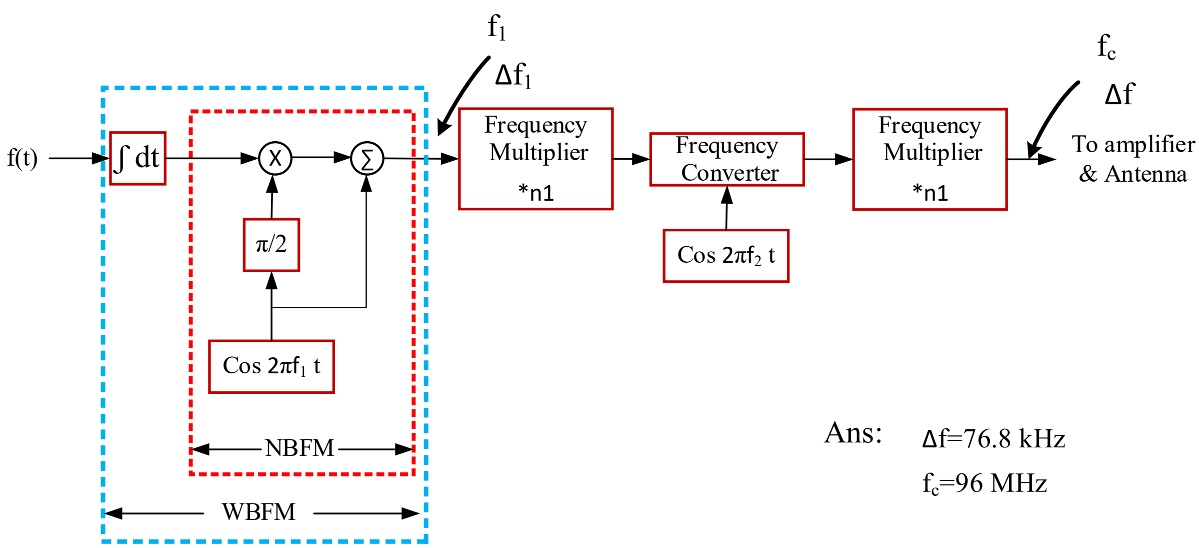
| | | |
|---|---|---|
| $\alpha$ = 1 v, $f_m$ = 1 kHz | 2 kHz | 40 kHz |
| $\alpha$ = 2v, $f_m$ = 1 kHz | 2 kHz | 80 kHz |
| $\alpha$ = 1 v, $f_m$ = 2 kHz | 4 kHz | 80 kHz |

Identify the type of angle modulation used (FM or PM Narrowband or wideband) for systems A and B.

Ans: system A: NBFM or NBPM
System B: WBPM.

**Q17:** Design commercial FM transmitter using Armstrongs' method. The final output is required to have carrier frequency of 91.2 $MHz$ and $\Delta f$ in the range of 75 $kHz$. Assume $f_1 = 200\ kHz$ and $\Delta f_1 = 25\ Hz$.

**Q18:** Compute the carrier frequency $f_c$ and the peak frequency deviation $\Delta f$ of the output of the FM transmitter shown in fig. below [indirect (Armstrong) FM transmitter]. If: $f_1 = 200\ KHz$, $n_1 = 64$, $f_2 = 10.8\ MHz n_2 = 48$, $\Delta f_1 = 25\ Hz$




Ans: $\Delta f$=76.8 kHz
$f_c$=96 MHz

**Q19:** An angle modulated signal given by:

$\emptyset(t) = A\cos[\omega_c t + 2\cos 60\,\pi t + 5\cos 40\,\pi t]$ with $f_c = \frac{\omega_c}{2\pi}\ Hz$

(a)Find the maximum phase deviation in radian.

(b) at $t = \frac{1}{30}$ sec., find the instantenous frequency deviation.

Ans: (a) 7 rad. (b) 86.6 Hz.

**Q20:** A communication system operates in the presence of white noise with two - sided power spectral density $S_n(\omega) = 0.25 \times 10^{-14}$ watt/Hz and with total path losses (including Antennas) of 100 dB. The input bandwidth is 10 $KHz$. Calculate the minimum required carrier power of the transmitter for a 10 $KHz$ sinusoidal input and a 40 dB output S/N ratio if the modulation is:

(a)AM (DSB – LC), with $m = 0.707$ and$m = 1$.

