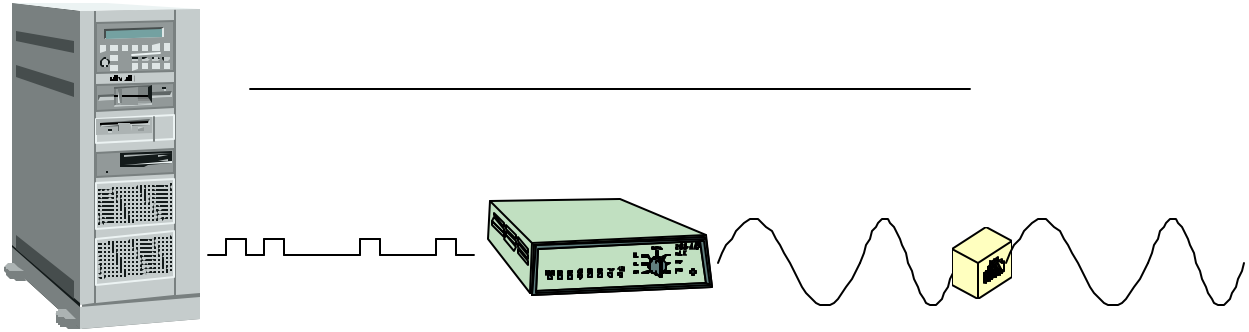
MODEM
Converting Digital to Analog and Analog to Digital



Computer - Digital Output - Modem - Analog Output - RJ 11 Jack

In the Beginning

- Limited Market
- Controlled Environment
- Specialists to Run Machine
- Specialists to Program
- Submit Jobs…and wait

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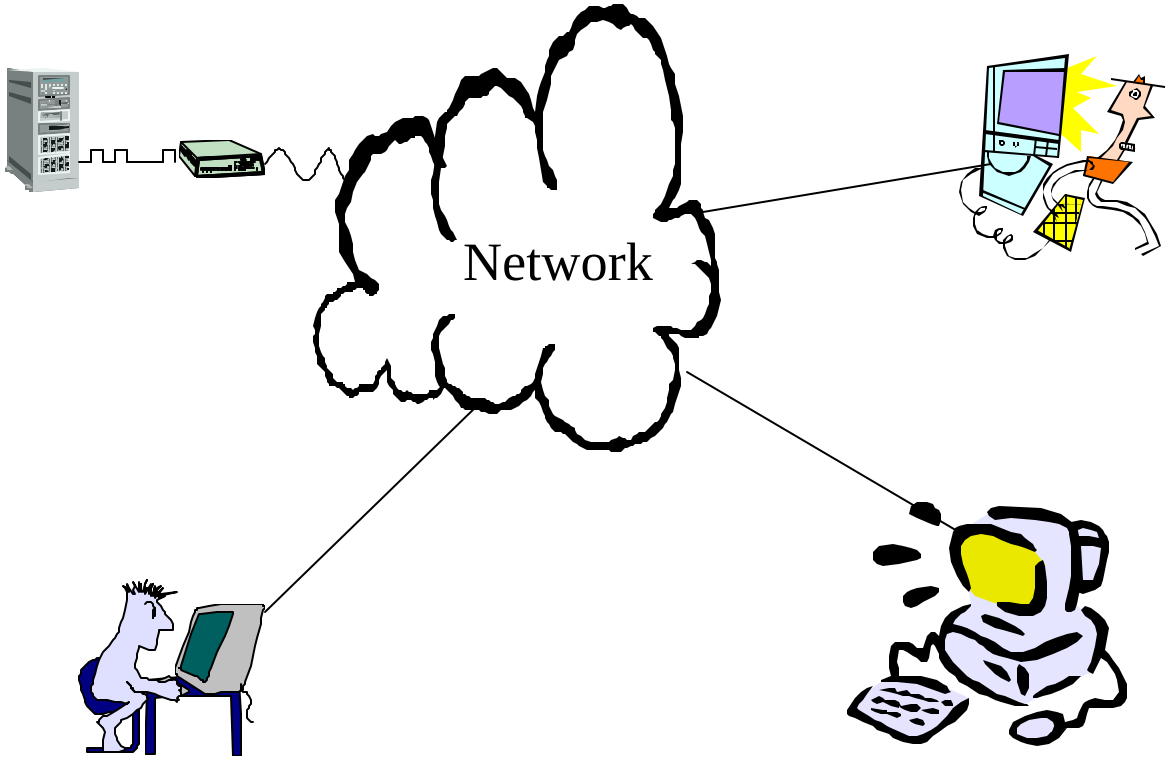
Remote Connections



