VOLTAGE CONTROLLED

FUNCTION GENERATOR

MODEL 5100A(R) SERIAL NO.____

OPERATING AND MAINTENANCE MANUAL

KROHN-HITE CORPORATION

Avon Industrial Park/Bodwell St., Avon Massachusetts 02322 U.S.A.

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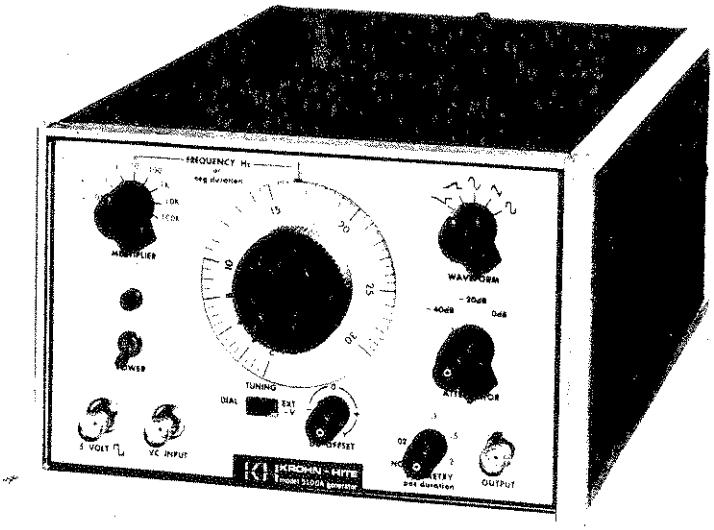
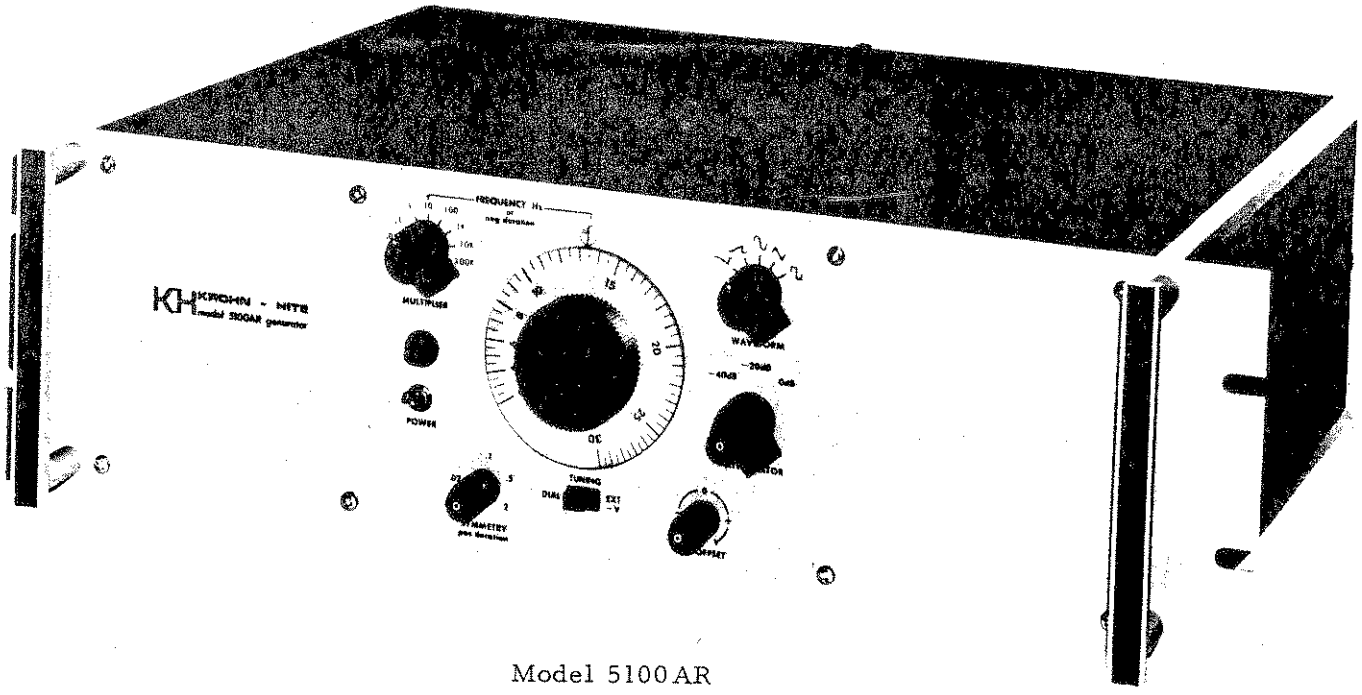


Model 5100A



Model 5100AR

Figure 1. Models 5100 and 5100AR Function Generator

SECTION 1
GENERAL DESCRIPTION

1.1 INTRODUCTION

The Krohn-Hite Model 5100A Function Generator provides sine, square, triangle, positive ramp and negative ramp functions over the frequency range of 0.002 Hz to 3 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 20 volts p-p open circuit or 10 volts across 50 ohms. The output attenuator has a range of 40 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 up to ±5 volts open circuit 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, and negative ramp. Positive and negative pulses with adjustable widths from 200 ns to 200 s are also available on the square wave function, and variable-slope sawtooth on the triangle function. Fixed amplitude square wave provided on auxiliary output.

Frequency Range

0.002 Hz to 3 MHz in 9 ranges.

Frequency Control

Single turn dial calibrated with a single linear scale from 2 to 30 in Hz, and a 9-position multiplier switch. When the SYMMETRY-pos duration control is on, the frequency dial control determines negative pulse width to a ratio of 10:1.

BAND	MULTIPLIER	FREQUENCY (Hz)
1	.001	0.002 - 0.03
2	.01	0.02 - 0.3
3	.1	0.2 - 3
4	1	2.0 - 30
5	10	20 - 300
6	100	200 - 3000
7	1K	2K - 30K
8	10K	20K - 300K
9	100K	200K - 3M

Frequency Accuracy (Symmetrical Waveforms)

5 percent of full scale on band 1; 2 percent of full scale on bands 2 thru 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 Synchronization

2 Volts rms external sine wave will lock generator over approximately ±5% of dial-indicated frequency with slight change in distortion. Input impedance 1000 ohms.

External Frequency Control

Dial Mode: Frequency may be externally varied above and below dial setting. A modulating voltage of ± 15 volts will change frequency by ± 5 percent about dial setting.

External -V Mode: Dial is electrically removed from circuit. Frequency is controlled by an external negative voltage. A voltage of -15 millivolts to -15 volts will vary frequency over a range of 1:1000, the high frequency depending upon the limit of the multiplier range. Positive voltage will stop oscillation.

Input Impedance: 500 ohms.

Response Time: Approximately 100 microseconds.

Maximum Control Voltage: ±15 volts (±25 volts may be applied without damage to circuitry).

Time Symmetry

Sine, square triangle, 99% from 0.002 Hz to 100 kHz, with SYMMETRY-pos duration control in NORM position.

Ramp Duration

47% with SYMMETRY-pos duration control in the NORM position. Duration and delay adjustable 10% to 90% by means of dial and SYMMETRY-pos duration.

Square Wave and Pulse

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

Symmetry-pos duration Control

Single turn potentiometer and switch for adjusting positive duration of pulse and positive slope of triangle. Width ratio is adjustable 100:1. When control is on, negative duration of pulse and negative slope of triangle are adjustable by means of the tuning dial, depending upon multiplier position, as follows:

MULTIPLIER	SYMMETRY-pos duration Control Range	FREQUENCY Hz Dial Range
.001	20S - 2000S	20S - 200S
.01	2S - 200S	2S - 20S
.1	.2S - 20S	.2S - 2S
1	20ms - 2S	20ms - 200ms
10	2ms - 200ms	2ms - 20ms
100	200μs - 20ms	200μs - 2ms
1K	20μs - 2ms	20μs - 200μs
10K	2μs - 200μs	2μs - 20μs
100K	.2μs - 20μs	.2μs - 2μs

NOTE: All other specifications apply with the SYMMETRY-pos duration control in the NORM (off) position.

Main Output

Sine, square, triangle, 20 volts peak to peak open circuit; 10 volts peak to peak across 50 ohms.
Ramps, 10 volts peak open circuit; 5 volts peak across 50 ohms.

Impedance: Constant 50 ohms ± 2 percent.

Amplitude Control: Three position rotary switch, calibrated 0dB, -20dB and -40dB, and infinite resolution vernier. Attenuator accuracy ± 0.2dB. Minimum output less than 3 millivolts peak to peak.

DC Component: Nominal zero except for ramp. At maximum output drift is less than 5 mv/°C. Drift reduced in proportion to attenuator switch setting.

Frequency Response: Sine wave 0.05dB from 0.002 Hz to 100 kHz; 0.15dB to 3 MHz.

Sine Wave Distortion: Less than 0.5% from 0.02 Hz to 100 KHz; 1% at 0.002 Hz, 3% at 3 MHz.

Hum and Noise: 0.02% of maximum output.

DC Offset: On front panel, 0 to ±5 volts maximum open circuit, 2.5 volts across 50 ohms. Stability 5 mv/°C, reduced in proportion to attenuator switch setting. Maximum peak signal plus dc offset ±10 volts.

