BY LAWRENCE R. LAFLER

A Low-Cost Emergency Broadcast System Monitor

Add-on circuit monitors the output of a broadcast receiver and sounds an alarm when an EBS warning signal is received

THE National Weather Service and the Civil Defense Agency, in conjunction with local broadcasters and other authorities, maintain an emergency warning system to alert the public in case of impending natural disaster or national defense emergency. This system consists of a network of AM and FM radio stations that will interrupt their normal programs to broadcast an emergency bulletin immediately after an official severe weather or Civil Defense warning is issued. You have probably heard tests of this emergency broadcast system (EBS) on local radio stations. During such tests, and in the event of an actual alert, participating stations broadcast a special two-tone signal used to activate warning devices at other radio stations and at regional Civil Defense offices.

For less than $25.00, you can build a circuit that will respond to the EBS alerting signal. This project receives signals from the earphone jack of a standard broadcast receiver and, in response

to the special EBS tones, actuates a Sonalert or similar audible alarm or a relay. For around-the-clock protection, the EBS Monitor and the radio to which it is connected can be left activated continuously. If an emergency occurs, the alarm could save your life.

How it Works. The EBS alert signal consists of simultaneous tones at 853 Hz and 960 Hz broadcast for 22.5 seconds. This unlikely combination of frequencies and its long duration make it easy to distinguish the warning signal from speech and music. (Its waveform is shown in Fig. 1.)

Commercial EBS alerting devices employ a separate tone decoder for each of the two audio frequencies and a time-delay circuit that triggers an alarm only when the two frequencies are present for 15 seconds or more. This is an expensive approach requiring a large battery power source. To minimize cost and battery drain without sacrificing performance, this project employs a single CMOS phase-locked loop (PLL) to detect the presence of both frequencies. Three other CMOS integrated circuits perform most of the remaining functions. The circuit, which is shown schematically in

