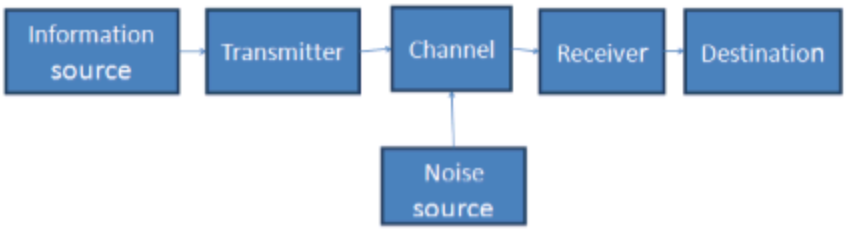
Elements of communication system

Block diagram of communication system



The block diagram of a communication system will have five blocks, including the information source, transmitter, channel, receiver and destination blocks.

1.**Information source** :-

- The objective of any communication system is to convey information from one point to the other. The information comes from the information source, which originates it
- Information can be in audio,video, text ,digital data etc form.

2.**Transmitter** :-

- The objective of the transmitter block is to collect the incoming message signal and modify it in a suitable form for transmission channel. Transmitter contain circuits like modulator,multiplexer,encoder,amplifier etc

3.**Channel** :-

- Channel is the physical medium which connects the transmitter with that of the receiver.
- The physical medium includes copper wire, coaxial cable, fibre optic cable, wave guide and free space or atmosphere.
- The choice of a particular channel depends on the feasibility and also the purpose of the communication system.

4.**Receiver**:-

- The receiver block receives the incoming modified version of the message signal from the channel and processes it to recreate the original (non-electrical) form of the message signal.

- Receiver contain circuits like demodulator,demultiplexer,decoder,decripter,amplifier etc.

5.**Destination**:-

- The destination is the final block in the communication system which receives the message signal .
- Usually, humans will be the destination block.

6.**Noise:-**

- Noise is random ,unwanted ,unpredicted electrical signal produce by natural processes both internal and external to the system. Noise always disturb communication channel.
- There are two types of noise
  External noise and internal noise
  External noise: It occurs due to following reasons
  1. **Human made noise/ Industrial Noise:**Produce by spark producing mechanism such as engine ignition system ,fluorescent light,electri motors. This noise occurs at frequency upto 500MHz.
  2. **Atmospheric noise:** It occurs due to natural disturbances such as lightning,thunderstorm etc.The frequency contain spread over the entire radio spectrum.
  3. **Space Noise:** It also called solar noise as it arise due to sun, Other star also produce space noise called cosmic noise.

  Internal Noise:

  1. **Johnson Noise/Thermal Noise :** This noise is due to random motion of electrons in various electronic components. This random motion produces random current or voltage in circuit called as thermal noise. As this noise spread equally all over usable spectrum it called white noise also.
  2. **Shot noise :** At very low frequency flicker noise and very high frequency transit time noise occurs ,these two noise called shot noise.

Electromagnetic Spectrum:

Diagram below is total electromagnetic Spectrum.

