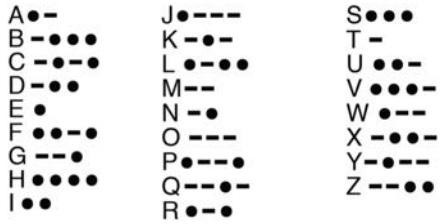
Overview

- This Lecture
  - Signals and Encoding
  - Source: Section 1.1, 3.4, 4.1, 4.2, 5.1
- Next Lecture
  - Data Transmission
  - Source: Sections 1.1, 4.3, 6.1

Data Representation



- Morse code
- Bit (0,1), Byte (8 bits)
- ASCII code (American Standard Code for Information Interchange, 7-bit code, keyboard characters)
- Unicode (16-bit, math symbols, more characters)
- Other codes (8-bit EBCDIC by IBM)

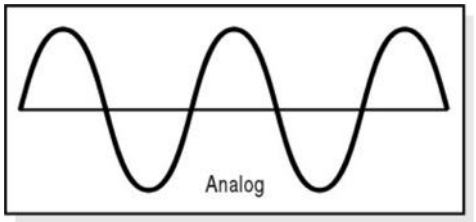
ASCII Code

0100001	21	!	1000001	41	A	1100001	61	a
0100010	22	"	1000010	42	B	1100010	62	b
0100011	23	#	1000011	43	C	1100011	63	c
0100100	24	$	1000100	44	D	1100100	64	d
0100101	25	%	1000101	45	E	1100101	65	e
0100110	26	&	1000110	46	F	1100110	66	f
0100111	27	'	1000111	47	G	1100111	67	g
0101000	28	(	1001000	48	H	1101000	68	h
0101001	29	)	1001001	49	I	1101001	69	i
0101010	2A	*	1001010	4A	J	1101010	6A	j
0101011	2B	+	1001011	4B	K	1101011	6B	k
0101100	2C	,	1001100	4C	L	1101100	6C	l
0101101	2D	-	1001101	4D	M	1101101	6D	m
0101110	2E	.	1001110	4E	N	1101110	6E	n
0101111	2F	/	1001111	4F	O	1101111	6F	o
0110000	30	0	1010000	50	P	1110000	70	p
0110001	31	1	1010001	51	Q	1110001	71	q
0110010	32	2	1010010	52	R	1110010	72	r
0110011	33	3	1010011	53	S	1110011	73	s
0110100	34	4	1010100	54	T	1110100	74	t
0110101	35	5	1010101	55	U	1110101	75	u
0110110	36	6	1010110	56	V	1110110	76	v
0110111	37	7	1010111	57	W	1110111	77	w
0111000	38	8	1011000	58	X	1111000	78	x
0111001	39	9	1011001	59	Y	1111001	79	y

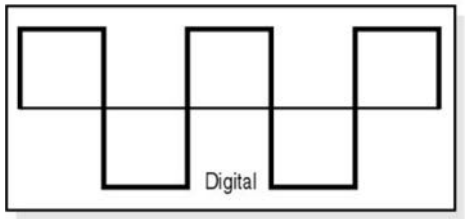
Definitions

- Computers are digital
- Signal: A way of conveying information
  - electrical voltage or current, radio waves, light
- To be transmitted, information must be transformed to electromagnetic signals.
  - Signals can be analog or digital
  - Digital transmission and Analog transmission

Analog signals
(Telephone/Radio)



Digital signals
(0/1 bit)

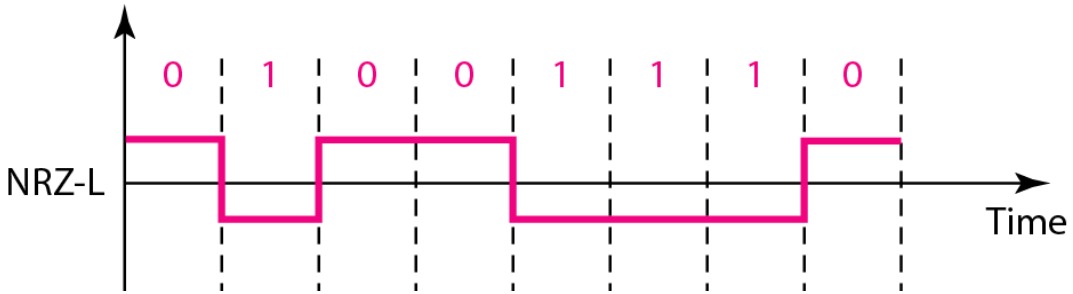


Digital Transmission

- Digital-to-digital conversion
  - Digital transmission of digital data
  - Converts sequence of bits to digital signals
- Encoding
  - Assigning a meaning to signals
  - A signal is worthless if no meaning is assigned
  - A different encoding gives a particular signal a different interpretation
  - NRZ, Manchester, Differential Manchester

Digital Transmission (cont.)

