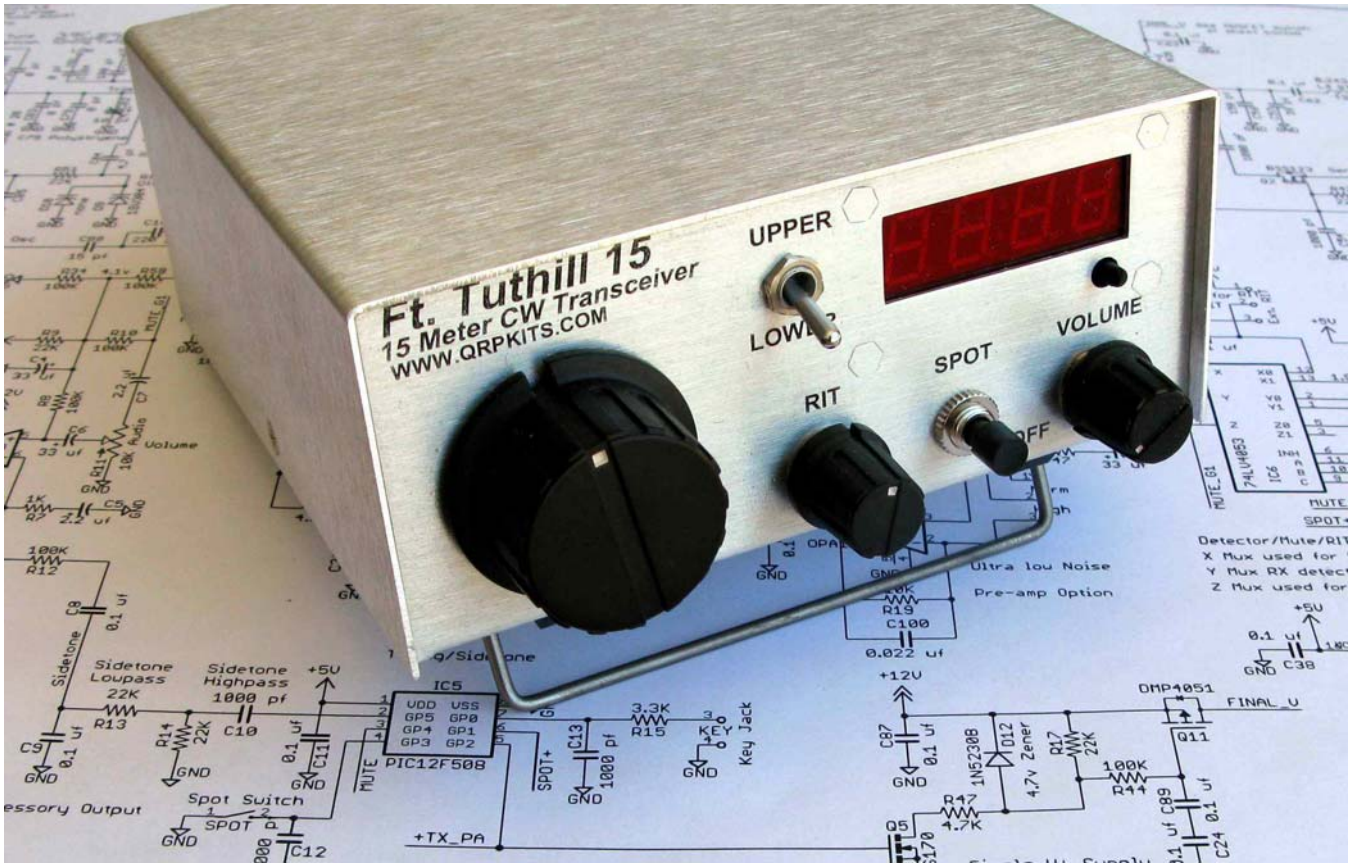
Arizona ScQRPion QRP Club



Ft Tuthill 15

5w DC CW Transceiver for 15m
Part 1 of 2, version 6

by Dan Tayloe, N7VE and Ken LoCasale, WA4MNT

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Specifications

These are measurements take from the current prototype, some variance in performance is expected from unit to unit.

Receiver

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

700 Hz five pole active R/C filter provides the selectivity, nominally 3 dB down at 1 kHz, **40 dB down at ~2 kHz,** 100 dB down at ~ 8 kHz

Audio filter design optimized for minimal ringing providing a **pleasing listening experience** even under static filled band conditions.

5 V pk-pk receiver detector design enables **stout large signal receiver performance**

Current Drain: Approximately 39 mA @ 12 V.

Supply voltage range: 10.5 to 14v

MDS receiver sensitivity: 0.09 uV or -128 dBm, as measured using 3 dB S+N/N

Transmitter

~5w Power Output : 12 V at 760 mA

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

TX harmonic output - All output harmonics exceed FCC specifications of -45 dBc

Transmitter is designed for a **straight key input**

Additional Features:

Both **RIT** and **XIT** are provided with ~ +/- **4000 Hz** tuning range (total RIT/XIT range of > 9 kHz)

Two tuning ranges, **~ 21.000 - 21.055 (DX window) and ~21.045 - 21.100 MHz (FISTs, QRP calling freq)**, are available using a front panel range switch.

Spot switch to allow setting precise TX spotting. Spotting mode is entered via a push button. A 800 Hz blip is sent once a second to remind the user that the rig is in the "spot" mode. Pressing and holding the spot switch alternates between XIT (“X”) and RIT (“R”) modes.

Transmit protection - When the transmitter is left key down for more than three seconds, the transmitter going into a "dotting" mode, a 33% transmit duty cycle. When terminated into a 50 ohm load, the transmitter can operate indefinitely in the dotting mode.

Transmitter will survive **brief exposure** of transmitting at full power into an open circuit load.

User hearing protection - The audio output has been designed to drive headphones and is equipped with audio compression to protect the user from sudden, large signals.

A regulated **5 V output** has been provided for light external 5 V loads such as an optional external keyer kit.

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 keyer chip (optional)
- Magnifying headpiece and/or magnifying glass. 3.5 power reading glasses may work also. Optimum is a 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.

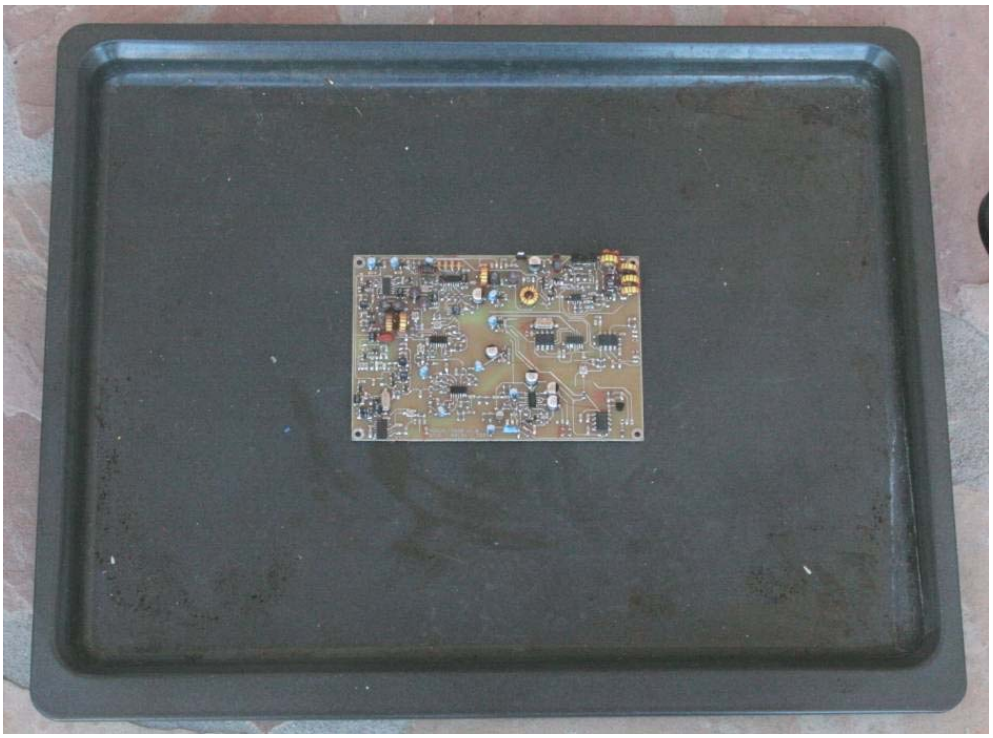

Figure 1. Working over an oversized cookie sheet is highly recommended

Parts List

The bare board comes with two pre-mounted surface mounted parts D9 and D10, 1SV304 varactor diodes.

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

Figure 2. Inventory of parts included in the kit

Capacitor list		
Quantity	**Value**	**Devices**
39	0.1 uF	C1, C3, C8, C9, C11, C15, C18, C22, C24, C26, C27, C28, C29, C30, C32, C33, C35, C36, C37, C38, C44, C46, C47, C53, C62, C63, C69, C71, C76, C77, C78, C81, C86, C87, C89, C94, C99, C103, C107
9	1000 pF	C10, C12, C13, C23, C54, C55, C85, C101, C108
8	33 uF	C2, C4, C6, C16, C17, C19, C20, C39
6	15 pF NPO Disk	C48, C51, C75, C80, C88 + Band offset switch cap
5	39 pF NPO Disk	C43, C49, C52, C57, C91
5	4.7 pF NPO Disk	C45, C70, C84, C97, C105
4	2.2 uF	C5, C7, C25, C31
4	22 pF NPO Disk	C65, C68, C72, C98
4	47 pF NPO Disk	C61, C67, C92, C93
4	2.2 pF NPO Disk	C41, C42, C50, C74
3	150 pF NPO Disk	C56, C58, C60
3	8.2 pF NPO Disk	C73 + 2 spare VFO pad caps
2	100 pF NPO Disk	C14, C34
2	220 pF NPO Disk	C21, C59
1	0.047 uf	C100
2	40 pF trim cap	C40, C96
1	10 pF trim cap	C79
1	Main tuning Polyvaricon	Main Tune
8	Not used	C17, C64, C66, C79, C83, C90, C102, C104, C106
1	100 uF	12 V filter cap for optional Digital Dial

Diode list		
Quantity	**Value**	**Devices**
1	1SV304 Varactor (pre-mounted on PCB board)	D9
1	1N4004	D1
8	1N4148	D2, D3, D4, D5, D6, D8, D13, D14
1	1N5262B 51 V zener	D7
1	1N5230B 4.7 V zener	D12
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	74LV4053	IC6
1	74AHC04N	IC7
1	OPA1611AID	IC8 - Premounted

Transistor list		
Quantity	**Value**	**Devices**
2	2N3904	Q1, Q12
6	BS170	Q4, Q5, Q6, Q7, Q8, Q9
2	BSS123	Q2, Q3 - Premounted
1	DMP4051LK3-13	Q11 - Premounted
1	2N5485	Q10

Resistor list		
Quantity	**Value**	**Devices**
18	22K	R5, R9, R13, R14, R16, R17, R32, R33, R36, R37, R42, R43, R46, R48, R51, R52, R53, R56
11	100K	R6, R8, R10, R12, R23, R34, R40, R41, R44, R57, R58
10	1K	R2, R7, R22, R25, R27, R29, R38, R55, R59, R60
4	3.3K	R1, R15, R28, R39
3	2.7K	R21, R24, R61
5	4.7K	R19, R26, R30, R35, R47
3	470	R20, R31, R45
2	22	R3, R18
1	100	12 V filter for optional Digital Dial
1	10K audio panel mount w/ switch	R11
1	10K linear panel mount	RIT

Inductor list		
Quantity	**Value**	**Devices**
3	1 uH – 5%	L2, L3, L7
6	T37-2	L1, L4, L5, L6, L8, L9
1	FT37-43	T1

Misc hardware list		
Quantity	**Value**	**Devices**
1	15 MHz series crystal	Y1
1	SPST_SWITCH N.O – Spot	
1	SPST Switch – Hi/Lo 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 Sheets	
1	7 foot red # 28 gauge wire	
1	3 foot green # 28 gauge wire	
1	3 foot gold # 28 gauge wire	
1	CHASSIS – Top and bottom shell	
2	4-40 x .25 FLAT HEAD SCREW	CHASSIS COVER SCREWS
1	BAIL KIT W/ SCREWS	
8	4-40 x .25 PAN HEAD SCREW	PCB and Digital Dial mounting screws
1	LARGE NORCAL KNOB	Tuning knob
2	SM. NORCAL KNOB	Volume & RIT knobs
4	RUBBER FEET, 1/4" THICK	
1	RED ACETATE	DIGITAL DISPLAY LENS
1	DECAL SET	

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. This kit makes keeping track of parts a bit simpler as it typically installs all of one part in a single step, making it easier to make sure all of a single part value has been installed.

