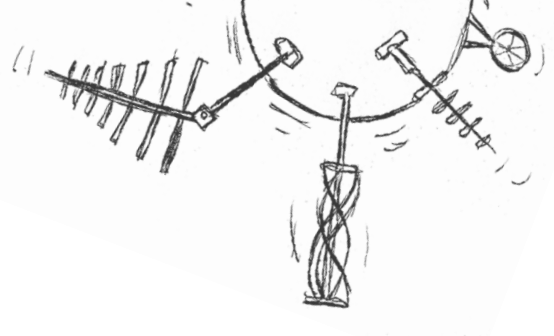


Newsletter 4.1

September 2012

Antenna Magus version 4.1 released!

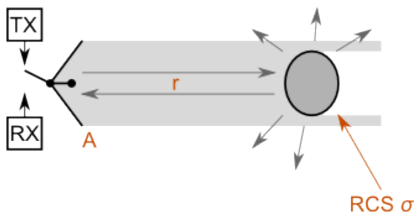
We are pleased to announce the new release of Antenna Magus Version 4.1. This release sees the addition of 15 new tools to assist antenna designers with every day antenna-related tasks. The antenna database is expanded by the addition of four exciting antennas: the *Axial choke horn with a dielectric lens*, the *Offset-fed Gregorian and Cassegrain reflectors* and the *"Eggbeater"* antenna.

24 useful tools and calculators

A summary of the tools included in the latest release, Version 4.1.

The tools added in the Version 4.1 update expand the Antenna Magus toolbox to a total of 24 tools. Thumbnails of all the available tools are shown above and a few examples are highlighted in this newsletter. More information on each utility can be found in Antenna Magus or on the website.

Radar cross section (RCS) calculator



Two way radar path

This calculator returns the Radar Cross Section (RCS) of an object, given a number of input objectives. The next example shows how the calculator may be used to calculate the effective aperture of an object for known RCS.

The Sea-Based X-Band Radar (SBX) system has been described as "…being able to track an object the size of a baseball over San Francisco in California from the Chesapeake Bay in Virginia, approximately 2,900 miles (4,700 km) away…". If this statement is correct, then what is the effective aperture of the receive antenna of the 1MW radar receive array?

At 10.2 GHz the RCS of a baseball-sized sphere can be calculated theoretically as approximately 78cm2. The SBX radar system can transmit 1MW, and if we assume a Minimum Detectable Signal (MDS) of -100dBm, then the effective aperture of the 22000 module radar is approximately 5 football fields - an impressive radar indeed!

Input:

frequency_centre (f0) = 10.2 GHz
power_received (Pr) = 100e-6 nW
power_transmitted (Pt) = 1e3 kW
radar_path_distance (r) = 9.4e3 km
effective_antenna_aperture (A) = 33e3 m^2

Output:

radar_cross_section (RCS) = 77.83 cm^2

Input and output parameters as given by Antenna Magus.

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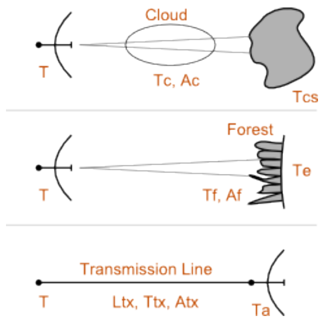
Passive remote sensing tool

The remote sensing tool calculates temperature (measured or that of the target object) for a number of passive remote sensing situations. The applications are illustrated to the right. This tool assumes that the radiation detected or sensed by the sensor (for example a radio telescope or satellite-based microwave radiometer) originates from the objects being observed, and accounts for approximate absorption effects of the transmission path. Such calculations are useful when calibrating remote sensing systems, and also when analysing measured data. For example, the information from a radiometer on EOS satellites (used to monitor vegetation coverage) needs to be corrected based on how the atmospheric and surface absorption affect the measured temperature at the sensor device.



A visual representation of the tool options as described above.

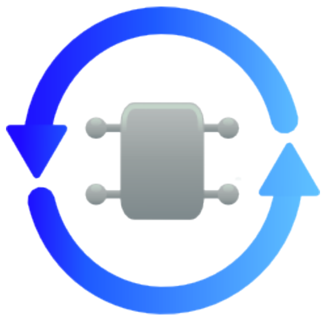
Input:

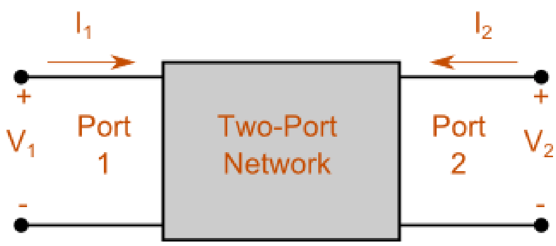
forest_temperature (Tf) = 330 K
forest_absorption_coefficient (Af) = 410e-3
earth_temperature (Te) = 570 K

Output:

temperature (T) = 489.3 K

Two port network conversion tool





Two-port network diagram.

