379 | Solid State FET Sine·Square Wave Generator

OPERATING MANUAL

GENERAL DESCRIPTION

The EICO Model 379 is a sine and square wave generator that provides highly stable sinusoidal voltages throughout the frequency range of 20 Hz to 2 mHz, and square-wave voltages ranging from 20 Hz to 200 kHz. Designed to generate the frequencies required for testing all audio and supersonic equipment, its low distortion sine-wave signals, coupled with its very sharp square-wave signals, make the Model 379 especially suitable for checking high-fidelity amplifiers and transducers. This instrument is also ideal for testing sonar apparatus.

FEATURES

1. The oscillator consists of a low distortion Sultzer feedback circuit that uses a high-impedance input FET for increased frequency stability

2. Sine-wave and square-wave voltages are generated simultaneously at the same frequency, and are made available at separate output terminals.

3. The output level of each of the two channels is independent of the other. Each channel is equipped with its own OUTPUT LEVEL control (SINE WAVE or SQUARE WAVE).

4. The sine-wave output provides continuous coverage of all the frequencies from 20 Hz to 2 mHz in five bands. The sinusoidal voltage may be varied from zero to 6.5 volts when driving a 600-ohm load.

5. Amplitude variations in the sine-wave signals are maintained within ±1 db throughout the four lower bands and ±2 db on the highest band. Distortion, rated at 0.25%, is less than 0.1% over a good portion of the audio spectrum. The continuous coverage of all frequencies from 20 Hz to 2 mHz makes this unit ideal for testing speaker systems.

6. The square-wave output can be varied from 0 to 10 volts peak-to-peak and covers all frequencies from 20 Hz to 200 kHz. These correspond to bands 1 through 4. In band 5, the square-wave channel is automatically disabled. With a rise time of less than 0.1 microsecond at 20 kHz, the waveform is ideally suited for square-wave testing the finest high-fidelity amplifiers.

7. The instrument power supply incorporates a power transformer for maximum safety, eliminating shock hazard.

SPECIFICATIONS

<u>Frequency Range</u>:

Sine wave	20 Hz to 2 mHz in five bands: 1. 20 Hz to 200 Hz 2. 200 Hz to 2 kHz 3. 2 kHz to 20 kHz 4. 20 kHz to 200 kHz 5. 200 kHz to 2 mHz
Square wave	20 Hz to 200 kHz (same as bands 1-4, above)

Output Voltage:

Sine wave	0 - 7.5 volts rms into high impedance load 0 - 6.5 volts rms into 600 ohms
Square wave	0 - 10 volts p-to-p into high impedance, positive direction with zero ground
Calibration Accuracy:	±3% except 5% from 20 Hz to 100 Hz and from 1 mHz to 2 mHz
Maximum Distortion:	0.25% across audio range
Rise Time at 20 kHz:	less than 0.1 microsecond
Power Requirements:	105 - 132 volts, 50/60 Hz, 10 va
Size:	7-1/2" high, 8-1/2" wide, 7-1/2" deep
Weight:	8 pounds 10 ounces

CIRCUIT DESCRIPTION

Basically, the Model 379 consists of a Sultzer resistance-coupled oscillator that provides a highly stable sine-wave output, and a bistable circuit that simultaneously converts the selected sine-wave frequency into a perfect square wave. As shown in the schematic diagram, a high resistance input FET, Q1, is used in source-follower configuration. The source voltage is directly coupled to emitter follower Q2, which buffers the signal to a regenerative feedback circuit consisting of transistors Q3, Q4, and Q5. Transistors Q4 and Q5 conduct on alternate half-cycles, providing positive feedback to the emitter circuit of Q3 via capacitors C2 and C3, and lamp I1. Potentiometer R8 sets the feedback level, thus controlling the amplitude of oscillation. The signal developed across R7 through R9 is in phase opposition to the voltage across R5, reducing any waveform distortion.

The frequency of oscillation is controlled by a switch-selected bridge "T" network connected between the output of the oscillator circuit (emitter circuit of Q4 and Q5) and the gate of FET Q1. The phase-shifting characteristic of the network is such that the negative feedback applied to Q1 cancels all frequencies except the one selected by the operator. The bridge "T" network is composed of 1% precision resistors and a large two-gang tuning capacitor, a combination that produces accurate frequency selection and wide band coverage.

After the network values are selected, oscillation builds up in Q3, Q4, and Q5. Lamp I1, in the feedback path, stabilizes the signal amplitude. Increasing the current flow through I1 causes its resistance to increase, lowering the current. Conversely, if less current flows, lamp resistance decreases and permits more current to flow. In this way, I1 stabilizes the feedback current, thus stabilizing signal amplitude.

The sinusoidal signals developed in the emitter circuit of Q4 and Q5 are coupled through C4 to OUTPUT LEVEL-SINE WAVE potentiometer R13, which sets the signal level at the sine-wave output terminals.

