

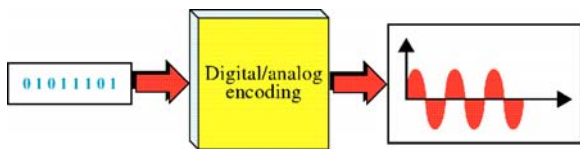
Analog Transmission

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Outline

- Digital-to-digital conversion
 - Encode digital data into a digital signal
 - Sending computer data
- Analog-to-Digital conversion
 - Digitizing an analog
 - Sending voice in telephone (Decrease effect of noise)
- Digital-to-Analog conversion
 - Modulating a digital signal
 - Sending computer data through public telephone line
- Analog-to-Analog conversion
 - Modulating an analog signal
 - Sending music from radio station

Digital to Analog Encoding

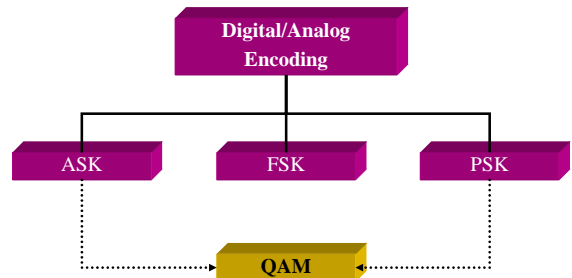


Basic Concepts

- Bit rate
 - Bits transfer in a second
 - Computer Efficiency (time to send)
- Baud rate
 - # of Signal per second
 - Data transmission (move data)
 - Few signal → efficiency
- Analogy (transportation)

Basic concepts

- Carrier signal (carrier frequency)
 - High frequency as a basis for information
 - Sender and receiver agree on the frequency
 - Digital data is modulated (shift keying) on the carrier by modifying carrier characteristics
- 3 characteristics of carrier signal
 - Amplitude
 - Frequency
 - Phase

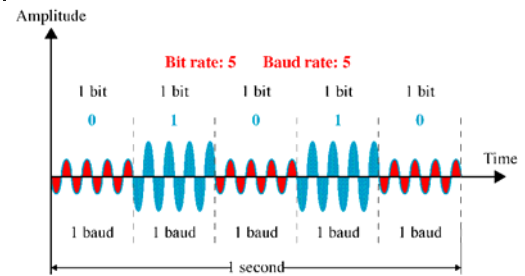


Amplitude Shift Keying

- Values represented by different amplitudes of carrier
- Usually, one amplitude is zero
 - i.e. presence and absence of carrier is used
- Susceptible to sudden gain changes
- Inefficient
- Up to 1200bps on voice grade lines
- Used over optical fiber

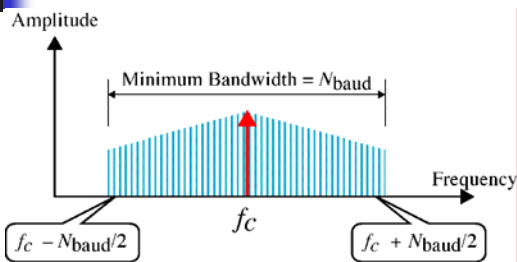
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Amplitude Shift Keying (ASK)



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Bandwidth for ASK



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ASK – Example I

Question

Find the minimum bandwidth for an ASK signal transmitting at 2000 bps. The transmission mode is **half-duplex**.

Solution

Baud rate = Bit rate = 2000
 Min. BW of ASK signal = its baud rate
 Therefore, the min. BW is 2000 Hz.

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ASK – Example II

Question

Given a bandwidth of 10,000 Hz (1000 to 11,000 Hz), draw the **full-duplex** ASK diagram of the system.

Find the carriers and the bandwidths in each direction.

Assume there is no gap between the bands in the two directions.

