INSTRUCTION MANUAL

MODEL 148
20 MHz
AM/FM/PM GENERATOR

WAVETEK

WAVETEK SAN DIEGO, INC.

9045 Balboa Ave., San Diego, CA 92123

WARRANTY

All Wavetek instruments are warranteed against defects in material and workmanship for a period of one year after date of manufacture. Wavetek agrees to repair or replace any assembly or component (except batteries) found to be defective, under normal use, during this period. Wavetek's obligation under this warranty is limited solely to repairing any such instrument which in Wavetek's sole opinion proves to be defective within the scope of the warranty when returned to the factory or to an authorized service center. Transportation to the factory or service center is to be prepaid by purchaser. Shipment should not be made without prior authorization by Wavetek.

This warranty does not apply to any products repaired or altered by persons not authorized by Wavetek, or not in accordance with instructions furnished by Wavetek. If the instrument is defective as a result of misuse, improper repair, or abnormal conditions or operations, repairs will be billed at cost.

Wavetek assumes no responsibility for its product being used in a hazardous or dangerous manner either alone or in conjunction with other equipment. High voltage used in some instruments may be dangerous if misued. Special disclaimers apply to these instruments. Wavetek assumes no liability for secondary charges or consequential damages and, in any event, Wavetek's liability for breach of warranty under any contract or otherwise, shall not exceed the purchase price of the specific instrument shipped and against which a claim is made.

Any recommendations made by Wavetek for use of its products are based upon tests believed to be reliable, but Wavetek makes no warranty of the results to be obtained. This warranty is in lieu of all other warranties, expressed or implied, and no representative or person is authorized to represent or assume for Wavetek any liability in connection with the sale of our products other than set forth herein.

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SAFETY

This instrument is wired for earth grounding via the facility power wiring. Do not bypass earth grounding with two wire extension cords, plug adapters, etc.

BEFORE PLUGGING IN the instrument, comply with installation instructions.

MAINTENANCE may require power on with the instrument covers removed. This should be done only by qualified personnel aware of the electrical hazards.

WARNING notes call attention to possible injury or death hazards in subsequent operations.

CAUTION notes call attention to possible equipment damage in subsequent operations.

Model 148 20 MHz AM/FM/PM Generator

SECTION 1
GENERAL DESCRIPTION

1.1 THE MODEL 148

Wavetek Model 148, 20 MHz AM/FM/PM Generator is a precision source of sine, triangle, square, ramp and pulse waveforms plus dc voltage. The waveforms may be controlled in symmetry as well as amplitude and dc offset. A built-in modulation generator can modulate frequency, phase and amplitude or modulation may be by an external source.

The generator may be run in continuous mode or triggered for a single pulse or gated for a burst of pulses. Triggering and gating may be by the Model 148 built-in modulation generator or by an external source. The triggered and gated waveform start/stop point is selectable from −90° through +90°. Start/stop control plus dc offset control gives haverwave capability.

The main output of waveforms may be attenuated and offset. A TTL sync pulse is available at main generator frequencies, and the modulation generator waveforms are available at fixed amplitudes.

Frequency of both the main generator and the modulation generator can be manually controlled at the front panel or electrically controlled by external voltages.

1.2 SPECIFICATIONS

1.2.1 Main Generator

1.2.1.1 Waveforms

Selectable sine ∿, triangle ⋀, square ⊓⊔, positive square ⎍, negative square ⊔⊓ and dc. A TTL sync pulse is provided on a separate output connector. All can be produced with variable symmetry, amplitude and dc offset.

1.2.1.2 Operational Modes

Continuous: Generator oscillates continuously at the selected frequency.

External Trigger: Generator is quiescent until triggered by an external signal, then generates one cycle at the selected frequency.

External Gate: Same as external trigger, except generator oscillates at the selected frequency for the duration of the positive state of the external signal plus the time to complete the last cycle.

Internal Trigger: Same as external trigger, except that the modulation generator is internally connected to the trigger input of the main generator.

Internal Gate: Same as external gate, except that the modulation generator is internally connected to the trigger input of the main generator.

1.2.1.3 Modulation Modes

Internal Modulation
Setting a front panel modulation switch in the INT position routes the selected modulation function from the modulation amplitude control to the selected modulating circuits of the main generator.

Amplitude Modulation (AM): ∿, ⋀, ⊓⊔ modulation functions are used in this internal modulation mode. With modulation amplitude ccw, carrier at function output is not amplitude modulated and approximately half of normal (AM OFF) amplitude. Clockwise rotation of modulation amplitude results in increasing amplitude modulation of the carrier to at least 100% AM.

Frequency Modulation (FM) and Sweep: ⟋|⟋| and |⟍|⟍ modulation functions are used to linearly sweep the main generator frequency. The frequency dial sets the lower sweep limit and the modulation amplitude control determines the upper frequency limit (not to exceed 2.0 × multiplier). A sweep set mode allows precision setting of upper frequency limit. For frequency deviation, the dial determines the center frequency and modulator ∿, ⋀ or ⊓⊔ varies the main generator frequency above and below center by an amount determined by the modulation amplitude.

Phase Modulation (PM): As in External Modulation. Amplitude of modulator ∿ , ⋀⋁ , ⊓⊔ functions varies phase up to ±50°.

External Modulation
A BNC feeds an external signal to the modulating circuits when selected by a front panel modulation toggle switch in the EXT position.

Amplitude Modulation (AM): External modulating signals with zero dc component produce suppressed carrier modulation; i.e., a carrier (at main generator function output) amplitude of zero. The function output modulated signal has an amplitude sensitivity of 3 volts peak (1.5 Vp into 50Ω) per volt peak in. A carrier signal level at the function output can be produced at a sensitivity of 3 Vp (1.5 Vp into 50Ω) per 1 Vp dc component in. Modulating the dc component modulates the carrier level. Percent modulation (AM) will be the ratio of the peak ac to peak dc of the modulating signal. Input impedance is >2.5 kΩ.

Frequency Modulation (FM) and Sweep: Sensitivity is 20% of frequency range/volt peak. Linear behavior results only when all instantaneous frequencies called for fall within the frequency range (2 × multiplier to 0.002 × multiplier). The instantaneous frequency called for is the multiplier and dial setting altered by the instantaneous voltage at the modulation input. Input impedance is 5 kΩ.

Phase Modulation (PM): Sensitivity is 10° phase shift/volt peak. Linear behavior results only when all instantaneous transition frequencies called for fall within the frequency range (2 × multiplier to 0.002 × multiplier).The instantaneous frequencies called for will depend heavily on the modulation frequency and waveform. Inoperative at frequency multiplier settings below 100. Input frequencies roll off at 6 dB/octave above one half of full range frequency and above 150 kHz. Input impedance is 10 kΩ.

1.2.1.4 Frequency Range

0.0002 Hz to 20 MHz in 10 overlapping ranges with approximately 1% vernier control.

1.2.1.5 Function Output (50Ω)

∿ , ⋀⋁ and ⊓⊔ selectable and variable to 30V p-p (15V p-p into 50Ω). ⊓ and ⊔ up to 15 Vp (7.5 Vp into 50Ω). All waveforms and dc can supply 150 mA peak current and may be attenuated to 60 dB in 20 dB steps. An additional 20 dB vernier also controls the waveform amplitudes.

1.2.1.6 Adjustable Waveform Start/Stop Point

Approximately −90° to +90° to 2 MHz (operative on sine and triangle waveforms only).

1.2.1.7 DC Output and DC Offset

Selectable through function output (50Ω). Controlled by front panel controls between ±15 Vdc (±7.5 Vdc into 50Ω) with signal peak plus offset limited to ±15 Vdc (±7.5 Vdc into 50Ω). DC offset and waveform attenuated proportionately by the 60 dB output attenuator.

1.2.1.8 External Modulation Input

AM: Sensitivity of 3 Vp out/Vp (1.5V into 50Ω). Input impedance is >2.5 kΩ.
FM: Sensitivity of 20% of frequency range/Vp. Input impedance is 5 kΩ.
PM: Sensitivity of 10° phase shift/Vp. Input impedance is 10 kΩ.

1.2.1.9 Symmetry

Symmetry of all waveform outputs is continuously adjustable from 1:19 to 19:1. Varying symmetry provides variable duty-cycle pulses, sawtooth ramps and nonsymmetrical sine waves.

NOTE

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

1.2.1.10 Sync Output (TTL)

TTL level pulse which will drive 10 TTL loads. Frequency and time symmetry are the same as for function output.

1.2.1.11 Trigger and Gate

Input Range: 1V p-p to ±10V.
Input Impedance: 10 kΩ, 33 pF.
Pulse Width: 25 ns minimum.
Repetition Rate: 10 MHz maximum.
Adjustable triggered signal start/stop point: approximately −90° to +90° to 2 MHz.

1.2.1.12 Frequency Precision

Dial Accuracy

±(1% of setting +1% of full range) on ×100 thru ×1M ranges.
±(2% of setting +2% of full range) on ×.01 thru ×10 and ×10M ranges.

Time Symmetry

±0.5% on ×100 thru ×100k ranges and from 0.2 to 2.0 on dial.
±5% on all other ranges and from 0.02 to 2.0 on dial.

1.2.1.13 Amplitude Precision

Amplitude Change With Frequency

Sine variation less than:
±0.1 dB thru ×100k ranges;
±0.5 dB on ×1M range;
±3 dB on ×10M range.

Step Attenuator Accuracy

±0.3 dB per 20 dB step at 2 kHz.

1.2.1.14 Waveform Characteristics

Sine Distortion

<0.5% on ×100 Hz to ×10 kHz.
<1.0% on ×.01 to ×10 Hz and ×100 kHz ranges.
All harmonics 30 dB below fundamental on ×1 MHz range.
All harmonics 26 dB below fundamental on ×10 MHz range.

Square Wave Rise/Fall Times

At FUNCTION OUT <25 ns for 15V p-p into a 50Ω load.

Triangle Distortion

Odd harmonics within 15% of correct value to 2 MHz.

1.2.2 Modulation Generator

1.2.2.1 Waveforms

Selectable sine ∿, triangle ⋀⋁, square ⊓⊔, up ramp ⟋|⟋| and down ramp |⟍|⟍.

1.2.2.2 Frequency Range

∿, ⋀⋁, ⊓⊔ 0.1 Hz to 100 kHz in three 100:1 ranges.
⟋|⟋|, |⟍|⟍ Sweep: 0.2 Hz to 200 kHz (2 × setting).

1.2.2.3 Output (600Ω)

∿, ⋀⋁ and ⊓⊔ are fixed level 10V p-p balanced about ground. ⟋|⟋| and |⟍|⟍ are fixed level 5 Vp from 0 to +5V.

1.2.2.4 Frequency Modulation (FM IN)

Voltage control of modulator frequency with sensitivity of 20% of range per volt. Input impedance is 5 kΩ.

1.2.2.5 Waveform Characteristics

Sine Distortion

<5%.

Time Symmetry

<1% from 1 Hz to 10 kHz.
<5% from 0.1 Hz to 100 kHz.

1.2.3 General

1.2.3.1 Stability (for amplitude, dc offset and frequency)

Short Term: ±0.05% for 10 minutes.
Long Term: ±0.25% for 24 hours.

1.2.3.2 Environmental

Specifications apply at 25°C ±5°C ambient. Instrument will operate from 0°C to 50°C ambient temperatures.

1.2.3.3 Dimensions

28.6 cm (11¼ in.) wide; 13.3 cm (5¼ in.) high; 27.3 cm (10¾ in.) deep.

1.2.3.4 Weight

5 kg (11 lb) net; 6.6 kg (14½ lb) shipping.

1.2.3.5 Power

90 to 105V, 108 to 126V, 198 to 231V and 216 to 252V selectable; 48 to 400 Hz; less than 40 watts.

NOTE

Unless otherwise noted, all specifications apply from 0.1 to 2.0 on frequency dial when FUNCTION OUT is at maximum and 50Ω terminated, with SYMMETRY control at OFF. Symmetry and vernier affect frequency calibration. Maximum possible asymmetry is a function of frequency setting.

SECTION 2
INITIAL PREPARATION

2.1 MECHANICAL INSTALLATION

After unpacking the instrument, visually inspect all external parts for possible damage to 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

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 120 Vac line supply and with a ½ amp fuse.

Conversion to other input voltages requires a change in rear panel fuse holder voltage card position and fuse (figure 2-1) according to the following procedure.

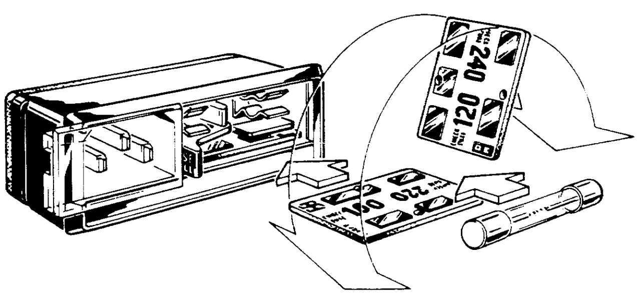


Figure 2-1. Voltage Selector and Fuse

1. Disconnect the power cord at the instrument, open fuse holder cover door and rotate fuse-pull to left to remove the fuse.

2. Remove the small printed circuit board and select operating voltage by orienting the printed circuit board to position the desired voltage to the top left side. Push the board firmly into its module slot.

3. Rotate the fuse-pull back into the normal position and insert the correct fuse into the fuse holder. Close the cover door.

4. Connect the ac line cord to the mating connector at the rear of the unit and the power source.

Card Position	Input Vac	Fuse
100	90 to 105	½ amp
120	108 to 126	½ amp
220	198 to 231	¼ amp
240	216 to 252	¼ amp

2.2.2 Signal Connections

Use RG58U 50Ω coaxial cables equipped with BNC connectors to distribute signals when connecting this instrument to associated equipment.

2.3 ELECTRICAL ACCEPTANCE CHECKOUT

This checkout procedure verifies the generator operation. If a malfunction is found, refer to the Warranty in the front of this manual. A dual trace, 150 MHz bandwidth oscilloscope with X 10 time base magnification, a 50Ω load, a coaxial tee and three 50Ω cables are required to perform this checkout.

Set up as in figure 2-2 and preset the generator front panel controls as follows.

Control	Position
Frequency Dial	2.0
FREQ MULT (bottom row of switches)	10K
VERNIER	cw
SYMMETRY	OFF
DC OFFSET	OFF
FUNCTION (bottom row of switches)	⊓⊔
TRIG START/STOP	0° CAL
ATTENUATION	20|0
AMPLITUDE	cw
FREQ/PERIOD MULT	10|1K
FREQ/PERIOD VARIABLE	cw
FUNCTION (modulation generator)	∿
MOD AMPLITUDE	ccw
MODULATION Switches	OFF
Mode Switch	CONT
TRIGGER LEVEL	10 o'clock
POWER	ON

Perform the steps in table 2-1. Only approximate values are required to verify operation.

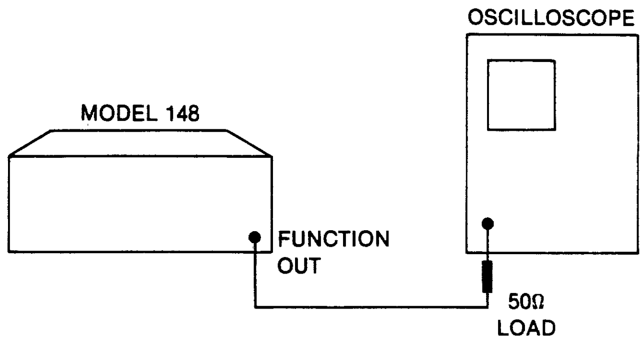


Figure 2-2. Initial Setup

Table 2-1. Initial Checkout

Step	Control	Position/Operation	Observation
1	FUNCTION	Rotate to all positions. Return to ∿ .	∿ , ⋀⋁ , ⊓⊔ are 15V p-p; ⎍ , ⊔⊓ are 7.5 Vp. DC is 0V.
2	ATTENUATION	Rotate ccw. Return to 20|0.	Waveform amplitude is successively 15, 1.5, 0.15 and 0.015V p-p.
3	AMPLITUDE	Rotate ccw. Return to 12 o'clock.	Ccw decreases amplitude.
4	DC OFFSET	Rotate cw. Return to OFF.	Ccw of 0 gives negative offset; cw of 0 gives positive offset. Clipping occurs when offset + waveform peak amplitude exceeds ±7.5V. OVERLOAD LED lights when clipping occurs.
5	SYMMETRY	Rotate cw. Return to OFF.	Frequency decreases to 2 kHz. Ccw of control midpoint gives 1:19; cw gives 19:1.
6	FREQ MULT	Rotate to all positions. Return to 10K.	Frequency is 2 × each setting.
7	FREQ VERNIER	Rotate ccw. Return cw.	Frequency decreases slightly when turned ccw (∿ 1% of range).
Set up the generator as in figure 2-3. Trigger on channel 2 and observe channel 2 (MODULATION GENERATOR OUT).			
8	MODULATION GENERATOR FUNCTION	Rotate to all positions. Return to ∿ .	∿ , ⋀⋁ , ⊓⊔ are 10V p-p; ⟋|⟋| , |⟍|⟍ give 2 kHz, 5 Vp ramp; SWP SET gives 5 Vdc.

Table 2-1. Initial Checkout (Continued)

Step	Control	Position/Operation	Observation
9	FREQ/PERIOD MULT	Rotate to all positions. Return to 10 I 1K.	Frequency is approximately the value to the right of the detent mark.
10	FREQ/PERIOD VARIABLE	Rotate ccw. Return to 12 o'clock.	Frequency decreases to approximately 10 Hz when full ccw.
Observe both channels.			
11	Mode	INT GATE.	
12	TRIGGER LEVEL	Rotate throughout its range.	The number of waveform cycles in each gated "burst" varies with the trigger level.
13	Mode	EXT GATE.	Gated waveforms the same as with INT GATE.
14	Mode	INT TRIG.	
15	TRIGGER LEVEL	Rotate throughout its range.	The relative position of the waveform on each channel shifts (indicates the change in trigger level).
16	TRIG START/STOP	Rotate throughout its range.	The waveform start/stop point varies from −90° to +90°.
17	Mode	EXT TRIG.	Triggered waveform.
Set up the generator as in figure 2-4.			
18	Mode	CONT.	
19	AM	INT.	Ch1 waveform amplitude varies with instantaneous amplitude of Ch2 waveform.
20	MOD AMPLITUDE	Rotate throughout its range.	Amount of modulation increases through 100% when cw. If waveform clipping occurs, OVERLOAD LED will light.
21	AM	EXT; return to OFF.	Ch1 waveform is suppressed carrier type. Amplitude varies with instantaneous amplitude of Ch2 waveform.
22	FM/SWP	INT.	Ch1 frequency varies with instantaneous amplitude of Ch2 waveform.
23	MOD AMPLITUDE	Rotate throughout its range.	Amount of modulation increases when cw.
24	FM	EXT; return to OFF.	Ch1 frequency varies with instantaneous amplitude of Ch2 waveform.
25	FREQ MULT	100.	

Table 2-1. Initial Checkout (Continued)

Step	Control	Position/Operation	Observation
26	Dial	1.2; set scope for 2 or 3 cycles; sync scope on line and fine tune generator frequency for stable pattern.	
27	PM	INT.	
28	AMPLITUDE	cw.	
29	MOD AMPLITUDE	Rotate throughout its range.	Phase or position of Ch1 waveform varies with instantaneous amplitude of Ch2 waveform.

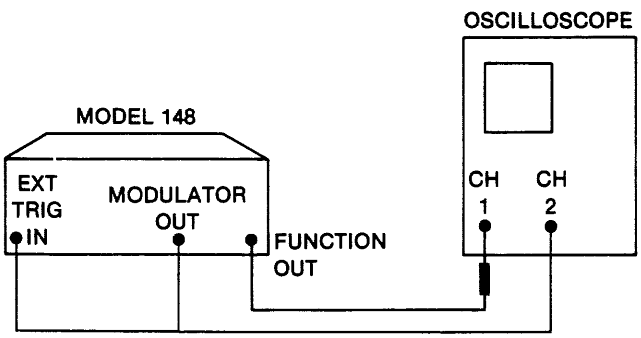


Figure 2-3. Second Setup

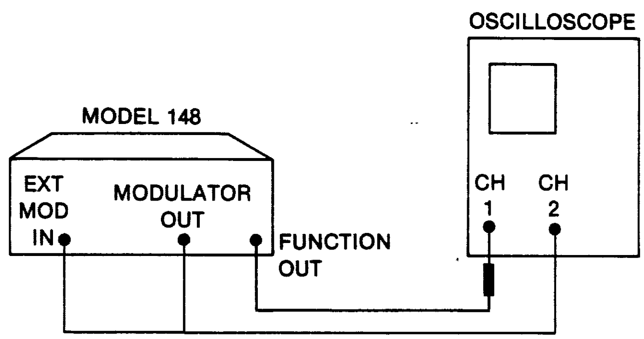


Figure 2-4. Third Setup

SECTION 3
OPERATION

3.1 CONTROLS AND CONNECTORS

The following item numbers are keyed to figure 3-1.

3.1.1 Main Generator

1 **Frequency Dial** — The frequency control of the main generator. The setting on this dial multiplied by the FREQ MULT **13** setting is the basic output frequency of the generator at the FUNCTION OUT **6** and SYNC OUT **7** BNCs. The FREQ VERNIER **13** and, in some cases, the modulation generator also affect the main generator frequency.

2 **Mode Switch** — This outer switch selects the operating mode of the main generator as follows:

a. **EXT GATE Mode** — The main generator is quiescent until a proper gate signal is applied at the EXT TRIG IN BNC **12** and then outputs the selected signal for the duration of the gate signal, plus the time to complete the last cycle generated.

b. **EXT TRIG Mode** — Same as for EXT GATE mode, except the main generator output is one cycle of selected signal only.

c. **CONT Mode** — The output signal is continuous.

d. **INT TRIG** — Same as for EXT TRIG mode, except the trigger signal is applied internally by the modulation generator.

e. **INT GATE** — Same as for EXT GATE, except the gate signal is applied internally by the modulation generator.

TRIGGER LEVEL Control — This inner control is a continuously variable adjustment of the trigger circuitry firing point. When full ccw, a positive going pulse at approximately −7.5V is required for triggering (see figure 3-2). In the full cw position, a positive going pulse at approximately +7.5V or more positive voltage is required for triggering. In the GATE modes, the generator will run continuously when the control is cw of 12 o'clock.

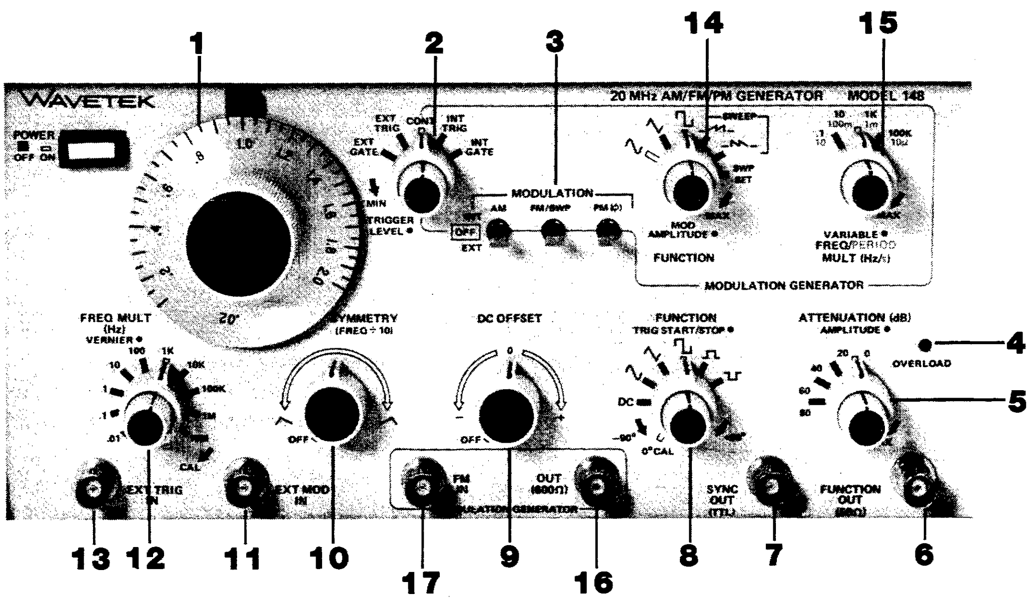


Figure 3-1. Controls and Connectors

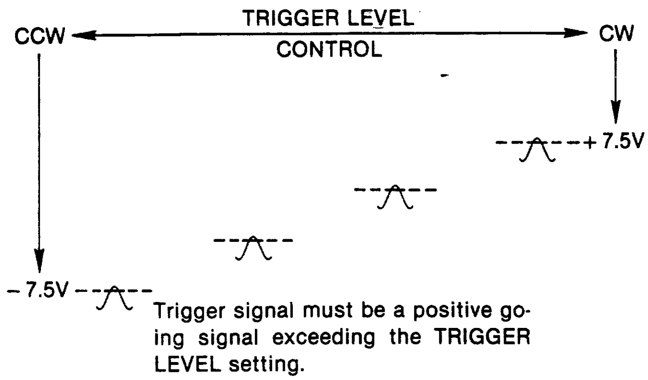


Figure 3-2. Minimum Trigger Signal

3 **MODULATION Switches** — These three switches (AM, FM/SWP and PM) set the type of modulation of the main generator (amplitude, frequency or phase) and select the source of modulation signals as either internal from the modulation generator or external at the EXT MOD IN BNC **11**. Each switch has an OFF position for no modulation. When the AM switch is set to INT, the main generator amplitude and attenuation are automatically 50% of normal to prevent overmodulation. When the AM switch is set to EXT, the main generator amplitude is automatically fixed at zero to allow suppressed carrier operation.

4 **OVERLOAD Indicator** — LED lights if ±7.5 peak voltage into 50Ω (output amplifier limits) is exceeded.

5 **ATTENUATION Switch** — This switch selects the attenuation range of the FUNCTION OUT **6** signal. The inner AMPLITUDE control is a vernier that sets the waveform amplitudes between the two values indicated by the ATTENUATION switch. The dc offset is attenuated to the value clockwise of the position selected. ∿ , ⋀ and ⊓⊔ are variable to 30V p-p (15V p-p into 50Ω). ⊓ and ⊔ are variable to 15 Vp (7.5 Vp into 50Ω). Waveforms and dc can supply 150 mA peak current. When the AM MODULATION switch is set to INT or EXT, the ATTENUATION and AMPLITUDE controls are affected. (Refer to item number **3**.)

6 **FUNCTION OUT (50Ω) Connector** — This BNC is the waveform (or dc) output of the main generator.

7 **SYNC OUT (TTL) Connector** — This BNC is the output of a TTL pulse at the main generator frequency, synchronous with the FUNCTION OUT **6** signal in frequency and waveform symmetry. The TTL pulse will drive 10 TTL loads.

8 **FUNCTION Switch** — This switch selects the primary waveform (or dc) output of the main generator at the FUNCTION OUT BNC: sine (∿), triangle (⋀), square (⊓⊔), positive half square (⊓) and negative half square (⊔).

TRIG START/STOP Control — This inner control sets the main generator waveform start and stop point. It applies only to the ∿ and ⋀ waveforms, to the trigger and gate modes and to waveforms less than 2 MHz. Range is 0 ±90°. A 0° CAL detent ensures standard waveforms that start and stop at 0°.

9 **DC OFFSET Control** — This control offsets the main generator output waveform vertically from its normal position and, when FUNCTION switch **8** is in DC position, controls polarity and voltage of dc output. Offset range is 0 ±15 Vdc (±7.5 Vdc into 50Ω). An OFF detent ensures zero offset. DC and dc offset are attenuated by the ATTENUATION control **5**, but not by the AMPLITUDE control **5**. Waveform peak voltage plus dc offset is limited to ±15V (±7.5V into 50Ω).

