WG-8038 Precision Waveform Generator Voltage Controlled Oscillator

FEATURES

- Low Frequency Drift With Temperature – 50ppm/°C Max.
- Simultaneous Outputs – Sine-Wave, Square-Wave and Triangle.
- High Level Outputs – T^2L to 28V
- Low Distortion – 1%
- High Linearity – 0.1%
- Easy to Use – 50% Reduction in External Components.
- Wide Frequency Range of Operation 0.001Hz to 1.0MHz
- Variable Duty Cycle – 2% to 98%

GENERAL DESCRIPTION

The 8038 Waveform Generator is a monolithic integrated circuit, capable of producing sine, square, triangular, saw-tooth and pulse waveform of high accuracy with a minimum of external components (refer to Figures 8 and 9) The frequency (or repetition rate) can be selected externally over a range from less than 1/1000Hz to more than 1MHz and is highly stable over a wide temperature and supply voltage range. Frequency modulation and sweeping can be accomplished with an external voltage and the frequency can be programmed digitally through the use of either resistors or capacitors. The Waveform Generator utilizes advanced monolithic technology, such as thin film resistors and Schottky-barrier diodes. The 8038 Voltage Controlled Oscillator can be interfaced with phase lock loop circuitry to reduce temperature drift to below 50ppm/°C.

FUNCTIONAL DIAGRAM

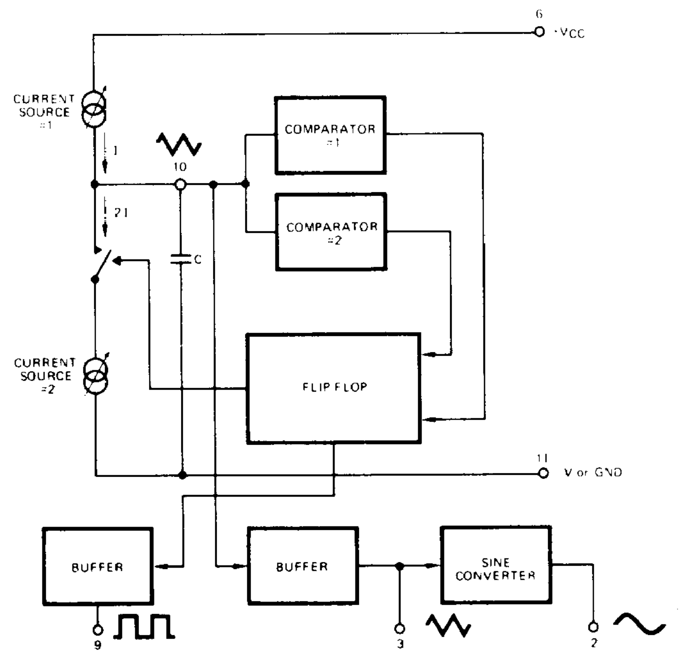
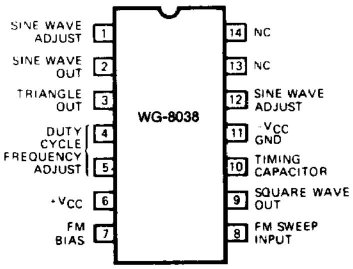


FIGURE 1. BLOCK-DIAGRAM OF WAVEFORM GENERATOR.

CONNECTION DIAGRAM



ORDERING INFORMATION

Model	Stability	Oper. Temp. Range	Package
WG-8038-CC	100 ppm/°C	0 to +70°C	14 pin Cer DIP
WG-8038-BC	50 ppm/°C	0 to +70°C	14 pin Cer DIP
WG-8038-BM	50 ppm/°C	−55 to +125°C	14 pin Cer DIP
WG-8038-AC	20 ppm/°C	0 to +70°C	14 pin Cer DIP
WG-8038-AM	20 ppm/°C	−55 to +125°C	14 pin Cer DIP

DATEL-INTERSIL, INC., 11 CABOT BOULEVARD, MANSFIELD, MA 02048/TEL. (617) 339-9341/TWX 710-346-1953/TLX 951340

MAXIMUM RATINGS

Supply Voltage	±18V or 36V Total
Power Dissipation	750mW (Note 5)
Input Voltage (any pin)	Not To Exceed Supply Voltages
Input Current (Pins 4 and 5)	25mA
Output Sink Current (Pins 3 and 9)	25mA
Storage Temperature Range	−65°C to +125°C
Operating Temperature Range:	
Suffix "M"	−55°C to +125°C
Suffix "C"	0°C to +70°C
Lead Temperature (Soldering, 10 sec.)	300°C

ELECTRICAL CHARACTERISTICS

(V_S = ±10V or +20V, T_A = 25°C, R_L = 10 KΩ, Unless Otherwise Specified) Note 3.

