~ NorCal Keyer ~

A Beginning Builder's Construction Guide

Follow these step-by-step pictorial guidelines as renowned homebrewer and QRP Hall of Fame member Jim Kortge, K8IQY shows us how he built his NorCal Keyer

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Background

This article covers the construction and packaging of the recently released NorCal Keyer Kit. It approaches these tasks as a learning exercise for new builders, so that they can develop proficiency and self-confidence. The kit itself is quite simple. It includes a printed circuit (PC) board, 7 capacitors, 4 resistors, three semiconductors, a small speaker, and a push button switch. One of the semiconductors is a PIC microprocessor, which provides most of the keyer's functionality.

A few user-supplied components are required too, including a small 100K potentiometer, jacks for input and output connections, a battery connector or box, and a case. The kit is designed for packaging in the ever popular Altoids mint tin.

Basic Tools

To build this kit requires a few basic electronic hand tools. The first is a suitable soldering iron. Anything between 25 and 40 watts is useable, with at least a 1/16-inch wide chisel tip. However, tips that are closer to 1/8-inch will provide better heating of the joint being soldered. While a temperature controlled soldering station is very nice, one can get by nicely with a much more modest solder iron setup. The iron shown in figure 1 is an inexpensive, adjustable 25-40 watt unit, and quite suitable for constructing this type of kit.

Figure 1: Soldering Iron

If you have never soldered any electronic parts, a little practice before starting on your kit might be in order. Go to your local Radio Shack, or other parts store, and buy a few small resistors and capacitors. If they have any sort of perforated PC board material available, get some of that too. You can practice putting the parts through the holes, bending the leads slightly, and soldering them in. Do not clip off the leads; the parts can be unsoldered and reused for more practice. If you can't find any perforated PC board material, buy a piece of blank PC board material, and drill several holes in it spaced the lead width of the parts you have available, and use that for practice. Another approach might be to take apart an old wireless telephone and remove the existing parts by heating the PC board with a small torch and rapping it on a solid surface to knock them out. Wear eye protection when using this method for parts removal!

Soldering a part requires placing the tip of the soldering iron against the component lead and the PC board surface, heating it for a few seconds, and then adding a little bit of solder. If the joint is hot, the solder will flow quickly. Once the solder has flowed, remove the soldering iron and the solder, and let the joint cool. If the job was done correctly, the solder will have flowed smoothly, and the joint will look shiny. Later in this article are many examples of correctly soldered joints.

Solder plays a key role in electronics construction. The right kind will work well, and is easy to use. The wrong kind can be hellish! A suitable solder for electronics work will contain approximately 37% tin, and 63% lead. Anything around those two values, with a rosin flux core is suitable. Do not use "no lead" solders intended for plumbing; they will not work well. Nor will solders with acid flux cores. Also, stay away from solders with water-soluble (organic) fluxes. While they seem to work well while building, failure to remove all of the flux later will lead to corrosion where the flux remains. This is also true of any acid flux core

solders.

The best solders also contain about 2% silver. This improves conductivity of the joint, and keeps it bright looking. Figure 2 shows a small roll of solder containing 2% silver, and readily available from Radio Shack. Kester also makes a similar product that is available from Mouser and DigiKey.

Figure 2 – Solder available from Radio Shack

The other basic tool that one needs, especially when soldering a PC board, is a pair of side cutters. A favorite is shown in figure 3. (P7210021.JPG) These are made by Xcelite, and are available from Mouser, DigiKey, and others supply sources. These cutters are used to clip off the excess lead length of parts soldered into the PC board.

Another tool that is very handy to have, but not a necessity, is a “third hand” apparatus of some kind. A commercial version is shown in figure 4. One of these will hold the PC board while parts are being soldered, or hold parts while leads are being attached. One could make the equivalent of this unit with a pair of “pincher” clothespins, a small block of wood, and a bit of fabricating.

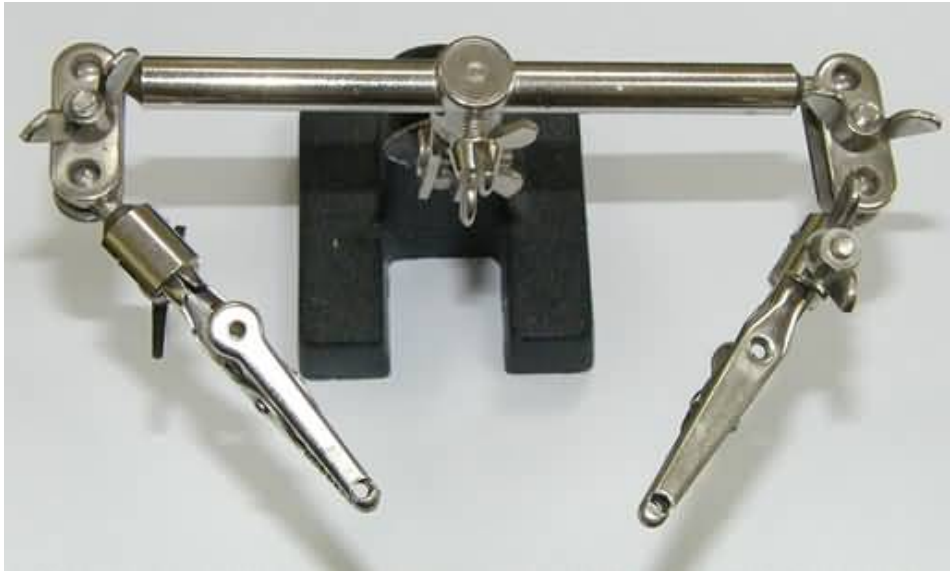


Figure 4: “Third Hand” holds PC board during assembly

Getting Started

Since the version of the NorCal Keyer kit I was asked to build included the “user supplied parts”, my kit came is a box instead of an envelope. Upon opening the box, this was what was inside. Figure 5.

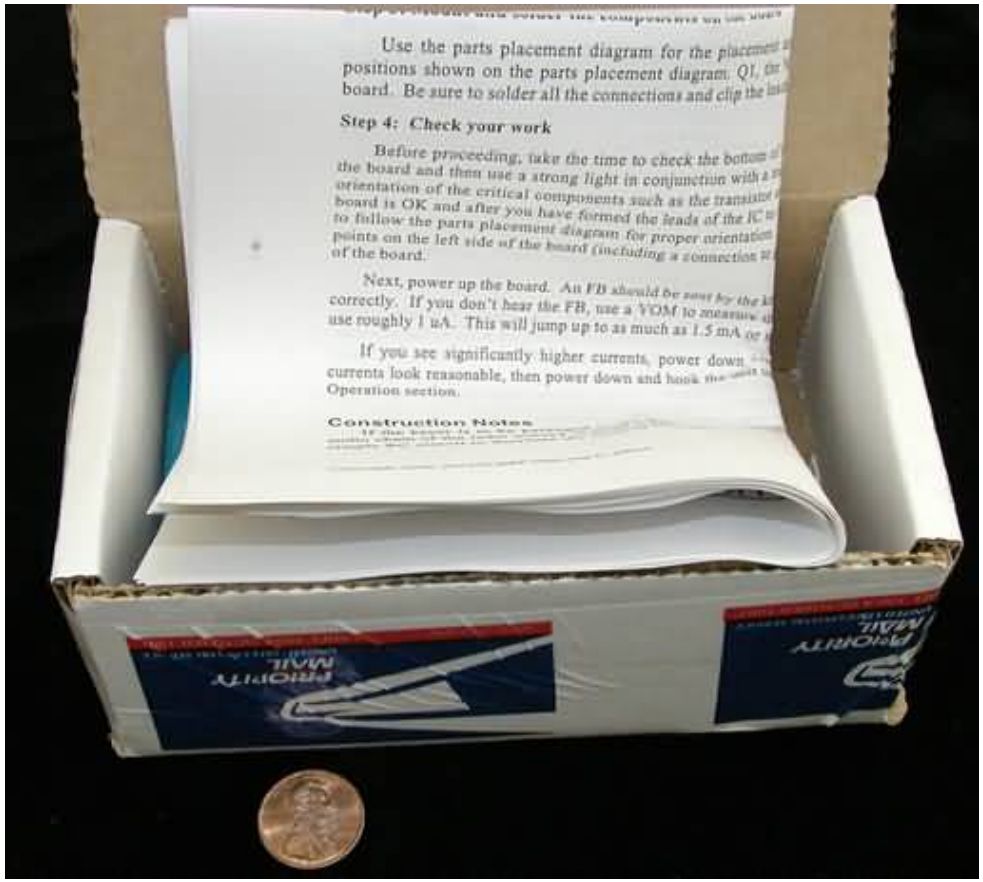
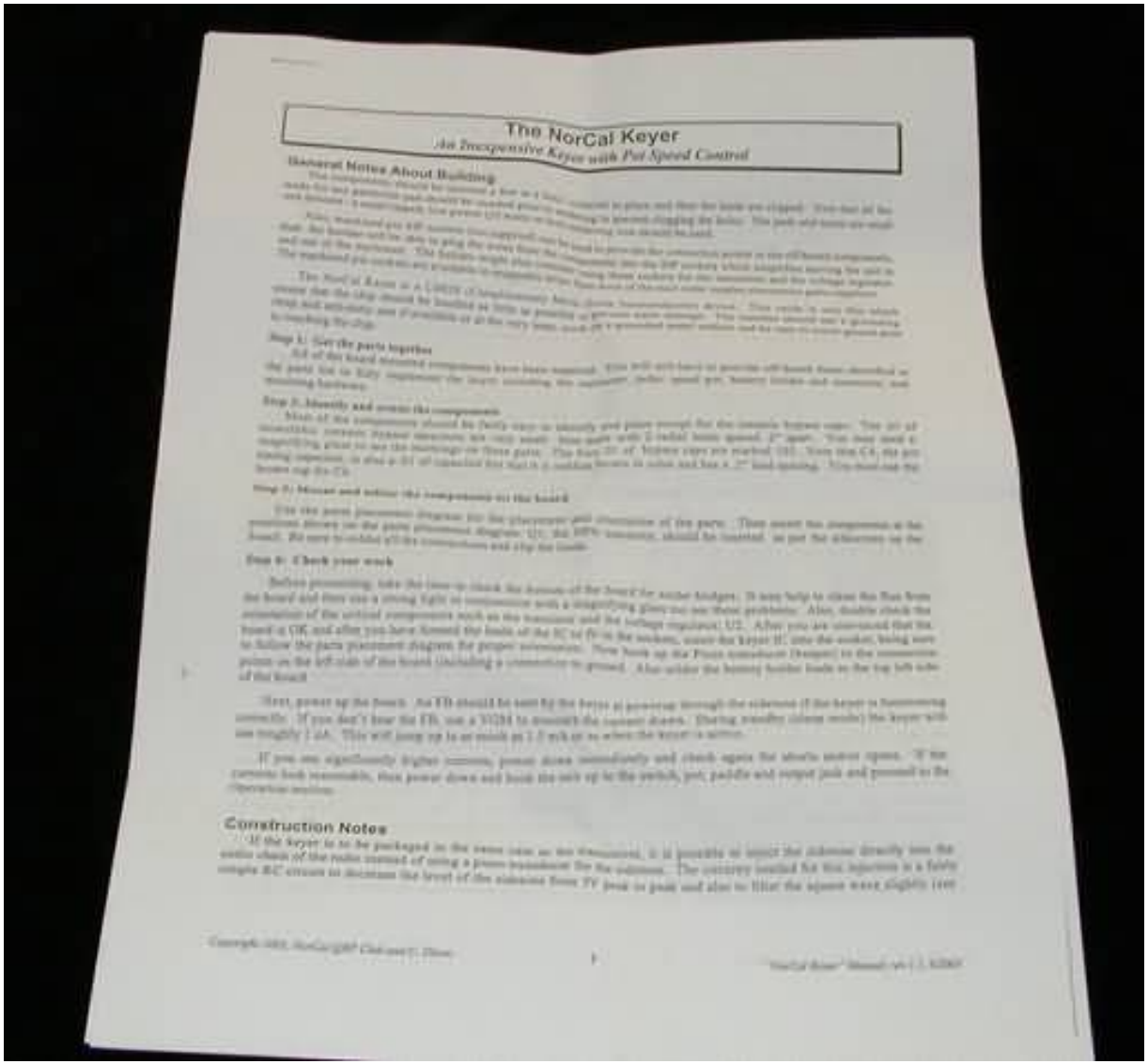


Figure 5 – Shipping box containing NorCal Keyer Kit

On the very top of the stack were the instruction sheets, shown in figure 6. With the box (or envelope) opened, most builders are “chomping at the bit” to get building, and want to toss the documentation aside.



