Considerations when Selecting an Antenna for an RF Immunity Test System

There are many things besides simple frequency range to consider when selecting an antenna for a particular RF immunity standard. These include the test distance involved, the VSWR presented by the antenna, possible antenna interaction with the test chamber, return loss, and antenna gain.

Test Distance

The equation used to calculate the field strength is

$$\boldsymbol{E} = \sqrt{(\mathbf{30}.\boldsymbol{P}.\boldsymbol{G})}/\boldsymbol{d}$$

Where:
E is the required field strength (v/m)
P is the power at the antenna connector (watts)
G is the gain of the antenna (linear, not dB)
d is the test distance (meters)

Rearranging to make P the subject of the equation

$$\boldsymbol{E}^2 = (\mathbf{30}.\boldsymbol{P}.\boldsymbol{G})/\boldsymbol{d}^2$$

$$\boldsymbol{d}^2\boldsymbol{E}^2 = (\mathbf{30}.\boldsymbol{P}.\boldsymbol{G})$$

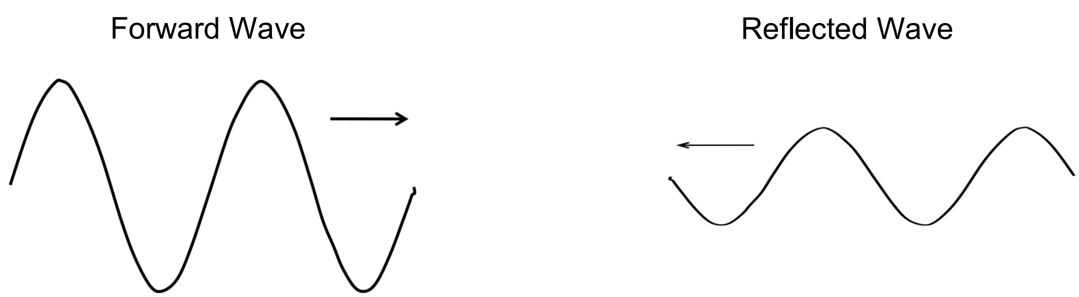
$$\boldsymbol{P} = \frac{\boldsymbol{d}^2\boldsymbol{E}^2}{\mathbf{30}\boldsymbol{G}}$$

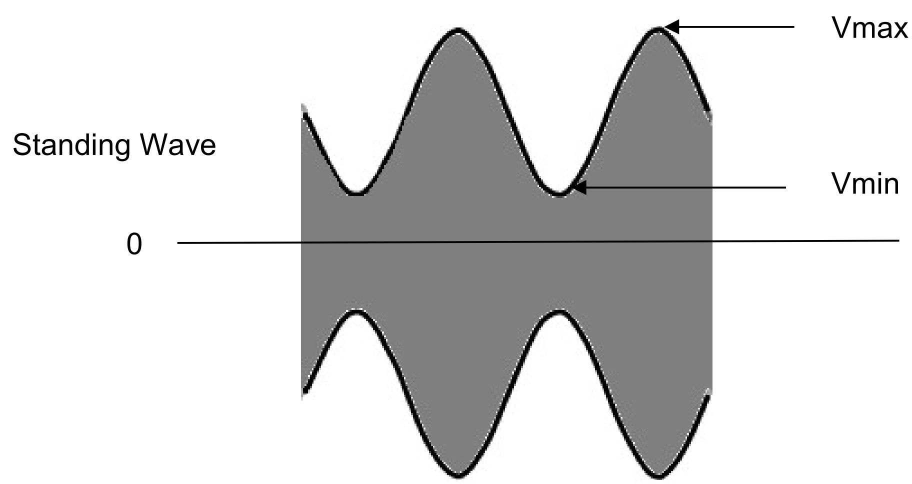
As can be seen, the power required varies as the test distance d squared.
So an increase in test distance from 1 meter to 3 meters requires 9 times the power.

