TECHNICAL DATA

AN EXCLUSIVE RADIO SHACK SERVICE TO THE EXPERIMENTER

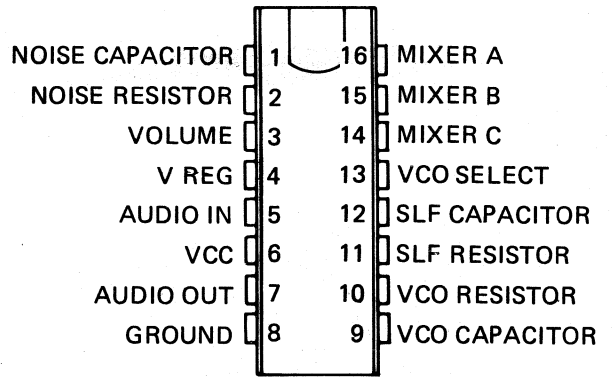## SN76495 COMPLEX SOUND GENERATOR

DESCRIPTION

The SN76495 Complex Sound Generator Integrated Circuit combines both analog (linear) and digital (I^2L circuitry. It consists of special-effects noises, tones, low frequency based sounds or a combination of these. By using various external components and by controlling the input logic, you can create a wide variety of sounds. The SN76495 can be used in any application that requires audio feedback to the operator, including entertainment equipment — such as arcade or home video games, pin-ball games, toys, alarms; or industrial equipment (indicators, controls, etc.).

Operation is from a 7.5 to 10.5-volt supply applied to a built-in regulator through the Vcc terminal; in which case, a regulated five volts is available from the Vreg terminal to power a small amount of external circuitry, or to provide a high-logic-level voltage to logic inputs.

DUAL-IN-LINE PACKAGE (TOP VIEW)

NOISE CAPACITOR	1	16	MIXER A
NOISE RESISTOR	2	15	MIXER B
VOLUME	3	14	MIXER C
V REG	4	13	VCO SELECT
AUDIO IN	5	12	SLF CAPACITOR
VCC	6	11	SLF RESISTOR
AUDIO OUT	7	10	VCO RESISTOR
GROUND	8	9	VCO CAPACITOR

FEATURES:

- Generates Noise, Tone or Low-Frequency-Based Sounds, or a Combination of These

- Allows Custom Sounds to be Created Easily

- Low Power Requirements

- Allows Multiple-Sound Systems

- Compatible With Microprocessor Systems

- On Board 125mW Audio Amplifier

ABSOLUTE MAXIMUM RATINGS AT Ta=25°C
(unless otherwise specified)

Supply Voltage, Vcc 12.0V
Input Voltage: Logic Input 12.0V
                Capacitor Input 5.0V
                Resistor Input 5.0V
Operating Free-Air Temperature Range . . . . 0°C to 70°C
Storage Temperature Range . . . . -65°C to 150°C

RECOMMENDED OPERATING CONDITIONS

	MIN	NOM	MAX	UNITS
Supply Voltage, Vcc	7.5	9.0	10.5	Volts
Operating Free-Air Temp		25		°C
Amplifier Load AC Coupled	8.0			Ohms

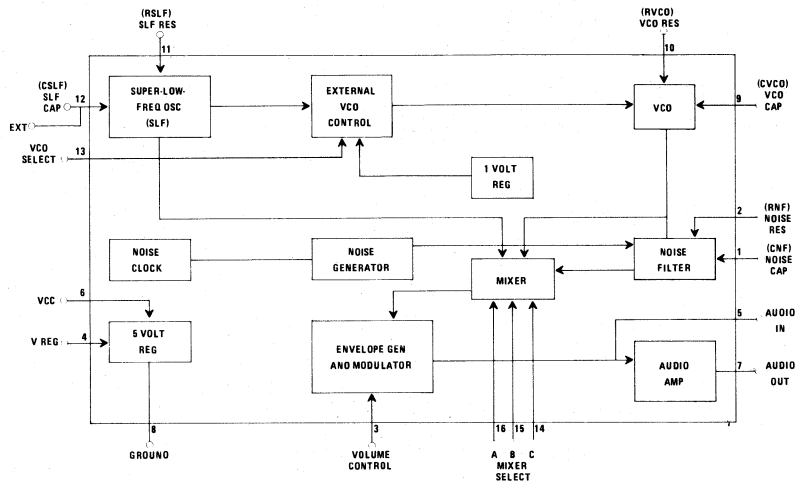**Note 1:** All voltage values are with respect to the ground terminal. (pin 8)