Auxiliary Square Wave Output

5 volts peak to peak open circuit, 2.5 volts across 50 ohms. Impedance 50 ohms. Rise and fall time less than 15 ns. Total aberrations less than 5 percent with 50 ohm matched load. Phase inverted with regard to main output square wave.

Ambient Temperature Range

0 to 50°C.

Controls

Front panel contains Frequency dial, frequency Multiplier switch, amplitude switch, amplitude vernier, power switch, function switch, tuning switch, Symmetry pos-duration, d.c. offset. Rear panel contains line switch, dc level, 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 50-400 Hz 20 watts.

Dimensions and Weights

Bench model 5100A: 8 5/8" wide, 5 1/4" high, 13 1/2" deep, 15 lbs/8 kgs, net: 18 lbs/9 kgs. shipping.

Rack mounting model 5100AR: 19" wide 5 1/4" high, 13 1/2" deep, 16 lbs/8 kgs, net; 22 lbs. 10 kgs shipping.

SECTION 2
OPERATION

2.1 POWER REQUIREMENTS

The Model 5100A 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 30 for continuous control of frequency, with a 9 position 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 of the main output, 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: 3-position switch for selecting 0dB (10V) through -40dB (0.1V) in 20-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 up to ±5 volts (or ±2.5 volts with 50-ohm load) .

SYMMETRY-pos duration: switched potentiometer for controlling positive pulse duration of main output (negative pulse duration of auxiliary square wave output) 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 duration of half of the waveform, and dial adjusts duration of other half.

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

Front only on 5100A rear only on 5100AR: OUTPUT, auxiliary square wave output, VC INPUT.

Rear, all models: EXTERNAL SYNC.

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 negative voltage applied to the VC INPUT. With any position of waveform switch, the auxiliary square wave can be taken from the 5 volts ⌐⌙ 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, and will provide the attenuation indicated on the scale. In selecting output amplitude, use the lowest value that includes the amplitude you want. For instance, if you require .75 volt, set the attenuator to -20 dB (1 volt) and adjust the vernier for an output of .75 volt as measured at the load. 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 offset plus the peak value of the signal exceeds the attenuator setting, the output signal will be clipped or distorted. Thus the combined output should not exceed 10 volts peak on the 0 dB position, 1 volt on the -20dB position, and 1 volt on the -40dB position.

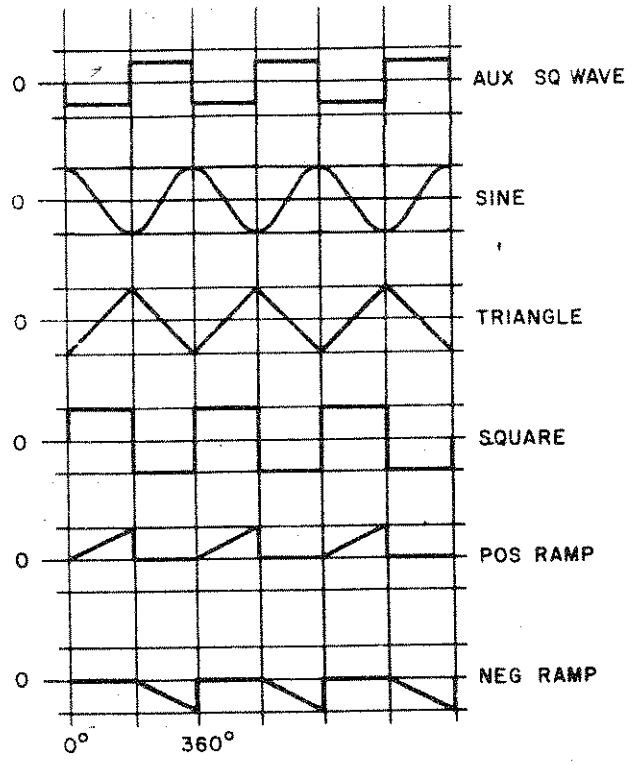


Figure 2. Phase Relationship of Waveforms

2.3.3 Symmetry and Duration Control

Symmetry control in the Model 5100A 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 5100A, 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 the positive half of the waveform can be varied over a 1:100 range, and the duration of the negative half over a 1:10 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 200 nanoseconds by means of the SYMMETRY-pos duration control, while the negative half can be set to 2 microseconds by means of the frequency dial. The frequency can be calculated as follows:

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

for the latter case:

$$\text{frequency} = \frac{1}{2 \times 10^{-7}\,\text{sec} + 20 \times 10^{-7}\,\text{sec}}$$

$$\text{frequency} = 454.5\ \text{KHz}$$

Note - The effect is reversed on the auxiliary square wave output because it is inverted in relation to the main square wave output.

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 1K 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 sine wave 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 sine wave distortion and change in triangle amplitude, both of which are maximum at the extremes of locking range. 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 p-p sync input to ±20 percent for a 20 volt p-p sync input. The main output square wave is in phase with the external synchronizing square wave. 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. A VC input of ±15 volts will modulate the frequency ±5 percent.

2.3.6 External Frequency Control

With the TUNING switch in the EXT-V position, a negative 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 -15 vdc level will provide the maximum output frequency normally obtainable for a given multiplier setting. The relationship between voltage and frequency is:

$$f = -2E_{VC} \times \text{Multiplier}$$

That is, with the multiplier switch in the X1K position, 150 millivolts gives 300 Hz, 1.5 volts 3 kHz, and 15 volts 30 kHz. Notice that with the multiplier in the X.001 position, 150 millivolts gives .0003 Hz, well below the dial range. At -15 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 positive voltage applied to the VC INPUT will stop oscillation, and a dc level will appear on the output. If the positive drive voltage is greater than 2 volts, the output level will settle above 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 main output signal. When the TUNING switch is in the EXT-V position, duration can be calculated as follows:

$$\text{Duration in seconds} = \frac{1}{4 \times \text{VC voltage} \times \text{multiplier}}$$

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.

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 (±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	15 X100
TUNING SWITCH	Dial
AMPLITUDE	0dB (10V) 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, and connect a 50 ohm load across the output of the generator. The voltage should drop by half (-6dB). Remove the load. Operate the AMPLITUDE control in sequence, starting at 0dB and going to -40dB, 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 is 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 ±5 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 10:1. (Since the auxiliary square wave is inverted, the effect on it should be opposite.) 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, 10 and 30 in all frequency bands. Frequency should be within 2 percent of full scale.

3.3.8 External Frequency Control

With the frequency set to 15 X100, connect the calibrated voltage source to the VC INPUT. Set the VC voltage to + 15 volts; the output frequency should change to approximately 1425 Hz. Change the VC voltage to -15 volts. The output frequency should change to approximately 1575 Hz.

Place the TUNING switch in the EXT-VC position. Apply -10 volts to the VC INPUT; the output frequency should be 2 kHz. Apply-150 millivolts to the VC INPUT; the output frequency should be 30 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

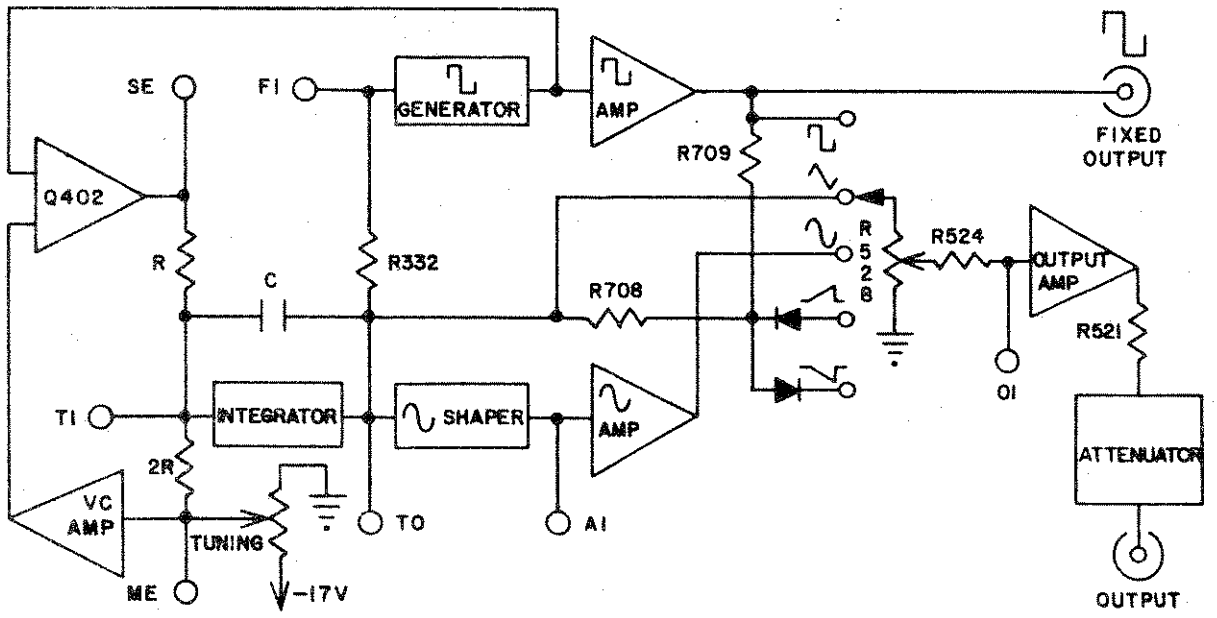


Figure 3. Simplified Schematic Diagram

A simplified schematic 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 frequency dial and the VC amplifier. 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 negative voltage, which 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. This negative level also determines the VC amplifier output level, which is applied to the collector of gate Q402. When Q402 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 Q402, 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 AMPLIFIER AND SYMMETRY CONTROL (See Figure 4)

