Volts/m For EMC and Antenna Measurement
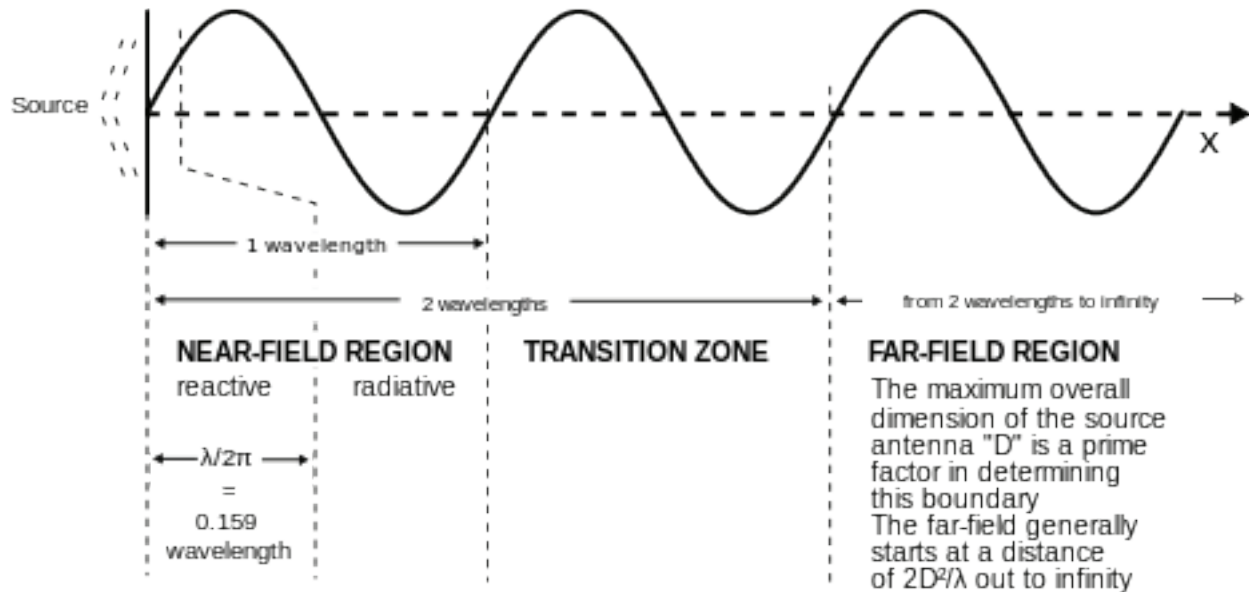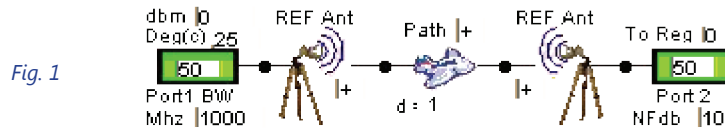
Application Note
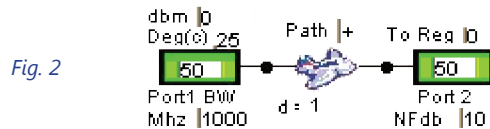

Image courtesy of Wikipedia Commons

This note describes the concept of electric field strength in the far field region. Design trade-offs in EMI and AUT measurements involve the gain beamwidth of the Tx antenna.

The example in this note assumes a separation of 1 meter and a frequency band .5 to 18GHz. A design example for a specified 1 volts-per-meter is presented along with cable loss compensation using the DE700_26 broad band reference horn. This note was generated using the DAMs Antenna Network and Measurement Simulator.
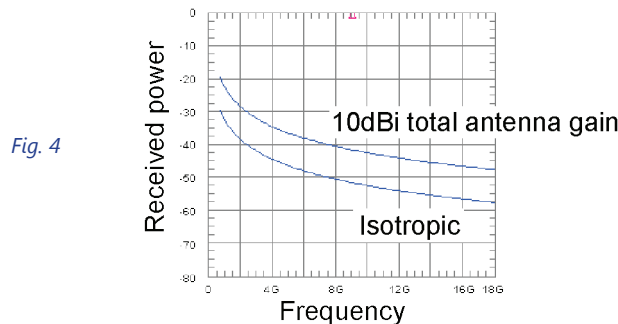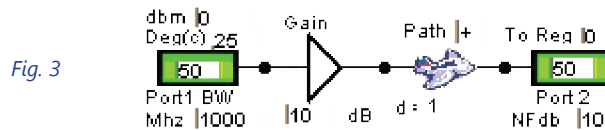
In the Far Field the electric field varies with the reciprocal of the distance. The electric field varies as 10dB per frequency decade. The network describing the link is depicted as:

Fig. 1

Next we will reduce the two antennas to unity isotropic gain. Since isotropic gain is unity the network reduces to the path.

