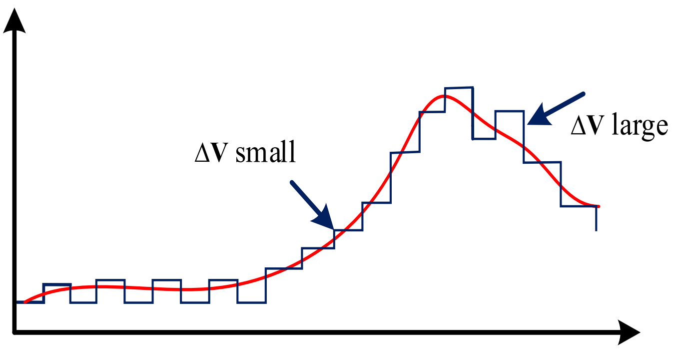
Other Types of Digitizing

1- Adaptive DM:

Previous DM is called linear DM since the step size is fixed. This has the disadvantage that the dynamic range of speech amplitude level large so that ΔV chosen is not the best, if more or less levels of $f(t)$ occur. In adaptive DM, the step size ΔV is changed (adapted) according to the slope of $f(t)$.

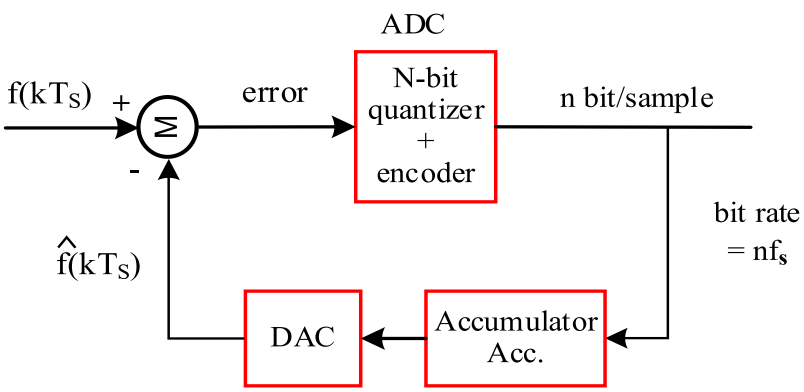
So, if $f(t)$ has small slope, ΔV is made small to reduce quantization noise, but if ΔV has large slope, ΔV is made large to avoid slope overload.



If the step size adaptation is made in continuous form with slope of the input, then the name CVSDM (continues variable slope DM) is used, or it is made in discrete form with finite number of step size to form discrete variable slope DM. In the CVSDM, peak detector circuit are used to control ΔV, while in discrete VSDM logic circuit are used to control ΔV.

2- Differential PCM (DPCM)

The difference between sampled signal $f(kT_s)$ and quantized signal $\hat{f}(kT_s)$ [error] is quantized into to n bits (recall that this is the same as DM with n=1, i.e $DM \equiv 1bit\ DPCM$). So the derivative of the signal is quantized into n bits.



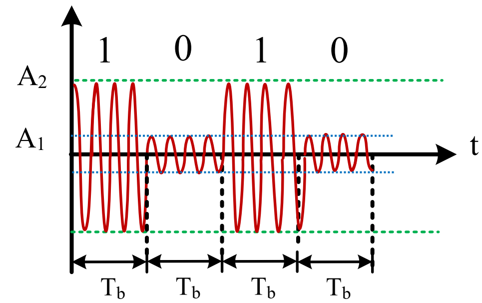
At the Rx, the accumulator (Acc.) will integrate DPCM signal to produce $\hat{f}(kT_s)$ to DAC output then smoothed using LPF.

Typical value of n is less than that used for PCM (n=3 or 4 bits) since n is used here not to code actual f(t) samples but to encode the derivative of f(t) which has less dynamic range.

b) Sinusoidal Modulation: (Digital Carrier Systems):

1- ASK: Amplitude Shift Keying:

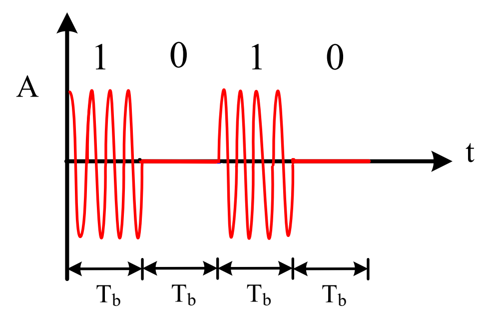
$$\left.\begin{aligned}\emptyset_0(t) &= A_1 \cos\omega_c t \\ \emptyset_1(t) &= A_2 \cos\omega_c t\end{aligned}\right\}$$ Over bit duration T_b ... (6-22)



