage. (At the higher frequencies, the limits are negative peak to waveform zero level.) The square wave always starts/stops at negative peak voltage. The rectangle pulses always start/stop at waveform zero level. The trapezoidal waveform start/stop points are continuously variable. When the large knob is set to 0° CAL, sine and triangle waveforms start/stop at waveform zero level; square and positive rectangular pulse waveforms start/stop at negative peak level; trapezoidal and trapezoidal pulse waveform start/stop points vary with the SLOPE/WIDTH control settings.

14. **SYNC OUT** — This is a square wave (or rectangular if SYMMETRY control is in use) with the same frequency and same polarity of the selectable square wave at a 50Ω output. Amplitude into an open circuit is greater than 4 V p-p (2 V p-p into 50Ω). See Figure 2-2.

15. **SWEEP/STEP TIME Control** — When operating in any of the sweep modes, this control determines the duration of the sweep or a single step by controlling the frequency of the sweep generator, which is independent of the frequency of the main generator. The large knob selects the range, which is bounded by the time values printed on the control panel on either side of the detent setting. The small VARIABLE knob varies the time throughout the range; rotating the VARIABLE knob ccw increases the sweep time at least by 10:1.

16. **SWEEP OUT** — This output provides a fixed 0 to nominal +5 V sawtooth or 10-step waveform, depending on the ramp or step sweep mode. The frequency of these waveforms is controlled by SWEEP/STEP TIME.

17. **SWEEP MODE/SWEEP WIDTH Control** — The large knob selects one of the step or ramp sweep signals. The small knob determines the amplitude of the sweep signal fed to the main generator, thereby determining the bandwidth of frequencies swept when in a sweep mode.

18. **GCV OUT** — This is Generator Control Voltage output, a voltage proportional to the generator output frequency.

19. **GEN MODE Switch** — Selects the operating mode of the main generator (50Ω OUT) as follows:

    a. CONT Mode — The generator operates continuously as a standard Voltage Controlled Generator (VCG). Frequency output is determined by front panel control settings in conjunction with external control voltage at VCG IN.

    b. TRIG Mode — The generator will give one complete cycle of output when the MAN TRIG is pressed or for each cycle of signal applied to TRIG IN. The generator output cycle begins and ends as determined by the TRIG START/STOP control. Since the internal sweep operates independently it can be used to provide a repetitive trigger signal by connecting the SWEEP OUT to TRIG IN.

    c. GATED Mode — Operates the same as TRIG mode except that the generator will continue to have output for the full time that the MAN TRIG switch is held down or the gate signal at TRIG IN exceeds the gating level set by the TRIG LEVEL control.

    d. SWP BURST Mode — When MAN TRIG is pressed or a pulse is applied to TRIG IN, both the main generator and sweep operator are triggered; the main generator sweeps and holds if the gate is longer than the sweep generator period or sweeps once if the gate is shorter than the sweep period. The 50Ω OUT signal exists only for the duration of the gate. Sweep characteristics are determined by the sweep controls. See Figures 2-12 and 2-13 for signal characteristics in SWP BURST mode.

e. CONT SWP Mode – The main generator operates continuously and is repetitively swept. Sweep characteristics are determined by the sweep controls.

f. TRIG SWP Mode – The main generator oscillates at the start frequency until a trigger signal is applied. The frequency then sweeps to the frequency determined by the SWEEP WIDTH control and then returns to the start frequency until another trigger is applied.

g. SWP HOLD Mode – The main generator oscillates at the start frequency until a gate signal is applied to the TRIG IN connector. The main generator then sweeps from the start frequency to the frequency determined by the SWEEP WIDTH control and remains at that frequency for the duration of the gate signal. When the gate falls, the generator returns to the start frequency. If the gate is quicker than the sweep, this mode is identical to TRIG SWP mode.

h. SINGLE STEP Mode – This mode is to be used in conjunction with STEP UP (or DOWN) on the SWEEP MODE control. The main generator oscillates at a start frequency until triggered. When MAN TRIG is pressed or a signal is applied to TRIG IN, the frequency output steps to the first of 10 levels determined by the SWEEP WIDTH control. Each successive trigger steps the frequency to another level. On the eleventh trigger, the frequency returns to start frequency.

20. **TRIG LEVEL Control** – A continuously variable adjustment of the TRIG IN circuitry. When full ccw, approximately a positive going pulse of +7.5 V (A, Figure 2-3) or greater voltage is required for triggering. In the full cw position, a positive going pulse of approximately –7.5 V (B, Figure 2-3) or more positive voltage is required for triggering. In the GATED mode, the generator will begin to run continuously at some position of the control cw past 12 o'clock. When using the MAN TRIG, this control must be ccw of the midpoint.

21. **MAN TRIG Switch** – When in any of the trigger modes, pressing this switch furnishes the trigger. When in any of the gate modes, this switch furnishes the gate signal for the duration that it is pressed and held down. The TRIG LEVEL control must be ccw from midpoint for proper MAN TRIG operation.

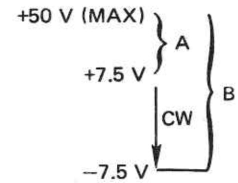


Figure 2-3. Range of Triggering Voltage

22. **TRIG IN** – A dc coupled input with 10 kΩ, 33 pF input impedance. The TRIG LEVEL control adjusts the sensitivity of the generator to this input signal. Trigger signals must be 1 V p-p or greater but within the range of ±50 V. Trigger signal width must be 25 ns or greater. Trigger frequency must be less than 20 MHz.

23. **VCG IN** – This connector allows external control of frequency. With 0 volt in, the basic generator frequency (50Ω OUT) is determined by the frequency range selected and the frequency dial setting. A positive VCG voltage will increase this frequency, and a negative voltage will decrease the frequency. Input impedance is 5 kΩ. Restrictions for linear operation are (1) the upper frequency limit is the value selected with the FREQ (Hz) switch, (2) the lower frequency limit is one-thousandth the value selected with the FREQ (Hz) switch. A 5-volt excursion covers the 1000: 1 frequency range.

2.4 INSTALLATION CHECKS

The following procedures are used to determine that the instrument is operating properly. Field calibration and checkout instructions (to be supplied) are to be used to ensure that the instrument complies with the specifications. If the instrument is not operating properly or within specifications, refer to the warranty on the back of the title page.

Use a Tektronix Model 454 oscilloscope (or equivalent) and a Counter-Timer when performing these installation checks.

1. After connecting the line cord to the ac line, set the front panel controls and switches as follows:

POWER	In
Frequency Dial	1.0
FREQ (Hz) Range	X 1K
FREQ (Hz) VERNIER	Fully Clockwise
SYMMETRY	OFF
WAVEFORM	⊓⊔
OUTPUT ATTEN (dB)	0
OUTPUT ATTEN (dB) VARIABLE	Fully Clockwise
DC OFFSET	OFF
TRIG START/STOP	0° CAL
SWEEP/STEP TIME	OFF
GEN MODE	CONT

2. Connect the 50Ω OUT (HI) connector with a shielded cable terminated in a 50 ohm load to the oscilloscope and set FREQ (Hz) VERNIER to obtain 1 kHz display on the oscilloscope. Approximately 10 V p-p should be displayed.

3. Rotate OUTPUT ATTEN (dB) VARIABLE control full ccw. Increasing signal attenuation should be observed. Return to full cw.

4. Set SLOPE control (small knob) full cw and WIDTH control (large knob) at approximately midpoint.

5. Check amplitudes of sine ∿ , triangle /\/ and trapezoidal ⊓\⊔ waveforms. They should be approximately 10 V p-p.

6. Use SLOPE/WIDTH control to vary the slope and time symmetry of the trapezoidal waveform.

7. Check minimum and maximum amplitudes of positive and negative pulse waveforms, both rectangular and trapezoidal. Amplitudes should be approximately 5 volts above or below the 0 volt level.

8. Switch the FREQ (Hz) range control to check range-to-range tracking accuracy. The oscilloscope should show approximately the FREQ (Hz) range value.

9. Select the square waveform and rotate the SYMMETRY switch to _/⌊ and the VARIABLE control full cw. Waveform asymmetry should be approximately 19:1. Rotate the VARIABLE control full ccw; the waveform should be symmetrical. Verify that the other switch position and VARIABLE control give approximately 1:19 waveform asymmetry.

10. Turn the SYMMETRY switch to OFF and select DC on the WAVEFORM selector. Use a shielded cable with BNC connectors to connect SYNC OUT to the oscilloscope trigger input.

11. Set the DC OFFSET switch to + and rotate the VARIABLE control full cw. The amplitude should be approximately +5 V into a 50Ω load.

12. Set the DC OFFSET switch to –. Amplitude should be approximately –5 V.

13. Rotate the OUTPUT ATTEN (dB) switch thru each position. Verify the attenuation on the oscilloscope. (The VARIABLE control is inoperative for DC.) Repeat using 50Ω OUT (LO) connector.

14. Turn the DC OFFSET switch to OFF and connect the SWEEP OUT to the oscilloscope without a load. Set SWEEP MODE switch to RAMP UP. With the SWEEP/STEP TIME switch set to 10 ms I 1 ms and the VARIABLE control set full cw (1 ms sweep), verify that the SWEEP OUT waveform is approximately a 1 kHz sawtooth. (RAMP DOWN position gives the same positive going sawtooth waveform.)

NOTE

The SWEEP/STEP TIME VARIABLE control is not calibrated.

15. Set the VARIABLE control full ccw. The SWEEP OUT waveform should be approximately 100 Hz.

16. Check the SWEEP OUT frequency in all positions of the SWEEP TIME switch and at both the cw and ccw ends of the VARIABLE control.

17. Change SWEEP MODE switch to observe stair steps up. (Both STEP UP and STEP DOWN give the same positive going waveform.) Notice that the SWEEP/STEP TIME setting is the duration of each step.

18. Set the WAVEFORM selector to ∿ , the SWEEP MODE switch to STEP UP, the SWEEP/STEP TIME switch to 10 s I 1 s, and the VARIABLE control to full cw (1 s sweep). Use a shielded cable equipped with BNC connectors and connect SWEEP OUT to VCG IN. Connect the oscilloscope to 50Ω OUT (HI) and observe the stepping of the output frequency.

19. Remove the cable from VCG IN and connect TRIG IN to SWEEP OUT. Set SWEEP MODE to RAMP UP. Set the GEN MODE switch to TRIG and the SWEEP/STEP TIME switch to 100 ms I 10 ms. Rotate the

TRIG LEVEL near 12 o'clock. The oscilloscope should display one cycle of the waveform each time the sweep output triggers the main generator.

20. Set the GEN MODE switch to GATED and rotate the TRIG LEVEL control while observing the oscilloscope. The multiple cycles of the selected output waveform should appear when the TRIG LEVEL control is rotated cw and reduce to one cycle, then none, when the control is turned ccw. At some point ccw the generator stops oscillating, and at some point cw it goes into continuous operation.

21. Turn SWEEP/STEP TIME switch to OFF. Use MAN TRIG switch to gate waveforms. Waveforms should be continuous when MAN TRIG switch is held down.

22. Set the GEN MODE switch to TRIG. Use MAN TRIG switch to trigger waveforms. One cycle should appear each time the trigger is pressed.

23. Turn SWEEP/STEP TIME switch to 10 ms I 1 ms and GEN MODE switch to GATED. Set TRIG START/STOP switch to VAR and rotate VARIABLE knob full cw. Observe the start/stop point of the waveform. Rotate the VARIABLE knob and trigger waveforms to observe the varying start/stop points. At full cw the waveform should start/stop at approximately +90° (positive peak); at full ccw, approximately −90° (negative peak); and at midpoint, 0°. (TRIG LEVEL may require adjusting.) Set TRIG START/STOP switch to 0° CAL. Disconnect the cable to TRIG IN.

NOTE

Steps 24 and 25 set low and high frequencies of the sweep range.

24. Set the GEN MODE switch to SWP HOLD, TRIG LEVEL control to 9 o'clock, FREQ (Hz) range to X 10K, SWEEP/STEP TIME switch to 10 s I 1 s and SWEEP MODE switch to RAMP UP. With a counter, the frequency dial and FREQ (Hz) VERNIER control, set the frequency to 30 Hz.

25. Rotate the TRIG LEVEL control to 3 o'clock (triggering the generator) and rotate the SWEEP WIDTH control to set the frequency to 30 kHz.

26. Rotate the TRIG LEVEL control to 9 o'clock, and the GEN MODE switch to CONT SWP. Output should be the 30 to 30 kHz swept signal continuously repeating.

27. Set GEN MODE switch to TRIG SWP and press the MAN TRIG switch. The generator output should be the swept signal occurring once for each trigger.

28. Set the GEN MODE switch to SINGLE STEP and SWEEP MODE switch to STEP UP. Press the MAN TRIG ten times while observing the stepped increase in output frequency. The eleventh trigger should return the frequency to 30 Hz.

29. Remove the cable from 50Ω OUT and connect to GCV OUT. Connect SYNC OUT to the oscilloscope trigger input. Trigger the generator as in the previous step. Observe the varying voltage corresponding to the varying frequency output. Reconnect the cable to 50Ω OUT (HI).

30. Set the GEN MODE switch to SWP BURST and press the MAN TRIG switch and hold. A frequency stepping and hold should occur. When the switch is released, no signal should be present.

2.5 OPERATING PROCEDURE

No preparation for operation is required beyond completion of the initial installation checks given in Paragraph 2.4 of this manual. It is recommended that a one-half hour warm-up period be allowed for the associated equipment to reach a stabilized operating temperature, and for the Model 164 to attain stated accuracies.

There are almost unlimited ways to set up the generator and waveforms that may be obtained. The following sections describe basic configurations and how to set them up.

2.5.1 Operation as a Function Generator

1. Depress the POWER switch. Properly terminate the 50Ω OUT (HI) connector.

2. Set the GEN MODE switch to CONT.

3. Set the FREQ (Hz) range switch to the desired multiplier.

4. Set the frequency dial to the desired setting. Use the frequency VERNIER for precision frequency setting if necessary.

5. Select desired basic output waveform using the WAVEFORM selector.

6. Set OUTPUT ATTEN (dB) switch for desired output

level and amplitude. If a LO amplitude signal is selected, use the 50Ω OUT (LO) connector.

For reference, the following table gives the approximate output amplitude levels at attenuator settings. The output levels of the positive and negative pulse waveforms are one-half of these levels.

TABLE 2-1

Attenuator Position	Peak-to-Peak Output into 50Ω Load	
	Maximum (variable full cw)	Minimum (variable full ccw)
0 dB	10 V	1 V
−10 dB	3.2 V	320 mV
−20 dB	1 V	100 mV
−30 dB	320 mV	32 mV
−40 dB	100 mV	10 mV
−50 dB	32 mV	3.2 mV
−60 dB	10 mV	1 mV

7. Set the SYMMETRY control for desired asymmetry. The SYMMETRY control is used to develop ramp waveforms from the triangle, to vary the duty cycle of the square wave, to vary the ratio of rise/fall time of the trapezoidal waveform. Figure 2-4 shows the effect of this control on output waveforms. The output frequency is divided by approximately a factor of 10 when an asymmetrical waveform is selected.

8. When the trapezoidal waveform is selected, the WIDTH control is used to vary the duty cycle of the waveform and the SLOPE control is used to vary both rise and fall times. See Figure 2-5. Use the SYMMETRY control if asymmetrical rise and fall times are desired. See Figure 2-4.

9. Select the desired polarity of dc offset and the amount of offset using the DC OFFSET control. Offset voltage plus peak voltage cannot exceed the voltage range limit, ±5 volts in the 0 dB range. If an excessive amount of dc offset is used, waveform clipping may be observed (see Figure 2-6). Both signal and offset are attenuated by the attenuator.

2.5.2 Operation as a Voltage Controlled Generator

The VCG input connector can be used to externally control the frequency of the generator. If a positive voltage is applied to the VCG input terminal, the frequency will increase from the setting of the frequency controls. A negative voltage will cause the frequency to decrease from the setting of the frequency controls.

A 5 V excursion in VCG voltage can vary the frequency up to 1000:1 in each range as follows:

Range	Limits for Linear Operation	
	Lower	Upper
X0.001	0.003 mHz	0.003 Hz
X0.01	0.03 mHz	0.03 Hz
X0.1	0.3 mHz	0.3 Hz
X1	3 mHz	3 Hz
X10	30 mHz	30 Hz
X100	300 mHz	300 Hz
X1K	3 Hz	3 kHz
X10K	30 Hz	30 kHz
X100K	300 Hz	300 kHz
X1M	3 kHz	3 MHz
X10M	30 kHz	30 MHz

The upper limit may be exceeded as there is an overranging capability; however, overranging will be nonlinear and the operation is unspecified. Operation below the lower limit of any range setting is not recommended.

The nomograph of Figure 2-7 shows the characteristics of the VCG circuit. Column A gives the frequency dial setting, column B, the VCG voltage and column C, a factor representing the resultant frequency of the generator.

In example 1, the dial is set at 1.5 and no VCG input is applied. Extend a straight line from 1.5 (dial setting) thru 0 volt (VCG voltage). The result is an output frequency factor of 1.5. Multiply 1.5 by the range multiplier for actual 50Ω OUT frequency.

In order to set the generator at 0.003 X the range multiplier (1/1000 of the range), the following procedure is to be followed (Example 2):

1. Using the frequency dial and a counter or oscilloscope, set the generator frequency to 0.03 X the range multiplier.

2. By rotating the VERNIER ccw, decrease the frequency to 0.003 X the range multiplier.

As can be seen from the nomograph a +5 volt VCG input will then cause the frequency to increase to the maximum of 3 X the range (an increase from 0.003 X to 3 X is 1:1000).

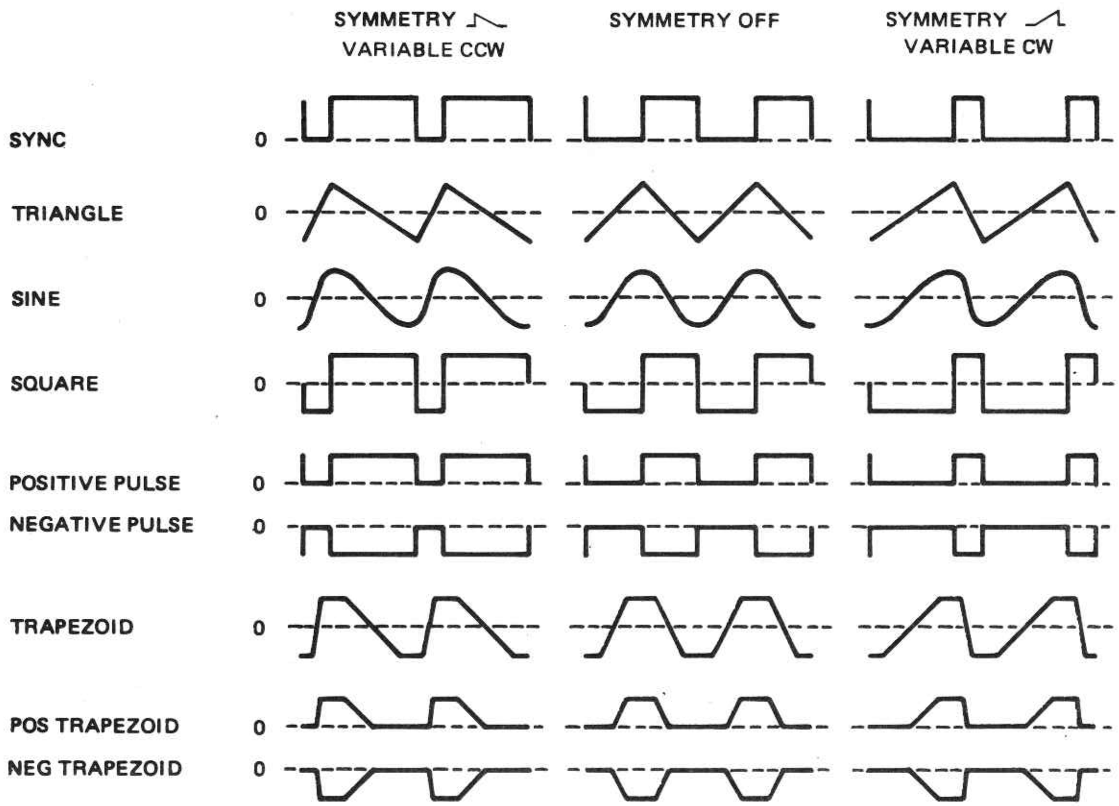


Figure 2-4. Effect of Symmetry Adjustment on Waveforms

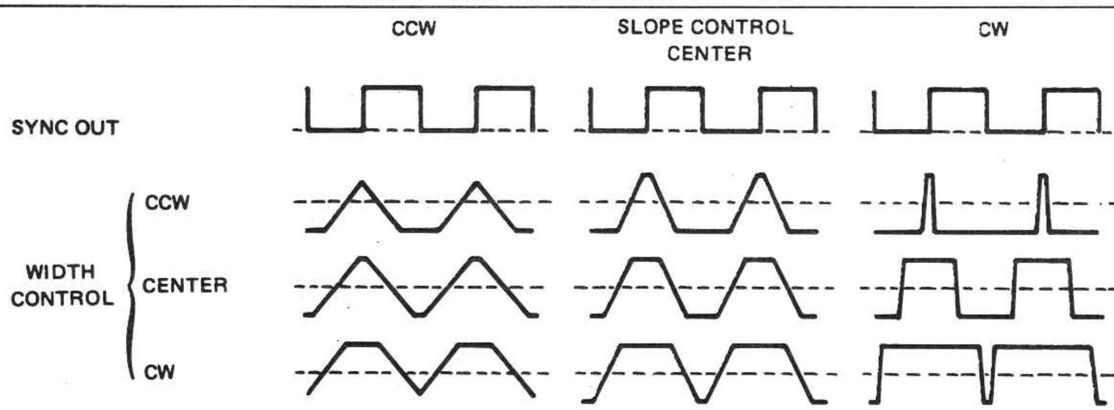


Figure 2-5. Effect of SLOPE/WIDTH Control on the Trapezoid Waveform

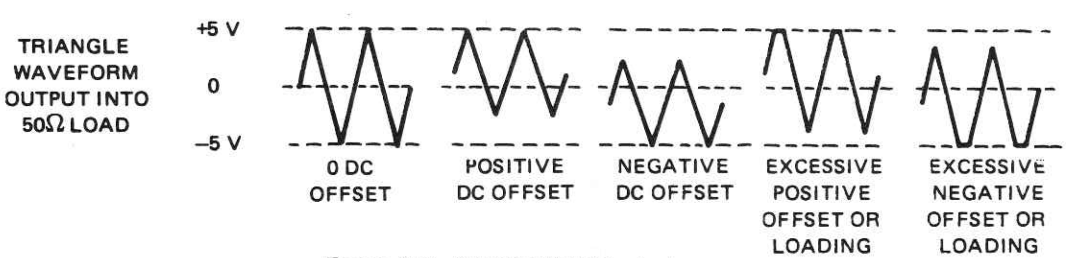


Figure 2-6. DC OFFSET Control

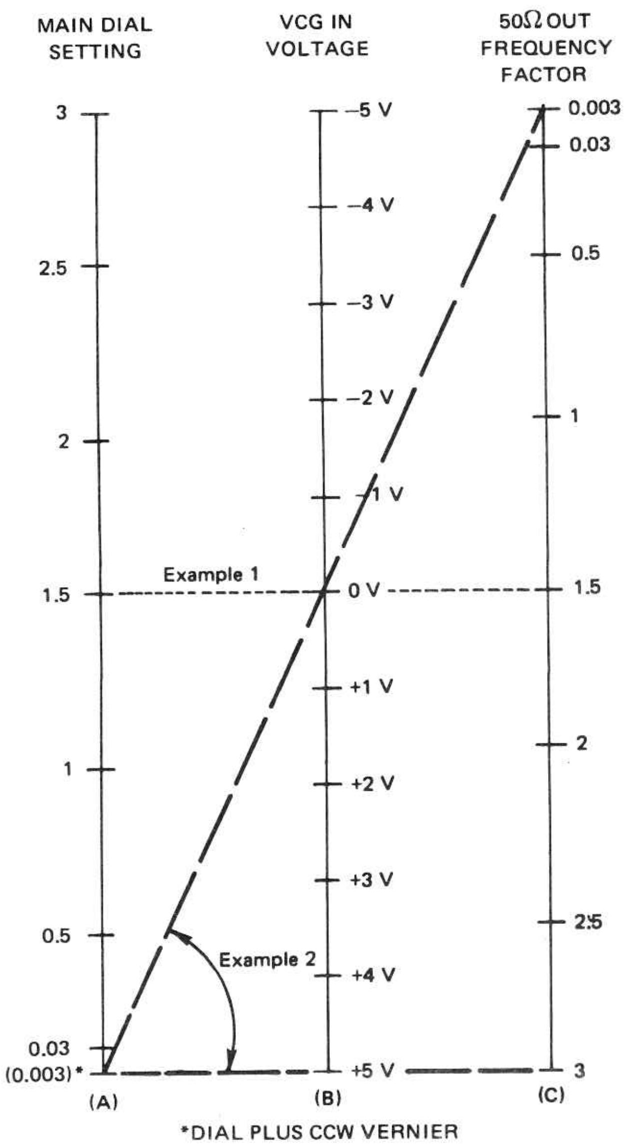


Figure 2-7. VCG Voltage-to-Frequency Nomograph

2.5.3 Operation as a Triggered Generator

1. Adjust the generator as for continuous operation (Paragraph 2.5.1); then set the GEN MODE switch to TRIG.

2. For external triggering, apply a repetitive signal, any waveform from 1 V p-p to less than ±50 V peak voltage (see TRIG IN specification, Paragraph 2.3, Item 22), to TRIG IN connector. Set the TRIG LEVEL control for proper triggering. See Figure 2-8 for the timing relationship of the trigger input, sync output and selected waveform output.

3. If manual triggering is desired, set the TRIG LEVEL control full ccw and operate the MAN TRIG switch for each cycle of selected output waveform.

NOTE

The SWEEP OUT connector may be used as a repetitive trigger source. In this case, the SWEEP/STEP TIME control determines the repetition rate of the triggered output signal.

2.5.4 Gated or Tone Burst Operation

With the generator adjusted as in trigger operation, change the GEN MODE control to GATED position. The generator output will then be a burst of cycles. If the trigger is the SWEEP OUT sawtooth waveform, the duration of the burst is adjustable by the TRIG LEVEL control (see Figure 2-8). Notice that the last cycle gated is completed at time t5, if the gate signal is removed between time t3 and t4. In manual gating, set TRIG LEVEL control full ccw. The tone burst continues as long as the manual switch is pressed.

The generator can be made to free run in this mode at certain settings of the trigger level control. By resetting the trigger level control, normal gated operation can be re-established.

2.5.5 Operation as a Sweep Generator

The second internal generator, the sweep generator, can modulate the main generator frequency in sweep or step fashion. The four modes, ramp up, ramp down, step up and step down, can be used in conjunction with the main generator modes as described in the next paragraphs.

2.5.5.1 SWEEP OUTPUT AND GENERATOR CONTROL VOLTAGE (GCV) OUTPUT

A fixed amplitude, 0 to >5 V, 600Ω impedance, ramp or staircase is provided at the SWEEP OUT connector. A voltage output, 0 to > 5 V, 600Ω impedance, which is directly proportional to the main generator frequency is provided at the GCV OUT connector.

2.5.5.2 SETTING THE SWEEP FREQUENCY LIMITS

1. Set the SWEEP/STEP TIME switch to 100 ms or faster by monitoring SWEEP OUT.

2. Select the desired SWEEP MODE switch setting.

3. Set the GEN MODE switch to SWP HOLD.

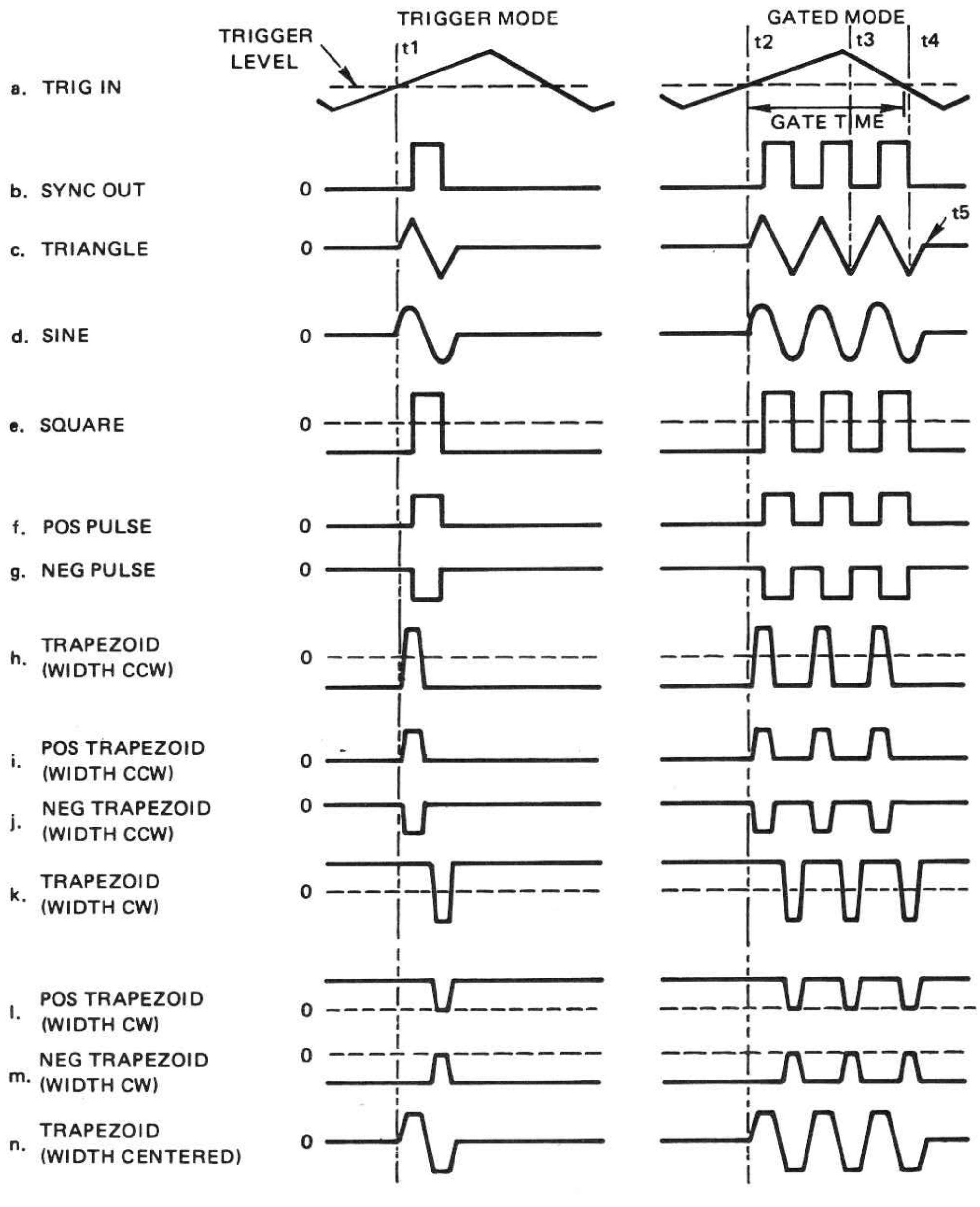


Figure 2-8. Trigger and Gated Operations

4. Set the TRIG LEVEL control full ccw.

5. Select the desired frequency range, using the FREQ (Hz) selector.

6. Set the desired sweep start frequency, using the frequency dial and VERNIER and monitoring the frequency at 50Ω OUT with an oscilloscope or counter.

7. Hold the MAN TRIG switch down; set the desired stop sweep frequency, using the SWEEP WIDTH control.

NOTE

Be sure this frequency does not exceed the range frequency limit; see Operating Frequency Range, Paragraph 1.2.2.

8. Sweep frequency limits are now set. Select the desired main generator mode using the GEN MODE switch. Notice that the generator frequency will sweep or step between the two limits when CONT SWP, TRIG SWP, SWP HOLD or SINGLE STEP is selected.

9. Select the desired SWEEP/STEP TIME.

2.5.6 Operation as a Continuous Sweep Generator

1. Select the desired SWEEP MODE switch setting and set up the sweep frequency limit as in Paragraph 2.5.5.2.

2. Set the GEN MODE switch to CONT SWP.

3. The proper waveform outputs at SWEEP OUT and GCV OUT are shown in Figure 2-9.

2.5.7 Operation as a Trigger Sweep Generator

1. Select the desired SWEEP MODE switch setting and set up the sweep frequency limit as in Paragraph 2.5.5.2.

2. Set the GEN MODE switch to TRIG SWP.

3. Connect a repetitive signal (see Trigger Input specification, Paragraph 1.2.9) to TRIG IN connector.

4. Adjust the TRIG LEVEL control for proper triggering.

5. The main generator will sweep from the start frequency to the stop frequency and reset back to start frequency for every cycle of the TRIG IN signal. However, if the trigger rate is faster than the sweep rate, the sweep generator will neglect all trigger signals during each cycle of sweep. See Figure 2-10.

6. Set the TRIG LEVEL control to full ccw if manual triggering is desired and operate the MAN TRIG switch for each cycle of sweep.

