Lecture 29: Radiation Hazards and SAR (Part 2: Measurement & Standards)

Mobile Device

DI05011011: Mobile Communication

Agenda for Today

- 1. How is SAR Measured?
- 2. SAR Measurement Equipment (Phantoms)
- 3. SAR Measurement Equipment (Probes & Liquid)
- 4. International Regulatory Bodies
- 5. SAR Limits by ICNIRP (10g Tissue)
- 6. SAR Limits by FCC (1g Tissue)
- 7. Comparing ICNIRP vs FCC
- 8. Mobile Phone Design and SAR Reduction
- 9. Antenna Placement Strategies
- 10. Dynamic Power Control (DPC)
- 11. SAR Sensors in Modern Smartphones
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How is SAR Measured?

- You cannot accurately measure SAR on a living human due to obvious ethical and practical reasons.
- Instead, SAR is measured in specialized RF laboratories using simulated human heads and bodies.
- The device under test (DUT) is forced to transmit at its absolute maximum power across all its frequency bands.
- A robotic arm with an electric field probe maps the RF energy absorbed inside the simulated tissue.

SAR Measurement Equipment (Phantoms)

- **Phantoms** are physical models representing the human body.
- **SAM (Specific Anthropomorphic Mannequin):** A standardized head phantom based on the 90th percentile of adult male head sizes.
- **Flat Phantoms:** Used to simulate body-worn usage (e.g., phone in a pocket).
- The phantoms are constructed from a thin fiberglass shell.

SAR Measurement Equipment (Probes & Liquid)

- **Tissue Simulating Liquid (TSL):** The phantoms are filled with a liquid recipe (water, sugar, salt, cellulose) that exactly mimics the dielectric properties of human brain/muscle tissue.
- Different frequencies require different liquid recipes.
- **E-Field Probes:** Miniature antennas on the end of a robotic arm that dip into the liquid.
- The probe measures the electric field strength at hundreds of points inside the phantom.

International Regulatory Bodies

- Two main organizations set the global guidelines for RF exposure limits:
- 1. **ICNIRP** (International Commission on Non-Ionizing Radiation Protection): Adopted by Europe, Australia, and most of the world.
- 2. **FCC** (Federal Communications Commission): Adopted by the USA, Canada, and parts of Asia.
- Both base their limits on preventing the body temperature from rising by 1°C.

SAR Limits by ICNIRP

- **Limit:** 2.0 W/kg.
- **Averaging Mass:** Averaged over 10 grams of contiguous tissue.
- **Why 10g?** It represents a volume roughly the size of a golf ball. ICNIRP believes this better represents the macroscopic heating effect.
- Generally considered a slightly less stringent measurement method than the FCC.

SAR Limits by FCC

- **Limit:** 1.6 W/kg.
- **Averaging Mass:** Averaged over 1 gram of contiguous tissue.
- **Why 1g?** It represents a much smaller volume, roughly the size of a sugar cube. It is designed to capture peak localized hotspots more aggressively.
- Generally considered the most stringent SAR standard in the world.

Comparing ICNIRP vs FCC

- You cannot directly compare an FCC SAR value with an ICNIRP SAR value.
- - A phone might have an FCC SAR of 1.2 W/kg (1g) and an ICNIRP SAR of 0.8 W/kg (10g).
- - The 1g measurement will almost always result in a higher calculated number because it finds smaller, more intense hotspots.
- - Both limits incorporate a safety factor of 50x below the known threshold for thermal damage.

Mobile Phone Design and SAR Reduction

- Engineers must carefully design smartphones to pass these strict regulations.
- Key strategies include:
- 1. Antenna Placement.
- 2. Material selection (RF shielding).
- 3. Software-controlled Dynamic Power Control.
- 4. Hardware SAR sensors.

Antenna Placement Strategies

- The antenna is the source of the radiation.
- **Historically:** Antennas were at the top of the phone (near the ear/brain).
- **Modern Design:** Primary cellular antennas are often moved to the bottom of the phone, near the microphone.
- This places the radiation source closer to the jaw/neck and further from the brain, reducing head SAR significantly.

Dynamic Power Control (DPC)

- The base station (cell tower) and the mobile phone constantly talk to adjust transmit power.
- If a phone has a strong signal, the tower tells it to turn its transmit power down.
- This saves battery and dramatically reduces SAR.
- A phone only transmits at maximum power (the tested SAR value) when it has a very weak signal (e.g., deep inside a building).

SAR Sensors in Modern Smartphones

- Many modern smartphones, especially tablets and 5G devices, include dedicated 'SAR Sensors' (usually capacitive proximity sensors).
- These sensors detect if a human body part is very close to the transmitting antenna.
- If flesh is detected, the phone automatically forces the modem to lower its transmit power limit to ensure it stays below regulatory limits.
- If the phone is placed on a table (no flesh detected), it transmits at higher power.

Summary

- SAR is measured in labs using SAM phantoms and tissue-simulating liquids.
- ICNIRP (10g, 2.0 W/kg) and FCC (1g, 1.6 W/kg) set the global safety limits.
- Both standards provide a 50x safety margin against thermal damage.
- Engineers reduce SAR via antenna placement (bottom of phone) and dynamic power control.
- Modern devices use capacitive sensors to back off power when near the body.

Next Lecture Preview

- In our final lecture on Radiation Hazards, we will explore:
- **1. Mitigation Techniques for Users:** How you can reduce your exposure.
- **2. Public Perception:** Addressing common myths and fears.
- **3. 5G Technology:** Are millimeter waves more dangerous?