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 10 hours. One good weekend should do it.

Bare PC Board Pictures

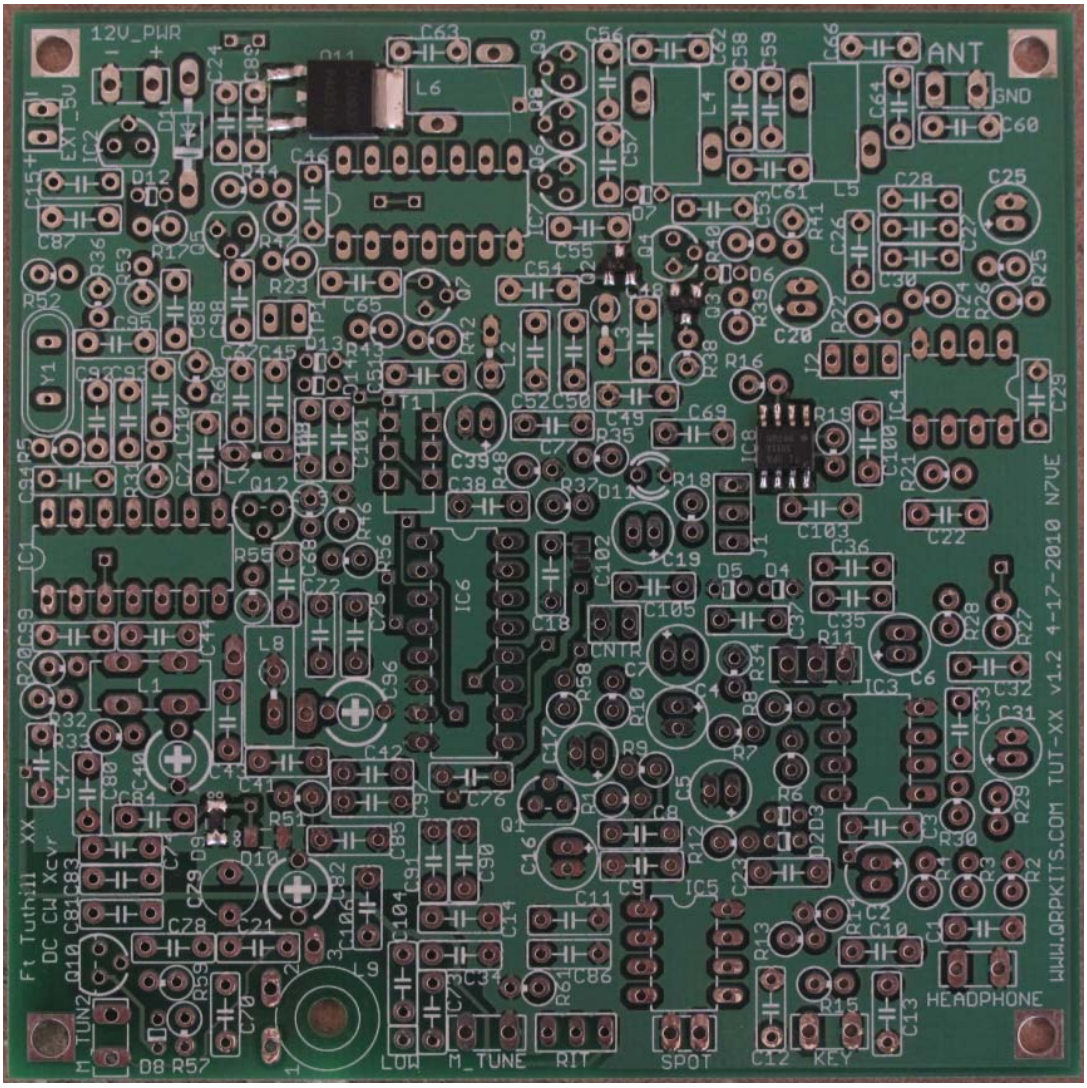

Figure 3. Top side view of the Ft Tuthill 15 board

Installation of Miscellaneous Diodes

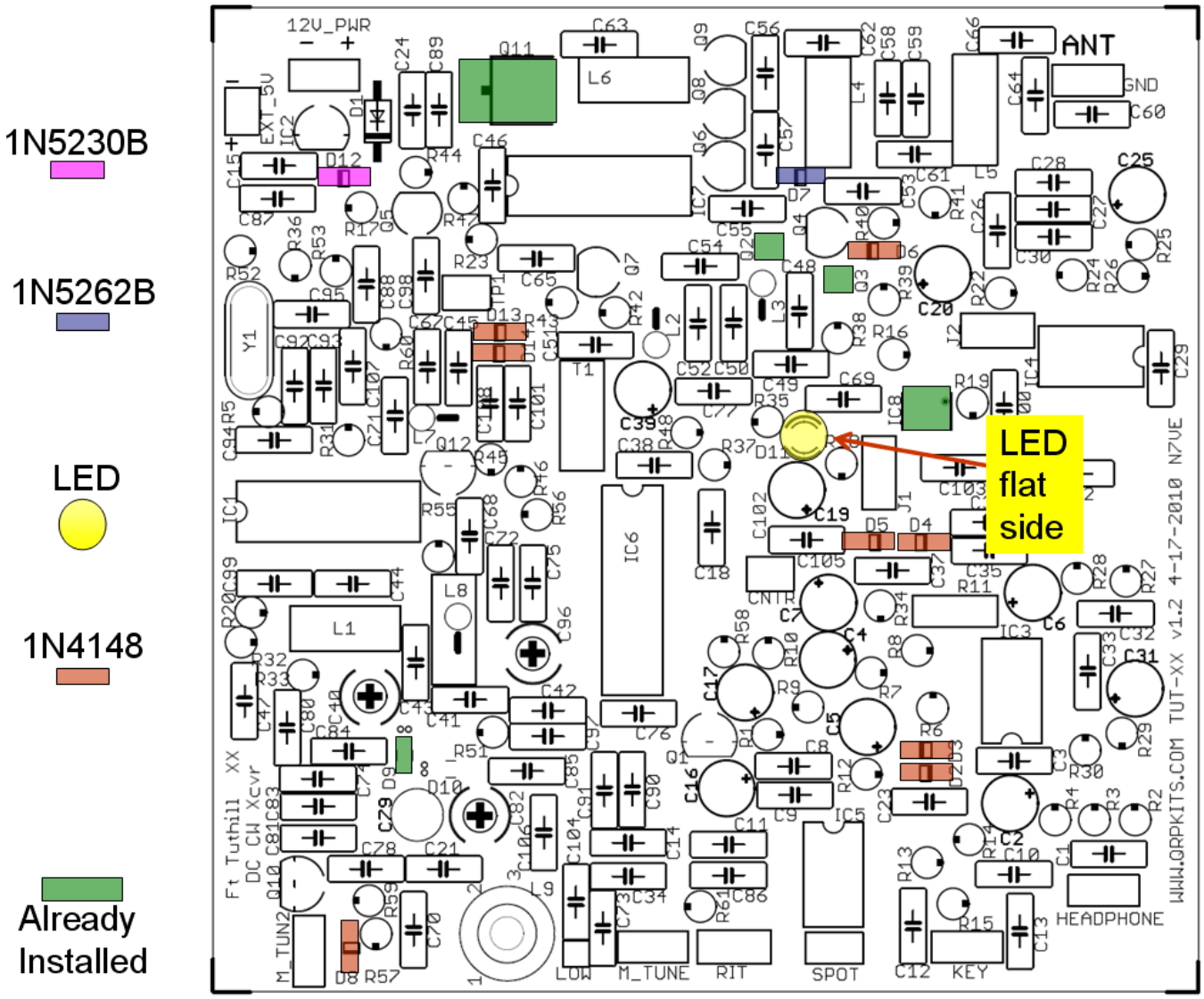

Figure 4. Parts location of misc diodes

Install the following parts in the following order:

Figure 5. LED. Flat LED side matches with the shorter lead.

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

Separate all the glass body diodes as shown. There are eight 1N4148, one 1N5262B, and one 1N5230B diodes. The 1N4148 are smaller than the other two diodes. These will be installed in the next steps.

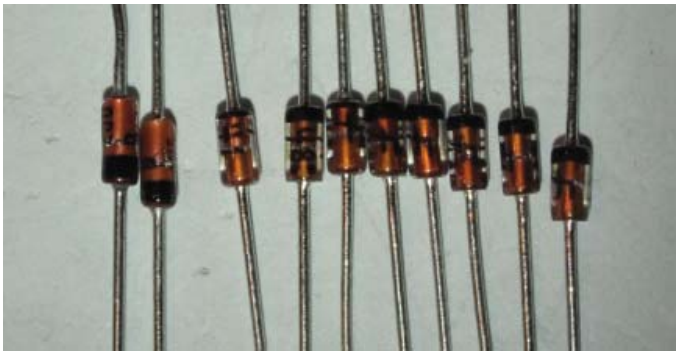

Figure 6. 8 1N4148 on the right, larger 1N5262B and 1N5230B diodes on the left

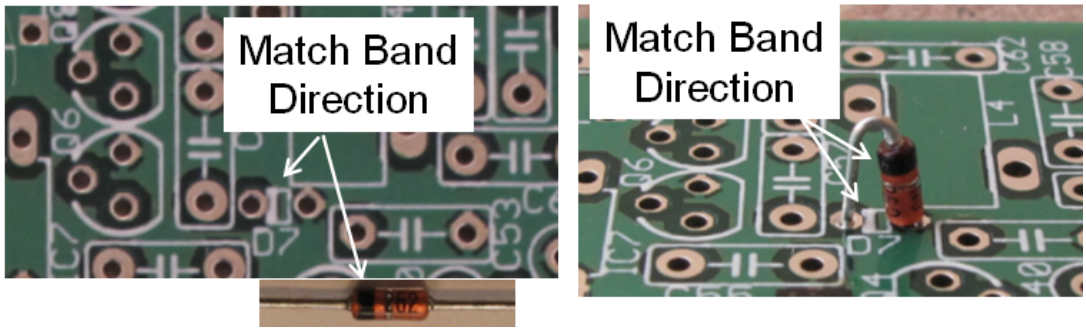

Figure 7. D7 details. Mount diode vertically with the white band on the board matching the band on the diode

Install ☐ D7 1N5262B 51 V 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. This diode, the 1N5030B and the 1N4148s are difficult to tell apart as they are both small glass diodes with tiny markings. ***Double check the polarity of the diode against the photos below.***

Install ☐ D12 1N5230B 4.7 V zener. See details above. This diode is also mounted vertically (on end) with the banded end in the air. Make sure the banded end connects to the hole as shown on the D12 board markings as was done with D7. ***There is only one 4.7 V zener like this***. ***Double check the polarity of the diode against the photos below.***

Install ☐ D8, ☐ D2, ☐ D3, ☐ D4, ☐ D5, ☐ D6, ☐ D13, ☐ D14 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 is pre-mounted on the PCB.

