Unit IV

The Subscriber Loop:

- The **subscriber loop** is the physical link between a telephone subscriber and the public switched telephone network (PSTN).
- Typically, it consists of a pair of copper wires (or fiber in modern systems) running from the subscriber's location to the local telephone exchange.
- It carries both voice signals and control signals for call setup and teardown.
- **Definition**: The physical connection linking a telephone subscriber (home or business) to the Public Switched Telephone Network (PSTN).
- **Medium**: Typically consists of a **pair of copper wires**, with **fiber optics** being more common for higher speeds.
- **Functions**:
  - Carries **voice signals** for phone calls.
  - Carries **control signals** for call setup, ringing, and disconnection.
  - Can carry **data signals** (e.g., via DSL) for internet access alongside voice calls.
- **Connection**: Links the subscriber’s premises to the local **telephone exchange**, where calls are routed.
- **Bidirectional**: Allows both **sending and receiving** of signals during a call.
- **Upgrades**: Traditional **copper loops** are being replaced by **fiber optics** in many areas for better speed and quality.

TelePhone Set

A **telephone set** is a device used for making and receiving voice calls over a telecommunication network, such as the Public Switched Telephone Network (PSTN) or modern digital systems. It consists of several components that work together to convert sound into electrical signals for transmission and then convert those electrical signals back into sound for the user to hear.

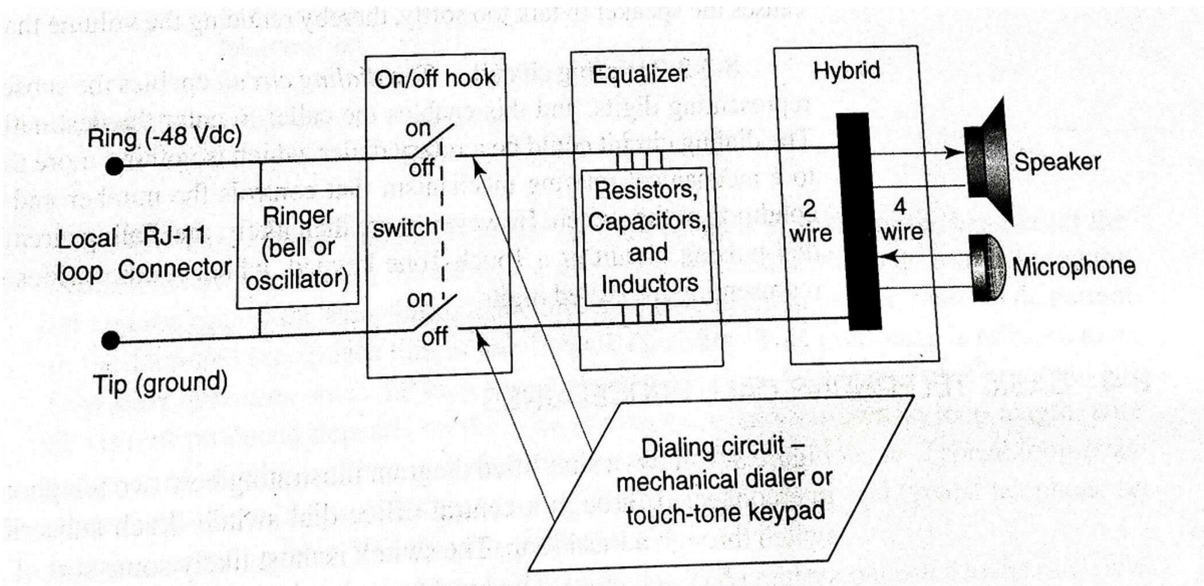
Functions of a Telephone Set:

A **telephone set** allows a user to make and receive voice calls over a network like the PSTN (Public Switched Telephone Network) or modern digital systems. The basic functions of a standard telephone set are:

1. **Microphone (Transmitter)**:
   - Function: Converts the user's voice (sound) into electrical signals.

- It captures the sound waves produced when a person speaks and converts them into analog or digital electrical signals that can be transmitted over the network.

2. **Speaker (Receiver)**:
    - Function: Converts electrical signals back into sound.
    - It receives the signals from the network and converts them into sound waves that the user can hear.
3. **Dialer**:
    - Function: Used to dial a phone number to make a call.
    - **Rotary Dialer**: An old mechanical dialer where the user rotates a disk with numbered holes to input the phone number.
    - **Push-button Dialer**: A modern dialer with buttons (usually with the digits 0-9) that send the corresponding number signals when pressed.
4. **Ringer**:
    - Function: Alerts the user to an incoming call.
    - It generates a sound (usually a ringing tone) when the telephone receives a call signal from the exchange or network.
5. **Hook Switch**:
    - Function: Detects when the phone is in use or idle.
    - When the user lifts the receiver, the hook switch completes the circuit, allowing the phone to send and receive signals. When the receiver is replaced, the circuit is broken, ending the call.
6. **Signal Processing (in Digital Telephones)**:
    - Function: Enhances the quality of the voice signal.
    - Digital phones often include **Digital Signal Processing (DSP)** to improve voice clarity and reduce noise. It may also handle compression, echo cancellation, and other functions to improve call quality.



Microphone: Captures sound and converts it to an electrical signal.
Amplifier/Signal Processor: Amplifies the signals and, in digital systems, may process them (e.g., noise filtering, echo cancellation).

Hook Switch: Detects whether the phone is in use or idle and determines when to send or receive signals.
Dialer: Allows the user to input the phone number to initiate a call.
Speaker: Converts the incoming electrical signals into sound so the user can hear the other party.
Ringer: Alerts the user when a call is incoming.
Connection to PSTN: Provides the physical connection to the telephone network for call setup and routing.

Procedure Of Telephone Set

1. Off-Hook (Signaling Initiation):

- The user lifts the handset, causing the telephone to transition from an **on-hook** (idle) state to an **off-hook** (active) state.
- This action closes the loop in the subscriber's line circuit, which allows a small electrical current (loop current) to flow from the telephone exchange.
- The exchange detects this current and interprets it as a request to initiate a call. The system then generates a **dial tone**, indicating readiness to accept dialing input.

2. Dialing (Addressing):

- The subscriber enters the recipient's number through either:
    - A **rotary dial**, which transmits a sequence of electrical pulses corresponding to each digit.
    - A **dual-tone multi-frequency (DTMF)** keypad, which generates pairs of audio frequencies unique to each key.
- The telephone exchange decodes these signals and maps the digits to the appropriate **subscriber line identifier**.
- In some cases, this may involve accessing a routing database in the Public Switched Telephone Network (PSTN) to locate the recipient's terminal equipment.

3. Ringing (Alerting):

- The exchange sends an **AC ringing signal** (typically 20–60 Hz) to the recipient's telephone line to activate the phone's ringer.
- Simultaneously, the caller receives a **ringback tone** (an audible indication that the call is being processed).
- The alerting continues until the recipient goes off-hook or the call times out.

4. Connection (Establishment of the Speech Path):

- When the recipient answers the call (off-hook state), the telephone exchange detects the cessation of the ringing signal current.

- The exchange then establishes a **two-way communication channel** (or speech path) between the caller's and recipient's subscriber lines.
- Analog systems utilize **4-wire to 2-wire hybrid circuits** for separating incoming and outgoing signals, while modern digital systems rely on **Time Division Multiplexing (TDM)** for transmitting voice data.

5. Call Termination (Disconnect and Resource Release):

- When either party hangs up (returns to the on-hook state), the circuit loop is broken.
- The exchange detects this event, terminates the communication path, and releases the associated network resources (trunk lines, switches, etc.).
- If the call involves a long-distance connection, additional signaling protocols (e.g., SS7) may facilitate the teardown of intermediate connections.

This process illustrates the integration of **analog signaling**, **switching technologies**, and **protocols** like SS7 (Signaling System No. 7) in modern telephone systems, ensuring efficient and reliable communication.

(Or)

1. **Off-Hook**:
   - You lift the phone handset to start a call.
   - This action completes the circuit and informs the telephone exchange that you want to make a call.

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2. **Dialing**:
   - You enter the phone number using a rotary dial or keypad.
   - The telephone exchange receives the number and begins routing the call.

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3. **Ringing**:
   - The telephone exchange sends a ringing sound to the recipient's phone.
   - At the same time, you hear a ring-back tone, letting you know the recipient's phone is ringing.

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4. **Connection**:
   - When the recipient answers (lifts their handset), the circuit is completed.
   - This allows you both to hear and talk to each other.

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5. **Call Termination**:
   - When either person hangs up (puts the handset back), the circuit is broken.
   - The call disconnects, and the telephone line becomes available for another call.

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Call Progress Tones and Signals

These are signals sent during a phone call to indicate its status, either from one machine to another or between machines and people. These signals ensure that the call setup and termination process is completed properly.

- **Purpose of Call Progress Tones**:
  These tones help keep the telephone system in order by indicating things like whether the phone is ready to dial, whether the recipient's phone is ringing, or if the network is busy.

Categories of Signaling

Signaling can be divided into two main types:

Station Signaling

- **What it is**:
  Station signaling happens between your telephone (the **station**) and the local switching machine (also known as a **telephone exchange**) through the phone line (loop).
- **What it does**:
  It helps manage the basic communication between your phone and the system. For example, it lets you know:
  - **Dial Tone**: Your phone is ready to make a call.
  - **Busy Signal**: The person you are trying to reach is already on another call.
  - **Ring-back Tone**: The phone you called is ringing, and you're waiting for someone to pick up.
- **Use**:
  This signaling makes sure that your phone and the telephone exchange can communicate correctly. It tells you whether the line is ready to use, if the other phone is busy, or if the call is ringing.

Interoffice Signaling

- **What it is**:
  Interoffice signaling occurs between different telephone exchanges (switching machines) when a call needs to be routed to another area or phone line.
- **What it does**:
  It helps the telephone system direct the call from one exchange to another. For example, if you're calling someone in a different city or country, interoffice signaling is

used to route your call through multiple exchanges to reach the other person's phone.
- **Use**:
  This signaling ensures that your call can travel across different areas and systems to get to the right destination. It helps connect calls between different telephone exchanges and networks.

Summary:

- **Station Signaling**: Ensures communication between your phone and the local telephone exchange, like when you hear a dial tone or a busy signal.
- **Interoffice Signaling**: Makes sure your call can travel between different telephone exchanges if you're calling someone far away.

Types of Signaling Messages

Signaling messages can be further divided into four types:

1. **Alerting**:
   - These signals alert both the calling and receiving parties that a call is being made or is being received.
   - Example: The **ringing tone** you hear when a call is being connected.
2. **Supervising**:
   - These signals monitor the status of the call, ensuring everything is going as planned (e.g., verifying that the line is still open or connected).
3. **Controlling**:
   - These signals help manage the call setup and termination processes, such as sending a signal to stop ringing once the call is answered.
4. **Addressing**:
   - These signals involve identifying the correct recipient or destination for the call, such as dialing the correct phone number or routing the call to the right exchange.

Off-Hook and On-Hook Conditions

1. **Off-Hook**:
   - When you lift the phone handset (or go off-hook), the telephone completes the circuit by closing a switch inside the phone.
   - This signals the telephone exchange that you are ready to make a call or answer one.
   - The **off-hook** condition is what allows the phone system to recognize that you're trying to initiate or receive a call.

    - **Example**: You pick up the phone to make a call. The switch inside the phone detects that the handset is lifted, and it sends a signal to the telephone exchange (or switching machine) to indicate that you are now off-hook.
2. **On-Hook**:
    - When you place the handset back on the cradle (or go on-hook), the circuit is broken, and the phone goes into an idle state.
    - In this state, there's no current flowing in the line, and the phone is **not** ready for use.
    - **Example**: You finish a call and place the handset back on the cradle. The phone is now on-hook, and the connection is terminated.

Off-Hook Signal and Ring Trip

- **Off-Hook Signal**: When the telephone receiver (handset) is lifted (off-hook), the telephone sends a signal (off-hook signal) to the central switching machine to indicate that the caller is ready to make or receive a call.
- **Ring Trip**: At the receiving end, when the recipient lifts the handset (goes off-hook), the switching machine detects this off-hook condition and **trips** (ends) the **ringing signal** to stop the phone from ringing. This tells the caller that the recipient has answered the call.

Summary of the Process:

- **Off-Hook**: Initiates the phone line to make a call (phone is in use).
- **On-Hook**: Ends the phone line connection (phone is idle).
- Call progress tones and signals help guide the status and flow of the call between the calling party, receiving party, and telephone exchanges.

This system ensures that every step in making a call—from dialing to talking to hanging up—happens in an orderly and efficient way.

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Simple Explanation of Electronic Telephones

Modern telephones have replaced many mechanical parts with **electronic circuits**. These electronic phones use small, powerful chips and processors to handle various tasks like dialing, storing numbers, and even showing caller ID. Here's how they work:

Main Parts of an Electronic Phone:

1. **Integrated Circuit (IC) Chip**:
   This is the main chip inside the phone that combines many functions, like:

    - **DTMF Tone Generator**: Makes the sounds (tones) when you press the keys on the phone to dial numbers.
    - **Microprocessor Interface**: Controls the phone's features like storing numbers, auto-dialing, and redialing.
    - **Memory (RAM)**: Stores temporary data like phone numbers.
    - **Tone Ringer**: Makes the ringing sound when someone calls.
    - **Speech Network**: Manages sound (your voice and the other person's voice).
    - **Voltage Regulator**: Converts power from the phone line to power the phone's electronics.
2. **Microprocessor (MPU)**:
   This small computer inside the phone controls all the functions, like:
    - Storing phone numbers.
    - Redialing numbers automatically.
    - Managing **caller ID**.
3. **Touch-Tone Keypad**:
   The set of buttons you press to dial. Each button sends a unique tone to the phone network, telling it which number you're dialing.
4. **Speaker and Microphone**:
   The microphone picks up your voice, and the speaker plays the other person's voice.
5. **Tone Ringer**:
   This makes the phone ring when there is an incoming call. Modern phones use a small electronic sound element (instead of a bell) to make the sound.
6. **External Crystal**:
   Helps keep the tones you send (like when dialing) accurate and stable.
7. **Voltage Regulator**:
   Ensures that the phone gets the right amount of power from the phone line to work properly.

How It All Works:

1. When you pick up the phone (**off-hook**), it sends a signal to the network.
2. The **microprocessor** manages things like storing numbers and dialing.
3. When you press the keys, the **DTMF(Dual-Tone Multi-Frequency) tone generator** sends the correct tones to dial the number.
4. The **tone ringer** sounds when you get a call.
5. The **speech network** makes your voice loud enough to be heard, and the other person's voice clear.
6. The **voltage regulator** makes sure the phone's electronics are powered correctly.

Why This Is Important:

Even though modern phones have many features like caller ID or auto-dialing, they still connect to the phone network the same way older phones did. This keeps everything compatible while making phones smaller and more powerful.

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Caller ID:

- **Caller ID** is a telecommunication feature that allows the recipient to see the phone number (and sometimes the name) of an incoming caller before answering.
- The information is sent as part of the call setup and displayed on a special screen on the telephone set or via a service provider's display feature.
- Caller ID may also include the geographic location of the call, depending on the service provider.

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Local Subscriber Loop:

A **local subscriber loop** (also known as the **subscriber line** or **telephone loop**) is the physical connection that links a subscriber's telephone to the local telephone exchange or central office. It is the path through which voice and data signals travel between a subscriber's telephone and the telephone network.

How It Works:

1. **Connection to the Exchange**:
   - The local loop starts at the telephone exchange (or central office) and extends to the user's phone.
   - It can be made of copper wires (traditional twisted pair) or fiber-optic cables (in more modern systems).
2. **Signal Flow**:
   - When you pick up the handset (off-hook), the phone sends a signal through the loop to the exchange, indicating that the user wants to make a call.
   - The exchange routes the call to the correct destination, sending back signals for dialing tones, ringing tones, or call status updates.
3. **Communication Path**:
   - During a call, the local loop carries the audio signals between your phone and the person you are speaking to.
   - It is also used for sending other data, like touch-tone (DTMF) signals when you press the keys on your phone.
4. **Power Supply**:
   - The telephone exchange provides a small DC voltage to power the telephone through the local loop, especially for traditional landline phones.
5. **Termination**:
   - When the call ends, the loop is "on-hook," meaning the circuit is open, and no current flows through the loop.

Key Features:

- **Two-Wire or Four-Wire**:
  The loop can consist of two wires for basic voice calls or four wires in more advanced systems (for separate send and receive signals).

- **Distance Limitation**:
  The performance of the local loop can degrade over long distances (especially in older copper-wire systems), leading to reduced signal quality or slower internet speeds in broadband connections.

How It Works:

- **Copper Wires**: The loop is made of **two copper wires** twisted together. These wires carry the signal from your phone to the telephone exchange (the main phone system).
- **Main Purpose**: The main job of the loop is to give you access to the phone network. Without it, you wouldn't be able to make or receive calls.

Signal Problems in the Local Loop:

- **Attenuation (Signal Loss)**: As your signal travels down the wires, it gets weaker. This is called **attenuation**. Over long distances, the signal can become too weak to use.
- **Phase Distortion**: Different sound frequencies (like the different parts of a voice) can get shifted by different amounts as they travel. This can cause distortion, making the call sound unclear.

What Affects the Signal:

The performance of the local loop depends on the **physical properties** of the wires:

1. **Wire Thickness**: Thicker wires usually reduce signal loss.
2. **Spacing Between Wires**: The distance between the two wires can affect how the signal travels.
3. **Insulation**: The material that separates the wires helps control how the signal moves.
4. **Conductivity**: How well the copper wires carry the signal.

These factors determine how well the signal travels and how much it gets distorted.

Main Components of the Local Loop:

1. **Feeder Cable**:
   This is the big cable that carries signals from the central office to the area where people live. It can carry a lot of wires inside it, connecting many homes and businesses.
2. **Serving Area Interface (SAI)**:
   This is where the big feeder cable is split into smaller cables to reach individual homes. It's like a distribution point.

Summary:

The local subscriber loop is the direct connection between a telephone and the central office, used for making calls, transmitting signals, and powering the phone. It's a critical part of traditional telephone networks and still forms the backbone of communication between users and the phone system.

The local subscriber loop is the system of wires that connects your phone to the telephone network. It carries signals, but the signal weakens over distance and can get distorted. The loop is made of copper wires, and its quality depends on factors like wire thickness and how the wires are spaced. The system includes large cables for long distances and smaller cables to connect to homes.

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Telephone Message-Channel Noise and Noise Weighting

Telephone Message-Channel Noise

- **Noise** in a telephone circuit refers to any unwanted electrical signals that interfere with the clarity of the voice transmission during a phone call.
- **Message-channel noise** is the specific type of noise that occurs within the **communication channel** (the wire or fiber-optic line) that carries the actual telephone message (your voice).
- The noise can come from various sources, including:
    - **Electrical interference** from nearby electrical devices (like lights or machines).
    - **Signal degradation** due to long-distance transmission, which weakens the signal over time.
    - **Crosstalk**: When signals from one line leak into another, causing interference.

This noise can result in **poor sound quality**, where the voice may become distorted or difficult to hear.

Noise Weighting

- **Noise weighting** is a technique used to **measure and account for the noise** in a telephone circuit by considering how human ears perceive different frequencies of sound.
- **Why it's important**: Our ears are more sensitive to certain frequencies than others. For example, we can hear higher frequencies better than very low frequencies, so the impact of noise at higher frequencies is more noticeable to us.
- **How it works**: Noise weighting applies a **filter** to the noise measurement to reflect this difference in perception. It essentially "weights" the noise according to how loud it would sound to a human listener.

Common types of noise weighting include:

- **A-weighting**: This is the most commonly used type of weighting. It emphasizes mid-range frequencies, where the human ear is most sensitive. It's used to measure general noise levels in many contexts.
- **C-weighting**: Used for measuring peak noise levels, particularly for noise that may have high-intensity, short bursts (like clicks or pops).

In telephone systems, **noise weighting** helps in assessing the impact of noise on the quality of the call, giving a more accurate representation of the actual listening experience.

In Simple Terms:

- **Message-channel noise**: Unwanted sounds or interference that distort your phone call.
- **Noise weighting**: A way to measure and account for noise in a way that reflects how people actually hear it (because we hear some types of noise more than others).

By using noise weighting, engineers can evaluate the quality of a telephone line more accurately, helping them improve the clarity of the call by minimizing the most disturbing types of noise.

1. A-Weighting

- **Purpose**: A-weighting is the most common method used to measure noise in general situations, like phone calls or environmental noise.
- **Why it's used**: The human ear is most sensitive to **mid-range frequencies** (like human speech), so A-weighting adjusts the measurement to reflect this sensitivity.
    - It **lowers** the weight (or importance) of very **low frequencies** (like deep bass sounds) and very **high frequencies** (like high-pitched noises).
    - It **emphasizes** mid-range sounds, which are where most of our hearing sensitivity lies.
- **Example**:
  When you hear a buzzing sound during a phone call, it may not bother you as much if it's a low-frequency hum (like a rumble), but a high-pitched squeal would be much more irritating. A-weighting helps measure the noise in a way that matches this perception, focusing on frequencies that are most bothersome to your ear.
- **Where it's used**:
    - Measuring general noise levels in rooms (like in offices or homes).
    - Evaluating phone call quality and ambient noise in environments.

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2. C-Weighting

- **Purpose**: C-weighting is used for measuring **peak noise levels**, particularly for short, **intense bursts** of sound.

- **Why it's used**: C-weighting allows a more **accurate measurement** of higher-intensity noises, like **clicks**, **pops**, or other brief loud sounds.
  - It doesn't adjust the low and high frequencies as much as A-weighting does, so it gives a **more balanced** measurement of the entire range of frequencies.
- **Example**:
  If you're listening to a phone call and suddenly hear a loud pop or click, C-weighting helps measure the **intensity** of that noise. This is important because **short bursts** of loud sounds can be more disturbing than continuous background noise, even if they're brief.
- **Where it's used**:
  - Measuring loud, sudden noises like **engine noise** in vehicles.
  - Monitoring **peak sounds** in systems that require accuracy in handling short, loud disturbances (such as in professional audio equipment).

Summary of Differences:

- **A-Weighting**: Focuses on **mid-range frequencies** (most sensitive to the human ear). Used for **general noise levels** (like phone calls or environmental noise).
- **C-Weighting**: Measures **peak or burst noises**, especially intense, short noises (like clicks or pops). It's more **balanced** across all frequencies, often used for **loud bursts of noise**.