An Inexpensive Morse Code Keyer

Build your own for under 10 bucks.

by Tony Marchese N2YMW

A friend of mine recently convinced me to take the examination for an amateur radio license. I had previously considered obtaining a license but was less than thrilled with the prospect of learning Morse code. I argued that I was as dumb as a stump when it came to memorization but was assured that learning code was not as tough as it seemed.

I realized that the best way for me to learn Morse code was to actually generate the sounds. I perused the various amateur radio publications in search of a CW practice oscillator. I found several in the $30 range but, being a frugal individual (a.k.a. cheapskate), I opted to construct an oscillator of my own design based upon the following parameters:

1. Automatic formation of the dit/dah length relationship followed with a "space." The relationship between the dit, dah, and space, according to the *ARRL Handbook*, is defined in terms of unit length with a dah three times longer in duration than either the dit or space. A paddle set was used in place of a straight key to accommodate this feature.

2. Memory—holding one paddle "down" repeats the tone with the appropriate spacing inserted in between. Holding both paddles "down" alternates between dit and dah with a space inserted between tones.

3. Variable character speed to allow for advancement.

4. Total project cost of less than $10. All ICs and components were to be standard, readily available items, as I have rarely had luck locating those neat, obscure components that are used in some designs. Fortunately, I have a box (OK, several boxes) of recycled circuit boards and parts, to which my wife affectionately refers as "junk."

5. Long battery life to last through the countless hours of practice.

6. Adjustable sidetone oscillator.

7. The ability to connect the device to a transmitter.

Theory of Operation

I computed the acceptable frequency ranges for both the adjustable sidetone and character length oscillators as an initial design step. The oscillators were constructed using gates C, D, E, and F of U1, a CD4049 CMOS hex inverter with: Frequency = 1/(2.2 RC). The sidetone oscillator uses a resistance which varies from 6.8k ohm through 16.8k ohm, and a 0.047 µF capacitor to generate a frequency which adjusts from approximately 550 Hz to 1400 Hz. This accommodates the typical sidetone frequency range of 800 to 1200 Hz.

The unit length oscillator incorporates a resistance which varies from 3.3k ohm to 13.3k ohm, and a capacitance of 2.0 µF to create an adjustable 17 to 69 hertz oscillator. This oscillator provides the clock for U4, a CD4017 CMOS decade counter. The state of the U5 multiplexer A0 and A1 lines selects the main timing clock from either the 2, 4, 6, or 8 output of the decade counter, depending on whether a dit, dah, or space is under production. This configuration provides a consistent unit length relationship which is independent of frequency or oscillator drift. The use of the even outputs divides the clock by 2, resulting in a unit length frequency of 8.5 to 34.5 Hz. As the *ARRL Handbook* equates code speed, in words per minute (wpm), to the Frequency x 1.2, the oscillator produces a continuously variable 10-41 wpm character rate.

The "tone" cycle is initiated by depressing either the DIT or DAH paddle. Activating the DIT paddle places a high on the K input to the U3A flip-flop. The J input to the flip-flop is low, provided the DAH paddle is not also depressed. With the inhibit line to pin 6 of the U2B NOR gate low, the transition caused by depression of the DIT paddle clocks the U3A flip-flop, causing the Q output to toggle low. Since the J input of the U3B flip-flop is high and the K input is low, clocking the gate with the same pulse sets the Q output high, thereby temporarily inhibiting any further paddle clock pulses. The NOT Q output toggles low at this time, enabling the decade counter, the multiplexer, and the U6B BCD counter, which turns on the Q1 transmitter key transistor. The multiplexer's Y0x inputs now selected as A0 and A1 are both low. The DIT tone is created as the sidetone oscillator present on the multiplexer's Y0A input is passed through output ZA to the speaker.