Square-wave signals are developed by Schmitt trigger Q6-Q7, which is driven by the sinusoidal waveform at the output of Q4 and Q5. When the input signal increases positively to a predetermined value, Q6 is driven into sharp conduction, cutting off Q7. When the polarity of the input signal is reversed and hecomes sufficiently negative, Q6 is cut off and Q7 is driven on. Conduction of Q6 and Q7 on alternate half cycles produces a square wave at the collector of Q7. Potentiometer R16 sets the d-c level at the hase of Q6. This controls the point on the input sine wave at which Q6 or Q7 conducts, thus controlling the symmetry of the resulting square-wave signal. Zener diode D4 maintains the collector supply voltage at a constant level.

The square-wave output at the collector of Q7 is coupled through C8 to emitter follower Q6 whose output is developed across OUTPUT LEVEL-SQUARE WAVE control R23. This control sets the signal level at the square-wave output terminals.

The power supply consists of a transformer-power, dual-type, full-wave rectifier circuit. Silicon diodes D6 and D8 conduct on alternate half-cycles of the a-c voltage developed across the secondary winding of power transformer T1, producing approximately +38 volts across C14. Diodes D7 and D9, driven by the same a-c input, simultaneously produce approximately -38 volts across filter capacitor C15. Each voltage is applied through an RC filter to an associated Zener diode which maintains the oscillator supply voltage constant, further improving oscillator stahility. The +38-volt output of the power supply is fed through normally closed contacts of RANGE switch section S1C to the collector circuits of Q6 through Q8. The switch contacts open when the RANGE switch is set to the X100K position, disabling the square-wave circuit.

OPERATING CONTROLS AND INDICATORS

Tahle 1 lists the operating controls and indicators on the Model 379 and indicates their functions.

Table 1. Controls and Indicators

Item	Function
∿ jacks J1, J2	Provide connections to sine-wave output of instrument.
OUTPUT LEVEL-SINE WAVE control R13	Sets output level of sinusoidal voltage.
RANGE switch S1	Selects one of five frequency hands: X10, X100, X1K, X10K, and X100K.
Frequency dial	Calihrated from 2 to 20, this dial is used in conjunction with RANGE switch to select output frequency between 2 Hz and 2 mHz.
OUTPUT LEVEL-SQUARE WAVE control R23	Sets output level of square-wave voltage.
⎍ jacks J3, J4	Provides square-wave output of instrument.
Neon lamp I2	When lit, indicates that a-c power is turned on.

OPERATION

Power Application:

a. Plug the line cord into a 105-132-volt a-c, 50- to 60-Hz outlet. DO NOT plug it into a source of higher voltage or different frequency range, or into a d-c outlet, since an improper power source will damage the instrument.

h. Rotate the OUTPUT LEVEL-SQUARE WAVE control clockwise until the self-contained switch clicks on and the front panel neon lamp lights.

Waveform Selection: Sine-wave and square-wave signals are available simultaneously. For sine-wave voltages, connect to the left pair of output terminals (marked ∿). For square waves, connect to the right pair (marked ⎍).

Frequency Selection:

a. Set the RANGE selector switch to the desired frequency hand. Each position on the RANGE switch corresponds to a direct reading scale on the dial, as follows:

Band 1:	20 Hz to 200 Hz
Band 2:	200 Hz to 2 kHz
Band 3:	2 kHz to 20 kHz
Band 4:	20 kHz to 200 kHz
Band 5:	200 kHz to 2 mHz

b. Rotate the large knob on the frequency dial until the red hairline on the indicator lines up with the desired frequency. Thus, a setting of 2.8 on the frequency dial corresponds to 28 Hz, 280 Hz, 2.8 kHz, 28 kHz or 280 kHz on hands 1 through 5, respectively.

Output Level Control: The OUTPUT LEVEL control adjacent to the selected sine-wave or square-wave output terminals controls the amplitude of the associated signal. Clockwise rotation of each OUTPUT LEVEL control increases signal level.

If very low-amplitude signals are required for testing (such as for high-gain audio systems), an improved signal-to-noise ratio will be obtained hy connecting a resistive voltage divider network across the selected output terminals. Make the connection as shown in figure 1.

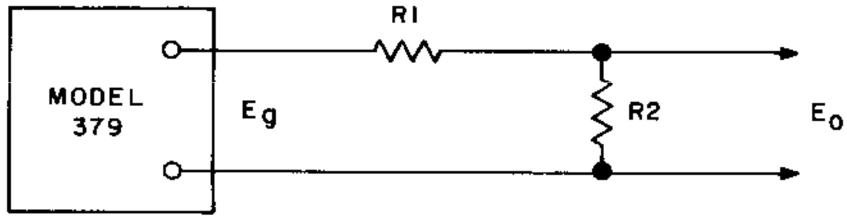


Figure 1. Simple Voltage Divider

The signal at the output of the network, E_O, will be a fraction of the generated signal, Eg, as follows:

$$E_O = \left(\frac{R_2}{R_1 + R_2}\right) Eg$$

As an example, to divide the generator voltage by 10, R1 can be made 900 ohms and R2 100 ohms, so that

$$E_O = \left(\frac{100}{900 + 100}\right) Eg = \frac{1}{10} Eg$$

Different pairs of resistors may be used in the dividing network to obtain other voltage divisions. The value of R2 should be low compared to the input impedance of the equipment under test. However, the total of the two resistances should be at least 600 ohms.

