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Communication Systems

Structure of Earth's Atmosphere and EM Wave Interaction

The atmosphere primarily contains nitrogen (78%) and oxygen (21%), with minor amounts of argon, carbon dioxide, water vapour, and other trace gases. It is layered as follows:

- **Troposphere (0–12 km):** Weather phenomena occur here; temperature falls with altitude.
- **Stratosphere (12–50 km):** Contains ozone; temperature rises with altitude.
- **Mesosphere (50–80 km):** Temperature drops with height.
- **Ionosphere (80–400 km):** Rich in ions and electrons; important for reflecting radio waves.
- **Greenhouse Effect:** Greenhouse gases trap heat radiated by Earth, leading to warming.

Modes of EM Wave Propagation

1. **Ground Wave:** Travels close to Earth's surface; suitable for frequencies below 1.5 MHz.
2. **Sky Wave:** Reflected by ionosphere; used for frequencies between 2 and 30 MHz.
3. **Space Wave:** Propagates directly through atmosphere; requires LOS (line of sight).
    - Transmission range:

$$d_T = \sqrt{2Rh_T}, \quad d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R}$$

Concept of Modulation

- **Definition:** Modifying a high-frequency carrier wave using a low-frequency message signal.
- **Why Needed:**
    1. Practical antenna size.
    2. Minimises signal overlap.
    3. Efficient transmission.

Types of Analog Modulation

- **AM (Amplitude Modulation):** Amplitude of carrier varies.

$$\mu = \frac{A_m}{A_c}$$

  Bandwidth $= 2f_m$.
- **FM (Frequency Modulation):** Frequency varies with message amplitude.
- **PM (Phase Modulation):** Phase of the carrier is modulated.

Signal Bandwidth Requirements

- Speech: 300 Hz – 3.1 kHz
- Music: 20 Hz – 20 kHz
- Video: up to 4.2 MHz
- TV: about 6 MHz

Basic Communication System Components

- **Transmitter:** Converts message into transmittable signal.
- **Receiver:** Extracts original message from received signal.

Optical Fiber Transmission

- **Principle:** Uses total internal reflection within core-cladding structure.
- **Core:** High refractive index (n_1); Cladding has lower refractive index (n_2).
- **Acceptance Angle:**

$$\sin\theta_e = \frac{\sqrt{n_1^2 - n_2^2}}{n_0}, \quad \text{for air } (n_0 = 1)$$

$$\sin\theta_e = \sqrt{n_1^2 - n_2^2}$$

- **Devices:** LED or laser as transmitter, photodiode as receiver.