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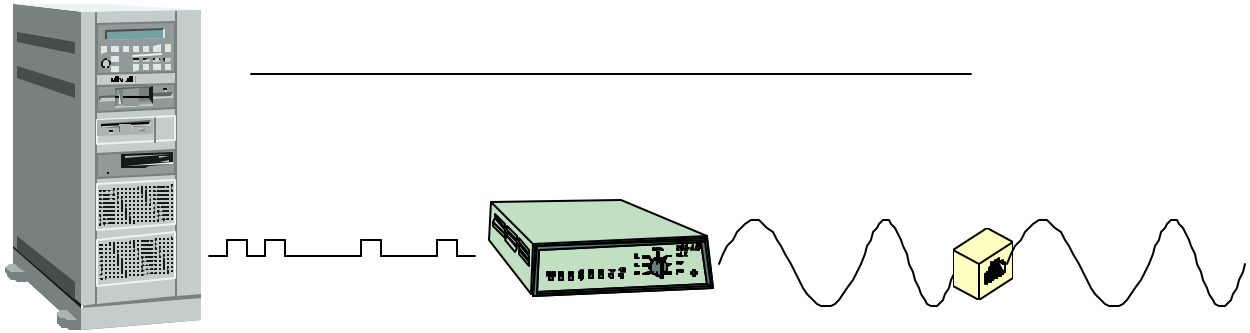
MODEM



Computer | Modem | Communications Network

Data Terminal Equipment (DTE)

Data Communication Equipment (DCE)

Layer 1, OSI Model, the Physical Layer

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Modem: What does it do?

Basic Tasks:

- Handle initial setup of the connection
- Convert machine's digital signals to signals appropriate for the network
- Send and receive information

Other Tasks (for advanced modems):

- Protect network from harmful voltages from DTE
- Initiate and accept calls automatically
- Detect errors
- Identify and report equipment failures.

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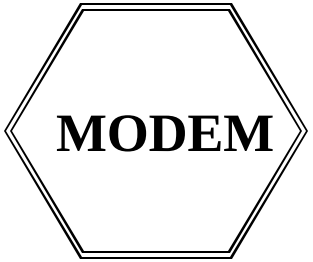
Describing a Modem

Synchronous Asynchronous

Analog

Digital



Switched

Non-Switched

Full Duplex Half Duplex

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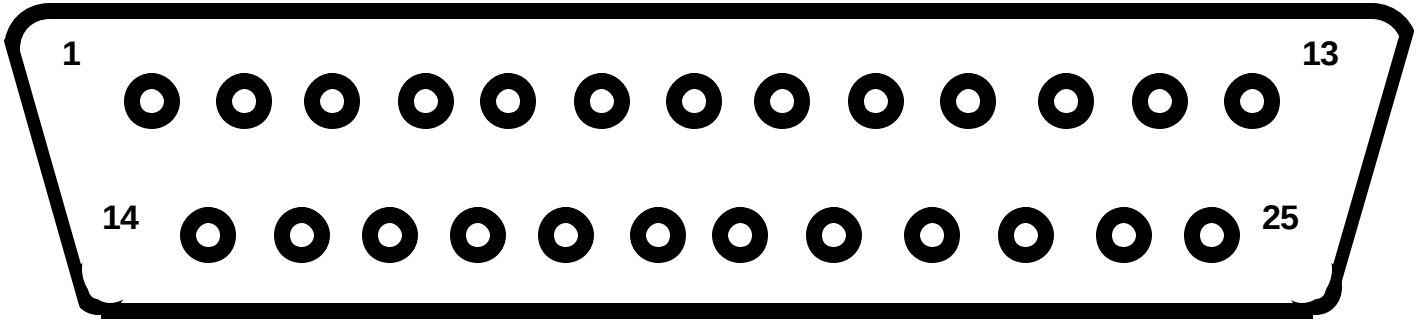
Modem: How does it work?

The physical connection:



RS - 232 Connector

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RS-232 Connector

Pin Wiring

PIN	ABBR.	FUNCTION
1	GND	Protective Ground to frame
2	TXD	Transmit data from DTE to DCE (modem receives)
3	RXD	Transmit data from DCE to DTE (computer/terminal receives)
4	RTS	DTE signals DCE it is ready to send data to DCE
5	CTS	DCE signals DTE that DCE is ready to receive; it tells the DTE that it is clear to send to DCE
6	DSR	Data Set (= DCE = modem) Ready. Modem indicates it is connected to the telephone line.
7	SG	Signal Ground/common/signal common. This is the reference point to all other voltages on the interface. It is not a frame ground, although it may be connected to PIN 1 internally.
8	DCD	Modem (DCE) tells the DTE that it is on-line, has Date Carrier Detect, and is prepared to receive data.
9		Positive DC test voltage
10		Negative DC test voltage
11		Equalizer mode
12	SI	Modem (DCE) tells the DTE if the modem is high or low speed. SI = Speed Indicator
13		Secondary Clear to Send
14		Secondary Transmitted Data
15		DCE Transmitter Signal Element Timing
16		Secondary Receive Data
17		Receiver signal element timing
18		Divided clock receiver
19		Secondary Request to send
20	DTR	DTE signals the DCE when it is in the Ready state.
21		Signal quality detector
22	RI	Modem (DCE) tells the DTE that it has detected ringing voltage (Ring Indicator)
23		Data signal rate selector
24		DTE transmitter signal element timing
25		Busy