NOTE

When dividing square-wave voltages or high-frequency sine waves, use low-value resistors in the voltage dividing network to avoid waveform distortion or reduced output.

Frequency Measurement

The Model 379 can be used to measure frequency by comparison. A common method is to use an oscilloscope as the indicating device. Any EICO scope (Model 427, 430, 435, 460, or 465) can be used for this purpose. Connect the sine-wave output to the horizontal axis of the scope and the unknown frequency to the vertical axis. Now adjust the controls on the scope (or the input voltages) for approximately equal deflections on each axis. Vary the frequency of the Model 379 until the scope pattern is a stationary ellipse, a circle, or a diagonal line of fixed length. Figure 2 illustrates some of the patterns that might be obtained, depending on the phase relationships between the two frequencies and between the scope's vertical and horizontal deflection channels. If one of these patterns is obtained, the unknown frequency corresponds to the frequency of the Model 379. Nonsinusoidal signals will produce distorted forms of a single loop pattern or a diagonal line of uneven brightness.

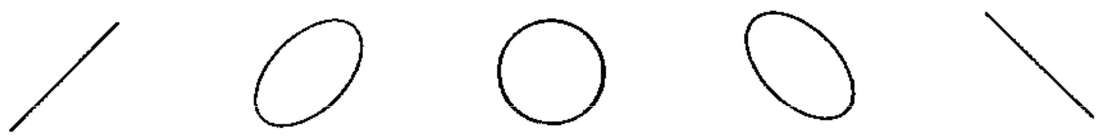


Figure 2. Scope Patterns for Identical Frequencies

If the unknown frequency is out of the range of the Model 379, it can be measured by means of Lissajous figures. These are stationary closed-loop patterns that appear on the screen when the frequency applied to one set of plates is a whole number of times greater than the frequency applied to the other set of plates, or if one frequency is a simple fraction of the other. Connect the known frequency (from the Model 379) to the horizontal input of the scope and the unknown frequency to the vertical input. To determine the frequency ratio of the unknown frequency to the known frequency from a Lissajous pattern, vary the frequency of the Model 379 until a Lissajous pattern is produced on the scope, then divide the number of horizontal peaks by the number of vertical peaks. Figure 3 illustrates some typical patterns.

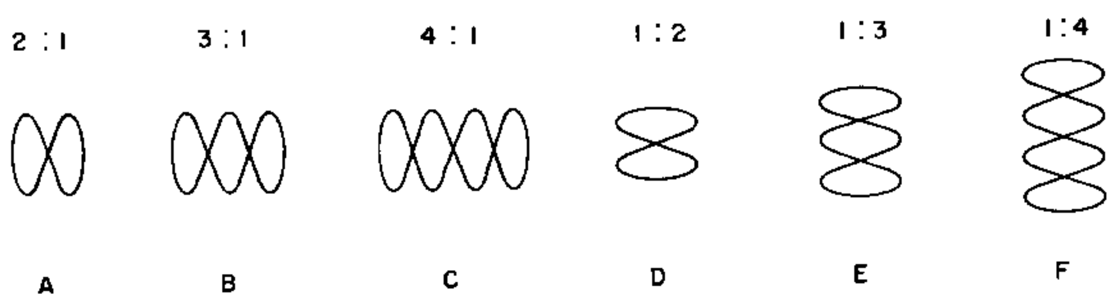


Figure 3. Typical Lissajous Patterns

In A, there are two horizontal peaks and one vertical peak, so the unknown frequency is twice the known frequency, a ratio of 2:1. In E, there is one horizontal peak to three vertical peaks, so the unknown frequency is one third the known frequency.

Square-Wave Testing

The square-wave output of the Model 379 can be used to measure such characteristics as frequency response, phase shift, and transient response in amplifiers. A wideband oscilloscope such as EICO Model 465 is also required to perform such tests. First, the square-wave output of the Model 379 should be viewed on the oscilloscope. Adjust the horizontal sweep so that at least two full cycles of a perfect square wave can be observed.

Now connect the Model 379 to the input of the amplifier under test and connect the output of the amplifier to the oscilloscope. Figure 4 shows possible waveshapes that can be obtained, depending on the characteristics of the amplifier being tested.