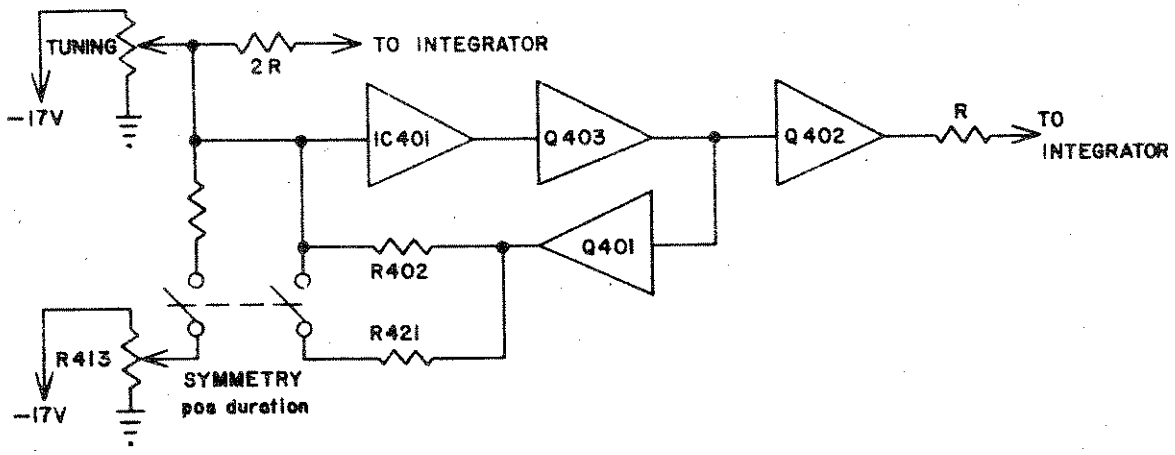


Figure 4. VC Amplifier and Symmetry Control

The VC amplifier has a gain of -1 and so inverts the voltage set by the tuning potentiometer.

The level established by the tuning potentiometer drives the 2R resistors, while the output of the VC amplifier drives the R resistors through gate Q402. When the VC amplifier is gated on, twice as much current will be provided to the integrator input as is provided by the tuning potentiometer, 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 -.5 by increasing its negative feedback; and (2) it switches in SYMMETRY potentiometer R243, which controls a negative bias applied to the input of the VC amplifier. This means that the current for the negative slope of the triangle 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 swings of the 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, Q301B-Q304 and Q307-Q308 provide the gain. Capacitor C is selected by the bandswitch.

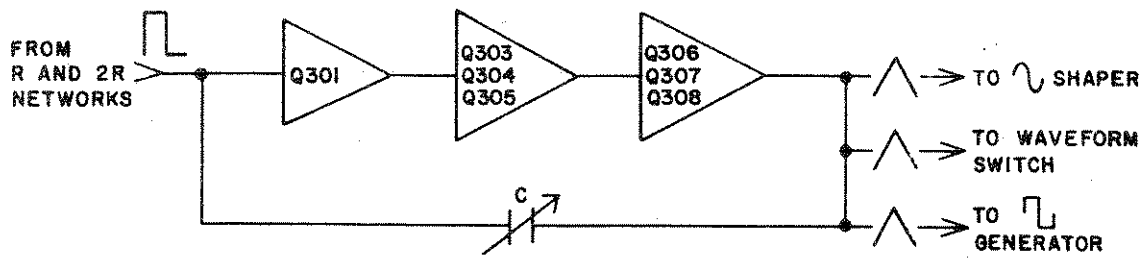


Figure 5. Integrator

4.4 SQUARE WAVE GENERATOR (See Figure 6)

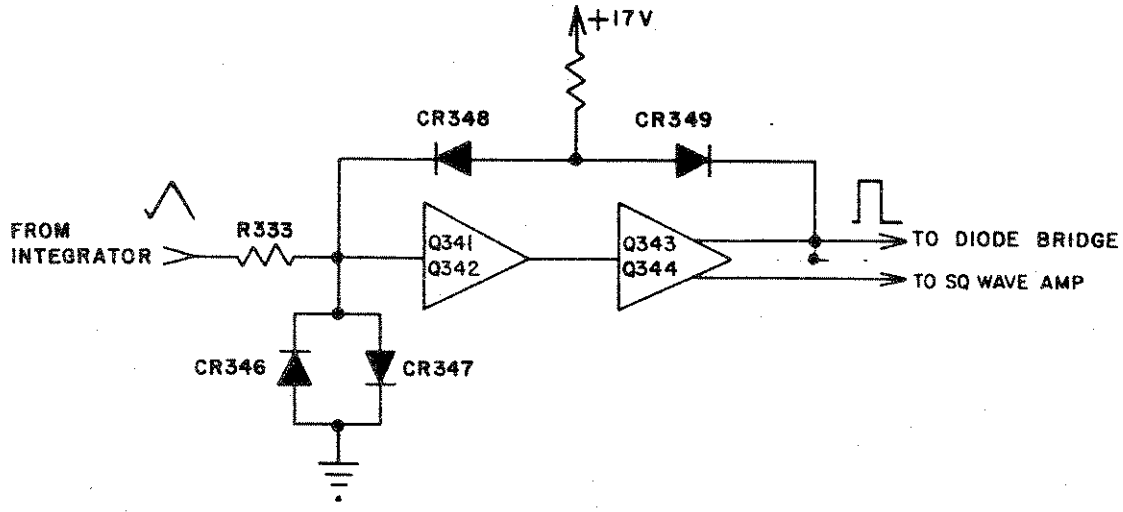


Figure 6. Square Wave Generator

The triangle, taken from the output of the integrator, triggers the square wave generator. Q341 and Q342 are a differential pair, and Q343 and Q344 are a differential pair. Q342 and Q343 form a regenerative sense amplifier with a feedback path from the collector of Q343 to the base of Q342. When the peak of the triangle reaches -10 volts, Q342 conducts, turning on Q343. As the triangle voltage goes from -10 to +10 volts, the voltage at the base of Q342 is clamped to about -0.6 volt by diode CR346. When the triangle reaches its positive peak of +10 volts, the base of Q342 goes positive turning off Q342 and turning on Q343. The voltage at the base of Q342 is limited to +.6V this time by the action of CR347. When the triangle again reaches -10 volts, the cycle repeats. The square wave from Q343 is applied to gate Q402.

4.5 SQUARE WAVE AMPLIFIER (See Figure 7)

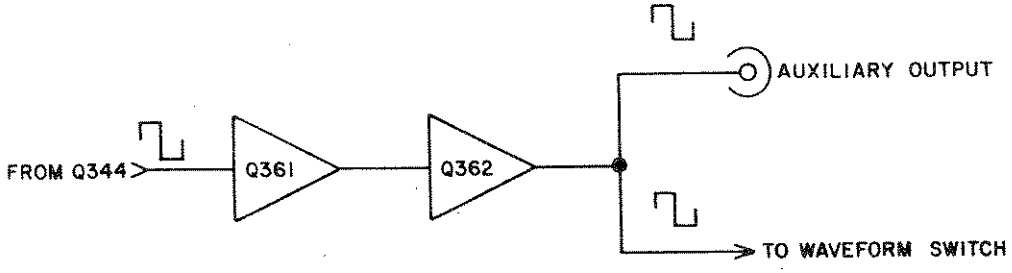


Figure 7. Square Wave Amplifier

The square wave developed at the collector of Q344 is applied to the base of Q361, which in turn drives the base of Q362. The square wave is taken from the emitter of Q362, while the auxiliary square wave goes through R368 to its own connector.

4.6 SINE SHAPER AND SINE AMPLIFIER (See Figure 8)

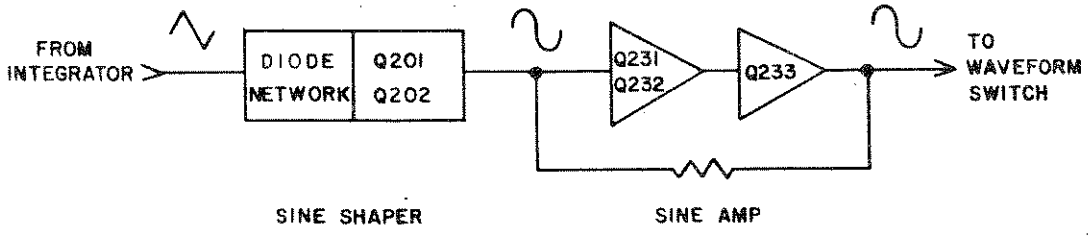


Figure 8. Sine Shaper and Sine Amplifier

The sine shaper consists of six pairs of diodes, each pair associated with a voltage divider. The function of the voltage divider is twofold: (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 main purpose of Q201-202 is to provide the dc voltages with which the diodes clip. The thermal drift of Q201 and Q202 also cancels the thermal drift of the diodes. Potentiometers R221 and R229 are adjusted to minimize distortion. The output of the sine shaper is applied to the sine amplifier and 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 R708 and R709. 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)

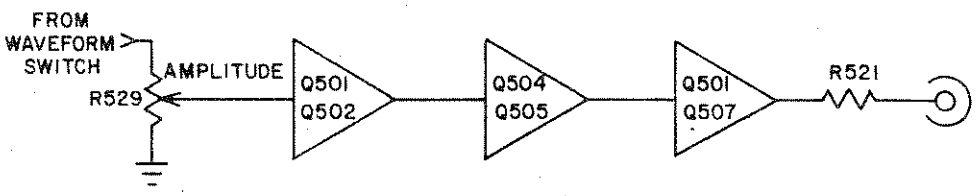


Figure 9. Output Amplifier

The output amplifier consists of a balanced input amplifier Q501-Q502, a second stage Q504-Q505, and output stage Q506-Q507. 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 C508. The input signal level is controlled by amplitude vernier R529.