The NorCal Keyer

An Inexpensive Keyer with Pot Speed Control

General Notes About Building

Construction Notes

Figure 6 – Assembly instructions

For a new builder, this information is important. It contains an overview of the kit, important construction information, parts lists, a schematic diagram, and a parts layout template for the PC board. My advice is to read it completely, at least once before beginning construction, and the “General Notes About Building”, “Construction Notes”, and “Parts List” a second time before going further. When you start unpacking your kit, you will have a good bit of sense regarding how the kit functions, and what parts were supplied.

Once the documentation has been read, it is time to unpack the rest of the goodies. Inside the Altoids tin were the “normally supplied” kit parts, all sealed in plastic, as shown in figure 7, …

Figure 7 – Kit components sealed in plastic

and the “user-supplied parts”, loose in the Altoids tin, as shown below.

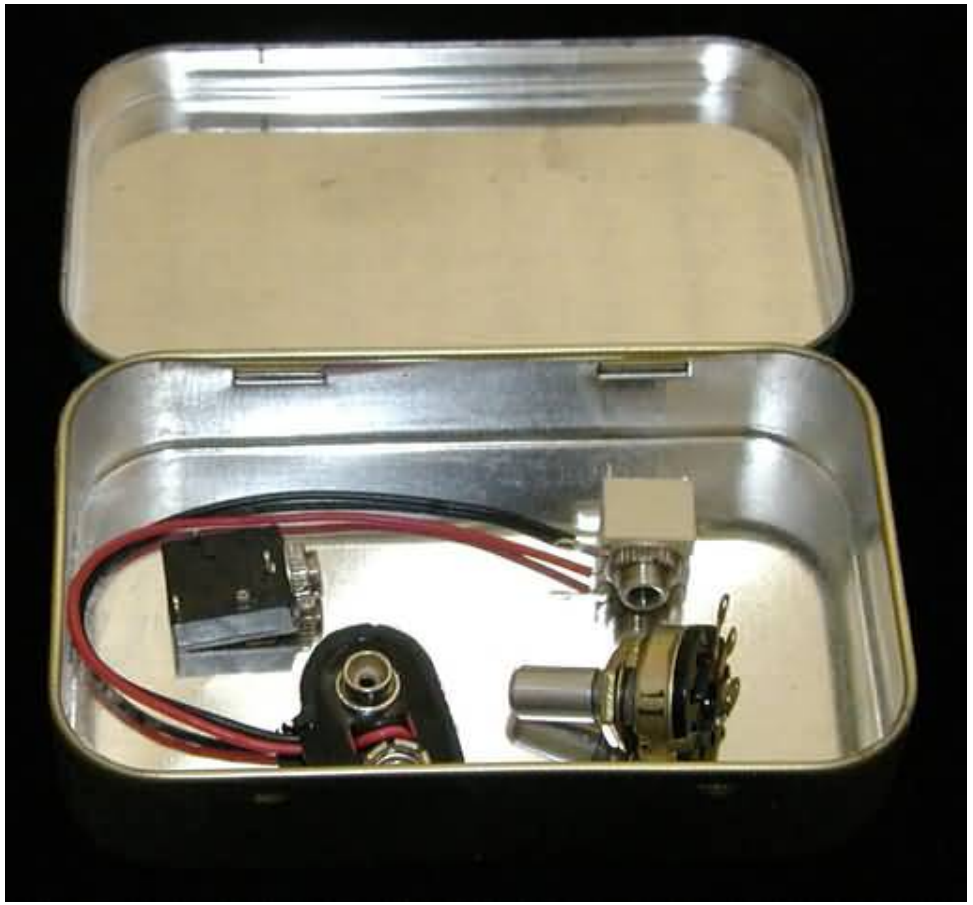
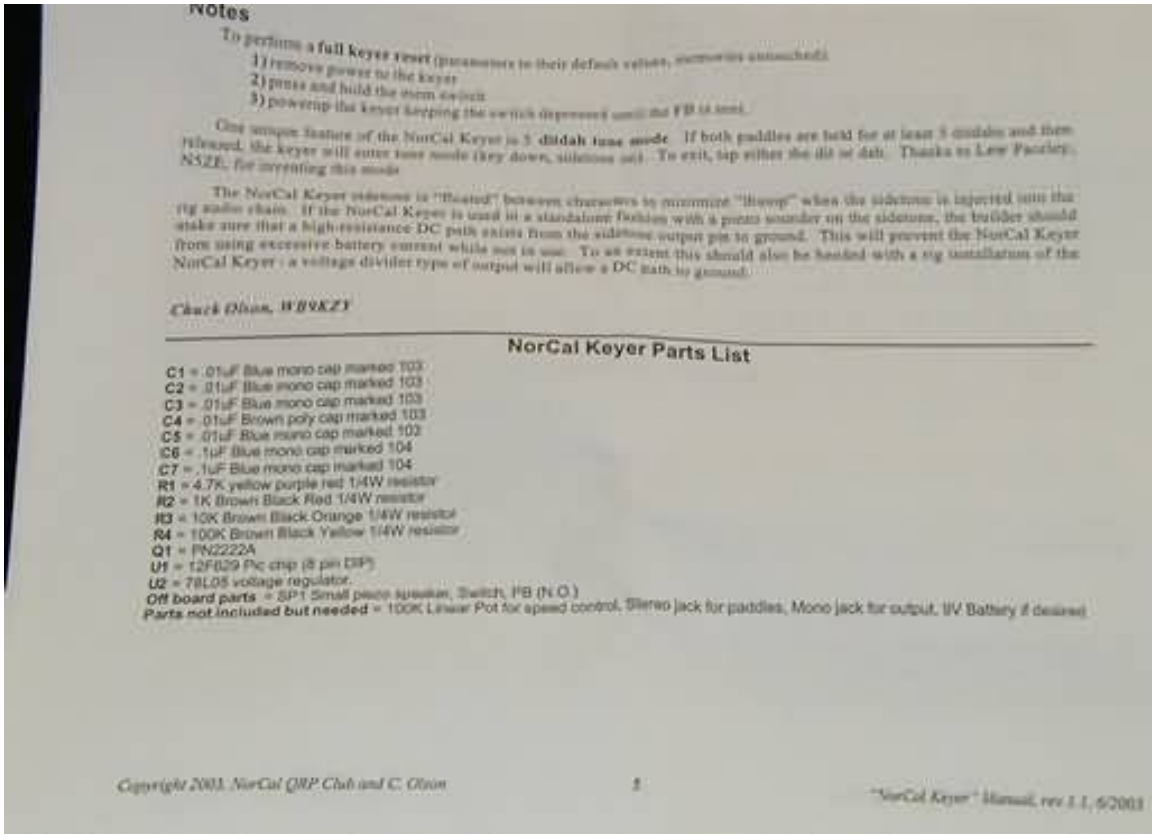


Figure 8 – User-supplied parts for kit.

With the parts packet is opened, one should check its contents against the parts list contained in the documentation, and shown in figure 9 to make sure all of the parts are there. If any parts are missing, replacements can be obtained from AmQRP.



Notes

To perform a **full keyer reset** (parameters to their default values, memories untouched):
1) remove power to the keyer
2) press and hold the mem switch
3) powerup the keyer keeping the switch depressed until the FB is sent.

One unique feature of the NorCal Keyer is **5 didah tune mode**. If both paddles are held for at least 5 dotlahs and then released, the keyer will enter tune mode (key down, sidetone on). To exit, tap either the dit or dah. Thanks to Lew Pacsley, N5ZE, for inventing this mode.

The NorCal Keyer sidetone is "blanked" between characters to minimize "Bleedp" when the sidetone is injected into the rig audio chain. If the NorCal Keyer is used in a standalone fashion with a piezo sounder on the sidetone, the builder should make sure that a high-resistance DC path exists from the sidetone output pin to ground. This will prevent the NorCal Keyer from using excessive battery current while not in use. To an extent this should also be handled with a rig installation of the NorCal Keyer - a voltage divider type of output will allow a DC path to ground.

Chuck Olson, WB9KZY

NorCal Keyer Parts List

C1 = .01uF Blue mono cap marked 103
C2 = .01uF Blue mono cap marked 103
C3 = .01uF Blue mono cap marked 103
C4 = .01uF Brown poly cap marked 103
C5 = .01uF Blue mono cap marked 103
C6 = .1uF Blue mono cap marked 104
C7 = .1uF Blue mono cap marked 104
R1 = 4.7K yellow purple red 1/4W resistor
R2 = 1K Brown Black Red 1/4W resistor
R3 = 10K Brown Black Orange 1/4W resistor
R4 = 100K Brown Black Yellow 1/4W resistor
Q1 = PN2222A
U1 = 12F629 Pic chip (8 pin DIP)
U2 = 78L05 voltage regulator.
Off board parts = SP1 Small piezo speaker, Switch, PB (N.O.)
Parts not included but needed = 100K Linear Pot for speed control, Stereo jack for paddles, Mono jack for output, 9V Battery if desired

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Figure 9 – Check-off contents found in kit

Keyer Parts Identification

When you have build several kits, knowing what a resistor is, and determining its value is almost taken for granted. When it is your first kit, however, recognizing resistors, capacitors, transistors, regulators, and PICs can be a bit daunting. Since this article is for beginning kit builders, a number of pictures were taken to help with this task. Using the parts list in the supplied documentation as a guide, all of the parts in this kit will be previewed, and their external features described.

Capacitors C1, C2, C3, and C5 – These four capacitors have a value of 0.01 uF, are blue in color, and marked as 103. Figure 10 shows this set of capacitors. The 103 designator translates into 10,000 pico Farad, which is the same as 0.01 micro Farad.

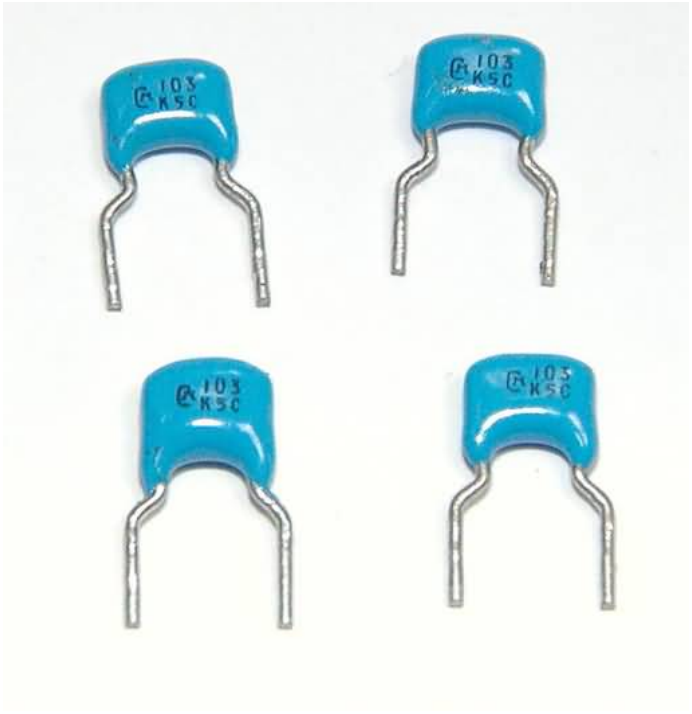

Figure 10 – C1, C2, C3 and C5 = “103”

Capacitor C4 – This capacitor also has a value of 0.01 uF, is brown in color, but has a different internal construction, making it stable with temperature changes. It is shown below.

Figure 11 – C4 = 0.01 uF

Capacitors C6 and C7 – These capacitors are much like the set with C1, only 10 times larger in value. They have a capacitance of 0.1 uF, are also blue in color, and marked as 104. The 104 designator translates into 100,000 pico Farad, equivalent to 0.1 micro Farad. Figure 12shows this capacitor pair.

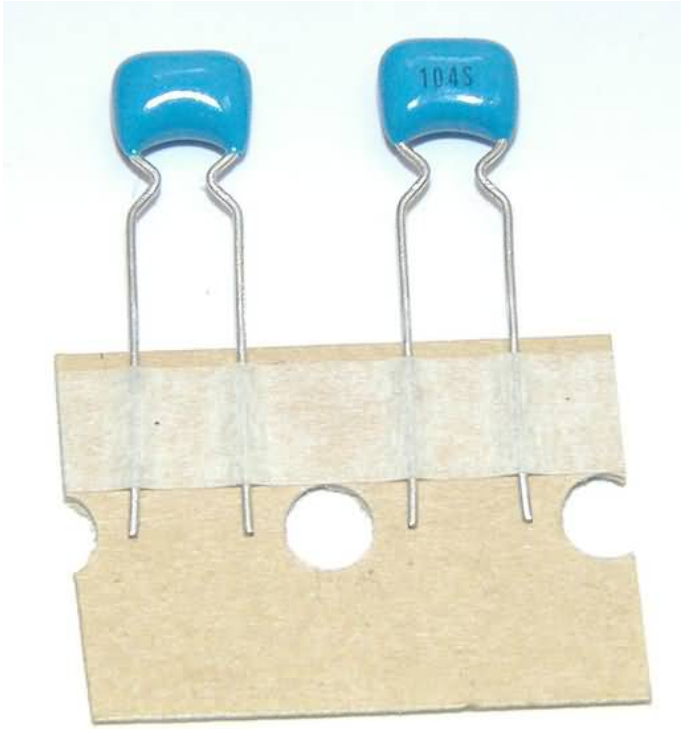

Figure 12 – C6 and C7 = “104”

This kit contains four resistors. The first, designated R1 has a value of 4.7 kilo Ohm (4700 Ohm), and is marked with colored bands of yellow, violet, and red. The first two colored bands provide the first two digits of the numeric value, the third band the multiplier, and the last band the tolerance.

