Ex 6-16

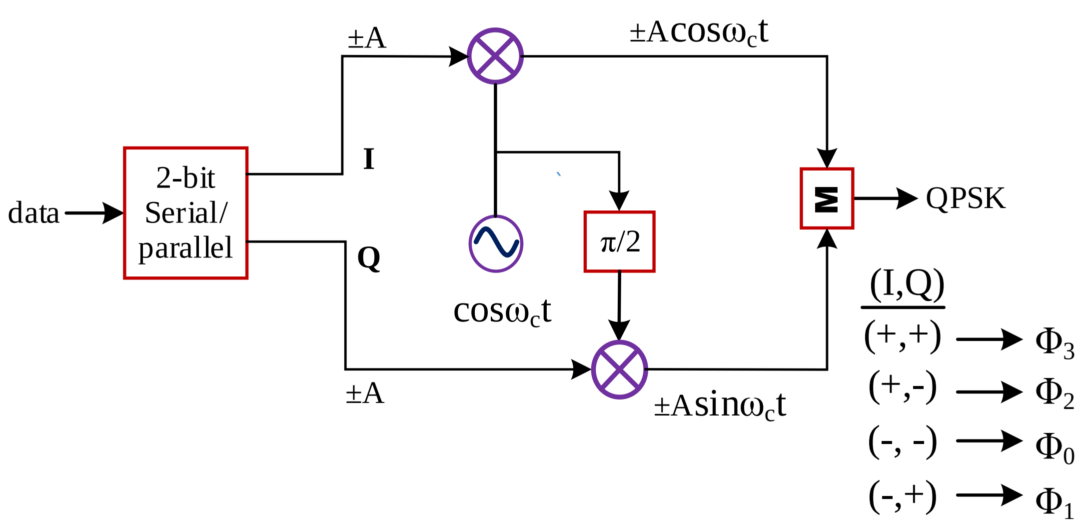
Find the symbol rate (baud rate) and bandwidth and for a 4-PSK signal transmitting at 2000 bps. Transmission is half-duplex mode.