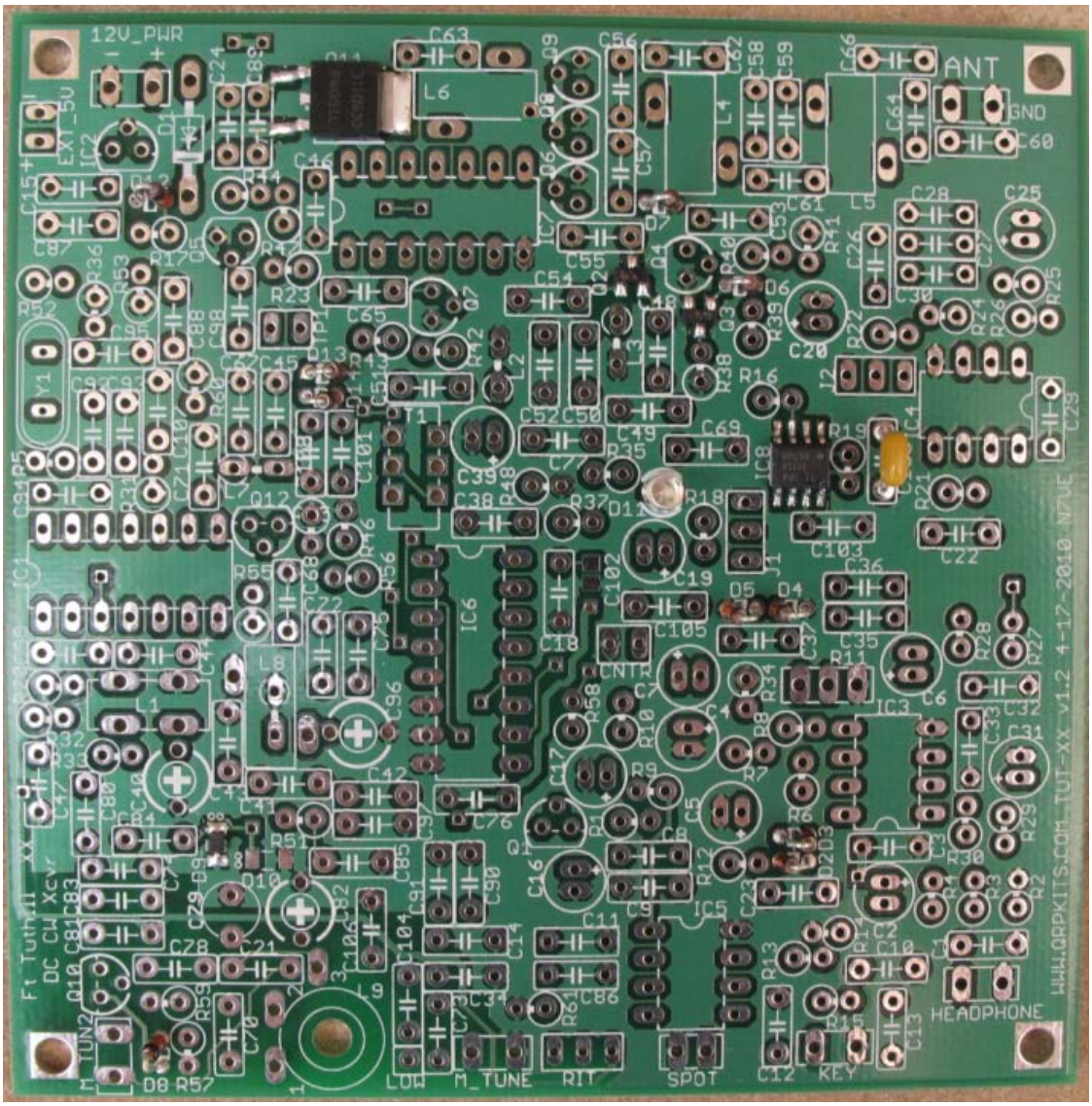

Figure 8. Parts mounted so far

Installation of the Capacitors

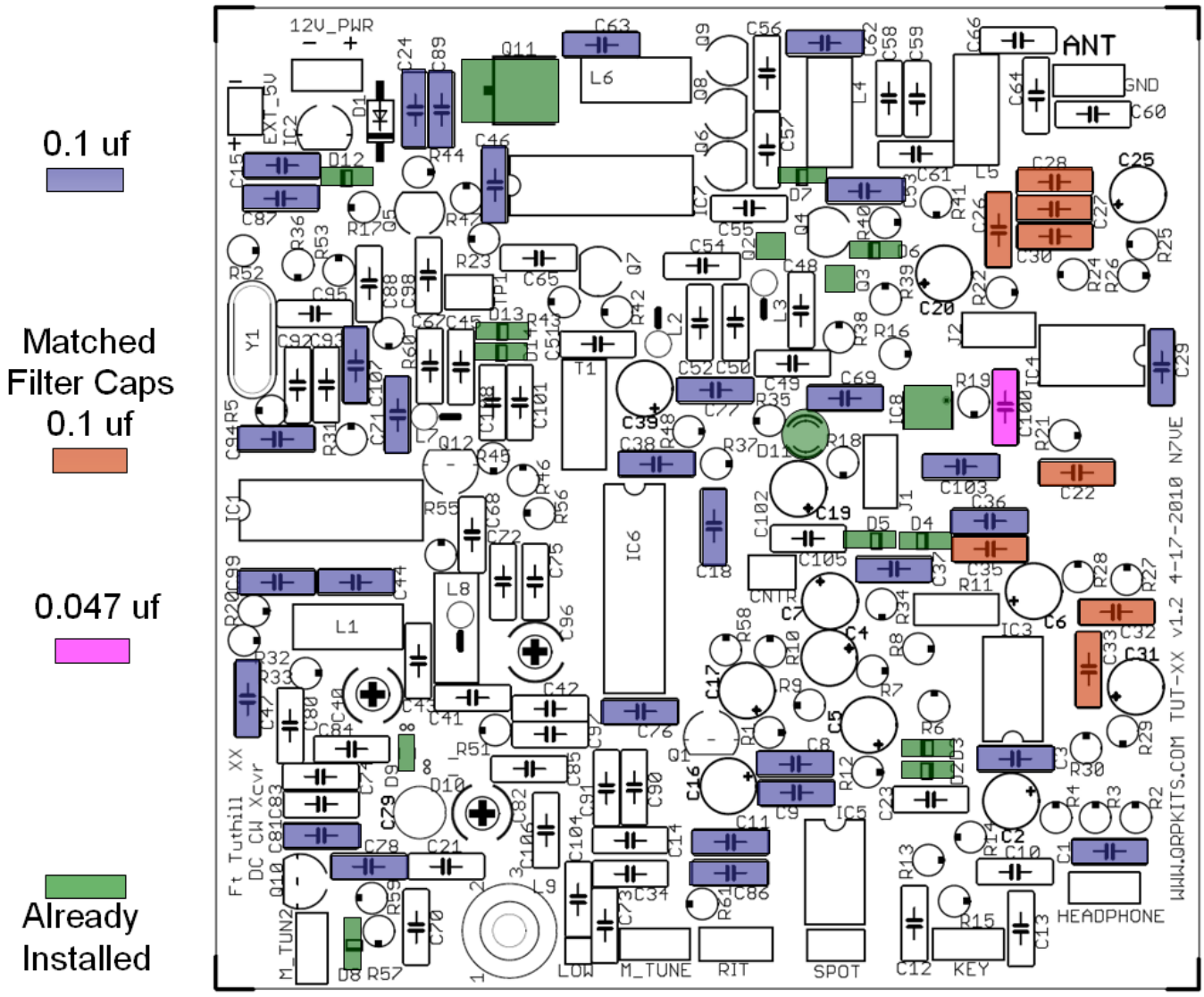

Figure 9. Installation location of the 0.1 uF and 0.047 uF caps

Figure 10. 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 39 0.1 uF capacitors, and 8 of them are in the filter section. These are marked “104”. It is strongly recommended that all 39 capacitors are measured and the closest 8 caps in value are used as the filter capacitor parts. If you have a choice, pick a group that is closer to 0.1 uF.

The matching process involves measuring the capacitors on the paper strip and recording the value directly on the strip. I suggest recording three digits if the measured value is over 0.1 uF (0.1xx uF) or two digits (0.09x) if the value is less than 0.1 uF.

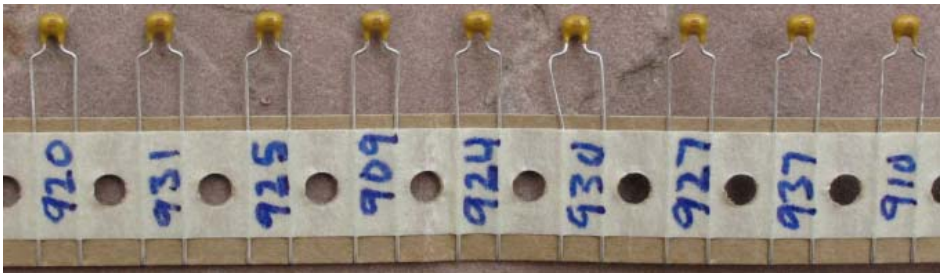

Figure 11. Example of capacitor matching process

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.

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 (marked “104”) ☐ C33, ☐ C32, ☐ C35, ☐ C22, ☐ C26, ☐ C27, ☐ C28, ☐ C30

- Install 0.1 uf caps (marked “104”) ☐ C1, ☐ C3, ☐ C8, ☐ C9, ☐ C11, ☐ C86, ☐ C76, ☐ C81, ☐ C78, ☐ C47, ☐ C99, ☐ C44, ☐ C94, ☐ C71, ☐ C107, ☐ C87, ☐ C15, ☐ C24, ☐ C89, ☐ C46, ☐ C63, ☐ C62, ☐ C53, ☐ C77, ☐ C69, ☐ C38, ☐ C18, ☐ C103, ☐ C36, ☐ C37, ☐ C29

