How to solve an EMC and harmonic mixing problem in a Yeasu Musen FRG-7 communications receiver (0 – 30 MHz general coverage, AM/SSB/CW).

Investigated by: ir. W.J. Vogel.

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Problem description:

While the receiver has been tuned at 21.6 MHz, and an unwanted signal at 98.1 MHz at a level of only 60 dB above the noise level of the receiver has been fed to the antenna input, this unwanted signal causes interference at the wanted signal. The interference level depends of the adjusted value of the capacitance of the variable capacitor in the RF preselector circuit. At full capacitance, the interference level is at its maximum.

Analyzation:

See the block diagram (fig. 3 of this document):

While the receiver has been tuned at 21.6 MHz, the 1st mixing oscillator has been tuned at 55.5 MHz + 21 MHz = 76.5 MHz. The 2nd harmonic is 153 MHz.

When we subtract the frequency of the unwanted signal at 98.1 MHz from the 2nd harmonic frequency of the 1st oscillator, 153 MHz, the resulting frequency is 54.9 MHz. This frequency falls in the passband of the 1st IF (55.5 – 54.5 MHz).

The wanted frequency range of 21 – 22 MHz has been converted to 55.5 – 54.5 MHz, so the frequency of 54.9 MHz has been converted from 21.6 MHz as the wanted signal and from 98.1 MHz as the unwanted signal.

Solving the problem:

See the text after photo 2 in this document.

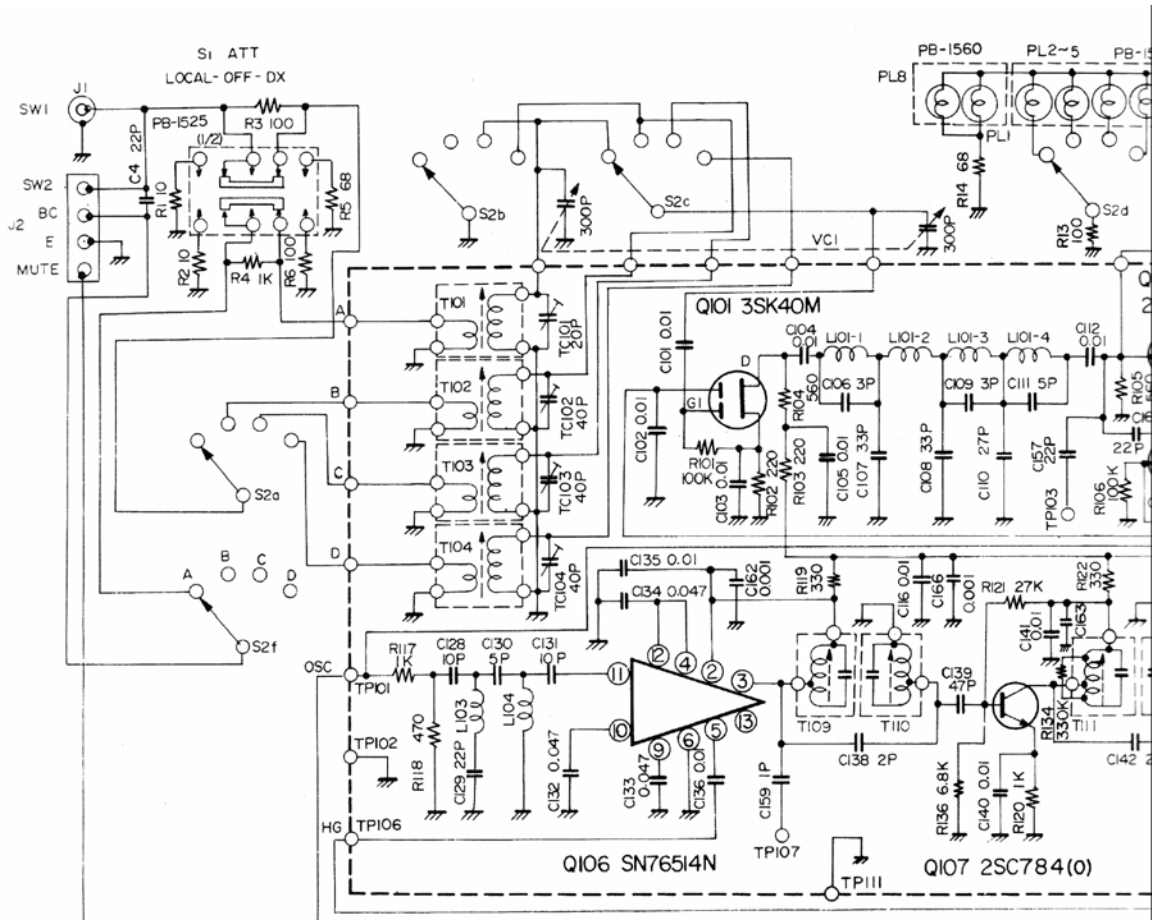

Fig. 1. Part of the schematic diagram of the Yeasu Musen FRG-7 receiver (RF preselection circuit).

