TYPE: SN76477N
COMPLEX SOUND GENERATOR

PRELIMINARY: OCT, 1977

FEATURES:

- GENERATES NOISE, TONE, LOW-FREQUENCY (OR MIXTURE) BASED SOUNDS
- SOUNDS ARE DEFINED BY USER (VIA EXTERNAL COMPONENTS)
- ALLOWS "CUSTOM" SOUNDS TO BE CREATED EASILY
- LOW-POWER REQUIREMENTS
- ALLOWS MULTIPLE-SOUND SYSTEMS
- COMPATIBLE WITH MICROPROCESSOR SYSTEMS

DESCRIPTION:

THE SN76477N COMPLEX SOUND GENERATOR IS A LINEAR/I^2L DEVICE WHICH PROVICES NOISE, TONE, OR LOW-FREQUENCY (OR A COMBINATION THEREOF) BASED COMPLEX SOUNDS. PROGRAMMING IS VIA EXTERNAL COMPONENTS, THAT ARE USER-DEFINED, WHICH ALLOWS A WIDE VARIETY OF SOUNDS TO BE CREATED. THE SN76477N IS DESIGNED FOR ULTIMATE FLEXIBILITY IN USER-DEFINED SOUNDS, AND MAY BE APPLIED IN ANY APPLICATION REQUIRING AUDIO FEEDBACK TO THE OPERATOR (I.E. ARCADE/HOME VIDEO GAMES, PINBALL GAMES, TOYS, ETC.; CONSUMER ORIENTED EQUIPMENT, SUCH AS TIMERS, ALARMS, CONTROLS, ETC.; INDUSTRIAL EQUIPMENT FOR INDICATORS, ALARMS, FEEDBACK CONTROLS, ETC.).

BLOCK DIAGRAM:

- ○ DENOTES PROGRAMMING VIA CAPACITOR
- □ DENOTES PROGRAMMING VIA RESISTOR
- △ DENOTES PROGRAMMING VIA LOGIC LEVEL
- ◇ DENOTES PROGRAMMING VIA ANALOG VOLTAGE

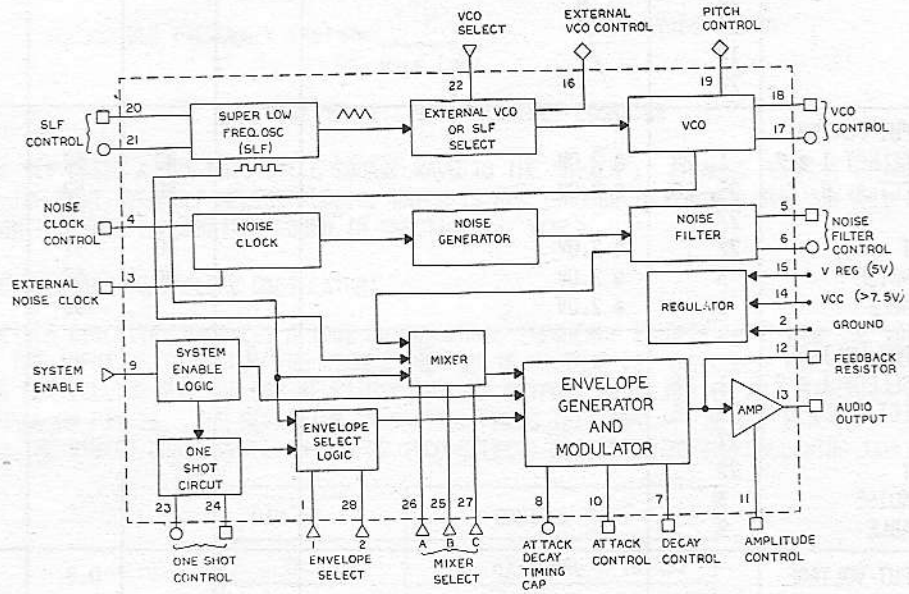


FIGURE 1: SN76477 BLOCK DIAGRAM

PRELIMINARY: OCT, 1977

ABSOLUTE MAXIMUM RATINGS AT T_A = 25°C (UNLESS OTHERWISE SPECIFIED)

