Subject - Principles of Telecommunication Engineering
BE 6th Semester EE Department
BBEC, Kokrajhar

Module- I
Introduction to Communication Issues

- Lecture Plan- Date- 08/05/2021

  Syllabus- Topics to be covered:
- History of communication,
- Issues of noise in communication,
- Sources and characteristics of different noise, thermal and shot noise, concept of white Gaussian noise.
- Noise temperature,
- Noise bandwidth and
- Noise figure

- Source-Communcation System Book(Dr. Sanjay Sharma) (Shared in watsapp) (Module wise)

1. Communication system

(a) Definition

• Process of establishing connection or link between two points for information exchange.
• Basic process of exchanging information.
Examples are-

- ▢ line telephony, line telegraphy,
- ▢ radio broadcasting, radio telegraphy,
- ▢ point to point communication, mobile communication,computer communication,
- ▢ radar communication, television broadcasting, radio telemetry, aircraft landing.

(b) History

• Line telegraphy (1840s)
• Line telephony(few decades later)
• Radio communication (twentieth century) after invention of triode valve,
• Satellites
• Fiber optics
• Computers
• Mobile phones

(c) Block diagram of communication system

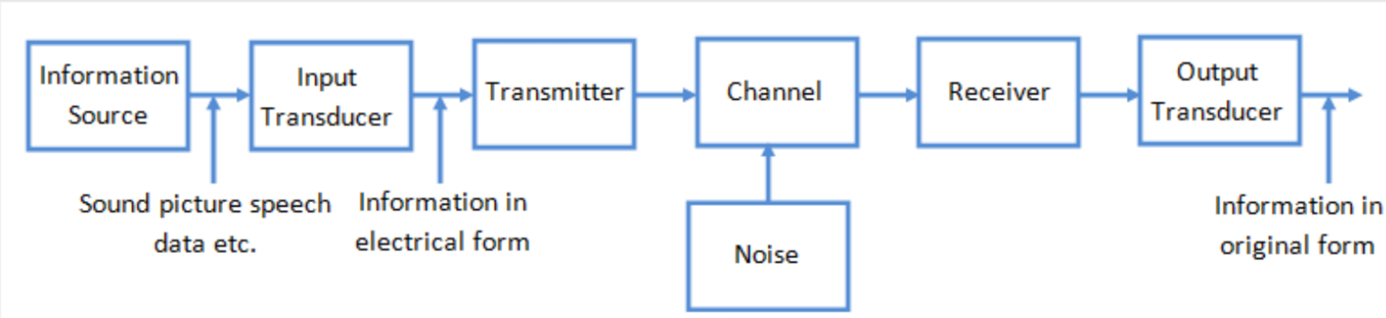


Fig- Block diagram of communication system

Functions of the blocks(explain in detail)

1. **Information source**- It provides required messages in the form of words, group of words, code, symbols, sound signal etc.

2. **Input transducer**-It is a device which converts one form of energy into another form.
 Example- Microphone

3. **Transmitter**- electronic device used to produce radio waves in order to transmit or send data with the aid of an antenna. It is used to process electrical signal from different aspects.

4. <u>**Channel**</u>- It is a physical medium which provides a physical connection
between the Transmitter and a Receiver.
Types of channel-

- ▢ Point to point channels (wire lines,microwave links, optical fibers)
- ▢ Broadcast channel (Satellite)

5. <u>**Noise**</u>- unwanted signal
"Channel is mostly affected by noise"

6. <u>**Receiver**</u>- It reproduces a message signal in electrical form from distorted received signal.