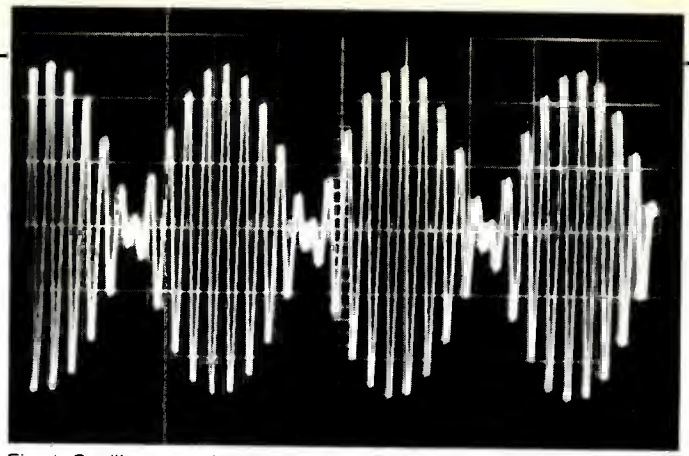
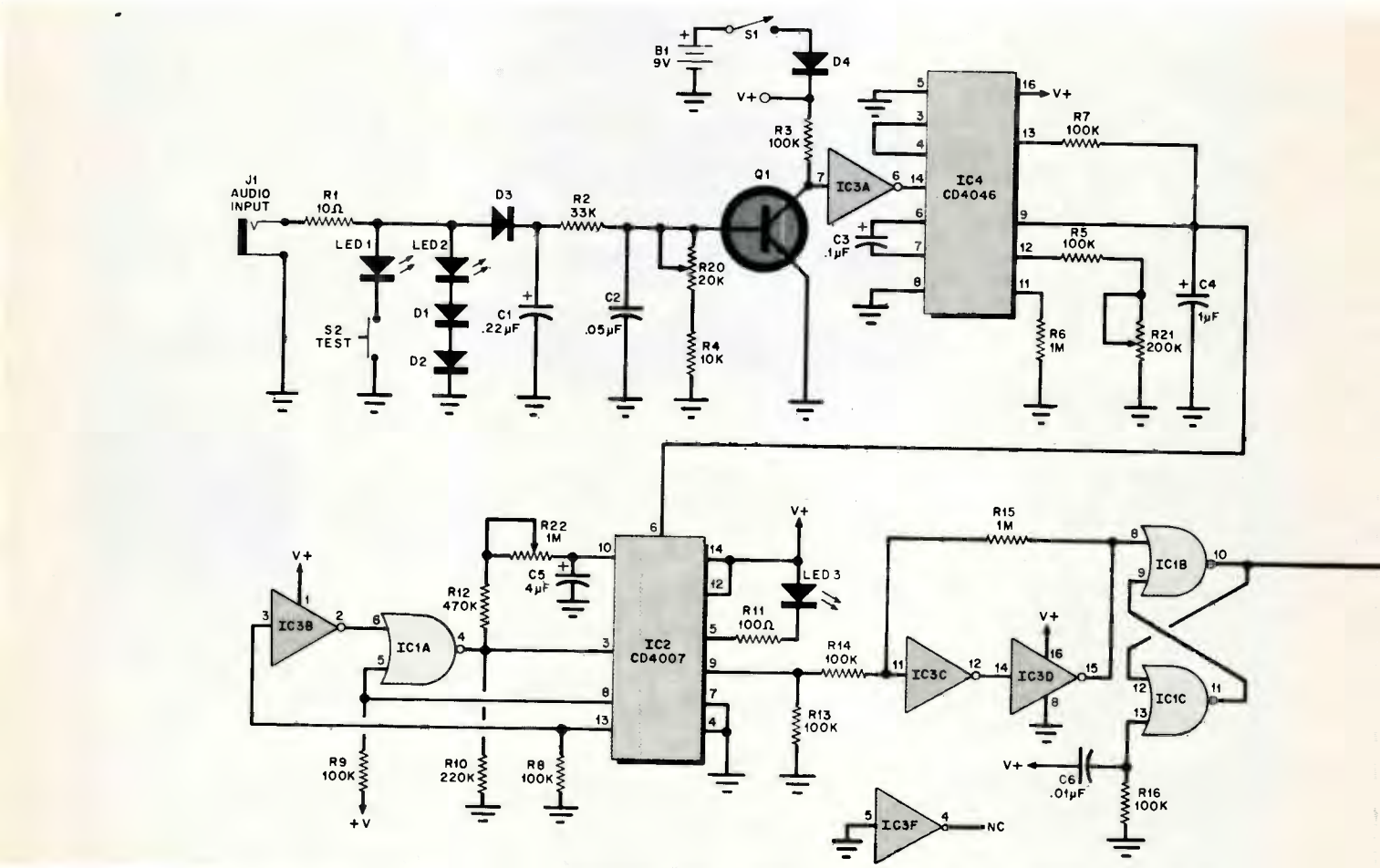


Fig. 1. Oscilloscope photo of the alert signal of the Emergency Broadcast System. It consists of two tones at 853 Hz and 960 Hz broadcast for 22.5 seconds.

Fig. 2, is such an energy miser that it will operate in its listening mode for more than one year on a single 9-volt transistor battery.

The one PLL is able to detect the two discrete audio tones by responding to the 107-Hz difference between their two frequencies. This 107-Hz difference tone can be separated from the rest of the alert signal by rectifying and filtering the signal. Diode *D3*, capacitors *C1* and *C2*, resistors *R2* and *R4*, and potentiometer *R20* perform this function.

