Paper – I: Communication Electronics

UNIT-I

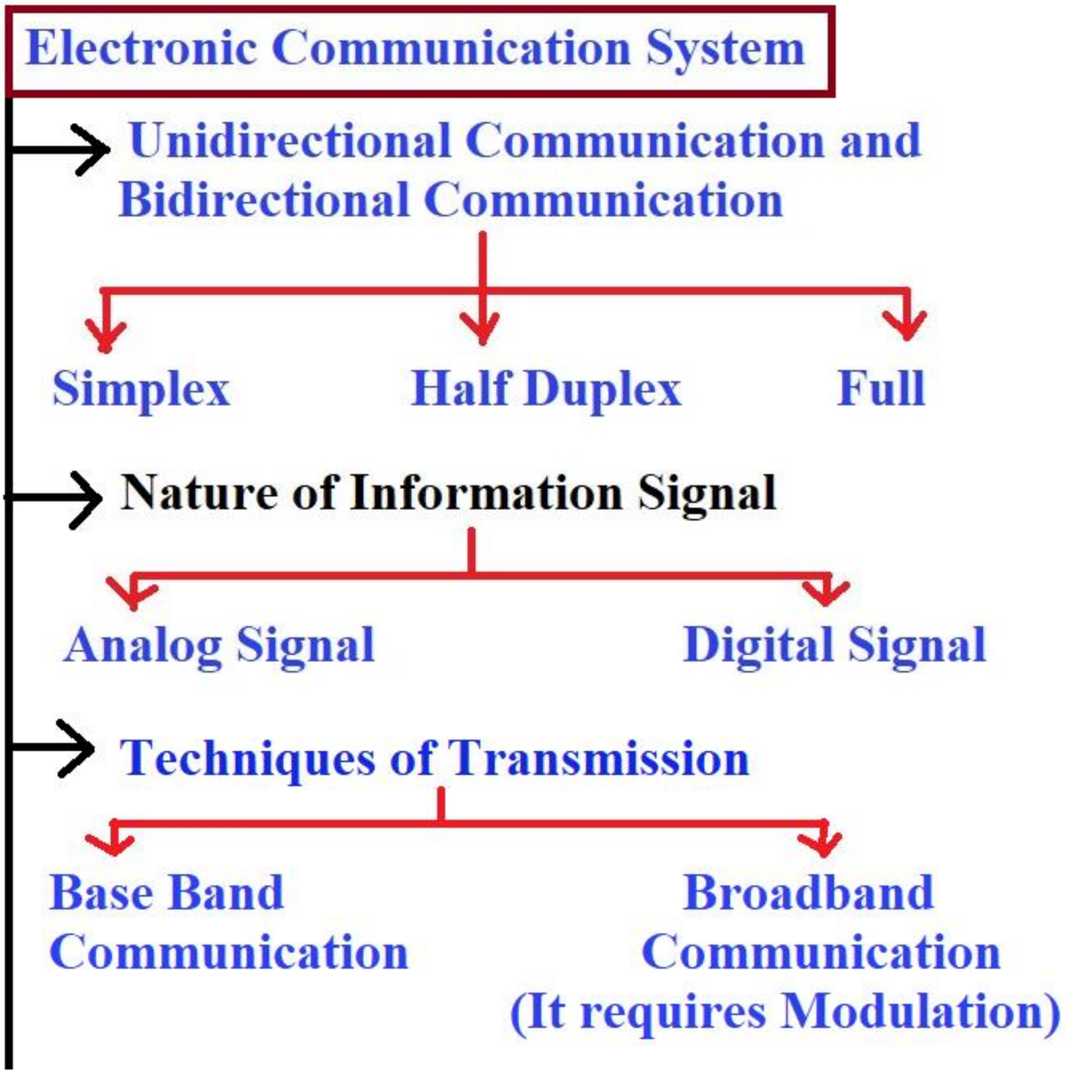
Introduction to Electronic Communication:

Introduction to communication- means and modes,Block diagram of an electronic communication system, Electromagnetic spectrum, Brief idea of frequency allocation for radio communication system in India (TRAI),Concept of Noise, signal-to-noise (S/N) ratio, Noise figure and noise temperature.Need of modulation and demodulation.

Means of Communications:

Forms of Communication	Types of Communication
1) Radio Broadcast	1) Cable Communication
2) Television Broadcast	2) Ground Wave Communication
3) Telephony	4) Sky Wave Communication
5) Telegraph	4) Satellite Wave Communication
6) Radar	5) Optic Fiber Communication
7) Sonar	
8) Fax (Facsimile Telegraphy)	
9) E-mail	
10) Teleprinting	
11) Mobile phones	
12) Internet	
13) Telemetering	

Modes of Communications (Types of Communications) :



There are three modes (Types) of Communication/ transmission namely:

1) Simplex Communication
2) Half Duplex Communication , and
3) Full Duplex Communication

The Communication/transmission mode defines the direction of signal flow between two connected devices.

The primary difference between three modes of Communication is that in a simplex mode of Communication the communication is unidirectional, or one-way;

whereas in the half duplex mode of Communication the communication is two-directional, but the channel is interchangeably used by both of the connected devices.

On the other hand, in the full duplex mode of Communication, the communication is bi-directional or two-way, and the channel is used by both of the connected devices simultaneously.

Simplex Communication

In simplex Communication mode, the communication between sender and receiver occurs in only one direction. The sender can only send the data, and the receiver can only receive the data. The receiver cannot reply to the sender.

Simplex Communication can be thought of as a one-way road in which the traffic travels only in one direction—no vehicle coming from the opposite direction is allowed to drive through.

To take a keyboard / monitor relationship as an example, the keyboard can only send the input to the monitor, and the monitor can only receive the input and display it on the screen.

The monitor cannot reply, or send any feedback, to the keyboard. Example of Simplex Communication is Radio and television communication.

Half Duplex communication.

The communication between sender and receiver occurs in both directions in half duplex Communication, but only one at a time. The sender and receiver can both send and receive the information, but only one is allowed to send at any given time.

Half duplex is still considered a one-way road, in which a vehicle traveling in the opposite direction of the traffic has to wait till the road is empty before it can pass through.

For example, in walkie-talkies, the speakers at both ends can speak, but they have to speak one by one. They cannot speak simultaneously.

Full Duplex Communication

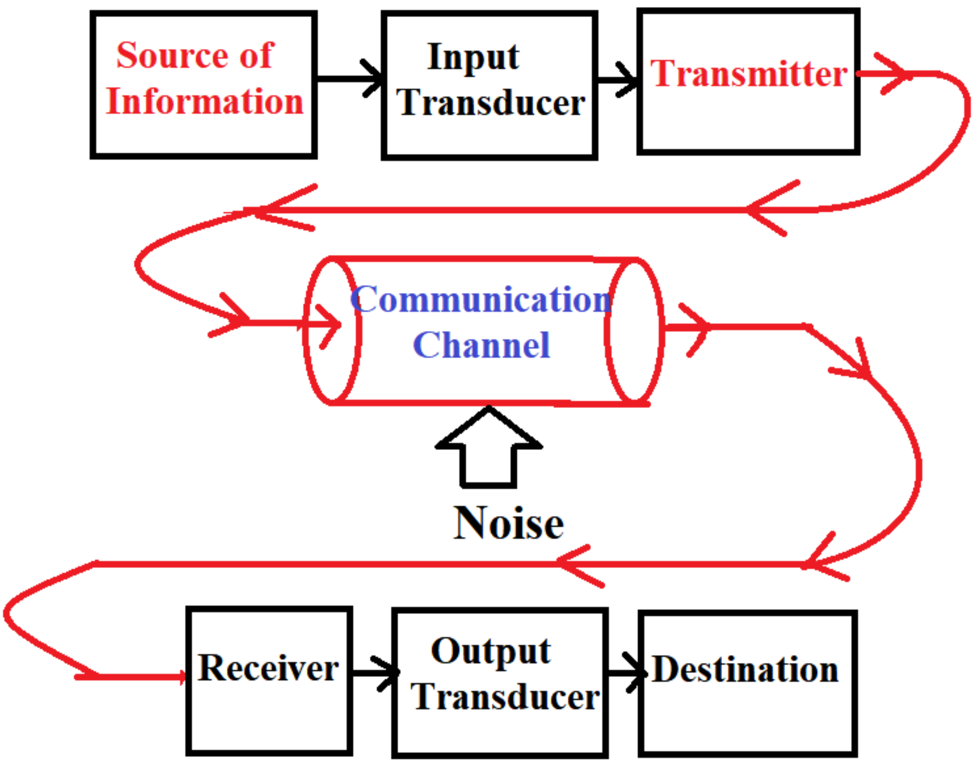
In full duplex Communication mode, the communication between sender and receiver can occur simultaneously. The sender and receiver can both transmit and receive at the same time. Full duplex transmission mode is like a two-way road, in which traffic can flow in both directions at the same time.

For example, in a land line and mobile telephone conversation, two people communicate, and both are free to speak and listen at the same time.