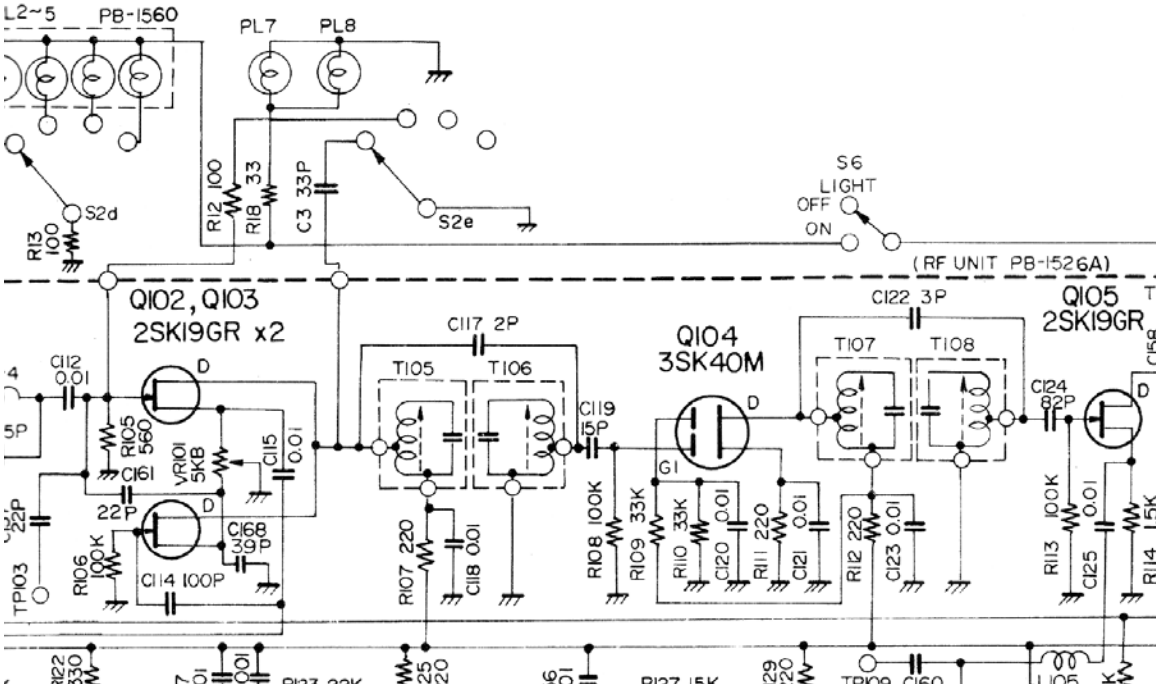

Fig. 2. Part of the schematic diagram of the Yeasu Musen FRG-7 receiver (IF gain switching circuit, with R12 or C3 (RF preselection switch in position A (0.5 – 1.6 MHz) or B (1.6 – 4.0 MHz)).

