Documentation for the symmetrical 1 kW antenna tuner

Edition: July 2017 / KM

Board: L / C / relay board

Functional scope:

This symmetrical tuner is used to tune symmetrical antennas such as dipole loops etc. The direct connection of the antenna via a chicken ladder is ideal, ie the chicken ladder is connected at the feed point of the antenna and led to the tuner.

The input of the tuner is also symmetrical. Usually you want to go from the transceiver to the tuner via a 50 ohm coaxial cable. A simple 1: 1 transformer (balun) is used to connect this to the tuner.

The antenna is tuned via an L element, i.e. an inductance in series with the antenna and a capacitance to ground. This is what the basic circuit of an asymmetrical tuner looks like:
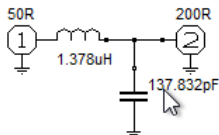
this circuit adapts an antenna with 200 ohms in the 30m band to the 50 ohm coaxial cable.

It works the <u>same way with a</u> symmetrical tuner, only that the circuit is symmetrical:
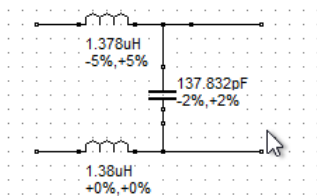
There is of course no longer any reference to ground.

The capacitor can be before (transceiver side) or after (antenna side) the inductance. As a rule of thumb you can remember:
If the antenna is too long, the capacitor is usually on the antenna side,
if the antenna is too short, it is usually on the TRX side. That doesn't always have to be the case, but it is usually the case.

In order to be able to set different inductance values   and capacitance values   in the finest possible steps, the tuner has a bank of 8 relays each which switch different combinations of capacitors or coils on and off.

<u>Coil values:</u>
187nH
375nH
750nH
1.5uH
3uH
6uH
12uH

24uH

the values   are chosen so that each value is twice the smaller value. This allows all inductance values   from 0 to 48uH to be set in steps of 178nH.

The coils are all duplicated because it is a symmetrical tuner. Capacitors:

_____

As with the coils, there are also 8 values   here:

25pF
33pF
50pF
89pF
165pF
340pF
600pF
1137pF
1939pF

The capacitance value 25pF is not populated, because that is the capacitance of the conductor tracks on the board, but this is also used for fine-tuning. Therefore, every value between 0 and just under 4nF can be set in steps of 25pF.

these values   are formed by connecting standard values   in series. It is noticeable that the values   are not exactly double the smaller value. That doesn't work because we have to use standard capacitors whose values are only roughly available.
However, that doesn't matter, the software helps us to find the right value.

In the software you simply set eg 1.5uH and 130pF and the program automatically calculates which coils and which capacitors have to be switched on in order to come as close as possible to the desired value.

Structure of the coils:

only air coils are used because they have the best possible quality. The circuit board is designed so that the large coils have enough space. They are wound with a diameter of 1.3mm CuL wire. Small coils stay in shape by themselves because the wire is quite stiff. Larger coils have to be wound on a body (preferably a plastic tube) and then fixed with, for example, varnish.

The winding data are in the circuit diagram: Inductance… D = coil diameter / len = coil length / N = number of turns

Since each coil is made twice, they should be measured so that our tuner remains as symmetrical as possible. The exact coil value is not critical, just both should be the same.

The board has a little more holes for the coils than necessary so that you have more options for installation. But I suggest that you stick to the following pictures. The coils are arranged here in such a way that they are each rotated by 90 degrees and not "looking" at each other directly. This largely avoids coupling.

Capacitors:

Mica capacitors that can withstand a few kV are so extremely expensive that they are out of the question for this tuner. But there is an excellent alternative: FKP1 capacitors. These are easily available, cheap, have good HF properties and are available with 2kV. The board is therefore designed for the use of FKP1 capacitors with 2kV. Each capacitor value is generated by series connection, see circuit diagram.
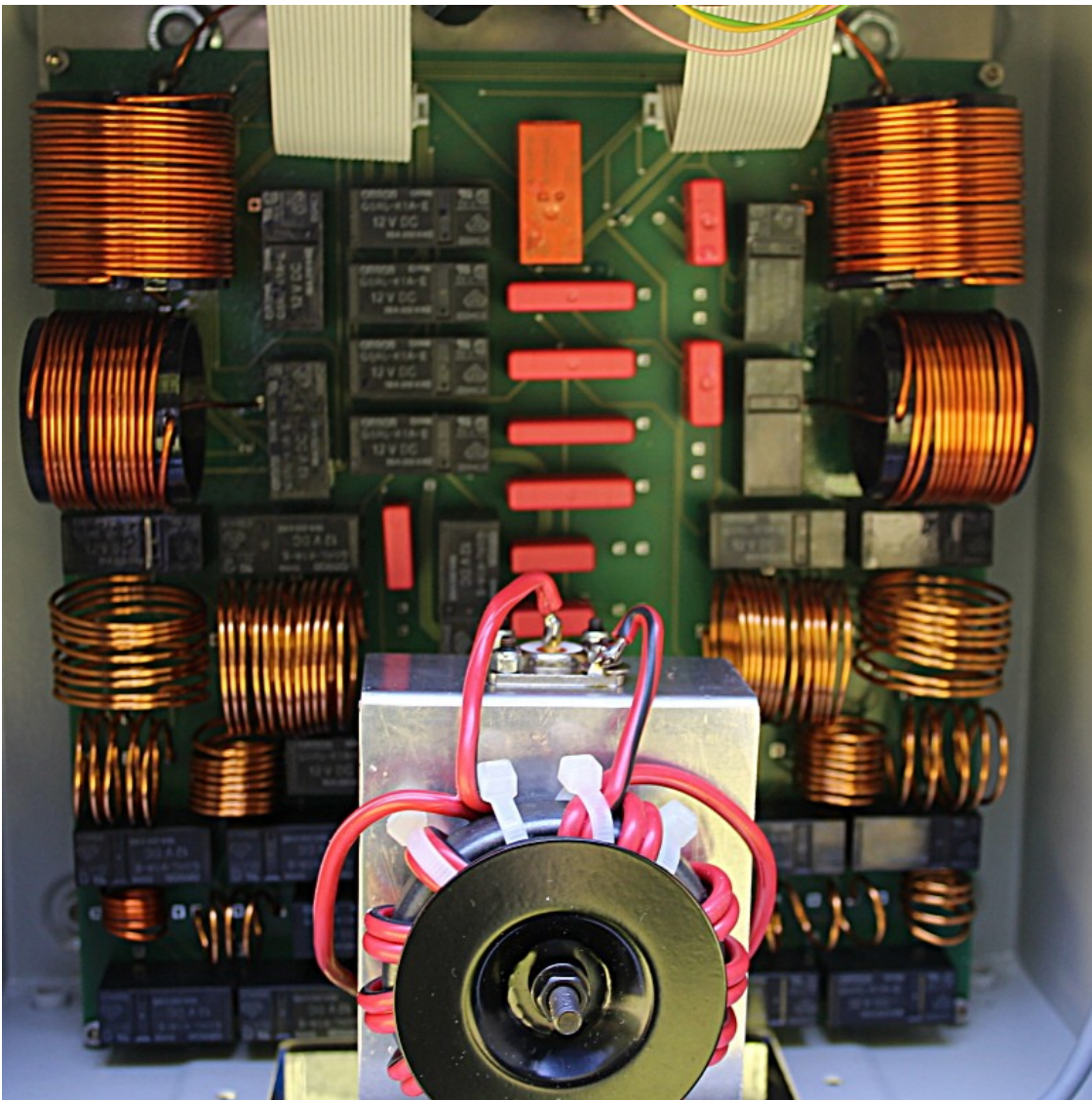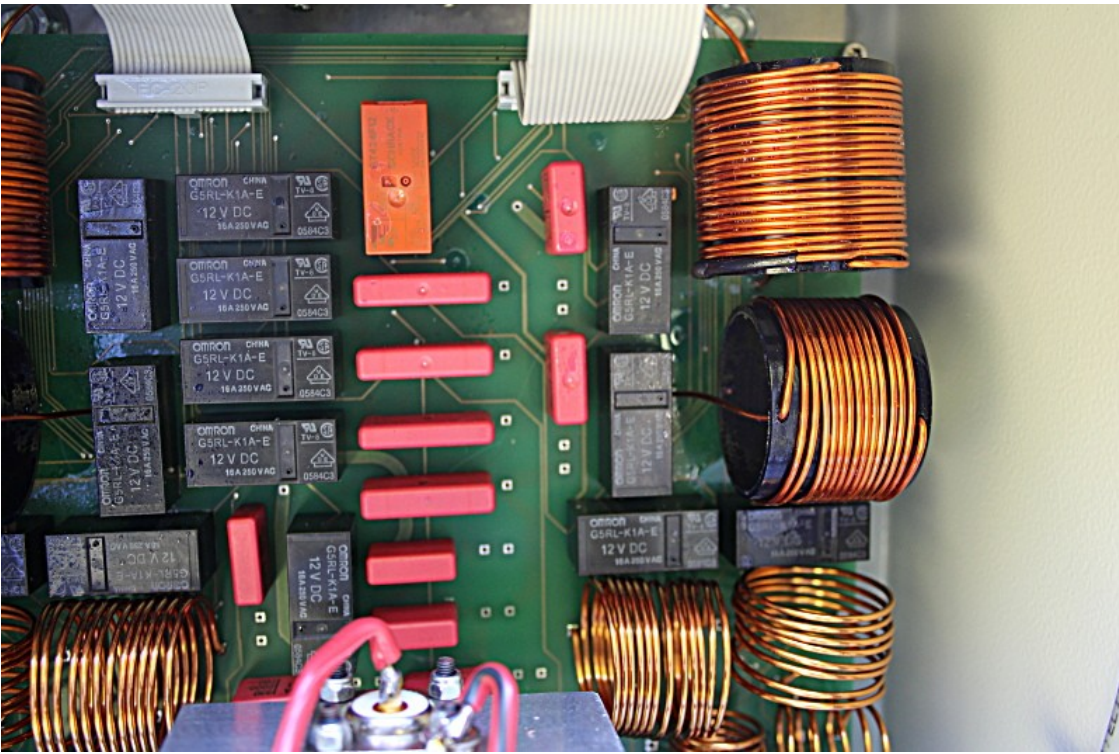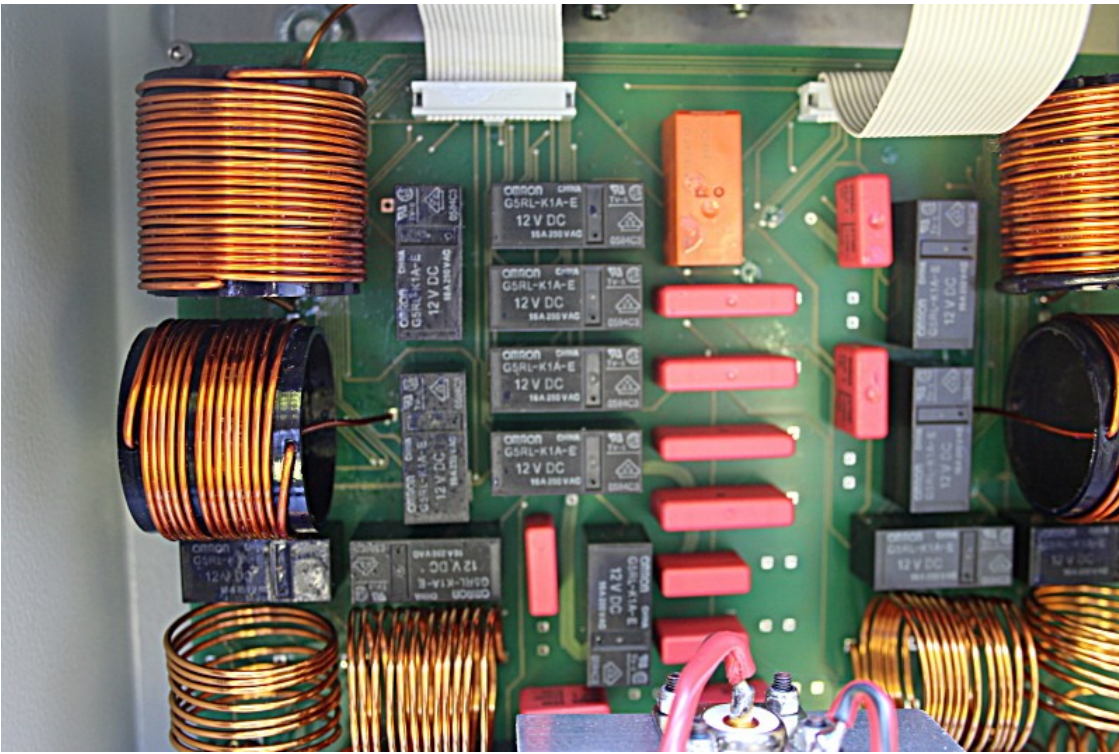
Relay:

high quality but affordable relays are used. These can easily withstand 1kW. They are bistable and therefore do not need any quiescent current.
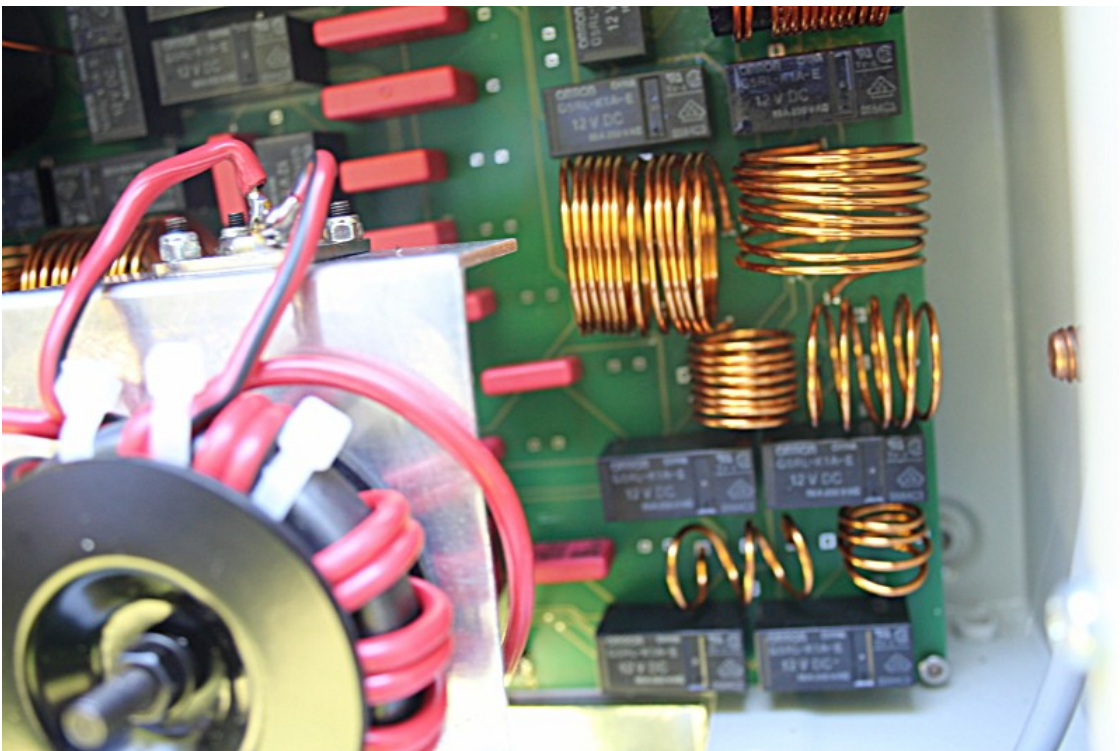
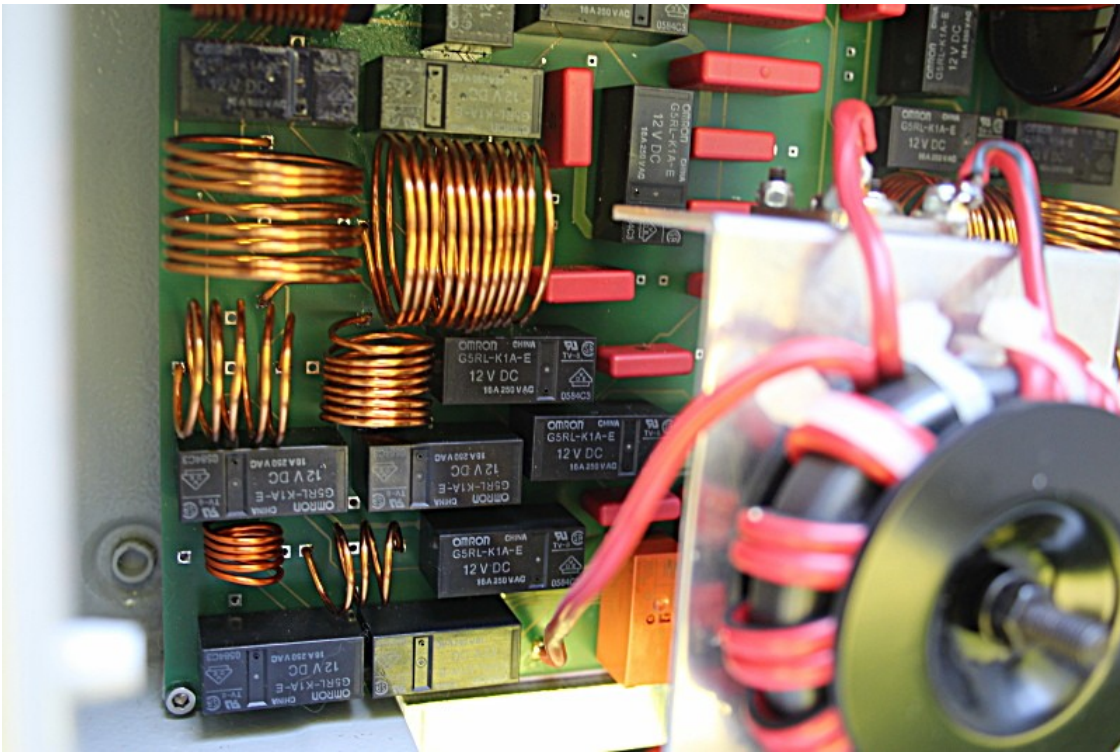8 relays… upper coil bank 8
relays… lower coil bank 8 relays…
capacitor bank
2 relays… capacitor front / rear / off

