

Power in EM Waves: Example

A cell phone tower has a transmitter with a power of 100 W. What is the magnitude of the peak electric field a distance 1500 m (~ 1 mile) from the tower? Assume the transmitter is a point source.

What is the intensity of the wave 1500 m from the tower?

A) 1.5 nW/m²

B) 3.5 μW/m²

C) 6 mW/m²

$$I = \frac{P}{4\pi r^2} = \frac{100 \text{ W}}{4\pi (1500 \text{ m})^2} = 3.5 \frac{\mu\text{W}}{\text{m}^2}$$

What is the peak value of the electric field?

$$I = \left\langle \left| \vec{S} \right| \right\rangle = \left\langle \frac{|\vec{E} \times \vec{B}|}{\mu_0} \right\rangle = \left\langle \frac{E}{\mu_0} \frac{E}{c} \right\rangle = \frac{1}{\mu_0 c} \frac{E_0^2}{2} \Rightarrow E_0 = \sqrt{2\mu_0 c I}$$

$$E_0 = \left(2 \cdot 4\pi \times 10^{-7} \cdot 3 \times 10^8 \cdot 3.5 \times 10^{-6} \right)^{1/2} = 51 \frac{\text{mV}}{\text{m}}$$