Fig. 2

The received link power is simply scaled by the overall antenna gain.

Fig. 3

Fig. 4

For the network in Fig. 3, within the far field, the electric field strength (volts/meter) can be calculated:

Eq. 1
$$P_{density} = E \ x \ H \ \ watts \ / \ meter^2$$

Because the fields are well defined in the Far field E and H are perpendicular and (1) is reduced to:

Eq. 2
$$P_{density} = E H = E^2 \eta \ \ watts \ / \ meter^2 = \frac{E^2}{120\pi}$$

If the transmit power and Tx gain are known then the total watts/meter^2 is:

Eq. 3
$$P_T = \frac{P_t G_{Tx}}{4 \pi r^2} \; watts / meter^2$$

Equating Eq. 2 and Eq. 3 yields the field strength in terms of transmit gain and power:

Eq. 4
$$Volts / meter = \frac{\sqrt{30 G_{Tx} P_t}}{r}$$

Eq. 4 is the traditional expression for field strength. It is notable that the field strength is independent of frequency.
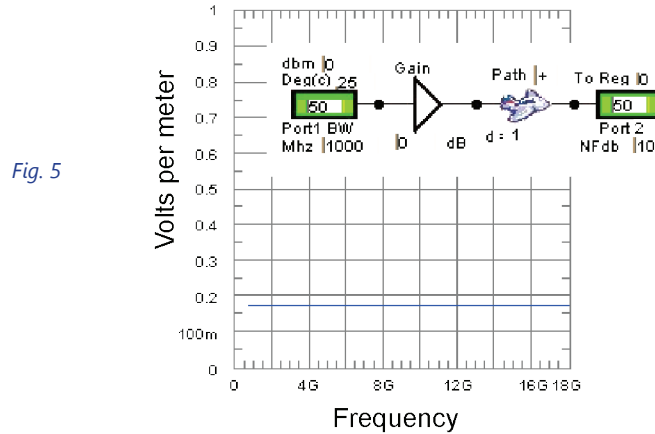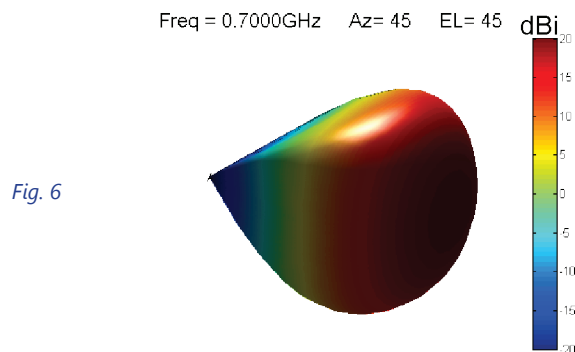
Fig. 5

Fig. 5 shows the constant volts/meter of an isotropic antenna fed with 0dBM at 1 meter. Then the next question might be "Does an antenna with flat frequency gain exhibit constant volts/meter ?" The answer is clearly yes. Consider an ideal beam one in which the Az and EL beam-width are identical. The directivity of such a beam is given by:

Eq. 5
$$D = \frac{41,253}{Beamwidth_{Az} Beamwidth_{EL}}$$

The constant represents the number of square degrees which can placed on an ideal sphere. Here we see no frequency factor. If we calculate the ideal gain for a beam-width of 20 deg (5) yields 20.1dBi gain. The beam is shown below.

Fig. 6

Freq = 0.7000GHz   Az= 45   EL= 45   dBi

Since the Gain is the same as the directivity for a loss-less antenna the above is valid as an ideal beam.
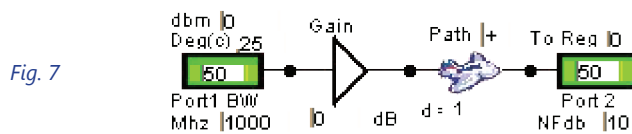
Example Problem