10 **SYMMETRY Control** — This control varies the symmetry of the waveforms (normally 50% duty cycle). Symmetry range, half cycle to half cycle, is 19:1 to 1:19. An OFF detent ensures 1:1 (50%) symmetry. When SYMMETRY control is used, main generator frequency is divided by 10.

11 **EXT MOD IN Connector** — This BNC receives the external modulation signal. This signal is applied to the modulating circuits when a MODULATION switch **3** is in the EXT position.

12 **EXT TRIG IN Connector** — This BNC receives the external trigger and gate signals. These signals are applied to the trigger and gate circuits when the mode switch **2** is in EXT TRIG or EXT GATE positions. Refer to paragraph 1.2 for trigger signal requirements. The TRIGGER LEVEL control **2** selectively accepts trigger and gate signals for the trigger and gate circuits.

13 **FREQUENCY MULT Switch** — This outer switch selects one of ten frequency multipliers for the dial **1** setting.

VERNIER Control — This inner control is a fine adjustment of the frequency dial **1** setting.

3.1.2 Modulation Generator

14 **FUNCTION Switch** — This switch selects the waveform output of the modulation generator. Output is at the OUT BNC connector **16** and is also available internally to the main generator. Waveforms are sine (∿), triangle (/\/), square (⊓⊔), ramp up (/|/|) and ramp down (|\|\ ). A SWP SET detent holds the OUT BNC at AMPLITUDE control **14** level; used to set upper sweep frequency.

MOD AMPLITUDE Control — This inner control attenuates the modulation generator signal that is internally fed to the main generator when modulating. It has no effect during internal triggering or gating and it has no effect on the OUT **16** signal.

15 **FREQ/PERIOD MULT Switch** — This outer switch (with ranges given in both frequency and period) selects the modulation generator frequency/period range.

VARIABLE Control — This inner control sets the frequency/period within a range.

16 **OUT (600Ω) Connector** — This BNC is the modulation generator waveform output: sine (∿), triangle (/\/) and square (⊓⊔) fixed level 10V p-p (5V p-p into 600Ω) waveforms balanced about ground and ramp (/|/|, |\|\ ) fixed level 0 to +5 Vp waveform.

17 **FM IN (5 kΩ) Connector** — This BNC is the input for frequency modulation of the modulation generator. Sensitivity is 20% of frequency range per volt in.

3.2 OPERATION

For convenience, the generator operation has been grouped in seven basic modes, from which many variations and combinations are possible. The following paragraphs give basic switch positions for each mode and requirements and suggestions for operation.

The basic modes of operation are:

a. **Continuous** — A continuous output signal.

b. **Triggered** — One cycle of waveform for each trigger signal.

c. **Gated** — A "burst" of waveforms for the duration of each gate signal.

d. **AM** — The instantaneous amplitude of the output signal varies with the instantaneous amplitude of the modulation signal.

e. **FM** — The instantaneous frequency of the output signal varies with the instantaneous amplitude of the modulation signal.

f. **PM** — The instantaneous phase of the output signal varies with the instantaneous amplitude of the modulation signal.

g. **DC** — The dc output can be set from +15 Vdc to −15 Vdc (+7.5 Vdc to −7.5 Vdc into 50Ω).

3.2.1 Continuous Operation

When setting up the generator, it is advisable to observe the output on an oscilloscope. Connect FUNCTION OUT to the scope input using a 50Ω cable and a 50Ω load. For continuous waveform output, select a basic waveform at the desired frequency. Ensure the modulation switches are set to OFF and the mode is set to CONT. The output amplitude can be as great as 15V p-p; attenuate as desired.

NOTE

For best waveform quality, use the ATTENUATION SWITCH for gross attenuation; then use the AMPLITUDE control for fine attenuation.

The waveform may be skewed to the left or right using the SYMMETRY control; e.g., making a ramp (/|) from a triangle (/\/) waveform.

NOTE

The output frequency is divided by 10 when the SYMMETRY control is switched from the OFF position.

The dc level of the waveform may be varied with the DC OFFSET control, but waveform clipping can occur.

NOTE

Waveform clipping will occur (OVERLOAD LED will light), unless waveform amplitude is decreased so that waveform plus offset is less than 7.5 volts at the waveform peak.

3.2.2 Triggered Operation

In triggered operation, there is one cycle of output for each trigger signal input. For triggered operation, first set up the generator for continuous operation (refer to paragraph 3.2.1). The main generator may be triggered internally by the modulation generator or triggered by an external source. If an unmodulated waveform is being output, the modulation generator is free to give the desired triggering frequency and should be selected as the trigger source. Use any modulation generator waveform as the trigger. Set the modulation generator frequency for the desired trigger frequency and sync on the modulation generator output.

NOTE

1. *Trigger frequency must be slower than the output waveform frequency.*
2. *The MOD AMPLITUDE control has no effect in INT TRIG and INT GATE modes.*

Rotate the TRIGGER LEVEL control to obtain a good trigger. If the waveform start/stop point is to be other than zero degrees, set the TRIG START/STOP control as required. (See figure 3-3.) Haverwaves can be set up using start/stop control and dc offset control.

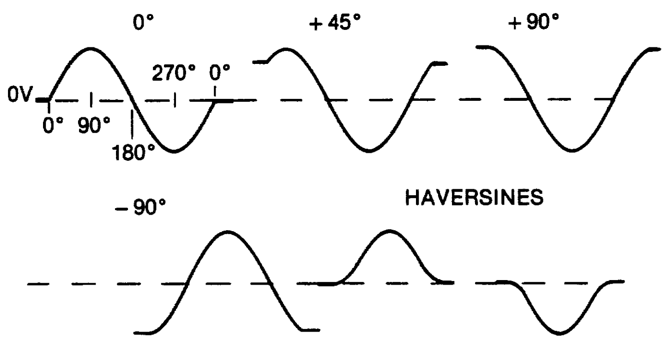


Figure 3-3. Waveform Start/Stop Examples

If external triggering is to be used, connect a repetitive signal with a positive going transition of greater than one volt to EXT TRIG IN using a 50Ω cable. Adjust the TRIGGER LEVEL control for proper triggering.

3.2.3 Gated Operation

In gated operation there is a "burst" of waveforms lasting the duration of the gate pulse plus the time required to complete the last cycle of waveform started. Set up as for triggered operation (refer to paragraph 3.2.2) and select a "trigger" signal whose duty time gives the desired waveform burst.

3.2.4 Manual Triggering and Gating

The TRIGGER LEVEL control can also be used for manually triggering or gating the generator. For manually triggering (single cycles), the generator mode should be EXT TRIG with no external signal input at the EXT TRIG IN connector. Each time TRIGGER LEVEL is rotated cw through mid-position, one triggered cycle will be generated. In EXT GATE mode, the generator runs continuously as long as the TRIGGER LEVEL is cw of mid-position.

3.2.5 AM Operation

In amplitude modulation, the instantaneous amplitude of the output signal varies with the instantaneous amplitude of the modulation signal.

NOTE

The output waveform will be clipped (OVERLOAD LED will light) if any instantaneous amplitude greater than ±15 volts (±7.5 volts into 50Ω) is produced.

Set up the generator as for continuous operation (refer to paragraph 3.2.1). Switch to internal or external amplitude modulation. If internal, note that the carrier (main generator waveform) mean amplitude is decreased to half. This is to prevent clipping (overdriving the output amplifier) when the carrier amplitude is modulated (increased and decreased) by another signal. Set the modulation generator frequency to a lower frequency than the main generator and sync the scope to the modulation generator output. Set the modulator amplitude for a desired percentage of amplitude modulation (0 to greater than 100% range) and set the main generator ATTENUATION and AMPLITUDE controls for a desired amplitude of modulated waveform. If external modulation is selected, observe that the carrier (main generator waveform) amplitude drops to zero (null). This is for suppressed carrier mode of amplitude modulation. Connect the modulator OUT (600Ω) to the EXT MOD IN with a coaxial cable. Set the main generator ATTENUATION and AMPLITUDE controls for a desired amplitude of suppressed carrier waveform. For best results when using an external modulation signal at EXT MOD IN, maintain as near as convenient a 5 Vp amplitude (which does not exceed 5 Vp); then use the main generator ATTENUATION and AMPLITUDE controls. An external source may also be used for regular AM operation, rather than suppressed carrier operation, by supplying a dc component along with the ac modulating signal (observing 5 Vp limit) to set the carrier level.

3.2.6 FM Operation

In FM operation, the instantaneous frequency of the output signal varies with the instantaneous amplitude of the modulating signal.

NOTE

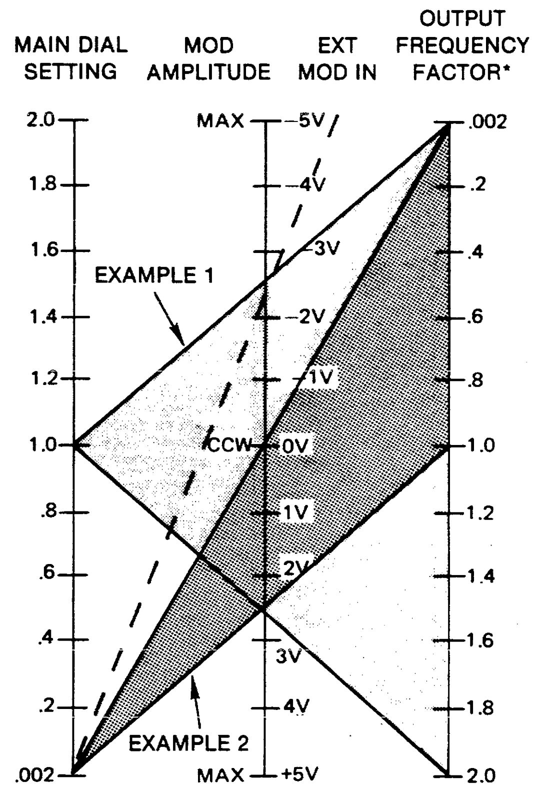
The output frequency modulation will not be linear when the instantaneous modulated frequency exceeds these range limits.

Upper Limit: 2.0 × FREQ MULT
Lower Limit: 0.001 × Upper Limit

Set up the generator as for continuous operation (refer to paragraph 3.2.1). The frequency setting will be the center frequency from which the modulated signal will vary. Switch to internal or external FM modulation. If internal, set the modulation generator frequency as desired and sync on the modulation generator signal. Set the modulation amplitude for the amount of modulation desired. Because the main generator is limited in frequency range (limited to approximately the dial range for any given multiplier setting), the main generator frequency dial and the modulation amplitude control must be balanced to stay within that range. The range is shown in figure 3-4 as the OUTPUT FREQUENCY FACTOR, which, when multiplied by the FREQ MULT setting, gives the actual output frequency. Example 1 shows the output being swept over the full frequency range when the main generator frequency dial is set at midpoint (1.0), the MOD AMPLITUDE control set at midrange and the modulation signal is a balanced waveform (∿ , ∿ or ⊓); that is, the modulation generator voltage swings both positive and negative. If the MOD AMPLITUDE control is rotated toward ccw, the voltage swing decreases and the angle subtended in the nomograph decreases. If the MOD AMPLITUDE control is rotated toward MAX, the angle subtended would overshoot the OUTPUT FREQUENCY FACTOR range, indicating that saturation is likely.

3.2.7 Sweep Operation

For sweep operation, set up the generator for continuous operation (refer to paragraph 3.2.1). The frequency setting will be the lower frequency of the continuously varying (or swept) frequency. Switch FM/SWP to internal or external modulation as desired. If internal set the modulation generator FUNCTION



*Multiply by FREQ MULT for actual output.

Figure 3-4. Frequency Modulation Nomograph

switch to SWP SET, monitor the FUNCTION OUT with a counter or oscilloscope and vary the MOD AMPLITUDE control for exactly the upper frequency desired. Note that the main generator is limited in frequency range (limited to approximately the dial range for any given multiplier setting). Select either /\|/\| for sweep up or |\|\ for sweep down. Select the sweep rate desired. Keep in mind the /\|/\| and |\|\ frequencies are double the indicated frequencies on the FREQ/PERIOD control.

Example 2 shows the output being swept from the bottom of the range to midrange by setting the main dial fully cw and the VERNIER fully ccw for absolute bottom of the range. The MOD AMPLITUDE control was left at midrange and the ramp (/\|/\|) waveform used as the modulator. The ramp is a positive going only waveform. Had a balanced waveform been used, the angle subtended would have included the dotted line and resulted in saturation. If an external modulation signal is to be used, the EXT MOD IN values in the nomograph indicate the signal level required for the desired results.

3.2.8 PM Operation

In PM operation, the instantaneous phase of the output signal varies with the instantaneous change in amplitude of the modulating signal. The change in phase is made by changing the frequency of the generator until the correct phase angle change is made. The modulation circuit differentiates the modulation signal; that is, its output is proportional to the rate of change of modulation signal amplitude. This voltage is fed to the main generator in exactly the same manner as the FM voltage is. The voltage effects a change in frequency and, in the case of a step function modulation, for example, exists only long enough to cause the desired phase shift. Typically, less than one cycle is required to change the phase. When the phase angle is increased, the frequency increases to achieve it. When the phase angle is decreased, the frequency decreases to achieve it. The frequency required to change the phase also depends upon the modulation frequency and waveform.

NOTE

The output phase will not be linearly modulated when the instantaneous transition frequencies required to effect the phase change exceed these range limits.

Upper Limit: 2.0 × FREQ MULT
Lower Limit: 0.001 × Upper Limit

Nominally, the phase of the main generator is shifted ten degrees for each volt of instantaneous modulation signal. When the main generator is set above a range midpoint, the modulation signal begins to lose its effectiveness. The effect is that the input signal is rolling off at 6 dB/octave due to form factor limitations of the input differentiator. This effect also occurs for modulation signal frequencies above 150 kHz.

Set up the generator as for continuous operation (refer to paragraph 3.2.1). Select a range so that the frequency dial can be set at midpoint or below (for linear operation) and switch to internal or external phase modulation.

NOTE

There is no PM operation for frequency multipliers of 100 or less.

If internal, set the modulation frequency as desired. (If other than sine waveform is selected, greater than 150 kHz modulation frequencies are possible and the effective roll off must be considered.) Set the modulation amplitude as desired. Full range is 5 Vp and phase shift is 10° per 1 Vp.

NOTE

Because the initial phase reference no longer exists when the phase shifts, phase shift measurement will not be possible with an oscilloscope alone. To measure the phase shift, an additional circuit such as a phase modulator will be necessary to establish a phase angle baseline.

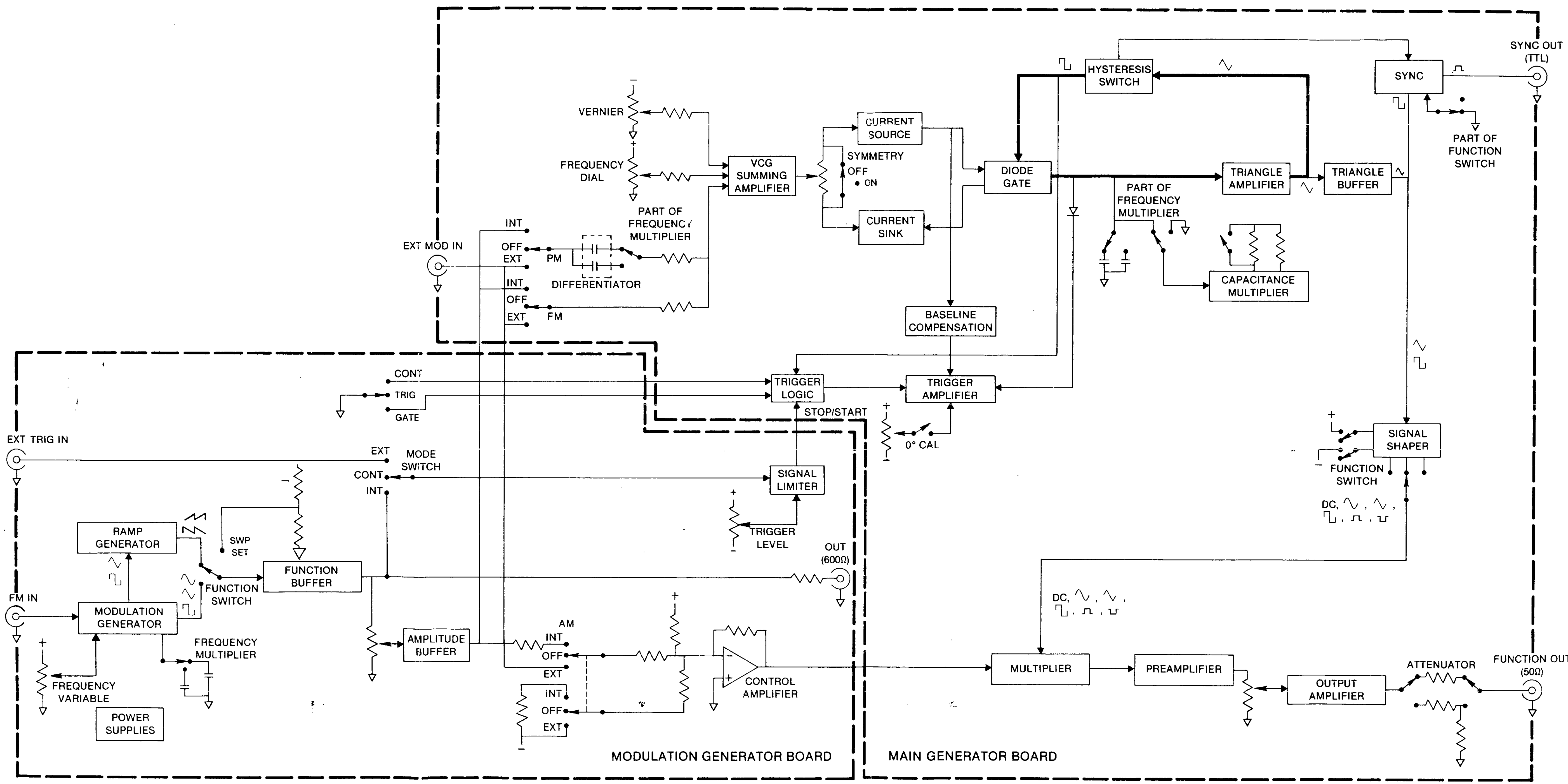


Figure 4-1. Functional Block Diagram

SECTION 4
CIRCUIT DESCRIPTION

4.1 FUNCTIONAL BLOCK DIAGRAM ANALYSIS

This section describes the functions of major circuit elements and their relationship to one another as shown in figure 4-1, functional block diagram, and figure 4-2, basic generator and timing diagram. Paragraph 4.2 provides further descriptions relating circuit blocks to schematics in section 7.

As shown in figure 4-1, the main generator VCG (Voltage Control of Generator frequency) summing amplifier receives inputs from the frequency dial, vernier, FM and PM switches which produce a sum current. The PM input is provided with a passive differentiator which produces a voltage proportional to the rate of change of the instantaneous voltage of the modulating signal.

The VCG summing amplifier is an inverting amplifier whose output voltage is used to control a complementary current source and current sink. For symmetrical output waveforms, the currents are equal and directly proportional to the algebraic sum of the VCG inputs. The diode gate, controlled by the hysteresis switch, switches either the current source or sink to the timing capacitor selected by the frequency multiplier control. When the current source is switched in, the charge on the capacitor will rise linearly producing the positive-going triangle slope. Likewise, the current sink produces the negative-going triangle slope.

The triangle amplifier is a unity gain amplifier whose output is fed to the hysteresis switch and to the triangle buffer. The hysteresis switch is a bistable device operating as a window detector with limit points set to the triangle peaks. When the hysteresis switch output is +2V, the triangle rises to the +1.25V limit, and the hysteresis switch goes to −2V. This switches currents at the diode gate and the negative-going triangle slope is started. When the triangle reaches the −1.25V limit, the hysteresis switch will switch back to positive, repeating the process. As shown in figure 4-2, this repetitive process results in the simultaneous generation of a square wave and a triangle wave at the same frequency.

The output frequency is determined by the magnitude of the capacitor selected by the frequency multiplier selector and by the magnitude of the currents supplied to and removed from it. Since the currents are linearly proportional to the sum of VCG inputs, so will be the output frequency. The capacitance multiplier provides the bottom four frequency ranges.

When the variable symmetry control is rotated, it first reduces the current sink by a factor of 19, making the negative-going triangle slope 19 times longer than normal. This results in an unsymmetrical waveform output and a frequency division by 10. Continued rotation gradually increases the current sink and reduces the current source in such a way that the period for the triangle to complete one cycle remains constant. This action produces continuously variable symmetry of the output waveforms over a 1:19 to 19:1 range while frequency remains constant at one-tenth of dial and multiplier settings.

The inverted square from the hysteresis switch is fed to the sync amplifier, where it is buffered and converted to a TTL level output, and to the square amplifier, where (if square or pulse functions are selected) a buffered square is sent to the signal shaper for conditioning.

The triangle buffer provides the ±1.25 triangle sufficient drive for the signal shaper and presents a small, constant load on the triangle amplifier.

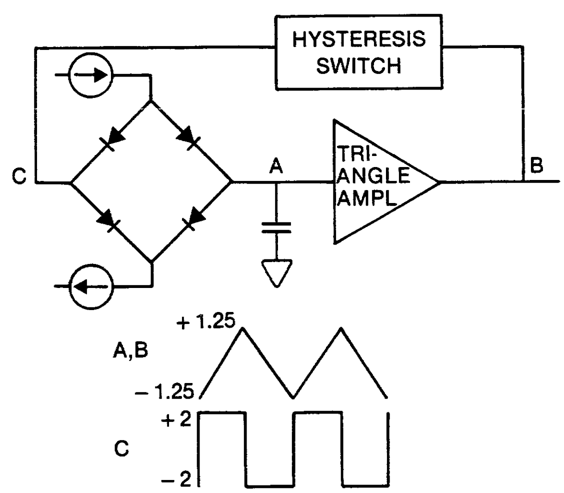


Figure 4-2. Basic Generator Block and Timing Diagram

The signal shaper contains switching elements and a diode array for signal conditioning the buffered triangle and square inputs into the various waveforms controlled by the function switch. The selected waveform is the carrier (+Y) input to the transconductance multiplier, an integrated circuit, four-quadrant multiplier.

The modulation (+X) input is a positive dc from the control amplifier when the AM switch is off, providing a fixed gain reference for the multiplier. Output currents from the multiplier are applied to the summing node of the preamplifier for conversion to an inverted voltage signal.

The preamplifier output is then attenuated by the front panel amplitude control and fed to the output amplifier summing node along with the dc offset control. The output amplifier is an inverting amplifier whose output is fed into step attenuator and then to the function output connector. The attenuator consists of a distributed network having 50Ω output impedance. This network provides attenuation in 20 dB (1/10) steps to 60 dB.

For continuous operation of the basic function generator loop (bold path in figure 4-1), the trigger amplifier must maintain a positive level above the most positive charge on the integrating capacitor in order to reverse bias the start/stop diode. Thus, in continuous mode the trigger logic senses the continuous control line from the front panel mode selector and holds the inverting trigger amplifier input low.

In triggered and gated modes the trigger amplifier outputs some level below the positive peak charging level, and the start/stop diode is forward biased to sink the current source and prevent the timing capacitor from charging to the positive peak. This stops waveform generation and holds the triangle output at some dc level called the trigger baseline. The trigger baseline is the level where a triangle, and thus sine, waveform starts and stops when triggered or gated.

The normal trigger baseline is zero volts, analogous to 0° phase of a sine or triangle waveform. The trigger start/stop control offsets the trigger amplifier output and can change the baseline for starting and stopping a sine or triangle waveform from its negative peak (−90°) to its positive peak (+90°). At the extreme positive peak level setting though, the diode is again reverse biased and generator operation goes continuous, independent of generator mode.

While the integrating capacitor is being held from charging, the start/stop diode must sink the current source, which has a magnitude variable with VCG inputs. Therefore, a compensation is necessary to the voltage level output by the trigger amplifier in order to maintain a constant baseline level as VCG inputs, current source magnitude and forward voltage drop by the start/stop diode are varied. The baseline compensation circuit measures the forward voltage across a diode placed in the current source and injects an offsetting current into the trigger amplifier to maintain an equal voltage differential between the baseline level and trigger amplifier output.

The trigger logic determines that after a waveform starts, it always stops at a complete cycle and at the same phase angle at which it started. The trigger logic receives a trigger stimulus from the signal limiter and latches the trigger amplifier output positive, allowing the generator loop to run. When the negative peak of the last cycle is reached (just one cycle in trigger mode), the square from the hysteresis switch latches the trigger amplifier back to its previous level. The integrating capacitor will charge back to the trigger baseline where the start/stop diode once again forward biases.

The generator mode switch sets the gated control line to determine whether the trigger logic is to latch the generator on for one cycle of for the duration of the trigger stimulus.

The modulation generator board contains the power supplies, the modulation generator and various switching elements to control the source and type of modulation and triggering signals to the main generator.

The modulation generator is an integrated circuit source of sine, triangle and square waveforms, whose frequency is controllable by front panel multiplier switch, variable control, and external voltage at the FM IN input. The triangle and square are applied to a ramp generator consisting of a balanced modulator and buffer amplifier to produce ramp waveforms. A modulation waveform or a SWP SET dc level is sent to the function buffer via the front panel function selector.

The function buffer output is sent to the modulation output (600Ω) connector, the generator mode switch for an internal trigger and gate stimulus, and the amplitude buffer after being attenuated by the front panel amplitude control. The amplitude buffer output goes to the AM, FM and PM switches "internal" positions. The EXT MOD IN connector provides a connection for an external signal to the switches "external" positions.

The FM and PM switches provide VCG inputs. The AM switch controls the control amplifier and thus the transconductance multiplier. When AM is off, the control amplifier produces a positive dc level giving the multiplier a fixed gain. With internal AM, the dc component from the control amplifier is cut in half, halving the output amplitude to prevent output clipping when modulating. The selected modulation waveform rides on the dc. The ac (modulation signal) has a peak value equal in magnitude to the dc level when the modulation amplitude control is maximum, making the sum of modulator and carrier signals equal to the maximum output capability of the output amplifier, and the difference equal to the zero output level, which is 100% modulation. Then, by varying the modulation signal, a variable 0 to 100% AM of the carrier (main generator) signal is produced. With external AM, the dc component is switched to 0 Vdc, resulting in zero amplitude output, and bipolar signal inputs at the EXT MOD IN connector will produce suppressed carrier (4-quadrant) modulation.

4.2 CIRCUIT ANALYSIS

4.2.1 VCG Amplifier

Figure 4-3 is a simplified schematic of the VCG circuitry. The value of a resistor "R" is 5 kΩ and supplies are ±15 Vdc. U1 is connected as a summing amplifier to sum the VCG inputs. A top of range input produces 1 mA through the feedback resistor resulting in −5 Vdc at the output of U1.

The negative input of U4 is held at the output level of U1 by controlling the current through Q2 as a feedback. One half the output of U1 is buffered by U3 and applied to the wiper of the variable symmetry control. The negative input of U2 is held at 0 Vdc by controlling the current through Q1 as a feedback. As long as the variable symmetry control is off, the two R/2 resistors have equal voltage across them and an equal current through them as through U1 feedback and there is no current at the output of U3. Since an equal current exists in the entire resistor string from + to − supply, the result is a positive control voltage relative to the negative supply at U6 + input and a negative control voltage with respect to the positive supply at U5 + input, each of which is proportional to the sum of the inputs to U1.