GENERAL CHARACTERISTICS	WG-8038-C MIN	WG-8038-C TYP	WG-8038-C MAX	WG-8038-B MIN	WG-8038-B TYP	WG-8038-B MAX	WG-8038-A MIN	WG-8038-A TYP	WG-8038-A MAX	UNITS
Supply Voltage Operating Range										
Single Supply	+10		+30	+10		30	+10		30	V
Dual Supplies	±5		±15	±5		±15	±5		±15	V
Supply Current (V_S = ±10V) Note 1.										
Suffix "M"					12	15		12	15	mA
Suffix "C"		12	20		12	20		12	20	mA
FREQUENCY CHARACTERISTICS (all waveforms)										
Maximum Frequency of Oscillation	100,000			100,000			100,000			Hz
Sweep Frequency of FM		10			10			10		kHz
Sweep FM Range (Note 2)		40:1			40:1			40:1		
FM Linearity 10:1 Ratio		0.5			0.2			0.2		%
Frequency Drift With Temperature Note 6		50			50	100		20	50	ppm/°C
Frequency Drift With Supply Voltage (Over Supply Voltage Range)		0.05			0.05			0.05		%/Vs
Recommended Programming Resistors (R_A and R_B)	1000		1M	1000		1M	1000		1M	Ω
OUTPUT CHARACTERISTICS										
Square-Wave										
Leakage Current (V9 = 30v)			1			1			1	μA
Saturation Voltage (I_{SINK} = 2mA)		0.2	0.5		0.2	0.4		0.2	0.4	V
Rise Time (R_L = 4.7kΩ)		100			100			100		ns
Fall Time (R_L = 4.7kΩ)		40			40			40		ns
Duty Cycle Adjust	2		98	2		98	2		98	%
Triangle/Sawtooth/Ramp										
Amplitude (R_T = 100kΩ)	0.30	0.33		0.30	0.33		0.30	0.33		xVs
Linearity		0.1			0.05			0.05		%
Output Impedance (I_{OUT} = 5mA)		200			200			200		Ω
Sine-Wave										
Amplitude (R_S = 100kΩ)	0.2	0.22		0.2	0.22		0.2	0.22		xVs
THD (R_S = 1MΩ) Note 4.		0.8	5		0.7	3		0.7	1.5	%
THD Adjusted (Use Fig. 8b)		0.5			0.5			0.5		%

NOTE 1: R_A and R_B collection currents not included.
NOTE 2: V_S = 20V; R_A and R_B = 10kΩ, f ≅ 9kHz; Can be extended to 1000.1 See Figures 13 and 14
NOTE 3: All parameters measured in test circuit given in Fig. 2
NOTE 4: 82kΩ connected between pins 11 and 12, Triangle Duty Cycle set at 50%. (Use R_A and R_B)
NOTE 5: Derate ceramic package at 12.5mW/°C for ambient temperatures above 100°C
NOTE 6: Over operating temperature range, Fig. 2, pins 7 and 8 connected, V_S = ±10V. See Fig. 6c for T.C. vs V_S

WG-8038

TEST CONDITIONS (See Fig. 2)

PARAMETER	R_A	R_B	R_L	C_1	SW_1	MEASURE
Supply Current	10kΩ	10kΩ	10kΩ	3.3nF	Closed	Current into Pin 6
Maximum Frequency of Oscillation	1kΩ	1kΩ	4.7kΩ	100pf	Closed	Frequency at Pin 9
Sweep FM Range (Note 1)	10kΩ	10kΩ	10kΩ	3.3nF	Open	Frequency at Pin 9
Frequency Drift with Temperature	10kΩ	10kΩ	10kΩ	3.3nF	Closed	Frequency at Pin 9
Frequency Drift with Supply Voltage (Note 2)	10kΩ	10kΩ	10kΩ	3.3nF	Closed	Frequency at Pin 9
Output Amplitude: Sine	10kΩ	10kΩ	10kΩ	3.3nF	Closed	Pk-Pk output at Pin 2
Triangle	10kΩ	10kΩ	10kΩ	3.3nF	Closed	Pk-Pk output at Pin 3
Leakage Current (off) Note 3	10kΩ	10kΩ		3.3nF	Closed	Current into Pin 9
Saturation Voltage (on) Note 3	10kΩ	10kΩ	10kΩ	3.3nF	Closed	Output (low) at Pin 9
Rise and Fall Times	10kΩ	10kΩ	4.7kΩ	3.3nF	Closed	Waveform at Pin 9
Duty Cycle Adjust: MAX	50kΩ	~1.6kΩ	10kΩ	3.3nF	Closed	Waveform at Pin 9
MIN	~25kΩ	50kΩ	10kΩ	3.3nF	Closed	Waveform at Pin 9
Triangle Waveform Linearity	10kΩ	10kΩ	10kΩ	3.3nF	Closed	Waveform at Pin 3
Total Harmonic Distortion	10kΩ	10kΩ	10kΩ	3.3nF	Closed	Waveform at Pin 2

