Newsletter 4.4

July 2013

Antenna Magus version 4.4 released!

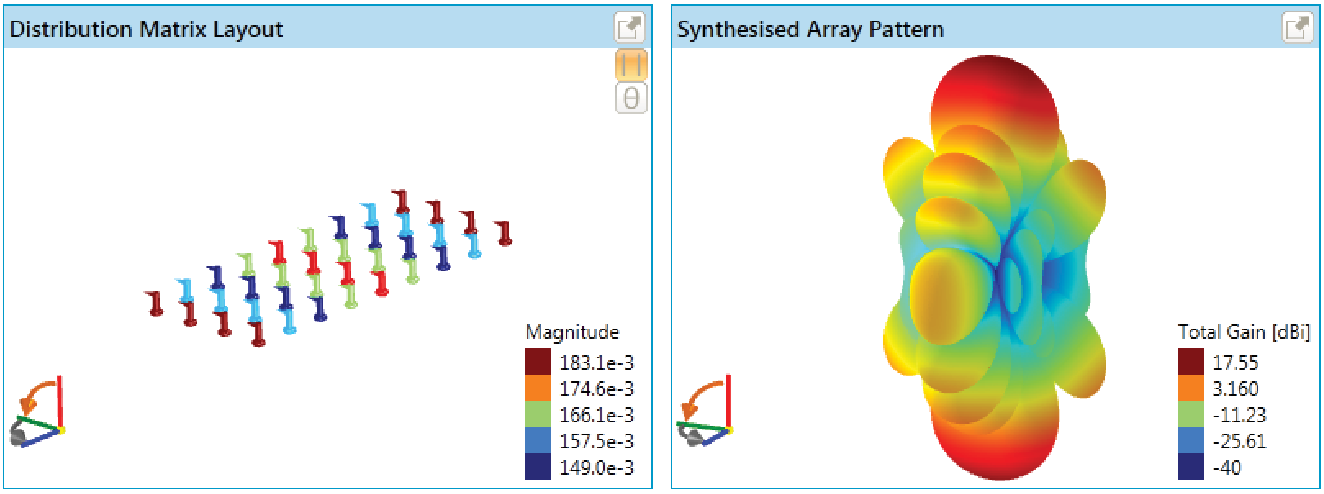
We are pleased to announce the new release of Antenna Magus Version 4.4. This release sees the addition of 5 new antennas:

- Horn-fed truncated reflector antenna
- Shunt-fed slanted V-dipole pair
- Offset Pattern-fed Cassegrain reflector antenna
- Monopole dielectric resonator antenna
- Bifilar helix antenna

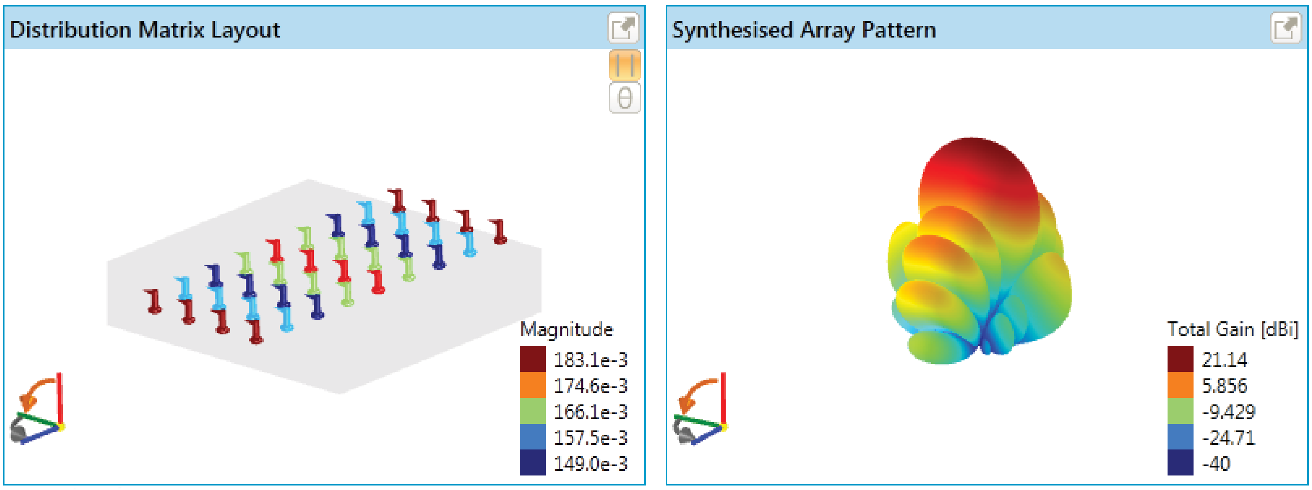
The array synthesis tool has also been extended to include the effects of a reflective ground plane when calculating the radiation pattern of a synthesized array.

