

0.002Hz TO 5MHz

FUNCTION GENERATOR

MODEL 5400A(R) SERIAL NO *3139*

5400A-1 *500*
5400 I *3152*

OPERATING AND MAINTENANCE MANUAL



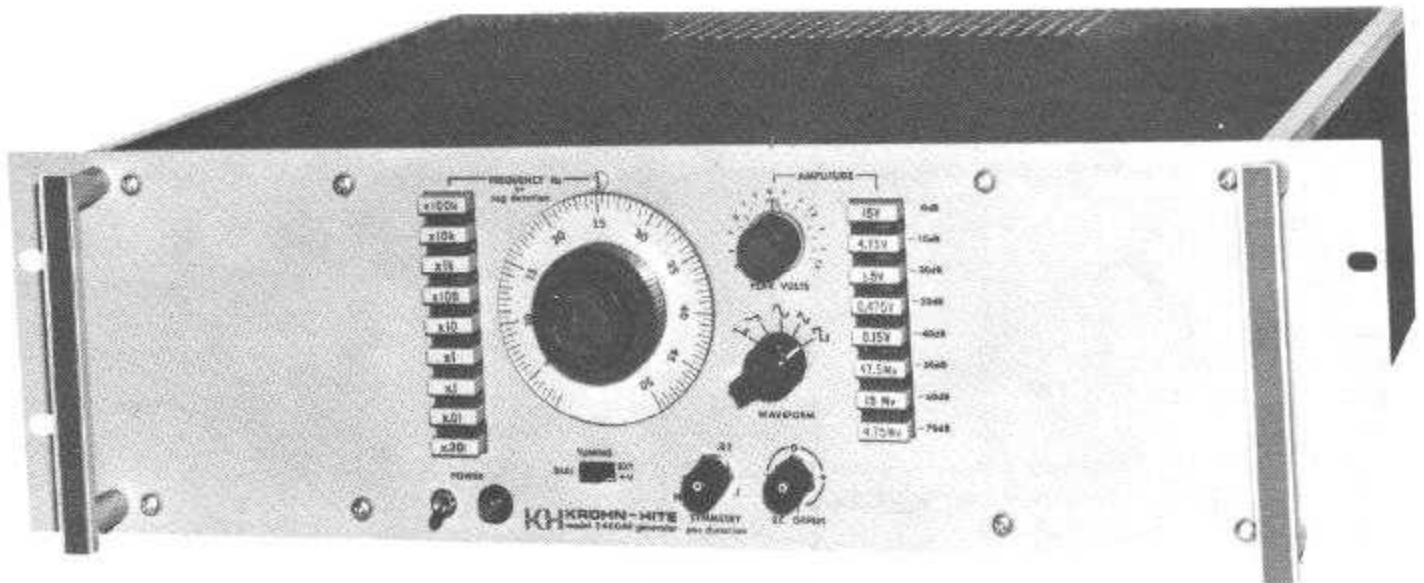
KROHN-HITE CORPORATION

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Model 5400A



Model 5400AR

Figure 1. Model 5400A and Model 5400AR Function Generator

SECTION 1

GENERAL DESCRIPTION

1.1 INTRODUCTION

The Krohn-Hite Model 5400A Function Generator provides sine, square, triangle, positive ramp and negative ramp functions over the frequency range of 0.002 Hz to 5 MHz. An auxiliary fixed amplitude square wave is provided, independent of the other functions, for synchronous gating, blanking, etc. Control of symmetry is provided for all functions, and allows for pulse or sawtooth operation. The maximum output amplitude is 30 volts p-p open circuit or 15 volts across 50 ohms. The output attenuator has a range of 70 dB, and has a vernier capable of an additional attenuation of 30 dB. Externally generated signals may be used to synchronize the frequency of the generator, to F-M the generator output about a center frequency, or to sweep the generator frequency over a range of at least 1000:1. The output signal may be offset by ± 10 volts by means of a front panel control.

The function generator is carefully inspected, aged, and adjusted before shipment, and should be ready for operation when it is unpacked. If it appears to have been damaged in shipment, make a claim with the carrier and notify Krohn-Hite immediately.

Study this manual carefully before operating the function generator. The operating instructions give information on applications and interfacing the instrument with other equipment.

1.2 SPECIFICATIONS

Waveforms

Sine wave, square wave, triangle, positive ramp, negative ramp. Positive and negative pulses with adjustable widths from 100ns to 1000s are also obtainable on the square wave function.

Frequency Range

0.002 Hz to 5 MHz in 9 ranges.

Frequency Control

Single turn dial calibration with single linear scale from 2 to 50 in Hz and a 9-band pushbutton multiplier switch.

<u>BAND</u>	<u>MULTIPLIER</u>	<u>FREQUENCY RANGE</u>	<u>PULSE WIDTH</u>
1	0.001	0.002Hz - 0.05 Hz	10s - 1000s
2	0.01	0.02Hz - 0.5Hz	1s - 100s
3	0.1	0.2Hz - 5Hz	0.1s - 10s
4	1	2Hz - 50Hz	10ms - 1s
5	10	20Hz - 500Hz	1ms - 0.1s
6	100	200Hz - 5kHz	0.1ms - 10ms
7	1k	2kHz - 50kHz	10us - 1ms
8	10k	20kHz - 500kHz	1us - 0.1ms
9	100k	200kHz - 5MHz	0.1us - 10us

Frequency Accuracy (Symmetrical waveforms)

1% of full scale for bands 1 thru 8; 2% of full scale on band 9.

Frequency Stability

10 minutes 0.05%
 24 hours 0.25%
 Vs line 0.01% for 10% line change
 Jitter (cycle to cycle) 0.025%

External Frequency Control (VC)

Range: 1000:1.

Input Impedance: 5000 ohms for D. C. to 1 MHz bandwidth.

Maximum Control Voltage: 10 Volts (± 25 Volts may be applied without damage to circuitry).

Response Time: Approximately 1 microsecond

Tuning Control

Dial Mode: Frequency may be externally controlled above and below dial setting.

External Mode: Dial is electrically removed from circuit. Frequency is controlled by external positive voltage of 10 millivolts to 10 Volts.

Main Output

Waveforms: Sine, square, triangle, positive ramp and negative ramp. Pulse obtainable by adjusting Symmetry control while on squarewave function.

Maximum Output: 30 Volts p-p open circuit; 15 Volts p-p across 50 ohms.

Impedance: Constant 50 ohms $\pm 2\%$.

Amplitude Control: Eight position pushbutton attenuator calibrated in open circuit peak volts and 10dB steps from 0dB to -70dB plus an infinite resolution vernier.

calibrated in peak volts. Attenuator accuracy ± 2 dB. Minimum output less than .5 millivolt p-p.

D. C. Component: Normal zero except for ramp. At maximum output drift is less than $5\text{mv}/^{\circ}\text{C}$. Drift reduced in proportion to pushbutton attenuator setting.

Frequency Response: Sine wave, .05dB from 0.005Hz to 100kHz; .3dB to 5MHz.

Sine Wave Distortion: Less than 0.5% from 0.002Hz to 100kHz; less than 3% to 5MHz.

Hum and Noise

0.02% of maximum output. Reduced in proportion to dB attenuator setting.

Time Symmetry

Sine, Square, Triangle waveforms, 99% from 0.002Hz to 100kHz with Symmetry control in NORM position.

Ramp Duration

47% with Symmetry control in the NORM position. Adjustable 1% to 99% by means of dial and Symmetry control.

Symmetry-pos duration Control

Single turn potentiometer and switch for adjusting positive duration of pulse and positive slope of triangle. Symmetry ratio, adjustable 100:1. With control on, negative duration of pulse and negative slope of triangle are adjustable by means of tuning dial. NOTE: All specifications apply with the Symmetry-pos duration control in the NORM position.

External Synchronization

2 Volts rms external sine wave signal will lock generator over approximately $\pm 5\%$ range with slight changes in distortion and amplitude. Input impedance 10K ohms.

Square Waves and Pulse

Rise and fall time less than 30ns, total aberrations less than 5% with 50 ohm matched load.

Triangle and Ramp Linearity

99% from 0.005Hz to 100kHz; 95% from 100kHz to 1MHz; 90% from 1MHz to 5MHz. Ramp fall time less than 30ns.

D.C. Offset

On front panel, ± 10 V open circuit, 5 V across 50 ohms. Stability $5\text{mv}/^{\circ}\text{C}$. Reduced in proportion to pushbutton attenuator setting. Maximum peak signal plus offset ± 15 Volts.

Auxiliary Square Wave Output

5 Volts p-p open circuit. 2.5 Volts p-p across 50 ohms. 50 ohms impedance. Rise and fall time less than 15ns. Total aberrations less than 5% with 50 ohm matched load.

Ambient Temperature Range

0 to 50°C.

Controls

Front panel contains frequency dial, frequency multiplier pushbuttons, amplitude pushbuttons, amplitude vernier, power switch, waveform switch, tuning switch, Symmetry-pos duration, d. c. offset. Rear panel contains line switch, d. c. level adj., symmetry adj.

Terminals (BNC Connectors)

(Front only on bench model, rear only on rack model.) External frequency control, main output and auxiliary output; External synchronization, on rear of all models.

Power Requirements

105-125 or 210-250 volts single phase 50-400Hz 40 watts.

Dimensions and Weights

Bench Model 5400A: 8 5/8" wide, 5 1/4" high, 14 1/2" deep, 12 lbs./6kgs, net; 18 lbs./9kgs. shipping.

Rack Mounting Model 5400AR: 19" wide, 5 1/4" high, 14 1/2" deep, 16 lbs./8kgs, net; 22 lbs. . 10kgs shipping.

SECTION 2

OPERATION

2.1 POWER REQUIREMENTS

The Model 5400A Function Generator may be used either with a 115 volt, 50-400 Hz line or with a 230 volt, 50-400 Hz line. The line voltage can be selected by operation of the LINE switch on the rear panel. When the line is 115 volts the fuse required is 0.4 ampere; for 230 volt operation, the fuse should be 0.2 ampere.

2.2 OPERATING CONTROLS AND CONNECTORS

2.2.1 Front Panel Controls

POWER: on-off switch and pilot light.

FREQUENCY HZ or neg duration: single turn dial with 5-to-1 vernier drive, graduated 2 to 50 for continuous control of frequency, with a 9 position pushbutton multiplier switch, X.001 to X100K in decades. With the SYMMETRY—pos duration control in the NORM position, the dial frequency times the multiplier equals the output frequency. With the SYMMETRY—pos duration control in use, the dial controls negative pulse duration, sawtooth negative slope, positive ramp delay, or negative ramp duration.

WAVEFORM: 5-position switch for selecting negative ramp, positive ramp, sine, triangle, or square wave.

AMPLITUDE: 8-button switch for attenuating 0dB (15V) through -70dB (4.75mv) in 10-dB increments, and infinite resolution vernier for fine adjustment to an additional -30 dB.

TUNING: 2-position switch used for selecting internal generator controlled (DIAL) or externally controlled (EXT +V) frequency.

DC OFFSET: switched potentiometer permitting dc offset of signal by ± 10 volts (or ± 5 volts with 50-ohm load).

SYMMETRY: pos duration—switched potentiometer for controlling positive pulse duration, positive sawtooth slope duration, negative ramp delay, or positive ramp duration. With this control in the NORM position, waveforms are symmetrical. When switched on, independently adjusts part of the waveform period and dial adjusts remaining portion.

2.2.2 Rear Panel Controls

Line: 2-position switch for selecting 115 or 230 volt operation.

SYM ADJ: 10-turn potentiometer for adjusting symmetry of waveforms.

DC OUTPUT LEVEL: potentiometer for adjustment of dc output level.

2.2.3 Connectors


OUTPUT: auxiliary square wave output. Front only on 5400A, rear only on 5400AR.

VC INPUT: Front only on 5400A, rear only on 5400AR.

EXTERNAL SYNC: Rear, all models.

2.3 PERFORMANCE

2.3.1 General

The output frequency of the generator is determined by its tuning mode of operation—whether its frequency control is internal, or is determined by the use of an external drive. With the TUNING switch in the DIAL position, the frequency is determined by the dial and multiplier setting, or if an external voltage is applied to the VC INPUT, the frequency may be varied about the dial setting. With the TUNING switch in the EXT+V position, the dial is removed from the circuit, and the output frequency depends upon the amplitude of a positive voltage applied to the VC INPUT. In all waveform positions, the auxiliary square wave can be taken from the  connector. The phase relationship of the various waveforms is shown in Figure 2.