- Install 0.047 uf cap (marked “473”) ☐ C100,

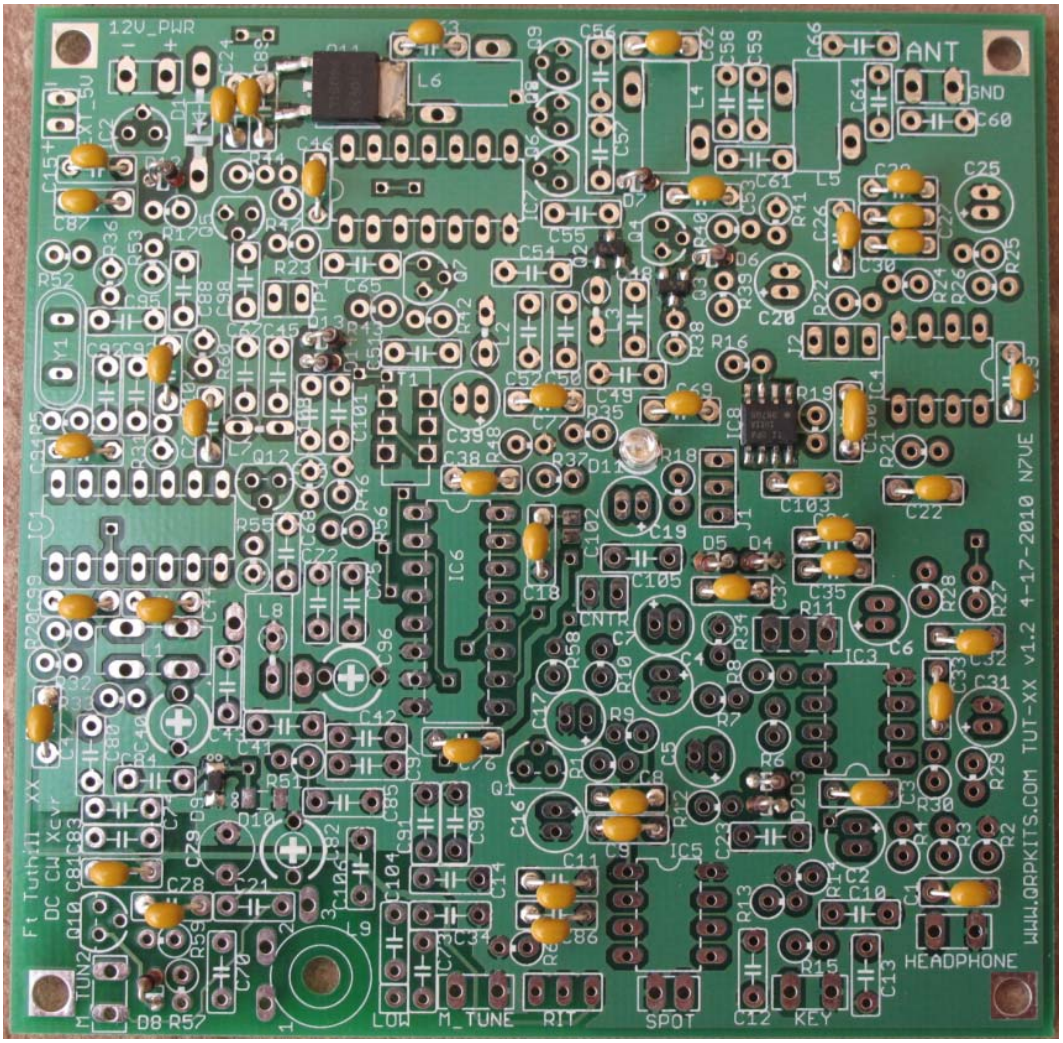

Figure 12. Parts mounted with 0.1 uF and 0.047 uF capacitors

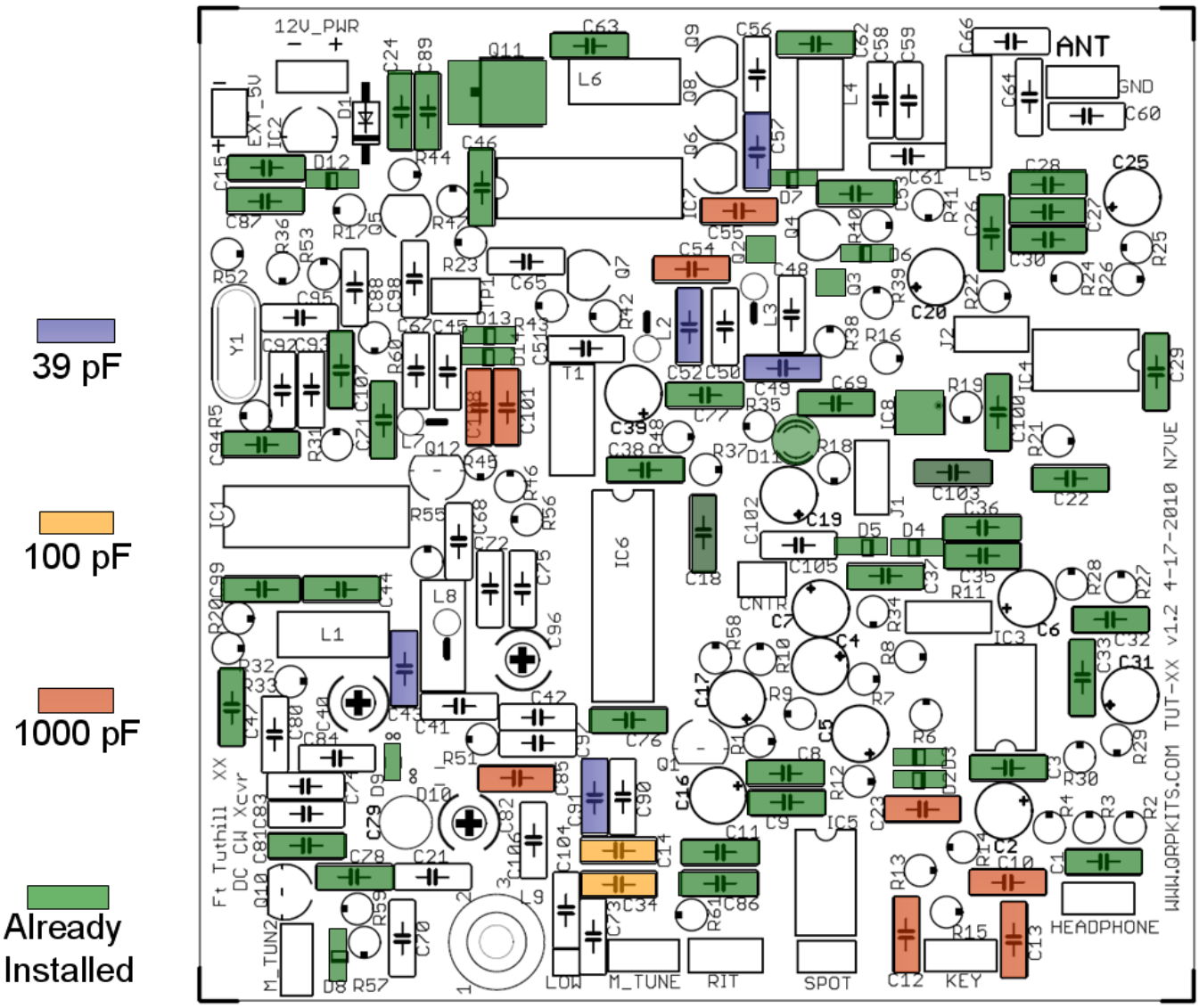

Figure 13. Location of 39pF, 100 pF and 1000 pF capacitors

Figure 14. Identification of 39 pF, 100 pF and 1000 pF capacitors

Pick out the nine 1000 pF caps (marked “102”), two 100 pF caps (marked “101”) and five 39 pF caps (marked “39”) as shown above.

The hole spacing in the board is 0.2” for all disc capacitors and the 1000 pf capacitors have a 0.1” lead spacing. Bend the leads outwards as shown, then bend them back down further out to form the leads for a 0.2” lead spacing. The goal is to get the end spacing similar to the 100 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 1000 pF disc caps (marked “102”) ☐ C12, ☐ C10, ☐ C13, ☐ C23, ☐ C85, ☐ C101, ☐ C108 (poorly marked, next to C101), ☐ C55, ☐ C54

  Install 100 pF disc caps (marked “101”) ☐ C14, ☐ C34

  Install 39 pF disc caps (marked “39”) ☐ C91, ☐ C43, ☐ C52, ☐ C49, ☐ C57

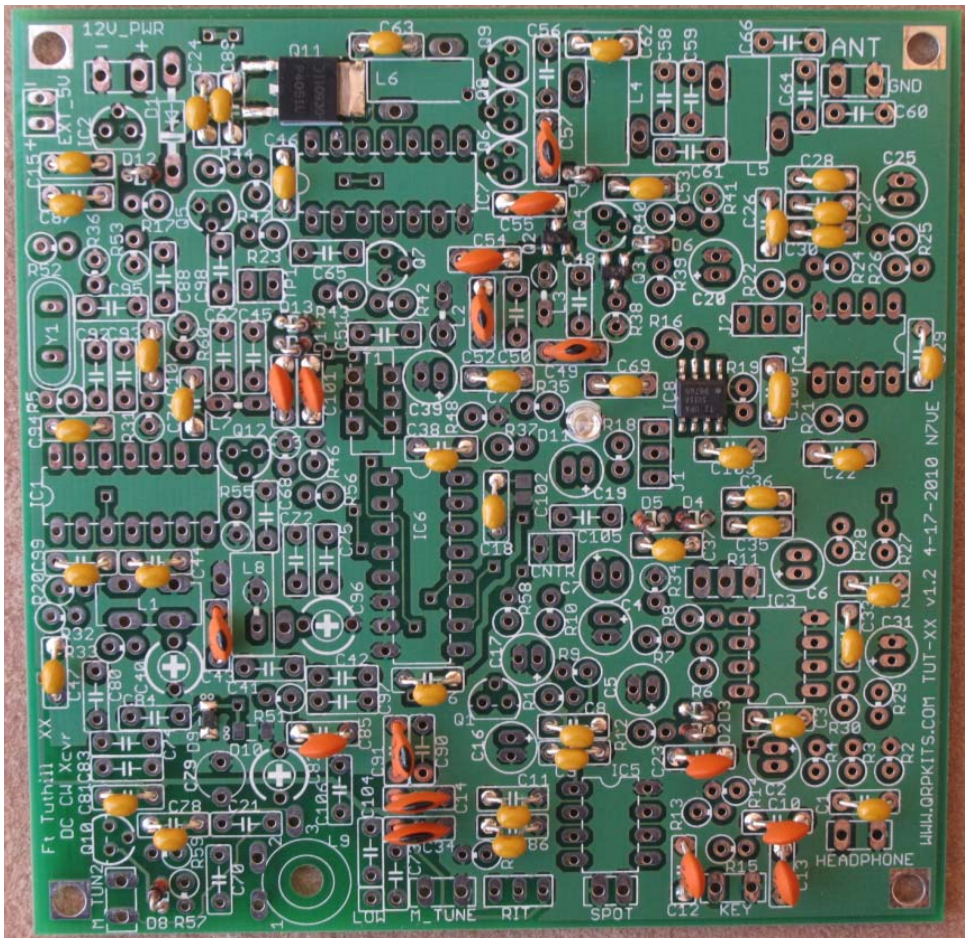

Figure 15. Board with 39pf, 100 pF and 1000 pF caps

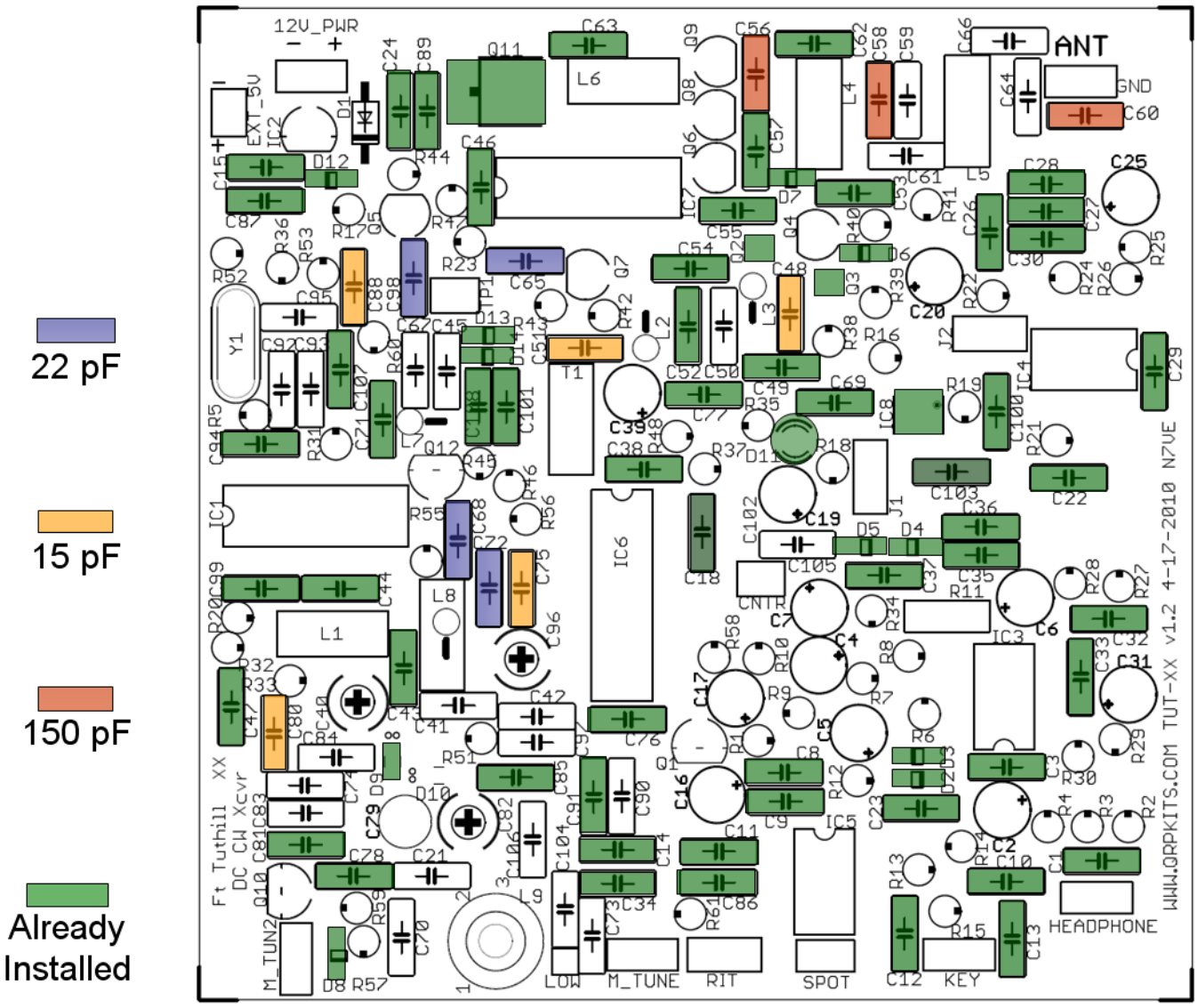

Figure 16. Location of 15 pF, 22 pF and 150 pF capacitors

Figure 17. Identification of 15 pF, 150 pF and 22 pF caps.

