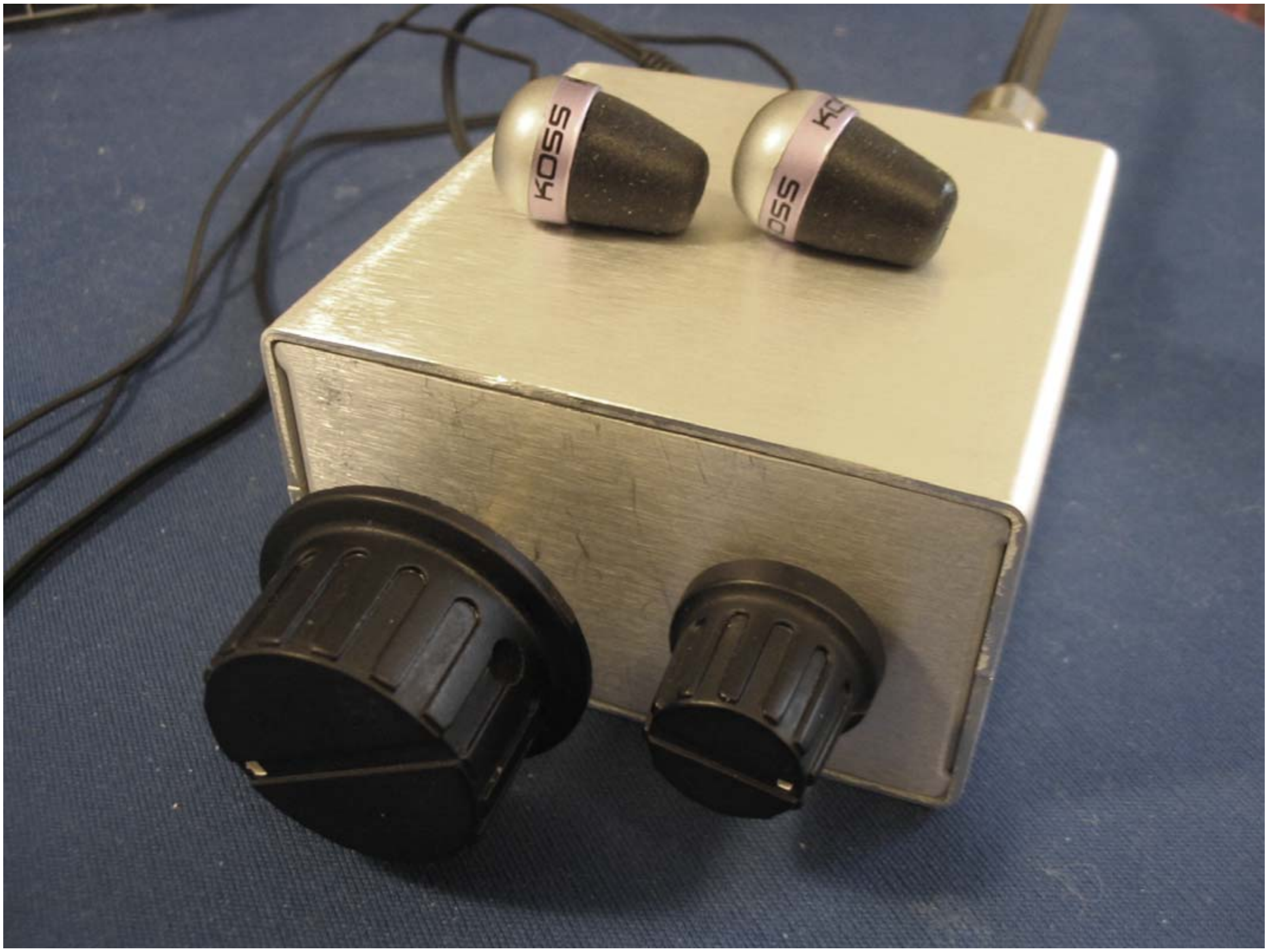
The American QRP Club TinEar Receiver Construction Manual



A Simple, All Discrete Part Direct Conversion Receiver For the 40 Meter Band

By Wayne McFee, NB6M

Revision 1.1

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The TinEar Receiver Construction Manual

Introduction

Thank you for buying the TinEar Receiver kit. This receiver is the result of a discussion that arose at the end of Pacificon, 2003, where an interest was expressed in a simple, discrete part receiver design, one that “everyone” could build at Pacificon, 2004.

However, once the Ugly-style prototype of this design was built, tested, and listened to, it became apparent that this little receiver would have appeal not only to those who could attend the next Pacificon, but also to the QRP community at large.

Simply put, the TinEar receiver performed much better than expected. It certainly cannot be compared to a superhet design with either a variable bandwidth IF filter, or a choice of narrow IF filters, in terms of selectivity. However, the clean, clear audio from this simple design, coupled with its wide tuning range, supplied by a simple, permeability tuned VFO, gives one the ability to tune more than the entire 40 Meter band and allows one to listen to any type of signal available. This covers the whole gamut from CW to AM, including Digital and Single Sideband.

One could certainly connect this little receiver to a computer’s sound card, and decipher any of the modes for which sound-card related software exist, or do like one Ugly-style builder has already done, plug an outboard audio amp and loudspeaker into it and listen to it in arm-chair style.

The TinEar receiver is designed to operate from a 9 Volt Battery, but will certainly need more than a simple hunk of wire as an antenna. The receiver’s input is designed for a 50 Ohm coaxial input, and a 40 Meter Dipole, even at very low height above ground, or even a portable whip such as a Hustler whip on a car, or a short, inductive loaded vertical and counterpoise, will supply more than enough signal strength to provide hours of listening enjoyment.

The audio output of this little receiver was deliberately designed to be just a little on the low side, compared to a “big rig”, both because of the type of power supply it is designed for, and because there is no AGC circuit. However, the use of sensitive earphones or ear buds will ensure that there will be more than sufficient audio.

Please note that some types of 9 Volt batteries can cause either motorboating (a thumping sound in the earphones) or a heavy hissing sound in the earphones, even when no antenna is connected. Duracell batteries, among other similar types, work well in this receiver, and give several hours of operation.

Circuit Description

The TinEar receiver is a direct conversion design that makes use of a single-tuned transformer input, leading to Product Detector that consists of a pair of MPF102 FETs connected in a cascode configuration.

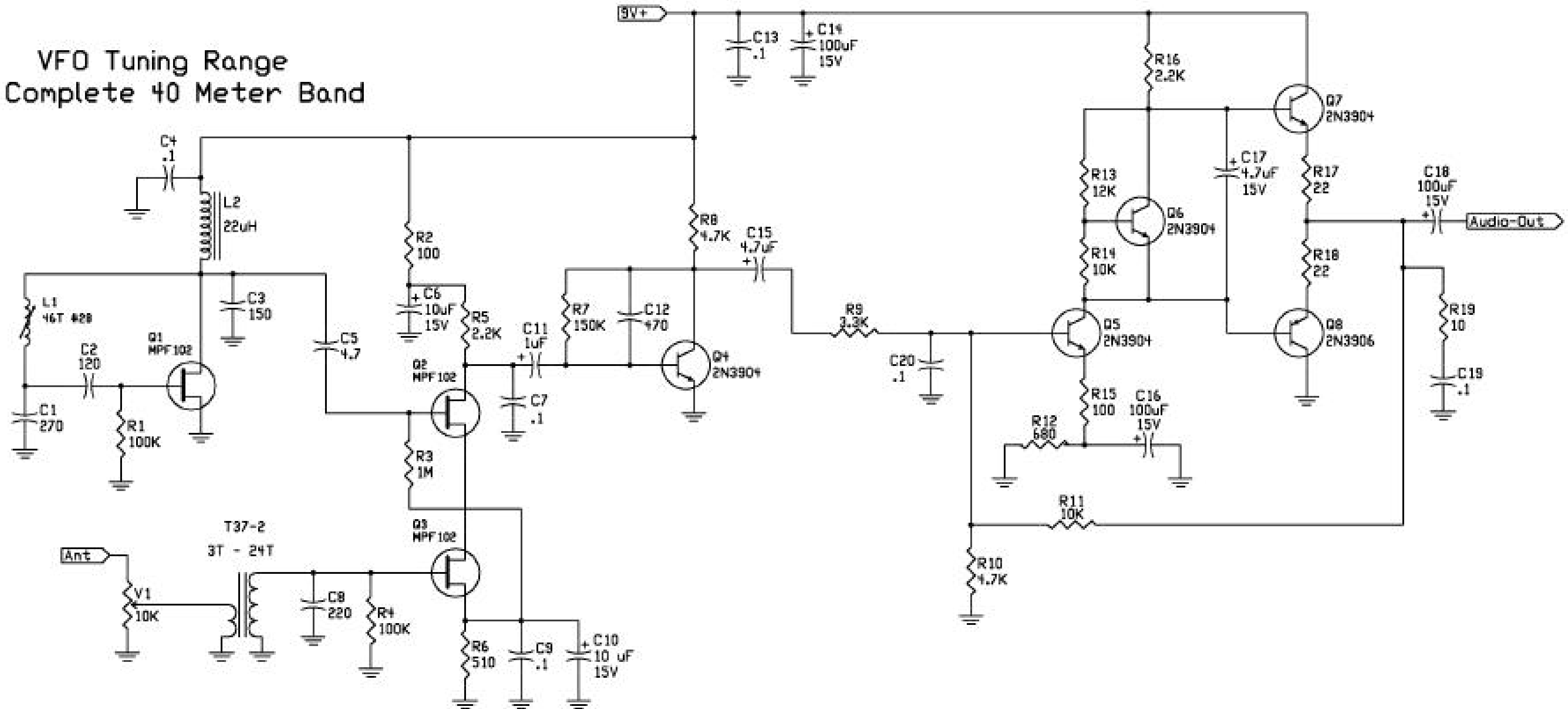
Approximately 5 Volts, Peak to Peak, of Local Oscillator energy is fed into this Product Detector from a simple, Permeability Tuned VFO. While requiring few parts, this VFO provides over 400 KHz of tuning range, and is more than acceptably stable. The key to this VFO's stability and frequency range is an air core tuning coil, that is wound on a section of a plastic drinking straw from "California Burger", the location of the monthly NorCal QRP Club meeting, and uses a 6-32 brass screw as the actual tuning element. One nice advantage of using a brass tuning element in a VFO coil is that the frequency goes up as one turns the screw clockwise, which is the direction of tuning we are used to.

Audio from the Product Detector is fed through a low-noise audio preamp, and then into a simplified, discrete part version of what one might find inside an audio amplifier IC such as the LM386.

Versions of this audio output amplifier circuit, with suitable output transistor and biasing changes can provide audio levels well into the loudspeaker range. However, this one is left at a "medium" earphone output, for the reasons outlined above.

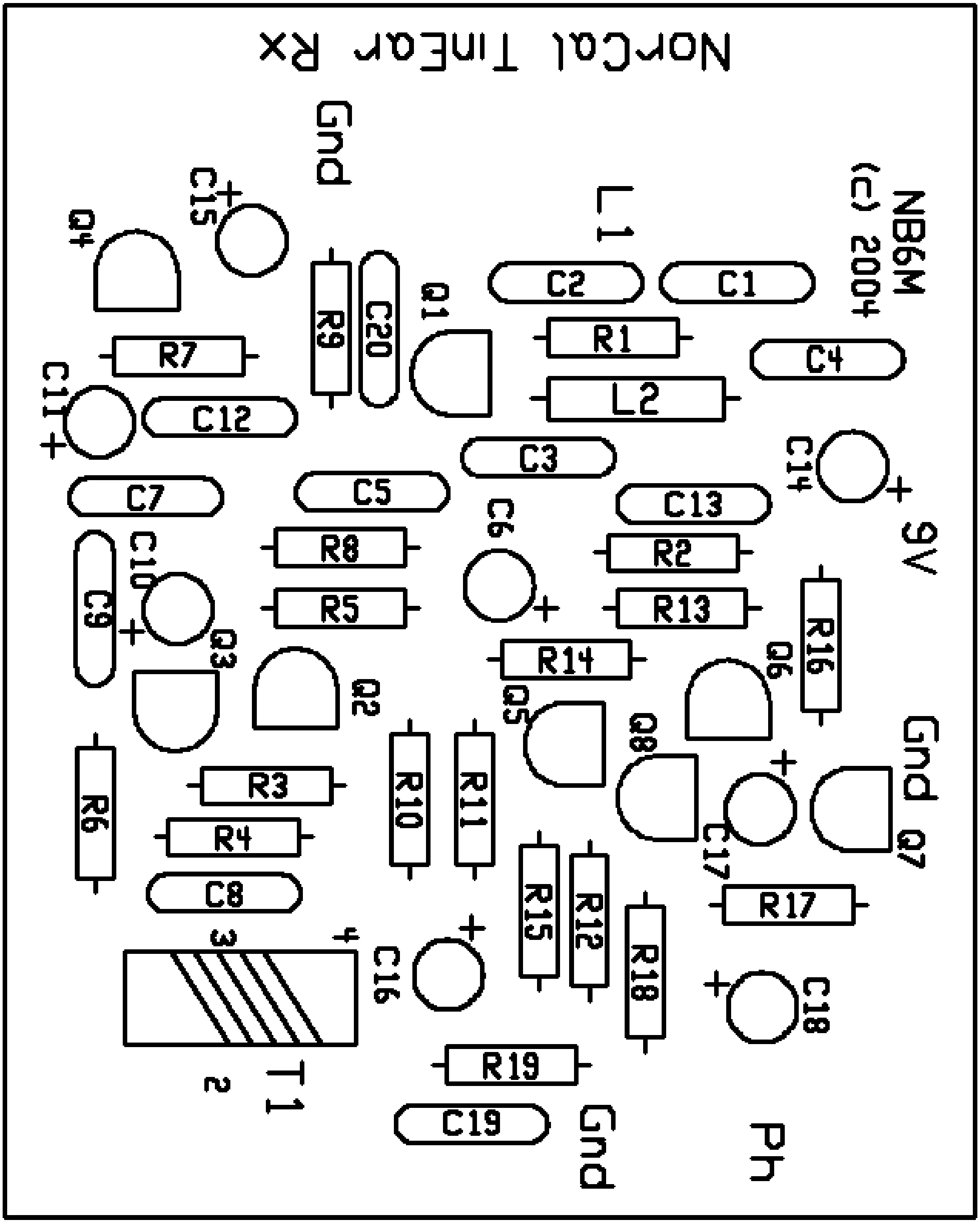
Occasionally, when a full-sized dipole antenna is used, there may be some noticeable hum at different parts of the band when the RF Gain is at max. However, by simply reducing the gain just slightly, hum is completely eliminated, and the signals of interest will still be heard, with a much reduced background noise level.

The TinEar Receiver schematic follows.