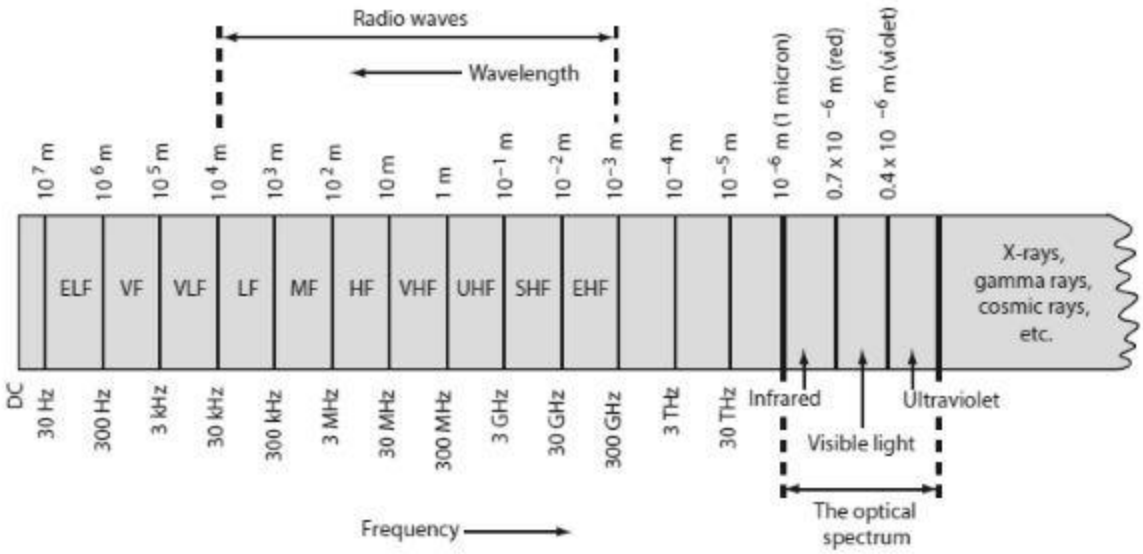


Diagram of Band in spectrum used in Electronic Communication:

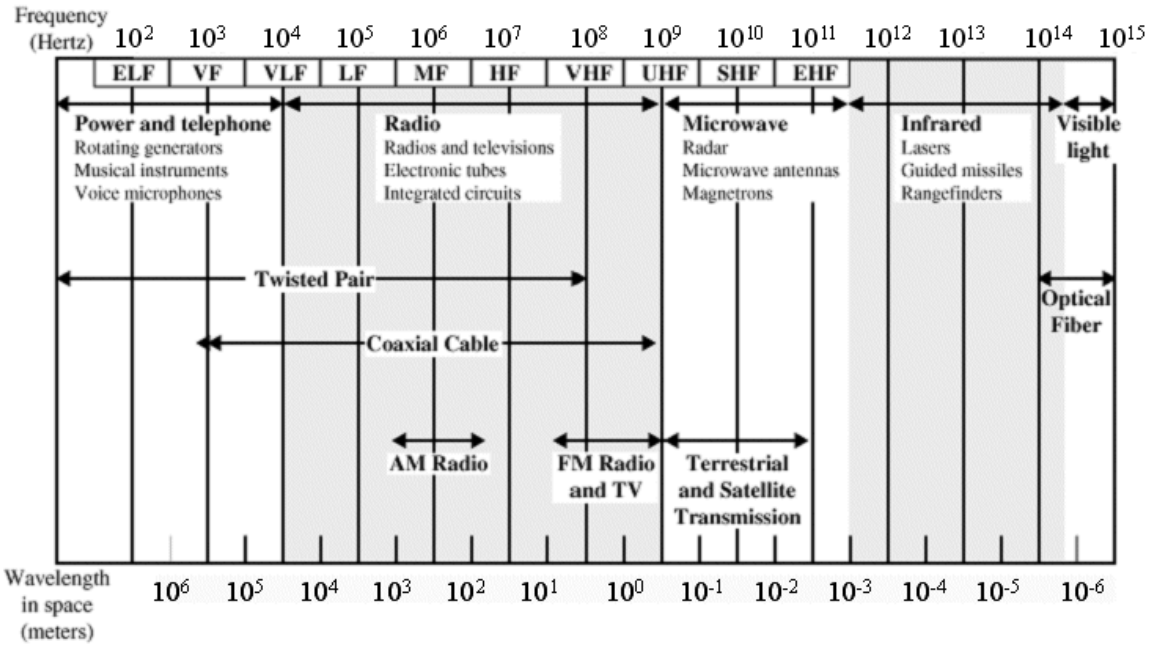


Figure 3.1 Electromagnetic Spectrum for Telecommunications

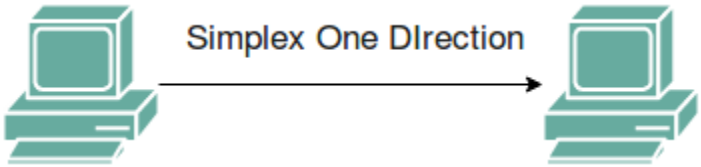
Types of communication

A. **According to Transmission mode**: There are three modes of transmission, namely: simplex, half duplex, and full

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

1.Simplex Communication

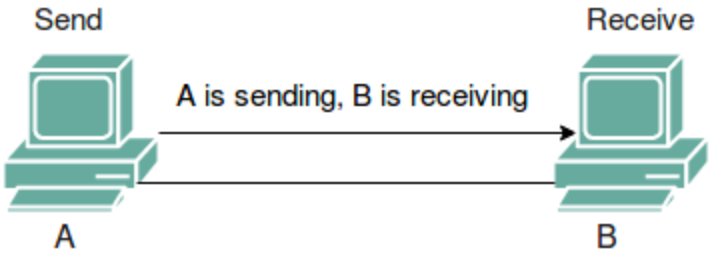
- In simplex transmission mode, the communication between sender and receiver occurs in only one direction. The sender can only send the data, and the receiver can only receive the data. The receiver cannot reply to the sender.
- Simplex transmission can be thought of as a one-way road in which the traffic 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