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IBM 25 Pin RS-232C	PIN	IBM 9 Pin RS-232C
Not Used	**1**	**Carrier detect**
Transmit data	**2**	**Received data**
Receive data	**3**	**Transmit data**
Request to send	**4**	**Data terminal ready**
Clear to send	**5**	**Signal ground**
Data set ready	**6**	**Data set ready**
Signal ground	**7**	**Request to send**
Carrier detect	**8**	**Clear to send**
+ Transmit current loop	**9**	**Ring indicator**
Not Used	**10**	**Not Available**
- Transmit current loop	**11**	**Not Available**
Not Used	**12 to 17**	**Not Available**
+ Receive current loop	**18**	**Not Available**
Not Used	**19**	**Not Available**
Data terminal ready	**20**	**Not Available**
Not Used	**21**	**Not Available**
Ring indicator	**22**	**Not Available**
Not Used	**23 & 24**	**Not Available**
- Receive current loop	**25**	**Not Available**

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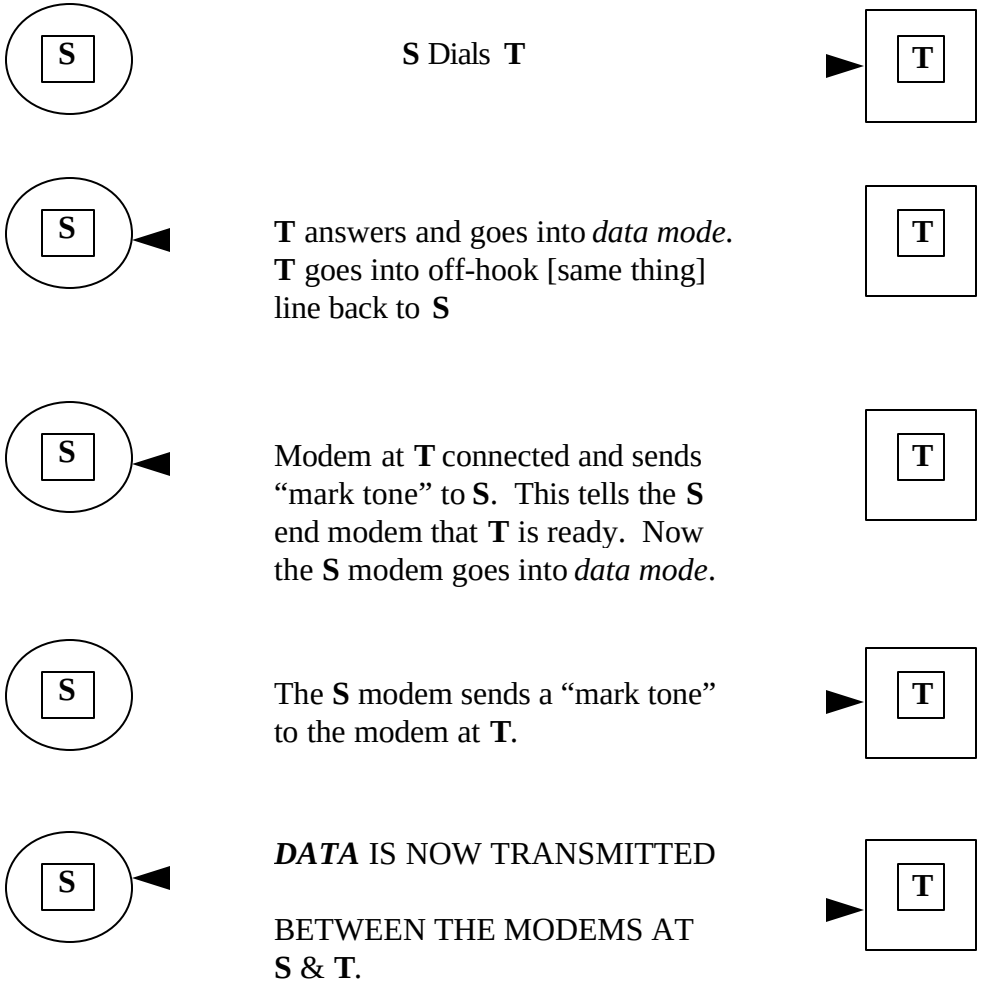
How does it work??



