# Noise in Amplitude Modulation System

→ In AM Receiver, mixer converts RF signal to IF.

→ Let the IF has power $P_i$.

→ If the noise on IF is white, then the Power Spectral density (PSD) of this white noise will be $S_o(f) = N_0/2$.

## Noise in SSB-SC Receiver

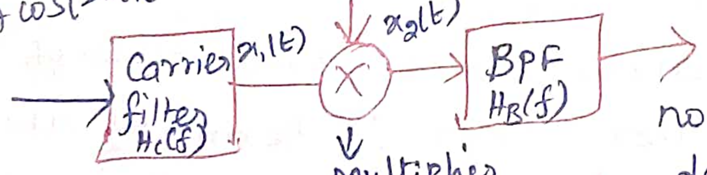
We will assume that the interfering noise is white Gaussian with 2 sided power spectral density of $N_0/2$.

## * Calculation of Signal power:

Synchronous Demodulator.

$x_i(t) = A\cos(2\pi(f_c+f_m)t)$    Signal $x_c(t) = \cos 2\pi f_c t$.    $P_o = A^2/8$

$x_i(t) = A\cos(2\pi(f_c+f_m)t)$, $P_i = \frac{A^2}{2}$




$x_o(t) = \frac{A}{2}\cos 2\pi f_m t$

noise spectral density $S_{no}$.

Multiplier (Demodulator).

noise spectral density $S_n = \frac{N_0}{2}$

→ only USB is used for transmission

$\therefore x_i(t) = A\cos[2\pi(f_c+f_m)t]$

→ Modulated carrier will have the frequency of $f_c + f_m$

→ The signal will be passed through carrier filter. It ~~pass~~ passes the frequency from $f_c$ to $f_c + f_m$.

→ ∴ $x_1(t)$ will be same as $x_i(t)$

$$x_1(t) = A\cos[2\pi(f_c + f_m)t]$$

→ $x_2(t) = x_1(t) \cdot x_c(t)$

$$= A\cos[2\pi[f_c + f_m)t] \cos 2\pi f_c t$$

→ $\cos A \cos B = \frac{1}{2}[\cos(A-B) + \cos(A+B)]$

→ using above equ'n $x_2(t)$ will be,

$$x_2(t) = \frac{A}{2}[\cos 2\pi(f_c + f_m - f_c)t + \cos(2\pi(f_c + f_m + f_c)t)$$

$$= \frac{A}{2}[\cos 2\pi f_m t + \cos(2\pi(2f_c + f_m) \cdot t]$$

→ The above signal passes through BPF. This filter passes $I^{st}$ term of above equation having frequency $f_m$.

→ The $2^{nd}$ term is not passed by filter.

$\rightarrow$ $\therefore x_o(t) = \frac{A}{2} \cos 2\pi f_m t$.

$\rightarrow$ Because of SSB transmission, amplitude of demodulated signal is reduced to half (A/2)

$\rightarrow$ $x_i(t) \rightarrow$ Peak amplitude is A.

$\rightarrow$ Its Rms value is $\frac{A}{\sqrt{2}}$

The normalized I/p signal power is

$$P_i = \frac{(\text{rms value of } x_i(t))^2}{R}$$

$$= \frac{(A/\sqrt{2})^2}{1} \quad (R=1 \text{ normalized value}).$$

$$P_i = \frac{A^2}{2}$$

$\rightarrow$ In demodulated signal, amplitude is A/2.

$$\therefore P_o = \left(\frac{A/2}{\sqrt{2}}\right)^2 \Big/ 1 = A^2/8$$

$\rightarrow$ The ratio of O/p signal power to I/p signal power, will be,

$$\frac{P_o}{P_i} = \frac{A^2/8}{A^2/2} = \frac{2}{8} = 1/4.$$

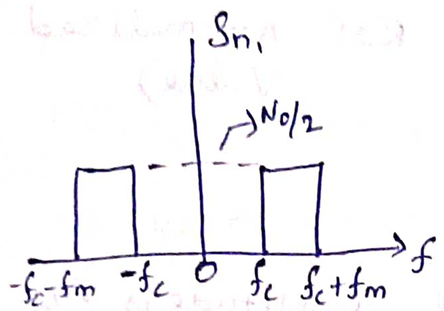
## Calculation Noise Power

→ If noise $n(t)$ having power spectral density $S_n(f)$ is multiplied with $\cos 2\pi f_c t$.

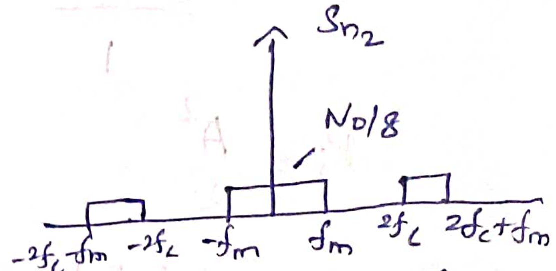
The resultant noise in the multiplied signal is, $S_n(f_c+f) = S_n(f_c-f) = \frac{S_n(f)}{2}$.

→ I/P noise is white Gaussian having spectral density of $S_n = N_0/2$.

This noise passed through carrier filter.



PSD of noise at O/P of carrier filter.



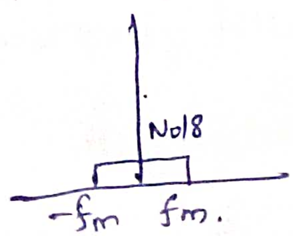
SD at multiplier & amplitude is reduced by $1/4$.

→ $S_{n2}$ passed through Base band filter.

→ The noise power can be obtained by integrating the power spectral density,

$$P_{no} = \int_{-\infty}^{\infty} S_n(f)\, df$$

$$= \int_{-f_m}^{f_m} \frac{N_0}{8}\, df.$$



SD of Baseband filter

$$P_{N_0} = \frac{N_0}{8}\left[f_m + f_m\right] = \frac{N_0 f_m}{4}$$

**Calculation of Signal to Noise Ratio:**

O/p signal power $P_0 = A^2/8$

O/p noise power : $P_{no} = \dfrac{N_0 f_m}{4}$

$$\left(S/N\right)_{O/P} = \frac{A^2/8}{N_0 f_m/4} = \frac{A^2}{2 N_0 f_m}.$$

$$P_i = A^2/2.$$

$$\left(\frac{S}{N}\right)_{O/P} = \frac{P_i}{N_0 f_m}.$$

The above noise ratio at o/p in presence of white Gaussian noise for SSB/SC transmission of AM.