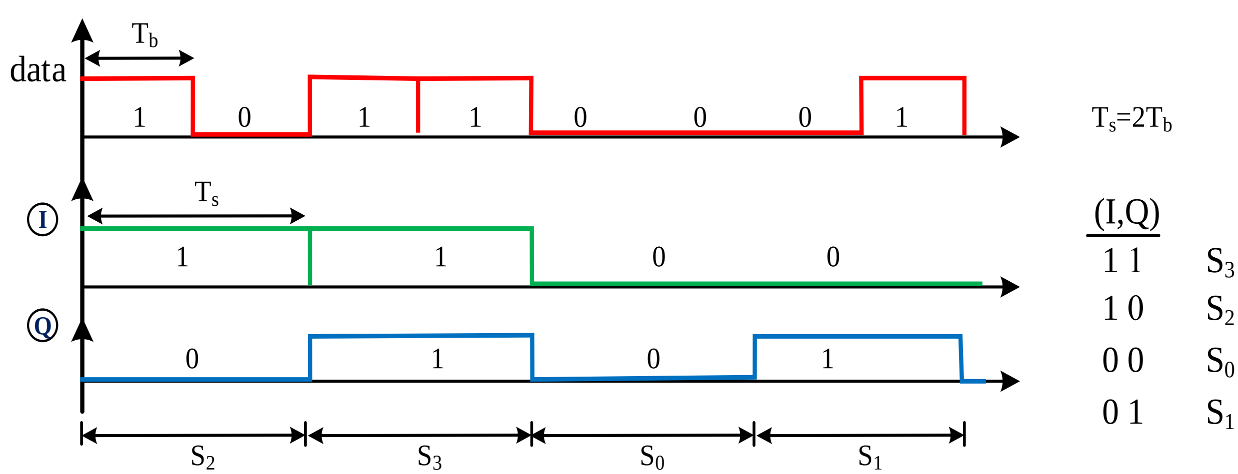
Solution

$R_s = R_b / 2 = 1000$ symbol/sec or 1000 baud

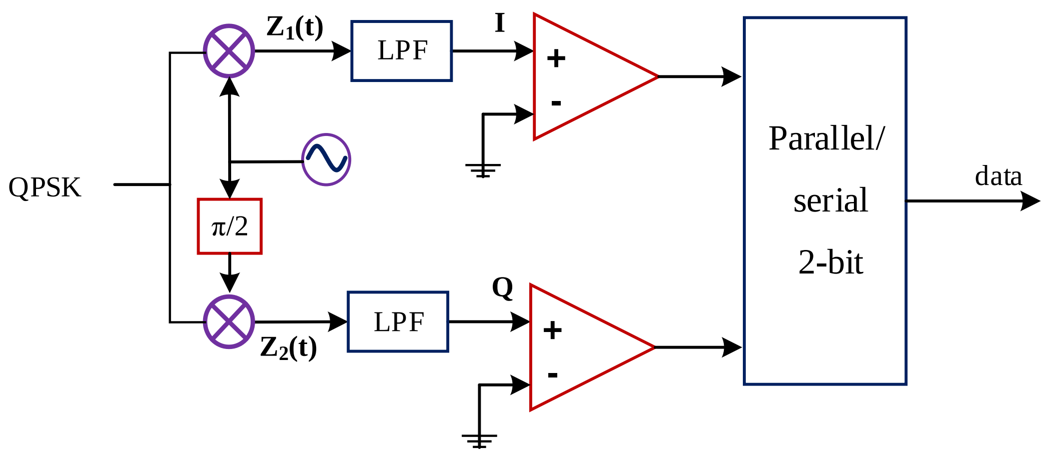
$BW = 2R_s = 2000$ Hz

QPSK Modulator:





QPSK Detector:



$$Z_1(t) = \pm A cos^2\omega_c t \pm A\ sin\omega_c t\ cos\omega_c t \ \Longrightarrow I = \pm A$$

$$Z_2(t) = \pm A\ \ cos\omega_c t\ sin\omega_c t\ \pm A sin^2\omega_c t \Longrightarrow Q = \pm A$$

Since the LPF cancel the $cos2\omega_c t$ and $sin\omega_c t cos\omega_c t$ terms

Note that the detector needs carrier phase

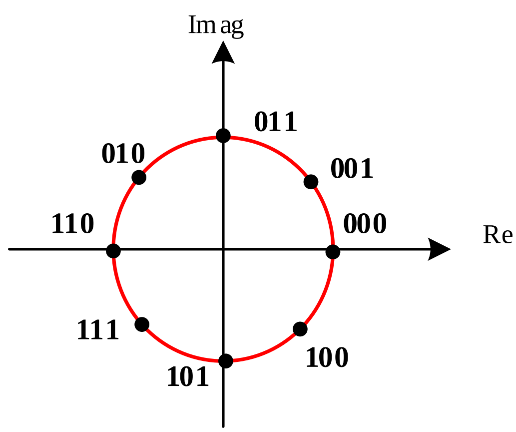
Recovery $cos\omega_c t$ at the Rx (coherent detection).

(b) MPSK in general M=8 16, …:

For M=8, the MPSK state diagram is shown Here:

$R_s = R_b/3$ & $T_s = 3T_b$

Note that again gray coding is used for assigning symbols such that adjacent phases bits differ in one bit only.



Ex 6-17

Given a bandwidth of 6000 Hz for an 8-PSK signal, what are the baud rate and bit rate?

Solution

M=8

R_b = BW/2 = 3000 bps

$$R_s = \frac{R_b}{log_2 M} = \frac{3000}{3} = 1000\ symbol/sec.$$

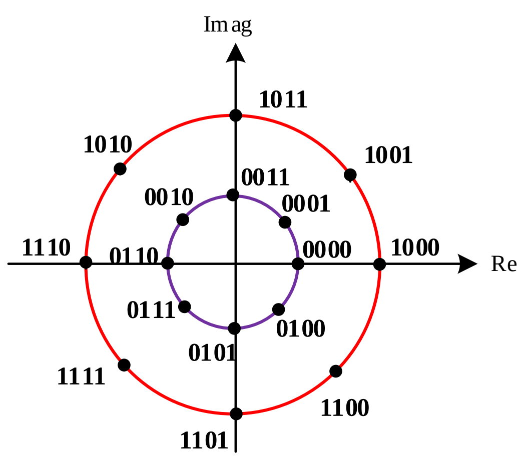
H.W 6-6

Draw the signal constellation for 16-PSK identifying the angles between each two levels.

(c) QAM Quadrature Amplitude Modulation:

Here two or more amplitude are used with 2, 4, 8, phases, for example 16 QAM may have two amplitudes and 8 phases. For M=16, R_s=R_b/4 and T_s=4 T_b.