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Hayes Command Set (partial)

AT	Alerts the modem to incoming commands
AT M1	This turns on a modem's speaker while dialing; M0 turns the speaker off; M2 leaves the speaker on all the time.
AT S0=1	Tells the modem to answer the phone on the first ring. S0 can be set from 0 (do not answer) to 255 rings (answer on the 255th ring)
AT S7=30	Tells the modem to attempt a handshake with the target modem for 30 seconds; if a connection cannot be made in this time frame, the modem will disconnect. S7=1 to 255 seconds (4.25 minutes)
AT DT *tel no*	Enter ATDT and a telephone number; the modem will dial the target number. The 'D' tells the modem to dial. The'T' indicates touch-tone
AT H0	Hangs the phone up - disconnects the line. H1 picks the phone up
AT L1	Sets the speaker volume to low; L3 sets it to high; and L2 sets the volume between high and low.
ATZ	Tells the modem to reset itself

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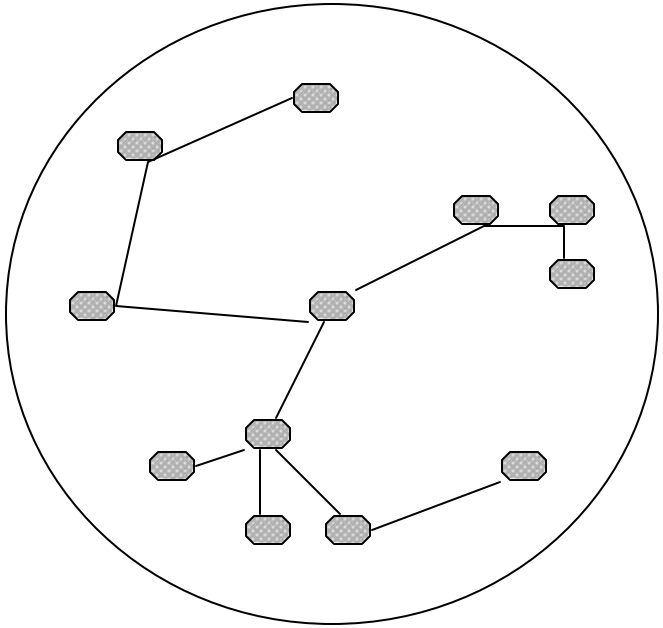
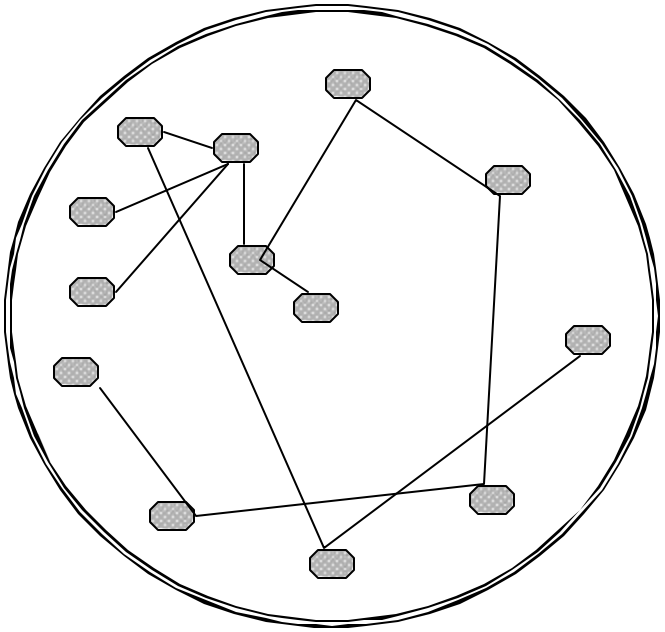
Private Line Modems

Company Q's Network



Company X's Network



= Locations

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Private Line Modems

Common Features

- MNP Error Control
- Diagnostics
- Loop Back
- Adaptive Line Rate
- Adaptive Inbound Rate
- Modem Sharing
- Signal Constellation Generator
- Reverse Channel Capability
- Network Management

