Optimizing the 2m Eggbeater EG145RE from ANjO-Antennen

Matthias, DD1US, September 5th2019, Rev 3.2

Preparing another ARISS school contact later this year we needed an omni antenna as a backup antenna. At the Ham Radio Fair in Friedrichshafen I bought a 2m Eggbeater antenna from ANjO-Antennen. It is the EGB145RE Premium line version. This antenna is mechanically very well made. It is very solid and all metal is aluminum or stainless steel including the mast clamp and the screws.

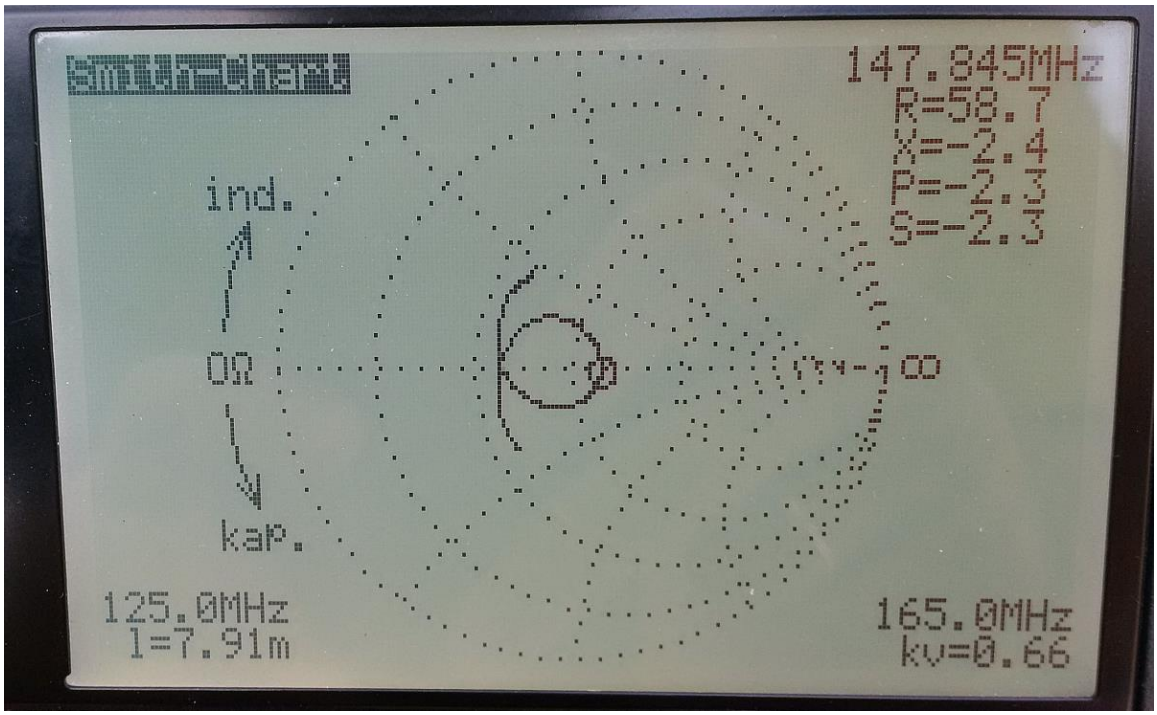
Here are the technical specifications of this antenna:

Frequency range	144-14 MHz
Polarization	RHCP (I assume close to the horizon this antenna is horizontally polarized)
Beam width	360 degree @horizontal plane
	120 degree @vertical plane
Gain	6.2dBic
Max. power	100W CW, 200W PEP
Connector	N female
Height	114cm
Weight	2.0kg
Wind load	81N @120km/h, 145N @160km/h

Yesterday I assembled and tested this antenna for the first time. Here are some pictures of the antenna on my portable mast in the garden. The height above ground is approximately 2.5m.

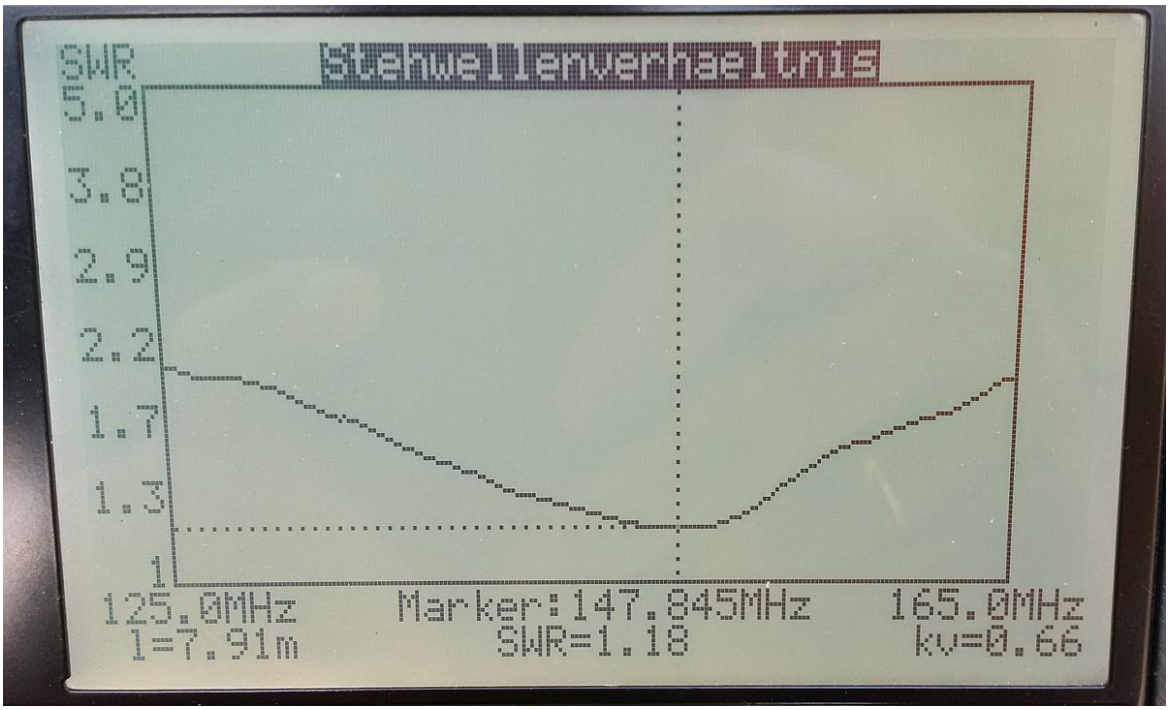
1.) Measuring the antenna as I received it from ANjO without any modifications:

Using my portable Vector Antenna Analyzer (FA-VA designed my DL1SNG) I measured the impedance of the antenna. All measurements were done in the frequency range 125-165 MHz. The coaxial cable is RG223 with a length of 4.0 m. I calculated the cable loss to be 0.7dB @144 MHz. The total loss including the connectors and one adapter is estimated to be approx. 1dB or slightly above. Please note that I did not enter the correct cable length in the VNA and thus the absolute phase information is not correct (e.g. the Smith Chart is tilted).
First here is the Smith chart:



It looks perfect except that the resonance is not in the 2m Ham Radio band but almost 3 MHz too high.

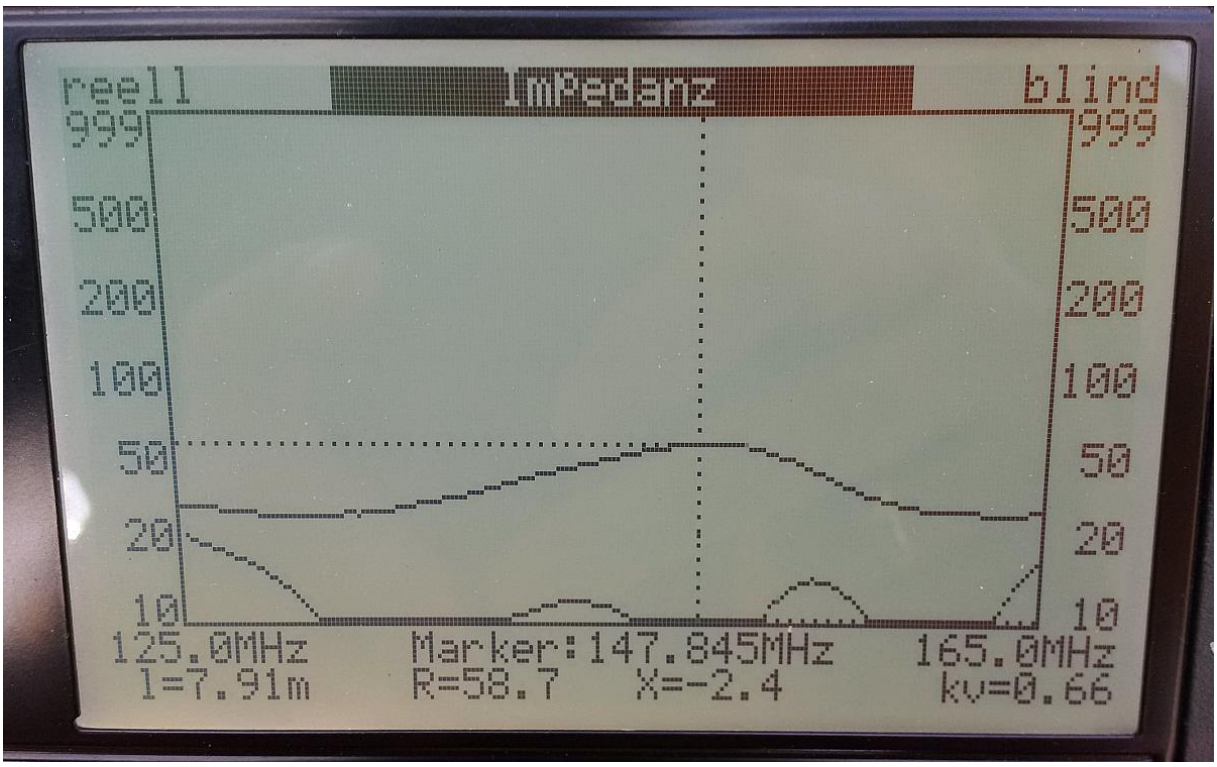
Here is the VSWR plot:



The antenna shows an excellent minimum VSWR of 1:1.18, unfortunately at 147.845 MHz.
Next, I measured the amplitude and phase of the impedance:

As can be seen the Impedance at 147.845 MHz is 58.7 Ohms and thus close enough to the targeted 50 Ohms. Very nice is the phase curve. The resonance point the phase is right between the 2 local minima and maxima which should give a perfect circular polarization.

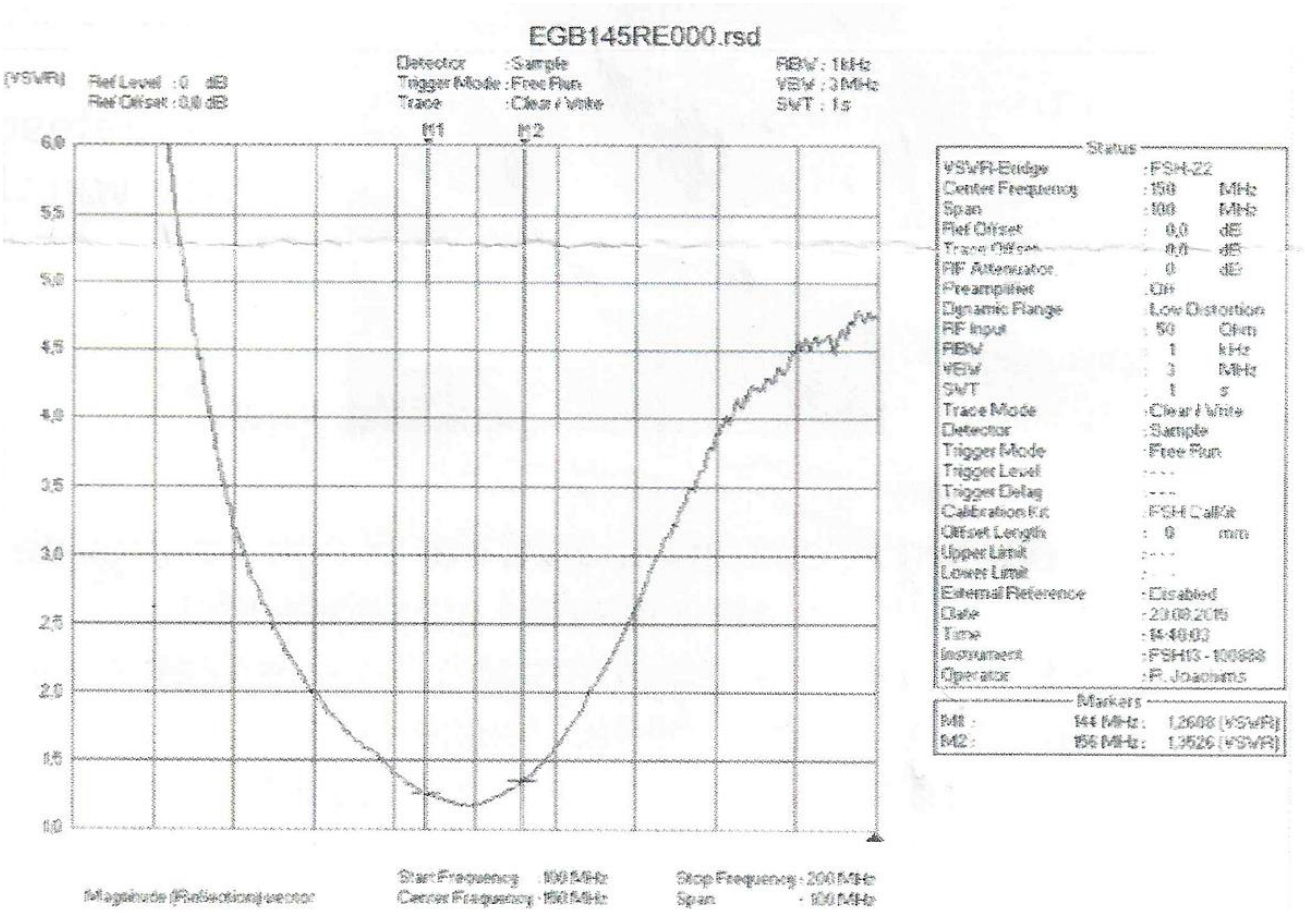
To be complete here is the plot of the real and imaginary part of the impedance:



This looks also very good at the resonance point at 147.845 MHz.

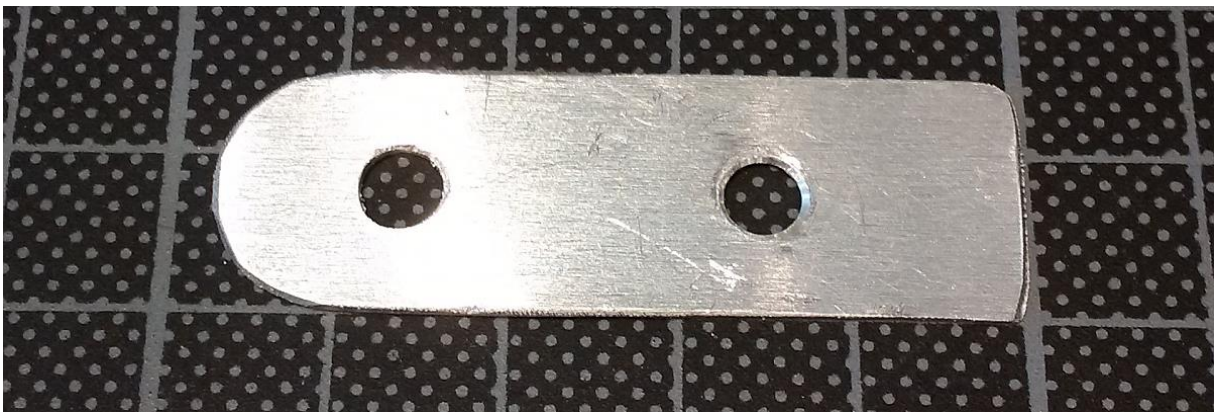
In summary, this antenna is mechanically and electrically very well made. Unfortunately, it is not perfectly tuned to 145 MHz but approx. 2% too high at 147.845 MHz.

When checking the VSWR curve in the Manual from ANjO it turns out, that also there the resonance point is rather at 150 MHz than at 145 MHz:



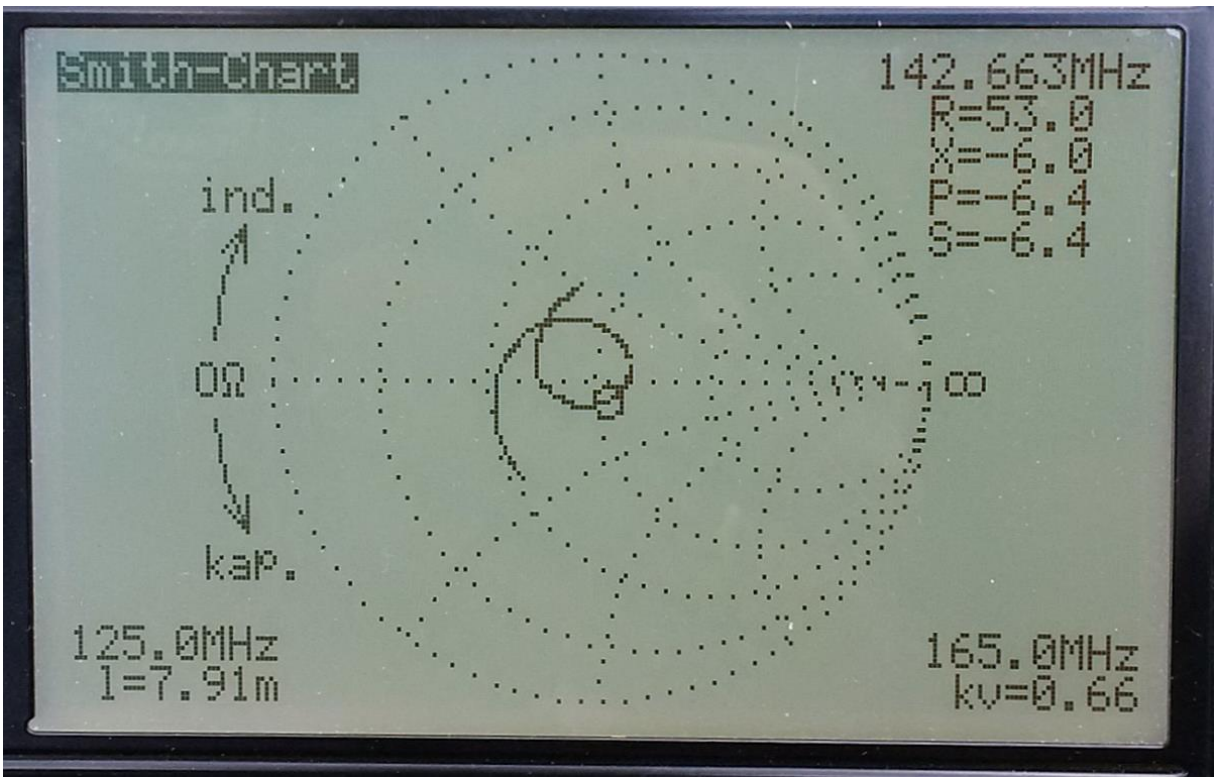
2.) Retuning the antenna by extending the circumference of the loop by 4cm:

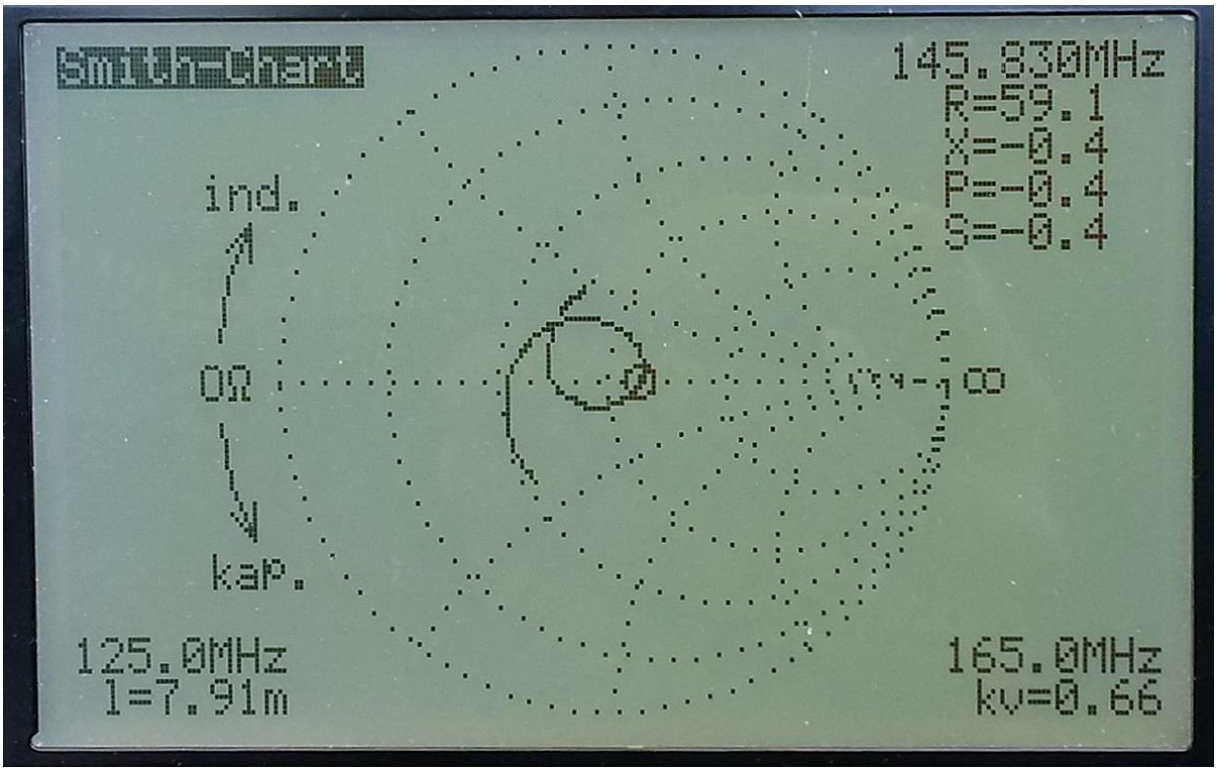
I decided to retune the antenna by extending the loop diameter. The loop is made from flat aluminum with a width of 15mm and a thickness of 2mm. Therefore, I made 4 extension bracket to increase the length of the loop at each side by 2cm (thus in total each loop is now 4cm longer). As I did not have 15mmx2mm flat aluminum pieces I cut the extensions out of a 1mm thick aluminum sheet. They are screwed to the original holes of the loop by M4 screws. Here are some pictures of the extension:



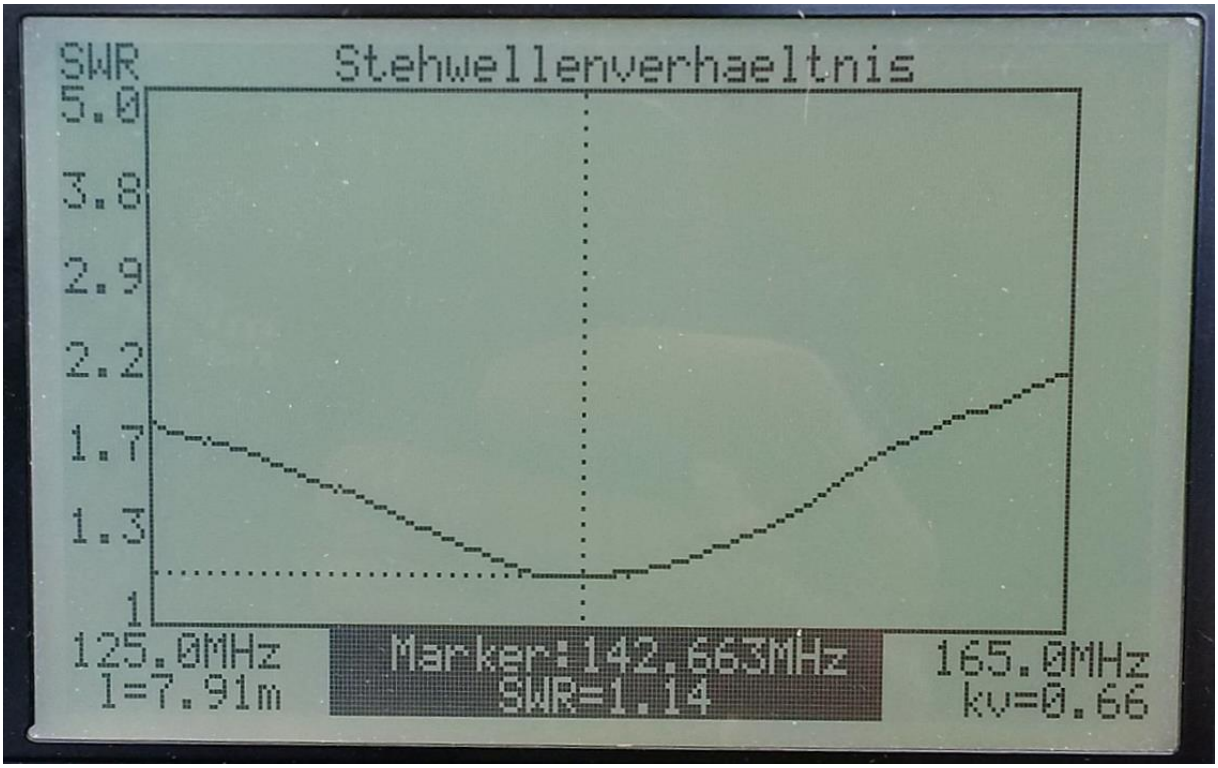
The extensions are attached to the black plastic holder using the existing M4 rods. Thus no mechanigal modification of the original antenna is needed and modification can be redone to get the antenna back to the original status.

