AH Systems Webinar - Supporting Notes

CHOOSING THE RIGHT ANTENNA FOR TODAY'S TESTING REQUIREMENTS

These supporting notes are intended for use with the AH Systems webinar on 'Choosing the Right Antenna for Today's Testing Requirements'

Premise 1 - Ideal chamber, so all points can be illuminated within the -0.0 to +6.0dB limits (no discounting 25% of points)

Premise 2 - If cannot achieve compliant test field under ideal conditions, impossible to achieve in real-life chamber conditions (cannot defeat the laws of physics, cannot blame 'room effects')

FIELD STRENGTH CALCULATION

Taming the Equation

$k_E = k\sqrt{(PxG)}$

For k_E a constant, $\sqrt{(PxG)}$ must be a constant

Therefore if G drops in value, P compensates by rising in value such that PxG remains the same

In the example power calculation G = 8dBi at 1GHz is used. This equates to 6.3 linear giving a power of 15.4W

In the first example of visualization of the net gain over the frequency of interest, the cable loss data was obtained from the A. H. Systems on-line cable-loss calculator using low-loss cable SAC-18G

Linear Gain and Relative Gain in dBi

Linear gain is simply how many times better (or worse) the antenna in question is compared to the classic isotropic antenna.

Linear gain $G = S_{ANT} / S_{ISO}$

Where S_{ISO} is the power density created by an isotropic antenna, and S_{ANT} is the power density of the antenna in question.

Note, linear gain is used in the field strength equation. If the antenna performance in a particular direction is better than isotropic, the linear gain is greater than 1. If worse, the linear gain is less than 1.

Relative gain in dBi is how much better (or worse) in dBs the antenna in question is compared to the classic isotropic antenna. The subscript 'i' is used to indicate the dB value is relative to isotropic.

The relative gain in dBi is calculated from

$G = 10 \log_{10} [S_{ANT} / S_{ISO}]$ dBi

GAIN and BEAMWIDTH IMPACT

Calculation of the zone-of-interest diameter

Applying Pythagoras theorem to the right angled triangle a, b, c.

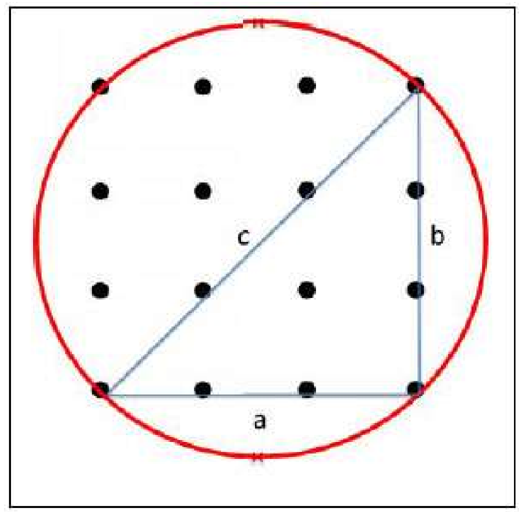
$a^2 + b^2 = c^2$

$1.5^2 + 1.5^2 = c^2$

$c^2 = 2 (1.5^2)$

$c = \sqrt{2} (1.5)$

$c = 2.12$



Therefore the radius of the zone-of-interest is 2.12 / 2 = 1.06m

Calculation of the zone-of-interest angle

For a right angled triangle $\tan \Theta = y / x$

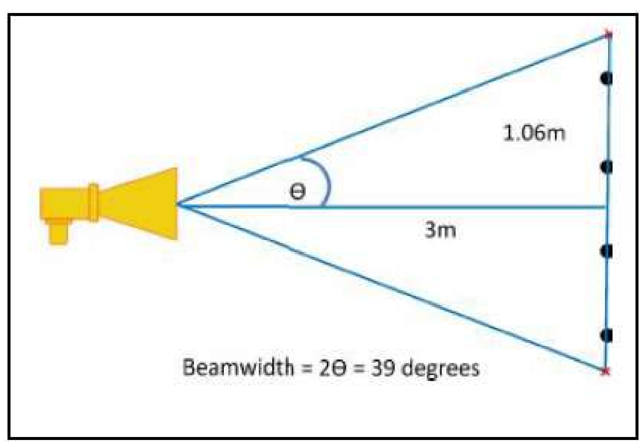
Conversely Θ is the angle whose tangent is y / x

The adjacent side x is 3m and the opposite side y is 1.06m

$\tan \Theta = 1.06 / 3$

Therefore $\Theta = 19.46$ degrees

The zone-of-interest angle is $2\Theta = 39$ degrees



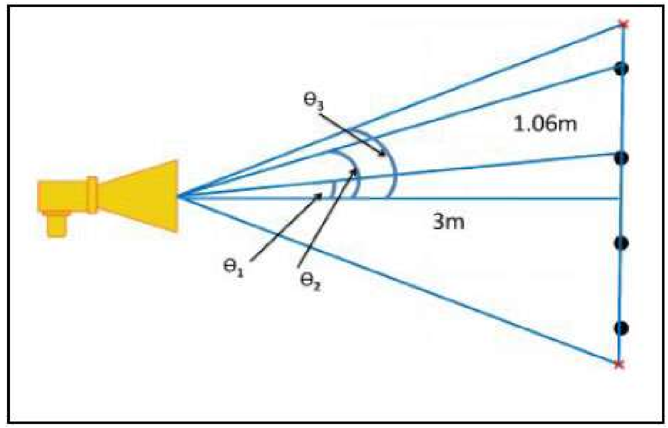
Transposing the calibration plane onto the antenna polar plot