SUPPLY VOLTAGE, V_{REG}, PIN 15	6.0V
SUPPLY VOLTAGE, V_{CC}, PIN 14	12.0V
INPUT VOLTAGE APPLIED TO ANY DEVICE TERMINAL	6.0V
STORAGE TEMPERATURE RANGE	-65°C TO +150°C
OPERATING TEMPERATURE RANGE	-55°C TO +120°C
LEAD TEMPERATURE 1/16 INCH FROM CASE FOR 10 SECONDS	+260°C

RECOMMENDED OPERATING CONDITIONS	MIN	TYP	MAX	UNITS
SUPPLY VOLTAGE, V_{REG}, PIN 15	4.5	5.0	5.5	V
SUPPLY VOLTAGE, V_{CC}, PIN 14	7.5		9.0	V
OPERATING FREE-AIR TEMPERATURE	0	25	70	°C

OPERATING CHARACTERISTICS AT T_A = 25°C AND V_{REG} = 5.0V

PARAMETER	PIN	CONDITIONS	MIN	TYP	MAX	UNITS
I_{CC}	14	V_{REG} = 5.0V; NO EXT. LOAD		15	40	mA
V_{REG}	15	V_{CC} = 8.25V; I_{LOAD} = 10mA	4.5		5.5	V
INPUT REGULATION	15	I_{LOAD} = 10mA V_{CC} = 7.5V TO 9.0V		150		mV
CONTROL INPUT CURRENT RANGE			1		200	uA
NOISE CLOCK	4					
NOISE FILTER	5					
DECAY	7					
ATTACK	10					
AMPLITUDE	11					
VCO	18					
ONE SHOT	24					
LOGICAL "1" INPUT CURRENT						
ENVELOPE SELECT 1 & 2	1, 28	@ 2.0V		40	52	uA
MIXER SELECT A, B, C	25, 26, 27	@ 2.0V		40	52	uA
Vco SELECT	22	@ 2.0V		40	52	uA
EXTERNAL NOISE	3	@ 2.0V		40	52	uA
SYSTEM ENABLE	9	@ 2.0V			100	uA
LOGICAL "1" INPUT VOLTAGE			2.0			V
ENVELOPE SELECT 1 & 2	1, 28					
MIXER SELECT A, B, C	25, 26, 27					
Vco SELECT	22					
EXTERNAL NOISE	3					
SYSTEM ENABLE	9					
LOGICAL "0" INPUT VOLTAGE					0.8	V
ENVELOPE SELECT 1 & 2	1, 28					
MIXER SELECT A, B, C	25, 26, 27					
Vco SELECT	22					
EXTERNAL NOISE	3					
SYSTEM ENABLE	9					

OPERATING CHARACTERISTICS AT T_A = 25°C AND V_{REG} = 5.0V (CONTINUED)

PARAMETER	PIN	CONDITIONS	MIN	TYP	MAX	UNITS
EXTERNAL Vco CUTOFF	16		2.5			V
TRIP POINTS ONE-SHOT CAP Vco CAP NOISE FILTER CAP SLF CAP	 23 17 6 21			2.5		V
MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE SWING	13	R_{LOAD} = 10K R_{FDBK} = 10K I_{11} = 200uA	2.5			V
DYNAMIC OUTPUT IMPEDANCE	13			100		OHMS

OPERATION:

1. SLF (SUPER LOW FREQUENCY OSCILLATOR)

THE SLF IS NORMALLY OPERATED IN THE RANGE OF 0.1 - 30 Hz, BUT WILL OPERATE UP TO 20 KHz. THE FREQUENCY IS DETERMINED BY THE SLF CONTROL RESISTOR (PIN 20) AND CAPCITOR (PIN 21) ACCORDING TO THE FOLLOWING EQUATION:

$$\text{SLF FREQUENCY (Hz)} \approx \frac{0.64}{R_{SLF}\,C_{SLF}} \qquad @\ V_{REG} = 5.0V$$

EQUATION 1: SLF FREQUENCY EQUATION

THE SLF FEEDS A 50% DUTY CYCLE SQUARE WAVE TO THE "MIXER"; IT ALSO FEEDS A TRIANGULAR WAVE TO THE "EXT. VCO/SLF SELECT" LOGIC, WHICH IS FED THROUGH TO CONTROL THE VCO WHEN PIN 22 IS HIGH (FURTHER EXPLANATION FOUND IN "SECTION 2: VCO").