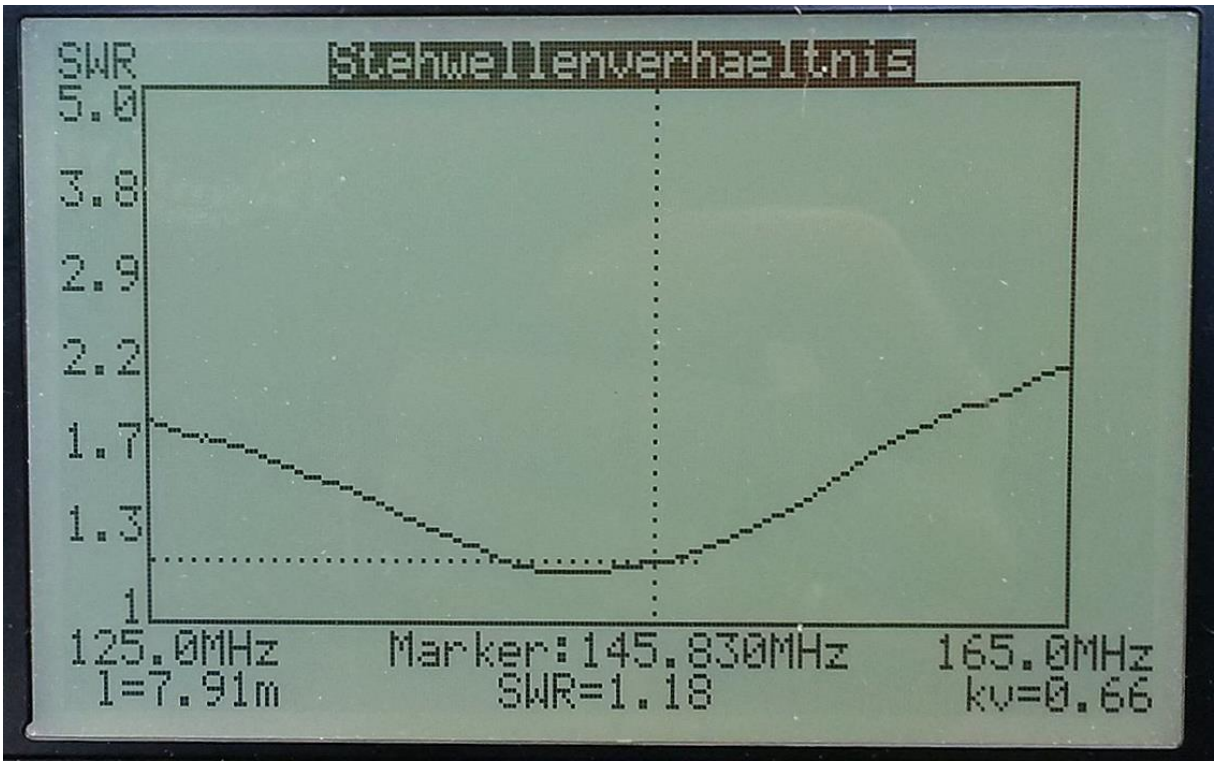
Here are the measurements after the modification:



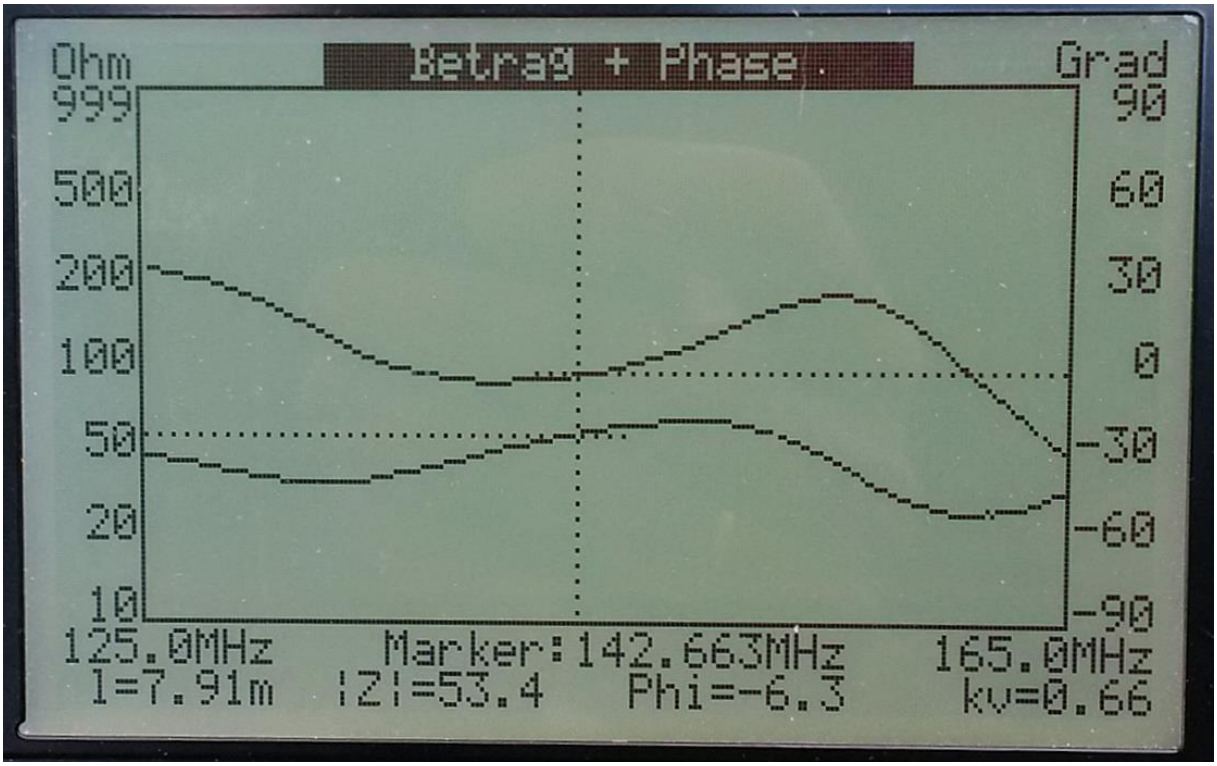


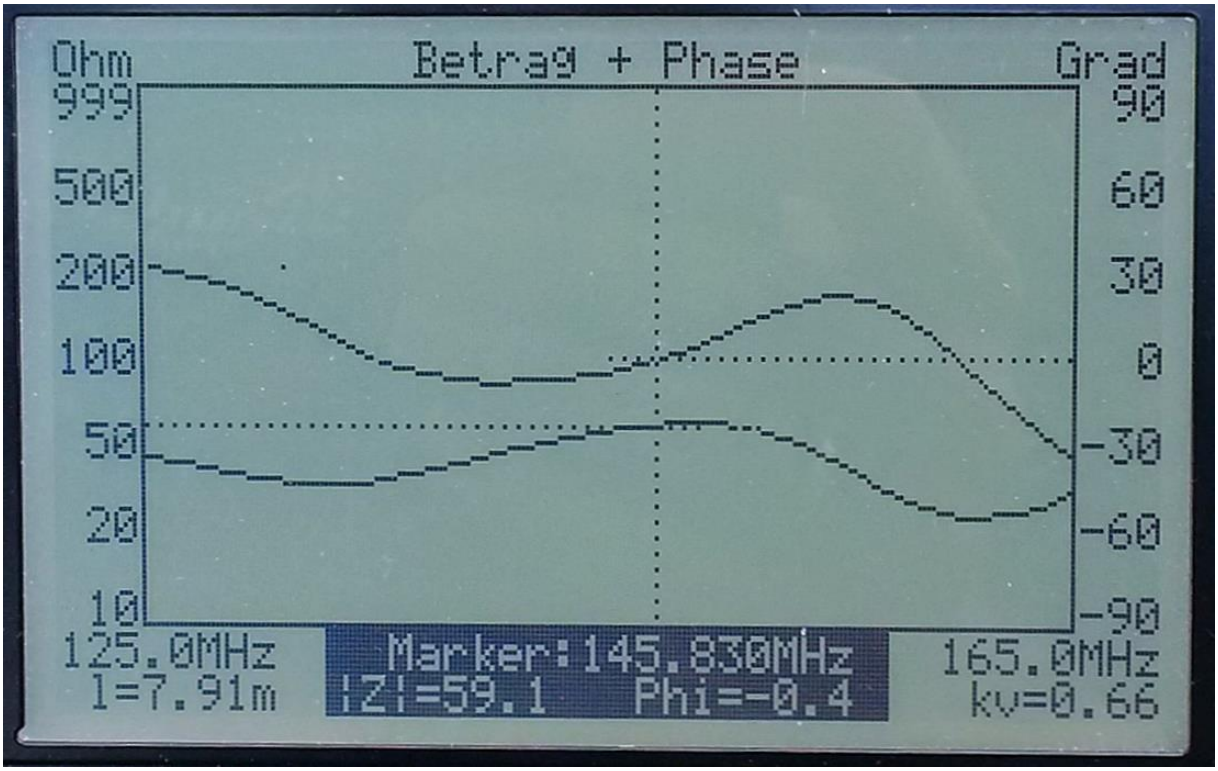
The resonance frequency is now at 142.663 MHz. However, at 145.830 MHz the impedance is still quite close to the 50 Ohm point in the center of the Smith chart.