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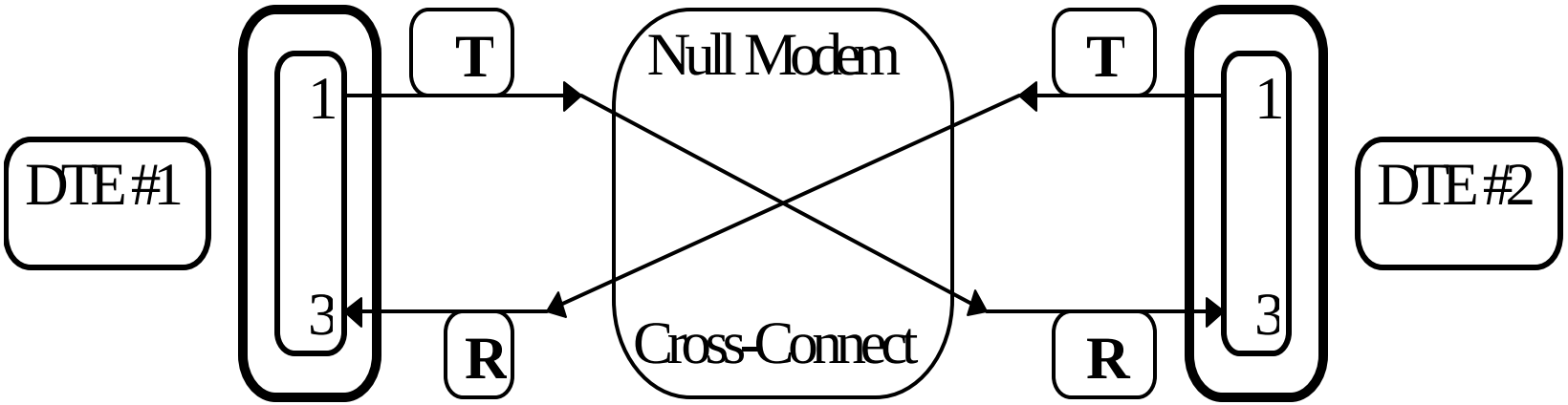
Null Modem



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Digital Terminations

DSU and CSU

- Isolate and protect the network from harmful voltages and signals generated by customer equipment
- Equalize the line to enhance transmission properties
- Recover timing bits
- Transmit the bits in a method and format compatible with the network
- Generate and recognize control signals
- Provide diagnostics and loopback capabilities for testing and maintenance

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Modulation Techniques

Frequency

Amplitude

Phase

Multibit

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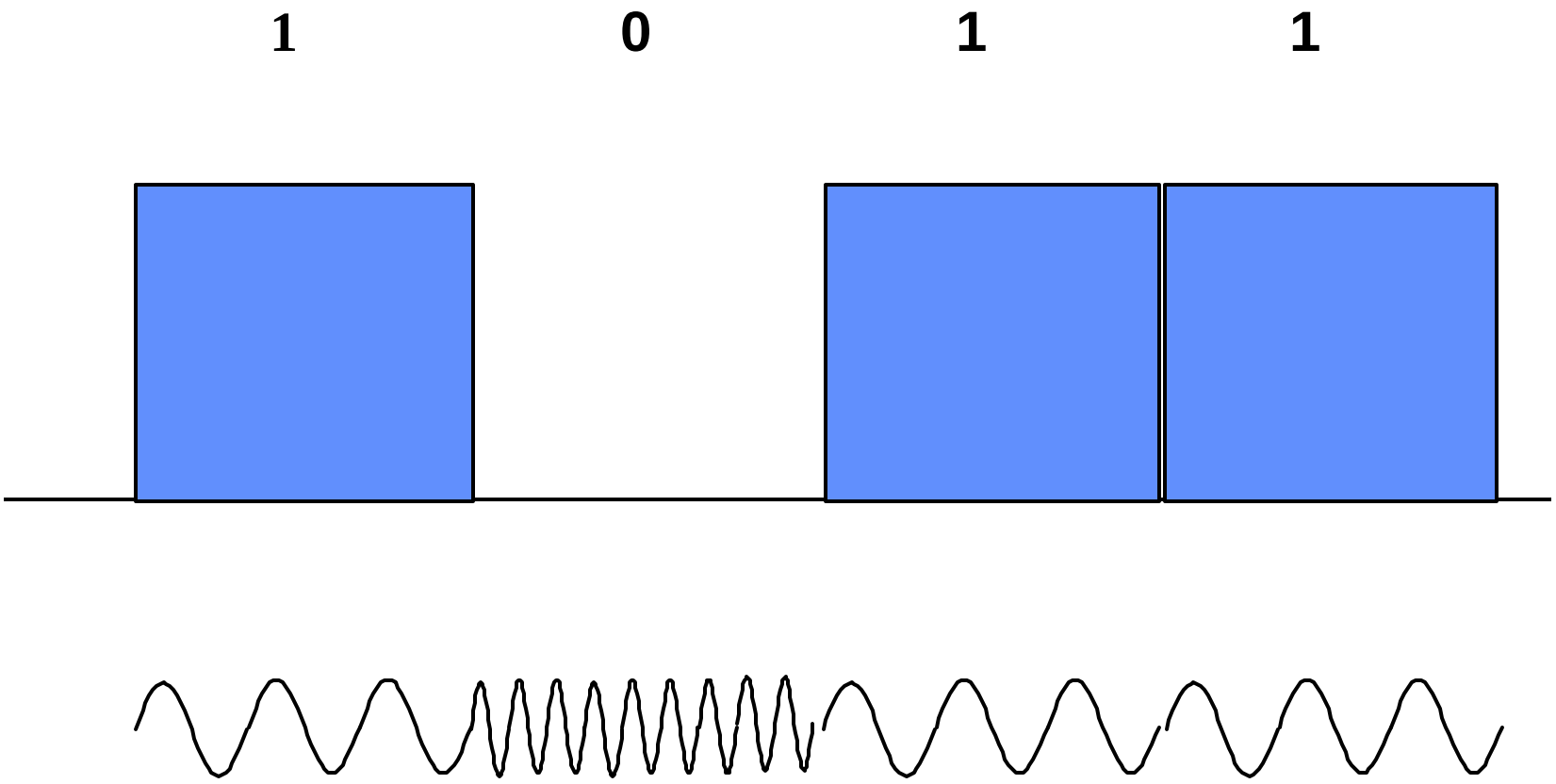
Frequency Modulation



