EGERTON UNIVERSITY

EEEN 462 – ANALOGUE COMMUNICATIONS

INTRODUCTION TO ANALOG PRIVATE AUTOMATIC BRANCH EXCHANGE (PABX)

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1. PRACTICAL SESSION OBJECTIVES

Upon successful completion of this practical session, you will be able to:

1. **Identify** the key hardware components of a typical analogue PABX system.
2. **Explain** the basic operational principles of call setup, switching, and termination within the PABX.
3. **Configure** basic PABX features such as station numbering, call forwarding, and ring patterns.
4. **Analyze** and trace the signaling tones (Dial Tone, Ringback Tone, Busy Tone) during a call.
5. **Troubleshoot** common PABX line faults using a multimeter and logical deduction.

2. PREREQUISITES

- Basic understanding of telephone signaling (DTMF, loop start signaling).
- Familiarity with using a digital multimeter (DMM).
- Knowledge of basic electrical circuits (voltage, current, resistance, short circuit, open circuit).

3. EQUIPMENT AND SOFTWARE REQUIRED

- **PABX System:** Analog PABX (e.g., a legacy system like Panasonic KX-TA series, Siemens HiPath 1000 series, or a similar model available in the lab).
- **Telephone Sets:** At least 3 analog telephone handsets.
- **Trunk Line:** One analog telephone line (PSTN) or a simulated trunk line (e.g., from another PABX or an FXS port of a VoIP gateway).
- **Test Equipment:**
    - Digital Multimeter (DMM)
    - Oscilloscope (optional, for advanced analysis)
- **Cabling:** RJ11 telephone cables and patch cords.
- **Documentation:** PABX Installation and Programming Manual.

4. THEORETICAL BACKGROUND

A Private Automatic Branch Exchange (PABX) is a private telephone network used within an enterprise. It switches calls between internal users (extensions) while allowing all users to share a certain number of external phone lines (trunks) for making calls outside the company.

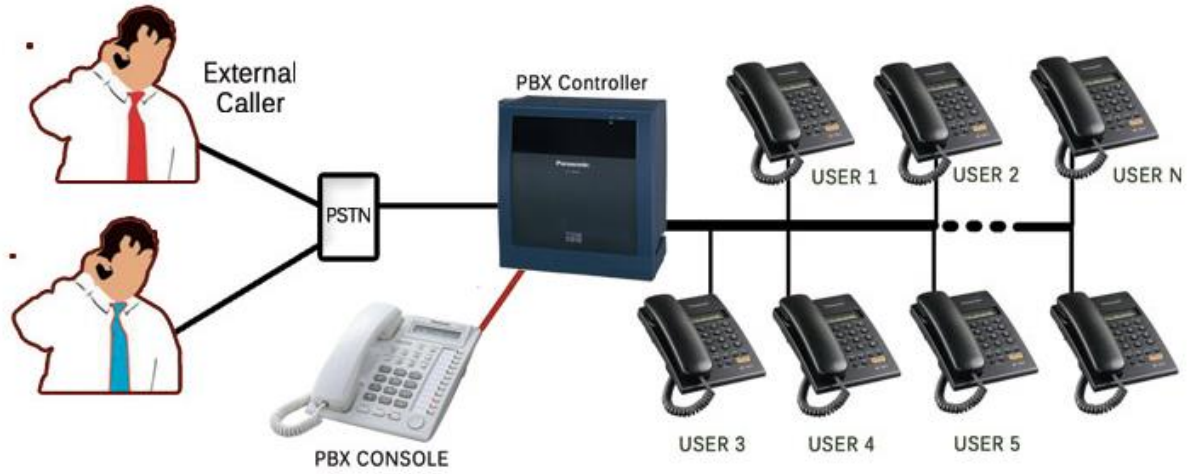

Figure 1. Functional units of a Private Automatic Branch Exchange (PABX)

A Private Automatic Branch Exchange (PABX) offers significant advantages primarily through **cost efficiency and enhanced internal communication**. By allowing numerous internal users (extensions) to share a limited number of external trunk lines, it drastically reduces the expense of subscribing to individual phone lines for each employee. Furthermore, it enables free and feature-rich communication between extensions, improving operational coordination with functions like call transfer, conferencing, and voicemail. The system also provides **centralized management**, allowing for streamlined billing, security controls, and scalable growth as the organization expands, making it a highly economical and functional solution for businesses.

4.1 Key Components:

1. **Central Processing Unit (CPU):** The brain of the PABX that controls call processing and feature activation.
2. **Switching Matrix:** The hardware that creates the electrical path (the "circuit") between two extensions or an extension and a trunk.
3. **Line Cards:** Interface cards for connecting analog telephone sets (extensions).
4. **Trunk Cards:** Interface cards for connecting to the Public Switched Telephone Network (PSTN).
5. **Power Supply:** Provides operating power, typically with a battery backup for operation during a power outage.

4.2 Basic Call Signaling (Analog Loop Start):

- **On-Hook:** The telephone handset is on the cradle. The circuit is open (high resistance, ~DC 48V on the line).
- **Off-Hook:** The handset is lifted. The telephone closes the circuit (low resistance, ~DC 20V, DC current flows ~20-50mA). This signals the PABX to provide a **dial tone**.
- **Dialing:** The user sends digits, typically as Dual-Tone Multi-Frequency (DTMF) signals (e.g., pressing '5' sends 1336 Hz + 770 Hz).
- **Alerting:** The PABX sends a **ringing signal** (e.g., 90V AC, 20 Hz) to the destination extension and a **ringback tone** to the caller.

- **Answering:** The called party goes off-hook, the PABX connects the audio path, and conversation begins.
- **Termination:** When one party goes on-hook, the PABX detects the open circuit and releases the connection.

5. PRACTICAL PROCEDURE

5.1 System Familiarization and Physical Setup

1. **Safety First:** Ensure all equipment is powered off before making any connections.
2. **Physical Inspection:** Locate and identify the following components on the PABX chassis:
    - CPU / Main Control Unit
    - Power Supply Unit
    - Slot for Extension/Station Cards (Line Cards)
    - Slot for Trunk Cards
    - Specific ports labelled for extensions (e.g., Ext. 101, 102,....) and trunks (C1, C2).
3. **Cabling:**
    - Connect three analogue telephone handsets to three different extension ports (e.g., Port 1, 2, and 3).
    - Connect one analog trunk line to a trunk port (e.g., Line 1).
4. **Power Up:** Switch on the PABX system. Allow a few minutes for it to initialize.

5,1: Basic Configuration via System Programming

Note: Programming is typically done from a designated "system phone" (often Extension 101). Refer to the specific PABX manual for exact codes.

1. **Assign Extension Numbers:**
    - Program the PABX so that the physical port for your first phone is assigned number **101**, the second **102**, and the third **103**.
    - *Example Command (check manual):* # 1 0 1 [PROG] might assign extension 101 to the port you are programming from.
2. **Verify Operation:** Lift the handset of phone 101. You should hear an internal dial tone. Dial 102. Phone 102 should ring, and phone 101 should hear a ringback tone. Answer from phone 102 and have a brief conversation. Verify two-way audio.
3. **Configure a Feature - Call Forwarding:**
    - On phone 102, program it to forward all calls to extension 103.
    - *Example Command:* *72 103 [PROG] (This varies by system).
    - **Test:** Call 102 from phone 101. Phone 102 should not ring; instead, phone 103 should ring.

5.3 Signal Analysis and Measurement

Use the DMM to measure DC voltages. Use the oscilloscope (if available) to observe AC signals like ringing and DTMF.

1. **On-Hook Voltage:**
    - At an unused extension port, measure the DC voltage between the Tip (T) and Ring (R) conductors. Record your reading. (Expected: ~48V DC).
2. **Off-Hook Voltage:**
    - Lift the handset on the phone connected to that port. Measure the DC voltage again. Record your reading. (Expected: ~6-20V DC, depending on line length and current).
3. **Observe Call Progress Tones:**
    - Using the oscilloscope, probe the line of an extension phone.
    - Lift the handset and observe the **Dial Tone** (often a continuous 350 Hz + 440 Hz tone).
    - Dial another extension and observe the **Ringback Tone** (e.g., 440 Hz + 480 Hz, 2 seconds on, 4 seconds off).
    - Ask the lab partner to leave their phone off-hook. Dial their number and observe the **Busy Tone** (e.g., 480 Hz + 620 Hz, 0.5 seconds on, 0.5 seconds off).

5.4 Troubleshooting Simulation

The instructor will introduce a fault into one of the extension lines.

1. **Symptom:** Phone 103 is dead (no dial tone).
2. **Diagnosis:** Using the DMM in resistance (ohms) mode (with the phone disconnected and PABX powered off for safety):
    - Check for a **Short Circuit:** Measure resistance between Tip and Ring. A very low resistance (e.g., < 10 Ω) indicates a short.
    - Check for an **Open Circuit:** Measure resistance between Tip and Ring. A very high resistance (e.g., > 1 MΩ) indicates a break in the line.
    - Check the **Telephone Handset:** Test the handset's resistance off-hook. It should be a low resistance (a few hundred ohms).
3. **Report:** Identify the most likely type of fault (short or open) based on your measurements.

6. OBSERVATIONS AND RESULTS

Please record your findings in a structured table.

Activity	Measurement/Observation	Expected Value	Your Reading
On-Hook Voltage	DC Voltage (T-R)	~48V DC	
Off-Hook Voltage	DC Voltage (T-R)	~6-20V DC	
Dial Tone Frequency	(If using scope)	e.g., 350+440 Hz	
Ringback Tone Pattern	On/Off timing	e.g., 2s on, 4s off	

Troubleshooting	Resistance (T-R) on faulty line	(Identify: Short/Open)	

7. POST-LAB QUESTIONS

1. Explain the significant voltage drop observed between the on-hook and off-hook states. What causes this drop?
2. Describe the sequence of events and signals that occur from the moment you lift the handset on extension 101 to the moment you start speaking with someone on extension 102.
3. What is the primary economic advantage of using a PABX for a medium-sized business compared to giving each employee a direct PSTN line?
4. Compare and contrast the traditional Circuit-Switching used in this PABX with the Packet-Switching used in modern VoIP systems. List one advantage of each.

8. REFERENCES

1. PABX System Manufacturer's Manual (e.g., Panasonic KX-TA308 Installation Manual).
2. Freeman, R. L. *Telecommunication System Engineering*. Wiley.
3. "Telephone Signalling Basics." Tutorials on AllAboutCircuits.com or similar.