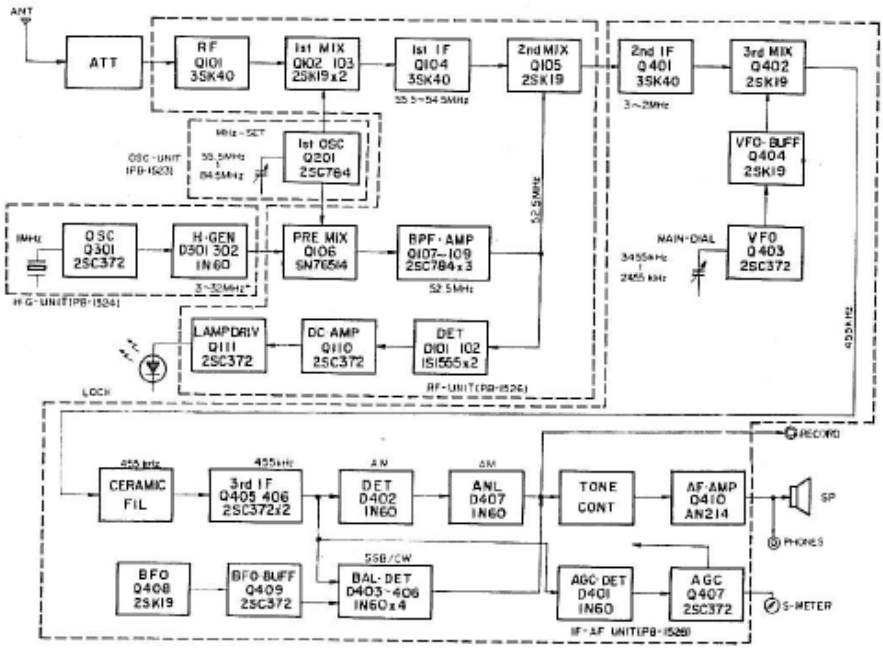

Fig. 3. Block diagram, copied from the Service Manual.

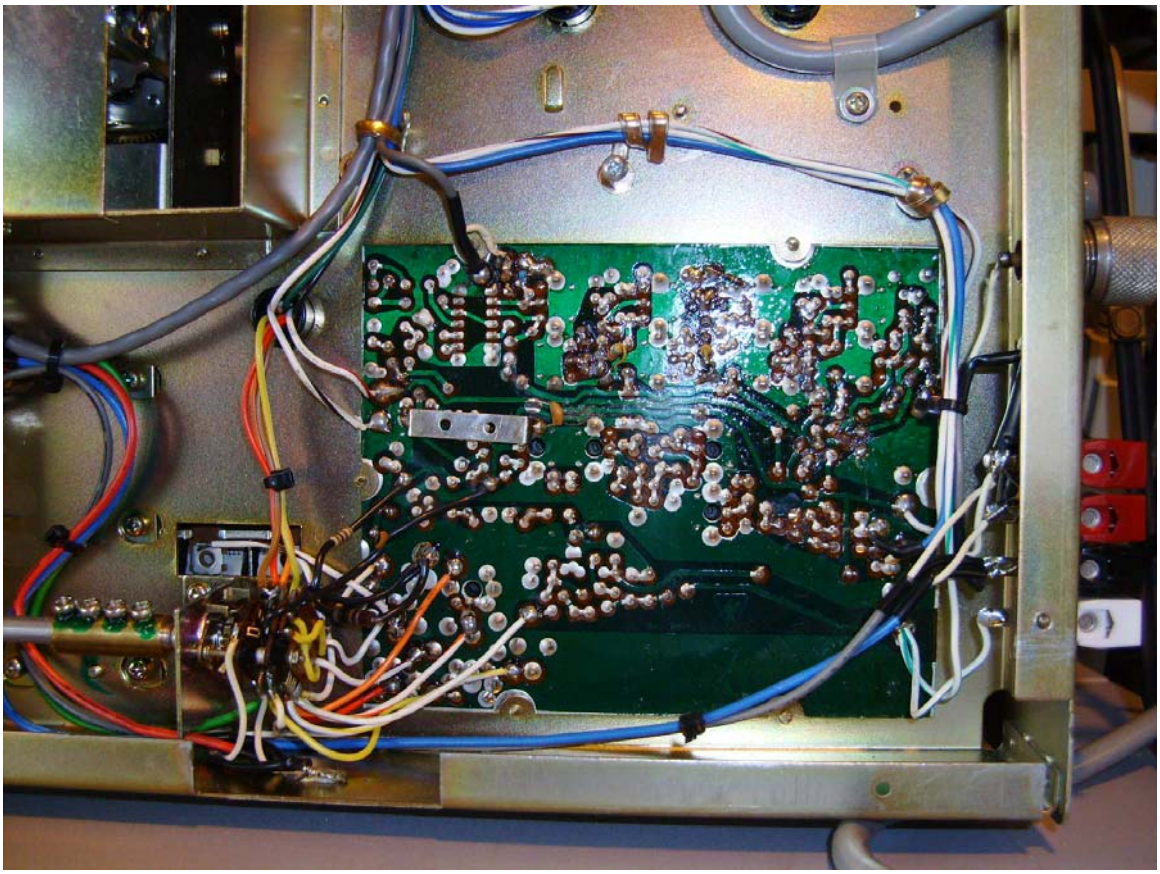

Photo 1. The part of the PCB in which the problem occurs.