Pick out the five 15 pF caps (marked "15"), four 22 pF caps (marked "22") and three 150 pF caps (marked "151") as shown above. Some of these parts will need to have the leads formed to fit the 0.2" holes as was done above. ***Warning: the small yellow 150 pF and 220 pF cap look very similar. Make sure you are using the 150 pF and not the 220 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 15 pF disc caps (marked “15”): ☐ C80, ☐ C75, ☐ C88, ☐ C51, ☐ C48 One extra 15 pF cap will be used with the band set switch and is not installed at this time.

Install 22 pF disc caps (marked “22”): - ☐ C72, ☐ C68, ☐ C98, ☐ C65

Install 150 pF disc caps (marked “151”): - ☐ C56, ☐ C58, ☐ C60

Sorry! Forgot to take a picture of the board with these new parts added!

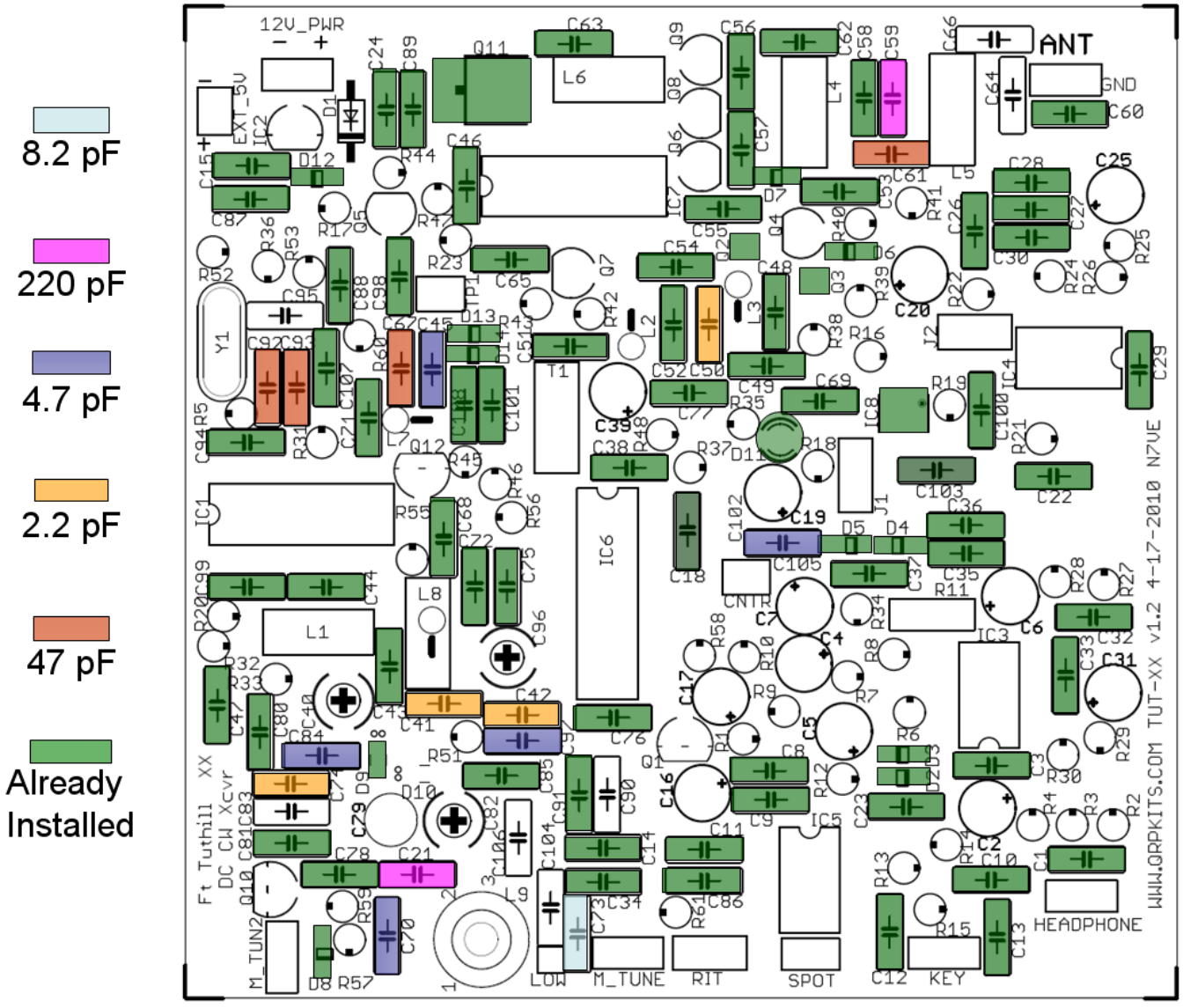

Figure 18. Location of 2.2 pF, 4.7 pF, 8.2 pF, 47 pF, and 220 pF capacitors

Pick out the five 4.7 pF caps (marked “4.7”), four 47 pF caps (marked “47”), four 2.2 pF caps (marked “2.2”), two 220 pF caps (marked “220”) and one 8.2 pF caps (marked “8.2”) as shown above. Some of these parts will need to have the leads formed to fit the 0.2” holes as was done above.

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 4.7 pF disc caps (marked “4.7”): ☐ C70, ☐ C84, ☐ C97, ☐ C45, ☐ C105

