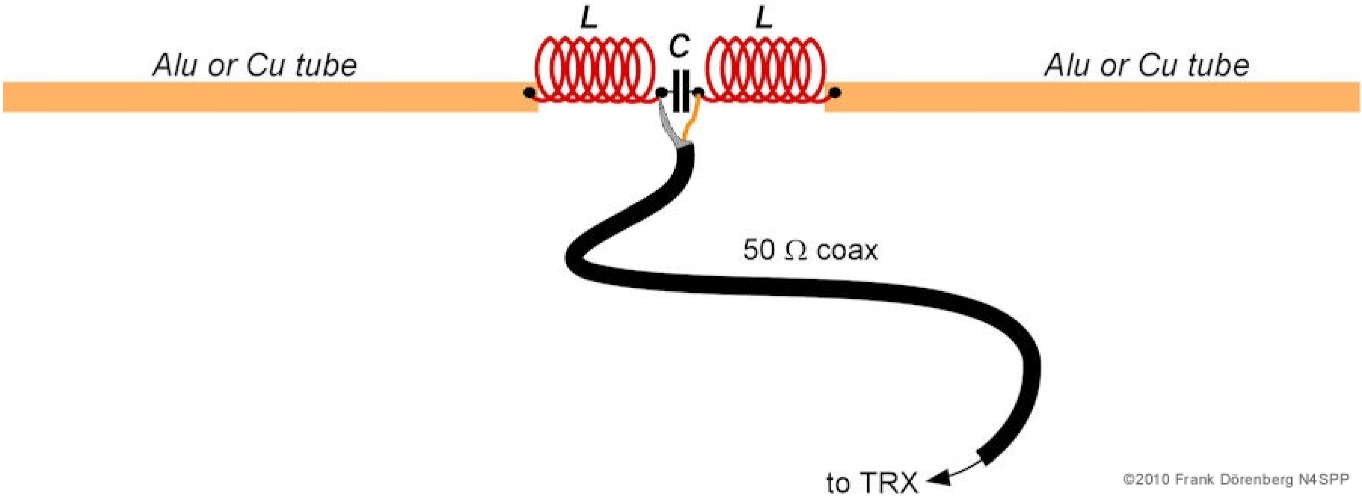
"KGD" SHORT MONO-BAND DIPOLE ANTENNAS

Antennas | Magnetic Loops ▼ | Verticals ▼ | Dipoles & doublets ▼ | Other ▼ | Accessories ▼

■ [KGD-20-FD] ■ [KGD-80-FD Mk 1] ■ [KGD-80-FD Mk 2] ■ [Simulation model]
■ [References]

INTRODUCTION

No, this is not a KG**B** antenna, even though it's overall length makes it a stealthy antenna: only 1m8 for the 40 m band! This antenna project is my implementation of the German "KGD" antenna: the "**K**urz **G**eratener **D**ipol" (i.e., "shorty dipole"). No, it is not a miracle antenna! But I am pleased with its performance, and it definitely is an option for those with space restrictions. The antenna was developed by a team of the DL-QRP-AG, the German association for QRP and homebrew amateur radio. They used to sell kits via QRPPproject, with the required dipole center-section with pre-wound coils, and pre-cut aluminum tubes. Unfortunately, they no longer do. But: so what? Amateur radio is about building yourself! And the kit manual is still available (ref. 1, in German). The QRPproject website has an extensive forum [in German], where this antenna has been discussed extensively (ref. 1).



The concept of the KGD antenna - a (very) short, base-loaded dipole

The antenna is a short, base-loaded dipole. In the original design, the dipole-legs are made of aluminium tubing. There is a loading coil at the base of each leg. A 50 Ω coax connects directly to the coils. A capacitor across the coax adapts the antenna impedance to the coax.

Do not get near the antenna when transmitting!
Do not let any people or animals get near the antenna when transmitting!
Do not use more than 50 W continuous power!

This antenna has a high "Q". So, at the resonance frequency, **very high voltages** will be generated across the coils - even when transmitting with only a couple of watts! A fluorescent light held near a coil will light up, even at low power.

Yours truly, holding a small fluorescent light tube near de coils of the KGD antenna
(transmitting a 30 W carrier)

Note that the high voltage is basically across the coils, not across the capacitor! So the capacitor does not have to be a high voltage type. However, the capacitor should be a low-loss type. That is: a capacitor with a small Equivalent Series Resistance (ESR), and a small Dissipation Factor (DF). Otherwise, the capacitor may become too hot (and disintegrate - **dangerous**), and the apparent current may exceed the capacitor's current-rating.

The table below shows the dimensions of the original design, for several frequency bands. Each leg has a length of only 1.75% of the wavelength (2% for 80m). All coils are made of 0.8 mm diameter enameled copper wire (a.k.a. CuL, magwire, transformer wire). You can also use AWG #20 wire (0.8128 mm Ø). In the original kit, the center section is made of solid polyamide, and has machined grooves for the coil windings. It is inserted into the aluminium tubes.

freq band	tube length (each leg)	tube ID	windings (each coil)	coil ID	capacitor
80 m	160 cm	20 mm	258	20 mm	Beta Match (note 1)
40 m	70 cm	18 mm	114	18.5 mm	470 pF (note 2)
30 m	50 cm	18 mm	71	18.5 mm	330 pF
20 m	35 cm	18 mm	47	18.5 mm	220 pF
17 m	30 cm	18 mm	35	18.5 mm	220 pf

Note 1: instead of capacitor, use a Beta Match coil with two turns per loading coil
Note 2: alternatively, use no capacitor, but interconnect the coils and tap each at 1.5 wdg from center

The original dimensions - from the manual

Note that the capacitor is not part of a tuned circuit. You can actually change the capacitor value by, say, 200% and the resonance frequency of the antenna will not change. "Doorknob" capacitors such as the one I used, tend to have a poor thermal coefficient, which makes them unsuitable for use in tuned circuits. However, in our application, they are OK (though over-dimensioned).

The feed-point impedance is the sum of the radiation resistance and the loss resistance of the antenna. It can be determined by measuring SWR at the feed-point, or using a network/antenna-analyzer at the feedpoint. The loss resistance is driven by the coil, the tubes, and electrical connections. If you change the coil dimensions (core diameter, wire gauge, inter-wire spacing) the coil losses will change, and a different capacitor value will be required. Likewise, if a different diameter tube is used. Obviously, this also affects the bandwidth of the antenna. If the losses are increased (not a good idea), e.g., by using thinner wire for the coils, actually no capacitor may be required. Conversely, the coil dimensions may be changed so as to still have the desired antenna resonance frequency, but a feed-point impedance that can be adapted to the coax with a 1:2 or 1:4 balun.

Using a 1:1 current choke is recommended, and is what I use (placed close to the feed point of the antenna).

Per the manual: if the dipole is installed near the ground (height < 1/8 λ), it should be used vertically. The coax should be perpendicular to the antenna for at least the first 1 m (3-4 ft). It appears that the antenna characteristics are very sensitive to the this, especially the first 10-20 cm! Obviously, the antenna should not be installed near metal down spouts, metal rain gutters etc.

A description of my other short 20 m dipoles (2x 3 m / 2x 10 ft fishing poles and 2x 2½ m / 2x 8 ft) is on this page.

KGD-40-FD: KGD DIPOLE FOR 40 MTRS

I have decided to take the liberty of appending my initials to designator of my version(s) of this antenna.

I still had a section of PVC tube from another project, and used that instead. It is dark-grey hard-PVC tube: regular Schedule-40 "rigid nonmetallic conduit - above ground and underground". It is marked as "UV resistant", which is good for an antenna! The ID is 15.7 mm and the OD is 21.5 mm.

I decided to use copper pipe from the local Do-It-Yourself store. They did not have any diameters that came close to the OD of my PVC tube, so I got a smaller diameter: "14/16 mm" (ID/OD). According to the sticker on it, it even comes with a 30 year guarantee! Contrary to the original design, my copper pipe will have to be fitted *inside* the PVC-tube.

The PVC is thermoplastic: it softens when heated. So, to avoid having to ream the ends of the PVC pipe, I checked, and after holding the end of the PVC pipe in boiling hot water for about a minute, the copper pipe can be pressed into the PVC pipe by hand (16 vs. 15.7 mm is not a lot...). My PVC tubes state that they are rated for 90 ºC (200 ºF). So, boiling water is hot enough to do this (unless you are on top of a very high mountain, as water will boil there at (much) lower temps). **C**PVC (hot water conduit and some sprinkler system pipes) has a higher temp rating. It will be (much) more resistant to heating of the coils, and will not become malleable in boiling water. If you **very (!!) carefully** heat up the (C)PVC about 30 cm (1 ft) above a small burner of your kitchen stove, while turning it **constantly** (like a spit), it will also soften enough to work with. But I do not take any responsibility if you do this and burn yourself, or burn your house down.

The original design has some sort of plastic piece that is pressed into the tip of the aluminium tube sections. A threaded rod of about 20 cm (8") long and several mm diameter is screwed into this. The rods form a capacitive load at the tips of the copper tubes, and are used to tune the resonance frequency of the antenna. See plots further below.

I decided to build the 40 meter version of this antenna. Total length is only about 160 cm (≈ 5 ft 4") without the tuning rods. I had to recalculate the number of coil turns from the design diameter of 18.5 mm, to 21.5 mm. When increasing the coil diameter, the required number of turns is decreased by a factor that is equal to the ratio of the square of the old and the square of the new diameter (basically the ratio of the cross-sectional areas):

$$n_{new} = n_{old} \times \frac{diam_{old}^2}{diam_{new}^2}$$

So, when going from 18.5 to 21.5 mm diameter, the number of turns would have to be reduced from 114 to 85. As you will see further below, the actual number for the PVC tubing that I used, turned out to be 92. The required length of wire (per coil) is about 5.8 m (reduced from 6.6 m). Using an on-line coil calculator (e.g., ref. 2A/C), the estimated inductance is ≈ 45 µH.

Note that the required number of turns will have to be reduced by about 5% if you weatherproof the coils with something like shrink tube.

Read the Construction section below, to see how I arrived at the final dimensions.

freq band	tube length (each leg)	CU tube OD/ID	windings (each coil)	coil ID	capacitor	Brass tuning rods (length sticking out)
40 m	70 cm	16/14 mm	92	21.5 mm	470 pF	65-85 mm

Note: coil parameters are the same for 0.8 mm CuL and AWG #20

The final dimensions of my 40 m KGD antenna

As described further below, I had to rebuild my antenna after I melted the PVC coil core by running at about 100 W for several minutes. This time, I used AWG #20 enameled copper wire, instead of 0.8 mm. After tuning, the frequency plot of my miniVNA antenna analyzer closely matches that of my first build. So construction of this antenna appears to be repeatable.

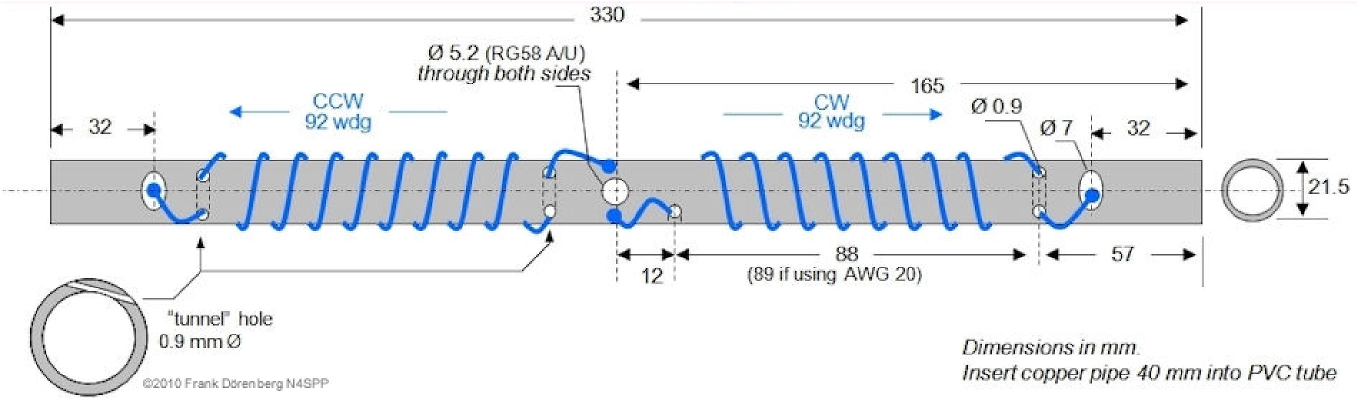
Note that, as always, "Harry's Law of Coils" applies. As Harry (SMØVPO) says:

- *You* cannot wind coils like *I*, and *I* cannot wind coils like *you*.
- Coil-winding data is a constant that varies from person to person.

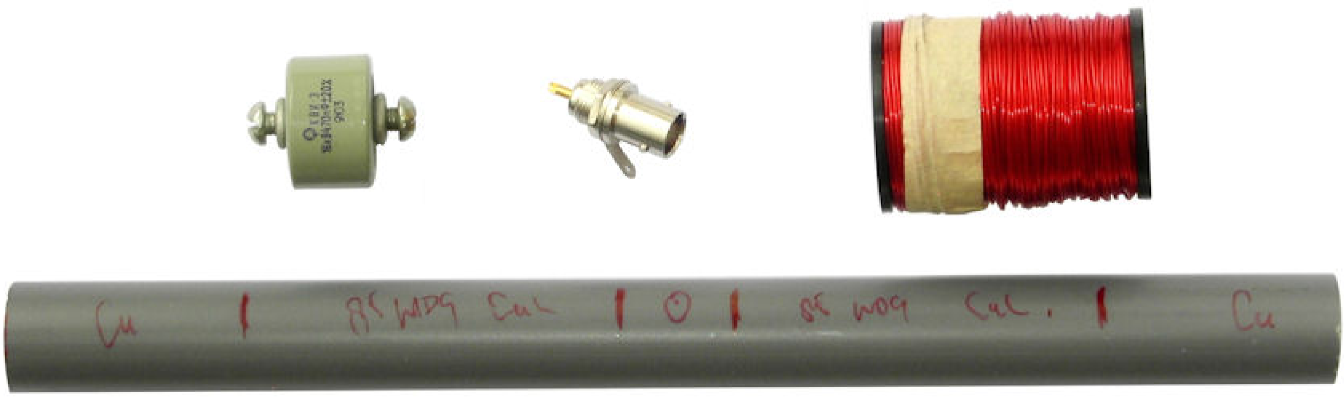
CONSTRUCTION AND ADJUSTMENT OF THE KGD-40-FD

These are the components that I used for my first KGD antenna:

- 1 section of hard PVC tube (Schedule-40), 32.5 cm long, 21.5 mm OD, 15.7 mm ID.
- 1 section of PVC tube, 40 cm long, with an OD that fits snugly into the above PVC tube.
- PVC glue
- 2 sections of copper tube, each 70 cm long, 16 mm outer diameter.
- for the coils: 2 x 6 m enameled copper wire (CuL, magwire, transformer wire), 0.8 mm diameter (or AWG #20).
- 1 capacitor, 470 pF. I used a 16 kV Russian-made "doorknob" capacitor. See the notes above.
- 2 ring-tongue terminals (to fix the end of the coil wire and the coax to the capacitor).
- 2 sections of brass rod, 20 cm long, M6 thread.
- 4 brass nuts, M6.
- 2 round plastic inserts, diameter to tightly fit the inside diameter of the copper tube. A hole must be drilled through the center (lengthwise), and a thread tapped for M6.
- 2 plastic inserts, at least 8 mm diameter, length to loosely fit across the inside of the copper tube. This is a spacer for the inserted tip of the brass rods, and will keep the rods centered inside the copper tube. A hole must be drilled across the middle of the insert, and tapped with an M6 thread.
- 1 meter coax, 50 Ω, e.g. RG58.
- BNC or PL connector for the coax.



Dimensions of the PVC-tube center section - my final design for the 40 mtr version

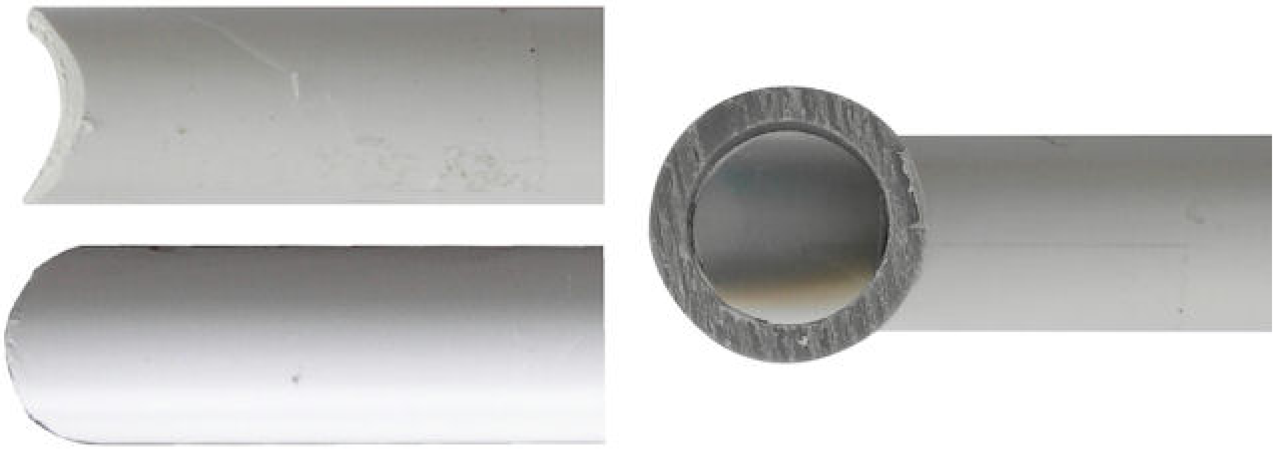


The main components of the antenna - the Russian-made 470 pF capacitor handles 16 kV

(copper pipe not shown to scale; brass tuning rods not shown)

With my first KGD antenna, I terminated the outer ends of the coils with a ring-tongue or spade terminal and screwed the terminals into an M3 hole that I had tapped into the copper pipe. The wall of the copper pipe is only 1 mm thick. On top of that, copper is rather soft. This is really not enough for a robust and solid thread. So, for my second antenna, I decided to solder the coil ends directly to the copper pipe. I added a hole at the tips of the PVC tubing for this purpose.

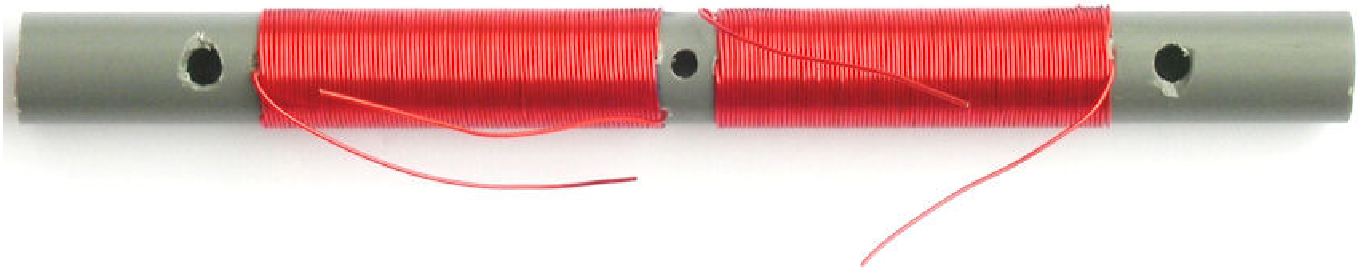
- Read these constructions steps at least once, before you start your own project!
- Cut the PVC pipe to length, per the table above.
- Drill holes in PVC pipe, per the diagram above:
  - the 5.2 mm diam. hole for the coax is drilled straight through the PVC pipe, i.e., two holes. If you only have a 5 mm drill, just move it in and out of the holes a couple of time to slightly (!) increase the diameter of the holes. It must be a relatively tight fit for the coax.
  - the two 8 mm holes at the tips of the PVC-tube are for connecting the coils to the Cu tube. Make the holes oblong or oval, by tilting the drill.
  - the four 0.9 (or 1.0) mm "tunnel" holes are for fixing and guiding the coil wires at the ends of the coils.
- The antenna characteristics are rather sensitive to the coax being at a right angle with respect to the large PVC tube. In my second version of the KGD I have expanded the original design with a second PVC tube that is fixed perpendicularly to the PVC coil core. The coax is passed through this second tube.
  - The exit hole of the coax is shown at the center of the dimensional diagrams above. The entry hole is on the opposite side.
  - Widen the exit hole with increasing drill bit sizes until the smaller diameter PVC tube almost fits into the hole. Carefully ream this hole with a conical grinding bit until the latter tube section fits tightly into the hole.
  - Round off one tip of the smaller PVC tube until it has the same diameter as the inside of the large PVC tube. See photo below. This tube will be inserted later, after the coils are wound.