- NRZ Encoding



- How many 0s?

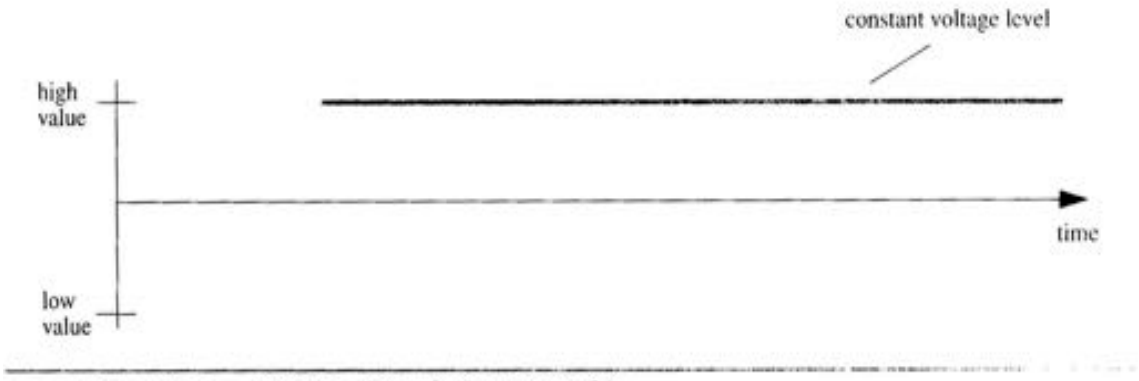
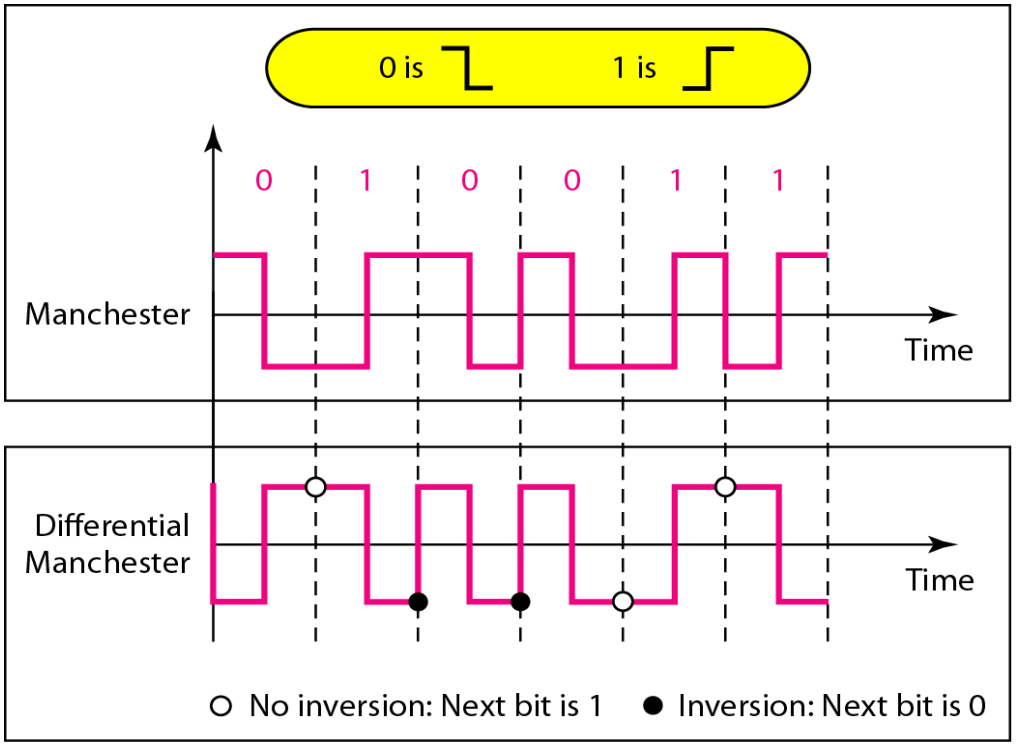


Figure 2.32 NRZ Encoding of a Sequence of 0s

Digital Transmission (cont.)