Figure 13 – R1 = 4.7 k-Ohm (yellow-violet-red)

Resistor R2 is a 1 kilo Ohm (1000 Ohm) unit, with bands of brown, black, and red.

Figure 14 – R2 = 1 k-Ohm (brown-black-red)

Resistor R3 is ten times larger than R2. It is a 10 kilo Ohm (10,000 Ohm) unit with bands of brown, black, and orange.

Figure 15 – R3 = 10 k-Ohm (brown-black-orange)

The last resistor is R4, which is ten times larger than R3. It is a 100 kilo Ohm (100,000 Ohm) unit with bands of brown, black,

and yellow, and shown in figure 16.

Figure 16 – R4 = 100 k-Ohm (brown-black-yellow)

By now, you have probably figured out most of the resistor color code. Here it is in its entirety.

Color	**Value**
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9

If you are curious about the tolerance bands, you might try researching that information on the Internet.

There are three active components in this keyer. The first is a PN2222A transistor, designated as Q1. Figure 17 shows what this part looks like.

Figure 17 – Q1 = PN2222A

The next active component is designated as U1, and is the heart of the keyer. U1 is the PIC microprocessor, which comes with the software, (actually firmware) already stored in the chips memory area. This part provides all of the functionality provided by the keyer, and is shown in figure 18. Notice that this 8-pin DIP chip is supplied with its leads pressed into conductive foam. This chip is sensitive to static charge, and keeping it plugged into conductive foam shorts all of its leads together so that it is not damaged by shipping or handling.

Figure 18 – U1 = PIC microprocessor in conductive foam pad

A five volt regulator, designated U2, is the last active part supplied with the keyer. It is the same size and shape as the transistor. However, the printing on it, which is difficult to read, identifies it as a 78L05. The photograph of this part, figure 19, was unable to clearly pickup the labeling information.

Figure 19 – 5V regulator U2 = “78L05”

Two non-PC board mounted parts are also included. One is a small piezoelectric speaker, called out as SP1. This is the same kind of speaker used in modem cards.

Figure 20 – Piezoelectric speaker SP1

The other kit supplied off board part is a small push button switch, designated as SW1 on the schematic diagram.

Figure 21 – Pushbutton switch = “SW1”

Not mentioned in the Keyer Parts List is the supplied printed circuit board. This is a high quality, double sided board, with plated through holes, solder mask, and silk screened parts labels. The component side of this PC board is shown below …

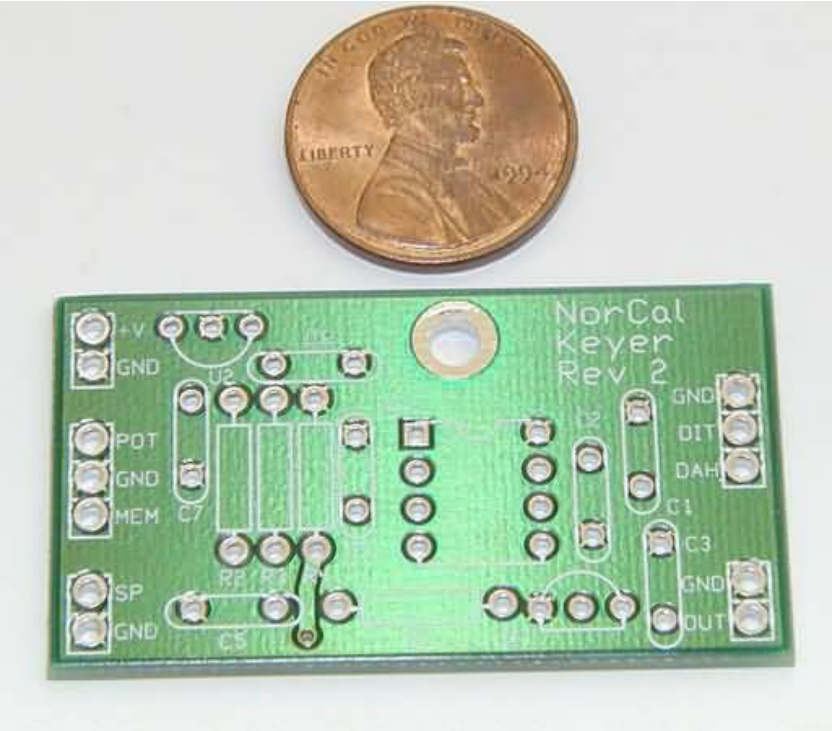

Figure 22 – Component side of PC board

and the solder side is shown below

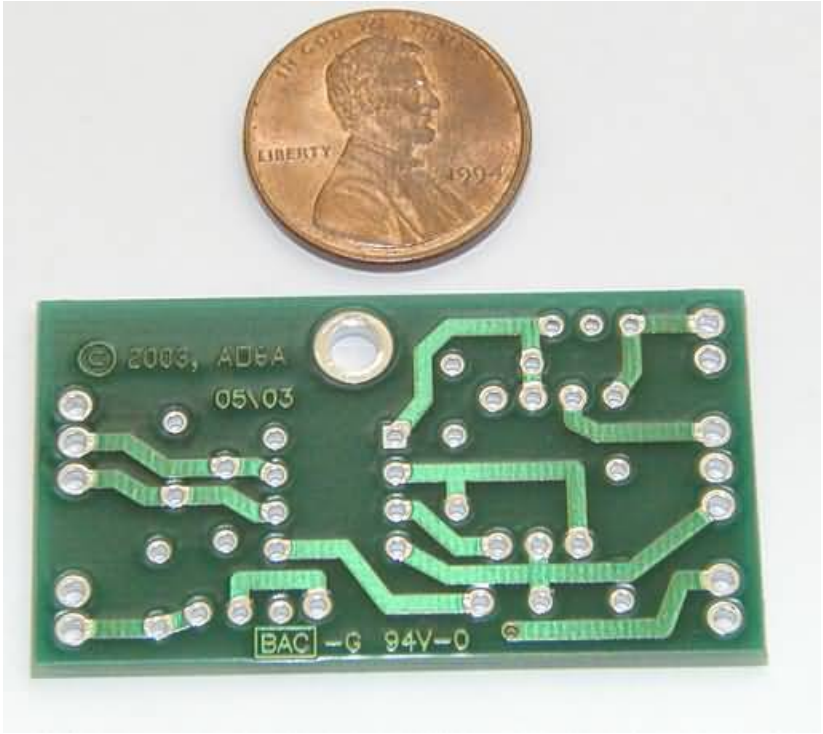

Figure 23 – Solder side of PC board

Four “user supplied” electronic parts are also needed to complete the keyer, along with a suitable case for packaging the unit. The first of these parts is a 100 kilo Ohm (100,000 Ohm) linear potentiometer, which controls keying speed. The potentiometer supplied for this article is shown in figure 24. It was a 17 mm diameter potentiometer with a ¼ inch shaft, and can be obtained from Mouser Electronics, their part number 31CN501. Other smaller, but more expensive potentiometers are also available from this source.

Figure 24 – 100 k-Ohm linear-taper potentiometer

The next part needed is a 1/8-inch, stereo jack for connecting the paddles to the keyer. This part is shown in figure 25. It too is available from Mouser as part number 161-3501. It might also be available from your local Radio Shack or electronics parts store.

Figure 25 – 1/8” stereo jack

A 1/8-inch mono jack, as shown in figure 26, is also required. This jack connects the keyer output to your transceiver, if the keyer is being used “on the air”, instead of as a code practice oscillator. This jack is Mouser part number 16PJ137, and may also be available at a local electronic parts store.

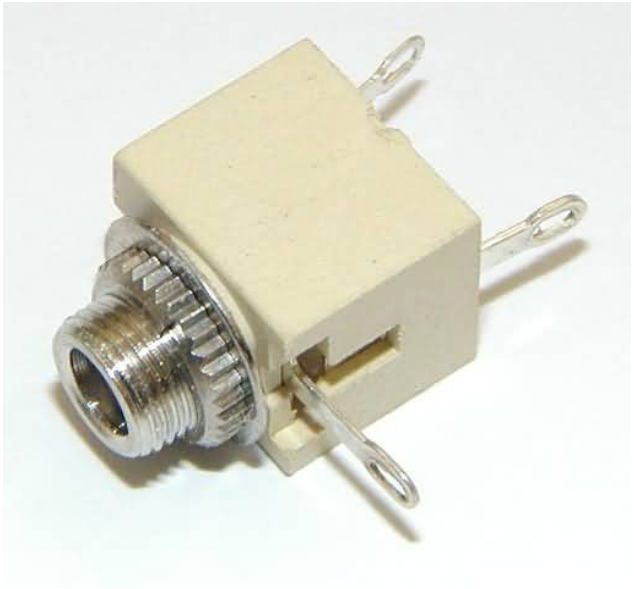

Figure 26 – 1/8” mono jack

As designed, the keyer is powered from a 9 volt battery, and so a battery connector, like that shown in figure 27, is needed. Mouser carries that part also as part number 123-6004. Radio Shack also carries this type of connector.

Figure 27 – 9V battery connector clip

The last part needed is a suitable case. This one is easy! The keyer was designed to fit into an Altoids tin. Most grocery stores and pharmacies carry these mints, in a variety of flavors. Buy the flavor(s) that you like, eat them, and you have the case. Figure 28 shows the “Wintergreen flavored” case that was supplied for this article. Regrettably, someone ate the contents!

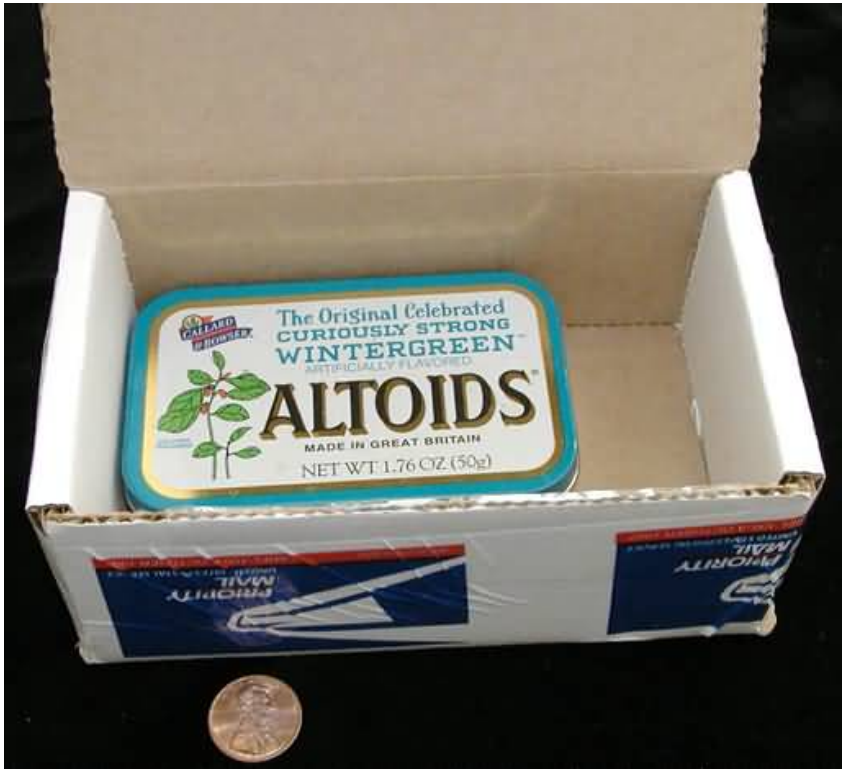

Figure 28 – Altoids mint tin used as the project case)

Keyer PC Board Construction

Enough of the basics; it is time to build! We will begin by soldering the parts (also called “stuffing”) into the printed circuit board. Generally, it is best to start with passive parts, the resistors and capacitors, and follow those with the active parts. This approach ensures that circuitry exists around the leads of static sensitive components, which protects them when they are soldered. Another good general rule to follow is to solder in the smallest parts first. This prevents a larger part from obscuring a smaller neighbor, which would make stuffing and soldering more difficult. As the parts are added to the PC board, the parts list can be used as a “check-off” sheet to assure nothing is missed.

Following this approach, the first part to be mounted is C1, one of the 0.01 uF, blue colored capacitors. This parts leads are placed through the appropriate holes in the PC board, and bent slightly outward on the bottom side of the board to hold the part in place. This is shown below.