Co:	The American QRP Club		
Title:	TinEar Receiver		
Board:	PC	Revision:	F
Author:	Wayne McFee NB6M	Size:	A
Date:	7 February 2004	Sheet	1 of 1

Board Layout



Parts List

TYPE/VALUE	IDENTIFIER	QUANTITY	COMPONENT NUMBER
.1	104	6_____	C4 C7 C9 C13 C19 C20
1 uF	1 uF Electrolytic	1_____	C11
4.7 uF	4.7 uF Electrolytic	2_____	C15 C17
10 uF	10 uF Electrolytic	2_____	C6 C10
100 uF	100 uF Electrolytic	3_____	C14 C16 C18
4.7 pF	4.7 NP0 (disk)	1_____	C5
120 pF	120 NP0 (disk)	1_____	C2
150 pF	150 NP0 (disk)	1_____	C3
220 pF	220 NP0 (disk)	1_____	C8
270 pF	270 NP0 (disk)	1_____	C1
470 pF	471 Monolithic	1_____	C12
22 uH	Red, Red, Black	1_____	L2 (Green Molded Choke)
2N3904	2N3904	4_____	Q4 Q5 Q6 Q7
2N3906	2N3906	1_____	Q8
MPF102	MPF102	3_____	Q1 Q2 Q3
10 Ohm	Brown, Black, Black	1_____	R19
22 Ohm	Red, Red, Black	2_____	R17 R18
100 Ohm	Brown, Black, Brown	2_____	R2 R15
510 Ohm	Green, Brown, Brown	1_____	R6
680 Ohm	Blue, Grey, Brown	1_____	R12
2.2K Ohm	Red, Red, Red	2_____	R5 R16
3.3K Ohm	Orange, Orange, Red	1_____	R9
4.7K Ohm	Yellow, Violet, Red	2_____	R8 R10
10K Ohm	Brown, Black, Orange	2_____	R11 R14
12K Ohm	Brown, Red, Orange	1_____	R13
100K Ohm	Brown, Black, Yellow	2_____	R1 R4
150K Ohm	Brown, Green, Yellow	1_____	R7
1M Ohm	Brown, Black, Green	1_____	R3
T37-2	Red Toroid Core	1_____	T1
10K Pot	Potentiometer	1_____	V1 (RF Gain)
Coil form	“California Burger” Straw	1_____	L1
#28 Wire	Coil of Red Magnet Wire	1_____	L1
Tuning Screw	Brass 6-32 Screw	1_____	
Rounded Nut	Rounded Brass Nut	1_____	
Bag of 4-40 Hardware and Nylon Sleeve		1_____	
Earphone Jack		1_____	
On/Off Switch		1_____	
BNC Connector		1_____	
Knobs		2_____	
PC Board		1_____	
Pre-Drilled Aluminum Case		1_____	

Tools and Equipment Needed

If you are an accomplished builder, you will already have in your possession all of the tools and equipment needed. All builders will need to have on hand some “5 Minute”, or “Quick Set”, two-part epoxy, which is needed for the tuning screw and tuning coil installation.

The Quick Set epoxy sold in Radio Shack stores has been used in several prototypes, with good success. The brand marketed as “5 Minute” epoxy in hardware stores is another good choice.

A toothpick makes a good tool for stirring the two-part epoxy mixture together, and for spreading the epoxy where needed.

A small piece of heavy-duty aluminum foil makes a good mixing basin for the epoxy.

For the less experienced builder, the following tools are needed. All of these items are sold at Radio Shack, as well as at a variety of other stores.

15 Watt Soldering Iron

.022”, or finer gauge, silver content solder

Small sized diagonal cutters

Long-Nosed, or Needle-Nosed Pliers

#1 Phillips Screwdriver

Narrow bladed Common Screwdriver

¼” Nut Driver or Wrench

Wire Stripping Tool, or Pocket Knife

Single-Edged Razor Blade, or sharp knife, for stripping insulation from magnet wire

Metal File or Hack Saw

The tools listed above are about the minimum needed. Others, such as a “solder sucker”, solder “wick”, and a pair of hemostats, are very helpful additions to the basic tool list.

The builder should have, or have access to, a Volt/Ohm Meter. The author has used the small, digital multimeter that is sold in Sears auto stores for several years. It costs about $30.00.

Of course, having, or having access to either a Frequency Counter, or a General Coverage Receiver will make adjusting the tuning range of the TinEar receiver easier, but it can easily be done simply by tuning up and down, listening to what is heard, and adjusting the tuning coil accordingly.

Construction

If you are an experienced builder, please feel free to disregard the following detailed instructions, and make use of the parts list, parts layout, and schematic to guide you in populating the printed circuit board.

However, as this kit is intended for newer builders as well as those more experienced, step-by-step construction details follow, including tips on soldering, with photographic illustrations, in order to help ensure that this receiver goes together easily and works as intended when assembly is completed, no matter the skill level of the builder.

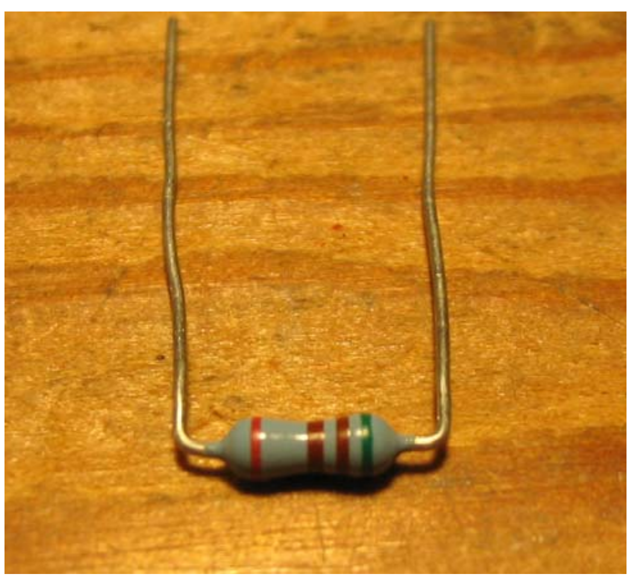
First, inventory the parts, checking against the parts list to ensure that all parts are present in the kit. It would be helpful to print out the page containing the parts list, and use it as a guide. A space has been provided next to each part quantity on the parts list, so that a pencil check mark can be made as each type of part is located and the appropriate number confirmed.

Should you discover that a part or parts is missing from the kit, or there are defective parts, contact:

Doug Hendricks, KI6DS
862 Frank Avenue
Dos Palos, CA 93620
USA

Part Lead Shaping and Individual Part Installation

All of the resistor leads will need to be bent down at a 90 degree angle, each one bent at a location about 1/16” from the body of the part, since the resistors all lie flat on the board. This is shown here. Resistor lead spacing on the board is .4”.

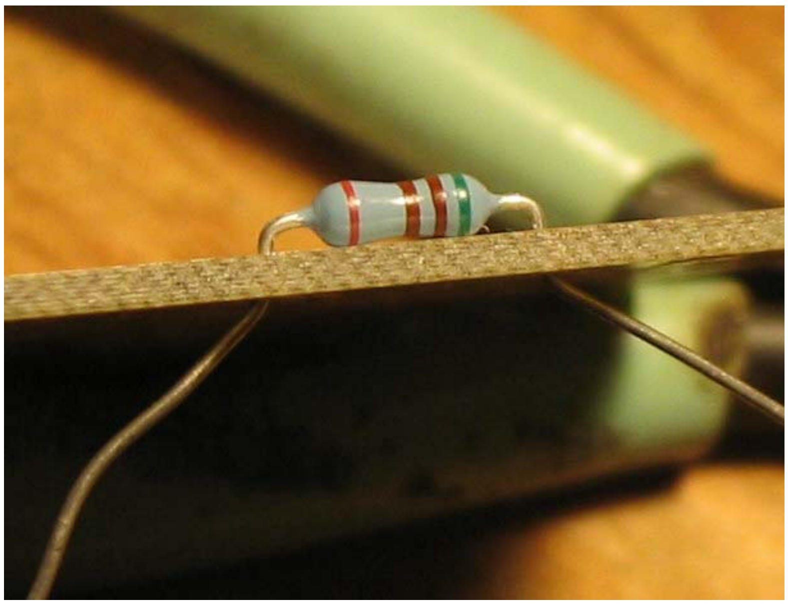


None of the capacitor leads will need to be bent, as they are simply inserted in their appropriate locations so that their bodies are as close to the top of the board as possible.

Although the transistor leads will spread slightly as they are inserted into their appropriate pads, this is easily accommodated by gently rocking the transistors from side to side as they are inserted.

The leads of the one, molded, RF choke, L2, will need to be bent down at 90 degree angles at a location just a little further from the body of the choke, as the lead spacing for L2, on the board, is .5”.

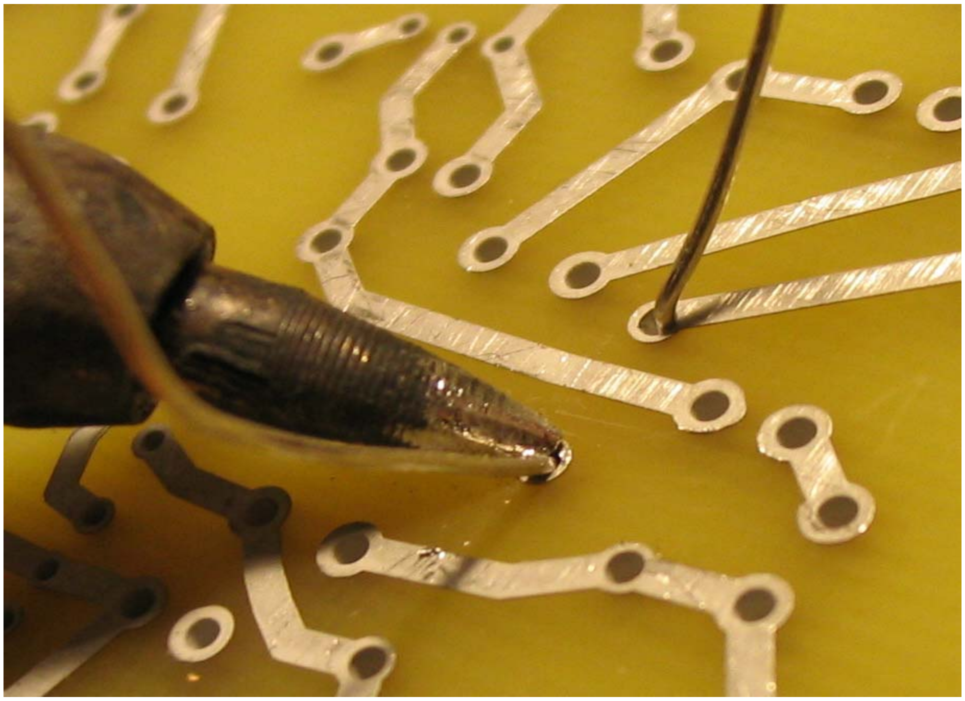
All of the board-mounted parts should be installed so that their bodies are close to, or against the PC board, so that their leads will be as short as possible, as shown here.



Note that the part has been inserted from the top of the board, as far as it will go, and the leads have been bent apart on the bottom of the board, so that the part is held in place for soldering.

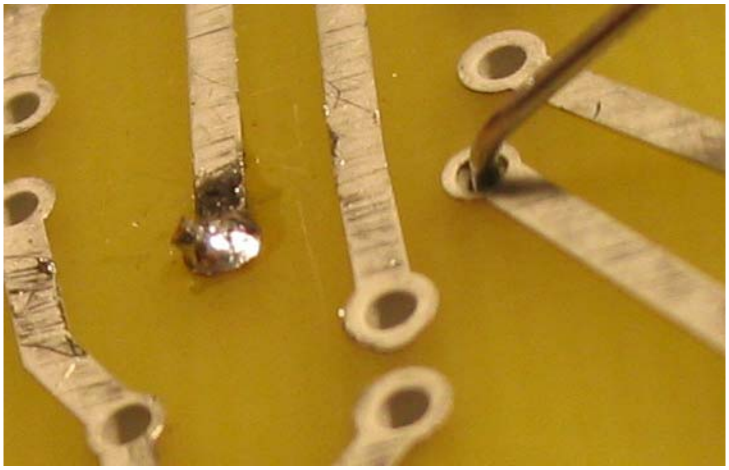
Soldering techniques

A 15 Watt soldering iron with a fine tip and silver-content solder, both available from Radio Shack, are highly recommended. When heating a pad and part lead for soldering, the tip of the soldering iron should be placed on the pad itself, with the tip up against the side of the lead to be soldered, as shown here.

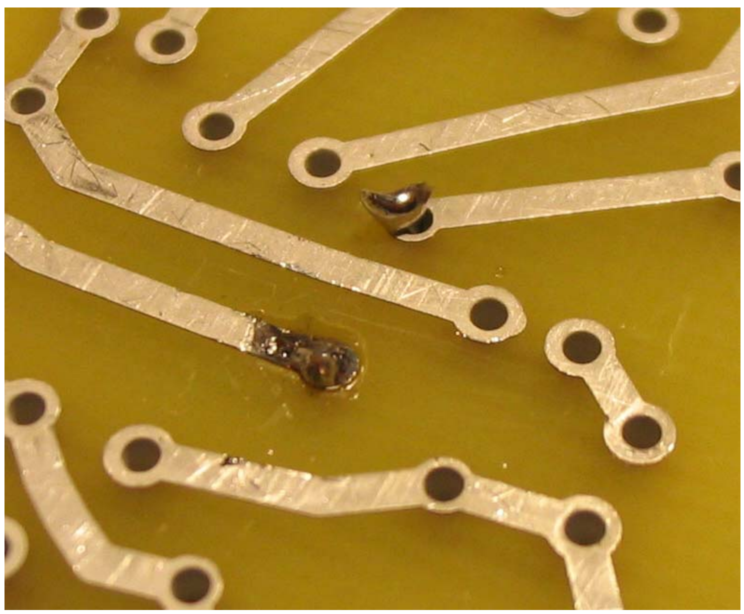


Only that amount of solder should be applied that just fills the pad hole around the lead. The resulting solder joint should be shiny, and it should be readily apparent that the solder has melted and flowed into the joint, rather than just sitting on the joint. The picture below shows a good solder joint.

This picture shows the soldered lead now trimmed close to the solder joint itself. It is important to clip the leads close so that they do not touch the bottom of the case and short the circuit when the printed circuit board is installed in the case.



