BUILD R-E's CALL-ALERT

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Eliminate the constant chatter on your favorite channel or repeater with the Call Alert.

MOST PEOPLE DON'T SEE MANY PARallels between the amateur radio service and the citizen's band, but there are similarities. CB channel 9 has helped thousands of stranded motorists, and Hams have provided communication when all else has failed during a disaster such as an earthquake.

However, because of all the activity that may be on your favorite CB channel or two-meter repeater, it is often tempting to turn off the rig or advance the squelch to the point where only the next-door neighbor can get through. In the case of CB, this greatly reduces your range, and with amateur radio it works only with simplex operation. The end result of all this is that you may miss a call from a friend or an emergency call from someone in trouble. The solution to this problem is a selective call system whereby your receiver or transceiver is always on, but does not pass audio until the correct *Touch-Tone* sequence is detected. Then you (and your entire team, if the system is used for club or emergency use) hear the call.

The Call-Alert

Call-Alert consists of two components, an encoder and a decoder. The encoder is a pocket-sized battery-powered device that produces the *Touch Tones*; it is held next to the transmitting microphone to provide acoustic coupling. The decoder, or monitor, is coupled to the receiver by plugging it into the external speaker jack. It can be powered from either an AC or DC source, for home or mobile use. Note that no modifications to your existing station are required to use either the encoder or the decoder. The Call-Alert simply acts as a switch between the receiver output and the listener. The system contains an indicator light to let you know that a call has been received, a switch to bypass the device when originating a transmission, a reset switch, and a built-in speaker and volume control.

As shown in the decoder block diagram in Fig. 1, the input from the receiver takes two paths. The lower path goes straight to an audio amplifier (IC7) through volume-control R25. The amplifier is held inoperative by flip-flop IC6-b until the upper logic path is satisfied. The audio stage can

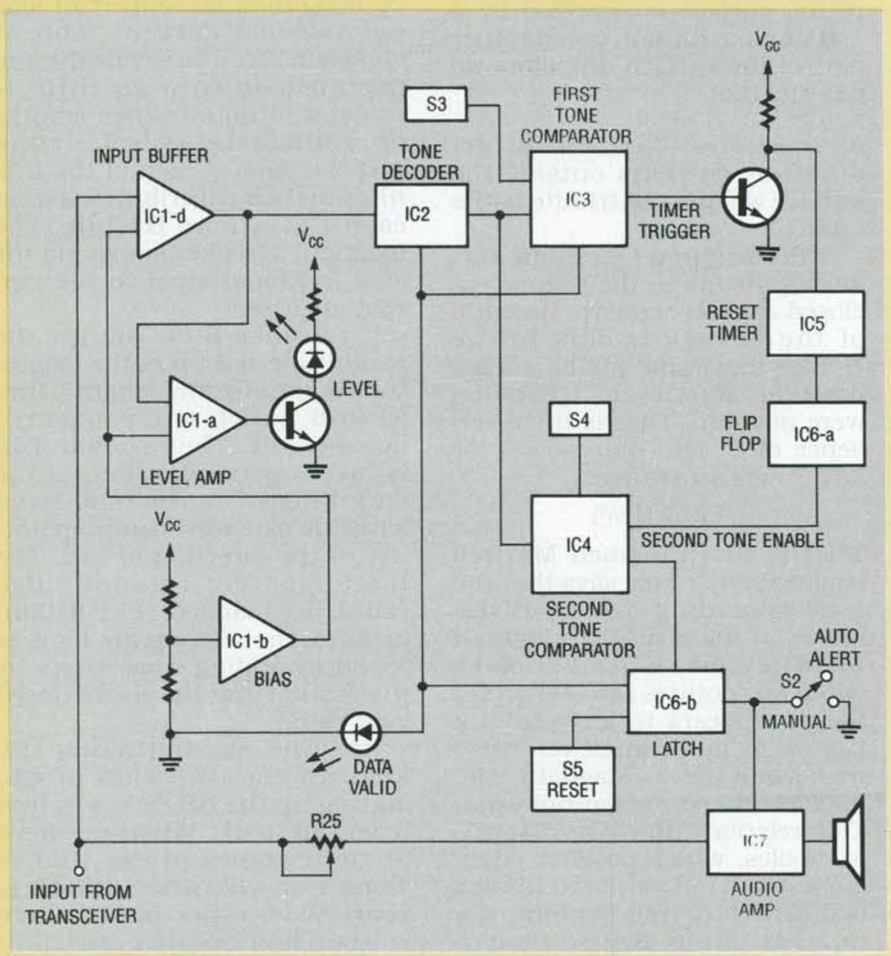


FIG. 1—DECODER BLOCK DIAGRAM. The lower input path goes straight to an audio amplifier (IC7), which is held inoperative until the upper logic path is satisfied.

also be turned on manually via switch S2.

