Unit - 3

Line Coding

A line code is the code used for data transmission of a digital signal over a transmission line.

Line coding is means converting sequence of data in bit to digital signal.

Classification of Line Coding

→ Unipolar → RZ, NRZ → One Voltage (0 or 1)

→ Polar → RZ, Manchester, NRZ → 2 Voltage (+ve, -ve)

→ Bipolar → RZ, NRZ → AMI [Alternat mark Diversion] → +ve, -ve, 0 → 3 voltage

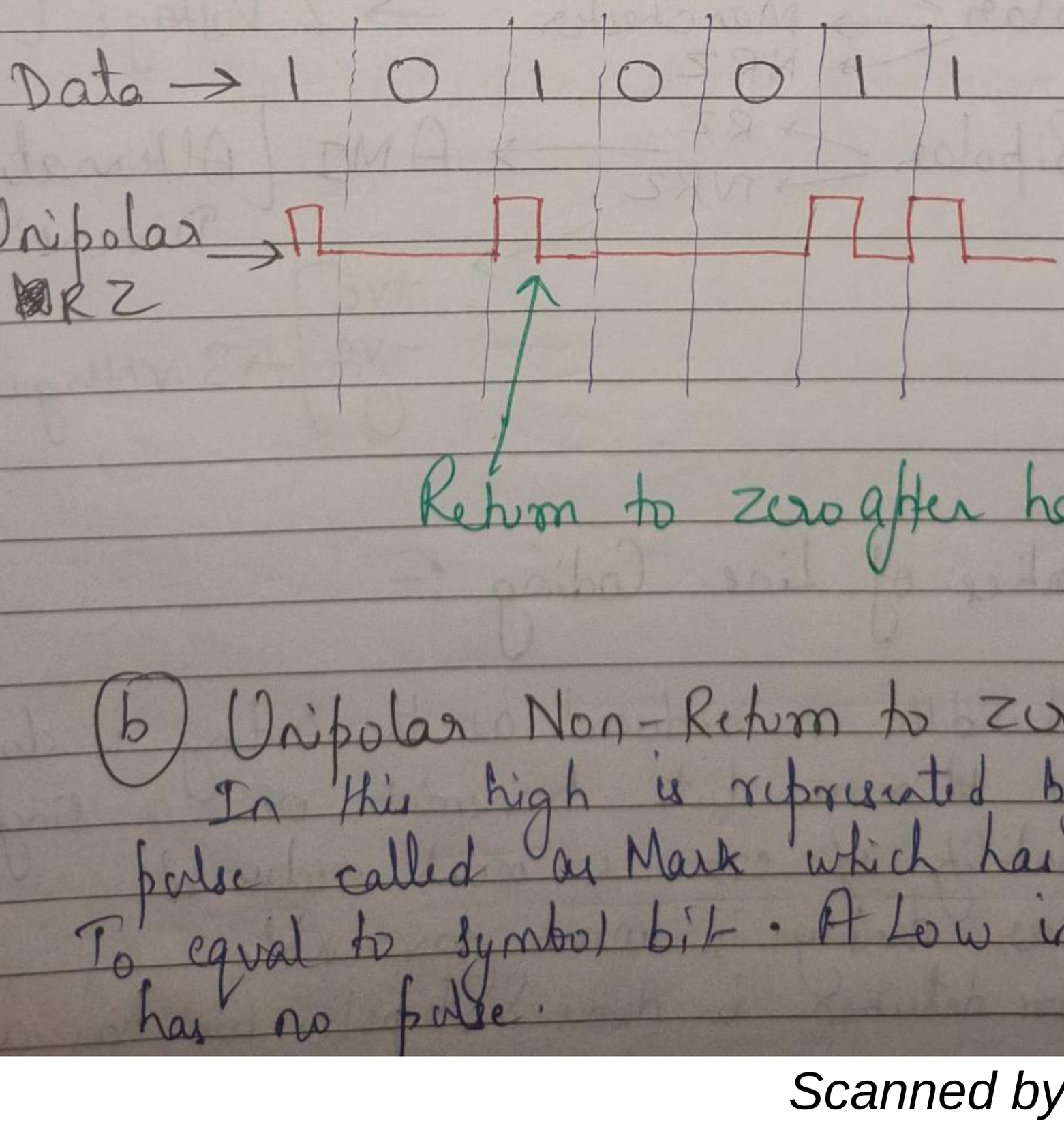
Properties of Line Coding :-

1. Bandwidth is reduced as the coding is done to make more bits transmit on a single signal.
2. Probability of error is much reduced
3. Power density is much favorable
4. Error detection is done & bipolar too has a correction capability.

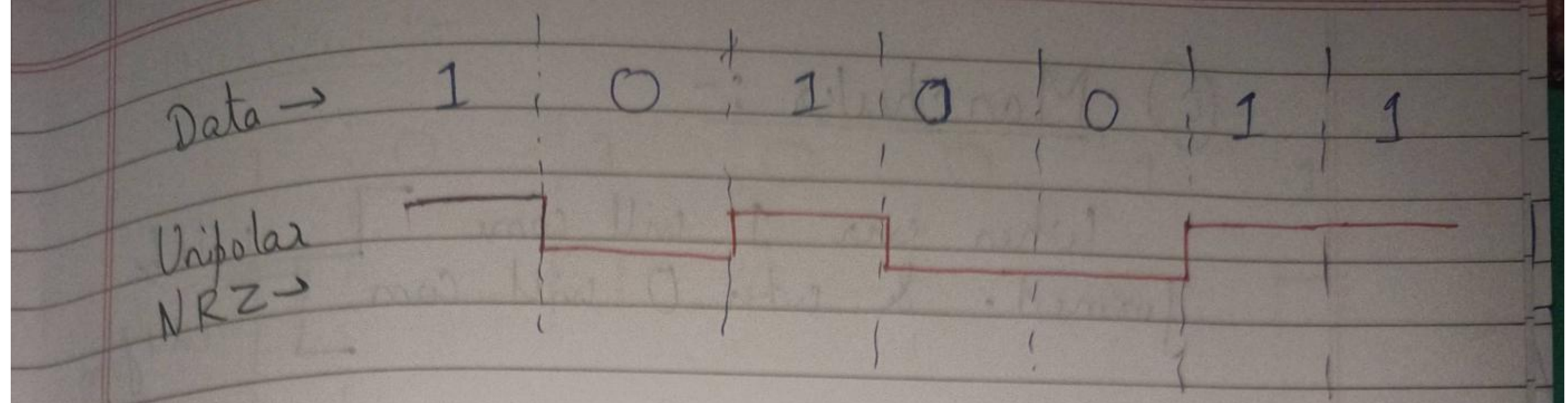
5. Long string of 1 & 0 is avoided to maintain transparency.

(I) Unipolar Signaling :-
Also known as On-off keying or simply OOK.
The presence of pulse represents a 1 and absence represent a 0.

(a) Unipolar ~~Non-~~ Return to Zero (RZ) :-
In this type, high is represented by +ve pulse called as Mark, which has duration T_0 equal to ~~symbol~~ half bit duration.
A low is data has no pulse.



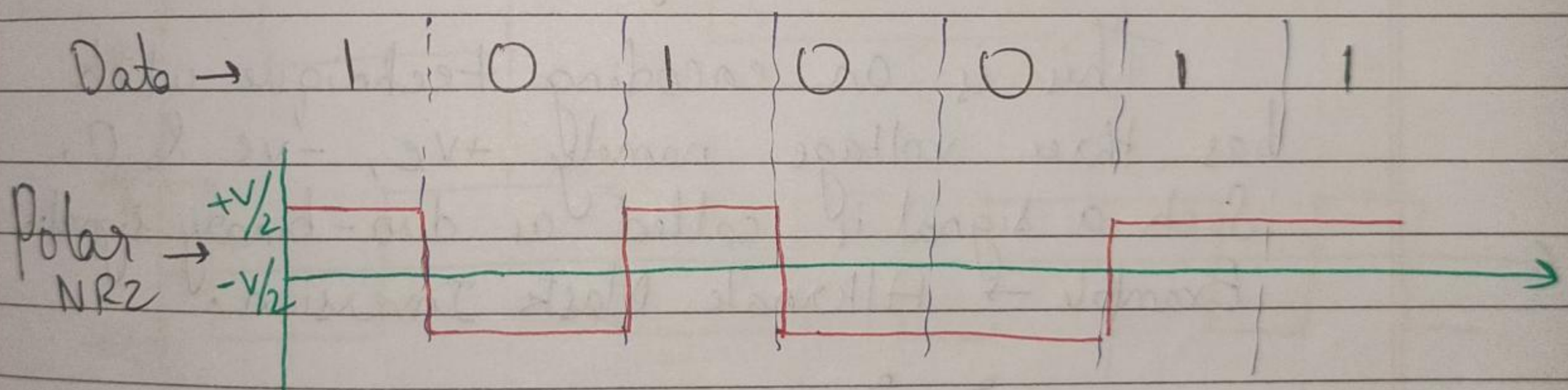
(b) Unipolar Non-Return to Zero (NRZ)
In this high is represented by +ve pulse called as Mark which has duration T_0 equal to symbol bit. A Low in data has no pulse.



(II) Polar Signaling :-

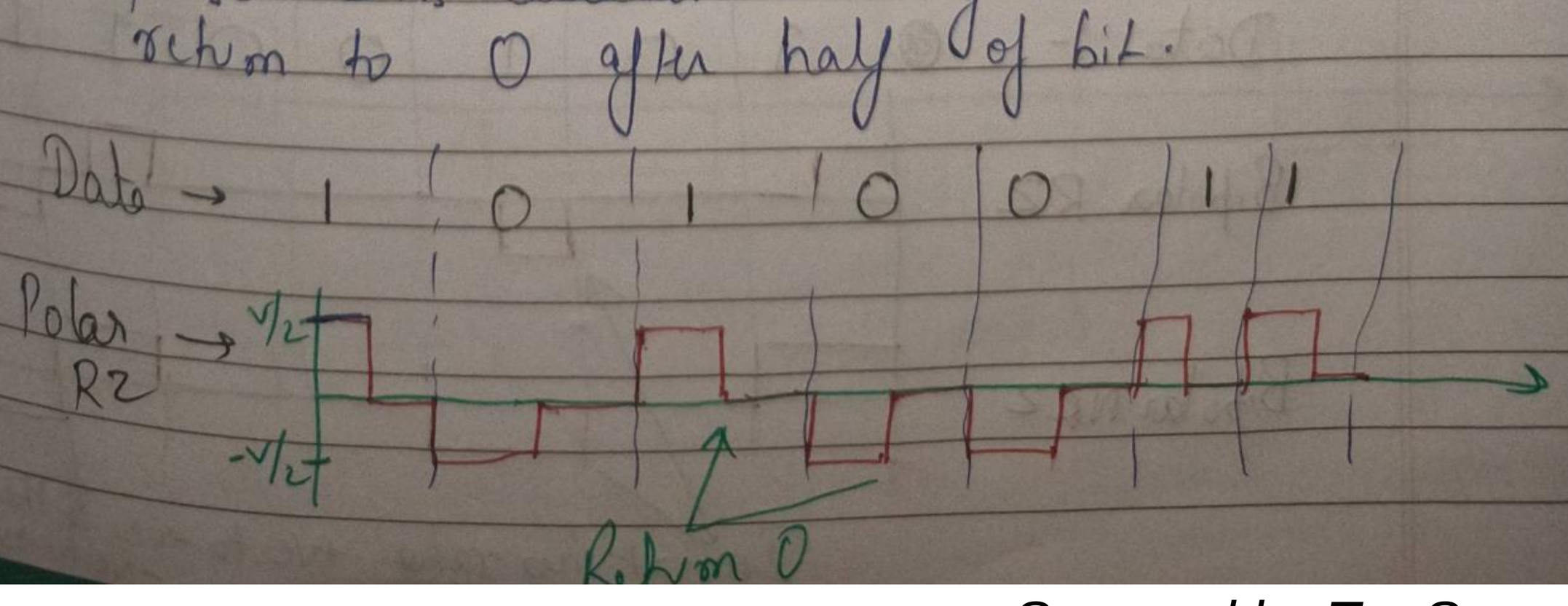
(a) Polar NRZ :-

In this, high in data is represented by positive pulse while low in data is represented by -ve pulse.