Similarly, U5 and U6 establish feedback by regulating current through FETs, producing a voltage drop across series resistors to the supplies equal to the control voltages. The FET currents will be switched at the diode gate into a timing capacitor to produce the triangle waveform.

4.2.2 Symmetry Control

Let the source of Q2 be −5 Vdc, the wiper of the symmetry control, −2.5 Vdc, and the source of Q1, 0 Vdc. The output of U3 will have no current, each R/2 resistor will have 1 mA, and generator frequency will be at maximum of the range. Open the symmetry switch and set the potentiometer to its electrical center. The output of U3 is still at an equipotential point, but now the total resistance with 5 Vdc across it has changed from R to 10R. Thus, current will drop to 100 μA and output frequency will drop to one-tenth of range. If the potentiometer is rotated, current will flow in U3 output to maintain the wiper at −2.5 Vdc. When the potentiometer is ccw, the wiper is at the positive direction and the upper R/2 will have 2.5V across it with a current source of 1 mA. But the lower R/2 is in series with 9R, which puts 2.5V across 19 × the normal resistance. Now the current sink will have one-nineteenth the magnitude of the current source. The output waveform for this condition is shown in figure 4-3. Regardless of where the symmetry control is rotated, frequency stays the same (one-tenth of range).

4.2.3 Range Switching

For frequency ranges associated with multiplier positions of 100 and 1K, main board schematic, sheet 1, the value of the current source and current sink setting resistors R326, R38, R48 and R330 is 5 kΩ, which provides integrating current sensitivity of 200 μA per volt of external FM input. With the timing capacitors of 1 and 0.1 μF, plus the bulk of the top range timing capacitor and the stray capacitance of the multiplier switch, the generator produces the calibrated output frequency for these ranges. In the top range (multiplier position of 10M), the current setting resistors are paralleled with resistors of one-ninth the value, causing both current sources to run at ten times the usual current, resulting in 2 mA per volt of external FM input. When this current is used with the nominal ~90 pF timing capacitor (fixed value plus strays), the top range of frequencies result. For the next three ranges down (multiplier positions 1M, 100K, 10K), the nominal timing capacitor is the fixed top range capacitor plus strays (i.e., ~90 pF) plus the switched values (11 pF, 910 pF, 0.01 μF). These result in joint timing capacitors of 101 pF, 1010 pF and 0.0101 μF. In these three ranges the positive and negative current sources are boosted by 1% over the next range down

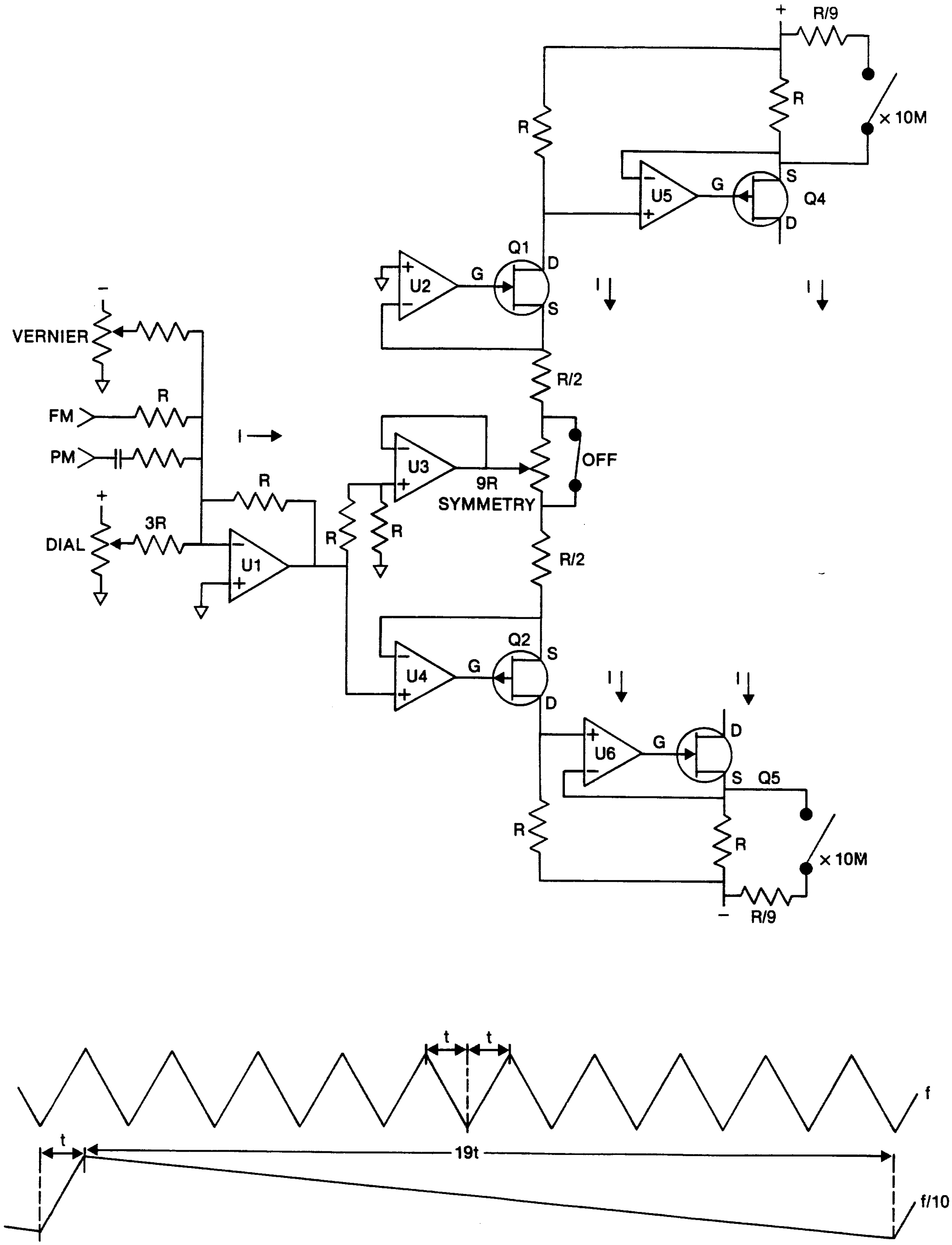


Figure 4-3. VCG Simplified Schematic

(multiplier 1K) by switching 500 kΩ resistors in parallel with the 5 kΩ basic current setting resistors R326, R38, R48 and R330 producing the output frequencies for these ranges. The four ranges below multiplier setting 100 all have the same integrating current and timing capacitor as the 100 multiplier range, but for each of these ranges, 90%, 99%, 99.9% and 99.99% of the integrating current is subtracted by the capacitance multiplier circuit.

4.2.4 Capacitance Multiplier

For the frequency ranges associated with multiplier positions of 10 through 0.01, a capacitance multiplier circuit (main board schematic, sheet 1), senses the timing capacitor charging current and subtracts the appropriate amount so that the effective charging current is a fraction of that delivered by the current sources. This is accomplished by the connection of the capacitance multiplier to the timing capacitor with one input-output terminal through a section of the frequency multiplier switch. The + terminals of U7 and U8 serve as potentiometric input to these amplifiers. U7 has a fixed resistive feedback network, giving it a fixed gain. Capacitor C26 is forced to comply to the triangle voltage wave being generated, because the R54 side is driven at the potential of the input/output terminal and the other side has the same waveform with some fixed gain from U7. Since the side driven at the input/output signal is a summing node, it is fed the necessary current by the feedback resistors R58, R59, R60 and R61. The feedback resistors are selected by the frequency multiplier control, taking on values which give the correct amplitude to the output of U8. This output with respect to common is the input/output waveform with a square wave superimposed; TP1 is the test point where this output can be picked up for signal tracing. The input/output waveform is a triangle wave so the differential across R62 and R63 is a square wave with the correct amplitude to subtract part of the timing capacitor charging current. Since this square wave amplitude is controlled in decades by the frequency multiplier control via R58, R59, R60 and R61, the instrument frequency is divided in decades even though the current sources and timing capacitor remain the same.

4.2.5 Triangle Amplifier

The main board schematic, sheet 2, shows the triangle amplifier; it uses Q8, an FET source follower, to drive Q10, a bipolar emitter follower, for an open loop gain of one. It is a fast, very high input impedance circuit with output impedance low enough to drive the hysteresis switch and the triangle buffer. In series with Q8 is a matched duplicate FET, Q9. Q9 has the identical drain current as Q8 and, therefore, the same gate-to-source voltage. In series with Q10 is a duplicate emitter follower, Q13. Q13 has the identical collector current as Q10; therefore, it has the same emitter-to-base voltage. Since the gate of the dummy FET, Q9, is connected to the emitter of the dummy emitter follower, Q13, the two terminals have the same voltage. Therefore, within the tolerances of the part parameters and some unaccounted error for base current, the active emitter follower output voltage will be at the value of the input gate. The remaining transistor, Q11, is a second emitter follower for driving the dynamic lead networks at the input of the hysteresis switch. In this role, it needs no dc integrity, as the output is not directly coupled.

4.2.6 Hysteresis Switch

The hysteresis switch (main board schematic, sheet 2) consists mainly of U14, a double input comparator, and Q14/Q15, an output flip-flop. Each differential pair of U14 compares an input voltage to common. The input network provides a positive bias to one and a negative bias to the other; therefore, when the input terminal (output of the triangle amplifier) is at ± 1.25V, the flip-flop changes state. The flip-flop selects which input comparator of the hysteresis switch will be activated in preparation for the next change of state. When the timing capacitor is integrating positively, the positive biased comparator is activated. When the timing capacitor voltage reaches + 1.25V, the flip-flop changes state, the negative comparator is activated and the direction of integration is reversed, so that when the timing capacitor signal reaches − 1.25V, the flip-flop switches back and the cycle starts over. In addition to the positive and negative biases at the comparator inputs, there is a dynamic lead network on each one. These lead networks are driven by Q11, a separate emitter follower, from the triangle amplifier. They provide the necessary lead to compensate for the inherent delays of the hysteresis switch, thereby keeping the higher frequency dial nonlinearity and sine distortion to a minimum.

4.2.7 Diode Gate and Timing Capacitor

The diode gate (current switch) and the timing capacitor circuits are shown in the main board schematic, sheet 2. The current source and sink are switched to the timing capacitor by the hysteresis switch via a diode bridge arrangement called the diode gate. Actually, the hysteresis switch is linked to the bridge network by two emitter followers, Q24 and Q25, with independent outputs biased to be at the same voltage. The simplified timing diagram illustrated in figure 4-2 shows these points as one terminal at C. When the hysteresis switch output is positive, CR16 is forward biased, so that the current sink is sourced by the drive circuit and is ineffective. CR13 and CR15 are reverse biased, providing isolation between the drive circuit and the timing capacitor. This leaves CR14 forward biased and free to conduct the current source output to the timing capacitor. When the timing capacitor voltage rises to the hysteresis switch point (+1.25V), the hysteresis switch output switches low, forward biasing CR13 which back biases CR14 and CR16 and allows the source to be isolated and the sink to discharge the timing capacitor through CR15. This state continues until the negative switch point is reached and reverts to the previous state.

4.2.8 Triangle Buffer

The triangle buffer (main board schematic, sheet 2) is a wide band dc amplifier providing a closed loop gain of one in potentiometric connection. The input differential stage, Q17/Q18, is a monolithic pair. The emitters are fed from a current sink Q19. The active collector load, Q20, is a current source providing greater open loop gain than a resistive load. Following this is an emitter follower, Q21, a zener diode level shifter, CR12, and another emitter follower, Q22, for the output stage. The gain is set to one by the 100% feedback to the input pair feedback side, base of Q18.

4.2.9 Signal Shaper

The signal shaper circuit (main board schematic, sheet 3) is uniquely set up for each different waveform by four wafers of the function selector switch. The ±15 volt power is switched off in the triangle wave mode and there is virtually no effect on the triangle wave fed to the circuit. In the positive pulse mode, the square wave, rather than the triangle wave, is fed to the circuit and the −15 volt power is switched off. As a result, the negative swing of the input square wave is clipped off. The negative pulse is formed, when selected by the function switch, in a similar manner. When the square or sine wave is selected, both plus and minus 15 volt power is applied to the circuit. The difference in circuit setup for sine and square is the resistive load at the circuit output and the shape of the signal fed to the input. For the sine wave mode, the matched set of diodes soft clip the input triangle at three different levels. These signals are resistively summed to produce a sine wave voltage input to the multiplier. For the square wave mode, the input square wave is symmetrically hard-clipped by the diode network presenting a square wave input voltage to the multiplier.

4.2.10 Transconductance Multiplier

After the main generator signal passes through the function selector switch and the signal shaper circuit, it enters a transconductance multiplier, U15 (main board schematic, sheet 3), where the amplitude is set by dc from the control amplifier or modulated by ac from the modulation generator via the AM switch. Currents in the open collectors of this IC are worked into a current mirror for optimum gain and fed to the preamplifier summing node for conversion to a voltage signal at TP7.

4.2.11 Preamplifier

The preamplifier (main board schematic, sheet 3), like the output (power) amplifier, is comprised of a high frequency ac amplifier combined with a low frequency dc amplifier. It converts the current from the multiplier to a voltage signal which is attenuated by the front panel amplitude control and amplified by the output amplifier. The Q37, Q38, Q39 circuit is the dc amplifier and the remaining circuitry is the high frequency amplifier. Again, like the output amplifier, the ac amplifier is symmetrically arranged from the R240/R230 summing node to R246 and Q42 at the output stage of the preamplifier. If the input current goes into the node, the voltage at the summing node will rise by a certain amount. By capacitive coupling via C92 and C93, the base voltage of Q40 rises closer to +15 volts and the base voltage of Q41 rises further away from −15 volts. Thus, the emitter base junction of Q40 will be less forward biased, thereby reducing the emitter current, while the Q41 emitter current increases. The result is that the voltage at the Q42 base decreases, increasing the emitter base junction forward bias and causing a decrease in output voltage due to an increase in Q42 current. The feedback path through R250/R251 to the summing node tends to cancel the rise in voltage there, causing the output voltage to stabilize. The amount of negative voltage at the output required to pull the summing node back to zero is controlled by the value of R250/R251.

4.2.12 Output Amplifier

The output amplifier is comprised of a low frequency dc amplifier and a high frequency ac amplifier. Refer to the simplified circuit of figure 4-4. The Q43, Q44 and Q45 circuit is the dc amplifier and the remaining circuitry is the ac amplifier. The ac amplifier is symmetrically arranged, top and bottom. The upper portion amplifies the positive swing of the output, while the lower mirror portion amplifies the negative swing. Operation is class AB; that is, there is independent positive half and negative half amplification, with a small amount of current flow in both sides near zero swing. The amplifier schematic has been simplified in figure 4-4 for the following discussion. Assume that both the input and the output voltages are zero, then the voltage at point A should also be zero. Because of the symmetrical configuration of the amplifier, the current through Q47 and Q49 will be equal and the output will remain at zero. If the input goes positive, the voltage at point A will rise by a certain amount. This will cause the base voltage of Q47 to rise closer to +26 volts. Thus, the emitter base junction of Q47 will be less forward biased, thereby reducing its emitter current. The result is that the voltage at point B which is the output voltage, will start to go negative. Finally, when the output has moved far enough negative to pull point A back to zero, by pulling current through the feedback resistor R_{fb}, the collector current of Q47 and Q49 will again be equal and the output voltage at point B will stabilize. The amount of negative voltage at the output required to pull point A back to zero is controlled by the ratio of R_{fb} to R_{in}, and this ratio is the closed loop gain of the output amplifier. The circuit containing Q43/Q44/Q45 is a high gain, low frequency amplifier used to bias the high frequency amplifier and to increase the low frequency loop gain. The high frequency amplifier is isolated from low frequency signals at the input by capacitance coupling to the bases of Q47 and Q49. It then employs the low frequency amplifier to bias the emitter of Q47 to obtain the required dc stability and high loop gain.

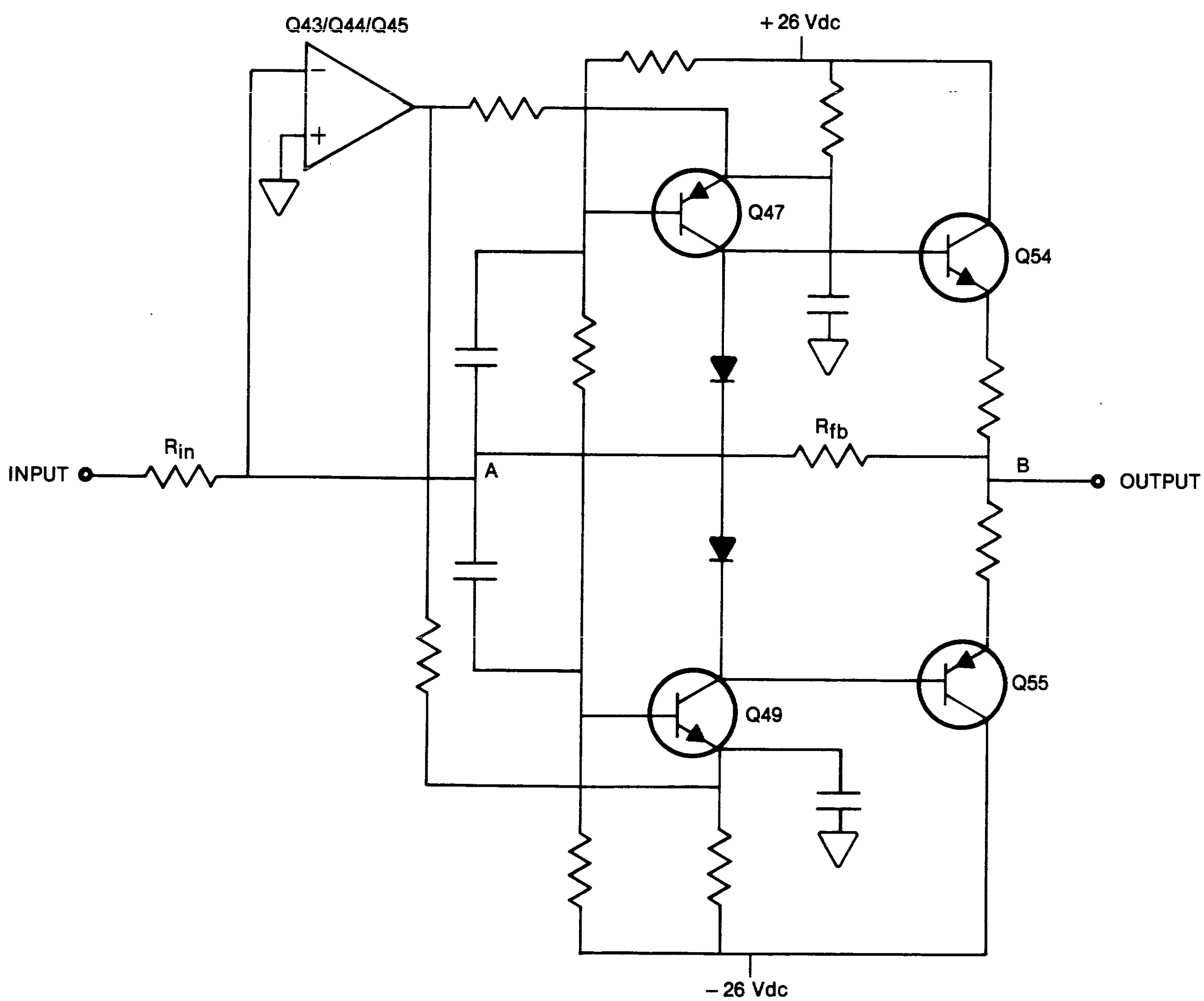


Figure 4-4. Simplified Output Amplifier

Other circuit components are shown on the main board schematic, sheet 3. Emitter followers Q46 and Q48 increase the driving power to the bases of Q47 and Q49. Q51 and Q54 are a harnessed pair sharing the load through R287, R290 and R291 during the positive signal swing. Q51 and Q54 are driven by the collector of Q47. CR40 through CR43 compensate for the emitter-base junction voltage drops of Q51, Q53, Q54 and Q55 to control idling current, reduce crossover distortion and prevent thermal runaway. The two resistor-capacitor networks, R268/C100 and R278/C101 are emitter bypass circuits to maintain the high frequency amplifier gain during the transition time prior to the dc amplifier taking effect. This improves the rise time, since the dc amplifier requires a few microseconds to respond and stabilize. Another compensation is C113 which bypasses R276 to give the signal a low impedance path during the signal transition allowing faster and more symmetrical rise and fall times. VR2 and VR3 are five volt regulators which normally run saturated to supply the output stage current to the collectors of the output transistors. If the output stage should demand an abnormal amount of current through a shorted transistor or output terminal, the current through R295 through R298 will generate five volts of drop. If more current is demanded, the regulators will simply maintain the five volt drop, allowing the output collector voltages to collapse, preventing excessive power dissipation in the amplifier components. The dc offset is fed as a current from the front panel control to the output amplifier summing mode.

4.2.13 Sync Amplifier/Square Amplifier

The side of the hysteresis switch (main board schematic, sheet 2) not used to drive the current switch has an inverted square signal which is used to drive an emitter coupled pair, Q16 and Q23. The collector output of Q23 is biased to provide a TTL level output. The sync out signal is connected to the front panel sync out (TTL) BNC with a coaxial cable.

Next to the sync amplifier, a similar emitter coupled pair, Q57 and Q58, is connected to the same input and biased to output a bipolar square wave to the function switch when square or pulse functions are selected. In other functions, emitter bias is reversed so that the square function remains confined to the hysteresis switch area.

4.2.14 Trigger Signal Limiter

Either an external signal or the modulator function are selected by the generator mode switch (auxiliary generator schematic) and summed through R50 and R51 with the trigger level control. That portion of the trigger signal more positive than the trigger level is clipped by forward biasing CR1; the negative portion is clipped by CR2. While CR1 is on, Q1 conducts and Q3 switches off to a TTL low level. While CR2 is on, Q1 is off and Q3 saturates to a TTL high level. R57 and R58 provide hysteresis to ensure a clean square wave output.

4.2.15 Trigger Logic/Trigger Amplifier

In continuous mode the continuous control line is low and U13-8 (main board schematic, sheet 2) holds the trigger flip-flop (U12) cleared. U12-3 is low, which is sent by emitter follower Q27 to a diode "AND". A low is sensed at R158, the trigger amplifier inverting input. The closed loop gain of the trigger amplifier is set by the ratio of R173 to R158. The trigger amplifier outputs a +1.5 to +2 Vdc to reverse bias the start/stop diode CR27 above the most positive charge on the integrating capacitor.

In trigger mode, both control lines are high, and U13 produces a narrow negative pulse, corresponding to a high to low transition of the signal limiter output, to clear U12. In the absence of a trigger stimulus, U12 is clocked by the negative-going edge of the current switch square translated by Q26 to TTL levels. U12-3 goes high and the trigger amplifier goes to a low level, forward biasing CR27 which sinks the VCG current source away from the integrating capacitor. The charge level on the integrating capacitor is held at the voltage drop across CR27 above the trigger amplifier output. Compensation current enters the trigger amplifier summing node through R155 to push its output voltage down exactly the same as the drop across CR27 at a particular magnitude of integrating current. The 0 Vdc trigger baseline may be modified with R4, the front panel start/stop control. Whenever a trigger is received, U13 is cleared and the trigger amplifier output goes high, allowing the integrating capacitor to charge. At the positive triangle peak, the hysteresis switch goes to a negative level and the negative-going triangle slope is generated. The high-to-low hysteresis transition clocks U12-3 high, but the negative portion of the square is also fed into the diode "AND" at CR20 which holds the trigger amplifier output high until the completion of the negative-going slope of the triangle. When the hysteresis switch returns to positive, the trigger amplifier returns to its low output, and the integrating capacitor charges until CR27 forward biases again. The integrating capacitor is again held at the trigger baseline level.

In gate mode, the gated-control line is low and U13 produces a negative pulse of the same duration as the signal limiter output. Thus, U12 is held cleared, the signal at CR24 is held low, and the trigger amplifier output is held high for the trigger duration. The last triangle cycle started is completed through the action explained in trigger mode.

4.2.16 Baseline Compensation

CR2 (main board schematic, sheet 1) is in series with the current supplied by the VCG current source. U9-3 is connected to CR2 anode and, since it is a voltage follower, it will have the same potential at its pin 6. U10-3 is connected to CR2 cathode and will regulate the current through Q7 to make the same potential at its pin 2; therefore, R64 will have the same voltage across it as the drop across CR2. The current leaving Q7 enters the trigger amplifier summing node, and becomes a voltage offset equal to the drop across CR2, because R64 and the feedback resistor for the trigger amplifier have the same value. Since CR2 and the start/stop diode are matched and carry equal currents, the trigger baseline will be stable with varying VCG inputs.

4.2.17 Modulation Generator and Ramp Generator

The function generator used as a modulation source in the instrument is the Intersil 8038 (U2 on the auxiliary generator board schematic). It is fitted with an auxiliary current balancing circuit (U1) to extend its useful dynamic range. The ramp output which is not built into the chip is developed by amplitude modulating the triangle function with the square function in a balanced modulator (U5). The output signals (∿ , ⋀⋁ , ⊓⊔ , ⟋|⟋| , |⟍|⟍) are selected in a function selector switch and fed to the modulation switches where modulation type is selected. The ramp signals have a fundamental frequency of two times that of the other waveforms.

SECTION 5
CALIBRATION

5.1 FACTORY REPAIR

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

5.2 REQUIRED TEST EQUIPMENT

Voltmeter	Millivolt dc measurement (0.1% accuracy)
Oscilloscope, Dual Channel	200 MHz bandwidth
Counter	20 MHz (0.01% accuracy)
50Ω Feedthru	±0.1% accuracy, 2W
Distortion Analyzer	To 200 kHz
RG58U Coax Cable	3 ft length BNC male contacts
BNC Tee	1 male, 2 female connectors

5.3 REMOVING GENERATOR COVERS

1. Invert the instrument and remove the four screws in the bottom cover. Remove the bottom cover and the four screws in the printed circuit board that attaches the top cover. Replace the bottom cover.
2. Turn the instrument upright; remove the top cover for access to power supply and modulation generator calibration points.
3. For access to main generator calibration points, replace the top cover, invert the instrument and remove the bottom cover.
4. When calibration is complete, secure the top cover with four screws before securing the bottom cover.

NOTE

Remove the covers only when it is necessary to make adjustments or measurements.

5.4 CALIBRATION

After referring to the following preliminary data, perform calibration, as necessary, per table 5-1. If performing partial calibration, check previous settings and adjustments for applicability. See figures 5-1 and 5-2 for calibration point location.

1. All measurements made at the FUNCTION OUT connector must be terminated into a 50Ω (±0.1%) load.
2. Start the calibration by connecting the unit to an ac source and setting the front panel switches as follows.

   Set all outer controls to the open marker position.

Frequency Dial	2.0
MODULATION Switches	OFF
SYMMETRY	OFF
DC OFFSET	OFF
TRIG START/STOP	0° CAL
All other inner controls	cw

3. Allow the unit to warm up at least 30 minutes for final calibration. Keep the instrument covers on to maintain heat. Remove covers only to make adjustments or measurements.

