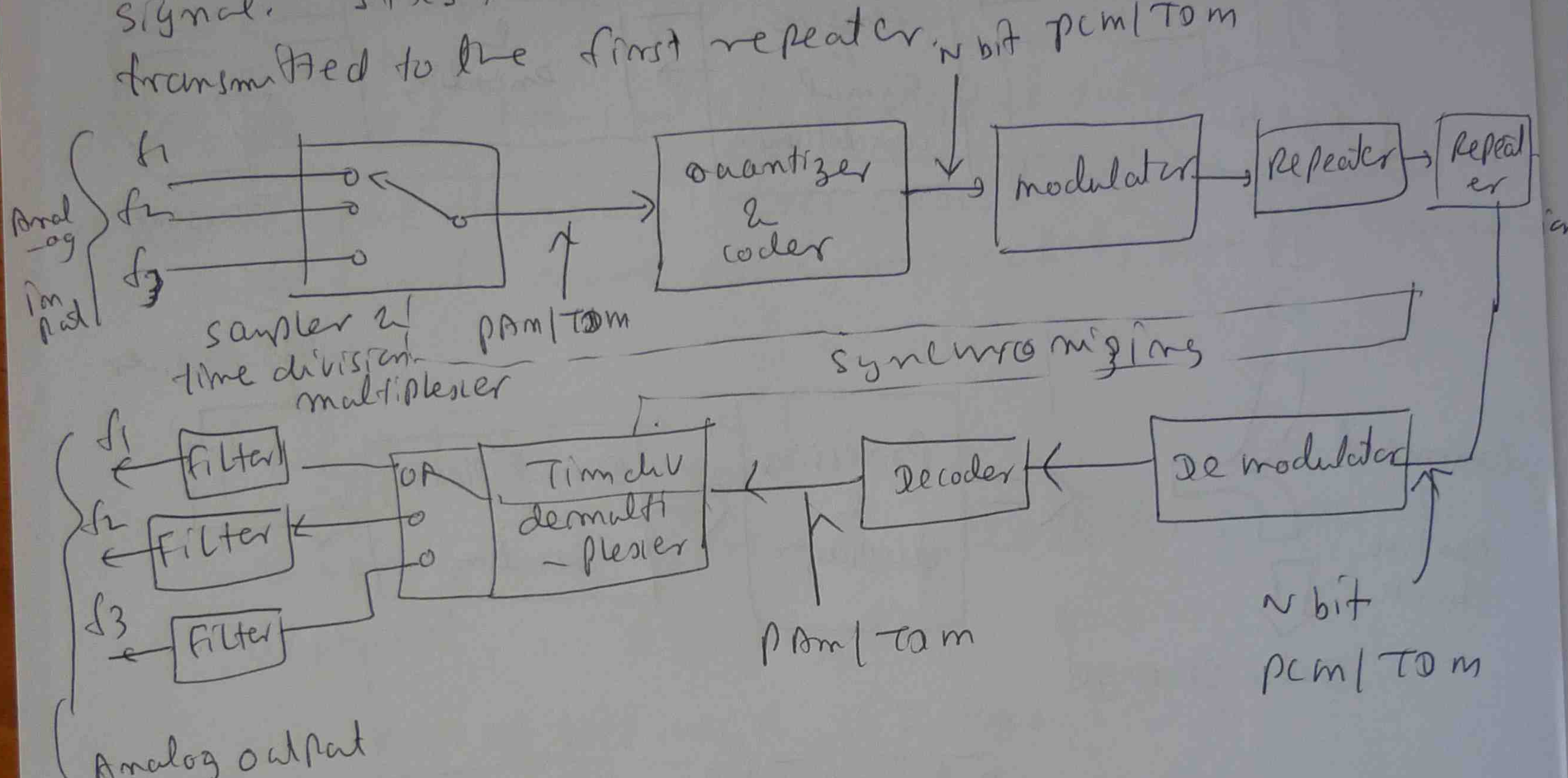
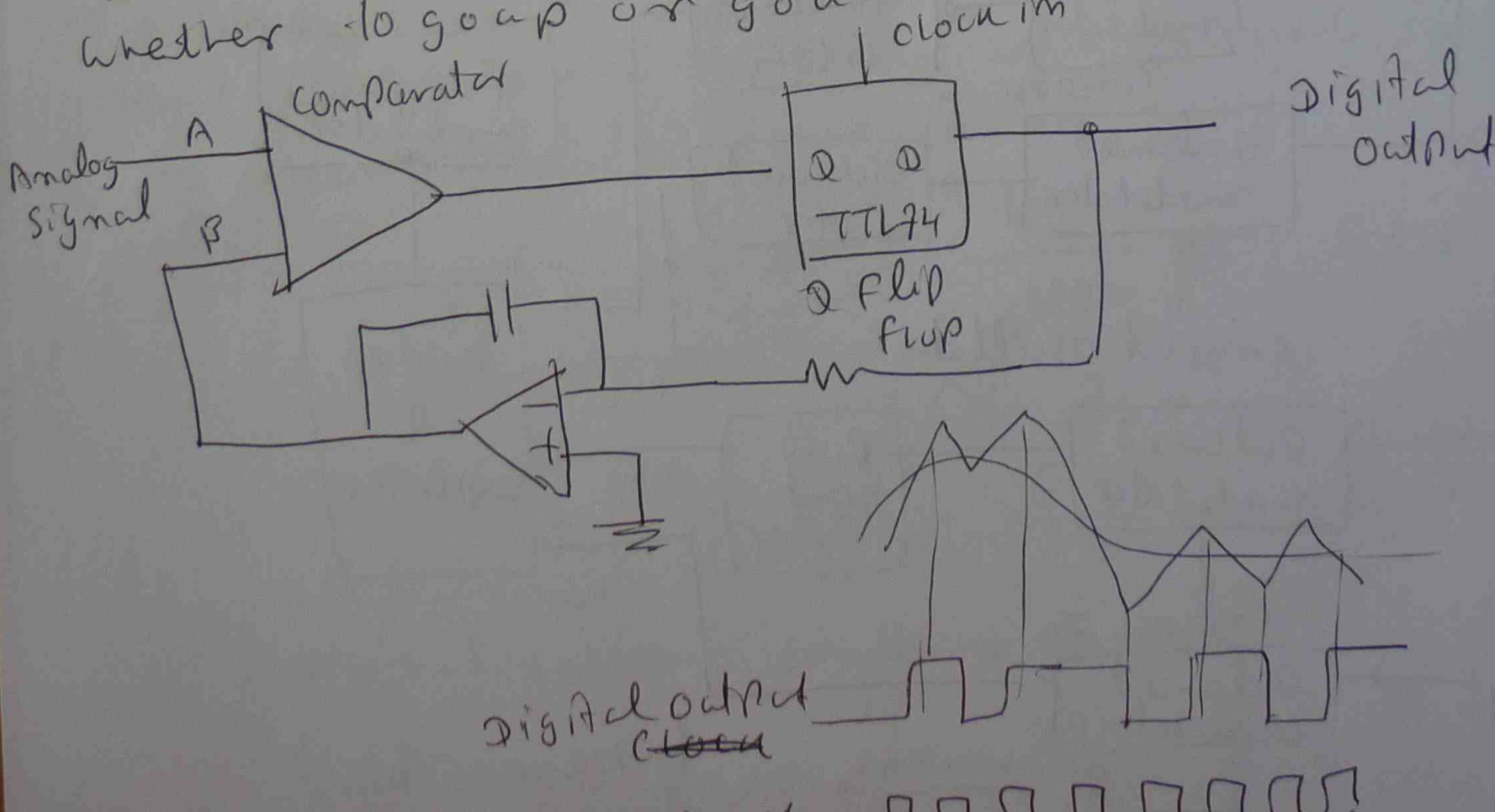
PCM | TDM Repeaters

TDM sampler initially creates a PAM signal that is then quantized into an n bit PCM/TDM signal. It is then modulated onto a carrier and transmitted to the first repeater.

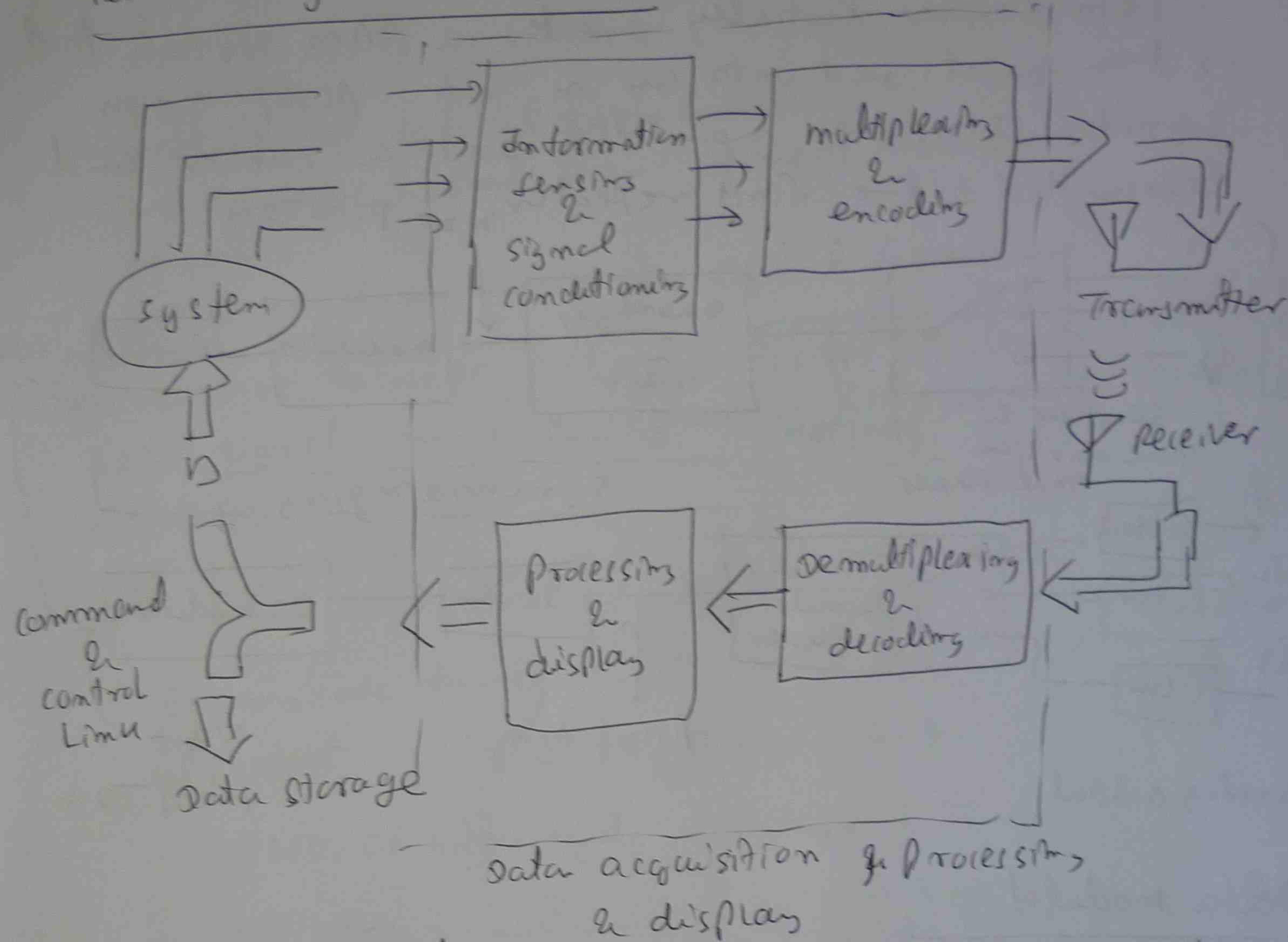


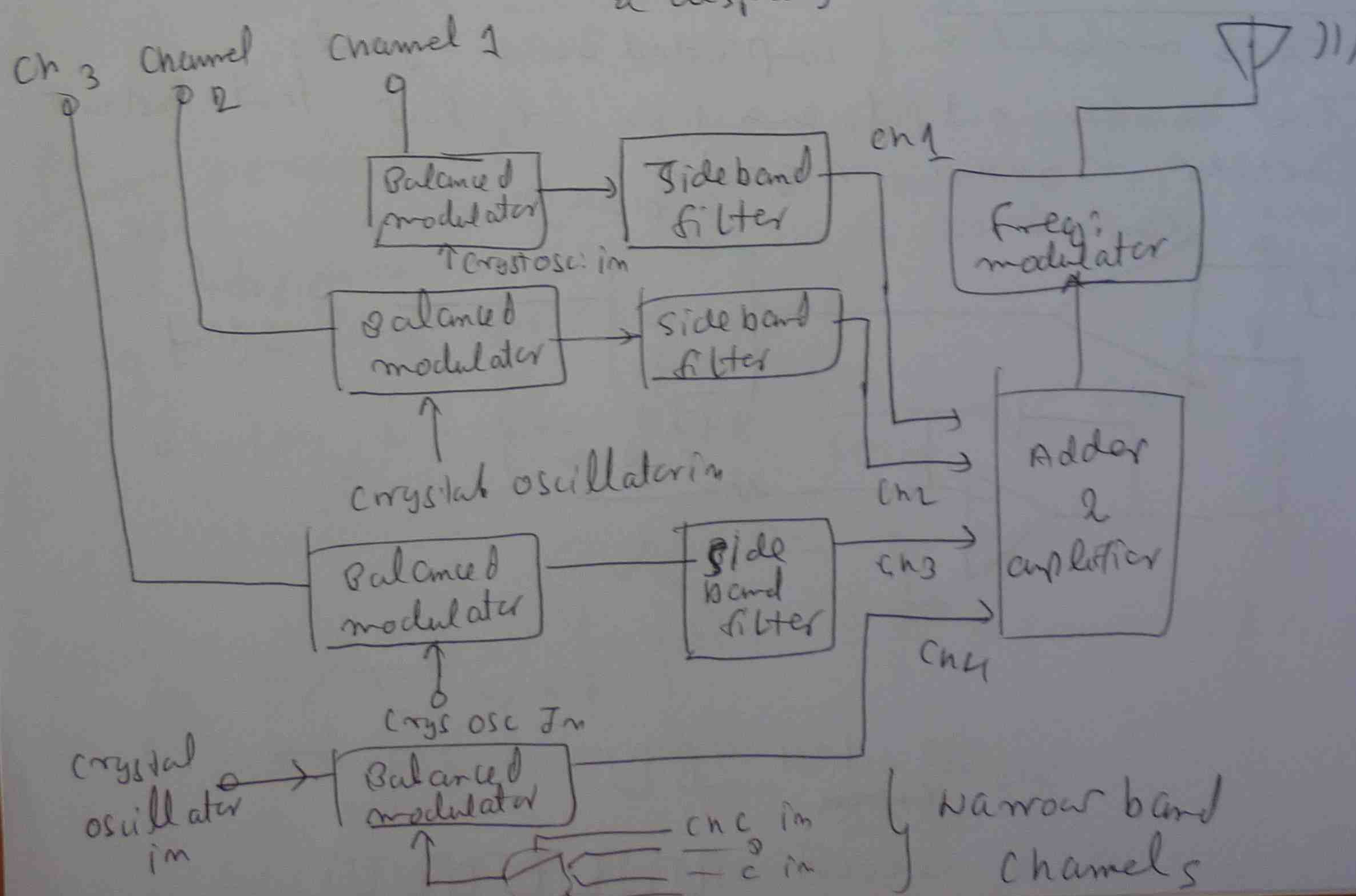
Delta modulation

Slope modulation. | companded voice signals.
The encoder outputs are high or low that instruct whether to go up or go down.



