

A PIC16F84-Based CW Decoder

Although designed primarily for learning CW, new and experienced CW ops are sure to like this simple and inexpensive CW decoder!

This project arose from a two-fold need connected with learning CW: First, it goes beyond the traditional oscillator-only method by providing you with a display with which you can verify the correctness of your keying—send and see. Secondly, you can connect the decoder to your receiver to help you copy code either as practice or during a QSO. Having an alphanumeric readout can be an especially big assist to newcomers who tend to be a bit nervous and have difficulty copying during their initial CW QSOs. The readout helps you cope with band conditions and variable sending speeds, too. A decoder such as this

one can't substitute for the ear/brain combination, but it can speed up the process of learning CW and enjoying it!

The received signal must be clear and strong; don't expect the decoder to perform well with a weak and fading signal in QRM. For such a situation, your ear/brain combination will do a much better job. With a decent incoming signal level, this decoder performs well, automatically adapting itself to the incoming CW at speeds between 5 and 30 WPM.

Decoder Software

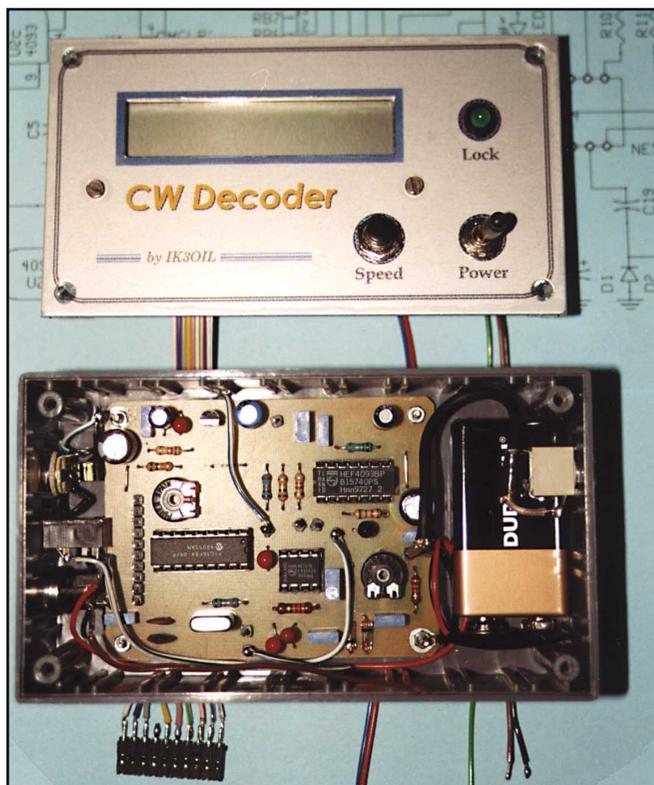
I developed the software using the PIC16xxx assembly language to run in a

PIC16F84 microprocessor (see the sidebar, "Development Tools"). The program measures the received signal *on* and *off* times, obtains some statistical mean values, then calculates three parameters that are then used for decoding: the mean lengths of the dit and dah cycles, the intercharacter pause and the interword pause. A flow chart of the program (macro level) is shown in Figure 1.

An interword automatic spacing function is provided, based on a regular timing of the pauses in the code received. If the decoder is used for training purposes, or while receiving improperly sent CW, the interword spacing can be turned off. With the interword spacing turned off, received



The asterisks appearing at the interword spaces are generated by sending a bogus Morse character. This display was generated using the straight key and as shown here, interword spacing is turned off.



An inside view of the decoder. The LCD's 10-pin connector at the bottom-left in the photo attaches to the PC-board-mounted connector at the left near the PIC (U1) and pot (RV1).