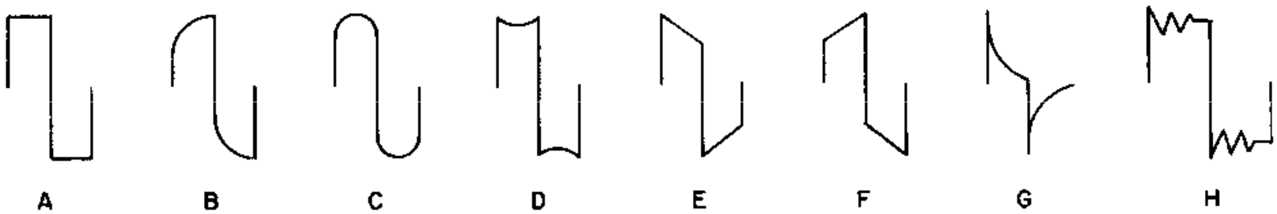


Figure 4. Square-Wave Testing Waveforms

Waveform A shows a perfect waveshape, indicating excellent frequency response and no phase shift. The rounding of the leading edge of waveform B indicates reduced gain at high frequencies. Rounding generally occurs when there is a substantial drop in gain up to the tenth harmonic. Thus, if a 2-kc square wave is reproduced at the output of an amplifier without rounding, the amplifier is flat to approximately 20 kc. Waveforms C and D show the effects of increased gain and decreased gain, respectively, at the square-wave frequency. The effect of phase shift in the amplifier is shown in waveforms E and F. If, at low frequencies, there is phase shift in the leading direction, the top of the square wave will be tilted as in waveform E. Phase shift in the lagging direction produces a display similar to waveform F. Steepness of tilt is proportional to the degree of phase shift.

Waveform G shows the pulse output from an amplifier when the square wave has undergone differentiation. This might occur when a coupling capacitor is partially open or when the resistor or capacitor in an RC coupling network is too low in value.

Waveform H shows a square wave with damped oscillations following the leading edge. This results when a square wave is applied to an amplifier in which distributed capacities and lead inductance resonate at low frequencies. In video amplifiers, it may result from an undamped peaking coil.

Measuring Audio Amplifier Response

A setup that can be used to determine the frequency response of an audio amplifier is shown in figure 5.

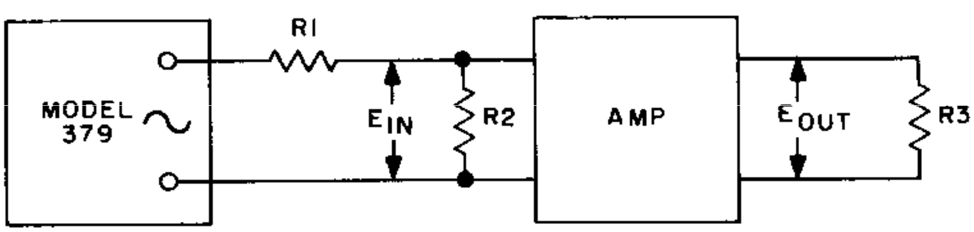


Figure 5. Frequency Response Test Setup

Use the voltage dividing network R1 and R2 when testing high-gain amplifiers. (See Output Level Control instructions under OPERATION.) When testing low-gain amplifiers, connect the output of the Model 379 directly to the input of the amplifier. The input voltage to the amplifier is E_{in}. This voltage may be calculated as described under OPERATION if its value is too low to be measured accurately.

Terminate the amplifier output in a suitable load such as a resistor (R3). Measure the output voltage, E_{out}, across this load. Amplifier voltage gain at any frequency is equal to the output voltage, E_{out}, divided by the input voltage, E_{in}. To obtain the data for a frequency response curve, measure E_{out} and E_{in} and calculate voltage gain throughout the audio frequency range.

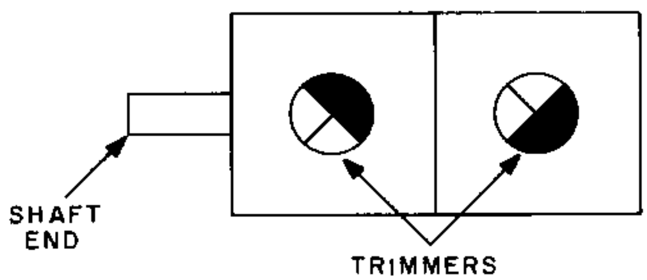
If a frequency run is to be made on a power amplifier, calculate the power delivered to the load, $\frac{E_{out}^2}{R_3}$, and divide by the power input, $\frac{E_{in}^2}{R_x}$. This is the power gain. Repeat these calculations throughout the desired frequency range. R_x is the input impedance of the amplifier.

ADJUSTMENT AND TEST

The Model 379 is shipped fully calibrated and tested, and requires no further adjustment. If it should ever be necessary to recalibrate the unit, proceed as follows:

a. Remove the four screws at the rear of the cabinet and withdraw the chassis from the cabinet.

b. Preset the trimmers on the two-gang variable capacitor as follows:



c. Set each of the two potentiometers on the printed circuit board to the approximate center of rotation.