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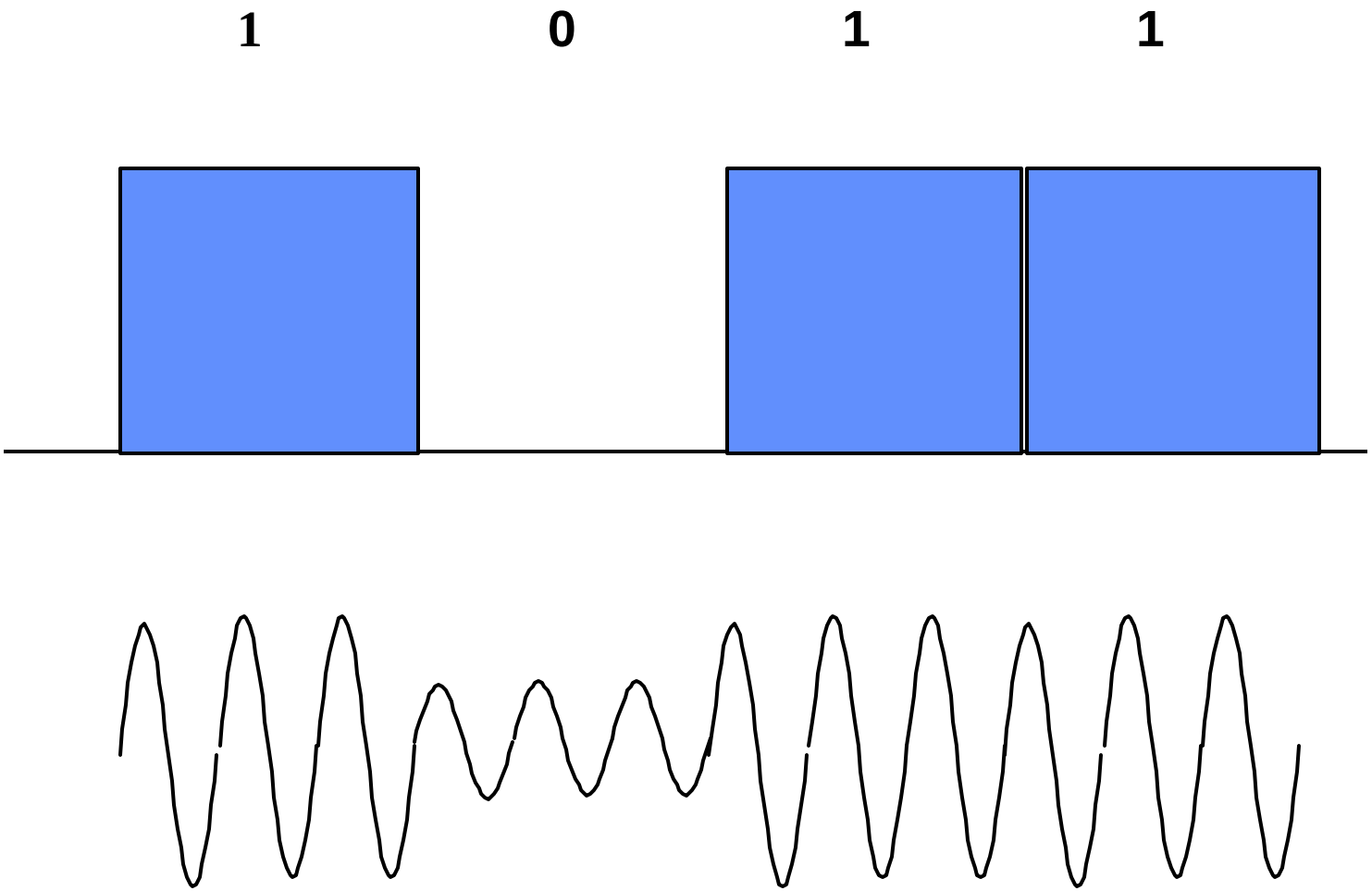
Amplitude Modulation



