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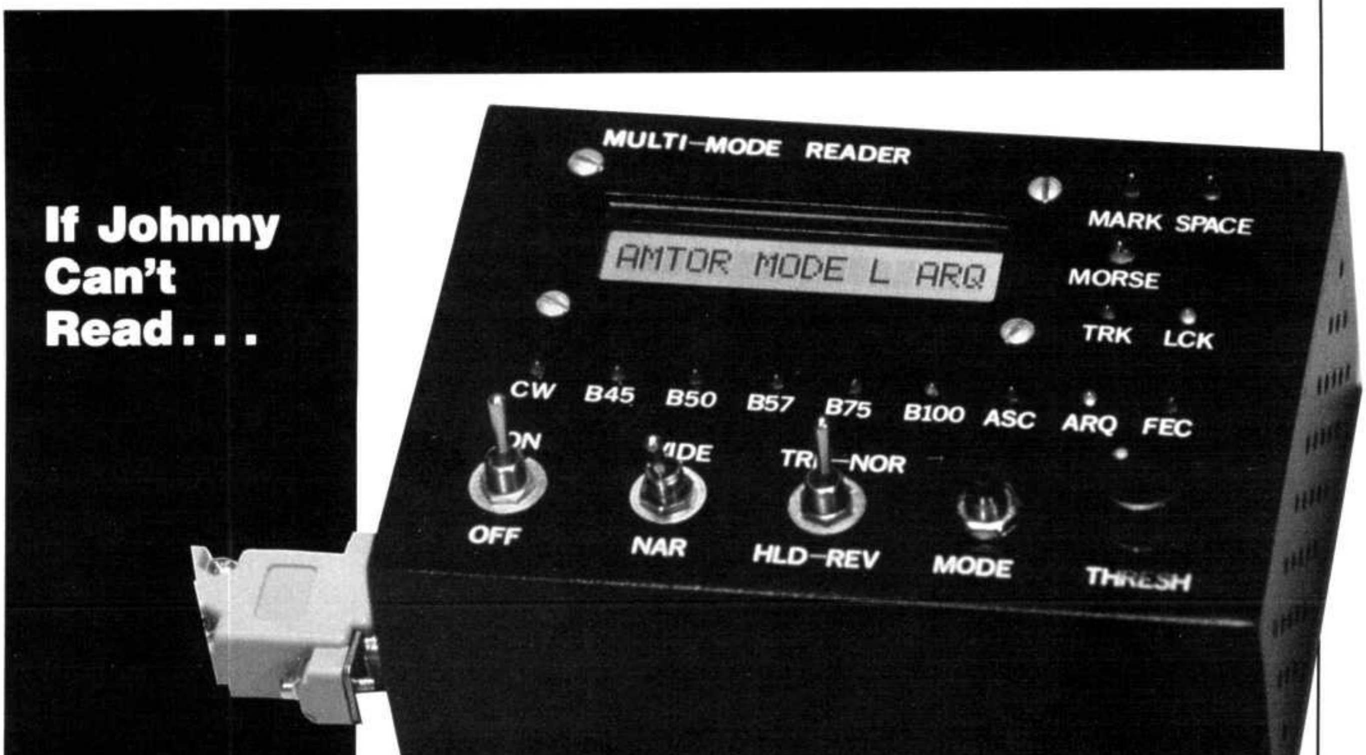
ARRL Experimenters' Exchange

JUNE 1991

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# Empirically Speaking. . .

## Pervasive Technology

The keynote address at the IEEE Vehicular Technology Conference in St Louis in May 1991 was given by Southwestern Bell Mobile Systems President John Stupka. Not surprisingly, his sermon to the converted was on the subject of cellular radio. He credited a speaker from Hewlett Packard with coining the term "pervasive technology," meaning a gadget so ubiquitous that everyone not only has one, but knows how to use it and can't remember not having one since birth. Another attribute of pervasive technology is that the technology may be extremely complex but is hidden from the user.

The telephone obviously qualifies for people brought up in industrialized countries. Radio broadcasting does for most people alive today, and television broadcasting is approaching that status.

The video cassette recorder doesn't meet the test on several counts. VCRs haven't been around all that long, not quite everyone has one, and very few VCR owners have figured out how to make the digital clock quit blinking "12:00" incessantly, much less know how to program it to record programs.

The cellular radiotelephone isn't yet into the pervasive category for several reasons. Cellular phones haven't been around all that long. Then there's cost—while the price of equipment has come down dramatically in a few years, the charges to make a phone call are still too high for the average person. Further, cellular phones have one more button than ordinary telephones. No one wants to read an instruction book before using something they expect to work just like a telephone.

Leaving the cellular world, it is an interesting mental exercise to apply the above thinking to Amateur Radio. Wait a minute. . . now this is going off the deep end by even suggesting that there should be an Amateur Radio transceiver in every pot and each child issued a ham call sign at birth. Perhaps that's a little optimistic and we need to keep things modest at first.

There's the question of what technology is, or should be, pervasive within the context of Amateur Radio. It seems that the 2-meter FM voice HT is about as close one could get. The HT is reasonably priced, easier to operate than a VCR, fits in the pocket or purse, and can hit a repeater practically everywhere in industrialized countries. They've been around since many hams were born. HTs are definitely the thing to have if you're having more than one.

Once thought to be "not ham radio, thank you," packet has become fairly mainstream. Its popularity comes because several system ingredients are practically pervasive: the HT and the personal computer. Although some neat packages have been assembled, some fresh design thinking is needed to hide the complexity and present a human engineered system to the user.

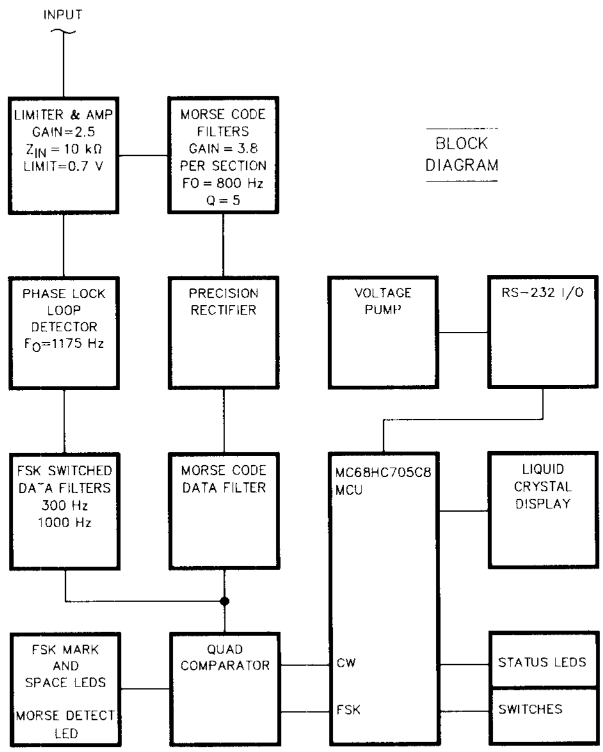
Amateur HF radios are a different story. The need for an external antenna is a basic complication, so much so that HF operation is difficult for many hams because of where they live. Although there are exceptions, HF transceivers are often designed for maximum "bells and whistles" rather than maximum ubiquity. Nevertheless, there has been progress: Remember what fun it was to dip and load?

This gives rise to some questions: Should Amateur Radio equipment be designed for maximum ease of operation, with the technology hidden, thus making it possible for greatest number of people to make use of them? Or, should we recognize that Amateur Radio is a technical avocation and let the technology hang out there so hams will know what's going on inside the boxes? If it's there to see, touch and feel, isn't it more likely that amateurs would get ideas on how to improve things? Is more progress made by improving the mainstream systems or by innovative advancements in the state-of-the-art in experimental technology? What's your view?—*W4RI*

# A Microcontroller Based Multimode Reader

**By Steve Haynal, AA6DG**
**PO Box 712**
**Angwin, CA 94508**

I have always been intrigued by everything I hear on my shortwave radio. I guess that's why I love Amateur Radio. Unfortunately, I have never been able to afford anything that can decode the many modes of data transmissions I hear. But when I received the new Motorola MC68HC705C8 microcontroller unit in the mail, (a complete computer on a chip), I decided this was the perfect chip to build a multimode reader around. The end result is something that you will be quite pleased with. It's a small reader, capable of deciphering Morse code from 3 to 80 WPM, Baudot RTTY at 45, 50, 57, 75 and 100 bauds, ASCII at 110 bauds, plus ARQ and FEC TOR modes. All this is printed out in plain English on a 16-character liquid-crystal display. Also, if you decide to save any of your copy, a EIA-232 serial port enables you to dump files for storage and/or printing. It's a nice device for someone wanting to "listen around" the bands or for the data communications old timer who needs a small portable reader.




## Theory

Let's get down to how the reader works. Basically there are three stages in this project. The first stage is the detector, some way to convert the incoming audio signal into computer readable data. I used a simple phased-locked loop detector system for the various kinds of FSK data, and a filter/level detector for the Morse code data. The second stage interprets exactly what this data means. I used the new Motorola MC68HC705C8S microcontroller unit or "computer on a chip." It has on-board ROM, CPU, RAM, I/O lines, timer, serial communications, and lots more. The third and last stage is the output. The reader will print the data out in plain English on a LCD display or talk to your computer through a EIA-232 interface.

Now let's take a little more detailed look at how the first stage works. Fig 1, the audio filter and limiter, shows part of the circuit involved in detection. The audio signal is fed in through the dc-blocking capacitor C1 where it is limited by R1, R2, D1 and D2. This limiter is an inverting amplifier set for a gain of 2.4 using one of the four opamps in the LM 348. Since any voltage above 0.7-V P-P is shunted by the back-to-back diodes, the output is effectively limited to about 0.7-V P-P. This protects the PLL detector from high voltages and also protects the Morse-code audio filters from overloading. From here the signal splits in two directions, one path leads to the PLL detector and the other to the Morse-code audio filters and level detector.

After the limiter, all of the various FSK signals are fed to the LM 565 phased-locked loop detector circuit of Fig 2. This is originally the FSK detector application circuit from the *National Semiconductor Data Book*. R17 controls the center frequency for which a tone on either side will produce a high or low output. This can be tuned from 950 to 1500 Hz. I added a switch for two data filters. They are both capable of good copy at speeds up to 110 bauds. One is a 300-Hz filter to provide good response for narrow amateur shifts of 170 Hz. The other is a 1000-Hz filter to handle the wider shifts used in press broadcasts. From here the signal is sent to the comparator circuit of Fig 3 where the PLL signal output is compared to the PLL reference output and a corresponding high or low signal is sent to the MCU. The other two comparators are fed the same signals and are used to drive the mark and space LEDs.

Before moving on, we need to go back to Fig 1 and trace out what happens to the Morse code data. On the right side of Fig 1, components C2-C5 and R3-R6 form two audio filters for the Morse code data only. They each have a quality factor of 5 and a gain of 3.8 in the pass band centered at 800 Hz. They are taken from an audio filter design process described in *Solid State Design for the Radio Amateur*. After the signal is filtered, it is sent to a precision rectifier that saves only the positive peaks of the sine-wave signal. The output here should be quite high, even clipping, if there is a signal present in the Morse-code pass band. This charges up capacitor C6 through R9 and produces a

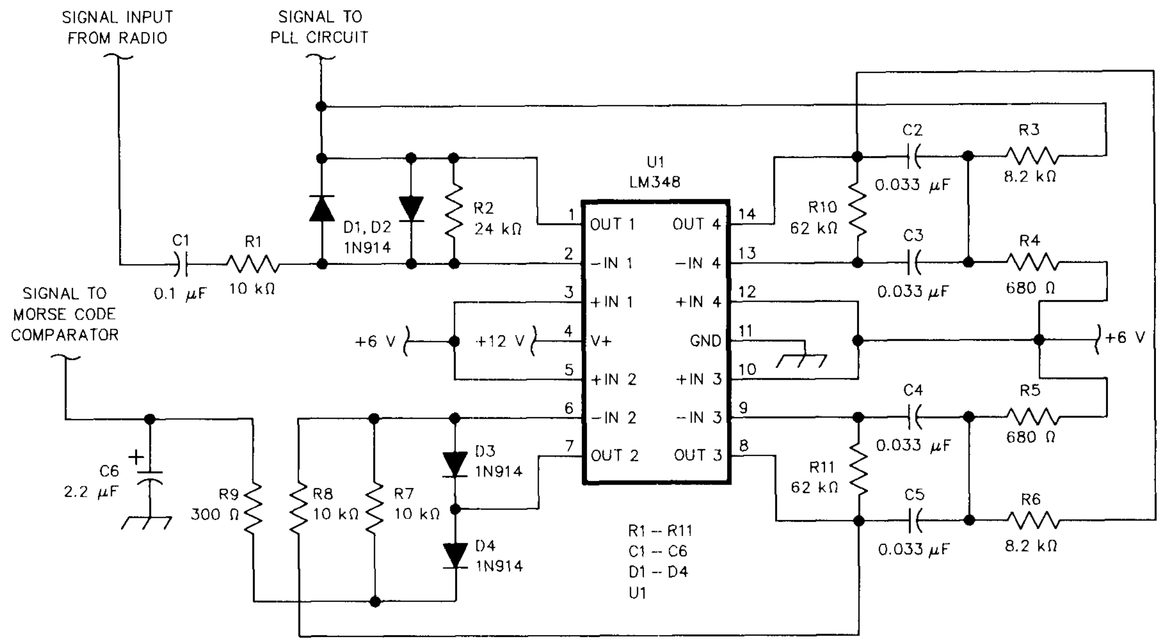



**Fig 1—Schematic of the audio filter and limiter section.**

steady dc voltage representing the strength of any signal in the pass band. This RC circuit must have a time constant long enough to provide a more or less steady dc voltage and at the same time short enough so that the output voltage can swing fast enough to copy high-speed Morse code.

