The VHF / UHF « Eggbeater » Antenna
~ Revisited ~

ON6WG / F5VIF

A new simple way to build the "Eggbeater"Antenna

Introduction

Previous designs described in « VHF / UHF « Eggbeater » Antenna ~ Part 1 » and « VHF / UHF « Eggbeater» Antenna ~ Part 1 – Appendix A » have used an unbalanced coaxial line, or a balanced line, a BALUN transformer and a phasing line section to provide a good match to 50 ohms. The fact is that the design described in « Part 1 » (still widely used because of it's simplicity) is not a proper way to connect the feed line to the antenna and the design described in the « Appendix A» section is a little bit tricky to assemble.
This document introduces a new simpler way to build the « Eggbeater » antenna. It introduces also a technically proper way to construct the « Eggbeater » antenna in order to achieve the best result.

The design

Some parts of the concept have been described in the « Appendix A » section. Therefore for more details please refer to «Appendix A » section. However the main lines are reminded here.
To avoid imbalance in the antenna system, the antenna requires a feed line carrying equal and opposite currents between the two loops. Only a parallel two conductor feed line will give this result. This type of system called « phasing line » is simple to build. So it will be used in this design. The detailed schematic of such a system is presented below in Fig A.

Note about the schematics presented below

For clarity, Fig A and Fig B, presented below show the loops separated, but in reality they are mounted at right angles to each other and one loop is mounted inside the other one.

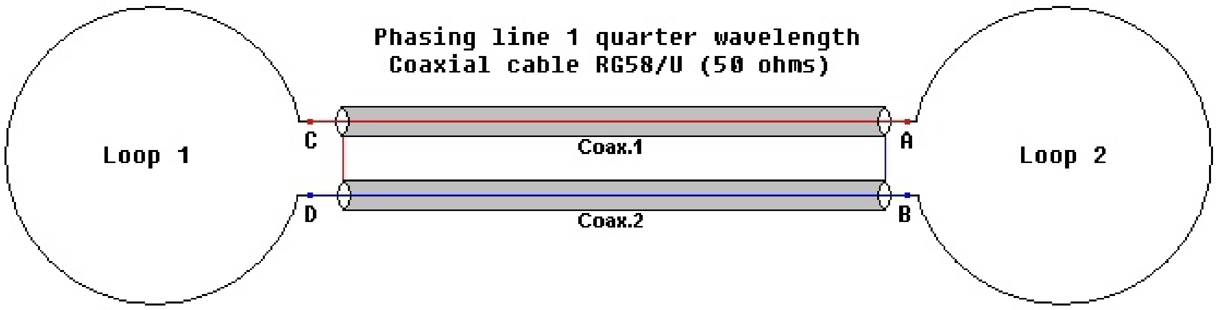

Fig A (Schematic not to scale)

The loops are connected to each other with a line made of two parallel pieces of coaxial cable RG-58. These two pieces of coaxial cable are one quarter wavelength. The braids are soldered together at both end. With this type of connection the impedance of the phasing line is 100 ohms. (*For more details about feeder made with two parallel coaxial cables see note in the "Appendix" on page 9*).
As the loops are connected in parallel, the impedance at points « ***C*** » and « ***D*** » or « ***A*** » and « ***B*** » is 50 ohms.

Phasing line calculation

1) Impedance :
After calculation, the impedance of the phasing line section is 100 ohms.
(Phasing line section formula : $Z0= \sqrt{(Z_L \times Z_I)} \rightarrow \sqrt{(100 \times 100)} \rightarrow \sqrt{10000} = 100\ \Omega$)
Therefore the phasing line section can be constructed with 50 ohm coaxial cable « RG-58 ».

2) Length (VHF Eggbeater) :
[(300 / F(in MHz) / 4] x Vf coax.1 x Vf coax.2 → [(300 / 145) / 4] x 0,4356 = 0,2253 **m**→22,53 **cm**
[(491.8 / F(in MHz) / 2] x Vf coax.1 x Vf coax.2 → [(491.8 / 145) / 2] x 0.4356 = 0,7387 **ft** → 0,7387 x 12 = 8.865 **inches**

N.B : velocity factor (Vf) for coaxial cable RG-58 : 0.66 is a usual value.
In a parallel coaxial line the dielectric is doubled in size and so the velocity factor Vf too.