2.5.8 Operation as a Sweep and Hold Generator

1. Select the desired SWEEP MODE switch setting and set up the sweep frequency limit as in Paragraph 2.5.5.2.

2. Set the GEN MODE switch to SWP HOLD.

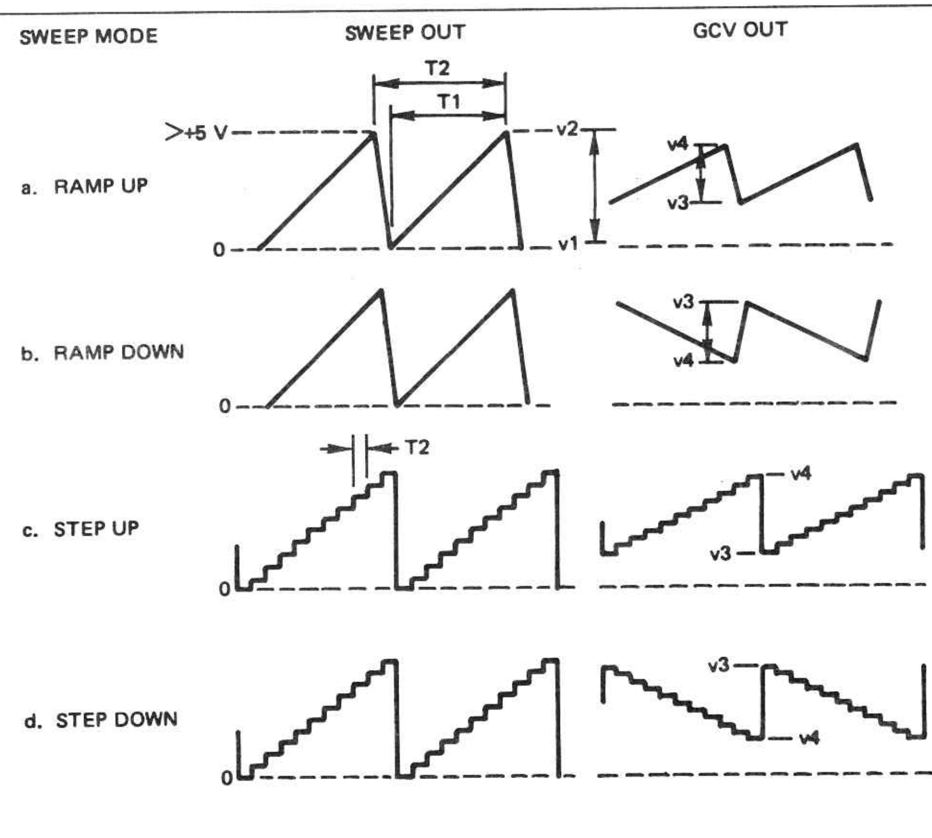
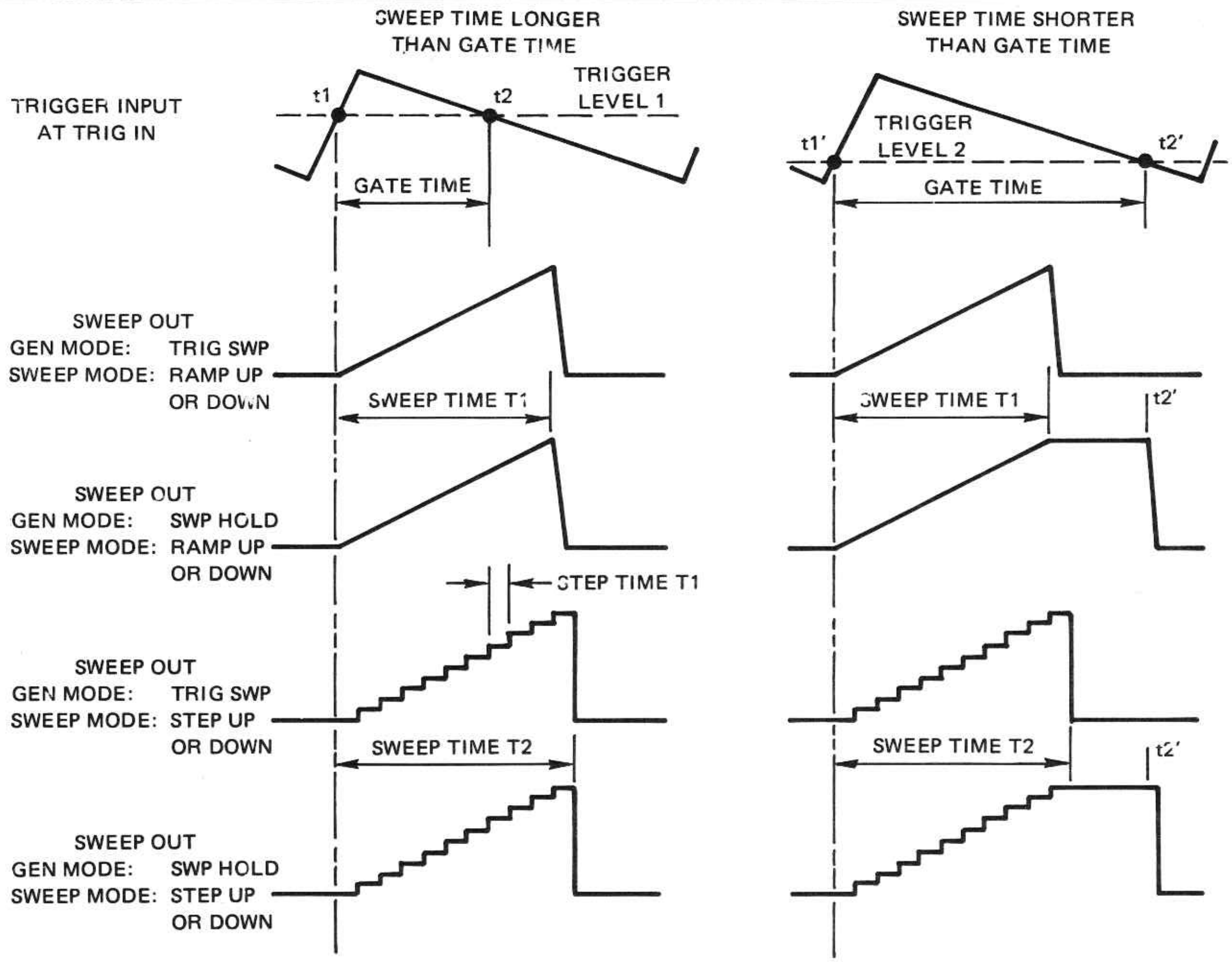


Figure 2-9. SWEEP OUT and GCV OUT at the Continuous Sweep Mode



NOTES

1. *T1 is the sweep time determined by the SWEEP/STEP TIME control setting when RAMP UP or RAMP DOWN is selected.*

2. *T2 is the time duration for each step and is also determined by the SWEEP/STEP TIME control setting when STEP UP or STEP DOWN is selected.*

3. *Voltage V3 is proportional to the sweep start frequency which is set by the frequency dial and VERNIER.*

4. *Voltage V4 is proportional to the sweep stop frequency. The voltage between V3 and V4 is proportional to the frequency range and is determined by the SWEEP WIDTH control setting.*

5. *Notice that the SWEEP OUT is always started from 0 volt to >+5 volts even if RAMP DOWN or STEP DOWN is selected. This is for the convenience of using it as the horizontal input signal of an oscilloscope or X-Y recorder.*

NOTE

The first step of staircase occurs after one "step time" delay from the start of gating signal, t1 and t1'. In the SWP HOLD mode, the staircase does not necessarily reset at time t2' when the gating signal is terminated, but at the time when first multiple "gate time" occurs after t2'.

Figure 2-10. Sweep Output for Triggered Sweep and Sweep-and-Hold Modes

3. Connect a repetitive signal (see TRIG IN specification, Paragraph 2.3, Item 22) to TRIG IN.

4. Adjust the TRIG LEVEL control for proper triggering.

5. The generator frequency will hold at its sweep stop frequency only if the gating time is longer than the sweep time. See Figure 2-10. Also the sweep generator will neglect all trigger input signals during a sweep cycle.

6. For manual triggering, set the TRIG LEVEL control full ccw and operate the MAN TRIG switch for each cycle of sweep.

2.5.9 Operation as a Single Step Generator

1. Select the desired STEP UP or STEP DOWN mode on the SWEEP MODE switch and set up the frequency limit as in Paragraph 2.5.5.2.

2. Set the GEN MODE switch to SINGLE STEP.

3. For maximum stepping rate (100 kHz), the SWEEP/STEP TIME control should be set at 100 μs I 10 μs with the VARIABLE full cw.

4. Connect a repetitive signal (see TRIG IN specification, Paragraph 2.3, Item 22) to TRIG IN connector.

5. Adjust the TRIG LEVEL control until the SWEEP OUT signal advances one step for every cycle of trigger input signal. See Figure 2-11.

6. If manual triggering is desired, set TRIG LEVEL to full ccw and operate MAN TRIG switch for each step.

2.5.10 Operation as a Sweep Burst Generator

1. Select the desired SWEEP MODE switch setting and set up the sweep limit as in Paragraph 2.5.5.2, except that the stop frequency should be set to approximately 10% beyond the desired stop frequency.

2. Set the GEN MODE switch to SWP BURST.

3. Connect a repetitive signal (see TRIG IN specification, Paragraph 2.3, Item 22) to TRIG IN as a gating signal. See Paragraph 2.5.4.

4. Adjust the TRIG LEVEL control for proper triggering.

5. For best results, the sweep limit should be set to longer than the duration of the burst to avoid the last-cycle transient due to the reset of the sweep signal. See Figure 2-12.

6. If the trigger rate is faster than the sweep rate, several sweep tone bursts can be generated during each sweep. If the trigger signal becomes a narrow pulse, an interesting signal can be generated as shown in Figure 2-13.

2.5.11 Synchronized Sweep Operation

Not only can the sweep generator be used to trigger the main generator, as in the case of TRIG or GATED mode of operation, but the main generator can also be used to trigger the sweep generator. The GEN MODE switch is set at TRIG SWP and triggered by the main generator (SYNC OUT connected to TRIG IN). The result is a continuous frequency sweeping signal but the sweep start is synchronized

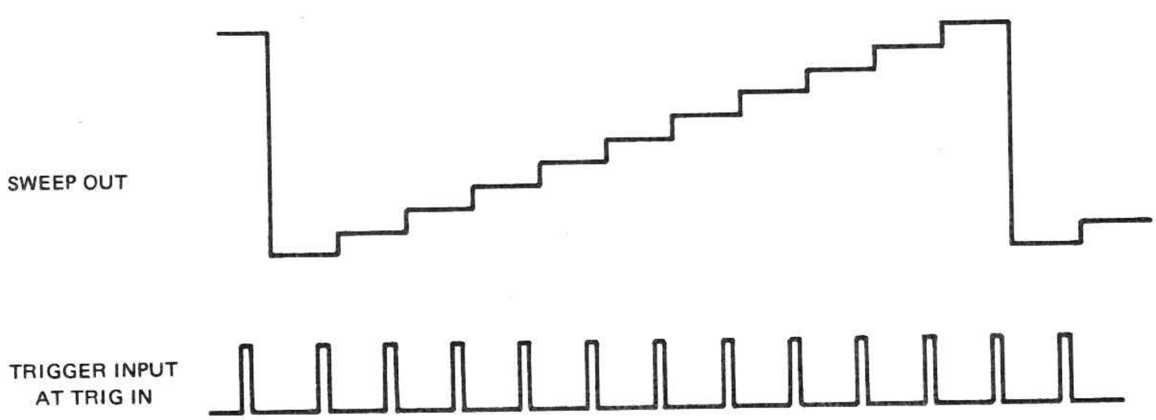


Figure 2-11. Single Step Mode Operation

to the main generator. Therefore, a stationary waveform display in oscilloscope is possible.

1. Set up the generator as in TRIG SWP mode. See Paragraph 2.5.7.

2. Connect SYNC OUT to TRIG IN with a coaxial cable.

3. Connect SWEEP OUT to the external trigger input of an oscilloscope and set the oscilloscope trigger to external and to negative trigger.

4. Adjust the TRIG LEVEL control of the generator until the output frequency is sweeping.

5. It may be necessary to adjust the generator SWEEP/STEP TIME slightly to obtain a stable display. For best results keep the ratio of main generator frequency less than 40:1.

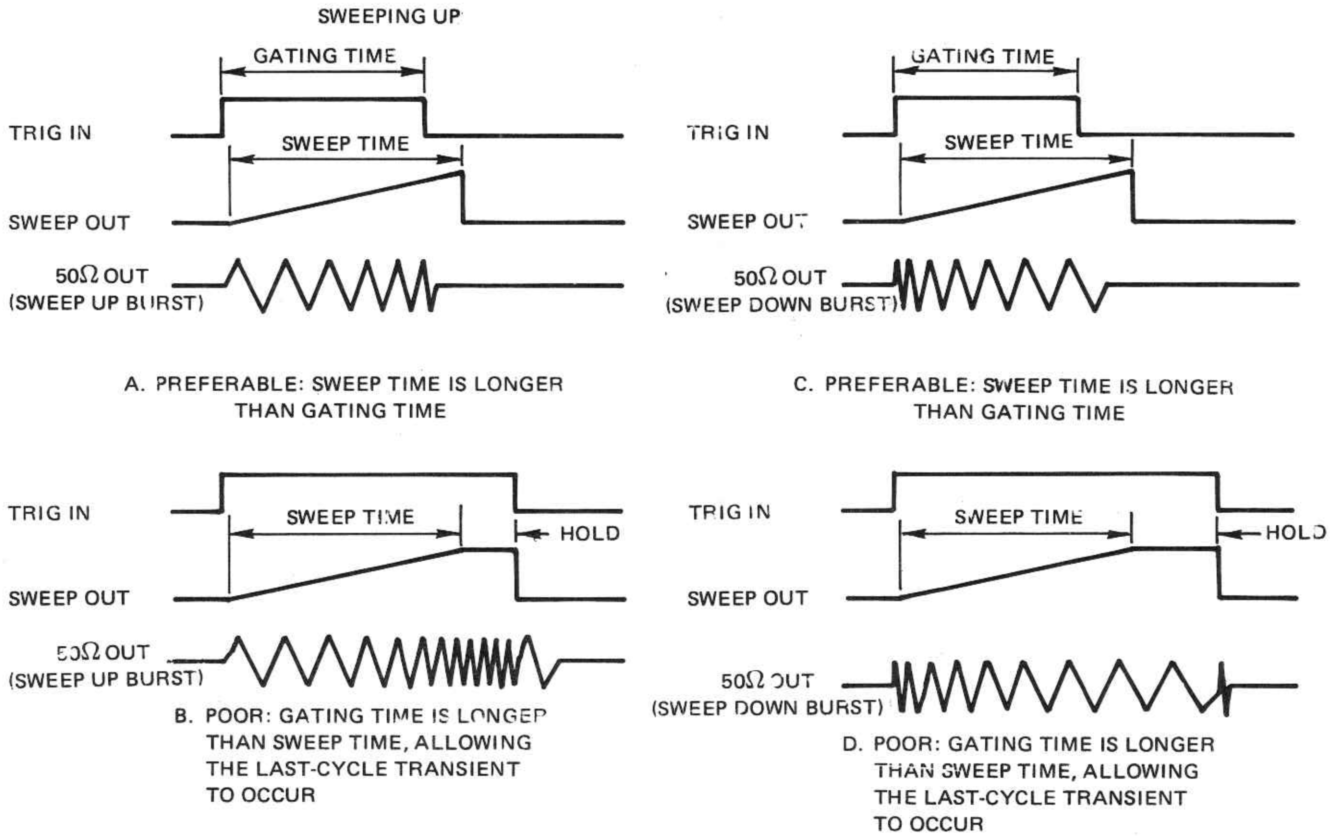


Figure 2-12. Sweep Burst Operation

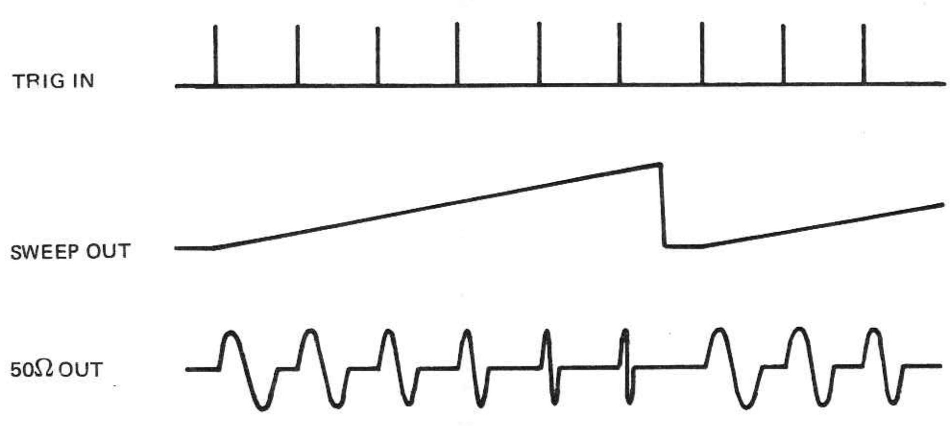


Figure 2-13. A Special Case of Sweep Burst Operation

SECTION 3
CIRCUIT DESCRIPTION

3.1 INTRODUCTION

This section provides a circuit description of the Model 164 generator for the understanding of its principles of operation. The paragraphs are grouped under six major categories. These categories are arranged in the sequence of first understanding the heart of the generator, and then examining the circuits that influence it and the circuits that it in turn influences.

The major circuit blocks that make up the generator are introduced in all capital letters. These blocks relate to the functional block diagrams of the main circuit board shown in Figure 3-3, and the sweep circuit board shown in Figure 3-4 at the back of this section. The circuit blocks are also identified on the appropriate schematic diagrams in Section 6.

3.2 BASIC WAVEFORM AND FREQUENCY DEVELOPMENT

The heart of the generator is a triangle and square wave generator. The triangle waves are developed by capacitor-charging ramps that are alternately reversed in polarity. The polarity reversal is caused by a flip-flop circuit that in turn produces the square waves. The flip-flop, or HYSTERESIS SWITCH changes states upon detecting amplitude limits of the charging ramps thru TRIANGLE AMPLIFIER NO. 1.

3.3 WAVEFORM DEVELOPMENT AND SELECTION

The WAVEFORM SELECTOR switch determines which of eight waveforms is to be output from the generator. A dc level can also be selected for output.

The triangle wave from triangle amplifier No. 1 is coupled thru unity gain TRIANGLE AMPLIFIER NO. 2 and made available to the waveform selector switch. Triangle amplifier No. 2 compensates for the output of amplifier No. 1 not having a low enough impedance to drive several other circuits. Triangle amplifier No. 2 provides the inputs for developing the sine and trapezoid waves. The SINE CONVERTER converts the triangle wave into a sine wave and makes it available to the waveform selector switch.

The square wave from the hysteresis switch and the triangle wave from triangle amplifier No. 2 are selected for input to the SQUARE & TRAPEZOID AMPLIFIER. With the square wave as input, the amplifier develops the square wave for output, as well as positive rectangular pulse and a negative rectangular pulse. The rectangular pulses result from rectifying either polarity of the square wave. With the triangle wave as input, the amplifier develops the trapezoid wave, a positive trapezoid pulse, and a negative trapezoid pulse. Similar to the rectangular pulses, the trapezoid pulses result from rectifying the trapezoid wave. The trapezoid wave is developed by a controlled overdriving of the triangle wave amplitude, the positive and negative peaks of the triangle being clipped. The SLOPE control determines the gain of triangle amplitude overdriving (see Figure 3-1). The WIDTH control determines the offset of the "amplitude window" between the clipped peaks (see Figure 3-2). The waveforms from the square & trapezoid amplifier are made available to the waveform selector switch.

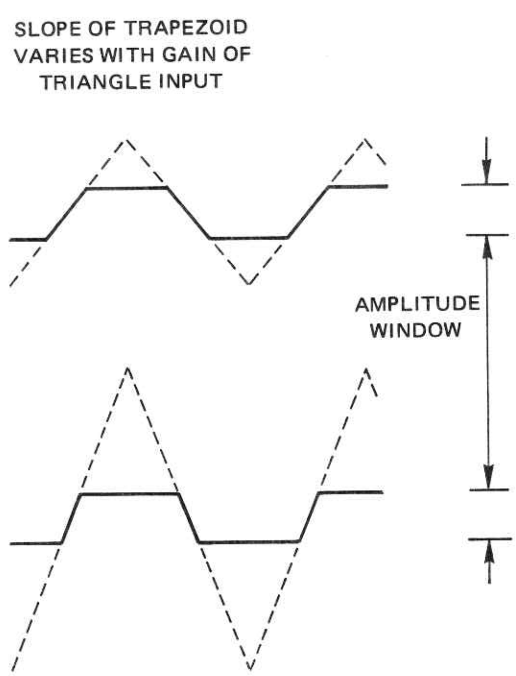


Figure 3-1. Trapezoid Slope Control

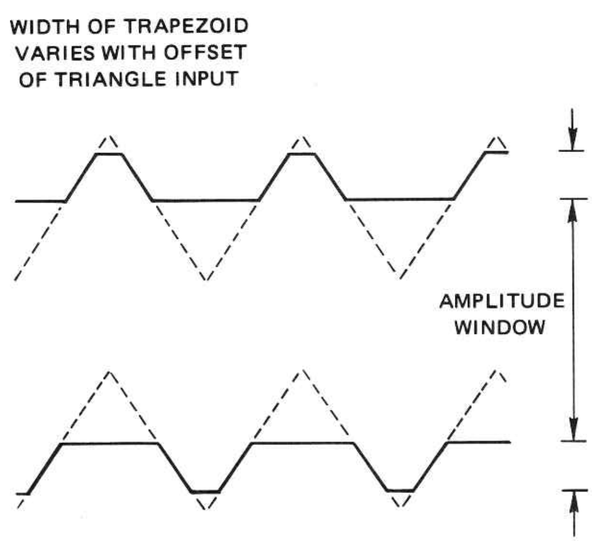


Figure 3-2. Trapezoid Width Control

The square wave from the hysteresis switch thru the SYNC AMPLIFIER is externally available at the SYNC OUT connector. The sync pulse, then, is a constant amplitude, square wave output of the generator's frequency and time symmetry.

3.4 FREQUENCY AND PERIOD CONTROL

The frequency of the waveforms is determined by selecting particular TIMING CAPACITORS to develop the triangle wave charging ramps. For slower charging times, and thus lower frequencies, a CAPACITANCE MULTIPLIER is used. The capacitance multiplier absorbs precise amounts of charging current, thereby slowing down the charging times.

The DIODE GATE supplies the appropriate polarity of charging current to the timing capacitors. Current is alternately switched from the POSITIVE CURRENT GENERATOR and then the NEGATIVE CURRENT GENERATOR with each alternation of the hysteresis switch square wave.

Waveform time symmetry is controlled by increasing or decreasing the two current sources relative to each other. Unequal charging currents thereby generate triangle wave ramps with unequal slopes. The current sources are normally equal in the amount of current supplied. The SYMMETRY CONTROL AMPLIFIER, however, can be switched into the circuit to allow setting an unbalance of the current sources' reference voltages. When this asymmetry is selected, frequency is divided by ten due to the supply limits of the current generators.

The input control voltage to the symmetry control amplifier and both current generators is provided by the VCG AMPLIFIER. Voltages from the FREQUENCY DIAL, the FREQUENCY VERNIER, the VCG IN connector, and the SWEEP CIRCUITS are summed together to determine the frequency control voltage from the VCG amplifier. The control voltage thru the GCV AMPLIFIER is externally available at the GCV OUT connector.

3.5 AMPLITUDE OFFSET AND ATTENUATION

The selected waveform is inverted and approximately doubled thru the PREAMPLIFIER. The VARIABLE output attenuator control provides up to 20 dB of attenuation of the waveform at the generator's output. Positive or negative reference level offset can be selected by the DC OFFSET control. The VARIABLE dc offset control provides the actual amount of offset to the selected waveforms center reference. The amount of dc offset can be affected externally at the EXT DC OFFSET connector.

The preamplifier waveform is again amplified by the OUTPUT AMPLIFIER. The output amplifier is also an inverting amplifier, only with a current limiting output stage for short circuit protection. The output amplifier establishes the generator's 0 dB attenuation reference. Two output attenuator stages decrease this reference amplitude in operator selected 10 dB steps down to −60 dB, attenuation between the steps provided from the variable output attenuator control of the preamplifier. OUTPUT ATTENUATOR NO. 1 provides the −10 dB, −20 dB, and −30 dB attenuation ranges. OUTPUT ATTENUATOR NO. 2 is switched in to provide an additional 30 dB attenuation for the −40 dB, −50 dB, and −60 dB ranges. The ATTENUATION SELECTOR switch determines if the attenuators are to be bypassed for the 0 dB range, if just output attenuator No. 1 is to be used, or if both output attenuators are to be employed for the generator's output.

3.6 TRIGGER AND GATED CONTROL

The enabling of generator operation is controlled by allowing or preventing the selected timing capacitor to charge. For continuous operation, the TRIGGER AMPLIFIER maintains a positive level above the positive peak developed by the charging capacitors. This reverse biases (turns off) the START/STOP DIODE SWITCH, preventing the trigger amplifier from affecting continuous operation.

When the trigger amplifier outputs some level below the positive peak charging level, the diode switch is forward biased (turned on) to hold the charging level constant. Preventing the capacitors to charge to the positive peak stops operation and holds the output at some dc level called the trigger baseline. The trigger baseline is thus the level from which a waveform cycle starts and at where it will stop.

The normal trigger baseline is zero volt, analogous to 0° phase of a waveform. The TRIGGER START/STOP control offsets the trigger amplifier output and thus the baseline for starting and stopping a waveform from its negative peak (−90°) to its positive peak (+90°). Upon reaching the positive peak level, though, the diode switch again reverse biases and operation becomes continuous.

When the charging level is being held, the positive current generator still varies its output with corresponding frequency control inputs. These varying currents must be taken up thru the diode switch to keep the timing capacitors from varying their charge, and thus the trigger baseline. The BASELINE COMPENSATION circuit monitors the output from the positive current generator to control the trigger amplifier, and thus the necessary compensating current thru the diode switch.

The TRIGGER CONTROL LOGIC determines that after a waveform starts, it always stops at a complete cycle at the same phase at which it started. The trigger control logic latches the trigger amplifier for an enabling output from the time the cycle starts to when the negative peak of the last cycle is reached (just one cycle in the trigger mode). Upon reaching the negative peak, the timing capacitor continues charging positive again as usual but stops upon reaching the trigger baseline. A square wave from the hysteresis switch synchronizes the last negative peak time for unlatching the trigger amplifier for its trigger baseline output.

The GENERATOR MODE CONTROL circuit determines whether the trigger control logic is to be "fired" for just one cycle, or is to be held on for the duration of the trigger level input. When in a gated mode, the trigger level is directly coupled for controlling the trigger control logic. In the trigger mode, the trigger level is capacitively coupled to provide a leading edge spike to "fire" the trigger control logic.

The SQUARING CIRCUIT is a level detector that generates a square pulse for the duration of a trigger level at the TRIG IN connector. The pulse is also generated for the duration of the MAN TRIG switch being held down.

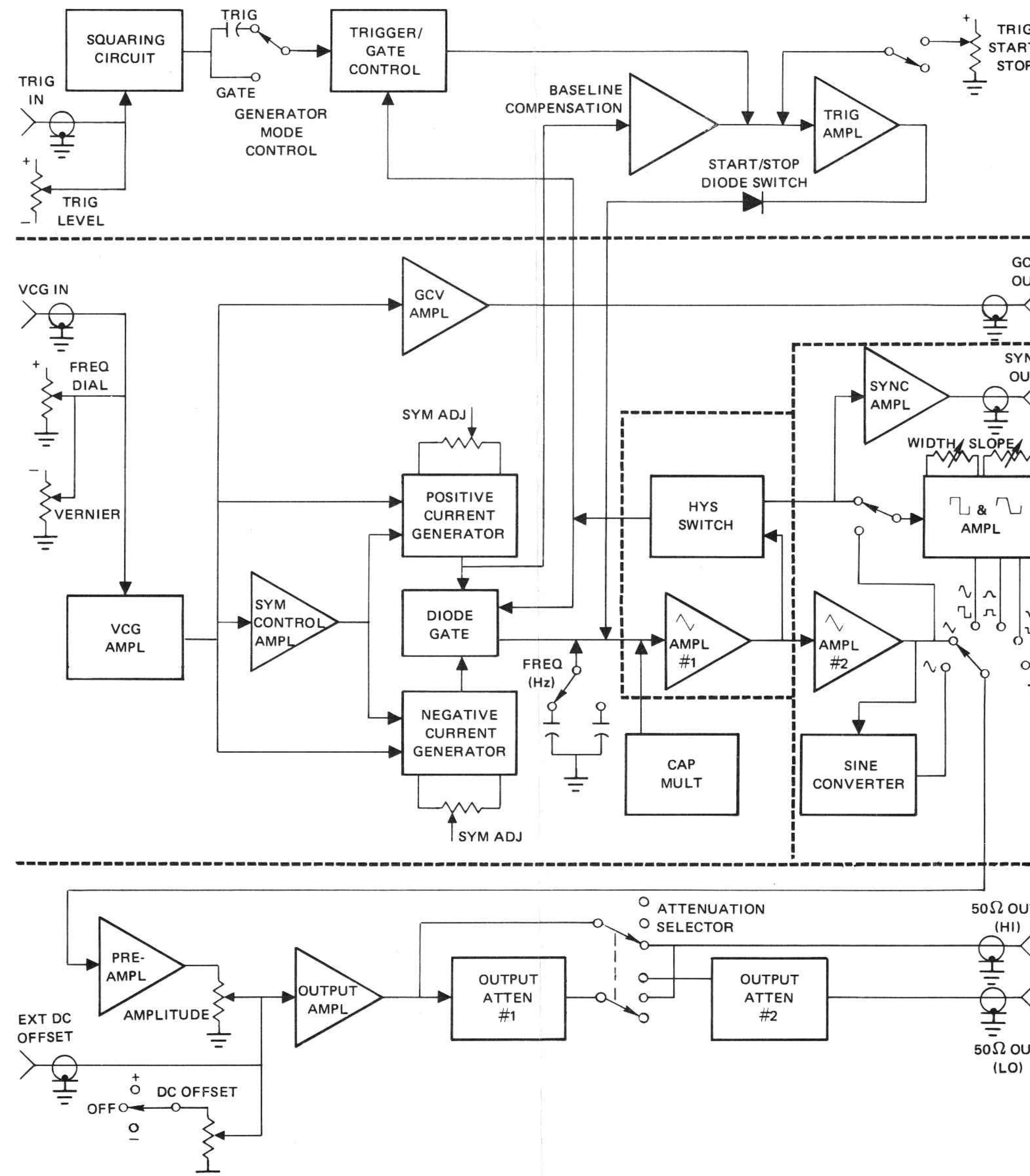


Figure 3-3. Main Board Functional Block Diagram

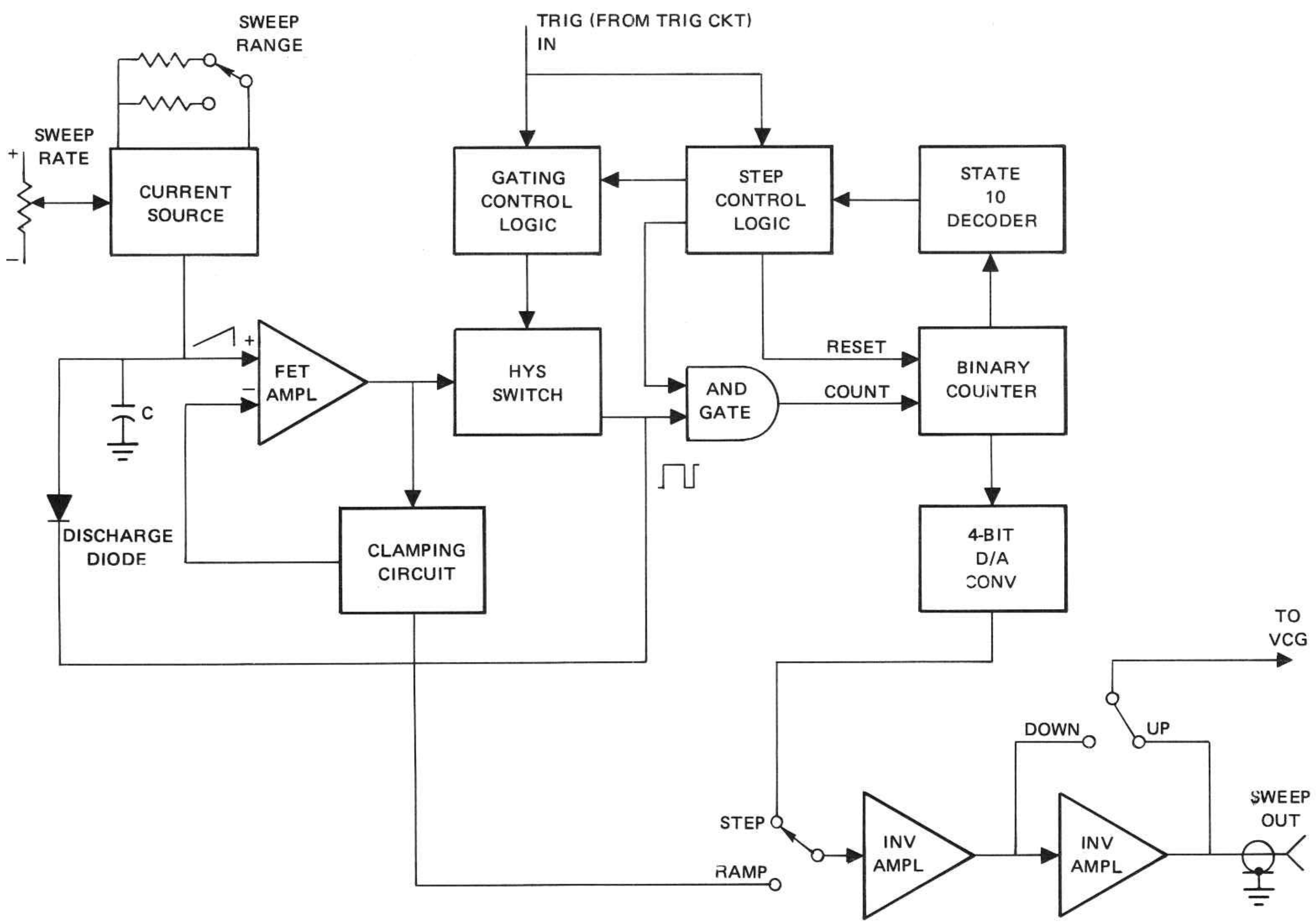


Figure 3-4. Sweep Board Functional Block Diagram

3.7 SWEEP CIRCUITS

The basic sweep generator consists of the current source, FET amplifier, clamping circuit, and hysteresis switch. See foldout Figure 3-4.

The current source charges capacitor C with a constant current I which produces a voltage ramp across C. The ramp is buffered by the FET amplifier and applied to the hysteresis switch. When the ramp reaches the threshold voltage of the hysteresis switch it changes state and discharges C very quickly thru the discharge diode. The clamping circuit clamps the peaks of the ramp to precise levels which assume 1000:1 sweep control.

For triggered and gated modes the entire generator may be either triggered or gated by the gating control logic circuit.

The step generator consists of the binary counter, state 10 decoder, step control logic, "and" gate, and the 4 bit D/A converter.

When in the step mode the entire ramp generator acts as a gated clock oscillator for the digital circuitry. In the continuous mode, clock pulses pass thru the "and" gate and cause the binary counter to increment up to state 10 and then reset. Each binary state is converted to an analog voltage by the D/A converter.

The D/A output is a staircase waveform.

In the triggered step mode, the step control logic causes the ramp generator to produce only 11 clock pulses which produces one cycle of the staircase. In the step hold mode, after state 10 is reached the "and" gate inhibits the counter until the trigger input signal goes low. On the next clock pulse the staircase resets.

The ramp output is applied to two unity gain amplifiers while the staircase output is applied to a times 5 amplifier in cascade with a unity gain amplifier. This allows selection of either the normal or inverted waveform of ramp or staircase to drive the VCG circuit for sweeping up or down, respectively.

The normal positive going waveform is available at the sweep output connector.

SECTION 4
PERFORMANCE VERIFICATION AND CALIBRATION

4.1 INTRODUCTION

This section provides instructions for verifying the performance of, and calibrating the Model 164 generator. The instructions are concise and written for the experienced electronics technician or field engineer. Performance is verified when the desired result of an adjustment is already present.

4.2 FACTORY REPAIR

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

4.3 RECOMMENDED TEST EQUIPMENT

The following test equipment is recommended.

1. Oscilloscope: Tektronix Model 7704 or equivalent with
   a. Differential amplifier (7A11) (250 MHz BW)
   b. Hi frequency amplifier (7A13)
2. Distortion Analyzer: HP334A or equivalent
3. Spectrum Analyzer: > 600 kHz
4. Five-digit Frequency Counter: > 30 MHz

4.4 ACCESS INSTRUCTIONS

The Model 164 is packaged so that it can be quickly disassembled to afford access to the majority of components within the unit, while allowing the instrument to be operated.

To remove the dust cover (case) from the Model 164, the following procedure should be followed:

1. Unplug the ac line cord and unscrew the four captive screws on the rear panel.
2. Remove the rear panel and power supply.
3. Unplug power supply connector from power supply board. Slide dust cover off slowly.
4. At this time, the power supply can be remounted and the Model 164 may be operated normally.

4.5 CALIBRATION INSTRUCTIONS

The following paragraphs provide complete sequential calibration procedures for the Model 164 instrument. Calibration of the generator is organized in a sequence of seven major groups. Each major group is a sequence of certain of the 30 individual selections and adjustments as listed below. The various calibration adjustments are located on either the Main Board PC Assembly or the Sweep Board PC Assembly as identified in foldout Figures 4-5 and 4-6, respectively, at the end of this section. Each calibration adjustment is independent of its following adjustment settings; an adjustment is, however, dependent on previous adjustment settings.

CALIBRATION ADJUSTMENT SEQUENCE

Paragraph	Calibration Sequence	Adjustment Sequence
Power Supply		
4.5.2	Power Supply Regulation	R10
Main Board		
4.5.3	Triangle Offset and Amplitude	R282, R370, R51, R142, R231, R106, R111, R124
4.5.4	Time Symmetry	R29, R39
4.5.5	Sine Distortion	R352, R368, R142, R369
4.5.6	Frequency	R15, C64, C65, R19, R12, R9, R20, C62, R18, R17, R16, R10, R74, R68, R66
4.5.7	Square Wave Purity	R279, C110
Sweep Board		
4.5.8	Sweep Circuit	R24, R19, R72, R71

4.5.1 Preliminary Procedures

Keep the generator covered and allow the unit to warm up for at least 30 minutes before calibration. Start the calibration by setting the front panel controls as follows:

FREQ (Hz)	X 1K
Frequency Dial	1.0
FREQ (Hz) VERNIER	Maximum cw (CAL)
WAVEFORM	∿ (Sine)
OUTPUT ATTEN (dB)	−10
OUTPUT ATTEN (dB) VARIABLE	3/4 cw
SYMMETRY	OFF
DC OFFSET	OFF
GEN MODE	CONT
TRIG START/STOP	0° CAL
SWEEP/STEP TIME	OFF

4.5.2 Power Supply Regulation

1. Before connecting the unit to an ac source, check the ac line voltage. To make sure the 115/230 and HI/LO switches are set at the correct position, refer to Paragraph 2.2.1.

