The N4UAU Super CW Station

by Sam Ulbing N4UAU

L ook, over in that ham shack! "Why, it's a clock!" "No, it's a keyer!" "No, it's a CW tutor!"

"No, it's the N4UAU Super CW Station!"

If you are a new ham or want to upgrade your ticket, this project will help you master CW. If you are an experienced ham, you will learn to send better and improve your ability to copy in your head. And you will find the receiver function to be a *fun* way to look around the bands while improving your ability to copy code. Whether you are new or experienced, the built-in alarm clock will keep you from forgetting your next sked.

My Keyer Does It All

It is Monday morning about 6 a.m. and I'm sitting in my shack drinking coffee and trying to get my brain in gear for a CW sked I've got at 06:30. Suddenly I hear "DIT DAH DAH, DIT DAH DIT DIT, DAH DAH DAH." It's my CW station telling me it's time to turn on the radio and copy the weather from "WLO." The high-seas forecast is sent by WLO in CW at about 30 wpm and I'm copying it perfectly while glancing through the headlines in the day's paper. You probably think I am a real CW whiz to be able to do that while still half asleep, but I am not. I can only copy about 25 wpm on a good day with all my concentration. And I'm not using my computer either. I am using my keyer to copy and display the code! That's right, my *keyer*.

Actually, I call it the "N4UAU Super CW Station" because it is much more than a keyer or a clock. It also copies and displays CW from your receiver, sends random code (characters, words or callsigns) to practice, and displays it. And when you are ready to send CW, it becomes an iambic keyer, with three memories, that will display what you are sending. It is easy to build, fits in a small box 4" by 6", and costs only about $100 to build.

Project Features and Operation

The CW STATION does many different things. It:
* Copies and displays CW characters from your receiver.
* Calculates and displays the speed of the CW.
* Has an 80-character display mode that stores and displays the last 80 characters of code so you can review your copy and sending accuracy.
* Has a built-in random code generator. You set the character speed, space speed, group size and sidetone frequency. It will send random code in any of three different modes. The first mode sends charac-

ters. It lets you select only those exact characters you want to practice. The second mode sends 300 different common CW words. The third mode sends random callsigns. This feature will help you get ready for that CW test which always has at least two callsigns you will need to copy.
* Works as an iambic keyer (2 to 40 wpm).
* Has three message memories. You see the words you are storing in memory and can backspace to correct any errors.
* Displays all the CW characters on a 40-character by two-line LCD.
* Sets and displays all speeds digitally so you know the exact speed you are copying or sending.
* Has a built-in clock and calendar with an alarm.
* Has a built-in sidetone oscillator with an adjustable frequency (600 to 900 Hz).
* Has an on-board audio amplifier that can drive a small speaker.
* Uses a tuning LED to "zero beat" the other station.
* Allows easy external powering with the on-board voltage regulator.
* Can be used with an external key.
* Has battery backup to preserve all memory if a power failure occurs.

The CW station uses only a few parts and is easily built because all the major parts are actually entire subcircuits in themselves. The heart of the project is the 87C52 microprocessor. It is a small process control computer with 8 kbytes of code that control the rest of the circuit. The 40-character by two-line LCD display has several processing circuits built into it that handle all the details of displaying the data. The LM567 decoder has circuitry built in to determine when a received signal is at the proper frequency and then demodulate it. The DS1202 is a time-keeping chip that has day of the week and leap year features.

