SOUND GENERATOR DESIGN CONSOLE

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Discover the the wonders of a sound-generator IC, without the bother of breadboarding, using this easy-to-build design console.

TEXAS INSTRUMENTS FEATURES A NUMber of interesting sound-generator IC's in their semiconductor line; one of the most versatile is their SN76488N. That IC, an improved version of their SN76477N, is a monolithic device that combines both analog and digital circuitry. Like the other devices in the line, it boasts a noise generator, a VCO (*V*oltage-*C*ontrolled *O*scillator), an SLF (*S*uper-*L*ow-*F*requency) oscillator, a noise filter, a mixer, attack/delay circuitry, control circuitry, and even one-shot circuitry for generating momentary sounds. In addition to those features, the 76488 offers an internal 125-milliwatt audio amplifier capable of driving an 8-ohm speaker, and external outputs for the VCO, the SLF oscillator, the noise clock, and the one-shot circuitry.

The device can produce noises, tones, or low-frequency sounds either individually or in any combination. All sounds are programmed using control inputs and user-selected external components. The uses for that versatile IC are limited only by the user's imagination; and if you run out of ideas, a little experimentation is sure to turn up many more.

While most hobbyists like to breadboard with discrete components when either designing or experimenting, that technique has several drawbacks when designing with this IC. Since this IC can produce a wide variety of sounds, with each sound being determined by the value of the external components connected to it, it is far easier to listen to the sounds produced by this IC while varying the value of the external components. The design console described here does just that; it enables you to control the value of those external components while listening to the sound produced.

Before we look at the console, and how it is built, it will be helpful to get to know the 76488 a little better. A block diagram of the device is shown in Fig. 1. Let's examine the operation of each functional circuit block.

SLF oscillator

The SLF feeds a 50%-duty-cycle squarewave to the mixer. It also feeds a triangular wave to the external VCO or SLF-select logic circuitry; that circuit selects either external-voltage or SLF modulation of the VCO. If the VCO-SELECT pin, pin 20, is high, the SLF is fed through to modulate the frequency of the VCO; if it is low, an external voltage is used (more on that shortly). The SLF's normal operating range is 0.1 to 30 Hz, but it will

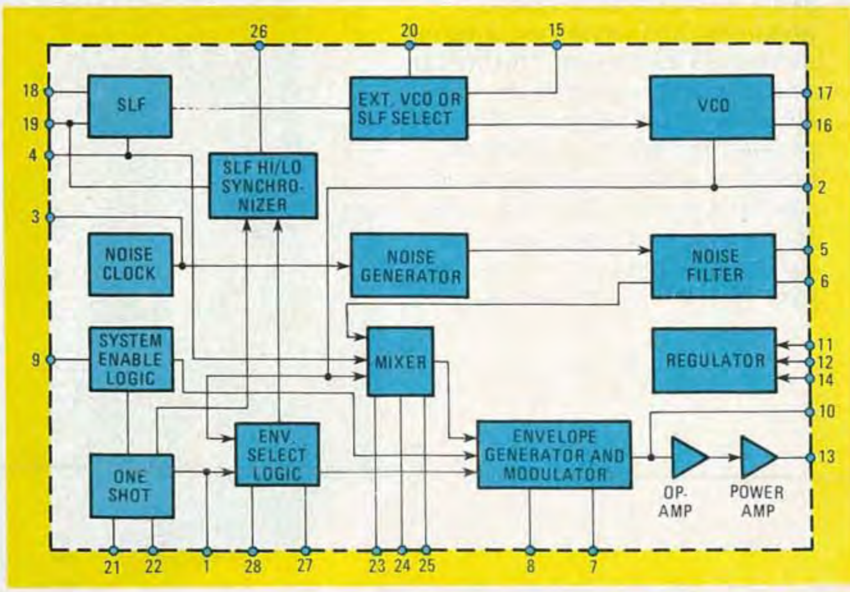

FIG. 1—BLOCK DIAGRAM of SN76488N sound generator. Refer to this figure as we describe the operation of the device.

produce frequencies of up to 20 kHz. The SLF frequency is determined by two external components, the SLF-control resistor connected to pin 18 and the SLF-control capacitor connected to pin 19. The output of the SLF is available externally from pin 4 and can drive one TTL load.