Table 5-1. Model 148 Alignment

Step	Check	Tester	Test Point	Control Setting	Adjust	Result	Remark
1	Power Supply Regulators	DC Voltmeter	C26 +	Paragraph 5.4, step 2		+ 26V ± 1.2V	Verify. See figure 5-5 for locations.
2			C29 –			– 26V ± 1.2V	
3			C33 +		R64	+ 15V ± 30 mV	
4			C34 –		R70	– 15V ± 30 mV	
NOTE: Steps 5 through 17 are modulation generator adjustments (see figure 5-5).							
5	Top of Scale Frequency	Scope	Mod Gen OUT	FREQ/PERIOD MULT: 1K∣100K FREQ/PERIOD VARIABLE: cw	R48	100 kHz	By scope face.
6	Bottom of Scale Frequency			FREQ/PERIOD VARIABLE: ccw	R93	1 kHz	
7	Hi Freq Symmetry			FUNCTION: ◿◿ FREQ/PERIOD MULT: 10∣1K FREQ/PERIOD VARIABLE: cw	R14	Falling edges coincide	Trigger on negative going edge, not auto trigger. Display two cycles. Out of adjustment 148 and adjusted scope will give double falling edges on each ramp.
8	Lo Freq Symmetry			FREQ/PERIOD VARIABLE: ccw	R17		Steps 7 and 8 interact; repeat if necessary.
9	Lo Freq, Hi Range Symmetry			FREQ/PERIOD MULT: 1K∣100K	R75		
10	Top of Scale Frequency	Counter		FREQ VARIABLE: cw FUNCTION: ⎍	R48	100 kHz	
11	Bottom of Scale Frequency			FREQ/PERIOD VARIABLE: ccw	R93	1 kHz	
12	∿ Zero Adjustment	DC Voltmeter		FUNCTION: ∿ FREQ/PERIOD MULT: 10∣1K FREQ/PERIOD VARIABLE: cw	R34	0V ± 10 mV	
13	⎍ Zero Adjustment			FUNCTION: ⎍	R33		
14	∿ Distortion	Distortion Analyzer		FUNCTION: ∿	R11, R12	Minimum distortion	0.5% typical.
15	Ramp Gain	Scope		FUNCTION: ◿◿	R46	Slopes coincide	Trigger on negative going edge, not auto trigger. Display two cycles. Out of adjustment 148 and adjusted scope will give double rising edges on each ramp.

Table 5-1. Model 148 Alignment (Continued)

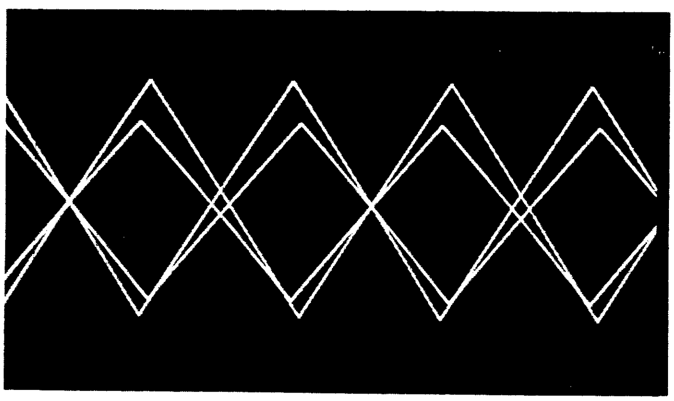
Step	Check	Tester	Test Point	Control Setting	Adjust	Result	Remark
16	Ramp Balance	Scope	Mod Gen OUT	FUNCTION: ◣◣	R30	Remove ± error	Steps 15 and 16 interact; repeat if necessary.
17	Ramp Zero				R81	Negative peaks on 0 Vdc	
NOTE: Steps 18 through 34 are main generator adjustments (see figure 5-4).							
18	Top of Dial Symmetry	Scope	FUNCTION OUT (terminate with 50Ω)	Paragraph 5.4, step 2	R36	Equalize + and − half cycles	
19	1000:1 Symmetry			Dial: .02 FREQ MULT: 100K Adjust FREQ VERNIER for 200 Hz	R23		
20	VCG Null			FREQ VERNIER: cw FM: EXT	R14	Minimum frequency shift	Set scope for one or two cycles. Observe shift in trailing edge of cycle as EXT MOD BNC is alternately shorted and opened. Disregard jitter in cycle midpoint.
21	Distortion	Distortion Analyzer		Dial: 2.0 FREQ MULT: 1K FUNCTION: ∿ FM: OFF	R87, R90	Minimum Distortion	0.15% typical.
22	Top of Dial Frequency	Counter		FREQ MULT: 10K	R10	20 kHz	If necessary, trim frequency with:
23	100:1 Frequency			Dial: .02	R8	200 Hz	
24	×10 MHz Frequency			Dial: 2.0 FREQ MULT: 10M	C68	20 MHz	C127
25	×1 MHz Frequency			FREQ MULT: 1M	C125	2 MHz	C133
26	×100K Frequency			FREQ MULT: 100K	C62	200 kHz	C126
27	Capacitance Multiplier Zero	DC Voltmeter	TP1	FREQ MULT: 1K	R56	0 Vdc ±1 mV	TP2 ground.
28	Capacitance Multiplier Frequency	Counter	FUNCTION OUT (terminate with 50Ω)	FREQ MULT: 10	R57	Period of 0.05s	
29	Output Amplifier Zero	DC Voltmeter		FUNCTION: DC AMPLITUDE: ccw FREQ MULT: 100K	R347	0 Vdc ±20 mV	
30	Carrier Balance	Scope		FUNCTION: ⊓⊔ AMPLITUDE: cw Modulator FUNCTION: ∿ AM: EXT	R226	See figure 5-2.	Connect modulator OUT (600Ω) to EXT MOD IN. Set scope display per figure 5-1.

Table 5-1. Model 148 Alignment (Continued)

Step	Check	Tester	Test-Point	Control Setting	Adjust	Result	Remark
31	Modulation Balance	Scope	FUNCTION OUT (terminate with 50Ω)	Modulator FUNCTION: ⋀⋁ and ∿	R210	See figure 5-3.	
32	Multiplier Zero	DC Voltmeter		FUNCTION: ∿ AM: OFF	R218	0 Vdc ±20 mV	
33	Multiplier Gain	Scope			R324	15V p-p	Sync scope to INT. Steps 29 through 33 interact; repeat if necessary.
34	Baseline Zero			Mode: INT TRIG	R159	0 Vdc ±100 mV	

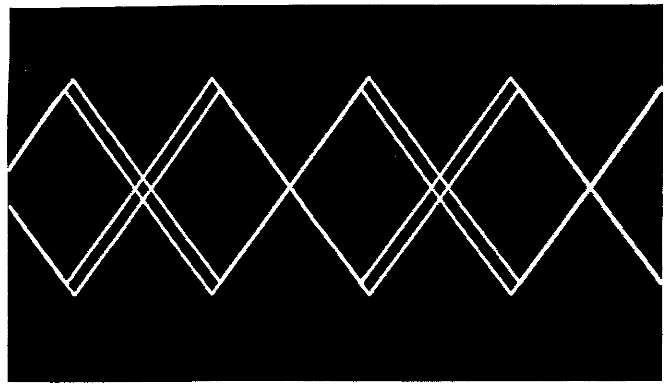
NOTE: Replace cover and allow the 148 to warm up for ½ hour before proceeding to step 35.

Step	Check	Tester	Test-Point	Control Setting	Adjust	Result	Remark
35	Overshoot & Ringing	Scope	FUNCTION OUT (terminate with 50Ω)	Mode: CONT FUNCTION: ⊓⊔ FREQ MULT: 1M	C139, R343	Best waveform	



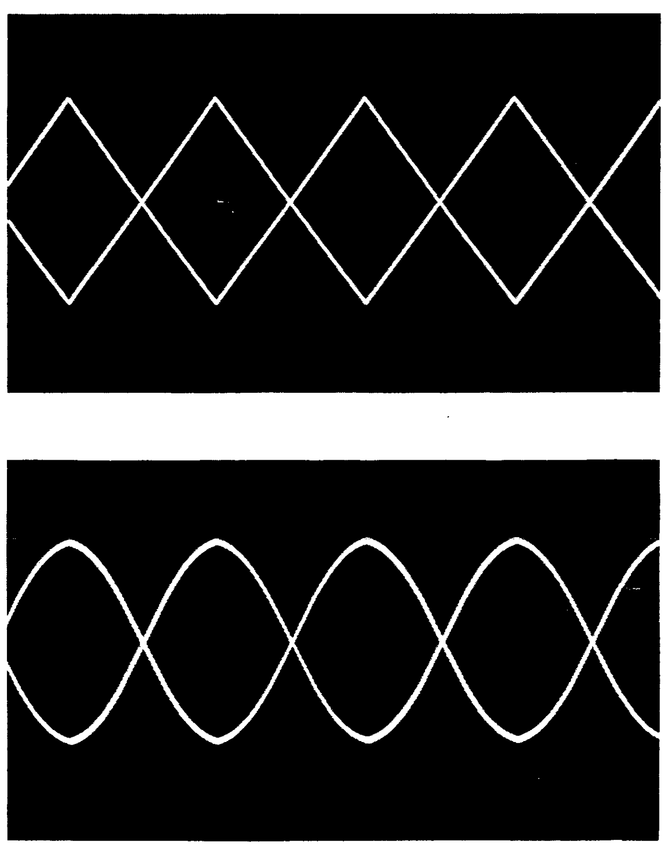
Adjust scope for internal triggering on alternate cycles to display unbalance in suppressed carrier envelope.

Figure 5-1. Suppressed Carrier



Adjust R226 for parallel trace segments.

Figure 5-2. Carrier Balance



Adjust R210 so that alternate envelope traces coincide.

Figure 5-3. Modulation Balance

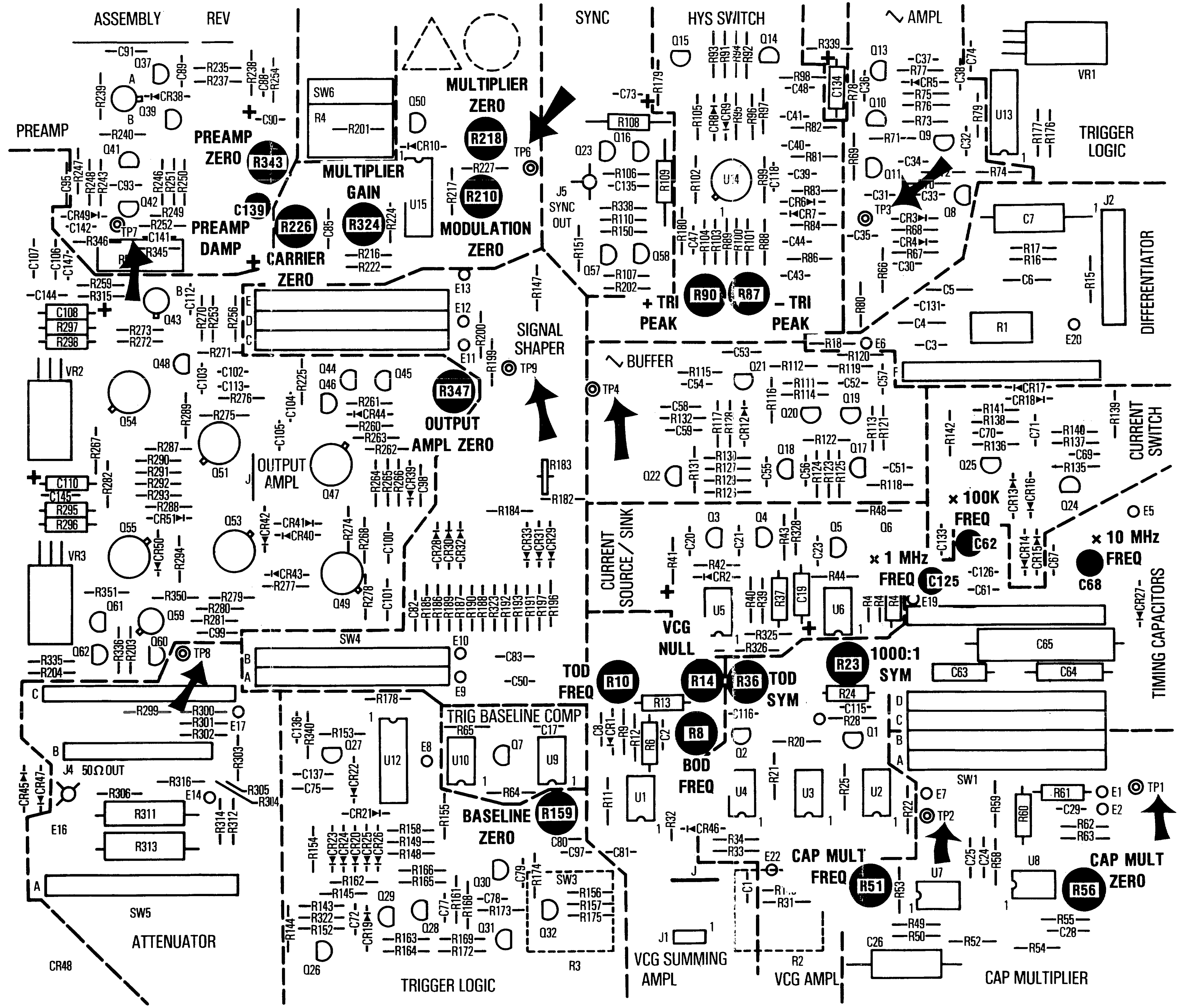


Figure 5-4. Main Generator Calibration Point Location

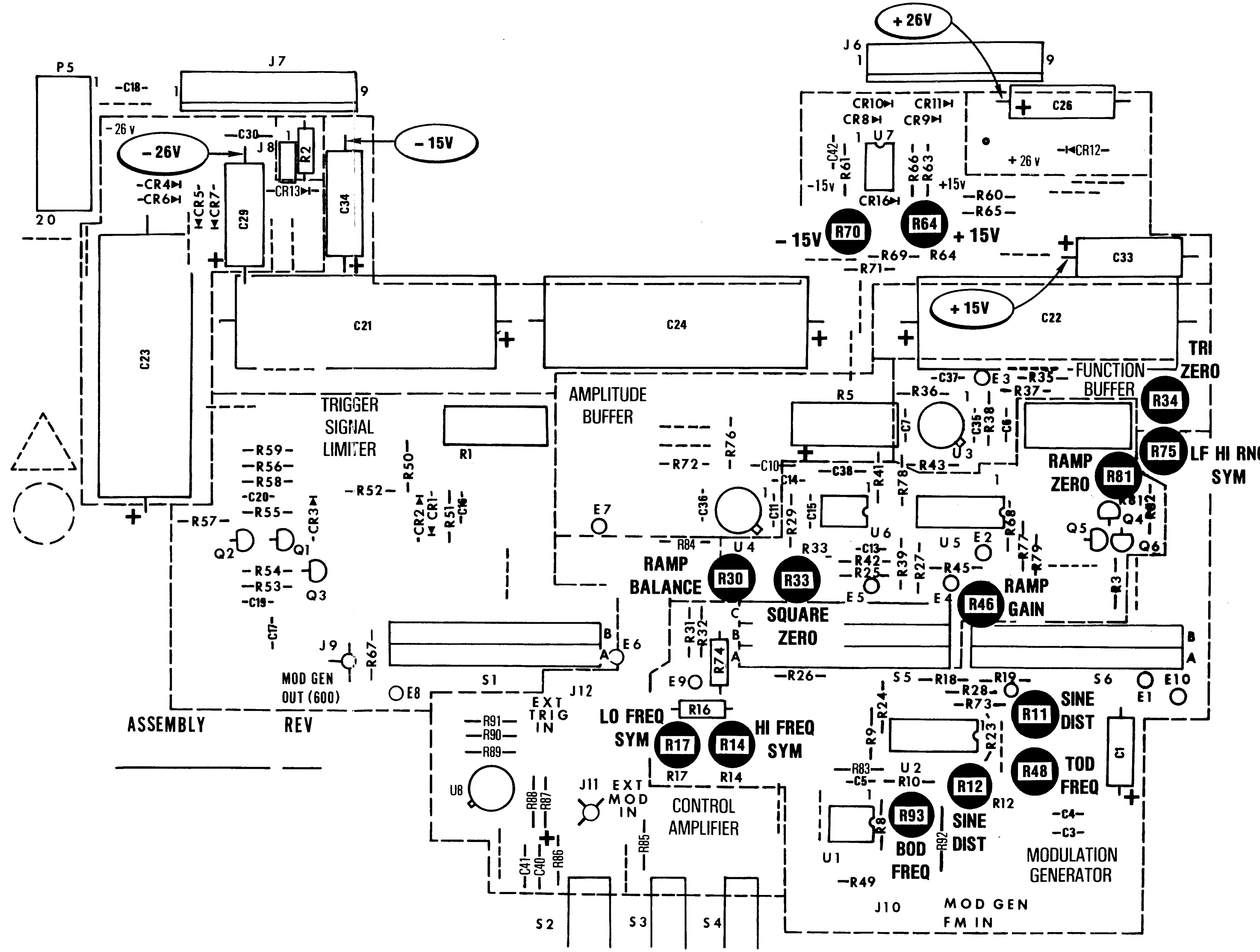


Figure 5-5. Auxiliary Generator Calibration Point Location

SECTION 6
TROUBLESHOOTING

6.1 FACTORY REPAIR

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

6.2 TROUBLESHOOTING TABLES

Table 6-1 gives an index of the troubleshooting tables by indications of common problems. The tables do not cover every possible trouble, but, when used in conjunction with circuit descriptions and schematics, will be an aid in systematically isolating faulty components.

6.3 TROUBLESHOOTING INDIVIDUAL COMPONENTS

6.3.1 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 across base-emitter junction.

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.

Table 6-1. Fault Isolation

Indication	Table
1. Fuse blows, no dial lamp, or no outputs.	6-2
2. Main generator has no function output.	6-3
3. Main generator waveforms offset or clipped, overload indicator on, or function outputs missing when TTL sync output OK.	6-4
4. Main generator waveforms distorted.	6-5
5. Main generator sine and triangle waveform problem.	6-6
6. Main generator square and pulse waveforms bad, sine and triangle OK.	6-7
7. Main generator sync out problem.	6-8
8. Main generator frequency does not respond correctly to dial and FM modulation.	6-9
9. Main generator fixed symmetry problem.	6-10
10. Main generator variable symmetry problem.	6-11
11. Main generator problem in bottom four frequency ranges only.	6-12
12. Main generator trigger and gate problem, EXT and INT.	6-13
13. Modulation generator OUT (600Ω) bad.	6-14
14. Modulation problem: AM, FM, PM.	6-15

6.3.2 Diode

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

6.3.3 Operational Amplifier

1. The "+" and "−" inputs of an operational amplifier will have less than 15 mV voltage difference when operating under normal conditions.

2. When the output of the amplifier is connected to the "−" input (voltage follower connection), the output should be the same voltage as the "+" input voltage; otherwise, the operational amplifier is defective.

3. If the output voltage stays at maximum positive, the "+" input voltage should be more positive than the "−" input voltage, or vice versa; otherwise, the operational amplifier is defective.

6.3.4 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 the source voltage is more negative than gate voltage for a 2N5462. Otherwise, the FET is defective.

3. If the device supplying gate voltage to an FET saturates, the FET has too large a Vgs (pinch off) for the circuit and should be replaced.

6.3.5 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.

6.4 GENERAL INSTRUCTIONS

When encountering a problem, it is advisable to return as many of the front panel controls as possible to their initial settings and still retain the problem. The troubleshooting tables in this section generally begin at these initial settings and specify all subsequent setups. Preset the front panel controls as follows.

Control	**Position**
Frequency Dial	2.0
FREQ MULT (main)	1K
VERNIER	cw
SYMMETRY	OFF
DC OFFSET	OFF
FUNCTION (main)	⊓⊔
ATTENUATION	20I0
AMPLITUDE	cw
FREQ/PERIOD MULT (modulator)	10I1K
VARIABLE	cw
FUNCTION (modulator)	∿
AMPLITUDE (modulator)	MAX
MODULATION Switches	OFF
Mode Switch	CONT
TRIGGER LEVEL	MIN

CAUTION

To prevent damage to components, turn unit off while removing or replacing components, connectors or pc boards.

The suspected malfunctioning condition should be double checked to eliminate the possibility of improper settings or connections. Before attempting fault isolation, the unit should be checked for proper line voltage selection (refer to section 2) and that the power suppies are correct up to the main generator board. A good visual inspection of the boards and chassis wires for damage or overheating often saves much time.

Once the malfunction is defined, begin the isolation procedure by selecting an indication in table 6-1 which best describes the malfunction and proceed to the referenced troubleshooting table. Check points and circuitry mentioned in the tables will either be obviously restricted to one of the two generator boards, or the board will be named.

Follow through the checks in the troubleshooting table, using schematics and assemblies as a guide. When positive results are not obtained, perform the indicated corrective procedure.

Table 6-2. Power Supplies

Indication: Fuse Blows, no dial lamp, or no outputs.

Check	Corrective Procedure
1. Check that fuse is good. Ensure line selector card in power connector matches line voltage.	Replace fuse; check for normal operation.
2. Turn unit off while removing or replacing connectors. Remove P6, P7 molex connectors on auxiliary generator board. Determine that fuse holds up. Reconnect P6.	a. Power connector. b. Primary wiring. c. Transformer.
3. Remove P1, P2, P3, P4 connectors to regulators on rear panel. Check + end of C24 for +28.0 Vdc ±10% and − end of C21 for −26.5 Vdc ± 10%.	a. CR8 - CR11. b. C21, C24. c. Transformer secondary.
4. Reconnect P7. Check + end of C22 for +40.5 Vdc ±10% and − end of C23 for −40.5 Vdc ±10%.	a. CR4 - CR7. b. C22, C23. c. Transformer secondary.
5. Disconnect P5 and reconnect P4 to VR4 (7824). Check + end of C26 for +26 Vdc ±5%.	VR4 circuit.
6. Reconnect P1 to VR1 (7924). Check − end of C29 for −26 Vdc ±5%.	VR1 circuit.
7. Reconnect P3 to VR3 (7812). Check + end of C33 for +15 Vdc.	a. R64 adjustment. b. VR3, U7 circuit. c. Excessive loading by auxiliary generator board. Look for overheated components and use jumpers to aid in isolation.
8. Reconnect P2 to VR2 (7912). Check − end of C34 for −15 Vdc.	a. R70 adjustment. b. VR2, U7 circuit. c. Excessive loading by auxiliary generator board. Look for overheated components and use jumpers to aid in isolation.
9. Reconnect P5. Check the ±26 Vdc and ±15 Vdc supplies.	Excessive loading by main generator board. Look for overheated components.

Table 6-3. Function Generator Loop

Indication: Main generator has no function output.

Check	Corrective Procedure
1. Set all controls in their initial positions (refer to paragraph 6.4).	
2. Check TP3 for a ±1.25V, 2 kHz triangle. If good, proceed to table 6-4.	
3. Check J5-13 for +15 Vdc, J5-5 for −15 Vdc, J5-3 for +26 Vdc, and J5-1 for −26 Vdc.	Table 6-2.
4. Check cathode CR27 for approximately +1.25 Vdc. Check CR27.	Table 6-13.
5. Check U5-2 for +10 Vdc and U6-2 for −10 Vdc. Use oscilloscope and high impedance probe with dial at 2.0.	Table 6-9.
6. Check for same dc level at FB1 and TP3, limited by saturation of triangle amplifier.	Troubleshoot triangle amplifier.
7. Check for + or −2.5 Vdc at the junction of CR17 and CR18, with the opposite polarity of the voltage at TP3.	a. CR6, CR7. b. U14 circuitry. c. Current switch circuit. d. Q26, CR19.
8. Check that voltages at cathode CR13 and anode CR16 are the same as voltages at junction of CR17 and CR18.	a. Current switch circuit. b. Q26, CR19.
9. Check diodes CR13 - CR16.	Replace faulty diode.
10. Lift one end of R74 (10Ω) so that a ±1.25V, 2 kHz triangular waveform from an external source can be injected into the triangle amplifier. Check TP3 for a +1.25V triangle.	Troubleshoot triangle amplifier.
11. Adjust amplitude and offset of external signal slightly until a ±2V square appears at junction CR17, CR18.	Troubleshoot the hysteresis switch.
12. Check for ±2V square at cathode CR13 and anode CR16. Remove external signal and replace R74.	a. Current switch. b. Q26, CR19.

Table 6-4. Output Amplifier

Indication: Main generator waveforms offset or clipped, overload indicator on, or function outputs missing when TTL sync output OK.

Check	Corrective Procedure
1. Set all controls in their initial positions (refer to paragraph 6.4).	
2. Check TP7 for function waveforms at 2.0V peak amplitude from ground.	Table 6-5.

Table 6-4. Output Amplifier (Continued)

Indication: Main generator waveforms offset or clipped, overload indicator on, or function outputs missing when TTL sync output OK.

Check	Corrective Procedure
3. Check J5-3 for +26 Vdc ±5% and J5-1 for −26 Vdc ±5%.	Table 6-2.
4. Check for <5 Vdc across R297 and R295.	a. 5 Vdc indicates Q54 and Q55 shorted. b. >5 Vdc indicates VR2, VR3 also failed.
5. Check waveforms at TP8.	Troubleshoot output amplifier and dc offset circuitry.
6. Check attenuator switches and coax J4 to J6.	

Table 6-5. Waveform Generation

Indication: Main generator waveforms distorted.

Check	Corrective Procedure
1. Set all controls at their initial positions (refer to paragraph 6.4).	
2. Check ±1.25V, 2 kHz triangle at TP4.	Table 6-6.
3. Check 2.5V square at collector Q57, offset by −1.75V.	Table 6-7.
4. Check all waveforms at the junction of R221 and R222. Amplitudes should be ±0.15V for bipolar waveforms.	a. SW4-A,B,C,D. b. CR28 - CR37 signal shaper circuitry.
5. Check TP6 for −5.6 Vdc.	U8 circuit on auxiliary generator board.
6. Check waveforms at emitter Q50 for 0.20V peak amplitude around +13 Vdc.	a. Calibration of R210, R218, R226, R324. b. U15, Q50, Q52 circuit.
7. Check TP7 for ±2.0V waveforms with no significant offset.	Final preamplifier Q39 - Q42.
8. Go to table 6-4.	

Table 6-6. Triangle Amplifiers

Indication: Main generator sine and triangle waveform problem.

Check	Corrective Procedure
1. Set all controls in their initial positions (refer to paragraph 6.4).	
2. Check triangle at FB1 with oscilloscope and high impedance probe. If waveform has a problem here (especially at lowered dial settings), yet has no significant offset and is identical to waveform at TP3, go to table 6-10, step 14.	
3. Check if waveform at TP3 is identical to waveform at FB1.	Troubleshoot triangle amplifier Q8 - Q11.
4. Check for an amplitude of ±1.25V at TP3.	a. R83, R84, R87 - R90, CR6, CR7. b. U14 circuit.
5. Waveform at TP4 should be identical to waveform at TP3.	Troubleshoot triangle buffer circuitry Q17 - Q22.
6. Verify that square disable signal is defeating square at collector Q57 when function selector is in dc, sine and triangle.	SW4-B.
7. Go to table 6-5.	

Table 6-7. Square Wave Generation

Indication: Main generator square and pulse waveforms bad, sine and triangle OK.

Check	Corrective Procedure
1. Set all controls in their initial positions (refer to paragraph 6.4).	
2. Check base of Q58 for a 2.5V square wave, offset by −1.75V.	U14, Q15, CR8, CR9.
3. Verify square disable signal at R151 is not grounded.	SW4-B.
4. Check collector Q57 for a ±1.0V square.	Q57, Q58 circuit.
5. Go to table 6-5.	

Table 6-8. Sync Circuits

Indication: Main generator sync out problem.

Check	Corrective Procedure
1. Set all controls in their initial positions (refer to paragraph 6.4).	
2. Check base of Q16 for a 2.5V square wave, offset by −1.75V.	U14, Q15, CR8, CR9.
3. Check collector Q23 for a TTL level square.	Q16, Q23 circuit.
4. Check wiring J3 to J5.	

Table 6-9. VCG Summing Amplifier

Indication: Main generator frequency does not respond correctly to dial and FM modulation.