2. Connect ac power and turn on the generator. Connect a voltmeter ground lead to TP1 (common) and the other lead to TP2 (+15 V) on the main circuit board (see foldout Figure 4-5).

3. Adjust potentiometer R10 in the power supply assembly to obtain +15 Vdc ±20 mV at TP2. The power supply assembly is at the rear of the unit; the potentiometer, although located on the inner side of the printed circuit board, can be seen. Adjust by finger pressure.

4. Check voltage at TP3 for −15 Vdc ±50 mV, at TP4 for +24 Vdc ±400 mV, and at TP5 for −24 Vdc ±400 mV.

5. Check voltage at TP6 for +5 Vdc ±250 mV.

4.5.3 Triangle Offset and Amplitude Adjustment

1. Set the WAVEFORM selector to DC, the OUTPUT ATTEN switch to 0 dB, the OUTPUT ATTEN VARIABLE control to maximum ccw, and the GEN MODE switch to TRIG.

2. Connect the 50Ω OUT (HI) to the oscilloscope and load with a 50Ω terminator.

3. Adjust R282 to obtain output dc voltage of less than ±5 mV.

4. Set the OUTPUT ATTEN VARIABLE control to maximum cw.

NOTE

DC level may change between full cw and full ccw.

5. Adjust R370 to obtain output dc voltage of less than ±5 mV.

6. Repeat Steps 3 thru 5 once.

7. Set the WAVEFORM selector to /\/ , rotate the frequency dial from 0.03 to 3.0 and adjust R51 for minimum change of output voltage, shifting less than 50 mV typically.

8. Set the frequency dial to 1.0 and the GEN MODE switch to TRIG.

9. Use voltage at TP7 as reference; adjust R142 until voltage at TP8 equals the voltage at TP7 to within 10 mV.

10. Adjust R231 to obtain 0 Vdc ±10 mV at 50Ω OUT (HI).

11. Set GEN MODE switch to CONT, and set frequency at 1 kHz (1.0 X 1K). Connect the differential oscilloscope to TP8 and ground at TP1.

12. Adjust R106 to make the negative peak of the waveform −1.250 V ±10 mV.

NOTE

As the frequency is increased, the signal will become flatter; as the frequency is decreased, the signal will look more like a /\/ .

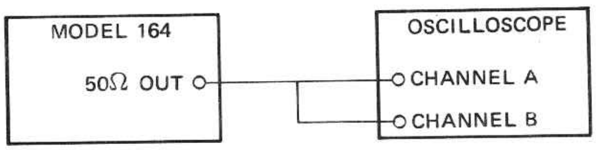
13. Connect the oscilloscope probe to TP9, and adjust R111 to make the /\/ waveform (approximately a 5 mV p-p signal) average voltage 0 V.

14. Adjust R124 for the square waveform at TP10 symmetrical above ground ±200 mV.

4.5.4 Time Symmetry Adjustment

1. Set the frequency dial to maximum cw, the FREQ (Hz) switch to X 100K and the WAVEFORM selector to ⊓⊔ . Connect 50Ω OUT (HI) to the oscilloscope.

2. Set the oscilloscope time base to 0.2 ms/division. Adjust the FREQ VERNIER control until the oscilloscope screen is filled by approximately one cycle (see setup and display in Figure 4-1).



Frequency:	500 Hz
Waveform:	
Symmetry:	= 100 a/b%
Time Base:	0.2 ms/division
Sweep Magnified:	X 10
Trigger:	Internal and Alternate
Channel A:	Normal
Channel B:	Inverted

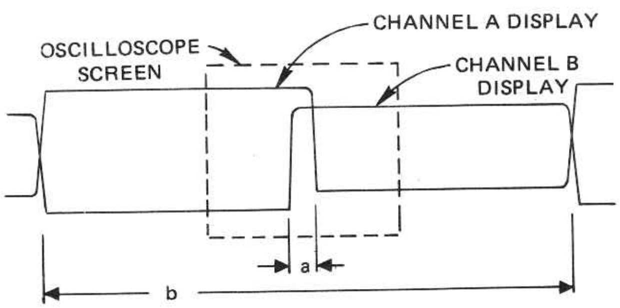


Figure 4-1. Alternate Time Symmetry Test Setup

3. Switch the oscilloscope trigger from + to −, and adjust R29 to obtain ⊓⊔ waveform time symmetry to within 0.5% (= 2 μs for 500 Hz).

4. Set the frequency dial to 2.0 and FREQ (Hz) to X 1K.

5. Set the oscilloscope time base to 50 μs. Use a similar procedure as above, and adjust R39 to obtain ⊓⊔ waveform time symmetry to within 0.1% (= 0.5 μs for 2 kHz.

6. Repeat Steps 1 thru 3 once.

4.5.5 Sine Distortion Adjustment

1. Set the FREQ (Hz) switch to X 1K, the frequency dial to 1.0 and the WAVEFORM selector to ∿ . Connect the 50Ω OUT (HI) to a distortion analyzer loaded with a 50Ω terminator. (See Figure 4-2 for test setup.)

2. Adjust R368 and R369 for minimum sine distortion. It may be necessary to reset R142 to achieve minimum sine distortion. R142 also affects the /\/ waveform offset.) Repeat Steps 7 and 9 of Paragraph 4.5.3 (Triangle Offset and Amplitude Adjustment).

NOTE

Trim resistor R351 may be changed for minimum sine distortion. Typical values are 825Ω and 909Ω.

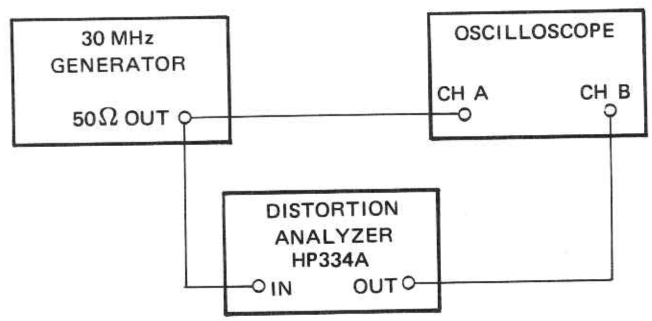


Figure 4-2. Distortion Test Setup

4.5.6 Frequency Calibration

1. Set the FREQ (Hz) switch to X 100K, the frequency dial to 0.03, the FREQ VERNIER maximum cw (CAL), and the WAVEFORM selector to ⊓⊔ . Connect 50Ω OUT (HI) to the oscilloscope.

2. Alternately short and open the VCG IN connector between its input and ground and adjust R15 at the same time until no observable frequency shift is seen on the oscilloscope.

3. Set the FREQ (Hz) switch to X 10M and the frequency dial to 2.0 Adjust C64 to obtain an output frequency of 20 MHz ±100 kHz. Select a different value of C65 if calibration cannot be achieved; each addition of 1 pF will reduce frequency by 200 kHz.

4. Set the FREQ (Hz) switch to 100K and the frequency dial to 3.0. Adjust R19 to obtain an output frequency of 300 kHz ±600 Hz.

NOTE

Select different value of R12 if frequency calibration in Steps 4, 9, and 10 cannot be achieved. Also, start from Step 3 again.

5. Set the frequency dial to 0.03 and the FREQ VERNIER control to maximum ccw. Adjust R9 to obtain an output frequency of 200 Hz ±20 Hz.

6. Repeat Steps 4 and 5 once.

7. Set the FREQ (Hz) switch to X 1M, the frequency dial to 3.0 and the FREQ VERNIER control to maximum cw (CAL). Adjust R20 to obtain an output frequency of 3 MHz ±10 kHz. Select a different value of C62 if calibration cannot be achieved; each addition of 10 pF will reduce frequency by 30 kHz.

8. Repeat Steps 3 and 7 once.

9. Set the FREQ (Hz) switch to X 10K. Adjust R18 to obtain an output frequency of 30 kHz ±60 Hz. (Refer to Note in Step 4.)

10. Set the FREQ (Hz) switch to X 1K. Adjust R17 to obtain an output frequency of 3 kHz ±6 Hz. (Refer to Note in Step 4.)

11. Set the FREQ (Hz) switch to X 100. Adjust R16 to obtain an output frequency of 300 Hz ±0.6 Hz (3.33 ms ±6 μs). Select a different value of R10 if calibration cannot be achieved.

12. Set the FREQ (Hz) switch to X 10 and the frequency dial to 0.1. Adjust R74 to obtain time symmetry of the ⊓⊔ waveform output better than 0.1%. Refer to Paragraph 4.5.4 (Time Symmetry Adjustment) for setup and measurement.

13. Set the frequency dial to 3.0. Adjust R68 to obtain an output frequency of 30 Hz ±0.06 Hz (33.3 ms ±6.0 μs). Check frequency accuracy at X 1 and X 0.1 ranges for better than 1%, or readjust R68. Select a different value of R66 if calibration cannot be achieved.

4.5.7 Square Wave Adjustment

1. Set the frequency dial to 1.0, the FREQ (Hz) switch to X 10K, the WAVEFORM selector to ⊓⊔ , and the OUTPUT ATTEN VERNIER to maximum cw. Adjust R279 to make the absolute negative peak voltage equal to the positive peak voltage within ±20 mV.

2. Set the FREQ (Hz) switch to X 1M. Adjust C110 to make a square waveform with the best square corner, but without overshoot.

4.5.8 Sweep Circuit Adjustment

1. Set the GEN MODE switch to TRIG SWP, the SWEEP MODE switch to STEP UP, the SWEEP/STEP TIME switch to OFF and the TRIG LEVEL control to maximum ccw.

2. Adjust sweep board potentiometer R24 for voltage between 0 mV and −2 mV at the SWEEP OUT connector.

3. Set the SWEEP/STEP TIME control to the 1 s/100 ms range. Adjust sweep board potentiometer R19 for voltage between 0 mV and −2 mV at the SWEEP OUT connector.

4. Set the GEN MODE switch to CONT SWP and the SWEEP MODE switch to RAMP UP. Connect the SWEEP OUT connector to the vertical input of the oscilloscope.

5. Turn the SWEEP/STEP TIME VARIABLE control fully cw. Adjust sweep board potentiometer R72 until the lower peak shows no flattening of the ramps, while still maintaining the lower peak at zero volt (see Figure 4-3).

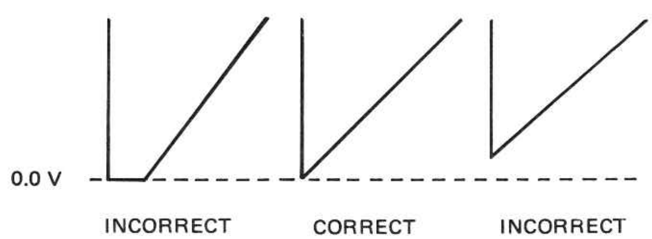


Figure 4-3. Ramp Negative Peak Adjustment

6. Adjust sweep board potentiometer R71 until the positive peak shows no flattening, but does not decrease in amplitude from the clipped level (see Figure 4-4).

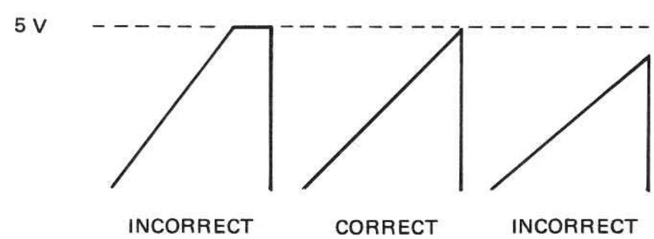


Figure 4-4. Ramp Positive Peak Adjustment

TEST POINT	FUNCTION
TP1	COM
TP2	+15V
TP3	-15V
TP4	+24V
TP5	-24V
TP6	+5V
TP7	∿ 1
TP8	∿ 2
TP9	∿ dc
TP10	⊓

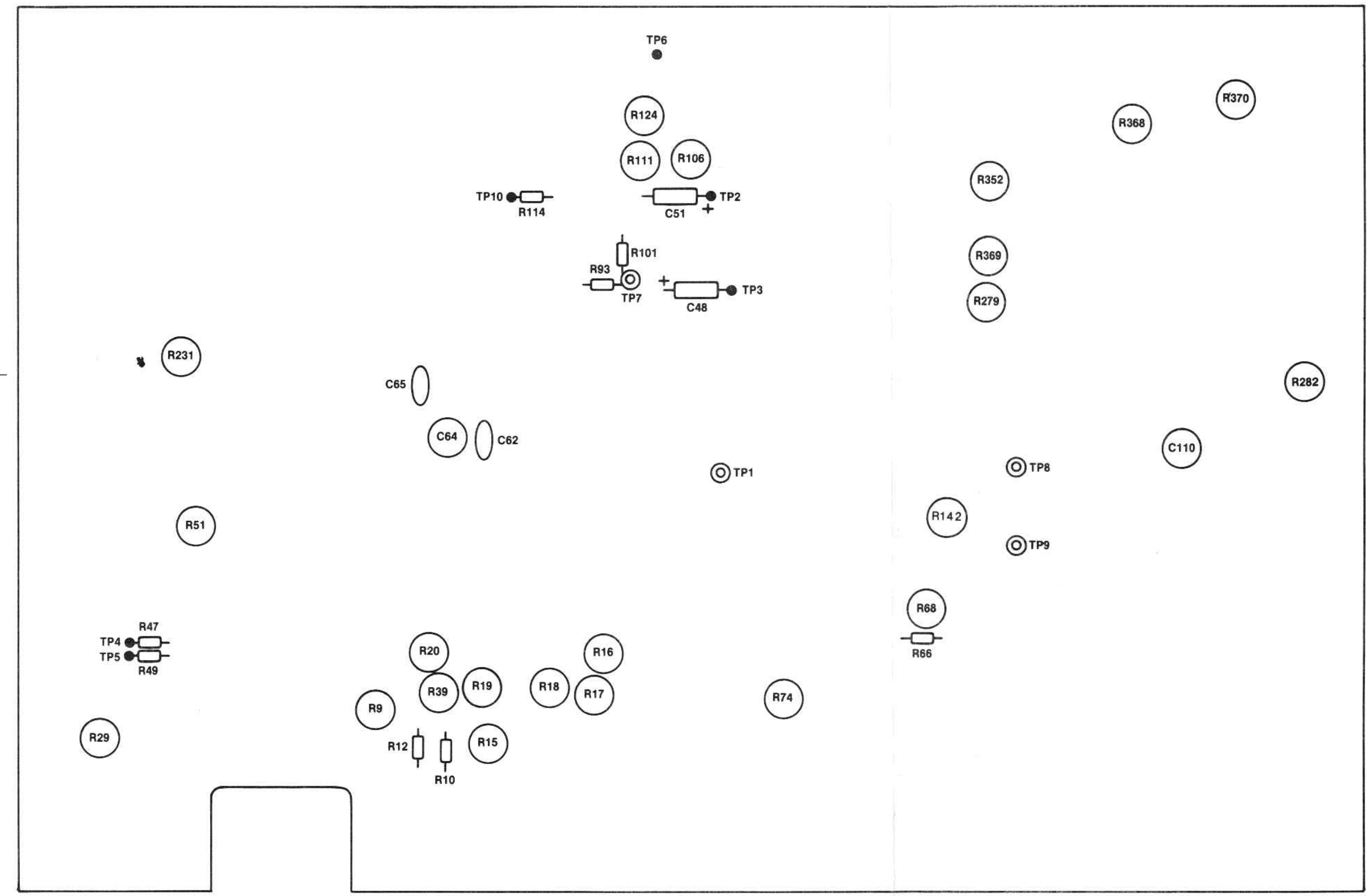
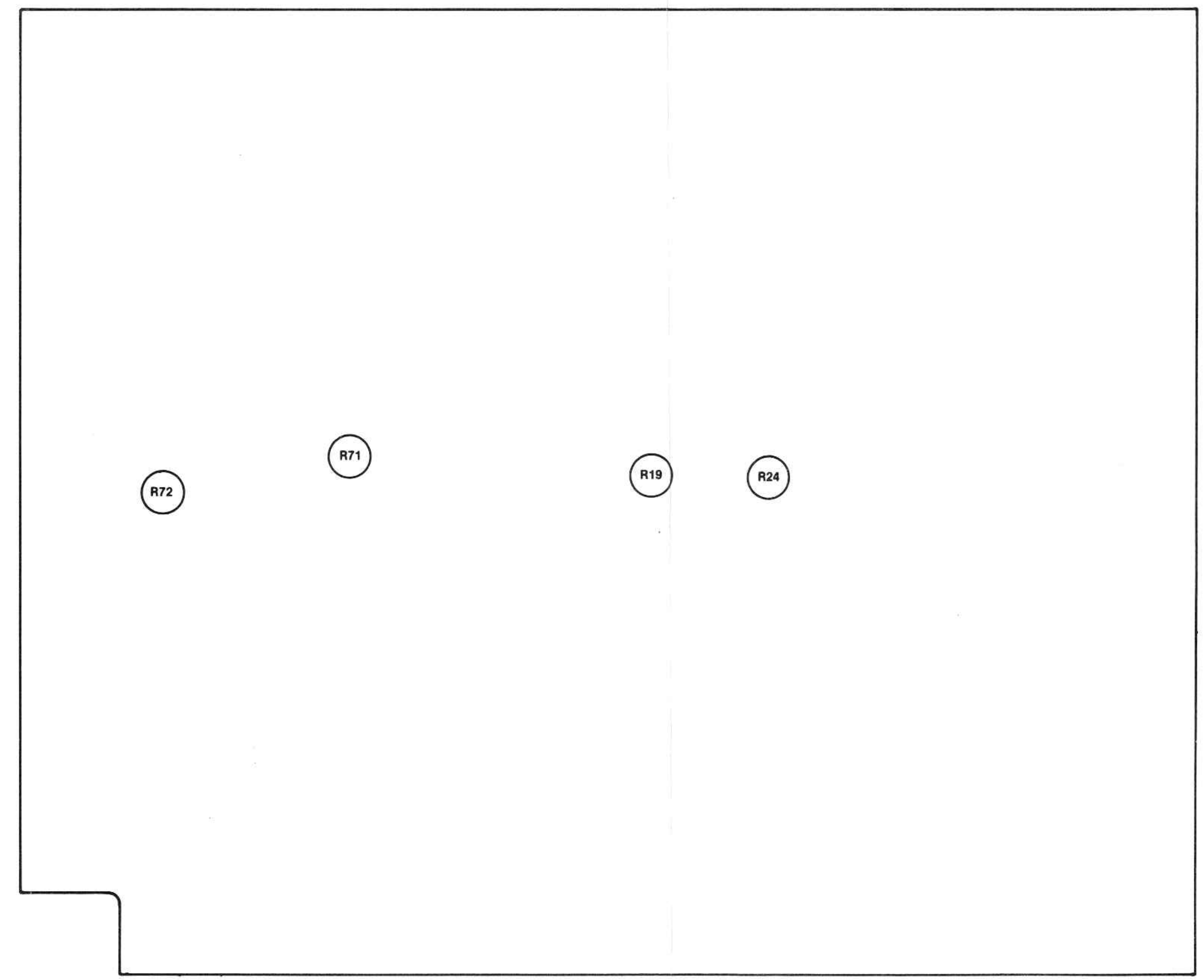


Figure 4-5. Main Circuit Board Calibration Components



SWEEP BOARD ASSY
D164-011

Figure 4-6. Sweep Board Calibration Components

SECTION 5
TROUBLESHOOTING

5.1 CORRECTIVE MAINTENANCE

This section presents a systematic approach to troubleshooting. The section is organized in three parts as follows:

Part 1 (5.2). Troubleshooting Technique for Individual Components. Frequently you can quickly locate a defective component by this technique without understanding the function of the circuit. It is also a necessary technique when extensive troubleshooting to component level is required.

Part 2 (5.3). Troubleshooting Guide. Start by observing the symptom of malfunctioning; then use the guide to find the defective component or malfunctioning circuit.

Part 3 (5.4). Troubleshooting Procedure for Individual Circuits. This is a supplemental procedure to Part 2 and used when Part 2 has failed to locate the defective components. However, procedure in Part 2 should always be checked first; usually, it will refer to a specific procedure in Part 3.

5.2 TROUBLESHOOTING TECHNIQUE FOR INDIVIDUAL COMPONENTS

5.2.1 Transistor

1. A transistor is defective if more than one volt is measured across its base emitter junction in the forward direction.

2. A transistor when used as a switch may have a few volts reverse bias voltage.

3. If the collector and emitter voltages are the same, but the base emitter voltage is less than 500 mV forward voltage (or reversed bias), the transistor is defective.

4. A transistor is defective if its base current is larger than 10% of its emitter current (calculate currents from voltage across the base and emitter series resistors).

5. In a transistor differential pair (common emitter stages), either their base voltages are the same in normal operating condition, or the one with less forward voltage across its base emitter junction should be OFF (no collector current); otherwise, one of the transistors is defective. Example, Q56A and Q56B.

5.2.2 Diode

1. A diode is defective if across it there is greater than one volt (typically 0.7 volt) forward voltage.

5.2.3 Operational Amplifier; e.g., UA741C, LM318

1. The "+" and "–" inputs of an OP AMP will have less than 15 mV voltage difference when operating under normal conditions.

2. If the output voltage stays at maximum positive, its "+" input voltage should be more positive than its "–" input voltage, or vice versa; otherwise, the OP AMP is defective.

3. The input of an OP AMP should not draw more than 500 mA of current (calculate current from voltage across its input series resistor) or it is defective.

5.2.4 FET Transistor

1. No gate current should be drawn by the gate of an FET transistor. If so, the transistor is defective.

2. The gate-to-source voltage is always reverse biased under a normal operating condition; e.g., the source voltage is more positive than the gate voltage for 2N5485 and TP308, and the source voltage is more negative than gate voltage for a 2N5462. Otherwise, the FET is defective.

5.2.5 Capacitor

1. Shorted capacitors have zero volts across their terminals.

2. Opened capacitor can be located (but not always) by using a good capacitor connected in parallel with the capacitor under test and observing the resulting effect.

5.3 TROUBLESHOOTING GUIDE FOR MAIN CIRCUITS

The following troubleshooting guide is a list of possible malfunction symptoms, their probable causes, and prescribed remedies. To use the guide, locate the symptom listed and follow the corresponding procedures to locate the fault. If more intensive test is required to locate the fault, the guide will refer to a more specific procedure.

	SYMPTOM	CORRECTIVE PROCEDURES
A.	**Output Waveform Problem**	
1.	Generator dead, blown fuse.	a. Replace fuse F1; if fuse blows again, refer to Paragraph 5.4.9.
2.	All output waveforms are distorted or are not output, but SYNC OUT is normal.	a. Set OUTPUT ATTEN to 0 dB and DC OFFSET VARIABLE to MIN (ccw). b. If output voltage can be adjusted to ±10 V into open circuit with the DC OFFSET control, problem is in the preamplifier; refer to Paragraph 5.4.5. c. Otherwise, problem is in the output amplifier; also refer to Paragraph 5.4.5.
3.	Power is on, but no output waveform at 50Ω OUT and SYNC OUT (GEN MODE at CONT).	a. Check for normal power supply voltage. b. Check the triangle generator circuits; refer to Paragraph 5.4.3.
4.	Waveform amplitude and frequency jittering.	a. Power supply out of regulation due to ac line voltage being too low. Check line voltage and make sure the HI/LO switch setting in the power supply module is correct. b. Malfunctioning power supply; refer to Paragraphs 5.4.10 and 5.4.11.
B.	**Problems in General (Distortion, Oscillation, High Frequency Roll Off, etc.)**	
1.	Problem appears in all waveforms, but SYNC OUT is normal.	a. Problem is in the output amplifier if problem is not seen at junction of R392 and R394. b. Otherwise, problem is in the preamplifier; refer to Paragraphs 5.4.5 and 5.4.7. *(Note: Most oscillation and high frequency roll off problems are caused by defective capacitors.)*
2.	Sine waveform problem only.	a. Problem is in the sine converter. C125 and C126 are shorted if no sine output; also refer to Step C.
3.	Square waveform problem only.	a. Defective Q45, Q49, CR37, CR40 or the associated components, and switch wafer.
4.	Trapezoidal waveform problem only.	a. Defective Q46, Q47, Q48, CR38, CR39 or the associated components, switch wafer, and controls.
5.	Both square and trapezoidal waveform problems.	a. Defective Q50 - Q53, CR41 - CR48, and the associated components.
6.	Trapezoidal WIDTH control problem.	a. Defective C95, R260 - R262 or the control potentiometer.
7.	Trapezoidal SLOPE control problem.	a. Defective control potentiometer, R253 - R256.
8.	Problem with triangle and sine waveforms only (or also trapezoidal).	a. Malfunctioning triangle No. 2; refer to Paragraphs 5.4.5 and 5.4.6. *(Note: High frequency roll off may be due to defective C44 - C49.)*

SYMPTOM		CORRECTIVE PROCEDURES
9.	Problem in SYNC OUT.	a. Q25 - Q27 or the associated circuitry.
10.	Problem in SYNC OUT and square waveform OUT.	a. Defective Q16.
11.	Distorted waveform, or generator not running when X .001 Hz to X 10 Hz is selected.	a. Problem in capacitance multiplier; refer to Paragraph 5.4.4.
C.	**Sine Distortion Problem**	
1.	Distortion OK at 1 kHz, but out of specification at 10 kHz and/or 100 kHz.	a. Due to the triangle, amplitude into the sine converter is varied. Check for defective C33 - C36, C41 and the associated resistors.
2.	Distortion out of specification in one or more frequency ranges.	a. Defective timing capacitor C53 - C62. In this case, triangle waveform will show nonlinear slope and distorted peak.
3.	Distortion out of specification due to distorted or unsymmetrical triangle.	a. If the leakage current of Q9, C22, C65, and C64 is large, it will cause nonlinear triangle and sine distortion in all frequencies. b. Distortion is caused by out-of-calibration or malfunctioning current generator if square wave time symmetry is off by more than 0.5%.
4.	Half of the sine waveform is missing.	a. Defective R368 or R369.
5.	Triangle waveform normal, but sine waveform distorted.	a. Check for normal triangle at sine converter input. It should be ±1.25 V p-p, and have better than 0.5% time symmetry and linear slope. b. If no defective resistor is found, replace the diode set CR54 - CR65.
6.	Distortion out of specification at frequencies greater than 1 MHz.	a. Problem is in the triangle amplifier No. 1 and hysteresis switch if frequency accuracy at X 10 MHz range is also out of specification. b. Check for defective capacitors, CR9 and CR10. c. Problem is in the preamplifier and output amplifier if square wave rise/fall time also does not meet the specification. Check for defective capacitor in the circuit. d. Defective CR14 - CR17, C22, C65 and C64. e. Defective C10 - C13, which may also cause frequency jumping when dial is rotated slowly (at X 10 MHz).
D.	**Time Symmetry Problem**	
1.	Positive slope of triangle remains constant when frequency dial is varied.	a. Defective IC3, IC6, Q1, Q3, Q5, C7 and the associated circuitry.
2.	Negative slope of triangle remains constant when frequency dial is varied.	a. Defective IC5, IC7, Q2, Q4, Q6, and the associated circuitry.
3.	Symmetry off a few percent at 3.0 of dial, but not much worse at .03 of dial.	a. R39 is out of calibration or defective. b. Defective R38, R40, R41, R46, R50, R53, or R59.

	SYMPTOM	CORRECTIVE PROCEDURES
4.	Symmetry off only if dial is set close to, or above 3.0.	a. IC5 is saturated due to frequency being out of calibration. b. IDSS (drain current, source shorted) of Q2 is too small; select a 2N5462 with IDSS of 3 mA.
5.	Symmetry off, several times worse if frequency dial and vernier is set to minimum.	a. Defective Q9, Q3, Q5, C10, CR15 or CR16 if the triangle at 50Ω OUT rises faster than it falls. b. Defective Q4, Q6, C11, CR14 or CR17 if the triangle at 50Ω OUT falls faster than it rises.
6.	Symmetry is out of specification at X 10 frequency range, and gets proportionally worse as frequency is decreased.	a. Defective Q8. b. R74 is out of calibration.
E.	**Waveform Problem**	
1.	Nonlinear or distorted triangle at one particular frequency range.	a. Check for defective frequency range capacitor C53 - C62 or C18.
2.	Nonlinear or distorted triangle at all frequencies.	a. Check for defective C22, C26, C64, Q9, CR14 - CR17.
3.	Nonlinear triangle only at its peak.	a. R124 is out of calibration. b. Square wave at E of Q23, E of Q24 is not symmetrical about ground due to defective Q23, Q24, CR14 - CR17 or the associated circuitry.
4.	⊓⊔ rise/fall time abnormally slow; also, sine wave rolling off at high frequency. High frequency oscillation on all waveforms.	a. Check for defective capacitor in output amplifier if waveform at E of Q72 is normal. (Rise/fall time less than 10 ns.) b. Otherwise, check for defective capacitor in the preamplifier.
5.	Nonlinear triangle at low frequency (X 10 to X 0.001 range).	a. Defective C18. b. Defective Q8, IC9, IC10, and the associated circuitry.
F.	**Frequency Accuracy Problem**	
1.	Frequency out of specification even at X 1 kHz range.	a. Check for normal triangle waveform at E of Q11 (±1.25 V ±5 mV and time symmetry within 0.5%), at 3 kHz. b. Defective dial potentiometer or mismatched dial and potentiometer (numbers marked on the dial and potentiometer should be the same), if frequency is out of specification at the same portion of the dial in every range. c. Defective current generator, especially IC1, IC5 and Q2, if triangle is unsymmetrical.
2.	Frequency out of specification at X 10 kHz, X 100 kHz, or X 1 MHz ranges.	a. Check for defective C33 - C36, C41. b. Check for defective Q13.
3.	Frequency out of specification at X 10 MHz range.	a. Defective Q13. b. Defective C31, C32, C37, C38, C26, or C41. c. Check for defective CR9 and CR10 (to check, set frequency to 3 kHz and compare waveform at the diode as shown in Figure 5-1).

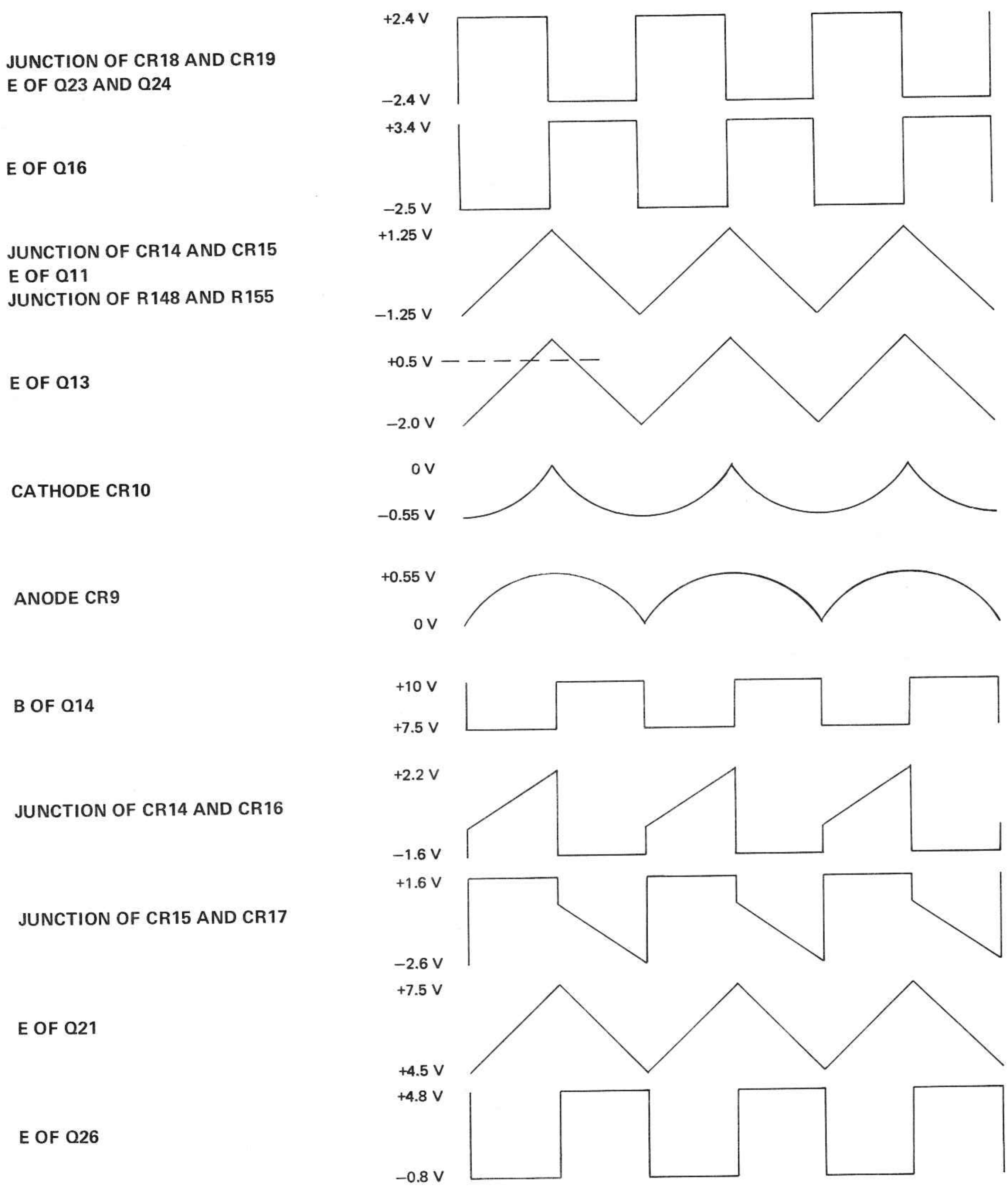


Figure 5-1. Key Waveforms of ∿ Amplifier No. 1, Amplifier No. 2, Comparator and Hysteresis Switch

SYMPTOM		CORRECTIVE PROCEDURES
4.	Frequency out of specification at X .001 to X 10 Hz range.	a. Defective R77 - R81 or C18. b. Defective IC9, Q8, IC10 in the capacitance multiplier.
G.	**Generator Mode Problem**	
1.	Generator not running in CONT mode.	a. Problem is in trigger circuit if voltage at E of Q44 is +1.2 volts; refer to Paragraph 5.4.1. b. Otherwise, check for defective CR36.
2.	Generator runs continuously in all GEN modes.	a. TRIG START/STOP control is at VAR and its variable is set too far cw. b. Defective CR36 if voltage at E of Q44 is +1.2 volts when TRIG mode is selected. c. Otherwise, troubleshooting the trigger circuit is covered in Paragraph 5.4.1.
3.	Both TRIG and GATED modes work as if in GATED mode.	a. Defective Q33 or CR24. b. Check for defective GEN MODE switch wafer and circuit connection. c. Otherwise, troubleshooting the squaring circuit is covered in Paragraph 5.4.1B.
4.	Both TRIG and GATED modes work as if in TRIG mode.	a. Defective Q33 or C73. b. Otherwise, troubleshooting the squaring circuit is covered in Paragraph 5.4.1B.
5.	TRIG mode not working, but GATED mode OK.	a. Defective C76 or CR24.
6.	MAN TRIG not working.	a. Defective Q31, C77, CR23, C75 or the associated circuitry. b. Check MAN TRIG switch setting.
7.	TRIG LEVEL control has no affect, or loads the ±15 volt power supply down when set to its extremes.	a. Defective C72, R182, or wiring. b. Defective control potentiometer.
8.	TRIGGER START/STOP level (baseline) varies more than 100 mV, at maximum output voltage.	a. R51 is not properly calibrated. b. Defective IC8, Q7, and associated circuitry. c. Mismatched CR36 and CR4.
9.	High frequency oscillation on TRIGGER START/STOP level, or baseline.	a. Defective capacitor C82 - C87 in trigger amplifier.
10.	Generator does not trigger with high frequency trigger as specified.	a. Defective CR24, C71, or C75.
11.	Other trigger problems.	a. Refer to Paragraph 5.4.

5.4 TROUBLESHOOTING PROCEDURE FOR INDIVIDUAL CIRCUITS

The following is a step-by-step procedure for troubleshooting a circuit which is believed to be malfunctioning. Checking should always start from the first step of each section of the procedure. Depending on the test result of each step, continue the test in sequence as indicated under the TRUE/FALSE column until problem is corrected.