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ASK – Example II

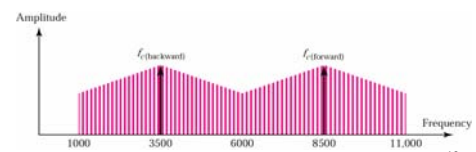
Solution

For full-duplex ASK, the BW for each direction
 $BW = 10,000 / 2 = 5,000$ Hz

The carrier frequencies can be chosen at the middle of each band

$$f_c \text{ (forward)} = 1,000 + 5,000/2 = 3,500 \text{ Hz}$$

$$f_c \text{ (backward)} = 11,000 - 5,000/2 = 8,500 \text{ Hz}$$



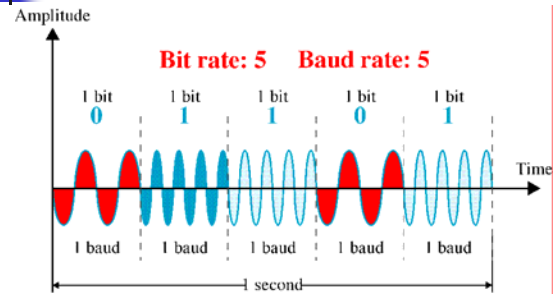
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Frequency Shift Keying

- Values represented by different frequencies (near carrier)
- Less susceptible to error than ASK
- Up to 1,200 bps on voice grade lines
- High frequency radio
- Even higher frequency on LANs using co-ax

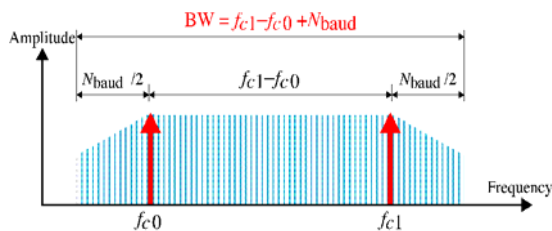
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Frequency Shift Keying (FSK)



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Bandwidth for FSK



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FSK – Example 1

Question

Find the minimum bandwidth for an FSK signal transmitting at 1000 bps. Transmission is in **half-duplex** mode, and the carriers are separated by 2000 Hz.

Solution

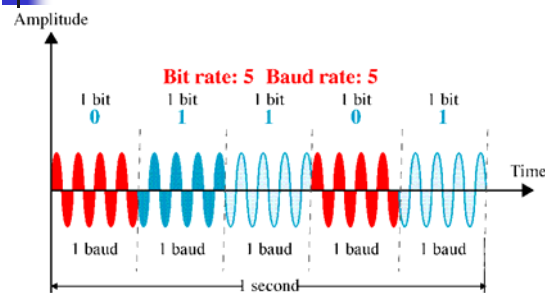
For FSK

$$BW = \text{baud rate} + f_{c1} - f_{c0}$$

$$BW = \text{bit rate} + f_{c1} - f_{c0} \\ = 1000 + 2000 = 3000 \text{ Hz}$$

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Phase Shift Keying (PSK)