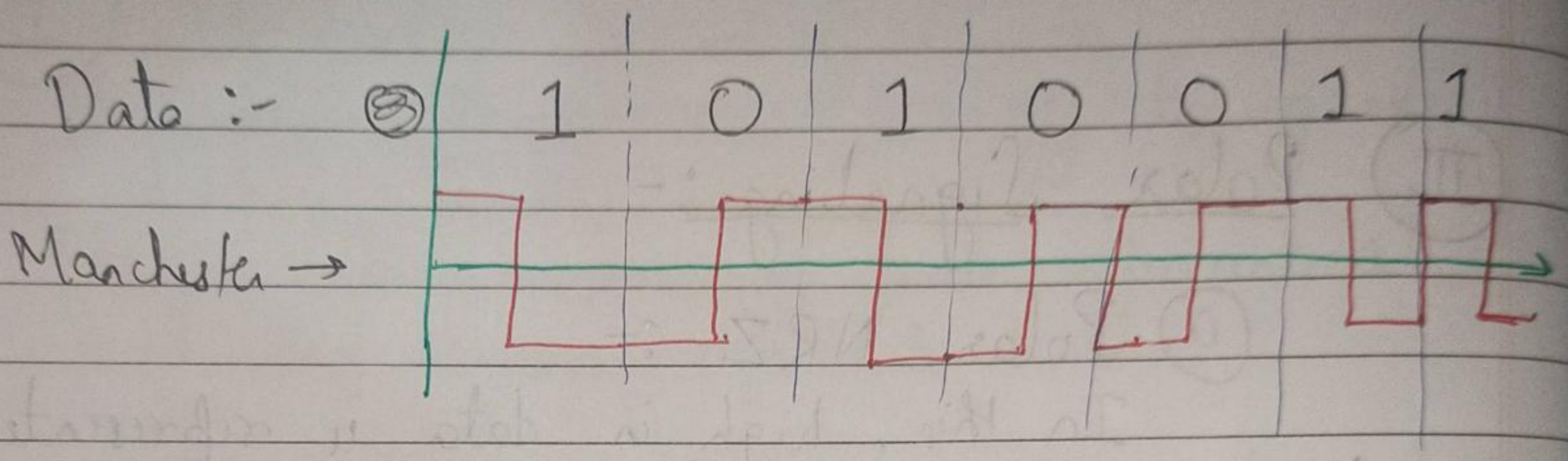
(b) Polar RZ :-

In this high in data is represented by positive pulse while low in data represented by -ve pulse. Its duration is half and it will return to 0 after half of bit.



(c) Manchester :-

When ever 1 will come ⌐⌙ will be formed. & when 0 will com ⌙⌐ will form

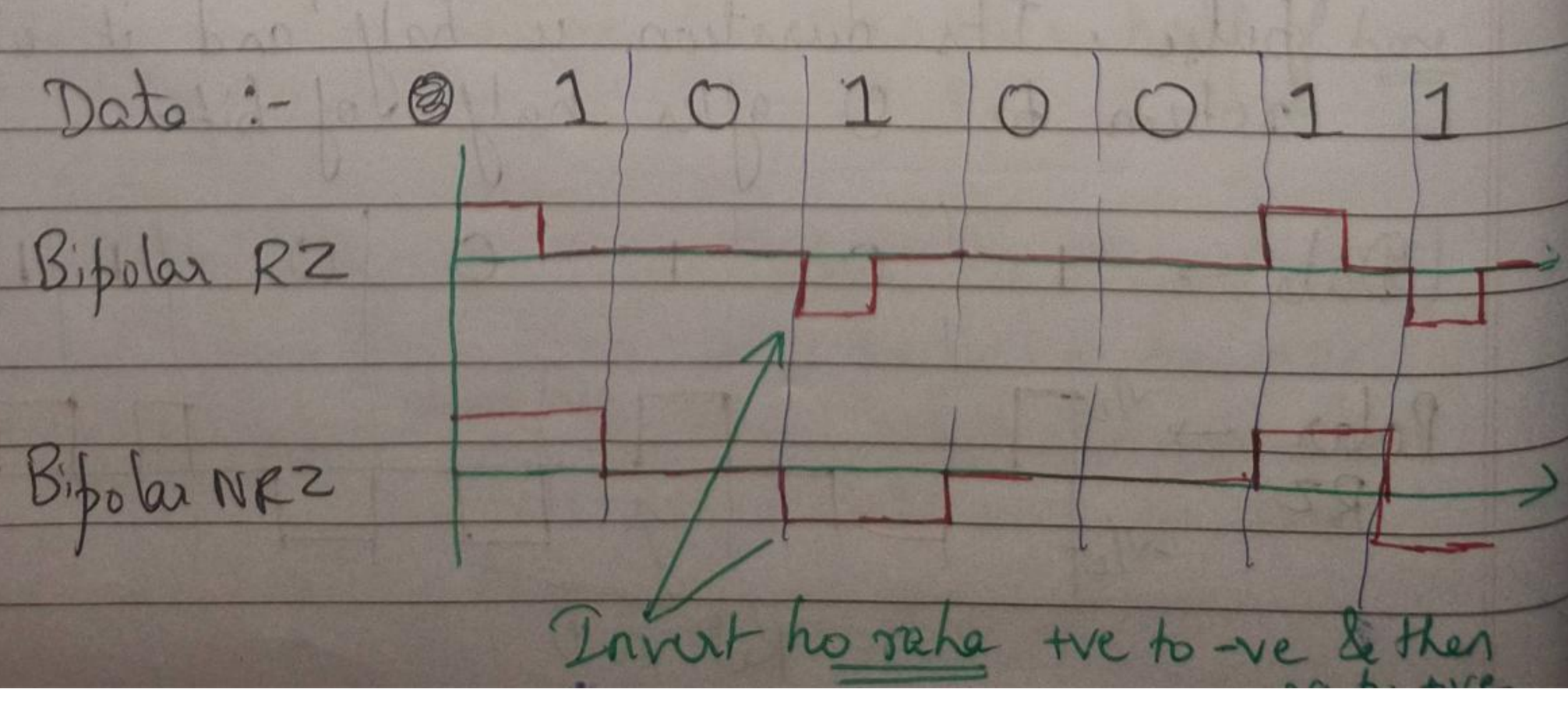


(III) Bipolar Signaling :-

This is an encoding technique which has three voltage namely +ve, -ve & 0. Such a signal is called as duo-binary signal.
Example → Alternate Mark Inversion.

* 1 आने पे Invert hota h.

(a) Bipolar RZ :-
(b) Bipolar NRZ :-

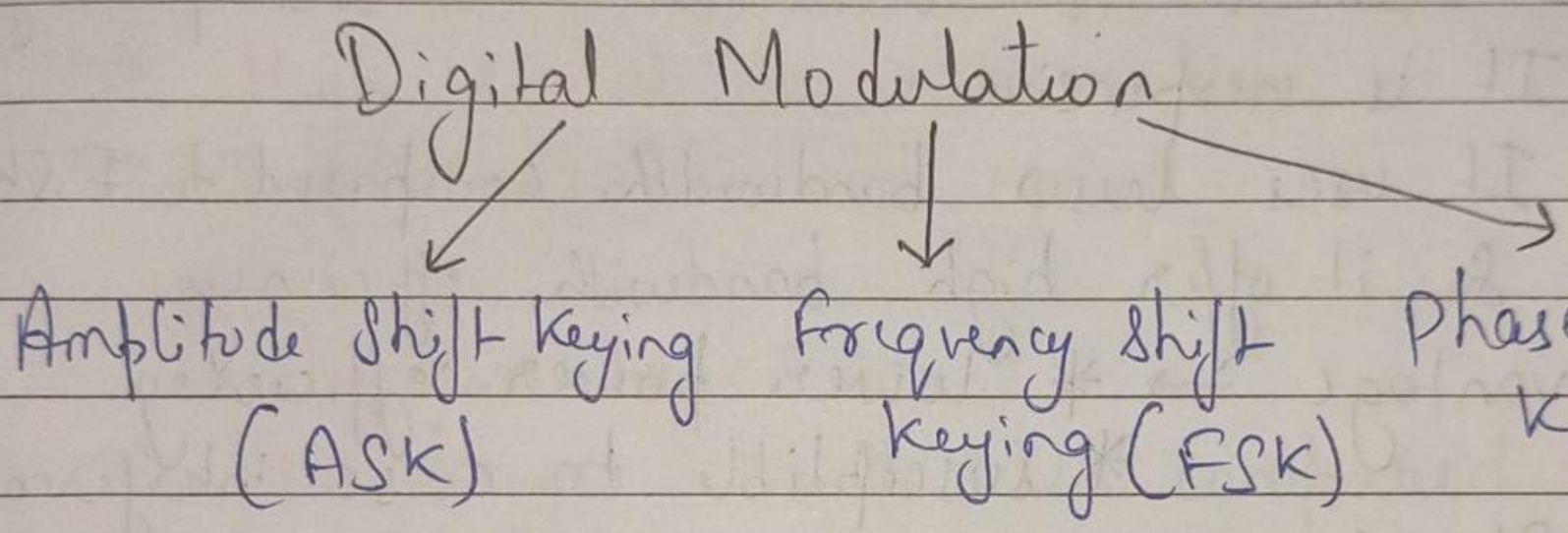


Overview :-

Digital Modulation :-

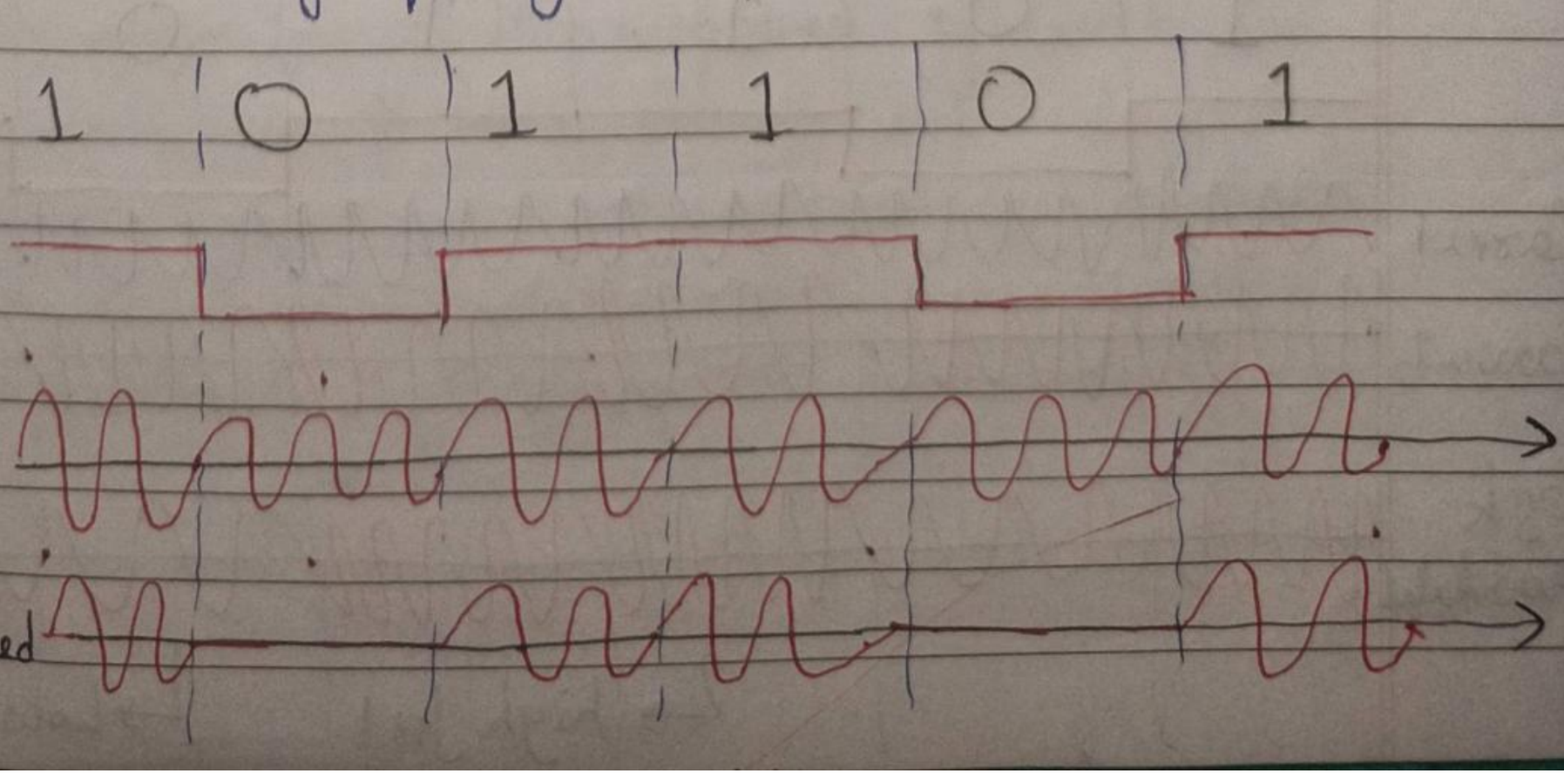
Modulation is superimposing of message signal on carrier signal by varying the properties of carrier signal.

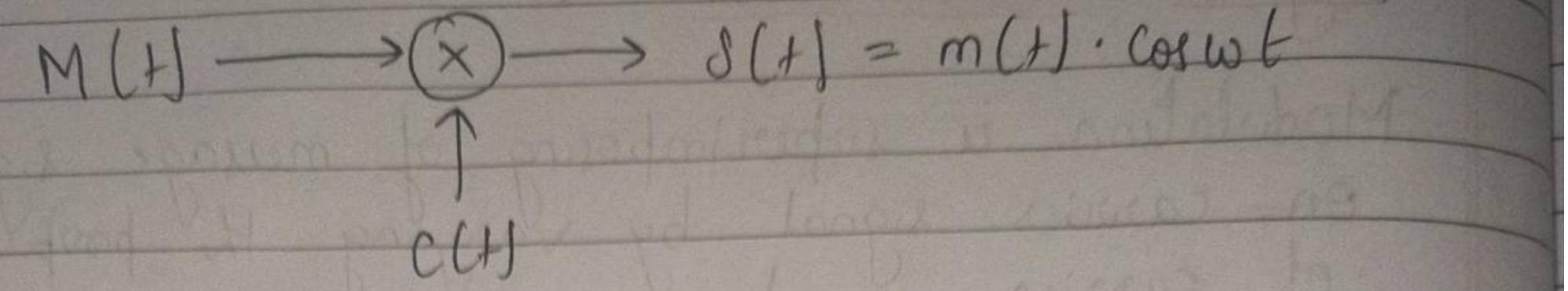
Types :- (a) Analog Modulation
(b) Digital Modulation



* ASK :- Amplitude Shift Keying is a technique in which carrier signal is analog and data to be modulated is digital. The amplitude of analog carrier signal is modified to reflect binary data.