Some standards allow the antenna to be moved closer to the Equipment under Test (EUT), but care should be taken to avoid cross-coupling between the antenna and the EUT.

VSWR

Unless perfectly matched to the feed cable, power will be reflected from the antenna. This results in a reflected wave travelling backwards along the cable. The forward and reflected waves combine to form a standing wave





The standing wave is called 'standing' because the wave moves neither left nor right. Instead the nodes (Vmin) and anti-nodes (Vmax) stay in a fixed position, The voltages at the node / anti-node still oscillate between plus V and minus V.

Note, many texts show just the top half of the standing wave, but this is the output of the diode detector, which means only the top half of the standing wave is depicted.

The VSWR is calculated as Vmax divided by Vmin, hence the word 'Ratio'

High antenna VSWR means much of the forward power is reflected, so the power to the antenna must be increased to achieve the required test field strength.

Lower frequency antennas often present a poor match (high VSWR) at the lower end of their operating band.

<u>Interaction with the Chamber</u>

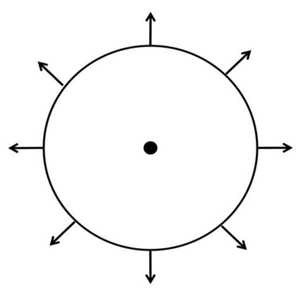
Antenna size can be an issue in that parts of the antenna (long rods, etc.) can be close to the walls / ceiling / floor of the test chamber. This is especially so if the antenna is raised in height as part of the test. This results in non-free space conditions, adversely affecting the performance of the antenna and it's ability to produce the required test field.

<u>Gain Over Isotropic</u>

An isotropic antenna is an ideal, where a point source creates a field that is radiated equally in all directions. Meantime a directional antenna radiates in one direction (ignoring minor side and back lobes).

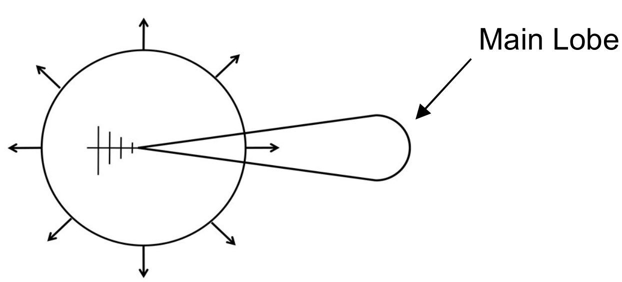
The figure shows the radiation pattern of an isotropic antenna. The antenna itself is depicted as a point source.

Isotropic Antenna Radiation Pattern



The next figure shows a directional antenna pattern superimposed onto an isotropic pattern

Radiation Patterns Compared



As can be seen, the directional antenna concentrates the field in one direction.

Gain over Isotropic (also known as Isotropic Gain) is a figure of merit listed in antenna data sheets in dBi (dB isotropic). When comparing two antennas, the higher the gain number, the better the antenna, as less power is required to create the test field in the direction of the main lobe.

This is confirmed by the previous equation

$$P = \frac{d^2 E^2}{30G}$$

As can be seen, a greater G results in less power required at the antenna to create a particular field strength

However, too narrow a lobe can be an issue when trying to illuminate the calibration plane evenly.

Return Loss

Return loss is closely aligned with VSWR, except that the higher the return loss, the better the match between the feed cable and the antenna. Return loss is the reflection coefficient stated in dB.

The reflection coefficient gamma is the voltage of the reflected wave divided by the voltage of the forward wave

$$\Gamma = \frac{Vref}{Vfwd}$$

To put this in dB notation we apply the formula

Return Loss $RL = 20log(\Gamma)$

In our example of 10% reflected back, this is

$$RL = 20log(0.1)$$

Giving a return loss of 20dB

Summary

Selecting a suitable antenna involves consideration of more than the frequency range covered. Other factors need consideration including power require for a test distance, antenna size, VSWR, gain and return loss. These can be found in the antenna data sheet.