Antennas

G3LDO looks at the Gamma Match, and discusses practical examples.

The driven element feed impedance of a multi-element Yagi is usually much lower than that of the coax feed, so some method of matching is required. My favourite beam antenna-to-coax feeder matching method is the gamma match. This is an unbalanced feed system and is well suited to plumber's delight construction, where all the metal parts are electrically and mechanically connected to the boom. The gamma match is popular for amateur arrays, particularly home-made arrangements. However, it is not popular with everyone. G6XN noted in [1] that a large increase in SWR bandwidth can be obtained by going from a gamma match to a balanced system. He went on to say that although no guidelines were available "…the author can do no more than invite the reader to share his misgivings about gamma matches".

I have also read (although not able to find a reference at the time of writing) that the asymmetrical feed causes some distortion of the polar diagram pattern. Perhaps some experimental work is in order. First of all, how does the gamma match work?

As you are aware, the impedance of a half-wave element is low at the centre and increases with distance from the centre. The gamma match comprises a short conductor, which is used to connect the centre of the coax to the correct impedance point along the antenna element. This short conductor has some inductive reactance, which is cancelled by installing a series capacitor, as shown in **Fig 1**.

Because of the many variable factors – driven-element length and diameter, gamma rod length and diameter, spacing between rod and driven element, and value of series capacitors – a number of combinations can provide the desired match. This, in turn, has given the gamma match a bad press regarding ease of adjustment and has resulted in the publication of some convoluted mathematical models and programs.

Taking the variables described above, the following should be considered:

- The feed impedance increases as the gamma rod is made longer and the connection to the element is moved away from the centre.
- The length of the gamma rod can be reduced for a given impedance match as the ratio of antenna element diameter to gamma rod diameter is increased.
- Gamma match adjustment is easier if the element is close to resonance.

It follows that the adjustment is much easier if some method of measuring impedance is to hand. For some years now, the instrument of choice has been the noise bridge. The adjustment has, ideally, to be made with the antenna *in situ*. While noise bridges are small, they require a receiver to detect the null. This problem has been overcome in the past using the receiver in the shack. The noise bridge can be connected to the antenna via the gamma match and the receiver is connected to the noise bridge via the antenna coax feed. The receiver speaker output is fed to the antenna adjustment point via a couple of disconnected leads from the rotator to a small speaker carried aloft for the purpose of listening to the noise null. These days you could use the diminutive FT-817 as a null detector.

There are also these nice little active SWR/impedance meters such as the MFJ-259/269 and the RX Vector Analyst models from Autek Research that make these sorts of measurement much easier.

Most publications recommend that the gamma rod is made from a thin metal tube, the diameter of which is $^1/_3$ to $^1/_6$ of the antenna element diameter. However, it is worth trying what is to hand and it is interesting to see just what you can get away with. For example, the arrangement shown in **Photo 1** uses 14SWG hard-drawn copper wire as the gamma rod to match a 50MHz two-element beam. The connection from the gamma rod to the antenna element is achieved using a hose clamp, which makes it very easy to adjust.

I also made a gamma match for a reference 144MHz dipole, see **Photo 2**, to be used in a series of comparative field strength measurements. The element was made from 14SWG hard-drawn copper wire (my favourite material for making VHF and UHF antennas). In this case, the gamma rod was the same diameter as the element, and a concentric trimmer capacitor was used for gamma rod reactance correction. No difficulties were experienced in obtaining a good match as shown on the MFJ-269 readings in Photo 2.

The traditional method of reactance correction is to use an air-spaced variable capacitor and enclose it in a weatherproof metal box. No matter how weatherproof you make the box,