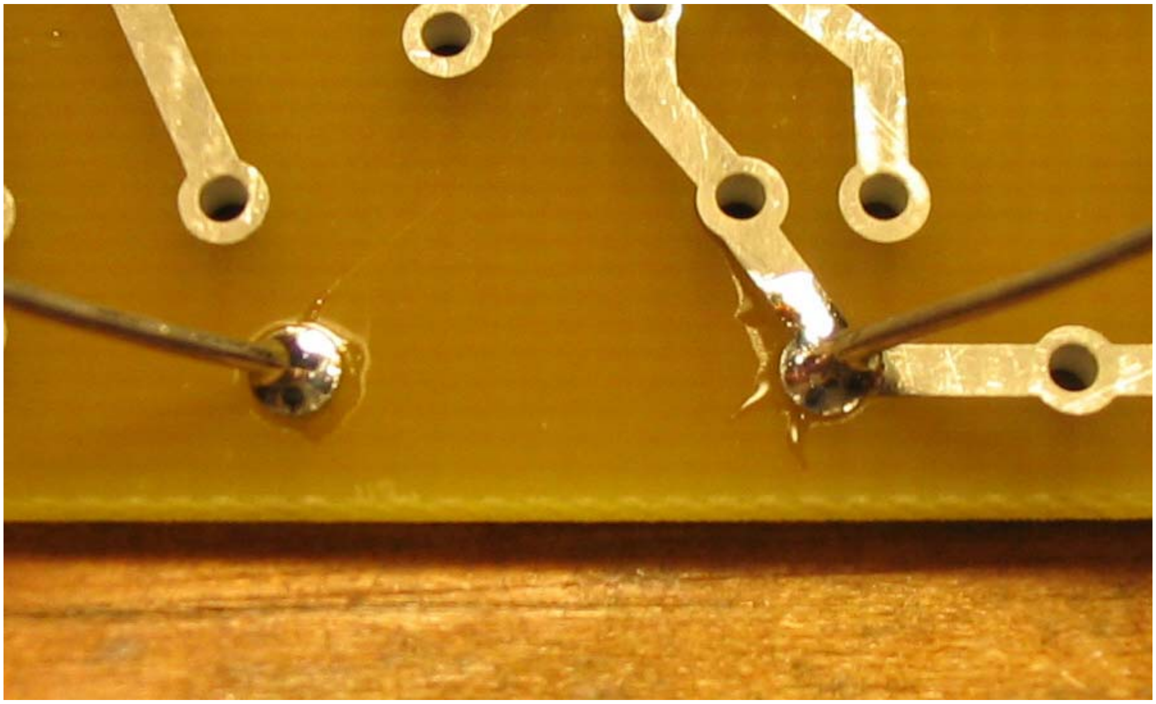
The picture below shows both a good and a bad solder joint.



It is apparent that when the joint in the lower left was soldered, the pad itself was heated, and solder flowed around the lead and down into the hole, forming both a good electrical and physical bond. In upper right is a joint that not only fails to make good electrical contact, but fails to make good physical contact as well. In this case, the soldering iron was not heating the pad, but was against the lead alone, heating it and flowing solder around the lead, but not onto the pad or down into the hole.

The key point in soldering parts into a circuit board is to place the tip of the soldering iron onto the pad itself, up against the lead, so that the pad itself is receiving most of the heat.

Solder is then applied right at the junction of the hot iron tip and the pad, and is allowed to melt and flow in and around the lead, onto the surface of the pad itself and down into the hole in the board.



The picture above shows two good solder joints, one where a part lead is soldered into a pad in a circuit board run, and the other, on the left, where the part lead is soldered into a pad that connects to the ground plane on top of the board.

It should be noted that the tip of the soldering iron will need to be held against the grounded pad a little longer than when a non-grounded pad is being soldered, as it will take a little more time for the soldering iron to bring the grounded pad to a high enough temperature for good solder flow.

Construction Checklist

L2	22 uH			Q1	MPF102			C12	470 pF	
				Q2	MPF102					
R1	100K			Q3	MPF102			C6	10 uF	
R2	100			Q4	2N3904			C10	10 uF	
R3	1M			Q5	2N3904			C11	1 uF	
R4	100K			Q6	2N3904			C14	100 uF	
R5	2.2K			Q7	2N3904			C15	4.7 uF	
R6	510			Q8	2N3906			C16	100 uF	
R7	150K							C17	4.7 uF	
R8	4.7K			C4	.1			C18	100 uF	
R9	3.3K			C7	.1					
R10	4.7K			C9	.1			T1	T37-2	
R11	10K			C13	.1					
R12	680			C19	.1			L1	Air Wound	
R13	12K			C20	.1					
R14	10K							BNC		
R15	100			C1	270 pF			On/Off Switch		
R16	2.2K			C2	120 pF			Phone Jack		
R17	22			C3	150 pF			RF Gain Pot		
R18	22			C5	4.7 pF			Tuning Screw		
R19	10			C8	220 pF			Knobs		

Print out this construction checklist, and check off each part as it is installed.

PC Board construction

Refer to the previous board layout diagram in order to locate the proper place for each part. Print the board layout diagram out, so that you can easily refer to it in order to install the parts. If you turn the page sideways so that the printed NB6M is right side up, and orient the PC board itself the same way, the following instructions will apply. The first Item we will install is the molded RF choke, L2, which is a 22 uH molded inductor that looks like an oversized resistor. It has a green body, and is marked with two red bands and then a black band.

You will note that all of the resistors and the RF choke also have either a Gold or silver band after the colored bands, which denotes the part tolerance. One begins "reading" the part value denoted by its colored bands at the end of the part opposite the gold or silver part tolerance band.

The choke goes in the location marked 22uH on the board layout, just down and to the right from the printed NB6M. As stated above, the lead spacing for this part is .5". Bend the leads at 90 degrees to the body, a little more than 1/16" from each end of the choke body, seat the part down against the top of the board, and bend the leads outwards, under the board, in order to hold the part in place.

Some builders like to insert several parts into their respective places before starting to solder them permanently into the board. If you are new to kit building, it is probably better to insert one part, check to make sure you have it in the right place, and solder it in place, completing the installation of each part, one part at a time.

Whether you install and solder one part at a time or install several before soldering, it is a good idea not to cut their leads off until they have actually been soldered. This practice provides a double check that they have actually been soldered into the board.

Make a check mark, in the box next to L2 on the construction checklist, once L2 is installed, soldered in place, and its leads have been clipped.

Resistor Installation

With L2 installed, we will begin installing the resistors, starting with R1, a 100 K resistor. The color code for 100 K is Brown, Black, Yellow.

Bend the leads, close to the resistor body, insert the leads into the pad holes in R-1's spot just to the left of L2, bend them outwards away from each other on the bottom of the board, in order to hold the resistor in place, turn the board over and solder R-1's leads. Trim the leads, and make a check in the box next to R1 on the construction checklist.

R2 is a 100 Ohm resistor, coded Brown, Black, Brown, and will be inserted at R-2s location, a little to the right of L2. As described above, bend its leads, insert it, spread the leads to hold it in place, turn the board over, and solder the leads. Trim the leads, and mark the box on the checklist.

R3 is a 1 Meg Ohm resistor, coded Brown, Black, Green. Its location is between Q2 and R4, in the lower right part of the board. Bend its leads, insert it, spread the leads to hold it in place, turn the board over, and solder the leads. Trim the leads, and mark the box on the checklist.

R4 goes just to the right of R3. It is a 100 K Ohm resistor, coded Brown, Black, Yellow. Bend its leads, insert it, spread the leads to hold it in place, turn the board over, solder the leads, trim them and mark the box.

R5, a 2.2 K Ohm resistor, coded Red, Red, Red, goes just to the left of Q2's spot. Install it, solder it, trim the leads and mark the box on the checklist.

R6 is a 510 Ohm resistor, color coded Green, Brown, Brown. It goes at the lower edge of the board, below R3 and R4. Complete its installation and mark the box.

R7's spot is in the lower left part of the board between Q4 and C12. It is a 150 K Ohm resistor, color coded Brown, Green, Yellow. Install it, solder and trim leads, and mark the box on the checklist.

R8 is a 4.7 K Ohm resistor that goes just to the left of R5, up and to the right of R7. It is color coded Yellow, Violet, Red. Install it and mark the box.

R9 is color coded Orange, Orange, Red, and is a 3.3 K Ohm resistor that goes to the left of R8, above R7. Install it and mark the box.

R10 goes just above R3, over in center right of the board, and is color coded Yellow, Violet, Red. It is a 4.7 K resistor. Install it and mark the box on the checklist.

Install the following resistors, soldering them in place, trimming their leads, and marking the appropriate boxes on the checklist after doing so.

R11 goes just above R10. It is color coded Brown, Black, Orange, and is a 10 K Ohm resistor.

R12 is a 680 Ohm resistor, coded Blue, Grey, Brown. Its location is in the right end of the board, not quite half way down from the top.

R13 goes in the center of the board, about a quarter of the way down from the top. It is a 12 K Ohm resistor, coded Brown, Red, Orange.

R14 is a 10 K Ohm resistor, coded Brown, Black, Orange, and is installed below and to the right of R13.

R15 is coded Brown, Black, Brown, a 100 Ohm resistor, which goes in right, center of the board, just below R12.

R16 is a 2.2 K Ohm resistor, coded Red, Red, Red, and is located in top, center of the board.

R17 is in the upper right corner of the board, and is a 22 Ohm resistor, color coded Red, Red, Black.

R18 is also a 22 Ohm resistor, coded Red, Red, Black, and should be installed just down and to the right of R17.

R19 is a 10 Ohm resistor, color coded Brown, Black, Black, and goes near the right edge of the board, just about half way down from the top.

That completes the installation of resistors. Go back and check each and every resistor lead to make sure you have a good solder joint, and to make sure you have clipped the wires off close to the bottom of the PC board

Transistor Installation

When you install the transistors, you will note that the pads for the MPF102 FETs are in a straight line, whereas the pads for the 2N3904s and the one 2N3906 have the base lead offset slightly. All of the transistors have their identifying types printed on their flat sides.

It is important to pay attention to the orienting transistor shape that is printed on the top of the board itself, and is also shown in the board layout drawing.

Again, if you orient both the board itself and the layout drawing so that the printed NB6M is in upper left, the instructions will be correct.

Q1 is an MPF102, and its location is towards the left edge of the board, about in center, top to bottom. Observe that the flat side of the transistor goes away from you, towards the upper edge of the board, as you have it oriented.

Star its leads into the appropriate pad holes, and gently rock the transistor from side to side, pushing in as you do so, which helps spread the leads so that the transistor can be seated closer to the surface of the board, and helps prevent scraping off slivers of metal from the leads, which might cause a short circuit to occur.

The pads for the transistor leads are a little smaller than those for the other components, but the soldering technique is the same.

Solder Q1s leads, clip them, and mark the construction checklist next to Q1.

Insert each of the following transistors, solder their leads, clip the leads, and mark the checklist appropriately.

Q2, an MPF102, goes just below the center of the board, and its flat side goes to the right.

Q3, an MPF102, goes just below Q2, but its flat side faces to the left.

Q4, a 2N3904, goes in the lower left corner of the board. Its flat side faces to the right.

Q5, a 2N3904, goes just above and to the right of the center of the board. Its flat side faces up.

Q6 is a 2N3904, and goes above and to the left of Q5, with its flat side facing right.

Q7 is a 2N3904, and goes up near the top edge of the board, just a little right of center. Its flat side faces up.

Q8, a 2N3906, goes just above and to the right of Q5, with its flat side facing up.

Now, go back and check each transistor lead, looking carefully to be sure you have not created a solder bridge between any of the pads, and to be sure solder joints are good and that the wires are clipped off short.

Capacitor Installation

We will start with the .1 uF bypass capacitors.

There are six of them, and they are marked 104.

Insert, solder, clip leads, and mark the construction checklist as each capacitor is installed.

C4 is in the upper left corner of the board.

C7 is against the lower edge of the board, a little left of center.

C9 is right at the lower edge of the board, just to the right of C7.

C13 is located just above and to the left of the center of the board.

C19 is at the right-hand edge of the board.

C20 is located on the left end of the board, just down from center.

Check each capacitor lead for good solder joints and leads clipped short.

Next we will install the NP0, disk ceramic capacitors. Again, once each one is installed, soldered, and leads are clipped, mark the construction checklist to record your progress.

C1 is a 270 pF capacitor, marked 271, and it goes in the upper left corner of the board.

C2 is a 120 pF cap, marked 121, which goes just below C1.

C3 is marked 151, and is a 150 pF capacitor which goes to the right of C2, just past Q1.

C5 is a 4.7 pF capacitor, marked 4.7, and it goes just below C3.

C8 is marked 221, and is a 220 pF capacitor which goes in the right hand, lower corner of the board.

C12 is a 470 pF capacitor, marked with 471. It is installed near the bottom edge of the board, between R7 and C7.

Check the leads of all the capacitors just installed, for good solder joints and leads clipped short.

With all of the NP0s taken care of, we will now install the Electrolytic capacitors. It is important to recognize that Electrolytic capacitors are polarized. This means they have a positive lead and a negative lead. If one lead is longer than the other one, the longer one is the positive lead. Or, the case may be marked with either a line of negative symbols alongside one lead, or a positive sign over one lead.

Whichever style of markings we have, we must identify which lead is which before inserting the Electrolytics into the board.

As before, when the installation of each part is complete, mark the construction checklist so as to keep track of your progress.

C6 is a 10 uF capacitor that goes almost in the center of the board. Its positive lead goes in the hole closest to the upper edge of the board. Again, if you have the board oriented so that the NB6M in the upper left corner is right-side up, these instructions will be correct.

C10 is also a 10 uF cap, and it goes in the lower center part of the board, be sure to note that its positive lead goes down, that is towards the edge of the board towards you.

C11 is a 1 uF capacitor, and in this case is actually a Tantalum capacitor, which has a yellow body and is marked 1uF. You will note that it has a positive sign and a line on its body which is above the positive lead. C11 goes right at the lower edge of the board, with its positive lead to the right.

C14 is a 100 uF capacitor, which goes at the top edge of the board, a little left of center, with its positive lead nearest that edge of the board.

C15 is a 4.7 uF cap, which goes in the lower left corner of the board, with its positive lead nearest that lower edge.

C16 is a 100 uF capacitor, and is located in the right hand part of the board, just above T1. Its positive lead goes up, or in the hole that is closest to the edge of the board with NB6M printed on it.

C17 is a 4.7 uF cap, which is located in the upper right corner of the board, with its positive lead up, again closest to the edge of the board with NB6M printed on it.

C18 is a 100 uF capacitor, located in the upper right corner of the board, with its positive lead down, or away from the edge of the board that has NB6M printed on it.

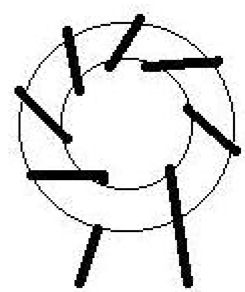
Go back and check each lead of the electrolytics just installed, looking to be sure you have good solder joints and have the leads clipped off short.

T1

T1 is a transformer that is wound on a T37-2, toroid core. That is a small, doughnut shaped core that is painted red.

In order to make it easier to wind, the primary is added after the 24 turn secondary has been wound, and the resulting coil has been installed on the board.