3) Length (UHF Eggbeater) :
[(300 / F(in MHz) / 4] x Vf coax.1 x Vf coax.2 → [(300 / 435) / 4] x 0,4356 = 0,0751**m** → 7,51 **cm**
[(491.8 / F(in MHz) / 2] x Vf coax.1 x Vf coax.2 → [(491.8 / 435) / 2] x 0.4356 = 0,2462 **ft** → 0,2462 x 12 = 2.95 **inches**

We are now in presence of a balanced load. To avoid current flow over the outside of the coaxial shield of the feeder, and consequently, distortion of the antenna pattern, radiation loss, and elliptical polarization, this system requires a balanced feed for proper operation. Such balanced system comprising a BALUN and a « Q-Section » phasing line is described in the « Appendix A » section.

Nowadays, with the development of new technologies in the field of ferrite materials, replacing a BALUN made of coaxial cable by ferrite round cable cores (sleeves) has become easy.
This will simplify greatly the design of the feeding system.
To achieve the proper feeding system, a 50 ohm coaxial cable is used. Then a choke BALUN is added by slipping ferrite round cable cores over the outside of the coaxial cable and place them as close as possible to the feed point. These ferrite sleeves will stop any cable radiation. The coaxial cable will be connected at points « ***A*** » and « ***B*** » or ***C*** » and « ***D*** ». Such a system is shown below in Fig B.

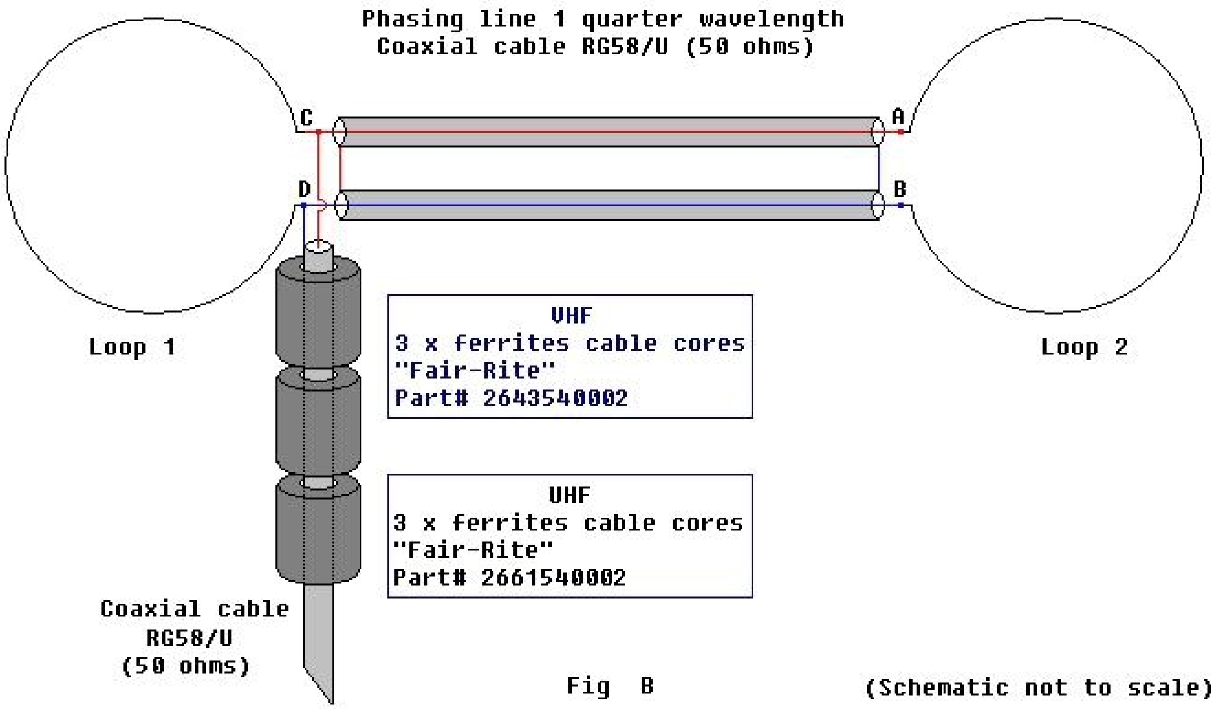

Fig B (Schematic not to scale)

It is beyond the scope of this article to explain how a choke BALUN made with ferrite cores is working. However, documentation on the subject can be found among the references listed at the end of this document. The development of the choke BALUN described here is based on the information found in these articles and in the technical information published by "Fair-Rite" Products Corp. This choke BALUN requires three ferrite cable cores.

