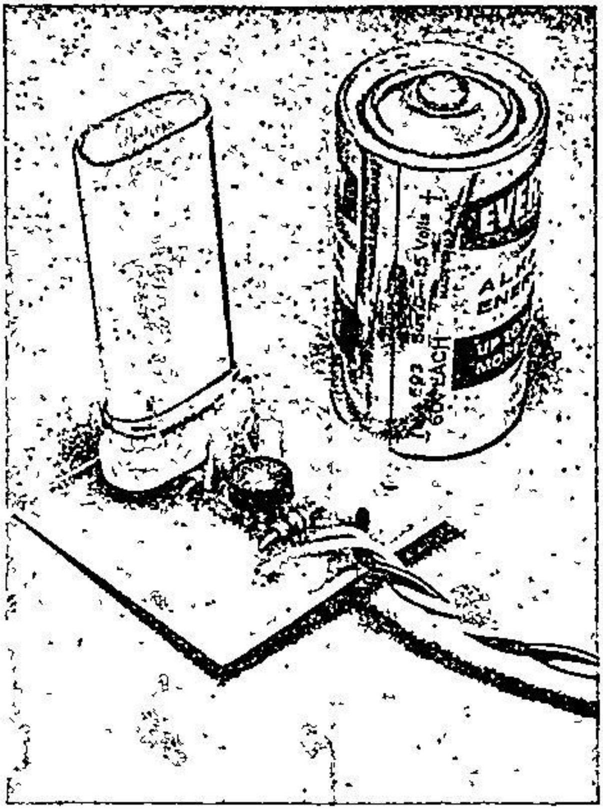
L'IL RICHIE

SIMPLE, STABLE, HARMONIC-RICH CRYSTAL OSCILLATOR IS BUILT AROUND A LOW-COST INTEGRATED CIRCUIT

By DON LANCASTER



L'il Richie is a small one—it's shown here alongside a conventional "C" cell—but the crystal is a 100 kHz bar and is larger than most crystals

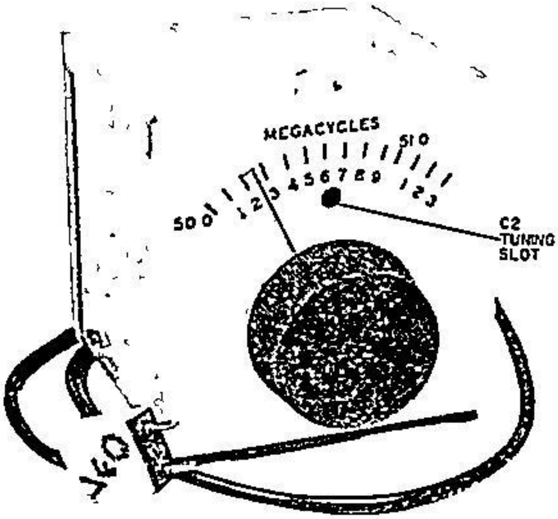
TAKE ONE low-cost integrated circuit, two resistors, one capacitor, and one crystal—combine properly—turn on the power, and you can generate crystal-controlled sine or square waves at any frequency between 100 kHz and 3 MHz, and, with slight modification, the 3- to 10-MHz range Uses of the "L'il Richie" are as varied as the user's imagination.

Amateur radio operators will find the harmonic-rich output useful as 100-kHz or 1-MHz crystal calibrators As a bonus, the addition of an output tank circuit creates a flea-power transmitter for field days, antenna testing, and hidden-transmitter hunts.

For AM servicing, just insert a 455-kHz crystal, and you have an i.f alignment generator. Switch to 500-, 1000-, or 1500-kHz crystals, and you have a handy signal generator for dial calibration, tracking adjustments, or antenna and r.f stage tuning

For TV or FM work, plug in the need-length of B&W Miniductor coil #3007 for *L1*. Unwind about half a turn from each end of the coil to serve as connecting leads. The coil length given does not include the leads

Two capacitors in parallel cover the entire 2-MHz frequency band. The larger capacitor, *C2*, is variable to 100 pF and determines the tuning range of the band. It is screwdriver-adjusted through a hole in the front panel. The smaller capacitor, *C1*, is variable to 15 pF and



Alignment of the VFO is a simple matter, and requires no special test equipment All you need is a receiver to monitor the VFO signal while you adjust capacitor C2 until the signal is heard.

tunes in the desired frequencies It is equipped with a vernier dial for ease of calibration and tuning The capacitors and the coil are connected as shown in Fig. 2

Both capacitors should be of high quality and of rugged construction to insure frequency stability. They are both mounted on a heavy aluminum subpanel, and the entire assembly is housed in a 4" x 4" x 4" aluminum box.

Use heavy pieces of wire—No. 12 or larger—to join the capacitors together. Connect the coil between the high side of the capacitors and the top of a 1" porcelain insulator. Affix solder lugs at both extremes of the insulator before mounting.

Strip one end of a short piece of RG-58/U cable and solder the center conductor to the lug on the high side of the insulator along with the coil terminal. The shield strands of the cable go to the ground lug under the insulator, together with the common (ground) lead from the capacitors. Be sure there is a good ground to the chassis.

The coax cable is run through a grommeted hole in one side of the case, and the free end is terminated with a suitable crystal holder that will mate with your particular crystal socket. Be sure to mark the pin with the ground shield, as well as the grounded side of the crystal socket on your transmitter Always connect ground to ground.

Alignment. The alignment of the VFO can be a little tricky, but if you proceed slowly and carefully, you should have no trouble at all. Plug the VFO into the crystal socket of your transmitter; then fire up the transmitter and allow it to warm up with plate voltage applied to the oscillator only.

Set the VFO's main tuning dial (*C1*) near its center of rotation. Turn on your receiver and set it to a frequency in the middle of the VFO's expected operating range. Through the access hole, tune *C2* —very slowly—until the receiver picks up the VFO signal. Alternately tune *C1* and *C2* for the strongest signal.

Put a dummy load across your transmitter's antenna output and set the transmitter to "transmit." If the transmitter loads properly, fine. If it does not, you are probably working on a frequency outside of the transmitter tuning range, and you must retune *C2* to operate in the correct frequency range

After you find the point where the transmitter loads properly, and you can pick up the signal, mark the receiver-indicated frequency on the VFO dial as your first calibration point Continue tuning the band, resetting *C1* to a different spot as you go along, and calibrating the VFO dial with the new frequency. Do not disturb the setting of *C2* after its initial adjustment.

If your transmitter exhibits an undue amount of drift, it is probably due to poor power supply regulation. You can correct this condition by adding the necessary circuitry to regulate your power supply.

ed crystal—3.58, 4.5, or 10.7 MHz—and you have a marker or signal generator all set to go. And, finally, the advanced experimenter can use the "L'il Richie" as a stable, crystal-controlled reference clock for electronic counting circuits.

How it Works. The two independent gates in *IC1* (Fig. 1) are biased in their class A region using resistors *R1* and *R2*. These two gates are cascaded with *C1* to form a two-stage, RC-coupled r.f. amplifier. Feedback from output to input via *XTAL* produces the desired oscillation, in the form of a square wave very nearly equal to the crystal's series-resonant frequency.

PARTS LIST

C1—1000-pF disc ceramic capacitor—see text
*IC1—μL914 epoxy micrologic dual gate (Fairchild)**
R1, R2—10,000-ohm, ¼-watt carbon resistor
XTAL—Series resonant, first-overtone crystal, 100 kHz to 3MHz with C1 as listed, to 10.7 MHz with selected value for C1
*Misc.—1½" x 1⅛" single-sided PC board** socket to fit XTAL with mounting screw, solder terminals (3), solder*

*Data sheet and distributor list are available from Fairchild Semiconductor, 313 Fairchild Drive, Mountain View, Calif.

**Complete kit, including printed circuit board but less crystal and socket, is available from Southwest Technical Products Corp., Box 16297, San Antonio, Texas 78216, for $1.75, postpaid in the U.S.A.

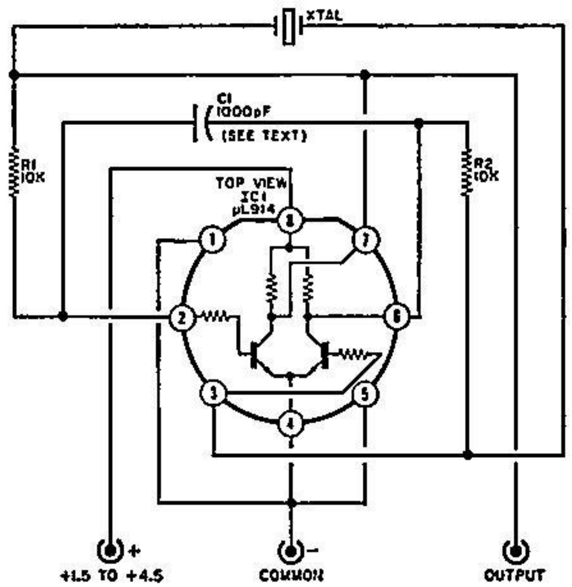


Fig. 1. The IC contains the bulk of the oscillation circuit. The only external components are bias resistors R1 and R2, feedback capacitor C1, and the frequency controlling element, XTAL. Output is a square wave at the crystal frequency. The d.c. level required for operation is not critical—between 1.5 and 4.5 volts.

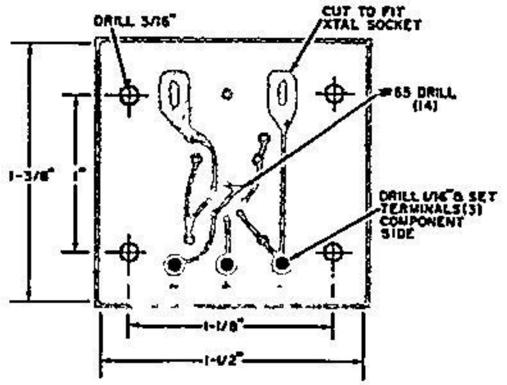


Fig 2 Make the printed board as shown here. It is best to use a PC for this oscillator as stray capacitance found in most point-to-point assembly might cause spurious oscillation at frequencies other than that of the crystal

The entire circuit requires only five low-cost parts and can be powered by any convenient supply from a single penlight cell (1 5 volts) up to 4.5 volts d.c.

Construction. Any neat construction technique can be used for this circuit, but long leads or sloppy construction can produce a device whose frequency may not entirely depend upon the crystal used. A complete kit, including the printed circuit board, is available from the source indicated in the Parts List, but if you want to do your own PC layout work, just follow Figs. 2 and 3.

Note that *IC1* is mounted with the positive power lead centered on the flat of its epoxy case (pin 8). And be sure that the crystal holder pins and the crystal socket match, as some older crystal holders have different pin diameters and spacings.

After assembly and inspection, insert a crystal of below 3 MHz, and perform an initial checkout using 3 volts from two flashlight cells. If you're planning on using crystals from 3 to 10 MHz, you'll have to experiment to get the value of *C1* just right to suit your particular crystal's drive requirements Higher frequency generators will require values of from 20 to 100 pF.

Some capacitor tinkering is required at these higher frequencies and a generator tailored in this manner will most likely work best with one particular crystal, and over a more limited power supply range. You might like to try a trimmer, or padder, for *C1* if you're planning high-frequency operation with multiple crystals. A 0 01-μF power supply bypass capacitor might also be required. A trimmer will let you "pull" the crystal slightly to bring it into exact calibration with Station WWV on 5 or 10 MHz

Occasionally, older surplus crystals or one with an unusual cut may take off on the second or third harmonic instead of the fundamental. Usually, a bit of ca-

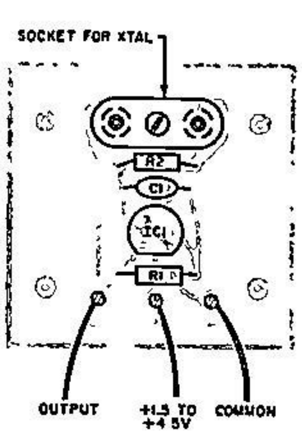


Fig. 3 Component assembly on the printed board Note that the IC has one flat side and that pin 8 on this flat side is connected to the positive battery terminal

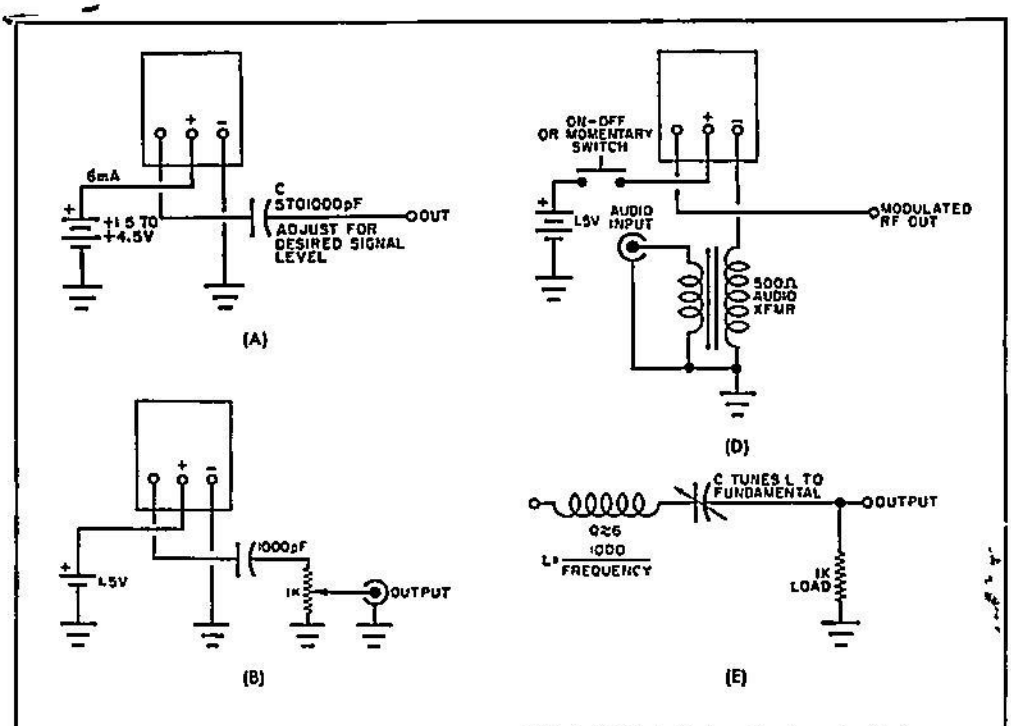


Fig 4 Some typical application circuits for L'il Richie (A) test oscillator or crystal calibrator, (B) oscillator with variable level output, (C) digital counter driver; (D) modulator and (E) tank circuit to convert L'il Richie into a very low power transmitter

pacitance shunting resistor *R2* will settle things down. Values will be in the 50- to 200-pF range.

Operating Hints. Figure 4 shows some circuits you might like to try In the test oscillator or crystal calibrator in Fig. 4(A), an output capacitor (*C*) is selected to get the desired signal level. If you want a continuous output level adjustment range, use the circuit shown in Fig. 4(B). The digital clock and divider connection is shown in Fig. 4(C); a coupling capacitor is not required here.

On-off switching, keying, or audio modulation are added with the circuit in Fig. 4(D). Or, if you want a sinusodial output instead of a square wave, just add a series-resonant tank circuit to the output, tuned to the crystal frequency, as shown in Fig. 4(E).

The generator's output voltage will be slightly less than the supply voltage. Expect around 1.2 volts peak-to-peak with penlight cell operation, and perhaps 4 volts for a 4 5-volt supply. Total circuit drain is less than 6 mA with the higher supply voltage.

Divider sets tuning limits of C-MOS oscillator

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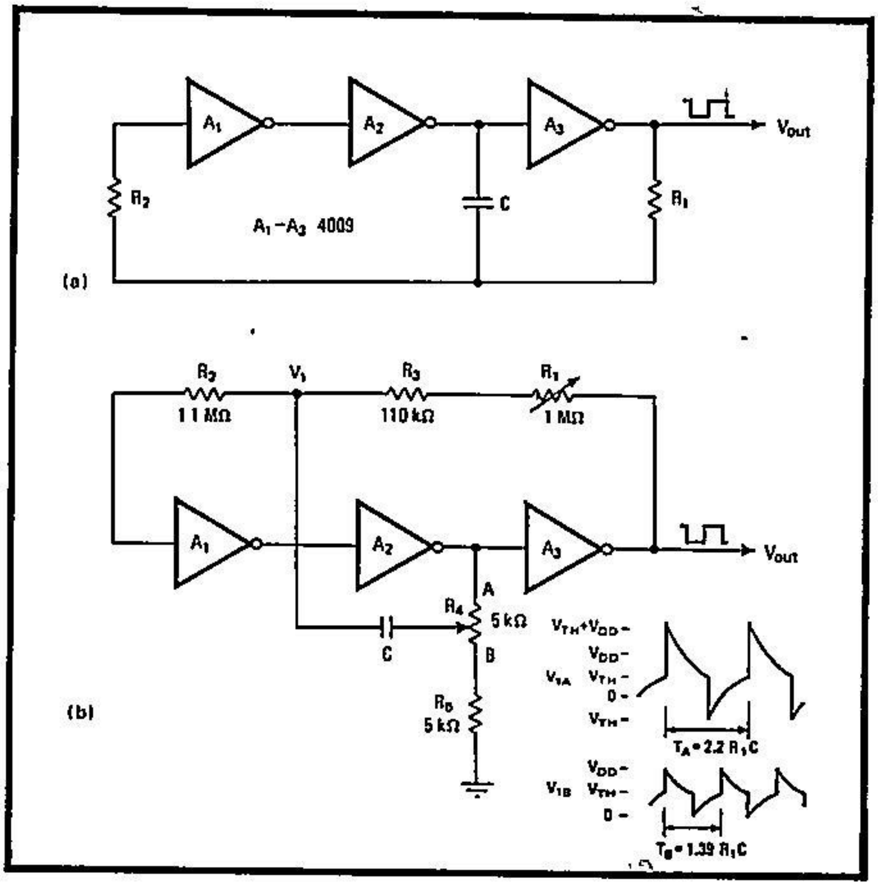
Useful as it is, the square-wave RC oscillator implemented in complementary-MOS has one shortcoming—setting its maximum and minimum frequencies of oscillation independently while also maintaining accuracy is extremely difficult. By placing a voltage divider in the feedback loop of the conventional three-gate circuit, however, a one-time trimming adjustment can accurately set the maximum and minimum frequency excursion and will force the ratio of the upper to the lower limit of oscillation to approach a value virtually determined by the resistors used in the same divider.

The standard RC oscillator generates a frequency of $f \approx 0.482/R_1C$, where $R_1 = R_2$, as shown in (a). Generally, it is not practical or economical to use a variable capacitor for C. A potentiometer could be substituted for R_1 to tune the frequency, but slight differences in integrated-circuit parameters will preclude predicting the maximum and minimum frequencies of oscillation with any degree of accuracy for a particular chip. The only other method for setting the upper and lower frequency limits is to parallel several capacitors across C, a tedious procedure at best.

Alternatively, R_1 can be a potentiometer that is placed virtually in parallel with voltage divider R_4–R_5 through C (b). In this way, capacitor C is no longer charged from the fixed-voltage output of the middle gate in (a), but from the voltage divider across the output. R_1 is thus used to change the circuit's time constant without affecting the potential that is applied to C.

The upper and lower limits of oscillation are determined by the position of R_4's wiper arm and by the values of R_4 and R_5. With the tap at point A, the circuit will oscillate at a frequency given by $f = 1/2.2R_1C$. With the wiper at point B, the frequency will be $f = 1/1.39R_1C$. The frequency ratio to be expected is thus $2.2/1.39 = 1.6$. The actual frequency change measured with the particular chip used for breadboarding was 56%, which is thus very close to the intended value. The ratio will increase as R_4 is made larger with respect to R_5.

The circuit has only one small disadvantage—the load presented by R_4 and R_5 does increase the power-supply drain by approximately 0.5 milliampere. □



Calibrate. IC anomalies, inherent circuit imbalance, and the expense of making C variable preclude setting upper and lower oscillation limits of typical RC oscillator (a) with any accuracy. Placing R_1 virtually in parallel with voltage divider (b) through C gives circuit one-knob frequency control, with upper-to-lower oscillation ratio in effect determined by R_4 and R_5.