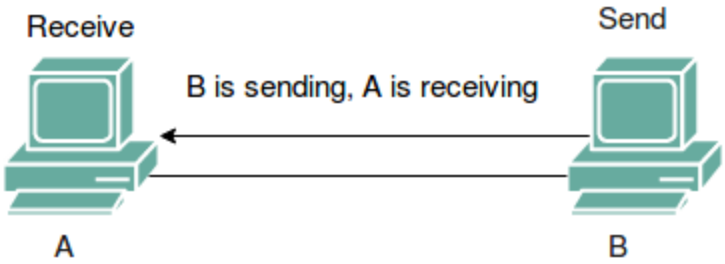


2. Half Duplex Communication

The communication between sender and receiver occurs in both directions in half duplex transmission, 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.

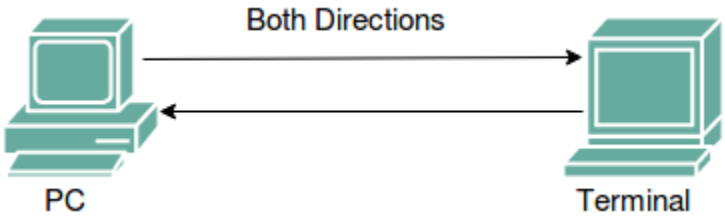




3.Full Duplex Communication

In full duplex transmission 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 telephone conversation, two people communicate, and both are free to speak and listen at the same time.



B.According to nature of signal

There are two types of communication according to nature of signal

1.**Analog Communication**: It is a communication in which analog signal is transmitted from transmitter to receiver. In this all analog types of modulation and demodulation techniques are used.

2.**Digital Communication**: It is a communication in which digital signal is transmitted from transmitter to receiver. In this all digital types of modulation and demodulation techniques are used.

C. **Base band and broad band communication**

1. Base band communication: In base band communication original signal without modulation is directly sent over transmission channel. E.g telephone or intercom system.

2. Broad band communication : In this signal modulated and then transferred on communication channel. Communication with modulation is called broad band communication. E.g TV communication.

D. Serial communication and Parallel communication:

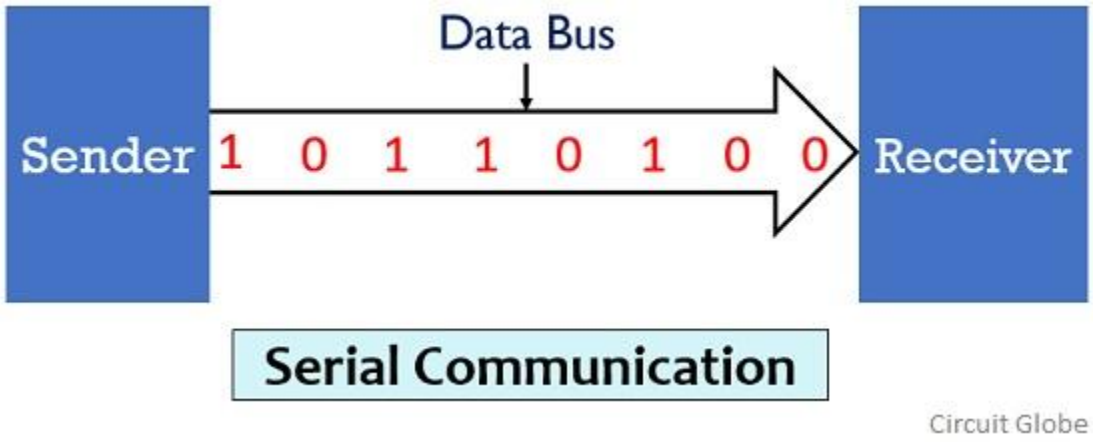
Basis for Comparison	**Serial Communication**	**Parallel Communication**
Data transmission speed	Slow	Comparatively fast
Number of communication link used	Single	Multiple
Number of transmitted bit/clock cycle	only one bit.	n number of link will carry n bits.
Cost	Low	High
Crosstalk	Not present	Present
System Up-gradation	Easy	Quite difficult
Mode of transmission	Full duplex	Half duplex
Suitable for	Long distance	Short distance
High frequency operation	More efficient	Less efficient

Serial Communication

Definition of Serial Communication

In serial communication the data bits are transmitted serially over a common communication link one after the other.