(b) FM, with $\Delta f = 10\ kHz$ and $\Delta f = 50\ kHz$

(c) PM, with $\Delta\theta = 1$ radian and $\Delta\theta = \pi$ radian.

**Q21:** A FDM system uses SSB – SC modulation and FM main carrier modulation. There are forty (40) equal bandwidth voice input channels, each bandlimitted to 3.3 $kHz$. A 0.7 $kHz$ guard band is allowed between channels and below the first channel:

(a) Determine the final transmission bandwidth if the peak frequency deviation is 800KHz.

(b) Compute the degradation in signal to noise of nput No.40 when compared to the input No.1 (Assume a white main spectral density to the discriminator and no deemphasis).

Ans: (a) 1.92 MHz (b) 36 dB.

**Q22:** Prove that NBFM requires the same transmission bandwidth as the AM.

# Chapter 6

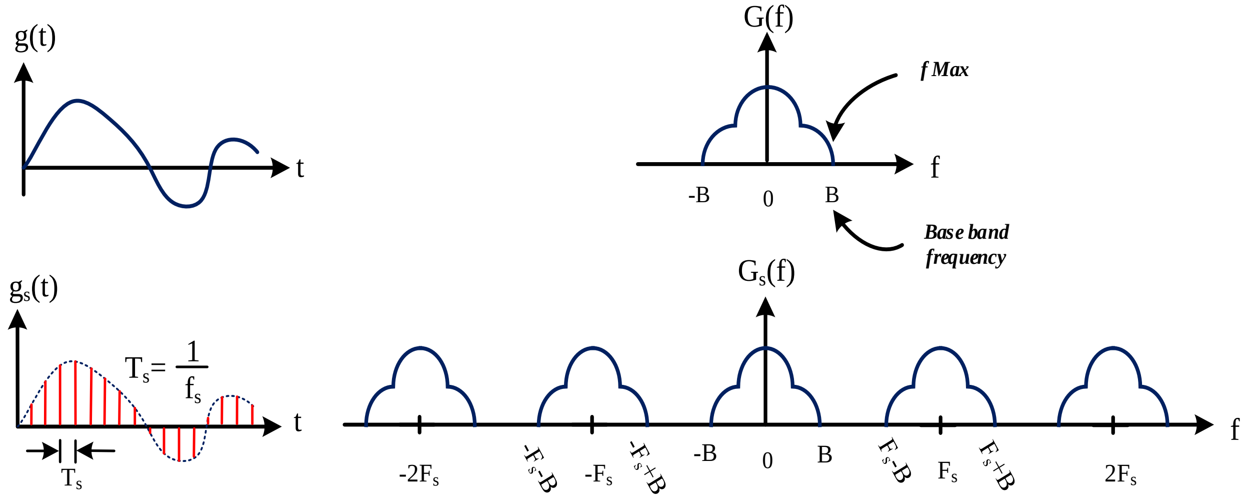
## Pulse and Digital Modulation

### Sampling Theorem:

A signal band limited to B Hz by regularly-spaced samples, provided sampling rate is at least 2B sample per second.

$$\mathrm{F}_s \geq 2B \quad \text{Or} \quad \mathrm{F}_s \geq 2f_{max} \qquad \ldots(6\text{-}1)$$

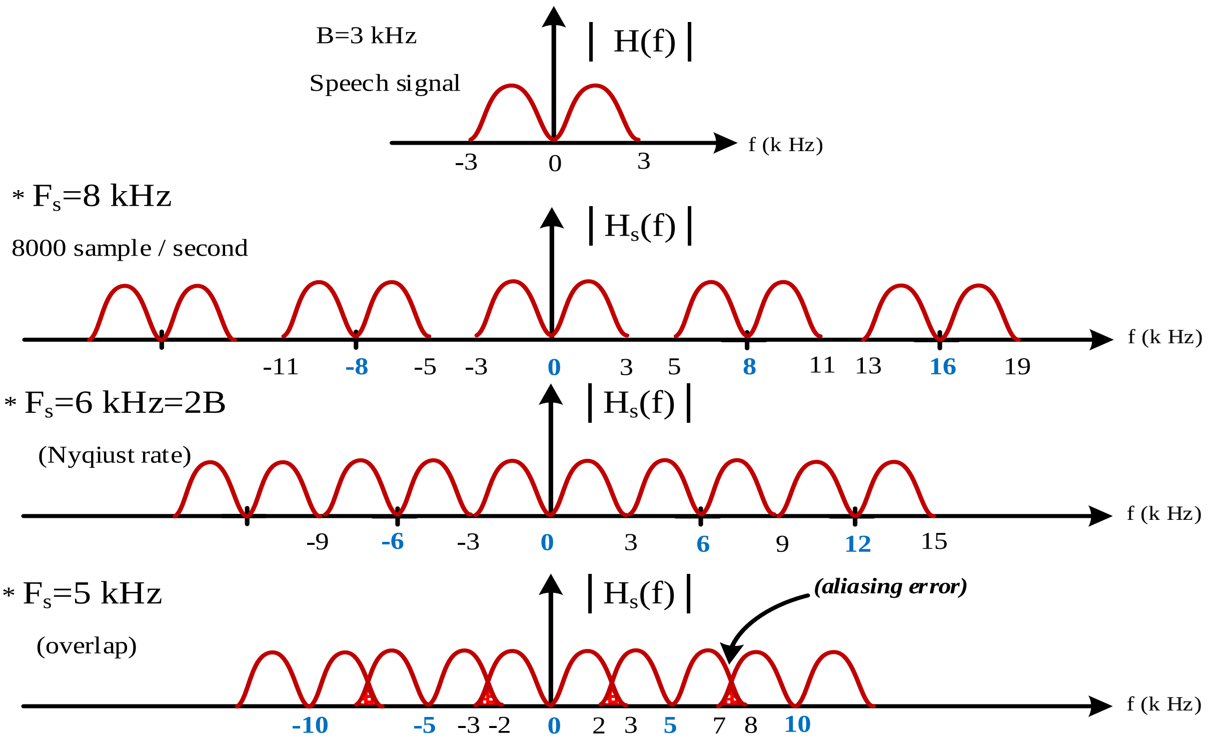
$$\mathrm{F}_s = 2f_{max}$$ Minimum sampling rate or Nyquist sampling rate ...(6-2)




$$g_s(t) = g(t)\sum_{n=-\infty}^{\infty}\delta(t-nT_s) = \frac{1}{T_s}\sum_{n=-\infty}^{\infty} g(t)e^{jn\omega_s t}$$

$$G_s(\omega) = \frac{1}{T_s}\sum_{n=-\infty}^{\infty} G(\omega - n\omega_s)$$

## Effect of sampling on a signal spectrum:




**Ex 6-1:** Determine the Nyquist rate of the sampling for the signal:

$$g(t) = 10\cos 100\pi t + 15\cos 150\pi t + 5cos300\pi t$$

**Solution:**

$$f_{max} = \frac{300\pi}{2\pi} = 150\ Hz$$

$$Nyquist\ rate = 2f_{max} = 2 \times 150 = 300\ Hz$$

**H.W:**

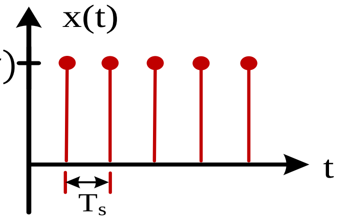
Determine the Nyquist rate of sampling required for

a) $g(t) = 10\cos 100\pi t \cos 200\pi t$

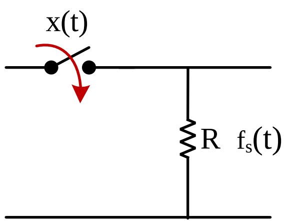
b) $g(t) = e^{-2|t|}$(approximate the BW where$|G(\omega)|$ drops to value less than 0.1)

The sampler behaves exactly as a multiplier. It multiplies f(t) by a gating function x(t) which is a train of impulses with frequency $f_s$ then,

$$f_s(t) = f(t).x(t)$$




Reconstruction of f(t) from fs(t) is done using LPF with cutoff $f_{max}$

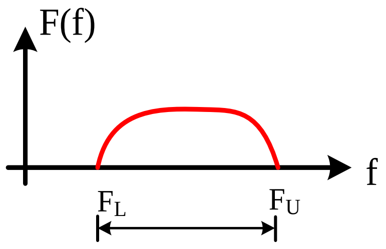



(Sampler)


(Reconstruction cct)

**<u>Note:</u>**

If f(t) is a baseband signal over a frequency range $f_L$ to $f_u$ such that $B=f_u- f_L$ then sampling theorem of such signals states that f(t) can be completely recovered from $f_s$(t) if:

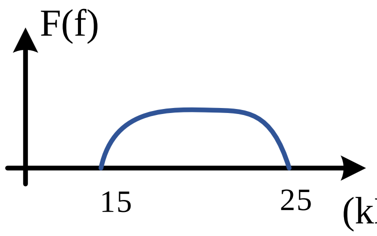



$f_s = \frac{2f_u}{k}$ , where k is the largest integer not exceeding $\frac{f_u}{B}$

**<u>Ex 6-2:</u>**

For the signal shown besides, $F_s = \frac{2*(25)}{k}$ where $k = int\left(\frac{25}{10}\right)$=2

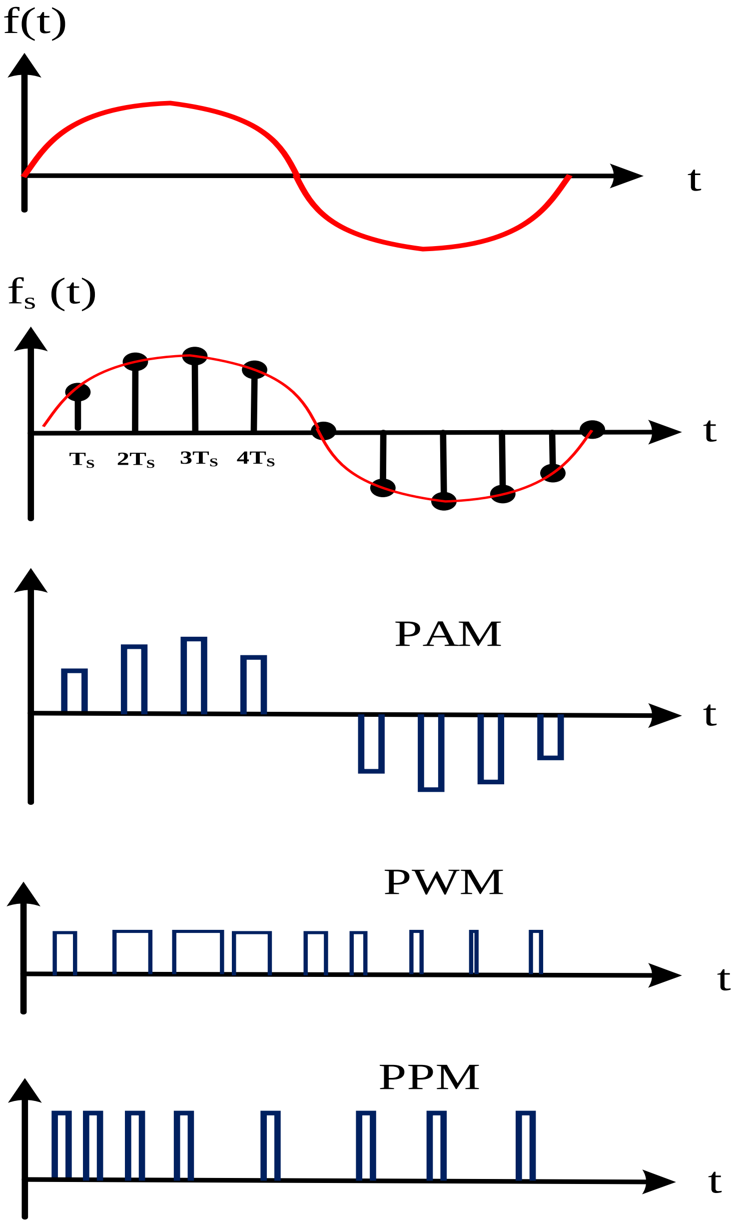
$f_s = \frac{2\times(25)}{2}$ or $f_s = 25$ kHz




Reconstruction in such case has done using BPF

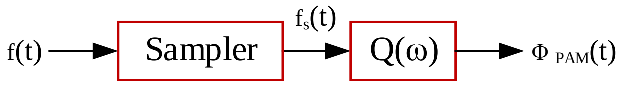
## Pulse Modulation Techniques:

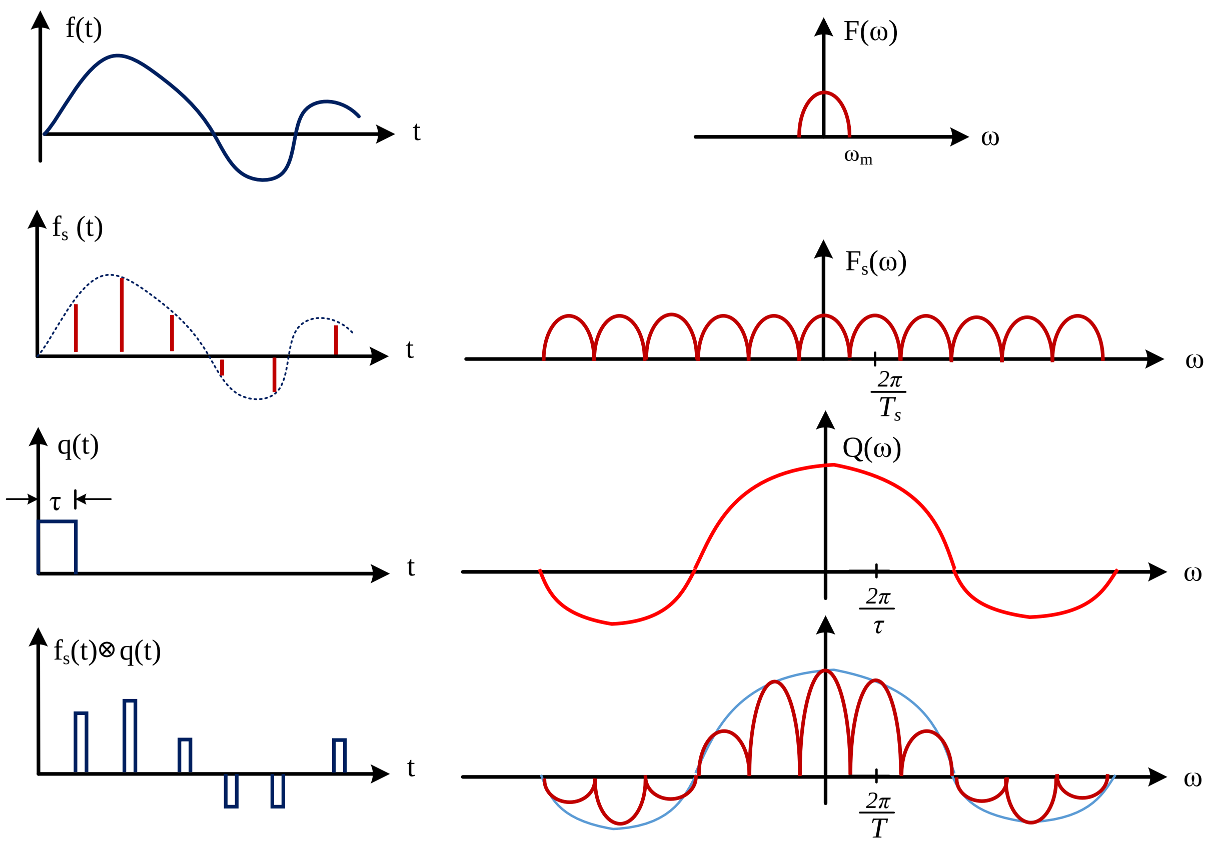
If an analog signal is sampled, the sampled values may be used to modify certain parameter of a periodic train pulses (amplitude, width or position). Accordingly, we have Pulse Amplitude Modulation (PAM), Pulse Width Modulation (PWM) or Pulse Position Modulation (PPM).



## 1- PAM

**Generation**:




Pulse Amplitude modulation the same as the output of the sampled at rate $f_s$ ($f_s \geq 2f_{max}$ *for baseband signals*).

$$\emptyset_{PAM}(nT_s) = \sum_{n=-\infty}^{\infty} f(nT_s)\, q(t - nT_s) \qquad \ldots \text{(6-3)}$$

PAM is usually used as TDM-PAM (TDM=Time Division Multiplexing) to transmit more than one message at the same channel.

**Detection:**