Test Procedure For Making Power Density Measurements

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In order to take practical measurements of the power densities generated from cell site antennas the following methodology is suggested:

Power Density Specification is typically presented in mW/cm^2 (milliwatts/square centimeter) units, when referring to measurements taken in the Far Field Region of the cell site antenna. This is because the physical relationship between the Electric and Magnetic components of the Electro-Magnetic Wave Front are quite stable in the Far Field Region, while markedly less so in the Near Field Region. More specifically, in the Far Field Region a Plane Wave exists where the Electric Field Vector (E Field), the Magnetic Field Vector (H-Field), and the direction of propogation are all mutually orthogonal.[1] The Fresnel Region is defined as the transition region between the Near Field and the Far Field Regions, and is given as two (2) times the square of the Largest Physical Dimension of the cell site antenna (in meters), divided by the physical dimension of one wavelength at the frequency being used, in meters.[2] Accordingly, all such power density measurements must be taken beyond the Fresnel Region, in the Far Field Region.

$$\text{Fresnel Region} = \frac{2 \text{ X Largest Antenna Dimension}^2}{\text{Wavelength}} \quad \text{(in meters)}$$

$$\text{Wavelength} = \frac{300}{\text{Frequency in MHz}} \quad \text{(in meters)}$$

First, we must solve for a Wavelength which is given as 300 divided by the Frequency in Megahertz, for meters.[3] At 850 MHz a Wavelength is 0.352941 meters. Accordingly, the Fresnel Region of a typical Swedecom ALP 9212 cell site antenna (1.230769 meters or 4 feet tall) operating at 850 MHz is 8.583827 meters away from the antenna. Far Field Measurements must accordingly be made at a distance greater than 8.583827 meters (approximately 28 feet) from the transmitting antenna.

A practical matched linear half-wave dipole antenna could be used as the power density measurement antenna by simply aligning its axis vertically to match the vertical polarization of the transmitting antenna, which would also act to effectively align its Sine (Doughnut) shaped power pattern such that its gain peak is oriented in the direction of the transmitting antenna.

The Maximum Effective Aperture, of a linear half-wave dipole antenna is given as 0.13 times the Wavelength squared.[4] Therefore, a linear half-wave dipole resonant at 850 MHz has a Maximum Effective Aperture of 161.93755 cm^2.

$$\text{Maximum Effective Aperture} = 0.13 \text{ Wavelength}^2$$

An accurate power measurement device which can distinguish between the amplitude of multiple received signals, from various emitters at various frequencies, and allow accurate power measurement of a specific emitter is a Spectrum Analyzer. The Hewlett Packard HP 8590 series Spectrum Analyzer employs on-screen markers such that precise power measurement in dBm (decibels relative to one milliwatt) of a specific emitter is possible. The frequency in Megahertz of the specific emitter must be programmed into the Spectrum Analyzer and its on-screen marker at the time the power measurement is taken. Power measurements taken in this manner with the HP 8590 series would be traceable to the National Institute of Standards and Technology (formerly the National Bureau of Standards), the highest standard of accuracy. Through the "Trace" funtionality of this series of equipment the "Max Hold" function could be utilized to further capture the absolute highest measurement within the dynamics of the changing fading environment, due to the cancellation and summing of in-phase and out-of-phase reflections, etc. In this way, a truly worst case measurement can be captured.

The methodology prescribed here is therefore to measure the power density on the specific frequency of the cell site antenna via a measurement half-wave dipole in the Far Field Region connected to an HP 8590 series Spectrum Analyzer, and then convert the marker amplitude to mW/cm^2, all in accordance with the finer points elaborated upon herein and below.

The amplitude shown by the Spectrum Analyzer's on-screen marker will be in dBm. The resultant dBm power must be converted to milliwatts (0 dBm = 1 milliwatt). This value is then divided by the effective aperture of the test dipole which is computed as 161.93755 cm^2. This results in the power density at the test dipole in milliwatts per square centimeter (mW/cm^2). As an example, if the Spectrum Analyzer's on-screen marker shows a reading of 0 dBm, we convert this to 1 mW. This figure is then divided by 161.93755 cm^2 to obtain power density at the test dipole of 0.006 mW/cm^2.

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