After two unit length oscillator cycles, the equivalent of a DIT, the decade counter's Q2 output sets high. This high is gated through the multiplexer's ZB output, which clocks the U6A BCD counter, setting the Q0 output high. The Q0 output resets the U6B BCD counter to turn off the transmitter key transistor. The Q0 output also drives the multiplexer's input select line A0 high to now select the Y1x inputs. This silences the sidetone as Y1A is grounded and selects the decade counter's Q4 output as the new source for the U5A BCD counter enable clock. The decade counter's Q4 output requires two additional unit length oscillator cycles, the equivalent of a SPACE, before setting high to clock the U6A BCD counter. Clocking the U6A BCD counter sets the Q1 output high. This clears the U3B flip-flop to disable both the decade counter and the multiplexer while releasing the paddle clock inhibit line, pin 6 of U2B, and resetting the U6A BCD counter. The memory function utilizes the U2B NOR gate to generate a clock pulse and initiate a tone cycle if either paddle is depressed during the release of the paddle clock inhibit line. If both paddles are depressed, the U3A flip-flop Q output toggles states, thereby alternating between DIT and DAH tones. The keyer is now ready to generate the next tone.

The operation of the DAH paddle is similar, except the U3A flip-flop Q output toggles high. This selects the decade counter Q6 output, which requires three times as many clock cycles as the use of Q2, and in doing so sets up the appropriate DIT/DAH length relationship. The decade counter Q8 output functions as the SPACE interval, identical in operation to the use of Q4, described in the previous section.

The final stage of the circuit is comprised of transistor Q2 which, in conjunction with resistors R11, R12, and R13, forms an adjustable gain amplifier for control of the sidetone volume.

Construction

The complete circuit, illustrated in the schematic shown in Figure 1, uses six standard 4000-series CMOS ICs in the design.