In the upper path, IC1-d is an input buffer for the tone decoder, IC2. Buffering is necessary because the tone decoder can be damaged by high input-signal levels; the buffer limits levels to under 5 volts. The buffer is biased by IC1-b, which also biases IC1-a, the level-indicator amplifier. Driven by its buffer, the tone decoder provides two outputs. The first output indicates which DTMF tone is received. The data is sent to the two comparators that compare the decoder's output with the user-selected switch settings. More about the switches later. The decoder also puts out a DATA VALID signal (DV) that goes high when any valid tone is received, which keys timing logic later in the circuit.

The first tone comparator, IC3, triggers IC5 when the tone and switch inputs coincide and the timer runs for 4 seconds. The timer resets everything after that time period to prevent "hacking" a system entry, and it also provides the signaling to set and reset flip-flop IC6-a. The flip flop enables the second comparator to listen for the second tone. When IC4 validates the second tone, it triggers a latch, IC6-b, which enables the audio stage and turns on the call-alert light. Reset switch S5 unlocks IC6-b, thus preparing the monitor for the next call.

Circuitry

The schematic for the decoder section is shown in Fig. 2. The whole system runs on 5 volts (with the exception of the audio stage), so the output of IC1-d will swing up to just under V_{CC}, thereby protecting the tone decoder's input (IC2). At high audio input levels, however, IC1-d's output will clip, preventing the decoder from functioning. Otherwise, at normal receiver output levels, the decoder works fine. There are LEVEL-SET and DATA-VALID indicators (LED1 and LED2, respectively) on the board that we'll discuss in detail later on. Pin 5 of IC1-b is set to ½ V_{CC} so the outputs of all three op-amps idle at 2.5 volts. The level amp (IC1-a) is set up to drive LED1 at proper audio input.

The 74HC85's (IC3 and IC4) are 4-bit magnitude comparators that compare two 4-bit "words," and indicate whether one word is larger, smaller, or equal to the other. Inputs A0–A3 are tied to the 4-position DIP switches S3 and S4, and the decoder outputs are tied to comparator inputs B0–B3. When both words match (the words can be binary, BCD, or hexadecimal, which is the case with the decoder as there are 16 DTMF tones) the comparator output at pin 6 will go logic high.

Because the comparator's enable line (pin 3) has to be high to operate, IC3 will respond first, as its enable is brought high by the DV (data valid) output at pin 12 of the decoder. When that happens, flip-flop IC6-a is toggled by a 4-second input from the 555 timer (IC5) and the second tone DV signal. That allows IC4 to listen for the second valid tone. The timer resets the flip-flop and the device waits for the next input. If the second valid tone arrives within 4 seconds, IC6-b latches on, which turns on audio amplifier IC7 and lights LED4. Reset switch S5 will clear IC6-b.

The audio amplifier, IC7, is a Motorola MC34119. That part was chosen because it can be powered from up to 18 volts and, at rest, it draws virtually no current which makes it totally silent. Keep in mind, though, that neither speaker lead can be grounded, so if you plan to add an external speaker jack, isolate it if you are using a metal case.

The decoder will work from 6 to 12 volts AC, or 9 to 15 volts DC. Although the bridge rectifier will work with either input polarity, it is a good idea to ground the negative with a DC input in case you share a power supply with other equipment—in a mobile environment, for example. For home or office use, a 9-volt DC adapter works perfectly.

The encoder

The encoder schematic is shown in Fig. 3. The circuit consists of a tone encoder, a switch to go from the first tone to the second, and an amplifier to drive the speaker. The heart of the unit is the TCM5089 tone encoder, manufactured by Texas Instruments, that will generate all 16

