Assembling Version 2 of the FM Converter Circuit Board

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VE3ILZ

Which version do you have?

- This document applies to version 2 of the board.

- If you have version 1 of the board, please refer to the OTHER FM_Converter_PCB_Assembly document.

Differences between V1 and V2: Physical (things that don’t show up on the schematic)

- Enlarge the solder holes for the external connections.
- Place a hole behind the two potentiometers so they can be adjusted from either side of the board.
- Change layout around PLL to reduce noise coupled into the PLL input terminal.
- Some component had to be moved around.
- Added some labels.
- Note that the board size, mounting holes, general layout has not changed.

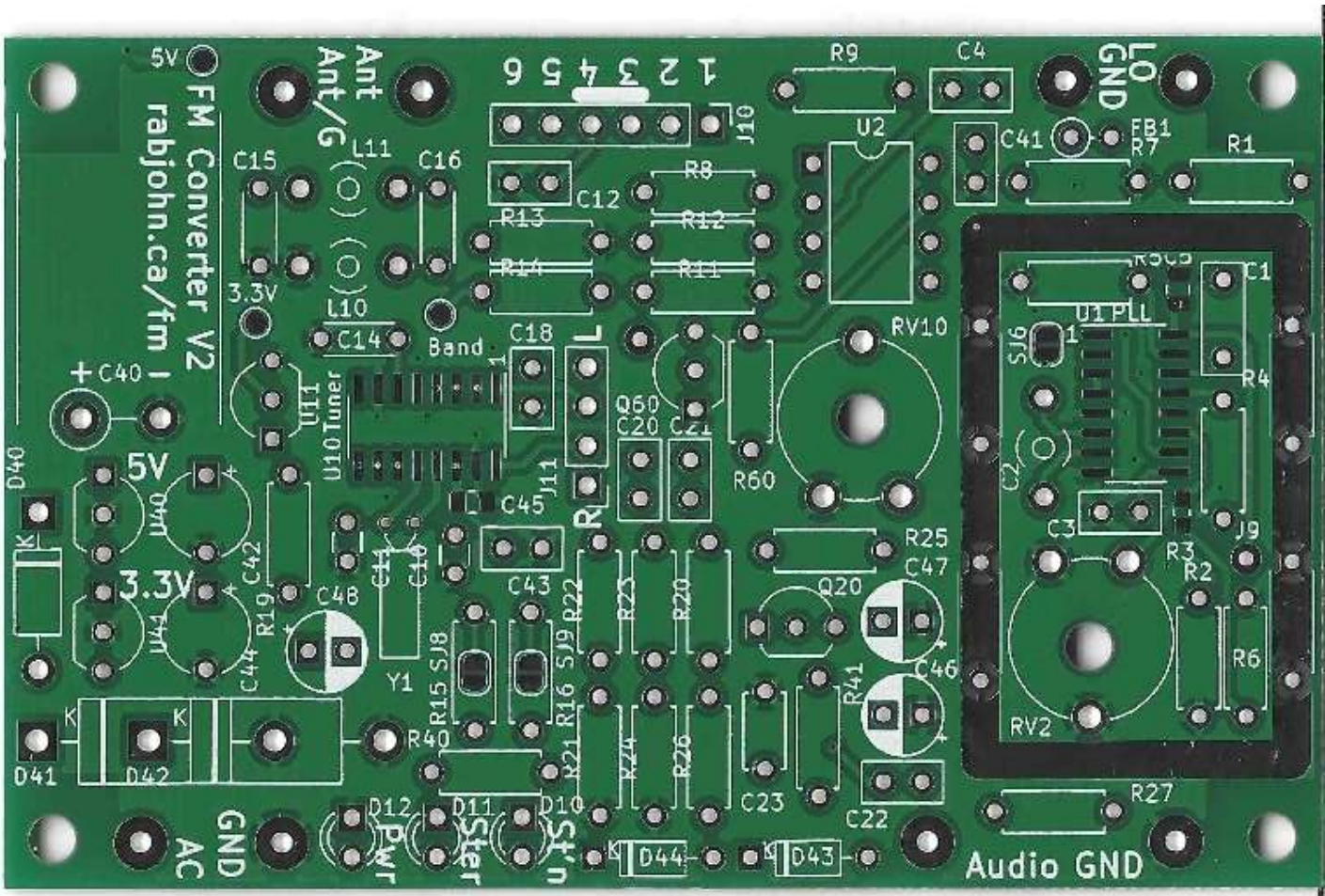
Differences between V1 and V2: Electrical (they show up on the schematic)

- Add provisions (R3, R6) for temperature compensation of the 4046 PLL.
- Add a few test points.
- Make a place for a resistor from VCO pin 9 to ground (see discussion of PLL stability).
- The negative voltage supply is now a doubler to make it more effective as an artificial AGC voltage.
- To make room, some components that were never used in the first version were removed (Resistor from U1 pin 2, C17, former R3).
- Add Q60 and R60 which can be used by the adventurous to make a converter that turns an AM/SW radio into an AM/FM radio (there is a separate document that describes this).

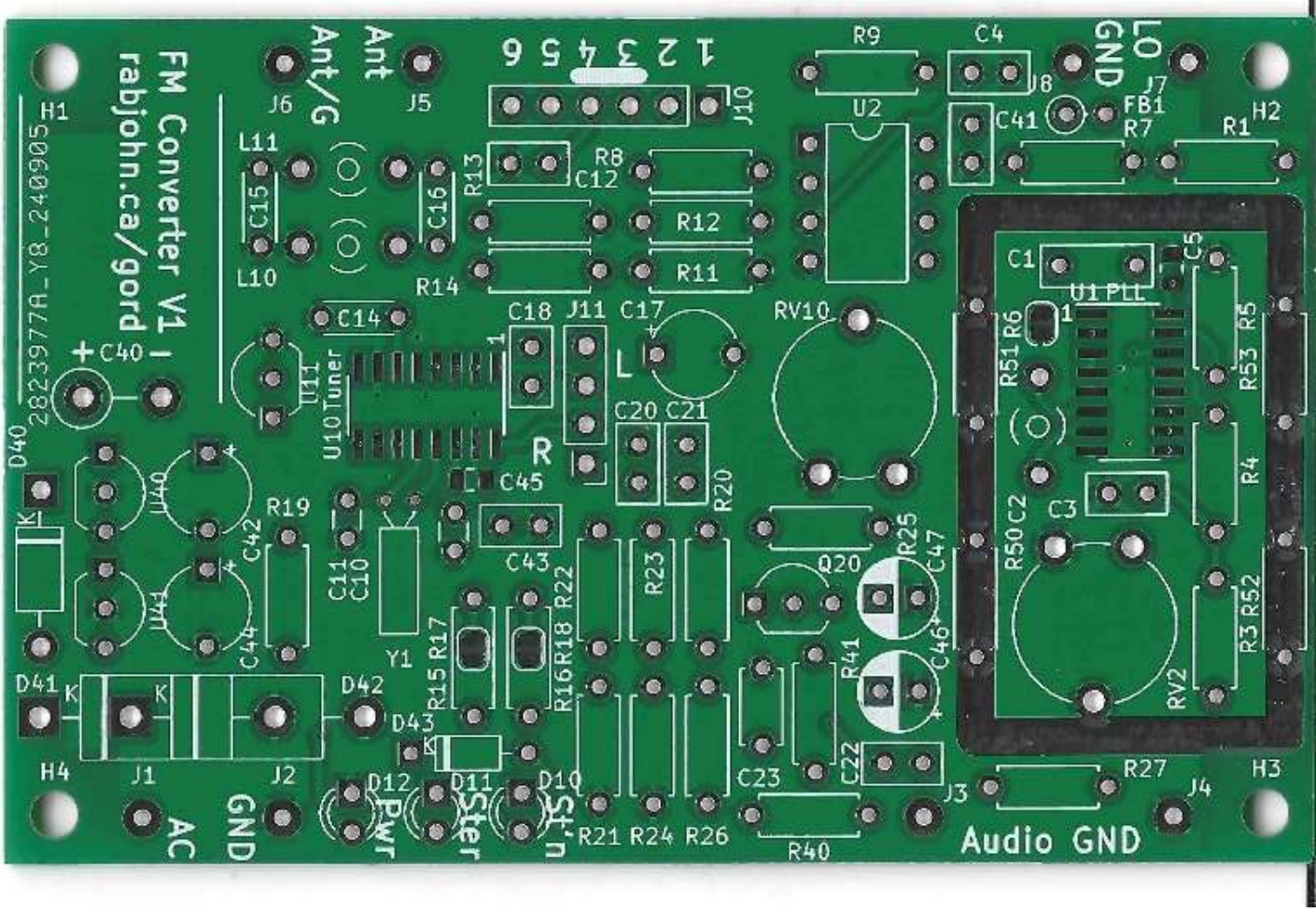
Component Differences between V1 and V2

Component	Version 1	Version 2	Why
R2	Not present	PLL pin 9 to ground	Added for improved stability
R3	Present, DNI	Temp Comp	For temp compensation of 4046
R6	Solder Jumper	Temp Comp	For temp compensation of 4046
SJ6	Not Present	Solder Jumper	Renamed from R6
C48	Not Present	Cap in doubler	Increases voltage from –ve supply
D44	Not Present	Diode in doubler	Increases voltage from –ve supply
C17	Present, DNI	Not Present	Removed to make room
Q60, R60	Not Present	Present	For experimenters