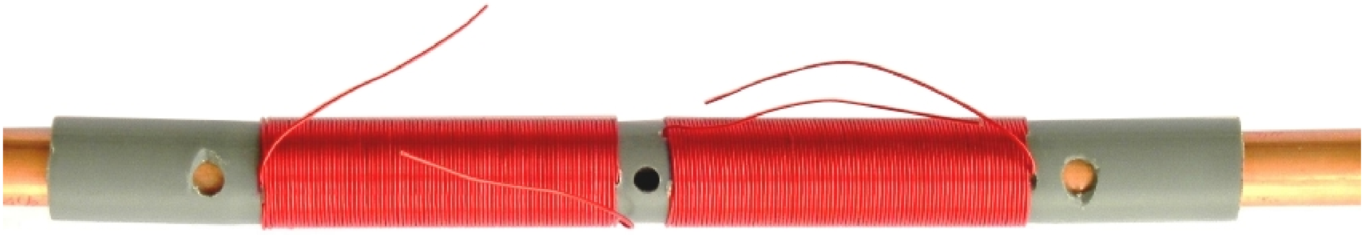
Shaped tip of small-diameter PVC tube and its perpendicular insertion into the PVC coil core

- With a conical grinding bit, chamfer the inside of the tube ends. This will facilitate insertion of the copper tubes.
- Wind the first coil:
  - Insert the coil wire through the tunnel hole near the hole for the coax, in the direction indicated in the diagram.
  - Make sure that about 10 cm of the wire sticks out.
  - The end that sticks out should be bent at a right-angle, towards the hole for the coax.
  - Wind 95 turns. During "tuning & pruning" of the antenna, this will be reduced.
  - Wind the coil tightly.
- Once the coil is wound, terminate the coil:
  - Keep tension on the wire, and thread it trough the tunnel hole near the oval hole at the tip of the PVC-tube, in the direction indicated in the diagram
  - Cut the wire such that about 10 cm of the wire sticks out.
  - The end that sticks out should be bent at a right-angle, towards the oval hole.
- Repeat for second coil.
  - Wind the second coil in the opposite direction: if the first coil was wound clockwise,

then wind the second coil counter-clockwise, and vise-versa. Note that this is per the original design. I have wound the coils in opposite directions as well as in the same direction, and found no difference in antenna characteristics. But we might as well stick with the original design...



The PVC center-section with the coils wound
(photo taken before rewinding one of the coils in counter/clockwise direction)



Copper tubes inserted into the PVC center-section

Let's prepare the copper pipes:

- Cut the copper pipe to length: 70 cm (27 9/16"). With a file, chamfer the outer edge of the pipe. This will make it easier to insert it into the PVC tube.
- Apply solder to the last 4 cm of one end of each pipe section. This is the end that will be inserted into the PVC tube.
  - I do this by heating the end of the pipe over the kitchen stove, applying rosin-core solder, and turning the pipe to evenly distribute the molten solder.
  - I hold the pipe with self-locking pliers, about 30 cm (1 ft) from the hot end.
  - When done, and the solder is still hot, tap the end of the pipe to remove excess solder.
  - Use a kitchen scrubbing sponge (one of those green things) to clean off the solder flux.
  - If the layer of solder is thick or uneven (with "gobs" of solder) then file of the high spots.
  - Cool off the pipe in cold water.
- Mark the copper tubes at 4 cm from the end that will be inserted into the PVC tube - that's how far they will be inserted. I use a piece of painters tape for this.

We are now ready to join the copper pipes into the PVC coil core. The PVC is thermoplastic: it softens when heated. My PVC tubes state that they are rated for 90 °C (200 °F). So, boiling water is hot enough to do this (unless you are on top of a very high mountain, as water will boil there at (much) lower temps).

- Put a small cutting board up against the wall of your kitchen counter. Put a large cutting board against it, on your counter.
- Put enough water in a sauce pan such that it is a little over 4 cm deep, and bring the water to the boil.
- Have your copper pipes ready to go!
- Put one end of the PVC tube vertically into the boiling water for one minute. It is OK to let it rest on the bottom of the pan.
- **Quickly** insert the copper tube into the PVC tube:
  - **You only get one chance to get it right!**
  - **Quickly** put the PVC tube onto the cutting board, perpendicular to the wall, cold end against the wall.
  - **Quickly** line up the tinned end of one of the copper pipes with the hot end of the PVC

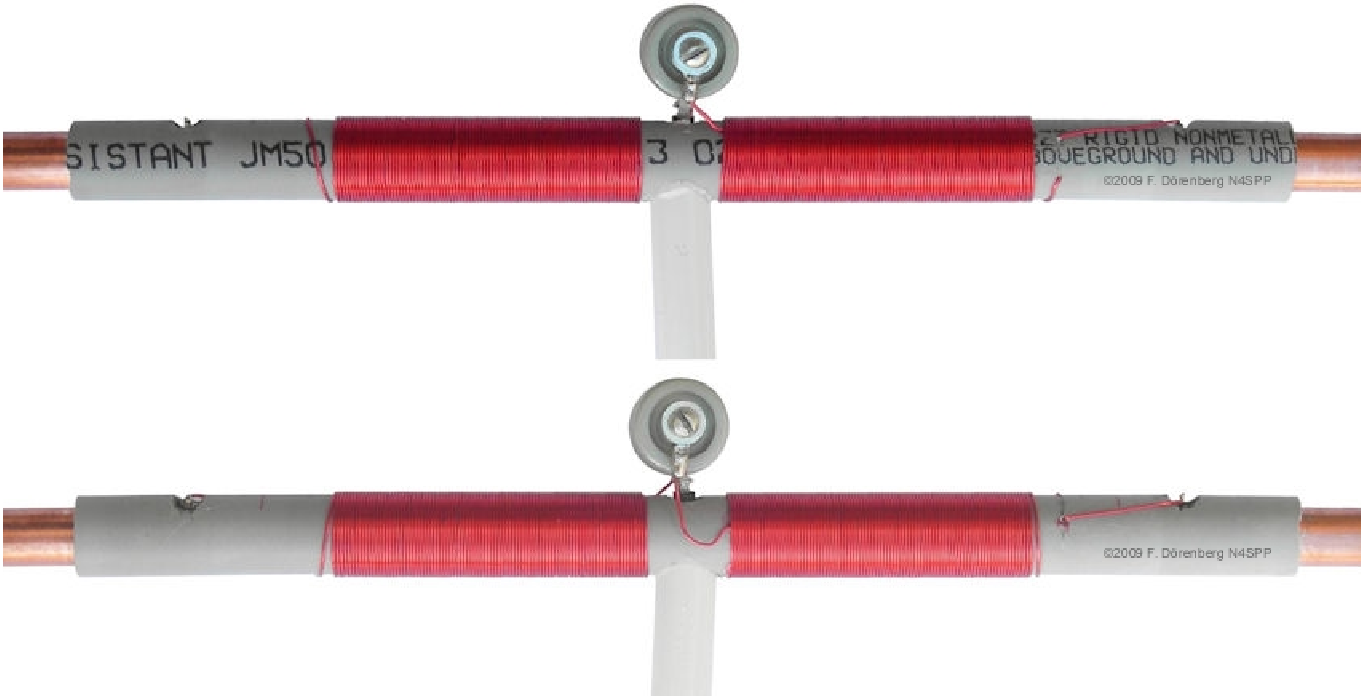
pipe, and **immediately** press it into the hot end of the PVC tube.

- Make sure that you you press the pipe in **straight**! If the centerlines of the pipe and the tube are not aligned, you will probably end up with a crooked antenna!
- Push in the cupper pipe up to the 4 cm marker.
- The PVC will cool off **quickly**, shrink back, and fix the copper tube in place - its position can no longer be adjusted! (though if you **very (!!) carefully** heat it up about 30 cm (1 ft) above a small burner of your kitchen stove, while turning it **constantly** (like a spit), the PVC will soften again and you can straighten the PVC and maybe adjust the position of the copper pipe...).

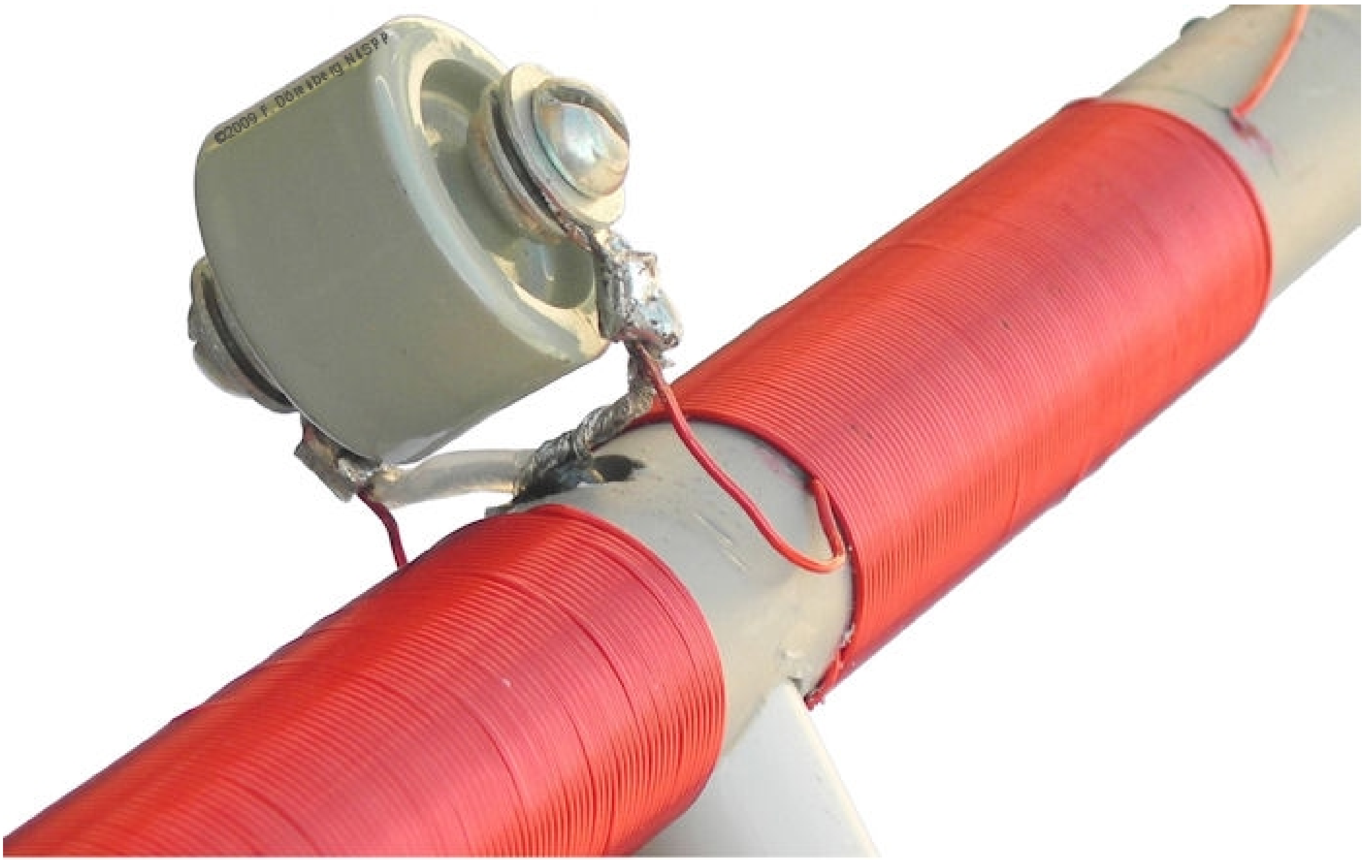
- Repeat the process with the second copper tube.

The antenna is now taking shape. We'll proceed with connecting the coils and the coax:

- The wire of the two outer coil ends is sticking out of the "tunnel holes" in the PVC tube, and is bent towards the nearest oval hole. Guide them over the center of the hole, cut off the wire 1 cm beyond that center. Bend that last 1 cm of the wire at a right angle, i.e., perpendicular to the centerline of the PVC tube.
- Remove the enamel of the last 1 cm of these wire ends. This is easiest done with a heavy-duty soldering iron (not a soldering gun!). Once the soldering iron is hot, apply enough solder tin to the tip of the iron to obtain a large drop of molten solder. Hold each wire ends into this gob until the enamel is burnt off.
- Solder each wire end to the (pre-soldered) copper pipe that is visible through the oval hole.
- The other coil ends will be connected to the capacitor and the coax. Hold the capacitor over the hole for the coax, about 1 cm away from the PVC pipe, with the "nuts" facing away from the PVC pipe (see photos below). Guide each coil-end wire perpendicularly away from the PVC tube, bend them up to the respective "nut", and cut them off at the "nut" (no, it won't hurt your nuts, hi!).
- Thread the coax through the designated holes, and leave about 10 cm sticking out of the hole where the capacitor will be mounted.
- Strip enough of the insulation off the coax such that the braid can be made into a pigtail that can be folded around the capacitor, almost up to one of the "nuts". See photos below. For my doorknob capacitor (2½ cm (1") diameter, 2 cm between the screw-in contacts), I needed to strip just over 2 cm.
- Fold the center conductor of the coax around the capacitor, almost up to the opposite "nut". Strip ½ cm (≈¼") of the center conductor's insulation, and apply solder to the center conductor.
- Solder the pigtail and one coil-end wire into a ring-tongue terminal and screw it to the capacitor , between two flat washers. Fasten tightly.
- Solder the center conductor and the other coil-end wire also into a ring-tongue terminal, and mount it on the opposite nut.
- Pull the coax such that the capacitor is pulled against the PVC tube.
- Slide the small-diameter PVC tube over the coax, rounded end first, and slide it all the way to the coil-core tube. Apply PVC glue to the rounded tip and to the edge of the hole in the large PVC tube. Fully insert the small tube into the hole (make sure to turn it so that the roundness of the tip aligns with the inside diameter of the large tube), and let the glue cure.
- Install a coax connector (PL-259 or BNC, per your preference) on the opposite end of the coax.



Coils hooked up to the copper tubes, capacitor and coax installed

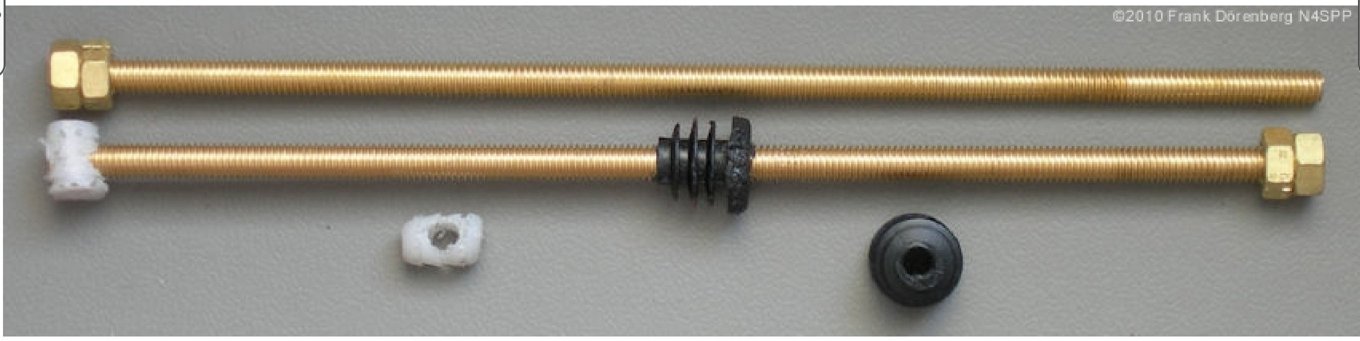


Close-up of the coils and capacitor

Before we can tune the antenna, we must install the tuning rods - note that they do **not** touch the copper radiator tube:

- Install two nuts at one end of each brass rod, and tighten the nuts against each other. These counter-tightened nuts will give use something to hold onto when turning the rods for tuning.
- Screw the rods halfway into the round plastic inserts (the black ones in the photos below) that will end up at the tips of the copper pipe.
- Apply glue to the hole in each of the two small spacer inserts (the white ones in the photos below). Screw one onto the tip of each brass rod (to the end opposite of the nuts). I used Gorilla Glue® (it expands while curing, so don't use a lot).
- Apply glue all the way around the (black) tip-inserts, but don't get any glue near the brass rod! Insert the rods into the copper tube, and fully seat the tip-inserts. You may want to hold them in

place with some sticky tape while the glue cures.



The tuning rods and associated plastic inserts

A tuning rod inserted halfway into the copper tube

Now we're basically ready to tune the antenna. But before we can do that, we'll have to install the antenna outside, away from metal objects if possible. As stated before, if the antenna can't be installed at least 1/8 λ (5 meters or 16 ft for the 40 mtr antenna), it should be installed vertically. The coax should be perpendicular to the antenna for at least the first 1 m (3-4 ft). As stated above, the antenna characteristics are sensitive to this, esp. for the first 20-30 cm - which is why we installed the guide-tube for the coax!

Installation of the antenna on my terrace - mounted 2 m off the ground

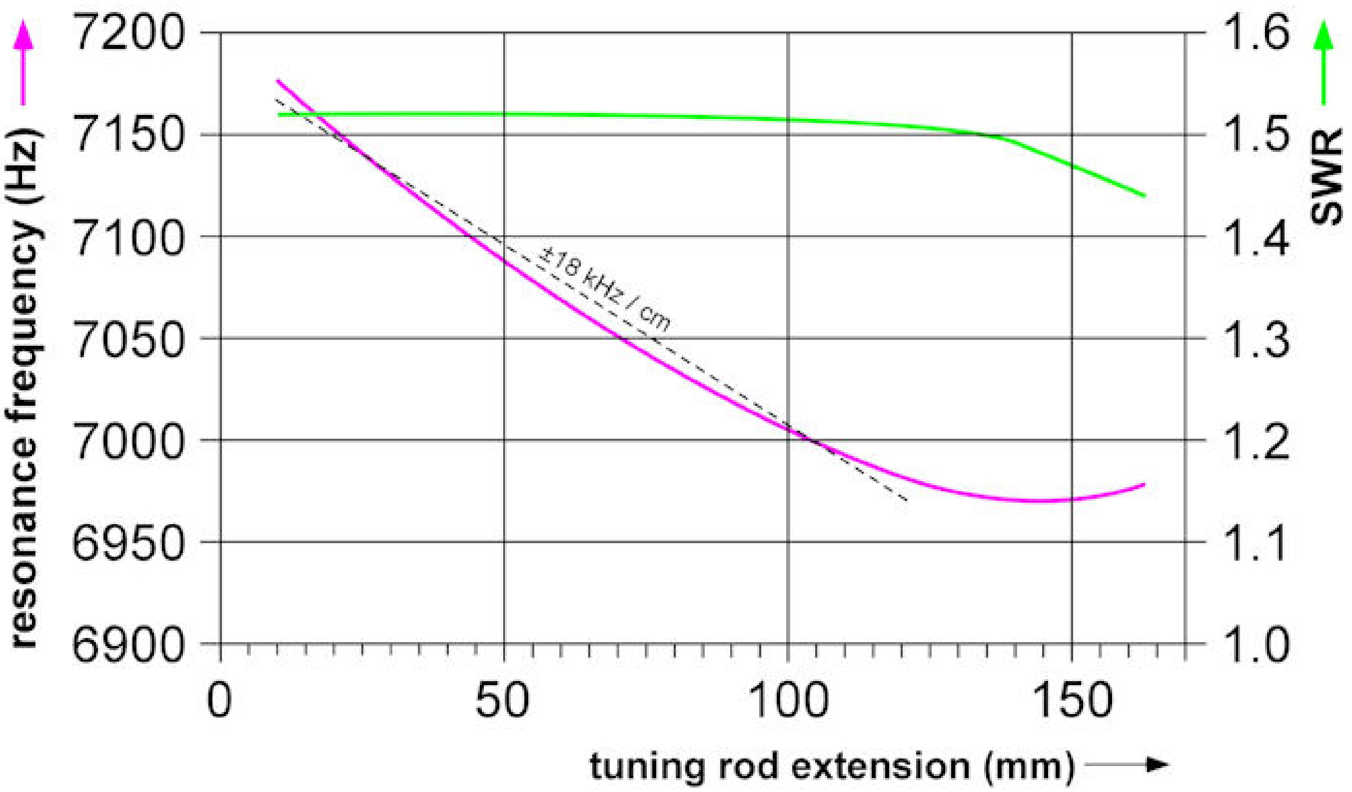
Detail of the tip of the antenna boom
(the boom is 40 mm Ø hard PVC, with a vertical through-hole just under 16 mm Ø, for tight fit with copper tube)

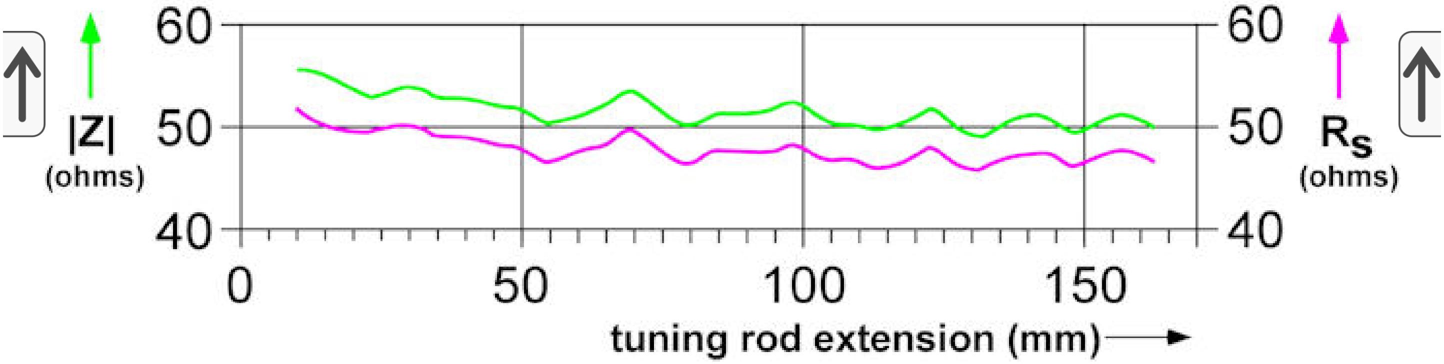
Typical for short antennas, this one also has a very narrow bandwidth around the resonance frequency. Tuning without access to some sort of antenna analyzer or SWR analyzer is difficult. You'd probably have to slowly sweep the frequency of your transmitter while transmitting a carrier, and look at the SWR meter of your tuner to find exact resonance frequency and associated SWR. The tuning procedure below is based on having an antenna analyzer (in my case, a miniVNA hooked up to my PC. Options are to hook up the analyzer right at the antenna, or in the "shack" at the tuner/transmitter at the end of the coax. I do the latter (measurements will include the feedline (12 meters of coax in my case), so I will be seeing what the tuner/transmitter will see later on.