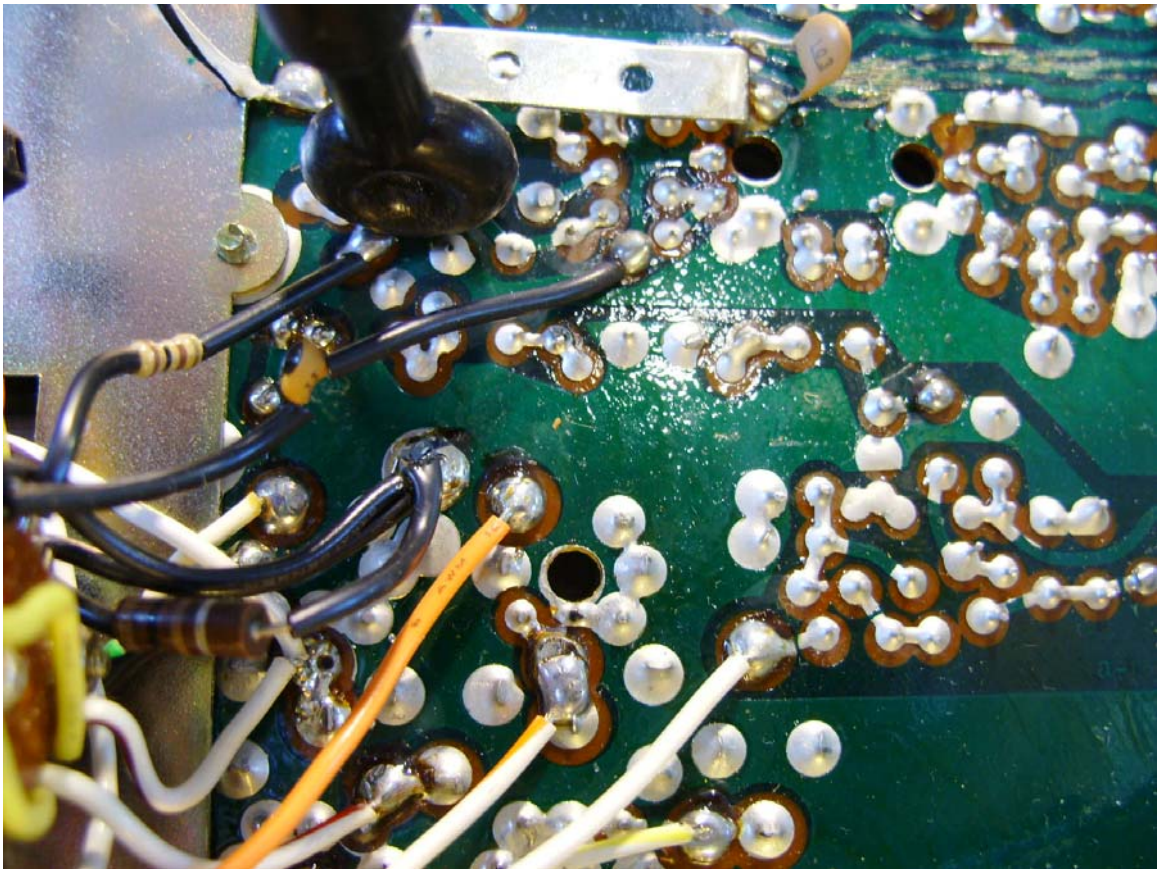

Photo 2. Locating the EMC and harmonic mixing problem.

In this photo the most sensitive location for the unwanted signal at 98.1 MHz has been shown. Notice the presence of the 100 Ohms resistor and the 33 pF capacitor, used for the gain reduction of the 1st IF for the position A and B of the preselection switch.

The wiring is very close to the wiring of the tuning capacitor and the RF part of the preselection switch. This is a design fault.

After this conclusion, I have removed these two components, so the 1st IF gain remains at its maximum at the preselection ranges A and B.

When the two red antenna connectors at the backside of the receiver are interconnected by a short wire, the receiver becomes very sensitive at mediumwave, while a low-gain active antenna with 50 Ohms output impedance has been used. MW signals of 1 uV at 50 Ohms source impedance are already receivable with a fair audio quality.
This feature is usable when the receiver is used in rural areas with a low level of electromagnetic interference of non-broadcast sources like switched mode power supplies.

The design has also another fault, see photo 3.

