COAXIAL GAIN ANTENNAS

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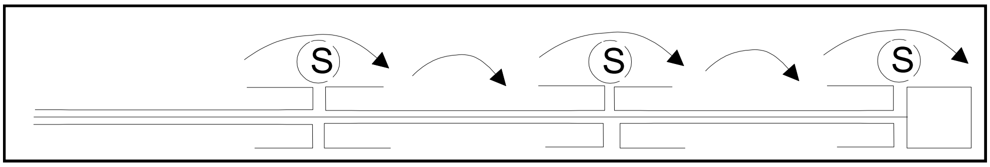
Great for bandwidth, but poorly understood. This should assist your understanding.

End Fed Coaxial Dipoles

The author has heard discussions asserting that the end fed skirted coaxial gain antenna could never make a decent antenna, because most of the power went to the bottom element. Whilst could be a factor if the slot excitation is uneven, industry sells these designs widely, and patterns show a true symmetry with close to theoretical gain. Practical difficulties with these designs arises more from phasing, matching, and mutual interaction of the elements in a poor design

We should view the inter-element gaps as slots presenting an impedance in series with the characteristic impedance of the transmission line, exciting the elements.



Above:- Sketch illustrates element excitation. The final dipole could be considered the load, or line termination, whilst the other dipoles are fed by annular slots in the transmission line. The author's experience is that tip design also has an enormous effect on impedances to me matched, as does slot width

More slots also reflect in a higher feed point impedance, needing greater transformations with attendant bandwidth reduction.

A genuine difficulty with this antenna arises where broadband use is required. As frequency changes, the phasing shows a progressive change as we move up the antenna, introducing beam tilt and pattern degradation as we move away from center frequency. A typical six section dipole of this construction built for 905 HZ, showed seven degrees of tilt variation from 890 to 915 mHZ. Broader dipole sections is the traditional way to increase bandwidth, but this may give rise to changes responses to the feed at each annular slot

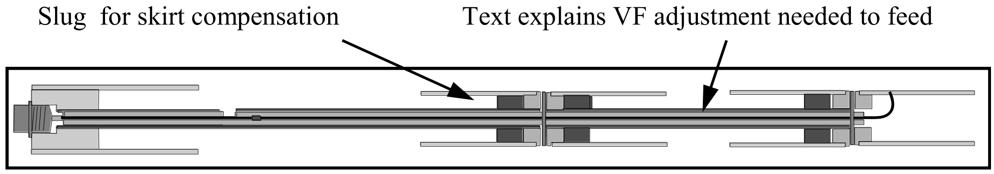
Decoupling and Phasing in Skirted Dipole Antennas

When building skirted dipoles, it is essential that the design minimizes extraneous currents on the line between elements. This is done by the inside of the dipole element acting as a quarter-wave decoupling choke. Many constructors fail to implement this correctly. The element build length is shortened by the appropriate 'K' factor so that the outer, radiating portion, is the correct resonant length. However, this leaves the inner section too short to provide the correct choke dimension, and is made worse by the extra length taken up by the end boss. King, in ‘Transmission Lines and Antennas’ makes it very clear that the inside of these elements requires a dielectric slug to effectively lengthen this short section to make it resonant. A spreadsheet is provided to help calculate the slug lengths in RF3.XLS, spreadsheet #12. You need to enter ‘e’, or dielectric constant of your slug material, and your dipole build dimensions. Calculation of ‘K’ factor is available per several equations in RF3.XLS, spreadsheet #11 (Download from the ‘(Unofficial) NEC Archives’, www.qsl.net/wb6tpu/swindex.html)

Because of end effects, some experimentation will be needed to obtain a correct shortening factor, which will likely be smaller than traditional tables would indicate. This is because the quarter wave coaxial transmission line section created by inner of outer skirt and outer of feed line does not function ’classically’ with the large length-to-diameter ratios possible in most antenna constructions. A further complication arises because this interior length is also subject to a shortening factor, usually 0.95 to 0.98.

King clearly states that all radiating and decoupling elements must be adjusted individually because of mutual interaction.

In these designs it is essential that the inter slot spacing is required to be 0.7 wavelength to keep the side lobes 15-20 dB below the main lobe (Jasik, ‘Antenna Engineering Handbook’, 1st ed., 22.8). To keep the phasing correct, the slots are one wavelength apart This phasing is achieved by using air section line with dielectric slugs, or a 0.66 VF line with some dielectric removed.



Above:- Typical skirted dipole design, showing slug placement. If dielectric of center conductor is not 0.7 to ensure phasing is correct with 0.7 wavelength gap spacing, we have to make it effectively so!