Transistor *Q1* amplifies the 107-Hz difference signal and, with the help of inverter *IC3A*, converts it to a square wave that is then applied to the input (pin 14) of *IC4*, the phase-locked loop. The loop acts as a frequency-to-voltage converter that can be programmed to respond to a narrow band of frequencies called the *lock range*. Over this lock range, the output (pin 9) of the phase-locked loop will be a voltage that increases as the frequency of the input signal increases. For an input frequency



outside of the lock range, the PLL output voltage will approach either 0 or 9 volts, depending on whether the input frequency is above or below the lock range. Capacitors *C3* and *C4*, together with resistors *R5*, *R6*, and *R7*, and potentiometer *R21* limit the lock range of the PLL to between 100 and 115 Hz. When a 107-Hz signal is applied to the input of the PLL, its output voltage will be approximately 4.5 volts. This output voltage level can, therefore, be interpreted as an indication that a 107-Hz input frequency is present.

At this point in the circuit, a network is needed that will have a logic 1 output when its input is approximately 4.5 volts, and a logic 0 output when its input is either greater than or less than 4.5 volts. Integrated MOSFETs contained in *IC2* together with inverter *IC3B* and NOR gate *IC1A* form such a network. Thus, the presence of the EBS alert signal causes the output of *IC1A* (pin 4) to go high. However, difference frequencies close to 107 Hz that are occasionally contained in voice, music and noise can also cause the output of *IC1A* to momentarily go high. False alarms due to these normal audio components can be avoided by requiring that the output of *IC1A* be high for at least 15 seconds before the circuit triggers alarm.

This delay is obtained by having the output of *IC1A* charge capacitor *C5* through resistors *R12* and *R22* before the logic level is passed to the next portion of the circuit. As *C5* charges, the voltage at pin 9 of *IC2* increases. Eventually it reaches the level required to switch from logic 0 to logic 1 the output of the Schmitt trigger made up of inverters *IC3C* and *IC3D* and resistors *R14* and *R15*. The output (pin 15) of the Schmitt trigger is connected to the input of the alarm trigger flip-flop consisting of NOR gates *IC1B* and *IC1C*. When the output of the Schmitt trigger switches to logic 1, the output of the alarm trigger flip-flop (pin 10) switches from logic 1 to logic 0. Once this happens, the output of the flip-flop will remain low even if the output of the Schmitt trigger returns to logic 0.

The logic 0 appearing at the output of the flip-flop activates the oscillator made up of NOR gate *IC1D* and inverter *IC3E*. This oscillator generates a square wave that alternately turns *Q2* on and off, activating alarm *A1*.

The circuit contains a few other components whose functions should be noted. Capacitor *C6* and resistor *R16* generate a positive pulse which resets the alarm trigger flip-flop each time power switch *S1* is closed. This assures that the alarm will be silent when power is applied to the circuit. Light-emitting diodes *LED1* and *LED2* indicate when the audio output of the broadcast receiver that drives the circuit is at the proper level. The receiver's output should be adjusted so that, when TEST switch *S2* is closed, *LED1* flickers on and off but *LED2* remains dark. If volume is too low, neither LED will flicker. If volume is too high, both LEDs will flicker. Diode *LED3* is used to indicate when a 107-Hz signal is being detected. It glows whenever the output of NOR gate *IC1A* is at logic 1. Diode *D4* prevents damage to the circuit that would otherwise occur if the battery leads were to become inadvertently reversed.

Construction. The EBS Monitor is most easily assembled using a printed circuit board. The full-size etching and drilling guide for a suitable printed circuit board is shown in Fig. 3. Its corresponding parts placement guide appears in Fig. 4. Mount the integrated circuits using sockets or Molex Solderconns rath-

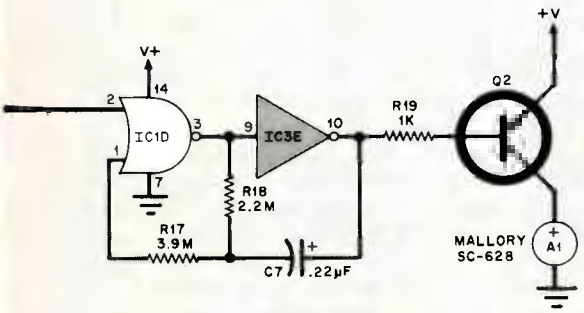


Fig. 2. The circuit in the project uses a CMOS phase-locked loop to detect the presence of the alert signal. The CMOS components cause little battery drain so that the monitor can be in use constantly.