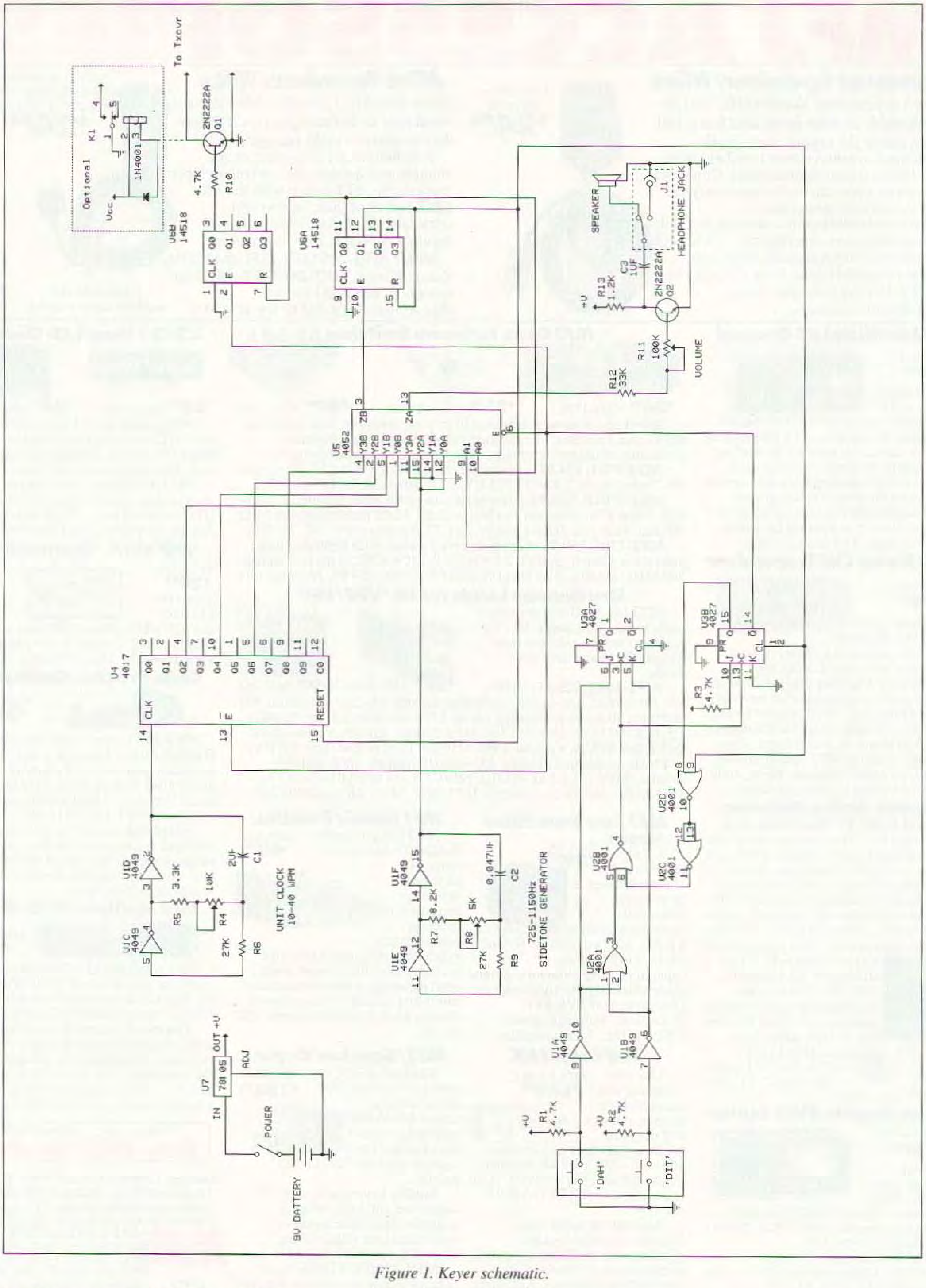

Figure 1. Keyer schematic.

