MORE SLIDES ON BASEBAND MODULATION

Bandwidth efficiency

- R/W is a useful parameter for measuring bandwidth efficiency (bits/s/hz)

  R : Bit rate

  W : Baseband bandwidth
- Larger the value of R/W more efficient the system is from bandwidth viewpoint
- For on-off signaling and polar signaling W = 2R

  R/W = 0.5 bits/s/Hz

  For bipolar signaling R/W = 1 bit/s/Hz

Comparison of various codes

Line Code	D.C.	Clock	Noise Immunity	Bandwidth	Transparency
ON-OFF	No Null	Yes	poor	2R	poor
POLAR	No Null	No	Good	2R	Good
BIPOLAR	Null	No	Poor	R	Poor

Quantization distortion error

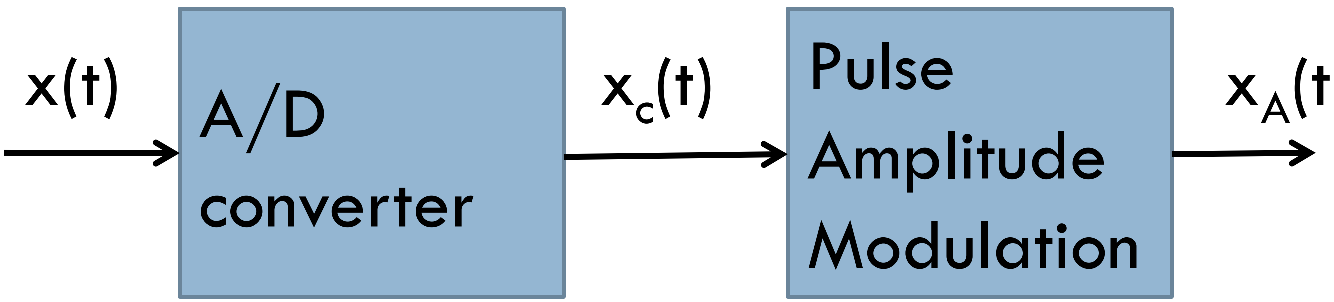
$$\textit{Maximum quantization error}$$

$$|e|_{\max} = \frac{q}{2} = \frac{2V_p}{L \times 2} = \frac{V_{pp}}{2L}$$

$$\frac{V_{pp}}{2L} \leq pV_{pp} \quad : \quad p \textit{ is a fraction}$$

$$L \geq \frac{1}{2p}$$

M'ary pulse modulation waveforms



$x(t)$: Analog Signal

$x_c(t)$: Binary Signal

$x_A(t)$: M'ary Signal

A convention

- At the the output of A/D converter

  L : Number of quantization levels

  l : Number of bits/sample

  $2^l = L$
- At the output of Pulse modulator

  M : Number of possible symbols(Waveforms) in the symbol set

  k : Number of bits per symbol

  $2^k = M$

PCM-PAM signalling

Analog signal : -1 to 1 volt. And 6 bit PCM

q = 2/64 = 1/32 volt. Signal between -1 &-31/32 volts coded as 000000

-31/32 & -30/32 coded as 000001 etc.

Sample value	16	4	8	6	30
PCM output	010000	000100	001000	000110	011110
8'ary values	2 0	0 4	1 0	0 6	3 6

Example

Analog signal fm = 3.5 kHz

Sampling frequency : 8 kHz

PCM bit rate (6 bits /sample) R = 48 kbits/sec

Bandwidth requirement : 2 R = 96 Khz

(On-Off signalling)

For PAM signalling Symbols/sec = 48/3 = 16 Ksymbols/sec

Bandwidth requirement = 16x2 = 32 KHz.