A core of RG 58 low loss cable of VF 0.78 was fed through 3/16” brass tubing to provide the inner feed to a 2.45 GHz, three dipole, version. With a 101 mm gap-to-gap dimension, 3 deg. of up tilt was measured. At 98 mm the antenna had –2 deg. of down tilt, and this moved to –6 deg. at 95 mm. This should indicate the need to establish the effective VF of your core-in-tube section before you build.

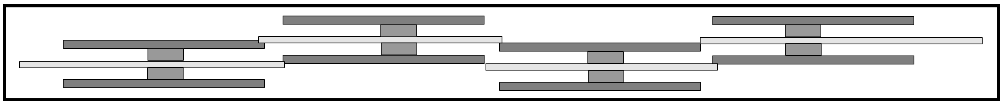
The final (tip) section can be simply an extension of the core, or a dipole section as shown above, or a sleeve on the core with the inner cable connected partway along the section.

Both tip treatment and element gap has enormous effect on the impedances to be matched and often takes the most work to get right. A five element 477 MHz design with 32 mm diam dipole skirts and a 10 mm diam aluminum tube final quarter wave section was built. Taking the first inter dipole gap as the reference point for matching, the impedance changed from 98—26j to 176 –107j when the gaps were increased from 1 mm to 3 mm. When the tubing tip was slipped off the core on the 3mm gap model, impedance changed from 176 -107j to 212 + 43j

Crossed Cable Section Antennas

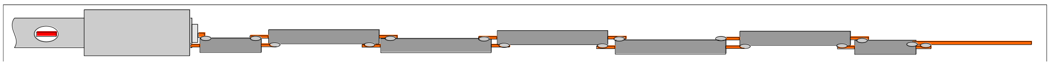
When building crossed cable section antennas, whether of air or dielectric type, the need to keep the elements phased correctly is critical.

With air section types we have a problem because the feed slots need to be 0.5 wavelength apart to produce correct phasing, but the radiating outer sections will be shortened to less than 0.5 wavelength by our 'K' factor. To keep our phasing we must calculate and include dielectric slugs as mentioned above. Worksheet 4 in RF3.XLS will calculate these for you.



Above:- The popular 'crossed cable' gives classic patterns when phased correctly. This is the popular air section version, with VF compensation by internal slugs.

End effects may mean your calculations are not entirely accurate. Where these antennas are made of crossed half wave sections of coaxial cable, we are in more difficulty, as we have no means of making any such phasing adjustment once we have cut our sections.



Above:- Crossed cable vertical colinears can give excellent patterns where phasing is correct. Always place a decoupling sleeve on the line to avoid line currents and consequent variation of match.

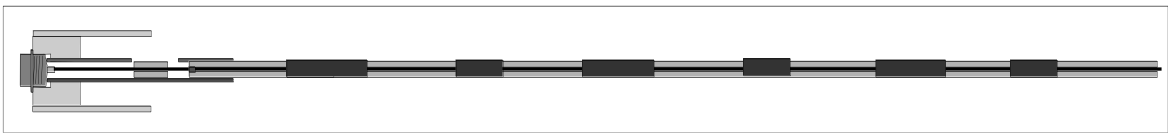
On the antenna range correctly built antennas of this type can show symmetrical patterns, so we must seek an explanation. I suggest that the presence of the outer jacket on the cable sections gives the outer a 'K' factor giving an equivalent shortening closer to the velocity factor of the normal cable operation, retaining phase.

A 3.8 metre section of RG59 had inner to outer shorted at both ends. It was suspended one metre above ground and 'dipped' at 29.02 MHz. This indicated a VF of 0.74, which was close to the 0.78 VF of the cable in its normal mode of operation as a transmission line. Where you cannot get a close match between cable VF and effective VF of radiating portions, you will get the best possible result by cutting the sections so that the electrical phasing at feed gaps is correct.

A Touch of Foil

The 'foil on core' form of antenna is widely sold and still not well understood. Simply, the feed extends only as the inner core of RG-213 cable. Elements of tubing or foil are attached at appropriate spacings. Good patterns and 6 dB are easy to obtain. Plenty of variations on the theme are evident in industrial offerings, some with complex variations of element and spacing length.