With gray level for each amplitude



Application:

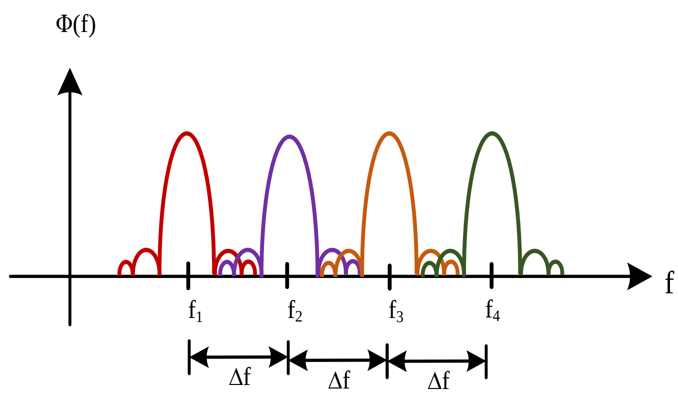
Telephone (digital transmission)

MFSK: Multi-level FSK:

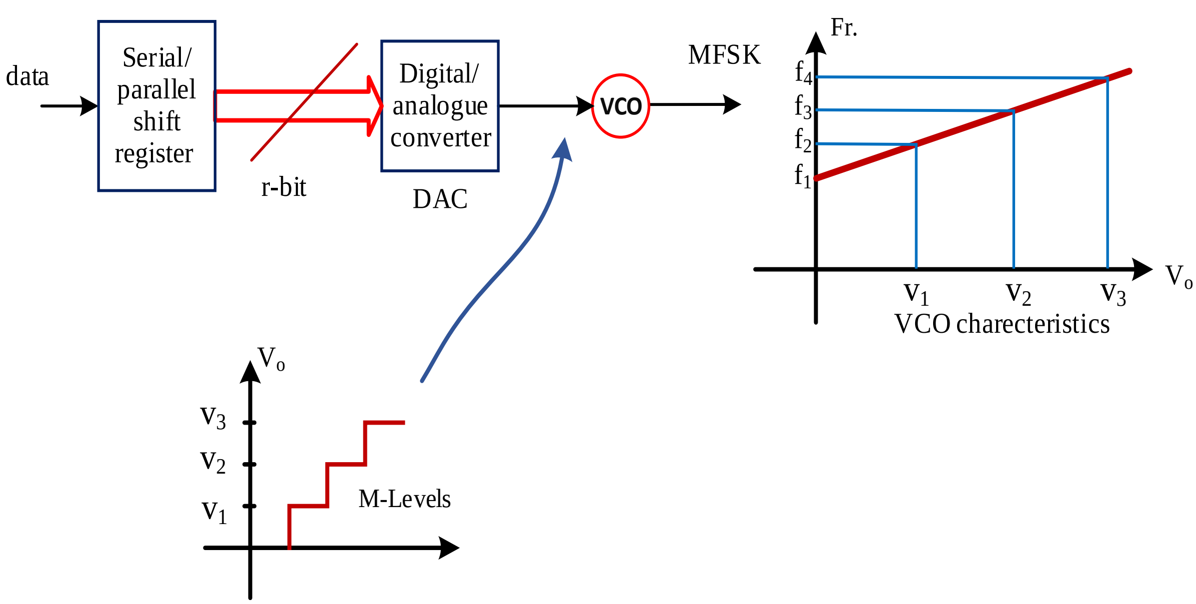
For M=4, then for frequencies are used to assign $\emptyset_0, \emptyset_1, \emptyset_2 \& \emptyset_3$. The spectrum of 4-FSK is as shown with the equal spacing Δf.

$$\left.\begin{aligned} \emptyset_0(t) &= A\cos\omega_1 t \\ \emptyset_1(t) &= A\cos\omega_2 t \\ \emptyset_2(t) &= A\cos\omega_3 t \\ \emptyset_3(t) &= A\cos\omega_4 t \end{aligned}\right\} \quad \dots (6\text{-}37)$$