The final step in the Morse code detection process uses one of the four comparators in Fig 3. Coming from the Morse code RC filter in Fig 1 is a dc voltage in the range of 6-10 V. This is the strength of the signal in the pass band. This voltage is compared to a voltage from the divider network of R25-27. If the signal strength voltage is higher, then it is assumed that there is a Morse code dot or dash present and the output is brought low which lights the LED. Finally, this information is fed to the MCU.

The heart of this project is the Motorola Microcontroller Unit, the MC68HC705C8S, in Fig 4. This contains the software program required to translate the incoming data into readable print. Since most of the work is done in software, there is minimal hardware requirements. The reset circuit of R31 and C19 insures that there is a short time between power up and initial reset. Pushbutton switch S2 brings the IRQ interrupt pin low for mode selection. The clock circuit, which consists of C21, C22, R33 and X1, provides the clock for both the internal CPU bus and timer. 8-bit I/O port A is used as a data bus for the LCD display. Port B is used to control eight of the status LEDs. Port C is used to input the Morse code data, to control the remaining three LEDs and three LCD control lines, and as an input for S3, the normal or reverse switch. Two lines from Port D serve as the RS-232 I/O, one as the FSK data input and the other five are unused. The FSK data is also fed into the timer capture pin so that accurate start and stop times can be taken from signal edge triggers.

To further describe how Fig 4 works, we need to take a short look at the software. A program of approximately 4 kbytes resides in the internal ROM. The simple Morse code algorithm sets up three standard time breakpoints. The first between dot and dash times, the second between bit and letter spaces and the third between letter and word spaces. The program keeps track of what breakpoints the level changes lie between and decides accordingly what it represents. In track mode these breakpoints are continuously adjusted to the times of the incoming data. Baudot and ASCII RTTY are the simplest to decode since they are meant to be interpreted by machine. Each Baudot or ASCII character has a specific pattern and timing diagram. The MCU starts its sampling for each character accurately to 4 µs at the signal's start pulse edge using its timer capture function. After this, it compares the sampled data for a corresponding data structure in ROM. TOR signals are the most difficult to decode since they are synchronous, having no start or stop pulses. This program uses two stages to decode TOR. The first stage samples continuously at 1-ms intervals looking for the 4-mark to 3-space ratio identifying TOR. Once the TOR signal is found, the second stage decodes it using a specific timing diagram and matching it with stored patterns. It calculates the starting time for the next sampling using the last edge trigger from the last sampling. In all modes, various means of software filtering

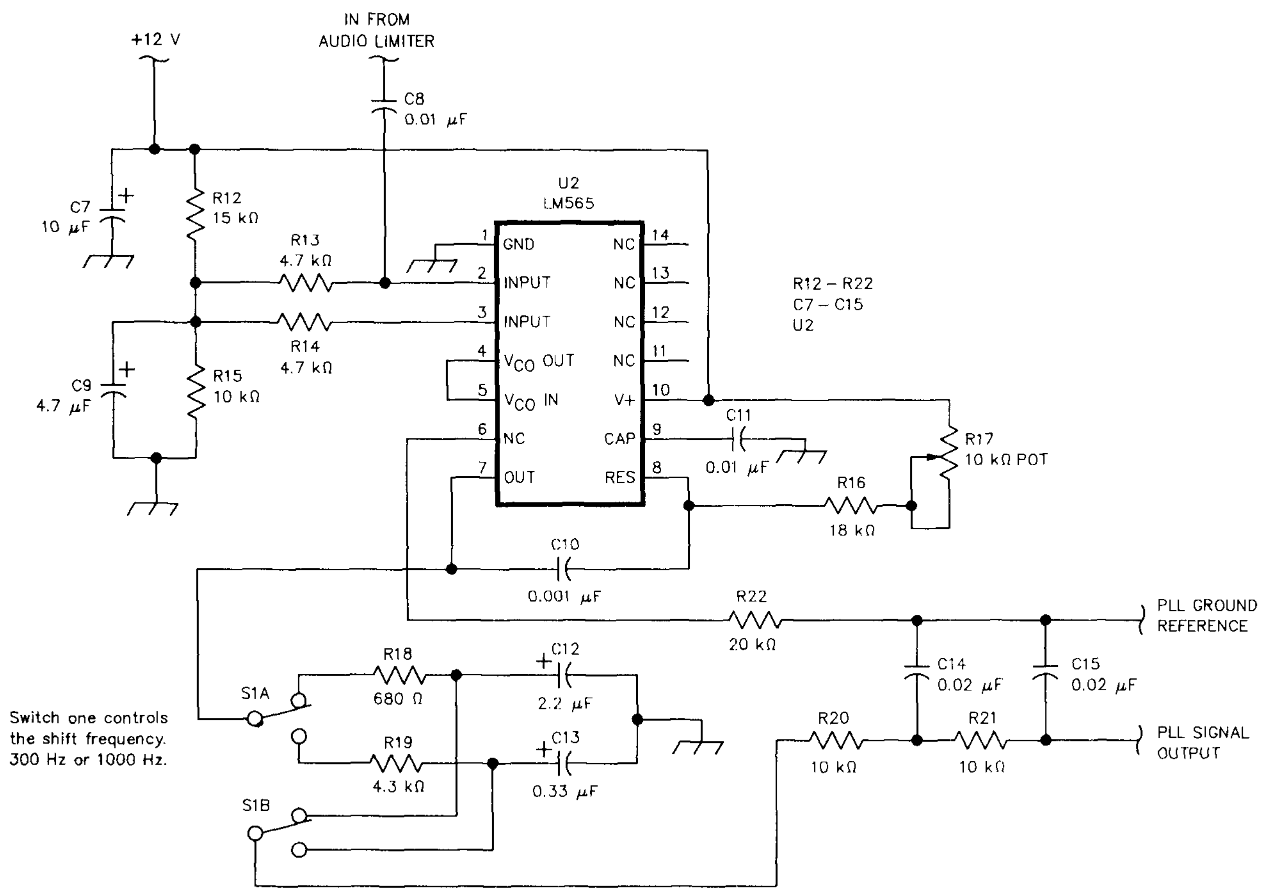



**Fig 2—Schematic of the phase-locked loop FSK detector.**

and debouncing are used to insure a more accurate copy. For those more interested in the nitty gritty of the software, a complete and well annotated source code is available on disk.

The final stage is the output and power regulation circuits. The primary output is to a 16X1 LCD. The display, the DMC16117, is easy to use and interface. It is an intelligent display and only requires ASCII data and cursor move commands. Eleven signal lines are connected directly to the MCU. Power and contrast control are via lines 1, 2 and 3. R35 controls the LCD contrast. The secondary output is the EIA-232 port. Fig 5 shows the MC145406P transceiver chip and the LM 555 voltage pump. The voltage pump supplies the necessary − 12 V (actually − 10 V) for EIA-232 communications without having to have an additional supply voltage. Finally, Fig 6 shows the voltage regulation circuit. Only a + 12 V supply is needed. The LM 7805 provides the + 5 V for the digital logic. Furthermore, the divider network of R30 and R54 provide + 6 V for single supply operation of the opamps in Fig 1.

## Construction

Fig 7 is a printed circuit board for this project at a scale of 1 to 1. I made the first prototype on a perf board but found

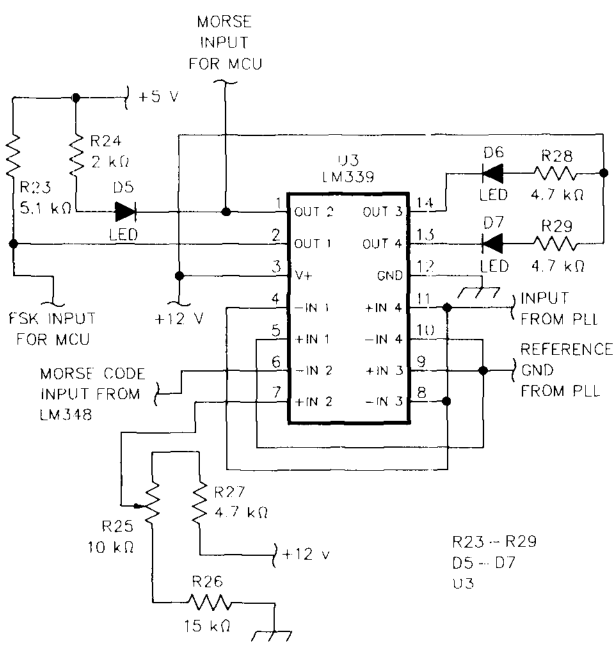



**Fig 3—Schematic of the signal comparator.**

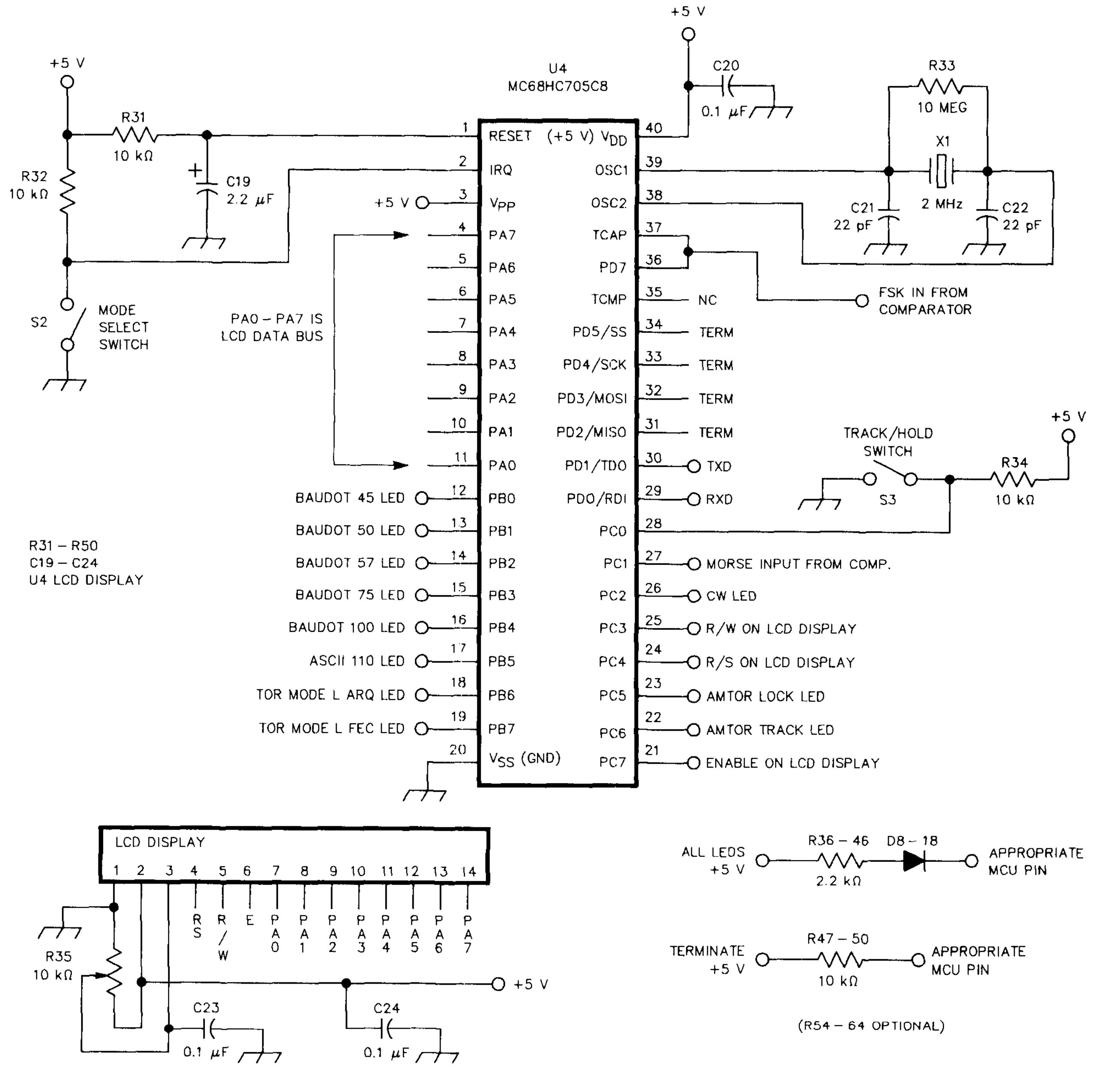



**Fig 4—Schematic of the microcontroller unit and liquid crystal display.**

the printed circuit board to be a lot easier[1]. For simplicity's sake, I made sure that this was a single sided board.

There are three options to decide on before buying all the parts. First, you may not want to put in all the status LEDs driven by the MCU. In that case, jumper over the spaces provided for the LEDs directly to the pull-up resistor. Second, if you want only EIA-232 I/O and no LCD, you will need the optional R54-64 resistors to terminate the LCD lines. There is enough space provided on the board if the resistors have one lead bent in order to stand erect. If you are planning to use an LCD, you *do not need* R54-64, they are only for those who don't want the LCD. Third, if you do not want the EIA-232 I/O then leave off everything in Fig 5. I imagine most people will want all the status LEDs, the LCD and the EIA-232 I/O.

All the parts are soldered into position following the silk screen diagram, Fig 8, and using the parts list. There are a few things to watch out for. Use a socket for the MCU. It'll be easier to program and modify. Be sure that the parts you buy are the right size. Make sure you have trim pots that will fit into the places provided for R17 and R35. I tried to use stand-up electrolytic capacitors with both leads on the same end whenever I had one. Be careful of the polarity and voltage ratings of the electrolytic and tantalum capacitors. Capacitors C2-C5 should be higher tolerance

[1]Notes appear on page 12.

