K7QO's 5W 20m Assembly Guide

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by

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Contents

List of Figures

Preface

First of all let me tell you that, as implied by the title of this document, this is a guide. It is the way in which I constructed the 5W transceiver kit designed and kitted by Diz, W8DIZ, at KitsAndParts.com. This guide is not in any way intended to replace the online instructions but are for the aid of some builders that may need additional information.

I like to build any project in steps followed by a test or number of tests to make sure that the project will work upon completion. Yes, I can put everything on the PCB before even applying power one time and have a high success rate. But that is only because I would still take extra steps and care in assembly. Not every one is so inclined.

I recommend that you do not rush this project. It is not a race. You want the kit to work the first time and every time. You may not get that if you rush and get sloppy. Take your time and double check everything that you can.

This is not beginners project, but you can do it even if you are a beginner. You just need to do some extra research as you go. Be prepared and plan ahead.

I am building the 20 meter version in this document. I am using only a production PCB dated 20190611 (Jun 11, 2019) that should be the final board layout, but there are no guarantees. I have a board produced from Gerber files that I made up from the ExpressPCB layout from Diz and converted and then work done using Sprint Layout 6.0 from Germany.

Diz gave me a matched set of crystals and the binocular toroids. That is all that I have gotten from Diz for helping some with during the prototyping process that Diz did. That means that I am building this unit from my own parts. The photos will reflect that in there will be differences in the way some parts look from the ones you get with the kit. Be aware and pay attention. I had all the parts needed, but by Diz providing the matched set of his crystals, then my build should give the same performance values you are going to get. The crystal matching is one of the most critical set of component values necessary to get good results.

Today is Jun 20 2019 and I do not have the board in my possession at this time. That will be tomorrow morning. I am going to do the enclosure today (Thursday) and start the build tomorrow. My race is to get everything up and running by 1700UTC on Saturday June 22 2019 in time for Field Day 2019. I am going to attempt to complete WAS within 24 hours of operating (the 36 hour exercise period) on 20m using only 5W or less of power.

Let's get started and see how I do. Not failure but low aim is crime.

This kit becomes available to the general QRP population in mid July 2019, so if you reading this before that time then get ready to order from the web page. I recommend you go over and look at the links on the 5W web pages to join the mail reflectors to monitor all that is going on.

Monitor also any notes for errors on my part or changes in this document via frequent visits to my web page for this document and the reflector list for others that may have ideas.

Enjoy,

Chuck Adams, K7QO

P.S. OK, just got a text message from DHL that the package is arriving one day early from China, so today I will be able to get started on assembly and will try to work the enclosure in at the same time. I will put the enclosure work in a chapter at the end of this document. Also note, that as I go I will attempt to put datasheets in for the ICs and transistors for those that want to look at some more details.

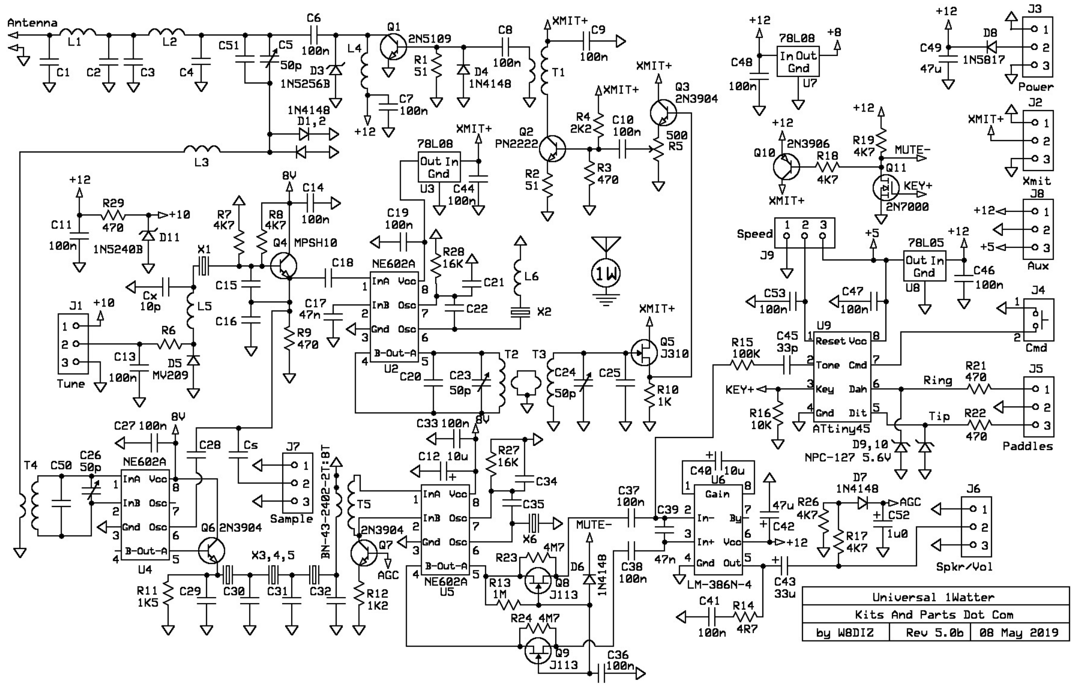
Chapter 1

5W Overview

The 5W is a follow on from the 1W (one watter) kit from Diz. If you have not built a 1W, then take the time to go to YouTube.com and see my series on building the one watter and look at the web pages at www.kitsandparts.com to get the details.

The 1W schematic, block diagram and PCB images taken from the web pages at kitsandparts.com are shown on the following pages for reference here to save you some time in going online. Hope that Diz doesn't mind.

The 1W was done for all ham bands from 160 meters to 10 meters, so the schematic has all the band dependent values shown in a table at the bottom of the page. If you have problems displaying the material in fine detail, then go to the web pages and download and print off the full size schematic for your own files.



	C1	C2	C3	C4	C15	C16	C18	C20	C21	C22	C25	C28	C29-32	C34	C35	C50	C51
160	1800	1800	1800	1800	470	470	4P7	120	330	100	180	43	680	180	180	120	100
80	1000	1800	-----	820	47	220	2P2	150	390	220	220	12	680	180	220	180	56
40	470	470	470	470	68	100	1P0	68	100	100	68	3P0	680	270	220	100	---
30	330	330	330	330	100	100	1P0	---	100	100	56	4P7	680	180	180	---	---
20	220	470	-----	220	100	470	3P0	22	100	100	56	22	470	100	100	---	---
17	180	390	-----	180	100	100	1P0	---	220	220	47	4P7	470	100	43	---	---
15	150	330	-----	150	47	100	1P0	47	220	220	47	3P0	680	120	68	---	---
12	120	270	-----	120	27	51	1P0		220	220	33	3P0	470	150	51	---	---
10	120	120	120	120	47	56	1P0	43	220	220	43	3P0	680	120	68	---	---
20	220	220	220	220	33	47	1P0	100	100	100	120	3P0	680	150	120	---	---

	L1-2	L3	L4	L5	L6	T1	T2	T3	T4	X1	X2-6	R6
160	T37-1:23	FT37-61:34	FT37-43:18	FT37-61:20	T37-2:23	FT37-61:20:4	FT37-61:18:2	FT37-61:2:30	FT37-61:4:31	8.192	10.0	100K
80	T37-1:17	FT37-61:20	FT37-43:14	FT37-61:13	T37-2:13	FT37-61:15:3	T37-1:30:1	T37-1:1:30	T37-1:4:31	13.56	10.0	100K
40	T37-2:17	FT37-61:20	FT37-43:10	T37-2:27	T37-2:18	FT37-61:10:2	FT37-61:7:1	T37-2:2:32	T37-2:4:30	23.04	16.0	4K7
30	T37-2:14	FT37-61:17	FT37-43:10	T37-2:33	T37-2:24	FT37-61:10:2	T37-2:32:2	T37-2:2:25	T37-2:4:32	22.118	12.0	4K7
20	T37-7:13	FT37-61:12	FT37-43:10	FT37-61:23	FT37-61:12	FT37-61:10:2	T37-7:20:1	T37-7:1:20	T37-7:4:28	8.064	6.00	100K
17	T37-6:12	FT37-61:10	FT37-43:10	T37-2:33	FT37-61:17	FT37-61:10:2	T37-6:24:1	T37-6:1:18	T37-6:3:21	22.118	4.032	4K7
15	T37-6:11	T37-2:30	FT37-43:10	T37-2:35	T37-2:18	FT37-61:10:2	T37-6:16:1	T37-6:1:16	T37-6:3:24	13.00	8.064	4K7
12	T37-10:11	T37-2:27	FT37-43:10	T37-2:32	T37-2:31	FT37-61:10:2	T37-10:13:1	T37-10:1:15	T37-10:3:24	20.00	4.915	4K7
10	T37-10:10	T37-2:24	FT37-43:10	T37-2:25	T37-2:18	FT37-61:10:2	T37-10:15:1	T37-10:1:15	T37-10:3:21	20.00	8.064	4K7
20	T37-7:13	FT37-61:12	FT37-43:10	T37-2:33	T37-2:18	FT37-61:10:2	T37-7:16:1	T37-7:16:1	T37-7:4:28	22.118	8.064	4K7

Figure 1: 1W schematic.

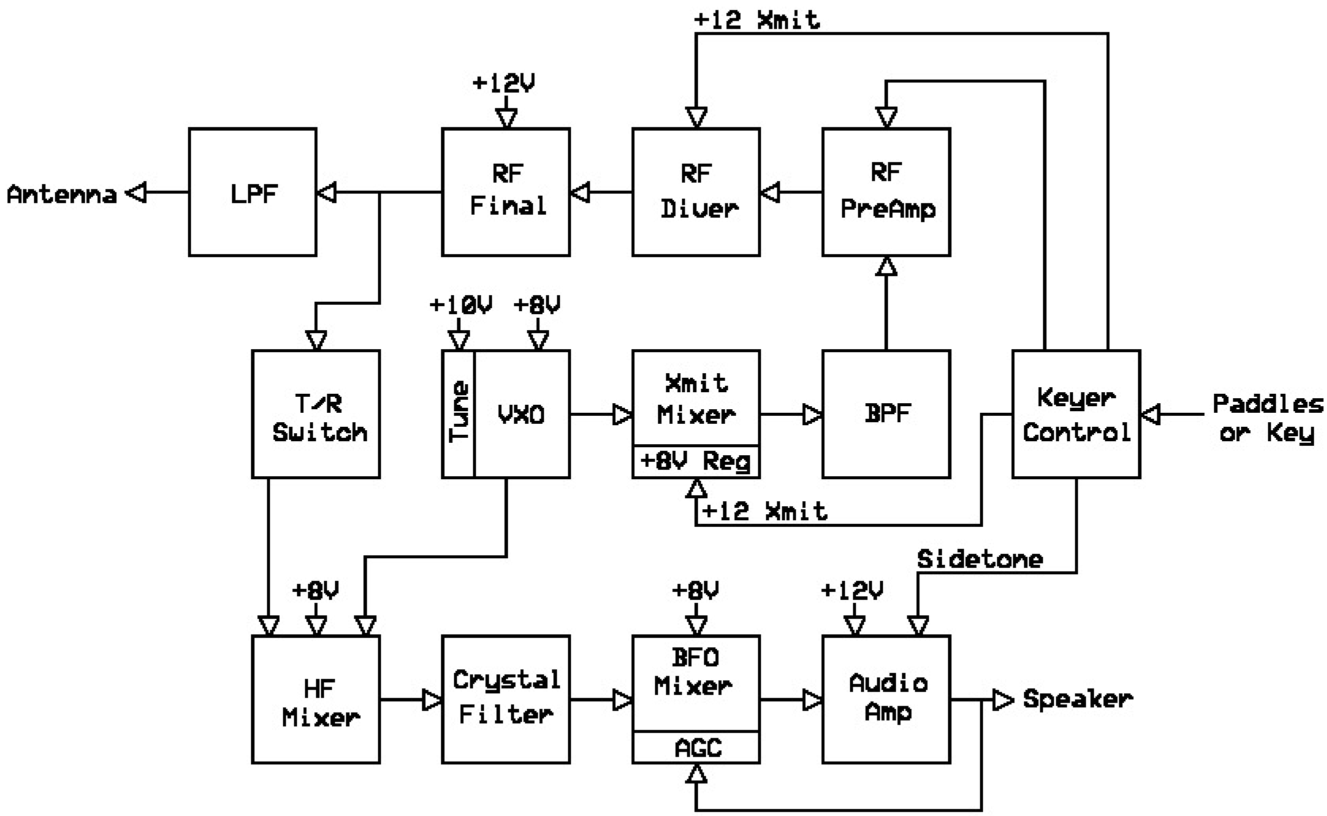


Figure 2: 1W block diagram.

Even though this is the block diagram for the 1W, it is also the block diagram for the 5W. The 5W just has a dual transistor push-pull RF power amplifier to get more power out. So, I will be using this along with the building of the 5W and showing each section as it is built, the components and how to test as we build.

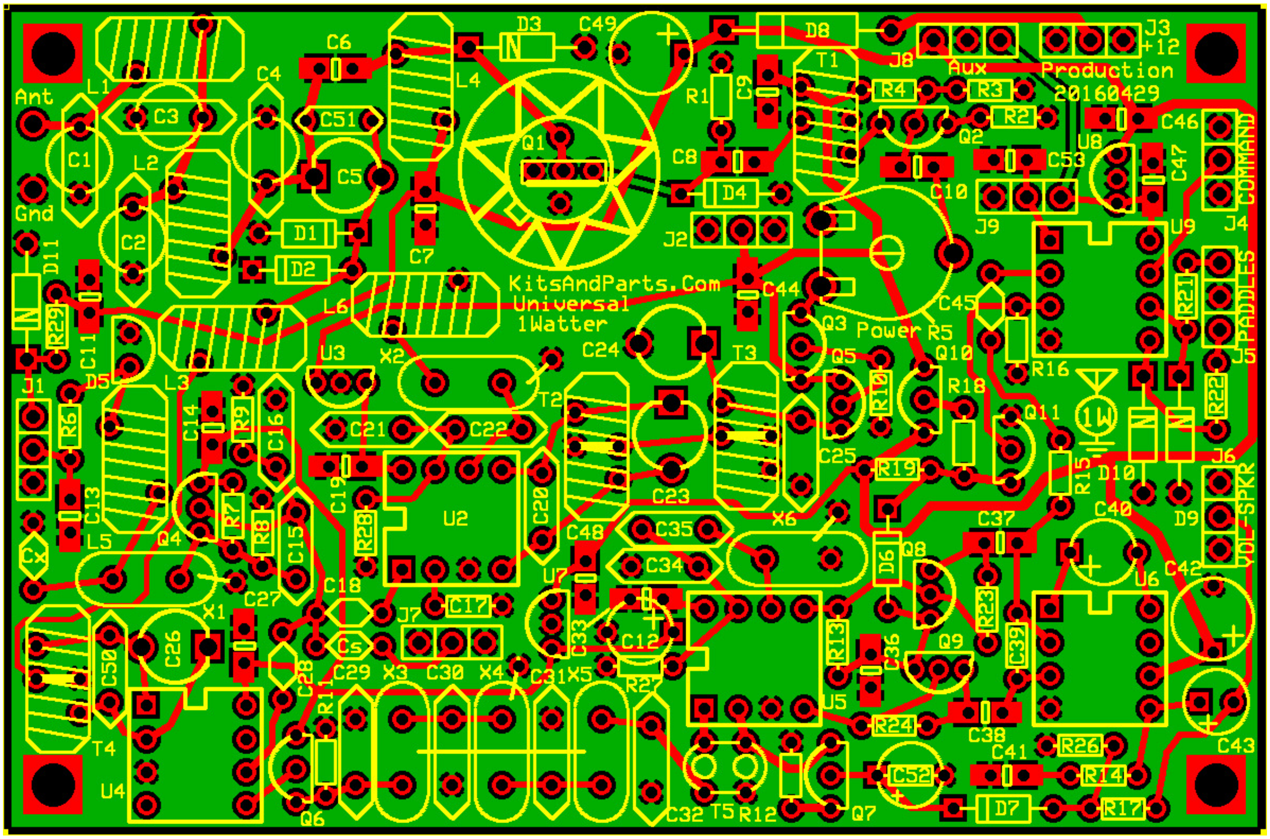
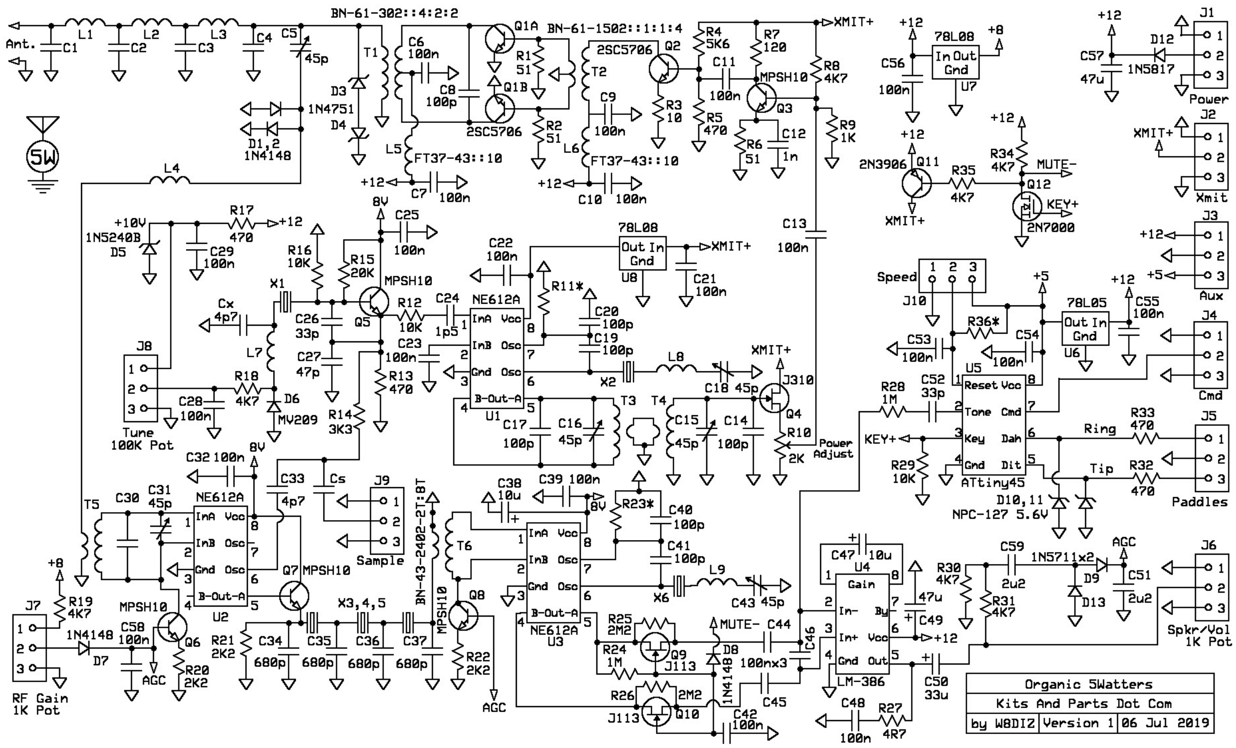


Figure 3: 1W PCB image.

The above image is taken from KitsAndParts.com web page for the last board revision shown for the 1W 20 meter version (1W20) kit.



Band	C1	C2	C3	C4	C30	L1	L2	L3	L4	L7	L8	L9	T3	T4	T5	X1	X2.3.4.5.6
17M	180p	390p	390p	180p	----	T50-10:11	T50-10:11	T50-10:11	FT37-61::10	T37-2::29	FT37-61::26	FT37-61::26	T37-10::16:1	T37-10::1:16	T37-10:4:28	22.1184	4.032
20M	220p	470p	470p	220p	----	T50-6:13	T50-6:13	T50-6:12	FT37-61::14	T37-2::31	FT37-61::20	FT37-61::20	T37-6::16:1	T37-6::1:16	T37-6:4:28	22.1184	8.064
30M	330p	680p	680p	330p	33p	T50-7:13	T50-7:13	T50-7:13	FT37-61::17	T37-2::28	FT37-61::15	FT37-61::15	T37-1::16:1	T37-1::1:16	T37-2:4:28	22.1184	12.00
40M	470p	1000p	1000p	470p	100p	T50-2:15	T50-2:15	T50-2:15	FT37-61::20	T37-2::30	FT37-61::10	FT37-61::10	FT37-67::14:1	FT37-67::1:14	T37-2:4:31	23.04	16.00

Figure 4: 5W schematic version 1.

This is the schematic for the 5W as shown on the web page as of Jul 9th 2019. It may change from time to time and I may not have updated this figure.

Some changes have been made to other parts of the circuit in addition to the 5W PA (RF power amplifier) section to give the 1W more power out. The two that I love the most have to do with the second receiver mixer, the beat frequency modulator (BFO), and the transmit mixer.

In the receiver, X6, L9 and C43 allow you to adjust the BFO frequency to get the tuning you want in the IF bandpass. This allows you to fine tune the audio out (including the narrow noise bandpass) for what you prefer. In the 1W you had to fiddle with the winding count on the toroid if you wanted to change things. Variations in the crystal frequency in the circuit gave different rigs different characteristics of sound.

In the transmitter, X2, L8 and C18 adjust the transmitter offset frequency from the VXO and thus the actual transmit frequency output from the transmitter and your on the air transmit frequency. This results in an offset from your receiver frequency, thus you can adjust your transmit monitoring frequency (with keyer generated tone off) to your comfort range and if you tune in a received station to the same tone you will be on his/her frequency as close as you can match the two tones. This should increase your capture rate for starting QSOs by calling a station, if the other CW station is in the know also.

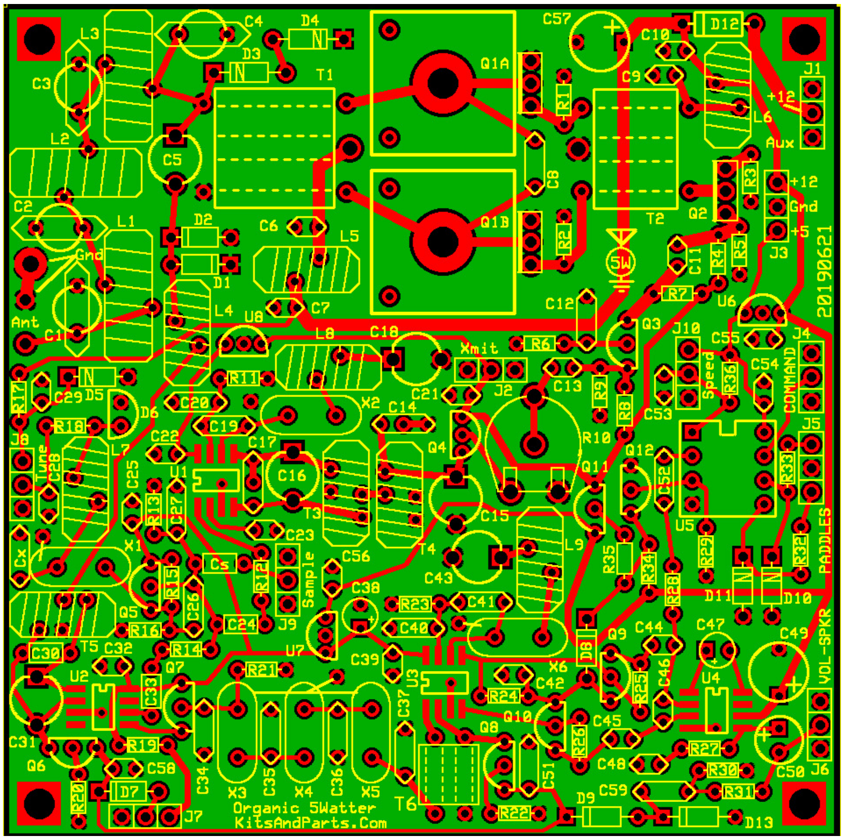


Figure 5: 5W PCB image.

Here is the production image dated 20190622 from the under construction page generated by Diz. The board shown in this manual is one rev before this one and varies only is some cosmetic changes and slight change in placement of some parts. Not enough for us to worry about. Just monitor where things are on your board.

The board is 89mm by 89mm in size and, as you can easily see, the parts density is pretty high. This is another reason I build in stages and hopefully I have the parts lists in order that you avoid tight spaces in installing parts. I install the SMD IC parts first before installing the parts in the immediate area. At least that is the plan.

1.1 Phase 1 — Power Supply

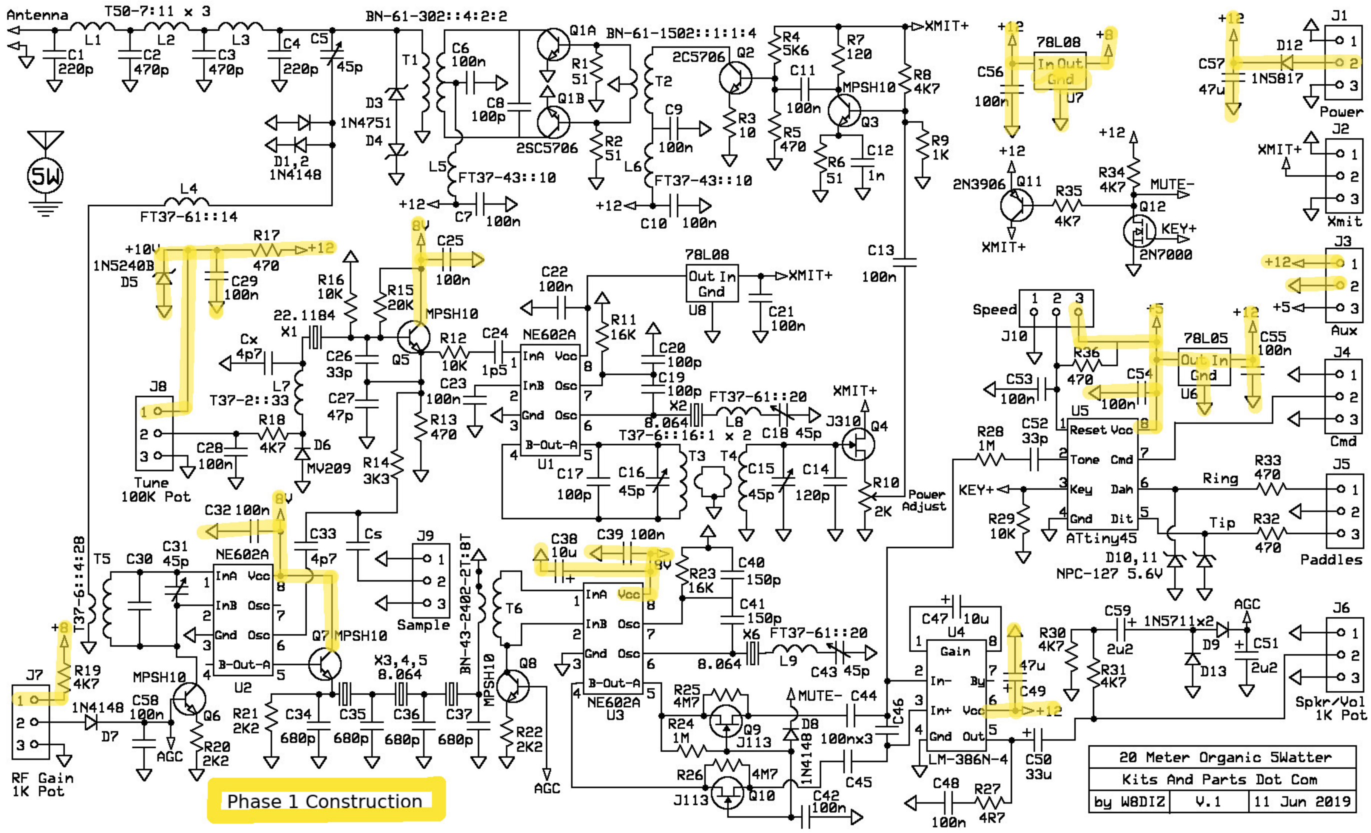


Figure 6: Phase 1 highlighted components.

I am going to build in sections and I will call each new section a phase.

Phase 1 will be the parts needed to provide the voltage needed by most sections. I have omitted C21, U8 and C22 here, although I could have easily included them, as they are not activated until we get the keyer and keying sections installed.

We will install these and then power up the transceiver to test things out. You may think this is too much trouble, but it provides us with proof that our power supply is going to work and that we are not going to fry the keyer IC by installing voltage regulators in the wrong place.

1.2 Phase 2 — Audio Amplifier

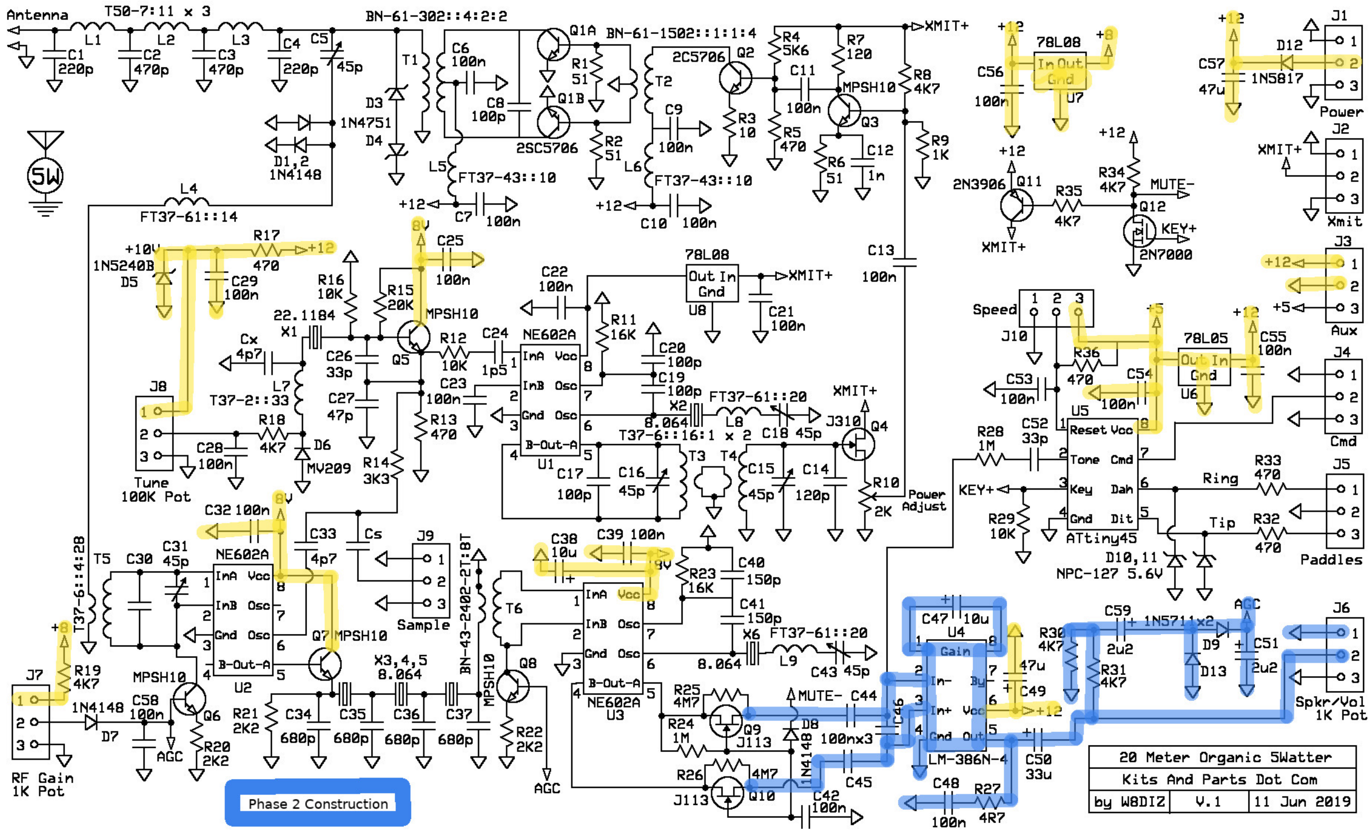


Figure 7: Phase 2 installation in blue.

Phase 2 will have us installing the audio section. The reason for starting with this section is that for builders that do not have a large supply of test equipment, you can get this transceiver built without too much else. Any additional test equipment you may have will be helpful and gather more data along the way.

Oh. How about taking data in a lab notebook for this transceiver that is to stay with the rig as long as they both exist. This will aid you in debugging things now or later in life. Also, make a copy and give/sell it with the rig, if it should change hands. It becomes a part of your legacy and history of the rig.

1.3 Phase 3 — Keyer and Keying Sections

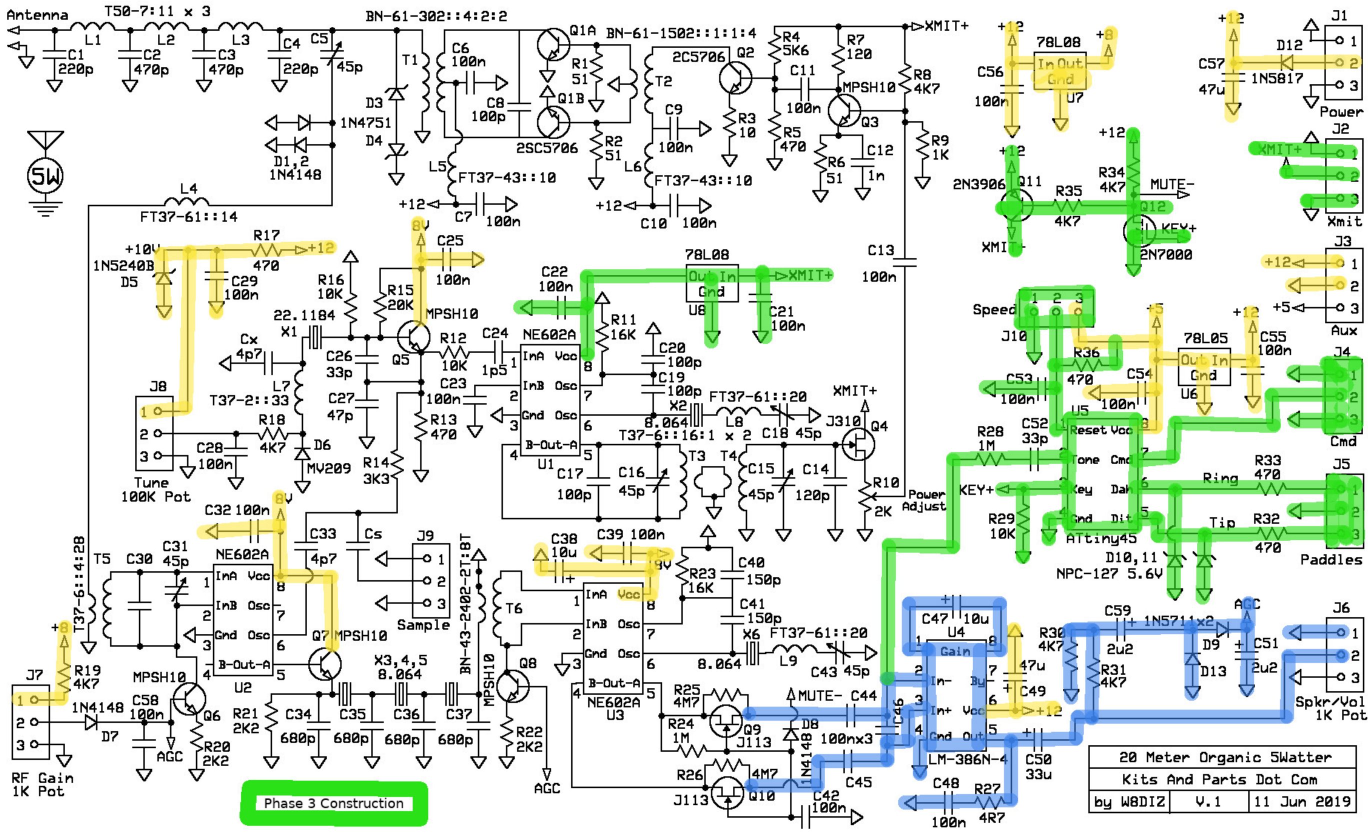


Figure 8: Phase 3 installation in green.

Here we install the keyer and keying interface sections. This will allow us to use the keyer later to test stages in the transmitter. We will in testing this phase use it to test the operation of U8 to turn on the transmitter signal chain.

1.4 Phase 4 — AGC, BFO and Muting Sections

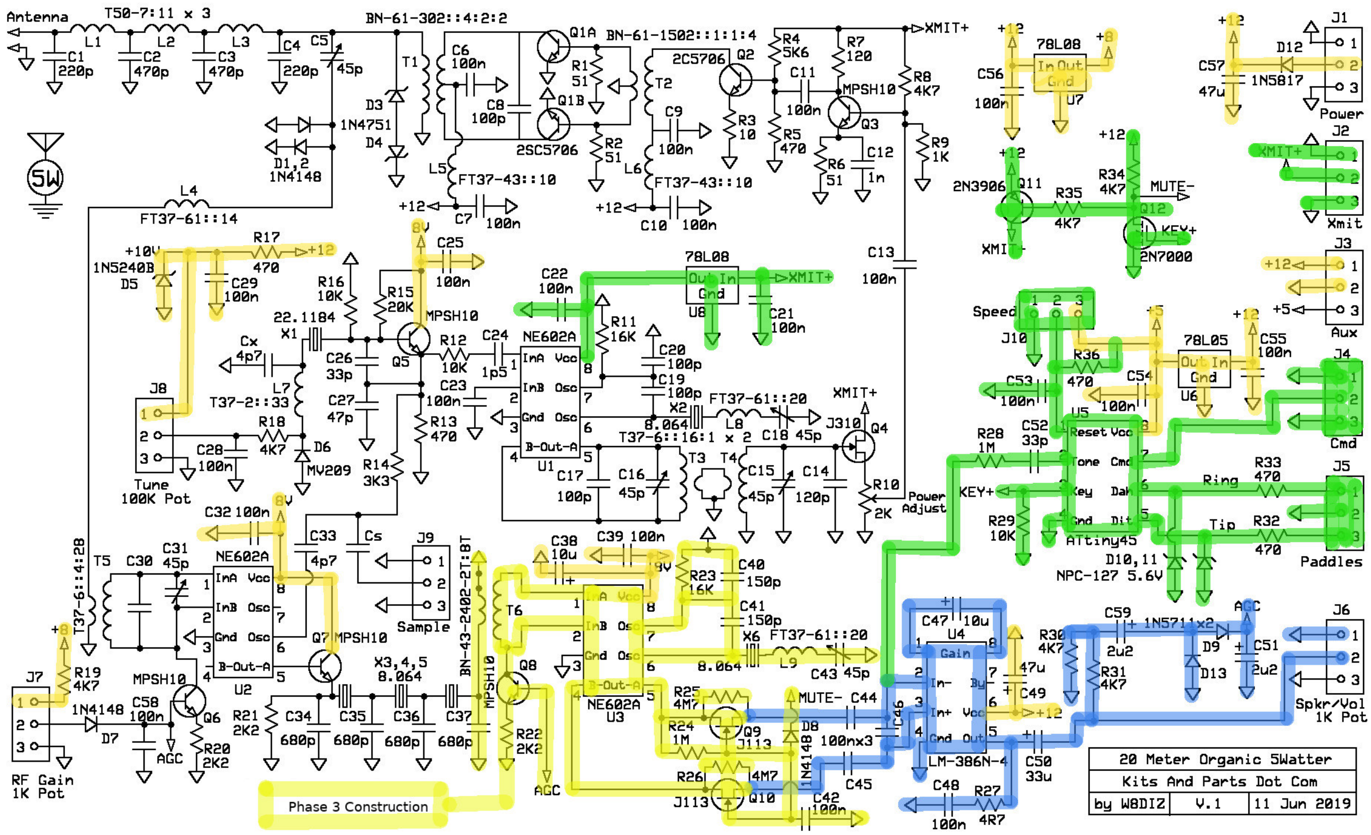


Figure 9: Phase 4 installation in yellow.

Phase 4 will be the installation of the second receiver mixer, a.k.a. the beat frequency oscillator (BFO). This section takes signals that have been converted to the IF bandpass frequencies and mixes them with the local oscillator frequency generated by X6 in the circuit and outputs the audio results through pins 4 and 5.

The resulting audio passes through the muting circuit using Q9 and Q10 which mutes the audio when in transmit mode and some signal passes through using R25 and R26. This small signal that passes through during transmit allows us to monitor our signal when it is active. The so called natural monitor or tone.

Also there is AGC action using Q8 with the AGC level passed from the audio circuit. For strong input signals from the antenna into the receiver signal chain, the feedback from the audio output sections can attenuate the signal by unbalancing the balanced input into U3 by control of Q8.

Chapter 2

Phase 1 — Power Supply

We will begin building the 5W transceiver by starting with just those elements of the circuit related to supplying power to other sections. This may seem like a trivial step, but I find that by making sure my power supply and connections to the PCB are solid and that all the proper voltages are supplied by the right regulator. Nothing would be more more of an insult than having the wrong voltage destroy a number of components.

First thing to do is always install stand offs, either metallic or plastic, to the four mounting corners of the PCB. I use metric screws and use M3 screws with M3 5mm length brass standoffs. This gives me an additional ground path for the transceiver to the enclosure mounted jacks and terminals.

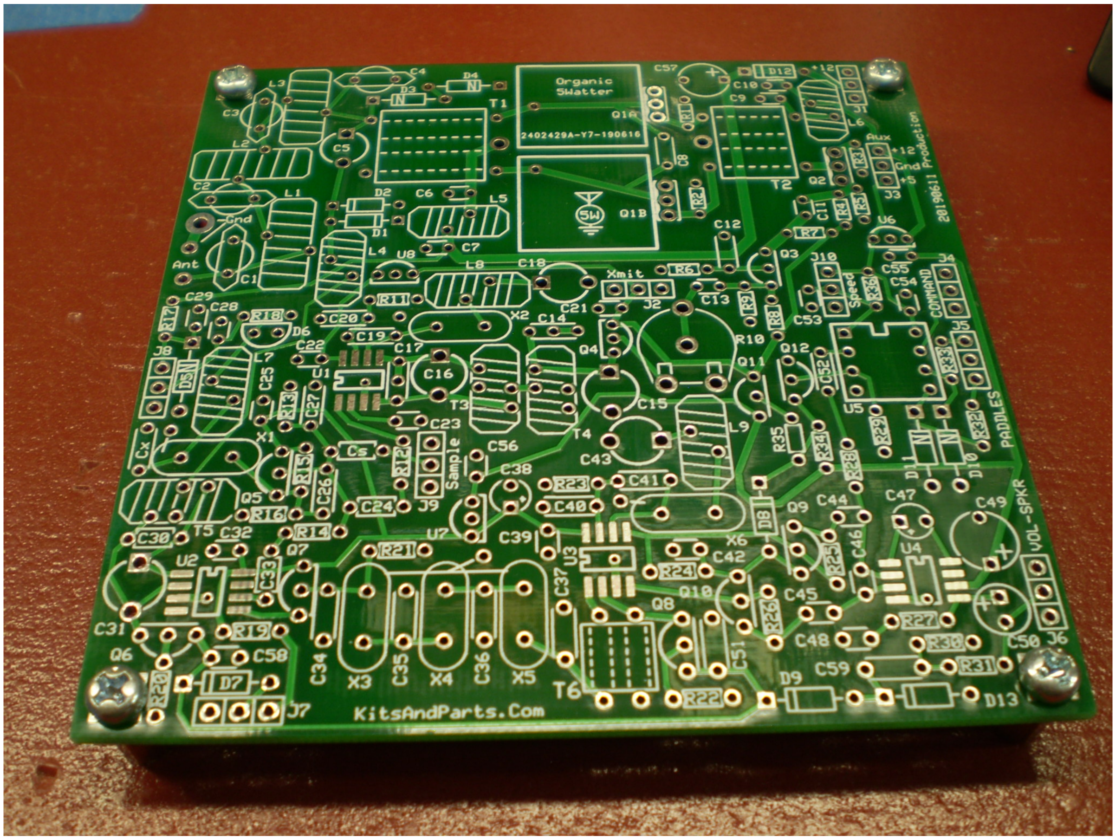


Figure 10: Standoffs mounted on the corners.

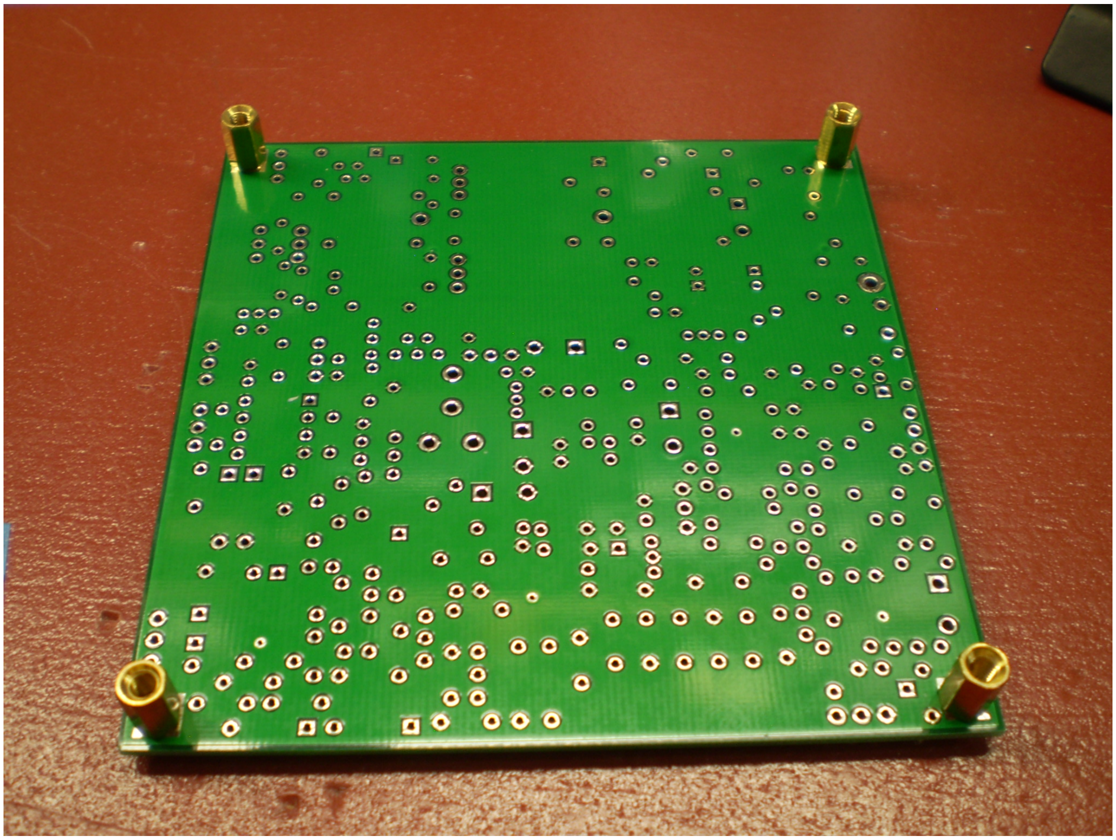


Figure 11: Bottom view showing brass standoffs.

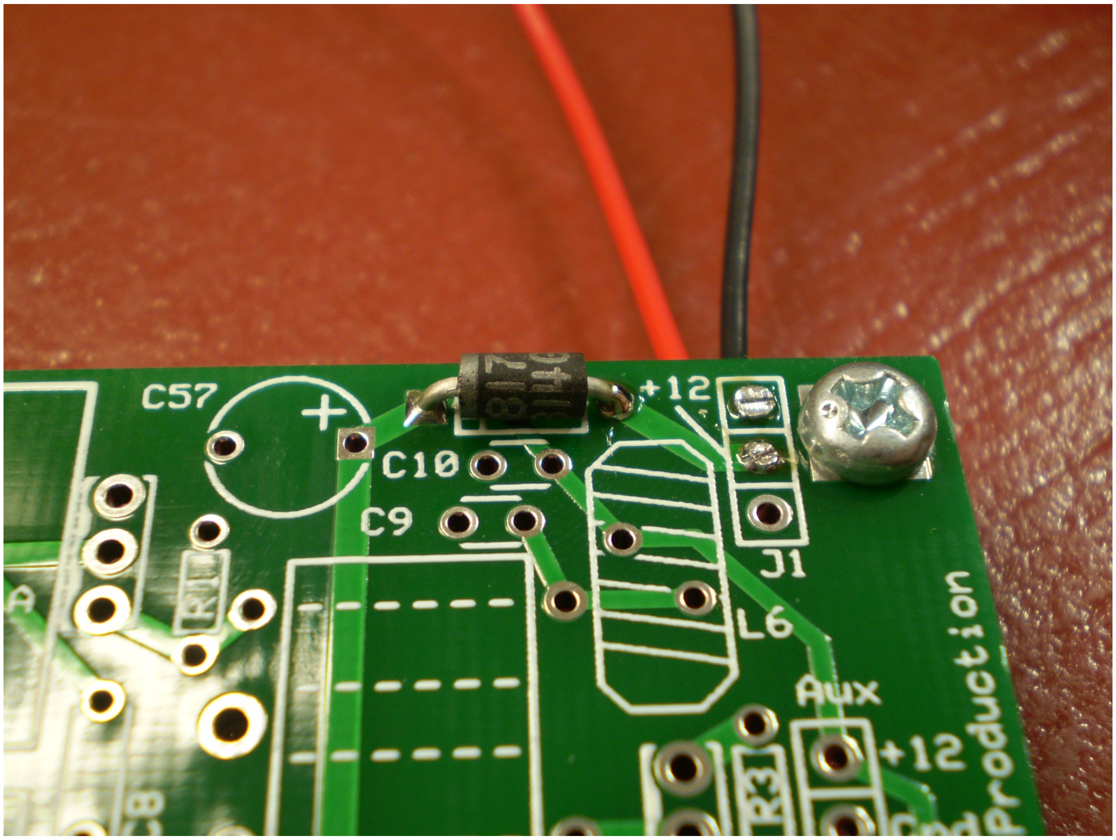


Figure 12: Power supply wires and D12.

- D12 — 1N5817 Schottky diode
- +12V and -12V wires (red and black) to battery

Since I almost never use headers, I connect my wiring from the bottom of the PCB to make a cleaner installation for routing wires. Just a personal thing.

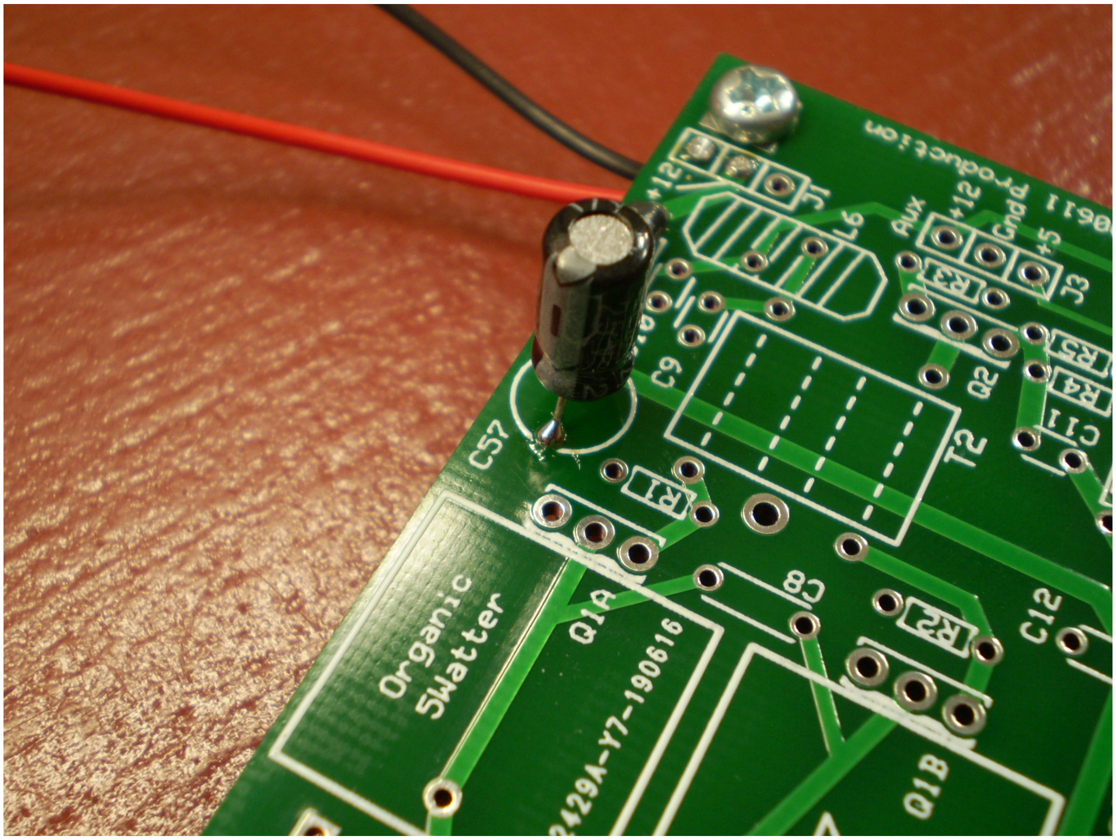


Figure 13: C57.

- C57 — 47μF electrolytic capacitor

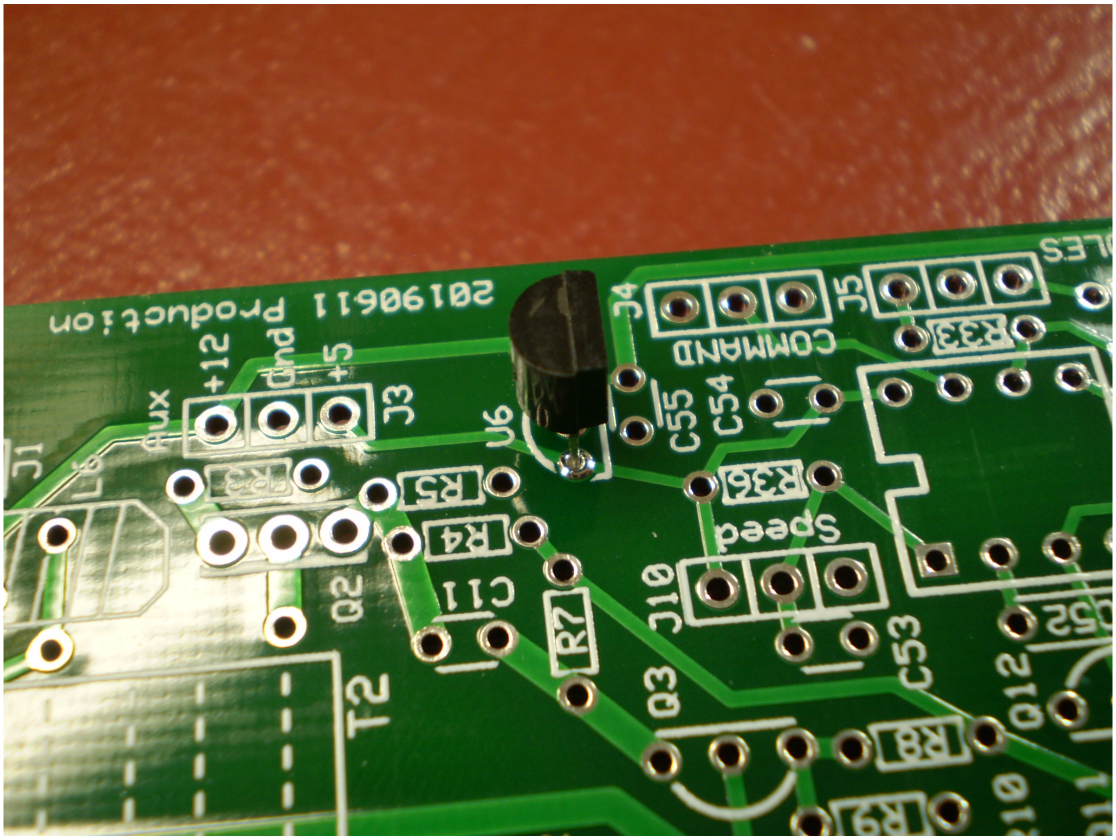


Figure 14: U6.

- U6 — 78L05 5V regulator

This regulator is used only for the microprocessor and must be the correct one. Double check the labeling on the part before installing.

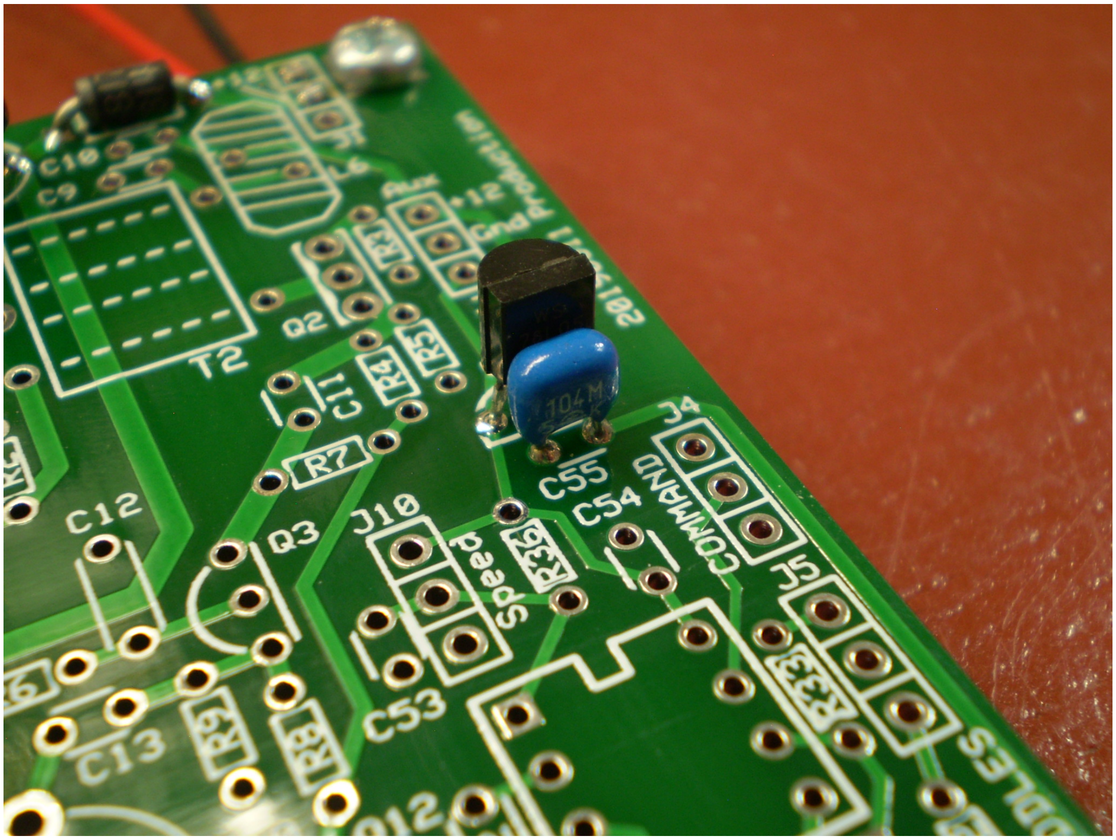


Figure 15: C55.

- C55 — 100n mono capacitor

As noted in the beginning, this is a part from my supply. I got a bunch of these over 20 years ago. They were made by Corning and no longer available.

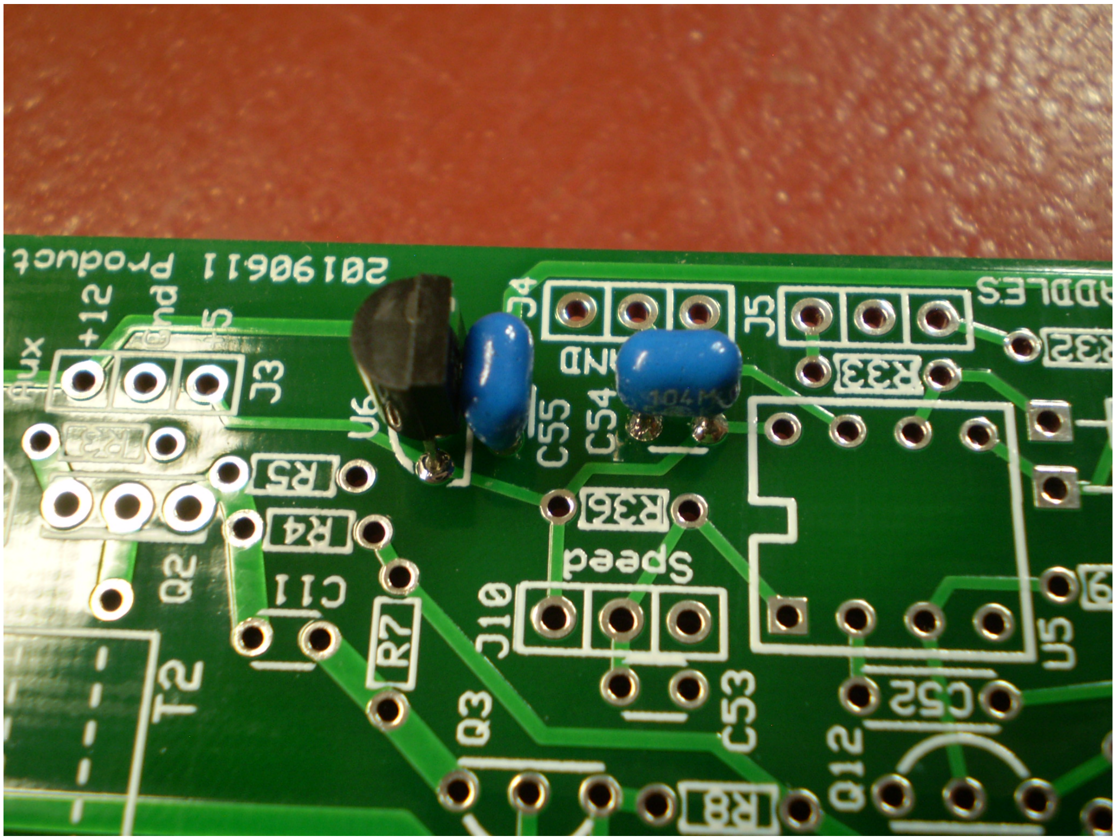


Figure 16: C54.

- C54 — 100n mono capacitor

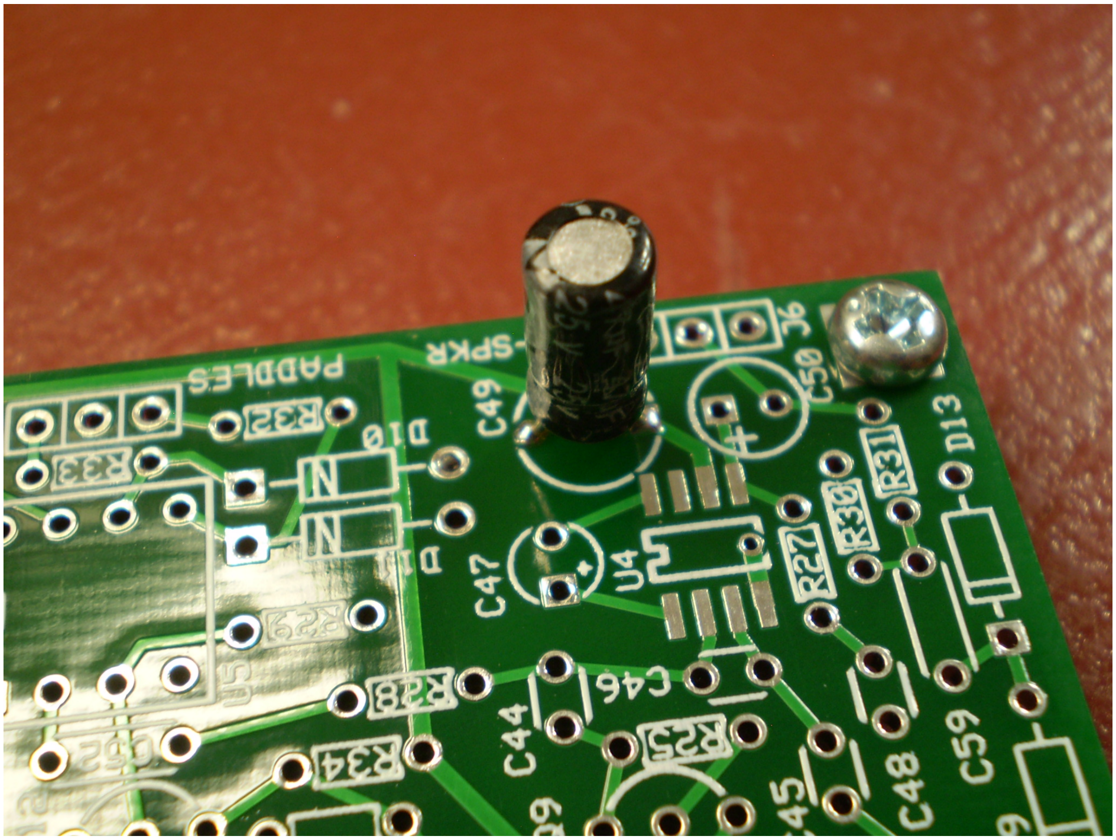


Figure 17: C49.

- C49 — 47μF electrolytic capacitor

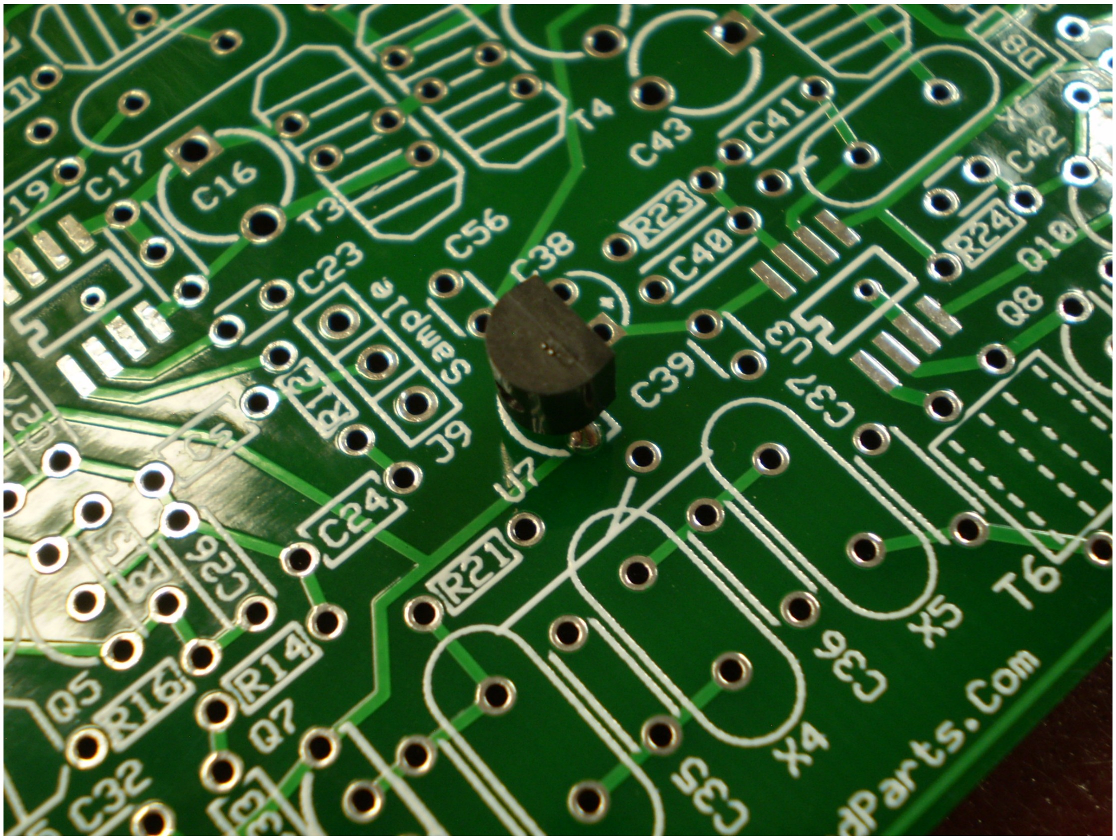


Figure 18: U7.