- Manchester and Differential Manchester



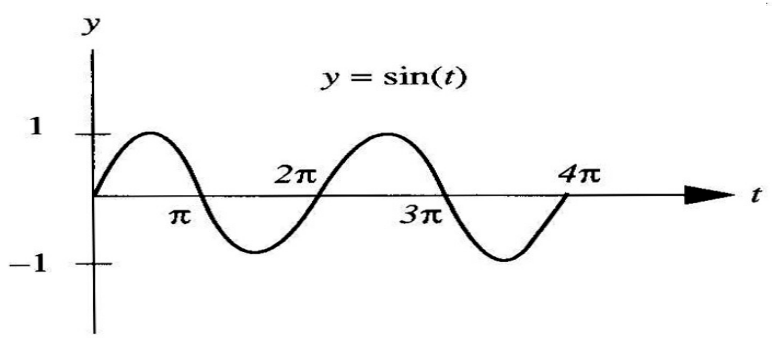
- Example:1001011

Analog Transmission

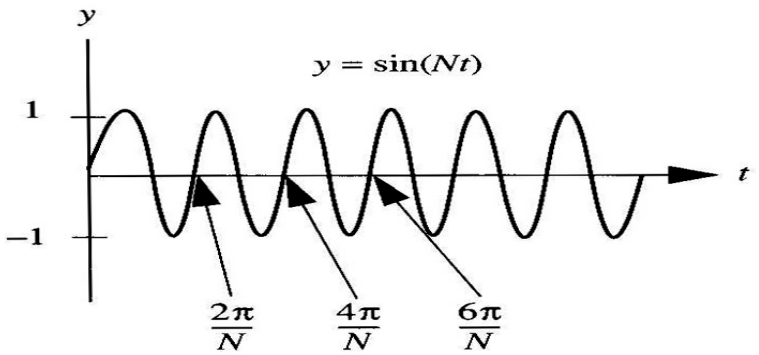
- Modem: Modulator-demodulator
  - Converts digital to analog (Modulation)
  - Send the analog signal over telephone line
  - Receive the analog signal
  - Convert the analog signal to digital (Demodulation)
  - D/A and A/D Conversion
- Methods: FSK, ASK, PSK, QAM

Analog Transmission (cont.)

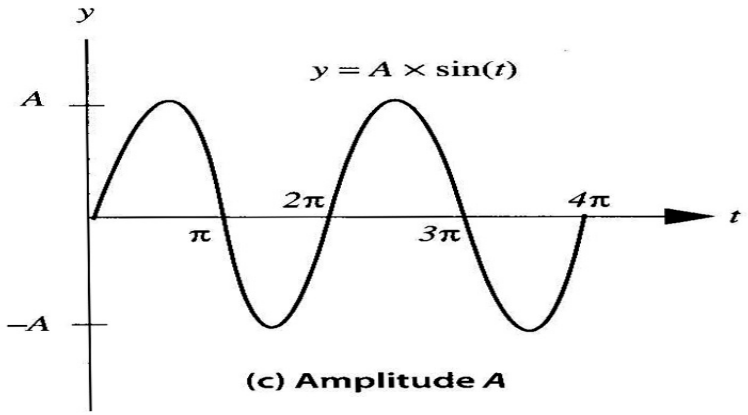
- Analog signals can be distinguished by amplitude, frequency, and phase.