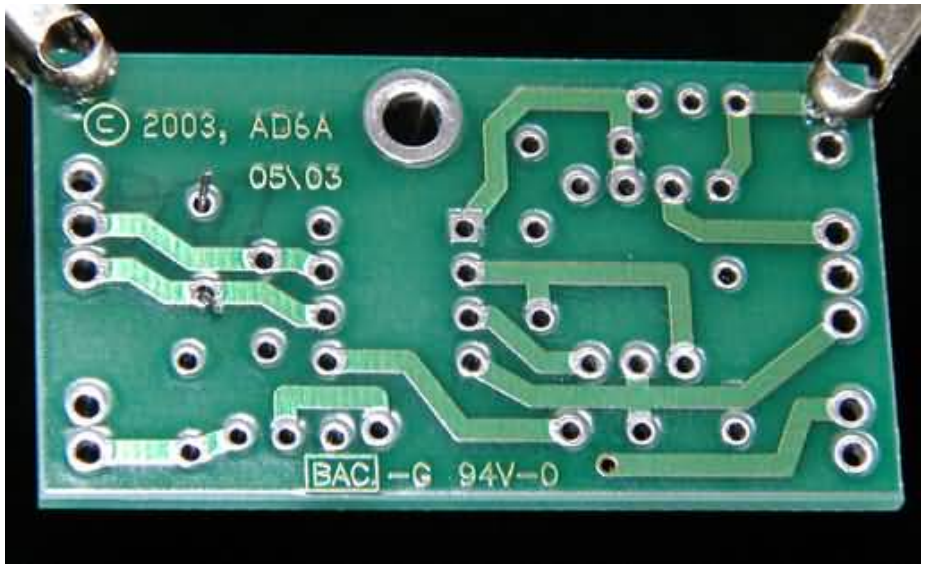

Figure 29 – Mounting capacitor C1

The leads are soldered, one at a time, and the excess lead length clipped off with the side cutters, resulting in the bottom of the board looking like …

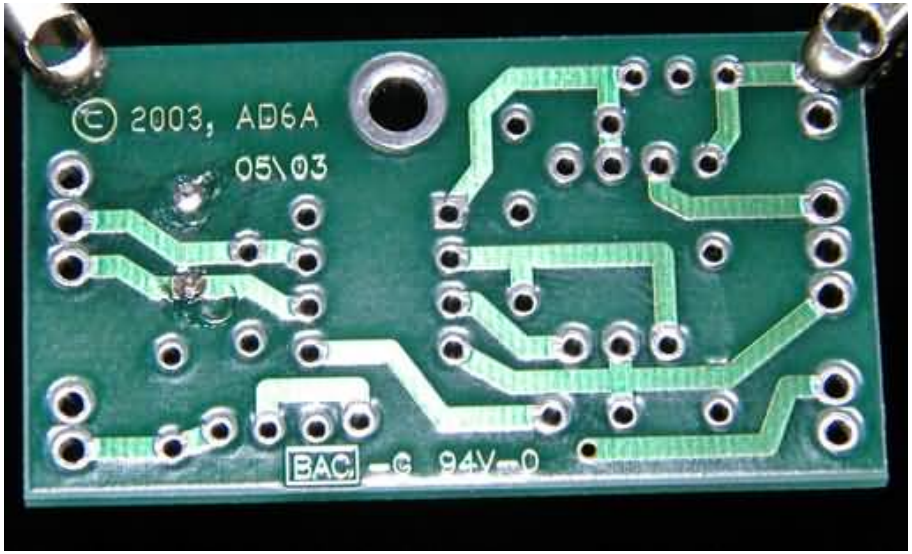

Figure 30 – Bottom of PC board with C1 soldered in place

and the top looking like below.

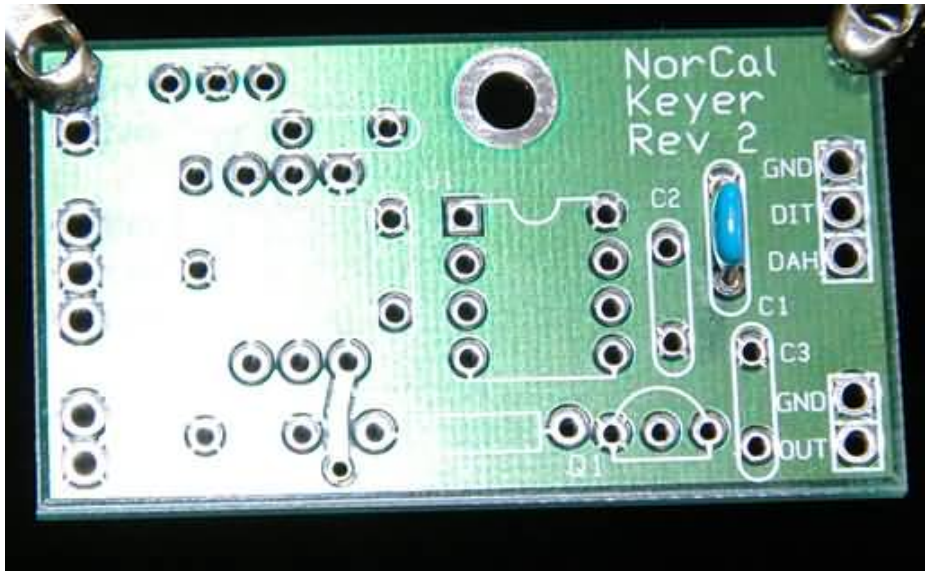

Figure 31 – Top of PC board with C1 mounted

In like manner, capacitors C2, C3, and C5 can be soldered in place, resulting in a PC board which looks like that shown below.

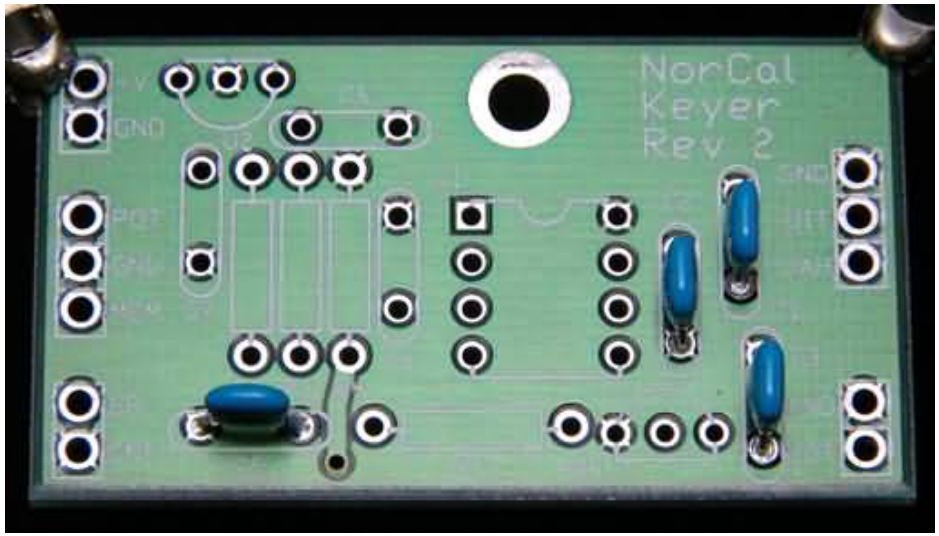

Figure 31 – PC board with C2, C3 and C5 soldered in place

With these parts soldered in place, check them off on the parts list, as was done below.

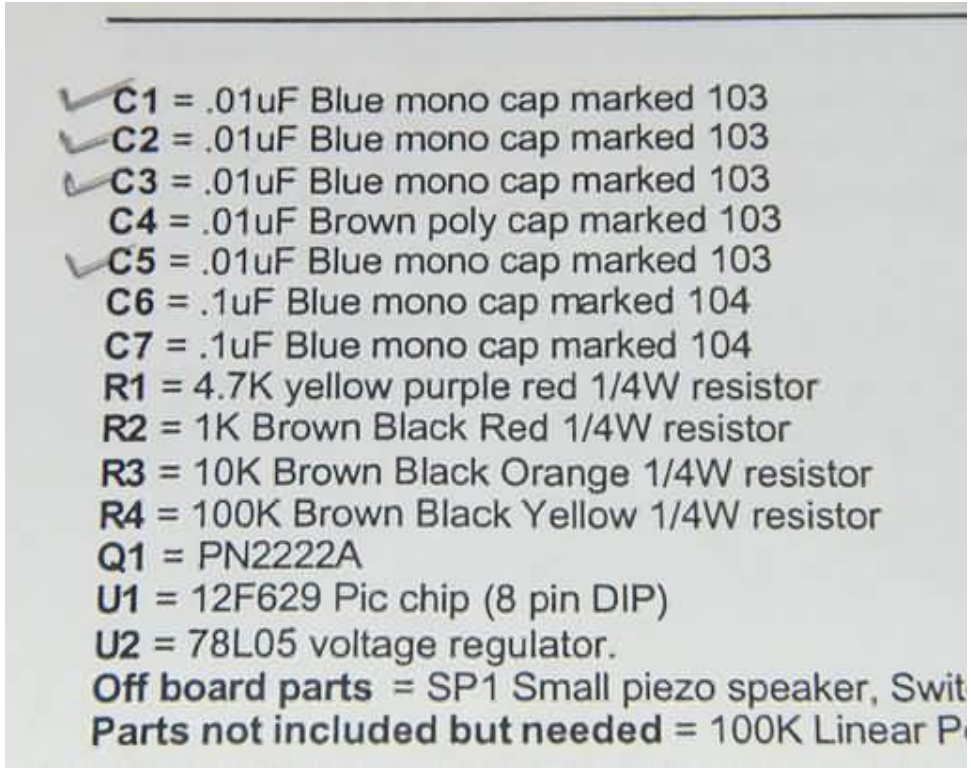

Figure 32 – Check off the parts as you attached them to PC board

Resistors R1 through R4 are next soldered in order. Starting with R1, bend the leads close to the body, so that it looks as shown below.

Figure 33 – R1 with leads bent for insertion to PC board

Fingers work well for this task, as do a small pair of long nose pliers. Slip the part into the PC board so that the body of the resistor lays on the surface, as shown next.

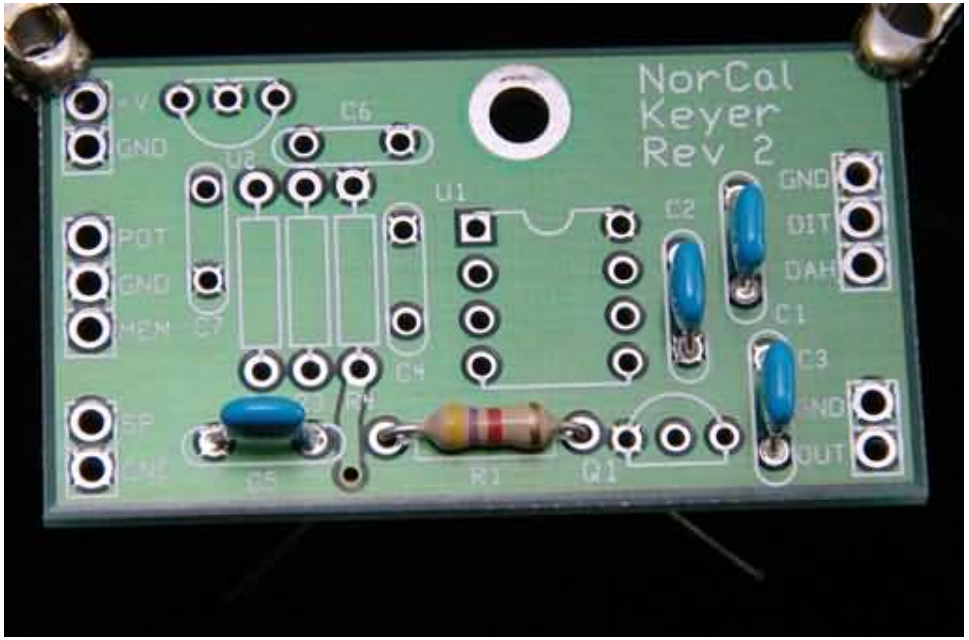

Figure 34 – R1 inserted into PC board

Bend the leads outward as shown below and solder it.