2.3.2 Amplitude

The AMPLITUDE controls affect only the main OUTPUT. The generator will provide the peak open circuit output voltage given on the push buttons with the vernier in the maximum clockwise direction. In selecting output amplitude, use the lowest value that includes the amplitude you want. For instance, if you require 1 volt, press the 1.5 volt button, and adjust the vernier for an output of 1 volt. The vernier scale gives approximate open circuit peak amplitude values. Since the dc output level, the dc offset, and the amplitude vernier are all at the input of the output amplifier, their settings are affected by the action of the attenuator, which is at the output of the amplifier. The attenuator provides an impedance of 50 ohms at all settings. If the dc level plus the peak value of the signal exceeds the pushbutton setting, the output signal will be clipped or distorted. Thus the output should not exceed 15 volts peak ac plus dc on the 0dB position, 1.5 volts on the -20dB position, etc.

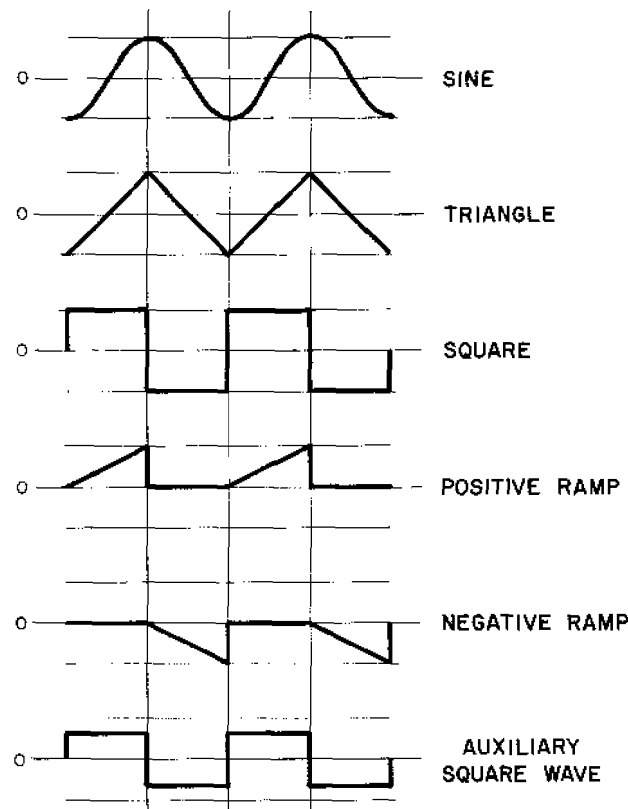


Figure 2. Phase Relationship of Output Signals

2.3.3 Symmetry and Duration Control

Symmetry control on the Model 5400A is not like the symmetry control in most other generators. Usually, the symmetry control offsets a normally symmetrical signal by varying both portions of the signal simultaneously, increasing the time of one portion and decreasing the time of the other. In the Model 5400A, when the SYMMETRY-pos duration control is in the NORM position, the waveforms are symmetrical; when the control is switched on, it controls half the waveform period, while the frequency dial controls the other half. The duration of each half of the waveform can be varied over a 1:100 range, the specific duration depending upon the multiplier setting. For instance with the multiplier set at X100K, the positive half of a square wave can be set to 100 nanoseconds by means of the SYMMETRY-pos duration control, while the negative half can be set to 10 microseconds by means of the frequency dial. Conversely, the negative half can be set to 100 nanoseconds while the positive half can be set to 10 microseconds. The frequency can be calculated as follows:

$$\text{Frequency} = \frac{1}{(\text{pos duration}) + (\text{neg duration})}$$

For the latter case:

$$\text{Frequency} = \frac{1}{1 \times 10^{-7} \text{ sec} + 100 \times 10^{-7} \text{ sec}}$$

$$\text{Frequency} = 99000 \text{ Hz}$$

When the triangle waveform is used, the duration controls can be used to generate a sawtooth—the SYMMETRY-pos duration control for the positive slope, and the frequency dial for the negative slope.

With the positive ramp, the SYMMETRY-pos duration control determines ramp duration while the frequency dial determines ramp delay. With the negative ramp, the frequency dial determines duration while the SYMMETRY-pos duration control determines ramp delay.

The dial graduations can be used to approximate duration, as follows:

For the frequency dial—

$$\text{duration in seconds} = \frac{1}{2 \times \text{dial setting} \times \text{multiplier}}$$

For the SYMMETRY-pos duration control—

$$\text{duration in seconds} = \frac{\text{control scale}}{\text{multiplier}}$$

2.3.4 External Synchronization

An external synchronizing signal can be used to lock the generator signal to another frequency reference. The SYNC INPUT impedance is 10 K ohms. A 2 vrms sine wave signal applied to the SYNC INPUT connector on the rear panel will lock the generator to a source within ± 5 percent of the dial frequency with some increase in distortion. As synchronizing voltage is increased, the locking range increases linearly—a 10 vrms input will provide a locking range of ± 30 percent, with considerable increase in distortion. If a square wave is used as the synchronizing signal, the sine output will be considerably distorted, and the locking range will increase linearly from ± 5 percent for a 4 volt peak to peak sync input to ± 20 percent for a 20 volt peak to peak synch input. The generator will synchronize on a harmonic of the dial frequency, with some distortion.

2.3.5 Modulating the Output Frequency

With the TUNING switch in the DIAL position, the indicated frequency can be modulated by the application of a signal to the VC INPUT connector. The range of modulation extends from 1/1000 of the maximum frequency obtainable on a particular multiplier setting to the maximum frequency of the multiplier setting. A positive voltage will increase the frequency above the dial setting, while a negative voltage will decrease the frequency below the dial setting. An applied voltage of ± 0.2 volt will change the frequency by 1 Hz \times Multiplier, or 1 dial division. For example, it may be necessary to produce a sine wave, varying in frequency linearly from 20 to 40 Hz and back, at the rate of 2 Hz. Set the generator frequency to 30 X1, and apply a triangle at 2 Hz, amplitude 4 volts peak to peak. The same effect can be obtained by offsetting the triangle drive to 0 to +4 volts, and setting the generator dial to 20 X1. With the generator dial set at 20 X1, a 0 to +4 volt square pulse would switch the output from 20 to 40 Hz.

2.3.6 External Frequency Control

With the TUNING switch in the EXT +V position, a positive voltage applied to the VC INPUT can be used to control output frequency to a ratio of at least 1000:1. The dial is electrically removed from the circuit. A +10 vdc level will provide the maximum output frequency normally obtainable for a given multiplier setting. The relationship between voltage and frequency is:

$$f = 5E_{VC} \times \text{Multiplier}$$

That is, with the multiplier switch in the X1K position, 100 millivolts gives 500 Hz, 1 volt 5 kHz, and 10 volts 50 kHz. Notice that with the multiplier in the X.001 position, 100 millivolts gives .0005 Hz, well below the dial range. At +10 volts frequency accuracy is typically within 1 percent (referred to the above formula), but may be off by as much as 15 percent at levels below 100 millivolts. Frequency linearity, however, is within 0.5 percent over the entire 1000:1 range. Maximum accuracy is obtained when all internal dc levels have been optimized. At very low VC levels, distortion can be minimized by adjustment of the SYM ADJ 10-turn potentiometer on the rear panel. The VC circuit can take a drive of up to ± 25 volts without damage.

A negative voltage applied to the VC INPUT will stop oscillation, and a dc level will appear on the output. If the negative drive voltage is greater than -2 volts, the output level will settle at the positive peak of the triangle, or at the negative peak of the sine wave or square wave. The ramps will settle at ground, or the value of the dc offset. If the negative drive is less than -2 volts, the dc level on the output is not predictable.

2.3.7 External VC and Duration Controls

When the SYMMETRY-pos duration control is on, an external VC level will control the duration of the negative portion of the signal. When the TUNING switch is in the EXT +V position, duration can be calculated as follows:

$$\text{Duration in seconds} = \frac{1}{10 \times \text{VC voltage} \times \text{multiplier}}$$

The VC input affects only the operation of the tuning dial; it does not affect the SYMMETRY-pos duration control.

SECTION 3

INCOMING INSPECTION AND CHECKOUT

3.1 INTRODUCTION

The following procedure should be used to verify that the generator is operating within specifications, both for incoming inspection and for routine servicing. Tests must be made with all covers in place and the procedure given below should be followed in sequence. Familiarize yourself with the initial setup and operating procedures given in Section 2.

3.2 EQUIPMENT REQUIRED

(a) Oscilloscope having direct coupled horizontal and vertical amplifier with 10mv/cm sensitivity and bandwidth of at least 30 MHz, Tektronix type 545 or equal with 1A5 plug-in unit.

(b) Frequency counter capable of measuring 1 Hz to 10 MHz and period from 1 second to 1000 seconds.

(c) AC Voltmeter, Ballantine Type 323 or equal ($\pm 2\%$ to 5 MHz).

(d) Calibrated voltage source, or regulated DC supply and digital voltmeter 0 to 10 volts.

(e) Distortion meter, Hewlett Packard Type 333A.

3.3 PROCEDURE

After allowing the instrument to warm up for 30 minutes, set the controls to the following positions:

FREQUENCY Hz	25 X100
TUNING SWITCH	Dial
AMPLITUDE	0dB (15V) vernier full CW
WAVEFORM	Sine
DC OFFSET	Off
SYMMETRY-pos duration	Norm

3.3.1 Waveforms

Connect the output of the generator to the oscilloscope with no load. Operate the WAVEFORM switch through all positions to check for the presence of all waveforms.

3.3.2 Amplitude Control

Set the WAVEFORM switch to sine. Rotate the amplitude vernier counterclockwise; the signal amplitude should diminish by more than 30dB. Rotate the vernier to the full clockwise position. Set the AMPLITUDE to 0dB (15V), and connect a 50 ohm load across the output of the generator. The voltage should drop by half (6dB). Remove load. Operate the AMPLITUDE pushbuttons in sequence, starting at 15 volts and going to 4.75 millivolts, reading the output amplitude on the scope with the scope VOLTS/CM control in the calibrated position. These values can be confirmed by the use of the acvm. Remember that the scope and generator are reading peak-to-peak volts, while the acvm reads in rms volts.

3.3.3 DC Offset

Operate the DC OFFSET control with amplitude vernier CCW; control should be capable of offsetting signal by ± 10 volts open circuit. Turn off the offset control.

3.3.4 Symmetry and Duration Controls

Change to square wave. Turn on the SYMMETRY-pos duration control, and operate it through its range. It should vary the positive half of the square wave over a ratio of 100:1. Then turn the frequency dial through its range. The negative portion of the square wave should vary over a range of 100:1. Return the SYMMETRY-pos duration control to NORM.

3.3.5 Auxiliary Square Wave

Connect the oscilloscope and the 50-ohm load to the auxiliary square wave output. The amplitude should be 2.5 volts peak-to-peak.

3.3.6 DC Level

Connect the dcvm to the output of the generator. It should be possible to set the level to zero by means of the DC OUTPUT LEVEL potentiometer on the rear panel.

3.3.7 Frequency Accuracy

Change the WAVEFORM to sine, and connect the frequency counter to the generator output. Check the frequency with the dial at 2, 25 and 50 in all frequency bands. Frequency accuracy should be within 1 percent of full scale on bands 1 through 8, and 2 percent of full scale on band 9 (X100K).

3.3.8 External Frequency Control

With the frequency set to 25 X100, connect the calibrated voltage source to the VC INPUT. Set the VC voltage to +1 volt; the output frequency should change to 3 kHz. Change the VC voltage to -1 volt. The output frequency should change to approximately 2 kHz.

Place the TUNING switch in the EXT +V position. Apply +10 volts to the VC INPUT; the output frequency should be 5 kHz \pm 50 Hz. Apply 100 millivolts to the VC INPUT; the output frequency should be approx. 50 Hz. Disconnect the VC input and set the TUNING switch to DIAL.

3.3.9 Sine Distortion

With the WAVEFORM switch on sine, and the dial set to 25 X100, check the sine distortion using the distortion meter. Distortion should be less than 0.5 percent.