Check	Corrective Procedure
1. Set all controls in their initial positions (refer to paragraph 6.4).	
2. Check for +15 Vdc at J5-13 and −15 Vdc at J5-5.	Table 6-2.
3. Check for approximately +15 Vdc to +150 mV dc at J1-2 as dial is rotated from 2.0 to .02.	a. Wiring J1 to dial. b. Dial potentiometer R1.
4. Check for 0 Vdc ±5 mV at U1-2 as dial is rotated. Use oscilloscope and high impedance probe for this and other VCG measurements.	U1 circuit.
5. Check for approximately −5 to 0 Vdc at anode of CR1 as dial is rotated from 2.0 to .02.	U1 circuit.
6. Proceed to table 6-10.	

Table 6-10. VCG Current Sources

Indication: Main generator fixed symmetry problem.

Check	Corrective Procedure
1. Set all controls in their initial positions (refer to paragraph 6.4).	
2. Ensure anode of CR1 does not attempt to go positive with dial at .02 and frequency vernier ccw. Use oscilloscope and high impedance probe for this and other VCG measurements.	a. Calibration of R8 and R14. b. U1 input offset.
3. Check U4-2 for −5 to 0 Vdc as dial is rotated from 2.0 to .02.	U4, Q2.
4. Check U3-2 for −2.5 to 0 Vdc as dial is rotated from 2.0 to .02.	U3.
5. Check U2-2 for 0 Vdc as dial is rotated.	U2, Q1.

Table 6-10. VCG Current Sources (Continued)

Indication: Main generator fixed symmetry problem.

Check	Corrective Procedure
6. Ensure gate voltage of Q1 and Q2 are not saturating and that there is no voltage across R25 and R27 as dial is rotated to .02 with frequency vernier ccw.	a. R23 adjustment. b. Q1, Q2. c. U2 - U4 input offset.
7. Check U5-3 for +10 to +15 Vdc and U6-3 for −10 to −15 Vdc as dial is rotated from 2.0 to .02.	a. R36 adjustment. b. U5, U6 input bias. c. SW2 not closed.
8. Check J5-3 for +26 Vdc ±5% and J5-1 for −26 Vdc ±5%.	Table 6-2.
9. Check U5-2 for +10 to +15 Vdc as dial is rotated from 2.0 to .02.	Q3, Q4, U5.
10. Check U6-2 for −10 to −15 Vdc as dial is rotated from 2.0 to .02.	Q5, Q6, CR2, U6.
11. Ensure gate voltages of Q4 and Q5 are not saturating and that there is no voltage across R42 and R44 as dial is rotated to .02 with frequency vernier ccw.	a. Q4, Q5. b. Loading from U9, U10.
12. Verify operation of SW1-C,D on upper four frequency ranges.	
13. VCG circuit is good; investigate triangle waveshape as a source of symmetry problem. If triangle has significantly different waveshape and/or dc offset at TP3 as it does at FB1, go to table 6-6, step 3.	
14. Check if problem is cleared up by lifting out of circuit one end of CR27.	a. CR27 leaking. b. CR27 not reverse biased; go to table 6-13.
15. Determine if triangle is nonlinear on a particular frequency range.	C61 - C65, C125, C126, C133 leaky.
16. Determine if triangle is nonlinear toward the bottom of all frequency ranges.	C32, C34, C67, C68, C127, Q8, CR13 - CR16 leaky.
17. If triangle is discontinuous at the peaks, the current switch may be operating significantly off from ±2V levels, or it may be switching slowly.	a. Hysteresis switch. b .Current switch. c. CR19, Q26. d. CR6 - CR9.

Table 6-11. VCG Amplifiers

Indication: Main generator variable symmetry problem.

Check	Corrective Procedure
1. Verify checks in table 6-10, steps 1 through 6.	
2. Set SYMMETRY control to midposition. Verify function output is roughly symmetrical and has a frequency of approximately 200 Hz.	a. R2, SW2 control. b. Wiring to E21, E22.
3. Check that waveform symmetry varies from approximately 1:19 to 19:1 as the SYMMETRY control is rotated.	a. Value of R2 with trim is too far from optimum value of 45K. b. Q1, Q2.
4. SYMMETRY control is OK.	

Table 6-12. Capacitance Multiplier

Indication: Main generator problem in bottom four frequency ranges only.

Check	Corrective Procedure
1. Set all controls in their initial positions (refer to paragraph 6.4).	
2. Check U7-3 and U8-3 for 0 Vdc.	a. SW1-B. b. U7, U8 input bias.
3. Check U7-6 for 0 Vdc ±100 mV.	U7 circuit.
4. Check U8-6 for 0 Vdc ±1 mV.	a. R56 adjustment. b. U8 circuit.
5. Set frequency multiplier to ×10. Verify that U7-6 amplifies the signal at U7-3 within saturation limits.	a. U7 circuit. b. SW1-B.
6. Check U8-6 for a composite square-triangle waveform whose square component is reduced as the dial setting is reduced. Check for high frequency oscillations.	a. U8, SW1-A circuit. b. C26. c. C29.
7. Check linearity of ±1.25V triangle at FB1.	a. U7, U8. b. C26.
8. Check frequency accuracy.	a. R51 adjustment. b. R58, SW1-A. c. C26. d. R62, R63.

Table 6-12. Capacitance Multiplier (Continued)

Indication: Main generator problem in bottom four frequency ranges only.

Check	Corrective Procedure
9. Check frequency agreement of lowest three ranges with ×10.	a. R59 - R61, SW1-A. b. C26, U7, U8. c. Extremely small drain on integrating current; refer to table 6-10, steps 13 through 17.
10. Verify symmetry at .1 on dial on ×10 range.	a. R56 adjustment. b. U8 circuit.

Table 6-13. Trigger Circuitry

Indication: Main generator trigger and gate problem, EXT and INT.

Check	Corrective Procedure
1. Set all controls in their initial positions (refer to paragraph 6.4).	
2. Go to external gate mode and triangle function on main generator. The following measurements should be taken with a scope and high impedance probe. Unless otherwise indicated, reference designations used apply to the main generator board.	
3. Check TRIG OUT signal at J5-9 for a TTL high to low transition as TRIGGER LEVEL control is brought cw through midposition.	Q1 - Q3 circuit on auxiliary generator board.
4. Check U13-14 for +5 Vdc ±5%.	VR1.
5. Check U13-8 for a TTL high to low transition as TRIGGER LEVEL control is brought cw through midposition. Check U13-8 for a TTL high when in external trigger mode and a TTL low when in continuous mode. Leave in continuous mode.	a. U13. b. SW1-A on auxiliary generator board.
6. Check U12-3 for a TTL low.	U12.
7. Check CR21 cathode for approximately −0.25 Vdc.	a. Q27, CR20 - CR26. b. U9, U10, Q7, CR2. c. Q28 - Q32 amplifier.
8. Check cathode CR27 for +1.25 Vdc.	a. R159 adjustment. b. U9, U10, Q7, CR2. c. Q28 - Q32 amplifier.
9. Ensure ±1.25V triangle at TP3.	a. CR27. b. Table 6-3.

Table 6-13. Trigger Circuitry (Continued)

Indication: Main generator trigger and gate problem, EXT and INT.

Check	Corrective Procedure
10. Go to external gate mode and verify ± 1.25V triangle at TP3 with TRIGGER LEVEL control cw. With TRIGGER LEVEL control ccw, CR27 should have − 0.7 Vdc on its cathode and TP3 should be near 0 Vdc.	a. R159 adjustment. b. Q28 - Q32 amplifier. c. Q26, U12. d. U9, U10, Q7, CR2.
11. TP3 should remain near 0 Vdc as dial is rotated to .02 and back to 2.0.	U9, U10, Q7, CR2.
12. Rotate TRIG START/STOP control cw. TP3 should immediately go to − 1.25 Vdc, then move positive to near + 1.25 Vdc, where the ± 1.25V triangle will appear. Return control to 0° CAL.	R4-SW6 control.
13. Set main generator to 2 MHz frequency and external trigger mode. Apply an approximate 1 MHz square from an external generator to the EXT TRIG IN connector. Check that as TRIGGER LEVEL control is brought to mid-position, an approximate 20 ns negative pulse appears at U13-8 following the positive-going edge of the external square.	a. J1 to J12 wiring on auxiliary generator board. b. SW1-A,B on auxiliary generator board. c. Q1 - Q3 circuit on auxiliary generator board. d. U13, C74.
14. Check function output for one triangle cycle followed by a 0 Vdc baseline for each externally triggered cycle.	a. Q28 - Q32 amplifier. b. Q26, Q27 circuits.
15. Remove external generator; check modulator OUT (600Ω) for a 10V p-p (open circuit), 1 kHz sine.	Table 6-14.
16. Set modulation generator for a 100 kHz triangle and select internal trigger mode. Connect scope to display both the modulator output and function output. Check for proper triggering of the function output along the positive-going slope of the modulator triangle as trigger level is adjusted.	a. SW1-B on auxiliary generator board. b. R1, CR1, CR2 on auxiliary generator board.
17. Go to internal gate mode and check for proper gating action as TRIGGER LEVEL control is rotated.	SW1-B on auxiliary generator board.

Table 6-14. Modulation Generator

Indication: Modulation generator OUT (600Ω) bad.

Check	Corrective Procedure
1. Set all controls in their initial positions (refer to paragraph 6.4).	
2. Check that main generator is functioning properly.	Indicated table.
3. The following checks should be taken on the auxiliary generator board with an oscilloscope and high impedance probe. Check that U1-7 varies from − 3 to 0 Vdc as modulation frequency VARIABLE is rotated from maximum to minimum.	R6, U1 circuit.

Table 6-14. Modulation Generator (Continued)

Indication: *Modulation generator OUT (600Ω) bad.*

Check	Corrective Procedure
4. Ensure U1-7 varies with a signal applied to modulator FM IN connector. Remove signal.	J3 to J10 wiring.
5. Check that U1-1 varies from −3.25 to 0 Vdc as frequency VARIABLE is rotated from maximum to minimum.	a. U1 circuit. b. U2 circuit.
6. Check U2-2,3,9 for −5.6 to −8.8V sine, −4.8 to −9.6V triangle, and −9.6 to −14.4V square.	U2 circuit.
7. Check modulation OUT (600Ω) for ±5V (open circuit) sine, triangle and square.	a. SW5-C. b. U3 circuit. c. J9 to J4 wiring.
8. Check modulation frequency multiplier switch frequencies and 100:1 VARIABLE control.	a. SW6-A. b. C1 - C4, U2.
9. Check modulation sweep functions for +5V peak at twice modulation frequency.	a. R30, R33, R46, R81 adjustments. b. U5, U6 circuits. c. SW5-A,B.

Table 6-15. AM, FM, PM Circuits

Indication: *Modulation problem: AM, FM, PM.*

Check	Corrective Procedure
1. Set all controls in their initial positions (refer to paragraph 6.4).	
2. Check modulator OUT (600Ω) for 5V peak (open circuit) on all modulator waveforms.	Table 6-14.
3. Check U4-6 on auxiliary generator board for same waveforms, variable with modulation amplitude control.	U4 circuit or R5 on auxiliary generator board.
4. Check TP6 on main generator for −5.6 Vdc.	U8 circuit on auxiliary generator board.
5. Set main generator for a 200 kHz sine and the modulator for an approximate 1 kHz sine. Set the AM MODULATION switch to internal. Check TP6 on the main generator board for an amplitude variable 1 kHz sine offset around −4.1 Vdc.	a. U8 circuit on auxiliary generator board. b. SW2 on auxiliary generator board.
6. Check function output for 0 to 100% AM, variable with modulation amplitude control.	a. R212, R218, R226, R324 adjustments on main generator board. b. U15 circuit on main generator board.

Table 6-15. AM, FM, PM Circuits (Continued)

Indication: Modulation problem: AM, FM, PM.

Check	Corrective Procedure
7. Set AM switch to external and connect modulator OUT (600Ω) to EXT MOD IN. Check TP6 on main generator for a 1 kHz ± 3.0V sine, offset by − 3.0 Vdc.	J2 to J11 wiring on SW2 on auxiliary generator board.
8. Check function output for suppressed carrier modulation signal.	U15 circuit on main generator board.
9. Set AM switch to OFF. Leave modulator OUT (600Ω) connected to EXT MOD IN. Set modulator amplitude to maximum.	
10. Verify that main generator frequency follows dial settings.	Table 6-9.
11. Set modulator FUNCTION to positive-going ramp, modulator frequency to .1I10 Hz range, VARIABLE to midposition. Set main generator frequency to .02 × 10 kHz. Check for a sweeping frequency at function output with FM switch in both INT and EXT.	SW3 on auxiliary generator board.
12. Turn FM switch OFF. Set modulator for a 1 kHz square. Check for a differentiated signal at the wiper of SW1-F on main generator board. The signal should be present on upper six main generator frequency ranges when the PM switch is in INT and EXT.	a. SW4 on auxiliary generator board. b. SW1-F, C3 - C7, C131 on main generator board.

SECTION 7
PARTS AND SCHEMATICS

7.1 DRAWINGS

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

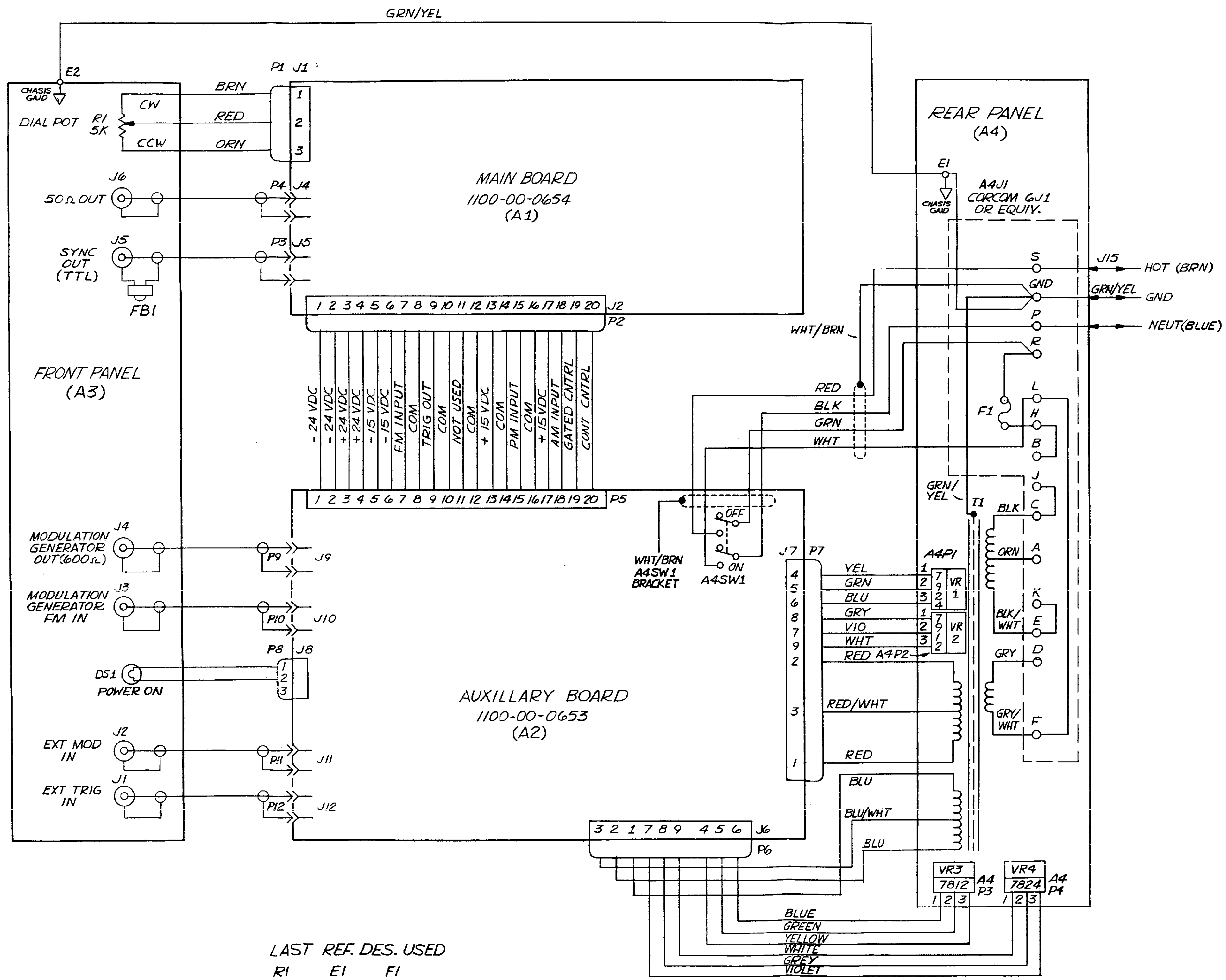
7.2 ORDERING PARTS

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

7.3 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.

Drawing	Drawing No.
Instrument Schematic	0004-00-0137
Chassis Assembly	0102-00-0655
Chassis Parts List	1100-00-0655
Main Board Schematic	0103-00-0654
Main Board Assembly	0101-00-0654
Main Board Parts List	1100-00-0654
Switch Assemblies and Parts List	1202-00-0039
Auxiliary Generator Board Schematic	0103-00-0653
Auxiliary Generator Board Assembly	0101-00-0653
Auxiliary Generator Board Parts List	1100-00-0653
Switch Assemblies and Parts List	1202-00-0040



LAST REF. DES. USED

R1	E1	F1
P12	T1	VR4
J12	SW1	

NOTE UNLESS OTHERWISE SPECIFIED

REV	ECN	BY	DATE	APP
C	# 2012		7-26-79	

REMOVE ALL BURRS AND BREAK SHARP EDGES

MATERIAL

FINISH WAVETEK PROCESS

DRAWN D.COOPER DATE 10/12/77

PROJ ENGR

RELEASE APPROV R.T. Warren 12/13/77

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

DO NOT SCALE DWG

SCALE

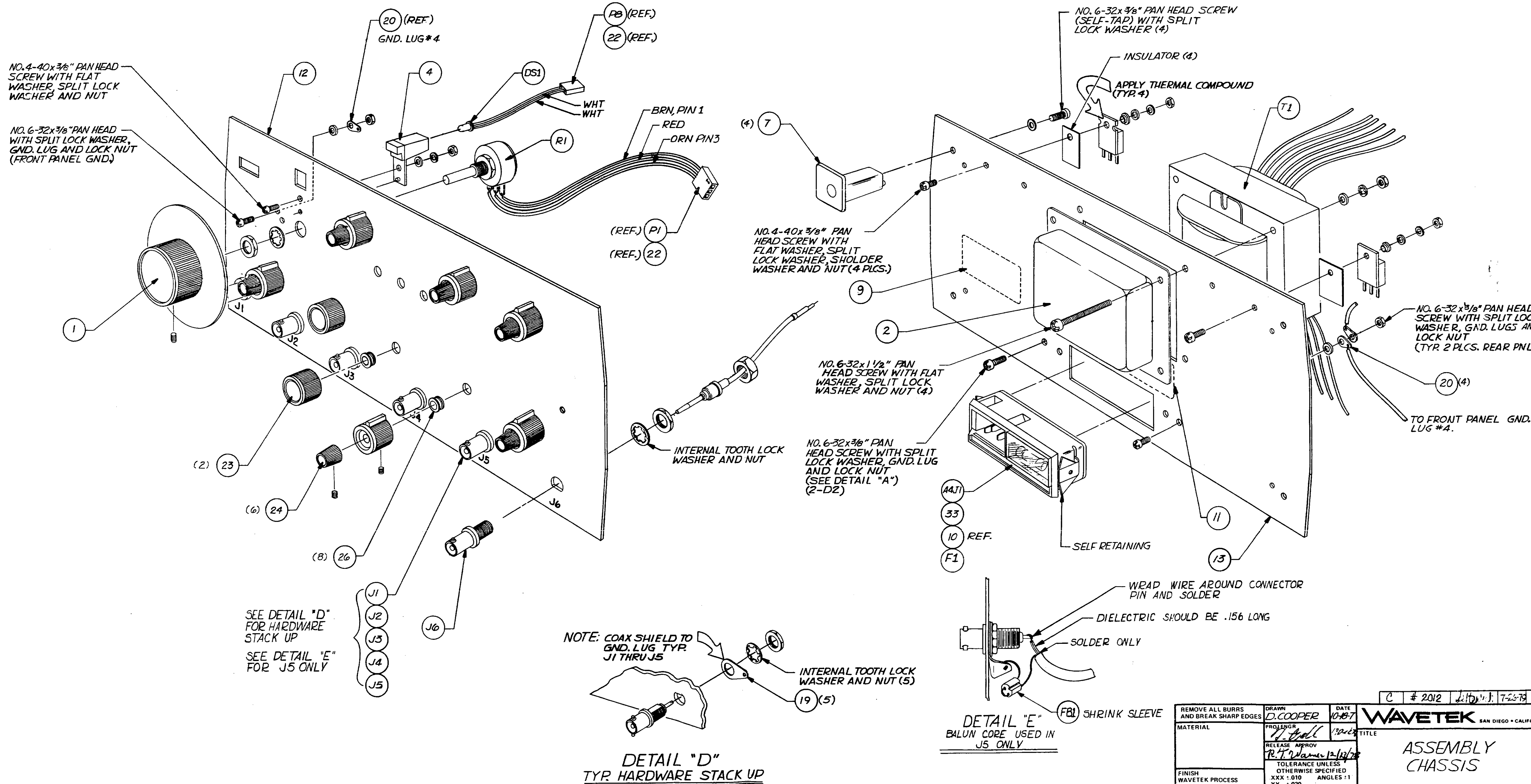
WAVETEK SAN DIEGO • CALIFORNIA

TITLE SCHEMATIC INSTRUMENT 20MHz AM/FM/PM GENERATOR

MODEL NO. 148 — DWG NO. 0004-00-0137 — REV C

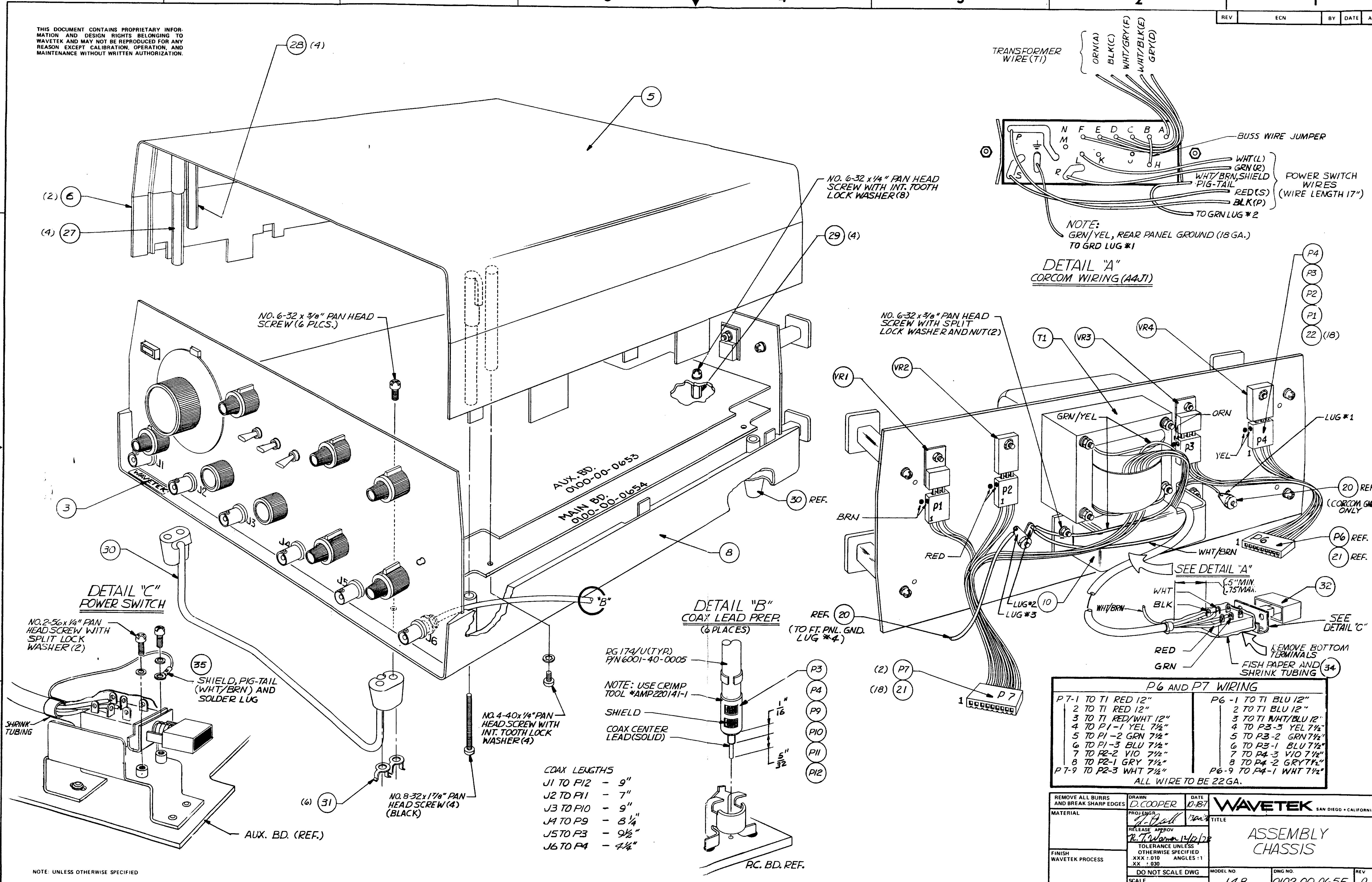
CODE IDENT 23338 — SHEET 1 OF 1

REV	ECN	BY	DATE	APP
B	# 1895		1/24/79	
C	# 2012		7-26-79	



NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN D.COOPER	DATE 10-18-7	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR	13 Oct	TITLE ASSEMBLY CHASSIS
	RELEASE APPROV R.T. Warner 12/12/78		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1		
	DO NOT SCALE DWG		MODEL NO. 148 / DWG NO. 0102-00-0655 / REV C
	SCALE		CODE IDENT 23338 / SHEET 1 OF 2



P6 AND P7 WIRING

P7		P6	
P7-1	TO T1 RED 12"	P6-1	TO T1 BLU 12"
2	TO T1 RED 12"	2	TO T1 BLU 12"
3	TO T1 RED/WHT 12"	3	TO T1 WHT/BLU 12"
4	TO P1-1 YEL 7½"	4	TO P3-3 YEL 7½"
5	TO P1-2 GRN 7½"	5	TO P3-2 GRN 7½"
6	TO P1-3 BLU 7½"	6	TO P3-1 BLU 7½"
7	TO P2-2 VIO 7½"	7	TO P4-3 VIO 7½"
8	TO P2-1 GRY 7½"	8	TO P4-2 GRY 7½"
P7-9	TO P2-3 WHT 7½"	P6-9	TO P4-1 WHT 7½"

ALL WIRE TO BE 22 GA.

