Antenna Radiation Pattern Synthesis

Many computer generated antenna patterns are modelled using the theoretical dipole patterns Cos^2. Unfortunately this does not represent the patterns produced by most practical antennas. In broadcasting applications the usual radiating element is a dipole mounted in front of a screen, this element is then mounted on a mast or tower with typically three or four panels around the structure.

At Alan Dick Broadcast we measure the patterns of all our antenna products on our outdoor Test Range. We use this test data to generate a primary pattern for the particular panel. In some cases a whole series of primary patterns are generated at different frequencies, for example in the FM band only three frequencies are measured, whilst at UHF measurements are made at intervals of 40MHz. In addition the primaries may be available at different Radii with or without full corner screens which is the case at UHF with our broadband Panel.

When a customer issues a specification for a particular antenna array pattern we model the complete array using the primary patterns described above.

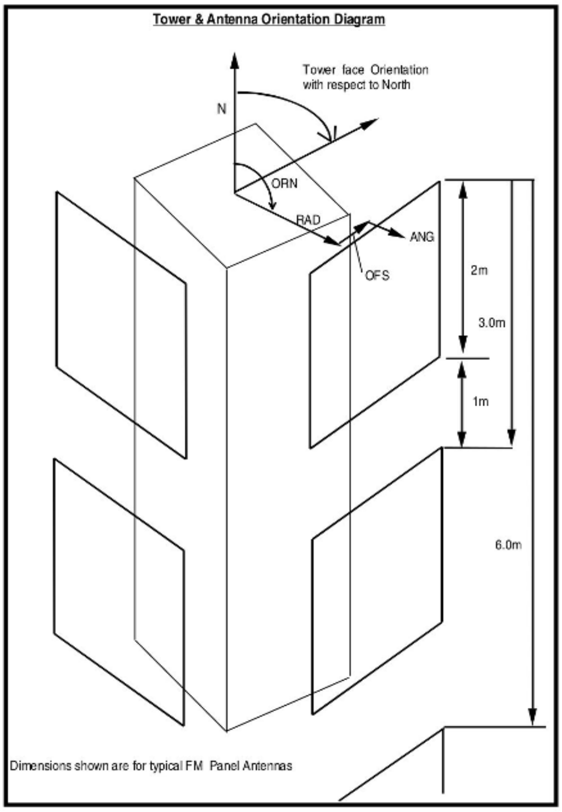
We select the most suitable antenna panel based upon the following criteria :

Frequency Band - Band I, Band II Band III, and Band IV/V

Polarisation - Horizontal, Vertical and Mixed/Circular

Panel Beamwidth - 90° or 120°

The first two are self evident. In the third case we have designed two types of panel, those whose beamwidth is such that when mounted in a square (or triangular) arrangement the pattern produced is omnidirectional. We refer to these as V - 90 (Square) or V -120 (Triangular), V for vertical, 90° or 120° for beamwidth. They may also be prefixed by H for Horizontal. In the Circular polarisation case we refer to Spearhead panels (120° beamwidth) and Crossbow 90° beamwidth.



To accurately model a complete antenna array as mounted on the final structure the accurate dimensions of the structure are vitally important. Small changes in the positioning can have a significant effect on the resulting Horizontal Radiation Pattern (HRP). The individual panel positioning information is entered using R angle θ format. The HRP input data form is shown below. RAD stands for Radius, ORN is Orientation, OFS is Offset, ANG Angle, PHS Phase, and HTP is the number of the pattern data of the relevant antenna Panel. All angles are measured in degrees relative to north, and generally measurements are in millimeters.

HRPn Array Data

File Edit Data Help

No. of ELM	Frequency	Dimensions
4	600	mm

ELM	RAD	ORN	OFS	ANG	AMP	PHS	HTP
1	430	0	0	0	1	0	474
2	430	90	0	90	1	0	474
3	430	180	0	180	1	0	474
4	430	270	0	270	1	0	474

Alan Dick Broadcast Ltd Tel: +0044 1242 820972 Email: sales@alandickbroadcast.com www.alandickbroadcast.com