First of all, the number of turns on a toroid relate to the number of times the wire actually passes through the hole in the center. So, when we take the wire through the center the first time, BEFORE we actually wrap it around and through again, that is one turn. When we do wrap the wire around and it passes through the hole again, the second time, that counts as the second turn.



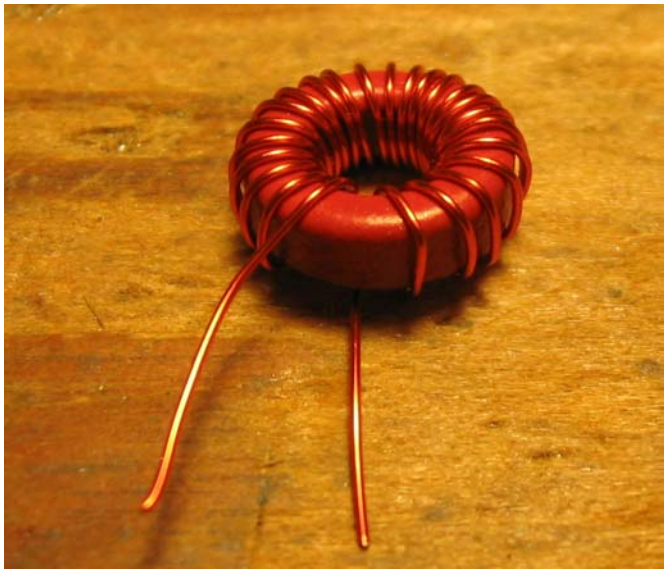
This toroid has seven turns. After winding the core with 24 turns, count the number of times the wire actually passes through the center, and you will have the actual turns count.

First measure and cut an 18” length of the #28 magnet wire that has been supplied in your kit.

It should only take about 12 inches or so to actually wind 24 turns on a T37 core, but having a few inches extra makes winding the last few turns easier.

You should start by pushing one end of the wire through the center of the core, and leaving enough of a “tail”, a couple of inches, so that you can hold onto it and the toroid core while you wind the other turns on.

Once you have 24 turns wound, carefully count the number of times the wire actually passes through the center, and verify that you have the correct number. Then, trim both ends so that there is about half an inch of each one sticking out past the outer edge of the toroid core.

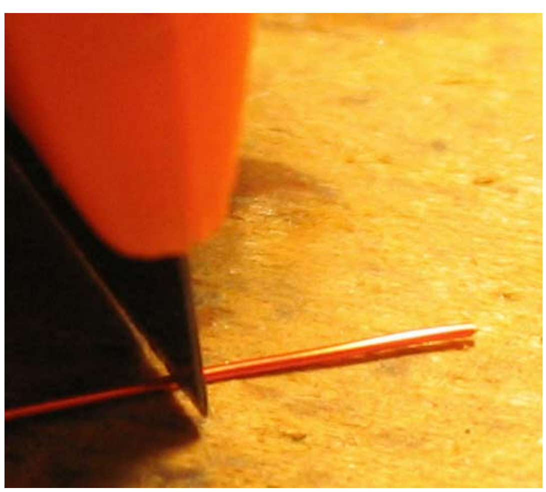


This picture shows a T37-2 with 24 Turns of # 28 wire.

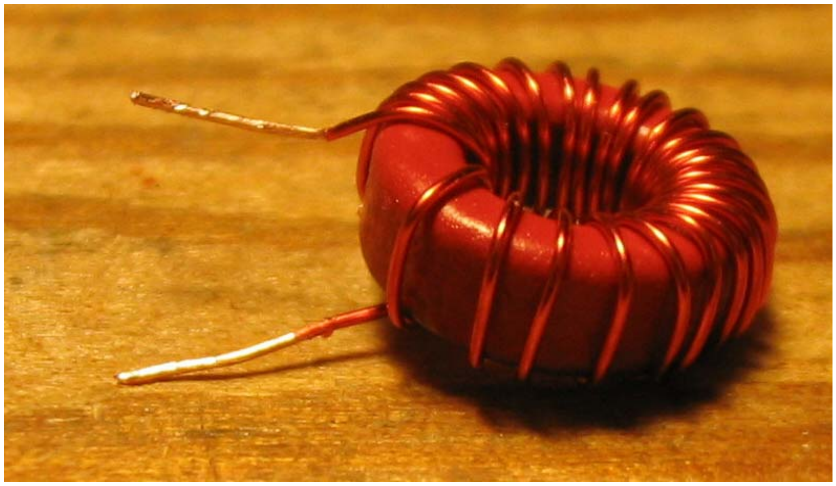
Now comes the part where we do something which ensures that our coil makes good contact with the pads where it is installed on the board. You will notice that the copper wire is actually coated with a thin, red film. This film is an insulating material that keeps the turns of a coil wound with this type of wire from shorting out together. Yes, insulation. That means that we need to carefully scrape the insulation off the ends of the wire so that they can actually be soldered to.

The easiest way to do that is with a single edged razor blade, or other similarly sharp instrument, by holding onto the toroid core, laying the end of the wire over the edge of a work bench, and turning the toroid, therefore turning the wire end, a little at a time while scraping away the insulation. It takes more time to describe this process than it does to actually do it.

You should end up with bared copper, starting just a little way from the outer edge of the core, and extending out a quarter of an inch or so. Here is a shot of the setup for scraping:

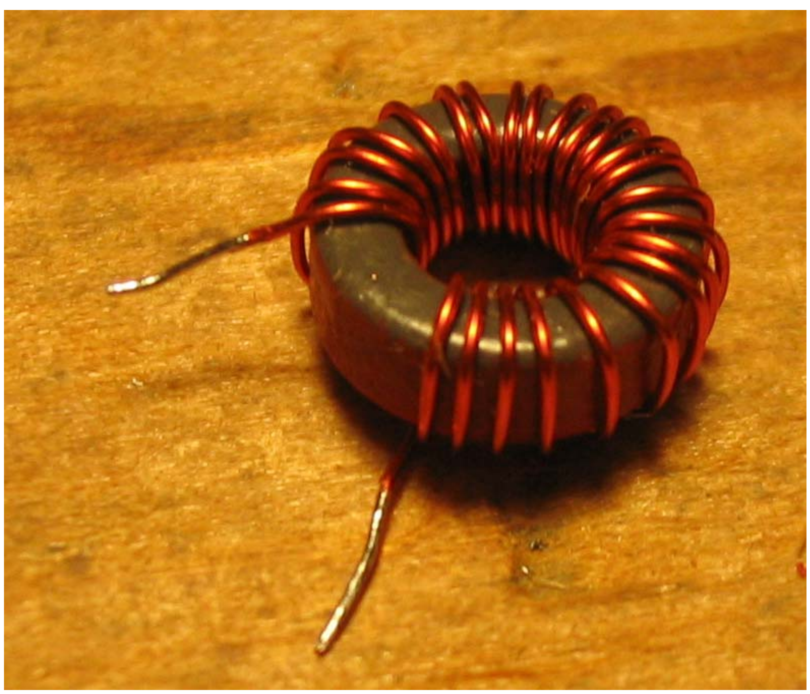


Once both wire ends have been scraped, they should look like this:



Again, you should see bare copper, starting just a little way from the outside edge of the core, and extending out for about a quarter of an inch. Here, you can definitely see the difference between the bare copper wire and the insulating film. That film MUST be removed or the ends of our coil will not make contact with their pads.

Then, both to double check our scraping job, and to be really sure our coil leads are going to solder well, we will "tin" them. That is, we will heat the bare copper ends and melt a thin coat of solder onto them. This does two things for us. First of all, if we have left any insulating material on the wire, this will show up very well as dull spots on the shiny surface of the tinned copper. And, second, it will coat the bare copper with a layer of solder, ensuring a very good electrical bond when the leads are soldered into the board. If you see dull spots, or bits of insulating material along the tinned part of the wire, simply scrape those areas again, and re-tin the wire ends. Here is a shot of tinned leads:



Now that our toroid coil is properly prepared, we can install it in the PC board. T1 goes in the lower right corner of the board, with its leads inserted in the pads identified as “2” and “3”.

Insert the leads, bend them over just slightly on the back of the board, and solder them into place. Clip any excess.

In order to complete our transformer, we will cut a 6” length of insulated wire, strip about 1/8” of insulation off one end, tin the bared wire with solder, and then inset it into the T1 pad marked “4”. Solder the wire into the pad. Trim any excess wire from the bottom of the board.

Now, we are going to pass the free end of the wire through the center of the toroid, so that it looks like this:

Then, we are going wind two more turns through the toroid with the free end, by passing the wire through it twice more, so that it looks like this:

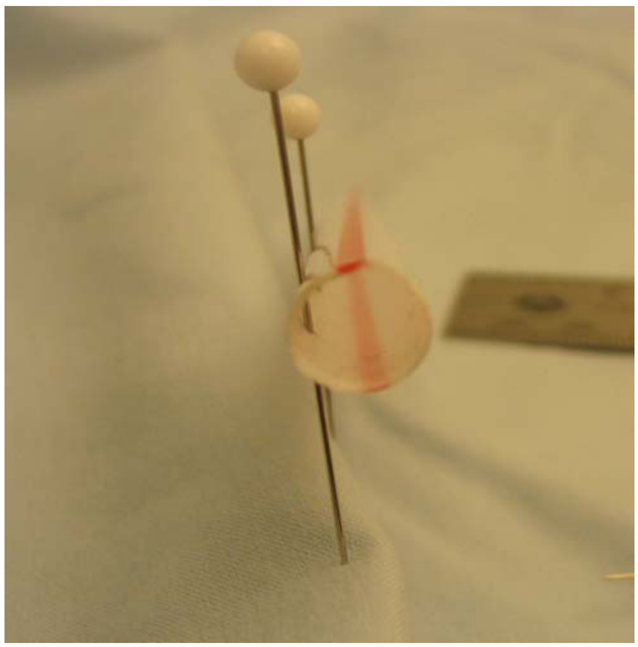
For the time being, we will leave the free end of the insulated wire as-is. It will be connected to the wiper of the RF Gain pot, once that is installed and the PC board is installed in the case.

L1 Construction

L1 is the tuning coil for the VFO in the TinEar receiver. It is wound with more of the #28 Magnet wire supplied with your kit, and needs 46 turns of the wire. Winding this coil is really going to be much easier than you think.

First, we are going to prepare the section of plastic drinking straw that came in your kit. This straw was actually donated by the proprietor of "California Burger", the location of the monthly NorCal QRP Club meeting. I think that it is very appropriate that this simple object, from that restaurant, should become part of the equipment many of us will use.

Using a needle, or safety pin, we will poke two holes, crosswise, through the edge of the straw, to provide a method of locking the ends of our coil in place. Here is a picture of the straw with two pins poked through it, showing what is meant by "the edge of the straw".



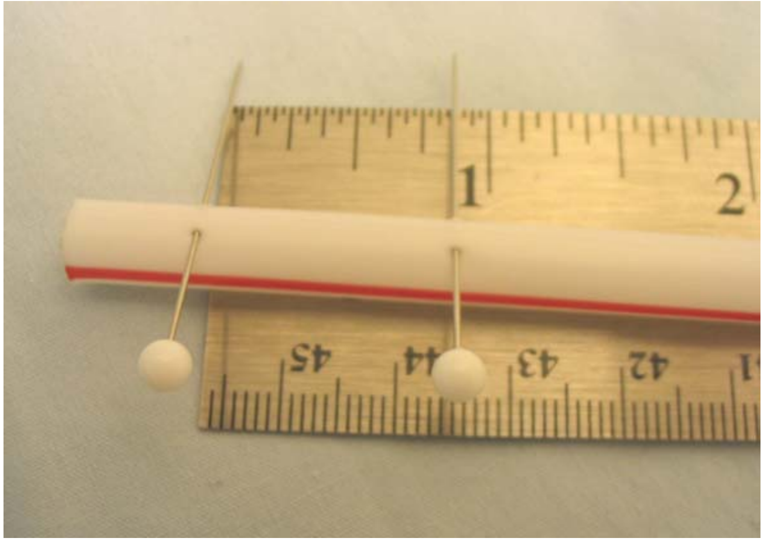
Our tuning screw, the 6-32 brass screw supplied in the kit, will need to be able to pass freely through the center of the coil, so the two wire anchoring holes will need to be created out at the edge of the straw, as shown.

These two pinholes will need to be fairly accurately placed in terms of distance from each other. The first one should be about 3/8ths of an inch from one end of the straw. The other should be 7/8ths of an inch from the first one. The reason for the accuracy of the distances is as follows.

The first hole should be about 3/8ths of an inch from one end of the straw so that there will be enough of the straw sticking out of the end of the actual wire coil to fit over the PEM nut and rounded brass nut that will form the mount for the coil on the inside of the front case panel.

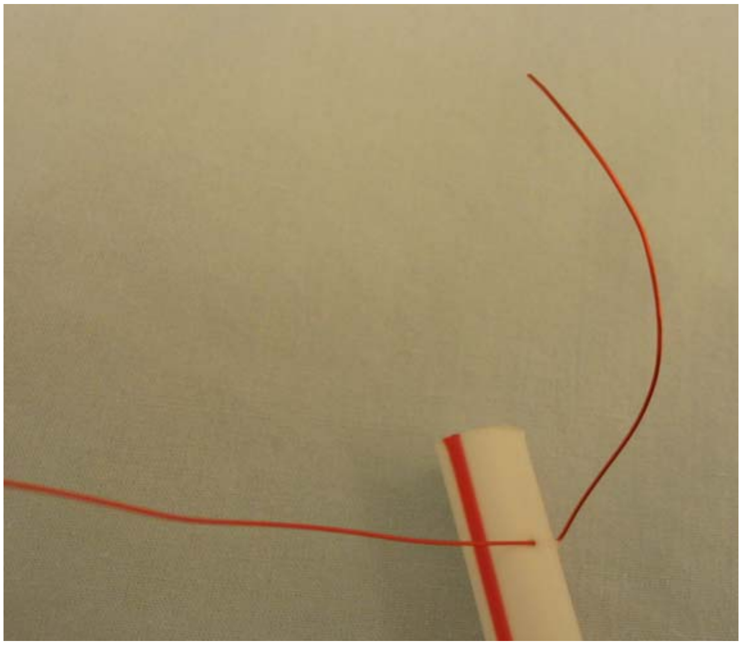
The second hole is made exactly 7/8ths of an inch from the first one so as to allow room for us to compress or spread the coil turns as necessary in order to set the tuning range of the receiver.

The picture below shows the two pinholes 7/8ths of an inch apart, with the first hole a little more than 3/8ths of an inch from the end of the straw.



Once you have created the two pinholes as described above, you are ready to begin winding the actual coil. The remaining section of #28 Magnet wire should be at least 60 inches long. It would be helpful to uncoil it and straighten it out first, laying it out on the floor in a fairly straight line so as to help prevent kinking of the wire as it is wound onto the straw.

