

## *Hendricks QRP Kits*



## *Ft Tuthill 160m*

3.5 to 5w DC CW Transceiver for 160m  
Part 1 of 2

by Dan Tayloe, N7VE

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## Specifications

As measured from current prototypes, some variance in performance is expected from unit to unit.

### *Receiver*

**Tuning range:** 1.800 to 1.880+ kHz in two tuning ranges (high/low)

**Current Drain:** Approximately 29 ma @ 12v without optional Digital Dial.

**Supply voltage range:** 12 to 13.8v

**Receiver bandwidth:** ~600 to 700 Hz bandwidth.

**MDS receiver sensitivity:** -116 dBm in a 700 Hz bandwidth

**Third order distortion (IP3):** +25 dBm

**Blocking Dynamic Range (BDR):** ~100 db (limited by the cw filter response)

**RIT tuning range:** Roughly + 2.5/-6.5 kHz from the transmit “spot” frequency

**Receiver Type:** Direct conversion receiver: Both sidebands (USB/LSB) are heard at the same time

### *Transmitter*

#### **Power Output**

~3.5-4w at 12v, ~5w at 13.8v

**Note:** *TX designed for CW type transmit duty cycle. Prolonged key down operation is not advised.*

#### **TX harmonic output**

- At full transmit power, harmonic suppression readily exceeds FCC specifications

## Building the Kit

### *Things you will need*

- Solder sucker (highly recommended) or solder wick
- Temperature control soldering iron with a fine tip
- 8 pin socket for the microcontroller (12F508 - optional)
- Magnifying headpiece and/or magnifying glass. 3.5 power reading glasses may work also. Try them on and check for focus at a 6 to 8" operating distance.
- Cookie sheet (highly recommended for building on top of in order to catch stray parts and most importantly to reduce **static discharge damage** to parts.

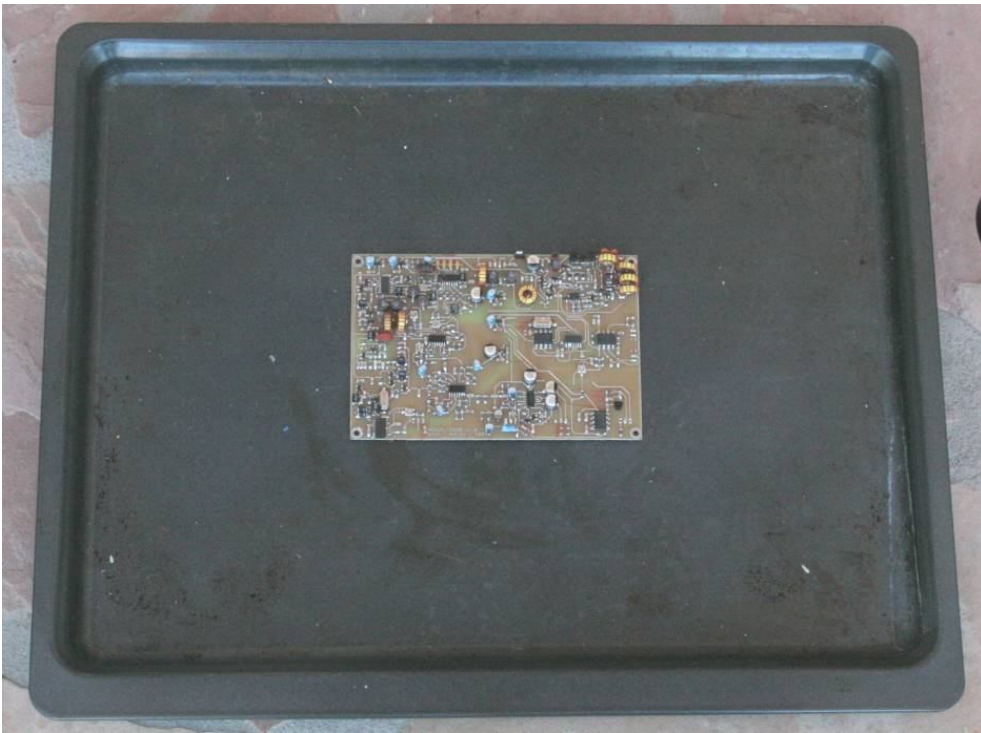


Figure 1. Working over an oversized cookie sheet is highly recommended



**Figure 2. A temperature controlled soldering helps a lot. 750 degrees is recommended for non-lead tinned boards**



**Figure 3. A very pointed soldering iron tip is a big help for small components**





**Figure 4. Headband Magnifiers. “Mag-eyes” from JoAnn Fabrics**

As far as magnification, I think that common reading glasses may be just as good. Try 3.5 or 3.25 magnification glasses. Try them on and check the focus distance. Ideal is a focus distance of about 8 inches.

I use the above Mag-eyes with my normal 1.5x reading glasses. I can gang both the reading glasses and the Mag-eyes together to get a really good, close up look at the parts. However, it does drive my eyes a bits nuts switching from no glasses to glasses, to Mag-eyes, to glasses plus Mag-eyes.

### ***Parts List***

The bare board comes with one pre-mounted surface mounted parts D9, a 1SV304 varactor diode.

Below is a list of the all parts that are included in the kit:

Figure 5. Inventory of parts included in the kit

Capacitor list		
Quantity	Value	Devices
42	0.1 uF	C8, C11, C15, C18, C21, C22, C23, C26, C27, C28, C29, C30, C32, C33, C35, C36, C37, C53, C55, C58, C62, C76, C86, C92, C1, C9, C38, C44, C47, C63, C64, C65, C66, C67, C68, C69, C71, C75, C77, C78, C81, C95
1	100 pF NPO Disk	C74
7	150 pF NPO Disk	C40, C43, C45, C46, C48, C51, C84
6	180 pF NPO Disk	C42, C49, C52, C72 + two for high/low range switch
6	270 pF NPO Disk	C14, C34, C73, C80, C87, C90
1	820 pF Disk	C61
9	2200 pF	C10, C12, C13, C54, C56, C57, C59, C60, C85
4	33 pF NPO Disk	C41, C50, C70, C93
5	2.2 uF	C5, C7, C24, C25, C31
8	33 uF	C2, C4, C6, C16, C17, C19, C20, C39
1	220 uF	C3
1	40 pF trim cap	C82
1	1000 pF Polystyrene	C79
1	Main tuning Polyvaricon	Main Tune
4	Not used	C83, C88, C89, C91

Diode list		
Quantity	Value	Devices
2	1SV304 Varactor (pre-mounted on PCB board)	D9, D10
1	1N4004	D1
7	1N4148	D2, D3, D4, D5, D6, D8, D12
1	1N5262B 51v zener	D7
1	3mm Blue LED	D11

Integrated Circuits list		
Quantity	Value	Devices
1	CA3086	IC1
1	78L05	IC2
2	NE5532N	IC3, IC4
1	PIC12F508	IC5
1	74HC4053	IC6

Transistor list		
Quantity	Value	Devices
1	2N3904	Q1
6	BS170	Q2, Q3, Q4, Q5, Q6, Q7
1	2N5485	Q10



Resistor list		
Quantity	Value	Devices
1	Zero ohm shorting loop	R64
9	47	R3, R4, R5, R36, R43, R44, R48, R49, R50
9	100K	R6, R8, R10, R12, R34, R40, R41, R57, R58
16	1K	R2, R7, R18, R19, R20, R22, R25, R27, R29, R31, R38, R53, R54, R55, R59, R60
4	4.7K	R26, R30, R37, R62
3	2.7K	R21, R23, R24
14	22K	R9, R13, R14, R16, R17, R32, R33, R35, R42, R45, R51, R52, R56, R63
6	3.3K	R1, R15, R28, R39, R47, R61
1	10K 6mm trim pot	R46
1	10K audio panel mount w/ switch	R11
1	10K linear panel mount	RIT

Inductor list		
Quantity	Value	Devices
5	22 uH	L1, L2, L3, L8, L10
3	T37-2	L4, L5, L6
1	T50-2	L7
1	FT37-43	T1

Misc hardware list		
Quantity	Value	Devices
1	SPST_SWITCH - Spot	
1	SPST – hi/low range switch	
1	1/8th stereo jack - Headphones	
1	1/8th mono jack - Key	
1	BNC antenna jack	
1	Power Jack	
2	Polyvaricon mounting screw	
1	Polyvaricon 1/4" nylon shaft	
1	Polyvaricon shaft screw	
1	Decal Sheet	
1	6 foot red # 28 gauge wire	
1	18" green # 28 gauge wire	
1	18" gold # 28 gauge wire	
1	9 foot red # 32 gauge wire	
1	2" hook up wire	
1	PC board	

Case hardware list		
Quantity	Value	Devices
1	CHASSIS – Top and bottom shell	
2	4-40 x .25 FLAT HEAD SCREW	
1	BAIL KIT W/ SCREWS	
8	4-40 x .25 PAN HEAD SCREW	
1	LARGE NORCAL KNOB	
2	SM. NORCAL KNOB	
4	RUBBER FEET, 1/4" THICK	
1	RED ACETATE	

## ***Tools and Construction Hints***

In building this transceiver as well as others, I have had some problems. These fall into several different categories:

- 1) ICs mounted backwards
- 2) Resistors and capacitors not soldered to the right set of pads
- 3) Diodes installed backwards
- 4) Not all parts were installed
- 5) Leads not totally stripped on the toroid cores

Please learn from my mistakes. Each time an IC is mounted, check the mounting polarity twice before soldering it in. I suggest checking the IC polarity, soldering down one corner pin, and then checking it one more time before finishing the job. I think the old saying is “measure twice, cut once.”

I have once been bit by not mounting all the parts. Double check the pictures against your kit to make sure things end up in the right place.

You may find that the components in the pictures may be slightly different from what is in your kit. Parts can change from order to order. These parts match what is included in the first 100 kits.

This manual has been set up to build a section, and then test it. The tests are normally quite simple. This should find most problems as we go from stage to stage rather than getting to the end and not knowing where to start.

I found building the transceiver over a large cookie sheet eliminated the problem of dropping parts and losing them. However, when doing the applied voltage tests, you should place a few sheets of clean paper under the boards to keep them from shorting out against the cookie sheet.

***Some parts are static sensitive!*** Please take the suggestion to build over a conductive surface like a large cookie sheet and always touch the cookie sheet before touching any part after leaving and returning to work.

This radio can be built in about six hours. One good Saturday should do it.

