HOMING IN

Radio Direction Finding

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Build the Montreal Fox Controller

Have you started building your foxboxes yet? Last month's "Homing In" showed you how obsolete business-band transceivers, discarded medical batteries, and military surplus ammunition boxes can slash the cost of making transmitters for international-style radio-orienteering (also called foxtailing and ARDF). Now you can save some serious cash on the control circuits, thanks to two generous hams in Montreal.

A controller board is the brains of a fox transmitter. For radio direction finding (RDF) contests under International Amateur Radio Union (IARU) rules, it makes the fox transmit for exactly one minute at its correct point in the sequence of five transmitters. It generates the appropriate CW message (e.g., MOE for fox #1) throughout the transmission and the station callsign at the end. Delayed starting and automatic shutoff after the hunt are other desirable controller features.

In 1970, I built my first solid-state CW callsign generator for a UHF repeater. It was a big improvement over a mechanical code wheel. It didn't seem like a big drawback that it had 20 discrete transistors and 80 diodes and required almost a square foot of perforated board to hold everything. If I hadn't spent several hours manipulating logic maps of the dits and dahs in my callsign, it would have taken over 200 diodes. Today, one IC and a handful of other parts will do all that, plus provide transmitter control and timing to meet IARU rules.

One-chip microcontrollers using reduced-instruction-set architecture are revolutionizing the design of logic circuits. CMOS technology minimizes current drain, while EEPROM or flash memories retain data through power-off periods and permit simple reprogramming in the field. Peripheral Interface Controllers (PICs) by Microchip Technology Incorporated are among the most popular microcontrollers for amateur radio home construction projects.

When I visited Montreal last October, I was shown a nifty little PIC controller for mobile T-hunts. I encouraged its developers (Jacques Brodeur VE2JX and François Tremblay VE2EMM) to make a special version for IARU radio-orienteering standards. They soon did just that. By eliminating the DTMF controlling/programming feature, it became a simple one-IC project. Raw parts cost for five controllers is about $15 each, not including shipping, circuit board, and programming of the PIC.

Two controllers in one

The Montreal Fox Controller uses a 16F84 reprogrammable PIC with nonvolatile flash memory. An inexpensive 4.194304 MHz microprocessor crystal (X1) provides timing accuracy and synchronization through long hunts, with about one second variation in six hours. The MCW output is a keyed tone to drive the mike input of a two-meter FM rig. The CW output is an open-collector pulldown for on-off keying of an A1 transmitter per IARU rules on 80-meter foxhunts.

MOx messages are sent in slow code, but station ID is sent at about 20 WPM, to avoid hunters confusing the callsign with the fox number. You can put out your foxes in advance and have them come on automatically at hunt time. Delayed startup is programmed with DIP switches in 30-minute increments from zero to three-and-a-half hours.

Fig. 1 is the complete schematic of the Montreal Fox Controller. Most of the parts should be locally available. Digi-Key Corporation [701 Brooks Avenue South, P.O. Box 677, Thief River Falls MN 56701; (800) 344-4539] carries all components, including the unprogrammed PIC IC.

VE2JX and VE2EMM are making the PIC program for this project available to all hams for ARDF and other noncommercial purposes. They don't want to go into the circuit board or parts business right now, so I am arranging for circuit boards to be sold by FAR Circuits [18N640 Field Court, Dundee IL 60118; (847) 836-9148]. As of this writing, the FAR boards are not yet fully checked out and ready to go. There may be additional sources of boards in Canada and Australia by the time you read this.

My original plan was to include all the circuit board and programmed PIC sources in this article. However, the development of this project was slowed greatly by the monstrous ice storm that struck Montreal in early January. "Four inches of ice formed on everything," Jacques wrote when his Internet access resumed. "Just imagine the weight! The downtown Montreal area was closed for removing the ice on the tall buildings—it was falling on the people. Hundreds of pylons for the transport power lines are down, tens of thousands of poles are broken, and the distribution network is so damaged that they say it cannot be repaired. It will have to be rebuilt to new completely. People could not use their cars, because the streets were littered with poles, trees, and electric lines. All business, industry and farming in the area stopped. Cows were dying, many farmers could not milk them."

As I write this two weeks later, 250,000 homes are still without power in the Montreal area. Not surprisingly, François and Jacques have been busy with emergency communications and their ham projects have been on hold. So check the "Homing In" Web site, where you will find an up-to-date list of sources for circuit boards and

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the "N" channel, but they are expensive and hard to obtain.