SECTION 4 CIRCUIT DESCRIPTION

4.1 SYSTEM OPERATION

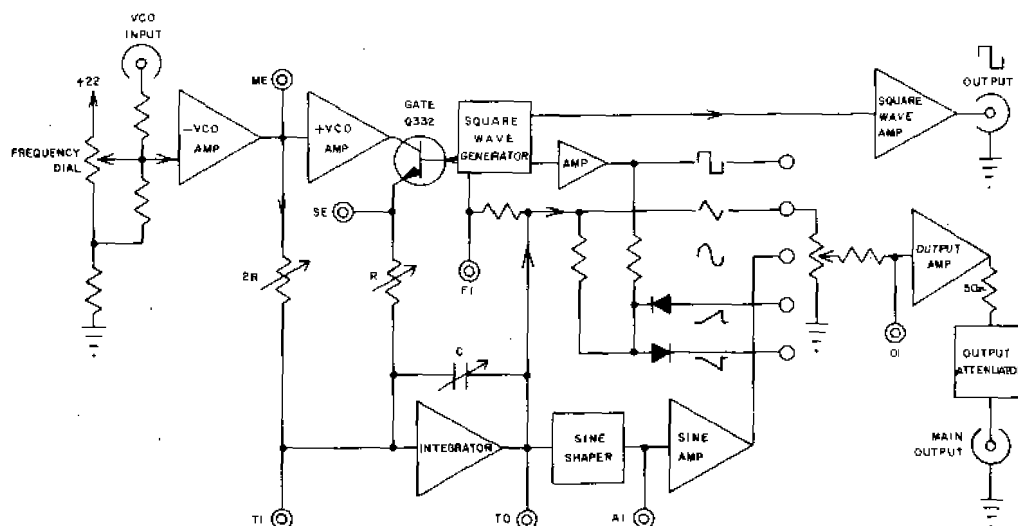


Figure 3. Model 5400A Block Diagram

A simplified block diagram of the function generator is shown in Figure 3. The basic oscillating system is comprised of the square wave generator and the integrator, with frequency controlled by the VC amplifiers. This system generates square and triangle waves, which are further processed to form the sine and ramp functions. The frequency control dial or the VC input sets a positive voltage at the input of the -VC amplifier. This amplifier produces a negative output proportional to its input; the negative output is applied to the $2R$ resistive network, setting a negative level at the input to the integrator, and charging the integrator feedback capacitor C . Capacitor C is one of the multiplier bandswitch capacitors. The output of the -VC amplifier also determines the +VC amplifier output level, which is applied to the collector of gate Q332. When Q332 is turned on by the square wave generator it drives the R resistive network, and the integrator charges the feedback capacitor in the opposite direction. When the square wave shuts off gate Q332, the cycle repeats.

The output of the integrator is a triangle, which is used as the triangle function, as the input to the sine shaper, and regeneratively as trigger for the square wave generator. The square wave generator output is used to provide both the main and auxiliary square wave outputs.

The sine and square waves are fed through amplifiers to the WAVEFORM switch. The triangle is fed directly to the switch and also through a summing network, where it is added to the square wave and clipped to provide the positive and negative ramps. The output amplifier inverts its input and provides a 50-ohm output to the attenuator.

4.2 VC AMPLIFIERS AND SYMMETRY CONTROL (See Figure 4)

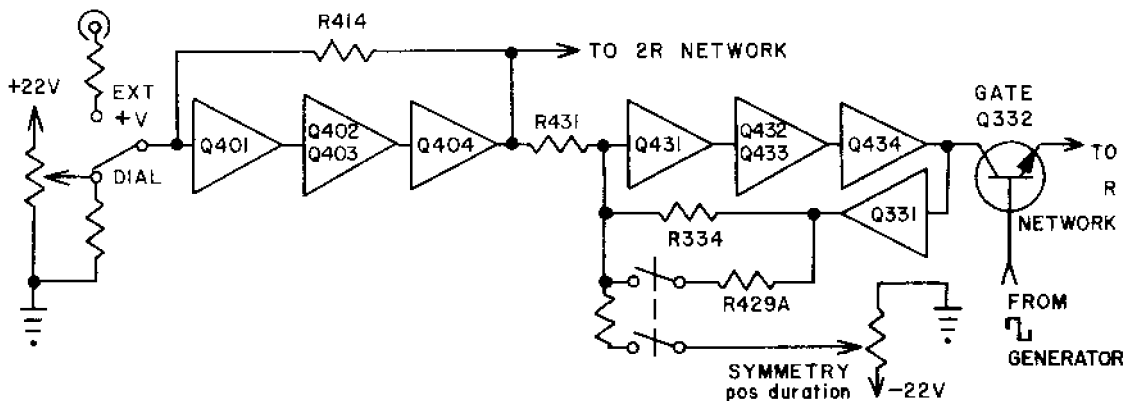


Figure 4. VC Amplifiers and Symmetry Control

The VC amplifiers are similar, both having two balanced differential stages and emitter follower output. Both amplifiers invert; the -VC amplifier has a gain of -0.5 and the +VC amplifier has a gain of -1 , which is precisely maintained by the feedback transistor, Q331. The output of the -VC amplifier drives the 2R resistors, while the output of the +VC amplifier drives the R resistors, through gate Q332. When Q332 amplifier is gated on, twice as much current will be provided to the integrator input as is provided by the -VC amplifier, reversing the charge on the integrating capacitor.

The operation of the symmetry control switch does two things: (1) it reduces the gain of the +VC amplifier to -0.5 by increasing its negative feedback; and (2) it switches in SYMMETRY-pos duration potentiometer R413, which controls a negative bias applied to the input of the +VC amplifier. This means that the drive for the R resistors is controlled by R413, while the drive for the 2R resistors is controlled by the frequency dial. The result is independent width control for the positive and negative duration of the output signal.

4.3 INTEGRATOR (See Figure 5)

The integrator is a negative infinite-gain amplifier with a feedback capacitor C to provide the integrating function. Two regenerative stages, Q301-Q304 and Q306-Q308 provide the gain. Capacitor C is selected by the bandswitch.

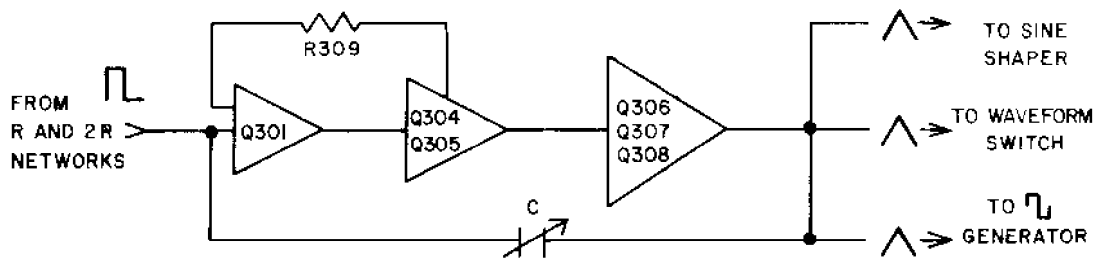


Figure 5. Integrator

4.4 SQUARE WAVE GENERATOR (See Figure 6)

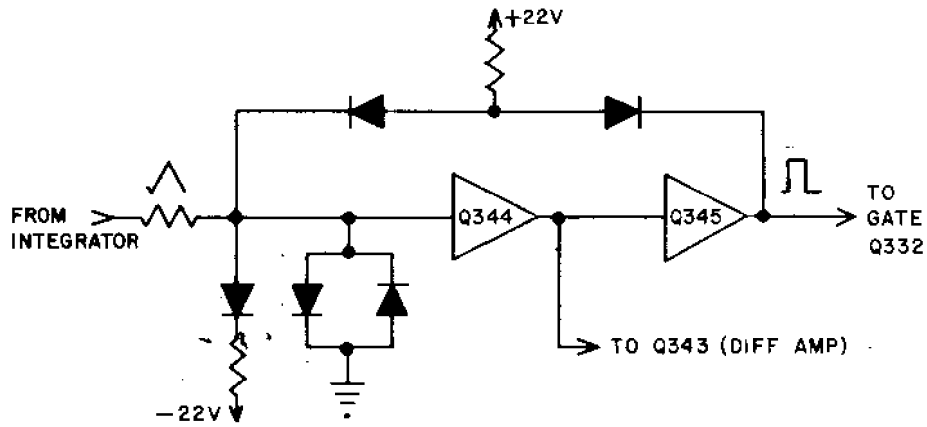


Figure 6. Square Wave Generator

The triangle, taken from the output of the integrator, triggers the square wave generator. Q344 and Q343 are a differential pair, and Q345 and Q346 are a differential pair. Q344 and Q345 form a regenerative sense amplifier with a feedback path from the collector of Q345 to the base of Q344. When the peak of the triangle reaches -10 volts, Q344 conducts, turning on Q345. As the triangle voltage goes from -10 to +10 volts, the voltage at the base of Q344 is clamped to about -0.6 volt by diode CR348. When the triangle reaches its positive peak of +10 volts, the base of Q344 goes positive, turning off Q344 and turning off Q345. The voltage at the base of Q344 is limited to +.6V this time by the action of CR349. When the triangle again reaches -10 volts, the cycle repeats. The square wave from Q345 is applied to gate Q332.

4.5 SQUARE WAVE AMPLIFIERS (See Figure 7)

The square wave developed at the collector of Q346 is applied to the base of Q373, which in turn drives the emitter of Q374. The auxiliary square wave is taken from the collector of Q374.

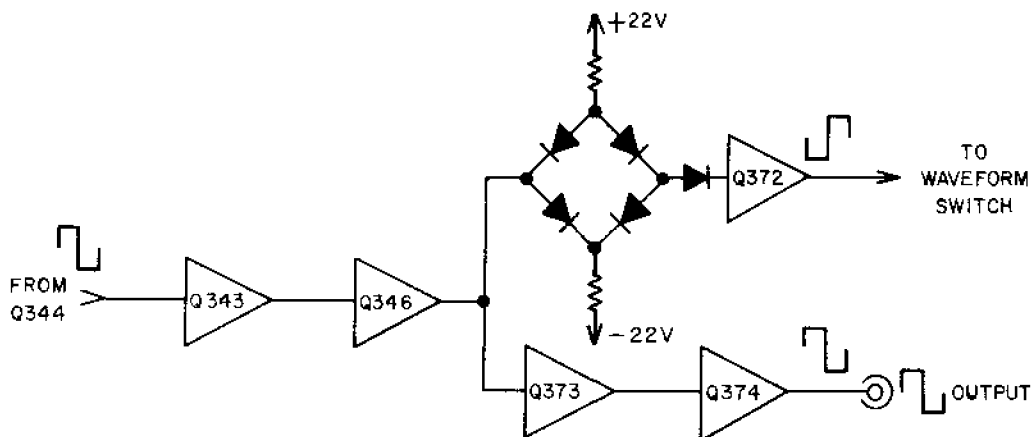


Figure 7. Square Wave Amplifiers

A second output from Q346 is applied to a diode bridge (CR371 through CR374), through diode-connected Q371, to the base of Q372. The diode bridge clips the square wave, and Q371 provides temperature compensation. The signal from Q372, which is applied to the WAVEFORM switch, is 180 degrees out of phase with regard to the square wave from Q374.

4.6 SINE SHAPER AND SINE AMPLIFIER (See Figure 8)

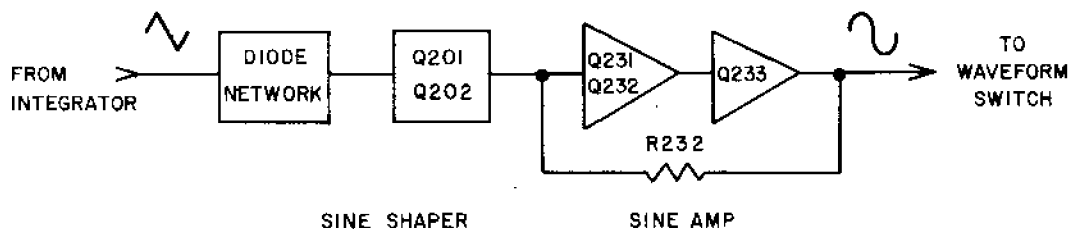


Figure 8. Sine Shaper and Sine Amplifier

The sine shaper consists of six pairs of diodes, each pair associated with a voltage divider. The function of the voltage divider is two-fold: (1) It changes the slope of the input signal, and (2) it sets the level at which the diodes clip the signal. Thus when the triangle is applied to the circuit, the divider resistance changes its slope and the diodes clip it at six discrete increments within each 90 degrees. The resultant approximates a sine wave. The emitter followers Q201-Q202 set and maintain the diode clamping level. The thermal drift of Q201 and Q202 also cancels the thermal drift of the diodes. Potentiometers R221 and R229 are adjusted to minimized distortion. The output of the sine shaper is applied to the sine amplifier Q231 through Q233 to the function switch.

4.7 RAMP FUNCTIONS

The ramp functions are developed at the function switch. The square wave and the triangle are added together at resistors R705 and R711. The sum is clipped by diodes CR701 and CR702, and the resultant is applied to the output amplifier.