***Example:** In Step A3 from the test result, if voltage at emitter of Q34 is less than −0.1 volt, continue the test in Step A4; otherwise, go to Step B and continue the test at Step B1.*

5.4.1 Troubleshooting of Trigger Circuit

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
A	**Quick Check of Trigger Circuit**		
A1	Set GEN MODE to GATED.	A2	
A2	Set TRIG LEVEL control fully ccw.	A3	
A3	Voltage at E of Q34 is less than −0.1 volt, greater than +3.5 volts with TRIG LEVEL fully cw. (Squaring circuit is OK if true.)	A4	B
A4	Voltage at E of Q40 is about +1.5 volts, −1.5 volts if TRIG LEVEL is fully cw.	A5	C
A5	Junction of R223 and R237 is zero volt. Also, E of Q44 is more positive than −2 volts but less positive than +0.6 volt.	A6	D
A6	Trigger circuit is working normally. Refer to Paragraph 5.3G for other trigger or gated mode problems.		
B	**Squaring Circuit Problem**		
B1	With TRIG LEVEL control fully ccw, CR24 is OFF (zero volt across it); fully cw, CR24 is ON (at least 0.5 volt across it).	B4	B2.1
B2	E of Q30 is about +5 volts.	B3	B3
B2.1	Defective Q30, R188, R189. May be due to extra loading, such as C74 being shorted.		
B3	E of Q31 is zero volt, but drops to −14 volts when MAN TRIG switch is depressed.	B4	B3.1
B3.1	Defective Q31, MAN TRIG switch, or the associated circuitry.		B3.2
B3.2	Check for defective Q28, Q29, CR24, and TRIG LEVEL control.		
B4	Voltage at junction of R201 and R199 is −15 V when CONT mode is selected; +15 V for TRIG mode, and +4.5 V for GATED mode.		
B4.1	Defective GEN MODE switch.		
B5	Select GATED mode. C of Q32 is +4 V if TRIG LEVEL is fully cw, but zero volt if fully ccw.	B6	B5.1
B5.1	Check for defective Q32 and Q33.		B6
B6	Defective Q34. *(Note: Q34 is a voltage follower.)*		A4
C	**Trigger Logic Circuit Problem**		
C1	Set GEN MODE to GATED, and TRIG LEVEL control fully ccw.	C2	
C2	Voltage across R204 is zero volt, more than 3 volts if CONT mode is selected.	C3	C2.1
C2.1	Defective Q35, R201, R202, switch wafer SW5-B, or connections.		
C3	Voltage at E of Q36 is about +2 volts, ⊓⊔ waveform if TRIG LEVEL control is cw or CONT mode is selected.	C4	C3.1
C3.1	⊓⊔ waveform is at E of Q36 in GATED mode with TRIG LEVEL fully ccw.	C4	C3.2
C3.2	Check for defective Q36, CR26 or C78. *(Note: Voltage at E of Q36 follows SYNC IN.)*		
C4	Voltage at E of Q40 is about +1.5 volts.	D	C4.1
C4.1	Check for defective CR27 and CR28.		C4.2
C4.2	Check for defective Q37 - Q40. *(Note: This circuit works like a flip-flop; Q37 and Q38 are alternately ON.)* Set TRIG LEVEL to cw or ccw, and check for correct voltage levels at E of Q37, Q39 and Q40 as shown in Figure 5-2 under GATED mode operation.		

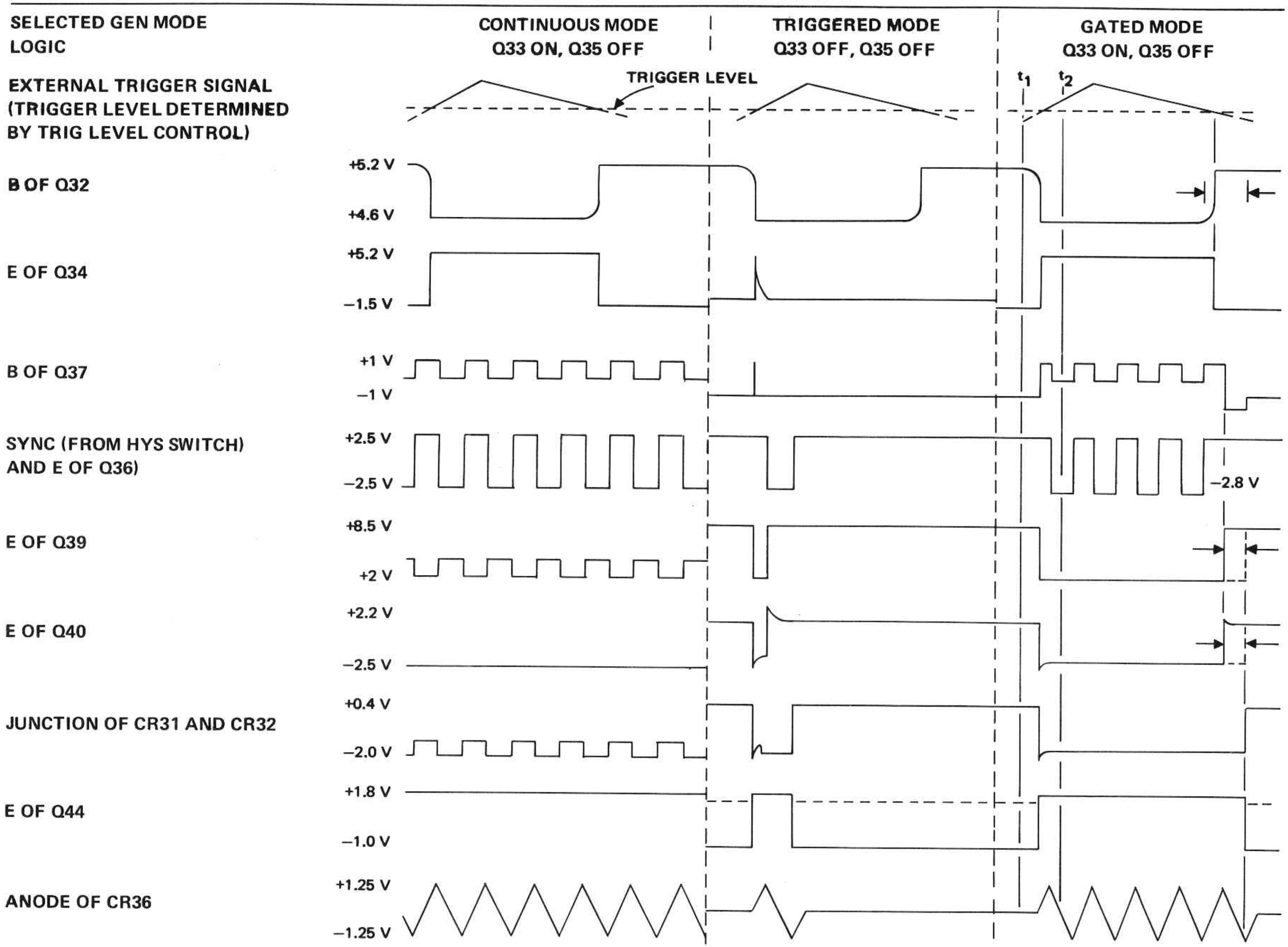


Figure 5-2. Typical Voltage and Waveforms for Trigger Circuit

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
D	**Trigger Amplifier Problem**		
D1	Set GEN MODE to GATED and TRIG LEVEL control fully ccw.	D2	
D2	Voltage at E of Q44 is about -0.7 volt (TRIG START/STOP at 0° CAL), +1.5 volts and generator is oscillating, if TRIG LEVEL is fully cw.	D2.1	D3
D2.1	Voltage at E of Q44 can be varied from −2 volts to +0.6 volt if TRIG START/STOP is set to VAR and its VARIABLE control is rotated.	D2.2	D3
D2.2	Trigger amplifier is operating normally.		
D3	Voltage across R229 is less than 1.5 volts.	D4	D3.1
D3.1	Baseline compensation circuit is malfunctioning; check for defective IC8 and its circuitry.		
D4	Zero voltage at junction of R223 and R237 (amplifier summing node).	D5	D4.1
D4.1	Check for defective Q41 - Q44. *Note: Voltage at E of Q42 is +8 volts, and E of Q43 is −8 volts. Q44 is a voltage follower.)* High frequency oscillation at E of Q44 indicates defective capacitors C82 - C87.		
D5	Check for defective CR31 - CR35.		
5.4.2	**VCG Amplifier and Current Generator Troubleshooting Procedure**		
E	**Current Generator Problem**		
E1	Set FREQ (Hz) to X 1K or more, SYMMETRY OFF, and FREQ VERNIER at CAL.	E2	
E2	Rotate the frequency dial from full cw to full ccw and observe voltage variation as described in Steps E3 thru E7.		
E3	Voltage at junction of R22 and R24 varies from 0 volt to about −5.7 volts.	E4	F
E4	Voltage at E of Q5 varies from about +14.5 volts to +6.7 volts.	E5	G
E5	There is no observable voltage (less than 1 μV) seen across R55.	E6	G4.1
E6	Voltage at E of Q6 varies from −15 volts to −9.3 volts.	E7	H
E7	There is no observable voltage seen across R56.	E8	H2.3
E8	Both current generators are operating properly.		
F	**VCG Amplifier Problem**		
F1	Troubleshooting hints: a. Pin 2 and pin 3 of IC1 is always zero volt. b. Under normal operating conditions, voltage at pin 6 is between 0 and -10 volts when dial is rotated from full cw to full ccw. c. Voltage at pin 6 will cut to half if X .001 Hz FREQ range is selected.	F2	
F2	If VCG amplifier works normally.	E4	
G	**Positive Current Generator Problem**		
G1	Voltage at pin 2 and pin 3 of IC3 is zero volt.	G2	G1.1
G1.1	Check for defective IC3 and Q1; voltage across R35 should be zero volt.		
G2	Voltage at pin 2 of IC5 varies from 0 to -5.7 volts when dial is rotated cw to ccw.	G3	H1.1

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
G3	Voltage at D of Q1 varies from about +14.5 volts to +6.7 volts when dial is rotated cw to ccw.		
G3.1	Check for defective R41, R40, C7, and SYMMETRY switch.		G.4
G4	Repeat Step E2, E4, and E5.	E2	G4.1
G4.1	Check for defective IC6, Q3, Q5, and the associated circuitry. *(Note: Check for correct power supply voltage and defective capacitor C8, C10, or C12.)*		
H	**Negative Current Generator Problem**		
H1	Voltage at S of Q2 varies from 0 volt to about −5.7 volts when dial is rotated cw to ccw.	H2	H1.1
H1.1	Check for defective IC5 and Q2.		
H2	Voltage at D of Q2 varies from −15 volts to −9.3 volts, and zero volt is across R37 when dial is rotated cw to ccw.	H3	H2.1
H2.1	Zero voltage at pin 2 of IC3.	H2.2	G
H2.2	Check for defective R40, R41, C7, and SYMMETRY switch.	H2.3	
H2.3	Check for defective IC7, Q4, Q6, and the associated circuitry. *(Note: Check for correct power supply voltage and defective capacitor C9, C11, or C13.)*		
H3	Repeat Steps E2, E6, and E7.	E2	H2.3
5.4.3	**Triangle Generator Troubleshooting**		
I	**Start/stop Switch and Diode Gate Problems**		
I1	A ±1.25 V triangle is seen at E of Q11 in CONT mode.	I1.1	I1.2
I1.1	Triangle generator is running; refer to Paragraph 5.3 for other problems.	5.3	
I1.2	Voltage at E of Q44 (trigger amplifier) is greater than +1.2 volts.	I1.4	I1.3
I1.3	Troubleshoot the trigger circuit.	5.4.1	
I1.4	CR36 is shorted.		I2
I2	Set dial to 3.0, FREQ (Hz) to X 1K, and SYMMETRY OFF.	I3	
I3	Both voltages across R163 and R164 are about 500 mV; voltages will decrease if dial is rotated cw.		I3.1
I3.1	Troubleshoot the current generator.	5.4.2	I4
I4	Voltage difference between G of Q9 and E of Q11 is less than 300 mV.	I5	J
I5	Voltage at E of Q11 is within ±1.25 volts.	I7	K
I6	Check for shorted C22, C64, or C65.		I7
I7	Check for defective Q23, Q24, C68, and the associated circuitry. *(Note: Q23 and Q24 are voltage followers, the voltages of which should be the same as C of Q14.)*		I8
I8	Voltage at C of Q14 is either +2.4 ±0.5 volt or −2.4 ±0.5 volt.		
I8.1	R124 is out of calibration.		K
I9	Check for defective CR14 - CR17. *(Note: None should have more than 900 mV forward voltage.)*		
J	**Triangle Amplifier No. 1 Problem**		
J1	6.4 volts ±0.6 volt across both CR6 and CR8.	J2	
J1.1	Defective CR6, CR8, C24 or C25.		

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
J2	Check for defective Q11 and Q12. *(Note: Q11 and Q12 are voltage followers.)*		
J3	Check for defective Q9 and Q10. *(Note: G to S voltage should be reversed bias. Voltage across R86 and R87 are the same.)*		J4
J4	Check for shorted C27.		
K	**Hysteresis Switch Problem**		
K1	Voltage at pins 2 and 8 of IC11 are about −2 volts.	K2	K1.1
K1.1	Voltage across R118 and R121 is less than 30 mV.	K1.2	K4.1
K1.2	Defective R119, R123, or R124.		
K2	Voltage at pins 3 and 9 of IC11 are about 0.7 volt below that at pins 2 and 8.	K3	K4.1
K3	Voltage at B of Q14 is no more than one volt less than that at B of Q15.	K3.1	K3.3
K3.1	Q14 is ON and Q15 is OFF (zero volt across R128 and 5 volts across R114).	K4	K3.2
K3.2	Check for defective Q14 and Q15.		
K3.3	Q14 is OFF and Q15 is ON (5 volts across R128 and zero volt across R114).	K4	K3.2
K4	Voltage at B of Q14 is 7.5 volts ±1 volt.	K5	K4.1
K5	Voltage at pin 7 of IC11 is within 0 and 200 mV.	K6	K4.1
K6	Voltage at E of Q11 is greater than +1.25 volts.	K8	K7
K7	Voltage at E of Q11 is less than −1.25 volts.	K9	I5
K8	Voltage at pin 4 of IC11 is greater than zero volt.	K3.3	K8.1
K8.1	Check for defective R101, R109, R110, R111, CR10, and C35 - C38.		
K9	Voltage at pin 1 of IC11 is less than zero volt.	K3.1	K9.1
K9.1	Check for defective R100, R108, R107, R106, CR9, and C31 - C34.		
5.4.4	**Troubleshooting the Capacitance Multiplier Circuit**		
L	**Capacitance Multiplier Problem**		
L1	Set FREQ (Hz) to X 10 and check for correct waveform as shown in Figure 5-3.	L1.1	L2
L1.1	Capacitance multiplier is running. Refer to Paragraph 5.3 for other capacitance multiplier related problems.	5.3	
L2	Check the multiplier statically by setting FREQ (Hz) to X 100. *(Note: The multiplier is disconnected from the main generator and therefore the circuit is under a dc bias condition.)*	L3	
L3	Voltage at wiper of SW1-C is zero volt.	L4	L3.1
L3.1	Check for defective switch wafer SW1-C and related circuitry.		
L4	Voltage at pin 6 of IC9 is 0 ±200 mV.	L5	L4.1
L4.1	Check for defective IC9, C17, and R64 - R68.		
L5	Voltage at pin 6 of IC10 is zero volt (or adjustable to zero with R74).	L6	L5.1
L5.1	Check for defective IC10, Q8, and C21. *(Note: Voltages at S of Q8A and Q8B are equal and more positive than voltages at G's under normal operating condition.)*		
L6	Short wiper of SW1-C to ground with a jumper wire. Switch FREQ (Hz) control between X 10 Hz and X .001 Hz and observe that voltage at wiper of SW1-B changes no more than 10 mV.	L1	L6.1

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
L6.1	Defective Q8, or Q8 has IDSS less than 1 mA and should be replaced. *(Note: Defective Q8 will cause frequency accuracy and time symmetry problem at low frequency, especially at X .001 Hz range.)*		

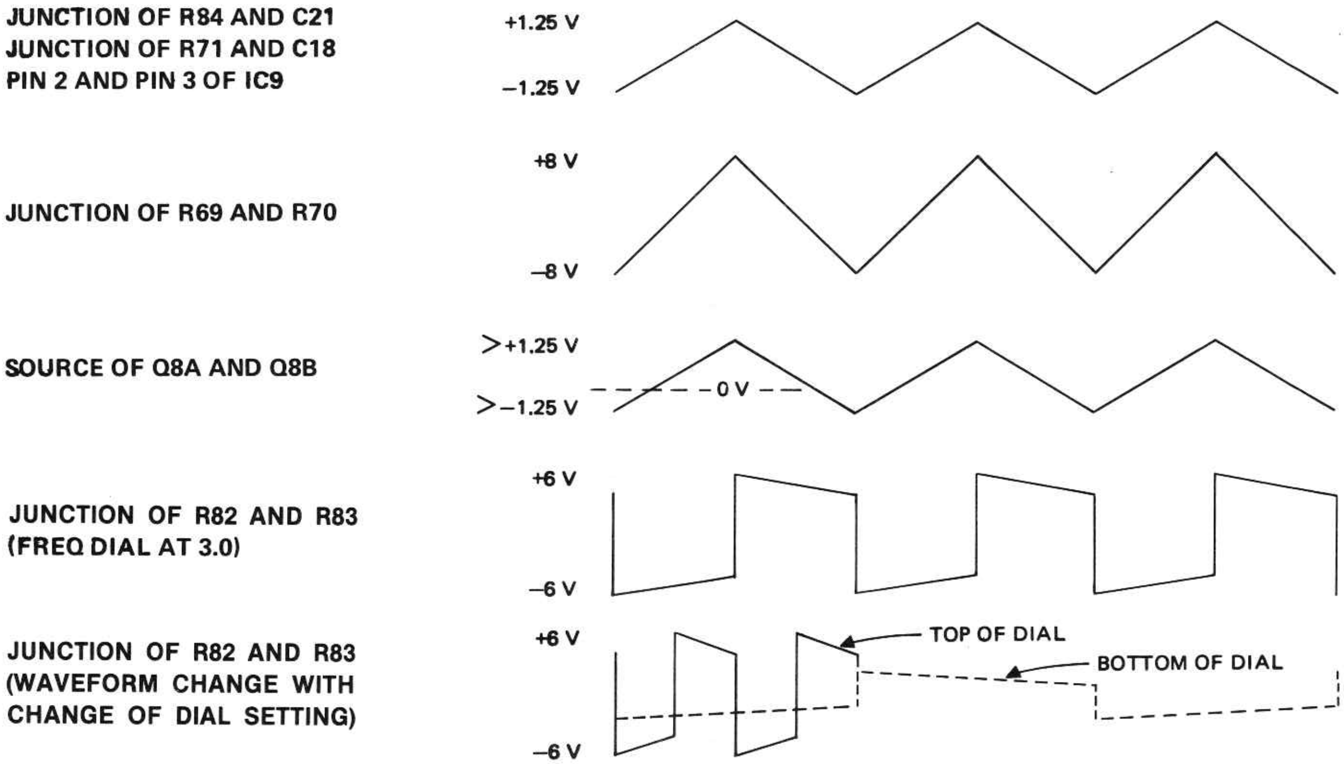


Figure 5-3. Key Waveforms of Capacitance Multiplier

5.4.5 Amplifier Troubleshooting Hints

1. If the output of an amplifier is saturated at a portion of the input waveform or all the time, the simplest method is to follow Paragraph 5.2 to locate a defective semiconductor or capacitor.

2. If high frequency oscillation is seen at the output of an amplifier, usually it is due to a defective capacitor. Sometimes, a defective capacitor can be located by touching the PC circuit traces to find the most signal sensitive area.

3. Look for burnt or overheated components.

4. Slow frequency response and rise/fall times are usually due to a defective capacitor. Use a good capacitor to jumper across each of the capacitors in the amplifier to locate the open-circuit capacitor.

5.4.6 Triangle Amplifier No. 2 Troubleshooting Hints

1. The triangle amplifier no. 2 circuit is a unity gain amplifier. Voltage at B of Q17 is the same as at the B of 19. A ±1.25 V p-p triangle signal is seen at these points when the generator is running.

2. Voltage at E of Q18 is about +11 volts.

3. Voltage at E of Q20 is about −7.5 volts.

4. A 2.5 V p-p triangle, with +5.5 volt offset should be seen at E of Q21 when the generator is running.

5. R142 adjusts the dc offset of the amplifier.

5.4.7 Preamplifier Troubleshooting Hints

1. The preamplifier circuit is an inverting amplifier thru which the selected waveform passes before going to the output amplifier.

2. The output waveform at junction of R393 and R394 is about 5.3 V p-p.

3. Voltage at junction of C129 and C130 is zero volt (summing junction).

4. Voltages across R385 and R390 are equal, about 8 volts.

5. Q67, Q68, and Q69 are dc-bias elements for the amplifier.

6. C133 is switched in or out of the circuit, depending on the waveform selected, to optimize the frequency response.

7. Defective C128 causes overshoot and dipping of square wave corners.

5.4.8 Output Amplifier Troubleshooting Hints

1. Like the preamplifier, the output amplifier is also an inverting amplifier.

2. Junction of C109 and C111 is zero volt (summing junction).

3. Voltages across R305 and R313 are equal, about 8 volts.

4. Q54, Q55 and Q56 are dc-bias elements.

5. Q61 and Q62 compose the output current limiting stage. Normally the two transistors do not conduct unless the output loading current exceeds 140 mA.

6. If C105 is opened, the square wave corners will show excessive rounding.

7. Defective C107 causes overshoot and dipping of square wave corners.

8. Defective C109 - C115 will cause high frequency waveform roll-off or oscillation on the waveform.

5.4.9 To Locate Short Circuit Components

1. Check for normal impedance and/or loading current to determine if the source of short is in power supply or other circuit. Refer to Paragraph 5.4.10.

2. Short circuit component can be located by troubleshooting the malfunctioning circuit if the short circuit does not cause low power supply voltage or blowing fuse.

3. If power supply voltage is low but fuse is not blown immediately, look for overheated components, burnt parts, or discolored circuit board.

4. Inspect the circuit board carefully for any solder bridges.

5. Localize the short circuit to one or a pair of power supply circuits by impedance measurement; refer to Paragraph 5.4.10. Then disconnect power supply voltages to each part of the circuit by removing jumper or series resistor (usually 10Ω to 100Ω) along the power supply path until the short circuit area is isolated. Then locate the short in that area. Power supply transistors and bypass capacitors are the most frequently shorted components.

5.4.10 Loading Current and Impedance of Power Supply

Typical current and impedance of each power supply loading are provided as a reference in case symptoms of a short circuit are observed. Before making any measurement, set the generator controls as follows:

FREQ	X 1K
DIAL	3.0
SYMMETRY	OFF
WAVEFORM	∿
OUTPUT ATTEN (dB)	−10 dB (no load at 50Ω OUT)
OUTPUT VARIABLE	Manually cw
GEN MODE	GATED
DC OFFSET	OFF
TRIG START/STOP	0° CAL

1. Loading current is measured by first unsoldering the power supply wire to the circuit board from the power supply connector so as to connect an ammeter in between.

2. Impedance is measured at the same point as above relative to the ground on the PC board, unless otherwise specified.

Typical impedance across and loading current into the main circuit board power supply are shown in the following table:

Typical impedance across and loading current into each power supply are shown in the following table:

Main Circuit Board

POWER SUPPLY	IMPEDANCE	LOADING CURRENT
+15 volts	400	400 mA
−15 volts	600	380 mA
+24 volts	20K	50 mA
−24 volts	20K	45 mA
+ 5 volts		0
between ±15 volts	1K	–
between ±24 volts	25K	–

Sweep Board

POWER SUPPLY	IMPEDANCE	LOADING CURRENT
+15 volts	3K	85 mA
−15 volts	4.2K	70 mA
+15 volts	3K	110 mA
between ±15 volts	2.7K	–

Note: Impedance and current are accurate to within ±20% and will vary if panel controls are set differently.

5.4.11 Power Supply Troubleshooting Hints

1. Unplug the power supply connector from the main board if power supply voltage is out of regulation.

2. 60 cycle ripple on supply voltage may be due to wrong HI/LO switch selection. Check ac line voltage and select the proper switch setting accordingly.

3. Power supply voltages are interrelated. Malfunctioning +15 volt supply will cause the −15, ±24 volt supplies to be out of regulation. Malfunctioning ±24 volt supplies, however, will not affect the others.

4. Q3, Q7, Q12, and Q16 are current limiting transistors which do not conduct under normal operating conditions. Supply voltage will be zero if these transistors have a short circuit.

5. The power supply voltages being normal without a load and the voltage being low under a normal load indicate Q2, Q6, Q10 or Q14 as being an open circuit.

6. Fuse blown with the power supply being plugged in may be due to wire insulation being broken, shorted transformer, power transistor shorted to heat sink, defective CR1 to CR8, or shorted power supply bypass capacitor. Isolate the short by disconnecting each part of the circuit.

5.4.12 Troubleshooting Guide for Sweep Circuit

	SYMPTOM	CORRECTIVE PROCEDURES
1.	No sweep signal output at SWP OUT when selecting CONT SWP.	a. IC2 or the associated circuit is defective if ramp signal is seen at pin 10 of IC10. b. Ramp generator is not running; refer to Step M.
2.	Lost or distorted sweep signal at SWP OUT when STEP UP or RAMP UP is selected.	a. IC3 or the associated circuit is defective.
3.	Ramp waveform is not linear, and gets worse at 10 s and 100 s sweep.	a. Q11, Q13, Q14, C24 or C25 is defective (excessive leakage current).
4.	Ramp waveform is not linear; same nonlinear waveform at all frequencies.	a. Check for defective diodes CR15 - CR20.
5.	Positive peak voltage of ramp is less than 5 volts.	a. If peak voltage varies with frequency, defective C31 or CR25. b. If voltage is low at all frequencies, defective CR28, R68, R70, R71, or CR22.
6.	Reference voltage of ramp does not reach zero.	a. If peak voltage varies with frequency, defective C30, CR23 or CR24. b. If voltage is high at all frequencies, defective CR29, R67, CR21, R69, R73 or R72.

SYMPTOM	CORRECTIVE PROCEDURES
7. High frequency oscillation on the ramp waveform.	a. Check for defective capacitors associated with IC2, IC3 and IC10.
8. No step signal output in any mode; ramp signal output is normal.	a. Q18 is defective if clock pulse is not seen at CLOCK input of the digital circuit (at R31). b. D/A amplifier is defective; refer to Step R. c. Follow Step S to check for defective components in the digital circuit.
9. Signal at SWP OUT is not stepping in TRIG SWP, SWP HOLD, or SINGLE STEP mode when triggered.	a. If the main generator is not operating in TRIG and GATED modes, problem is in the main generator trigger circuit. b. If there is no ramp output when RAMP UP is selected and the generator is triggered, problem is in the ramp control logic circuit.

5.4.13 Troubleshooting of Sweep Circuit

NOTE

The following circuits are located on the sweep board.

STEP	PROCEDURE	IF TRUE GO TO	IF FALSE GO TO
M	**Quick Troubleshooting Procedure for Ramp Generator**		
M1	Set GEN MODE to CONT SWP, SWEEP/STEP TIME to any position other than OFF.	M1.1	
M1.1	A ramp signal (0 to +5 volt sawtooth) is seen at junction of R62 and R63.	M1.2	M2
M1.2	Ramp generator is running normally; refer to Paragraph 5.4.12 for other sweep problems.		
M2	Set SWEEP/STEP TIME to OFF.	M2.1	
M2.1	Voltage at G of Q14A is 0 volt.	M2.3	M2.2
M2.2	Defective switch wafer SW9-B.		
M2.3	Voltage at junction of R62 and R63 is 0 ±30 mV.	M3	M2.4
M2.4	Ramp generator amplifier is malfunctioning; refer to Step N.	N	
M3	Voltage at pin 7 and pin 10 of IC11 is 0 to −50 mV dc.	M4	M3.1
M3.1	Voltage at pin 7 of IC11 is greater than zero volt.	M3.2	M3.3
M3.2	Check for defective Q20, SW8-A, and the associated circuitry.		
M3.3	If voltage at pin 7 is below −50 mV, IC11 is defective.		
M4	Voltage at C of Q19 is greater than zero volt.	M5	M4.1
M4.1	Check for defective SW5-A, C35, C33, and the associated circuit components.		
M5	Generator control logic is normal. Follow Step Q to check out the hysteresis switch circuit.	Q	
N	**Ramp Generator Amplifier Troubleshooting**		
N1	Set SWEEP/STEP TIME to OFF.	N2	
N2	Voltage at G of Q14A should be zero volt.	N3	N2.1
N2.1	Check for defective SW9-B.		
N3	Voltage at junction of R62 and R63 is 0 ±50 mV.	N3.1	N4
N3.1	Voltages at S of Q14A and Q14B are greater than zero volt.	N3.3	N3.2
N3.2	Q14 is defective.		

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
N3.3	The ramp generator amplifier is operating normally.		
N4	Check for defective IC10; refer to Paragraph 5.2.3.		N4.1
N4.1	If oscillation is seen, C27 is defective.		N4.2
N4.2	Check for defective diodes, CR15 - CR18; refer to Paragraph 5.2.2.		N3.1
P	**SWEEP/STEP TIME Control Circuit Troubleshooting (when ramp generator is not running at CONT SWP)**		
P1	Voltage at E of Q7 is +5 volts ±0.5 volt.	P2	P1.1
P1.1	Q7 is defective.		P2
P2	Voltage across CR12 is 6.4 ±0.5 volt.	P3	P2.1
P2.1	Check for defective CR12 and C21.		
P3	Voltage at E of Q10 is +5.5 volts ±1 volt.	P4	P3.1
P3.1	Defective Q10.		
P4	Set SWEEP/STEP TIME to 100/10 μs, and VARIABLE fully cw.	P5	
P5	Voltage at G of Q14A is less than zero volt if voltage at B of Q9 is less than −0.5 volt; or voltage at G of Q14A is greater than +5 volts if voltage at B of Q9 is greater than +0.5 volt.	P6	P5.1
P5.1	C24 is defective (shorted) if voltage at G of Q14A is zero.		P5.2
P5.2	Q8 or Q9 is defective if voltage across R54 is not zero volt when voltage at B of Q9 is greater than +0.5 volt; or if voltage across R54 is not greater than 5 volts when voltage at B of Q9 is less than 0.5 volt.		P5.3
P5.3	C22 is defective (shorted) if voltage at B of Q9 is zero.		P5.4
P5.4	Voltage at B of Q11 should be more positive, or at least 0.9 volt more negative than its collector, or Q11 is defective.		P5.5
P5.5	Q12 is defective if voltage at C of Q12 is greater than 400 mV.		
P6	SWEEP/STEP TIME control circuit is functioning, unless ramp waveforms are not linear due to excess leakage current of Q11, Q13, Q14A, C24 or C25.		
Q	**Ramp Generator Hysteresis Switch Troubleshooting (when ramp generator is not running in CONT SWP)**		
Q1	Set GEN MODE to CONT SWP.	Q2	
Q2	Voltage at pin 7 of IC11 is zero to −50 mV.	Q3	Q2.1
Q2.1	Voltage at junction of CR28 and CR30 is equal to or less than zero volt.	Q2.2	Q2.3
Q2.2	IC11 is defective.		
Q2.3	Defective switch wafer SW8-A or SW5-A, or PC circuit (voltage at R98 should be zero volt in CONT SWP mode).		
Q3	Voltage at pin 10 of IC11 is zero to −50 mV.	Q4	Q3.1
Q3.1	Voltage is positive at pin 10.	Q3.2	Q3.3
Q3.2	CR29 is defective.		
Q3.3	Voltage at junction of CR29 and CR31 is positive.	Q2.2	
Q3.4	Defective C35, switch wafer SW5-A or PC circuit (voltage at R99 is +15 volts in CONT SWP mode).		
Q4	Voltage at pin 10 of IC10 is less than zero.	Q4.1	Q6
Q4.1	Voltage at E of Q15 is greater than +0.5 volt.	Q4.2	Q4.3
Q4.2	Problem is in the SWEEP/TIME control circuit.	P1	
Q4.3	Voltage at pin 1 of IC11 is less than zero volt.	Q5	Q4.4
Q4.4	R72 is out of calibration.		Q4.5
Q4.5	Check for defective CR21.		

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
Q5	Check for defective Q15 and Q18. (Both are voltage followers.)		Q5.1
Q5.1	Zero volt across R86 (Q17 OFF) if voltage at E of Q16 is more negative than voltage at E of Q17; otherwise, voltage across R76 is zero (Q16 OFF).	Q5.3	Q5.2
Q5.2	Q16 or Q17 is defective.		
Q5.3	IC11 or the associated circuit is defective. See Figure 5-4 for correct voltage levels.		
Q6	Voltage at pin 10 of IC10 is greater than +5 volts.	Q6.2	Q6.1
Q6.1	Problem is in the ramp generator amplifier or sweep/time control circuit.	N1	
Q6.2	Voltage at pin 4 of IC11 is greater than zero.	Q7	Q6.3
Q6.3	R70 is not calibrated.		Q6.4
Q6.4	CR22 is defective.		Q5.5
Q7	Voltage at E of Q15 is less than −0.5 volt.	Q4.2	Q5

5.4.14 10-Step D/A Converter Troubleshooting Hints

NOTE

The step control logic timing diagram is shown in Figure 5-4.

1. Voltage at pins 2 and 3 are always +2 volts, or IC1 is malfunctioning.

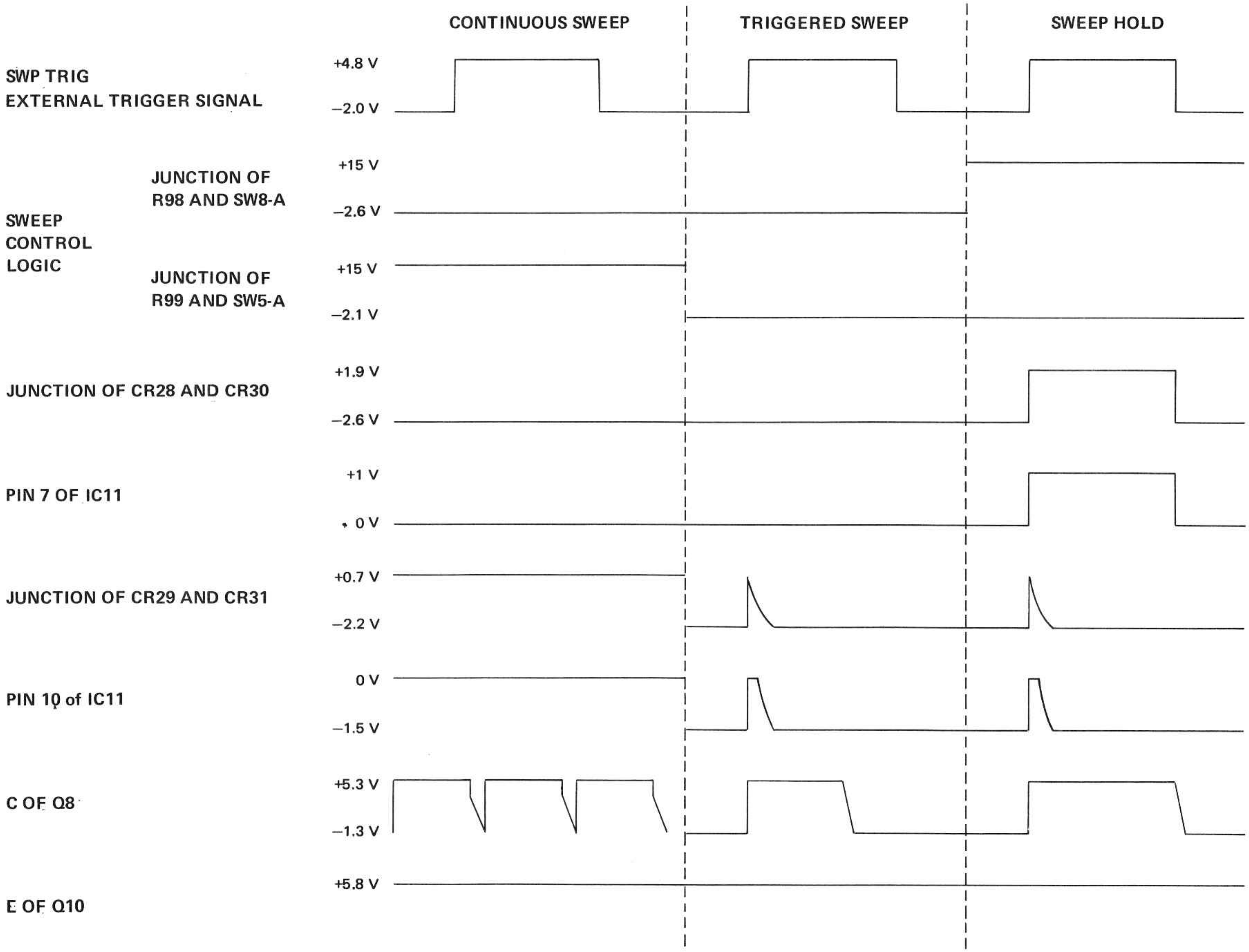
2. Resistors R3 - R7, R9 and R10 are connected in such a way that the current ratio thru the current switches (CR1 - CR11 and CR35) are 4:4:2:1. Staircase is generated by switching the currents in different combinations thru Q1 into the summing junction of IC2 (pin 4).