Voltage controlled oscillator (VCO)

The VCO produces a tone whose frequency depends upon the voltage at its input. That controlling voltage can be either the SLF output described above, or an externally generated signal applied to the EXTERNAL VCO CONTROL pin, pin 15. The higher the voltage applied to the VCO, the lower the VCO frequency. The minimum VCO frequency is determined by two external components: the VCO-control resistor connected to pin 17 and the VCO-control capacitor connected to pin 16. The maximum frequency of the VCO is ten times the minimum frequency. The method of controlling the VCO is selected by the logic-level present on pin 20. If that logic level is low, the VCO frequency is controlled by the external signal applied to pin 15. The input at pin 15 may be a DC voltage, which produces a constant tone, or any digital or analog signal. If the logic level at pin 20 is high, the VCO frequency is controlled by the output from the SLF oscillator.

The output of the VCO is a squarewave and is supplied to the mixer and, if selected by the envelope-select logic, to the envelope generator and modulator. The VCO output is available at pin 2 and can drive a single TTL load.

Noise clock

The noise clock internally generates a clock signal and supplies it to the noise generator; the minimum frequency of that clock signal is 10 kHz. The clock signal is also available externally at pin 3; it is capable of driving one TTL load.

Noise generator/filter

The noise generator produces pseudo-random white noise that passes through the variable-bandwidth low-pass noise filter before being fed to the mixer. That filter has its cutoff point defined by the noise-filter control resistor connected to pin 5 and the noise-filter control capacitor connected to pin 6.

Mixer

The mixer combines one or more signals from the SLF, VCO, and noise generator by performing a logical AND function and feeds the resulting output signal to the envelope generator and modulator. The signals that are to be input to the mixer are chosen by setting the logic levels present on the MIXER-SELECT pins, pins 23, 24, and 25, in accordance with those shown in Table 1. Figure 2 shows how the mixer combines an SLF and noise signal to produce an SLF/noise output. If more than

TABLE 1—MIXER

Mixer select inputs

A (PIN 24)	B (PIN 25)	C (PIN 23)	Mixer output
L	L	L	VCO
H	L	L	SLF
L	H	L	noise
H	H	L	VCO/noise
L	L	H	SLF/noise
H	L	H	SLF/VCO/noise
L	H	H	SLF/VCO
H	H	H	inhibit

H = high level
L = low level or open

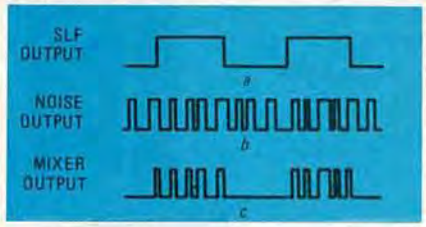

FIG. 2—THE MIXER combines the SLF output, shown in *a*, and a noise signal, shown in *b*, to produce the output shown in *c*.

one sound at a time is desired, (for example, a car engine and siren, or a steam engine and whistle), multiplexing is required. That can be done by switching the mixer-select lines at such a rate that the two sounds seem to occur simultaneously. A multiplexing-drive signal with a 50% duty cycle is required to provide equal amplitudes for both sounds. The frequency of that signal should be above the range of human hearing (i.e., above 20 kHz).

One shot

The one-shot circuit controls momentary sounds, and is triggered by a high-to-low logic-level transition at the SYSTEM-ENABLE pin, pin 9. The duration of the one-shot's output is determined by the one-shot control resistor connected to pin 22 and the one-shot control capacitor connected to pin 21. The maximum duration of the signal is approximately 10 seconds. The signal can be cut off earlier by taking the SYSTEM-ENABLE pin high. If that is done, however, the one-shot timing must be allowed to end before another one-shot timing sequence can be triggered; that is necessary to allow an internal latch to reset. The output of the one-shot is fed through the envelope-select logic to the envelope generator and modulator. Rather than being a sound source, the one-shot signal merely provides an envelope for the sound that is output from the mixer. The one-shot circuit is operational only when the one-shot envelope is selected as explained in the next section. Its output is available at pin 1 and can drive one TTL load. While in the one-shot mode, the SLF ramp can be forced to start at either a high or low level by placing a high or low logic-level respectively on the SLF-SELECT pin, pin 26.