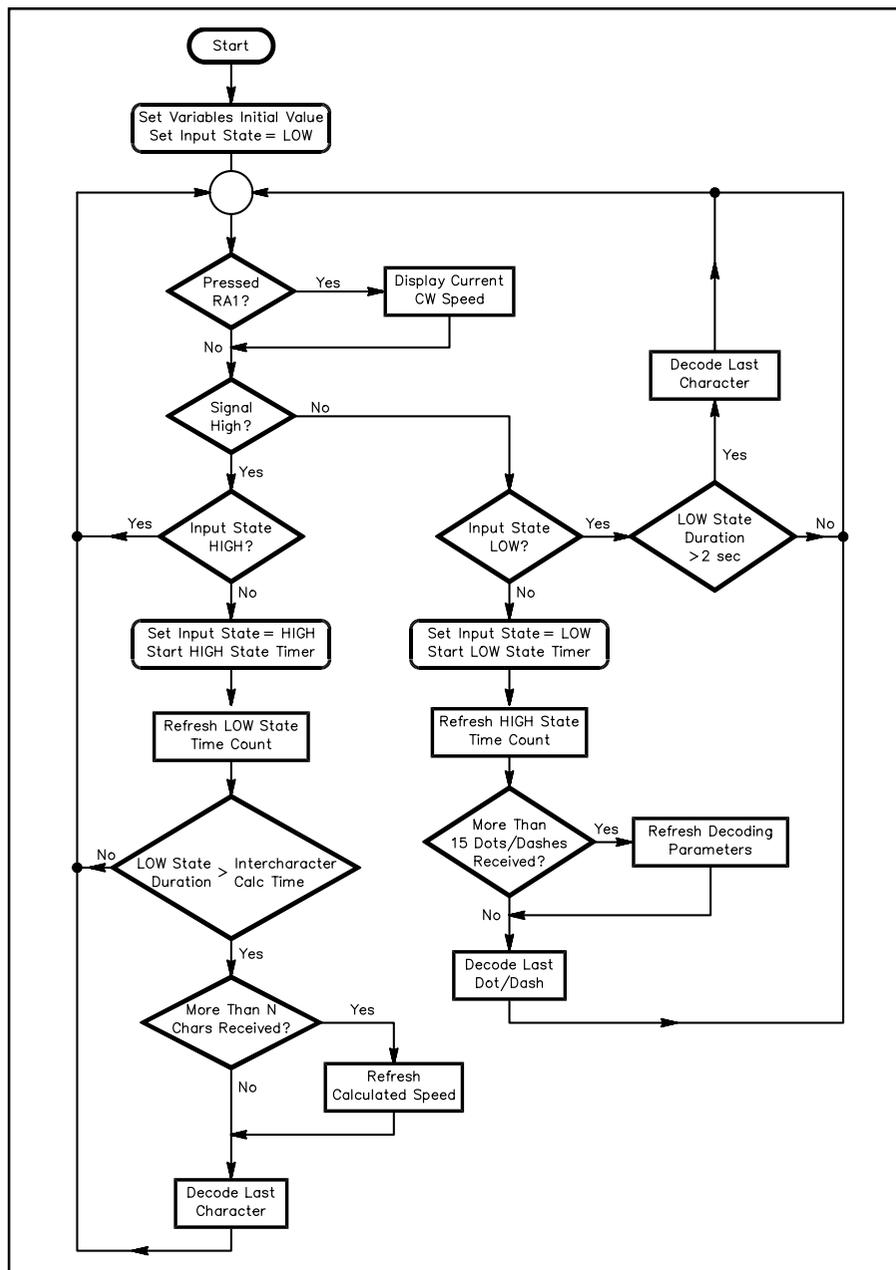


Figure 1—A flowchart of the decoder's software routine. RA1 refers to the PIC pin (18) to which the SPEED pushbutton (S2) is connected.

characters follow one another as a single, continuous alphanumeric string.

The decoder's initial setting is approximately 15 WPM and is refreshed every 15 dits or dahs received. The character set includes all letters, numbers 0 through 9, the period, comma, hyphen, double dash and question mark. Unrecognized characters are displayed as asterisks (*). The prosign SK is displayed as an octothorpe (#).

