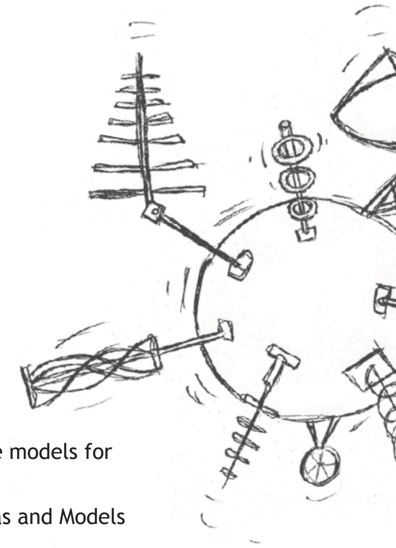


Newsletter 3.3

October 2011

Antenna Magus version 3.3 released!

Antenna Magus Version 3.3 introduces some very exciting extensions to Antenna Magus.

- 6 new antenna topologies
- A new array distribution in the Array Tool
- 3 new tools added to the Toolbox
- Antenna Magus extended to include models for AWR Design Environment
- Many improvements to the Antennas and Models

New Export capability: AWR Design environment

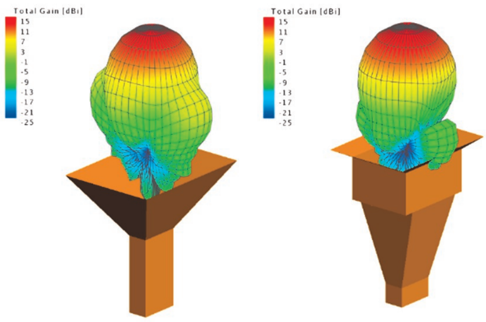
New export functionality allows export of Antenna Magus models to AWR Design environment. This new capability was announced at European Microwave Week 2011.

Antenna Magus users can export certain planar antennas directly to AWRDE for analysis using the AXIEM solver. As with all Antenna Magus export models, the AWRDE models are fully parametric - with a number of them using specially developed PCELLS to provide flexible geometries that are otherwise not possible to create parametrically. These parametric models can easily be integrated into circuitry and optimized together with other parts of the system.

New Antennas and Arrays

Compound pyramidal box horn antenna

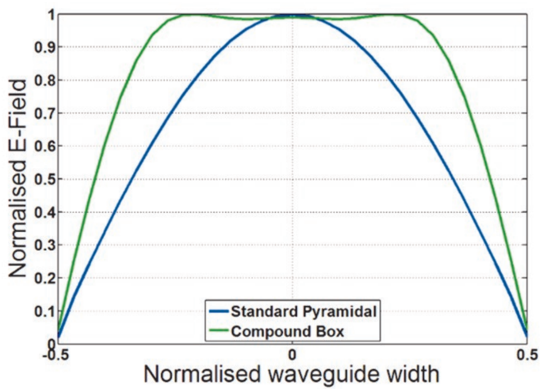
The classical *pyramidal horn* antenna supports a single propagating mode (TE10) that generates a field distribution (magnitude) across the mouth or aperture of the horn similar to the profile shown in the figure below. The radiating aperture of the horn is therefore only partially exploited, resulting in aperture efficiency in the order of 65% relative to an ideal aperture excitation.



The comparative radiation patterns of a pyramidal and compound box horn with the same gain (note the smaller physical aperture size of the compound box horn.)

One way to improve the efficiency of the aperture excitation of a horn antenna is to use a structure that supports multiple modes. The *compound box horn* is one simple modification of the *pyramidal horn* antenna that includes a step and a short un-flared box section that couples some of the energy in the TE10 mode to the TE30 mode. The length of the box is designed such that the TE10 and TE30 propagating mode components reach the waveguide-to-flare transition of the horn 180° out-of-phase, resulting in a more even aperture distribution and an improvement in aperture efficiency (a typical box-horn has an aperture efficiency around 82% relative to an ideal aperture excitation).