In this for data 0, ~~signal~~ it modulated signal gives 0 else it gives same carrier output for data 1. The frequency & phase remain constant.





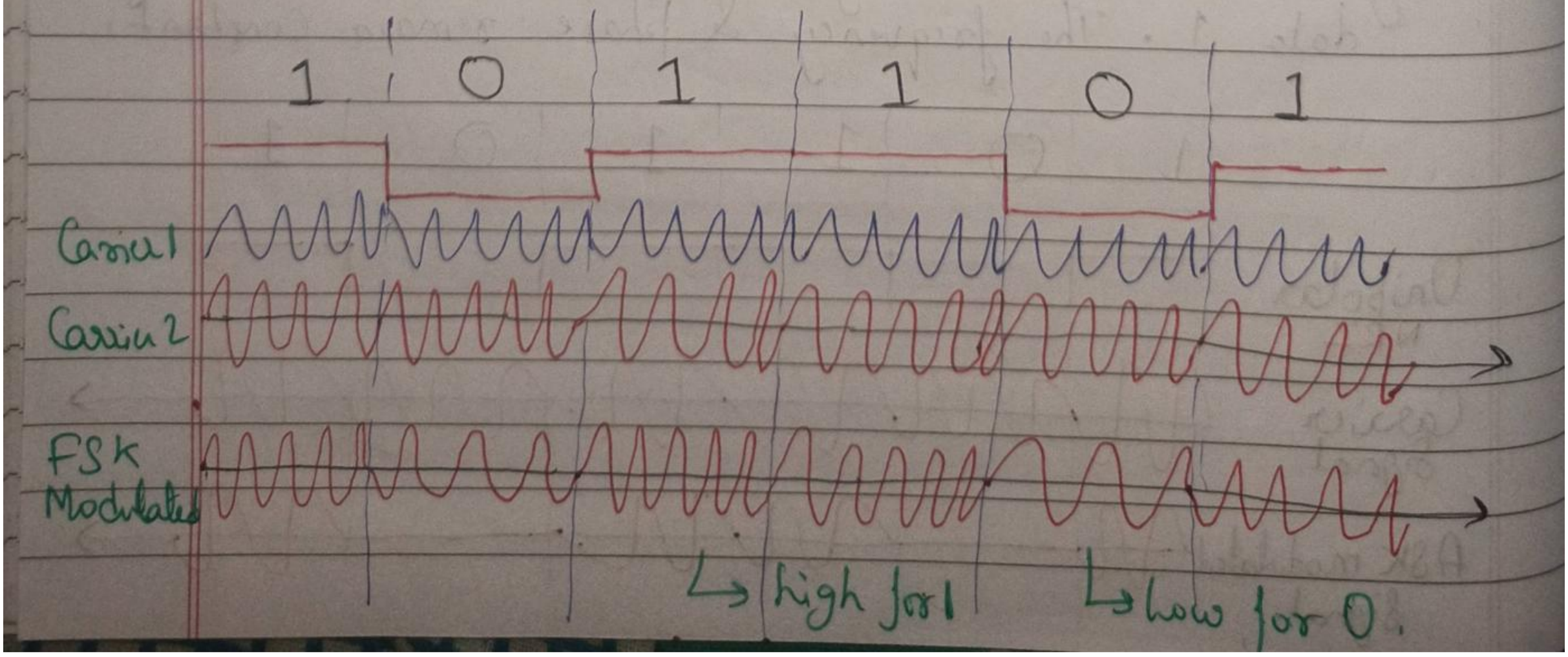
Advantages :-

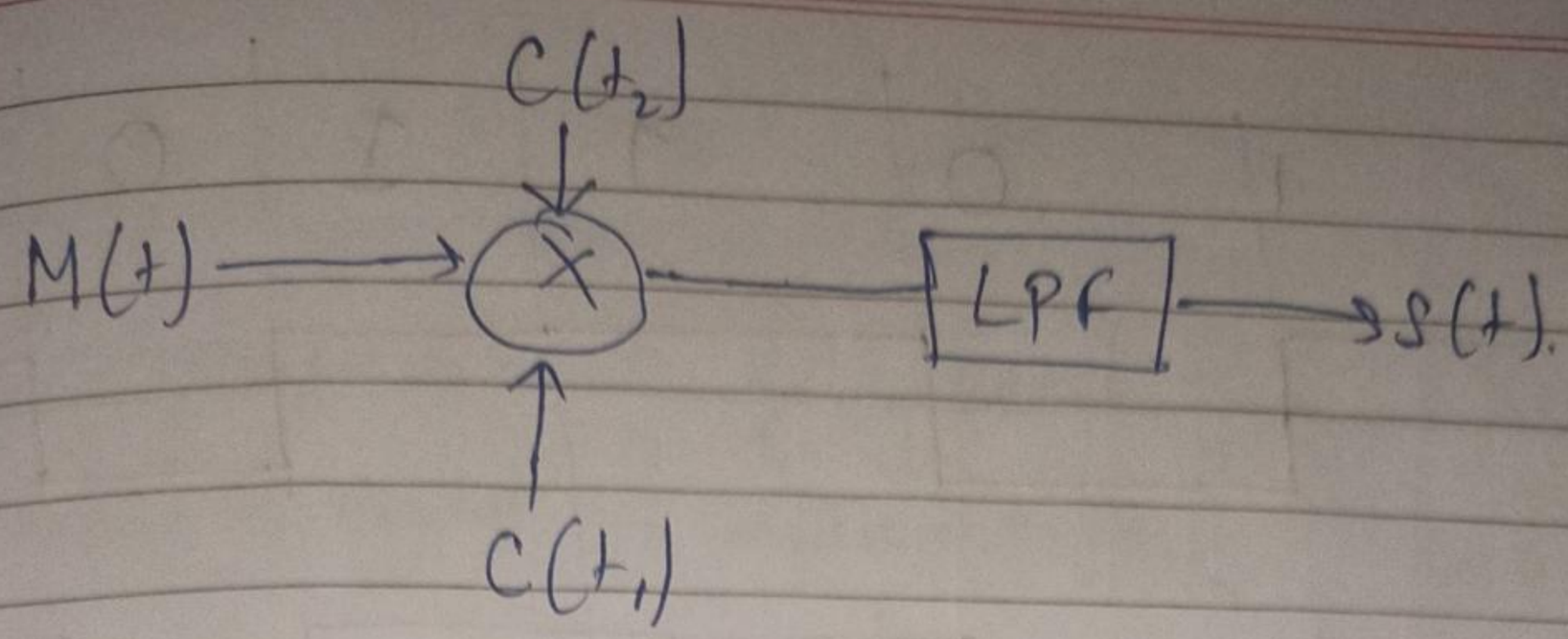
→ It can be used to transmit data over optical fiber.
→ It is inexpensive
→ It uses lesser bandwidth compared to FSK
So it offer high bandwith efficiency.

Disadvantage → * lower power efficiency.
* susceptible to noise interference.

* FSK :-

In this the frequency of analog signal is modified to reflect binary data. The output of a frequency shift key modulation wave is high for binary high and low for binary low frequency. Amplitude & phase remain same.





Advantages :-
→ help to avoid noise problem of ASK
→ Low chance of error
→ High signal to noise ratio.
→ Implementation is easier.

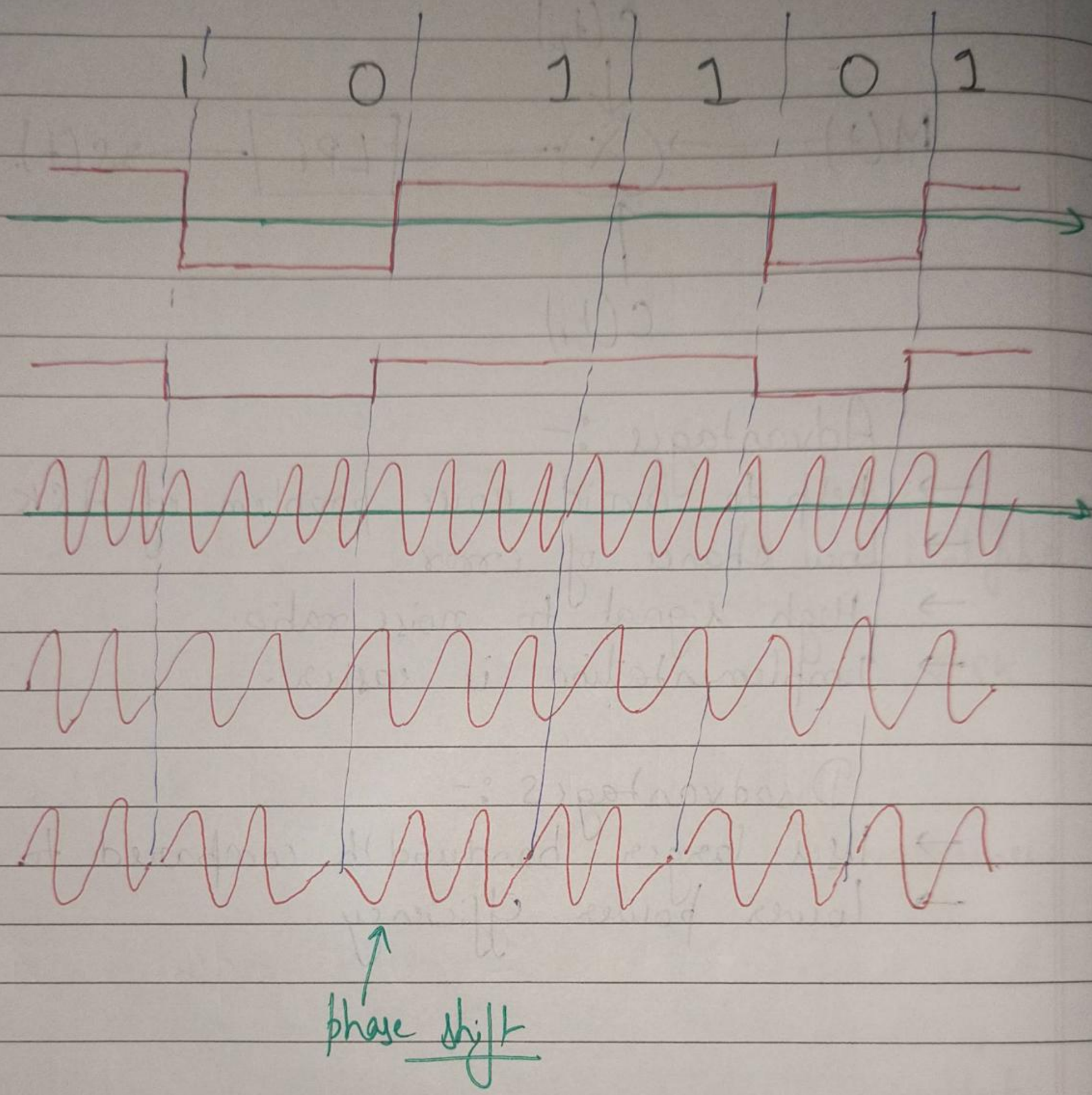
Disadvantages :-
→ Uses larger bandwidth compared to ASK
→ Lower power efficiency.

* Phase Shift Keying (PSK) :-

In this phase of analog signal is modified to reflect binary data. Amplitude & frequency remain same.

Advantage :- * More power efficient
* Low error

Disadvantage :- * offers low bandwidth efficiency.
* Non-coherent reference signal
* Detection & recovery of binary data is complex.