# Bare PC Board Pictures

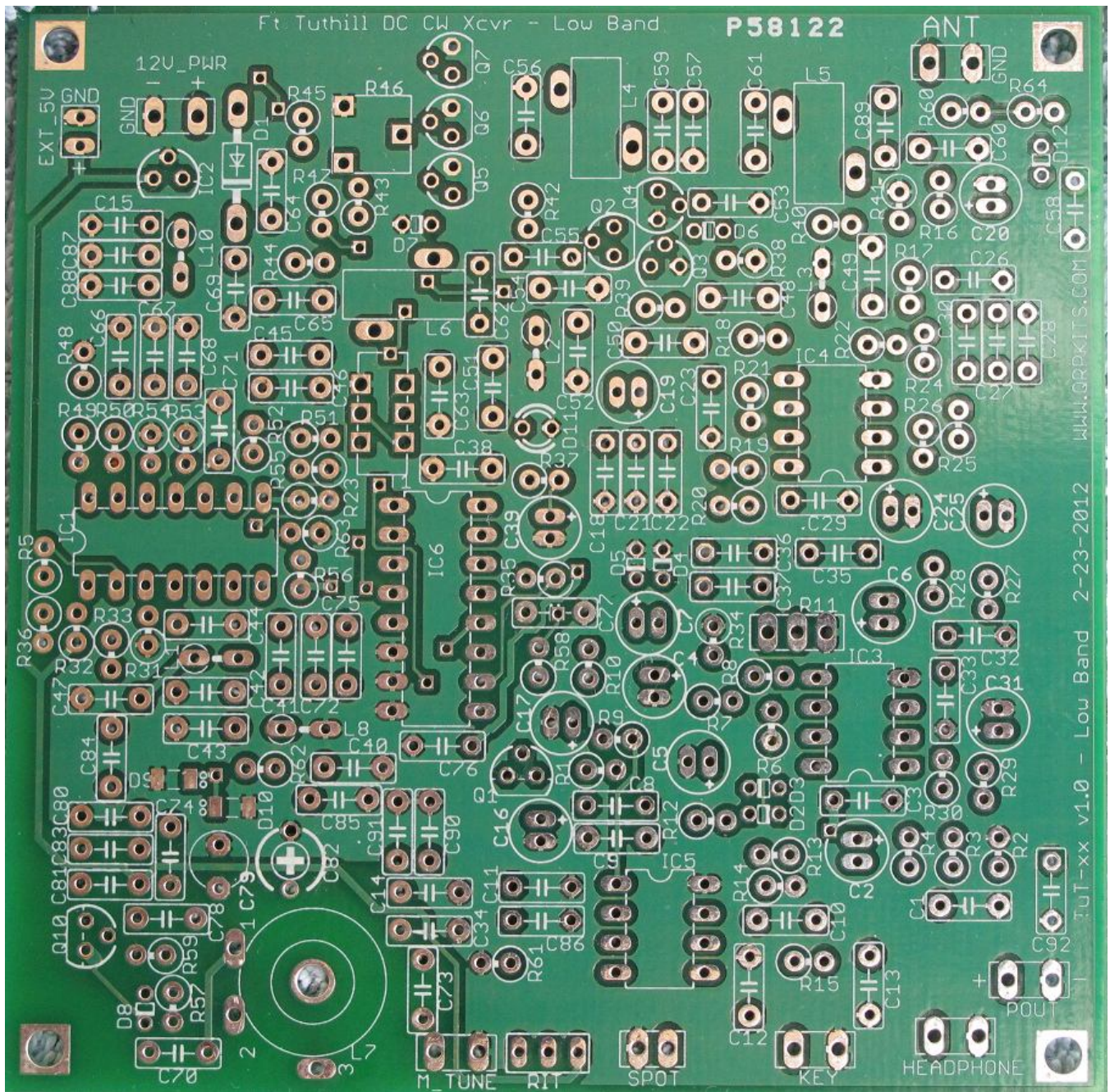


Figure 6. Top side view of the Ft Tuthill 160 board



## Installation of Miscellaneous Diodes

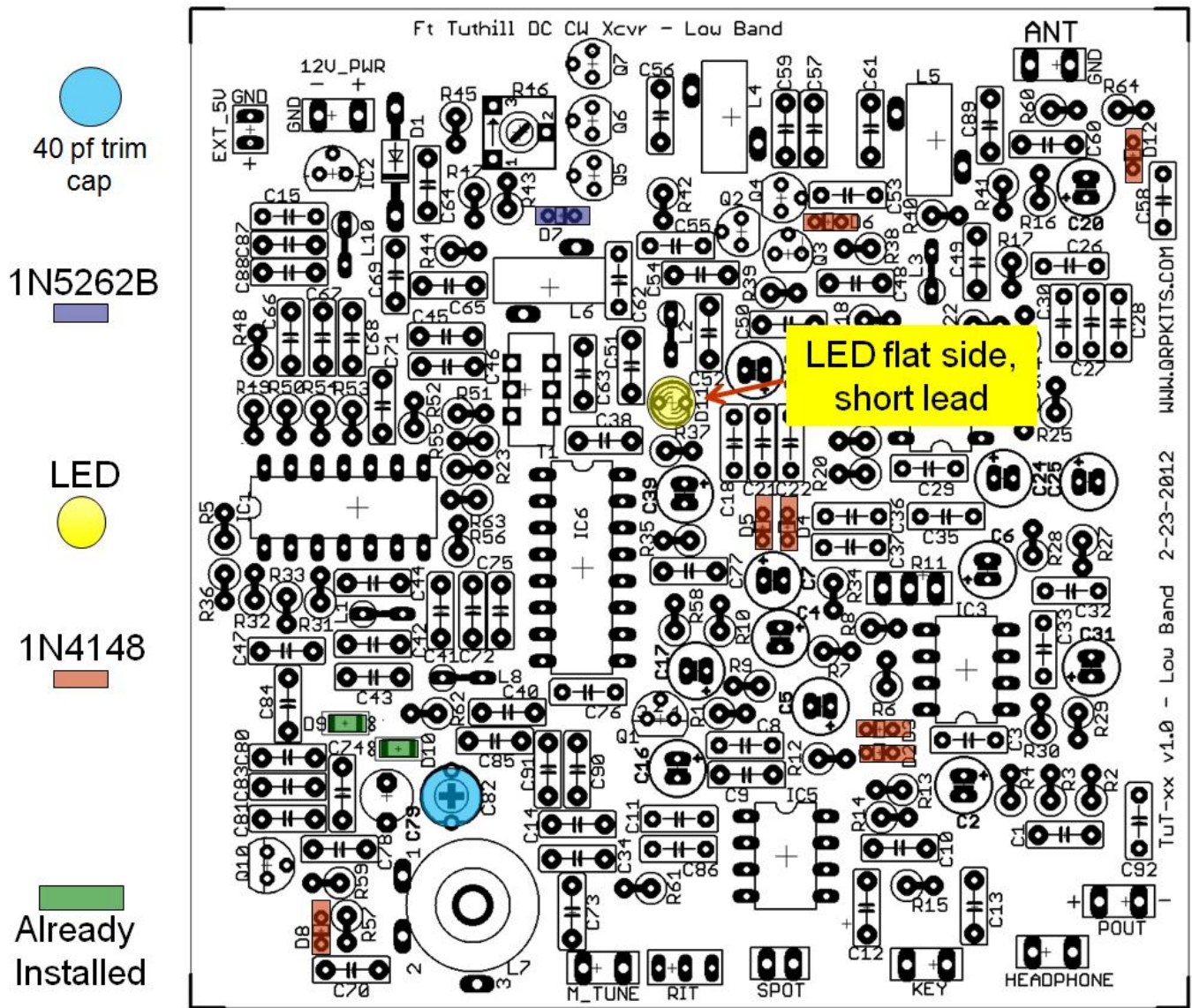


Figure 7. Parts location of misc diodes

Install the following parts in the following order:



Figure 8. LED. Flat LED side matches the **short** lead side.

Install □ D11 (LED). **Looking closely, one side of the LED has a flat spot. The LED needs to be installed with the flat side oriented as shown above. TIP: The short lead on the LED is the side with**

*the “flat” spot.* Make sure the LED is inserted as far as it will go into the board as we do not want excess lead length.



Figure 9. D7, 1N5262B 51v Zener diode

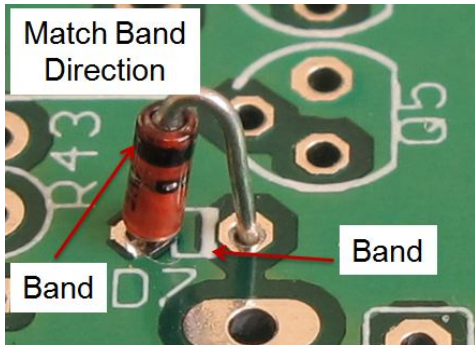


Figure 10. D7 details. Mount diode vertically with the white band on the board matching the band on the diode

Install □ D7 1N5262B 51v zener. See details above. This diode is mounted vertically (on end) with the banded end in the air. Make sure the banded end connects to the hole as shown on the D7 board markings. *There is only one part like this.* This diode and the 1N4148s are difficult to tell apart as they are both small glass diodes with tiny markings. However the 1N4148s will all be mounted together in a strip, while the 1N5262B zener will be all by itself. ***Double check the polarity of the diode against the photos below.***



Figure 11. Picture of 1N4148 small signal diodes

Install □ D8, □ D2, □ D3, □ D4, □ D5, □ D6, □ D12 1N4148 small signal diodes. Like the above zener, these diodes are mounted vertically (on end) with the banded end in the air. Make sure the banded end connects to the hole as shown on the board markings. ***Double check the polarity of the diodes.***

D9 and D10 come pre-mounted on the PCB.



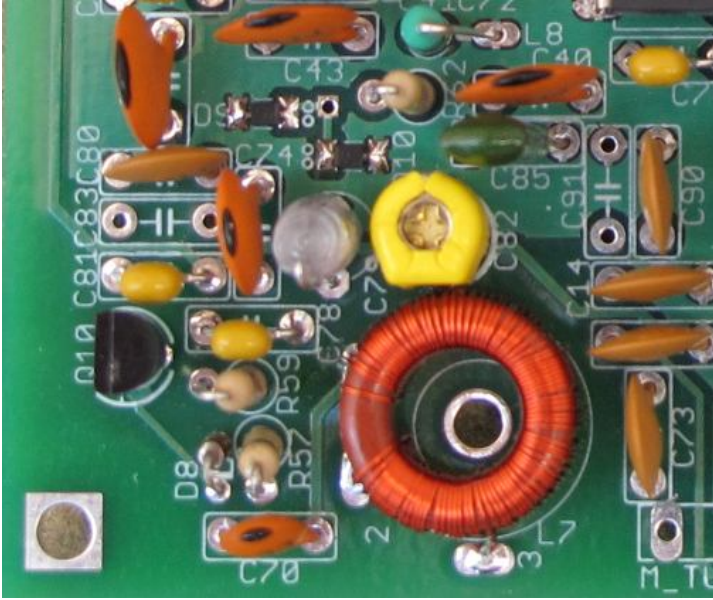


Figure 12. Trimmer capacitor C82 shown mounted flat side towards VFO coil L7

Install trimmer capacitor □ C82 – ***Mount flat side towards the VFO coil L7 as shown above!***  
Note: This step is being moved up to this section because the mounting holes seem small for some styles of trim caps. ***If the holes are too small for the trimmer capacitor leads, solder the leads to the top side of the holes.*** At this early stage in the assembly, there will be plenty of room to do this. The board pictures at the end of the section will not show C82 mounted, but it is indeed mounted at this time.