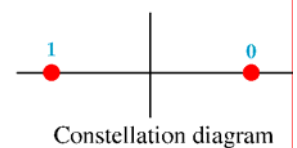


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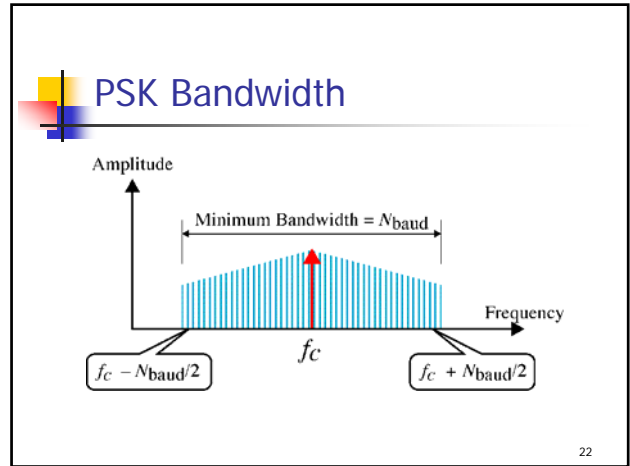
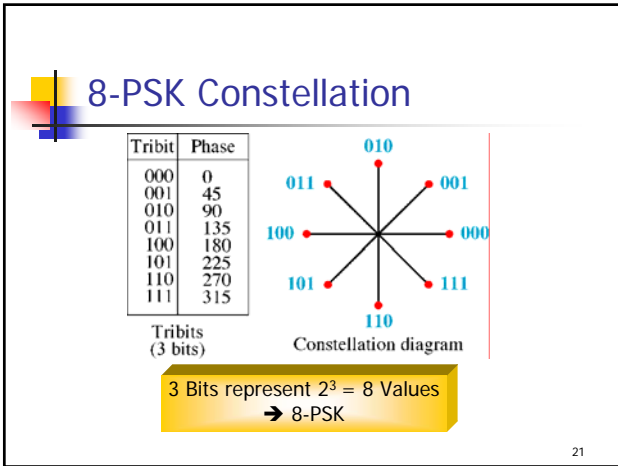
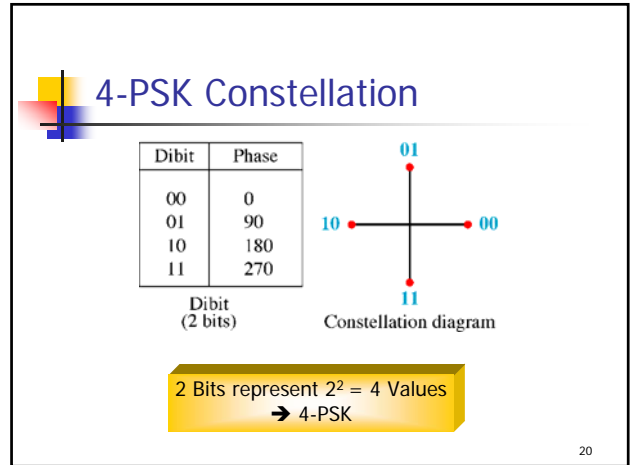
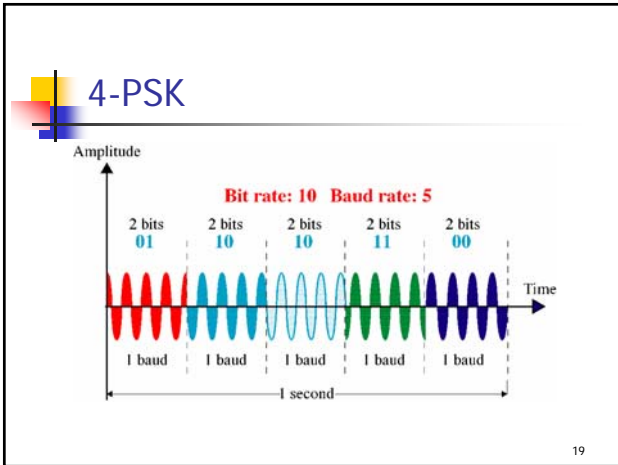
PSK Constellation

Bit	Phase
0	0
1	180

Bits



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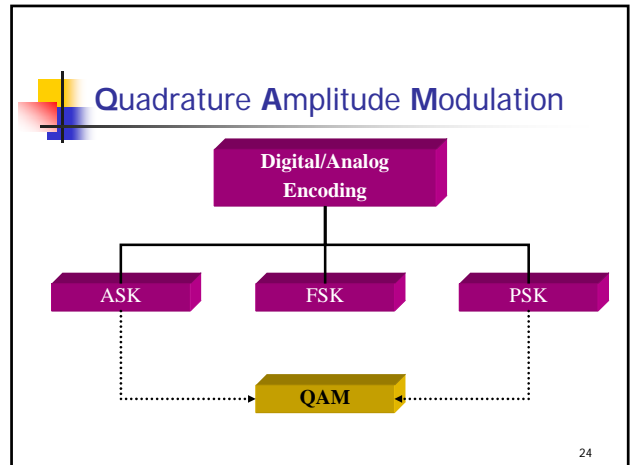