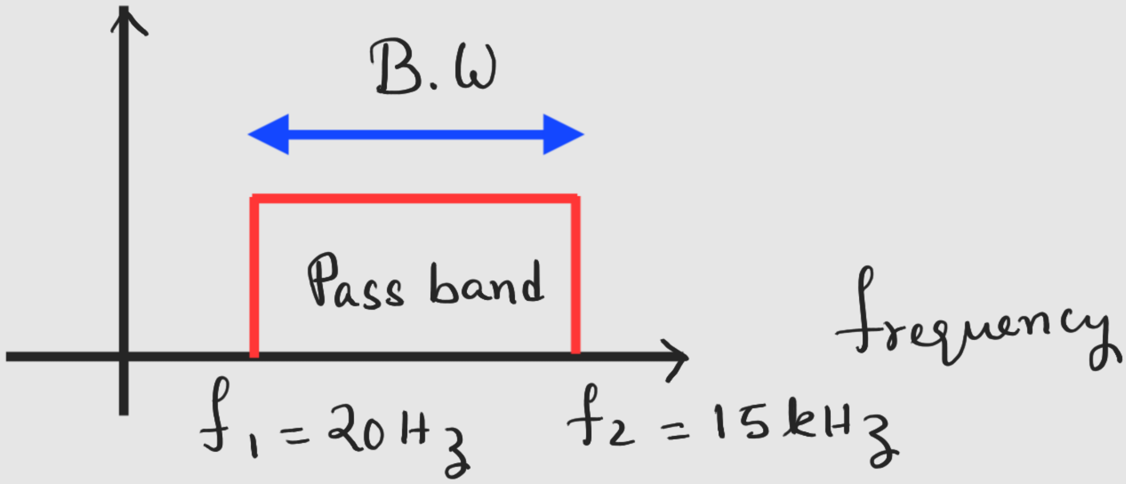
7. <u>**Destination**</u>- It converts an electrical message signal into its original form.

(d) <u>Concept of Bandwidth</u>

<u>*Definition*</u>-

- ▢ Frequency range over which an information signal is transmitted.
- ▢ Difference between upper and lower frequency limits of the signal.

Ex:



Range of music signal is given in the figure. Determine Bandwidth.

Sol: $B.W = f_2 - f_1 = 15000 - 20$

$= 14980\ Hz$.

N.B:

Voice signal ⇒ 300 – 3400

Music " ⇒ 20 – 15000

TV signal ⇒ 0 – 5 MHz

Digital data ⇒ 300 – 3400

2. Issues of noise in communication

(a) Effects of noise

- Degrades the system performance for both analog and digital system
- Receiver cannot understand the sender
- Reduce the efficiency of communication system

(b) Definition

- Noise is an unwanted electrical disturbance which gives rise to audible or visual disturbances in communication system.

(c) Sources of noise-

1. Natural sources (external noise sources include atmospheric disturbances)eg- electric storms, lighting, ionosphere effect.

2. Manmade sources (Electric motors, welding machines)

3. Fundamental sources(internal noises within the electronic equipment)

(d) Classification of noise

1. Thermal noise
2. Partition noise
3. Shot noise
4. Low frequency or flicker noise
5. High frequency or transit time noise

1. Thermal noise

- Also named as Johnson noise or Nyquist noise or white noise.
- Measured by John B. Johnson in 1928
- It is an electronic noise generated by the thermal agitation of the charge carriers i.e.the electrons inside the electrical conductor.
- This thermal noise actually occurs regardless of applied voltage because the charge carriers vibrate as a result of temperature.

Named as White noise-

- Thermal Noise are random and often referred as White Noise or Johnson Noise.
- Thermal noise are generally observed in the resistor or the sensitive resistive components of a complex impedance due to the random and rapid movement of molecules or atoms or electrons.

- *Thermal noise power depends on the bandwidth and temperature of the conductor.*

Average thermal noise power is given by-

Pn= kTB watts

where, k= Boltzmann's constants=1.38×10^-23Joules/Kelvin

B= Bandwidth of noise spectrum(Hz)

T= Temperature of the conductor, in Kelvin

Example 1

A receiver has a noise bandwidth of 12kHz.A resistor which matches with the receiver input impedance is connected across the antenna terminals. What is the noise power contributed by this resistor in the receiver bandwidth. Assume temperature to be 30 degree Celsius.