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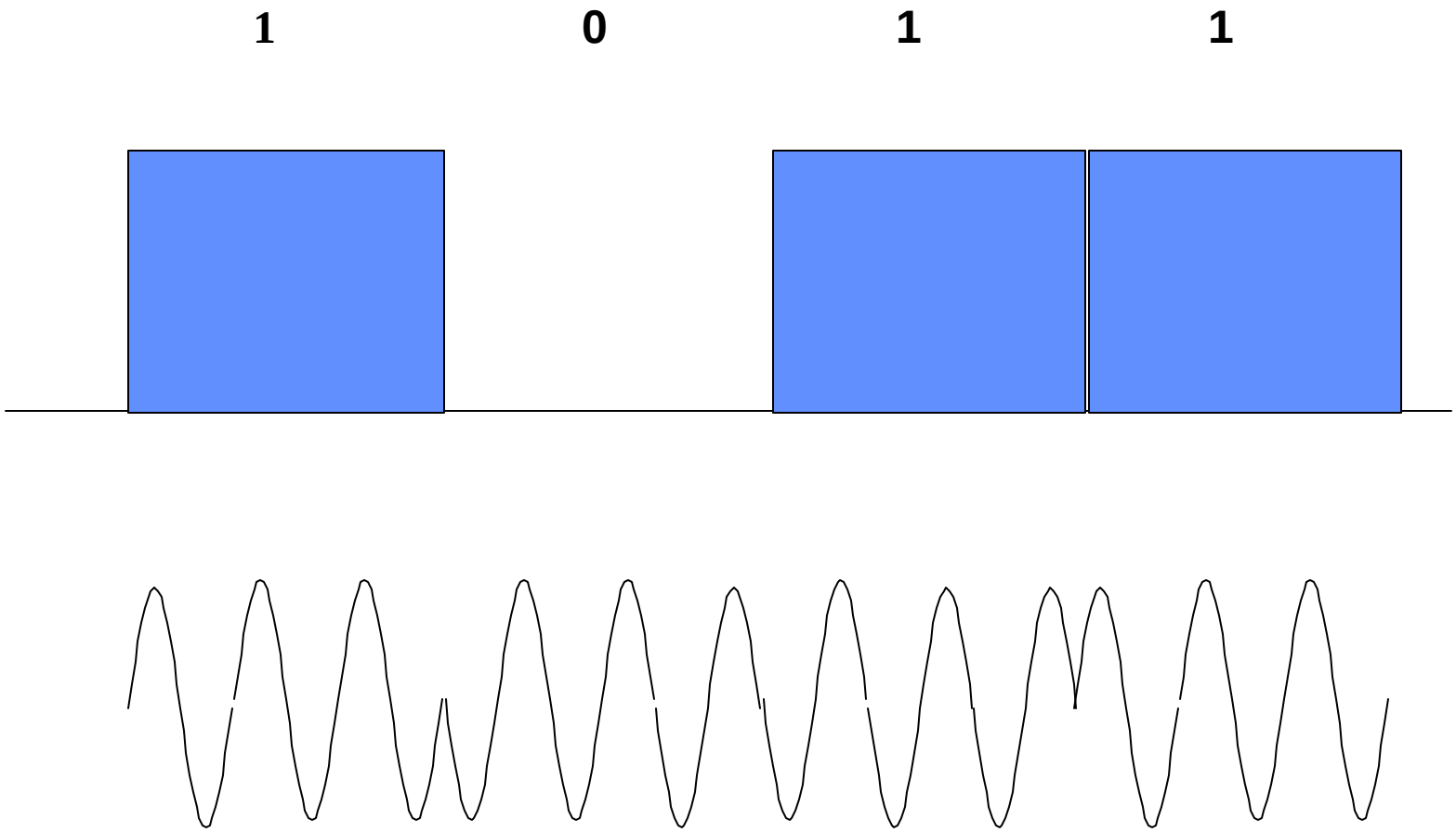
Phase Modulation