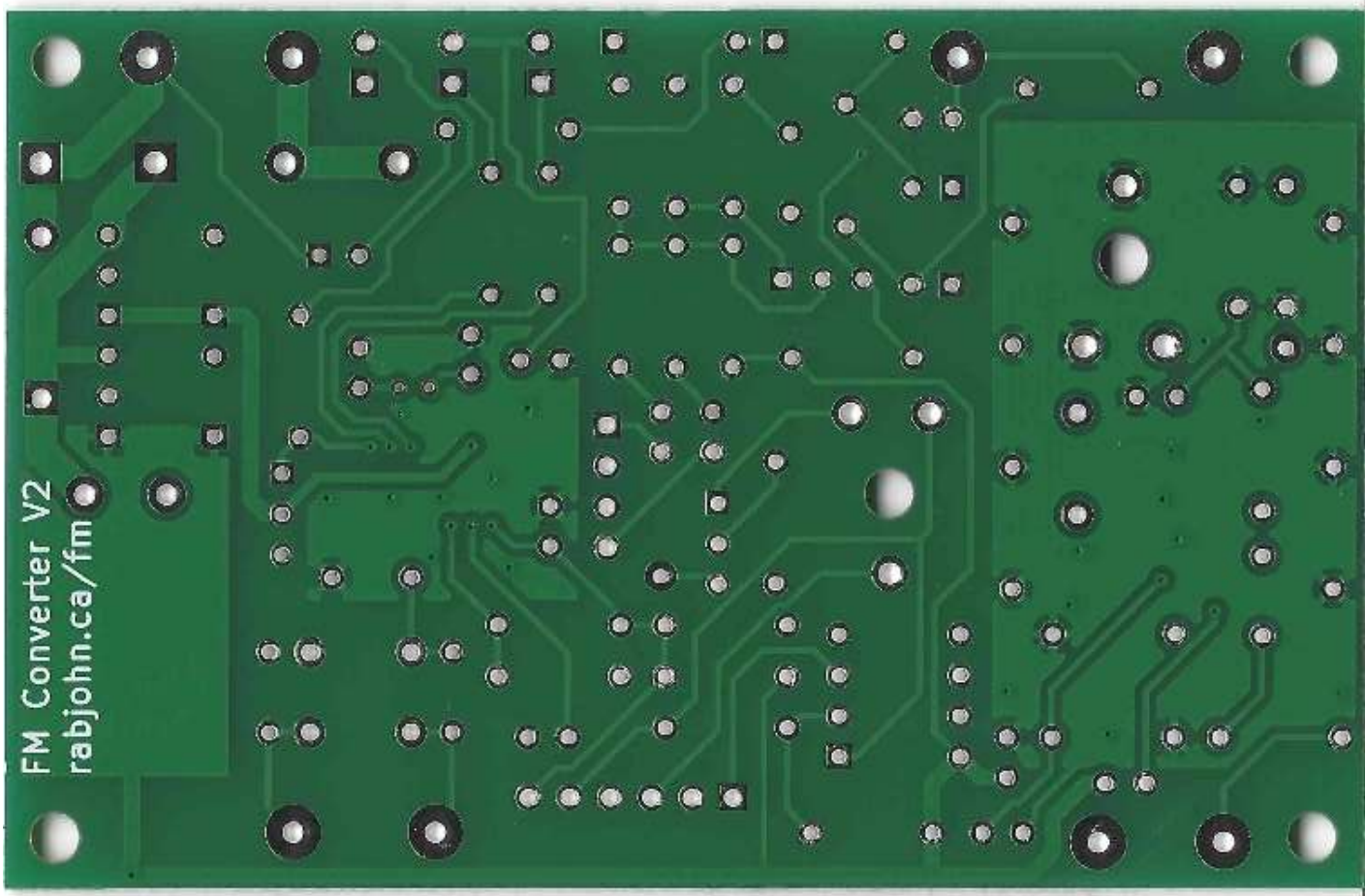
Version 2



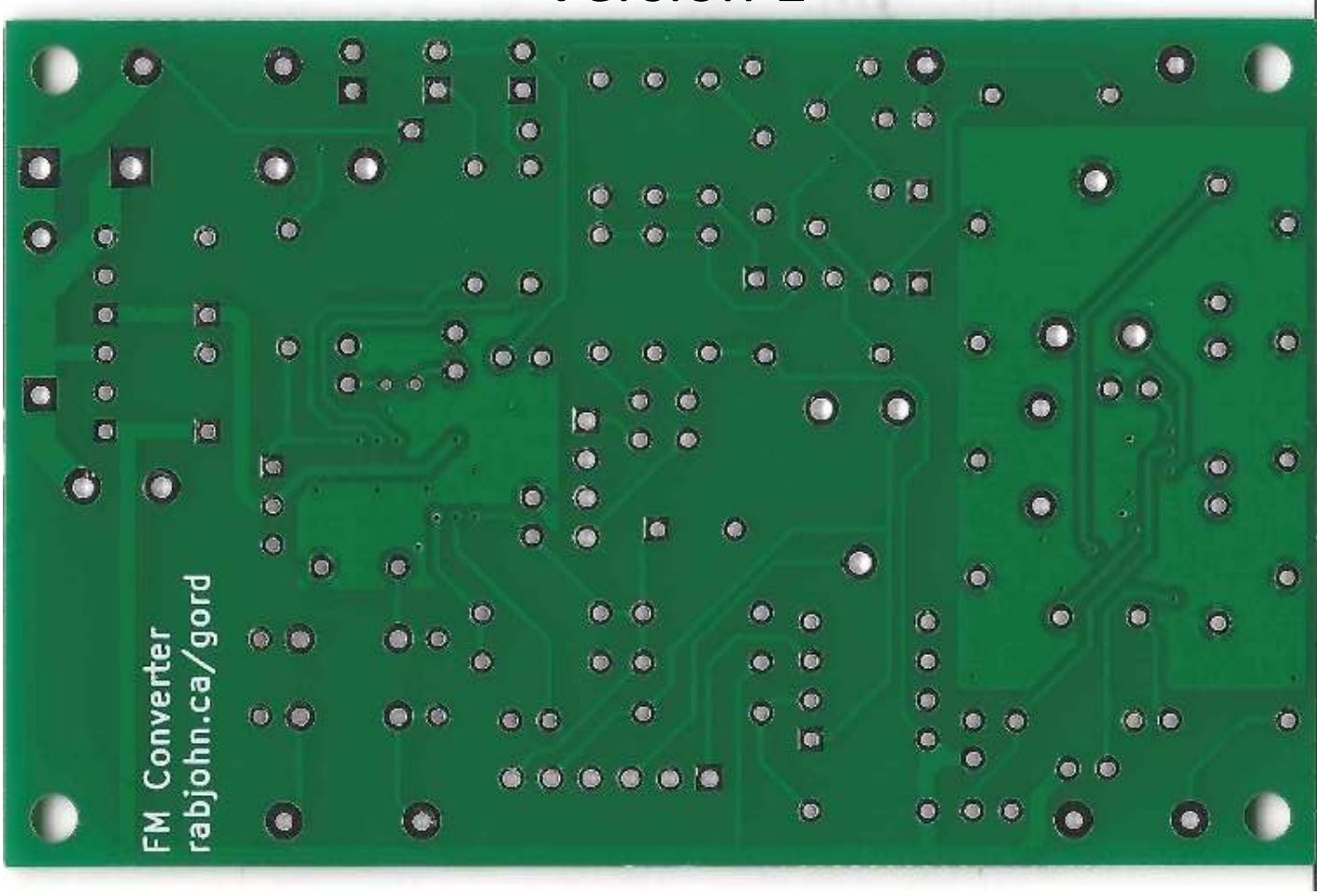
Version 1

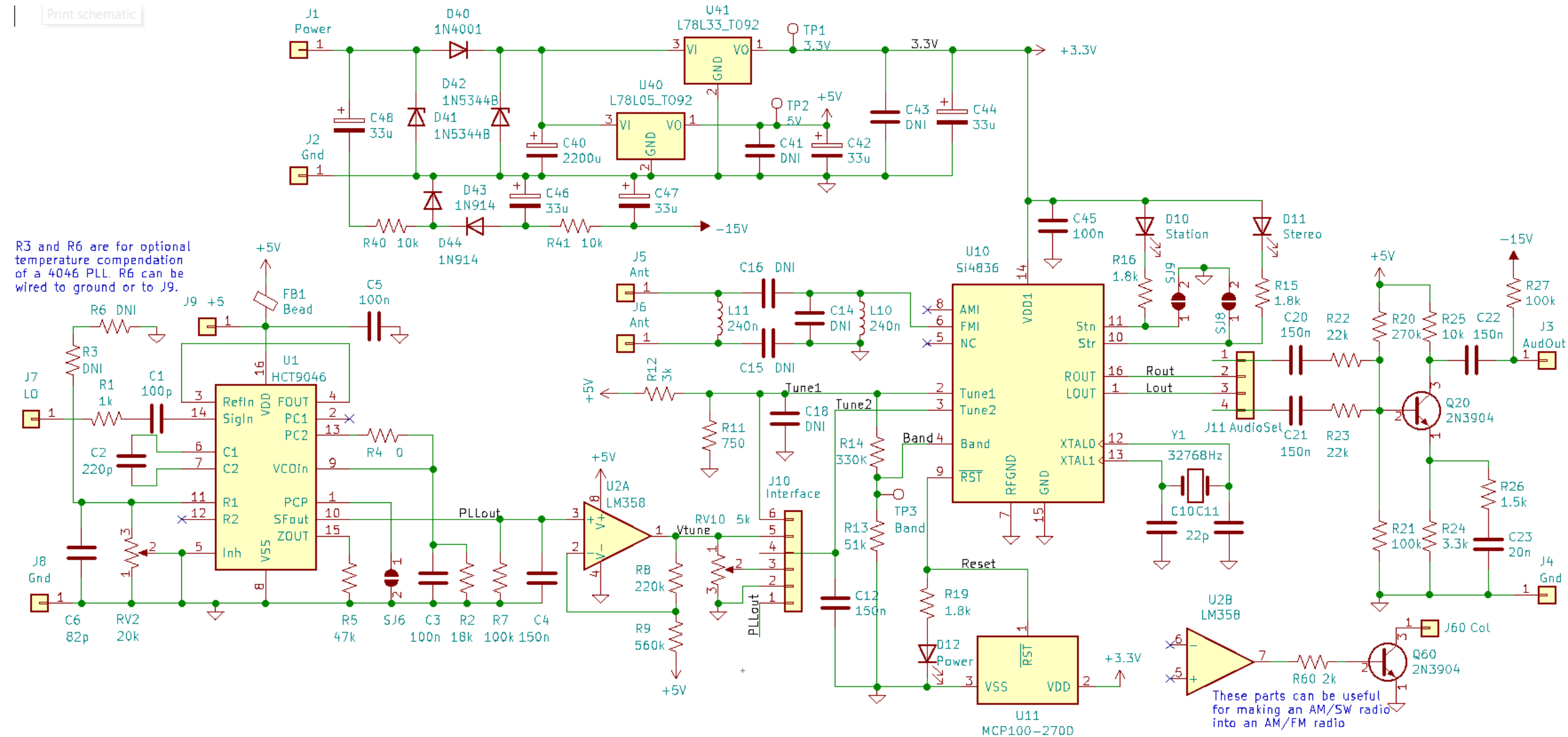


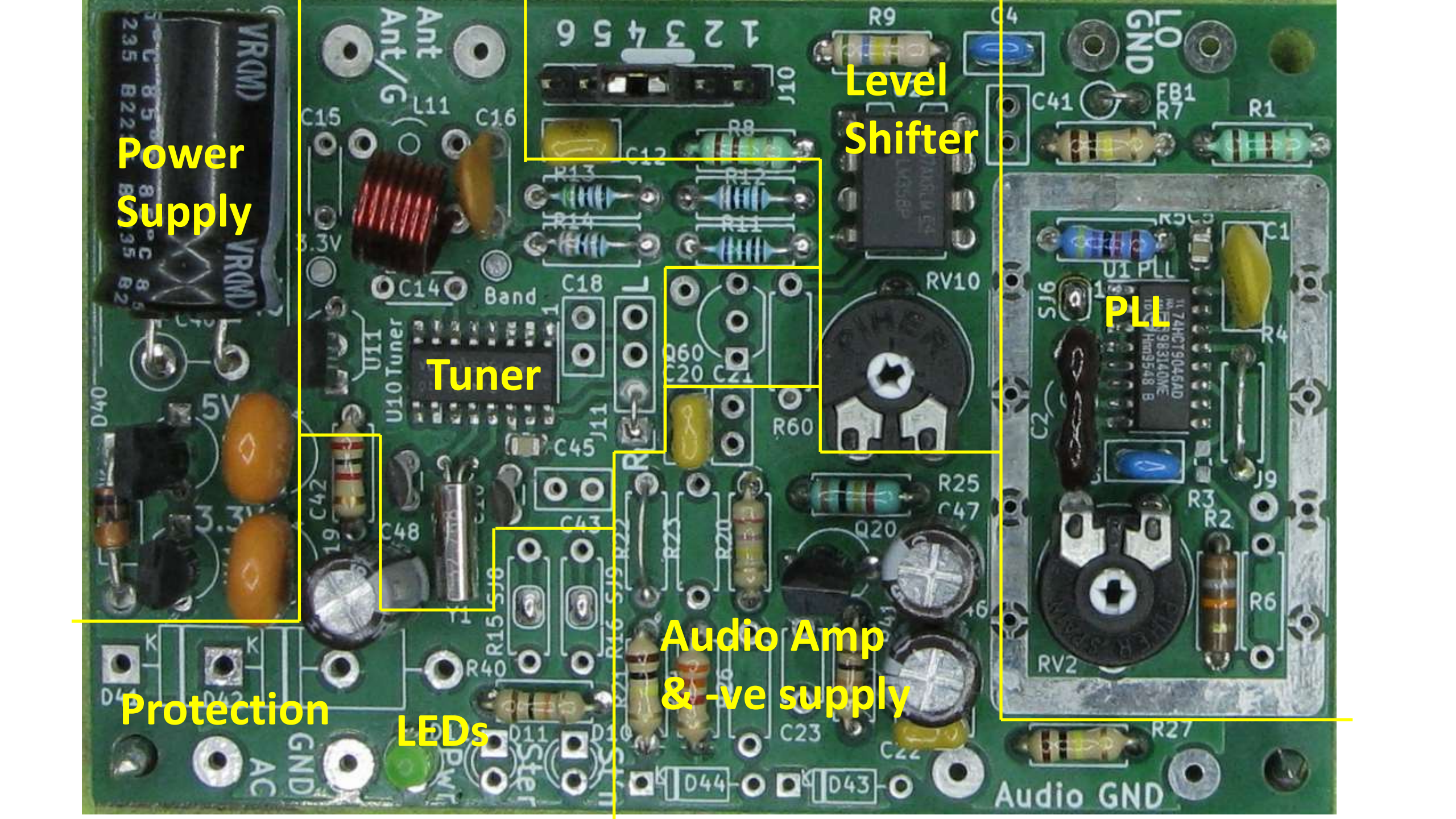
Version 2



Version 1



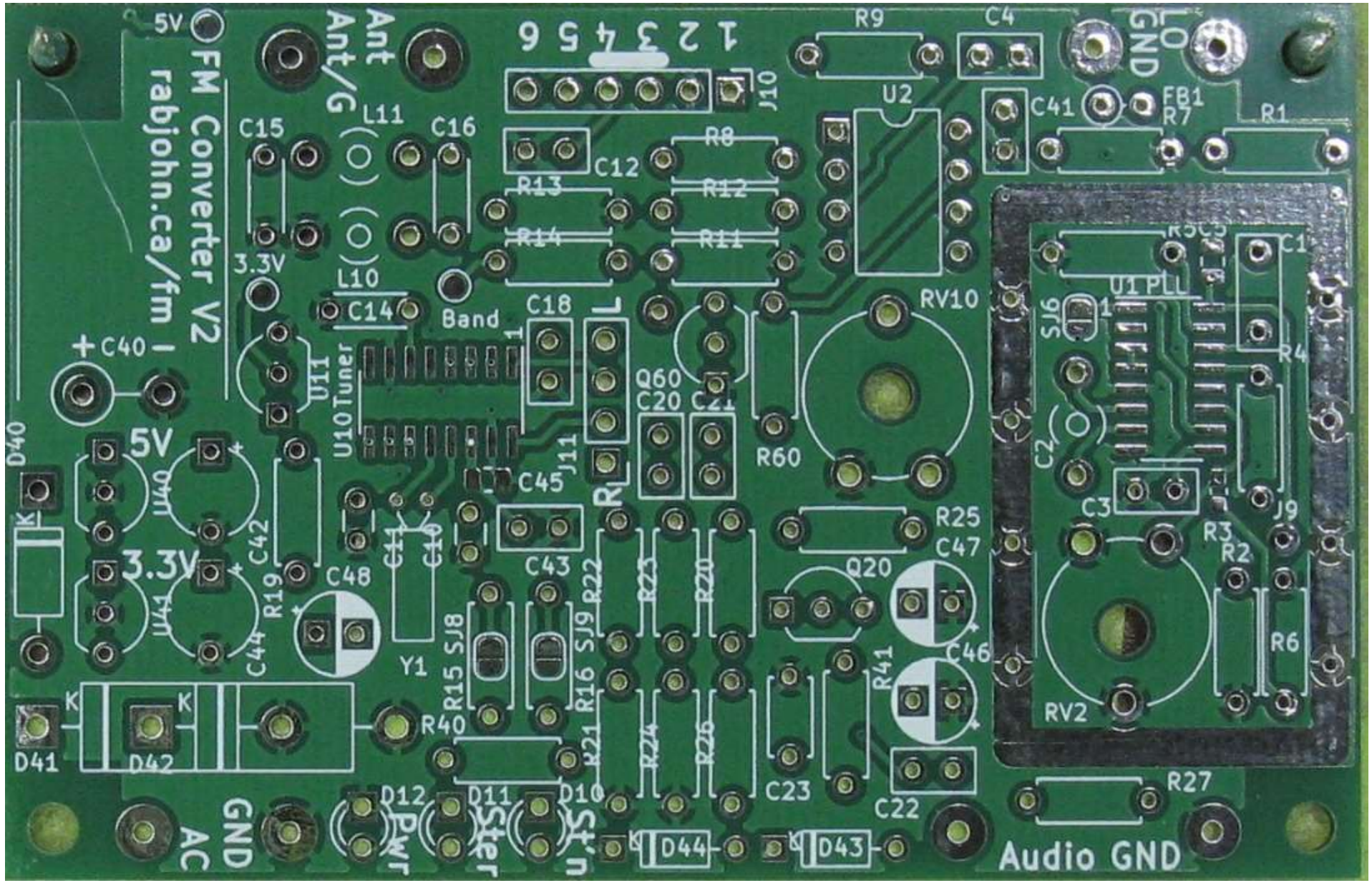

Print schematic
J1
Power
D40
1N4001
U41
L78L33_TO92
TP1
3.3V
3.3V
+3.3V
J2
Gnd
D42
1N5344B
D41
1N5344B
U40
L78L05_TO92
TP2
5V
+5V
C48
33u
C40
2200u
C41
DNI
C42
33u
C43
DNI
C44
33u
D43
1N914
C46
33u
C47
33u
R40 10k
D44
1N914
R41 10k
-15V
R3 and R6 are for optional temperature compendation of a 4046 PLL. R6 can be wired to ground or to J9.
+5V
J9 +5
FB1
Bead
C5
100n
R6 DNI
R3
DNI
J7
LO
R1
1k
C1
100p
U1
HCT9046
RefIn
SigIn
C1
C2
R1
R2
Inh
VDD
VSS
FOUT
PC1
PC2
VCOin
PCP
SFout
ZOUT
C2
220p
R4 0
PLLout
J8
Gnd
C6
82p
RV2
20k
R5
47k
SJ6
C3
100n
R2
18k
R7
100k
C4
150n
+5V
U2A
LM358
RV10 5k
Vtune
RB
220k
R9
560k
+5V
PLLout
J5
Ant
J6
Ant
C16 DNI
L11
240n
C14
DNI
L10
240n
C15 DNI
+5V
R12
3k
R11
750
Tune1
C18
DNI
Tune2
J10
Interface
R14
330k
Band
TP3
Band
R13
51k
C12
150n
U10
Si4836
AMI
FMI
NC
Tune1
Tune2
Band
RST
VDD1
RFGND
GND
Stn
Str
ROUT
LOUT
XTALO
XTAL1
C45
100n
R16
1.8k
D10
Station
D11
Stereo
SJ9
SJ8
R15
1.8k
Rout
Lout
Y1
32768Hz
C10
C11
22p
J11 AudioSel
C20
150n
R22
22k
C21
150n
R23
22k
+5V
-15V
R20
270k
R25
10k
C22
150n
R27
100k
J3
AudOut
Q20
2N3904
R26
1.5k
R21
100k
R24
3.3k
C23
20n
J4
Gnd
Reset
R19
1.8k
D12
Power
U11
MCP100-270D
RST
VSS
VDD
+3.3V
U2B
LM358
R60 2k
J60 Col
Q60
2N3904
These parts can be useful for making an AM/SW radio into an AM/FM radio


Power Supply
Tuner
Level Shifter
PLL
Audio Amp & -ve supply
Protection
LEDs
Audio GND

Choices

- Tuner chip: Use a Si4825 or a Si4836. Si4836 is stereo, and has indicator LEDs, but Si4825 is cheaper and works as well.
- Antenna coupling: Transformer coupling for a balanced twinlead antenna (like a folded dipole) or single-ended coupling for a single wire antenna. Single-ended is easy and works well.
- PLL chip: A 74HCT9046 is highly recommended. A 74HC4046 will do in a pinch but needs temperature compensation (discussed in main document).
- Higher voltage electrolytic caps needed if operated from 12VAC.
- Schottky rectifier and 5V LDO required if operated from 6VDC.
- Protection, negative DC supply: depends on application.

Assembly Instructions. 0. Bare Board



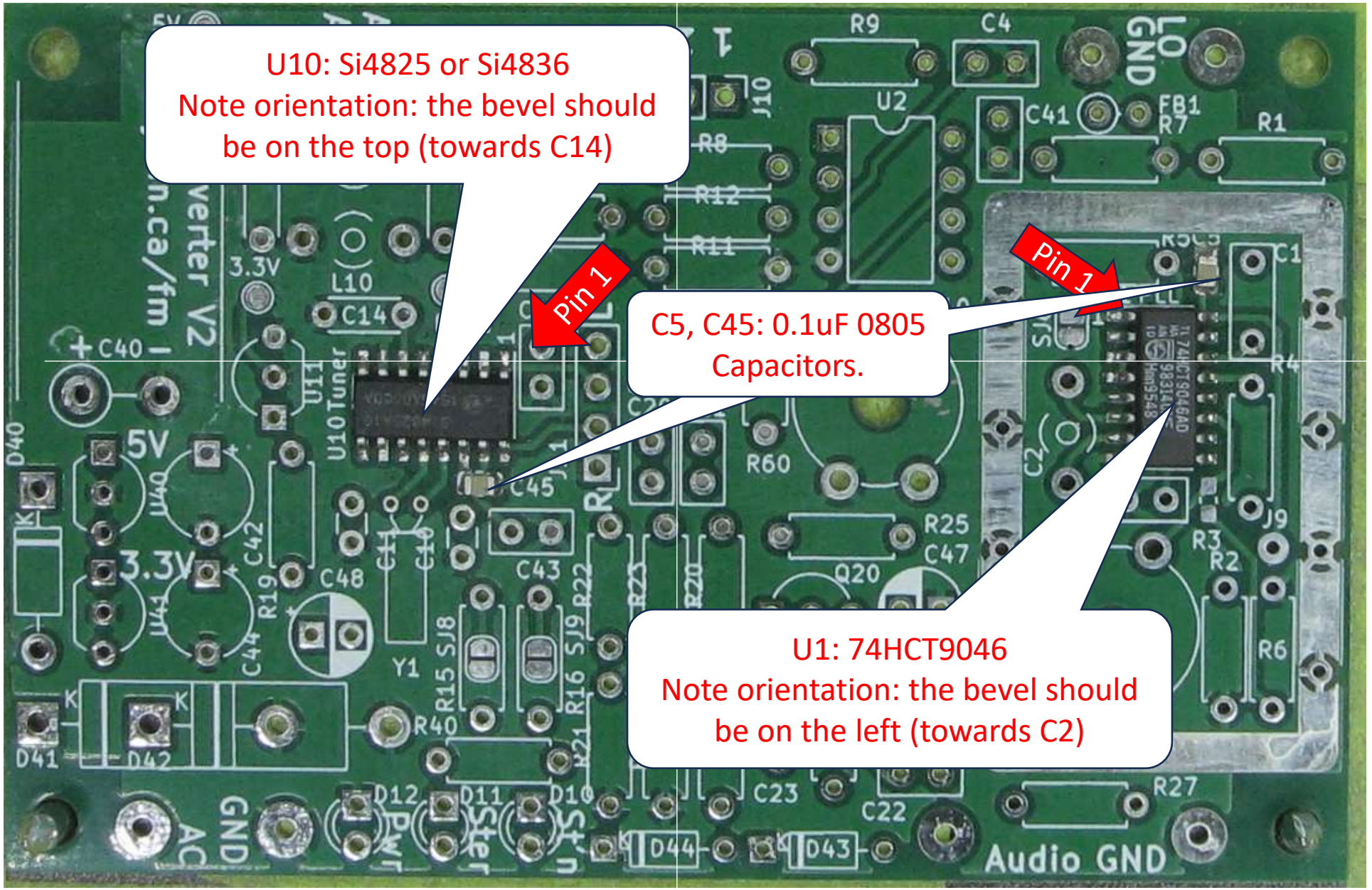
Soldering the SMT components

- I recommend using lead-tin solder paste. (lead-free is more difficult to work with) (this is not flux! this is solder in a paste form)
- Place paste on the solder pads for the two SMT ICs and the two SMT caps. You'll need a microscope unless you are very experienced. I use a toothpick.
- Plunk the ICs into the paste.
- I recommend: Use a hot plate to get the board up to ~100-150C, then use a fine tipped soldering iron for local heating. You can melt the solder paste on a single pin to secure the IC in place, then solder the rest of the pins one at a time. Easy to touch-up.
- Alternatively, reflow the solder paste using either:
  - Hot plate at about 220C
  - Hot air gun (use low air flow so you do not dislodge the components)
  - Oven (makes adjusting on-the-fly more difficult). Toaster oven may be OK.
- There are those who can do this all with just a fine soldering iron. Not me!
- Clean with flux remover. Remove excess solder paste.

Electrostatic Discharge Precautions

- Semiconductors (especially the integrated circuits) can be damaged by electrostatic discharge (ESD).
- Familiarize yourself with proper handling procedures.
- Days with low humidity are the worst. Cold winter days are particularly bad, and can be exacerbated because of thick sweaters that generate static electricity. Use an ESD smock.
- Use a wrist strap to leak charge off of your body.
- Make sure the soldering iron tip has a path to ground.
- Keep parts in their ESD-safe bags until they are needed.

Assembly Instructions. 1. SMD

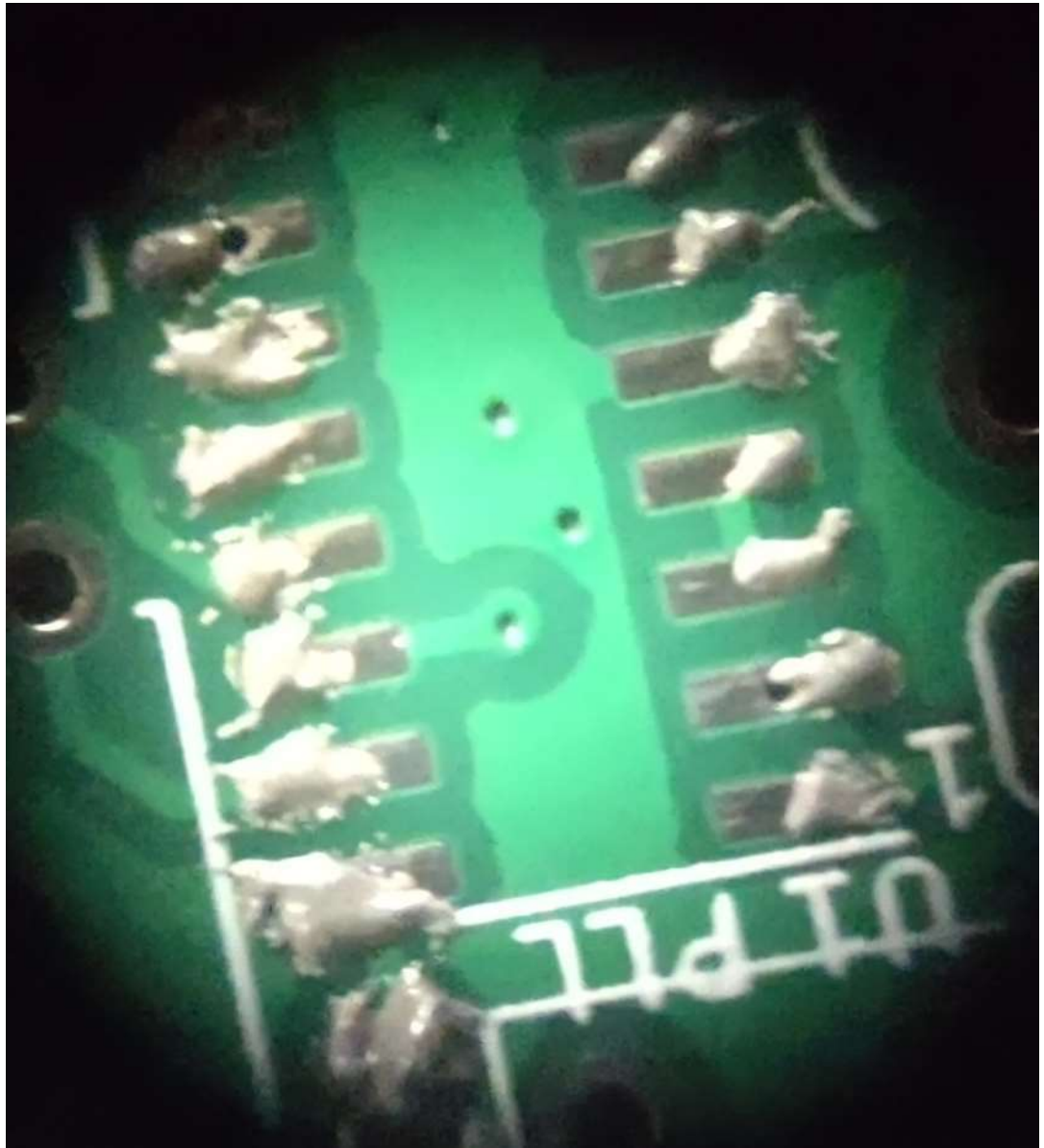


Although this board can accommodate a 74HC4046 PLL, it is not recommended, as it is less temperature stable.

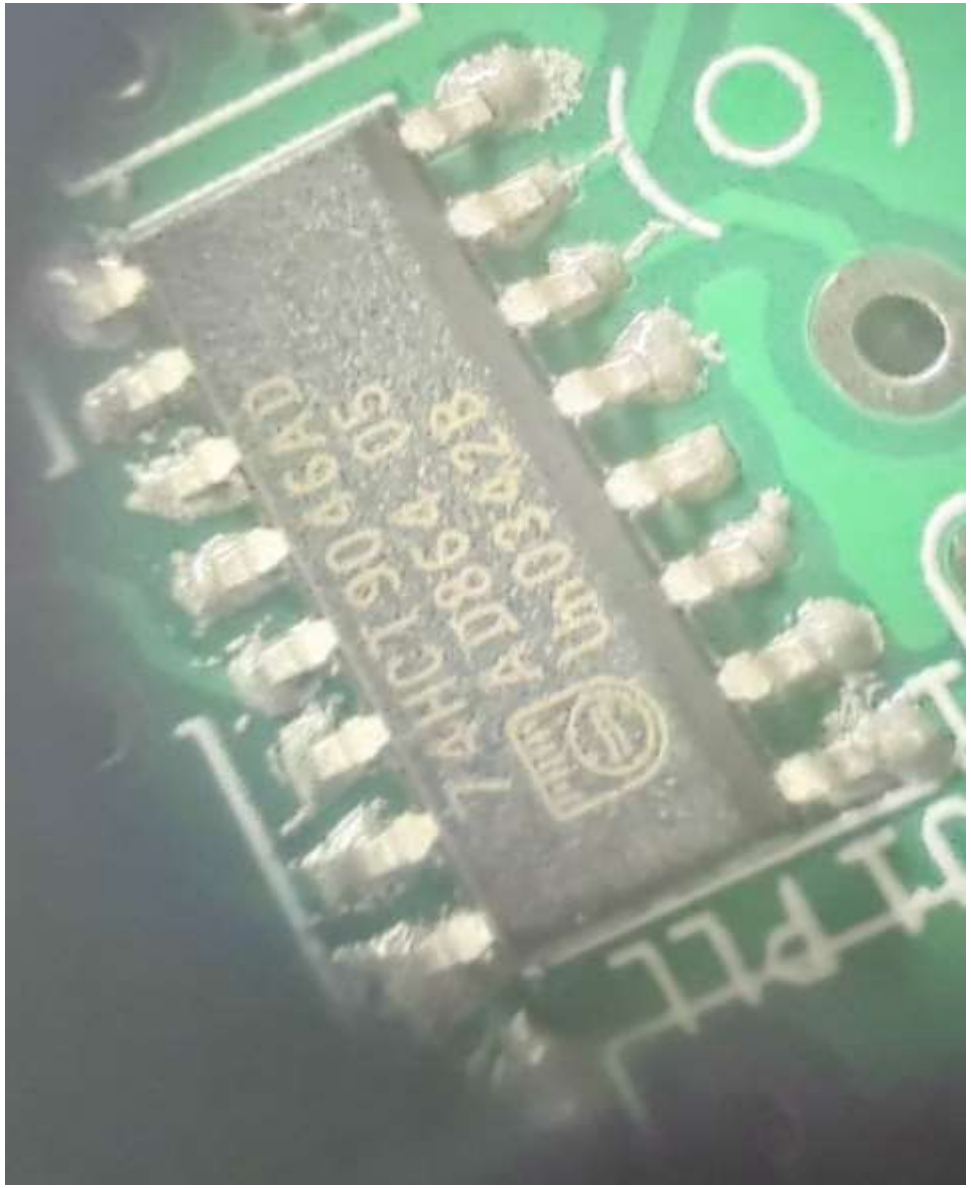
If you must use it, be prepared to add temperature compensation.