Figure 1. SN76495 BLOCK DIAGRAM

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OPERATION

1. SUPER LOW FREQUENCY OSCILLATOR (SLF)

The SLF is normally operated in the range of 0.1 to 30 Hz, but will operate up to 20 kHz. The frequency is determined by two external components, the SLF control resistor (Rslf) pin 11 and capacitor (Cslf) at pin 12 according to the following equation:

Equation 1: (@Vreg = 5V)

$$\text{SLF Frequency (Hz)} = \frac{0.66}{(9k \text{ ohms} + Rslf) \times Cslf}$$

The SLF feeds a 50% duty cycle square wave to the "mixer"; it also feeds a triangular wave to the external VCO of SLF select logic, where, if VCO select (pin 13) is at a low logic level (ground), it is fed through to the VCO to modulate the frequency of that oscillator. (See further explanation below).

2. VOLTAGE CONTROLLED OSCILLATOR (VCO)

The VCO produces a tone output whose frequency is dependent upon the voltage at the input of the VCO. This controlling voltage may be either the SLF output described above; an internal voltage producing a constant tone; or externally, by placing a voltage on the SLF capacitor, pin 12. The higher the voltage applied to the VCO, the lower the frequency of the VCO output. The selection of the control modes (external, pin 13, internal SLF) is via the binary logic on pin 13 according to the following table:

Pin 13	Control Mode
0	External (pin 12)
1	Internal (SLF)

Table 1: VCO Control Mode Selection

The first mode, VCO controlled by SLF, is selected by placing the VCO select pin low. The triangular voltage from the SLF is applied to the VCO and varies the voltage level applied to the VCO capacitor connected between pin 9 and ground. As the applied voltage from the SLF oscillator increases, the VCO frequency decreases and conversely, as the voltage decreases the VCO frequency increases, resulting in a frequency modulated output. The minimum VCO frequency (in Hertz) which can be modulated by the SLF oscillator can be found by the equation:

Equation 2: (@Vreg = 5V)

$$\text{Minimum VCO Freq. (Hz)} = \frac{0.60}{(9k \text{ ohms} + RVCO) \times CVCO}$$

The frequency range of the VCO is internally determined at an approximate ratio of 10:1, so that maximum frequency of the VCO will be approximately ten times the minimum frequency that is determined by the external components RVCO and CVCO.

The second method of supplying a control voltage for the VCO is to use an internal voltage preset at 1 volt. This mode, is selected by taking VCO select to a high level. In this mode, the VCO puts out a constant tone determined by CVCO and RVCO in this relationship:

Equation 3: (@Vreg = 5V)

$$fVCO \text{ (Hz)} = \frac{1.45}{(RVCO + 9k \text{ ohms}) \times CVCO \times 0.9V}$$

A third method of controlling the voltage to the VCO is to apply the controlling voltage (Vext) to the SLF capacitor pin. This voltage level (0 to 2.30 volts) will determine the output frequency of the VCO. Output frequency in this mode is determined by this relationship:

Equation 4: (@Vreg = 5V)

$$fVCO \text{ (Hz)} = \frac{1.45}{(RVCO + 9k \text{ ohm}) \times CVCO \times (Vext - 0.1V)}$$

3. MIXER

The mixer logic selects one, or a combination of the inputs from the generators and feeds the output to the amplifier via the Envelope Generator and modulator. The mixer performs a logical AND function on these sounds; therefore, the output of the mixer is not a combination of simultaneous sounds. The output of the mixer is determined by the logic levels at the mixer select inputs as shown in Table 1 below:

TABLE 1

MIXER SELECT INPUT			MIXER OUTPUT
A (PIN 16)	B (PIN 15)	C (PIN 14)	
0	0	0	VCO
1	0	0	SLF
0	1	0	NOISE
1	1	0	VCO/NOISE
0	0	1	SLF/NOISE
1	0	1	SLF/VCO/NOISE
0	1	1	SLF/VCO
1	1	1	INHIBIT

1 = HIGH LEVEL
0 = LOW LEVEL OR OPEN

Figure 2 is an example of how two signals would be combined by the mixer according to the logical AND function with the mixer select times set for SLF/noise (C input high, A and B inputs low).
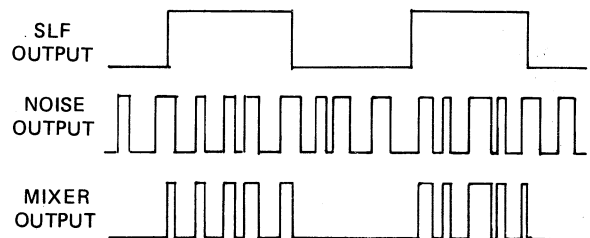

Figure 2

To obtain two sounds simultaneously (e.g., car engine and siren or steam engine and whistle), multiplexing is required. The multiplexing is accomplished by switching the mixer select lines at a sufficiently rapid rate that the two sounds seem to occur at the same time. The frequency of the multiplexing should be above the human hearing range. A multiplexing drive signal with a 50% duty cycle is required to provide equal amplitudes for both sound functions.

4. VOLUME

Output volume from the SN76495 can be controlled by varying a voltage level on pin 3. This voltage level should range from 3.5 volts, for maximum volume, to .4 volts or below for no output. **Under no circumstances should this pin be taken above 5 volts or below 0 volts. Voltages outside of this range could damage the unit.**

5. NOISE GENERATOR/FILTER

The noise generator produces pseudo-random white noise that passes through the noise filter before being applied to the mixer. The variable-band-width low-pass filter has its cutoff point defined by the noise filter control resistor (Rnf) at pin 2 and the noise filter control capacitor (Cnf) at pin 1 according to the following equation:

Equation 5: (@Vreg = 5V)

$$fCutoff (Hz) = \frac{0.43}{(9k\ ohm + Rnf) \times Cnf}$$

6. OUTPUT AMPLIFIER

The output (audio) amplifier is contained entirely on chip. The amplifier operates in a transimpedance mode and has a push-pull output capable of delivering 125 mA into a capacitively coupled 8 ohm load. This produces a two volt peak to peak output signal. The amplifier input (pin 5) can be used to sum several external current signals. If the signals are composed of a varying voltage they must first be converted to current signals. This can be accomplished by using a resistor in series between the external source and the input (pin 5). The relationship of this resistor value (Rseries) to the external signal voltage (Vmax) is given by the following equation:

Equation 6: (@Vreg = 5V)

$$-100\mu A \langle Vmax - \frac{3V}{(R\ series)} \langle 100\mu A$$

Gain of the amplifier can be controlled by adding a resistor in parallel to the internal 10 Kohm feedback resistor. This will decrease gain and allow a larger input current.

7. REGULATOR

The circuit will operate from a single supply (pin 6). An internal 5 volt regulator allows the use of 7.5 volt to 10.5 volt unregulated supply applied to Vcc (pin 6) and in addition to supplying power for the chip, the internal regulator will provide a 5 volt regulated supply of up to 5 mA from Vreg (pin 4) for use outside the integrated circuit.

DESIGN SEQUENCE FOR DEVELOPING COMPLEX SOUND

An approach to designing custom complex sounds will be illustrated and discussed in this section. These steps may vary depending on your particular applications for the IC.

The first step is to build a "sound demonstrator box" similar to the one shown below. This is a time-saving step and will aid in analyzing and understanding each section of the chip, help in determining

what sounds are desired and in determining the component values to obtain those sounds. The demonstrator box typically requires a couple of days for a technician to build. If portable operation is desired, a 9-volt battery may be used for a power source.

The next step is to check out each section of the IC using the demonstrator box.