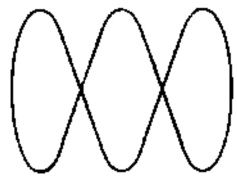
d. Connect the sine-wave output of the Model 379 to a high-impedance scope (such as EICO Model 465) and an AC voltmeter that provides both rms and peak-to-peak readings (such as EICO Model 235). Both instruments must be isolated from the power supply ground.

e. Set the Model 379 RANGE switch to X100 and the frequency dial to 2.

f. Rotate the OUTPUT LEVEL-SINE WAVE control fully clockwise, then adjust R8 (located next to the lamp on the printed circuit board) for a voltmeter reading of 7.5 volts rms.

g. Set RANGE switch to X10 (output frequency of 20 Hz) and record the output voltage.

h. Rotate frequency dial to 18 (output frequency of 180 Hz). Connect 60 Hz to the horizontal input of the oscilloscope, then adjust the two trimmers on the variable capacitor so that the following Lissajous pattern is obtained, with an rms voltage 0.3 to 0.4 volt higher than the value recorded in step g.



i. Connect the oscilloscope and voltmeter across the OUTPUT LEVEL-SQUARE WAVE terminals of the Model 379. With the generator still set at 180 Hz, adjust R16 on the printed circuit board for a symmetrical square wave. The amplitude of the signal should be approximately 10 volts peak-to-peak.

j. Check for a square-wave output on the four lower bands.

MAINTENANCE

To gain access to the chassis, remove the four screws at the rear of the chassis. (Two of these support the line cord while in storage.) Slide the chassis out from the front of the cabinet by pulling on the frame around the front panel.

Visually inspect the parts on the printed circuit board for evidence of arcing or overheating, charred resistors, etc. Check that bulb I1 glows dimly.

With the Model 379 set to some medium frequency, use a VTVM to compare the voltages at the transistor terminals with those listed in table 2. All voltages are measured with respect to ground. Some minor variations in voltage readings can be expected as a result of line voltage variations or small changes in component tolerances.

Table 2. Voltage Measurements

Transistor	Emitter	Base	Collector
Q2	-2	-1.3	+24
Q3	-23	-22	-3.7
Q4	-3.75	-3.7	+24
Q5	-4.5	-4.7	-24
Q6	+0.8	-3.4	+4.9
Q7	+0.8	+1.1	+9
Q8	+7	+7.2	+15
	Source	Gate	Drain
Q1	-1.3	-3.6	+12
Common anodes of diodes D7 and D9:	-38		
Common cathodes of diodes D6 and D8:	+38		

Each part is identified on the PC board by a reference designation. Use the overall schematic diagram as a troubleshooting aid. An understanding of circuit operation (see CIRCUIT DESCRIPTION) will facilitate trouble localization.

In the interests of safety, do not remove the 3-pin power cord, but use either a standard 3-wire a-c line socket or a 3-to-2 pin adapter. Always connect the wire on the adapter to chassis ground.

PRICE EA.	STOCK NO.	SYM. NO.	DESCRIPTION	QTY
RESISTORS				
.08	10400	R2,12	car., 10K, 1/2W, 10%	2
.08	10410	R14,15 22	car., 100K, 1/2W, 10%	3
.08	10416	R17,20	car., 15K, 1/2W, 10%	2
.09	10422	R35	car., dep., 68K, 1/2W, 10%	1
.11	10424	R19	car., 22K, 1/2W, 10%	1
.09	10428	R4	car., 47K, 1/2W, 10%	1
.08	10430	R1,3	car., 4.7K, 1/2W, 10%	2
.08	10432	R21	car., 1K, 1/2W, 10%	1
.08	10437	R10,11	car., 56 ohms, 1/2W, 10%	2
.07	10439	R18	car., 100 ohms, 1/2W, 10%	1
.08	10442	R5	car., 1.5K, 1/2W, 10%	1
.08	10448	R7	car., 68 ohms, 1/2W, 10%	1
.11	10458	R9	car., 82 ohms, 1/2W, 10%	1
.17	10859	R24	car., 1M, 1W, 10%	1
.18	10862	R36,37	car., 330 ohms, 1W, 10%	2
.71	11063	R29	car., dep., 4.7M, 1/2W, 1%	1
.47	11064	R28	car., dep., 470K, 1/2W, 1%	1
.47	11065	R27	car., dep., 47K, 1/2W, 1%	1
.46	11066	R32	car., dep., 600K, 1/2W, 1%	1
.94	11067	R31	car., dep., 6M, 1/2W, 1%	1
.39	11142	R26	car., dep., 4.7K, 1/2W, 1%	1
.39	11143	R33	car., dep., 60K, 1/2W, 1%	1
.39	11144	R34	car., dep., 6K, 1/2W, 1%	1
.39	11152	R25	car., dep., 470 ohms, 1/2W, 1%	1
.13	11570	R38	car., dep., 6.8K, 1/2W, 5%	1
.14	11571	R6	car., dep., 2.7K, 1/2W, 5%	1
2.64	11903	R30	car., dep., 60M, 2W, 1%	1