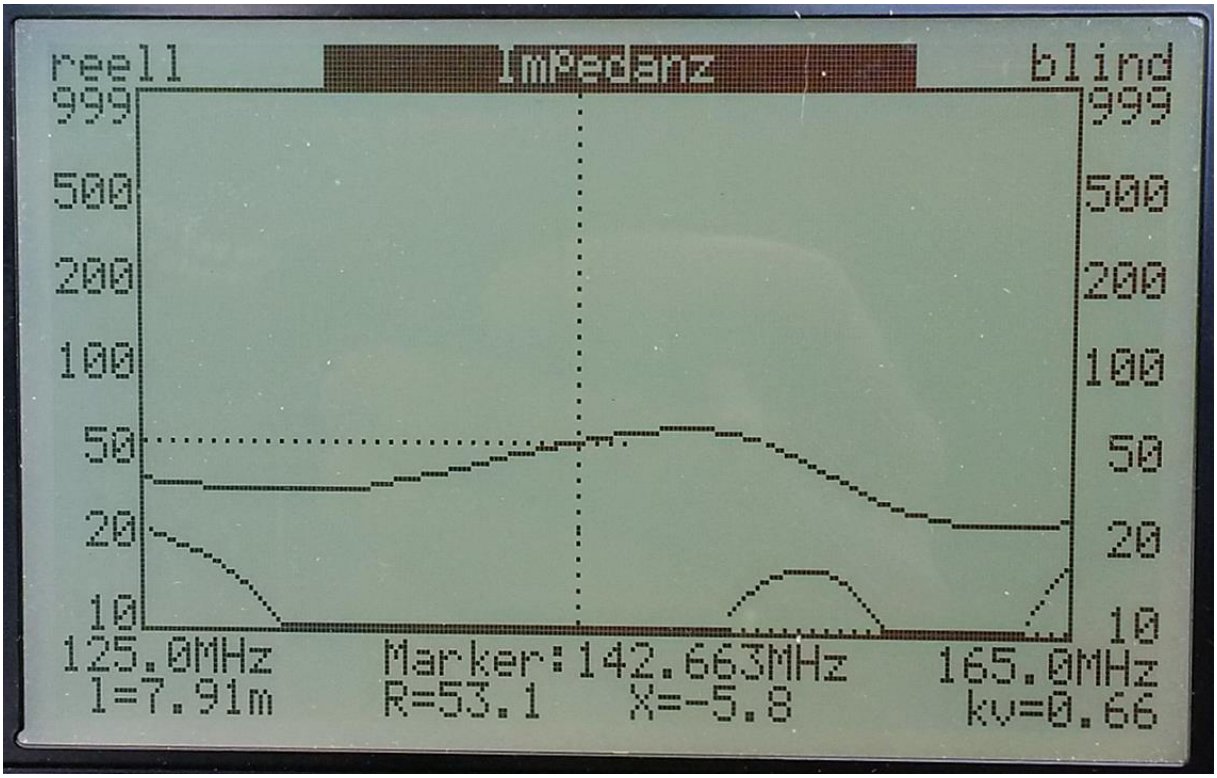


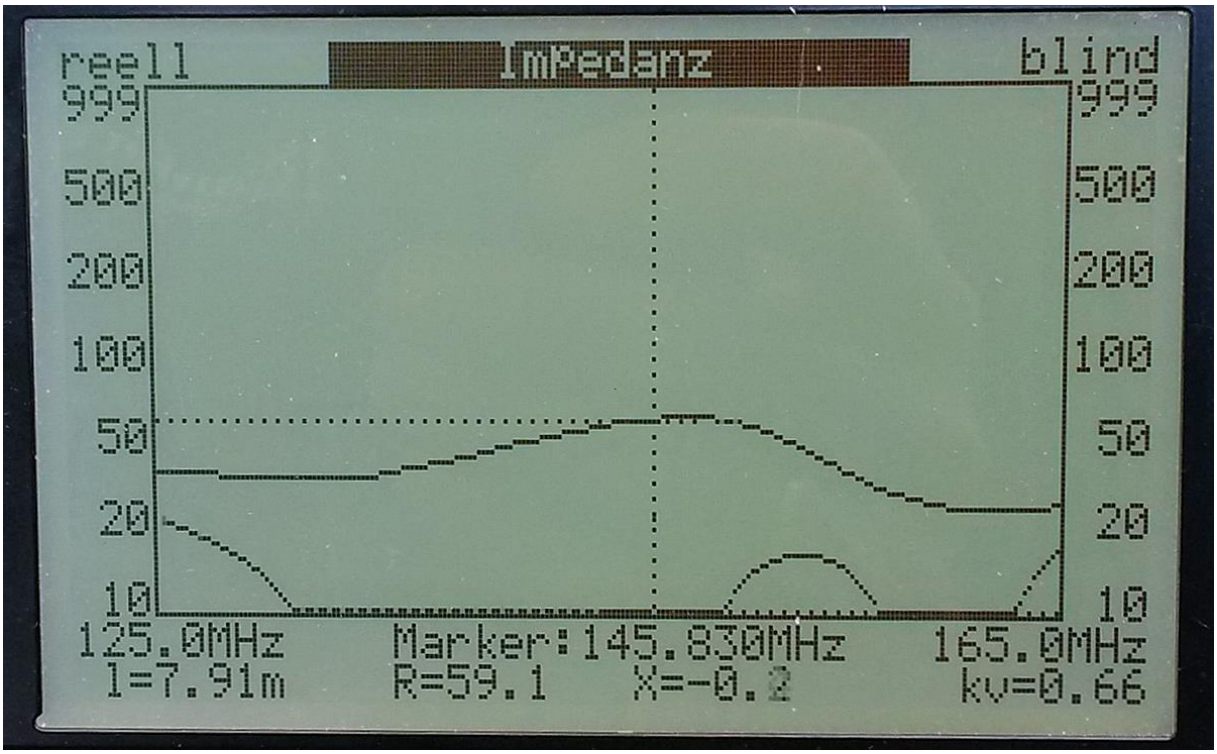
The minimum VSWR is 1:1.14 at a frequency of 142.663 MHz. At 145.830 MHz the VSWR is still quite low at 1:1.18.





Even though the minimum VSWR is achieved at 142.663 MHz, the center between the 2 local maximum/minimum of the phase curve is rather at 145.830 MHz. I expect that here the optimum circular polarization is achieved.





This graph for real and imaginary impedance is no longer as nice and symmetrical as the original design.

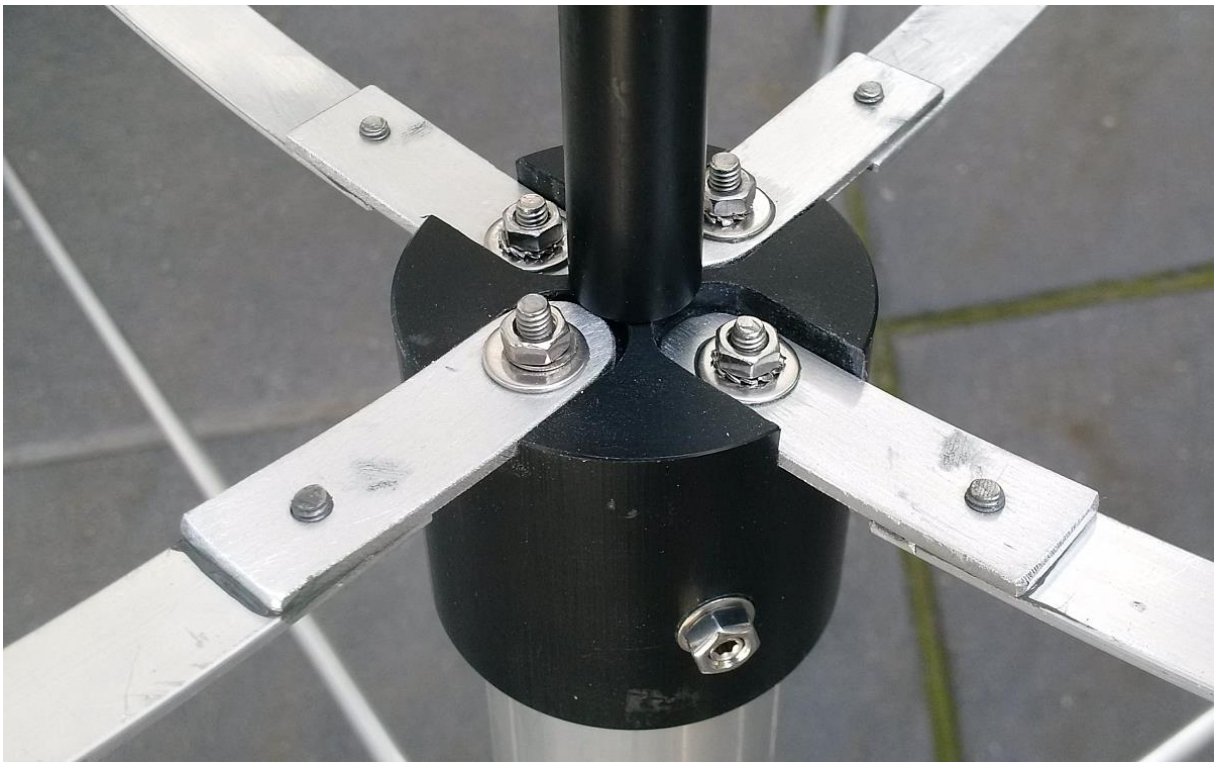
My conclusion is, that the 4 times 2cm extension is a bit too long. I guess an optimum length is 1.3cm.

However, with a shorter extension the screw to connect the extension to the original aluminum loop will interfere with the black plastic holder. Thus, it would be best to have the 2 aluminum loops made longer by 1.3cm at each end. This would also keep the original mechanical strength of the loop.

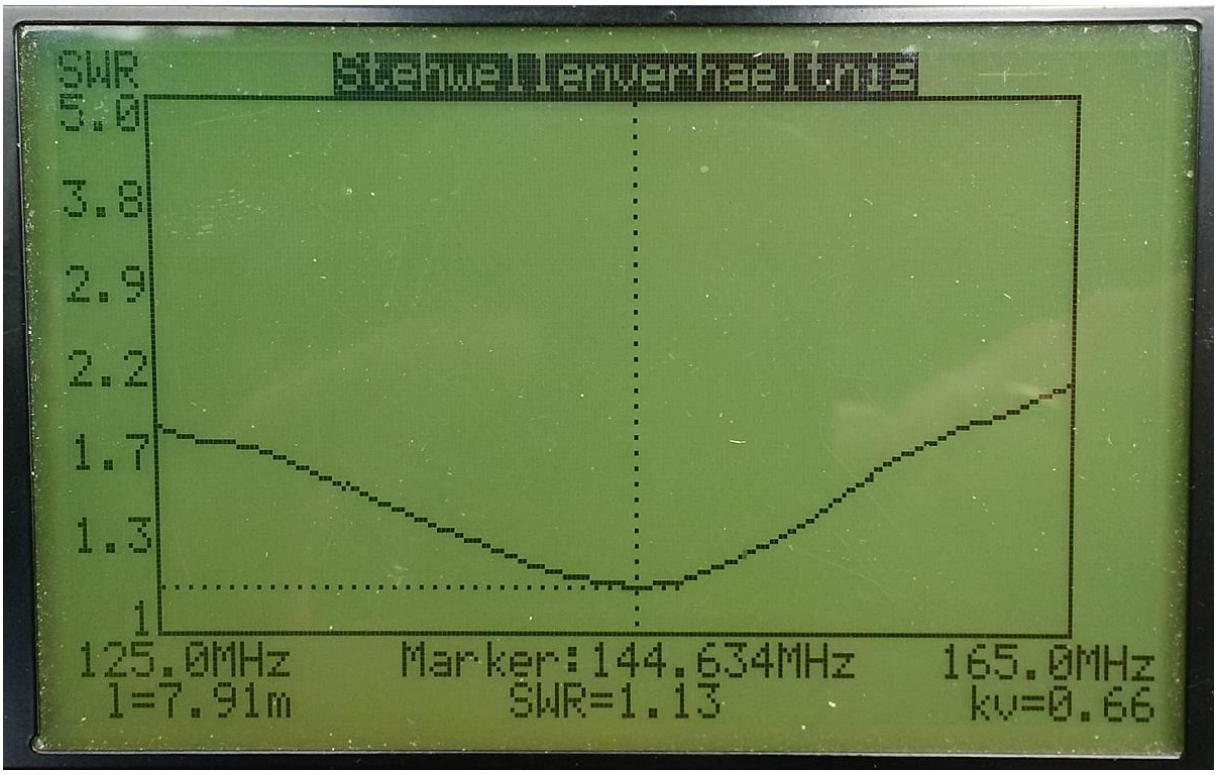
I also assume, that the optimum phase curve is strongly influenced by the internal phasing lines.