NOTE 1: The hi and lo frequencies can be obtained by connecting pin 8 to pin 7 (f_{hi}) and then connecting pin 8 to pin 6 (f_{lo}). Otherwise apply Sweep Voltage at pin 8 ($2/3\ V_{CC} + 2V$) $\leq V_{SWEEP} \leq V_{CC}$ where V_{CC} is the total supply voltage. In Fig. 2, Pin 8 should vary between 5.3V and 10V with respect to ground.

NOTE 2: $10V \leq V_{CC} \leq 30V$, or $\pm 5V \leq V_S \leq \pm 15V$.

NOTE 3: Oscillation can be halted by forcing pin 10 to +5 volts or −5 volts.

DEFINITION OF TERMS:

Supply Current — The current required from the power supply to operate the device, excluding load currents and the currents through R_A and R_B.

Frequency Range — The frequency range at the square wave output through which circuit operation is guaranteed.

Sweep FM Range — The ratio of maximum frequency to minimum frequency which can be obtained by applying a sweep voltage to Pin 8. For correct operation, the sweep voltage should be within the range ($2/3\ V_{CC} + 2V$) $< V_{sweep} < V_{CC}$.

FM linearity — The percentage deviation from the best-fit straight line on the control voltage versus output frequency curve.

Frequency Drift with Temperature — The change in output frequency as a function of temperature.

Frequency Drift with Supply Voltage — The change in output frequency as a function of supply voltage.

Output Amplitude — The peak-to-peak signal amplitude appearing at the outputs.

Saturation Voltage — The output voltage at the collector of Q_{23} when this transistor is turned on. It is measured for a sink current of 2mA.

Rise Time and Fall Time — The time required for the square wave output to change from 10% to 90%, or 90% to 10%, of its final value.

Triangle Waveform Linearity — The percentage deviation from the best-fit straight line on the rising and falling triangle waveform.

Total Harmonic Distortion — The total harmonic distortion at the sine-wave output.

TEST CIRCUIT

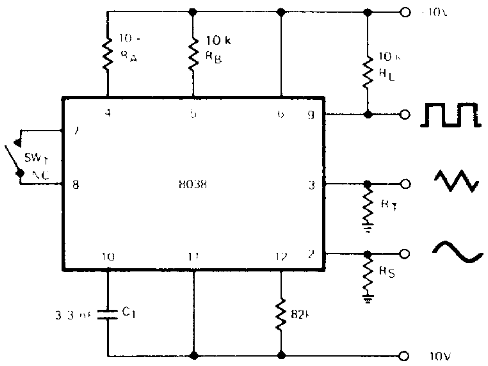


FIGURE 2

WG-8038

CHARACTERISTIC CURVES

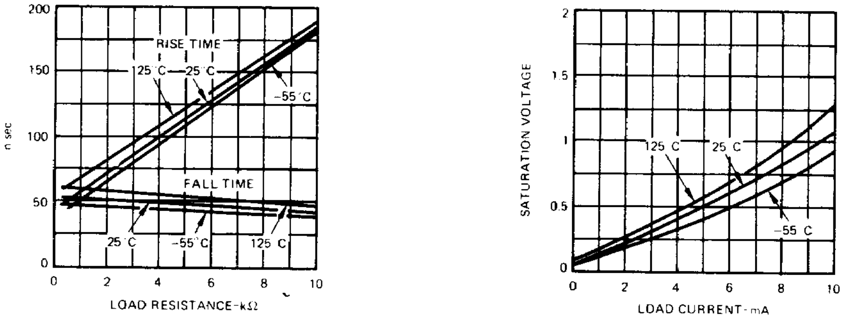


FIGURE 3. PERFORMANCE OF THE SQUARE-WAVE OUTPUT (PIN 9).