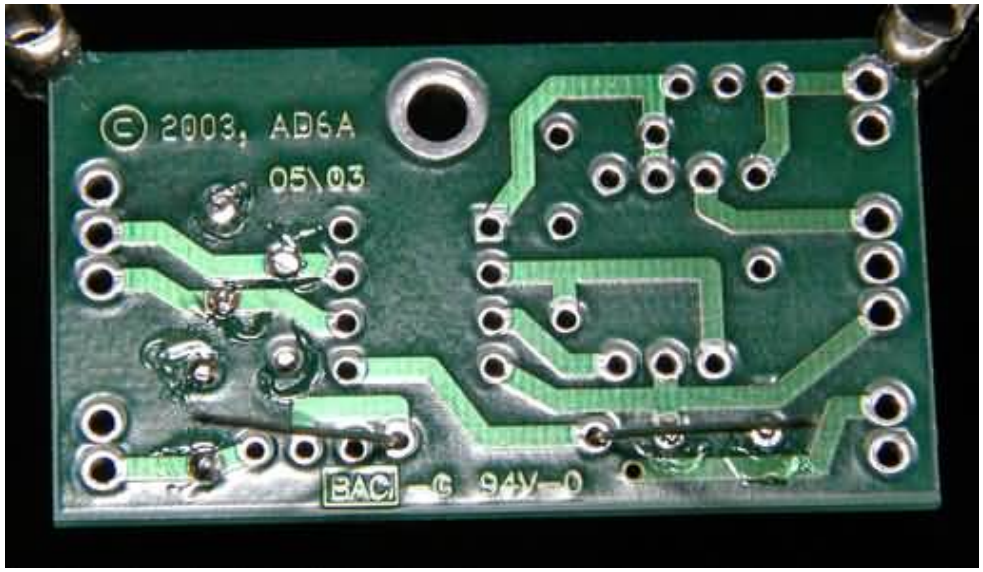

Figure 35 – Bend leads outward to hold resistor close to surface of the PC board

Clip off the leads as shown below..

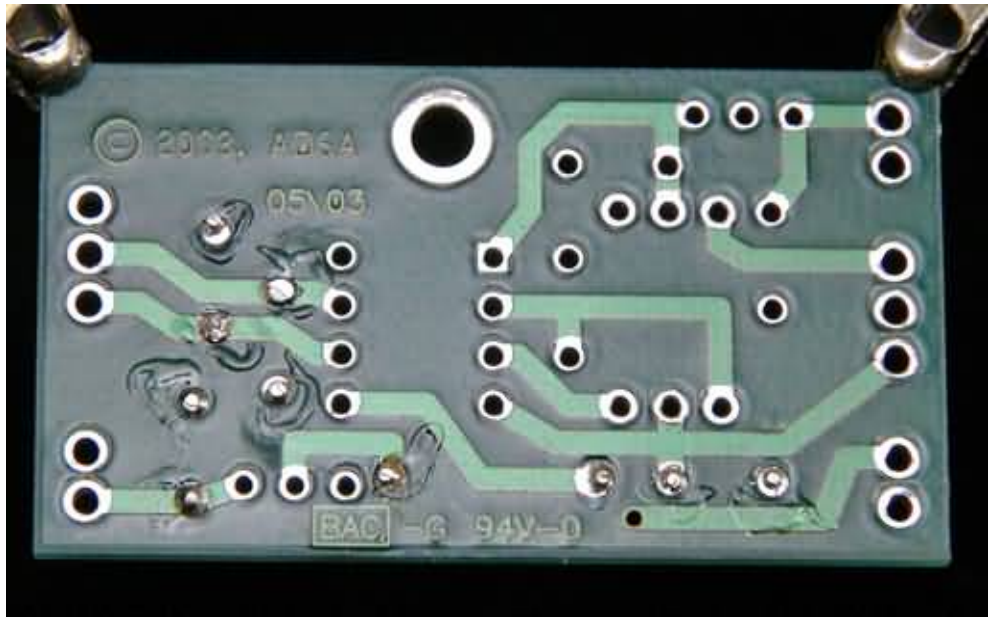

Figure 36 – R1 with leads clipped off

When the remaining three resistors (R2 through R4) have been mounted using the same steps as before, the board will look like this …

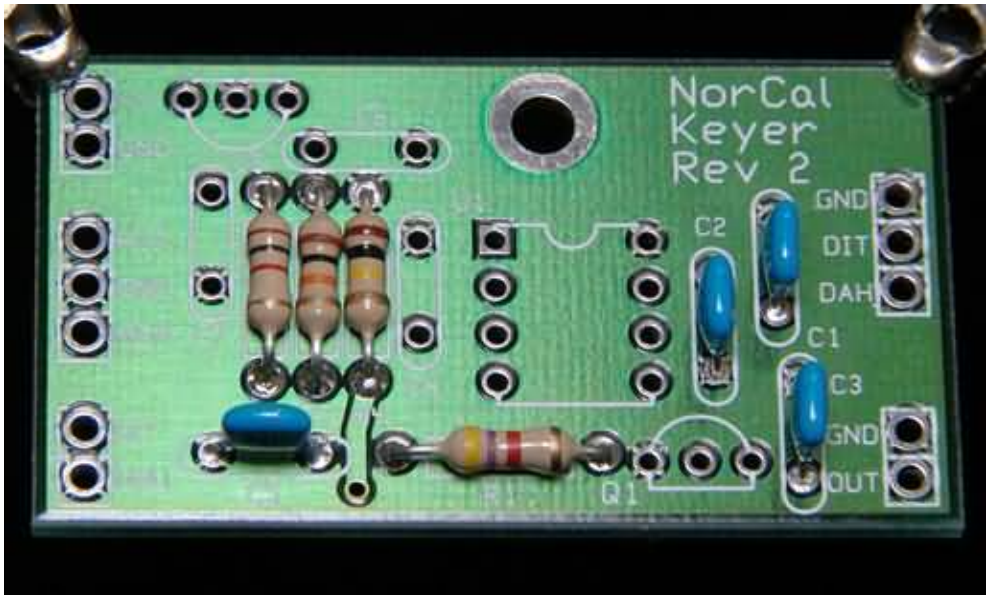

Figure 37 – All resistors soldered in place

Check these parts off on the parts list also, as shown here …

Figure 38 – Resistors checked off the list

Following the smaller part, larger parts approach, C4, the brown 0.01 uF capacitor is now soldered in place. With it installed, the board will look as shown below.

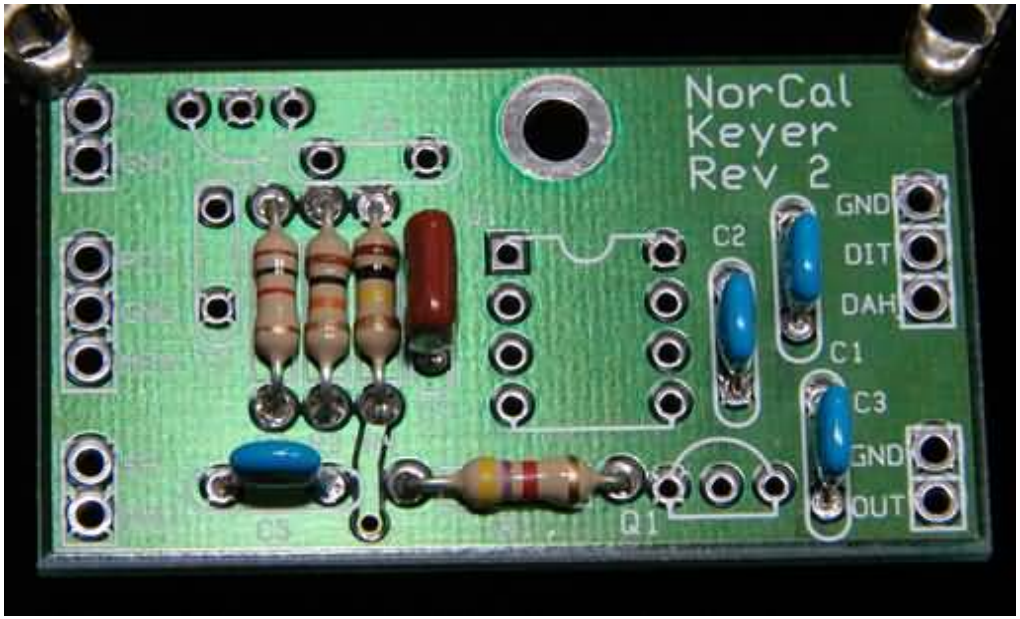

Figure 39 – Capacitor C4 soldered in place

This part can now be checked off on the parts list, as shown here …

Figure 40 – Check off C4

In like manner, solder in C6 and C7, the blue 0.1 uF capacitors, resulting in the board looking like below …

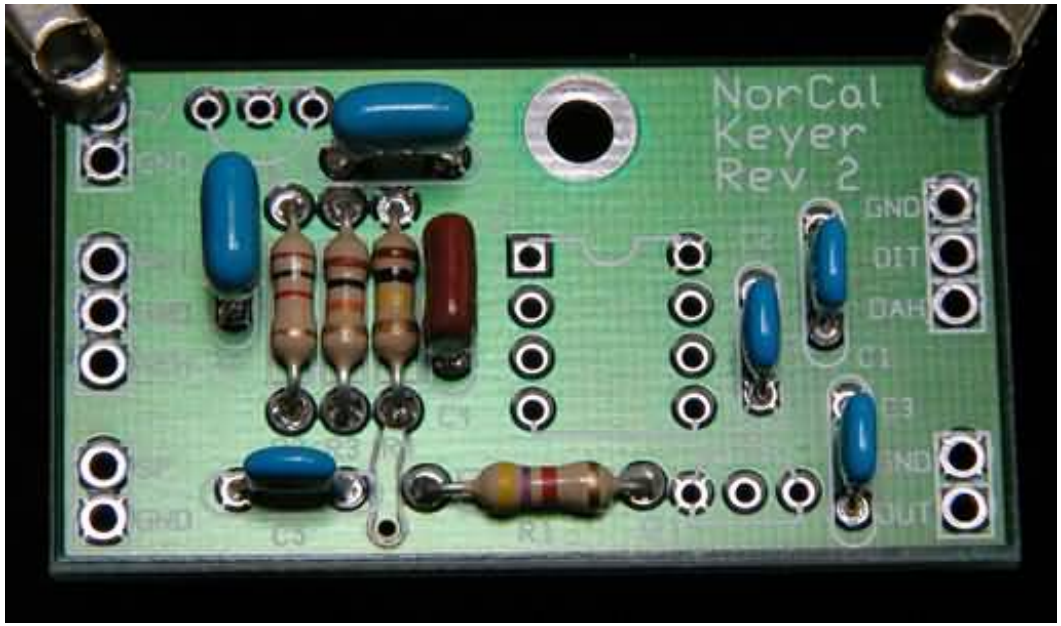

Figure 41 – Capacitors C6 and C7 installed

and checked off on the parts list …

Figure 42 – C6 and C7 checked off the Parts List

Now that all of the PC board mounted parts are in place, the active components can be placed. Start with Q1, the PN2222A transistor. Make sure the leads are straight, and spaced apart to match the mounting holes. When soldered in place, the board will look like this …

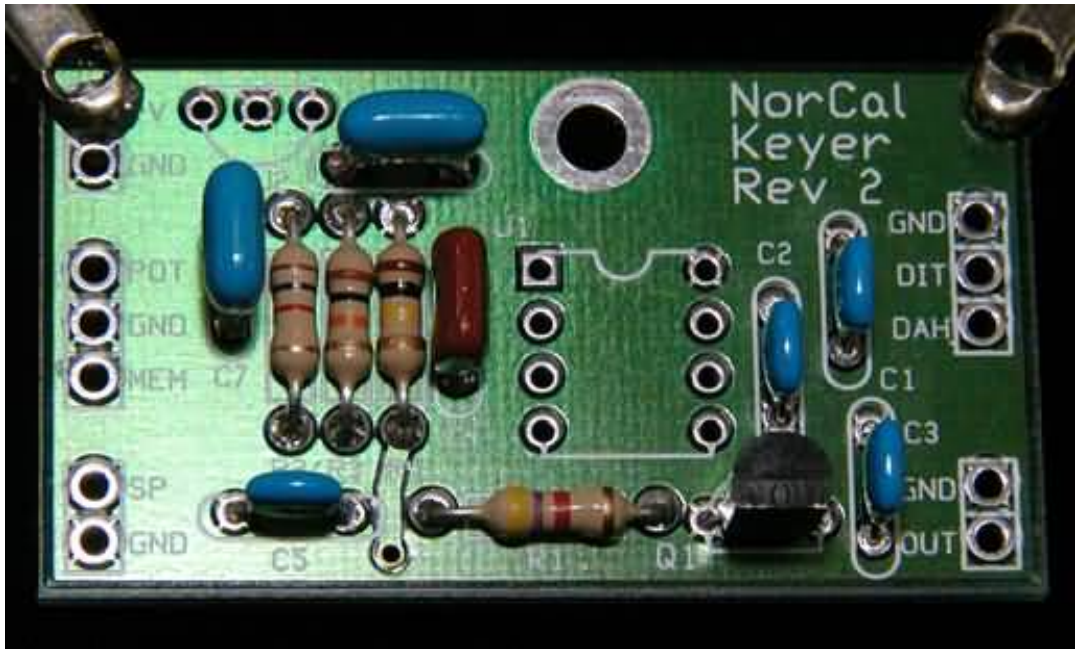

Figure 43 – Transistor Q1 installed on the PC board

Follow this part with the installation of U2, the 5 volt regulator. With it installed, the board will look like this …