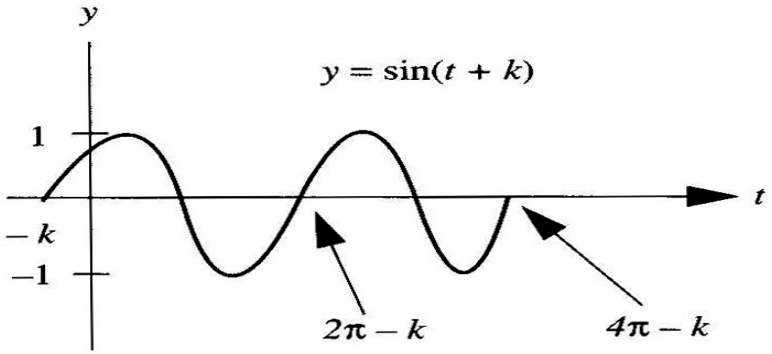
(a) Period 2π



(b) Period $\frac{2\pi}{N}$



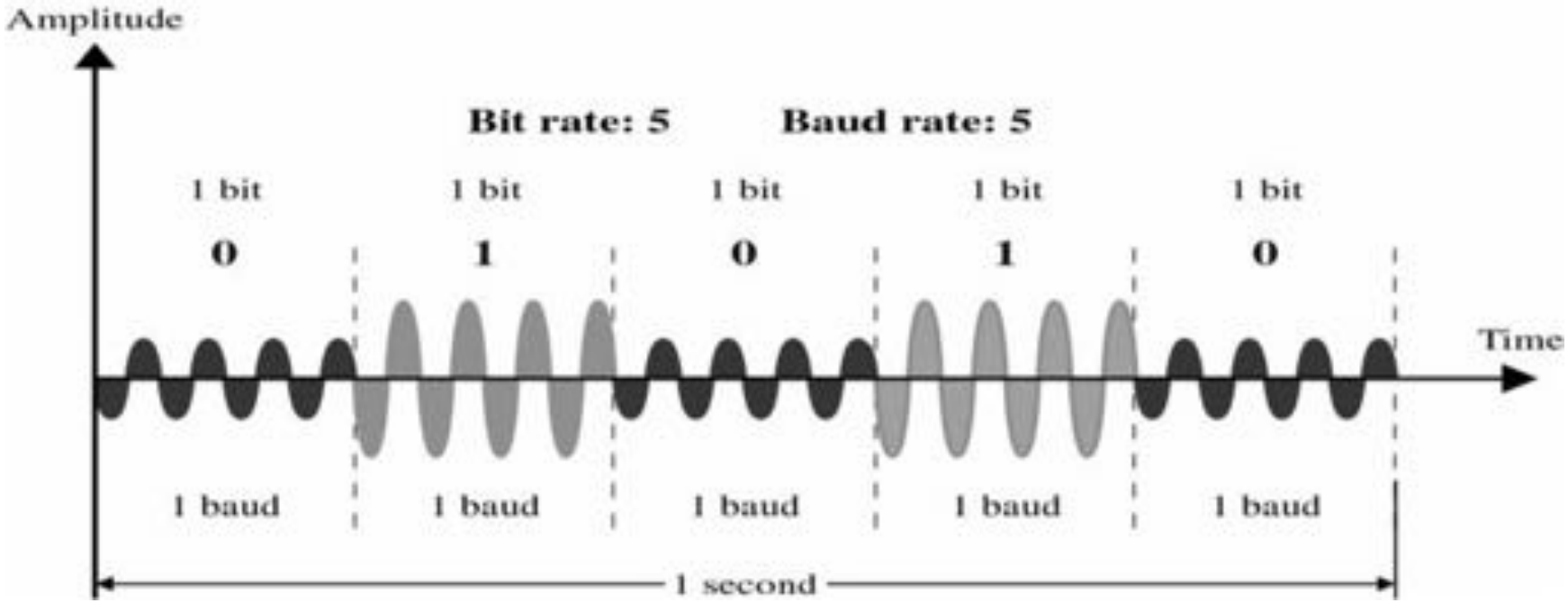
(c) Amplitude A



(d) Phase Shift k

Analog Transmission (cont.)

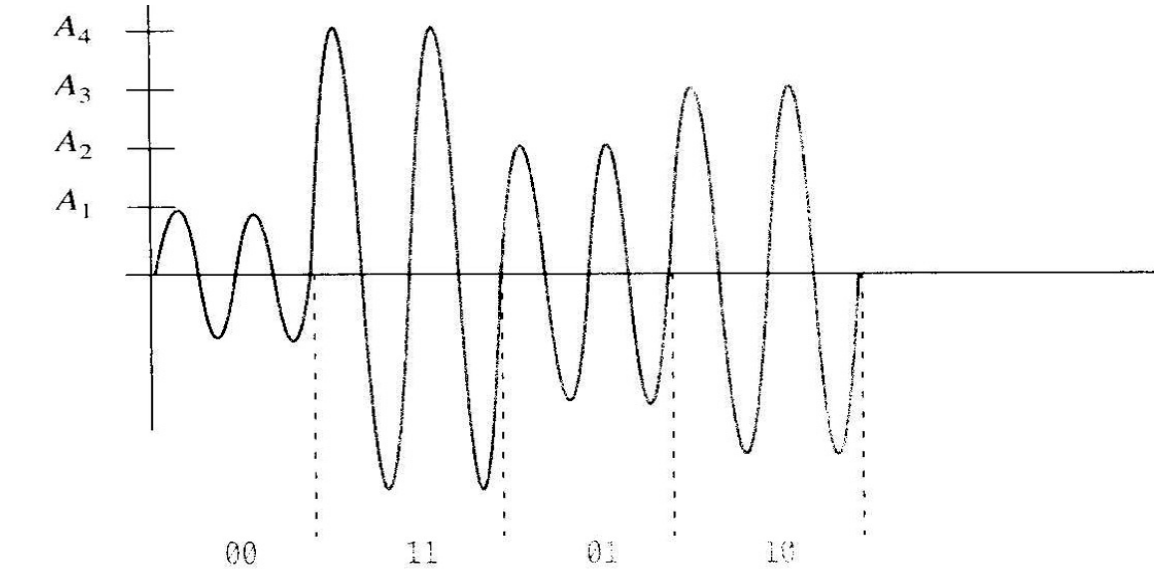
- Amplitude modulation
  - Amplitude shift keying (ASK): The amplitude of the carrier signal is varied to create signal element.
  - ASK is highly susceptible to noise interference



Analog Transmission (cont.)