Sol:

$$B = 12 kHz = 12 \times 10^3 \ Hz$$

$$T = 30°C = 30 + 273$$

$$= 303°K$$

Noise power,

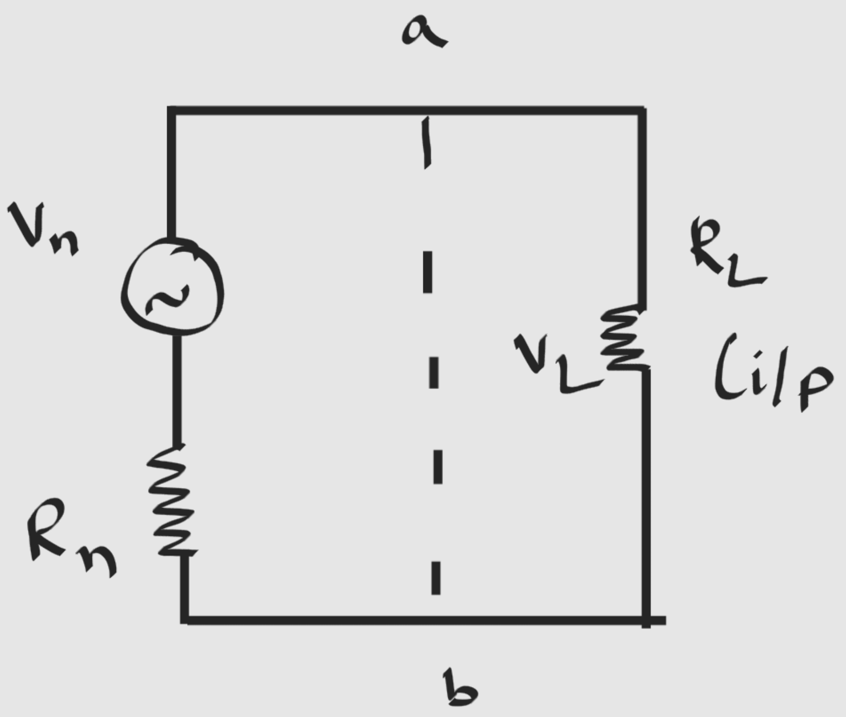
$$\boxed{P_n = kTB}$$

$$= 1.38 \times 10^{-23} \times 303 \times 12 \times 10^3$$

$$= 5.01768 \times 10^{-17} \ W$$

Equivalent circuits for thermal noise - Modeling of Noise power-

1. Voltage equivalent circuit (Thevenin equivalent circuit)



$V_n \rightarrow$ Noise voltage source

$R_n \rightarrow$ Noise less resistance

Concept of Maximum Power Transfer

Theorem:

$$R_n = R_L = R$$

(all power will be transferred to the load)

$\rightarrow$ impedance matching)