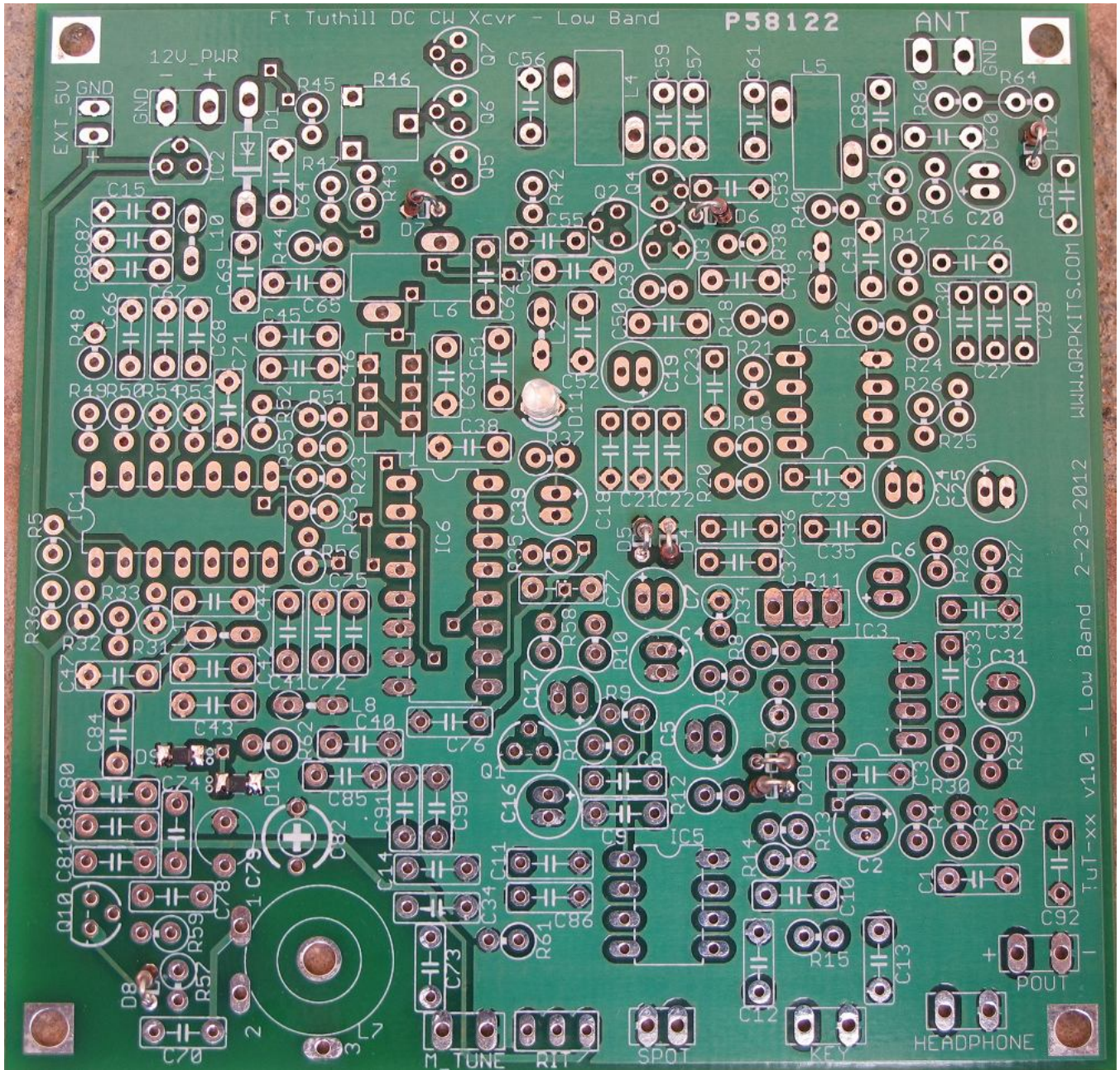


Figure 13. Parts mounted so far



## Installation of the Capacitors

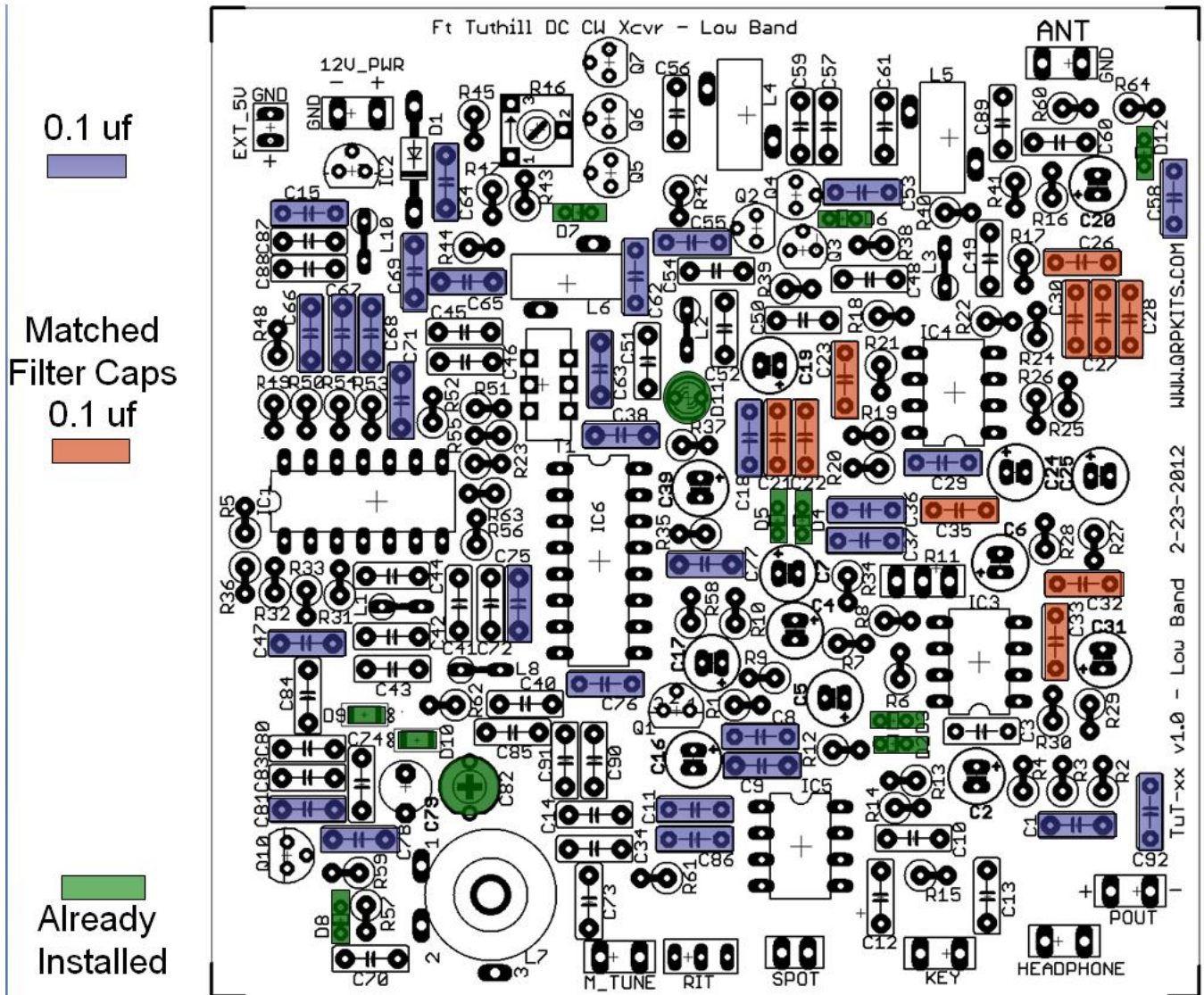


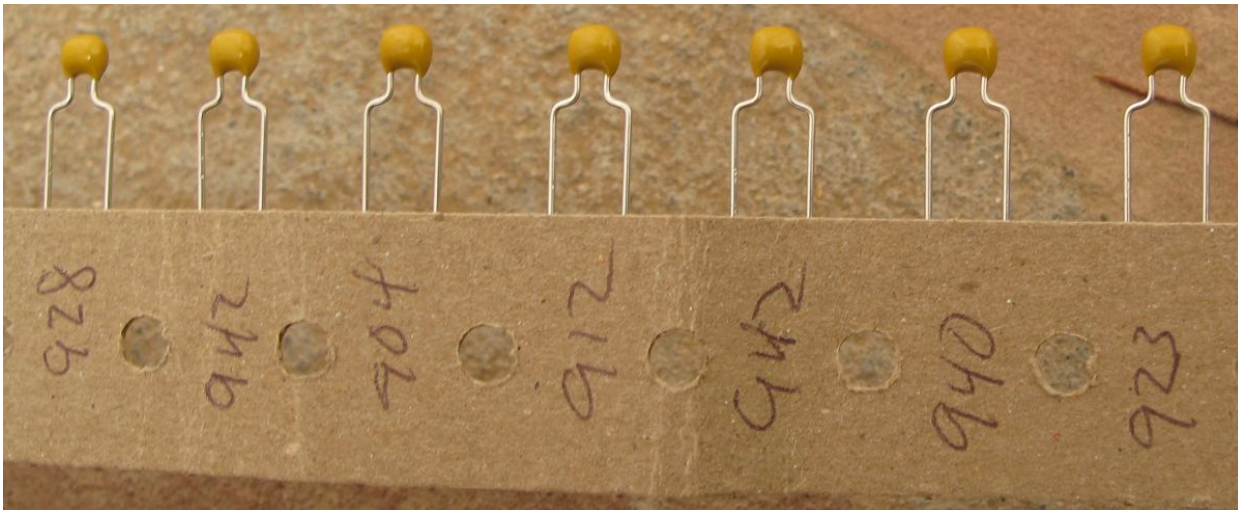
Figure 14. Installation location of the 0.1 uF caps



Figure 15. Picture of 0.1 uf Cap marked "104"

The kit will work best if the 0.1 uF capacitors of the filter section are matched. This kit has a total of 40 0.1 uF capacitors, and 10 of them are in the filter section. These are marked "104". It is strongly recommended that all 40 capacitors are measured and the closest 10 caps in value are used as the filter capacitor parts.