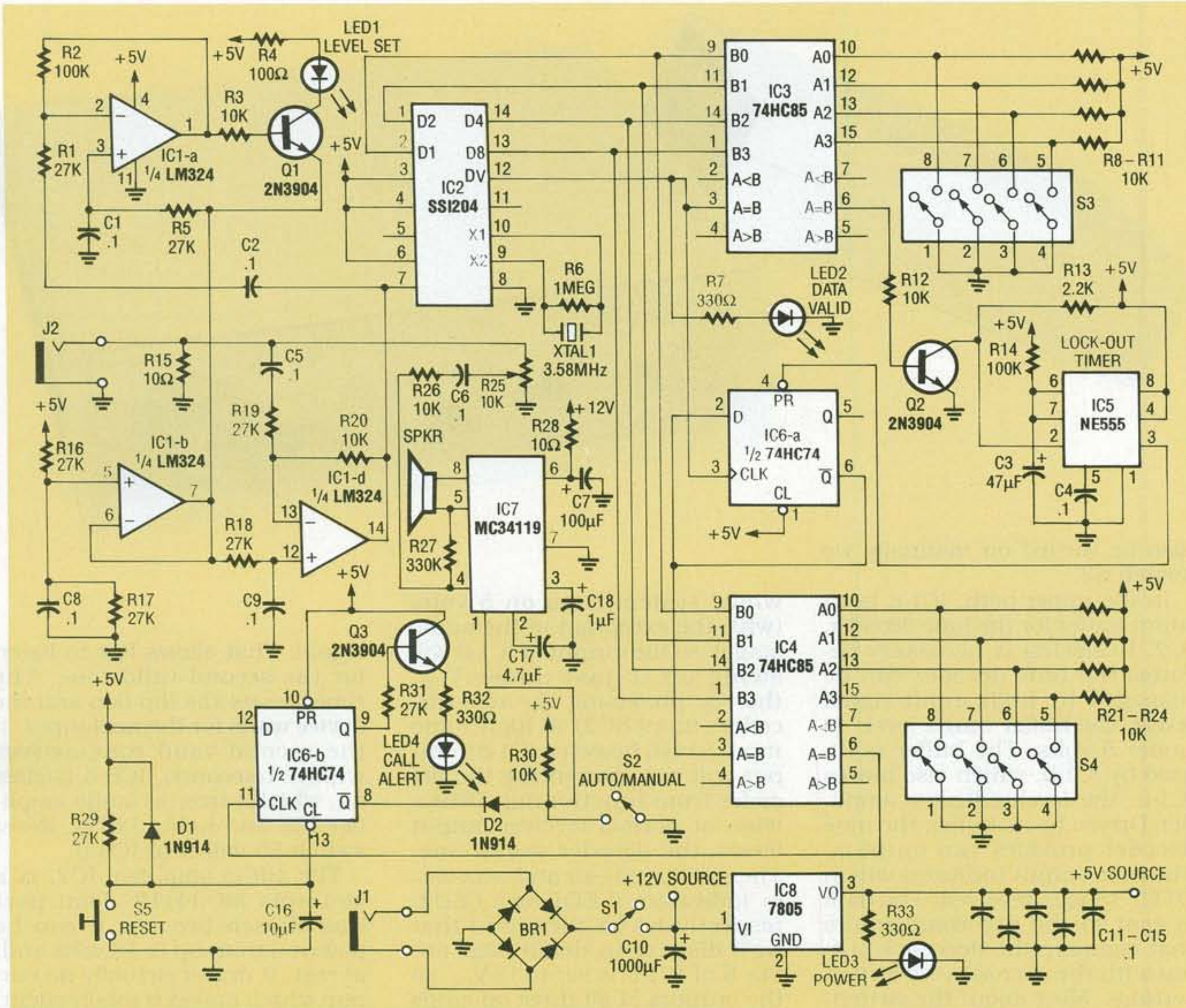


FIG. 2—SCHEMATIC FOR THE DECODER. Everything but the audio stage runs at 5 volts so the output of IC1-d will swing up to just under V_{CC}.

Touch Tones by returning a row pin and a column pin to V_{SS} or, in our case, ground. (Although most *Touch-Tone* keypads have only 3 columns and 4 rows, there is a fourth column available for use, or four additional tones called A–D, for a total of 16 tones.)

The encoder uses two 8-position DIP switches, one for each tone. As there are four columns and four rows, and one of each is

PARTS LIST—DECODER

All resistors are ¼-watt, 5%

R1, R5, R16–R19, R29, R31—27,000 ohms
R2, R14—100,000 ohms
R3, R8–R12, R20–R24, R26, R30—10,000 ohms
R4—100 ohms
R6—1 megohm
R7, R32, R33—330 ohms
R13—2200 ohms
R15, R28—10 ohms
R25—10,000 ohms, audio taper potentiometer with SPST switch (S1)
R27—330,000 ohms

Capacitors

C1, C2, C4–C6, C8, C9, C11–C15—0.1 µF, ceramic disk
C3—47 µF, 16-volt electrolytic
C7—100 µF, 16-volt electrolytic
C10—1000 µF, 16-volt electrolytic
C16—10 µF, 16-volt electrolytic
C17—4.7 µF, 16-volt electrolytic
C18—1 µF, 16-volt electrolytic

Semiconductors

IC1—LM324 quad op-amp
IC2—SSI204 *Touch Tone* decoder
IC3, IC4—74HC85 4-bit magnitude comparator
IC5—NE555 timer
IC6—dual D-type flip-flop
IC7—MC34119 power amp with enable
IC8—7805 5-volt regulator
D1, D2—1N914 switching diode
Q1–Q3—2N3904 NPN transistor
BR1—50-volt bridge rectifier
LED1, LED2—miniature red light-emitting diode
LED3—green panel-mount light-emitting diode
LED4—red panel-mount light-emitting diode

Other components

XTAL1—3.58-MHz crystal
S1—SPST switch (mounted on R25)
S2—SPST toggle switch
S3, S4—4-position DIP switch
S5—momentary pushbutton switch
J1, J2—audio and power input jacks (use whatever best suits your needs)

Miscellaneous: PC board, project case, speaker, control knob, labeling, hardware, wire, solder, etc.

