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QST Issue: Jun 1988
Title: AD7Iambic Cheap Keyer, The
Author: Paul Newland, AD7I

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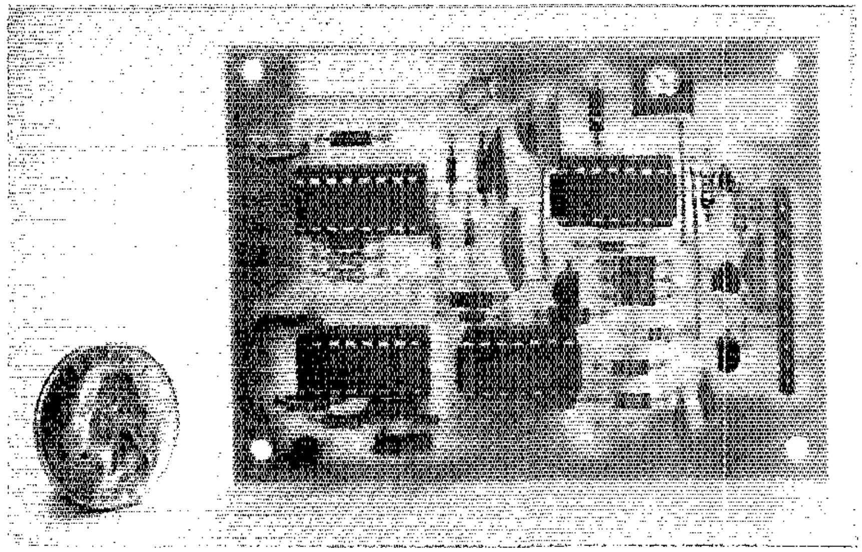
The AD7Iambic Cheap Keyer

Need a small, low-cost, low-current-drain keyer? This four-IC CMOS unit will have you slinging flawless strings of dots and dashes in no time—and for next to nothing!



By Paul Newland, AD7I
ARRL Technical Advisor
PO Box 205
Holmdel, NJ 07733

I'm not a great CW operator, but I do enjoy using that mode. CW is excellent for getting the most from low-power (QRP) operation. One thing gets in the way of my enjoyment of CW, however: I suffer from a chronic case of QLF (that is, my skill with a straight key is pretty poor). I rely on an electronic keyer to make my signals easier to copy for people I work on CW. I prefer to have keyers as integral parts of the rigs I operate (usually QRP rigs or old klunkers), rather than housing them in separate boxes at the operating position. This philosophy is an outgrowth of my desire for minimum box count for portable operation; it represents one fewer box to pack and one fewer set of cables to remember (or forget) before an outing.

Including a keyer in each rig can get to be expensive if you use commercial keyer boards or chips. To save money, I have often relied on some of the popular, simple one or two generic-chip keyers for built-in applications. Overly simple keyers usually give less than adequate performance, however. In my case, these keyers don't make my signals sound much better than when I use a straight key! I always find myself reverting to commercial iambic keyers with dot and dash memories—in spite of their cost.

I decided to see just how many chips I'd need to make a basic iambic keyer with dot and dash memories. This article shows the result of my efforts: A keyer that I not-so-modestly call the AD7Iambic Cheap Keyer, or *Cheaper* for short. The component count for the Cheaper isn't minimal, but the *cost* is.

The Cheaper provides the features mentioned earlier, as well as sidetone generation. The keyer uses four common ICs, seven diodes, four transistors, 21 resistors, 13 capacitors and two potentiometers. I checked a catalog from a popular mail-order house and found the total cost of the components used for the Cheaper—including the perf board and a speaker, but not IC sockets—to be less than $10. If you choose to use an etched PC board instead of point-to-point wiring on a perf board, it will cost more to build the keyer. If you want to add an enclosure (assuming you're not going to build the Cheaper into a radio), it's still less expensive to build than the custom single-chip solution. The Cheaper is still fairly small; the overall parts count isn't much more than that for the single-chip solution!

Design Philosophy

My designs usually fall somewhere between unique invention and blatant plagiarism (and frequently lean toward the latter). I find that often the best designs are improvements on other effective designs; the Cheaper is no different. Here are some of the building blocks incorporated in the keyer. The clock circuit was designed by Roy Lewallen, W7EL, and was used in his keyer project that first appeared in an issue of *SPRAT*—a QRP journal—several years ago. This clock has the advantage of good asynchronous starting without elongating the first clock period. I used a couple of other borrowed ideas in the Cheaper, but I don't know who to credit for either one. First, I used exclusive-OR gates for memory elements, which I must say is a pretty clever idea. Second, a Schmitt-trigger gate configured as an AF oscillator serves as a handy, low-cost, minimum-parts-count sidetone generator. Fig 1 shows the schematic of the Cheaper. For a discussion of how the circuit works, see the sidebar, "Cheaper's Circuit Operation."

Building the Keyer

I built the Cheaper on a piece of perf board. Nothing about the layout is critical, so feel free to change the layout shown in Figs 2 and 3 to suit your needs. Just about any construction method is fine; dead bug, wire wrap, point-to-point and etched-PC-board wiring are all fine. One caution you need to observe is the sensitivity of CMOS ICs to static electricity. Always use a grounding wrist strap or its equivalent to protect the ICs during handling. Also, if you elect not to use the PC-board layout shown in Fig 2, be sure to place the bypass capacitors as close as possible to their respective IC pins. The signal levels in the keyer are very small, and poor RF bypassing can make the Cheaper do some mighty strange things.

A word of caution about capacitors: I designed the Cheaper with CMOS ICs to provide keying at minimal current drain. Because of this, no on/off switch is included. Be sure to use low-leakage capacitors in the keyer (either ceramic or tantalum). Don't use garden-variety electrolytics if the Cheaper will be battery powered; electrolytics are often very leaky. The keyer will work fine if you use leaky

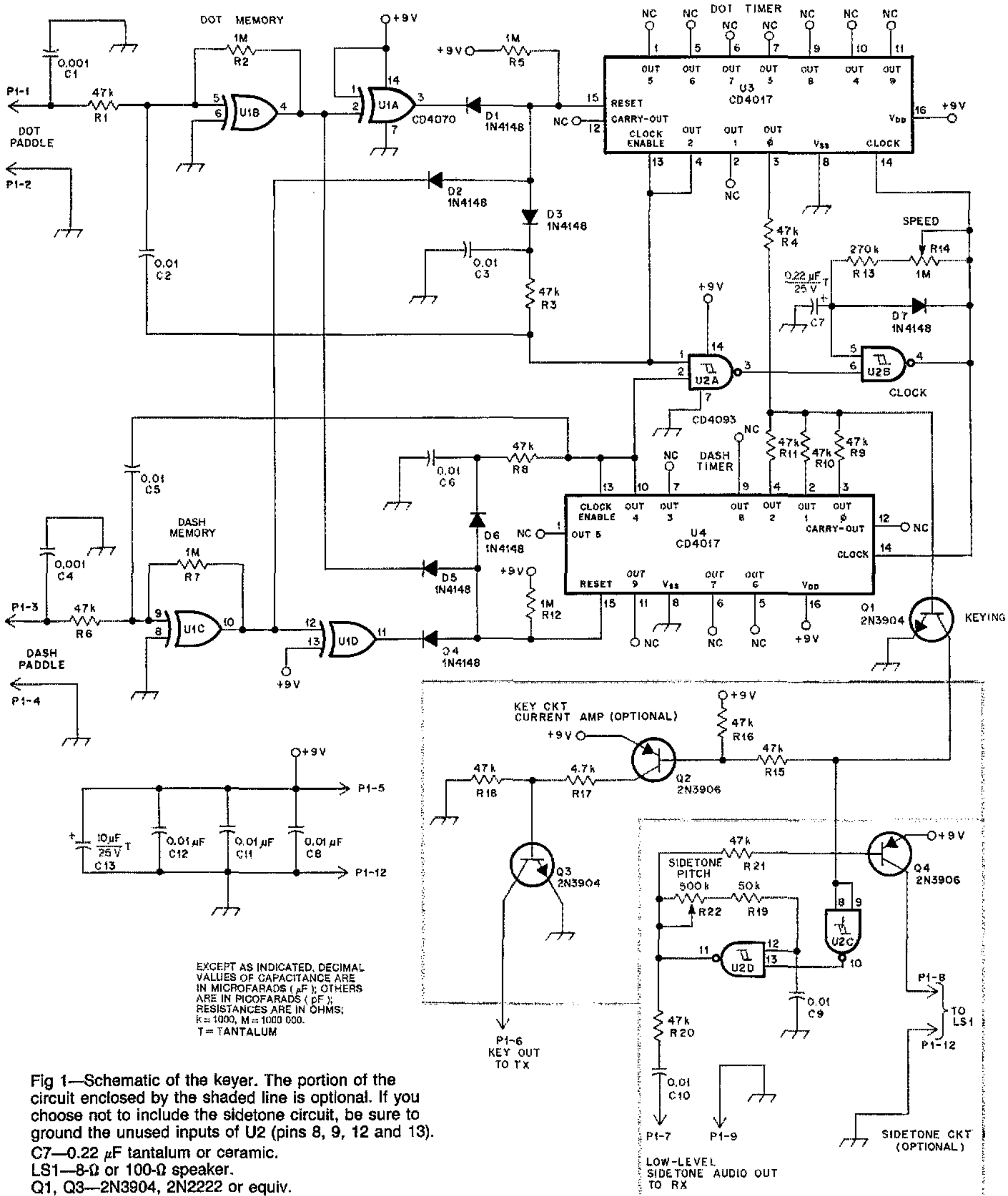


Fig 1—Schematic of the keyer. The portion of the circuit enclosed by the shaded line is optional. If you choose not to include the sidetone circuit, be sure to ground the unused inputs of U2 (pins 8, 9, 12 and 13).

C7—0.22 μF tantalum or ceramic.
LS1—8-Ω or 100-Ω speaker.
Q1, Q3—2N3904, 2N2222 or equiv.
Q2, Q4—2N3906, 2N2907 or equiv.
R14—1-MΩ potentiometer.
U1—CD4070.
U2—CD4093.
U3, U4—CD4017.

Miscellaneous

2½ × 3-in. perf board.
Two 14-pin IC sockets.
Two 16-pin IC sockets.

Cheaper's Circuit Operation

The Cheaper circuit is composed of five major sub-circuits. They are:

- Dot timer
- Dash timer
- Dot memory
- Dash memory
- Asynchronous clock

First, let's focus on the dot and dash timers. The heart of each timer is a CMOS 4017 decade counter (see Fig 1). This chip's count advances on the rising edge of the clock input when both the reset and inhibit inputs are low. If the inhibit line is high, clock signals are ignored. When the reset line is high, the counter immediately goes to the zero state. The outputs of this counter are decoded. That is, when the counter output is in the zero state, the zero output is high and all other outputs are low. When the counter is in the two state, the two output is high and all other outputs are low, and so on.

The dot and dash timers operate in a similar way. For clarity, we'll cover just the dash timer. When no dashes are desired, the timer is in the four state and is held there because the inhibit input is tied to the four output. If both the dot and dash timers are inhibited, both inputs of U2A are high and the clock is disabled. When in the idle state, the outputs of both the dot memory (U1B) and dash memory (U1C) are high. Note that when the dot memory is in the idle state (high), D5 is reverse biased, and when the dash timer is idle, D6 is reverse biased. This is because U1B and U1C are configured as inverters.

The only thing keeping the dash timer from being reset is that D4 is forward biased, holding the dash timer's reset input low (inactive). When the dash paddle is closed, the output of the dash memory formed by U1C, R6 and R7 goes low (C4 bypasses stray RF). This signal is inverted by U1D, and D4 is then reverse biased. Because all diodes at the reset input of the dash timer are reverse biased, the reset signal goes high, forcing the counter to go from four to zero.

When the dash timer is in the zero state, the keying transistor, Q1, is biased on by the current flowing through R9. Because of the low base-emitter voltage drop of Q1, most of R9's current goes into the base-emitter junction of Q1. When the state-four output of the dash timer goes low (when the timer leaves the four state), the clock signal from U2B goes from high to low and quickly back to high. (The speed of this process is determined by how fast C7 discharges through D7.) The time constant provided by R8 and C6 ensures that the dash timer remains reset long enough to ignore the first rising edge of the clock. (If this time constant is too short, the first dash would only be two Morse elements in length instead of the requisite three.) On the second rising edge of the clock, the dash timer moves from state zero to state one. Now the bias current for Q1 is provided by R10 instead of R9. Similarly, R11 provides bias current for state two. State three provides the space for the interelement timing period.

The next rising edge of the clock moves the dash timer into the idle state (state four) and disables the clock. A clear pulse from the dash timer's state-four output also tries to clear the dash memory (U1C) via C5. If the paddle is open, this pulse clears the memory to a high state. If the paddle is still closed, the pulse momentarily clears the dash memory, but because of the remaining key closure, the memory is set again as soon as the charge on C5 is dissipated in R6.

If the dot paddle is closed while a dash is being sent, the dot memory is set before the dash timer reaches state four. During the period when C5 is trying to clear the dash memory, the dot timer is reset (D4, D5 and D6 all reverse biased). This makes the keyer send a dot followed by a space immediately after the dash/space combination is finished. Voilà—iambic operation! During the time when the dot timer is active, the dash timer is held idle by forward-biased D5 until the dot-timer cycle finishes.

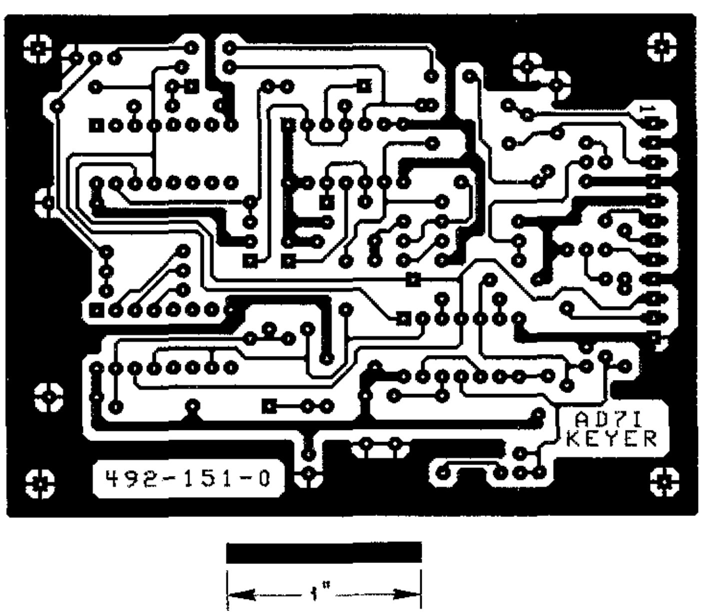


Fig 2—PC-board layout for the CMOS keyer. The pattern is shown full size from the foil side of the board. Black areas represent unetched copper foil.

caps, but battery life will be markedly reduced.

Optional Circuitry

The circuitry enclosed by the shaded line in Fig 1, including the keying amplifier and the sidetone circuit, is not essential. I designed the Cheaper to use CMOS gates because of their flexibility, as well as the low current drain already mentioned. These devices can be powered from anything between 3 and 15 V (74HC-series parts could also be used, but over a narrower supply voltage range). The problem is that these devices can only supply a few hundred microamps of current from their outputs for a guaranteed logic level. If these gates are used to drive a transistor with a gain of 50 or so, only a small amount of keying current will be available to drive a transmitter. Often, this is too little current for anything but QRP rigs. Q2 and Q3 (with associated resistors) form the keying amplifier, and increase available current to levels suitable for keying almost any transmitter. The value of drive current can be controlled by changing the values of R17 and R18. In general, decreasing the value

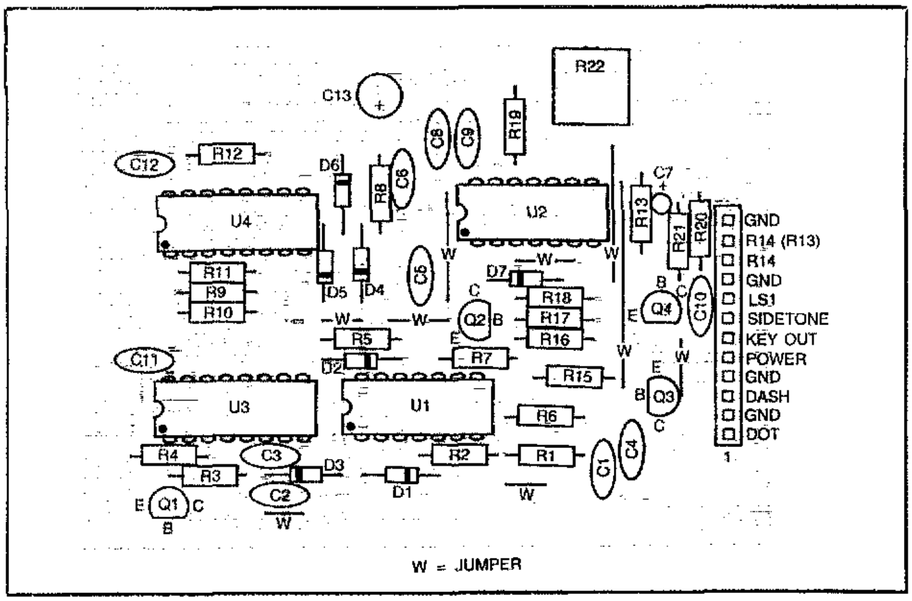


Fig 3—Parts-placement diagram for the keyer. Parts are mounted on the non-foil side of the board; the shaded area represents an X-ray view of the copper pattern. W indicates wire jumpers.

of R17 will increase the available keying current.

The second optional item is the sidetone generator formed by a Schmitt-trigger gate (U2D) with an RC circuit for feedback. The sidetone frequency can be changed by varying R22. As the resistance of R22 is increased, the frequency of the sidetone decreases. Low-level audio output is available to drive an audio amplifier (such as the one in a transceiver), and the high-level output is suitable for driving a small speaker. Try to avoid using the high-level output to drive a speaker if you are running the Cheaper from a 9-V battery. The sidetone circuit itself doesn't draw much current, but a speaker sure does! Whenever possible, let the rig provide the sidetone, or you'll be feeding the Cheaper an awful lot of batteries.

Operation

The Cheaper operates just like any other electronic keyer. The circuit has one anomaly that you should be aware of, however. When power is first applied (when you connect a battery, or turn on your rig if the Cheaper is built into it), a reset pulse is not always sent to the dot or dash counter chips. The lack of a reset signal can cause more than one of the counters to be in active states at the same time, and the keyer will stick in the key-down mode. All it takes to "un-stick" the keyer is to squeeze the paddle after power is applied. This anomaly generally isn't a problem because battery life is long, and the power is only cycled when changing cells. If you build the keyer into a rig, however, this key-down bug can be more objectionable. In this case, try a different set of 4017 counters at U3 and U4.

Summary

I designed the Cheaper to provide a basic, low-cost iambic keyer. You may be able to reduce the cost even farther. I welcome suggestions for any modifications that further reduce cost or component count of the Cheaper while retaining the features described.

The Cheaper is a good weekend project for anyone who needs a good, basic, iambic keyer with dot and dash memories. Besides, it's a cheap way to make for better CW keying—it certainly helped to cure my case of QLF!

PC boards and kits of parts are available from A & A Engineering, 2521 W La Palma Ave, Unit K, Anaheim, CA 92801, tel 714-952-2114. For the PC board alone, order no. 151-PCB, and enclose $6.95 plus $1.50 shipping and handling per board. A kit of parts including the PC board, all board-mounted parts and the speed-control potentiometer is also available as no. 151-KIT. Enclose $19.95 plus $1.50 shipping per kit. The ARRL and QST *in no way warrant this offer.*

Strays

I would like to get in touch with...

☐ anyone with source for a 50-MHz duplexer. Matthew Bush, KA9RIX, 7061 35th Terrace N, St Petersburg, FL 33710, or 813-345-0609 after 6 PM.

☐ any hams who are also in the antique car hobby. George Stringos, N1ELC, 5 Robinson Rd, West Woburn, MA 01801.

☐ any Native American amateur or club. M. McDaniel, W6FGE, 940 Temple St, San Diego, CA 92106.

☐ anyone who knows of any foreign-language nets, particularly German-speaking, in the US. E. J. Puneky, WA5JKS, 905 Monroe St, Gretna, LA 70053.

☐ anyone with info on the use of the call N6DBZ on an episode of *Magnum P.I.* Randy Jones, N7CKJ, E 1704 Ross Ct, Spokane, WA 99207.

☐ anyone with a service manual for Drake R4C. Jacques Castille, F6GZT, 100 Ave de Fontresquieres, 30200 Bagnols-sur-Ceze, France.

☐ anyone who knows of a modification to automatically resume scan on a Yaesu FT480R. Bob Jones, WB7VMA, Rte 2, Box 46, Bonanza, OR 97623, tel 503-545-6466.

☐ anyone with an operating manual, schematic and/or service manual for Hickok Model 650 universal video generator. Charles Ferguson, K4WK, 209 Home Ave, Graham, NC 27253.

☐ anyone who has modified an ICOM IC22S to allow frequency selection without diode programming, or any other mods. Todd Rusk, N6OEN, 9777 Witter Springs Rd, Witter Springs, CA 95493.

QEX: THE ARRL EXPERIMENTERS' EXCHANGE AND AMSAT SATELLITE JOURNAL

A local oscillator (LO) is the heart of a transverter. The 759-MHz LO featured in May's issue is easily duplicated and produces a signal to be mixed with the IF to produce the transmitted signal in an upconverter, or with the received signal to produce the IF in a downconverter. This design can also be modified to allow the LO to be used as an exciter for a 903-MHz beacon transmitter, a crystal-controlled 903-MHz portable transmitter, or as the low-frequency portion of a microwave frequency-multiplier chain.

The May issue of *QEX* includes articles on:

- "Practical Spread Spectrum: Achieving Synchronization with the Slip-Pulse Generator," by Andre Kesteloot, N4ICK
- "A 759-MHz Local Oscillator," by Dave Mascaro, WA3JUF

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