SN 76495 DEMO/TEST BOX
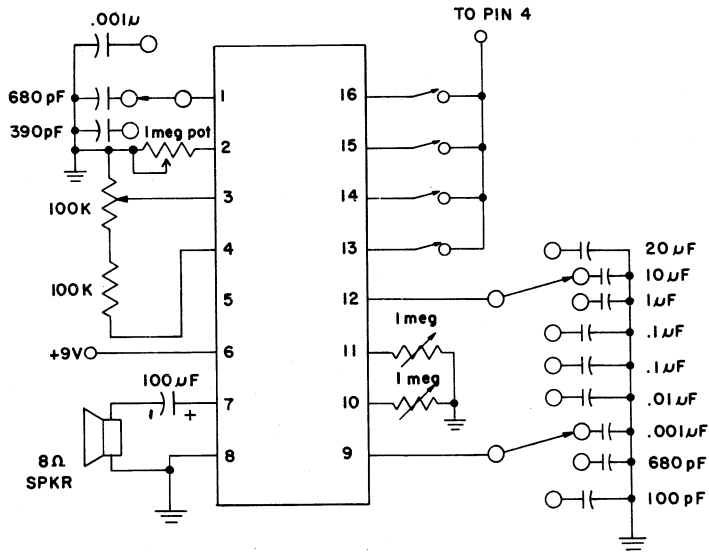
NEGATIVE TERMINAL OF THE
BATTERY CONNECTS TO GROUND

The third step is to choose a simple sound, such as a tone or noise only, and approach the reproduction of that sound scientifically. For example, a phasor sound can easily be generated using this chip. The V_{CO} and SLF oscillators are used. This requires mixers B and C (pins 14 and 15) to be tied high (to V_{CC}). Mixer A must be held low. This is done internally in the IC by leaving pin 16 open.

The SLF oscillator output voltage ramps up and down, and varies the frequency of the V_{CO}. Setting the V_{CO} select pin high allows the V_{CO} output voltage in turn to control the frequency of the SLF oscillator.

This inter-control action between the V_{CO} and the SLF oscillator generates the phasor sound. By experimenting with various values of resistance and capacitors on pins 9, 10, 11 and 12, the designer can get various levels of phasor sounds.

Step four requires logging the component values and logic levels used in your sound for future reference. The table below shows a sound logging table, including values for the phasor example.

This step is very important since it will keep a log of interesting sounds and prevent the wasted time of trying to repeat an identical sound you have produced in the past. All component values can be determined from the "demonstrator box". Use an ohmmeter to measure required resistor values by connecting it to a particular sound section's resistor jack and opening the switch that is in series with the IC. The capacitor values are determined from the labels on your demonstrator box.

SOUND	PHASOR						
RESISTORS							
SLF	1K						
VCO	1.5K						
NOISE							
CAPACITORS							
SLF	10 MFD						
VCO	0.1 MFD						
NOISE							
MIXER							
SWITCHES							
A	OPEN						
B	OPEN						
C	OPEN						

Table: Complex Sound Log

Step five is to draw the schematic needed to generate this particular sound. If copies of the IC's pinout are made, similar to the one shown here, your time is devoted only to drawing in the necessary external component values.