Using RG58 coaxial cable to feed the antenna

Ferrite cable cores PN 2643540002 were selected for the VHF antenna design, and ferrite cable cores PN 2661540002 were selected for the UHF antenna design, both from "Fair-Rite" Products.

Using RG213 coaxial cable to feed the antenna

Ferrite cable cores PN 2643102002 can be used in the VHF antenna design and one can use ferrite cable cores PN 2661102002 in the UHF antenna design, both also from "Fair-Rite" Products.

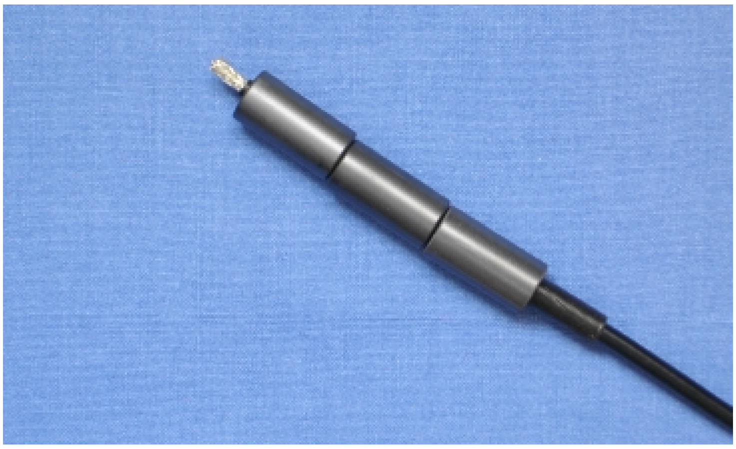

Fig C

Fig C shows three ferrite cable cores PN 2661540002 slipped over a RG-58 coaxial cable. The ferrite cores are fastened close to the open end of the cable. Then the open end of the cable will be connected to the UHF antenna.

Power handling

The power that can be handled by the antenna is limited by the use of ferrite sleeves. With the use of three ferrite sleeves the antenna can handle easily 40 to 50 watts. If more power is needed the temperature of the ferrite cable cores must be verified. The temperature must stay at a low level. If the temperature rises too much, one or more ferrite cable cores must be added. Adding ferrite cable cores will rise the choking impedance and consequently will reduce the common mode current. This common mode current must be reduced to such a level that the choke cannot be overheated and thus lose its properties, damage the ferrite cores or the coaxial cable.

Practical test and results

Tests have been performed on a UHF “Eggbeater” prototype antenna specially build for this purpose (see Fig D). A ground reflector was also added to the antenna. As it is seen in the table below, the antenna equipped with the parallel two conductor phasing line and a feeding system as described above provides an excellent match over the entire UHF band.

UHF 70 cm Band / MHz	430	432	435	436	437	438	440
SWR	1,1	1,1	1,1	1,1	1,1	1,1	1,1

Receiving signals

A test was conducted to compare the prototype antenna with an “Eggbeater” antenna equipped with a simple 90 ohm coaxial phasing line and without ferrite cable cores at the feed point. No significant difference was found between the two signals.

Transmitting signals

A similar test was conducted during a transmission of signals. Here also no significant difference was found between the two transmitted signals.

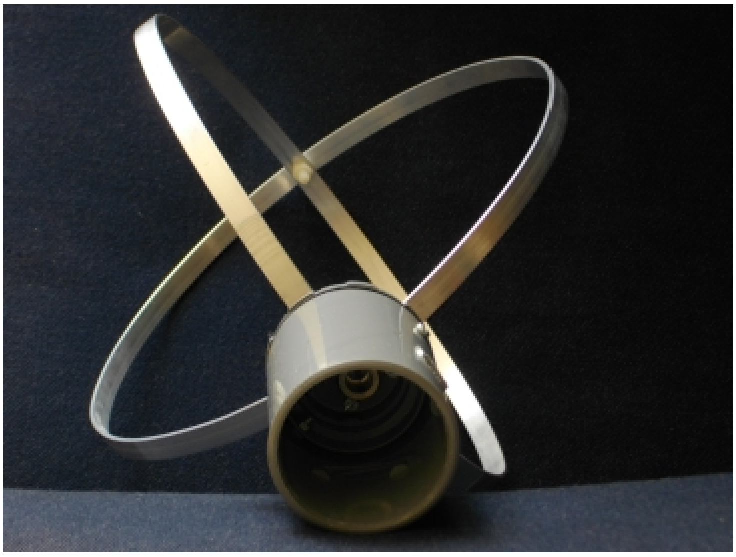

Fig D

Fig D shows the UHF “Eggbeater” antenna used to perform the various tests needed before the release of this article. This prototype is made of flat aluminium rod 10 mm in size.