Envelope select

The envelope-select logic determines which envelope is combined with the mixer output in the envelope generator and modulator. That envelope is selected using the ENVELOPE-SELECT pins, pins 27 and 28. The operation of the envelope-select circuit is summarized in Table 2. Figure 3 shows the four possible envelopes that could be generated. The noise and VCO inputs to the mixer are shown in Fig. 3-a. If the mixer-only function is selected as shown in Fig. 3-c, the mixer output is supplied continuously to the audio amplifier. If the VCO function is selected as shown in Fig. 3-b, the squarewave output of the VCO is the envelope for the mixer output, meaning that the mixer output is passed on to the audio

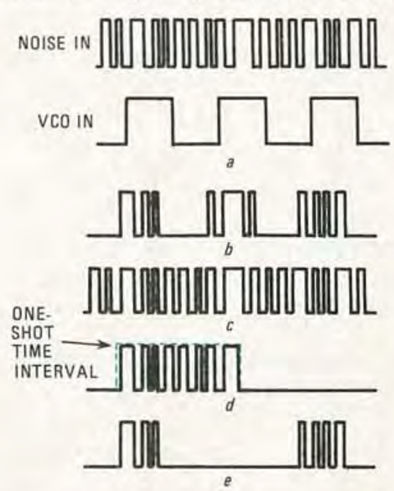

FIG. 3—WITH THE MIXER AND VCO outputs as shown in *a*, the four possible envelopes that could be generated are shown in *b–e*.

TABLE 2—ENVELOPE SELECT

Envelope select 1 (Pin 28)	2 (Pin 27)	Function selected	Waveform (see figure 3)
L	L	VCO	*b*
L	H	Mixer only	*c*
H	L	One-shot	*d*
H	H	VCO with alternating cycles	*e*

H = high level
L = low level or open

amplifier while the VCO output is high but not when it is low. The VCO with-alternating-polarity function, shown in Fig. 3-e, is similar to the VCO function described above except that the output from the mixer is enabled only during every other VCO pulse. When the one-shot function is selected, the output from the mixer is enabled only for the duration of the one-shot pulse as shown in Fig. 3-d.

Decay control

The decay circuitry, which is part of the envelope-generator-and-modulator block, alters the fall time of the envelope selected by the envelope-select logic. The decay time is determined by the decay-timing capacitor that is connected to pin 8, and the decay-timing resistor that is connected to pin 7. The decay has no effect on the mixer-only function, but for the one-shot, VCO, and VCO-with-alternating-cycle functions, the decay ramp is triggered by each high-to-low transition of the envelope; it serves to prolong the sound at a decreasing volume that is proportional to the selected decay-rate. Figure 4 shows examples of how a waveform may be modified by decay when the mixer output is noise and the one-shot envelope is selected. Figure 5 shows a similar example, this time using a VCO rather than a one-shot envelope.

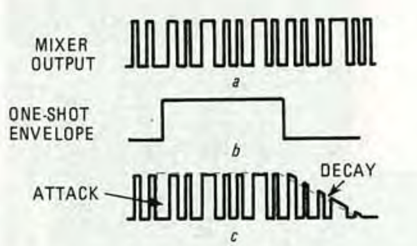

FIG. 4—HOW A WAVEFORM IS MODIFIED by decay when the mixer output is noise and a one-shot envelope is selected.

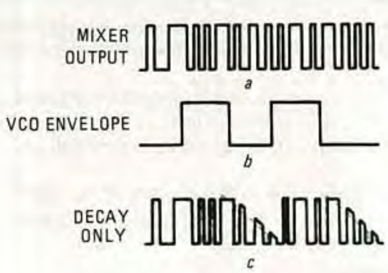

FIG. 5—IN THIS EXAMPLE of how a waveform is modified by decay, the VCO envelope is selected.