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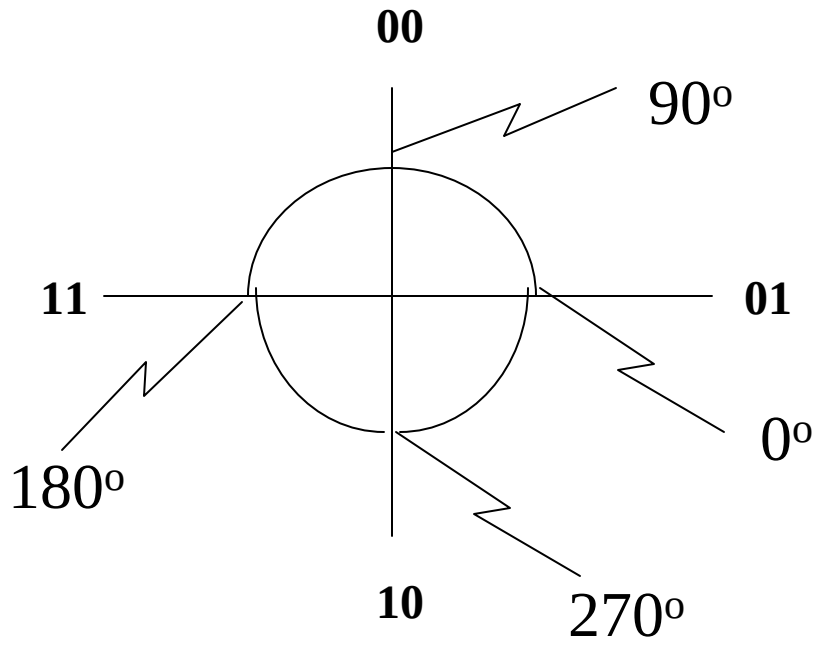
Multibit Modulation

QPSK -- Quadrature Phase Shift Keying



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Multibit Modulation

QAM -- Quadrature Amplitude Modulation

Phase Angle (Degrees)	Amplitude	Binary Number
0	1	1100
0	2	1101
0	3	1110
0	4	1111
90	1	0100
90	2	0101
90	3	0110
90	4	0111
180	1	0000
180	2	0001
180	3	0010
180	4	0011
270	1	1000
270	2	1001
270	3	1010
270	4	1011

16QAM

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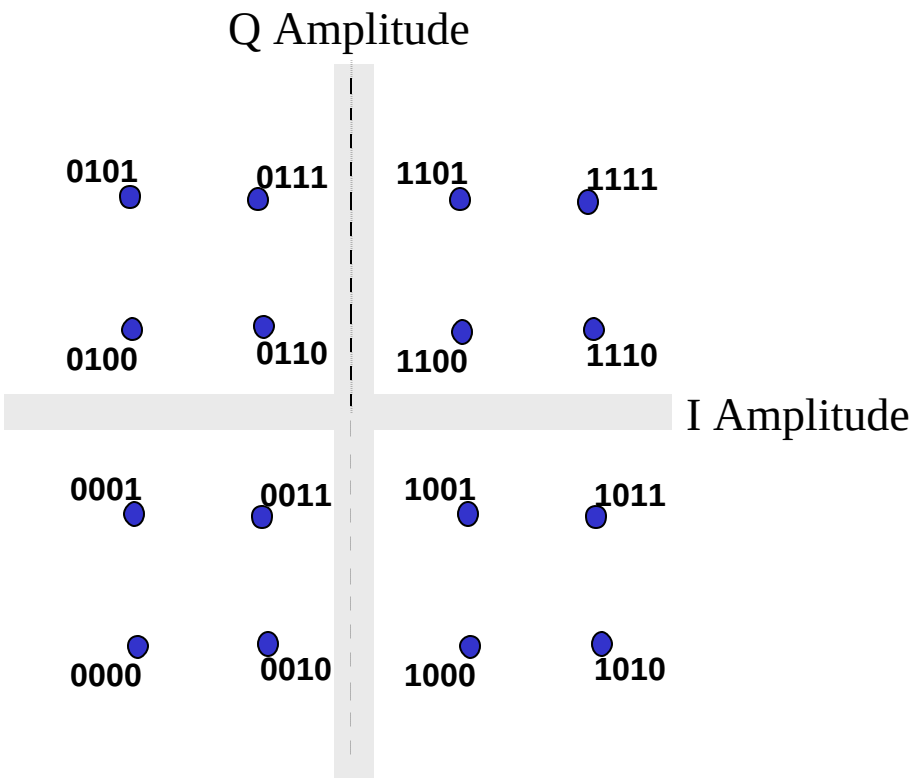
Multibit Modulation

QAM -- Quadrature Amplitude Modulation



16QAM - 16 Possible
Combinations of I and Q

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Increased Speeds Through New Standards

V.32 - Speeds to 9,600 bps

V.32bis - Speeds to 14,400 bps

V.34 - Highest rates on copper

V.42bis - Improves effective rate

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Cablemodems

Same modulation techniques - QPSK/QAM

Higher speeds - 500 kbps to 4 Mbps today
44 Mbps possible

Higher frequencies

Standards

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