Then, poke one end through the pinhole closest to the end of the straw, and bend about 2 to 3 inches of it over, to hold it, as shown below.

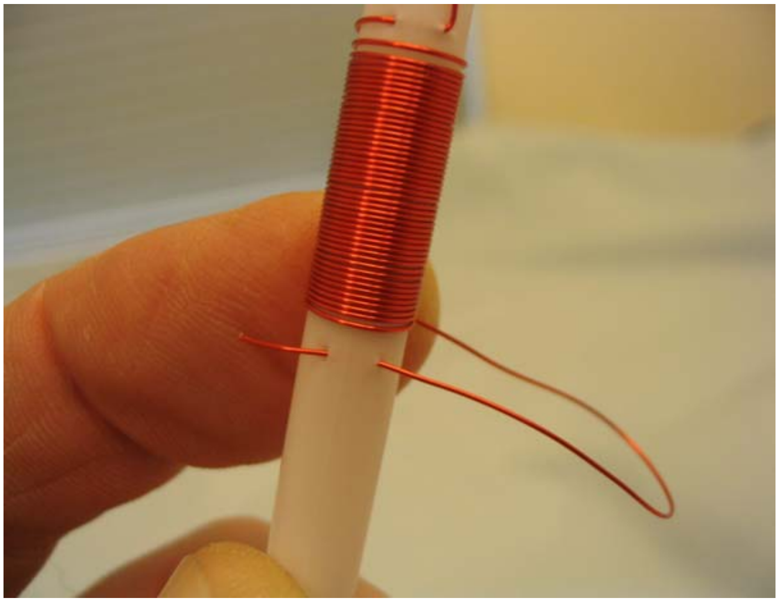


Now, the idea is to hold the straw in the right hand and lightly grasp the wire a few inches away from the straw.

Turn the straw with the right hand, winding turns onto it, while letting the already straightened wire slip through your left hand. Count the number of times the bent-over end of the wire goes around, and continue winding until you have 46 turns wound onto the straw.

These turns do not have to be wound very tight at all, just keeping a little tension on the wire while winding it on, by turning the straw with the right hand, will be tight enough. Remember, the reason we made the two pinholes exactly 7/8ths of an inch apart was so that we could adjust the coil by either sliding the turns apart or compressing them slightly, in order to set the tuning range of the receiver. That means that the turns have to be loose enough to slide, but not so loose that they slip by themselves.

Once you have 46 turns wound on, hold the turns in place with a fingertip, cut the wire so as to leave four or five inches of free end, and poke the free end through the second hole, as shown below.



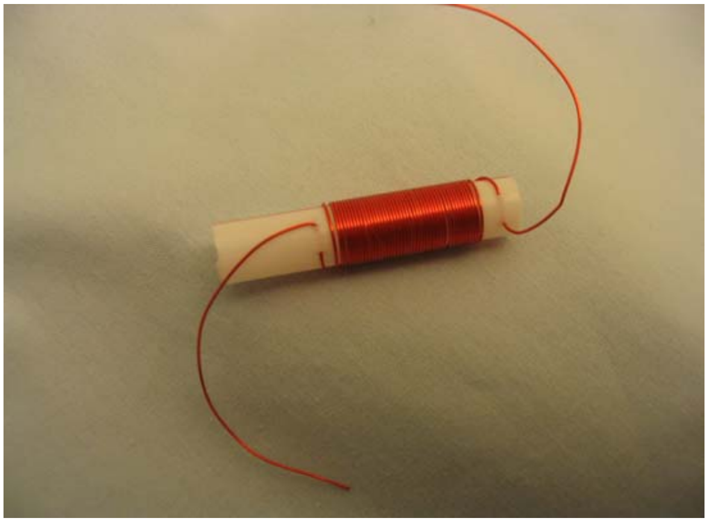
The reason for leaving four or five inches of wire is so that there will be enough to add a turn or two in case you mis-counted while winding the turns on. However, it is easy enough to hold the turns in place with a fingertip and count the turns again, using the end of a needle or safety pin to separate the turns to make counting easier, before cutting the wire.

If you should happen to slip while winding on turns, and the coils of wire become overly loose, it is a simple matter to re-tighten the turns with the fingers, beginning at the already anchored end, and then continue winding until the correct number of turns has been wound on.

Also, there is no need at this point to have all the turns neatly touching each other, since we will be adjusting the coil anyway, at a later time.

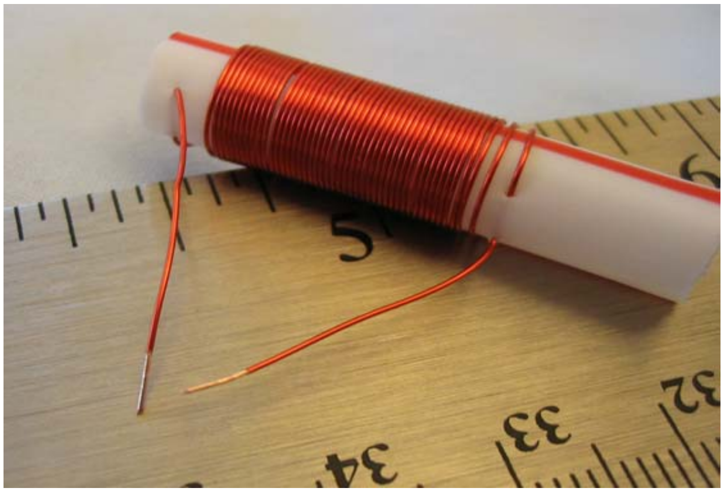
Once the coil turn count has been verified, and the free end of the wire snugged up, that end is bent over, like the first end was, in order to hold the turns in place.

The next step is to cut the long end of the straw off, leaving only about 1/8th of an inch of plastic drinking straw sticking out of the actual coil on that end. The picture below shows the finished coil, with both ends bent over in order to hold the turns in place and the excess straw cut off.



Now, just as we did with the toroid coil winding before, we need to scrape the ends of the wires free of insulating material and tin the ends with solder before installing L1 in its proper location on the PC board.

First, trim the lead lengths so that the free end closest to the shorter end of the straw is 1 and ¼" long, and the one closest to the longer end of the straw is 1 and 1/8" long. This picture shows the finished coil, with the wire ends trimmed to length and properly scraped for tinning.



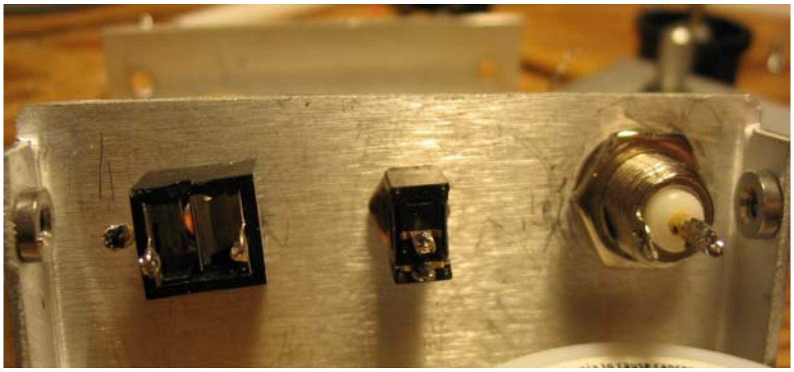
Once the coil wire ends are tinned, L1 is installed in its spot on the PC board, and soldered into place. Electrically, either wire can go to either L1 pad. However, physically, it may be better to connect the rear (longest) L1 wire to the pad nearest the 270 pf capacitor. Be sure to trim the wire ends on the bottom of the board, after soldering.

Case Preparation

Preparation of the case consists of installing the RF Gain pot on the front panel, and installing the BNC jack, Earphone Jack, and Power Switch on the back panel.

Install the RF Gain pot on the front panel so that its solder connections face towards the PEM nut where the Tuning Screw will be installed, as is shown below.

Install the BNC connector, Power Switch, and Earphone Jack on the rear panel, as shown below.

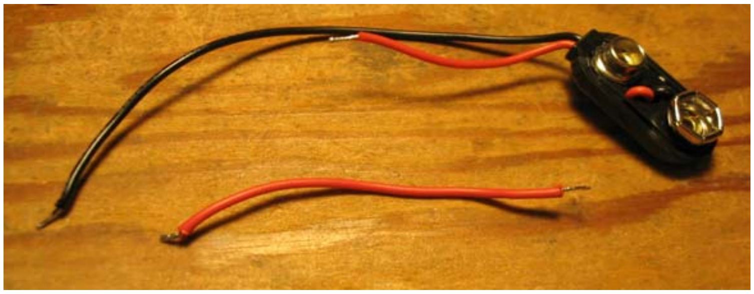


The next step is to prepare the battery power connector for installation. The red wire is cut 1 ½" from the snap-on battery connector, the two wire ends stripped of insulation about 1/8" from the ends and the ends tinned with solder.

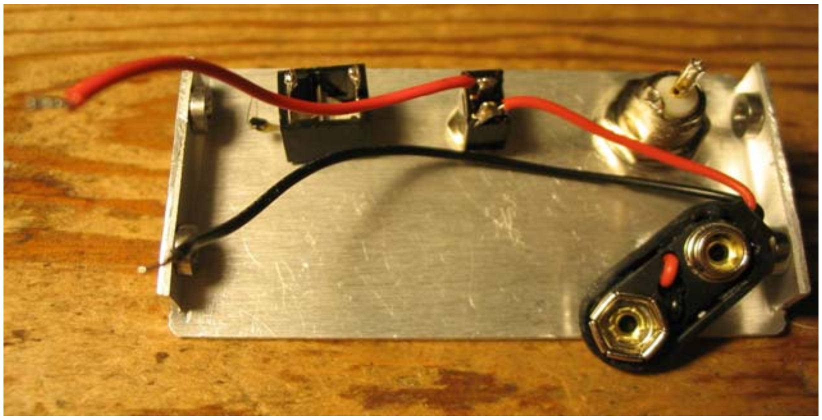
The section of red wire that will connect from the power switch to the PC board is cut to a length of 2 ½" and the wire end is stripped of insulation and tinned with solder.

The black wire is cut to a length of 4" and its end stripped of insulation and tinned with solder.

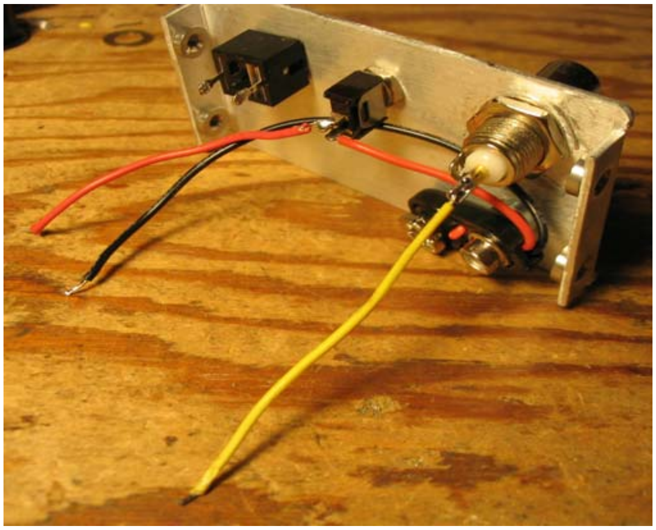
This photo shows the battery connector and wires prepared for installation.



Next we will solder the battery connector wires to the power switch, as shown in the photo below. One red wire goes to the lower contact, and the other goes to the center contact on the switch.

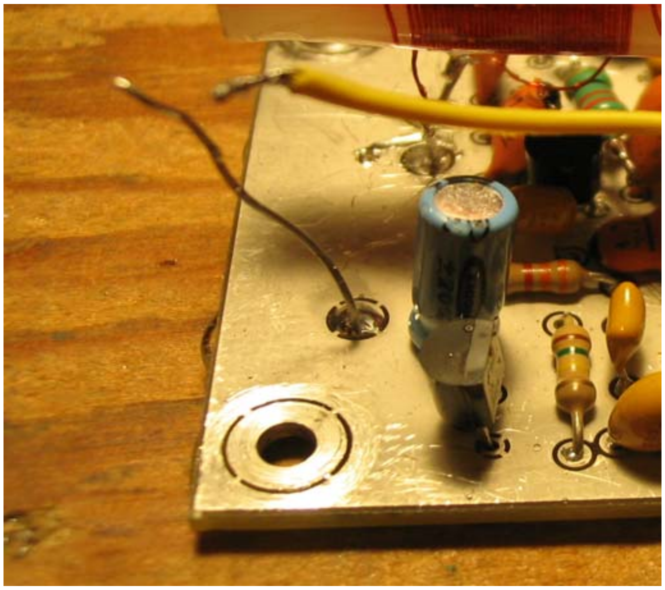


Next we will cut a piece of insulated hookup wire to a length of 3”, strip the ends, and tin the ends with solder. When the wire is prepared as described, solder one end of it into the center connector of the BNC jack, as shown below.

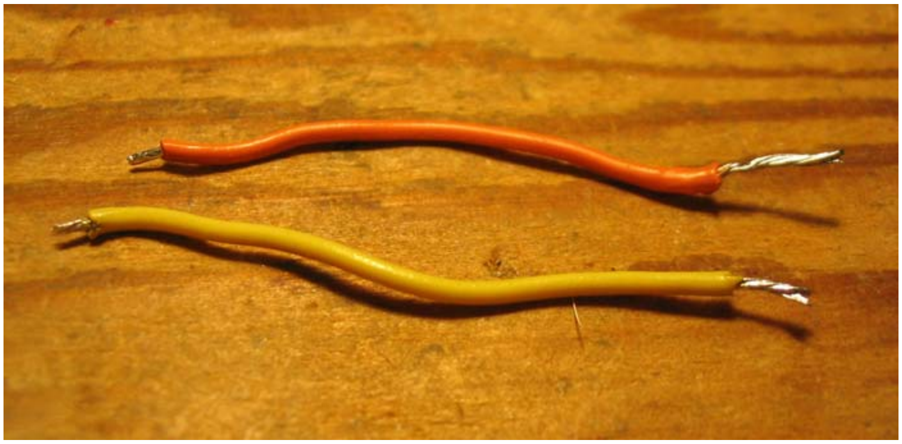


That completes the preparation of the case front and rear panels, and we are now ready to prepare the PC board for installation.