Electromagnetic Spectrum

Sr. No.	Range of Frequency	Application
01	3 Hz to 30 Hz Extremely Low Frequency	Animal Communication
02	30 Hz to 300 Hz Super Low Frequency	AC POWER LINES
03	300 Hz to 3000 Hz (3 KHz) Voice Frequency	Normal Range of Human Speech
04	3 KHz to 30 KHz Very Low Frequency	Submarine communication
05	30 KHz to 300 KHz Low Frequency	Aeronautical Communication
06	300 KHz to 3000 KHz (3MHz) Medium Frequency	AM Broadcasting for Radio stations
07	3MHz to 30 MHz High Frequency	BBC Radio, Armature Radio(Two Way) Short wave communication
08	30 MHz to 300 MHz Very High Frequency	FM Radio TV Channel (few)
09	300 MHz to 3000 MHz (3GHz) Ultra High Frequency	Cell phone, Military Services
10	3 GHz to 30 GHz Super High Frequency	Satellite and RADAR, Communication (Micro wave)
11	30 GHz to 300 GHz Extremely High Frequency	Military Wave Satellite

Block diagram of an Electronic Communication System:



The Electronics Communication system contains the following blocks:

1) The Source of Information Signal

2) Input transducer

3) Transmitter (Modulator Circuit Amplifier Frequency filter Antenna)

4) Communication Channel

5) Noise

6) Receiver (Antenna, Frequency filter, De Modulator Circuit, Amplifier)

7) Output Traducer

8) Destination

The Source of Information Signal

Information Signal is transmitted from source to destination. Transmitter consist of modulation circuit, Amplifier, frequency filter and Antenna .

The signal is modulated for long distance transmission. Information signal is also called as Modulating signal or base band signal.

For example voice information, video signal or picture or text message. Information signal is always in the form of electric signal. It is low frequency signal and amplitude is also low.

An analog signal is a continuous wave normally denoted by a sine wave and may vary in signal strength (amplitude) or frequency (time).

A digital signal is described as using binary (0s and 1s), and therefore, cannot take on any fractional values. This kind of signal denoted by digits that's why it is called Digital Signal.

Input transducer

It converts information in to an electrical signal. For example microphone converts sound wave in to electrical signal.Video recording camera converts video signal in to an electric signal.

Transmitter:

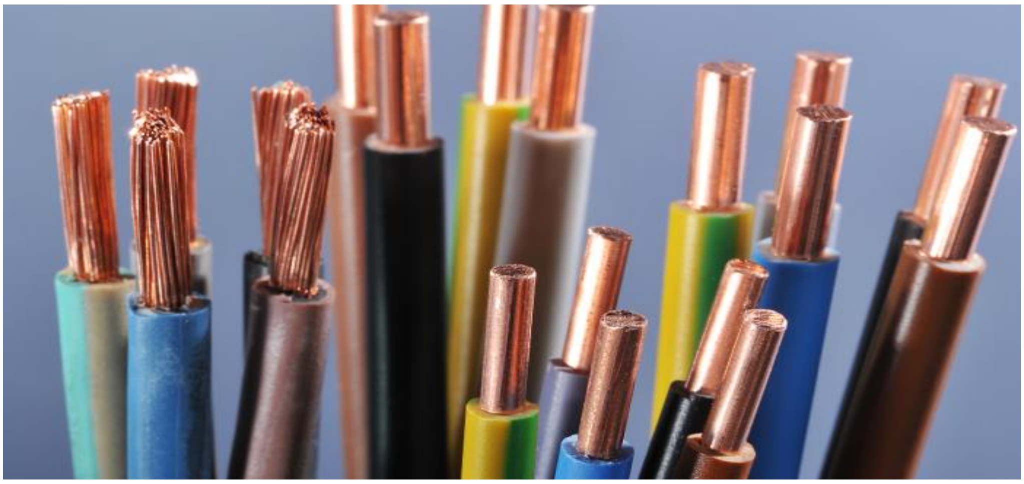
It consists of Modulation circuit such as Amplitude modulation, frequency Modulation etc. It also consist Amplifier Circuit and Frequency filters.

The Antenna is used to convert the electric signal in to an electromagnetic wave.

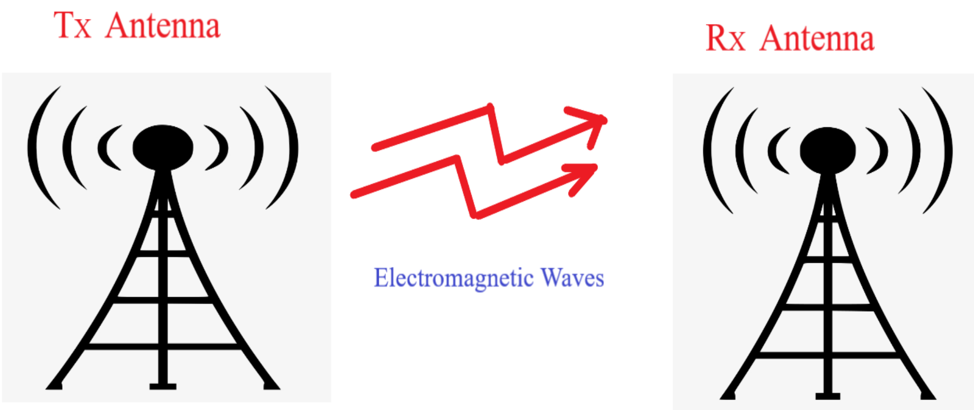
Communication Channel:

There are three Types of Communication Channels used widely

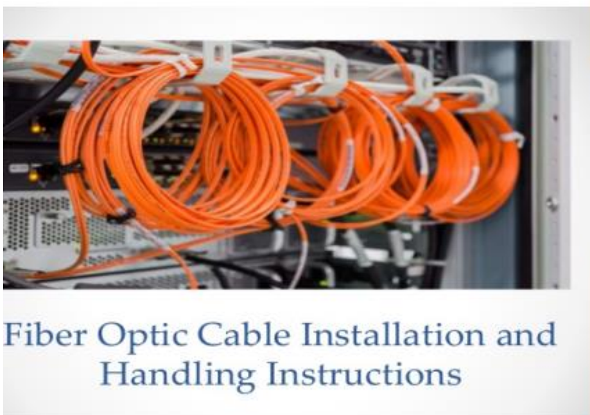
A) Metallic cable made by Copper or Aluminium

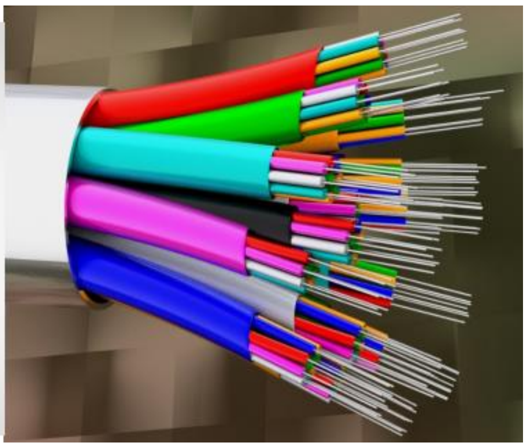


B) Free space



C) Fiber Optic Cable





Noise in Communication:

Noise is unwanted non electric, electric or electromagnetic energy that degrades or affects the original quality of information signal in communication process.

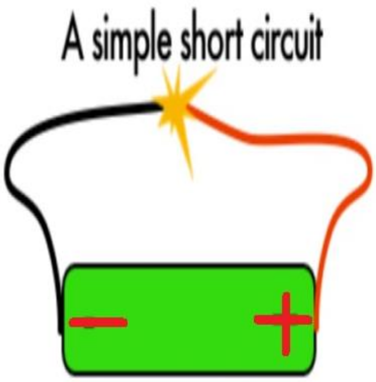
Basically it is divided in to Internal and External Noise.

Noise enters in to signal at the coupling points as well as due to metallic communication channel. It can be minimized.

Internal Noise: Heating of component, Shot Noise (Random arrival of electrons), Partition noise (In NPN/PNP transistor), Low frequency flickering noise.

External Noise is Atmospheric, lightening, Industrial and solar noise

Noise occurs in digital and analog systems both , but Analog systems are less tolerant to noise there digital signals are more tolerant to noise.



Receiver:

It consists of Demodulation circuit such as Amplitude Demodulation, frequency Demodulation etc. It also consist Amplifier Circuit and Frequency filters. The Antenna is used to convert the electromagnetic wave in to an electric signal.

Output Traducer:

It converts the electric signal in to original information for example Loud speaker converts audio information in to sound waves. TV display converts video signal in to Image or Picture.

Destination:

The location where original information is collected. Computer or mobile phone or Land line phone.

Noise in Electronic Communication:

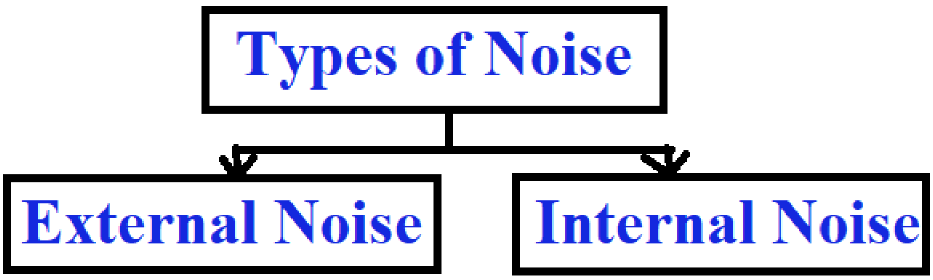
Noise in Electronic Communication is nothing but unwanted or random signal which affects the information signal in communication. Noise may be electric signal or it is also non electric signal such as solar radiation, thermal radiation or Electromagnetic waves or strong magnetic field.