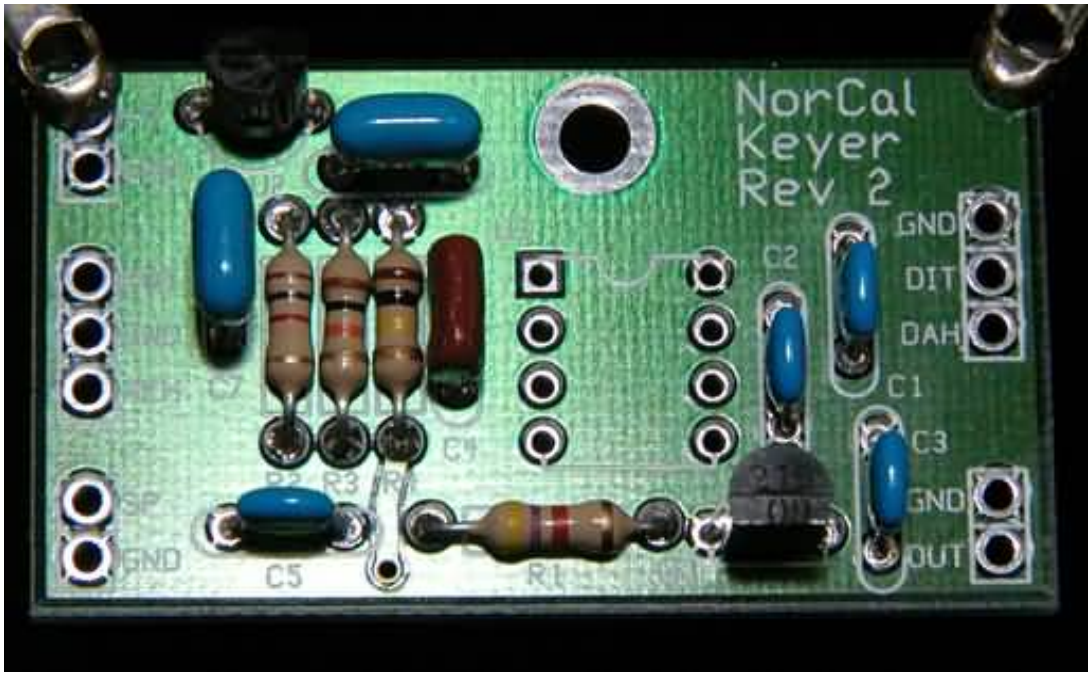

Figure 44 – The 5V regulator, U2, is installed

Finally, solder in the PIC chip, or preferably, use an 8 pin socket for the chip. Using a socket allows one to easily remove this device should it fail, or replace it if an updated version becomes available. Make sure the device or socket is oriented properly before soldering, and only solder two opposite pins initially. Recheck the orientation again before soldering the remaining pins. It is a lot easier to remove the chip or socket with two pins soldered, and with all eight. With the chip or socket installed, the board will look like below.

Figure 45 – Socket installed

Check off these three active parts on the parts list, as shown here …

Figure 46 – Check off Q1, U1 and U2

Finally, if you have opted to use a socket for U1, bend the leads to fit, and plug in the chip. The completed board will look like this …

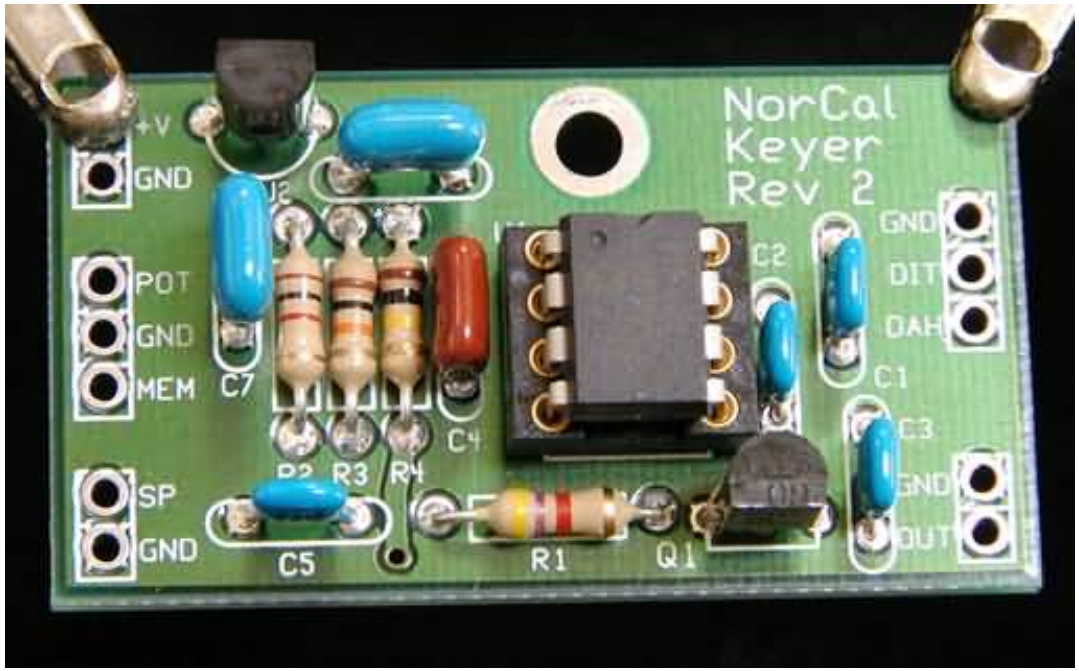

Figure 47 – The completed board

With the PC board finished, one more optional operation can be performed. Using some isopropyl alcohol and an old tooth brush, clean the flux off the solder side of the PC board. While this step is not necessary, since the rosin flux is non-conductive, cleaning the board makes it look much nicer, as shown here …

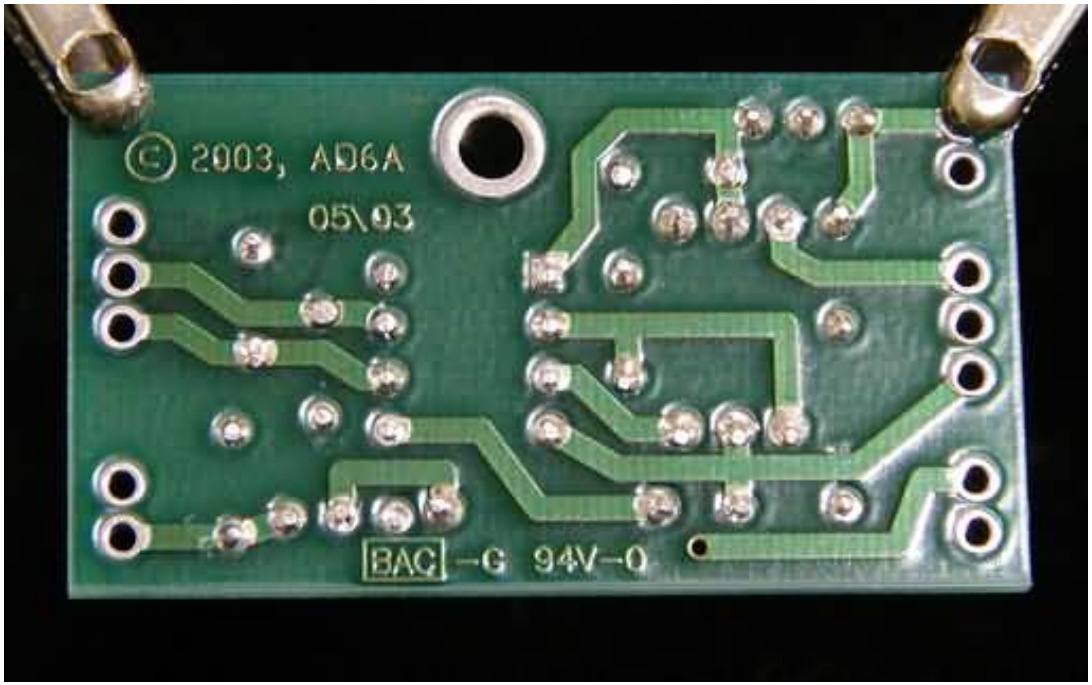

Figure 48 – Board cleaned with isopropyl alcohol

Keyer External Parts Construction

Before the PC board can be initially tested, two of the external parts must be attached. First, the piezoelectric speaker, SP1 must be wired in, followed by the battery connector. Solder a pair of small gauge insulated wires (#26 is a good choice) about 4 inches long to the speaker leads. A good choice for wire are small sections of multi-conductor cable available from electronic supply houses. An example of this type of cable will be shown in a later picture. Solder the other end of this pair to the appropriate holes in the PC board. Solder in the leads from the battery connector also.

With these connections made, attach the battery. The keyer should send “FB” (short for “fine business”) in Morse code at 16 words per minute (WPM). Figure 49 shows the keyer performing for this initial test. If it does not send “FB”, follow the trouble shooting steps in the provided documentation. Assuming that “FB” is heard, disconnect the battery so that the remaining external parts can be connected.

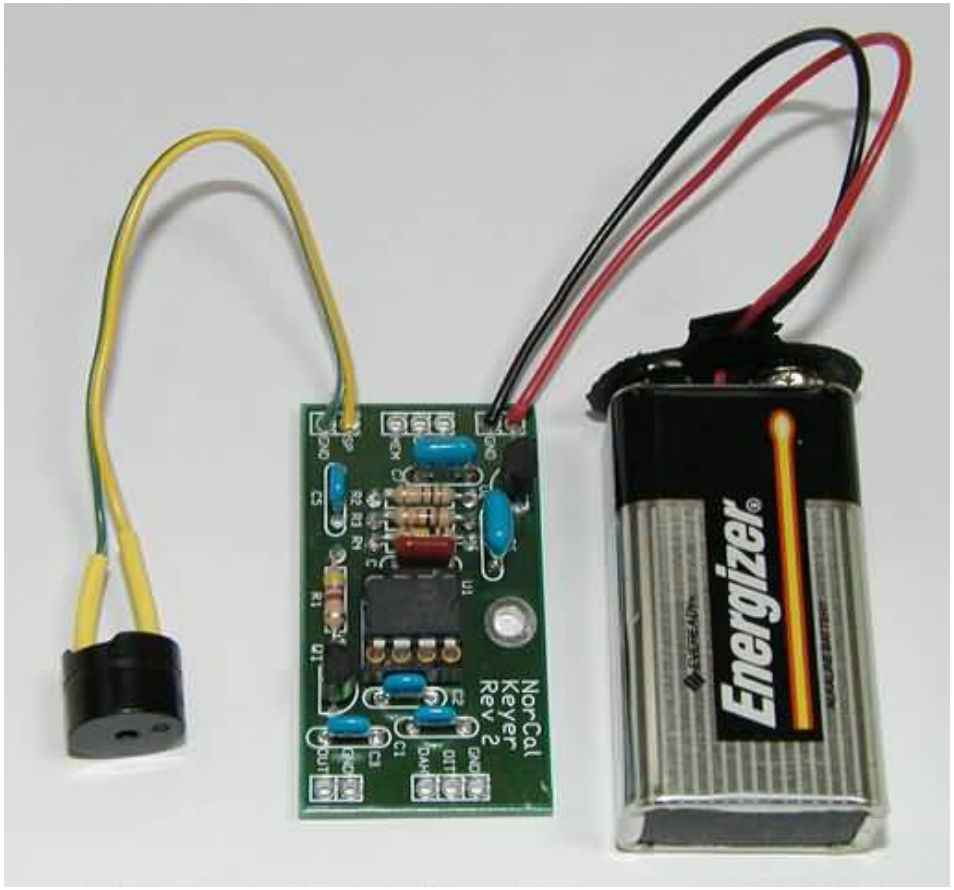

Figure 49 – Initial tests with the Keyer

Prepare a set of 4-inch leads for the potentiometer, VR1, as shown next.