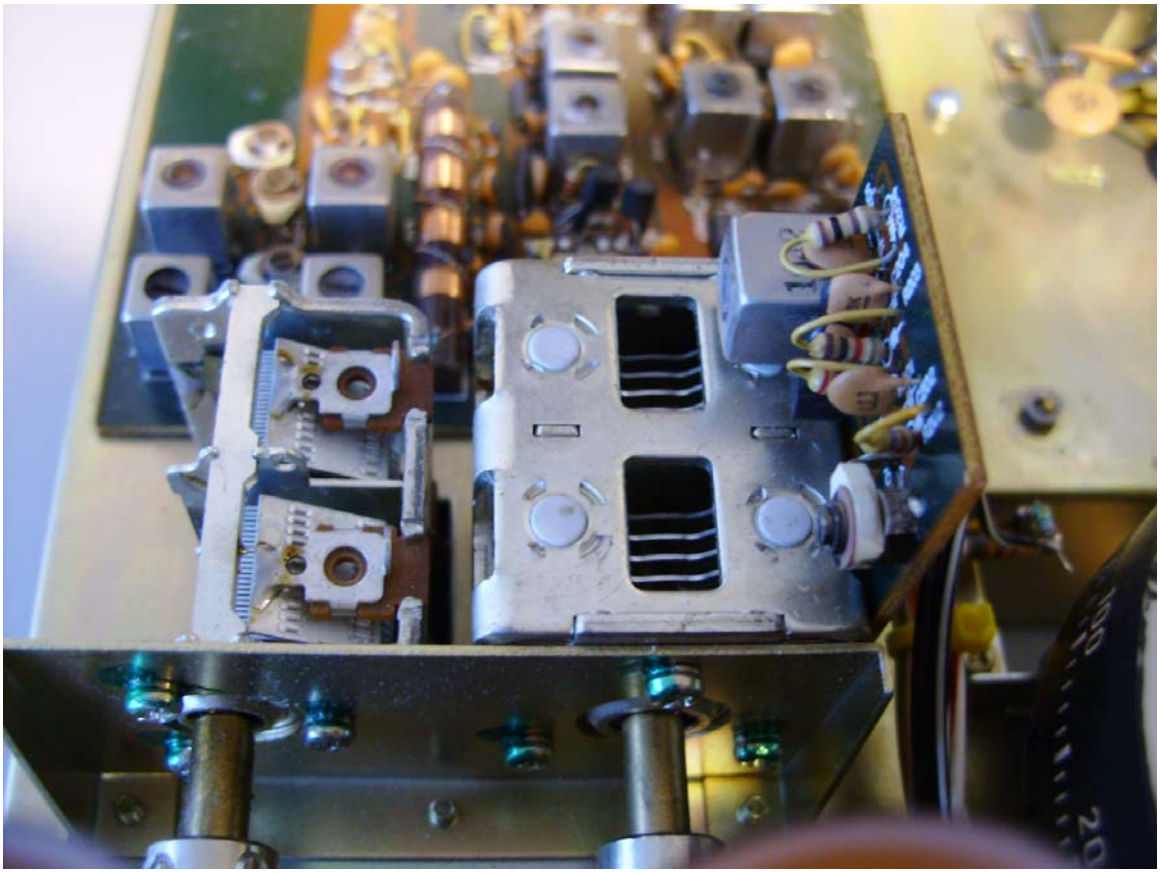

Photo 3. Two tuning capacitors of different systems with a common ground (mounting bracket).

What's occurring is this situation? The answer is: mutual coupling, common inductance!. Let's explain this with a schematic diagram:

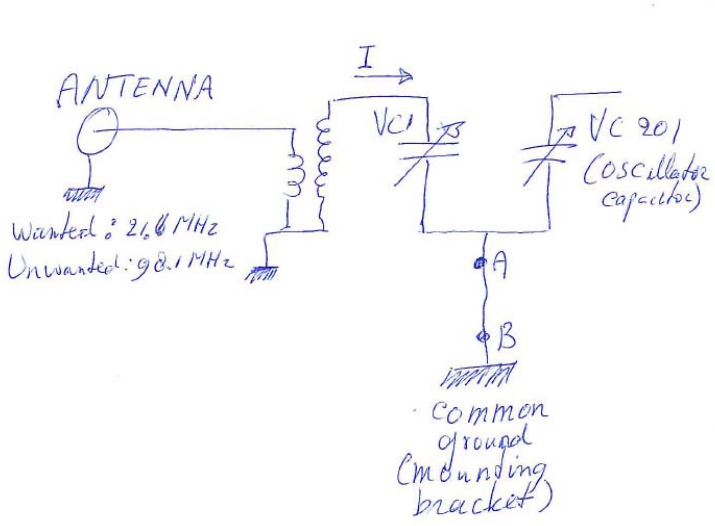

Fig. 4. The schematic diagram of this part of the receiver.

