

# Lecture 30: Radiation Hazards and SAR (Part 3: Mitigation & Future)

## Mobile Device

DI05011011: Mobile Communication

# Agenda for Today

- 1. Mitigation Techniques for Users
- 2. The Inverse Square Law in Practice
- 3. Impact of Network Coverage
- 4. Base Station vs. Mobile Device Radiation
- 5. Public Perception and Misconceptions
- 6. Epidemiological Studies
- 7. The Precautionary Principle
- 8. 5G Technology and Radiation
- 9. Millimeter Waves (mmWave)
- 10. Skin Depth and Absorption
- 11. Beamforming in 5G
- 12. Example: 4G Broadcast vs 5G Beamforming
- 13. Summary of Radiation Hazards
- 14. Preview

# Mitigation Techniques for Users

- While compliant phones are considered safe, users who wish to apply the precautionary principle can reduce their exposure:
- 1. **Use Hands-Free Options:** Speakerphone, wired earphones, or Bluetooth headsets.
- 2. **Text Instead of Call:** Texting keeps the phone away from the head and transmits data in short bursts.
- 3. **Limit Call Duration:** Shorter calls mean less total energy absorbed.
- 4. **Avoid Low Signal Areas:** Do not make long calls when you have 1 bar of signal.

# The Inverse Square Law in Practice

- RF energy obeys the **Inverse Square Law**: Intensity is inversely proportional to the square of the distance from the source.
- Moving a phone just a few inches away from your head drops the absorbed energy dramatically.
- - Distance = 1 cm - Power = 100%
- - Distance = 2 cm - Power = 25%
- - Distance = 10 cm - Power = 1%
- This is why speakerphones and headsets are so effective.

# Base Station vs. Mobile Device Radiation

- A common public fear is living near a cell tower (Base Station).
- **Fact:** You receive vastly more radiation from the phone in your pocket than from a tower 100 meters away.
- Base stations transmit at higher power (20W - 100W), but because of the inverse square law, the energy reaching the ground is minuscule.
- Protesting a cell tower in your neighborhood ironically forces your phone to transmit at maximum power, increasing your personal exposure.

# Public Perception and Misconceptions

- **Myth:** 'Radiation from phones causes brain tumors.'
- **Reality:** Major epidemiological studies (studying millions of users over decades) have not found a conclusive link between phone use and brain cancer rates.
- While cell phone use has skyrocketed since the 1990s, brain cancer incidence rates have remained flat.
- Organizations like IARC classify RF as 'possibly carcinogenic' (Group 2B)—the same category as pickled vegetables and aloe vera extract.

# The Precautionary Principle

- Because latency periods for some cancers can be 20-30 years, continuous monitoring is required.
- Health agencies advocate the **Precautionary Principle**: taking reasonable measures to avoid exposure just in case unknown risks exist.
- This is why SAR limits have massive safety margins (50x below harm threshold) built into them.
- Special attention is given to children, as their skulls are thinner and brains are still developing.

- The rollout of 5G caused significant public concern.
- 5G uses three spectrum bands:
  1. **Low-band:** Similar to 4G (sub-1 GHz).
  2. **Mid-band:** Similar to Wi-Fi (1 - 6 GHz).
  3. **High-band (mmWave):** 24 GHz to 100 GHz. (This is the new part).
- Despite the higher frequencies, 5G is still **strictly non-ionizing**.

# Millimeter Waves (mmWave) and Skin Depth

- Physics dictates that the higher the frequency, the lower the penetration depth into biological tissue.
- 4G frequencies penetrate a few centimeters into the body.
- **5G mmWave frequencies penetrate only a few millimeters.**
- They are almost entirely absorbed by the outer layers of the skin and the cornea of the eye.
- They do not reach the brain or internal organs.

# Beamforming in 5G

- 4G cell towers broadcast RF energy in a wide sector (like a floodlight), exposing everyone in the area.
- 5G uses **Massive MIMO and Beamforming**.
- Beamforming acts like a spotlight. It directs a focused beam of RF energy directly to the user's device, and nowhere else.
- Result: Ambient RF exposure for people not actively using their devices is significantly reduced in a 5G network compared to 4G.

## Example: 4G Broadcast vs 5G Beamforming

- **Scenario:** You are sitting on a park bench. Someone 10 meters away is downloading a large movie.
- - **In a 4G network:** The tower blasts a wide signal. Both you and the downloader are bathed in the RF energy.
- - **In a 5G network:** The tower creates a targeted beam to the downloader's phone. You, sitting 10m away, receive almost zero RF energy from that transmission.

# Summary of Radiation Hazards

- Users can minimize exposure via distance (headsets) and ensuring good signal.
- Living near cell towers actually reduces your personal device's transmit power.
- Decades of research show no conclusive link between non-ionizing RF and cancer.
- 5G utilizes mmWaves which do not penetrate deep into the body.
- 5G beamforming reduces ambient RF pollution compared to older broadcast technologies.

- In the next lecture, we transition to a new unit: 4G and 5G Networks.
- **1. Introduction to 4G technology:** The shift to pure IP networks.
- **2. Features of 4G.**
- **3. Types of 4G:** LTE vs WiMAX.