Circuit Description

The circuit (see Figure 2) is simple and employs only four ICs. The main characters in the decoder are a programmed PIC16F84 microprocessor^{1,2} and a 16-character, 1-line

LCD. Ground the unused pins (B0-B3) of the LCD and its R/W pin. You can increase the LCD's line length to 24 or 40 characters by performing a simple software modification (You'll need to be able to program your own PIC to do this.—Ed.) If a two-line LCD is easier (and/or cheaper) to obtain, use it.

Power is applied to the unit via J1 through S1. A 9-V source is easily obtainable and avoids input-voltage marginality. Although a 9-V battery can supply power for short-term portable or other intermittent operation, use an ac-operated supply for prolonged operation. U3, a 78L05 regulator, delivers +5 V dc to the circuit. The entire circuit draws about 15 mA.

Received audio is applied to J3, the AUDIO jack. The minimum acceptable au-

Figure 2—Schematic of the CW decoder. The labels P1 and J near S2 and W2, respectively, refer to the identifiers on the PC board top. Ground the unused pins of the LCD (B0-B3) and the R/W-pin. For some component IDs, we deviate from QST style to accommodate existing author-supplied IDs. Unless otherwise specified, resistors are 1/4 W, 5% tolerance carbon-composition or film units. Equivalent parts can be substituted; n.c. indicates no connection. Parts can be obtained from several sources (see Note 2) including Digi-Key Corp, 701 Brooks Ave S, Thief River Falls, MN 56701-0677; tel 800-344-4539, 218-681-6674, fax 218-681-3380; <http://www.digikey.com>, Mouser Electronics, 958 N Main St, Mansfield, TX 76063-4827; tel 800-276-2206, 972-271-5546, local Dallas orders call 972-271-5546, fax 972-271-2462 and others.

C1—47 μ F, 16 V electrolytic
C2—4.7 μ F, 10 V tantalum
C3—100 μ F, 16 V electrolytic
C4, C7, C9, C10, C15, C16, C19, C20—0.1 μ F

C5, C6—82 pF disc ceramic
C8, C13—1 μ F, 50 V tantalum
C11, C14—220 μ F, 16 V electrolytic
C12—22 μ F, 50 V electrolytic
C17—1.5 μ F, 25 V tantalum
C18—0.47 μ F, 35 V tantalum

D1-D2—1N34, OA95, AA118 germanium diode

DS1—LED

DS2—16-character \times 1 LCD (Optrex 16117A, etc.); a 2-line display may be used.

J1, J3—Coaxial panel-mount phono jack

J2—Two-circuit panel-mount jack

J4—Ten-pin SIP, 0.1-inch centers

P1—SIP header

R1, R2—1.8 k Ω

R3, R5, R6, R13—18 k Ω

R4—22 k Ω

R7—820 Ω

R8-R10—10 k Ω

R11—33 k Ω

R12—3.3 k Ω

RV1, RV2—4.7-k Ω PC-mount potentiometer

U1—PIC16F84 programmed microprocessor; see text and Note 2.