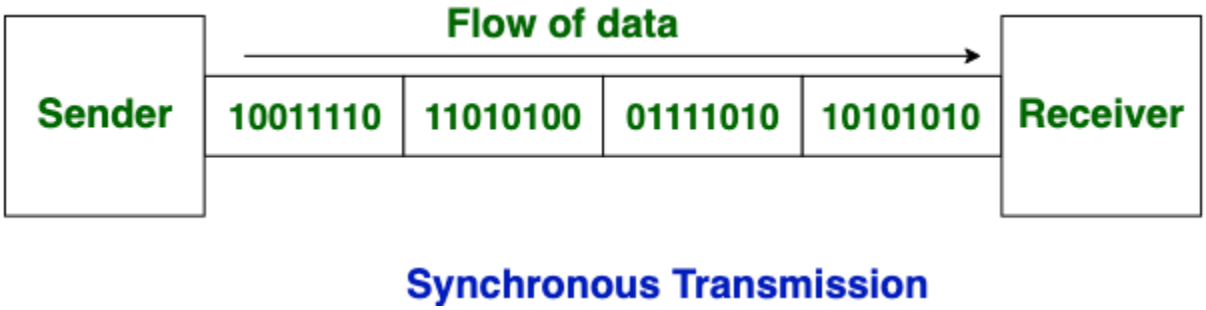
The figure below shows the serial data transmission:



There are two types of serial transmission

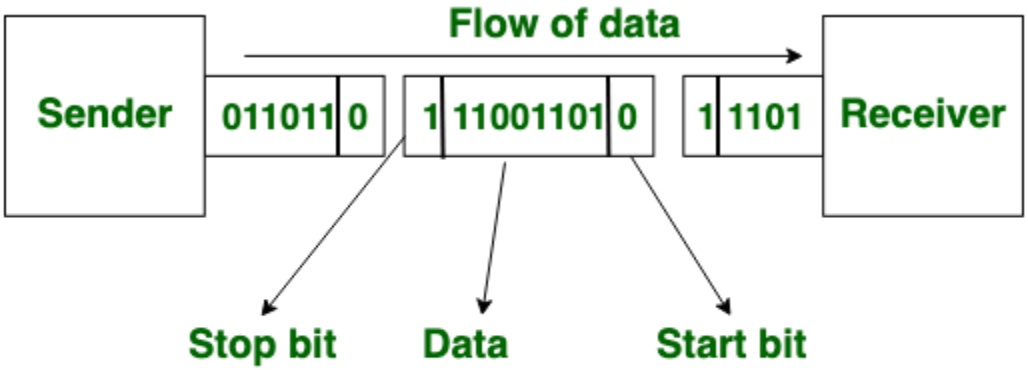
1. Asynchronous transmission
2. Synchronous transmission

Synchronous Transmission:
In Synchronous Transmission, data is sent in form of blocks or frames. This transmission is the full duplex type. Between sender and receiver the synchronization is compulsory. In Synchronous transmission, There is no gap present between data. It is more efficient and more reliable than asynchronous transmission to transfer the large amount of data.



Asynchronous Transmission:
In Asynchronous Transmission, data is sent in form of byte or character. This

transmission is the half duplex type transmission. In this transmission start bits and stop bits are added with data. It does not require synchronization.



Asynchronous Transmission

Now, let's see the difference between Synchronous and Asynchronous Transmission:

S.NO	SYNCHRONOUS TRANSMISSION	ASYNCHRONOUS TRANSMISSION
1.	In Synchronous transmission, Data is sent in form of blocks or frames.	In asynchronous transmission, Data is sent in form of byte or character.
2.	Synchronous transmission is fast.	Asynchronous transmission is slow.
3.	Synchronous transmission is costly.	Asynchronous transmission economical.
4.	In Synchronous transmission, time interval of transmission is constant.	In asynchronous transmission, time interval of transmission is not constant, it is random.