Assembly Instructions. 1. SMD

Blobs of solder paste on each pad

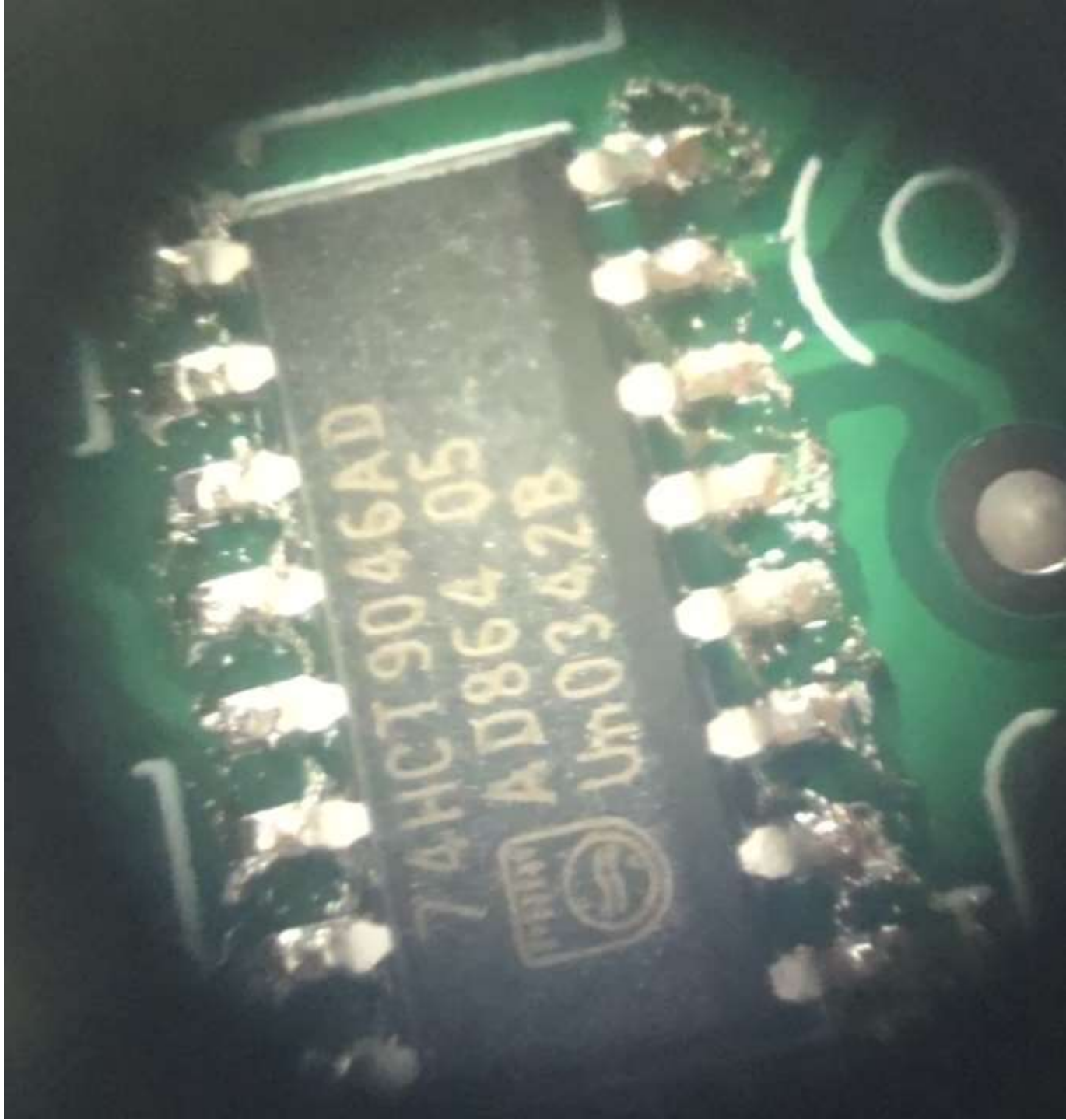


Drop the IC into the paste



Assembly Instructions. 1. SMD

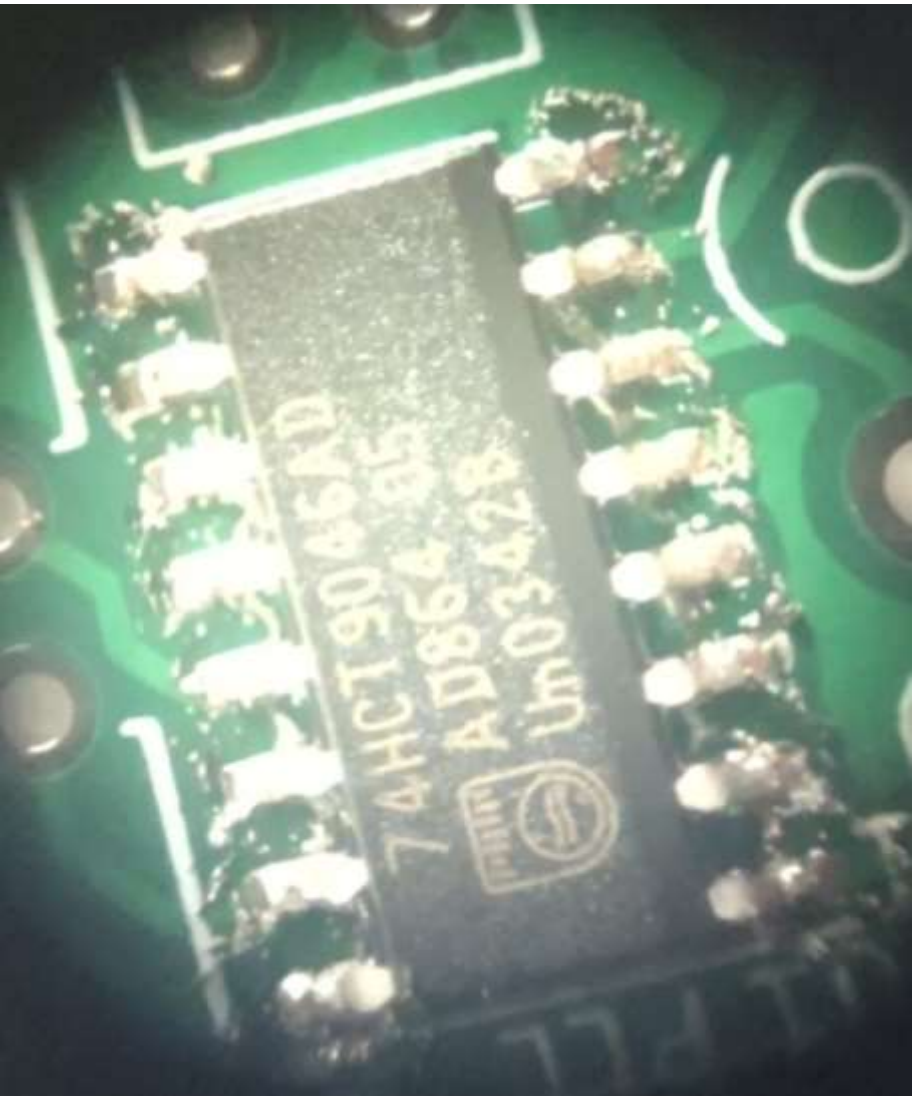
Heat the board to ~100-150 C.
Reflow one pin with a fine-tip iron to get the IC in the right location.
Reflow each pin..
Solder-wick can remove excess solder if necessary.



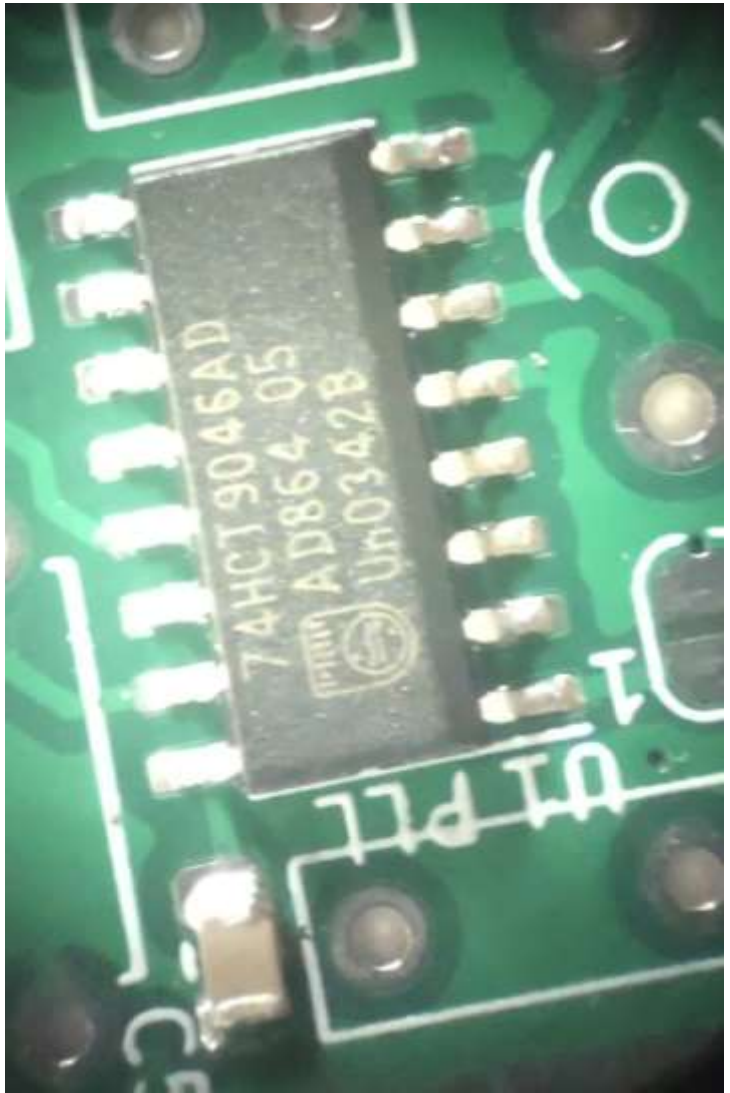
Assembly Instructions. 1. SMD

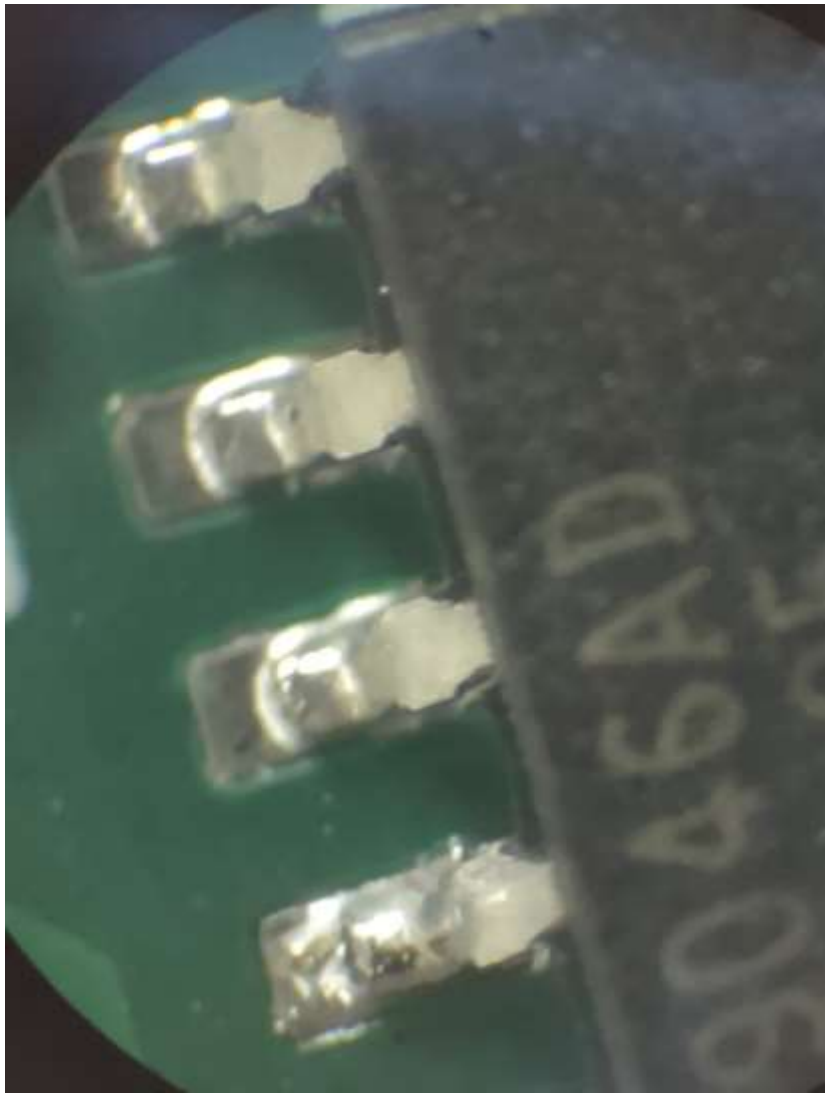
Clean the board up with flux remover. Inspect each pin.

