Paper presentation – Ultra-Portable Devices

Paper:

S.K.S. Gupta, S. Lalwani, et al., "**Towards a propagation model for wireless biomedical applications**", IEEE International Conference on Communications, 2003. ICC '03, Page(s): 1993 - 1997 vol.3, 2003

Presented by:

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Outline

- Propagation in Free Space Vs. Human tissue

- Power in Propagation of EM waves in Human Tissue

✓ Absorbed Power: Near Field(NF) and Far Field (FF)

✓ Received Power: NF and FF

- Simulation Results

- Experimental Results

- Summary

Free Space Vs. Human tissue Propagation

Free Space

$$\left(\frac{1}{d}\right)^{n}$$

Coefficient of path loss

Rate at which Rx Power decreases.
Other Loss: fading due to multipath.
Model Eg.: Okumura Hata , 2 Ray Model

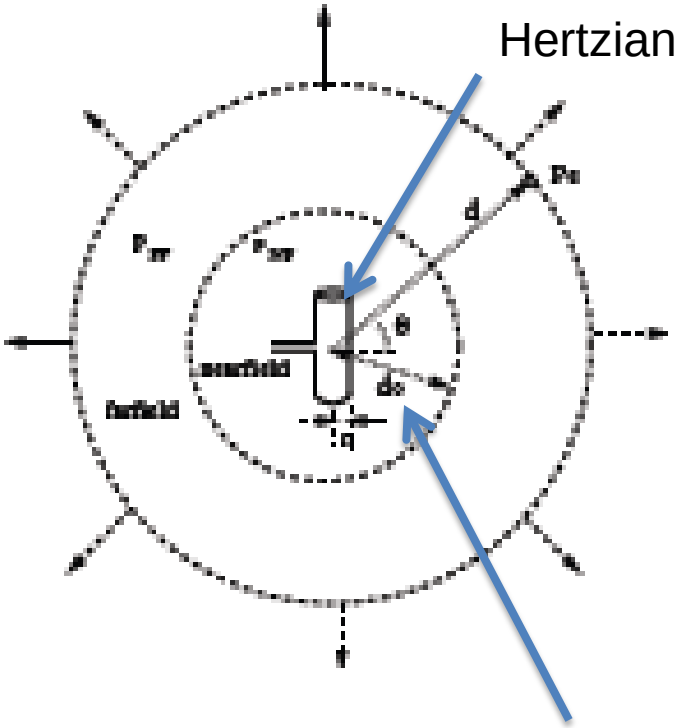
Human Tissue

$$(?)$$

Losses: Due to absorption of power in tissues (dissipated as heat → SAR), attenuation due to lossy medium

Absorbed Power

Power Absorbed = $P_{NF} + P_{FF}$



$$d_0 = \frac{\lambda}{2\pi}$$

Derivation of Power

- SAR in Near field: depends on Magnetic field

Reflection coefficient
(zero in this case as both Tx and Rx in same homogenous medium)

$$SAR_{NF} = \frac{\sigma}{\rho} \frac{\mu\omega}{\sqrt{\sigma^2 + \varepsilon^2\omega^2}} \left(1 + c_{corr}\tau\right)^2 H_{rms}^2 \, watts / Kg$$

Correction factor to take into account changed reflection at small distances

RMS value of H field

Derivation of Power [contd..]

- P_{NF} → average SAR over the entire tissue in NF

$$P_{NF} = \int_{R=r}^{d_0} \int_{\theta=0}^{\pi} \int_{\phi=0}^{2\pi} \Delta P$$

$$SAR_{NF} \times \rho \times dV$$

Derivation of Power [contd..]

- SAR in FF depends upon Electric Field

$$SAR_{FF} = \frac{\sigma}{\rho} E_{rms}^{2} watts / Kg$$

$$P_{NF} = \int_{R=d_0}^{d} \int_{\theta=0}^{\pi} \int_{\phi=0}^{2\pi} \Delta P$$