4.9 POWER SUPPLY (See Figure 10)

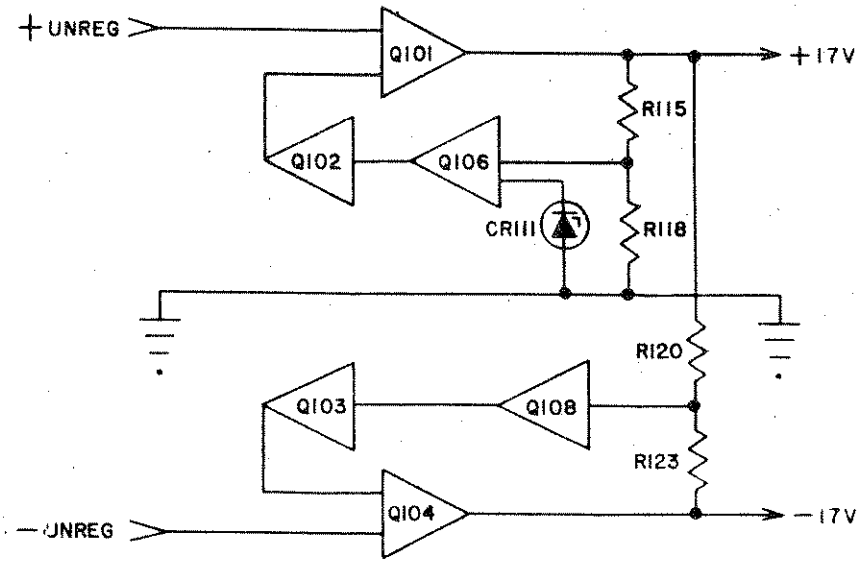


Figure 10. Power Supply

The power supply provides positive and negative 17 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 + 17 volts to ground would shut off Q101 providing short circuit protection.

SECTION 5
MAINTENANCE

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 R621 and R622 and C602 are common to two or more bands, as shown in the table below. For other symptoms, refer to the chart on the following pages.

Table I. Bandswitch Components

Band #	1	2	3	4	5	6	7	8	9
MULTIPLIER	.001	.01	1.	1	10	100	1K	10K	100K
C Value	1mf	1mf	1mf	1mf	1000pf	1000pf	1000pf	1000pf	100pf
C#	C606	C606	C606	C606	C604	C604	C604	C604	C602
R Value	5M	500K	50K	5K	500K	50K	5K	500	500
R#	R621	R616	R615	R614	R616	R615	R614	R613	R613
2R Value	10M	1M	100K	10K	1M	100K	10K	1K	1K
2R#	R622	R620	R619	R618	R620	R619	R618	R612	R612

Table 2. Troubleshooting Chart

Setup:	Dial: 20 Multiplier: X100 Waveform: ∧∨	Attenuator: Switch and vernier CW DC Offset: Off Tuning Switch: Dial

Symptom	Check	Probable Defective Component
No signal Main and Fixed Outputs	1. Tuning switch should be in dial position.	1.
	2. Positive and Negative Voltages (+ 17±.5V, -17±.5V)	2. Fuse, Rectifier, Regulator Overload (if low voltage)
	3. Tuning pot center arm (-8± 1V)	3. Tuning pot or switch (S601)
	4. Test point ME dc voltage (+ 8± 1V)	4. VC loop, including Q403
	5. Polarity at testpoint TI should be opposite that at TO	5. Integrator
	6. Voltage at TO should be above + 10V or below -10V	6. Integrator
	7. Check voltage at test point SE	7a. If TO ≥ + 10V, and SE = + 8, Integrator or network 7b. If TO ≥ + 10V and SE = 0, Flip-flop or Q401 7c. If TO ≥ -10V, and SE = + 8V, Flip-flop or Q401 7d. If TO ≥ -10V and SE ≠ 0, Integrator or network
No signal on main output, fixed output normal	1. Check for signal (3V p-p) on center arm when R529 output amplitude pot is maximum CW	1. Function Switch

Table 2. Troubleshooting Chart (Continued)

Symptom	Check	Probable Defective Component
No signal on main output, fixed output normal (contd.)	2. Check signal on R521 (20V p-p)	2. Output amplifier
	3. If signal on R521 is correct	3. Attenuator
Sine wave only missing	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	1. Sine Amplifier (Q231, etc.)
	2. If sine amp appears normal, check the sine shaper	2. Sine shaper
Main and auxiliary square wave missing	1. Signal on Junction of R365 and R368 should be the same as on collector of Q344	1. Q361, Q362
Main square wave only missing	1. Check all positions of waveform switch	1. Waveform switch
Defective signal as tuning dial is turned	1. As dial is turned from 2 to 30, dc voltage on tuning pot center arm should vary from -0.8 to -12 vdc, and voltage on test point ME should vary from +0.8 to +12 vdc.	1a. Tuning potentiometer 1b. VC loop including Q403
	2. If trouble is at low frequency at end of dial only, check square wave symmetry	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

(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 (±2% to 5 MHz).

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

(e) Distortion meter Hewlett Packard Type 333A.

6.3 POWER SUPPLY

Turn the generator on set the frequency to 5 X100 and allow it to warm up for about 30 minutes. Measure the voltage between ground and + 17 volts and then -17 volts. Tolerances are ±0.5 volt. If off trim R118B to bring both within 0.5 volt.

6.4 INTEGRATOR

Connect the oscilloscope to TI, and set 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 low pass filter in series with the probe, and make sure that the ground connection is close to TI. The 7 kHz filter may be fabricated by connecting a 10K resistor in series with the probe, with .0022 mfd capacitor to ground).

6.5 AUXILIARY SQUARE WAVE

Set the frequency to 30 X100, and connect the auxiliary square wave output to the oscilloscope with a 50-ohm termination at the scope. Set the positive peak of the square wave to + 1.25 volts by means of R353, and the negative peak to -1.25 volts by means of dc level potentiometer R367.

6.6 DC LEVELS

Set the frequency to 5 X100, sine waveform; set the output amplitude CCW and attenuator to 0dB, the TUNING switch to DIAL, and SYMMETRY control at NORM. Connect the dc voltmeter to the OUTPUT, adjust the output level to 0 volts by means of the main output DC LEVEL ADJ control R528 on the rear panel. Return the amplitude vernier to maximum using the dc voltmeter, check the voltages listed in the table below, and if necessary adjust the potentiometers indicated; all should be set to 0 volt.

Table 3. DC Levels

Voltage	Test Point	Adj. No.	Tolerance
Integrator input	TI	R308	± 1 mv
Integrator output (switch to ⩘)	Main Output	R349	± 1 mv
Sine Amplifier input	AI	R246	± 10 mv
Sine Amplifier output	Main Output	R231	± 20 mv

6.7 MAIN SQUARE WAVE

Switch the waveform to square wave, and connect the main output to the oscilloscope with a 50-ohm terminator at the scope. Set the frequency to 30 X100K. Adjust amplitude to 10 volts peak-to-peak. Adjust C515 for minimum droop and overshoot.

6.8 FREQUENCY CALIBRATION

Set the frequency dial at 2. The dc voltage across the two outside terminals of potentiometer R604, the dial pot, should be 0.19 volt. If it is not 0.19 volt, rotate

the dial until it is, and mechanically adjust the position of the dial on the shaft so that the dial indicates 2. Connect the frequency counter to the output. Set the dial to 10, and the multiplier to X1. The frequency should be 10 ± 0.6 Hz. Switch to 10 X10. The frequency should be ten times as great. Adjust C603 for a 10 to 1 change between the X1 and X10 positions.

Set the frequency to 2.5 X100K. Adjust C601 for 250 KHz ± 1%. Set the frequency to 29 X100K. Adjust C331 for 2.9 MHz ± 1%. Repeat both until both are within tolerance.