- U7 — 78L08 8V regulator

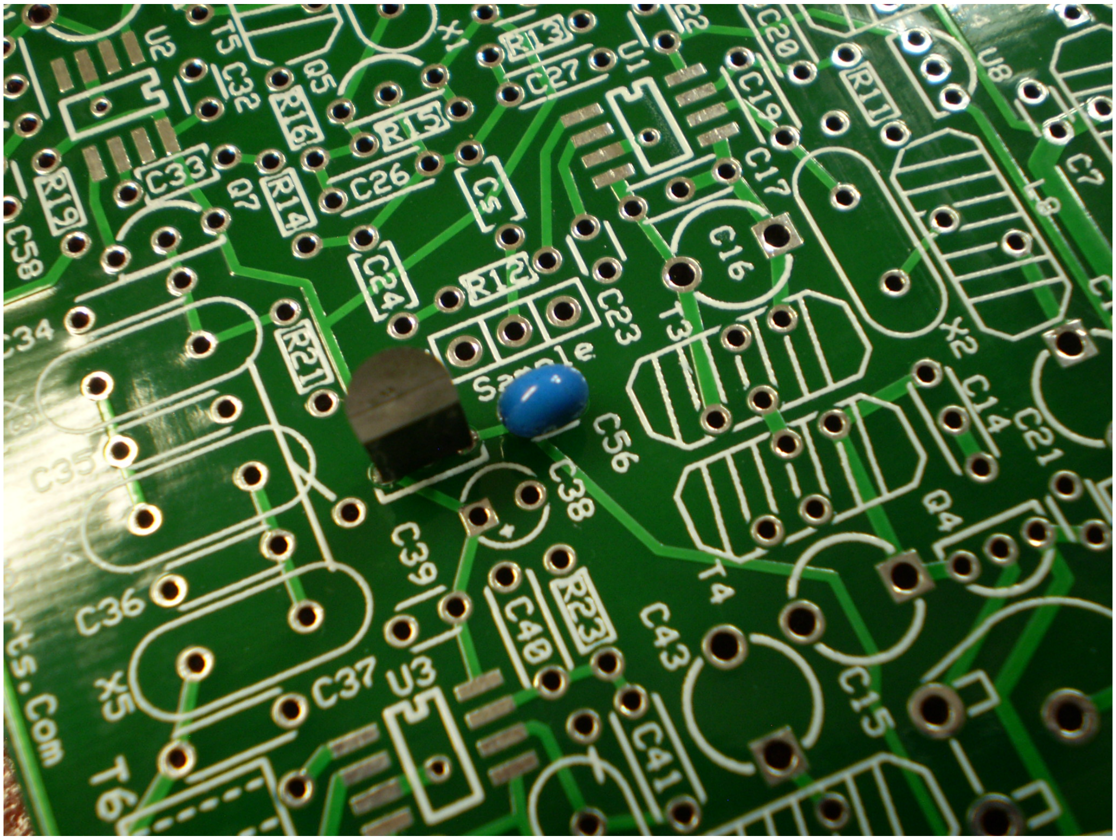


Figure 19: C56.

- C56 — 100n mono capacitor

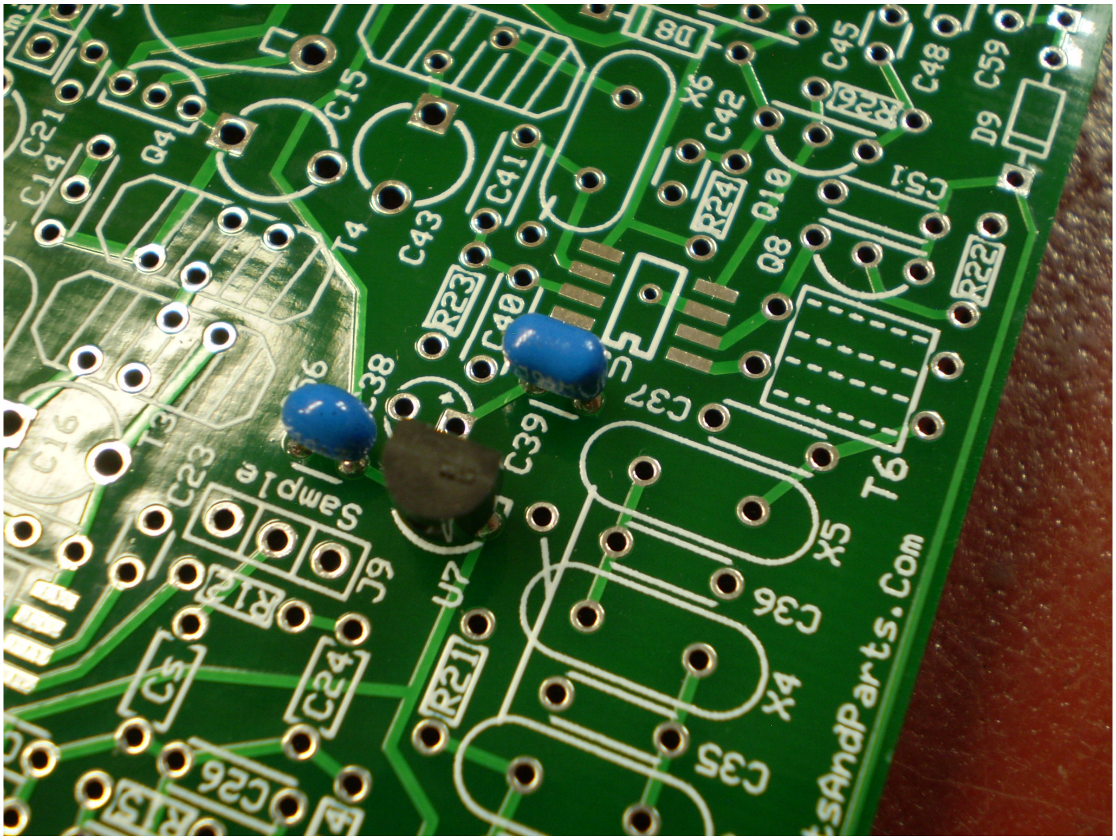


Figure 20: C39.

- C39 — 100n mono capacitor

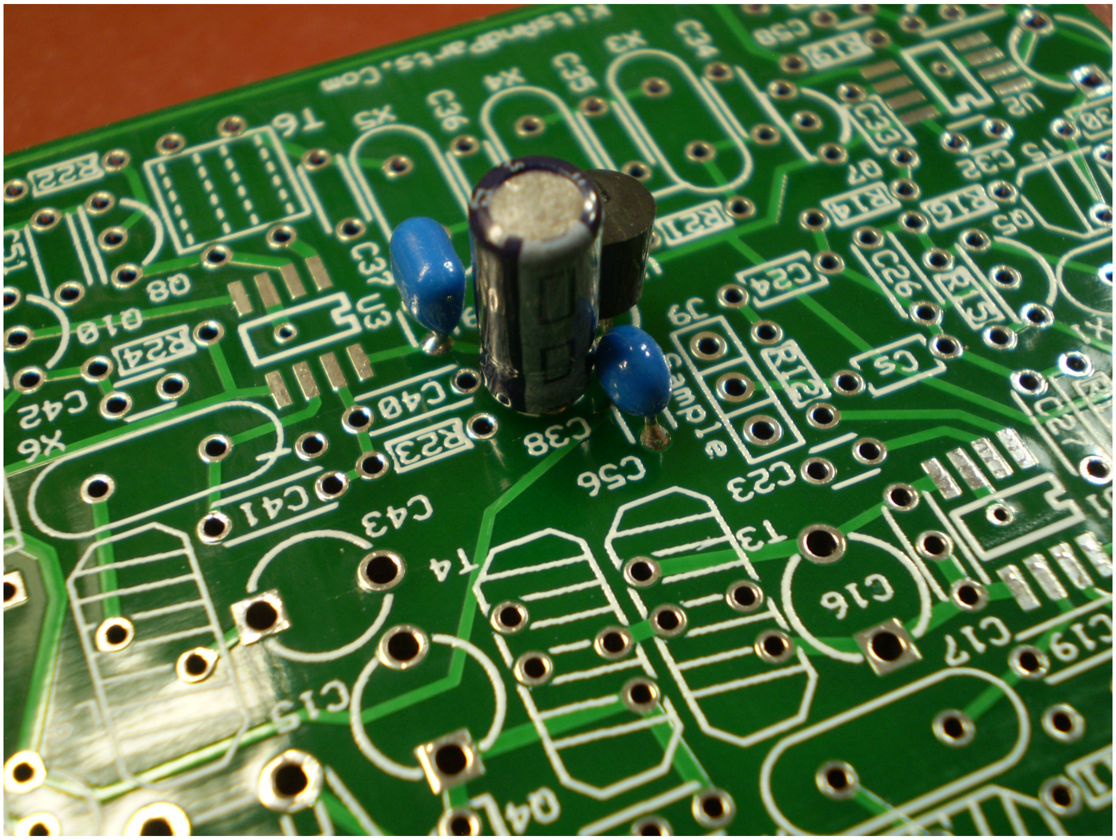


Figure 21: C38.

- C38 — 10μF electrolytic capacitor

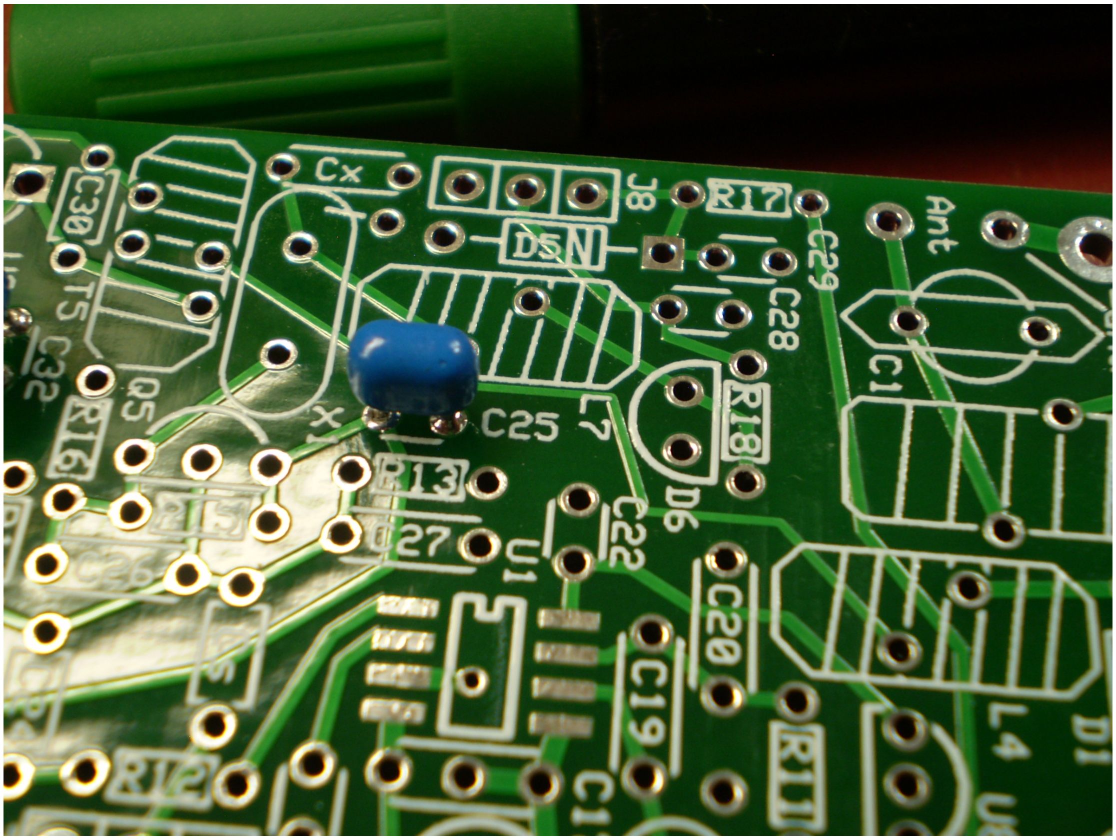


Figure 22: C25.

- C25 — 100n mono capacitor

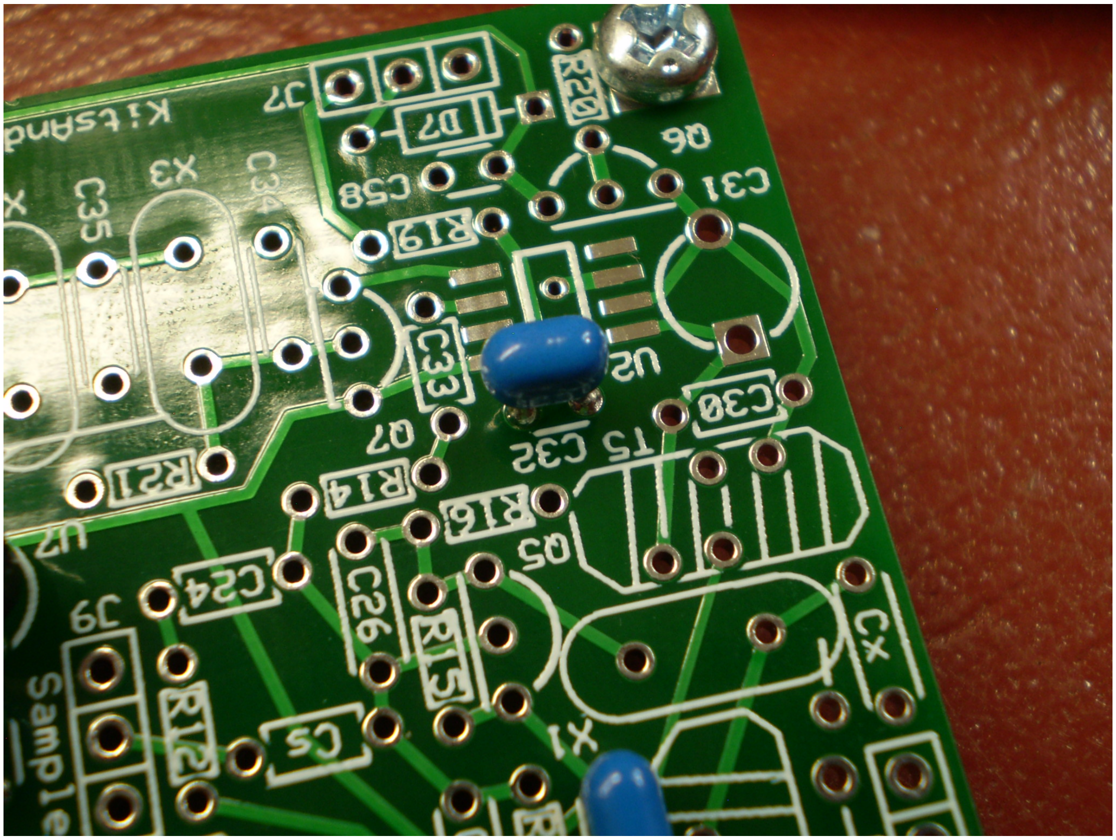


Figure 23: C32.

- C32 — 100n mono capacitor

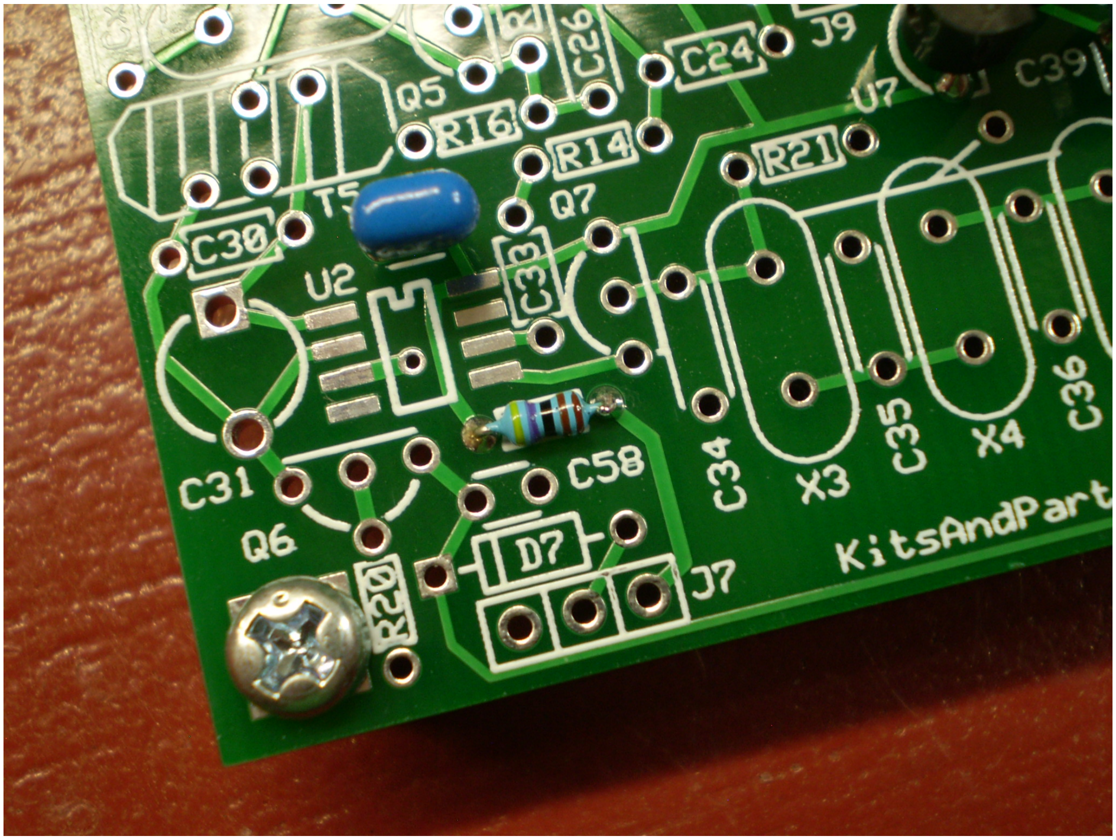


Figure 24: R19.

- R19 — 4.7K ohm resistor (4K7)

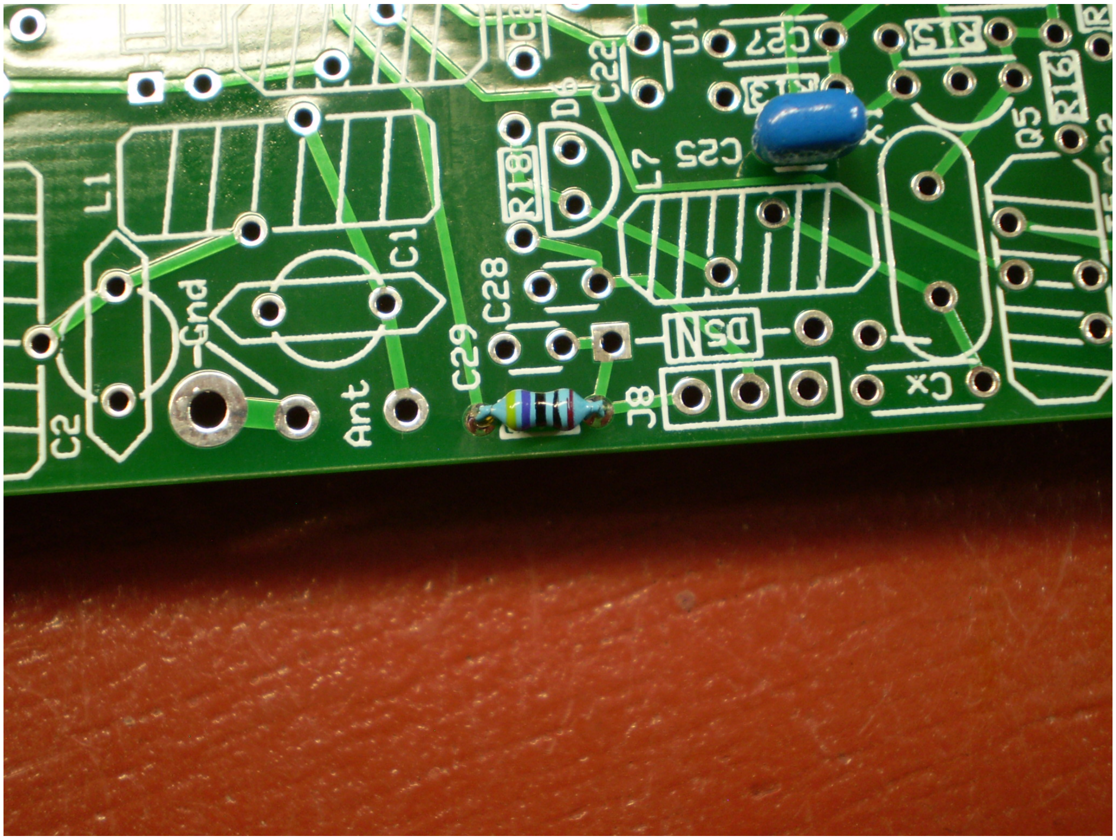


Figure 25: R17.

- R17 — 470 ohm resistor

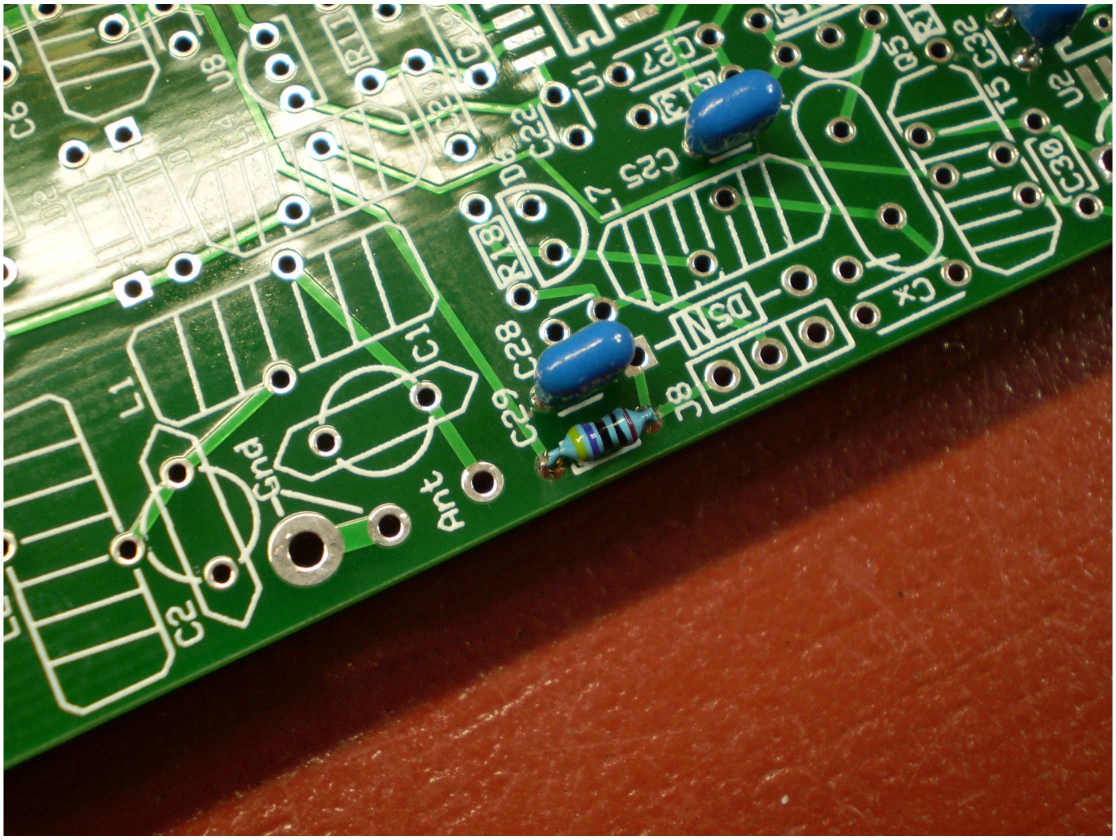


Figure 26: C29.

- C29 — 100n mono capacitor

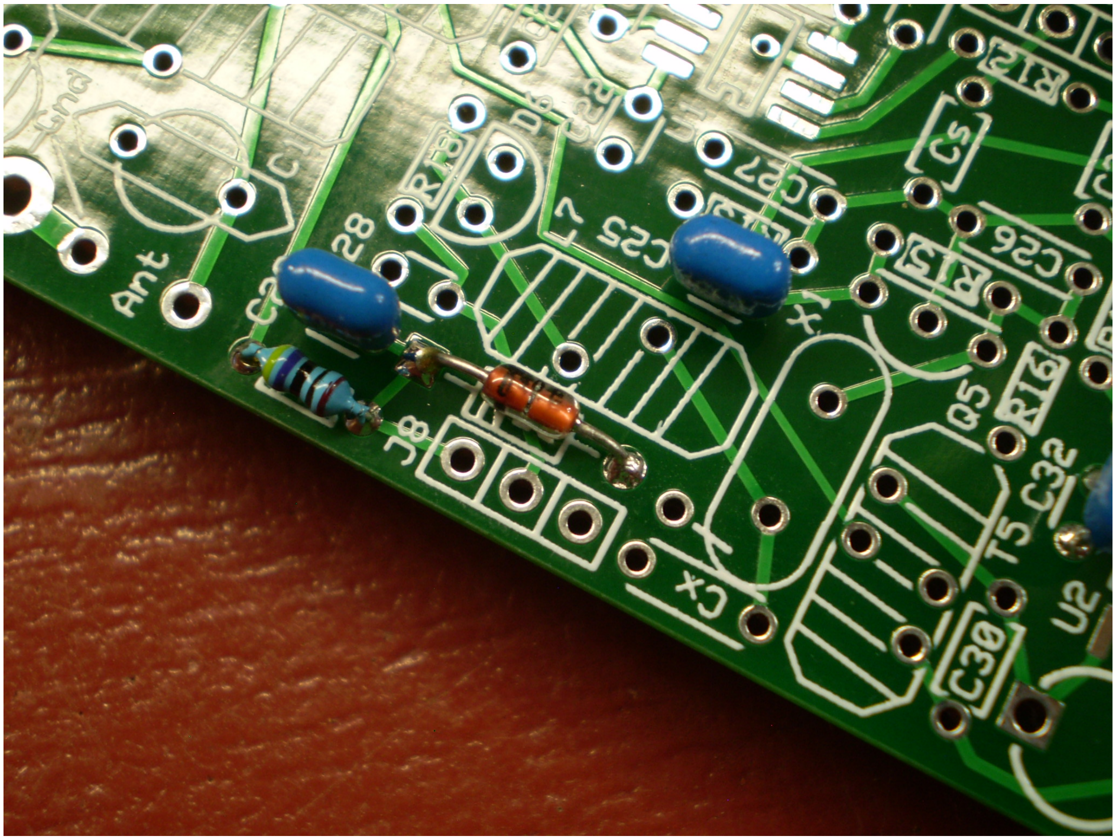


Figure 27: D5.

- D5 — 1N5240B 10V zener diode

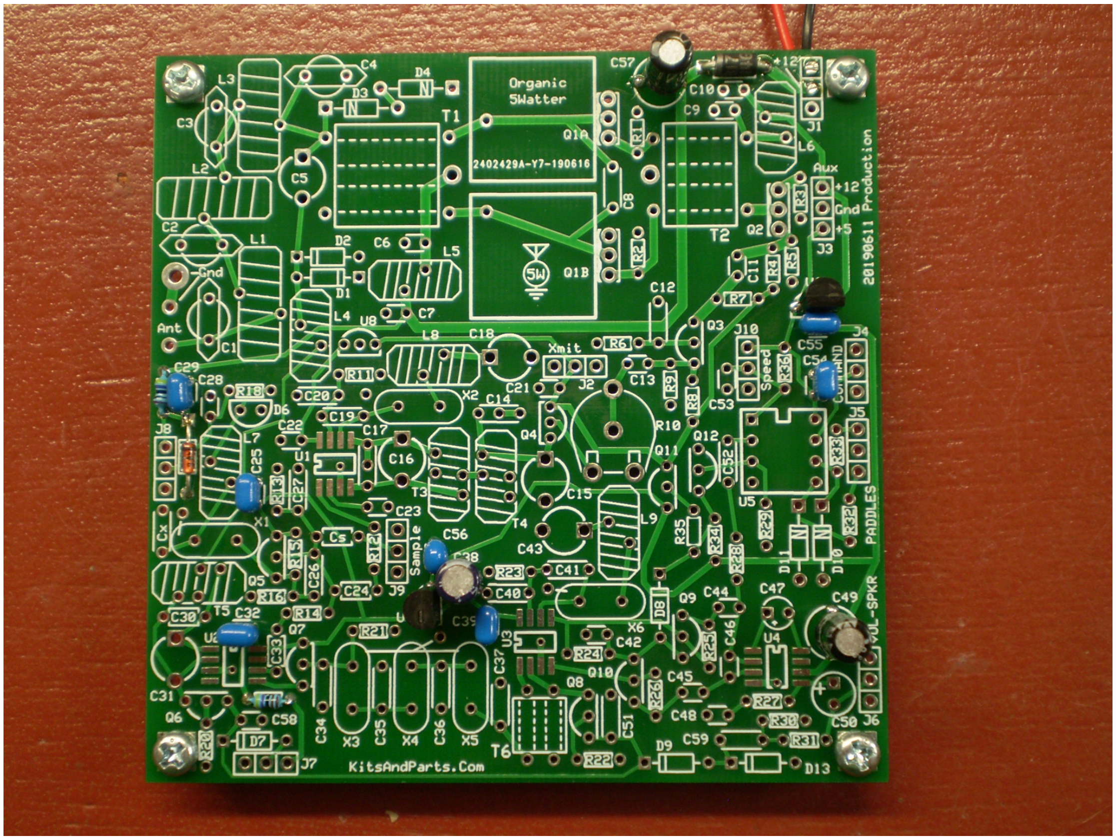


Figure 28: Phase 1 view of board.

2.1 Test Measurements

Now comes the moment of truth. I am using a Gruber Gel Cell that I bought from them at their plant here in Phoenix. It is a 12V 9AHr battery which is a pretty hefty power supply for a QRP rig. I plan on using this one for Field Day with this transceiver this weekend. I have a small park 3 blocks from the lab and that way, as a single OP singer radio. I'll be a few hundred meters from a restaurant and air conditioning.

Test Point	Value
Supply Current	11.28mA
D12 (anode)	13.21V
D12 (cathode)	12.96V
U3-8	8.00V
U2-8	8.00V
J7-1	7.96V
U4-6	12.95V
J8-1	10.05V
Q5 (collector)	8.00V
J3-3	4.97V
J3-1	12.96V

From these measurements I can determine several things about the construction so far. The battery voltage is 13.21V with almost no load.

The 11.28mA current may seem excessive, but voltage regulators typically draw a larger current with nothing connected to them. Also, the diode D5 will draw a large amount of current to maintain the 10V regulation. I did the R19 4K7 resistor and measured the voltage at J7-1 (pin 1 of the header J7) to be sure that I will get full tuning bandwidth with the varactor diode.

The other measurements can easily be seen to be good comparing with the schematic and the voltage source supplying the voltage.

Your values will vary from the above depending up your supply voltage and variations in voltage regulators. Hopefully, your voltages will not be too far from those above.

Chapter 3

Phase 2 — Audio Amplifier

Here we are going to build the first working section that we can test without any test equipment other than our ears. We will build the audio section, power the transceiver on and listen for a hiss in the output. I use powered computer speakers as I can control the volume and I did not have to use the audio 1K pot. I just wired the audio jack direct to J6 so that I would not have the weight and trouble with adding the rest of the parts on the PCB and turning board right side up and then inverting to solder. Lot less weight.

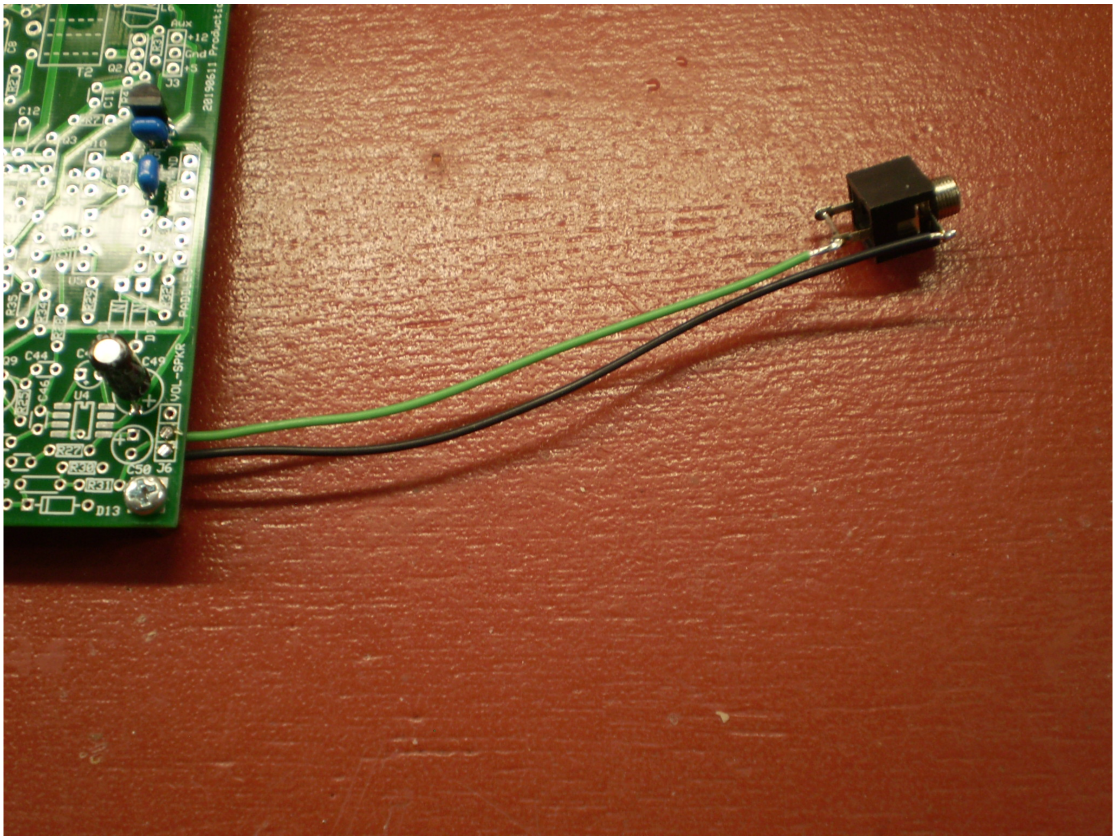


Figure 29: Headphone jack.

Here I have wired the 3.5mm headphone jack to J6 without using the 1K volume control pot at this time. This will save me a lot of work in installing the rest of the parts in the transceiver. I just use the powered computer speakers for listening as I test section by section.

I will warn you about the volume level after we add the keyer section in the next chapter.

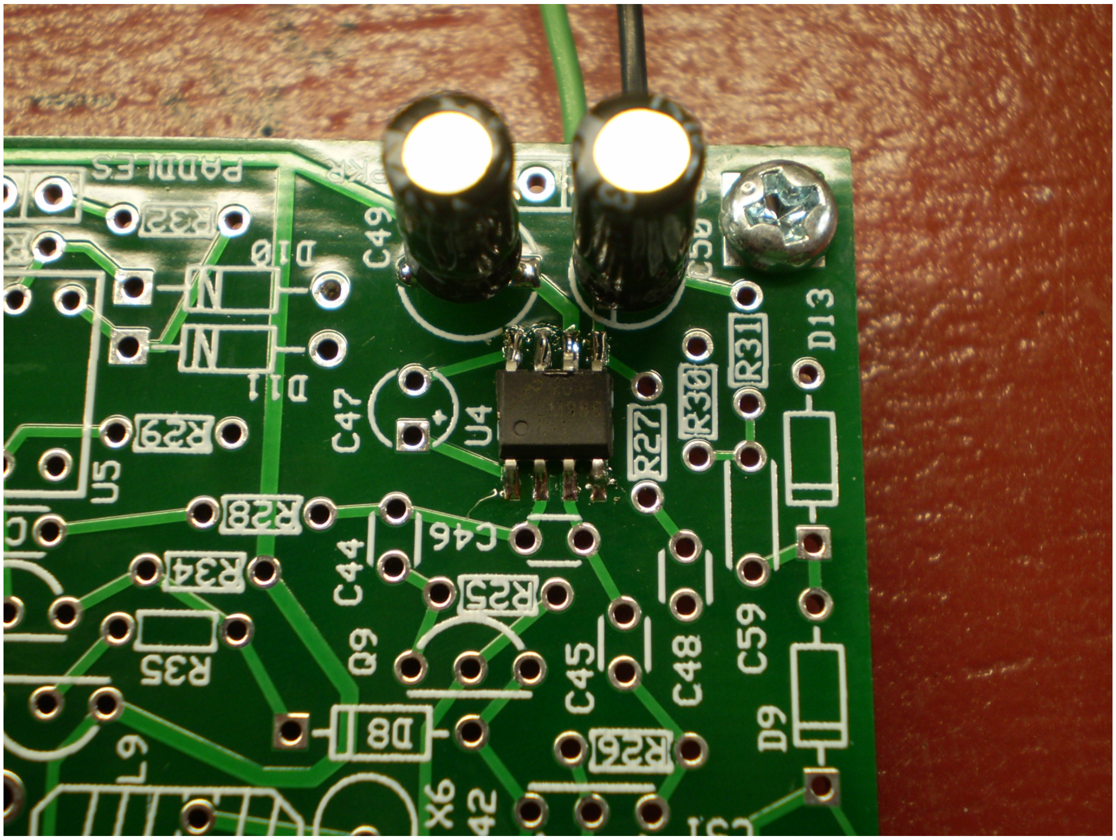


Figure 30: U4 and C50.

- U4 — LM386N-4 audio IC
- C50 — 33μF electrolytic capacitor

I missed a picture here. C49 in the photo was installed in phase 1. Be sure to do U4 first as this gives you room to work. I didn't and paid the price in looks. Wasn't a big deal, but you can do better. You can see the four IC pins closer to us are much better looking.

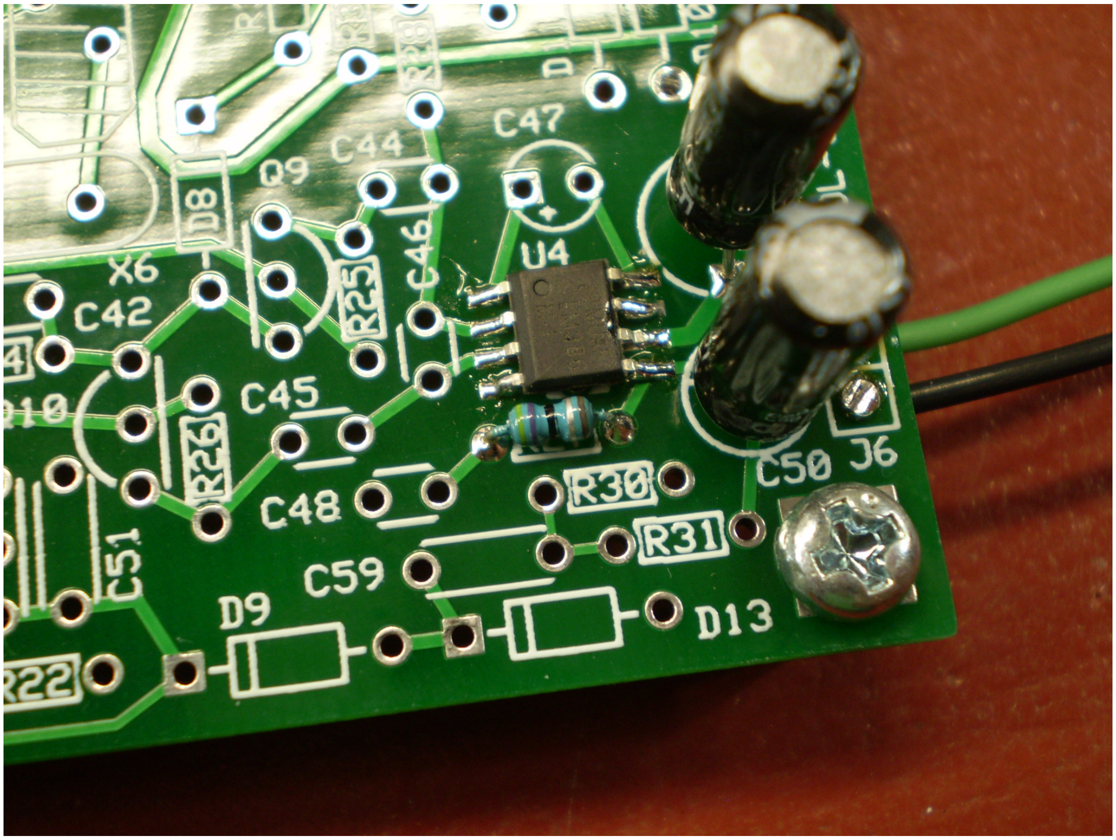


Figure 31: R27.

- R27 — 4R7 ohm resistor

Note the 4.7 (4R7) ohm resistor color code and don't get it mixed up with other values starting with a 47 combination. The R notation for the decimal point is a historical carry over from times when technology was not as advanced as we are now in labeling parts and printing.

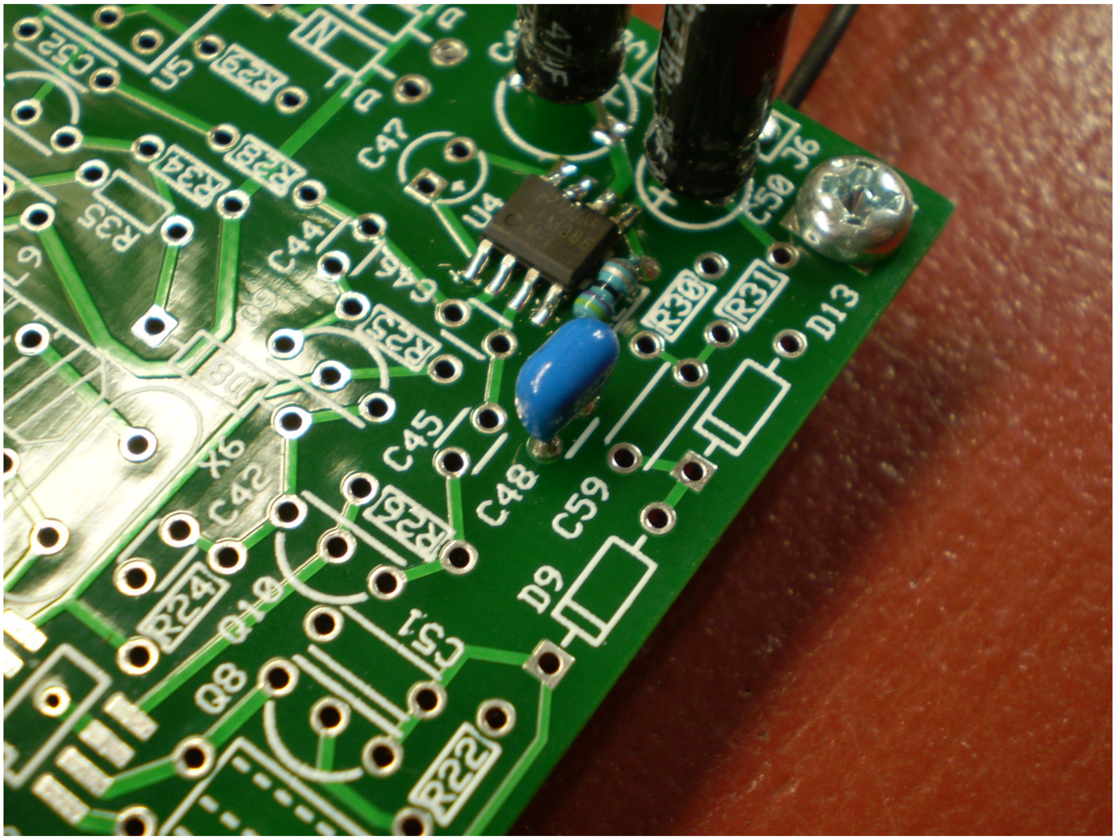


Figure 32: C48.

- C48 — 100nF mono cap

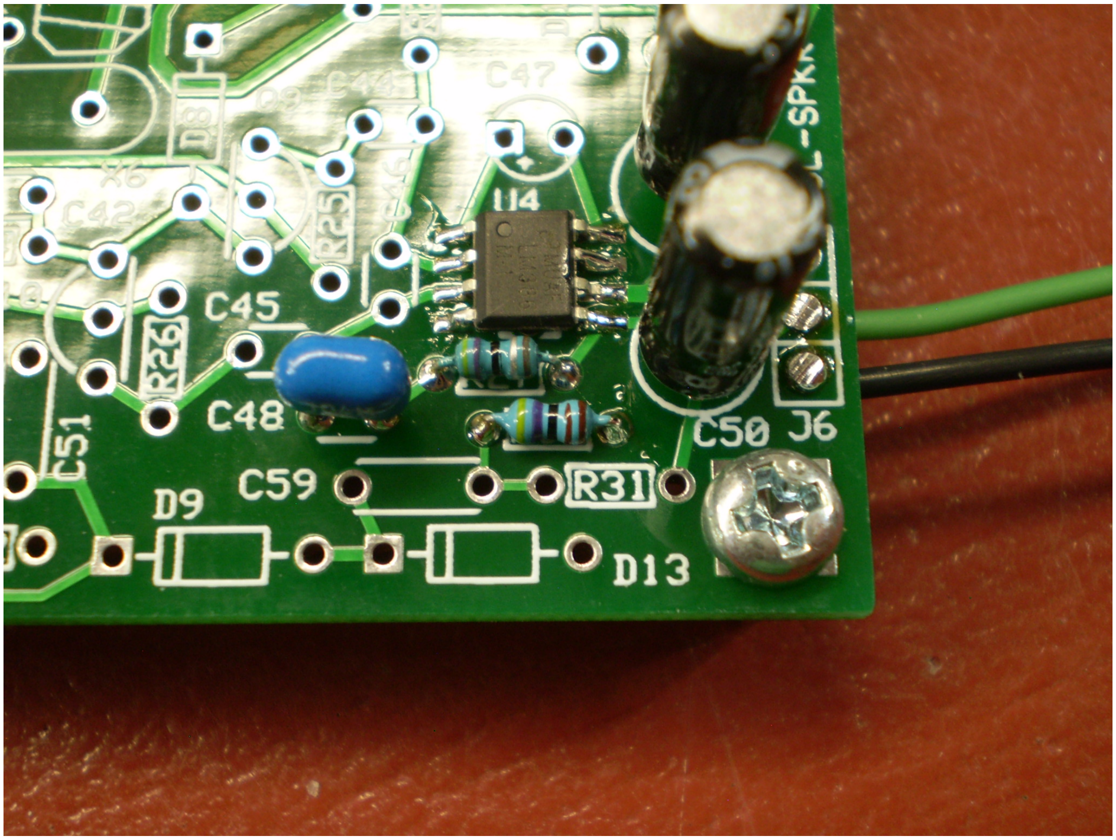


Figure 33: R30.

- R30 — 4K7 ohm resistor (4.7K)

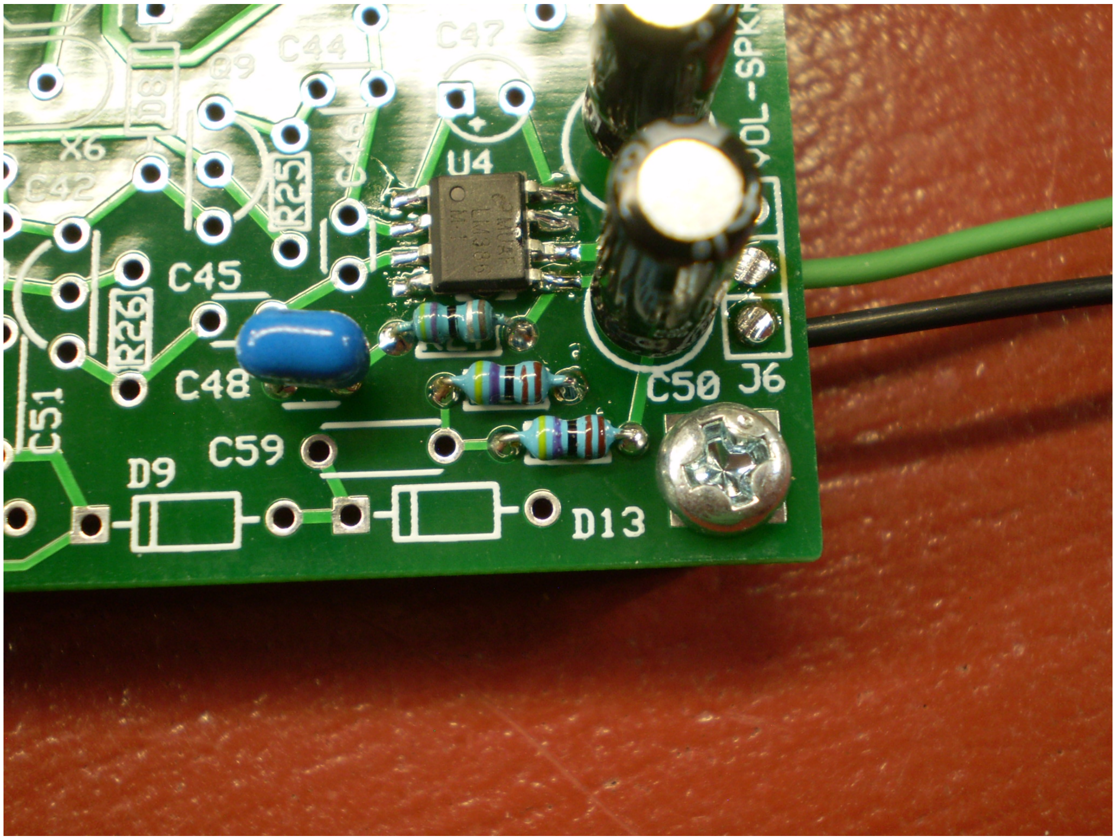


Figure 34: R31.

- R31 — 4K7 ohm resistor (4.7K)

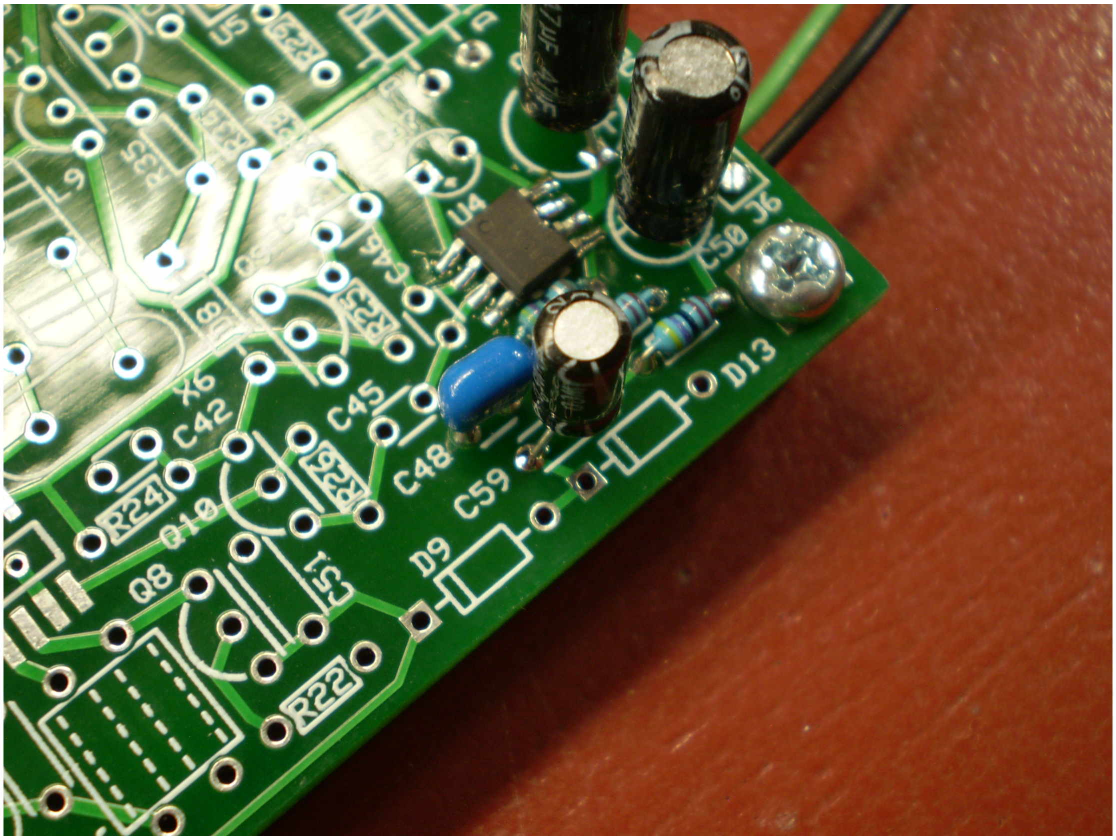


Figure 35: C59.

- C59 — 2.2μF mono cap

I did not have a mono cap, so used an electrolytic. You will have a mono cap in your kit.

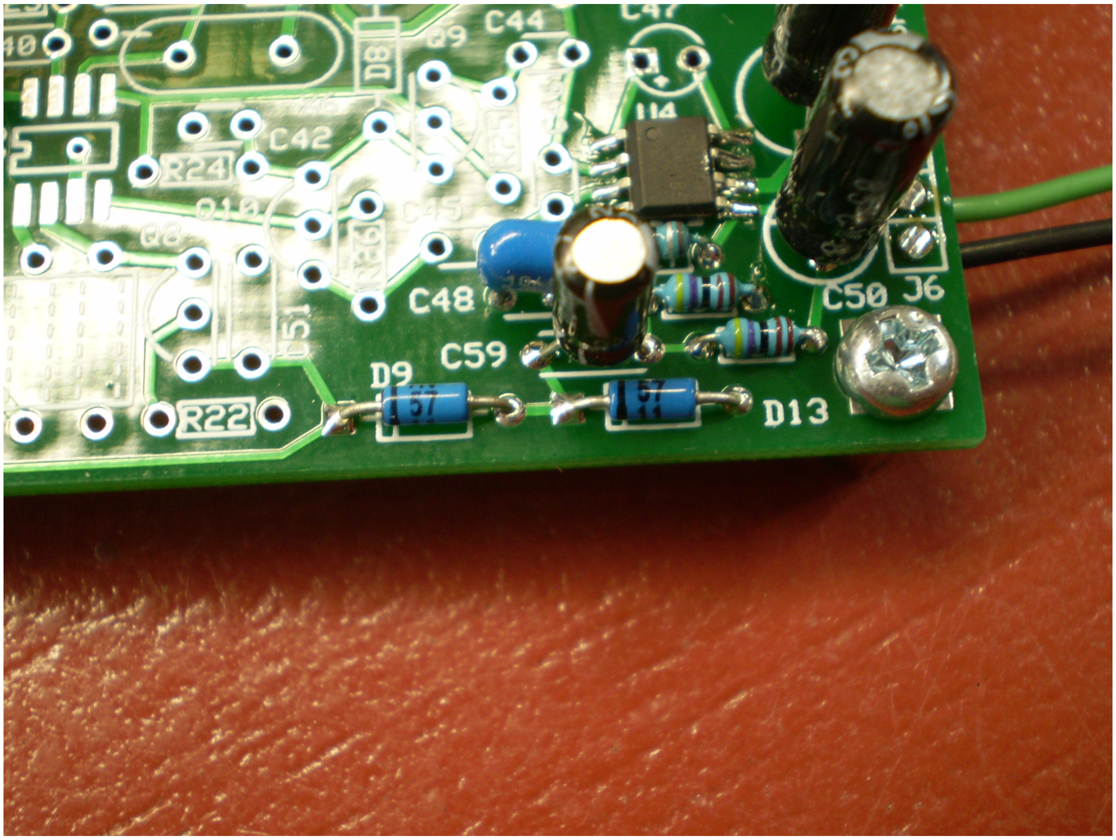


Figure 36: D13 and D9.

- D13 — 1N5711 Schottky diode
- D9 — 1N5711 Schottky diode

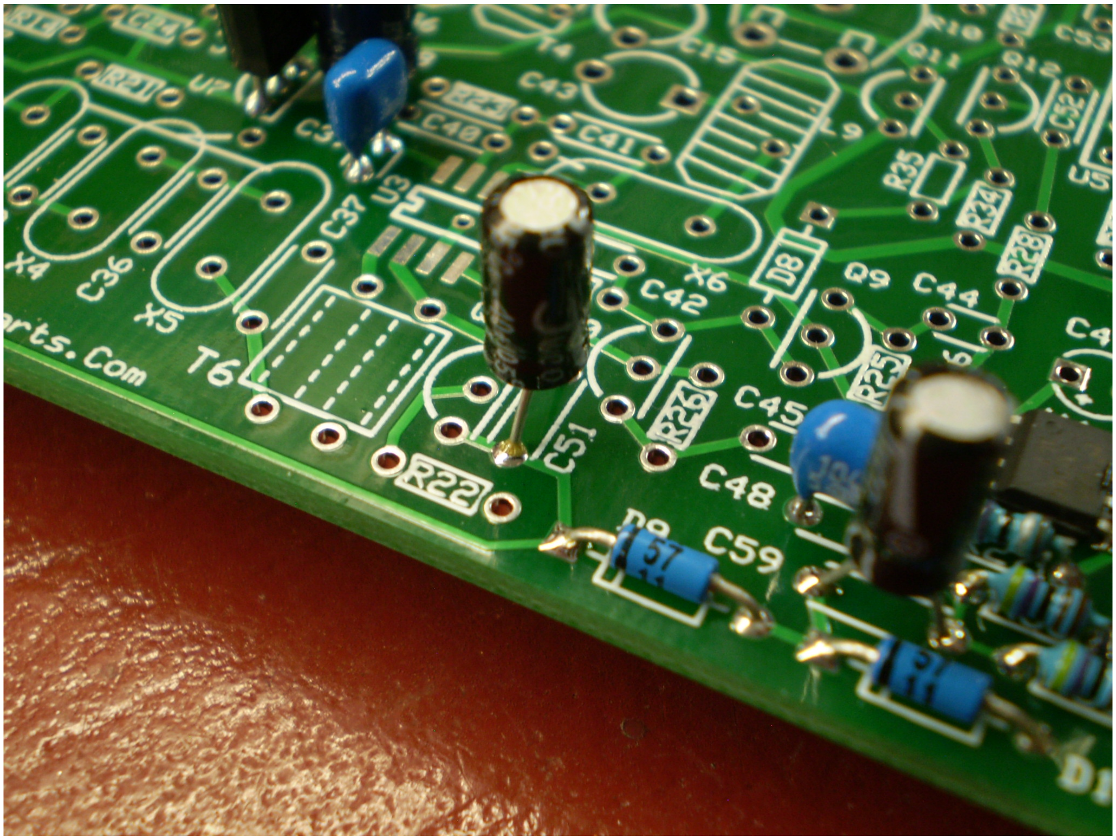


Figure 37: C51.

- C51 — 2.2μF mono cap

I did not have a mono cap, so used an electrolytic. You will have a mono cap in your kit.

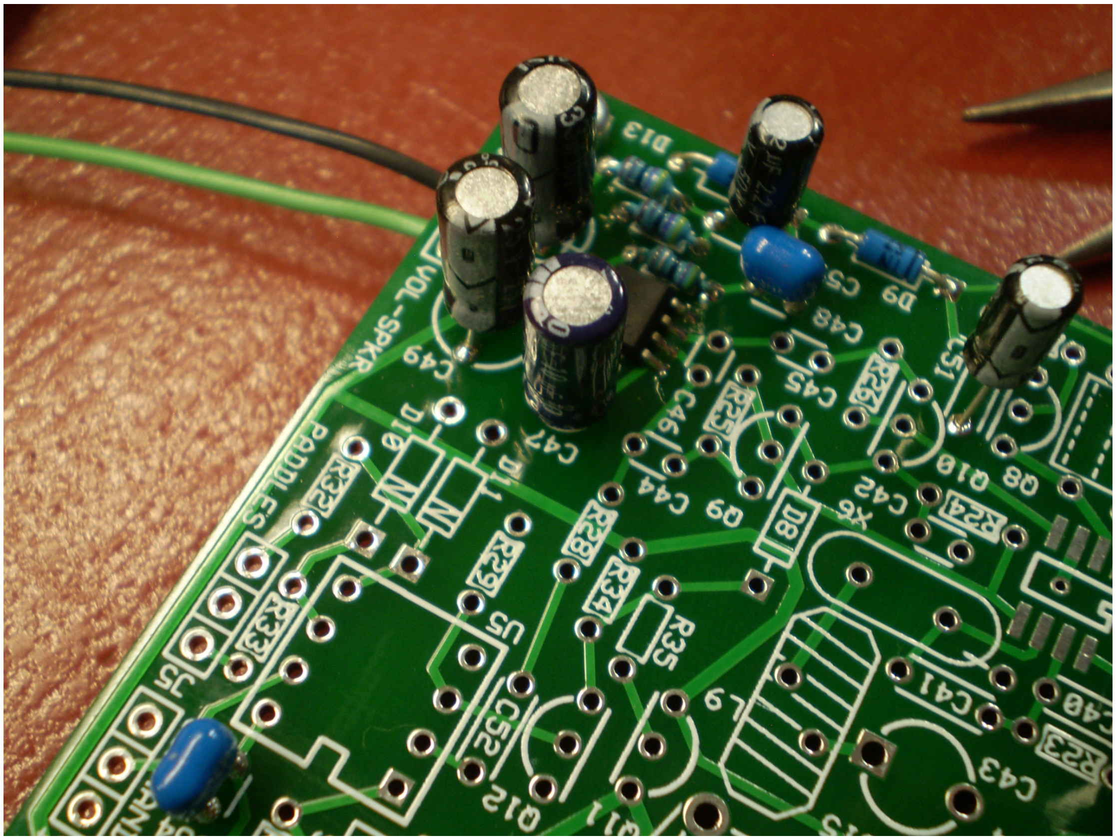


Figure 38: C47.

- C47 — 10μF electrolytic cap

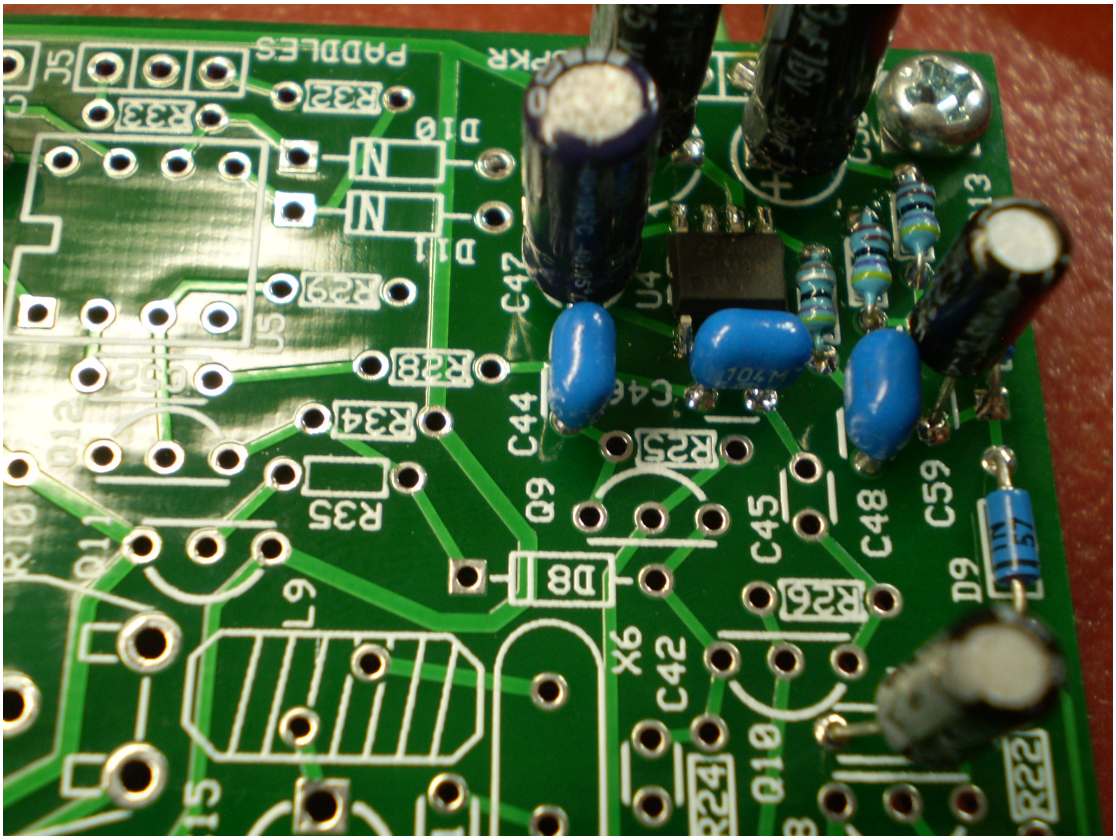


Figure 39: C46 and C44.

- C44 — 100n mono cap
- C46 — 100n mono cap

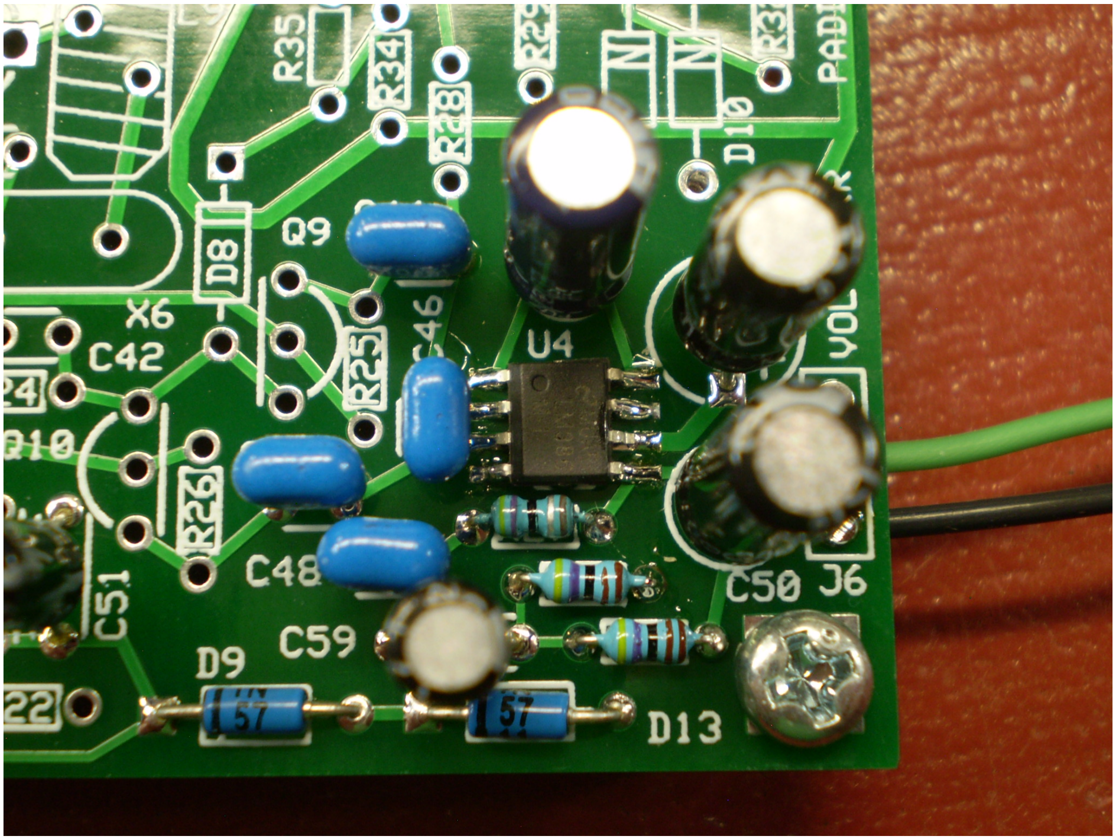


Figure 40: C45.

