CIRCUIT CIRCUS

By Charles D. Rakes

More NE602-Based Circuits

This time around we're going to continue from where we left off last month and explore a few more circuits built around the NE602 double-balanced mixer. In case you missed the last installment of *Circuit Circus*, here's a brief description of the NE602. The chip's 8-pin package contains a voltage regulator, an on-board oscillator, an input-differential amplifier, and a "Gilbert-cell" mixer. The oscillator can operate at frequencies up to 200 MHz, while the mixer circuit offers about 18 dB of gain with a noise figure of less than 5 dB. Its current requirement is normally less than 3 mA, making it a good choice for use in portable equipment.

PARTS LIST FOR THE VLF CW-SSB-AM RECEIVER

SEMICONDUCTORS
U1—NE602 double-balanced mixer, integrated circuit
U2—LM386 low-power audio amplifier, integrated circuit
Q1—2N3904 general-purpose NPN silicon transistor

RESISTORS
(All fixed resistors are ¼-watt, 5% units.)
R1, R2—100,000-ohm
R3, R4—1000-ohm
R5—10-ohm
R6—10,000-ohm potentiometer

CAPACITORS
C1–C3—.01-µF, ceramic-disc
C4—.05-µF, ceramic-disc
C5, C6, C13—0.1-µF, ceramic-disc
C7, C8—680-pF, ceramic-disc
C9—330-pF, ceramic-disc
C10—.0015-µF, mylar
C11—365-pF, variable broadcast (see text)
C12—220-µF, 16-WVDC, electrolytic
C14—100-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
L1, L2—1.8-mH choke (Mouser Electronics, part 43LH218)
T1—10,000-ohm to 2000-ohm audio transformer (Mouser Electronics, part 42KL002)
SPKR1—4 or 8-ohm speaker
Perfboard materials, enclosure, 9-volt power source, IC sockets, knob, wire, solder, hardware, etc.

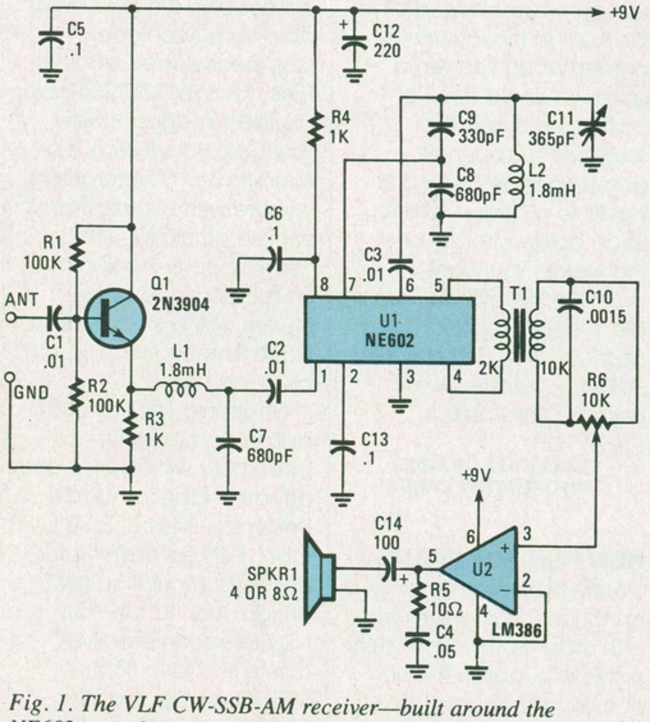

Fig. 1. The VLF CW-SSB-AM receiver—built around the NE602—can be used to tune a number of beacons and several mysterious RF signals that appear between 150 kHz and 250 kHz.

Once again, if you cannot locate the NE602 locally, it can be purchased by mail from D.C. Electronics, PO Box 3203, Scottsdale, AZ 85271-3203; Tel. 1-800-423-0070. Contact them directly for pricing and shipping information, etc.

VLF CW-SSB-AM RECEIVER

Our first circuit—a VLF CW-SSB-AM receiver, see Fig. 1—can be used to receive a number of beacons and several mysterious RF signals that appear between 150 kHz and 250 kHz. The circuit, built around the NE602 (U1), has at its input a 2N3904 general-purpose transistor set up in an emitter-follower configuration. That transistor functions as a buffer between the antenna and input of U1.