A heat sink will also be required on the 2N3055 pass transistor. If you intend to use an encapsulated bridge rectifier, it too will need a heat sink. Other than that, there are no restrictions on construction. Use of an IC socket would be a good idea for the LM324.

Changes in the wind

I really don't like to place a current shunt in the negative lead. It is cheap and dirty, but requires the negative side of the charger to float. The battery negative may be grounded if you desire. If the shunt resistor were to be placed in the positive side, a separate supply would be necessary to run the op amp.

I may change the way the current limiting operates. By controlling the FET via the current limiting op amp, we could eliminate the PWM from the LM317. I've not looked at the spec sheets for the LM317, so really can't say for sure if running the adj line on and off will damage the LM317.

As I mentioned in the first part of the column, this project is just a starting point. Refinements will be necessary to suit your needs, as well as mine. I'll keep you posted on any changes that I've worked into the charger. 73

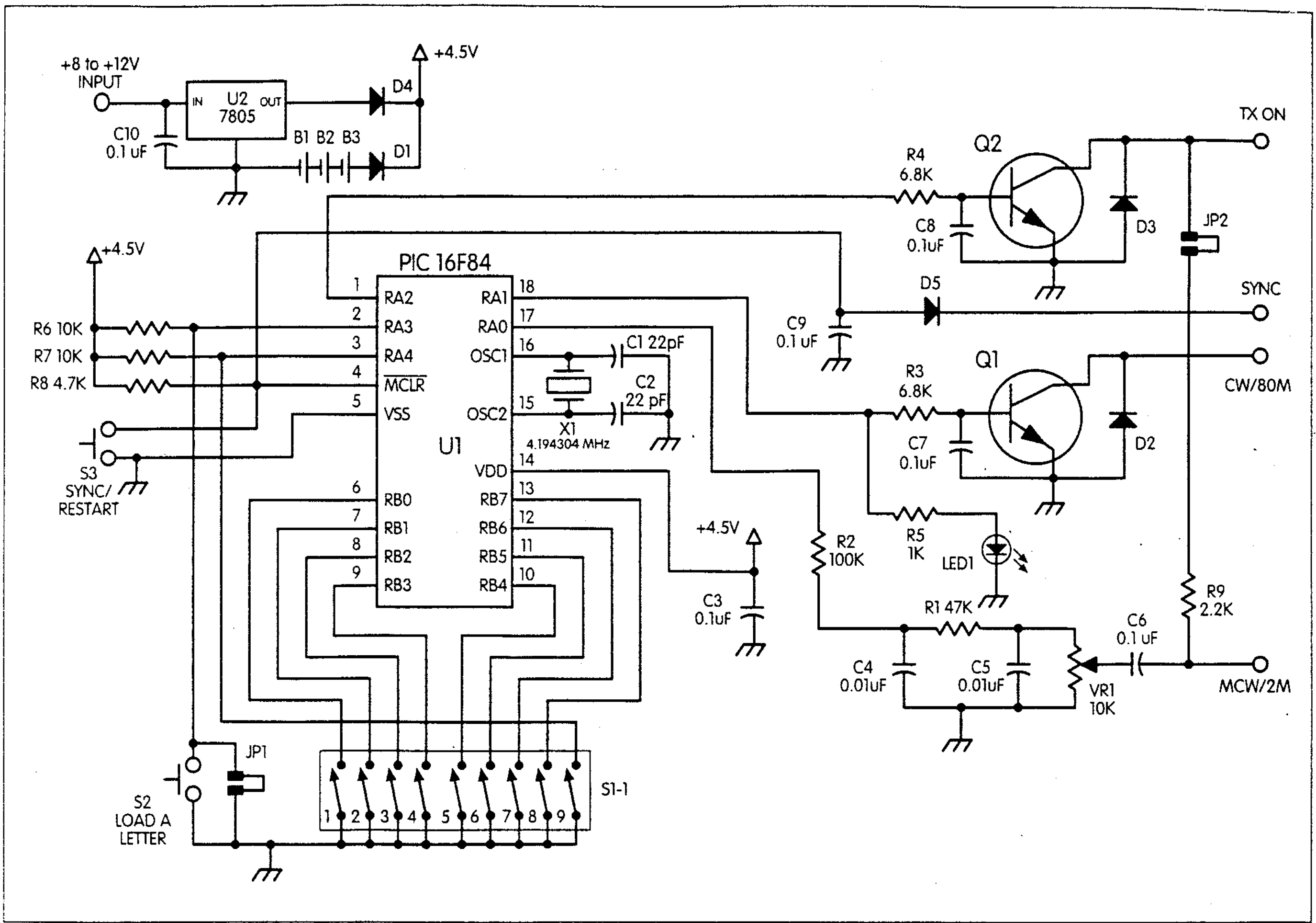

Fig. 1. Schematic diagram of the Montreal Fox Controller. Unless otherwise indicated, resistances are in ohms, decimal capacitances are in microfarads, and diodes are silicon signal types such as 1N4148. Transistors are common switching types such as 2N2222A.

preprogrammed PICs for this project. At this site you will also find the source code and hex files for the firmware, which you can use to program your own PICs. The source code file includes the table of values for CW characters that you will use to change the callsign in the field.