2. VCO (VOLTAGE CONTROLLED OSCILLATOR)

THE VCO CIRCUITRY PRODUCES A TONE OUTPUT WHOSE FREQUENCY IS DEPENDENT UPON THE VOLTAGE AT THE INPUT OF THE VCO. THE HIGHER THE PIN 16 VOLTAGE IS, THE LOWER THE FREQUENCY IS. THE CONTROLLING VOLTAGE MAY BE EITHER THE SLF OUTPUT, OR IT MAY BE AN EXTERNALLY APPLIED SIGNAL ON PIN 16. THE SELECTION OF CONTROL MODES (EXTERNAL - PIN 16; INTERNAL - SLF) IS VIA THE BINARY LOGIC LEVEL ON PIN 22 (VCO SELECT) ACCORDING TO THE FOLLOWING TABLE:

PIN 22	CONTROL MODE
0	EXTERNAL (PIN 16)
1	INTERNAL (SLF)

TABLE 1: VCO CONTROL MODE SELECTION

2. VCO (VOLTAGE CONTROLLED OSCILLATOR) CONTINUED

THE INPUT AT THE "EXTERNAL VCO CONTROL" (PIN 16) MAY BE A DC VOLTAGE, PRODUCING A CONSTANT TONE AT THE OUTPUT OF THE VCO, OR ANY WAVEFORM, PRODUCING A FREQUENCY MODULATED OUTPUT FROM THE VCO. A FREQUENCY MODULATED WAVEFORM ALSO RESULTS WHEN THE SLF RAMP CONTROLS THE VCO (PIN 22 = HIGH), AS SHOWN IN FIGURE 2 BELOW:

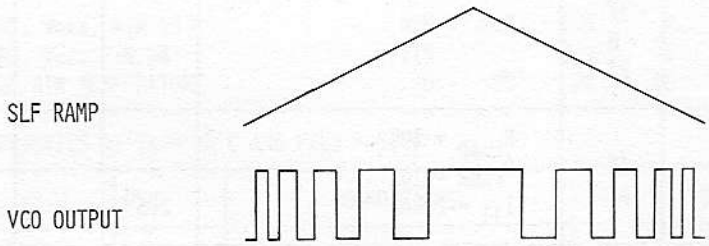


FIGURE 2: VCO FM OUTPUT

AN ALTERNATE METHOD TO APPLY AN EXTERNAL VOLTAGE TO THE VCO INPUT IS TO PLACE THE CONTROLLING VOLTAGE ON THE SLF CONTROL CAPACITOR PIN (PIN 21). IN SOME APPLICATIONS THIS MAY BE MORE CONVENIENT THAN USING THE PIN 16 INPUT. THE FREQUENCY "RANGE" OF THE VCO IS INTERNALLY DETERMINED AT AN APPROXIMATE RATIO OF 10:1. THE MINIMUM FREQUENCY OF THE VCO MAY BE DETERMINED BY ADJUSTING THE RC TIME CONTANT OF THE "VCO CONTROL" RESISTOR (PIN 18) AND THE "VCO CONTROL" CAPACITOR (PIN 17), ACCORDING TO THE FOLLOWING EQUATION:

$$\text{MIN VCO FREQ. (Hz)} \approx \frac{0.64}{R_{VCO}\, C_{VCO}} \qquad @\ V_{REG} = 5.0V$$

EQUATION 2: MINIMUM VCO FREQUENCY

THE "PITCH CONTROL" (PIN 19) VARIES THE DUTY CYCLE OF THE VCO OUTPUT ACCORDING TO THE FOLLOWING EQUATION:

$$\text{VCO DUTY CYCLE} \approx 50 \quad X \quad \frac{\text{VOLTAGE AT PIN 16}}{\text{VOLTAGE AT PIN 19}} \quad \%$$