Install 47 pF disc caps (marked “47”): - ☐ C92, ☐ C93, ☐ C67, ☐ C61

Install 2.2 pF disc caps (marked “2.2”): - ☐ C41, ☐ C42, ☐ C50, ☐ C74

Install 8.2 pF disc caps (marked “8.2”): - ☐ C73

Install 220 pF disc caps (small yellow cap marked “221”): - ☐ C21, ☐ C59

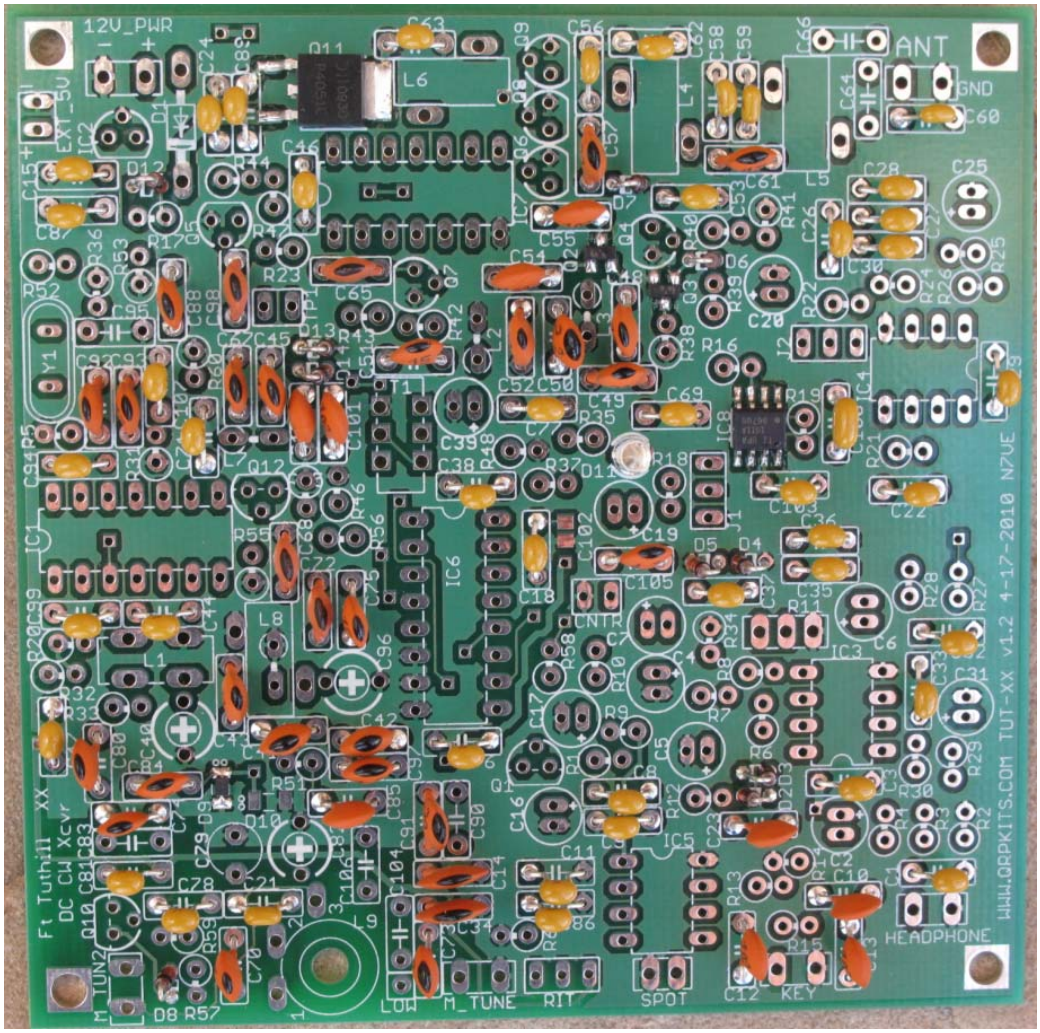

Figure 19. Board with 2.2 pF, 4.7 pF, 8.2 pF, 47 pF, and 220 pF capacitors

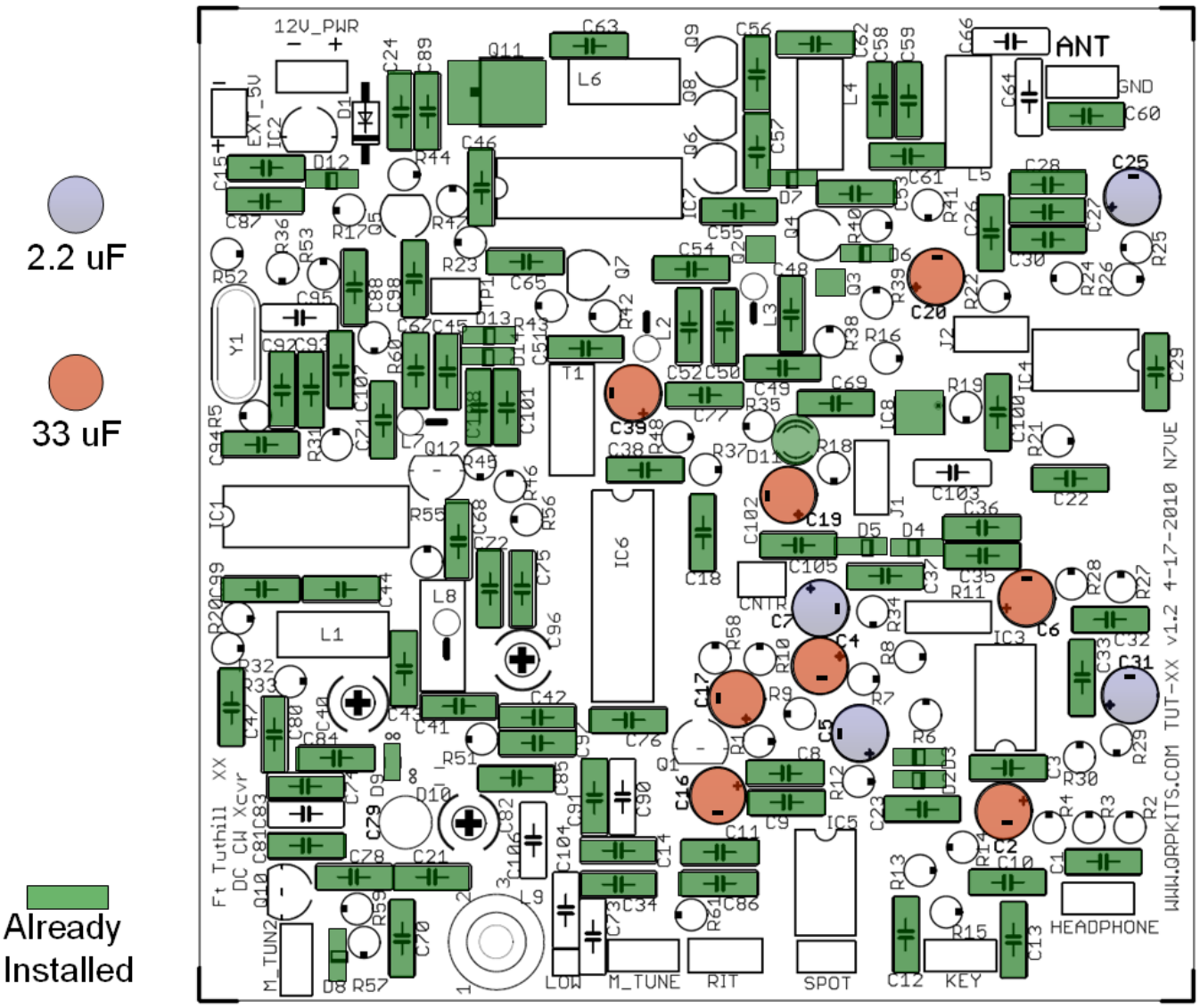

Figure 20. Location of 2.2 uF and 33 uF capacitors

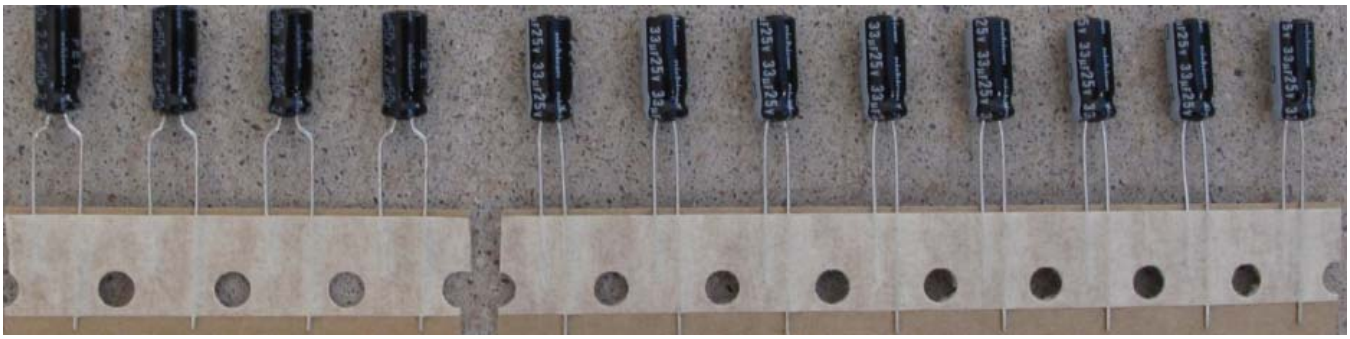

Figure 21. Identification of 2.2 uF and 33 uF caps.

The electrolytic caps are polarized. ***The side stripe on the cap needs to line up with the "-" in the figure above.*** Install the following parts in the following order:

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

Cap polarization can be double checked with the installed parts below (note white stripe postion):

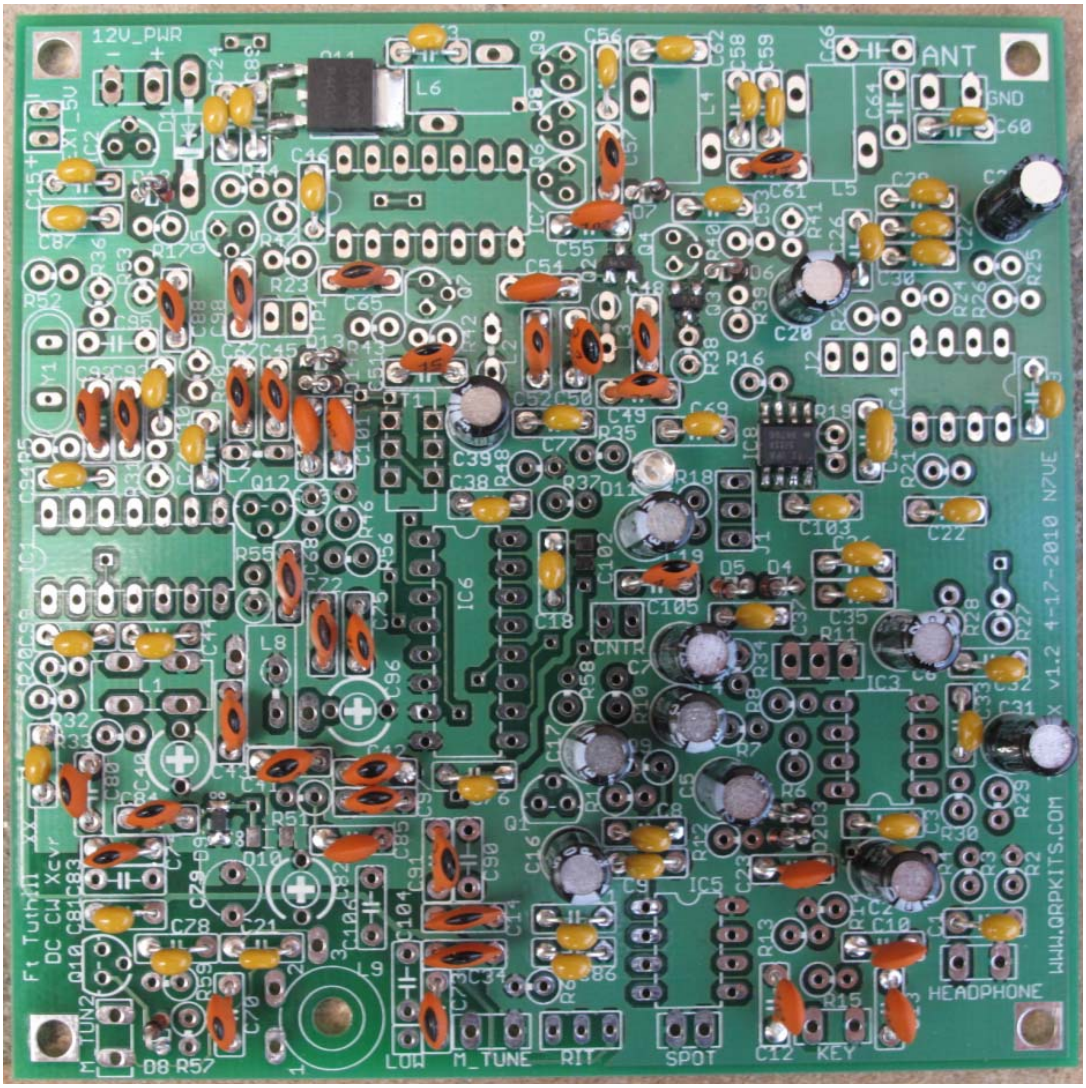

Figure 22. Board with 2.2 uF and 33 uF caps added

Installation of the Resistors

It is very easy to get resistors confused. I will admit that in one build I got some 22K and 3.3 resistors mixed up (red-red-orange vs. orange-orange-red). First start by sorting all the resistors into seven different piles, one pile for each resistor type. You can use a volt-ohm meter to double check the resistor values as an additional precaution.

The seven resistor types in this kit and their associated color codes are:

100K (brown – black – yellow) – 11 resistors total
22K (red – red – orange) – 18 resistors total
4.7K (yellow – violet – red) – 5 resistors total
3.3K (orange – orange – red) – 4 resistors total
2.7K (red – violet – red) – 3 resistors total
1K (brown – black – red) – 10 resistors total
470 (yellow – violet – brown) – 3 resistors total
22 (red – red – black) – 2 resistors total

Some of the more numerious resistors will come on strips (22K, 100K, 1K) which will make things a bit easier.

All resistors are mounted vertically. The base of the resistor is mounted on the circle portion of PCB symbol, while the direction of the pad for the other lead is indicated by the square on the circle as shown below.

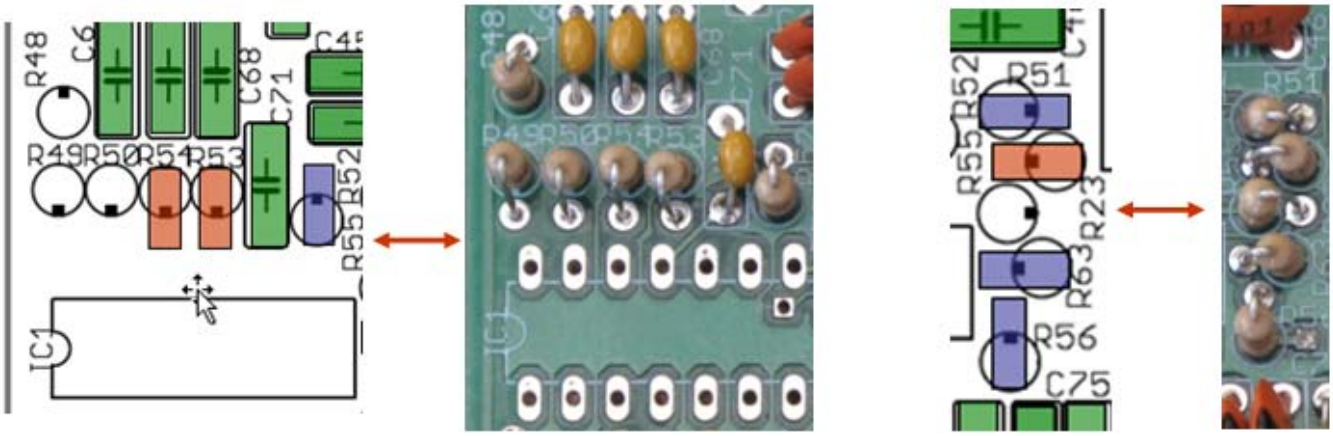

Figure 23. Overlay resistor orientation vs. PCB mounted part resistor orientation

Notice the "Rxx" designation on the overlay diagram and the placement of the real resistors on the board. Again, the resistor body goes on the circle, and the resistor lead goes in the direction of the small square on the circle. Note in particular R48 and R49 in the first drawing and the direction it indicates for the lead side of the resistor. Compare that with the mounted resistor in the photo. Like wise, in the second drawing, R56 at the bottom is pointed North-South (NS) while the other resistors above it are pointed East-West (EW).

The overlay has exaggerated the correct resistor installation direction by the use of a colored rectangle to indicate the proper orientation when a resistor is to be installed in a particular spot.

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.