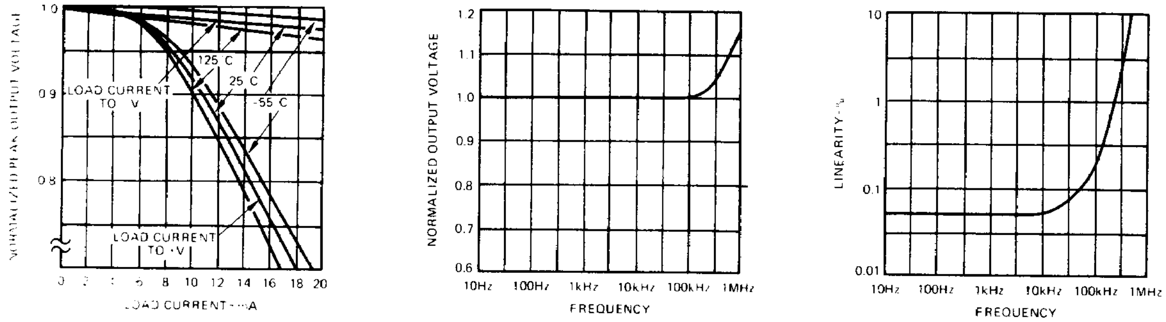


FIGURE 4. PERFORMANCE OF TRIANGLE-WAVE OUTPUT.

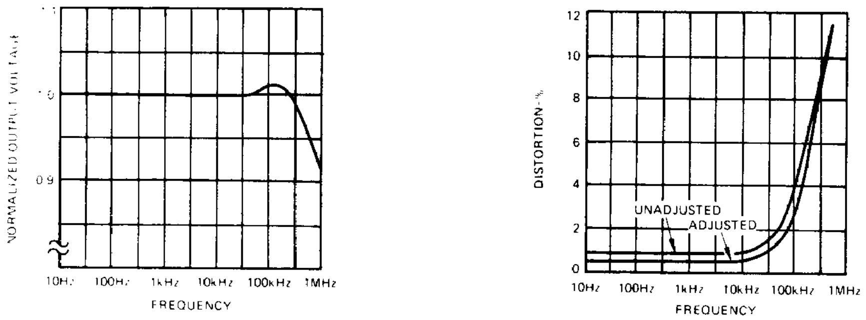


FIGURE 5. PERFORMANCE OF SINE-WAVE OUTPUT.

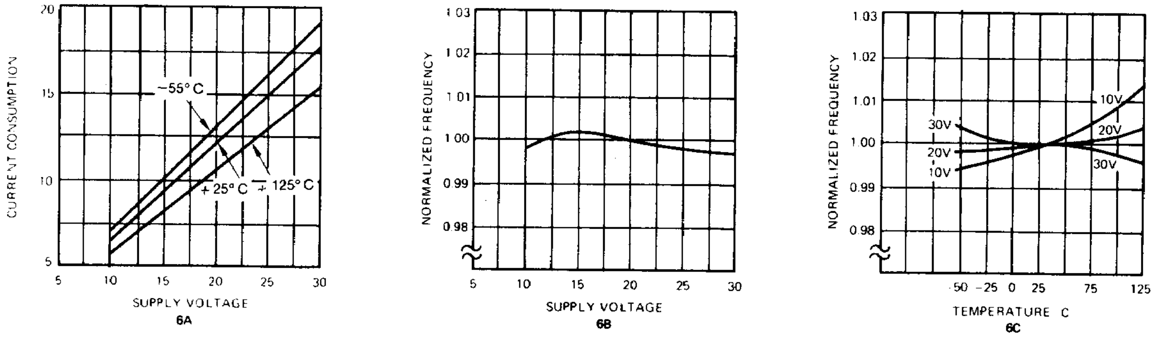
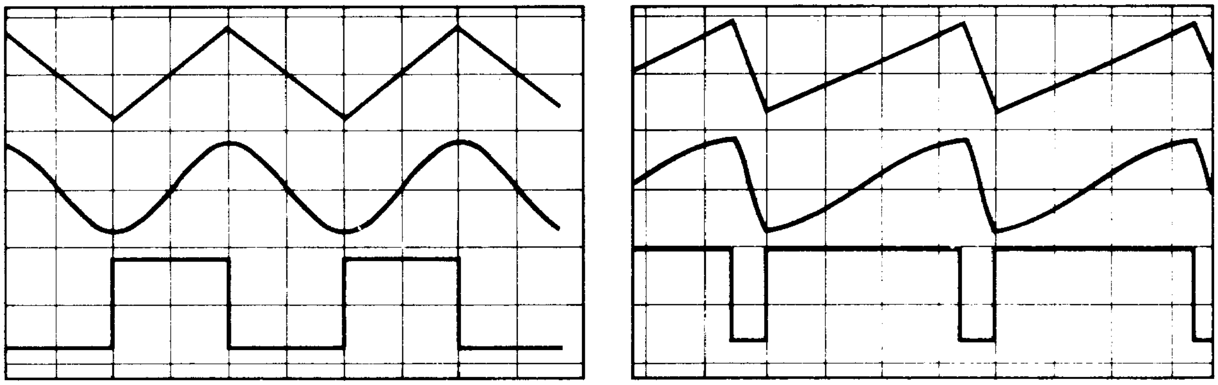


FIGURE 6. CURRENT CONSUMPTION AND FREQUENCY STABILITY.