System enable

The system-enable logic provides enable/select control for the sound output of the system. A high logic-level at the SYSTEM ENABLE pin (pin 9) inhibits the sound output, a low logic-level (or open pin connection) enables it. That pin is also used to trigger the one-shot circuit for momentary sounds such as gunshots, bells, explosions, etc. The one-shot logic is triggered on the negative-going edge of a system-enable input signal. The input applied to pin 9 must be held low for the entire duration of the one-shot sound, including attack and decay periods, if the sound is to be completed. Taking pin 9's input high early, terminates the sound.

Output amplifier

The output amplifier (see Fig. 6) is contained entirely on the IC and and has a push-pull output capable of delivering 125 mW into an 8-ohm load connected to pin 13. External signals may be input to the amplifier via pin 10.

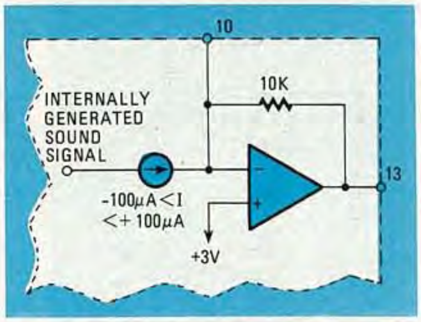

FIG. 6—THIS AMPLIFIER is entirely contained on the IC and is capable of supplying 125 mA into a capacitively-coupled 8-ohm load.

Regulator

The 76488 will operate from a single-voltage power supply connected between pin 12 (positive) and pin 14 (ground); an internal 5 volt regulator allows use of an unregulated supply of between 7.5 and 10.5 volts. In addition to supplying power for the IC, the regulator is capable of providing a regulated 5-volts, at up to 5 mA, from pin 11 for use by any external circuitry. That is used to supply the high-level logic voltage used by the design console.

That concludes our look at the SN76488; its pinout is shown in Fig. 7. We'll now turn to construction of the design console itself.

Console construction

Construction of the design console is relatively simple and straightforward. The schematic for the circuit is shown in Fig. 8. Little about the design is critical, and substituting freely from your junk-box can help hold down the device's cost. In the author's version, for instance, mica capacitors were used in place of ceramic discs in some instances simply because they were on hand. You can't, of course, substitute for the sound-generator IC. If your local supplier does not stock that device, it is available from Active Electronics, PO Box 1035, Framingham, MA 01701.

A 8⅞₁₆ × 7⅞₁₆-inch instrument case and cover were used to house the prototype

PARTS LIST

All resistors 5% unless otherwise noted
R1-R6—1 megohm, potentiometer, linear taper
R7—100,000 ohms
R8—50 ohms, potentiometer, audio taper
Capacitors
C1, C18—390 pF, ceramic disc
C2 9—680 pF, ceramic disc
C3—1000 pF, ceramic disc
C4, C13—.22 μF, ceramic disc
C5, C12—.47 μF, ceramic disc
C6, C11—4.7 μF, 25 volts, electrolytic
C7, C9, C10, C15—10 μF, 25 volts, electrolytic
C8—220 μF, 10 volts, electrolytic
C14—22 μF, 10 volts, electrolytic
C16—1 μF, 10 volts, electrolytic
C17, C22—0.1 μF, ceramic disc
C20—.005 μF, ceramic disc
C21—.01 μF, ceramic disc
Semiconductors
IC1—SN76488N sound generator (TI)
B1—9-volt battery
S1-S5—1 pole, 6 position rotary switch
S6-S19—SPST miniature slide switch
S20, S21—SPDT miniature slide switch
S22—SPST momentary pushbutton switch, normally open
TP1–TP18—test point jack
J1–J3—phono jack
Miscellaneous: IC socket, perforated construction board, case, etc.
Adhesive backed overlays for the front panels are available from Design Specialty, 15802 Springdale St, No. 80, Huntington Beach, CA 92649. The cost is $3.00 each, postpaid. California residents add state and local taxes.