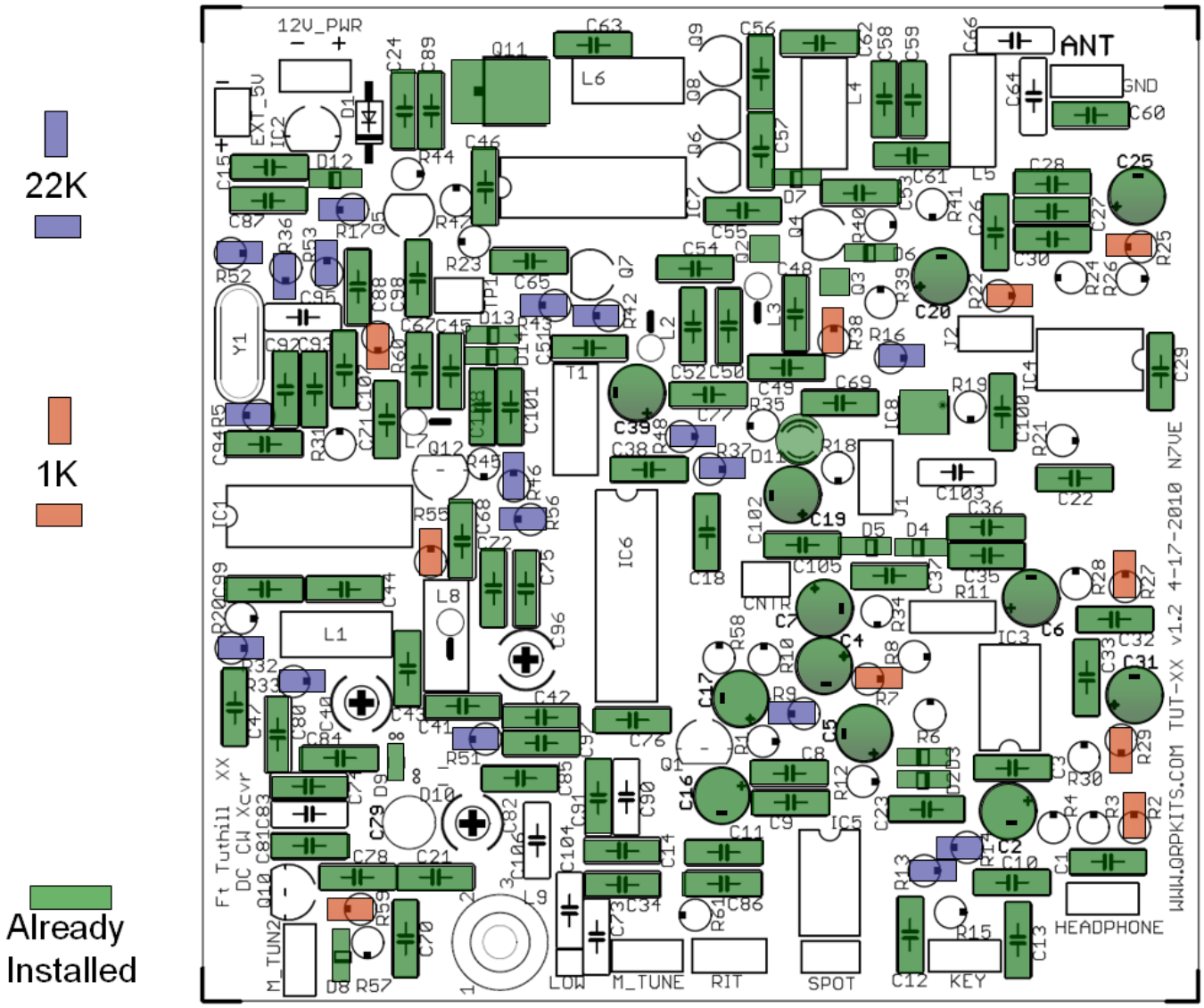

Figure 24. Installation locations of 1K and 22K resistors

Figure 25. Identification of 1K and 22K resistors. Leads should be bent as shown for installation

Figure 26. Resistors are mounted vertically, body on the circle

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 ten 1K resistors (marked brown – black – red). Starting from the bottom left: ☐ R59, ☐ R55, ☐ R60, ☐ R38, ☐ R22, ☐ R25, ☐ R27, ☐ R7, ☐ R29, ☐ R2

Install 18 total 22K resistors (marked red – red – orange). ☐ R32, ☐ R33, ☐ R51, ☐ R56, ☐ R46, ☐ R5, ☐ R52, ☐ R36, ☐ R53, ☐ R17, ☐ R43, ☐ R42, ☐ R48, ☐ R37, ☐ R16, ☐ R9, ☐ R14, ☐ R13

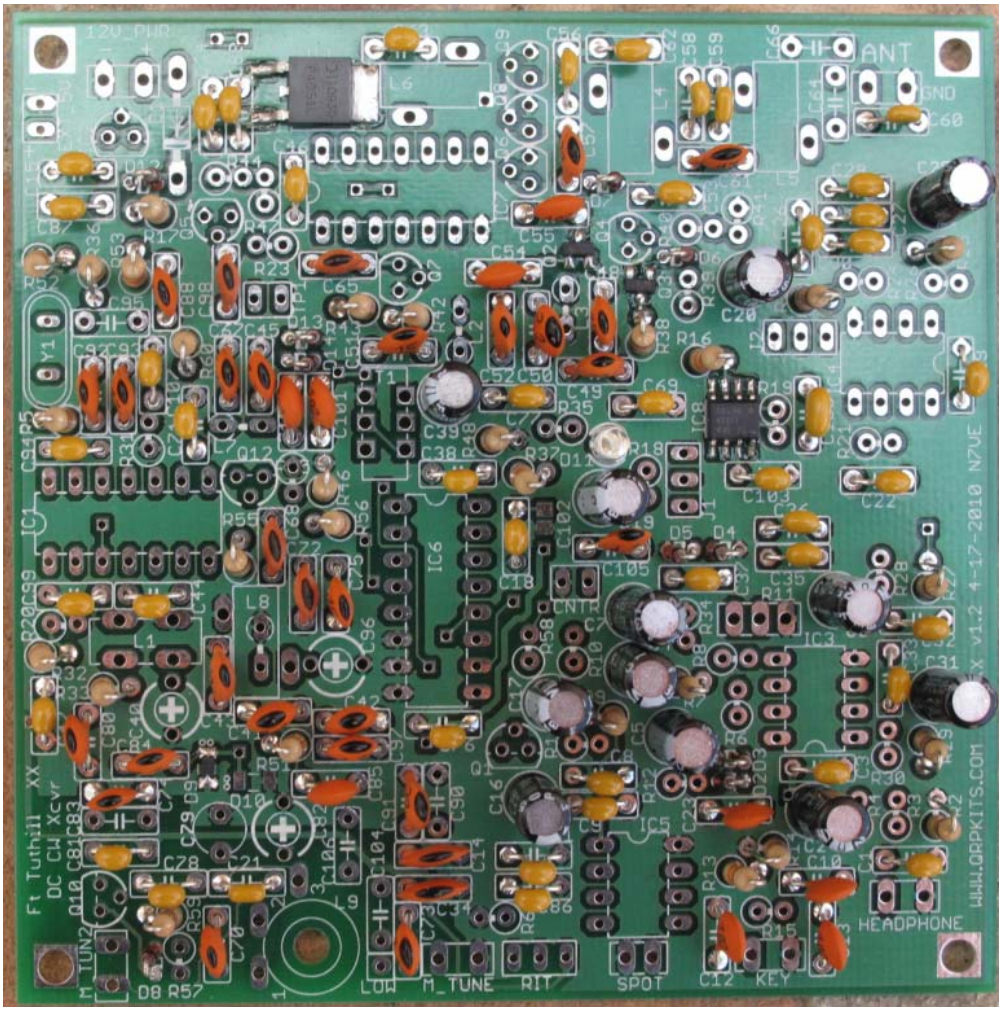

Figure 27. Board with 1K and 22K resistors installed

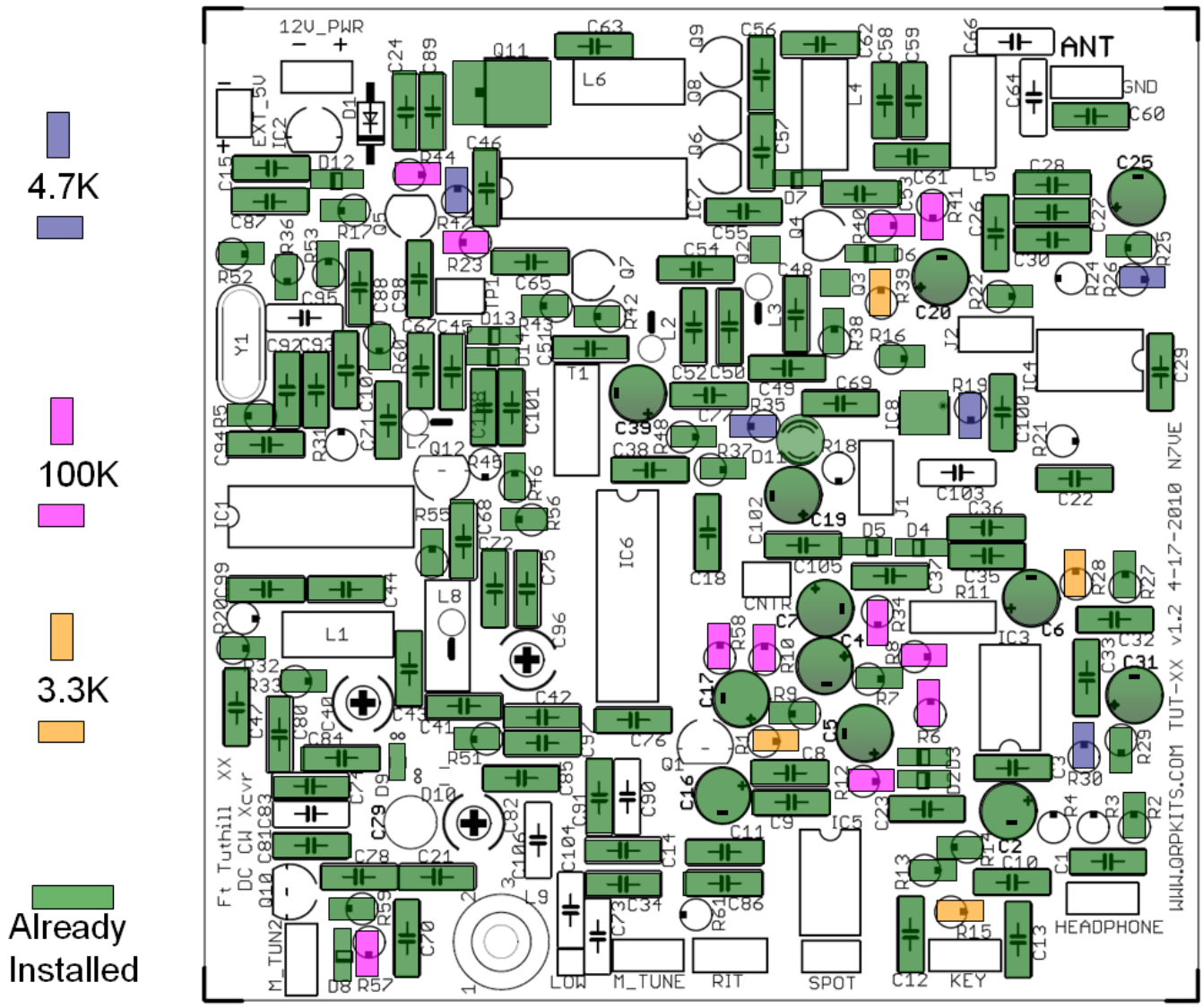

Figure 28. Installation locations of 100K and 4.7K and 3.3K ohm resistors

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 11 total 100K resistors (marked brown – black – yellow). Starting from the bottom left: ☐ R57, ☐ R12 ☐ R6, ☐ R58, ☐ R10, ☐ R34, ☐ R8, ☐ R41, ☐ R40, ☐ R44, ☐ R23

Install five total 4.7K ohm resistors (marked yellow – violet – red). ☐ R47, ☐ R35, ☐ R19, ☐ R26, ☐ R30