Inductor L1 and capacitor C7 form a simple low-pass filter that is used to attenuate RF signals above the 250-kHz level and to keep strong AM-broadcast signals from getting into U1's input circuit. Components L2, C8, C9, and C11 comprise a tuned circuit, which sets the operating frequency of U1's internal oscillator. Capacitor C11, a 365-pF broadcast-variable capacitor (which can be salvaged from an old broadcast receiver or purchased new), is used to tune the oscillator from about 150 kHz to 250 kHz.

The signal picked up by the antenna (not shown) is fed through the buffer (Q1) to the input of U1 at pin 1. Within U1, the incoming RF signal is mixed with the local-oscillator signal. The

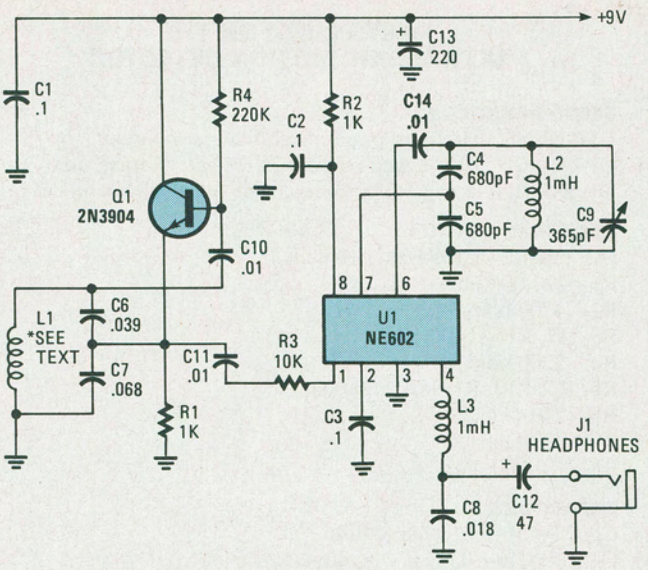

Fig. 2. In this metal-detector circuit, transistor Q1 (a 2N3904 general-purpose transistor) is configured as a Colpitts oscillator. When sense-loop L1 is brought near metal, the loop's inductance changes, shifting the oscillator's operating frequency.

resulting balanced-audio output of U1 at pins 4 and 5 is fed to the primary winding of an audio transformer, T1. The transformer's secondary is connected to the input of an LM386 low-power audio amplifier (U2) through volume-control potentiometer R6. The output of U2 is then used to drive SPKR1.

This type of receiver is commonly referred to as a DC receiver (direct-conversion receiver). The RF input is converted directly to audio by mixing the incoming RF signal with the signal produced by the local oscillator, which is tuned to about the same frequency. The DC receiver is one of the simplest and most sensitive receivers you can build.

The antenna for the VLF receiver should be as high and as long as possible for the best reception of long-wave signals, although a short antenna will work well enough to pull in a few of the stronger signals. In any case, you may find that experimenting with an antenna system can be just as much fun as building the receiver itself.

METAL DETECTOR

Our next entry, see Fig. 2, places the NE602 at the center of a simple yet sensitive metal detector. Transistor Q1, a 2N3904 general-purpose NPN transistor, is connected as a Colpitts oscillator, operating at a frequency of about 250 kHz. The oscillator's inductor, L1, serves as the metal sensor. When the loop is brought near a metal object, the loop's inductance changes, causing a shift in oscillator frequency, which is transmitted to pin 1 of U1.

Integrated circuit U1's internal oscillator is also operating at a frequency of about 250 kHz. When the two oscillators are operating at, or about the same frequency, U1's mixer output at pin 4, is an audio tone that equals the difference frequency of the two oscillators. If the loop oscillator is operating at 250 kHz and the local oscillator is operating at 250.5 kHz, the audio tone would be the difference of the two, or 500 Hz.