PARTS LIST

A1—Solid-state audible warning device (Mallory SC-628 Sonalert or similar)
B1—9-volt transistor battery
C1,C7—0.22-μF, 15-volt tantalum capacitor
C2—0.05-μF, Mylar capacitor
C3—0.1-μF, 15-volt tantalum capacitor
C4—1-μF, 15-volt axial-lead aluminum electrolytic capacitor
C5—4-μF, 15-volt axial-lead aluminum electrolytic capacitor
C6—0.01-μF disc ceramic capacitor
D1 through D4—1N4001
IC1—CD4001 quad 2-input NOR gate
IC2—CD4007 dual complementary pair plus inverter
IC3—CD4009 hex inverter
IC4—CD4046 phase-locked loop
J1—Miniature phone jack
LED1—Green light-emitting diode
LED2—Red light-emitting diode
LED3—Yellow light-emitting diode
Q1—2N3904 npn silicon transistor
Q2—2N4402 pnp silicon transistor
The following are ¼-watt, 5% tolerance carbon-composition fixed resistors unless otherwise specified.
R1—10 Ω
R2—33 kΩ
R3, R5, R7, R8, R9, R13, R14, R16—100 kΩ
R4—10 kΩ
R6, R15—1 MΩ
R10—220 kΩ
R11—100 Ω
R12—470 kΩ
R17—3.9 MΩ
R18—2.2 MΩ
R19—1 kΩ
R20—20-kΩ, linear-taper, pc-mount trimmer potentiometer
R21—200-kΩ, linear-taper, pc-mount trimmer potentiometer
R22—1-MΩ, linear-taper, pc-mount trimmer potentiometer
S1—Spst switch
S2—Normally open, momentary-contact pushbutton switch
Misc.—Printed circuit board, suitable enclosure, IC sockets or Molex Solderconns, battery retainer and connecting clip, hookup wire, two-conductor cable, miniature phone plugs, hardware, etc.

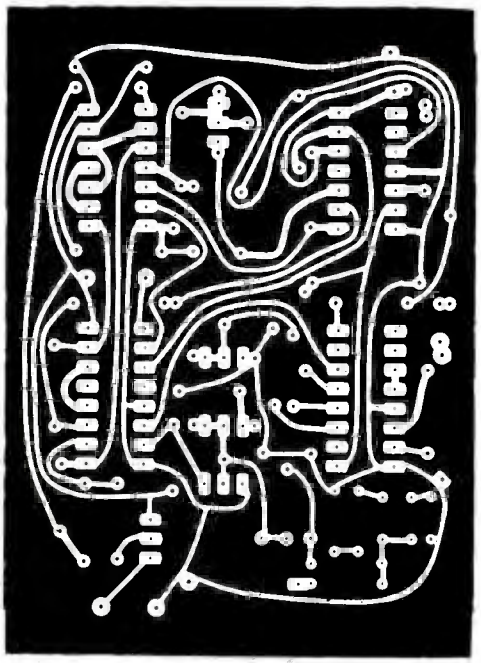
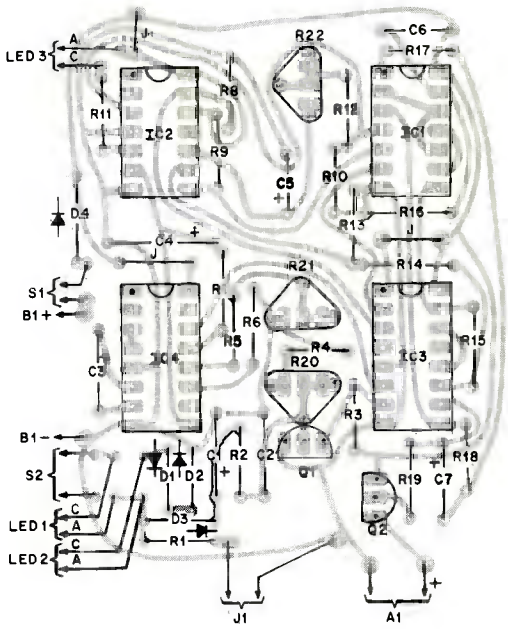


Fig. 3. Actual-size etching and drilling guide for a suitable printed circuit board.