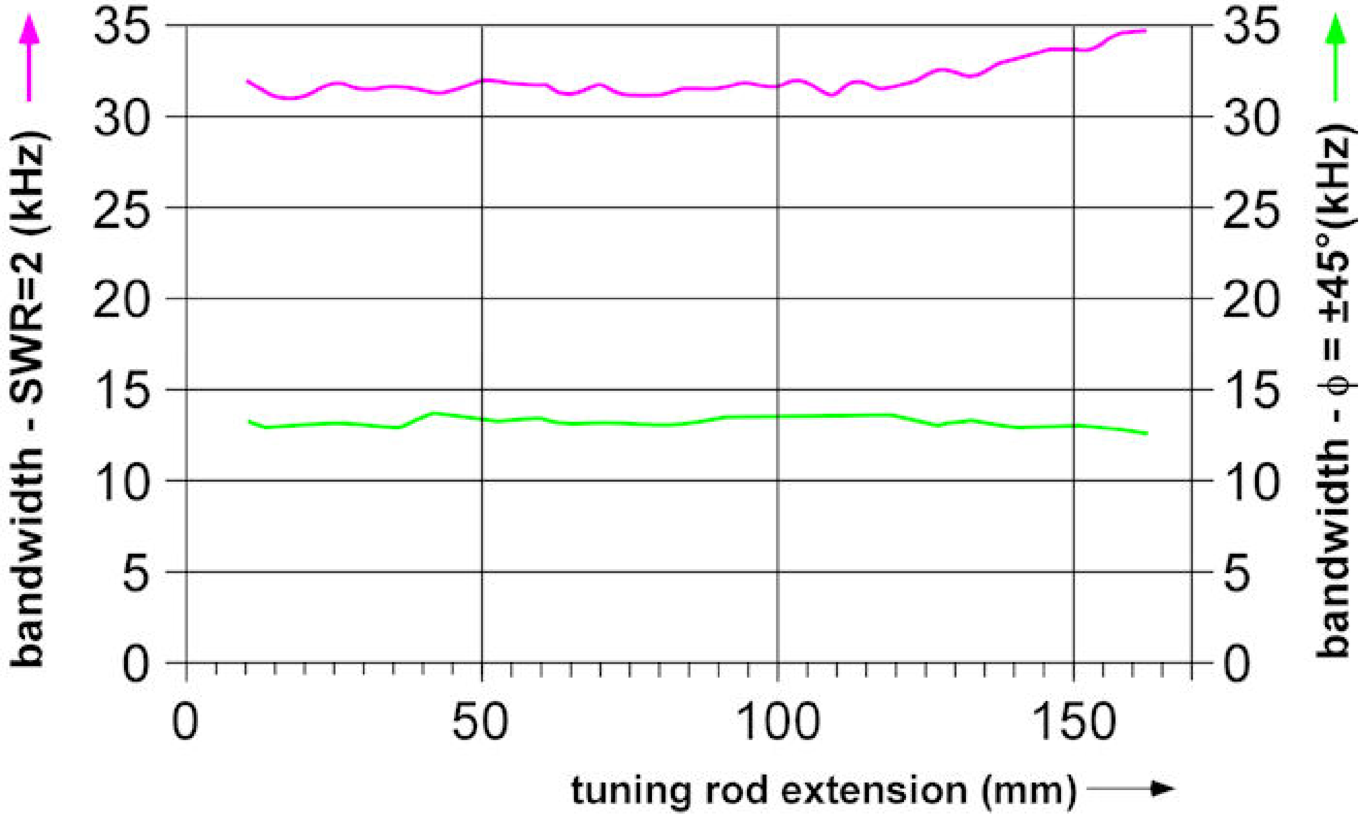
- Install the antenna where you will be operating it! Tuning results significantly depend on installation location.
- Hook up the analyzer and sweep from, say, 6-8 MHz. You should find a nice, sharp resonance dip in the SWR curve.
- Determine where you want the resonance frequency to be, keeping in mind that the antenna has a nominal bandwidth of about 45 kHz between the SWR=2 frequencies. At the resonance frequency, you should be able to operate the antenna without a tuner. On 40 mtrs, I primarily operate with digi-modes (Hellschreiber, PSK31). I decided to try and tune the resonance frequency to the boundary between the narrow-band and wide-band segment of the 40 mtr band: 7040 kHz.

- As the coils have more turns than we expect to need (it is easier to cut wire off than to cut it "on"), the resonance frequency should be below the low end of the 40 mtr band frequency range. Reducing the number of coil turns will increase the resonance frequency.
- Turns are removed at the end of the coils nearest the copper pipe. The same number of turns must be removed from both coils.
- Assuming the initial resonance frequency is indeed too low (if not, something has gone wrong!), we'll remove one turn from both coils. This will also give us a feel for how much the resonance frequency shifts per removed turn. This isn't a constant delta-frequency! The increase-per-removed-turn goes up as more turns are removed. I have observed 35 to 55 kHz shift per removed turn.
- With my second 40 mtrs KGD, I started with a generous 100 turns, and the tuning rods sticking out about 85 mm. Resonance frequency was 6680 kHz, SWR 1:1.1, and Rs=49 ohms.
- Removing 2 turns raised the resonance frequency to 6749 kHz (about 35 kHz per turn). SWR and R hardly changed.
- Removing 3 more turns (now down to 95) raised the resonance frequency to 6871 kHz (about 41 kHz per turn). No change in SWR, R went down to 47.5 ohm.
- Removing 3 more turns (now down to 92) raised the resonance frequency to 7000 kHz (about 43 kHz per turn).
- I could have removed one more turn, but I did not want to overshoot my target frequency. So, I pulled up the resonance frequency by screwing in the tuning rods until only 68 mm was left sticking out. With that, the resonance frequency was right at 7040 kHz, though SWR ended up at 1:1.5 and R at 53 ohms.
    - one of the two rods was a little hard to turn. I applied one (!!) drop of gun oil (high viscosity (= "thick") penetrating oil for firearms and fishing reels) right where the rod enters the insert. After turning the rod back & forth a couple of turns, this did the trick.
- I have left it at this for the time being. Of course, I could have removed one more turn, and pull down the resonance frequency by screwing the tuning rods outward as necessary...

I have also measured the resonance frequency, SWR, impedance, and bandwidth as function of the insertion/extension of the tuning rods (0-165 mm, in 5 mm steps). See the plots below. Note: these plots are for vertical installation, and with a total of 13 mtrs (40 ft) of RG58A/U coax! The resonance frequency varies linearly with the rod position, until the (20 cm) rods are sticking out of the copper tubes by more than ≈12 cm. For more than ≈15 cm, the resonance frequency actually starts going up again! The SWR is constant at ≈1.5, up to ≈12 cm rod extension. Given the observed |Z| and Rs, it appears that the value of the capacitor is basically correct.

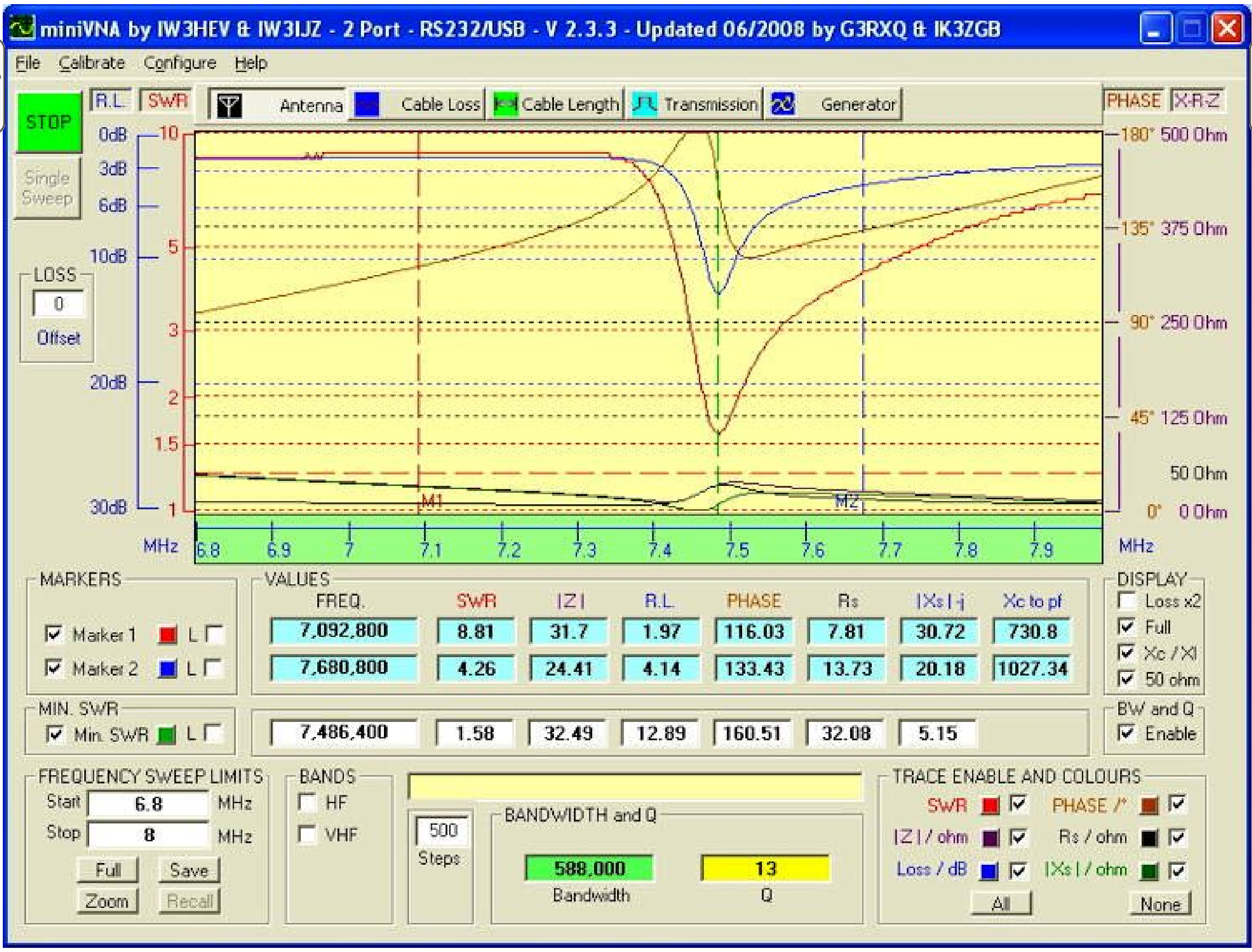






Now the antenna has been tuned, we are ready for action! After having built the antenna on a rainy afternoon and cleaned up the tools etc., I hooked up my miniVNA antenna analyzer. The resulting plot for this original set-up is shown below. It was not good! Resonance frequency about 400 kHz too high, and bandwidth appeared too wide (low "Q") - this turned out to be an "operator failure" on my part.

After completing the antenna on a rainy afternoon early August 2009, and cleaned up the tools etc., I hooked up my miniVNA antenna analyzer. The resulting plot for this original set-up is shown below. It was not good! Resonance frequency about 400 kHz too high, and bandwidth appeared too wide (low "Q" of 13) - this turned out to be an "operator failure" on my part. The old adage holds true: "*a fool with a tool is still a fool!*"

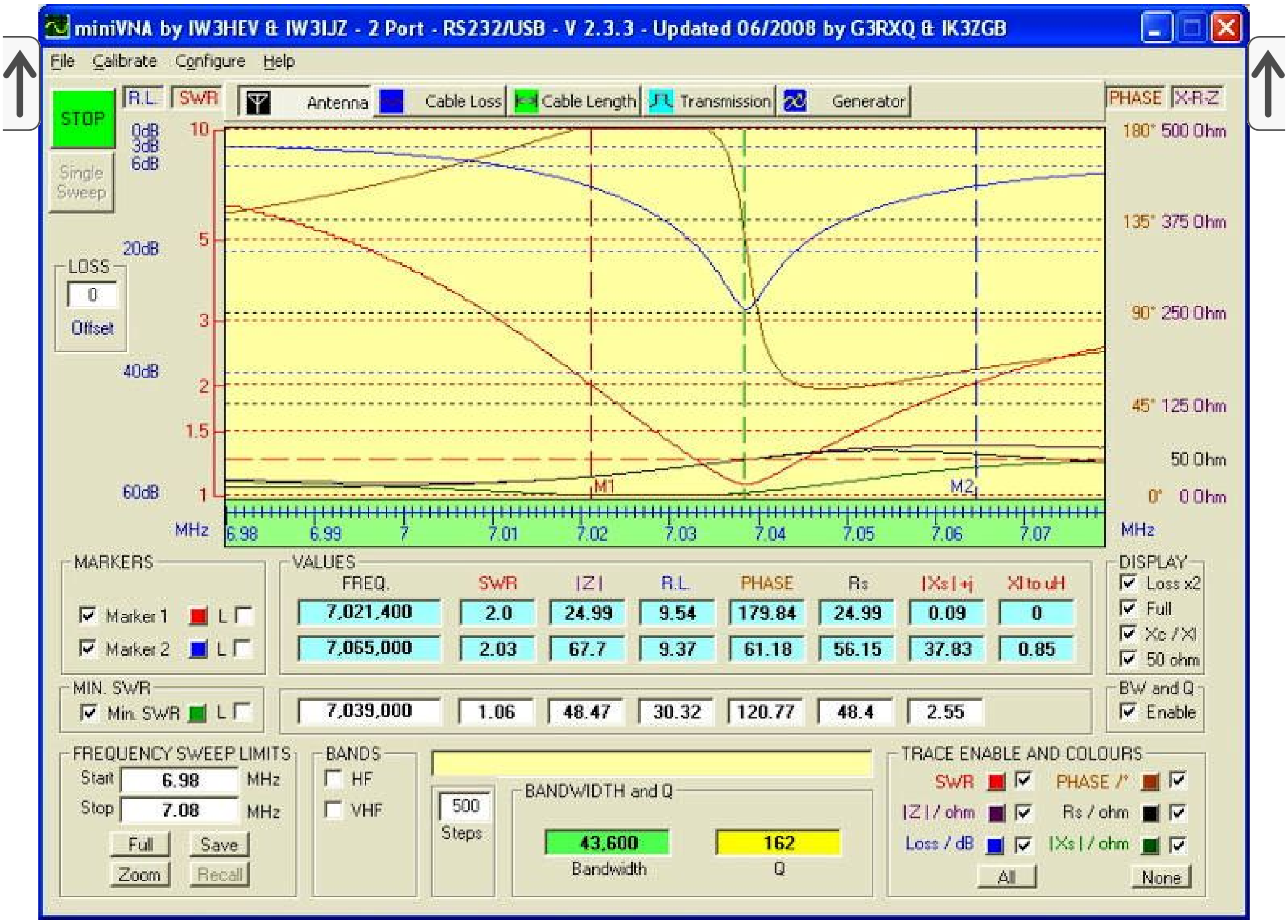


Sweep of the antenna response for the prototype (too few coil turns) set-up and 470 pF
(I originally made the big mistake to misinterpret the indicated BW and Q values)

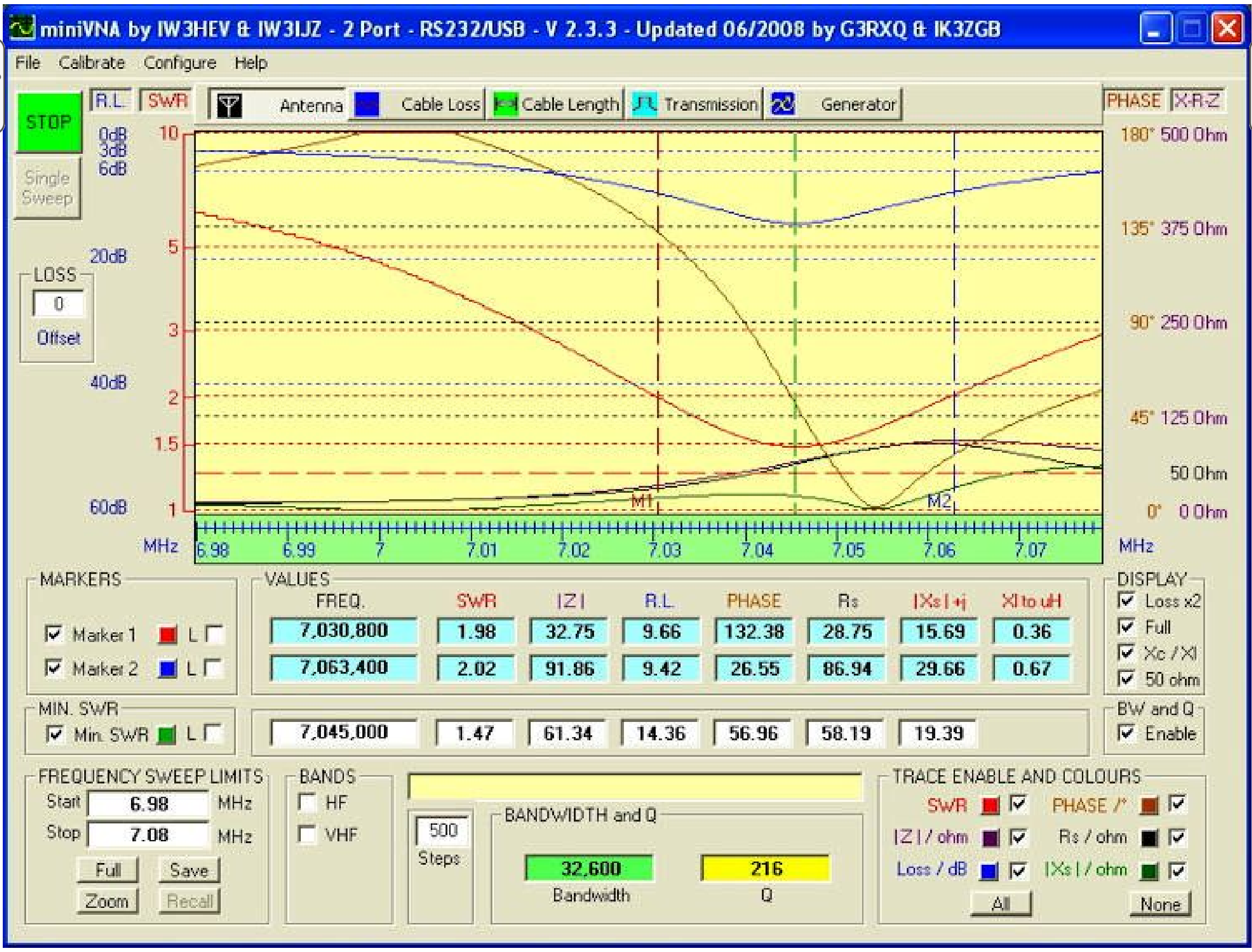
I consulted with the kind fellow-hams of the *QRPproject* forum. Suggestions and observations were that:

- the particular capacitor that I used may not be suitable for HF
- the PVC that I used may not suitable for HF-coils (should use polyethylene, nylon, ...)
  - I tested the PVC in the microwave oven: it does not heat up. Also, I made a resonant circuit with an air-wound inductor and a capacitor, and check the resonance frequency with a dip-meter. The resonance frequency did not change when inserting a strip of the PVC into the inductor.
- due to capacitive charge presented by the metal tubes, the tube diameter is a critical dimension.
- I may have reduced the number of coil turns too much.
- should be able to reduce the resonance frequency by adding the tuning rods at the tip of the tubes.
- the original design calls for the two coils to be wound in opposite directions. I.e., one clockwise, the other counter-clockwise. In this respect, the dipole does not have two identical halves!
- the tuning rods must not make contact with the copper tubes.
- check the frequency-marker settings in the GUI of the analyzer software

I should have heeded the last suggestion! My miniVNA connected after the 1 m coax actually shows a SWR=2 bandwidth of 42 kHz, i.e., a respectable Q of 166. I hate to admit it, but the the bandwidth and Q that I reported previously where completely wrong. I assumed that the BW and Q indication of my antenna analyzer GUI was automatic, once the "BW and Q enable" box was checked. Well, it is, but not driven by the automatically determined "lowest SWR" frequency, but purely based on the two marker frequencies that are manually selected by the operator - me... Looking at the original screen capture below, I find a BW of 45 kHz and a Q of 166 (after 15 mtrs of coax).