3. Set GEN MODE to TRIG SWP and STEP UP; without triggering the generator, voltages at pins 11, 12, 13 and 14 of IC4 should be less than +0.8 volt or the problem is in the logic circuit; refer to Paragraph 5.4.15.

4. If some of the steps are missing in the step waveform output, refer to Step R24 in Paragraph 5.4.16.

5.4.15 Digital Step Generator Troubleshooting Guide

	SYMPTOM	CORRECTIVE PROCEDURE REFERENCE
1.	Generator will not step in any mode.	R1
2.	Generator will not run in TRIG SWP, SWP HOLD or SINGLE STEP.	R8
3.	Generator runs continuously in TRIG SWP, SWP HOLD or SINGLE STEP.	R9
4.	Staircase will not hold in the SWP HOLD mode.	R12
5.	Staircase has the wrong number of steps.	R19
6.	Generator takes a single step in TRIG SWP or SWP HOLD rather than 10 steps.	R9
7.	Staircase has the correct number of steps, but the wrong levels.	R24


CONTINUOUS SWEEP
TRIGGERED SWEEP
SWEEP HOLD
SWP TRIG
EXTERNAL TRIGGER SIGNAL
+4.8 V
−2.0 V
SWEEP
CONTROL
LOGIC
JUNCTION OF
R98 AND SW8-A
+15 V
−2.6 V
JUNCTION OF
R99 AND SW5-A
+15 V
−2.1 V
JUNCTION OF CR28 AND CR30
+1.9 V
−2.6 V
PIN 7 OF IC11
+1 V
0 V
JUNCTION OF CR29 AND CR31
+0.7 V
−2.2 V
PIN 10 of IC11
0 V
−1.5 V
C OF Q8
+5.3 V
−1.3 V
E OF Q10
+5.8 V

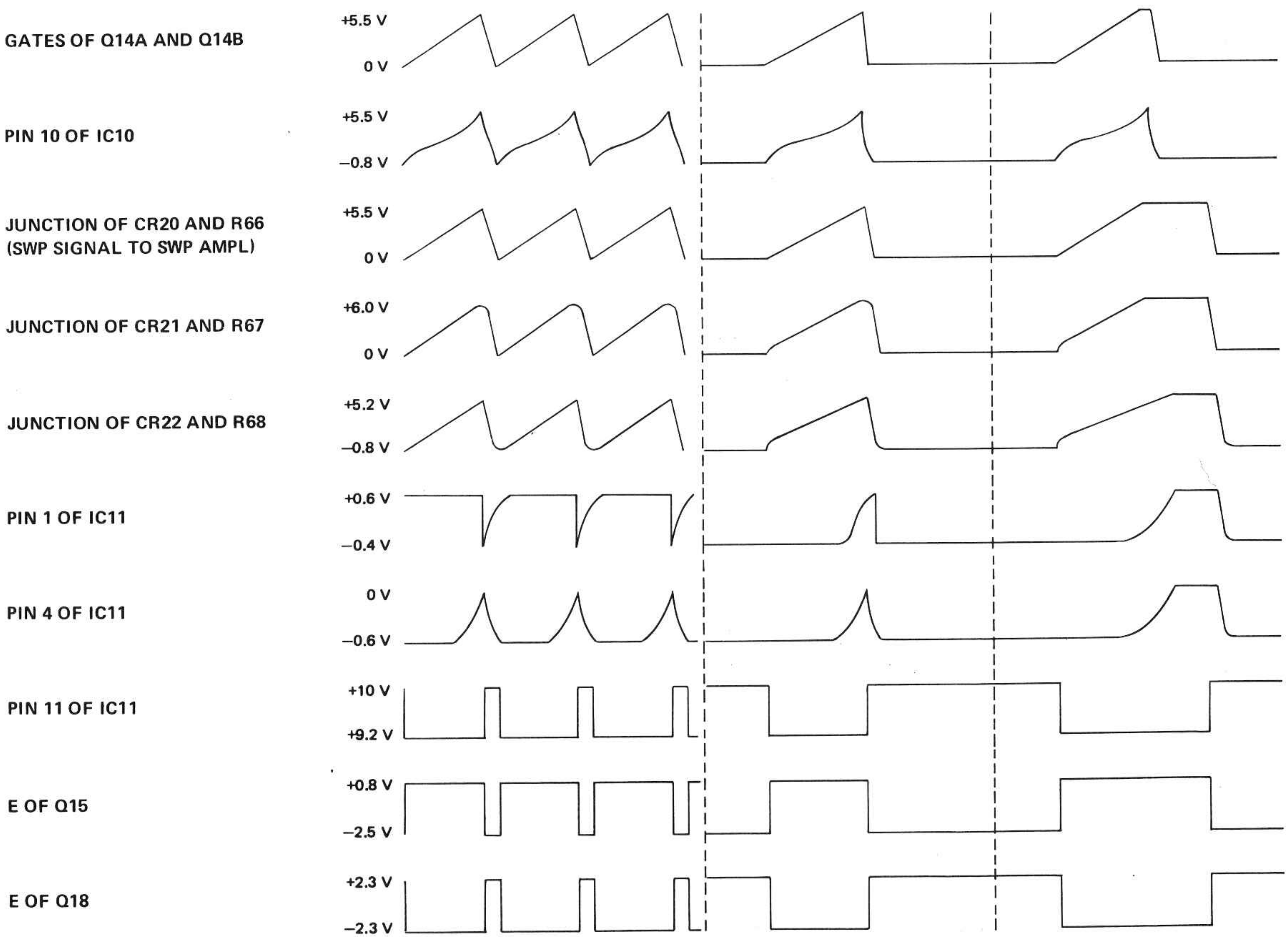


Figure 5-4. Sweep/Step Control and Ramp Generator Timing Diagram

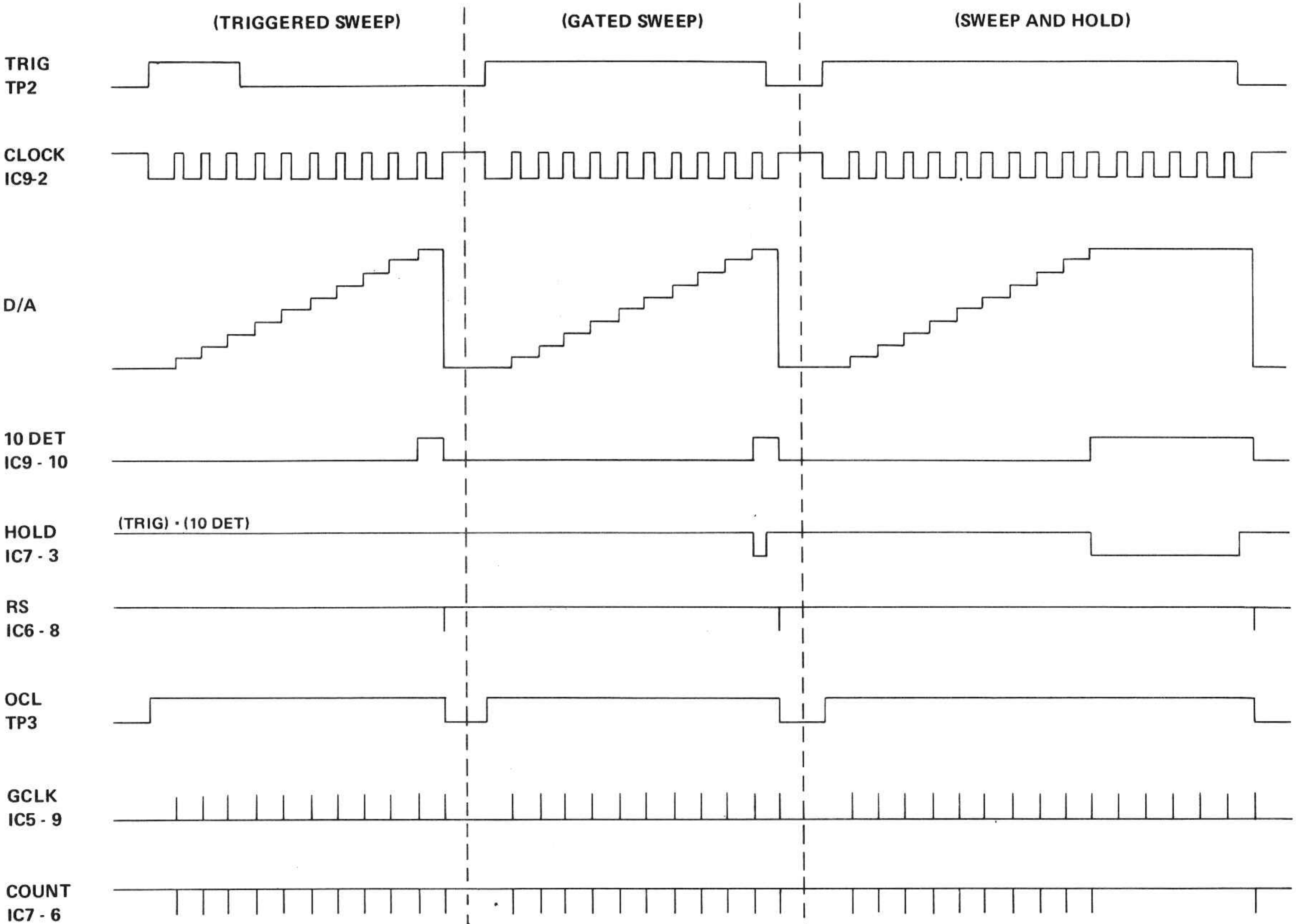


Figure 5-5. Step Control Logic Timing Diagram

5.4.16 Troubleshooting the Digital Step Generator

STEP	PROCEDURE	IF TRUE, GO TO	IF FALSE, GO TO
R	**Digital Step Generator Problem**		
R1	Place generator in STEP UP, CONT SWP with SWEEP/STEP TIME at 100 μs. Clock pulses should appear at TP1.	R2	R7
R2	Pulses at IC4 pin 2?	R3	R4
R3	IC4 defective.		
R4	Pin 4 of IC7 high?	R5	R6
R5	IC5 or IC9 defective.		
R6	IC8 or IC9 defective.		
R7	Troubleshoot the analog sweep generator circuit.		
R8	Troubleshoot the analog sweep generator circuit or the trigger amplifier circuit.		
R9	Place generator in TRIG SWP, STEP UP, with SWEEP/STEP TIME at 10 μs. Apply a 10 kHz ⊓⊔ to the TRIG IN connector. Pulses should appear at IC5 pin 5.	R10	R11
R10	IC7 or Q4 defective.		
R11	IC5 or IC9 defective.		
R12	Place generator in SWP HOLD, STEP UP, with SWEEP/STEP TIME at 10 μs. Apply a 2.5 kHz ⊓⊔ to the TRIG IN connector. IC6 pin 6 should pulse low when staircase attains its maximum level.	R13	R14
R13	IC9 pin 12 should be a TTL duplicate of the TRIG IN connector.	R15	R16
R14	IC6 or IC8 defective.		
R15	Is IC7 pin 1 high?	R17	R18
R16	Q5 or IC9 defective.		
R17	IC9 or IC7 defective.		
R18	IC8 defective.		
R19	Place generator in CONT SWP, STEP UP, with SWEEP/STEP TIME at 10 μs. Does IC6 pin 8 pulse low before counter state 11 (BCD)?	R20	R21
R20	IC6 or IC8 defective.		
R21	Does IC6 pin 8 pulse low at counter state 11 (BCD)?	R22	R23
R22	IC4 defective.		
R23	IC6 or IC8 defective.		
R24	IC4 or the D/A converter defective.		

SECTION 6
PARTS LISTS AND SCHEMATIC DIAGRAMS

6.1 DRAWINGS

Assembly drawings are positioned adjacent to the schematics. Additional voltage or waveform information, beyond that given in the circuit description, may be shown on the schematic diagrams, at test points and key locations throughout the instrument.

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 permit. 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 part number, circuit reference, board, serial number of unit, and if applicable, the function performed.

6.4 DRAWINGS

The following assembly drawings (with parts lists) and schematics are in the arrangement shown below:

CROSS REFERENCE FOR DRAWING NUMBERS

Drawings	Old Number	New Number
Chassis Assembly	164-000	0102-00-0306
Chassis Schematic	164-200	0004-00-0047
Chassis Parts List	*	1101-00-0047
Main Board Schematic	164-215	0103-00-0119
Main Board Assembly	164-015	0101-00-0119
Main Board Parts List	*	1100-00-0119
Sweep Board Schematic	164-211	0103-00-0118
Sweep Board Assembly	164-011	0101-00-0118
Sweep Board Parts List	*	1100-00-0118
Rear Panel Assembly	162-001	1206-00-0002
Rear Panel Parts List	*	1206-00-0002
Power Supply Schematic	147-230	0103-00-0061
Power Supply Assembly	147-030	0101-00-0061
Power Supply Parts List	*	1101-00-0061

*Same as Assembly Number

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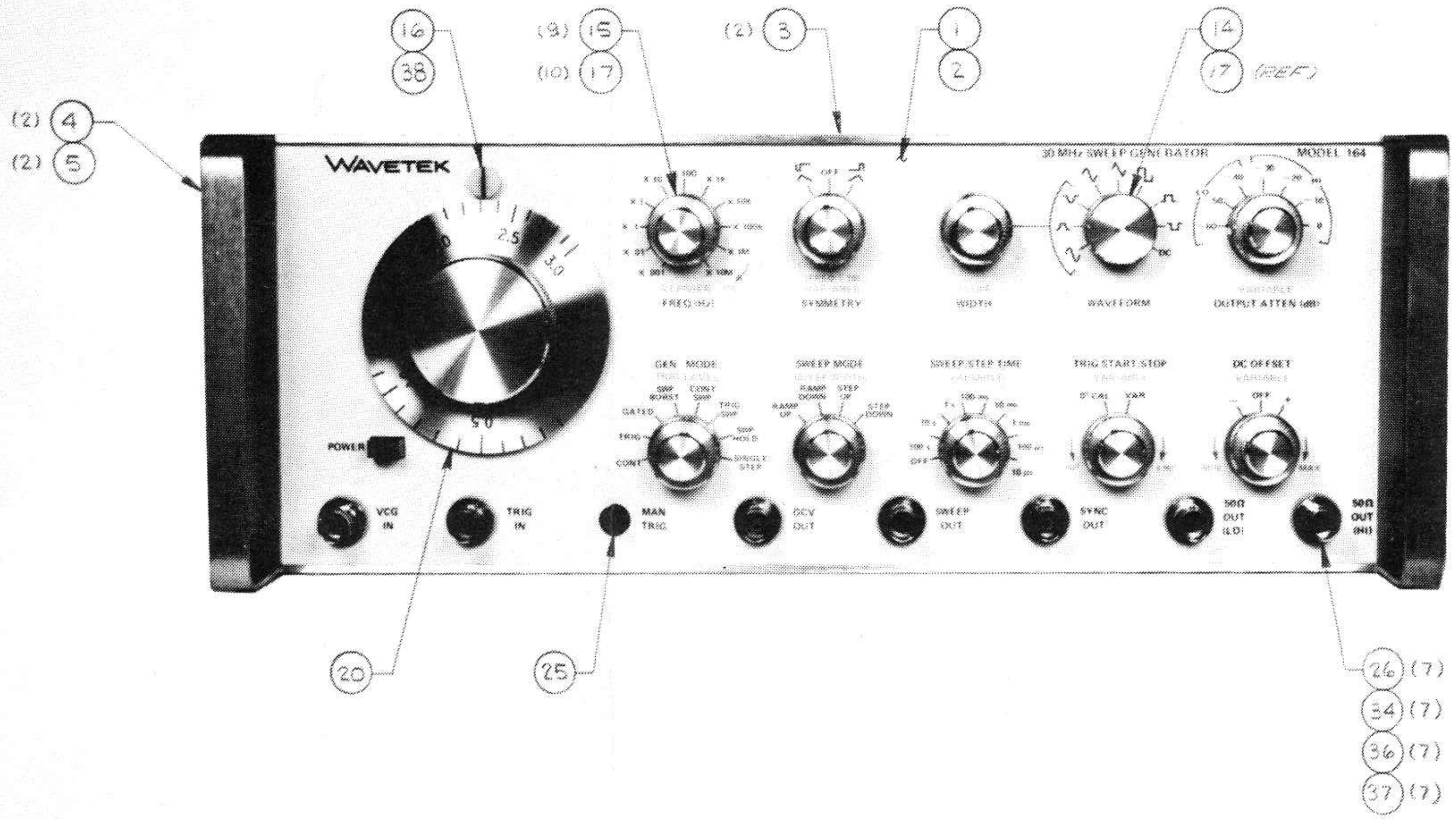
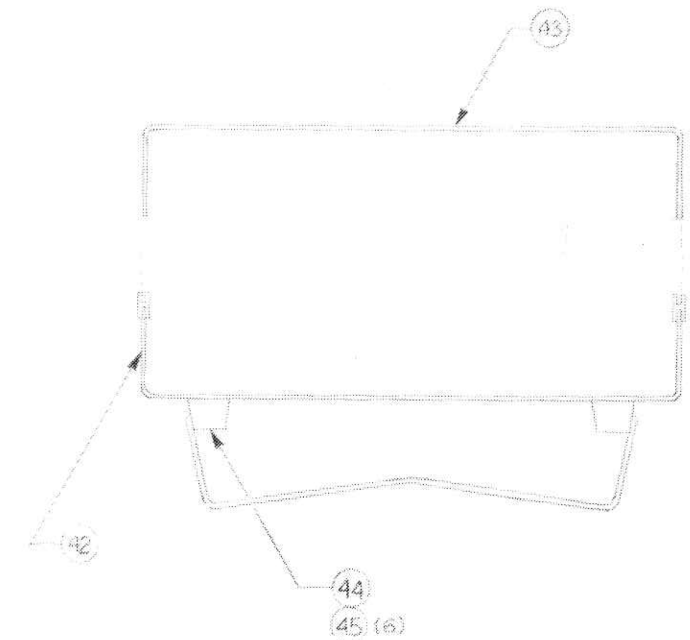
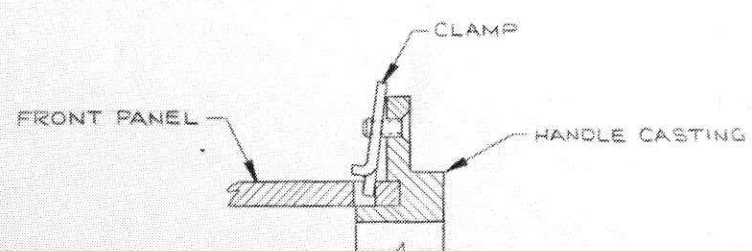
REV	ECN	BY	DATE	APP
B	ECN #823	Ro	[illegible]	
C	ECN 1074	Ro	[illegible]	
D	ECN 1113	Ro	[illegible]	
E	ECN 1052	Ro	[illegible]	
F	ECN 1088	Ro	[illegible]	
G	ECN 1115	Ro	[illegible]	
H	ECN 1160	Ro	[illegible]	
J	ECN 1324	Ro	[illegible]	
K	ECN 1528	RO	3-16-77	
L	ECN 1797	RO	[illegible]	[illegible]
—	ECN 4017 (CL III)	AT	10-20-83	[illegible]
M	ECN 4263	DAM	[illegible]	[illegible]





"COVER ASSEMBLY"



NOTE: BEFORE CLAMPING HANDLE CASTING IN PLACE, TRIM (TOP & BOTTOM) MUST BE IN PLACE

HANDLE DETAILS

2. * INDICATES ITEMS NOT SHOWN.

1. FOR CHASSIS WIRING SEE CHASSIS SCHEMATIC

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 3-5-74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL —	PROJ ENGR [illegible]	[illegible]	TITLE ASSEMBLY CHASSIS
	RELEASE APPROV [illegible] 11-18-82		
FINISH WAVETEK PROCESS —	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 XX ±.030 ANGLES ±1°		MODEL NO 164 — DWG NO 0102-00-0306 — REV M
	DO NOT SCALE DWG		
	SCALE NONE		CODE IDENT 23338 — SHEET 1 OF 5

0102-00-0306 M

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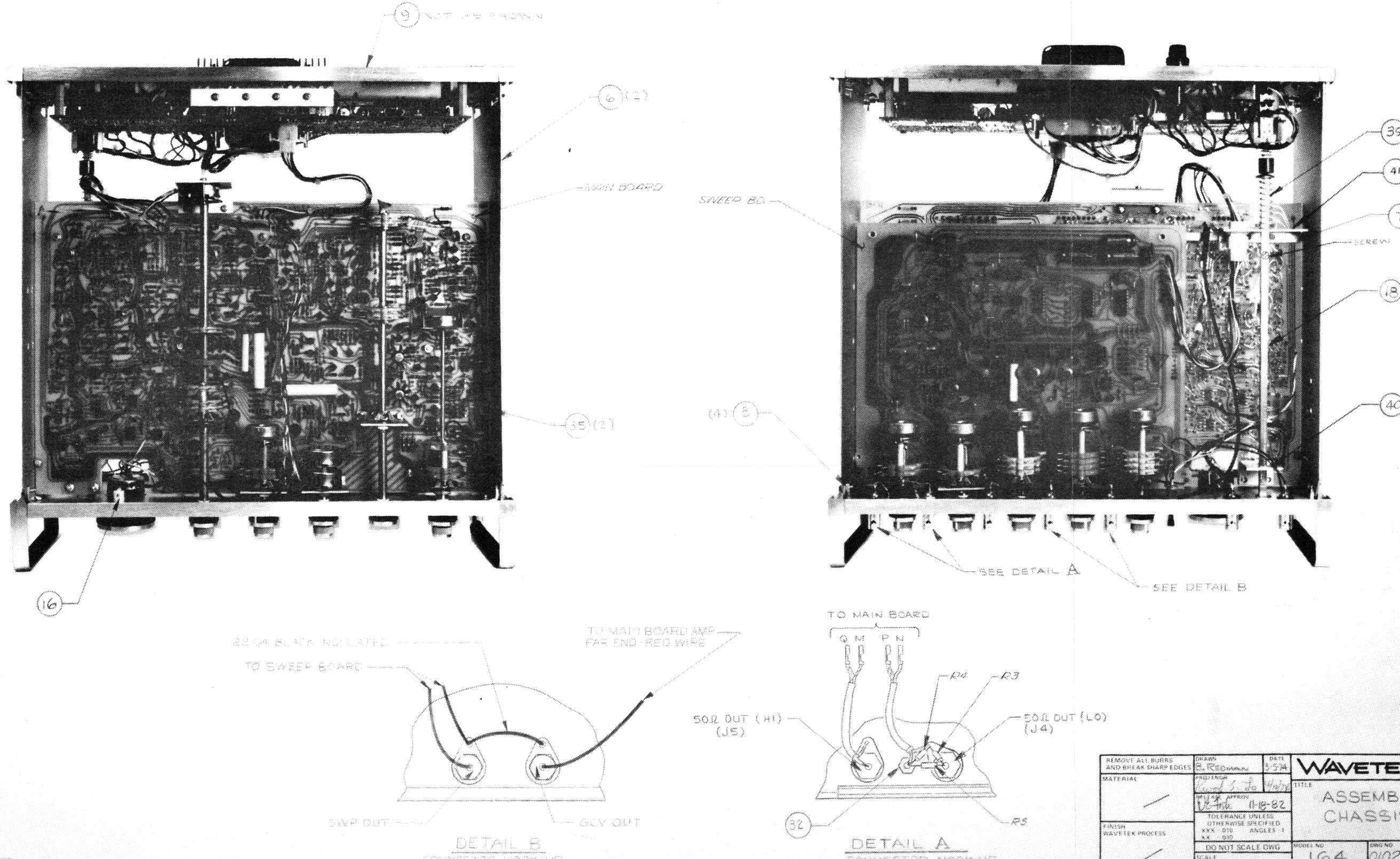
REV	ECN	BY	DATE	APP



NOTE: UNLESS OTHERWISE SPECIFIED

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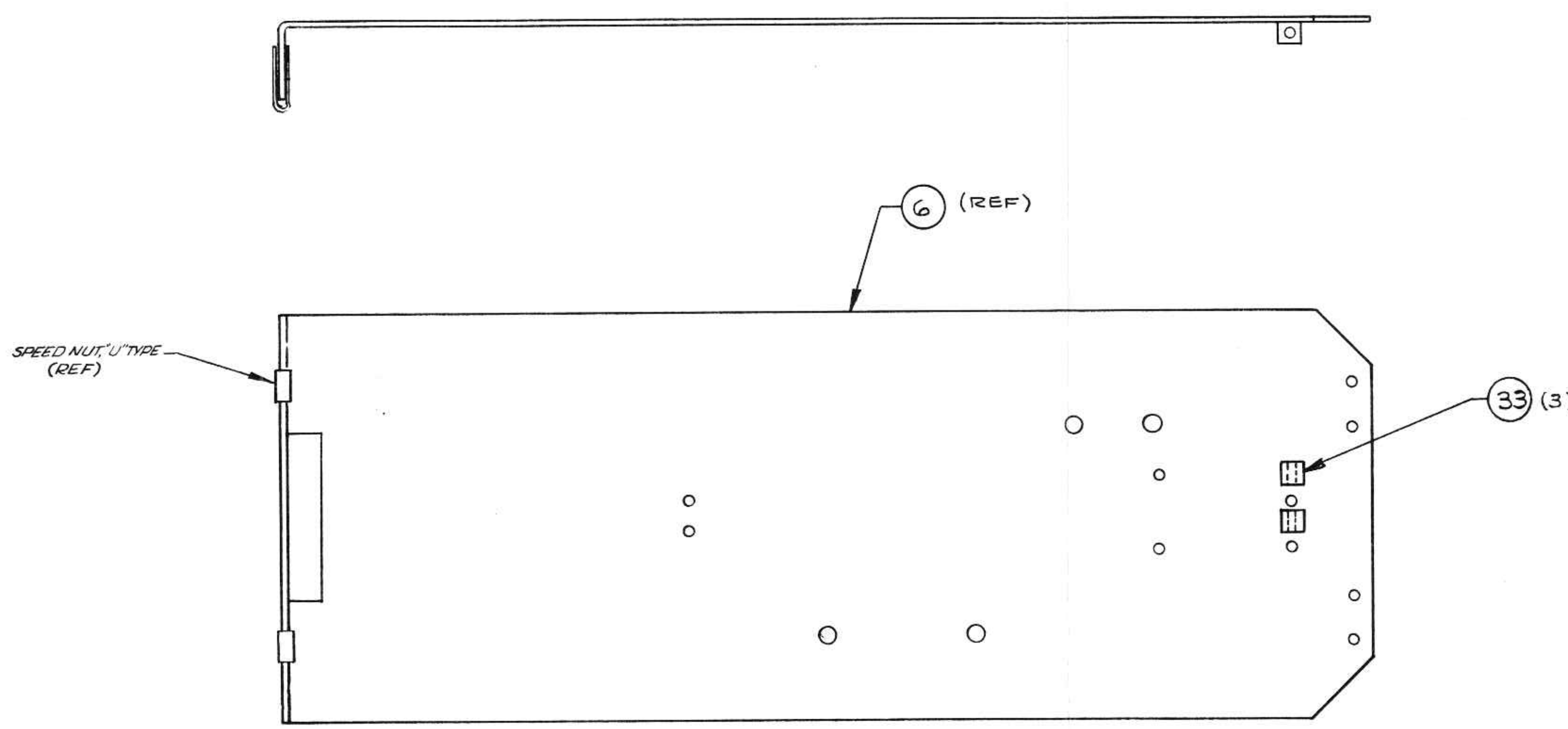
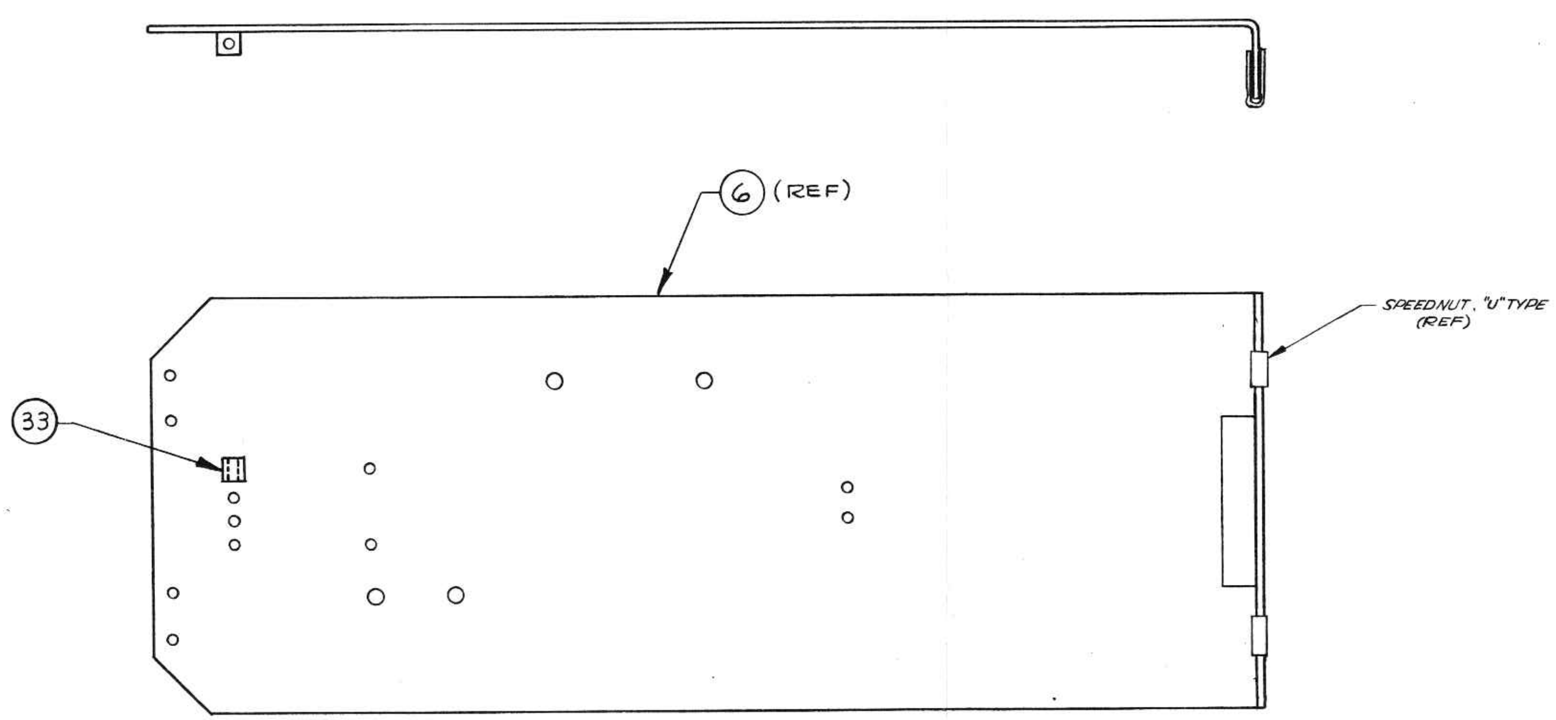
MATERIAL /	PROJ ENGR		TITLE ASSEMBLY, CHASSIS
	RELEASE APPROV 11-18-82		
FINISH WAVETEK PROCESS /	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1 XX ±.030		
	DO NOT SCALE DWG		MODEL NO 164 · DWG NO 0102-00-0306 · REV M
	SCALE NONE		CODE IDENT 23338 · SHEET 2 OF 3



SIDE PLATE
(RIGHT HAND)



SIDE PLATE
(LEFT HAND)

INSERT INSTALLATION DETAIL

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 3-4-74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL —	PROJ ENGR Kwok Lo	4/12/74	TITLE ASSEMBLY, CHASSIS
	RELEASE APPROV DE Fish 11-18-82		
FINISH WAVETEK PROCESS —	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1°		
	DO NOT SCALE DWG		MODEL NO. 164 / DWG NO. 0102-00-0306 / REV M
	SCALE FULL		CODE IDENT 23338 / SHEET 3 OF 3

REV	ECN	BY	DATE	APP
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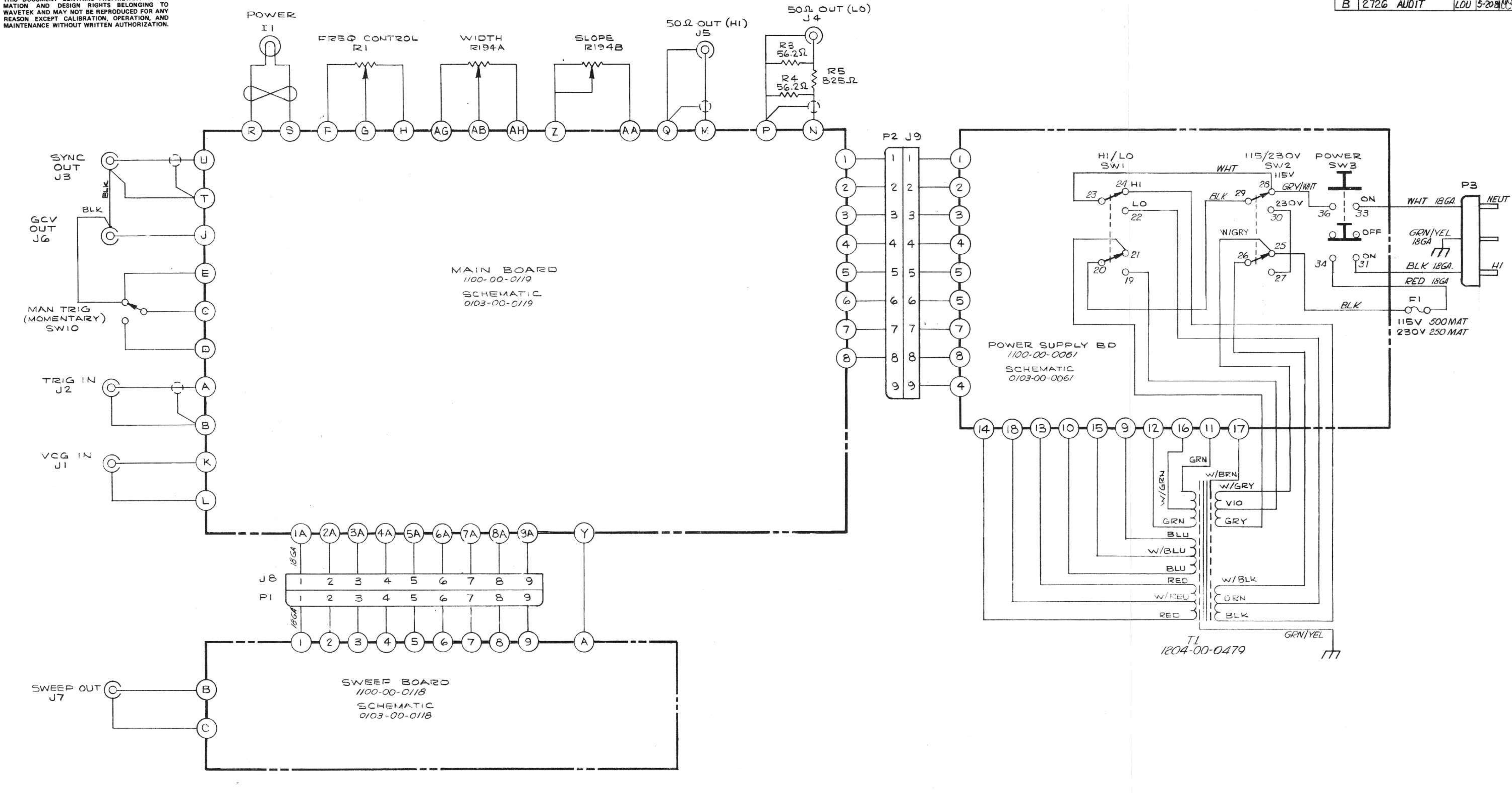
B	2726 AUDIT	LOU	5-20-83	