All you need to do is solder

Photo A. The keyer's main menu.
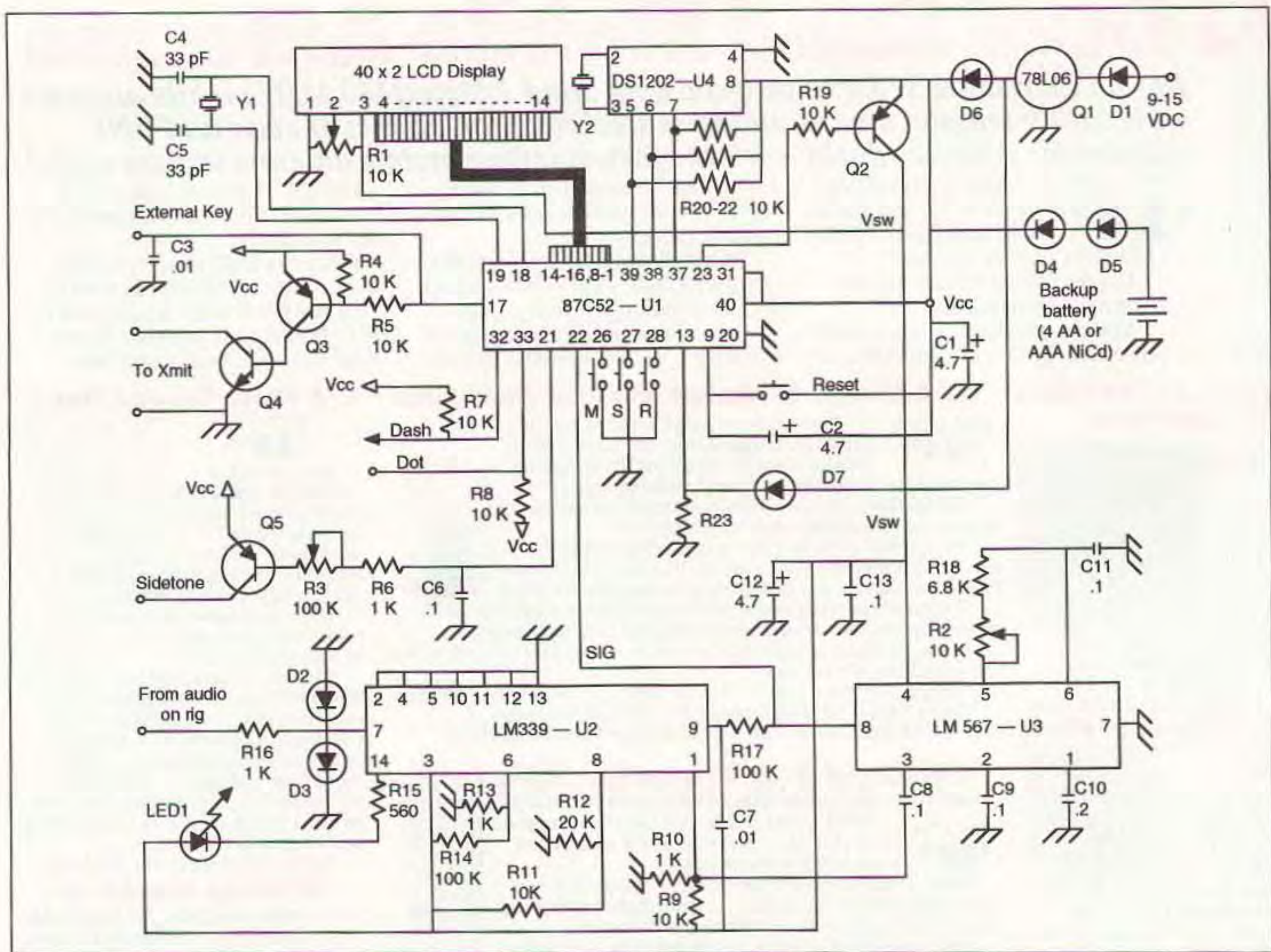

Photo B. The character menu.

Figure 1. Schematic for the Super CW Station.

these parts together, set the display brightness to your liking, set the decoder to the frequency for your rig, and enjoy it!

Circuit Description

There are basically two sections to the CW station. The *microprocessor circuit* does all the processing in an 87C52. In it is an 8 kbyte program which the 11.0592 MHz crystal runs at a rate of about half a million instructions per second. When an incoming signal is received, the microprocessor measures the time of the element and determines whether it is a dot or a dash. This information is saved until an inter-character space is received. The microprocessor then determines what character was received by looking it up in a table, then that character is sent to the top line of the LCD display via 11 lines. The second line shows the speed of the code and the time of day. If you want to use the built-in iambic keyer function, the microprocessor will sample the paddle input lines and send the appropriate dots, dashes and corresponding spaces for that speed. It will also determine what character is being sent and display it on the LCD. The microprocessor sends the dots and dashes to pin 17, where they go to two transistors (Q3 and Q4) which can drive your transmitter.

Another signal is output at pin 21. This is a sidetone signal which goes to the audio

amp (Q5). With the sidetone you can listen to your sending if you just want to practice and not actually transmit. The 10k pot (R1) is used to adjust the brightness of the LCD.

Four push-buttons are connected to the microprocessor. These are used to set speeds and control the various functions of the microprocessor. To prevent loss of clock or memory data, the circuit allows battery backup. When a power failure occurs, a signal is sent to the microprocessor at pin 13, causing the microprocessor to shut down all the circuits and put itself into a sleep mode. When power is restored, the keyer will wake up with all the data saved.

The *demodulator circuit* is the other part of the circuit. It decodes signals from your radio and sends them to the microprocessor. When a CW tone is heard on the speaker of your receiver, it is a series of dots and dashes that are modulated at around 750 hertz. In order for a computer to decode the tone it is necessary to make the signal either a high or low voltage level (5 volts or 0 volts). As with human CW operators, it is also necessary to filter out as much extraneous noise as possible so that a clean signal is available for copying. The demodulator helps do this with two IC chips.