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN D. COOPER	DATE 10-18-7
MATERIAL	PROJ ENGR [signature]	13 Oct 7
	RELEASE APPROV R. T. Warner 12/13/73	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1	
	DO NOT SCALE DWG	
	SCALE	

WAVETEK SAN DIEGO • CALIFORNIA

TITLE: ASSEMBLY CHASSIS

MODEL NO.	DWG NO.	REV
148	0102-00-0655	C
CODE IDENT 23338	SHEET 2 OF 2	

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
NONE	ASSY DRWG CHASSIS	0102-00-0655	WVTK	0102-00-0655	1
1	DIAL ASSY	143-582	WVTK	1201-00-0582	1
T1	TRANSFORMER	1204-00-0021	WVTK	1204-00-0021	1
2	END BELL	110-333	WVTK	1400-00-0174	1
3	PLATE,NAME	139-305	WVTK	1400-00-2180	1
4	INDICATOR,DIAL	180-303	WVTK	1400-00-4970	1
5	COVER,TOP	180-300-1	WVTK	1400-00-5000	1
6	EXPANDER	180-301	WVTK	1400-00-5010	2
7	POST	180-302	WVTK	1400-00-5020	4
8	COVER,BOTTOM	180-300-2	WVTK	1400-00-5030	1
10	SHIELD,PWR	1400-00-6210	WVTK	1400-00-6210	1
11	LABEL,WARNING	1400-00-6940	WVTK	1400-00-6940	1
13	PANEL,REAR	1400-00-8203	WVTK	1400-00-8203	1
34	INSULATOR,PWR SWITCH REF:1600-99-0001	1400-00-8370	WVTK	1400-00-8370	1
9	I.D. LABEL	1400-00-9090	WVTK	1400-00-9090	1
12	PANEL,FRONT	1400-01-1090	WVTK	1400-01-1090	1
J1 J2 J3 J4 J5	BNC CONN	KC-7946	KING	2100-01-0002	5

WAVETEK PARTS LIST — TITLE: CHASSIS — ASSEMBLY NO. 1101-00-0655 — PAGE: 1 — REV D

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
J6	BNC CONN	KC-19-152	KING	2100-01-0006	1
P6 P7	CONN,9PIN	09-50-7091	MOLEX	2100-02-0051	2
A4J1	RECEPTACLE	6J1	CORCM	2100-03-0026	1
P10 P11 P12 P3 P4 P9	CABLE CONTACT	226286-2	AMP	2100-03-0040	6
A4P1 A4P2 A4P3 A4P4 P1 P8	HOUSING,CONN 3-POS	87499-5	AMP	2100-03-0042	6
19	SOLDER LUG	1497	SMITH	2100-04-0012	5
20	SOLDER LUG	1485-6	SMITH	2100-04-0025	4
35	SOLDER LUG	5413	SESTM	2100-04-0034	1
21	PIN	08-50-0105	MOLEX	2100-05-0025	18
22	PINS,CONN	87667-2	AMP	2100-05-0030	18
23	STD KNOB	RB-67-1-SB-M	ROGAN	2400-01-0008	2
24	COAX KNOB SET	RB-67-1-SB+0-M-9	ROGAN	2400-01-0009	6
DS1	LAMP	CM7-7876	CHMIN	2400-02-0013	1
F1	FUSE,250V,1/2A,SB	313.500	LITFU	2400-05-0010	1
26	BUSHING NYLINER	4L2FF	THOMN	2800-01-0002	8
27	STANDOFF,MALE/FEMALE 1.750 H,.250 HEX	1475-M03-F05-832	UNICP	2800-02-0010	4

WAVETEK PARTS LIST — TITLE: CHASSIS — ASSEMBLY NO. 1101-00-0655 — PAGE: 2 — REV D

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
	8-32				
28	STANDOFF,MALE/FEMALE 2.375 H,.250 HEX 4-40	1495-M03-F05-440	UNICP	2800-02-0011	4
29	STANDOFF .625 H,.250 HEX 6-32	8217-A-0632	AMTOM	2800-02-0013	4
30	BAIL ASSY W/FT	180-500	WVTK	2800-08-0010	1
31	SPEEDNUT,SELF RETAIN	C7494-632-4	TINN	2800-09-0003	6
FB1	BALUN CORE	2873000902	FARIT	3100-00-0002	1
A4SW1	SWITCH ASSY PB	5102-00-0008	WVTK	5102-00-0008	1
NONE	WIRE,COAX	BTX019-10050	BRKTC	6001-40-0005	1
33	PWR CORD	0-7788-008-GY	PACRD	6001-80-0005	1
VR3	IC	MC7812CP	MOT	7000-78-1200	1
VR4	IC	7824	FAIR	7000-78-2400	1
VR2	IC	7912	MOT	7000-79-1200	1
VR1	IC	7924	FAIR	7000-79-2400	1

WAVETEK PARTS LIST — TITLE: CHASSIS — ASSEMBLY NO. 1101-00-0655 — PAGE: 3 — REV D

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

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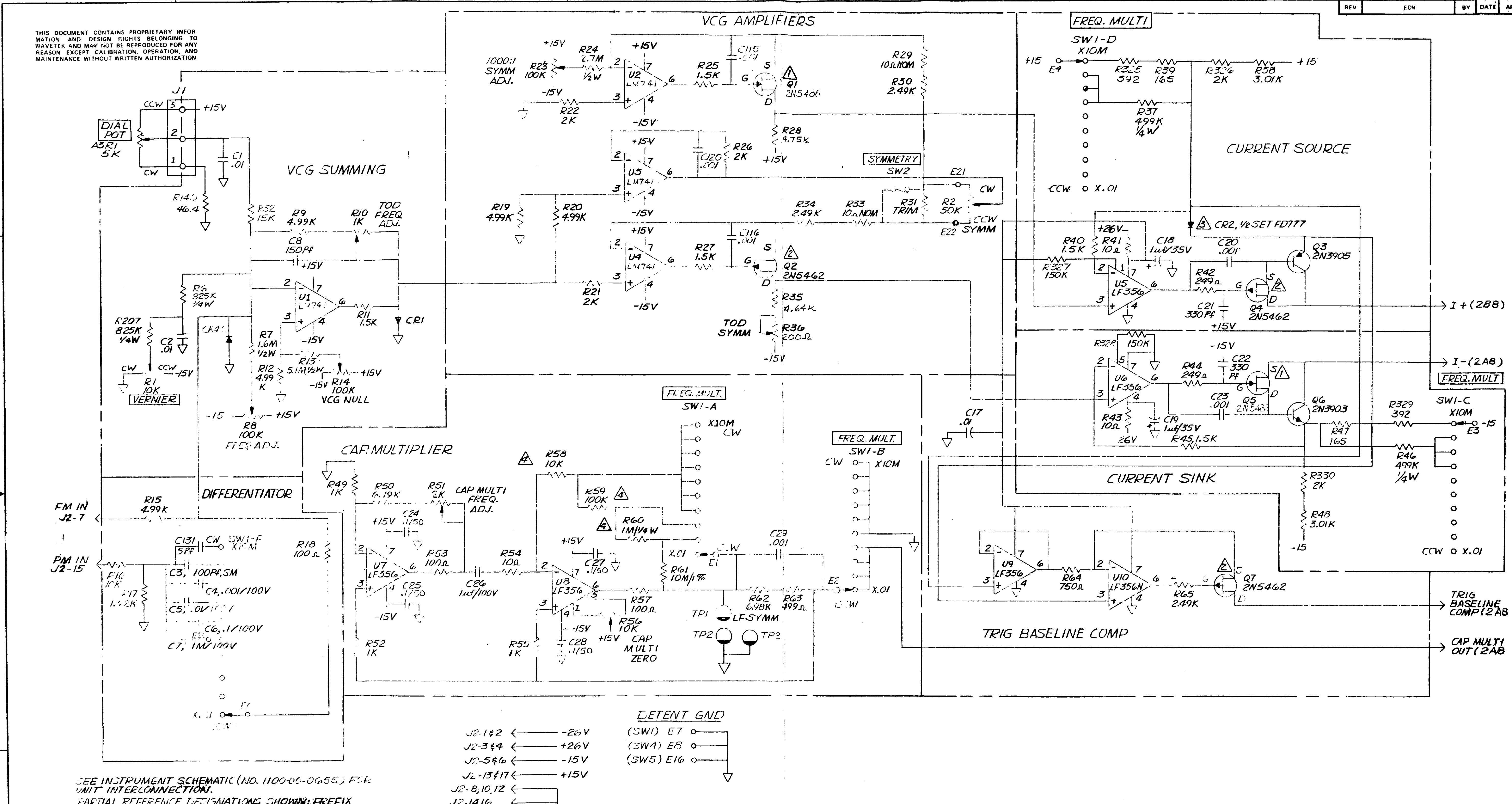
SCALE

WAVETEK SAN DIEGO • CALIFORNIA

TITLE PARTS LIST CHASSIS

MODEL NO. 148 — DWG NO. 1101-00-0655 — REV D

CODE IDENT 23338 — SHEET 1 OF 1



SEE INSTRUMENT SCHEMATIC (NO. 1100-00-0655) FOR UNIT INTERCONNECTION.
PARTIAL REFERENCE DESIGNATIONS SHOWN. PREFIX WITH UNIT REF. DES. A1

4. 4789-00-0043 (RESISTOR SET)
3. 4898-00-0004 (FD777)
2. 4998-00-0008 (2N5462)
1. 4998-00-0010 (2N5485)
8. 4898-00-0010 (DIODE SET)
7. 1509-80-0008 (CAP SET)
6. 4998-00-0004 (2N3565)
5. 4998-00-0009 (2N5485)

M/GND = MULTIPLIER GROUND
ALL RESISTORS ARE 1/8 WATT
ALL DIODES ARE FD-6666

NOTE UNLESS OTHERWISE SPECIFIED

LAST REF. DES. USED:

R351	C167	TP8	U16
FB3	VR3	SW6	E26
CR51	Q62	J4	

REV	ECN	BY	DATE	APP
G				
F	ECN # 1834, 1903		1-22-79	

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MATERIAL
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DRAWN D. COOPER 1-18-78
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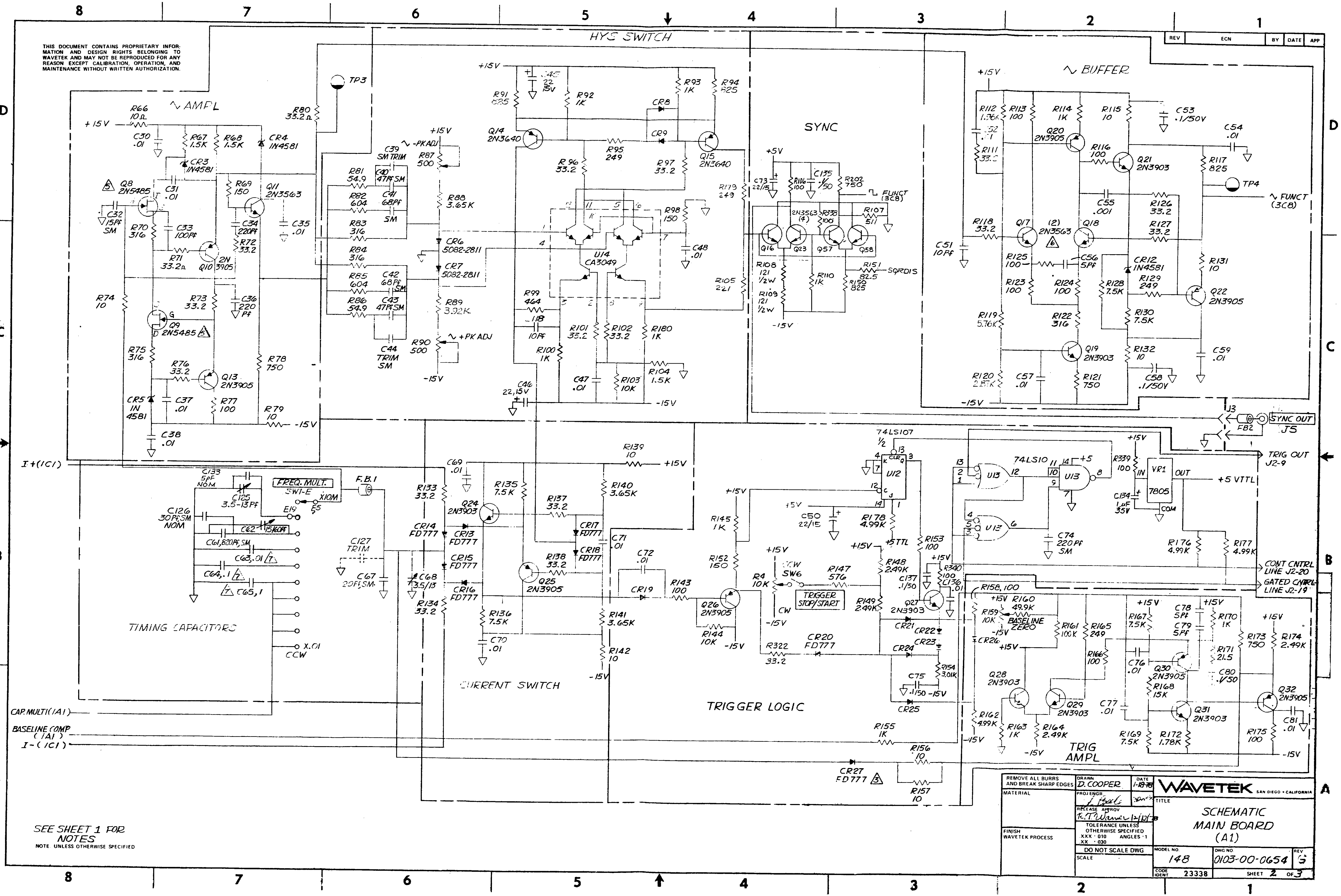
WAVETEK SAN DIEGO • CALIFORNIA

TITLE SCHEMATIC MAIN BOARD (A1)

MODEL NO. 145 DWG NO 0103-00-0654 REV G
CODE IDENT 23338 SHEET 1 OF 3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∿ AMPL
HYS SWITCH
SYNC
∿ BUFFER
TIMING CAPACITORS
CURRENT SWITCH
TRIGGER LOGIC
TRIG AMPL
FREQ. MULT. SW1-E
TRIGGER STOP/START
BASELINE ZERO
SYNC OUT J5
TRIG OUT J2-9
CONT CNTRL LINE J2-20
GATED CNTRL LINE J2-19
∿ FUNCT (3C8)
I+(IC1)
CAP. MULTI (IA1)
BASELINE COMP (IA1)
I-(IC1)
+5 VTTL
SEE SHEET 1 FOR NOTES
NOTE: UNLESS OTHERWISE SPECIFIED
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DATE 1-18-78
WAVETEK SAN DIEGO • CALIFORNIA
TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1 XX ±.030
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MODEL NO 148
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SHEET 2 OF 3

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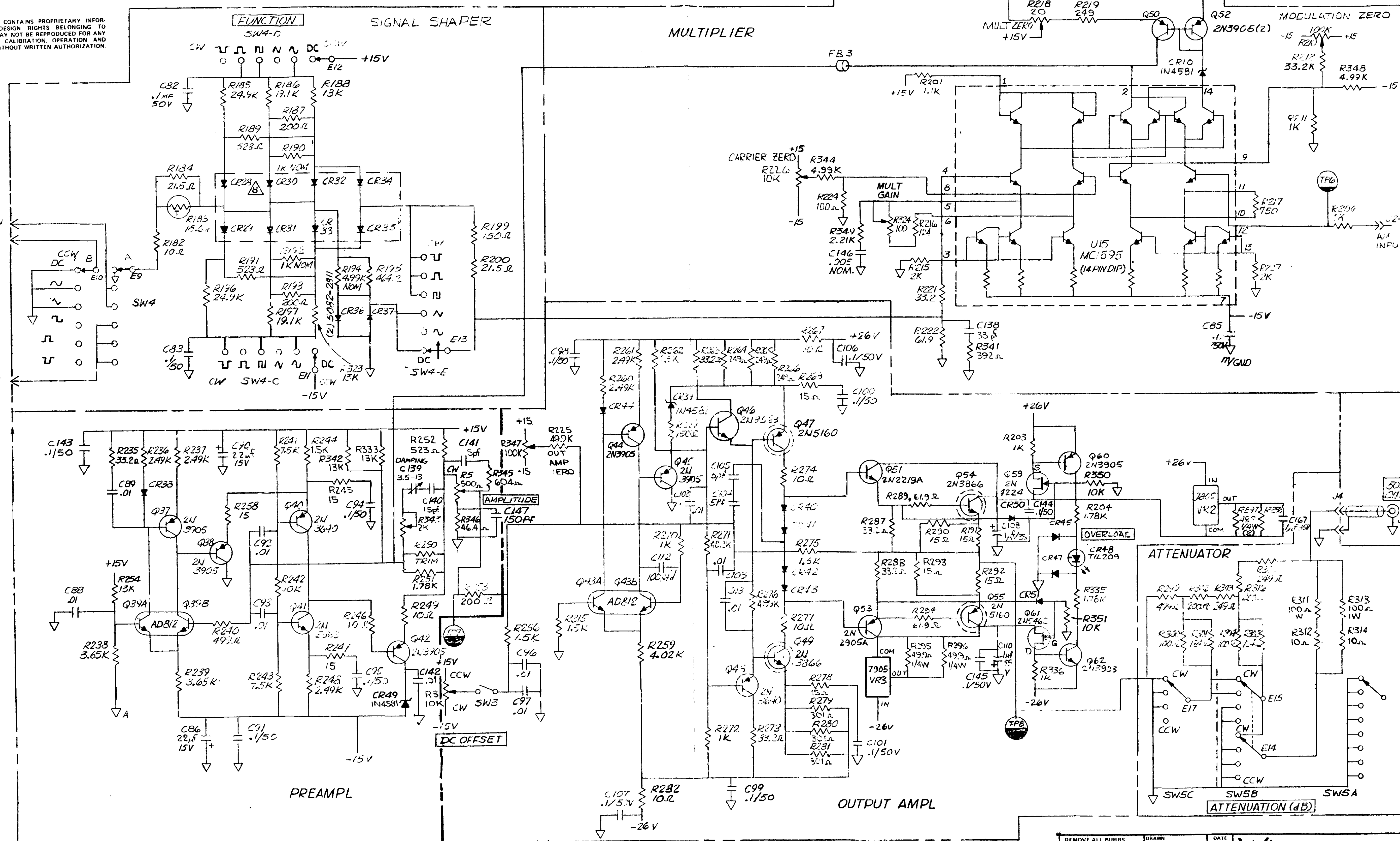

NOTE: UNLESS OTHERWISE SPECIFIED   SEE SHEET 1 FOR NOTES

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN D. COOPER	DATE 1-18-78
MATERIAL	PROJ ENGR	
	RELEASE APPROV	12-13-78
	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 XX ±.030 ANGLES ±1	
FINISH WAVETEK PROCESS	DO NOT SCALE DWG	
	SCALE	

WAVETEK SAN DIEGO • CALIFORNIA

TITLE: SCHEMATIC MAIN BOARD (A1)

MODEL NO 142 — DWG NO 0103-00-0654 — REV S

CODE IDENT 23338 — SHEET 3 OF 3

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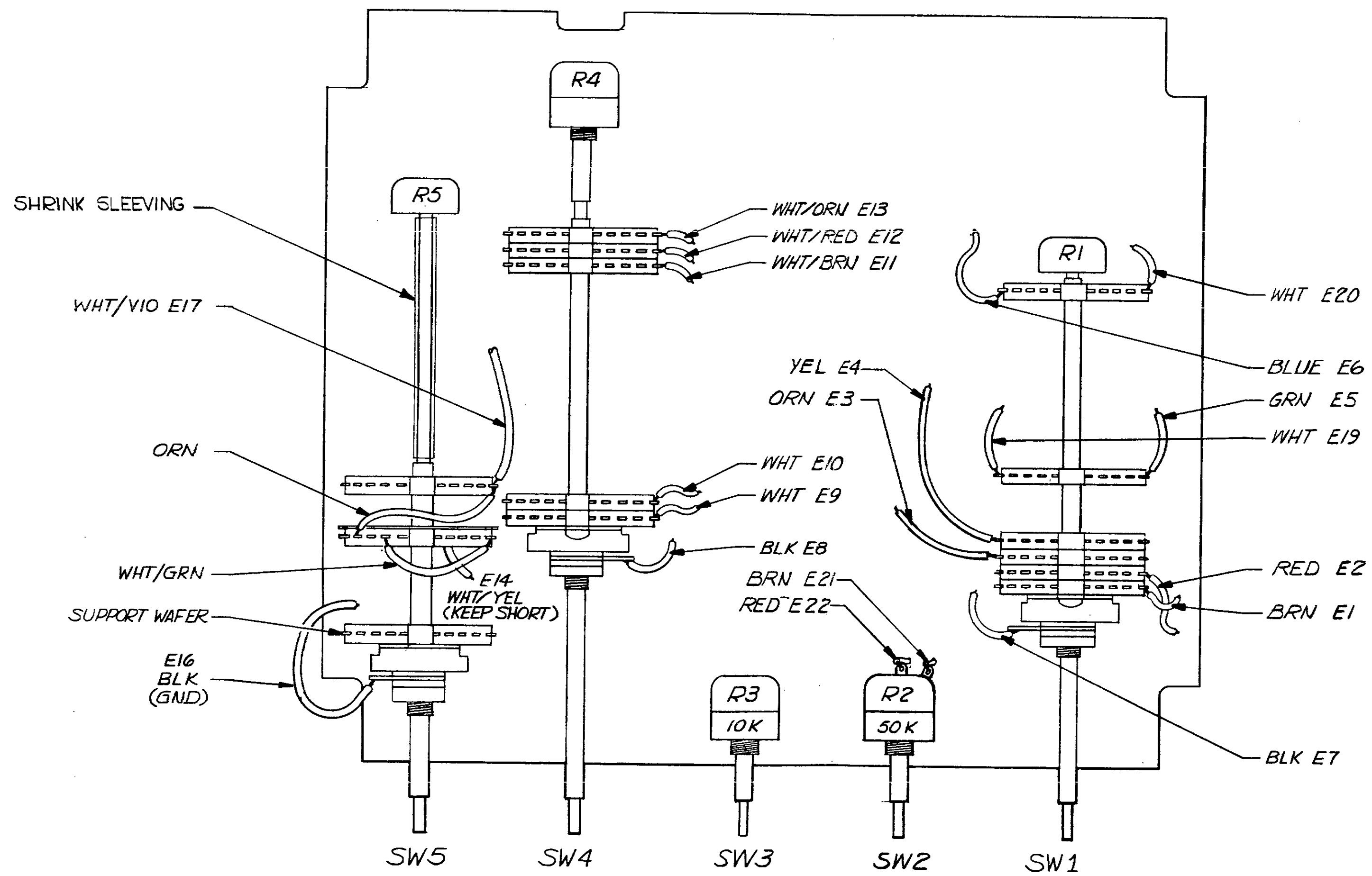
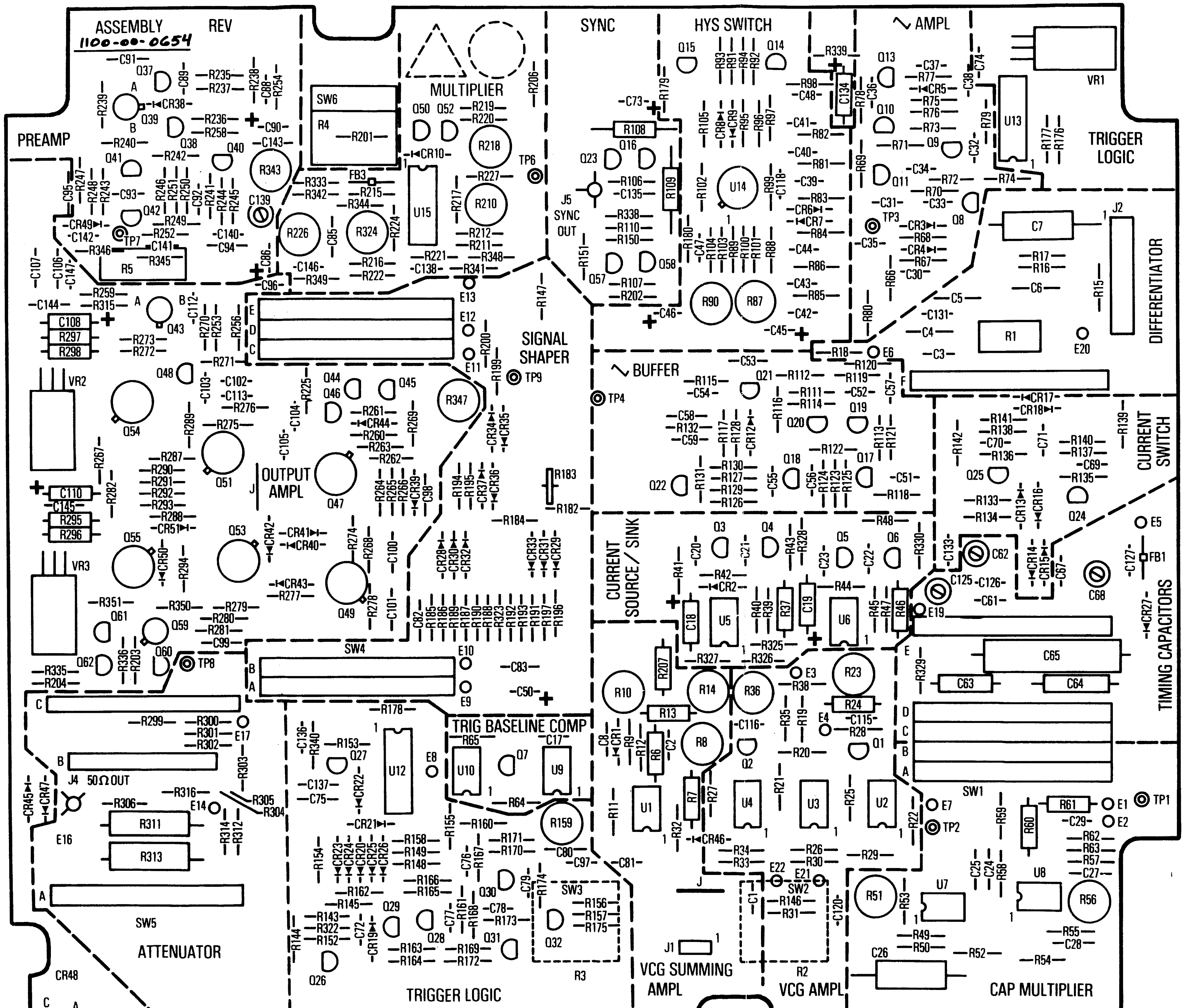
REV	ECN	BY	DATE	APP



SWITCH INSTALLATION AND WIRING

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN D. COOPER	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR / RELEASE APPROV	TITLE ASSEMBLY MAIN BOARD
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1°	
	DO NOT SCALE DWG	MODEL NO. 148 / DWG NO. 0101-00-0654 / REV F
	SCALE	CODE IDENT 23338 / SHEET 2 OF 2



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

ASSEMBLY MAIN BOARD

MODEL NO 148 | DWG NO 0101-00-0654

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
R316					
R21 R215 R22 R227 R26 R326 R330	RES,MF,1/8W,1%,2K	RN55D-2001F	TRW	4701-03-2001	7
R171 R184 R200	RES,MF,1/8W,1%,21.5	RN55D-21R5F	TRW	4701-03-2159	3
R105	RES,MF,1/8W,1%,221	RN55D-2210F	TRW	4701-03-2210	1
R349	RES,MF,1/8W,1%,2.21K	RN55D-2211F	TRW	4701-03-2211	1
R129 R165 R179 R219 R220 R264 R265 R266 R303 R306 R42 R44 R45	RES,MF,1/8W,1%,249	RN55D-2490F	TRW	4701-03-2490	13
R148 R149 R164 R174 R236 R237 R248 R260 R261 R30 R34 R65	RES,MF,1/8W,1%,2.49K	RN55D-2491F	TRW	4701-03-2491	12
R185 R196	RES,MF,1/8W,1%,24.9K	RN55D-2492F	TRW	4701-03-2492	2
R120	RES,MF,1/8W,1%,2.87K	RN55D-2871F	TRW	4701-03-2871	1
R279 R280 R281	RES,MF,1/8W,1%,301	RN55D-3010F	TRW	4701-03-3010	3
R154 R38 R48	RES,MF,1/8W,1%,3.01K	RN55D-3011F	TRW	4701-03-3011	3
R122 R70 R75 R83 R84	RES,MF,1/8W,1%,316	RN55D-3160F	TRW	4701-03-3160	5
R212	RES,MF,1/8W,1%,33.2K	RN55D-3322F	TRW	4701-03-3322	1
R101 R102 R111 R118 R126 R127 R133 R134 R137 R138 R221 R235	RES,MF,1/8W,1%,33.2	RN55D-33R2F	TRW	4701-03-3329	24