- C45 — 100n mono cap

Picture is of finished audio section. Double check all your work.

3.1 Phase 2 Testing

Now it is time to check our work.

- Connect PC powered speakers to audio jack.
- Connect power supply to power supply leads to the PCB.

I used a DMM in current mode to monitor the current from the battery to the transceiver. I measured 16.40mA at this stage, which is up from the 11.28mA from the previous test.

If you do not already have a test lead, use a 30cm length of insulated wire with 1mm to 2mm exposed end. Touch this wire to the top pad of R25. You should hear an increase in noise in the speakers.

Do the same thing again at the bottom pad of R26. Again you should hear an increase in noise.

Both these tests are feeding some audio noise into the balanced input of the LM386 audio amp IC. This shows that the circuit is working correctly.

We could use an audio generator to feed a tone into the same points, but if you do this use no more than a 1mV peak signal to not overload the audio section and possibly destroy the IC. It doesn't take much to have a loud signal on the output.

Chapter 4

Phase 3 — Keyer and Keying Sections

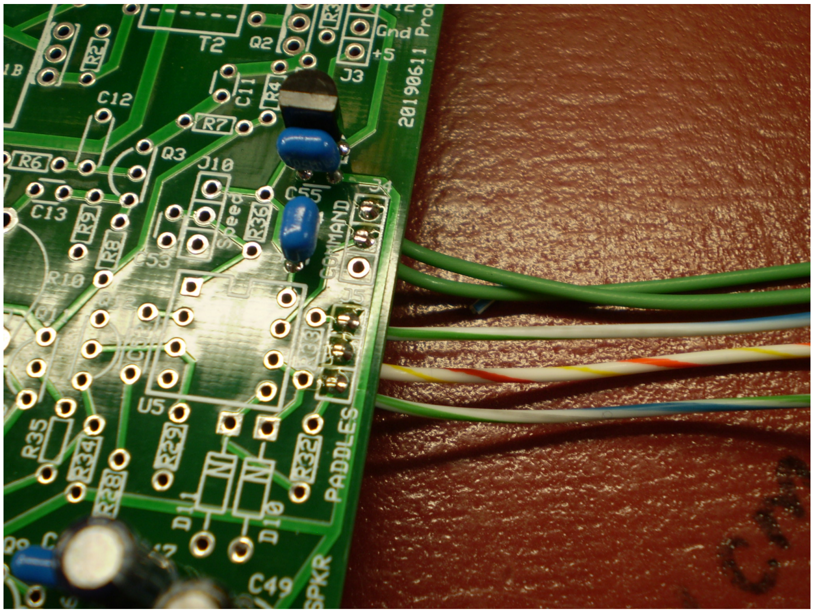


Figure 41: Command Button and Paddle Headers.

- J4 header and cables for command button
- J5 header and cables for paddle jack

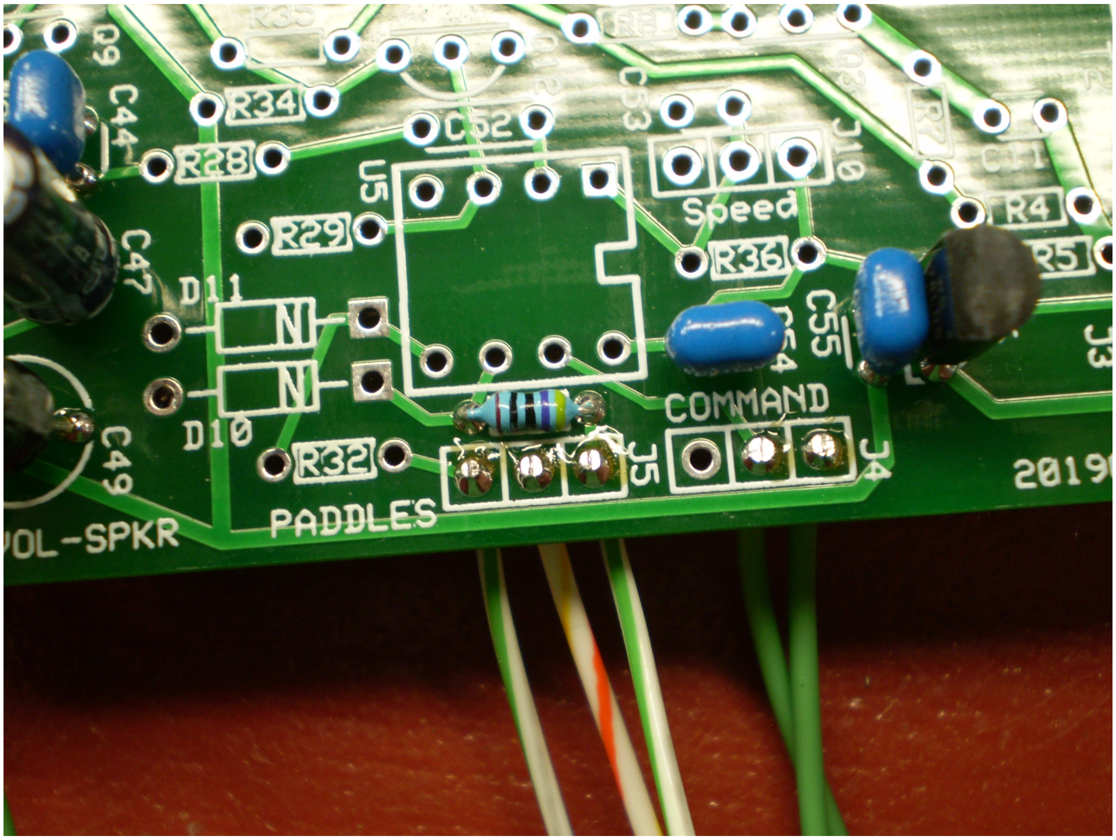


Figure 42: R33.

- R33 — 470 ohm resistor

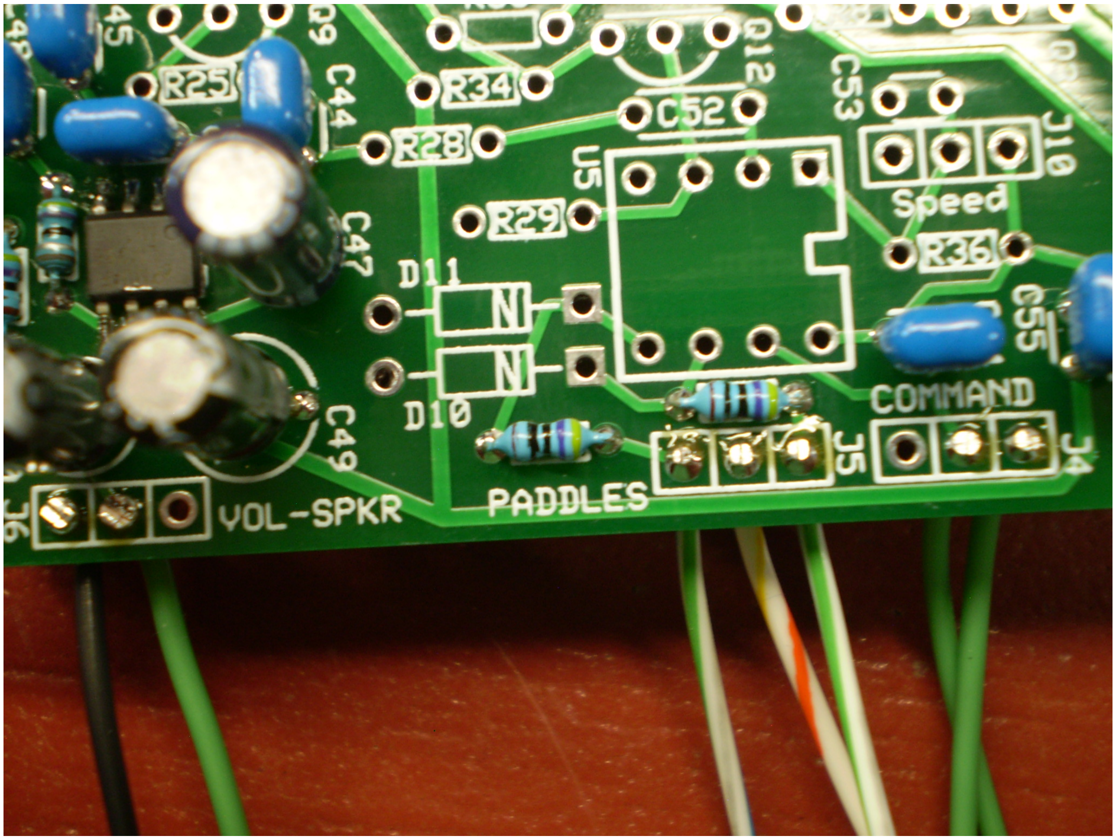


Figure 43: R32.

- R32 — 470 ohm resistor

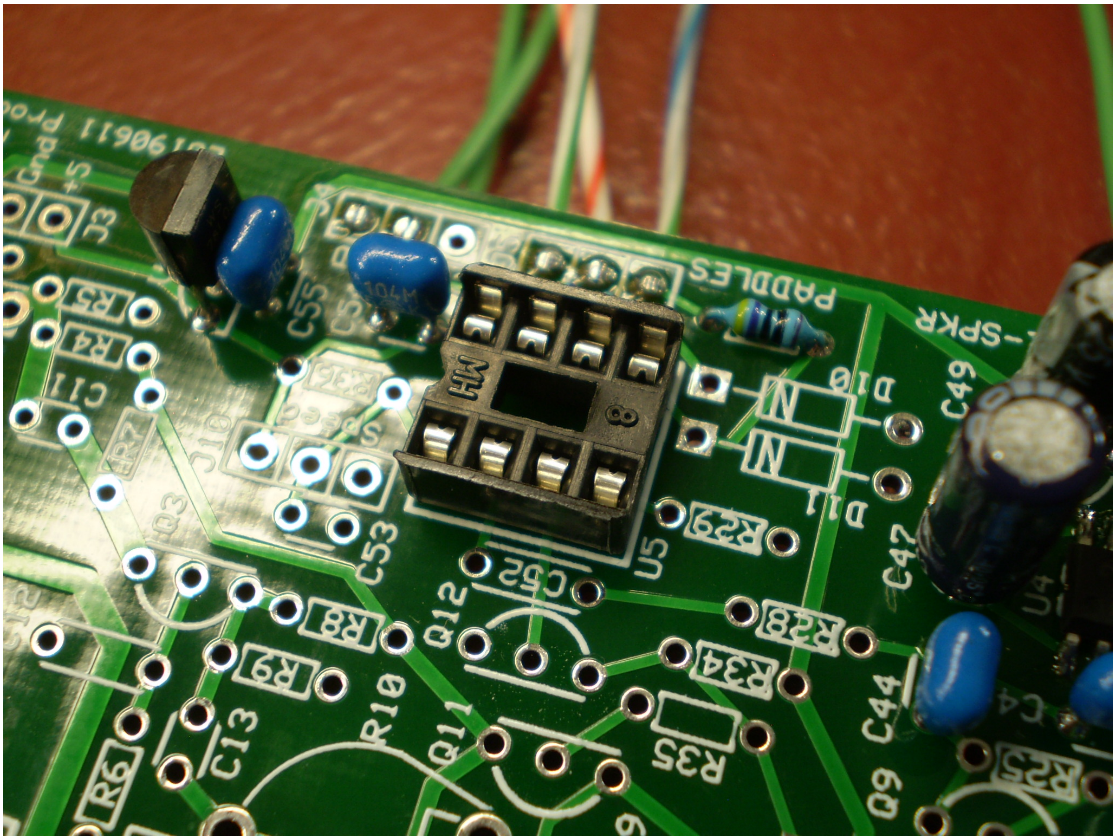


Figure 44: U5 socket.

- U5 8-pin socket

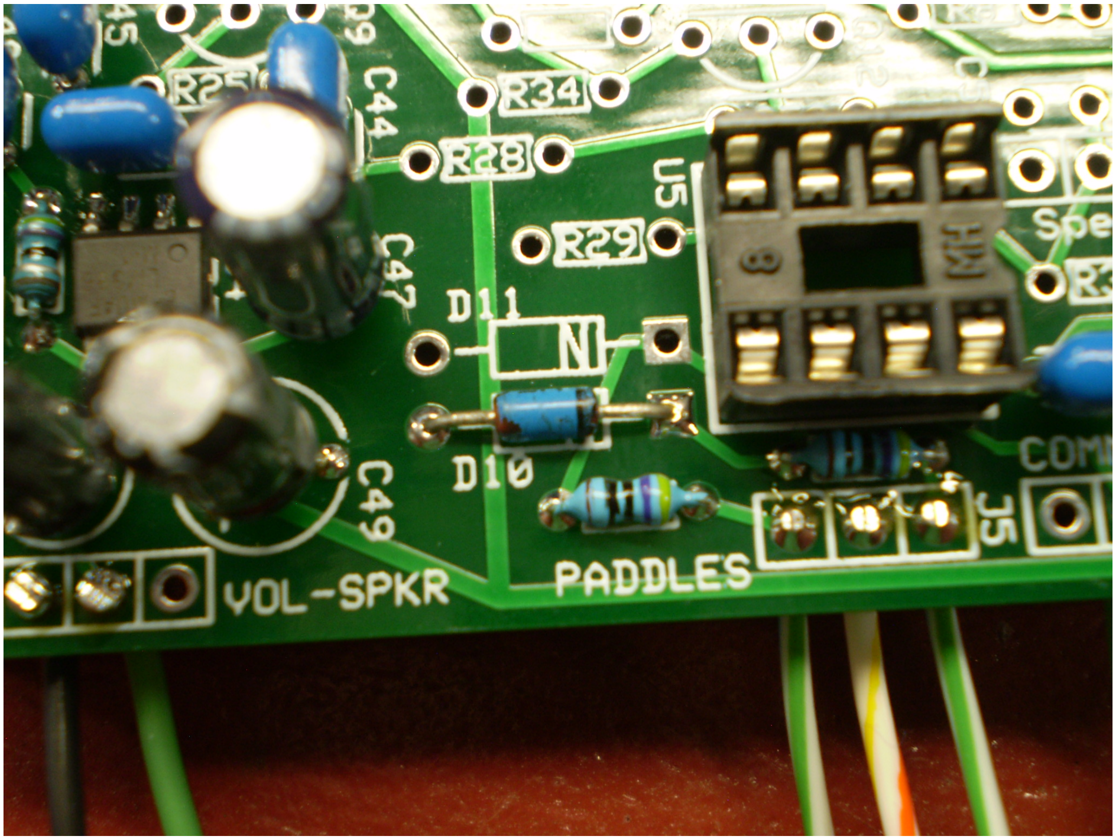


Figure 45: D10.

- D10 — NPC-127 5.6V zener diode

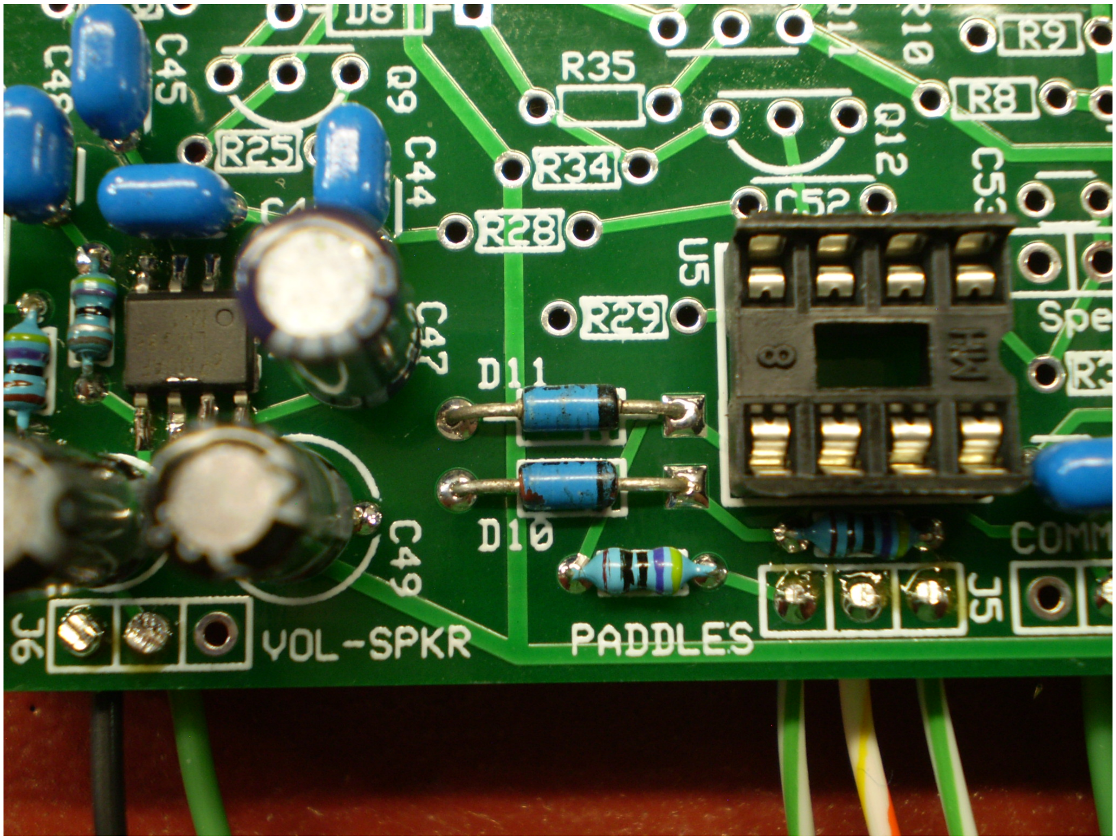


Figure 46: D11.

- D11 — NPC-127 5.6V zener diode

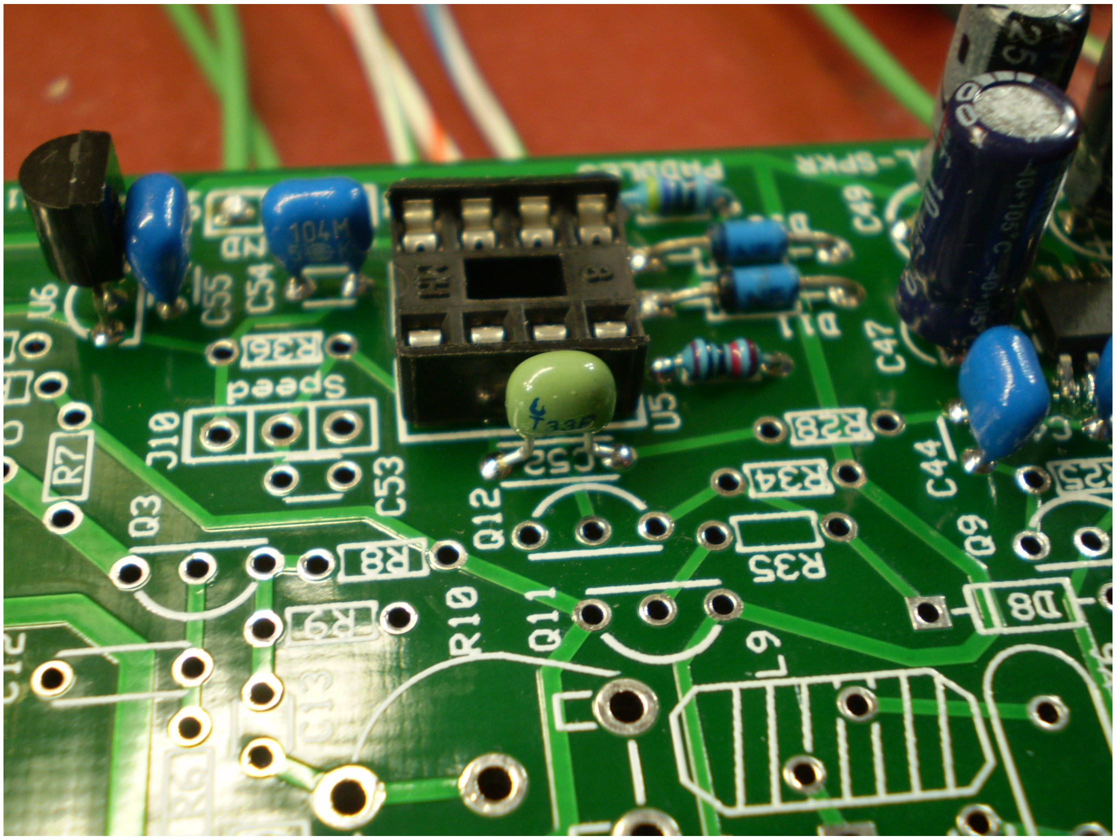


Figure 47: R29 and C52.

- R29 — 10K resistor
- C52 — 33pF mono capacitor

R29 is to the right of the IC socket. The cap is one in my collection that is supposed to be from the best manufacturer in China for mono caps.

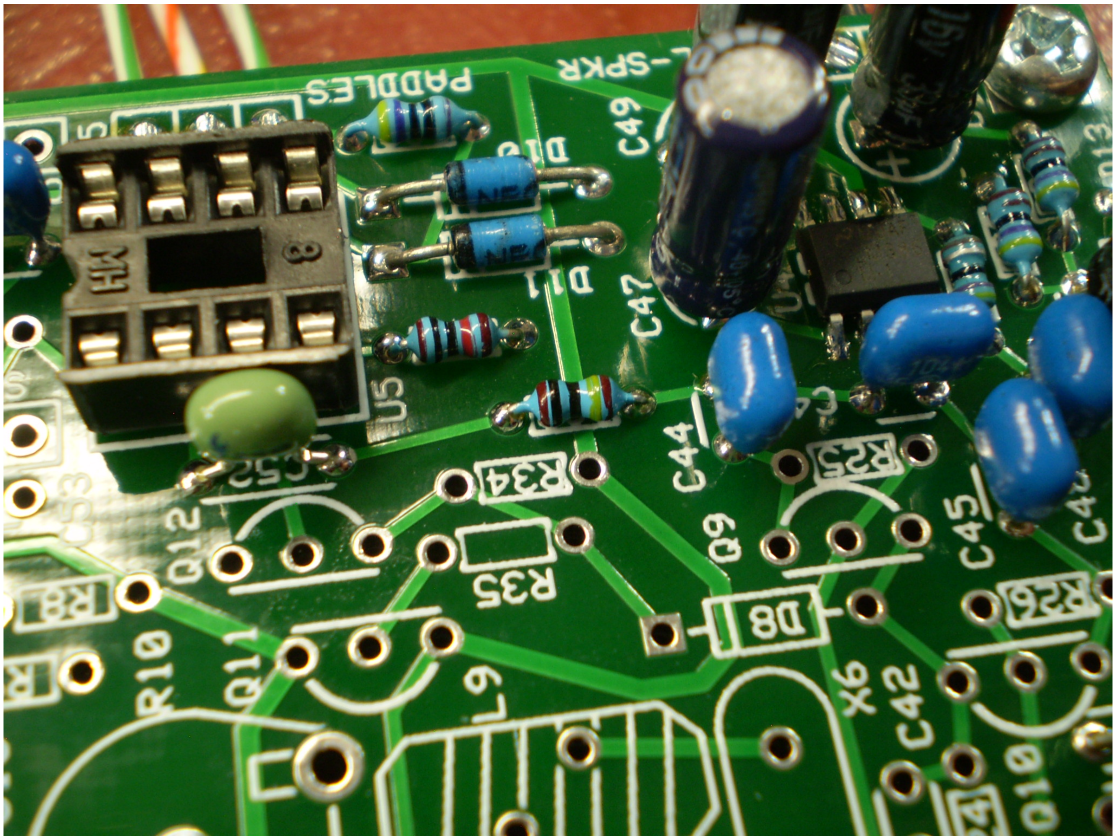


Figure 48: R28.

- R28 — 1M ohm resistor

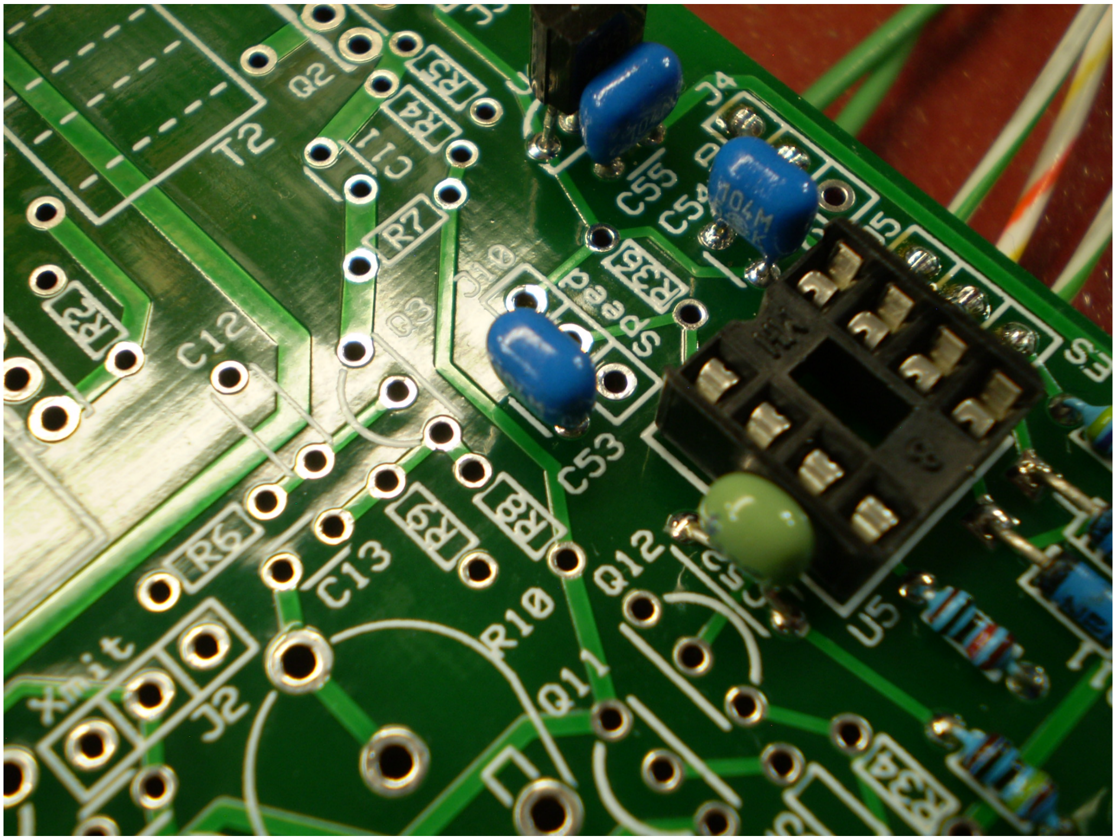


Figure 49: C53.

- C53 — 100n mono cap

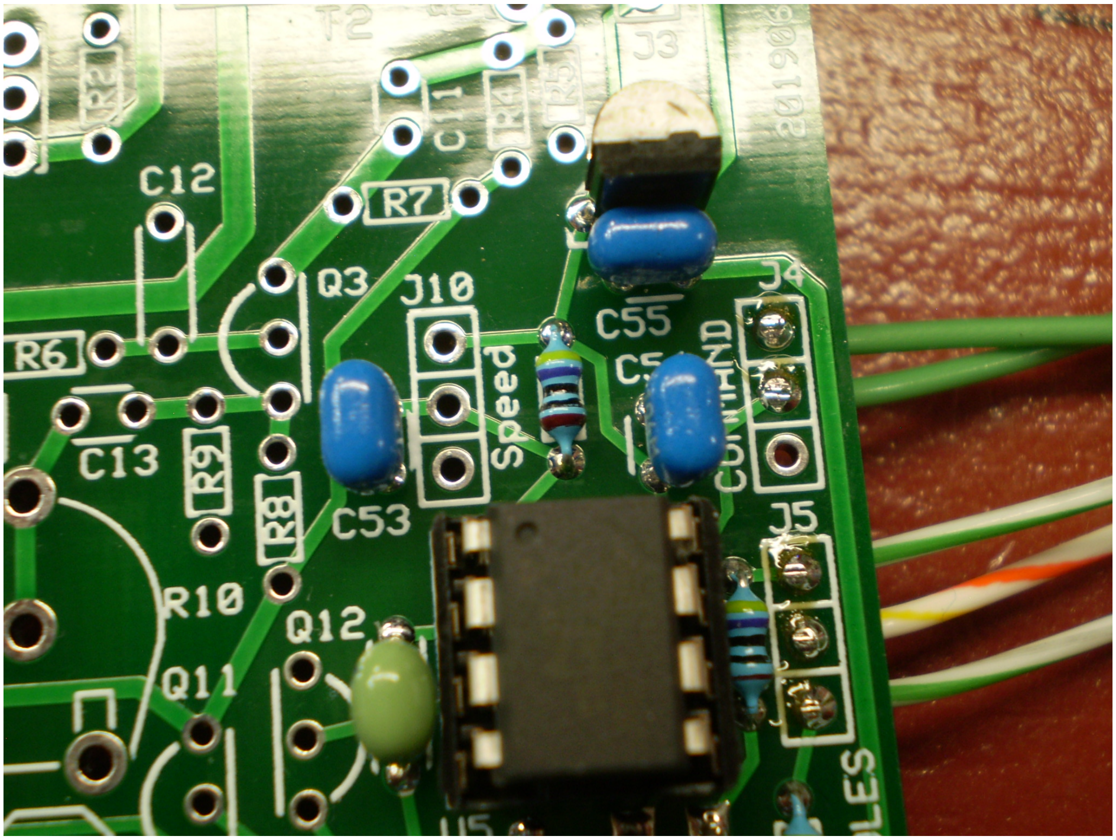


Figure 50: .

- C53 — 100n mono cap

Note that I have installed R36 for testing. You should not install this resistor and I highly recommend going with a speed control pot. When I installed this transceiver into an inclosure and used the pot for working FD 2019 the night that I finished this project, it saved my bacon several times in not wasting valuable time getting the keyer into command mode to change the speed.

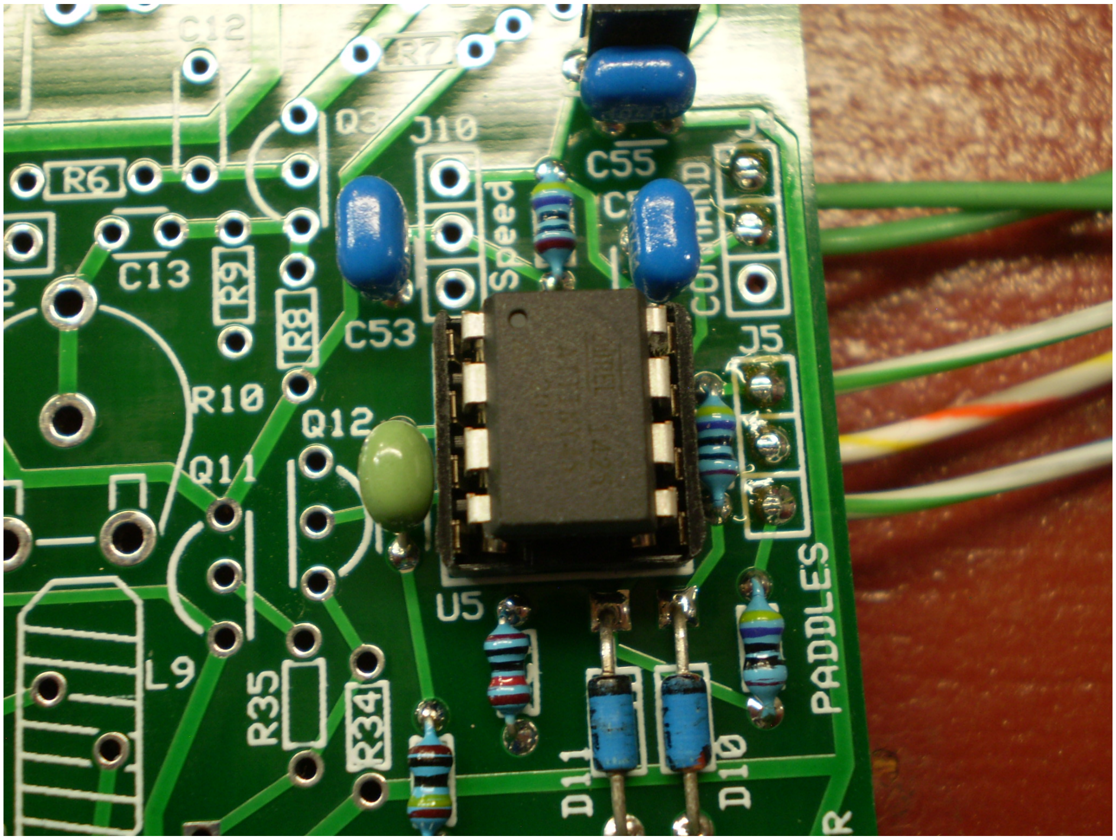


Figure 51: J10 and R36.

- J10 is optional header for speed control pot for keyer
- R36 — 470 ohm resistor to be installed if control pot not used

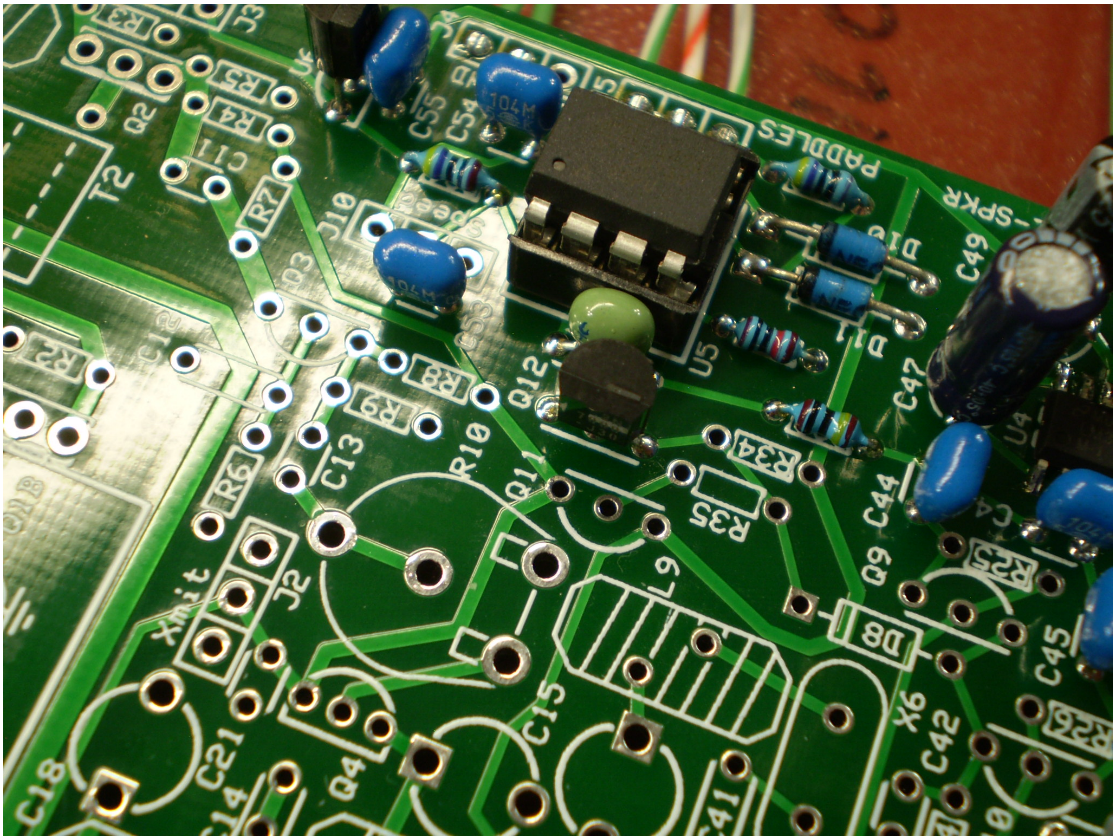


Figure 52: Q12.

- Q12 — 2N7000 JFET

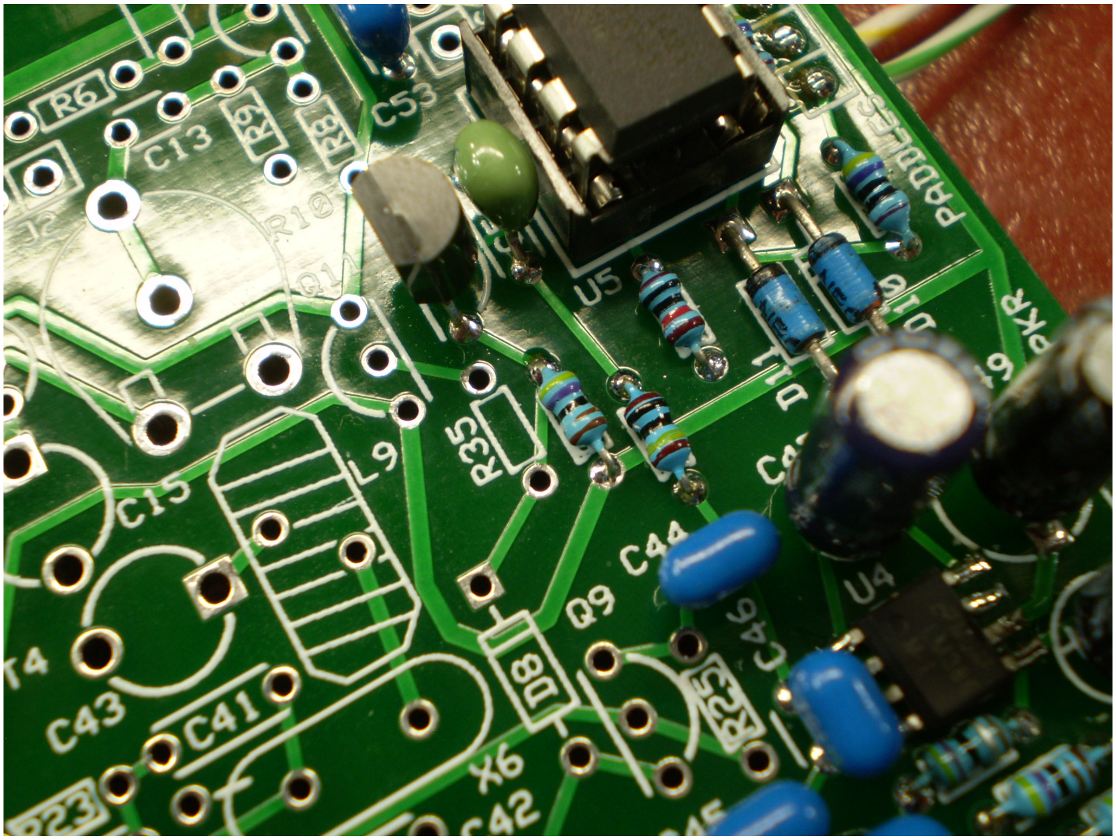


Figure 53: R34.

- R34 — 4K7 ohm 1/8W resistor

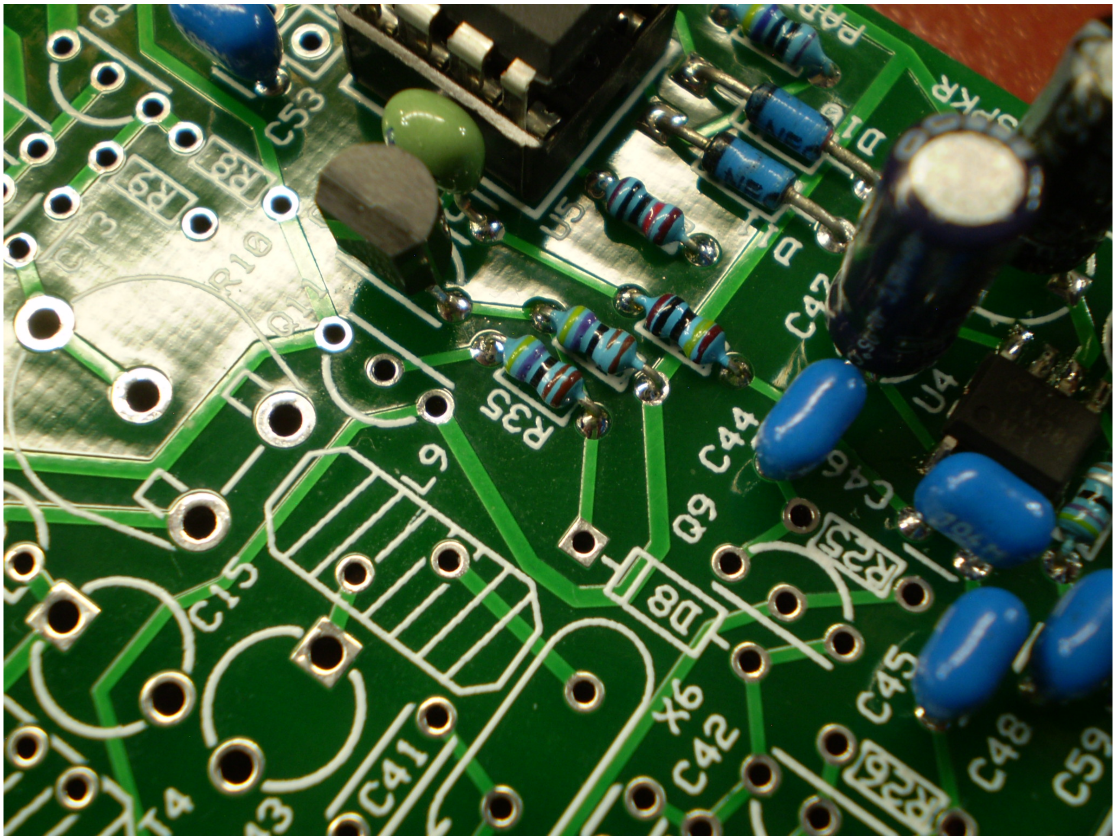


Figure 54: R35.

- R35 — 4K7 ohm 1/8W resistor

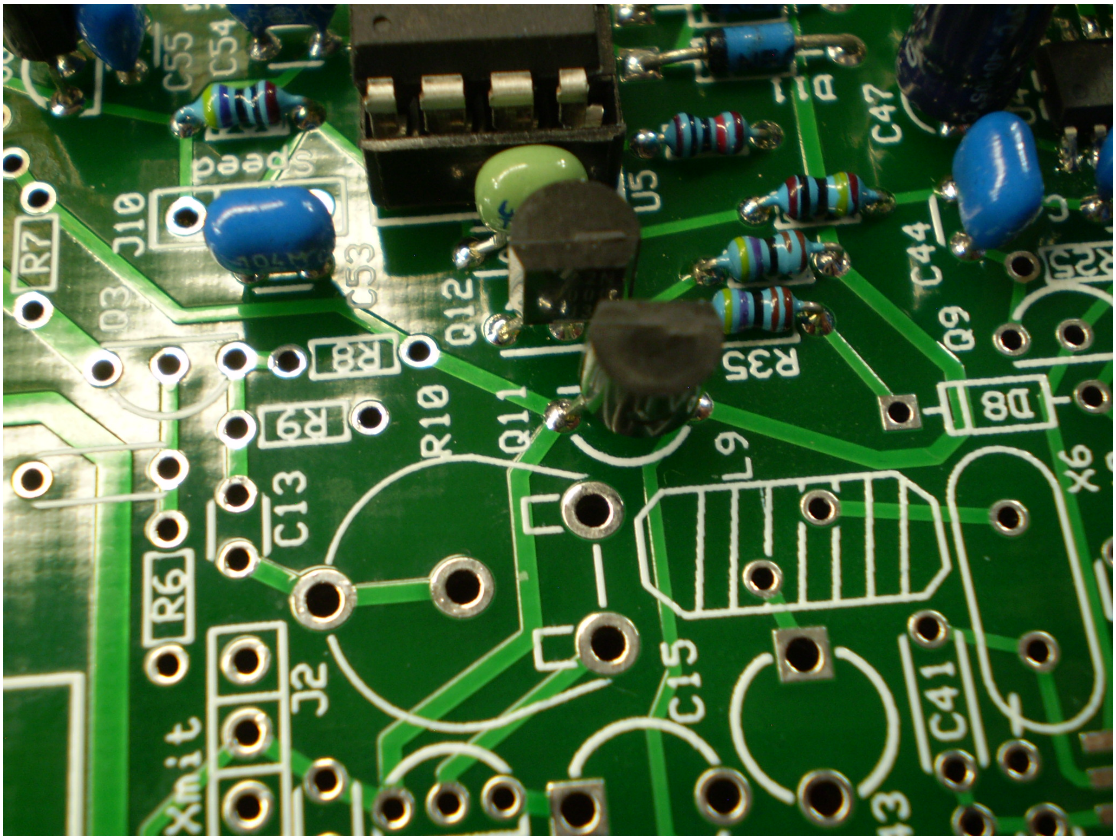


Figure 55: Q11.

- Q11 — 2N3906 PNP transistor

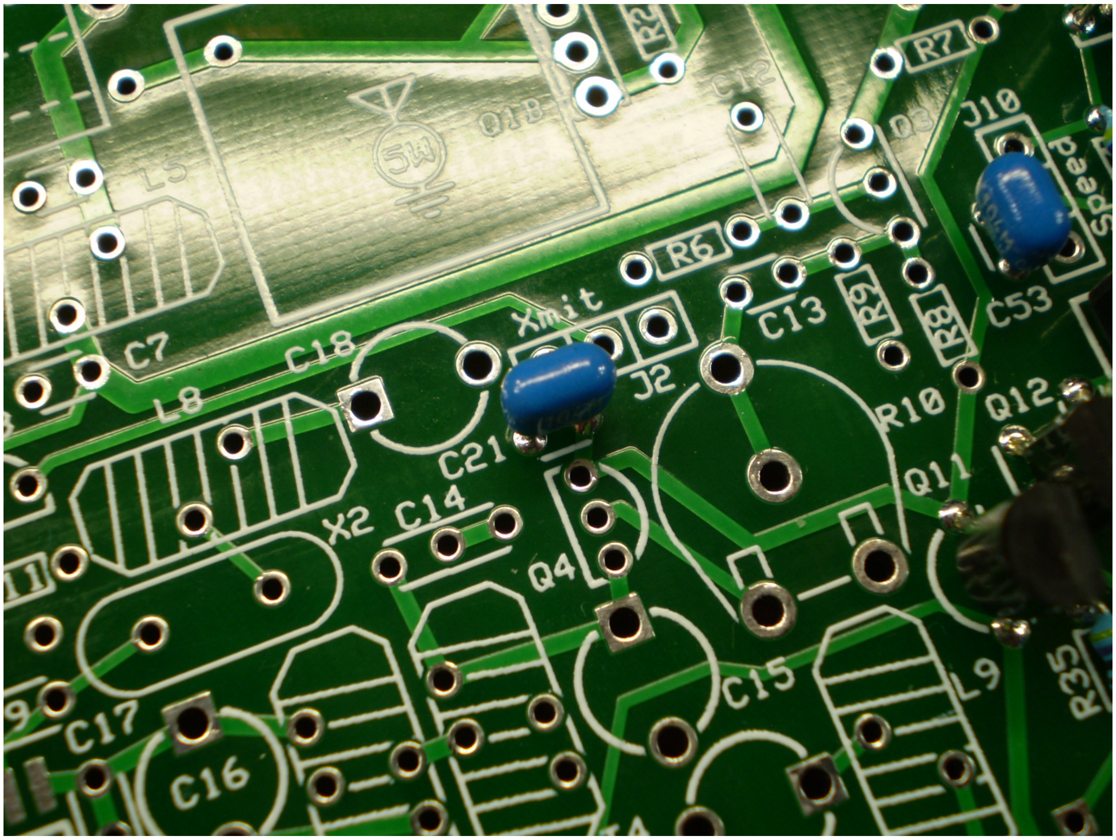


Figure 56: C21.

- C21 — 100n mono cap

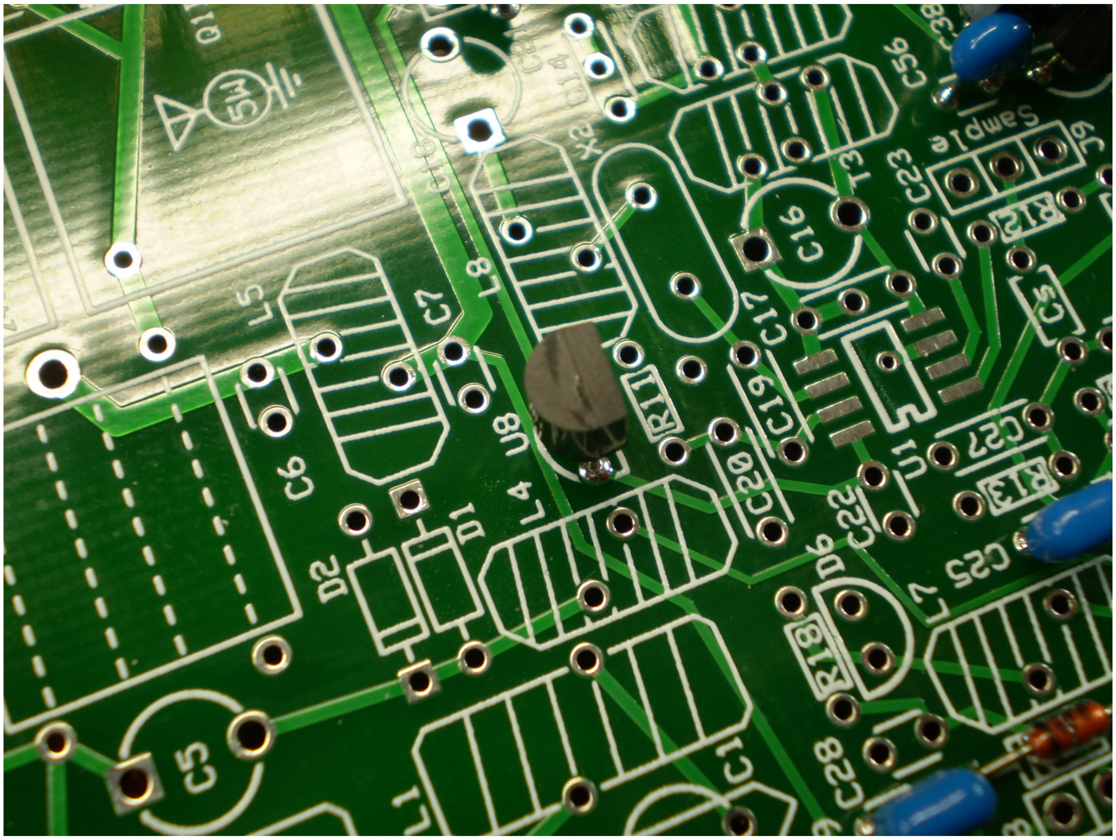


Figure 57: U8.

- U8 — 78L08 8V voltage regulator

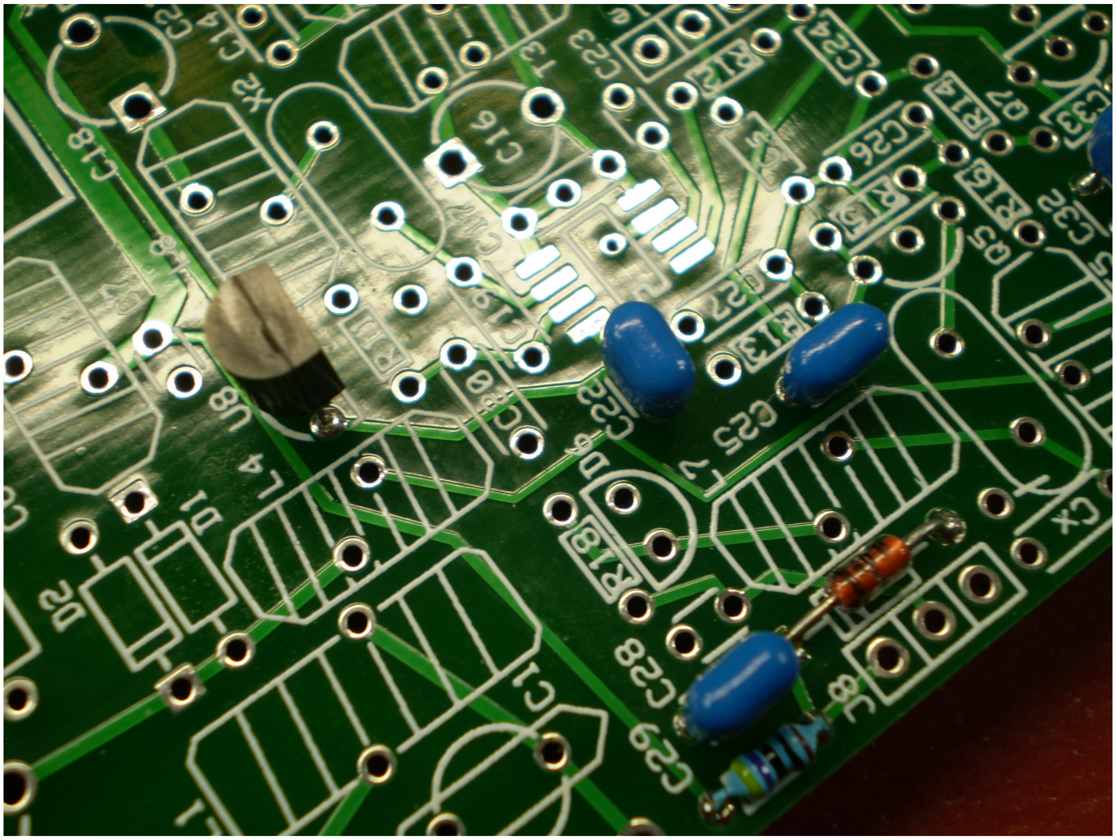


Figure 58: C22.

- C22 — 100n mono cap

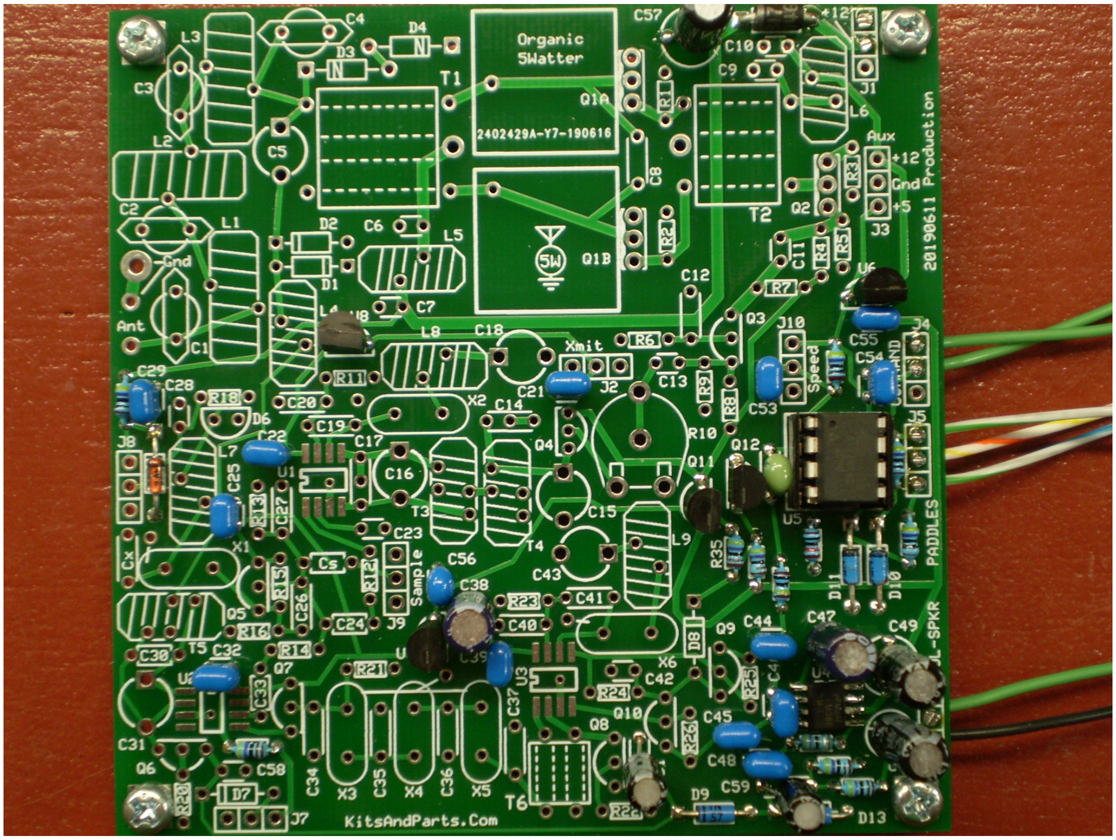


Figure 59: Top View of PCB.

This is current state of the assembly of components on the board.

4.1 Phase 3 Testing

Be sure to set your PC speaker volume control to about 1/10 or low volume level, just in case. Once again it is time to test our construction for errors. As before connect the PC speakers to the phone jack, the dual lever paddle to the paddle jack and the power supply to the power cables.

If the volume is high enough on the PC speakers, you should hear 5W being sent from the keyer at 15WPM, the default value.

Send some characters using the paddle to see that you have the dit and dah correctly connected. The dit should be the left paddle and the dah should be the right paddle. This emulates the default paddle use of an old semi-automatic paddle or bug.

Look at the manual online and explore all the commands that are available with the keyer. Set the default keyer speed to your prefered speed if you do not like the 15WPM default. You can use the command mode speed setting or if you installed a speed control pot, then adjust it.

Now. Measure the voltage at pin 8 of U1, the first transmit mixer IC location. The voltage should read 0.00V.

Using the paddle, put the transceiver in the tune mode with the X command. You should hear a tone from the keyer start up in the speaker and remain on. With the tone active measure the voltage again at pin 8 of U1 (U1-8). It should read 8.00V or so. I get a value of 8.01V with my transceiver.

This test assures us that the transmitter will be activated by the keyer when code is being sent by you using the paddle or using the beacon mode of the keyer.

That concludes testing for this section.

Chapter 5

Beat Frequency Oscillator (BFO)

OK. I screwed up. I put the construction sequence in a notebook before starting. I somehow skipped this section and it followed the IF filter and first receiver mixed steps and I had done those and then got to this section. It doesn't effect you other than you'll see parts that you won't be installing at this time.

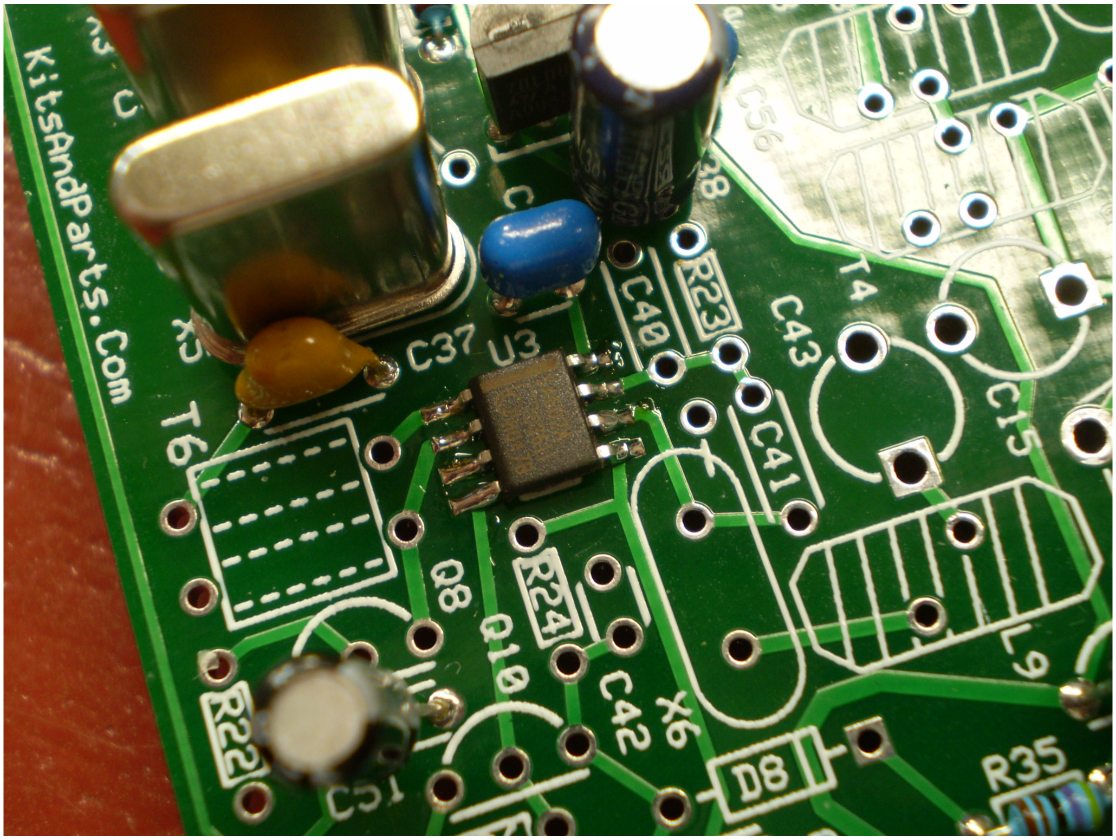


Figure 60: U3.

- U3 — NE612A or SA602A IC

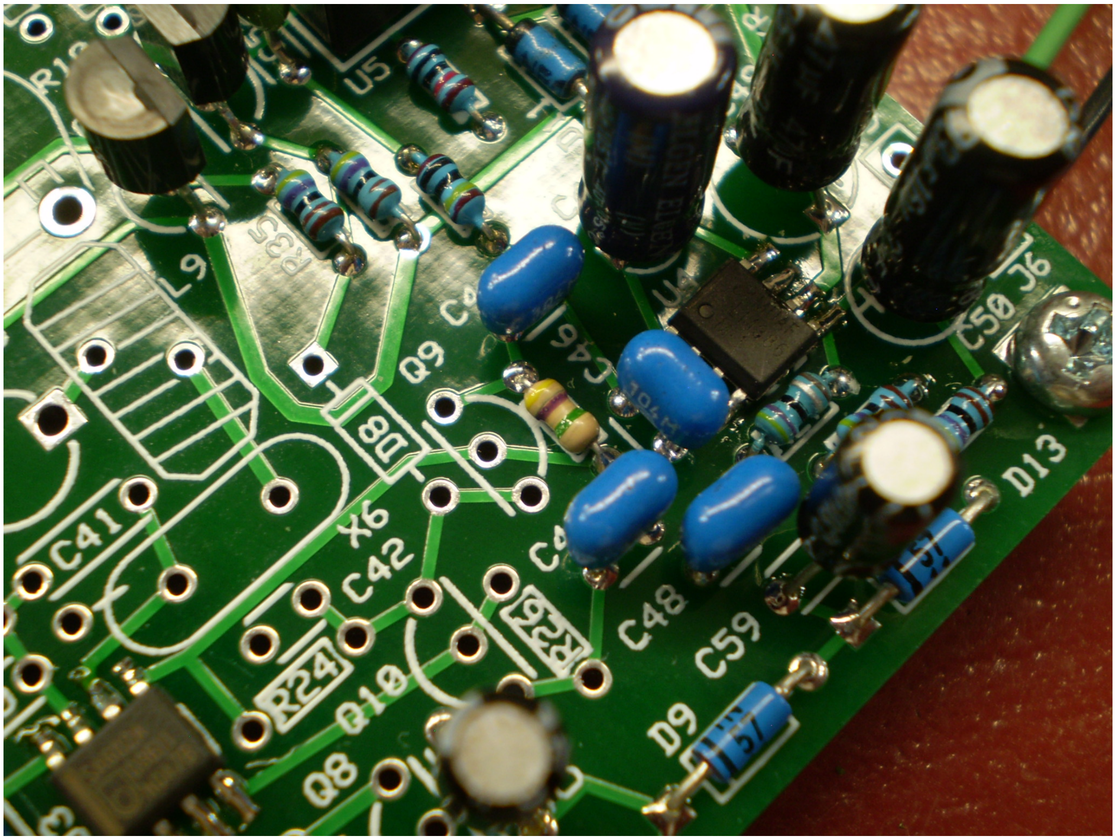


Figure 61: R25.

- R25 — 4.7M resistor

I used a 1/8W carbon resistor here instead of a thin metal film as I did not have the value in my thin metal film resistor supply. Works the same.

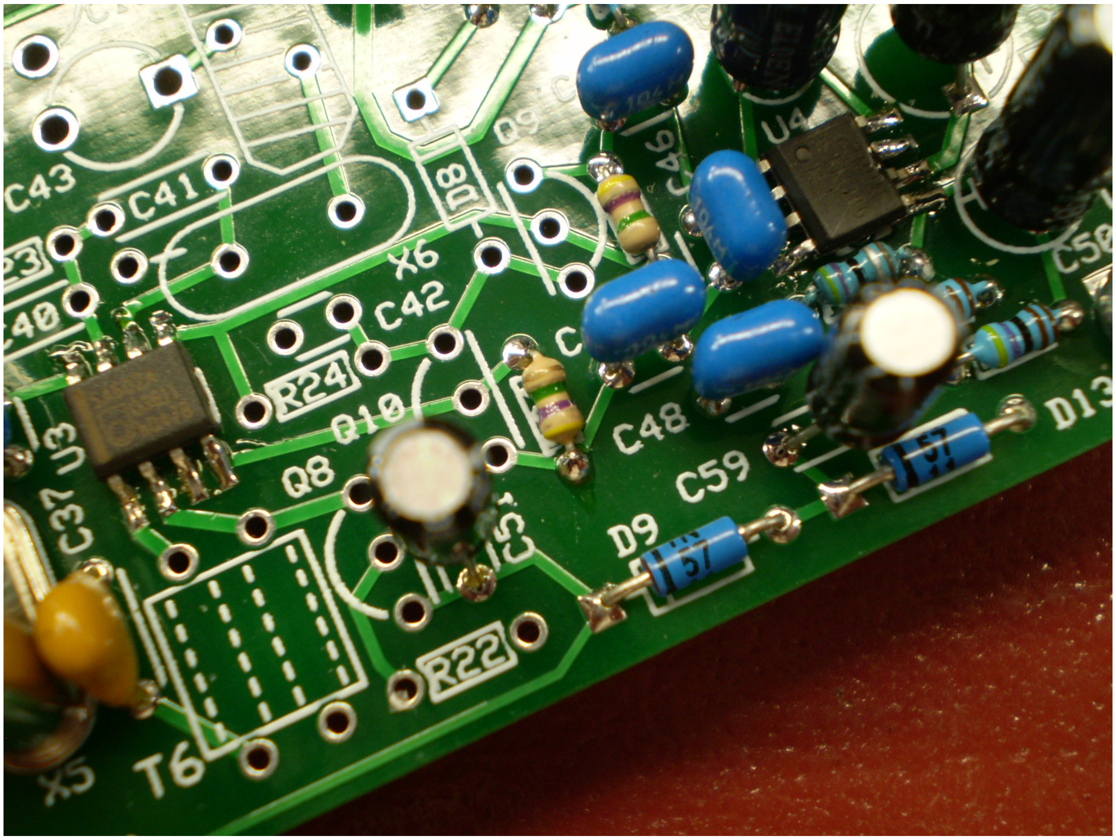


Figure 62: R26.