Assume a test chamber is required to deliver a constant field strength of 1 volts per meter at 1 meter from a 0dBM source. Determine the gain and beam-width of the Tx antenna.
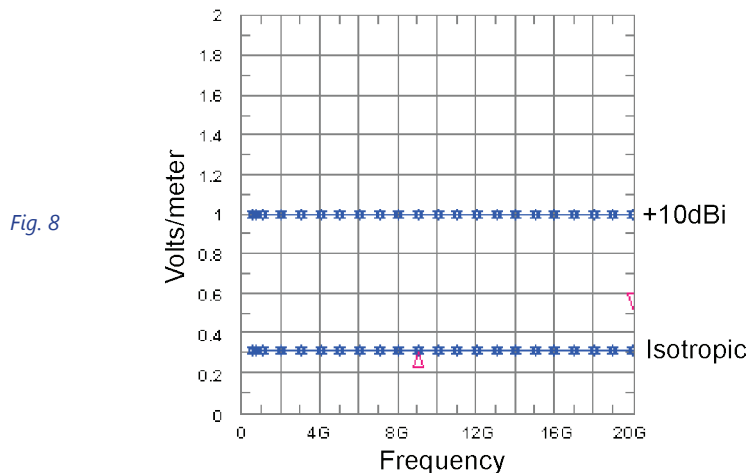
Assume the Tx cable has 1dB loss at 0.5GHz. Use the DE700_26 horn gain profile to compensate the cable and maintain 1 volts/meter.

Example Solution

We first create the schematic with the Tx represented as a simple gain block with 0dBm input power level.

Fig. 7

Next the Volts/meter is calculated and the Gain increased until 1 volt per meter is achieved.

Fig. 8

Using Eq. 5 the beam-width is easily calculated from the gain. If we assume equal Az-EL beam-width, then we would use:

Eq. 6

$$BW^2 = \frac{41253}{10^{10/10}} = 4125 \Rightarrow BW = 64\deg$$

Now assume the Tx is fed with a lossy coax cable known to have 1dB loss at 0.5GHz. Since cable loss precisely follows skin loss, we can easily plot the cable loss. The math icon is used to convert the 1dB loss to linear S21 and scale the frequency variation relative to 0.5GHz.
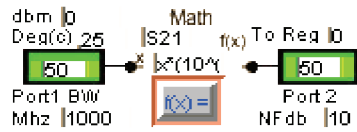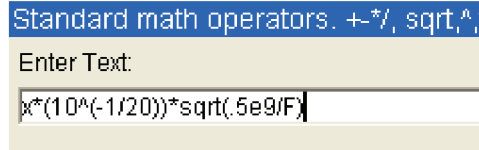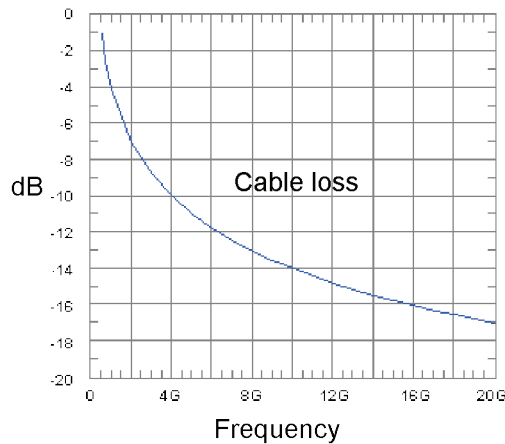

Fig. 8

Standard math operators. +-*/, sqrt,^;

Enter Text:

x*(10^(-1/20))*sqrt(.5e9/F)