Telementry Block diagram

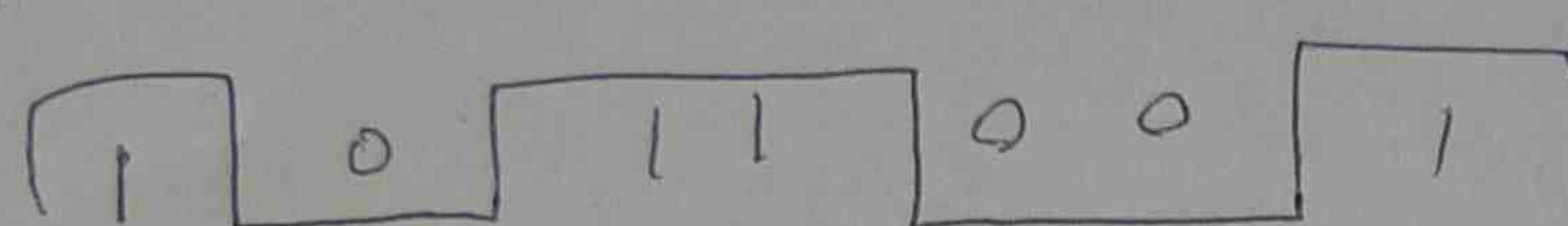




Coding

Earliest form of electrical communication.
send message rather than direct transmission of voice.
coded speed transmitted in digital format

Less sensitive to noise, Less cross talk, lower distortion
faded signals more easily recreated, Greater transmission efficiency.



Binary code to represent 26 letters in alphabet

$$B = \log_2 26 = 4.7$$

No. of bits reqd (Integer) $\simeq 5$

$$\text{Efficiency} = \frac{B}{Bit} \times 100 = \frac{4.7}{5} \times 100 = 94\%$$

Pb — Determine the number of bits required for a binary code to represent 110 different possibilities and compare its efficiency with decimal system to accomplish the same goal.

$$B = \log_2 N = \log_2 110 = \frac{\log 110}{\log 2} = 6.78$$

$$Bit \simeq 7$$

$$\mu = \frac{B}{Bit} \times 100 = \frac{6.78}{7} \times 100 = 97\%$$

Decimal system $\log_{10} 110 = 2.04$

$$Bit \simeq 3$$

$$\mu = \frac{B}{Bit} \times 100 = \frac{2.04}{3} \times 100 \simeq 68\%$$

Pb A digital transmission has an error probability of 10^{-4} and is 10^{8} bits long. Calculate the expected number of error bits.

$$\text{Average number of errors} = \overset{\text{Bit long}}{m} \times \text{error probability}$$

$$= 10^{8} \times 10^{-4}$$

$$= 10^{4} = 10000$$

$$\boxed{C = BW \log_2 \left(1 + \frac{S}{N}\right)}$$

C = channel capacity (b/s)
BW = Bandwidth (Hz)
S/N = Signal to noise power ratio.

Pb Calculate the capacity of a telephone channel that has a S/N of 1023.

Phone BW = ~~3 Hz~~ 3 kHz

$$C = BW \log_2 \left(1 + \frac{S}{N}\right)$$

$$= 3 \times 10^{3} \log_2 (1 + 1023)$$

$$= 3 \times 10^{3} \times 10 = 30{,}000 \text{ bits.}$$

Code Noise Immunity

Error occurs as a result of noise

Average number of errors = m x error probability

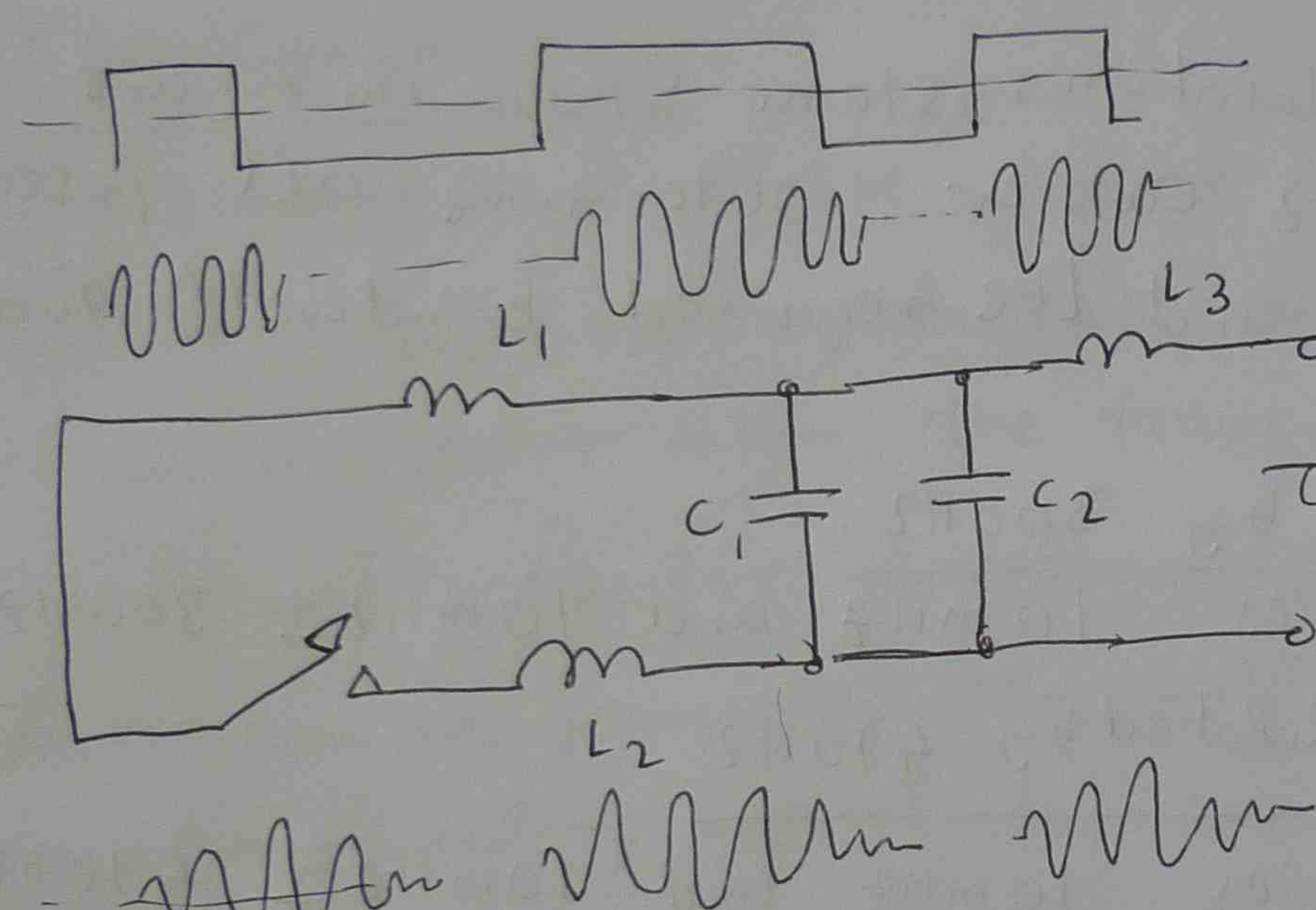
Error probability in digital system is the number of errors per total number of bits received.

Binary coding system has superior noise immunity.

Week (11) Code Transmission

The most elementary form of transmitting highs and lows is to simply key a transmitter's carrier on and off. The carrier is conveying intelligence by simply turning it on or off according to a pre-arranged code. This type of transmission is called continuous wave (C.W). The wave is periodically interrupted (Interrupted continuous wave ICW).

CW is Am. It suffers from noise to a much greater extent than Fm systems.



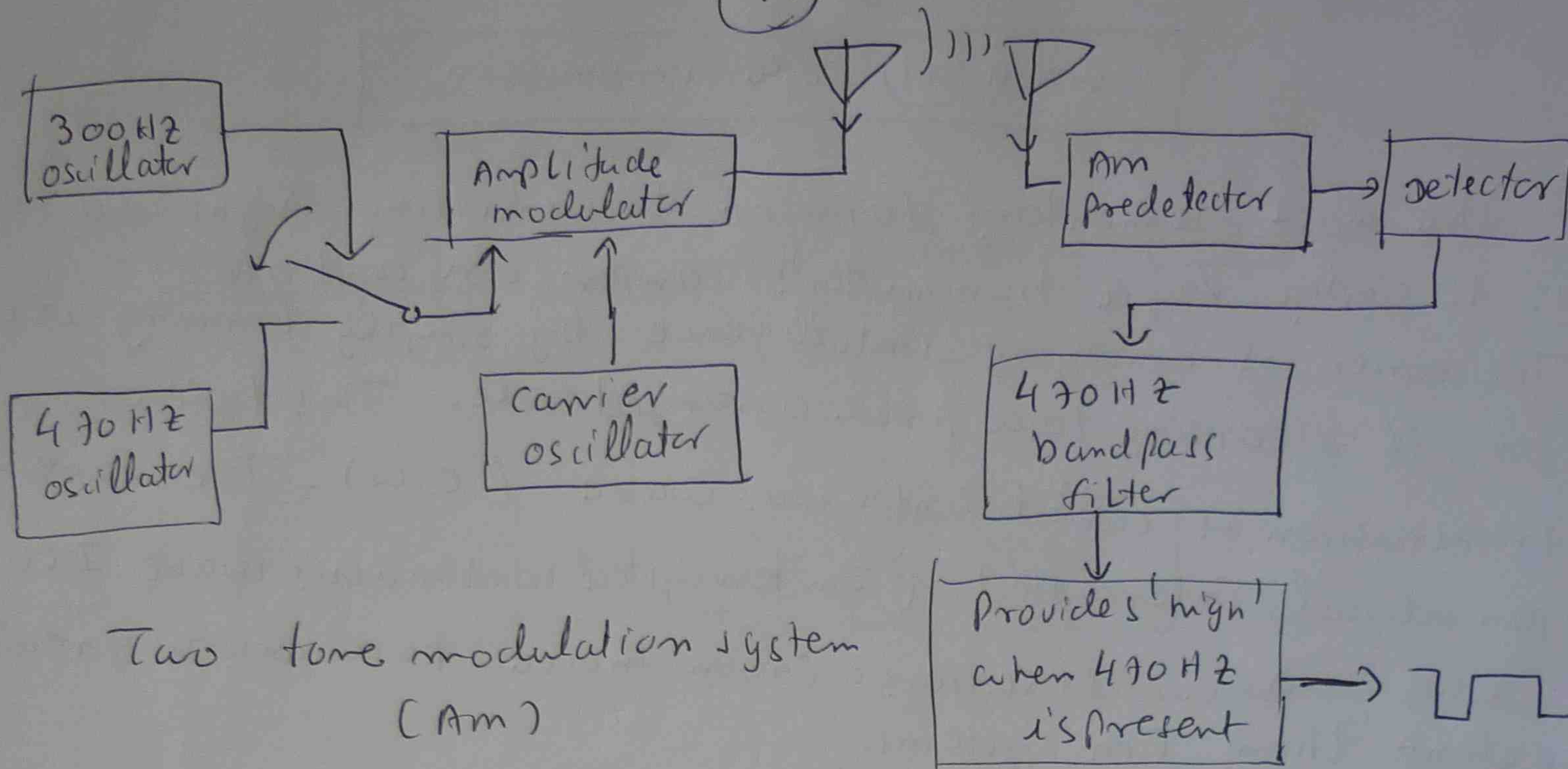
To keyed circuit

keying filter and resulting waveforms

Two tone modulation

Two tone modulation is also a form of Am, but ~~I~~ in it the carrier is always transmitted. Instead of simply turning the carrier on and off, the carrier is amplitude modulated by two different frequencies representing either mark (or) space. The two frequencies are usually separated by 170 Hz.

When transmitter is keyed, the carrier is moduated by a 470 Hz signal, while it is modulated by a 300 Hz signal for the space condition. At the receiver, after detection, either 300 (or) 470 Hz signals are present.



Two tone modulation system (Am)

pb The two tone modulation system shown in figure operates with a 10 MHZ carrier. Determine all possible transmitted frequencies and the required bandwidth for this system.

When carrier is modulated by 300 HZ.

The output frequencies 10 MHZ and 10 MHZ ± 300 HZ

when the carrier is modulated by 470 HZ

output frequencies 10 MHZ and 10 MHZ ± 470 HZ

Bandwidth = 470 HZ × 2 = 940 HZ

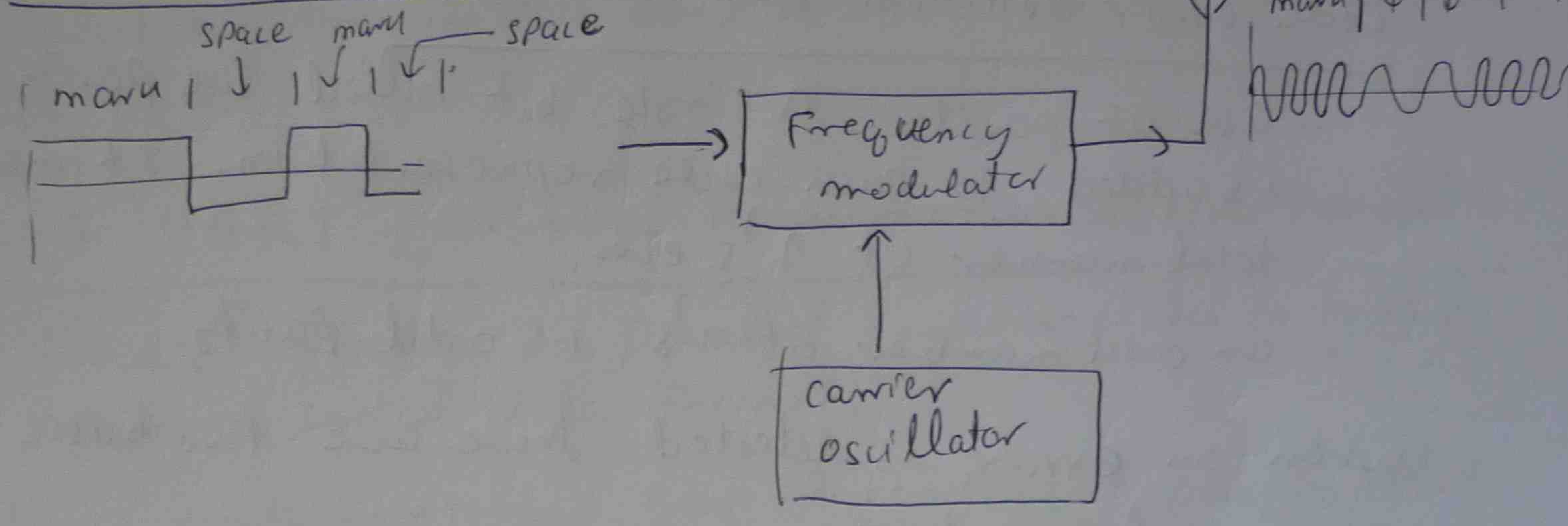
1 KHZ channel will be adequate.