Pulse Code Modulation

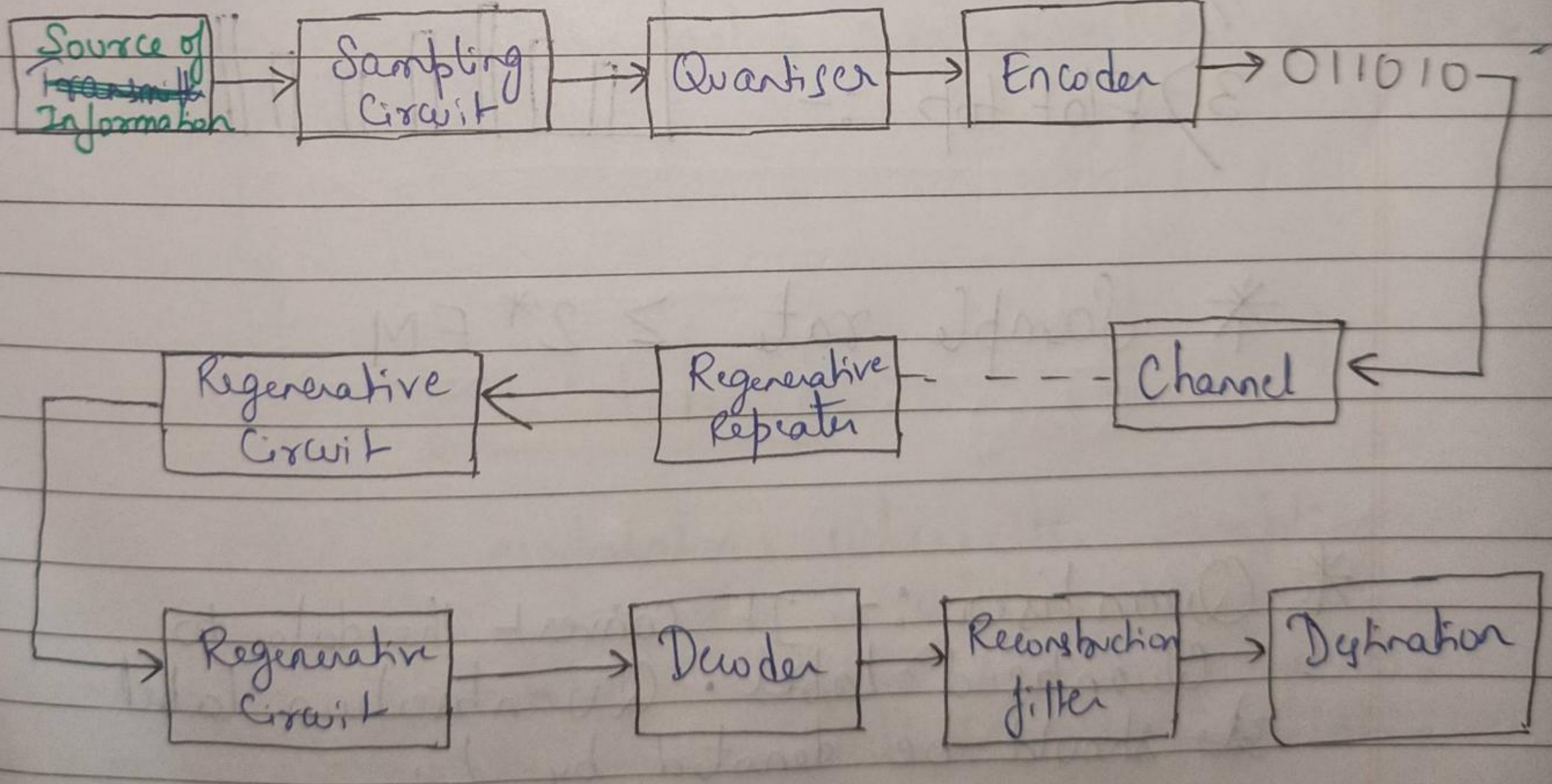
It is a method of converting analog signal into a digital signal, so that the modified analog signal can be transmitted through the digital communication network.

Parts :-

1) Transmitter → Analog to digital
   - * Sampler
   - * Quantizer
   - * Encoder

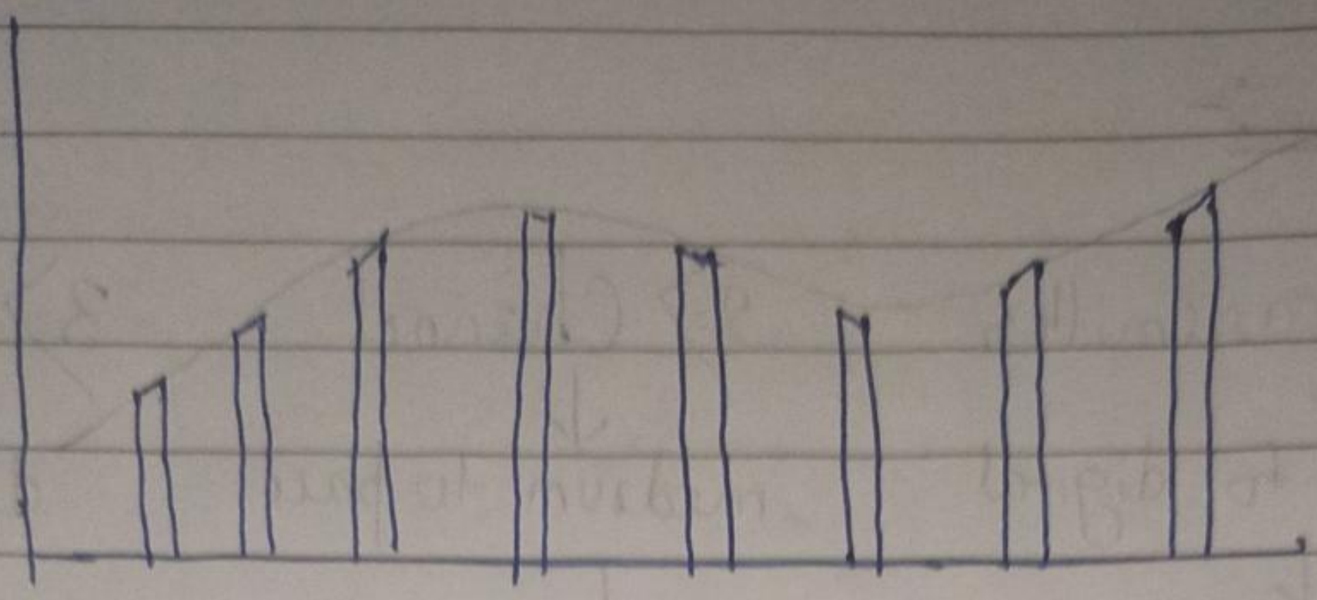
2) Channel → medium to pass
   - * Series of regenerative repeater

3) Recieves → digital to analog
   - * Regenerative Circuit
   - * Decoder
   - * Reconstruction filter.



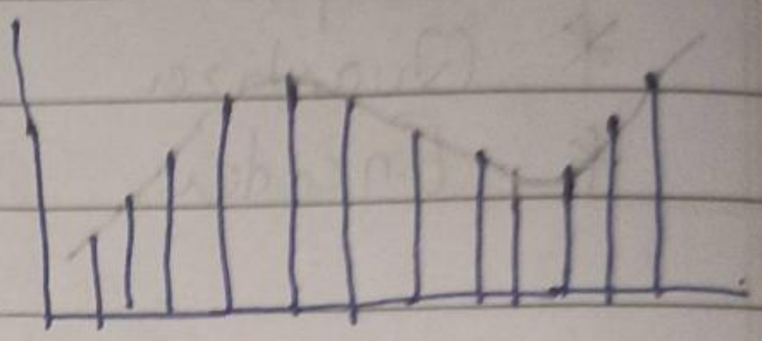
* Transmitter part → Analog to digital

* Sampler → Analog signal ko sample karta h.
  ↳ Do ON/OFF only.



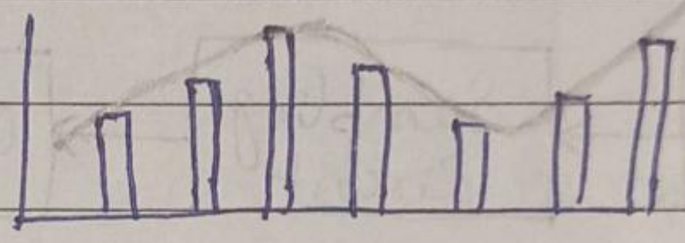
Types :-

1) Ideal :- Discreat



2) Natural :-

3) Flat top :-



* Sample rate $\geq 2^*$ FM

* Quantiser :- It convert the data to Quantised label. Quantisation label should be denoted by L.

$$L = 2^n$$

$n \rightarrow$ no. of bit.

* Encoder → The digitidization of analog signal is done by encoder. It is not necessary that it will convert only in binary digit. Sampling done here is sample-and-hold process. It minize the bandwidth.

* Regenerative Repeater → This section increases the signal strength. The output of the channel also has one ~~repe~~ regenerative repeater circuit. to compensate the signal loss and reconstruct the signal & also increase the strength.

* Decoder → Decode the pulse coded waveform to reproduce the original signal. This act as a demodulator.

* Reconstruction filter :- A low pass filter is employed after digital-to-analog conversion to get back original signal.

Delta Modulation :-

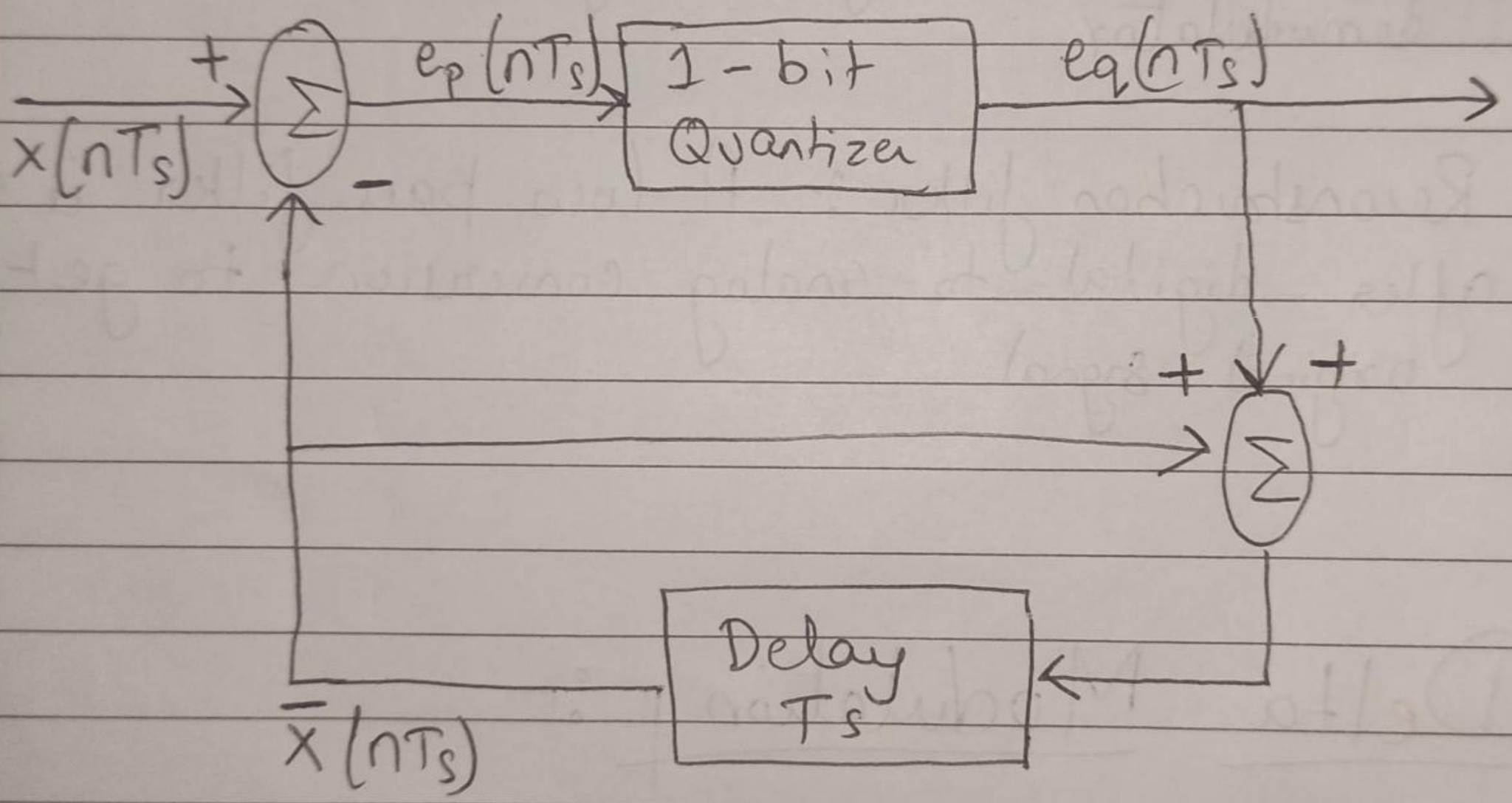
The type of modulation where the sampling rate is much higher ~~#~~ & in which the step size after quantization is of a smaller value, Δ, such a modulation is called delta modulation.

features :-

→ An over-sampled input is taken to make full use of signal correlation.
→ The quantization design is simple.
→ Quality is moderate
→ Step size is very small i.e. Δ & same.
→ Input sequence is higher than Nyquist rate.
→ Bit rate is decided by user

Delta Modulation is simplified form of DPCM technique, also viewed as 1-bit DPCM. As sampling interval is reduced, the signal will be higher.