6.9 SINE WAVE DISTORTION

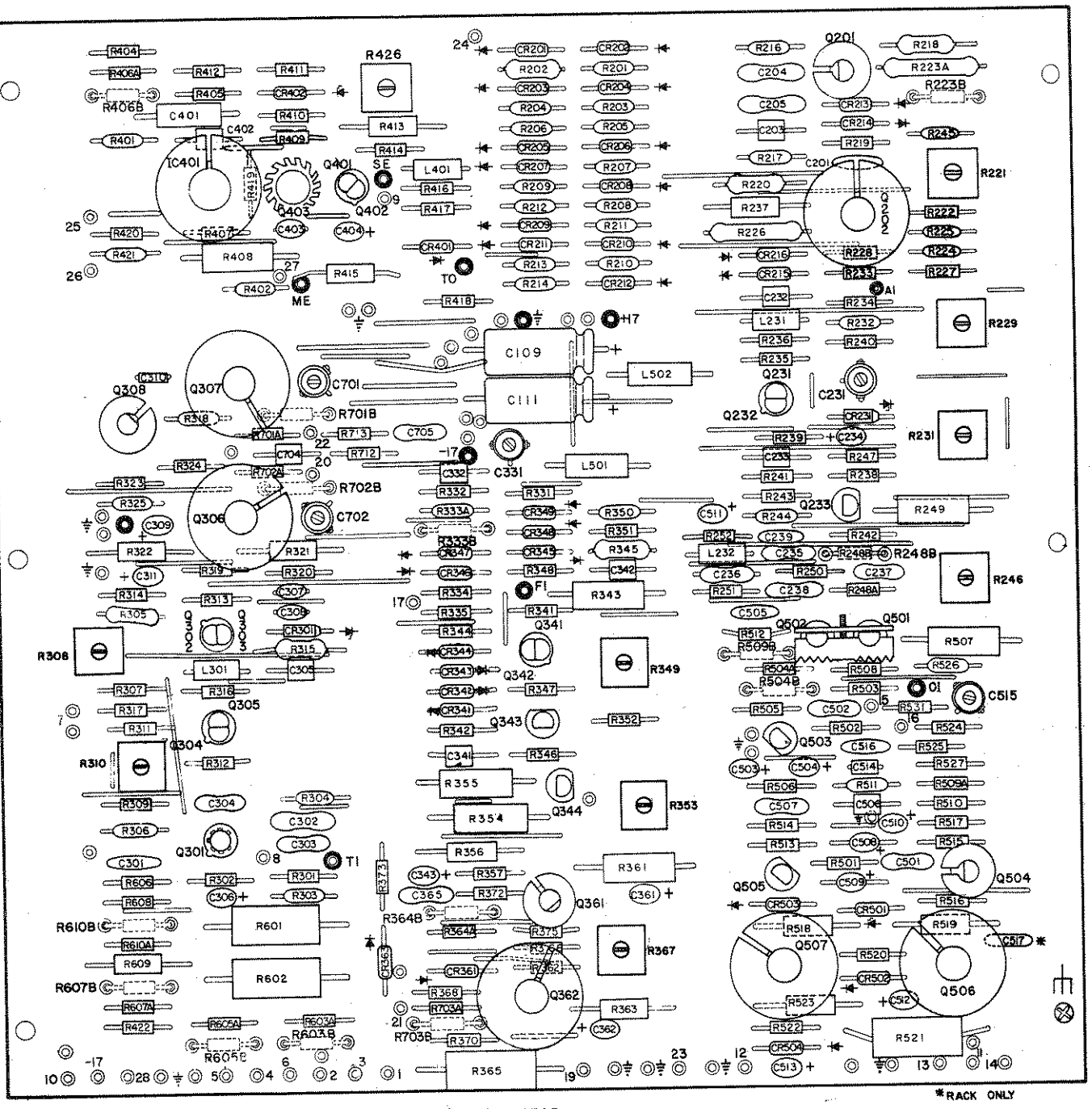
Connect the generator to the distortion analyzer; set WAVEFORM to sine, frequency to 2 X1K, amplitude to maximum, and attenuator to 0dB. Set the distortion analyzer to 2 KHz and adjust for a null. Adjust the generator SYM ADJ pot on the rear panel and then pots R229 and R221 in the sine shaper for minimum distortion.

6.10 RAMP AND TRIANGLE ADJUSTMENTS

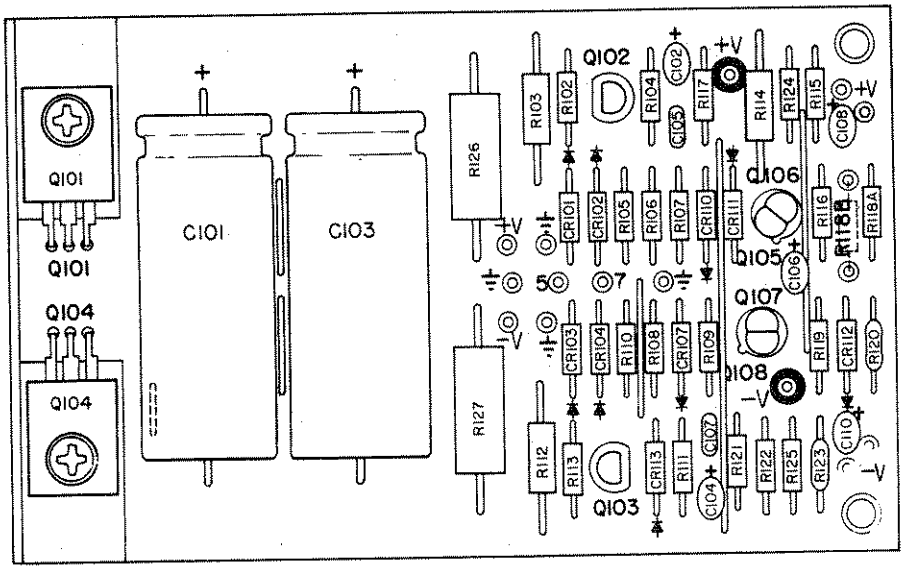
Connect the oscilloscope to the generator, with a 50-ohm terminator at the scope. Set the generator to ramp, frequency to 10 X100. Switch from X100 to X100K; adjust C702 for most linear slope at 100K. Switch to triangle waveform, and switch from X100 to X100K. Adjust C701 for most linear waveform.

6.11 SINE FREQUENCY RESPONSE

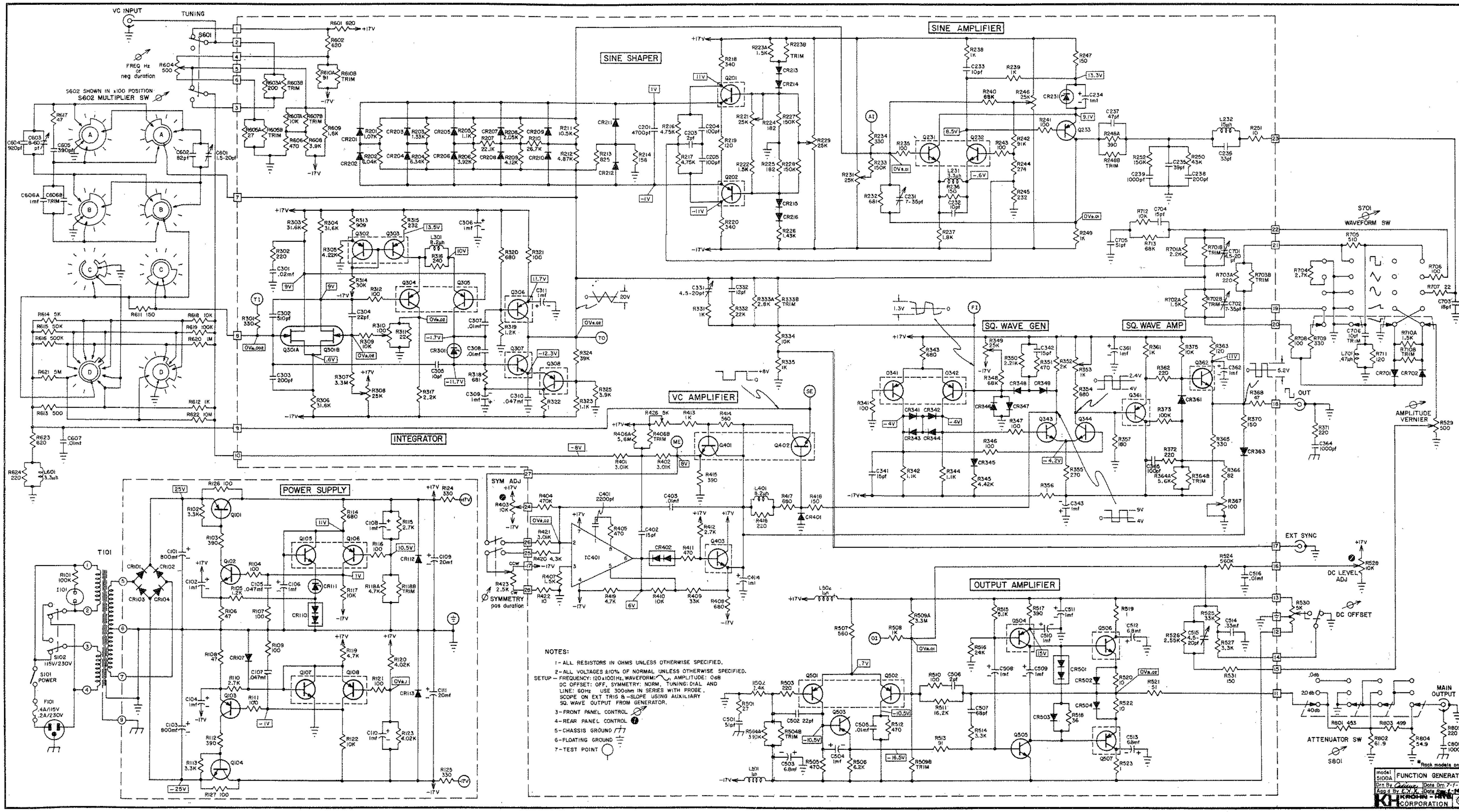
Set the generator to 20 X100, with the output terminated at the acvm. Switch WAVEFORM to sine, attenuator at 0dB, and amplitude vernier maximum CW. Switch from 20 X100 (2 KHz) to 10 X10K (100 KHz) and then to 30 X100K (3 MHz). Tolerance from 2 KHz to 100 KHz should be 0.5%, and from 100 KHz to 3 MHz 1.5%. Adjust C231 to bring the 100K band within tolerance.