Circularity test

A successful test of the circularity of the polarization could demonstrate the effectiveness of the ferrite cores and consequently of the entire concept.

This test is somewhat complicated to achieve. The "Eggbeater" antenna is horizontally polarized at low radiation angles and the circular polarization can be seen only if the observer is above the antenna. In addition, a wide open area around the antenna is required to perform reliable measurements.

To determine if the polarization is circular in this very particular case, we simply need to perform a comparative measurement between horizontal and vertical polarization. A relative measurement is sufficient. This relative measurement can be provided by the calibrated S-meter of a receiver. This measurement has to be done above the antenna under test.
However, to show the measurement of circularity in it's full value we need a baseline measurement to be performed on a reference dipole.

Method of measurement

The measurements were performed in the middle of the 70 cm UHF band.
A horizontally polarized dipole is connected to the receiver in charge of making the measurements. It is located above the “Eggbeater” antenna being tested at an almost vertical angle (87 degrees in the vertical plane) and approximately 20 meters in height.
A horizontally polarized reference dipole antenna is placed beside the “Eggbeater” antenna and is connected to a signal generator sending an unmodulated carrier of several milliwatts.

The reference measurement is made between the two horizontally polarized dipoles.
Signal level indicated by the S-meter : S 9 + 5 dB approximately.
The receiving dipole is then placed in vertical polarization.
Signal level indicated by the S-meter : S 5
The difference is nearly five S-points between horizontal and vertical polarization.

The signal generator is then connected to the “Eggbeater” antenna.
The receiving dipole is still placed in vertical polarization.
Signal level indicated by the S-meter : S 9
The receiving dipole is then placed in horizontal polarization.
Signal level indicated by the S-meter : S 9

Circularity test conclusion : The “Eggbeater” antenna is perfectly circularly polarized. It also suggests that the ferrite sleeves fulfil their role properly.

Fig. E

Fig. F

Fig E and Fig F show the reference dipole and “Eggbeater” antenna in place during the test of circularity. The pictures are taken from the position of the dipole receiving the signal sent by the “Eggbeater” antenna.

An additional measurement was also completed at an angle of 45 degrees with regard to the “Eggbeater” antenna (Fig E and Fig F). To make this measurement, the dipole receiving the signal sent by the “Eggbeater” antenna was also tilted at an angle of 45 degrees. The same procedure as above was used to make the measurement and the same results were obtained. This additional measurement confirms the previous conclusion.

An inverse measurement has also been made (the receiver is connected to the “Eggbeater” antenna which is on the ground so it becomes the receiving antenna, the signal generator is connected to the dipole antenna placed above the “Eggbeater” antenna so it becomes the transmitting antenna).
Using the “Eggbeater” antenna as the receiving antenna, it has also been noticed that there is no difference between the level of the vertically polarized signal and the horizontally polarized signal.
This measurement was made at an angle of 45 degrees.

Linearity test n°. 1 : ("Eggbeater" antenna with reflector)

The test performed is intended primarily to highlight the horizontal polarisation of the "Eggbeater" antenna in the horizontal plane.

Method of measurement

To make the reference measurement, a reference dipole is connected to the receiver and is placed near the "Eggbeater" antenna being tested. The "Eggbeater" antenna is used with its reflector.
A horizontally polarized dipole is connected to the signal generator. It is placed at some distance (in this case about 30 meters) from the "Eggbeater" antenna so that the signal received on the S-meter does not exceed S-9.
The three antennas are placed at the same height (about 1.5 meters).
The reference measurement is made between the two horizontally polarized dipoles.
Signal level indicated by the S-meter : S 9
The receiving dipole is then placed in vertical polarization.
Signal level indicated by the S-meter : S 5

The receiver is then connected to the "Eggbeater" antenna and the dipole connected to the signal generator is placed in horizontal polarization.
Signal level indicated by the S-meter : S 8

The dipole connected to the signal generator is then placed in vertical polarization.
Signal level indicated by the S-meter : S 1

Linearity test n°. 2 : ("Eggbeater" antenna without reflector)

Method of measurement

The method used is the same as above. Here is the result.
The measurement is made between the "Eggbeater" antenna and the dipole connected to the signal generator placed in horizontal polarization.
Signal level indicated by the S-meter : S 9
The dipole antenna connected to the signal generator is then placed in vertical polarization.
Signal level indicated by the S-meter : S 1

By removing the reflector the pattern diagram of the "Eggbeater" antenna is modified, and the angle of departure of the wave is lowered. Consequently, the signal coming from the signal generator is now stronger compared to the linearity test n° 1 ("Eggbeater" antenna with reflector).