Frequency Shift keying (FSK)

Frequency shift keying is a form of frequency modulation in which the modulating wave shifts the output between two pre-determined frequencies — usually termed the mark and space frequencies.

- 85 HZ shift is the standard for narrow band FSK
- 850 HZ shift is the standard for wide band FSK

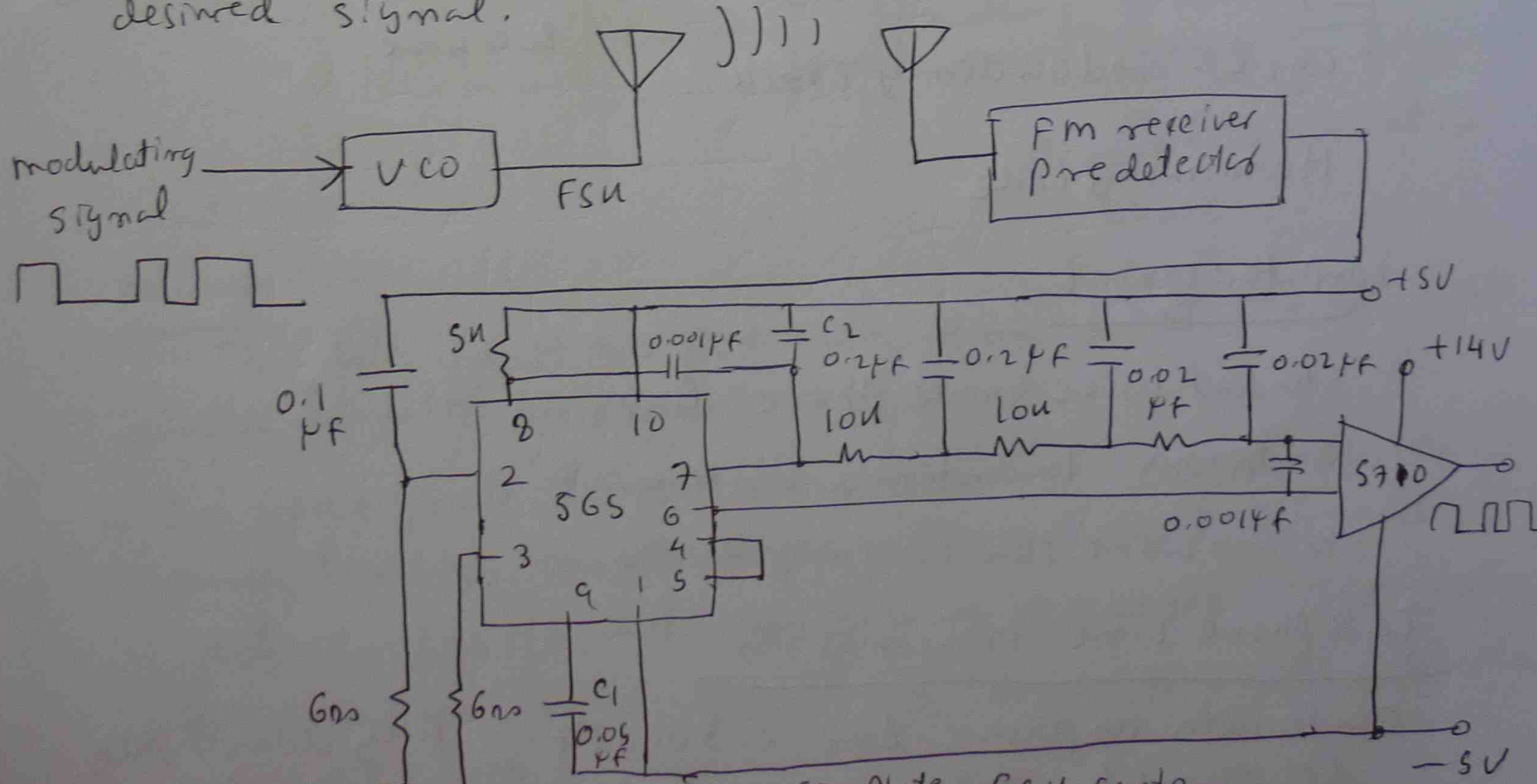
FSK Transmitter



FSK transmitter

FSK Generation

- The generation of FSK can be easily accomplished by switching an additional capacitor into the tank circuit of an oscillator when the transmitter is keyed.
- Shunting capacitor across crystal.
- FSK can be generated by applying the rectangular wave modulating signal to VCO. VCO output is desired signal.



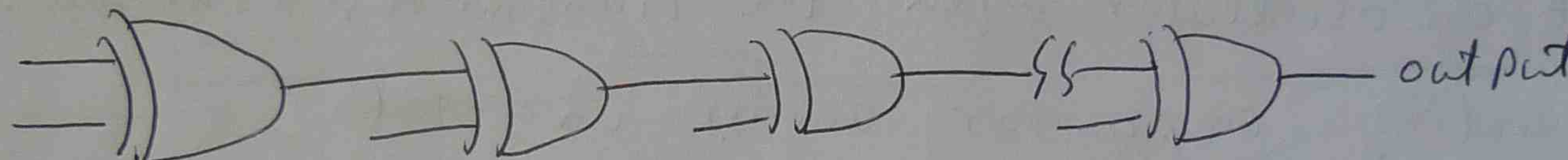
complete FSK system

Code error detection and correction

- use of parity. A single bit called the parity bit is added to each code representation. It makes total number of 1's even,
- an odd number of 1's is odd parity

When an error is detected there are two basic system alternatives.

1. An automatic request for retransmission
2. Display of an unused symbol for the character with a parity error. called symbol substitution



other methods

Block Check character - High data rate 2400 b/s & above.

cyclic redundancy check

Hamming code

computer control

Standard voice grade phone lines.

antenna to antenna system

microwave carrier frequencies.

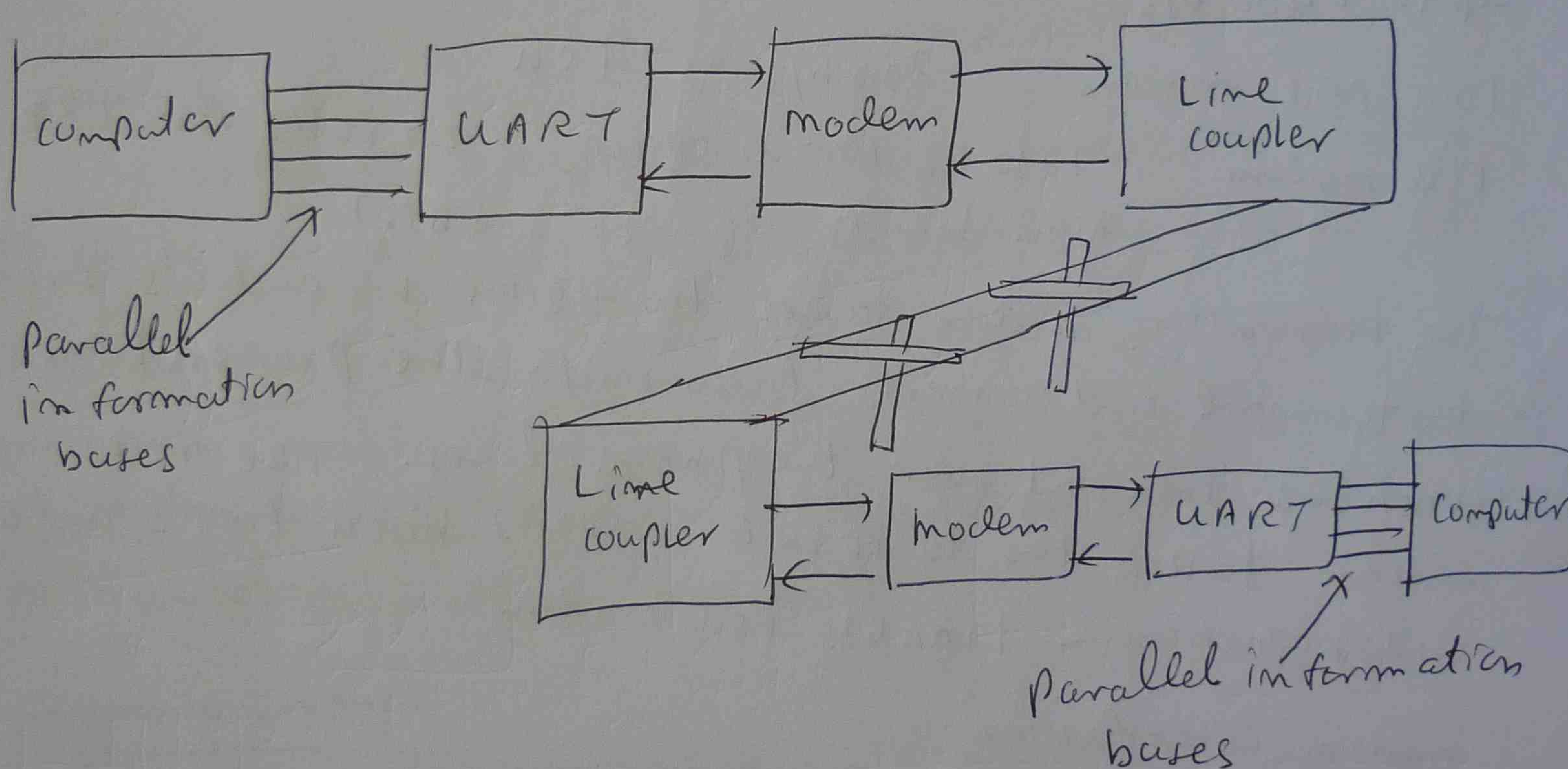
Telephone line Transmission

Bandwidth of phone line - 3000 Hz, they donot pass dc. The data to be transmitted are often parallel data from a number of lines in a computer and therefore cannot be transmitted over a two wire transmission line.

LSI UART (Universal Asynchronous Receiver Transmitter)

UART converts the parallel computer data into the required serial data format.

- Logic mode control / stop bit control / parity select control, pin disable transmission, select the desired character length, clock oscillator, Holding register,



modem

The data must be put in a form that can be sent over a limited bandwidth line.

- In voice grade lines transformers, carrier systems, and loading considerations attenuate all signals below 300 Hz and ~~34~~ above 3400 Hz. The data are connected into the phone via acoustic coupler or direct wiring.

While the bandwidth from 300 to 3400 Hz is suitable for voice transmission, it is not appropriate for digital data transmission since pulse signals have many components outside this range.

To transmit data via phone lines require a conversion into a signal totally within the range 300 to 3400 Hz. This conversion is performed by a modem (modulator / demodulator)

In Full duplex data transmission, frequency-division multiplexing (FDM) can be used for data rates up to 2400 b/s.

Low speed modem - 300 b/s FSK

FSK modem - 1070 Hz for 0 space, 2225 Hz for 1 in high band. (upto 600 b/s)

The transmitting modem takes the digital 1's and 0's from the terminal and converts them into the proper tones which are then sent over the phone lines. The receiving modem takes the tones and converts back to 1's and 0's.

wider spectrum - 1200 b/s FSK modem

<u>modem interfacing</u>

RS232C uses 25 wire cable / connection used for transmitting digital data & control signals.

<u>Low speed modem</u>

Full duplex mode, line hybrid transformer.

<u>medium speed modem</u>

Carrier frequency 2400 Hz, 1200 Hz for sending & receiving signal.

SC11004 modem.

Data communication networks

Protocol

Rule to control the process. Hand shaking.

Framing

Data are normally transmitted in blocks. Framing function deals with the separation of block into the information (text) and control sections. A maximum block size is dicated by the protocol. Each block normall contain control information such as address field.

Block character checker (BCC) for detection

Line control

Line control is the procedure used to decide which device has permission to transmit at any given time.

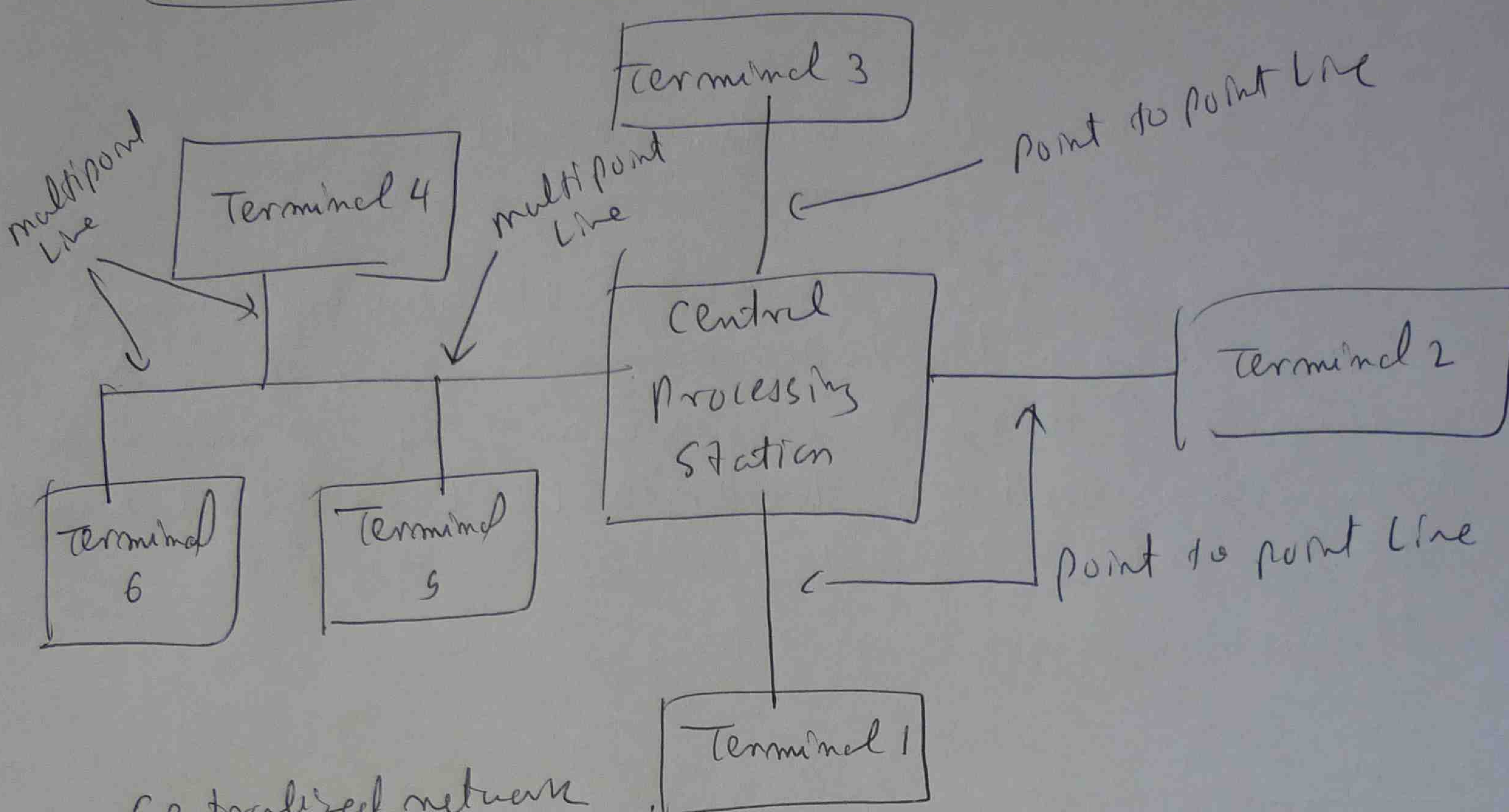
Flow control

There is a limit on rate with which a receiving device can accept the data. The protocol process used to monitor 2 control these rates

Sequence control

A message must pass through numerous links before it reaches it's final destination. Sequence control keeps message blocks from being lost or duplicated and ensures that they are received in the proper sequence.