Before Flux Cleaning

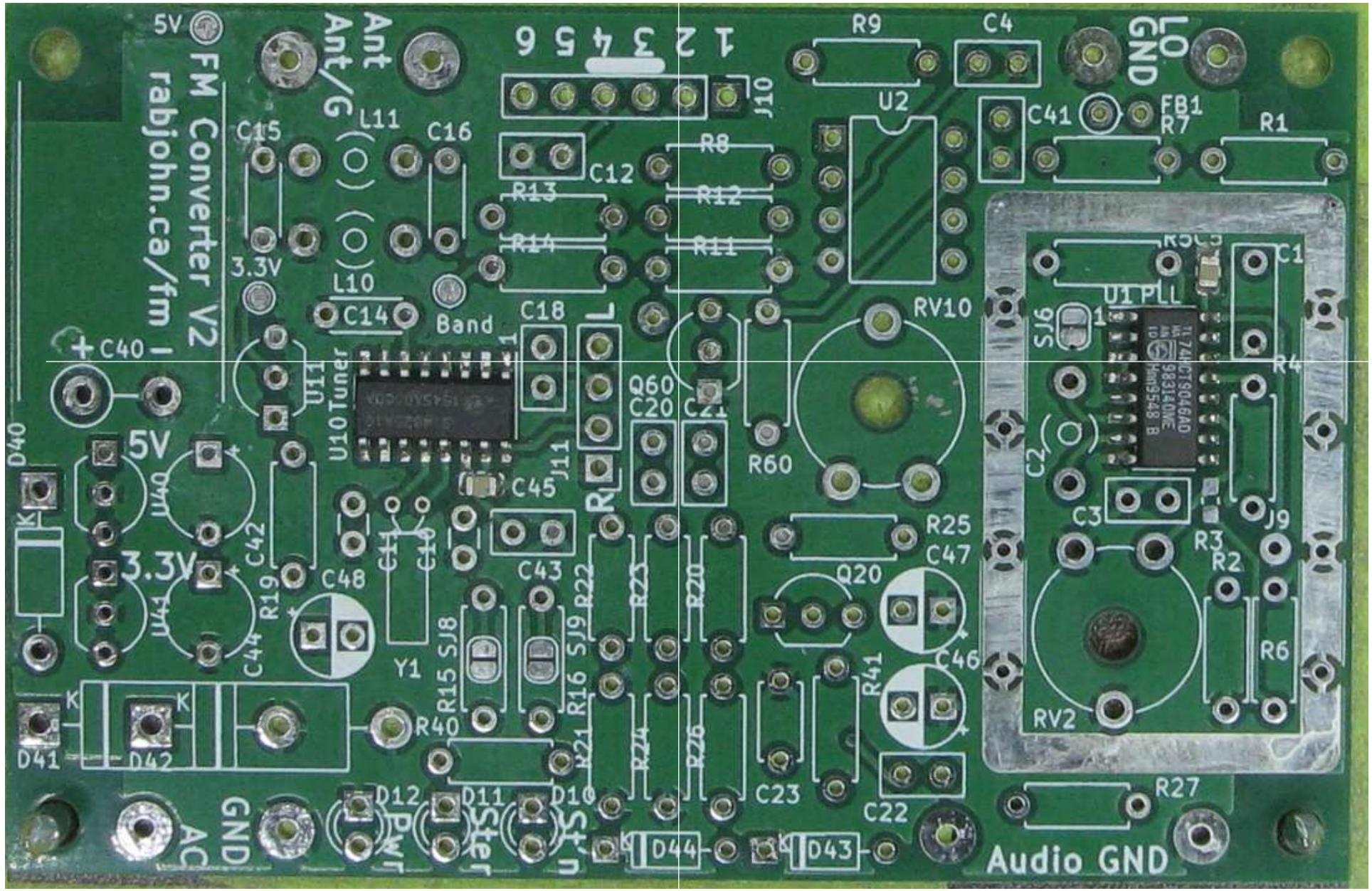


After Flux Cleaning

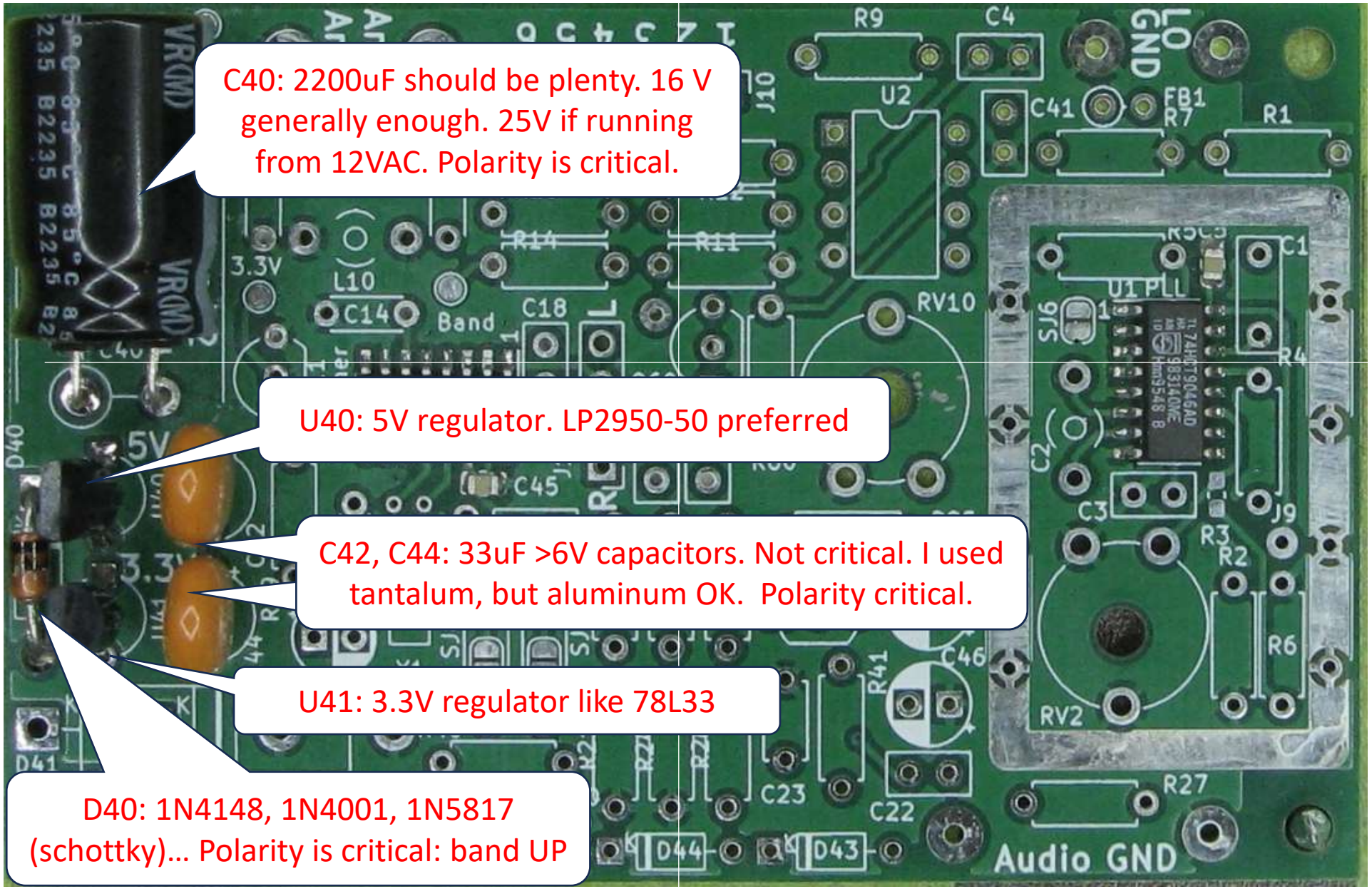




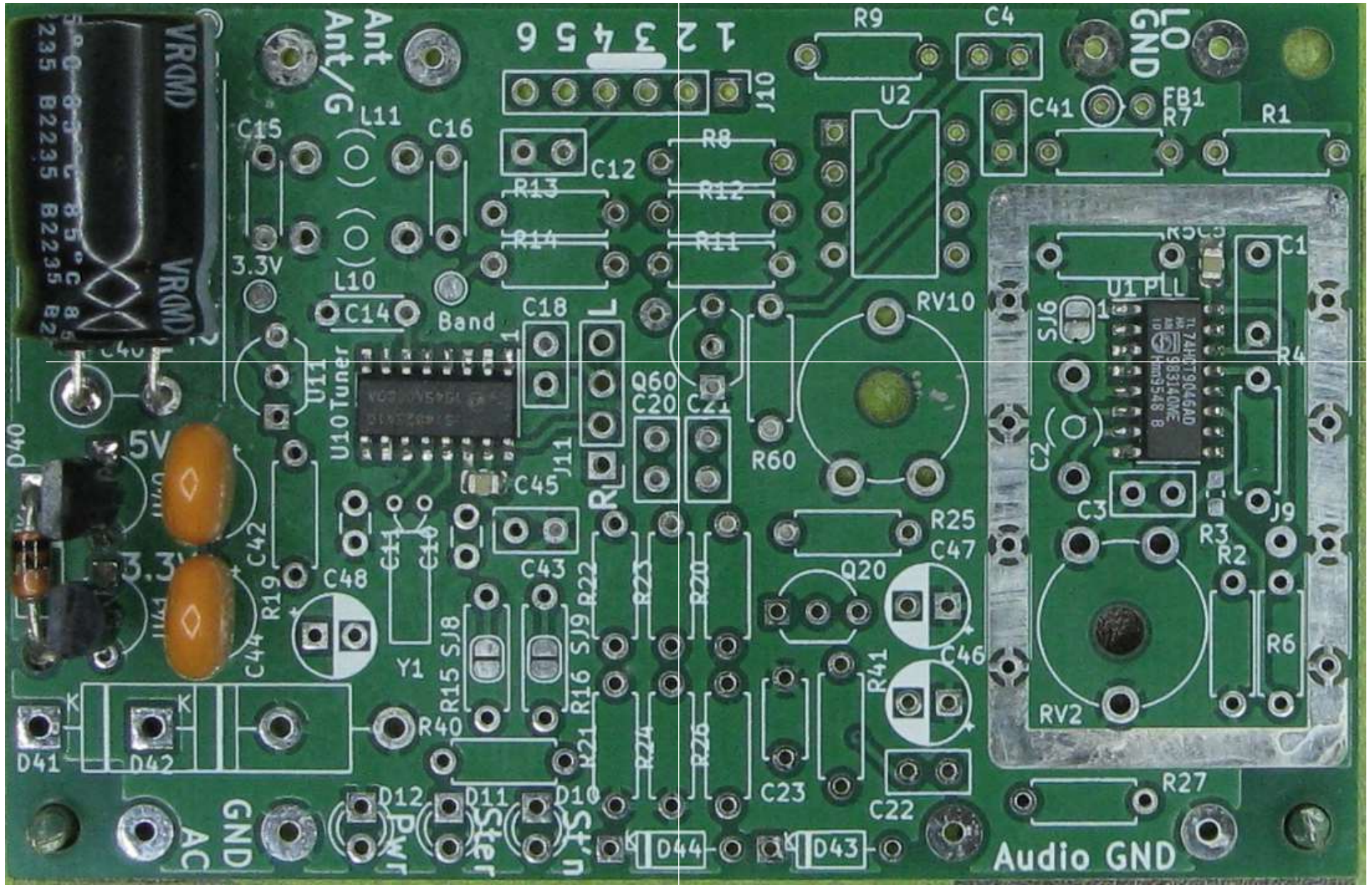
Assembly Instructions. 1. SMD



Assembly Instructions. 2. Power Supply

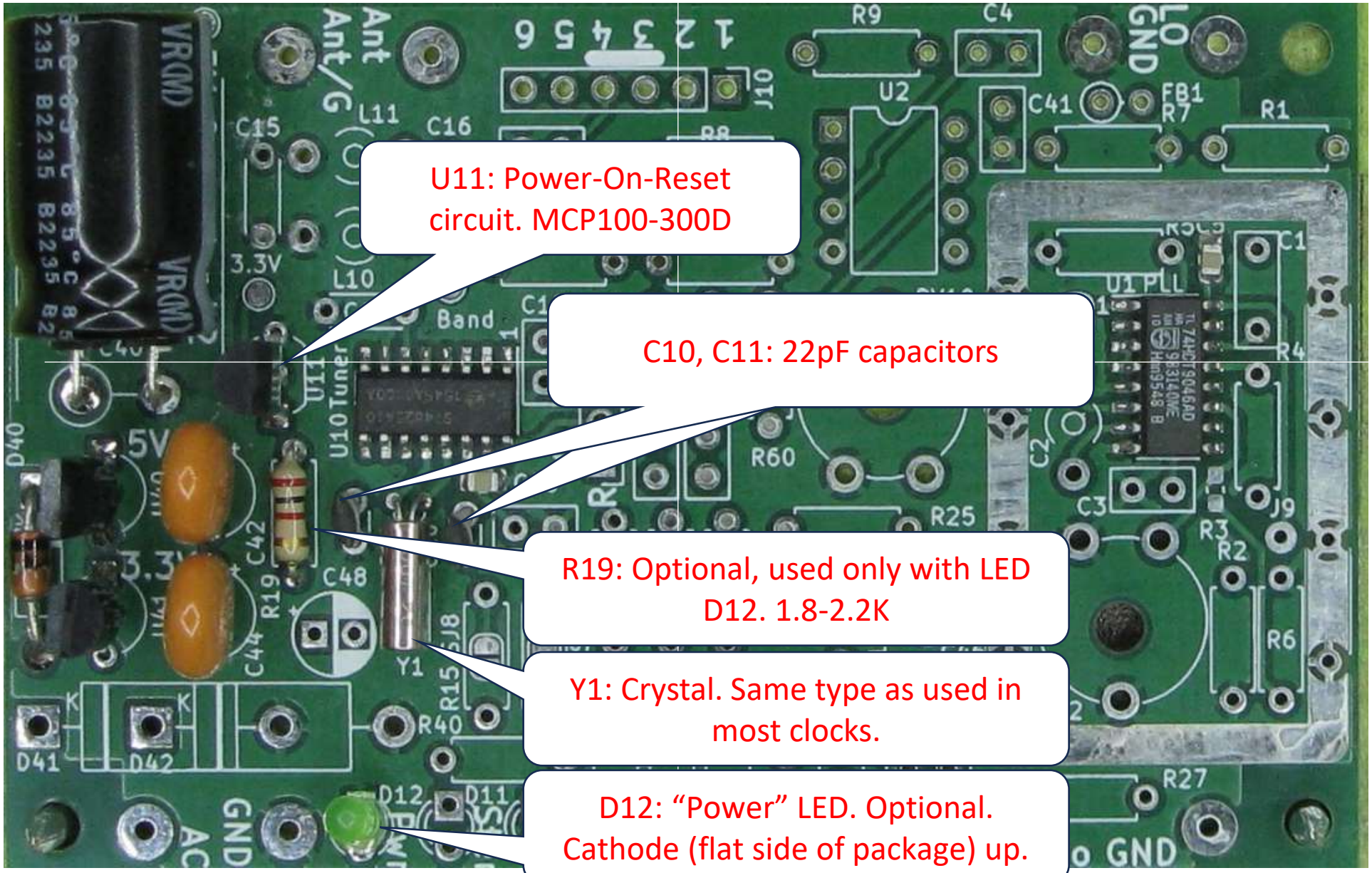


Assembly Instructions. 2. Power Supply

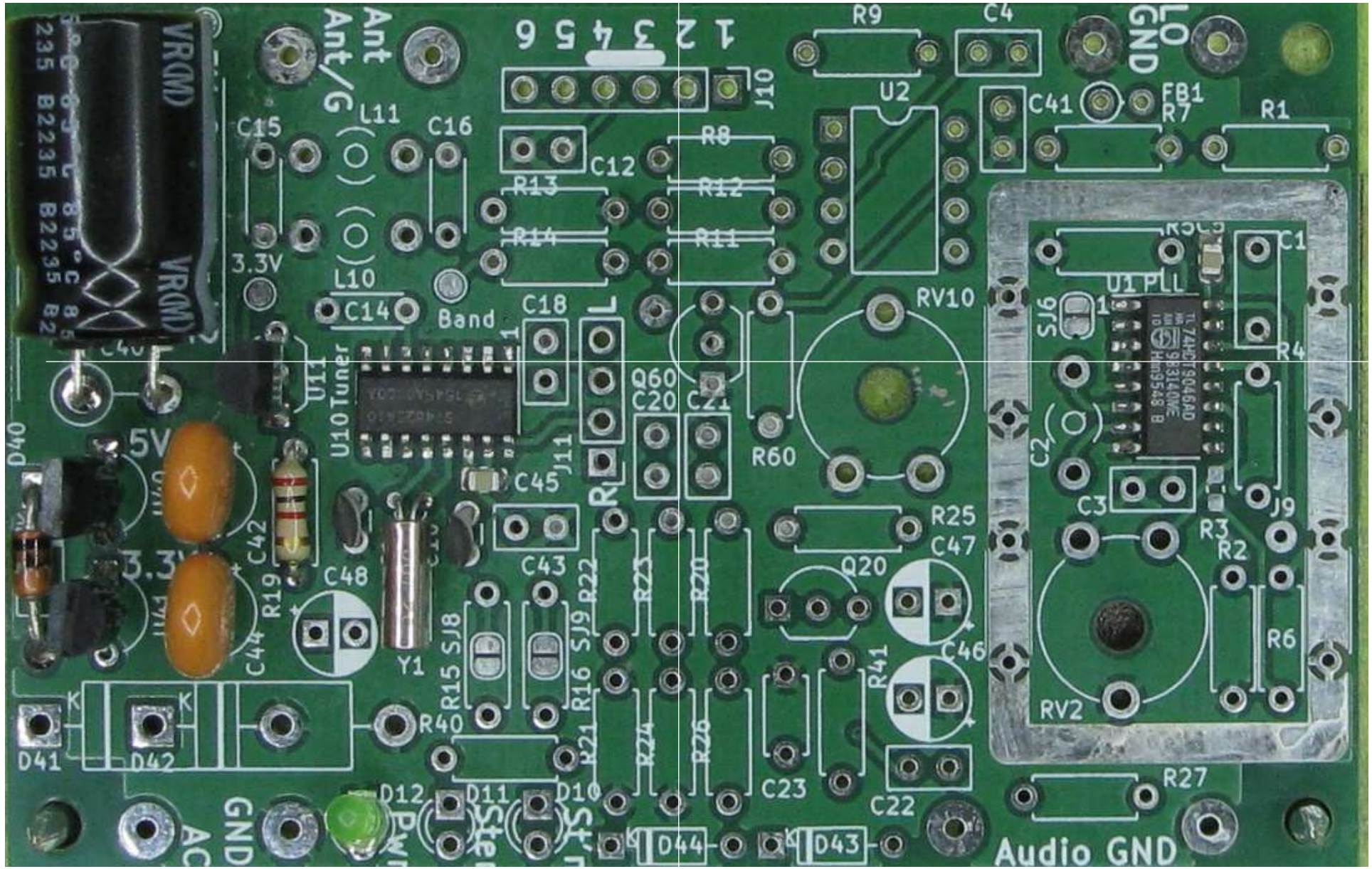


You can test the power supply. (3.3V & 5.0V)

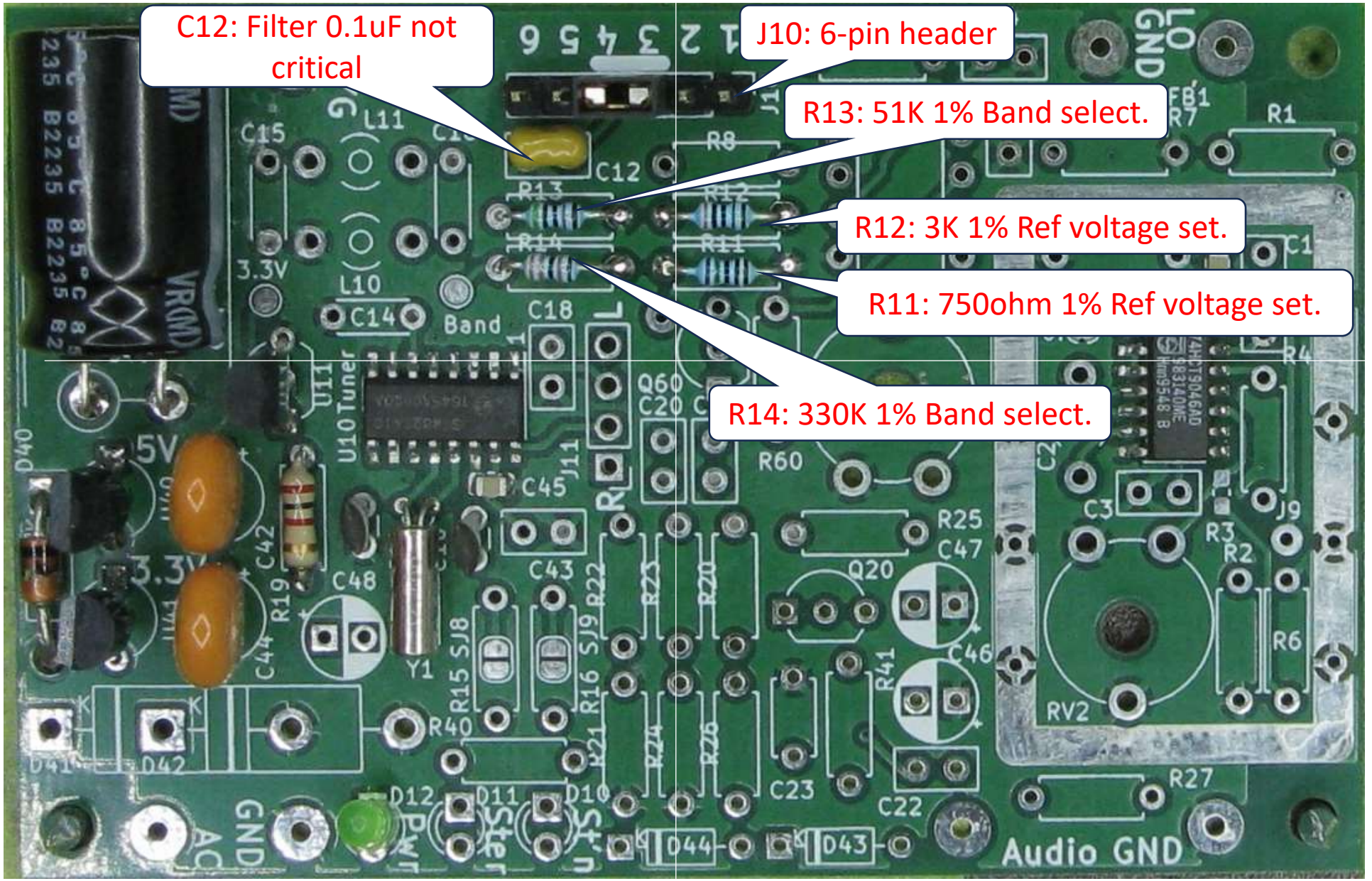
Assembly Instructions. 3. Parts surrounding FM tuner



Assembly Instructions. 3. Parts surrounding FM tuner

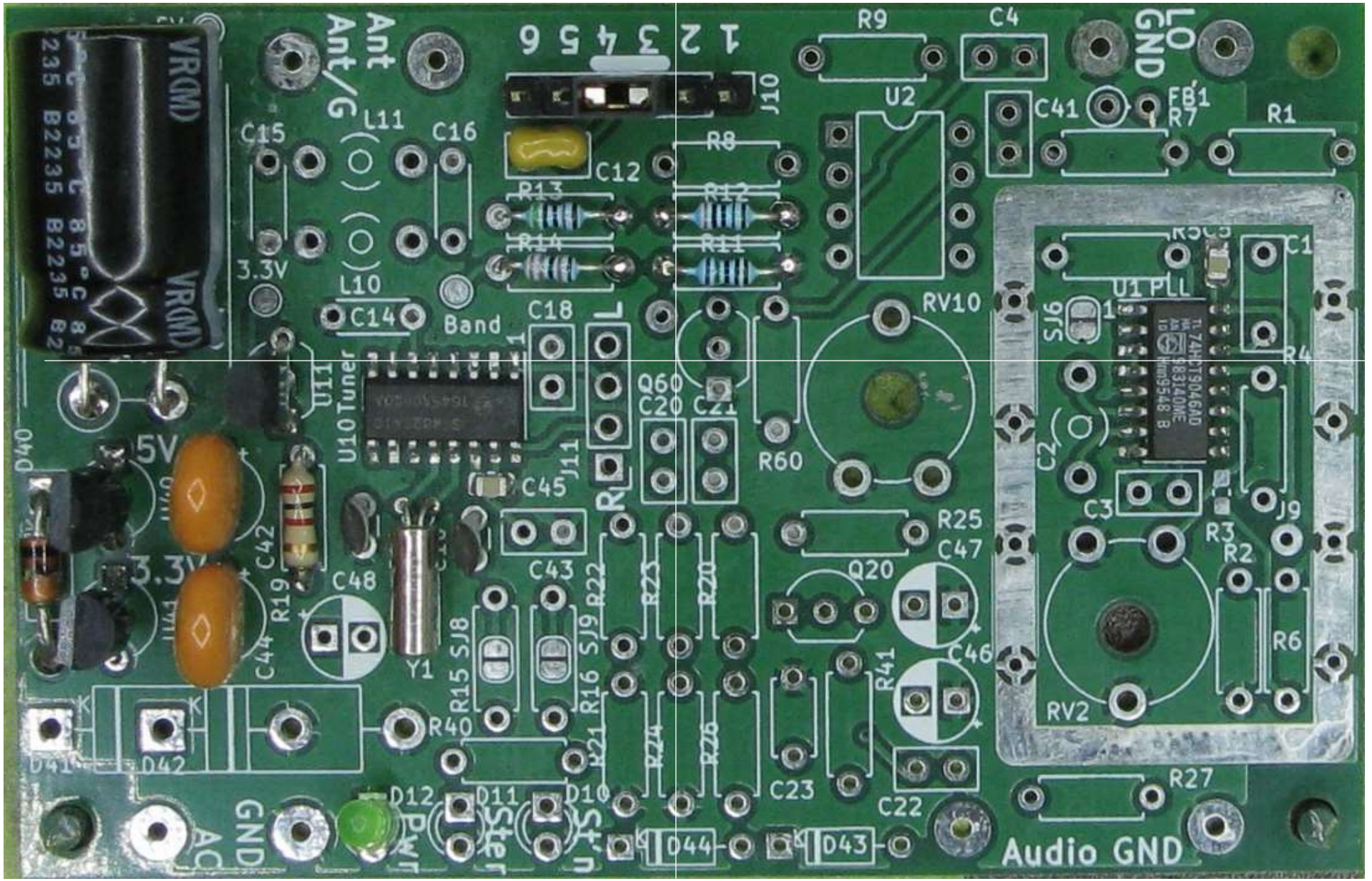


Assembly Instructions. 4. Parts surrounding FM tuner

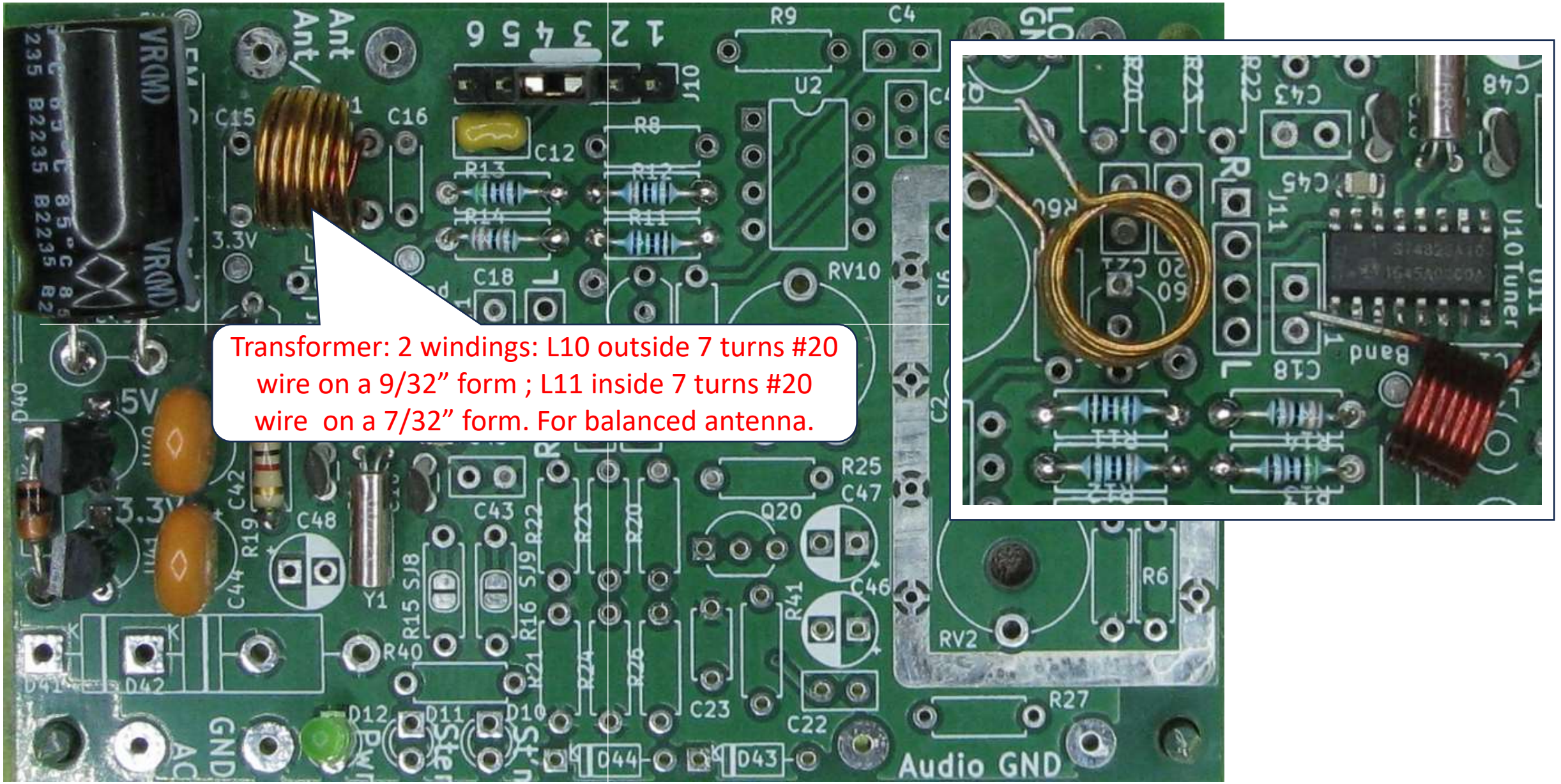


R13, R14 select the band of operation, and deemphasis options. See Si4825/4836 data sheet and application data for other band options.