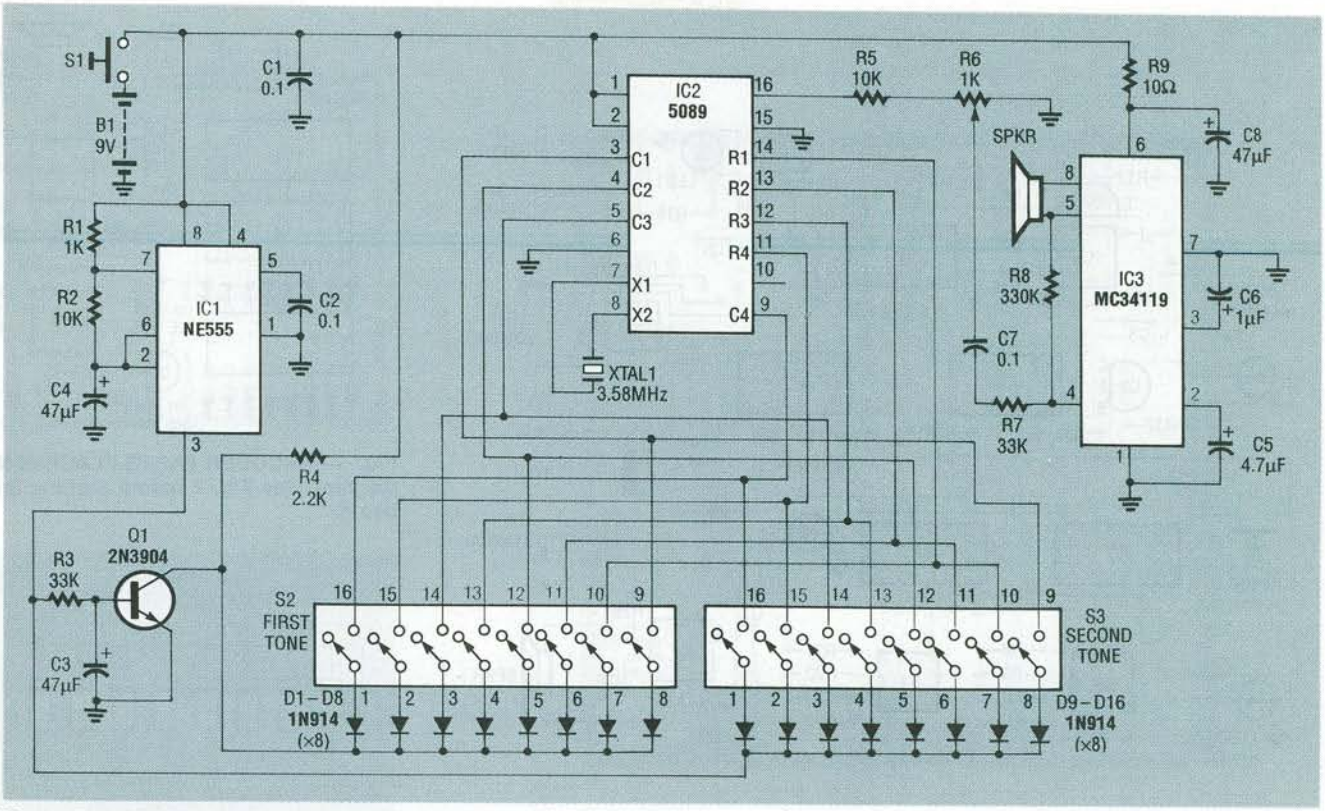


FIG. 3—ENCODER SCHEMATIC. The heart of the unit is the TCM5089 tone encoder that will generate all 16 *Touch Tones*.

required to determine a particular DTMF tone, two on positions are required per DIP. This is also the derivation of the expression "2 of 8" coding. The two DIP switches, S2 and S3, are controlled sequentially by IC1, a 555 timer running in its astable mode to generate a square wave. When first turned on by pushbutton switch S1, the output at pin 3 goes high and is inverted by Q1 which triggers S2 to key in the first tone. After a half second, IC1's pin 3 goes low to enable S3, generating the second tone. The RC network of C3-R3 at the base of Q1 creates a delay between the two tones; otherwise a combination of two of the same tones would be read as a single tone. The diodes in series with the switches isolate the row and column programming for each tone. The 300 milliwatt output from IC2 is attenuated and fed to IC3.

Decoder construction

With the exception of the controls and indicators, all parts for the decoder mount on the PC board. A pre-made PC board is available as part of a kit (see the parts list), and a foil pattern for the board is provided here if you want to make your own. Perforated construction board and point-to-point wiring can also be used. If you're using a PC board, follow the parts layout shown in Fig. 4.