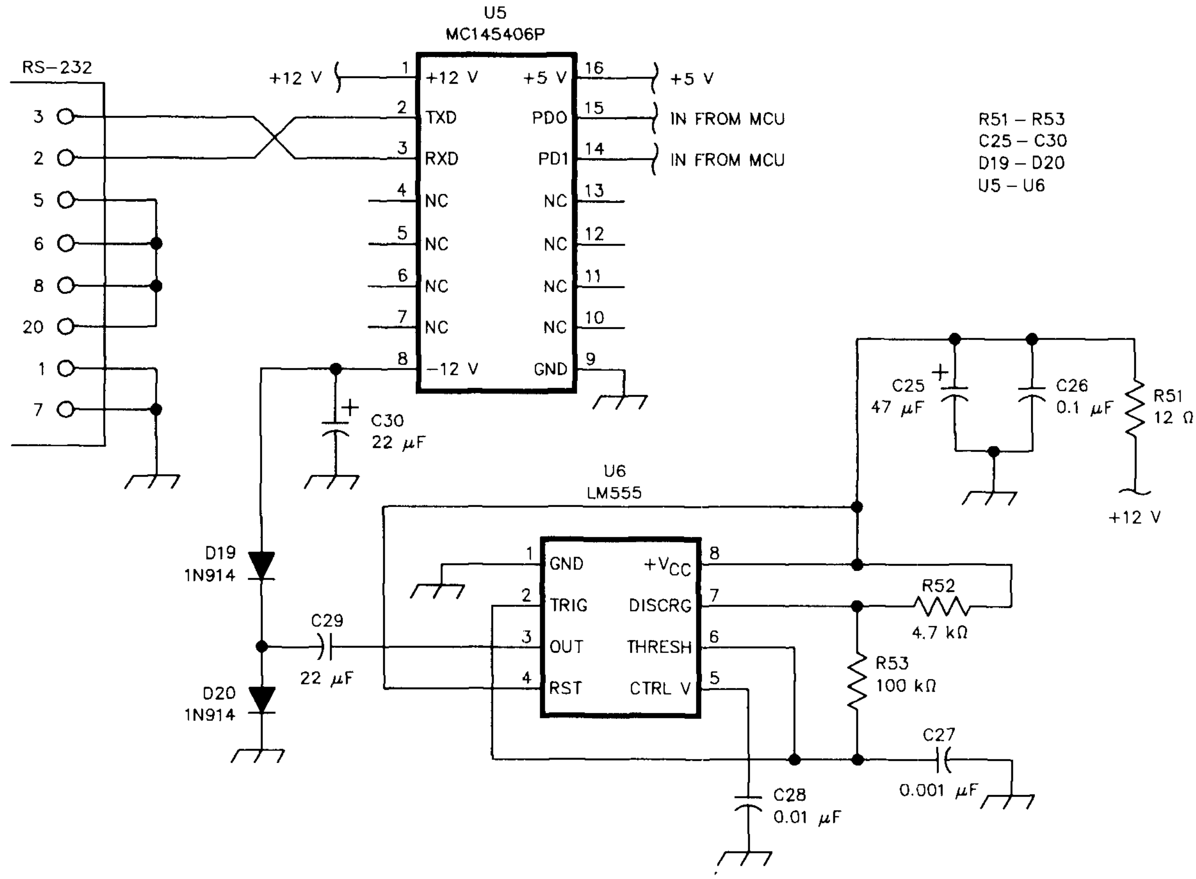



**Fig 5—Schematic of the EIA-232 interface and -10 V pump.**

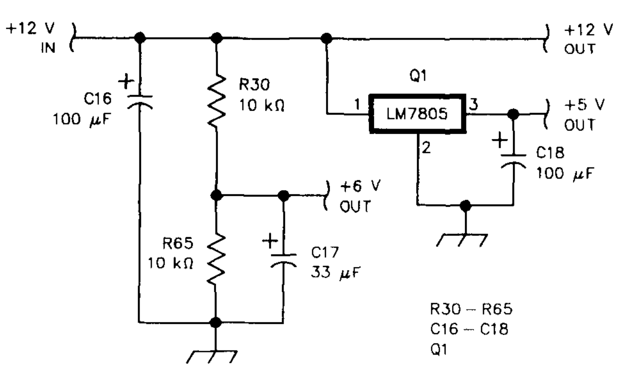



**Fig 6—Schematic of the power regulation section.**

for better results since they are used in the Morse code audio filters. There is room provided for a large 2-MHz crystal, but a smaller one will make things less crowded. The crystal should be precise since all timing depends on it. I used one with 2.000 MHz printed on the case.

Unfortunately, not all the traces could fit on one side. The voltage lines, five in all, must be hand wired, preferably on the solder side. You must connect all pads together with the same voltage printed by it on the PCB. Also, the two FSK and the two CW pads must be wired together. This wiring can be seen in photo C.

There are three jumpers, all labeled on the PCB and silk screen. J2 is the break point in the Morse code line where a key can be attached for practice. It can be jumpered now or run out to the external connector later for optional Morse code practice. All other lines are brought into the PCB after the enclosure is made.

A good enclosure can really make the project look nice. I thought about buying a ready-made enclosure but decided it really wasn't worth it. They are expensive and I'd still have to spend a lot of time milling out the ports and drilling holes for the LEDs and switches. I decided to use a unique method of constructing enclosures I learned in school. It uses copper-clad board cut into pieces that form a box. The plans for the enclosure I built are shown in Figs 9 and 10. These pieces are soldered together using the same solder and iron you used to mount the parts. The holes and ports need to be drilled and milled before the box is soldered

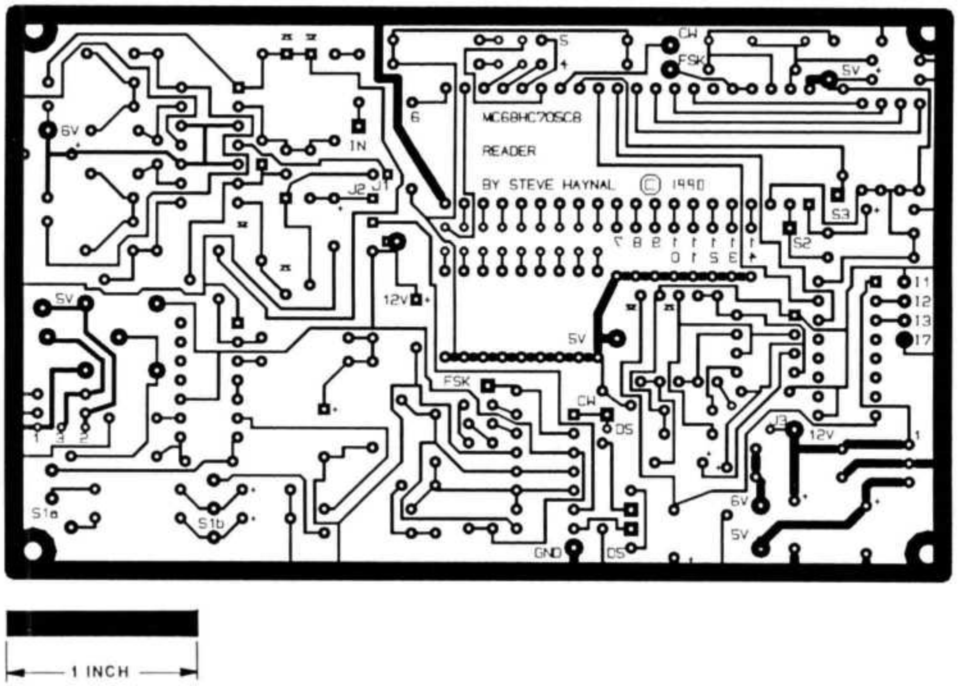



**Fig 7—Positive of the printed-circuit board.**

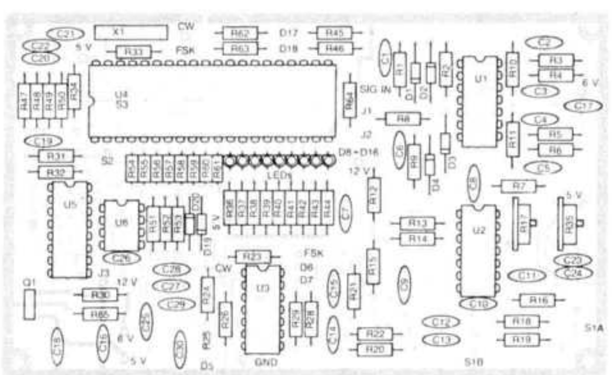


**Fig 8—Silk Screen diagram for parts placement.**

together. The base plate is not soldered into place but held in by 6-32 screws which fasten into a lip soldered on either side of the box about 1/8 of an inch from the bottom. I tapped the holes in the lip so there is no need for nuts. The board is mounted on the base plate using ¼-inch standoffs, 4-40 machine screws and nuts. The LCD and connectors are also held into place with 4-40 machine screws and nuts. I applied a bit of auto-body filler in the rough cracks and places and then sanded it smooth. This gives it a nice finish to paint. I used enamel-based spray paint. I applied primer and then several coats of black. Next I applied the lettering. They are rub-off letters from a stationary store. Finally, I applied a few layers of clear spray paint to make sure the letters didn't peal off. You may have your own plans for an enclosure or decide to buy a ready-made enclosure and modify it. You could even build this project on perf board. I noticed very little RFI from this project in its perf board prototype stages.

It is tricky wiring in everything to the board. I used ribbon cable as much as possible to reduce the confusion. Even with this there are a lot of wires. Photo B should give you an idea of how I wired mine. The LCD has 14 pins, each with a number. These must be wired on to the board to their corresponding number appearing on the solder side. There are four lines that go out to the EIA-232 connector. Each begins with an I and appears on the solder side. The number after the I is the pin of the EIA-232 connector each must attach to. Fig 11 is a wiring diagram of the EIA-232 port. All the LEDs are wired into position using ribbon cable and following the silk-screen diagram. Make sure that the cathode of the LED goes to the free end of the pull-up resistor. D5 is split up, but both connections are marked on the solder side. When all the LEDs are in position, hot glue them in place. The switches are mounted in place and wired in as shown on the schematics. R25 and R27 are mounted off the board. Pot R25 should be a shaft pot mounted for easy external adjustment. The center tap and one end of R25 go to the board while the other is connected to 12 V through R27.