Sweep of the antenna with its final dimensions and 15 mtr coax



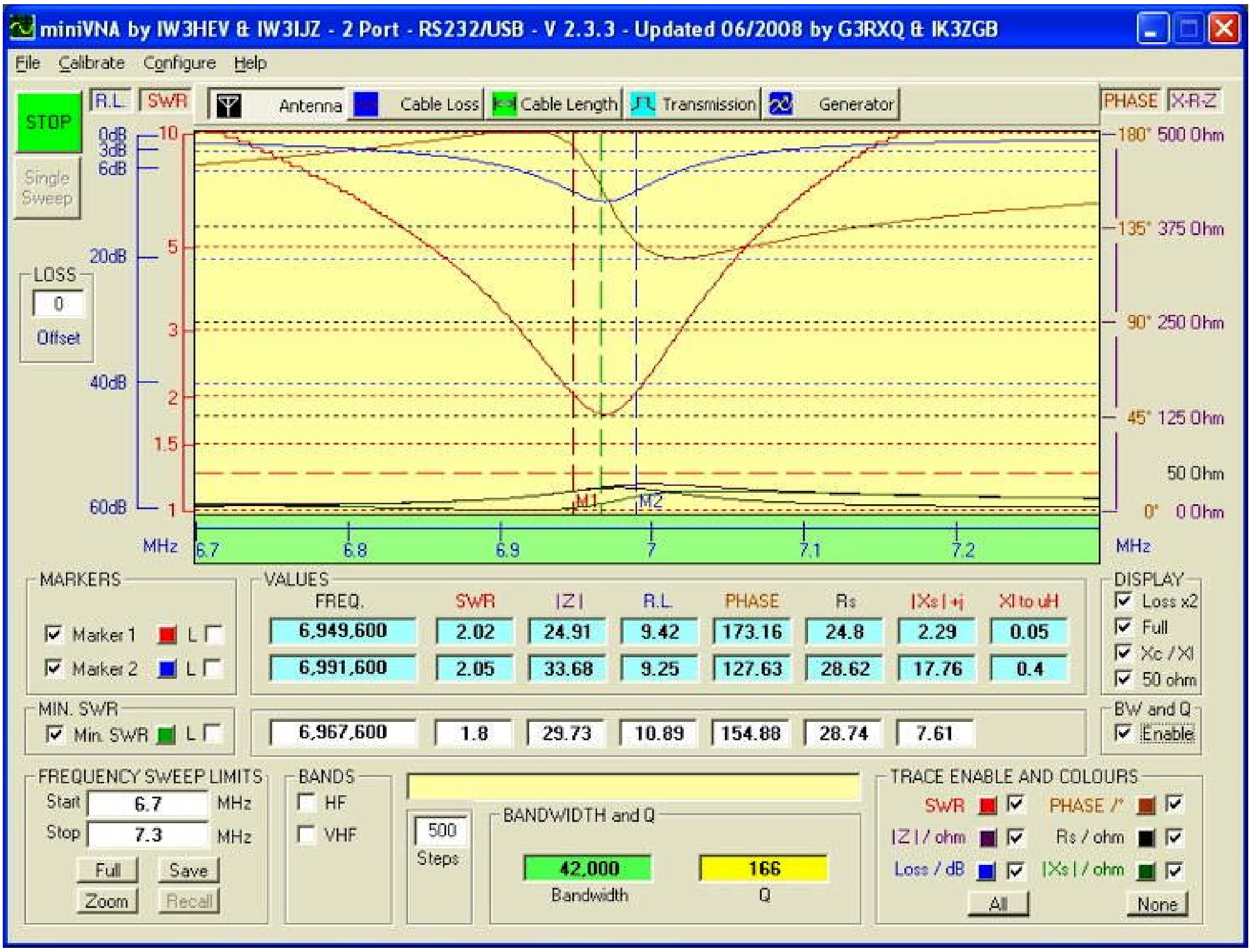
Sweep of the antenna with its final dimensions, 15 mtr coax and a choke-balun

I took a number of experiments, corrections, and adjustments to finalize the antenna:

- I played around with the tuning-rods. When inserted half way, the the resonance frequency changed about 15 kHz per cm of insertion.
- I concluded that the coils did not have enough turns. I cut and drilled a new section of PVC tube, and wound the coils (in opposite directions), with 95 turns instead of 85.
- Resonance frequency with half of the tuning-rods inserted: 6841 kHz. Too low. But SWR very close to 1, and an SWR=2 bandwidth of 40 kHz.
- I reduced the number of turns by 3; at 94 turns, f_{res} was 6903 kHz, and at 92 turns 7017 kHz: about 60 kHz per turn. Reducing one more turn would overshoot my target frequency, so I left it at 92. SWR=2 bandwidth is 44 kHz.
- Played with the tuning rods to see their effect. Pulling them out from 10 to 11 cm reduced f_{res} to 7004 kHz - the wrong direction! Inserting 11½ cm (8½ sticking out) increased f_{res} to 7039, right where I wanted it to be. Now the SWR=2 bandwidth is 43.6 kHz and SWR = 1:1.06. See plot below. Pretty much as per the spec!
- I added my 1:1 current choke at the end of the 15 mtr coax. The f_{res} went up by by 6 kHz, and SWR increased to 1:1.46, see plot below. This still needs to be explained...
- The antenna analyzer plot goes all over the place if the coax is moved near the antenna; as the manual says: guide the coax away from the antenna at a right-angle, for at least 1 m.
- Hooked up the antenna to my transceiver. The received signal strengths are really quite impressive (compared to all the other home-built compact antennas that I have tried).
- As to be expected, I did not need an antenna tuner for frequencies around f_{res}. The SWR meter of my antenna tuner claims an SWR of 1.5, but tuner-SWR indications are not known for accuracy...
- Will try it out as a transmitting antenna next, and see if anyone can hear me! TX performance will be reported here shortly.

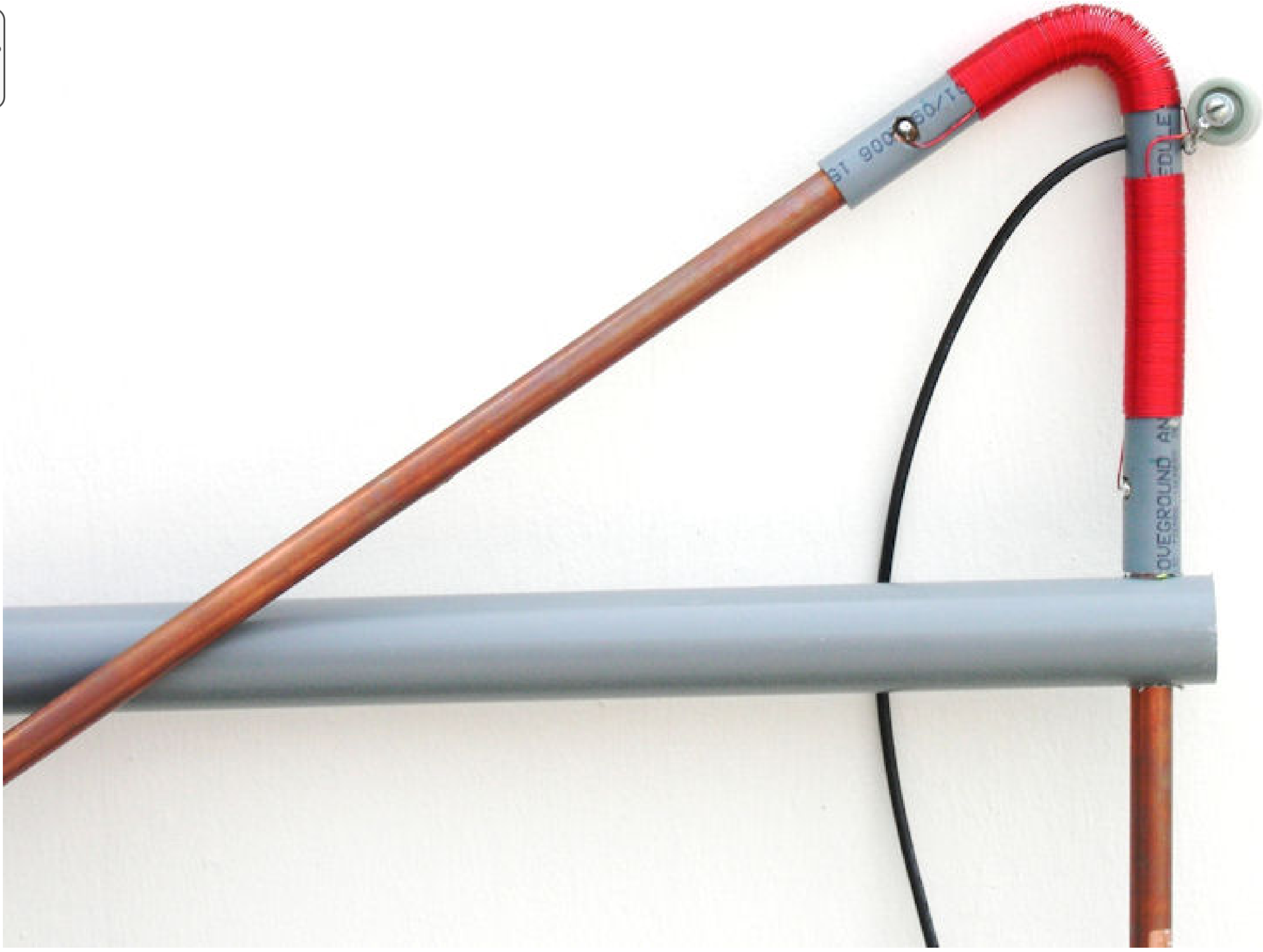
Late afternoon on 20 August 2009, I fired up the antenna (7040 kHz, PSK31 mode, 30 W, no additional antenna "tuner"), and called "CQ antenna test". **SUCCESS!** After just a couple of calls, it was my friend Rolf, DF7XH, who answered. He was playing around with the Drake gear that he is reconditioning, and had stumbled upon my signals. Conditions at that time of day were not great, but our signals were strong. I have had QSOs with Rolf on 40 and 20 mtr before, using [my Cobra multi-band dipole](). That was a struggle. Today, he could not hear me with the Cobra, but with the KGD copy was solid! Distance: 760 km (≈475 mi). Zero sunspots. We also tried my KGD in horizontal position, but could not copy each other (note that the KGD-manual recommends vertical orientation for installation close to the ground). Rolf successfully uses an "Up & Outer" L-antenna (ref. 9A/B/C).

For experimental purposes, I briefly repeated the analyzer sweep with a 1000 pF capacitor. The resonance frequency did not change (this confirms what is pointed out in the manual: the capacitor is there to adapt the antenna impedance to the coax, not for resonance). However, the bandwidth increased four-fold (really bad) and of course the Q reduced correspondingly. Also, the real portion of the impedance has gone down by a factor of 2 (from 32 to 16 ohm). Looks like I should try 330 or 390 pF to get to 50 ohm.



Sweep of the antenna response for the original set-up - with a 1000 pF capacitor

Keep in mind that this is not an antenna for "QRO" high transmit power, transmitter with an "afterburner", and other forms of waste of energy. Coil losses cause the coils to heat up a lot, and soften the PVC. Using silver plated wire for the coils, leaving space between the windings, and using thicker wire, may reduce this effect. The photos below show what happened during a QSO with Rolf, DF7XH, late August of 2009. I doubled my output power to about 80-100 W, using a digi-mode with 100% duty-cycle. After a couple of minutes, the SWR suddenly went off the scale. I went outside to inspect the antenna. It had folded over, into an inverted-V form. The limit appears to be 30-50 W. As they used to say at the beginning of each episode of the 1970s TV series "The 6 million dollar man": "*Gentlemen, we can rebuild him. We have the technology!*"



When operating several minutes with 80-100 W (100% duty-cycle), the coils get hot enough to soften the PVC
(the PVC is rated for 90 ºC (200 ºF) max)

KGD-20-FD: KGD DIPOLE FOR 20 MTRS

I have also constructed the 20 meter version, just for fun, because 1) it is easy, 2) I was curious to see how well it performs, and 3) because I still had the coil core and coils of my first prototype 40 meter KGD. Based on the formula near the top of this page, I would need only 35 turns. Based on the final number of turns of my 40 meter version, I would end up with 38 turns. I started with 40, but this still turned to be too few (or the copper tube too short). With the tuning rods sticking out 60 mm, the resonance frequency was close to 14900 kHz, SWR about 1.6, *R* about 33 ohms (the latter could also be caused by tolerance of the 200 pF capacitor). Pulling out the rods to 150 mm lowered the resonance frequency to about 14400 kHz, and SWR to below 1.2. So I made a new coil core and used longer copper tubes.

freq band	tube length (each leg)	CU tube OD/ID	windings (each coil)	coil ID	capacitor	Brass tuning rods (length sticking out)
20 m	50 cm	16/14 mm	33	21.5 mm	220 pF	56 mm (14070 kHz) 22 mm (14230 kHz)

Note: coil parameters are the same for 0.8 mm CuL and AWG #20
Note: tuning rod extension measured from tip of the copper tubing

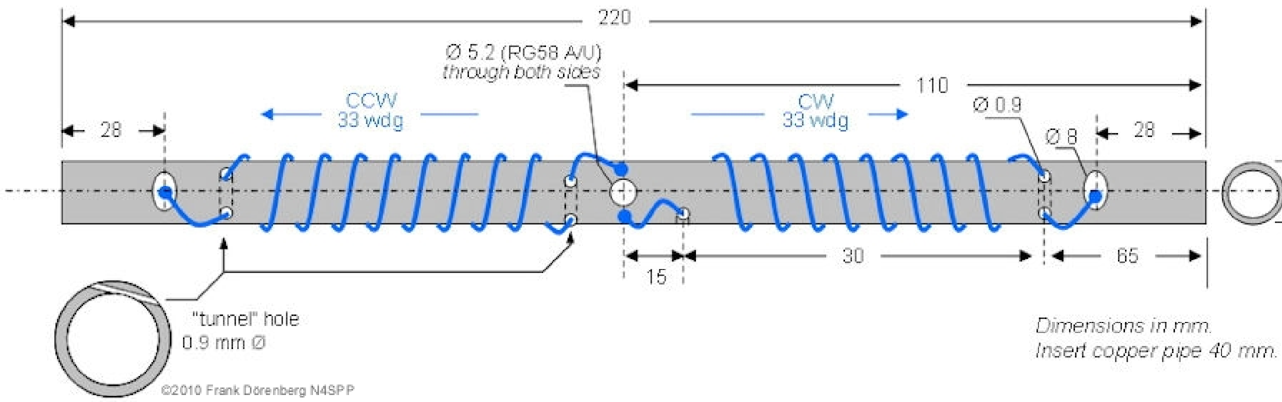
The final design of my 20 mtr version

The list of components for the 20 mtr KGD is basically the same as for the 40 mtr KGD, except that:

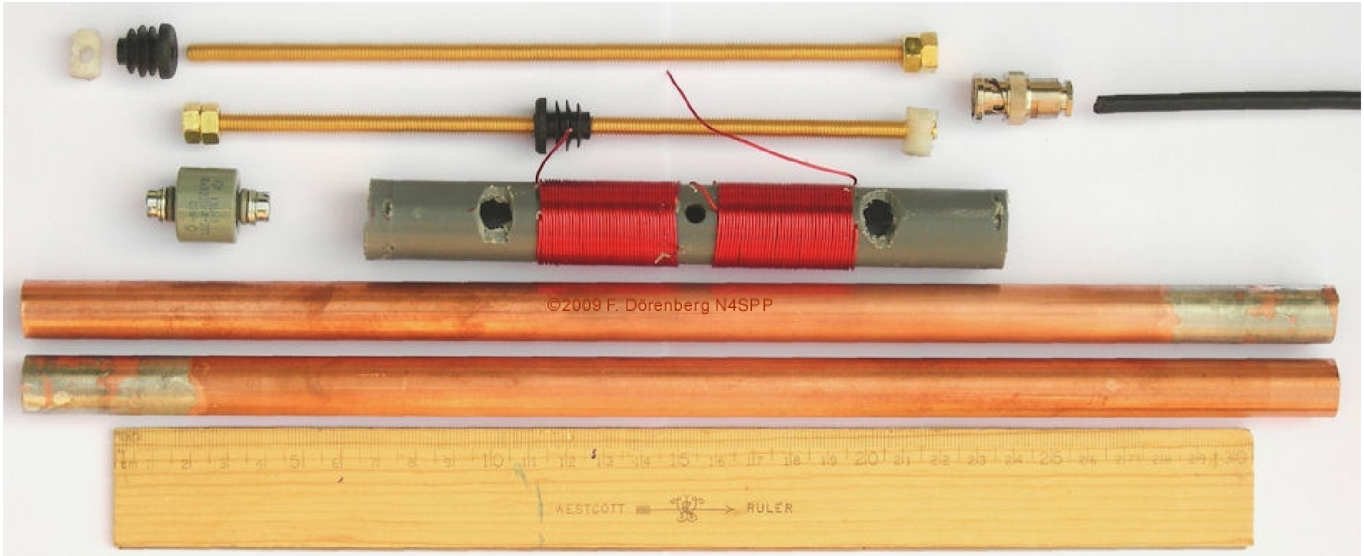
- the PVC tube is now 22 (≈ 9") cm long.
- the sections of copper pipe are only 50 cm (20") long.

- the capacitor is 220 pF (at least 5 kV rating)
- a total of about 7 mtr of 0.8 mm wire is used for the coils
- tuning rods are 25 cm (10") of 4 mm brass rod (not threaded)

Again, I added a 75 cm section of 15 mm diam. PVC tube to guide the coax perpendicularly away from the coil core. See KGD-40-FD construction above.



Dimensions of the PVC-tube center section - final design for my 20 mtr version



The components of my 20 mtr KGD prototype

I have also tried to tune my prototype KGD-20-FD. The initial resonance frequency was already too high (14910 kHz, SWR 1:1.56, Rs of only 35 ohms). So reducing the number of turns wasn't going to help me. I could only play with the tuning rods. Changing the rod position from 58 mm sticking out to 168 mm sticking out (the max), the resonance frequency went down to 14426 kHz, and SWR went down to 1:1.24. That is, the resonance frequency goes down when the rods are inserted. Note that this opposite to what I have observed for my 40 mtr KGD!. Oddly, lowest resonance frequency (14384 kHz) and lowest SWR (1:1.13) was obtained with the rods sticking out 150 mm. It looks like I need to change one or more parameters: increase number of turns even more, or use copper pipes that are longer than the original spec. I am using copper pipes that have a smaller diameter than the aluminium pipes of the original design. The difference may have a more pronounced effect as the pipes become shorter... The low impedance may at least partially be caused by the actual value of the capacitor being high: the cap has ±20% tolerance... I have several more of these capacitors on hand, so I tried several: no significant change. Removing the 12 mtr coax cable and attaching the analyzer directly at the short coax of the antenna did change resonance frequency, SWR and impedance significantly! See table below. The table also shows that the capacitor value does not change the resonance frequency. Per design, it is only there for adapting the antenna impedance to the coax impedance.

capacitor	resonance frequency	SWR	|Z|	R_S
220 pF (13 m coax)	14670 kHz	1 : 1.15	47 Ω	46 Ω
220 pF (1 m coax)	14270 kHz	1 : 1.5	33 Ω	33 Ω
220 pF (1 m coax)	14270 kHz	1 : 1.2	58 Ω	58 Ω

Influence of coax and capacitor on characteristics of the 20 mtr KGD prototype

I completed construction on 6 February 2010. Of course, once installed and and tuned, I had to put the antenna to the test. I positioned the tuning rods for 14230 kHz, and used my antenna tuner to tune the residual SWR from 1.5:1 to 1:1. I turned the antenna such that the legs are pointing east-west. Assuming a standard dipole radiation pattern, the lobes would be north-south.

Now, how do you a reasonably objective test the antenna all by yourself? Simply by transmitting SSTV images and checking one of the standard SSTV webcam sites. I.e., use a remote receiver. Another option is checking the waterfall display of one of the many available Web-SDR receivers. On this day, I used the GØHWC SSTV-cam website (which consolidates a large number of STTV-cams around the world). I was very (!!) pleasantly surprised to find that the receiver of OZ5AGQ had actually received me, see image below. His station is located about 25 km northwest of Copenhagen, some1560 km (≈ 1000 miles) north of my QTH (25º E). So the antenna works quite nicely for its size! Note that this test was done at noon time, with the antenna horizontal, and placed close to (and on the south side of) my apartment.

Late March of 2010 I had a very solid Feld-Hell QSO with Jan, SP3AMZ (1465 km, 60 deg NE)). The same night, I nearly had a QSO (from my QTH in the south of France) with a station near Seattle (8600 km, 325 deg) - he could hear me, but not "read" me...

My SSTV image, received by OZ5AGX

As pointed out above for my KGD-40-FD antenna, these KGD antennas are for low-power! I transmitted with about 50 watts in SSTV: 100% duty cycle. After a single image transmission (70 sec), the antenna coils do get warm to the touch!

In January of 2010, I have built a new coil core with plenty of turns (2 x 44) and 2 x 50 cm copper tubes. I want to be able to use the antenna for narrow-band digi-modes (14060-14080 kHz) and SSTV (14230 kHz). So I increased the resonance frequency until it was slightly high. See table below. The resonance frequency increased 170 kHz (at 44 windings) to 250 kHz (at 33 windings) per reduction by one coil turn.