The authors used jacks for J1 and J2 (for power and audio inputs, respectively) that mounted directly on the PC board. However, the jacks are not provided with the kit because each builder will have his own idea regarding

PARTS LIST—ENCODER

All resistors are ¼-watt, 5%
R1—1000 ohms
R2, R5—10,000 ohms
R3, R7—33,000 ohms
R4—2200 ohms
R6—1000 ohms, miniature PC-mount potentiometer
R8—330,000 ohms
R9—10 ohms

Capacitors
C1, C2, C7—0.1 µF, ceramic disk
C3, C4, C8—47 µF, 16-volt electrolytic
C5—4.7 µF, 16-volt electrolytic
C6—1 µF, 16-volt electrolytic

Semiconductors
IC1—NE555 timer
IC2—TCM5089N *Touch Tone* encoder
IC3—MC34119 audio amplifier
D1–D16—1N914 switching diode
Q1—2N3904 NPN transistor

Other components
XTAL1—3.58 MHz crystal
S1—momentary pushbutton switch
S2, S3—8 position DIP switch

Miscellaneous: 1-inch speaker, PC board, project case, 9-volt battery clip, foam rubber, wire, solder, etc.

Note: The following items are available from Project-Mate, Ste. 207, 2727 W. Manor Pl., Seattle, WA 98199 (206) 283-4700:

- **A decoder kit containing a PC board and all PC-mounted components (except J1 and J2)—$48.50 + $2.50 S&H**
- **An encoder kit containing a PC board, battery clip, and all PC-mounted components—$22.50 + $2.50 S&H**
(Orders may be combined for the same $2.50 S&H fee)
- **A 1-inch speaker—$4.50 post paid**
There is a 10% discount on a second kit, and a 15% discount on 5 or more by radio clubs.

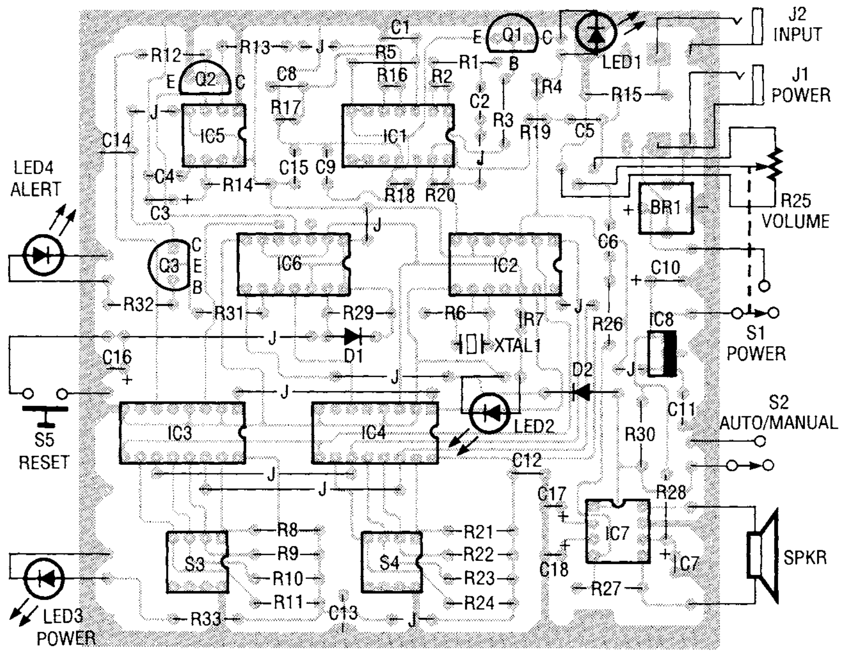


FIG. 4—DECODER PARTS-PLACEMENT DIAGRAM. With the exception of the controls and indicators, all parts for the decoder mount on the PC board.

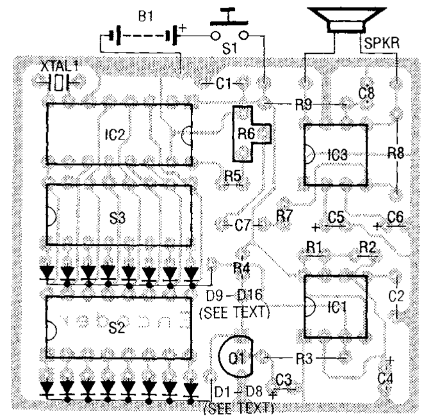


FIG. 6—ENCODER PARTS-PLACEMENT diagram. See Fig. 7 before stuffing this board.