Array synthesis reflective ground plane addition

A new addition to the array synthesis tool is the option of including the effect of a reflective ground in the radiation pattern calculation. This feature is especially useful where measured or simulated single-element pattern data is available, while the elements will be operating over a large ground plane or close to a large conducting structure in the array environment. The pattern data can be imported and positioned a certain distance away from a reflective ground plane and the resultant radiation pattern synthesised within a few seconds. Below is an example of a 4 x 9 planar dipole array showing the layout and synthesised radiation patterns including and excluding a reflective ground plane.



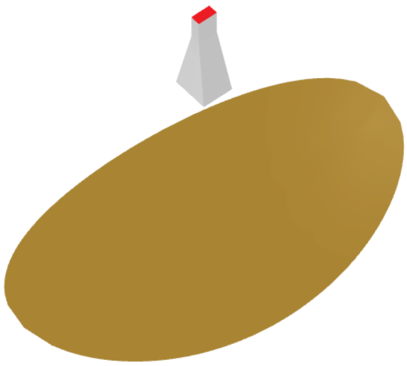
Planar 4 x 9 array synthesis example excluding the reflective ground plane.

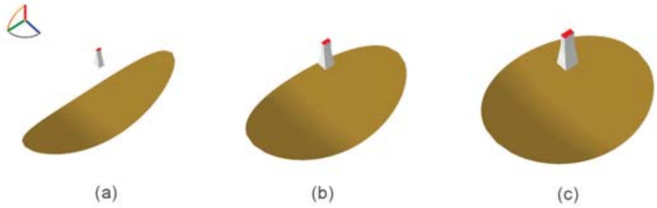


Planar 4 x 9 array synthesis example including a reflective ground plane at z = - 0.25 λ.

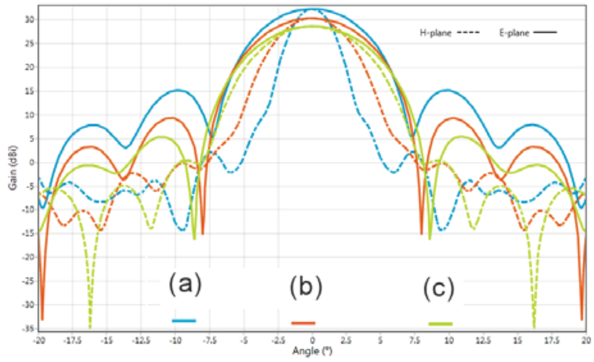
New antennas in Version 4.4

Truncated reflector





Comparing three 3 dB H-plane beamwidth designs: (a) 2°, (b) 3.5° and (c) 5°.

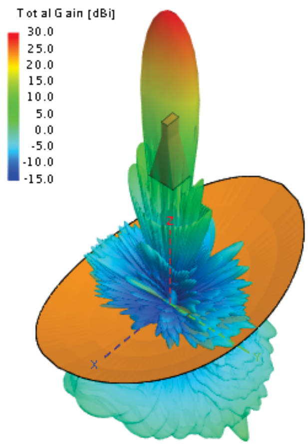


Zoomed pattern cuts for three 3 dB H-plane beamwidth designs: (a) 2°, (b) 3.5° and (c) 5°.

Truncated versions of the parabolic reflector may be termed 'shaped-beam parabolic antennas' and have the advantage that they may be designed for specific (and different) E and H beamwidths. This is useful in systems such as mechanically scanned search radars, airport surveillance radars, air traffic control radars and military height finder radars - where fan beam radiation patterns are required.