Delta Modulator :-



When,

$$x(nT_s) > \hat{x}(nT_s)$$

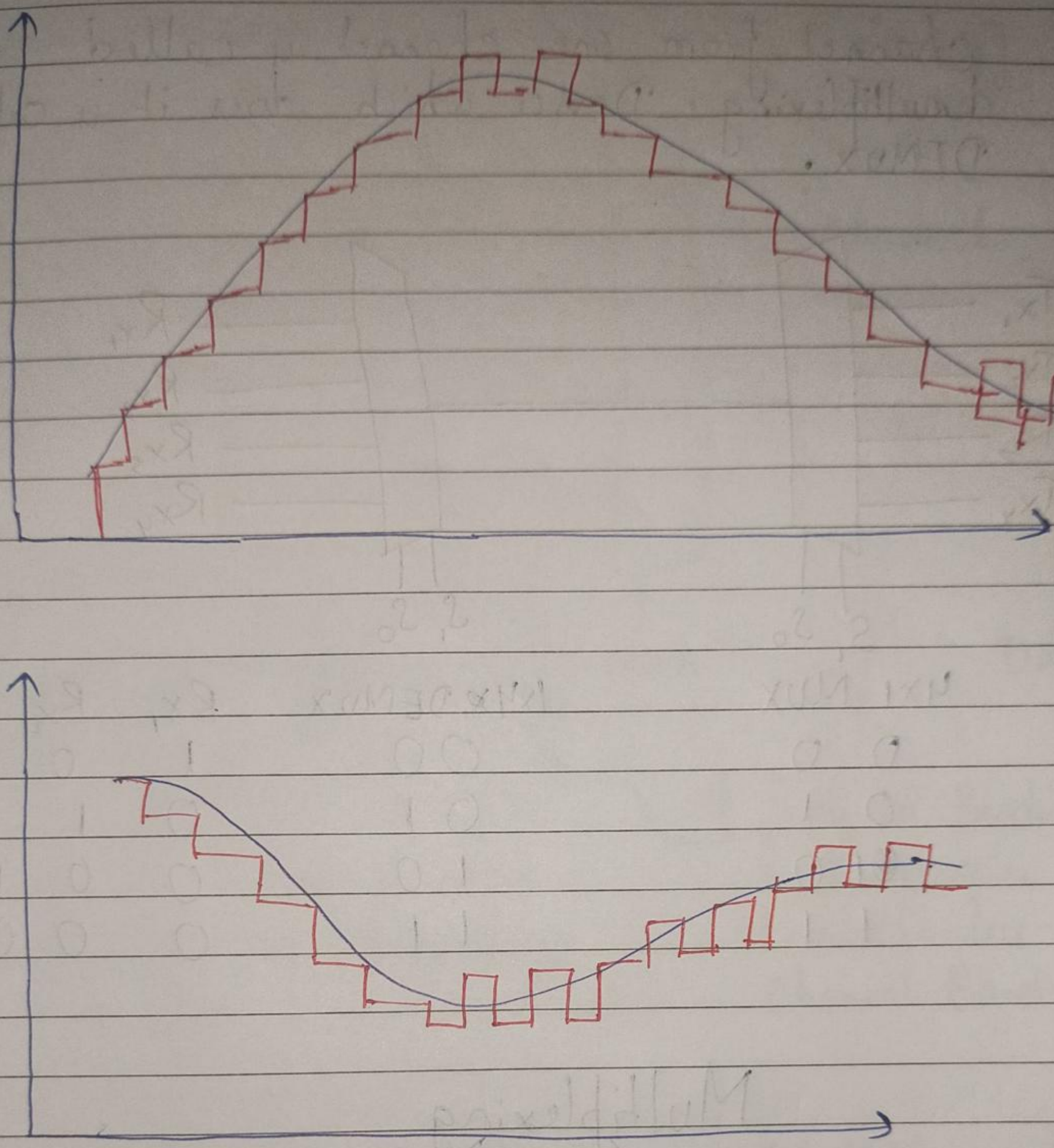
$$\downarrow$$

$$+\Delta \longrightarrow (1)$$

$$x(nT_s) < \hat{x}(nT_s)$$

$$\downarrow$$

$$-\Delta \longrightarrow (0)$$

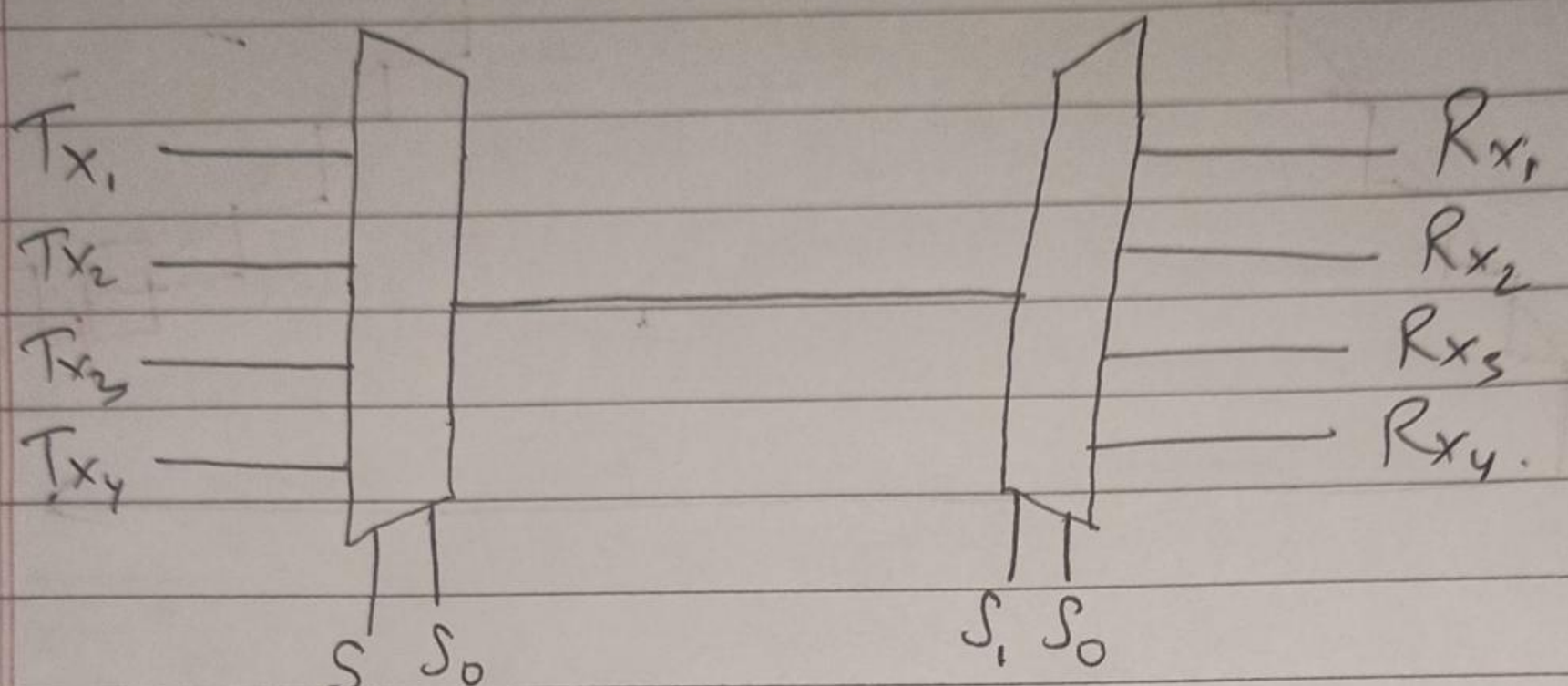


Multiplexing

Multiplexing is used in the cases where the signal of lower bandwith and transmitting media is having higher bandwidth.

Multiplexing is process of combining multiple signal into one signal. Devices which does multiplexing is called MUX. It reverse process i.e. extracting the

channel from one channel is called demultiplexing. Device which does it is called DEMUX.



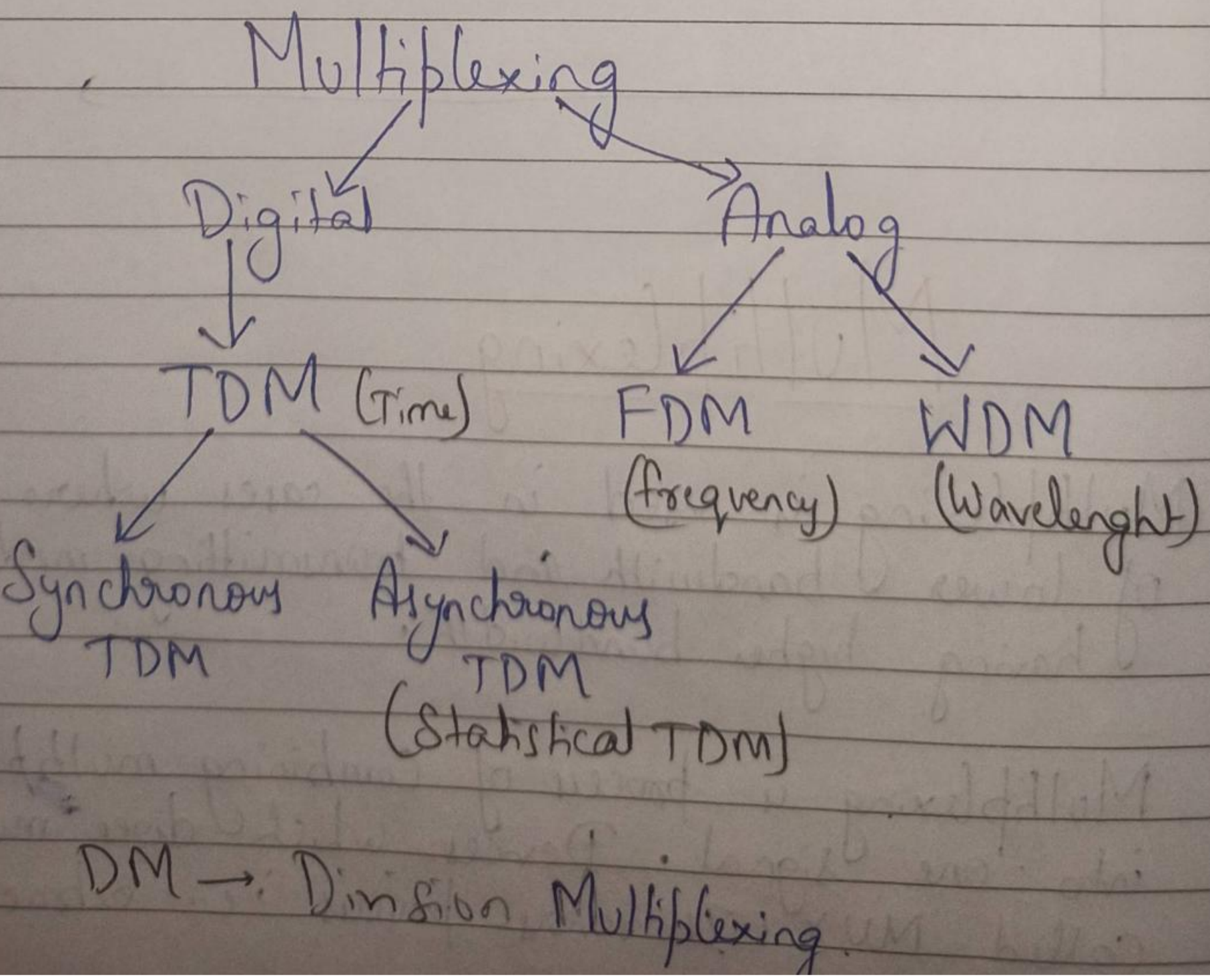
4x1 MUX

0	0
0	1
1	0
1	1

1x4 DEMUX

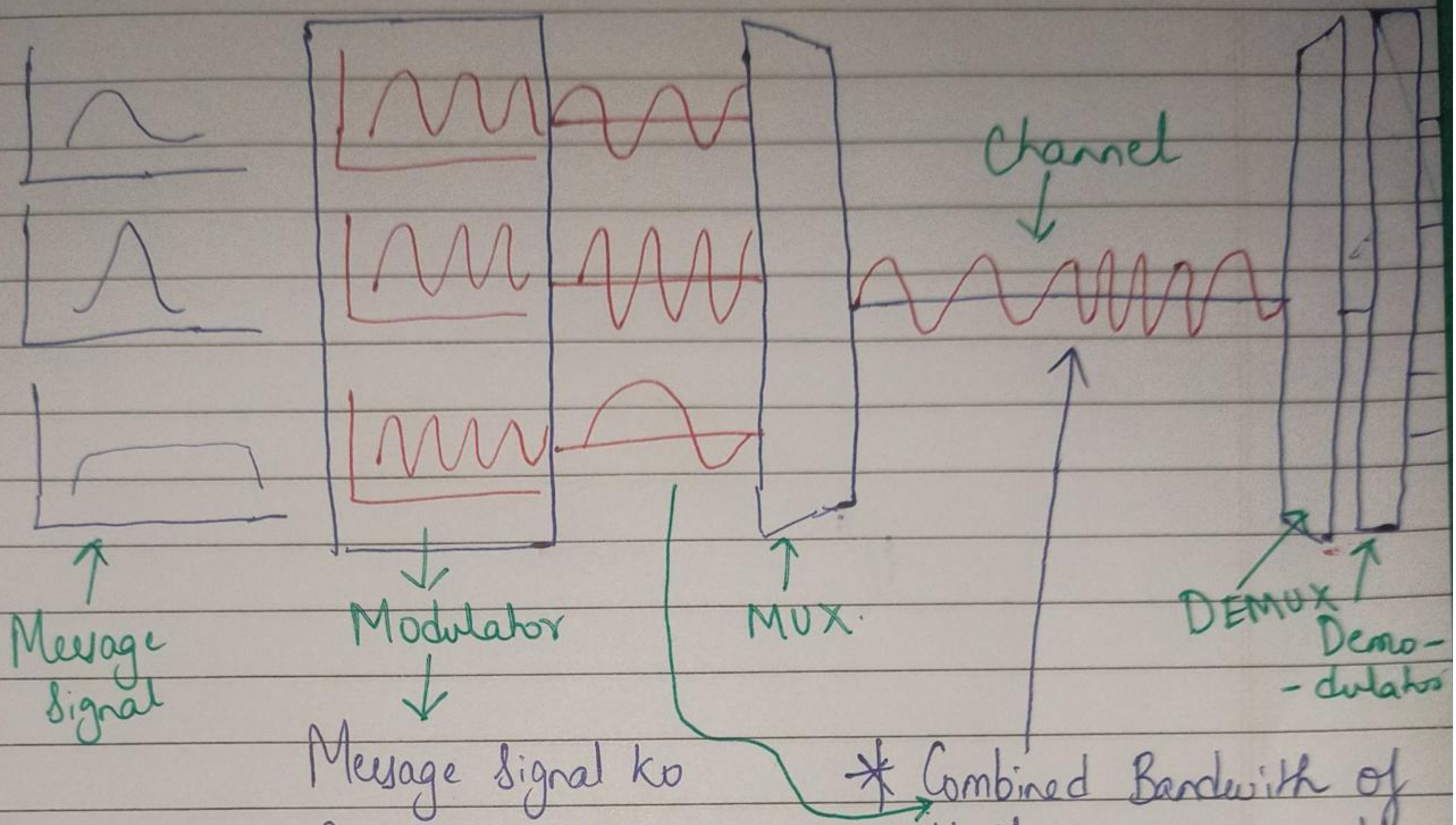
0	0
0	1
1	0
1	1

Rx_1	Rx_2	Rx_3	Rx_4
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1



DM → Dimsion Multiplexing

(a) FDM [Frequency Division Multiplexing].