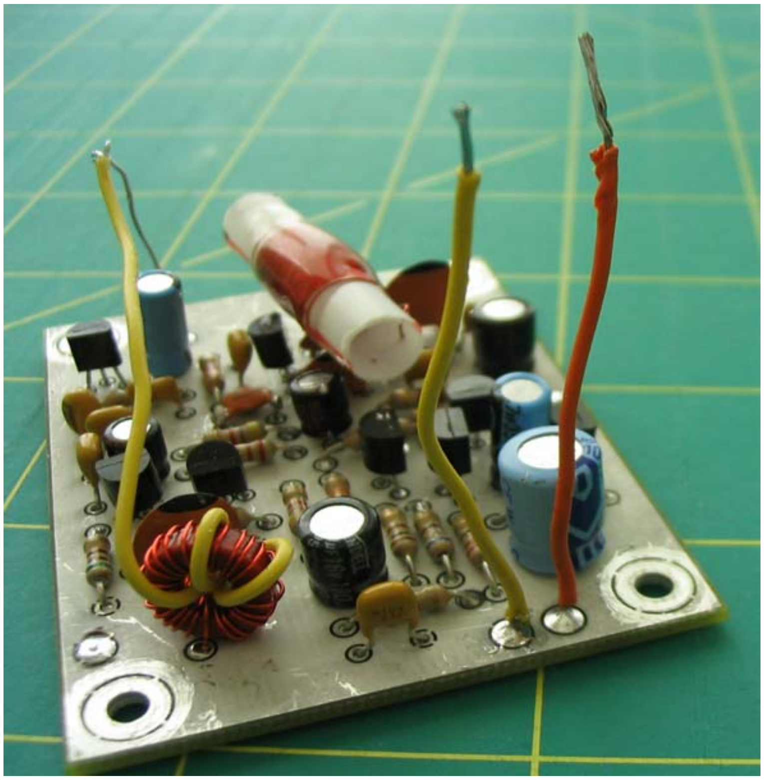
Actually, there are only two more things to add to the PC board. The first of these is a ground wire for the RF Gain pot, which can either be an inch long piece of cut-off part lead, or can be a short piece of insulated hookup wire. A cut-off part lead was used here, and was soldered to the ground pad provided, as shown below.



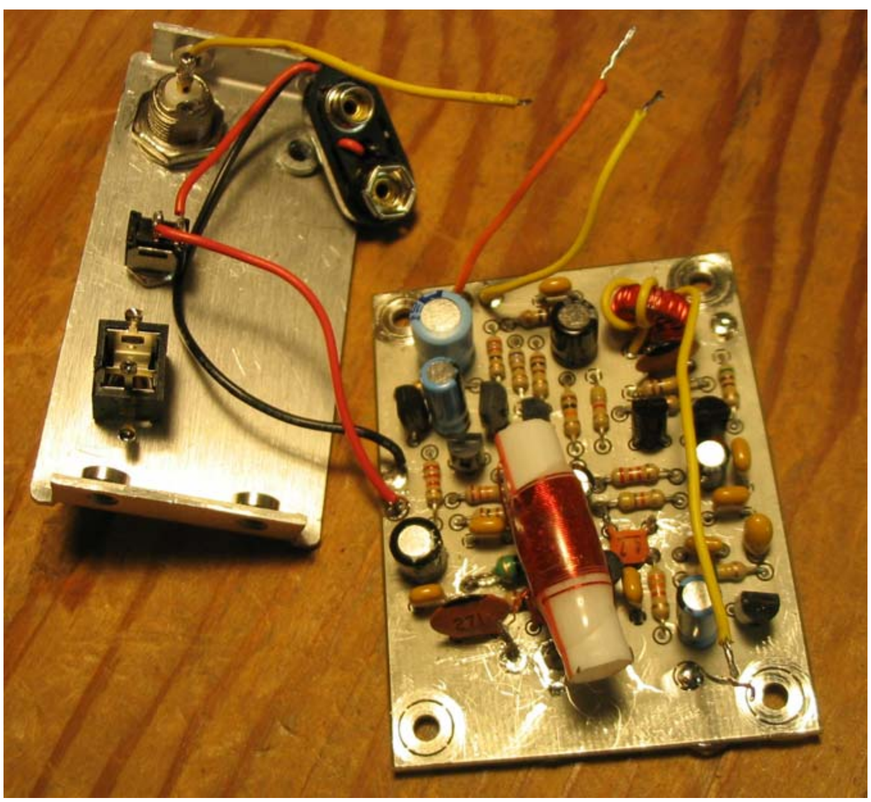
Now, we will prepare two 2” lengths of insulated hookup wire. Three of the wire ends will be stripped of insulation for about 1/8”, but the fourth wire end needs to be stripped of insulation for a length of about 3/8”. This is because that end will be soldered to both the “tip” and “ring” connections on the earphone jack. This preparation is shown below.



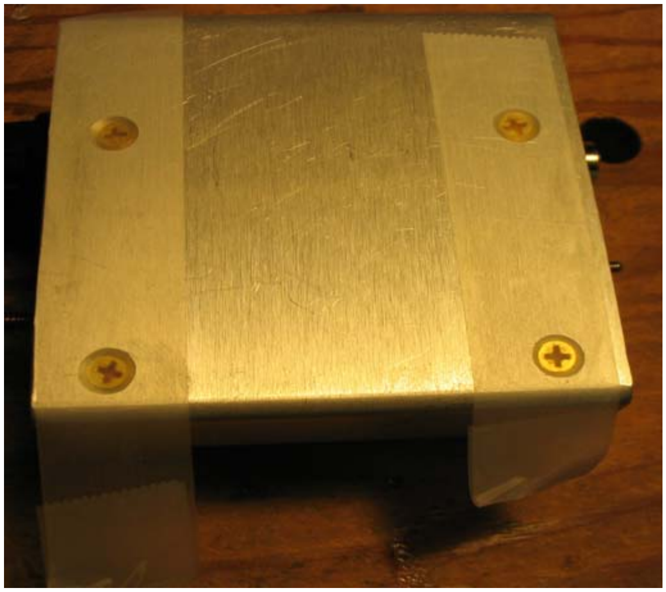
Next, these two wires are soldered into the two audio output pads, taking care to ensure that the short end of the wire with the longer stripped end is soldered into the H/P pad, and one end of the other wire is soldered into the ground pad, as shown below.



Now, before we install the PC board into the case bottom, we need to solder the DC power leads to the board, as shown below, and trim any excess wire on the board bottom. Red goes to the 9V+ pad, and black goes to GND.

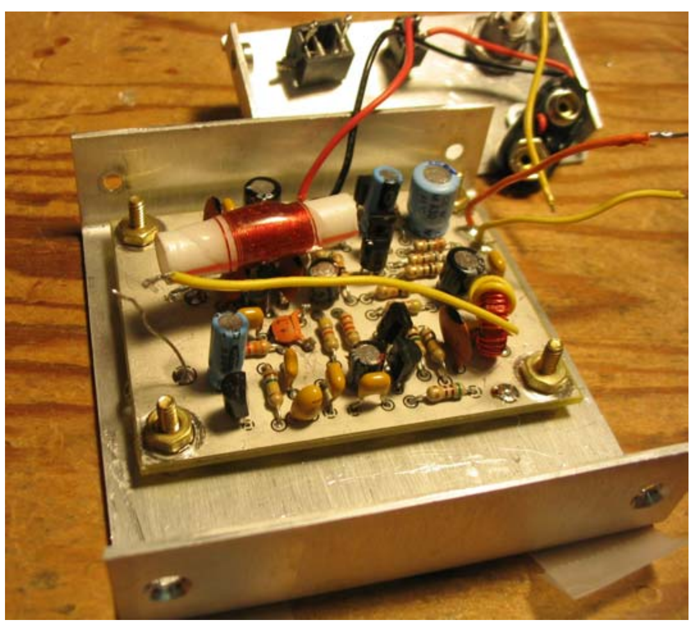


We are ready to install the PC board into the case bottom, and, before doing so, turn the case bottom over, place the four 4-40 board mounting screws into their respective holes, and then run two strips of Scotch tape across the screw heads, so as to hold them in place. This will make the PC board installation much easier, and is shown below.



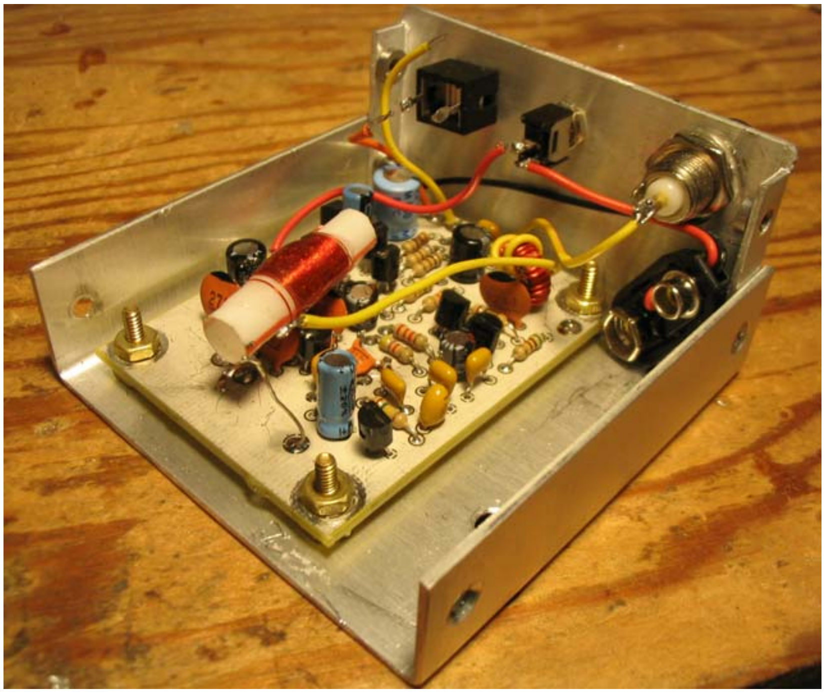
As is shown in the above photo, the two tape ends are folded back onto themselves for a short distance, in order to make the tape removal much easier.

Now, turn the case bottom over, place the four spacers provided onto the board mounting screws, set the PC board down onto the mounting screws so that the DC Power wires are next to the nearest side of the metal case, install the four 4-40 nuts provided, and tighten them down just snug. Be a little careful, as over-tightening the nuts could damage the PC board. The board installation is shown below.

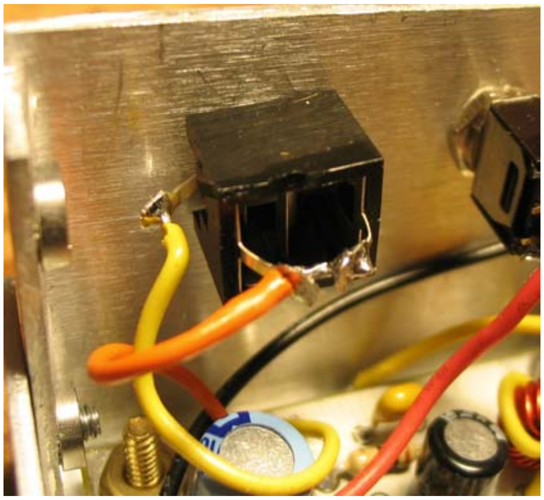


Before you remove the tape, be sure to take a good look underneath the board, checking to be sure there are no wire ends sticking out of the bottom of the PC board far enough to ground out on the case bottom. If you see wire ends that touch the case bottom, or you are not sure, remove the PC board and clip any suspect wire a little closer to the PC board.

The next step is to remove the tape, and install the case rear panel, as shown below.

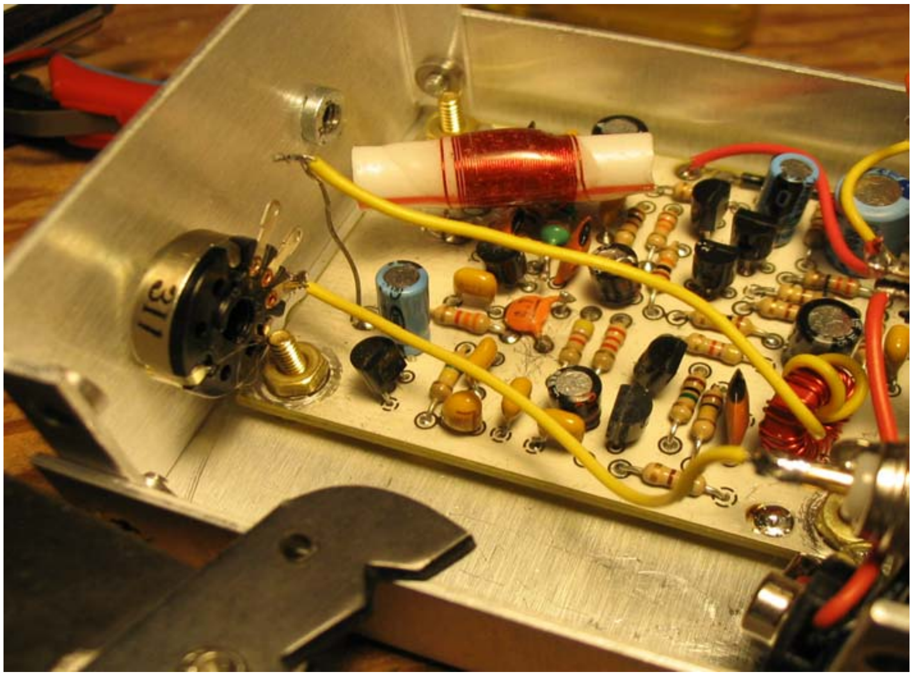


Now we will connect the audio output wires to the earphone jack. The ground wire from the audio connections of the PC board will connect to the ground lug of the earphone jack, which is the lug that is on the side of the jack, close to the rear panel. The "hot" wire from the H/P output connects to BOTH the "tip" and "ring" solder lugs, which are the lugs on the rear of the jack itself, as shown below.



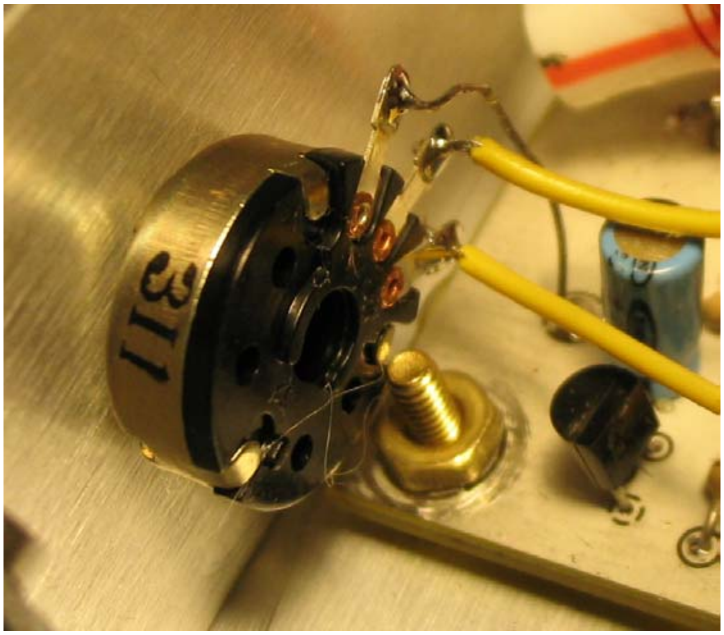
With the audio connections completed, we are finished with the rear panel connections. Now we will make the necessary connections to the front panel, beginning with the antenna lead wire that we previously soldered to the center connector of the BNC Jack.