$$R_S = \frac{R_b}{2} \quad , T_S = 2T_b$$



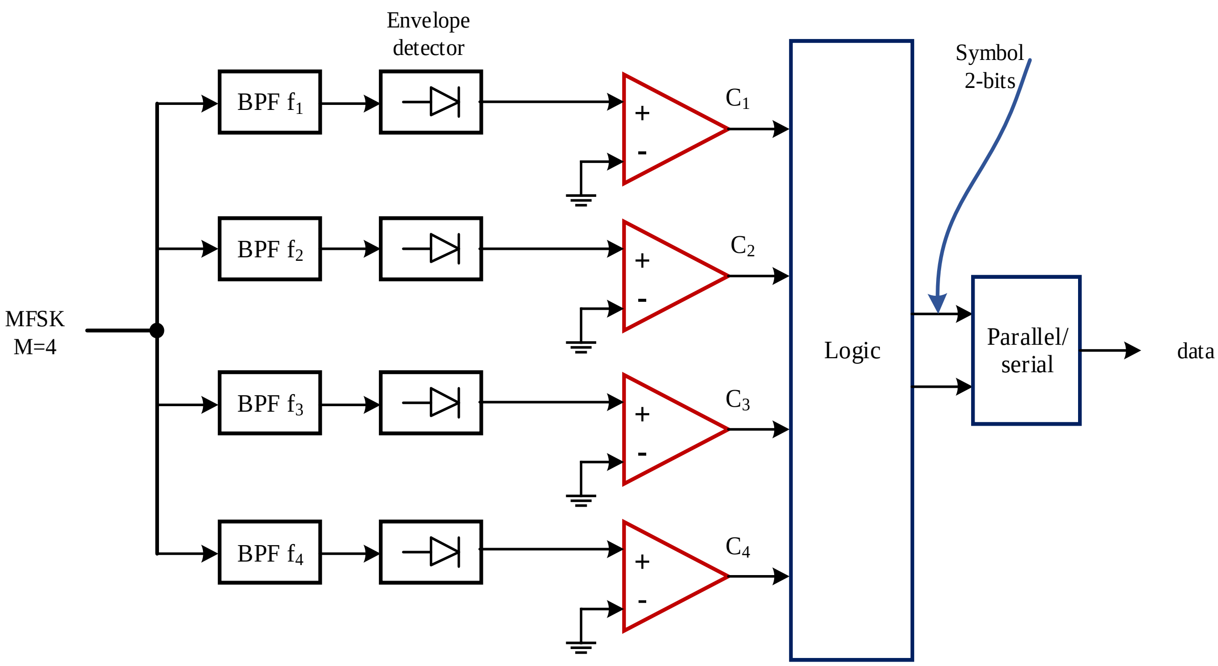
MFSK modulator:



Noncoherent MFSK Detector:

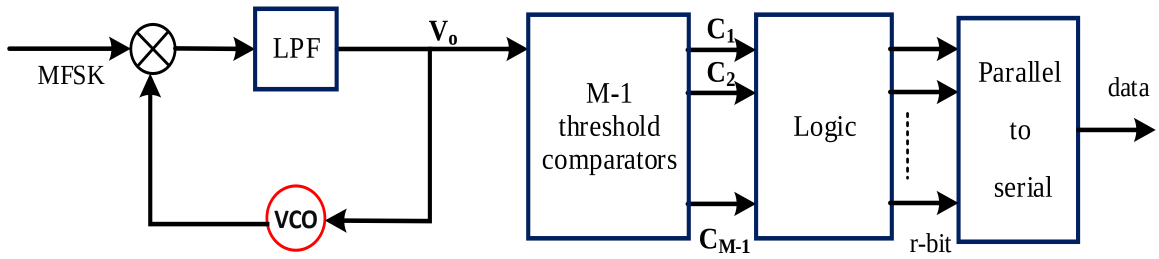
C_1	C_2	C_3	C_4	symbol
1	0	0	0	0 0
0	1	0	0	0 1
0	0	1	0	1 0
0	0	0	1	1 1

Logic Truth Table

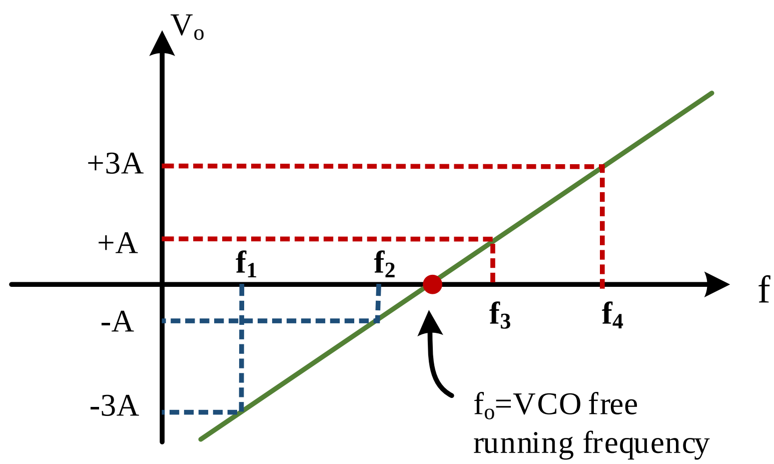


Note that only once of the envelope detectors is high during T_s time, corresponding to one of the received frequencies $f_1, f_2, f_3 \& f_4$.