Network organisation



Centralised network

Switching of data

circuit switching — dedicate line for entire communication

message switching — send a message to a switching center, where it is forwarded and stored.

The data is forwarded when next ckt is available

packet switching

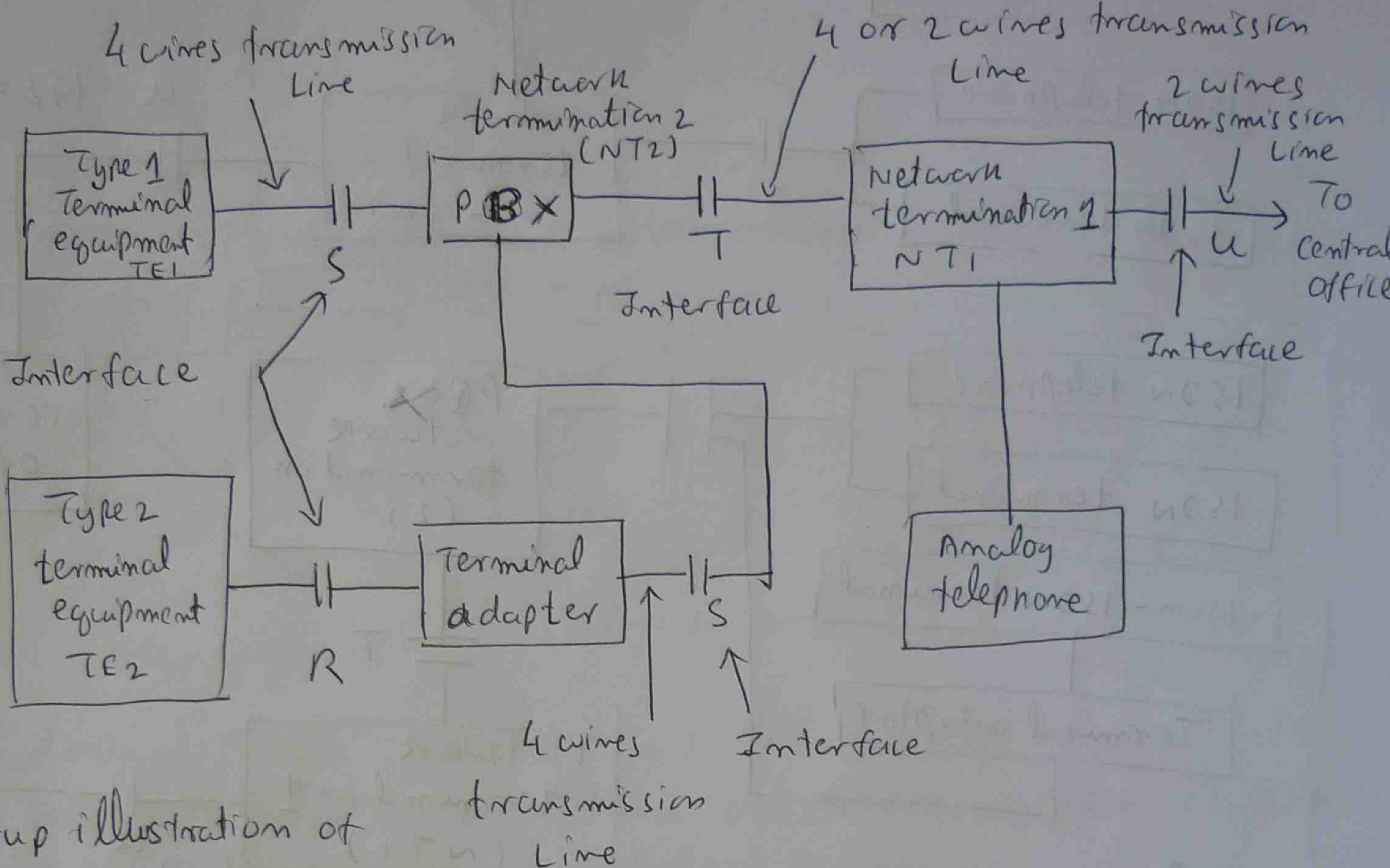
Data are divided up into small segment of size 1000 bit.

They are held for very short period at switching center. & then transmitted in near real time.

Each packet switches.

Week 12 ISDN

ISDN - Integrated Services Digital Network



ISDN setup illustration of R, S and T Interface

TE1 equipment - Digital telephones and terminals comply with ISDN

TE2 equipments - Not compatible with ISDN specifications.
It needs a terminal adapter to change the data to ISDN 64Kb/s B channel rate.

TE2 equipments interfaces the network via R reference point.

NT1 - Telephone company network termination

NT2 - Local area Network, Public Branch Exchange (PBX)

customer ties NT1 point with S interface

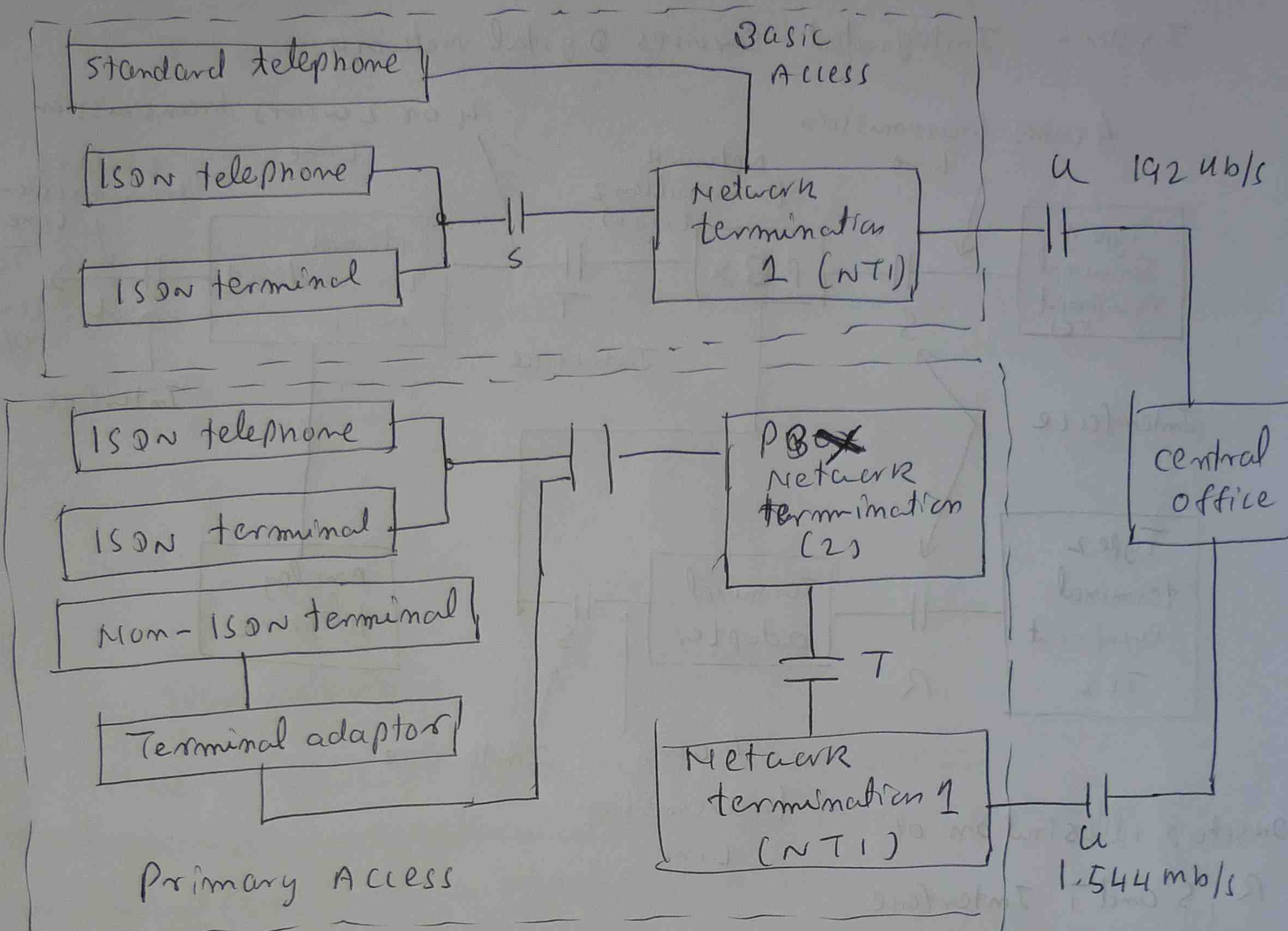
NT2 interfaces with T interface to ISDN

ISDN specifications - Two B channels & one D channel

B channel operates at 64 Kb/s, D Channel 16Kb/s

B channel — voice & data, D channel — signaling.

Basic and primary access ISDN systems



Basic Access - 192 kb/s - Serve small installations

Primary Access - Total overall data rate 1.544 mb/s
Serve installations with large data rates.

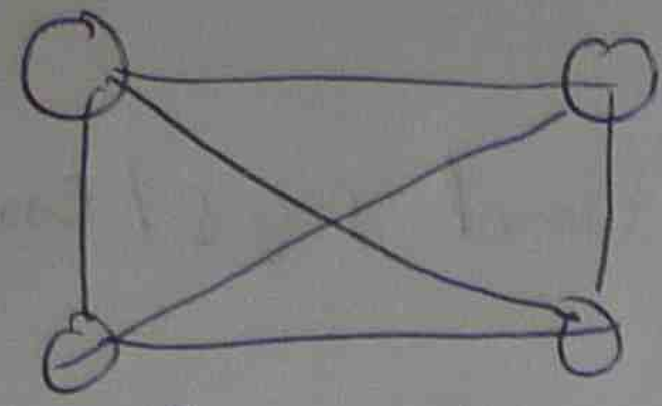
This channel contains 23 64kb/s B channels + 64kb/s D channel

Local Area Networks

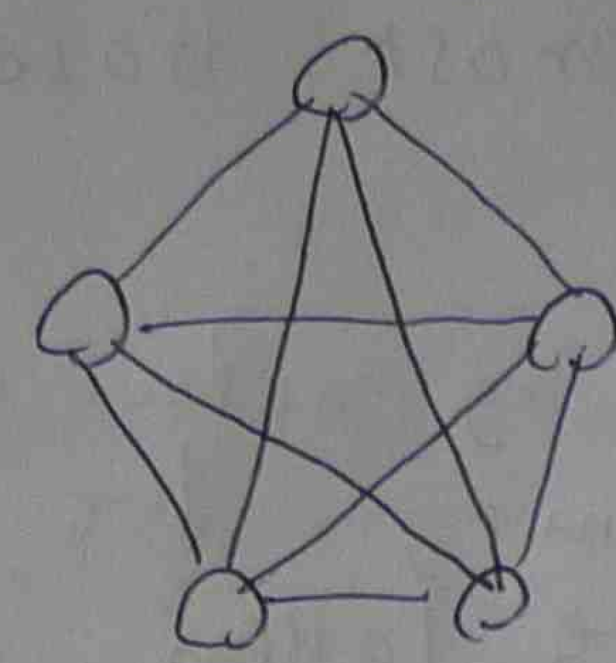
Interconnected locally distributed computer networks.

System (1) Tie each system through a modem into the organization's telephone system (PBX). This does not allow one system to talk to a number (or all) of other systems simultaneously.

System (2) For small organizations, connect each system to others with cables.



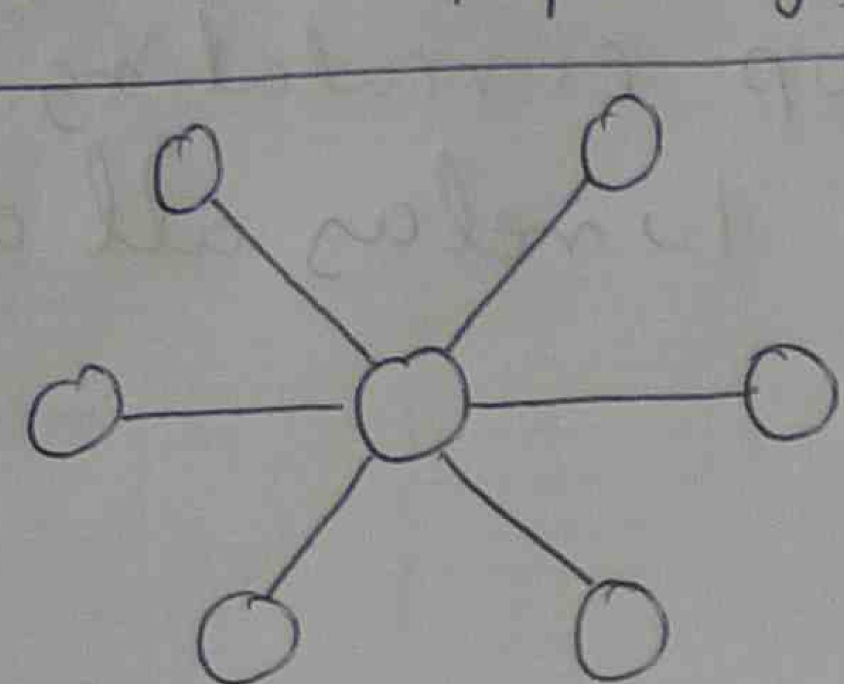
4 systems



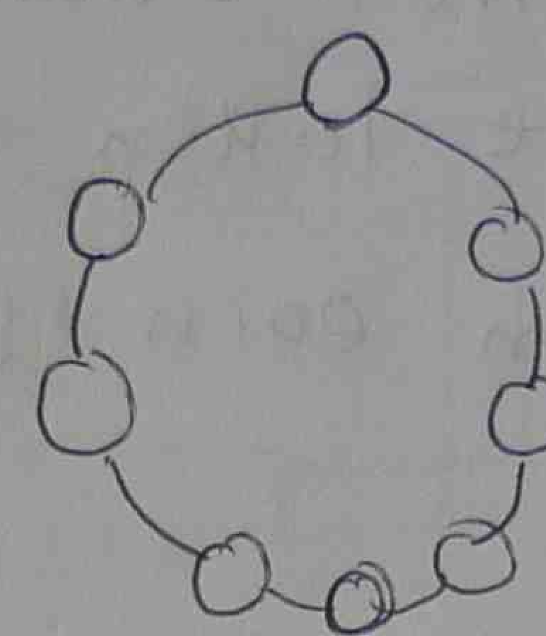
5 systems.

"n" system → (n − 1) additional interconnection becomes necessary.