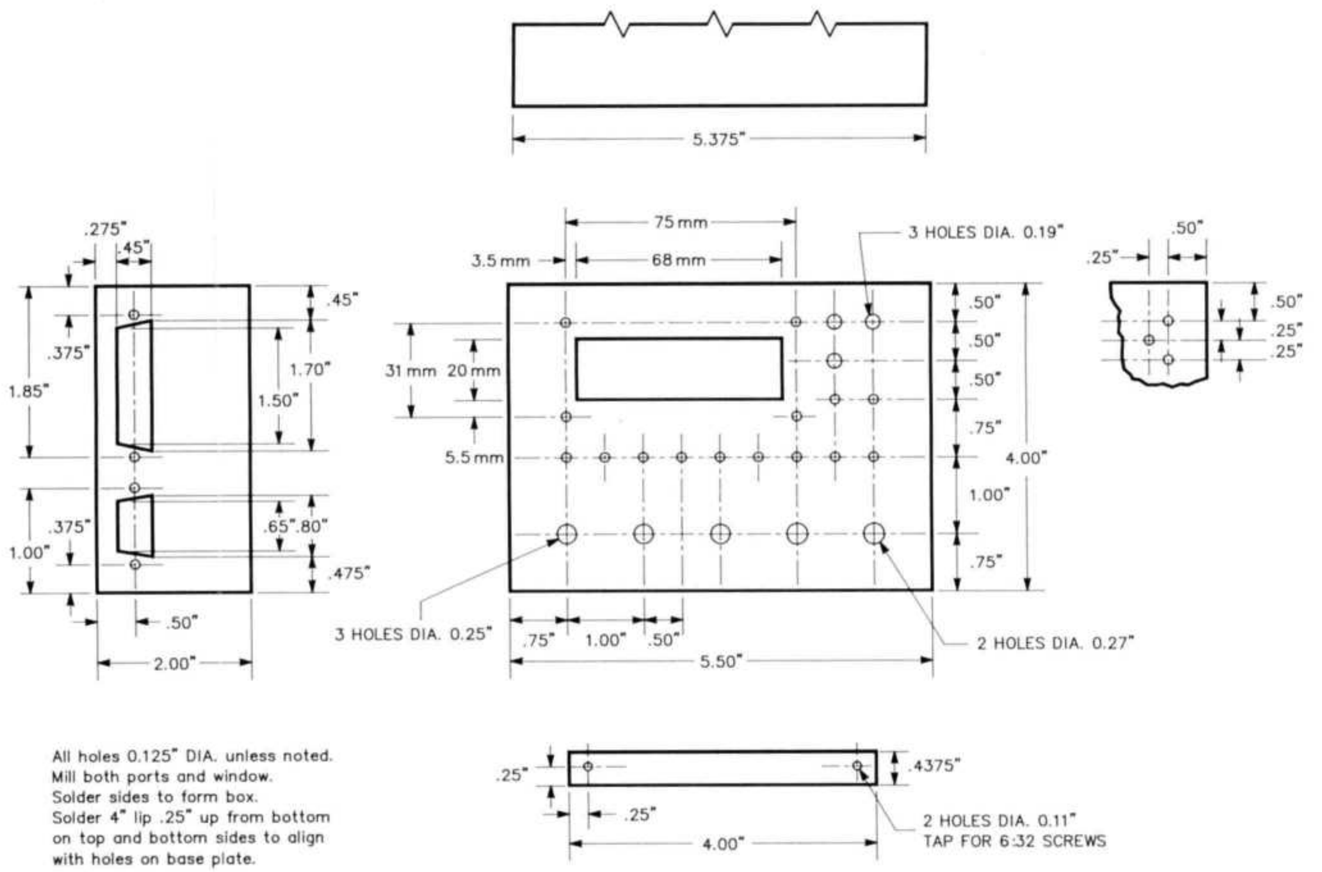



**Fig 9—The homemade enclosure.**

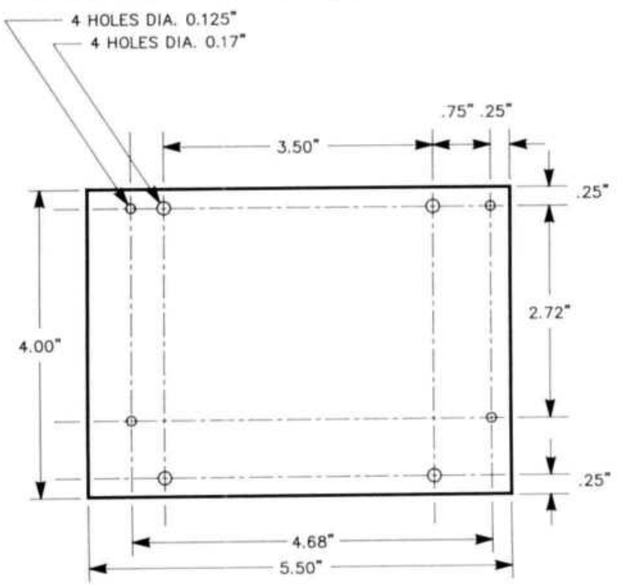



**Fig 10—Base plate for the enclosure.**


**Photo A—Front view.** ***(all photos courtesy of Carlos Reeder)***

I ran all the other lines that go in or out of the box through a DB-9 female connector. This simplifies things greatly. Fig 12 shows the wiring for this connector. Pins 6 and 7 must be jumpered on the mating end of the connector for Morse code detection. For code practice you can connect a key to pin 7 as shown in Fig 12. The power switch, not shown on the schematics, is between the power in on the DB-9 connector and the 12-V line on the board. There is room in the enclosure for a 9-V and two 1.5-V AA size

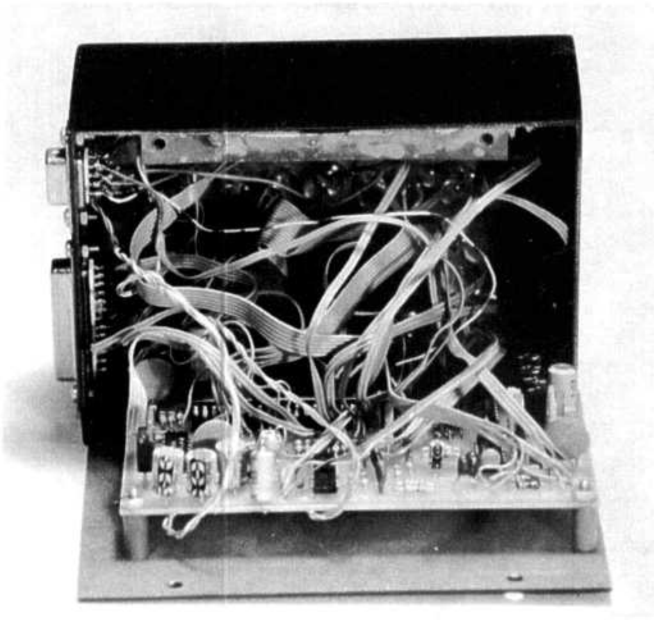


*Photo B—View showing the internal wiring. Notice how the circuit board folds out of the main enclosure.*

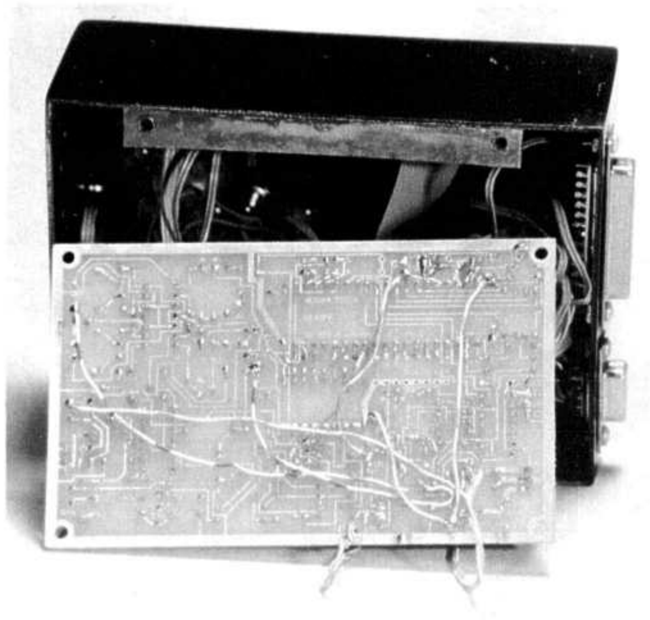


*Photo C—View of the bottom of the circuit board. Notice the separate wiring for power and signals.*

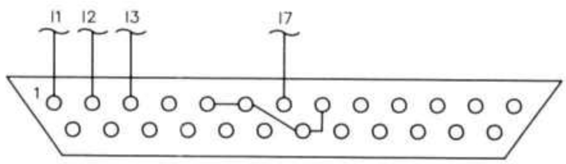



**Fig 11—Wiring for the EIA-232 DB-25 connector. Switch lines I2 and I3 to create a null modem.**

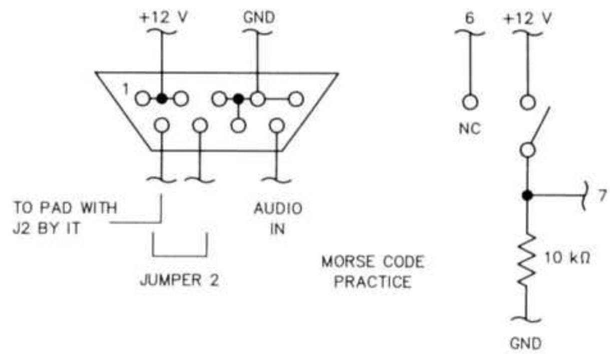



**Fig 12—The wiring diagram for the DB-9 connector used to bring power and signals into the enclosure. Also, the wiring for the Morse code practice function.**

batteries, all in series. This is one option you might choose for portability.

The last thing you need before powering the reader up is a programmed MCU. There are a few ways to go about getting one. The easiest is to order a preprogrammed chip directly from me, plug it in and power it up[2]. Another way is to program your own. Fig 13 is a small programming board that will fit right into the socket on the reader. Now it is just a matter of dumping the data out through the serial port of your IBM[3]. This is the way to go for those interested in the "nitty gritty". Whichever way you go about it, be sure to buy the MC68HC705C8S. The last S means that it contains EPROM. That way, if there are any improvements to this program, you won't need to buy another new chip to get an upgrade. Furthermore, if you ever want to experiment with your own projects, you'll have a versatile, reusable and reprogrammable MCU to use.

### Alignment and Adjustment

This is the most exciting and nerve wracking part—when you finally turn it on. Hopefully there are no problems. On initial power up, the CW LED should be lit. MOEIAE CODE should be printed on the LCD or terminal if the track/hold switch is in the track position. If the track/hold switch is in the hold position, the built-in instructions will be printed. Adjust the contrast control, R35. If you are using a EIA-232 terminal or computer hook up, be sure that the baud rate is set to 4800,N,8,1. The only adjustment needed is to set the center frequency of the PLL. This should be set to near 1200 Hz. Hook up a signal generator to the audio input and set the frequency to 1200 Hz. Adjust R17 until the lit mark or space LED changes. I choose to make the center frequency a little lower than the standard to take advantage of the SSB filters that are in most radios. If you don't have a signal generator, just find a steady tone on your receiver and tune it in until you have a maximum S-meter deflection. Now set the pot so the break point occurs at that frequency.

If the unfortunate happens and you do have problems, there should be solutions. If the LCD is half lit up with solid

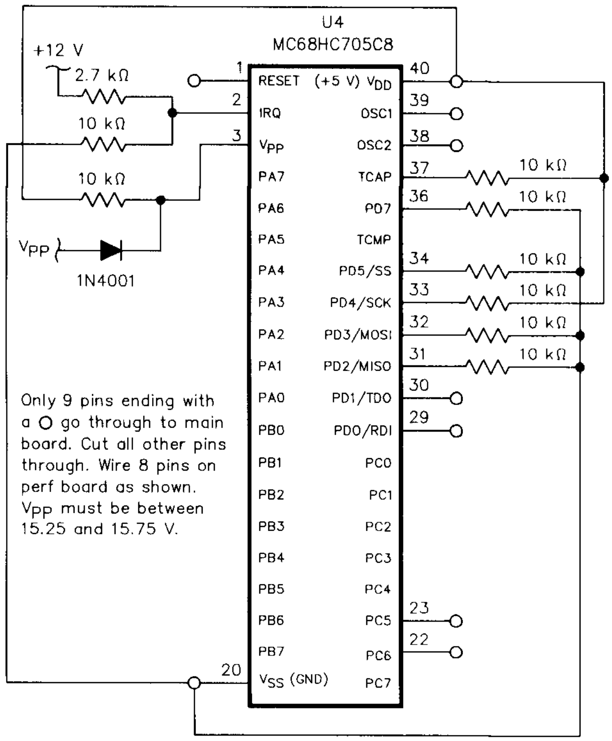



**Fig 13—Schematic of the programming board.**

blocks, then the MCU has not initialized the display. Check your wiring to the display. Check that the MCU is working by making sure that only the CW LED is lit. If this is not lit, then the MCU is not operating. Check the clock circuit and the power to the MCU. Maybe you are unable to communicate to the reader via the EIA-232 port. In this case, you may need a null modem. It is easiest to switch the wires going to pins 2 and 3 of the EIA-232 connector in the reader itself. If problems are present in the stages before the MCU, try to trace them out logically. Use the circuit description in the first part of this article and follow the path of the signal. Many times there may be a solder bridge or short between two traces. Finally, make sure all supply voltages are present. Feel free to contact me if you have more difficult problems.

## Operation

There are built-in instructions. They will print out if the track/hold switch is in the hold position during power up. The printout will stop if the track/hold switch is toggled. More detailed instructions for each mode are listed here.

### *Morse Code*

Now that everything is up and running, we can actually take a look at what is out there. It's easy to practice on good strong well-sent signals in the amateur bands. Once you have found one, adjust the Morse code threshold control so that the Morse code detect LED is blinking. Now tune in the signal again (this adjusts its frequency) until you get maximum response from the LED. Turn the threshold control until the LED is blinking on with only the Morse code. Repeat these steps a few times to get the best responses. Flip the track/hold switch to track and wait for the output to start printing something that makes sense. Once it has tracked the signal, flip the switch to hold and read what is being sent.

Sometimes it may not track the incoming signal. It is programmed for a wide range of speeds, 3-80+ WPM. Its reset conditions set the initial speed to 40 WPM. At 40 WPM, the software filtering allows it to track signals down to about 3 WPM and up to 80 WPM. You will not be able to retrack an extremely fast signal after copying a slow one or vice versa. Also, if you've been trying to copy static, which appears to the reader as "fast" Morse code, you won't be able to track the slower signals. When this occurs, just press and hold the mode selection switch. This will select the current mode again and reset the variables.

There is a lot of sloppy code on the airwaves and most computers can't make heads or tails of it. Don't expect this device to do the miraculous when it comes to copying Morse code. I think you'll be pleased when copying clear well-sent signals. Finally, there is some Farnsworth code on the air. The dits and dahs are timed for 15 WPM but the letter and word spaces are much longer. This qualifies the code for much slower speeds. This will print out with spaces between each letter.

### *Frequency Shift Keying*

Whether it's Baudot, ASCII, or TOR signals, they're tuned in the same way. For practice, find a strong Baudot signal on the ham bands. You will notice, as you slowly tune through the signal, that the mark/space LEDs go through a pattern. When *both* tones are high, one of the LEDs will be on or mostly on. The other LED will be on or mostly on when *both* tones are quite low. The signal is correctly tuned in at a spot between these two positions when the LEDs have about equal time on. After awhile this tuning procedure will become second nature to you.

### *Baudot*

There are many speeds to try for Baudot. Most amateurs use 45 bauds. Try this first. You may need to flip the normal/reverse phasing switch depending on which sideband you're using. Usually, the lower side band is considered normal for FSK work on the amateur bands. Also, for amateur work, keep the shift width switch in the narrow position. Many times when copying weaker Baudot signals the output will stay in figures case since it missed the switch to letters case character. You can switch to letters case by holding down the mode selection switch and triggering a current mode reset. Commercial stations usually use 50 or 75 bauds with a wide shift. Tune them in after you try the hams. Finally, many signals out there are private. They sound like Baudot but they are using encryption. The reader only copies standard Baudot code.

### *ASCII*

ASCII sounds like fast Baudot. I haven't found too much of it on the air. The best way to try this mode is to copy the W1AW teleprinter bulletins. After sending the bulletin in Baudot 45, they repeat it in ASCII. Again, it uses a narrow shift and you may need to toggle the normal/reverse phasing switch. You may find that sometimes the copy is better if the wide shift is used. This is due to the faster data rate.