In the first stage of communication system always an information signal is converted an electric signal. The electric signal means flow of electrons in particular width of communication channel. Whenever the flow of these electrons is diverted due to any other external or internal forces at that time it is said that information signal is affected by noise or noise is enter in to an information signal .

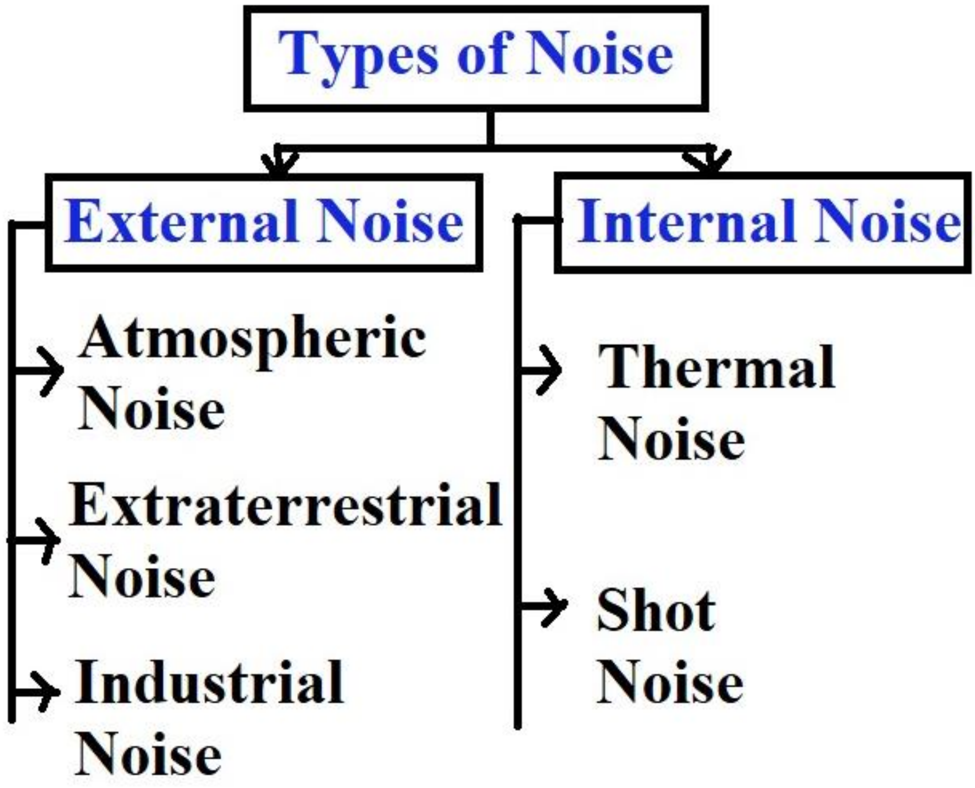
Different types of electronic components or metallic cables are use to carry the information in the form of flow of electrons. But the flow of electron is always in a systematic pattern and it is according to nature of an information signal.

Some time due to internal heat created in metal or semiconductor component or due to external magnetic field or Electromagnetic Interference (EMI) the systematic pattern of flow an electron in information signal gets change or gets affected and this called as noise is introduce in information signal.

Basically Noise is divided in to two types such as External Noise and Internal Noise.



External Noise is further classified as Atmospheric Noise, Extraterrestrial Noise and Industrial Noise.



Atmospheric Noise is nothing but the lightening which occurs in rainy season and it is source of high voltage.

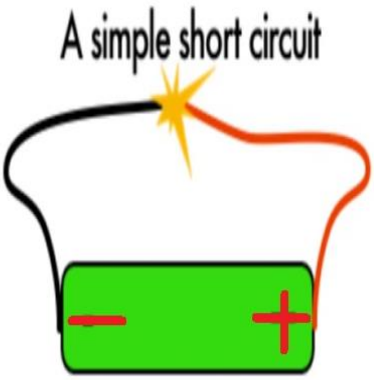
Solar noise is also another example of External Noise it contains the cosmic rays which is having electromagnetic radiations it affects on information signal in communication channel as well as information signal in the form of Electromagnetic waves.

Industrial Noise is example of External Noise and due to Single phase or three phase electric motors use in Industry the noise in the form of Electromagnetic interference is generated.

Man made Noise is also example of External Noise in day to day life while joining the two metals in the process of welding due to high voltage External Noise is created. While starting the self start vehicle such as scooter or car the starter motors and battery produces External Noise.

Extraterrestrial Noise such as Noise due to Radio Communication.

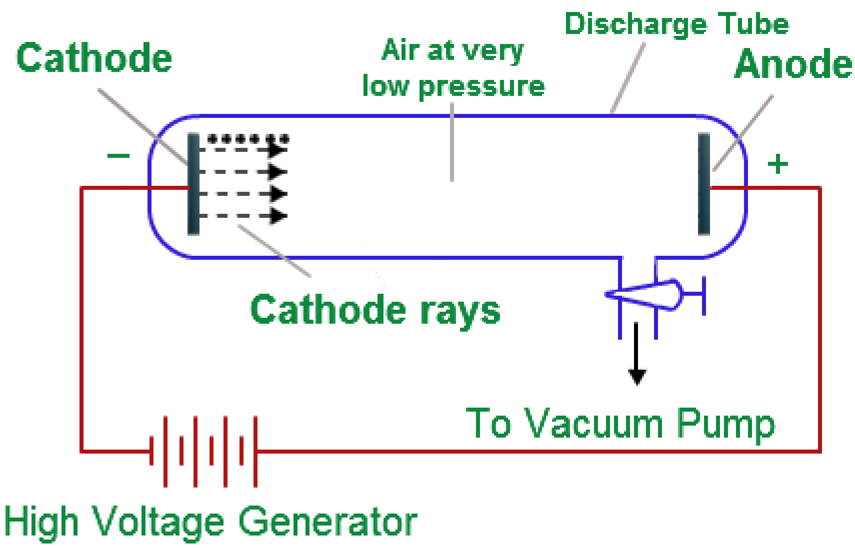




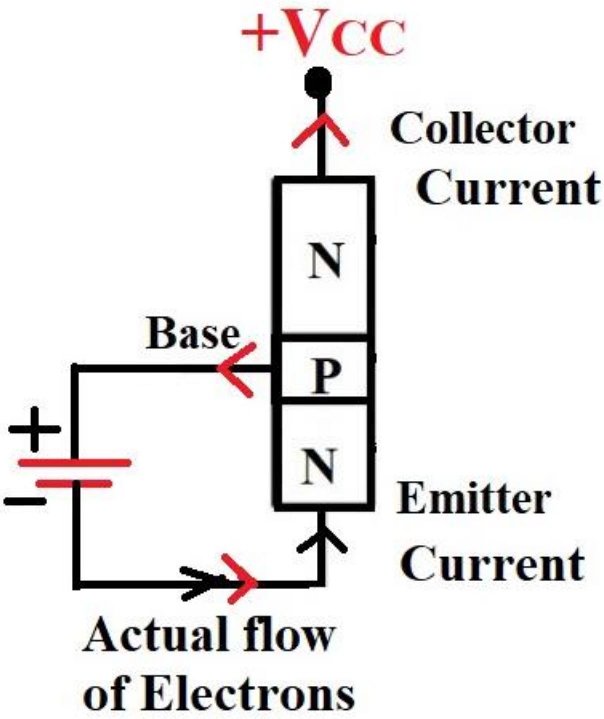
Internal Noise is further classified as Thermal Noise, Shot Noise, Partition Noise.

Thermal Noise is due to unwanted heating of components or metallic cables use in communication. Due to heat the resistance of material changes and flow of electron gets affected. Examples of components which produces thermal Noise ate Diode, Transistor and Resistor.

Shot Noise is due to random arrival of electrons for example knock out of electrons from cathode terminal due to strong electric field between Anode and Cathode. It is use in picture tube (It is not short circuit only shot).



Partition Noise basically takes place in BJT, in this case as shown below when an electron emitted from emitter enters in to base at that time very few electrons gets divided in to two path such as Base current electron and Collector current electron.



Flicker Noise is also example of Internal Noise which occurs in picture tube due to mismatch of number of vertical frames to be appear in one second.