- Can we send more than one bit at a time?

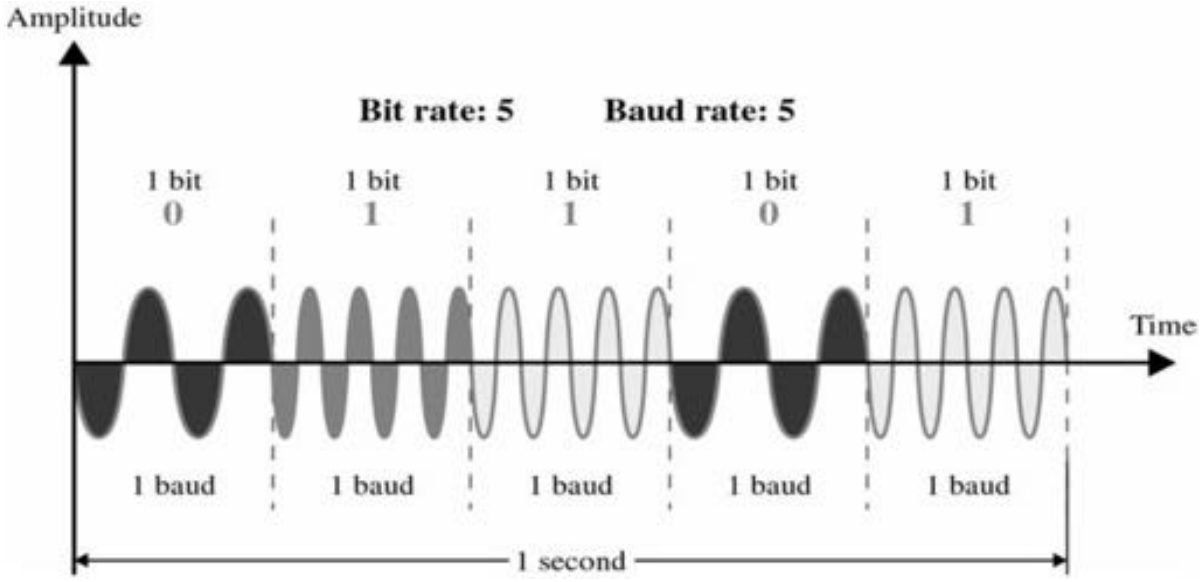
Amplitude of Signal	Bit Values
A_1	00
A_2	01
A_3	10
A_4	11



Amplitude Shift Keying (Four Amplitudes), Two Bits per Baud

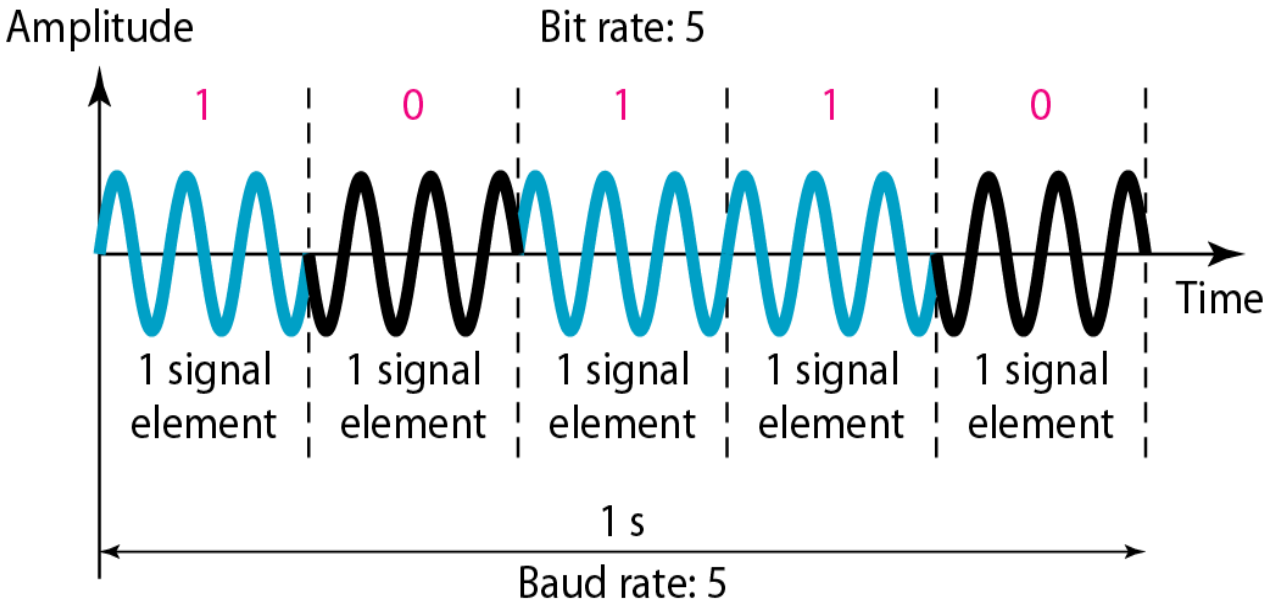
Analog Transmission (cont.)

- Frequency modulation
  - Frequency shift keying (FSK): Frequency of signal is varied to represent binary 1 or 0
  - FSK avoids most of the noise problems of ASK, but is limited by the physical capabilities of the carrier

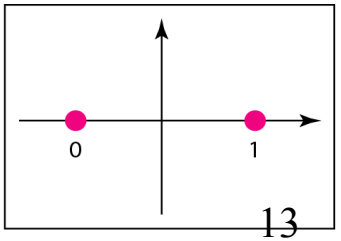


Analog Transmission (cont.)

- Phase modulation
  - Phase shift keying (PSK): The phase of the signal is varied to represent different signal elements.
  - PSK is not susceptible to the noise degradation that affects ASK, nor to the bandwidth limitations of FSK
  - Constellation diagram



bit	phase
1	0°
0	180°

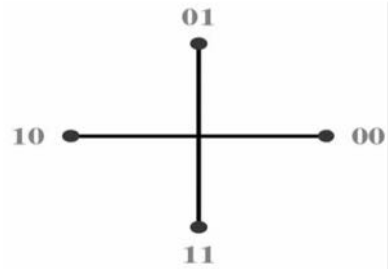


Analog Transmission (cont.)

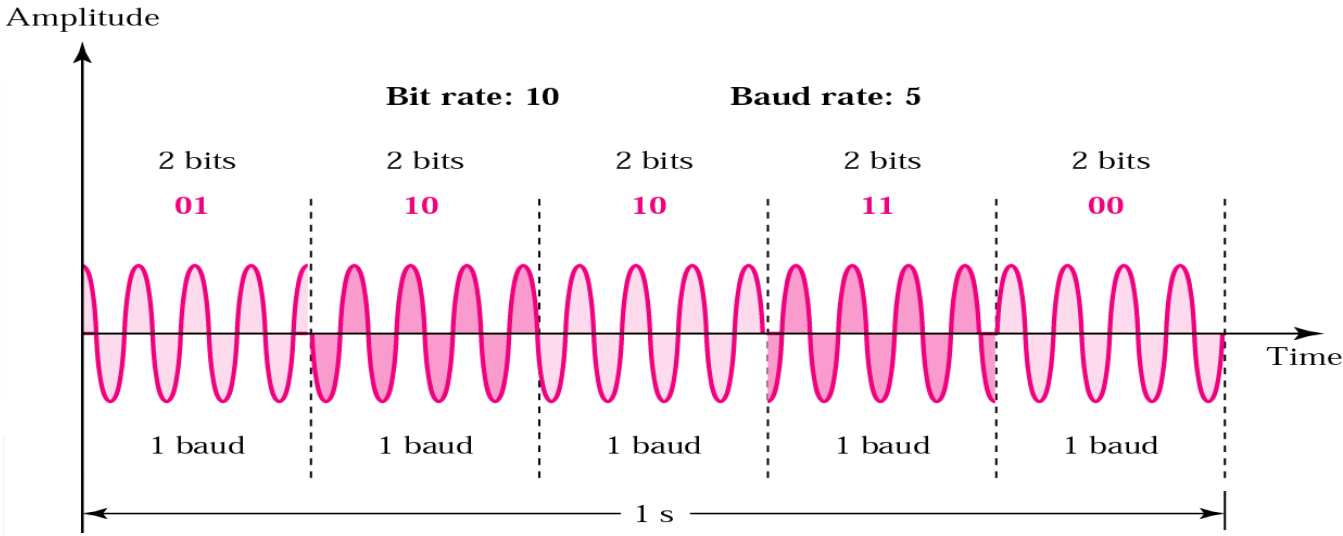
- 4-PSK

Dibit	Phase
00	0
01	90
10	180
11	270

Dibit
(2 bits)