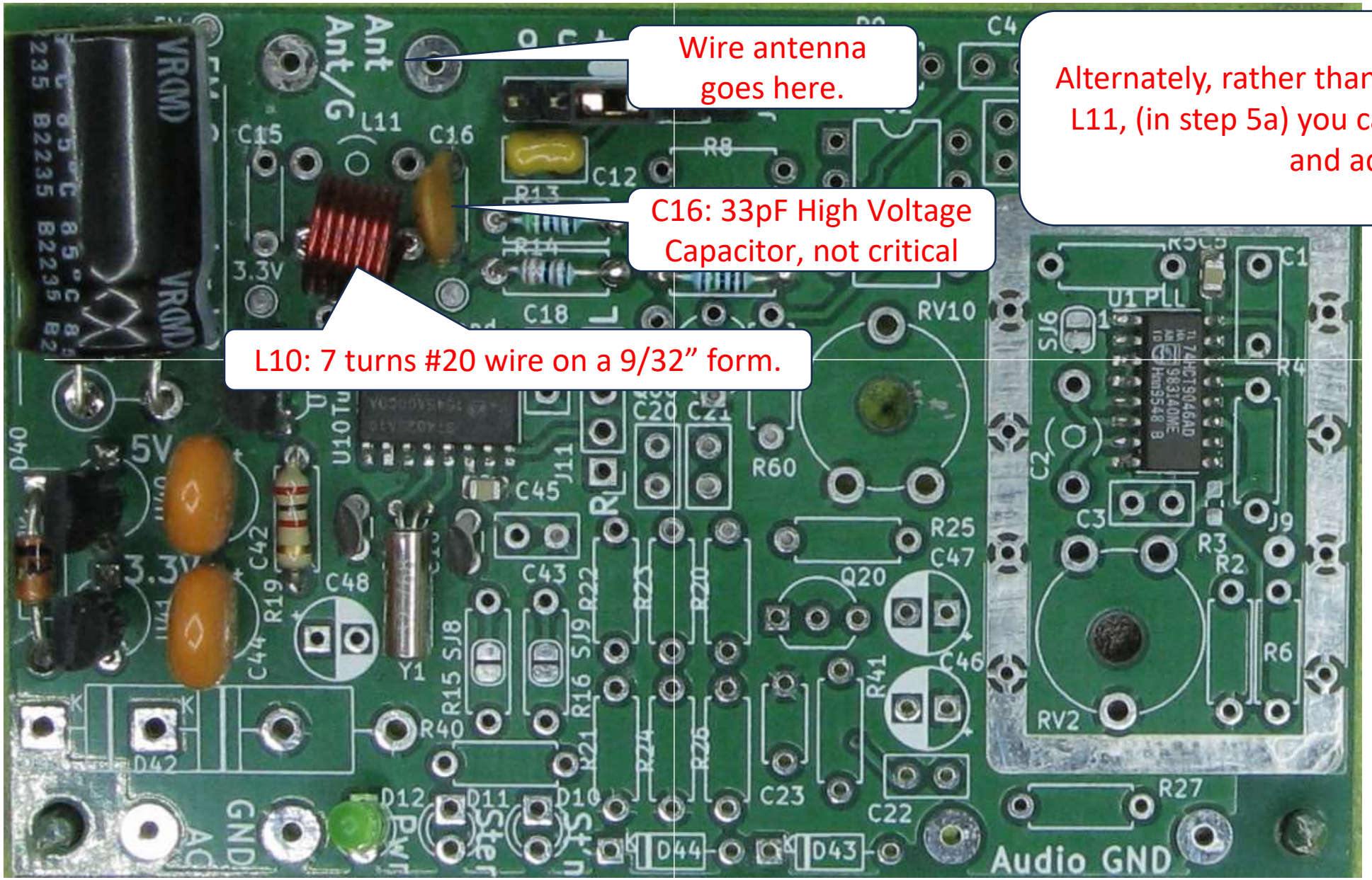
Assembly Instructions. 4. Parts surrounding FM tuner



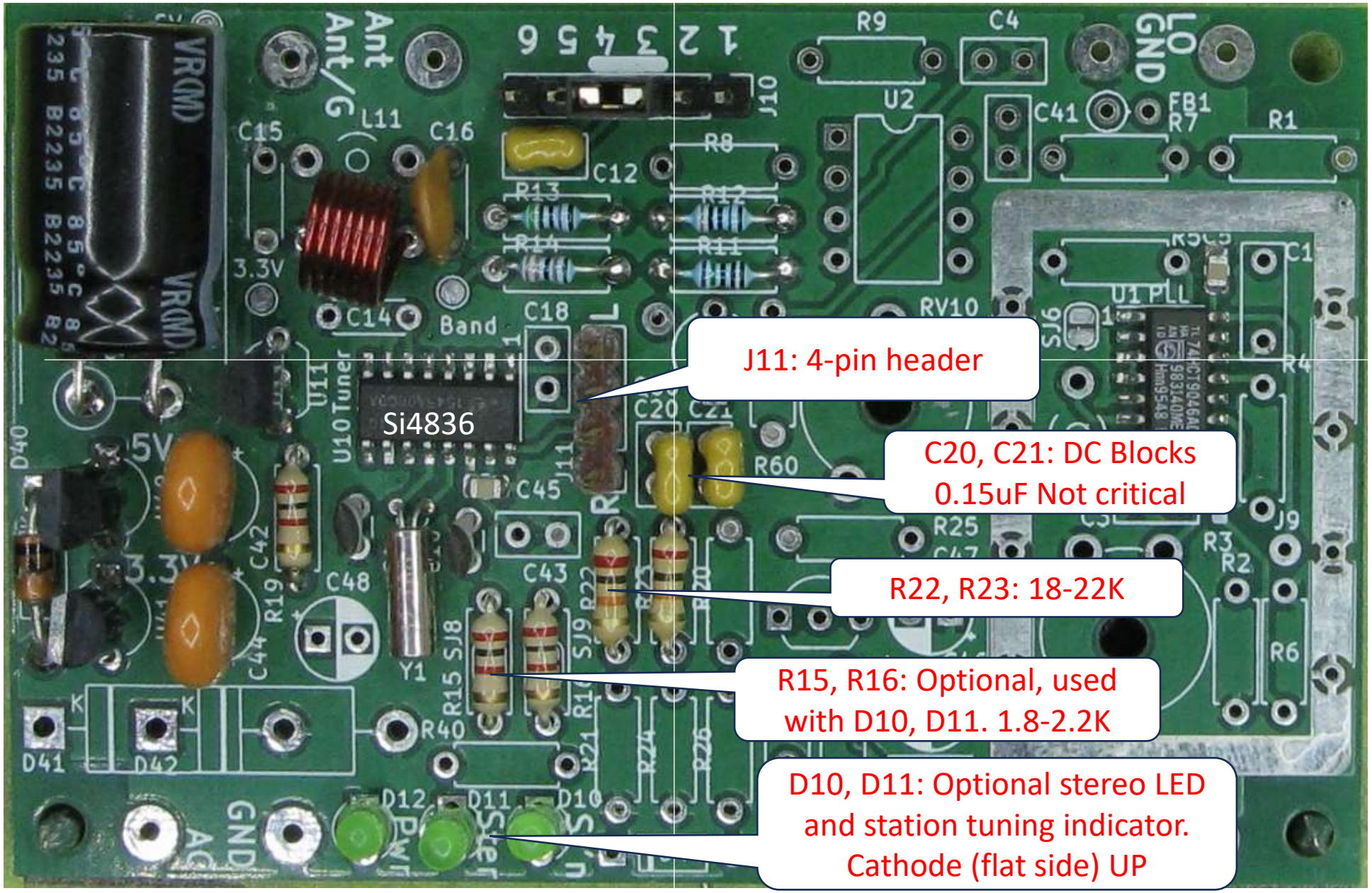
Assembly Instructions. 5a Transformer Antenna Circuit (for balanced antenna)



Assembly Instructions. 5b L-C Antenna Circuit (for whip antenna)

