SYSTEM ARCHITECTURE
ADVANCED SYSTEM ARCHITECTURE
BATEMAN
Chapter5: Bandpass digital modulation

2013/Fall-Winter Term
Monday 12:50

Room# 1-322 or 5F Meeting Room

Instructor: Fire Tom Wada, Professor

Chapter5: Bandpass digital modulation

5.1 Introduction

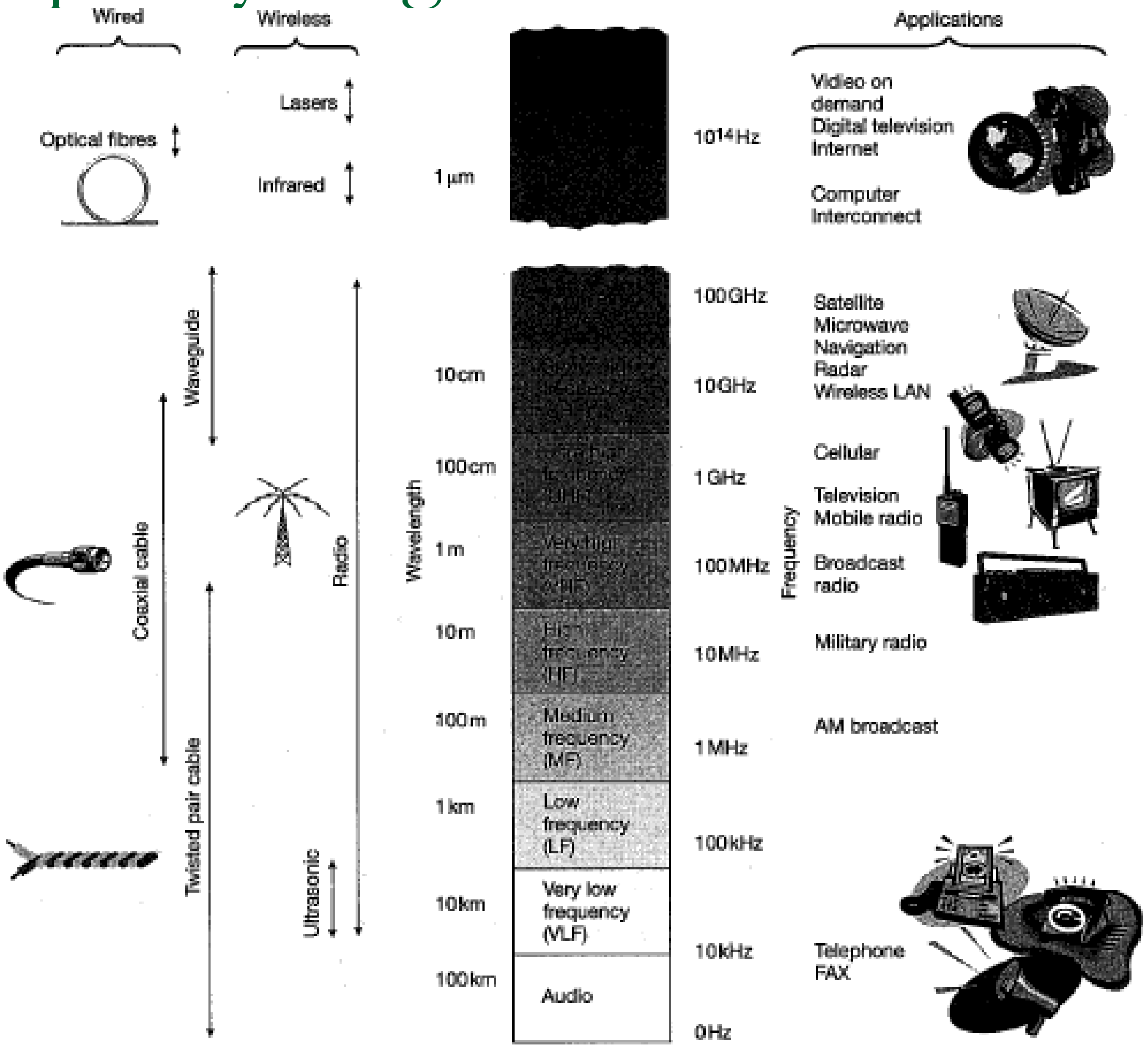
5.2 Amplitude Shift Keying (ASK)

5.3 Frequency Shift Keying (FSK)

5.4 Phase Shift Keying (PSK)

5.5 Comparison of binary modulation schemes

Frequency range for communication



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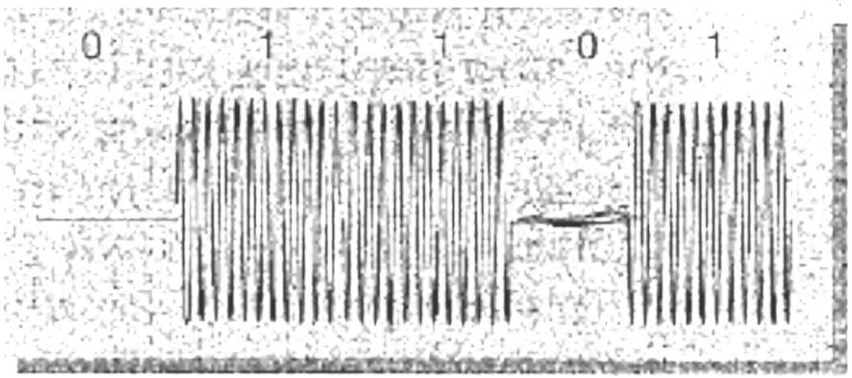
5.5 Comparison of binary modulation schemes

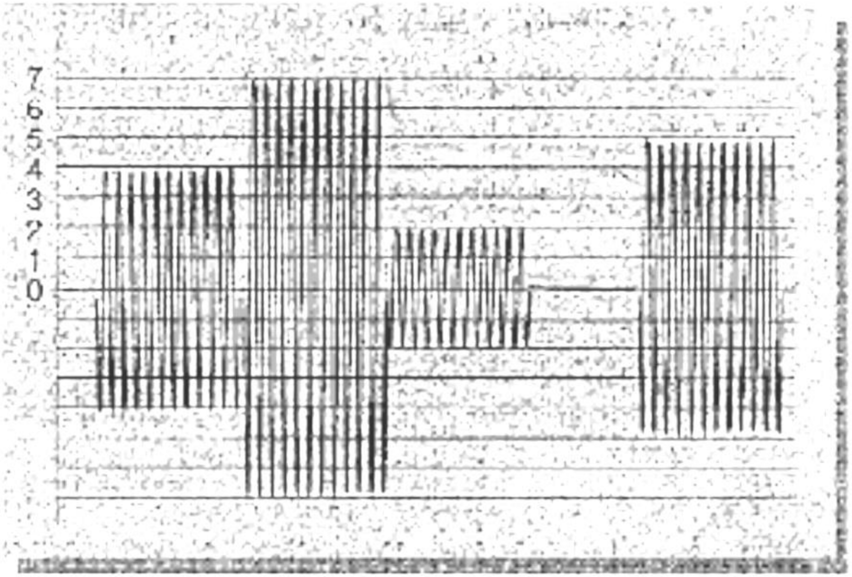
What is Amplitude Shift Keying (ASK)

- Simplest form of bandpass data modulation is ASK.

Binary ASK (1bit)
= ON-OFF Keying

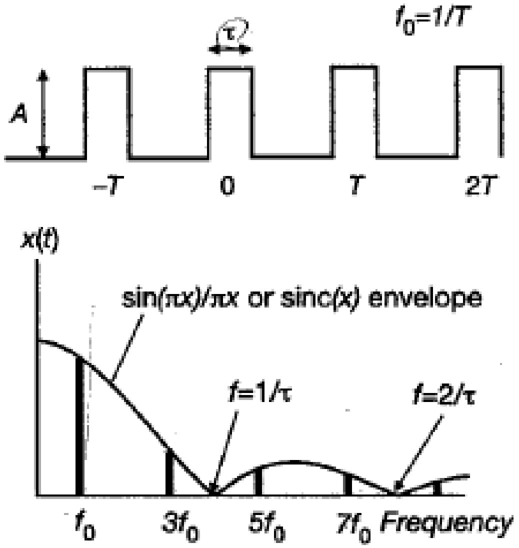


8-ary ASK
8-ASK (3bit)

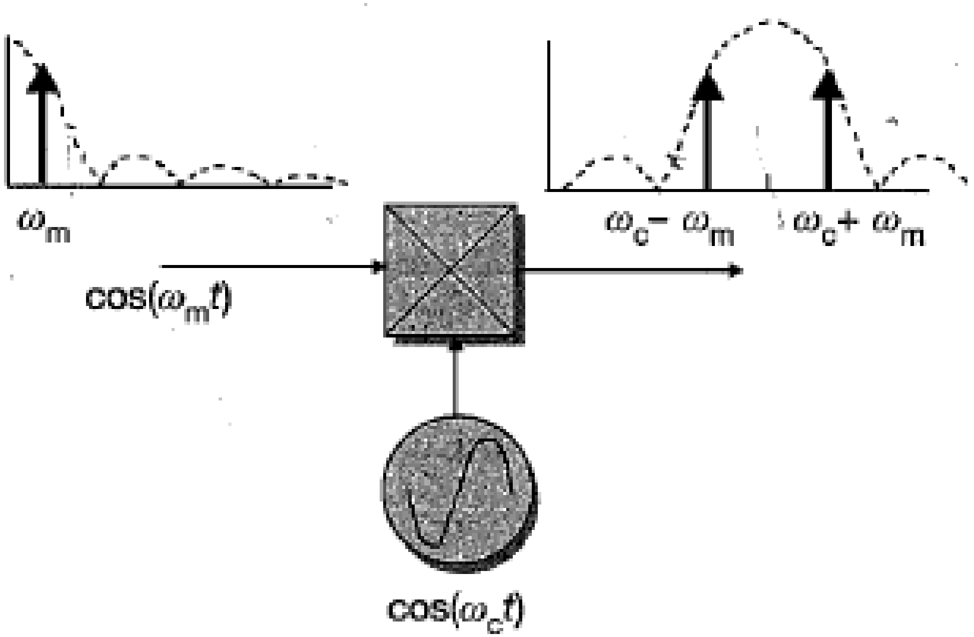


ASK spectrum is Symmetry

When pulse is up-converted, Symmetry Spectrum appears!

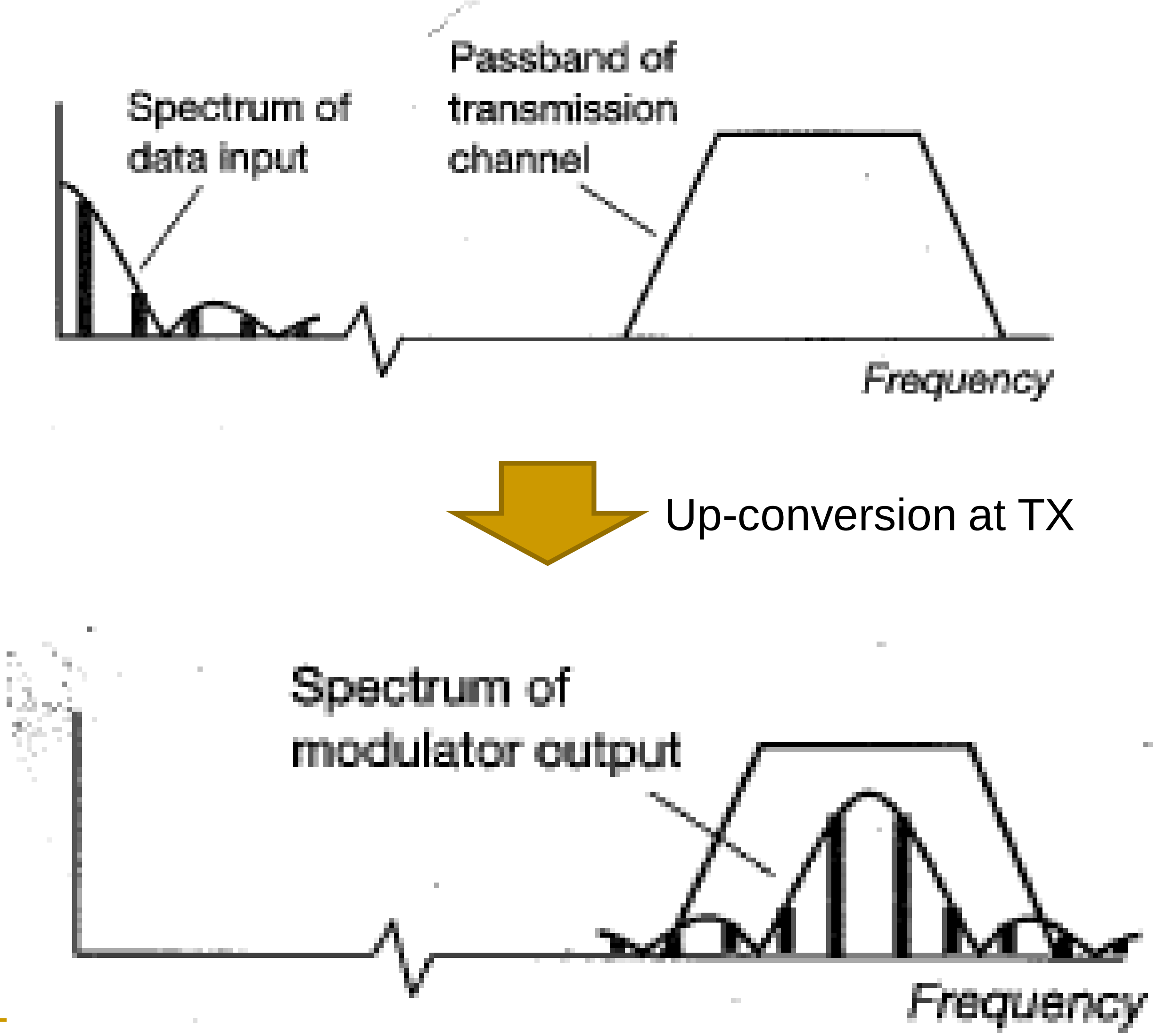


From page 5



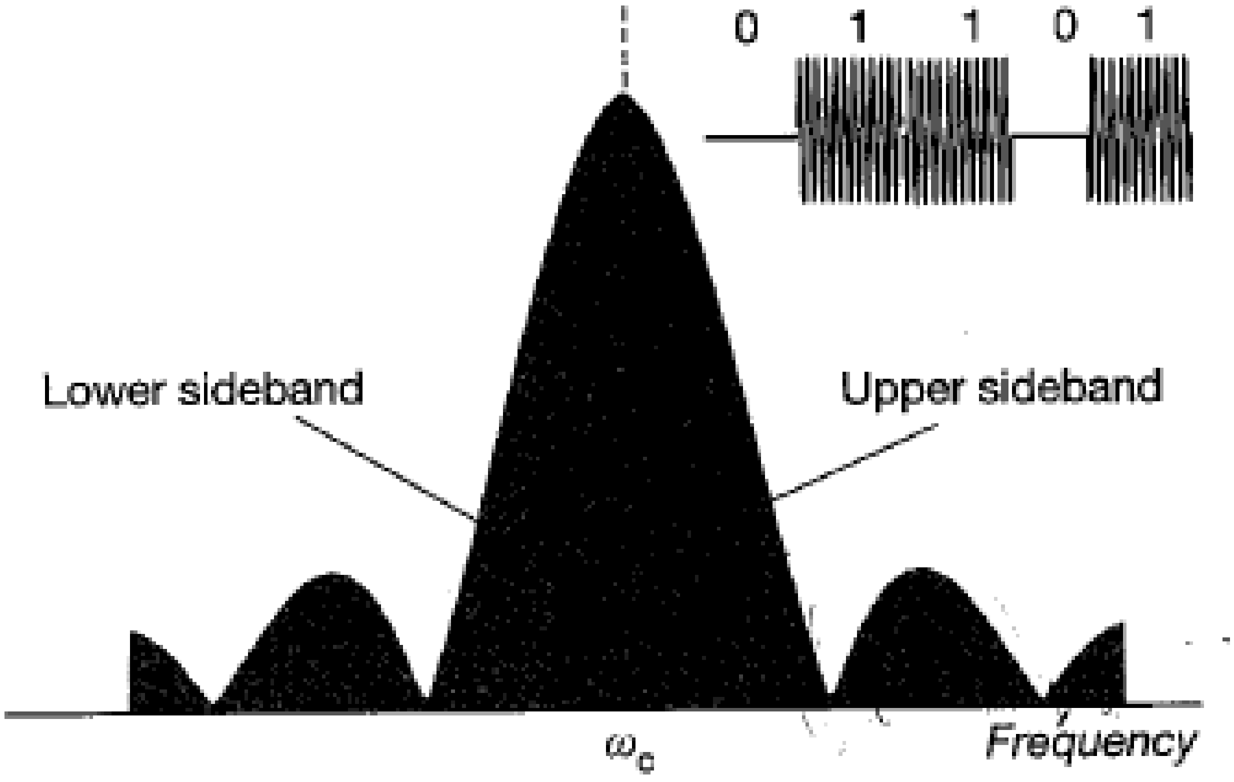
$$\cos \omega_m t \cdot \cos \omega_c t = 0.5 \cos(\omega_c - \omega_m)t + 0.5 \cos(\omega_c + \omega_m)t$$

Up-conversion process

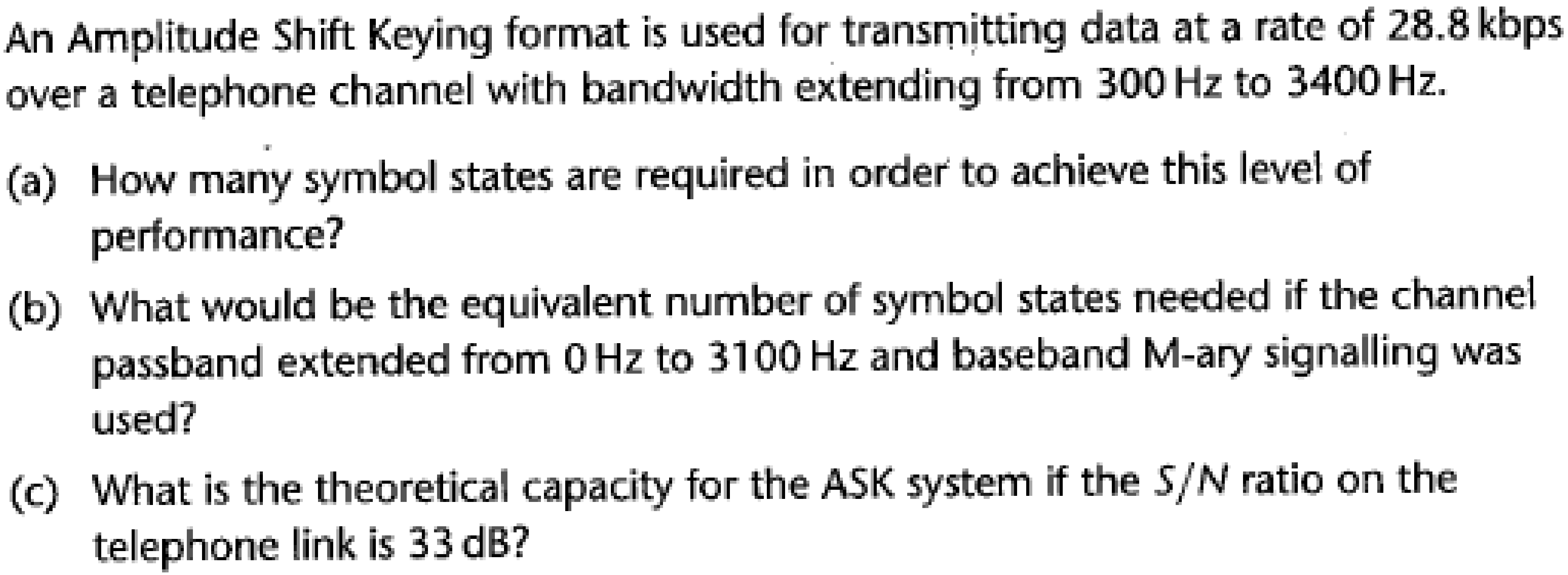


Up-conversion at TX

Double sideband spectrum



Example 5.1



An Amplitude Shift Keying format is used for transmitting data at a rate of 28.8 kbps over a telephone channel with bandwidth extending from 300 Hz to 3400 Hz.

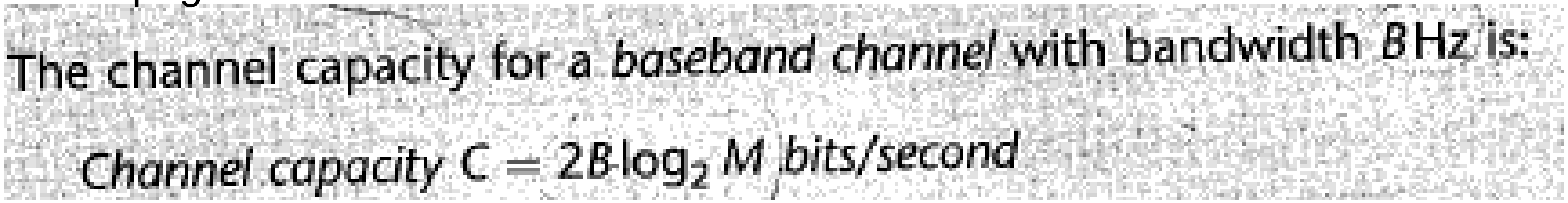
(a) How many symbol states are required in order to achieve this level of performance?

(b) What would be the equivalent number of symbol states needed if the channel passband extended from 0 Hz to 3100 Hz and baseband M-ary signalling was used?

(c) What is the theoretical capacity for the ASK system if the S/N ratio on the telephone link is 33 dB?

Solution 5.1(a)

From page 42



The channel capacity for a *baseband channel* with bandwidth B Hz is:

Channel capacity $C = 2B \log_2 M$ *bits/second*

(a) The capacity of a bandpass ASK channel is given by:

$$C_{\text{ASK}} = B \log_2 M \longrightarrow$$

Bandwidth efficiency of binary ASK = 1 *bit/second/Hz*

compared with

$$C_{\text{baseband}} = 2B \log_2 M$$

Hence,

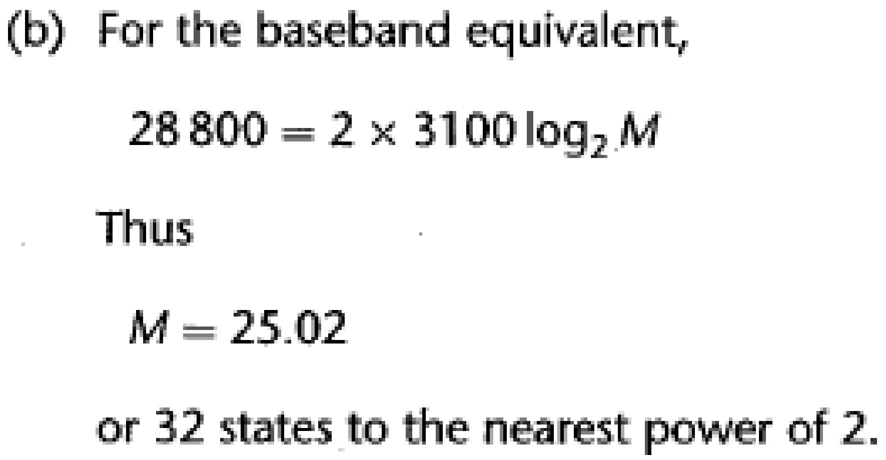
$$28\,800 = (3400 - 300) \log_2 M$$

and

$$M = 626.1$$

or 1024 states to nearest power of 2.

Solution 5.1(b,c)



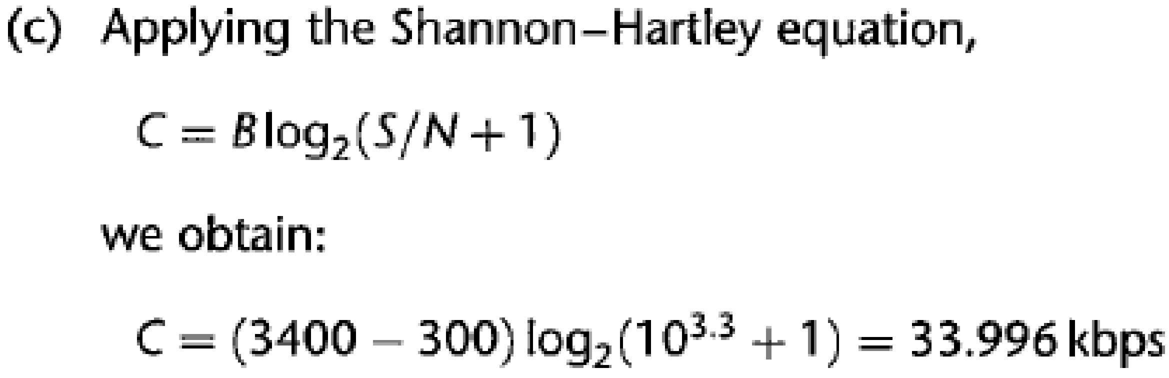
(b) For the baseband equivalent,

$$28\,800 = 2 \times 3100 \log_2 M$$

Thus

$$M = 25.02$$

or 32 states to the nearest power of 2.



(c) Applying the Shannon–Hartley equation,

$$C = B \log_2(S/N + 1)$$

we obtain:

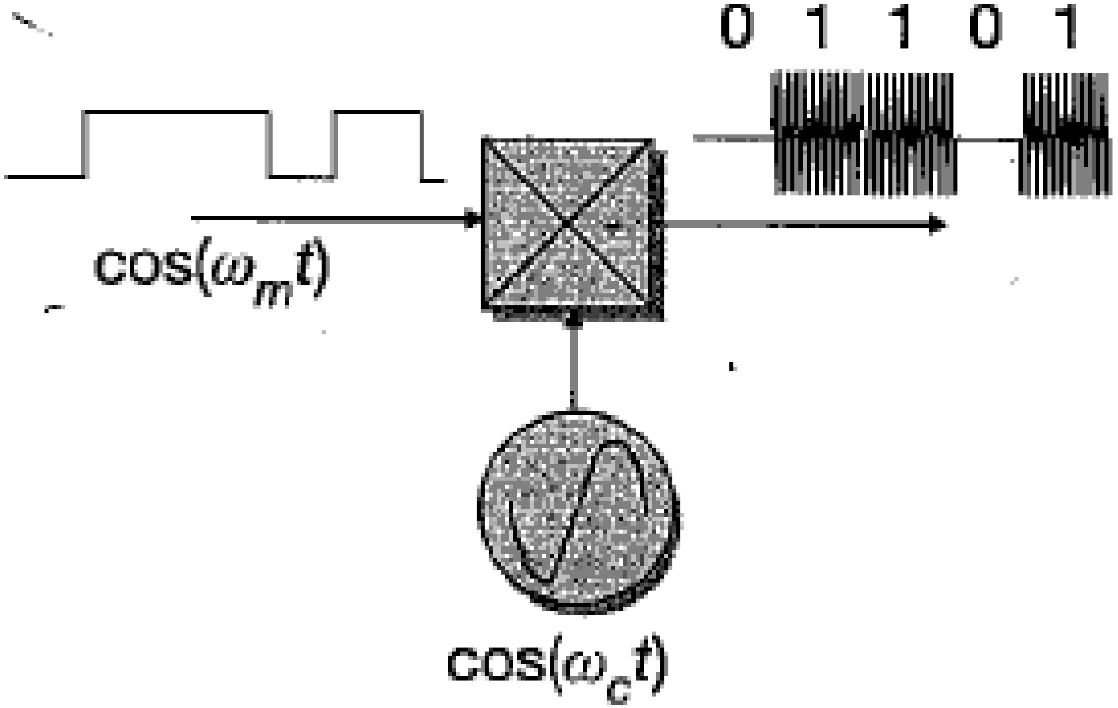
$$C = (3400 - 300)\log_2(10^{3.3} + 1) = 33.996\ \text{kbps}$$

33dB=$10 log_{10} SNR$

SNR=$10^{\frac{33}{10}}$

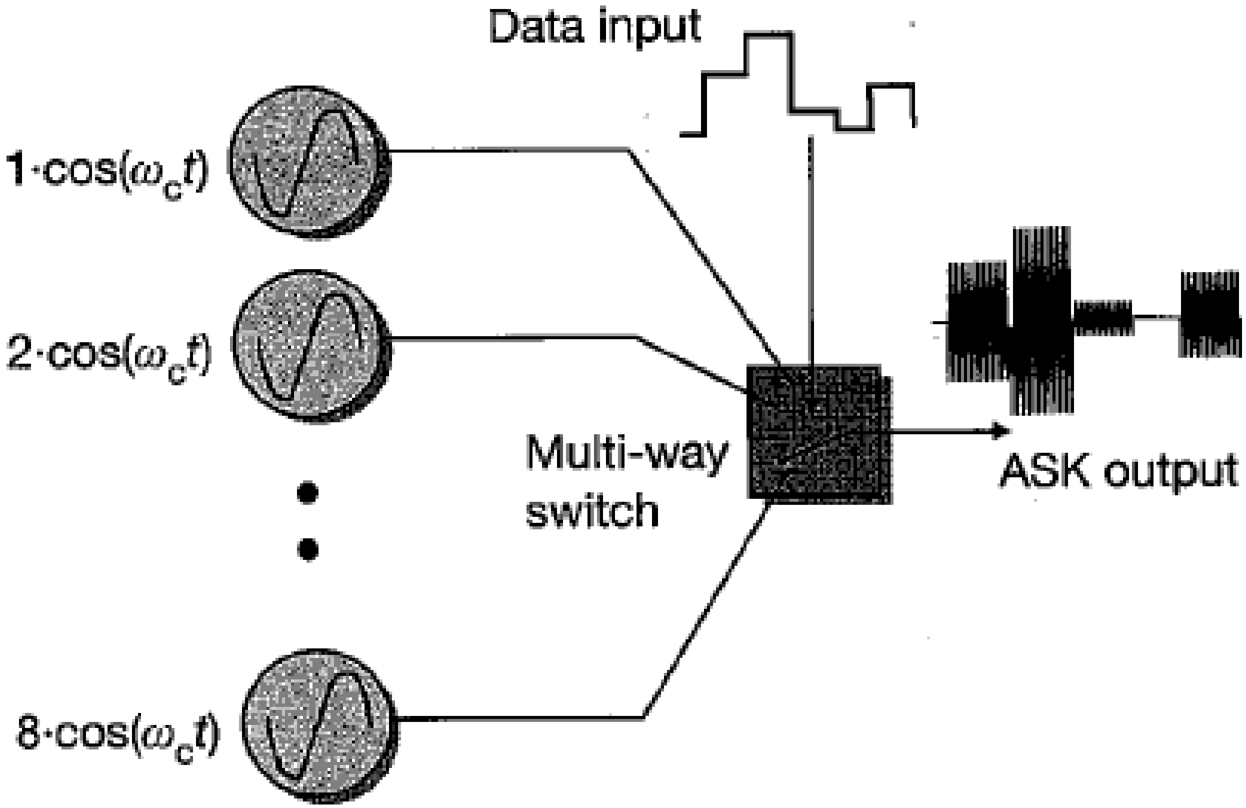
Generation of ASK (1)

Linear modulation



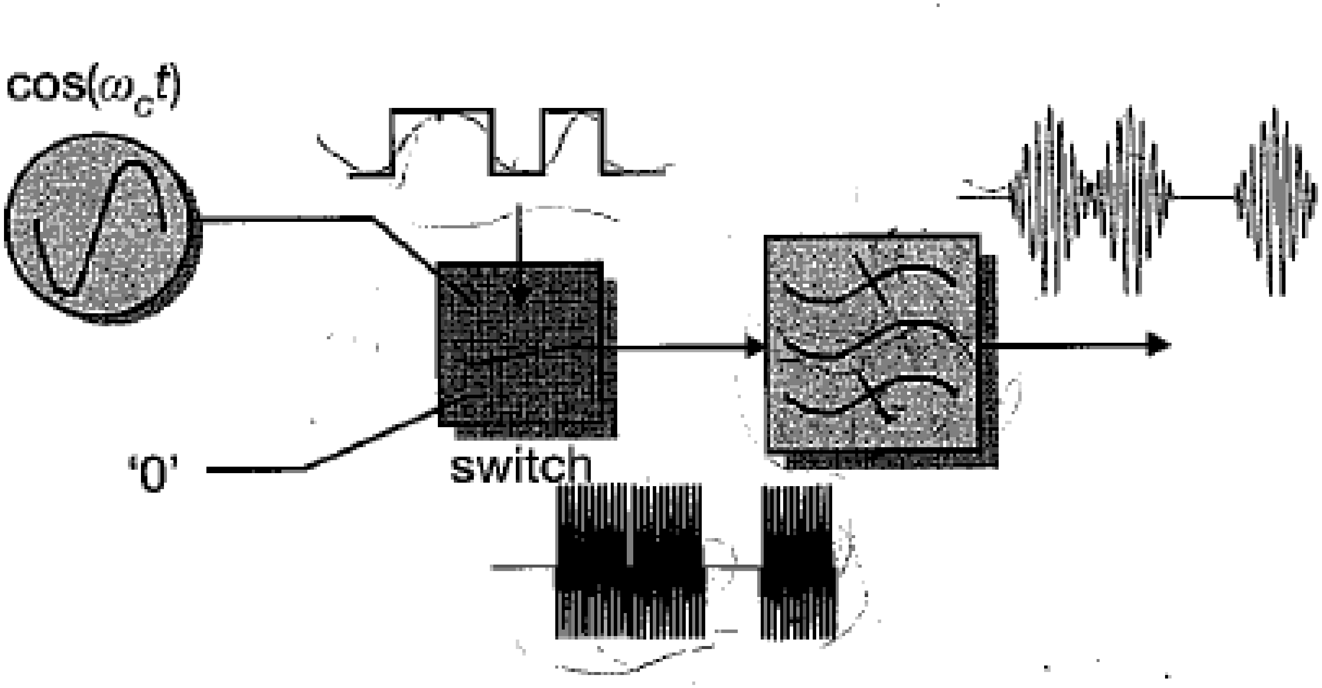
Generation of ASK (2)

8-ASK



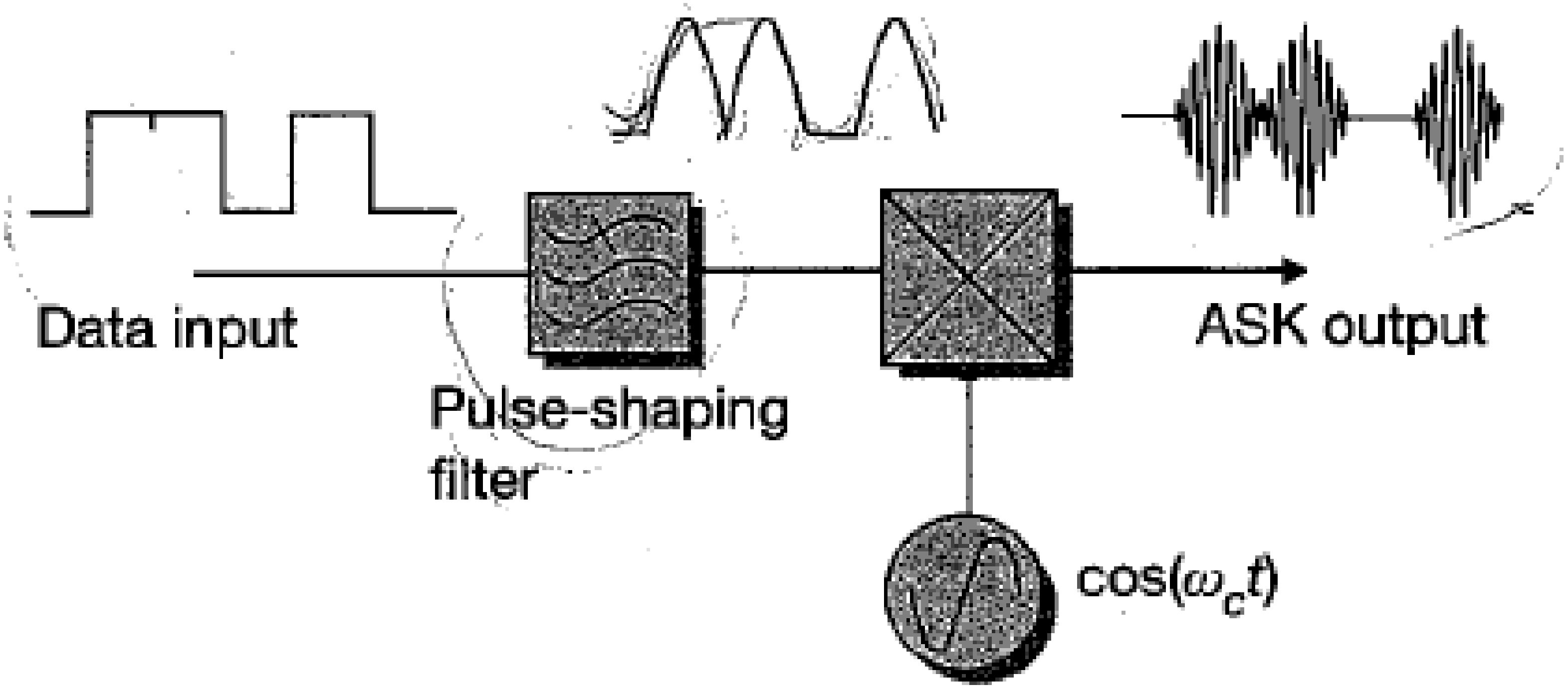
Bandwidth limited ASK generation (1)

Bandpass filtering method



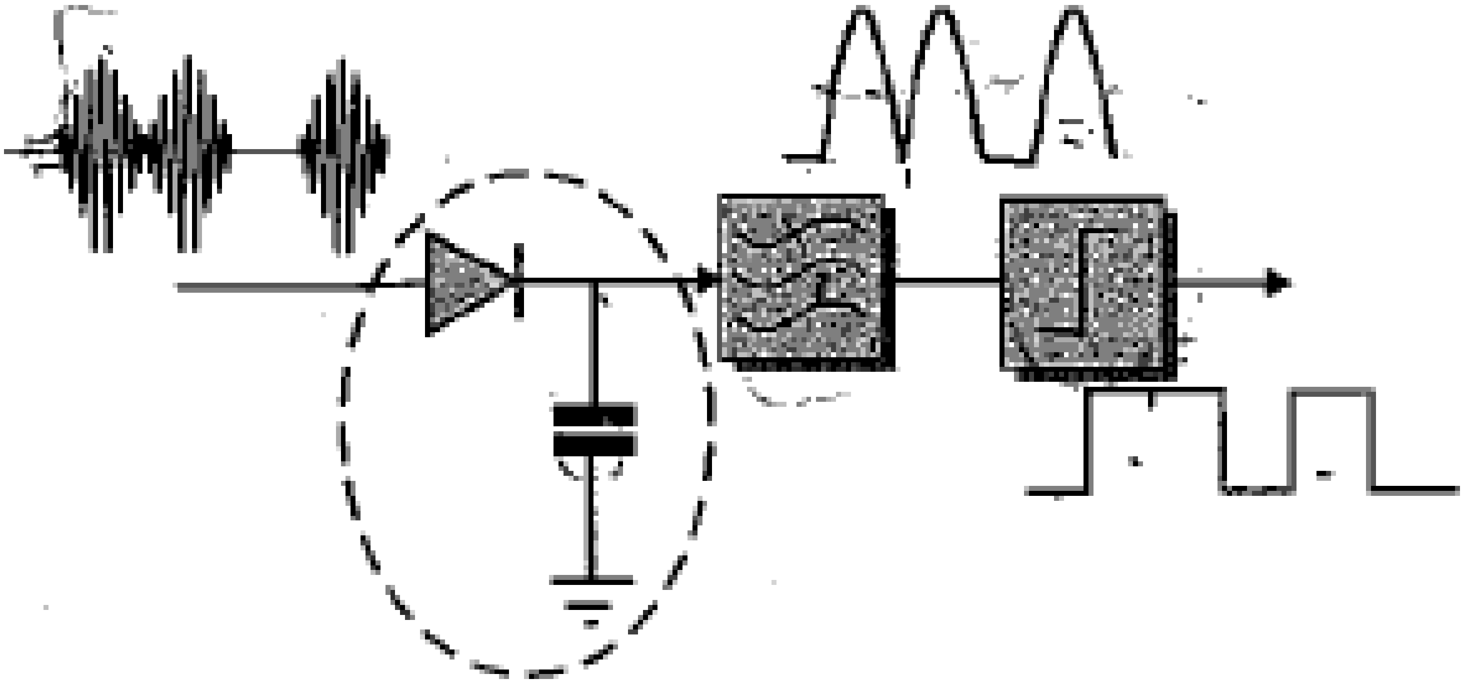
Bandwidth limited ASK generation (2)

Baseband filtering method



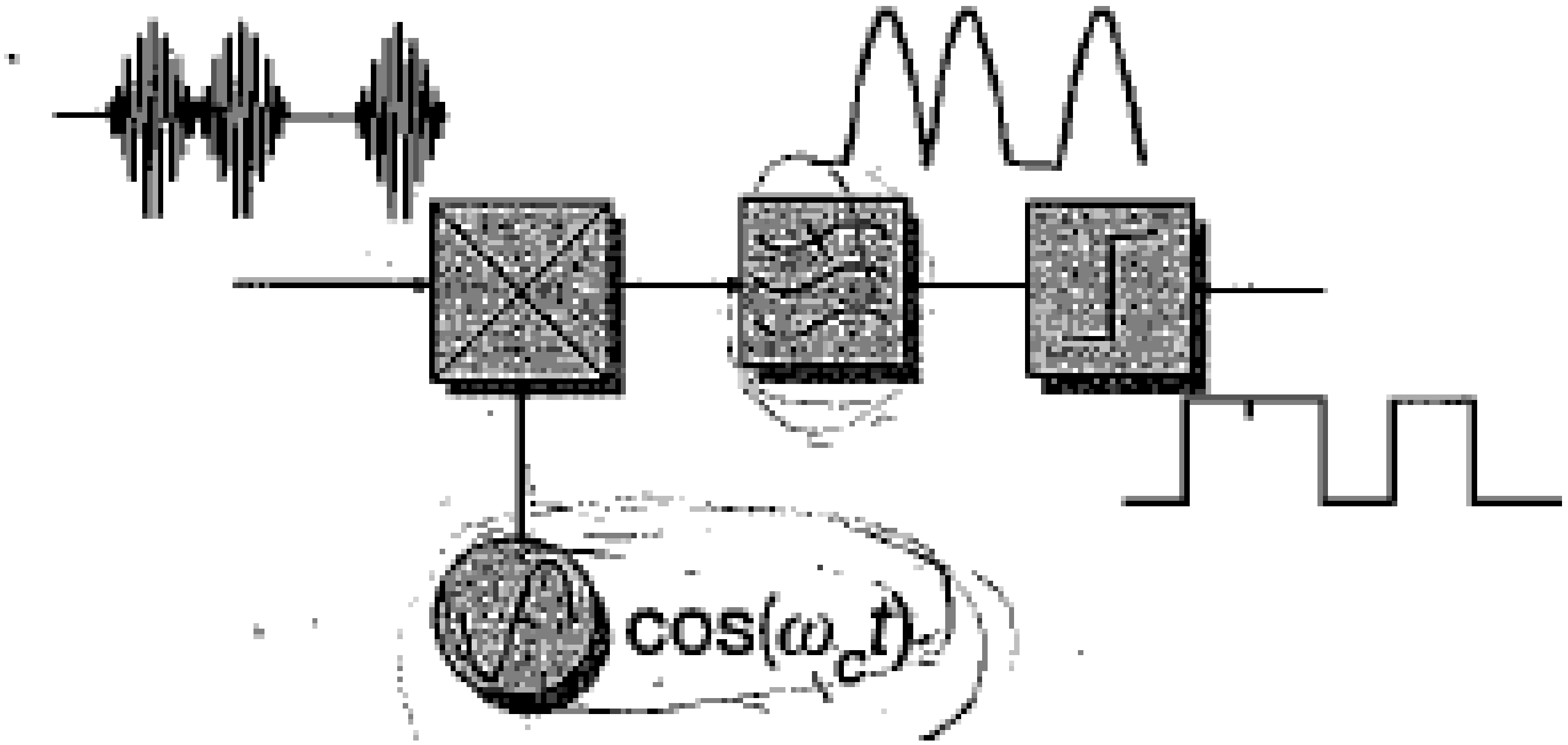
Detection ASK –non-coherent-(1)

Envelop detector

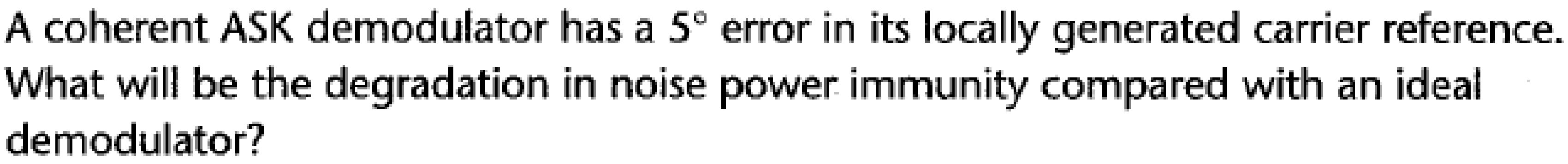


Detection ASK –coherent-(2)

$$a(t)\cdot\cos\omega_c t\cdot\cos(\omega_c t+\theta)=0.5\cdot a(t)\cos(\theta)+0.5\cdot a(t)\cos(2\omega_c t+\theta)$$



Example 5.2



A coherent ASK demodulator has a 5° error in its locally generated carrier reference. What will be the degradation in noise power immunity compared with an ideal demodulator?

Solution 5.2

The *voltage* output of the mixer used to compare the incoming symbol $a(t) \cdot \cos(\omega_c t)$ with the reference $\cos(\omega_c t + 5°)$ will be reduced by a factor $\cos(5°)$ from its maximum value as a result of the carrier phase error.

This in turn equates to a reduction in symbol *energy* at the input to the receiver of $\cos^2(5°) = 0.9924$ (symbol energy is proportional to power × symbol length or voltage^2 × symbol length).

The noise components passing through the mixer will also be affected by the phase error in the carrier reference, but since the noise vectors are assumed to be randomly distributed through 360°, the carrier phase error will reduce the effect of some noise vectors and enhance others with the net effect that the *average noise voltage* at the mixer output will remain unchanged.

Hence it is only the symbol energy that is truly affected by carrier reference phase error and not the noise power. This means that the effective received symbol energy to noise power density will be reduced by a factor $1/\cos^2(5°) = 1.0076$, or 0.0033 dB, as a result of the phase error.

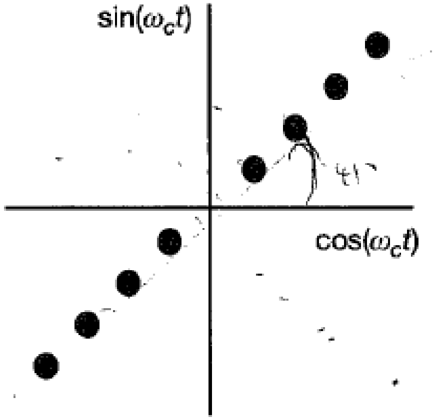
Example 5.3 constellation

Sketch the constellation diagram for 8-ary ASK with a bipolar modulating signal and with a carrier frequency of $\cos(\omega_c t \oplus 45^\circ)$. What would be the output from a non-coherent detector for this type of ASK waveform?

Solution

A constellation diagram is usually drawn with symbols having a phase $\cos(\omega_c t + 0^\circ)$ on the horizontal axis, and those with phase $\cos(\omega_c t + 90^\circ)$ on the vertical axis. For the carrier in this example, the symbols must lie on a line at 45° to the horizontal axis as shown below.

The bipolar nature of the input modulating signal means that the amplitudes of the ASK symbols will have both positive and negative values. A negative value amplitude for an ASK symbol simply means that the carrier phase is inverted for these symbols (that is, they appear in the opposite quadrant of the constellation diagram).



8-ary ASK vector diagram
(bipolar input)

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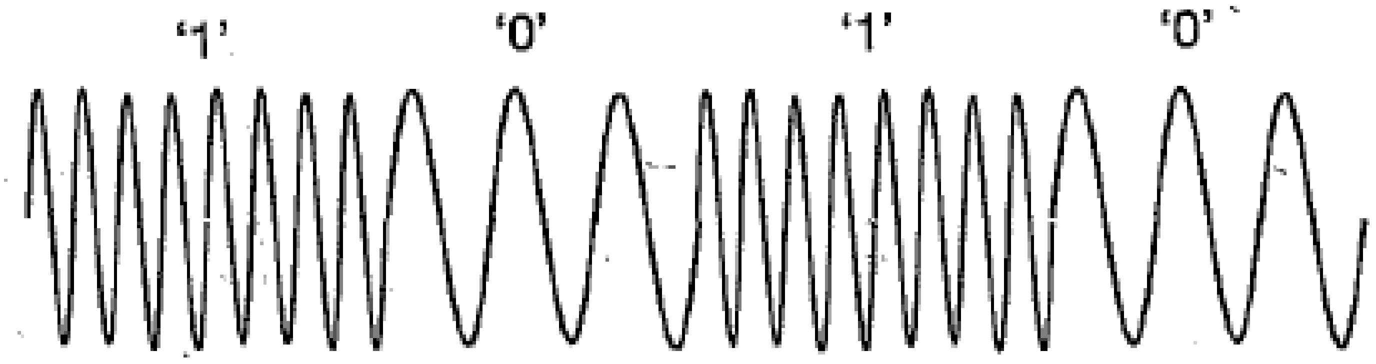
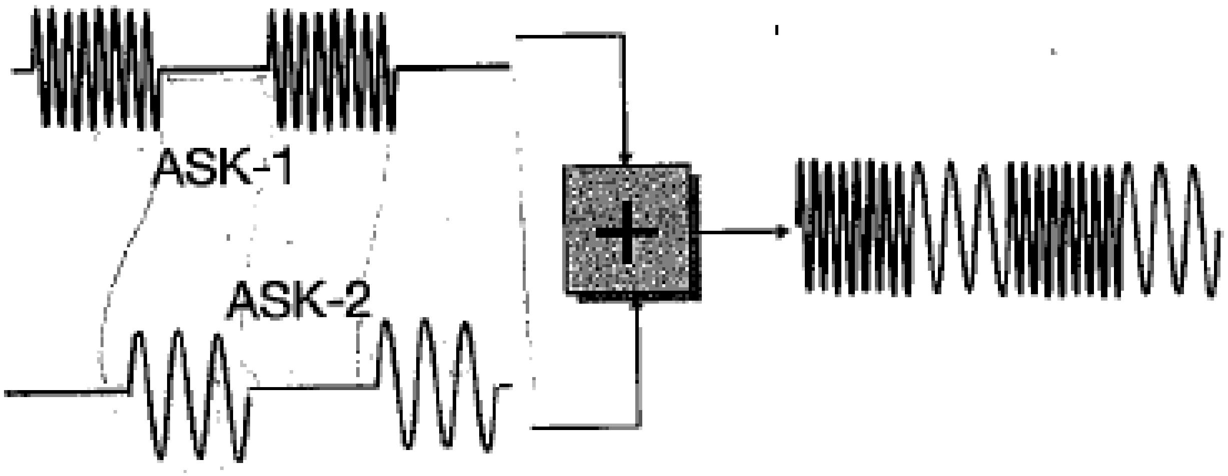
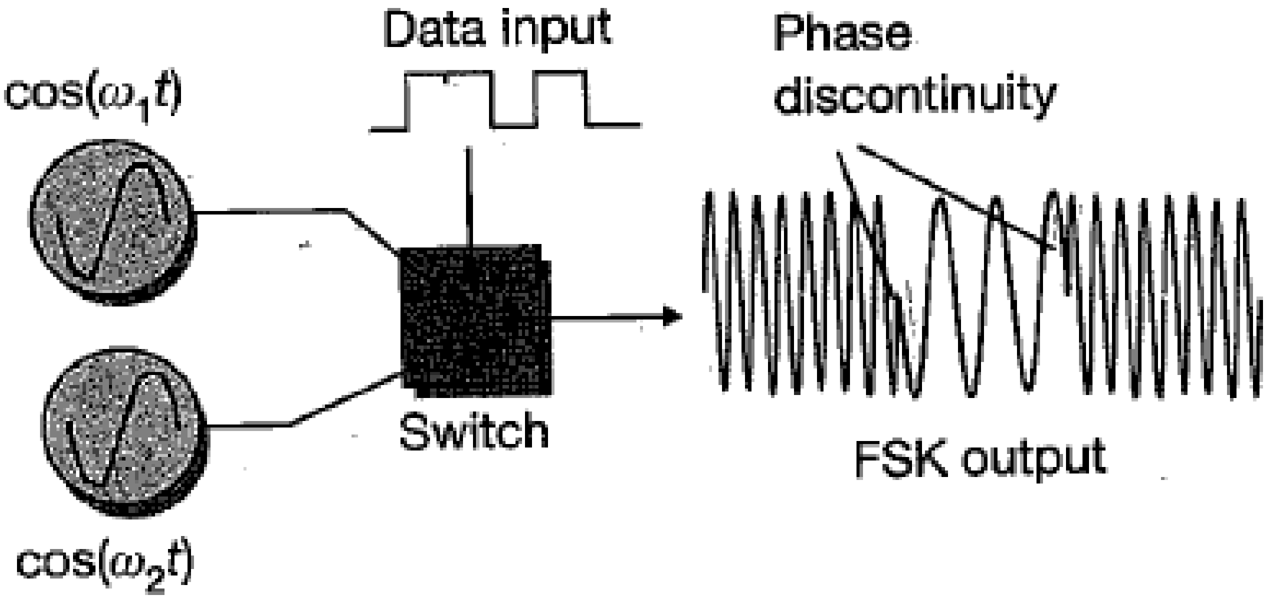
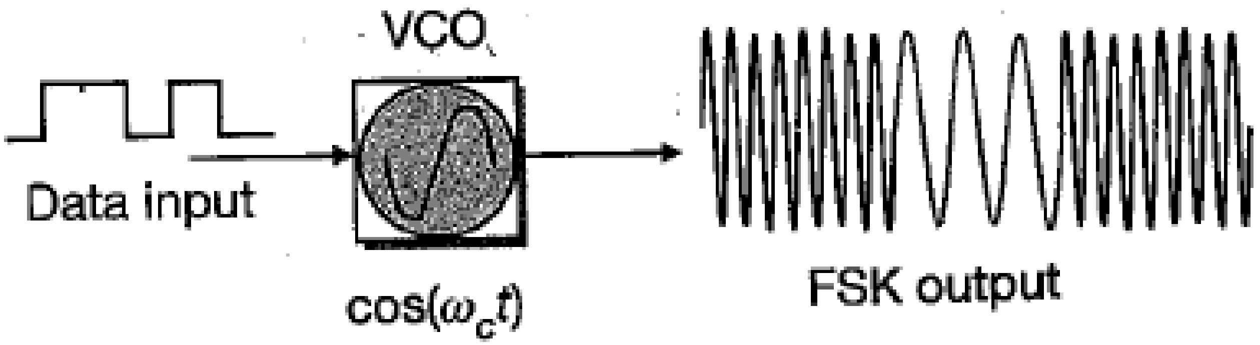
FSK waveform



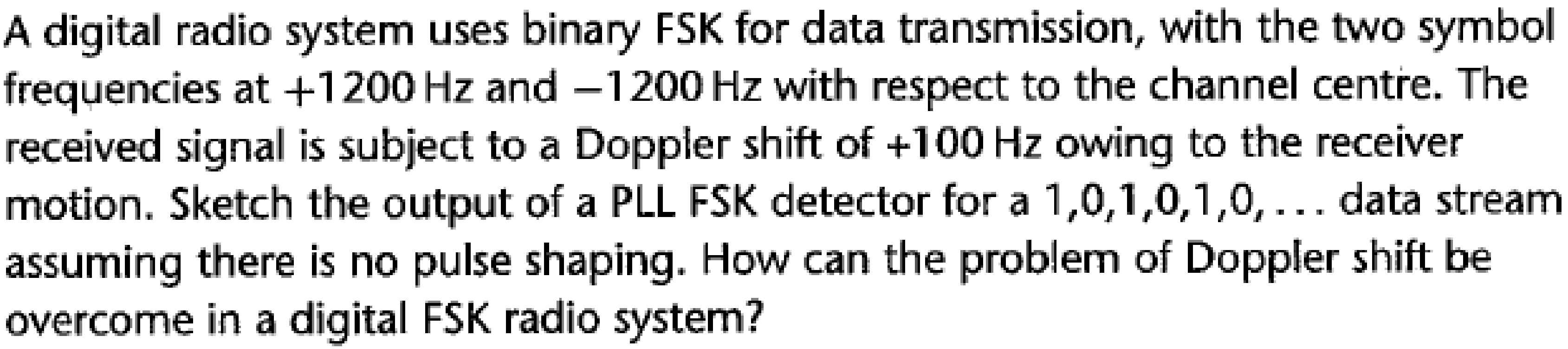


FSK signal generation





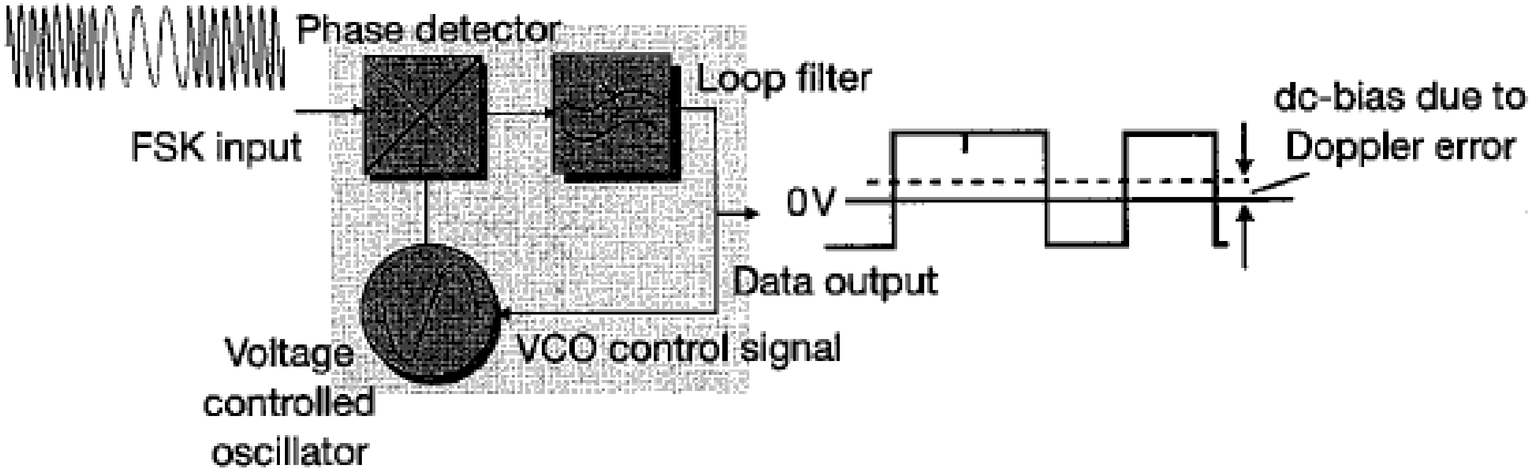
Example 5.4



A digital radio system uses binary FSK for data transmission, with the two symbol frequencies at +1200 Hz and −1200 Hz with respect to the channel centre. The received signal is subject to a Doppler shift of +100 Hz owing to the receiver motion. Sketch the output of a PLL FSK detector for a 1,0,1,0,1,0, . . . data stream assuming there is no pulse shaping. How can the problem of Doppler shift be overcome in a digital FSK radio system?

Solution 5.4

The effect of the Doppler shift on the receiver signal is to make the symbols appear at frequencies of +1300 Hz and −1100 Hz with respect to the notional centre frequency of the PLL detector. The result is that the PLL output will have a dc-bias voltage superimposed on the recovered data signal as shown below, proportional to the Doppler offset.



PLL

To eliminate the Doppler shift the output of the PLL detector can be ac-coupled; however, this would also affect any low frequency content in the data signal itself. A coding scheme such as Manchester encoding (see Section 4.4) could be used here to remove any low frequency content in the data signal.

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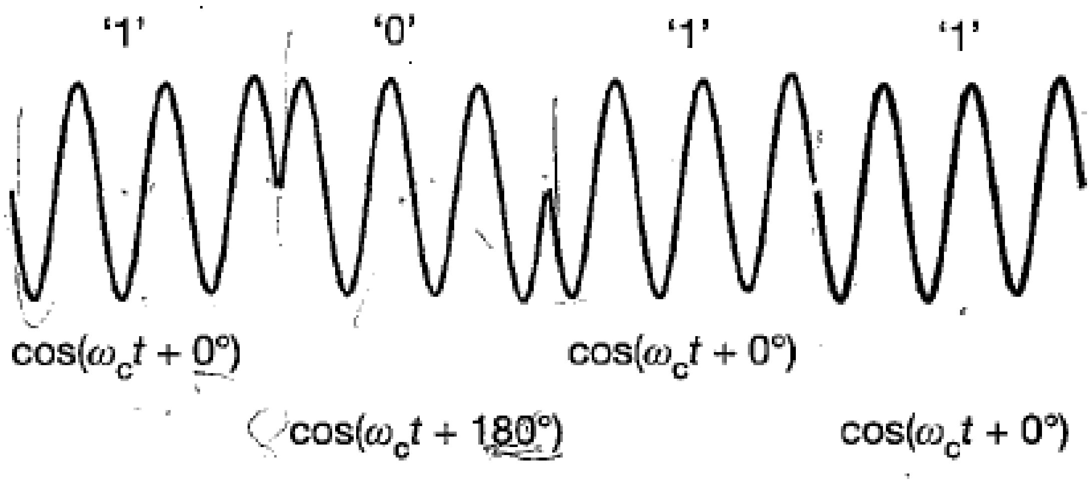
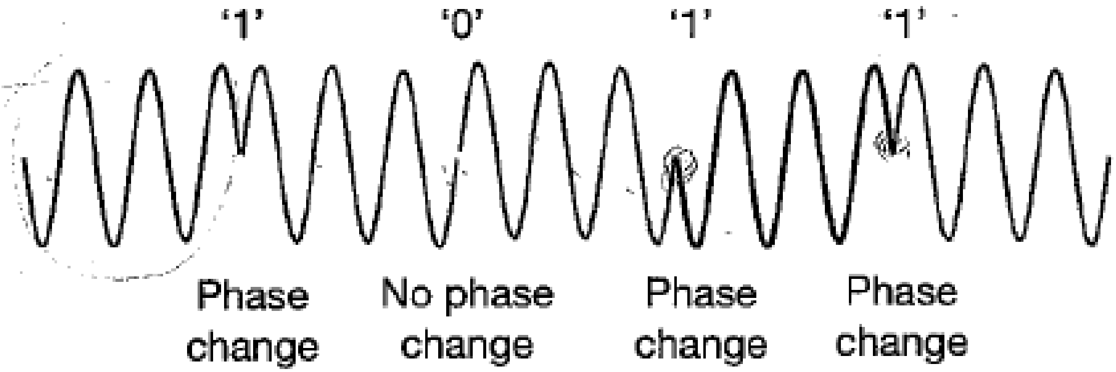
Coherent and Differential PSK

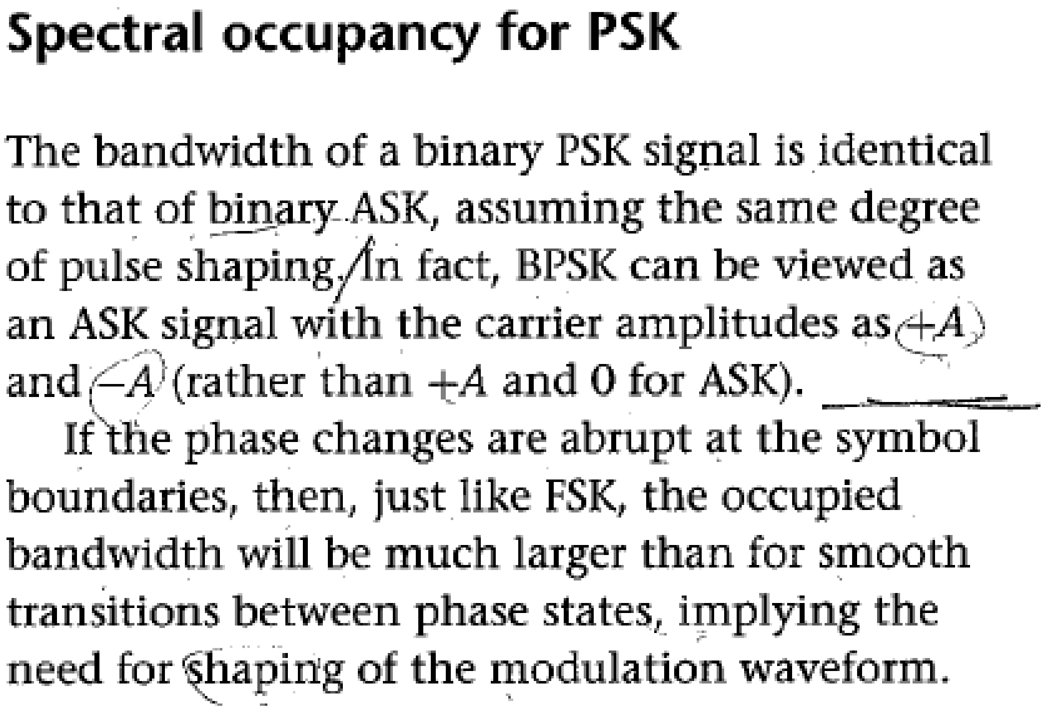


Coherent phase shift keying



Differential phase shift keying

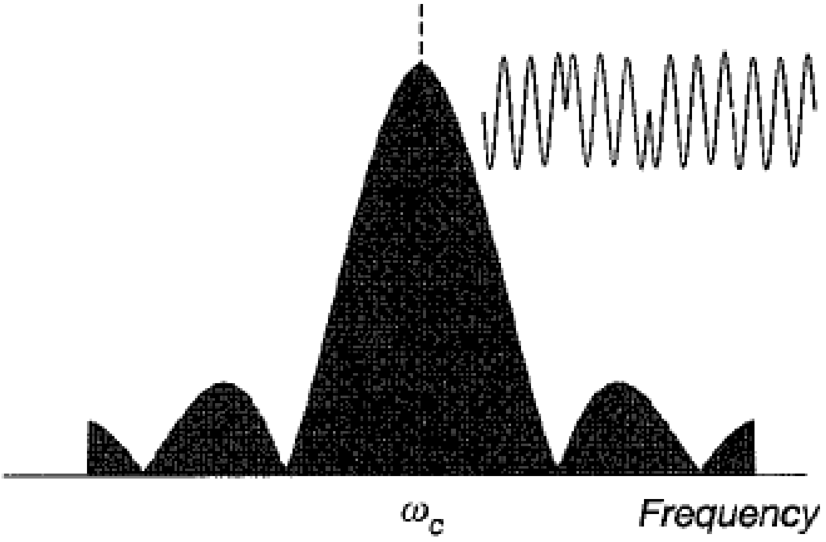
PSK Spectrum



Spectral occupancy for PSK

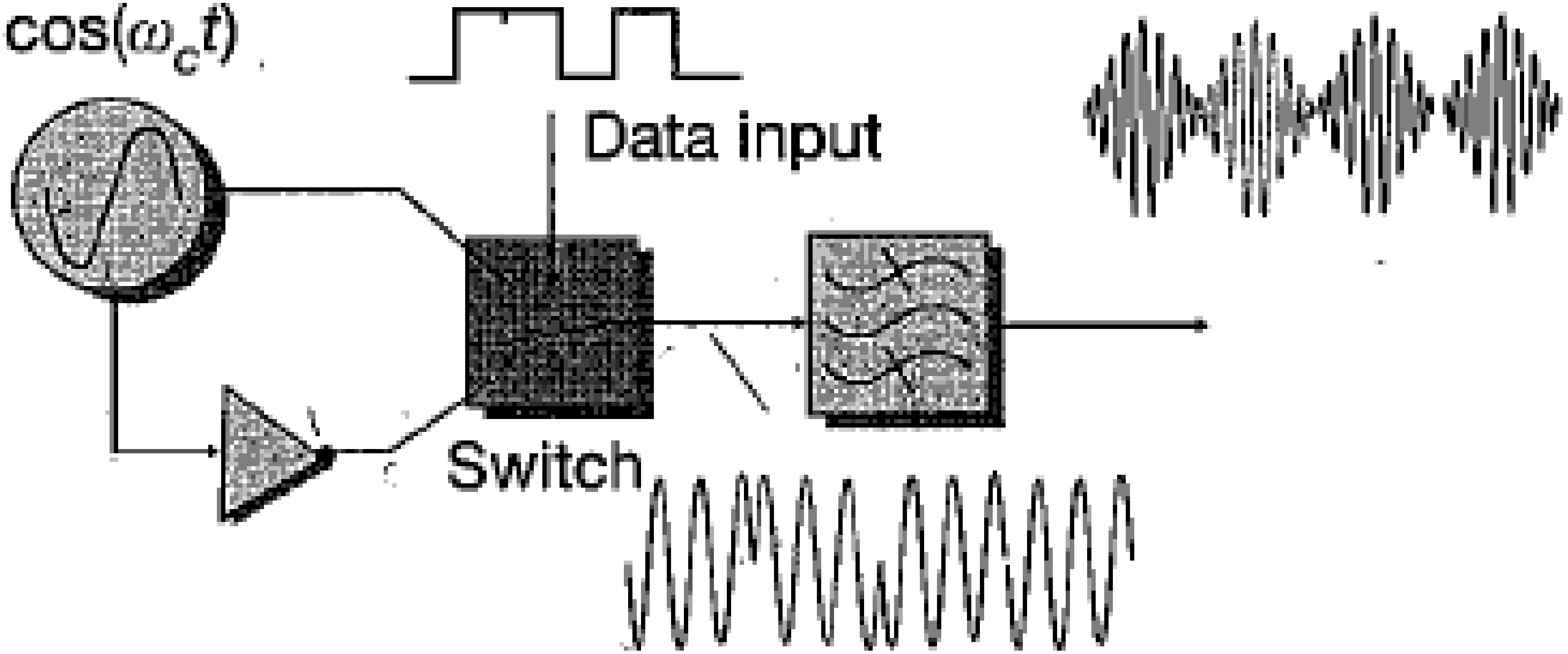
The bandwidth of a binary PSK signal is identical to that of binary ASK, assuming the same degree of pulse shaping. In fact, BPSK can be viewed as an ASK signal with the carrier amplitudes as $+A$ and $-A$ (rather than $+A$ and 0 for ASK).

If the phase changes are abrupt at the symbol boundaries, then, just like FSK, the occupied bandwidth will be much larger than for smooth transitions between phase states, implying the need for shaping of the modulation waveform.

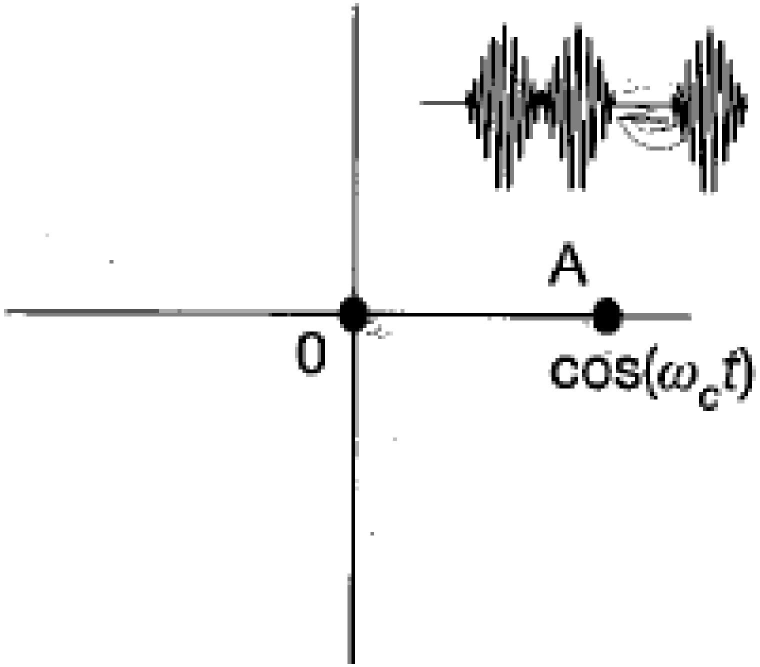


BPSK spectrum

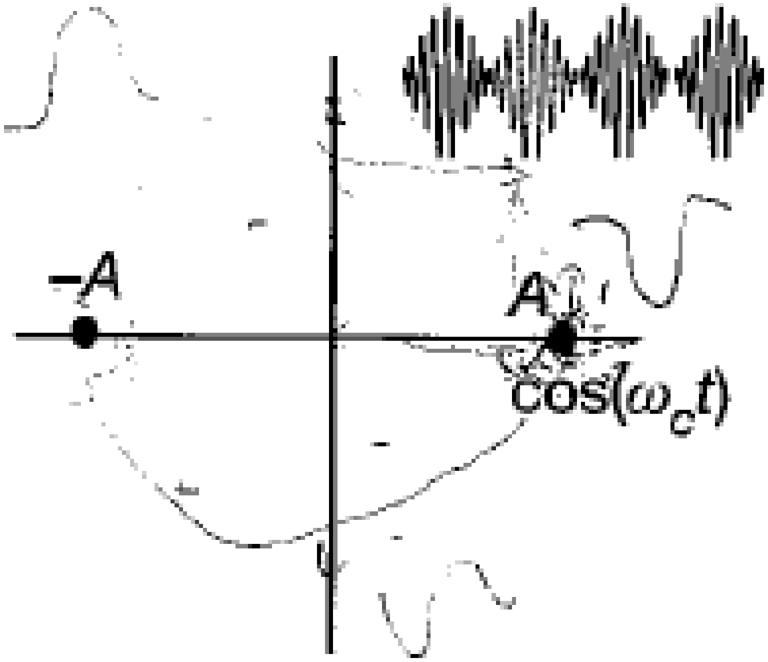
PSK signal generation



Constellation of PSK and ASK



ASK constellation diagram



PSK constellation diagram

Need two presenter

- Each presenter shall chose two problems from 5.1 to 5.12. The one for even and the other for odd problems.
- Show your answer at the beginning of next lecture. Each has 5 minutes.
- Next lecture will be 12/2 (mon)