Converting Field Strength to Power

Background

Precompliance testing should be performed during the design process. This can be done with a GTEM cell or at a compliance test laboratory. It is recommended that precompliance testing be performed so that there are no surprises during final compliance testing. This will help keep the product development and release on schedule.

Working with a laboratory offers the benefit of years of compliance testing experience and familiarity with the regulatory issues. Also, the laboratory can often provide feedback that will help the designer make the product compliant.

On the other hand, having a GTEM cell or an open air test site locally offers the designer the ability to rapidly determine whether or not design changes impact the product's compliance. Set-up of an open air test site and the associated calibration is not trivial. An alternative is to use a GTEM test cell.

After the design has been completed and passes compliance testing, final certifications will need to be obtained. Application will need to be made with the respective regulatory bodies for the geographic region in which the product will be operated.

Derivation of Conversion Factors

In the Code of Federal Regulations Title 47, Part 15 there are numerous tables containing limits for emission levels. These limits are usually expressed as field strength in microvolts per meter at a given distance from the radiator. While one could use a field strength meter to measure the emissions of a device, such a test setup is not available in all laboratories. However, most RF laboratories have spectrum analyzers. Thus, it would be desirable to establish a relationship between field strength and power.

The following derivation is simplistic and makes the following assumptions:

- the emission is radiating isotropically
- the signal is being radiated into a sphere
- the power is being radiated evenly over the surface of that sphere
- the efficiency of the radiator is unity

Represent the power density as

$$P_{Density} = \frac{P_{Trans}}{4 \cdot \pi \cdot D^2}$$

Then the electric field, in microvolts per meter, can be represented as

$$E = 1 \cdot 10^6 \sqrt{\frac{377 \cdot P_{Trans}}{4 \cdot \pi \cdot D^2}}$$

Now solve the equation to isolate transmitted power

$$P_{Trans} = \frac{4 \cdot \pi \cdot D^2}{377} \cdot \left(\frac{E}{1 \cdot 10^6}\right)^2$$

For the preceding equations the unit of power (P) is Watts, the unit of field strength (E) is microvolt per meter, the unit of distance (D) is meters.

To convert the power to decibels relative to a milliwatt (dBm), take the common (base 10) logarithm of the power and add thirty as below:

$$P_{Trans}(dBm) = 10 \cdot \log\left[\frac{4 \cdot \pi \cdot D^2}{377} \cdot \left(\frac{E}{1 \cdot 10^6}\right)^2\right] + 30$$

Finally, this equation can be simplified to

$$P_{Trans}(dBm) = 20 \cdot \log(D \cdot E) - 104.7713$$

If the distance is three meters as is the case with many 47 CFR 15 specifications, the equation becomes

$$P_{Trans}(dBm) = 20 \cdot \log(E) - 95.2289$$

Again, D is in meters and E is in µV/m. With this set of equations, one can convert between field strength and power. Below is a table containing some commonly encountered field strengths converted to power in dBm using the above equations.

Field Strength	Power
200µV/m @ 3m	-49.20dBm
500µV/m @ 3m	-41.25dBm
1250µV/m @ 3m	-33.29dBm
12500µV/m @ 3m	-13.29dBm
50mV/m @ 3m	-1.25dBm