EQUATION 3: PITCH CONTROL OF VCO DUTY CYCLE

BY LEAVING PIN 19 HIGH, A CONSTANT 50% DUTY CYCLE MAY BE ACHEIVED. THE SPECIFIC % DUTY CYCLE, APPLIES TO CONSTANT TONES PRODUCED BY APPLYING A CONSTANT DC VOLTAGE AT THE "EXTERNAL VCO CONTROL" PIN (PIN 16). HOWEVER, THE "PITCH CONTROL" MAY STILL BE USED TO AESTETICALLY ALTER THE PITCH OF ANY FREQUENCY MODULATED VCO OUTPUT SIGNALS.

3. NOISE CLOCK

THE "NOISE CLOCK" CLOCKS THE "NOISE GENERATOR". THIS CIRCUIT REQUIRES A 43K RESISTOR TO GROUND AT PIN 14 TO SET AN INTERNAL CURRENT LEVEL. AN EXTERNAL NOISE CLOCK MAY BE SUPPLIED AT PIN 3 TO ALLOW GENERATION OF LOWER FREQUENCY NOISE. THIS EXTERNAL CLOCK SHOULD BE A MAXIMUM 5 VOLT PEAK-TO-PEAK SQUARE WAVE.

4. NOISE GENERATOR/FILTER

THE NOISE GENERATOR IS A BINARY PSUEDO RANDOM WHITE NOISE GENERATOR WHOSE OUTPUT PASSES THROUGH THE NOISE FILTER BEFORE BEING INPUTED TO THE MIXER. THE FILTER IS A VARIABLE BAND WIDTH LOW-PASS FILTER WHOSE 3DB POINT IS DEFINED BY THE FOLLOWING EQUATION:

$$\text{3DB FREQUENCY (Hz)} \approx \frac{1.28}{R_{NF}\ C_{NF}} \qquad @\ V_{REG} = 5.0V$$

EQUATION 4: NOISE WAVEFORM 3 DB FREQUENCY

5. THE "MIXER" LOGIC SELECTS ONE, OR A COMBINATION, OF THE INPUTS FROM THE GENERATORS AND FEEDS THE OUTPUT TO THE "ENVELOPE GENERATOR AND MODULATOR".

MIXER SELECT			MIXER
C (PIN 27)	B (PIN 25)	A (PIN 26)	OUTPUT
0	0	0	VCO
0	0	1	SLF
0	1	0	NOISE
0	1	1	VCO/NOISE
1	0	0	SLF/NOISE
1	0	1	SLF/VCO/NOISE
1	1	0	SLF/VCO
1	1	1	INHIBIT

TABLE 2: MIXER SELECT LOGIC

6. SYSTEM ENABLE LOGIC

THE "SYSTEM ENABLE" LOGIC PROVIDES AN ENABLE/INHIBIT FOR THE SYSTEM OUTPUT. THE SOUND OUTPUT IS CONTROLLED ACCORDING TO THE FOLLOWING TABLE:

PIN 9	OUTPUT
0	ENABLED
1	INHIBITED

TABLE 3: SYSTEM ENABLE LOGIC

THIS INPUT ALSO TRIGGERS THE "ONE-SHOT" LOGIC FOR MOMENTARY SOUNDS, SUCH AS GUNSHOTS, BELLS, EXPLOSIONS. THE "ONE-SHOT" LOGIC IS TRIGGERED BY THE NEGATIVE-GOING EDGE. THIS MAY BE ACCOMPLISHED BY MEANS OF A MOMENTARY SWITCH, OR BY A SQUARE WAVE INPUT AT PIN 9. PIN 9 MUST BE HELD LOW FOR THE ENTIRE DURATION OF THE ONE-SHOT SOUND (INCLUDING ATTACK AND DECAY PERIOD). THE ONE-SHOT LOGIC IS OPERABLE ONLY WHEN THE PROPER "ENVELOPE SELECT LOGIC" SELECTION IS MADE (SEE SECTION 8: ENVELOPE SELECT LOGIC).