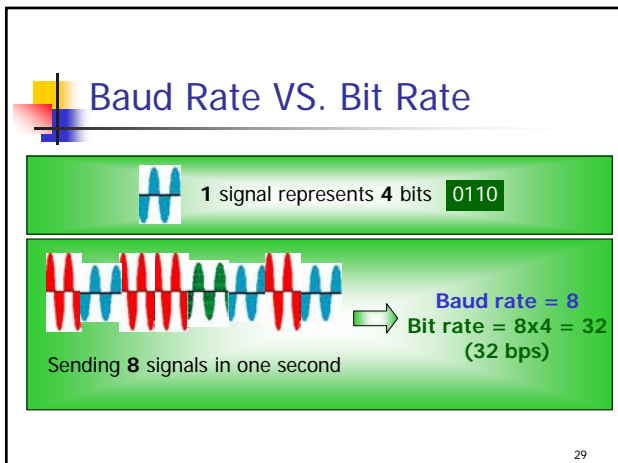
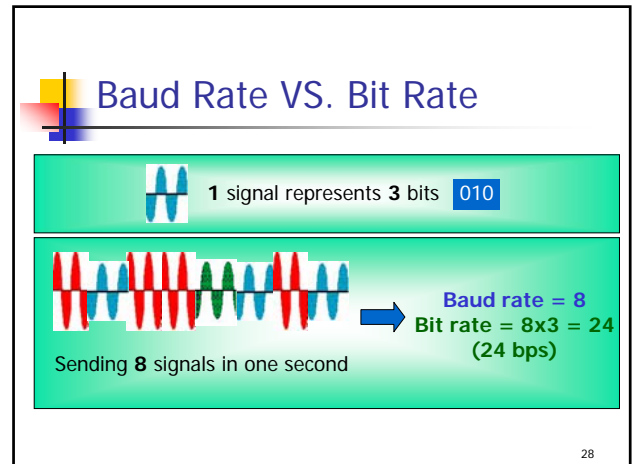
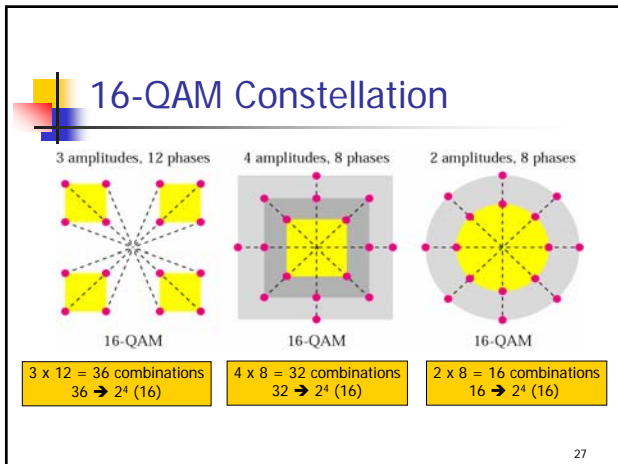
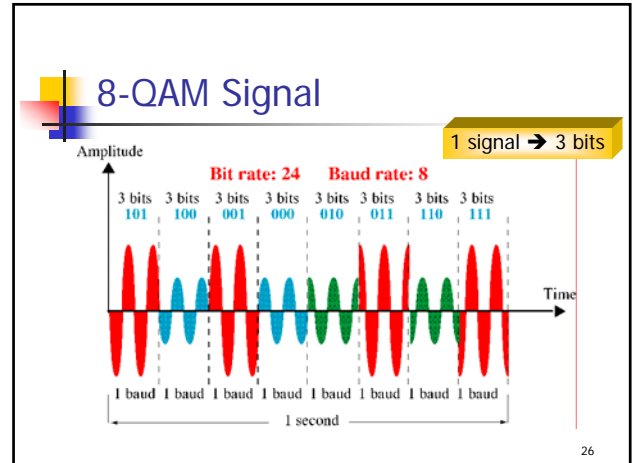
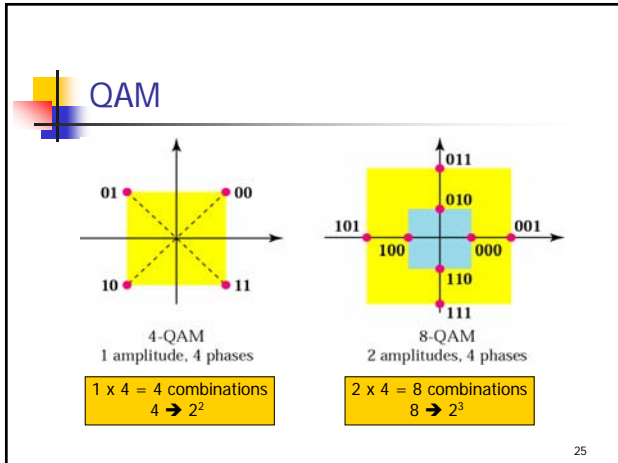
PSK – Example 1