WAVETEK PARTS LIST — TITLE: PCA,MAIN BD — ASSEMBLY NO. 1100-00-0654 — PAGE: 7 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R263 R273 R287 R288 R322 R71 R72 R73 R76 R80 R96 R97					
R140 R141 R238 R239 R88	RES,MF,1/8W,1%,3.65K	RN55D-3651F	TRW	4701-03-3651	5
R325 R329 R341	RES,MF,1/8W,1%,392	RN55D-3920F	TRW	4701-03-3920	3
R89	RES,MF,1/8W,1%,3.92K	RN55D-3921F	TRW	4701-03-3921	1
R259	RES,MF,1/8W,1%,4.02K	RN55D-4021F	TRW	4701-03-4021	1
R271	RES,MF,1/8W,1%,40.2K	RN55D-4022F	TRW	4701-03-4022	1
R195 R99	RES,MF,1/8W,1%,464	RN55D-4640F	TRW	4701-03-4640	2
R35	RES,MF,1/8W,1%,4.64K	RN55D-4641F	TRW	4701-03-4641	1
R146 R346	RES,MF,1.8W,1%,46.4	RN55D-46R4F	TRW	4701-03-4649	2
R28	RES,MF,1/8W,1%,4.75K	RN55D-4751F	TRW	4701-03-4751	1
R240 R299 R63	RES,MF,1/8,1%,499	RN55D-4990F	TRW	4701-03-4990	3
R12 R15 R162 R176 R177 R178 R19 R194I R20 R276 R344 R348 R9	RES,MF,1/8W,1%,4.99K	RN55D-4991F	TRW	4701-03-4991	13
R160 R225	RES,MF,1/8W,1%,49.9K	RN55D-4992F	TRW	4701-03-4992	2
R107	RES,MF,1/8W,1%,511	RN55D-5110F	TRW	4701-03-5110	1
R189 R191 R252	RES,MF,1/8W,1%,523	RN55D-5230F	TRW	4701-03-5230	3

WAVETEK PARTS LIST — TITLE: PCA,MAIN BD — ASSEMBLY NO. 1100-00-0654 — PAGE: 8 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R81 R86	RES,MF,1/8W,1%,54.9	RN55D-54R9F	TRW	4701-03-5499	2
R147	RES,MF,1/8W,1%,576	RN55D-5760F	TRW	4701-03-5760	1
R119	RES,MF,1/8W,1%,5.76K	RN55D-5761F	TRW	4701-03-5761	1
R345 R82 R85	RES,MF,1/8W,1%,604	RN55D-6040F	TRW	4701-03-6040	3
R50	RES,MF,1/8W,1%,6.19K	RN55D-6191F	TRW	4701-03-6191	1
R222 R289 R294	RES,MF,1/8W,1%,61.9	RN55D-61R9F	TRW	4701-03-6199	3
R62	RES,MF,1/8W,1%,6.98K	RN55D-6981F	TRW	4701-03-6981	1
R121 R173 R202 R217 R64 R78	RES,MF,1/8W,1%,750	RN55D-7500F	TRW	4701-03-7500	6
R128 R130 R135 R136 R167 R169 R241 R243	RES,MF,1/8W,1%,7.5K	RN55D-7501F	TRW	4701-03-7501	8
R117 R150 R91 R94	RES,MF,1/8W,1%,825	RN55D-8250F	TRW	4701-03-8250	4
R151	RES,MF,1/8W,1%,82.5	RN55D-82R5F	TRW	4701-03-8259	1
R37 R46	RES,MF,1/4W,1%,499K	RN60D-4993F	TRW	4701-13-4993	2
R295 R296 R297 R298	RES,MF,1/4W,1%,49.9	RN60D-49R9F	TRW	4701-13-4999	4
R207 R6	RES,MF,1/4W,1%,825K	RN60D-8253F	TRW	4701-13-8253	2
R108 R109	RES,MF,1/2W,1%,121	RN65D-1210F	TRW	4701-23-1210	2
R311 R313	RES,MF,1W,1%,100	RN70D-1000F	TRW	4701-33-1000	2

WAVETEK PARTS LIST — TITLE: PCA,MAIN BD — ASSEMBLY NO. 1100-00-0654 — PAGE: 9 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
	RES,MF,MIXED SET	4789-00-0043	WVTK	4789-00-0043	1
R58	RES,MF,1/8W,1%,10K PART OF 4789-00-0043 QTY(1)				
R59	RES,MF,1/8W,1%,100K PART OF 4789-00-0043 QTY(1)				
R60	RES,MF,1/4W,1%,1M PART OF 4789-00-0043 QTY(1)				
R61	RES,MF,.6W,1%,10M	ML-181	CADDO	4799-00-0003	1
CR12 CR3 CR39 CR4 CR49 CR5	DIODF,ZENER 6.2V	1NE23A	NPC	4801-01-0823	6
CR10	DIODE	1N4581	MICRO	4801-01-4581	1
CR13 CR14 CR15 CR16 CR17 CR18 CR20	DIODE	FD-777	FAIR	4807-02-0777	7
CR1 CR19 CR21 CR22 CR23 CR24 CR25 CR26 CR38 CR40 CR41 CR42 CR43 CR44 CR45 CR46 CR47 CR50 CR51 CR8 CR9	DIODE	FD-6666	FAIR	4807-02-6666	21
CR36 CR37 CR6 CR7	DIODE	5082-2811	HP	4809-02-2811	4
CR2 CR27	DIODE,M/PR,FD-777	164-501-93	WVTK	4898-00-0004	1

WAVETEK PARTS LIST — TITLE: PCA,MAIN BD — ASSEMBLY NO. 1100-00-0654 — PAGE: 10 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
	QTY:2:4807-02-0777				
CR28 CR29 CR30 CR31 CR32 CR33 CR34 CR35	DIODE,SET,8-FD-777 QTY:8:4807-02-0777	182-500-98	WVTK	4898-00-0010	1
CR48	LED	TIL-209A	TI	4899-00-0005	1
Q51	TRANS	2N2219A	NSC	4901-02-2191	1
Q53	TRANS	2N2905A	NSC	4901-02-9051	1
Q11 Q16 Q23 Q41 Q46 Q57 Q58	TRANS	2N3563	FAIR	4901-03-5630	7
Q14 Q15 Q40 Q48	TRANS	2N3640	FAIR	4901-03-6400	4
Q49 Q54	TRANS	2N3866	MOT	4901-03-8660	2
Q19 Q21 Q24 Q27 Q28 Q29 Q31 Q6 Q62	TRANS	2N3903	NSC	4901-03-9030	9
Q10 Q13 Q20 Q22 Q25 Q26 Q3 Q30 Q32 Q37 Q38 Q42 Q44 Q45 Q50 Q52 Q60	TRANS	2N3905	ITT	4901-03-9050	17
Q59	TRANS	2N4224	NSC	4901-04-2240	1
Q47 Q55	TRANS	2N5160	MOT	4901-05-1600	2
Q61	TRANS	2N5462	MOT	4901-05-4620	1
Q1 Q5	TRANS	2N5486	MOT	4901-05-4860	2
Q17 Q18	TRANS,M/PR,2N3563	142-501-52	WVTK	4998-00-0004	1

WAVETEK PARTS LIST — TITLE: PCA,MAIN BD — ASSEMBLY NO. 1100-00-0654 — PAGE: 11 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
	QTY:2:4901-03-5630				
Q2 Q4 Q7	TRANS,SEL,2N5462 QTY:1:4901-05-4620	142-501-55	WVTK	4998-00-0008	3
Q8 Q9	TRANS,M/PR,2N5485 QTY:2:4901-05-4850	142-501-53	WVTK	4998-00-0009	1
R183	THERMISTER	LB12J2	FNWL	5300-00-0002	1
U10 U5 U6 U7 U8 U9	IC,OP-AMP	LF356N	NSC	7000-03-5600	6
U1 U2 U3 U4	IC	MA-741	FAIR	7000-07-4100	4
Q39 Q43	IC	AD 812	ANDEV	7000-08-1200	2
U15	IC	MC1595L	MOT	7000-15-9500	1
U14	IC	CA-3049	RCA	7000-30-4900	1
VR3	IC	MC7905CP	MOT	7000-79-0500	1
U13	IC	74LS10	TI	8000-74-1010	1
VR1 VR2	VOLTAGE REGULATOR	7805393	FAIR	8000-78-0500	2
U12	IC	74LS107	TI	8007-41-0710	1

WAVETEK PARTS LIST — TITLE: PCA,MAIN BD — ASSEMBLY NO. 1100-00-0654 — PAGE: 12 — REV G

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 BD
MODEL NO. 148 — DWG NO. 1100-00-0654 — REV G
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 BD	0101-00-0654	WVTK	0101-00-0654	1
NONE	SCHEMATIC MAIN BD	0103-00-0654	WVTK	0103-00-0654	1
NONE	ASSY,SWITCHES MAINBOARD	148-0039	WVTK	1202-00-0039	1
NONE	SPACER	8480	WVTK	1400-00-0653	3
C104 C105 C131 C1331 C141 C56 C78 C79	CAP,CER,5PF,1KV	DD-050	CRL	1500-00-5011	8
C118 C51	CAP,CER,10PF,1KV	DD-100	CRL	1500-01-0011	2
C112 C33	CAP,CER,100PF,1KV	DD-101	CRL	1500-01-0111	2
C115 C116 C120 C20 C23 C29 C55	CAP,CER,.001MF,1KV	DD-102	ARCO	1500-01-0211	7
C1 C102 C103 C113 C136 C142 C17 C2 C30 C31 C35 C37 C38 C47 C48 C52 C54 C57 C59 C69 C70 C71 C72 C76 C77 C81 C88 C89 C92 C93 C96 C97	CAP,CER,.01MF,50V	CK-103	CRL	1500-01-0310	32
C100 C101 C106 C107 C135 C137 C143 C144 C145 C24 C25 C27 C28 C53 C58 C75 C80 C82 C83 C85 C91 C94 C95 C98 C99	CAP,CER,.1MF,50V	CK-104	CRL	1500-01-0410	25
C140	CAP,CER,15PF,1KV	DD-150	ARCO	1500-01-5011	1

WAVETEK PARTS LIST — TITLE: PCA,MAIN BD — ASSEMBLY NO. 1100-00-0654 — PAGE: 1 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
C147 C8	CAP,CER,150PF,1KV	DD-151	ARCO	1500-01-5111	2
C34 C36	CAP,CER,220PF,1KV	DD-221	ARCO	1500-02-2111	2
C138	CAP,CER,33PF,1KV	DD-330	ARCO	1500-03-3011	1
C21 C22	CAP,CER,330PF,1KV	DD-331	ARCO	1500-03-3111	2
C1461	CAP,CER,.005MF,50V	CK-502	CRL	1500-05-0210	1
C3	CAP,MICA,100PF,500V	DM15-101J	ARCO	1500-11-0100	1
C32	CAP,MICA,15PF,500V	DM15-150J	ARCO	1500-11-5000	1
C67	CAP,MICA,20PF,500V	DM15-200J	ARCO	1500-12-0000	1
C74	CAP,MICA,220PF,500V	DM15-221J	ARCO	1500-12-2100	1
C1261	CAP,MICA,30PF,500V	DM15-300J	ARCO	1500-13-0000	1
C40 C43	CAP,MICA,47PF,500V	DM15-470J	ARCO	1500-14-7000	2
C41 C42	CAP,MICA,68PF,500V	DM15-680J	ARCO	1500-16-8000	2
C61	CAP,MICA,820PF,300V	DM15-821F	ARCO	1500-18-2101	1
C4	CAP,MYLAR,.001MF100V	225P10291WD3	SPRAG	1500-41-0204	1
C5	CAP,MYLAR,.01MF,100V	225P10391WD3	SPRAG	1500-41-0314	1
C6	CAP,POLYE,.1MF,100V	225P10491WD3	SPRAG	1500-41-0444	1
C26 C7	CAP,MYLAR,100V,1MF	225P10591YD3	SPRAG	1500-41-0514	2

WAVETEK PARTS LIST — TITLE: PCA,MAIN BD — ASSEMBLY NO. 1100-00-0654 — PAGE: 2 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
C125 C139 C68	VARI,3.5-13PF,250V	7S-TRIKO-02 3.5/13PF	TRIKO	1500-51-3000	3
C62	VARI,15-60PF,200V	538-011-112F	ERIE	1500-56-0010	1
C108 C110 C134 C18 C19	CAP,TANT,1MF,35V	150D105X9035A2	SPRAG	1500-71-0502	5
C45 C46 C50 C73 C86 C90	CAP,TANT,22MF,15V	196D226X9015KA1	SPRAG	1500-72-2601	6
	CAP SET,POLYC MIXED MATCHED SET	180-501-101	WVTK	1509-80-0008	1
C63	CAP,POLYC,.01MF,100V PART OF 1509-80-0008 QTY(1)				
C64	CAP,POLYC,.1MF,100V PART OF 1509-80-0008 QTY(1)				
C65	CAP,POLYC,1MF,100V PART OF 1509-80-0008 QTY(1)				
NONE	MAIN BOARD	1700-00-0654	WVTK	1700-00-0654	1
U15A	SKT,IC,14PIN	14-DIF	CINCH	2100-03-0011	1
NONE	COAX SOCKET	226287-2	AMP	2100-03-0038	2
NONE	SPRING SOCKET	50935-1	AMP	2100-03-0039	2
J1	3 POS HEADER	22-10-2031	MOLEX	2100-03-0052	1

WAVETEK PARTS LIST — TITLE: PCA,MAIN BD — ASSEMBLY NO. 1100-00-0654 — PAGE: 3 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
NONE	TERM	2000F1	USECO	2100-05-0009	4
NONE	TERM	2005P1	USECO	2100-05-0010	2
NONE	PIN,MALE	61182-2	AMP	2100-05-0020	8
J2	HEADER,20 PIN	929836-01-10	AP	2100-05-0042	1
NONE	HEAT SINK	NF-207	WAKE	2800-11-0001	4
NONE	TRANSIPAD	10123N	METRS	2800-11-0003	2
NONE	TRANSIPAD	10160	METRS	2800-11-0004	4
NONE	HEATSINK	NF-209	WAKE	2800-11-0008	2
FB1 FB3	FERRITE BEAD	56-590-65/3B	FERRX	3100-00-0001	2
R324	POT,TRIM,100	91AR100	BECK	4600-01-0103	1
R10	POT,TRIM,1K	91AR1K	BECK	4600-01-0209	1
R159 R226 R56	POT,TRIM,10K	91AR10K	BECK	4600-01-0315	3
R14 R210 R23 R347 R8	POT,TRIM,100K	91AR100K	BECK	4600-01-0421	5
R218	POT,TRIM,20	91AR20	BECK	4600-02-0000	1
R36	POT,TRIM,200	91AR200	BECK	4600-02-0101	1
R343 R51	POT,TRIM,2K	91AR2K	BECK	4600-02-0201	2
R87 R90	POT,TRIM,500	91AR500	BECK	4600-05-0104	2

WAVETEK PARTS LIST — TITLE: PCA,MAIN BD — ASSEMBLY NO. 1100-00-0654 — PAGE: 4 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R3	POT,SWITCH,10K	GH-1879	CTS	4602-01-0300	1
R2	POT,SWITCH,50K	4602-05-0302	WVTK	4602-05-0302	1
R7	RES,C,1/2W,5%,1.6M	RC20GF-165	STKPL	4700-25-1604	1
R24	RES,C,1/2W,5%,2.7M	RC20GF-275	STKPL	4700-25-2704	1
R13	RES,C,1/2W,10%,5.1M	RC20GF-515	STKPL	4700-25-5104	1
R106 R113 R116 R123 R124 R125 R143 R153 R158 R166 R175 R18 R224 R300 R304 R338 R339 R340 R53 R57 R77	RES,MF,1/8W,1%,100	RN55D-1000F	TRW	4701-03-1000	21
R100 R110 R114 R145 R155 R163 R170 R180 R1901 R192I R203 R206 R211 R270 R272 R336 R49 R52 R55 R92 R93	RES,MF,1/8W,1%,1K	RN55D-1001F	TRW	4701-03-1001	21
R103 R144 R16 R242 R350 R351	RES,MF,1/8W,1%,10K	RN55D-1002F	TRW	4701-03-1002	6
R161	RES,MF,1/8W,1%,100K	RN55D-1003F	TRW	4701-03-1003	1
R115 R131 R132 R139 R142 R156 R157 R182 R246 R249 R267 R274 R277 R282 R29I R312 R314 R33I R41 R43 R54 R66 R74 R79	RES,MF,1/8W,1%,10	RN55D-10R0F	TRW	4701-03-1009	24

WAVETEK PARTS LIST — TITLE: PCA,MAIN BD — ASSEMBLY NO. 1100-00-0654 — PAGE: 5 — REV G

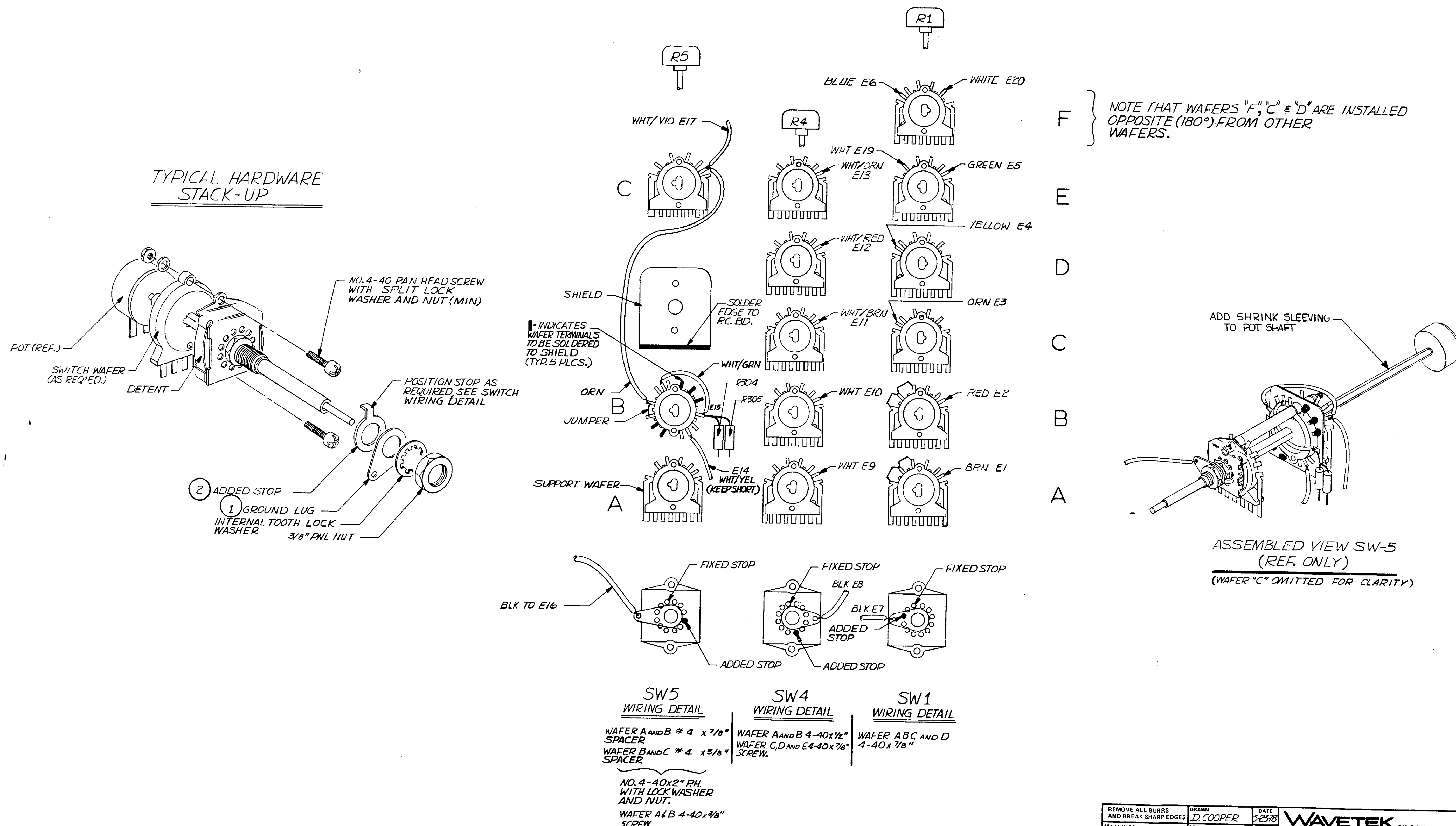
REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R201	RES,MF,1/8W,1%,1.1K	RN55D-1101F	TRW	4701-03-1101	1
R216 R301 R305	RES,MF,1/8W,1%,124	RN55D-1240F	TRW	4701-03-1240	3
R188 R254 R323 R333 R342	RES,MF,1/8W,1%,13K	RN55D-1302F	TRW	4701-03-1302	5
R152 R199 R269 R69 R98	RES,MF,1/8W,1%,150	RN55D-1500F	TRW	4701-03-1500	5
R104 R11 R244 R25 R256 R262 R27 R275 R315 R40 R45 R67 R68	RES,MF,1/8W,1%,1.5K	RN55D-1501F	TRW	4701-03-1501	13
R168 R32	RES,MF,1/8W,1%,15K	RN55D-1502F	TRW	4701-03-1502	2
R327 R328	RES,MF,1/8W,1%,150K	RN55D-1503F	TRW	4701-03-1503	2
R245 R247 R258 R268 R278 R290 R291 R292 R293	RES,MF,1/8W,1%,15	RN55D-15R0F	TRW	4701-03-1509	9
R17	RES,MF,1/8W,1%,1.62K	RN55D-1621F	TRW	4701-03-1621	1
R39 R47	RES,MF,1/8W,1%,165	RN55D-1650F	TRW	4701-03-1650	2
R172 R204 R251 R335	RES,MF,1/8W,1%,1.78K	RN55D-1781F	TRW	4701-03-1781	4
R186 R197	RES,MF,1/8W,1%,19.1K	RN55D-1912F	TRW	4701-03-1912	2
R112	RES,MF,1/8W,1%,1.96K	RN55D-1961F	TRW	4701-03-1961	1
R187 R193 R253 R302	RES,MF,1/8W,1%,200	RN55D-2000F	TRW	4701-03-2000	5

WAVETEK PARTS LIST — TITLE: PCA,MAIN BD — ASSEMBLY NO. 1100-00-0654 — PAGE: 6 — REV G

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN / DATE	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR	TITLE: PARTS LIST MAIN BD
	RELEASE APPROV	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1	
	DO NOT SCALE DWG	MODEL NO. 148 — DWG NO. 1100-00-0654 — REV G
	SCALE	CODE IDENT 23338 — SHEET 1 OF 2

REV	ECN	BY	DATE	APP



1. ALL DETENTS SHOWN FROM FRONT VIEW IN FULL COUNTER CLOCKWISE POSITION.

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES

MATERIAL

FINISH WAVETEK PROCESS

DRAWN D. COOPER — DATE 3-23-78

PROJ ENGR [illegible]

RELEASE APPROV [illegible]

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

DO NOT SCALE DWG

SCALE

WAVETEK SAN DIEGO • CALIFORNIA

TITLE ASSEMBLY DETENT MAIN BOARD

MODEL NO	DWG NO.	REV
148	1202-00-0039	A

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.