7. "ONE-SHOT" LOGIC

THE DURATION OF THE "ONE-SHOT" IS DEFINED BY THE FOLLOWING EQUATION:

$$\text{DURATION (SECONDS)} \approx 0.8\ R_{OS}\ C_{OS} \qquad @\ V_{REG} = 5.0V$$

EQUATION 5: ONE-SHOT DURATION

7. "ONE-SHOT" LOGIC (CONTINUED)

IN EQUATION 5, Ros IS THE "ONE-SHOT CONTROL" RESISTOR (PIN 24) AND Cos IS THE "ONE-SHOT CONTROL" CAPACITOR (PIN 23). MAXIMUM DURATION OF THE ONE-SHOT IS APPROXIMATELY 10.0 SECONDS. WHEN THE ONE-SHOT IS CONTROLLED BY EXTERNAL LOGIC, THE ONE-SHOT CONTROL RESISTOR AND CAPACITOR MAY BE ELIMINATED. SIMPLY BEGIN ONE-SHOT WITH PIN 9 (SYSTEM ENABLE) AND END CYCLE BY TAKING PIN 23 (ONE-SHOT CAPACITOR) HIGH.

8. ENVELOPE SELECT LOGIC

THE ENVELOPE SELECT LOGIC DETERMINES THE ENVELOPE THAT IS APPLIED TO THE MIXER OUTPUT ACCORDING TO THE FOLLOWING TABLE:

ENVELOPE SELECT 1	ENVELOPE SELECT 2	SELECTED FUNCTION
PIN 1	PIN 28	
0	0	VCO
0	1	MIXER ONLY
1	0	ONE-SHOT
1	1	VCO WITH ALTERNATING POLARITY

TABLE 4: ENVELOPE SELECT LOGIC OUTPUT

9. ATTACK AND DECAY CONTROL

THE ATTACK/DECAY CIRCUITRY ALTERS THE RISE AND FALL OF THE ENVELOPE. AN EXAMPLE OF A NOISE WAVEFORM UTILIZING THE ENVELOPE GENERATOR UNDER ONE-SHOT CONTROL IS:

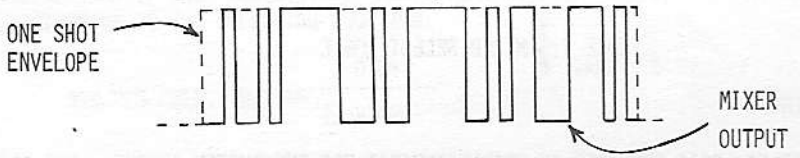


FIGURE 4: ONE-SHOT CONTROLLED NOISE WAVEFORM

BY UTILIZING THE ATTACK AND DECAY CONTROL INPUTS (PIN 7,10), THE WAVEFORM MAY BE AFFECTED IN THE FOLLOWING MANNER:

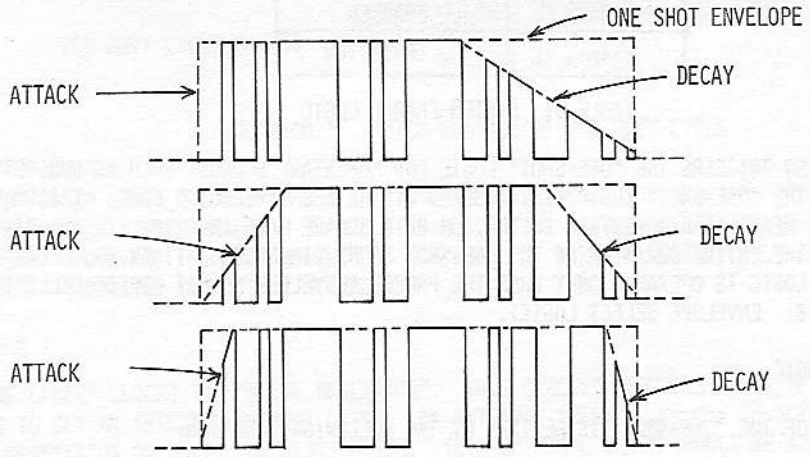


FIGURE 5: EXAMPLES OF VARYING DEGREES OF ATTACK AND DECAY ON A WAVEFORM

9. ATTACK AND DECAY CONTROL (CONTINUED)

THE AMOUNT OF ATTACK AND DECAY IS DETERMINED BY THE "ATTACK CONTROL" RESISTOR (R_A) (PIN 10) AND THE "DECAY CONTROL" RESISTOR (R_D) (PIN 7) AND THE "ATTACK/DECAY TIMING CAPACITOR" (C_{A-D}) (PIN 18) ACCORDING TO THE FOLLOWING EQUATIONS:

ATTACK TIME (SECONDS) $\approx R_A C_{A-D}$ @ $V_{REG} = 5.0V$
DECAY TIME (SECONDS) $\approx R_A C_{A-D}$ @ $V_{REG} = 5.0V$

EQUATION 6: ATTACK AND DECAY TIME

10. OUTPUT AMPLIFIER

THE OUTPUT AMPLIFIER IS DESIGNED TO INTERFACE WITH SOUND MODULATORS OR ADDITIONAL AMPLIFIER STAGES. IT REQUIRES AN EXTERNAL FEEDBACK RESISTOR FROM PIN 12 TO PIN 13, AND IS DESIGNED AS A LOW IMPEDANCE OUTPUT. THE PEAK OUTPUT VOLTAGE IS DETERMINED BY THE FOLLOWING EQUATION:

$$V_{OUT} \approx \frac{3.4\ R_F}{R_G} \quad @ \quad V_{REG} = 5.0V$$

WHERE R_F = FEEDBACK RESISTOR (PIN 12 - 13)

R_G = GAIN RESISTOR (PIN 11)

EQUATION 7: OUTPUT VOLTAGE

THE DYNAMIC OUTPUT RANGE IS LIMITED TO $2.5V_{p-p}$ BEFORE CLIPPING OCCURS.

11. REGULATOR

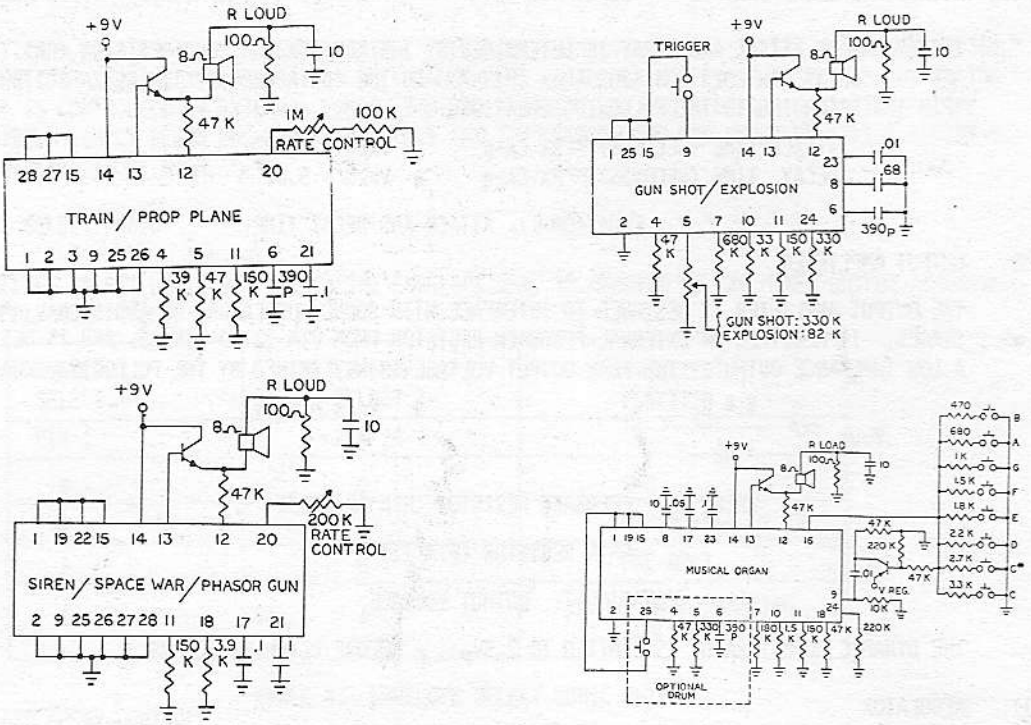
EITHER A 5 VOLT REGULATED SUPPLY MAY BE APPLIED TO PIN 15 (V_{REG}) OR A 7.5 VOLT MIN/9.0 VOLT MAX UNREGULATED SUPPLY MAY BE APPLIED TO PIN 14 (V_{CC}). PIN 15 (V_{REG}) CAN BE USED AS A 5 VOLT REGULATED SUPPLY FOR THE REST OF THE SYSTEM WITH A CURRENT SUPPLY OF UP TO 10mA OUT OF THE IC.