The matching process involves getting a blank piece of paper, measuring each 0.1 uF capacitor, placing the part on the paper next to the recorded value. I suggest recording digits as shown below. Here "942" was 0.0942 uF.



**Figure 16. Example of capacitor matching process**

Matching is not strictly necessary, but there is the outside chance that a filter section could go unstable and oscillate if 0.1 uF caps are used that happen to be far apart in value. Matching the 0.1 uF caps produces a very nice filter response with a relatively flat pass band. In the above example picture, I ended up using all 0.095x uf and 0.096x uf caps to get 10 caps matched to within under 2%.

As the parts are installed, it is recommended to both **check the box** below and **cross off the part on the picture** above. Install the following parts in the following order:

- Install 0.1 uf matched caps  C33,  C32,  C35,  C21,  C22,  C23,  C26,  C27,  C28,  C30
- Install 0.1 uf caps  C1,  C8,  C9,  C11,  C86,  C76,  C75,  C47,  C81,  C78,  C71,  C68,  C67,  C66,  C69,  C15,  C64,  C65,  C63,  C38,  C62,  C55,  C53,  C18,  C77,  C36,  C37,  C29,  C92,  C58

**Note: At the end of this step there will be three 0.1 uf caps that will be installed later (C95, C44, C3)**







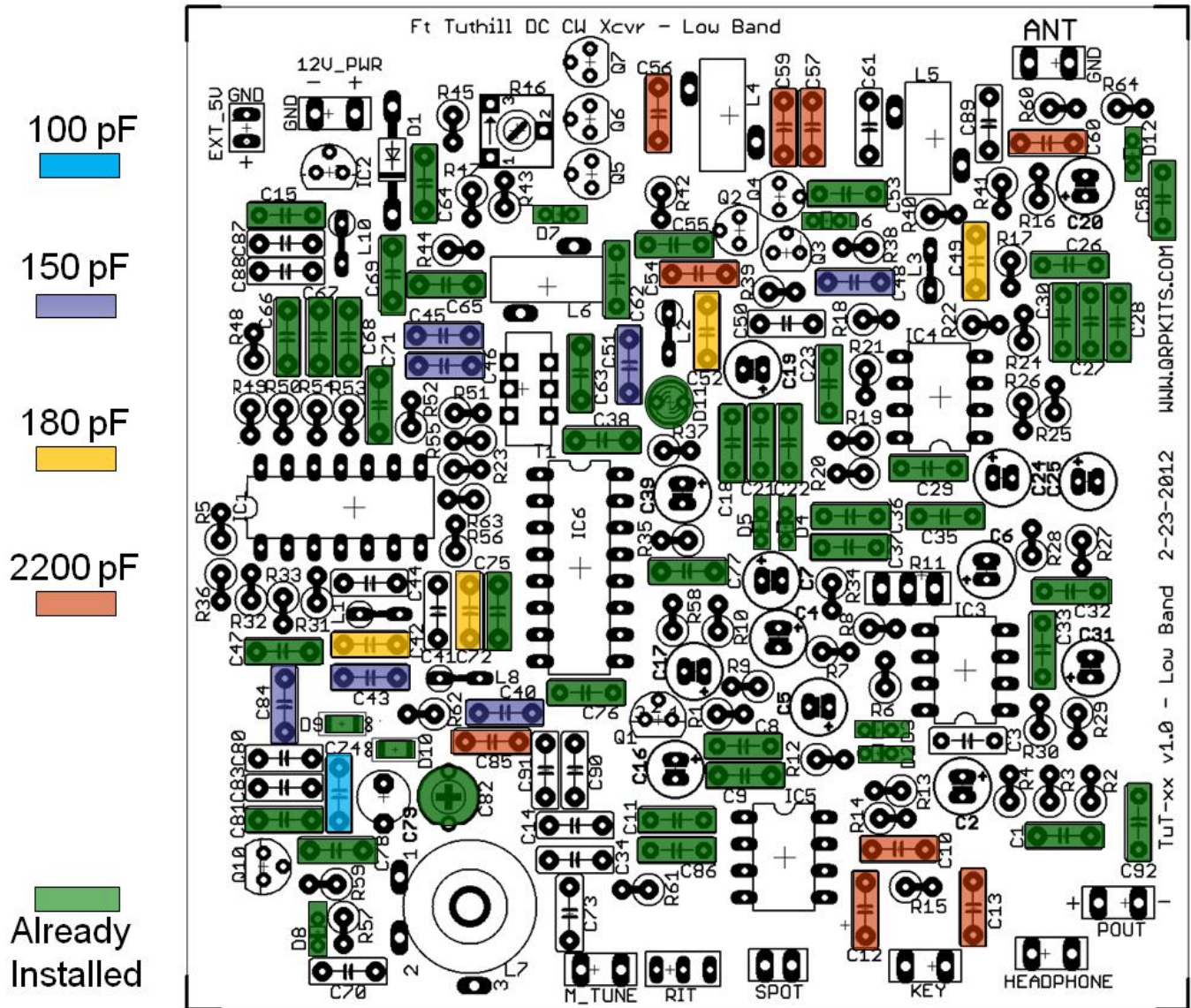


Figure 18. Location of 100pf, 150 pF, 180pf and 2200 pF capacitors



Figure 19. Identification of 100, 150, 180 and 2200 pF capacitors

As the parts are installed, it is recommended to both **check the box** below and **cross off the part on the picture** above. Install the following parts in the following order:

- Install 100 pF disc caps (marked “101”), □ C74



- Install 150 pF disc caps (marked "151") □ C40, □ C43, □ C45, □ C46, □ C48, □ C51, □ C84
- Install 180 pF disc caps (marked "181") □ C42, □ C49, □ C52, □ C72
- Install 2200 pF disc caps (marked "222")
  - Bottom right: □ C12, □ C10, □ C13
  - Bottom left: □ C85,
  - Top right: □ C54, □ C56, □ C57, □ C59, □ C60