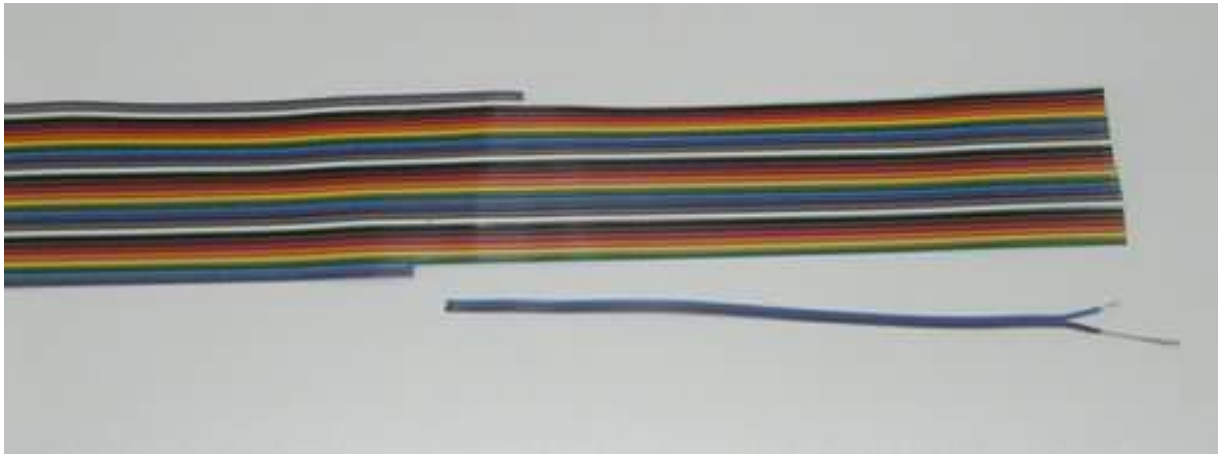

Figure 50 – Leads for the potentiometer

Solder these to the potentiometer terminals. Prepare another set of leads and solder these to switch, SW1. Photos of these parts with their attached leads are shown in figures 51 and 52.

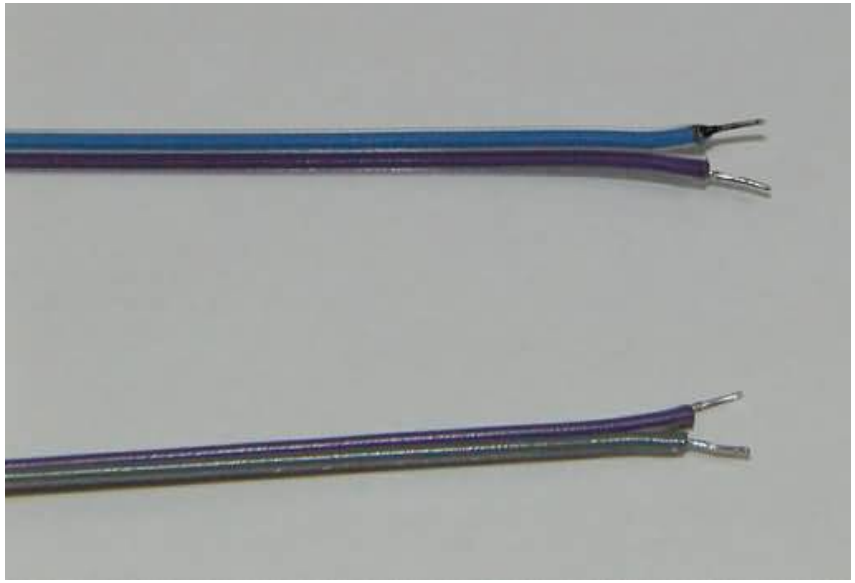

Figure 51 – Leads for potentiometer and switch

Figure 52 – Potentiometer and switch with leads attached

Solder the leads for these parts into their respective holes in the PC board. The board will now look as shown below.

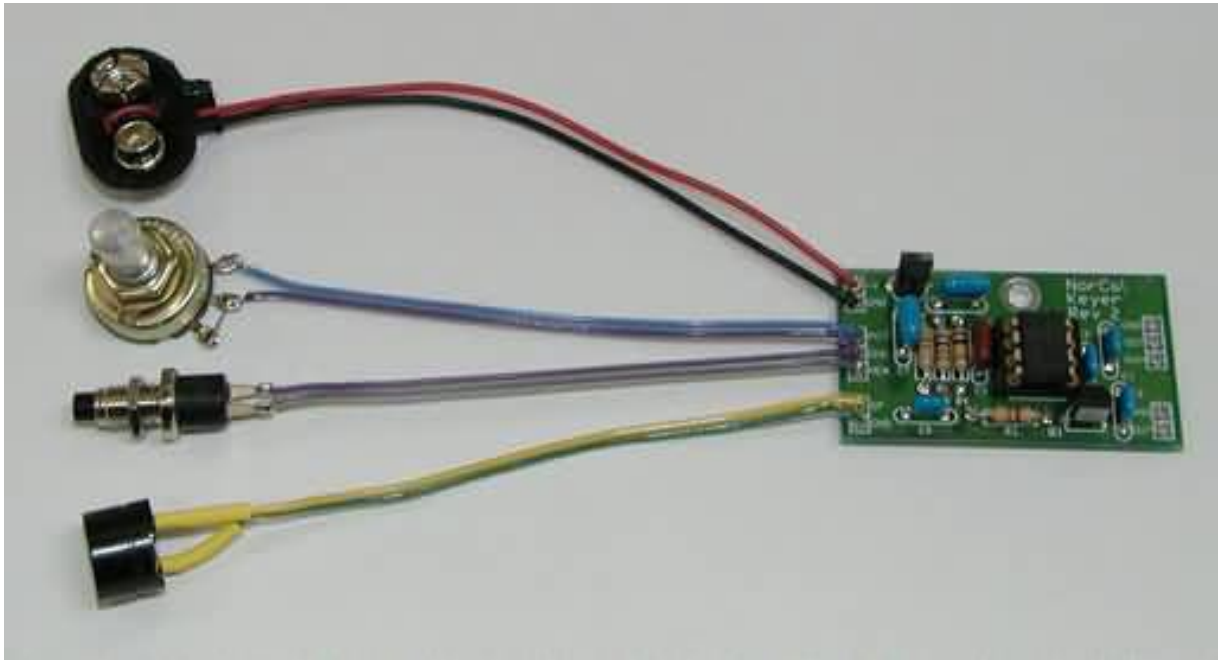

Figure 53 – PC Board with potentiometer and pushbutton switch leads attached

Repeat the above steps for preparing leads for the two jacks, using three leads for the stereo jack, and two leads for the mono jack. Solder the leads to each jack so that they look like this …

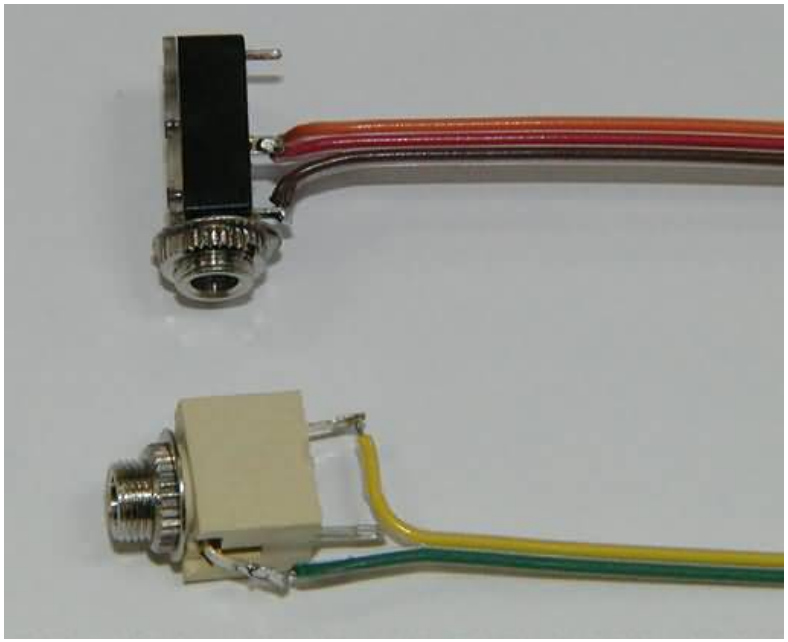

Figure 54 – Jacks with leads attached

Solder the respective ends to the correct holes in the PC board. With this step completed, the PC board and external components will look as shown below.

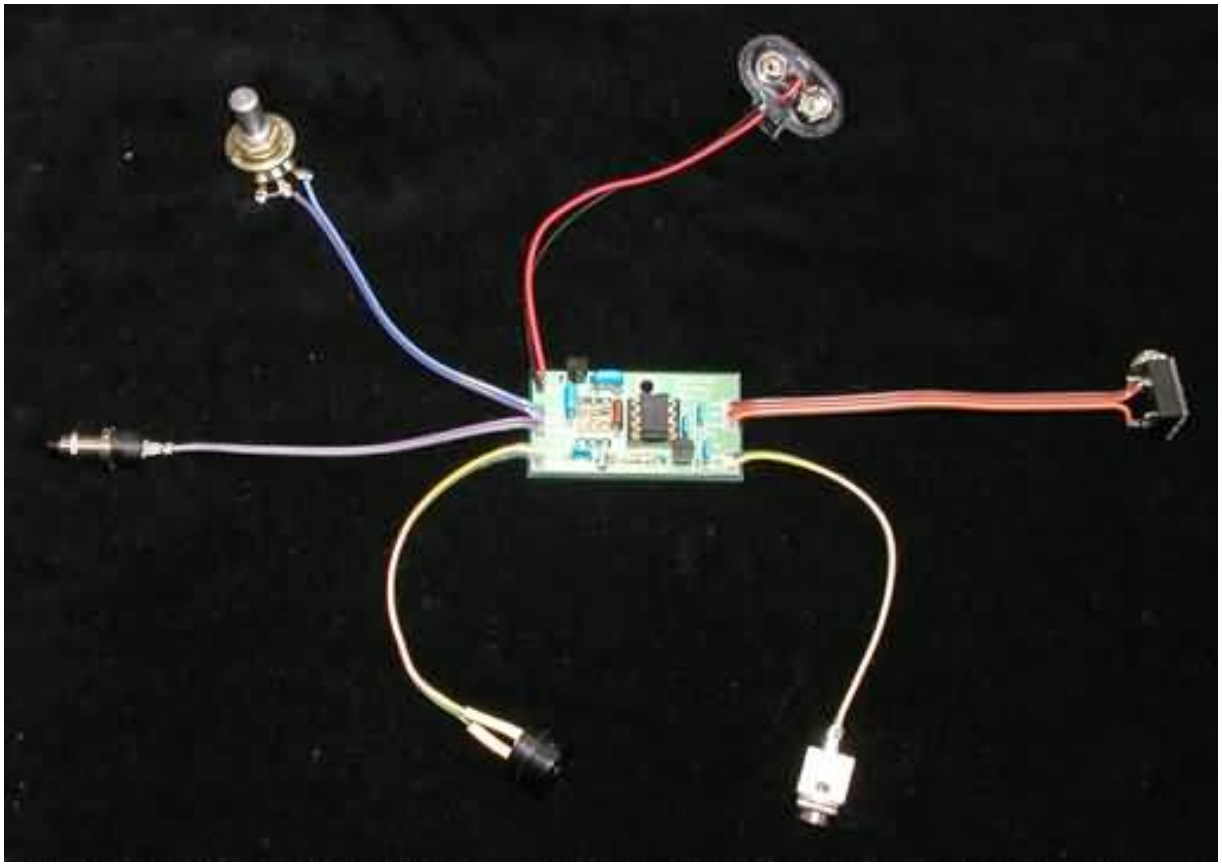

Figure 55 – Completed PC board with external component attached

The keyer is complete now, and ready to be fully tested, and then mounted into an appropriate case. Those steps are next.

Keyer Functional Checkout

Beginning on page two of the supplied documentation is an “Operation” discussion. Follow what is written there to check out all of the full functionality and capability of the keyer. Figure 56 shows the keyer, with paddles attached, during this testing. Once satisfied that everything is working correctly, disconnect the battery, and move on the packaging phase of this project.