Coherent MFSK (PLL detectors):



VCO free running frequency is chosen midway between f_2 & f_3 (center of the band). Suppose that the liner region of PLL gives V_o= -3A, -A, +A & +3A, corresponding to f_1, f_2, f_3 & f_4 respectively.



(M-1) threshold comparators (3 comparator here) will give C_1, C_2 & C_3 output and in a similar schematic as in MASK these outputs will be decoded into the received data (V_{th} are -2A, 0, +2A).

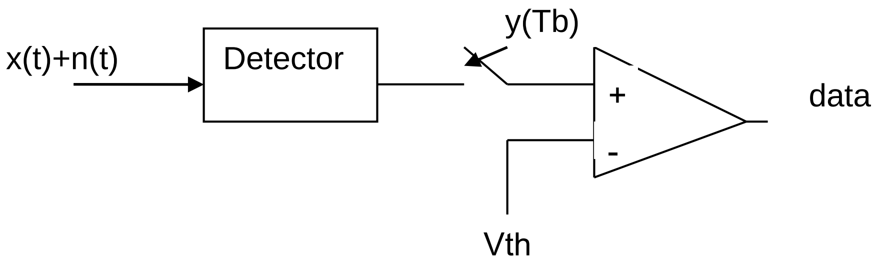
Application of MFSK:

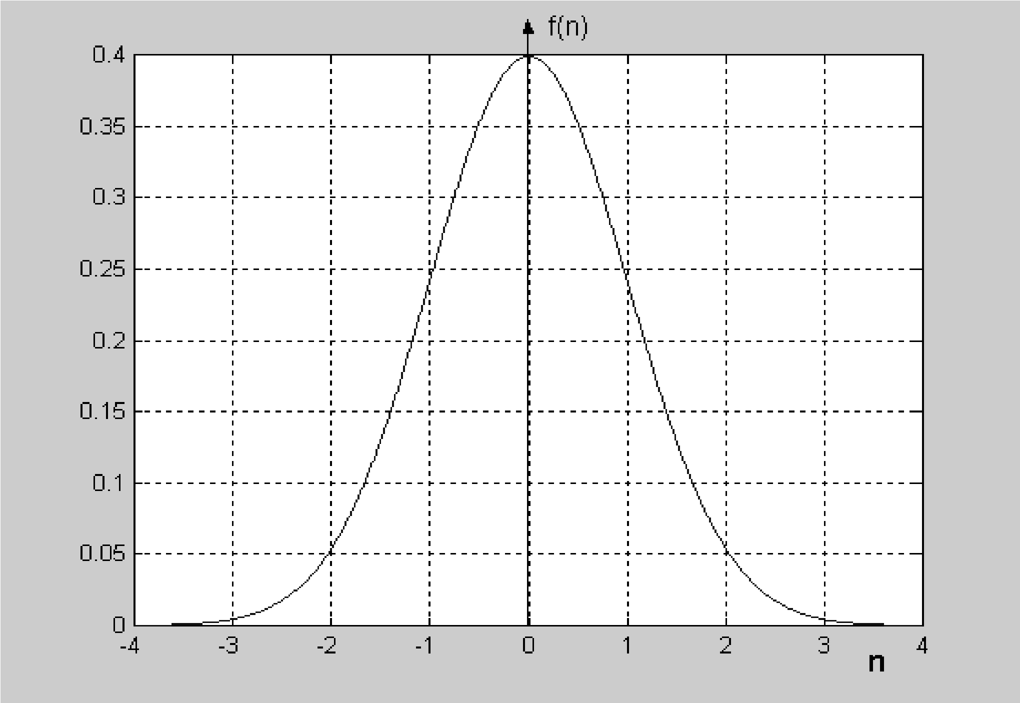
Main important application is in HF (High frequency) transmission to combat multipath fading on ionospheric layer. Note that not all frequencies will be faded.

Detection of Digital Signals in Noise

Binary Signals:

Let x(t) be a binary signal having two waveforms shapes (one for logic "0" and the other for logic "1"). n(t) is the noise component added due to channel such that the Probability Density Function (PDF) of n(t) is f(n) with zero mean.





y(Tb) is the detector output at t=Tb (bit duration for both "0" and "1" signals). A comparator with threshold voltage Vth is used to decide if the