Effect of Noise on Communication Process

- **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.**

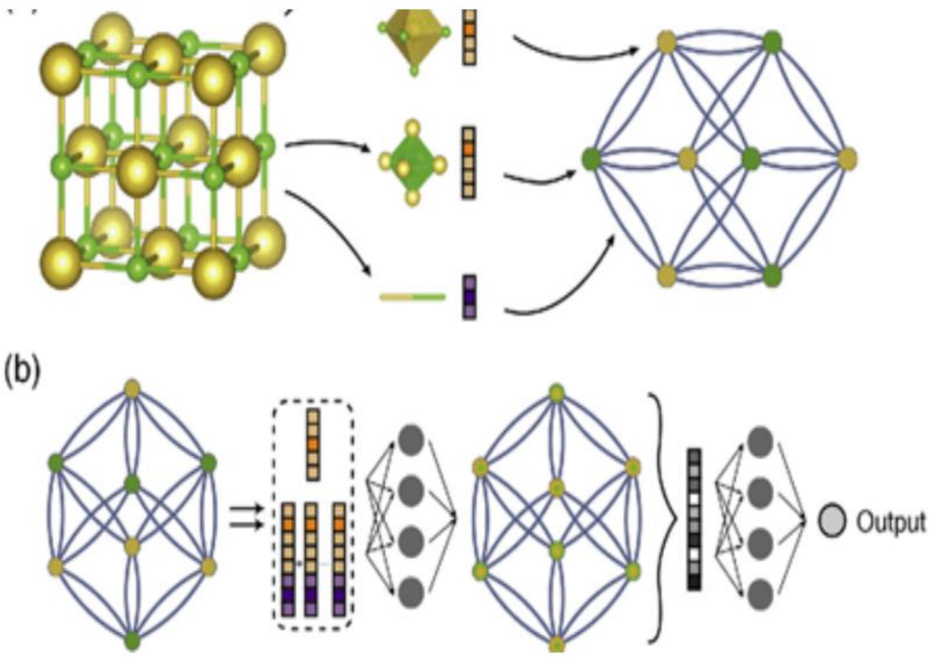
Thermal Noise:

It is very frequently occurring Noise in communication process because in communication circuits the electronic components are over heated or metallic cables are over heated.

It is important to study the effect of heat on the flow of electrons.

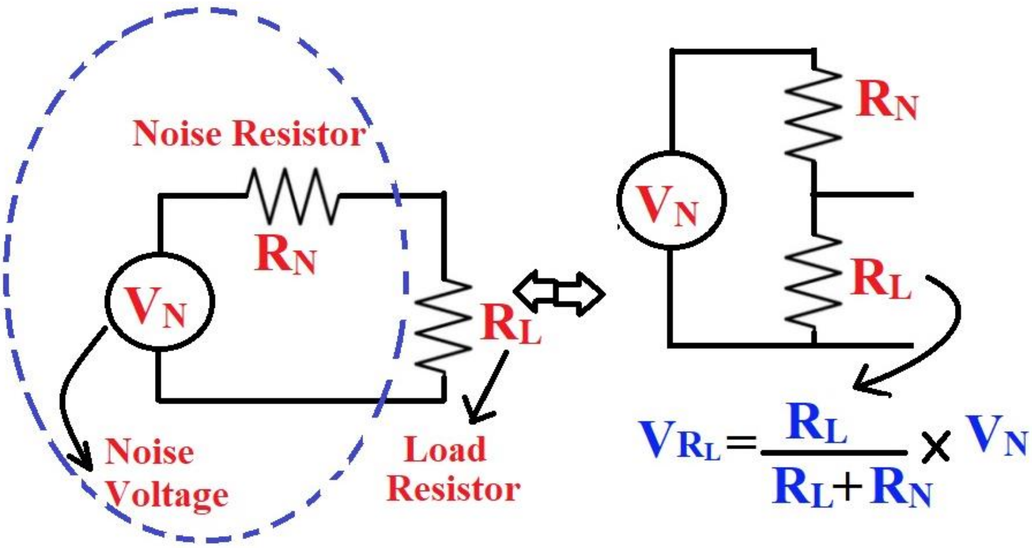
When an electron is thermally excited at that time due to oscillation or vibrations of electrons along is mean position small amount of voltage is created which is called as Noise Voltage **(V_N)**.In any conductor the electrons are in large number and Noise voltage plays very significant role.

Thermal excitation of atoms and electrons.



As explain above Due to Thermal excitation of electrons Noise voltage **(V_N)** is created and random movement of electrons offers certain Resistance which is called as Noise Resistance **(R_N)** and due to this fact the power delivered from transmitter to Receiver decrease.

It is very important to know the equation for Noise voltage V_N for this purpose let us consider the source of Noise voltage **(V_N)** and Noise Resistance **(R_N)** connected to any load Resistance **(R_L)** to which the Power is to be Delivered or Transferred as shown below.



Let us calculate Power delivered by Noise voltage **(V_N)** to load Resistance **(R_L)**, consider **R_L=R_N because in this case only maximum power will be delivered.**

$$\text{If } R_L = R_N$$

$$\text{then } V_{RL} = V_N/2$$

$$\text{But Power } P = VI$$

$$\text{and } V = IR$$

$$I = V/R$$

$$P = \frac{V^2}{R}$$

$$P = \frac{V_{RL}^2}{R}$$

$$\text{But } V_{RL} = V_N/2$$

$$P = \frac{V_N^2}{4R}$$

$$V_N = \sqrt{4PR}$$

In above equation Power P is Power delivered by Noise Voltage **(V_N)** therefore it is called as Noise Power **(P_N)**.

$$V_N = \sqrt{4P_NR}$$

$$\text{But } P_N = KTB$$

$$V_N = \sqrt{4KTBR} \quad \text{——(1)}$$

Where

K= Boltzmann's Constant

$K = 1.38 \times 10^{-23}$ Joule/Kelvin

T= Temperature in degree Kelvin

B= Bandwidth of Communication Channel in Hz.

Bandwidth = $f_2 - f_1$

Example on Noise:

An Amplifier circuit use in communication is having the frequency range of 18 MHz to 20 MHz. The Input resistance of Amplifier is 10 Kilo Ohm. Calculate the Noise Voltage at the Input if Amplifier if it Operates at 27 degree centigrade.

Answer: Bandwidth=BW=f2−f1= 20 MHz −18 MHz = 2 MHz

$$V_N = \sqrt{4P_NR}$$

$$\text{But } P_N = KTB$$

$$V_N = \sqrt{4KTBR} \quad \text{——} (1)$$

Substituting all constants and known values

Noise Voltage (V_N)= 18 micro Volt.

The Calculation for Noise figure and Noise factor:

In communication the strength of original information signal is very important which is called as signal power. The Noise is introduce in communication channel which can only minimize. The noise harms the original information signal therefor the it is better to minimize the power of noise.

The ratio of Signal Power to Noise Power helps to find the quality of original information signal received at the destination and it is called as Signal to Noise ratio.

Definition of Signal to Noise Ratio (SNR):

It is the ratio of define as the ratio of power of Signal **(P_S)** to the Power of Noise **(P_N).**

$$\textbf{Signal to Noise Ratio (SNR)} = \frac{\textbf{Power of Signal } (P_S)}{\textbf{Power of Noise } (P_N)} = \frac{P_S}{P_N}$$

It is always express in decibel (dB). Therefore always written in terms of **$10\times\log_{10}$** as shown below.

$$\underline{\textbf{Signal to Noise Ratio (SNR) in dB}} = 10\times\log_{10}\left(\frac{P_S}{P_N}\right) \textbf{ dB}$$

But Power P=VI and V = I R therefore I=V/R

Writing the Power by using I=V/R

$$P = V \times (V/R) = V^2 / R$$

Therefore the Power of Signal in terms of Voltage and Resistance will be written as **$P_S = (V_S{}^2 / R)$** Where **V_S = Signal Voltage** and Power of Noise in terms of Voltage and Resistance will be written as $\mathbf{P_N = (V_N{}^2/ R)}$ Where $\mathbf{V_N}$ **= Noise Voltage.** Substituting the equations of Power of Signal and Power of Noise in equation of SNR we can write.

Power of Signal in terms of Voltage and Resistance

$P_S = (V_S{}^2/ R)$

Where V_S = Signal Voltage and

Power of Noise in terms of Voltage and Resistance

$P_N = (V_N{}^2/ R)$ Where V_N = Noise Voltage.

$$SNR = 10\times\log_{10} (P_S / P_N) \text{ dB} \text{ —— } (2)$$

$$SNR = 10\times\log_{10} [(V_S{}^2/ \cancel{R}) / (V_N{}^2/ \cancel{R})] \text{ dB}$$

$$SNR = 10\times\log_{10} [(V_S{}^2/V_N{}^2)] \text{ dB}$$

$$SNR = 10\times\log_{10} [(V_S /V_N)^2] \text{ dB}$$

$$SNR = 10\times\log_{10} \times(V_S /V_N)^2 \text{ dB}$$

$$SNR = 2 \times10\times\log_{10} \times(V_S /V_N) \text{ dB}$$

$$SNR = 20\times\log_{10} \times(V_S /V_N) \text{ dB} \text{ —— } (3)$$

Noise Figure is indicated by symbol "F" and it is the ratio of Signal to Noise ratio at the Input to the Signal to Noise ratio at the Output [(S/N)input / (S/N)output].

$$\text{Noise Figure (F)} = \frac{\text{Signal to Noise ratio at the Input}}{\text{Signal to Noise ratio at the Output}}$$

$$\text{Noise Figure (F)} = \frac{\text{(S/N)input}}{\text{(S/N)output}}$$

$$\text{Noise Figure (F)} = \frac{\text{(S/N)input}}{\text{(S/N)output}} \qquad \text{(4)}$$

Noise Factor is indicated by symbol "NF" and it is the product of 10×log$_{10}$ and Noise Figure (F).

Therefore Noise Factor (NF) = 10×log$_{10}$ ×[Noise Figure (F)] dB.

