

Electromagnetic Field Analysis of Near Body Wireless Technologies



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Introduction

- Wireless technologies are more integrated into daily life than ever before
- Radiation levels near human bodies are increasing dramatically and the effects are still unknown [1]

Analysis

- The source is a short dipole transmitting different power levels at different radio frequencies
- The magnitude of the E-field is compared between devices at 1 cm away from the transmitter

FCC

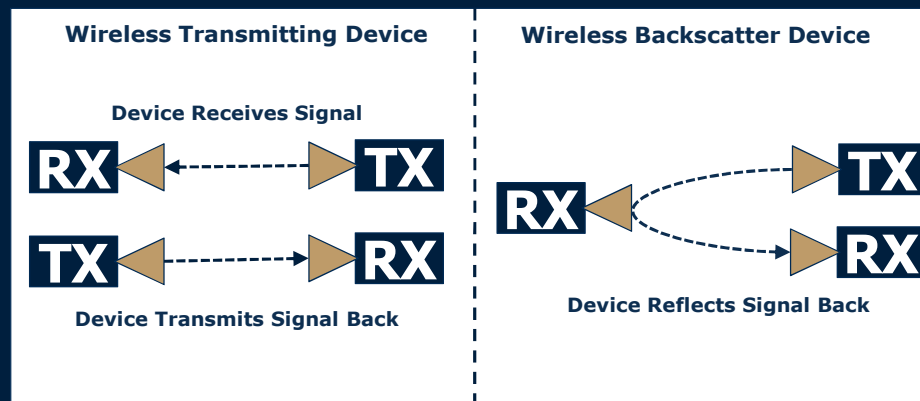
- A portable device is defined as a device normally used within 20 cm of the human body [2]
- Specific absorption ratio (SAR) must be under 1.6 W/kg and is calculated with electric field (E), conductivity (σ), and mass density of tissue (ρ) [2]
- SAR is calculated as follows: [2]

$$SAR = \frac{|E|^2 \sigma}{\rho}$$

Hypothesis / Goal

- Survey of off-the-shelf sensor technologies to compare the electric fields of near body transmitters
- Does backscatter technology reduce the amount of electromagnetic radiation from a near body transmitter?

Traditional Wireless vs. Backscatter



Analysis Setup

Power Radiated From Antenna (P_f)

Electric Field Measured ($|E|$)

1 cm away

Theory for Analysis [3]

$$\sqrt{\frac{12\pi}{\omega\mu\beta}} P_f = Idz$$

$$E = \frac{Idz}{4\pi} \left[\frac{j\omega\mu}{r} + \sqrt{\frac{\mu}{\epsilon}} \frac{1}{r^2} + \frac{1}{j\omega\epsilon r^3} \right] e^{-j\beta r} \sin\theta \hat{\theta} + \frac{Idz}{2\pi} \left[\sqrt{\frac{\mu}{\epsilon}} \frac{1}{r^2} + \frac{1}{j\omega\epsilon r^3} \right] e^{-j\beta r} \cos\theta \hat{r}$$

$$|E| = \sqrt{|E_r|^2 + |E_\theta|^2}$$

Results

Tech.	TX Power (mW)	Frequency (MHz)	E-Field (V/m)	Avg. Dist. Used (m)
Cell Phone	300	1920	3950	8000
Active RFID	3	915	1490	3
Backscatter	1000	915	3	3
WiFi	30	2400	880	20
Bluetooth	3	2400	280	1

Conclusions

- The backscatter RFID system has the lowest electric field of any system at 1 cm away by orders of magnitude
- A change in electric field creates an even larger drop in SAR
- In order to get wireless transmission over long distances, a high electric field nearby may be unavoidable

References

- [1] Aly, A.A. et al. "Research Review on Biological Effect of Cell Phone Radiation on Humans," IEEE, 2008.
- [2] Federal Communications Commission. "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields," June 2001.
- [3] Stutzman W.L. and Thiele, G.A. "Antenna theory and Design." John Wiley and Sons, 1998.

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