Transmission Media → Guided Media and Unguided Media

1. Transmission Line Characteristics
   (i) Primary Parameters:
   - Series resistance per unit length (R) of two conductors
   - Inductance per unit length (L) of the conductor
   - Capacitance per unit length (C) between the two conductors
   - Seaking conductance per unit length (G)

   ![Diagram of primary parameters]

   \[ Z_c = \frac{1}{\sqrt{LC}} \]

   → Propagation constant (Y) (determines attenuation & phase change)
   \[ Y = \sqrt{\frac{R+j\omega L}{G+j\omega C}} \]

   (ii) Secondary Parameters:
   → Characteristic impedance (Z_c) (Input impedance)
   \[ Z_c = \frac{1}{\sqrt{LC}} \]

   (iii) Phase Velocity & Phase delay:
   \[ v = \frac{\Delta A}{\Delta t} = \frac{\omega}{\beta} \]
   \[ T = \frac{1}{v} = \frac{\beta}{\omega} \]

   (iv) Frequency dependence of secondary parameters:
   At low frequency, \( \omega L \ll R \) and if \( b = 0 \) - then
   \[ Z_c = \sqrt{\frac{R}{LC}} \]
   \[ Y = \sqrt{j\omega LC} \]

   At high frequency, \( \omega L \gg R \) and if \( b = 0 \) - then
   \[ Z_c = \sqrt{\frac{1}{LC}} \]
   \[ Y = \sqrt{-\omega^2LC + j\omega RC} \]
2. Distortion -
Distortion is when received signal is different from transmitted signal. For distortionless transmission,
→ amplitudes of all frequency components are multiplied by the same factor
→ all frequency components are delayed by the same amount when they are transmitted.
Two types of distortion, attenuation, and phase distortion.

3. Crosstalk -
When two transmission lines are very close, they interfere with each other and it results in crosstalk i.e. signals of one line cross over to the other. Crosstalk occurs due to three types of mutual coupling between the lines:
→ **Galvanic coupling** - due to common resistance of the two lines
→ **Capacitive coupling** - due to capacitance between the conductors
→ **Inductive coupling** - due to mutual inductance of the two lines

4. Guided Media -
→ Twisted Pair Cable
   - Unshielded Twisted Pair Cable (UTP)
   - Shielded Twisted Pair Cable (STP)
One wire → carry signals to the receiver
Another wire → ground reference
UTP connector is RJ45

[Diagram of UTP and STP cables]

[Diagram of plastic cover → UTP]
Electromagnetic Polarization:

It is the property of EM waves that can oscillate in more than one direction. It means polarization of electric field.

Wavefront:

It is an idealized model of light, obtained by choosing a line that is perpendicular to the wavefronts of the actual light.

Electromagnetic Spectrum:

<table>
<thead>
<tr>
<th>Radio wave &amp; Microwave</th>
<th>Infrared</th>
<th>Ultraviolet</th>
</tr>
</thead>
<tbody>
<tr>
<td>300 KHz</td>
<td>300 GHz</td>
<td>300 THz</td>
</tr>
</tbody>
</table>
Radiation and Propagation of Waves:

- Electromagnetic Radiation is a form of energy released by electromagnetic processes.

Propagation of Waves:
- Ground Propagation (below 2 MHz)
- Sky Propagation (reflected by ionosphere) (2-30 MHz)
- Line of sight propagation (above 30 MHz)

Inverse Square Law:
An intensity of light is inversely proportional to the square of the distance from the source.

\[
\text{Intensity} \propto \frac{1}{(\text{distance})^2}
\]

Wave Attenuation:
- It is defined as reduction in power density with increase in distance. The reduction in power density is equivalent to power loss hence it is called attenuation.

Wave Absorption:
The earth atmosphere consists of particles. They can absorb electromagnetic energy. The reduction in power due to energy absorbed by particles is called absorption loss.

Skip Distance:
- It is a distance on the earth's surface between the two points where radio waves from a transmitter, refracted downward by different layers of the a ionosphere, fall.
Wireless transmission
- Radio Waves (3KHz - 1GHz) - Omnidirectional Antenna (all directions)
- Microwaves (1GHz - 300GHz) - Unidirectional Antenna (parabolic dish antenna)
- Infrared (300GHz - 400THz) - Satellite Communication System

Telephone Network:
1. Components:
   - Two local loops
   - Trunks
   - Switching offices

2. LATA's (Local Access Transport Areas):
   - It is handled by end-nets and tandem switches
   - Intra-LATA services (telephone companies)
   - Inter-LATA services (long-distance companies)

3. Signalling:
   - Basic circuit for voice and signalling
   - Cross-band signalling (different circuit)

4. Services:
   - Analog Services
     - Analog Switched Services
     - Analog Leased Services
   - Digital Services
     - Switched/ISDN services - 56Kbps
     - Digital Data Services - digital version of analog leased service (64Kbps)
DSL (Digital Subscriber Line) - to provide high-speed access to the Internet:

- ADSL (Asymmetric DSL) → 56K modem, residential use.
- VDSL (Very high bit rate DSL) → 25–55 Mbps
- HDSL (High bit rate DSL) → nearly 2 Mbps
- SDSL (Symmetric DSL) → 768 Kbps, business use

5. Cable TV network for data transfer:

<table>
<thead>
<tr>
<th>Data upstream</th>
<th>Video band</th>
<th>Data downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 MHz</td>
<td>42–54 MHz</td>
<td>550 MHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>750 MHz</td>
</tr>
</tbody>
</table>

Variable cable band