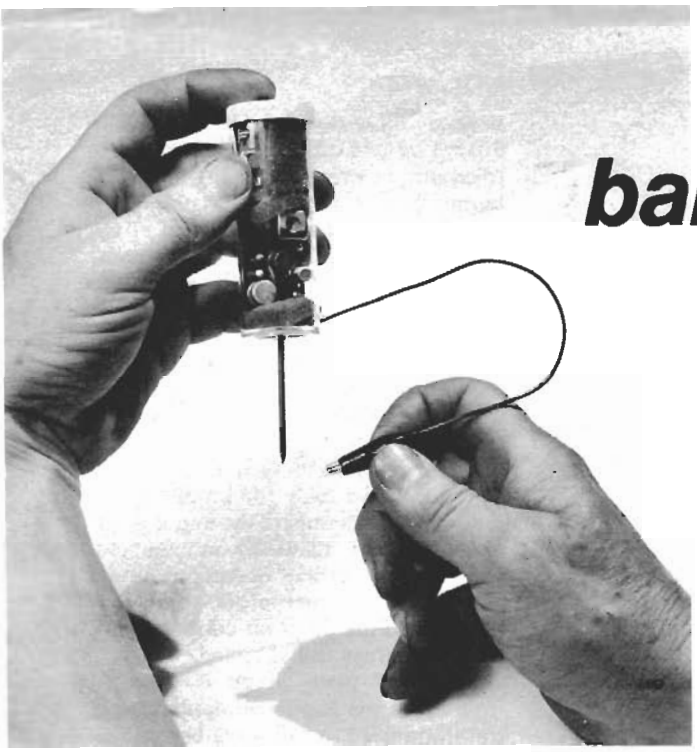


bargain transistor signal squirter

Simple one-evening project delivers a handy little signal generator for audio, i.f., and rf circuits

by JOSEPH V. D'AIRO

ANYONE WHO BUILDS OR SERVICES AUdio or rf equipment needs some type of signal generator. But as a rule, signal generators are bulky, expensive, complex, and inconvenient to use. This one is an exception to the rule.

Dubbed the *Signal Squirter,* it is a self-contained, hand-held signal generator that uses only two "bargain" transistors, and half a handful of other easy-to-obtain components.

By "squirting" a signal consisting of af and modulated 455 kHz i.f., with harmonics that extend above the AM broadcast band, it pinpoints defective stages in most types of audio and rf equipment at the touch of a button.

How it works

The Squirter combines an audio-frequency multivibrator and a radio-frequency oscillator, which interact in a manner that produces a complex waveform with components that spread from the audio through the i.f. and into the higher radio frequencies.

A multivibrator is basically two cascaded amplifier stages, with the output of the second connected back to the input of the first. Each amplifier inverts the signal applied to it and feeds it back to its partner. In effect, each stage provides positive feedback for the other. This results in oscillation.

Q1 and Q2 in Fig. 1 are the two amplifiers, coupled together by C2 and C4. R3 and R4 provide bias, and R2 and R5 emitter stabilization. C6 bypasses R5 for the audio and radio frequencies, increasing stage gain. The frequency of audio oscillation is determined primarily by C2, C4, R3, and R4.

In the radio-frequency oscillator, T1 provides positive feedback, frequency selection, and impedance matching for Q2. C3 and C5 bypass the cold ends of the two windings to ground, preventing rf signal loss in R4 and R6. Their values are too small to affect the audio frequencies materially.

The output signals are coupled through C4 to Q1, where they are amplified and then coupled to the probe by C1.

Since Q1 and Q2 are common to the signal paths of both oscillators, they act as modulator-mixers. All combinations of the two original and the sum and difference frequencies generated by the two oscillators, plus their harmonics, are present at the output.