The audio tone passes through a low-pass filter, made up of L3 and C8,

PARTS LIST FOR THE METAL DETECTOR

RESISTORS

All resistors are ¼-watt, 5% units.)
R1, R2—1000-ohm
R3—10,000-ohm
R4—220,000-ohm

CAPACITORS

C1–C3—0.1-µF, ceramic-disc
C4, C5—680-pF, ceramic-disc
C6—.039-µF, mylar
C7—.068-µF, mylar
C8—.018-µF, mylar
C9—365-pF, broadcast variable (see text)
C10, C11, C14—.01-µF, ceramic disc
C12—47-µF, 16-WVDC, electrolytic
C13—220-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

U1—NE602 double-balanced mixer, integrated circuit
Q1—2N3904 general-purpose NPN silicon transistor
L1—See text
L2, L3—1-mH choke (Mouser Electronics Part 43LH210)
J1—Headphone jack
Perfboard materials, enclosure, 9-volt power source, #20 enamel-coated copper wire, IC socket, wire, solder, hardware, etc.

PARTS LIST FOR THE ULTRASONIC MOTION DETECTOR

SEMICONDUCTORS

U1—NE602 double-balanced mixer, integrated circuit
Q1–Q5—2N3904 general-purpose, NPN silicon transistor
D1, D2—1N914 general-purpose, small-signal silicon diode

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—220,000-ohm
R2—4700-ohm
R3, R7, R11—1000-ohm
R4—2200-ohm
R5, R6, R10, R13—100,000-ohm
R8—270-ohm
R9—470-ohm
R12—10,000-ohm

CAPACITORS

C1–C3—.01-µF, ceramic-disc
C4, C5, C16—0.1-µF, ceramic-disc
C6, C7—.0033-µF, ceramic-disc
C8—680-pF, ceramic-disc
C9—220-pF, ceramic-disc
C10, C11—4.7-µF, 16-WVDC, electrolytic
C12—10-µF, 16-WVDC, electrolytic
C13—47-µF, 16-WVDC, electrolytic
C14, C15—220-µF, 16-WVDC, electrolytic

INDUCTORS

L1—1.8-mH choke (Mouser Electronics, part 43LH218)
L2—27-mH choke (Mouser Electronics, part 43LH327)
L3—33-mH choke (Mouser Electronics, part 43LH333)

ADDITIONAL PARTS AND MATERIALS

SPKR1, SPKR2—2-inch Piezo tweeter speaker)
BZ1—Piezo buzzer
Perfboard materials, enclosure, 9-volt power source, IC socket, wire, solder, hardware, etc.

and then travels on to the headphone jack (J1) through coupling capacitor C12. When the sense loop is passed over a metal object, the Colpitts oscillator's frequency is shifted, causing the audio tone to change, thereby indicating that metal has been detected.

Inductor L1 is a home-made coil, made from 5 turns of #20 enamel-coated copper wire wound on a 9-inch diameter wood or plastic form. After winding the coil, tape the windings in place and attach a non-metallic handle to the search loop. The coil should be connected to the circuit via shielded mike or mini-coaxial cable.

To obtain the best operating stability, the metal-detector circuit should be neatly assembled (keeping the component leads as short as possible) and housed in a metal cabinet. Transistor Q1 and its associated components should be located away from U1 and its support components, so that the two oscillators won't lock together when the circuit is tuned for a very low-frequency, audio-output tone. A standard 9-volt transistor-radio battery will do for the power source.