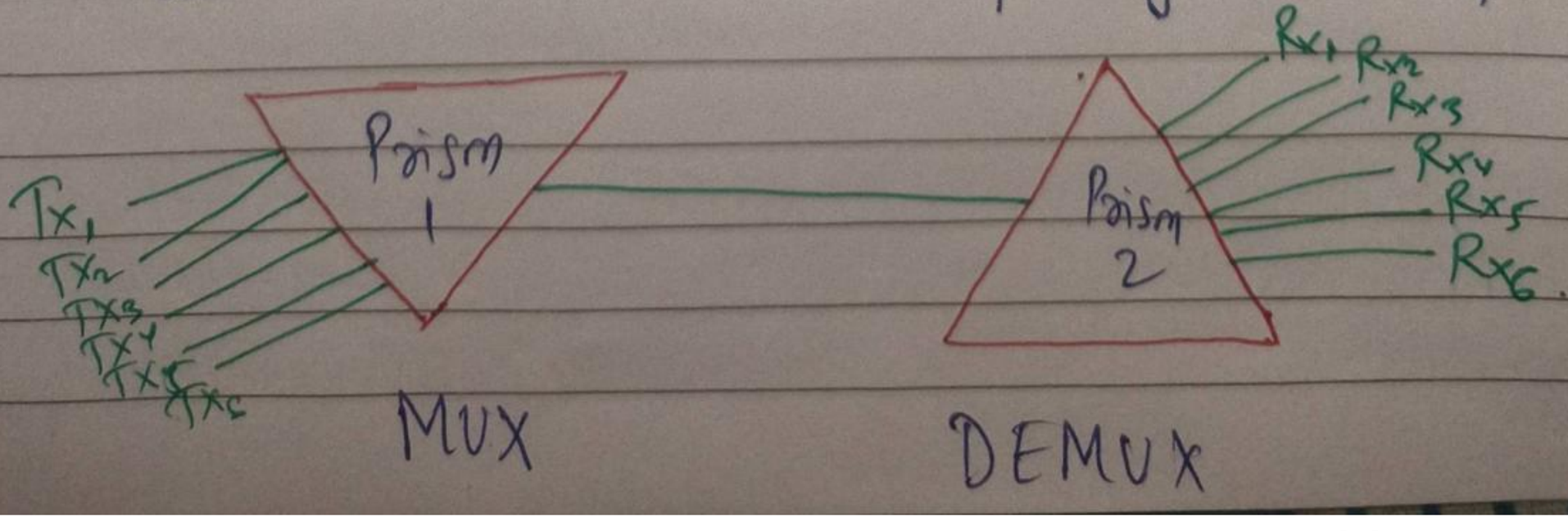


Message signal ko Carrier signal pe super impose karega.

* Combined Bandwith of all the carrier signal should be less than the Channel Bandwith

(b) WDM [Wavelength Division Multiplexing] :-

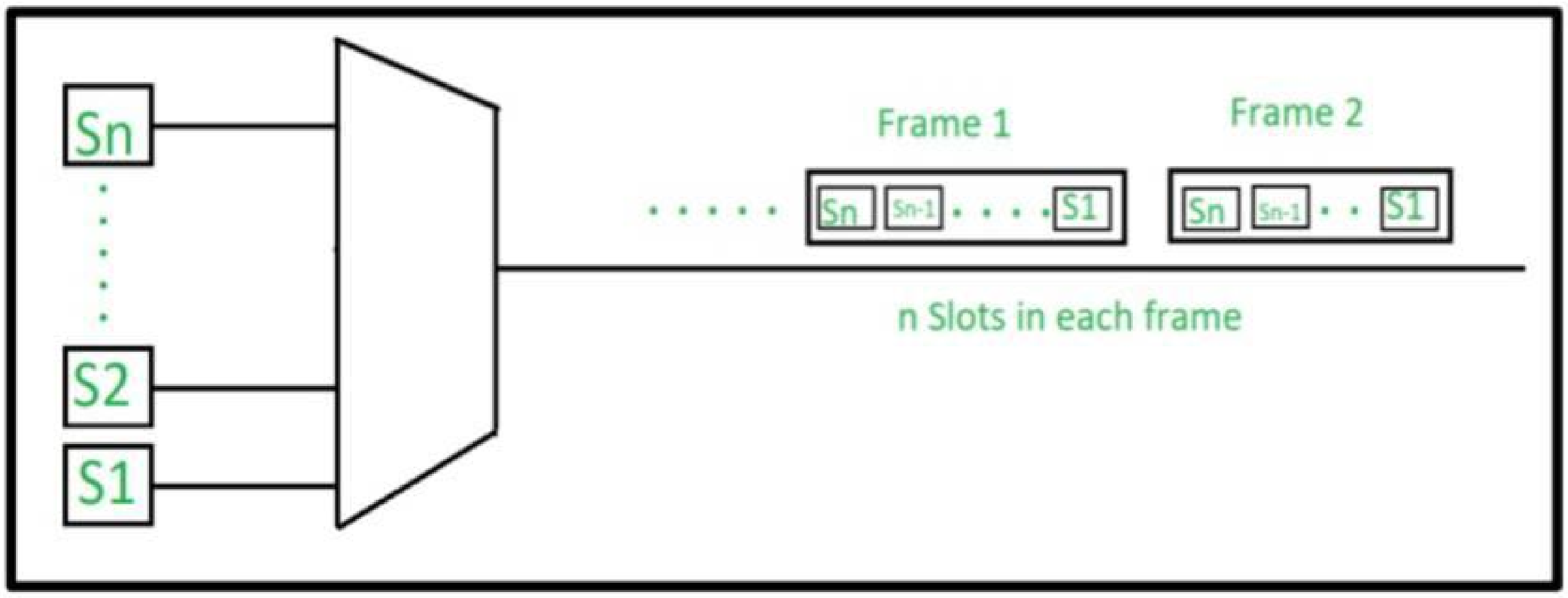
It is an analog technique in which many data stream of different wavelength are transmitted in the light spectrum. If wavelenght increases frequency decreases. A prism which can turn different wavelenght into one line can be used as output of MUX & input of DEMUX



Time Division Multiplexing (TDM):-

This happens when data transmission rate of media is greater than that of the source, and each signal is allotted a definite amount of time. These slots are so small that all transmissions appear to be parallel. In frequency division multiplexing all the signals operate at the same time with different frequencies, but in time division multiplexing all the signals operate with same frequency at different times.

In TDM, the time frame is divided into slots. This technique is used to transmit a signal over a single communication channel, by allotting one slot for each message.

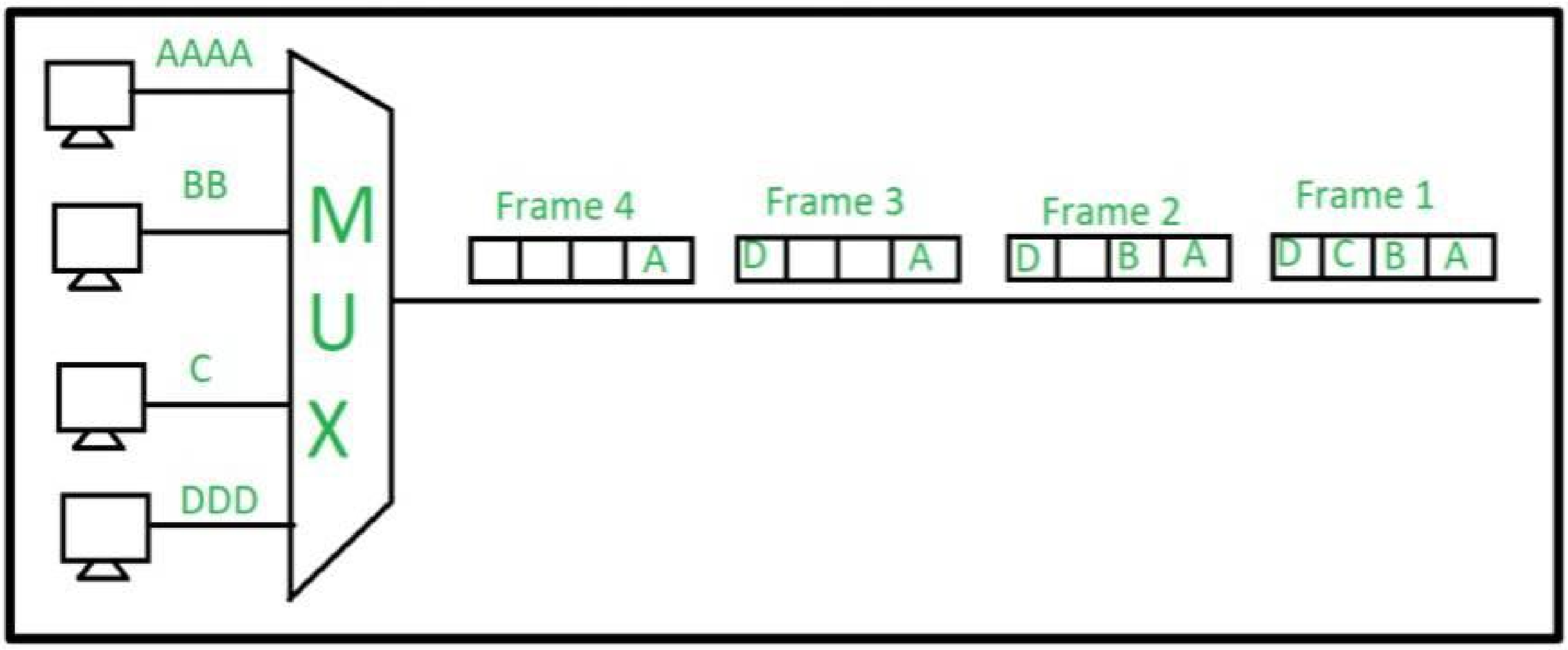


The main ones are **Synchronous and Asynchronous TDM**.

Synchronous TDM

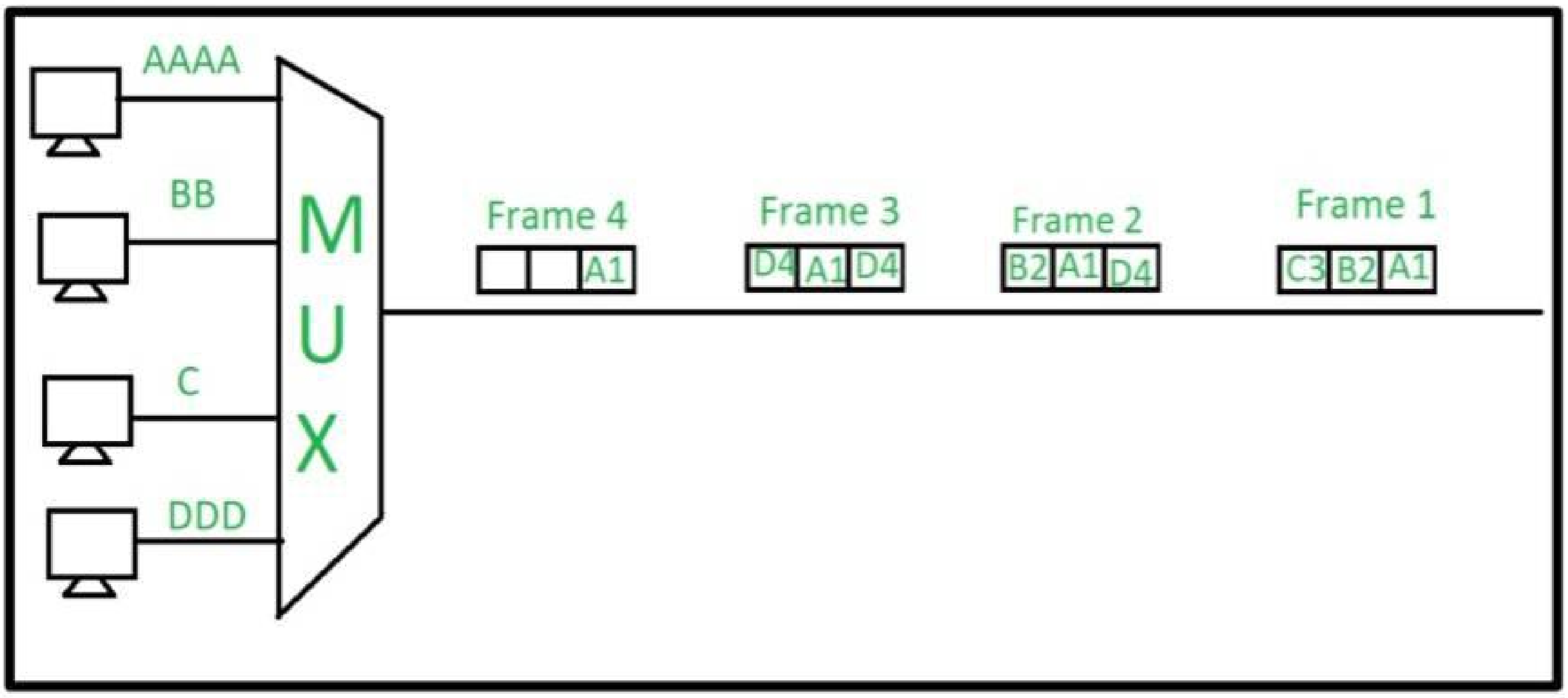
In Synchronous TDM, the input is connected to a frame. If there are 'n' number of connections, then the frame is divided into 'n' time slots. One slot is allocated for each input line.