3.) Retuning the antenna by reducing the extension of the circumference of the loop to 2.6cm:

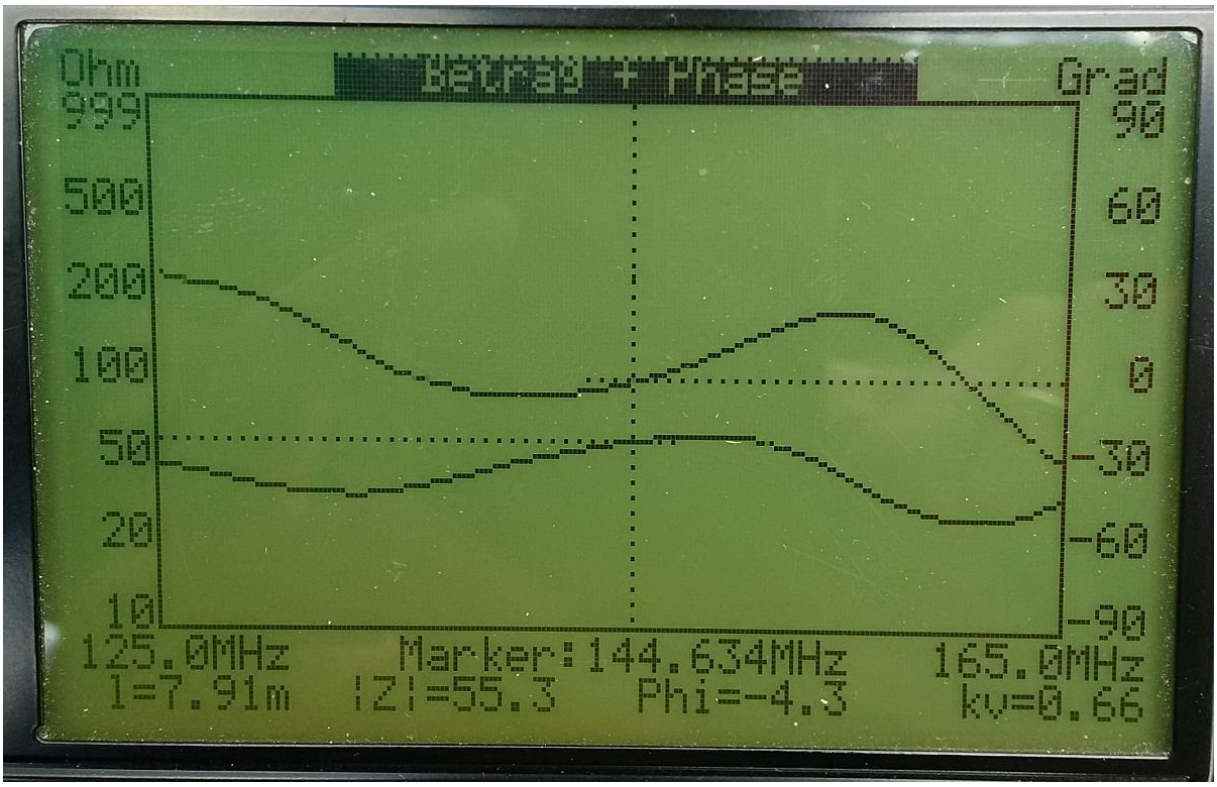
As I had made the extension of the circumference of the loops in the first step a bit too long, I decided to optimize it further. I changed the extension to 2.6cm, which means at each end of each loop I added 1.3cm. This time I used aluminum material with a thickness of 3mm to make it sturdier and also to be able to tap a 4mm thread in the aluminum. In order to avoid that the screws are interfering with the black plastic holder I shortened the loops and drilled new holes in them. Accordingly, I made the extension brackets a bit longer to achieve at the end the targeted extension. Here are pictures of the changed antenna:



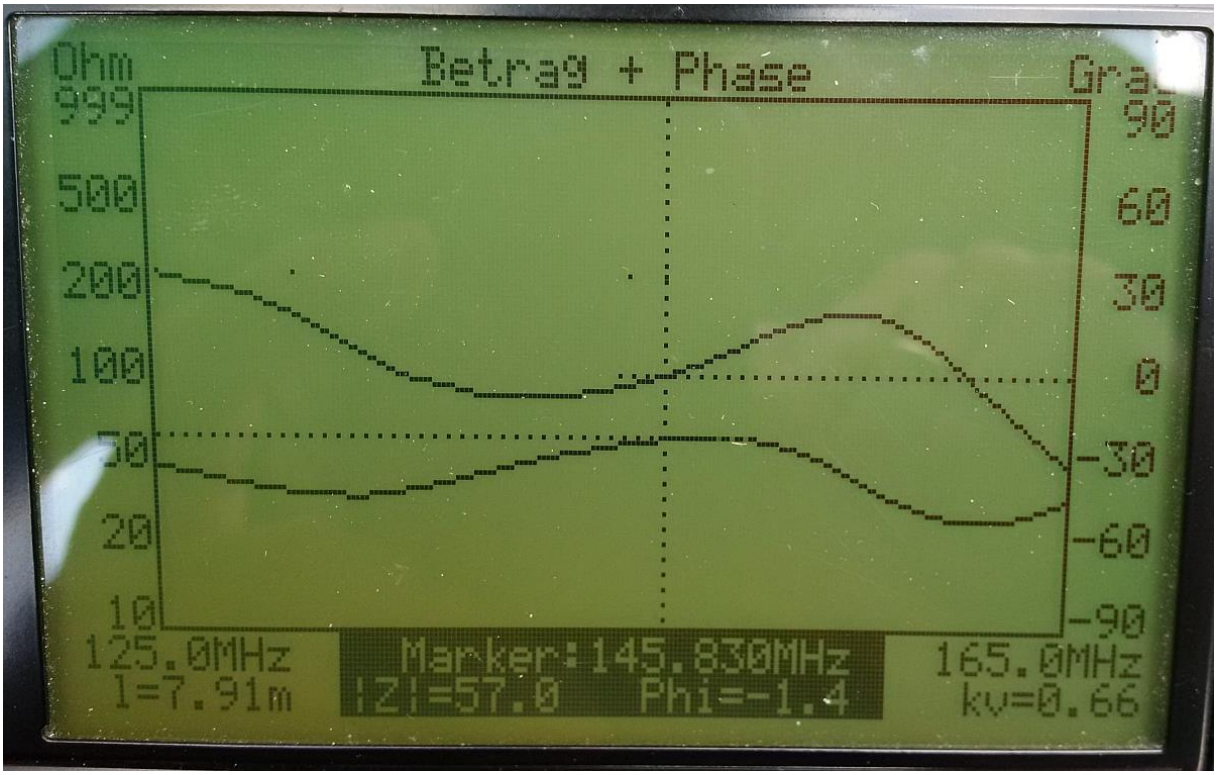
Here are the measurement results with the described changes. I did not alter the setup of the VNA (i.e. I kept the line length definition as before) to make the plots comparable to the previous measurements:



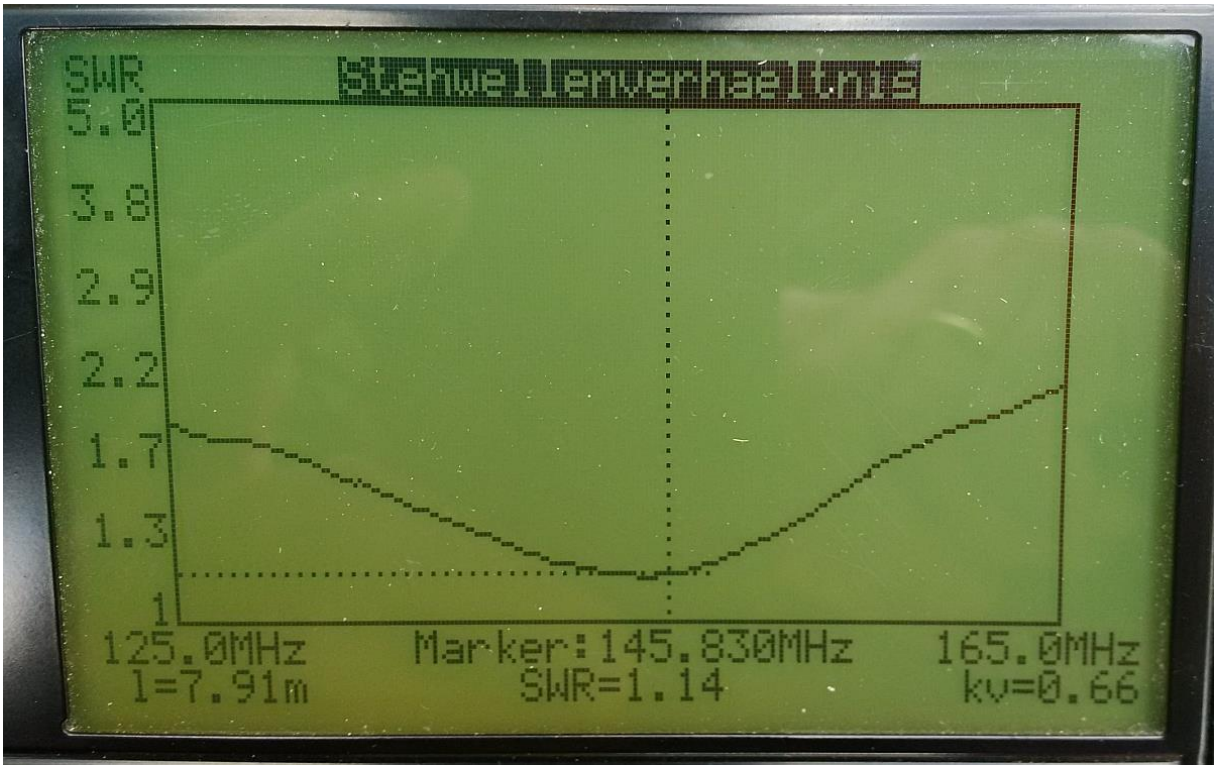
The minimum VSWR improved slightly to 1:1.13 and is now at 144.634 MHz which is almost at the center of the European 2m Ham Radio band.



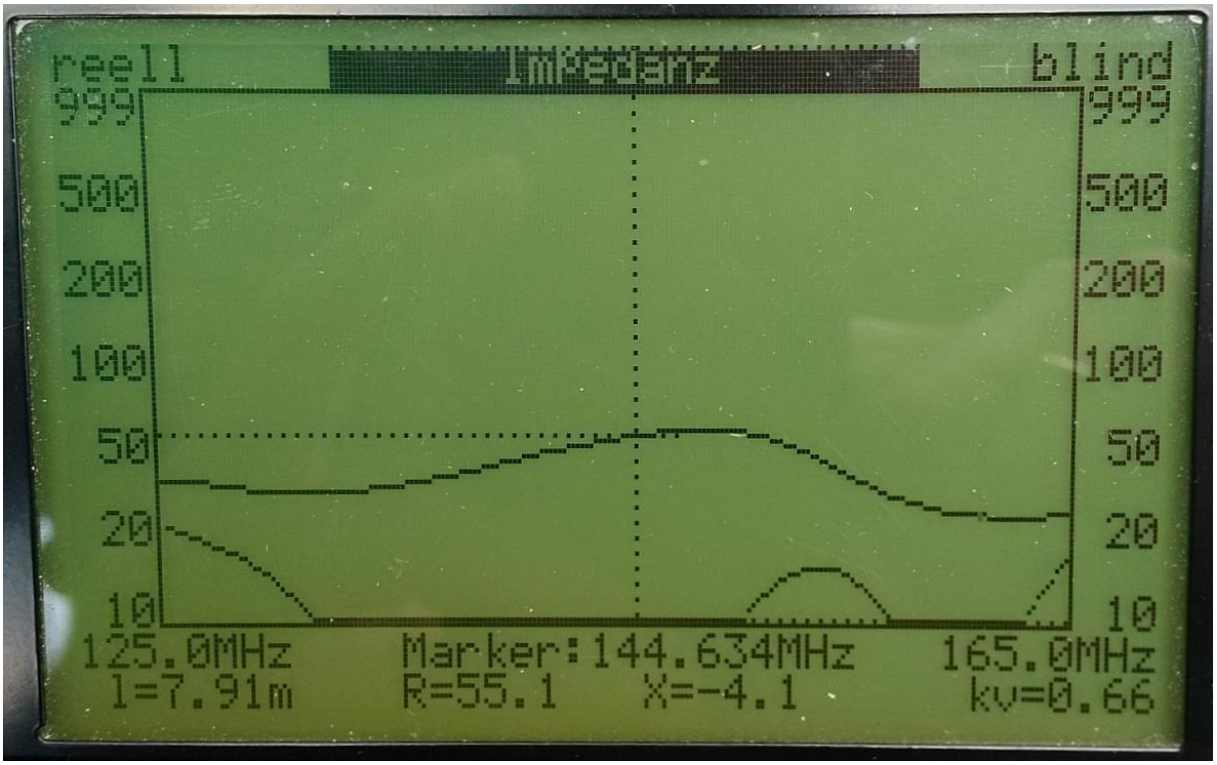
Also, the phase curve looks good. The frequency of minimum VSWR is a bit lower than the center of the local minimum and maximum of the phase curve which is rather at 145.830 MHz as can be seen in the next graph:

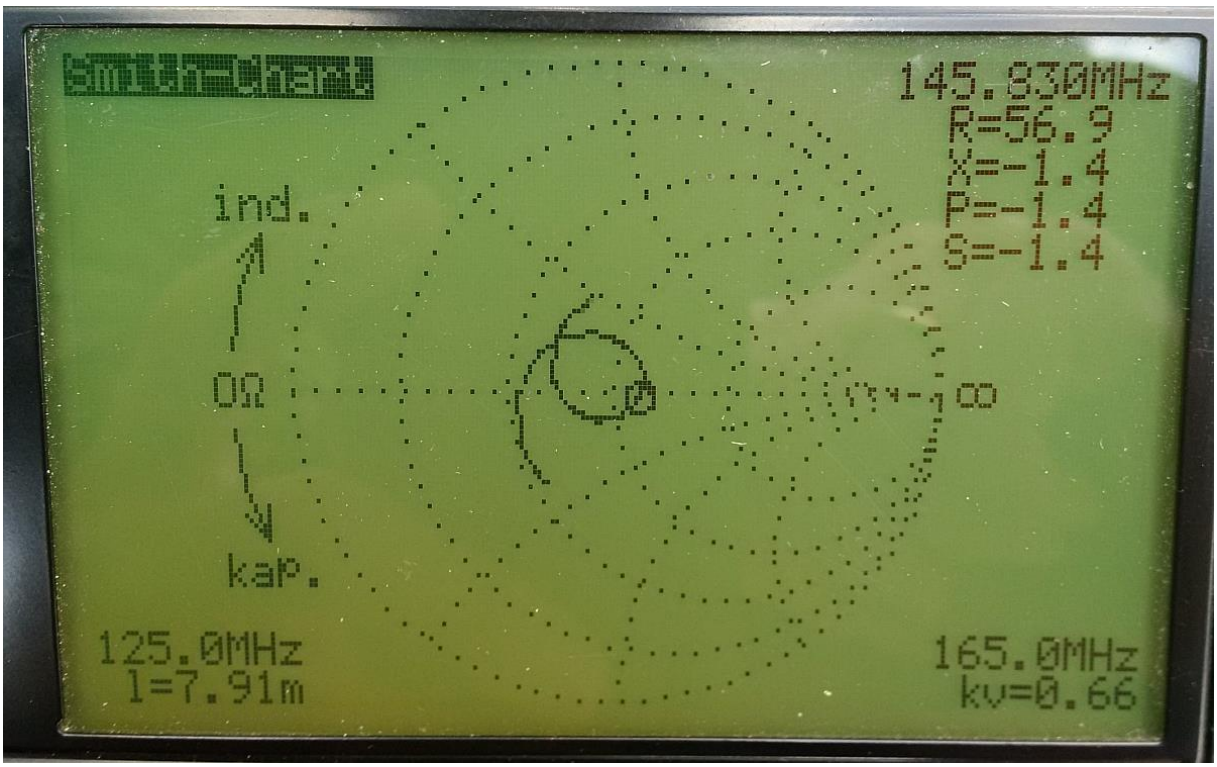


The VSWR at 145.830 MHz is 1:1.14 and thus almost as good as at 144.634 MHz (1:1.13).



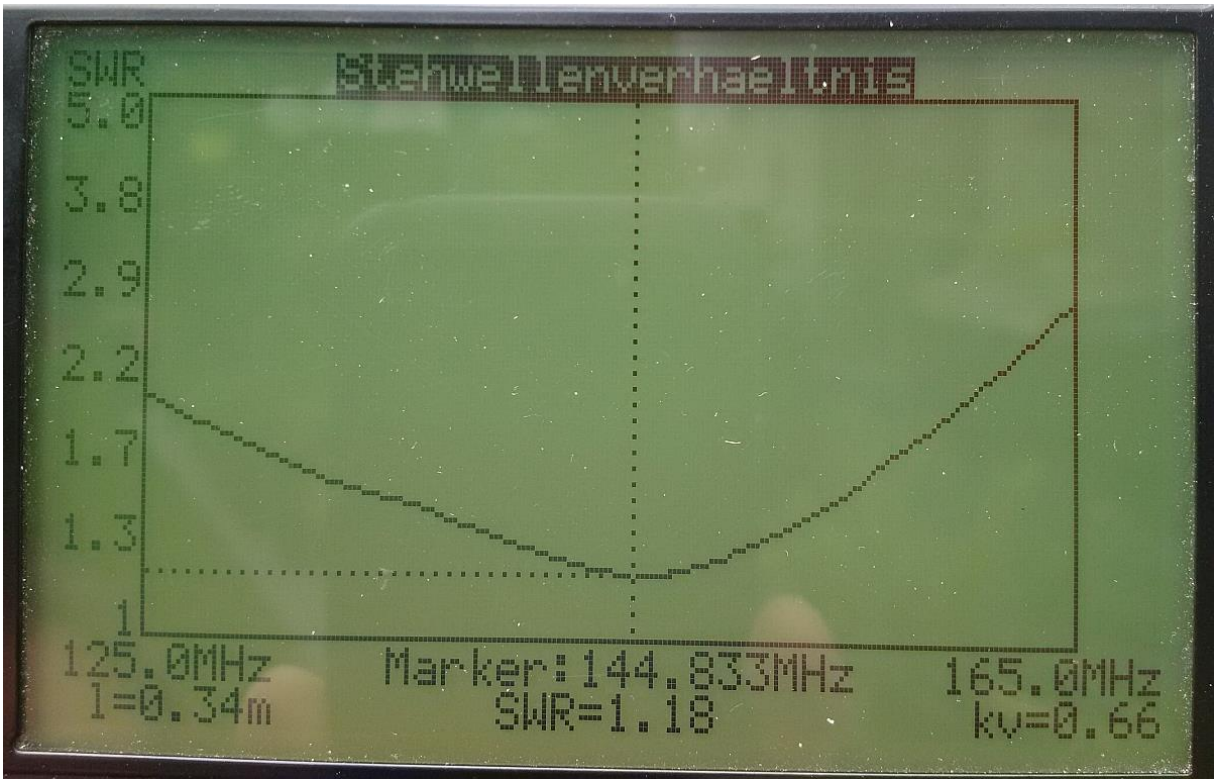
Also the Impedance curve and the Smith Chart plot look fine:





Please note that the measurement values are a bit too opimistic as I had a 4m long RG223 cable between the DUT and the VNA.

In the next plot you can see the VSWR with the VNA directly connected to the pigtail cable of the antenna:



The minimum VSWR increased from 1:1.13 to 1.18 which is still very good. This corresponds to a difference in the return loss of 2.6dB which means that the actual cable loss is 1.3dB. Still close enough to the assumptions made above.

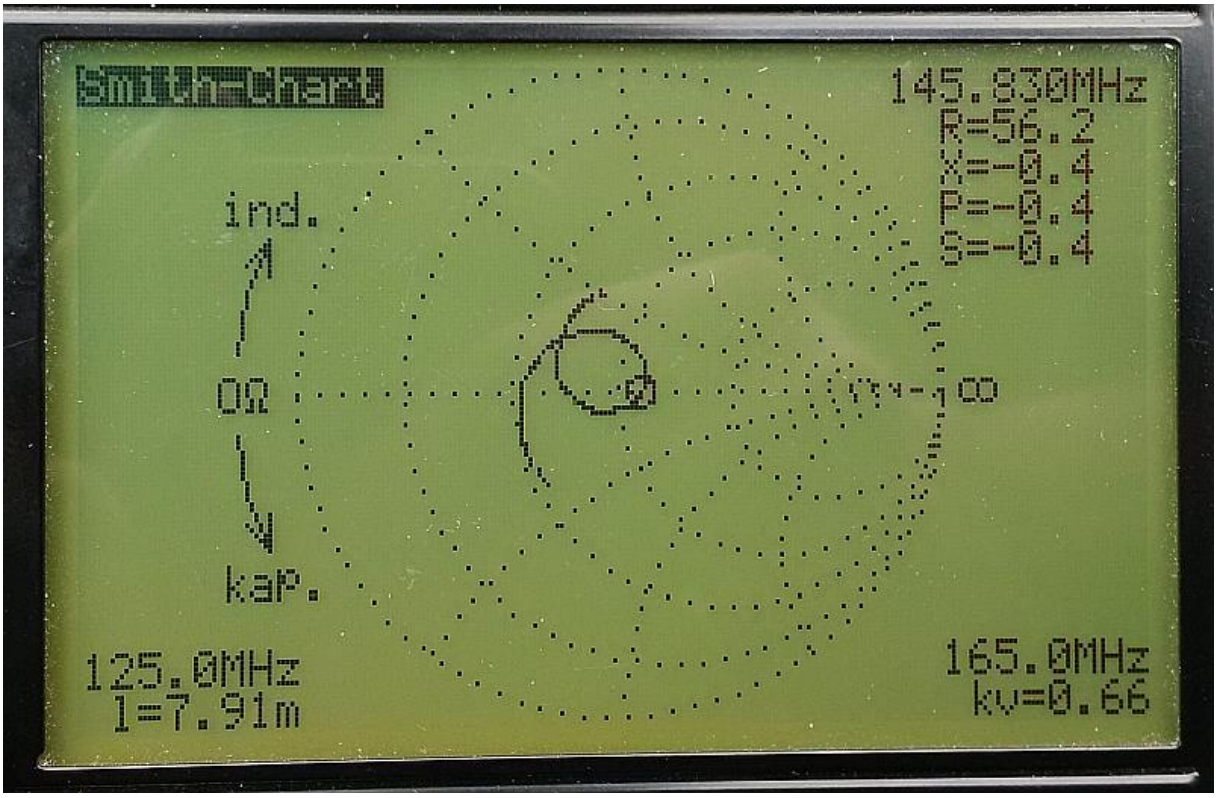
4.) Testing the new adapted loops from ANjO Antennen:

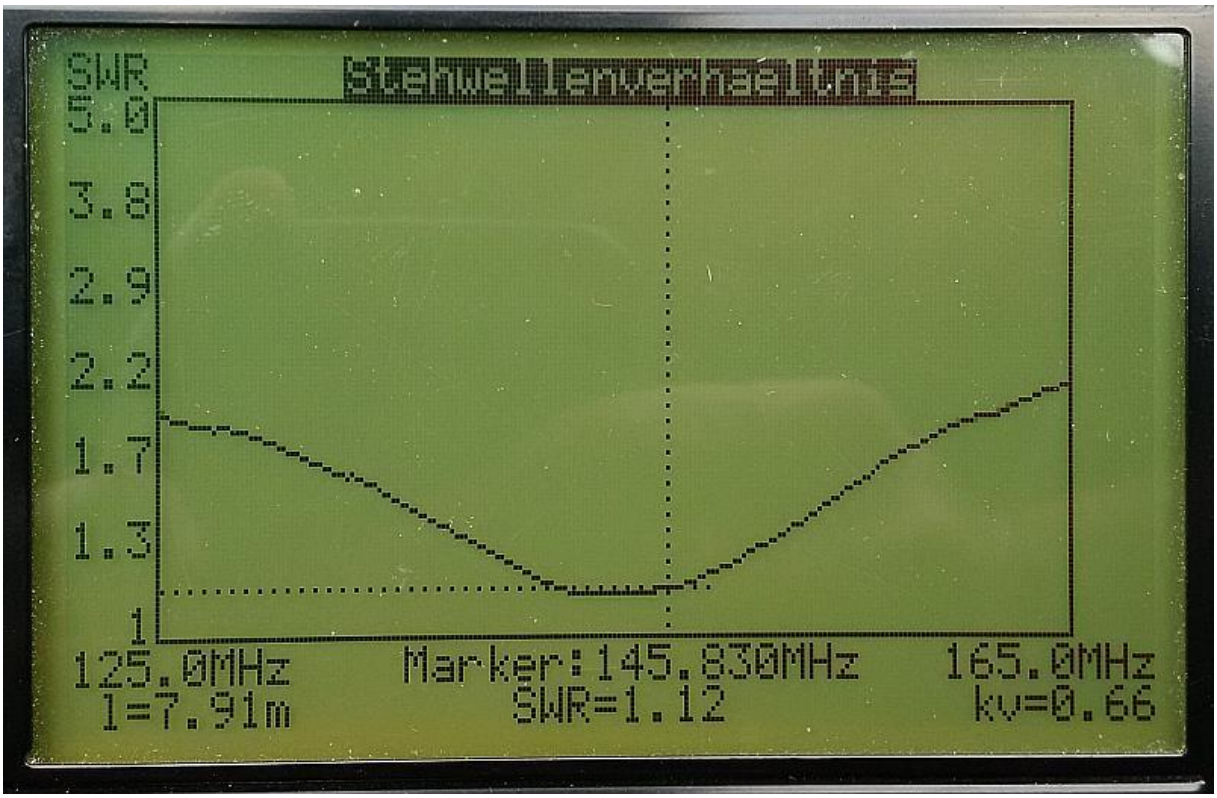
I wrote a letter to ANjO-Antennen and Mr. Joachims responded very fast and kindly. He was surprised about my measurements. He told me that he will recheck their measurement setup and calibration of their analyzer. They also offered me to send 2 loops with the optimized length which I had determined, which is 2133mm from the round tip to the round tip. Of course, I accepted their offer. A few weeks later the new loop elements arrived and also a 3cm extension of the vertical support element. Here are pictures of the setup with the changed loop Elements:

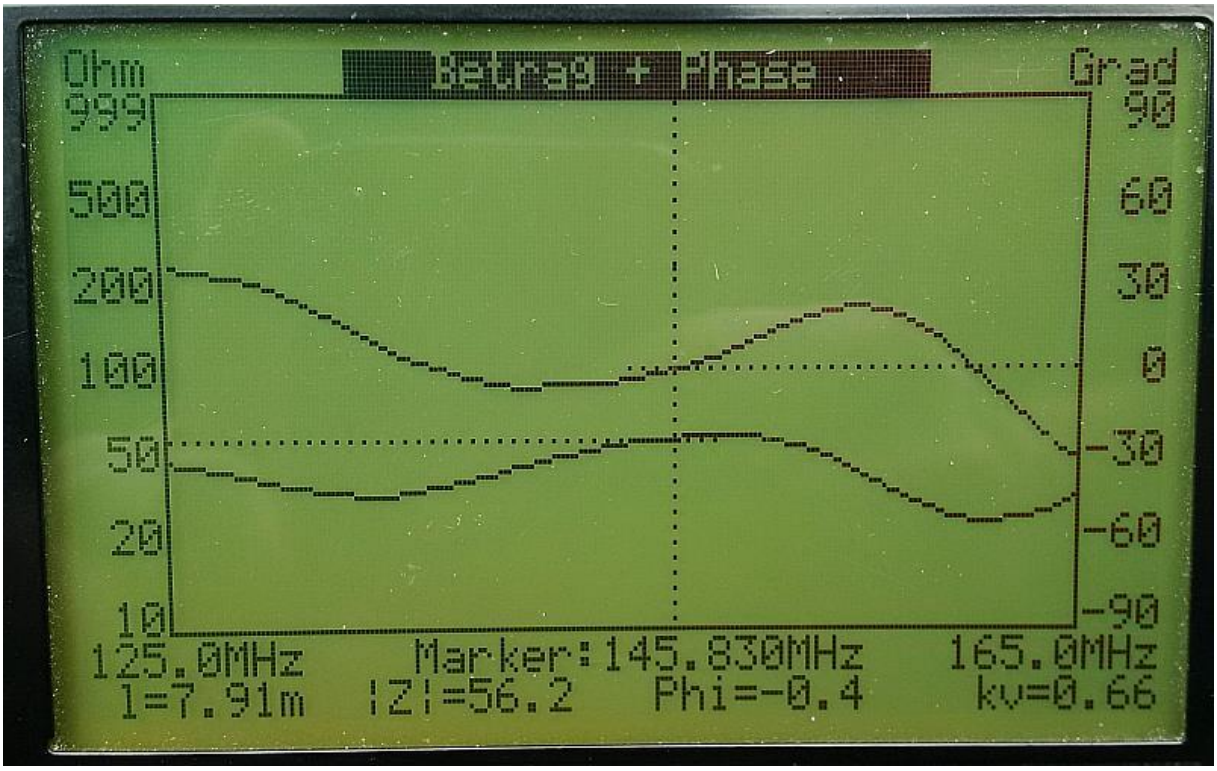

The extension of the vertical support element simply screws on to the existing element and keeps the circulars shape of the antenna.

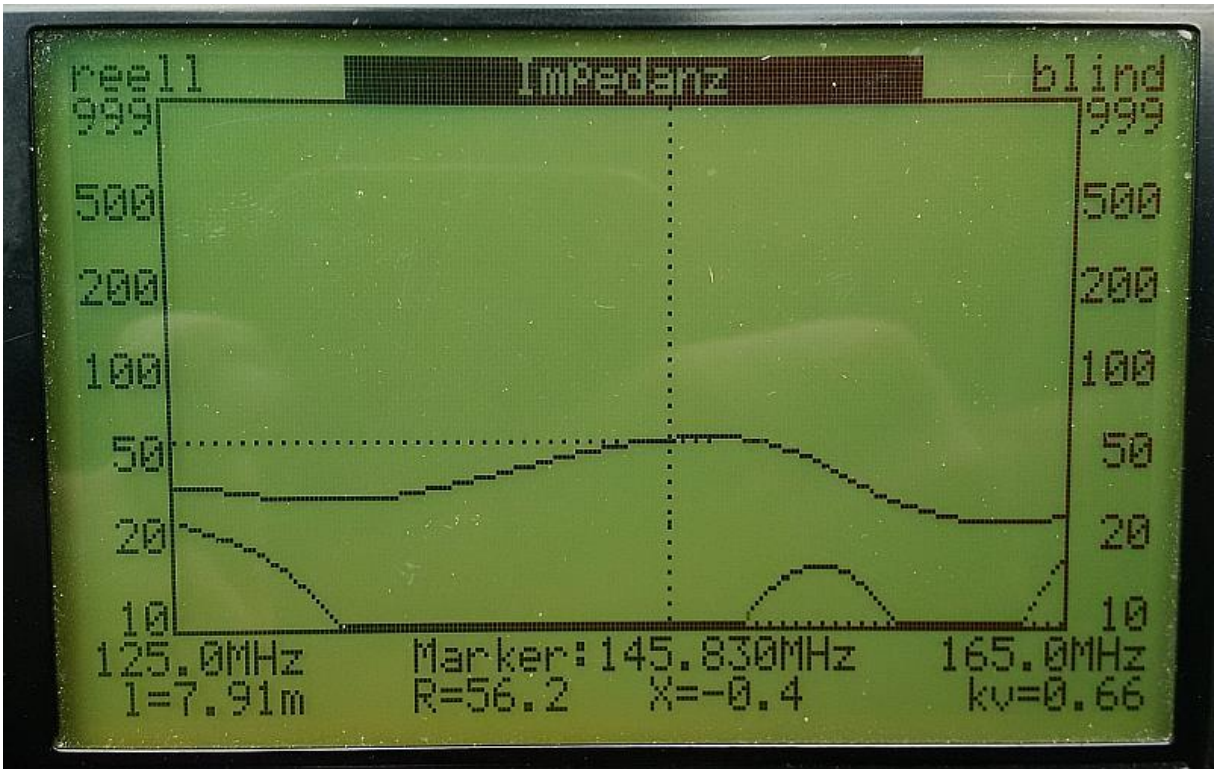

The new loops are mounted just like the original loops.

Here are the measurements of the modified Eggbeater antenna. The first measurement was made at 145.830 MHz (close to the ARISS downlink frequency):