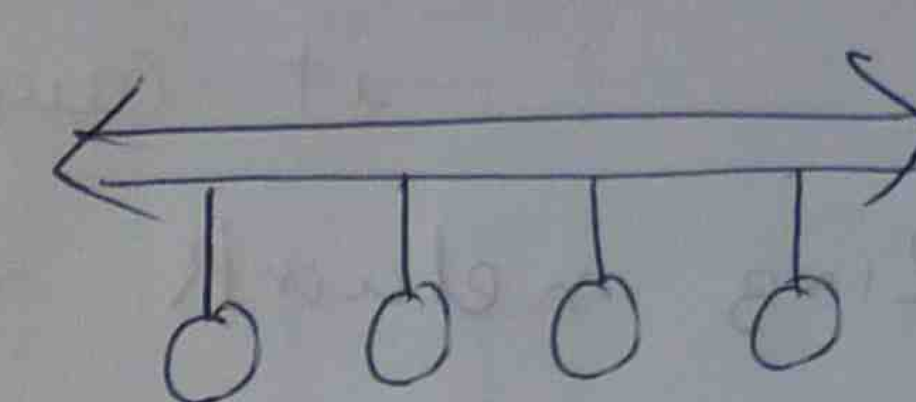
Network topology



Star network



Ring Network



Bus Network

Cable – 50Ω coaxial (or) fibre optics.

The transmission of information on these system is via base band (or) via a modulation scheme.

Base band - A system where the digital signals are placed directly on the coaxial cable.

Example – Transmission of voice at base frequency.

Broad band - If the base band is used to modulate a carrier, it is referred to as a broad band system. This permits multiplexing different frequency channels (FDM) and allows digital data and voice/video signals to be transmitted simultaneously.

Channel access use

A user gets control of the channel so as to allow transmission. Carrier sense/multiple access with collision detection (CSMA/CD) & token passing

CSMA/CD is used by most base band systems.

Token - passing technique

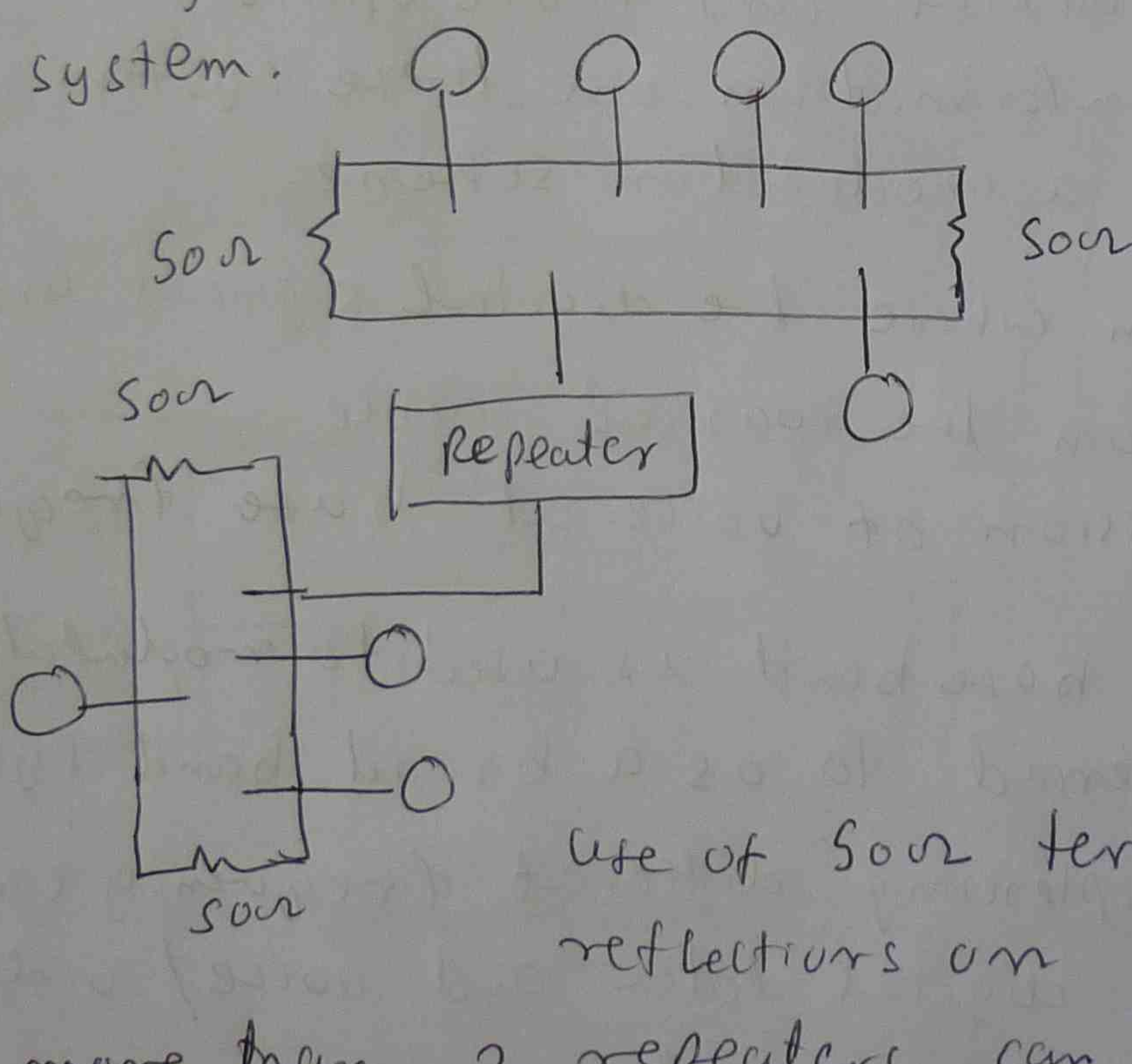
- well suited to the ring network topology.
If user wish to transmit, the station must wait until possession of the token exists.
- Each station is assured of access for transmission of its messages. (Advantage)

Disadvantage - If an error changes the token pattern, it causes the token to stop circulating.

Ring network rely on each system to relay all data to next user.

Ethernet LAN

Base band, bus topology CSMA/CD local area network system.



Each segment can be up to 500m long & can contain a maximum of 100 stations.

use of 50Ω terminators to prevent reflections on 50Ω coaxial cable.

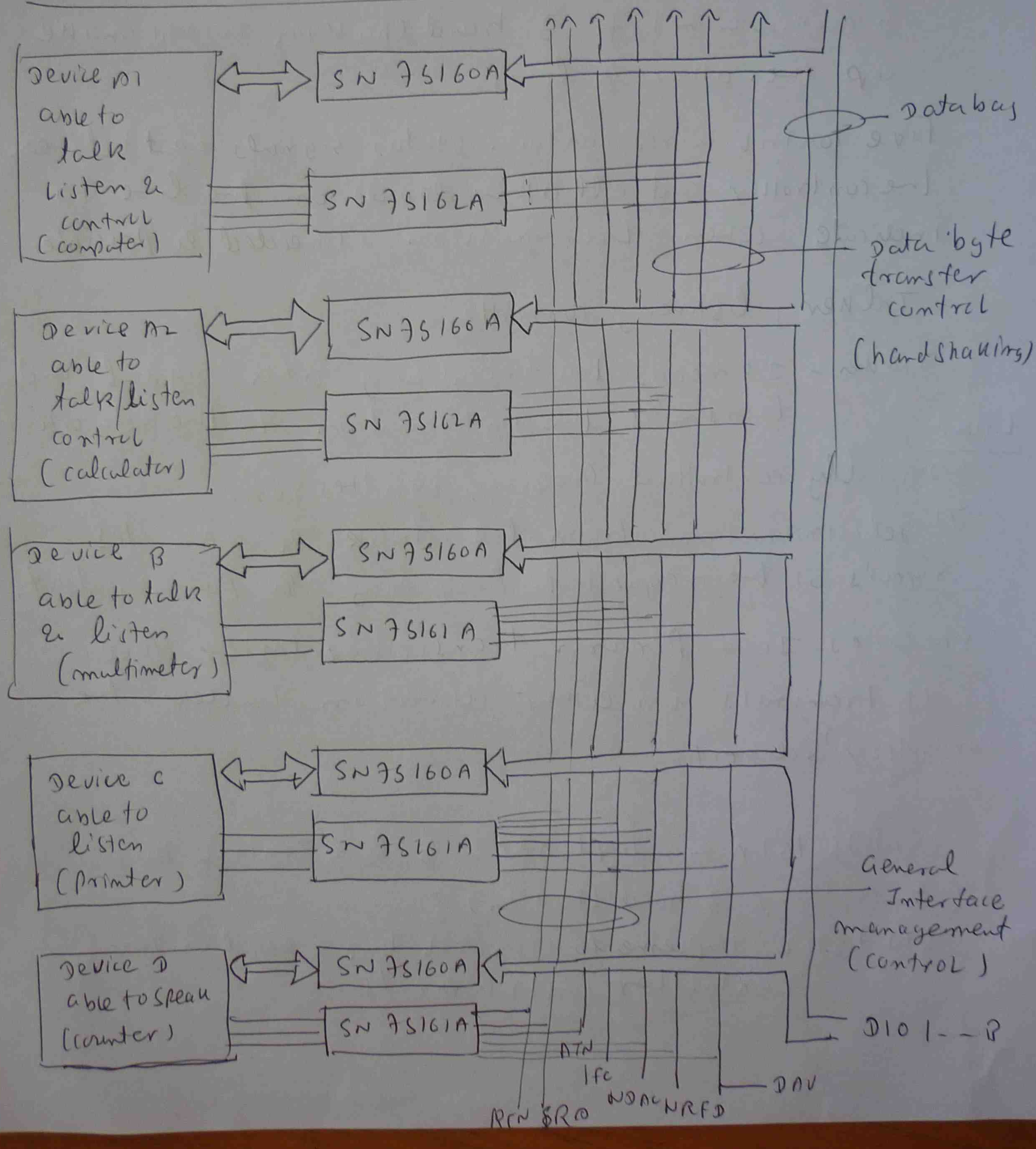
no more than 2 repeaters can exist between two stations

- Two LSI circuits are usually used.
(1) Local area network controller for Ethernet (LANCE) (48 pin microprogrammed intelligence device - 11R - serial / serial - 11R data conversion)
(2) serial interface adapter (SIA)

LANCE — CSMA / CD channel management
— Data packetization.

SIA 20MHz crystal control oscillator supplies 10MHz clock signal to synchronize data transfer.

IEEE 488 General Purpose Interface Bus (GPIB)



GPIB – upto 15 → 20 stations can be interconnected on line, 20m long

Data are carried asynchronously by 16 lines in bit parallel, byte-serial form, bi directionally.

8 lines carry data up to 1 mb/s.

5 control wires + 3 hand shaking wires make up the other 8 lines.

Five control wires contain status signals sent between the controller and all other devices on the line to indicate when transmission is needed & possible.

Talker, listener, controller.

Talker – It reads the frequency of a signal and transmits the information to the network.

Listener

Digitally controlled frequency synthesizer.

It gets instructions from the network & generates signals of the requested frequency & power output.

SN series IC – Perform transceiver interface.

It transmits in either direction under the controller's direction.

SN75161A – implement 8 line control bus.

(5 control, 3 hand shaking)

SN75162 implements control bus operation for controller instruments.

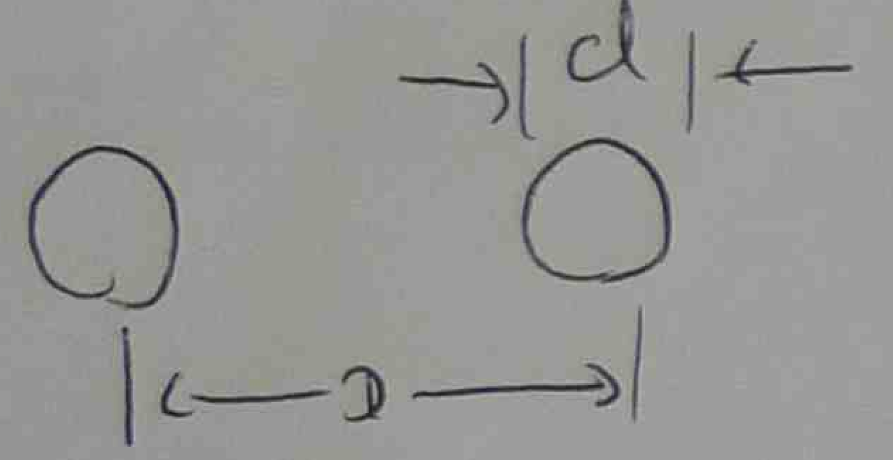
Week (13) - Transmission Lines

characteristics impedence $Z_0 = \sqrt{\frac{L}{C}}$

Pb (1) A commonly used coaxial cable RG 8A/U has a capacitance of 29.5 pF / ft and inductance of 73.75 nH / ft. Determine its characteristic impedence for a 1 ft section and for a length of 1 mile.

1 ft section $\quad Z_0 = \sqrt{\frac{L}{C}} = \sqrt{\frac{73.75 \times 10^{-9}}{29.5 \times 10^{-12}}} = 50\,\Omega$

1 mile section $\quad Z_0 = \sqrt{\frac{5280 \times 73.75 \times 10^{-9}}{5280 \times 29.5 \times 10^{-12}}} = 50\,\Omega$