$$SAR_{FF} \times \rho \times dV$$

Received Power

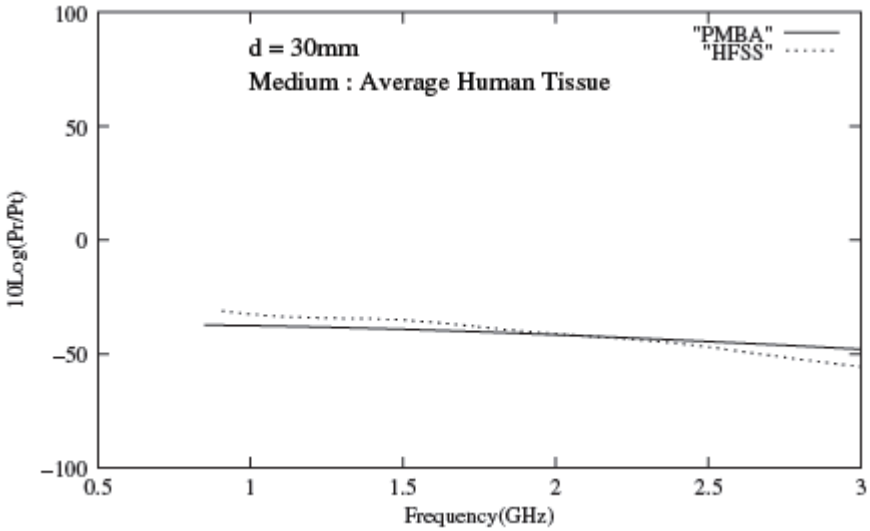
- In NF: No general formula; based on measurement; some approximation for dipoles and monopoles

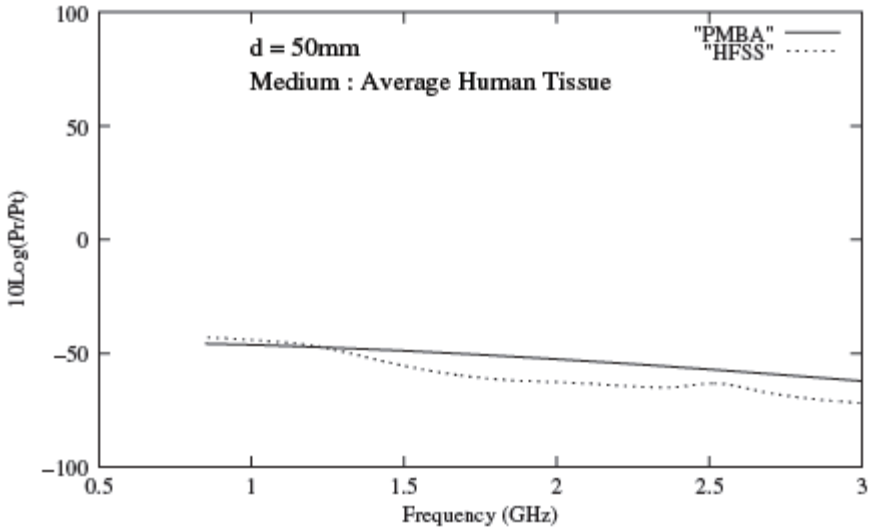
$$P_R = \frac{16\delta(P_T - P_{NF})}{\pi L^2} A_e$$

- In FF: Power density depends upon distance.

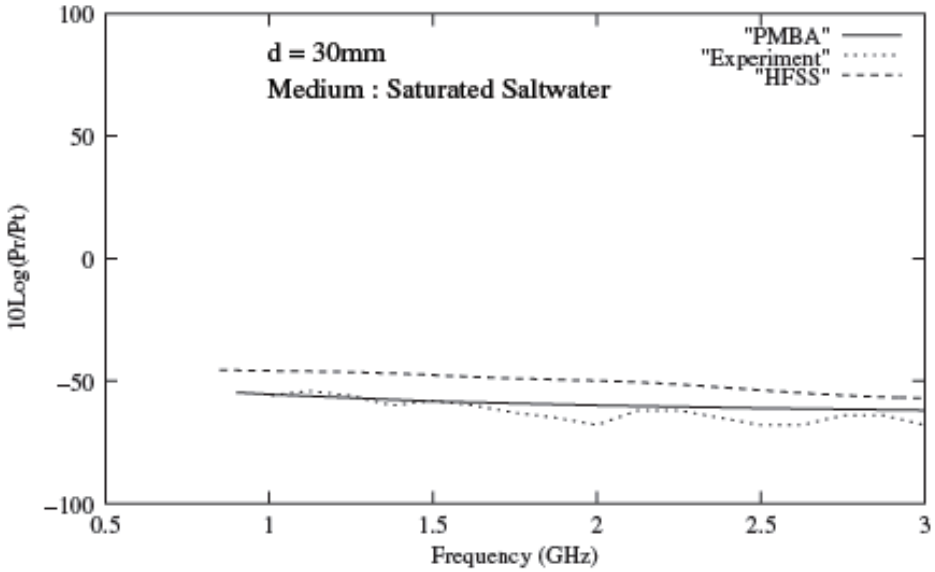
$$P_R = \frac{(P_T - P_{NF} - P_{FF})\lambda^2}{(4\pi d)^2} G_t G_r$$