The interference is at its maximum when the preselector is not tuned, and when VC1 has been adjusted at its maximum capacitance. In that case, the current I from the 98.1 MHz interfering signal is at its maximum. This current flows through the common impedance which can be measured between the points A and B.

Therefore, a voltage occurs which will influence the 1st oscillator and which will also cause the harmonic mixing problem.

Solution of the problem:

Mount these tuning capacitors to separate grounds, see the next photo.

Without other measures, this harmonic mixing problem is now improved more than 20 dB.

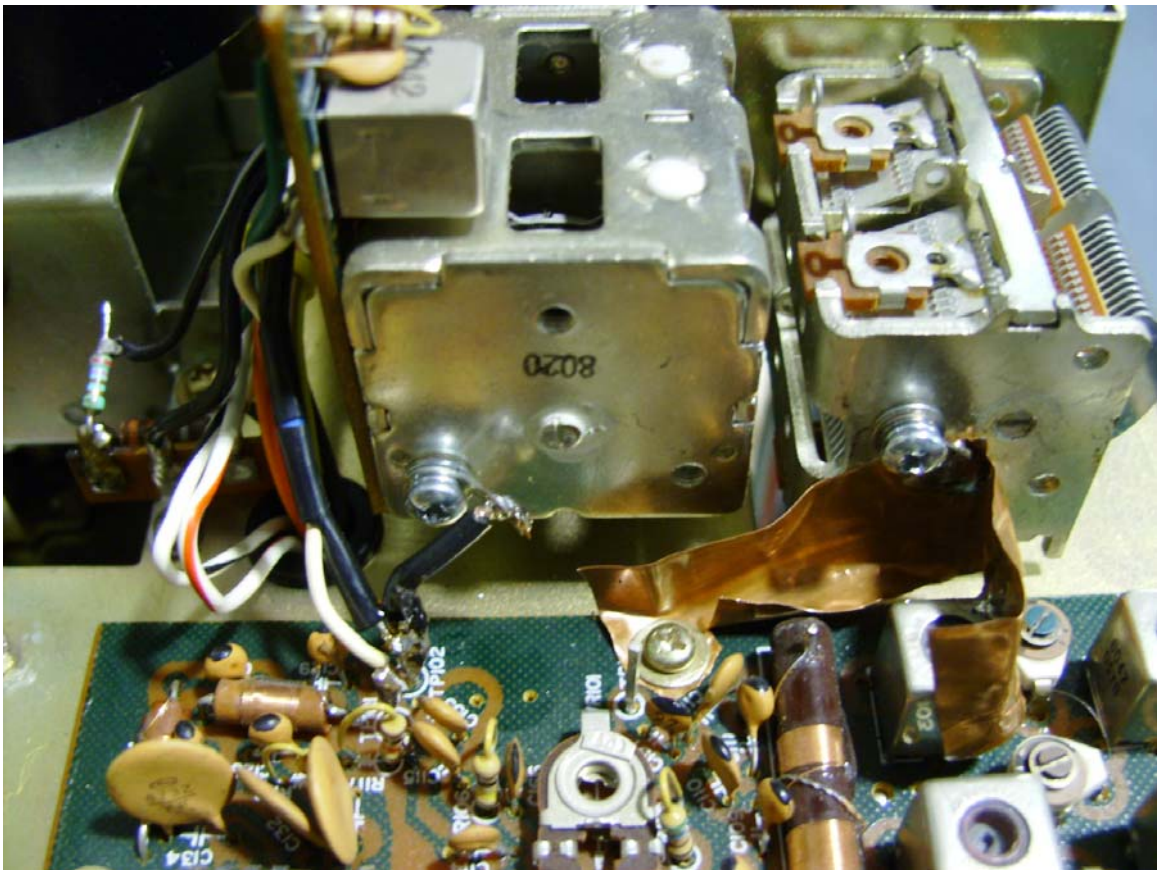

Photo 4. Separate grounds for each tuning capacitor.