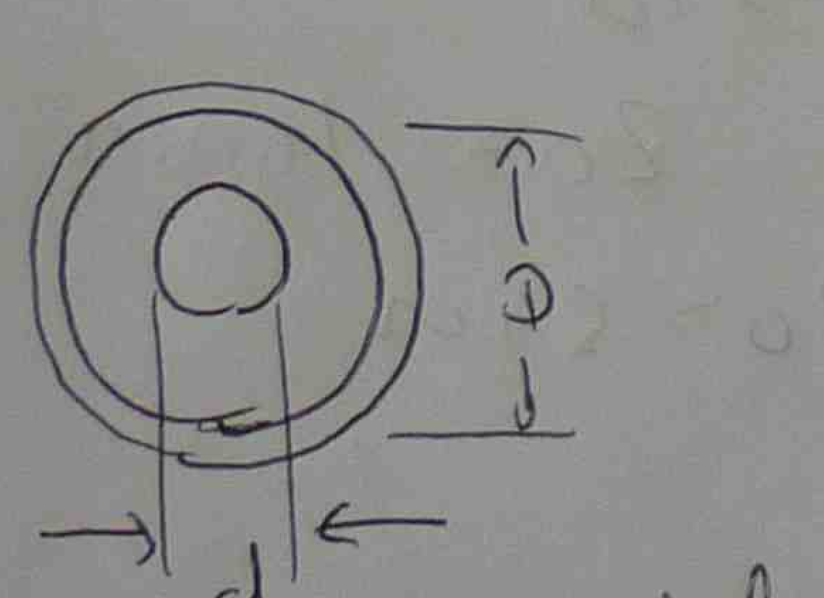


Parallel wires in air

$$Z_0 = 120 \cosh^{-1} \frac{D}{d}$$

for $D >> d$

$$Z_0 \simeq 276 \log_{10} \frac{2D}{d}$$



coaxial

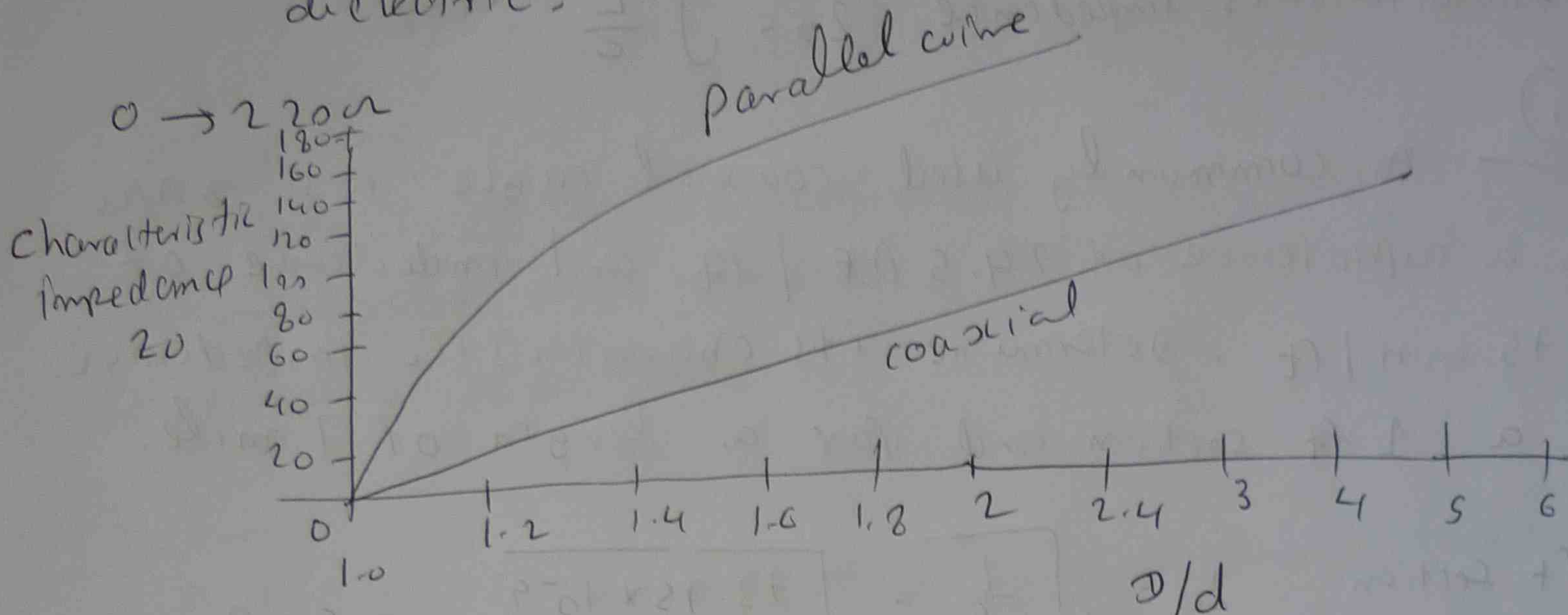
$$Z_0 = \frac{138}{\sqrt{\varepsilon}} \log_{10} \frac{D}{d}$$

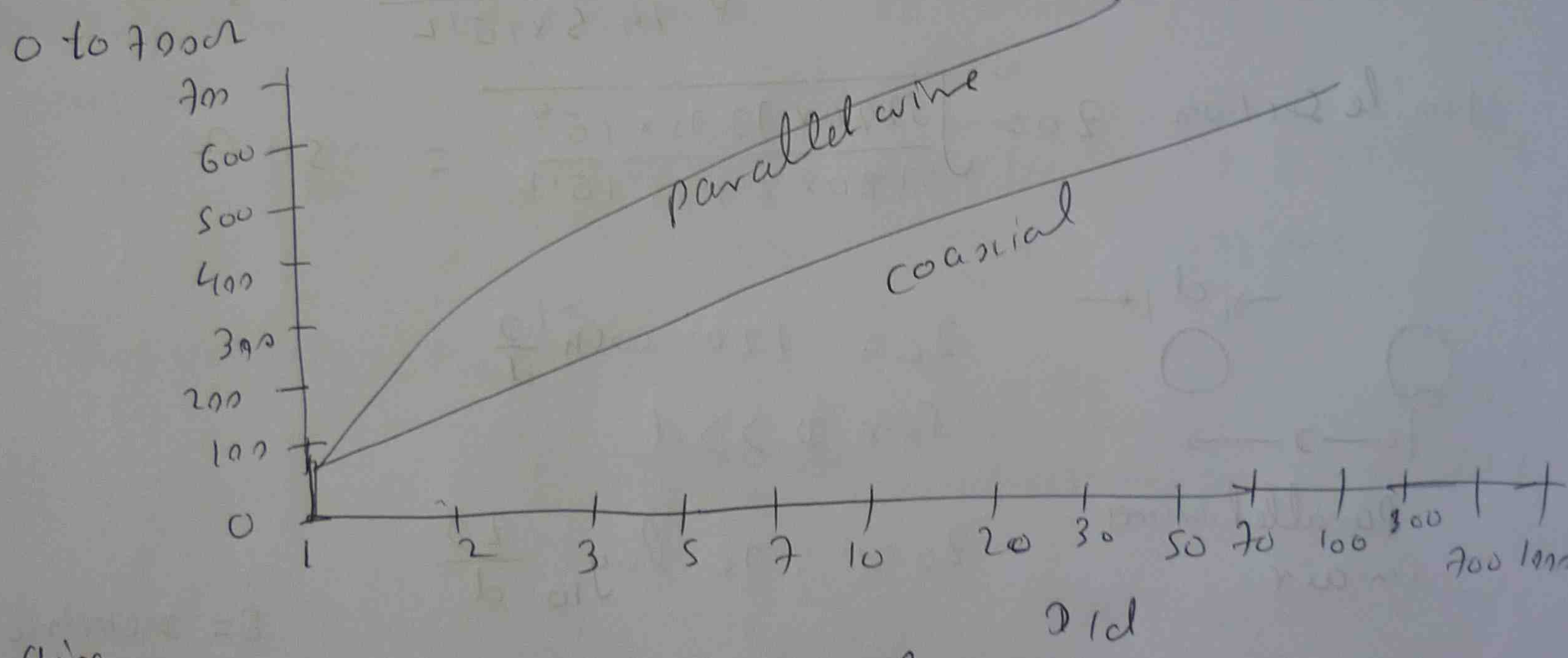
curve is for $\varepsilon = 1.00$

ε = Dielectric constant
D = Inner diameter of outer conductor
d = outer diameter of inner conductor

Pb 2 Determine the characteristic impedence of
(a) A parallel wire line with $D/d = 2$ with air dielectric
(b) An air dielectric coaxial line with $D/d = 2.35$

(c) RG 8A/u coaxial cable with $D = 0.285$ in and $d = 0.08$ in. It uses a polyethylene dielectric.





air

D/d ratio 2 for parallel wire line $Z_0 = 160\Omega$

D/d ratio 2.35 for coaxial line $Z_0 = 50\Omega$

For dielectric

$$Z_0 = \frac{138}{\sqrt{\varepsilon}} \log_{10} \frac{D}{d}$$

$$= \frac{138}{\sqrt{2.3}} \log_{10} \frac{0.285}{0.08} = 50\Omega$$

$t = \sqrt{LC}$

$V_p = \dfrac{D}{\sqrt{LC}}$

V_p = velocity propagation

D = Distance of travel

$\sqrt{LC}$ = time (t)

Delay line

velocity of electric wave through vacuum 3×10^8 m/s

A transmission line decreases the velocity due to its inductance & capacitance

Pb 3

Determine the amount of delay and the velocity of propagation introduced by a 1 ft section of RG 8A/u coaxial cable used as a delay line.

$t = \sqrt{LC} = \sqrt{73.75\times10^{-9}\times29.5\times10^{-12}} = 1.475\times10^{-9}$ s

(or) 1.475 ms

The velocity of Propagation

$V_p = \dfrac{D}{\sqrt{LC}} = \dfrac{1\text{ ft}}{1.475\text{ ms}} = 6.78\times10^{8}$ ft/s

(or) 2.07×10^{8} m/s

Velocity factor $V_f = \dfrac{1}{\sqrt{\varepsilon}}$

where V_f = velocity factor

ε = relative dielectric constant

Pb 4

Determine the velocity factor for RG 8A/u cable by using the velocity of propagation 2.07×10^{8} m/s.

$V_f = \dfrac{V_p}{3\times10^8} = \dfrac{2.07\times10^8}{3\times10^8} = 0.69$

(or) $V_f = \dfrac{1}{\sqrt{\varepsilon}} = \dfrac{1}{\sqrt{2.3}} = 0.66$

wave length =>

pb 5

Determine the wave length of a 100 MHz signal in free space and while travelling through an RG 8A/u coaxial cable.

In free space

wave velocity 3×10^8 m/s

$$\lambda = \frac{V}{f} = \frac{3 \times 10^8 \text{ m/s}}{1 \times 10^8 \text{ Hz}} = 3 \text{ m}$$

In RG-8A/u cable. velocity of propagation = 2.07×10^8 m/s

$$\lambda = \frac{V}{f} = \frac{2.07 \times 10^8 \text{ m/s}}{1 \times 10^8 \text{ Hz}} = 2.07 \text{ m}$$

Reflected | Incident | Standing wave ratio | VSWR |

Smith Chart ⟶ 4269T | 6042

From page (119)

pb Calculate the power received at satellite given the following conditions

1. The power gain of the transmitting parabolic dish antenna is 30,000
2. The transmitter drives 2 uW of power into antenna at carrier frequency 6.21 GHz
3. The satellite receiving antenna has power gain 30
4. The transmission path is 45000 km.

$$\left(\frac{P_R}{2uW}\right)_{dB} = 10 \log_{10} \text{power gain of antenna} + 10 \log_{10} \text{power gain} - \left(32.5 + 20 \log_{10} \text{Transmission path} + 20 \log_{10} \text{carrier freq}\right)$$

$$\left(\frac{P_{R1}}{2uW}\right)_{dB} = 10 \log_{10} 30{,}000 + 10 \log_{10} 30 - \left(32.5 + 20 \log_{10} 45000 + 20 \log_{10} 6210\right)_{dB}$$

$$= 44.8\,dB + 14.8\,dB - (32.5 + 93.1 + 75.9)\,dB = -141.9\,dB$$

$$\frac{P_R}{2uW} = \frac{1}{\log^{-1} 14.19\,dB} = \frac{1}{1.55 \times 10^{14}} \Rightarrow P_R = \frac{2uW}{1.55 \times 10^{14}} = 12.9\,pW$$

Transmitting Antenna

- convert its input electrical energy into electro-magnetic energy. (Transducer)

Receiving Antenna

- Intercept the transmitted wave and converts it back to electrical energy.

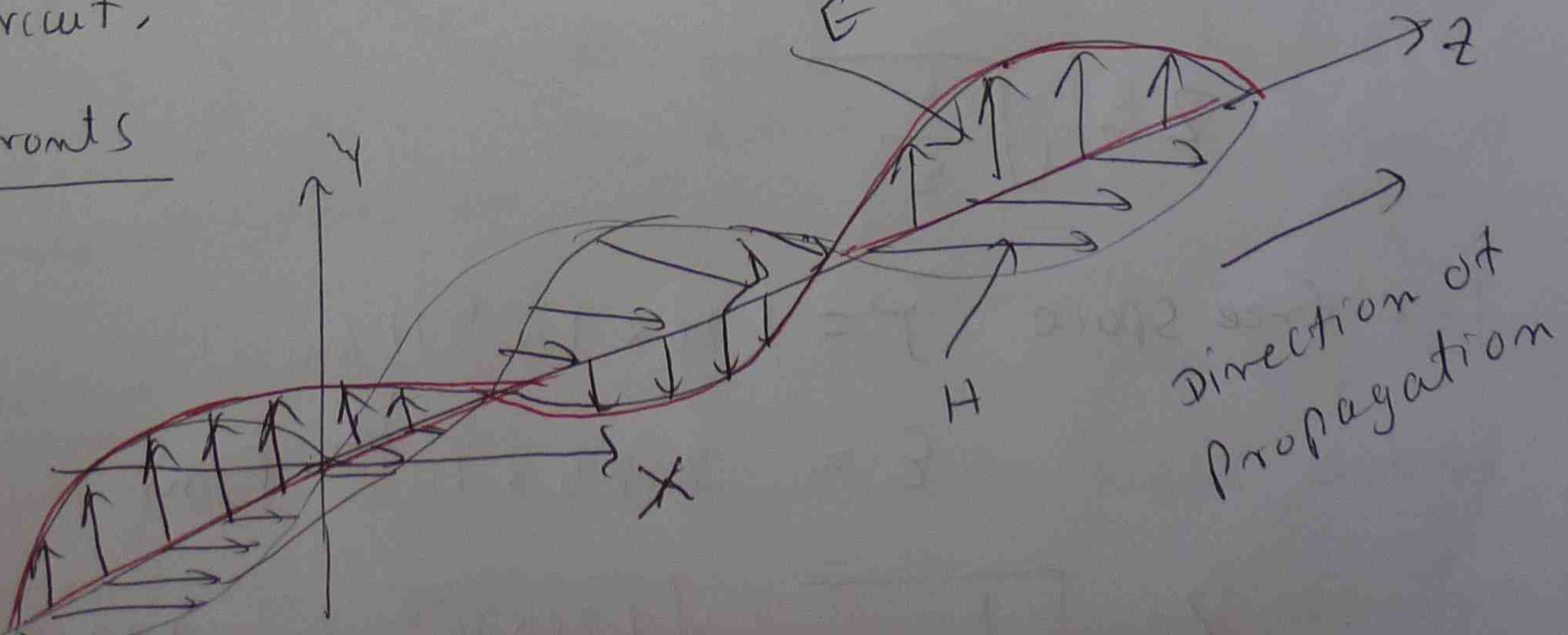
Electromagnetic waves

Electromagnetic field → Electric field, magnetic field

When the field collapses, the field energy is usually returned to the circuit.
If the field does not fully return its energy to the circuit, the wave has been at least partially radiated.
The radiated energy causes interference to electronic equipments. (Radio frequency interference RFI)
Electromagnetic Interference (EMI) (or) Noise.

In the case of radio transmitter, it is hoped that the antenna efficiently causes the wave energy to be set free. The antenna is designed so as to not allow the electromagnetic wave energy to collapse back into the circuit.