- R26 — 4.7M resistor

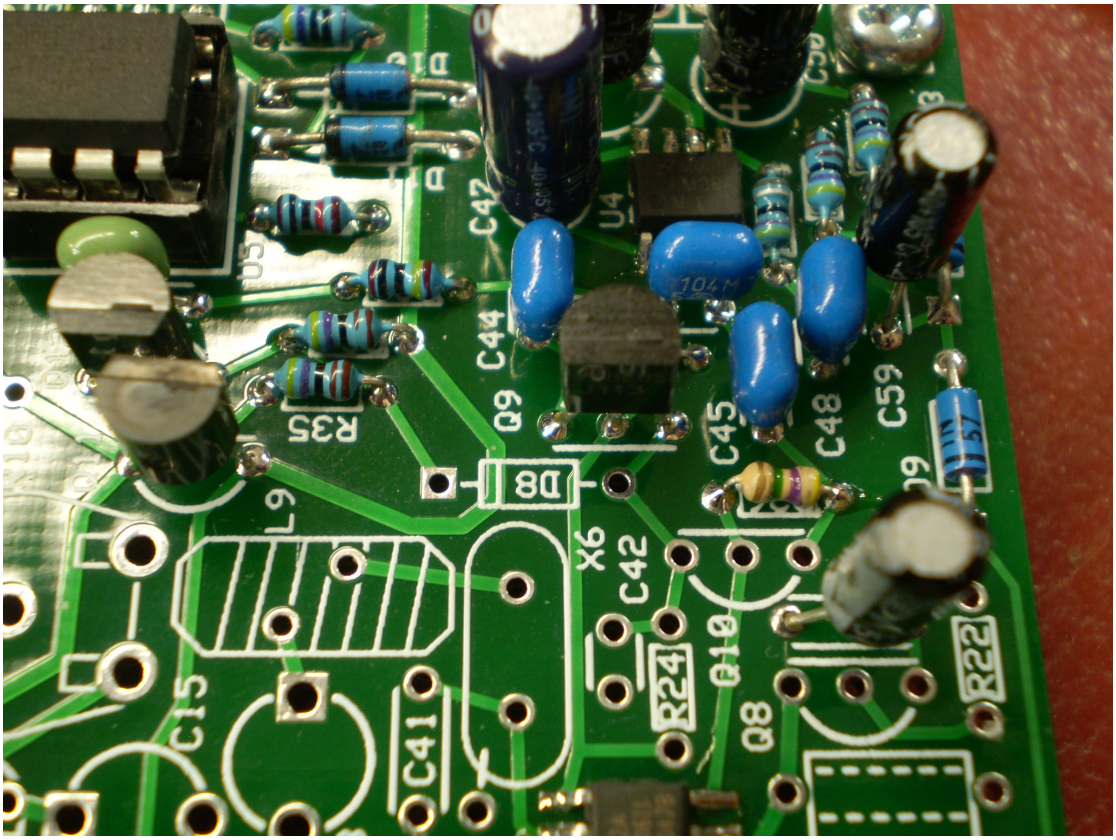


Figure 63: Q9.

- Q9 — J113 JFET

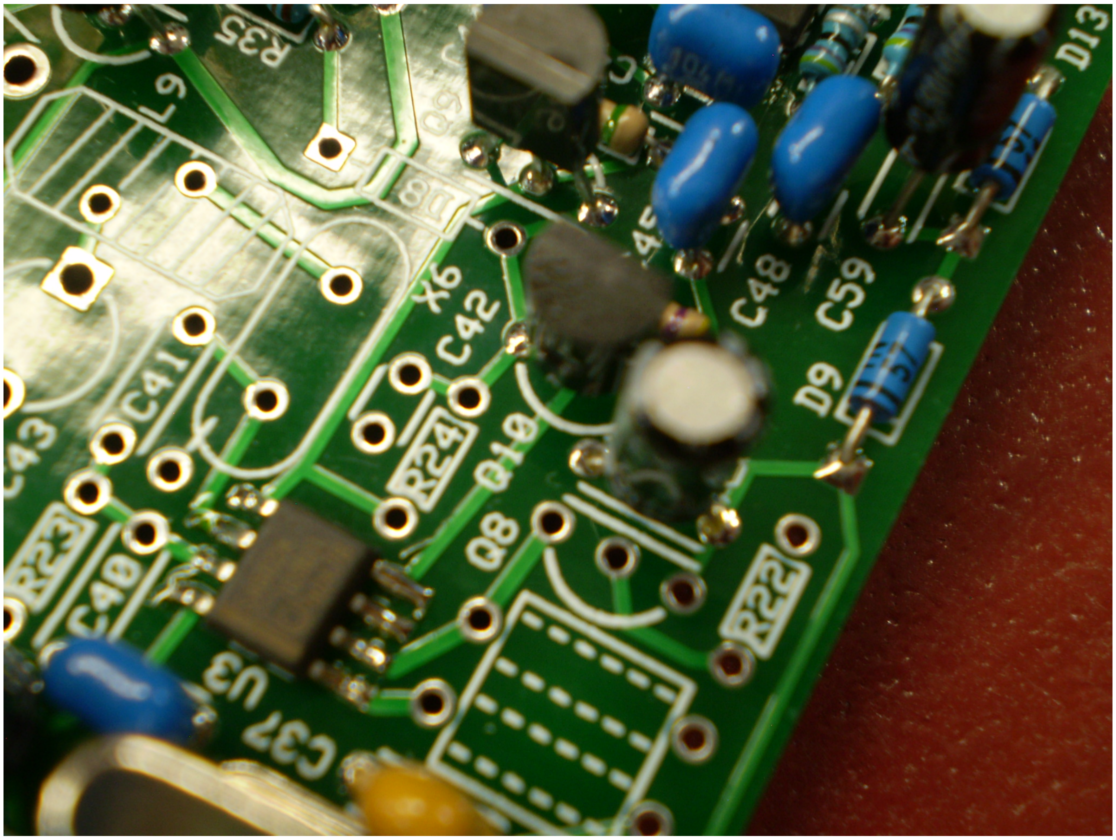


Figure 64: Q10.

- Q10 — J113 JFET

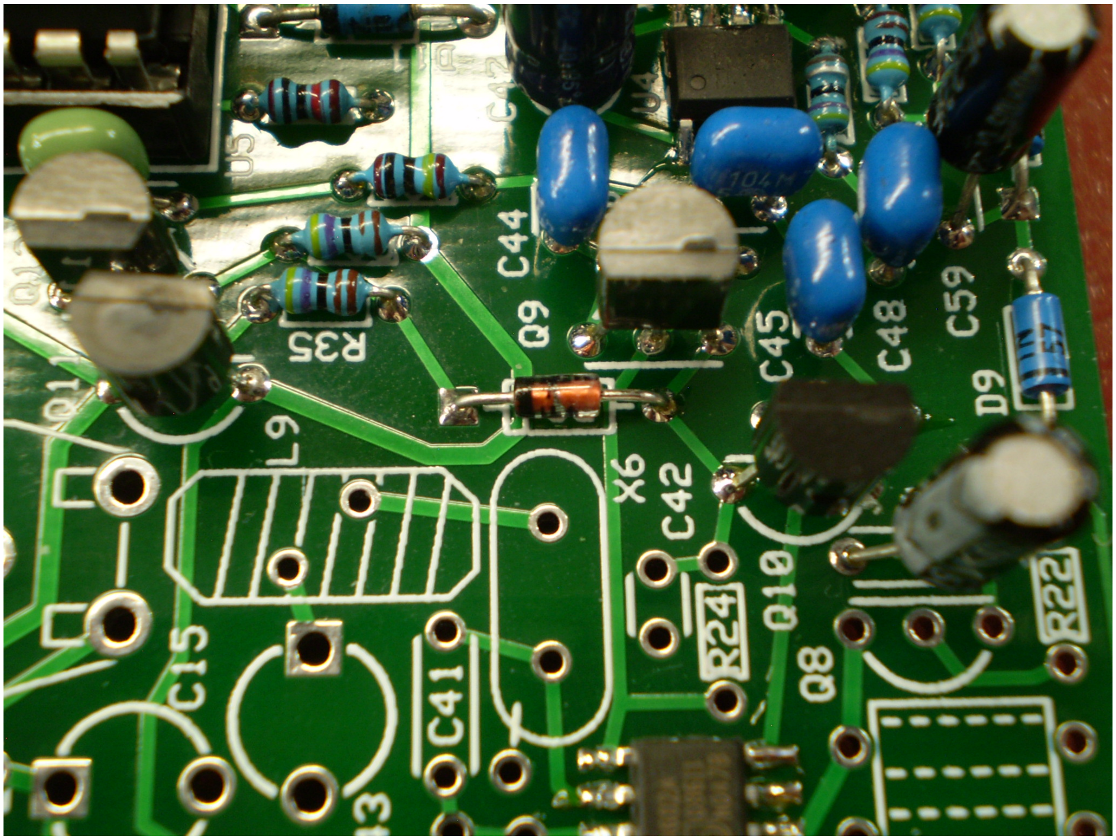


Figure 65: D8.

- D8 — 1N4148 Si diode

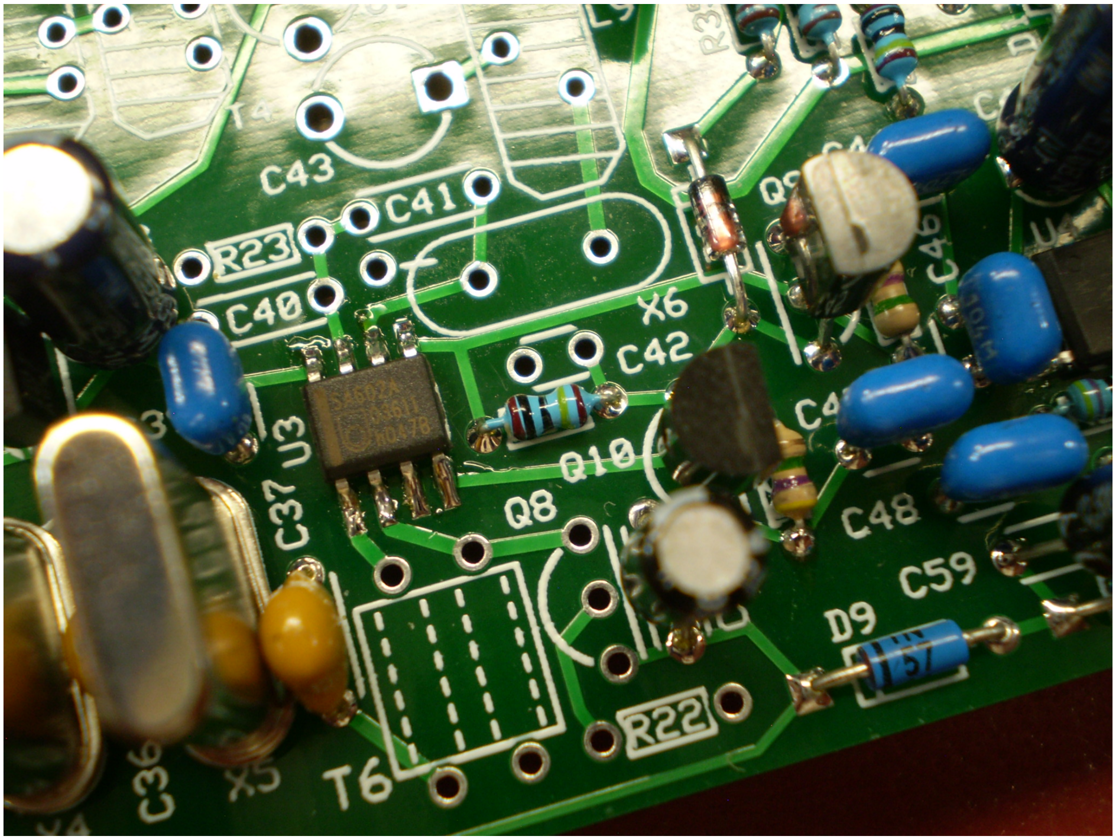


Figure 66: R24.

- R24 — 1M resistor

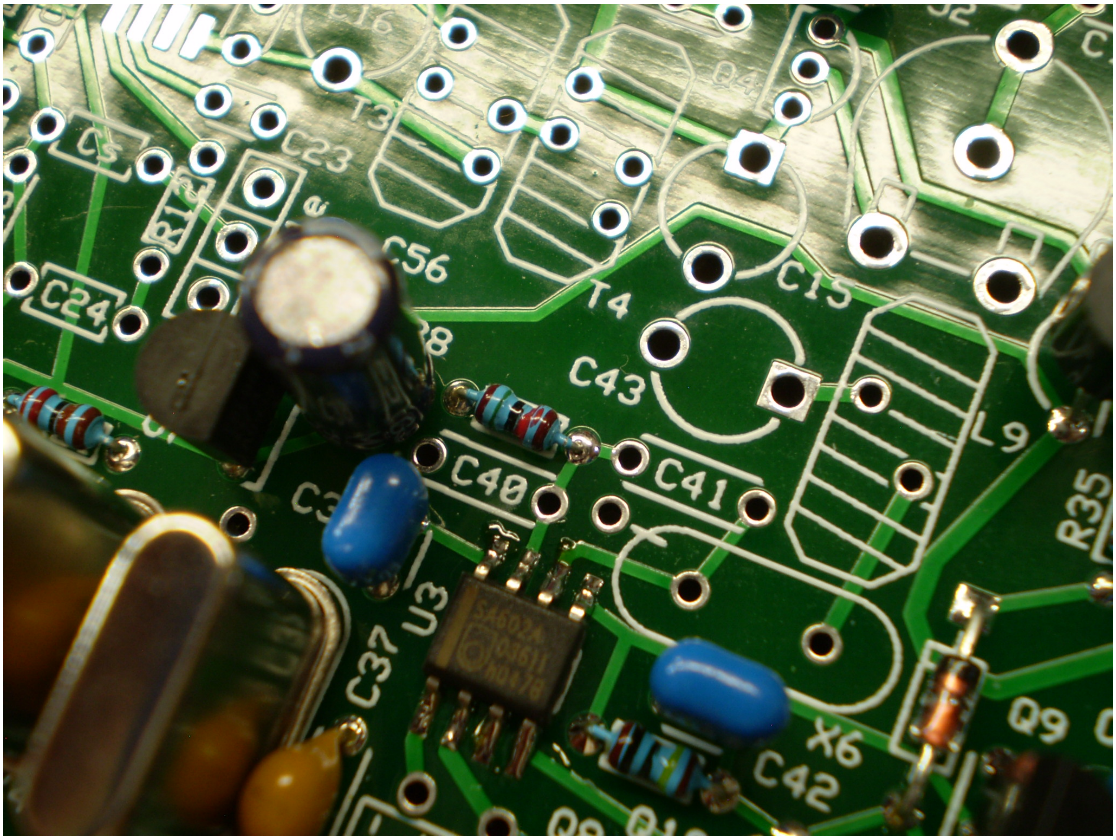


Figure 67: C42.

- C42 — 100nF cap
- R23 — do not install

C42 is in the lower middle left of the photo and didn't get a photo of its own.

I installed R23 because at the time I was using a previous version of the schematic and Diz changed the schematic. I removed the resistor later.

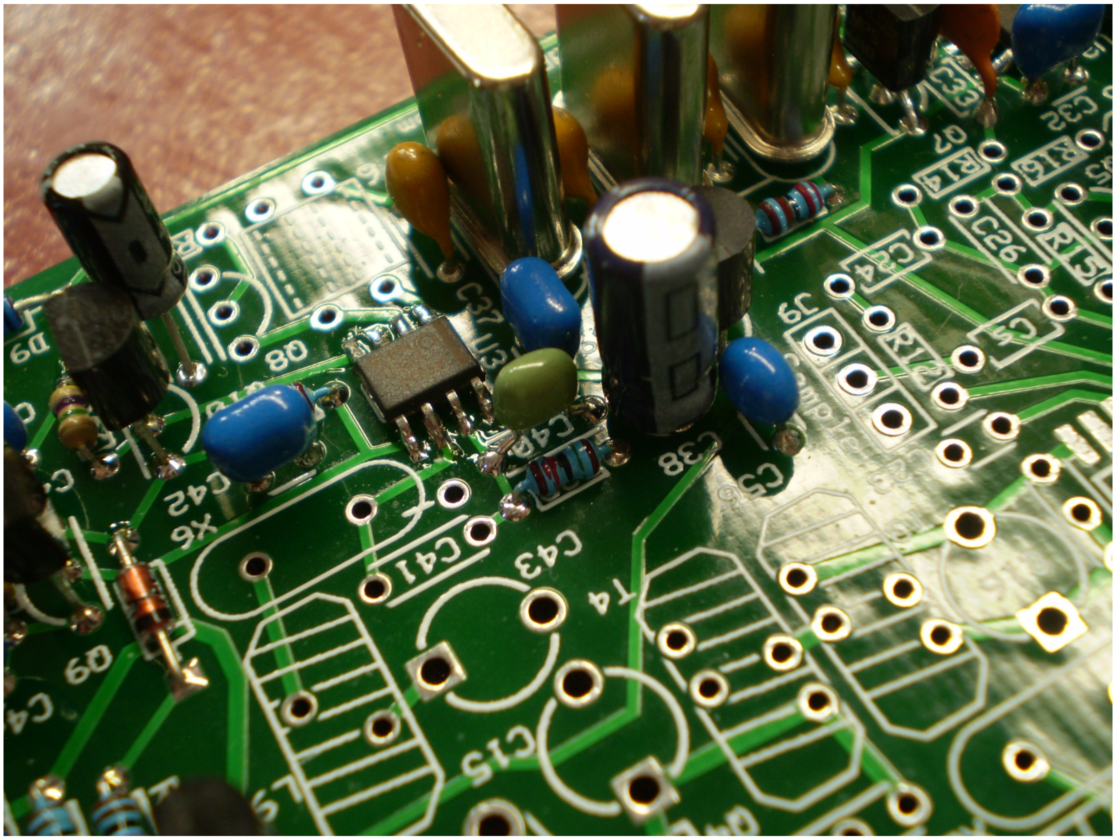


Figure 68: C40.

- C40 — 100pF mono cap

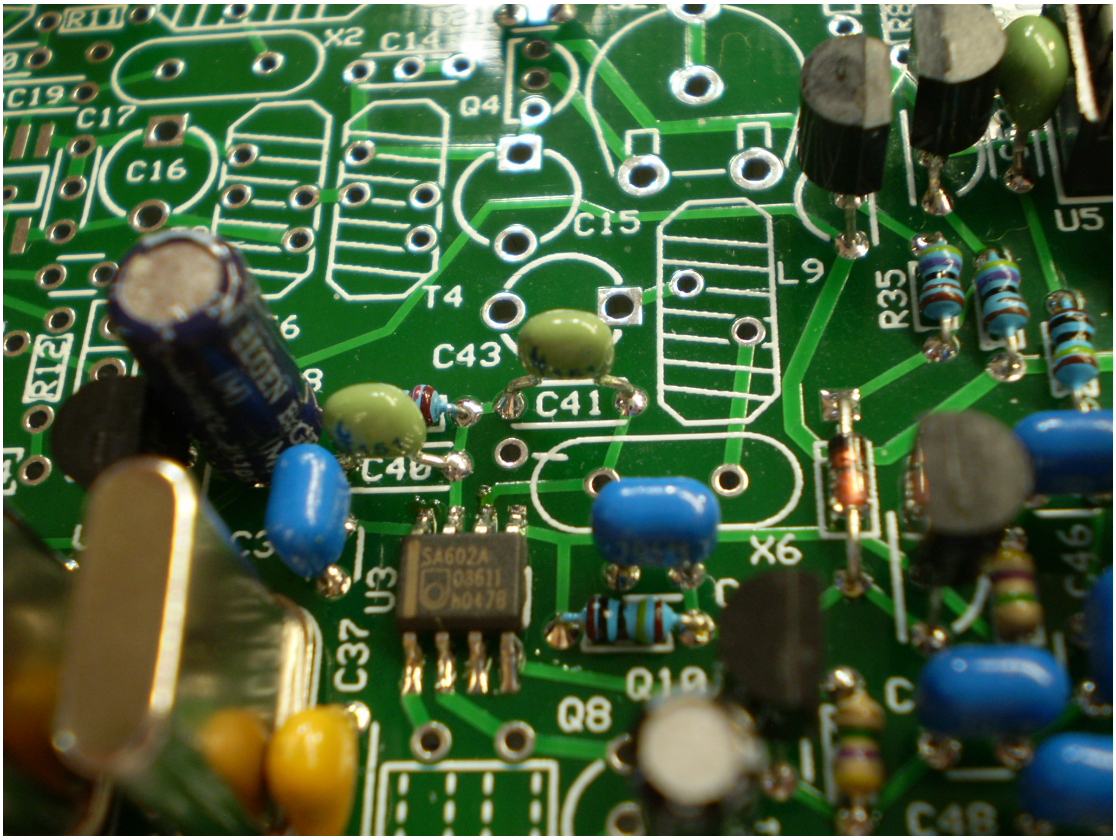


Figure 69: C41.

- C41 — 100pF mono cap

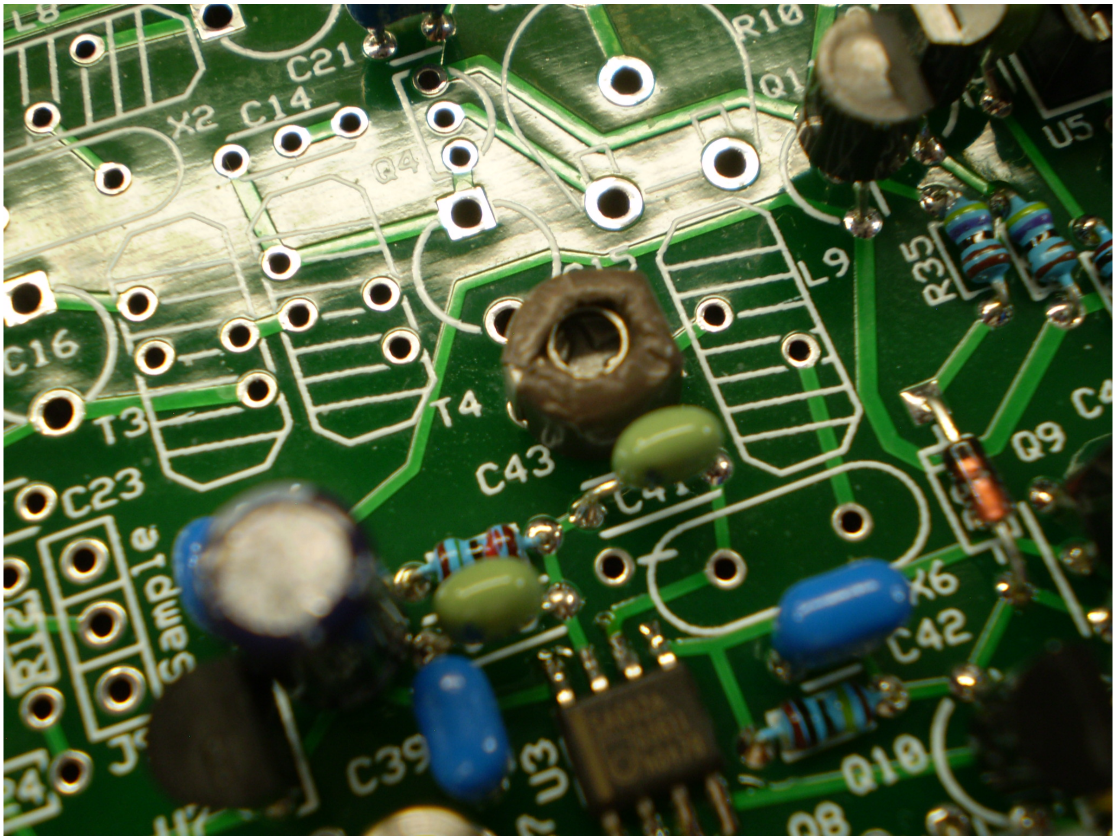


Figure 70: C43.

- C43 — 45pF trimmer cap

I am using another trimmer cap as my supply does not include any 45pF caps. Your cap should be yellow.

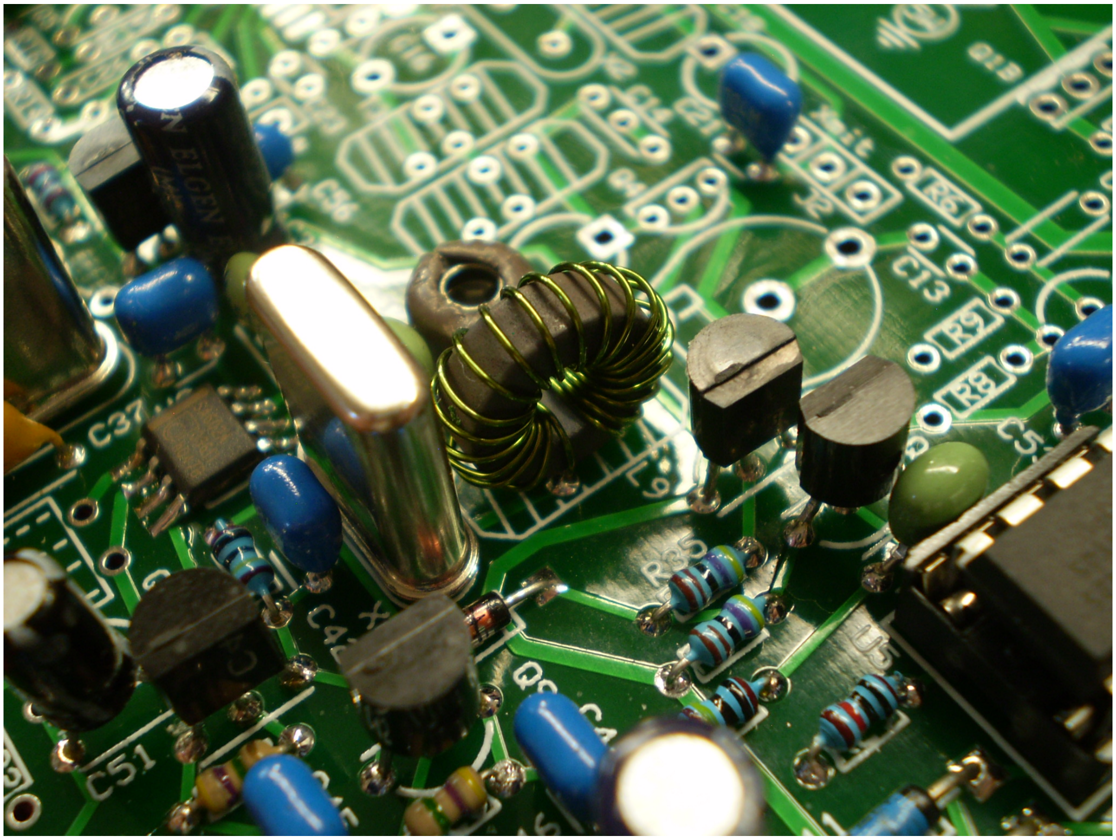


Figure 71: L9.

- L9 — FT37-61 toroid core with 20 turns (20T)

Again, I’m using my own wire, so color and size may be different than yours.

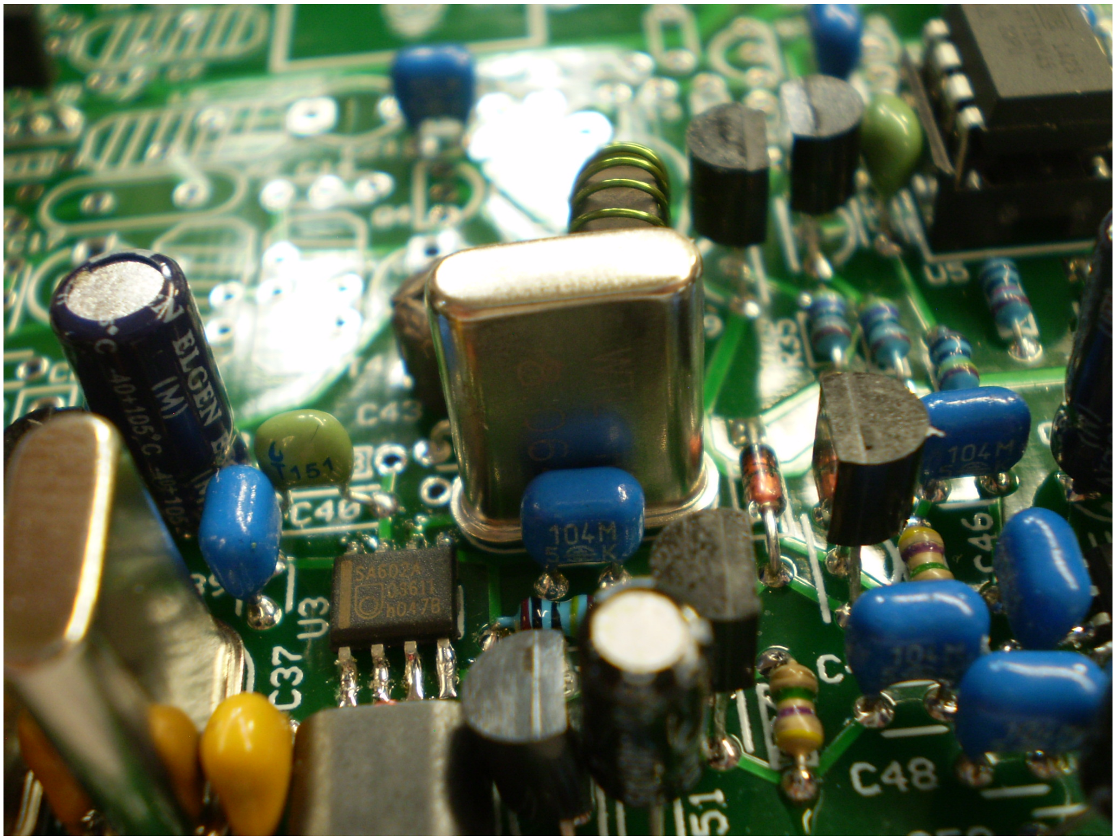


Figure 72: X6.

- X6 — 8.064MHz HC-49U crystal

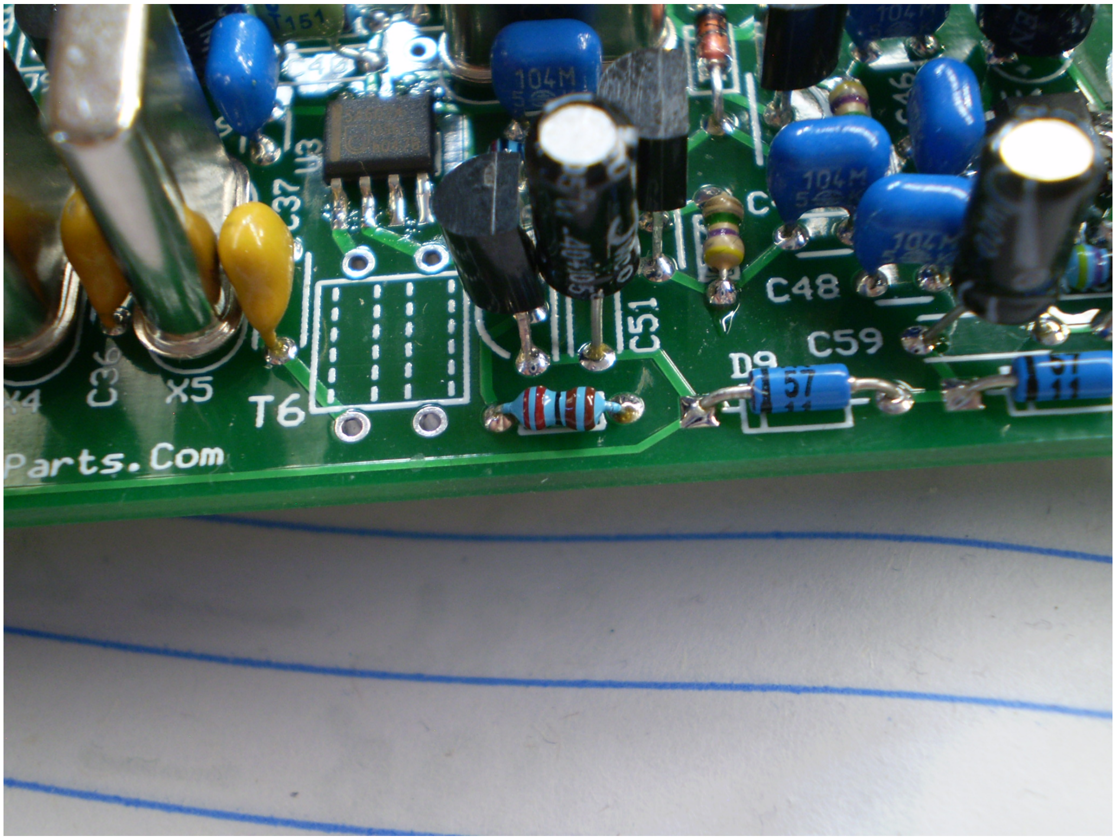


Figure 73: R22.

- R22 — 2K2 (2.2K) resistor
- Q8 — MPSH10 NPN transistor

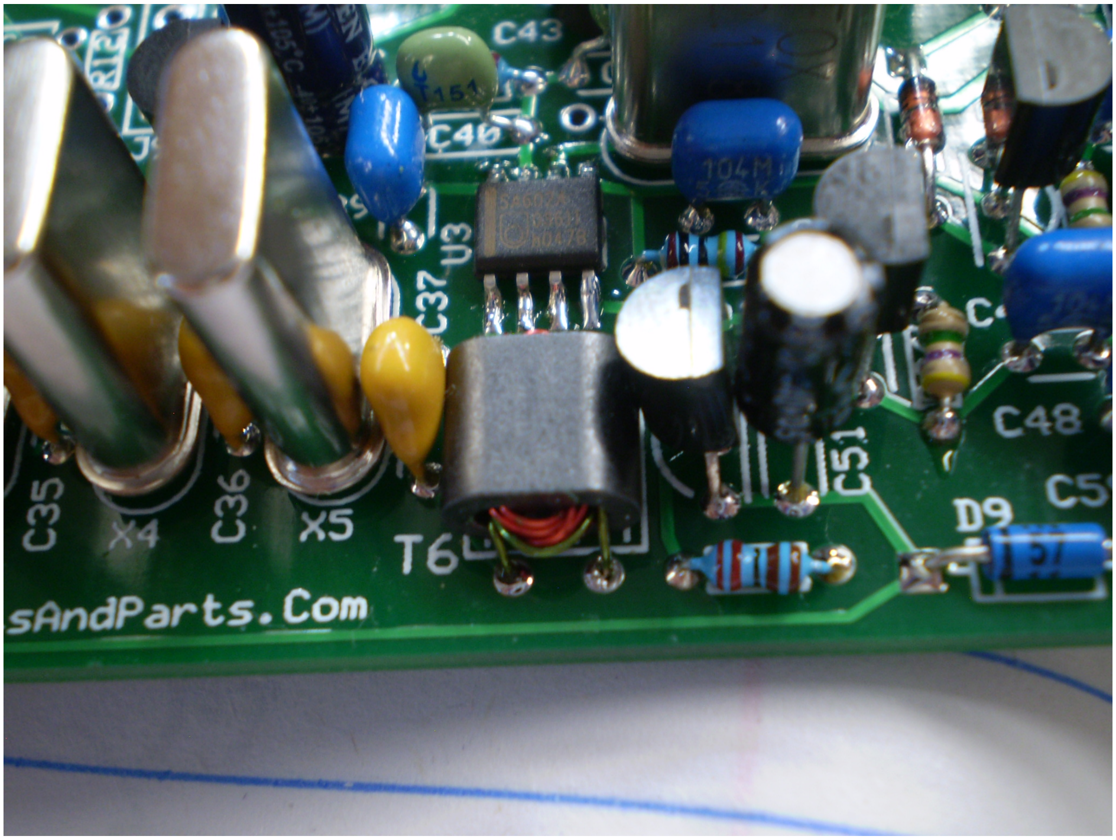


Figure 74: T6.

- T6 — BN-43-2402 binocular toroid core, 2T:8T
- C37 — 680pF mono cap

Windings are 2T and 8T with the 8T windings connected to pins 1 and 2 of U3. Diz will have instructions on winding on the web page for the 5W and the band you are building. This transformer is band independent.

Remember I screwed up and all the parts you see to the left of the transformer you will not have installed at this time, but do install C37, the 680pF mono cap.

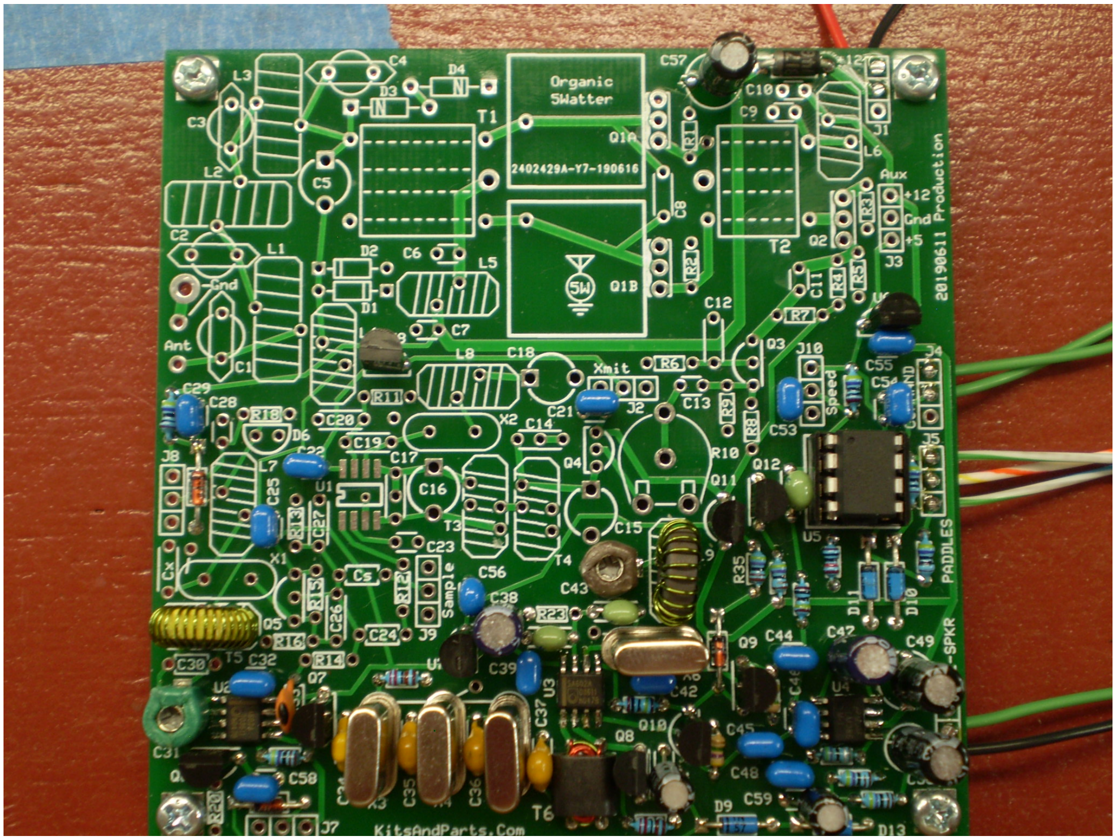


Figure 75: Top View.

Here is the top view of my transceiver build and I have all the stuff to the left bottom that you will not have.

5.1 Testing

Once again, for testing let's use the long insulated wire with 1mm stripped on the end.

Power up the transceiver again with speakers attached. Touch the wire to the pad of X5 that connects to C37 and T6 primary winding. You should hear and increase in noise level in the speakers. The noise frequency spectrum, the sound spectrum, will sound differently than that of the test we did with just the audio amp in the section 2 build.

What we have now is a receiver for 8.064MHz. If you connect an outside antenna, you will hear all the RF noise at the antenna at this frequency. Unfortunately there are no HF broadcast stations at this frequency to listen to.

Adjust C43 to see if the range of the noise sound can be lowered or raised in pitch. We'll adjust this later on in the project.

Chapter 6

RF gain, First Receiver Mixer and IF Amp and Crystal Filter

In this chapter you will see that the second receiver mixer area is vacant because I had been following the build instructions I had written down in a notebook and I seem to follow instructions pretty well. So, your build will have the area to the right filled in.

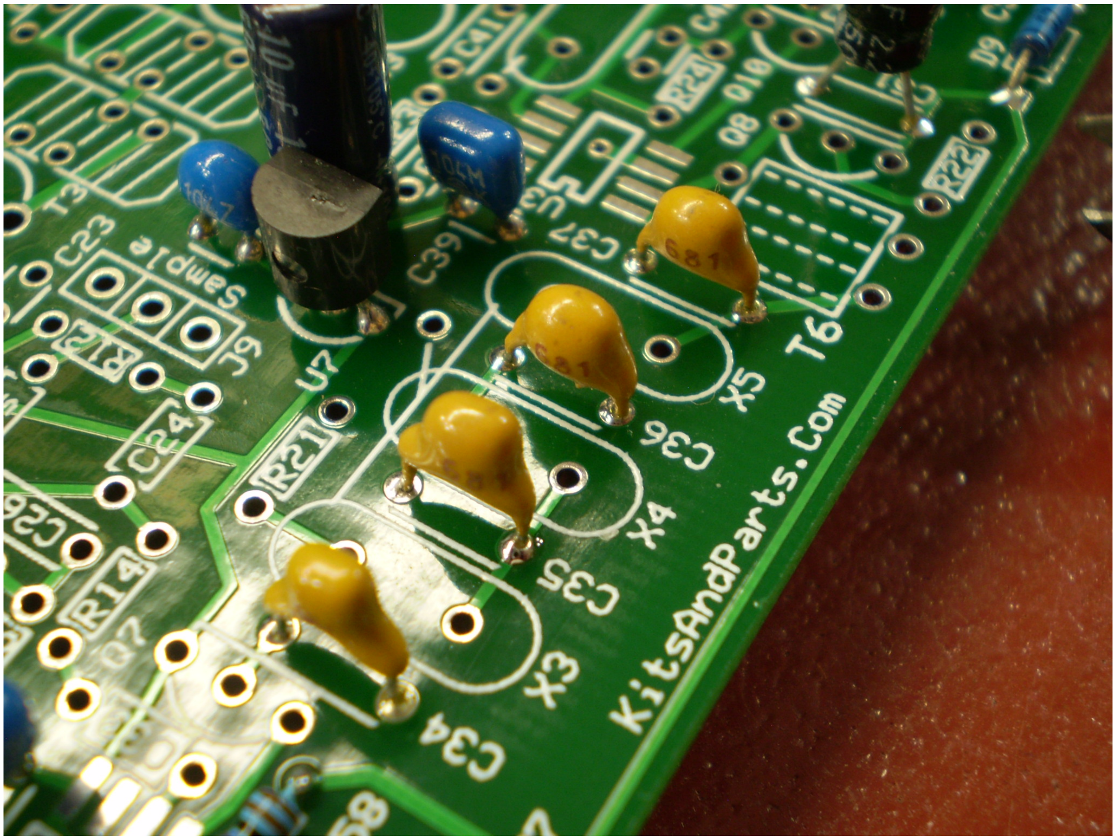


Figure 76: C34, C35, C36 and C37.

- C34 — 680pF mono cap
- C35 — 680pF mono cap
- C36 — 680pF mono cap
- C37 — 680pF mono cap (this one installed in previous stage)

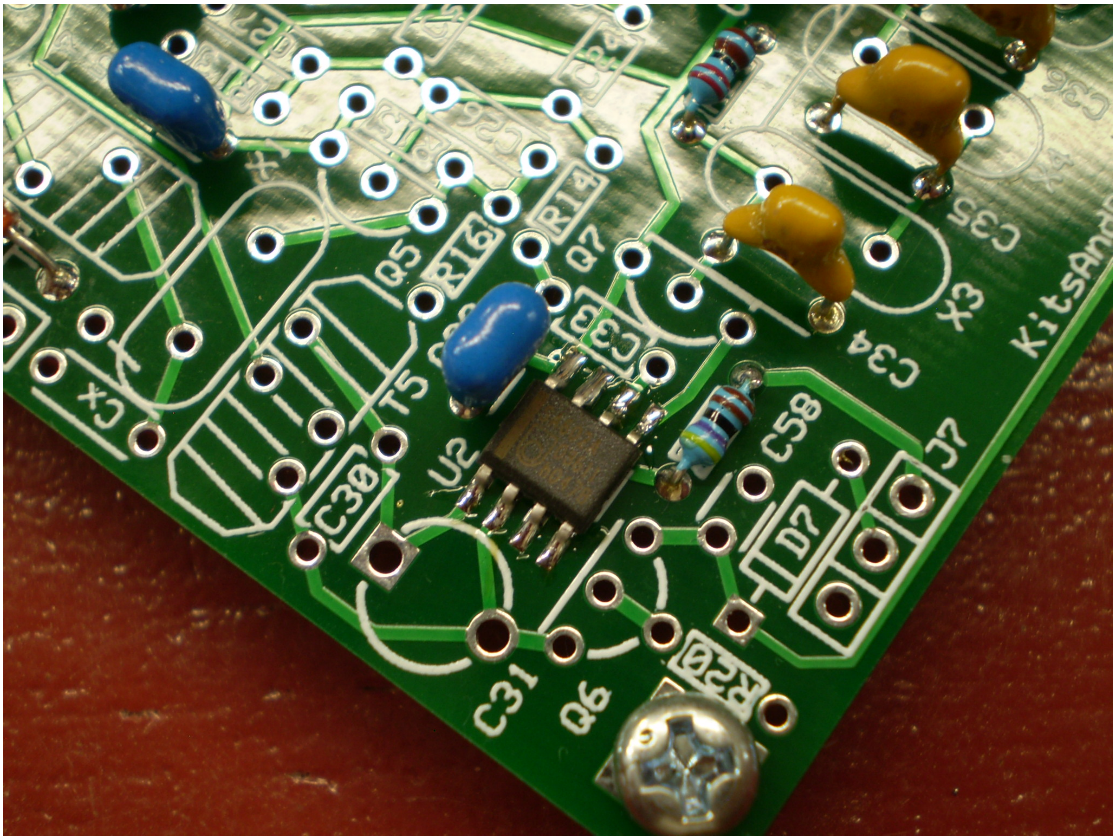


Figure 77: U2.

- U2 — SA602A or SA612A IC

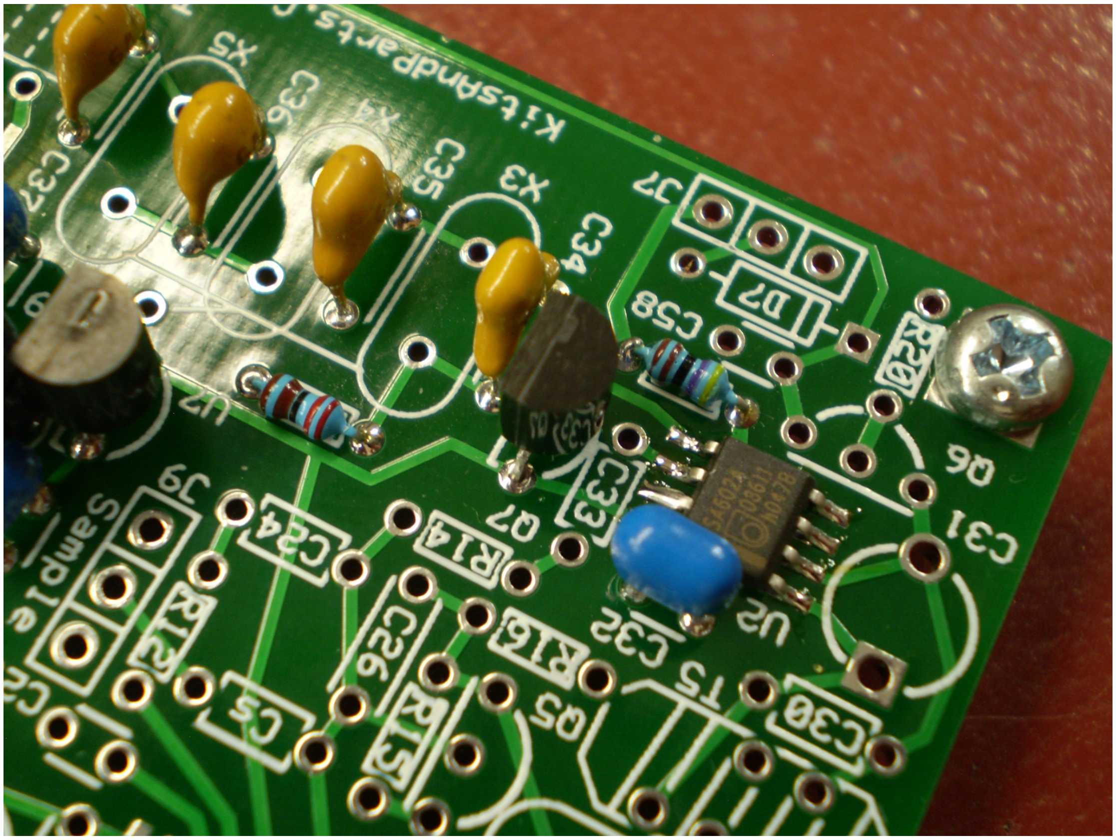


Figure 78: Q7.

- Q7 — MPSH10 NPN transistor

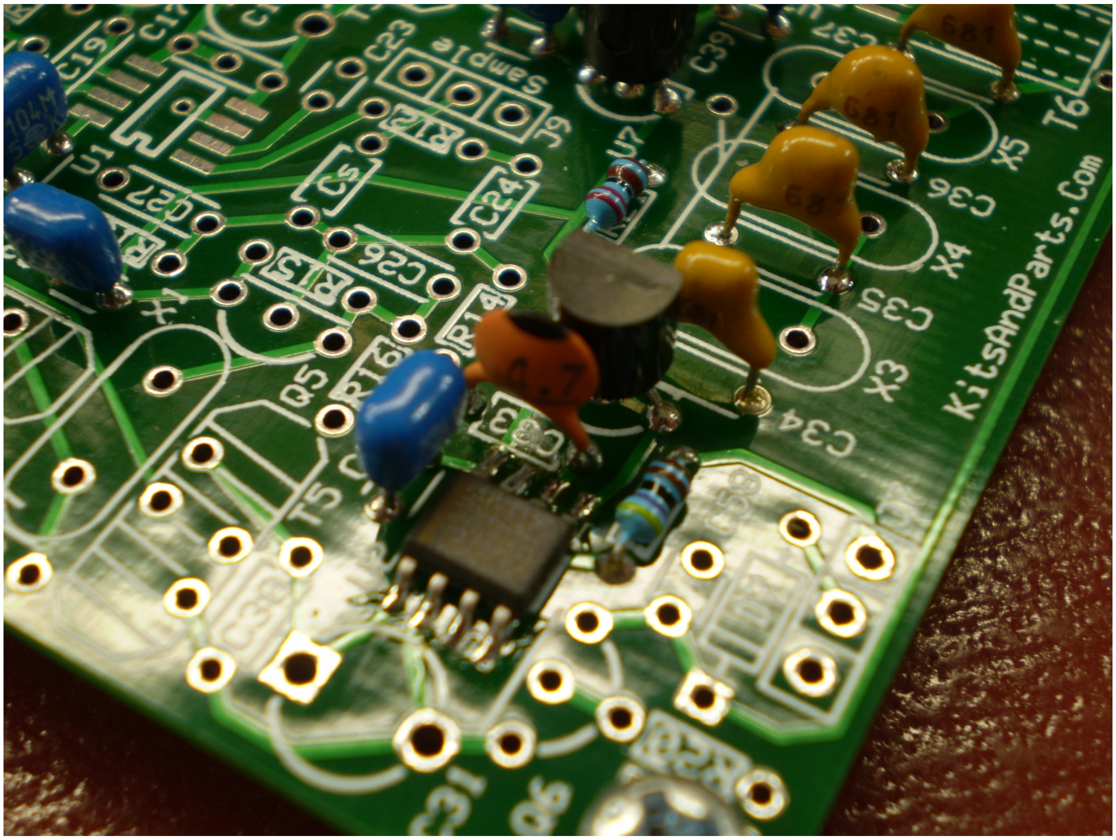


Figure 79: C33.

- C33 — 4p7 (4.7pF) capacitor

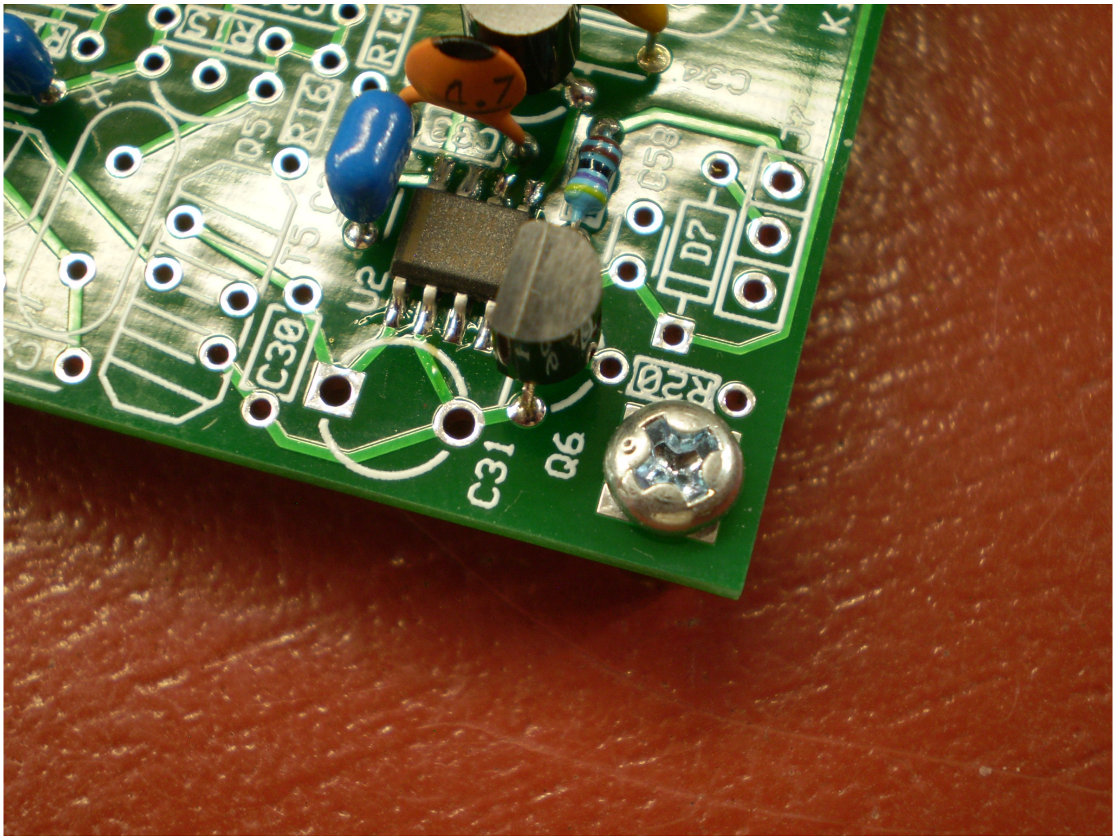


Figure 80: Q6.

- Q6 — MPSH10 NPN transistor

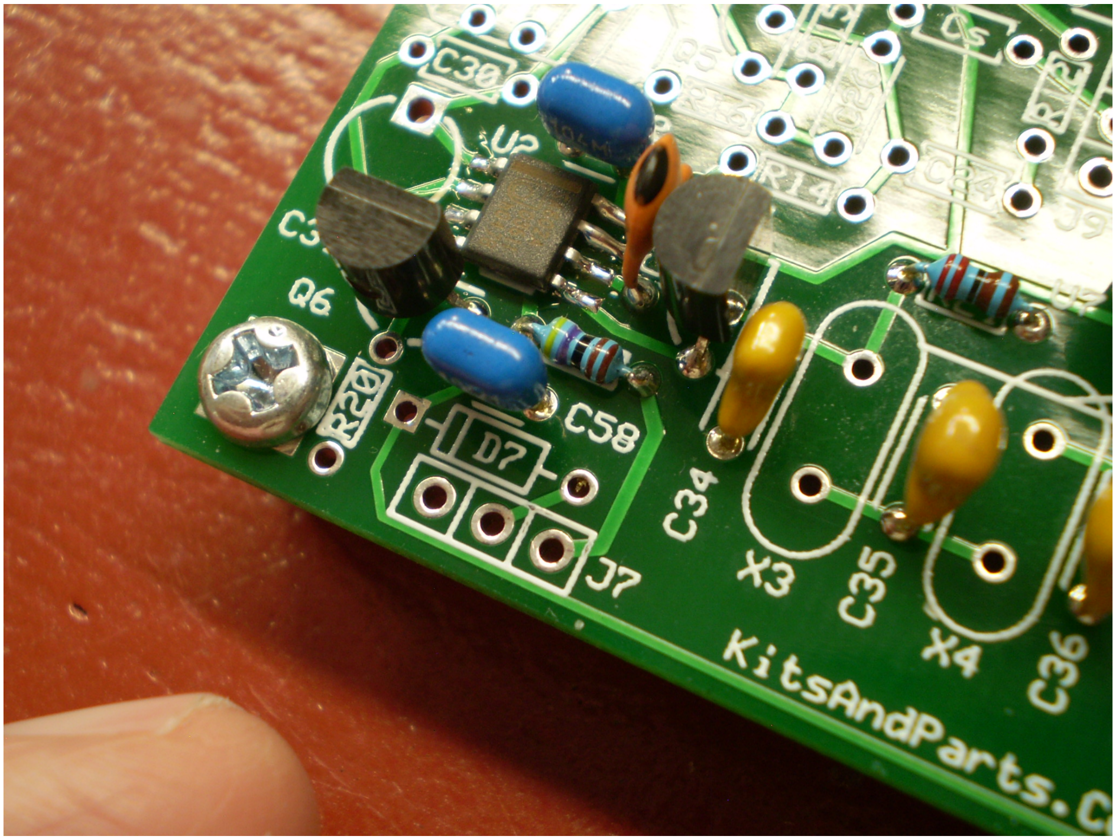


Figure 81: C58.

- C58 — 100nF mono cap

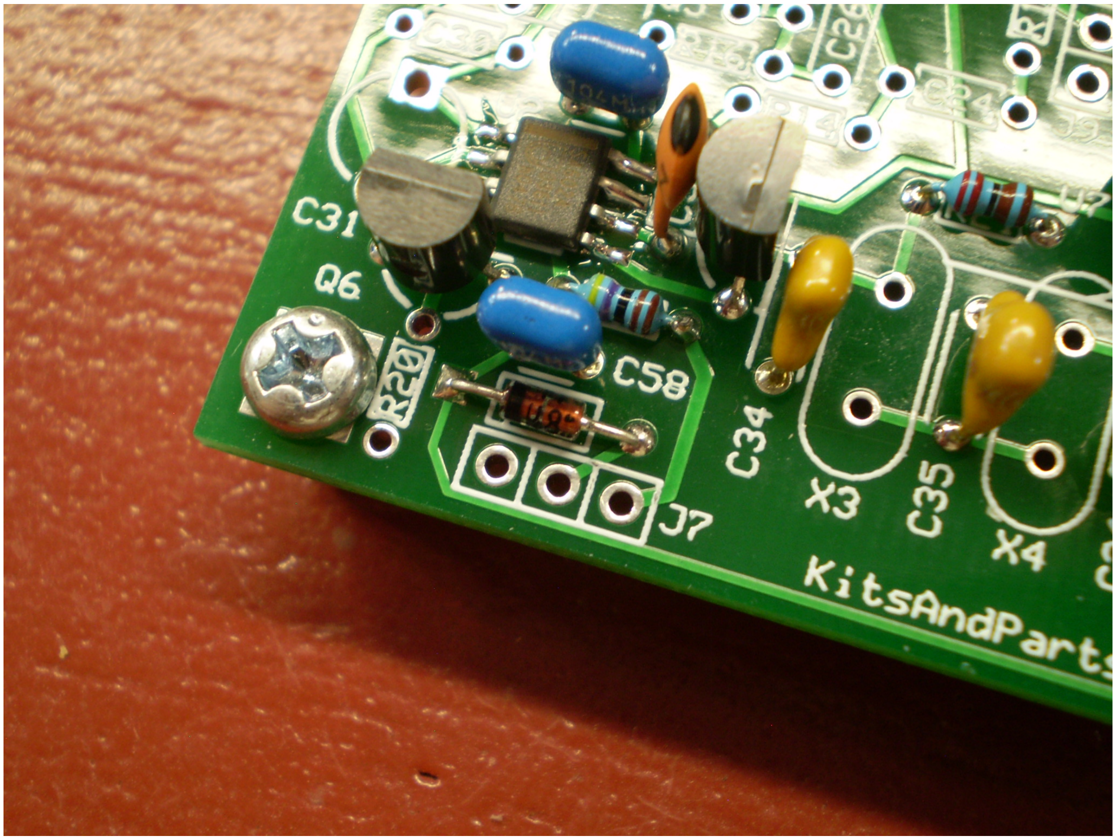


Figure 82: D7.

- D7 — 1N4148 Si diode

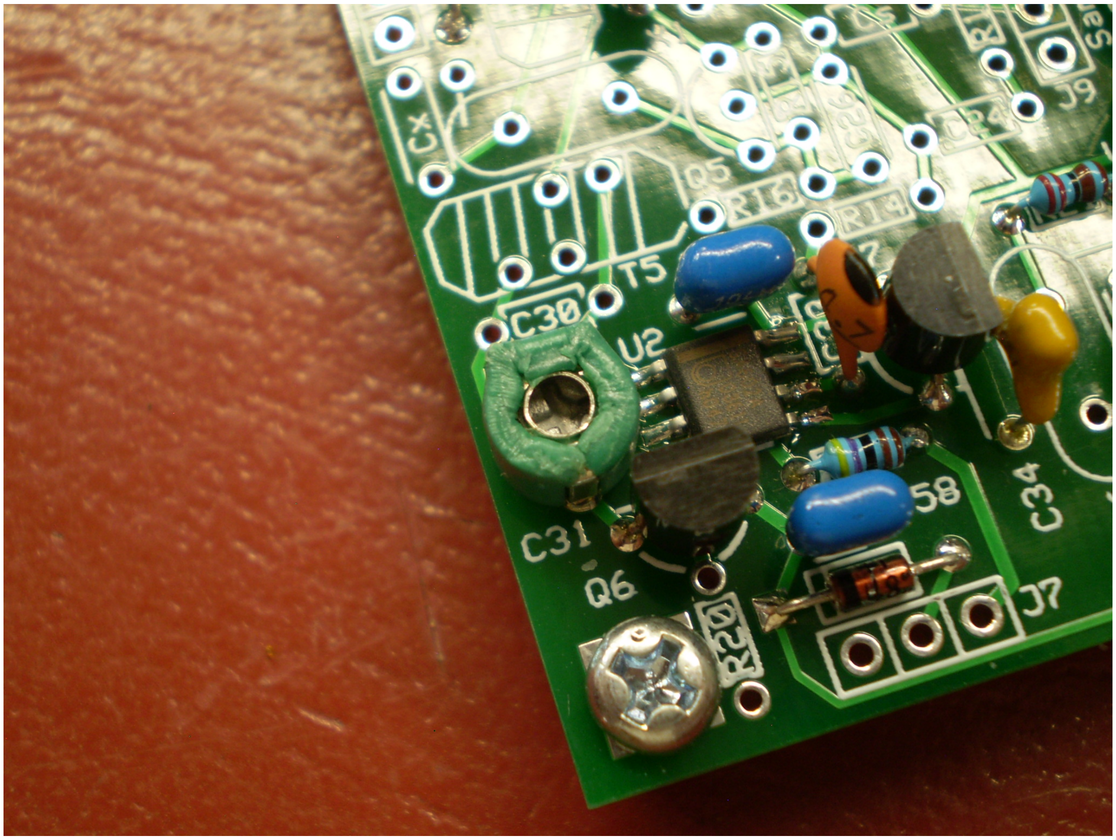


Figure 83: C31.

- C31 — 45pF trimmer cap
- C30 — not used for 20m. Install if for another band requiring it.

Your C31 should be yellow.

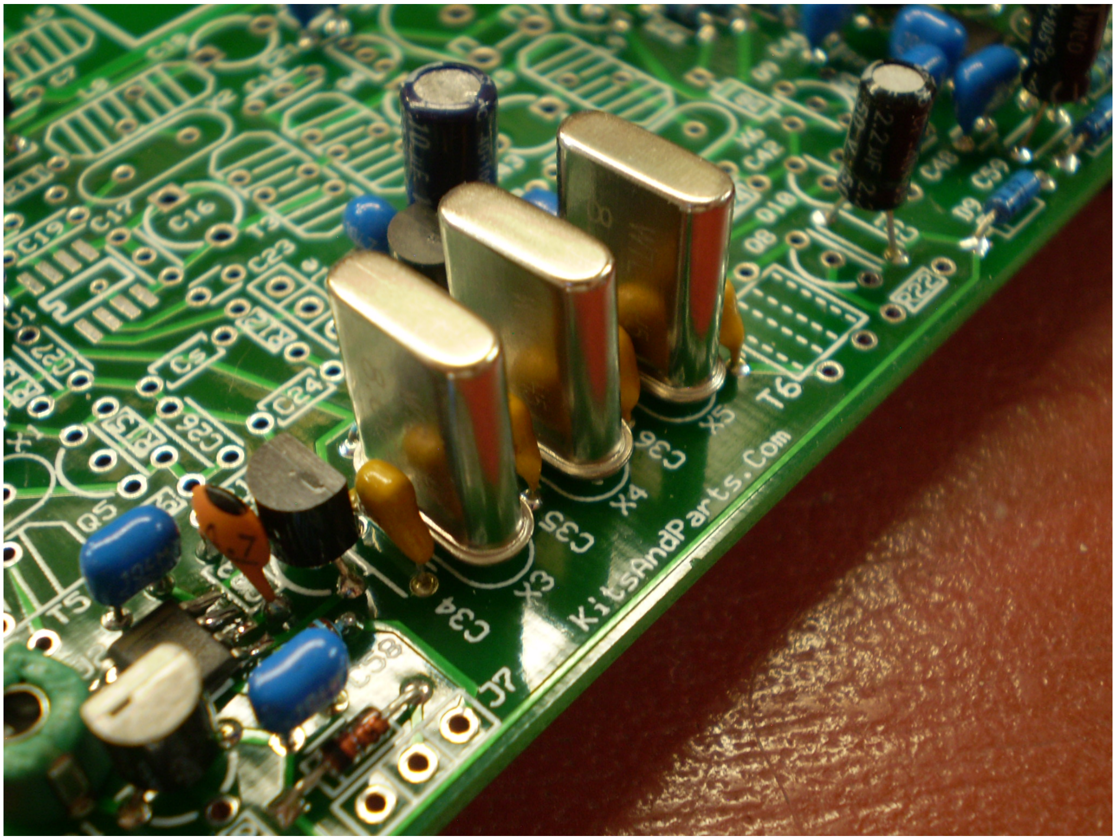


Figure 84: X3, X4 and X5.