If you do not have Web access, send E-mail to me and I will send you the files via return E-mail. If you are not E-mail or Web-equipped, send me a five-inch by seven-inch self-addressed stamped envelope with three ounces of postage and I will send you hard copies. If you get the program via postal mail, you will have to enter it by hand from the hard copy, a rather tedious task.

You may discover, as I did, that it's useful to have the capability of assembling PIC micro code and programming PICs yourself. Microchip [2355 West Chandler Boulevard, Chandler AZ 85224; (602) 786-7200] has a full line of development tools and software for programming PICs and debugging micro code including SPASM, a freeware DOS assembler program. Several other companies also make such tools. Plans for building your own PIC programmer from scratch can be found on the Internet.

For programming my PICs, I chose the PIC-1+ from IT Technologies [3704 Cheviot Avenue, Suite 3, Cincinnati OH 45211; (513) 661-7523)]. It is available in kit form for $39, including power supply, DB-25 data cable, and DOS software. The old 286 computer next to my workbench runs it just fine. I recommend spending $9 more to get the 18-pin zero-insertion-force PIC socket. The PIC-1+ can program the Pica's program memory, set configuration fuses, verify programs, and read PIC memory to a file. Its software also performs data memory programming, reading of data memory, and bulk erasing of EEPROM-based PICs. Links to Microchip, IT and the freeware PIC programmer are at the "Homing In" Web site.

Perforated board construction is fine for this project, as **Photo A** shows. High frequencies are present only near X1, C1, and C2. Keep the leads of these components short and place them close to the PIC. Put C3 near U1 with short leads to provide good high frequency bypassing. Be sure to use a socket on U1 to facilitate any firmware changes or upgrades.

S1 is a nine-section DIP switch. VE2JX suggests marking it backwards on the board, with S1-9 on the left. This places the least significant bits of each function on the right, the normal convention. An open switch section represents a logic 1; a closed switch is a logic zero. I discovered the hard way, as did Jacques, that surplus rocker-style DIP switches can have high enough contact resistance to make callsign and function programming unreliable. Look for high quality slide-type DIP switches with gold-plated contacts.

Keying transistors Q1 and Q2 are pulldowns for transmitter keying circuits requiring grounding of a positive voltage, as typical VHF/UHF mobile rigs do. With JP2 in place, the MCW/2m output provides both keying and audio to most handie-talkies. If your radio requires keying current greater than 40 milliamperes like some older mobile sets, you may need to change the value of R4 and/or provide a beefier transistor at Q2. The same is true of R3 and Q1 on the CW/80m output. The RA1 and RA2 outputs of the 16F84 will source up to 20 mA.

François and Jacques added several components for "insurance" purposes. C7, C8, and C9 prevent problems from spikes and noise, so they may not be mandatory in your application. D2 and D3 protect Q1 and Q2 from the inductive kick of relays and are needed only if your transmitter has them. If you will use your controllers only on two meters with MCW audio, you can delete R4, C8, Q2 and D3. Conversely, if your unit is only for an 80-meter CW fox, leave out R1, R2, R4, R9, C4, C5, C6, C8, Q2, D3, VR1, and JP2.

U2, D4, and C10 are optional. Maximum current drain of the PIC circuit is only eight milliamperes, half of which is indicator LED1. Three AAA alkaline batteries will power it for over 150 hours. U2 and associated components allow you to eliminate the batteries and power the board from the same +8 to +14 V source that powers your fox transmitter. Remember that any power interruption resets all the PIC timers, so don't disconnect power after you synchronize the foxes for a hunt. Using batteries in addition to the regulator provides backup to carry the timer through any external power interruptions. Schottky diodes D1 and D4 (1N5817) prevent the batteries and regulator from damaging one another.

Ready to test?

Before installing the PIC in its socket, check your workmanship. Make resistance measurements to verify that one terminal of each push-button and DIP switch section is connected to circuit ground. Close all DIP switches and jumper JP1. The emitter of each transistor and pins 2, 5, 6, 7, 8, 9, 10, 11, 12, and 13 of U1 should show continuity to ground. If you included regulator U2, apply +12 volts to the input and verify +5 volts at the output. With JP1 removed and power applied from fresh batteries or U2, verify that about +4.8 volts is present at U1 pins 2, 3, 4, and 14, but not other pins.