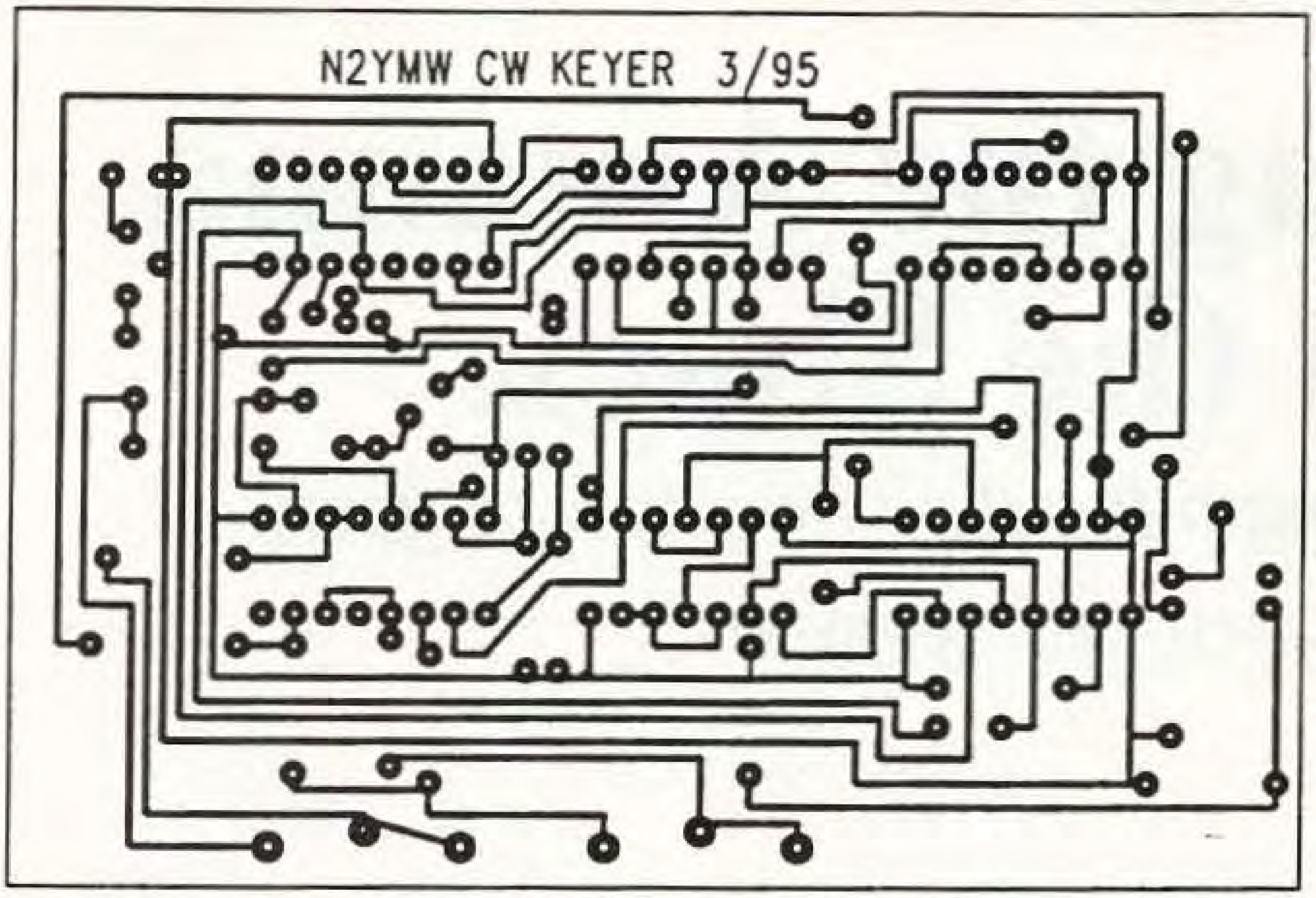

Figure 2. Printed circuit board artwork.