MODEL 5100A PC505



PC507


VC INPUT
TUNING
FREQ Hz or neg duration
S602 SHOWN IN x100 POSITION
S602 MULTIPLIER SW
SINE SHAPER
SINE AMPLIFIER
INTEGRATOR
VC AMPLIFIER
SQ. WAVE GEN
SQ. WAVE AMP
S701 WAVEFORM SW
OUT
AMPLITUDE VERNIER
POWER SUPPLY
SYM ADJ
SYMMETRY pos duration
EXT SYNC
DC LEVEL ADJ
DC OFFSET
OUTPUT AMPLIFIER
MAIN OUTPUT
ATTENUATOR SW
S801
*Rack models only
S101 POWER
S102 115V/230V
NOTES:
1 - ALL RESISTORS IN OHMS UNLESS OTHERWISE SPECIFIED.
2 - ALL VOLTAGES ±10% OF NORMAL UNLESS OTHERWISE SPECIFIED.
SETUP - FREQUENCY: (20 x 100) Hz, WAVEFORM: ∿, AMPLITUDE: 0dB
DC OFFSET: OFF, SYMMETRY: NORM, TUNING: DIAL AND
LINE: 60Hz USE 300ohm IN SERIES WITH PROBE,
SCOPE ON EXT TRIG & -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
model 5100A
FUNCTION GENERATOR
Date Drn 7-1-71
App'd By E.X.K.
KH
CORPORATION

RESISTORS

Symbol	Description			Mfr	Part No.
R101	100K	10%	1/4W	AB	CB1041
R102	3.3K	10%	1/4W	AB	CB3321
R103	390	10%	1/2W	AB	EB3911
R104	100	20%	1/4W	AB	CB1012
R105	1.2K	10%	1/4W	AB	CB1221
R106	47	10%	1/4W	AB	CB4701
R107	100	10%	1/4W	AB	CB1011
R108	47	10%	1/4W	AB	CB4701
R109	100	10%	1/4W	AB	CB1011
R110	2.7K	10%	1/4W	AB	CB2721
R111	100	10%	1/4W	AB	CB1011
R112	390	10%	1/2W	AB	EB3911
R113	3.3K	10%	1/4W	AB	CB3321
R114	680	10%	1/2W	AB	EB6811
R115	2.7K	10%	1/4W	AB	CB2721
R116	100	20%	1/4W	AB	CB1012
R117	10K	10%	1/4W	AB	CB1031
R118A	4.7K	10%	1/4W	AB	CB4721
R118B	TRIM			AB	TYPE CB
R119	4.7K	10%	1/4W	AB	CB4721
R120	4.02K	1%	1/8W	KH	M3-T1-4.02K
R121	100	20%	1/4W	AB	CB1012
R122	10K	10%	1/4W	AB	CB1031
R123	4.02K	1%	1/8W	KH	M3-T1-4.02K
R124	330	10%	1/4W	AB	CB3311
R125	330	10%	1/4W	AB	CB3311
R126	100	10%	5W	SA	1500S
R127	100	10%	5W	SA	1500S
R201	1.07K	1%	1/8W	KH	M3-T1-1.07K
R202	6.04K	1%	1/4W	KH	M4-T1-6.04K
R203	1.33K	1%	1/8W	KH	M3-T1-1.33K
R204	6.34K	1%	1/8W	KH	M3-T1-6.34K
R205	1.1K	1%	1/8W	KH	M3-T1-1.1K
R206	3.92K	1%	1/8W	KH	M3-T1-3.92K
R207	22.1K	1%	1/8W	KH	M3-T1-22.1K
R208	2.05K	1%	1/8W	KH	M3-T1-2.05K
R209	4.12K	1%	1/8W	KH	M3-T1-4.12K
R210	26.7K	1%	1/8W	KH	M3-T1-26.7K
R211	10.5K	1%	1/8W	KH	M3-T1-10.5K
R212	4.87K	1%	1/8W	KH	M3-T1-4.87K
R213	825	1%	1/8W	KH	M3-T1-825
R214	158	1%	1/8W	KH	M3-T1-158
R216	4.75K	1%	1/8W	KH	M3-T1-4.75K
R217	4.75K	1%	1/8W	KH	M3-T1-4.75K
R218	340	1%	1/4W	KH	M4-T1-340
R219	120	10%	1/4W	AB	CB1211
R220	340	1%	1/4W	KH	M4-T1-340
R221	25K POT			BKM	72PM
R222	1.5K	10%	1/4W	AB	CB1521
R223A	1.5K	1%	1/2W	KH	M5-T1-1.5K
R223B	TRIM			AB	TYPE CB
R224	182	1%	1/8W	KH	M3-T1-182
R225	182	1%	1/8W	KH	M3-T1-182
R226	1.43K	1%	1/2W	KH	M5-T1-1.43K
R227	150K	10%	1/4W	AB	CB1541
R228	150K	10%	1/4W	AB	CB1541
R229	25K POT			BKM	72PM
R231	25K POT			BKM	72PM
R232	681	1%	1/8W	KH	M3-T1-681
R233	150K	10%	1/4W	AB	CB1541
R234	330	10%	1/4W	AB	CB3311
R235	100	10%	1/4W	AB	CB1011
R236	150	10%	1/4W	AB	CB1511
R237	1.8K	10%	1/2W	AB	EB1821
R238	1K	10%	1/4W	AB	CB1021
R239	1K	5%	1/4W	AB	CB1025
R240	68K	10%	1/4W	AB	CB6831
R241	100	10%	1/4W	AB	CB1011
R242	91K	5%	1/4W	AB	CB9135
R243	100	10%	1/4W	AB	CB1011
R244	274	1%	1/8W	KH	M3-T1-274
R245	232	1%	1/4W	KH	M4-T1-232
R246	25K POT			BKM	72PM
R247	150	10%	1/4W	AB	CB1511
R248A	390	10%	1/4W	AB	CB3911
R248B	TRIM			AB	TYPE CB
R249	1K	10%	1W	AB	GB1021
R250	43K	5%	1/4W	AB	CB4335
R251	10	10%	1/4W	AB	CB1001
R252	150K	10%	1/4W	AB	CB1541
R301	330	10%	1/4W	AB	CB3311
R302	220	10%	1/4W	AB	CB2211
R303	31.6K	1%	1/8W	KH	M3-T1-31.6K
R304	31.6K	1%	1/8W	KH	M3-T1-31.6K
R305	4.22K	1%	1/4W	KH	M4-T1-4.22K
R306	31.6K	1%	1/8W	KH	M3-T1-31.6K
R307	3.3M	10%	1/4W	AB	CB3351
R308	25K POT			BKM	72PM
R309	10K	10%	1/4W	AB	CB1031
R310	100 POT			BKM	72PM
R311	22	10%	1/4W	AB	CB2201
R312	100	20%	1/4W	AB	CB1012
R313	909	1%	1/8W	KH	M3-T1-909
R314	30K	5%	1/4W	AB	CB3035
R315	232	1%	1/4W	KH	M4-T1-232
R316	240	5%	1/4W	AB	CB2415
R317	2.2K	10%	1/4W	AB	CB2221
R318	681	1%	1/8W	KH	M3-T1-681
R319	1.2K	10%	1/4W	AB	CB1221
R320	680	10%	1/4W	AB	CB6811
R321	100	5%	1/2W	AB	EB1015
R322	1	10%	1/2W	AB	EB1061
R323	1.1K	5%	1/4W	AB	CB1125
R324	39K	5%	1/4W	AB	CB3935
R325	3.9K	5%	1/4W	AB	CB3925
R331	1K	5%	1/4W	AB	CB1025
R332	22K	5%	1/4W	AB	CB2235
R333A	2.8K	1%	1/8W	KH	M3-T1-2.8K
R333B	TRIM			AB	TYPE CB
R334	10K	10%	1/4W	AB	CB1031
R335	1K	10%	1/4W	AB	CB1021
R341	100	20%	1/4W	AB	CB1012
R342	1.1K	5%	1/4W	AB	CB1125
R343	680	10%	1W	AB	GB6811
R344	1.1K	5%	1/4W	AB	CB1125
R345	4.42K	1%	1/4W	KH	M4-T1-4.42K
R346	100	20%	1/4W	AB	CB1012
R347	100	20%	1/4W	AB	CB1012
R348	68K	10%	1/4W	AB	CB6831
R349	25K POT			BKM	72PM
R350	2.21K	1%	1/8W	KH	M3-T1-2.21K
R351	470	10%	1/4W	AB	CB4711
R352	2K	5%	1/4W	AB	CB2025
R353	1K POT			BKM	72PM
R354	680	10%	1W	AB	GB6811
R355	270	5%	1W	AB	GB2715
R356	1	10%	1/2W	AB	EB1061
R357	180	5%	1/4W	AB	CB1815
R361	1K	10%	1W	AB	GB1021
R362	220	10%	1/4W	AB	CB2211
R363	120	10%	1/2W	AB	EB1211
R364A	5.6K	10%	1/4W	AB	CB5621
R364B	TRIM			AB	TYPE CB
R365	330	10%	2W	AB	HB3311
R366	82	10%	1/4W	AB	CB8201
R367	100 POT			BKM	72PM
R368	47	10%	1/4W	AB	CB4701
R370	150	10%	1/4W	AB	CB1511
R371	22 (5200)	10%	1/4W	AB	CB2201
R371	220 (5300)	10%	1/4W	AB	CB2211
R372	220	10%	1/4W	AB	CB2211
R373	100K	10%	1/4W	AB	CB1041
R375	10K	10%	1/4W	AB	CB1031
R401	3.01K	0.1%	1/8W	KH	M3-T1-3.01K
R402	3.01K	0.1%	1/8W	KH	M3-T1-3.01K
R403	10K POT			CTS	307089
R404	470K	10%	1/4W	AB	CB4741
R405	470	10%	1/4W	AB	CB4711
R406A	5.6M	10%	1/4W	AB	CB5651
R406B	TRIM			AB	TYPE CB
R407	1.5K	10%	1/4W	AB	CB1521
R408	680	10%	1W	AB	GB6811
R409	33K	10%	1/4W	AB	CB3331
R410	10K	10%	1/4W	AB	CB1031
R411	470	10%	1/4W	AB	CB4711
R412	2.7K	10%	1/4W	AB	CB2721
R413	1K	10%	1/2W	AB	EB1021
R414	560	10%	1/4W	AB	CB5611
R415	390	10%	1/2W	AB	EB3911
R416	220	10%	1/4W	AB	CB2211
R417	680	10%	1/4W	AB	CB6811
R418	150	10%	1/4W	AB	CB1511
R419	4.7K	10%	1/4W	AB	CB4721
R420	4.3K	5%	1/4W	AB	CB4325
R421	3.01K	0.1%	1/8W	KH	M3-T1-3.01K
R422	10	10%	1/4W	AB	CB1001
R423	2.5K POT			KH	A3028
R426	5K POT			BKM	72PM
R501	27	10%	1/4W	AB	CB2701
R502	2.4K	5%	1/4W	AB	CB2425
R503	220	10%	1/4W	AB	CB2211
R504A	390K	10%	1/4W	AB	CB3941
R504B	TRIM			AB	TYPE CB
R505	470	10%	1/4W	AB	CB4711
R506	6.2K	5%	1/4W	AB	CB6225
R507	560	10%	1W	AB	GB5611
R508	1K	10%	1/4W	AB	CB1021
R509A	3.3M	10%	1/4W	AB	CB3351
R509B	TRIM			AB	TYPE CB
R510	100	10%	1/4W	AB	CB1011
R511	16.2K	1%	1/8W	KH	M3-T1-16.2K
R512	470	10%	1/4W	AB	CB4711
R513	91	5%	1/4W	AB	CB9105
R514	3.3K	5%	1/4W	AB	CB3325
R515	5.1K	5%	1/4W	AB	CB5125
R516	24K	5%	1/4W	AB	CB2435
R517	390	10%	1/4W	AB	CB3911
R518	36	5%	1/2W	AB	EB3605
R519	1	10%	1/2W	AB	EB10G1
R520	10	10%	1/4W	AB	CB1001
R521	51	5%	2W	AB	HB5105
R522	10	10%	1/4W	AB	CB1001
R523	1	10%	1/2W	AB	EB10G1
R524	560K	10%	1/4W	AB	CB5641
R525	33K	10%	1/4W	AB	CB3331