This wire is connected to the lowest RF Gain pot solder lug, as shown below. Solder it in place.



The next connection to be made is the wire coming from the RF Transformer, T1. This wire connects to the center RF Gain pot solder lug, as shown below. Solder it in place.

This leaves us with just the RF Gain pot's ground wire connection to be made. It connects to the top solder lug on the RF Gain pot. Solder it in place as shown below.



The only concern here, since a bare, cut-off part lead was used, is that the ground wire cannot touch either of the other two solder lugs on the RF Gain pot, or the signal coming in will be shorted to ground, and very little or nothing will be heard when the receiver is activated.

Now that all wiring connections have been made, it is a good idea to check the resistance between the positive DC power connection on the PC board, and ground, with an Ohm Meter, just to be sure nothing is shorted to ground, before we install the 9 Volt Battery.

An Ohm Meter reading between the positive DC power connection and ground, taken on the PC board itself, should give a reading close to 130 Ohms. Measurements of prototype TinEar PC boards have given readings very close to that figure.

If your reading is significantly less than that, as in close to zero Ohms, or is zero Ohms, you have a short circuit between the DC power line and ground, and not only will the receiver fail work but the battery would be shorted to ground and might overheat either the wiring to the receiver, or overheat the battery itself, which could cause serious injury.

Correct any short circuit before connecting the battery and testing the receiver. Perhaps the first place to look for a problem would be to look for wires sticking far enough out of the bottom of the board to touch the case bottom. If the 9V+ line is shorted to ground, and you can't see the trouble right away, remove the PC board from the case and see if it is still shorted. If not, you know the trouble is a part lead or a wire that is extending too far down from the PC board.

In any case, for further help with troubleshooting, refer to the Voltage and Resistance chart in the Troubleshooting section later in the manual.

Tuning Screw Installation and Adjustment

Most of us like just a little resistance to be felt when we turn the tuning knob of any rig, be it transmitter or receiver.

In this case, tuning is accomplished by means of a brass 6-32 screw, which has our tuning knob attached to it by means of a threaded, ¼" diameter Nylon Sleeve, and is screwed into, or out of, the tuning coil by the act of turning the tuning knob.

The brass screw is threaded through a PEM nut, which has already been pressed into a hole in the front panel of the TinEar receiver. In order to provide more stability for the tuning screw and to provide a manner of creating that "turning tension" we desire, a rounded brass nut, provided in the kit, will be epoxied to the inner face of the PEM nut.

To begin with, we will assemble the tuning screw with its Nylon Sleeve and Tuning Knob,

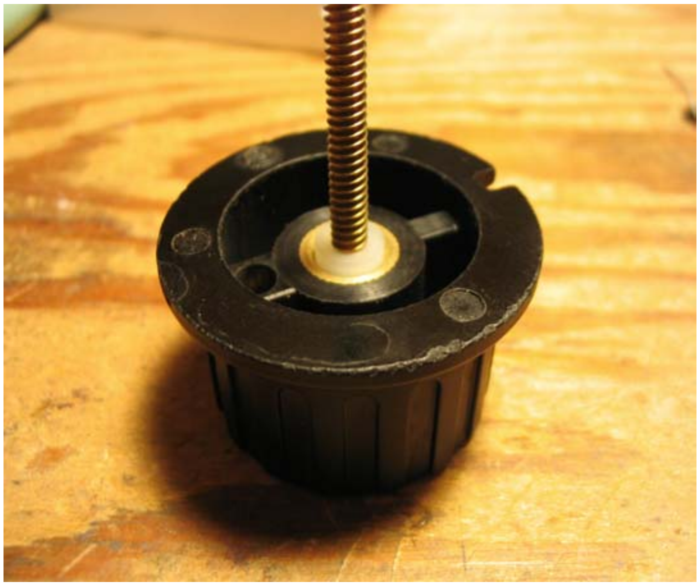
Because the head of the 6-32 brass screw will probably be too large to fit inside the ¼" shaft receptacle of the tuning knob, you will have the choice of either cutting the head of the screw off with a Hack Saw, or of reducing the diameter of the screw head with either a file or a grinder.

Whichever method you choose, it will be much easier to thread the Nylon Sleeve supplied in the kit onto the screw before either cutting the screw head off or reducing its diameter, as a screwdriver can be used to turn the screw while the Nylon Sleeve is held with pliers.

If you choose to reduce the diameter of the screw head, the Nylon Sleeve can be used as a guide for how much metal to remove, since it will fit in the ¼" shaft hole in the tuning knob.

Here is a photo of the tuning screw with Nylon Sleeve threaded on, and screw head reduced in diameter to fit in the ¼" shaft hole in the tuning knob.

The tuning screw is then inserted into the tuning knob, and its setscrew tightened down enough to prevent slippage of the Nylon Sleeve on the threads of the brass screw. This photo shows the tuning screw installed in the tuning knob.



Now that the tuning screw and knob are assembled, we will use it both to hold the rounded brass nut in place on the inner face of the PEM nut pressed into the rear of the front panel, and as a way to adjust the rounded brass nut's tightness, acting as a locknut, which provides us with the turning resistance to the tuning knob that we desire.

First, insert the tuning screw into the PEM nut from the front, screwing it in until the end of the tuning screw is sticking out of the inside face of the PEM nut about an eighth of an inch.

Then, using a small piece of heavy-duty aluminum foil or other material as a mixing basin, squeeze two small drops of epoxy resin, and hardener, respectively, into the mixing basin. For this operation, not very much is needed, so two drops of about 1/8" across, each, will be more than enough.

Take a look at the rounded brass nut provided. One flat face is smooth, and the other has a raised, sharp lip that was created by the lathe that was used to round it. When we have our epoxy resin and hardener mixed, we will apply just a little bit of epoxy to the smooth, flat face of the rounded nut, rather than the face with the raised, sharp edge, because we want the rounded brass nut to butt smoothly up against the rear face of the PEM nut.

Use a toothpick or other implement to mix the two parts of the epoxy. Stir it together enough that you are sure they are well mixed, and then use the toothpick or other implement to apply a light coating of epoxy to the flat, smooth face of the rounded nut.

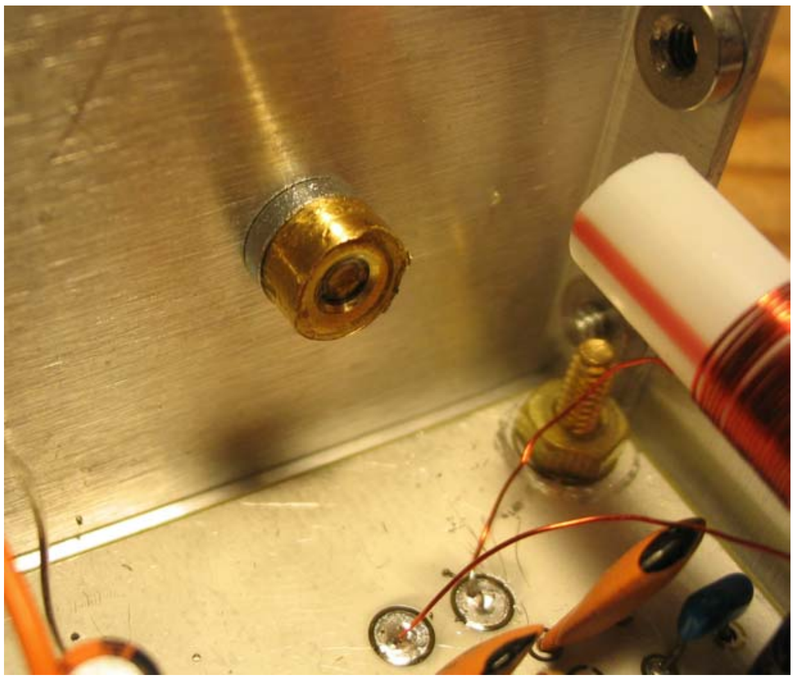
Try not to get epoxy onto the threads, or put so much on the face of the nut that it will be squeezed onto the threads of the tuning screw.

Then, setting the implement aside, take hold of the tuning knob with one hand and thread the rounded nut onto the protruding end of the tuning screw with the other, right up against the PEM nut.

Turn the tuning knob, while adjusting the tightness of the rounded brass nut up against the PEM nut, until you feel the desired amount of turning resistance.

Leave the tuning screw in place with its end just even with the inner face of the rounded nut, so that it will hold the rounded nut in place while the epoxy is allowed to set up. This will keep the rounded nut in position at the degree of tightness that you set it to.

Here is a picture of the rounded nut being held in place while the epoxy is allowed to set up.



Note that the rounded brass nut will also provide more of a mounting surface for the tuning coil than the PEM nut alone would have done.

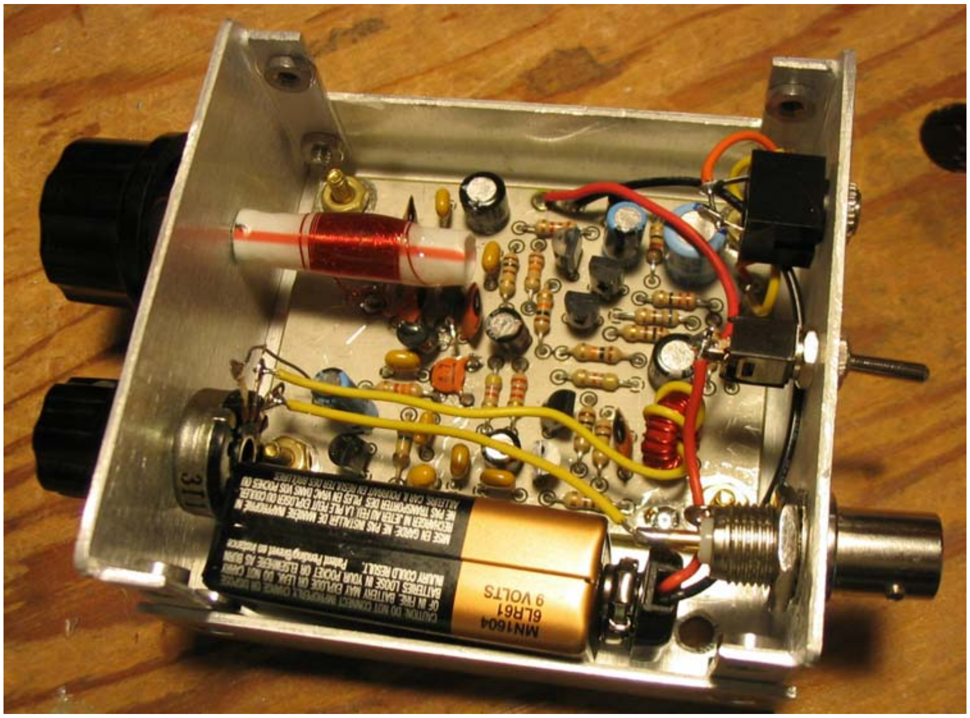
Once the epoxy holding the rounded brass nut in place has well set up, slip the open end of the straw, on which the tuning coil is wound, over both the rounded brass nut and the PEM nut, and align the tuning coil so that it is in line with the tuning screw.

This is most easily accomplished by turning the tuning screw all the way in, and positioning the unsupported end of the tuning coil so that the end of the tuning screw is centered in the coil form.

With the tuning screw and tuning coil now installed in their respective operating positions, it is time to install the smaller knob onto the shaft of the RF Gain pot. Do so, and tighten its setscrew.

With the DC power leads connected to the On/Off switch as directed, “down” is “Off” on the switch. Check that it is in the off position, and connect the 9 Volt Battery.

Below is a picture of the completed TinEar receiver.



Test and Alignment

Having made our safety check for short circuits, by taking an Ohm Meter reading from the 9V+ DC power pad to GND, on the PC board, and getting a reading somewhere around 130 Ohms, we are ready to apply power, check out the receiver, and adjust the tuning range by compressing or spreading the turns of L1.

First of all, we need an antenna.

While a full-sized 40 Meter dipole, even just a few feet off the ground, is ideal, this receiver works reasonably well with other types of resonant antennas, such as a shortened, coil loaded vertical and counterpoise, a trap vertical or dipole, or even as short an antenna as a Hustler whip, intended for a car, as long as the counterpoise is good enough to provide resonance.

The input of the TinEar is designed for a 50 Ohm coax connection, both because it made the overall design of the receiver simpler, and because it was thought that this little receiver could then be used with a simple, companion transmitter, in which case a resonant antenna would definitely be needed.

With the top of the TinEar case left off, and with the antenna and earphones connected, turn the power switch on. Background noise, at least, should be heard.

If you have access to a frequency counter, a reading taken at the junction of C5 and R3 will quickly tell you where you are, frequency wise.

Or, if you have receiver capable of tuning the 40 Meter band, turn it on and tune it to 7.000 MHz. You will be able to hear the VFO in the TinEar as you tune by that frequency.

If you have neither of the above, you can still adjust the tuning range of the TinEar receiver by means of tuning up and down through its complete tuning range, if necessary, and listening to what you hear.

Both below and above the 40 Meter band are commercial stations, voice and digital. At the bottom end of the band we should hear CW. Up from there, in frequency, we will hear digital signals, and then Lower Sideband Voice signals, with some commercial voice stations thrown in for good measure.

Knowing this, listen while you tune up and down through the entire tuning range of the receiver.

If you were able to hear CW at the upper end of the tuning range (tuning screw in), but couldn't tune high enough to hear any or very little Lower Sideband signals, the tuning range is too low, and the turns of the tuning coil need to be spread out.

If you were able to hear Lower Sideband signals, but couldn't tune low enough (tuning screw out) to hear any, or very little CW, then the tuning range is too high, and the turns of the tuning coil need to be compressed.

Ideally, one would adjust the turns so that the receiver tunes from above the Canadian National Standards station, CHU, which broadcasts on 7.335 MHz, to below the bottom of the 40 Meter band.

In assembling and testing several prototypes, it was found that most were absolutely rock solid, frequency wise, and some had a small amount of drift which settled down after the VFO "warmed" up for a little while, 20 minutes to half an hour in some cases.

This is testimony to the fact that building the circuit on a PC board introduces variables which have not been experienced when the same circuit is built on a solid copper substrate, "Ugly" style.

Once the tuning range of the TinEar receiver is adjusted, mix up enough epoxy to coat all of the turns of the tuning coil with a thin coating, and gently apply it with the toothpick or other implement, being careful not to either spread or compress the turns as you do so.

As the epoxy is being applied, and for a few minutes thereafter, it will be necessary to turn the whole unit so as to prevent the epoxy from dripping off the surface of the coil.

Once the epoxy has hardened enough to hold its shape, set the unit aside overnight to give it time to completely harden up.