Substituting for **Noise Figure (F) we can write**

Noise Factor (NF) = 10×log$_{10}$ ×[(S/N)input / (S/N)output] dB.

$$\textbf{Noise Factor (NF)} = 10\times\log_{10} \times \left[\frac{\text{(S/N)input}}{\text{(S/N)output}}\right] \qquad \text{(5)}$$

Noise Current= $I_N = \sqrt{2\, q\, I_o\, B}$

Where

I_O=Bias Current

q=Charge on electron

=1.6×10^{-19}Coulombs

B=Band Width of Communication Channel

Noise Temperature $(T_N)=T_O(NF-1)$

Where

T_O=Absolute temperature= Room temperature

NF= Noise Factor

1. A 50 **Ω** resistor operates at room temperature (27˚C). How much noise power does it provide to a matched load over the bandwidth of

a) A CB channel 10 KHz

b) A TV channel 6 MHz

Ans:

a. We know that the equation for noise power $\mathbf{P_N = KTB}$

$$\mathbf{P_N = 1.38 \times 10^{-23} (273 + 27) \times 10 \times 10^3\ Watt}$$

$$\mathbf{P_N = 1.38 \times 3 \times 10^{-17}\ Watt}$$

$$\mathbf{P_N = 4.14 \times 10^{-17}\ Watt}$$

b. $\mathbf{P_N = KTB}$

$$\mathbf{= 1.38 \times 10^{-23} (300) \times 6 \times 10^6\ Watt}$$

$$\mathbf{= 1.38 \times 3 \times 6 \times 10^{-15}\ Watt}$$

$$\mathbf{= 24.84 \times 10^{-15}\ Watt}$$

2. What is the noise voltage for each of above case?

Ans:

$$V_N = \sqrt{4KTB \times R}$$

$$V_N = \sqrt{4RP}$$

$$V_{CB} = \sqrt{4 \times 50 \times 4.14 \times 10^{-17}}$$

$$V_{CB} = \sqrt{828 \times 10^{-17}}$$

$$V_{CB} = 0.09 \text{ micro Volt}$$

$$V_{TV} = \sqrt{4 \times 50 \times 24.84 \times 10^{-15}}$$

$$V_{TV} = \sqrt{4968 \times 10^{-15}}$$

$$V_{TV} = 2.23 \text{ micro Volt}$$

3. Calculate the noise current of a diode with a bias of 15 mA observed over 25 KHz.

Answer: We know that the equation for noise power I_N **is**

$$I_N = \sqrt{2qI_0 B}$$

$$I_N = \sqrt{2 \times 1.6 \times 10^{-19} \times 15 \times 10^{-3} \times 25 \times 10^{3}}$$

$$= \sqrt{5 \times 1.6 \times 15 \times 10^{-18}}$$

$$= \sqrt{120 \times 10^{-18}}$$

$$I_N = 10.95 \times 10^{-9}\ \text{Amp}$$

$$I_N = 10.95\ \text{nanoampere}$$

4. The Signal to Noise ratio is 30 dB at the input of an amplifier Circuit and 27.3 dB at the output of an amplifier Circuit. Calculate noise figure of the amplifier and noise temperature.

Ans: Let us convert the given Signal to Noise ratio in dB to log as shown below

$$\frac{S_i}{N_i}\text{dB} = 10\log\frac{S_i}{N_i}$$

$$30 = 10\log\frac{S_i}{N_i}$$

$$3 = \log\frac{S_i}{N_i}$$

Taking Antilog on both side of above equation, log and Antilog will get canceled

$$\frac{S_i}{N_i} = \text{Antilog}\ 3 = 1000$$

$$\frac{S_o}{N_o}\text{dB} = 10\log\frac{S_o}{N_o}$$

$$\frac{S_o}{N_o} = \text{Antilog}\ 2.73 = 537$$

We know that the equation for noise temperature T_N is

$$T_N = T_o (NF - 1)$$

Where T_o is room temperature, and NF= Noise figure and equation for Noise figure is

$$\text{Noise Figure (F)} = \frac{(S/N)\text{input}}{(S/N)\text{output}}$$

$$NF = \frac{1000}{537}$$

$$NF = 1.86$$

$$T_N = T_o (NF - 1)$$

Assuming $T_o = 27^\circ C = 300\ ^\circ K$

$$T_N = 300\,(1.86 - 1)\ ^\circ K$$

$$T_N = 300\,(0.86)\ ^\circ K$$

$$T_N = 258\ ^\circ K$$

5. a. The signal voltage at input of an amplifier is 100 micro volt and the noise voltage is 2 micro volt. What is (S/N) in dB?

b. If (S/N) at output is 30 dB, what is the noise figure of that amplifier?

Answer:

$$SNR = 20 \times \log_{10} \times (V_S / V_N)\ \text{dB}$$

$$SNR = 20 \log \frac{100\ \mu V}{2\ \mu V}\ \text{dB}$$

$$SNR = 20 \log (50)\ dB$$

$$SNR = 33.9\ dB$$

$$\text{Noise Factor (NF)} = 10 \times \log_{10} \times \left[\frac{(S/N)input}{(S/N)output} \right]$$

$$NF = \frac{33.9}{30} = 1.13$$

6. A receiver has a noise temperature of 100°K. What is noise figure in dB? Compare another receiver with equivalent noise temperature 90 °K with this receiver, assuming all other specification same.

Answer:

$$\text{Noise temperature} = T_N = T_o (NF - 1)$$

$$\text{Given } T_N = 100^\circ K, \text{ Consider } T_o = 300^\circ K = 27^\circ C$$

$$100^\circ K = 300^\circ K (NF - 1)$$

$$1/3 = (NF - 1)$$

$$NF = 4/3 = 1.33$$

$$\text{Another receiver Given } T_N = 90^\circ K,$$

$$\text{Consider } T_o = 300^\circ K = 27^\circ C$$

$$\text{Noise temperature} = T_N = T_o (NF - 1)$$

$$90^\circ K = 300^\circ K (NF - 1)$$

$$0.3 = (NF - 1)$$

$$NF = 1 + 0.3 = 1.3$$

A receiver with T_N less will have NF also less. Therefore **$(S/N)_{Output}$** must be less. Therefore another receiver will have less amount of noise. So another receiver is a better receiver.

7. The output voltage of AM transmitter is given by equation

$$300\,(1+ 0.4 \sin 6280t) \sin 3.14 \times 10^7 t.$$

This voltage is fed to a load of 500Ω resistance. Determine

(i) Carrier frequency, (ii) modulating frequency (iii) Carrier power (iv) total power output

Answer: The given equation is

$$e_{AM} = 300\,(1+0.4\sin 6280t) \sin 3.14 \times 10^7 t$$

Comparing this with equation of AM waves,

$$e_{AM} = E_c\,(1+m_a \sin\omega_m t) \sin\omega_c \times t$$

we have $E_C = 300V$, $m_a=0.4$, $\omega_m=6280$,

and $\omega_c=3.14 \times 10^7$

(i) Carrier Frequency,

$$f_c=\frac{\omega_c}{2\pi}=\frac{3.14 \text{ X } 10^7}{2 \text{ X } 3.14}=5 \text{ MHz}$$

(ii) Modulating Frequency,

$$f_m=\frac{\omega_m}{2\pi}=\frac{6280}{2 \text{ X } 3.14}=1000\text{Hz}$$

(iii) Carrier power

$$P_c=\frac{(E_c)^2}{2R}=\frac{(300)^2}{2 \text{ X} 500}=90 \text{ Watt}$$

(iv) Total power output

$$P_{total}=P_c\left[1+\frac{m_a^2}{2}\right]$$

$$P_{total}=90\left[1+\frac{(0.4)^2}{2}\right]$$

$$P_{total} = 90 \times 1.08$$

$$P_{total} = 97.2 \text{ Watt}$$

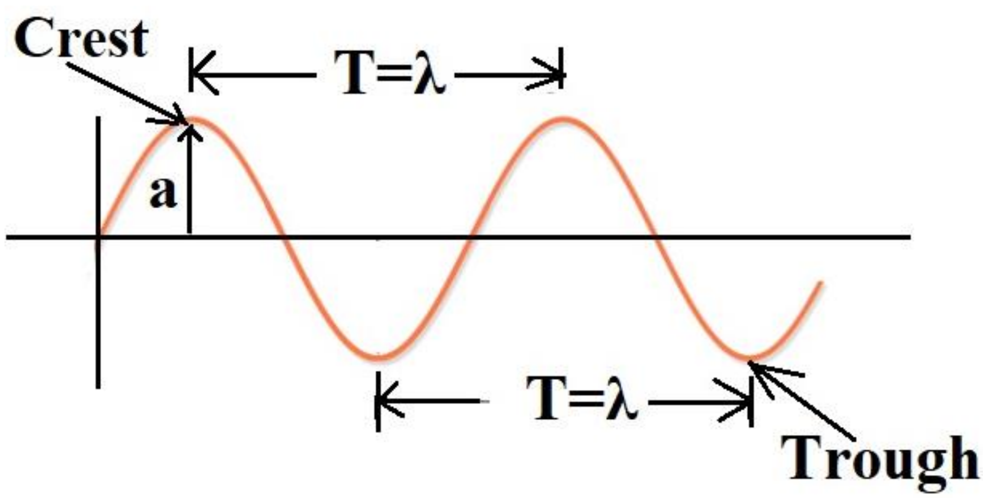
NEED OF MODULATION :

Why Modulation?