So a total of 26 relays are used.

Pictures of the L / C / relay board:

the coils are balanced by pulling them apart. The exact value is not so important, it is important that the two identical coils have the same values   so that the tuner remains well symmetrical.
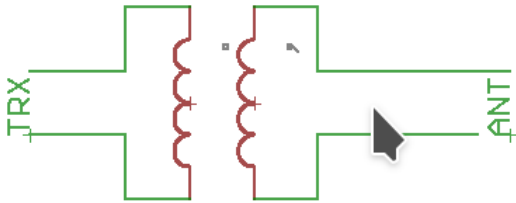

Balun for asymmetrical feed:

this is very easy to build. Take any suitable ferrite core (e.g. Amidon FT240-43) and wind up a twin strand (10 turns). Then you have two connection options:

Current balun (standing wave barrier):
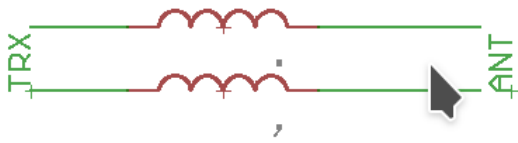
Voltage balun (1: 1 transformer):

both work. I prefer the second, the 1: 1 transformer, because it has galvanic isolation, which is certainly advantageous during thunderstorms.

Equipping and balancing:

The pin headers for the contact plugs for the connection to the controller are built into the plugs JP5 and JP6 (relay connections).

You make the air coils (the large ones on plastic tubes) and check whether the inductance values   are reasonably correct and assemble the board. Capacitors and relays are simply soldered in according to the assembly plan, and you're done.

To test, you take an inductance meter and connect it to JP1 and JP3. All relays K10 to K17 are switched on with a 12V power supply unit. The upper coil branch is now on continuity, you only measure the inductance of the conductor tracks and note this display in order to then subtract it from the measured coil values.

