



RF RADIATION EXPOSURE

Based on ET Docket No. 93-62.

- **<http://www.fcc.gov/oet/rfsafety>**

All Details are in OET Bulletin 65

- **<http://www.fcc.gov/oet/info/documents/bulletins/#65>**

† Near-Field or Fresnel Region:

The radiation is substantially confined within a cylindrical pattern having the same diameter as the antenna. This region may be considered to extend out from the antenna to a distance of R_{nf} as defined on the following slide.*

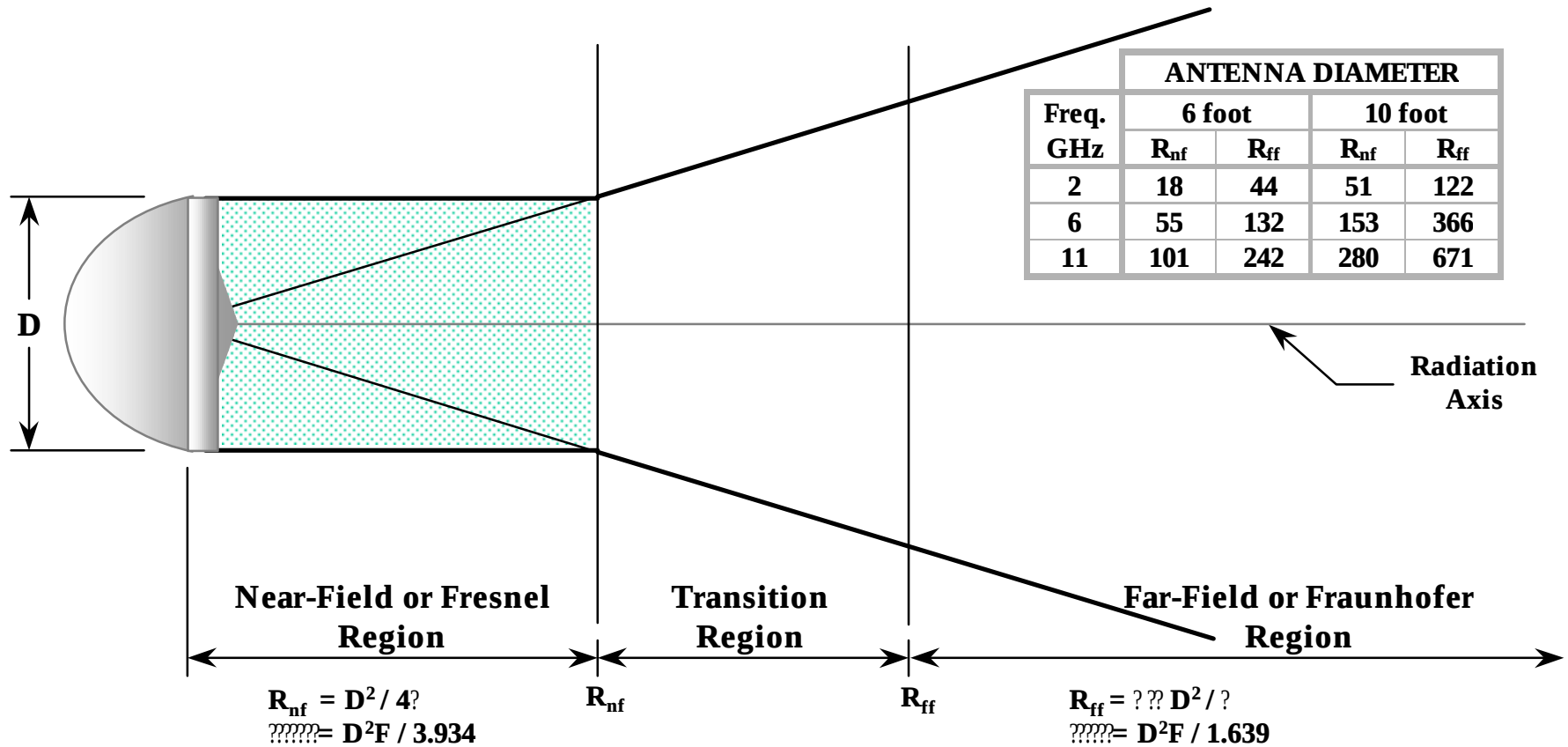
† Transition Region:

Since the distance to the far-field region is two to three times the length of the near-field region, there is a transition region between the two.* Within the transition region the power density decreases inversely with distance.

† Far-Field or Fraunhofer Region:

At a substantial distance from an antenna, the power density begins to decrease in proportion to the inverse square of the distance from the antenna. This occurs at a distance from a parabolic antenna where the difference in path length between a ray on the axis of the beam, and a ray from the edge of the antenna to a given point on the beam axis, is less than $1/16$ of a wavelength. This region begins at a distance designated as R_{ff} as defined on the following slide.

Antenna Near & Far Fields



R_{nf} = Distance from the antenna to Near-Field boundary (ft).
 R_{ff} = Distance from the antenna to Far-Field boundary (ft).
 D = Diameter of antenna (ft).
 λ = Wavelength (ft). F = Frequency (GHz).

Ref.: "Evaluating Compliance with FCC Guidelines
 for Human Exposure to Radiofrequency EM Fields"
 OET Bulletin 65, Edition 97-01, August 1997.
 FCC Office of Engineering and Technology

† Power density calculations for the Near-Field Region of a Parabolic Antenna.