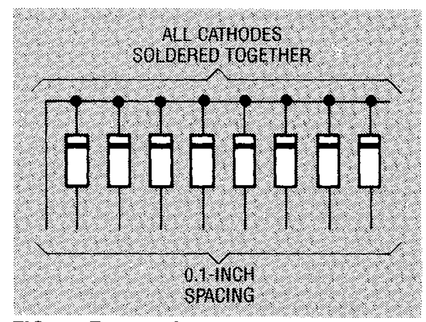
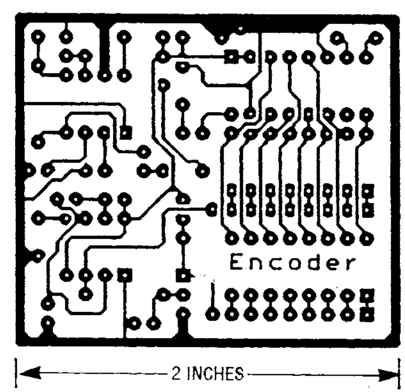


FIG. 7—THE TWO DIODE ARRAYS consist of eight 1N914 diodes spaced 0.1-inch apart with the cathodes all soldered to a common bus. A spare piece of perforated construction board can be used as a 0.1-inch spacing guide.



FOIL PATTERN FOR THE ENCODER.

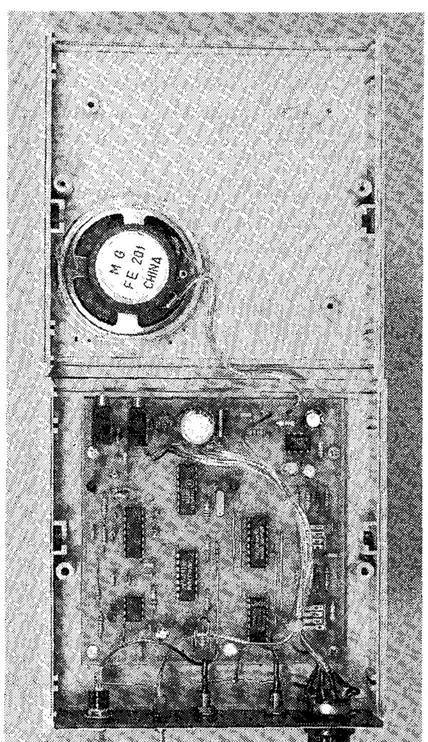


FIG. 5—THE FINISHED DECODER board can easily be installed inside any suitable enclosure. All front-panel controls return to ground, so a single wire can connect all of them to the board.

jack selection. By hardwiring the input connections, the jacks can be eliminated entirely.

The finished decoder board, shown in Fig. 5, measures 4×4 inches, with a loaded height of 1 inch. It can easily be installed inside any suitable enclosure. The prototype has the speaker mounted on the top side of the case; for mounting the unit under an automobile dashboard, you may want to mount the speaker on the bottom of the case for better sound quality. Keep in mind that all front-panel controls return to ground, so a single wire can connect all of them to the board.

Encoder construction

The encoder is assembled on its own PC board, which is also available from the source mentioned in the parts list or can be made from the foil pattern we've provided. Figure 6 shows the parts-placement diagram for the encoder.

Before you can build the encoder board, the two diode arrays (D1–D8 and D9–D16) must be assembled. Each array consists of eight 1N914 diodes spaced 0.1 inch apart with the cathodes all soldered to a common bus. Figure 7 shows how you should assemble the arrays, and a spare piece of perforated construction board can be used as a 0.1-inch spacing guide.

Position DIP switches S2 and S3 with the number-1 position on the outer edge of the board. (The prototype has the switches backward, although it doesn't af-

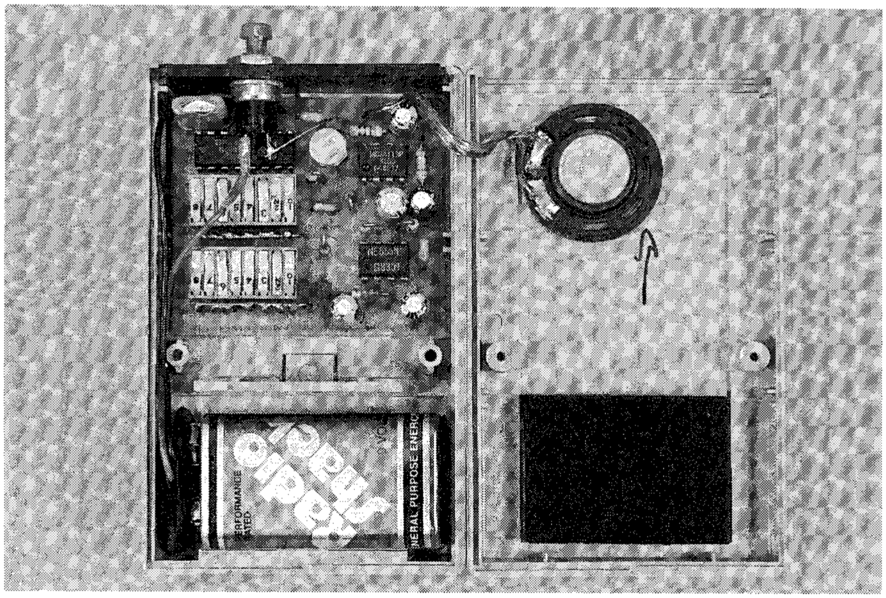


FIG. 8—THE POCKET-SIZED ENCODER CASE used for the prototype has a built-in compartment for a 9-volt battery, although you should secure a piece of foam rubber in the bottom of the battery compartment to hold the battery in place.

fect the operation.) The authors drilled a hole in the PC board underneath potentiometer R6 and a matching hole in the back of the case so that the level adjustment could be set with the case closed: this, however, is not necessary.