Coil windings	resonance freq (kHz)	SWR	R_s	Installation	Tuning rod & insertion
44	11660	1.1	54	horizontal	Ø 4 mm, 125 mm out
	11708	1.2	57	horizontal	M6, 100 mm out
	11680	1.6	72	vertical	M6, 100 mm out
	11840	1.3	59	vertical	Ø 4 mm, 6 cm out
	11850	1.3	60	horizontal	Ø 4 mm, 6 cm out
	12130	1.4	60	horizontal	none
	12130	1.5	63	vertical	none
	12130	1.2	43	vertical	none
41	12632	1.3	47	horizontal	none
	12160	1.2	42	horizontal	Ø 4 mm, 125 mm out
	12074	1.3	40	horizontal	Ø 4 mm, 170 mm out
	12188	1.3	42	horizontal	M6, 100 mm out
	12634	1.3	44	vertical	none
36	13600	1.6	53	vertical	none
	13624	1.5	55	horizontal	none
34	14112	1.6	67	horizontal	none
	14118	1.8	69	vertical	none
33	14333	1.2	60	vertical	none
	14342	1.4	67	horizontal	none
	14066	1.2	58	vertical	Ø 4 mm, 54 mm out
	14208	1.2	58	vertical	Ø 4 mm, 22 mm out

Experimental tuning data for the final KGD-20-FD
(current choke at feedpoint, 12 m coax)

I also changed the "tuning rod" concept. I figured out an easier way to fix the tuning rods in place. It can be used with both threaded rods and smooth rods. It is a simple plastic strain-relief fitting for cables (UK: "*cable gland*", D: "*Kabelverschraubung*"). See photo below. The ones that I use fit snugly into the copper pipe, and hold a non-threaded M4 brass rod firmly in place when tightened. This allows for very simple and quick adjustment, a lot easier than tediously screwing in/out a threaded M6 rod (the "official" design). I have since added small rings of shrink tube to the smooth rods, to mark preferred rod positions.

A tuning rod and strain-relief fitting

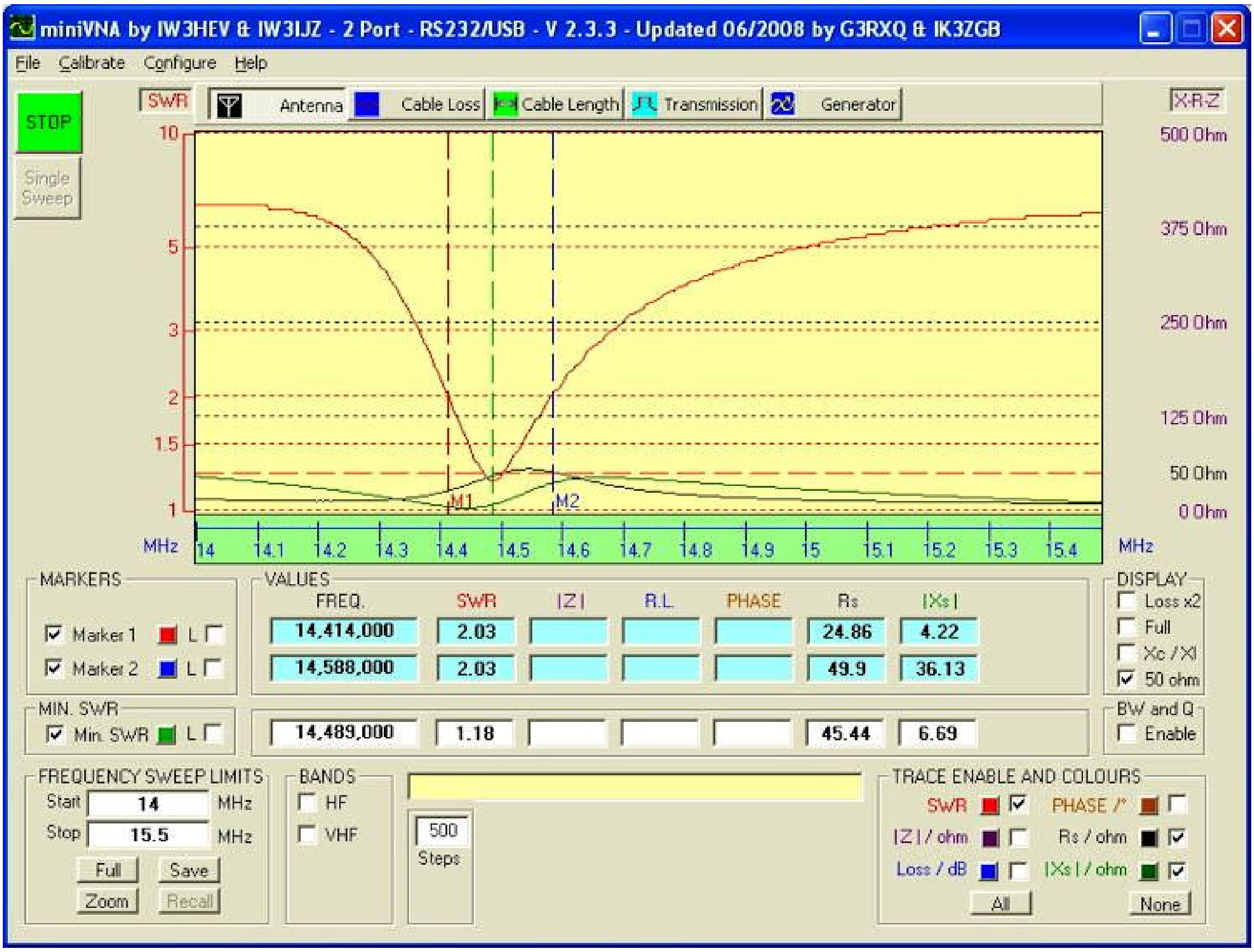
The two tuning rod constructions side by side

The KGD-20-FD and KGD-40-FD side by side

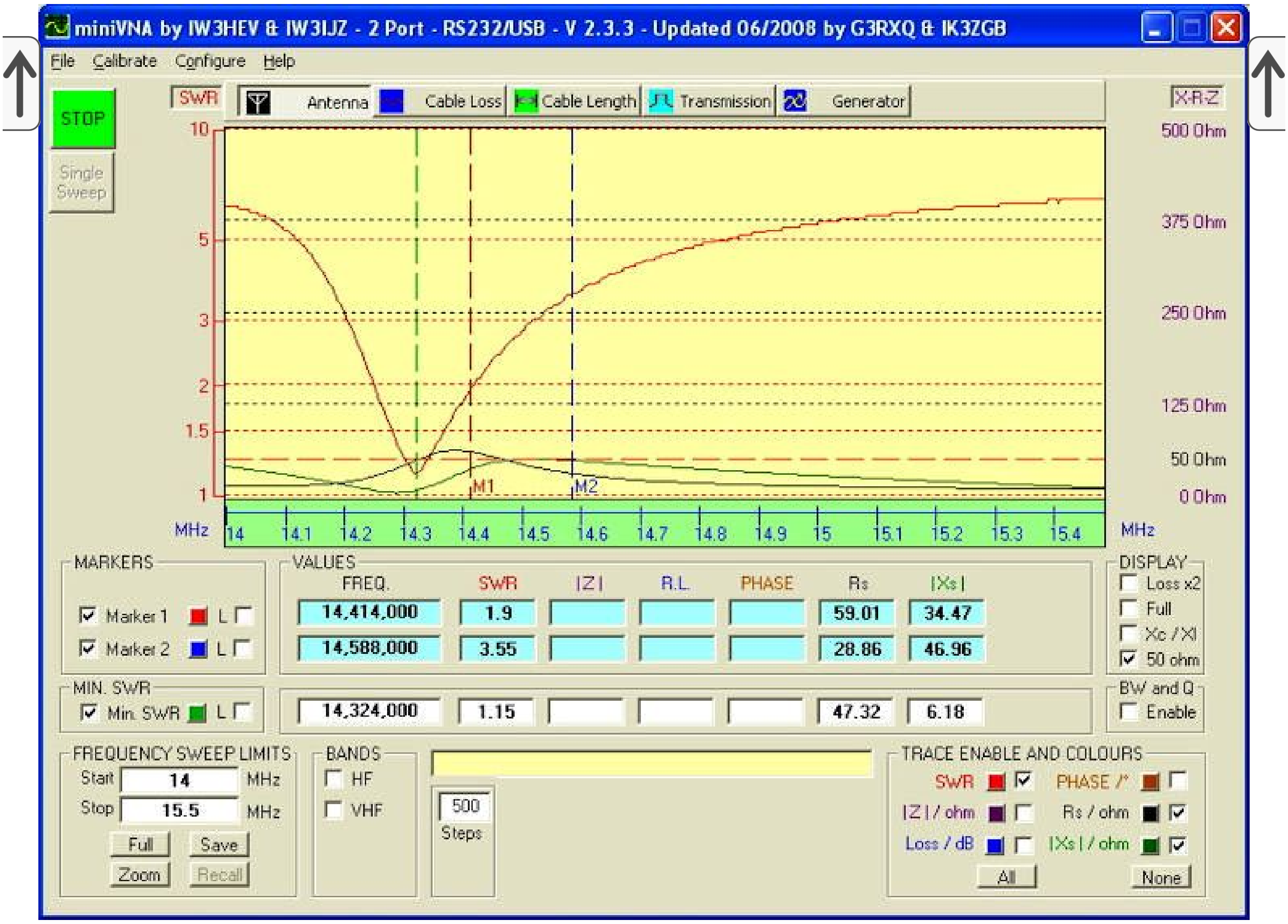
As stated before, the KGDs are rather narrow-bandwidth antennas. On 20 mtrs, I'd like to be able to work on two frequencies: 14230 kHz (SSTV) and around 14070 kHz (Hellschreiber). So I decided to add a switch to each of the coils of my prototype KGD-20-FD. The idea being to short out several turns in each coil, thereby shifting the resonance frequency. The photo below shows the switches installed across the last four turns of each coil. No significant voltage is induced across these turns, so no special switches are required. As shown in the table below: a frequency shift of 1.45 MHz (!) for shorting the last four turns of each coil. The switches work, but the antenna has to be tuned for the lower resonance frequency of interest, with the switches installed! I am only looking for a shift of 170 kHz, so I have to see if this can be achieved with shorting fewer turns or even a partial turn. Tricky!

switches	resonance frequency	SWR	|Z|	R_S
not installed	14489 kHz	1 : 1.18	45 Ω	7 Ω
both open	14342 kHz	1 : 1.15	47 Ω	8 Ω
one open, one closed	14984 kHz	1 : 2.04	29 Ω	18 Ω
both closed	15782 kHz	1 : 1.03	49 Ω	1 Ω

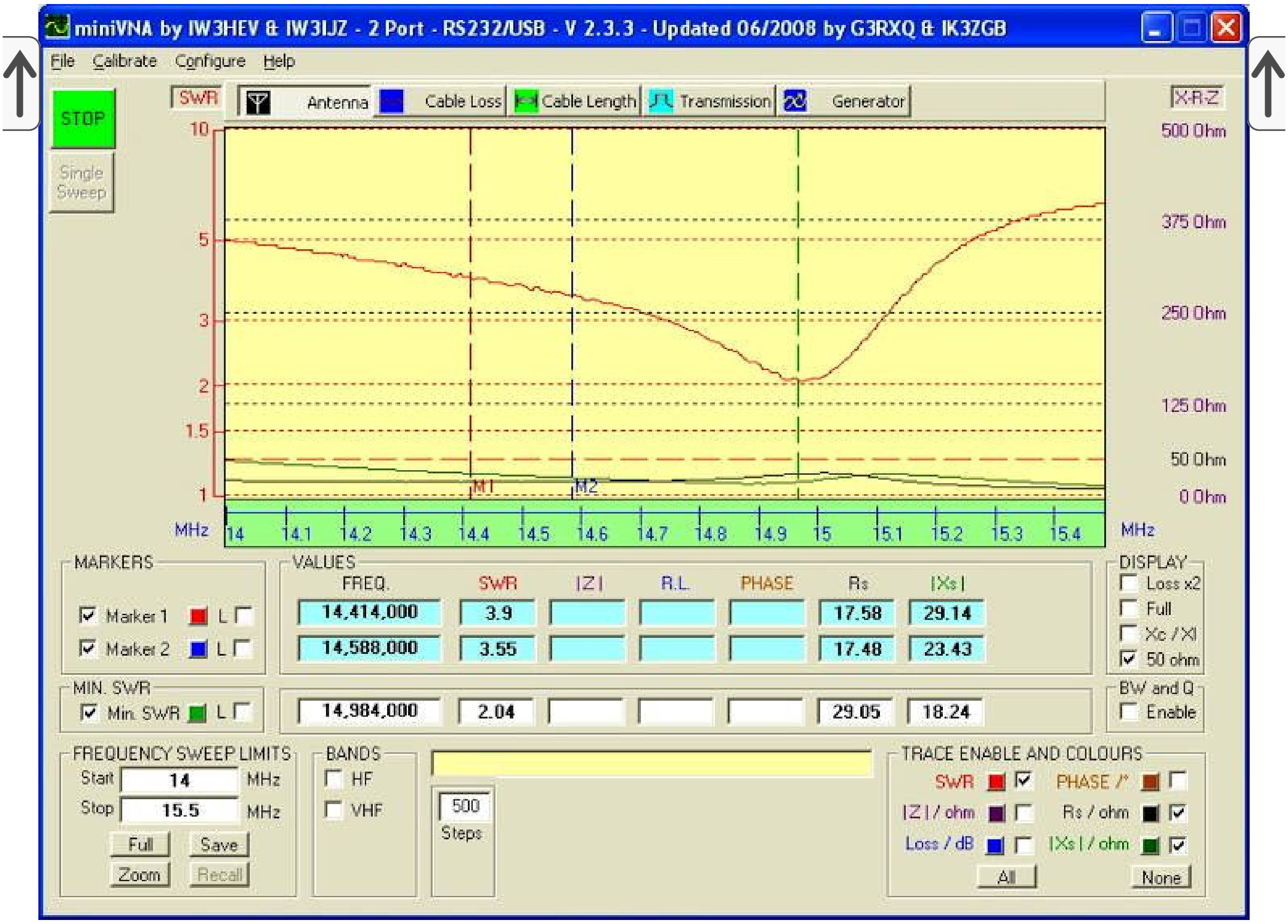
Influence of the coil-shortening switches on the characteristics of the KGD-20-FD prototype



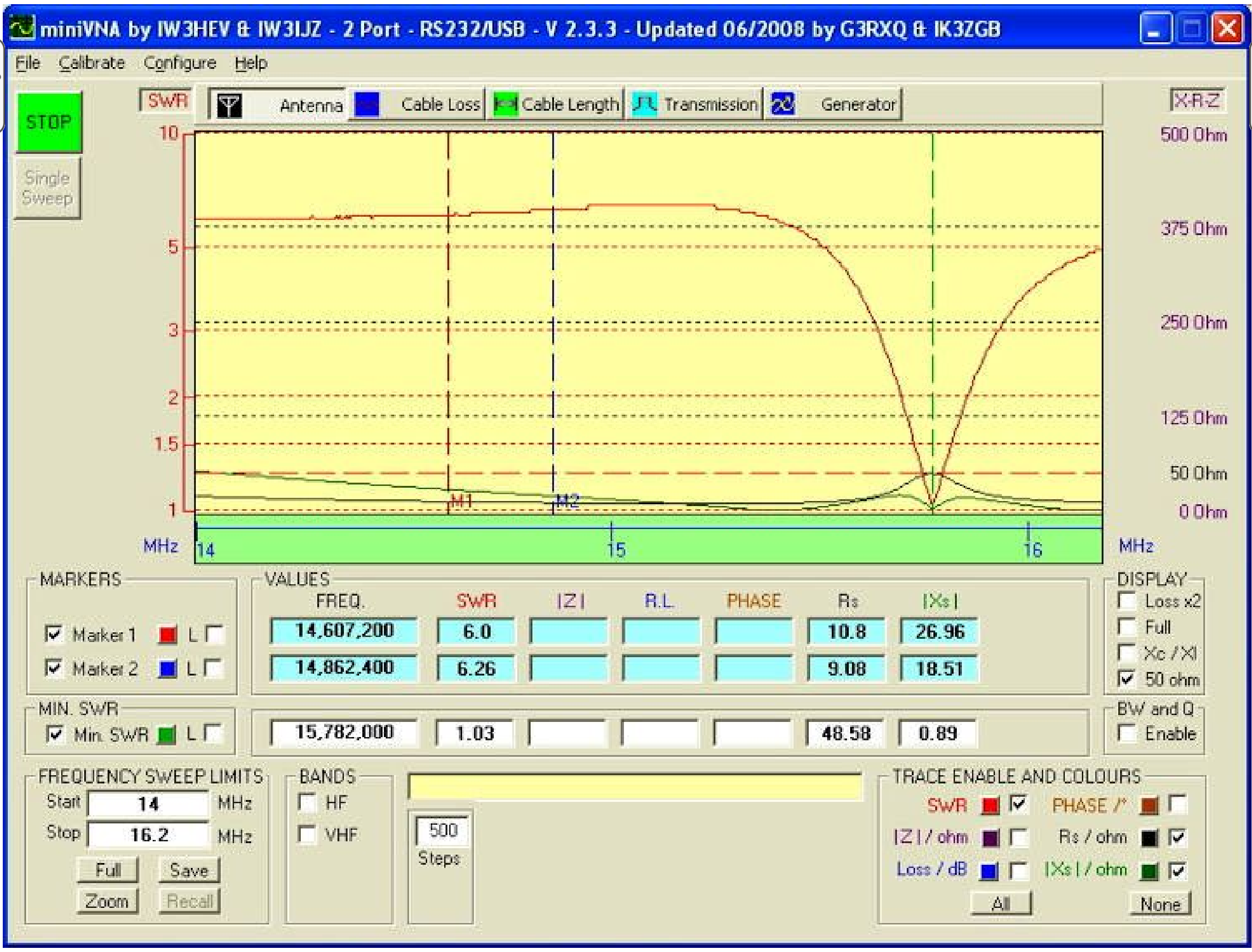
Sweep of the antenna without switches



Sweep of the antenna with both switches open



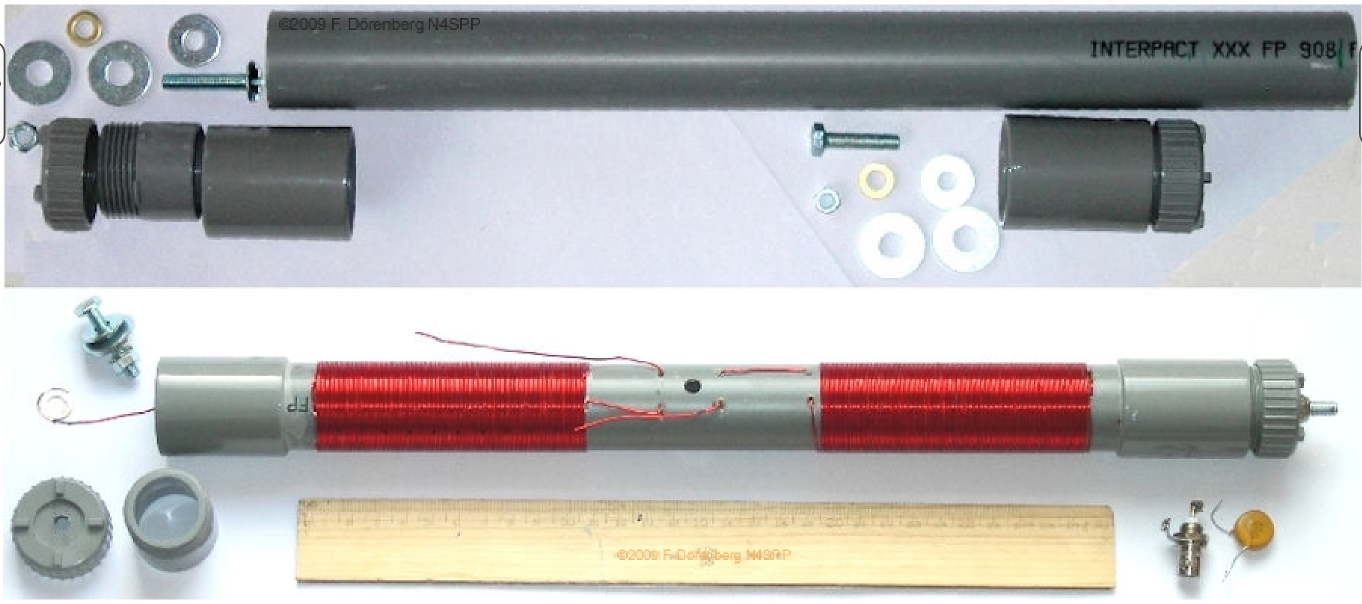
Sweep of the antenna with one switch open, the other closed



Sweep of the antenna with both switches closed

KGD-80-FD MK1: MY FIRST KGD DIPOLE FOR 80 MTRS

Of course I would like to be able to install a full-size 80 mtr dipole, and sufficiently high above ground. This is simply out of the question at my QTH. So, why not give the 80 mtr version of the KGD a try? I am using standard 32 mm diameter PVC pipe, sleeves and end-caps from the Do-It-Yourself store. As the antenna "legs" are at least 1m6 long (≈ 5ft), I have opted for 2½ meter long aluminium tubing with an OD of 7.5 mm (5.5 mm ID), rather than copper pipe. Copper would be too heavy (and more expensive). I will tap an M6 thread into the pipe, to attach it to the PVC center section with the coils. Yes, the OD that I selected is rather small., so the dipole legs will be drooping and "floppy". But for experiments its is OK.