### *ARQ*

There is a lot of ARQ AMTOR on the ham bands. Find one of those signals that sound like two crickets chirping to each other and tune them in like any FSK signal. To do the final tuning in, you'll need to watch the TOR lock status LED. When it lights in sync with the longer of the two chirps, you know that you are tuned in even if nothing is being printed on the screen. They may be sending control signals. You may have to retune your receiver to hear both ends of the conversation. They have to copy only one signal, you must copy two with a possible frequency difference. Finally, all TOR signals use a narrow shift and you may have to flip the normal/reverse phasing switch.

*FEC*

The best way to practice copying FEC is to copy the W1AW teleprinter bulletin again. After ASCII it is repeated in FEC. Tune it in like ARQ. After awhile you'll notice the rhythm of the timing characters and you'll recognize any FEC signal. In both modes of TOR, if the reader is unable to copy a letter and knows it made a mistake because of the error correction of TOR, it will print a "_" to indicate a missing letter.

*Mode Determine*

This routine may help in determining the speed of a Baudot signal. It times many of the shortest marks of information and then files them into respective categories. After a short time, it determines which category is the largest and then prints the corresponding mode. It runs in a continuous loop. After you are satisfied that one mode appears most frequently, you need to manually switch to that mode.

*EIA-232 Operation*

You can select each mode directly from your computer. Each of the ten modes must be called up by the following mnemonic.

MOR - Morse Code
B45 - Baudot 45
B50 - Baudot 50
B57 - Baudot 57
B75 - Baudot 75
B10 - Baudot 100
ASC - ASCII 110
ARQ - ARQ TOR
FEC - FEC TOR
DET - Mode Determine

You can type more. For example, you can select Morse code by typing in Morse code. What matters is that the first three letters are MOR. After you have selected a mode, press return. If you don't, the reader will automatically press return for you after awhile. The reader will print a "?" if it doesn't understand what you typed. Finally, by not typing in anything and just pressing return you will force a switch to letters case while copying Baudot or TOR.

**Final Words**

So, what are you waiting for? Get out there and tune in some of those stations. I've had good luck copying Pyongyang, North Korea, on 13780, 15633 and 14566 kHz between 0400 and 0600 UTC. They transmit at 50 bauds. There is also a station in Colorado that broadcasts weather bulletins for the entire world among other information. It's on 19323 kHz around 1900 UTC and uses 75 bauds. I've also picked up the USIA broadcasts from New York on 15213 kHz at 2100 UTC using a speed of 75 bauds. There is W1AW that broadcasts amateur teleprinter bulletins 3 or 4 times a day. You can look up their schedule in a recent *QST*. Also, listen around 17207 and 13077 kHz for some TOR communications. I've even picked up a few interesting International Police, INTERPOL, broadcasts using TOR. There's enough out there to keep you listening and entertained for years.

**Notes**

[1]The printed circuit board is available from Atlas Circuits Company, PO Box 892, Lincolnton, North Carolina 28092 for $13.00. This includes shipping and handling.

[2]A 5¼ inch disk for MS DOS machines containing the necessary programs to self-program the MCU is available for $10.00. A programmed MC68HC705C8S, MC145406P transceiver, plus the programming disk is available for $50.00. Orders for these two packages or requests for help should be addressed to: Steve Haynal, PO Box 712, Angwin, CA 94508.

[3]The necessary programs to self-program the MCU can be ordered from the author, address above.

**Parts List**

*(The parts, including the LCD, but not the Motorola parts, are available from: Digi-Key, 1-800-DIGI-KEY. The LCD, DMC16117, is also available from Marlin P. Jones and Assciates, PO Box 12685, Lake Park, FL 33403-0685. The Motorola parts are available from Ocean State Electronics, PO Box 1458, Westerly, RI 02891, tel: 1-800-866-6626.)*

**Resistors**

R51—12 Ω
R9—300 Ω
R4,R5,R18—680 Ω
R24—2 kΩ
R36-46—2.2 kΩ
R19—4.3 kΩ
R13,R14,R27-R29,R52—4.7 kΩ
R23—5.1 kΩ
R3,R6—8.2 kΩ
R1,R7,R8,R15,R20,R21,R30-R32,R34,R47-50,R54-65—10 kΩ
R12,R26—15 kΩ
R16—18 kΩ
R22—20 kΩ
R2—24 kΩ
R10,R11—62 kΩ
R53—100 kΩ
R33—10 MΩ
R17,R35—Trim pot, 10-kΩ
R25—Panel mount pot, 10-kΩ

**Capacitors**

C21,C22—22 pF
C10,C27—0.001 μF
C08,C11,C28—0.01 μF
C14,C15—0.02 μF
C2-C5—0.033 μF
C1,C20,C23,C24,C26—0.1 μF
C13—Tantalum, +25 V, 0.33 μF
C6,C12,C19—Tantalum, +25 V, 2.2 μF
C9—+25 V, 4.7 μF
C7—+25 V, 10 μF
C29,C30—+25 V, 22 μF
C17—+25 V, 33 μF
C25—+25 V, 47 μF
C16,C18—+25 V, 100 μF

**Diodes**

D1-D4,D19,D20—1N914
D5-D7—Large LEDs
D8-D18—Small LEDs

**Integrated Circuits**

U1—LM 348
U2—LM 565
U3—LM 339
U4—MC68HC705C8
U5—MC145406P
U6—LM 555

**Miscellaneous**

Q1—LM 7805
S1—2 POS, 2 Pole
S2,S3—1 POS, 1 Pole
LCD display—DMC16117
X1—2 MHz

# EA-88 IBM PC Radio Interface

**By Marijan Miletic, YU3EA/N1YU**
**Reboljeva 2**
**61113 Ljubljana**
**Yugoslavia**

Radio amateurs use computers for communications, antenna design, propagation forecasting, electronic calculations, PCB artwork, etc. Shortwave contesters widely use excellent software from K1EA for duplicate checks, logging and packet-radio net integration. The missing link between computer and radio is a simple piece of hardware which will permit easy interfacing of the standard IBM PC and modern transceivers with computer-control facilities.

This radio interface should be capable of three major functions:

1. control the station frequency and mode
2. receive and transmit Morse code
3. record and play speech

The technology for the above tasks has been available for some time in the form of smart electronic keyers, digital voice devices and dedicated communication interfaces. A few articles have appeared in *QST* and other technical magazines. The EA-88 board simply integrates all that hardware on a small PC compatible plug-in board.

Three Japanese Amateur Radio transceiver manufacturers' are using different communication standards for their products. Fortunately, all use serial lines with TTL levels; only the software differs. ICOM employs modern local area networks (LANs) for connecting many rigs together with unique addresses.

Key and PTT lines on modern equipment stay below +15 V with low current consumption. Receiving Morse code from the crowded shortwave ham bands is a complex task best left to powerful digital signal processors. Receiving one's own transmission is built-in for hard-core paddlers and poor typists.

Operator voice identity must be preserved even in contest communications unless an additional confusing factor is willingly introduced. Modern PCs have megabytes of memory that can be conveniently used for storing all the on-line messages one would ever need. One should build a personal library of canned recordings on disk and load them when required. Many chips are available from the telecommunications industry which convert voice into serial bit streams by continuous variable slope delta modulation (CVSD).

CVSD modulators compare input audio signals with artificially generated ramp voltage from internal integrators and generate binary signals which are further synchronized by an oscillator into the serial bit stream. Detectors keep track of the last three or four bits, and when they are all equal, change polarity of the ramp slope. Modern semiconductor technology manages to keep tolerances of critical components in CVSD circuits within very tight limits. Filters are not an integral part of the CVSD circuit.

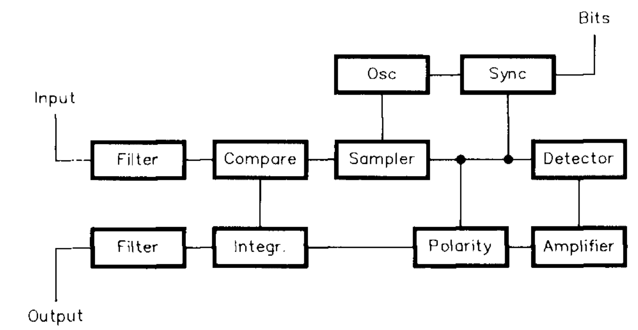



**Fig 1—Block diagram of CVSD subsystem.**

**BEA-88 hardware specifications**

| | |
|---|---|
| PC I/O addresses: | data $0340, control $0341. |
| Bit assignments for 8251A USART: | |
| CW: Send = RTS Key = DTR Key_in = DSR | |
| SSB: Select = RTS Play = DTR | |
| KEY input/output: | +15 V, 4/40 mA maximum |
| PTT output: | +15 V, 80 mA maximum |
| CVSD sampling frequency: | 38.4-kHz/4-bit comparator |
| Memory usage rate: | 4.8 kbyte/s |
| Microphone sensitivity: | 10 mV |
| Audio output level: | 1 Vpp/600 ohm |
| LAN TTL level: | 5 V/5 mA |
| TXD, RXD levels: | standard 74LS ratings, 0..+5V |
| Communication speed: | 4800 or 1200 bauds |
| Power consumption: | +5 V/100 mA, + 12 V/10 mA |

The EA-88 plugs directly into an IBM PC slot and all connections with the radio station are made by a Cannon plug with the following signals:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| LAN | TXD | RXD | PTT | KEY | MIC | BIAS | OUT | GND |

Bias is used for testing, but it also provides dc polarization for electric microphones. In LAN ICOM communications, TXD and RXD should be strapped together.

Microphone sensitivity can be adjusted with a serial resistor, while output level can be reduced by adding a parallel resistor.

The basic block diagram of the EA-88 is shown in Fig 2, schematic in Fig 3, PCB artwork in Fig 4 and simple testing feature in Fig 5.

The main digital integrated circuit is INTEL USART 8251A (Universal Synchronous Asynchronous Receiver Transmitter).

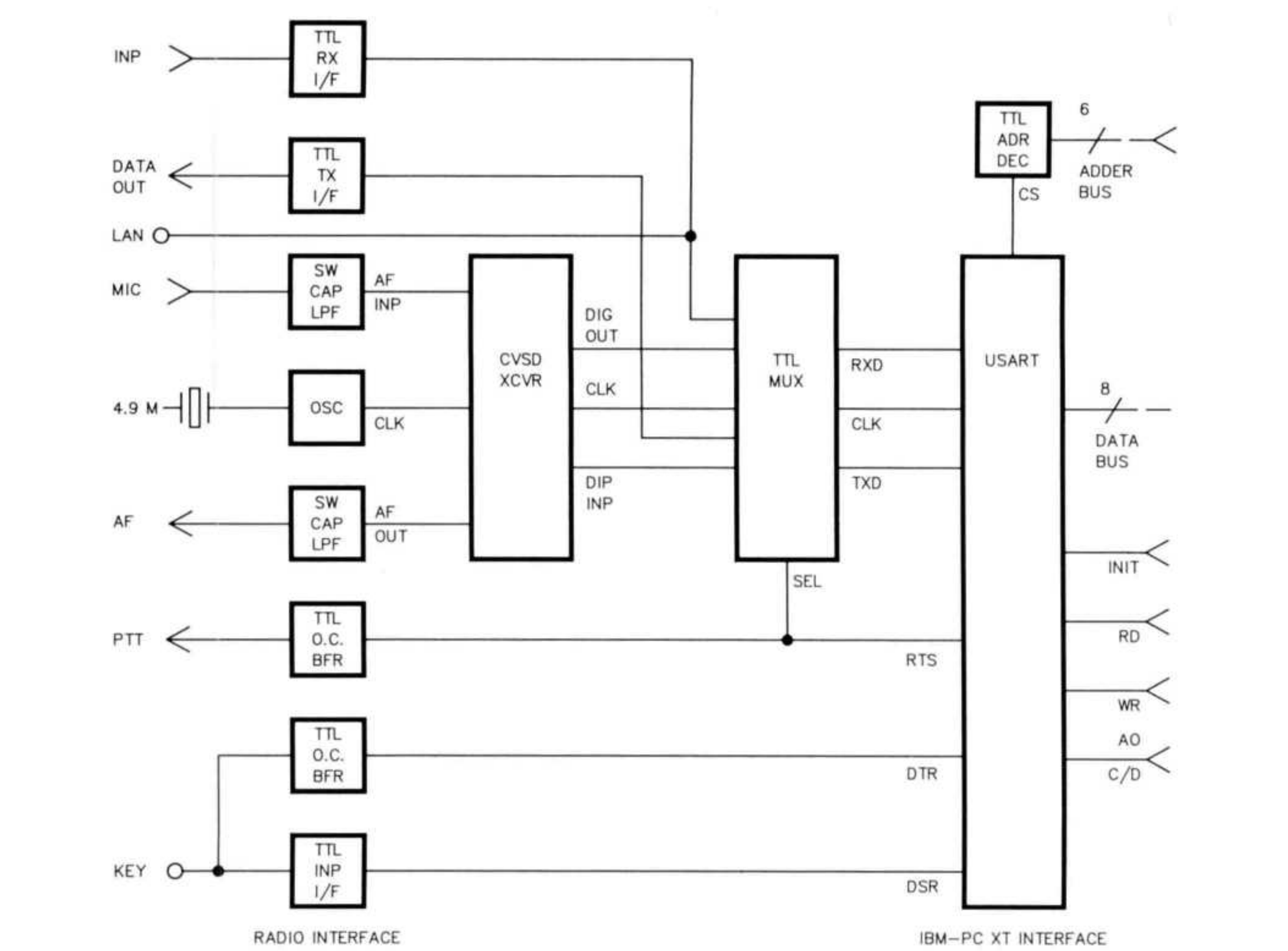



**Fig 2—Basic block diagram of EA-88.**

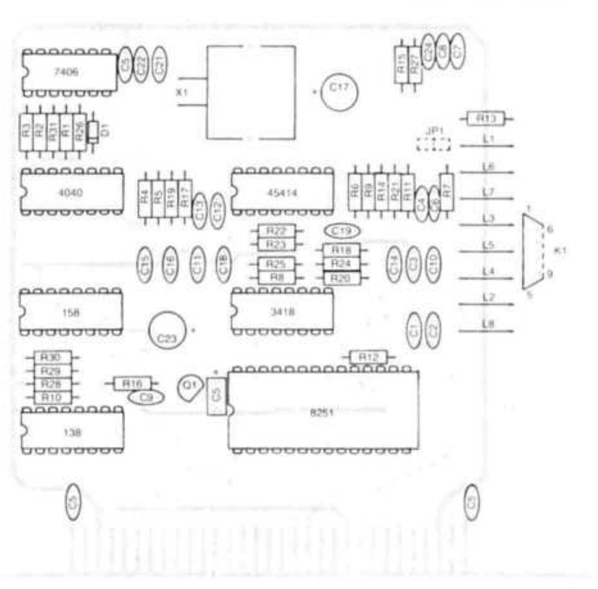


**Fig 3—Parts placement.**

Reset, read, write and control/data signals are direct input from the PC bus. USART is selected by a 74LS138 decoder on the base I/O addresses of 340 for data and 341 for commands. Six address lines are used. Bus data are transferred in byte format on eight parallel lines. All the timing signals are generated by 74HC4040 from TTL oscillator controlled by quartz on 4915.2 kHz. Multiplexer 74LS158 switches proper signals from the reception to the transmission.