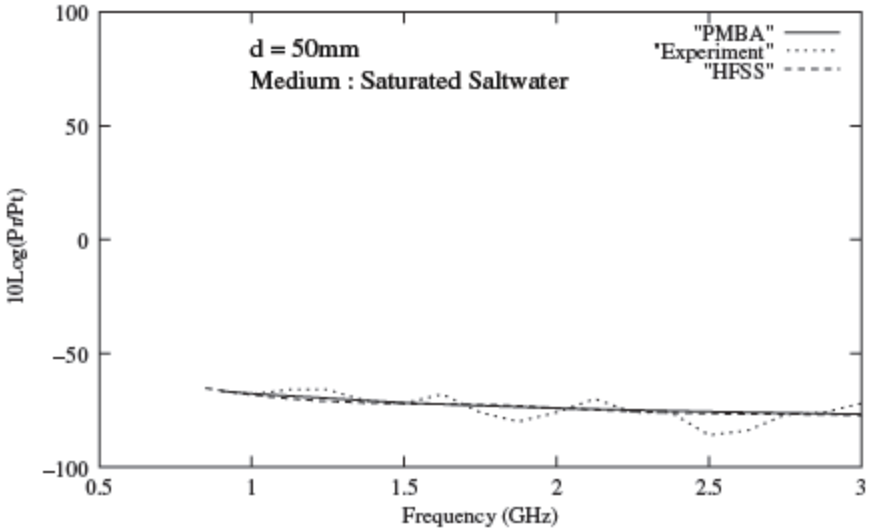
Simulation Results





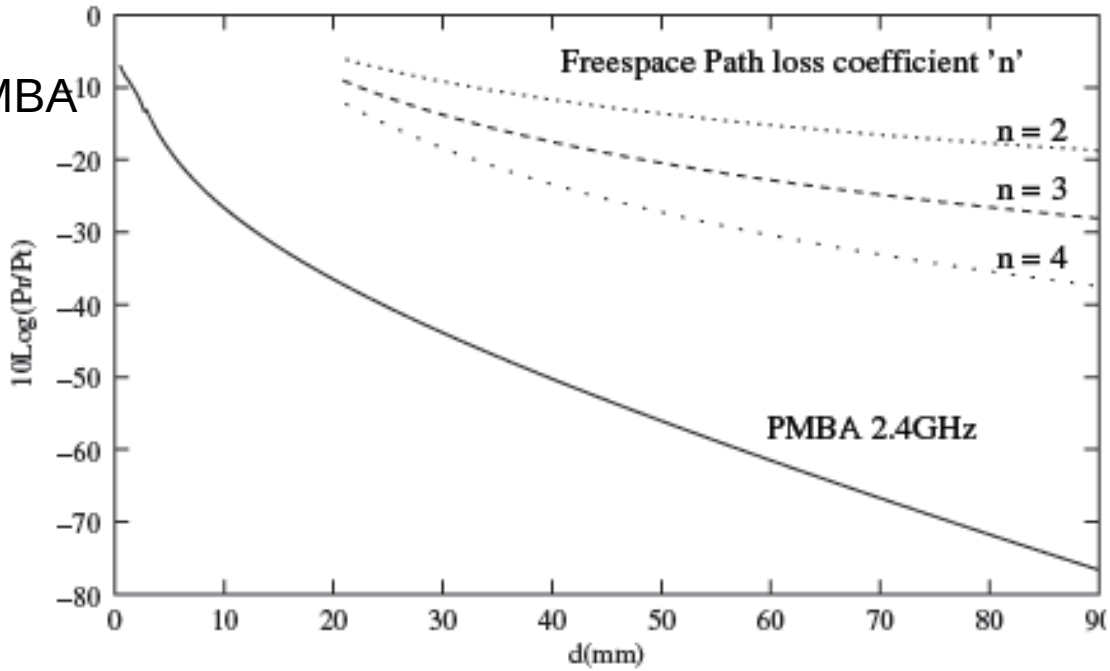
Experiement Results





PMBA vs Free Space Pathloss

- Additional 30-35 dB loss in PMBA



Summary

- Power absorbed in near field has to be taken into account while calculating Pathloss inside human tissues.
- Path Loss Model has been developed for propagation inside homogeneous tissues (PMBA)
- Friis Formula is special case with near field and far field absorption loss equal to zero.