U2—4093 CMOS quad NAND sch

U3—78L05 regulator

U4—NE567 tone decoder

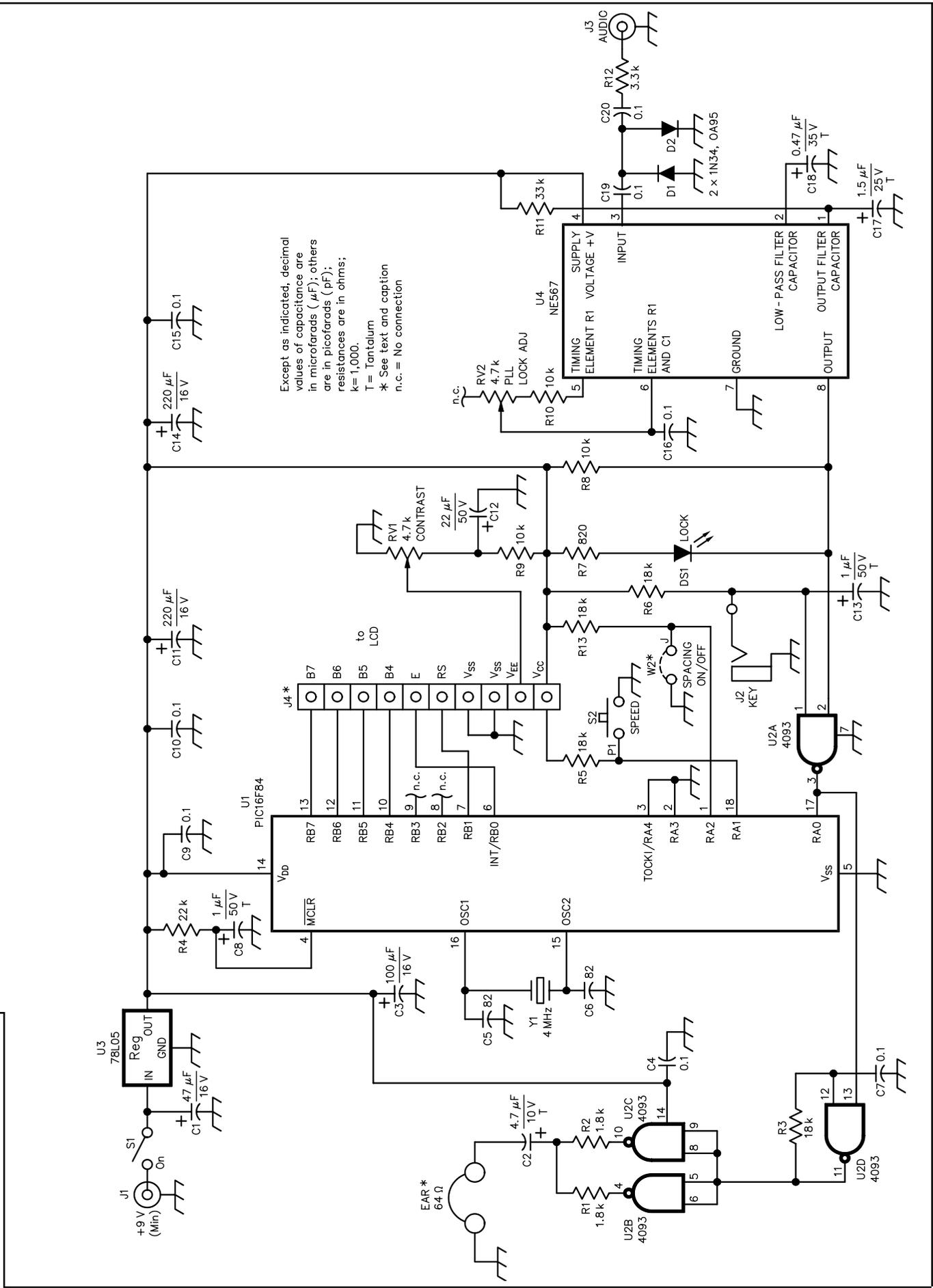
X1—4-MHz microprocessor crystal

Misc: PC board, IC sockets (one 8-pin, two 14-pin), SIP headers, hardware, enclosure.