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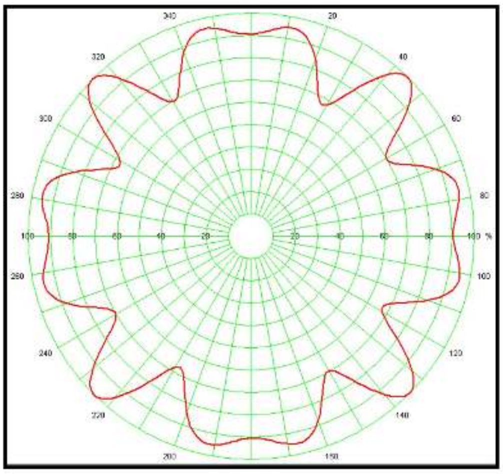
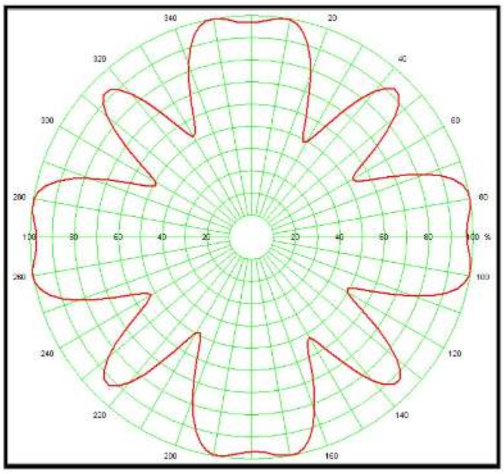
In addition the panel may be laterally offset, or fired at a differing angle to the Radius angle. Having computed the optimum pattern to meet the specification a check must be carried out to ensure that it is physically possible to position the panels on the structure. It is often the case that the calculation must be repeated as one panel may conflict with another adjacent panel on a corner.

Effect of Panel Radius

Where the specification calls for a good omnidirectional HRP, say within +/-1.5dB the radius of the panel is the one controlling factor. In many cases the designer is constrained by an existing structure which was designed for some other application and is too large. At UHF we typically use radii of 350mm. This is a compromise between accessibility to the components inside the structure and the need for a good HRP. The diagrams below show the effect of increasing radius on the pattern @ 600MHz



Panel radius 430mm



Panel radius 550mm

Impedance compensation

It is increasingly common for antennas to be designed for broadband applications, where several services use an antenna. Typically 4 channels are used at UHF, but in the FM band seven channels has become common in the UK. This calls for careful design of the phase arrangement feeding the panels. It is common to offset the panels laterally and compensate by feeding the panels in phase quadrature (0,90,180,270). The phase delay is achieved by increasing cable lengths. Unfortunately the relative length of the phasing cables will vary with frequency. This causes the pattern to deteriorate from optimum at the band edges. This can be overcome by inverting physically the 180 panel and feeding it at 0 degrees, also 3dB hybrids can be used to provide the 90 degree phase shift.

HRPn Array Data

File Edit Data Help

No. of ELM	Frequency	Dimensions
4	600	mm

ELM	RAD	ORN	OFS	ANG	AMP	PHS	HTP
1	430	0	80	0	1	0	474
2	430	90	80	90	1	90	474
3	430	180	80	180	-1	0	474
4	430	270	80	270	-1	90	474

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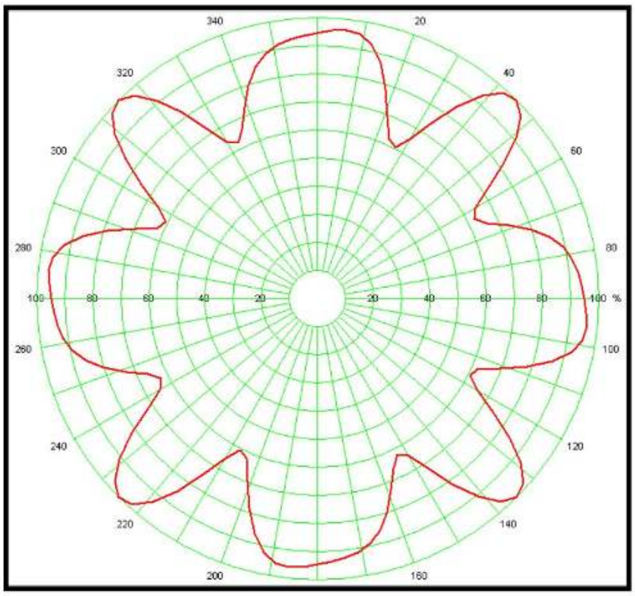
Conclusion

It can be seen from the above that modelling the antenna array using computer techniques can greatly reduce testing time. In many instances it is unnecessary to test the Horizontal radiation pattern as the results can be readily predicted using the measured primaries. Where a highly unusual (or directional) pattern is required it may be necessary to measure a representative sample of the array to confirm the pattern. The effect of making changes can be readily investigated without moving the hardware.



Implementation

When it finally comes to realising the computers design into a practical antenna great detail is required. It is important that the detailed mechanical drawings of the support structure are available. Sometimes we are advised that the structure is say 6ft square, when we get to site we may discover that some of the bracings are mounted outside the 6 ft square, this will increase the radius by 2 ½" and a consequent deterioration in the HRP circularity. At UHF a typical square spine of 640mm can be completely unusable with outside bracings or large bolts pointing out. We use an all welded section with no protrusions inside or outside. In addition a special small non standard ladder section is incorporated inside the spine section. In another case the vertical distance between repeats of the diagonal bracing pattern may not match the antenna panel spacing. This will require the mounting arrangement to differ for each panel, adding to both the design time and manufacturing cost. Another reason for this problem is mounting panels on a tapering tower.