PRICE EA.	STOCK NO.	SYM. NO.	DESCRIPTION	QTY
POTENTIOMETERS				
.96	16509	R16	50K	1
1.04	16510	R8	100 ohms	1
1.21	18193	R13	5K	1
2.28	18194	R23	1K, W/SPST switch	1
CAPACITORS				
.44	20085	C6	mylar, .22 mfd, 200V, 10%	1
.11	22003	C18	cer., 10 pf, 20%, NPO	1
.35	22010	C5	cer., 7 pf, ±.25 pf, N750	1
.11	22521	C3	disc, cer., 1000pf, 500V, 10%, Z5E	1
.12	22536	C10	disc, cer., 25 pf, 500V 10%, NPO	1
.15	22569	C7	disc, cer., 18 pf, 500V, 5%, NPO	1
.15	22570	C9	disc, cer., 12 pf, 500V 5%, NPO	1
.28	23001	C1,8	elec., 10 mfd, 25V	2
.80	23074	C2	elec., 250 mfd, 35V	1
2.25	23089	C16,17	elec., 2000 mfd, 25V	2
1.84	23104	C14,15	elec., 500 mfd, 75V	2
.90	23108	C4	elec., 25 mfd, 50V	1
10.26	29030	C13	var., 20-470 pf	1
2.25	29530	C11,12	trimmer, 7-45 pf	2
TRANSFORMER				
7.24	30106	T1	power	1
HARDWARE				
.01	40000		nut, hex, #6-32 x 1/4	12 ,
.02	40001		nut, hex, 3/8-32 x 1/2	3
.01	40007		nut, hex, #4-40 x 1/4	7
.01	40008		nut, hex, #8-32 x 1/4	8
.01	~~41000~~		screw, #6-32 x ~~1/4,~~ b.h.	1
.07	41041		screw, #6-32 x 1/4, set	4
.01	41073		screw, #6 x 1/4, P.K., B.H., type "A" black	2
.01	41086		screw, #6-32 x 5/16, b.h.	7
.01	41090		screw, #4-40 x 5/16, b.h.	7
.01	41140		screw, #6 x 1/4, r.h. phillips, type "F"	10

PRICI EA.
HARD
.01
.04
.03
.01
.01
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.01
.07
.04
n/c
n/c
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.05
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BINDI
.50
.50
.86
.80
.87
1.14
.10
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.08
.10
SWIT
5.02