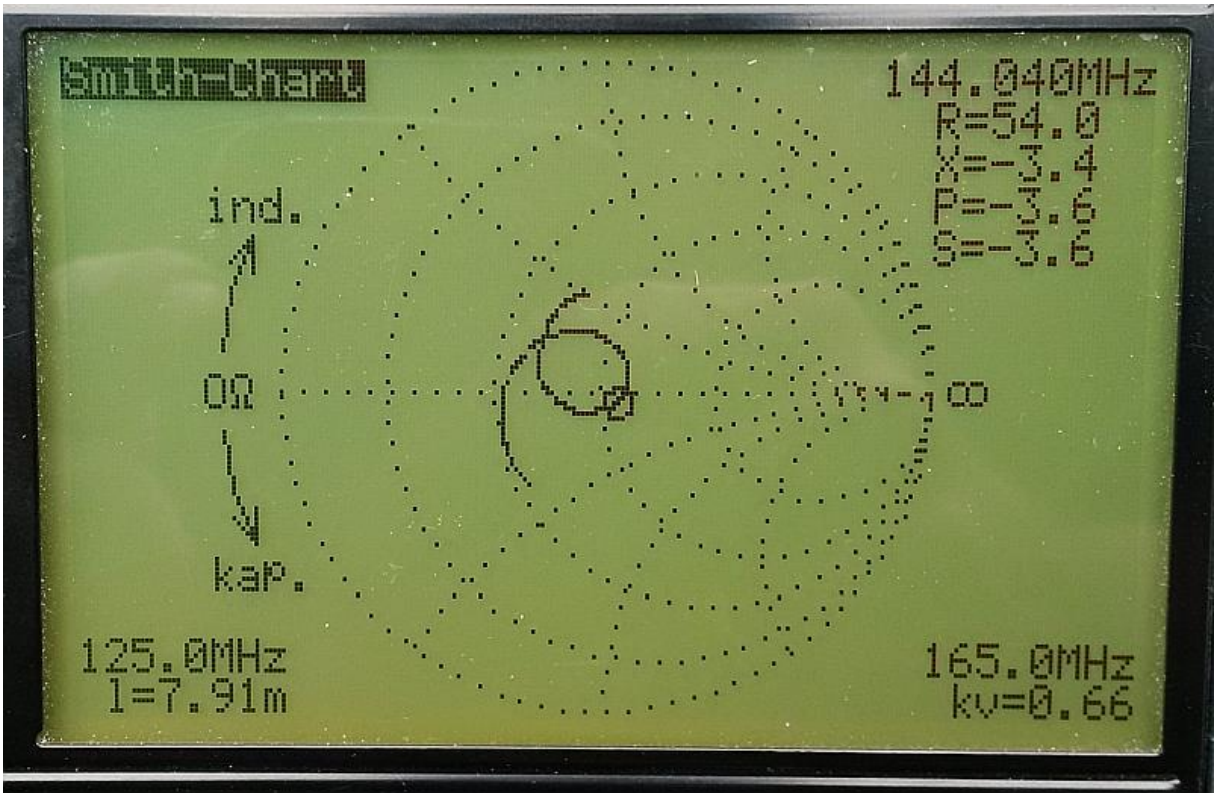


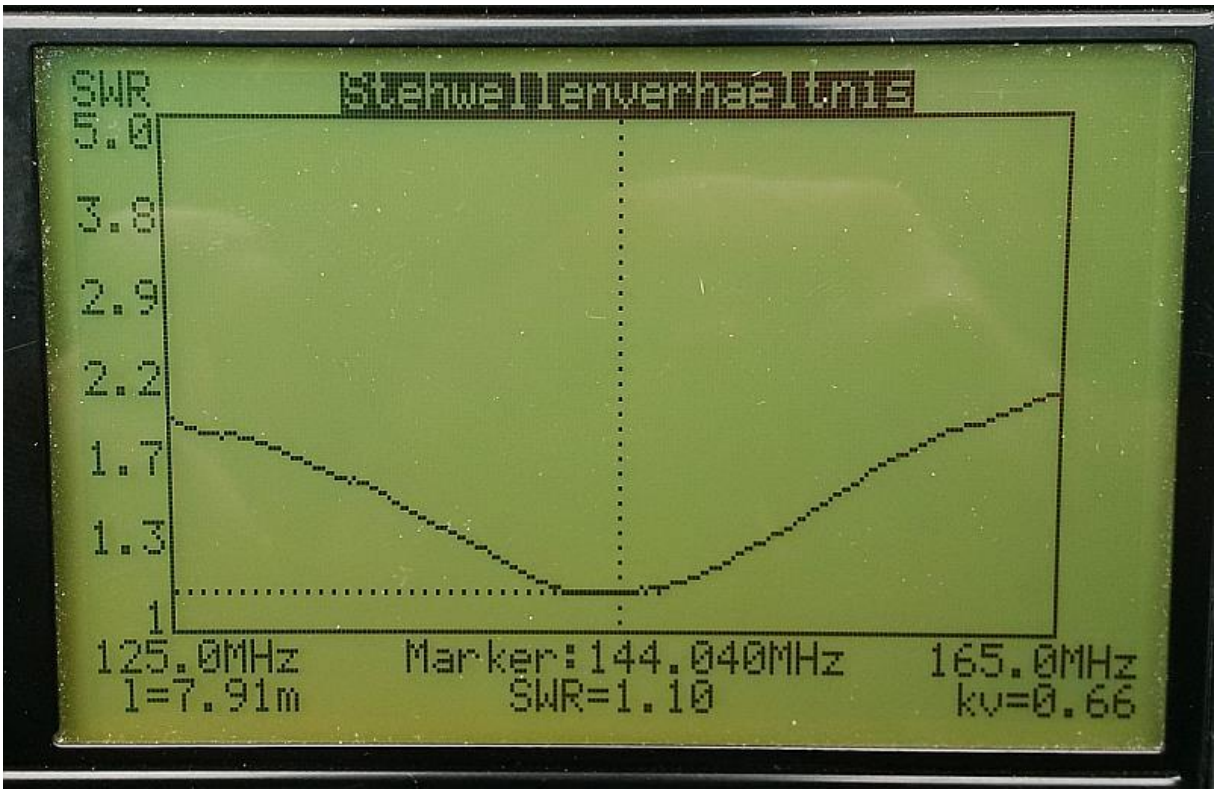


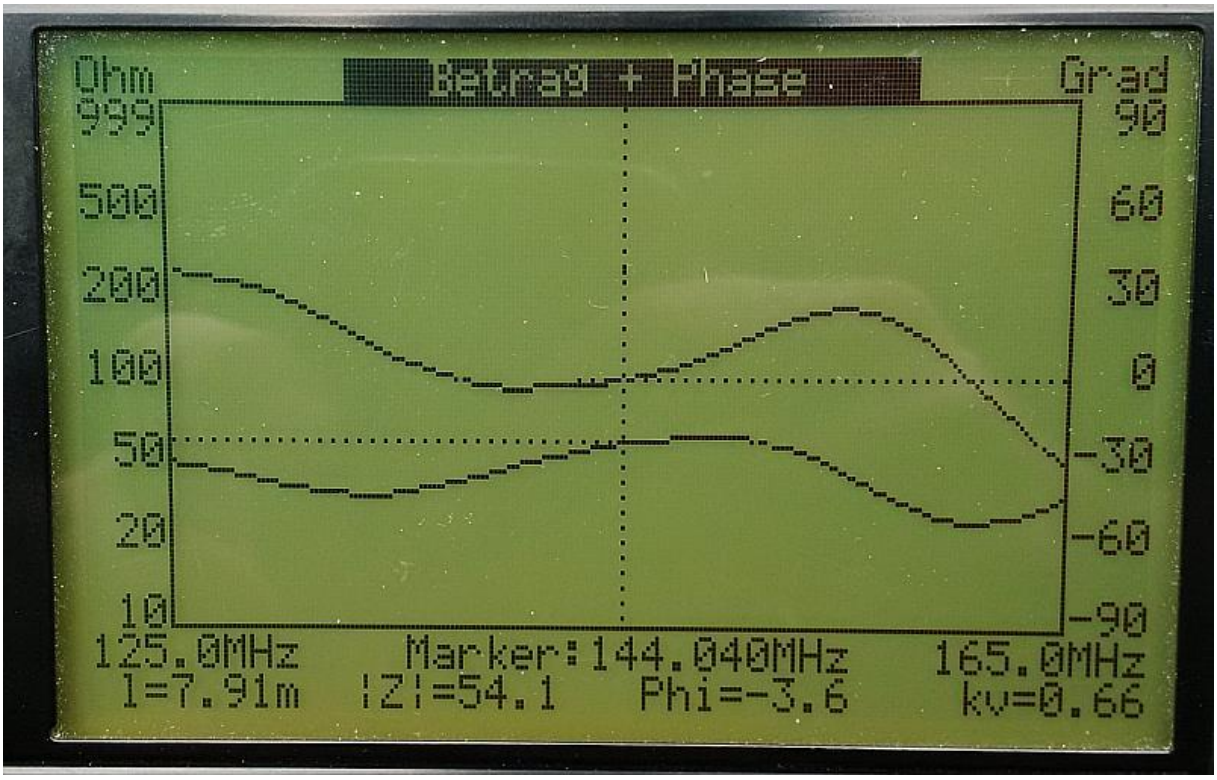


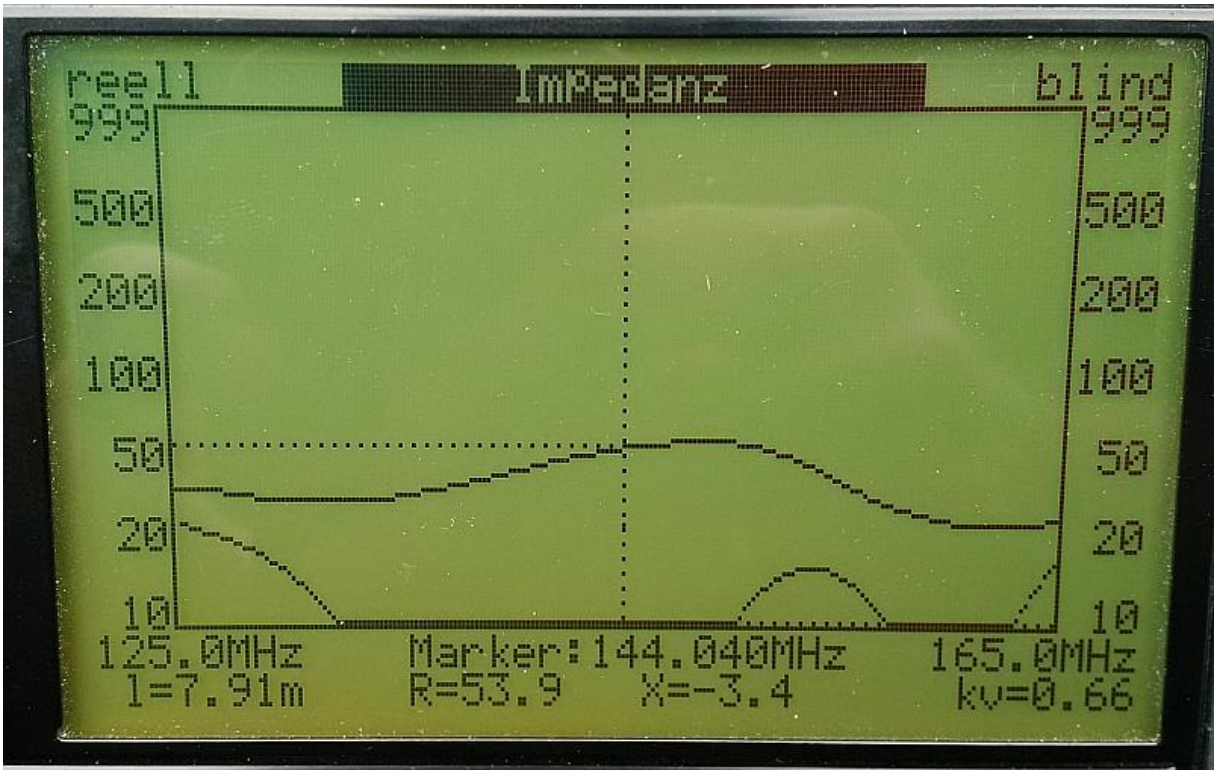
The results are almost identical to the measurements with my own modification. The VSWR is event a little bit better (1:1.12 versus 1:1.14) and correspondingly the impendance a little bit closer to 50 Ohms.

Fore reference I also made some measurements at the lower band edge of the 2m Ham Radio band at 144.040 MHz as the eggebater is also a nice omnidirectional horizontally polarized antenna towards the horuizon and can be used for terrestrial SSB operations.









Also, here the antenna shows an almost perfect match to 50 Ohms with a VSWR of 1:1.10.

I would like to thank Mr. Joachims from ANjO Antennen for adopting my proposed optimization and sending me new elements.

I am always grateful to get feedback and will be happy to answer questions.

Please direct them to the Email address which you will find below.

Best regards

Matthias DD1US

Email: DD1US@AMSAT.ORG Homepage: http://www.dd1us.de

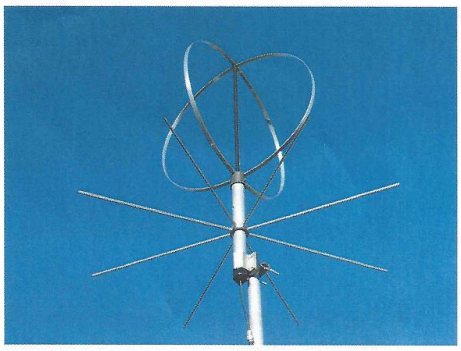
Appendix: Mounting instruction (in German language)

Eggbeater-Antenne für 145MHz

ANjO EGB145RE

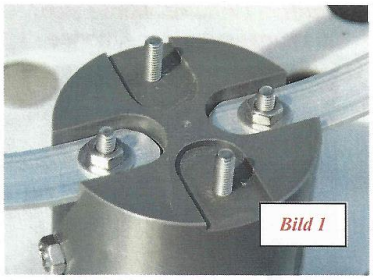
Technische Daten der Antenne:

Frequenz	144 - 146MHz
Länge	1,14m
Gewinn	6,2 dBic
Öffnungswinkel	Horizontal rundstrahlend, vertikal 120°
Polarisation	Rechts Zirkular
Belastbarkeit	100 W CW, 200 W PEP
Anschlüsse	N-female
Masse	2,0 kg
Windlast bei 120km/h	81N
Windlast bei 160km/h	145N
Spannbereich Mastschelle	Variabel von ca. 25 bis 60mm



Montageanleitung:

1. Die beiden ringförmigen Strahlerelemente sind identisch. Durch die Formgebung des Montagesockels haben die beiden um 90° versetzten Ringe einen lichten Abstand von 5mm zueinander.



2. Montieren Sie zuerst einen Ring in den tiefen Aussparungen des Montagesockels.
   Siehe Bild 1

Hiernach den zweiten um 90° versetzten Ring in den flachen Aussparungen des Sockels.
Siehe Bild 2

Die Befestigung erfolgt mit selbstsichernden Muttern unter Zwischenlage von Unterlegscheiben.

Am oberen Kreuzungspunkt der Ringe beträgt der lichte Abstand ebenfalls ca.5mm.
Dies wird durch ein Fixierteil gewährleistet.
Die Steifigkeit der ringförmigen Strahlerelemente wird durch eine isolierte Stütze in Verbindung mit dem Kreuzungspunkt-Fixierteil hergestellt.
Die Stütze stellt eine feste Verbindung zwischen Montagesockel und Kreuzungspunkt der Strahlerelemente her.

ANjO ANTENNEN
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Internet: www.joachims-gmbh.de

3. Montieren Sie die isolierte Stütze indem Sie diese auf den M5 Gewindestutzen des Montagesockels fest aufschrauben *Siehe Bild 3*

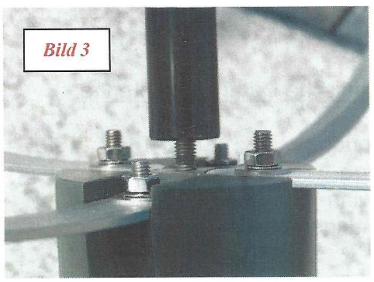


Bild 3


Bild 4

4. Die Stütze wird am Kreuzungspunkt der Strahlerringe mit einem Fixierteil verschraubt. Hierdurch werden die Strahlerringe auch im 90° Winkel zueinander befestigt. *Siehe Bild 4 & 4a*


Bild 4a

5. Verschrauben Sie die acht Reflektorstäbe mit dem zum Lieferumfang gehörenden Sechskanntschlüssel im Reflektorring. *Siehe Bild 5*

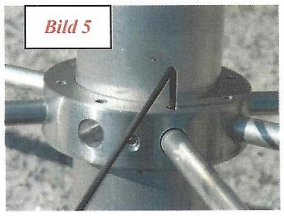
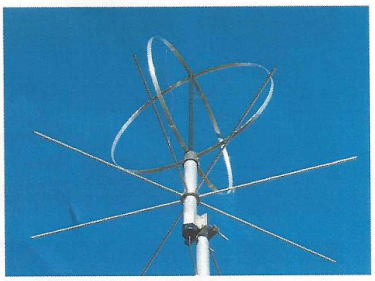


Bild 5

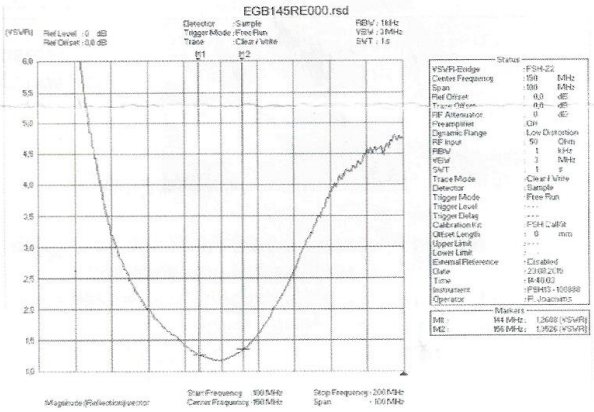
Der Haltering darf nicht verschoben werden. Dadurch würde sich das Strahlungsdiagramm und auch die Anpassung der Antenne verändern



6. Die Antenne wird mit einer speziell angefertigten Parallelklemme aus dem Werkstoff 1.4301 (V2A) am Standrohr oder einem seitlichen Ausleger befestigt.

7. Ein Abgleich ist nicht mehr erforderlich!
Die Antenne wurde sorfälltig mit Network-Analyzer vermessen.

Das folgende Bild zeigt die <u>gemessene 50Ω Anpassung.</u>



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