4.8 OUTPUT AMPLIFIER (See Figure 9)

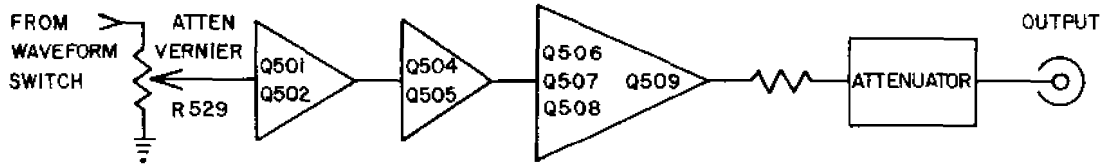


Figure 9. Output Amplifier

The output amplifier consists of a balanced input amplifier Q501-Q502, a second stage Q504-Q505, and output stage Q506 through Q509. The input signal is applied to the base of Q502. The collector of Q501 drives Q505 which in turn drives output transistors Q506 and Q507. At low frequencies Q504 is used as a constant current source, allowing for maximum voltage swing of the output transistors. At higher frequencies additional drive signal is provided to Q504 through C509. The input signal level is controlled by amplitude vernier R529. Q508 and Q509 provide additional output capability at high signal levels.

4.9 POWER SUPPLY (See Figure 10)

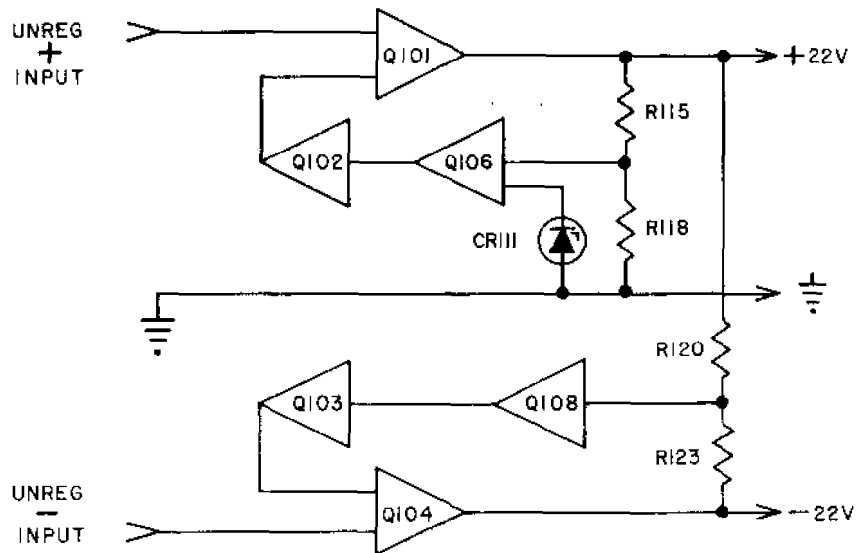


Figure 10. Power Supply

The power supply provides positive and negative 22 volt regulated power to all circuits. Zener CR111 is used as the reference in the positive supply; the negative supply, which is similar, is referred to the positive supply. Q101 is a series regulator; variations in output voltage are sensed by Q106, whose emitter voltage is determined by Zener CR111. Q105 provides temperature compensation. The output of Q106 is applied to the base of Q102 which drives Q101. A short circuit from +22 volts to ground would shut off the supply, providing short circuit protection.

SECTION 5 MAINTENANCE

5.1 INTRODUCTION

If the function generator is not working properly, first check it as a "black box." That is, check all the external controls to make certain that it is set up for the purpose intended. (The generator will not oscillate if the tuning switch is in the EXT +V position and no VC input is provided). Then isolate the nature of the malfunction. If the trouble occurs on only one frequency band, it is more than likely one of the contacts of the bandswitch. The bandswitch components, except for R610, R611, and C602 are common to two or more bands, as shown in Table 1. For other symptoms, refer to the Troubleshooting Chart, Table 2.

Table 1. Bandswitch Components

Band #	1	2	3	4	5	6	7	8	9
MULTIPLIER	.001	.01	.1	1	10	100	1K	10K	100K
C Value	5mf	5mf	5mf	.047mf	.047mf	470pf	470pf	470pf	39pf
C #	C607	C607	C607	C606	C606	C605	C605	C605	C602
R Value	500K	50K	5K	50K	5K	50K	5K	500	500
R#	R610	R606	R604	R606	R604	R606	R604	R601	R601
2R Value	1M	100K	10K	100K	10K	100K	10K	1K	1K
2R #	R611	R607	R605	R607	R605	R607	R605	R602	R602

Table 2. Troubleshooting Chart

Setup:		
Dial: 25	Multiplier: X100	Waveform: \wedge
Attenuator: 0db and vernier CW	DC Offset: Off	Tuning Switch: Dial
Symptom	Checking Procedure	Probable Cause
No signal Main and Fixed Outputs	<ol style="list-style-type: none"> 1. Check position of tuning switch 2. Positive and Negative Voltages (+22±.5V, -22±.5V) 3. Tuning pot center arm (+10V±1V) 4. Test point ME dc voltage +5V±.5 5. Polarity at testpoint TI should be opposite that at TO 6. Voltage at TO should be above +10V or below -10V 7. Check voltage at test points TO and SE 	<ol style="list-style-type: none"> 1. Switch should be on DIAL 2. Fuse, Rectifier, Regulator Overload (if low voltage) 3. Tuning pot or switch (S601) 4. VC loops 5. Integrator 6. Integrator 7a. If TO ≥ +10V, and SE = +5, Integrator or band switch tuning resistors 7b. If TO ≥ +10V, and SE = 0, Square wave generator or Q332 7c. If TO ≥ -10V, and SE = +5V, Square wave generator or Q332 7d. If TO ≥ -10V and SE = 0, Integrator or bandswitch tuning resistors
No signal Main output only	<ol style="list-style-type: none"> 1. Check for signal (5V p-p) on R718 center arm when R718 is maximum CW (R718 is output amplitude pot) 	<ol style="list-style-type: none"> 1. Function Switch

Table 2. Troubleshoot Chart (Continued)

Symptom	Checking Procedure	Probable Cause
No signal Main output only (contd.)	<ol style="list-style-type: none"> 2. Check signal on R528 (30V p-p) 3. If signal on R528 is correct 	<ol style="list-style-type: none"> 2. Output Amplifier 3. Attenuator
Sine wave only missing	<ol style="list-style-type: none"> 1. Test point AI should be 0vdc with very small signal. If AI dc level is not 0vdc, level on Q233 collector should be of opposite polarity. 2. If sine amp appears normal, check the sine shaper 	<ol style="list-style-type: none"> 1. Sine Amplifier (Q231, etc.) 2. Sine shaper
Auxiliary square wave only missing	<ol style="list-style-type: none"> 1. Signal on junction of R385 and R714 should be the same as on Q346 collector 	<ol style="list-style-type: none"> 1. Q373, Q374
Main square wave missing	<ol style="list-style-type: none"> 1. Signal on Q372 emitter should be the same as Q346 collector 	<ol style="list-style-type: none"> 1. Q371, Q372, CR371, CR372, CR373, CR374
Defective signal as dial is turned	<ol style="list-style-type: none"> 1. As dial is turned from 2 to 50, dc voltage on tuning pot center arm should vary from 1.9 to 20vdc, and voltage on test point ME should vary from +0.4 to 10 vdc. 2. If trouble is at low frequency end of dial only, check Square wave symmetry 	<ol style="list-style-type: none"> 1a. Tuning potentiometer 1b. VC loops 2. Integrator

SECTION 6

CALIBRATION

6.1 INTRODUCTION

The following procedure is provided for the calibration and adjustment of the generator in the field, and adherence to this procedure should restore the generator to its performance specifications. If the generator cannot be calibrated by the procedure given, refer to Maintenance Section 5, or consult our Factory Service Department. The locations of test points and adjustable components are shown in Figure 11.

6.2 TEST EQUIPMENT REQUIRED

(1) Oscilloscope having direct coupled horizontal and vertical amplifier with 1 mv/cm sensitivity and bandwidth of at least 30 MHz, Tektronix type 545 or equal with 1A5 plug-in unit. Use a X1 probe or shielded cable for scope input.

(2) Frequency counter capable of measuring 1 Hz to 10 MHz and period from 1 second to 1000 seconds.

(3) AC Voltmeter, Ballantine Type 323 or equal ($\pm 2\%$ to 5 MHz).

(4) Calibrated voltage source, or regulated DC supply and digital voltmeter 0-15 volts, accuracy ± 1 millivolt.

(5) Distortion meter Hewlett Packard Type 333A.

6.3 POWER SUPPLY

Turn the generator on and allow it to warm up for about 30 minutes. Measure the voltage between ground and +22 volts and then -22 volts. Tolerances are ± 0.5 volt. If off trim R118B to bring both within 0.5 volt.



6.4 INTEGRATOR

Set the frequency to 5×100 . Connect the oscilloscope to T1, and adjust the scope to 1 mv/cm (cal), ac coupled. Adjust R310 for minimum signal. (If there is too much noise on the signal, connect a 7 kHz filter in series with the probe, and make sure that the ground connection is close to T1. The 7 kHz filter may be fabricated by connecting a 10K resistor in series with probe, with .0022 mfd capacitor to ground.)

6.5 DC LEVELS

Set the frequency to 50×10 , sine waveform; set the output amplitude to minimum, and attenuator voltage to 15 volts, the TUNING switch to DIAL, and SYMMETRY control at NORM. Connect the dvm to the OUTPUT, adjust the output level to 0 volts by means of the main output DC LEVEL ADJ control R717 (rear panel). Using the dc voltmeter, check the voltages listed in Table 3, and if necessary adjust the potentiometers indicated; all should be set to 0 volt. Set output amplitude to maximum.

Table 3. DC Levels

Voltage	Test Point	Adjustment	Tolerance
Integrator input	TI	R308	± 1 mv
Integrator output	TO	R395	± 1 mv
Sine Amplifier input	AI	R246	± 10 mv
Sine Amplifier output	Main Output	R231	± 20 mv
Auxiliary Square wave	 Output	R387	± 10 mv
Square wave (switch to )	Main Output	R374	± 30 mv

6.6 SINE WAVE DISTORTION

Connect the generator to the distortion analyzer; set WAVEFORM to sine, frequency to 5 X1K, amplitude to maximum, and attenuator to 15 volts. Set the distortion analyzer to 5 kHz and adjust for a null. Adjust the generator SYM ADJ pot on the rear panel and then pots R229 and R221 in the sine shaper for minimum distortion. Turn the generator tuning dial maximum CW. Set the distortion analyzer to 1 kHz and adjust the generator dial for a null. Adjust SYM ADJ pot for minimum distortion. Disconnect the analyzer.

6.7 VC AMPLIFIERS

Switch the TUNING switch to EXT + V. Do not apply any voltage to the VC input. With the dc voltmeter measure the voltage at the base of Q401. Adjust R423 to 0 ± 10 mv. Measure the voltage at the emitter of Q404. Adjust R416 to 0 ± 10 mv.

6.8 SQUARE WAVE FLATNESS

* SET TUNIGN TO "DIAL"

Connect the main output of the generator to the oscilloscope using a 50 ohm cable and a 50 ohm terminator at the scope. Set the waveform to square wave and the frequency to 1 MHz. Set the scope to 0.2 usec/cm gain to 2 v/cm and adjust scope for 6 cm deflection peak-to-peak. Adjust C506 on the main card for maximum flatness. Aberrations should not exceed 0.3 cm. on scope.

6.9 EXT VC CALIBRATION

With the generator in the EXT +V mode, switch the frequency multiplier to X1K, and apply 10 volts from the calibrated voltage source to the VC input. Connect the frequency counter to the output. Output frequency should be $50 \text{ kHz} \pm 50 \text{ Hz}$. If off, adjust trimmer capacitor C604 on the Bandswitch. Set the multiplier to X100K and reduce VC voltage to 1 volt. Output frequency should be $500 \text{ kHz} \pm 100 \text{ Hz}$. If off, adjust trimmer capacitor C601 on the bandswitch. Change external voltage to 10 volts. Output frequency should be $5 \text{ MHz} \pm 10 \text{ KHz}$. If off, adjust capacitor C343 on the main card.

6.10 SINE WAVE RESPONSE

Set the generator to 10 x 100, dial mode, output terminated with 50 ohm load; waveform switch to sine, amplitude full CW, and attenuator at 15 volts. Connect the ACVM across the output, and switch from 10 x 100 (1 kHz) to 50 x 100K (5 MHz). Adjust C231 in sine buffer for a change of less than 3 percent.

6.11 DIAL CALIBRATION

With the generator in the DIAL mode, switch the frequency multiplier to X1K and adjust the dial for an output frequency of 50 kHz. The dial should read 50 ± 1 division. Set the multiplier to X100K and adjust the dial for an output frequency of 500 kHz. The dial should read 5 ± 1 division. If the dial is off, loosen the dial set screws and adjust the position of the dial on its shaft. At 50 kHz (50 X1K) tighten set screws.