RESISTORS (CONT'D)

Symbol	Description			Mfr	Part No.
R526	2.55K	1%	1/8W	KH	M3-T1-2.55K
R527	3.3K	10%	1/4W	AB	CB3321
R528	10K POT			CTS	307089
R529	500 POT			KH	B2928
R530	5K POT			KH	A2938
R531	150	10%	1/4W	AB	CB1511
R601	820	10%	2W	AB	HB8211
R602	620	5%	2W	AB	HB6215
R603A	200	5%	1/4W	AB	CB2015
R603B	TRIM			AB	TYPE CB
R604	500 POT			KH	B2945
R605A	27	10%	1/4W	AB	CB2701
R605B	TRIM			AB	TYPE CB
R606	470	10%	1/4W	AB	CB4711
R607A	10K	10%	1/4W	AB	CB1031
R607B	TRIM			AB	TYPE CB
R608	3.9K	10%	1/4W	AB	CB3921
R609	1.8K	5%	1/2W	AB	EB1825
R610A	91	5%	1/4W	AB	CB9105
R610B	TRIM			AB	TYPE CB
R611	150	10%	1/4W	AB	CB1511
R612	1K	0.1%	1/4W	KH	M4-T1-1K
R613	500	0.1%	1/2W	KH	M5-T1-500
R614	5K	0.1%	1/8W	KH	M3-T1-5K
R615	50K	0.1%	1/8W	KH	M3-T1-50K
R616	500K	0.1%	1/4W	KH	M4-T1-500K
R617	47	10%	1/4W	AB	CB4701
R618	10K	0.1%	1/8W	KH	M3-T1-10K
R619	100K	0.1%	1/8W	KH	M3-T1-100K
R620	1M	0.1%	1/2W	KH	M5-T1-1M
R621	5M	2%	1/2W	KH	M11-5M
R622	10M	2%	1W	KH	M12-10M
R623	620	10%	1/2W	AB	EB6211
R624	220	10%	1/4W	AB	CB2211
R701A	2.2K	5%	1/4W	AB	CB2225
R701B	TRIM			AB	TYPE CB
R702A	1.5K	5%	1/4W	AB	CB1525
R702B	TRIM			AB	TYPE CB
R703A	220	10%	1/4W	AB	CB2211
R703B	TRIM			AB	TYPE CB
R704	2.7K	10%	1/4W	AB	CB2721
R705	510	5%	1/4W	AB	CB5115
R706	100	10%	1/4W	AB	CB1011
R707	22	10%	1/4W	AB	CB2201
R708	100	10%	1/4W	AB	CB1011
R709	330	5%	1/4W	AB	CB3315
R710A	1.5K	10%	1/4W	AB	CB1521
R710B	TRIM			AB	TYPE CB
R711	120	10%	1/4W	AB	CB1211
R712	10K	10%	1/4W	AB	CB1031
R713	68K	10%	1/4W	AB	CB6831
R801	453	1%	1/8W	KH	M3-T1-453
R802	61.9	1%	1/8W	KH	M3-T1-61.9
R803	499	1%	1/8W	KH	M3-T1-499
R804	54.9	1%	1/8W	KH	M3-T1-54.9
R805	220	10%	1/4W	AB	CB2211