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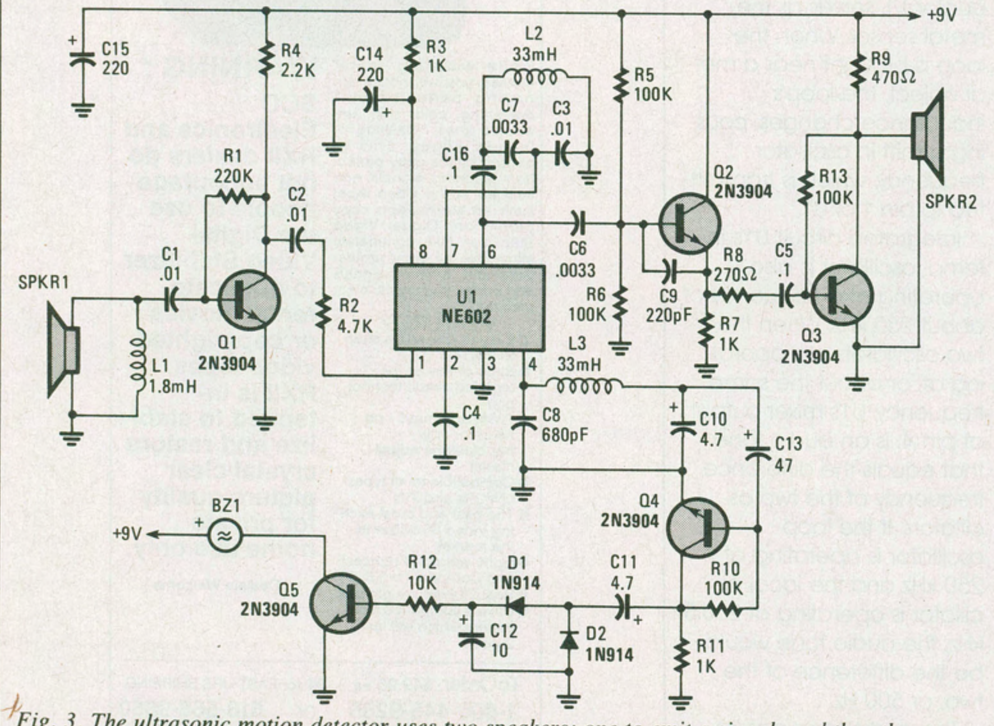

Fig. 3. The ultrasonic motion detector uses two speakers; one to emit a signal, and the other to detect the reflected signal. If motion—which causes a slight shift in the emitted signal frequency—is detected, the difference between the emitted and reflected signal is used to sound a buzzer.

CIRCUIT CIRCUS

(Continued from page 74)

To use the circuit, position the search loop away from any metal object and adjust C9 for a low-frequency audio tone. It is much easier to detect metal objects at greater distances from the search loop if the output-tone's frequency is very low. That's because it is much easier to detect a two- or three-hertz change at 15 Hz than at 150 Hz. Therefore, it is wise to set C9 for the lowest possible output frequency for maximum sensitivity. When searching for buried objects, position the search loop parallel to the ground and about one inch above its surface. Then simply sweep over the desired area.

ULTRASONIC MOTION DETECTOR

Our final entry for this month, shown in Fig. 3, places the NE602 in the middle of an ultrasonic motion-detector circuit. The component values shown for L2, C3, and C7 set U1's internal oscillator to a frequency of about 20 kHz. Transistor Q2 is connected in an emitter-follower configuration and is used to isolate the local oscillator's tank circuit from loading effects of the speaker-driver circuit. It is also used to couple the 20-kHz oscillator signal to the input of Q3 (the speaker driver). Transistor Q3 increases the signal to a level suitable to drive a piezo tweeter, SPKR2.

A second piezo speaker, SPKR1, operating as a microphone, is connected across L1 (a 1.8-mH choke), which greatly attenuates any low-frequency sounds that might reach the speaker and interfere with the circuit's operation. That high-pass filter passes the 20-kHz signal to the input of a grounded-emitter amplifier, Q2, and on to the input of U1 at pin 1.

A low-pass filter made up of L3, C8, and C10 allows frequencies below 50 Hz to pass to the input of Q4, another grounded-emitter amplifier. Diodes D1 and D2 convert the low-frequency signals to DC, which is then used to bias Q5 on, causing BZ1 to sound.

The operation of the motion detector is simple. The two piezo speakers are located side-by-side, with about 1-inch separation between edges and facing in the same direction. One speaker, SPKR2, operates as an output device, sending out a 20-kHz signal, while the other speaker, SPKR1, operating as a mike, picks up any reflected 20-kHz sound. As long as there's no movement, the frequency picked up by SPKR1 is the same as the frequency leaving SPKR2.

But when an object moves in front of the speakers the 20-kHz sound is slightly shifted in frequency due to the Doppler effect. The difference in frequency is picked up by SPKR1, amplified by Q1, and fed to pin 1 of U1. If the reflected signal is 20,010 Hz and the transmitted signal is 20 kHz, the difference frequency is 10 Hz. The 10-Hz signal appears at pin 4 of U1 and then passes through the low-pass filter to the amplifier and sounder circuits.

The motion detector can detect a person passing in front of the speakers as far as 10 feet away; smaller objects must be closer. The rate of movement also makes a difference in the detection range of the circuit. A faster moving object will produce a greater output and will be detected at a greater range. ■