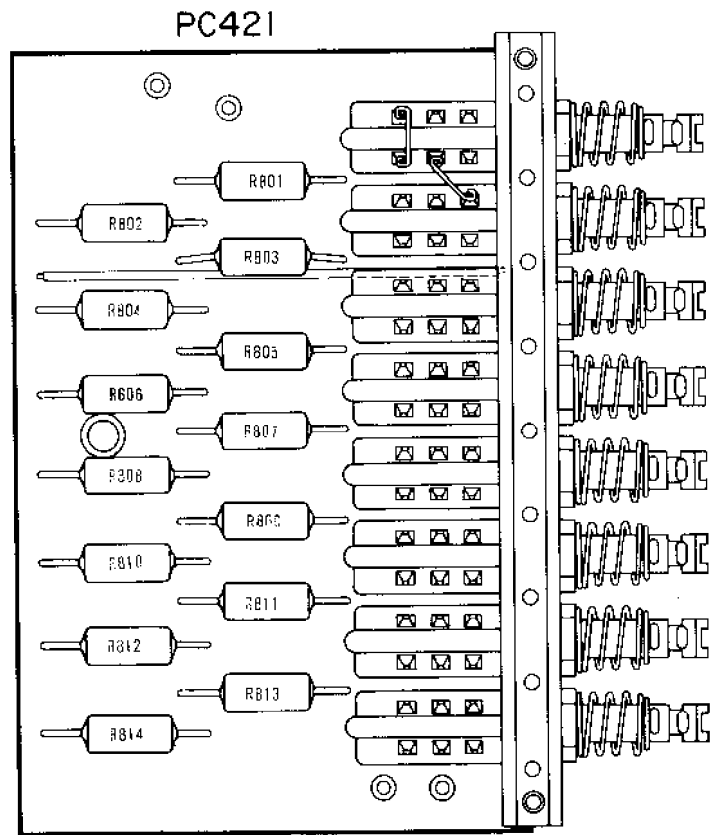
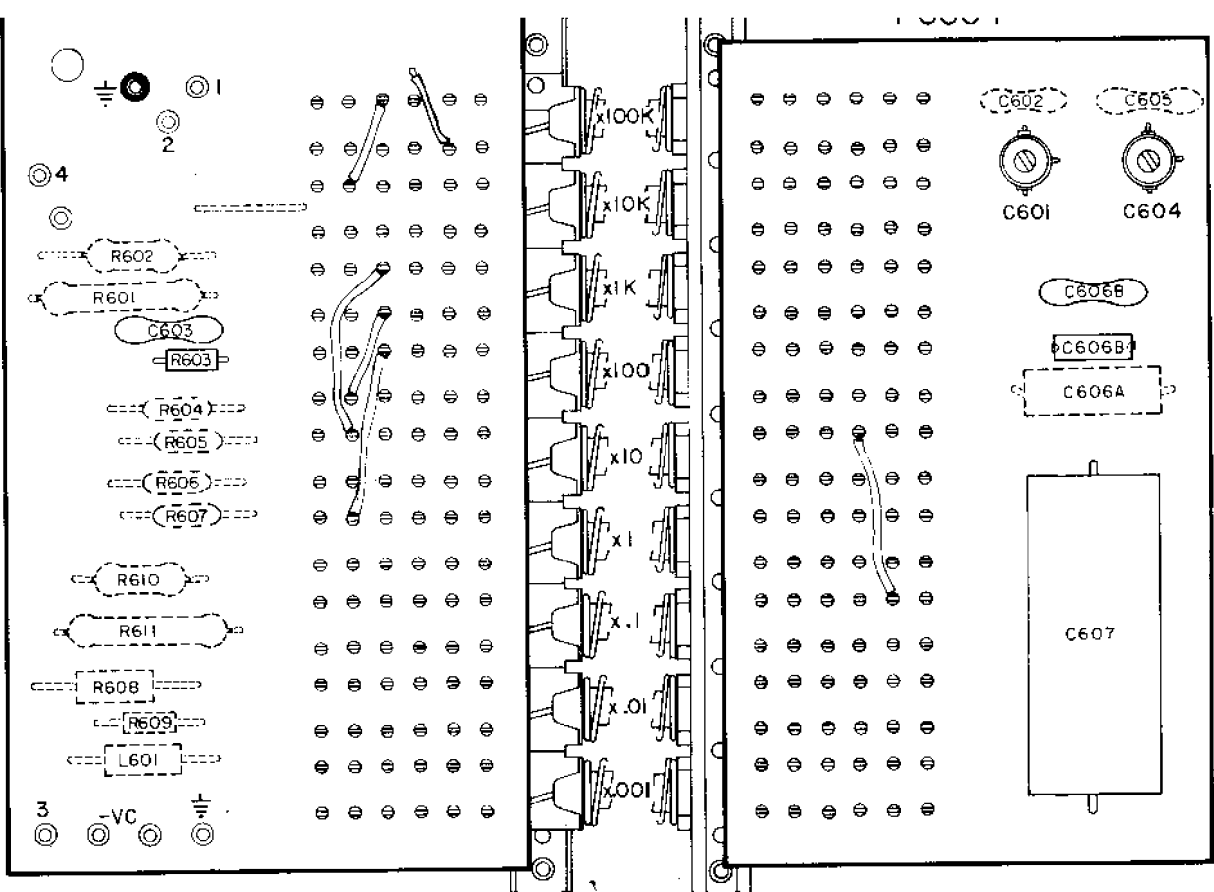
6.12 TRIANGLE FREQUENCY RESPONSE

With the frequency set at 10 X1K, triangle waveform, terminate the output with the 50-ohm load, and connect it to the a-c voltmeter. Set the generator for maximum output. Measure the voltage at 10 X1K, and switch to 50 X100K. Adjust C704 for minimum amplitude change between the 10 KHz and 5 MHz frequencies. With this setup unchanged, go on to the next step.

6.13 RAMP FREQUENCY RESPONSE

With the same setup as in paragraph 6.12, connect the output to the oscilloscope, with the 50-ohm terminator at the scope. Display the 5-MHz triangle, as adjusted in 6.12, and switch to the positive ramp waveform. Adjust C706 for a ramp amplitude of one-half the peak-to-peak triangle amplitude.

NOTES



RESISTORS

Symbol	Description	Mfr.	Part No.									
R101	100K	10%	1/4W	AB	CB1041	R322	1	10%	1/2W	AB	EB1061	
R102	3.3K	10%	1/4W	AB	CB3321	R323	1.1K	1%	1/8W	KH	M3-T1-1.1K	
R103	390	10%	1/2W	AB	EB3911	R324	39K	5%	1/4W	AB	CB3935	
R104	100	20%	1/4W	AB	CB1012	R325	3.92K	1%	1/8W	KH	M3-T1-3.92K	
R105	1.2K	10%	1/4W	AB	CB1221							
R106	47	10%	1/4W	AB	CB4701	R331	1.8K	5%	1/2W	AB	EB2225	
R107	100	10%	1/4W	AB	CB1011	R332	680	10%	1/4W	AB	CB6811	
R108	47	10%	1/4W	AB	CB4701	R333A	390	10%	1/2W	AB	EB5615	
R109	100	10%	1/4W	AR	CB1011							
R110	2K	5%	1/4W	AB	CB2025	R334	5.11K	0.1%	1/8W	KH	M3-T1-5.11K	
R111	100	10%	1/4W	AB	CB1011	R335	220	10%	1/4W	AB	CB2211	
R112	390	10%	1/2W	AB	EB3911	R336	680	10%	1/4W	AB	CB6811	
R113	3.3K	10%	1/4W	AB	CB3321	R337	150	10%	1/4W	AB	CB1511	
R114	750	5%	1/2W	AR	CB7515	R338	5K			BKM	72PM	
R115	4.02K	1%	1/8W	KH	M3-T1-4.02K	R341	15K	5%	1/4W	AB	CB1535	
R116	100	20%	1/4W	AB	CB1012	R342	620	5%	1/4W	AB	CB6215	
R117	10K	10%	1/4W	AB	CB1031	R343A	2.21K	1%	1/8W	KH	M3-T1-2.21K	
R118A	4.22K	1%	1/4W	KH	M4-T1-4.02K	R343B	TRIM			AB	TYPE CB	
R118B	TRIM			AB	TYPE CB	R344	10K	10%	1/4W	AB	CB1031	
R119	4.7K	10%	1/4W	AR	CB4721	R345	220	10%	1/4W	AB	CB2211	
R120	4.22K	1%	1/4W	KH	M4-T1-4.02K	R346	220K	5%	1/4W	AB	CB2245	
R121	100	20%	1/4W	AB	CB1012	R347	9.1K	5%	1/4W	AB	CB9125	
R122	10K	10%	1/4W	AB	CB1031	R348	4.3K	5%	1/4W	AB	CB4325	
R123	4.22K	1%	1/4W	KH	M4-T1-4.02K	R349A	240K	5%	1/4W	AB	CB2445	
R124	330	10%	1/4W	AB	CB3311	R349B	TRIM			AB	TYPE CB	
R125	330	10%	1/4W	AB	CB3311	R350	10K	5%	1/4W	AB	CB1035	
R126	220	10%	2W	AB	HB2211	R351	10	10%	1/4W	AB	CB1001	
R127	220	10%	2W	AR	HB2211	R352	100	10%	1/4W	AB	CB1011	
R201	1.07K	1%	1/8W	KH	M3-T1-1.07K	R353	1K	10%	1W	AB	GB1021	
R202	6.04K	1%	1/4W	KH	M4-T1-6.04K	R354	1.5K	5%	1/2W	AB	EB1525	
R203	1.33K	1%	1/8W	KH	M3-T1-1.33K	R355	220	10%	1/4W	AB	CB2211	
R204	6.34K	1%	1/8W	KH	M3-T1-6.34K	R356	4.42K	1%	1/4W	KH	M4-T1-4.42K	
R205	1.1K	1%	1/8W	KH	M3-T1-1.1K	R357	2.21K	1%	1/2W	KH	M5-T1-2.21K	
R206	3.92K	1%	1/8W	KH	M3-T1-3.92K	R358	1.8K	10%	1/4W	AB	CB1821	
R207	22.1K	1%	1/8W	KH	M3-T1-22.1K	R359	75	5%	1/4W	AB	CB7505	
R208	2.05K	1%	1/8W	KH	M3-T1-2.05K	R360	100	10%	1/4W	AB	CB1011	
R209	4.12K	1%	1/8W	KH	M3-T1-4.12K	R361	330	10%	2W	AB	HB3311	
R210	26.7K	1%	1/8W	KH	M3-T1-26.7K	R362	2K	5%	1/2W	AB	EB2025	
R211	10.5K	1%	1/8W	KH	M3-T1-10.5K	R363	1K	10%	1W	AB	GB1021	
R212	4.87K	1%	1/8W	KH	M3-T1-4.87K	R364	100	10%	1/4W	AB	CB1011	
R213	825	1%	1/8W	KH	M3-T1-825	R365	1.5K	5%	1/2W	AB	EB1525	
R214	158	1%	1/8W	KH	M3-T1-158	R371	2.7K	5%	1/2W	AB	EB2721	
R215	220	10%	1/4W	AB	CB2211	R372	2.7K	5%	1/2W	AB	EB2721	
R216	4.75K	1%	1/8W	KH	M3-T1-4.75K	R373	15K	10%	1/4W	AB	CB1531	
R217	4.75K	1%	1/8W	KH	M3-T1-4.75K	R374	5K POT			BKM	72PM	
R218	340	1%	1/4W	KH	M4-T1-340	R375	22K	10%	1/4W	AB	CB2231	
R219	120	10%	1/4W	AR	CB1211	R376	510	5%	1/4W	AB	CB5115	
R220	340	1%	1/4W	KH	M4-T1-340	R377	470	10%	1/4W	AB	CB4711	
R221	5K POT			BKM	72PM	R378	10K	10%	1/4W	AB	CB1031	
R222	1K	10%	1/4W	AB	CB1021	R379	510	5%	1/4W	AB	CB5115	
R223	2.05K	1%	1/2W	KH	M5-T1-2.05K	R380	27	10%	1W	AB	GB2701	
R224	200	1%	1/8W	KH	M3-T1-200	R381	100	10%	1/4W	AB	CB1011	
R225	200	1%	1/8W	KH	M3-T1-200	R382	330	10%	1/2W	AB	FB3311	
R226	2K	1%	1/2W	KH	M5-T1-2K	R383	56	10%	1/4W	AB	CB5601	
R227	75K	5%	1/4W	AB	CB7535	R384	1.7K	10%	1/2W	AB	EB1221	
R228	75K	5%	1/4W	AR	CB7535	R385	340	1%	3W	TL	EL-3	
R229	25K POT			BKM	72PM	R387	5K POT			BKM	72PM	
R231	25K POT			BKM	72PM	R388	2.2K	10%	1/2W	AB	EB2221	
R232	1.1K	1%	1/8W	KH	M3-T1-1.1K	R389	15	10%	1/4W	AB	CB1501	
R233	150K	10%	1/4W	AB	CB1541	R390A	150	5%	3W	TL	EL-3	
R234	330	10%	1/4W	AB	CB3311	R390B	TRIM			AB	TYPE EB	
R235	100	10%	1/4W	AR	CB1011	R391	100	10%	1/4W	AB	CB1011	
R236	100	5%	1/4W	AR	CB1015	R392	10K	10%	1/4W	AB	CB1031	
R237	2K	5%	1/2W	AB	EB2025	R393	10K	10%	1/4W	AB	CB1031	
R238	1K	10%	1/4W	AB	CB1021	R394	100K	10%	1/4W	AB	CB1041	
R239	1K	5%	1/4W	AB	CB1025	R395	25K POT			BKM	72PM	
R240	100K	5%	1/4W	AB	CB1045	R397	100	10%	1/4W	AR	CB1011	
R241	100	10%	1/4W	AB	CB1011	R398	4.7K	10%	1/4W	AB	CB4721	
R242	100K	5%	1/4W	AB	CB1045	R400	10	10%	1/4W	AB	CB1001	
R243	100	10%	1/4W	AB	CB1011	R402	1K POT	0.5%	LINEARITY		3351-R1K-L-5	
R244	274	1%	1/8W	KH	M3-T1-274	R403A	30K	5%	1/4W	AB	CB3035	
R245	232	1%	1/4W	KH	M4-T1-232	R403B	TRIM			AB	TYPE CB	
R246	25K POT			BKM	72PM	R404A	5.49K	1%	1/4W	KH	M4-T1-5.49K	
R247	1	10%	1/2W	AR	EB1051	R404B	TRIM			AB	TYPE CB	
R248	160	5%	1/2W	AB	EB1615	R405A	47	10%	1/4W	AB	CB4701	
R249	1	10%	1/2W	AB	EB1061	R405B	TRIM			AB	TYPE CB	
R250	1K	10%	1W	AB	CB1021	R406	9.76K	1%	1/8W	KH	M3-T1-9.76K	
R251A	430	5%	1/4W	AR	CB4315	R407	187K	1%	1/8W	KH	M3-T1-187K	
R251B	TRIM			AR	TYPE CB	R408	10K POT	30%	3/4W	CTS	307089	
R252	15K	10%	1/4W	AR	CB1531	R409	3M	5%	1/4W	AB	CB3055	
R300	470	10%	1/4W	AB	CB4711	R410	3M	5%	1/4W	AB	CB3055	
R301	330	10%	1/4W	AB	CB3311	R411	10K	5%	1/4W	AB	CB1035	
R302	220	10%	1/4W	AR	CB2211	R413	2.5K POT	20%	2W	KH	A3028	
R303	51.1K	1%	1/8W	KH	M3-T1-51.1K	R414	5.1K	1%	1/4W	KH	M4-T1-5.1K	
R304	51.1K	1%	1/8W	KH	M3-T1-51.1K	R415	2.7M	10%	1/2W	AB	EB2751	
R305	4.22K	1%	1/4W	KH	M4-T1-4.22K	R416	25K POT			BKM	72PM	
R306	51.1K	1%	1/8W	KH	M3-T1-51.1K	R417	100	20%	1/4W	AB	CB1012	
R307	5.1M	10%	1/4W	AB	CB5151	R418	61.9K	1%	1/8W	KH	M3-T1-61.9K	
R308	25K POT			BKM	72PM	R419	61.9K	1%	1/8W	KH	M3-T1-61.9K	
R309	10K	10%	1/4W	AB	CB1031	R420	100K	1%	1/8W	KH	M3-T1-100K	
R310	100 POT			BKM	72PM	R421	2.4K	5%	1/4W	AB	CB2425	
R311	22	10%	1/4W	AB	CB2201	R422	3.3M	5%	1/4W	AB	CB3351	
R312	100	20%	1/4W	AB	CB1012	R423	25K POT			BKM	72PM	
R313	909	1%	1/8W	KH	M3-T1-909	R424	1.7K	5%	1/4W	AB	CB1225	
R314	30K	5%	1/4W	AB	CB3035	R425	10K	5%	1/4W	AB	CB1035	
R315	232	1%	1/4W	KH	M4-T1-232	R426	100	10%	1/4W	AB	CB1011	
R316	330	5%	1/4W	AB	CB3315	R427	100	20%	1/4W	AB	CB1012	
R317	2.2K	10%	1/2W	AB	FB2221	R428	4.7K	10%	1/4W	AB	CB4721	
R318	681	1%	1/8W	CH	M3-T1-681	R429	5.11K	0.1%	1/8W	KH	M3-T1-5.11K	
R319	2.7K	5%	1/4W	AB	CB2725	R431	5.11K	0.1%	1/8W	KH	M3-T1-5.11K	
R320	1K	5%	1/4W	AB	CB1025	R432	61.9K	1%	1/8W	KH	M3-T1-61.9K	
R321	100	5%	1/2W	AB	EB1015	R433	61.9K	1%	1/8W	KH	M3-T1-61.9K	
R253	6.2K	5%	1/4W	AB	CB6225							