Antenna Magus allows the *compound box horn* to be designed for gain or beamwidth at a specific operating frequency. The feed waveguide dimensions are chosen based on the operating frequency and can easily be tweaked to specific standard waveguide sizes after design with minimal effect on the radiation performance.



The comparative field magnitude across the waveguide section at the start of the horn flare in a pyramidal and a compound box horn.

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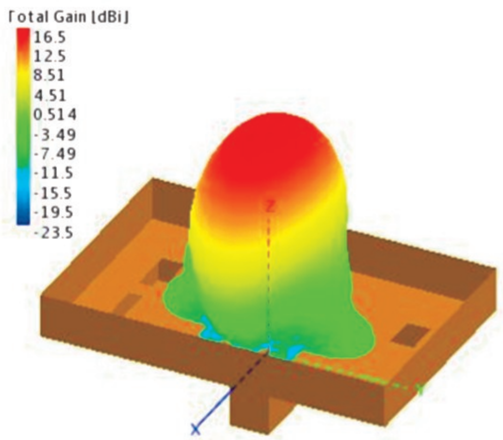
Cavity-backed slot array

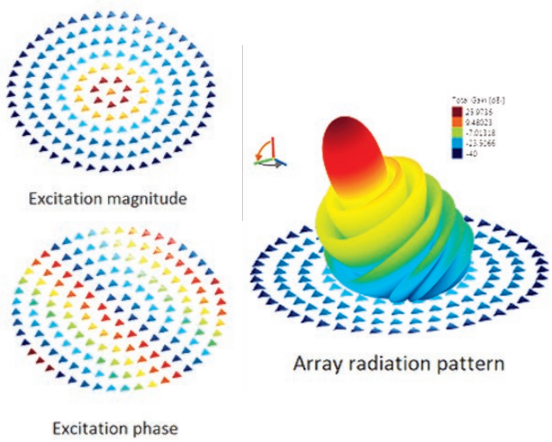
Cavity-backed slots allow for very efficient low-loss structures at high frequencies, but often require complex feed structures. By using a single cavity backing for a number of slots and leveraging the modal distribution in the cavity to realise the excitation distribution of the slot array the complexities of the feed structure can be greatly reduced. This approach is used in a number of slot array structures, like the radial line slot array to simplify construction of larger arrays.

The specific antenna implemented in Antenna Magus is based on a structure developed for satellite digital multimedia broadcasting (DMB) where high-gain as well as high isolation between closely located antennas was required. The 2x4 rectangular slot array provides linear polarisation with 17 dBi gain over a 10% bandwidth. This is an ideal simple-to-construct efficient array and can be used as a building block for larger arrays with minimal inter-element interaction.



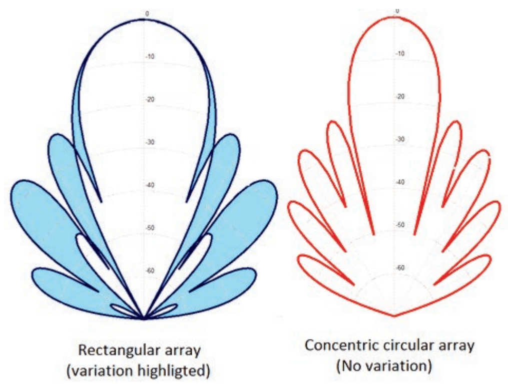
Concentric circular arrays in the Array Tool

A new class of Array layout has been added to the Array Tool in Antenna Magus. The *concentric-circular array* class is specifically aimed at generating radiation patterns that are rotationally symmetrical around the boresite direction of the array, independent of the steering angle of the main beam as shown in the image below.



A concentric circular array design showing the element excitation magnitude and phase and the resultant synthesised radiation pattern.

The advantages of the pattern symmetry become clear if one compares a *concentric-circular array* to a *rectangular array* with similar performance in the primary cut planes. The images shown below were generated by overlaying multiple pattern cuts with various azimuth angles around the boresite direction to determine the maximum rotational variation of the pattern. The *rectangular array* shows quite considerable variation, while the *concentric-circular array* shows no variation, providing for better sidelobe control as well as more efficient array aperture usage.