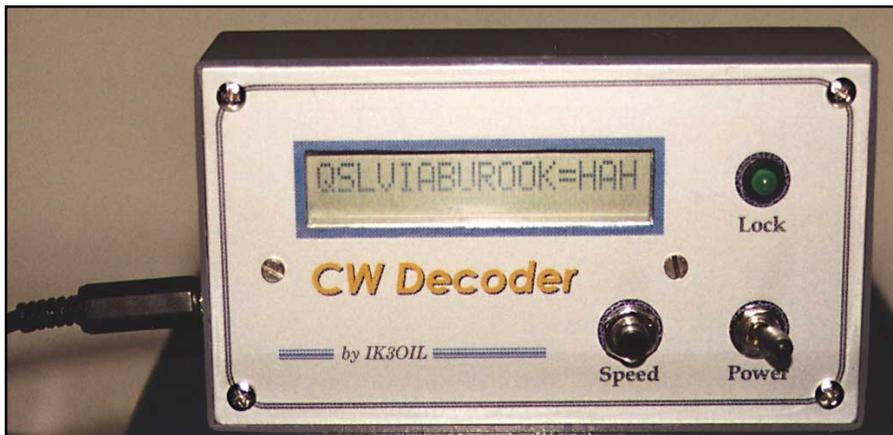
dio-input level is 100 mV P-P with a time duration of at least 20 ms. An on-board germanium-diode clipper (D1, D2) handles large input-signal levels. A KEY input is provided for sending practice, and both inputs (AUDIO and KEY) activate the display and audio monitor. So whatever you're receiving or keying appears on the LCD.

U4, an NE567 tone decoder, takes charge of processing the audio-input signal. While receiving CW, LED DS1 (LOCK), connected to the pin 8 of U4, indi-

¹Notes appear on page 40.



Except as indicated, decimal values of capacitance are in microfarads (µF); others are in picofarads (pF); resistances are in ohms; k=1,000.
 T = Tantalum
 * See text and caption
 n.c. = No connection



Here's how the display appears with no interword spacing.

Development Tools

If you've built (or read) any of the PIC projects described earlier in *QST*, you'll know PIC development tools abound. You may find several commercial development tools for the PIC16F84 microprocessor (see, for example, the Microchip Starter Kits), but if you are interested in a low-cost approach, at the Microchip Web site (<http://www.microchip2.com/index.html>), you can download the assembler software (MPASM) and the simulator (MPISM), together with the technical documentation, from <http://www.microchip.com/10/Tools/pTools/MPASM/index.htm> and <http://www.microchip.com/10/Tools/Archive/index.htm>, respectively. To program the PIC, I used a circuit described by David Tait (see *Note 1*, too—*Ed.*). It's available free from the Internet site <http://www.man.ac.uk/~mbhstjdj/files/>. For schematic capture and PC-board layout software, I use *Circad*. You can download a shareware version from the Holophase Internet site <http://www.holophase.com/>. —Francesco Morgantini, IK3OIL

icates correct frequency lock. The lock frequency of the PLL in U4 can be adjusted between 700 Hz and 1 kHz by the **PLL LOCK** trimmer, RV2. Using the given component values, a bandwidth of about 100 Hz is obtained. The measured lock delay of the PLL is about 10 ms.

The decoder has a narrow bandwidth, so the audio monitor and LED help in receiver tuning.

Pin 8 of U4 also drives pin 2 of U2A, a section of a 4093 CMOS **NAND**-gate IC. U2A's output (pin 3) is connected to the PIC (U1) at pin 17 (RA0) and to a second CMOS gate (U2D, pin 13) working as an audio generator. The two remaining 4093 gates (U2B and U2C) act as a buffer capable of driving a medium-impedance load of 64 Ω (two 32-Ω earphones connected in series).

Trim pot RV1 is the LCD's **CONTRAST** control. The only required tuning adjustment is handled by trim pot RV2 to obtain the best frequency lock using a strong and clear CW signal from your receiver.

When first powered on, U1 is set to an intermediate keying rate of about 15 WPM. Therefore, it may take a few characters before the decoder locks to the received signal if its speed is much faster or slower than the initialization speed. Pressing pushbutton S2 displays the keying rate in characters per minute. To turn off the interword spacing, install jumper W2 to ground point J of *Figure 2*.