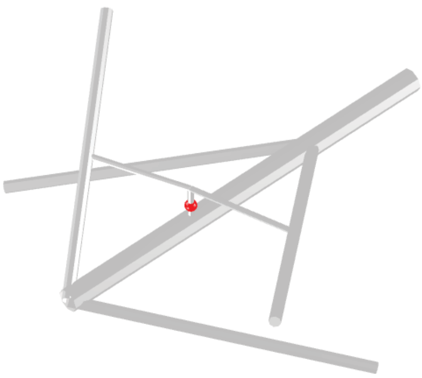
In order to realise a fan beam, the reflector is truncated (either cut-off horizontally, or using an elliptical intersection) and fed by an on-axis sectoral horn antenna. The antenna is usually focused experimentally by finding the optimal axial position (and transverse position if there are alignment errors) which minimizes the null between the main lobe and first side lobe. This is required, as the reflector's focus is not located at a singular geometrical point, but shifts with frequency.

Antenna Magus offers various design options for this antenna: beamwidth (both E and H plane), peak gain, or gain with height restriction may be chosen. The following two images compare three different H-plane 3dB beamwidth designs (2°, 3.5° and 5° respectively) with a constant E-plane beamwidth of 6°, while the third image shows the typical 3D radiation pattern of the antenna designed for a peak gain of 30 dBi.

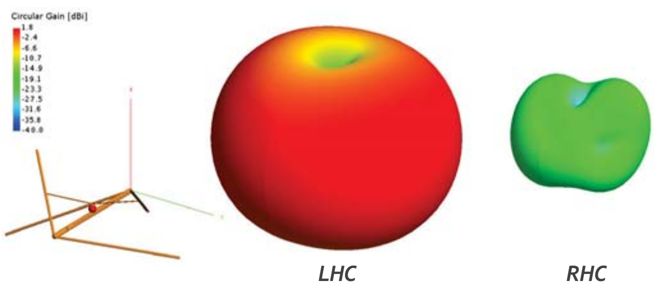


Typical 3D radiation pattern at the centre frequency.

Shunt-fed Slanted V-Dipole pair

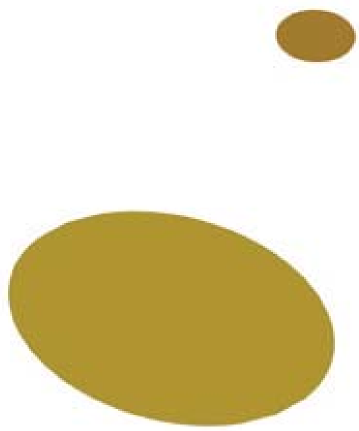


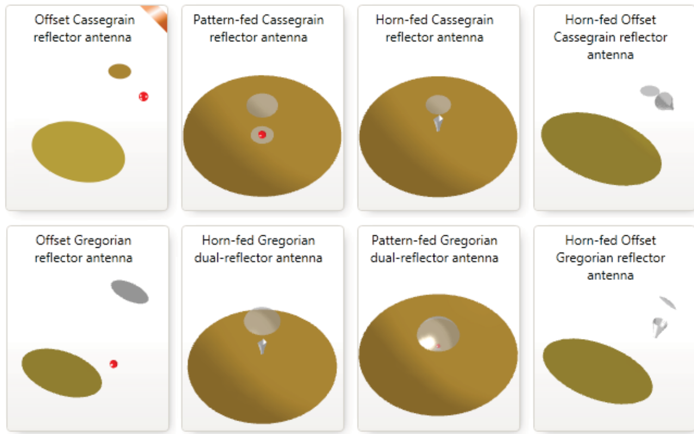
The *Shunt-fed Slanted V-dipole pair* implemented in Antenna Magus consists of two V-dipoles separated 0.25 λ, supported by a horizontal mast. This configuration provides a very mechanically robust, simple, low cost circularly polarised antenna that can be used in high-power transmit applications and harsh environmental conditions. Although each dipole is linearly polarised, an omnidirectional circularly polarised pattern is obtained by adjusting the slant angles and diameter of the dipoles. These antennas are typically used for FM and TV broadcasting where circular polarisation is required, and can be used in linear arrays to achieve a narrow-beam doughnut radiation pattern.



Typical LHC and RHC gain patterns at the centre frequency.