1	2	3	4	5	6	7	8
NOISE CAP	NOISE RES	VOLUME	VOLT REG	AUDIO IN	VCC	AUDIO OUT	GROUND

SN76495

MIXER			VCO SELECT	SLF CAP	SLF RES	VCO RES	VCO CAP
A	B	C					
16	15	14	13	12	11	10	9

IC PINOUT

FUNCTION SUMMARY			
DESCRIPTION	PIN NO.	LIMIT	FUNCTION
SLF Control Resistor (Rslf)	11	IRslf=250μA (See Note 4)	IRslf=2.75Volts/ (9Kohm+Rslf)
SLF Control Capacitor (Cslf)	12		fslf=.66/(9Kohm+ Rslf)xCslf
VCO Select	13	9V Maximum	Input Low(Note 5)=VCO Controlled by SLF Input High(Note 5)= Internal Voltage Controls VCO
VCO Control Resistor (RVCO)	10	IRVCO=250μA max.	IRVO=2.75Volts/ (9Kohm+RVCO)
VCO Control Capacitor (CVCO)	9		fslf=.60/(9Kohm+ RVCO)xCVCO
VCO External Control	12	0 to 2.30 Volts	Increase in Voltage Decreases VCO Frequency
Noise Filter Resistor (2Rnf)	2	IRnf=250μA max.	Low Pass Filter
Noise Filter Capacitor (Cnf)	1		IRnf=2.75Volts/ (9Kohm+Rnf) fcutoff=.43/ (9Kohm+Rnf)xCnf
Mixer Select A	16	9V Maximum	Selects one or a combination of generator outputs. Mixer output is a logic "AND" function of mixer inputs.
Mixer Select B	15	9V Maximum	
Mixer Select C	14	9V Maximum	
Volume	3	.4 to 3.5 Volts	Controls output volume. 3.5 volts give maximum output. Minimum voltage (Off) at .4 volts.
Amplifier Input	5		Can be used to sum exter- nally applied signals. Ampli- fier output is push-pull and is designed to swing 2 volts peak to peak when driven internally by sound genera- tors.
Amplifier Output	7		

Note 4: To reduce sound variations from chip to chip, it is suggested that control resistors be large in value to negate the effects of the internal current protect resistors. This also reduces the value of the control capacitors.