REV	ECN	BY	DATE	APP

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R4	ASSY,SWITCH POT	148-0682	WVTK	1201-00-0682	1
NONE	SPACER	144-305	WVTK	1400-00-2113	1
NONE	SPACER	144-306	WVTK	1400-00-2123	1
NONE	SHIELD,SWITCH	1400-00-8320	WVTK	1400-00-8320	1
1	SOLDER LUG	1497	SMITH	2100-04-0012	3
R5	POT,MOD 500 FROM:4600-05-0105	4600-75-0104	WVTK	4600-75-0104	1
R1	POT,CONT,10K FROM:4600-01-0312	4609-71-0301	WVTK	4609-71-0301	1
SW5-B	WAFER	T-106	CTS	5104-02-0002	1
SW1-A SW1-B SW1-C SW1-D SW1-E SW1-F SW4-A SW4-B SW4-C SW4-D SW4-E SW5-A SW5-C	WAFER	147-400	WVTK	5104-02-0015	13
2	SWITCH STOP	215-33-001-01-22	CTS	5104-07-0003	3
SW4	DETENT,MOD FROM:5104-01-0010	5104-99-0048	WVTK	5104-99-0048	1
SW1	DETENT,MOD FROM:5104-01-0010	5104-99-0049	WVTK	5104-99-0049	1
SW5	DETENT,MOD FROM:5104-01-0010	5104-99-0050	WVTK	5104-99-0050	1

WAVETEK PARTS LIST

TITLE: ASSY,SWITCHES MAINBOARD

ASSEMBLY NO. 1202-00-0039

PAGE: 1

REV A

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 ASSY, SWITCHES MAINBOARD

MODEL NO 148

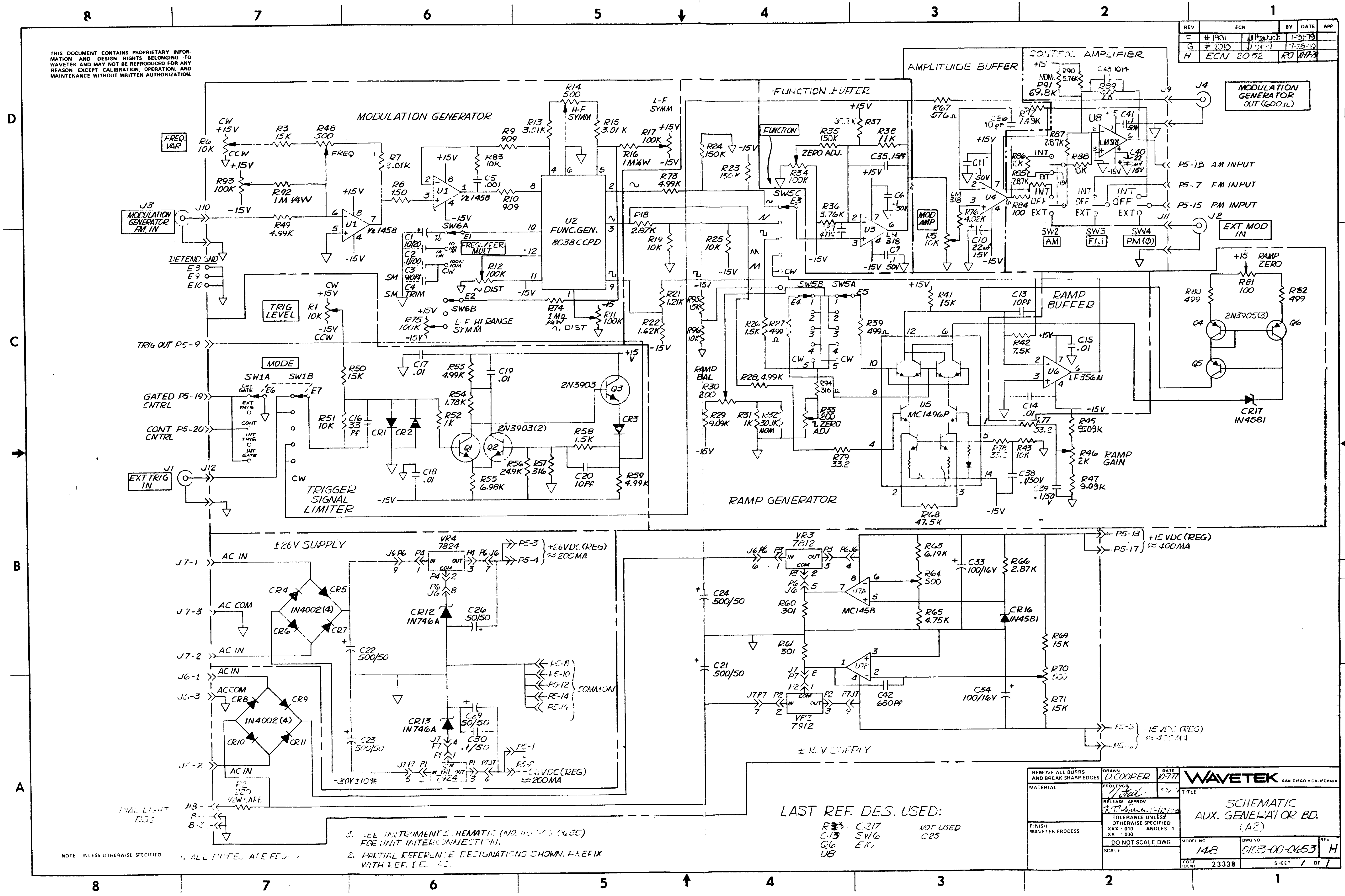
DWG NO 1202-00-0039

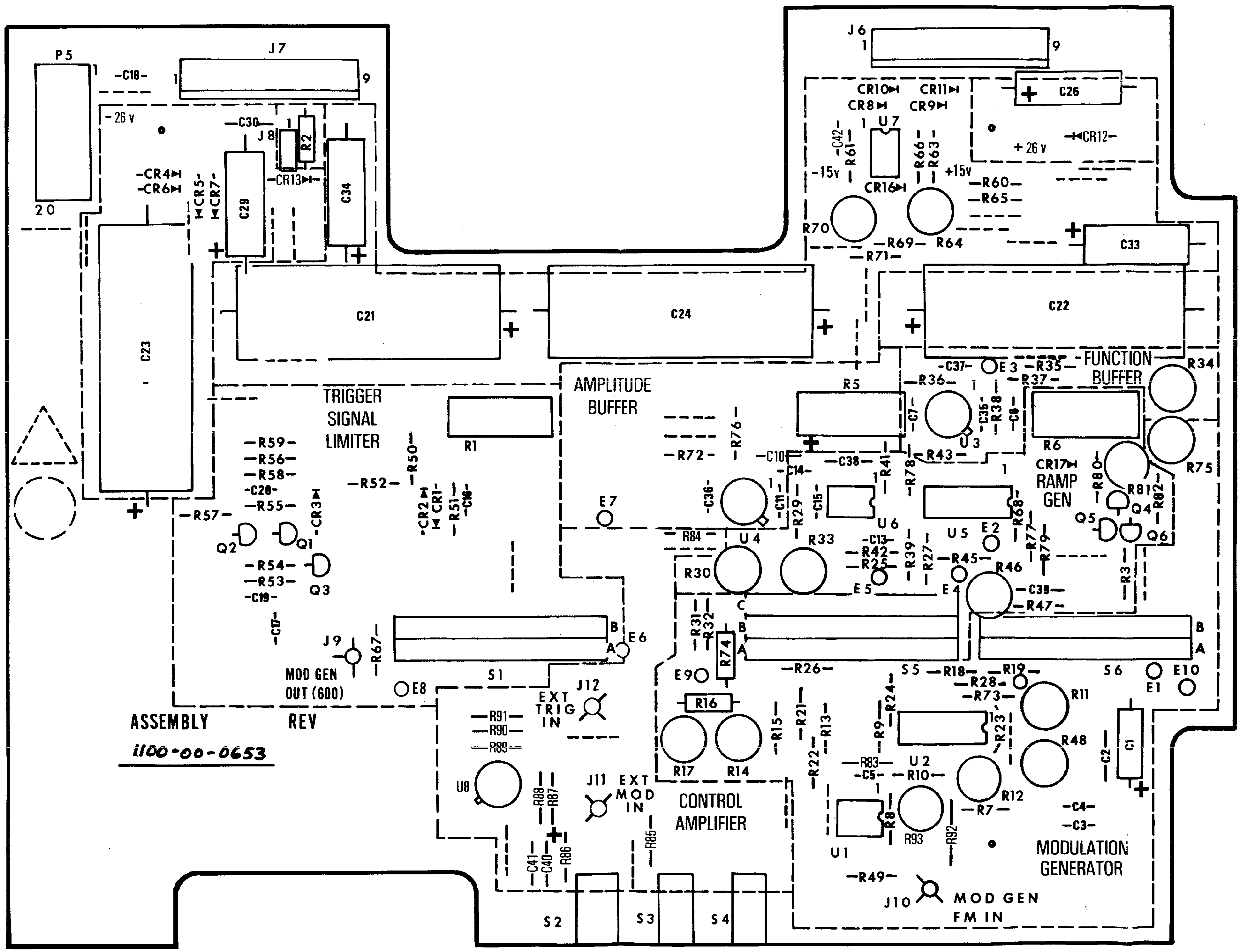
REV A

CODE IDENT 23338

SHEET OF

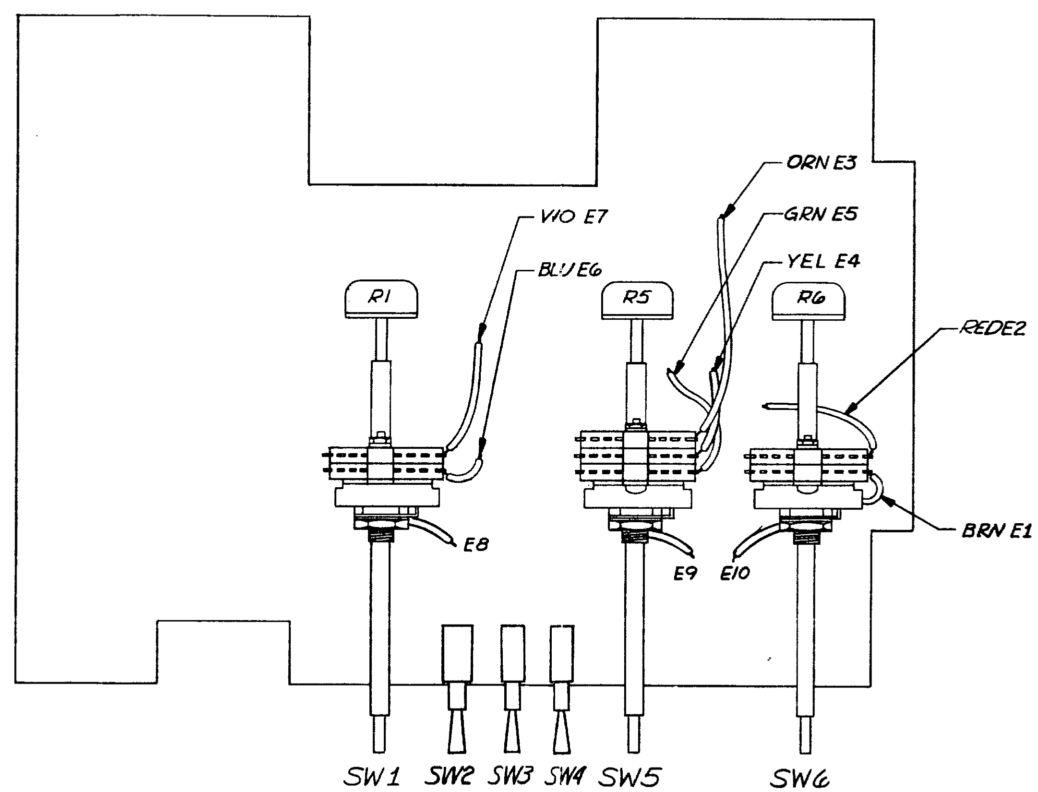
BISHOP GRAPHICS/ACCUPRESS REORDER NO A-3894


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.
REV | ECN | BY | DATE | APP
F | # 1901 | 1-31-79
G | # 2010 | 7-25-79
H | ECN 2052 | RO
MODULATION GENERATOR
FUNCTION BUFFER
AMPLITUDE BUFFER
CONTROL AMPLIFIER
MODULATION GENERATOR OUT (600 Ω)
FREQ VAR
J3 MODULATION GENERATOR FM IN
U2 FUNC.GEN. 8038CCPD
TRIG LEVEL
TRIG OUT P5-9
MODE
GATED P5-19 CNTRL
CONT P5-20 CNTRL
EXT TRIG IN
TRIGGER SIGNAL LIMITER
RAMP GENERATOR
RAMP BUFFER
MOD AMP
P5-18 AM INPUT
P5-7 FM INPUT
P5-15 PM INPUT
EXT MOD IN
U5 MC1496P
U6 LF356N
±26V SUPPLY
VR4 7824
+26VDC(REG) ≈ 200MA
-26VDC(REG) ≈ 200MA
COMMON
VR3 7812
VR2 7912
+15 VDC (REG) ≈ 400MA
-15VDC (REG) ≈ 400MA
±15V SUPPLY
LAST REF. DES. USED:
R93 C43 Q6 U8
CR17 SW6 E10
NOT USED C25
3. SEE INSTRUMENT SCHEMATIC FOR UNIT INTERCONNECTION.
2. PARTIAL REFERENCE DESIGNATIONS SHOWN. PREFIX WITH REF. DES. A2.
1. ALL DIODES ARE FDH...
NOTE UNLESS OTHERWISE SPECIFIED
REMOVE ALL BURRS AND BREAK SHARP EDGES
DRAWN D.COOPER 10-7-77
WAVETEK SAN DIEGO • CALIFORNIA
TITLE SCHEMATIC AUX. GENERATOR BD. (A2)
TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 XX ±.030 ANGLES ±1
FINISH WAVETEK PROCESS
DO NOT SCALE DWG
MODEL NO 148
DWG NO 0103-00-0653
REV H
CODE IDENT 23338
SHEET 1 OF 1



REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR		TITLE ASSEMBLY AUX. GENERATOR BD.
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX .010 XX .030 ANGLES 1°		
	DO NOT SCALE DWG		MODEL NO 148
	SCALE		DWG NO 0101-00-0653
			CODE IDENT 23338 SHEET 1 OF 2

REV	ECN	BY	DATE	APP



SWITCH INSTALLATION AND WIRING

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN D.COOPER	DATE 3-22-78	WAVETEK SAN DIEGO • CALIFORNIA	
MATERIAL	PROJ ENGR		TITLE ASSEMBLY AUX. GENERATOR BD. (A2)	
	RELEASE APPROV			
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1			
	DO NOT SCALE DWG		MODEL NO 148	DWG NO 0101-00-0653 REV F
	SCALE		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.

REV	ECN	BY	DATE	APP

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
NONE	ASSY DRWG AUX GEN	0101-00-0653	WVTK	0101-00-0653	1
NONE	SCHEMATIC AUX GEN	0103-00-0653	WVTK	0103-00-0653	1
NONE	ASSY,SWITCHES AUX GENERATOR	148-0040	WVTK	1202-00-0040	1
1	BRACKET,PWR SWITCH	1400-00-8903	WVTK	1400-00-8903	1
2	SHIELD	1400-00-9443	WVTK	1400-00-9443	1
C13 C20 C36 C43	CAP,CER,10PF,1KV	DD-100	CRL	1500-01-0011	4
C5	CAP,CER,.001MF,1KV	DD-102	ARCO	1500-01-0211	1
C14 C15 C17 C18 C19	CAP,CER,.01MF,50V	CK-103	CRL	1500-01-0310	5
C11 C30 C38 C39 C41 C6 C7	CAP,CER,.1MF,50V	CK-104	CRL	1500-01-0410	7
C35	CAP,CER,15PF,1KV	DD-150	ARCO	1500-01-5011	1
C16	CAP,CER,33PF,1KV	DD-330	ARCO	1500-03-3011	1
C37	CAP,CER,47PF,1KV	DD-470	ARCO	1500-04-7011	1
C42	CAP,CER,680PF,1KV	DD-681	ARCO	1500-06-8111	1
C3	CAP,910PF,100V,5%	DM15-911J	ARCO	1500-19-1100	1
C33 C34	CAP,ELECT,100MF,16V	500D107G016DC7	SPRAG	1500-31-0101	2
C26 C29	CAP,ELECT,50MF,50V	500D506G050DD7	SPRAG	1500-35-0003	2
C21 C22 C23 C24	CAP,ELECT,500MF,50V	39D507G050GL4	SPRAG	1500-35-0103	4

WAVETEK PARTS LIST — TITLE: PCA,AUX GENERATOR — ASSEMBLY NO. 1100-00-0653 — PAGE: 1 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
C2	CAP,POLYE,.1MF,100V	225P10491WD3	SPRAG	1500-41-0444	1
C1	CAP,TANT,10MF,20V	150D106X9020B2	SPRAG	1500-71-0601	1
C10 C40	CAP,TANT,22MF,15V	196D226X9015KA1	SPRAG	1500-72-2601	2
NONE	AUX GENERATOR	1700-00-0653	WVTK	1700-00-0653	1
J6 J7	CONN,9PIN	09-60-1091	MOLEX	2100-02-0052	2
J10 J11 J12 J9	COAX SOCKET	226287-2	AMP	2100-03-0038	4
NONE	SPRING SOCKET	50935-1	AMP	2100-03-0039	4
J8	3 POS HEADER	22-10-2031	MOLEX	2100-03-0052	1
4	STANDOFF,SWAGE .250 H,.250 DIA 6-32,.062 MAT'L	1530B-1/4-11	USECO	2800-03-0001	4
5	STANDOFF,SWAGE .125 H,.187 DIA 2-56,.062 MAT'L	SS153-1D-5A	UNICP	2800-03-0006	2
R81	POT,TRIM,100	91AR100	BECK	4600-01-0103	1
R11 R12 R17 R34 R75 R93	POT,TRIM,100K	91AR100K	BECK	4600-01-0402	6
R30 R33	POT,TRIM,200	91AR200	BECK	4600-02-0101	2
R46	POT,TRIM,2K	91AR2K	BECK	4600-02-0201	1
R14 R48 R64 R70	POT,TRIM,500	91AR500	BECK	4600-05-0104	4

WAVETEK PARTS LIST — TITLE: PCA,AUX GENERATOR — ASSEMBLY NO. 1100-00-0653 — PAGE: 2 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R2	RES,C,1/2W,5%,220	RC20GF-221	STKPL	4700-25-2200	1
R84	RES,MF,1/8W,1%,100	RN55D-1000F	TRW	4701-03-1000	1
R31 R52	RES,MF,1/8W,1%,1K	RN55D-1001F	TRW	4701-03-1001	2
R19 R25 R43 R51 R83 R86 R88 R96	RES,MF,1/8W,1%,10K	RN55D-1002F	TRW	4701-03-1002	8
R38	RES,MF,1/8W,1%,11K	RN55D-1102F	TRW	4701-03-1102	1
R21	RES,MF,1/8W,1%,1.21K	RN55D-1211F	TRW	4701-03-1211	1
R8	RES,MF,1/8W,1%,150	RN55D-1500F	TRW	4701-03-1500	1
R26 R58	RES,MF,1/8W,1%,1.5K	RN55D-1501F	TRW	4701-03-1501	2
R3 R41 R50 R69 R71 R95	RES,MF,1/8W,1%,15K	RN55D-1502F	TRW	4701-03-1502	6
R23 R24 R35	RES,MF,1/8W,1%,150K	RN55D-1503F	TRW	4701-03-1503	3
R22	RES,MF,1/8W,1%,1.62K	RN55D-1621F	TRW	4701-03-1621	1
R54	RES,MF,1/8W,1%,1.78K	RN55D-1781F	TRW	4701-03-1781	1
R89	RES,MF,1/8W,1%,2K	RN55D-2001F	TRW	4701-03-2001	1
R72	RES,MF,1/8W,1%,2.49K	RN55D-2491F	TRW	4701-03-2491	1
R56	RES,MF,1/8W,1%,24.9K	RN55D-2492F	TRW	4701-03-2492	1
R18 R66 R85 R87	RES,MF,1/8W,1%,2.87K	RN55D-2871F	TRW	4701-03-2871	4

WAVETEK PARTS LIST — TITLE: PCA,AUX GENERATOR — ASSEMBLY NO. 1100-00-0653 — PAGE: 3 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R60 R61	RES,MF,1/8W,1%,301	RN55D-3010F	TRW	4701-03-3010	2
R13 R15 R7	RES,MF,1/8W,1%,3.01K	RN55D-3011F	TRW	4701-03-3011	3
R32T	RES,MF,1/8W,1%,30.1K	RN55D-3012F	TRW	4701-03-3012	1
R57 R94	RES,MF,1/8W,1%,316	RN55D-3160F	TRW	4701-03-3160	2
R77 R78 R79	RES,MF,1/8W,1%,33.2	RN55D-33R2F	TRW	4701-03-3329	3
R37	RES,MF,1/8W,1%,35.7K	RN55D-3572F	TRW	4701-03-3572	1
R76	RES,MF,1/8W,1%,4.02K	RN55D-4021F	TRW	4701-03-4021	1
R65	RES,MF,1/8W,1%,4.75K	RN55D-4751F	TRW	4701-03-4751	1
R68	RES,MF,1/8W,1%,47.5K	RN55D-4752F	TRW	4701-03-4752	1
R27 R39 R80 R82	RES,MF,1/8,1%,499	RN55D-4990F	TRW	4701-03-4990	4
R28 R49 R53 R59 R73	RES,MF,1/8W,1%,4.99K	RN55D-4991F	TRW	4701-03-4991	5
R67	RES,MF,1/8W,1%,576	RN55D-5760F	TRW	4701-03-5760	1
R36 R90	RES,MF,1/8W,1%,5.76K	RN55D-5761F	TRW	4701-03-5761	2
R63	RES,MF,1/8W,1%,6.19K	RN55D-6191F	TRW	4701-03-6191	1
R55	RES,MF,1/8W,1%,6.98K	RN55D-6981F	TRW	4701-03-6981	1
R91T	RES,MF,1/8W,1%,69.8K	RN55D-6982F	TRW	4701-03-6982	1
R42	RES,MF,1/8W,1%,7.5K	RN55D-7501F	TRW	4701-03-7501	1

WAVETEK PARTS LIST — TITLE: PCA,AUX GENERATOR — ASSEMBLY NO. 1100-00-0653 — PAGE: 4 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
R10 R9	RES,MF,1/8W,1%,909	RN55D-9090F	TRW	4701-03-9090	2
R29 R45 R47	RES,MF,1/8W,1%,9.09K	RN55D-9091F	TRW	4701-03-9091	3
R16 R74 R92	RES,MF,1/4W,1%,1M	RN60D-1004F	TRW	4701-13-1004	3
CR12 CR13	DIODE	1N746A	FAIR	4801-01-0746	2
CR17	DIODE,ZENER 6.2V	1N823A	MPC	4801-01-0823	1
CR16	DIODE	1N4581	MICRO	4801-01-4581	1
CR10 CR11 CR4 CR5 CR6 CR7 CR8 CR9	DIODE	SCF-1	SEMT	4801-02-0091	8
CR1 CR2 CR3	DIODE	FD-6666	FAIR	4807-02-6666	3
Q1 Q2 Q3	TRANS	2N3903	NSC	4901-03-9030	3
Q4 Q5 Q6	TRANS	2N3905	ITT	4901-03-9050	3
SW3 SW4	SWITCH,TOGGLE	7103 P3Y9AV2Q	C&K	5106-00-0019	2
SW2	SWITCH,TOGGLE	7203 P3Y9AVQ	C&K	5106-00-0024	1
6	ASSY,RIBBON CABLE	922522-20-02-5.0	A/P	6002-00-0010	1
U3 U4 U8	IC	LM318H	AMD	7000-03-1800	3
U6	IC,OP-AMP	LF356N	NSC	7000-03-5600	1
U1 U7	IC	MC1458P	MOT	7000-14-5800	2
U5	IC	MC1496P	MOT	7000-14-9600	1

WAVETEK PARTS LIST — TITLE: PCA,AUX GENERATOR — ASSEMBLY NO. 1100-00-0653 — PAGE: 5 — REV G

REFERENCE DESIGNATORS	PART DESCRIPTION	ORIG-MFGR-PART-NO	MFGR	WAVETEK NO.	QTY/PT
U2	IC	ICL 8038 CCPD	INTSL	7000-80-3800	

WAVETEK PARTS LIST — TITLE: PCA,AUX GENERATOR — ASSEMBLY NO. 1100-00-0653 — PAGE: 6 — REV G

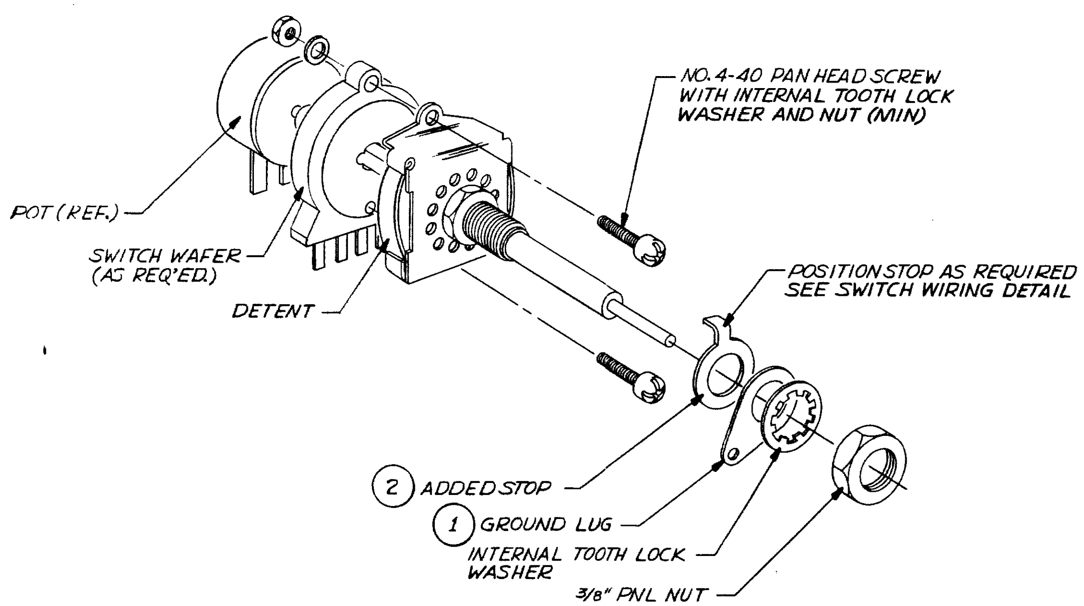
NOTE UNLESS OTHERWISE SPECIFIED

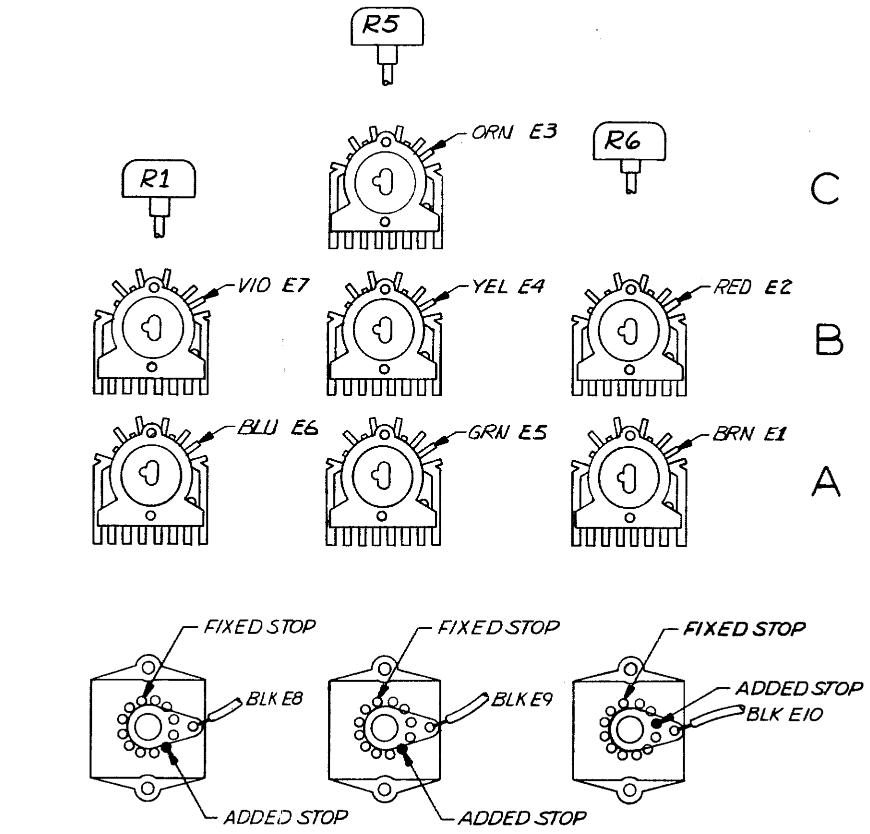
REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN	DATE	WAVETEK SAN DIEGO • CALIFORNIA
MATERIAL	PROJ ENGR		TITLE PARTS LIST AUX GENERATOR
	RELEASE APPROV		
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED .XXX ±.010 .XX ±.030 ANGLES ±1		
	DO NOT SCALE DWG		MODEL NO 148 — DWG NO. 1100-00-0653 — REV G
	SCALE		CODE IDENT 23338 — SHEET OF

BISHOP GRAPHICS/ACCUPRESS REORDER NO. A-3694

REV	ECN	BY	DATE	APP

TYPICAL HARDWARE STACK-UP





SW1 WIRING DETAIL	SW5 WIRING DETAIL	SW6 WIRING DETAIL
WAFER A AND B 4-40x1/2"	WAFER A,B AND C 4-40x3/4"	WAFER A AND B 4-40x1/2"

1. ALL DETENTS SHOWN FROM FRONT VIEW IN FULL COUNTER CLOCKWISE POSITION.

NOTE UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN D. COOPER	DATE 3-24-78
MATERIAL	PROJ ENGR [signature]	
	RELEASE APPROV R.T. Warner 12/18/78	
FINISH WAVETEK PROCESS	TOLERANCE UNLESS OTHERWISE SPECIFIED XXX ±.010 ANGLES ±1 XX ±.030	
	DO NOT SCALE DWG	
	SCALE NONE	

WAVETEK SAN DIEGO • CALIFORNIA

TITLE: ASSEMBLY AUX. GENERATOR BD. DETENTS

MODEL NO	DWG NO	REV
148	1202-00-0040	

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
1	SOLDER LUG	1497	SMITH	2100-04-0012	3
R1 R5 R6	POT,CONT,10K FROM:4600-01-0312	4609-71-0305	WVTK	4609-71-0305	3
SW1-A SW1-B SW5-A SW5-B SW5-C SW6-A SW6-B	WAFER	147-400	WVTK	5104-02-0015	7
2	SWITCH STOP	215-33-001-01-22	CTS	5104-07-0003	3
SW1 SW5 SW6	DETENT,MOD FROM:5104-01-0010	5104-99-0034	WVTK	5104-99-0034	3

WAVETEK PARTS LIST

TITLE ASSY,SWITCHES AUX GENERATOR

ASSEMBLY NO. 1202-00-0040

PAGE: 1

REV

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 ASSY, SWITCHES AUX GENERATOR

MODEL NO 148 | DWG NO 1202-00-0040 | REV

CODE IDENT 23338 | SHEET 2 OF 2