Open collector TTL buffer 7406 drives PTT and KEY control lines up to 80 and 40 mA, respectively. External key input is defined by TTL LS specifications to +15 V max. Analog audio signals are filtered above 4 kHz by a Motorola MC145414 dual low-pass switched-capacitor filter with two operational amplifiers used for microphone amplification and output conditioning to 1 mW at 600 ohms. Careful band pass shaping is provided with proper selection of RC components. Conversion into the digital data stream is done with a Motorola MC3418 CVSD transceiver sampling at 38.4 kHz with 4-bit slope control. This gives over 30-dB S/N ratio for 50-dB input variation. The memory usage rate is 4.8 kbyte/s per second of speech. Data communication with the radio station is asynchronous or LAN at rates of 4800 or 1200 bauds using standard TTL at +5 V levels. All signals interfacing with the radio station

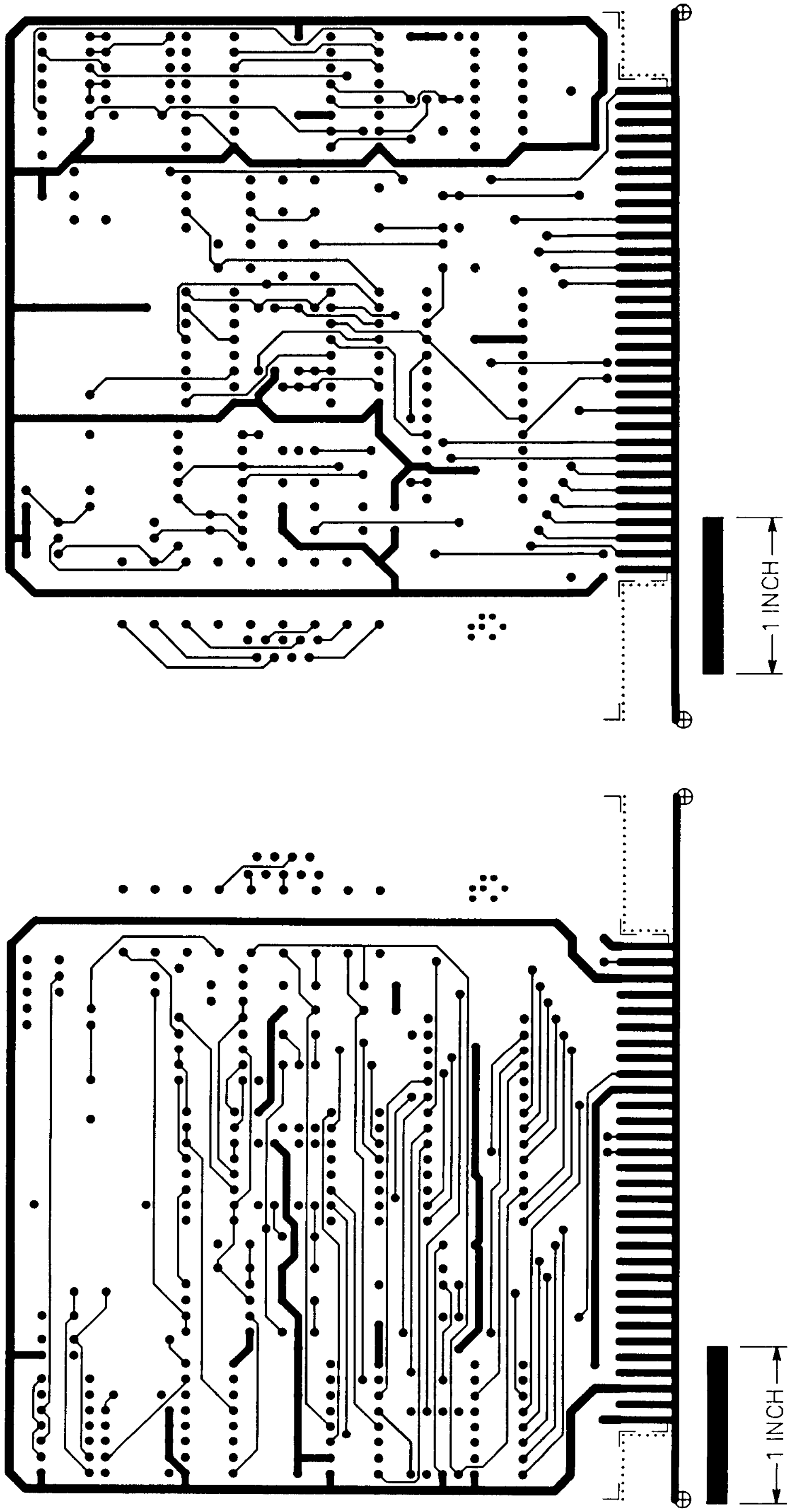



**Fig 4—Artwork.**

are 1-kΩ low impedance and filtered by a miniature 100-μH RF chokes and 1-nF ceramic capacitors. Ten volts for analog ICs are generated from +12 V from the computer bus with the transistor-emitter follower filtering.

Simple programs in Turbo Pascal® are supplied for the testing of EA-88 board, playing and recording speech and Morse key decoding. Contest programs permit storing of up to ten different CW and phone messages assigned to the function keys F1 to F10. Utmost attention was paid to the simplification of the user interface. CW pile-ups can be easily handled with only two keys, corrections require a maximum of two keystrokes, deletion one, etc. Windows and menu techniques are used with different assignments for a major contests. All software has been thoroughly tested over a 6-year period. Underlying concepts were described in the *National Contest Journal*, February 1988. The EA-88 board and software will be soon available from MFJ.

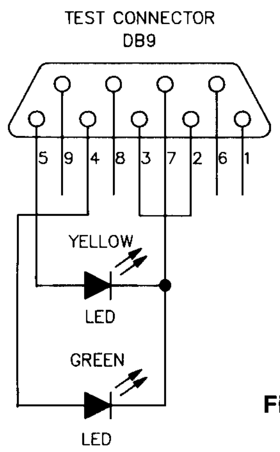



**Fig 5—EA-88 testing feature.**

# Bits

### 6th Annual Satellite Colloquium

The 6th Annual Satellite Colloquium, sponsored by AMSAT-UK, will be held July 25-28, 1991 at the University of Surrey. Question-and-answer sessions with various amateur-satellite experts are planned, as are tours of the UoSat command station.

*Accommodations: All Single Rooms only—Standard* is a single student room with washing facilities. Linen and towels are provided. Toilets, showers and baths are on the same floor. Kitchen is available and coffee/tea is provided to each room. *En suite* is at a higher cost, and is therefore better appointed. Showers, WC are in the room.

*Standard* £25:00 per night, includes 3 course dinner and English breakfast, membership of club and bars.

*En suite* £41:00 per night, includes 3 course dinner and English breakfast, membership of club and bars.

*Day rate* Registration from 0930 hours. Lectures finish 17:45 hours daily. £20:50 per day, includes all lectures per day. Coffee tea, biscuits, three course lunch, bar, Colloquium presentation folder, notepaper and pens. Trade shows, videos, etc.

*Saturday Buffet and Social* £17:50 per person (included in overnight costs for 27 July).

Booking should be made by July 1, 1991. Day only bookings by July 15, 1991.

*Traders, Demos and the Like*—A large space in the Conference Halls is available for rent to traders at a nominal fee. The area is also available to clubs and special interest groups for display services. The fees are not high, but get in touch, as soon as possible, if you want a few feet of space. Delegates can use this area, free of charge, for setting up a personal satellite related demo. We encourage this kind of activity and, again, get in touch as soon as possible to ensure you have a space.

*Proceedings of the Colloquium '91 papers*—Anyone wishing to present a paper, or have one read if attendance is not possible, should advise AMSAT-UK as soon possible, should advise AMSAT-UK as soon as possible. Papers can be on any satellite or packet-satellite subject you like, either very technical or a simple "How I did it my way" theme. Papers should be received at AMSAT-UK by June 15, 1991.

*The program:*

Wednesday, 25 July. Delegates may arrive only after 1800 hours. Dinner is served between 1800-1900 hours.

Thursday, 26 July. Registration from 1000 hours. Space videos until lunch, international space discussions/talks by IARU, AMSAT officials. Open meeting.

Friday, 27 July. Colloquium starts. Registration from 0900 hours.

Saturday, 28 July. Colloquium all day. A-UK. AGM 1800 hours.

Sunday, 29 July. Colloquium until 16:30 hours. Close.

Those interested in attending this year's Colloquium are urged to contact Ron Broadbent, G3AAJ, as soon as possible to ensure that the proper amount of space is reserved. Ron's address is: 94 Herongate Road, Wanstead Park, London E12 5EQ England. Tel: [from US] 011 (44) 81-989-6741, or fax: [from US] 011 (44) 81-989-3430.

Conducted by: Stan Horzepa, WA1LOU
75 Kreger Drive
Wolcott, CT 06716-2702

## DSP DREAMLAND AT DAYTON

As they say on the radio, "the 1991 Dayton HamVention® was fine business, old man." For the first time in the history of the HamVention, attendance exceeded the seating capacity of Fenway Park. It was the biggest crowd I had the pleasure to be stuck in since Woodstock. And like Woodstock, the weather could have been better.

Friday morning, only the outdoor flea market was open (the indoor exhibition hall did not open until noon). Murphy was right on cue, as the skies opened up in the middle of the morning. Naturally, I left my umbrella in the car! The rain let up after a half-hour or so and the rest of the HamVention weekend was less wet, although the sky looked threatening all day Saturday.

My fellow traveler this time was a Dayton first-timer, Roland, KC1QT. Roland is an ex-field serviceman, so he is used to doing a lot of driving. That is why we drove to Dayton instead of flying. The man is a road warrior. The only time the car wasn't moving was at one gas station and two rest areas. Roland eats McDonald's cuisine in transit. We made the trek from downtown Wolcott to downtown Dayton in record time...11.5 hours. After experiencing Dayton, Roland is now a confirmed Dayton fanatic and has started the Dayton equivalent of a Christmas Club, stashing away $20 each week so that next April he can do the flea market justice.

As expected, digital signal processing (DSP) was the theme of the 1991 Dayton HamVention. At the forums and in the booths, DSP was the magic word (or abbreviation). What was new at Dayton, packet radio-wise? In alphabetical order, here is what I saw and heard.

**AEA** (2000-196th St SW, PO Box C2160, Lynnwood, WA 98036, phone 206-775-7373) had their DSP-2232 TNC on display. It and its sister, the DSP-1232, contain DSP circuitry that allow the units to emulate every imaginable modem in Amateur Radio. AEA's DSPs have all of the features of their PK232MBX TNC including a CCITT V.26b 2400-bit/s modem, plus the PACSAT, OSCAR-13 and OSCAR-15 satellite modems, the K9NG and G3RUH 9600-bit/s modems, and more. Adding new modems to the box is a simple matter of changing an EPROM or loading downloaded binary files into it. The status of AEA DSPs is that the hardware is ready, but the software is not. It may be ready by the time this is published. By the way, the difference between the DSP-1232 and DSP-2232 is that the -1232 has two *switchable* radio ports, while the -2232 has two *simultaneous* radio ports.

AEA also showed its new PCB-88, which is essentially a PK-88 TNC on an IBM PC plug-in card with added features: "true" Data Carrier Detect circuitry and a standard modem disconnect header.

**Gracelis** (formerly Grace Communications, 623 Palace St, Aurora, IL 60506, phone 708-987-9346) displayed their new PackeTwin System that provides 9600-baud operation for individual-user stations. The system is contained on an IBM PC plug-in card with two interface ports; one for very high data rates and the other for 1200- to 19,200-baud operation. For the PackeTwin System's second port, Gracelis also offers optional modem cards that operate at 1200, 2400, 9600 and soon 19,200 baud and a 2-watt 70-cm 9600-baud data radio.

One of the few freebies at the HamVention was *Gracelis NOS* software. This IBM PC window-based software provides separate windows for AX.25, NET/ROM and TCP/IP packet-radio operation. *Gracelis NOS* supports all of their products as well as any other TNC connected to your IBM PC's serial port. (A nominal fee is charged for disk duplication and shipping.)