THEORY OF OPERATION



SQUARE-WAVE DUTY CYCLE – 50% SQUARE-WAVE DUTY CYCLE – 80%

FIGURE 7. PHASE RELATIONSHIP OF WAVEFORMS.

The performance of the sine-wave output is shown in Figure 5. Figure 6 shows additional general information concerning current consumption and frequency stability and Figure 7 shows the phase relationship between the three waveforms.

WAVEFORM TIMING

The *symmetry* of all waveforms can be adjusted with the external timing resistors. Two possible ways to accomplish this are shown in Figure 8. Best results are obtained by keeping the timing resistors R_A and R_B separate (a). R_A controls the rising portion of the triangle and sine-wave and the 1 state of the square-wave.

The magnitude of the triangle-waveform is set at 1/3 V_{CC}; therefore the rising portion of the triangle is,

$$t_1 = \frac{C \times V}{I} = \frac{C \times 1/3 \times V_{CC} \times R_A}{1/5 \times V_{CC}} = \frac{5}{3} R_A \times C$$

The falling portion of the triangle and sine-wave and the 0 state of the square-wave is:

$$t_2 = \frac{C \times V}{I} = \frac{C \times 1/3\, V_{CC}}{\frac{2}{5} \times \frac{V_{CC}}{R_B} - \frac{1}{5} \times \frac{V_{CC}}{R_A}} = \frac{5}{3} \times \frac{R_A R_B C}{2 R_A - R_B}$$

Thus a 50% duty cycle is achieved when $R_A = R_B$.

If the duty-cycle is to be varied over a small range about 50% only, the connection shown in Figure 8b is slightly more convenient. If no adjustment of the duty cycle is desired, terminals 4 and 5 can be shorter together, as shown in Figure 8c. This connection, however, carries an inherently larger variation of the duty-cycle.

With two separate timing resistors, the *frequency* is given by

$$f = \frac{1}{t_1 + t_2} = \frac{1}{\frac{5}{3} R_A C \left(1 + \frac{R_B}{2 R_A - R_B}\right)}$$

or, if $R_A = R_B = R$

$$f = \frac{0.3}{R\,C} \quad \text{(for Figure 8a)}$$

If a single timing resistor is used (Figures 8c only), the frequency is

$$f = \frac{0.15}{R\,C}$$

Neither time nor frequency are dependent on supply voltage, even though none of the voltages are regulated inside the integrated circuit. This is due to the

(a) (b) (c)

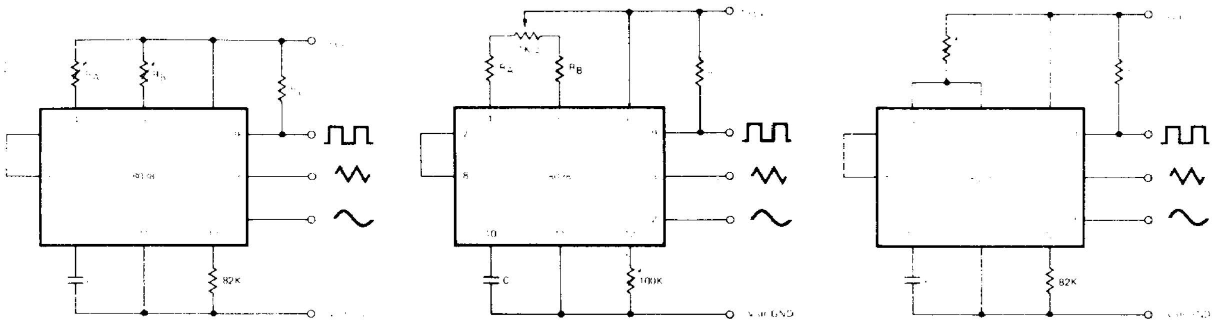


FIGURE 8. POSSIBLE CONNECTIONS FOR THE EXTERNAL TIMING RESISTORS.

fact that both currents *and* thresholds are direct, linear function of the supply voltage and thus their effects cancel.

To minimize *sine-wave* distortion the 82kΩ resistor between pins 11 and 12 is best made a variable one. With this arrangement distortion of less than 1% is achievable. To reduce this even further, two potentiometers can be connected as shown in Figure 9. This configuration allows a reduction of sine-wave distortion close to 0.5%.