- X3 — 8.064MHz HC-49U crystal
- X4 — 8.064MHz HC-49U crystal
- X5 — 8.064MHz HC-49U crystal

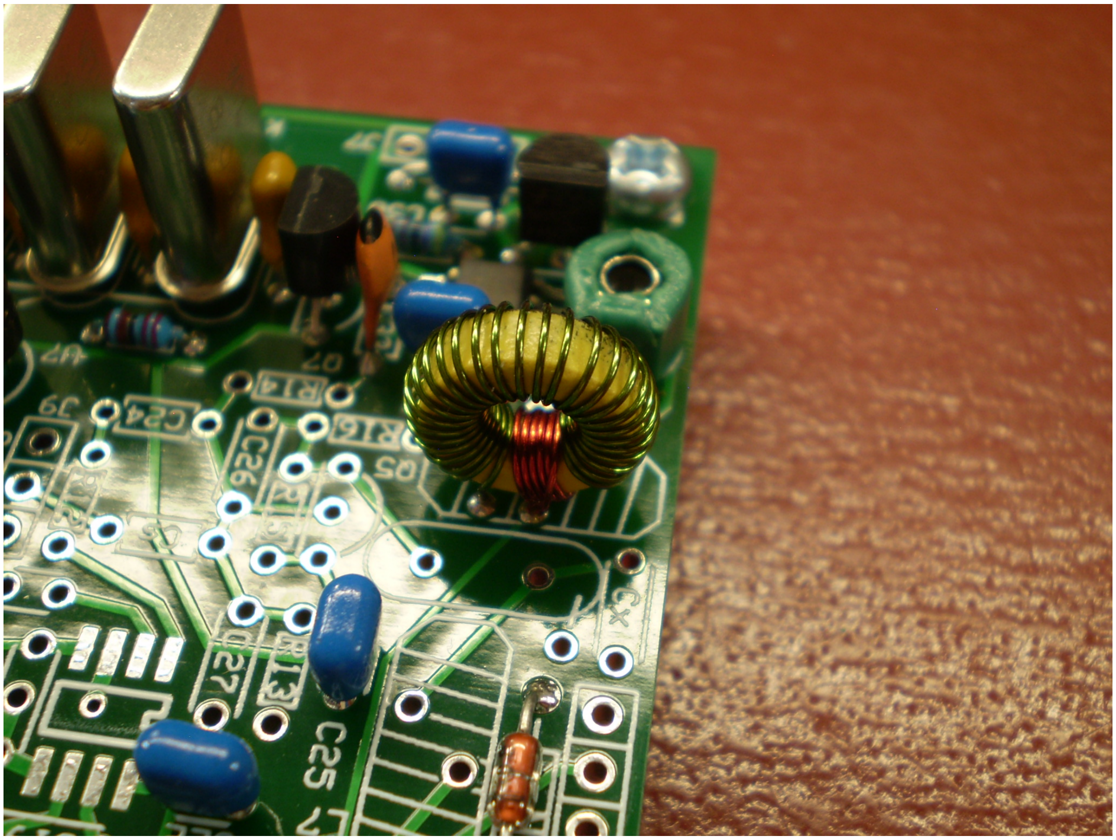


Figure 85: T5.

- T5 — T37-6 toroid transformer 4T:28T

Looks so pretty when they come out looking like that one. I wound this one with old turns count that Diz had while we where prototyping the builds.

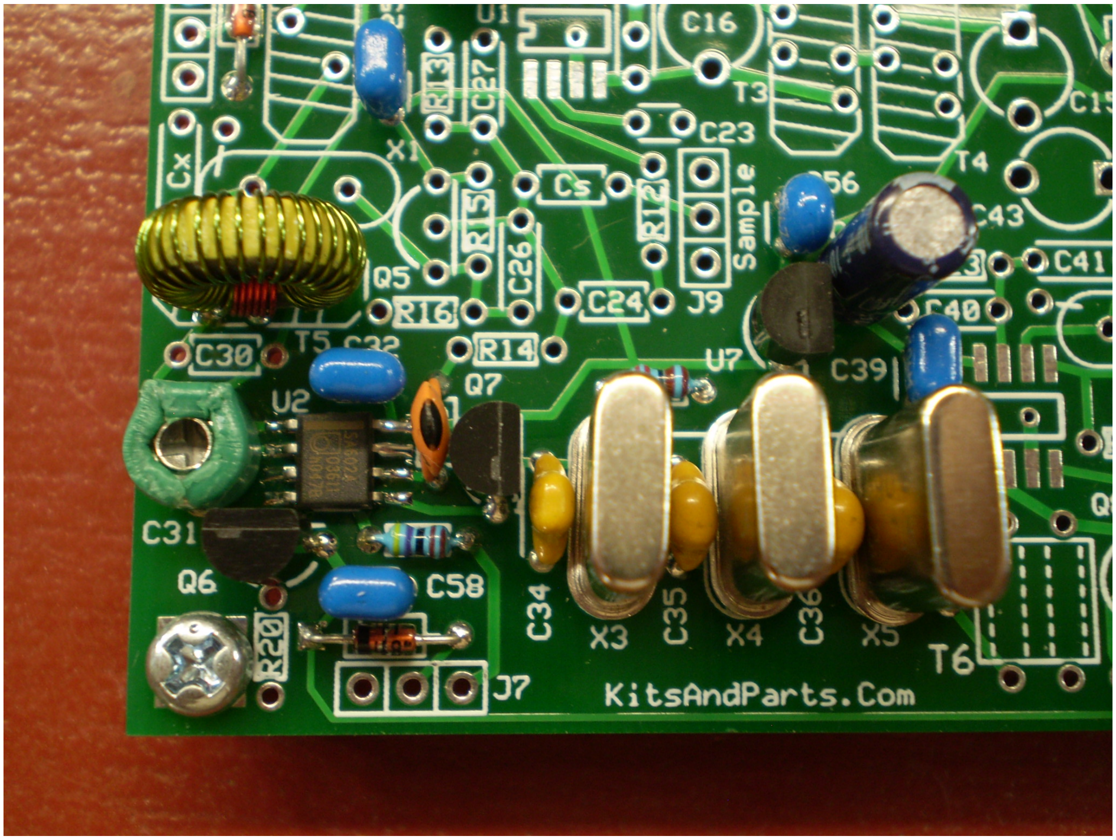


Figure 86: Top View.

- R20 — 2K2 resistor
- R21 — 2K2 resistor

6.1 Testing

Because the VXO is not installed, the first RF mixer won't be doing much of anything. You can power up the transceiver for testing and place the wire test probe at the lower pad of L4, which is not installed. This feeds in RF noise through the transformer T5. This may increase the noise heard in the speaker. The noise will now be narrower in frequency range due to the IF filtering.

Since we do not have an RF gain pot installed, the receiver should not attenuate the input signal. This is all we can do here at this time.

Chapter 7

Variable Crystal Oscillator (VXO)

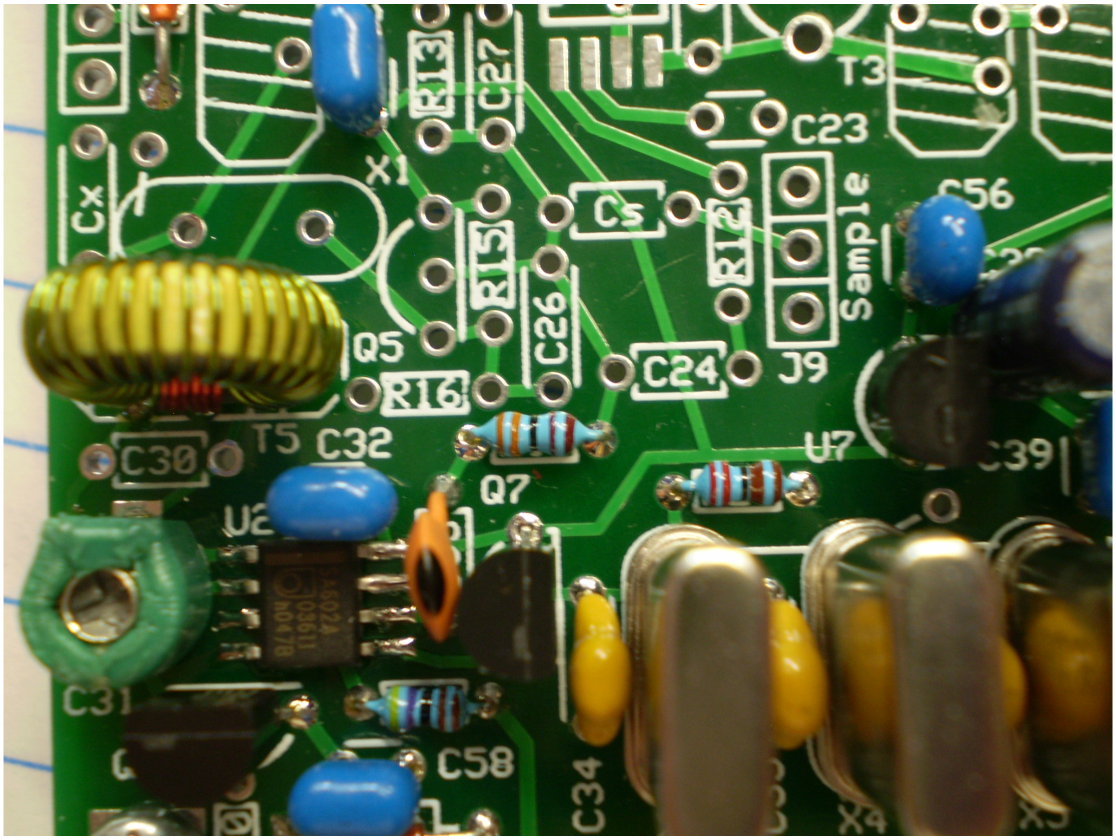


Figure 87: R14

- R14 — 3.3K 1/8W resistor

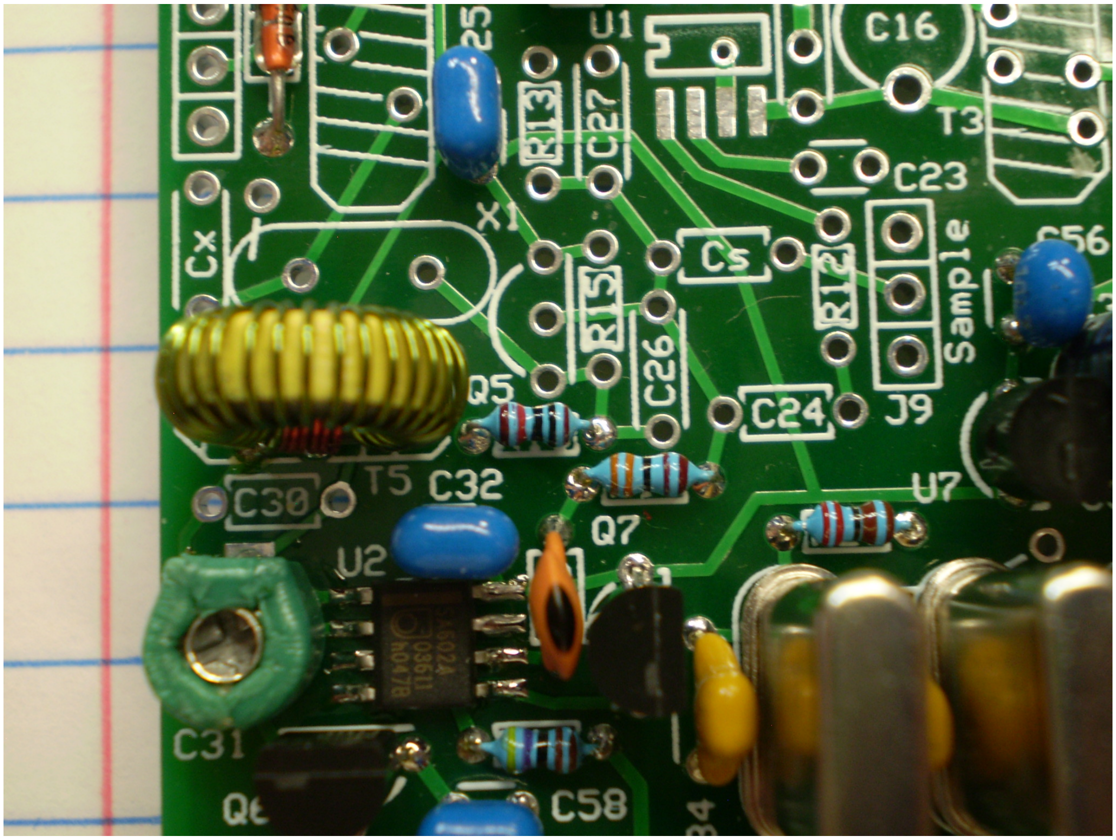


Figure 88: R16

- R16 — 10K 1/8W resistor

Now that I look at the photo closely I see that I put the resistor in reverse direction that I normally do so that I can read the color code from left to right. This one you read from right to left.

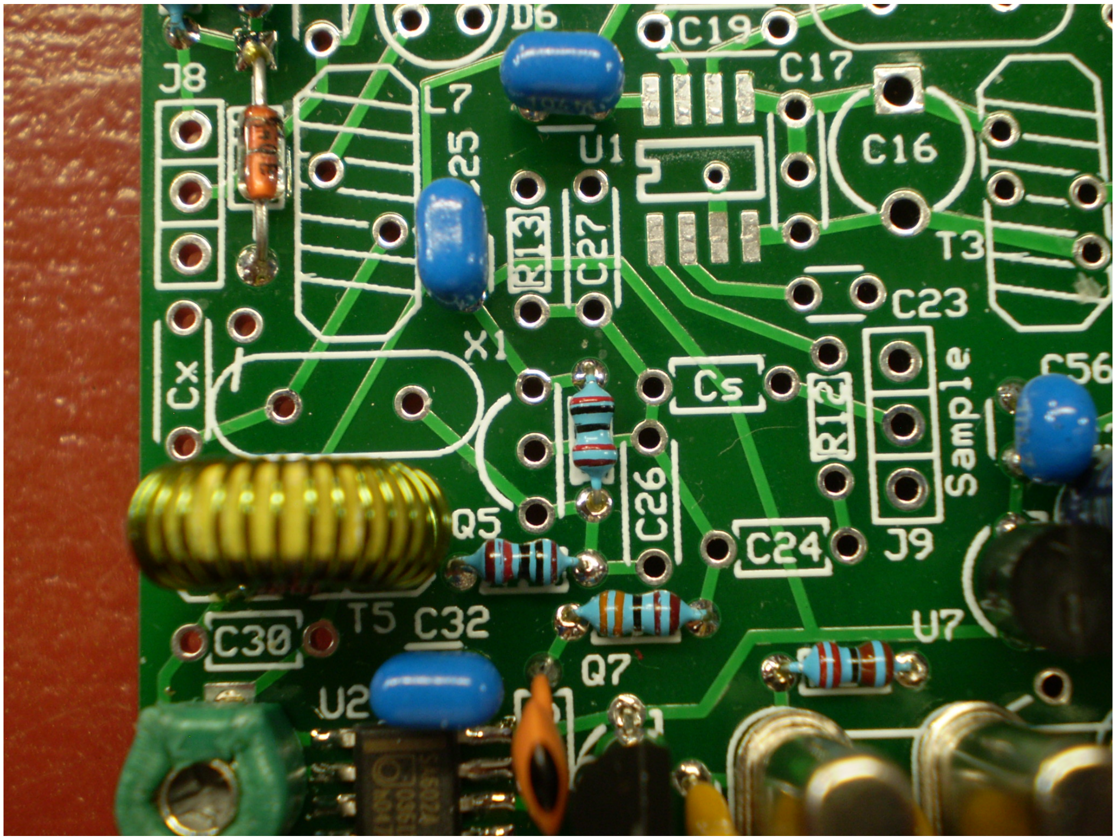


Figure 89: R15

- R15 — 20K 1/8W resistor

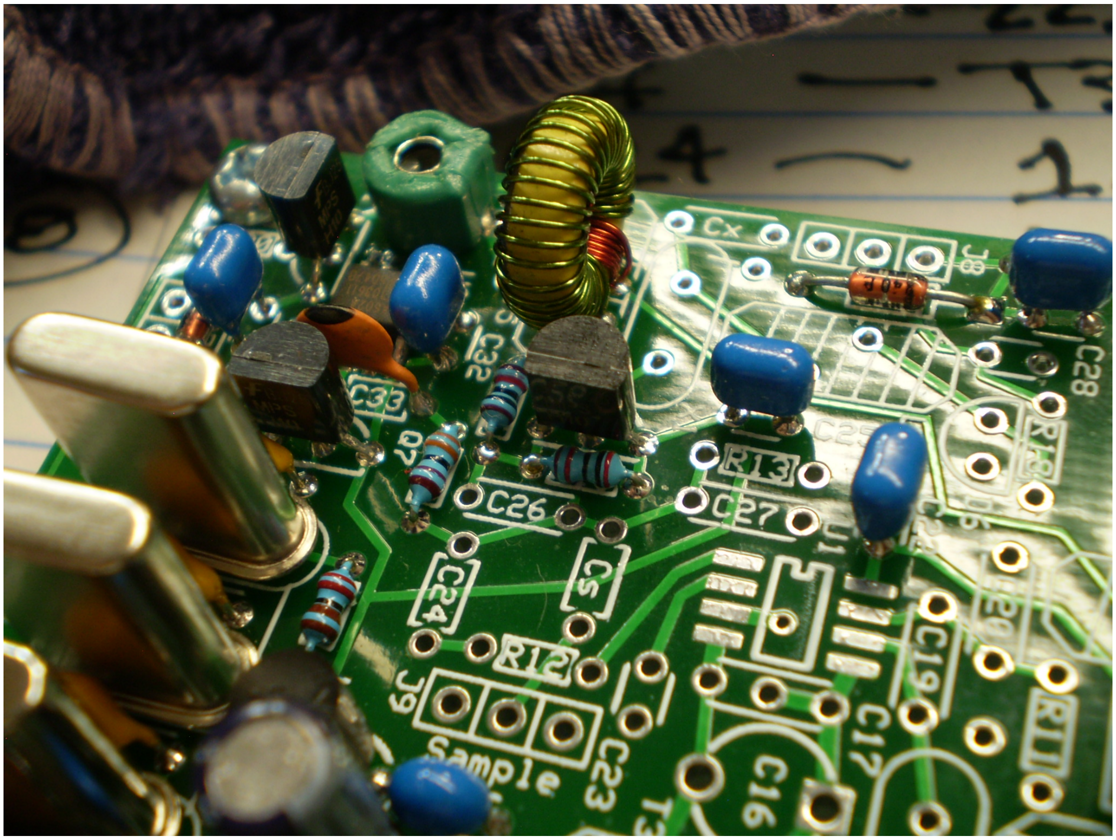


Figure 90: Q5

- Q5 — MPSH10 NPN transistor

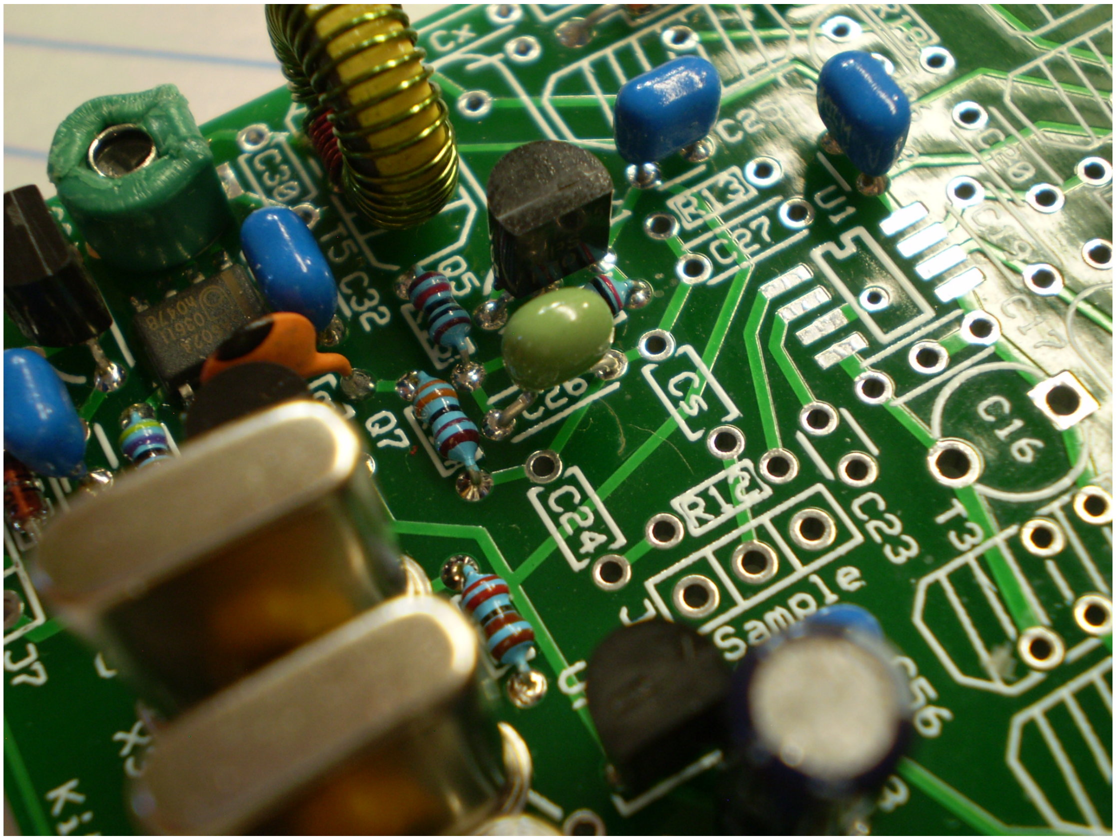


Figure 91: C26

- C26 — 33pF cap

Here will be another color cap from Diz as I am using my own.

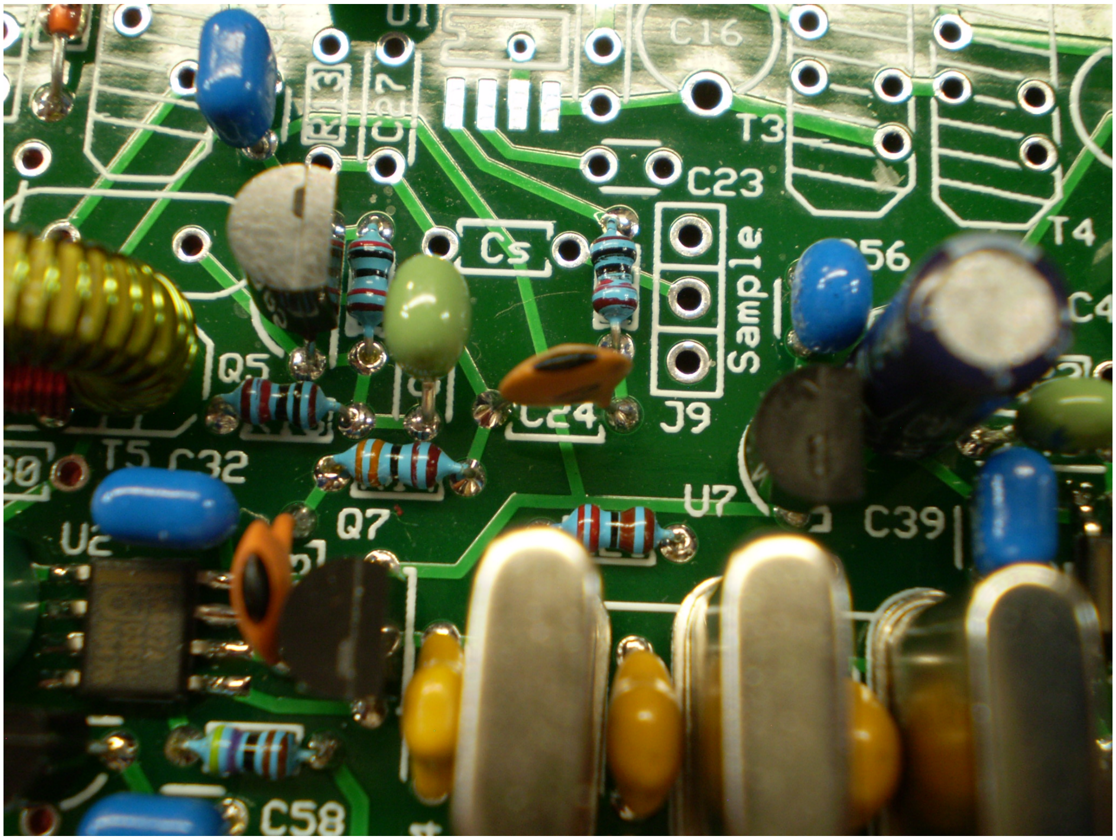


Figure 92: C24 and R12

- C24 — 1p5 (1.5pF) capacitor
- R12 — 10K resistor

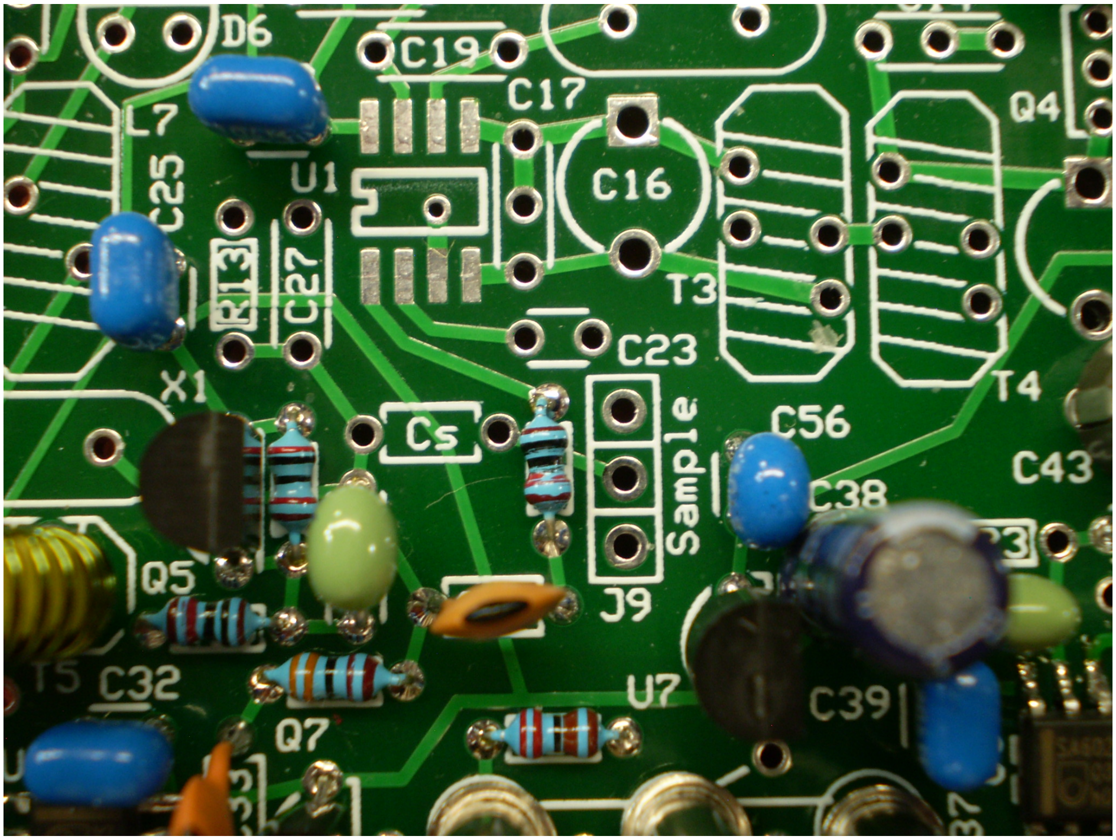


Figure 93: R12

- R12 — 10K resistor

Another look at R12 for some reason.

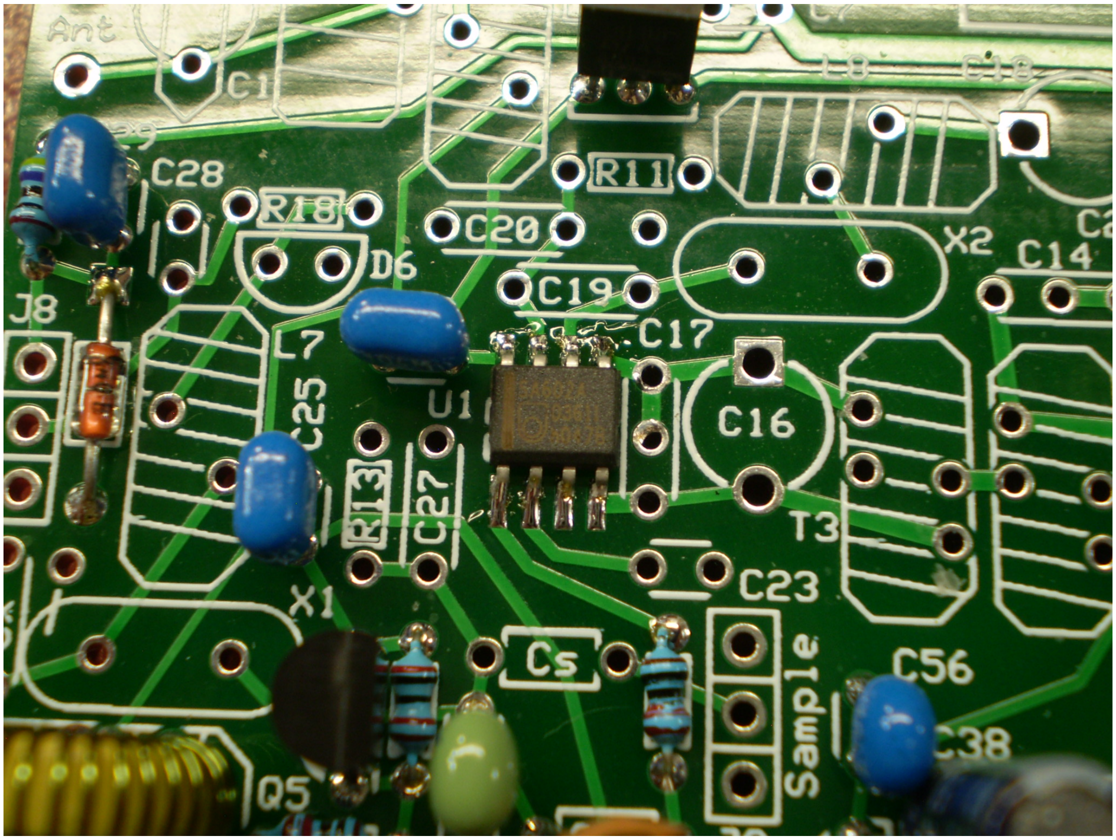


Figure 94: U1

- U1 — NE612A or SA602A IC

I put this IC in before it got too crowded so that the soldering would be easy.

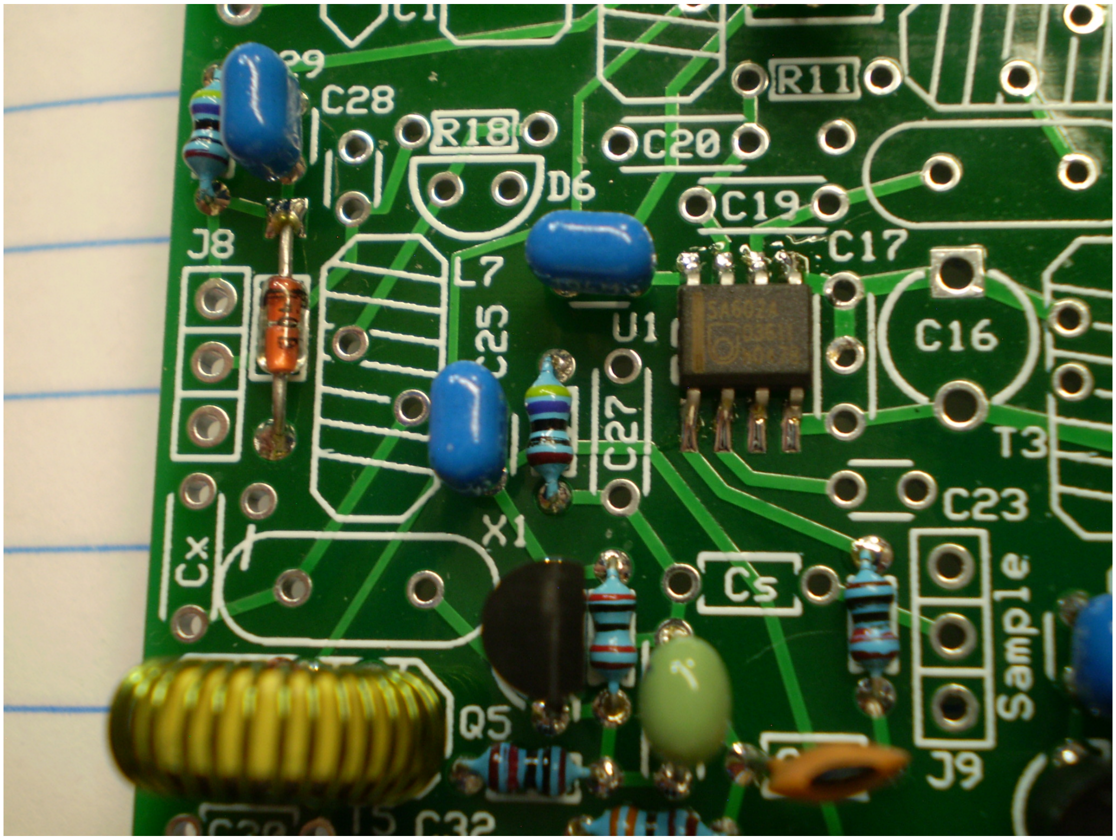


Figure 95: R13

- R13 — 470 ohm resistor

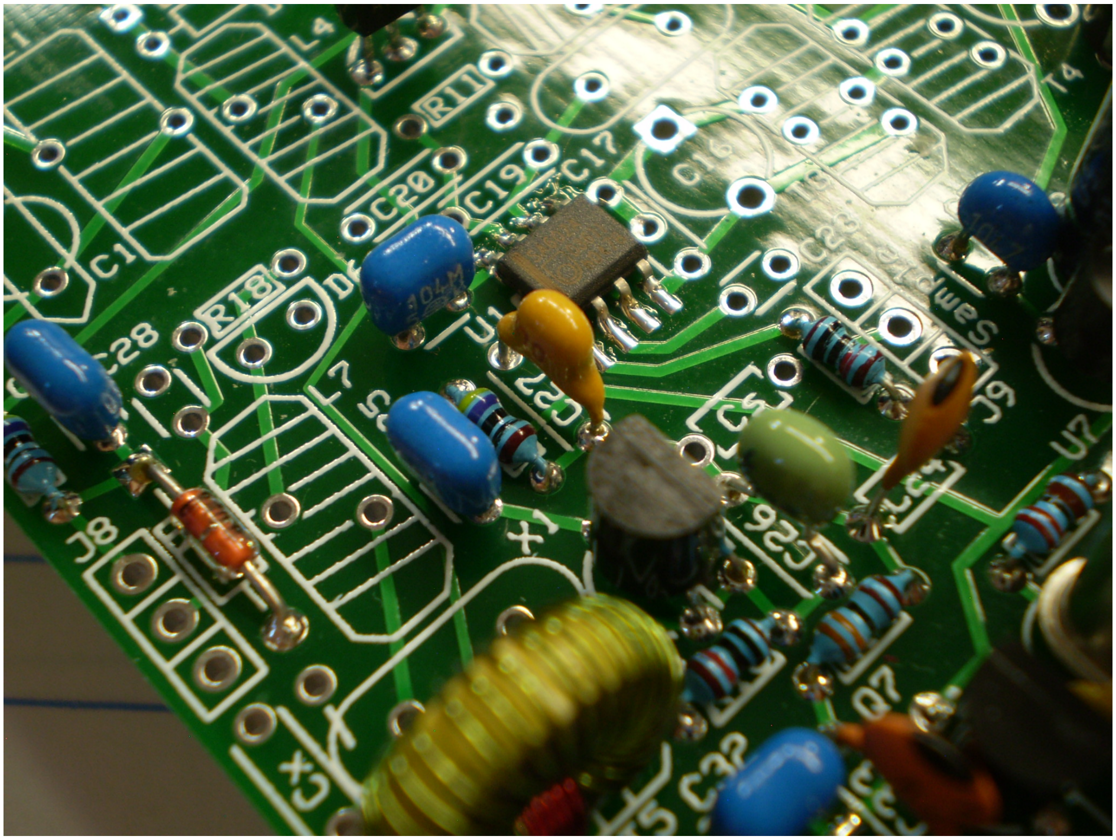


Figure 96: C27

- C27 — 47pF cap

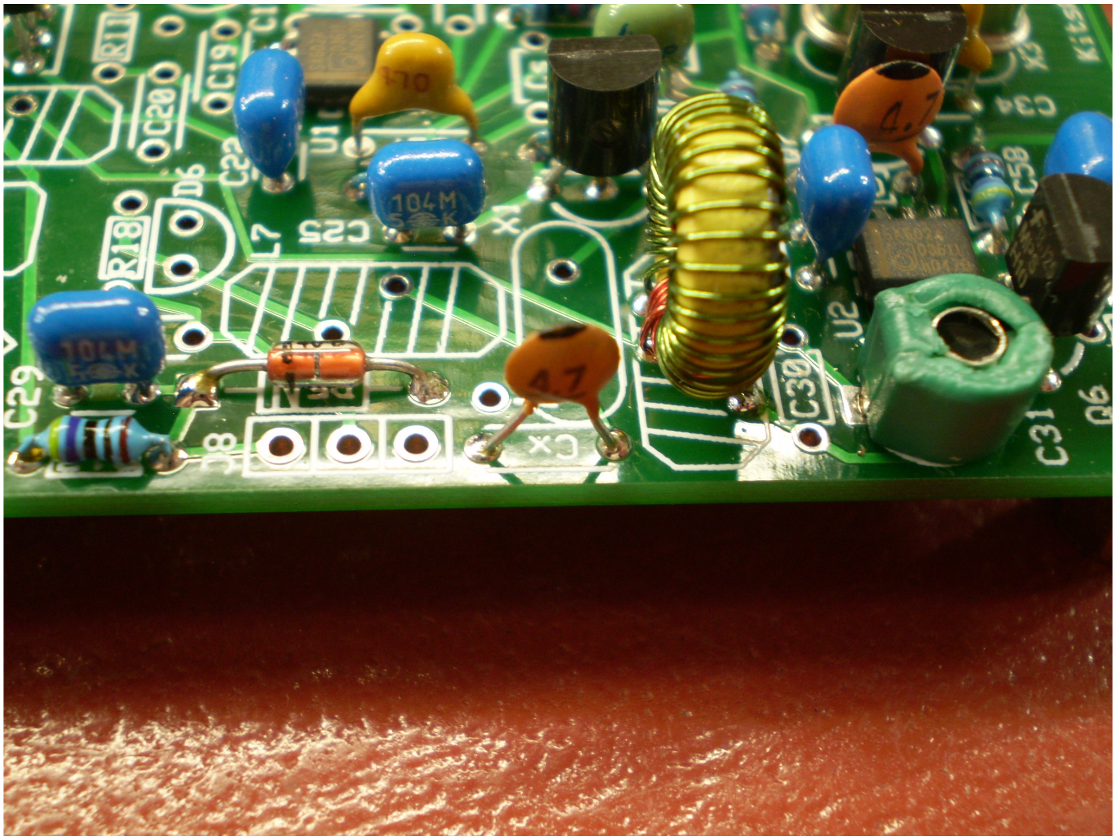


Figure 97: Cx

- Cx — 4.7pF cap

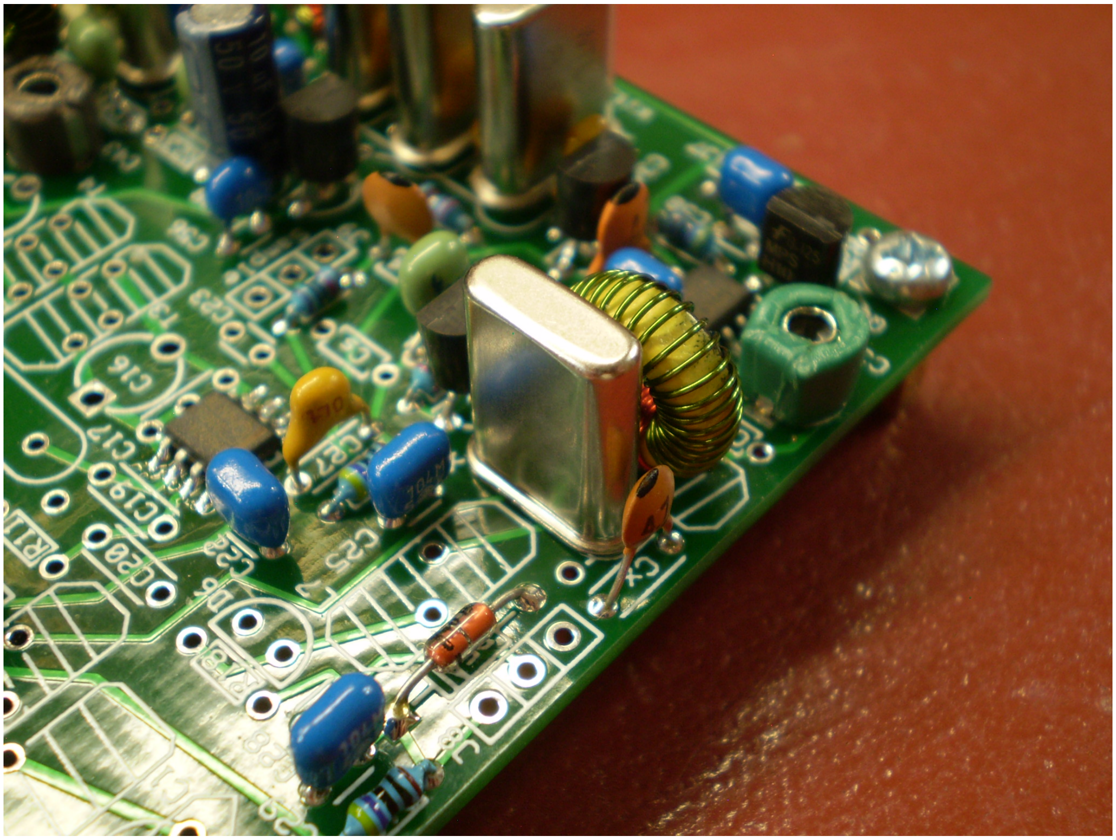


Figure 98: X1

- X1 — 22.1184MHz HC-49U crystal unit

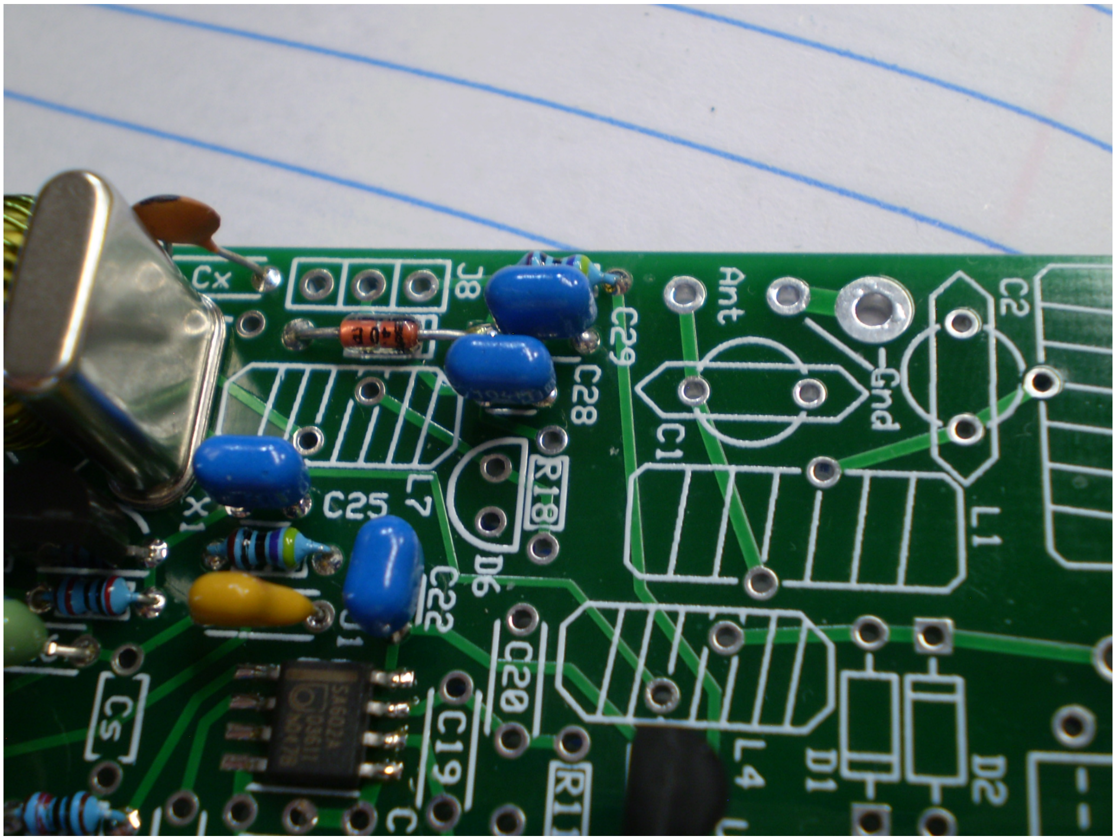


Figure 99: C28

- C28 — 100nF mono cap

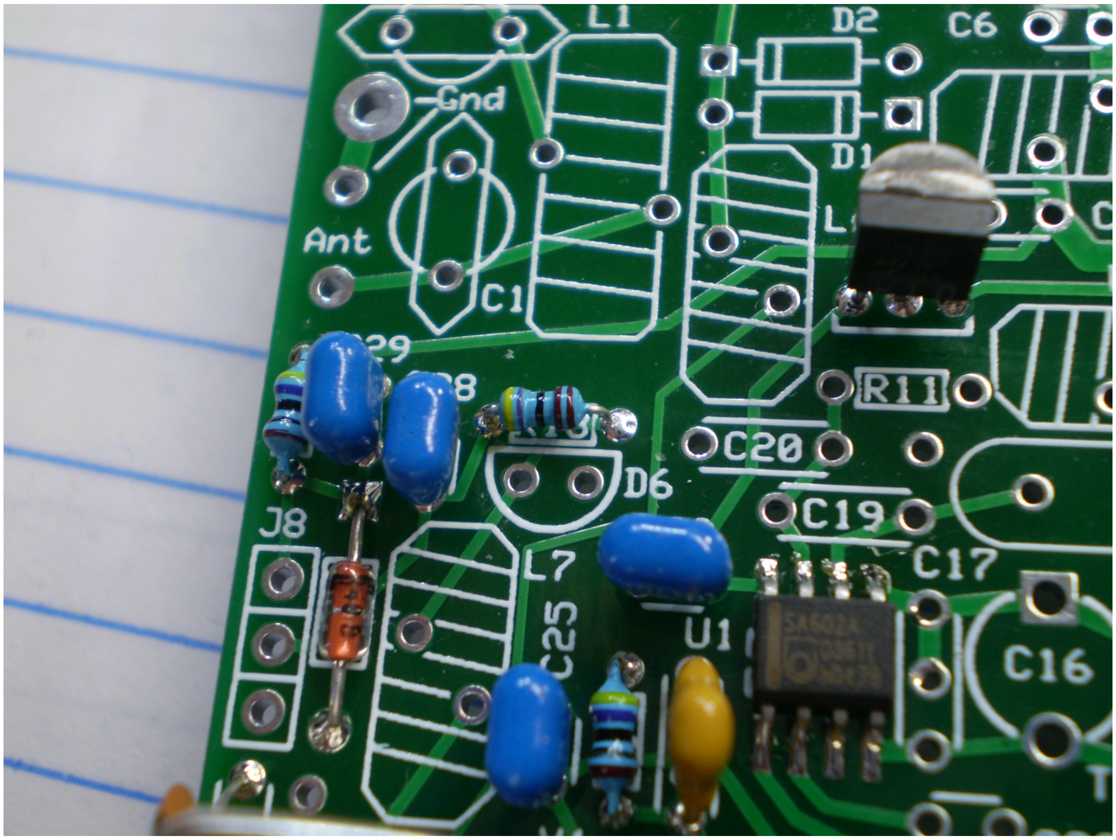


Figure 100: R18

- R18 — 4K7 resistor

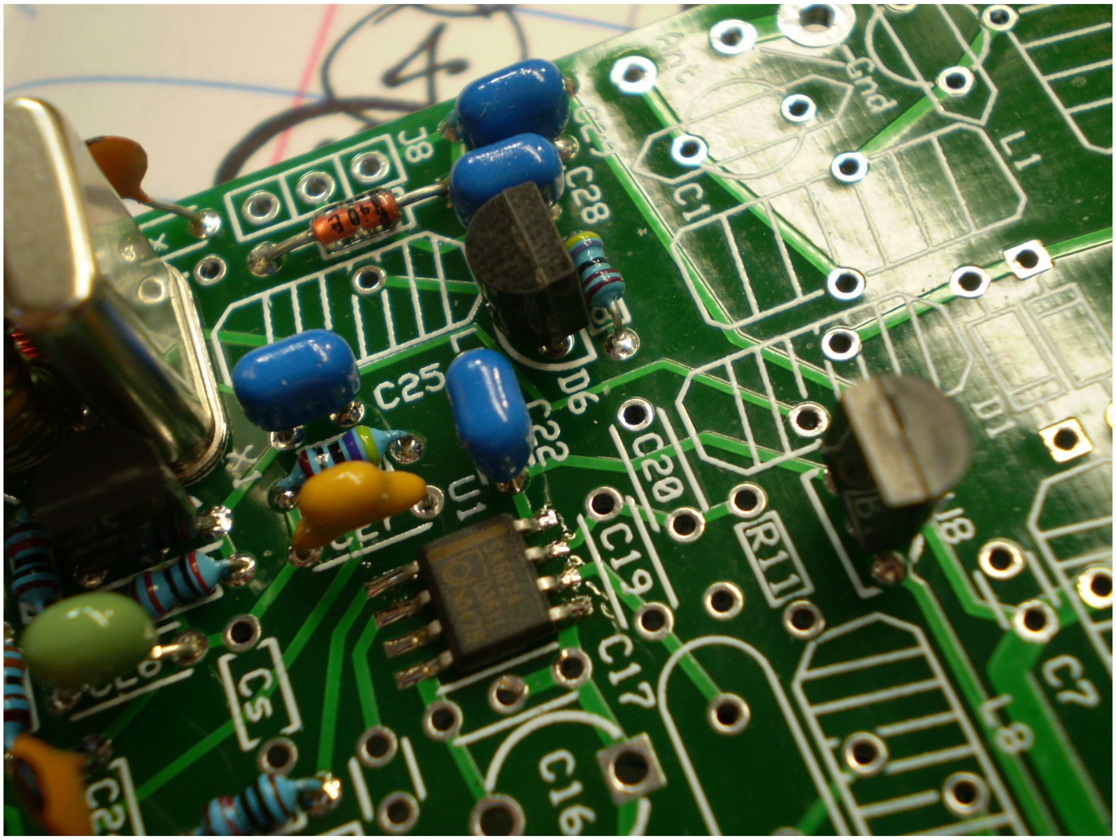


Figure 101: D6

- D6 — MV209 varactor diode

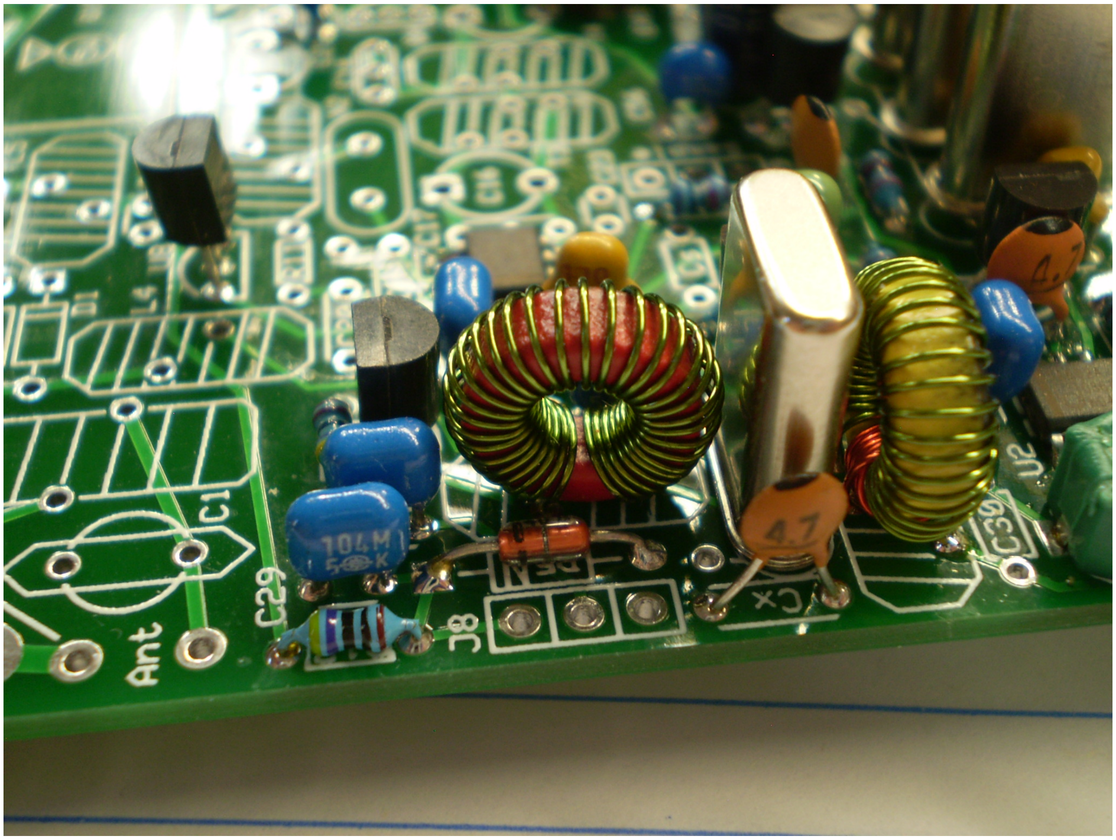


Figure 102: L7

- L7 — T37-2 toroid with 31T for 20m

Once again, my number of turns looks to be 33T as this is a prototype build from previous schematic.

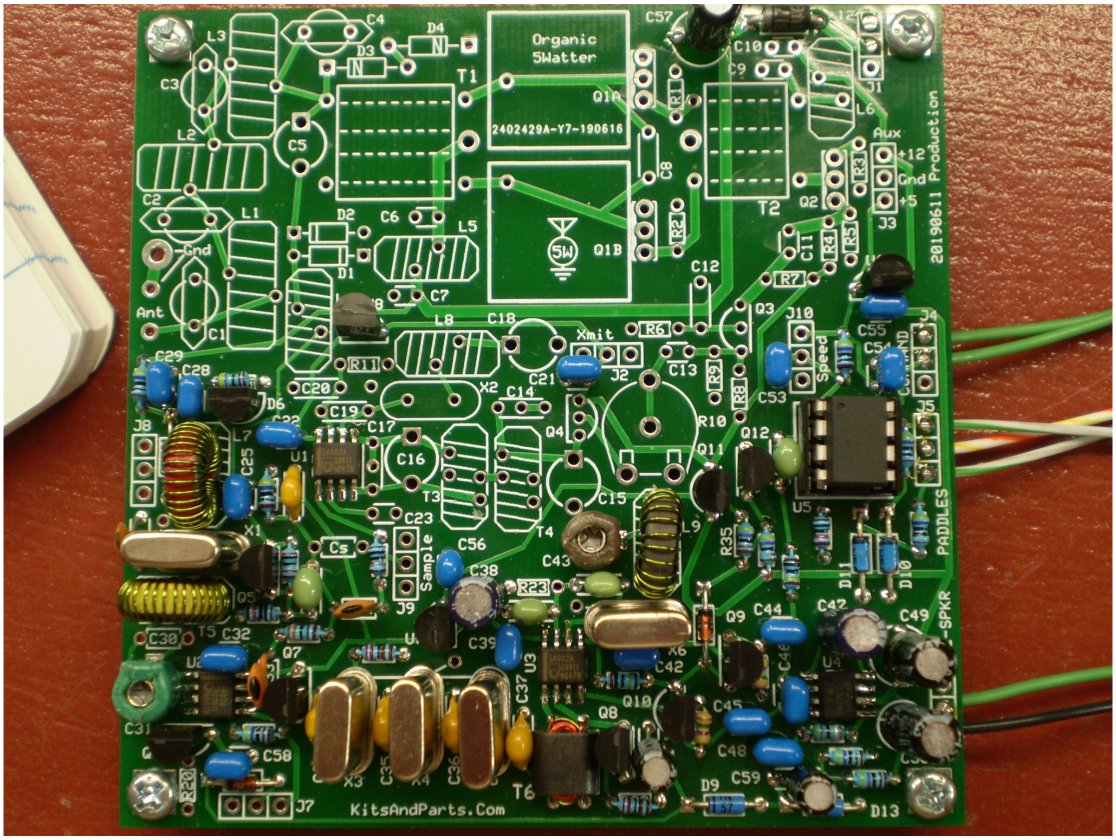


Figure 103: Top View

This is top view of project to this point. You now have a working receiver.

7.1 Testing

For this test, you need to either install a tuning pot or use a temp connection to allow tuning.

Set up PCB for testing by hooking up speakers and power supply. Also, hook up some kind of antenna wire to the lower pad of L4. This feeds 20m signals to the receiver.

You now adjust C31 for maximum noise or signal level. You should have two peaks in turning the cap one complete turn. You may not be able to tell in some cases depending upon your experience and hearing sensitivity.

Now adjust C43 to a comfortable sound range to you. We will do some more later when the transmitter is up and running.

If 20m is open and there is propagation, you should be able to hear signals. Tune in one and adjust C31 to see if you can peak the trimmer cap again. Adjust C43 for range that sounds like your best receiver or to a comfortable range that you like.

Chapter 8

First Transmit Mixer, BPF and RF Preamp

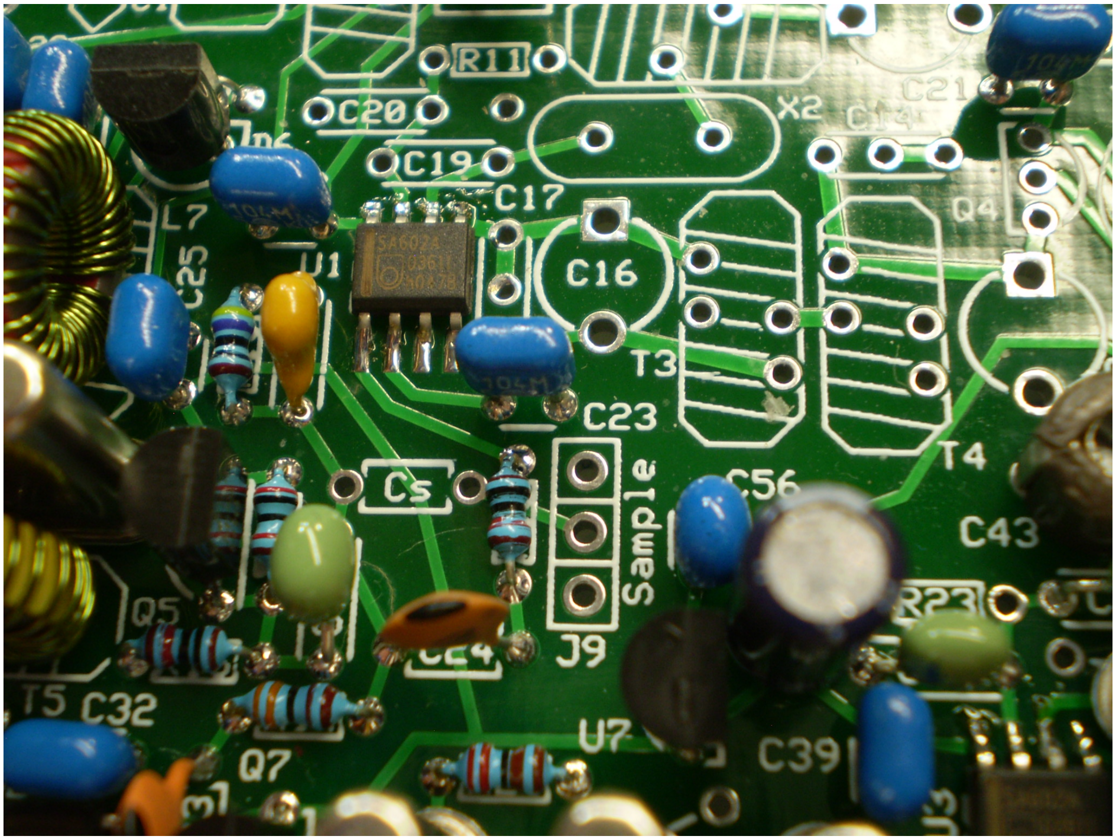


Figure 104: C23

- C23 — 100nF mono cap

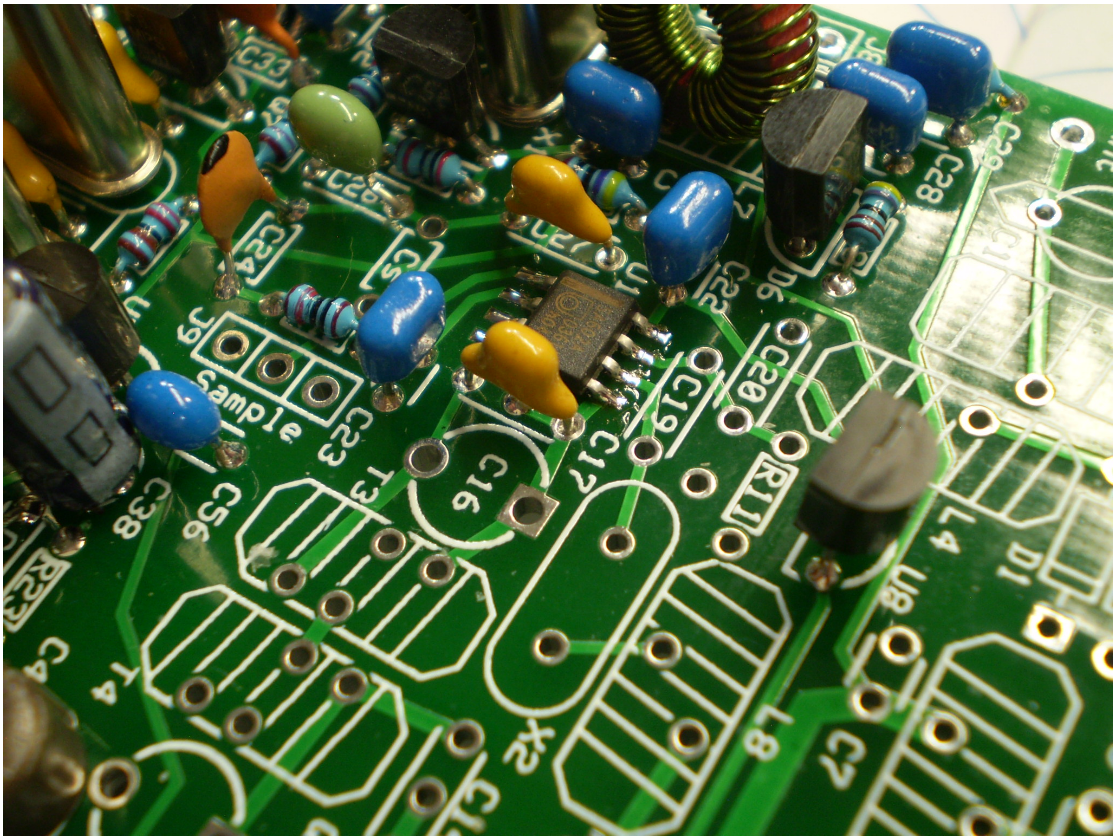


Figure 105: C17

- C17 — 100pF mono cap

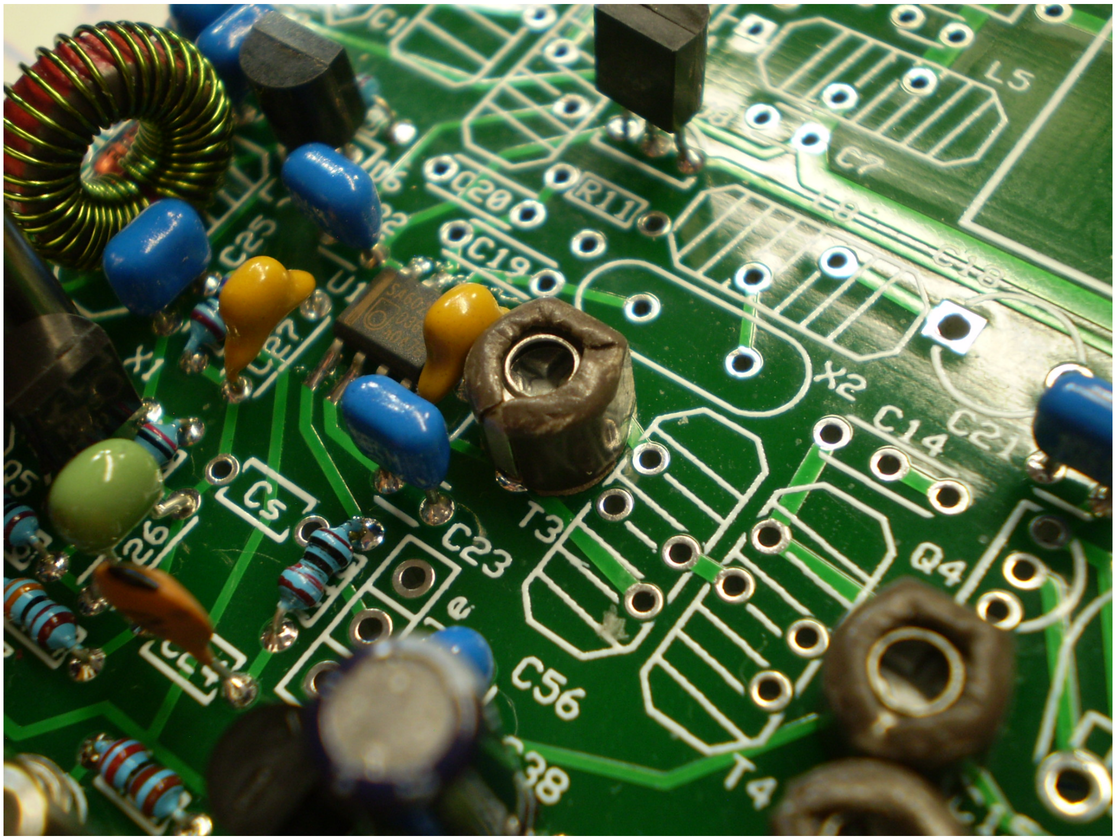


Figure 106: C16

- C16 — 45pF trimmer cap

Once again, you should have a yellow trimmer cap here.