- The magnitude of the on-axis power density varies with location within the near-field. However, the maximum value of the near-field power density can be calculated by the following equation:

$$W_{nf} = \frac{4 \eta P}{D^2} = \frac{16 \eta P}{\pi A}$$

Where: W_{nf} ? Maximum power density in the Near - Field Region in mW / cm²
 η ? Aperture efficiency, typically 50 - 60% for commercially available antennas
 P ? Average transmitter power in mW
 D ? Antenna diameter in cm
 A ? Area of antenna aperture ($\pi D^2/4$) in cm²

† Power density calculations for the Transition Region of a Parabolic Antenna.

- Within the transition region, the magnitude of the on-axis power density decreases inversely with distance from the antenna. Therefore the power density within this region can be calculated the following equation:

$$W_t = W_{nf} R_{nf} / R$$

Where: W_t ? Power density in the transition region in mW / cm^2

W_{nf} ? Maximum power density in the Near - Field Region in mW / cm^2

R_{nf} ? Distance from the antenna to Near - Field boundary in feet

R ? Distance to point of interest in feet

† Power density calculations for the Far-Field Region of a Parabolic Antenna.

- The power density in the far-field region decreases inversely as the square of the distance from the antenna surface. Within this region the power density can be estimated by the following equation:

$$W_{ff} = \frac{P G}{4\pi R^2}$$

Where: W_{ff} ? Maximum power density on axis in the Far - Field Region in mW / cm²

P ? Average power fed to the antenna in mW

G ? Gain of antenna in the direction of interest relative to an isotropic radiator

R ? Distance to the point of interest in cm

FCC Office of Engineering & Technology Bulletin 65 Edition 97-01 (August 1997) Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

Frequency Range (MHz)	Maximum Permissible Exposure (MPE) (mW/cm ²)	
	Occupational/ Controlled Exposure*	General Population/ Uncontrolled Exposure**
30 - 300	1.0	0.2
300 - 1500	$f / 300$	$f / 1500$
1500 - 100,000	5.0	1.0
f = Frequency in MHz * Controlled Environments - A location where individuals are aware of radiation exposure. (Averaging time 6 min.) ** Uncontrolled Environments - Individuals have no knowledge or control over their exposure. (Averaging time 30 min.)		

Exemple:

- Antenna Diameter = 8 ft
- Aperture efficiency = 55%
- Operating frequency = 5.8 GHz
- MW transmitter output = +30 dBm (1Watt)
- Transmission line loss = 0.2 dB (worst case)

Power @ antenna input port = 30 dBm - 0.2 dB = 29.8 dBm

$$P_{mw} = 10^{P_{dbm}/10} = 10^{2.98} = 954.99 \text{ mW}$$

$$D = 8 \text{ ft} \times \text{m}/3.2808 \times 100\text{cm}/\text{m} = 243.84 \text{ cm}$$

$$A = \pi D^2/4 = \pi \times (243.84)^2/4 = 46699.297 \text{ cm}^2$$

W = Power density in Near - Field Region of example system.

$$W = P/A = 954.99 \text{ mW} / 46699.297 \text{ cm}^2 = 0.0204498 \text{ mW/cm}^2$$

- Bulletin-65 Maximum allowable power density for 11.2 GHz is 1.0 mW/cm²,
or 22.2 times greater than calculated maximum power density.

Example:

- Antenna Diameter = 2ft
- Aperture efficiency = 62% (for G=29.3dbi)
- Operating frequency = 5.8 GHz
- MW transmitter output = +30 dBm (1Watt)
- Transmission line loss = 0.2 dB (worst case)

Power @ antenna input port = 30 dBm - 0.2 dB = 29.8 dBm

$$P_{mw} = 10^{P_{dbm}/10} = 10^{2.98} = 954.99 \text{ mW}$$

$$D = 2 \text{ ft} \times \text{m}/3.2808 \times 100\text{cm}/\text{m} = 60.96 \text{ cm}$$

$$A = \pi D^2/4 = \pi \times (60.96)^2/4 = 2918.635 \text{ cm}^2$$

W = Power density in Near - Field Region of example system.

$$W = 4 \pi P / A = 4 \pi \times .62 \times 954.99 \text{ mW} / 2918.63 \text{ cm}^2 = 0.81146 \text{ mW}/\text{cm}^2$$

- Bulletin-65 Maximum allowable power density for 5.8 GHz is 1.0 mW/cm².

**Near-Field Power Density Calculations
for 2, 6, & 11 GHz MW Radios with High Power PA's**

Operating Frequency (GHz)	Power into Antenna-Feeder Losses (dBm)	Antenna Diameter (feet)	Near-Field Power Density (mW/cm²)	Max Permissible Exposure (MPE) (mW/cm²)*
1.96	+30-1.5 = +28.5	6	0.05928	1.00
5.8	+30-0.2 = +29.8	2	0.81146	1.00
5.8	+30-0.2 = +29.8	8	0.04498	1.00
6.2	+33-1.8 = +31.2	10	0.03975	1.00
11.2	+34-4.6 = +29.4	6	0.07295	1.00
11.2	+34-4.6 = +29.4	10	0.02626	1.00

*** Maximum Permissible Exposure for Uncontrolled Environment from FCC OET
Bulletin 65, Edition 97-01; Aug. 97.**