FIG 1 © RADCOM 584

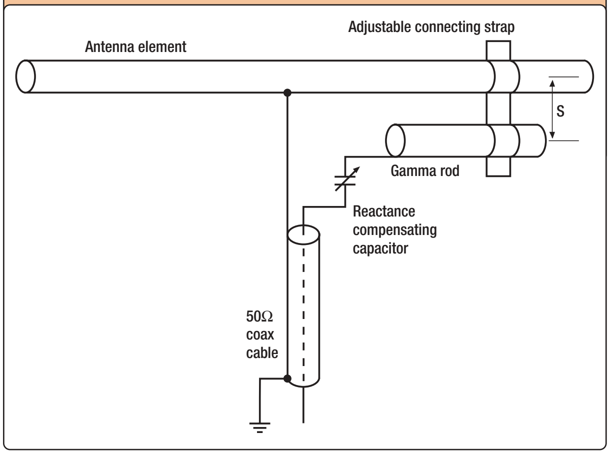

Fig 1
Diagram of the gamma match. With this arrangement, the centre of the driven element does not require an insulator and can be connected directly to a metal boom (plumbers delight construction).

PHOTO 1

Photo 1
Gamma match on a 50MHz two-element beam using 14SWG copper wire as the gamma rod. Gamma rod reactance is cancelled with a Philips variable trimmer capacitor. Note the low SWR reading on the MFJ.

PHOTO 2

Photo 2
144MHz dipole constructed from 14SWG copper wire and using a gamma rod of the same material. The centre of the dipole element is soldered to the copper tube mast. A concentric ('beehive') trimmer capacitor is used for gamma rod reactance correction.

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FIG 2 © RADCOM 000

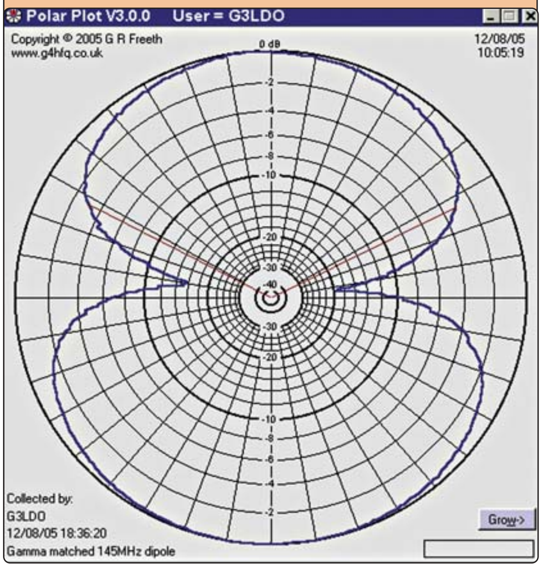

FIG 3 © RADCOM 000

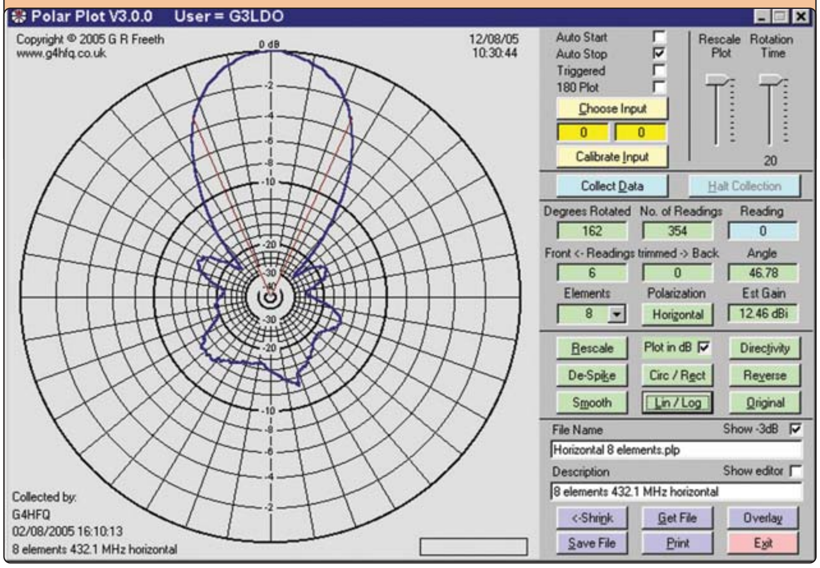

Fig 2: Polar diagram of the 144MHz dipole antenna shown in Photo 2.