Offset Pattern-fed Cassegrain reflector antenna



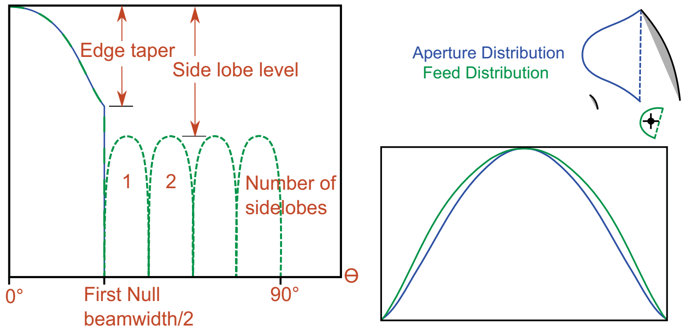


Summary of the dual reflector antennas in Antenna Magus.

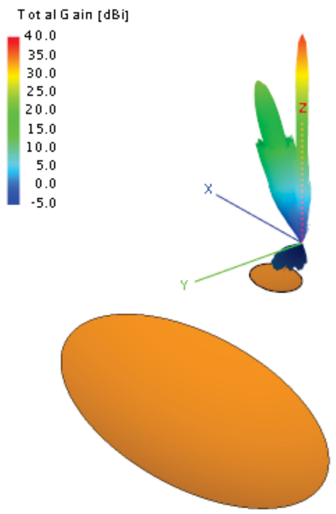
The *Pattern-fed Offset Cassegrain reflector* is the 8th dual-reflector included in Antenna Magus and the 4th Cassegrain-type reflector antenna template.

Dual-reflectors are compact and offer a lot of design flexibility though they are more complex to design and manufacture than single reflector antennas. Sub reflector shaping can be used to increase the focus-depth or to optimise illumination for an existing feed antenna and main reflector. By using a dual reflector with an offset feed, aperture blockage can be decreased and mounting on a flat or rotating platform is simplified. There are however some factors like spill over, radiation pattern asymmetry, feed/sub and main-reflector alignment and other manufacturing complexities that have to be considered when choosing an offset-fed dual reflector topology.

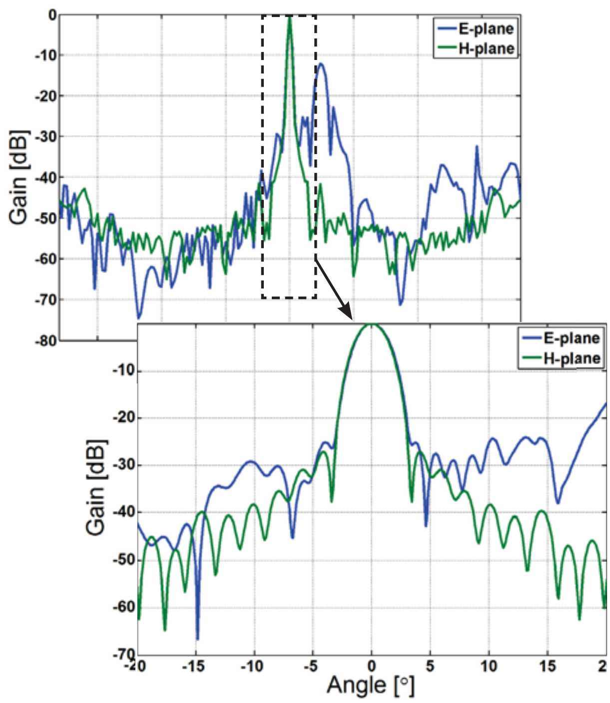
When compared with the *Horn-fed Offset Cassegrain*, the pattern-fed option reduces simulation time and complexity and makes provision for designs based on feed properties such as feed beamwidth, edge taper and feed distribution efficiency as illustrated on the right. Properties of any existing feed antenna can be approximated using the pattern-feed approach, or the desired radiation pattern properties of an ideal feed antenna can be determined based on the reflector design. Though a physical feed antenna is not included in the pattern-fed design, approximate antenna dimensions are used to ensure that minimal blockage occurs.



Feed antenna pattern properties accounted for by Antenna Magus when designing the Pattern-fed Offset Cassegrain reflector.