A comparison of the rotational variation around the boresite direction of a rectangular and a concentric-circular array layout.

Backfire-helix-fed parabolic reflector

The *backfire-helical-fed parabolic reflector* provides an effective means of obtaining a high-gain circularly polarised radiation pattern using a relatively simple and low-cost feed structure. In most instances, the helical feed may be held in place by a simple on-axis supporting post, circumventing the need for feed strut braces.

The design and placement of the backfire helix feed is critical. By using a small ground plane and selecting the pitch angle and number of turns of the helix correctly the required beamwidth of the backfire radiation to illuminate the dish can be achieved. The practical beamwidth variation range is relatively small when com-

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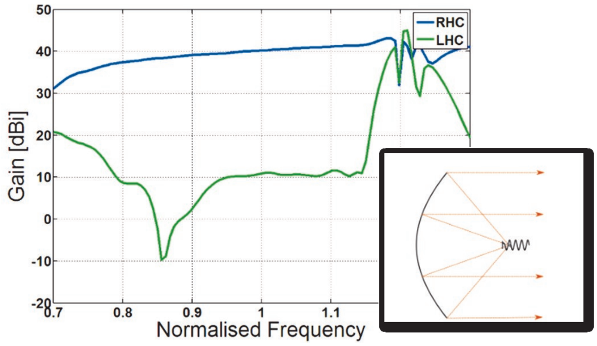
pared to a horn feed, limiting the range of F/D ratio parabolic reflectors that can reasonably be used for this kind of feed approach.

In practice, the coaxial cable used to feed the helix would be fed along an on-axis support post from the center of the reflector – for physically smaller antennas at higher frequencies, a semi-rigid feed coax may even provide the actual support for the feed element. The exact placement of the feed is typically adjusted experimentally during construction to ensure ideal placement at the focal point of the reflector.

Antenna Magus allows this antenna to be designed for gain or beamwidth at a specific frequency.



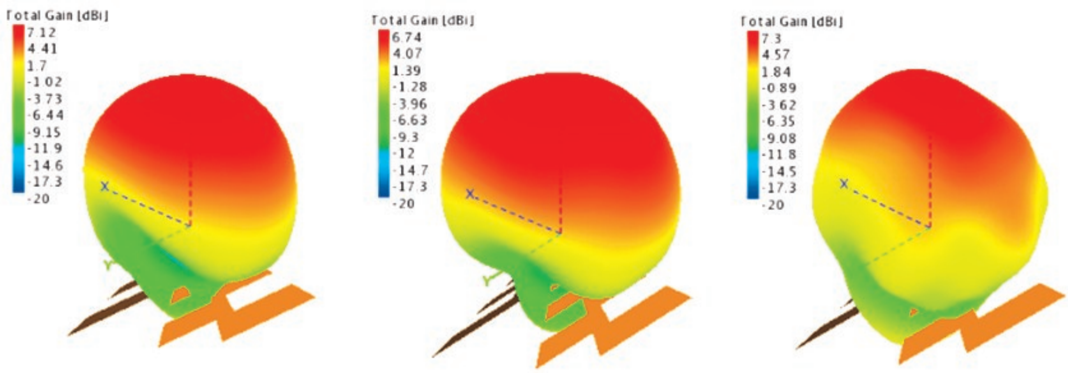
The on-axis circular polarisation performance of a typical backfire-helix-fed parabolic reflector antenna.

Planar/folded 2-arm trapezoidal log periodic antenna

Log-periodic antennas provide structures whose electrical properties vary periodically with the logarithm of frequency. The result is impedance and radiation characteristics that repeat periodically with frequency and have minimal variation over a wide band.

