

How to convert dBμV/m test results into Effective Isotropic Radiated Power (EIRP)

Test results for the radiated signal performance of York EMC Services' reference signal generators are supplied in terms of the electric field strength, the units of which are dBμV/m, as this is the common measurement used for EMC emissions tests.

In some cases, for example antenna link calculations, it can be useful to know what the effective isotropic radiated power (EIRP) is. This is a measurement of the power radiated from the source and it can be derived, given a couple of assumptions, from the value given for the electric field strength.

Procedure

The first assumption relates to the measurement environment, namely that it is occurring in free space. Reflections from nearby objects, or the attenuation of the signal by anything other than distance, are not accounted for. A good Fully Anechoic Room (FAR) gives this kind of environment, an Open Area Test Site (OATS) less so because of complications like ground-plane reflections. With this in mind, the basic situation is shown in Figure 1.

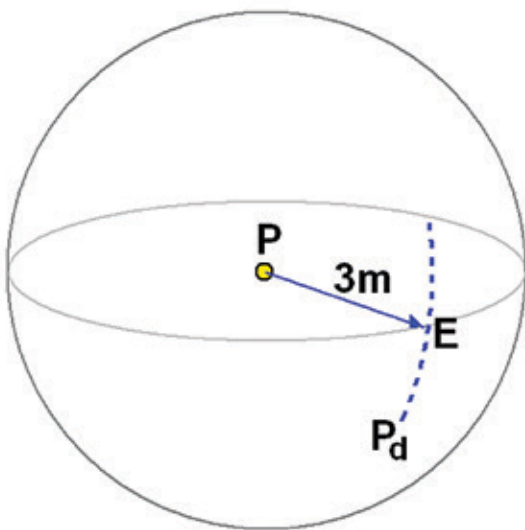


Figure 1. Basic relationship between radiated power and field strength Where P = power (W), E = electric field strength (V/m) and P_d = power density (W/m²)

This highlights the second assumption made, namely that the source is isotropic, radiating equally in all directions. This is not the case for a CNE or CGE using their respective standard monopole and monocone antennas, as they produce a "doughnut"-like radiation pattern. Other antennas exhibit their own non-isotropic radiation patterns. For example, a horn antenna has a highly focussed beamwidth which, in the case of a transmitting antenna, concentrates the power entering it over a small fraction of the total area of the theoretical sphere illustrated above. In this case, because it would be assumed that the same power is

being transmitted in all directions, the EIRP is much higher than the actual input power, which in turn leads to the gain characteristic of the antenna. As such, the EIRP calculated for a non-isotropic antenna is valid only for the particular arrangement of the transmit and receive antennas used to make the measurement.

So, making the assumption that the source is transmitting equally in all directions, the power reaching any point on the sphere described by the measurement distance is;

$$\text{Power Density } P_d = \frac{P}{4 \times \pi \times r^2}$$

Where P is measured in watts and $r = 3 \text{ m}$ in this case.

The power density is also defined by the field strength E and the free-space impedance Z_0 ;

$$\text{Power Density } P_d = \frac{E^2}{Z_0}$$

where E is measured in V/m and $Z_0 = 120\pi$ or approximately 377 Ω. Combining these two gives;

$$\frac{P}{4 \times \pi \times r^2} = \frac{E^2}{120\pi} \quad \text{which rearranged to;}$$

$$P = \frac{E^2 \times 4 \times \pi \times 3^2}{120\pi} \quad \text{simplifying to;}$$

$$P = E^2 \times 0.3$$

It is usual to define the power and field strength in terms of dBm and dBμV/m. Defining E in μV/m gives;

$$P = \left(\frac{E}{10^6} \right)^2 \times 0.3 = E^2 \times \frac{0.3}{10^{12}}$$

Changing P from watts to dBW gives;

$$P_{(dBW)} = 10 \log P_{(W)} = 10 \log \left(E^2 \times \frac{0.3}{10^{12}} \right)$$

$$P_{(dBW)} = 20 \log E + 10 \log \left(\frac{0.3}{10^{12}} \right)$$

which, since this refers to E in terms of μV/m, equates to;

$$P_{(dBW)} = E_{(dB\mu V/m)} - 125.2$$

Finally, to give the conversion in terms of dBm, where 30 dBm = 1 dBW

$$P_{(dBm)} = E_{(dB\mu V/m)} - 95.2$$

In summary, bearing in mind the assumptions being made, the Effective Isotropic Radiated Power can be derived from the 3 m field strength test measurements supplied with the CNE and CGE reference sources by subtracting 95.2 from the numerical value given in dBμV/m. By following the same process for the case of 10 m test measurements, 84.8 should be subtracted instead.