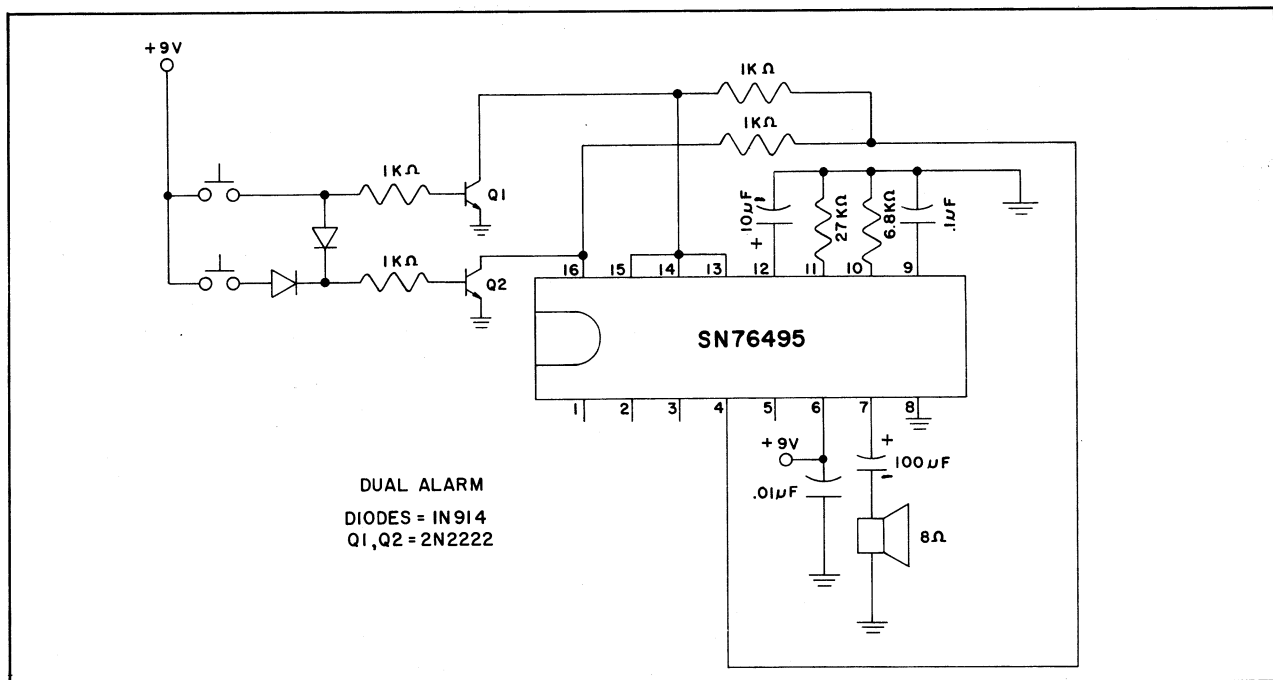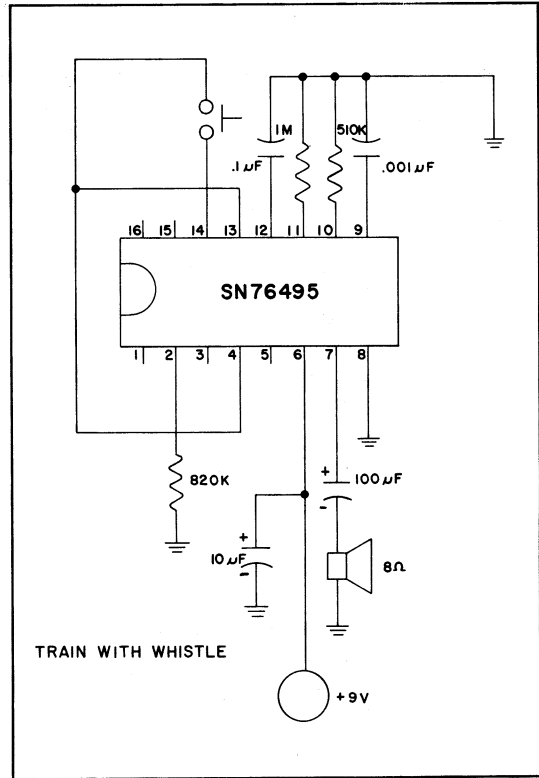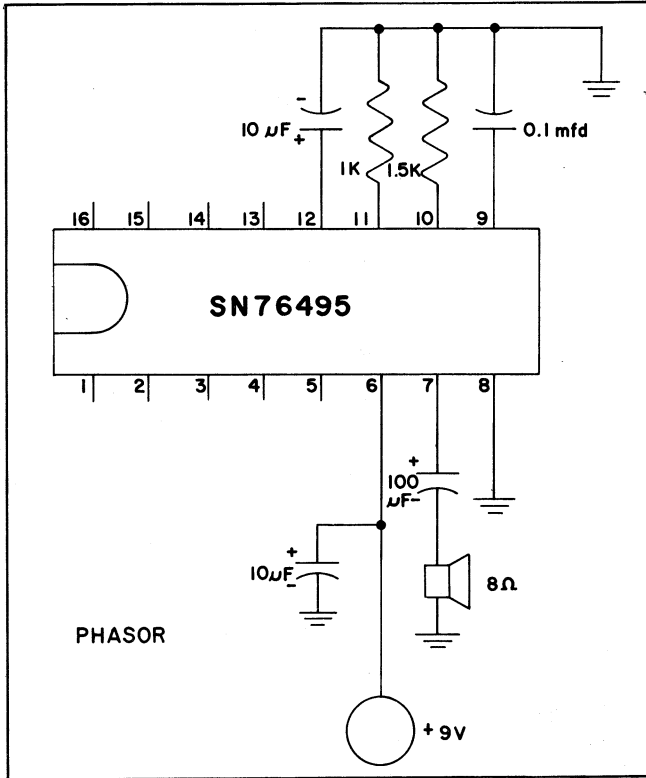Note 5: As defined by Vil and Vih in electrical specification.