5.	In Synchronous transmission, There is no gap present between data.	In asynchronous transmission, There is present gap between data.
6.	Efficient use of transmission line is done in synchronous transmission.	While in asynchronous transmission, transmission line remains empty during gap in character transmission.
7.	Synchronous transmission needs precisely synchronized clocks for the information of new bytes.	Asynchronous transmission have no need of synchronized clocks as parity bit is used in this transmission for information of new bytes.

Concepts of Communication System

1.Signal Bandwidth:-

Bandwidth of information signal which is going to transmitted from transmitter to receiver.Mathematically it is a difference between upper and lower frequency limit of signal.e.g AM signal has signal bandwidth 20KHz

2.Channel Bandwidth:-

Channel bandwidth is different than signal bandwidth and it is depend on physical properties of transmission medium.

It is also defined as range of frequencies which can be transmitted over communication channel. It depend on construction thickness and length of medium. E.g Coaxial cable has bandwidth 1 GHz, Satellite link 15 MHz to 3500 MHz.

Data Rate:

Data rate is a rate at which the binary bits move from source to destination. It is expressed in bits per seconds (bps).

Baud rate:

Baud rate is a rate at which symbols move from source to destination.It is expressed in baud per second.

Nyquist Theorem:

Nyquist Theorem is also called sampling theorem.
Sampling is process which converts continuous signal into discrete values.
It state as for a sample to be reproduce accurately at a receiver ,each cycle of analog input signal must be sampled at least twice.
So the minimum sampling rate ***Fsmin*** is equal to twice the highest input frequency ***Fm*** is called Nyquist / sampling rate or frequency.

The reciprocal of Nyquist rate is Nyquist interval or sampling interval **Ts.**

According to nyquist or sampling theorem ***Fsmin = 2 Fm***
And ***Tsmax = 1/ Nyquist rate***
Or Tsmax = 1/2 Fm

Example:
Determine the nyquist sampling rate and sampling interval if telephone signal of 4 KHz is to be transmitted using digital communication techniques.
Solution:
Here maximum i/p frequency is *Fm* = 4KHz = 4000Hz
So
Nyquist sampling rate Fs = 2Fm
Fs = 2 * 4000
= 8000Hz
Nyquist sampling interval ,Ts = 1/ 2Fm
= 1/8000
= 0.000125 seconds
= 125 µsec.
So Nyquist sampling rate is 8000Hz
Nyquist sampling interval is 125 µsec

Signal To Noise Ratio :-

Signal-to-noise ratio (abbreviated **SNR** or **S/N**) is a measure used in science and engineering that compares the level of a desired signal to the level of background noise. SNR is defined as the ratio of signal power to the noise power, often expressed in decibels

SNR = Average signal power/ Average noise power
= Ps/Pn
Usually Exprssed in decibels as,
SNR (dB)= 10 * log (Ps/Pn)

Example:
A receiver has input signal power of 1.2 mW .The noise power is 0.4 mW , calculate signal to noise ratio.
Solution:
Ps= 1.2 mW Pn= 0.4 mW
SNR (dB) = 10 * log (Ps/Pn)
= 10 * log(1.2/0.4)
= 10 * log (3)
SNR (dB) = 4.77 dB

Noise figure:-

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. Essentially the **noise figure** defines the amount of **noise** an element adds to the overall system.

Channel Capacity : Channel capacity or information capacity of a data communication is a measure of how much information can be propogated through a communication system. It is a function of

1. Bandwidth of communication channel (B)
2. Time of transmission (t)

Information theory is study of most efficient ways to transmit information. Simply stated Hartley's law is

$C \alpha B * t$

i.e Channel capacity is directly proportional to bandwidth and time of transmission.

One important expression is

$C= 2 B \log_2 N$

Where N is number of bits per symbol.

Shannon Theorem:

Shannon information capacity theorem highlights the relationship between channel capacity ,channel bandwidth and signal to noise ratio.

Mathematically is given as

$C=B \log_2[1+ (S/N)]$

$C = 3.32 B \log_{10}[1+ (S/N)]$

Where B =Channel bandwidth

C = Channel capacity

Error handling Coding:-

Please watch

https://www.youtube.com/watch?v=gOcwmBhrY30

There are various coding techniques which help us to detect and even correct the received data. Here we study two types of error handling coding

1. **Forward error correction (FEC)** :

It is an error correction technique to detect and correct a limited number of errors in transmitted data without the need for retransmission.