The audio signal is brought into an LM339 quad comparator (U2) at pin 7. When the signal voltage is less than the voltage at pin 6

(set by R13 and R14), the output at pin 1 goes to ground. When the signal voltage is greater than the pin 6 voltage, 500 millivolts are applied to U3 because of the voltage divider formed by resistors R9 and R10.

U2 serves two purposes. First, it rejects noise levels that are not as strong as the desired signal. Second, it keeps the voltage to U3 independent of the signal strength. It is either 0 when no signal is recognized, or 500 millivolts if a signal is present. This is important for U3 to work properly. U3 is an LM567 designed to decode DTMF type signals and is basically a phase-locked loop. The lock frequency is set by R18, the 10k pot (R2) and C11.

C9 and C10 set the bandwidth. The maximum possible bandwidth of 14% of the center frequency (105 Hz at 750 Hz) is a pretty narrow filter, but it is ideal for our purpose. When the 500 millivolt signal from U2 is in the passband of the LM567, the output at pin 8 goes to 0 volts; otherwise, it is held at 5 volts by the 8752.

Tuning into a bandwidth of 100 Hz can be tricky. To make it easier, a second comparator on the LM339 is used to indicate when the sending station is in tune. The LED will flash the CW when it is tuned in; otherwise it will be off. Between looking at the LED and listening to the frequency of the code, you can tune in a station quickly and accurately.

Building the Project

With only a few parts and the PC board, this project is easy to build. There are a number of wires running from the PC board to switches and displays on the case. A careful layout will make the project neater. I have used a 4" by 6" aluminum case for my CW station and a Lexan top (see the photos). The aluminum box acts as a ground for all the jacks mounted to it, so I do not need to run a separate ground wire for each jack, thus reducing clutter.

The Lexan top protects the rather soft surface of the LCD display. Also, because it is easily heated and bent, I was able to set the LCD and LED at a better viewing angle. I used Lexan because it does not break, but Plexiglas works well, too, if you are careful. You can also use a plastic box, but you will need to run a ground wire to all the jacks. The current draw is about 30 milliamps (without the speaker) and you can power it from a 9- to 15-volt source. I have found a wall transformer to be a good power supply.

Using the CW Station

When you turn on the CW station, you will see the clock displayed. In this mode you can set the clock or alarm data, or you can enter the main menu by pressing the "M" button. In the main menu, "73 DE N4UAU" is displayed on the top line of the LCD. The second line shows: "M=TONE S=CODE R=80CHR P=KEY." You have the choice of going to one of several sub-menus, depending on what you want to do with your CW station:

1. Touch either the dot or dash paddle to use the CW station as a code translator and iambic keyer.
2. Press the "S" button to enter the random code generator.
3. Press the "R" button if you want to use the 80-character feature.
4. Press the "M" button to set the sidetone frequency.

Receiving and Sending CW

To copy incoming code, tune in a station. The tuning LED will be off until you tune it into the 100 Hz passband. When you see the LED flashing on and off with the Morse code, you are tuned in and you will see the received code scrolling across the top line of the LCD. The bottom line will show the speeds you set and the actual speed of the incoming code. The current time of day is also displayed on this line.

When you are in the receiving mode, you can send code just by touching your paddles or key. The receiver will stop copying the incoming code and will send and display your code. The code you are sending is displayed in capital letters to distinguish it from the received code, which is in small letters.

Photo C. The keyer connected to a paddle.

Electronic parts:

U1	87C52 preprogrammed micro
U2	LM339
U3	LM567
U4	DS1202
40 x 2 LCD display	
Q4	NPN transistor—2N4400
Q2,Q3,Q5	PNP transistor—2N3906
Y1	11.0592 MHz xtal
Y2	32.768 kHz xtal (6 pF)
Q1	78L06 voltage regulator
D2,D3,D4,D5,D7	1N4148 diode
D1,D6	1N4001 diode
R3	100k pot
R1,R2	10k pot
R14,R17	100k resistor
R4-5,R7-9,R11,R19-23	10k resistor
R18	6.8k resistor
R6,R10,R13,R16	1k resistor
R15	560 ohm resistor
R12	20 ohm resistor
C1,C2,C12	4.7 µF capacitor
C10	0.2 µF capacitor
C6,C8,C9,C11,C13	0.1 µF capacitor
C3,C7	0.01 µF capacitor
C4,C5	33 pF capacitor
For U1	40-pin socket
For U3,U4	8-pin socket
For U2	14-pin socket
PC board	
LED 1	LED—high intensity
M,S,R,RESET	N.O. push-button switches
Hook-up wire	

Parts for box shown:
4" x 6" aluminum box
1/8" Lexan, 5" x 8"
Speaker
12 VDC wall transformer
Assorted hardware

To change your sending speed, press the "S" button and use the dot and dash paddles to increase or decrease the speed (2 wpm to 40 wpm). When you stop sending, the keyer will shift back to the receiving mode.