Fig 3: Polar diagram of a multi-element 430MHz Yagi antenna constructed by G4HFQ, using the half-folded dipole driven element described in the text

corrosion to the capacitor can still occur because of condensation. This problem can be overcome by using a fixed capacitor whose value is determined by experiment with a variable capacitor. The value of the variable capacitor is then measured and a silver mica (or similar) fixed capacitor (or several series/parallel combinations) substituted. This arrangement will handle 100W without breakdown and only requires a smear of grease to achieve weatherproofing.

All experimental evidence so far has not found that the gamma match causes a reduction of SWR bandwidth compared with other feed methods. SWR bandwidth becomes rather narrow when the element is part of a close-spaced Yagi. SWR bandwidth can be increased by using a larger diameter element.

POLAR DIAGRAM SYMMETRY.

In the November 2002 'Antennas', I described a method of plotting a polar diagram of an antenna using a computer and a program called *PolarPlot*, [2] written by Bob Freeth, G4HFQ.

The purpose of this program is to plot the polar diagram of a beam antenna using a signal source, such as a signal generator or QRP transmitter. The variation in signal strength as the antenna is rotated is measured and plotted using a receiver and a computer, using the *PolarPlot* program.

The volume of a beat note, in the SSB or CW mode of a plain un-modulated carrier has good correlation with the RF input level, provided the receiver is operated in a linear manner. The audio output of the receiver is then connected to the line-in socket of the computer's sound card.

In an ideal world measurement of antennas is undertaken using an antenna range, suitably equipped with a full set of laboratory test equipment. For the amateur, though, a more restricted set of equipment must suffice, as described below.

This seemed like a good method of checking to see if the gamma match introduces any asymmetry into a polar diagram. The 2m gamma-matched dipole, shown in Photo 2, was used as the Antenna Under Test (AUT) and energised using a Marconi TF2019A signal generator. The signal was monitored on another dipole located some four wave- lengths distance from the AUT, which in turn was connected to a FT-817.

The result of the plot is shown in **Fig 2**, and shows a degree a symmetry that would be expected using a conventionally-fed dipole.

G4HFQ, aided and abetted by G2HCG, has been experimenting with 430MHz Yagis using what can be best described as a half-folded dipole driven element. The type of feed was described by MW0OPS in [3], based on [4], in a design for a portable 2m VHF Yagi. This rather clever design, which uses a plastic tube as both the boom and element-carrying container, has the most lopsided feed arrangement I have yet to see. However, the polar diagram, shown in **Fig 3**, appears to be as good as any using other feed arrangements.

MORE ABOUT *PolarPlot*

PolarPlot runs on a standard PC that has sound recording capability with a line-in or microphone socket. It has been tested on all flavours of *Windows* running on desktop machines and laptops.

It is now available to radio amateurs free of charge from G4HFQ's website [2].

The *PolarPlot* relies upon the linearity of the receiving audio system for accuracy of plot and the measurement of gain. Whilst the linearity of the average sound card is generally quite good, the linearity of the receiver depends on how it is operated. At a minimum, the receiver must be capable of controlling the RF gain to such an extent as to be able to negate the operation of AGC.

If you can turn AGC off as well as control the RF gain then this is ideal. The AGC on the FT-817 receiver, used as described above, has several settings for the AGC; one of these is OFF. However the 'S' meter bar still works so I am not convinced that the AGC has been switched out. The RF control is very non-linear; however, with a bit of fiddling the receiver could be made to work in a linear manner.

If the sound card's linearity begins to degrade as the peak input level capability is approached (due to overload protection circuitry) the program can be instructed to treat a lower value on the linear part of the curve as peak input.

To measure the transmitting station's polar diagram, the receiving station's antenna remains stationary and the transmitting station's antenna rotates. To measure the receiving station's polar diagram the transmitting station's antenna remains stationary and the receiving station's antenna rotates. The control panel shown in Fig 3 gives some idea of the range of signal processing and scaling arrangements in the program. ♦

REFERENCES

[1] *HF Antennas for all Locations*, L A Moxon, G6XN.
[2] www.g4hfq.co.uk
[3] 'Antennas', *RadCom*, March 2005
[4] www.clarc.org/Articles/uhf.htm