**Heath** is getting out of the ham-radio business and they had a booth at Dayton to unload stuff. I picked up a real bargain: the Heath TNC-1 clone kit for $30! I need another TNC like a hole in the head, but for $30, I couldn't resist. So, I bought one of the two remaining kits for a friend back home who is working on getting licensed. Roland bought the other unit.

**Kantronics** (1202 E 23rd St, Lawrence, KS 66046, phone 913-842-7745) showed their new D4-10 70-cm radio that is designed for high-speed packet-radio backbone operation. The radio will handle data at 19,200 bauds and has an output of 10 watts. To provide the 19,200-baud data rate, Kantronics also showed their new DE19200 modem that plugs into their Data Engine. The DE19200 is compatible with the G3RUH modem and works with signals of only one microvolt in strength. Kantronics also announced that their DE2400 modem for the Data Engine is now in production. The DE2400 offers 2400-bit/s compatibility with Kantronics' KPC-2400 TNC modem.

Firmware upgrades for the Kantronics KAM and Telemetry Unit were also on display. For non-packet-radio HF modes, the new KAM firmware adds support to the host interface between the KAM and your computer. New Kantronics IBM PC-compatible software, *Host Master II*, takes advantage of the new KAM firmware. The new Telemetry Unit firmware allows the user to define almost any linear sensor for remote monitoring (the sensor must output 0-5 V dc at 4-20 mA).

**MFJ** (Box 484, Mississippi State, MS 39762, phone 601-323-5869) featured their new MFJ-1292 video digitizer that allows you to create digitized snapshots with your camcorder and to send those pictures via packet radio, SSTV or fax. The MFJ-1292 hardware interfaces a camcorder to an IBM PC that runs the MFJ-1292 software for converting the digitized pictures for ham-radio transmission (the hardware is contained on an IBM PC plug-in card).

**PacComm** (3652 W Cypress St, Tampa, FL 33607, phone 813-874-2980) had a prototype of a 70-cm 9600-baud RF modem that should be in production by the time you read this. Also on display was an analog-to-digital converter board for the PacComm TINY-2 TNC that allows you to use packet radio to monitor and control remote devices such as repeaters, remote stations, etc.

PacComm is also working on a DSP project. They are currently developing software for their DSP box; the hardware will be developed later. PacComm had some Yamaha fax modem chips on display. Will there be 4800- and 9600-baud packet-radio modems based on this chip in the next PacComm catalog?

The **TAPR** booth was a beehive of activity. See the following three stories below on what TAPR had to say and show.

Among the missing this year was **DRSI**.

At the packet-radio forum Greg Jones, WD5IVD, Lyle Johnson, WA7GXD, and Chuck Green, NØADI, summarized TAPR happenings. Besides what is mentioned in the following stories, TAPR is also developing a low-cost deviation meter to facilitate setting radio transmitters for proper packet-radio operation.

Bdale Garbee, N3EUA, described the efforts to build a "real" packet-radio network in Colorado, ie, a high-speed network that will support existing applications as well as new applications such as digital voice, video and remote control. Bdale listed the building blocks of such a network: conventional CSMA, point-to-point dedicated links, full-duplex digital repeaters, distinction between user and network resources, and cells. The Colorado Packet Association (COPA) is the focal point for the development of this network. In the works this summer are a full-duplex digital repeater in Colorado Springs and an east-to-west high-speed microwave backbone.

Jeff King, WB8WKA, discussed how the Yamaha CCITT V.29-compatible fax modem chip may be used for 9600-bit/s packet-radio applications. Jeff envisions using the chip to speed up applications such as user-to-PBBS contacts, TCP/IP FTP and SMTP sessions, PBBS mail-forwarding and full-duplex digital repeating.

Paul Newland, AD7I, described the TAPR METCON-1 project in great detail (see the following story). Paul hinted that in the future TAPR may develop METCON-2 which could be programmed by the user with BASIC.

Tom Clark, W3IWI, began discussing the DSP project and then he switched topics and got the crowd all riled up when he spoke about the latest happenings between the FCC and the "PBBS Eleven" (see the story below). Tom is not having fun and the forum attendees understand why.

By the way, those pranksters showed up again at the Radisson Inn and glued me to the bar stool like they did last year. So, I missed the Saturday night packet-radio gathering at McNasty's for the *n*th consecutive year! (You fill in the *n*, I lost count.) Next year, I'm going to pack a can of glue solvent.

### TAPR METCON-1 BETA-TEST KITS AVAILABLE

METCON-1, a simple telemetry and control system for packet radio, is available for beta testing. Twenty beta-test kits, available from TAPR, include the main METCON-1 system board and one voltage-to-frequency board. The system operates by connecting the main METCON-1 board to the EIA-232-D port of a TNC. The remote TNC and METCON-1 are accessed by connecting to the TNC. METCON-1 acts like a remote computer connected to the TNC. METCON-1 uses an 8751 microcomputer to allow a connected user to read and write on/off levels at the microcomputer's I/O port using a line-oriented command set. Outputs are dry relay contacts to allow you to connect anything you want (within reason; a good upper limit is 24 V ac/dc at 0.5 A). A maximum of six outputs is possible.

Another feature is that METCON-1 can measure the frequency of an input signal (0-10 kHz) in addition to indicating if the input is an open or closed circuit. The advantage of this system is that the external voltage-to-frequency converter board that is configured to read either temperature or frequency, can be placed next to the source to be measured. An opto-isolator isolates the voltage-to-frequency converter board and the main system board. One voltage-to-frequency board comes with the kit and can be built in either the temperature or voltage configuration.

Although METCON-1 is a simple system, it does have a number of features including a time of day clock that can be used to time-stamp output. A status table can be dumped at selected intervals (0, 1, 15 minutes). Block reads and writes are supported for fast memory transfer. Notification can be set at different states.

Interested individuals are invited to participate in the METCON-1 beta test. The results of the test will refine the definition and applications of METCON-1 for the next stage of development. One application suggested by beta-testers is using METCON-1 during a balloon ascent to relay telemetry regarding height, temperature, and other balloon status. Another application is for controlling and monitoring remotely located radio sites.

If you would like more information on METCON-1 or how to participate in the beta test, contact TAPR (PO Box 12925, Tucson, AZ 85732, phone 602-749-9479). The cost of the beta-test kit is $100.

*—from Greg Jones, WD5IVD*

### TAPR DSP HARDWARE UPDATE

There are now four DSP-1 beta boards built. All but one worked immediately upon completion of wiring. The one that did not work had a short which caused the DSP chip to remain in a HALT condition. The short was fixed and the board worked thereafter.

The assembly instructions have been revised to reflect the experiences of the builders of the four beta boards. The plan is to print the revised instructions and complete packaging the remaining six beta units. Once packet-radio modem software is written for these units, they will he distributed for construction and testing. The beta test will continue during additional software development.

The following tasks remain after the beta boards are distributed:

1. Design and order a rear bracket.
2. Revise the board layout to correct minor errors.
3. Determine costs accurately to determine whether we can offer the unit as an assembled and tested device. (An informal survey of those in attendance at the Dayton HamVention packet-radio forum indicated that an assembled and tested DSP-1 would be preferred over a kit even if it cost $30 to $50 more.*—Editor*)
4. Get feedback from Beta testers to determine if the unit can be offered as a kit or if this option is too demanding on the "average" builder.
5. Get FCC qualification as required under Part 15 regulations.

We're hopeful that these tasks can be completed during the summer and that the DSP-1 will be available soon after.

*—by Lyle Johnson, WA7GXD, from* Packet Status Register

### TAPR PACKETRADIO STATUS

Progress on the TAPR packetRADIO came to a screeching halt last fall. But, new resources were added to the project and since the beginning of the year, significant progress has been made on the RF sections of the radio. This progress has encouraged the TAPR Board of Directors to pass a motion for continuation of the project. We are very much in a development phase for the prototypes and work will continue in this area to the point of making a decision on the future of the project.

—*by Greg Jones, WD5IVD,* Packet Status Register

## FCC AND "THE PBBS ELEVEN"

On January 25, the FCC's Norfolk, Virginia, field office sent Notices of Violation to eight east coast PBBS operators, and Notices of Apparent Liability ($300 fines) to three others. On April 17, the FCC canceled the fines, but withdrew unattended operation privileges for three of the 11.

Allegedly, the PBBS of one operator had originated and the PBBSs of the others had handled an "ALL@USA" message that urged readers to call a 900 telephone number to "vote" on a political issue, namely the presence of US troops in the Middle East.

According to the FCC in Norfolk, "This activity was a facilitation of the business affairs of the Coalition to Stop US intervention in the Middle East and therefore in violation of Section 97.113(a)."

Notices of Violation stipulated that each recipient, within ten days, reply to the FCC with the following:

- Full explanation of "the circumstances of the violation."
- A specific description of the action taken to correct and to prevent recurrence of the violation.

The $300 fines were levied against the alleged originator of the message, WA3QNS, and the operators of the PBBSs where the message entered and exited the packet-radio system, N3LA and KJ4LQ.

Most of the PBBS SYSOPs responded in part to the FCC notices by noting that they had policed themselves in this instance; a "SYSOP alert" had notified them of the offending message and they then pulled it from the system (but not before someone had brought the matter to the attention of the FCC).

Most of the SYSOPs also told the Commission they now were taking additional steps to screen at least some messages, especially those for general distribution, before accepting them.

One of the SYSOPs, Tom Clark, W3IWI, received the following reply from the Norfolk FCC, "We have carefully reviewed your letter and, inasmuch as you have stated you have taken corrective action to prevent a repeat of the violation, no further action will be taken at this time."

This reply raised a few eyebrows because W3IWI never admitted he had committed a violation. Instead, Tom stated to the FCC that he had been in full compliance with the premises espoused by the FCC in the NPRM 85-105 Report and Order, which state that "only after-the-fact screening is possible since the (PBBS) control operator can only indirectly supervise the station transmissions... While screening of messages at the entry point serves to prevent the introduction of improper messages into an ARRL AX.25 packet protocol network by amateur stations, it remains for monitoring by other amateur operators to detect the introduction of messages from non-amateur stations...the nature of the ARRL AX.25 packet protocol is such that control operators of intermediate retransmitting stations are unable to fully screen retransmitted messages."

The Norfolk office did not agree with the argument presented by some amateurs that the responsibility for message screening should lie with the originating station. "The concept of control of an amateur station...is not severable into technical control, content control of messages the licensee originates, and content control of messages originated by other users.

"The Commission licenses individual amateur stations, not systems of amateur stations. Further, all amateur service rules apply to each amateur station even when it is operating in a system, not to the system as a whole. Station licensees and station control operators, therefore, are both responsible for the messages originated as well as those retransmitted by the station."

This response reflects the same reasoning used by the FCC in Docket 90-561, declining the ARRL request for rule making to permit automatic control when third party communications are being transmitted.

## GB1MIR/U TO OPERATE FROM *MIR*

According to reliable sources, a British YL, Helen, will join the cosmonauts aboard the Soviet space station *Mir* on May 21. She has received the call sign GB1MIR/U and will conduct a mission similar to the recent Shuttle Amateur Radio Experiment (SAREX) on STS-37. Helen will talk almost exclusively with school children in Great Britain via Amateur Radio. To commemorate this mission, special event stations will be set up around Great Britain.

At present, Helen is in the USSR receiving last minute training from UW3AX on the operation of the Amateur Radio station aboard *Mir*. It is not known if GB1MIR/U will only contact special event stations or if there will be general QSOs. No operating schedule has be announced.

In other news concerning *Mir* and U2MIR, ICOM donated a 70-cm transceiver and it is expected that U2MIR will soon be heard on a downlink frequency of 432.675-MHz FM. It is not known whether this will be packet-radio or voice communications.

—*from AMSAT*

## NTS EMBRACES DIGITAL SYSTEMS

Field Services Manager Rick Palm, K1CE, added three area Digital Coordinators to the roster of National Traffic System Officials. Based on recommendations from the NTS Area Staff Chairmen and the Volunteer Resources Committee, K1CE issued formal appointments to Nick Zorn, N4SS (Digital Coordinator for the Eastern Area); Dr. Tom Comstock, N5TC (Central Area); and Dan Farrell, WF6O (Pacific Area).

Digital Coordinators are responsible for the following functions:

1. Establishment of HF digital communications standards for NTS applications.
2. Expansion of NTS capabilities, especially in the areas of system redundancy/reliability and emergency/disaster communications.
3. Integration with other modes within the system.
4. Management of HF Digital Station roster.
5. Reporting of HF Digital Stations' traffic activity to ARRL HQ.

The Digital Coordinator's role is analogous to the TCC Director's role. Just as TCC Directors manage their roster of TCC operators, Digital Coordinators will manage their roster of HF digital system operators, reporting traffic totals to HQ for inclusion in the regular NTS activity reports in *QST*'s Public Service column.

This is an historic occasion for the development of the National Traffic System for the future. With enhancement of its traffic-handling capabilities, embracing new technologies, its future should be ensured. The National Traffic System will be able to continue to point with pride to its banner: advancing the state of the radio art and contributing significantly to the public welfare.

—*from* ARRL Field Forum

## THE YU3 23-CM 38,400-BIT/S PACKET-RADIO NETWORK

*Hardware Technical Description: Introduction*

At the very beginning of packet radio in our area, we noticed the severe limitations of a single channel, 1200-bit/s CSMA network. The terrain requires many repeaters to serve all the amateur population and our network has to handle traffic from Austria, Italy, Hungary and other parts of Yugoslavia as well.

The solution we found is to build a network of nodes with user-access channels in the 2-meter and 70-cm bands at low speeds (1200 bit/s and soon 2400 bit/s), interconnected via 38,400-bit/s links operating in the 23-cm band. At this time, the network has three such high-speed links connecting four main nodes: 4N3K, 4N3L, 4N3H and 4N3P. The network is operating well and several other nodes are under construction.