The pocket-sized case used for the prototype has a built-in compartment for a 9-volt battery, although you can use any case you like. The PC board is held inside the case with double-sided foam tape. Pushbutton switch S1, the battery-clip leads, and a 1-inch Mylar speaker are wired to the circuit board, and the switch and speaker are mounted on the front and top panels of the case, respectively. A 5/8-inch hole is drilled on the top of the enclosure for the speaker, which was secured to the case with some instant glue. We suggest that a bead of glue be placed completely around the speaker for a good acoustic seal. When you position the holes for the speaker and S1, make sure they do not interfere with the circuit board. When the case is assembled, the final step is to secure a piece of foam rubber in the bottom of the battery compartment to hold the battery in place. Figure 8 shows the completed encoder.

Preliminary setup

The first step is to pick an arbitrary two-bit code (two tones) and set both units to the same code. Legal codes are from 0-0 to D-D (0-0, 0-1, 0-2, etc.), including the "#," "*," and A–D tones. The prototype units were set to code 3-6, so we'll use that combination to demonstrate setting the DIP switches.

The decoder is hexadecimal, so two 4-position DIP switches are used to set the code—one DIP switch per tone. Because the 10K pull-up resistors in the decoder are connected to ground when a DIP switch is closed, an "on" switch position provides a low and an "off" switch position provides a high. Figure 9 shows the DIP-switch settings for S3 and S4 depending on which digit, or code, you have selected. For the 3-6 code, DIP-switch S3 must have switches 1 and 2 in the "on" position and 3 and 4 "off," and S4 must have switches 1 and 4 "on" and 2 and 3 "off."

The encoder requires the setting of two 8-position DIP switches, S2 and S3 (one DIP switch per tone), to generate the two-tone code. Figure 10 shows the DIP-switch settings for S2 and S3. From Fig. 10 we can see that, to generate the first tone (3 in this example), that DIP-switch S2 should have switches 3 and 7 closed. For the second tone (6 in this example), S3 should have switches 3 and 6 closed. At this point, when pressing S1 (with a good battery installed), the encoder should produce a two tone warble, and potentiometer R6 sets the volume.

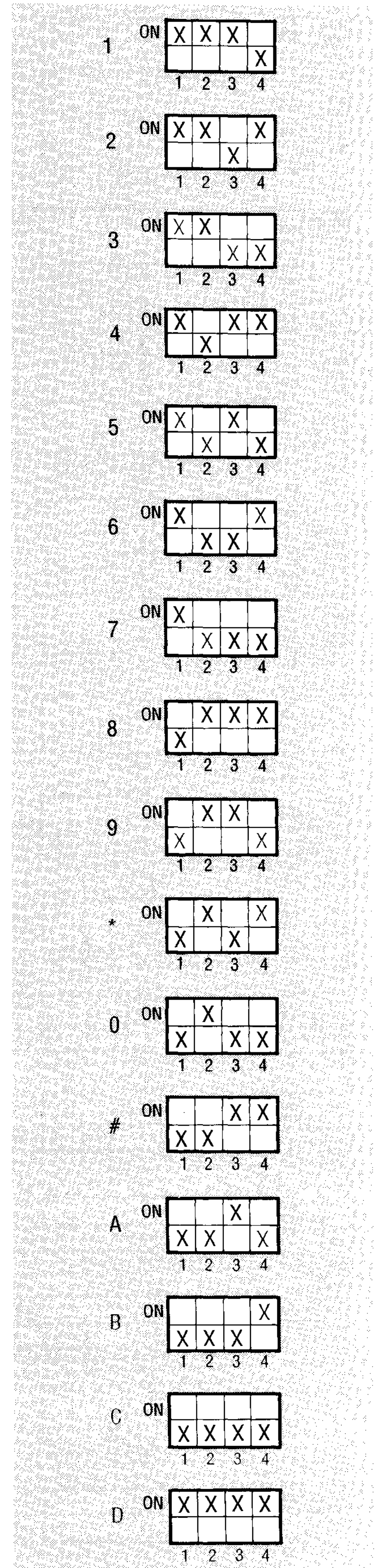
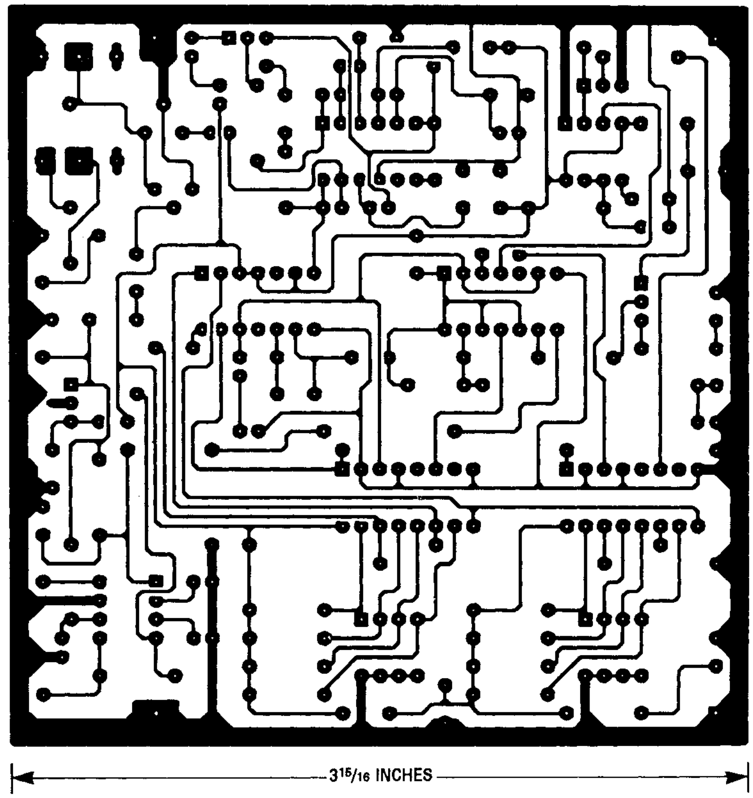