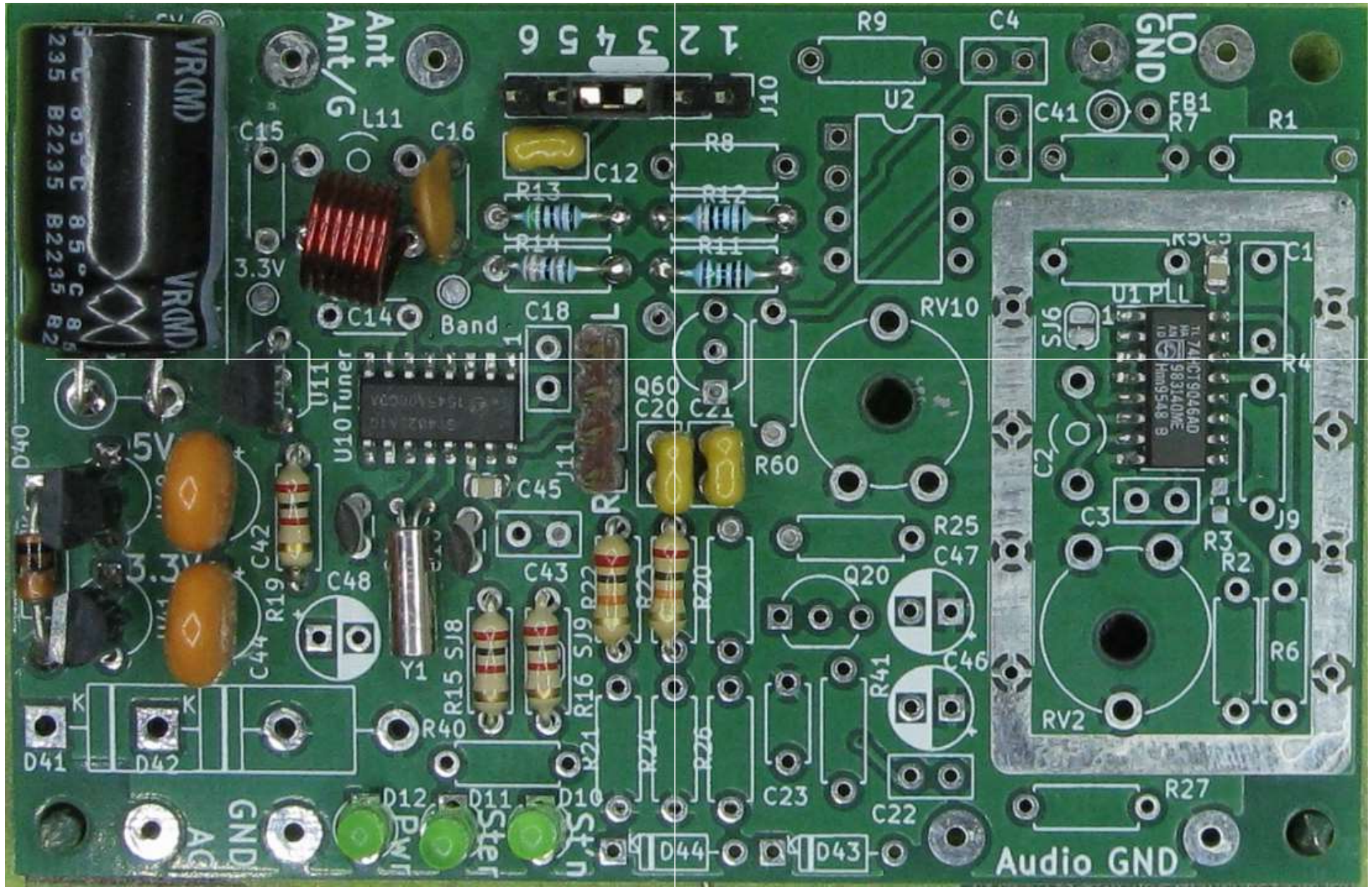


Assembly Instructions. 6a. Audio Circuitry for Si4836



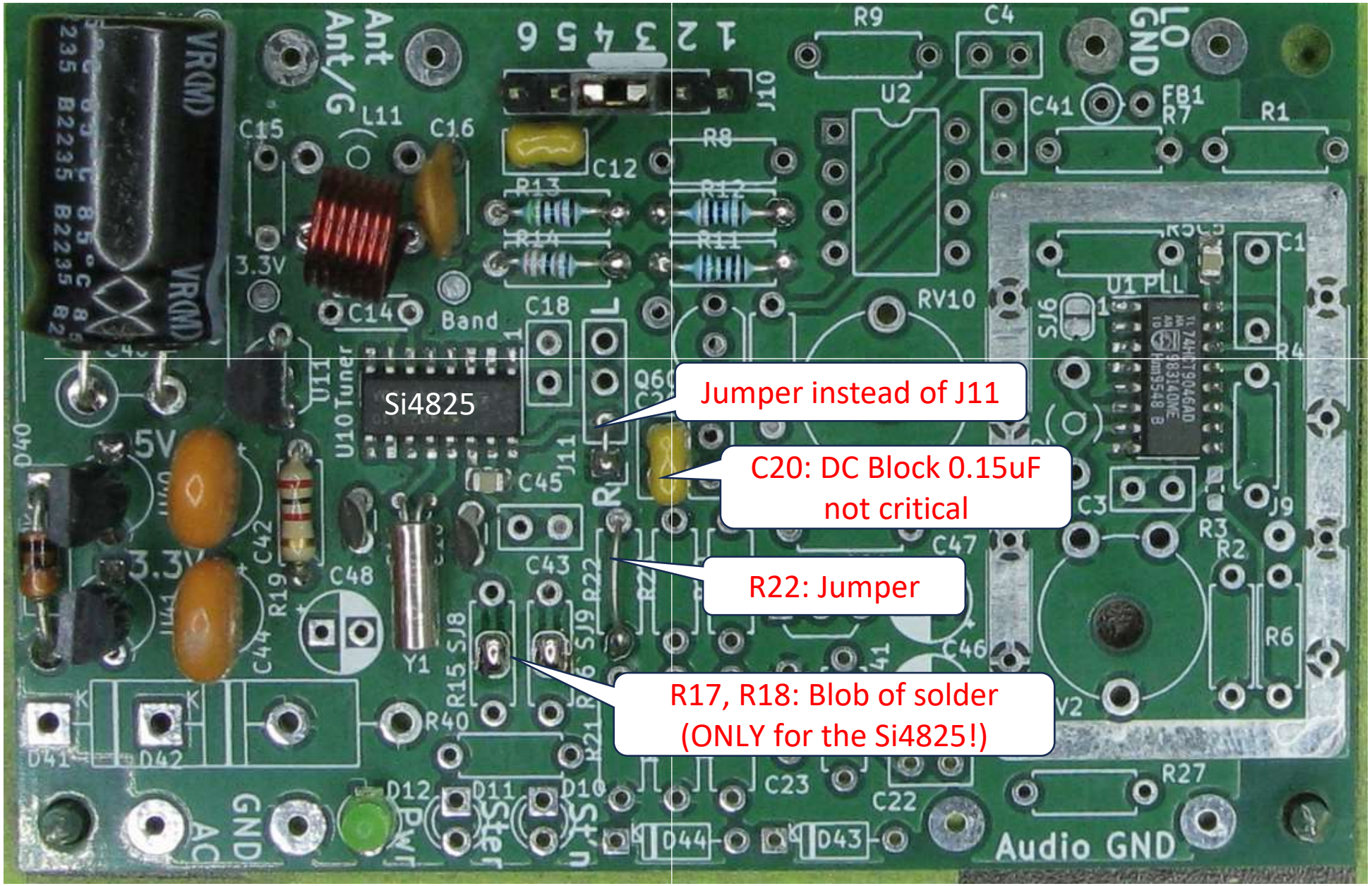
Si4836 ONLY

Assembly Instructions. 6a. Audio Circuitry for Si4836



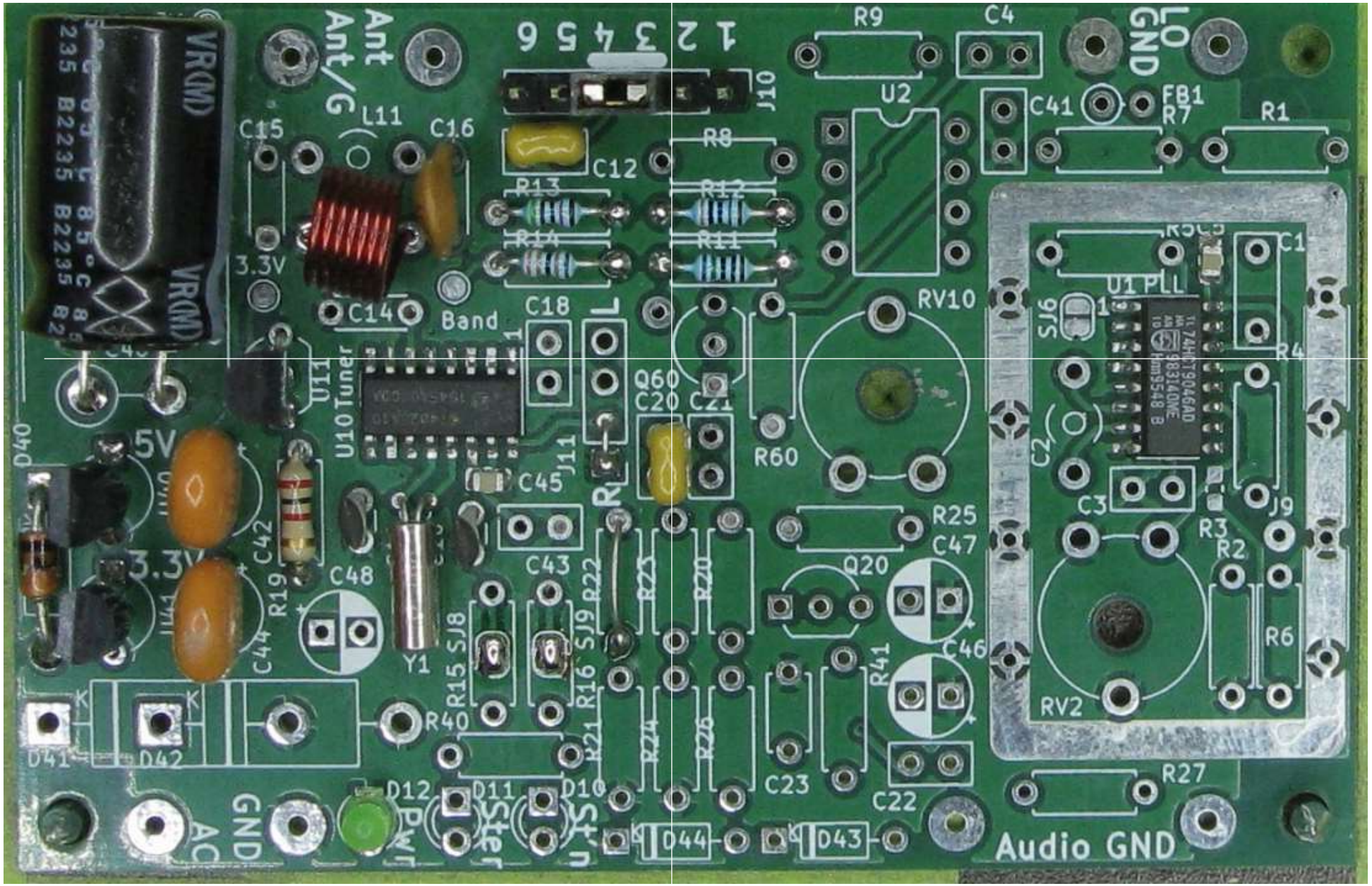
You can test the tuner now

Assembly Instructions. 6b. Audio Circuitry for Si4825



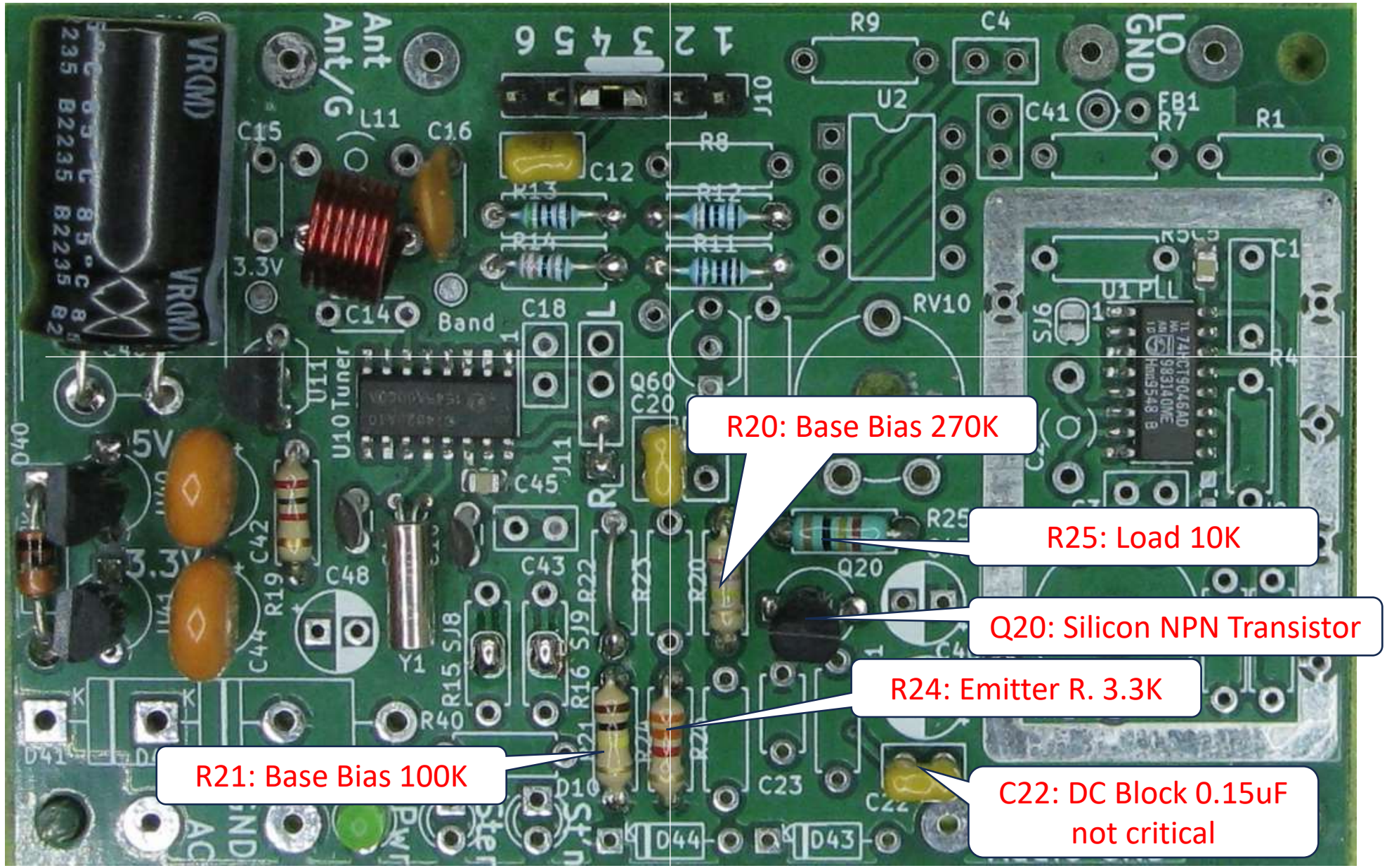
Si4825 ONLY

Assembly Instructions. 6b. Audio Circuitry for Si4825

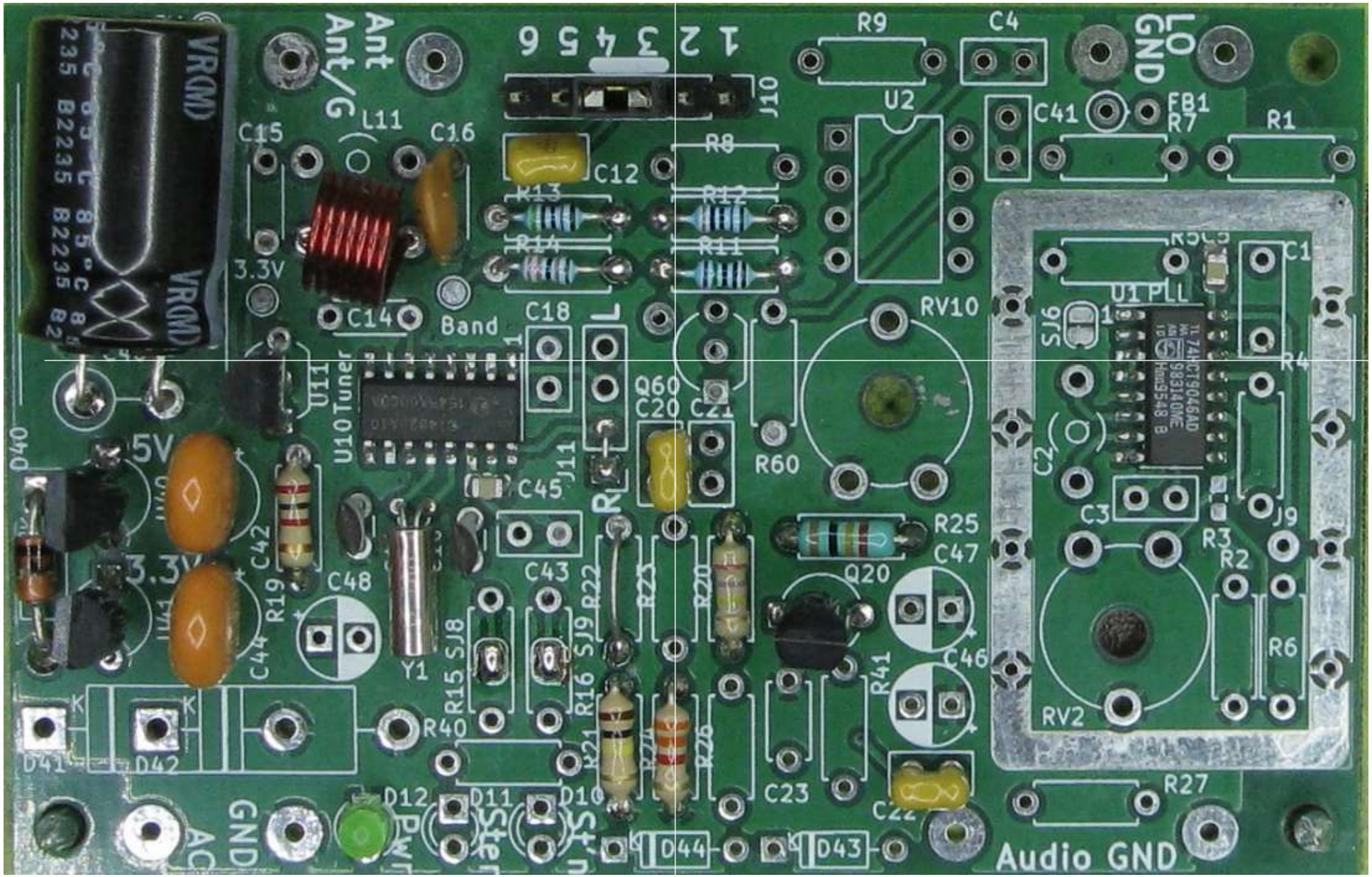


You can test the tuner now

Assembly Instructions. 7. Audio Amplifier

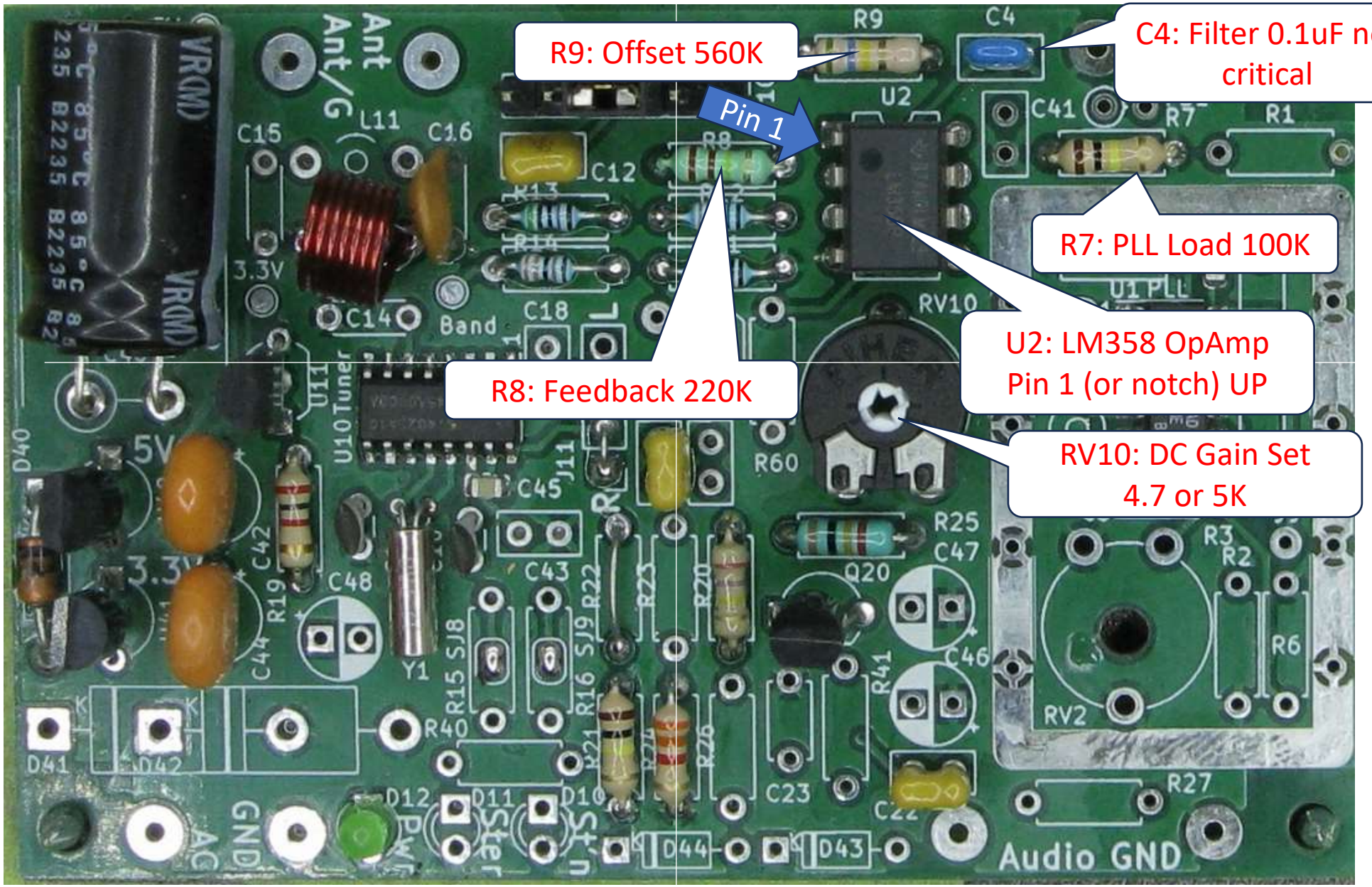


Assembly Instructions. 7. Audio Amplifier

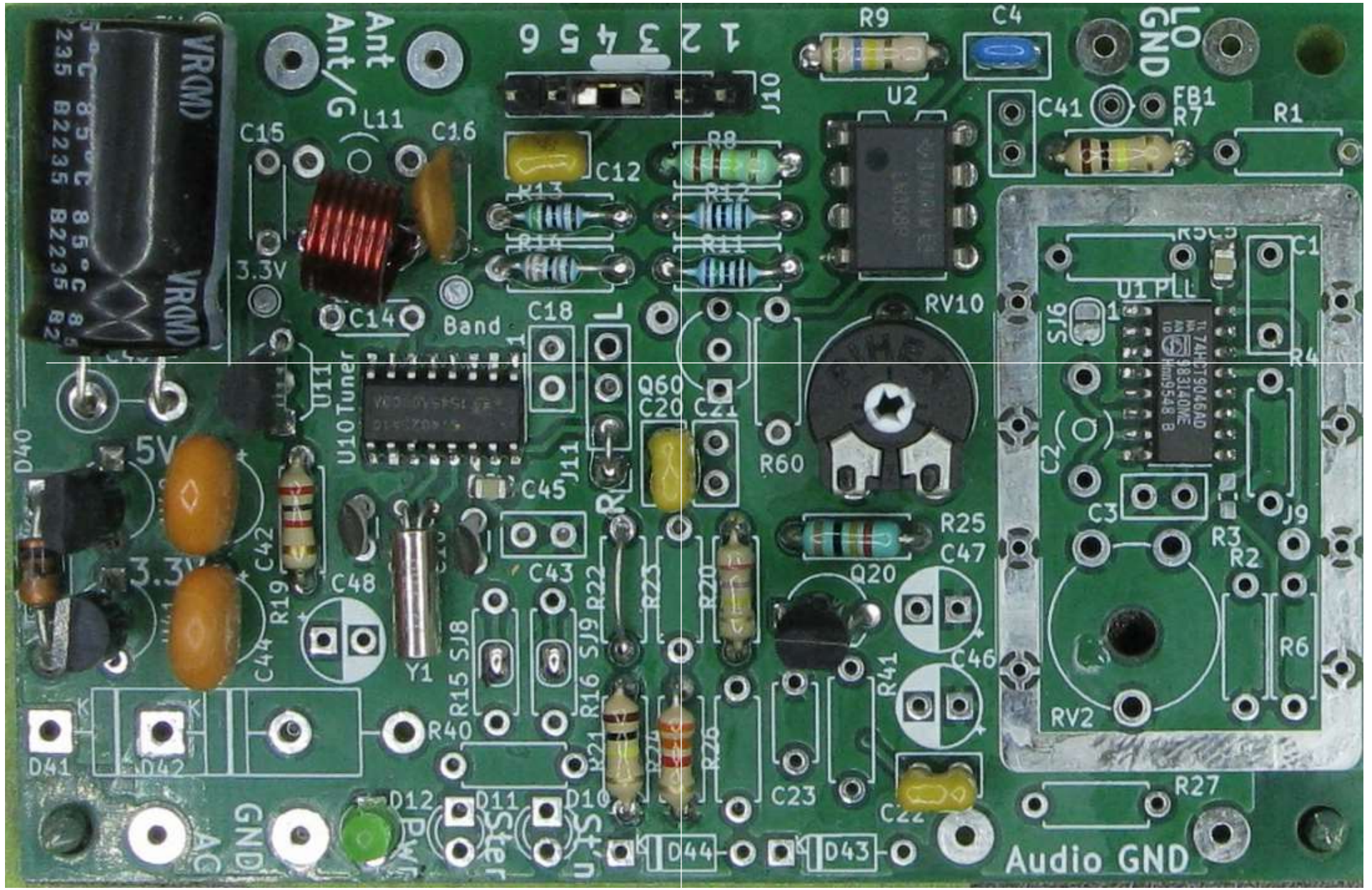


You can test the tuner + audio amplifier now

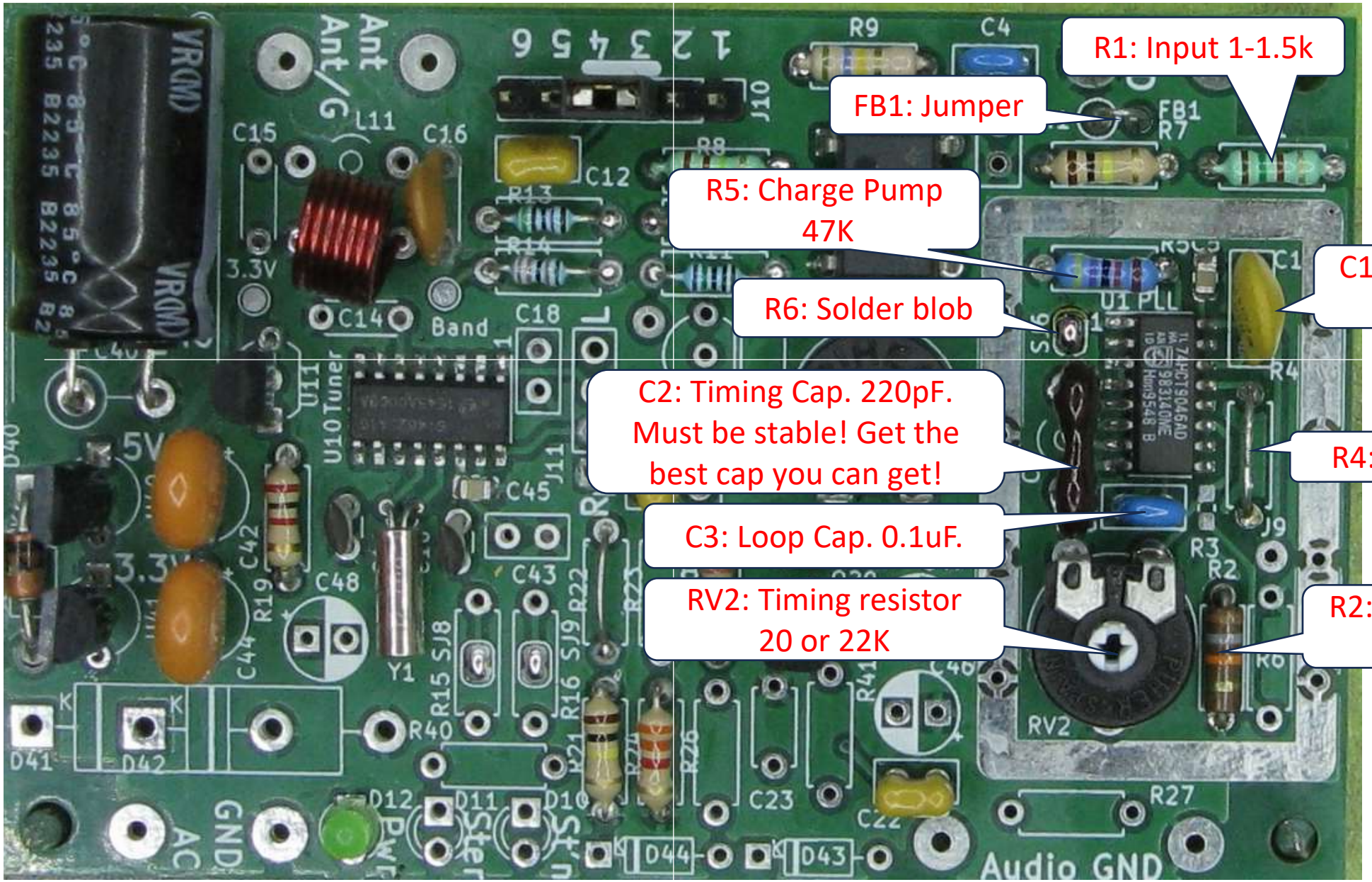
Assembly Instructions. 8. Level Shifter



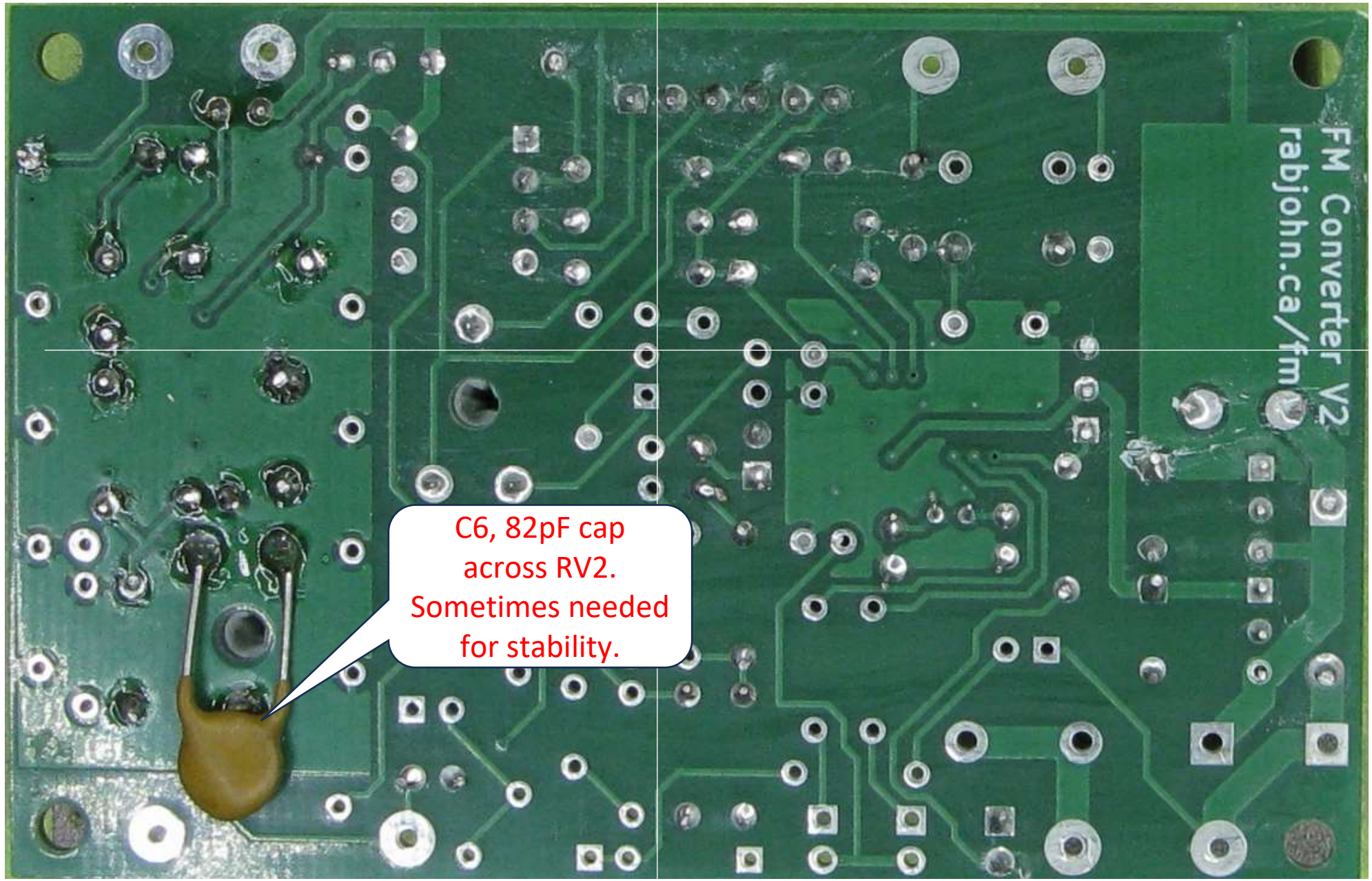
Assembly Instructions. 8. Level Shifter



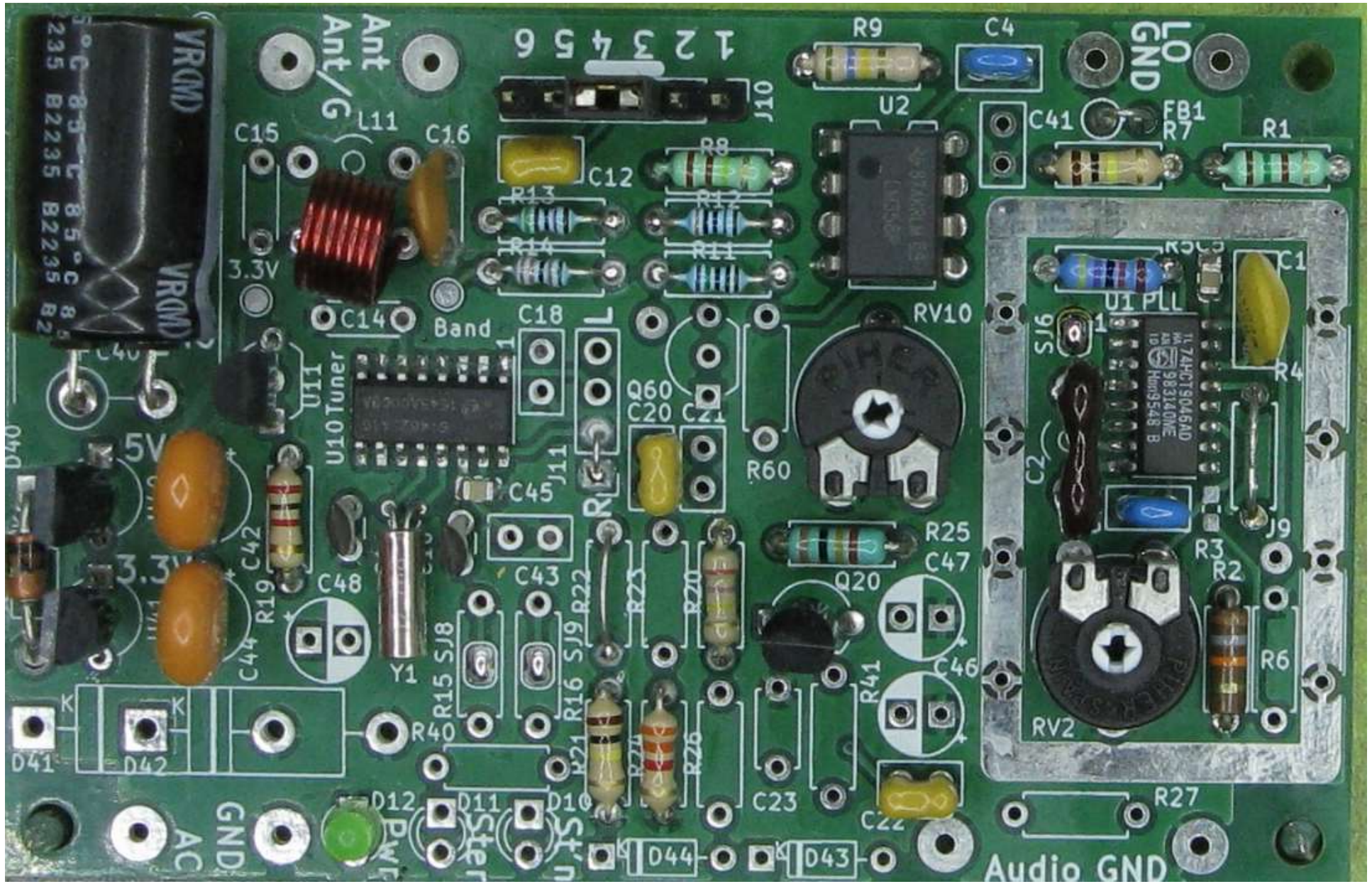
Assembly Instructions. 9. PLL



Assembly Instructions. 9back. PLL