ω_c : carrier angular frequency

Special case from ASK if A_1=0, then

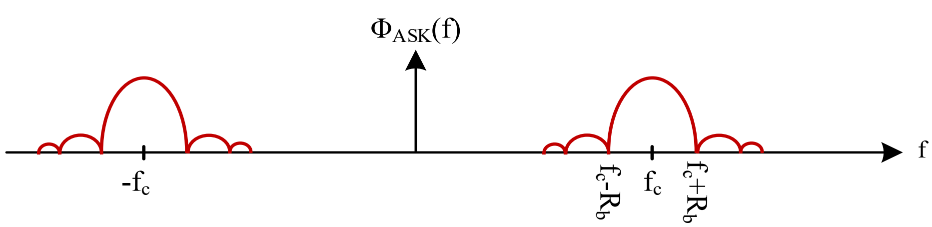
$$\left.\begin{aligned}\emptyset_0(t) &= 0 \\ \emptyset_1(t) &= A \cos\omega_c t\end{aligned}\right\}$$ Over bit duration T_b ... (6-23)



This is called OOK

(ON-OFF Keying)

The spectrum of OOK is



$$BW_{PCM} \approx 2R_b$$ Hz ... (6-11)

(First null bandwidth)

Ex. 6-11

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

Solution:

$BW \approx 2R_b = 2*2000 = 4kHz$

Ex. 6-12

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.

Solution:

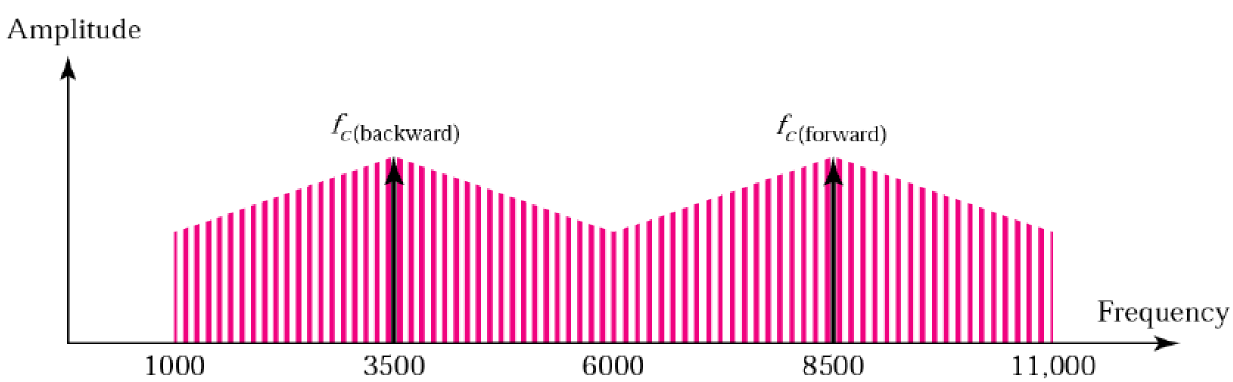
For full-duplex ASK, the bandwidth for each direction is

BW = 10000 / 2 = 5000 Hz

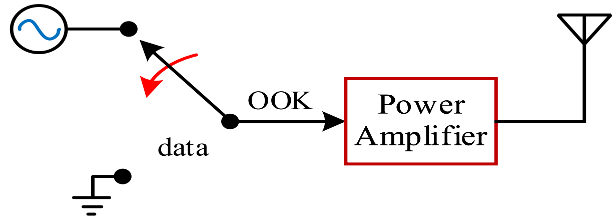
The carrier frequencies can be chosen at the middle of each band

fc (backward) = 1000 + 5000/2 = 3500 Hz

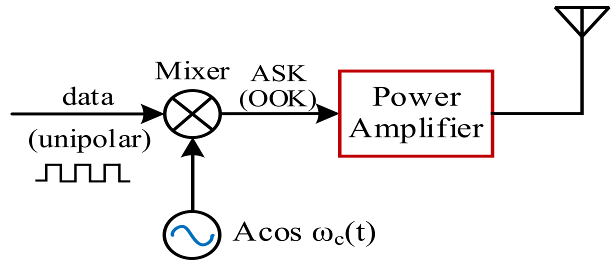
fc (forward) = 11000 – 5000/2 = 8500 Hz



Modulator of ASK:



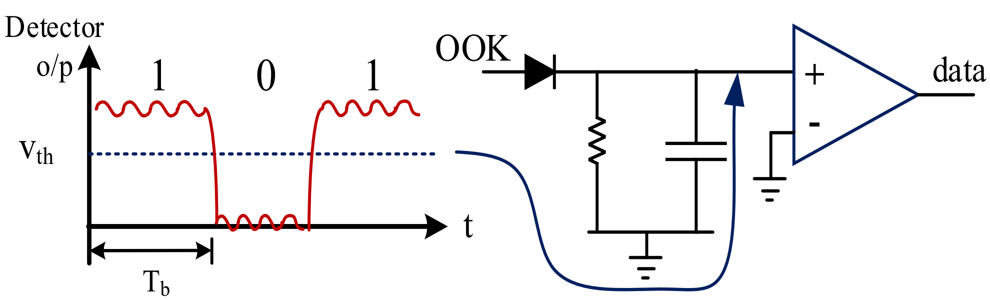
Or using Mixer



Demodulator of ASK:

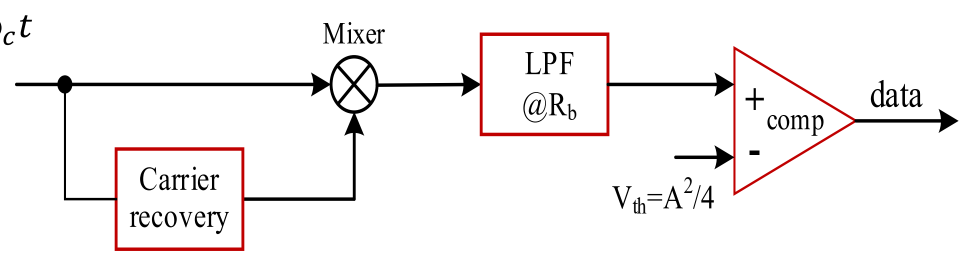
1) **Non coherent (no need for carrier recovery):**

This has done using envelope detector.



2) **Coherent detector:**

$$OOK = \begin{cases} A\cos\omega_c t \\ 0 \end{cases}$$



Here, a carrier recovery circuit is required to generate the carrier signal cos ω_ct then, the LPF will cutoff of $\mathbf{R_b}$ is used to give the high and low states of the data.

$$mixer\ o/p = \begin{cases} A^2 cos^2(\omega_c t) = \frac{A^2}{2} + \frac{A^2}{2} cos 2\omega_c t \\ 0 \end{cases}$$ rejected by LPF

Then LPF output will be either $\mathbf{A^2/2}$ or **"0"** and with V_{th}= $\mathbf{A^2/4}$, data are obtained by a threshold comparator.

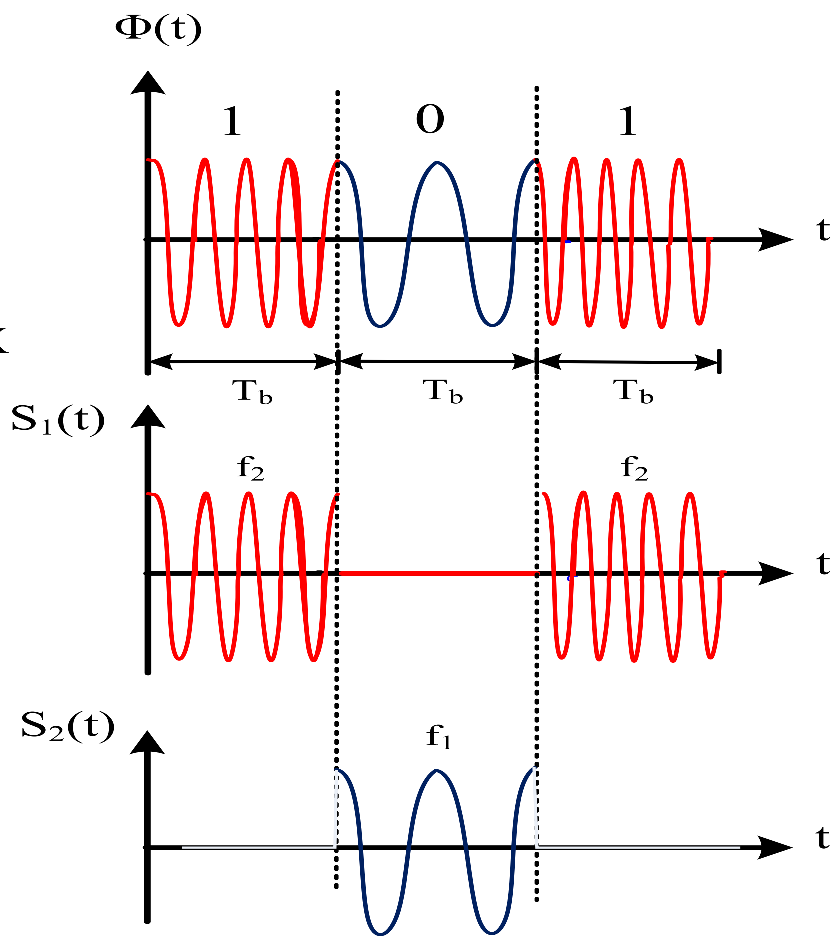
2-Frequency Shift Keying (FSK):

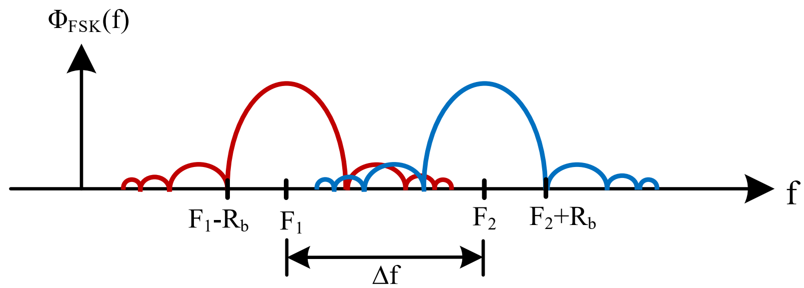
$$\left.\begin{aligned} \emptyset_0(t) &= A\cos\omega_1 t \\ \emptyset_1(t) &= A\cos\omega_2 t \end{aligned}\right\}$$ Over bit duration T_b ... (6-25)

For $\omega_2 > \omega_1$, then timing of FSK is as shown. It is clear than FSK is the sum of two (OOK) one for logic "0" and the other for logic "1" And hence the spectrum of FSK consists of two sinc functions, one at f_1 and the other at f_2 as shown.

$$\emptyset(t) = S_1(t) + S_2(t)$$

FSK (OOK) (OOK)





If $\Delta f = f_2 - f_1$ then the null BW will be:

$$BW = \Delta f + 2R_b \quad \text{Hz} \qquad \text{... (6-26)}$$

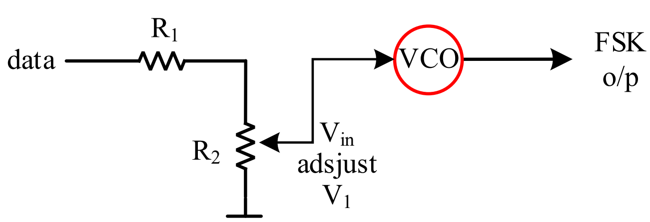
Ex 6-13

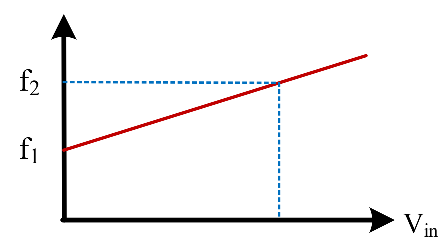
Find the minimum bandwidth for an FSK signal transmitting at 2000 bps. Transmission is in half-duplex mode, and the carriers are separated by 3000 Hz.

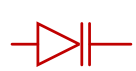
Solution:

$BW = \Delta f + 2R_b = 3000 + 2*2000 = 7kHz$

Modulator of FSK:





A voltage-controlled oscillator is usually used for FSK modulation. A VCO is an oscillator with an internal tuning capacitor, which controlled by an external voltage V_{in}. This capacitor is called varicap ().