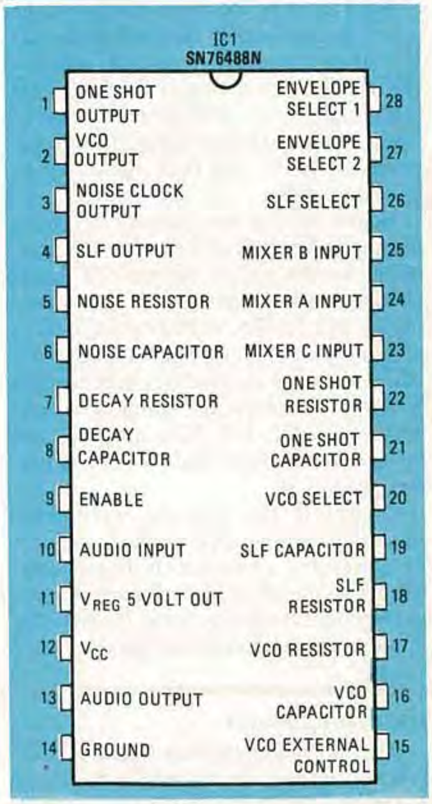

FIG. 7—PINOUT of the SN76488N sound generator IC from Texas Instruments.

console. In lieu of a phenolic case cover, a ⅛-inch piece of plywood may be used. We've used both and prefer the plywood because it is easier to work with.

Assembly is begun by mounting the capacitors on rotary switches S1-S5 so that when looking at each switch from front to back and rotating it clockwise, the component values are selected in the order shown in Fig. 8. The layout of the front panel can be seen in the photo on the first page of this article. After the switches are wired, cut holes in the console cover to match that layout. Although not required, the easiest way to do that is to mount a full-sized version of the front panel layout and use it as the cutting template. For those who wish to go that route, full-sized copies of the overlay, with adhesive backing so that it can be applied directly to the front panel, are available from the source given in the Parts List.

After the cover preparation is complete, mount the slide switches to the cover, using either screws or an adhesive. If using screws, use the flat-head type and countersink them flush with the cover surface. If an adhesive is used, a cyanoacrylate adhesive (super glue) works well on the phenolic material, while a silicone-rubber compound works well with plywood. When using a cyanoacrylate adhesive, use extreme caution to avoid getting any of it on your fingers or on the movable-slide part of the switch. If a silicone rubber compound is used, be sure to allow ample time for the compound to cure before attempting any further work with the switches.

After securing the slide switches to the cover, the remaining switches and jacks should be mounted. If desired, attach a 2½ inch speaker to the inside of the case after drilling a sufficient number of "grill" holes to insure adequate volume; provisions have also been made for an external speaker.

Begin wiring the console by connecting together all of the +5-volt points; do the same for all of the grounds. Next, connect the wiper terminal of each variable resistor, R1–R6, to its associated jack, and that jack to its associated switch. Finally, make the connections between S8, S22, and J21; make the component connections to J21, J22, S21, and S20, and connect the positive lead of a 9-volt battery snap to S9.

Complete the console wiring by mounting a 28-pin DIP socket on a piece of perforated construction board and, using two pieces of 14-conductor ribbon-cable, connect the pins of the 76488 to the appropriate components as the schematic shows.