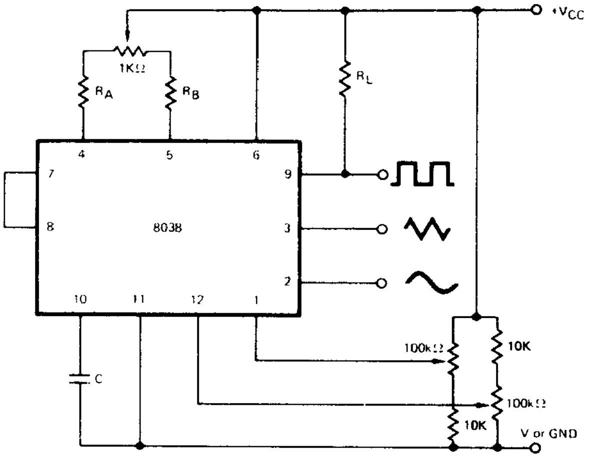


FIGURE 9. CONNECTION TO ACHIEVE MINIMUM SINE-WAVE DISTORTION.

SELECTING R_A, R_B and C

For any given output frequency, there is a wide range of RC combinations that will work. However certain constraints are placed upon the magnitude of the charging current for optimum performance. At the low end, currents of less than 1μA are undesirable because circuit leakages will contribute significant errors at high temperatures. At higher currents ($I > 5$ mA), transistor betas and saturation voltages will contribute increasingly larger errors. Optimum performance will be obtained for charging currents of 10μA to 1 mA. If pins 7 and 8 are shorted together, the magnitude of the charging current due to R_A can be calculated from:

$$I = \frac{R_1 \times V_{CC}}{(R_1 + R_2)} \times \frac{1}{R_A} = \frac{V_{CC}}{5R_A}$$

A similar calculation holds for R_B.

The capacitor value should be as large as possible.

WAVEFORM OUT LEVEL CONTROL AND POWER SUPPLIES

The waveform generator can be operated either from a single power-supply (10 to 30 Volts) or a dual power-supply (±5 to ±15 Volts). With a single power-supply the average levels of the triangle and sine-wave are at exactly one-half of the supply voltage, while the square-wave alternates between +V and ground. A split power supply has the advantage that all waveforms move symmetrically about ground.

The square-wave output is not committed. A load resistor can be connected to a different power-supply, as long as the applied voltage remains within the breakdown capability of the waveform generator (30V). In this way, the square-wave output be made TTL compatible (load resistor connected to +5 Volts) while the waveform generator itself is powered from a much higher voltage.

FREQUENCY MODULATION AND SWEEPING

The frequency of the waveform generator is a direct function of the DC voltage at terminal 8 (measured from $+V_{CC}$). By altering this voltage, frequency modulation is performed.

For small deviations (e.g. ±10%) the modulating signal can be applied directly to pin 8, merely providing dc decoupling with a capacitor, as shown in Figure 10a. An external resistor between pins 7 and 8 is not necessary, but it can be used to increase input impedance. Without it (i.e. terminals 7 and 8 connected together), the input impedance is 8kΩ; with it, this impedance increases to (R+8kΩ).

For larger FM deviations or for frequency sweeping, the modulating signal is applied between the positive supply voltage and pin 8 (Figure 10b). In this way the entire bias for the current sources is created by the modulating signal and a very large (e.g. 1000:1) sweep range is created ($f = 0$ at $V_{sweep} = 0$). Care must be taken, however, to regulate the supply voltage; in this configuration the charge current is no longer a function of the supply voltage (yet the trigger thresholds still are) and thus the frequency becomes dependent on the supply voltage. The potential on Pin 8 may be swept from V_{CC} to $(2/3\ V_{CC} + 2V)$.