After this is done, the object of which is to firmly prevent any movement of the tuning coil turns, through RF heating or any other way, any VFO drift should be at a very minimum, or gone completely.

Troubleshooting

Should your TinEar receiver not function as desired, don't give up. This is a pretty simple circuit, and it should be relatively easy to determine where the trouble is.

Generally speaking, the first culprit to suspect is your solder joints, particularly those that make the connections for the tuning coil, L1, and the secondary of the input transformer, T1, since those were to be made with the ends of magnet wire windings that should be scraped free of insulating material and tinned before being soldered into the board.

Visually, a poor solder joint around a magnet wire lead looks like what a balloon looks like when you poke your finger into it. The solder will look "indented" by the wire, rather than smoothly flowing up it, as it will do when the solder joint is a good one.

However, to start in the beginning, if you don't hear any signals when you tune through the tuning range of the receiver, try turning the RF gain all the way up, and then unplugging and plugging in the antenna, while listening carefully.

If you hear no difference at all with the antenna unplugged and then plugged in, no background noise, nothing, then check to be sure your battery is good, check with a voltmeter to see if you are actually getting power to the 9V+ pad on the PC board, check to be sure your earphones are working, and check your connections at the earphone jack.

If the audio circuits are working at all, you should hear clicking in the earphones when you carefully touch the blade of a small screwdriver to the left end of R10, on the board, or the right end of R9, and should hear a buzz in the earphones when you touch that screwdriver blade tip to the bottom end of R7 on the board (end nearest the battery), and an even louder buzz when you touch that screwdriver blade tip to the top of R3 (end furthest away from the battery).

In a normally working TinEar, there is just a barely discernable background hiss with the antenna disconnected, and an immediately great increase in background noise (and apparent signals) when the antenna is connected.

If touching a small screwdriver blade tip to the above described points produced the indicated sounds in the earphones, but there is no change in background noise level, and no signals heard while the VFO is tuned completely throughout its range, suspect that the VFO is not oscillating, in which case, the immediate suspect is the solder joints where the two ends of the tuning coil attach to the circuit board.

Here is where a friend with either an oscilloscope or a voltmeter with an RF probe can be of great help, in checking to make sure the VFO is indeed oscillating, by taking a reading from the Drain of Q1, taken on the end of L2 closest to Q1, where there should be 5 Volts, plus, RMS, of RF, or at the junction of C5 and R3, where there should be about 1.8 Volts, RMS, 5 Volts +, Peak to Peak of VFO energy.

Or, take a DC voltage reading on the Gate of Q1. When it is oscillating, you should read about –2.4 volts (a negative voltage is developed here, due to the oscillation process).

See the following Voltage and Resistance chart for approximate readings at various points in the circuit. Remember that your readings may vary somewhat, but should be reasonably close.

Voltage and Resistance Chart

Circuit Point	Resistance to GND	Diode Mode Resistance	RF Volts RMS	DC Volts
9V+ Pad	130 Ohms	.061	0	9.23 Volts
Q1 Drain	130 Ohms	.061	6.4 Volts	9.23 Volts
Q1 Gate	98 K Ohms	.718	2.7 Volts	-2.4 Volts
Q1 Source	0 Ohms	.000	0	0
R2-R5 Junction	218 Ohms			9.06 Volts
Q2 Drain	612 Ohms	.265		4.7 Volts
Q2 Gate	973 K Ohms	.881	2.0 Volts	.97 Volts
Q2 Source	532 Ohms	.264	1.0 Volts	2.4 Volts
Q3 Drain	532 Ohms	.264	1.0 Volts	2.4 Volts
Q3 Gate	0 Ohms	.000	0	0
Q3 Source	423 Ohms	.185	< .01 Volts	.99 Volts
Q4 Collector	4.78 K Ohms	.766		2.2 Volts
Q4 Base	151.4 K Ohms	.679		.67 Volts
Q4 Emitter	0 Ohms	.000		0
Q5 Collector	24 K Ohms	1.787		4.69 Volts
Q5 Base	4.65 K Ohms	.767		1.73 Volts
Q5 Emitter	773 Ohms	.319		1.07 Volts
Q6 Collector	2.3 K Ohms	.651		6.22 Volts
Q6 Base	14.13 K Ohms	1.192		5.34 Volts
Q6 Emitter	24 K Ohms	1.787		4.69 Volts
Q7 Collector	130 Ohms	.061		9.23 Volts
Q7 Base	2.3 K Ohms	.651		6.22 Volts
Q7 Emitter	14.56 K Ohms	.696		5.53 Volts
Q8 Collector	0 Ohms	.000		0
Q8 Base	24 K Ohms	1.787		4.69 Volts
Q8 Emitter	14.56 K Ohms	.683		5.37 Volts

NOTE: There is a very real difference in resistance readings taken from the various points if the digital Volt/Ohm Meter is in “normal” resistance mode as opposed to the Diode testing mode, as can be seen in the above chart. Although your readings may vary somewhat from those shown, the key point is that when taking readings around transistors there should be a different value read from each lead of the transistor, whichever mode is being used. As witness the readings taken from the Drain, Gate, and source of Q2 above. The charted values listed above were taken from the designated point, to Ground.

The individual junctions of a transistor can be checked using the Diode mode of the meter, as in from emitter to base, for instance, by first reading with meter lead polarity one way, and then reversing the leads. There should be a definite difference in readings.

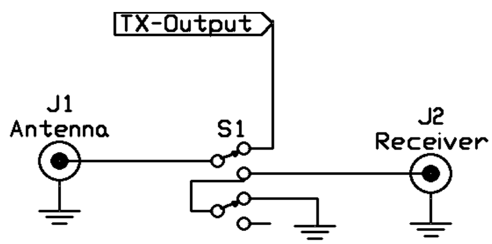
If you are having difficulty, there is nothing wrong with asking for assistance, either on line in one of the QRP forums, by email, or asking your closest “Elmer”. All of us are more than willing to help out.

Operational Considerations

The kit version of the TinEar receiver is designed for coverage of the 40 Meter band. However, with minor changes, specifically changing the number of turns on L1 and changing the inductance and capacitance values in the secondary of T1, it can be put on any of the lower HF bands, 160 through 30 Meters.

Prototypes have been used on 80, with 120 turns of #28 on L1, and with 470 pf for C8 and 29 turns on a T50-2 for the secondary of T1. For 30 Meters, 24 turns of # 28 on L1, 270 pf for C8 and 18 turns on a T37-6 were used.

A crystal controlled, simple transmitter has been used as a companion to the TinEar receiver by adding a Double-Pole, Double-Throw toggle switch and a second BNC connector to the output of the transmitter, as shown in the circuit below.



TinEar T/R Circuit
Physically Located In Transmitter

As wired, the switch both selects either the transmitter or receiver connection to the antenna, and grounds the receiver’s antenna line when “transmit” is selected. In this way the transmitted signal heard in the receiver is at a comfortable level at all but the highest RF Gain settings.

The transmitter used was an adaptation of the “Universal QRP Transmitter” described in “Solid State Design for the Radio Amateur”, and has an output of 1.5 Watts. If a higher output transmitter is used as a companion to the TinEar receiver, use appropriate care to turn the RF gain down before transmitting, as the higher the output power, the higher volume level the “sidetone” heard in the receiver is likely to be.

In operation, you will note that when the RF Gain is turned down just a bit from “full on”, the VFO frequency will be slightly shifted by the pulling effect the changes in loading have on the mixer. You will also note that if you use the TinEar receiver with a companion transmitter as noted above, the VFO frequency will be affected and pulled by the strong transmitter signal if the RF gain is left turned up to the higher levels. This effect is lessened if the RF Gain is set at the halfway point or below.

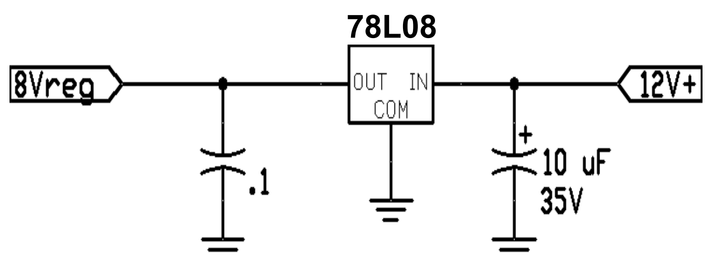
However, even with these idiosyncrasies and the fact that one has to turn the RF Gain down slightly and manually change the antenna over when it is time to transmit, the TinEar receiver and simple transmitter combination is fun to use.

From NB6M, in Concord, California, near San Francisco, contacts as far away as Houston, Texas, have been made with this combination on 40 Meters. Both stations in this contact were QRP, the simple transmitter putting out 1.5 Watts, and the Houston station running 3 Watts. While copy was not solid on either end, it was Q5 for most of the time and made for a very enjoyable and worthwhile QRP contact.

Voltage regulation was not built into the TinEar circuit itself because the prototypes were more than acceptably stable when run directly from 9 Volt batteries.

Should you care to operate the TinEar receiver from a 12 Volt power supply, or if varying battery voltages introduce more drift into the VFO than you find acceptable, one solution is to install a DC power jack in the rear panel of the case, and install the parts of a simple voltage regulator right on the contacts of the jack itself.

Below is a voltage regulator circuit that has been added to one prototype so that it could be operated from a 12 Volt power supply.



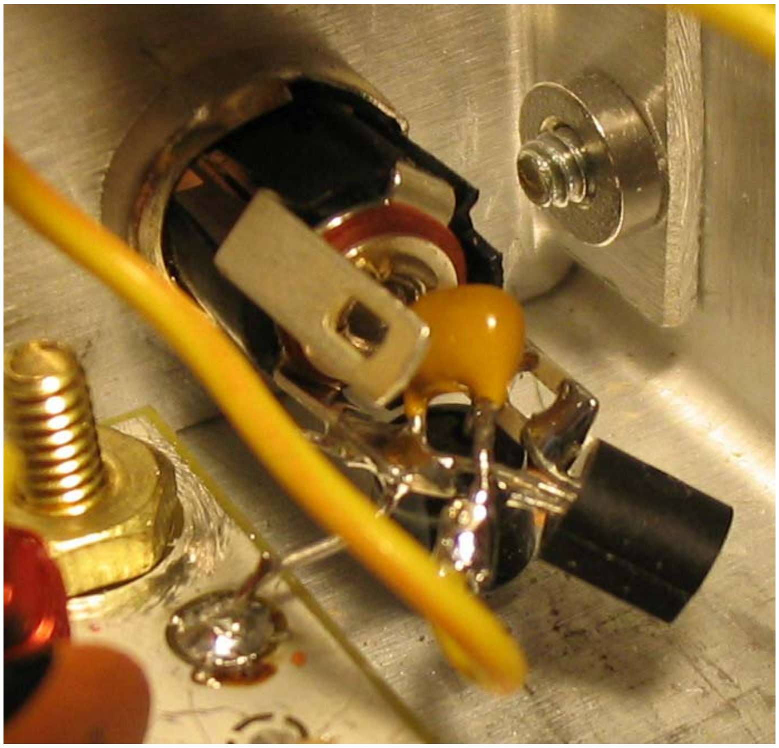
In preparation for its installation, the black wire from the battery connector was unsoldered from the PC board, and the red wire from the battery connector was unsoldered from the On/Off switch. A DC power connector was installed in the rear panel of the case, below the BNC connector.

The three-terminal regulator and its bypass capacitors were soldered directly to the contacts of the power jack.

All of the ground leads shown in the schematic above are soldered to the negative contact of the power jack. A bare part lead is run from there to the convenient, nearby PC board ground pad, and the top of the 10uF capacitor and the “In” lead of the 78L08 are soldered to the positive contact of the power jack.

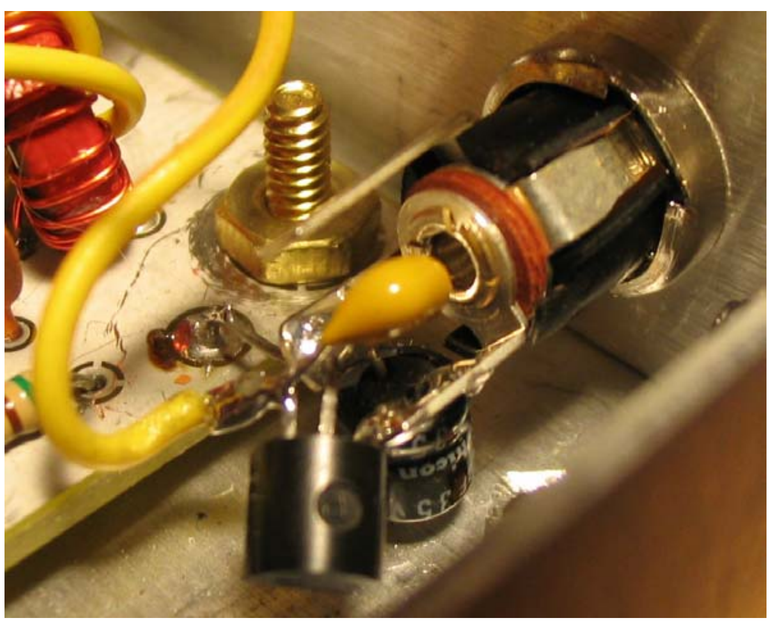
Note that the top of the .1 uF capacitor and the “Out” lead of the 78L08 are NOT connected to either of the power jack contacts. They are soldered together, and a wire soldered to them is run from there to the On/Off switch on the rear panel of the case.

The picture below shows the installation from one angle.



The bare wire soldered to the Negative contact of the power jack, and its connection to the nearby ground pad on the PC board can be clearly seen. The yellow, insulated wire is soldered to the junction of the "Out" pin of the regulator and its .1 uF bypass capacitor.

Here is a shot of the installation from another angle.



Conclusions

Ideas for the circuitry in this receiver came from the very excellent ARRL publication, “Experimental Methods in RF Design”, by Wes Hayward, W7ZOI, Rick Campbell, KK7B, and Bob Larkin, W7PUA. I would like to take this opportunity to express my thanks and appreciation to these outstanding designers for their continuing contribution to Amateur Radio, as well as for their generosity in freely sharing their knowledge with the rest of us. Any design flaws in this receiver are mine alone.

I would also like to thank Richard Fisher, KI6SN, for his assistance as a “Beta Builder” and his continued testing and evaluation of this project. For both of us, “Ugly” is definitely beautiful when it comes to building RF circuitry.

While the TinEar receiver is a simple, direct conversion design, unadorned with such refinements as audio filters or AGC, it is a nice little receiver. Its tuning range gives one a wide choice of signals to listen to. It can easily be modified for use on other bands, and can be used with a variety of QRP transmitters, including the Tuna Tin II and many others, to form a complete station.

It is our hope that by building and using the simple TinEar receiver, you will both learn more about the inner workings of receivers in general and have many hours of listening and operating pleasure.

Enjoy,

Wayne NB6M