in (3201)

RESISTORS CONT.

Symbol	Description	Mfr.	Part No.	Symbol	Description	Mfr.	Part No.
R434	100k	1%	1/8W	KH	M3-T1-100K		
R435	2.4k	5%	1/4W	AB	CB2425		
R436	1.2k	5%	1/4W	AB	CB1225		
R437	10k	5%	1/4W	AB	CB1035		
R438	100	10%	1/4W	AB	CB1011		
R439	10	10%	1/4W	AB	CB1001		
R440	820	10%	2W	AB	HB9211		
R441	10	10%	1/4W	AB	CB1001		
R442	100	20%	1/4W	AB	CB1012		
R501	2.4k	5%	1/4W	AB	CB2425		
R502	100	20%	1/4W	AB	CB1012		
R503	TRIM			AB	TYPE CB		
R504	470	10%	1/4W	AB	CB4711		
R505	6.2k	5%	1/4W	AB	CB5225		
R506	470	10%	1/4W	AB	CB4711		
R507	680	10%	1W	AB	686811		
R508	2.55k	1%	1/8W	KH	M3-T1-2.55k		
R509	330	10%	1/4W	AB	CB3311		
R510	100	10%	1/4W	AB	CB1011		
R512	16.2k	1%	1/8W	KH	M3-T1-16.2k		
R513	TRIM			AB	TYPE CB		
R514	75	5%	1/4W	AB	CB7505		
R516	39k	5%	1/4W	AB	CB3035		
R517	820k	10%	1/4W	AB	CB8241		
R518	39k	5%	1/4W	AB	CB3935		
R519	5.1k	5%	1/4W	AB	CB5125		
R520	270	10%	1/4W	AB	CB2711		
R521	36	5%	1/2W	AB	EB3605		
R522	10	10%	1/4W	AB	CB1001		
R523	10	10%	1/4W	AB	CB1001		
R525	10	10%	1/4W	AB	CB1001		
R526	10	10%	1/4W	AB	CB1001		
R528	200	1%	1/2W	KH	M5-T1-200		
R529	200	1%	1/2W	KH	M5-T1-200		
R530	200	1%	1/2W	KH	M5-T1-200		
R531	200	1%	1/2W	KH	M5-T1-200		
R532	220	10%	1/4W	AB	CB2211		
R601	500	0.1%	1/2W	KH	M5-T1-500		
R602	1k	0.1%	1/4W	KH	M4-T1-1k		
R603	47	10%	1/4W	AB	CB4701		
R604	5k	0.1%	1/8W	KH	M3-T1-5k		
R605	10k	0.1%	1/8W	KH	M3-T1-10k		
R606	50k	0.1%	1/4W	KH	M3-T1-50k		
R607	100k	0.1%	1/8W	KH	M3-T1-100k		
R608	750	5%	1/2W	AB	EB7515		
R609	220	10%	1/4W	AB	CB2211		
R610	500k	0.1%	1/4W	KH	M4-T1-500k		
R611	1M	0.1%	1/2W	KH	M5-T1-1M		
R612	500k	0.1%	1/4W	KH	M4-T1500k		
R701	5k POT	20%	2W	KH	A2938		
R702	3.3k	10%	1/4W	AB	CB3321		
R703	15k	10%	1/4W	AB	CB1531		
R704A	1.3k	5%	1/4W	AB	CB1325		
R704B	TRIM			AB	TYPE CB		
R705A	1k	5%	1/4W	AB	CB1025		
R705B	TRIM			AB	TYPE CB		
R706	6.8k	10%	1/4W	AB	CB6821		
R707A	150	10%	1/4W	AB	CB1511		
R707B	TRIM			AB	TYPE CB		
R708	220	10%	1/4W	AB	CB2211		
R709	47	10%	1/4W	AB	CB4701		
R710	TRIM			AB	TYPE CB		
R711	270	5%	1/2W	AB	EB2715		
R712	220	10%	1/4W	AB	CB2211		
R713	100	10%	1/4W	AB	CB1011		
R714	51	5%	1/2W	AB	EB5105		
R715	680	10%	1/4W	AB	CB6811		
R716	1.8k	70%	1/4W	AB	CB1821		
R717	10k POT	30%	3/4W	CTS	307089		
R718	500 POT	20%	2W	KH	A2945		
R719	100	10%	1/4W	AB	CB1011		
R801	108.1	1%	3/4W	KH	M6-T1-108.1		
R802	113	1%	1/2W	KH	M5-T1-113		
R803	142.3	1%	1/4W	KH	M4-T1-142.3		
R804	96.25	1%	1/8W	KH	M3-T1-96.25		
R805	142.3	1%	1/4W	KH	M4-T1-142.3		
R806	96.25	1%	1/8W	KH	M3-T1-96.25		
R807	142.3	1%	1/4W	KH	M4-T1-142.3		
R808	96.25	1%	1/8W	KH	M3-T1-96.25		
R809	142.3	1%	1/4W	KH	M4-T1-142.3		
R810	96.25	1%	1/8W	KH	M3-T1-96.25		
R811	142.3	1%	1/4W	KH	M4-T1-142.3		
R812	96.25	1%	1/8W	KH	M3-T1-96.25		
R813	142.3	1%	1/4W	KH	M4-T1-142.3		
R814	65.81	1%	1/8W	KH	M3-T1-65.81		
R815	100	10%	1/4W	AB	CB1011		