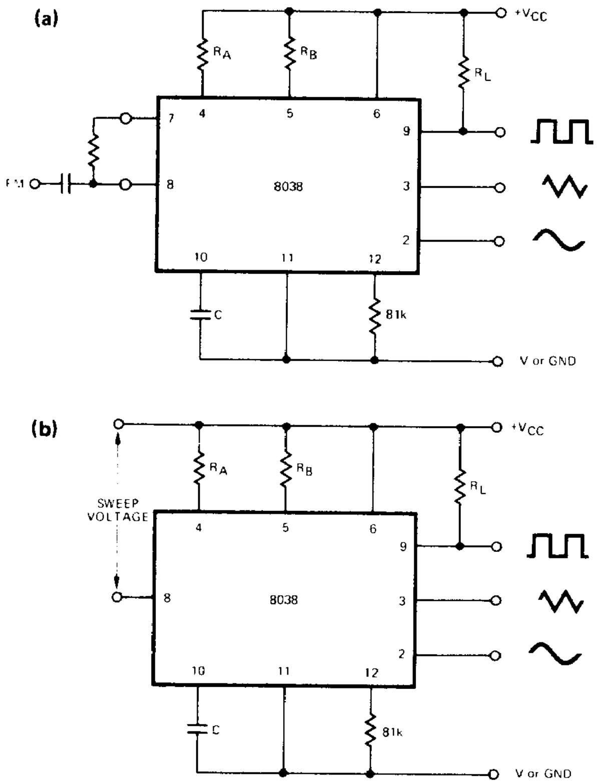


FIGURE 10. CONNECTIONS FOR FREQUENCY MODULATION (a) AND SWEEP (b).

APPLICATIONS

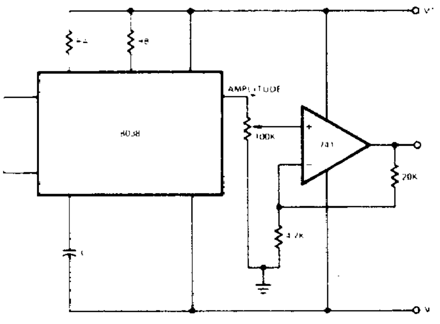


FIGURE 11. SINE WAVE OUTPUT BUFFER AMPLIFIERS

The sine wave output has a relatively high output impedance (1KΩ Typ). The circuit of Figure 11 provides buffering, gain and amplitude adjustment. A simple op amp follower could also be used.

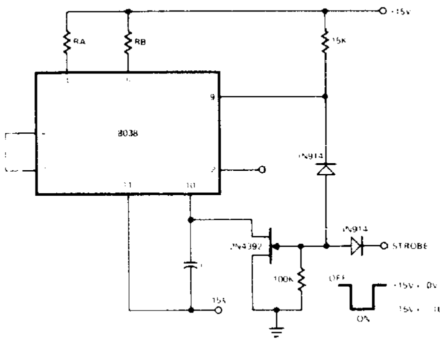


FIGURE 12. STROBE – TONE BURST GENERATOR

With a dual supply voltage the external capacitor on Pin 10 can be shorted to ground to halt the 8038 oscillation. Figure 12 shows a FET switch, diode ANDed with an input strobe signal to allow the output to always start on the same slope.

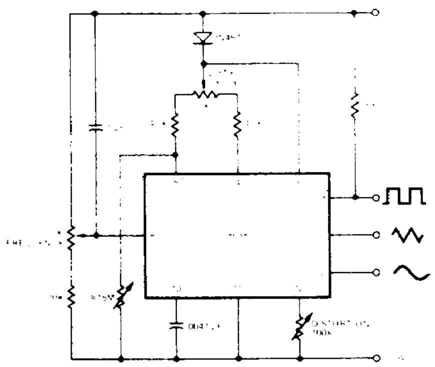


FIGURE 13. VARIABLE AUDIO OSCILLATOR, 20Hz to 20 KHz

To obtain a 1000:1 Sweep Range on the 8038 the voltage across external resistors RA and RB must decrease to nearly zero. This requires that the highest voltage on control Pin 8 exceed the voltage at the top of RA and RB by a few hundred millivolts.

The Circuit of Figure 13 achieves this by using a diode to lower the effective supply voltage on the 8038. The large resistor on pin 5 helps reduce duty cycle variations with sweep.