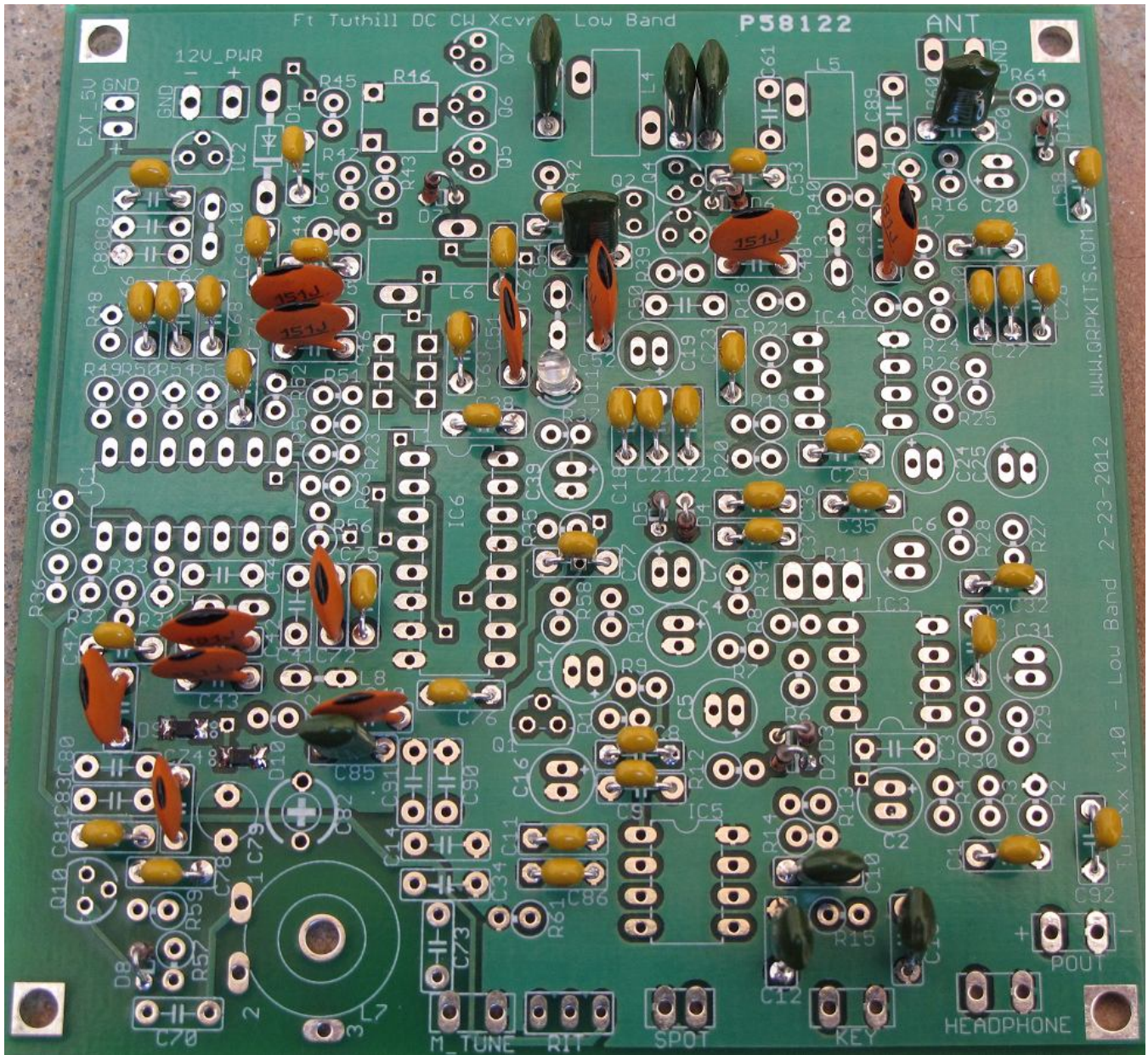


Figure 20. Board with 100, 150, 180 and 2200 pF caps



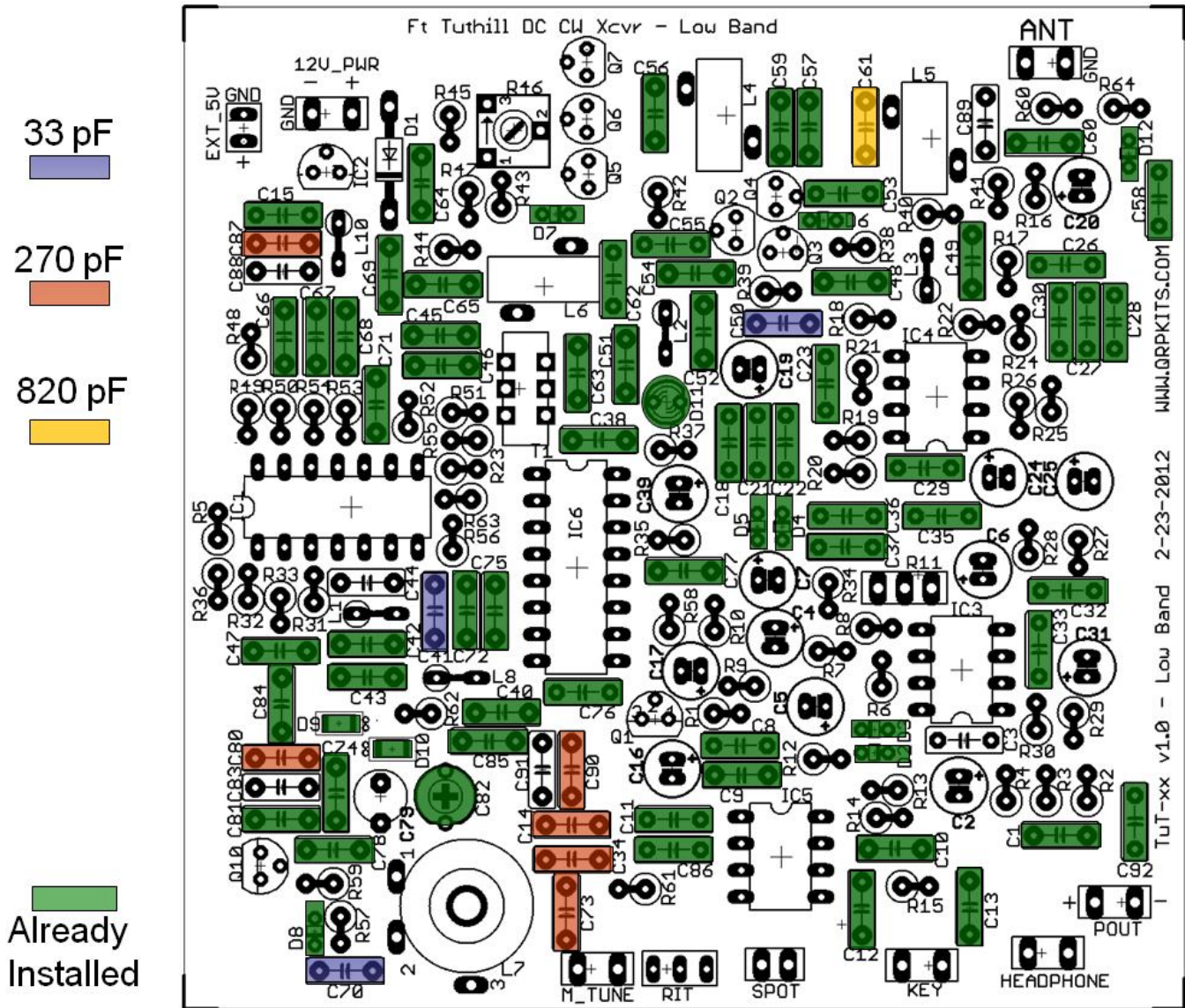


Figure 21. Location of 33 pF, 270p and 820 pF capacitors

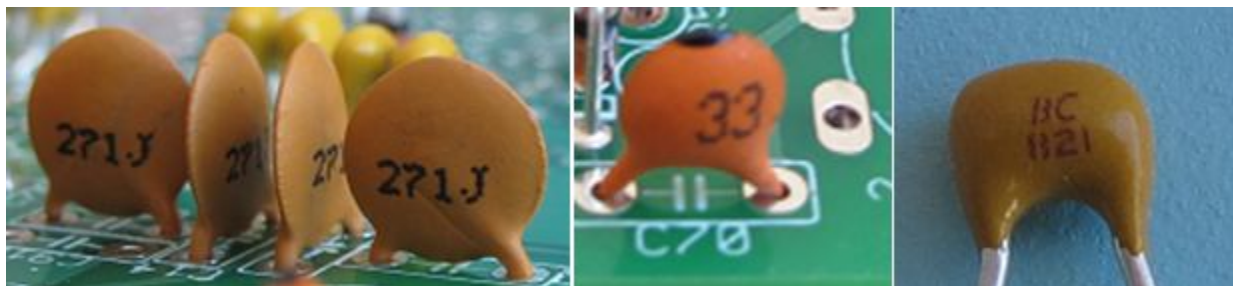


Figure 22. Identification of 33, 270 and 820 pF caps.

As the parts are installed, it is recommended to both **check the box** below and **cross off the part on the picture** above. Install the following parts in the following order:

Install 33 pF disc caps (marked “33”): □ C70, □ C41, □ C50 *C93 is not installed at this time*

Install 270 pF disc caps (marked “271”): □ C14, □ C34, □ C73, □ C80, □ C87, □ C90

Install 820 pF disc caps (marked “821”): □ C61

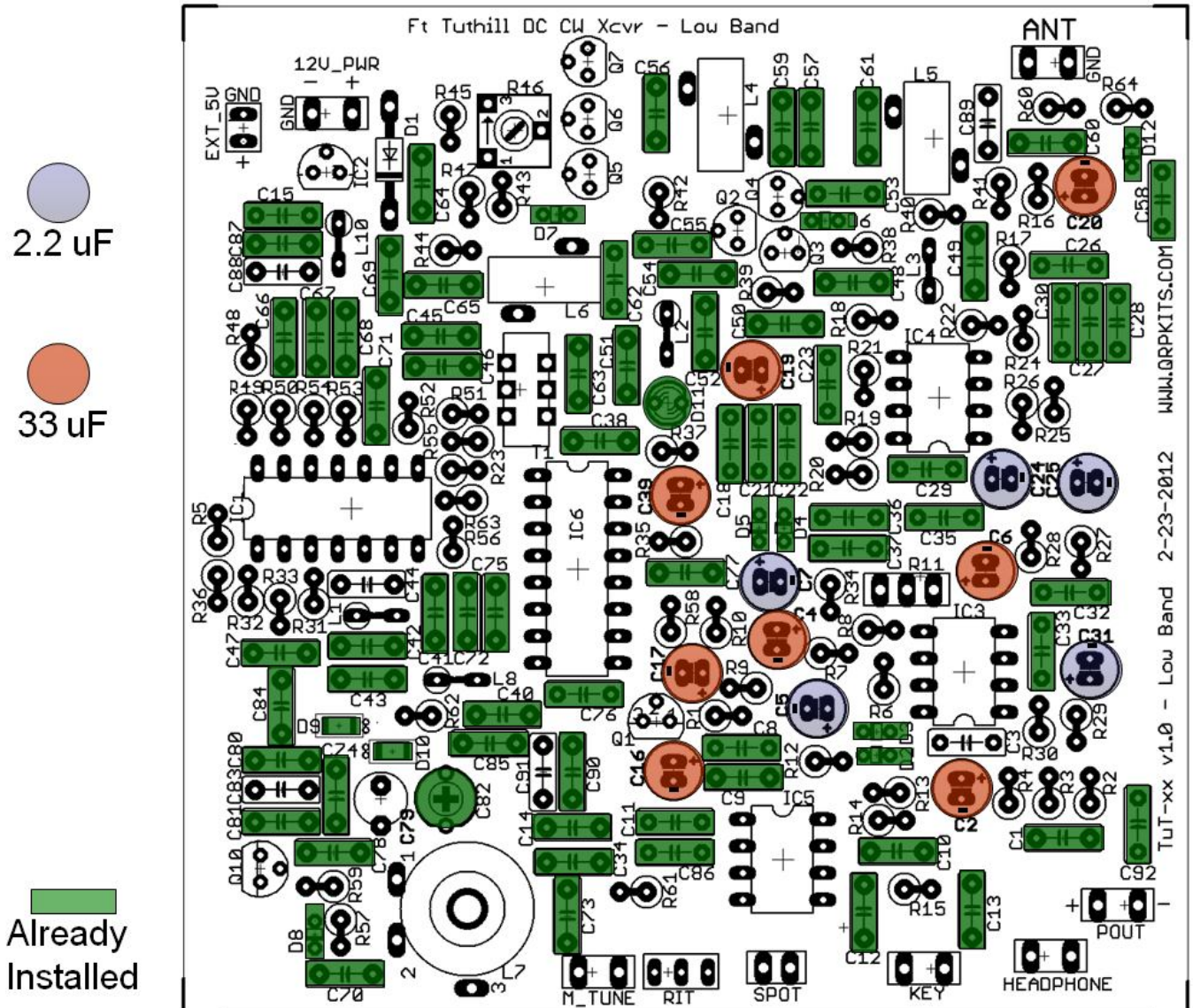


Figure 23. Location of 2.2 uF and 33 uF capacitors

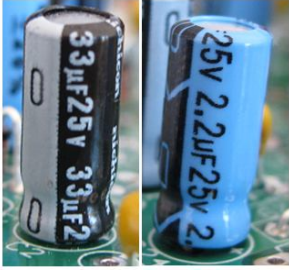


Figure 24. Identification of 33 uF and 2.2 uF caps.

The electrolytic caps are polarized. *The black stripe on the cap needs to line up with the “-“ in the figure above. TIP: long cap lead goes into the ”+“ pad on the board.* Install the following parts in the following order:

- Install 2.2 uF caps:  C31,  C25,  C24,  C7,  C5
- Install 33 uF caps: -  C20,  C19,  C39,  C17,  C4,  C16,  C2,  C6

Note: There is one left over 33 uf cap (C94) for later installation on the bottom side

Cap polarization can be double checked with the installed parts below:



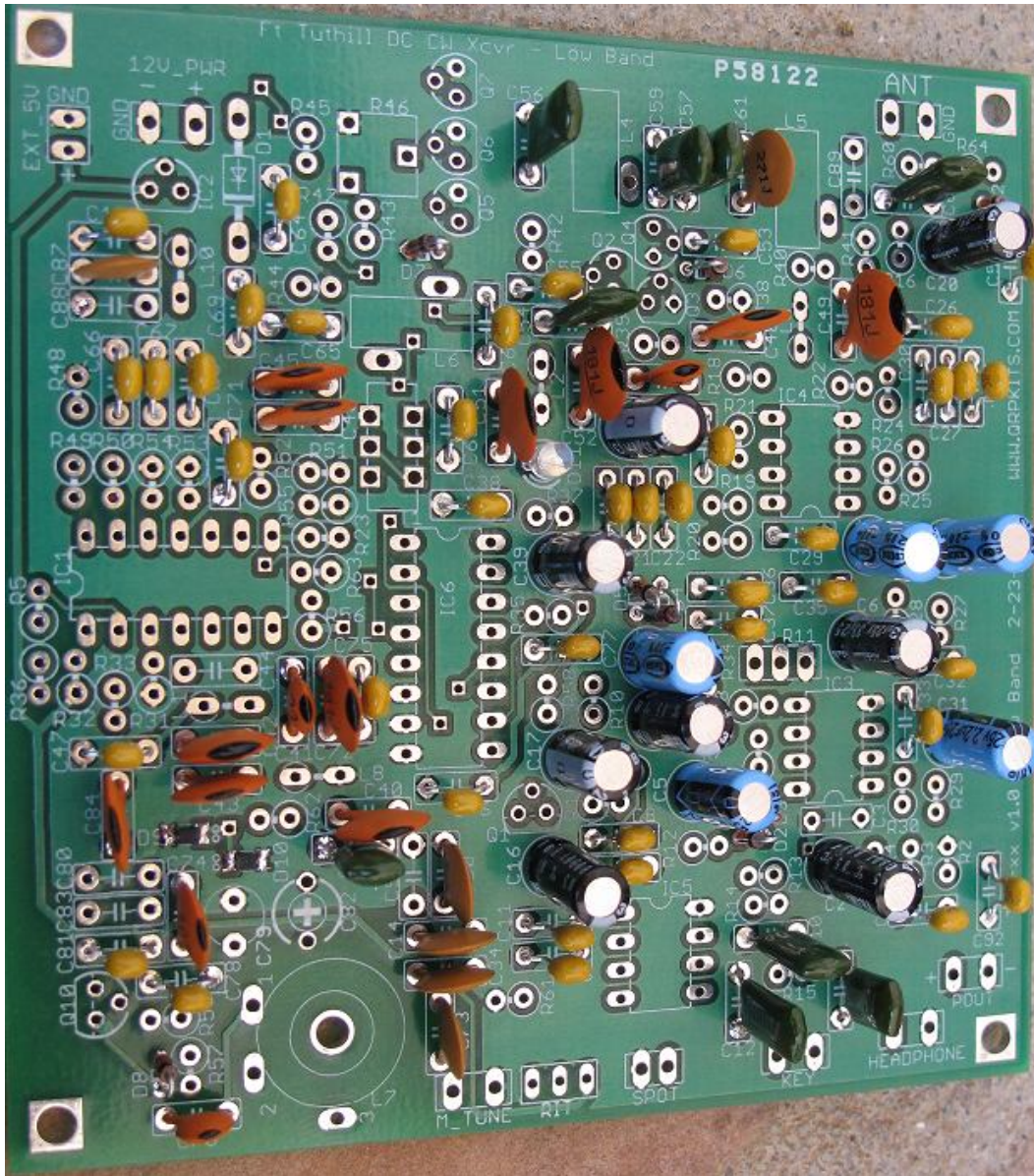


Figure 25. Board with 2.2 uF and 33 uF caps added





*All the prototype builders got at least one resistor in the wrong spot.* I suggest placing the resistor in the board, spreading the leads outward on the bottom to hold them into place, then double checking the parts placement a second time before soldering the resistors in place and trimming off their leads.

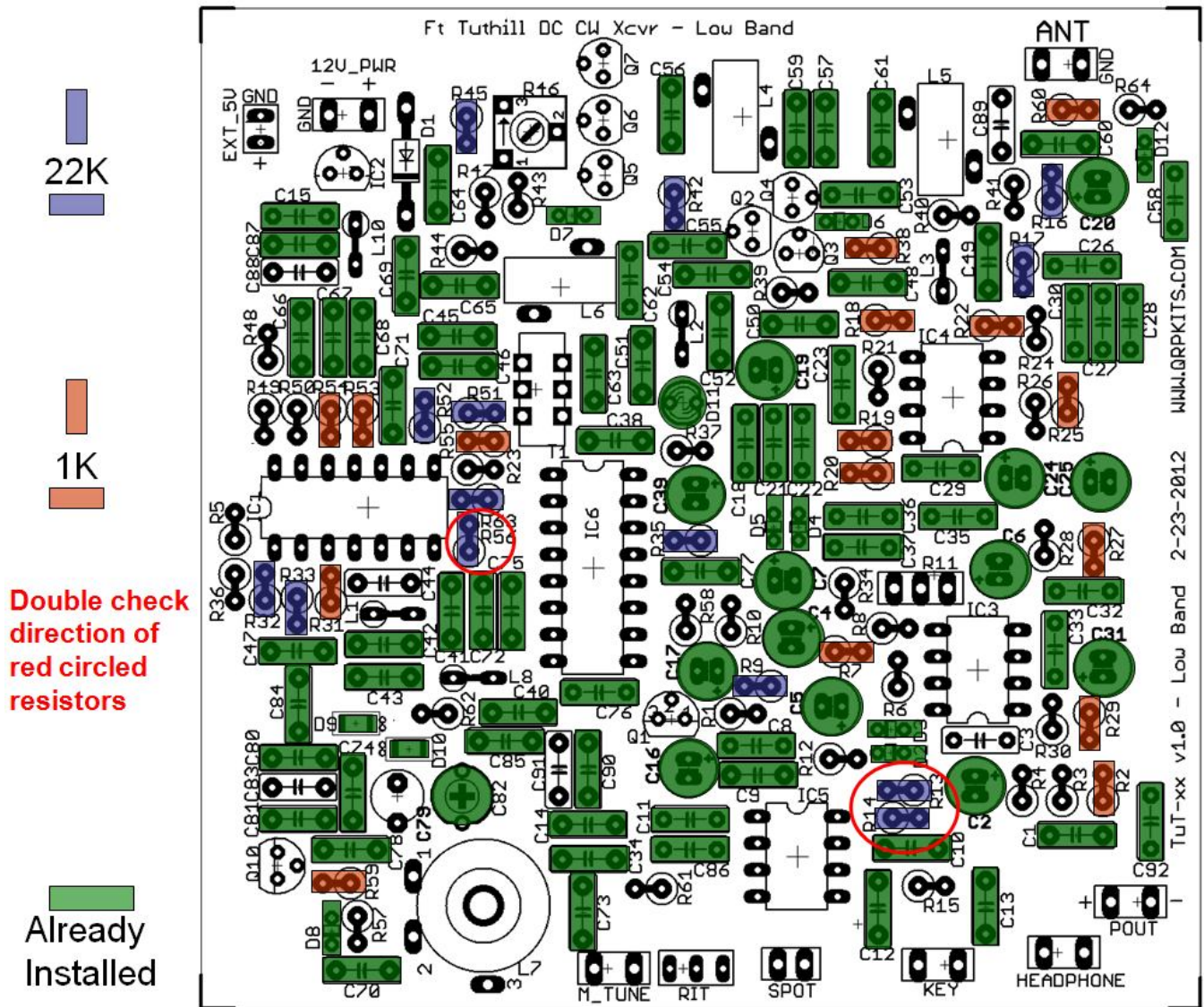
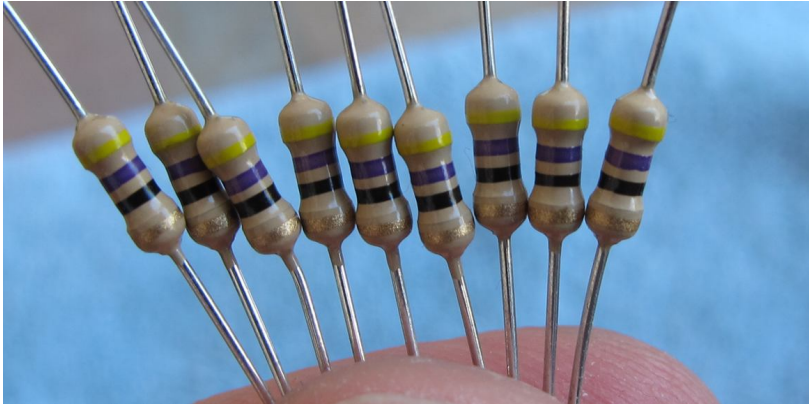


Figure 27. Installation locations of 1K and 22K resistors



**Figure 28. Perform visual inspection to make sure all resistors are the same value**

When installing resistors, it is very easy to mix up red-red-orange (22K) with orange-orange-red (3.3K). I recommend gathering all resistors of the same type, *line them up in your fingers* and inspect them to make sure they are all exactly the same and that they are the right colors. See above.



**Figure 29. Identification of 1K and 22K resistors**



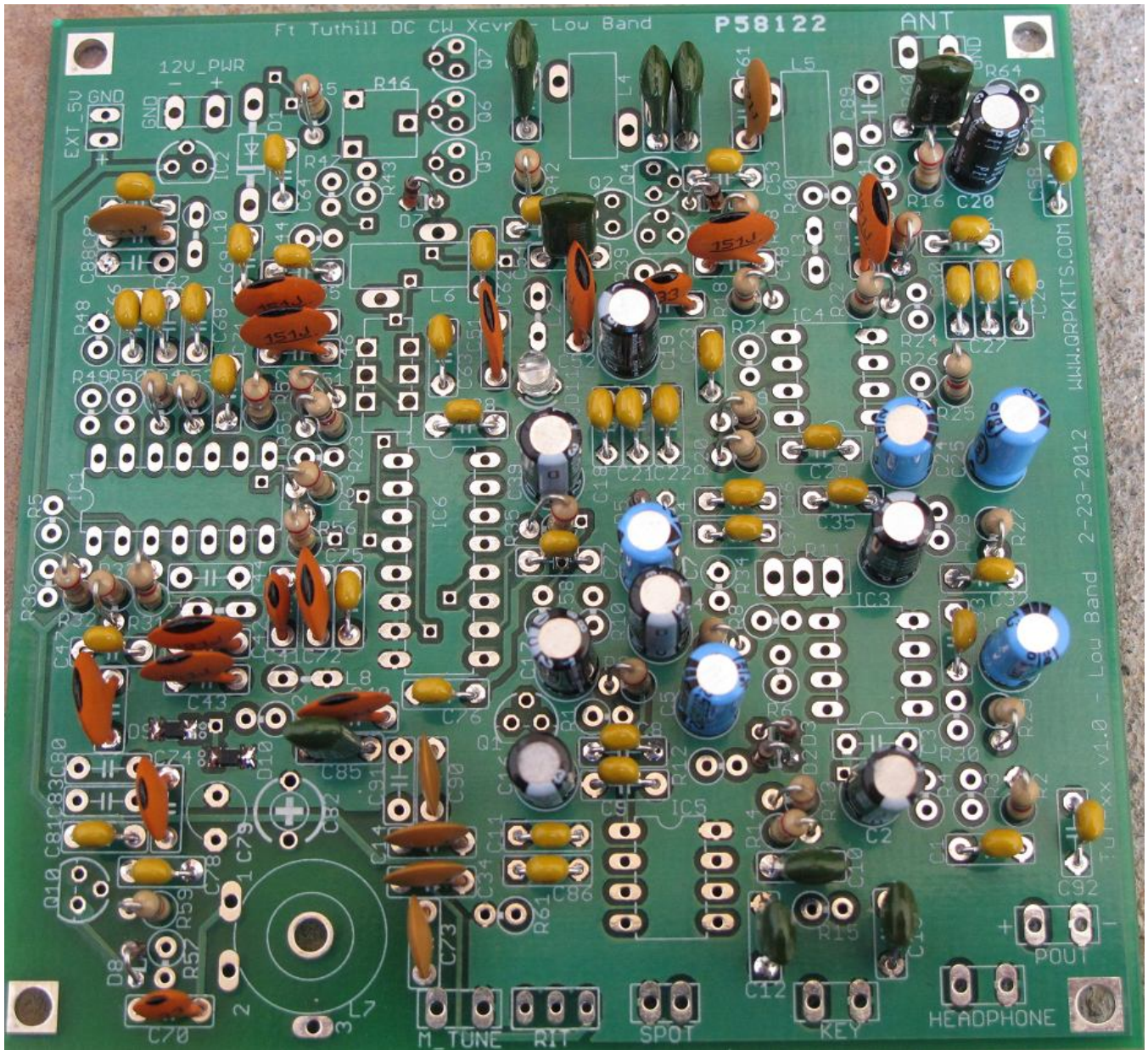
**Figure 30. Resistors are mounted vertically, body on the circle, close to the PCB**