Fig. 9

If we next insert the isotropic gain block and plot the volts per meter (with the lossy cable), we see the variation from about 0.9v to 0.15v and 1 volt per meter is not achieved.
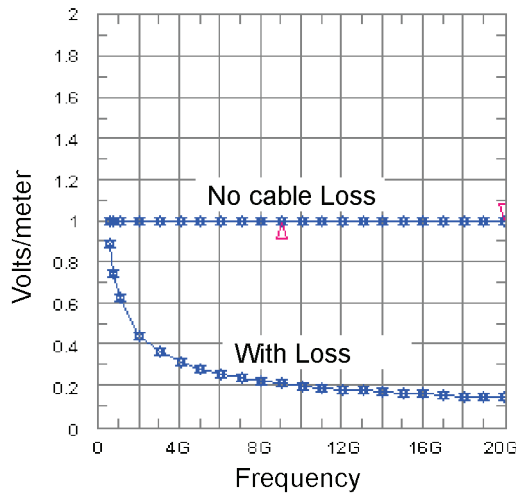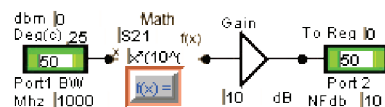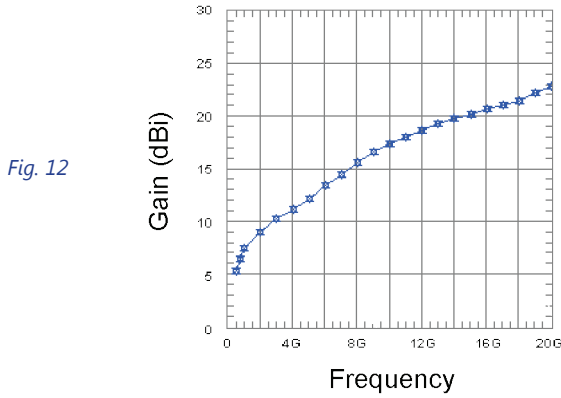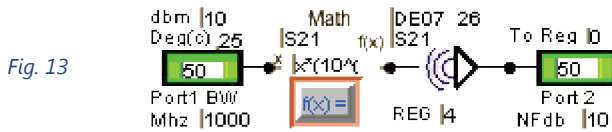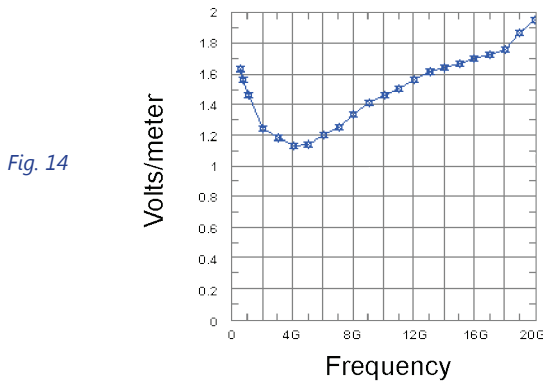

Fig. 10

Fig. 11

We next consider the natural gain profile of the DE700_26 horn. The horn gain exhibits a natural increase with frequency depending on the shape of the lens..
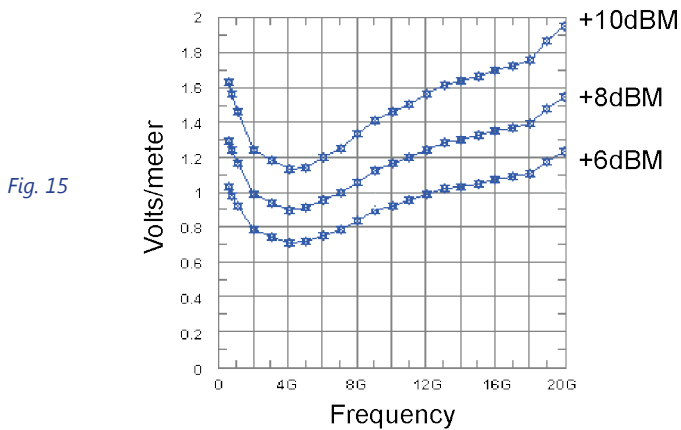
Fig. 12

If we use the DE700_26 horn for the Tx and calculate the volts/meter we see the flattening of the profile.

Fig. 13

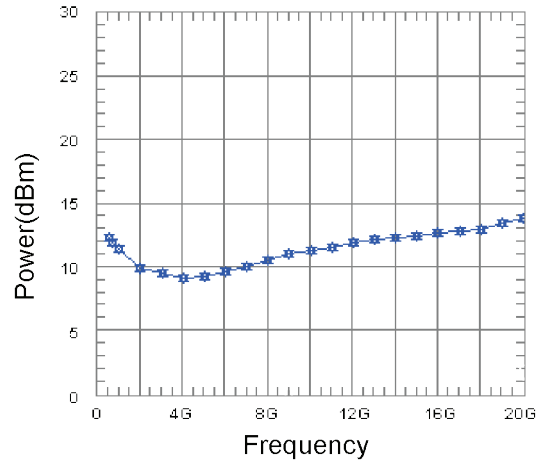*DE700_26 over-compensates cable:*

Fig. 14

The DE700_26 lens overcompensates the cable but still improves the system. We can reduce the drive power until the profile is centered on 1 volt per meter. A drive power of 8dBM produces a variation of only 0.6 volts from 0.5GHz to 20GHz.

Fig. 15

+10dBM

+8dBM

+6dBM

Next, the driver power can be plot by setting the port power to 8dBM and using the simulator "Calculate Power".

This demonstrates the use of defining a Tx which can be made as an integral part of a test system.