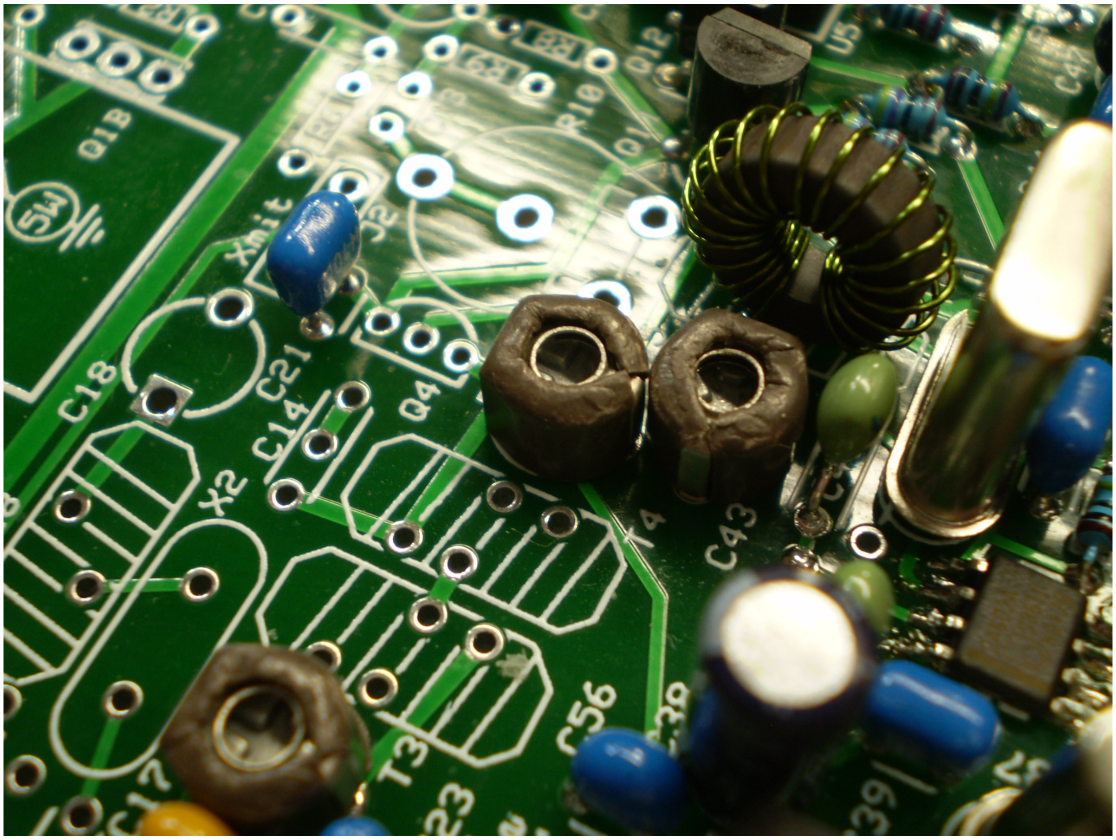


Figure 107: C15

- C15 — 45pF trimmer cap

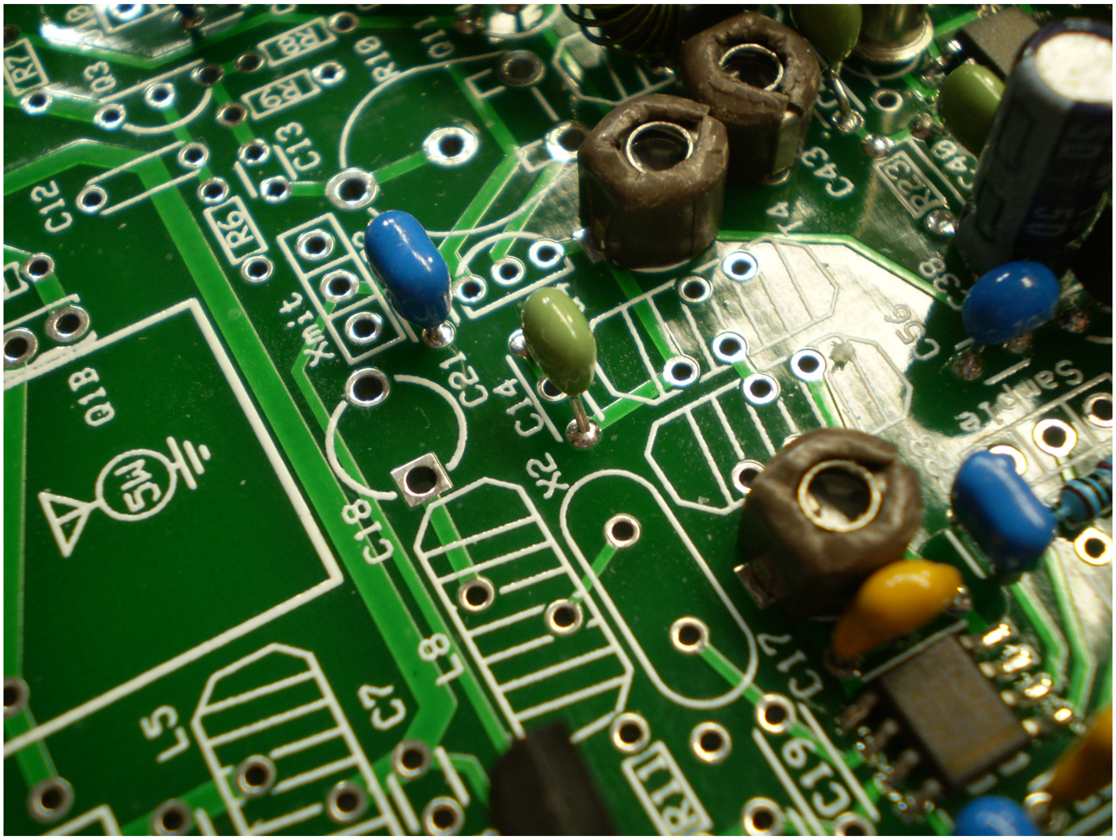


Figure 108: C14

- C14 — 100pF mono cap

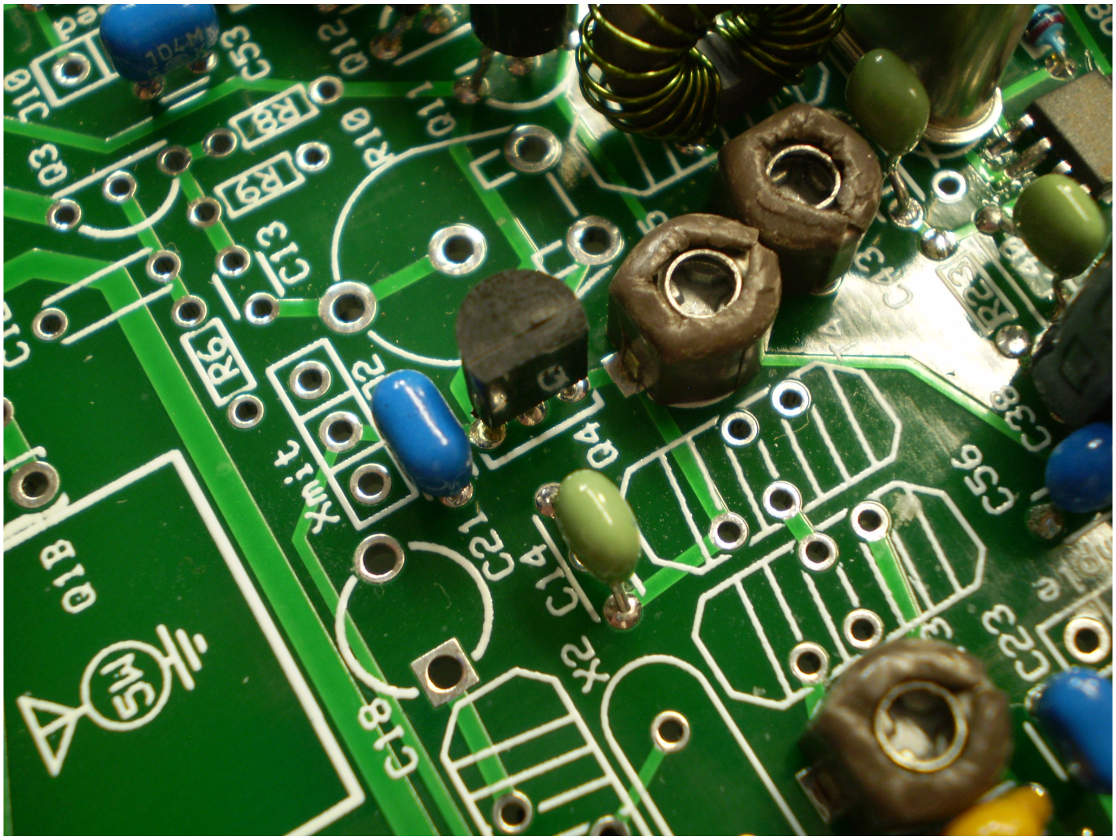


Figure 109: Q4

- Q4 — J310 JFET

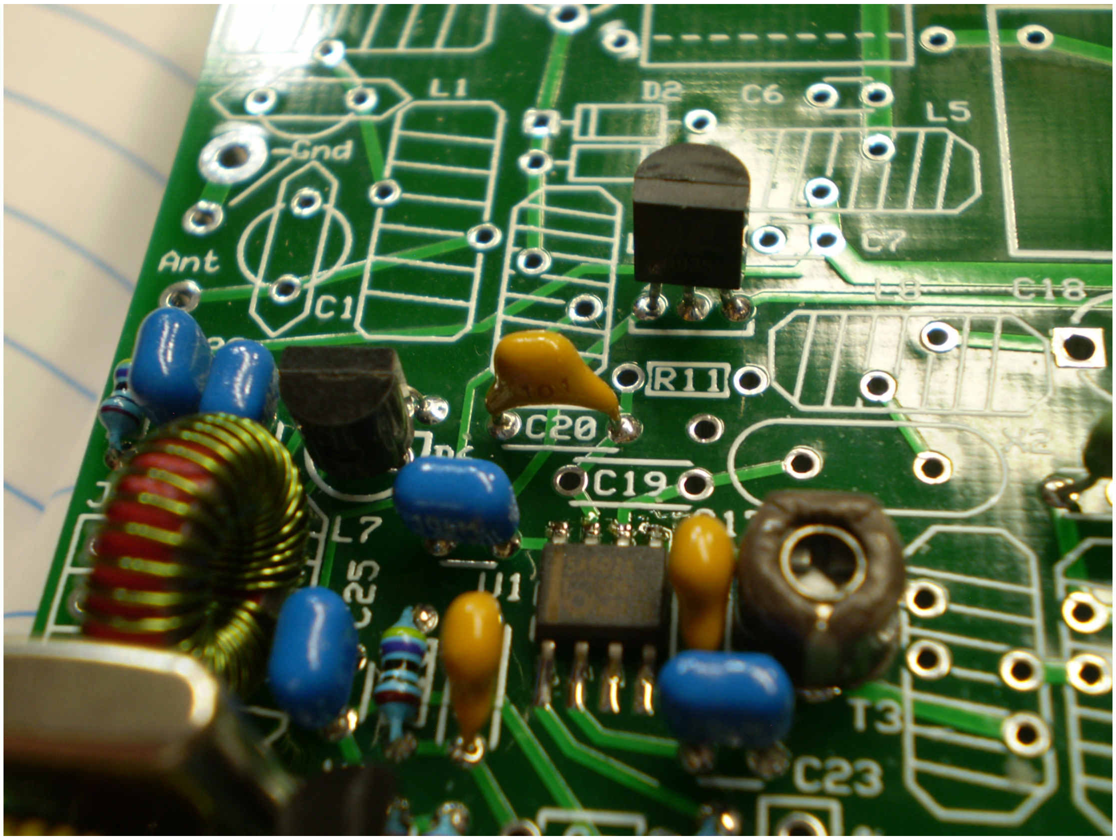


Figure 110: C20

- C20 — 100pF mono cap

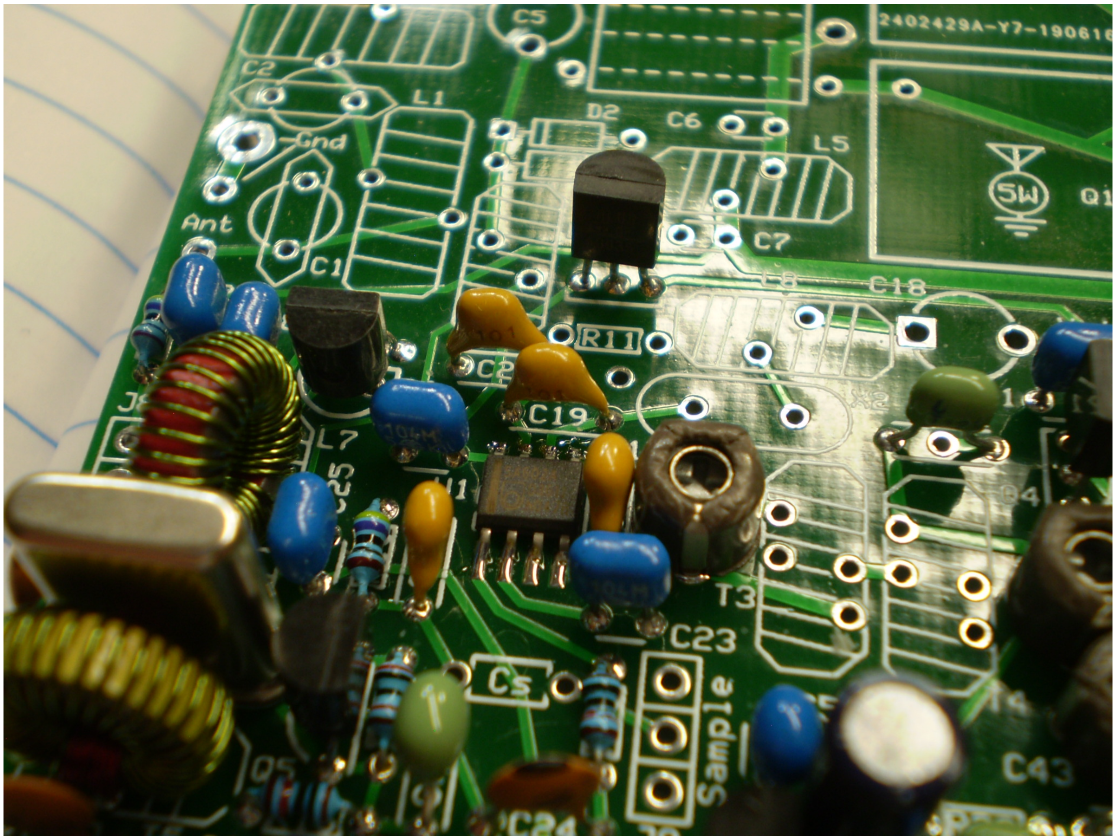


Figure 111: C19

- C19 — 100pF mono cap

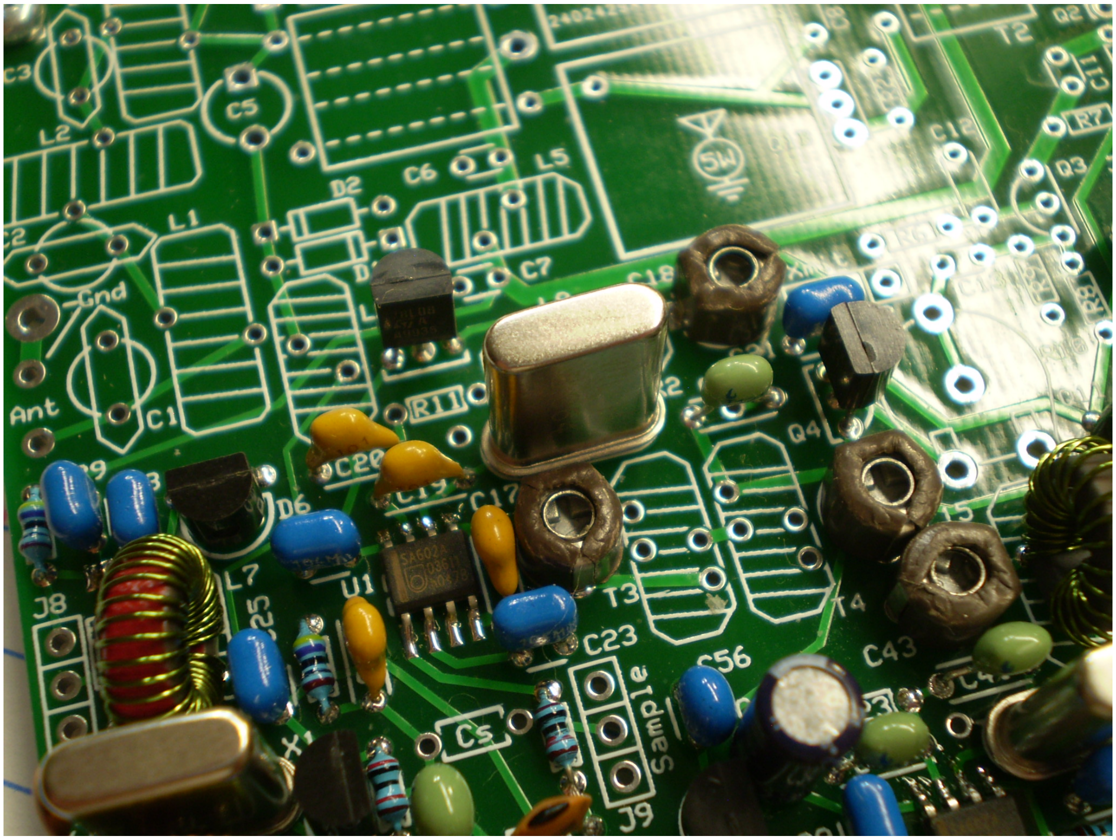


Figure 112: X2

- X2 — 8.064MHz HC-49U crystal unit

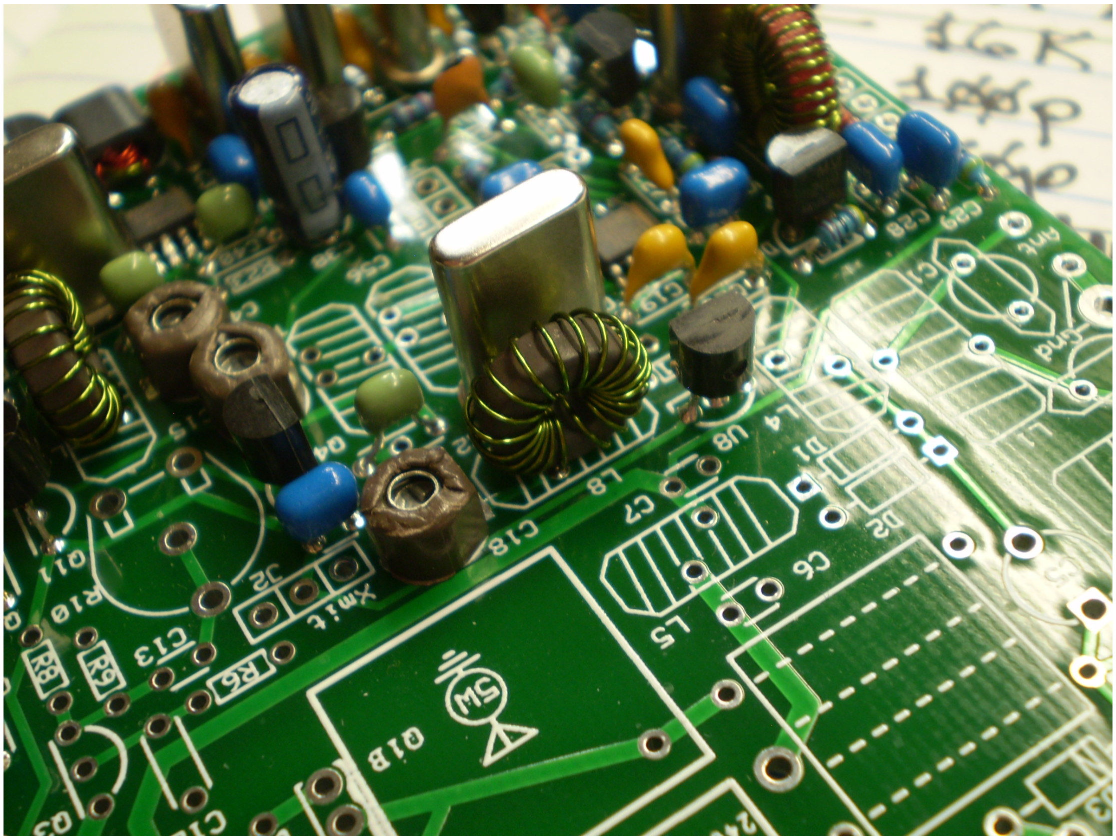


Figure 113: L8

- L8 — FT37-61 ferrite toroid with 20T
- C18 — 45pF trimmer cap (yellow)

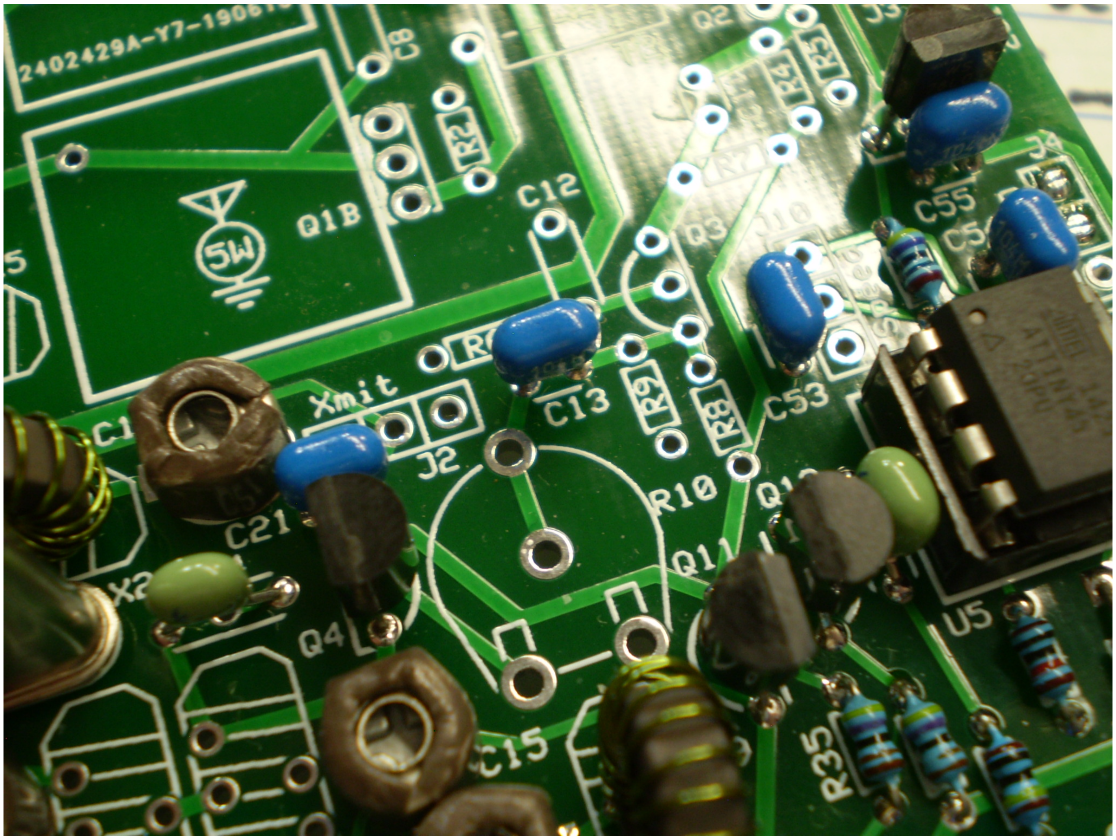


Figure 114: C13

- C13 — 100nF mono cap

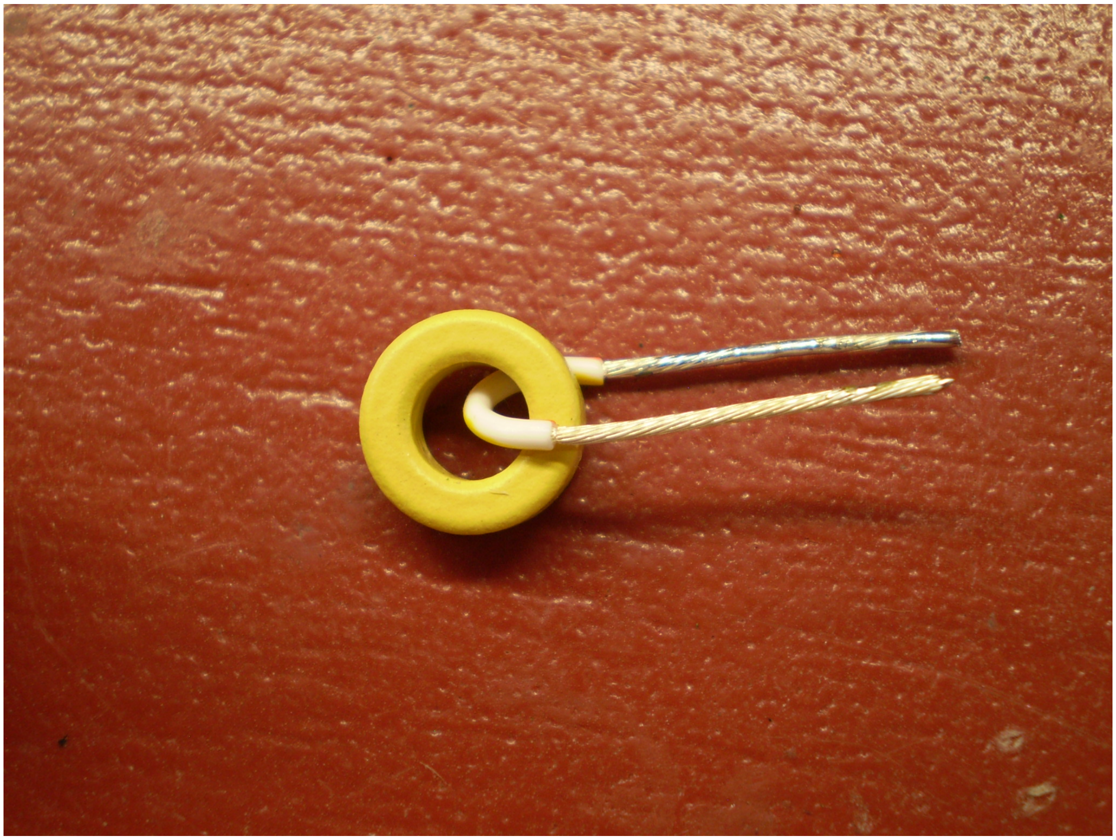


Figure 115: Single Turn Wire

Here I did an experiment using teflon coated #24 stranded wire for the one turn on transformers T3 and T4. You will be using the magnetic wire provided in the kit from Diz. Follow his instructions on the web page for the 5W.

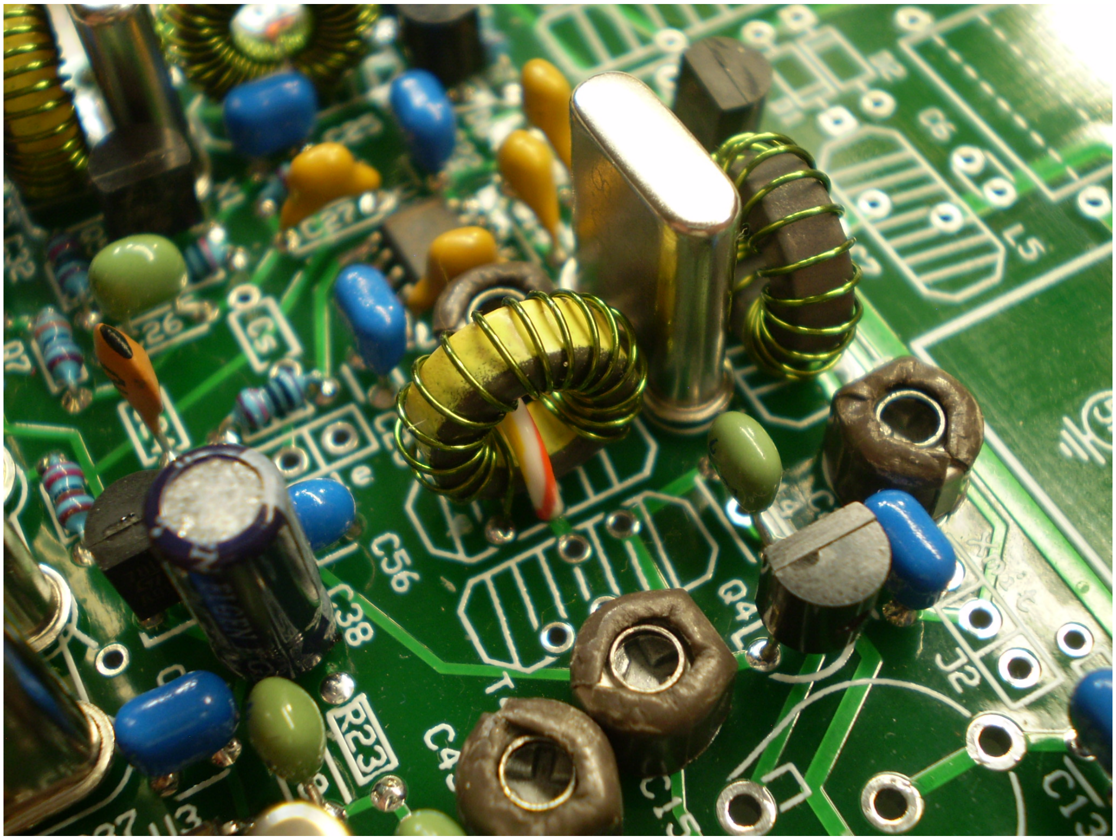


Figure 116: T3

- T3 — T37-6 ferrite toroid with 16T:1T ratio

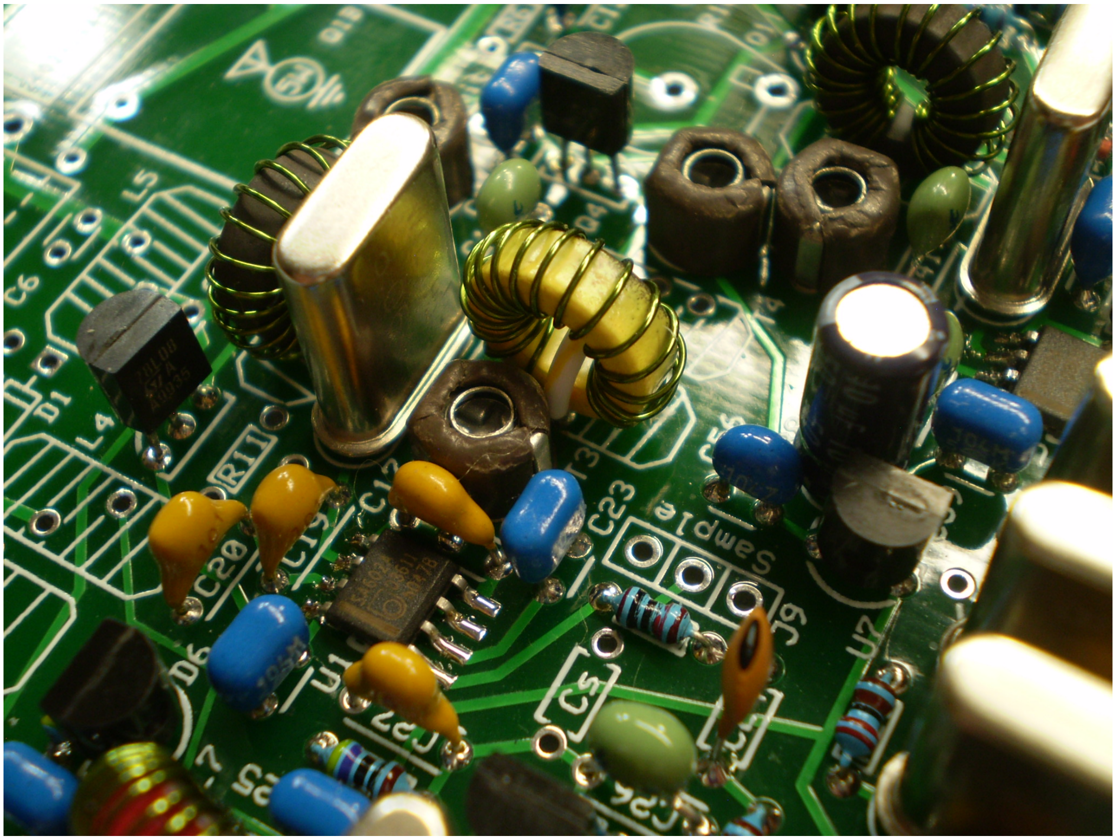


Figure 117: T3

View of the transformer from the other side.

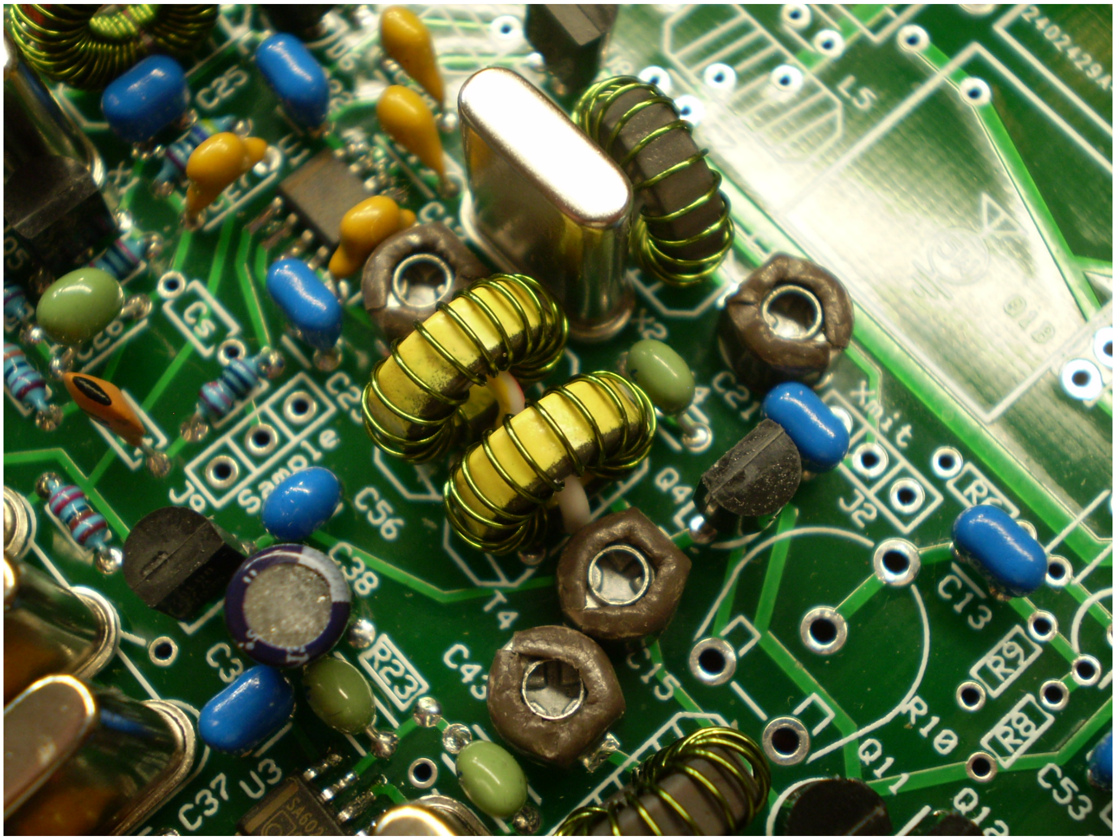


Figure 118: T4

- T4 — T37-6 ferrite toroid with 1T:16T ratio

8.1 Testing

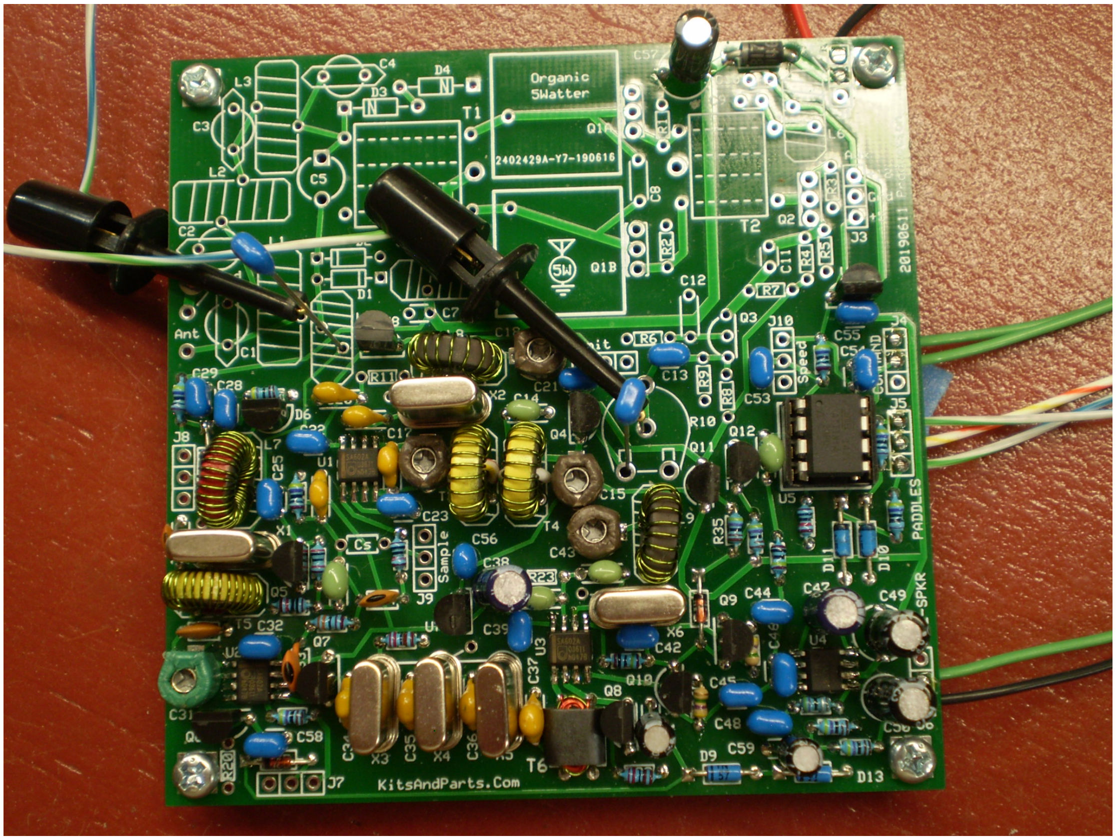


Figure 119: Test Setup

The above photograph is my test setup. I want you to install R10, which I did not have. I want you to, using a test lead with hooks or clips, connect from the right lead of C13 (the lead that is next to R9) to a 100nF cap that is temporarily friction fit into the pads for L4 as shown above.

This will feed the output from the transmit mixer through the band pass filter to the input of the receiver.

Power up the transceiver and turn off the keyer generated tone using the A command. Now, put the transceiver in the tune mode using the X command. You should hear two tones in the speakers.

Place the 5W into the command Mode by pressing the command push button switch you wired to J4. You will quickly hear an "R" sent by the 5W telling you it is now in the command mode. Now use the paddle to send the letter "X". After a secocnd or two you will hear a steady note telling you the 5W is in the tune mode.

Adjust C18 to see which of the two tones changes. That is the transmitter signal. Adjust C16 and C15 to get maximum sound out of the speakers for that signal. This tunes the BPF for now and will be adjusted to a more accurate setting in the final transmitter alignment.

You may adjust C43 in the receiver second mixer (also known as the BFO) for a pleasant tone and to change the frequency difference between the transmitter frequency and the frequency input into the BFO to generate the tone heard for the signal.

Key the transmitter to turn off the tune mode. Now key the transmitter with the paddle to see if you can hear the generated signal from the transmitter in the receiver. Be sure not to generate a continuous sequence of all dits or all dahs that puts the keyer into the deadman mode. In that mode you have to power off the rig and turn it back on.

See if varying R10 changes the signal level.

This concludes the testing for the transmit mixer section and BPF.

Chapter 9

T/R Switch and Low Pass Filter (LPF)

- D1 — 1N4148 Si diode

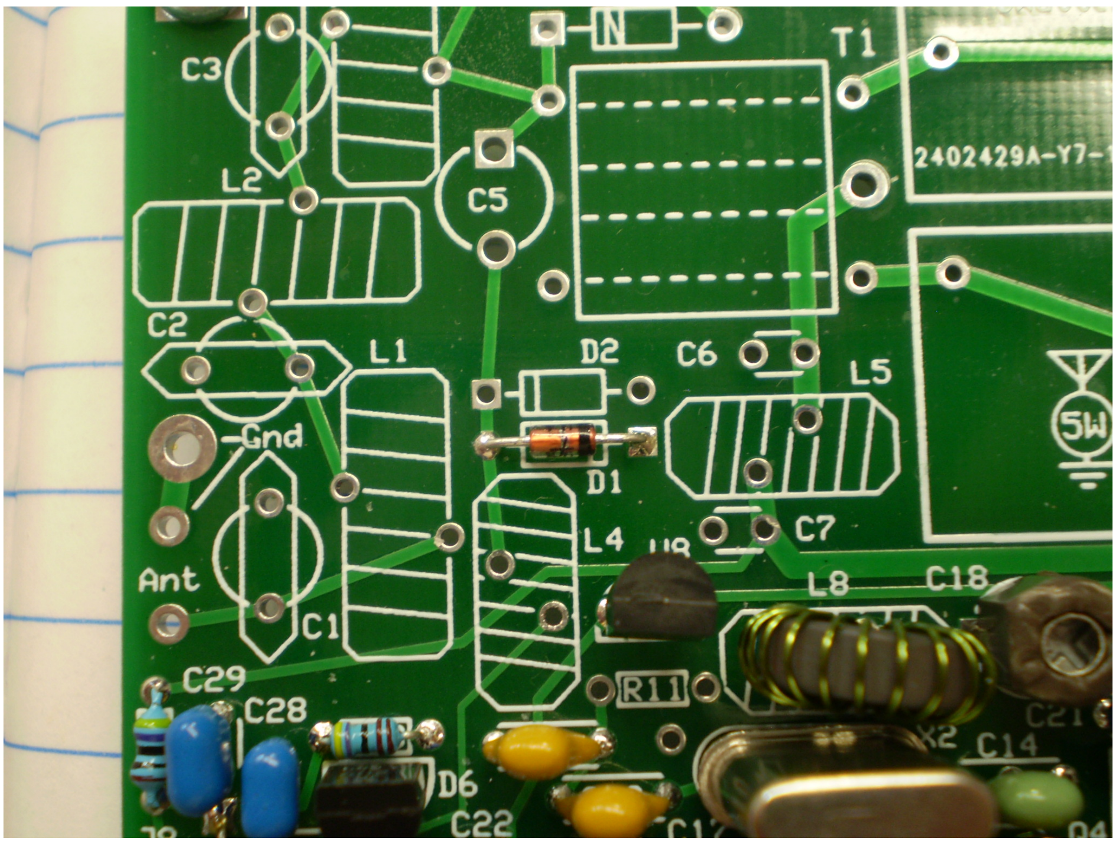


Figure 120: D1

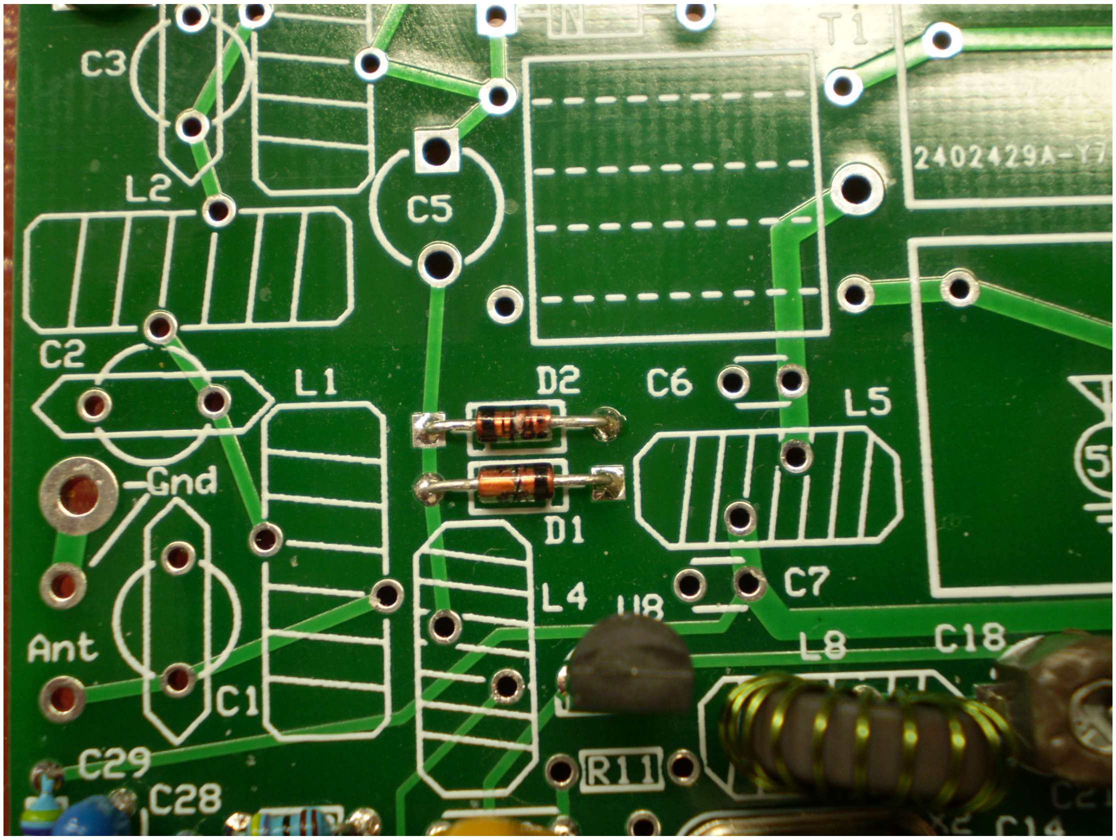


Figure 121: D2

- D2 — 1N4148 Si diode

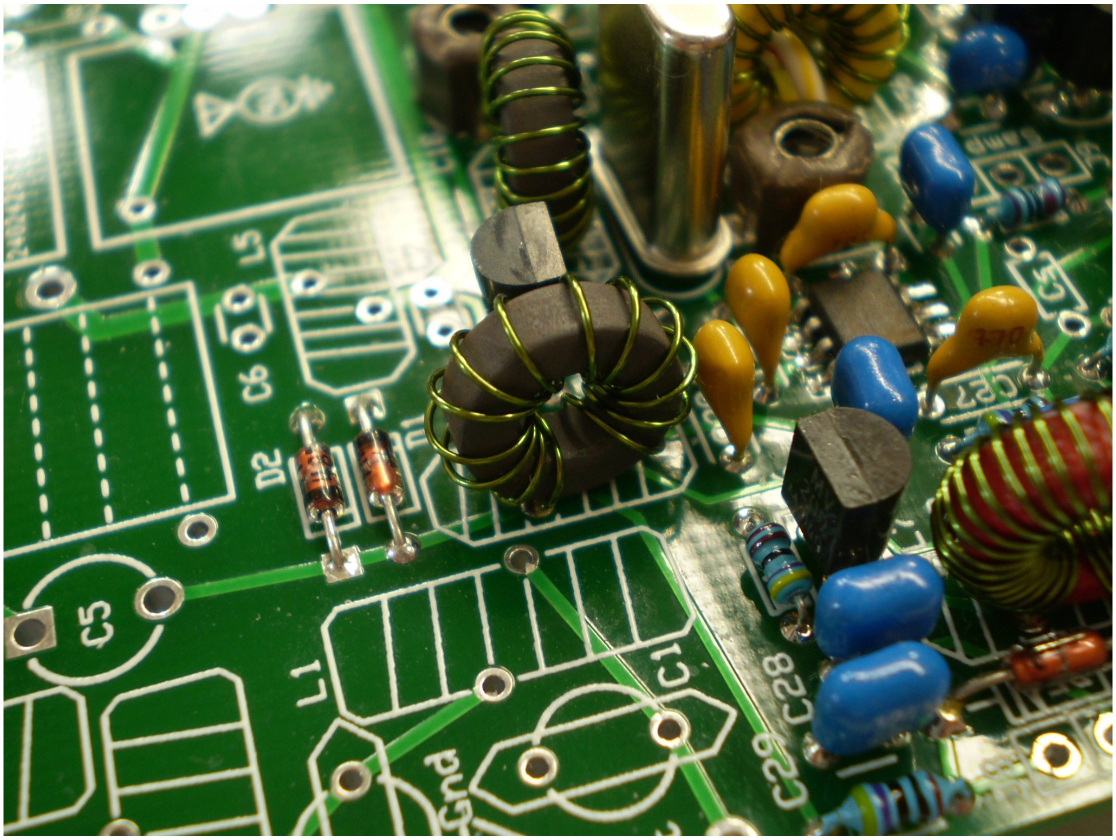


Figure 122: L4

- L4 — FT37-61 ferrite toroid with 14T

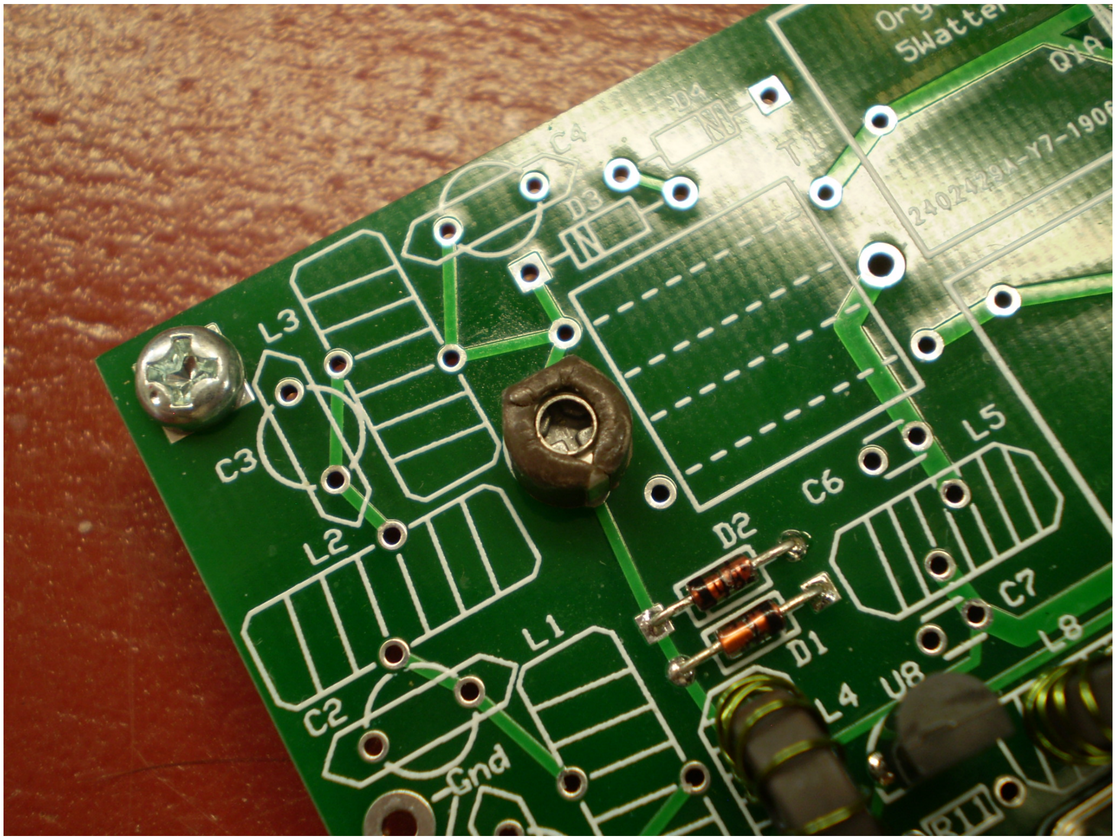


Figure 123: C5

- C5 — 45pF yellow trimmer cap

Remember I did not have 45pF trimmer caps.

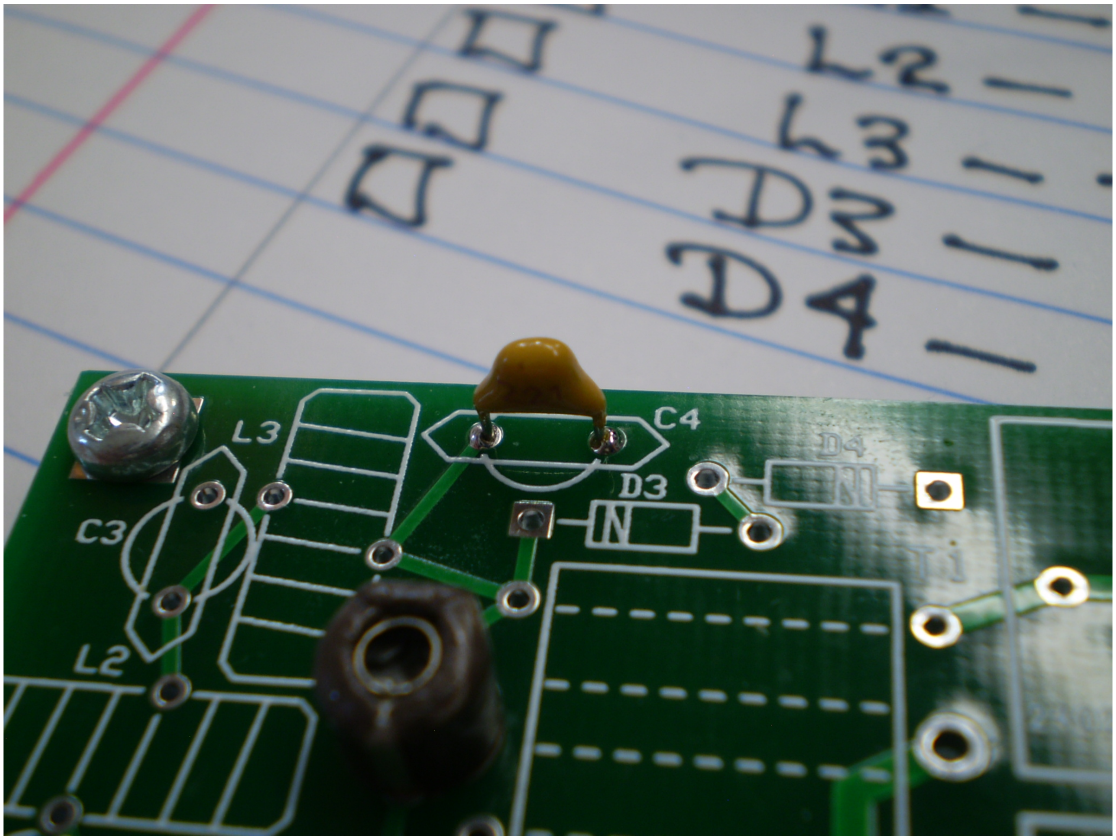


Figure 124: C4

- C4 — 220pF mono cap

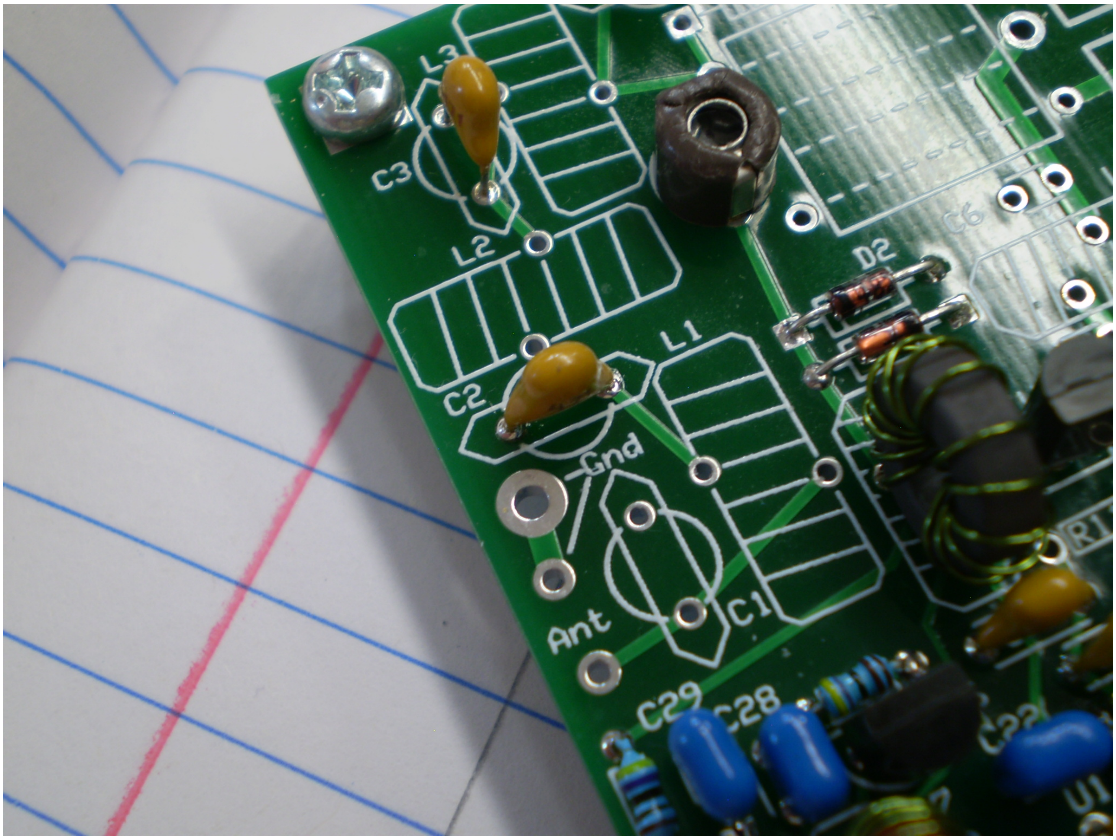


Figure 125: C3 and C2

- C3 — 470pF mono cap
- C2 — 470pF mono cap

These values of 470pF are for the production kit and the 220pF values I used in the prototype.

When I used this rig in Field Day, I was running at 3W and probably the reason I couldn't get the full 5W at 13V supply voltage.