In this technique, the sampling rate is common for all signals and hence the same clock input is given. The MUX allocates the **same slot** to each device at all times.



Asynchronous TDM

In Asynchronous TDM, the sampling rate is different for each of the signals and a common clock is not required. If the allotted device, for a time slot transmits nothing and sits idle, then that slot is **allotted to another** device, unlike synchronous. This type of TDM is used in Asynchronous transfer mode networks.



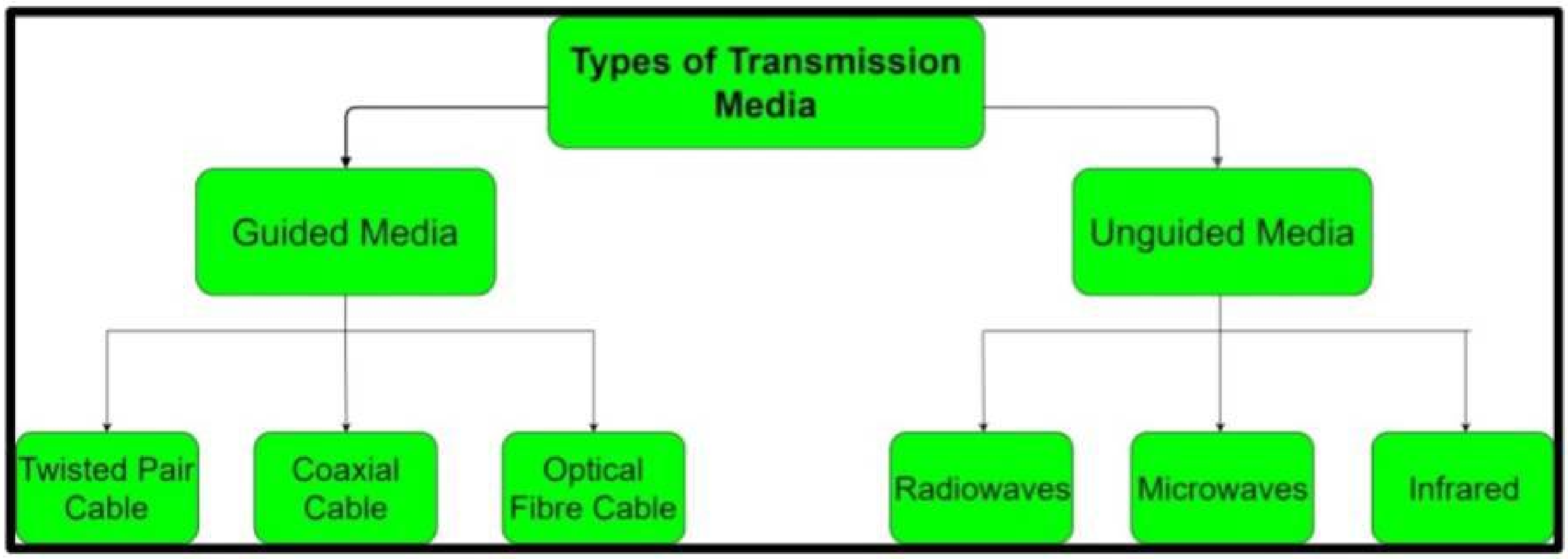
Difference between TDM and FDM:

.NO	TDM	FDM
1.	TDM stands for Time division multiplexing.	FDM stands for Frequency division multiplexing.
2.	TDM works with digital signals as well as analog signals.	While FDM works with only analog signals.
3.	TDM has low conflict.	While it has high conflict.
4.	Wiring or chip of TDM is simple.	While it's wiring or chip is complex rather than simple.
5.	TDM is efficient.	While it is inefficient.
6.	In TDM, time sharing takes place.	While in this, frequency sharing takes place.
7.	In TDM, synchronization pulse is necessary.	While in it Guard band is necessary.

Guided Media and Unguided media:-

Types of Transmission Media

In data communication terminology, a transmission medium is a physical path between the transmitter and the receiver i.e. it is the channel through which data is sent from one place to another. Transmission Media is broadly classified into the following types:



1. Guided Media:-

It is also referred to as Wired or Bounded transmission media. Signals being transmitted are directed and confined in a narrow pathway by using physical links.

Features:

- High Speed
- Secure
- Used for comparatively shorter distances

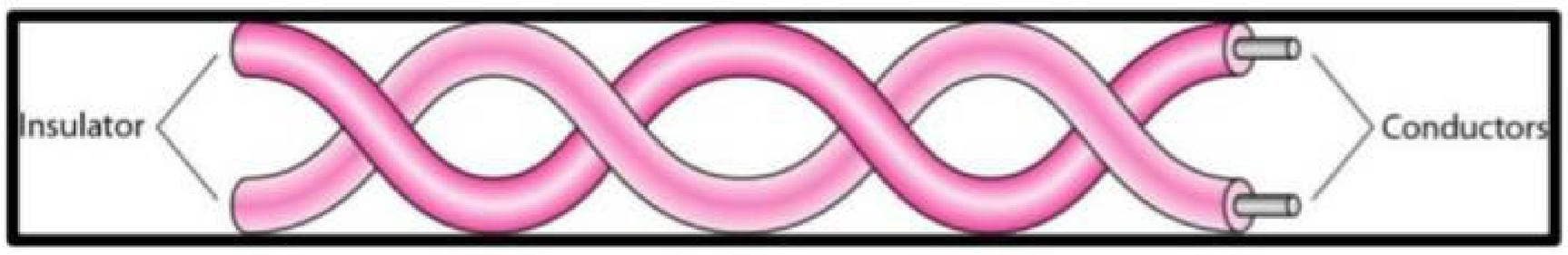
There are 3 major types of Guided Media:

(i) Twisted Pair Cable –

It consists of 2 separately insulated conductor wires wound about each other. Generally, several such pairs are bundled together in a protective sheath. They are the most widely used Transmission Media.

One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference. The receiver uses the difference between the two.

In addition to the signal sent by the sender on one of the wires, interference (noise) and crosstalk may affect both wires and create unwanted signals.



Twisted Pair is of two types:

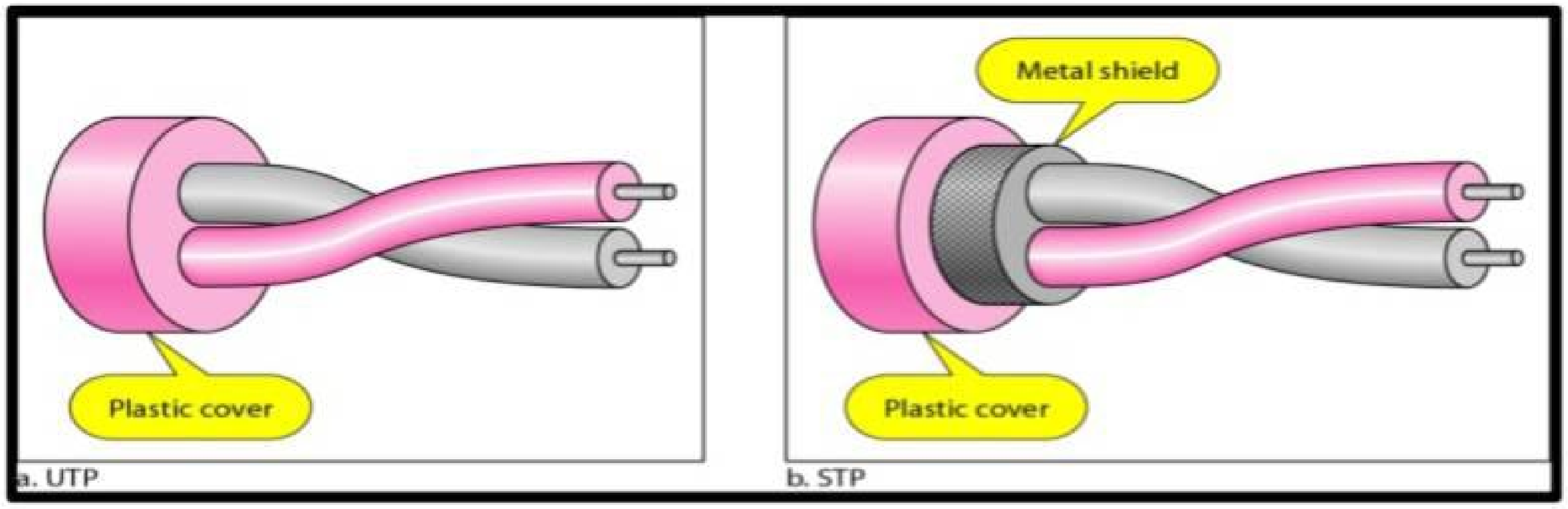
1. **Unshielded Twisted Pair (UTP):**
   This type of cable has the ability to block interference and does not depend on a physical shield for this purpose. It is used for telephonic applications.
   Advantages:

- Least expensive
- Easy to install
- High speed capacity

Disadvantages:

- Susceptible to external interference
- Lower capacity and performance in comparison to STP
- Short distance transmission due to attenuation

2. **Shielded Twisted Pair (STP):**
   This type of cable consists of a special jacket to block external interference. It is used in fast-data-rate Ethernet and in voice and data channels of telephone lines.



Advantages:

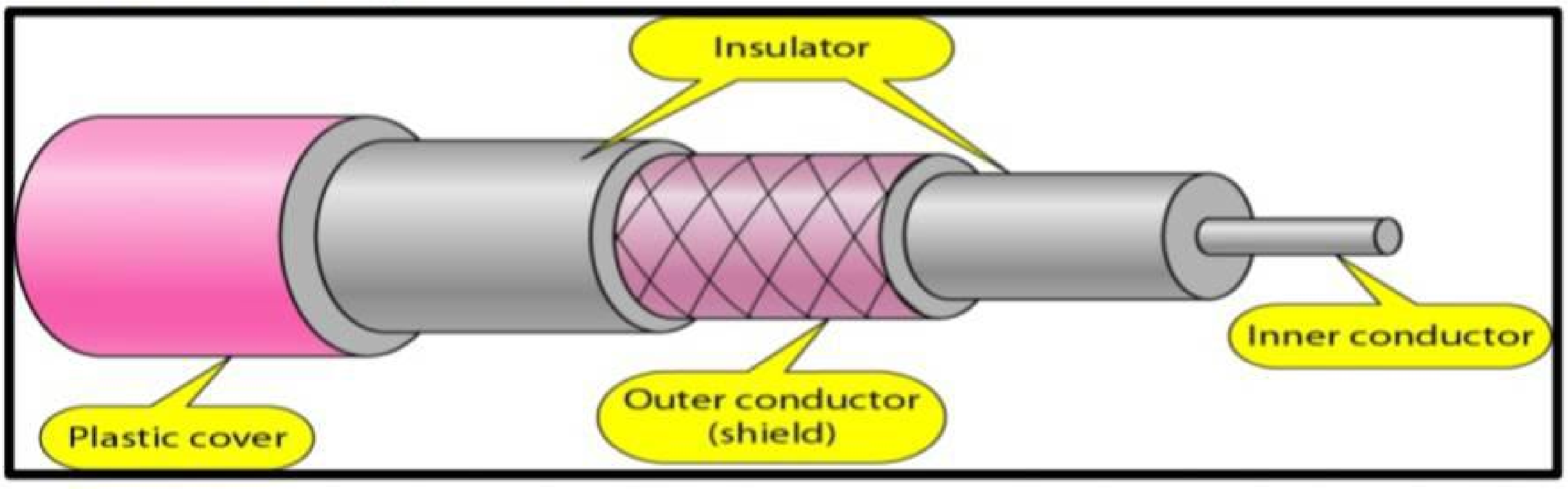
- Better performance at a higher data rate in comparison to UTP
- Eliminates crosstalk
- Comparatively faster

Disadvantages:

- Comparatively difficult to install and manufacture
- More expensive
- Bulky

(ii) Coaxial Cable –

It has an outer plastic covering containing 2 parallel conductors each having a separate insulated protection cover. Coaxial cable transmits information in two modes: Baseband mode (dedicated cable bandwidth) and Broadband mode (cable bandwidth is split into separate ranges). Cable TVs and analog television networks widely use Coaxial cables.