Constellation diagram



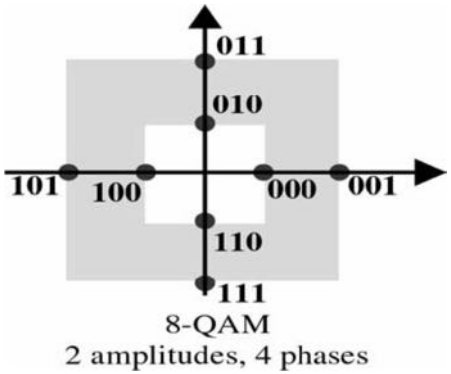
Try 8-PSK

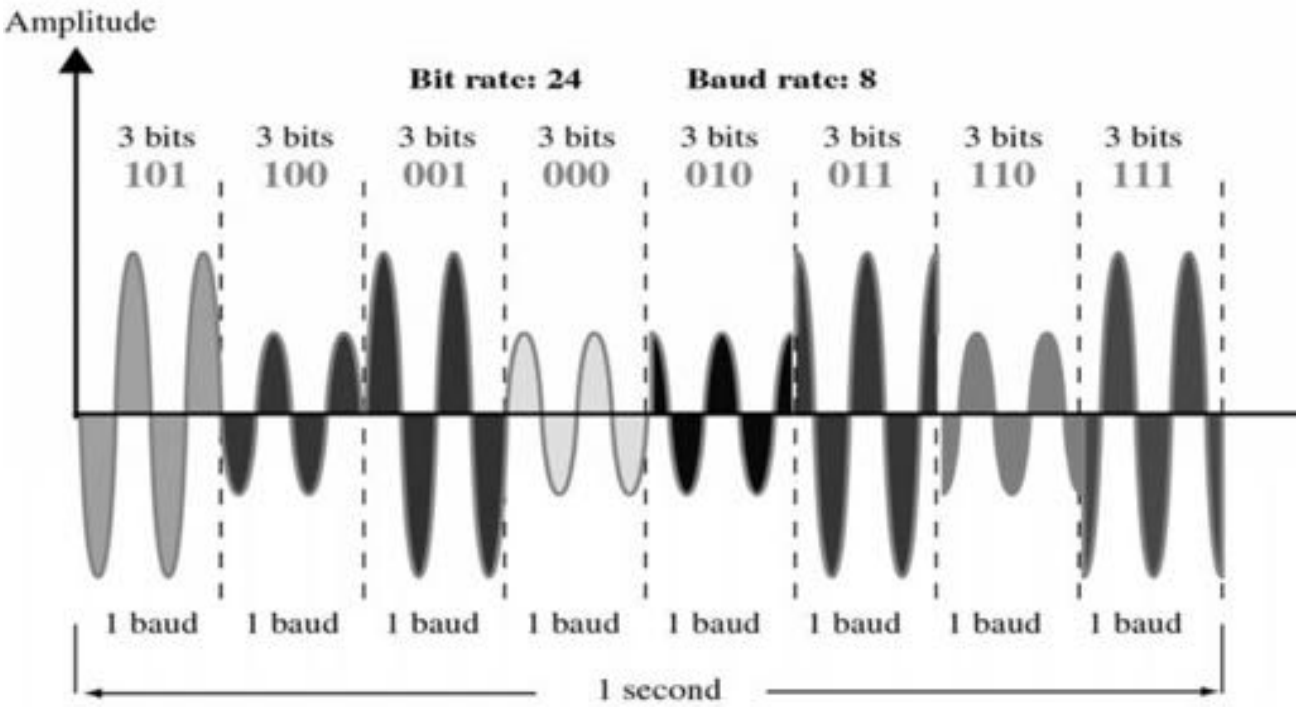
- PSK is limited by the ability of the equipment to distinguish small differences in phase (Why not combine PSK with ASK?)

Analog Transmission (cont.)

- Quadrature Amplitude Modulation (QAM): a combination of ASK and PSK

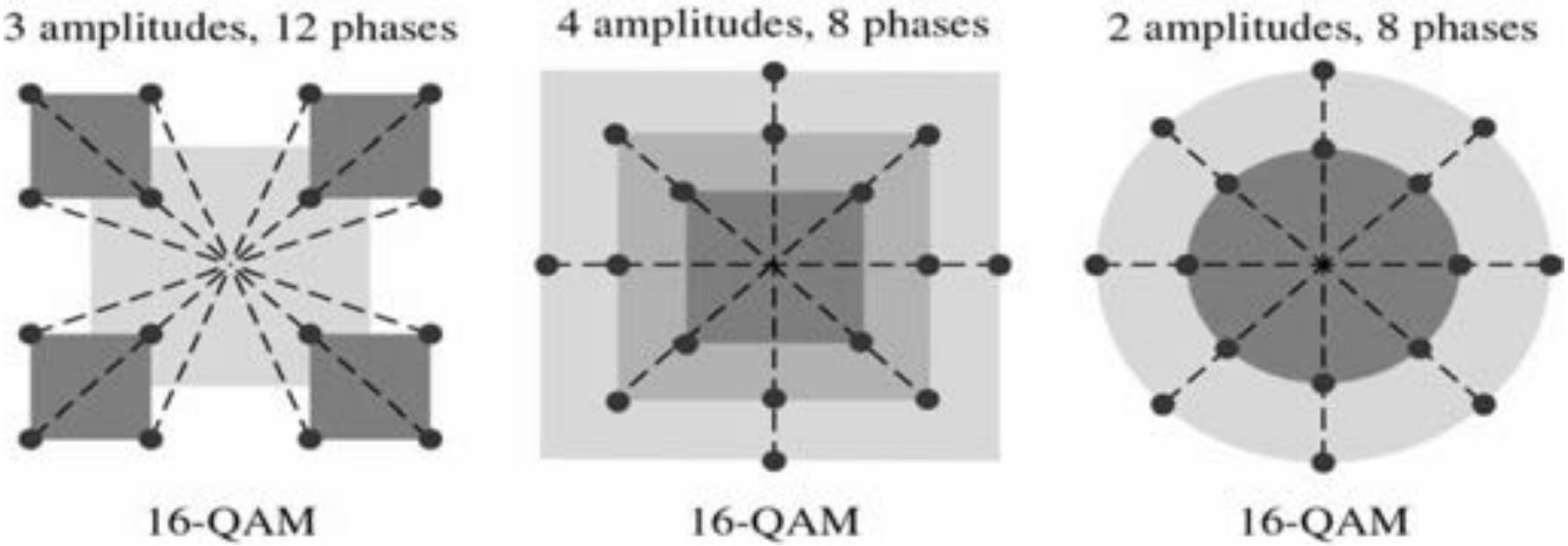
Bit Values	Amplitude of Signal	Phase Shift
000	A_1	0
001	A_2	0
010	A_1	1/4p
011	A_2	1/4p
100	A_1	2/4p
101	A_2	2/4p
110	A_1	3/4p
111	A_2	3/4p





Analog Transmission (cont.)

- Variations of QAM are numerous. The example is 8 QAM, try design 16 QAM



Analog Transmission (cont.)

- Bit Rate and Baud rate
  - Bit rate : the number of bits per second.
  - Baud rate : the number of signal elements per second. (Number of signal changes per second)
  - Bit rate = baud rate × n

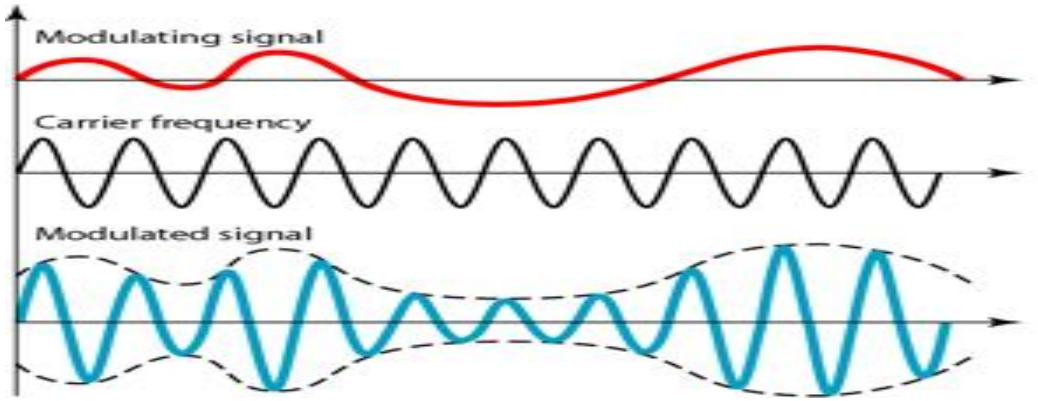
  (n is Number of bits represented by each signal element)
  - In the analog transmission of digital data, the Baud rate is less than or equal to the bit rate
  - An analog signal carries 4 bits per signal element. If 1000 signal elements are sent per second, find the baud rate and bit rate. (1k bauds per second, 4kbps)

Modulating/Carrier/Modulated signals

- Modulating signal: information to transmit
- Carrier signal: base signal (high frequency) that device produces (to be changed by modulating signal)
- Modulated signal: carrier signal altered (characteristics changed) by the modulating signal.
- Frequency of the carrier signal is greater than the highest frequency of the modulating signal

Analog-to-analog conversion

- Analog-to-analog conversion is the representation of analog information by an analog signal.
- Use a high frequency signal to carry the information of a low frequency signal.



Analog-to-digital conversion

- Digital representation of analog data
  - Multimedia, music, movies, microphone, camera
  - Accurate replay of high quality analog signals
- Digitization: Analog signal is sampled, quantized and encoded as streams of bits.

Summary

- Data Representation
- Digital Transmission
  - Encoding Methods for Digital to digital conversion
- Analog Transmission
  - Modulation Methods for digital to analog conversion
- Analog-to-digital/Analog-to-analog conversion