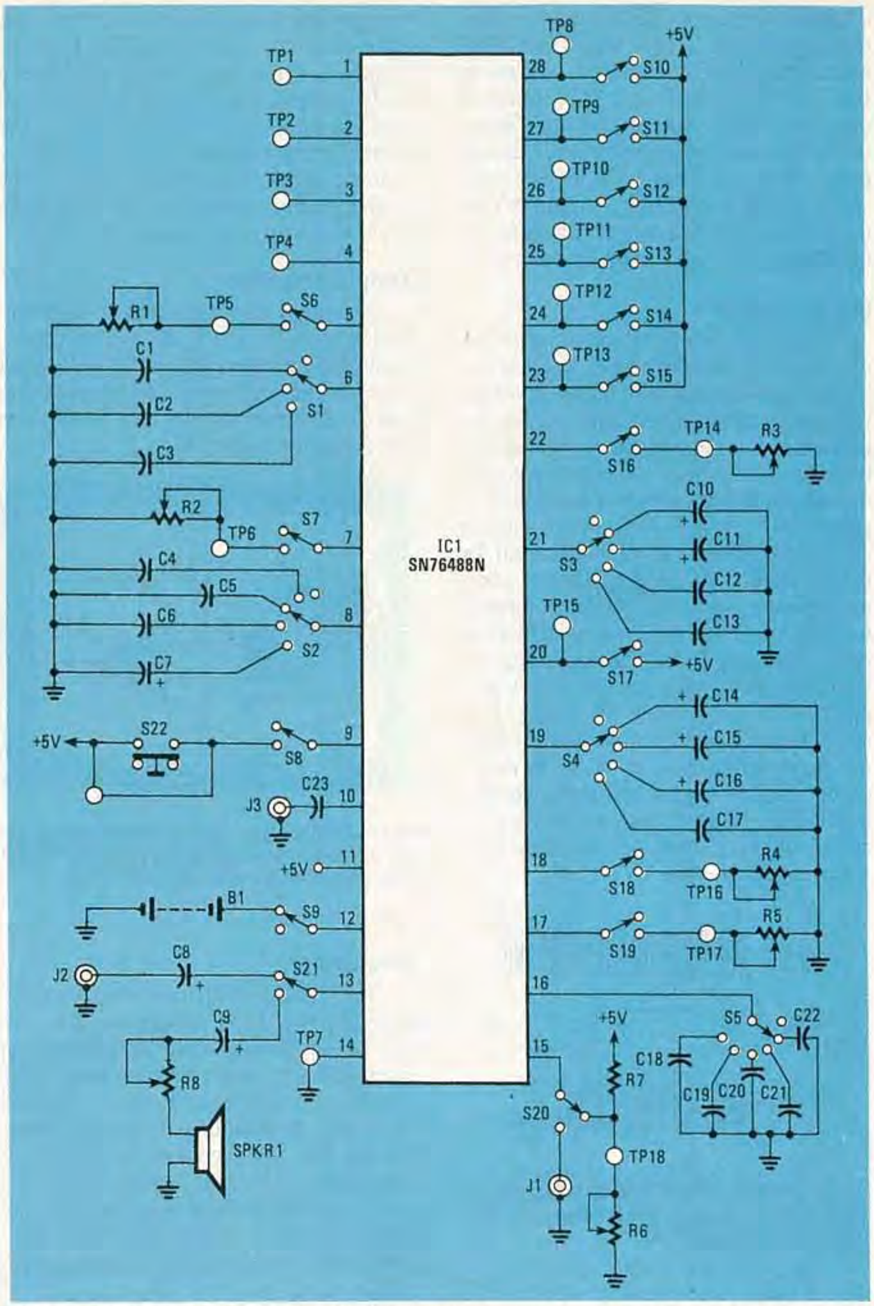

FIG. 8—SCHEMATIC DIAGRAM of the SN76488N design console. As nothing in the circuit is especially critical, reasonable substitutions from your junkbox can be made to reduce the construction cost.

Using the console

After becoming familiar with the functions of the console controls, using them to create your own custom sounds will be easy, fun, and exciting. To help with the familiarization process, console set-up procedures for a few sounds are provided below. Before setting up the console for each new sound, set all controls and switches so that no component or control signals are connected to the 76488.

Gunshot/explosion

1. Close S10 and S13 (pins 28 and 25).
2. Set R3 (pin 22) to 330K by using a voltmeter to measure the resistance between TP7 and TP14 (pins 14 and 22). After the resistance value is set, close S16 (pin 22).
3. Set S3 (pin 21) to .47 µF.
4. Set S1 (pin 6) to 680 pf.
5. Following the same procedure as outlined in step 2, set R2 (pin 7) to 120K.
6. For the gunshot, set R1 (pin 5) to 33K and S2 (pin 8) to .47 µF.
7. Turn the console power on at pin 12, close S8, and momentarily depress S22 (pin 9). Upon release of the switch, the gunshot sound will occur.
8. For the explosion, set R1 to 220K and S2 to 10 µF. Again momentarily depress S22.

Siren/phasor

1. Set S17 (pin 20) to +.
2. Set S4 (pin 19) to 10 µF.
3. Set R5 (pin 17) to 1.8K.
4. Set S5 (pin 16) to .1 µF.
5. Turn on console power.
6. Vary R4 (pin 18) to obtain the siren and phasor sounds.

Those are just a few of the sounds that the console is capable of generating. There are, of course, quite a few more. To find them, all you need is a little practice and patience. Happy experimenting! **R-E**