We know that in Communication an Antenna is used to convert the Electrical Signal in to an Electromagnetic Waves and vice versa. The wireless communication the Electromagnetic Waves are transmitted from Source to Destination in free space. The speed of Electromagnetic Waves is almost equal to the speed of light (**c=Velocity of Light =3×10^8 meter/Sec**).

Electric Signal:

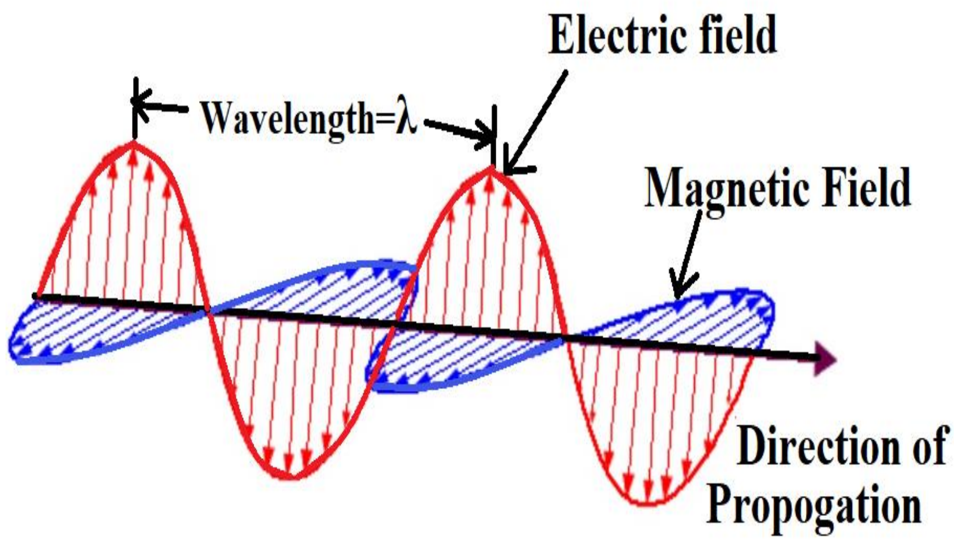
As shown below an Electric signal is graph of change in voltage with respect to time.

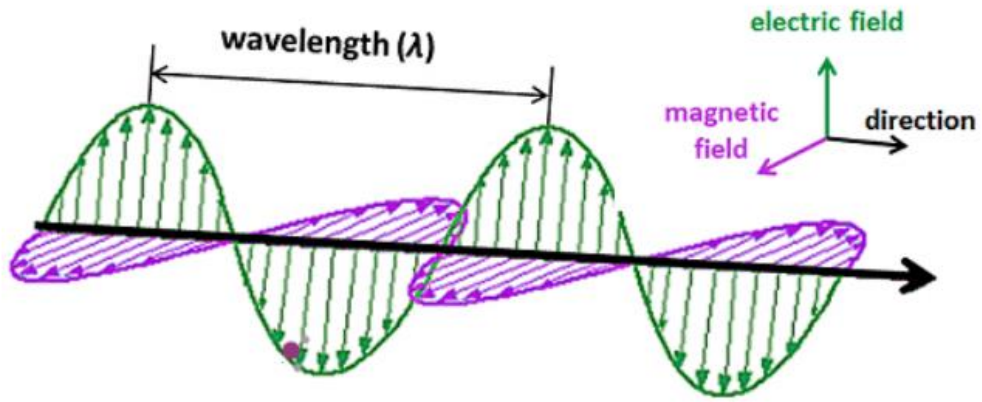


$$T=\lambda \;,\; f=1/T$$

Electromagnetic Wave:

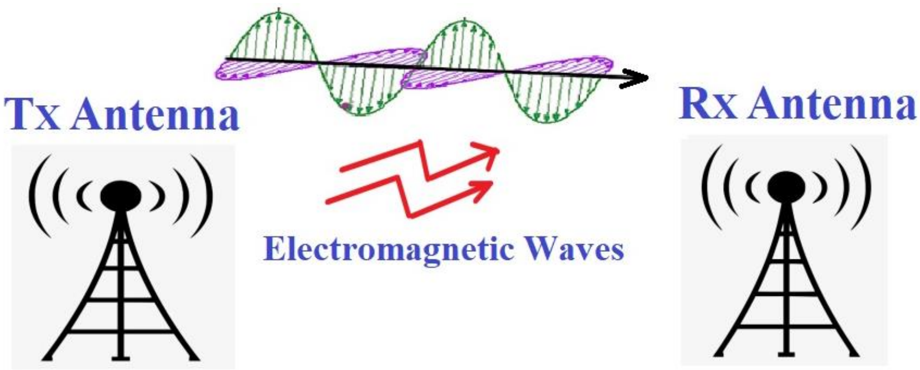
As shown below an Electromagnetic Wave is combination of electric signal and magnetic signal.





In wireless communication the size (Length) of antenna is decided by the wavelength of Electromagnetic Waves.

For efficient communication (transmission) of Electromagnetic Waves **without modulation**, the relation between the wavelength of an Electromagnetic Waves and Size (Length) of an Antenna (used as transmitter or Receiver) is equal to the wavelength (λ) of an Electromagnetic Waves. **(This is without modulation).**



But all information signals are basically low frequency signals and wavelength (λ) of low frequency signal is very long sometimes it is in kilometer.

The relation between wavelength and frequency is inversely proportional [**f =1/ λ**]

And relation between frequency (f or γ), wavelength (**λ**) and velocity of light (**C**) is given by **C=f ×λ or C= γ × λ.**

Therefore the size (Length) of Antenna must be in Kilometre, for example if Electromagnetic Wave of an Information Signal is of frequency f=100 KHz, then the wavelength (λ) is calculated as

$$f = \frac{c}{\lambda}$$

Where f= frequency ,
λ = Wavelength and
c = Velocity of light
c = 3×10^{8} meter/Sec

Example :Calculate wavelength = λ,Given f= 100 KHz.

Answer:

$$C = f \times \lambda \quad \text{or} \quad C = \gamma \times \lambda$$

Where $C = 3 \times 10^8$ meter/Sec

$C = f \times \lambda$ where, wavelength $= \lambda$

$$\lambda = C / f$$

$$\lambda = \frac{3 \times 10^8 \text{ meter/Sec}}{100 \times 10^3 \text{Hz}}$$

$$1/\text{sec} = \text{Hz}$$

$$\lambda = \frac{3 \times 10^8 \text{ meter Hz}}{100 \times 10^3 \text{Hz}}$$

$$\lambda = 3 \times 10^8 \times 10^{-5} \text{meter}$$

$$\lambda = 3 \times 10^3 \text{ meter}$$

$$\lambda = 3 \text{ Kilometre}$$

In this way the size of an Antenna is 3 Kilometre for the Electromagnetic Wave of Information Signal of 100 KHz and it is very long. (This size of 3 Kilometre is for transmitting the signal without modulation).

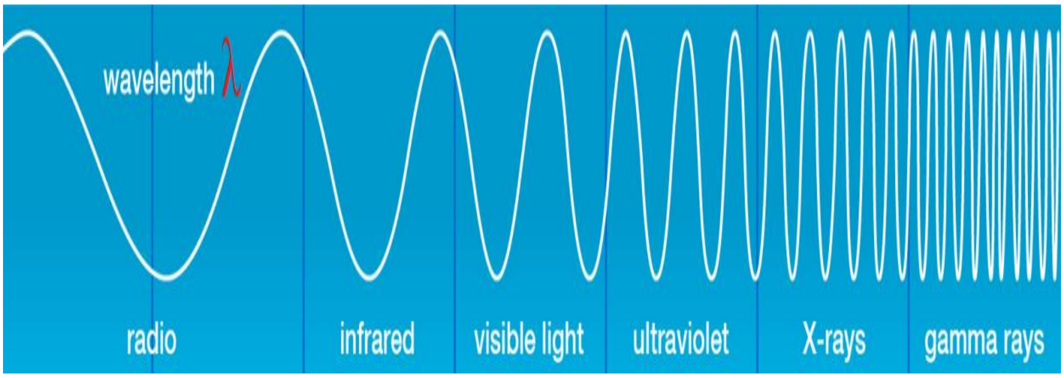
Always an Information signal is having low frequency (few Hz or KHz). Therefore the size of an Antenna is increases because the wavelength **(λ)** of low frequency signal is very large (Inverse relation between **f and λ**).

