Nadar Saraswathi College of Engineering & Technology

Engineering Excellence for Empowerment

NSCET E-LEARNING PRESENTATION

LISTEN … LEARN… LEAD…

ELECTRONICS & COMMUNICATION ENGINEERING

II nd YEAR / IVth SEMESTER

EC 8591 – COMMUNICATION THEORY

S.PRATHAP M.E.,

Assistant professor

Nadar Saraswathi College of & Technology,

Vadapudupatti, Annanji (po), Theni – 625531.

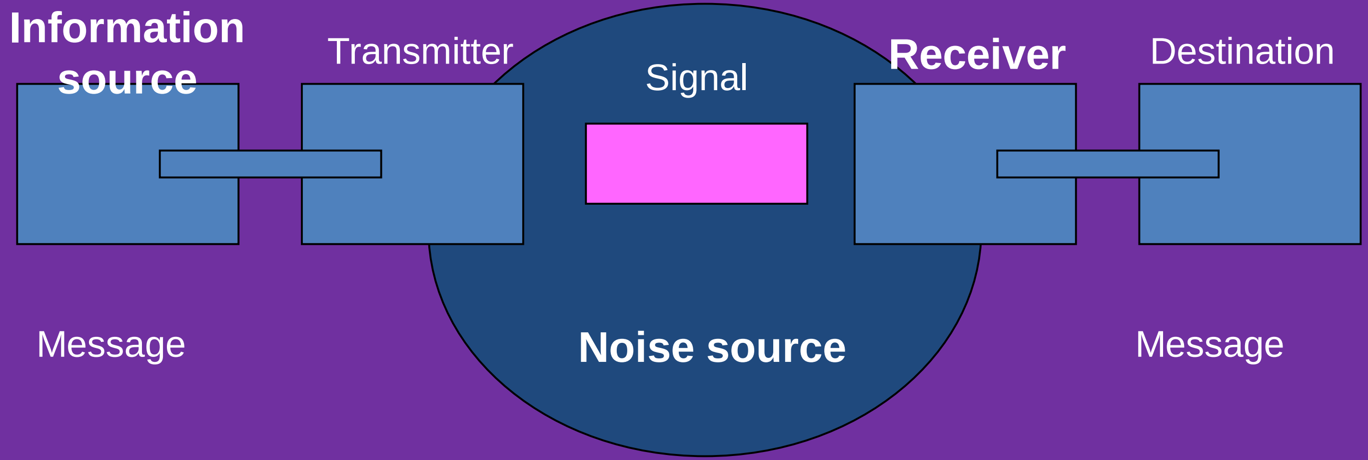
UNIT 04

NOISE CHARACTERIZATION

- Exchange – two-way
- Information (but reflects knowledge)
- Intentional or unintentional
- Linguistic or nonlinguistic
- Needs, wants, perceptions, knowledge

Shannon's model

- Claude E. Shannon conceptualized the communication theory model in the late 1940s.
- It remains central to communication study today.



Noise in Communication Systems

❖Channel is the main source of noise in communication systems

❖ Transmitter or Receiver may also induce noise in the system

There are mainly 2-types of noise sources

❖ Internal noise source (are mainly internal to the communication system)

❖ External noise source

External Noise Sources

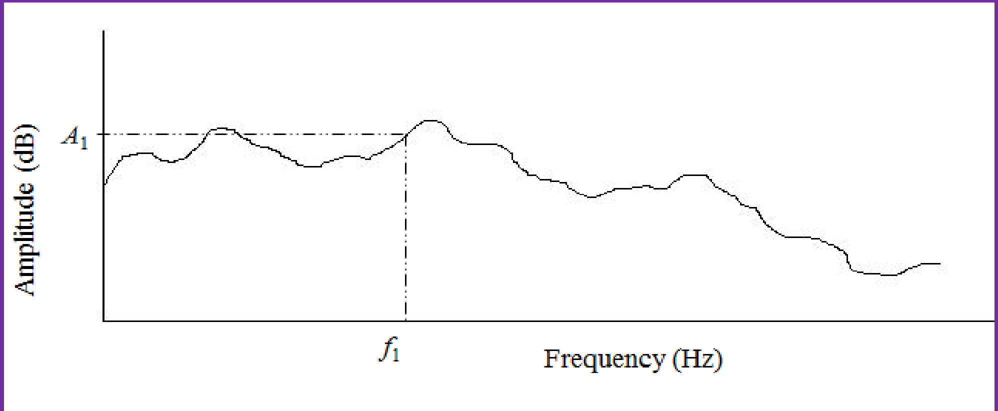
Natural

Man-made

Need of noise characterization

For

- Monitoring the instrument behavior
- Provide an estimate of the noise level
- Detect deviations from the gaussianity or stationarity



Noise Effect

Degrade system performance for both analog and digital systems.

The receiver cannot understand the sender.

The receiver cannot function as it should be.

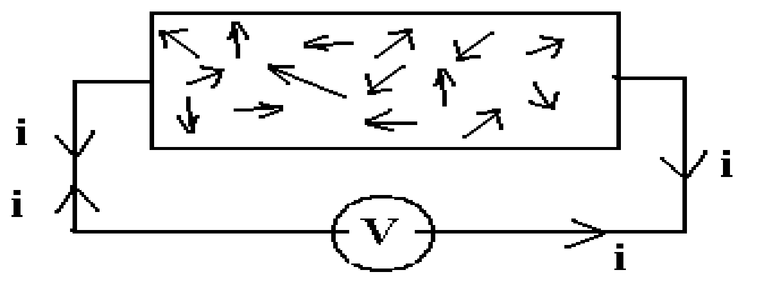
Reduce the efficiency of communication system.

Noise Vs Interference

- Noise is a general term which is used to describe an unwanted signal which affects a wanted signal.
- Interference arises for example, from other communication systems (cross talk), 50 Hz supplies (hum) and harmonics, ignition (car spark plugs) motors … etc.

Thermal Noise (Johnson Noise)

- This type of noise is generated by all resistances (e.g. a resistor, semiconductor, the resistance of a resonant circuit, etc.).
- Experimental results (by Johnson) and theoretical studies (by Nyquist) give the mean square noise voltage as



SHOT NOISE

- Shot noise - random fluctuations in electron emission from cathodes in vacuum tubes (called shot noise by analogy with lead shot).
- For PN junctions the mean square shot noise current is
- Shot noise is found to have a uniform spectral density as for thermal noise

Other Noises

Low Frequency or Flicker Noise

•Active devices, integrated circuit, diodes, transistors etc. also exhibits a low frequency noise, which is frequency dependent.

Excess Resistor Noise

•Thermal noise in resistors does not vary with frequency, as previously noted, by many resistors also generates as additional frequency dependent noise referred to as excess noise.

Burst Noise or Popcorn Noise

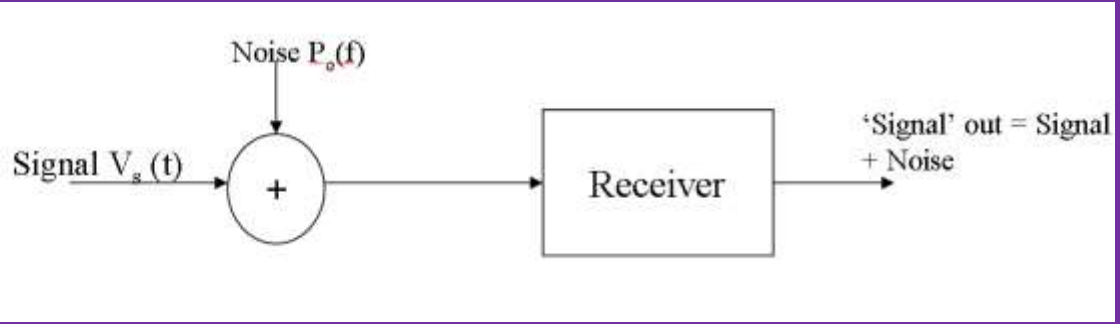
•Some semiconductors also produce this noise with a spectral density which is proportional to

Man-made Noise Sources

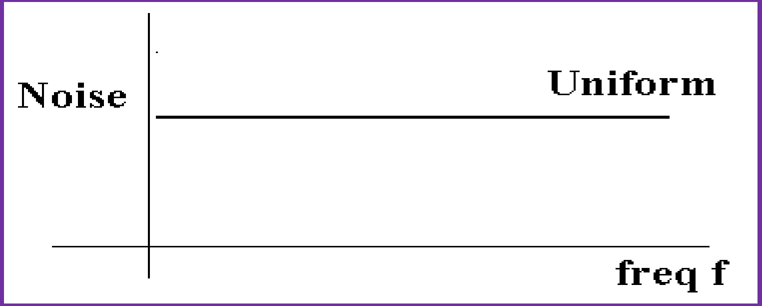
- High voltage power-line discharges
- Electrical motor noise generated by armature and switching taking place in the motor
- Ignition noise in automobiles and aircraft
- At Telephone exchanges where switching (electrical) takes place is a source of Impulsive Noise.

Additive White Gaussian Noise

- Noise is usually additive in that it adds to the information bearing signal. A model of the received signal with additive noise is shown below
- Constant PSDs over a wide range of frequencies



White



White noise = $p_o(f)$ = Constant

We generally assume that noise voltage amplitudes have a Gaussian or Normal distribution.

Assumptions on Noise Characteristics

- We typically combine all noise sources into a single additive white Gaussian noise (AWGN).

- The noise process is an ergodic process with zero mean and PSD equal to No/2.

- The noise process is uncorrelated with the transmitted signal

Signal to Noise Ratio (SNR)

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

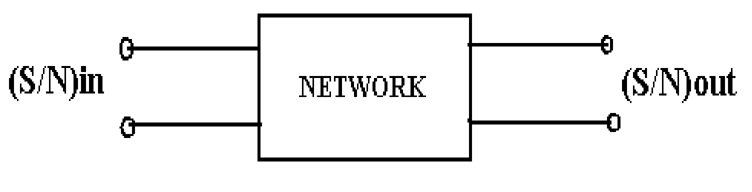
$$\boxed{S = \mathsf{E}\left[|X(t)|^2\right] \quad \text{and} \quad N = \mathsf{E}\left[|N(t)|^2\right].}$$

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

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

Noise Factor or Figure

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



Noise factor F =

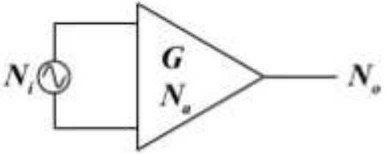
- The noise figure / factor is the measure of how much a network degrades the

Noise Analysis in Amplifier

To simplify the analysis, two types of noise model are used.

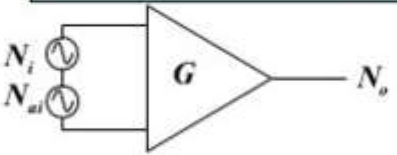
- Amplifier with noise
- Amplifier without noise

input noise, Ni
artificial noise source, Nai



(a) Amplifier with noise

$$N_o = GN_i + N_a$$

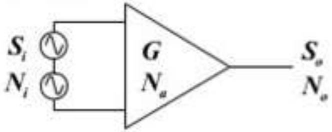


(b) Amplifier without noise

$$N_o = G(N_i + N_{ai})$$

where $N_{ai} = \frac{N_a}{G}$ and $P_n = N_i = kT_iB$

Noise Analysis in Amplifier



Model Amplifier with noise

(1)

$$S_o = GS_i$$

$$N_o = GN_i + N_a = G\left(N_i + \frac{N_a}{G}\right) = G(N_i + N_{ai})$$

$$SNR_o << SNR_i$$

Noise Figure, F

(2)

$$\frac{SNR_i}{SNR_o} = \frac{\dfrac{S_i}{N_i}}{\dfrac{GS_i}{G(N_i + N_{ai})}} = \frac{N_i + N_{ai}}{N_i} = 1 + \frac{N_{ai}}{N_i}$$

$$F = 1 + \frac{N_{ai}}{N_i}$$

(3) **We have:**

$N_i = kT_iB$ **and** $N_{ai} = kT_eB$

=> $F = 1 + \dfrac{kT_eB}{kT_iB}$

Noise Figure:

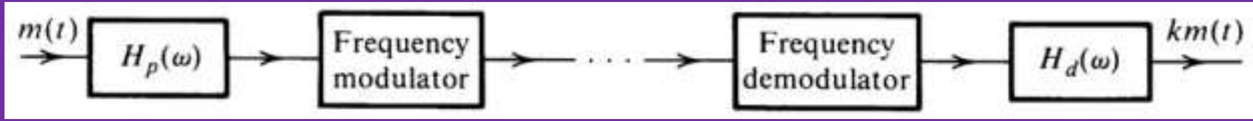
$$F = 1 + \frac{T_e}{T_i}$$

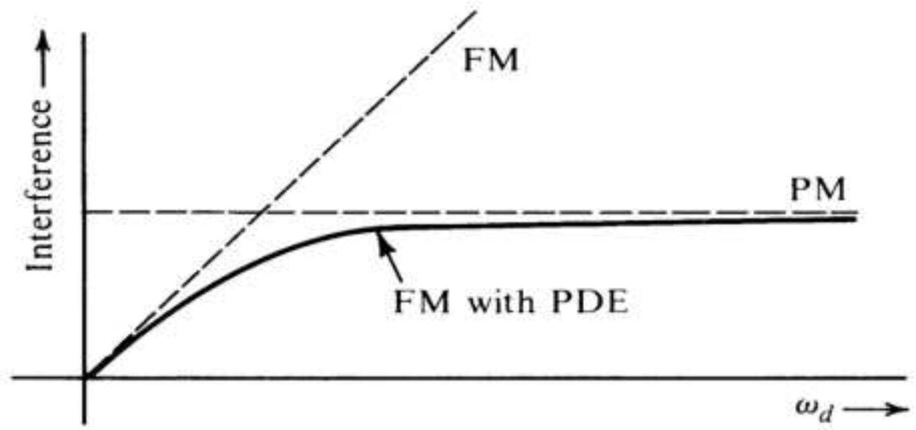
Noise Temperature:

$$T_e = (F - 1)T_i$$

Pre-emphasis & de-emphasis

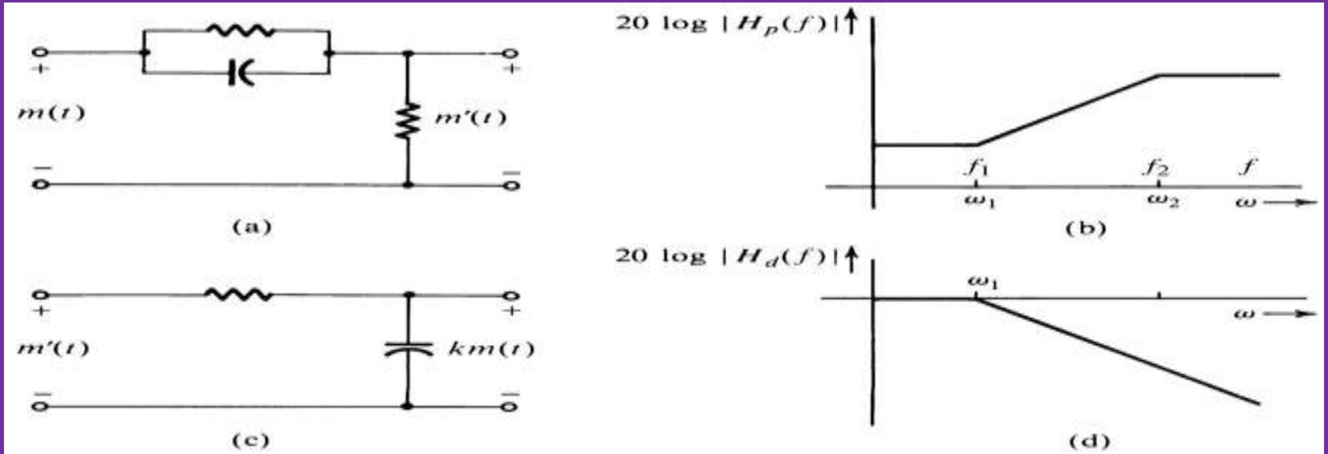
- Pre-emphasis is needed in FM to maintain good signal to noise ratio.
- The characteristics of the pre-emphasis and de-emphasis filters depend largely on the PSD of the message process.
- The net effect of these filters should be a flat frequency response since the noise component before filtering has a parabolic PSD


m(t)
$H_p(\omega)$
Frequency modulator
Frequency demodulator
$H_d(\omega)$
km(t)


Interference
FM
PM
FM with PDE
ω_d

Pre-emphasis & de-emphasis

- In commercial FM broadcasting of music and voice, 1st order lowpass and highpass RC filters with a time constant of 75 μs are employed.
- $f_o = 1/(2\pi \times 75 \times 10^{-6}) \approx 2100$ Hz is the 3 dB frequency of the filter



Thank You