* 5400AR ONLY

CAPACITORS

Symbol	Description	Mfr.	Part No.	Symbol	Description	Mfr.	Part No.
C101	800uf	LYTIC	40V	MAL	TCW801H040J1P1P		
C102	1uf	20%	35V	MAL	TDC105M035AL		
C103	800uf	LYTIC	40V	MAL	TCW801H040J1P1P		
C104	1uf	20%	35V	MAL	TDC105M035AL		
C105	.047uf	20%	100V	ERT	8121-100-651-473M		
C106	1uf	20%	35V	MAL	TDC105M035AL		
C107	.047uf	20%	100V	LRT	8121-100-651-473M		
C108	1uf	20%	35V	MAL	TDC105M035AL		
C109	20uf	LYTIC	50V	SP	3002066059CC4		
C110	1uf	20%	35V	MAL	TDC105M035AL		
C111	20uf	LYTIC	50V	SP	3002066059CC4		
C201	.01uf	20%	500V	SP	C0238501G103M		
C202	.01uf	20%	500V	SP	C2038501G103M		
C231	4.5-20uf	TRIMMER		STT	75-TRIKO-02-N750		
C232	100pf	10%	500V	ASP	9213-10110		
C233	10pf	10%	500V	ASP	9213-10110		
C234	1uf	20%	35V	MAL	TDC105M035AL		
C235	1uf	20%	35V	MAL	TDC105M035AL		
C236	1uf	20%	35V	MAL	TDC105M035AL		
C237	47pf	10%	500V	ELM	DM15C470K		
C238	33pf	5%	500V	ELM	DM15C330J		
C239	180pf	10%	500V	ELM	DM15C181K		
C240	6.2pf	10%	500V	ELM	9212-62910		
C300	56pf	10%	500V	ELM	DM15C56K		
C301	.02uf	20%	500V	SP	C0238501G203M		
C302	510pf	10%	500V	ELM	DM19C511K		
C303	200pf	10%	500V	ELM	DM15C201K		
C304	22pf	10%	500V	ELM	DM15C220K		
C305	10pf	10%	500V	ASP	9213-10110		
C306	.01uf	20%	500V	SP	C0238501G103M		
C307	.01uf	20%	500V	SP	C0238501G103M		
C308	1uf	20%	35V	MAL	TDC105M035AL		
C309	1uf	20%	35V	MAL	TDC105M035AL		
C341	12pf	10%	500V	ASP	9213-12110		
C342	8.2pf	10%	500V	ASP	9212-82910		
C343	3-5pf	TRIMMER		STT	75-TRIKO-02-N750		
C344	1uf	20%	35V	MAL	TDC105M035AL		
C345	.047uf	20%	100V	ERT	8121-100-651-473M		
C346	.47uf	20%	100V	ERT	8131-100-651-474M		
C347	.5pf	10%	500V	ASP	9300-15110		
C348	15pf	10%	500V	ASP	9300-15110		
C370	100pf	10%	500V	ELM	DM15C101K		
C371	1uf	20%	35V	MAL	TDC105M035AL		
C372	1uf	20%	35V	MAL	TDC105M035AL		
C373	1000pf	20%	500V	SP	C0238501E102M		
C375	120pf	5%	500V	ELM	DM15C121J		
C376	1000pf	20%	500V	SP	C0238501E102M		
C378	1000pf	20%	500V	SP	C0238501E102M		
C379	1uf	20%	100V	ERT	8131-100-651-104M		
C380	1uf	20%	35V	MAL	TDC105M035AL		
C381	1uf	20%	35V	MAL	TDC105M035AL		
C382	22pf	10%	500V	ELM	DM15C220K		
C383	2pf	10%	500V	ASP	9208-20910		
C401	1000pf	20%	500V	SP	C0238501E102M		
C402	3300pf	20%	500V	SP	C0238501F332M		
C403	1000pf	20%	500V	SP	C0238501E102M		
C404	15pf	10%	500V	ASP	9300-15110		
C431	1500pf	20%	500V	SP	C0238501E102M		
C432	3300pf	20%	500V	SP	C0238501F332M		
C433	1000pf	20%	500V	SP	C0238501E102M		
C434	5.1pf	10%	500V	ASP	9210-51910		
C435	1uf	20%	35V	MAL	TDC105M035AL		
C436	1uf	20%	35V	MAL	TDC105M035AL		
C501	6.8uf	20%	35V	MAL	196D685X0035FB		
C502	22pf	10%	500V	ELM	DM15C220K		
C503	6.8uf	20%	35V	MAL	196D685X0035FB		
C504	1uf	20%	35V	MAL	TDC105M035AL		
C505	.01uf	20%	500V	SP	C0238501G103M		
C506	4.5-20pf	TRIMMER		STT	75-TRIKO-02-N750		
C507	2pf	10%	500V	ASP	9208-20910		
C508	1pf	10%	500V	ASP	9206-10910		
C509	1uf	20%	100V	ERT	8131-100-651-104M		
C510	1uf	20%	100V	ERT	8131-100-651-104M		
C511	1uf	20%	35V	MAL	TDC105M035AL		
C512	6.8uf	20%	35V	MAL	196D685X0035FB		
C513	6.8uf	20%	35V	MAL	196D685X0035FB		
C514	7.5pf	10%	500V	ASP	9212-75910		

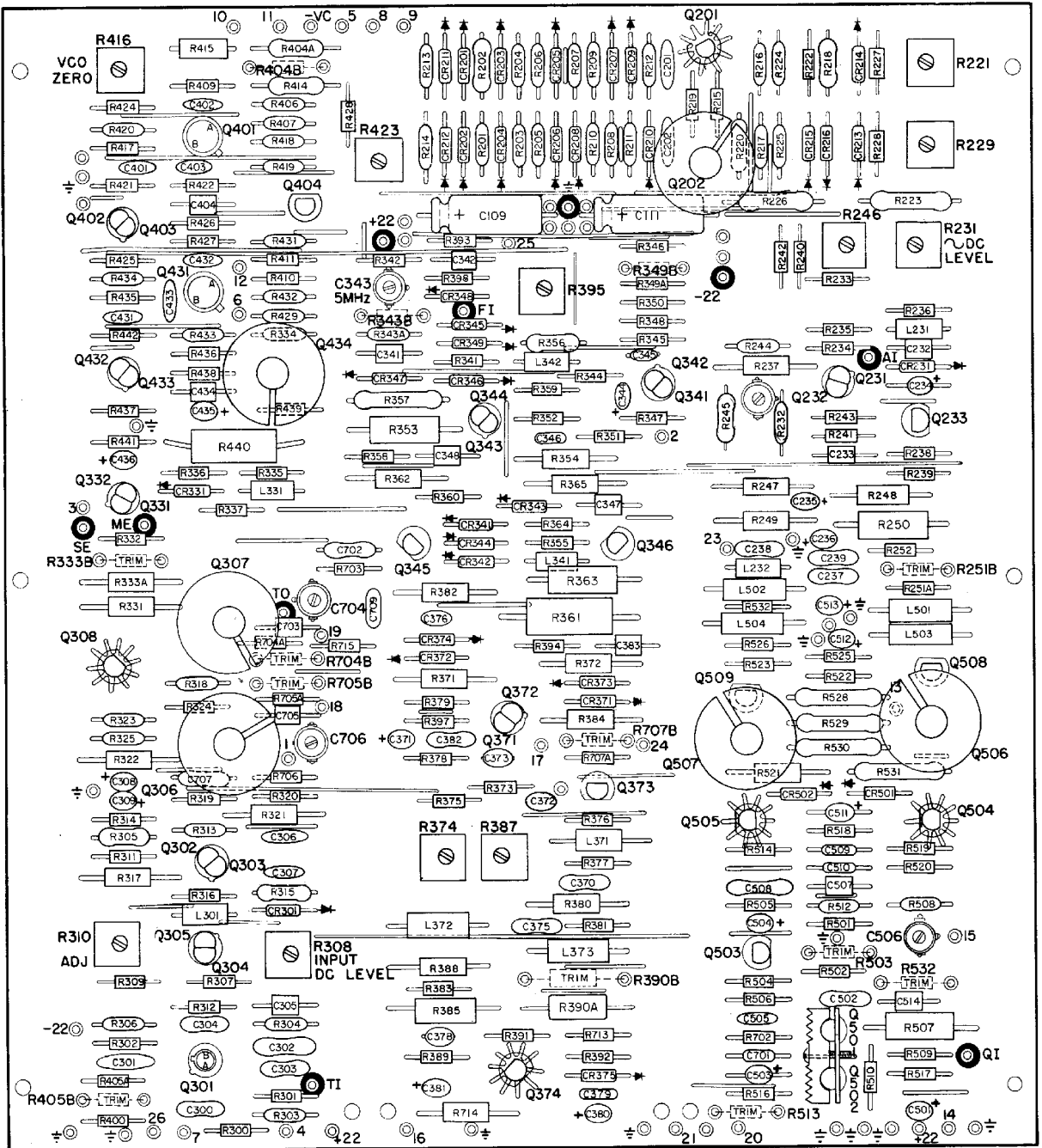
TRANSISTOR, DIODES & MISC.

Symbol	Description	Mfr.	Part No.	Symbol	Description	Mfr.	Part No.
Q101	MJE2370	MOT	MJE2370	CR201	1N4149	TR	1N4149
Q102	T1S92	TI	T1S92	CR202	1N4149	TR	1N4149
Q103	T1S93	TI	T1S93	CR203	1N4149	TR	1N4149
Q104	MJE2520	MOT	MJE2520	CR204	1N4149	TR	1N4149
Q105	2N5225	MOT	2N5225	CR205	1N4149	TR	1N4149
Q106	2N5087	MOT	2N5087	CR206	1N4149	TR	1N4149
Q107	2N5225	MOT	2N5225	CR207	1N4149	TR	1N4149
Q108	2N5087	MOT	2N5087	CR208	1N4149	TR	1N4149
Q201	T1S92	TI	T1S92	CR209	1N4149	TR	1N4149
Q202	2N2905A	TI	2N2905A	CR210	1N4149	TR	1N4149
Q231	MPS6566	MOT	MPS6566	CR211	1N4149	TR	1N4149
Q232	MPS6566	MOT	MPS6566	CR212	1N4149	TR	1N4149
Q233	MPS6518	MOT	MPS6518	CR213	1N4149	TR	1N4149
Q301	SU2365	SIL	SU2365	CR214	1N4149	TR	1N4149
Q302	MPS6518	MOT	MPS6518	CR215	1N4149	TR	1N4149
Q303	MPS6518	MOT	MPS6518	CR216	1N4149	TR	1N4149
Q304	MPS6518	MOT	MPS6518	CR231	1N749A ZENER	CI	1N749A
Q305	MPS6518	MOT	MPS6518	CR301	1N965B ZENER	CI	1N965B
Q306	2N2905A	TI	2N2905A	CR331	1N4149	TR	1N4149
Q307	2N2219A	TI	2N2219A	CR341	1N4149	TR	1N4149
Q308	T1S93	TI	T1S93	CR342	1N4149	TR	1N4149
Q331	MPS3646	MOT	MPS3646	CR343	1N4149	TR	1N4149
Q332	MPS3646	MOT	MPS3646	CR344	1N4149	TR	1N4149
Q341	MPS6566	MOT	MPS6566	CR345	1N4149	TR	1N4149
Q342	MPS6566	MOT	MPS6566	CR346	1N4149	TR	1N4149
Q343	MPS3640	MOT	MPS3640	CR347	1N4149	TR	1N4149
Q344	MPS3640	MOT	MPS3640	CR348	1N4149	TR	1N4149
Q345	MPS3646	MOT	MPS3646	CR349	1N4149	TR	1N4149
Q346	MPS3646	MOT	MPS3646	CR371	1N4149	TR	1N4149
Q371	T1S97	TI	T1S97	CR372	1N4149	TR	1N4149
Q372	T1S97	TI	T1S97	CR373	1N4149	TR	1N4149
Q373	MPS6518	MOT	MPS6518	CR374	1N4149	TR	1N4149
Q374	MPS3646	MOT	MPS3646	CR375	1N957B ZENER	CI	1N957B
Q401	NS7302	NS	NS7302	CR501	MZ2361	MOT	MZ2361
Q402	2N5087	MOT	2N5087	CR502	1N4149	TR	1N4149
Q403	2N5087	MOT	2N5087	CR701	1N4149	TR	1N4149
Q404	2N5087	MOT	2N5087	CR702	1N4149	TR	1N4149
Q431	NS7302	NS	NS7302	L231	3.3uhy 10% .4W	DLV	1537-24
Q432	2N5087	MOT	2N5087	L232	8.2uhy 10% .4W	DLV	1537-34
Q433	2N5087	MOT	2N5087	L301	8.2uhy 10% .4W	DLV	1537-34
Q434	2N2219A	TI	2N2219A	L331	8.2uhy 10% .4W	DLV	1537-34
Q501	MPS6518	MOT	MPS6518	L341	3.3uhy 10% .4W	DLV	1537-24
Q502	MPS6518	MOT	MPS6518	L342	3.3uhy 10% .4W	DLV	1537-24
Q503	MPS3640	MOT	MPS3640	L371	8.2uhy 10% .4W	DLV	1537-34
Q504	MPS6518	MOT	MPS6518	L372	1uhy 10% .4W	DLV	BP774-2
Q505	MPS6566	MOT	MPS6566	L373	1uhy 10% .4W	DLV	BP774-2
Q506	2N2219A	TI	2N2219A	L501	1uhy 10% .4W	DLV	BP774-2
Q507	2N2905A	TI	2N2905A	L502	1uhy 10% .4W	DLV	BP774-2
Q508	T1S92	TI	T1S92	L503	1uhy 10% .4W	DLV	BP774-2
Q509	T1S93	TI	T1S93	L504	1uhy 10% .4W	DLV	BP774-2
CR101	1N4002	MSC	1N4002	L601	3.3uhy 10% .4W	DLV	1537-24
CR102	1N4002	MSC	1N4002	L801	FERRITE, TOROID	AB	T0620CT0TA
CR103	1N4002	MSC	1N4002	F101	.4A/115V S10-B10 .2A/230V S10-B10	BUS	MDA
CR104	1N4002	MSC	1N4002	T101	POWER TRANSFORMER	KH	82883
CR107	1N456	TR	1N456	S101	TOGGLE SWITCH	CK	7101
CR110	MZ2361	MOT	MZ2361	S102	SLIDE SWITCH	SWC	46256LFR
CR111	Z4843 ZENER	COD	..	S601	PUSH-BUTTON SWITCH	SHD	9XF10-40-GRM
CR112	1N4002	MSC	1N4002	S602	SLIDE SWITCH	CW	GF326
CR113	1N4002	MSC	1N4002	S701	ROTARY SWITCH	KH	B2926
				S801	PUSH-BUTTON SWITCH	SHD	8XF10-20-GR