Linearity test conclusion The polarization is perfectly linear and horizontal in the horizontal plane.

Remark : The level (S-1) of the vertically polarized signal received on the "Eggbeater" antenna is practically non-existent compared to the same signal recorded on the horizontal reference dipole (S-5). The rotating horizontal polarization is therefore much more effective.

During the different phases of the test, it was found that the signals received on the reference dipole were subject to fluctuations due to parasitic reflections. Such fluctuations are completely absent on the signals received by the "Eggbeater" antenna, making them particularly stable.

Figure G shows the antennas used during this experiment. The dipole on the left is connected to the UHF signal generator. The dipole on the right of the picture is the reference dipole.

Fig G

The "Eggbeater" antenna and terrestrial propagation

The "Eggbeater" antenna will give very good results for contacts from valley to the top of mountains. It can be useful also to use this antenna for terrestrial communications when contacts are possible only by reflection on cliffs, walls, or objects more or less distant from the station.
In other cases, the pattern diagram of the "Eggbeater" antenna is of no interest for terrestrial use. Direct ground wave communication can be used of course but without much performance. In this case the reflector must be removed, resulting in a flattening of the radiation pattern and lowering of the departure angle of the wave (see result of the "Linearity test n° 2) however at the expense of the gain.

Conclusion

The replacement of the 90 ohm phasing line section by a parallel two conductor low loss phasing system, an excellent match over the entire band, the use of ferrite cores to prevent pattern distortion and radiation loss, a "one lobe omni-directional (balloon like)" field pattern preventing fading and favouring high angles with a gain of 6 dB, a circular polarization, make this antenna in its class a top choice for **L**ow **E**arth **O**rbit satellite communications.

Appendix

Shielded parallel lines (based on an information written by † Etienne Isaac ex-ON4KCX)

Use of two coaxial cables set against one another. The braids are connected together at the ends. On the side of the transmitter, the mutual braids are connected or not connected to the ground.

Features

- The impedance is doubled compared to a single coaxial line.
- The dielectric is doubled in size.
- The capacity between the central conductors is divided by two.
- The signal attenuation is divided by 1.4 (in dB) in comparison with a single coaxial cable.
- No radiation during transmission and no noise or static interference during reception of signals.
- The installation requires no special precautions.
- The radius of curvature can be in the order of 1.2 to 2 inches.

Fastening the two coaxial cables together

- By linking them with tarred twine.
- With nylon cable ties.
- With adhesive tape (not very reliable in the rain or in the sun).

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Bibliography

The following works were useful to elaborate this "Eggbeater" antenna design.
Click on the blue link to reach the article or the document.

A Ham's Guide to RFI, Ferrites, Baluns, and Audio Interfacing by Jim Brown K9YC :
Link : http://www.audiosystemsgroup.com/RFI-Ham.pdf

Common-Mode Chokes by Chuck Counselman, W1HIS :
Link : https://remoteqth.com/img/ZAW-WIKI/cmcc/CommonModeChokesW1HIS.pdf

Balun and Transformer Core Selection by W8JI :
Link : http://www.w8ji.com/core selection.htm

How to Choose Ferrite Components for EMI Suppression. Fair-Rite Products Corp.
Link : https://www.fair-rite.com/wp-content/uploads/2015/08/CUP-Paper.pdf

Baluns and Ferrites Presentation Jacques Audet VE2AZX
Link : http://ve2azx.net/technical/BALUNS2023.pdf

Ferrite cores technical informations

Fair-Rite Products Corp.
Link : https://fair-rite.com/

Where to order ferrite cores ?

Ferrite cores are available from Mouser Electronics,Inc.
Link and at first choose your country: https://eu.mouser.com/

Ferrite cores part number list : memo

RG 58 Coaxial cable :	VHF :	Fair-Rite PN 2643540002	=	Mouser 623- 2643540002
	UHF :	Fair-Rite PN 2661540002	=	Mouser 623- 2661540002
RG 213 Coaxial cable :	VHF :	Fair-Rite PN 2643102002	=	Mouser 623- 2643102002
	UHF :	Fair-Rite PN 2661102002	=	Mouser 623- 2661102002

Pictures and schematics : by the author ON6WG / F5VIF

French translation of this article / Traduction française de cet article :

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