Assembly Instructions. 9. PLL

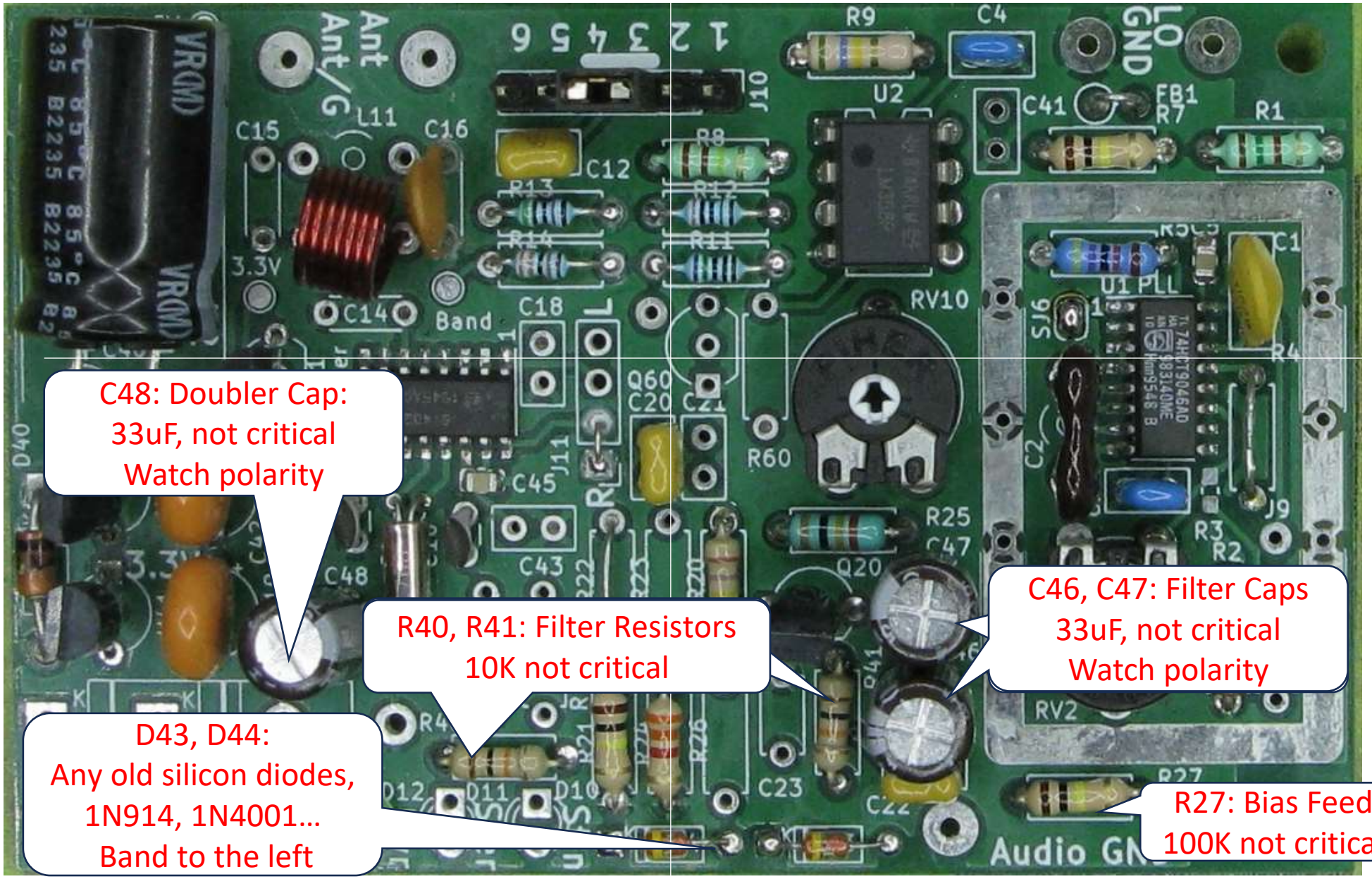


The basic converter is done. You can test it now

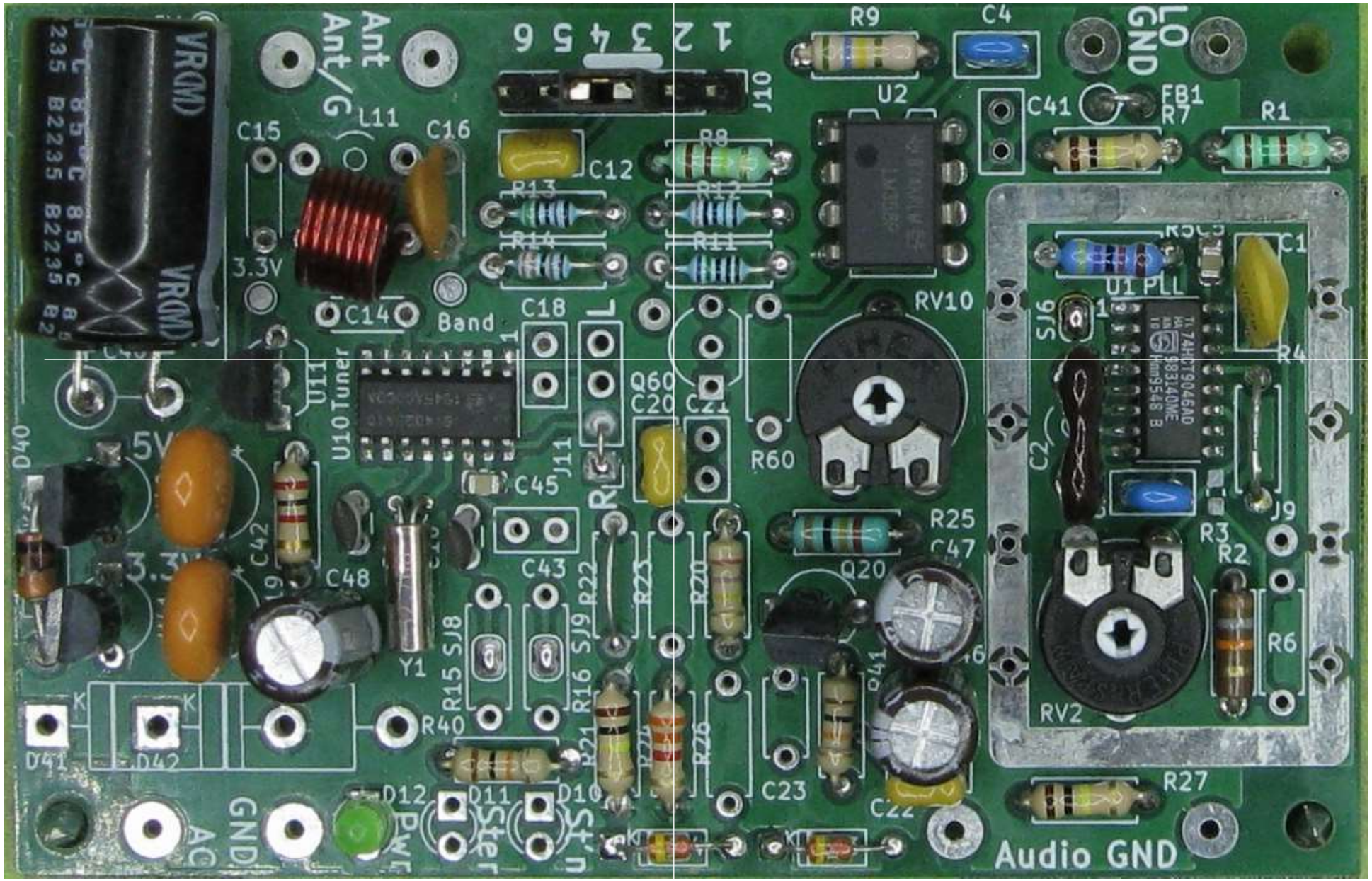
Negative Supply Voltage Supply

- This voltage reverse-biases the host radio's detector (deactivating it). If the detector is not deactivated (either by disconnecting it or reverse biasing it), it can cause distortion.
- The negative voltage also reduces the gain of the IF amplifier (eliminating it as a potential source of noise or AM feedthrough).
- If the detector diode is disconnected, the reverse supply is not necessary.
- In parallel filament radios, the IF amplifier tube can be removed to reduce AM feedthrough.
- In radios powered by DC (eg. car radios), the negative voltage generator does not work.
- In series heater string radios (AC-DC sets using the 8.2V Zener diode), it will generate about -7V; enough to disable the detector.

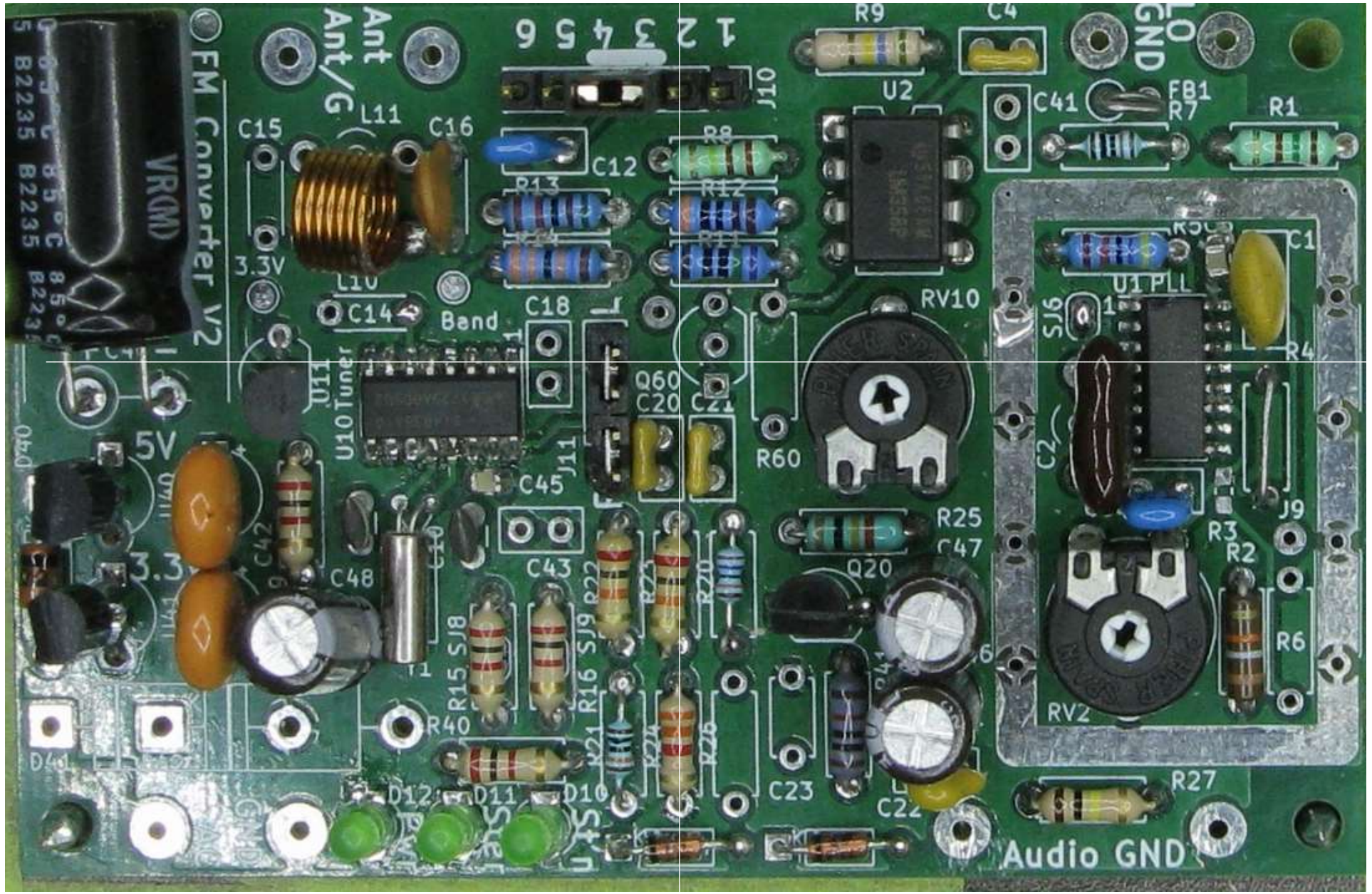
Assembly Instructions. 10. Negative Supply