Step six requires a breadboard of the circuit. Then make any necessary adjustments to the component values.
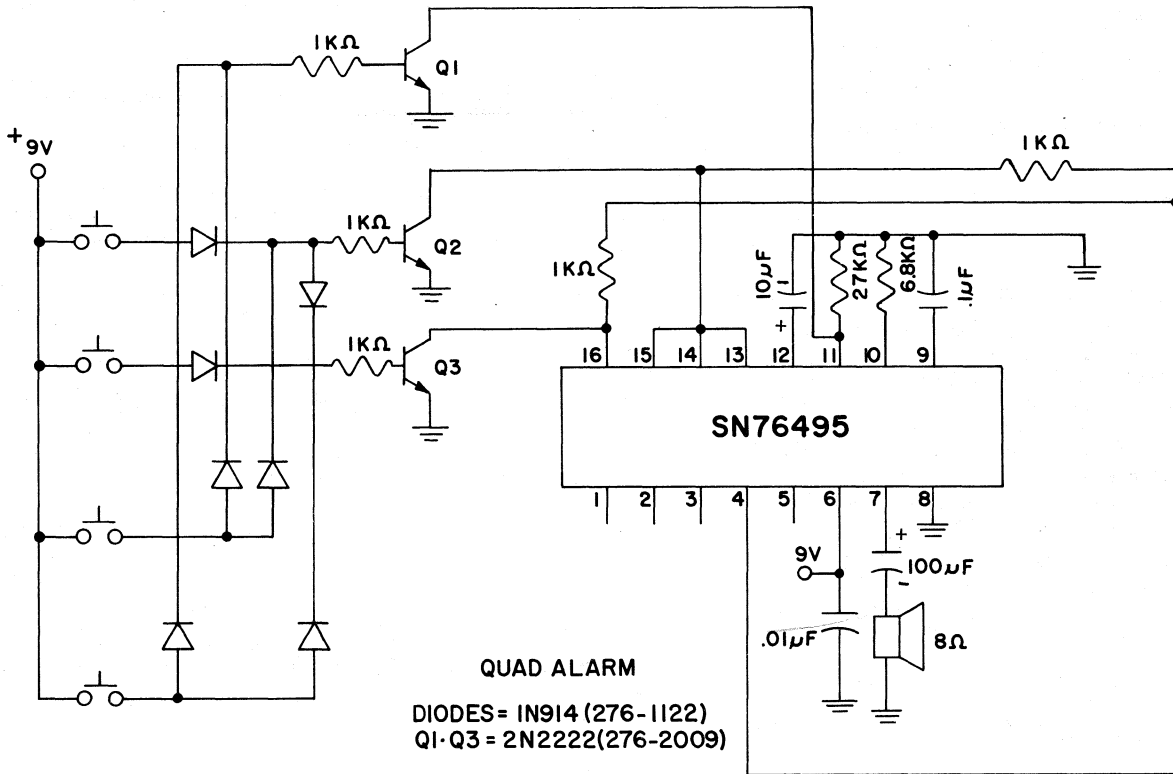
Step seven is used when several sounds that you have developed (through steps three to five) need to be combined. Compare each individual sound schematic produced in step five. Select all common components on each circuit and draw this on another IC pinout copy. Then determine if any differing values may be compromised to the same value as that used in another sound. For example, if a gun-shot was determined to have a certain set of RC one-shot values, and a ricochet had another set, then could there be a compromise between the two which would make one set common to both? Decide on the type of switching logic you will need to switch between sounds, plus any component additions and add to this drawing.

In step eight, this preliminary system should be bread-boarded. Then each sound should be adjusted until that sound is satisfactory.

TYPICAL APPLICATIONS

PHASOR

TRAIN WITH WHISTLE

DUAL ALARM

DIODES = IN914
Q1,Q2 = 2N2222

QUAD ALARM

DIODES = IN914 (276-1122)
Q1·Q3 = 2N2222 (276-2009)

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Electrical Characteristics at Vcc = 9 Volts, Ta = 25 Degrees C*

* Unless otherwise noted

PARAMETER		PIN NOS.	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Vih	High-level input voltage	14,15,16		2.0		9.0	V
Vil	Low-level input voltage (Note 2)	14,15,16				0.8	V
Vopp	Peak to Peak Output Voltage Swing	7	Rload=8 ohms AC Coupled	1.6	2.0		V
Vreg	Regulation Output Voltage	4	Vcc=9.0V, External Load on P4 = 5mA	4.5		5.5	V
Vreg	Regulation	4	Vcc=7.5V to 10V, External Load = 5mA		150		MV
Trip Points: Noise Filter Capacitor		1			3.2		V
SLF Capacitor		12			2.3		V
External Vco Cutoff Voltage		12			2.30		V
Iih	High Level Input Current	14,15,16	Vih=2.0V		35	50	μA
Control Input Current (Note 3)		2,10,11		-1		-250	μA
Icc		6	Vcc=9V Pins 2,8,10,11 at GND. All other pins open.		19	26	mA

Note 2: Logic pins left open are normally low.

Note 3: All control pins have an internally connected series 7Kohm (typical value) current protection resistor.