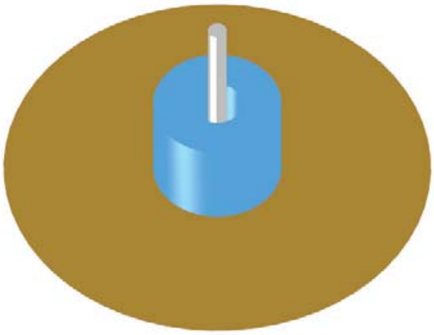


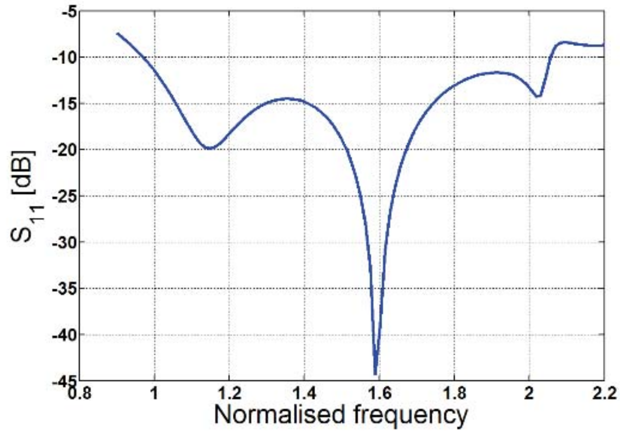
3D radiation pattern of the Pattern-fed Offset Cassegrain.



Normalised radiation pattern of the Pattern-fed Offset Cassegrain dual reflector.

Monopole dielectric resonator antenna

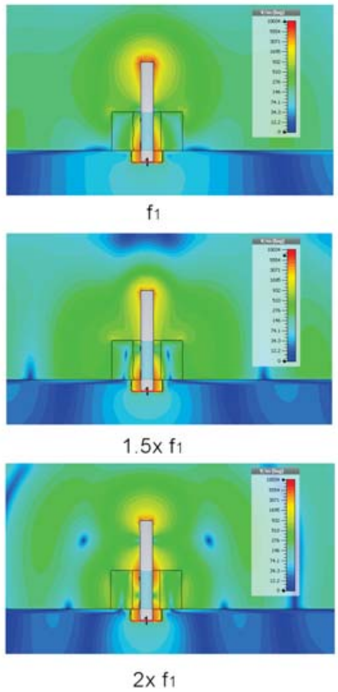




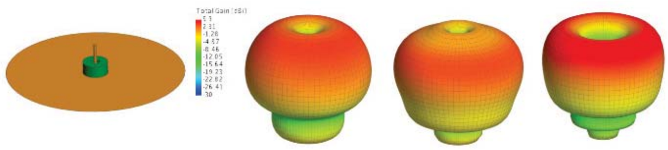
Typical reflection coefficient versus frequency for a 2:1 design.

The *Hybrid monopole dielectric resonator antenna* is an attractive option for designers who want a simple, compact antenna that can achieve wider bandwidths. This antenna uses an annular ring dielectric resonator (DRA) with a reported bandwidth of up to 3:1. The wide bandwidth performance is actually achieved by 3 distinct resonances (f1, f2 and f3) with associated omnidirectional patterns. These resonances can be associated with the physical dimensions of the antenna: the height of the monopole (f1), combined effect of the monopole and DRA (f2) and the DRA by itself (f3). The middle resonance (f2) is achieved by the DRA effectively loading the monopole so that it achieves the current distribution of a slightly shorter monopole.

The following figures show the radiation performance and reflection coefficient in a 50 Ω system of a design for 2:1 bandwidth using a DRA with εr = 20. The last figure compares near field cuts at different frequencies. Note how the positions of the peak radiation change with frequency.



Near field cuts around the antenna at low (f1), center (1.5x f1) and upper (2x f1) frequencies.



Total gain pattern at fmin,1.5 fmin and 2 fmin on a ground plane with a diameter of 1.3λ fmin.

Bifilar helix

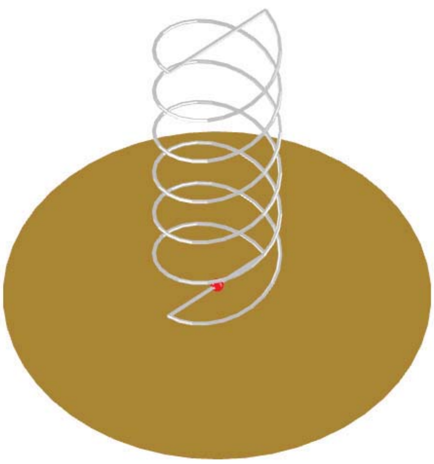


Image of the Bifilar helix antenna.