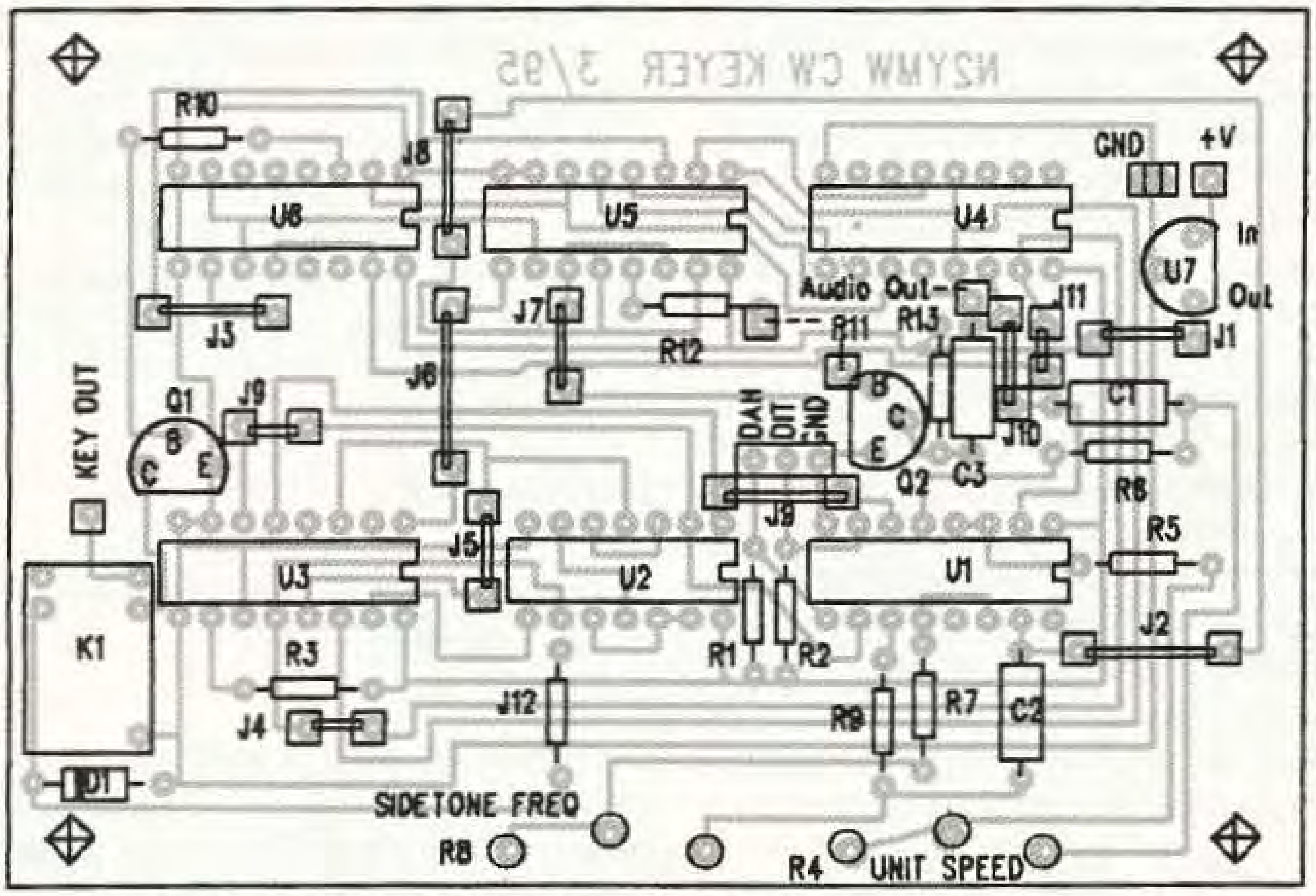

Figure 3. Printed circuit board parts layout.

Parts List

All of the required parts were obtained by mail order for less than $10.

U1	4049	Hex inverter/bμffer
U2	4001	Quad two-input NOR gate
U3	4027	Dual JK, set/clear flip-flop
U4	4017	Decade counter
U5	4052	Dual four-channel analog multiplexer/demultiplexer
U6	14518	Dual BCD up counter
U7	78L05	5V regulator
J1-J11		Jumper wires
Q1	2N2222	NPN transistor
R1, R2, R3, R104.		7k resistor, 1/4 watt
R4, R8		10k potentiometer
R5		3.3k resistor, 1/4 watt
R6, R9		27k resistor, 1/4 watt
R7		6.8k resistor, 1/4 watt
R12		33k resistor, 1/4 watt
R13		1.2k resistor, 1/4 watt
C1		2.0 μF capacitor
C2		0.047 μF capacitor
C3		1.0 μF capacitor
K1	5V PC board relay—optional (Radio Shack 270-243 or equivalent)	
1200 ohm piezo speaker	(Radio Shack 273-091 or equivalent)	
SPST switch		
9V battery connector		
Metal case, approximately 5" x 3" x 2"	(Radio Shack 270-238 or equivalent)	
Miscellaneous hardware		

Parts Sources:
Mouser Electronics, several locations nationwide (800) 346-6873

Radio Shack

A PC board is available for $5.50 plus $1.50 S&H from FAR Circuits, 18N640 Field Court, Dundee, IL 60118.

CMOS was chosen because this component series consumes minimal power, thereby prolonging battery life. I wire-wrapped the original design on a phenolic board which was then installed in a metal enclosure to minimize RFI. The printed circuit board shown in Figures 2 and 3 has since been developed to simplify construction. I was able to stuff and solder the circuit board in less than one hour.

I have been quite satisfied with the keyer's operation during my many hours of practice. I have not yet had a chance to connect the unit to a QRP transceiver but hope to do so by the end of the year. Please note: The 2N2222A NPN transmitter key transistor is used in an open collector configuration. The transistor will safely switch a maximum of 40 volts, which may be inadequate for some transmitters, especially the older, vacuum tube variety. Figure 1 details the optional relay circuitry which is required to switch the higher voltages typically found in older radios. Please check the transmitter's operating manual prior to connection of this unit. I hope you enjoy this project as much as I have.