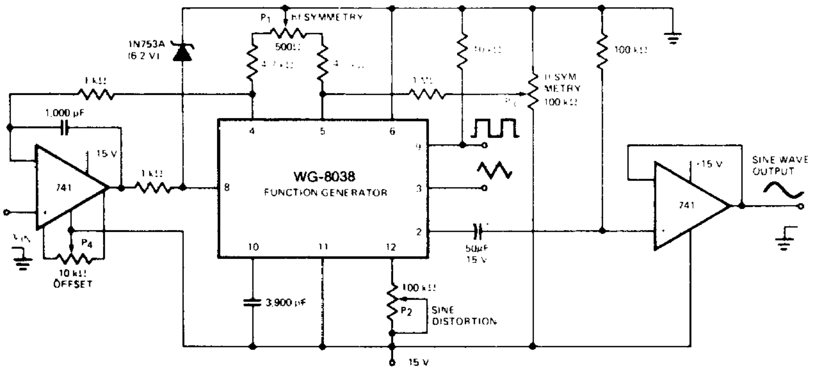
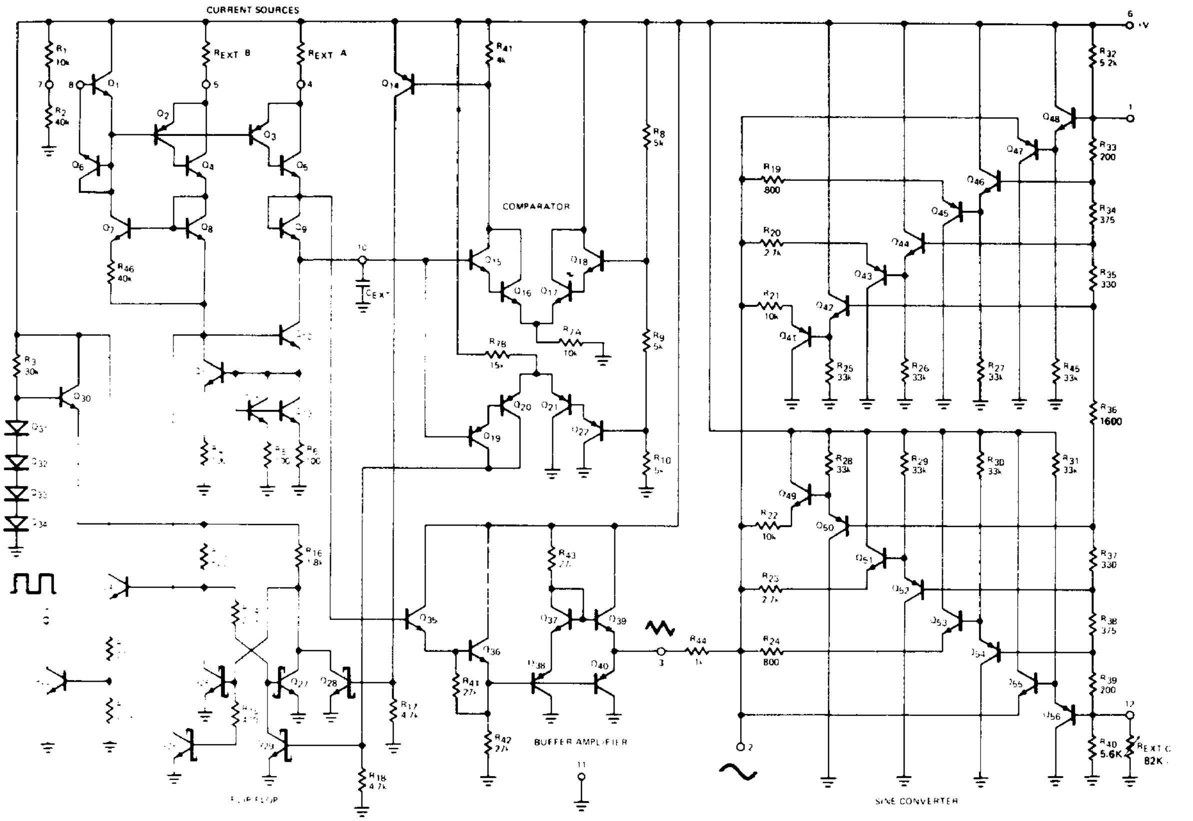


FIGURE 14. LINEAR VOLTAGE CONTROLLED OSCILLATOR

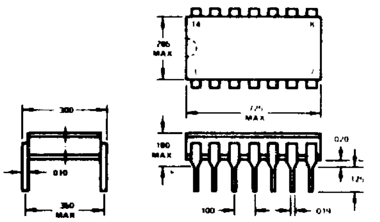
The linearity of input sweep voltage verses output frequency can be significantly improved by using an op amp as shown in Figure 14.

DETAILED SCHEMATIC



PACKAGE DIMENSIONS

14 PIN CERDIP



Printed in U.S.A. Copyright © 1980 Datel-Intersil, Inc. All rights reserved.

11 CABOT BOULEVARD, MANSFIELD, MA 02048 / TEL. (617)339-9341 / TWX 710-346-1953 / TLX 951340
Santa Ana, (714)835-2751, (L.A.) (213)933-7256 • Sunnyvale, CA (408)733-2424 • Gaithersburg, MD (301)840-9490
• Houston, (713)781-8886 • Dallas, TX (214)241-0651 OVERSEAS: DATEL (UK) LTD—TEL: ANDOVER (0264)51055
• DATEL SYSTEMS SARL 602-57-11 • DATELEK SYSTEMS GmbH (089)77-60-95 • DATEL KK Tokyo 793-1031

PRICES AND SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE