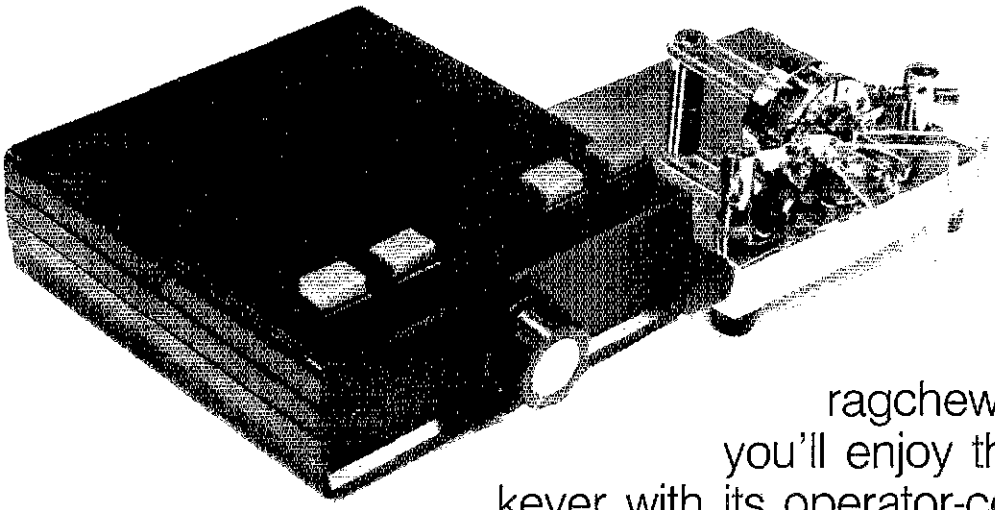
The CMOS Super Keyer II



Whether you're a ragchewer or a contester, you'll enjoy this feature-packed keyer with its operator-controlled flexibility!

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The original CMOS Super Keyer appeared in October 1981 *QST*[1] and several editions of *The ARRL Handbook*. It proved to be very popular and, almost a decade later, requests for kits continue to arrive! Now, the CMOS Super Keyer II—a worthy successor—is here. As you'll see, modern technology allows much more to be done with a minimal amount of hardware, a smaller PC board and simplified construction.[2]

A glance at the photos of the completed CMOS Super Keyer II is all it takes to realize that the keyer doesn't need a keypad or a myriad of switches and knobs to control it. But don't conclude from this that it's just a bare-bones memory keyer! In fact, this keyer will satisfy the needs of casual ragchewers as well as avid DXers and contest operators. Because there are so few controls necessary to operate this keyer, handicapped amateurs will find it easy to manage. As an aid to the handicapped, a manual-on-disk is available—see note 2.

Features

Peek inside the Super Keyer II (see Fig 1) and you'll see that the small (1.4 × 2.4-inch) PC board contains only one IC, a couple of transistors and a few other components. It's the program in the IC that really makes this keyer remarkable. It provides:

- An iambic keyer with dot and dash memories.
- Four 48-character messages.
- Character and Real-Time messages.
- Timed pauses within messages.
- Messages that can call other messages and contain operational commands.
- Message-loop capability for continuous play.
- Message break-in to allow for paddle-inserted text.
- Input queue to store multiple message activation.
- Contest serial numbering (000-9999).
- Digital and linear analog speed control (6-60 WPM).
- Adjustable weighting (dot/dash ratio) of 25-75%.
- A built-in 700-Hz sidetone monitor.
- A transmitter key-down (tune) function.
- Hand-key mode.
- Compensation for transmitter-induced keying distortion.
- Selectable automatic character spacing.
- Keyer-status inquiry functions.
- Ultra-low power consumption for battery operation.

How does the Super Keyer II provide all this flexibility without a keypad or a bunch of switches and knobs? Simple: Commands are sent to the keyer in Morse code—using the paddles!

A detailed explanation of the operational features of the keyer will be given later. First, let's have a look at the schematic and find out how easy it is to build your own Super Keyer II.

Circuit Description

The keyer schematic is shown in Fig 2. The main component is the Motorola

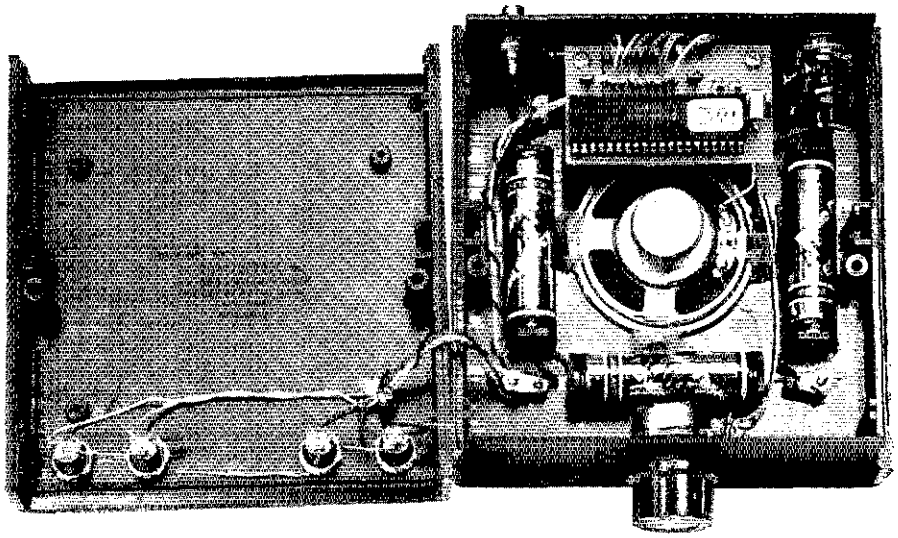

Fig 1—An inside view of the CMOS Super Keyer II. Around the speaker, three AA, single-cell holders are glued to the box bottom. A pair of ¾-inch spacers support the PC board at the rear of the cabinet. The analog speed control (R13) is center-mounted on the front panel. On the back panel are the paddle and key-line jacks. As shown in the title photo, the four push-button switches are mounted on the top half of the cabinet, two on each side of R13.

[1]Notes appear on p 21.

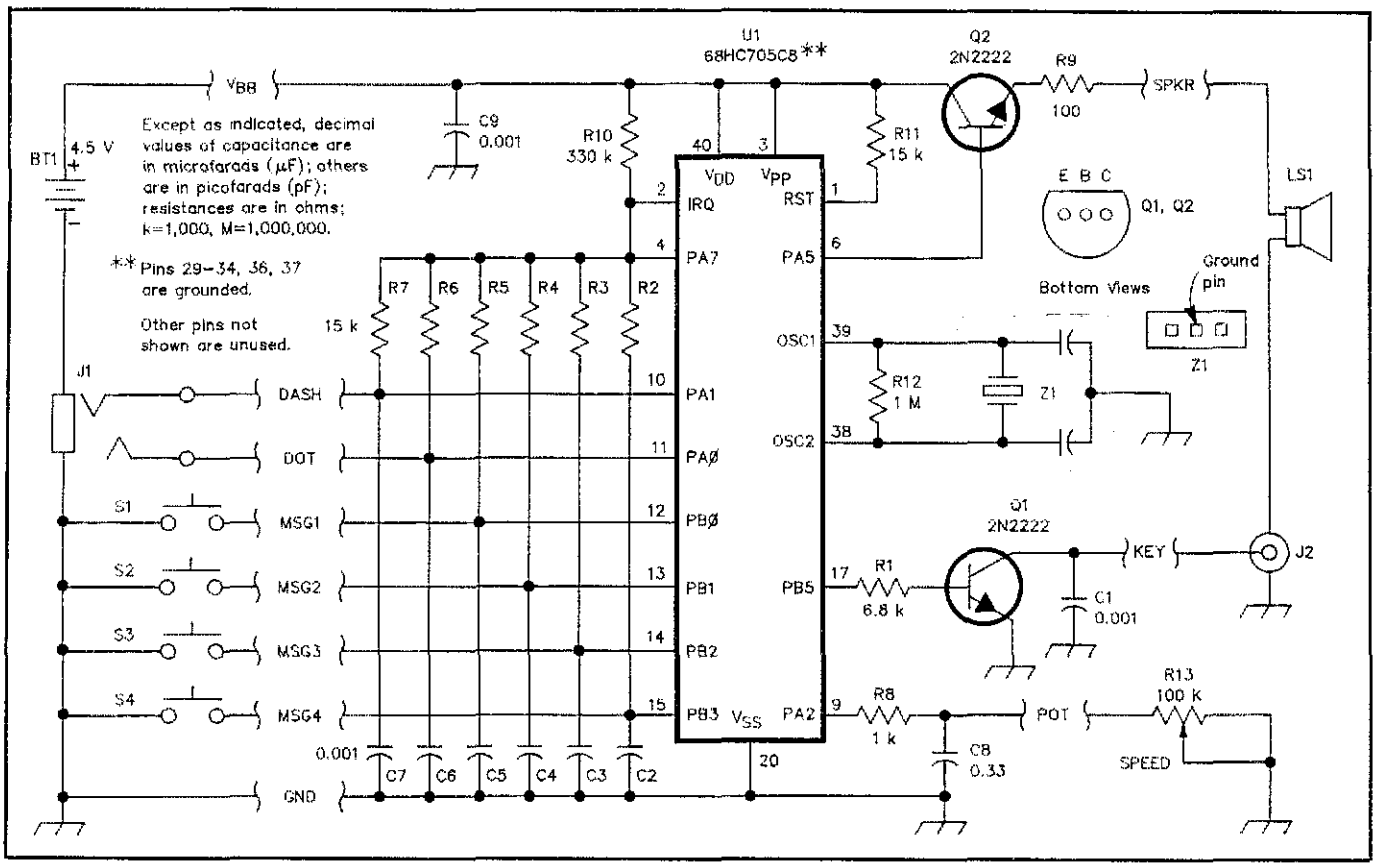

Fig 2—Schematic diagram of the keyer. All capacitors are 25-V disc ceramic units. Resistors are ¼-W carbon-composition or metal-film units. RS part numbers in parentheses are Radio Shack®.

BT1—Three 1.5-V AA alkaline cells (RS 23-552) wired in series; NiCd cells can also be used—see text.
J1—¼-inch, three-circuit key jack (RS 274-312).
J2—Phono jack (RS 274-346).
LS1—2-inch diam, 8-Ω speaker (RS 40-245).
Q1,Q2— 2N2222 or similar NPN (RS 276-2009).
R13—100-kΩ pot, linear taper (RS 271-092).
S1-S4—SPST push-button switch (RS 275-1566).
U1— Motorola 68HC705C8 (see note 2).
Z1—2-MHz resonator with built-in capacitors (Digi-Key part no. PX200; available from Digi-Key® Corp, 701 Brooks Ave S, Thief River Falls, MN 56701, tel 800-344-4539).

Miscellaneous

Enclosure—Pac-Tec™ CM5-125 used for prototype shown here. (Pac-Tec boxes are available from Electronic Precepts of Florida, 7401 114th Ave N, Suite 502A, Largo, FL 34643, tel 800-367-4649. The CM5-125 case comes in four colors: black, gray, tan and PC bone (an off-white). Price: $13.09 plus shipping and handling in quantities of 1 to 39. (The ARRL and *QST* in no way warrant this offer.)
Two ¼-inch standoffs
Three single-cell battery holders (RS 270-401)
Knob (RS 274-416)

68HC705C8 CMOS microcomputer (U1). This IC contains an 8-bit central-processing unit, timer, bidirectional I/O lines, 304 bytes of RAM, and nearly 8 kbytes of PROM. A 2-MHz clock is employed, with the frequency set by a ceramic resonator (Z1).

Dot, dash, and message-input lines are pulled up by R2-R7 and momentarily grounded by paddle or push-button closures. Analog speed is controlled by a software analog-to-digital converter (ADC) in conjunction with R8, C8, and R13. C8 is charged quickly through R8 with PA2 configured as an output. PA2 is then made an input, and the discharge time through R13 is measured.

A software-generated 700-Hz sidetone is selectively output on PA5. Q2 is a voltage follower that provides speaker drive through R9. Transmitter keying is done by Q1, which will handle low-voltage, positive-key-line rigs only. Take care not to exceed any of the maximum ratings of the 2N2222 transistor used at Q1 (V_{CEO} = 30, I_C = 800 mA, P_D = 1.2 W). If your transceiver has a negative key line or one that exceeds Q1's limits (likely if you own an older transceiver with a vacuum-tube final amplifier), use an interface circuit between the keyer and the transceiver. Some suitable circuits were recently described in *QST*.[3]

The CMOS Super Keyer II is designed for low power consumption. When idle, the microcomputer "sleeps"—not even the clock runs—yielding a current drain of under 10 μA! Thus, there's no need for an on/off switch. While the keyer is active, its current consumption rises to about 5 mA (with the sidetone monitor turned off), but after two seconds of inactivity, the keyer automatically goes back to sleep. The monitor is the major power consumer, requiring peak currents of about 40 mA. So, to extend battery life, the monitor should normally be turned off, and the rig's sidetone used to monitor sending.

The keyer works with any supply voltage in the range of 3 to 5.5. Three series-connected, AA alkaline cells provide a nominal 4.5 V and will yield many months of service under normal operating conditions. You could also use four series-connected, rechargeable NiCd cells to supply 4.8 V, an approach similar to that taken with the original Super Keyer.

Build Your Own

The PC board and associated components are available as a partial kit (see note 2). A part-placement guide is shown in Fig 3. Chassis-mounted parts, as used in the unit shown here, are all available from Radio Shack®. Similar components are also stocked by mail-order electronics parts suppliers.[4]

A 1.5 × 5.08 × 5.25-inch plastic enclosure obtained at a local hamfest houses the keyer shown in the accompanying photos. With miniature switches and connectors and tighter packaging, a considerably smaller box would suffice. If you so desire, you can use remotely-located message buttons instead of (or in parallel with) the chassis-mounted switches.

Though housed in a plastic box, the keyer

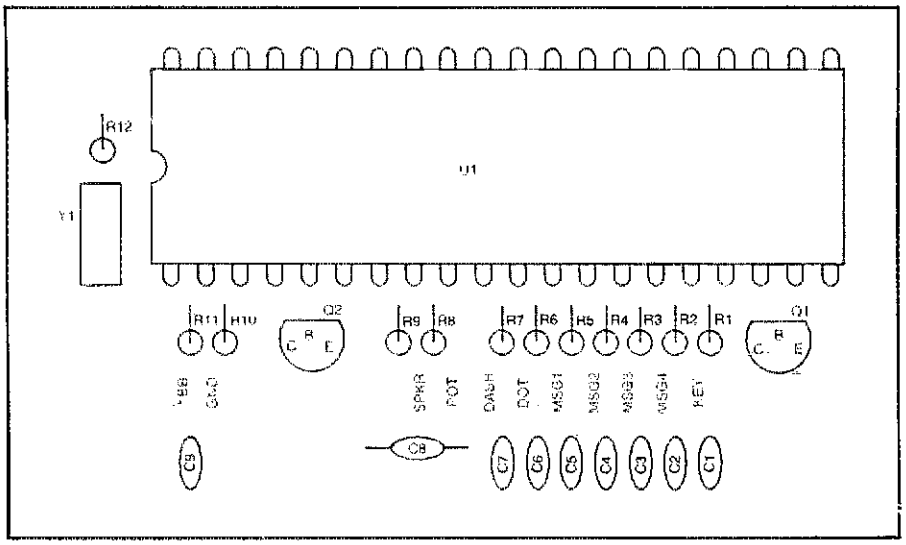

Fig 3—Part-placement guide for the CMOS Super Keyer II. Parts are placed on the nonfoil side of the board; the shaded area represents an X-ray view of the copper pattern.

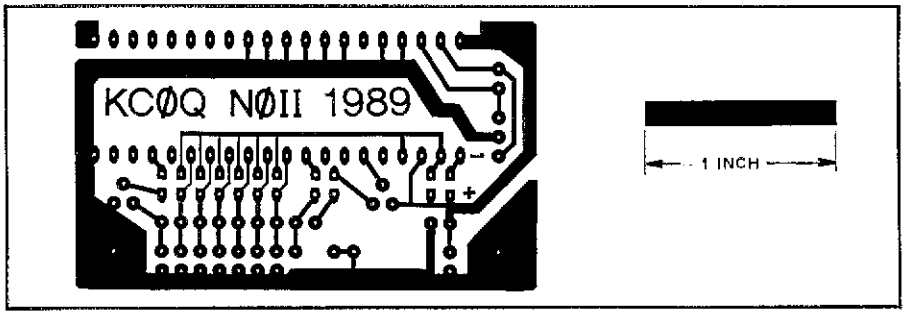

Fig 4—Circuit-board etching pattern for the CMOS Super Keyer II. The pattern is shown full-size from the foil side of the board. Black areas represent unetched copper foil. Ready-made PC boards are available; see note 2.

has not shown any allergic reactions to RF even when it was used adjacent to a kilowatt amplifier driving coax-fed antennas. But if your shack (or Field Day site) is hot with RF, consider the use of a metal enclosure and shielded cables.

The keyer can be built without the manual speed control, R13. If you opt to do this, also use a 100-kΩ resistor for R8 and install a jumper wire in place of C8. Then, only digital speed control is available, so you might find this procedure useful: Program messages 1 and 2 with /SU2 and /SD2, respectively, so simple button pushes provide convenient up/down speed control in 2-WPM steps. (The /SU and /SD commands are described later.)

Operational Description

When power is first applied to the keyer, it responds by sending OK in Morse code. The initialization state of the keyer is:

- Speed: 20 WPM (at the current knob position).
- Weighting: 50%.
- Monitor: on.
- Auto-space: off.
- Messages: empty.
- Load mode: Character.
- Input queue: on.
- Serial number: 001.
- Number option: 0.
- Function speed: 20 WPM.

Speed Control

Speed range, determined by the software, is 6 to 60 WPM. The analog control (R13) varies the speed over a 3-to-1 range. Software compensation allows the speed to vary *linearly* with knob rotation—this rare feature makes speed adjustment easy. As you might expect, operating speed can also be set digitally. When speed is set digitally, it is assigned to the current knob position. This allows you to tailor the absolute speed range of the analog control to suit your operating needs. For example, at KCØQ, the fully-counterclockwise position of the knob is programmed to be 13 WPM. Speed then increases linearly with clockwise rotation to a maximum of about 39 WPM.

To make function control easy, another—independent—speed can be programmed for use when entering commands. For example, even if you're operating at 35 WPM, function-controlling commands can be entered at 20 WPM or any other speed you choose. Alternatively, the command-entry speed can be made to default to the current operating speed. (See the explanation of the Reset mode under *Button Functions*.)

Keyer Commands

All paddle-entered keyer commands are sent in Morse code. If you enter an invalid command, or an incorrect parameter for a command, the keyer emits a burst of rapid dots. (*Which most definitely sounds like an electronic raspberry!*—Ed.) Multiple commands cannot be entered at one time. That is, each command must be entered separately and preceded by the simultaneous press of buttons 1 and 2. The presence of one or more *d*s represents the need for a digit(s) as part of the command.

Function Commands

Most function commands are employed only once to customize the keyer to your preferences. The keyer's functions are controlled using the push-button switches and the paddles. From left to right, (see the title-page photo) the buttons are designated as 1, 2, 3 and 4. To alert the keyer that a command is to be entered, momentarily and simultaneously press buttons 1 and 2. The keyer automatically disables transmitter keying, enables the sidetone, switches to the current command-entry speed, and acknowledges your request by sending K. Then, key in the desired command characters. For example, entering S25 sets the operating speed to 25 WPM. When the command is completed (the keyer knows when this occurs; no other action is necessary), the transmitter key line is again enabled and the speed and sidetone return to their previous state.

The K*dd* command is included to compensate for keying distortion that may be introduced by your transmitter or amplifier. As is shown clearly in some *QST* product reviews, semi-break-in and full-break-in (QSK) operation can significantly shorten the keying on-time. This is caused by internal sequencing delays when changing between receive and transmit. The result is a light or choppy CW envelope. Although increasing the duty cycle with the weight command (W*dd*) helps, it is correct for only one speed. However, keying compensation (K*dd*) corrects the problem for all speeds by increasing the on-time of the keyer output, and commensurately decreasing the off-time, by a period of up to 25 milliseconds.

The *Zd* command selects various treatments for zeros when playing the contest serial number. Leading zeros may be inhibited or replaced by an *O* or *T*. Independently, an *O* or *T* can also replace any other zeros, and an *N* can be substituted for the number *9*.

Inquiry Commands

In addition to the commands that change settings and modes, there is a full set of keyer inquiry commands you can use. Inquiry commands allow you to determine the current state of the keyer. State information is sent to you in Morse code with the monitor auto-

matically enabled (even if it was disabled) and keying output disabled. Inquiries are initiated by momentarily and simultaneously pressing buttons 1 and 2. After receiving the F reply from the keyer, enter the desired inquiry with a leading question mark. For example, ?S asks what the current operating speed is; the keyer responds by sending two digits. Other inquiries evoke responses of ON, OFF, or other meaningful characters as appropriate. The complete set of inquiries is: ?A, ?F, ?K, ?L, ?N, ?Q, ?S, ?W, ?Z, ?1, ?2, ?3, and ?4. The last four are message inquiries that play the contents of message buffers 1 through 4, respectively. None of the inquiry responses key the transmitter.

Embedded Commands

Character-mode messages (described later) can contain embedded commands. To distinguish the commands from normal text, the command strings are prefixed by a slash bar (/) and entered as a separate word. When encountered during a message playback, the desired function is executed.

Break (/B) suspends the message for paddle entry and then automatically resumes the message when an exaggerated word space is detected. It makes constructing contest message loops a breeze!

Gap (/G*d*) allows spacing to be modified when emphasis is desirable. Expanded gaps can be used, for example, in call signs like WØEJ and WØIZ, to make the E or I easier to copy. It can also be used to shorten or lengthen the space between words.

Relative speed changes (/SU*d*, /SD*d*) can very useful. For example, the message /SU5 QRZ TEST DE WØIZ /SD5 is played at increased speed, but leaves the normal operating speed unchanged.

Messages

Four message buffers are provided. Each can hold 48 bytes (384 bits), which is generous enough, for example, to store *the quick brown fox jumped over the lazy dogs back*. The message buffers are volatile: If power is removed from the keyer, the messages will be erased.

A message-editing feature is included. If you make a mistake while entering a message, send a stream of seven or more dots. This tells the keyer to locate the last word and erase it. The keyer then plays back the previous word (if any) so you know where you left off. You can erase as many words as necessary. When you've reached the desired position, simply continue with the entry.

Loading a message is easy. Just press and hold one of the four buttons. After two seconds, the sidetone is enabled and the keyer emits a tone to signify that transmitter keying is inhibited. The keyer then sends an R or C to tell you if it's in Real-Time or Character mode, then message loading may begin. Enter the message text via the paddles. When you're done, terminate the message by simply tapping the same button again. If the message-buffer capacity is exceeded in either mode, the message is terminated automatically.

A message is played by tapping one of the four push-button switches. If the input-queue feature is enabled, the keyer will remember as many as eight button closures and play the messages in turn. Or, with the queue disabled, a button closure cancels any ongoing message and immediately starts the new one. Messages are aborted whenever a paddle is closed, allowing instant interruption for manual sending.

Real-Time Mode

The Real-Time mode works like it does in the original CMOS Super Keyer: What goes in is what comes out. You determine the spacing, so it will be as perfectly timed, compressed, or exaggerated as you make it.

In this mode, pauses are stored as spaces. It's important to know this because those spaces consume memory. After you've asked the keyer to accept a message, you don't have to rush the first entry because the keyer won't start storing pause-spaces until the first paddle closure is made. Once message entry begins, however, the keyer loads continuously: any pauses introduced are stored as spaces in the message. The elapsed time between the end of the last character entered to message termination is stored as a space at the end of the message. Real-Time mode does *not* permit the use of embedded function commands.

Character Mode

In the Character mode, complete character encodings are stored (rather than just bits to represent dots, dashes, and spaces). The software sanitizes your sending and produces perfectly timed Morse code when the message is played. Also, there is no need to worry about word spacing. Just stop sending after every word—the keyer will prompt you by sending an I (this doesn't appear as output) and wait for you to send the next word. Unlike Real-Time mode, there is no limit to the elapsed time between words, so there's no need to rush your entry.

Messages entered using the Character mode can contain embedded function commands for greater operating flexibility. These commands include those for speed changes, playing and incrementing the serial number, decrementing the serial number for repeats, and more.

A message can call any other message, allowing the messages to be linked, if desired. If a message calls itself, directly or via another called message, a continuous loop results.

Loops are useful for beacons, calling CQ, moonbounce and meteor-scatter operation, and in contesting. Loops are even more useful with the embedded Pause and Break functions. Speed-independent pauses in multiples of 0.1 second can be inserted anywhere, and the message resumes automatically after the time expires. A message Break allows you to insert one or more words manually. The message then resumes after a pause that exceeds a normal word space.

Button Functions

As mentioned earlier, single-button closures activate messages, and the 1-2 combination readies the keyer to accept paddle-entry functions. For added convenience, certain keyer function commands are duplicated by other double-button closures. The 2-3 combination is acknowledged by the keyer sending D, and decrements the serial number. Pressing 2-4 enables the Xmit (tune) function and is acknowledged by an X from the keyer. Similarly, pressing 1-3 sets the hand-key mode (preferred by some operators when tuning up their rigs), and is acknowledged by the keyer sending an H. The 3-4 button pair is for inquiry, and waits for paddle entry after acknowledging with ?. Finally, pressing buttons 1 and 4 simultaneously is acknowledged by the keyer as RV and causes a reversal in paddle sense (swapping the dot and dash sides of the paddle).

One four-button combination is recognized: 1-2-3-4. It's a Reset mode. It comes in handy, for instance, if you've mistakenly set the command-entry speed so high that you find you can't make further entries! If such a mistake occurs, don't panic or pull the batteries. Just press all four buttons simultaneously. The operating speed is reset to 20 WPM at the current knob position and the function-entry speed defaults to follow the knob setting. You can then decrease the speed to a comfortable value.

Summary and Acknowledgments

The CMOS Super Keyer II is versatile, simple and affordable. It has the advantage of battery operation and can serve your needs from a basic iambic keyer to a powerful contest machine.

Designs such as this are never done in a vacuum. We gratefully acknowledge the assistance, suggestions, and encouragement offered by Bob, W9KNI; Joe, NØBB; Dale, WØIZ; Barry, WAØRJT, and Jim, WØSR.

Notes

[1]J. Russell and C. Southard, "The CMOS Super Keyer," *QST*, Oct 1981, pp 11-17.

[2]A detailed operating manual and parts kit for the PC-board-mounted parts (programmed CPU IC, IC socket, ceramic resonator, transistors, resistors, capacitors, and etched PC board) are available from Idiom Press, Box 583, Deerfield, IL 60015. Price: $45 (subject to change without notice). Please add $3 shipping and handling in the US, $5 for surface-mail foreign orders. Credit cards are not accepted. (The ARRL and *QST* in no way warrant this offer.) As a service to the visually impaired, an operating manual is available on disk free of charge. To obtain the manual-on-disk, please send a PC- or MS-DOS® -formatted, 3½ or 5¼-inch floppy disk and self-addressed stamped mailer to Idiom Press. When corresponding with the authors or Idiom Press, include a business-size, self-addressed, envelope with one unit of First Class postage.

[3]See J. Galm, "Cheap and Easy Control-Signal Level Converters," *QST*, Feb 1990, pp 24-27, for a means of interfacing this keyer with negative-key-line transmitters—*Ed.*

[4]Mouser Electronics, 2401 Hwy 287 N, Mansfield, TX 76063, tel 800-346-6873.

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Bud Southard, NØII, was first licensed in 1953 as W9ZPU. He earned a BSEE degree from Marquette University, and is a software engineer at Rockwell International. A high-speed CW enthusiast, Bud can often be spotted touring on his Harley "hog."