The *planar/folded 2-arm trapezoidal log periodic* antenna is similar to the *rounded planar log-periodic* antenna already available in Antenna Magus, but it has straight arms. Though, strictly speaking, this breaks the log-periodicity of the structure, it simplifies manufacture and geometrical layout of the antenna. By folding the *planar 2-arm log periodic* antenna at the feed point, it is possible to achieve wideband directed radiation performance without the need for a cavity structure.

Antenna Magus allows this structure to be designed for a specified operating band and provides bi-directional and uni-directional radiation designs (planar or folded structure respectively.)

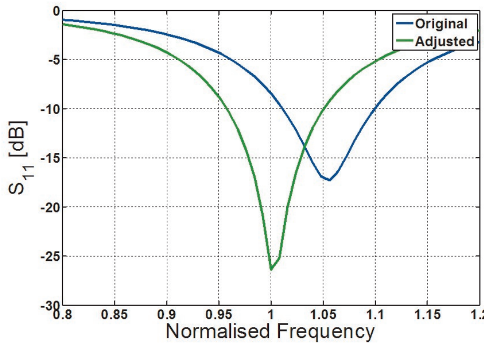


The radiation patterns of a folded 2-arm log periodic antenna over a 4:1 band at the lower, centre and upper frequencies in the band.

Simple dipole antenna designed for usage in a dipole array

The simple *wire dipole* is a ubiquitous antenna, familiar to anyone that has ever attended a course on antennas or considered electromagnetic radiation. The design of these structures is deceptively simple - each arm should be just a little less than a quarter-wavelength long and driven in anti-phase to provide a linearly polarised radiator with 73 Ohm input impedance.

When the basic dipole is used in an array, however, the close proximity of the elements in the array causes interaction between elements, altering the currents (and thus impedances and radiation characteristics) of each element. This interaction, or mutual coupling, affects the way that the element should



Comparative single element reflection coefficient of a dipole designed for single-element operation and a dipole designed for inclusion in an array.

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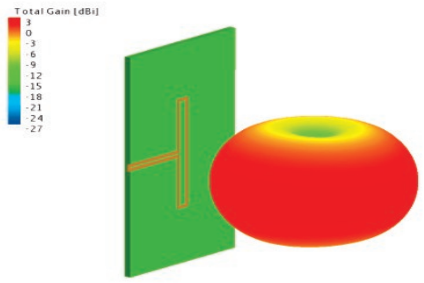
be designed, both in terms of the length of the element arms and the anticipated input impedance. The figure shows the comparative reflection coefficient of a dipole in an array environment when designed for single element usage (original) and when adjusted for use in an array (adjusted). The input impedance of the dipole in the array is designed so that it performs as though it were a single isolated element.

Printed folded dipole

The *planar folded dipole* is a simple structure that can be etched onto the same substrate as electronic components. The antenna provides higher bandwidth and impedance than a simple planar dipole.

This type of antenna is popular in mass-production electronics where a simple integrated antenna is required. Though, strictly speaking, a balun should be used, the coplanar strips input of the antenna may be connected directly to a differential drive or input with minimal effect on performance.



The typical radiation pattern of a folded planar dipole.

New tools and calculators

Antenna Magus Version 3.3 sees the introduction of 3 new approximation tools to the Toolbox. These approximations are exceptionally useful in making good design decisions in the earlier stages of a system development, where the exact details of antenna topologies, system properties and other implications are not yet clear.

The first tool implements the *Radar range equation* - which relates the transmitted and received power in a radar system given the target size and distance from the receive and transmit antennas. This relation can be used to consider the system level requirements and performance capabilities of a bi-static radar system.

The second new tool predicts the approximate *gain of an antenna, given the mainbeam beamwidth*, or vice-versa. The method used for this approximation is based on theoretical or idealised models that are adjusted based on observation of practical or realistic radiation patterns.

Finally, a tool has been added that calculates the *expected gain given the area of an aperture* and the efficiency with which that aperture is exploited. The calculation is based on the equation below, which is derived in most textbooks.

$$Gain = \frac{efficiency * Area * 4 * \pi}{\lambda^2}$$

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