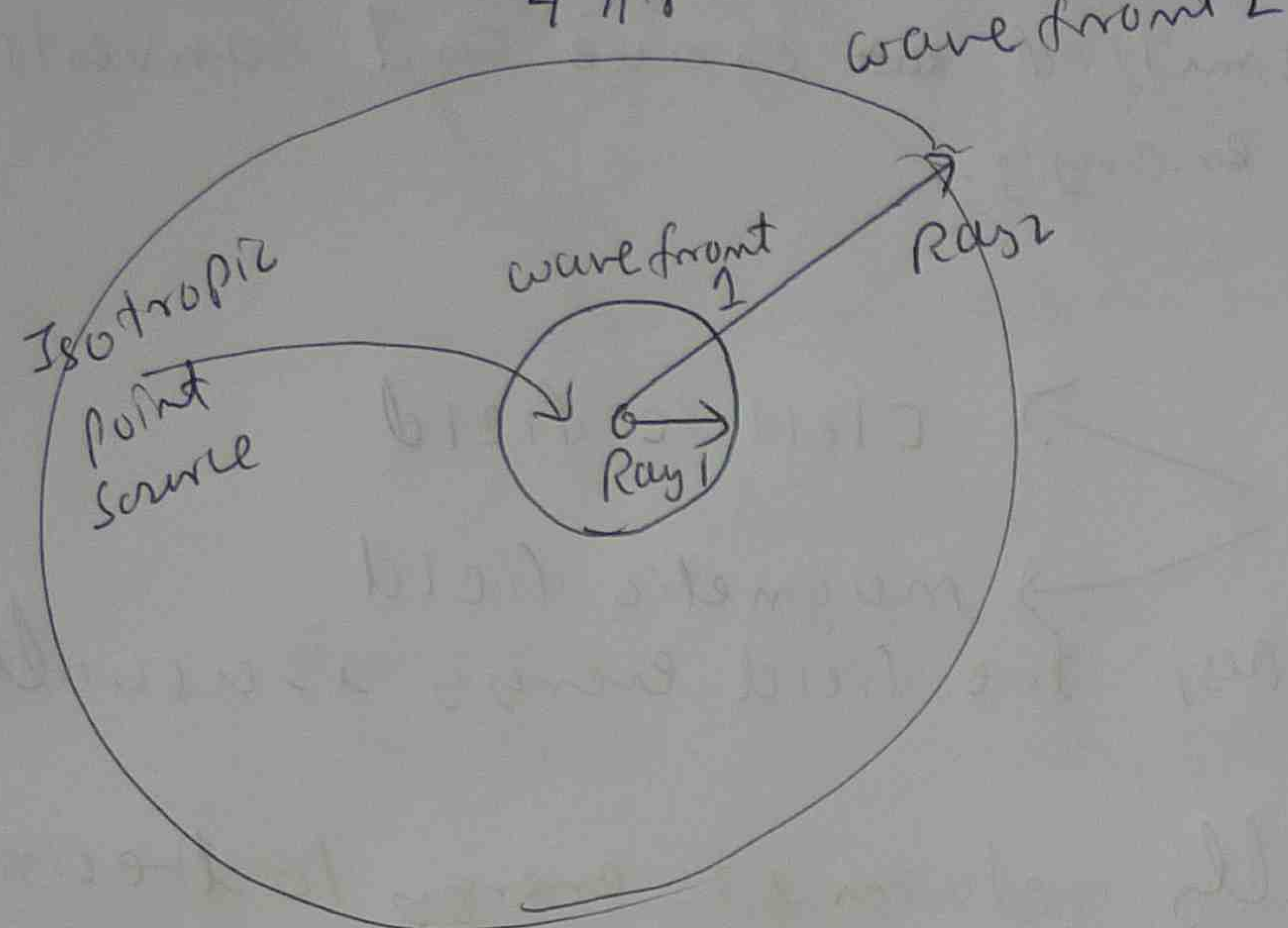
Wave fronts



Transmitted power = P

Power density P'

$$P' = \frac{P}{4\pi r^2}$$



Characteristic impedance of free space

The strength of electric field E (V/m) $= \frac{\sqrt{30 P_t}}{r}$

P_t = Transmitted power (watt)

The characteristic impedance of any electromagnetic wave conducting medium

$$Z = \sqrt{\frac{\mu}{\varepsilon}}$$

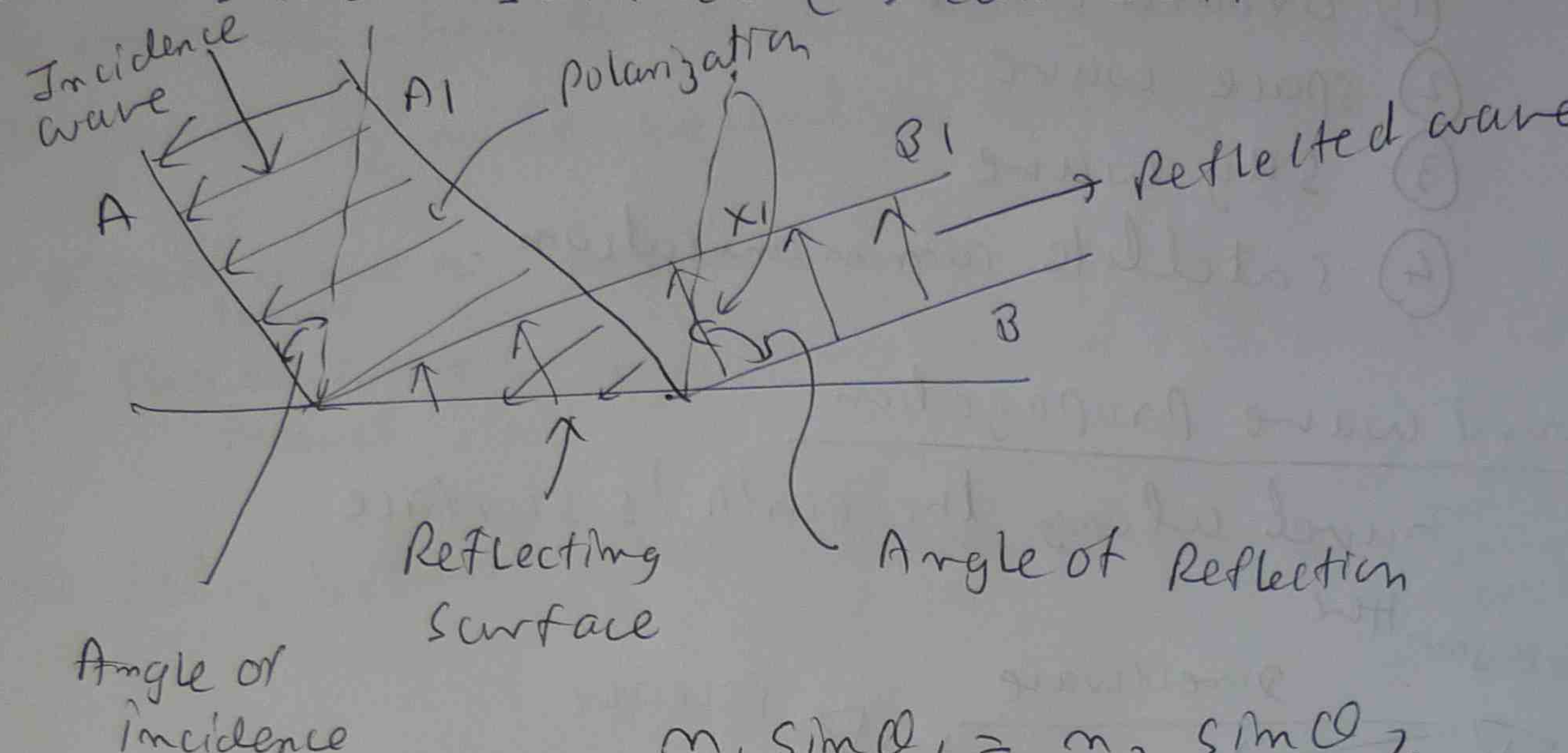
For free space $\mu = 1.26 \times 10^{-6}$ H/m

$\varepsilon = 8.85 \times 10^{-12}$ F/m

$$Z = \sqrt{\frac{\mu}{\varepsilon}} = \sqrt{\frac{1.26 \times 10^{-6}}{8.85 \times 10^{-12}}} = 377 \Omega$$

Reflection / Refraction

Radiowaves are reflected by any conductive medium such as metal surface (or) earth surface.



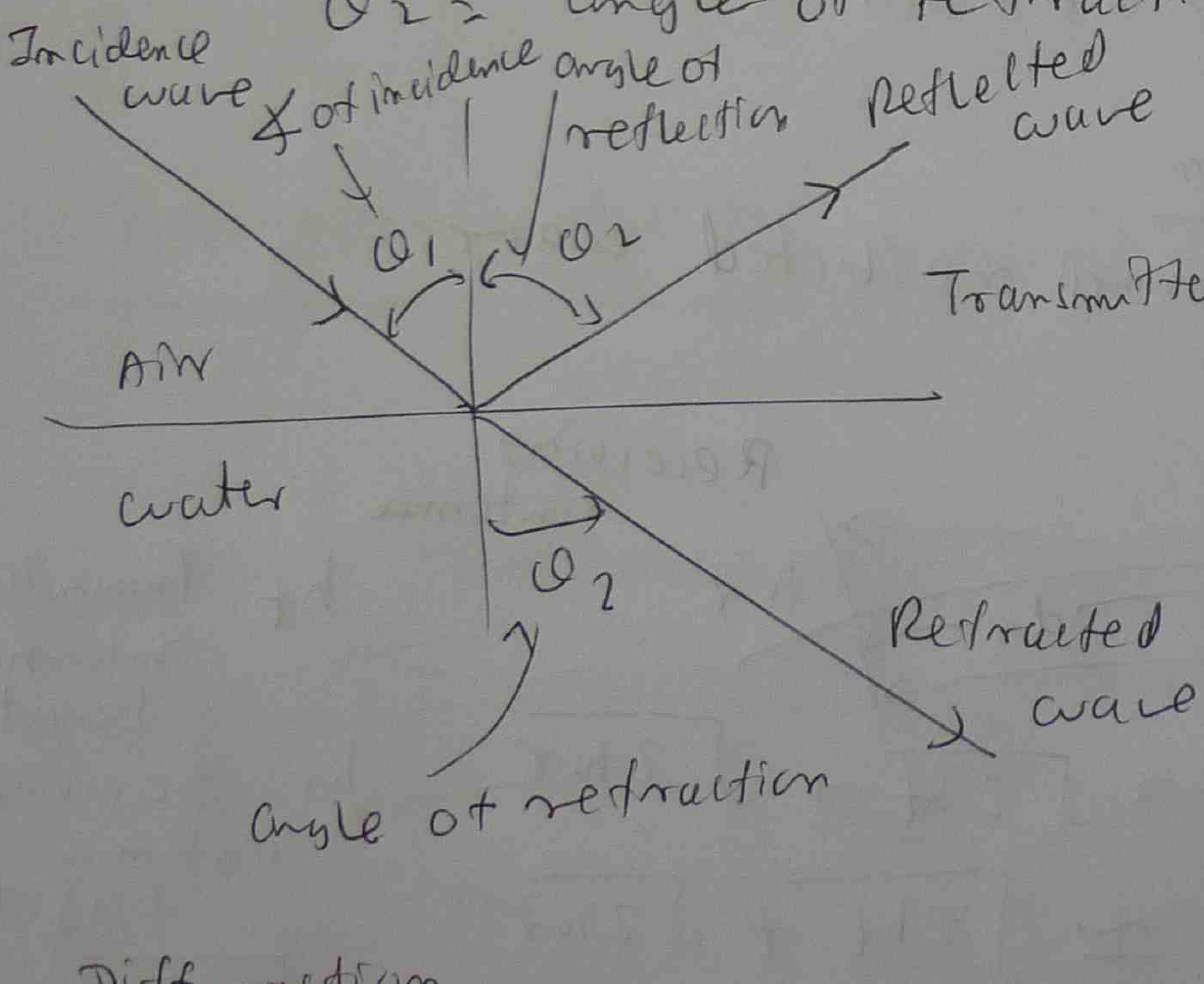
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

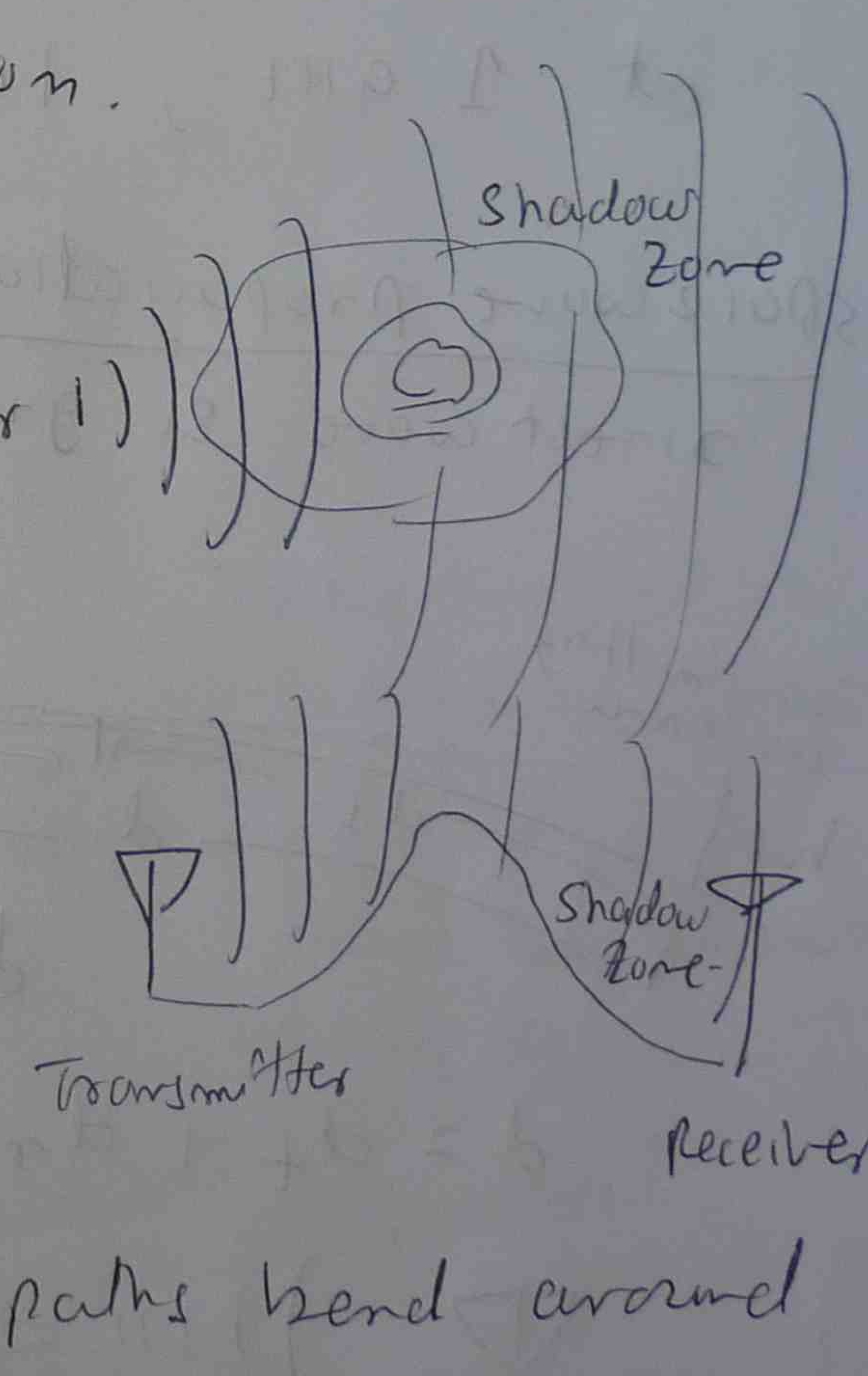
n_1 = refractive index of incidence medium

n_2 = refractive index of refractive medium

θ_1 = angle of incidence

θ_2 = angle of refraction.





Diffraction

waves travelling in straight paths bend around an obstacle.