Fig. 4. Component layout for the monitor's printed circuit board is shown below.



er than soldering them directly to the board. This makes replacement of defective ICs infinitely easier and eliminates the possibility of damaging them during soldering. Be sure to observe polarities and pin basings when you mount the diodes, transistors, LEDs, ICs, and electrolytic capacitors.

The LEDs should be mounted off the board so that they can project through the front panel of the enclosure that is employed to house the project. The switches should also be mounted on the front panel. Connect the LEDs and switches to the pc board using flexible hookup wire. Input jack *J1* should be mounted on the rear of the enclosure and connected to the board using two-conductor cable. Fasten a retaining clip for the 9-volt battery to the enclosure and connect suitably long leads from the appropriate foil pads to a 9-volt battery clip. Then install the battery and snap the connecting clip in place. Finally, prepare a two-conductor patch cord of convenient length terminated with miniature phone plugs at each end.

Alignment. There are only three adjustments that must be made before the EBS Monitor is ready for service. Potentiometer *R20* must be adjusted so that, when the audio output of the broadcast receiver is at the proper level and the EBS signal is present, a 107-Hz square wave will be applied to the input of the PLL. Potentiometer *R21* must be adjusted so that the lock range of the PLL is centered around 107 Hz. Third, potentiometer *R22* needs to be set so that, once *LED3* begins to glow, there will be a 12- to 18-second delay before the alarm sounds. The easiest way to make these adjustments is to first make a recording of the EBS alert signal when a local radio station is conducting an EBS test. Use a high-quality cassette or open-reel tape recorder that has an earphone or line-level output jack. After you have recorded the two-tone signal, patch the output of the recorder to the project's input jack and proceed as follows.

First, connect a voltmeter between pin 14 of *IC4* and the circuit ground. Then close switch *S1* and play back the EBS alert signal. (Rewind and repeat this step as necessary so that the tone is present during all of the remaining steps.) Hold switch *S2* closed and adjust the recorder's output level until *LED1* glows but *LED2* remains dark. Vary potentiometer *R20* until the voltmeter reads 3 to 5 volts dc. Vary potentiometer *R21* until *LED3* glows most or all of the time that the tone is present. Vary potentiometer *R22* until the delay between the application of the tone and the activation of the audible alarm is between 12 and 18 seconds. The delay can be reduced by moving the wiper of *R22* toward capacitor *C5* as viewed from the top of the board.

Use. Your EBS monitor is ready for service. Apply power to both the project and the broadcast receiver with which it will be used. Tune in a local radio station that participates in the Emergency Broadcast Service, has a strong signal in your area, and broadcasts 24 hours a day. If possible, choose an FM station, because static interference during an electrical storm will be less severe and the operation of the Monitor will be more reliable.

Patch the output of the receiver to input jack *J1* and, if necessary, adjust the output level so that *LED1* flickers in step with the demodulated signal when *S2* is depressed but that *LED2* remains dark. When the project is operating in its listening mode, *LED3* should flicker on occasionally. As long as it flashes brightly, the battery is in good condition. As the battery becomes weaker and needs replacing, *LED3* will diminish in brightness.

Take advantage of the broadcaster's EBS tests to check the circuit periodically for proper operation. These tests are never conducted at night, so you will not be disturbed by false alarms if you leave the project in its listening mode while you sleep. When the alarm sounds, remove power from the project and disconnect the patch cord from the output jack of your broadcast receiver. You will then be able to hear the emergency message that follows. ◇