As the parts are installed, it is recommended to both *check the box* below and *cross off the part on the picture* above. Install the following parts in the following order:

Install 1K resistors (marked brown – black – red). Starting from the bottom left:  R59,  R31,  R55,  R53,  R54,  R60,  R38,  R18,  R22,  R25,  R19,  R20,  R27,  R7,  R29,  R2

Install 22K resistors (marked red – red – orange). Starting from the bottom middle:  R32,  R33, *Make sure R56 is N-S not E-W*  R56,  R63,  R51,  R52,  R45,  R42,  R16,  R17,  R35,  R9, *Make sure R13, R14 are E-W, not N-W*  R13,  R14





**Figure 31. Board with 1K and 22K resistors installed**

Note: R62 (22K) should also be installed, but is not shown in the above photo.



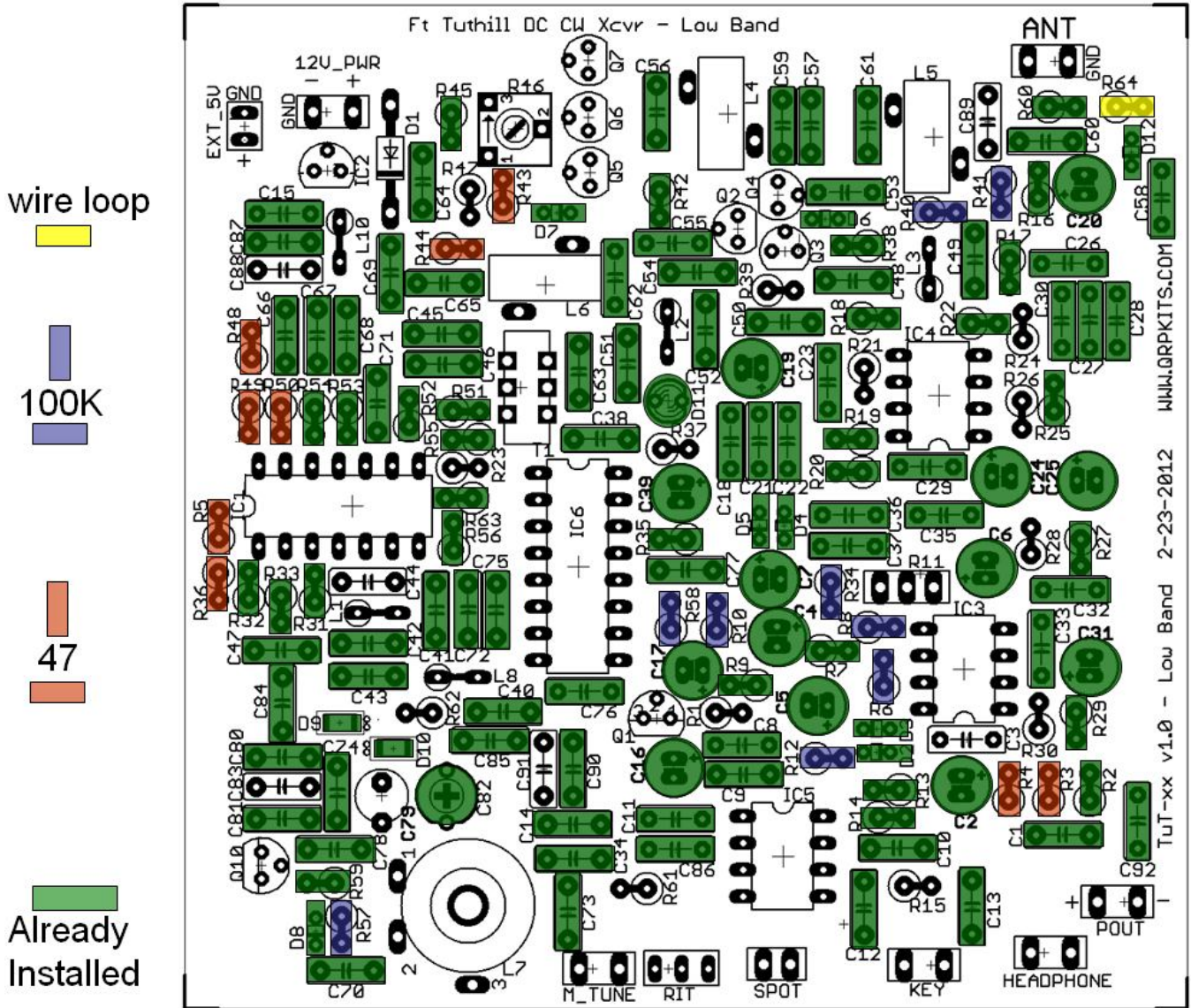


Figure 32. Installation locations of wire short, 47, and 100K ohm resistors

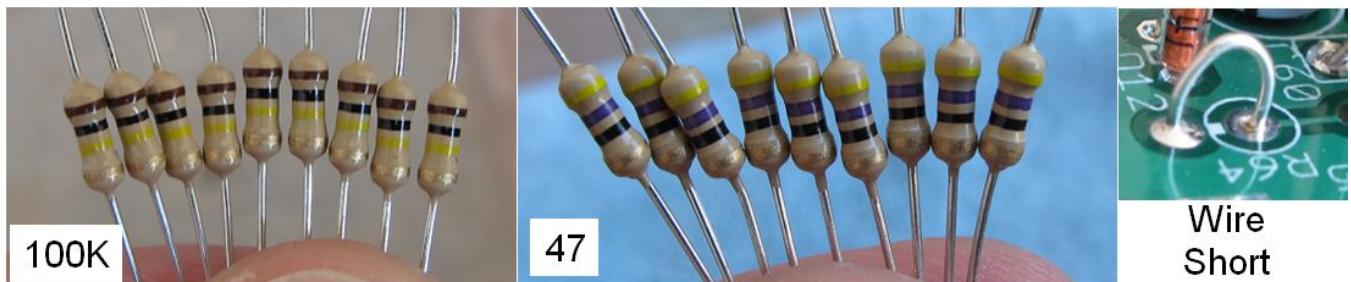


Figure 33. Hold all 100K and 47 ohm resistors together and double check they are all correctly identified

As the parts are installed, it is recommended to both **check the box** below and **cross off the part on the picture** above. Install the following parts in the following order:



Install 100K resistors (marked brown – black – yellow). Starting from the bottom left: □ R57, □ R58 □ R10, □ R34, □ R8, □ R6, □ R12, □ R40, □ R41

Install 47 ohm resistors (marked yellow – violet – black). Starting from the bottom right: □ R4, □ R3, □ R36, □ R5, □ R49, □ R50, □ R48, □ R44, □ R43

Install wire loop. This is simply a lead scrap that is bent in a U and used as a short: □ R64