The components of my KGD-80 antenna - before and after assembly

I completed construction around Christmas of 2009. As the photo below shows, with nearly 5½ meter (18 ft) span, the dipole is a "little" wide for my terrace. Obviously this should not have been a surprise, hihi. Also, my "mast" is only 2 meters high, so vertical installation is also not (yet) an option. Note that the original KGD-spec prescribes vertical installation if the height is less than 1/8 λ. Obviously my umbrella stand is not 10 m tall. Anyway, I hooked up the analyzer to get a quick impression: resonance (with an impedance quite close to 50 ohms "real") at about 1.6 MHz, well below the 160 meter band....

Initial installation of the KGD-80-FD on my terrace

Oh well. This was not going to work. But let's not waste the entire effort and do some more experiments. I removed one "leg" of the dipole, removed the coax and capacitor, connected the coils in series, connected the center of the coax to the end of the bottom coil, and the braid of the coax to the down spout of the rain gutter (total length over 70+ meters (230 ft)). Now I can install it on top of the mast, as a vertical mono-pole.

Got resonance at 2.058 MHz with an SWR of 1.14. Resonance frequency still much too low . Coil too big, tube too long? Strange... I clipped a wire across the bottom coil and measured again. Resonance went up to 2.922 MHz with an SWR of 1.1. Also noticed a second resonance dip at 10.666 MHz but with an SWR of 1.8. The table below shows the measurement results of other configurations. In case you wonder why I used a length of 7 meters for the radial wire: I just happened to have a 7 m section of household hook-up wire laying around.

windings per coil	radiator length (cm)	resonance freq (kHz)	SWR	R_S (Ω)	counterpoise	Feedline
112	250	2922	1.1	49	rain gutter	coax
111	250	3240	1.1	45	7 m radial	choke + coax
106	250	3328	1.1	46	7 m radial	choke + coax
100	250	3116	1.2	56	rain gutter	coax
	240	3165	1.3	60	rain gutter	coax
98	250	3476	1.1	46	7 m radial	choke + coax
94	250	3568	1.1	46	7 m radial	choke + coax
92	250	3610	1.2	41	7 m radial	choke + coax
83	250	3802	1.1	46	7 m radial	choke + coax
70	240	3776	1.5	74	rain gutter	coax
	250	3721	1.6	77	rain gutter	coax
	250	3548	2.7	20	7 m radial	choke
	250	3924	1.2	59	7 m radial	450 Ω + 4:1 balun
	250	2972	2.3	42	rain gutter	450 Ω + 4:1 balun
	250	7840	1.1	51	rain gutter	450 Ω
	250	3558	2.8	18	7 m radial	choke + coax
	250	3832	1.3	64	7 m radial	choke + coax
	250	3828	1.4	69	7+2 m radial	choke + coax
65	250	3974	1.3	62	7 m radial	choke + coax

It (finally!!) occurred to me that in the configuration with the rain gutter, the actual radiator is the gutter and the "antenna" acts as a counterpoise. Other than the low resonance frequency, the configuration on the first line of the table is actually pretty good (besides efficiency). None of the other configurations appealed to me, so I have decided to abandon this antenna for the time being. I did re-use the coil core and aluminium tubing in one of my 80 m short verticals - with success!

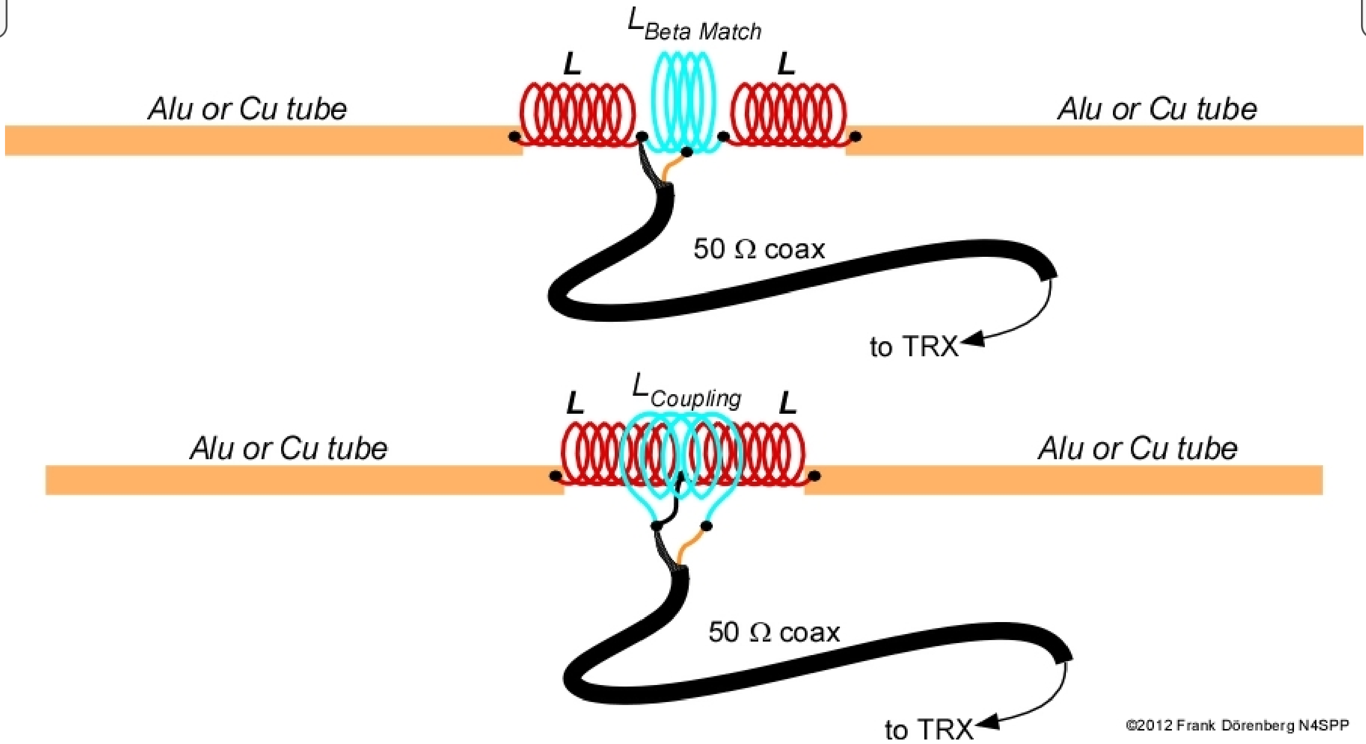
KGD-80-FD MK2: MY SECOND KGD DIPOLE FOR 80 MTRS

In April of 2014, I decided to give the KGD-80 another chance. This time in the form of a short, "hatted" 80m dipole: the **KGD-80-FD Mk 2**. The original KGD-80 design is as follows:

- dipole legs: 160 cm each (5 ft 3"), 20 mm (≈3/4") diameter aluminium tubing.
- loading coils: 258 turns on 20 mm diam. polyamide rod; 120 µH according to coil calculators

(ref. 2A/B/C).

- coupling: Beta-Match coil, 2+2 turns. Alternatively: inductive coupling to the loading coils.



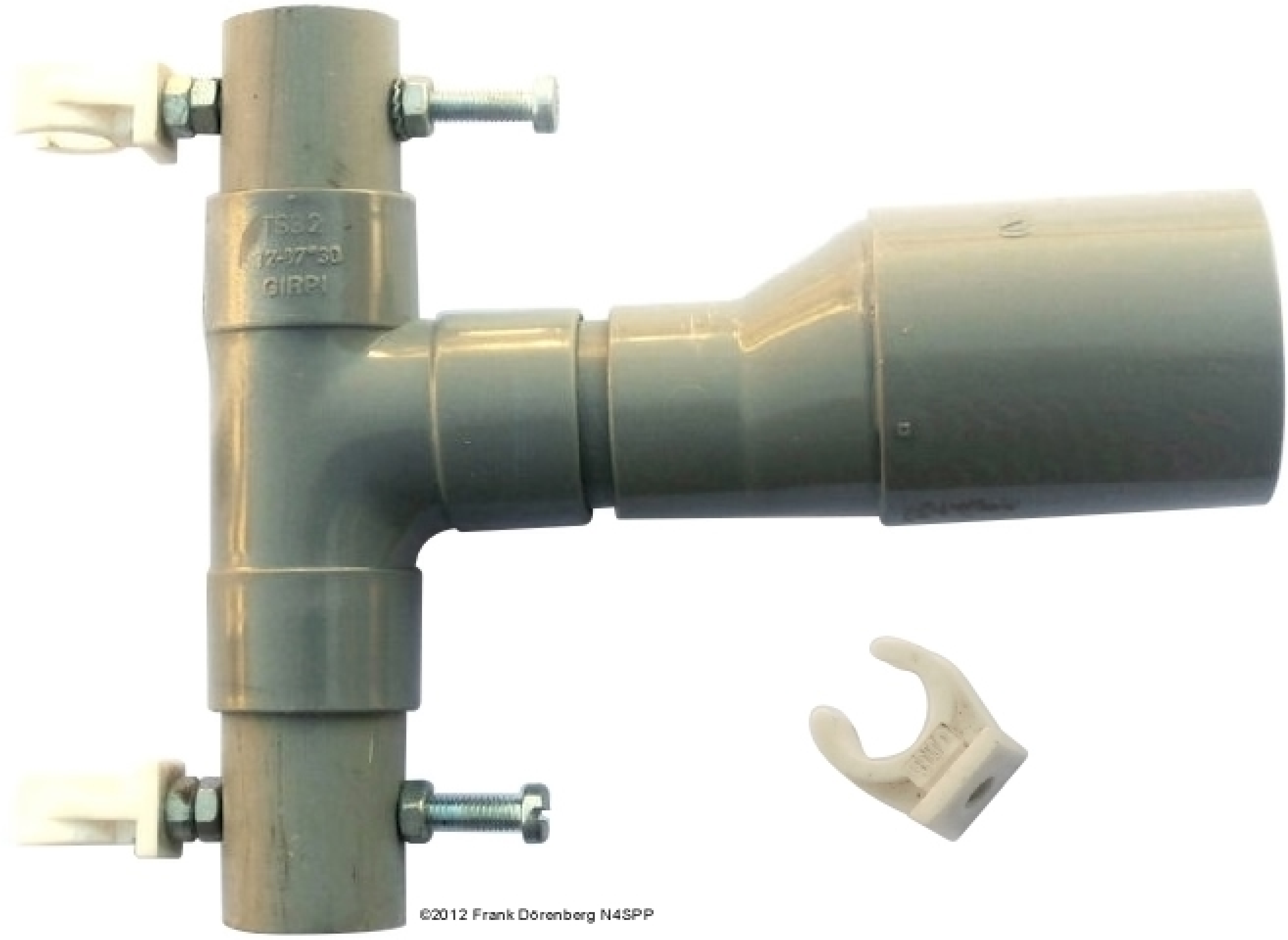
impedance transformation with a Beta Match coil between the loading coils (top) and inductive coupling (bottom)

For starters, I decided to initially forego a Beta Match coil or inductive coupling, and just use my automatic antenna tuner/coupler. The dipole will be installed vertically - as recommended in the original KGD manual. I used the following components:

- dipole legs: 200cm each (6 ft 7"), 20 mm (≈3/4") diameter aluminium tubing = standard DIY store item in the area where I live (south of France).
- 120 μH loading coils:
  - **Option 1:** 1.5 mm diam. CuL on 50 mm (2") diameter PVC core.
  - **Option 2:** 1.5 mm or 0.8 mm (#20 AWG) enameled copper wire on a T200-2 iron powder core.
- tuning rods: 50 cm (20") each, 4mm diam. brass tubing (rod would be OK, but heavier).
- center insulator: 20 mm delrin rod. A friend slightly reduced to diameter, to (tightly) fit inside the aluminium tubing.
- end-hat loading:
  - 6 spokes/radials of 50 cm (20") length, 3mm diam. brass rod.
  - perimeter ("skirt") wire, made of 1.25 mm diam. household installation wire. The wire is straightened by clamping one end in a bench vise and pulling on the other end with a pair of pliers.
- installation:
  - "yardarm" cantilever: PVC tubing, 50 mm x 2 meter
  - 50-to-32mm PVC reduction piece
  - 32mm PVC T-piece
  - two 10 cm sections of 32 mm PVC tubing
  - clips for 18 mm tubing (to tightly fit onto the 20 mm Alu tubing)
- feedline: 300 ohm ladder line/window line, horizontally to my nearby automatic antenna tuner/coupler.

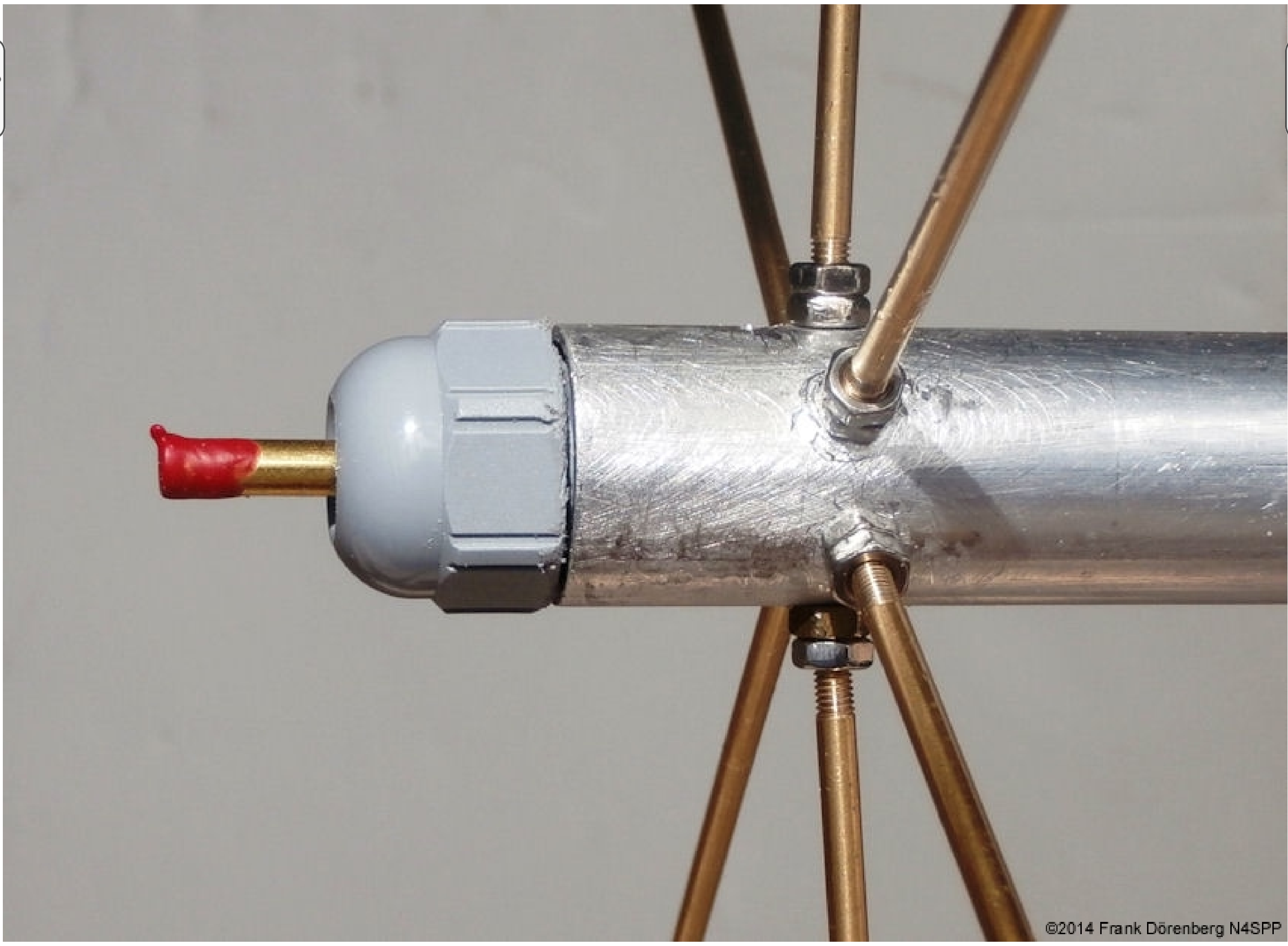
Yes, I know: I am mixing metals (aluminimum, brass, stainless steel) and there will be bi-metallic corrosion effects at their junctions. But this antenna is experimental, will not be installed permanently, and is not a commercial product...

The dipole will be loaded with end-hats. This is a very effective way of loading (ref. 5A/B/C).



The PVC adapter. The dipole center section is clipped onto it.

The white plastic clips allow me to quickly attach the dipole's center section to the PVC adapter, or detech it from that adapter. This is very helpful during experiments. I also cannot leave the antenna installed permenently.

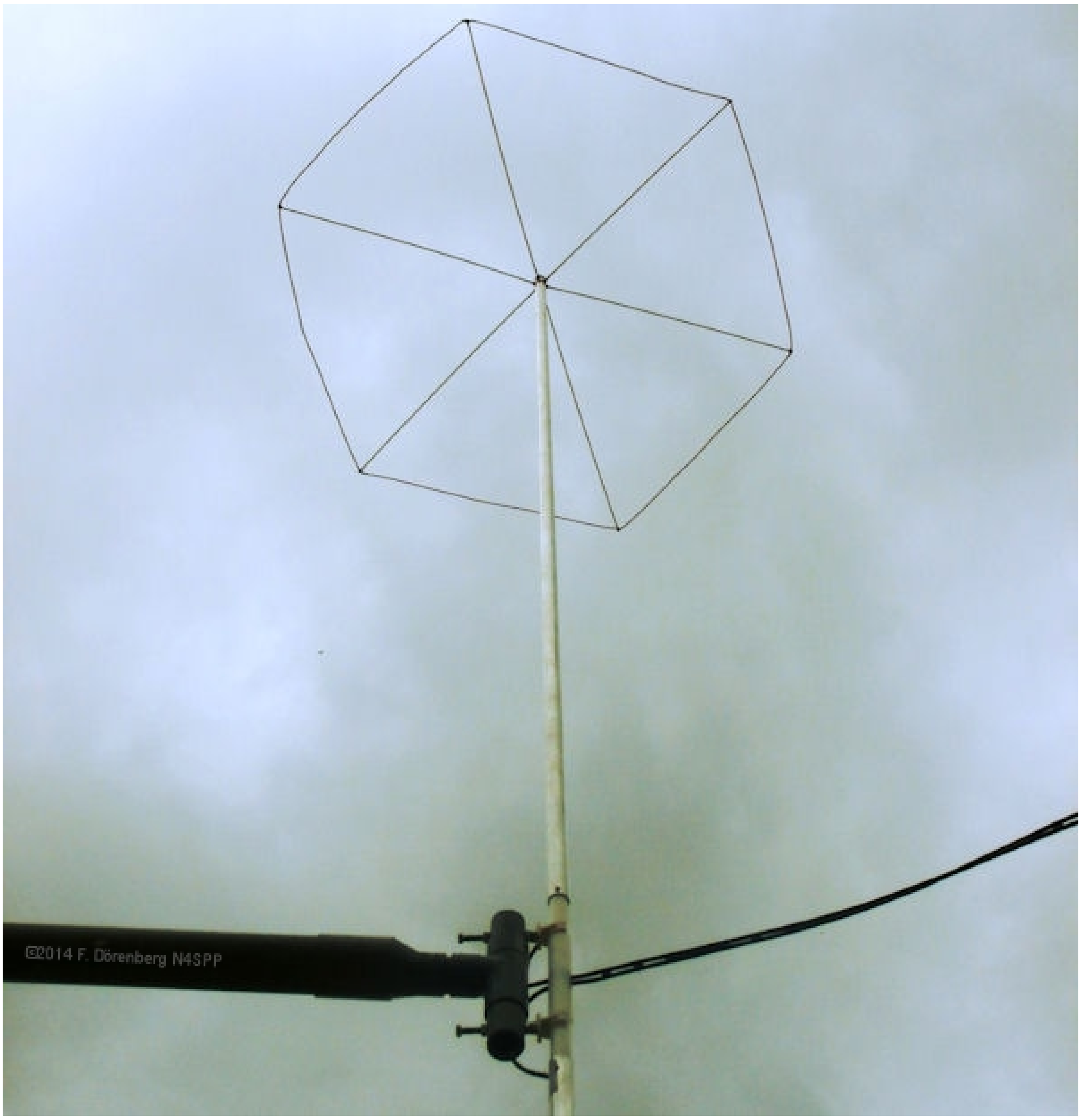


Close-up of end-hat of six spokes of 50 cm (20") - the tuning rod is barely sticking out of the tube