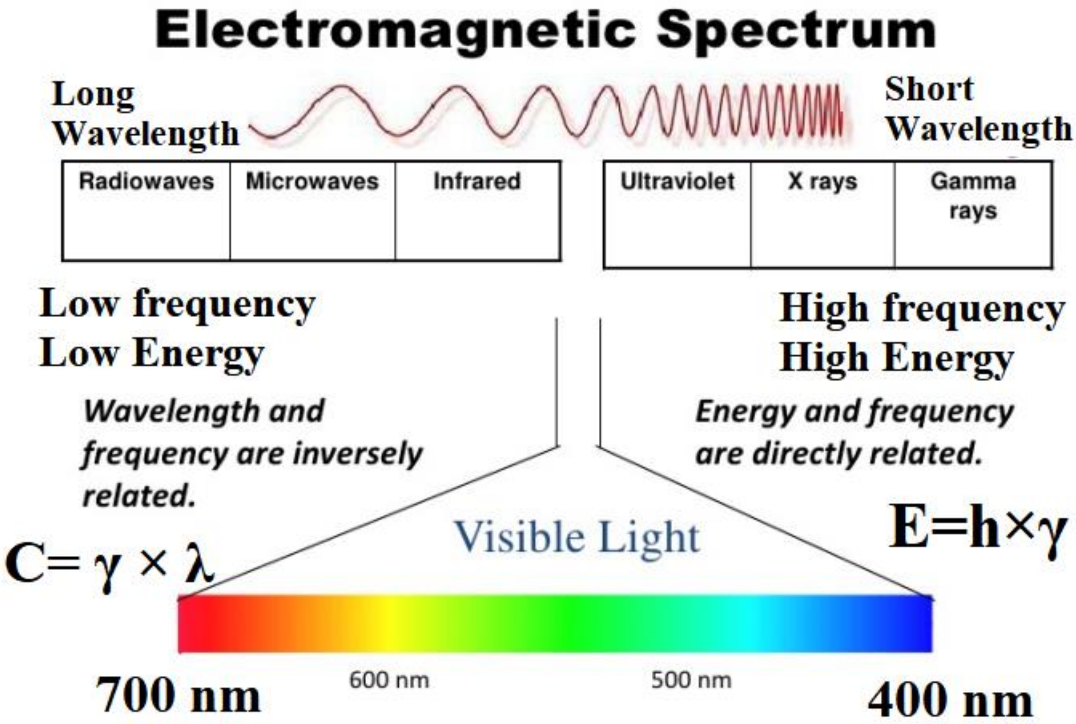
For example the frequency of Human speech (Voice Frequency) is **300 Hz to 3000Hz** that is bandwidth of Human speech is **3000Hz − 300 Hz = 2700 Hz =2.7KHz** is actual required bandwidth.

But to avoid the interference (Cross Talk) the allotted BW **(Bandwidth= $f_2 - f_1$) is 4 KHz.**

To transmit this signal of **4 KHz**, without modulation the size of Antenna is required is greater than 3 Kilometre.

But the wavelength **(λ)** of High frequency signal is very low which is in few meters/Centimeters only. Therefore if we use the logic of carrying the Low frequency signal with the help of high frequency signal then the size of Antenna can be reduce and this logic is called as Modulation.



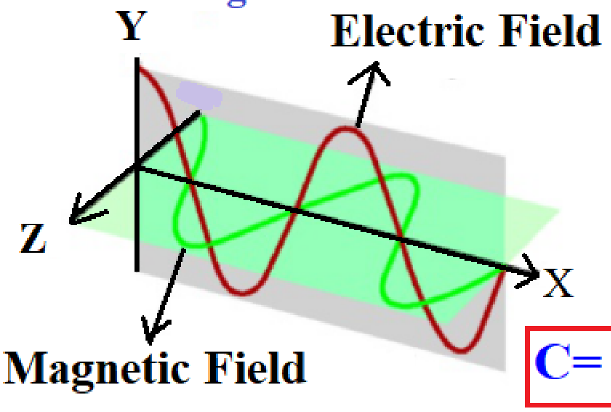


We know that the relation between the speed of light (C),Wavelength of light **(λ)** and frequency of light signal (**γ or f) is given by equation C=γ ×λ.**

But the energy of light signal is E=h×γ. Therefore γ=C/λ

Therefore E=h×(C/λ). Speed of light C, and planks constant (h) are constants therefore the **energy of light is inversely proportional to wavelength (λ) of light.**

In 1873, Maxwell proposed that visible light consists of Electromagnetic Radiation or Waves.



Electromagnetic radiation is the emission and transmission of energy in the form of electromagnetic waves.

$C = \gamma \times \lambda$ and $E = h \times \gamma$

Speed of light (C) in Vaccum is ($C = 3 \times 10^8$ meter/Sec). Also $C = \gamma \times \lambda$, where λ is wavelength of light and γ is frequency of light

To solve this problem and to reduce the size of an Antenna to the extent of **($\lambda/4$)** the Information Signal (low frequency signal) is transmitted (Carried) with the help of High frequency Electromagnetic Wave (EM) wave. (High frequency EM wave is called as Carrier Wave).

This process of transmitting the low frequency signal (Information Signal) with the help of High frequency EM wave (Carrier signal) is called as Modulation.

In the process of modulation any one parameter such as Amplitude, frequency or phase of high frequency signal (Carrier Signal) is change according to instantaneous value of Information Signal.

Hence forth we will only use the term low frequency signal (Information Signal) and High frequency signal (Carrier Signal).

Due to Modulation the size (Length) of Antenna becomes equal to the **$\lambda/4$** of High frequency signal (Carrier Wave) and this size is very less approximately in few Centimeters.

Let us calculate the value of wavelength **(λ)** for Carrier signal of frequency **f =300 MHz.** Using

$$C=f\times\lambda \quad \textbf{or} \quad C=\gamma\times\lambda$$

Where C=3×10^8 meter/Sec

C=f× λ   where, wavelength = λ

λ= C/ f

$$\lambda=\frac{3\times10^{8}\,\text{meter/Sec}}{300\times10^{6}\,\text{Hz}}$$

But 1/sec = Hz

$$\lambda=\frac{3\times10^{8}\,\text{meter}}{300\times10^{6}}$$

$$\lambda = 1\ \text{meter}$$

$$\lambda = 100\ \text{Centimeter}$$

$$\lambda/4 = 25\ \text{Centimeter}$$

This is the Size (Length) of Antenna required when Carrier signal of **f=300 MHz** is used to carry the information signal (low frequency signal).

Irrespective of frequency of information signal the Size (Length) of Antenna totally depends on frequency of Carrier Signal only.

In this way, first advantage of Modulation is Size (Length) of Antenna is reduce (becomes very small).

In mobile communication carrier signal of **300 MHz to 900 MHz** is use, therefore the Size of Antenna in Mobile phone is in Centimetre and antenna is inbuilt only.

In case of FM radio stations (Frequency Modulation) frequency of Carrier signal used is **88 MHz to108 MHz** therefore the size of Antenna required to catch the radio station frequency is slightly large (Due to low carrier frequency). The tape recorders or radios used in car are having long antenna.

But with the help of pocket FM Radio receivers we can listen (tune) FM radio station. Headphone cable of 2 feet to 3 feet used in head phone and Headphone cable of 2 feet to 3 feet is only use as an Antenna. This FM radio kit are available in electronic market from 50rupees to 100 rupees.It operates on lithium ion battery and it does not require pencil cell.

Advantages of Modulation:

1) Due to Modulation the size (Length) of Antenna becomes equal to the **$\lambda/4$** of High frequency signal (Carrier Wave) and this size is very less approximately in few Centimeters.

2) When separate carrier frequency is used for many Informational signals in that case the Mixing or Interference of Signal will not takes place.

3) Due to High frequency carrier signal the strength of Signal (High frequency High energy) increases and it helps in good fidelity to receiver antenna.

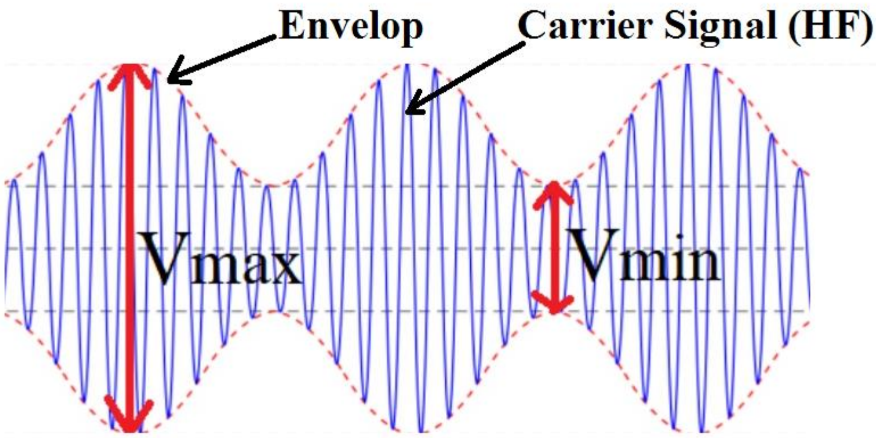
4) Due to High frequency carrier signal the Noise is reduced because High frequency (Short wavelength) signal are having High Energy which catches very less Noise (It is less Immune to Noise).

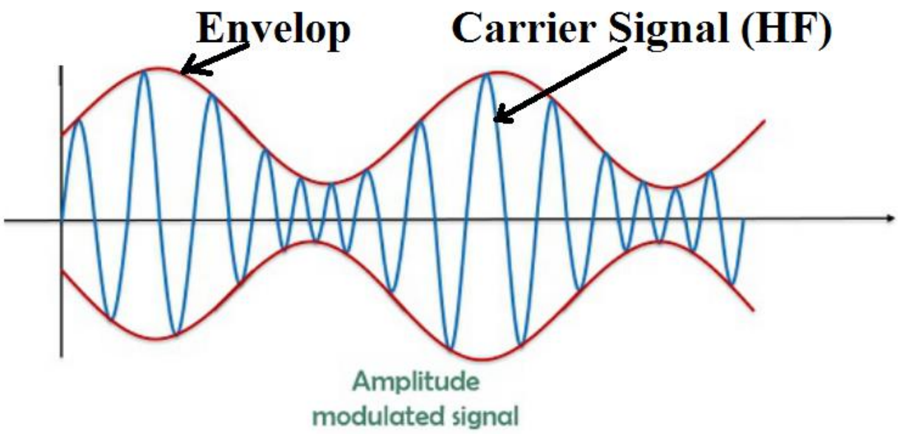
Need of Demodulation:

Demodulation is process in which an information signal is separated from carrier signal.