FIG. 9—THE DECODER has two 4-position DIP switches used to set the code. Here they're set for the 3-6 code.

		1	2	3	4	5	6	7	8
1	ON							X	X
		X	X	X	X	X	X		
2	ON					X		X	
		X	X	X	X		X		X
3	ON			X				X	
		X	X		X	X	X		X
4	ON						X		X
		X	X	X	X	X		X	
5	ON					X	X		
		X	X	X	X			X	X
6	ON			X			X		
		X	X		X	X		X	X
7	ON				X				X
		X	X	X		X	X	X	
8	ON				X	X			
		X	X	X			X	X	X
9	ON			X	X				
		X	X			X	X	X	X
*	ON		X						X
		X		X	X	X	X	X	
0	ON		X			X			
		X		X	X		X	X	X
#	ON		X	X					
		X			X	X	X	X	X
A	ON	X						X	
			X	X	X	X	X		X
B	ON	X					X		
			X	X	X	X		X	X
C	ON	X			X				
			X	X		X	X	X	X
D	ON	X	X						
				X	X	X	X	X	X

FIG. 10—THE ENCODER has two 8-position DIP switches, S2 and S3, that must be set to generate the two-tone code.



FOIL PATTERN FOR THE DECODER.

System test

The first test of the decoder is to apply power and see if LED2 (DATA VALID) flashes briefly. This indicates that the decoder, IC2, is functioning. Now, with a receiver supplying audio, adjust its volume using LED1 to set the level. With an FM receiver, and the squelch off on a quiet channel, the LED should show about ⅓ brightness. On a busy channel it should flicker following voice peaks. CB is somewhat different because the background noise is quieter, and here we adjust to an active channel. A weak glow following voice peaks is the correct setting. At this point the LED2 should remain off until a valid code ID received.

For two-meter testing, a scanner, set to the experimental portion of the band, can be used as the receiver and a hand-held used as the transmitter. Using the built-in *Touch-Tone* pad, pressing any *Touch-Tone* digit should cause LED2 to light, and code 3-6 will trigger the decoder on and you will hear your transmitter. The ALERT lamp, LED4, will stay lit after transmitting, and the RESET button will turn it off.

The next step is to set the encoder level by using it to key the decoder. Note that if the encoder is held directly against the mike, the audio may become distorted. Try holding the encoder a quarter of an inch from the mike element. Get it to the point where the receiving station hears clean *Touch Tones* at approximately the same level as voice. You will find that it takes very little audio from the encoder when it's placed close to the microphone.

For CB you can use a rig with a 50-ohm dummy load for the transmitter and another transceiver (a walkie-talkie) as the receive source. Set the encoder output level to work best with the transmitter, then set receiver audio. For an on-the-air test, set the levels and drive around with the encoder making various calls throughout the day. The system should work well and it will be a pleasure to have the rig quiet between calls. Another test procedure is to attach the encoder speaker to the decoder input with clip leads and fire up the system. The proper encoder output should be close to that for on-the-air use.

You can probably think of other applications. For example, the output of the ALERT lamp (LED4) can be used to control other devices in your shack. **R-E**