NOTE: UNLESS OTHERWISE SPECIFIED

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MATERIAL	PROJ ENGR	4/4/74
	RELEASE APPROV	11-18-82
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 ANGLES ±1 .XX ±.030	
	DO NOT SCALE DWG	
	SCALE —	

WAVETEK SAN DIEGO • CALIFORNIA

TITLE SCHEMATIC, INSTRUMENT

MODEL NO.	DWG NO.	REV
164	0004-00-0047	B
CODE IDENT 23338	SHEET 1 OF 1	

REV | ECN | BY | DATE | APP

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
NONE	ASSY DRWG. CHASSIS	0102-00-0306	WVTK	0102-00-0306	1
20	DIAL ASSY	130-333-11	WVTK	1201-00-0015	1
9	REAR PANEL ASSY	162-001	WVTK	1206-00-0002	1
16	INDICATOR, DIAL	141-317	WVTK	1400-00-2020	1
43	COVER, TOP	147-376	WVTK	1400-00-3509	1
3	TRIM REF: 3200-06-0005	147-018	WVTK	1400-00-3549	2
4	HANDLE, R/A FROM: 1400-00-3561	147-364	WVTK	1400-00-3589	2
8	CLAMP	147-316	WVTK	1400-00-3590	4
5	TRIM, HANDLE REF: 3200-06-0006	147-345	WVTK	1400-00-3619	2
7	BAR, SUPT	147-347	WVTK	1400-00-3633	1
6	PLATE, SIDE	147-378	WVTK	1400-00-3723	2
18	ROD, POWER SW	147-382	WVTK	1400-00-3740	1
39	SPRING REF: 3200-01-0001	147-383	WVTK	1400-00-3750	1
1	PANEL, SUB	162-301	WVTK	1400-00-3773	1
40	BRKT	162-310	WVTK	1400-00-3823	1

WAVETEK PARTS LIST | TITLE: STD CHASSIS | ASSEMBLY NO. 1101-00-0047 | REV N

PAGE 1

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
41	BRKT, CONN	162-311	WVTK	1400-00-3833	1
2	PANEL, FT	164-300	WVTK	1400-00-3850	1
NONE	COVER MODEL 162/164	162/164-1652	WVTK	1400-02-1652	1
26	CONN BNC	KC-7946	KING	2100-01-0002	7
32	TERM	1401A-9	USECO	2100-04-0006	1
34	SOLDER LUG	1497	SMITH	2100-04-0012	7
14	KNOB STD	RB-67-1-SB-M	ROGAN	2400-01-0008	1
15	COAX KNOB SET	RB-67-1-SB+O-M-9	ROGAN	2400-01-0009	9
17	BUSHING NYLINER	4L2FF	THOMN	2800-01-0002	10
44	BAIL ASSY W/FT	147-505	WVTK	2800-08-0007	1
45	NUT, SPEED, SELF RETAIN	C7494-632-4	TINN	2800-09-0003	6
NONE	NUT, PANEL	C8681-832-24	TINN	2800-09-0005	4
33	FAST, CHASSIS	1591-B11	USECO	2800-09-0021	3
35	WASHER, SHOULDER	2661	SMITH	2800-27-0002	2
36	WASHER, SHOULDER	2668	SMITH	2800-27-0004	7
37	WASHER NYLON FLAT	2264-N-385	AMTOM	2800-28-0005	7

WAVETEK PARTS LIST | TITLE: STD CHASSIS | ASSEMBLY NO. 1101-00-0047 | REV N

PAGE 2

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
38	RETAINING RING	515-0051	DILCO	2800-36-0002	1
R3 R4	RES, MF, 1/8W, 1%, 56.2	RN55D-56R2F	TRW	4701-03-5629	2
R5	RES, MF, 1/8W, 1%, 825	RN55D-8250F	TRW	4701-03-8250	1
25	SWITCH, TOGGLE	7108 P3DCQN	C&K	5106-00-0006	1
21	PWR CORD	17251	BELDN	6001-80-0005	1

WAVETEK PARTS LIST | TITLE: STD CHASSIS | ASSEMBLY NO. 1101-00-0047 | REV N

PAGE 3

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE
MATERIAL	PROJ ENGR	
	RELEASE APPROV	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1°	
	DO NOT SCALE DWG	
	SCALE	

WAVETEK SAN DIEGO • CALIFORNIA

TITLE: PARTS LIST STD CHASSIS

MODEL NO.	DWG NO.	REV
164	1101-00-0047	N
CODE IDENT 23338	SHEET 1 OF 1	

BISHOP GRAPHICS/ACCUPRESS REORDER NO. A-3894

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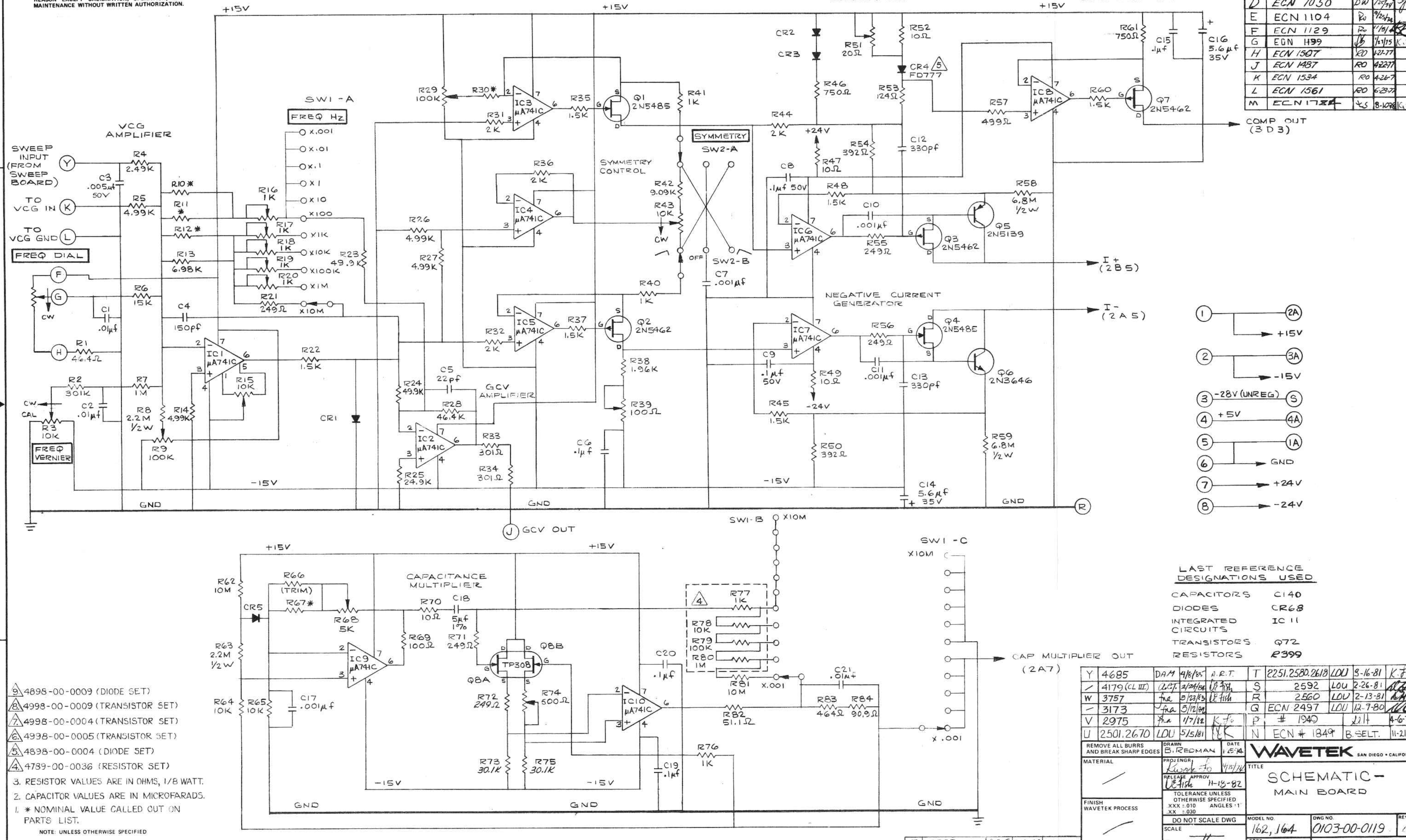


LAST REFERENCE DESIGNATIONS USED

CAPACITORS	C140
DIODES	CR68
INTEGRATED CIRCUITS	IC 11
TRANSISTORS	Q72
RESISTORS	R399

REV	ECN	BY	DATE	APP
B	ECN 980	DW	7/10/74	
C	ECN 1049	DW	7/22/74	
D	ECN 1050	DW	7/25/74	
E	ECN 1104	Ro	9/25/74	
F	ECN 1129	Ro	11/5/74	
G	ECN 1199		1/21/75	
H	ECN 1507	RO	4-21-77	
J	ECN 1487	RO	4-22-77	
K	ECN 1534	RO	4-26-77	
L	ECN 1561	RO	6-29-77	
M	ECN 17__		8-10-77	

Y	4685	DAM	4/8/85	A.R.T.	T	2251.2580.2618	LOU	3-16-81
/	4179 (CL III)		2/24/84		S	2592	LOU	2-26-81
W	3757		8/23/83		R	2560	LOU	2-13-81
/	3173		3/12/82		Q	ECN 2497	LOU	12-7-80
V	2975		1/7/82		P	# 1940		4-6-79
U	2501.2670	LOU	5/5/81		N	ECN # 1849	B. SELT.	11-21-78

Z	4867		1-6-86	A.R.T.

9. 4898-00-0009 (DIODE SET)
8. 4998-00-0009 (TRANSISTOR SET)
7. 4998-00-0004 (TRANSISTOR SET)
6. 4998-00-0005 (TRANSISTOR SET)
5. 4898-00-0004 (DIODE SET)
4. 4789-00-0036 (RESISTOR SET)
3. RESISTOR VALUES ARE IN OHMS, 1/8 WATT.
2. CAPACITOR VALUES ARE IN MICROFARADS.
1. * NOMINAL VALUE CALLED OUT ON PARTS LIST.

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN B. REDMAN
RELEASE APPROV 11-13-82
TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1° XX ±.030
DO NOT SCALE DWG
SCALE —

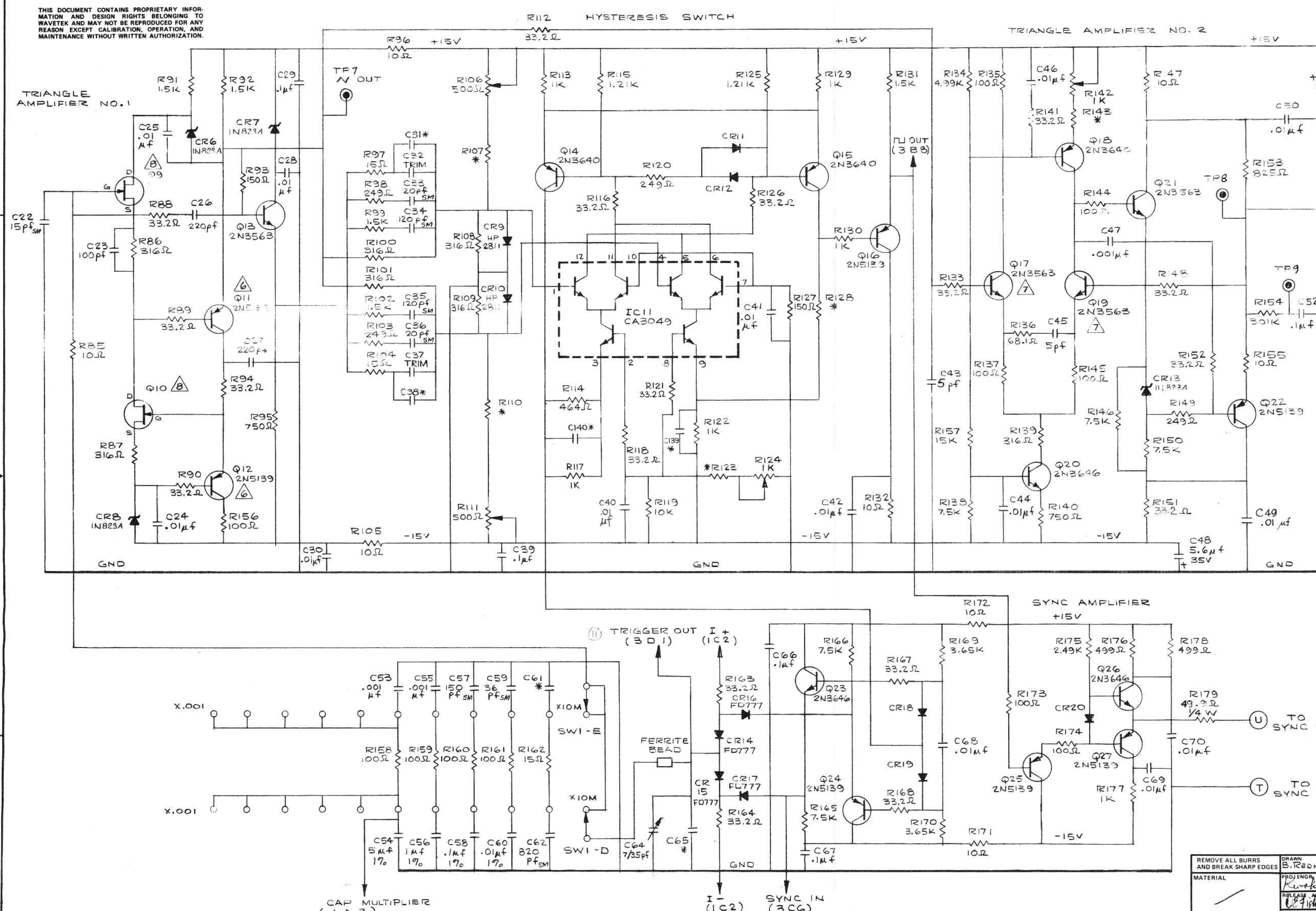
WAVETEK SAN DIEGO • CALIFORNIA

TITLE SCHEMATIC - MAIN BOARD

MODEL NO.	DWG NO.	REV
162, 164	0103-00-0119	Z

CODE IDENT 23338 SHEET 1 OF 4

0103-00-0119 Z



NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES

MATERIAL

FINISH
WAVETEK PROCESS

DRAWN B. REDMAN — DATE 1-25-74

PROJ ENGR

RELEASE APPROV 11-18-82

TOLERANCE UNLESS OTHERWISE SPECIFIED
XXX ±.010 ANGLES ±1°
XX ±.030

DO NOT SCALE DWG

SCALE

WAVETEK SAN DIEGO • CALIFORNIA

TITLE
SCHEMATIC — MAIN BOARD

MODEL NO. 164, 162

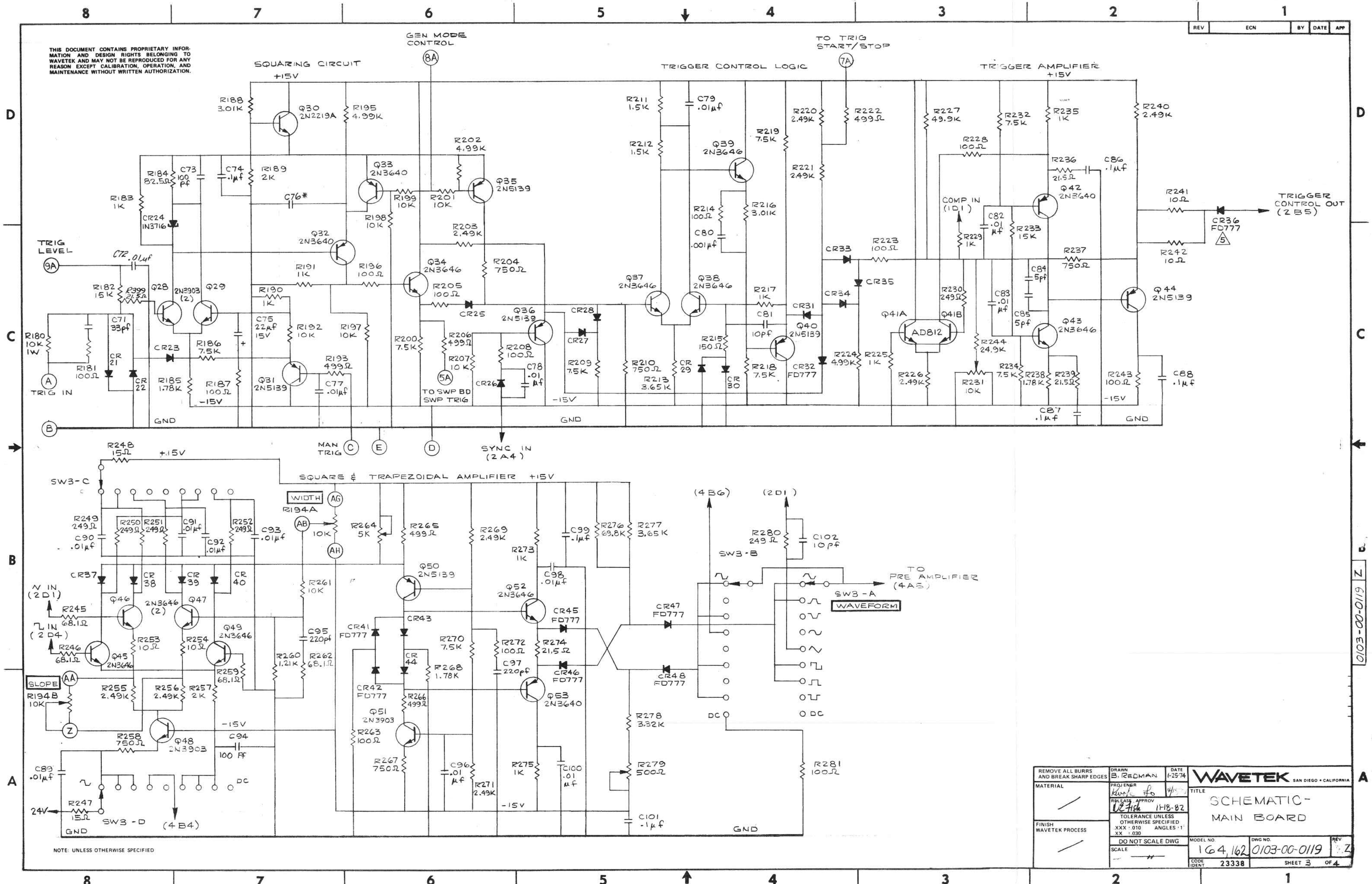
DWG NO. 0103-00-0119

REV Z

CODE IDENT 23338

SHEET 2 OF 4

0103-00-0119 Z



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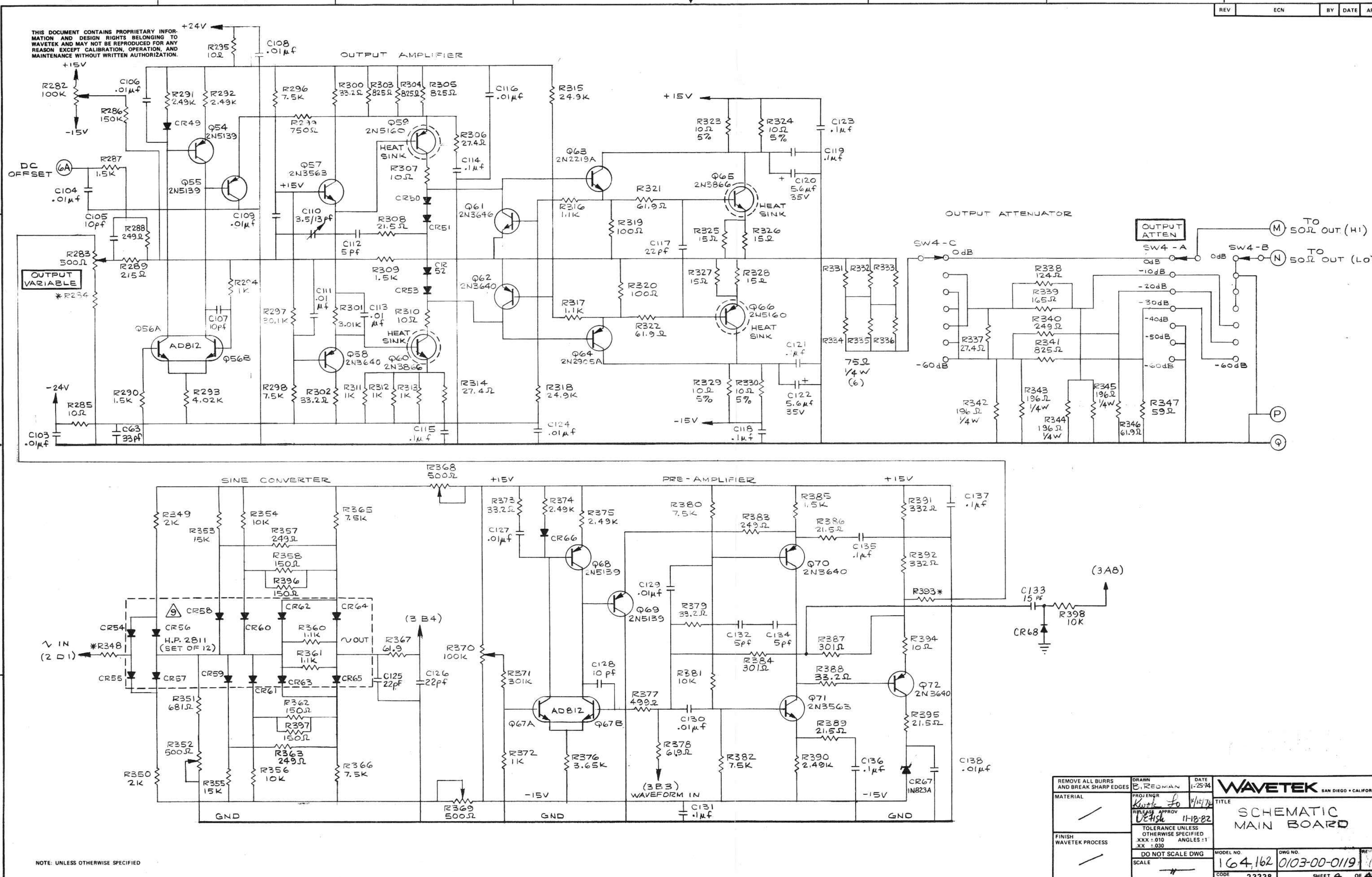
SQUARING CIRCUIT
GEN MODE CONTROL
TRIGGER CONTROL LOGIC
TO TRIG START/STOP
TRIGGER AMPLIFIER
+15V
TRIG LEVEL
TRIG IN
TRIGGER CONTROL OUT (2B5)
COMP IN (1D1)
TO SWP BD SWP TRIG
MAN TRIG
SYNC IN (2A4)
GND
-15V
SQUARE & TRAPEZOIDAL AMPLIFIER +15V
WIDTH
R194A
SLOPE
R194B
SW3-C
SW3-D
SW3-B
SW3-A
WAVEFORM
TO PRE AMPLIFIER (4A6)
(4B6)
(2D1)
(4B4)
24V
NOTE: UNLESS OTHERWISE SPECIFIED
REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN B. REDMAN
DATE 1-25-74
TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1°
DO NOT SCALE DWG
SCALE
WAVETEK SAN DIEGO • CALIFORNIA
TITLE SCHEMATIC-MAIN BOARD
MODEL NO. 164, 162
DWG NO. 0103-00-0119
REV Z
CODE IDENT 23338
SHEET 3 OF 4



REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN, DATE 1-25-74
MATERIAL	PROJ ENGR
FINISH WAVETEK PROCESS	RELEASE APPROV 11-18-82

TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1°

DO NOT SCALE DWG

WAVETEK SAN DIEGO • CALIFORNIA

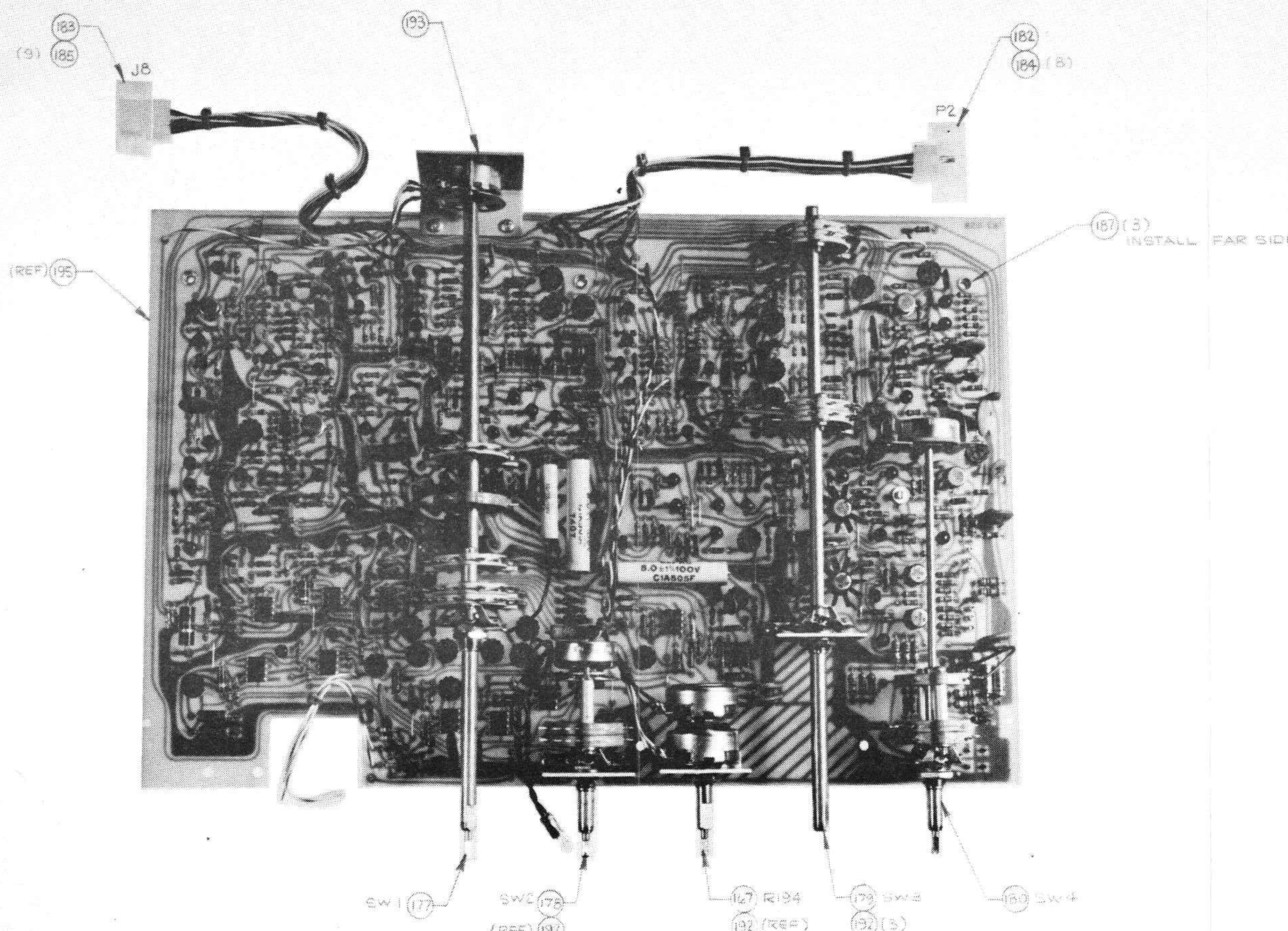
TITLE: SCHEMATIC MAIN BOARD

MODEL NO. 164, 162 — DWG NO. 0103-00-0119 — REV Z

CODE IDENT 23338 — SHEET 4 OF 4

NOTE: UNLESS OTHERWISE SPECIFIED

REV	ECN	BY	DATE	APP
D	ECN 904	[illegible]	[illegible]	[illegible]
E	ECN 1050	[illegible]	[illegible]	[illegible]
F	ECN 1092	[illegible]	[illegible]	[illegible]
G	ECN 1104	[illegible]	[illegible]	[illegible]
H	ECN 1129	[illegible]	[illegible]	[illegible]
J	ECN 1199	[illegible]	[illegible]	[illegible]
K	ECN 1320	RO	[illegible]	[illegible]
L	ECN 1324	RO	[illegible]	[illegible]
M	ECN 1507	RO	[illegible]	[illegible]
N	ECN 1523	RO	[illegible]	[illegible]
P	ECN 1849	PWB	[illegible]	[illegible]
Q	# 1949	JDH	[illegible]	[illegible]
R	2497	LOU	[illegible]	[illegible]
S	2560	LOU	2-13-81	[illegible]
T	2592	LOU	2-26-81	[illegible]
U	2670	LOU	5-5-81	[illegible]
V	2726 AUDIT	LOU	5-20-81	[illegible]
W	2975	[illegible]	1/7/82	[illegible]
/	3179 (II)	[illegible]	[illegible]	[illegible]
/	3443 (II)	[illegible]	[illegible]	[illegible]
Y	3757	[illegible]	[illegible]	[illegible]
Z	3906	[illegible]	[illegible]	[illegible]
/	4179 (G.II)	[illegible]	3-29-84	[illegible]
AA	4867	[illegible]	1-6-86	[illegible]

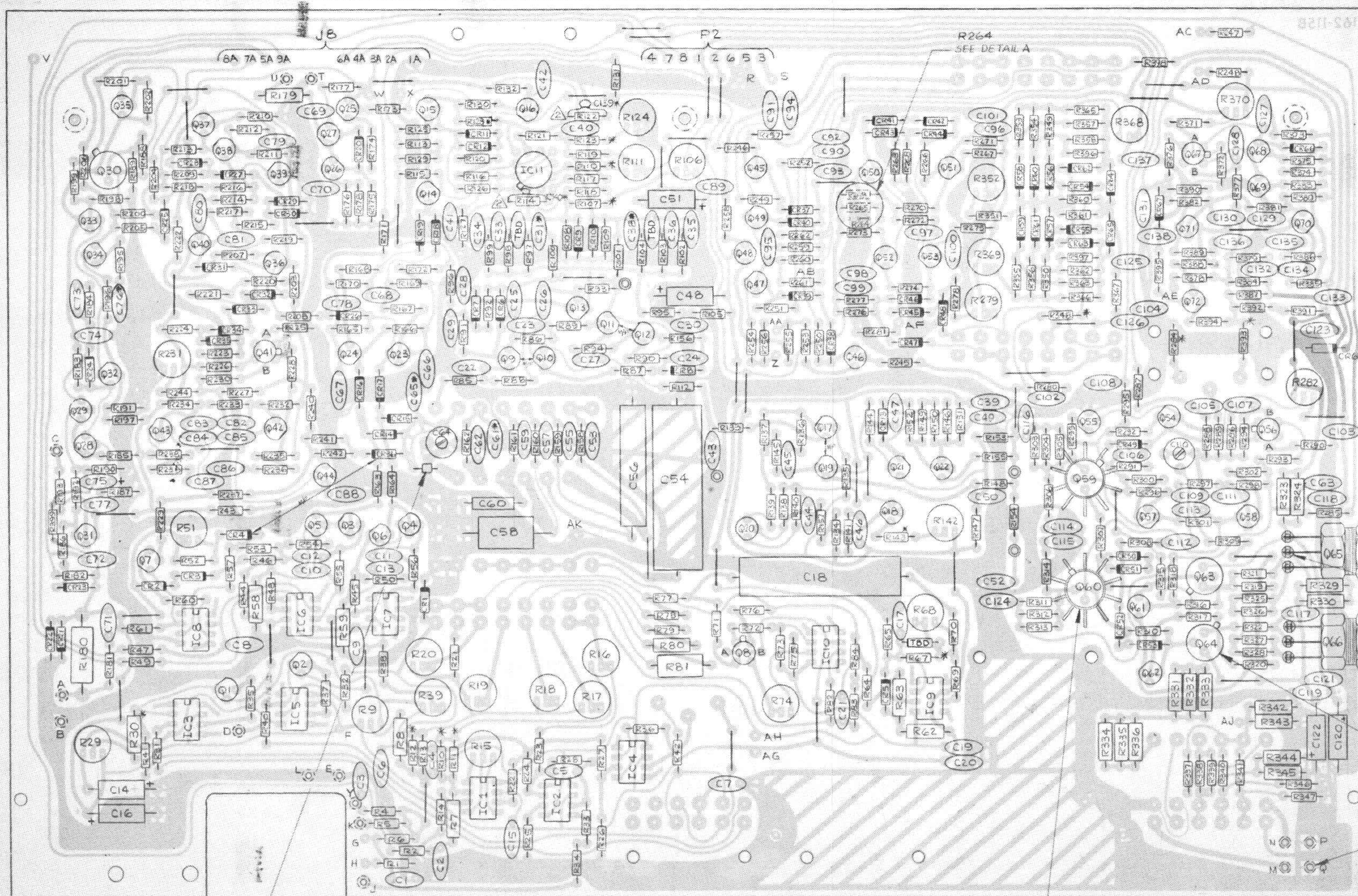


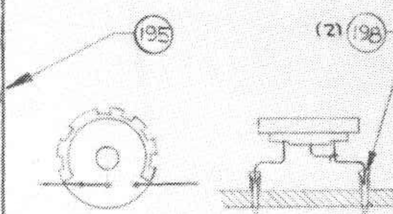
2. INSTALL CAPACITOR ACROSS R114 AND R122 PIGGYBACK STYLE AND SOLDER.

1. * NOMINAL VALUE CALLED OUT ON PARTS LIST.

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN S. REDMAN	DATE 3-15-74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR		TITLE ASSEMBLY, MAIN BOARD
FINISH WAVETEK PROCESS	RELEASE APPROV	11-19-82	
	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1°		
	DO NOT SCALE DWG		MODEL NO 164 — DWG NO 0101-00-0119 — REV AA
	SCALE		CODE IDENT 23338 — SHEET 1 OF [illegible]





R264 - WRAP CENTER LEG AROUND OUTSIDE LEG AND SOLDER. INSTALL INTO PINS AS SHOWN. DRILL HOLES TO .040 DIA IF REQUIRED.

DETAIL 'A'

(191) (6) INSTALL NEAR SIDE

(173) (2)

(174) (2)

(189) (8)

(188) (19) INSTALL 4 NEAR SIDE INSTALL 15 FAR SIDE

(195)

(2) (198)

(169)

(2) (172) POSITION HEATSINK FOR Q60 SO THAT IT IS AS FAR AS POSSIBLE FROM DETENT BODY, THEN APPLY A DROP OF #3140 RTV TO THE TOPS OF Q59 AND Q60 TO FIX THE HEATSINKS IN PLACE.