The 1.2-GHz, 23-cm network in Slovenia is the result of a collective effort of more than ten enthusiasts, whose work was coordinated by Iztok, YU3FK. Within this group, I was in charge of developing the hardware and, in the following, I will describe the technical aspects of our network.

*Selecting the Transmission Standards*

It was immediately clear that we could not use standard narrow-band amateur transceivers and low-speed modems for our network interlinks. New hardware had to be developed. Furthermore, we could not use the 70-cm band without overriding the IARU band plan since the latter only extends from 432 to 438 MHz in Yugoslavia. Finding a clear, wide-band channel in this frequency band was a challenge, too, so, it was decided to use the 23-cm band.

The modulation standard also had to be selected, considering the constraints of both modem and transceiver design. Coherent modulation techniques (like straightforward PSK) provide the best spectrum efficiency and longest communications range. Unfortunately, they require good frequency stability for both transmitters and receivers. The lock-in time of the demodulator may require long synchronization headers (long TXDELAY). The transceivers have to be designed for this particular transmission standard; alignment and testing may be very difficult for amateurs without much test equipment.

Considering the above constraints, we decided to build wide-band FM transceivers equipped with 200-kHz wide ceramic filters (like FM broadcast receivers). Such transceivers, together with suitable modems, can support digital communications up to about 64,000 bit/s. The penalty for using an FM discriminator in place of a coherent demodulator is around 5 dB in terms of receiver sensitivity or communications range with well-designed modems.

The FM transceiver could be modulated with the NRZI data. Unfortunately, the NRZI data has a noticeable dc component, which requires a dc-restoration network in the receiver even with data randomization (scrambling). Therefore, Manchester coding was selected. Although it requires twice the bandwidth, a Manchester-coded signal has no dc or low-frequency component. Manchester modems can be built as simple digital state machines (no alignment) with fast and reliable digital carrier-detect logic.

To remain 100% compatible with the existing network, TNC 2 clones with NET/ROM software are used. This software can operate up to about 40,000 bit/s with a 10-MHz Z80 clock, so a standard speed of 38,400 bit/s was selected for the network. Initial problems with TNC 2 clones operating at 10 MHz were solved by carefully selecting the components used and by designing new TNC 2 clone logic with less critical timing.

At the beginning, we agreed to use simplex transceivers and CSMA with low-speed 1200-bit/s packet radio on 2 meters and 70 cm. A network with full-duplex transceivers could provide a slightly higher capacity at a significantly higher cost. However, each node would require two or three transceivers with bulky duplexer filters and dedicated TNCs. The selection of the operating frequencies in the network would cause problems, too. Such a network could not support advanced high-speed users in the 1.2-GHz band, precluding the possibility for any further experimentation. This complicated solution was considered out of reach of our limited resources.

*Transceiver Design*

The wideband transceiver is a simple single-channel crystal-controlled FM transceiver. Except for the RX/TX antenna and supply switches, the receiver and the transmitter circuits are completely independent.

The receiver is a double-conversion receiver. The first (variable) IF is in the 65-MHz range and the second IF is 10.7 MHz. A single crystal oscillator, operating between 26.5 and 27 MHz, is used for both conversions. The oscillator output is multiplied by 45 ($5 \times 3 \times 3$) for the first conversion and by 2 for the second conversion. The receiver has two RF amplifier stages at 1.2 GHz (BFQ69 and BFR91), a mixer at 1.2 GHz/65 MHz (BFR34A), another mixer stage at 65 MHz/10.7 MHz (BF981) and a standard 10.7-MHz FM IF (CA3089). The receiver achieves a noise figure of about 4 dB.

The transmitter includes a varactor-modulated crystal oscillator in the 9.8- to 10-MHz range followed by seven frequency doubler stages for a total multiplication factor of 128 and a power amplifier. High-speed switching transistors (BSX39) are used up to 300 MHz. The last two multiplier stages use a BFR91 and a BFR96. Finally, the four-stage power amplifier uses a BFR91, two BFR96s and a BFQ68, supplying between 1.5 and 2 watts at 1.2 GHz.

The RX/TX switching is fully electronic. The RF switch uses four BA379 PIN diodes. To speed up the switch-over, the receiver is powered all the time except for the two front-end RF amplifier stages. The transceiver is able to work reliably with a TXDELAY of only 5 ms, but for reliability reasons the TXDELAY parameter was finally set to 20 ms.

*Modem Design*

Two different modems were developed. Both modems include a state machine that operates with a clock that is 64 times the bit-rate frequency. The same state machine is used during transmission and reception to synchronize a 50% duty-cycle square-wave with the incoming signal.

Both demodulators include a limiter followed by an exclusive-OR gate and an integrator. Limiting the incoming signal degrades the demodulator sensitivity by 2 to 3 dB. This is the price paid for such a simple circuit. A few dB are lost in the integrator, too, which is a simple RC low-pass filter followed by a voltage comparator in place of a synchronized integrate-and-dump.

The first modem has an EPROM-based state machine with a 74HC374 8-bit D-latch. Most of the analog functions are performed with an LM339 quad comparator. A 16-bit shift register (two 74HC164) generates a ¼-bit delay for the Data Carrier detection since this modem was developed to work with standard TNC 2 clones. The modem can have its own clock oscillator, but for 38,400 bit/s, the required 2.4576-MHz clock can also be derived from the TNC.

The second modem uses 74LS logic only, thus eliminating the need for a relatively slow EPROM that needs to be programmed. The state machine is built with just four TTL ICs: 74LS86 exclusive-OR gates, 74LS153 multiplexer, 74LS163 counter and 74LS175 D-latches. LM311 comparators are used for the analog functions. Since this modem is intended to work with the new TNC 2 clone (to be described later) and the latter already has a very reliable Data Carrier Detect (DCD) circuit, no DCD circuit was included in the modem itself.

The Manchester modems were also tested with standard amateur narrow-band FM transceivers. By connecting the modem to the MIC and SPKR connectors, very reliable operation was possible at 2400 bit/s. Higher speeds (up to 4800 bit/s) require a direct connection to the varactor and discriminator. We believe that 2400-bit/s Manchester is a valid and cheaper alternative for user links to the now widely used Bell 202 1200 bit/s. Unfortunately, 2400-bit/s Manchester is not compatible to the Kantronics 2400-bit/s QPSK standard, but in our area, very few amateurs have commercially built TNCs.

*Revised TNC 2 Clone*

The first experiments were made with off-the-shelf TNC 2 clones. These have a number of drawbacks that are summarized as follows.

1. Most clones have a very unreliable reset circuit/nonvolatile RAM protection logic, which leads to very undesirable "latch-ups," especially if the TNC is installed on a difficult to reach location.

2. Although the original TNC 2 had EPROM-based state-machine RX synchronization, most clone makers replaced it with a 74LS393 counter with a rough RESET logic. The performance of this circuit is very poor with weak signals.

3. Most clones have a poorly designed address decoder. MREQ is gated with A15 to select the 27256 EPROM. This circuit requires a very fast 150-ns EPROM for 10-MHz Z80 clock operation. Gating MREQ with RD releases the EPROM access time requirement by at least 50 ns.

4. TNC 2 clones usually do not have digital carrier-detect logic. This is not a problem for Manchester modems, where a reliable DCD can be built easily. It is a problem with AFSK modems (Bell 202). The transceiver squelch has to be adjusted critically and an unnecessarily long TXDELAY is required.

5. The EIA-232-D drivers and related negative supply are a source of trouble. In a multiple NET/ROM node, it is much simpler to interconnect the TNCs at TTL levels.

6. Many TNC 2 clones have other design mistakes that cause unreliable operation. These vary from one TNC to another.

To avoid these problems, we developed a revised TNC 2 clone. It includes a very reliable reset logic and an improved address decoder. The RX synchronizer is a state machine operating with a clock that is 32 times the bit-rate frequency. The state machine uses four TTL ICs: 74LS86 exclusive-OR gates, 74LS157 multiplexer, 74LS163 counter and 74LS175 D-latches. The state machine includes DCD logic that looks where the transitions occur. If they occur at the beginning or the end of the bit time, the signal is good. If they occur in the middle of a bit, the input is considered noise. An RC low-pass filter followed by an LM311 comparator supply the DCD.

The remaining circuits are similar to other TNCs. A 74LS74 and an exclusive-OR gate are used for the NRZI/NRZ conversion and a 74LS109 is used for the NRZ/NRZI conversion. A 74LS14 drives the asynchronous port. EIA-232-D receivers accept TTL signals while the TTL inputs can be protected by resistors from EIA-232-D voltages. The clock oscillator uses a 74HCOO followed by a 74LS74 and a 4040. There are, of course, the four big chips, too. The Z80 CPU, Z80 SIO-0, EPROM and RAM. In spite of all the additions and improvements, the revised TNC 2 has fewer chips than some clones.

*Experimental Results*

The most important information from early tests is the capacity of the link, which was experimentally measured as 8,700 bit/s of useful data (not including headers, address information and acknowledgment packets) between two stations on an otherwise clear channel.

The theoretical range between two transceivers in free space is around 1000 km with medium gain antennas (10 dBd). This is about 10 dB less than a link with ideal coherent modems could do. The range was confirmed by a practical experiment. The link, 4N3K-12 to 4N3L-12, is 9 km apart and it operated reliably with an additional 20 dB attenuator in the antenna cable.

The single-channel CSMA network allows us to do something we did not even think about. We can monitor the propagation conditions on 1.2 GHz. With good propagation conditions, we noticed connections between nodes that do not have a common visibility nor antennas oriented in the right direction. Although these effects are a nuisance for a packet-radio network, they can be easily made harmless by a correct setting of the network node parameters.

*—by Matjaz Vidmar, YT3MV, from* Connect International

**GATEWAY CONTRIBUTIONS**

Submissions for publication in Gateway are welcome. You may submit material via the US mail to 75 Kreger Dr, Wolcott, CT 06716, or electronically, via CompuServe to user ID 70645,247, or via Internet to horzepa@gdc.portal.com. Via telephone, your editor can be reached on evenings and weekends at 203-879-1348 and he can switch a modem on line to receive text at 300, 1200 or 2400 bit/s. (Personal messages may be sent to your Gateway editor via packet radio to WA1LOU@N1DCS or IP address 44.88.0.14.)

The deadline for each installment of Gateway is the tenth day of the month preceding the issue date of *QEX*.

# Corrigendum

**Low-Power Portable Packet Terminal,** by Steven Avritch, WB1EOB, January 1991 *QEX* (issue 107). See Fig 1—The polarity of C10 is reversed. The positive side goes to ground, the negative side connects of pin 6 of U2.

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Several errors appeared in **HF Frequency Synthesizer... Easier Than Ever,** by Pierre Boillat, HB9AIS, January 1991 *QEX* (issue 107). Here are the corrections as received from the author.

- The IC MC 145 13 is produced by: Motorola Semi Conductors SA, Av. du General Eisenhower, 31023 Toulouse, Cedex, France. It is also available from several sales offices in Switzerland; I would be surprised if it was not available in the USA.
- The word "self" for L1 and L2 (an English word) was used instead of "coil."
- To obtain a frequency as pure as possible, it is necessary to adjust the 10-kΩ pot so as to reach PLL sync (LED from pin 28, via T4 *switched off* within 0.2 to 1 second).
- Other questions can be answered with this corrected schematic.

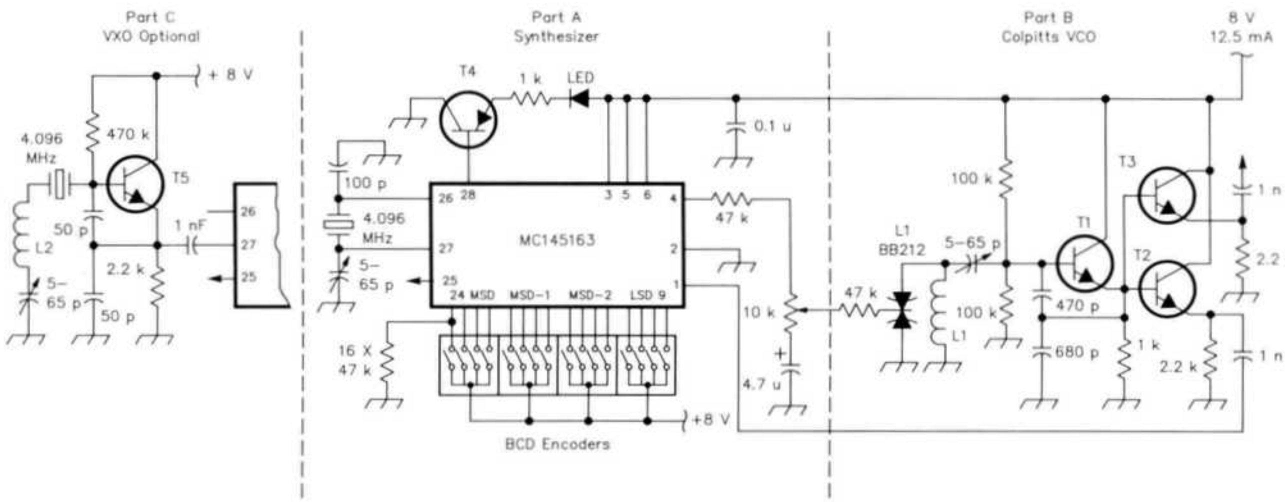


**Fig 1—4.5-9.999 MHz frequency synthesizer.**
**T1-3, T5, 2N2222**
**T4, BC2907**
**L1, 17t, Tore Philips No. 4322 020 97170, about 15 μH**
**L2, 47t, Tore Philips No. 4322 020 97170, about 100 μH**
**MC 145163, Motorola**
**BB 212, Philips**