12. NOTE:

CONTROL RESISTORS AND CAPACITORS MAY BE ELIMINATED IF THE DESIRED SOUND DOES NOT REQUIRE THAT GENERATOR OR LOGIC SECTION. FOR DEDICATED SOUND, THE LOGIC INPUTS (PINS 1, 9, 22, 25, 26, 27, 28) MAY BE HARD WIRED FOR HIGH OR LOW LOGIC LEVELS. INDIVIDUAL SOUNDS (SINGLE OR MULTIPLE) WILL DETERMINE WHICH OF THE OTHER COMPONENTS ARE REQUIRED.

PIN ASSIGNMENT:

ENVELOPE SELECT 1 (INPUT)	1	28	ENVELOPE SELECT 2 (INPUT)
GROUND	2	27	MIXER SELECT C (INPUT)
EXTERNAL NOISE CLOCK (INPUT)	3	26	MIXER SELECT A (INPUT)
NOISE CLOCK RESISTOR (INPUT)	4	25	MIXER SELECT B (INPUT)
NOISE FILTER CONTROL RESISTOR (INPUT)	5	24	ONE-SHOT CONTROL RESISTOR (INPUT)
NOISE FILTER CONTROL CAPACITOR (INPUT)	6	23	ONE-SHOT CONTROL CAPACITOR (INPUT)
DECAY CONTROL RESISTOR (INPUT)	7	22	VCO SELECT (INPUT)
ATTACK/DECAY TIMING CAPACITOR (INPUT)	8	21	SUPER LOW FREQUENCY OSC. CONTROL CAP. (INPUT)
SYSTEM ENABLE (INPUT)	9	20	SUPER LOW FREQUENCY OSC. CONTROL RES. (INPUT)
ATTACK CONTROL RESISTOR (INPUT)	10	19	PITCH CONTROL (INPUT)
AMPLITUDE CONTROL RESISTOR (INPUT)	11	18	VCO CONTROL RESISTOR (INPUT)
FEEDBACK RESISTOR (INPUT)	12	17	VCO CONTROL CAPACITOR (INPUT)
AUDIO OUTPUT	13	16	EXTERNAL VCO CONTROL (INPUT)
V_{CC}	14	15	V_{REG}



NOTE 1: THE VALUE OF RESISTOR R_{LOAD} MAY BE VARIED TO PRODUCE THE DESIRED SOUND LOUDNESS.
NOTE 2: PINS THAT ARE NOT SHOWN IN THE APPLICATION SCHEMATIC ARE NOT CONNECTED (OPEN).
NOTE 3: ALL CAPACITORS IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

FIGURE 6: TYPICAL APPLICATION SCHEMATICS

MULTIPLE SOUND APPLICATIONS:

WHEN MULTIPLE SOUNDS ARE DESIRED IN A SYSTEM, THEY CAN BE ACCOMPLISHED IN THE FOLLOWING MANNER:

- DETERMINE INDIVIDUAL SCHEMATIC FOR EACH DESIRED SOUND.
- RE-EVALUATE SOUND/SCHEMATICS WHILE ATTEMPTING TO MAXIMIZE COMMON VALUES AMONG EXTERNAL COMPONENTS.
- DETERMINE SWITCHING/TIMING REQUIREMENTS FOR EACH SOUND AND FOR SYSTEM.
- IMPLEMENT SWITCHING REQUIREMENTS INTO MICROPROCESSOR PROGRAM, MECHANICAL SWITCHES, (I.E. TRIGGER), AND/OR ELECTRONIC SWITCHES.

MECHANICAL DIMENSIONS: