MODEMS

EEEN 464 – DIGITAL COMMUNICATION

Friday, 10 April 2026

WHERE WE ARE IN THE SYLLABUS

Course Purpose:
To enable students understand the fundamental principles of digital transmission systems as used in fixed and mobile telephony, wired and wireless computer networks, data storage and digital broadcasting.

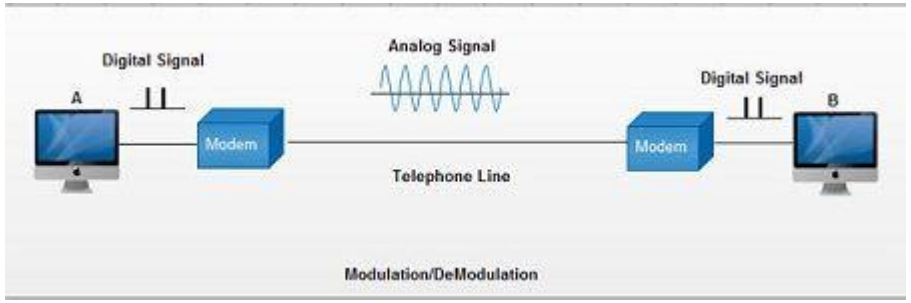
Expected Learning Outcomes:
At the end of the course, students will be able to:

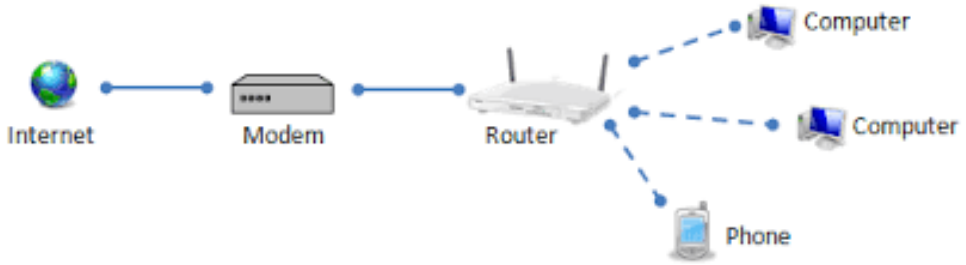
(i) describe binary and duo binary pulse Amplitude Modulation (PAM);
(ii) design digital coding schemes;
(iii) derive error performance equations for digital modulation schemes(ASK,FSK,PSK,DPSK);
(iv) state strengths and weaknesses of M-ary PSK with QAM signaling schemes;
(v) design a basic digital communication systems.

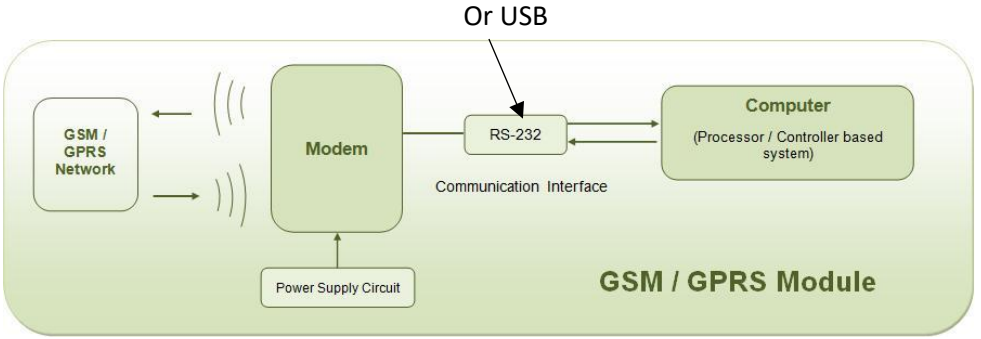
Course Content:
Signal digitization: Pulse Amplitude Modulation (PAM), sampling theorems and sampling circuits, Pulse code modulation (PCM). Quantization and signal conditioning: Uniform and non-uniform quantization; companding methods; vocoders; signal-to- quantization noise ratio. Waveform coding: Pulse transmission, PCM, Pulse-shaping; Delta modulation; adaptive delta modulation; Differential Pulse Code Modulation (DPCM), M-ary encoding. Digital Modulation: Amplitude shift keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), Quadrature Amplitude Modulation (QAM) and Differential Phase Shift Keying (DPSK). Signal recovery in ASK, FSK and PSK; Gaussian Minimum Shift Keying (GMSK); Performance comparison. Information theory: information sources, entropy, channel capacity; Source Coding; entropy coding. Error control: Error control coding techniques; Transmission errors; Error detection methods; intersymbol interference and the eye pattern; Linear block codes; Cyclic codes; convolution codes. Multiplexing: Frequency division multiplex (FDM), Time Division Multiplexing (TDM), plesiochronous digital hierarchy (PDH). Spread spectrum communication: Direct sequence and frequency hopping methods; synchronization, spreading codes and their generation. Data transmission: Local data transmission protocals (Ethernet, token ring); Modems; high Asymmetric Digital subscriber line (ADSL); Very–high Speed Digital subscriber line (VDSL), integrated services digital network (ISDN).

WHAT IS A MODEM?

1. A modem (MODulator-DEModulator) is an electronic device that transforms a signal to a form suitable for transmission on a channel, and also decodes such transmitted information from the receiver to the original form.
2. The goal is to produce a signal that can be transmitted and decoded easily to reproduce the original digital data.
3. The most common modem is a internet modem that turns the digital data of a personal computer into modulated electrical signals in the voice frequency range of a telephone channel.
4. Modems are generally classified by the amount of data they can send in a given unit of time, usually expressed in bits per second (bit/s, or bps)







MODEM IN GENERAL COMMUNICATION SYSTEM

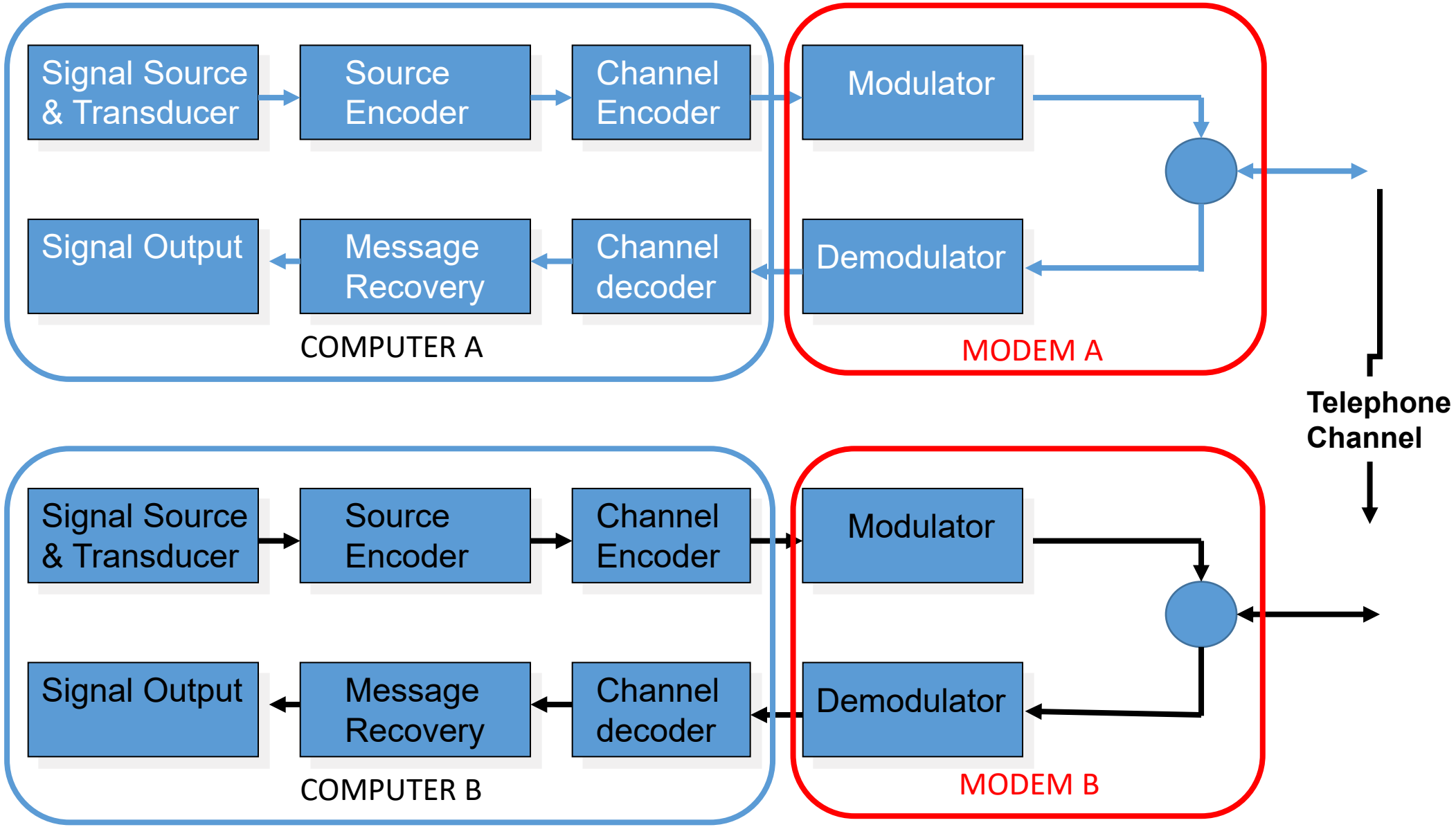
Signal Source & Transducer → Source Encoder → Channel encoder → Modulator

Channel

- Free space
- Twisted telephone wire
- Co-axial cable
- Water
- Fibre optic cable

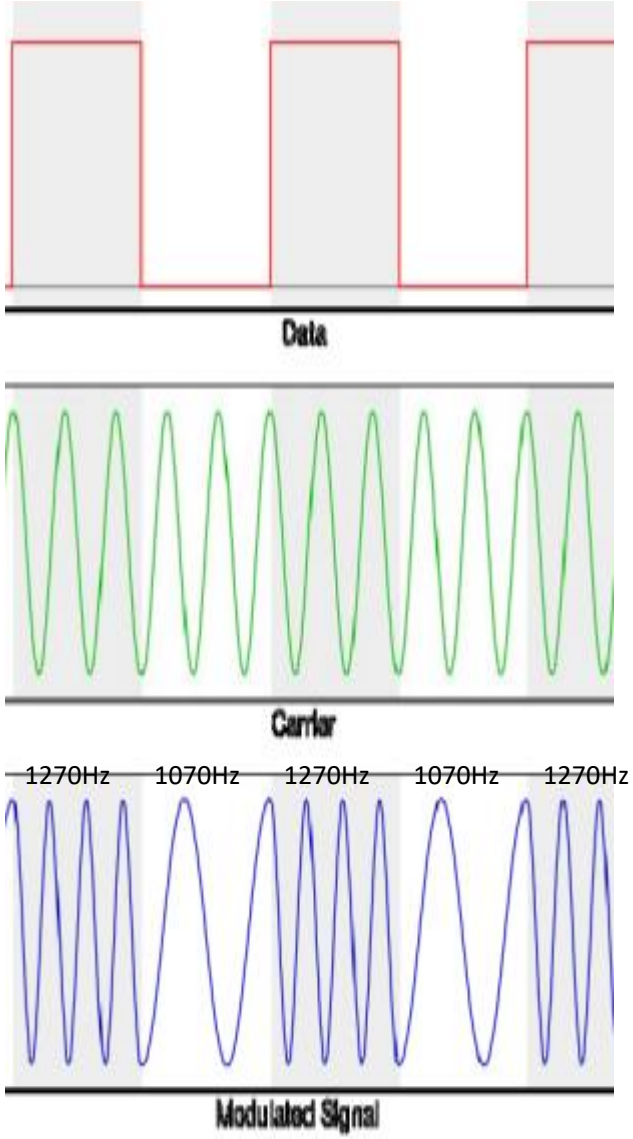
Signal Output ← Message Recovery ← Channel decoder ← Demodulator

MODEM IN 2-WIRE TELEPHONE SYSTEM SYSTEM



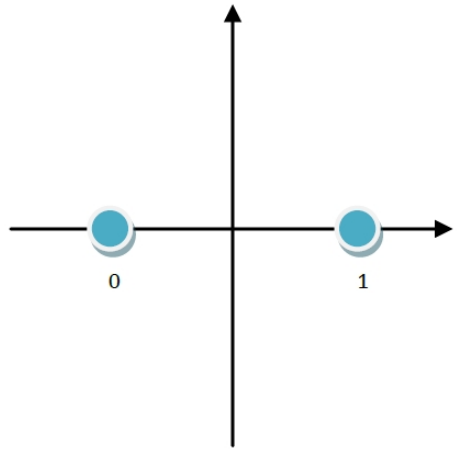
FIRST MODEM BELL 103 (300 BITS/S)

1. **Bell 103 modem or Bell 103 dataset was the first commercial modem for computers**, released by AT&T Corporation in 1962.
2. **The 300 bit/s modems used frequency-shift keying (FSK)** to send data.
3. A stream of 1s and 0s in computer data is translated into sounds which can be easily sent on the phone lines.
4. In the Bell 103 system, the originating modem sends 0s by playing a **1,070 Hz tone, and 1s at 1,270 Hz,** with the **answering modem transmitting its 0s on 2,025 Hz and 1s on 2,225 Hz.**
5. These frequencies were selected because they are in the range that suffers **minimum distortion on the phone system and are not harmonics of each other.**

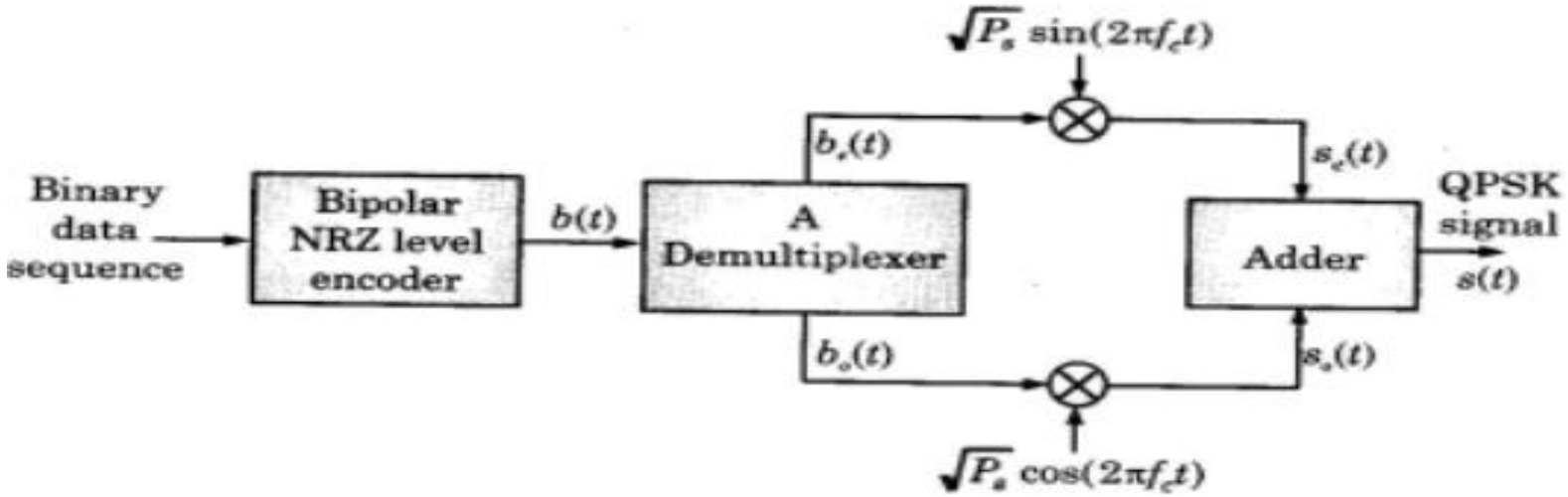


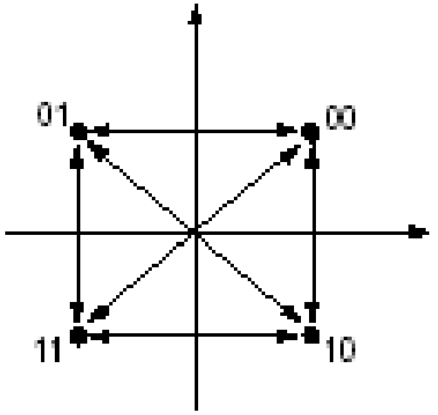
1200 BPS MODEM

- Instead of Frequency Shift Keying (FSK) the **1200 bps modem uses Quadratic Phase Shift Keying (QPSK).**
- Using QPSK two bits are transmitted simultaneously.
- The modulation technique is used to double the data-rate or to reduce the bandwidth of the signal.



(a) FSK 300 bps Modem

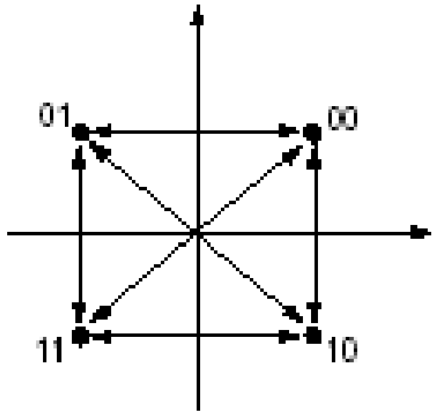




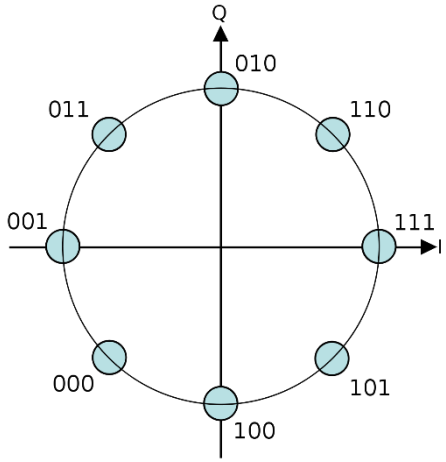
(a) QPSK 1200 bps Modem

2400 PBS MODEMS INTRODUCED IN LATE 1980s

1. **Voice-band modems generally remained at 300 and 1,200 bit/s (V.21 and V.22) into the mid-1980s.**
2. **2,400-bit/s system** similar in concept to the 1,200-bit/s Bell signaling was introduced in the U.S. and Europe in late 1980s.
3. **The bit rate increases were achieved by defining 8 (2^3) distinct symbols (M-ary coding), which allowed the encoding of 3 bits per symbol instead of only 1.**
4. The use of smaller shifts had the drawback of making each symbols more vulnerable to interference, but improvements in phone line quality at the same time helped compensate for this.



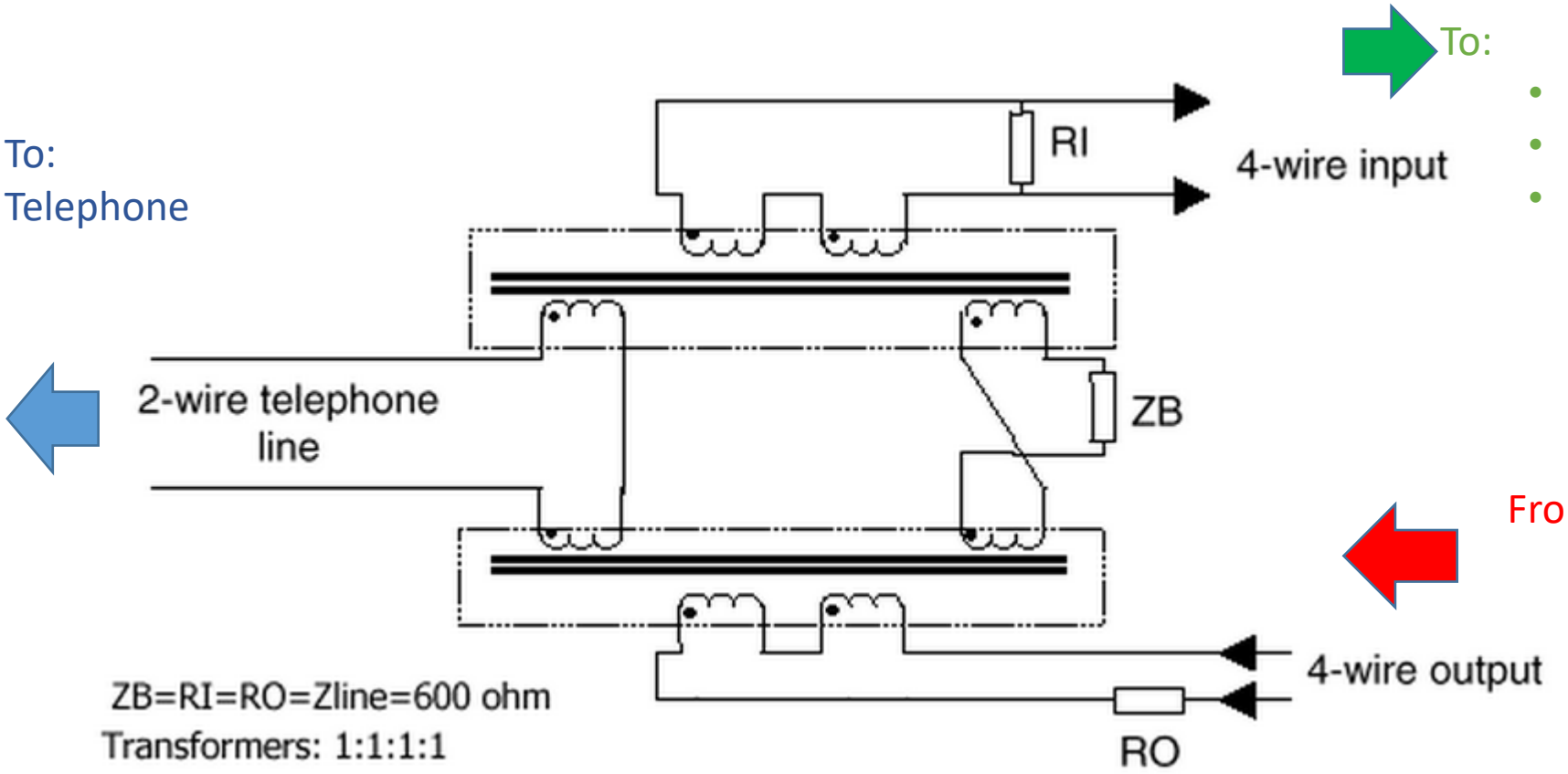
(a) QPSK 1200 bps Modem



(a) 8PSK 2400 bps Modem

VOICE 2-4 WIRE CONVERSION

2-4 wire conversions are necessary to interface the traditional 2-wire telephone to radio systems, PCM systems and Fibre Optic systems which cannot support simultaneous transmissions on one channel (PCM) or one frequency (radio) or one wavelength (fibre optic).



To:

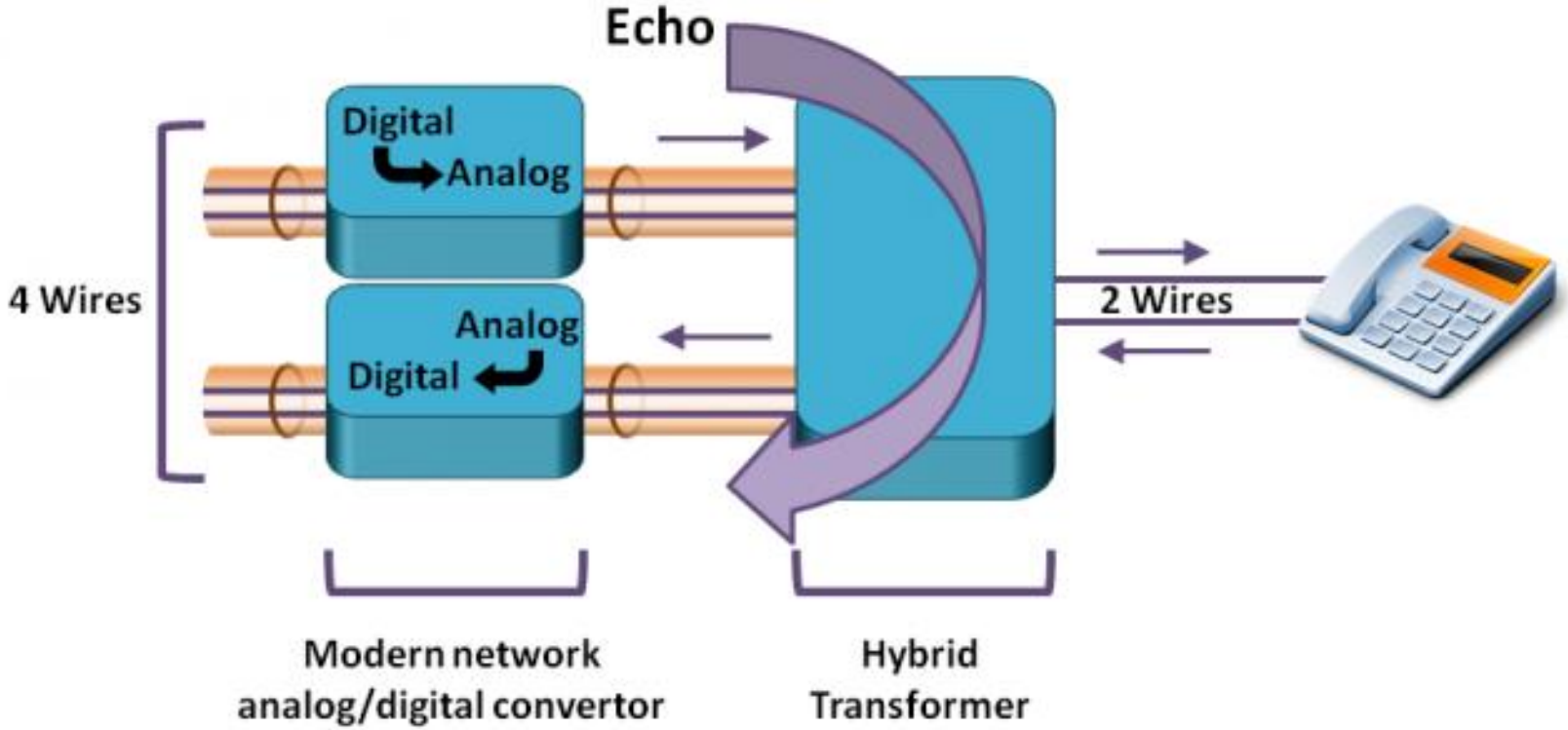
- PCM system
- Modem
- Digital Radio

From:

- PCM system
- Analog comm Modem
- Digital comm Modem

ECHOS IN DIGITAL COMMUNICATION

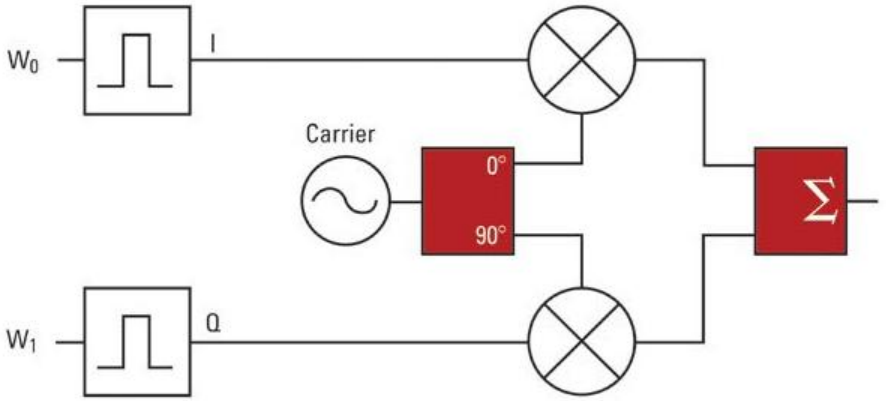
A portion of the signal on the receive part can leak back to the transmit part resulting in an echo signal as shown.



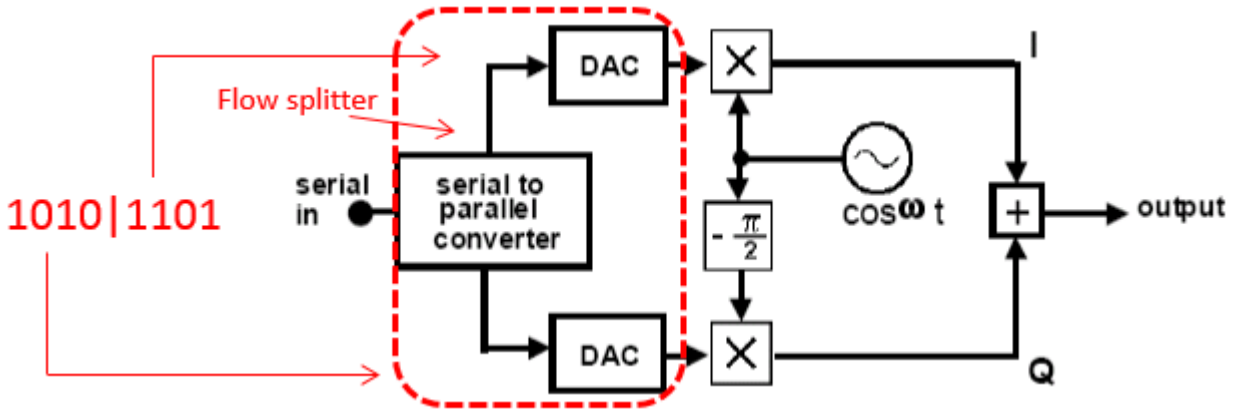
BREAKING THE 9600 BPS BARRIER/01

- **In the early 1990s**, modems operating over a wired telephone channel typically achieved 9.6 kbit/s
- The maximum achievable rate for a wired modem was then 14 kbit/s for two-way communication **(3,429 baud × 4 bits/symbol, using QAM).**

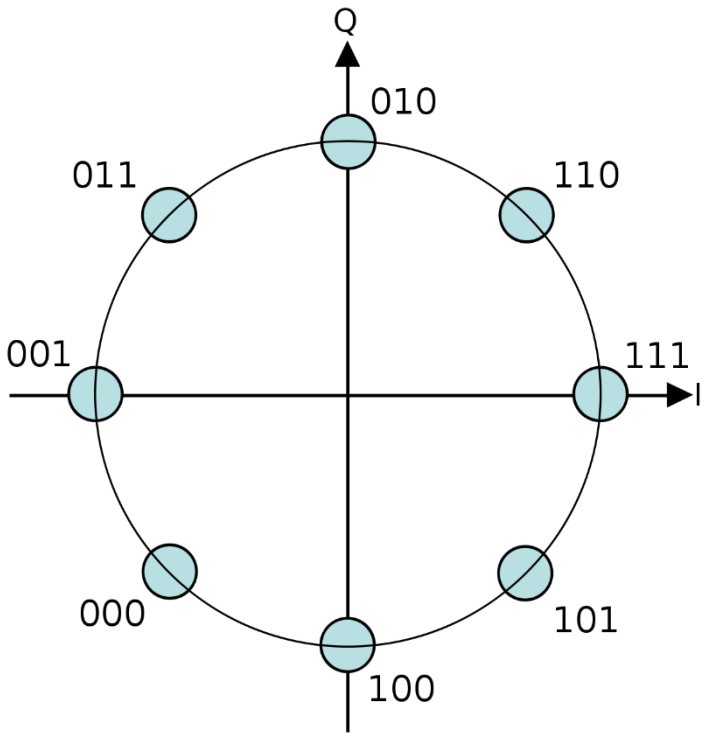
2 DIGITAL SOURCES



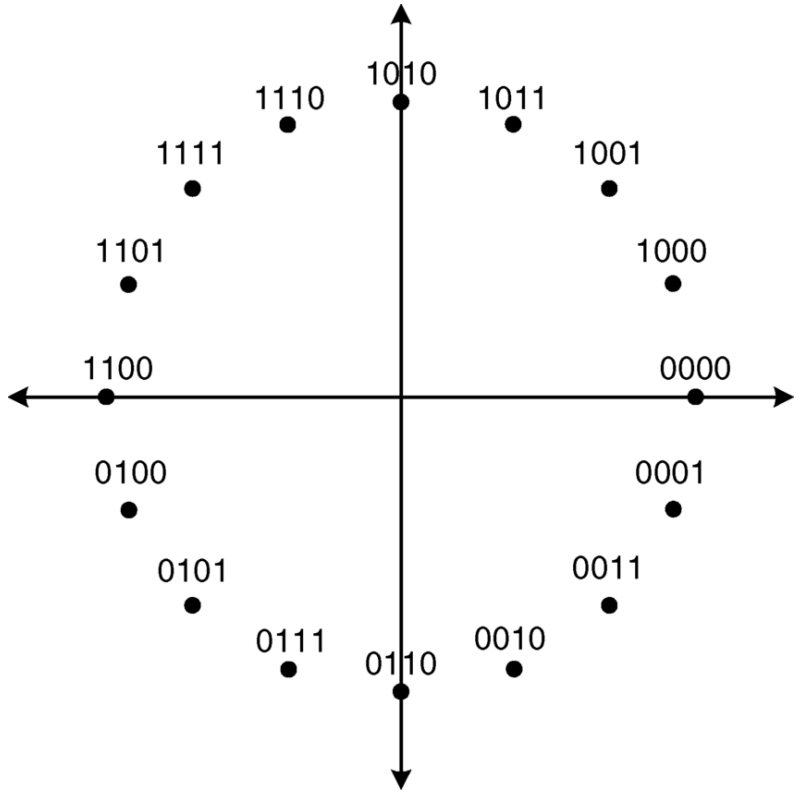
ONE DIGITAL SOURCE



BREAKING THE 9600 BPS BARRIER USING 8PSK & 16 PSK

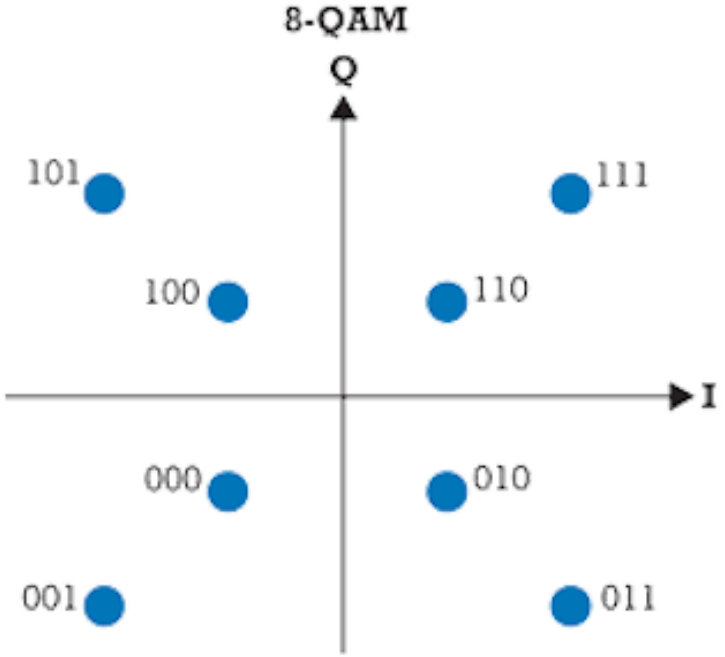


(a) 8PSK 2400 bps Modem

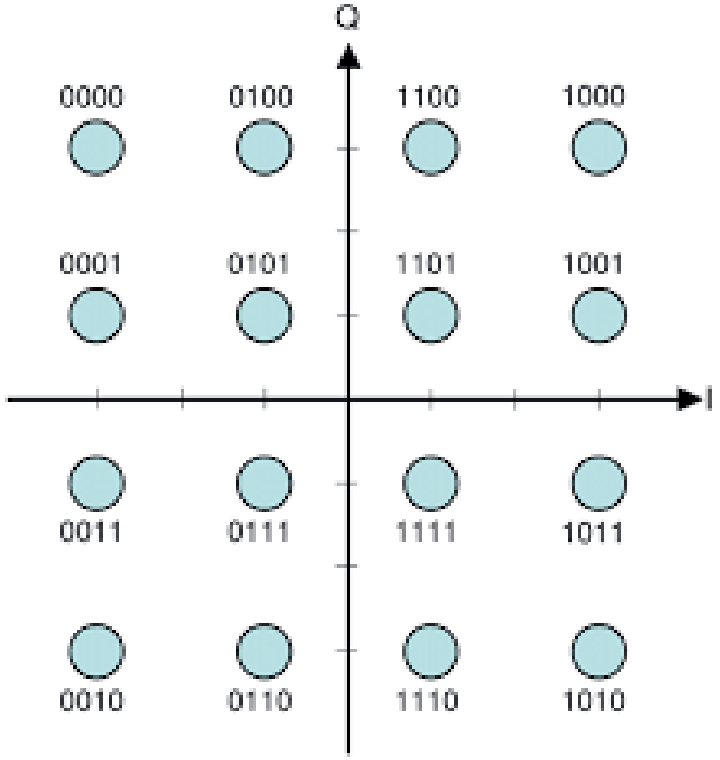


(b) 16PSK 14,000 bps Modem

BREAKING THE 9600 BPS BARRIER USING 8QAM & 16 QAM



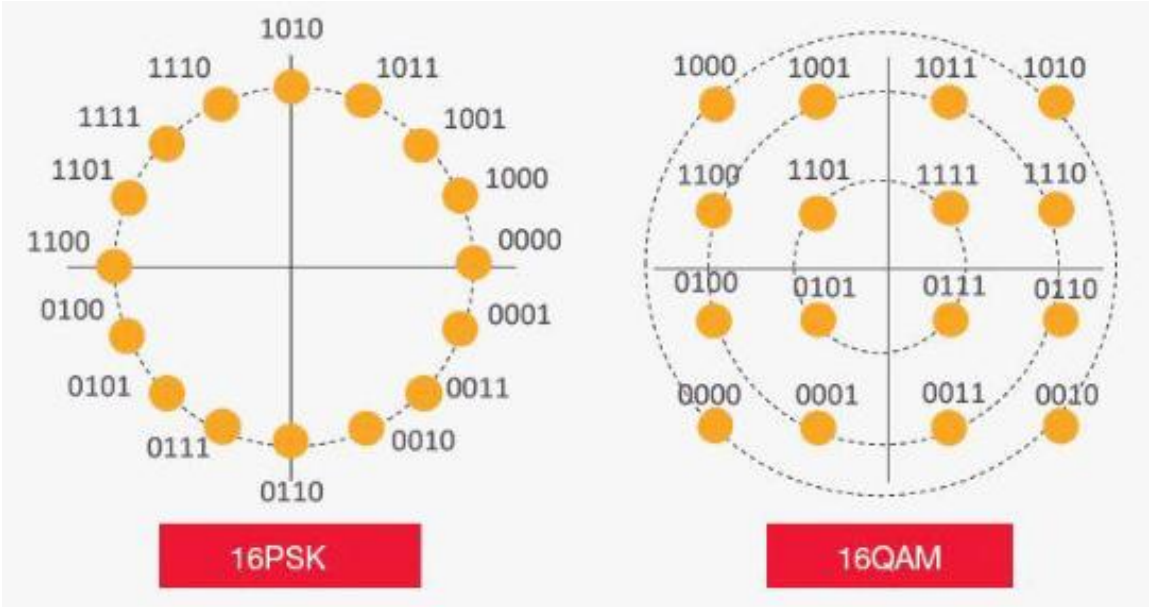
(a) 8QAM 2400 bps Modem



(b) 16QAM 14,000 bps Modem

COMPARING QAM VS PSK

1. **QAM uses both amplitude and phase shifts**
2. **PSK only uses phase shifts to encode data.**
3. This leads to differences in performance with regard **to data rate, bandwidth efficiency, and noise sensitivity**.



COMPARISON: PSK Vs QAM

	QAM	PSK
1. Modulation method	Modulates both the amplitude and phase	Modulates only the phase
2. Data rate and spectral efficiency	Can achieve higher data rates and spectral efficiency (more bits per symbol)	Has lower data rates and spectral efficiency than QAM
3. Noise and Fading Sensitivity	More sensitive to noise and fading than PSK especially at higher orders 64QAM, 128QAM	More robust to noise and fading than QAM
4. Complexity	Requires more complex transmitters and receivers	Simpler to implement than QAM

APPLICATIONS OF QAM

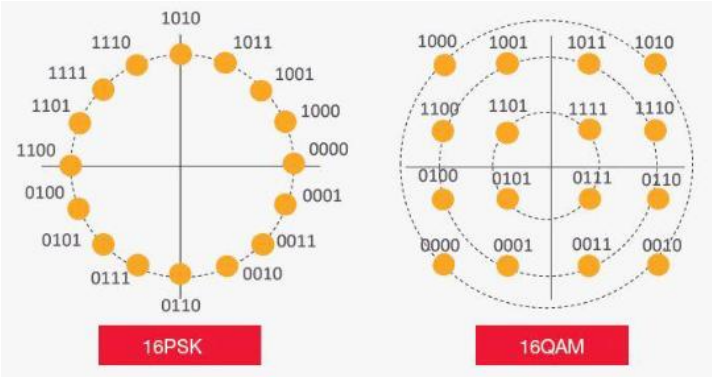
QAM is commonly used in applications that require high data rates and have good signal-to-noise ratios (SNRs), such as:

1. **Digital Television:** DVB-T2, Quadrature Amplitude Modulation (QAM) is used as a modulation scheme for digital terrestrial television broadcasting
2. **Digital subscriber lines (DSL):** VDSL (Very High-speed Digital Subscriber Line), QAM (Quadrature Amplitude Modulation) is a modulation technique used to transmit data over copper lines.
3. **Wireless local area networks (WLANs):** Wi-Fi 6 (802.11ax) utilizes 1024-QAM, a higher-order modulation scheme compared to the 256-QAM used in Wi-Fi 5 (802.11ac), enabling each symbol to carry more data bits and thus increasing data throughput and efficiency.

APPLICATIONS OF PSK

PSK modulation is used in applications where low power consumption and robustness to noise are critical, e.g

1. **Satellite communication: constant envelop modulation is generally considered as the most suitable for the satellite communications** because it minimizes the effect of non-linear amplification in the high-power amplifier like TWTA
2. **Radio frequency identification (RFID)**
3. **Bluetooth:** Bluetooth uses DQPSK (differential quadrature phase-shift keying) and 8-DPSK modulation



EVOLUTION OF THE MODEM

- A 56k modem is a voice-band modem nominally capable of download speeds up to 56 kbit/s (56,000 bits per second) using Trellis Modulation.

- **1990 -2000:** 56K modem was the most popular access method for personal Internet usage,
- **2000 and Beyond:** broadband Internet technologies such as DSL and cable Internet access, Mobile 3G and 4G, GPON, have been more widely adopted and made available.

GSM/GPRS MODEMS

1. A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone.
2. From the mobile operator perspective, a GSM modem looks just like a mobile phone.
3. When a GSM/GPRS modem is connected to a computer, this allows the computer to use the GSM modem to communicate over the mobile network.
4. While these GSM/GPRS modems are most frequently used to provide mobile internet connectivity, many of them can also be used for sending and receiving SMS and MMS messages.

3G MODEM

- A **3G Modem** is mobile broadband modem that allows a personal computer or a router to receive Internet access via a mobile broadband connection (WCDMA/UMTS or variants e.g. HSDPA) instead of using telephone or cable television lines

4G MODEMS

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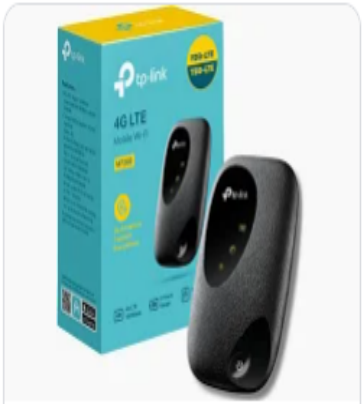

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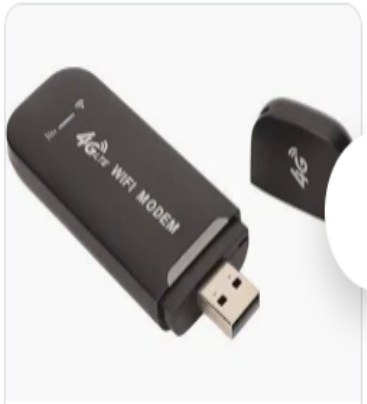
Zuri Digital Solutions



4g lte usb wifi router modem dongle mobile wifi hotspot...

Ksh 1,324.00

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