Coaxial cable (or coax) carries signals of higher frequency ranges than those in twisted – pair cable, in part because the two media are constructed quite differently. Instead of having two wires, coax has a

central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid, or a combination of the two. The outer metallic wrapping serves both as a shield against noise and as the second conductor, which completes the circuit. This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover.

Advantages:

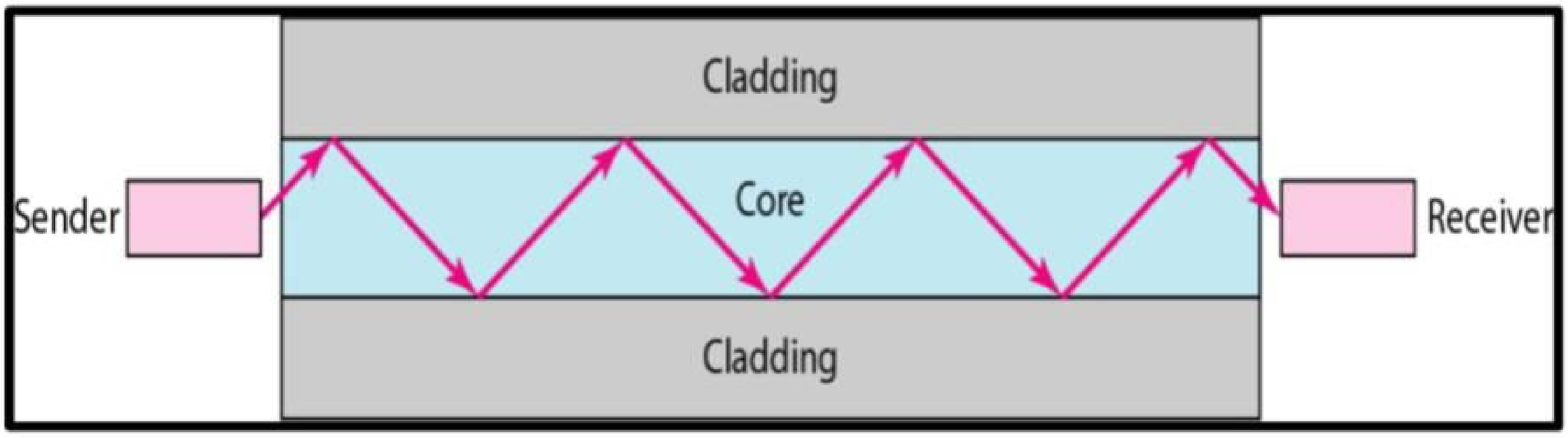
- High Bandwidth
- Better noise Immunity
- Easy to install and expand
- Inexpensive

Disadvantages:

- Single cable failure can disrupt the entire network

(iii) Optical Fiber Cable –

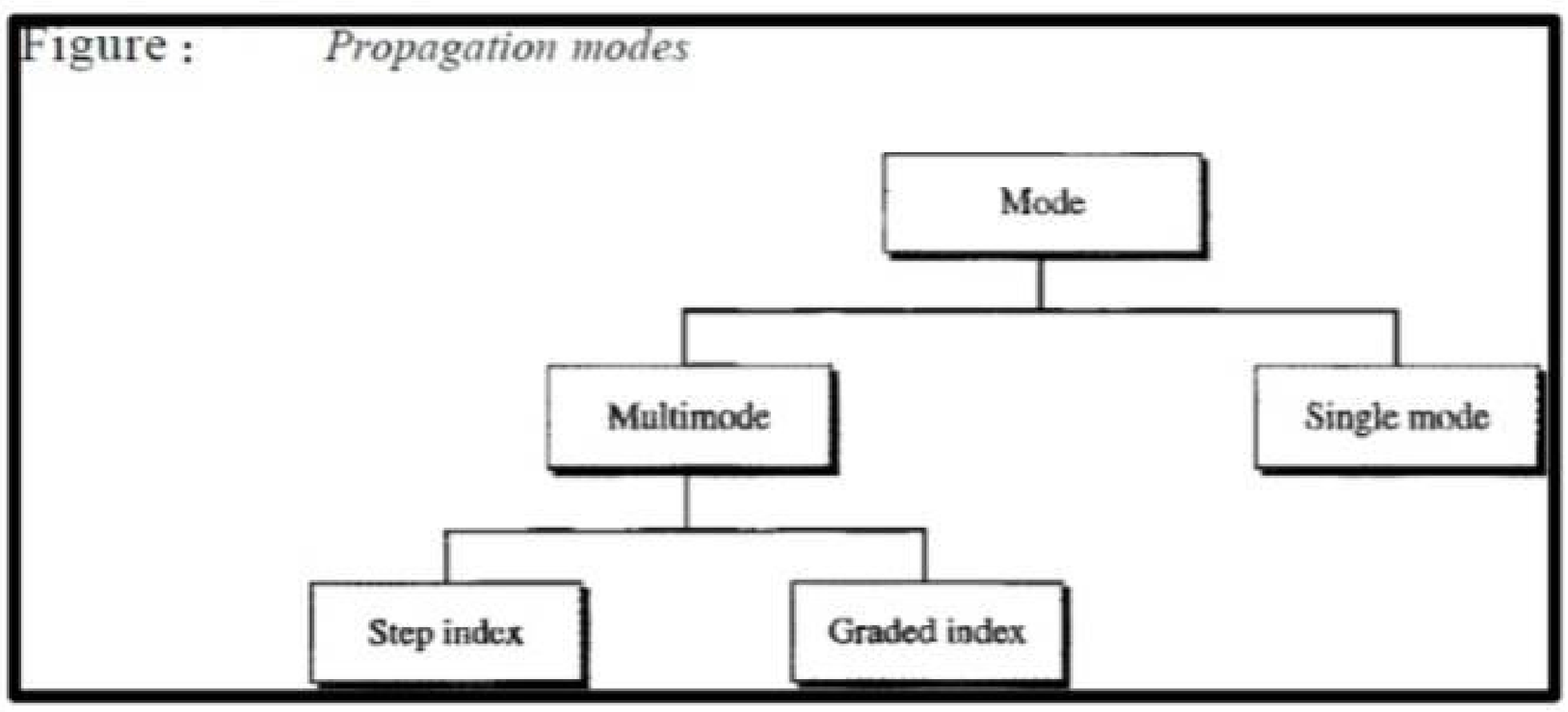
It uses the concept of reflection of light through a core made up of glass or plastic. The core is surrounded by a less dense glass or plastic covering called the cladding. It is used for transmission of large volumes of data. The difference in density of the two materials must be such that a beam of light moving through the core is reflected off the cladding instead of being refracted into it.



Propagation Modes in Optical Fiber

Current technology supports two modes (multimode and single mode) for propagating light along optical channels, each requiring fiber with different physical characteristics. Multimode can be implemented in two forms: step-index or graded-index.

Figure : *Propagation modes*

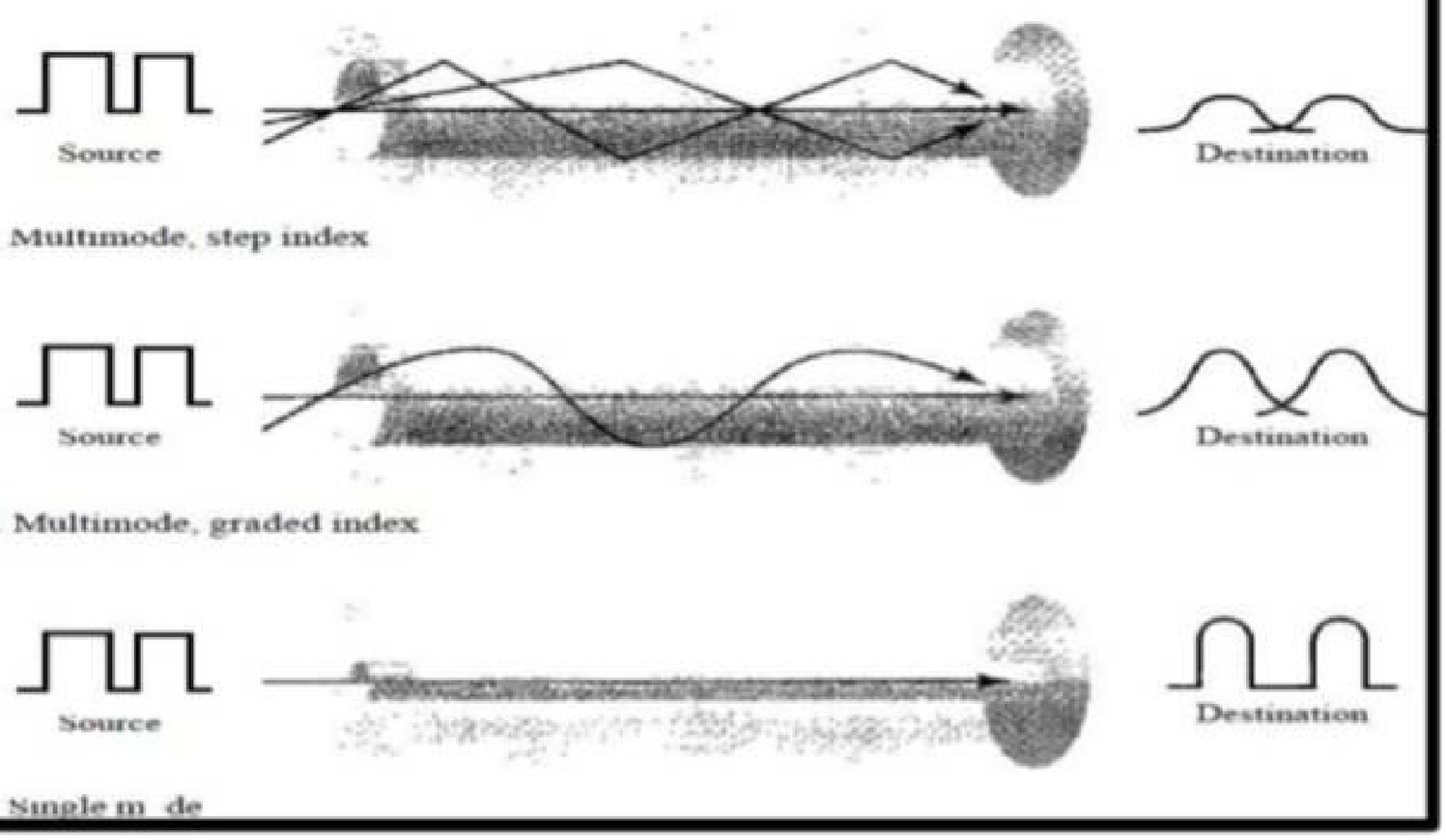


Multimode: Multimode is so named because multiple beams from a light source move through the core in different paths. **In multimode step-index fiber**, the density of the core remains constant from the center to the edges. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding. At the interface, there is an abrupt change due to a lower density; this alters the angle of the beam's motion. The term *step index* refers to the suddenness of this change, which contributes to the distortion of the signal as it passes through the fiber.

A second type of fiber, called multimode graded-index fiber, decreases this distortion of the signal through the cable. The word *index* here refers to the index of refraction. As we saw above, the index of refraction is related to density. A graded-index fiber, therefore, is one with varying densities. Density is highest at the center of the core and decreases gradually to its lowest at the edge.

Single-Mode: Single-mode uses step-index fiber and a highly focused source of light that limits beams to a small range of angles, all close to the horizontal. The single – mode fiber itself is manufactured with a much smaller diameter than that of multimode fiber, and with substantially lower density (index of refraction). The decrease in density results in a critical angle that is close enough to 90° to make the propagation of beams almost horizontal. In this case, propagation of different beams is almost identical, and delays are negligible. All the beams arrive at the destination "together" and can be recombined with little distortion to the signal.

Figure : *Modes*



Advantages:

- Increased capacity and bandwidth
- Light weight
- Less signal attenuation
- Immunity to electromagnetic interference
- Resistance to corrosive materials

Disadvantages:

- Difficult to install and maintain
- High cost
- Fragile
- unidirectional, i.e., will need another fibre, if we need bidirectional communication

Unguided Media:-

It is also referred to as Wireless or unbounded transmission media. No physical medium is required for the transmission of electromagnetic signals.

Features:

- Signal is broadcasted through air
- Less Secure
- Used for larger distances

There are 3 major types of Unguided Media:

(i) Radiowaves –

Radio waves are used for multicast communications, such as radio and television, and paging systems. They can penetrate through walls. Highly regulated. Use omni directional antennas
These are easy to generate and can penetrate through buildings. The sending and receiving antennas need not be aligned. Frequency Range: 3 KHz – 1GHz. AM and FM radios and cordless phones use Radiowaves for transmission.

Further Categorized as (i) Terrestrial and (ii) Satellite.

(ii) Microwaves –

Microwaves are used for unicast communication such as cellular telephones, satellite networks, and wireless LANs. Higher frequency ranges cannot penetrate walls. Use directional antennas - point to point line of sight communications.
It is a line of sight transmission i.e. the sending and receiving antennas need to be properly aligned with each other. The distance covered by the signal is directly proportional to the height of the antenna. Frequency Range: 1 GHz – 300GHz. These are majorly used for mobile phone communication and television distribution.

(iii) Infrared –

Infrared waves are used for very short distance communication. They cannot penetrate through obstacles. This prevents interference between systems. Frequency Range: 300 GHz – 400THz. It is used in TV remotes, wireless mouse, keyboard, printer, etc