Voltage divider rule,

$$V_L = \frac{R_L}{R_n + R_L} V_n$$

$$V_L = \frac{R}{2R} V_n \quad (\because R_L = R_n = R)$$

$$V_L = \frac{V_n}{2}$$

Power, $P_L = \frac{V_L^2}{R}$

$$= \frac{(V_n/2)^2}{R} = \frac{V_n^2}{4R} \quad \text{—— (1)}$$

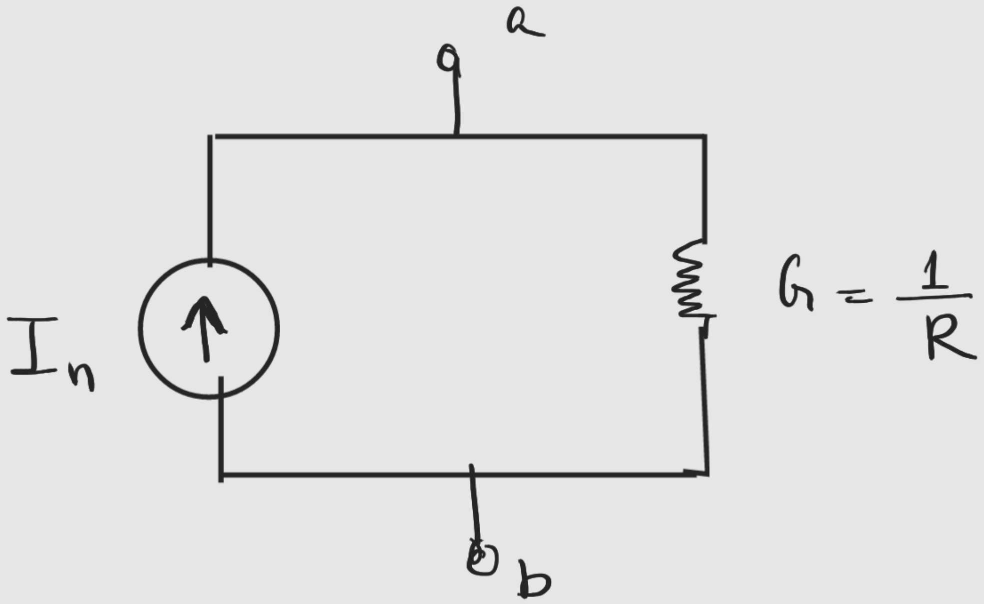
& we know, Noise power $= P_n = P_L = kTB$ —— (2)

On equating ① & ②, we get

$$\frac{V_n^2}{4R} = kTB$$

$$V_n = \sqrt{4kTBR}$$

2. Current equivalent circuit(Norton equivalent circuit



RMS noise current,

$$I_n = \sqrt{4GkTB}$$

Calculate Noise voltage

Example 2. Calculate the noise voltage at the input of a receiver RF amplifier, using a device that has 100ohm equivalent noise resistance and a 200 ohm input resistor in series. The bandwidth of the amplifier is 1MHz, the temperature is 25 degree Celsius and Boltsmanns constant= 1.38×10^-23J/K.

Sol – $R_i = 200\,\Omega$, $R_n = 100\,\Omega$,

$B = 1\,MHz$, $T = 25^\circ C$

$= 25 + 273$

$= 298\,^\circ K$

Noise voltage,

$$V_n = \sqrt{4kBTR_{eq}}$$

$$R_{eq} = R_i + R_n = 100 + 200$$

$$= 300\,\Omega$$

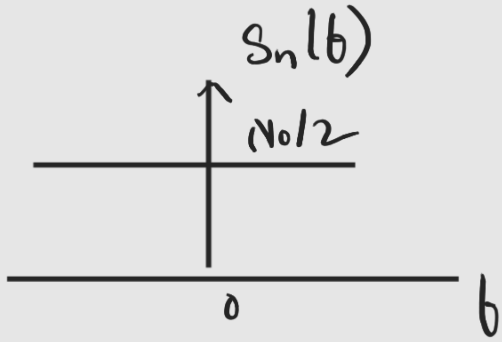
$$V_n = \sqrt{4 \times 1.38 \times 10^{-23} \times 298 \times 10^{6} \times 300}$$

$$= 2.2\,\mu V$$

White Gaussian Noise

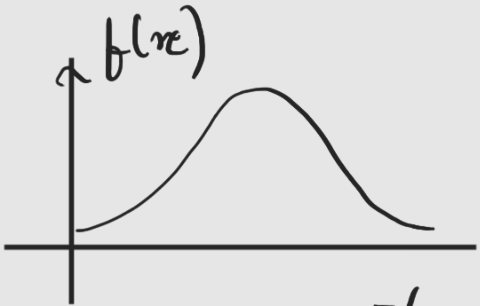
- Example of white noise- Thermal noise
- White noise- power spectral density is uniform over the entire frequency range of interest.
    - ▢ Why it is called white Gaussian noise? - white noise has gaussian distribution and white noise Probability density function is similar to gaussian i.e. Bell shaped curve.

→ PSD, $S_n(f) = \frac{N_0}{2}$



where $N_0 = kT_e$

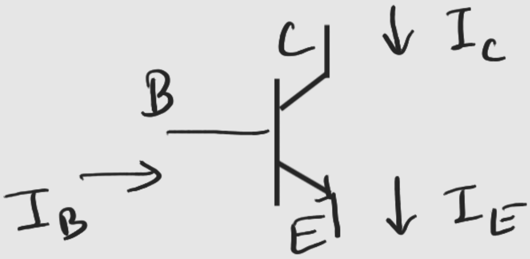
→ Bell shaped curve.



$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

2. Partition noise

- When a circuit is divided in between two or more paths then the noise generated is partition noise.
- Reason - random fluctuation in division
- Caused when charge carriers in a current can choose between multiple paths. Example- Noise in BJT



3. Shot noise

- These noise generally arises in the active devices due to the random behaviour of Charge particles or carries.
- In case of electron tube, shot Noise is produces due to the random emission of electron form cathodes.
- For diodes, mean square shot noise current

$$I_n^2 = 2(I + 2I_0)qB \text{ ampere}^2$$

where, I = direct current accross junction

I_0 = reverse saturation current

4. Low- Frequency Noise : They are also known as FLICKER NOISE. These type of noise are generally observed at a frequency range below few kHz.Power spectral density of these noise increaseswith the decrease in frequency. That why the name is given Low- Frequency Noise.

5. High- Frequency Noise : These noises are also known TRANSIT- TIME Noise. They are generally observed in the semi conductor devices when the transit time of a charge carrier while crossing a junction is compared with the time period of that signal.

Important Terms and Definition (2019)

(i) Noise bandwidth, Bn

- The noise bandwidth is defined as the bandwidth of an ideal (rectangular) filter which passes the same noise power as does the real filter.
- This filter is being used to reduce the noise power actually passed on to the receiver.

(ii) Noise figure

- Noise factor in decibels is called noise figure.
- Noise factor-

$$\text{Noise Factor, } F = \frac{S/N \text{ ratio at i/p}}{S/N \text{ ratio at o/p}}$$

$$= \frac{P_{si}}{P_{ni}} \times \frac{P_{no}}{P_{so}}$$

where, P_{si}, P_{ni} = signal & Noise power (i/p)

P_{so}, P_{no} = signal & Noise power (o/p)

$$\text{Noise figure, } F_{dB} = 10 \log_{10} F$$

$$= 10 \log_{10} (S/N)_i - 10 \log_{10} (S/N)_o$$

Different ways to reduce noise figure

- Use diodes and FETs(low noise)
- Receiver can be operated at low temperatures
- Satelite low noise receiver
- Use high gain amplifiers

(iii) Noise temperature

- The noise temperature is the temperature of a resistor that has noise power equal to that of the device or circuit.
- Equivalent noise temperature

Noise at input of amplifier input is given by,

$$P_{na} = (F-1) k T_0 B$$

↓

(replace by fictitious temp T_{eq})

$$\therefore \quad k T_{eq} B = (F-1) k T_0 B$$

$$T_{eq} = (F-1) T_0$$

Example 3. An amplifier has a noise figure of 3dB. Determine the noise temperature.

Sol:

Noise Figure, $F_{dB} = 10 \log_{10}(F)$

Noise Factor, $F = \text{Antilog}(F_{dB}/10)$

$= \text{Antilog}(3/10)$

$= 2$

$\therefore \quad T_{eq} = (F-1)\, T_0$

$= (2-1) \times 300$

$= 300^\circ K$. //