The Demodulation Circuit used in Amplitude Demodulation process consist of half wave rectifier with capacitor as filter. The capacitor used in this circuit is simply low pass filter, therefore the capacitor passes the low frequency signal (information signal) to the output and it bypasses the high frequency signal (carrier signal) to the ground.

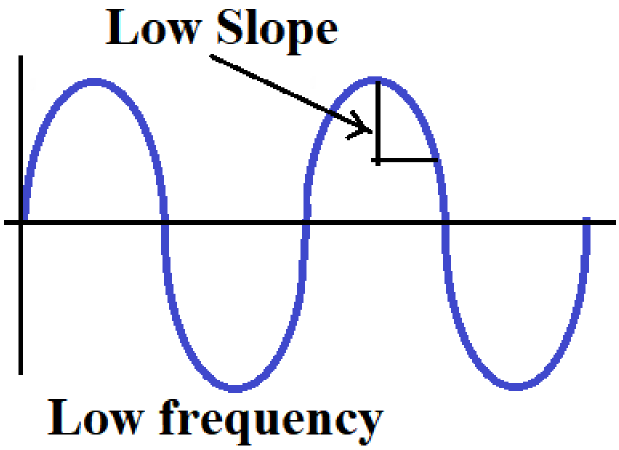
The Demodulation Circuit used in Amplitude Demodulation process is called as envelop detector because the outer side of envelop is nothing but an information signal means this circuit detects information.

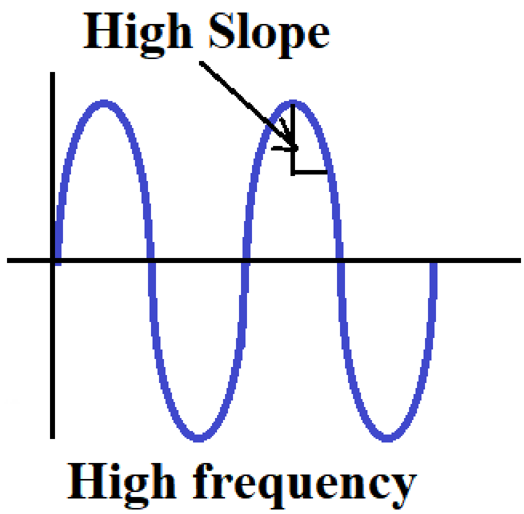


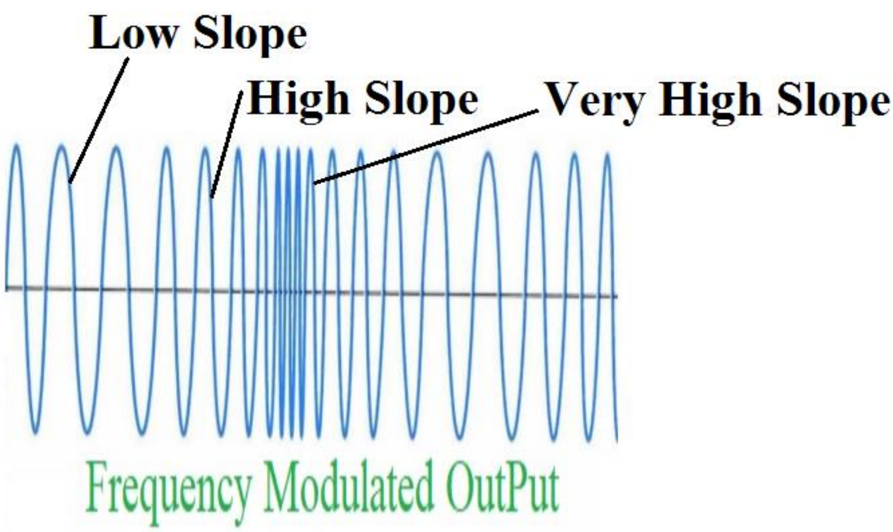


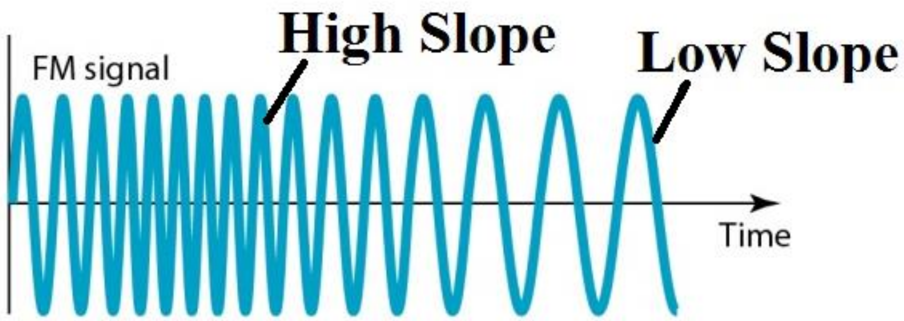
In Frequency Modulation process the frequency of carrier signal changes according to instantaneous value of an Information signal. The change in frequency is nothing but change in slope of signal.

The Demodulation Circuit used in Frequency Demodulation process is called as slope detector.


Low Slope
Low frequency


High Slope
High frequency

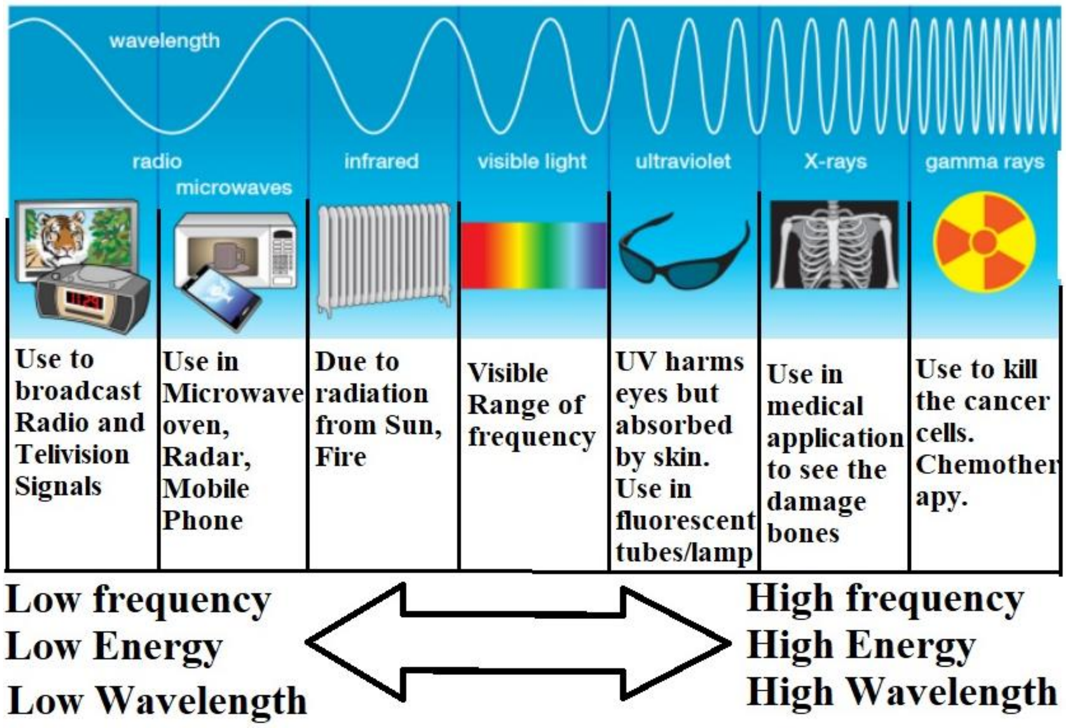

Low Slope
High Slope
Very High Slope
Frequency Modulated OutPut



The microwave is having frequency above 1GHz and wavelength is very less approximately 30 Centimetre. Due to less wavelength the microwaves are having very High Energy and it produces lot of heat therefore it is also used in Cooking application. But microwaves get penetrated through thin metal also therefore Metals are not allowed in Microwave Oven.

Relation between Wavelength and Energy.

Types of Electromagnetic Radiations



The relation between the frequency and time is inverse **(f=1/T).** The energy **E=h×γ. We know that Time=T=λ=wavelength, Therefore (f=1/λ). Frequency (f)** and **wavelength (λ) are inversely proportional.**

We know that the relation between the speed of light (C),Wavelength of light **(λ)** and frequency of light signal (γ **or f) is given by equation C=γ ×λ.**
But the energy of light signal is E=h×γ. Therefore γ=C/λ.
Therefore E=h×C/λ. Speed of light "c" and planks constant "h" are constants therefore the **energy of light is inversely proportional to wavelength (λ) of light.**