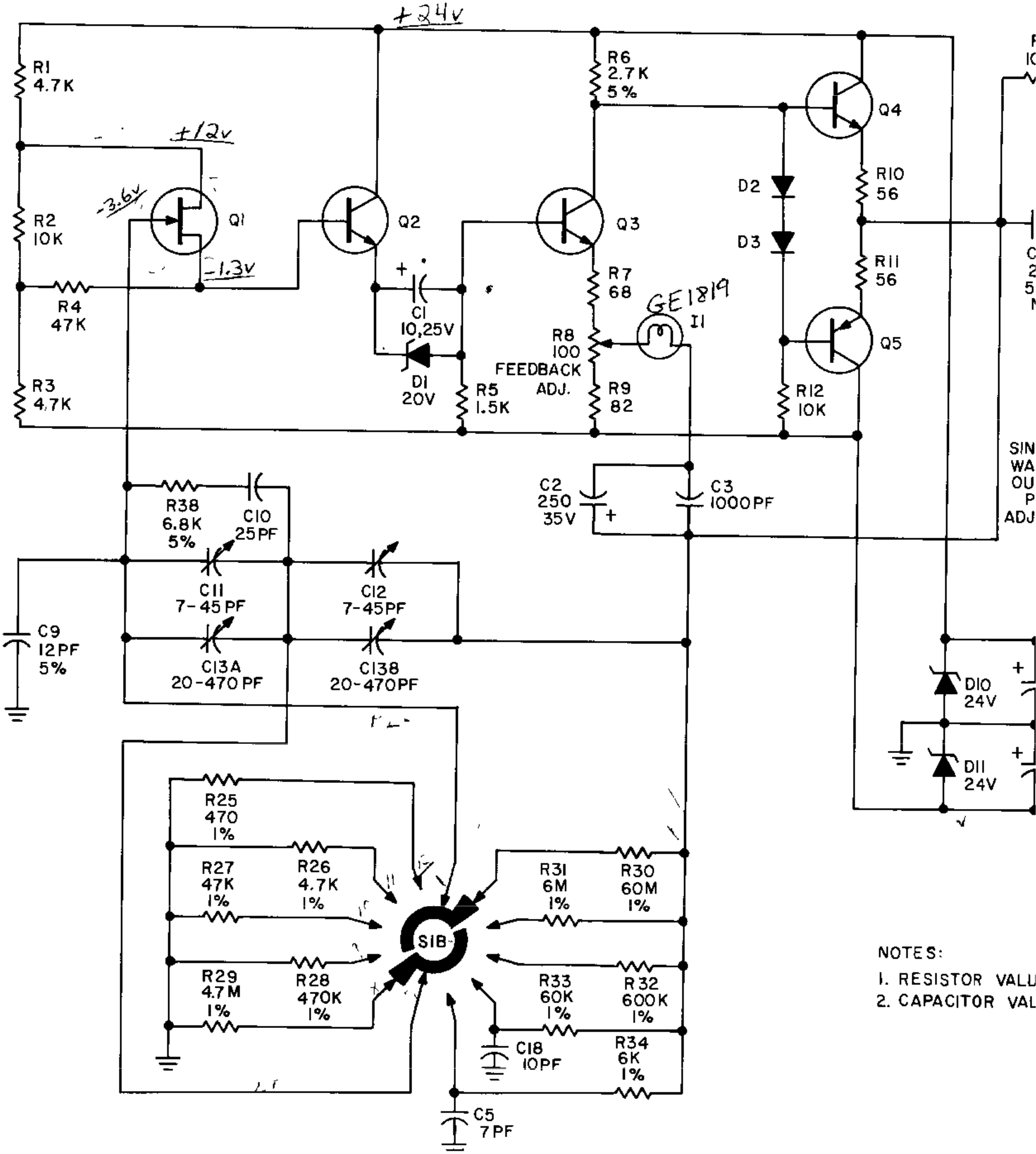
LIST

PRICE EA.	STOCK NO.	SYM. NO.	DESCRIPTION	QTY
HARDWARE (cont)				
.01	41191		screw, #6 x 1", b.h., self tap, black oxide	2
.04	41194		screw, #2 x 3/8, self tap, type B, b.h., cad. plated.	2
.03	41197		screw, #2-56 x 5/32, b.h.	2
.01	42001		washer, flat, 3/8	3
.01	42002		washer, lock, #6	11
.01	42007		washer, lock, #4	7
.02	42012		washer, star	1
.01	42039		washer, flat, metal #4	2
.07	42043		washer, shoulder, bakelite, black	2
.04	42045		washer, flat, metal, 1/8	2
n/c	42080		washer, shoulder, bakelite, red	2
n/c	42081		washer, flat, bakelite, red	2
.04	42084		washer, black #6 x 1-3/32 O.D.	2
.05	42093		washer, fiber, #4, 1/16 th	2
.02	43000		lug, ground, #6	4
.03	43019		lug, ground, #8	4
.24	44011		spacer, black, #6	2
.01	~~45033~~		~~standoff~~	~~3~~
.04	45500		spade, lug, #6	5
.09	46016		foot	4
.02	51300		solder lug, p.c. board	15
BINDING POSTS, KNOBS & TERMINAL STRIPS				
.50	52001		binding post, #8, black	2
.50	52002		binding post, #8, red	2
.86	53101		tuning knob	1
.80	53108		knob, 3/4" dia.	2
.87	53109		knob bar	1
1.14	53514		dial pointer	1
.10	54008		terminal strip, 4 post	1
.10	54012		terminal strip, 1 post, left, upright	1
.08	54018		terminal strip, 4 post, w/gnd.	1
.10	54080		terminal strip, 2 post	1
SWITCH				
5.02	60224	S1	switch, rotary, range	1

PRICE EA.	STOCK NO.	SYM. NO.	DESCRIPTION	QTY
SHEET METAL & MISCELLANEOUS				
2.05	57009		linecord, 3 conductor	1
2.00	66212		manual, operating	1
2.50	66473		manual, assembly	1
3.33	80234		panel, front	1
4.20	81582		chassis	1
3.48	81583		bracket, cap. shield	1
1.08	81584		bracket, sw. shield	1
.12	82105		strain relief	1
2.71	82580		p.c. board	1
.60	83004		coupling, lucite	1
2.04	84000		ball drive, 6:1	1
2.25	86016		frame	1
1.31	87016		handle	1
7.20	88172		cabinet	1
.35	89424		nomenclature label	1
n/c	89858		handle hardware	2
1.86	89869		dial	1
.65	97738		socket, bayonet, miniature	1
DIODES & TRANSISTORS				
1.80	93031	D1	diode, zener, IN1778A, 20V, 5%, 1W	1
4.00	93034	D4	diode, zener, 3V, 5%, 1W	1
1.68	93046	D6, 7 8, 9	diode, silicon, 200V, .5a	4
.80	93048	D2, 3	diode, .65-7V at 10 ma	2
2.10	93049	D10, 11	diode, zener, 24V, 10% 1W	2
.81	94047	Q8	transistor, GE2N3391A	1
1.60	94057	Q1	transistor, 2N4303	1
1.14	94074	Q2, 3, 6, 7	transistor, MPS-6513	4
.69	94075	Q4	transistor, BC-107B	1
.96	94076	Q5	transistor, 2N5366	1
.73	95007	D5	diode, 1N34	1
BULBS				
.82	92026	I1	bulb, GE 1819	1
.72	97736	I2	bulb assembly, neon, 7" leads	1

Prices and specifications subject to change without notice. To order replacement parts, remit with order; specify part number and descriptions. Add $1.00 for mailing and handling; if a power transformer is included in the order, add instead $1.50 for mailing and handling.