If everything checks out OK, then remove power, install JP1, plug in U1, and try it out. Set the DIP switches for continuous cycling, fox #1, and zero delay per **Table 1**. Apply power, press SYNC/RESTART (S3), and view LED1 to verify that the unit sends MOE nine times in slow CW, then identifies rapidly as DE FOXBOX.

Besides flashing the CW characters, the LED provides other operational indications. During the delayed-start wait time, it flashes once per second. If you set the DIP switches for an improper combination, such as fox #5 cycling once every three minutes, it flashes rapidly to signal your error.

DIP switches S1-1 through S1-9 determine the fox number and message as shown in **Table 1**. In accordance with IARU regulations, fox #1 sends MOE continuously at about 8 words per minute. Fox #2 sends MOI, fox #3 sends MOS, and so forth. Even if you don't know CW, you can determine which fox you're hearing by counting the dits after MO (which is "dah-dah, dah-dah-dah").

The IARU does not prescribe the message for fox numbers greater than five. In the VE2JX design, fox #6 sends MON (ending in "dah-dit") and fox #7 sends MOD (ending in "dah-di-dit"). For foxtailing events in a very large park where contestants can get lost, there is usually a fox on a separate frequency sending MO continuously at the finish line, which is usually at the same place as the start. Such a mode is provided in this unit.

Pressing the SYNC/RESTART push-button (S3) with JP1 in place causes the microcontroller to read the octal code settings of S1 and commence operation in accordance with these settings. Press S3 when you power up, when you change modes, and when you begin a delayed start cycle. To operate a set of IARU-style foxes in sequence, set the DIP switches in each one to its unique fox number. The setting for number of foxes and start delay must be the same for each fox. Now press S3 on each unit simultaneously.

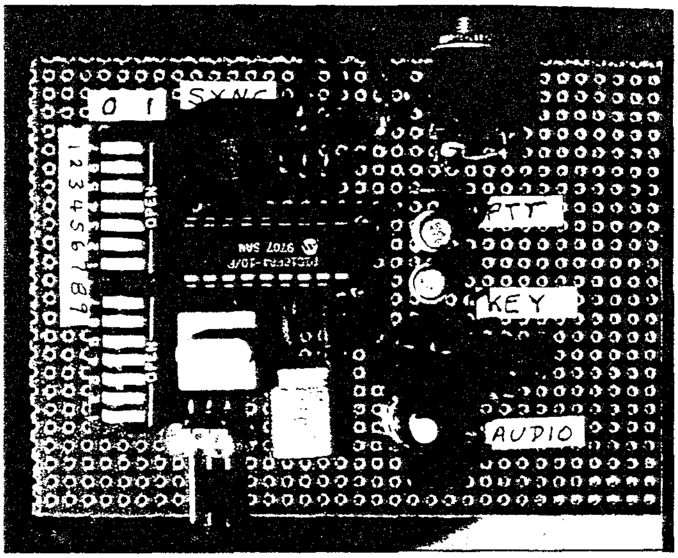

Photo A. Prototype of the Montreal Fox Controller on perforated circuit board. To facilitate program changes, be sure to provide a socket for the PIC.

You don't have enough fingers? OK, connect the SYNC terminal on each unit together and short this connection to circuit return (ground) momentarily to perform the restart. Of course, the circuit returns of each board must also be connected together to do this. If you will be synchronizing several foxboxes regularly, make up a wire harness just for this operation.

Station identification remains in data memory when power is removed. Changing it from FOXBOX to your own callsign is a simple procedure. Monitor the CW tone output at RA0 (U1-17) with headphones or a speaker amplifier. (Computer speakers work well for this.) Alternately, you can watch the CW flashing of the LED. With power on, remove jumper JP1 and press SYNC/RESTART.

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Setting	Cycle	Message	Delay
x,x,x	S1-9,8,7	S1-6,5,4	S1-3,2,1
0,0,0	Continuous	MO	None
0,0,1	Continuous	MOE	0:30
0,1,0	2 minutes	MOI	1:00
0,1,1	3 minutes	MOS	1:30
1,0,0	4 minutes	MOH	2:00
1,0,1	5 minutes	MO5	2:30
1,1,0	6 minutes	MON	3:00
1,1,1	7 minutes	MOD	3:30

Table 1. DIP switch settings for transmit cycle, fox message, and start delay.