Assembly Instructions. 10. Negative Supply



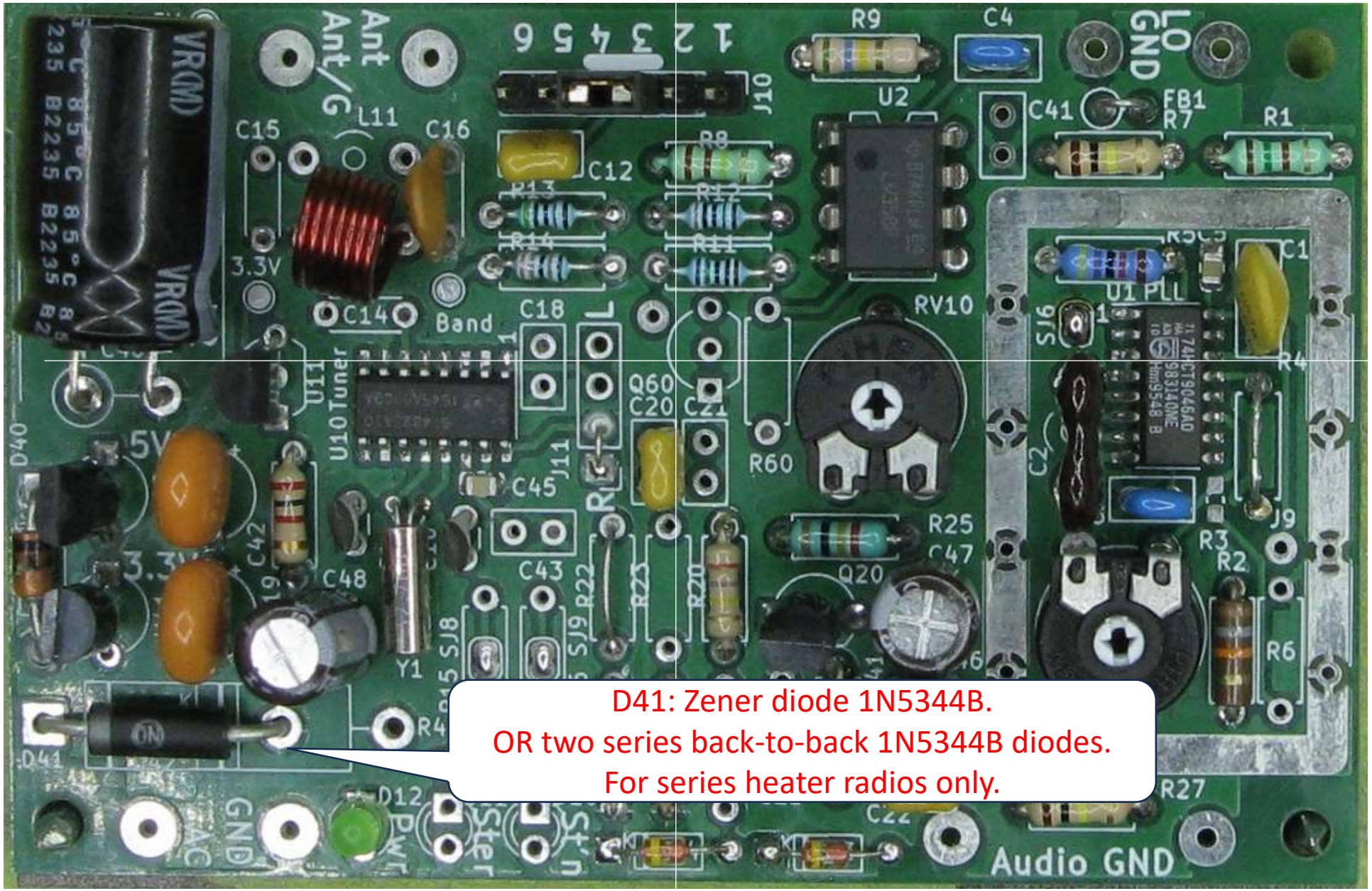
Here’s a board made with the Si4836



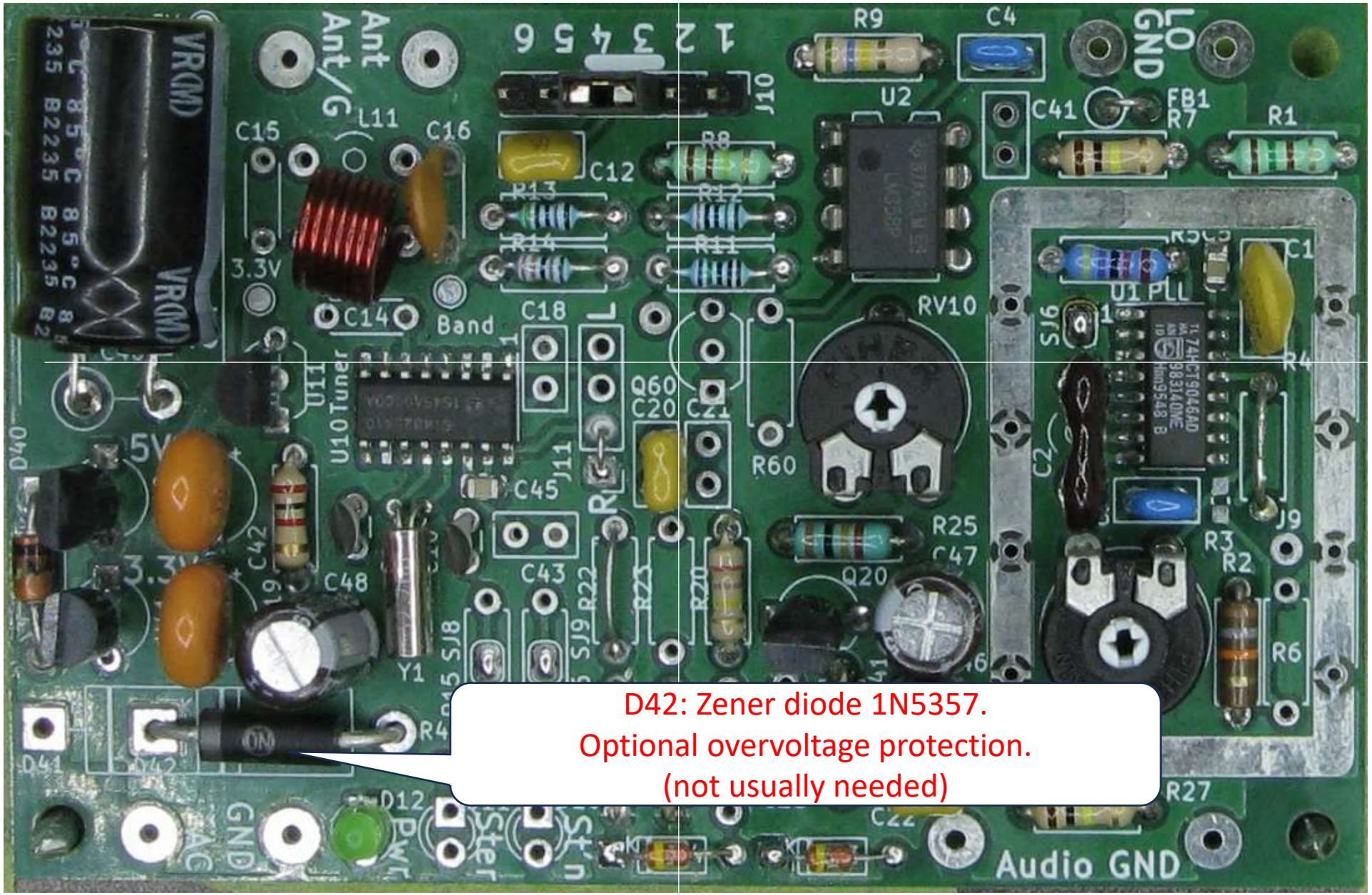
Protection Diodes

- In series heater radios, where the FMC is powered in series with the heaters, an 8.2V Zener diode is used at D41. This caries the 150mA (typical) heater current, and limits the voltage into the converter to 8.2V.
- D41 is *absolutely necessary* for series-string operation.
- In series heater radios, where the converter is powered in parallel with one of the heaters (recommended only with 300mA series string), a Zener diode (10V -20V, high enough that it is not on) is used at D42. This diode is usually off, but if the heater opens, it prevents the converter from getting damaged by excess voltage.
- In parallel heater radios, no protection diode is required.

Assembly Instructions. 11A. Protection (D41)

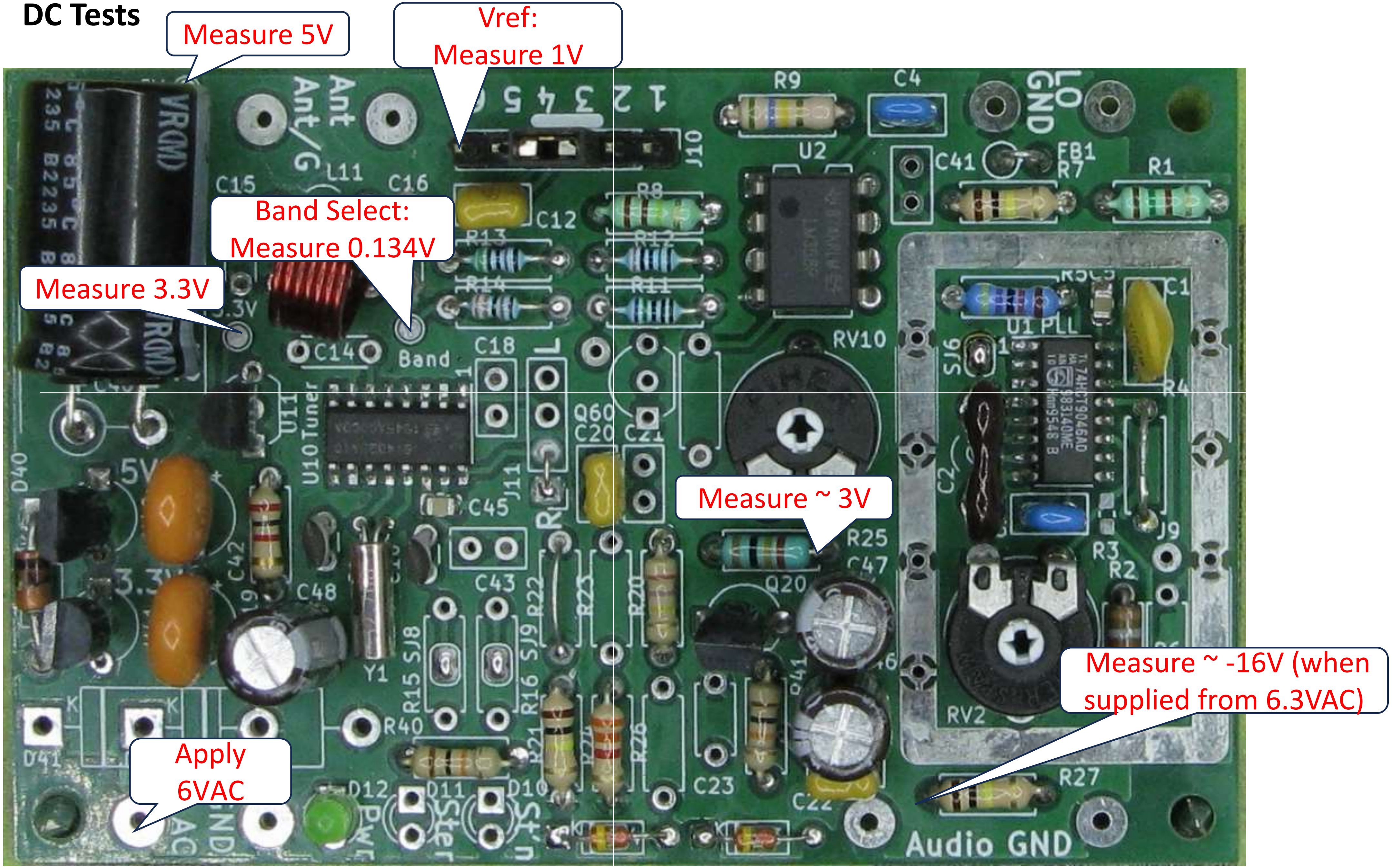


Assembly Instructions. 11B. Protection (D42)



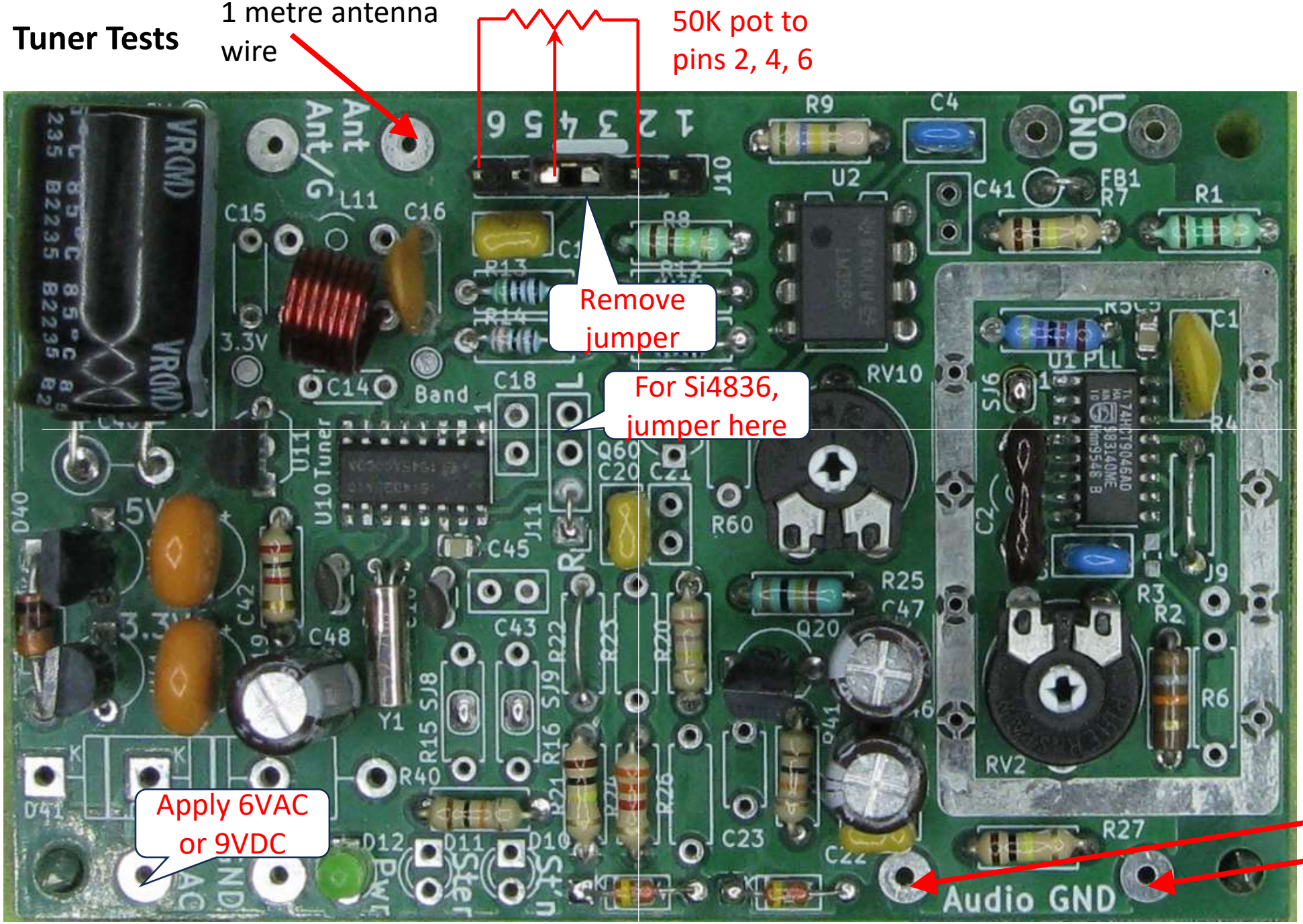
Tests

DC Tests



Measure 5V
Vref: Measure 1V
Band Select: Measure 0.134V
Measure 3.3V
Measure ~ 3V
Measure ~ -16V (when supplied from 6.3VAC)
Apply 6VAC

Tuner Tests



Connect an audio amplifier, antenna, power source (9V battery works), and a 50K pot.

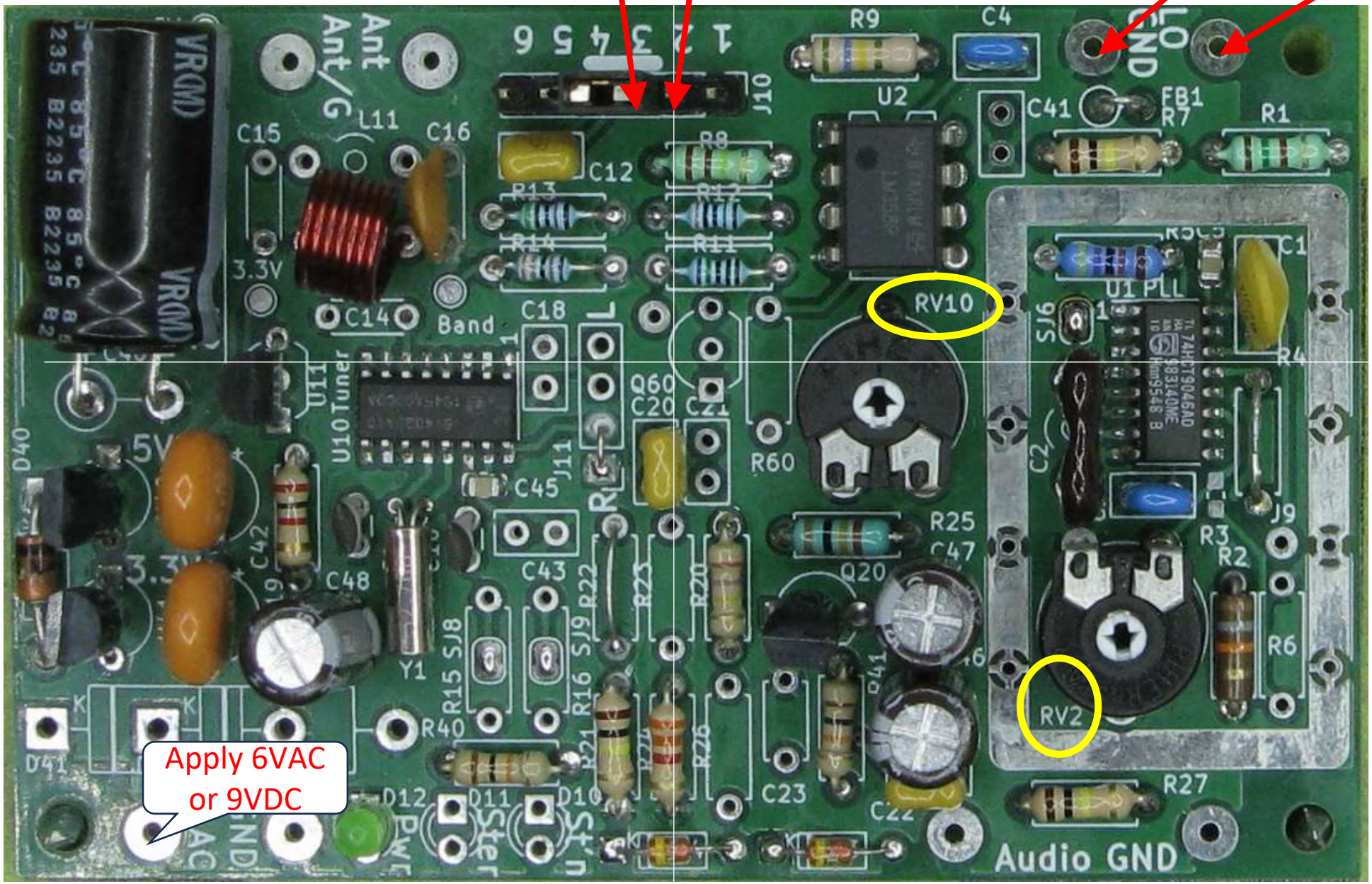
If you use a Si4836 chip, jumper pins 1 to 2 and 3 to 4 on J11

As you rotate the pot, you should receive stations across the entire FM band with good fidelity.

PLL Adjustments and test

To Voltmeter
(3 to 2=ground)

To an adjustable, stable RF source, 1MHz to 2MHz



Connect an RF source, power source (9V battery works), and a voltmeter.

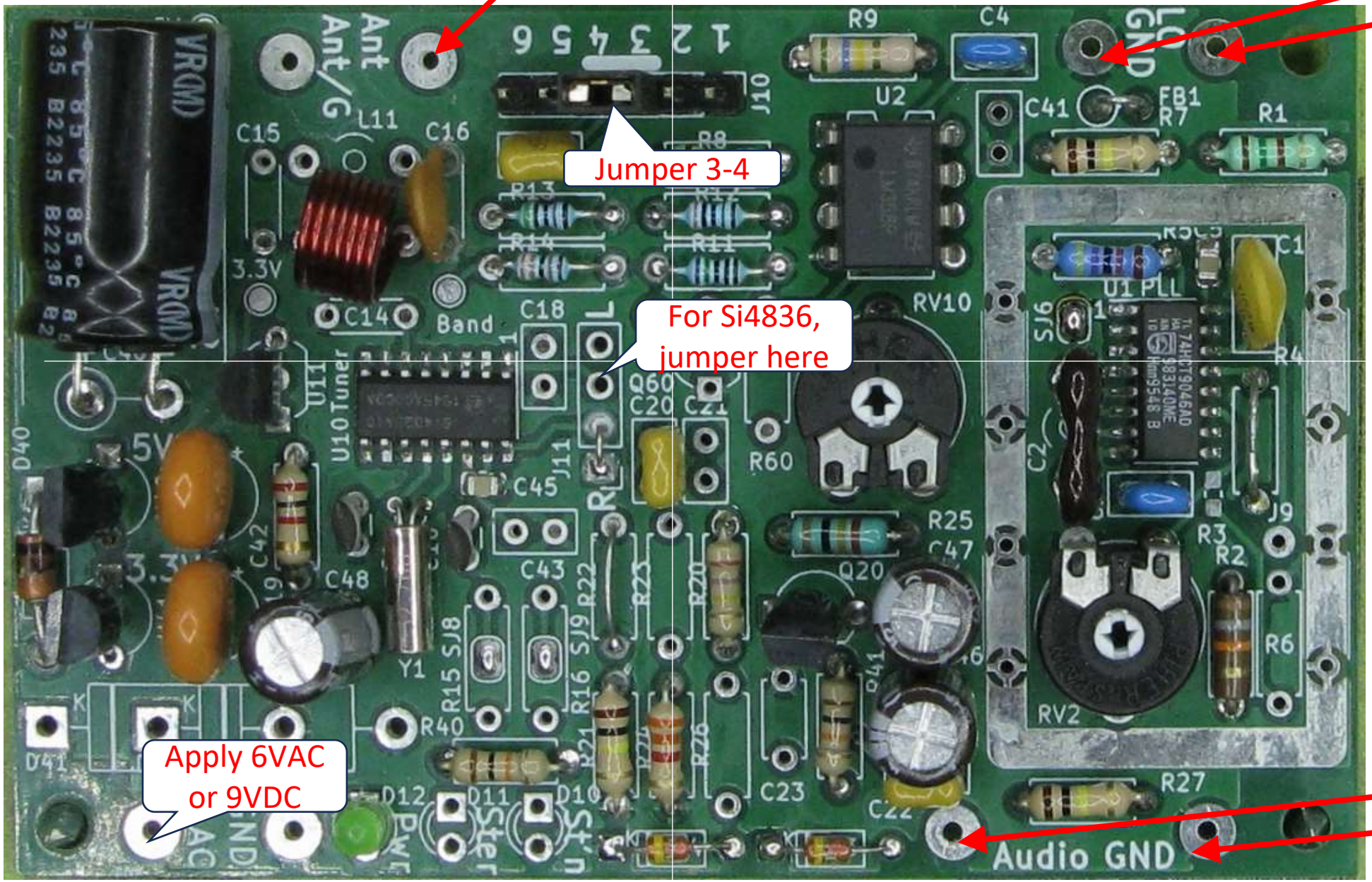
Rotate RV10 fully clockwise, RV2 fully counterclockwise.

Set source to 1MHz. Rotate RV2 until the voltage rises (80mV max)

Set source to 2MHz. Adjust RV10 for 1V on voltmeter.

As the source is varied from 1MHz to 2MHz, the voltage should vary smoothly from under 0.08V to 1V

Full Test (after PLL adjustment)



To an adjustable, stable RF source 1MHz to 2MHz

Connect the RF source, audio amp, antenna, power supply (or a 9V battery works).

Jumper J10 from pin 3 to 4. If you use a Si4836 chip, jumper pins 1 to 2 and 3 to 4 on J11

As the RF source is adjusted from 1MHz to 2MHz, stations across the full FM band should be heard.

To an audio amplifier

Alignment

- Jumper J10 pin 3 to 4. If you use a Si4836, jumper J11 pins 1 to 2 and 3 to 4
- Connect board to radio as described in the FM_conversion_ACset or FM_conversion_AA5 or FM_conversion_car radio
- Connect a DC voltmeter from J10 pin 4 to pin 2 (ground).
- You might need an antenna, a metre of wire.
- Turn on radio and let it warm up. Rotate RV10 fully clockwise, RV2 fully counterclockwise.
- Tune the radio to where you want the low end of the FM band to be (probably around 550kHz).
- The voltage should be quite low, 10-20mV or so, Rotate RV2 CW until the voltage just starts to rise, no more than 80mV.
- Tune the radio to where you want the high end of the FM band to be (probably around 1600kHz).
- Adjust RV10 until the voltage 1.0V.
- You’re done. As you tune the radio across the band, you should hear all your local FM stations!