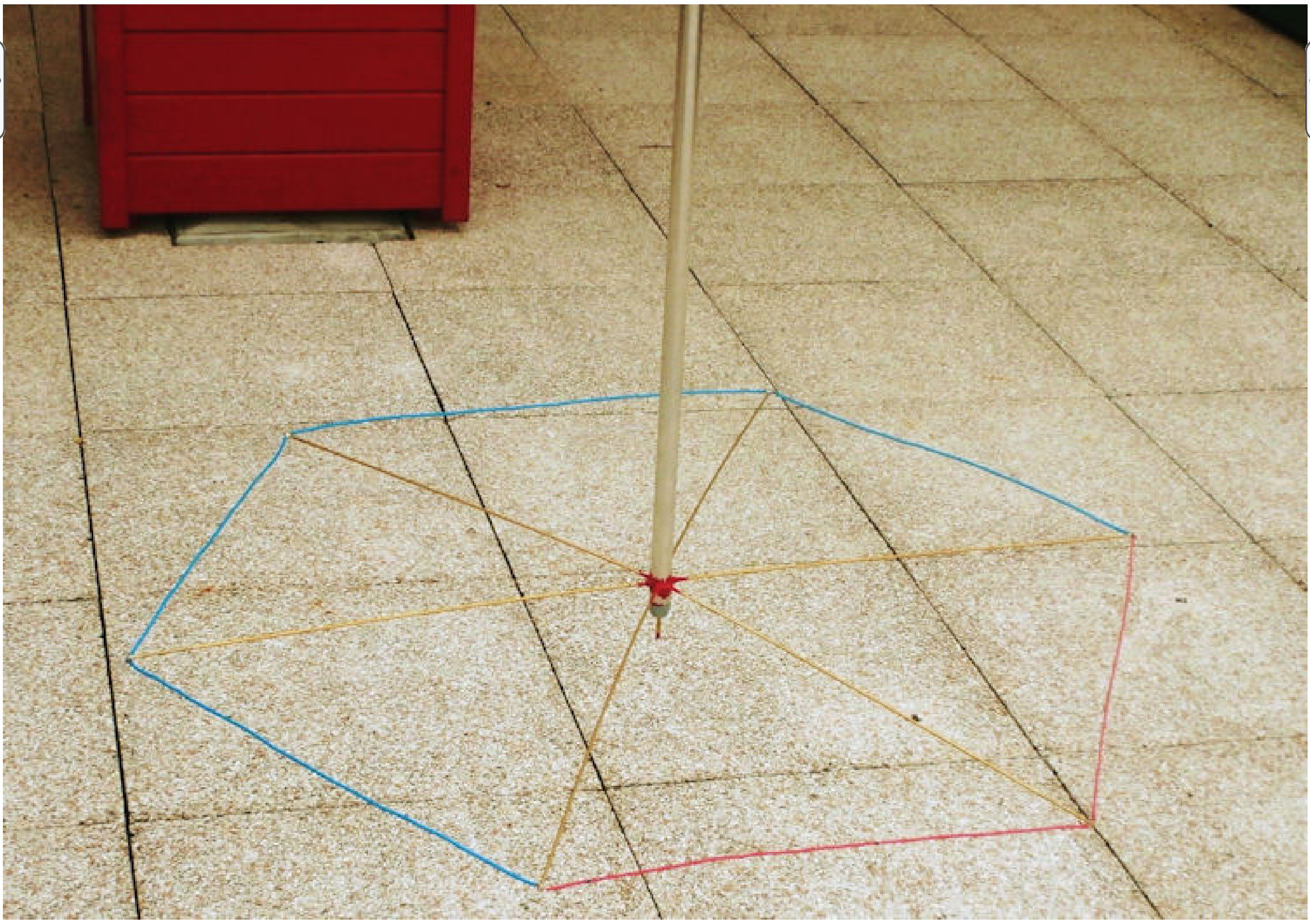
As the photo above clearly shows, the attachment of the brass rods to the tip of the aluminium dipole tube is flimsy, I admit it. The tubing is rather thin, and the thread of the brass rods is easily stripped of. But for the intended proof-of-concept experimentation is was adequate.

The center section of the dipole is clipped onto the PVC adapter shown above. The T-piece of that adapter is stuck onto a horizontally installed PVC tube with 50 mm (2") diameter. This 2m long tube is attached to the concrete flat roof that overhangs part of my terrace.

The KGD-80-FD Mk 2 installed
(in the foreground: [Paco the cat], and a glass table with a modern 30 inch aircraft weather radar antenna underneath)



The top hat of my KGD-80-FD Mk 2



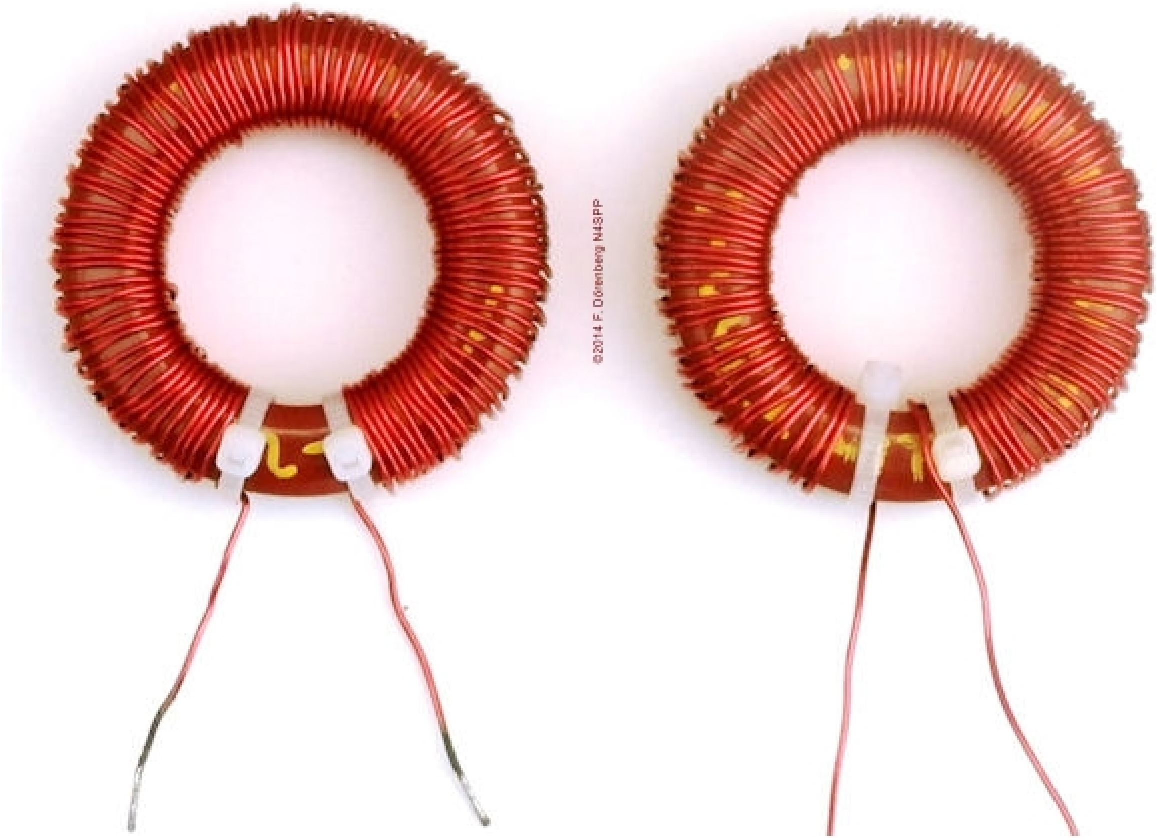
The bottom hat of my KGD-80-FD Mk 2
(when fully extended, the tuning rod touches the ground)

As stated above, the original design calls for for loading coils of 120 µH at the feed point. They are wound onto the 20 mm diam. insulator section between the dipole tubes. In my other KGD-antennas, the coils are wound onto this center section. Here, I decided to try something else. I had two iron-powder toroidal cores from an antenna tuner project. They are type T-200-2 (i.e., 2.00 inch outer diameter and material nr. 2). Iron-powder cores are suitable for high "Q" inductors, and are hard to drive into saturation - unlike ferrite cores. Cores of "type 2" material are used in automatic antenna tuners such as the LDG model AT-100 (1 kW) and the Elecraft model KAT2. So they can't be all that bad, hi.

Note that LC-meters typically measure inductance at a relatively low frequency: 100 kHz - 1 MHz. However, inductance of a coil is to some extent frequency dependent! If the measurement frequency is well below the operating frequency, LC-meters indicate an inductance value that is lower than the inductance at the operating frequency (and much lower, compared to the self-resonance frequency of the coil).

Core material "type 2" has an A_L of 120. That is: 100 coil turns should result in 120 µH inductance. These cores fit about 5 meters of 0.8 mm enameled copper wire. With 95 turns (and my personal winding technique) I obtained an inductance of 117 µH. Close enough.

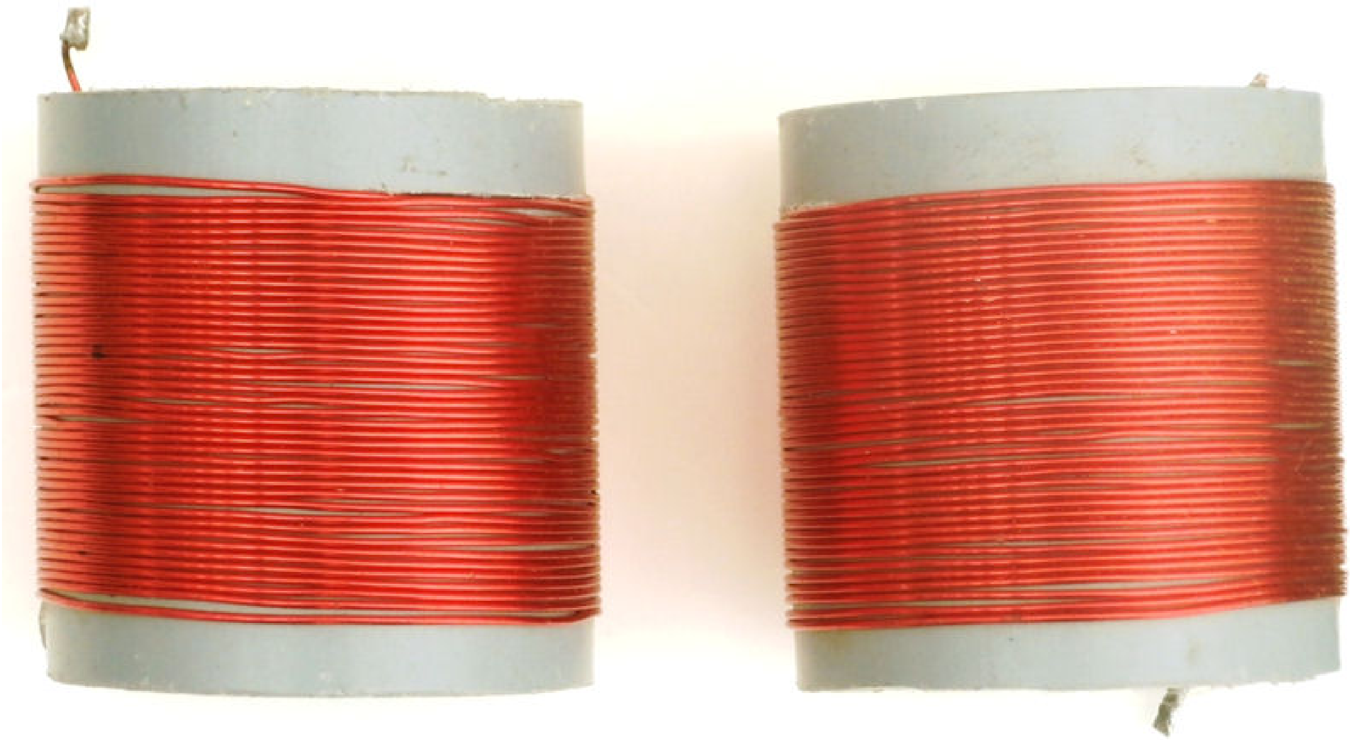
Note that the cores that I used are coated, so they are weather-protected. Even so: any dirt and water on the coils (esp. between the windings) will significantly reduce the "Q" of the coils! For permanent installation, the coils must be protected.



The two 117 µH loading coils, 95 turns wound on T200-2 iron powder cores

With these coils, the resonant frequency of the antenna (installed vertically, feed point about 240 cm off the ground) was about 2 MHz. Hey, I'm trying to make a 80 mtr dipole, not one for 160 m (1.8 MHz)! As the dipole legs are 25% longer than the 1.6 m in the original KGD-80 design, it was to be expected that the resonance frequency is well below 3.6 MHz with the nominal loading coil inductance. On top of that, I added loading "spikes" at the tip of each dipole leg. This also reduces the resonance frequency.

To get the resonance frequency up to where I wanted it (just below 3600 kHz), I obviously had to reduce the inductance of the loading coils. One quick way to do that was to use two 77 µH coils from another antenna experiment. They were wound on 50 mm (2") PVC.

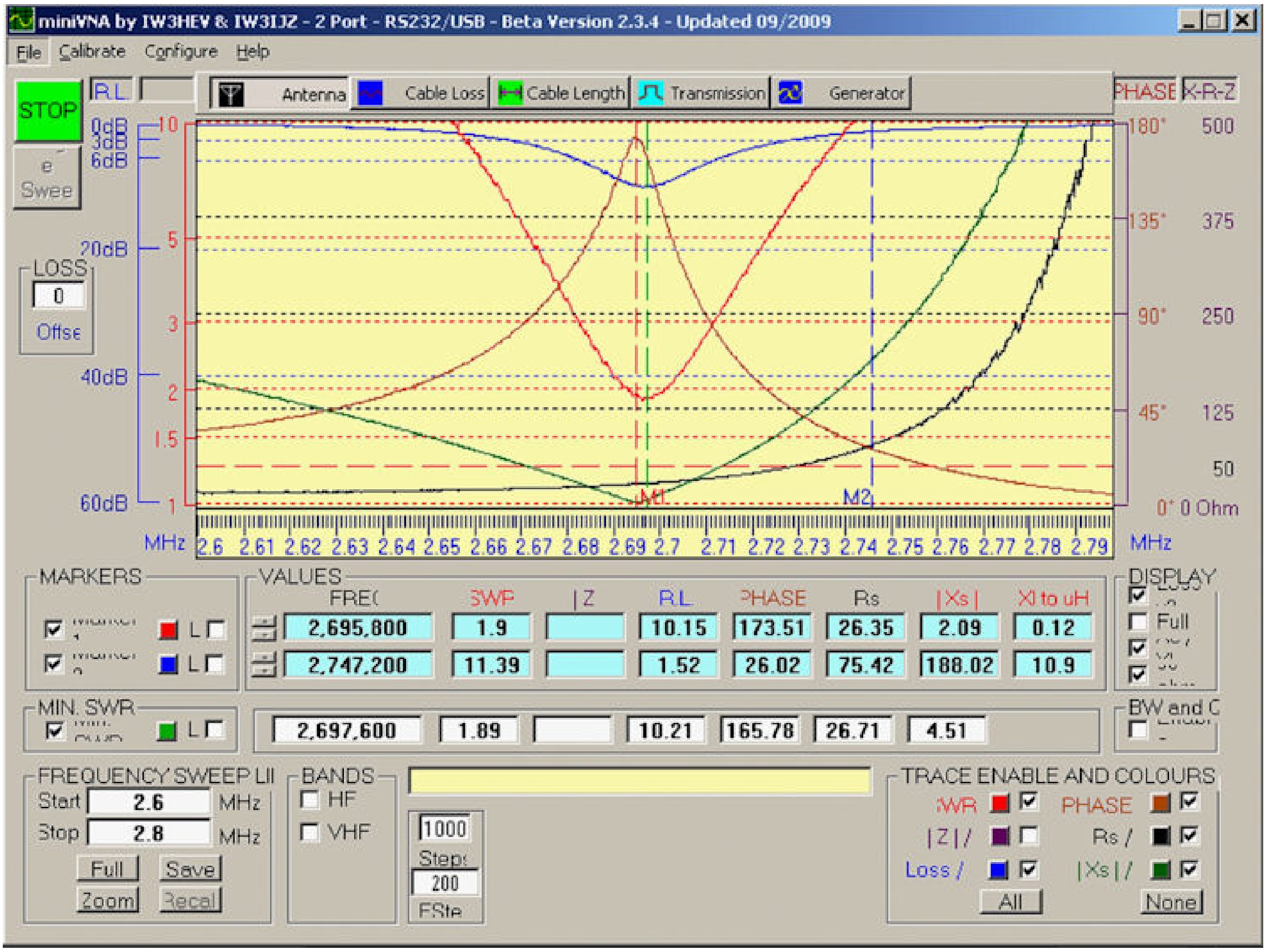


Experimental loading coils: 42 turns of 0.8 mm (#20 AWG) enameled copper wire on 50 mm diam. PVC tubing = 77 µH

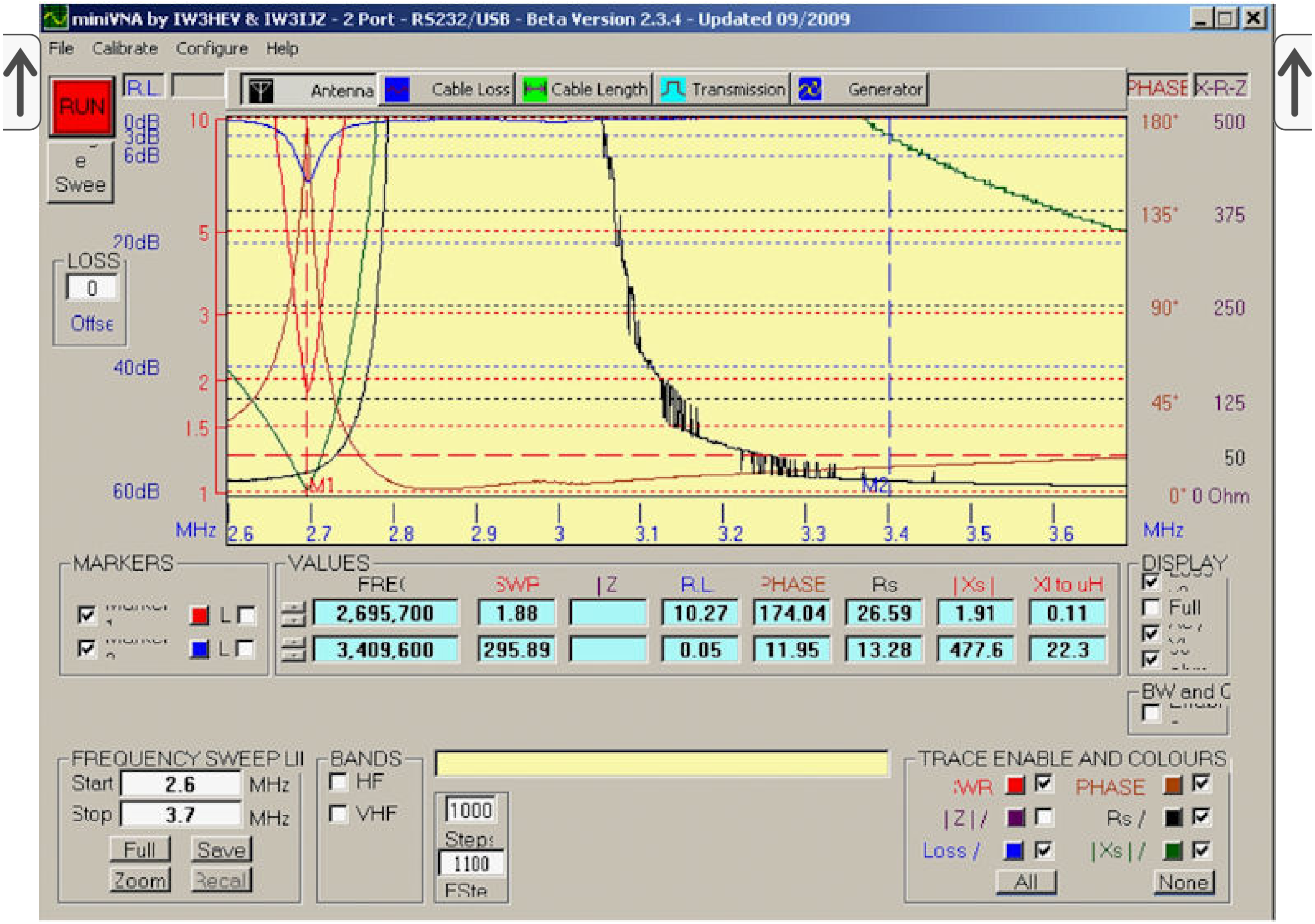
(according to various calculators, these coils should actually have an inductance of 67-71 µH; ref.

2A/B/C, 3)

With these coils, the resonance frequency went up from 2.0 to 2.7 MHz, see the analyzer plots below. Note that the SWR is 1:2 at resonance, as I did not install an impedance adapter at the feedpoint.