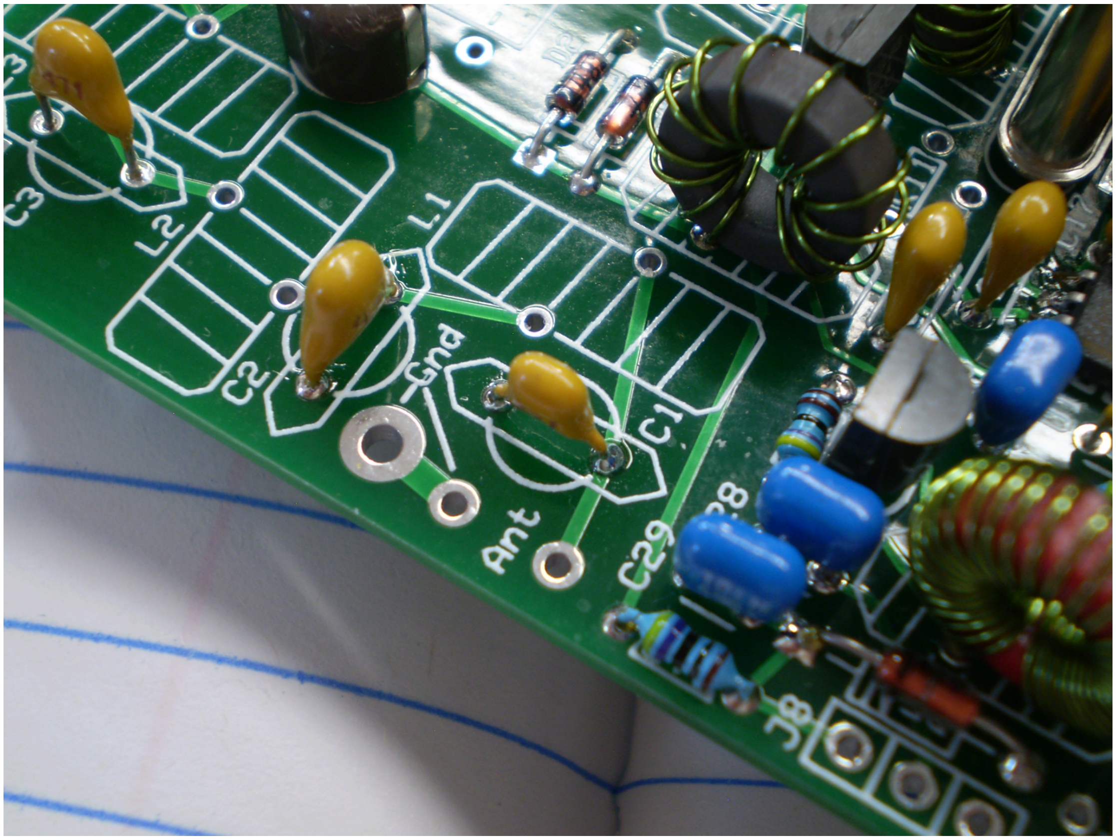


Figure 126: C1

- C1 — 220pF mono cap

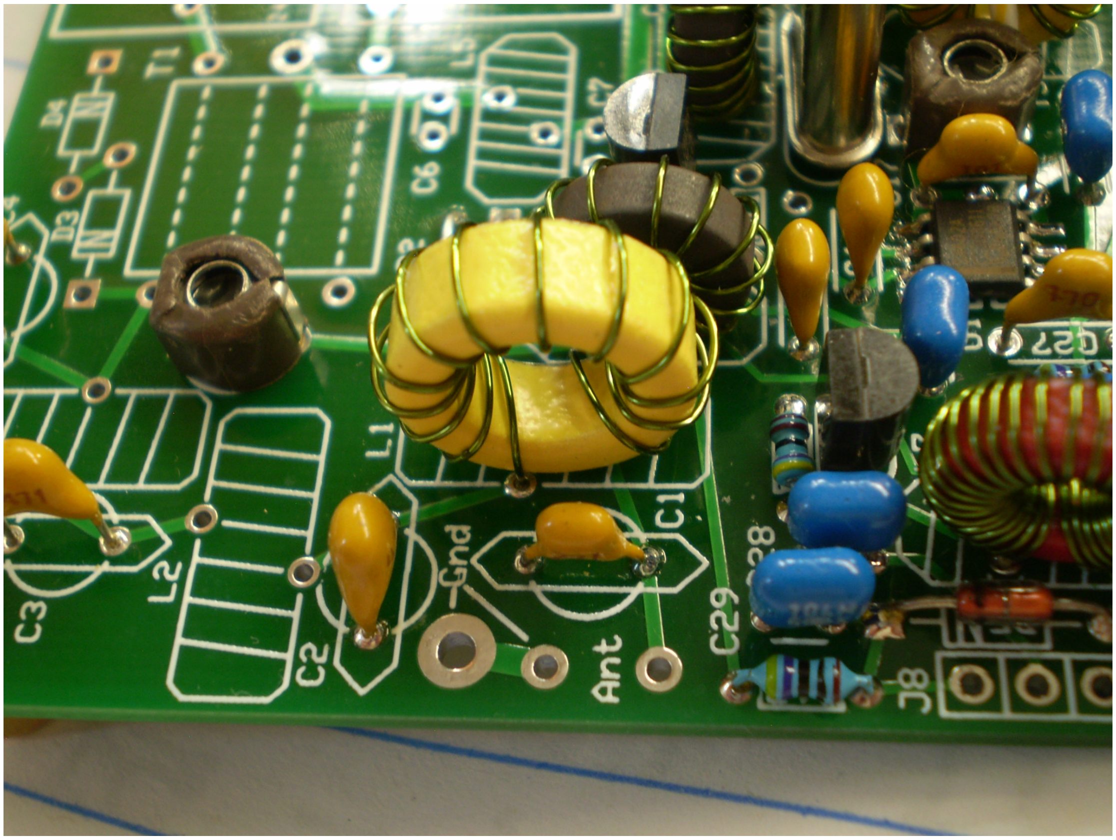


Figure 127: L1

- L1 — T50-6 ferrite toroid with 13T

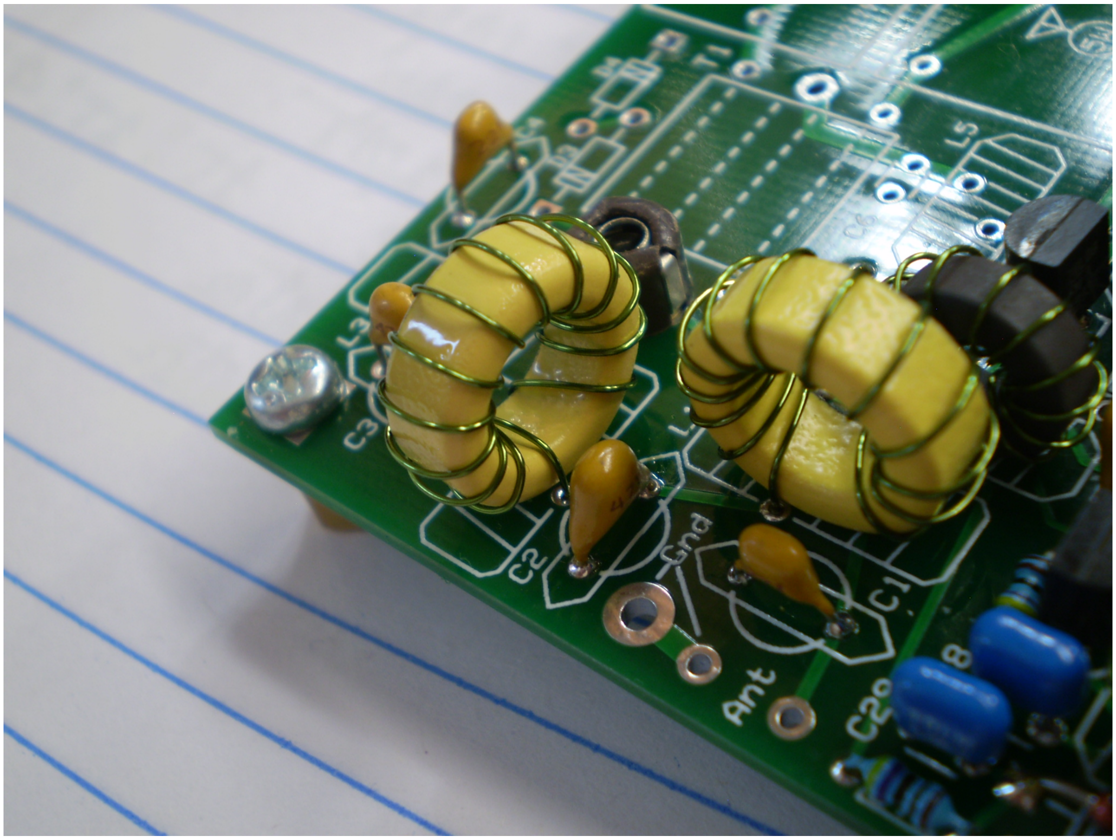


Figure 128: L2

- L2 — T50-6 ferrite toroid with 13T

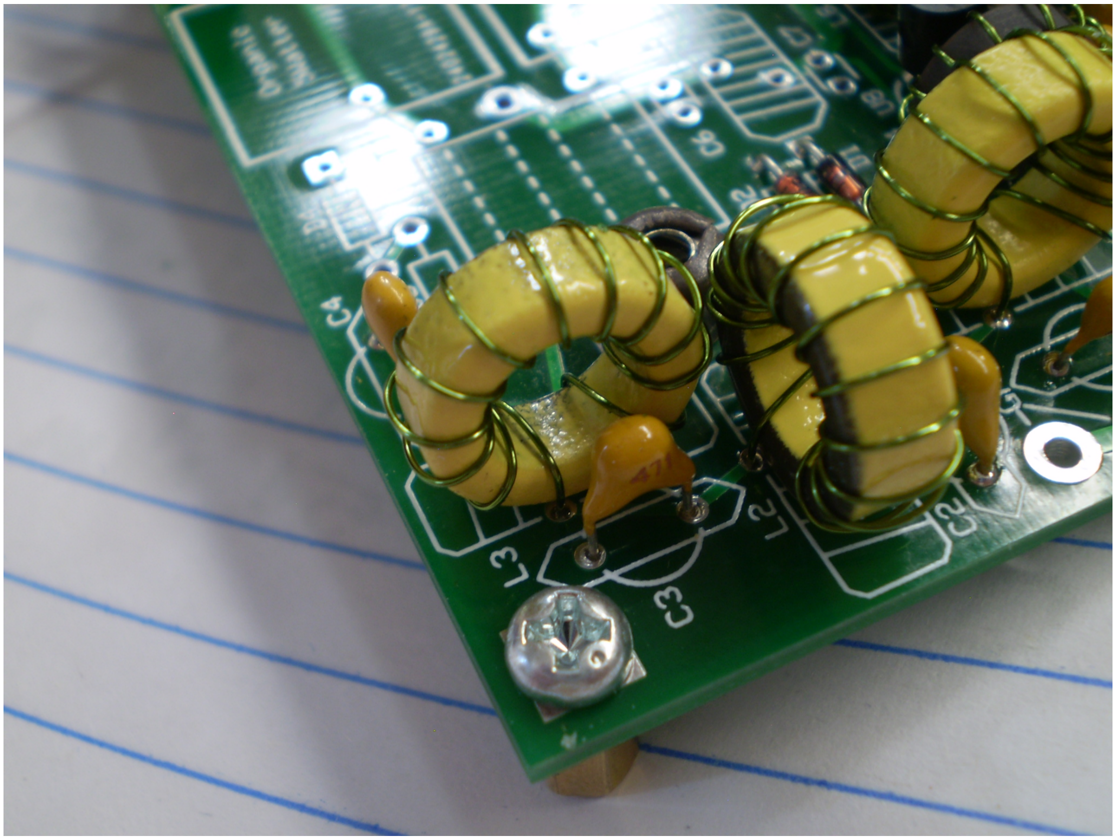


Figure 129: L3

- L3 — T50-6 ferrite toroid with 13T

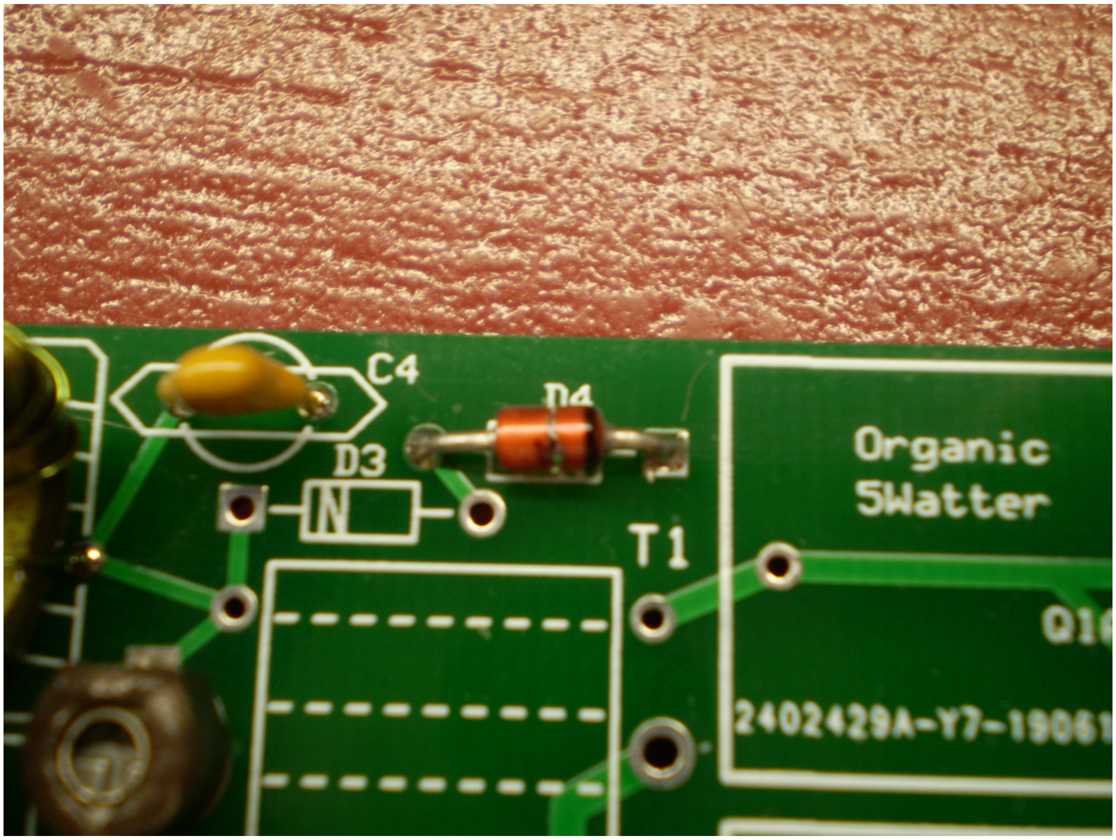


Figure 130: D4

- D4 — 1N4751 zener diode

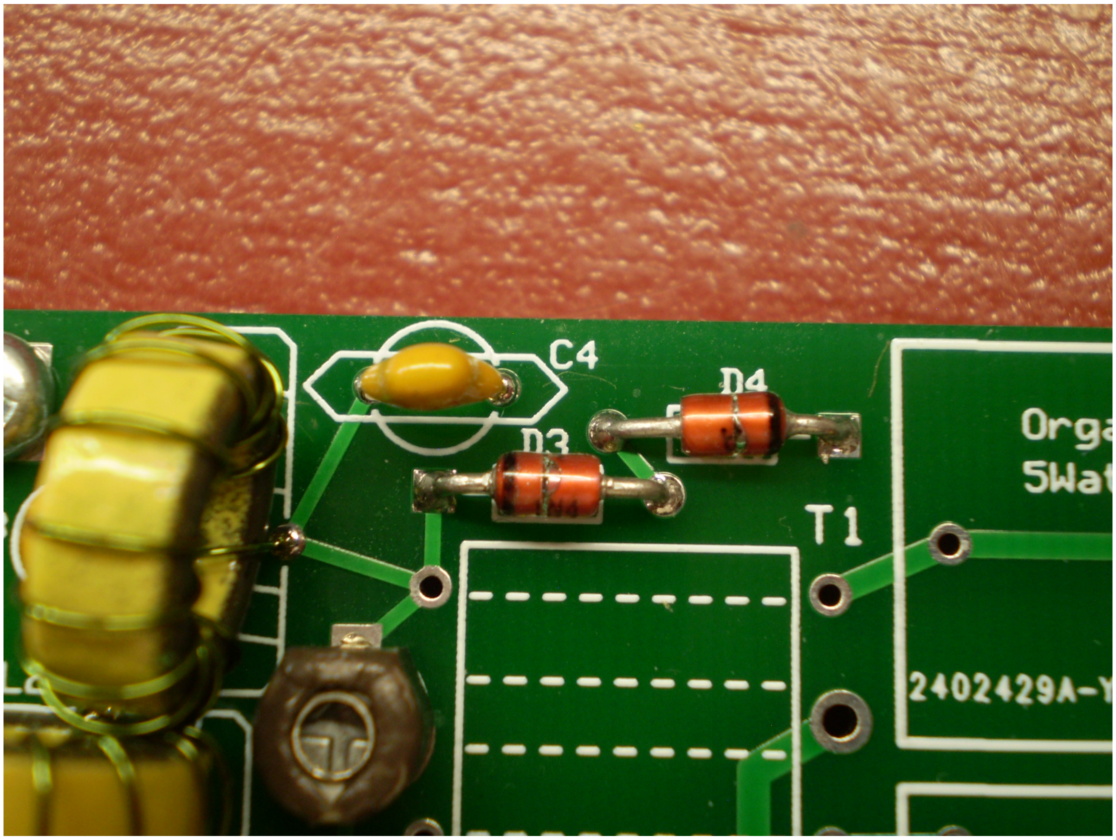


Figure 131: D3

- D3 — 1N4751 zener diode

9.1 Testing

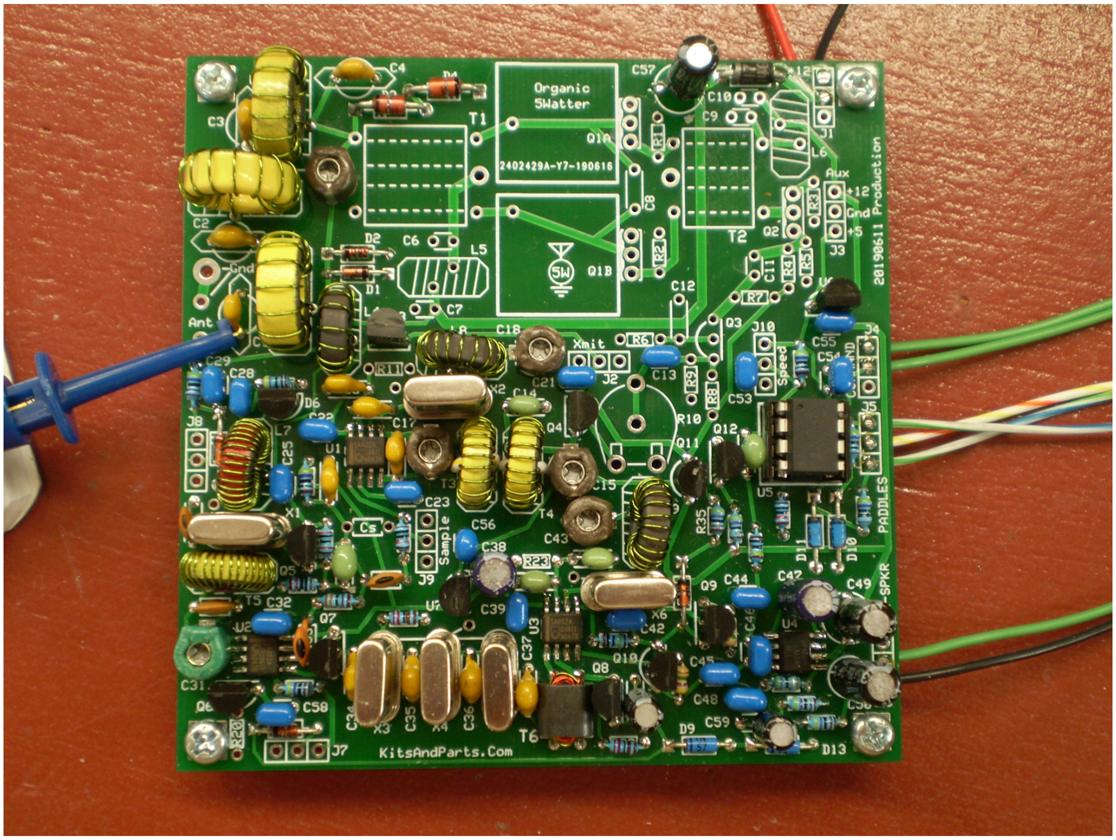


Figure 132: Top View of PCB

For testing of the LPF and T/R switch, power up transceiver as previously done for testing. Attach an outside antenna using a test lead and attach to the lead show for C1. This inputs on air signals into the receiver.

Tune around, if the band is open, for a CW signal. Tune C5 for maximum signal out of the speaker(s). C5 should be at or near the minimum value. See the 5W web page for the build instructions and at the bottom of the page is a diagram showing three conditions for the trimmer cap: minimum, maximum and half position.

The reason for having the tuning at the minimum of the cap is to maximize the effect of the T/R switch to attenuate the signal into the receiver when we are transmitting.

Note that R10 is missing because I do not have a 2K variable and I can not find my box of assorted 6mm variable resistors, so I did a temp fix to get things checked out and I do not want you do be doing the same. I did my own boards for the 1W and I used a center pad to allow 6mm variables. Diz added the same thing to the 5w.

I used a 10K variable 6mm pot for the final configuration with a 2.7K resistor in parallel to get very close to the 2K value that Diz called for. Luckily you don't have to do that.

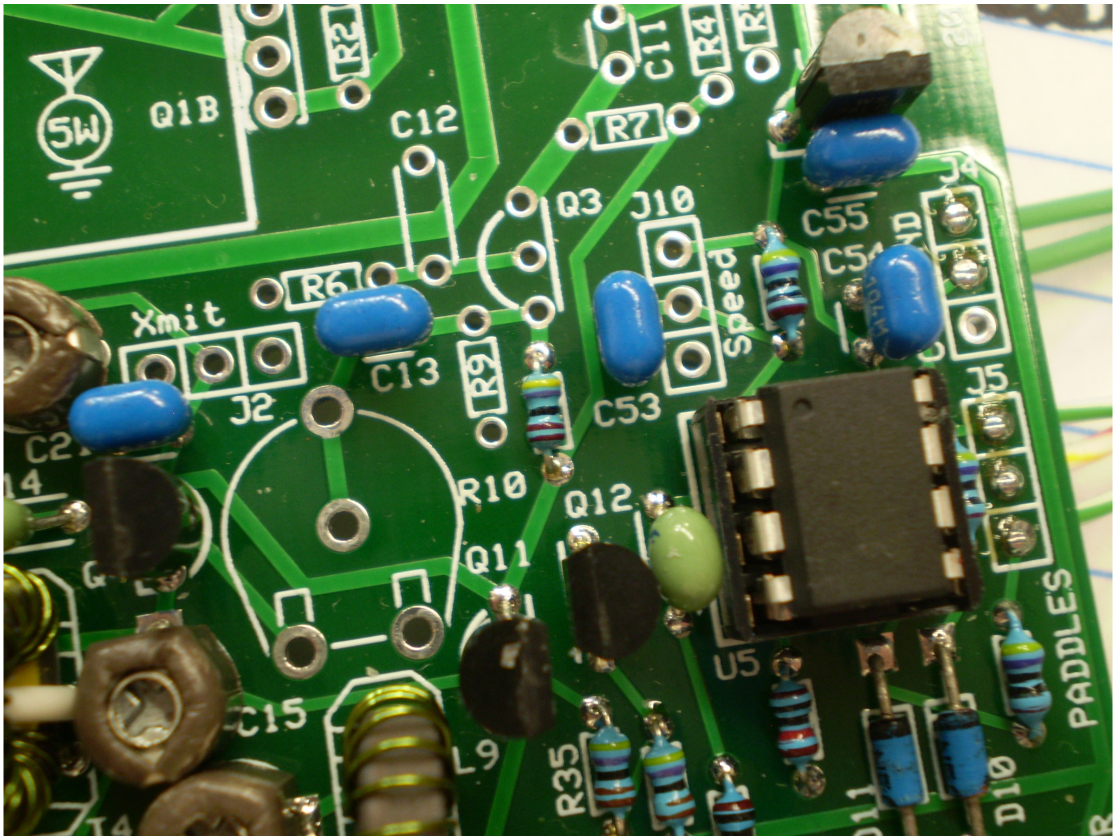


Figure 133: R8

- R8 — 4.7K (4K7) 1/8W resistor

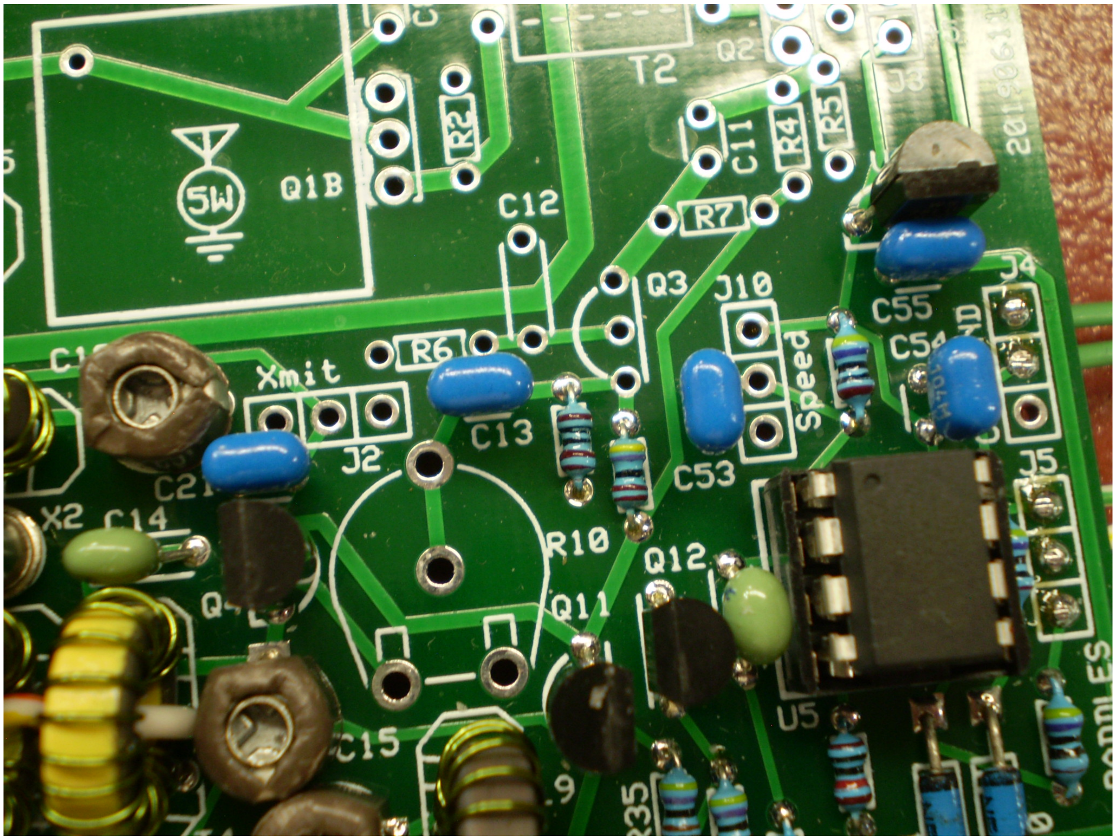


Figure 134: R9

- R9 — 1K 1/8W resistor

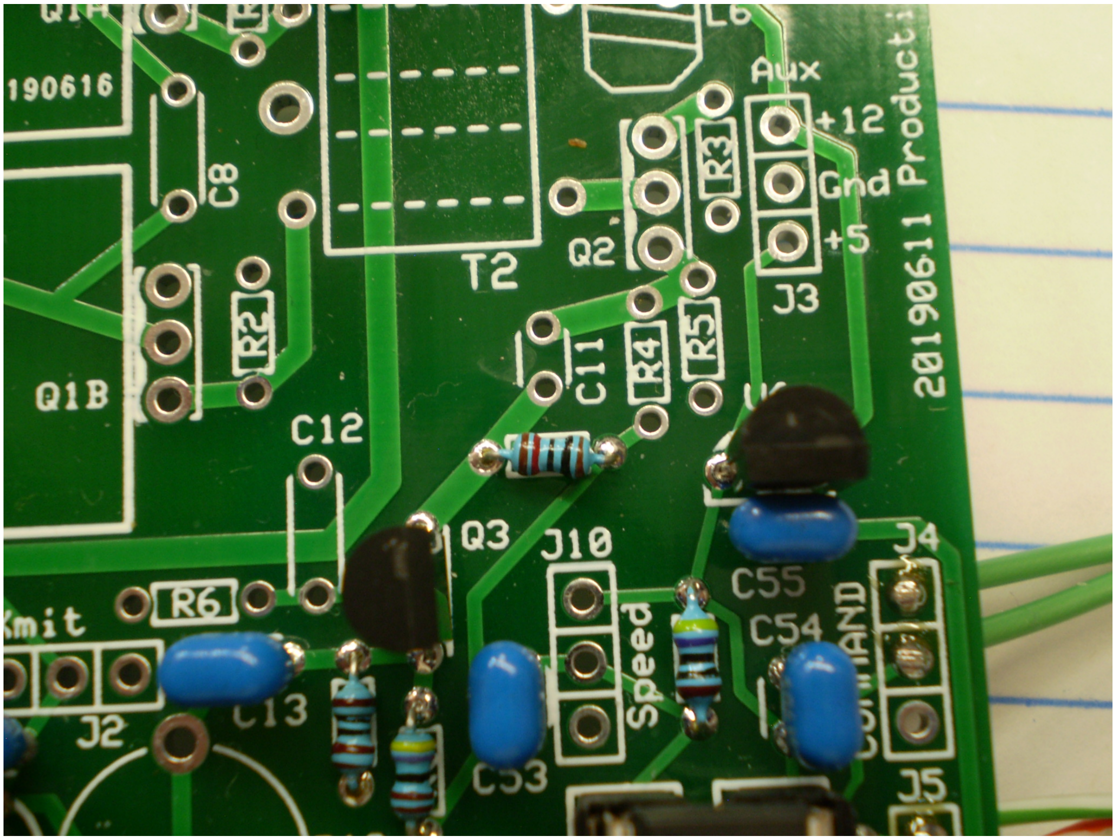


Figure 135: R7

- Q3 — MPSH10 NPN transistor
- R7 — 120 ohm 1/8W resistor

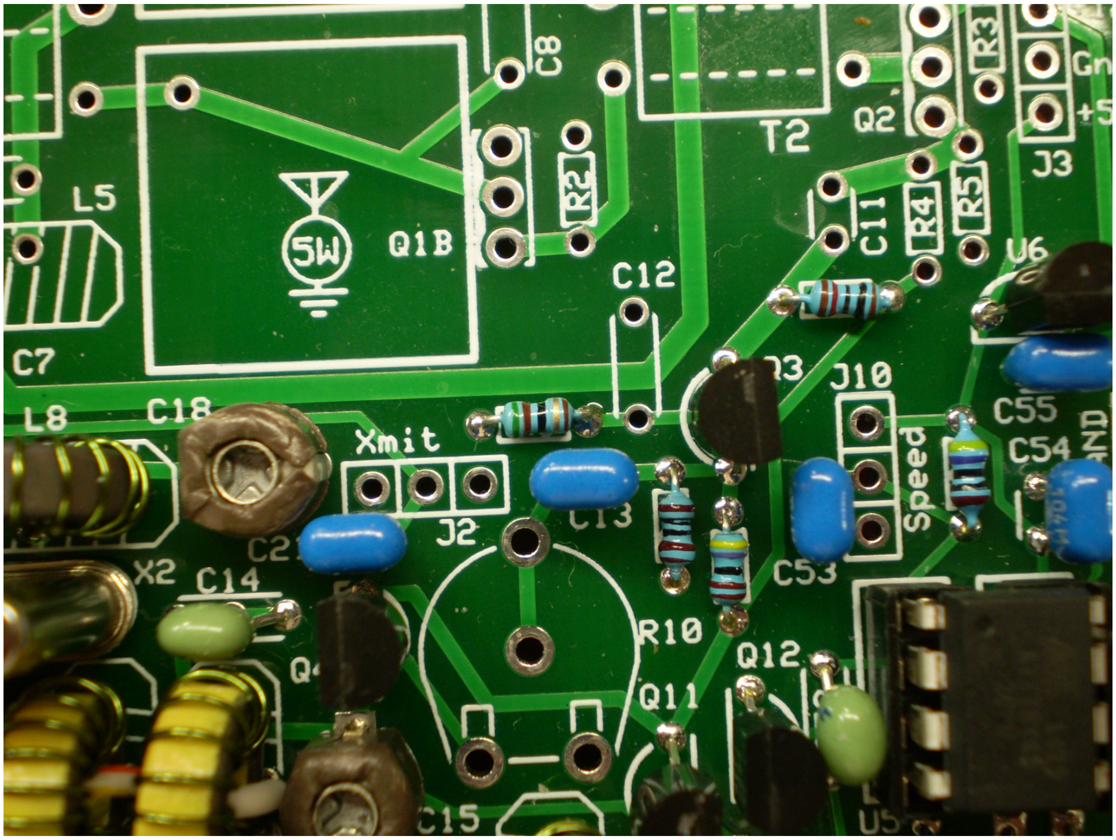


Figure 136: R6

- R6 — 51 ohm 1/8W resistor

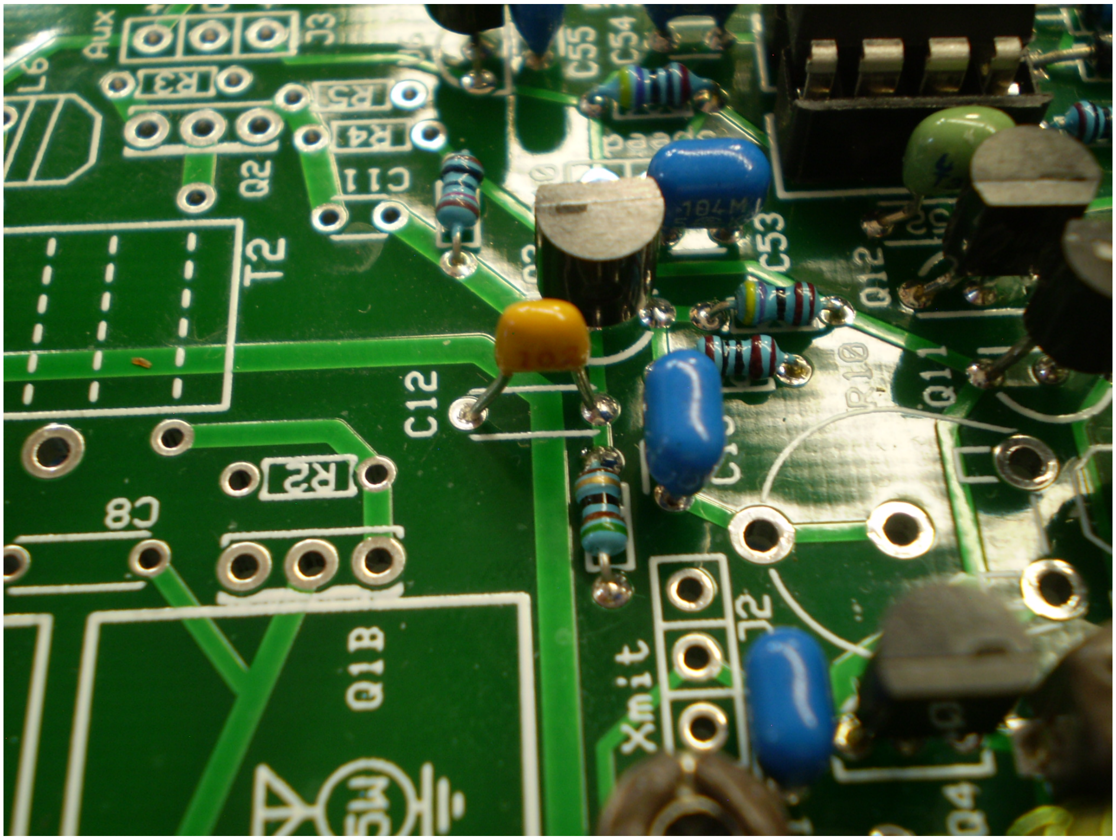


Figure 137: C12

- C12 — 1nF mono cap

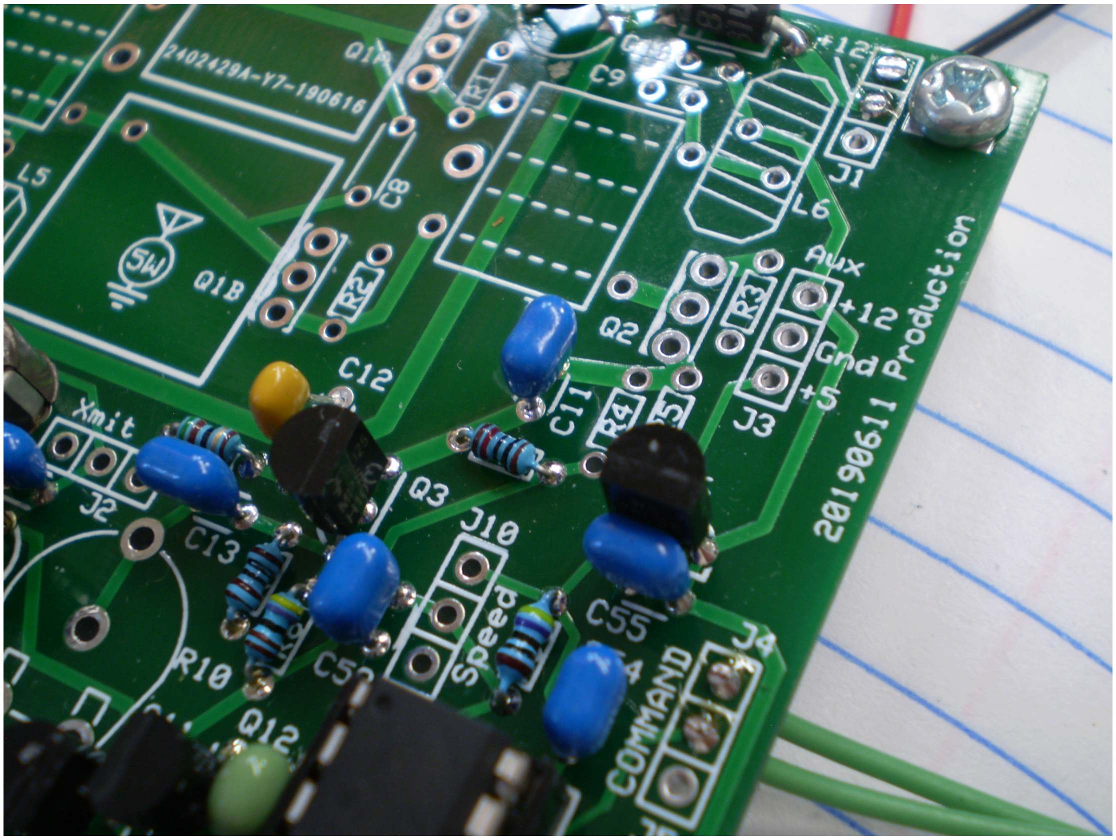


Figure 138: C11

- C11 — 100nF mono cap

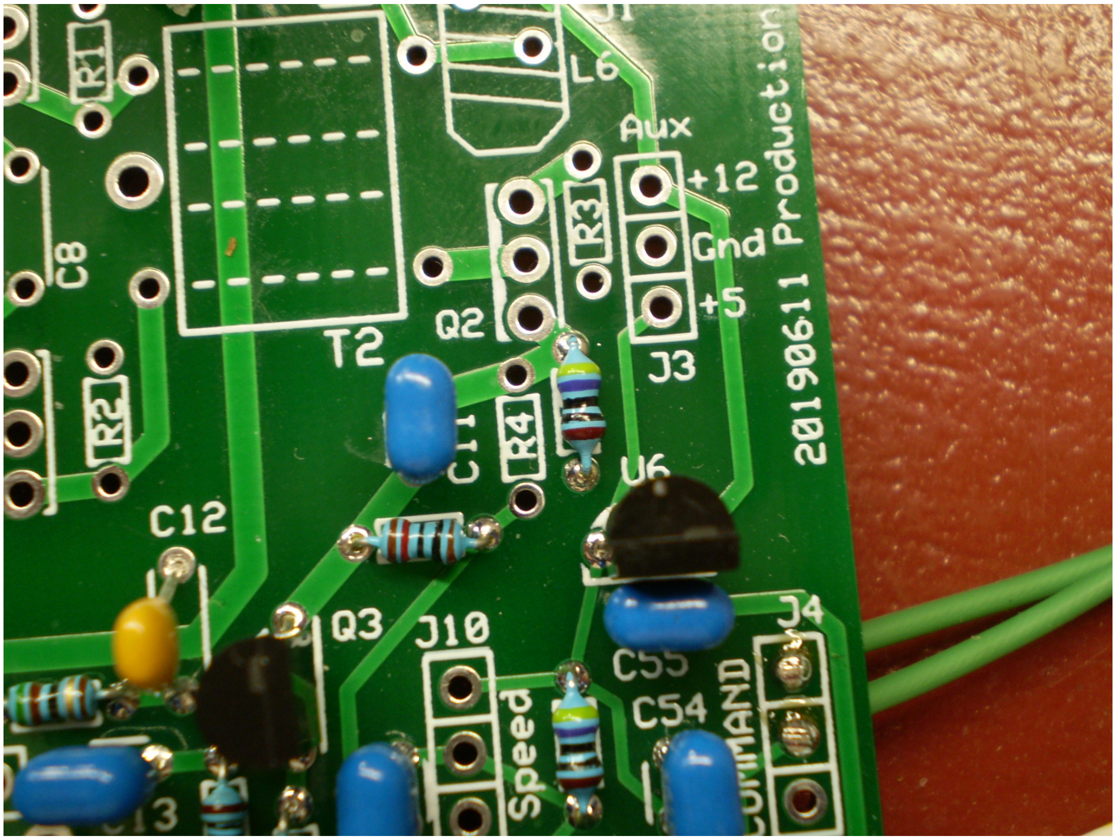


Figure 139: R5

- R5 — 470 ohm 1/8W resistor

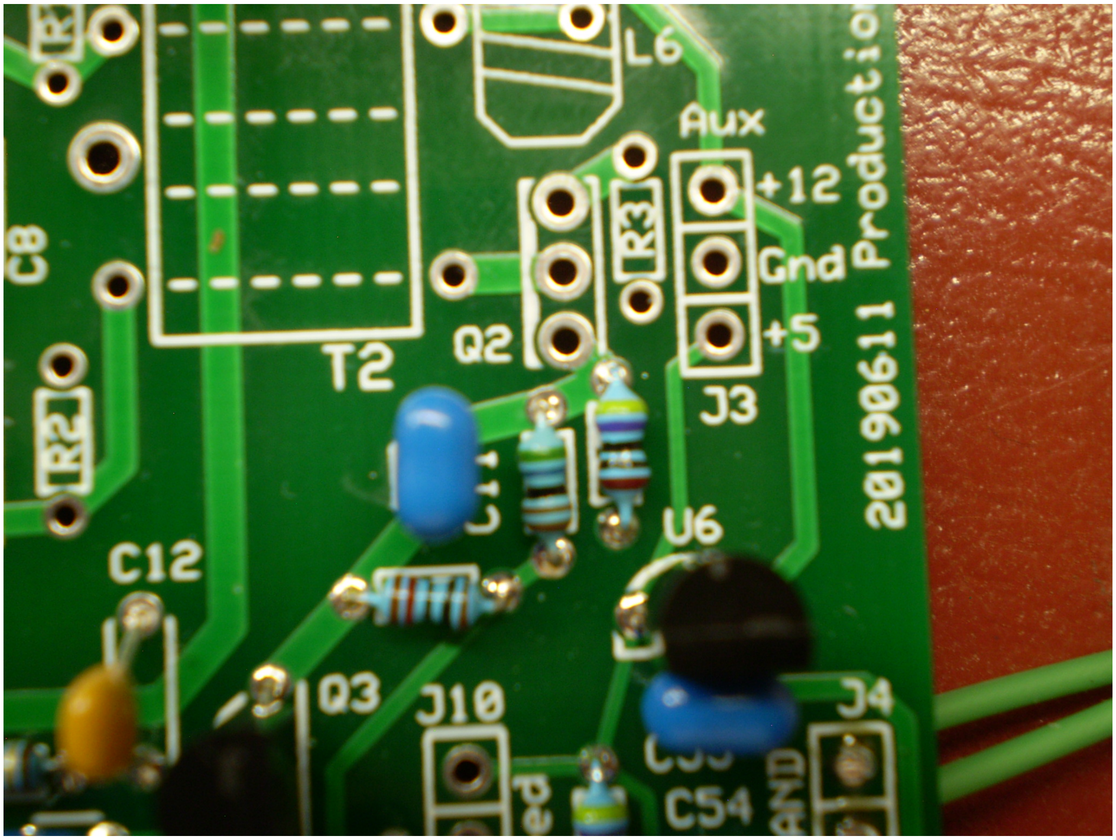


Figure 140: R4

- R4 — 5.6K 1/8W resistor

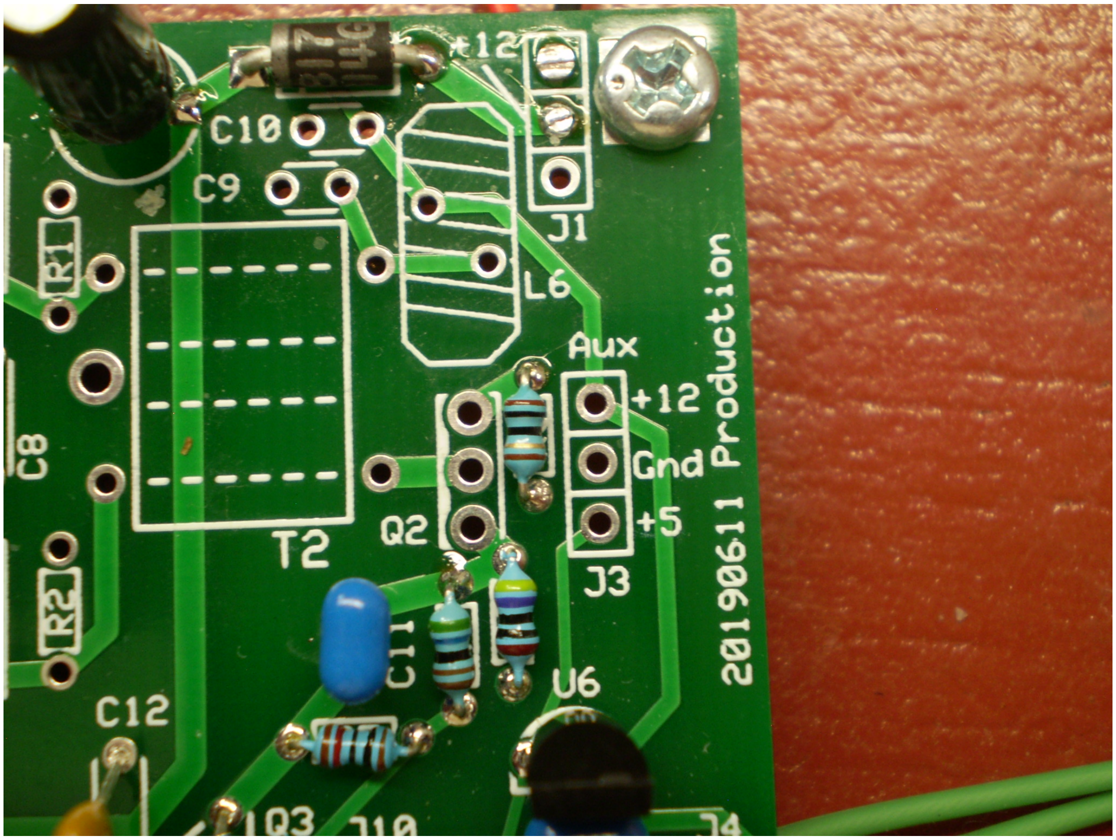


Figure 141: R3

- R3 — 10 ohm 1/8W resistor

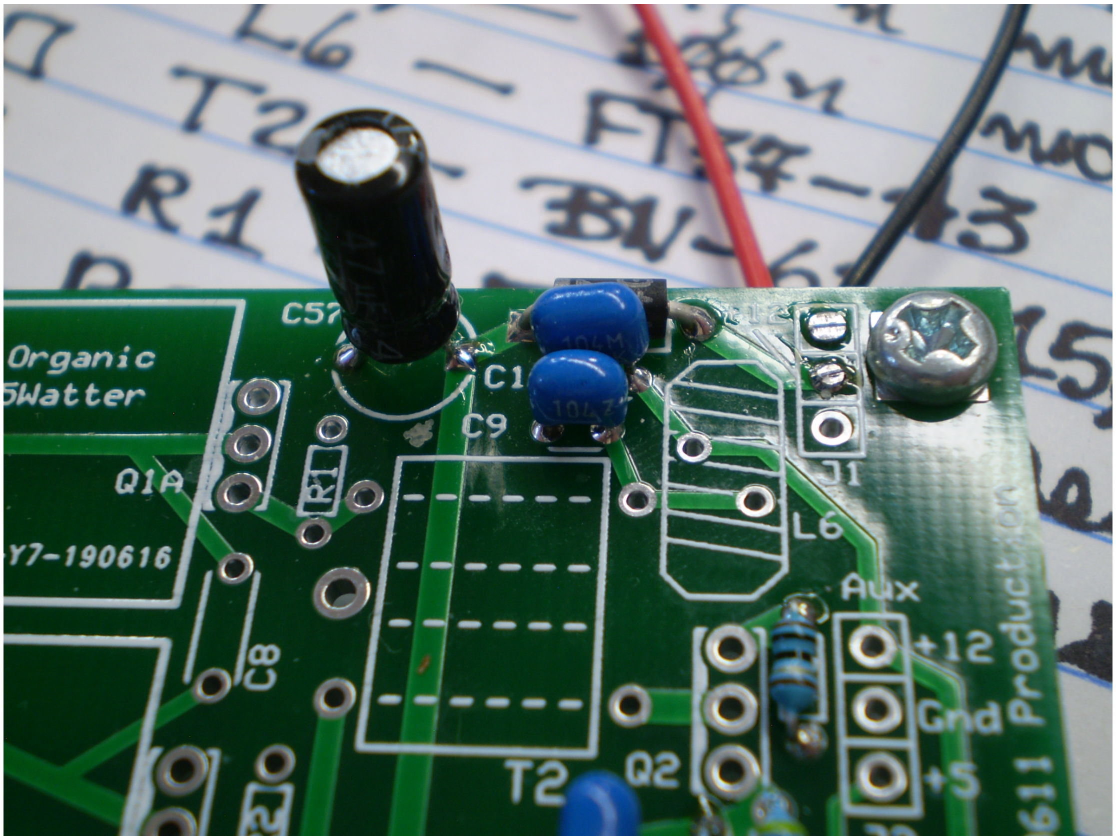


Figure 142: C9 and C10

- C9 — 100nF mono cap
- C10 — 100nF mono cap

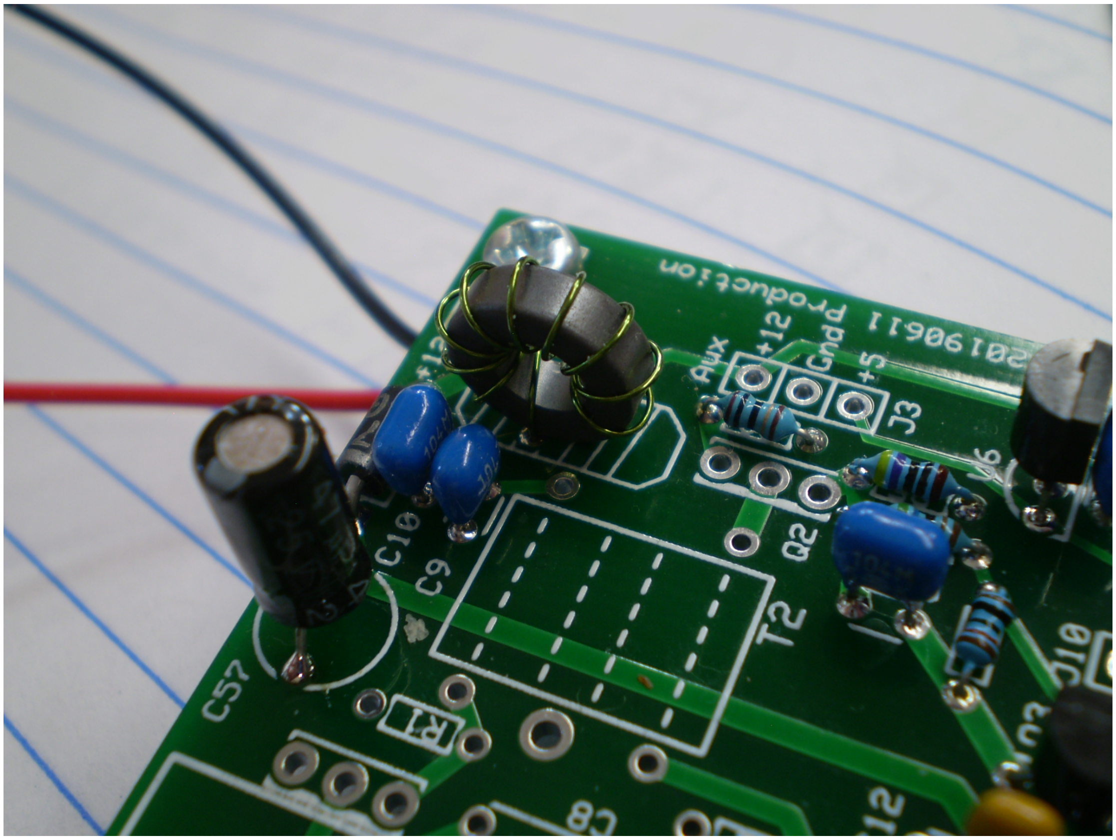


Figure 143: L6

- L6 — FT37-43 ferrite toroid with 10 turns (10T)

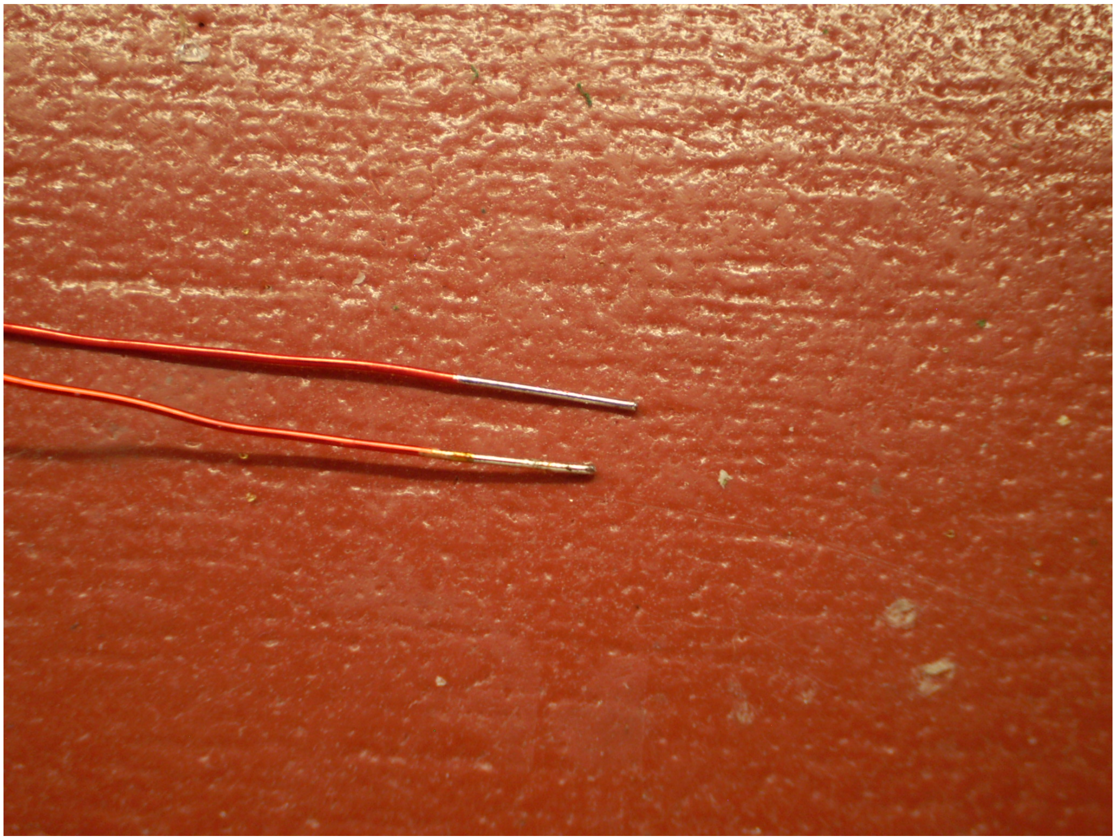


Figure 144: T2 build sequence

For the primary center tapped winding of T2, I cut the wire to length and then cut the center and tinned the two ends as shown above. I like doing it this way as it is easy to twist the two ends together and solder for the center tap.

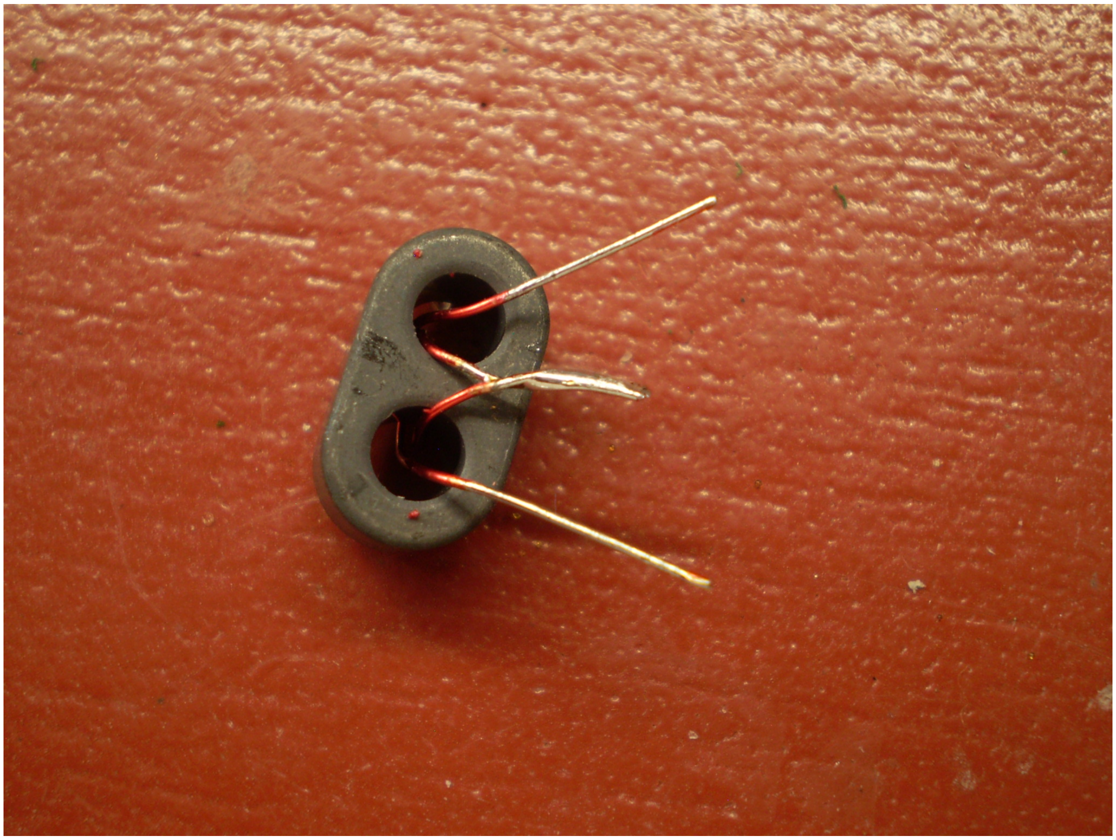


Figure 145: T2 with primary

Here I have installed the primary winding and tinned the ends.

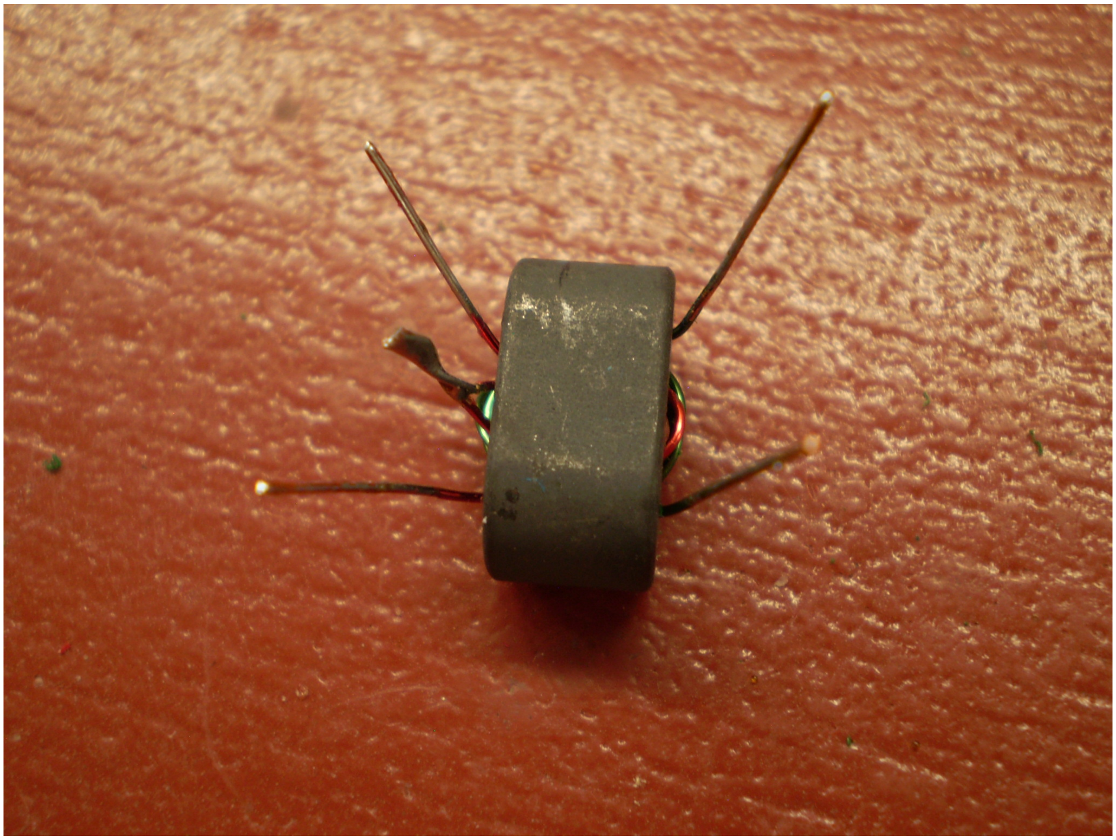


Figure 146: T2 completed

I have added the four turn (4T) secondary and tinned the ends and bent the wires ready for installation. This looks like a dead bug.

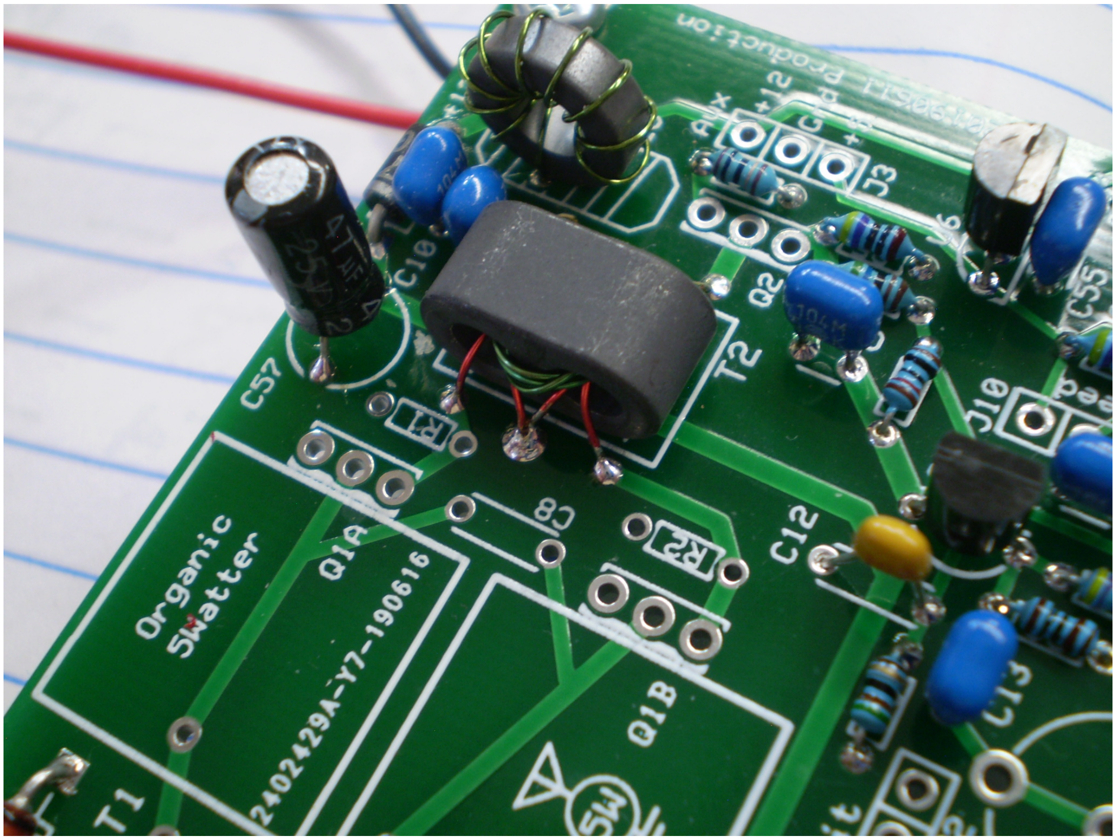


Figure 147: T2

T2 installed in place.

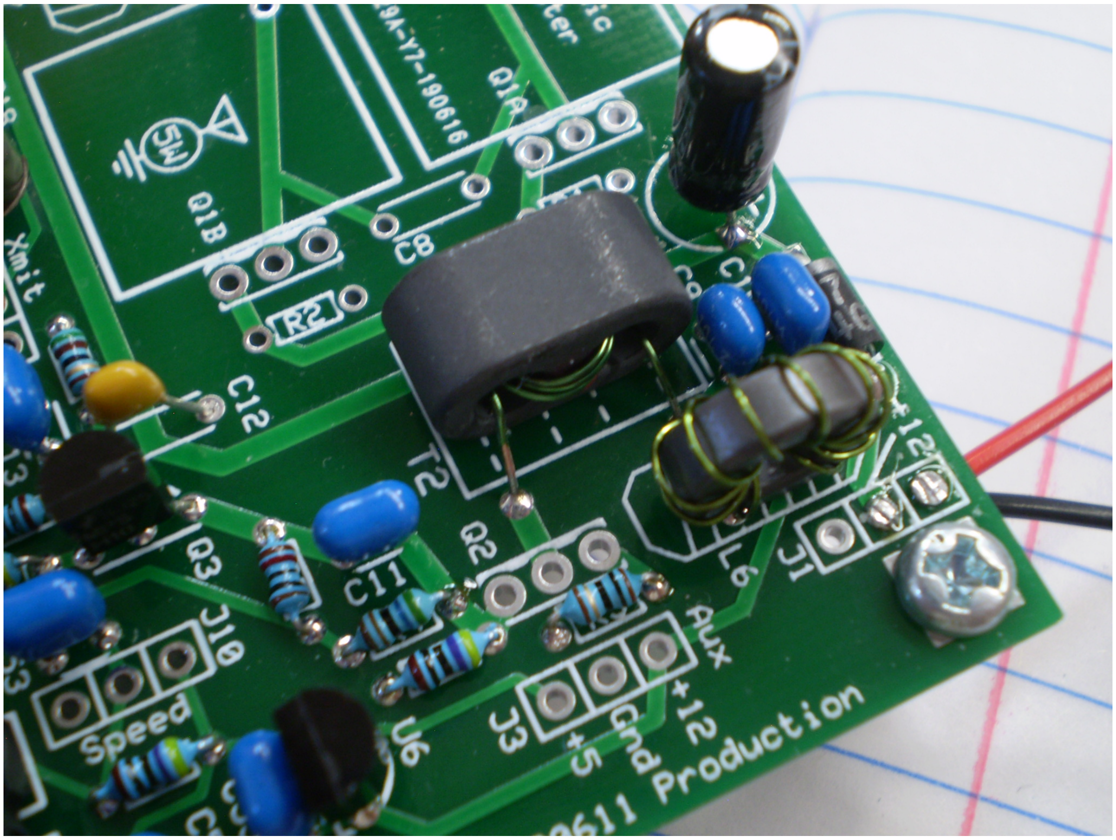


Figure 148: T2

T2 installed in place.

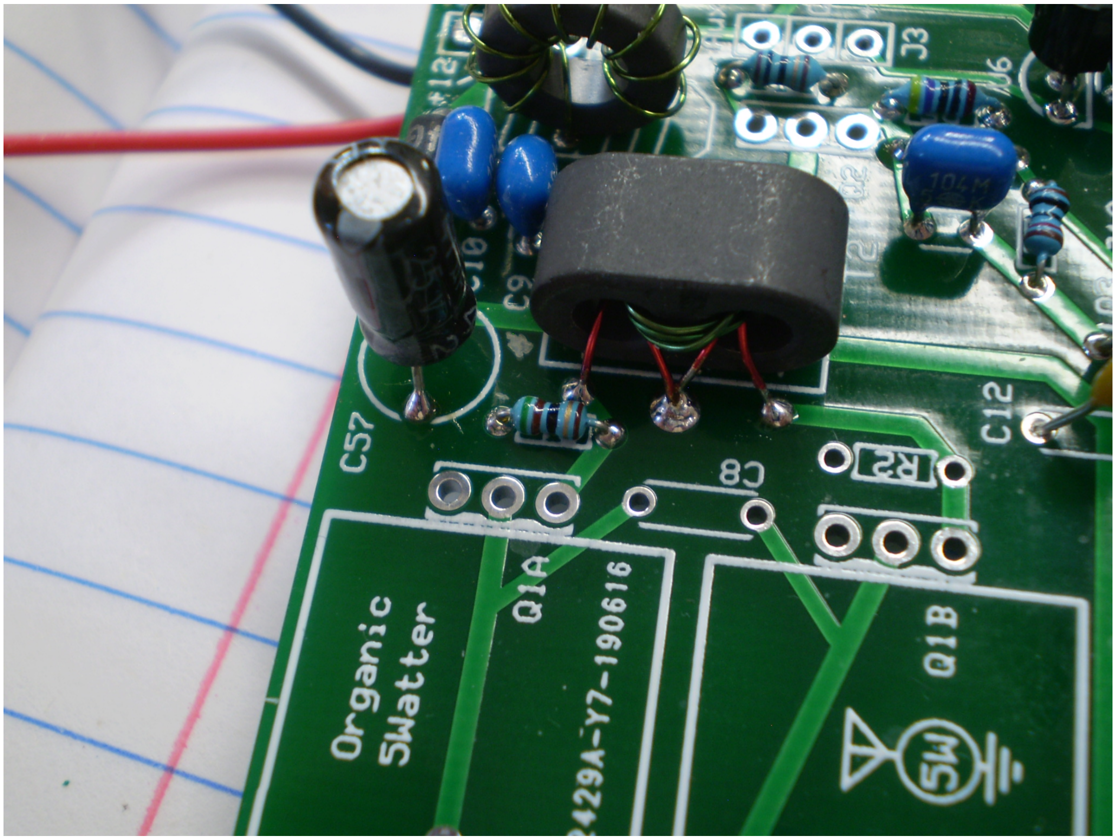


Figure 149: R1

- R1 — 51 ohm 1/8W resistor

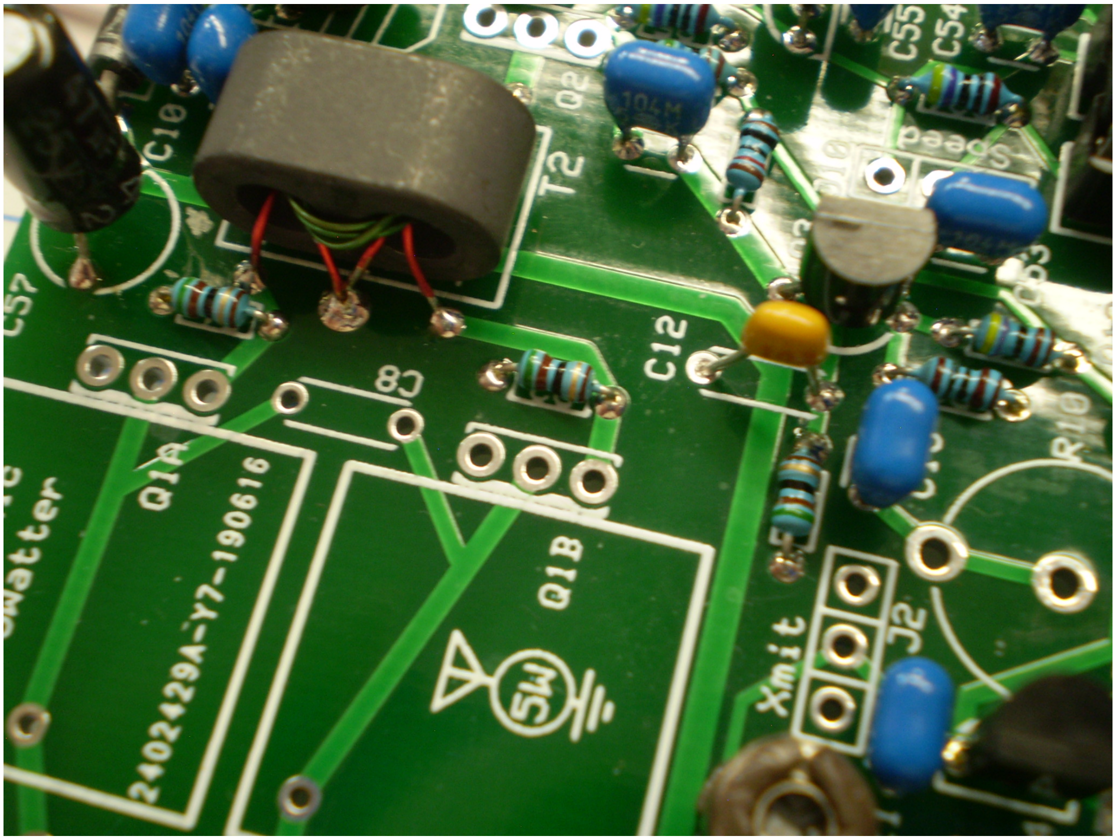


Figure 150: R2

- R2 — 51 ohm 1/8W resistor

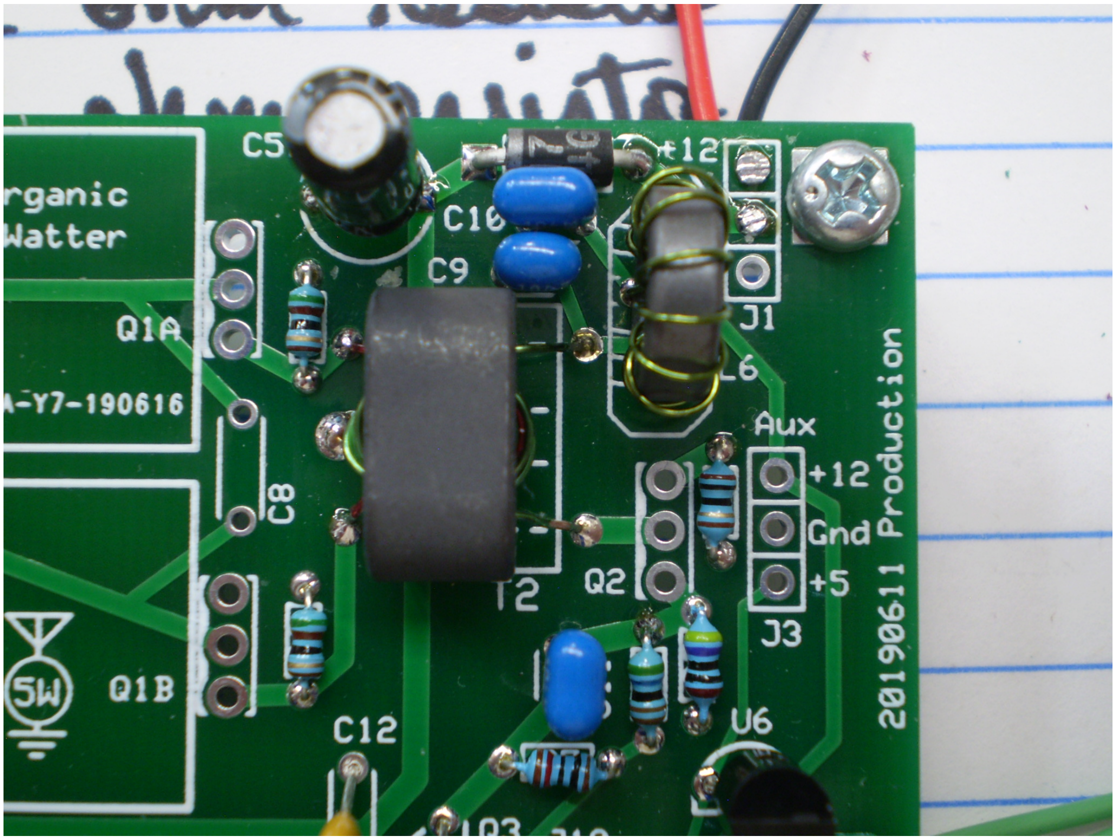


Figure 151: Overview

View of the driver section.

