PRINCIPLES OF COMMUNICATION (BEC-28)
UNIT-3
NOISE

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Content of Unit-3

- **Noise:** Source of Noise, Frequency domain, Representation of noise, Linear Filtering of noise, Noise in Amplitude modulation system, Noise in DSB-SC SSB-SC, and DSB-C, Noise Ratio, Noise Comparison of FM and AM, Pre-emphasis and De-emphasis, Figure of Merit.

Signal to Noise Ratio (SNR)

Signal-to-Noise Ratio (SNR) is the **ratio of the signal power to the noise power**. The higher the value of SNR, the greater will be the quality of the received output

the received signal $Y(t)$ is the sum of the transmitted signal $X(t)$ and the noise $N(t)$, i.e.

$$\boxed{Y(t) = X(t) + N(t).}$$

Since $X(t)$ and $N(t)$ are uncorrelated, we have superposition of signal powers, i.e.

$$R_Y(0) = R_X(0) + R_N(0) \quad \text{or equivalently}$$
$$\mathsf{E}\left[|Y(t)|^2\right] = \mathsf{E}\left[|X(t)|^2\right] + \mathsf{E}\left[|N(t)|^2\right].$$

Define the *signal power* and the *noise power* at the receiver as

$$\boxed{S = \mathsf{E}\left[|X(t)|^2\right] \quad \text{and} \quad N = \mathsf{E}\left[|N(t)|^2\right].}$$

In addition, the *signal-to-noise ratio (SNR)* is defined as

$$\boxed{\text{SNR} = S/N}$$

Examples

1. A video signal of having BW of 100 MHz power of 1MHz is transmitted through a channel, power loss in the channel is given by 40dB. Noise PSD is given by 10^{-20} Watts/Hz, Find SNR at the input of the receiver.

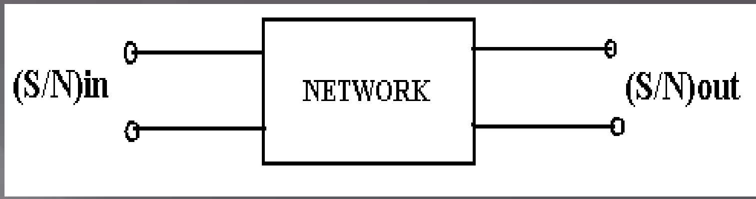
Solution:

Noise Factor or Figure

- The ratio of output SNR to the input SNR can be termed as the Figure of merit (F). It is denoted by F. It describes the performance of a device.

- The amount of noise added by the network is embodied in the Noise Factor F.

$$\text{Noise factor } F = \frac{\left(S/N\right)_{IN}}{\left(S/N\right)_{OUT}}$$



- Noise figure is a measure of the degradation in signal to noise ratio and it can be used in association with radio receiver sensitivity. Noise figure is a number by which the noise performance of an amplifier or a radio receiver can be specified. The lower the value of the noise figure, the better the performance.

Noise Performance of Various Modulation Schemes

Noise in DSB-SC

The receiver model for coherent detection of DSB-SC signals is shown in Fig. 1 The DSB-SC signal is, *s (t) = Ac m(t) cos (ωc t) . We assume m(t) to* be sample function of a WSS process *M(t) with the power spectral density, SM (f) , limited to ± W Hz.*

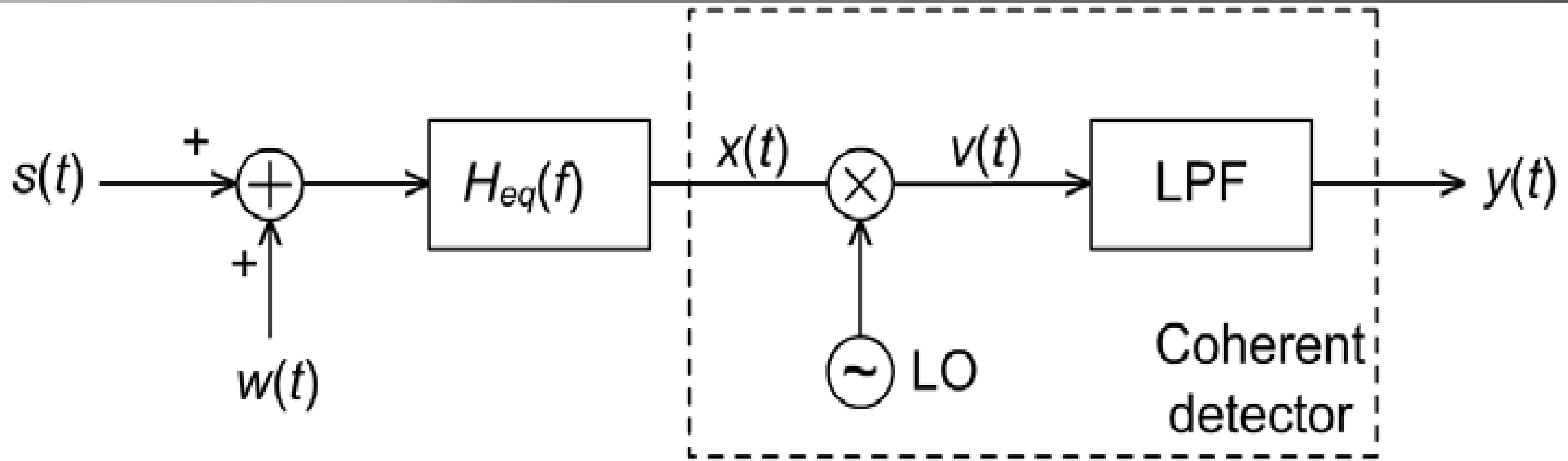


Fig. 1 Coherent Detection of DSB-SC.

the random phase added to the carrier term, *Rs (τ) , the autocorrelation function of the process S(t)* (of which *s (t) is a sample function), is given by,*

$$R_s(\tau) = \frac{A_c^2}{2} R_M(\tau) \cos(\omega_c \tau)$$

where *RM (τ) is the autocorrelation function of the message process.*

Cont….

Fourier transform of *Rs (τ) yields Ss (f) given by,*

$$S_s(f) = \frac{A_c^2}{4}\left[S_M(f - f_c) + S_M(f + f_c)\right]$$

Let *PM denote the message power, where*

$$P_M = \int_{-\infty}^{\infty} S_M(f)\,df = \int_{-W}^{W} S_M(f)\,df$$

$$\text{Then,} \quad \int_{-\infty}^{\infty} S_s(f)\,df = 2\frac{A_c^2}{4}\int_{f_c - W}^{f_c + W} S_M(f - f_c)\,df = \frac{A_c^2 P_M}{2}.$$

the average noise power in the message bandwidth 2*W is 2W**N_0/2= *W**N_0 .Hence,

$$\left[(SNR)_r\right]_{DSB-SC} = \frac{A_c^2 P_M}{2\,W\,N_0}$$

To arrive at the *FOM , we require (SNR)0 . The input to the detector x (t) = s (t) + n(t) , where n(t) is a narrowband noise quantity. Expressing n(t)* in terms of its in-phase and quadrature components, we have

$$x(t) = A_c\,m(t)\cos(\omega_c t) + n_c(t)\cos(\omega_c t) - n_s\sin(\omega_c t)$$

Assuming that the local oscillator output is cos(ωc t) , *the output v (t) of the* multiplier in the detector is given by

$$v(t) = \frac{1}{2}A_c\, m(t) + \frac{1}{2}n_c(t) + \frac{1}{2}\left[A_c\, m(t) + n_c(t)\right]\cos(2\omega_c t) - \frac{1}{2}A_c\, n_s(t)\sin(2\omega_c t)$$

As the LPF rejects the spectral components centered around 2 *fc , we have*

$$y(t) = \frac{1}{2}A_c\, m(t) + \frac{1}{2}n_c(t)$$

So, the message component at the output is (1/2)**Ac m(t).*

The average message power at the output is $(A_C)^2/2*P_M$

As the spectral density of the in-phase noise component is *N0 for f ≤ W ,*

the average noise power at the receiver output is $2W*N_0/4 = (W*N_0)/2$ Therefore,

$$\left[(SNR)_0\right]_{DSB-SC} = \frac{\left(A_c^2/4\right)P_M}{(W N_0)/2} = \frac{A_c^2\, P_M}{2W N_0}$$

So,

$$[FOM]_{DSB-SC} = \frac{(SNR)_0}{(SNR)_r} = 1$$

Thank you