Sweeps of the 2 x 2m antenna, with 77 µH loading coils and "capacitive hat" loading


miniVNA by IW3HEV & IW3IJZ - 2 Port - RS232/USB - Beta Version 2.3.4 - Updated 09/2009
File Calibrate Configure Help
RUN
Antenna
Cable Loss
Cable Length
Transmission
Generator
MARKERS
VALUES
FREQ
SWR
R.L
PHASE
Rs
|Xs|
Xl to uH
2,695,700
1.88
10.27
174.04
26.59
1.91
0.11
3,409,600
295.89
0.05
11.95
13.28
477.6
22.3
DISPLAY
Full
FREQUENCY SWEEP
Start 2.6 MHz
Stop 3.7 MHz
Full Save
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Loss /
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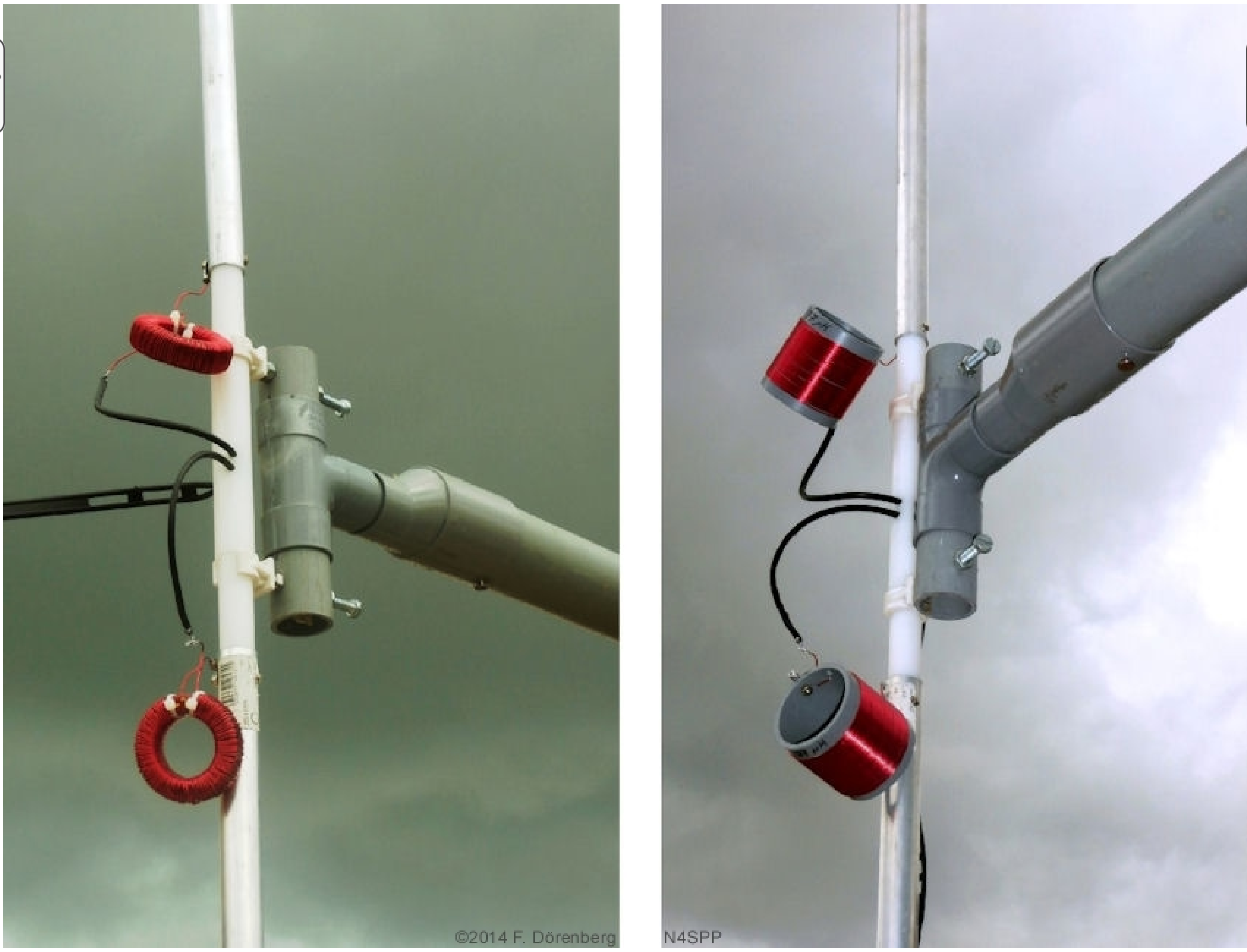
All
None



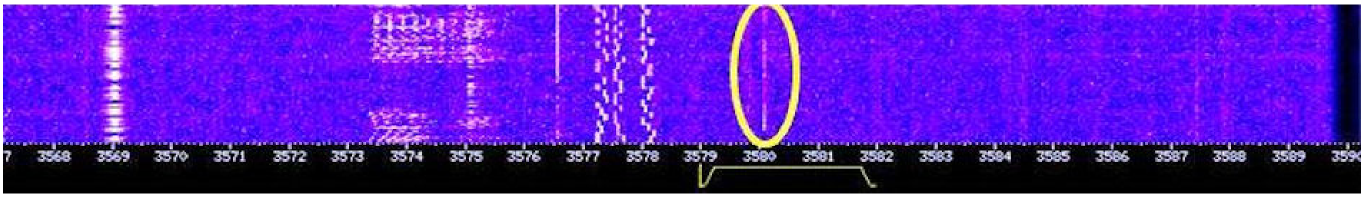
Two loading coil configurations: 117 µH on iron powder core (left) and 77 µH on PVC core (right)

After stepwise reducing the number of coil windings several times, I concluded that the coils should have about 46 µH to get up to 3600 KHz.

When I reduce the number of coil windings, I usually completely remove the coil from the antenna. On one such occasion, I dropped an iron powder core coil and the core broke into two pieces. Darn! I did not have a T200-2 replacement in my junk box. But luckily, I did have a T130-2 on hand: same Type-2 material, but smaller outside diameter (1.30 inch instead of 2.00) and smaller cross-section. No problem! The T200-2 core that broke had 52 windings on it. I got the same inductance with 57 windings on the T130-2 core.

Same inductance: T-130-2 and T-200-2 core

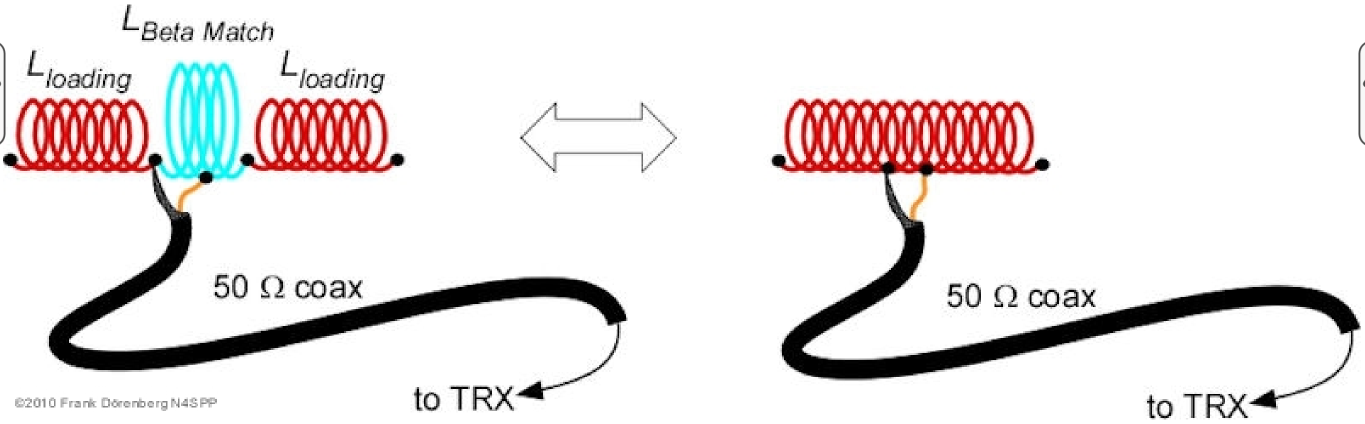
Early September 2014, I re-installed the antenna. For convenience, I connected the antenna to my nearby automatic antenna tuner/coupler, with about 5 mtrs of 300 Ω "window" type twin-lead cable. I ran some tests with a [remote Web-SDR receiver](), located 925 km (≈575 miles) to the north (18°) of my QTH. No trace of my signals - *until after sunset*. **Nice DX for such a small antenna on 80 mtrs, installed at such a low height (only 0.03 λ)!**



Waterfall trace at remote receiver - 80m
(3-Sept-2014, 21:00 local time, local sunset 20:28, sunset at RX 20:22, power: 80 W)

I did do some quick experiments with a Beta Match coil (see [diagram at the top of this KGD-80-FD Mk 2 section]()) across the feedpoint of the dipole.

- A Beta Match supposedly is simple, wide-band, low loss, and reduces static charge (= noise) between the dipole legs.
- To dimension the Beta Match "shunt coil", I made a simple Excel spreadsheet calculator (ref. 7). It calculates the required coil, based on the actual resonance impedance at the feedpoint (measured with an antenna analyzer).
- Note that *adding* a Beta Match coil adds inductance, effectively makes the existing loading coils larger. This causes the resonance frequency to shift downward. So the loading coils will have to be made a little smaller (remove one or more turns).

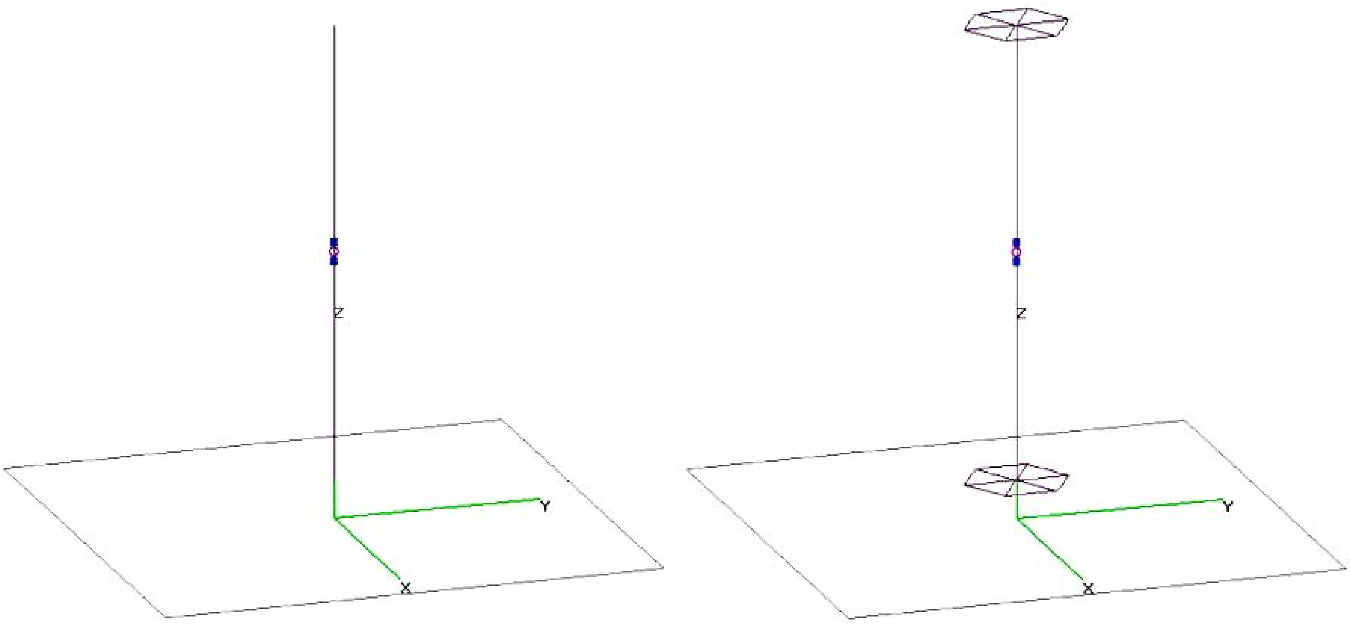


Beta Match coil - added to center-loading coils vs. part of those coils

My spreadsheet suggest that I should use a Beta Match coil of about 1 µH. For instance: 7 turns of 1.5 mm copper wire on a 32 mm PVC core, with 3 mm spacing between the turns. Results from sweeps with my antenna analyzer were not what I expected, so I have to spend to more time on this one of these days...

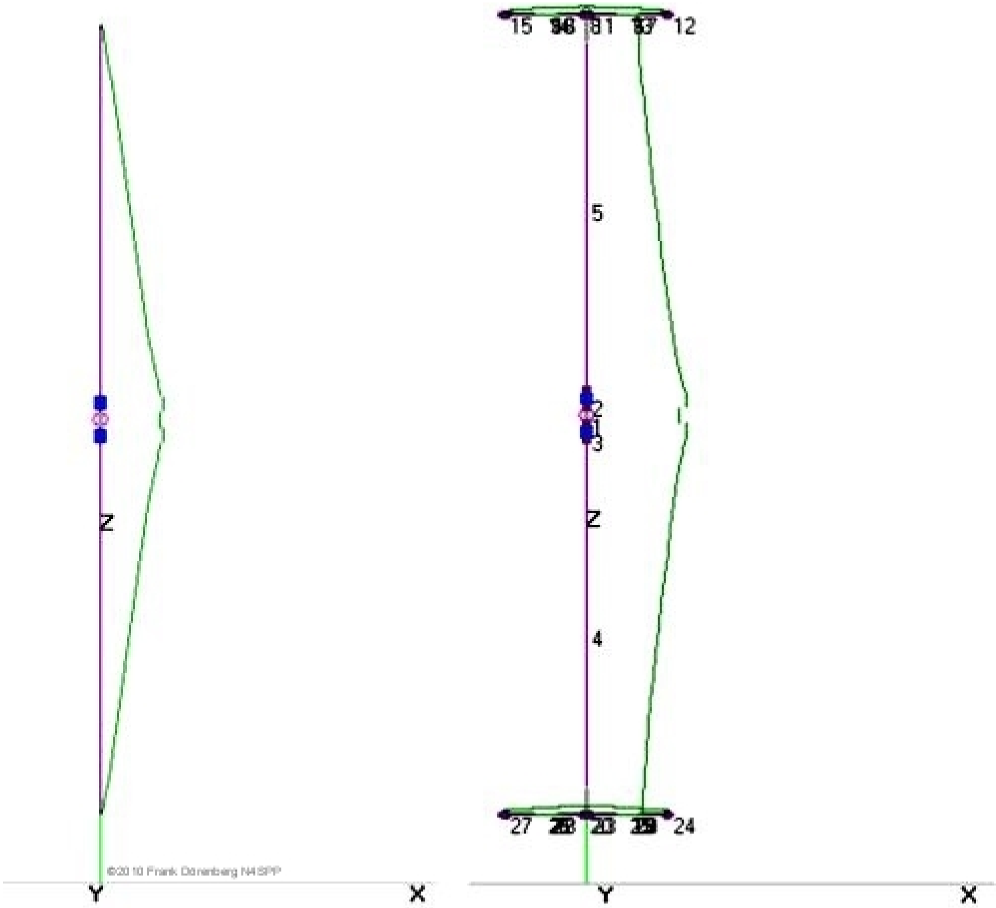
ANTENNA SIMULATION MODEL

I made a simple 4NEC2 model of my KGD-80-FD Mk 2 antenna (incl. loading coils, and the feedpoint installed at 2.4 m above ground), both with and without end-hats (ref. 6).



Geometric models of my KGD-80-FD Mk 2, without hats and with hats

The diagrams below show the resulting current distribution (green lines). This clearly shows the advantage of the end-hats: the current does not taper to zero at the tip of the dipole legs. Instead, it is non-zero at the tip of the main element. At the "hub" of the hat, the current splits equally into six branches (in "my" hat, there are six spokes in a symmetrical configuration). Due to the perimeter wire, the six current distributions in the "hat", terminate at the mid-points between the six spokes. So, the total area under the green current-distribution lines is significantly larger than without the hats. Ref. 5. That's good! This area is equivalent to the antenna's radiation resistance. Short antennas have a small radiation resistance, hence are less efficient. The end-hats (especially with a perimeter wire) are very effective way to increase the radiation resistance. Note that the radiation resistance cannot be measured directly, and is not the same as feed-point impedance. Note that the effect of the "hat" has not much to do with "capacitance". So calling it a "capacitive hat" or "capacity hat" is a (common) misnomer, even though the hat does have some capacitance. Ref. 5.



Current distribution of the KGD-80-FD Mk 2, without hats and with hats
(common-mode suppression at feedpoint assumed)

If the spokes of the hat are arranged in a symmetrical manner, actual radiation from each individual spoke is offset by the radiation from the other spokes. Effectively, the hats do not contribute to the far-field radiation pattern and strength. The required spoke-length decreases, when the number of spokes is increased or if a perimeter wire is added. Conversely, the effectiveness of the hat is increased, when spokes are added (though diminishing increase as the total number of spokes goes up), or a perimeter wire is added. Of course, the hat could be made of a disk made of solid metal or metal mesh. But that adds weight and wind-load.

Clearly, *physically* ("mechanically") my antenna is a symmetrical dipole. But due to the vertical installation, one end is much closer to the ground than the opposite end. This means that the loading by the ground is asymmetrical. This can be compensated by off-center feeding or by using a smaller loading coil in the lower dipole leg than in the upper leg (ref. 8), or asymmetrical extension of the KGD tuning rods. Fully extending a tuning rod reduces the resonance frequency by about 30 kHz.

The above antenna is "base loaded": the loading coils are placed at the feedpoint. Yes, the efficiency of this antenna could be increased *somewhat*, by inserting the loading coils at a point that is 30-50% of the radiator length away from the feedpoint. But that complicates the construction of the antenna quite a bit...

REFERENCES

- **Ref. 1:** "KGD - Kurz Geratener Dipol", instructions and associated forum entries from QRPproject [in German]
- **Ref. 2:** Coil / inductor calculators
  - **Ref. 2A:** "Helical coil calculator" on pages of the Tesla Coill webring
  - **Ref. 2B:** "K1QW Inductor Calculators"
  - **Ref. 2C:** "ON4AA Single-layer Helical Round Wire Coil Inductor Calculator"
- **Ref. 3:** "Turns-length calculator for ferrite and iron powder core toroids"
- **Ref. 4:** "The Beta Match: 2 Views", L.B. Cebik (W4RNL, SK)

- **Ref. 5:** "capacitance" end-loading hats
  - **Ref. 5A:** "A triangle for the Short Vertical Operator" [hatted short dipoles], in "Antennas Tales and Technicals", update of Feb 1999, L.B. Cebik (W4RNL, SK)
  - **Ref. 5B:** "Notes on Hatted Vertical Dipoles for 10 meters", in "Antennas Tales and Technicals", L.B. Cebik (W4RNL, SK)
  - **Ref. 5C:** "End-Hat Loading" section in "Half-Length Dipoles (for 40 Meters) Part 3: Element Loading to Achieve Dipole Resonance", L. B. Cebik (W4RNL, SK)
  - **Ref. 5D:** "Practical antennas for the low bands", Rudy Severns (N6LF), presented at the 2007 Seapac hamfest, Seaside/OR, 116 slides. [pdf]
- **Ref. 6:** "4NEC2 model of KGD-80-FD without hats and with hats (with loading coils and installed 2.4 m above average ground), Frank Dörenberg, N4SPP, 25-May-2014
- **Ref. 7:** "Beta-match Coil Calculator for Known Antenna Impedance", Frank Dörenberg, N4SPP, 25-May-2014
- **Ref. 8:** "Vertical dipole for 40m (and higher)" (with Beta Match coil), Ed Bosshard (HB9MTN); associated EZNEC files: here.
- **Ref. 9:** the "up & Outer" antenna:
  - **Ref. 9A:** "The "Up-and-Outer", a golden-goodie", C.F. Rockey (W9SCH, SK), in "SPRAT", Journal of the G QRP Club, Issue 67, Summer 1991, page 18p. 18
  - **Ref. 9B:** "A four-band "Up and Outer" antenna", C.F. Rockey (W9SCH, SK), in "SPRAT", Journal of the G QRP Club, Issue 69, Winter 1991-1992, p. 16
  - **Ref. 9C:** "The "Up and Outer" Antenna" by Craig LaBarge (WB3GCK) [pdf]
- **Ref. 10:** loading of antennas
  - **Ref. 10A:** "Loading of short antennas", by Doug Flory (WB6BCN) in "antenneX Online", Issue No. 80, December 2003 [pfd]
  - **Ref. 10B:** "Shortened Dipole Study for Conditions On BVARC's Rag Chew Net", Larry Jacobson (K5LJ), Rick Hiller (W5RH), expanded from same-title article in "Newsletter of the Brazos Valley Radio Club", September 2009
  - **Ref. 10C:** "Element Loading to Achieve Dipole Resonance", part 3 of "Half-Length Dipoles for 40 Meters", L. B. Cebik (W4RNL, SK)
  - **Ref. 10D:** "Signal/noise-ratio performance of loaded wire antennas", P.A. Ramsdale, Proc. IEE, Vol. 124, No. 10, October 1977, pp. 840-844 [pdf]
  - **Ref. 10E:** "Designing a Shortened Antenna", Luiz Duarte Lopes (CT1EOJ), QST Magazine, October 2003, pp. 28-32 [pdf]
  - **Ref. 10F:** "Short Vertical Antennas and Ground Systems - VK1BRH", Ralph Holland (VK1BRH), in "Amateur Radio", Vol. 63, No. 10, October 1995 (non-commercial reproduction allowed) [pdf]
- **Ref. 11:** "Signal/noise-ratio performance of loaded wire antennas", P.A. Ramsdale, Proc. IEE, Vol. 124, No. 10, October 1977, pp. 840-844 [pdf]

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