The *Bifilar helix* is constructed using two volutes with an equal number of turns, and their starting points positioned 180° apart. The ends of the volutes are connected with a shorting wire which adds to the structural integrity of the antenna.

Bifilar helix antennas are often constructed using thick metal rods or pipes, making them mechanically robust and able to withstand strong winds and harsh environmental conditions. These constructions make them ideal for shoreline installations. These antennas can be purchased off-the-shelf for many marine communication frequency bands and are well suited for rapid installation.

The 180° phase shift between the two volutes allows for circular polarization with an end-fire beam in the direction of the helix axis. The radiation pattern is stable with a well-defined end-fire lobe and low side and back lobes across the operation band. A typical radiation pattern is shown in the following image.

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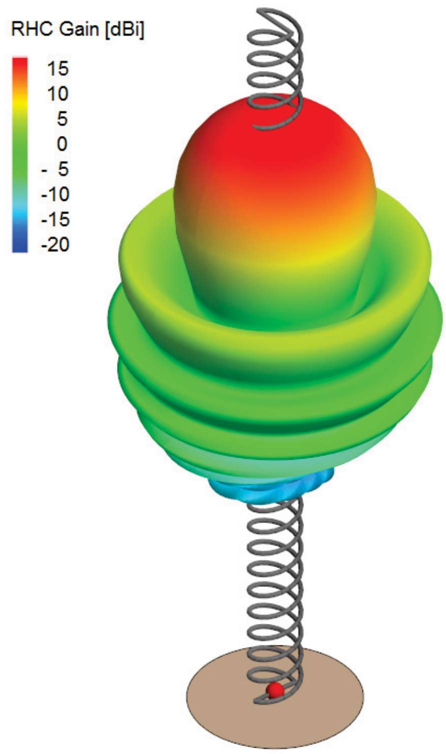
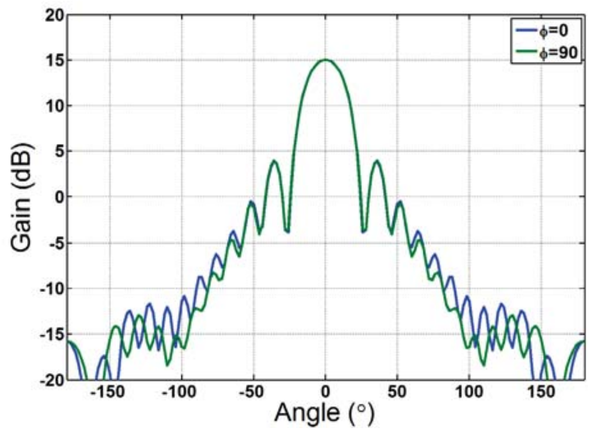
(Bifilar helix continued...)

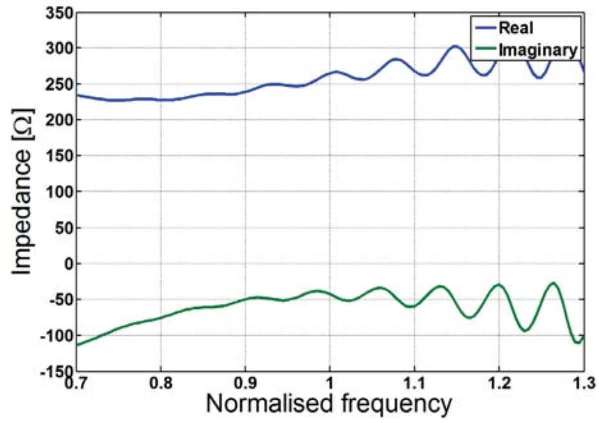


Typical circularly polarised 3D gain pattern at the centre frequency.



Typical circularly polarised radiation pattern cut.

The input impedance exhibits oscillatory behaviour at the high-frequency end of the band as the input resistance increases from 200 Ω to 300 Ω as illustrated in the figure on the right. The -10 dB S11 bandwidth in a 200 Ω system is roughly 1.85:1.



Typical impedance vs. normalised frequency.