Construction

The decoder is assembled on a 2³/₈ × 3¹/₈-inch PC board (see *Note 2*). To make assembly easy, use physically small components. To make the LCD, DS2, easy to connect to and disconnect from the decoder, I use a 10-conductor flat ribbon cable and a 10-pin right-angle SIP header on the PC board as shown in the photo. Be sure to correlate the pins of J4 to the pin-out of the LCD you use.

Use shielded wire to connect the **AUDIO** jack to the PC board. This helps minimize extraneous signal pickup.

Final Notes

You shouldn't have any difficulty finding the required components or assembling the decoder. If you are interested in obtaining more information, a copy of the PIC software or the *Circad* PC-board files, contact me at ik3oil@iol.it (see *Note 2*).

Notes

¹John Hansen, W2FS, "Using PIC Microcontrollers in Amateur Radio Projects," *QST*, Oct 1998, pp 34-40.

²PC boards and *programmed* PICs for this project are available from FAR Circuits, 18N640 Field Ct, Dundee, IL 60118-9269; tel 847-836-9148 (voice and fax). Prices: *Programmed* PIC, \$20; PC board, \$5 plus \$1.50 shipping for up to four boards and ICs. Visa and MasterCard accepted with a \$3 service charge. See the caption of *Figure 2* for component-distributor information.

The software and *Circad* files can be found in *IK3OILCW.ZIP* on the Internet at <http://www.arri.org/files/qst/>.

First licensed in 1990, Francesco Morgantini, IK3OIL, holds an electronic engineering degree from Padova University. His Amateur Radio interests include "homebrewing" and experimenting with HF RF circuits and QRP. Francesco's SSB/CW solid-state multiband station is entirely homemade! For QRP, Francesco has built several little rigs for various amateur bands. Other interests include experimenting with microprocessors, particularly for use in DDS and DSP for Amateur Radio purposes. Francesco has had several articles published in the *Italian Amateur Radio Society* journal. See the July/August 1998 issue of *QEX* for Francesco's description of a homemade PLL VFO project.* You can contact Francesco at Via Leoncavallo, 21, 35010 Vigonza (PD), Italy; ik3oil@iol.it.

*Francesco Morgantini, IK3OIL, "A Continuous Coverage HF VFO," *QEX*, July/Aug, 1998, pp 32-37. See Feedback in November 1999 *QST*.

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New Products

NEW IC-706 AMPLIFIER RELAY FROM W1WEF

◇ W1WEF has added another accessory to his line of contest interfaces. The new device facilitates connection of any version of the ICOM IC-706 transceiver to nearly any HF or 6-meter amplifier. A 13-pin DIN connector on a short pigtail plugs into the accessory connector on the rear of the '706, and an RCA (phono) jack is provided to connect a cable to the amplifier's relay control point. When the IC-706 is keyed in CW, or the PTT/VOX is tripped on SSB, the amplifier is enabled. The relay contacts are rated for 1 A at 250 V dc.

The price is \$29 plus \$3 shipping and handling. For more information or to place an order, contact Jack Schuster, W1WEF, 408 Thompson St, Glastonbury, CT 06033; w1wef@snet.net.

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◇ With a design similar to the pocket protectors used to hold pens and pencils, Cutting Edge Enterprises' *PowerPort PocketPRO* lets you carry the new sub-mini H-Ts—like the Yaesu VX-1R, the Alinco S and C series and the ICOM IC-Q7A—upright and secure in your shirt pocket.

The *PocketPRO* is constructed of glove leather and features a clip that passes over the front of your shirt pocket to keep the protector in place. Three compartments, a wide center section for the radio, and two narrow sections on each side for holding pens, pencils or spare antennas, are provided.

Price: \$19.95. For further information, contact Cutting Edge Enterprises, 1803 Mission Street, Suite 546, Santa Cruz, CA 95060; tel 800-206-0115; fax 831-426-0115; cee@cruzio.com.

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