Install four total 3.3K ohm resistors (marked orange – orange – red). ☐ R15, ☐ R1, ☐ R28, ☐ R39

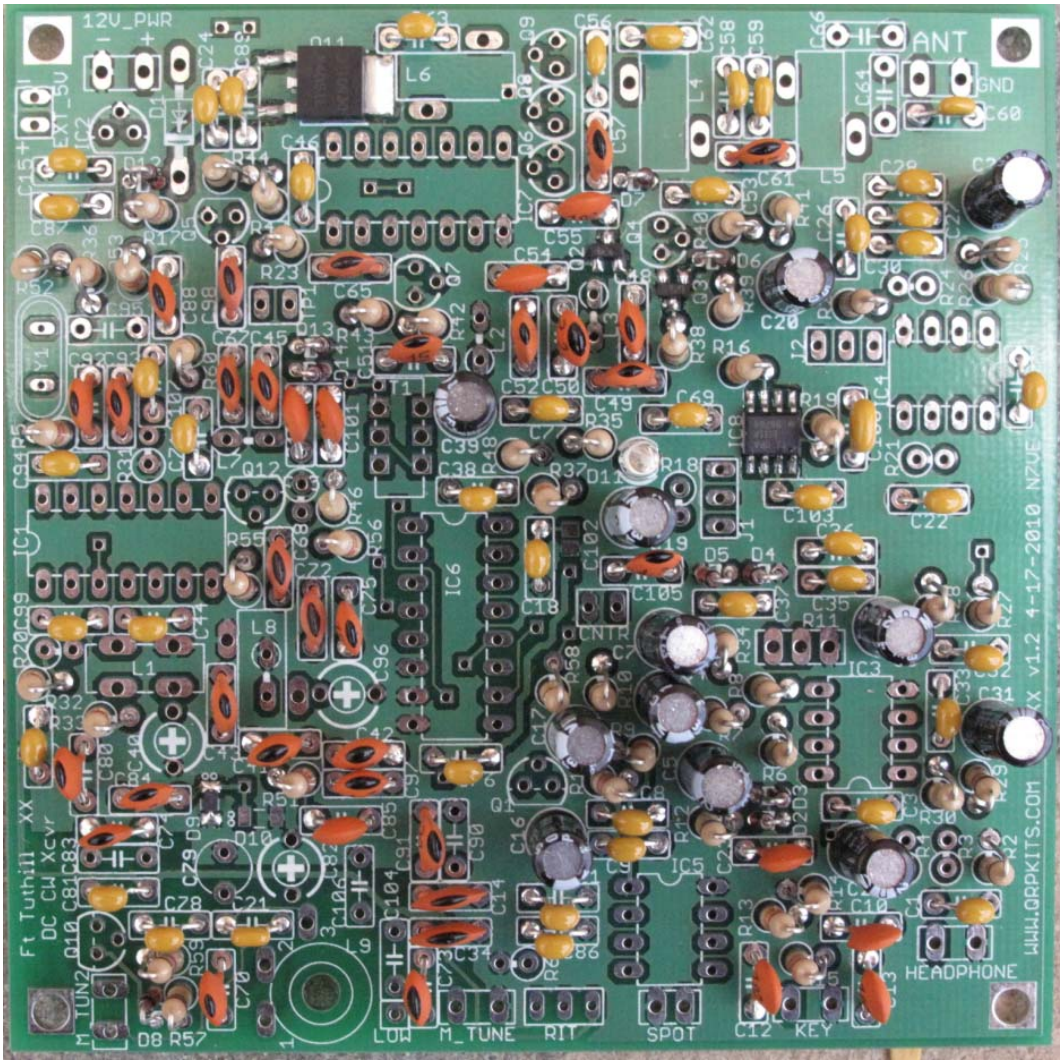

Figure 29. Board with 3.3K, 4.7K, and 100K resistors installed

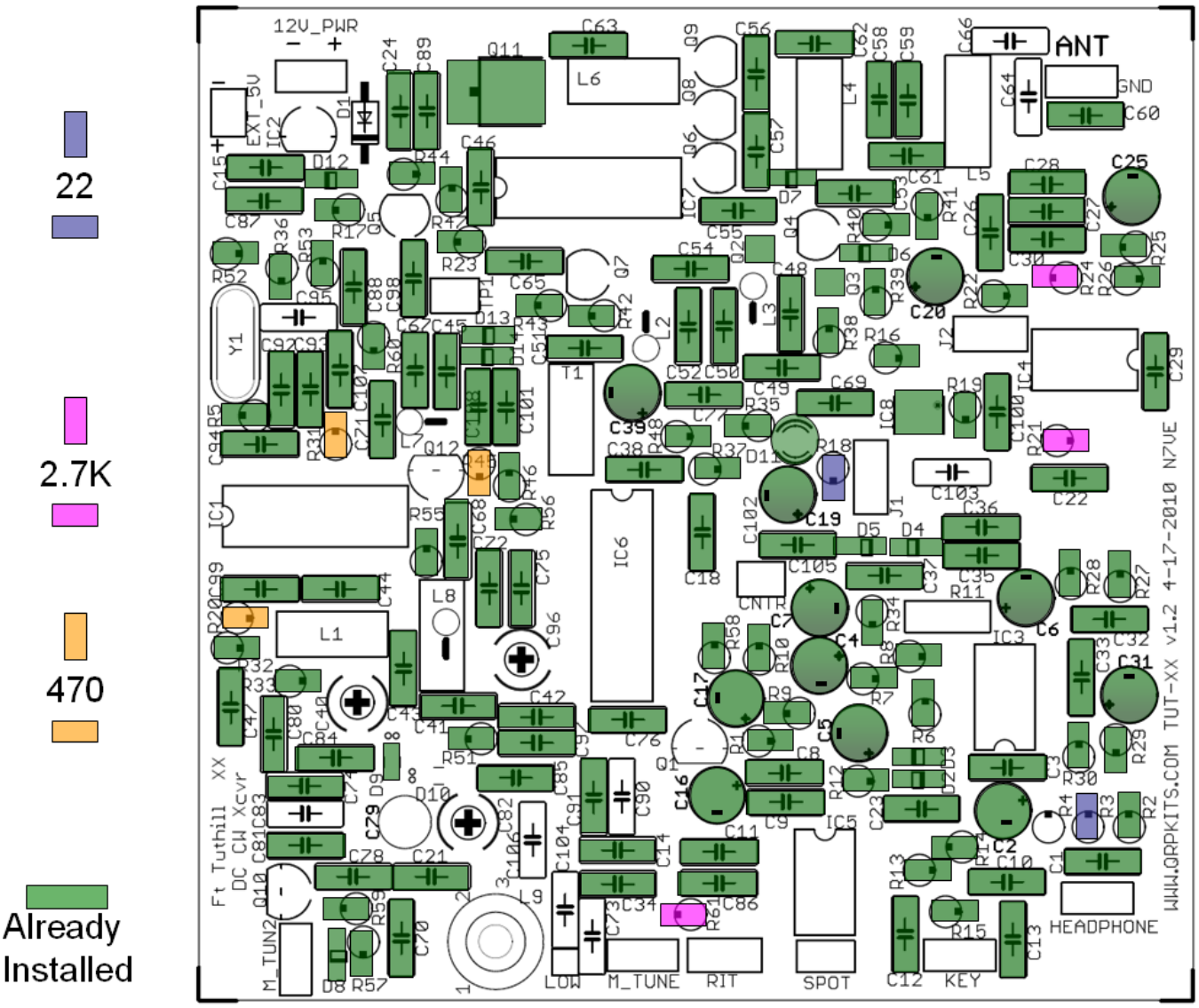

Figure 30. Installation locations of 22, 470 and 2.7K ohm resistors

Figure 31. Identification of 2.7K, 470 and 22 ohm resistors in order left to right

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 22 resistors (marked red-red-black). Starting from the top left: ☐ R3, ☐ R18

Install 470 resistors (marked yellow-violet-brown). Starting from the top left: ☐ R20, ☐ R45, ☐ R31

Install 2.7K resistors (marked red-violet-red). Starting from the top left: ☐ R61, ☐ R21, ☐ R24

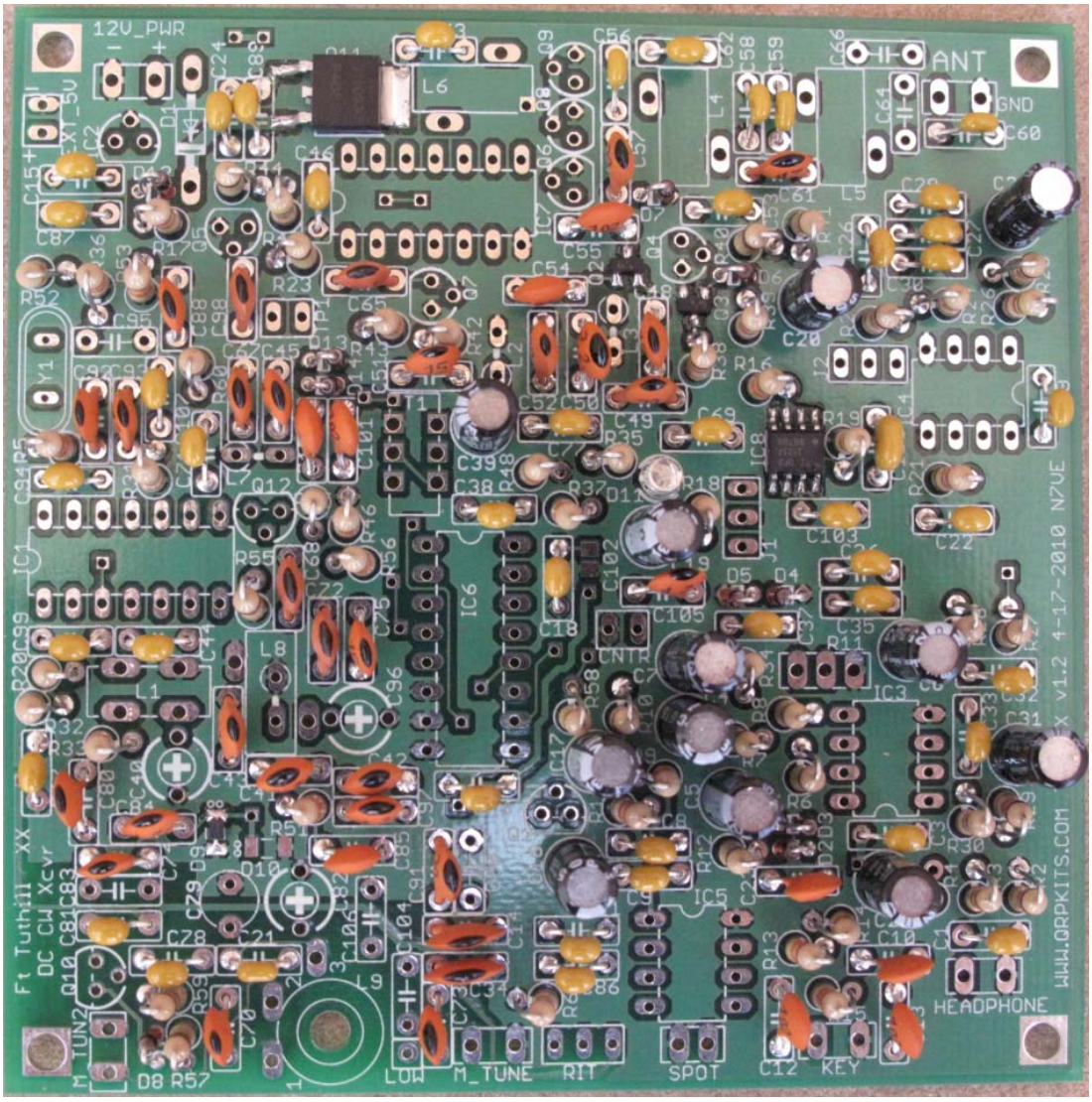

Figure 32. Board with 22, 470 and 2.7K ohm resistors