This tool allows the conversion between various two-port parameters including Z (impedance), Y (admittance), ABCD (chain) and S (scattering). Antenna Magus supports the inclusion of complex and differing source and load impedances when considering S-Parameters. This allows all conversions between two-port parameter representations.

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$ ***Z-parameters***

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$ ***Y-parameters***

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & -B \\ C & -D \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix}$$ ***ABCD-parameters***

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$ ***S-parameters***

Parameters of devices such as the HEMT transistor described here can be converted with ease, as shown in this Z to S parameter conversion example.

Input:

Z11 = 13.8 - 37.0j
Z21 = 95.18 + 380.3j
Z12 = 12.12 + 0.6395j
Z22 = 122.1 - 17.01j
Source impedance = 70 + 30j
Load impedance = 25 – 35j

Output:

S11 = -0.3469 – 0.5674j
S12 = 0.04776 + 0.04832j
S21 = -1.039 + 1.933j
S22 = 0.7769 - 0.1714j

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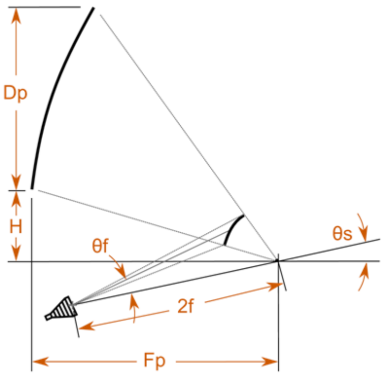
New antennas

Antenna Magus 4.1 introduces 4 new antennas.

The *Axial choke horn with a dielectric lens* is a popular reflector feed antenna, while the *Offset-fed Gregorian and Cassegrain* are practical and flexible reflector antennas with low blockage and compact size. The simple, robust *"Egg-beater"* antenna is ideal for circular polarised radiation in the UHF and VHF bands. It is also a great option for low-cost mobile satellite communication applications.

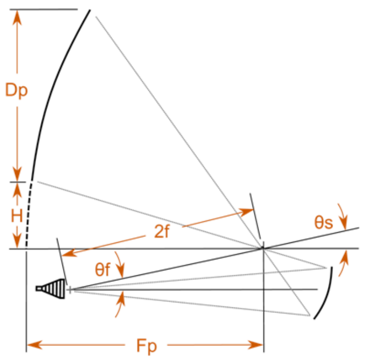
Offset-fed Cassegrain and Gregorian reflectors



(a)

Offset-fed Gregorian *Offset-fed Cassegrain*

Offset-fed Parabolic



(b)

Side view of the Horn-fed Offset Cassegrain (a) and Gregorian (b) construction.

The Horn-fed offset- Gregorian and Cassegrain reflector antennas compared to an offset-fed single-reflector antenna. [Note the difference in feed-horn orientation and sub-reflector placement and the compactness of the dual reflector topologies when compared to the single reflector structure.]

Dual-reflector antennas are based on principles that have been used in optical telescopes for centuries, with Cassegrain and Gregorian telescopes dating back to the late sixteen hundreds. These antennas share many of the underlying principles of operation with typical single-reflector structures. They employ dual reflection to achieve compact structures by allowing the position of the feed antenna to be mirrored around the focus point of the added sub-reflector.

Offset dual-reflectors also have a number of advantages when compared to their asymmetrical counterparts. By moving the feed to an offset position, aperture blockage can be minimised (as illustrated in the previous illustrations) and fewer/smaller struts are required to support the feed and sub-reflector.

The following image shows a comparison between three different offset reflectors - an *offset Gregorian*, an *offset Cassegrain* and a *single reflector with an offset pyramidal horn feed* - all designed for 35 dBi gain and a 35° 10dB feed-beamwidth.

Offset-fed Cassegrain and *Gregorian reflectors* have the advantage that the main reflector and the horn feed can be designed almost independently. Although this requires that various additional factors be considered in the design process, the dual-reflector structures are more compact and offer more design freedom.

The choice between the Gregorian or Cassegrain options is not a simple one! This choice depends on the specific requirements of the application in question. Some of the important considerations are:

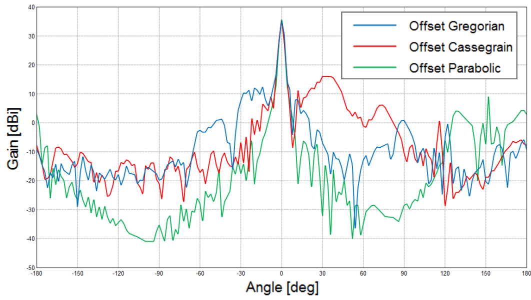
- **Size:** The Cassegrain's sub-reflector is positioned slightly closer to the main reflector, making it more compact than the Gregorian in the horizontal direction. The feed on the other hand is positioned further away from the main and sub-reflectors making it less compact in the vertical direction.