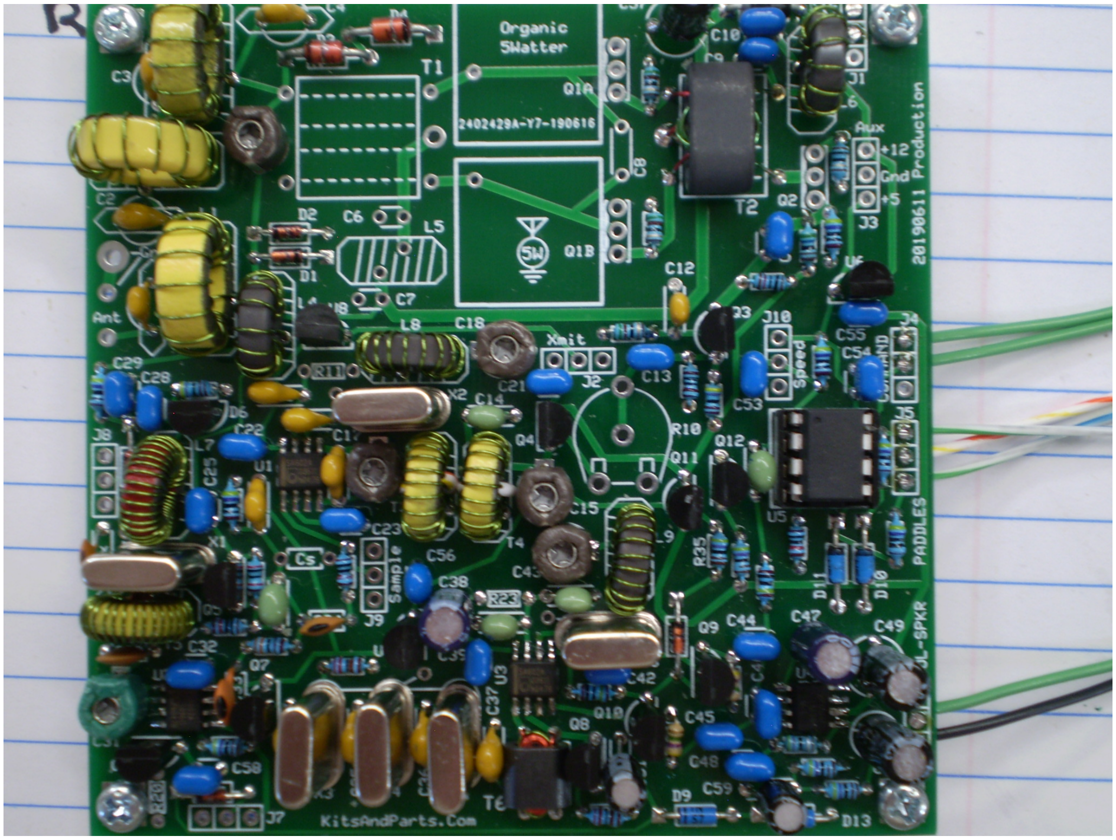


Figure 152: Top View of PCB

Don’t know why I thought we needed this, but I did take it.

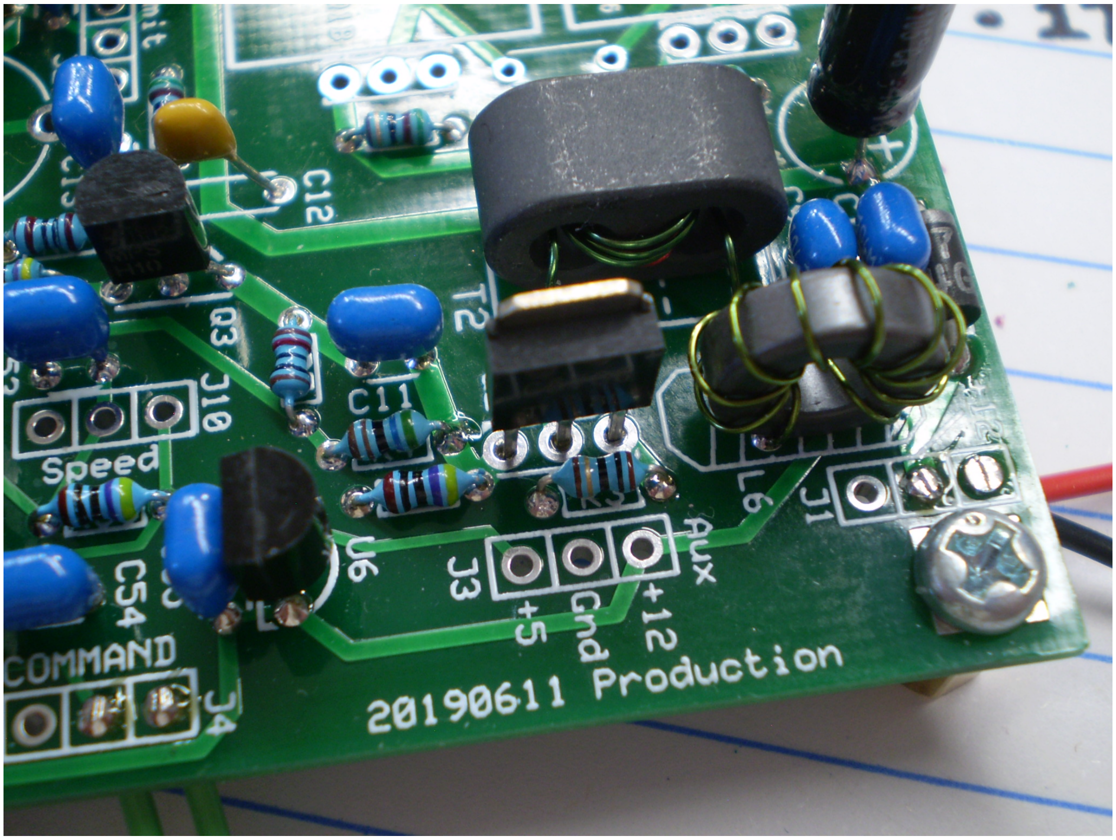


Figure 153: Q2

- Q2 — 2SC5706 NPN transistor

Note that I did not apply as much solder to get wicking at the top. Just in case I ever need to replace this transistor and I did not want to use a socket.

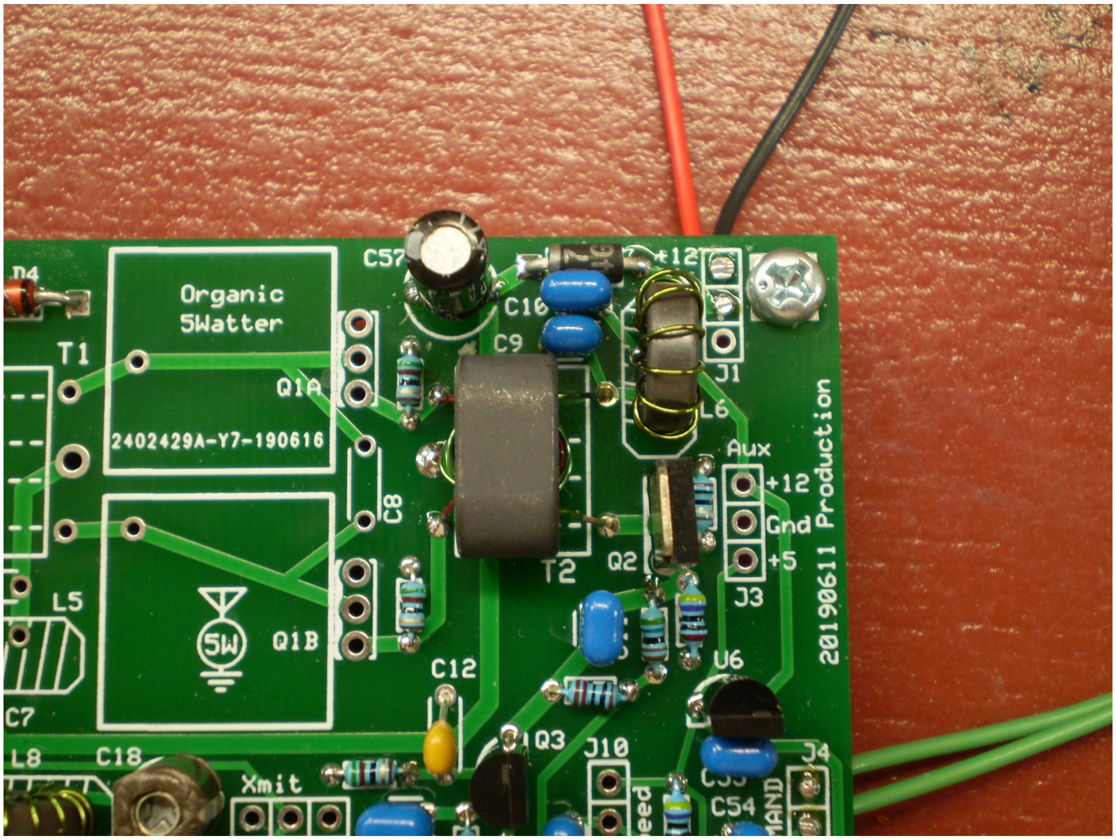


Figure 154: Driver Section

Top view of the driver section just completed

9.2 Testing

You can test the transceiver again at this point by hooking everything up and powering up. Use the paddle to key the rig and at this time you should be able to easily hear the transmitter in the receiver. The driver Q2 is feeding power into R1 and R2, so it has a load and will not damage the transistor.

9.3 Final PA Section

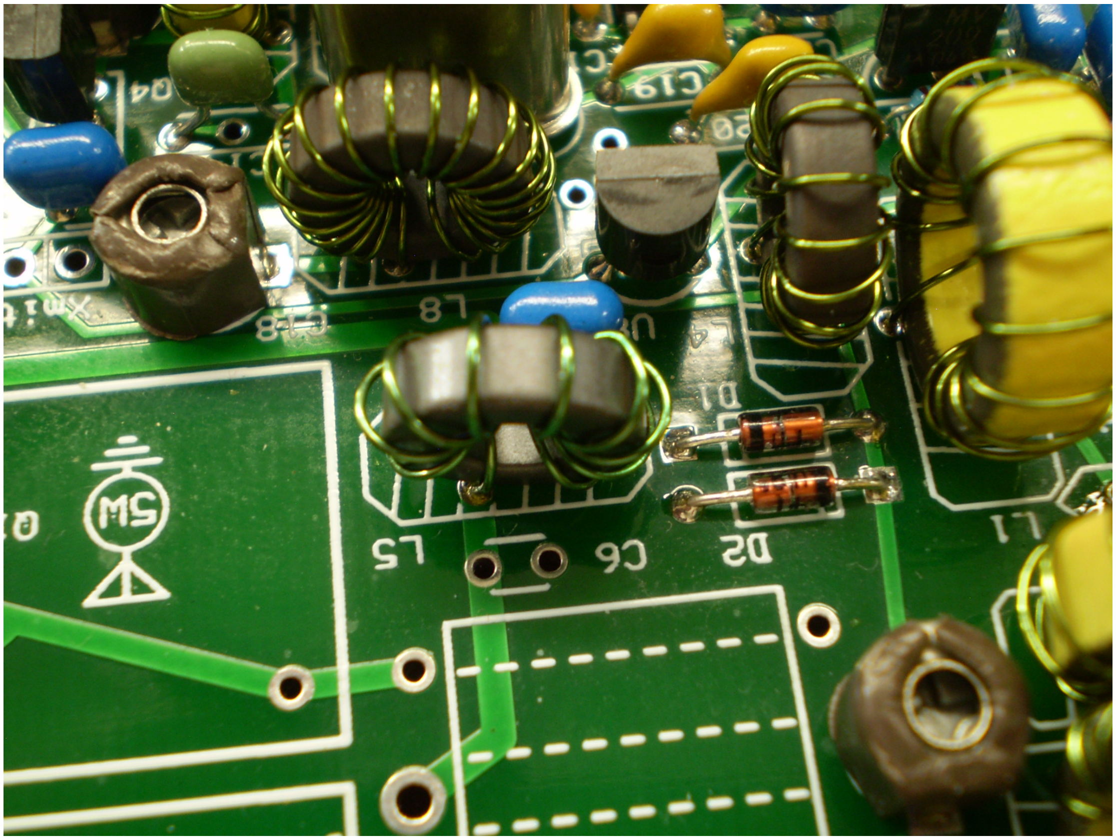


Figure 155: L5

- C7 — 100nF mono cap (behind the toroid)
- L5 — FT37-43 ferrite toroid with 10T

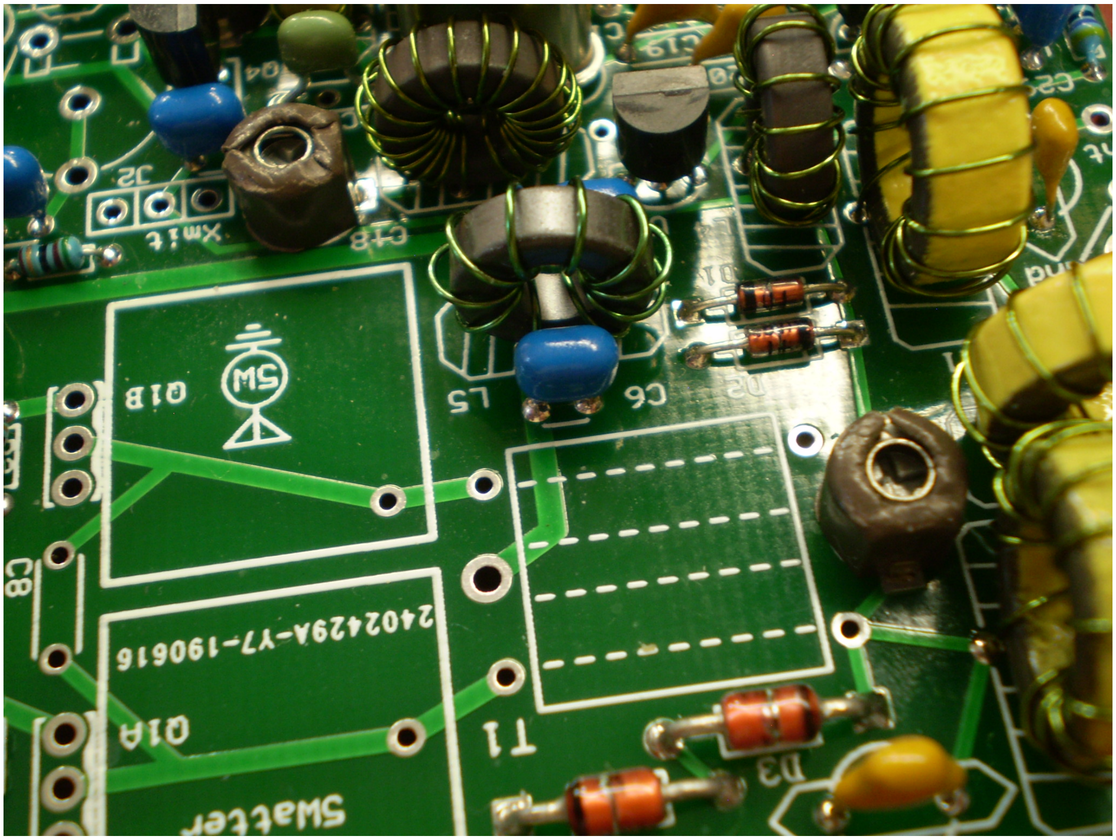


Figure 156: C6

- C6 — 100nF mono cap

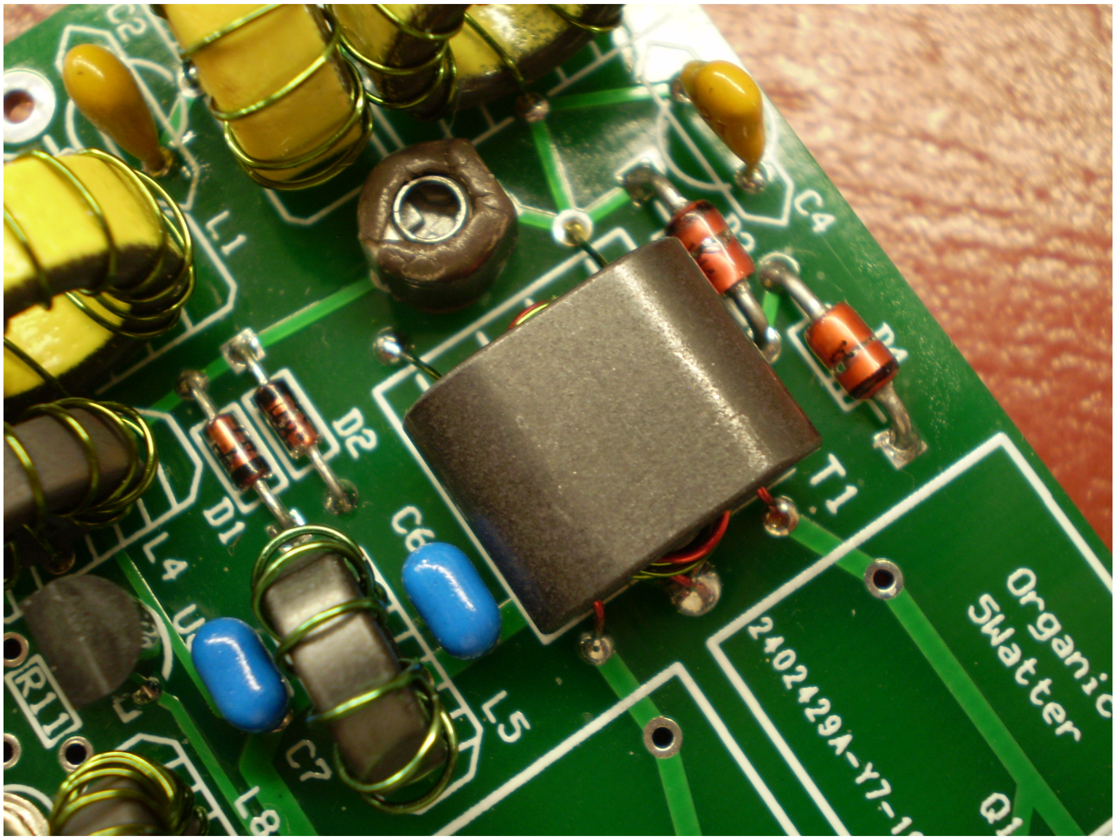


Figure 157: T1

- T1 — BN-61-302 binocular core with 4T:2T:2T windings

Check with web page for the 5W transceiver and the building instructions for details on winding this transformer.

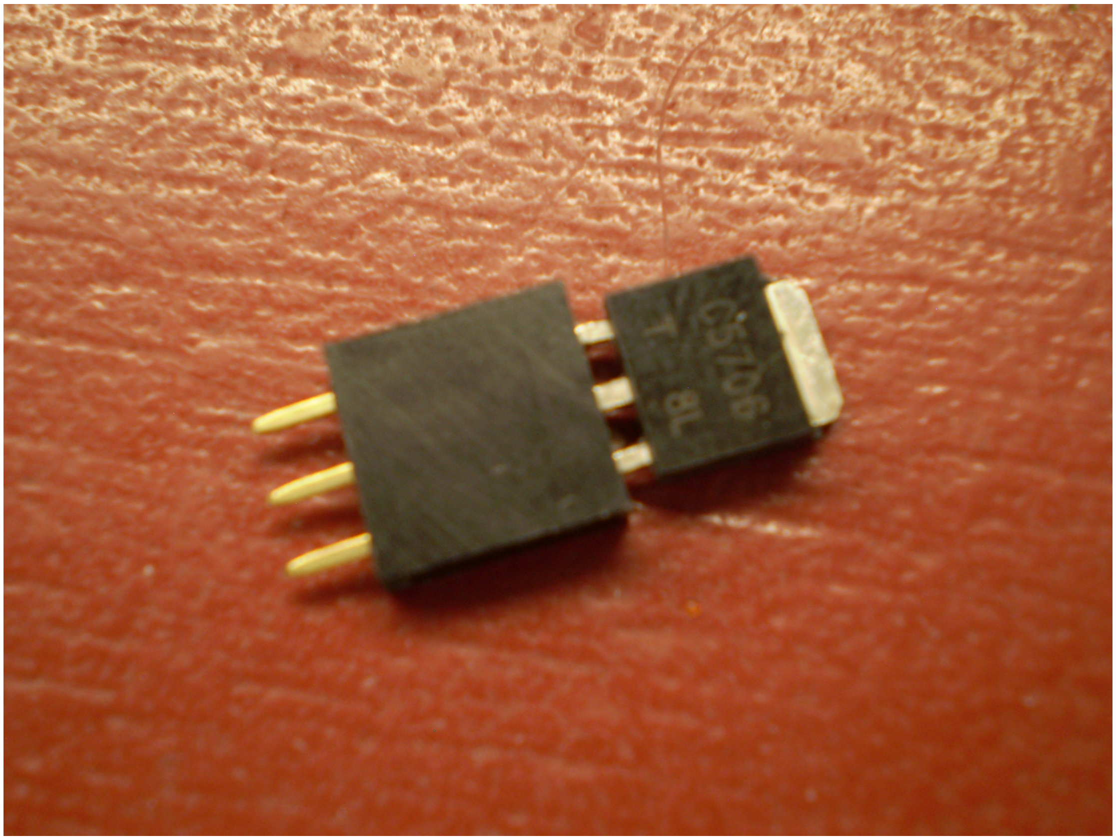


Figure 158: PA transistor socket

Diz was cutting 8-pin sockets to get 3-pins for mounting transistors and I showed him this and a source on the web for the parts. This is what you will be using.

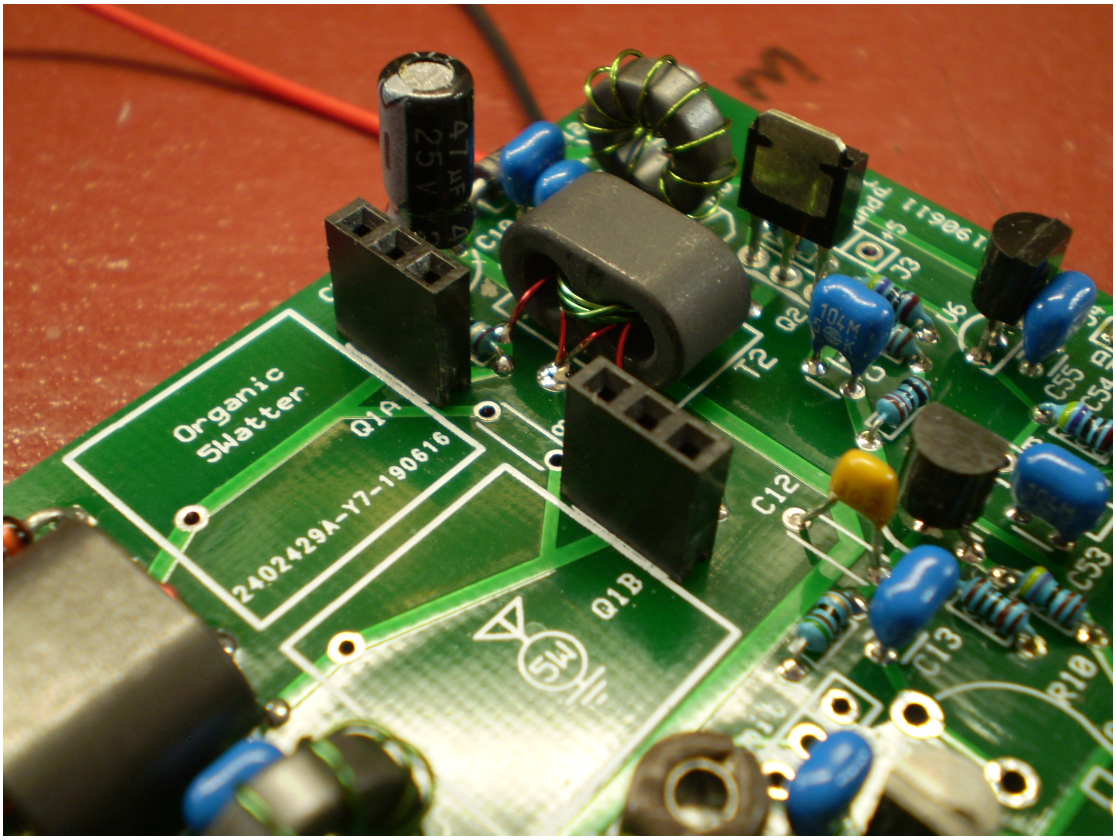


Figure 159: Q1A and Q1B sockets

- sockets for PA transistors
- Q1A — 2SC5706 NPN PA transistor plugged into socket
- Q1B — 2SC5706 NPN PA transistor plugged into socket

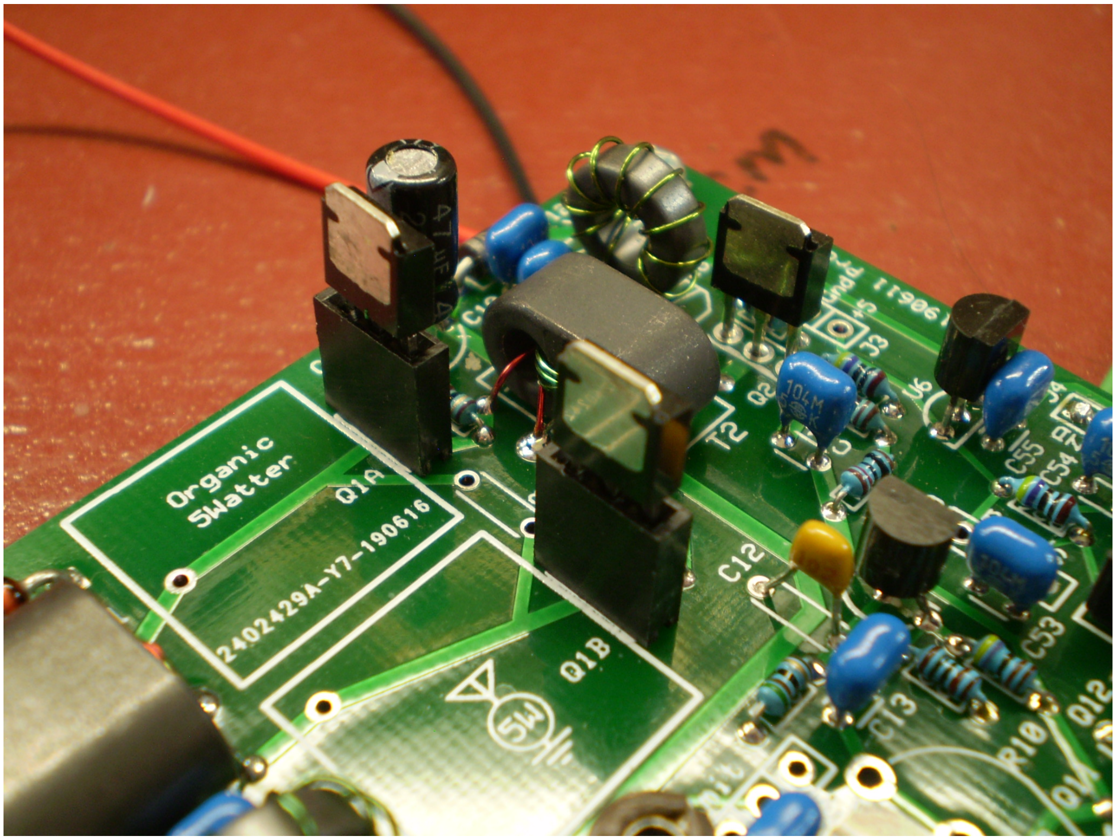


Figure 160: Q1A and Q1B transistors

- Q1A — 2SC5706 NPN PA transistor plugged into socket
- Q1B — 2SC5706 NPN PA transistor plugged into socket

Diz will have two heat sinks with nuts and screws to put on the transistors to keep their temperatures down during operation. Please install them at this time and do not operate the transceiver without them. With the screw and nut combo you will be able to keep using the heat sinks on new replacement transistors if the need arises.

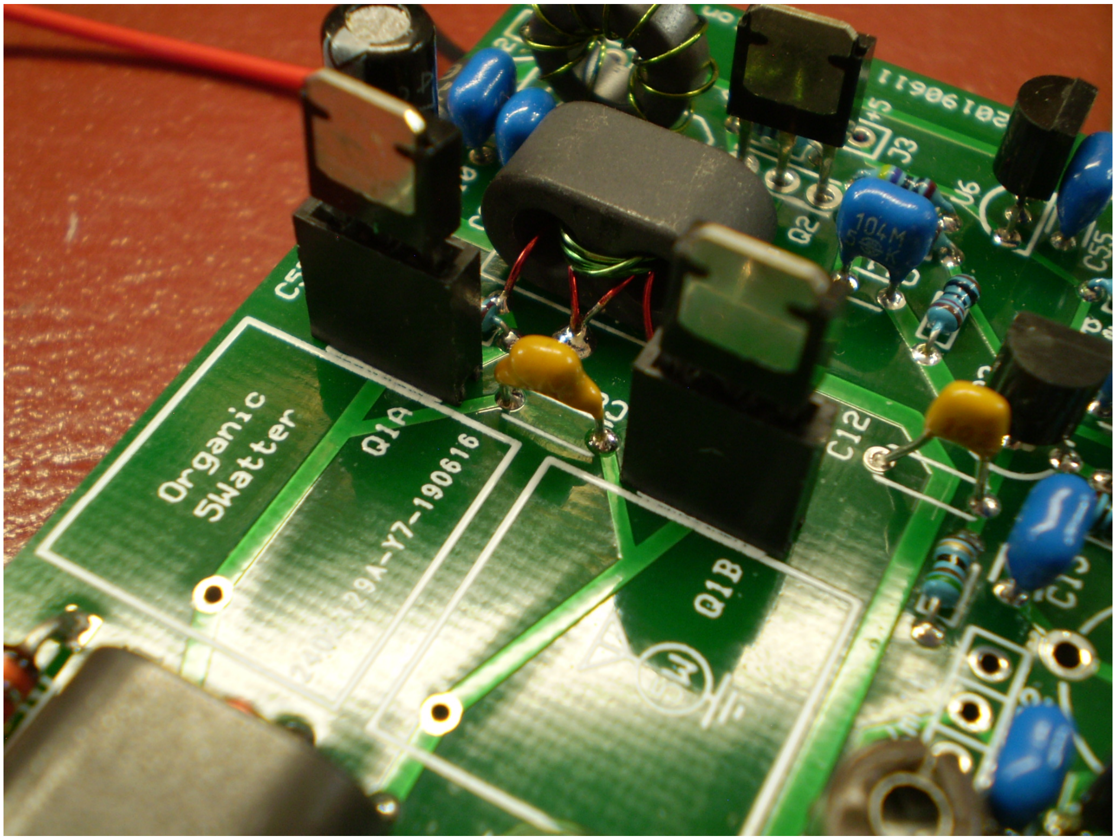


Figure 161: C8

- C8 — 100pF mono cap

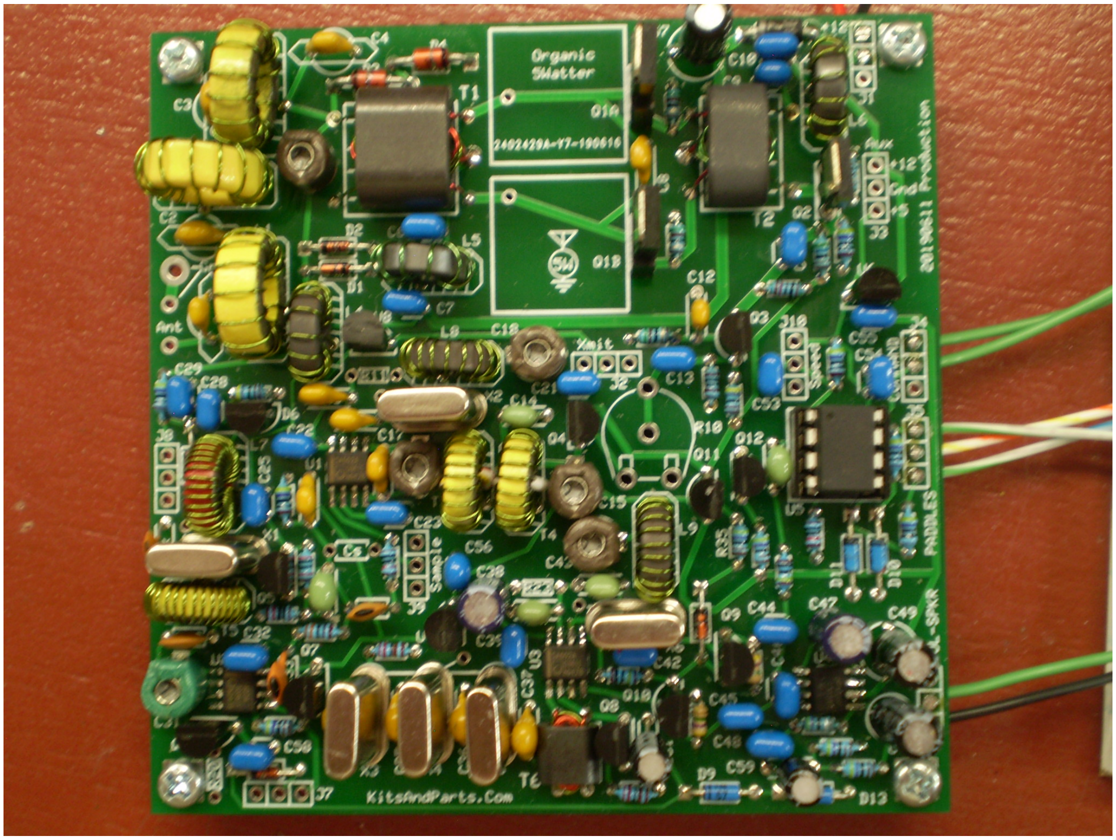


Figure 162: Assembled Transceiver Board

At this time you are just so excited and you want to power up the transceiver and put it on the air without an enclosure. I recommend that you not do that.

Take the time to build or buy an enclosure and hook everything up. Never power up the rig without a tuned antenna or a 50 ohm dummy load on the BNC antenna connector. You will be buying spare final PA transistors (2SC5706 NPN) from Diz. You should buy some anyway, just in case. I bought some from Diz for spares just in case something happens.

At the 1W level, the PA transistor in the 1W transceiver had no problems, since the RF signal was at 10V peak. But at 5W, the RF level goes to 22V peak and any SWR ratio greater than more than 2:1, as seen by the input antenna connection, will create a voltage high enough to instantly destroy the final transistors. Diodes D3 and D4 might save them, but the voltage level could destroy everything. I'm not taking any chances myself.

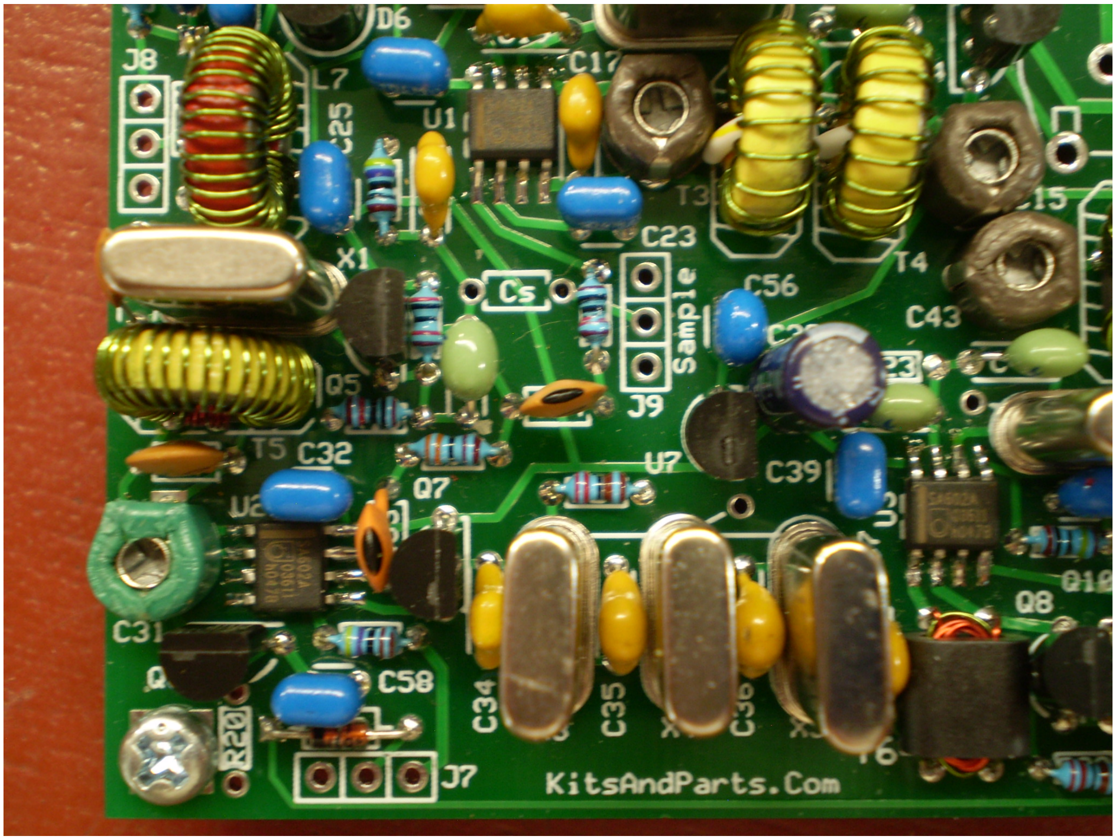


Figure 163: Lower Left Hand Quadrant

Photograph of the lower left hand quadrant of the transceiver. I will solder connecting wires at the terminal positions for the final assembly into an enclosure.

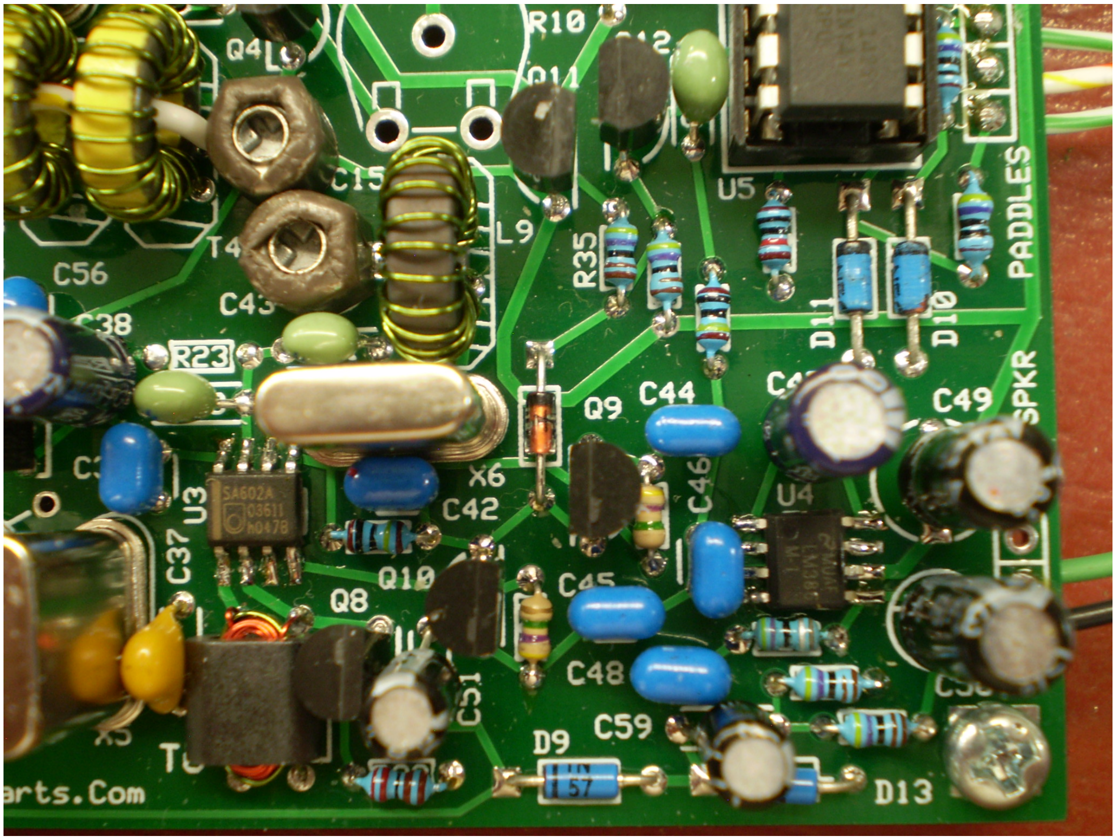


Figure 164: Lower Right Hand Quadrant

Lower right hand side of the assembled transceiver.

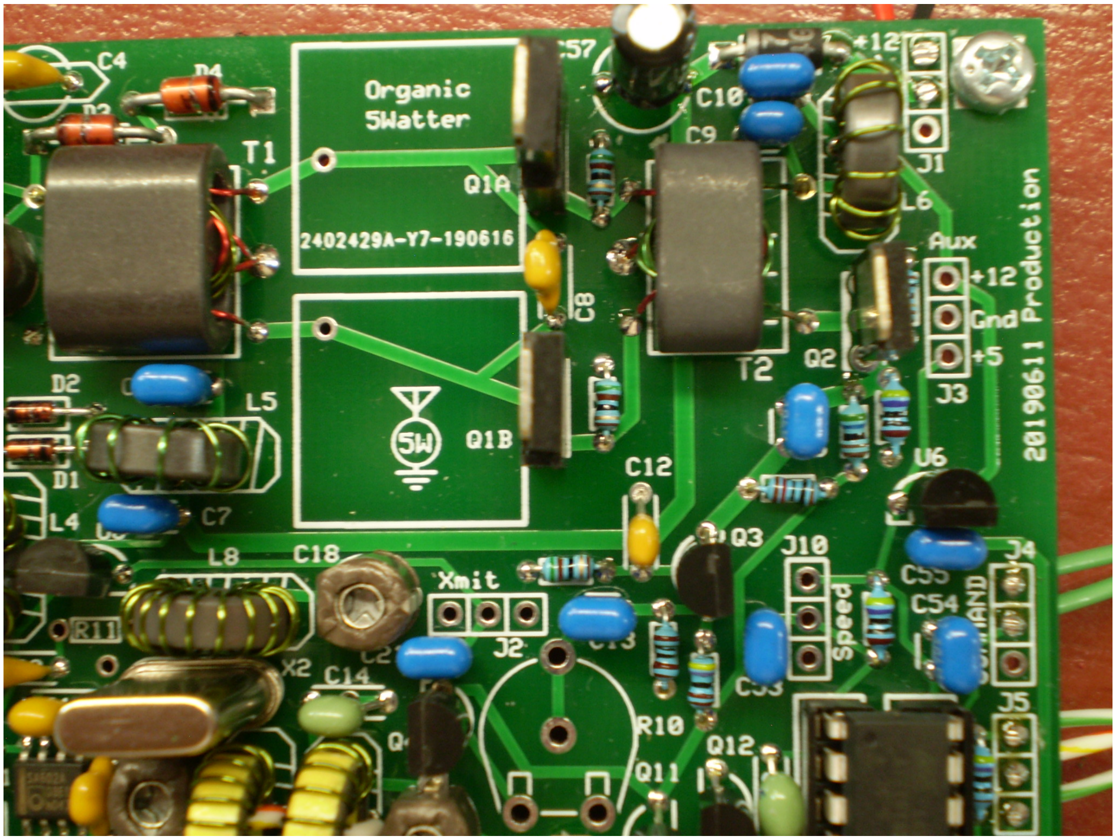


Figure 165: Upper Right Hand Quadrant

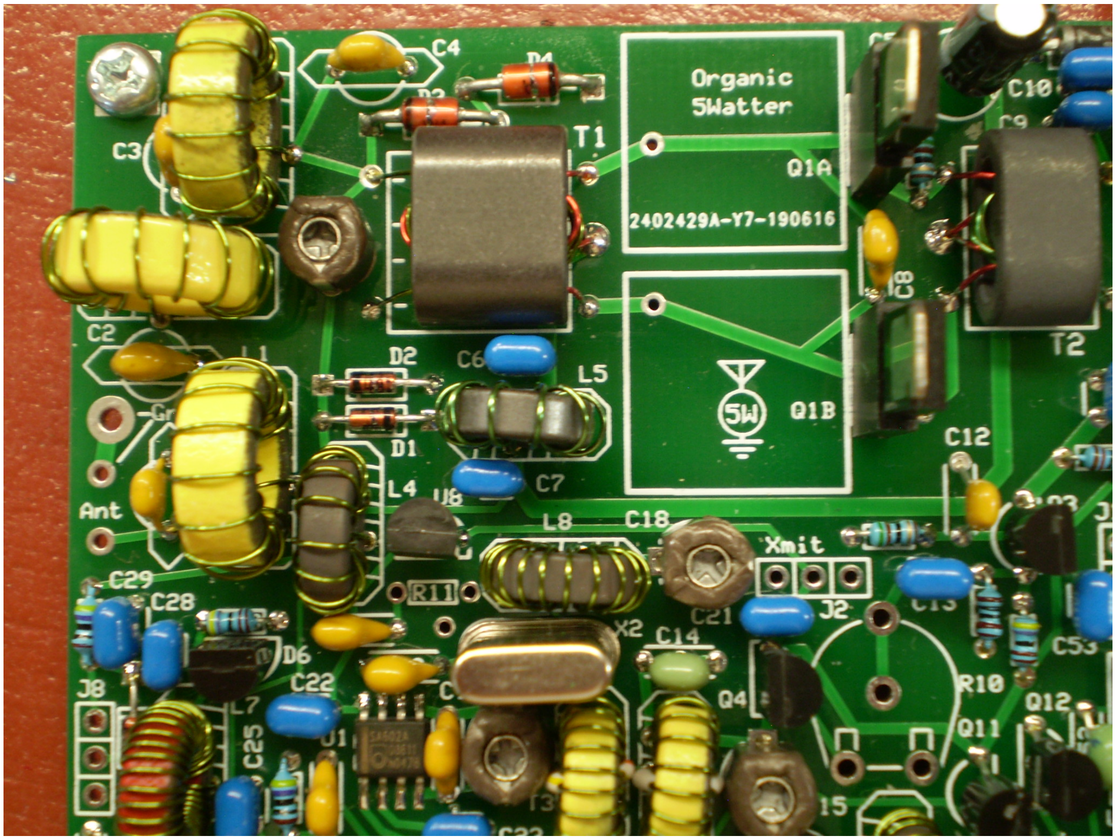


Figure 166: Upper Left Hand Quadrant

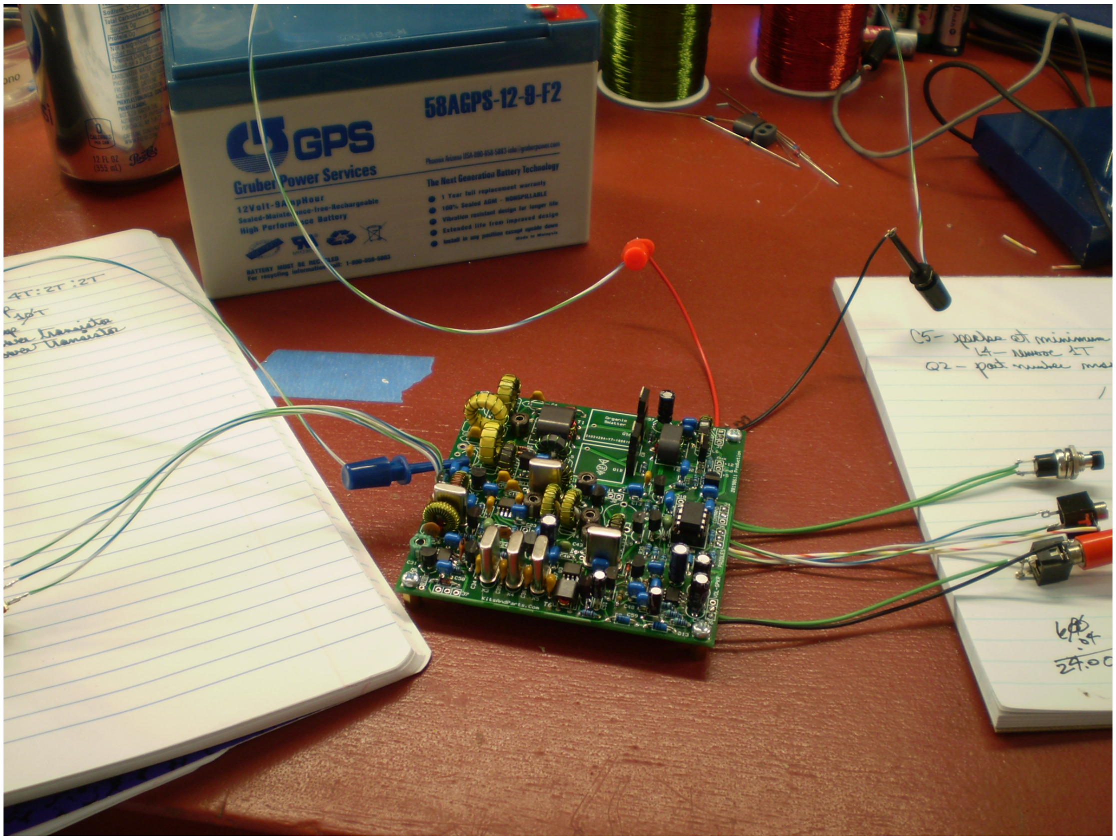


Figure 167: On the workbench

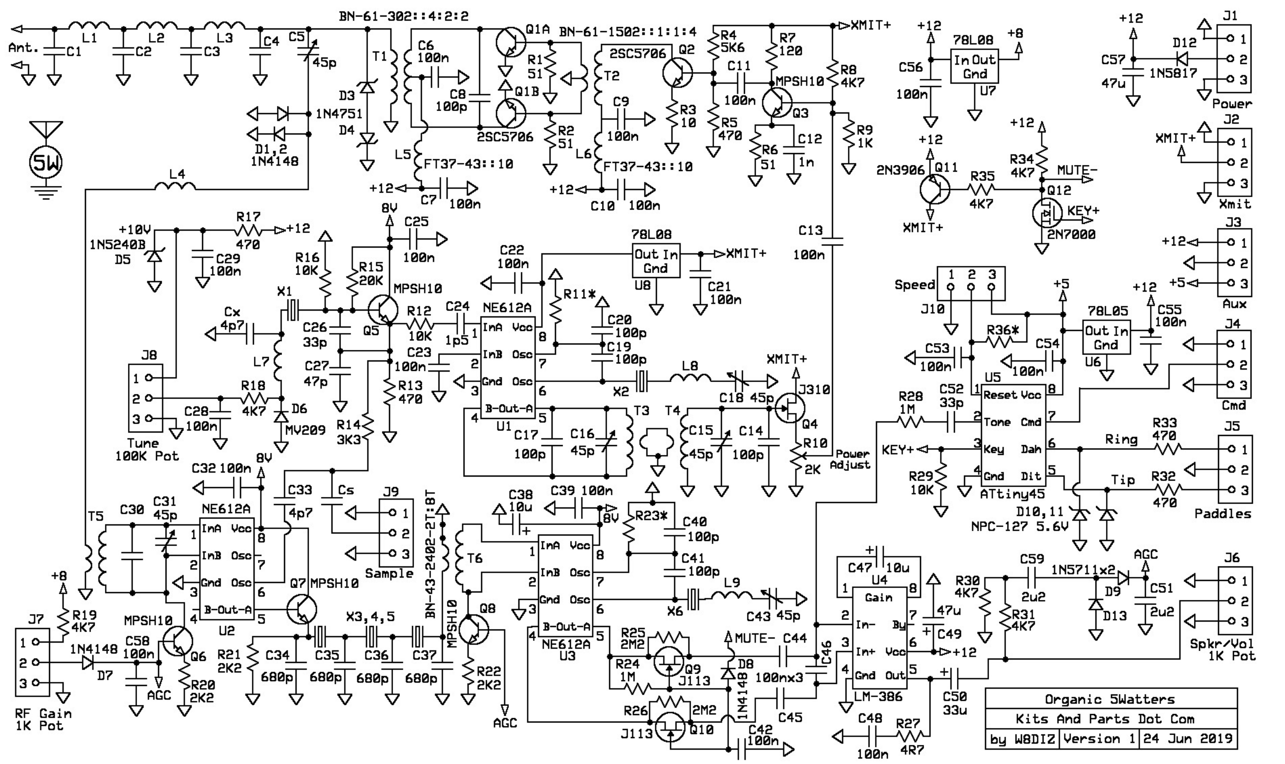
OK. I did this because this was Sat morning the day of FD 2019. I was checking 20m for propagation conditions at the start of the emergency exercise. The band was dead, so I then went to work on an aluminum enclosure to install the transceiver into for working the contest.

Note that there is no paddle attached so that I can't accidently key the rig and destroy the final PA transistors.

I built the enclosure and installed the transceiver into it without painting and final finishes so that I could take it and the battery you see with an antenna to a park a short distance from the lab. I was able to work 52 stations (52 Q's or contacts in contestor terms) and get 22 states on my way to working WAS with this rig alone.

Chapter 10

Summary and Notes



Band	C1	C2	C3	C4	C30	L1	L2	L3	L4	L7	L8	L9	T3	T4	T5	X1	X2.3.4.5.6
20M	220p	470p	470p	220p	----	T50-6::13	T50-6::13	T50-6::12	FT37-61::14	T37-2::31	FT37-61::20	FT37-61::20	T37-6::16:1	T37-6::1:16	T37-6::4:28	22.1184	8.064
30M	330p	680p	680p	330p	33p	T50-7::13	T50-7::13	T50-7::13	FT37-61::17	T37-2::28	FT37-61::15	FT37-61::15	T37-1::16:1	T37-1::1:16	T37-2::4:28	22.1184	12.00
40M	470p	1000p	1000p	470p	100p	T50-2::15	T50-2::15	T50-2::15	FT37-61::20	T37-2::30	FT37-61::10	FT37-61::10	FT37-67::14:1	FT37-67::1:14	T37-2::4:31	23.04	16.00

Figure 168: Schematic of 5W Transceiver.

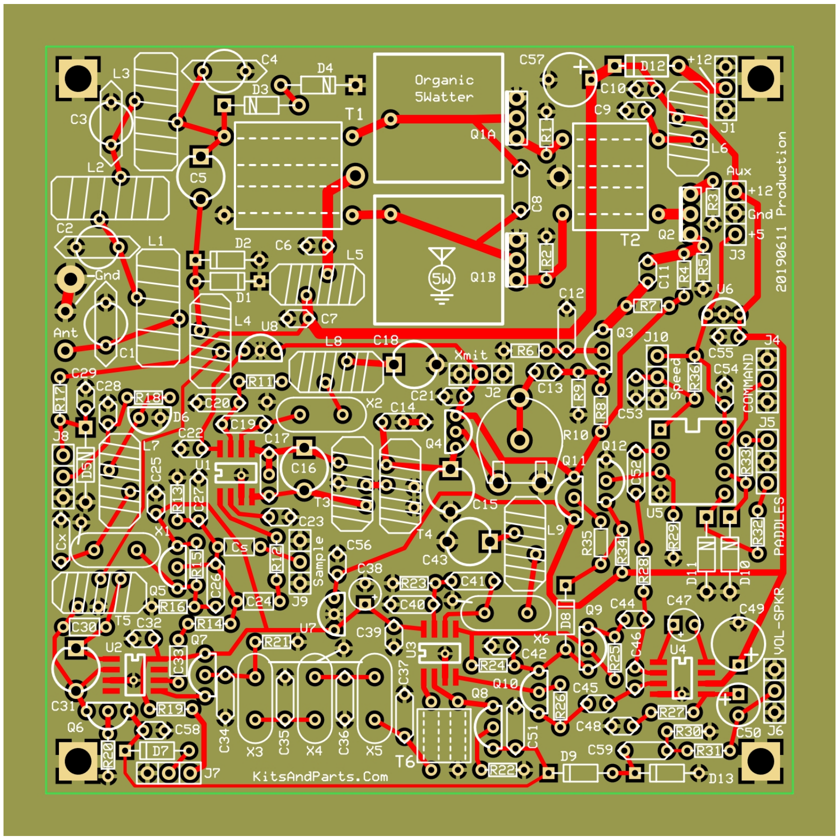


Figure 169: PCB Used in this guide.

This is the PCB that I used for the build in this manual. It is the prototype that Diz and I used to build. His for 40m and mine for 20m. The above is from my use of Sprint Layout 6.1 software and for the generation of Gerber files to get 10 boards made at JLCPCB to hurry build to give Diz more information before ordering production boards, even though the board shows a production date.

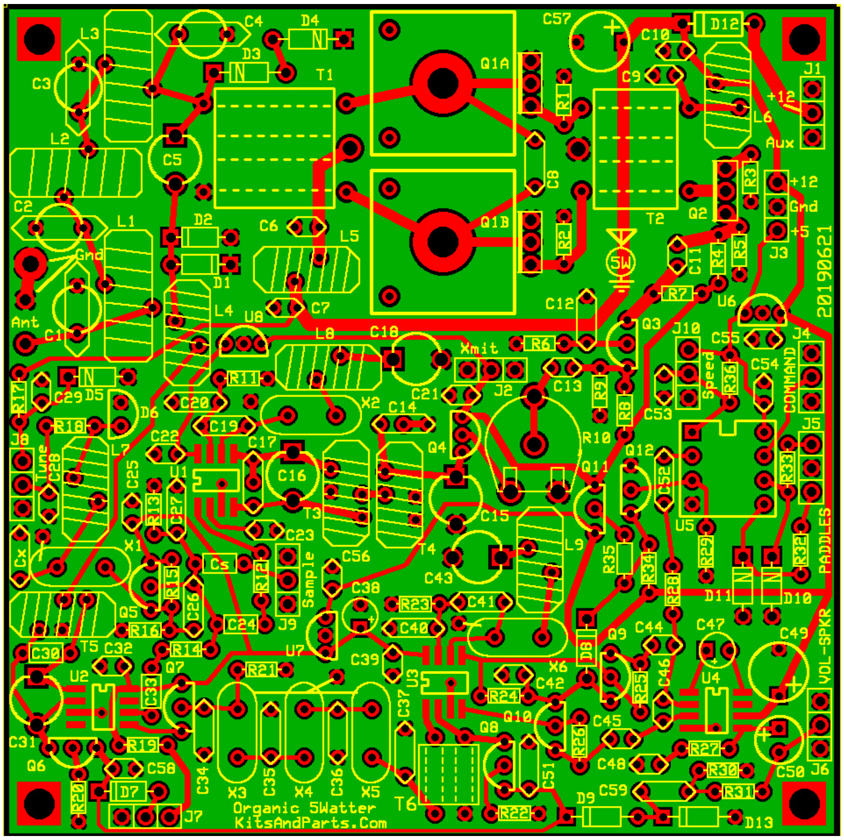


Figure 170: 5W Production PCB.

This is the board that you will be using for your build. Only differences are the placement of J1 for the power supply connection and allowance for mounting some PA transistors flat against the board if there is any chance to the part being used.

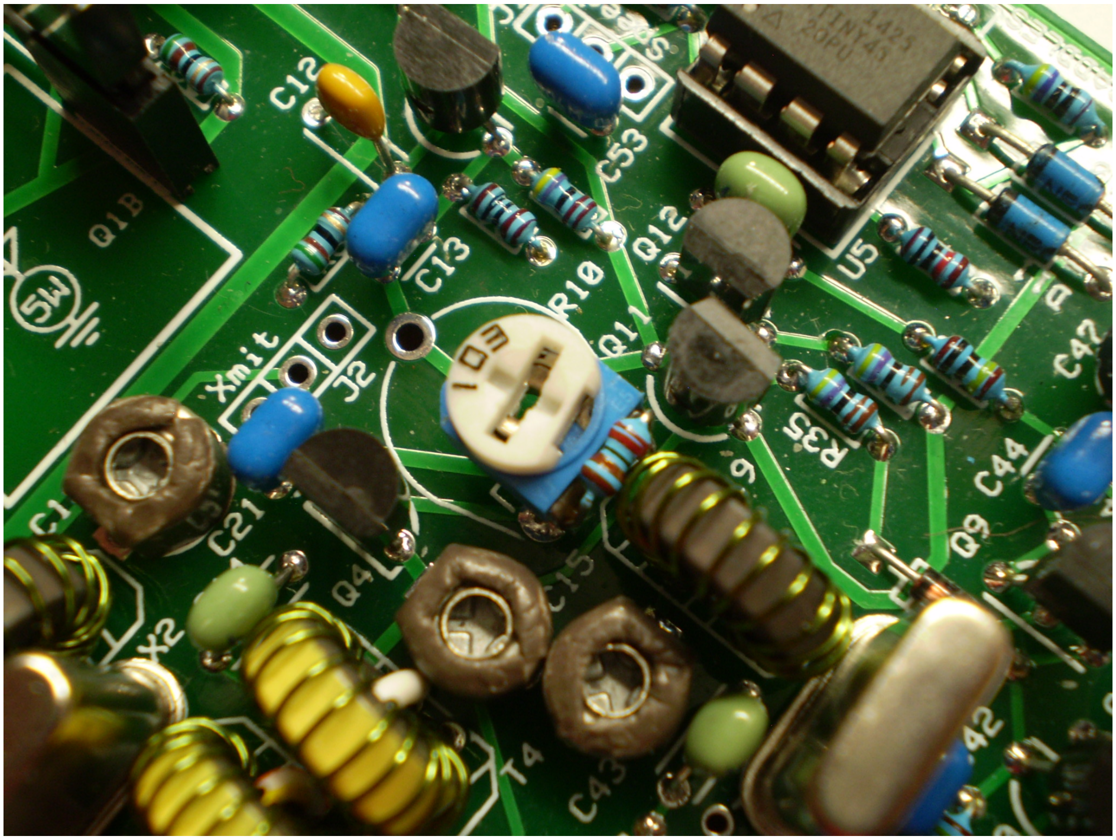


Figure 171: R10.

This is my replacement for the 2K drive level pot as I only had a 500 ohm like that used in the 1W. This is a 10K 6mm variable resistor with a resistor in parallel to get close to the 2K value in the kit.

Figure 172: Painted Enclosure.

Here I have the K7QO patented (joke) aluminium enclosure outside with the paint curing in the AZ sunlight. Used Rustoleum paint and the red is a beautiful candy apple red. Just one coat as I wasn't going to spend a week in getting a showroom quality paint job.

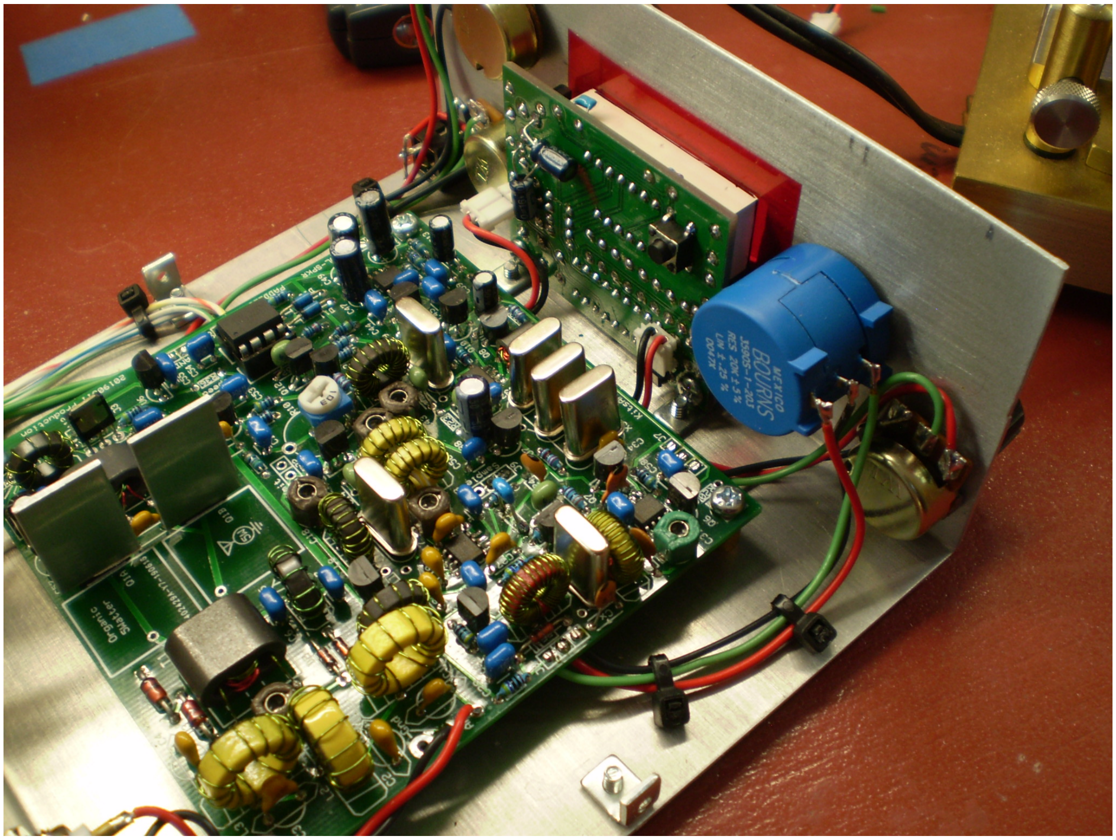


Figure 173: 5W in the enclosure.

Several notes. I used a 10T pot for tuning as I wanted fine resolution over a 1T pot. I am using aluminum sheared plate material for a heat sink epoxied to the final PA transistors. I'm only running 3W until I get some heat sinks ordered off of ebay.

Figure 174: 5W Front View.

I could do some decals for labeling, but I may never get around to it as I plan on using the transceiver on the desk as shown to try for DXCC on 20m as the band gets better with the new sunspot cycle. I've been licensed continuously since 1957 and have never tried chasing DX, but I will try now. Not a full time persuit, but will plan on a few DX contests per year and I do have a two element 20m beam to put up and try.

I'll put the current state of both WAS and DXCC on my web page to allow you to follow my progress, if you even care. BTW. Diz gave this rig S/N 001 as his is S/N 000.