In this method, the sender sends many redundant bits along with the data f. The receiver performs necessary error detection and correction based upon the additional redundant bits. FEC is used for simplex type of transmission.

Example of FEC is Hamming code

Advantages and Disadvantages

- Because FEC does not require handshaking between the source and the destination, it can be used for broadcasting of data to many destinations simultaneously from a single source.
- Another advantage is that FEC saves bandwidth required for retransmission. So, it is used in real time systems.
- Its main limitation is that if there are too many errors, the frames need to be retransmitted.

2. Automatic repeat request (ARQ):

Here very small amount of redunduancy bits are added in data.It is a protocol for error control in data transmission. When the receiver detects an error in a packet, it automatically requests the transmitter to resend the packet. This process is repeated until the packet is error free or the error continues beyond a predetermined number of transmissions. ARQ is sometimes used with Global System for Mobile (GSM) communication to guarantee data integrity.

Hamming Code:

The hamming code technique, which is an **error-detection and error-correction technique**, was proposed by **R.W. Hamming**. Whenever a data packet is transmitted over a network, there are possibilities that the data bits may get lost or damaged during transmission.

Let's understand the Hamming code concept with an example:

Let's calculate **Hamming code for data 1010 for even parity**

First, let us talk about the redundant bits.

The **redundant bits also called parity bits** are some extra binary bits that are not part of the original data, but they are generated & added to the original data bit. All this is done to ensure that the data bits don't get damaged and if they do, we can recover them.

Now the question arises, how do we determine the number of redundant bits to be added?

We use the formula, $2^p >= m+p+1$ where **p= parity bits** & **m = data bit**.

From the formula we can make out that there are **m= 4 data bits** and **p= 3 parity bits**, m+p =4+3 =**7-bit hamming code**.

Data is D0 D1 D2 D3 i.e 1 0 1 0

D0=1 , D1=0 , D2=1, D3=0

7 bit Hamming code format is

1	2	3	4	5	6	7
P1	P2	D0	P3	D1	D2	D3
P!	P2	1	P3	0	1	0

Now we have to find values of P1,P2 and P3

To calculate P1

Check bits 1,3 5,7,9,11….

i.e P1,D0,D1,D3 =P1 ,1 ,0 ,0

so to maintain even parity of above data P1 should be 0

so **P1=1**

To calculate P2

Check bits 2,3,6,7,10,11….

i.e P2 ,D0, D2 ,D3 = P2, 1, 1 , 0

so to maintain even parity of above data P2 should be 0

so **P2=0**

To calculate P3

Check bits 4 ,5 ,6,7,12….

i.e P3 ,D1, D2 ,D3 = P3, 0, 1 , 0

so to maintain even parity of above data P3 should be 0

so **P3=1**

So we get P1=1 ,P2 = 0 ,P3 =1

So we again write 7 bit Hamming code format and put the values of P1 ,P2 P3 in it

7 bit Hamming code format is

1	2	3	4	5	6	7
P1	P2	D0	P3	D1	D2	D3
1	0	1	1	0	1	0

So the answer is

So 7 bit hamming code for data 1010 using even parity is 1011010

Error Detection and Correction

If we introduce error in above example i.e our 7 bit hamming code for even parity is 1011010 and we send 1011000 then to find error again calculate all parity bits.

First write down all bits in format

1	2	3	4	5	6	7
P1	P2	D0	P3	D1	D2	D3
1	0	1	1	0	0	0

Now calculate P1 again for even parity . To find P1 check bits 1,3,5,7,9….

i.e 1,1,0,0 – This data have even parity so P1 is correct.

Now calculate P2 again for even parity . To find P1 check bits 2,3,6,7,10,11….

i.e 0,1,0,0 – This data do not have even parity so P2 is wrong i.e bit at position 2 has error

Now calculate P3 again for even parity . To find P1 check bits 4,5,6,7,12….

i.e 1,0,0,0 – This data do not have even parity so P3 is wrong i.e bit at position 4 has error.

Here we get error at position 2 and 4 so the Actual error is at position 2+4=6.

Here we find bit at position 6 is erroneous.

1	2	3	4	5	6	7
P1	P2	D0	P3	D1	D2	D3
1	0	1	1	0	0	0

So to correct that bit we just invert that bit .so correct hamming code is.

1	2	3	4	5	6	7
P1	P2	D0	P3	D1	D2	D3
1	0	1	1	0	1	0