Question Given a bandwidth of 4000 Hz for an 8-PSK signal, what are the baud rate and bit rate?

Solution For PSK the baud rate = BW = 4000.
But in 8-PSK,
Bit rate is 3 times the baud rate
Bit rate = $4000 * 3 = 12,000$ bps.

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Bit rate – Baud rate comparison

Modulation	Units	Bits/Baud	Baud rate	Bit Rate
ASK, FSK, 2-PSK	Bit	1	N	N
4-PSK, 4-QAM	Dibit	2	N	2N
8-PSK, 8-QAM	Tribit	3	N	3N
16-QAM	Quadbit	4	N	4N
32-QAM	Pentabit	5	N	5N
64-QAM	Hexabit	6	N	6N
128-QAM	Septabit	7	N	7N
256-QAM	Octabit	8	N	8N

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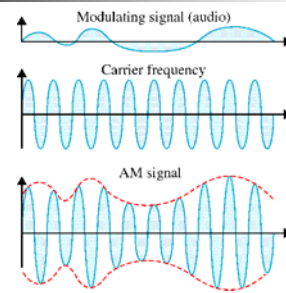


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Analog/Analog Encoding

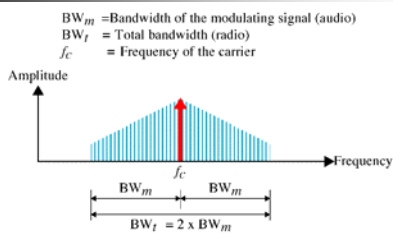


Amplitude Modulation



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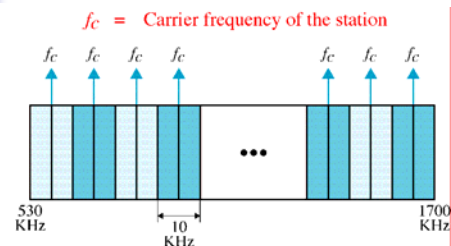
AM Bandwidth



The total bandwidth required for AM can be determined from the bandwidth of the audio signal:
 $BW_t = 2 \times BW_m$

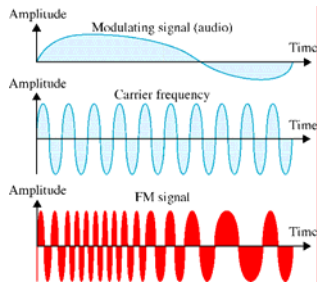
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AM Band Allocation



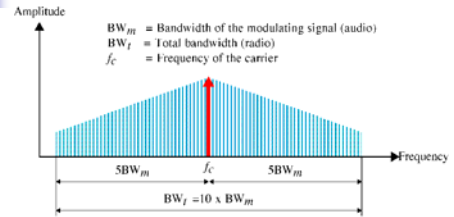
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Frequency Modulation



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FM Bandwidth

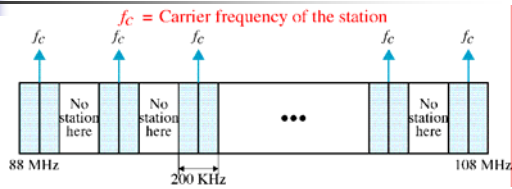


The total bandwidth required for FM can be determined from the bandwidth of the audio signal:

$$BW_t = 10 \times BW_m$$

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FM Band Allocation



Audio stereo = 15KHz \rightarrow BW = 150KHz
 FCC \rightarrow 200 KHz

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