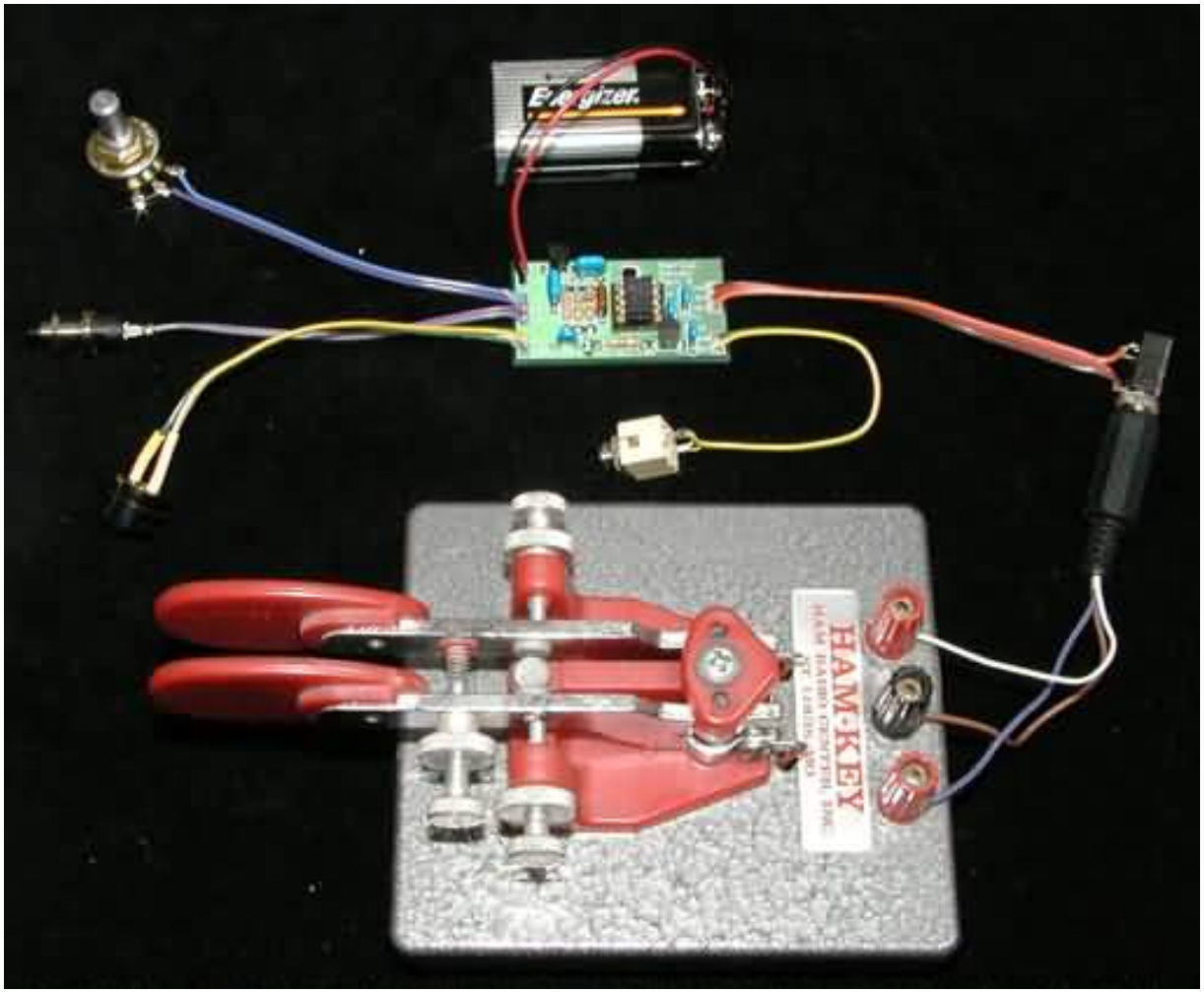

Figure 56 – Keyer with paddles attached for testing

Packaging the Keyer

This section assumes an Altoids tin will be used to house the keyer. All controls are mounted on the front and back surfaces of the tin, to preserve the graphics on the lid and bottom. If another type of case is used, follow the general approach that is described, with appropriate changes to accommodate what you have selected.

Here are the steps that can be used …

1) Apply paper, using clear tape, over the areas where holes will be created.

2) Mark the affixed paper where the centers of the holes are needed, and note the required hole sizes on a sheet of paper. The photo below shows the front of an Altoids tin, at this stage in the process.

Figure 57 – Altoids tin with paper noting hole locations

3) Punch or drill holes of the appropriate size at the required locations. Punching holes works better than drilling if the tools are available, as the very thin metal in an Altoids tin tends to tear while drilling. If drilling is the only option available, clamp a piece of wood beneath the area to be drilled, for support.

Figure 58 - Front of the Altoids tin with the holes now punched

4) Mount all of the external controls in their respective holes. The output jack was mounted on the rear panel of the tin, just below the hinge location.

5) Attach to PC board to the case floor with two small strips of 1/8-inch thick double sided foam tape. Super glue can be used to affix the speaker to the case top, making sure that its leads will pass by the right edge of the PC board when the case lid is closed. With these steps completed, the keyer will look as shown below.

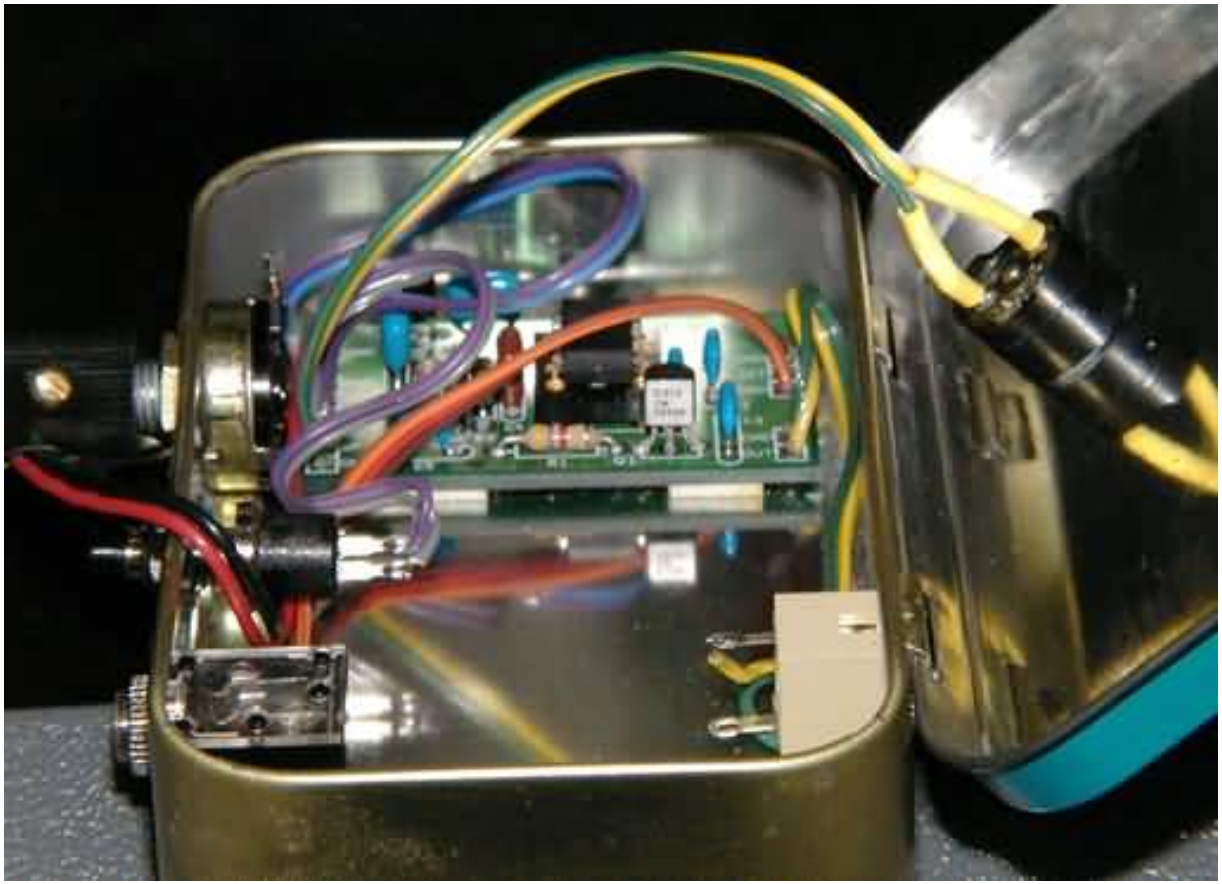

Figure 58 – Side view of inside Altoids tin

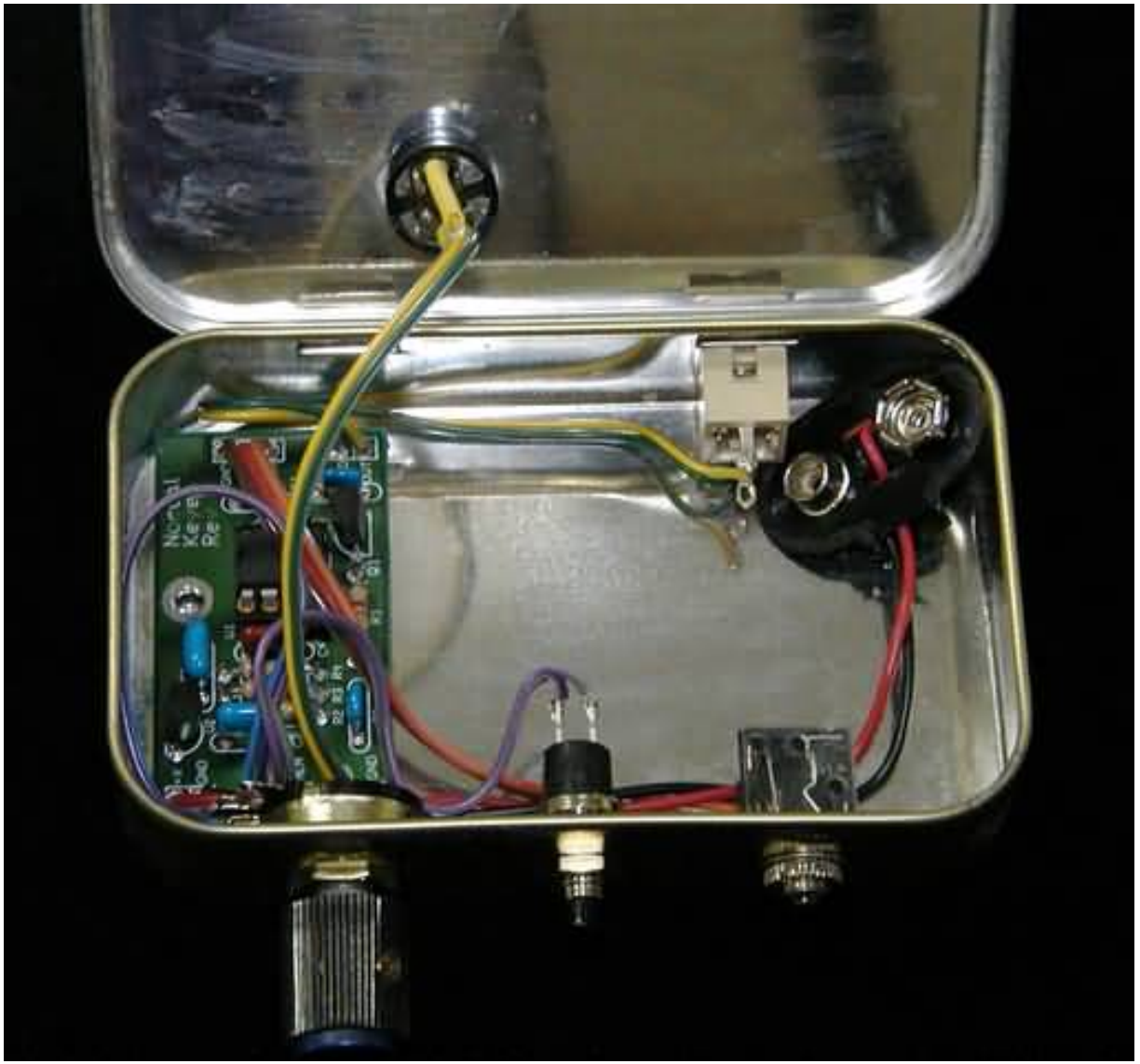

Figure 59 – inside Altoids tin showing components mounted

Attach the 9 volt battery to the floor of the case using a small strip of Velcro (hook and loop) tape, so that it can be easily removed and replaced when dead. This arrangement will also allow the battery to be removed, if the power connector cannot be snapped off when the battery is installed. Note that no power switch is used; disconnecting the battery fulfills that function. With the battery installed, the keyer looks like this …

Figure 60 – Keyer in Altoids tin with battery installed

Sharp eyed readers will have perhaps noticed that the connections to the rear mono jack, and the front panel mounted switch were redone. (Look back at figure 59) These two components originally protruded into the battery space too far, making battery mounting impossible. Their terminals were shortened and their wires reattached, which provided the needed additional room.

As a final packaging touch, small rubber feet were placed on the bottom surface at each corner to elevate the keyer approximately 3/16-inch above its resting surface. This provides easier access to the controls and jacks.

Figure 61 – Rubber feet on bottom of Altoids tin adds a nice soft touch

The completed keyer is shown below. No control labeling was applied due to time constraints. However, rub on or P-Touch ™ type labels could be applied to the blue areas on the front and rear surfaces of the lid, above the controls, if desired.

Figure 62 – Front view of the completed NorCal Keyer

Final Comments

It took about two days to build this keyer, including all of the photography that accompanies this article. For a beginner, that same time frame would make sense, or perhaps a day longer. The key is to proceed slowly and carefully, to minimize making mistakes. Those take an inordinate amount of time to undo, and are very frustrating for beginning builders. Remember to read the documentation before you unpack all of the parts, and reread the critical sections before you start building.

This keyer is an excellent beginning builders project. It is logical to assemble, well documented, and modestly priced. In addition, it works wonderfully well, both for sending CW “on the air” or in use as a code practice oscillator setup. Either way, it is another winner from NorCal!

Hopefully, you find the information presented informative and useful. If you have comments or questions, please contact me via email at jokortge@prodigy, or via snail mail at my call book address.

72 and happy building,

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Back to AmQRP Home Page