CAPACITORS

Symbol	Description			Mfr	Part No.
C101	800mf	LYTIC	40V	MAL	TCM801H040J1P1P
C102	1mf	20%	35V	MAL	TDC105M035AL
C103	800mf	LYTIC	40V	MAL	TCM801H040J1P1P
C104	1mf	20%	35V	MAL	TDC105M035AL
C105	.047mf	20%	50V	ERT	8121-050-651-473M
C106	1mf	20%	35V	MAL	TDC105M035AL
C107	.047mf	20%	50V	ERT	8121-050-651-473M
C108	1mf	20%	35V	MAL	TDC105M035AL
C109	20mf	LYTIC	50V	SP	30D206G050CC4
C110	1mf	20%	35V	MAL	TDC105M035AL
C111	20mf	LYTIC	50V	SP	30D206G050CC4
C201	4700pf	20%	500V	SP	C023B501F472M
C203	2pf	10%	500V	ASP	9208-20910
C204	100pf	10%	500V	ELM	DM15C101K
C205	100pf	10%	500V	ELM	DM15C101K
C231	7-35pf	TRIMMER		STT	TRIKO-02-N1500
C232	10pf	10%	500V	ASP	9213-10110
C233	10pf	10%	500V	ASP	9213-10110
C234	1mf	20%	35V	MAL	TDC105M035AL
C235	39pf	10%	500V	ELM	DM15C390K
C236	33pf	10%	500V	ELM	DM15C330K
C237	47pf	10%	500V	ELM	DM15C470K
C238	200pf	10%	500V	ELM	DM15C201K
C239	1000pf	20%	500V	SP	C023B501E102M
C301	.02mf	20%	500V	SP	C023A501G203M
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	1mf	20%	35V	MAL	TDC105M035AL
C307	.01mf	20%	500V	SP	C023B501G103M
C308	.01mf	20%	500V	SP	C023B501G103M
C309	1mf	20%	35V	MAL	TDC105M035AL
C310	.047mf	20%	50V	ERT	8121-050-651-473M
C311	1mf	20%	35V	MAL	TDC105M035AL
C331	4.5-20pf	TRIMMER		STT	TRIKO-02-N750
C332	12pf	10%	500V	ASP	9213-12110
C341	15pf	10%	500V	ASP	9300-15110
C342	15pf	10%	500V	ASP	9300-15110
C343	1mf	20%	35V	MAL	TDC105M035AL
C361	1mf	20%	35V	MAL	TDC105M035AL
C362	1mf	20%	35V	MAL	TDC105M035AL
C364	1000pf	20%	500V	SP	C023B501E102M
C365	100pf	10%	500V	ELM	DM15C101K
C401	2200pf	10%	100V	CD	WMF1D22
C402	15pf	10%	500V	ASP	9300-15110
C403	.01mf	20%	500V	SP	C023B501G103M
C404	1mf	20%	35V	MAL	TDC105M035AL
C501	51pf	10%	500V	ELM	DM15C510K
C502	22pf	10%	500V	ELM	DM15C220K
C503	6.8mf	20%	35V	SP	196D685X0035FB
C504	1mf	20%	35V	MAL	TDC105M035AL
C505	.01mf	20%	500V	SP	C023B501G103M
C506	2pf	10%	500V	ASP	9208-20910
C507	68pf	10%	500V	ELM	DM15C680K
C508	1mf	20%	35V	MAL	TDC105M035AL
C509	1mf	20%	35V	MAL	TDC105M035AL
C510	1mf	20%	35V	MAL	TDC105M035AL
C511	1mf	20%	35V	MAL	TDC105M035AL
C512	6.8mf	20%	35V	SP	196D685X0035FB
C513	6.8mf	20%	35V	SP	196D685X0035FB
C514	.33mf	20%	100V	ERT	8131-100-651-334M
C515	4.5-20pf	TRIMMER		STT	TRIKO-02-N750
C516	.01mf	20%	500V	SP	C023B501G103M
C601	1.5-20pf	TRIMMER		ELM	T50210
C602	82pf	10%	500V	ELM	DM15C820K
C603	8-60pf	TRIMMER		ELM	T50410
C604	920pf	1%	500V	ELM	CM19C921F
C605	390pf	10%	500V	ELM	DM15C391K
C606A	1mf	-2%-4%	200V	TRW	X663F-8
C606B	TRIM				
C607	.01mf	20%	500V.	SP	C023B501G103M
C701	4.5-20pf	TRIMMER		STT	TRIKO-02-N750
C702	7-35pf	TRIMMER		STT	TRIKO-02-N1500
C703	18pf	10%	500V	ELM	DM15C180K
C704	15pf	10%	500V	ASP	9300-15110
C705	51pf	10%	500V	ELM	DM15C510K
C706	10pf	10%	500V	ASP	9213-10110
C801	1000pf	20%	500V	SP	C023B501E102M

TRANSISTORS, DIODES & MISC.

Symbol	Description	Mfr	Part No.
Q101	MJE2370	MOT	MJE2370
Q102	TIS92	TI	TIS92
Q103	TIS93	TI	TIS93
Q104	MJE2520	MOT	MJE2520
Q105	2N5225	MOT	2N5225
Q106	2N5087	MOT	2N5087
Q107	2N5225	MOT	2N5225
Q108	2N5087	MOT	2N5087
Q201	TIS97	TI	TIS97
Q202	2N2905A	TI	2N2905A
Q231	MPS6566	MOT	MPS6566
Q232	MPS6566	MOT	MPS6566
Q233	MPS6518	MOT	MPS6518
Q301	SU2366	TEL	SU2366
Q302	MPS6518	MOT	MPS6518
Q303	MPS6518	MOT	MPS6518
Q304	MPS6518	MOT	MPS6518
Q305	MPS6518	MOT	MPS6518
Q306	2N2905A	TI	2N2905A
Q307	2N2219A	TI	2N2219A
Q308	TIS93	TI	TIS93
Q341	MPS3640	MOT	MPS3640
Q342	MPS3640	MOT	MPS3640
Q343	MPS3646	MOT	MPS3646
Q344	MPS3646	MOT	MPS3646
Q361	TIS93	TI	TIS93
Q362	2N5189	RCA	2N5189
Q401	MPS3646	MOT	MPS3646
Q402	MPS3646	MOT	MPS3646
Q403	2N2219A	TI	2N2219A
Q501	MPS6518	MOT	MPS6518
Q502	MPS6518	MOT	MPS6518
Q503	MPS3640	MOT	MPS3640
Q504	MPS6518	MOT	MPS6518
Q505	MPS6566	MOT	MPS6566
Q506	2N2219A	TI	2N2219A
Q507	2N2905A	TI	2N2905A
IC401	MC1539G	MOT	MC1539G
CR101	1N4002	MSC	1N4002
CR102	1N4002	MSC	1N4002
CR103	1N4002	MSC	1N4002
CR104	1N4002	MSC	1N4002
CR107	1N4149	APD	1N4149
CR110	MZ2361	MOT	MZ2361
CR111	Z4835 ZENER	CODI	Z4835
CR112	1N4002	MSC	1N4002
CR113	1N4002	MSC	1N4002
CR201	1N4149	APD	1N4149
CR202	1N4149	APD	1N4149
CR203	1N4149	APD	1N4149
CR204	1N4149	APD	1N4149
CR205	1N4149	APD	1N4149
CR206	1N4149	APD	1N4149
CR207	1N4149	APD	1N4149
CR208	1N4149	APD	1N4149
CR209	1N4149	APD	1N4149
CR210	1N4149	APD	1N4149
CR211	1N4149	APD	1N4149
CR212	1N4149	APD	1N4149
CR213	1N4149	APD	1N4149
CR214	1N4149	APD	1N4149
CR215	1N4149	APD	1N4149
CR216	1N4149	APD	1N4149
CR231	1N749A ZENER	TR	1N749A
CR301	1N961B ZENER	TR	1N961B
CR341	1N4149	APD	1N4149
CR342	1N4149	APD	1N4149
CR343	1N4149	APD	1N4149
CR344	1N4149	APD	1N4149
CR345	1N4149	APD	1N4149
CR346	1N4149	APD	1N4149
CR347	1N4149	APD	1N4149
CR348	1N4149	APD	1N4149
CR349	1N4149	APD	1N4149
CR361	1N4149	APD	1N4149
CR363	1N4149	APD	1N4149
CR401	1N4149	APD	1N4149
CR402	MZ2361	MOT	MZ2361
CR501	MZ2361	MOT	MZ2361
CR502	1N4149	APD	1N4149
CR503	1N4149	APD	1N4149
CR504	1N4149	APD	1N4149
CR701	1N4149	APD	1N4149
CR702	1N4149	APD	1N4149
F101	.4A/115V Slo-Blo .2A/234V Slo-Blo	BUS	MDA
L231	3.3uhy 10% .4W	DLV	1537-24
L232	15uhy 10% .4W	DLV	1537-40
L301	8.2uhy 10% .4W	DLV	1537-34
L401	8.2uhy 10% .4W	DLV	1537-34
L501	1uhy 10% .4W	DLV	BP774-2
L502	1uhy 10% .4W	DLV	BP774-2
L601	3.3uhy 10% .4W	DLV	1537-24
L701	.47uhy 10% .4W	DLV	1537-06
S101	TOGGLE SWITCH	AS	ST1-1
S102	SLIDE SWITCH	SWC	46256LFR
S601	SLIDE SWITCH	CW	GF326
S602	ROTARY SWITCH	KH	B2927
S701	ROTARY SWITCH	KH	B2926
S801	ROTARY SWITCH	KH	B2928
T101	POWER TRANSFORMER	KH	B2882

MANUFACTURERS CODE

AB	(01121)	Allen Bradley Co.	Milwaukee, Wisc.
APD	(50273)	American Power Devices	Andover, Mass.
AS	( )	American Switch	Gloucester, Mass.
ASP	(82142)	Airco Speer	Dubois, Pa.
BKM	(30646)	Beckman Instr. Inc.	Cedar Grove, N.J.
BUS	(71400)	Bussman Mfg Co.	St. Louis, Mo.
CODI	( )	Commuter Diode Corp.	Fairlawn, N.J.
CTS	(71450)	CTS Corp.	Elkhart, Ind.
DLV	(99800)	Delevan Electronics	East Aurora, N.Y.
ELM	(72136)	Electromotive Mfg.	Willimantic, Conn.
ERT	(72982)	Erie Technological	Erie, Pa.
KH	(88865)	Krohn-Hite Corp.	Cambridge, Mass.
MAL	(37942)	P.R. Mallory & Corp.	Indianapolis, Ind.
MOT	(04713)	Motorola Semiconductor	Phoenix, Ariz.
MSC	(14552)	Micro Semiconductor Corp.	Culver City, Calif.
RCA	(49671)	Radio Corp. of America	Harrison, N.J.
SA		Sage Electric Division	Darlington, S.C.
SP	(56289)	Sprague Electric Co.	North Adams, Mass.
STT		Stettner-Trush	Cazanovia, N.Y.
SWC	(82389)	Switchcraft Inc.	Chicago, Ill.
TEL		Teledyne Semiconductor	Mountain View, Calif.
TI	(01295)	Texas Instruments, Inc.	Dallas, Texas
TR	(03877)	Transitron Electric Co.	Wakefield, Mass.
TRW	(84411)	TRW Corp.	Ogallala, Neb.