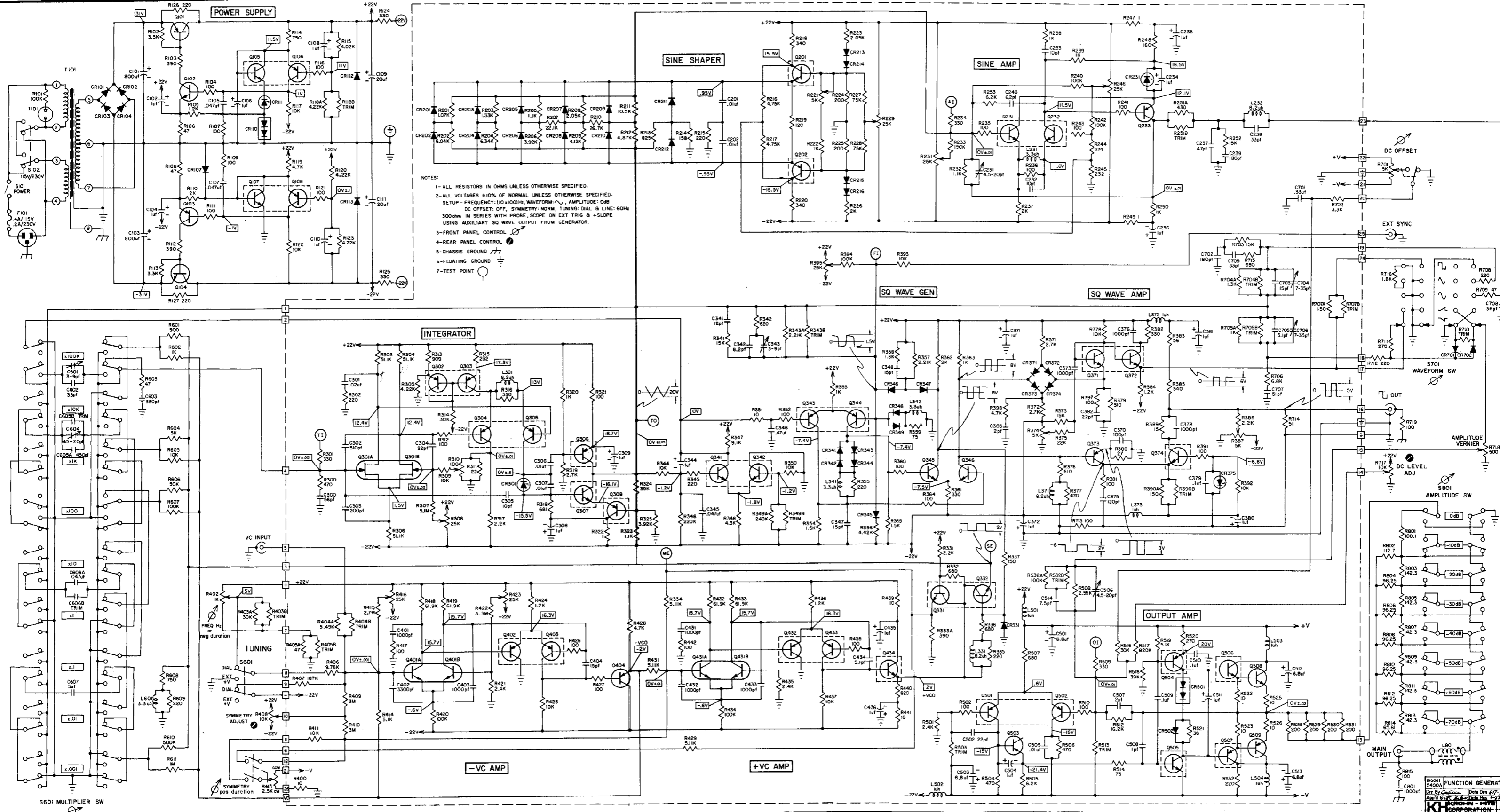
MANUFACTURERS CODE

AB (01121)	Allen Bradley Co.	Milwaukee, Wisc.	MAL (04713)	P.R. Mallory & Co.	Indianapolis, Ind.
ASP (82142)	Airco Speer	Dubois, Pa.	MOT (14552)	Motorola Semiconductor	Phoenix, Ariz.
BUS (71400)	Bussman Mfg. Co.	St. Louis, Mo.	MSC (36462)	Micro Semiconductor Corp.	Culver City, Calif.
CI (06751)	Components, Inc.	Biddeford, Maine	SIL (17856)	National Semiconductor Ltd.	Plattsburgh, N.Y.
CK (09353)	C&K Components	Watertown, Mass.	SP (56289)	Sprague Electric Co.	Sunnyvale, Calif.
CTS (71450)	CTS Corp.	Elkhart, Ind.	STT	Stettner-Trush	North Adams, Mass.
CW (79727)	Continental Wirt Elec.	Philadelphia, Pa.	SWC (82389)	Switchcraft Inc.	Cazanovia, N.Y.
DLV (99800)	Delevan Electronics	East Aurora, N.Y.	TI (01295)	Texas Instruments, Inc.	Chicago, Ill.
ELM (72136)	Electromotive Mfg.	Williamantic, Conn.	TI (94322)	TeI Labs	Dallas, Texas
ERI (72982)	Erie Technological	Erie, Pa.	TR (03877)	Transiltron Electric Co.	Manchester, N.H.
GE (03508)	General Electric	Syracuse, N.Y.	TRW (84411)	TRW Corp.	Wakefield, Mass.
KH (88865)	Krohn-Hite Corp.	Cambridge, Mass.			Ogallala, Neb.

PC506

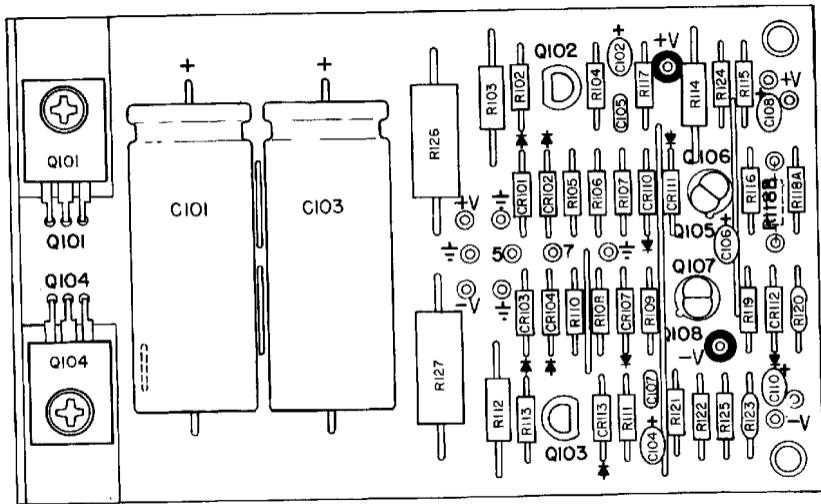


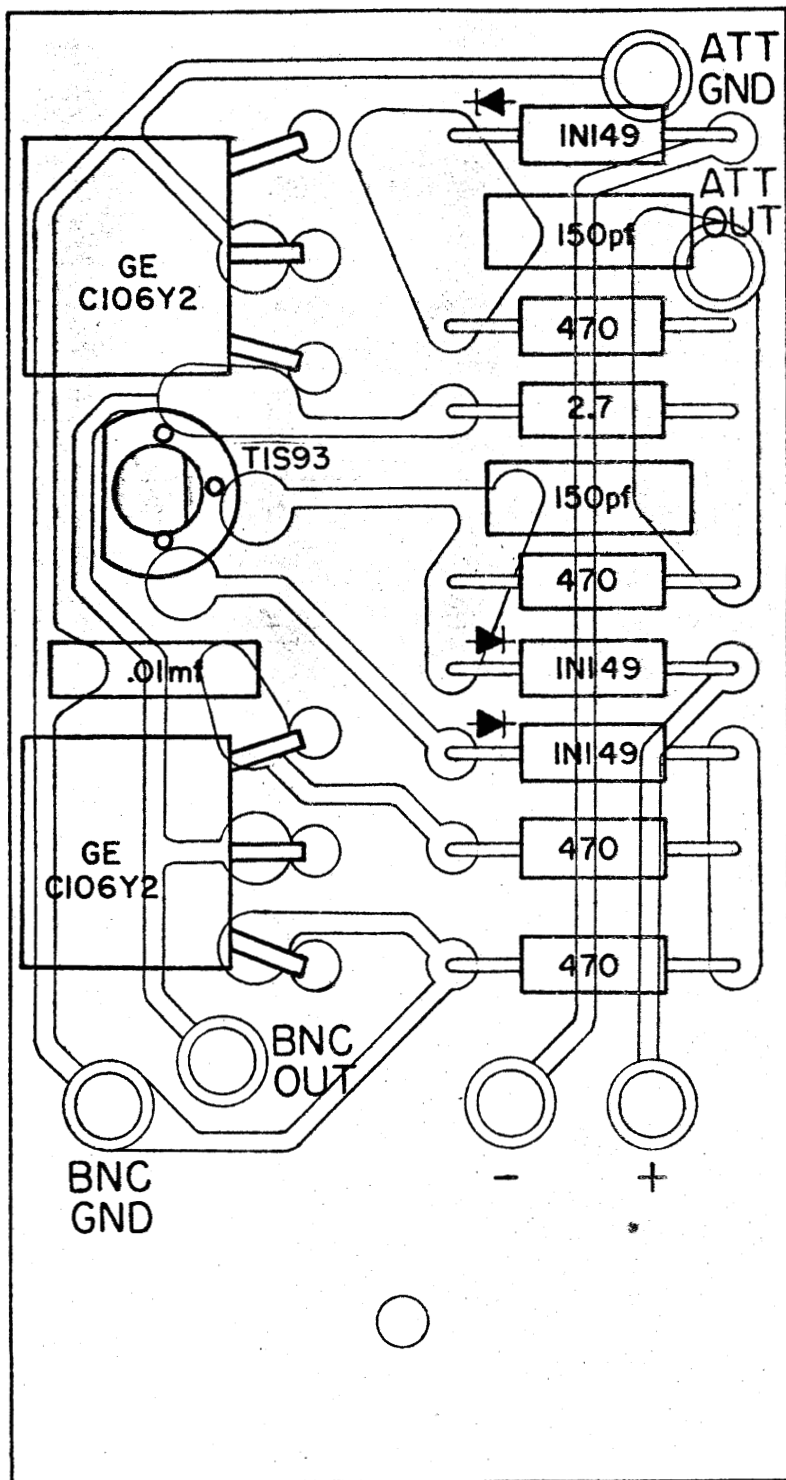
Generator PC Board



NOTES:

- 1- ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED.
- 2- ALL VOLTAGES $\pm 10\%$ OF NORMAL UNLESS OTHERWISE SPECIFIED.
 SETUP - FREQUENCY: 10×1001 Hz, WAVEFORM: ~, AMPLITUDE: 0dB
 DC OFFSET: OFF, SYMMETRY: NORM, TUNING: DIAL B LINE: 60Hz
 300ohm IN SERIES WITH PROBE, SCOPE ON EXT TRIG B +SLOPE
 USING AUXILIARY SQ WAVE OUTPUT FROM GENERATOR.
- 3- FRONT PANEL CONTROL
- 4- REAR PANEL CONTROL
- 5- CHASSIS GROUND
- 6- FLOATING GROUND
- 7- TEST POINT





OUTPUT PROTECTION CIRCUIT

**MODELS: 4100A, 4200, 4300, 5000,
5100A, 5200, 5300, 5400A**

OUTPUT PROTECTION CIRCUIT

This instrument has incorporated a protection circuit, which is connected in series with the 50 ohm output impedance terminal. If a voltage is accidentally applied to the output terminal, that would cause excess current to flow in the output transistors, the SCR's will turn on bypassing this current. When the SCR's are turned on, the instrument will present a short circuit to the load.

This circuit will be damaged if the source load is capable of supplying more than 2 amps. If it is likely that this situation may develop, a 2 amp fast blow fuse may be inserted in series with the output.

At low oscillator frequencies, the circuit will automatically recover when the voltage is removed from the output. At higher frequencies, it will be necessary to turn the output amplitude down or shut the instrument off momentarily after the voltage is removed from the output.