The microprocessor calculates and displays the actual speed of the code it is pro-

cessing by averaging the speed of the last 20 characters. It takes into consideration the element speed you set at the start, the number of blank spaces, and the characters being sent. The code display provides feedback on how good your sending is. If you are running characters together, you will see "&" rather than the letters you thought you sent. Increase your spacing a bit between the dots and dashes and you will see the letters.

You can use the keyer with an external key. However, you will need paddles to set speeds, etc. If you do not have paddles, a pair of push-button or microswitches can be used as a paddle to set speed. You can swap between using the internal and an external key any time you are in the receive mode.

When you first enter the keyer mode, the display will ask if you want to store a message. You can store three different messages. If you make a mistake when you are storing the message, just stop and press the "S" button. The cursor on the display will backspace and erase a letter at a time. When you have erased the error, just continue sending the message. You can send the message anytime you are using the keyer functions by pressing "M" and the appropriate memory location ("M," "S" or "R" button). The "R" message is also used by the alarm clock feature (see below).

The Random Code Generator

When you enter this mode you will see the first of three menus, the *speed menu*, which displays "CHAR=XX SPC=YY." You can set two speeds. The character speed sets how fast the elements are sent, and the space speed sets the spaces between characters and groups. This will let you send Farnsworth at any speed you want.

The next menu is the *mode and groups menu*. The mode can be set to "WRDS," "SIGN," or "CHRS." The WRD mode will send 300 common CW words and abbreviations. The SIGN mode sends callsigns. The U.S.-designated callsigns are used and suffix addenda are also sometimes added; i.e. /AG, /AA, /AE, /M, /2, etc. This allows you to get used to the callsigns most commonly used in exams.

In the CHRS mode, random characters are sent. You can set the character group size from 0 to 15. With the group set to 0 the keyer will send characters one at a time. Each time you press the dot paddle, the keyer will send and display the next character and then stop. If you want to hear the same character again, press the dash paddle. You can do this as often as you want until the sound of that character is familiar. To listen to a different character, press the dot paddle.

In the WRDS mode, the group size is used to set the way words are sent. Normally, words are sent to fill the LCD display and the Tutor stops so you can check your copy.

If you want to try practicing copying words in your head, you can set the group size to 0 or 1. The code generator will send random words continuously and they will scroll across the screen. You won't be able to write the words and check them, but if you want to learn to copy in your head this will give you good training.

The third menu is the *character menu*, which lets you select which characters you want to practice. It is only displayed if you select the CHRS mode. When it is first displayed, you will see all the possible characters. To select just some of the characters, use your paddles to "erase" the characters you do not want to copy, and leave the ones you do want to practice.

When you are ready to copy random code, the code will be sent and displayed on the LCD screen. When the screen is full, the Tutor will stop and let you compare your copy with what was sent. To send another set of 80 random characters, just press a paddle.

The 80-Character Mode

In this mode you can send or receive code but it will not scroll across the screen. Instead, it will fill up the 80 characters on the screen and stop. This feature is especially useful if you are copying code with pencil and paper, because it lets you concentrate on copying, and after 80 characters you can check your results. This mode is also helpful when you are practicing your sending, because it will let you concentrate on sending, and when the display is full you can check to see how well you sent.

Constant Tuning and Sidetone

This mode will let you send a continuous tone to the transmitter, and a sidetone signal. You can use this mode to tune your antenna or to change the frequency of the sidetone oscillator. The sidetone frequency can be set from 600 Hz to 900 Hz.

The Clock Mode

The clock mode displays the time, date and day of the week. In this mode, it also shows if the alarm is set. When the alarm is activated, the clock will send the message stored in memory "R." It sends it in CW on the sidetone speaker (but not to the transmitter!) and simultaneously displays it on the LCD. This message can be up to 15 characters in length. If you do not have a message in memory, the alarm just beeps.

Obtaining the Parts

Except for the 8752 and PC board, all parts are available from catalog parts suppliers like Digi-Key, Mouser, JDR, etc. The pre-programmed 87C52 and PC board are available from the author (5200 NW 43rd St., Suite 102-177, Gainesville, FL 32606; E-mail n4uau@freenet.ufl.edu) for $40. In addition, the author has a convenience pack of all the electronic parts for $85 and a limited number of box parts (aluminum box, pre-bent Lexan cover, speaker and wall transformer) for $15. Florida residents add sales tax please.