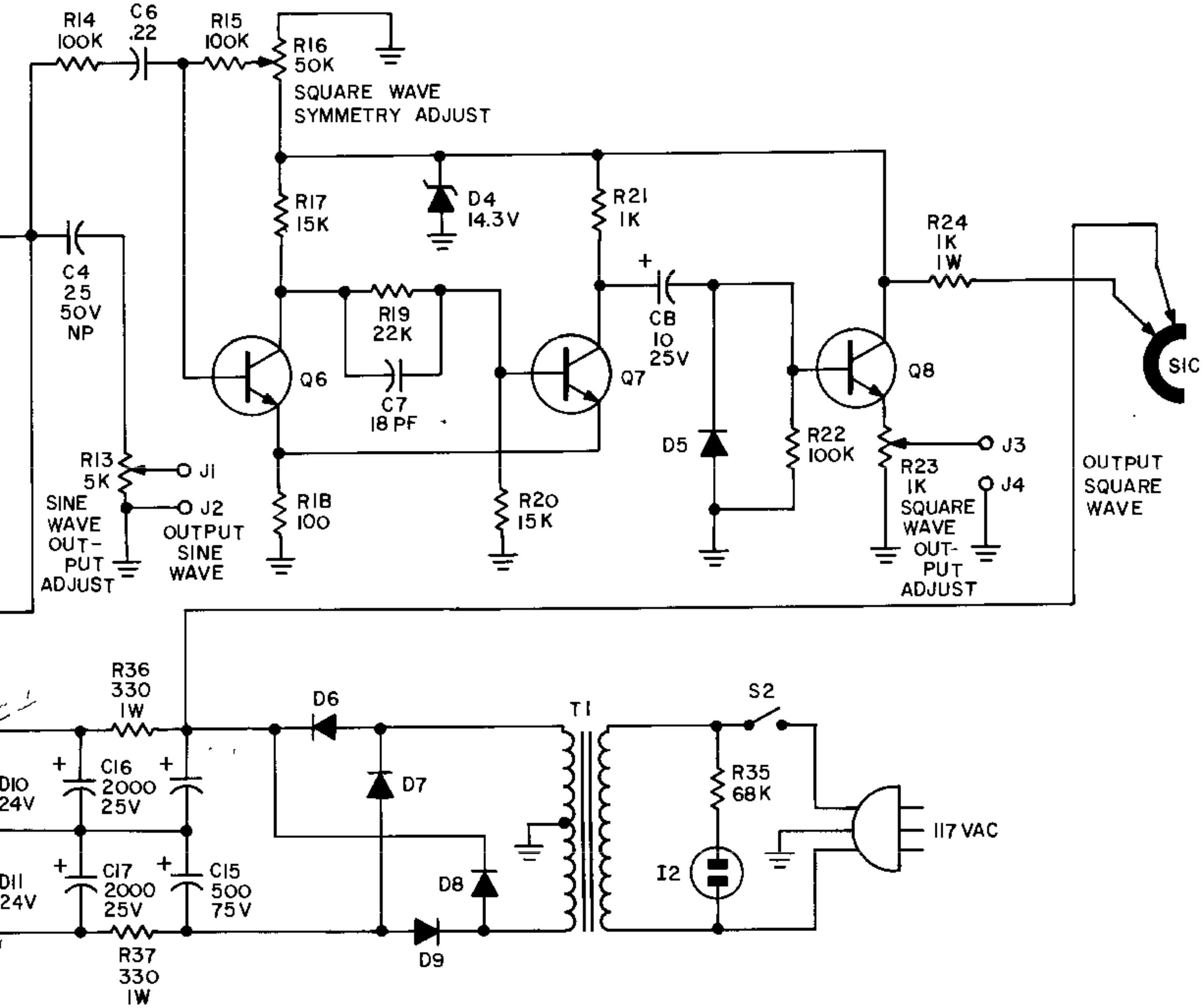
Blue ink - ideal voltages



NOTES:

1. RESISTOR VALU

2. CAPACITOR VAL



OR VALUES ARE IN OHMS, 1/2 WATT, 10% UNLESS OTHERWISE SPECIFIED.
TOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

SCHEMATIC DIAGRAM