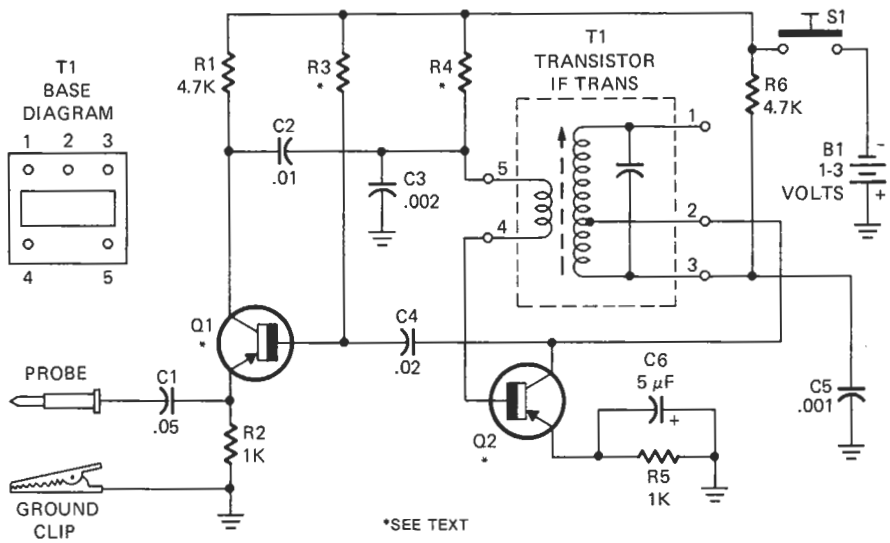


FIG. 1—SCHEMATIC SHOWS simplicity of unit, which uses only two transistors, a 3-volt battery, and several resistors and capacitors.

PARTS LIST

CAPACITORS:
C1—.05 μF, 200 volts or greater, ceramic
C2—.01 μF, 25 volts, miniature ceramic
C3—2,000 pF, 25 volts, miniature ceramic
C4—.02 μF, 25 volts, miniature ceramic
C5—1,000 pF, 25 volts, miniature ceramic
C6—5 μF, 3 volts, miniature electrolytic

RESISTORS:
R1, R6—4,700 ohms, ¼ watt, 10%
R2, R5—1,000 ohms, ¼ watt, 10%
R3, R4—¼ watt—see text

TRANSISTORS:
Q1, Q2—Rf "bargain" transistors—see text

MISCELLANEOUS:
B1—1-3 volts; one or two type "N" cells or mercury button (Mallory RM520), or Nicad button (Eveready N24)
T1—Miniature 3rd i.f. transformer (Lafayette 99 F 63034, catalog 710)
S1—Subminiature spst normally-open push-button switch (Grayhill 39-1)
Empty plastic medicine bottle and cap or other housing, two-inch finishing nail or other probe, miniature alligator clip and insulator, foam rubber or cotton wadding, phenolic or other circuit board.

Parts selection

Parts for the Signal Squirter are readily available and easily substituted.

Q1 and Q2 can be either silicon or germanium. They should have betas of about 50 and collector-emitter leakages below 10 microamperes at three volts. If

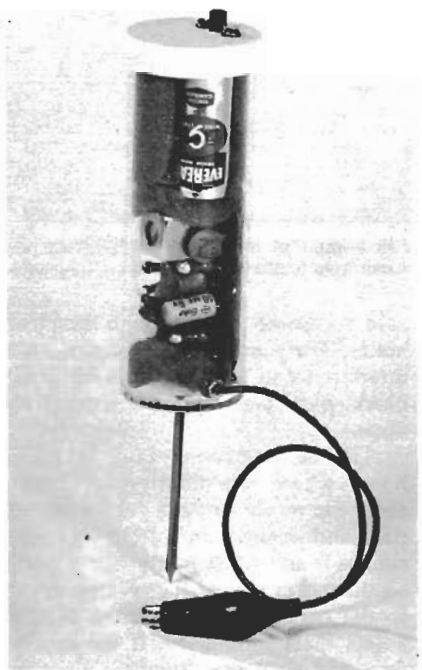
the transistors can't be checked out beforehand, select the best units by substitution in the Squirter.

Don't forget to reverse the polarity of B1 and C6 if npn transistors are used.

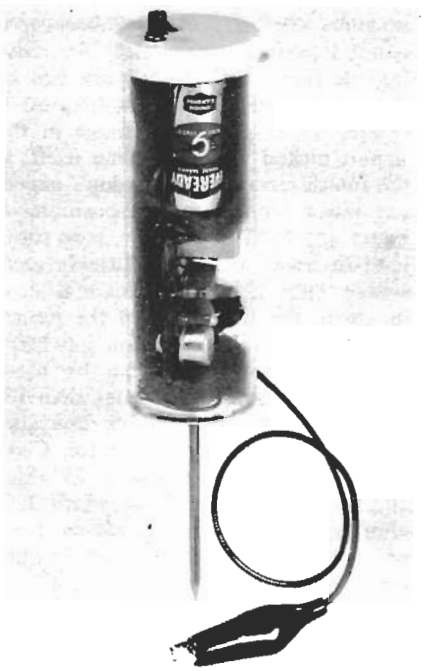
Quarter-watt resistors strike the best compromise between size and price, but you can use anything on hand that you have room for.

The capacitors can also be whatever there is room for. Miniature ceramic disc capacitors are generally good and maintain a moderate cost. C1 should be a high-voltage unit, especially if you expect to use the Squirter in tube-type equipment.

Most of the parts can be salvaged from a discarded transistor radio, if desired.



CLOSE-UP of the assembled "squirter". This one is built into a pill bottle.



ANOTHER VIEW shows how parts are cushioned with pieces of foam rubber.

Construction

Any practical method of construction and any non-metallic housing can be used for the Squirter. The prototype model was built on a piece of perforated phenolic board and installed in a plastic medicine bottle, for easy handling.

No printed circuit pattern was developed—it would be nearly impossible to accommodate all the types and sizes of components that could be used.

Whatever type of construction is decided upon, the general layout shown in the schematic diagram (Fig. 1) should be followed for best results. Don't forget to allow room in the housing for the batteries and the push-button switch.

The Squirter will operate satisfactorally with any supply voltage from about 1 to 6. However, it should be limited to a maximum of 3 volts to prevent possible excessive signal radiation. A pair of type "N" cells were used in the original model, but a single Nicad or mercury button cell could be used to conserve space (see Parts List). In any case, be sure that adjacent cells are insulated from each other and from internal wiring.

A 2-inch finishing nail makes an excellent probe for the medicine bottle version. Heat the nail and push it through the closed end of the bottle to make its mounting hole. Drilling the plastic is not recommended, as it will crack easily. Punch a second hole for the ground lead.

Before installing the nail, solder a lead to it that is long enough to reach back out the bottle. This will allow the probe to be connected before the board is installed in the bottle. After placing the nail in its hole, cement it in place, for rigidity.

The supply leads from the circuit board must be long enough to reach the batteries and switch when the Squirter is assembled. All wiring is completed before the Squirter is mounted in its case.

Pad the inside of the medicine bottle liberally with foam rubber or cotton wadding to support the board and batteries.

Begin actual construction with only Q2, R5, R6, C3, C5, C6, and T1. Omit all other parts temporarily. (A transistor socket can be used for Q2 if you intend to select transistors.) Substitute a one-megohm potentiometer for R4, setting it to about 500,000 ohms. Place an operating AM radio nearby—its antenna as close to the Squirter as possible.

Connect the batteries and tune the radio around the band, listening for a "swishing" sound or a prominent beat note. Adjust the pot to the highest resistance setting that gives a fairly even distribution of sounds across the band.

If no sound is heard, try different settings of the pot and tune again. If still no sound is heard, re-check wiring, move the radio closer, or try a different transistor for Q2. It may be helpful to attach a short piece of wire to the collector of Q2.

When the best setting for the pot has been found, disconnect it and measure the resistance it is set to. Use the nearest value fixed resistor (10%) for R4.

Next, wire in the rest of the components, substituting the pot for R3 this time. Connect a short piece of wire to the emitter of Q1, and again, listen for a signal in the radio. Adjust the pot for maximum output and best tone at about 910 kHz, then measure its value and substitute a fixed value resistor.

You may now want to re-adjust R4.

When the Squirter is operating to your satisfaction, connect the ground cliplead to a ground point in the radio, and the output from C1 to the input of an i.f. stage, or to a piece of wire that is as close to one as possible. Set the dial of the radio to about 1600 kHz and adjust the slug in T1 for maximum output.

As a final check, set the volume control on the radio to about one-third of the way up and connect the output from C1 to its center terminal. A loud squeal should come from the radio.

The board can now be installed in its case with its battery supply.

Using the Squirter

When troubleshooting a piece of equipment with a signal generator, a repairman starts injecting signals into the last stage of a defective unit (usually the audio output stage) and works his way forward, checking each stage along the signal path. When he finds a stage that does not process the signal properly, he investigates that stage more closely, checking voltage, resistance, etc., to find the defective component(s). This is the procedure to be followed with the Squirter.

Connect the ground clip to a convenient ground point in the unit under test. Then, working forward from the last stage, touch the probe to the input of each successive stage while monitoring the output.

Assuming all circuits following the one under test have checked out "good", the stage is probably defective if no output is detected, and should be looked into more closely.

Make allowances for various differences in stage gains and impedances when using the Squirter (or any other signal injector). **R-E**