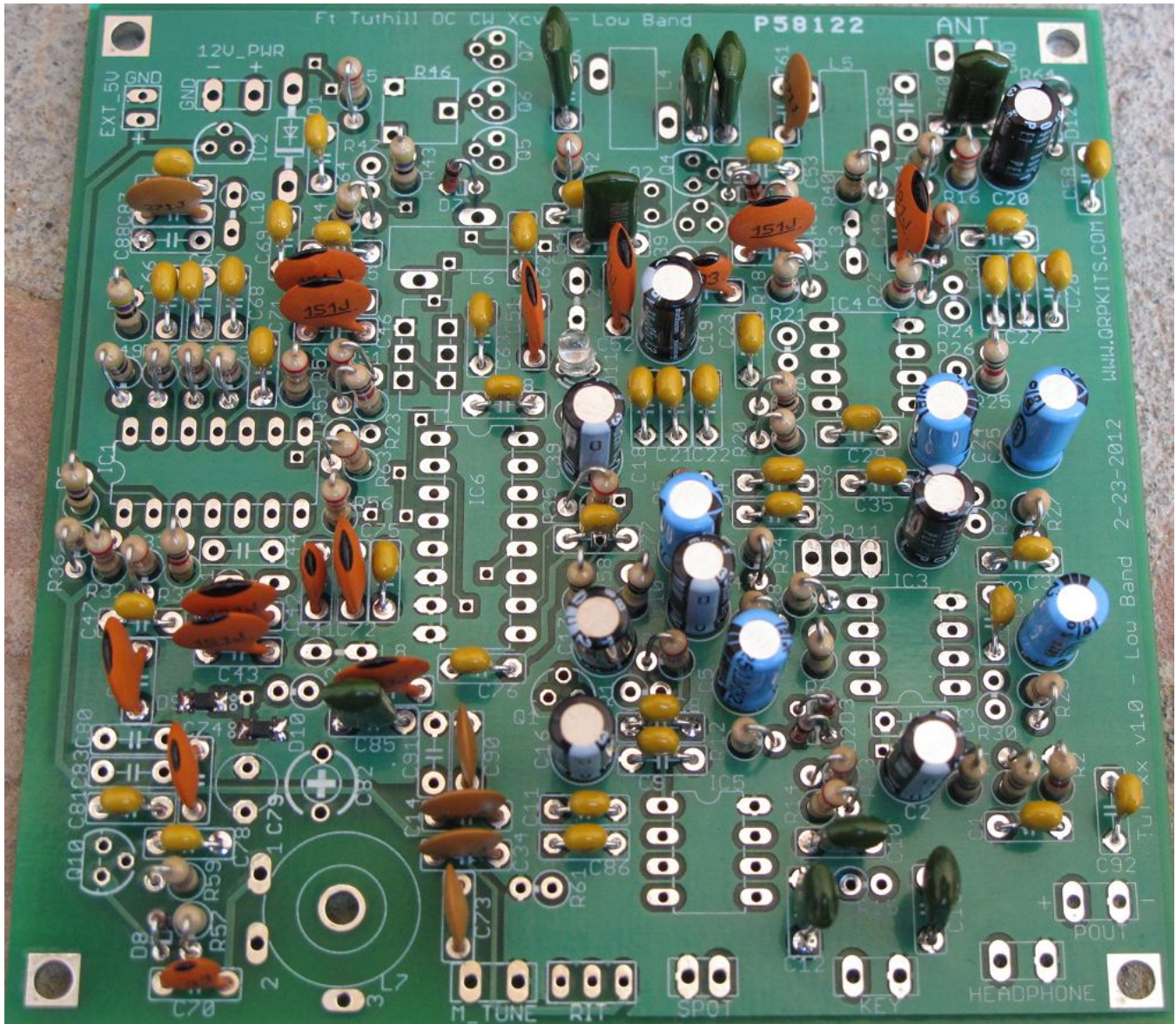


Figure 34. Board with wire loop, 100K and 47 resistors installed



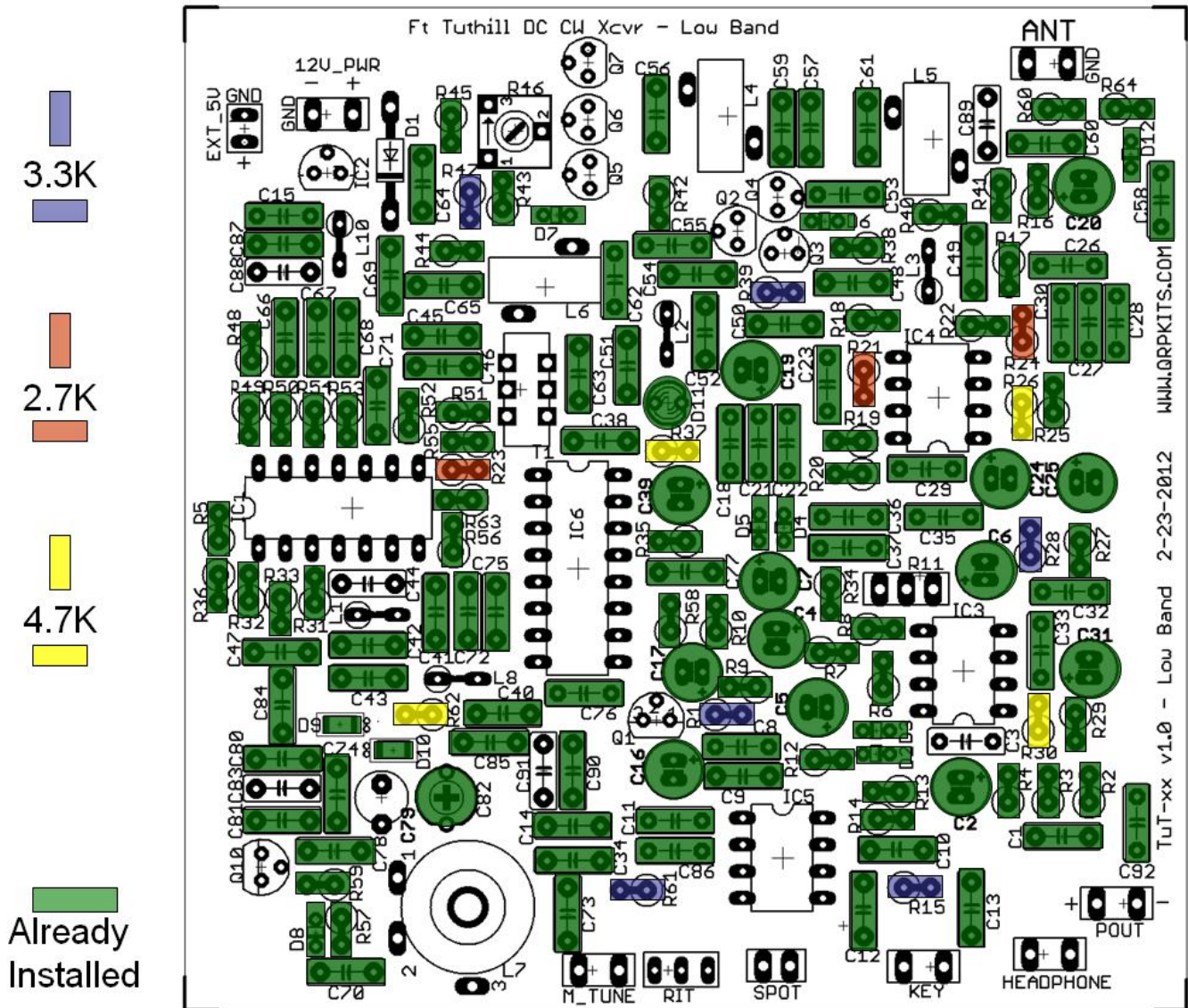


Figure 35. Installation locations of 2.7K, 3.3K and 4.7K ohm resistors

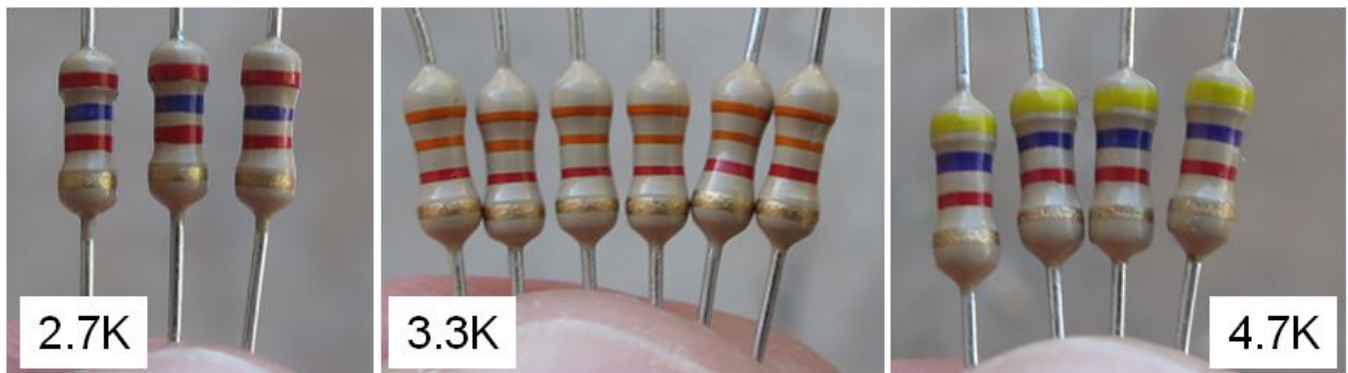


Figure 36. Identification of 2.7K, 3.3K and 4.7K resistors



As the parts are installed, it is recommended to both **check the box** below and **cross off the part on the picture** above. Install the following parts in the following order:

Install 3.3K resistors (marked orange-orange-red). Starting from the top left:  R47,  R39,  R28,  R1,  R15,  R61

Install 2.7K resistors (marked red – violet – red).  R23,  R21,  R24

Install 4.7K resistors (marked yellow – violet – red).  R26,  R30,  R37,  R62

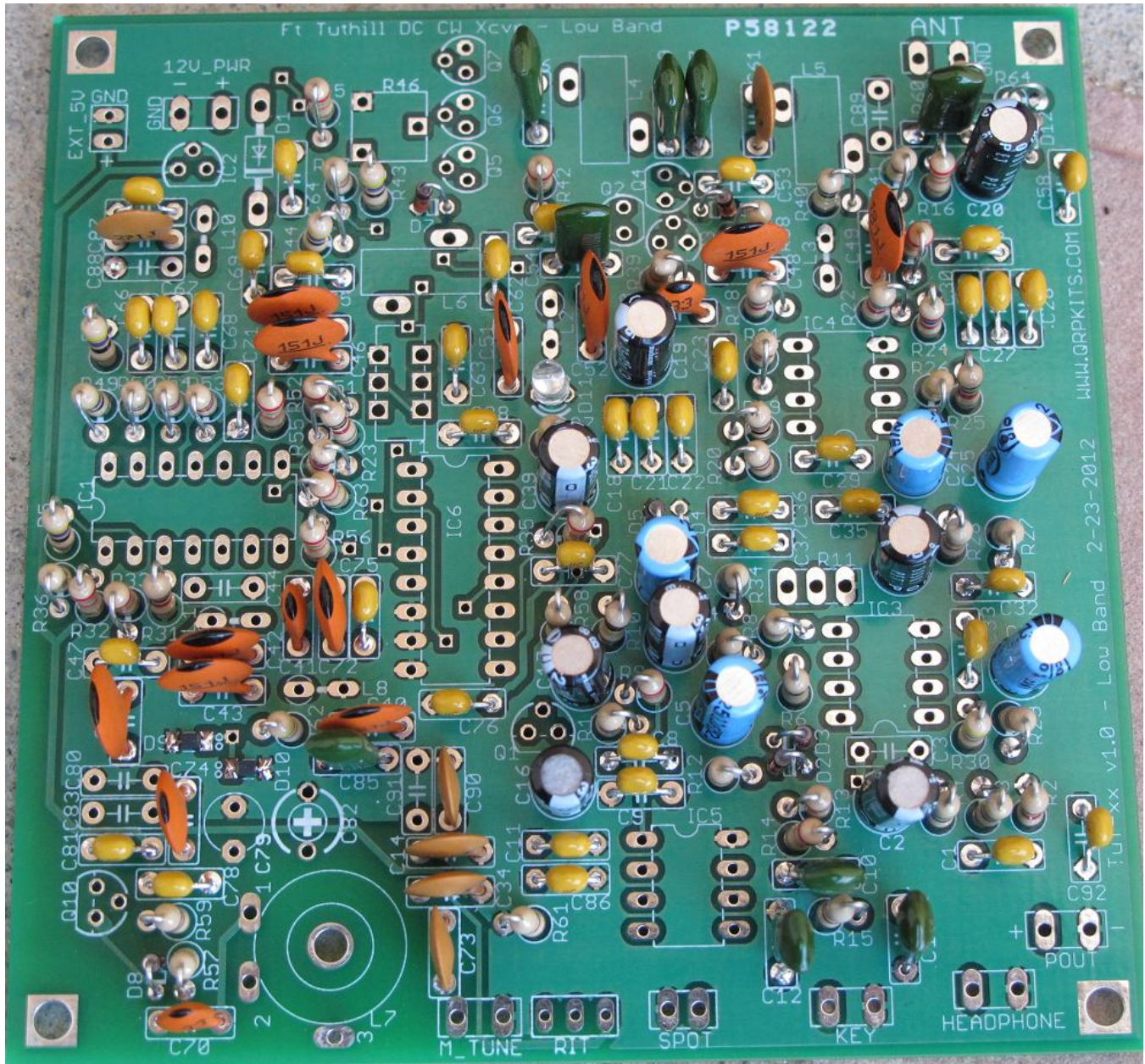


Figure 37. Board with 2.7K, 3.3K and 4.7K resistors