After building investigating over 40 of these designs, it appears that optimum gain occurs with some down-tilt, and as we pass through the 'flat pattern' point, side lobes are becoming a problem. This design clearly has unequal feed, with more power being radiated



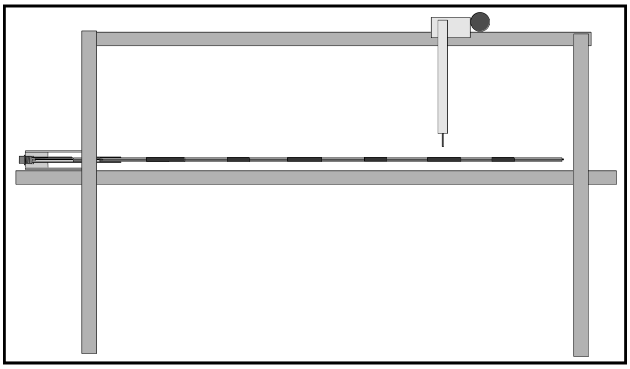
Above. A typical example of the 'foil on core' design. This example incorporates a transmission line transformer for matching.

by the

earlier sections, and no amount of fiddling can change it. However if 3 deg. of down tilt does not deter you, these antennas are easy and cheap to build.

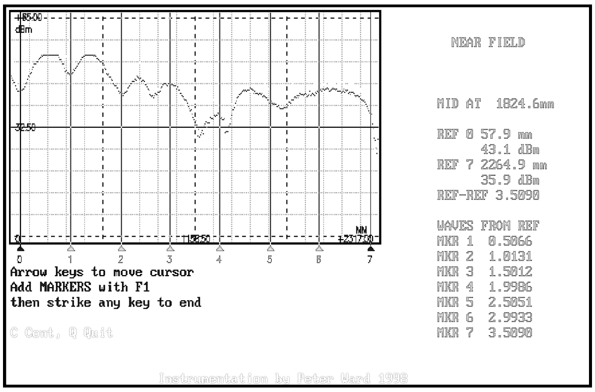
Phasing is the key to getting a good pattern in these designs, and a lot of time is saved if an indication of phasing is available prior to all the work involved in assembly and range testing.. The author uses a wooden track, 1.2 m above the floor, with a moveable near-field probe running on a wooden track above the antenna. By using a ten-turn pot., with a rubberised wheel attached on the probe carriage, the voltage from the pot. gives position, and the probe gives signal strength as the antenna is traversed.

Right:- The simple wooden frame uses a cupped cornice moulding to hold the antenna. Probe, associated wires and operator presence all influence the field, but it gives a clear indication of phasing.



The theoretical curves for current and voltage distribution on a dipole antenna are well known. The voltage probe will actually produce a trace as per the solid line above, which is a reproduction of a trace over a dipole made of two telescoping ‘rabbit ear’ antennas, fed via ferrite balun.

In particular the voltage sign is not relevant to our RSSI detector, and all voltages are displayed as a positive excursion. The end effects are also clearly evident. The consequences are that when using our probe, we have to use care to look for symmetry over the elements, and not assume where element end actually ‘has’ to be.



Left:- The near field probe is supported by software that inserts cursors where desired, in this case corresponding to the ends of the elements. The recorded strength of the field from the traverse is then plotted, and it is quickly seen whether phasing is correct.

To help the analysis, as the cursors are moved, their distance in wavelengths from a reference point is shown.

The plot above shows a ‘disaster’, and detecting it at this stage saves enormous amounts of work. It also shows the voltage distribution is not even in these designs. Surprisingly, with care, an almost even distribution is obtainable, and in this author’s experience, appears to coincide with several degrees of down tilt.

Getting Maximum Dipole Bandwidth

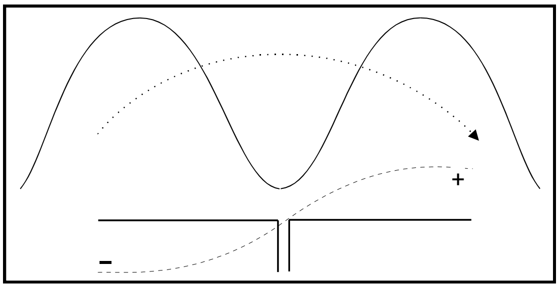
The impedance bandwidth of fat monopoles was explored by Formato, and an interesting article published in Dec 1994 ‘Electronics and Wireless World’, titled ‘Maximising Monopole Bandwidth’. Whilst I have not done any confirming work on dipoles, there will be a close association of results. Formato summarizes the monopole impedance bandwidth performance, using a 2.5:1 VSWR reference, as follows:-

Maximum monopole bandwidth occurs when the ratio of monopole length to diameter is five.

Maximum bandwidth is about 50% of the frequency at which the monopole is a quarter-wave long

Frequency of minimum VSWR is about 1.3% less than the quarter-wave frequency.

Approximately two thirds of the bandwidth is above the quarter-wave frequency, and about one third below.



Right:- Resolving theory and practice often requires care.
Dashed line, current distribution on a dipole antenna
Dotted line, voltage distribution.
Solid line, voltage distribution as measured by probe.