The field probe positions and zone-of-interest periphery positions are at

$\Theta_1 = \tan^{-1} = 0.25 / 3 = 4.76$ degrees

$\Theta_2 = \tan^{-1} = 0.75 / 3 = 14$ degrees

$\Theta_3 = \tan^{-1} = 1.06 / 3 = 19.5$ degrees



For the purposes of this discussion, the angles were taken as 5 degrees, 15 degrees and 20 degrees respectively

Example demonstrating the impact of beamwidth

When the half-power beamwidth coincides with the zone-of-interest angle (2Θ), then the four probe positions on the periphery must be at 18v/m (the minimum permitted field measurement). This means the boresight field strength is 25.5v/m

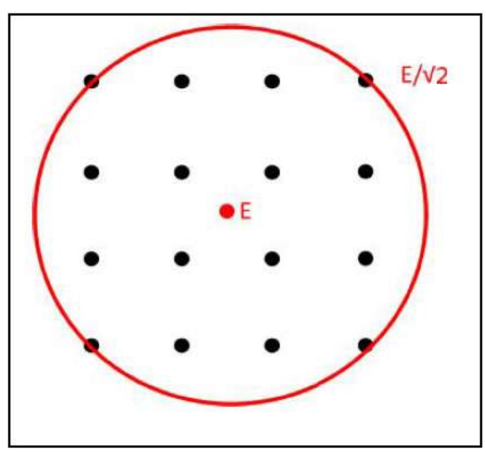
This is because :

$S = E^2 / Zo$

$E = \sqrt{(S.Zo)}$

The power density at the periphery of the zone-of-interest is half that at the center of the zone-of-interest (i.e. S at the boresight)

That is $S_{3dB} = ½ S$



The field strength at the periphery $E_{peri} = \sqrt{(S.Zo/2)}$

Substituting $S = E^2 / Zo$

$E_{peri} = \sqrt{[(E^2 / Zo).(Zo/2)]}$

$E_{peri} = \sqrt{[(E^2 / \cancel{Zo}).(\cancel{Zo}/2)]}$

$E_{3dB} = \sqrt{[(E^2 / 2)]}$

$E_{peri} = E / \sqrt{2}$

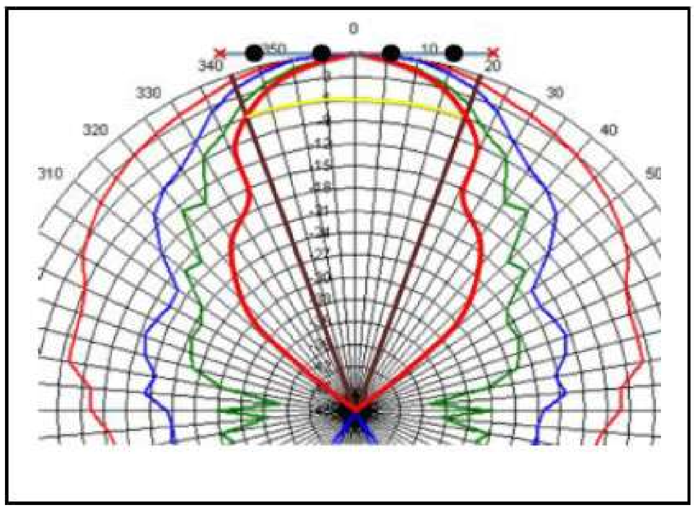
Conversely $E = \sqrt{2} \times E_{peri}$

Therefore the boresight field strength E is √2 times 18v/m, i.e. 25.5v/m

Impact of the limiting 6dB beamwidth (quarter-power beamwidth)

When the quarter-power beamwidth angle coincides with the zone-of-interest angle (that is the angle is 39 degrees and the quarter-power beam diameter at the calibration plane is 2.12m), then the four probe positions on the periphery must be at 18v/m (the minimum allowed field measurement at any probe position). This translates to 36v/m (maximum permitted) at the center of the zone of interest.

If the quarter-power beamwidth is narrower than the zone-of-interest angle (39 degrees), the 18v/m minus 0.0dB / plus 6.0dB <u>cannot</u> be achieved.



Determining the Beamwidth Loss from the Marked Up Polar chart

Following the red trace (1GHz gain data) clockwise, and starting at 0 degrees (boresight), the trace crosses the zone-of-interest limit line (brown rightmost) at 1dB down from the gain at the boresight. The same method is used with the blue trace (9GHz) extrapolated to 10GHz. This data was then transposed to the system-loss visualization graph.

Why Beamwidth <u>Loss</u>?

If you accept the case that the power from the amplifier must be increased to compensate for cable loss, then likewise, the increased power required to compensate for the lower field strength at the zone-of-interest periphery should also be regarded as compensating for a loss.