- **Spill-over requirements**: The feed of the Gregorian illuminates the sub-reflector at a greater incidence angle than that of the offset Cassegrain, providing more feed beamwidth flexibility and the potential to better control spill-over.

Continue on the next page...

Offset-fed reflectors continued...

The next graph shows a comparison between the radiation patterns of the three reflector designs displayed in the image on the previous page. Note the Cassegrain's higher first sidelobe level due to unwanted spill over from the horn feed. One can compensate for this by changing the orientation and position of the feed and sub-reflector. This would however introduce unwanted blockage which has to be compensated for by enlarging the main reflector.

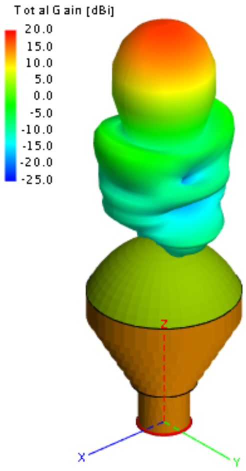


Gregorian vs Cassegrain vs Parabolic offset-fed reflector gain comparison.

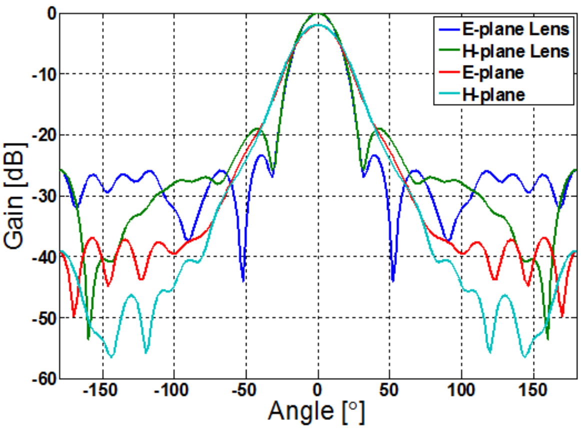
Axial choke horn antenna with a dielectric lens

The *Axial choke conical horn* is a very popular reflector feed as it provides an almost-flat wavefront in the main beam with a sharp roll-off which is ideal for uniform dish illumination with little spillover.

By increasing the flare angle and adding a dielectric lens in the aperture of the horn, a more focussed, narrow symmetrical beam can be achieved with a horn structure that is physically smaller when compared to an axial choke horn without a lens and the same gain.



Lens horn 18 dBi gain pattern.



Gain comparison between an axial choke horn with and without a lens.

Antenna Magus uses a simple Meniscus lens. It should be noted that lens systems on horns are limited to use within certain physical restrictions. For example, the minimum flare angle is determined by the lens material.

The gain pattern shown above is for a horn designed for a gain of 18 dBi and a lens material with a relative permittivity of 2.56.

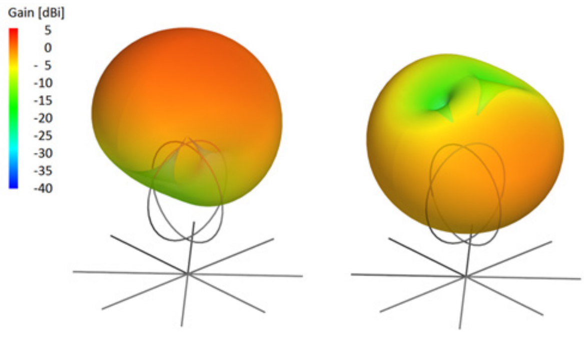
The pattern cuts shown in the left image compare the performance of an *Axial-choke horn with a dielectric lens* designed for 18 dBi, to that of the identical structure with the lens removed. The lens increases the total on-axis gain by 2 dBi and improves the main-beam symmetry.

"Egg-beater" antenna

The *"Eggbeater" antenna* is an example of an electrically large antenna consisting of a pair of orthogonal loops each with circumference of one wavelength. This simple, robust antenna is ideal for operating in UHF and VHF bands, is capable of withstanding extreme weather conditions (including high wind-loading) and is easy to assemble and transport.

The antenna configuration is equivalent to two pairs of horizontal dipoles, orthogonally positioned, with a 90 degree phase difference. This gives the eggbeater the radiation characteristics of being left- or right-hand circularly polarised in the zenith direction and horizontally polarised on the horizon. This makes it ideal for omnidirectional satellite communications. For example the SANAE base in Antarctica uses an *Egg-beater antenna* on their satellite base station where it has to survive extremely low temperatures (below -50 °C) and has to withstand strong (> 160km/h) winds.

Right-hand circular and left-hand circular radiation patterns at the operating frequency for a right-hand circular design are shown below. The polarisation is linear on the horizon and becomes more circular at greater elevation angles.



RHC and LHC radiation patterns at the design frequency.

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