Now you open K10 and you should measure the inductance value of the coil L1. Then you close K10 again and open K11 to measure L2 etc.
The same is done with the lower coil branch K18 to K25.

The coils are adjusted by pulling them apart or compressing them. Finally, they are fixed with varnish.

There is no adjustment for the capacitors, but you should check the values   by switching the corresponding relays.

Then the L / C / relay board is ready.

Control board:

The control board has a simple task, it should make the tuner remote controllable so that we can mount it at the optimal point, i.e. at the feed point of the antenna or chicken ladder, and then adjust it from Shack.

The control board has a serial interface (RS-232 level) and awaits command data there. These commands contain instructions which relay to open and which to close.

Serial interface:

only input RxD (output TxD is not used by the firmware). Baud rate: 1200, 1 stop
bit, no parity
PC compatible, i.e. +/- 12V level.

There are two types of commands:

1. Commands for manual input using a terminal program (mainly used for testing)

2. Short, machine-readable commands (used by the control software)

Commands for manual control via the terminal program:

Switch capacitor: Cab (Enter)
a… capacitor number 1 to 8 b… 0 =
off, 1 = on

Example: C11 switches on the relay of the capacitors C19 / 20/21/22. And C10
turns it off again.

Switch coil: Lab (Enter)
a… coil number 1 to 8 b… 0 =
off, 1 = on

Connect capacitors to the transmitter side or the antenna side:

V1… switches on relay K9, i.e. the capacitors on the transmitter side (V = front), V0 switches it off

H1… switches on relay K26, ie the capacitors on the antenna side (H = rear), H0 off again

(With the coils, of course, 2 relays are always switched at the same time, for the two symmetrical branches,
this is done automatically).

With these commands you can test the whole tuner very well and switch all relays individually. As soon as all relays have been tested, the tune.exe program can be used.

Connection:

The connection between the control board and the relay board is made by two flat cables with press-on connectors, which saves a lot of soldering work.
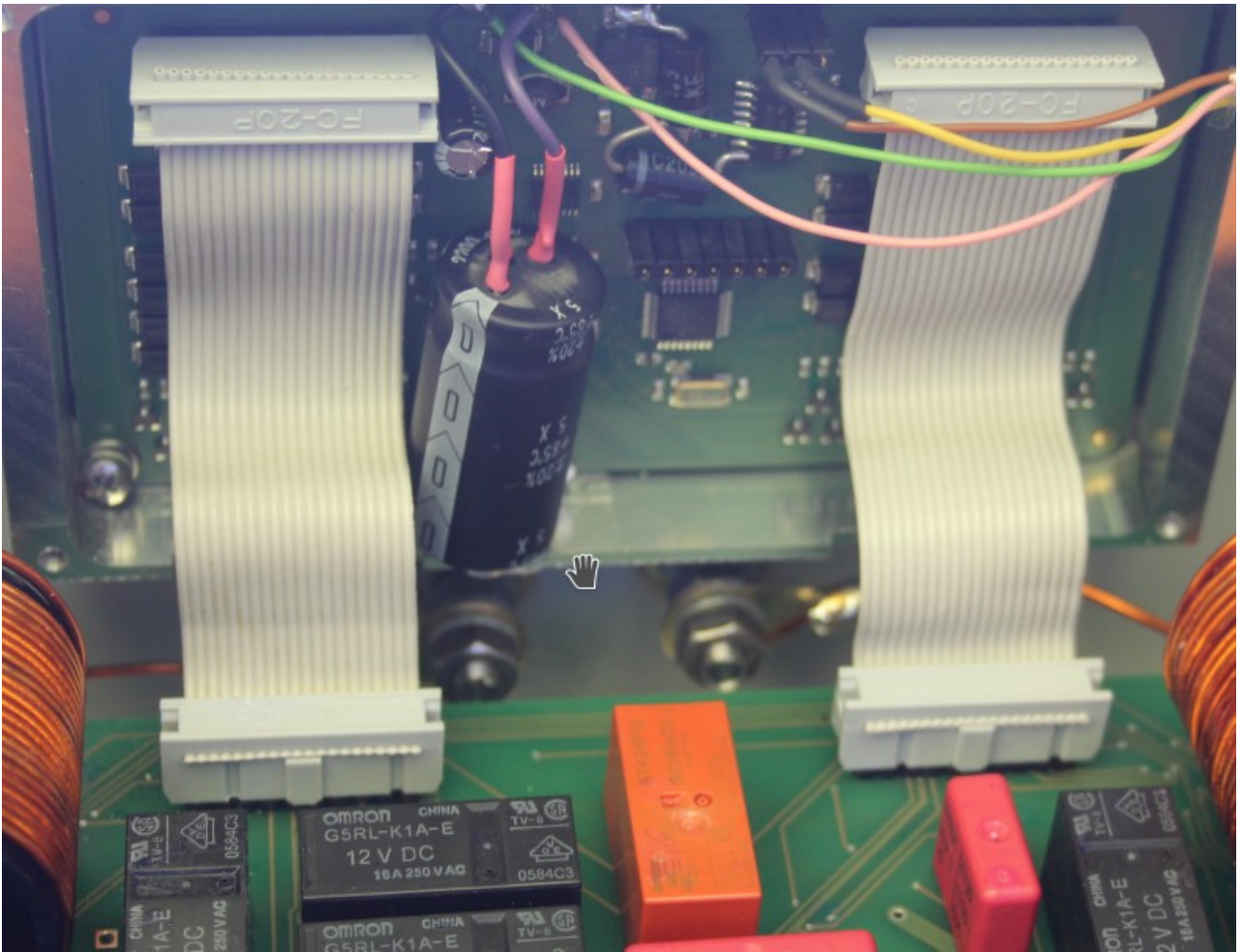
the distance from the shack to the tuner is over 70m for me and the cable is relatively thin. Therefore I soldered a 1000uF electrolytic capacitor to the power supply so that short current peaks when switching the relays are intercepted.
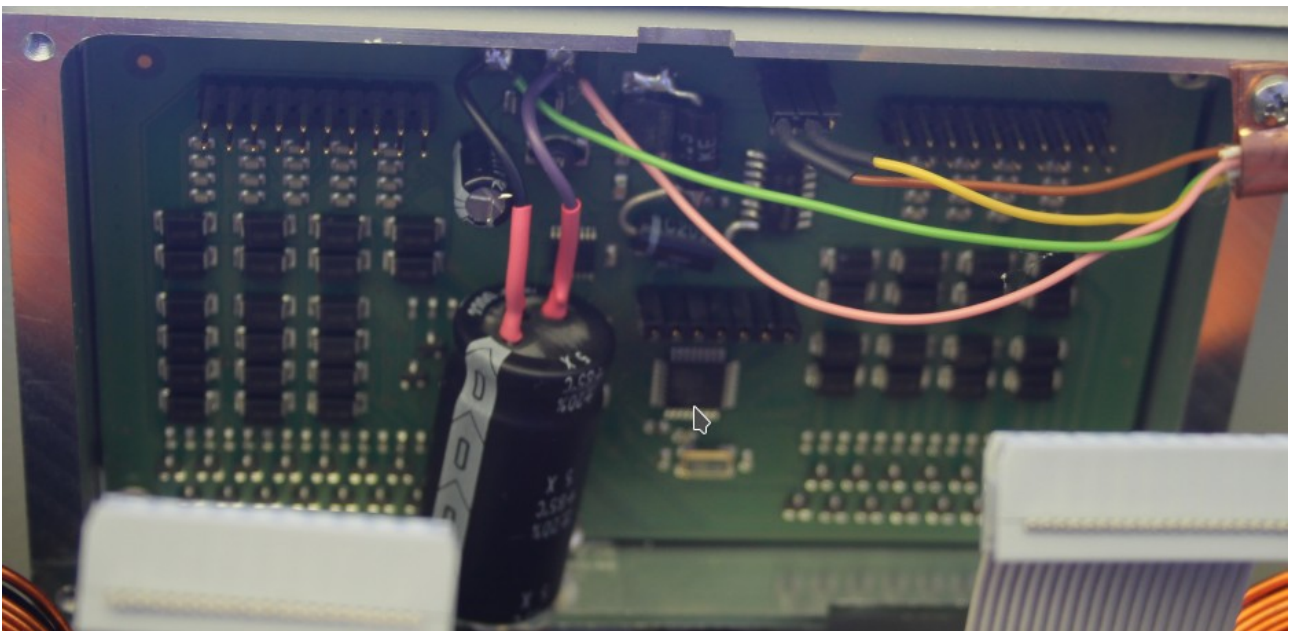
if you look closely, you can see two thick diodes in the top center, which I have also installed. Once the MAX232 of the serial interface broke during a thunderstorm,

due to overvoltage in the data line. So I soldered two TVS diodes to the serial input, nothing has happened since then.