NOTE: UNLESS OTHERWISE SPECIFIED

MASTER

REV	ECN	BY	DATE	APP

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN DATE 3-19-74
MATERIAL	WAVETEK SAN DIEGO • CALIFORNIA
FINISH WAVETEK PROCESS	RELEASE APPROV 11-18-82
TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ± 1 XX ± .030	TITLE ASSEMBLY, MAIN BOARD
DO NOT SCALE DWG	MODEL NO. 164
SCALE 2/1	DWG NO. 0101-00-0119 REV AA
CODE IDENT 23338	SHEET 2 OF 2

REV	ECN	BY	DATE	APP

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
NONE	ASSY DRWG, MAIN	0101-00-0119	WVTK	0101-00-0119	1
NONE	SCHEMATIC, MAIN	0103-00-0119	WVTK	0103-00-0119	1
SW4	ATTEN SW ASSY	162-023	WVTK	1202-00-0028	1
SW1	FREQ SW ASSY	162-020	WVTK	1202-00-0029	1
SW2	SYMM SW ASSY	162-021	WVTK	1202-00-0030	1
SW3	FUNC SW ASSY	162-022	WVTK	1202-00-0031	1
192	BRKT	133-305	WVTK	1400-00-1673	1
193	BRKT, MTG	162-303	WVTK	1400-00-3783	1
NONE	CAP, CER, 5PF, 1KV	DD-050 LONG LEAD	CRL	1500-00-5001	1
C112 C132 C134 C43 C45 C84 C85	CAP, CER, 5PF, 1KV	DD-050	CRL	1500-00-5011	7
C102 C105 C107 C128 C81	CAP, CER, 10PF, 1KV	DD-100	CRL	1500-01-0011	5
C23 C73 C76T C94	CAP, CER, 100PF, 1KV	DD-101	CRL	1500-01-0111	4
C10 C11 C17 C47 C53 C55 C7 C80	CAP, CER, .01MFD, 1KV	DD-102	CRL	1500-01-0211	8
C1 C100 C103 C104 C106 C108 C109 C111 C113 C116 C124 C127 C129 C130 C138 C2 C21 C24 C25 C28 C30 C40 C41 C42 C44 C46 C49 C50 C68 C69 C70	CAP CER MON .01MF 50V, AXIAL	CAC02Z5U103Z100A	CORNG	1500-01-0310	44

WAVETEK PARTS LIST — TITLE: MAIN — ASSEMBLY NO. 1100-00-0119 — REV CF — PAGE 1

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
C72 C77 C78 C79 C82 C83 C89 C90 C91 C92 C93 C96 C98					
C101 C114 C115 C118 C119 C121 C123 C131 C135 C136 C137 C15 C19 C20 C29 C39 C52 C6 C66 C67 C74 C8 C86 C87 C88 C9 C99	CAP, CER, MON, .1MF, 50V, AXIAL	CAC03Z5U104Z050A	CORNG	1500-01-0405	27
C133	CAP, CER, 15PF, 1KV	DD-150	CRL	1500-01-5011	1
C4	CAP, CER, 150PF, 1KV	DD-151	CRL	1500-01-5111	1
C117 C125 C126 C5	CAP, CER, 22PF, 1KV	DD-220	CRL	1500-02-2011	4
C26 C27 C95 C97	CAP, CER, 220PF, 1KV	DD-221	CRL	1500-02-2111	4
NONE	CAP, CER, 30PF, 1KV	DD-300	CRL	1500-03-0001	1
C63 C71	CAP, CER, 33PF, 1KV	DD-330	CRL	1500-03-3011	2
C12 C13	CAP, CER, 330PF, 1KV	DD-331	CRL	1500-03-3111	2
C3	CAP, CER, .005MF, 50V	CK-502	CRL	1500-05-0210	1
C34 C35	CAP, MICA, 120PF, 500V, RADIAL	DM15-121J	ARCO	1500-11-2100	2
C22	CAP, MICA, 15PF, 500V	DM15-150J	ARCO	1500-11-5000	1
C57	CAP, MICA, 150PF, 500V	DM15-151J	ARCO	1500-11-5100	1
C33 C36	CAP, MICA, 20PF, 500V, RADIAL	DM15-200J	ARCO	1500-12-0000	2

WAVETEK PARTS LIST — TITLE: MAIN — ASSEMBLY NO. 1100-00-0119 — REV CF — PAGE 2

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
C31T C38T C65T	CAP, MICA, 27PF, 500V	DM15-270J	ARCO	1500-12-7000	3
C59	CAP, MICA, 36PF, 500V	DM15-360J	ARCO	1500-13-6000	1
C61T	CAP, MICA, 68PF, 500V, RADIAL	DM15-680F	ARCO	1500-16-8001	1
C62	CAP, MICA, 820PF, 300V	DM15-821F	ARCO	1500-18-2101	1
C60	CAP, POLYC, .01MF, 100V, AXIAL	PA2B103F	ELCUB	1500-41-0304	1
C58	CAP, POLYC, .1MF, 100V, AXIAL	PA2B104F	ELCUB	1500-41-0404	1
C56	CAP, POLYC, 1MF, 100V, AXIAL	210-B1C-105F	IMB	1500-41-0504	1
C18 C54	CAP, POLYC, 5MF, 100V	C1A505F	ELPAC	1500-45-0504	2
C110	CAP, VAR, 3.5-13PF, 250V	7S-TRIKO-02 3.5/13PF	TRIKO	1500-51-3000	1
C64	CAP, VAR, 7-35PF 250V	7S-TRIKO-02 7/35 PF	TRIKO	1500-53-5000	1
C75	CAP, TANT, 22MF, 20V	202A2002226M3	MATSO	1500-72-2621	1
C120 C122 C14 C16 C48 C51	CAP, TANT, 5.6MF, 35V	150D565X9035B2	SPRAG	1500-75-6502	6
195	MAIN	162-115	WVTK	1700-00-0116	1

WAVETEK PARTS LIST — TITLE: MAIN — ASSEMBLY NO. 1100-00-0119 — REV CF — PAGE 3

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
183	CONN, 9PIN	03-06-1091	MOLEX	2100-02-0010	1
182	CONN, PLUG, 9 PIN	03-06-2091	MOLEX	2100-02-0011	1
185	PIN, FEMALE	350628-1	AMP	2100-05-0002	9
184	PIN, MALE	350629-1	AMP	2100-05-0003	8
191	TERM	2005B1	USECO	2100-05-0010	6
NONE	CONN	60598-9	AMP	2100-05-0017	15
188	PIN, MALE	60809-2	AMP	2100-05-0020	19
198	PINS, TERM	7715-7	USECO	2100-05-0023	2
170	LAMP	7876	JKL	2400-02-0013	1
NONE	STANDOFF, SWAGE .250 H, .250 DIA6-32, .062 MAT'L	B1530B-1/4-11	USECO	2800-03-0001	2
187	SPACER, SWAGE .250 H, .250 DIA	6310-4-2C	LYNTR	2800-04-0002	3
172	HEAT SINK	207	WAKE	2800-11-0001	2
189	TRANSIPAD	10123N	METRS	2800-11-0003	5
173	HEATSINK NUT	1103A	THERM	2800-11-0005	2
174	HEATSINK BODY	1103B	THERM	2800-11-0006	2

WAVETEK PARTS LIST — TITLE: MAIN — ASSEMBLY NO. 1100-00-0119 — REV CF — PAGE 4

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
169	FERRITE BEAD	56-590-65/3B	FERRX	3100-00-0001	1
R39	POT, TRIM, 100	91AR100	BECK	4600-01-0103	1
R124 R142 R16 R17 R18 R19 R20	POT, TRIM, 1K	91AR1K	BECK	4600-01-0209	7
R15 R231	POT, TRIM, 10K	91AR10K	BECK	4600-01-0315	2
R282 R29 R370 R9	POT, TRIM, 100K	91AR100K	BECK	4600-01-0402	4
R51	POT, TRIM, 20	91AR20	BECK	4600-02-0000	1
R106 R111 R279 R352 R368 R369 R74	POT, TRIM, 500	91AR500	BECK	4600-05-0104	7
R264 R68	POT, TRIM, 5K	91AR5K	BECK	4600-05-0205	2
R194	POT, DUAL, 10K, LINER	4600-21-0302	WVTK	4600-21-0302	1
R323 R324 R329 R330	RES, C, 1/2W, 5%, 10	RC-1/2-100J	STKPL	4700-25-0100	4
R62	RES, C, 1/2W, 5%, 10M	RC-1/2-106J	STKPL	4700-25-1005	1
R63 R8	RES, C, 1/2W, 10%, 2.2M	RC-1/2-225J	STKPL	4700-25-2204	2
R30T R58 R59	RES, C, 1/2W, 10%, 6.8M			4700-25-6804	3
R180	RES, C, 1W, 10%, 10K	RC32GF103J	AB	4700-35-1002	1
R135 R137 R144 R145 R156 R158 R159 R160 R161 R173 R174 R181 R187 R196 R205	RES, MF, 1/8W, 1%, 100	RN55D-1000F	TRW	4701-03-1000	26

WAVETEK PARTS LIST — TITLE: MAIN — ASSEMBLY NO. 1100-00-0119 — REV CF — PAGE 5

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R208 R214 R223 R228 R243 R263 R272 R281 R319 R320 R69					
R113 R117 R122 R129 R130 R177 R183 R190 R191 R217 R225 R229 R235 R273 R275 R294 R311 R312 R313 R372 R40 R41 R76	RES, MF, 1/8W, 1%, 1K	RN55D-1001F	TRW	4701-03-1001	23
R10T R119 R192 R197 R198 R199 R201 R207 R261 R354 R356 R381 R398 R64 R65	RES, MF, 1/8W, 1%, 10K	RN55D-1002F	TRW	4701-03-1002	15
R105 R132 R147 R155 R171 R172 R241 R242 R253 R254 R285 R295 R307 R310 R394 R47 R49 R52 R70 R85 R96	RES, MF, 1/8W, 1%, 10	RN55D-10R0F	TRW	4701-03-1009	21
R316 R317 R360 R361	RES, MF, 1/8W, 1%, 1.1K	RN55D-1101F	TRW	4701-03-1101	4
R115 R123T R125 R260	RES, MF, 1/8W, 1%, 1.21K	RN55D-1211F	TRW	4701-03-1211	4
R338 R53	RES, MF, 1/8W, 1%, 124	RN55D-1240F	TRW	4701-03-1240	2
R127 R215 R358 R362 R396 R397 R93	RES, MF, 1/8W, 1%, 150	RN55D-1500F	TRW	4701-03-1500	7
R102 R131 R211 R212 R22 R287 R290 R309 R35 R37 R385 R45 R48 R60 R91 R92 R99	RES, MF, 1/8W, 1%, 1.5K	RN55D-1501F	TRW	4701-03-1501	17
R157 R182 R233 R353 R355 R6	RES, MF, 1/8W, 1%, 15K	RN55D-1502F	TRW	4701-03-1502	6

WAVETEK PARTS LIST — TITLE: MAIN — ASSEMBLY NO. 1100-00-0119 — REV CF — PAGE 6

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR		TITLE: PARTS LIST MAIN
	RELEASE APPROV		
FINISH: WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1°		
	DO NOT SCALE DWG		MODEL NO. 164 — DWG NO. 1100-00-0119 — REV CF
	SCALE		CODE IDENT 23338 — SHEET 1 OF 2

REV	ECN	BY	DATE	APP

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R286	RES, MF, 1/8W, 1%, 150K	RN55D-1503F	TRW	4701-03-1503	1
R104 R162 R247 R248 R325 R326 R327 R328 R97	RES, MF, 1/8W, 1%, 15	RN55D-15R0F	TRW	4701-03-1509	9
R339	RES, MF, 1/8W, 1%, 165	RN55D-1650F	TRW	4701-03-1650	1
R185 R238 R268	RES, MF, 1/8W, 1%, 1.78K	RN55D-1781F	TRW	4701-03-1781	3
R38	RES, MF, 1/8W, 1%, 1.96K	RN55D-1961F	TRW	4701-03-1961	1
R189 R257 R31 R32 R349 R350 R36 R44	RES, MF, 1/8W, 1%, 2K	RN55D-2001F	TRW	4701-03-2001	8
R289	RES, MF, 1/8W, 1%, 215	RN55D-2150F	TRW	4701-03-2150	1
R236 R239 R274 R308 R386 R389 R395 R399	RES, MF, 1/8W, 1%, 21.5	RN55D-21R5F	TRW	4701-03-2159	8
R103 R120 R149 R21 R230 R249 R250 R251 R252 R280 R288 R340 R357 R363 R383 R55 R56 R71 R72 R98	RES, MF, 1/8W, 1%, 249	RN55D-2490F	TRW	4701-03-2490	20
R175 R203 R220 R221 R226 R240 R255 R256 R269 R271 R291 R292 R374 R375 R390 R4	RES, MF, 1/8W, 1%, 2.49K	RN55D-2491F	TRW	4701-03-2491	16
R244 R25 R315 R318	RES, MF, 1/8W, 1%, 24.9K	RN55D-2492F	TRW	4701-03-2492	4
R306 R314 R337	RES, MF, 1/8W, 1%, 27.4	RN55D-27R4F	TRW	4701-03-2749	3

WAVETEK PARTS LIST — TITLE: MAIN — ASSEMBLY NO. 1100-00-0119 — REV CF — PAGE 7

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R1	RES, MF, 1.8W, 1%, 46.4	RN55D-46R4F	TRW	4701-03-4649	1
R67T	RES, MF, 1/8W, 1%, 47.5K	RN55D-4752F	TRW	4701-03-4752	1
R176 R178 R193 R206 R222 R265 R266 R377 R57	RES, MF, 1/8, 1%, 499	RN55D-4990F	TRW	4701-03-4990	9
R134 R14 R195 R202 R224 R26 R27 R5	RES, MF, 1/8W, 1%, 4.99K	RN55D-4991F	TRW	4701-03-4991	8
R227 R23 R24	RES, MF, 1/8W, 1%, 49.9K	RN55D-4992F	TRW	4701-03-4992	3
R82	RES, MF, 1/8W, 1%, 51.1	RN55D-51R1F	TRW	4701-03-5119	1
R347	RES, MF, 1/8W, 1%, 59	RN55D-59R0F	TRW	4701-03-5909	1
R321 R322 R346 R367 R378	RES, MF, 1/8W, 1%, 61.9	RN55D-61R9F	TRW	4701-03-6199	5
R143T R351	RES, MF, 1/8W, 1%, 681	RN55D-6810F	TRW	4701-03-6810	2
R136 R245 R246 R259 R262	RES, MF, 1/8W, 1%, 68.1	RN55D-68R1F	TRW	4701-03-6819	5
R13	RES, MF, 1/8W, 1%, 6.98K	RN55D-6981F	TRW	4701-03-6981	1
R276	RES, MF, 1/8W, 1%, 69.8K	RN55D-6982F	TRW	4701-03-6982	1
R140 R204 R210 R237 R258 R267 R299 R46 R61 R95	RES, MF, 1/8W, 1%, 750	RN55D-7500F	TRW	4701-03-7500	10
R138 R146 R150 R165 R166 R186 R200 R209 R218 R219 R232 R234 R270 R296 R298	RES, MF, 1/8W, 1%, 7.5K	RN55D-7501F	TRW	4701-03-7501	19

WAVETEK PARTS LIST — TITLE: MAIN — ASSEMBLY NO. 1100-00-0119 — REV CF — PAGE 9

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
CR1 CR11 CR12 CR18 CR19 CR2 CR20 CR21 CR22 CR23 CR25 CR26 CR27 CR28 CR29 CR3 CR30 CR31 CR33 CR34 CR35 CR37 CR38 CR39 CR40 CR43 CR44 CR49 CR5 CR50 CR51 CR52 CR53 CR66 CR68	DIODE 1N4148 COMPUTER, G/P, 75V, 200M A, SWITCHING	1N4148	FAIR	4807-02-6666	35
CR10 CR9	DIODE 5082-2811 SCHOTTKY, 15V, 20MA	5082-2811	HP	4809-02-2811	2
CR36 CR4	DIODE, M/PR, FD-777 QTY: 2: 4807-02-0777	164-501-93	WVTK	4898-00-0004	1
CR54 CR55 CR56 CR57 CR58 CR59 CR60 CR61 CR62 CR63 CR64 CR65	DIODE, SET, 5082-2811 QTY: 12: 4809-02-2811	142-501-56	WVTK	4898-00-0009	1
Q30 Q63	TRANS 2N2219A NPN GENERAL PURPOSE TO-5	2N2219A	NSC	4901-02-2191	2
Q64	TRANS 2N2905A PNP GENERAL PURPOSE TO-5	2N2905A	NSC	4901-02-9051	1
Q13 Q21 Q57 Q71	TRANS, NPN, TO-92	2N3563	FAIR	4901-03-5630	4
Q14 Q15 Q18 Q32 Q33 Q42 Q53 Q58 Q62 Q70 Q72	TRANS, PNP, TO-92	2N3640	FAIR	4901-03-6400	11
Q20 Q23 Q26 Q34 Q37 Q38 Q39 Q43 Q45 Q46 Q47 Q49 Q52 Q6 Q61	TRANS, NPN, -TO-92	MPS3646	MOT	4901-03-6460	15

WAVETEK PARTS LIST — TITLE: MAIN — ASSEMBLY NO. 1100-00-0119 — REV CF — PAGE 11

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R33 R34 R384 R387	RES, MF, 1/8W, 1%, 301	RN55D-3010F	TRW	4701-03-3010	4
R188 R216 R301	RES, MF, 1/8W, 1%, 3.01K	RN55D-3011F	TRW	4701-03-3011	3
R297 R73 R75	RES, MF, 1/8W, 1%, 30.1K	RN55D-3012F	TRW	4701-03-3012	3
R154 R2 R371	RES, MF, 1/8W, 1%, 301K	RN55D-3013F	TRW	4701-03-3013	3
R100 R101 R108 R109 R139 R86 R87	RES, MF, 1/8W, 1%, 316	RN55D-3160F	TRW	4701-03-3160	7
R391 R392	RES, MF, 1/8W, 1%, 332	RN55D-3320F	TRW	4701-03-3320	2
R278	RES, MF, 1/8W, 1%, 3.32K	RN55D-3321F	TRW	4701-03-3321	1
R112 R116 R118 R121 R126 R133 R141 R148 R151 R152 R163 R164 R167 R168 R284T R300 R302 R373 R379 R388 R88 R89 R90 R94	RES, MF, 1/8W, 1%, 33.2	RN55D-33R2F	TRW	4701-03-3329	24
R107T R11 R110T R169 R170 R213 R277 R376	RES, MF, 1/8W, 1%, 3.65K	RN55D-3651F	TRW	4701-03-3651	8
R12T	RES, MF, 1/8W, 1%, 37.4K	RN55D-3742F	TRW	4701-03-3742	1
R128T R50 R54	RES, MF, 1/8W, 1%, 392	RN55D-3920F	TRW	4701-03-3920	3
R293	RES, MF, 1/8W, 1%, 4.02K	RN55D-4021F	TRW	4701-03-4021	1
R114 R83	RES, MF, 1/8W, 1%, 464	RN55D-4640F	TRW	4701-03-4640	2
R28	RES, MF, 1/8W, 1%, 46.4K	RN55D-4642F	TRW	4701-03-4642	1

WAVETEK PARTS LIST — TITLE: MAIN — ASSEMBLY NO. 1100-00-0119 — REV CF — PAGE 8

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R365 R366 R380 R382					
R153 R303 R304 R305 R341	RES, MF, 1/8W, 1%, 825	RN55D-8250F	TRW	4701-03-8250	5
R184	RES, MF, 1/8W, 1%, 82.5	RN55D-82R5F	TRW	4701-03-8259	1
R42	RES, MF, 1/8W, 1%, 9.09K	RN55D-9091F	TRW	4701-03-9091	1
R393T R84	RES, MF, 1/8W, 1%, 90.9	RN55D-90R9F	TRW	4701-03-9099	2
R7	RES, MF, 1/4W, 1%, 1M	RN60D-1004F	TRW	4701-13-1004	1
R342 R343 R344 R345	RES, MF, 1/4W, 1%, 196	RN60D-1960F	TRW	4701-13-1960	4
R179	RES, MF, 1/4W, 1%, 49.9	RN60D-49R9F	TRW	4701-13-4999	1
R331 R332 R333 R334 R335 R336	RES, MF, 1/4W, 1%, 75	RN60D-75R0F	TRW	4701-13-7509	6
R77 R78 R79 R80	RES, MF, MIXED SET	164-501-89A	WVTK	4789-00-0036	1
R81	RES, MF, .6W, 1%, 10M	ML-181	CADDO	4799-00-0003	1
CR13 CR6 CR67 CR7 CR8	DIODE, ZENER, 6.2V, IN823	1N823A	MOT	4801-01-0823	5
CR24	DIODE, GER TUN, FOSC 1.4	1N3716	GE	4802-01-3716	1
CR14 CR15 CR16 CR17 CR32 CR41 CR42 CR45 CR46 CR47 CR48	DIODE, ULTRA FAST	FD777	FAIR	4807-02-0777	11

WAVETEK PARTS LIST — TITLE: MAIN — ASSEMBLY NO. 1100-00-0119 — REV CF — PAGE 10

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
Q60 Q65	TRANS	2N3866	MOT	4901-03-8660	2
Q28 Q29 Q48 Q51	TRANS, GENERAL PURPOSE, NPN, TO-92	2N3903	NSC	4901-03-9030	4
Q16 Q22 Q24 Q25 Q27 Q31 Q35 Q36 Q40 Q44 Q5 Q50 Q54 Q55 Q68 Q69	TRANS, GENERAL PURPOSE, PNP, TO-92	2N5139	FAIR	4901-05-1390	16
Q59 Q66	TRANS	2N5160-18	MOT	4901-05-1600	2
Q2 Q3 Q7	TRANS, P-CHANNEL JFETS	2N5462	MOT	4901-05-4620	3
Q1 Q4	TRANS, N-CHANNEL JFETS	2N5485	MOT	4901-05-4850	2
Q8	TRANS	TP-308	TPS	4902-00-3080	1
Q17 Q19	TRANS, M/PR, 2N3563 QTY: 2: 4901-03-5630	142-501-52	WVTK	4998-00-0004	1
Q11 Q12	TRANS, M/PR, 2N5139 QTY: 2: 4901-05-1390	164-501-88	WVTK	4998-00-0005	1
Q10 Q9	TRANS, M/PR, 2N5485 QTY: 2: 4901-05-4850	142-501-53	WVTK	4998-00-0009	1
IC1 IC10 IC2 IC3 IC4 IC5 IC6 IC7 IC8 IC9	OP AMP, INTERNALLY COMP, HIGH PERFORMANCE	LM741CN	NSC	7000-07-4100	10
Q41 Q56 Q67	IC	MP 312-52	MPS	7000-08-1200	3
IC11	DIFFERENTIAL AMP, DUAL HIGH FREQ	CA3049T	RCA	7000-30-4900	1

WAVETEK PARTS LIST — TITLE: MAIN — ASSEMBLY NO. 1100-00-0119 — REV CF — PAGE 12

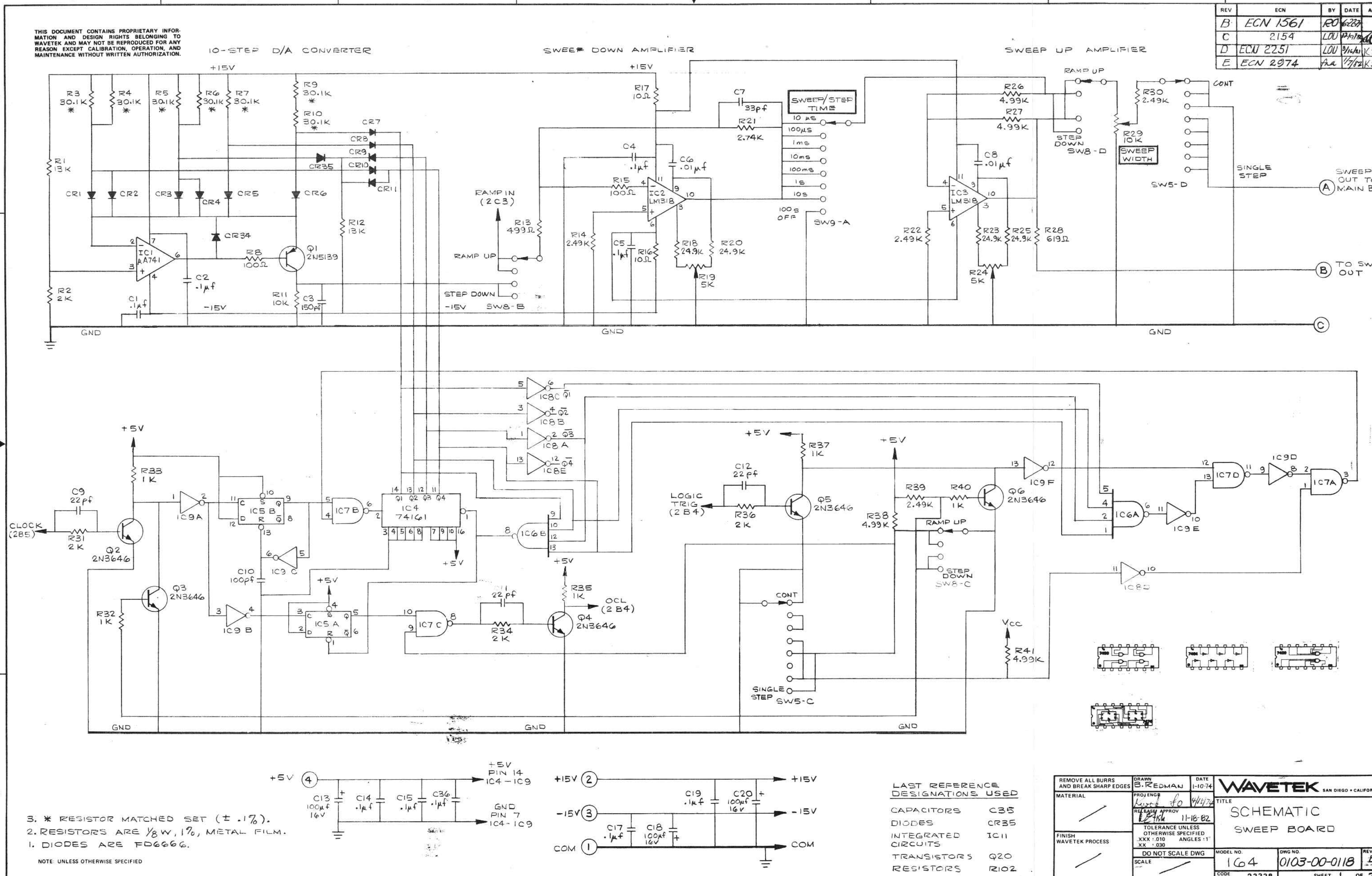
NOTE: UNLESS OTHERWISE SPECIFIED

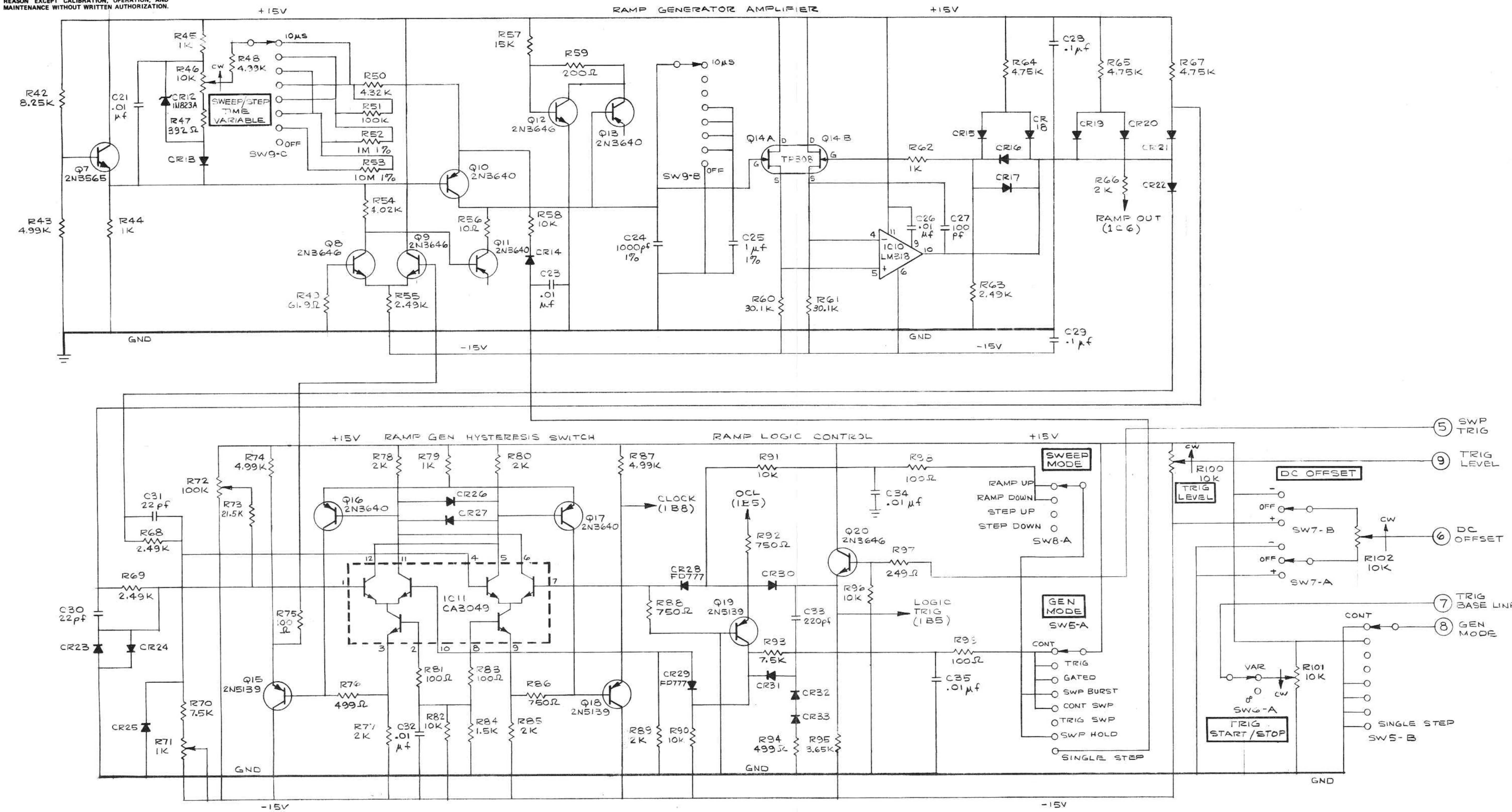
REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN | DATE
PROJ ENGR
RELEASE APPROV
TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 ANGLES ±1° .XX ±.030
DO NOT SCALE DWG
SCALE

WAVETEK SAN DIEGO • CALIFORNIA

TITLE: PARTS LIST MAIN

MODEL NO. 164 | DWG NO. 1100-00-0119 | REV CF
CODE IDENT 23338 | SHEET 2 OF 2

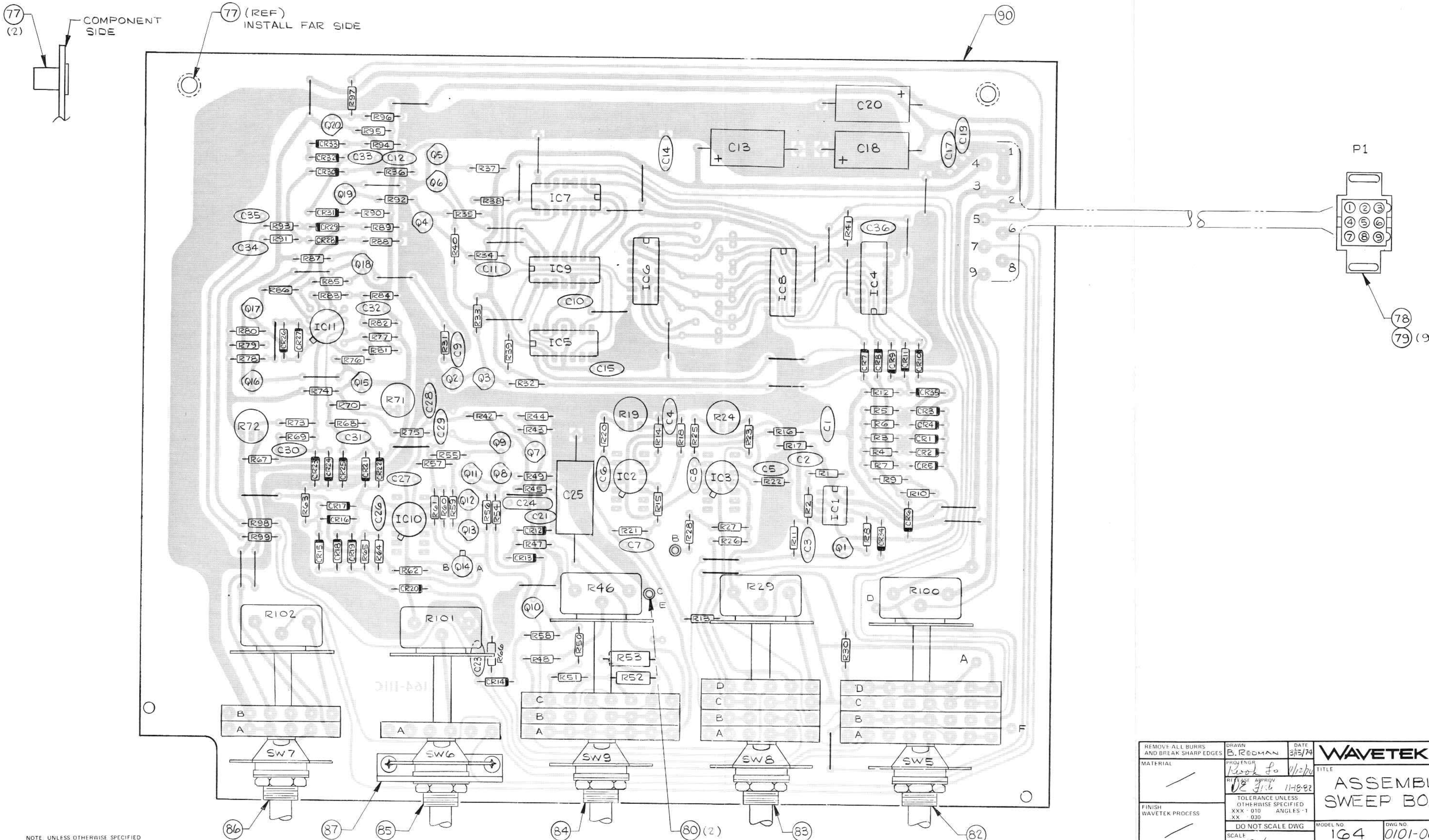

THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION AND DESIGN RIGHTS BELONGING TO WAVETEK AND MAY NOT BE REPRODUCED FOR ANY REASON EXCEPT CALIBRATION, OPERATION, AND MAINTENANCE WITHOUT WRITTEN AUTHORIZATION.
10-STEP D/A CONVERTER
SWEEP DOWN AMPLIFIER
SWEEP UP AMPLIFIER
REV | ECN | BY | DATE | APP
B | ECN 1561
C | 2154 | LOU
D | ECN 2251 | LOU
E | ECN 2974
+15V
R3 30.1K *
R4 30.1K *
R5 30.1K *
R6 30.1K *
R7 30.1K *
R9 30.1K *
R10 30.1K *
R1 13K
R2 2K
CR1 CR2 CR3 CR4 CR5 CR6
CR7 CR8 CR9 CR10 CR11 CR35 CR34
IC1 µA741
C1 .1µf
C2 .1µf
-15V
R8 100Ω
Q1 2N5139
R11 10K
C3 150pf
R12 13K
GND
RAMP IN (2C3)
R13 499Ω
RAMP UP
STEP DOWN
SW8-B
R17 10Ω
C7 33pf
R21 2.74K
C4 .1µf
C6 .01µf
R15 100Ω
IC2 LM318
R14 2.49K
C5 .1µf
R16 10Ω
R18 24.9K
R20 24.9K
R19 5K
SWEEP/STEP TIME
10 µs
100µs
1ms
10ms
100ms
1s
10s
100s OFF
SW9-A
R26 4.99K
R27 4.99K
C8 .01µf
IC3 LM318
R22 2.49K
R23 24.9K
R25 24.9K
R28 619Ω
R24 5K
RAMP UP
STEP DOWN
SW8-D
R30 2.49K
R29 10K
SWEEP WIDTH
CONT
SINGLE STEP
SW5-D
SWEEP OUT TO MAIN BD (A)
TO SWP OUT (B)
(C)
IC8C IC8B IC8A IC8E
+5V
R33 1K
C9 22pf
CLOCK (2B5)
R31 2K
Q2 2N3646
Q3 2N3646
R32 1K
IC9A IC9B
IC5 B
IC5 A
IC3 C
C10 100pf
IC7 B
IC4 74161
IC6 B
IC7 C
C11 22pf
R34 2K
Q4 2N3646
R35 1K
OCL (2B4)
R37 1K
C12 22pf
LOGIC TRIG (2B4)
R36 2K
Q5 2N3646
R38 4.99K
R39 2.49K
R40 1K
Q6 2N3646
RAMP UP
STEP DOWN
SW8-C
CONT
SINGLE STEP
SW5-C
IC9 F
IC6A
IC9 E
IC7 D
IC9 D
IC7 A
IC8 D
Vcc
R41 4.99K
+5V (4)
+5V PIN 14 IC4 - IC9
GND PIN 7 IC4 - IC9
C13 100µf 16V
C14 .1µf
C15 .1µf
C36 .1µf
+15V (2)
-15V (3)
COM (1)
C19 .1µf
C20 100µf 16V
C17 .1µf
C18 100µf 16V
3. * RESISTOR MATCHED SET (± .1%).
2. RESISTORS ARE 1/8 W, 1%, METAL FILM.
1. DIODES ARE FD6666.
NOTE: UNLESS OTHERWISE SPECIFIED
LAST REFERENCE DESIGNATIONS USED
CAPACITORS C35
DIODES CR35
INTEGRATED CIRCUITS IC11
TRANSISTORS Q20
RESISTORS R102
REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN B. REDMAN
DATE 1-10-74
TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1°
DO NOT SCALE DWG
SCALE
WAVETEK SAN DIEGO • CALIFORNIA
TITLE SCHEMATIC SWEEP BOARD
MODEL NO. 164
DWG NO. 0103-00-0118
REV E
CODE IDENT 23338
SHEET 1 OF 2



REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 1-16-74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR Kwok Lo	4/15/74	TITLE SCHEMATIC SWEEP BOARD
FINISH WAVETEK PROCESS	RELEASE APPROV	11-18-82	
	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1°		
	DO NOT SCALE DWG		MODEL NO. 164 · DWG NO. 0103-00-0118 · REV E
	SCALE		CODE IDENT 23338 · SHEET 2 OF 2

NOTE: UNLESS OTHERWISE SPECIFIED

REV	ECN	BY	DATE	APP
C	ECN 1797	RO	8-31-76	
D	2249	LOU	9/11/80	
E	ECN 2974		11/5/82	



NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 3/15/74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR Kwok Lo	11/12/74	TITLE ASSEMBLY, SWEEP BOARD
	RELEASE APPROV	11-18-82	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ± .010 ANGLES ±1 .XX ± .030		
	DO NOT SCALE DWG		MODEL NO. 164 — DWG NO. 0101-00-0118 — REV E
	SCALE 2/1		CODE IDENT 23338 — SHEET 1 OF 1

REV	ECN	BY	DATE	APP

WAVETEK PARTS LIST — TITLE: SWEEP — ASSEMBLY NO. 1100-00-0118 — PAGE: 1 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
NONE	ASSY DRWG, SWEEP	0101-00-0118	WVTK	0101-00-0118	1
NONE	SCHEMATIC, SWEEP	0103-00-0118	WVTK	0103-00-0118	1
82	MODE SW ASSY	164-005	WVTK	1202-00-0034	1
83	SWEEP SW ASSY	164-006	WVTK	1202-00-0035	1
84	STEP SW ASSY	164-007	WVTK	1202-00-0036	1
85	TRIG SW ASSY	164-008	WVTK	1202-00-0037	1
86	D/C OFFSET SW ASSY	164-009	WVTK	1202-00-0038	1
87	BRKT	133-305	WVTK	1400-00-1673	1
C10 C27	CAP, CER, 100PF, 1KV	DD-101	CRL	1500-01-0111	2
C21 C23 C26 C32 C34 C35 C6 C8	CAP, CER, MN, .01MF, 50V	CAC02Z5U103Z100A	CORNG	1500-01-0310	8
C1 C14 C15 C17 C19 C2 C28 C29 C36 C4 C5	CAP, CER, MON, .1MF, 50V	CAC03Z5U104Z050A	CORNG	1500-01-0405	11
C3	CAP, CER, 150PF, 1KV	DD-151	CRL	1500-01-5111	1
C11 C12 C30 C31 C9	CAP, CER, 22PF, 1KV	DD-220	CRL	1500-02-2011	5
C33	CAP, CER, 220PF, 1KV	DD-221	CRL	1500-02-2111	1
C7	CAP, CER, 33PF, 1KV	DD-330	CRL	1500-03-3011	1
C24	CAP, MICA, 1000PF, 500V	DM19-102F	ARCO	1500-11-0201	1
C13 C18 C20	CAP, ELECT, 100MF, 16V	500D107G016DC7	SPRAG	1500-31-0101	3

WAVETEK PARTS LIST — TITLE: SWEEP — ASSEMBLY NO. 1100-00-0118 — PAGE: 2 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
C25	CAP, POLYC, 1MF, 100V	210-B1C-105F	IMB	1500-41-0504	1
90	SWEEP	164-111	WVTK	1700-00-0118	1
78	PLUG, 9PIN	03-06-2091	MOLEX	2100-02-0011	1
79	PIN, MALE	02-06-2103	MOLEX	2100-05-0003	9
NONE	CONN	60598-9	AMP	2100-05-0017	2
80	PIN, MALE	61182-2	AMP	2100-05-0020	2
77	SPACER, SWAGE .250 H, .250 DIA .150DIA THRU, .062MTL	6310-4-2C	LYNTR	2800-04-0002	2
R71	POT, TRIM, 1K	91AR1K	BECK	4600-01-0209	1
R72	POT, TRIM, 100K	91AR100K	BECK	4600-01-0402	1
R19 R24	POT, TRIM, 5K	91AR5K	BECK	4600-05-0205	2
R15 R75 R8 R81 R83 R98 R99	RES, MF, 1/8W, 1%, 100	RN55D-1000F	TRW	4701-03-1000	7
R32 R33 R35 R37 R40 R44 R45 R62 R79	RES, MF, 1/8W, 1%, 1K	RN55D-1001F	TRW	4701-03-1001	9
R11 R58 R82 R90 R91 R96	RES, MF, 1/8W, 1%, 10K	RN55D-1002F	TRW	4701-03-1002	6
R51	RES, MF, 1/8W, 1%, 100K	RN55D-1003F	TRW	4701-03-1003	1
R16 R17 R56	RES, MF, 1/8W, 1%, 10	RN55D-10R0F	TRW	4701-03-1009	3

WAVETEK PARTS LIST — TITLE: SWEEP — ASSEMBLY NO. 1100-00-0118 — PAGE: 3 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R1 R12	RES, MF, 1/8W, 1%, 13K	RN55D-1302F	TRW	4701-03-1302	2
R84	RES, MF, 1/8W, 1%, 1.5K	RN55D-1501F	TRW	4701-03-1501	1
R57	RES, MF, 1/8W, 1%, 15K	RN55D-1502F	TRW	4701-03-1502	1
R59	RES, MF, 1/8W, 1%, 200	RN55D-2000F	TRW	4701-03-2000	1
R2 R31 R34 R36 R66 R77 R78 R80 R85 R89	RES, MF, 1/8W, 1%, 2K	RN55D-2001F	TRW	4701-03-2001	10
R73	RES, MF, 1/8W, 1%, 21.5K	RN55D-2152F	TRW	4701-03-2152	1
R97	RES, MF, 1/8W, 1%, 249	RN55D-2490F	TRW	4701-03-2490	1
R14 R22 R30 R39 R55 R63 R68 R69	RES, MF, 1/8W, 1%, 2.49K	RN55D-2491F	TRW	4701-03-2491	8
R18 R20 R23 R25	RES, MF, 1/8W, 1%, 24.9K	RN55D-2492F	TRW	4701-03-2492	4
R21	RES, MF, 1/8W, 1%, 2.74K	RN55D-2741F	TRW	4701-03-2741	1
R60 R61	RES, MF, 1/8W, 1%, 30.1K	RN55D-3012F	TRW	4701-03-3012	2
R95	RES, MF, 1/8W, 1%, 3.65K	RN55D-3651F	TRW	4701-03-3651	1
R47	RES, MF, 1/8W, 1%, 392	RN55D-3920F	TRW	4701-03-3920	1
R54	RES, MF, 1/8W, 1%, 4.02K	RN55D-4021F	TRW	4701-03-4021	1
R50	RES, MF, 1/8W, 1%, 4.32K	RN55D-4321F	TRW	4701-03-4321	1
R64 R65 R67	RES, MF, 1/8W, 1%, 4.75K	RN55D-4751F	TRW	4701-03-4751	3

WAVETEK PARTS LIST — TITLE: SWEEP — ASSEMBLY NO. 1100-00-0118 — PAGE: 4 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R13 R76 R94	RES, MF, 1/8, 1%, 499	RN55D-4990F	TRW	4701-03-4990	3
R26 R27 R38 R41 R43 R48 R74 R87	RES, MF, 1/8W, 1%, 4.99K	RN55D-4991F	TRW	4701-03-4991	8
R28	RES, MF, 1/8W, 1%, 619	RN55D-6190F	TRW	4701-03-6190	1
R49	RES, MF, 1/8W, 1%, 61.9	RN55D-61R9F	TRW	4701-03-6199	1
R86 R88 R92	RES, MF, 1/8W, 1%, 750	RN55D-7500F	TRW	4701-03-7500	3
R70 R93	RES, MF, 1/8W, 1%, 7.5K	RN55D-7501F	TRW	4701-03-7501	2
R42	RES, MF, 1/8W, 1%, 8.25K	RN55D-8251F	TRW	4701-03-8251	1
R52	RES, MF, 1/4W, 1%, 1M	RN60D-1004F	TRW	4701-13-1004	1
R10 R3 R4 R5 R6 R7 R9	RES, SET, 7-30.1K, 1/8W QTY: 7: 4701-03-3012	164-501-90A	WVTK	4789-00-0024	1
R53	RES, MF, .6W, 1%, 10M	ML-181	CADDO	4799-00-0003	1
CR12	DIODE, ZENER 6.2V	1N823A	MOT	4801-01-0823	1
CR28 CR29	DIODE	FD777	FAIR	4807-02-0777	2
CR1 CR10 CR11 CR13 CR14 CR15 CR16 CR17 CR18 CR19 CR2 CR20 CR21 CR22 CR23 CR24 CR25 CR26 CR27 CR3 CR30 CR31 CR32 CR33 CR34 CR35 CR4 CR5 CR6	DIODE	1N4148	FAIR	4807-02-6666	32

WAVETEK PARTS LIST — TITLE: SWEEP — ASSEMBLY NO. 1100-00-0118 — PAGE: 5 — REV G

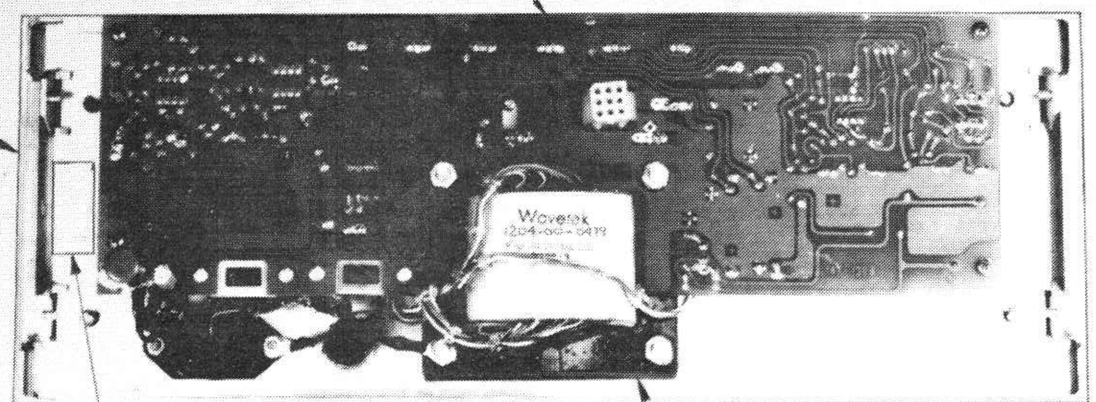
REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
CR7 CR8 CR9					
Q7	TRANS	2N3565	FAIR	4901-03-5650	1
Q10 Q11 Q13 Q16 Q17	TRANS	2N3640	FAIR	4901-03-6400	5
Q12 Q2 Q20 Q3 Q4 Q5 Q6 Q8 Q9	TRANS	2N3646	NSC	4901-03-6460	9
Q1 Q15 Q18 Q19	TRANS	2N5139	FAIR	4901-05-1390	4
Q14	TRANS	TP-308	TPS	4902-00-3080	1
IC10 IC2 IC3	IC	LM318H	AMD	7000-03-1800	3
IC1	IC	LM741CN	NSC	7000-07-4100	1
IC11	IC	CA3049T	RCA	7000-30-4900	1
IC7	IC	7400	TI	8000-74-0000	1
IC8 IC9	IC	7404	TI	8000-74-0400	2
IC6	IC	7420	TI	8000-74-2000	1
IC5	IC	7474	TI	8000-74-7400	1
IC4	IC	74161	TI	8007-41-6100	1

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR		TITLE: PARTS LIST SWEEP
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 ANGLES ±1° .XX ±.030		
	DO NOT SCALE DWG		MODEL NO. 164 — DWG NO. 1100-00-0118 — REV G
	SCALE		CODE IDENT 23338 — SHEET 1 OF 1

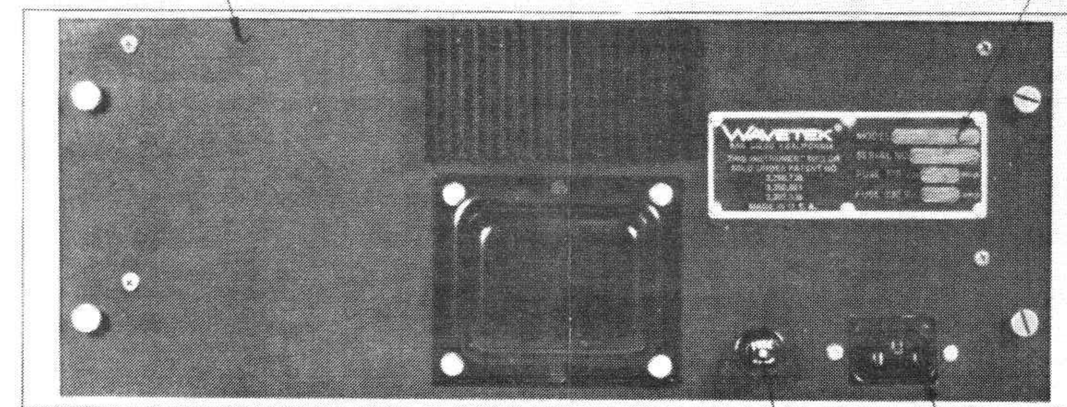
REV	ECN	BY	DATE	APP
B	ECN 1052	RG	10/1/74	
C	ECN 1324	RG	7-10-5	
D	DDC #1464	DC	9-16-6	
E	ECN 1525	RO	3-4-77	
F	ECN 1771	JCS	2-28-78	K.Jo
G	ECN 1797	RO	6-5-78	K.Jo
H	2726 AUDIT	LOU	5-30-80	RK
J	#4711		3/1/85	
K	#8296	R.C. 5-14-87	5/26/87	DX

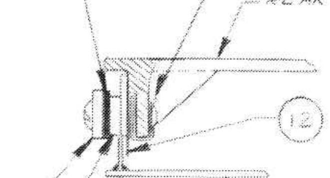
POWER SUPPLY: SEE 1100-00-0061 FOR ASSEMBLY



SAFETY GND. STAMP

NOT AS SHOWN 1





TRANSISTOR CLAMP DETAILS

SEE 0101-00-0061 FOR FURTHER DETAILS.

1. FOR CHASSIS WIRING SEE INSTR. SCHEMATIC 0004-00-0046

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 3-1-74
MATERIAL /	CHECKED Kirk Jo	4/1/74
FINISH WAVETEK PROCESS /	11-18-82	
	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX .010 ANGLES ± .XX .030	
	DO NOT SCALE DWG	
	SCALE NONE	

WAVETEK SAN DIEGO • CALIFORNIA

TITLE: ASSEMBLY, REAR PANEL

MODEL NO	DWG NO	REV
162/164	1206-00-0002	K
CODE IDENT 23338	[redacted]	

REV	ECN	BY	DATE	APP

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
4	TRANSFORMER	147-500	WVTK	1204-00-0479	1
NONE	ASSY, TRANSFORMER POWER HARNESS 164-0002	164-1989	WVTK	1207-00-1989	1
1	CASTING, REAR FROM: 1400-00-3671	147-359	WVTK	1400-00-3679	1
12	INSULATOR	147-367	WVTK	1400-00-3700	1
11	BAR, CLAMP	147-379	WVTK	1400-00-3733	1
14	STRIP, COMP REF: 3200-08-0001	162-312	WVTK	1400-00-3840	1
20	CONN, RECEPT, POWER	EAC-301	SWCFT	2100-03-0005	1
NONE	SOLDER LUG	11A144	ZIER	2100-04-0025	2
2	FUSE, 1/2A, 250V	313. 500	LITFU	2400-05-0010	1
17	FUSE HOLDER	031. 1653/031. 1666	SCHUR	2400-05-0012	1
9	NUT, SPEED, TYPE "U"	C18050-632-4	TINN	2800-09-0002	12

WAVETEK PARTS LIST

TITLE: REAR PANEL ASSY

ASSEMBLY NO. 1206-00-0002

REV K

PAGE 1

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE
MATERIAL	PROJ ENGR	
	RELEASE APPROV	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 ANGLES ±1° .XX ±.030	
	DO NOT SCALE DWG	
	SCALE	

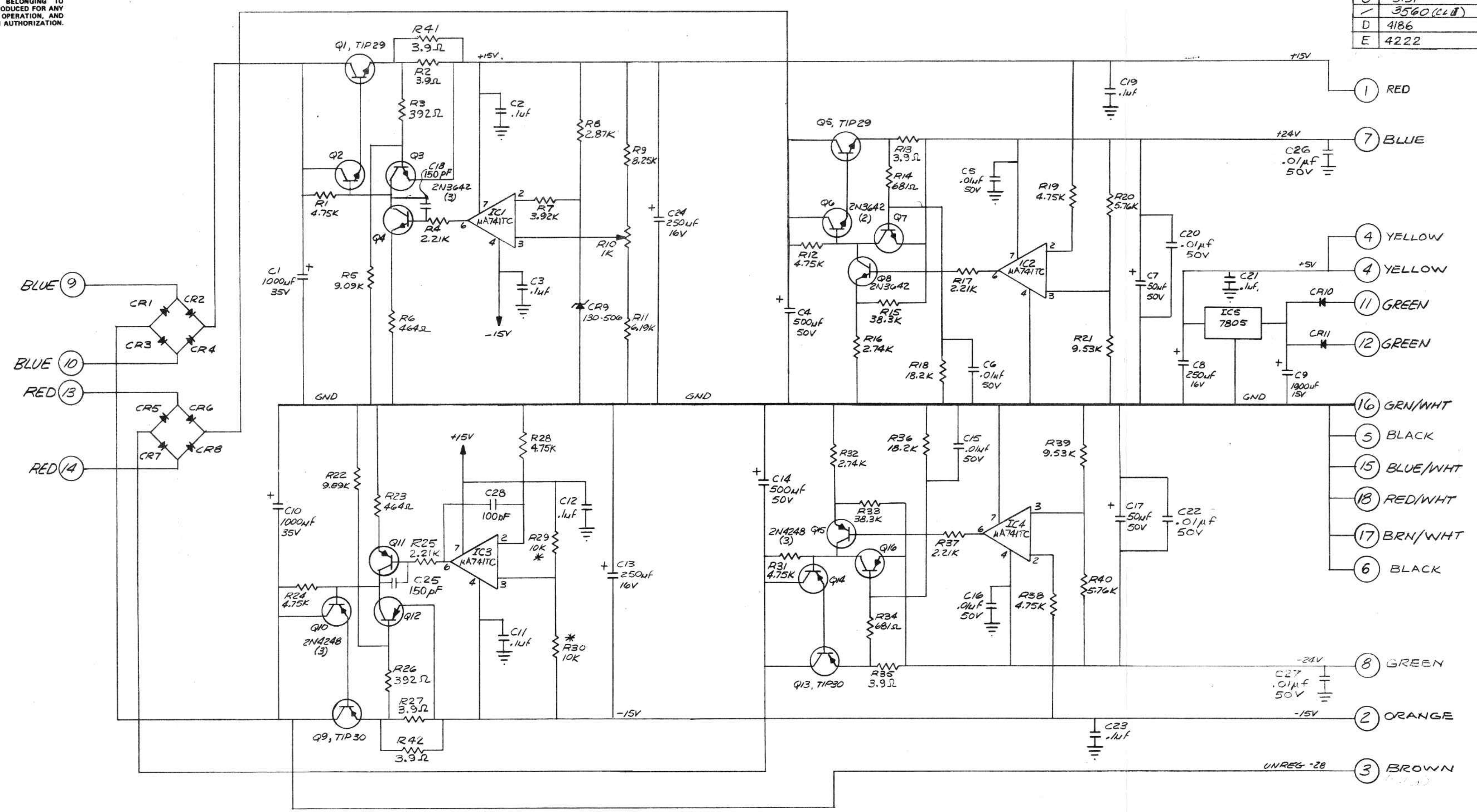
WAVETEK SAN DIEGO • CALIFORNIA

TITLE: PARTS LIST REAR PANEL ASSY

MODEL NO	DWG NO	REV
164	1206-00-0002	K

CODE IDENT 23338 — SHEET 1 OF 1

REV	ECN	BY	DATE	APP
B		BA	12-13-74	
C	3131		4/8/	
/	3560 (CL II)		2/14/	
D	4186		2/24/	
E	4222			



LAST DESIGNATORS USED		NOT USED
CAPACITOR	C28	
DIODE	CR11	
INTEGRATED CIRCUIT	IC5	
TRANSISTOR	Q16	
RESISTOR	R42	

4) COLORED CALLOUTS INDICATE TRANSFORMER LEADS
3) SEE CHASSIS SHEMATIC D147-200 FOR INTERWIRING
2) DIODES ARE SCE-1
1) * INDICATES MATCHED PAIR (R29, R30)

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN Bocchicchio DATE 9/11/74
PROJ ENGR Kwok S. Fo 4/12/74
RELEASE APPROV 3/11/75
TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1°
DO NOT SCALE DWG
SCALE

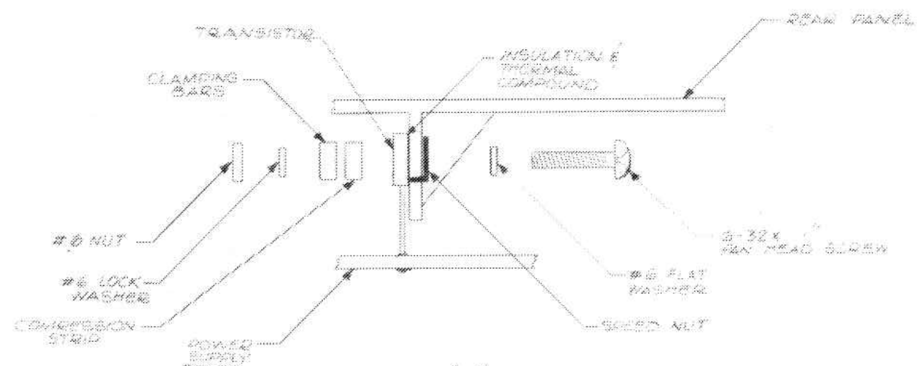
WAVETEK SAN DIEGO • CALIFORNIA

TITLE: SCHEMATIC POWER SUPPLY BOARD

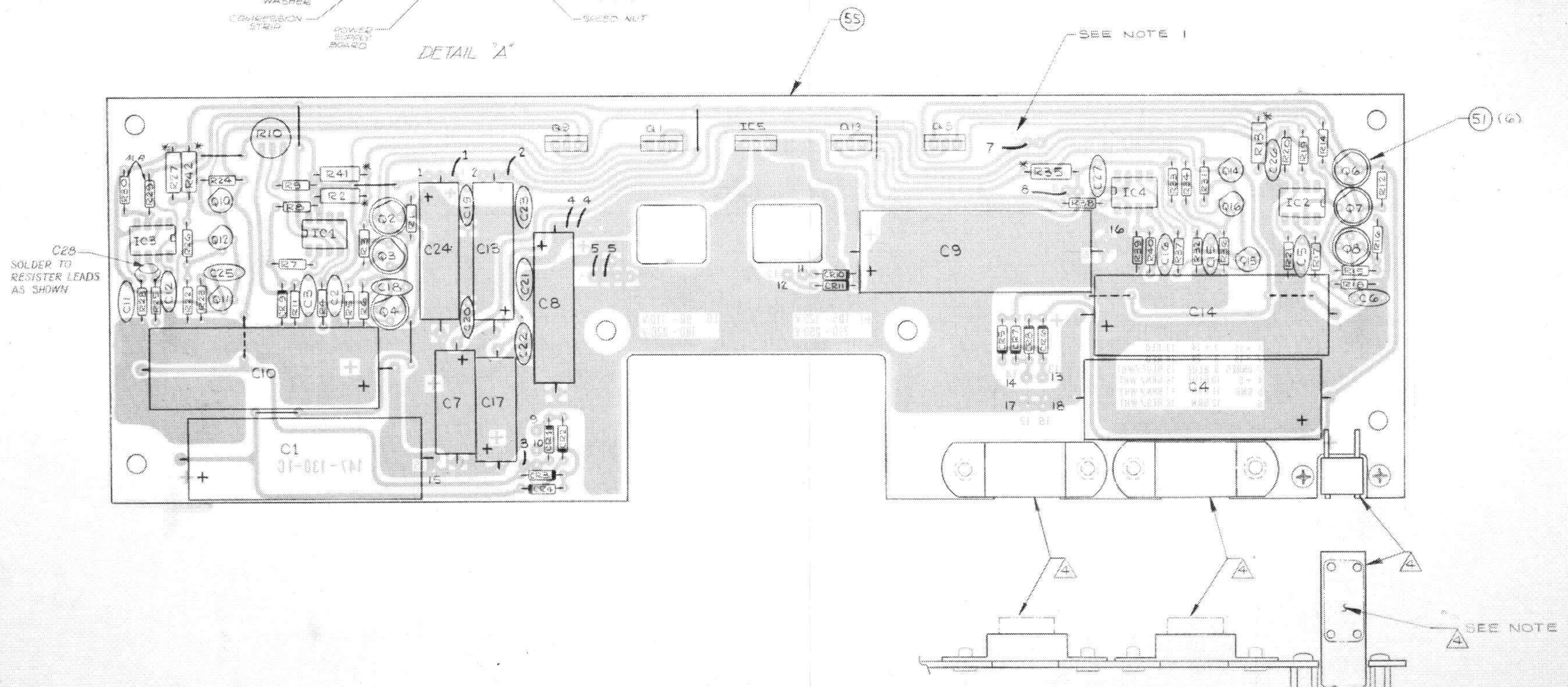
MODEL NO. 164 | DWG NO. 0103-00-0061 | REV E
CODE IDENT 23338 | SHEET 1 OF 1

0103-00-0061 E

REV	ECN	BY	DATE	APP
E	ECN 1103	Ro		
F	ECN 1116	BA	10-15-74	
G	ECN 1212	BA	2-18-5	
H	ECN 1324	Ro	7-7-5	
J	ECN 1797	RO	9-1-78	
K	ECN 2293, 2609			
L	ECN 2459, 2905			
/	3362			
M	4222			
N	4920	DAM		
P	4603	DAM		A.R.T.
R	8402			



DETAIL "A"

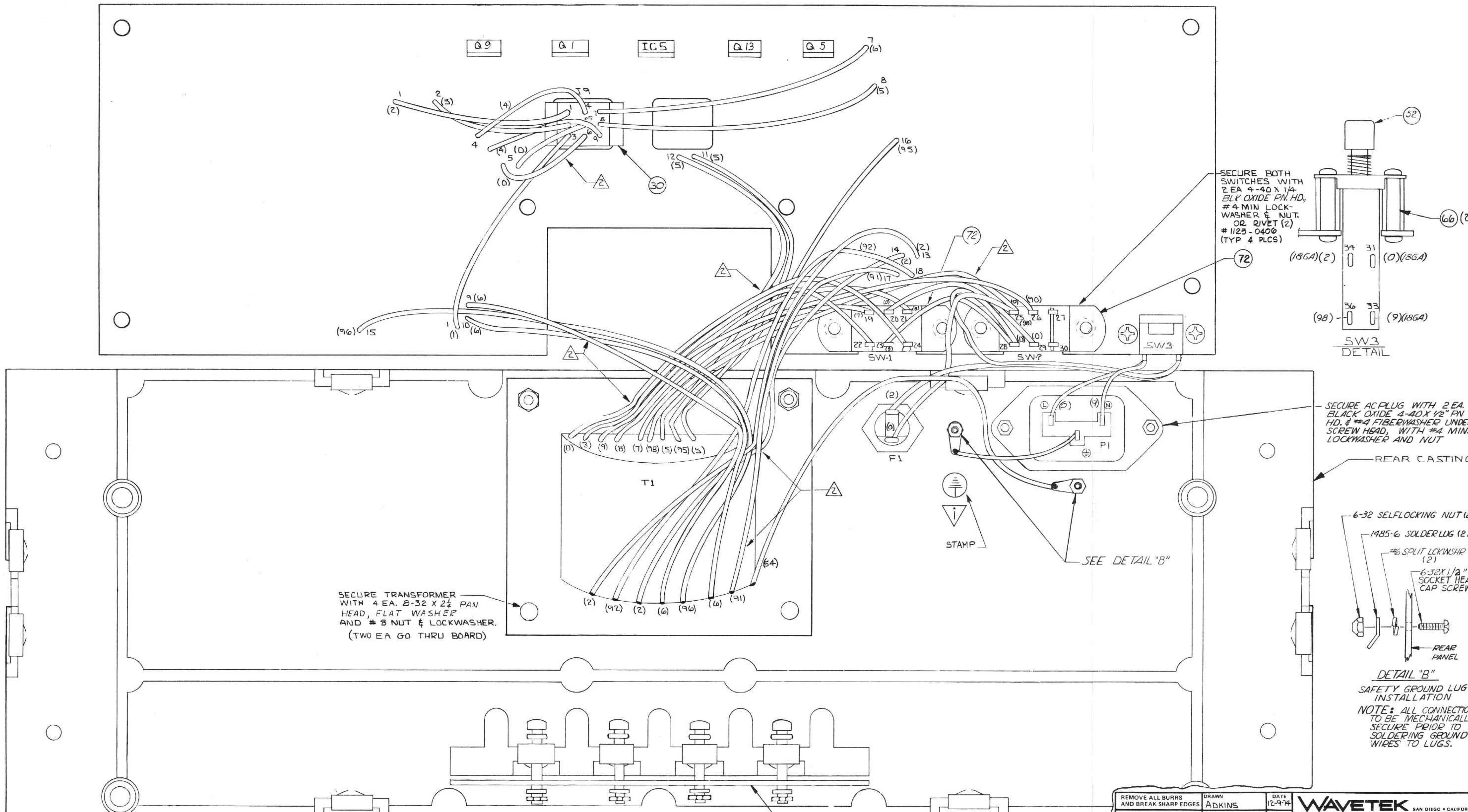


4. SHOWN FOR REFRENCE ONLY. SEE SHEET 2 FOR DETAILS.
3. APPLY SILICONE RUBBER (ITEM 59) AS REQUIRED TO THIS AREA ENCAPSULATING PROTRUDING SWITCH CONTACT PINS (THIS SIDE ONLY)
2. ✱ INDICATES RESISTORS MOUNTED OFF BOARD.
1. NUMBERS INDICATE CHASSIS WIRING. SEE CHASSIS SCHEMATIC.

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN B. REDMAN	DATE 3-14-74	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL /	PROJ ENGR		TITLE ASSEMBLY, POWER SUPPLY BD
	RELEASE APPROV (T.C.)		
FINISH WAVETEK PROCESS /	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 XX ±.030 ANGLES ±1		
	DO NOT SCALE DWG		MODEL NO. 147, 164 · DWG NO. 0101-00-0061 · REV R
	SCALE 2/1		CODE IDENT 23338 · SHEET 1 OF

NOTE:
INSTALL IC5, Q1, Q5, Q9 & Q10
WITH FULL LENGTH LEADS



4. WIRES MUST BE OF LENGTH THAT ALLOWS ASSY TO CLOSE TOGETHER.
3. (X) DENOTES WIRE COLOR PER RESISTOR CODE.
2 — PLACE WIRE TIES HERE. (APPROX)
NOTE: UNLESS OTHERWISE SPECIFIED
1. ASSY SHOWN WITH TRANSFORMER SECURED TO REAR CASTING AND POWER SUPPLY BOARD FOLDED BACK 180°.

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN ADKINS	DATE 12-9-74
MATERIAL	PROJ ENGR (T.O.)	3/11/75
	RELEASE APPROV (T.O.) 3/11/75	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 ANGLES ±1° .XX ±.030	
	DO NOT SCALE DWG	
	SCALE	

WAVETEK SAN DIEGO • CALIFORNIA

TITLE ASSEMBLY POWER SUPPLY

MODEL NO.	DWG NO.	REV
164	0101-00-0061	R
CODE IDENT 23338	SHEET 2 OF 2	

0101-00-0061 R

REV	ECN	BY	DATE	APP

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
9 9A	RAIL, SIDE	130-304	WVTK	1400-00-1073	2
8	CASTING, REAR FROM: 1400-00-4711	740-301	WVTK	1400-00-4739	1
7	PANEL, REAR	740-303	WVTK	1400-00-4770	1
NONE	PANEL, FT, R/M	740-308	WVTK	1400-00-4800	1
4	SHIELD	740-309	WVTK	1400-00-4813	1
NONE	COVER R/A-132	740-1632	WVTK	1400-02-1632	1
NONE	BINDING POST	BP21B	SUPEL	2100-01-0001	6
NONE	TERM, LOCK LUG	1414-10	SMITH	2100-04-0007	2
20 20A	SHORTING LINK	938-L	GENRD	2100-04-0020	2
17 17A	KNOB	020-322	ELMA	2400-01-0002	2
25 25A	KNOB CAP	040-302	ELMA	2400-01-0004	2
18 18A	LENS RED	BNG-51	ALCO	2400-02-0001	2
NONE	LAMP	7876	JKL	2400-02-0013	2
3	METER	740-503	WVTK	2400-06-0002	1
26	BAIL ASSY W/FT	130-507	WVTK	2800-08-0006	1
27	NUT, SPEED, SELF RETAIN	C7494-632-4	TINN	2800-09-0003	6

WAVETEK PARTS LIST — TITLE: R/M CHASSIS — ASSEMBLY NO. 1101-00-0061 — REV A — PAGE 1

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
NONE	NUT, SPEED, TYPE/U	C8091-632-4	TINN	2800-09-0004	4
NONE	PLUG BUTTON	PC47291	UNCAR	2800-09-0010	2
NONE	FAST, CHASSIS	1591-B11	USECO	2800-09-0021	8
NONE	STUD, PRESS, 6-32X. 625	FHS632-10	PEM	2800-09-0028	2
NONE	CAPTIVE SCREW	CA1376-10-3-9	TRIDR	2800-23-0001	2
NONE	POT, CONT, 1K	UM-5906	CTS	4600-01-0202	2
NONE	RES, C, 1/2W, 10%, 560K	RC-1/2-564J	STKPL	4700-25-5603	1
NONE	RES, MF, 1/8W, 1%, 18. 2K	RN55D-1822F	TRW	4701-03-1822	1
12	SWITCH, TOGGLE	7201P3DZGN	C&K	5106-00-0010	1
NONE	PWR CORD	17258-B	BELDN	6001-80-0003	1

WAVETEK PARTS LIST — TITLE: R/M CHASSIS — ASSEMBLY NO. 1101-00-0061 — REV A — PAGE 2

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES
MATERIAL
FINISH WAVETEK PROCESS
DRAWN / DATE
PROJ ENGR
RELEASE APPROV
TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 ANGLES ±1° .XX ±.030
DO NOT SCALE DWG
SCALE

WAVETEK SAN DIEGO • CALIFORNIA

TITLE: PARTS LIST R/M CHASSIS

MODEL NO. 164 — DWG NO. 1101-00-0061 — REV A

CODE IDENT 23338 — SHEET 1 OF 1