Equipment:

if you assemble this board yourself, assemble all components according to the assembly plan, there is a special feature:

Two wire bridges must be made on the board, as shown in the picture, these two bridges are best made after the assembly on the underside of the board: see the link to the picture: ctrl_Bruecken.png

Then the voltage regulator is checked and the firmware is flashed. It is an Atmel microcontroller ATmega88PA, you need an Atmel programmer. The pin assignment of the program connection on the board can be found in the circuit diagram.

The firmware is a .HEX file which is flashed. Then the fuses have to be set to the following values:

ext fuse: FF
high fuse: DF
low fuse: E6

now you set the lock bit on: FB. This protects the flash from errors.

Installation:

you connect the control board with the 2 flat cables to the relay board and send switching commands with a terminal program, see above. If the relays all switch correctly, the software tune.exe can be used.

Control software:

The control software "tune.exe" has two sliders, one for the inductance and one for the capacitance. If you set the slider to a value, a switching command is sent serially to the control board and the relays are switched in such a way that the desired inductance and capacitance value is set.

You can also set whether the capacity should be connected to the transceiver side or the antenna side.

Once you have found the tuning for the antenna on the desired band, you can save the tuner setting for each band. Then you only need to press the appropriate recall button when changing the band and the antenna is tuned.

Operating system:

 tune.exe is written independent of the operating system, but there are still a few system-specific things to consider:

Windows:

tune.exe is simply started; no installation is required. Before using it, you have to enter the number of the serial interface in the upper left corner, for example COM3 or COM4 or whatever. In case of doubt, you can determine the COM number in the device manager.

Linux (PC or Raspi, Odroid or other single board computers):

here tune.exe runs under the control of the "mono" package. So you have to install mono first and then start the tuner by entering: mono tune.exe

> *Attention Raspi and Co .:*
> ancient and buggy mono versions are often offered here. After installing the package: mono-complete you enter in the command line: mono -V to display the version. If this is older than 4.3, it should be updated from other sources. You can still try to start "mono tune.exe", but with old versions you shouldn't be surprised about malfunction or crash.

Before you can control the tuner, the name of the serial interface must be entered in the top left. Usually you will use a USB-to-serial converter. These have the name:

/ dev / ttyUSB0
you enter that in the top left.
(If you already have another interface in operation, the name could also be / dev / ttyUSB1). You can determine the name by entering in the console: ls / dev / ttyUSB * Then the existing interface names are output.

Voting process:

As long as there is no automatic voting, this is done manually. This even has advantages, as there are several tuning points for each antenna, but not all of them are equally good. Autotuners are satisfied with the first tuning point at which the SWR is better than 1.5. Manually

can we do that more precisely. I have a setting of for my antennas on each band
1.1 found.

Since every antenna is different, there are no guidelines. But a few rules can be observed that often (if not always) apply:

* Antenna too short: capacitor on the TRX side

* Antenna too long: condenser on the antenna side

* Inductivities greater than 3uH and capacitances greater than 1nF are almost only applicable for the lowest bands, i.e. 160m and possibly 80m. Otherwise the values   should be chosen rather small.

* The easiest way to find the tuning is with a simple SWR meter (is much better and faster than with the best measuring devices, at least that was the case with me).

I usually start at 0 and then jerk the inductance up. Then I look with the C to see if the SWR goes down. If not, I'll go up a little bit with the L, and so on.
It can seem difficult at first, but persevere, with a little practice you will soon get the hang of it and find the optimal tuning points very quickly.

Once you have found the vote, don't forget to save the settings for the corresponding band.

The tunervalues.num file can be found on the hard drive and should be saved as it contains the tuning values found.