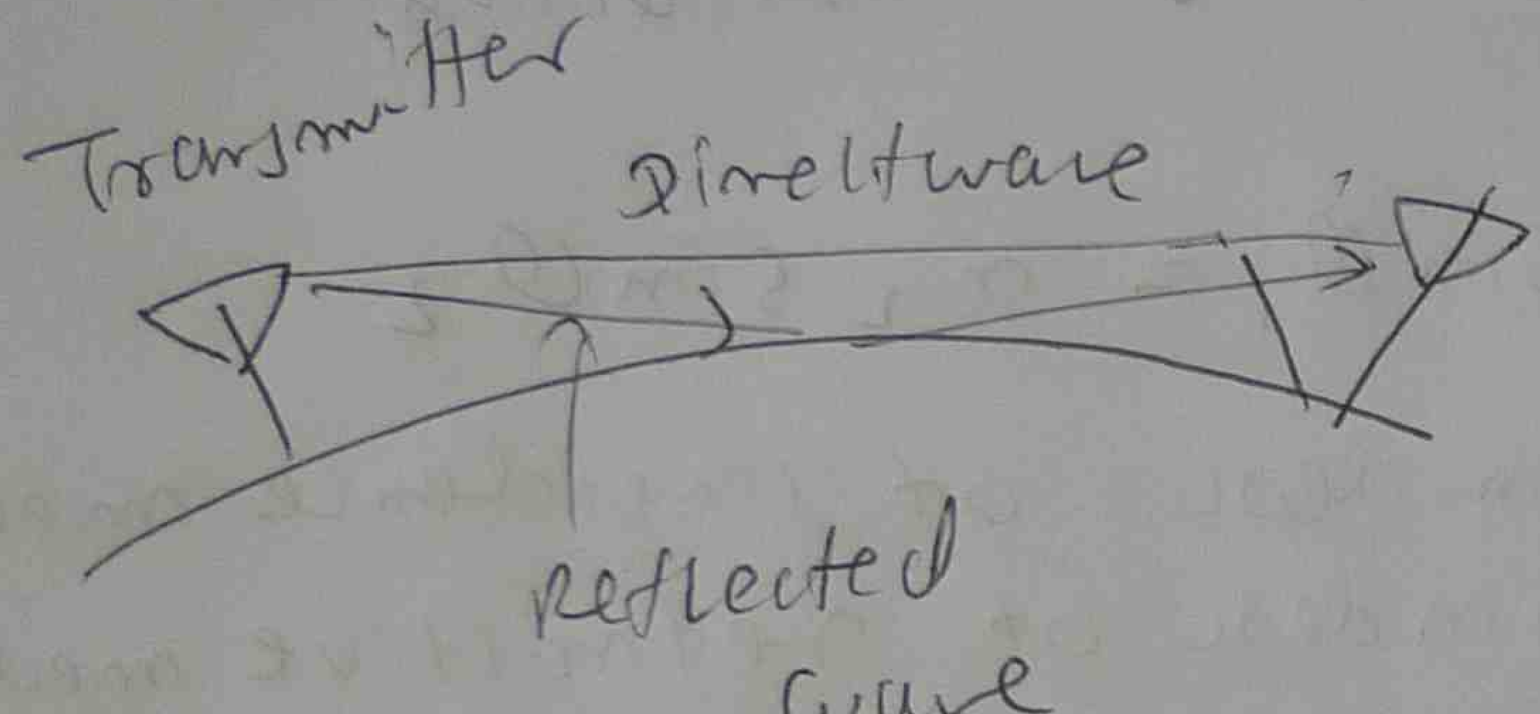
Diffraction process allowing reception beyond mountain (Shadow Zone)

4 basic modes of getting a radio wave from transmitting to receiving antenna

1. ground wave
2. space wave
3. sky wave
4. satellite communication.

Ground wave Propagation

Travel along the earth's surface



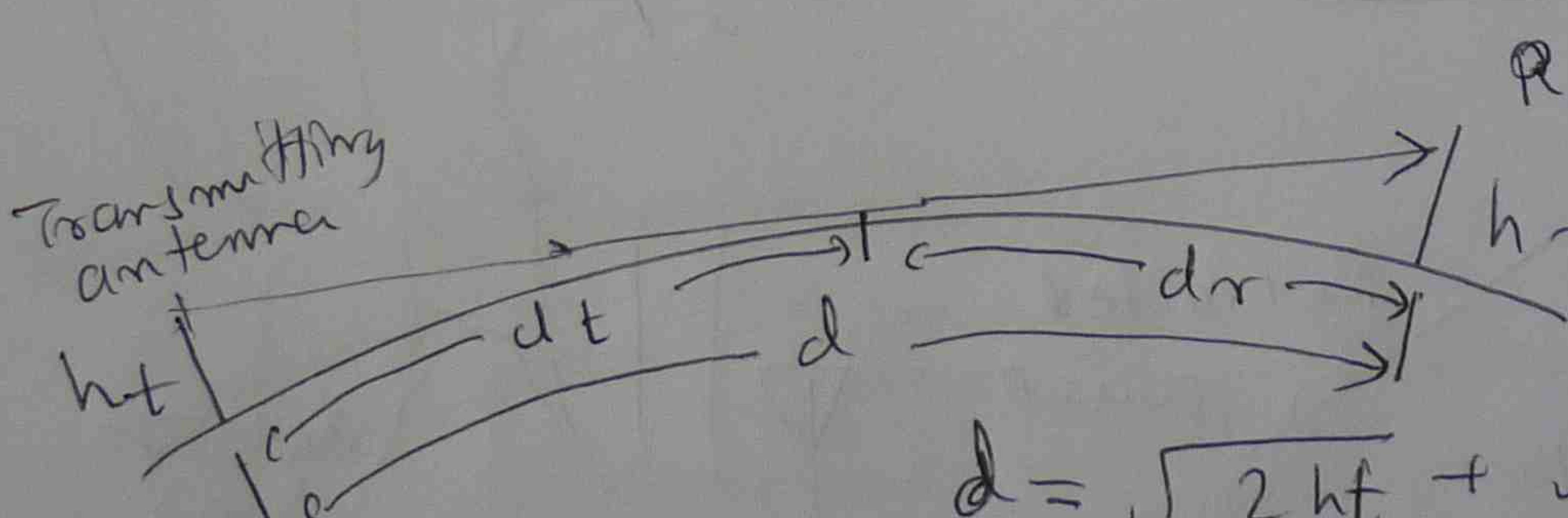
not very effective at freq: above 2 MHZ

ELF 30 → 300 HZ , attenuation 0.3 dB/m

at 1 GHz , 1000 dB/m loss.

Space wave Propagation

Direct wave & ground reflected wave.

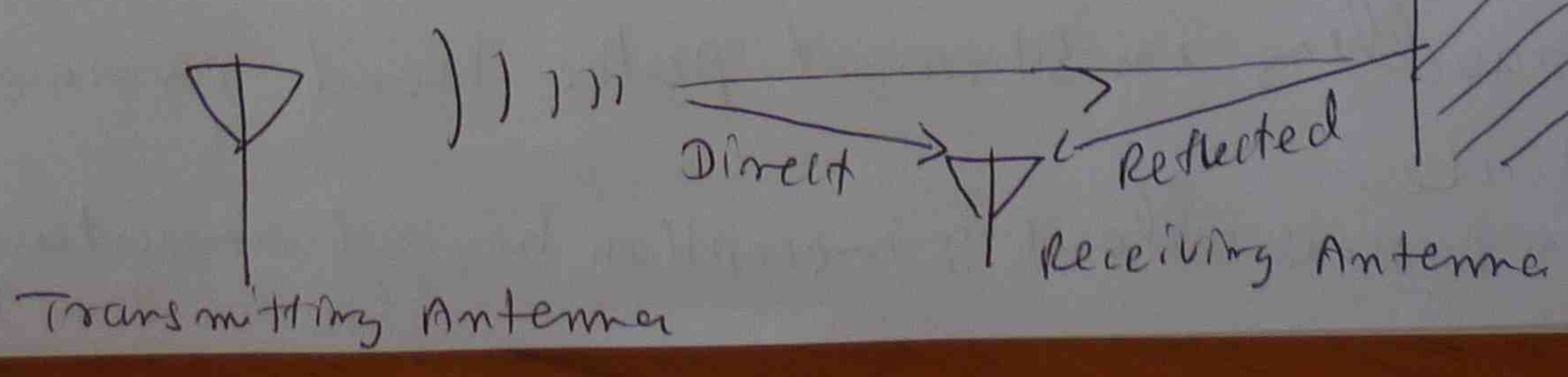


$$d = \sqrt{2h_t} + \sqrt{2h_r}$$

h_t = transmitting antenna height

h_r = receiving antenna height

$$d = d_t + d_r \pm \sqrt{2h_t} + \sqrt{2h_r}$$



Ghosting — Diffraction.

Pb — Determine the ghost width on a TV screen 15 in wide when a reflected wave results from an object $\frac{1}{2}$ mile behind a receiver

Direct wave travel = 0.5 mile

d = Reflected wave travel = 2 x Direct wave = 2 x 0.5 = 1 mile.

$$\text{Time delay between direct \& reflected signal} = \frac{d}{\text{Velocity of light}}$$

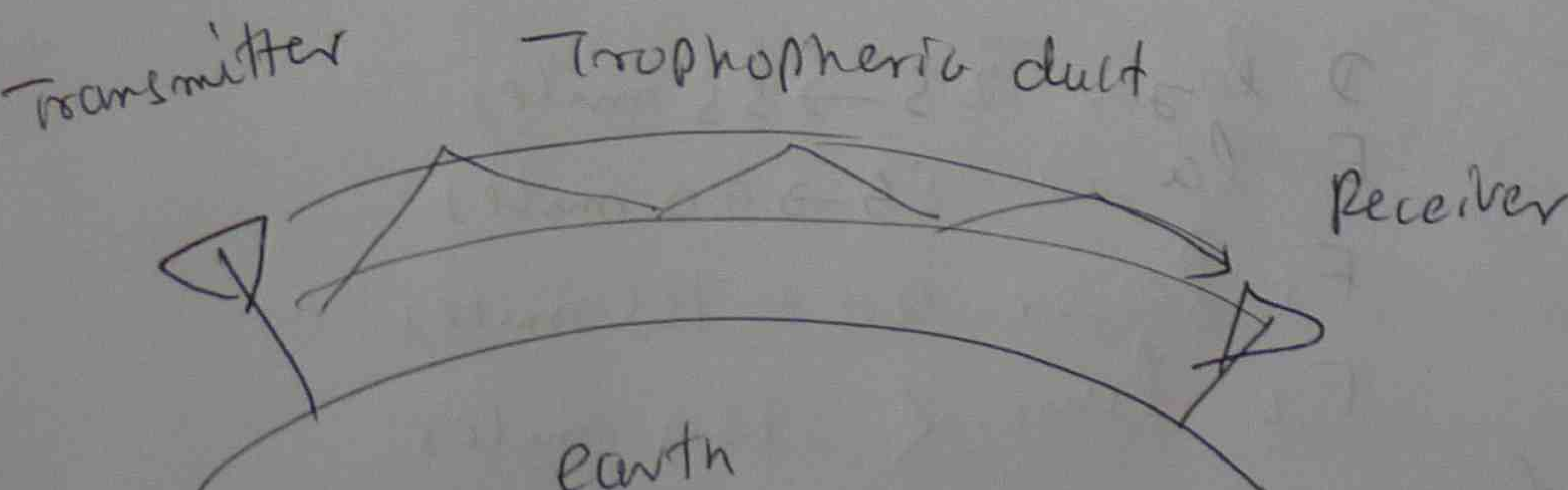
$$= \frac{1 \text{ mile}}{186000 \text{ mile/s}}$$

$$= 5.38 \mu s$$

$$\text{Ghost width} = \frac{t}{\text{Trace of TV signal}} \times \text{TV screen width} = \frac{5.38 \mu s \times 15 \text{ in}}{53.5 \mu s/\text{trace}}$$

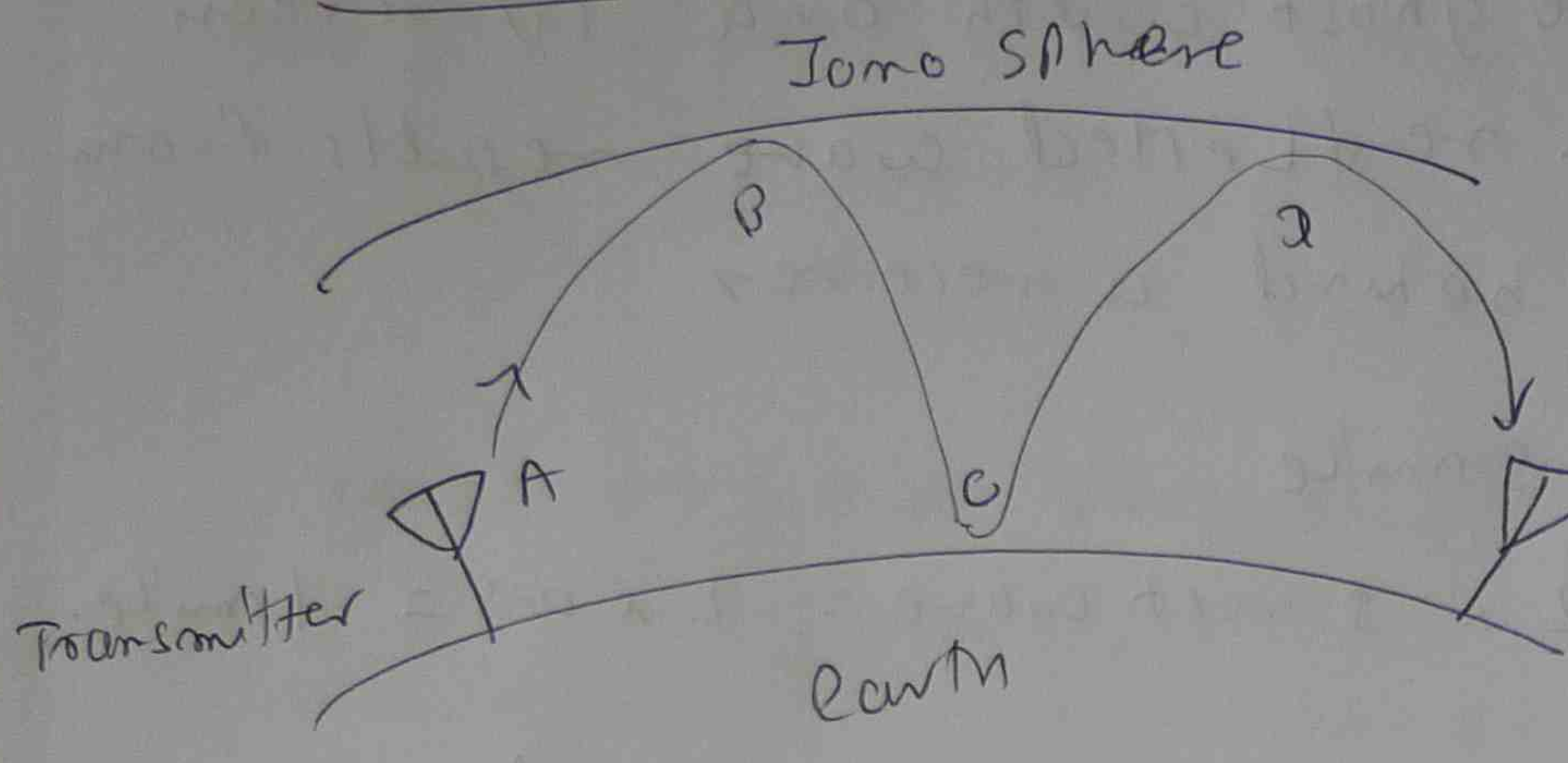
$$= 1.51 \text{ in}$$

Trophopheric ducting

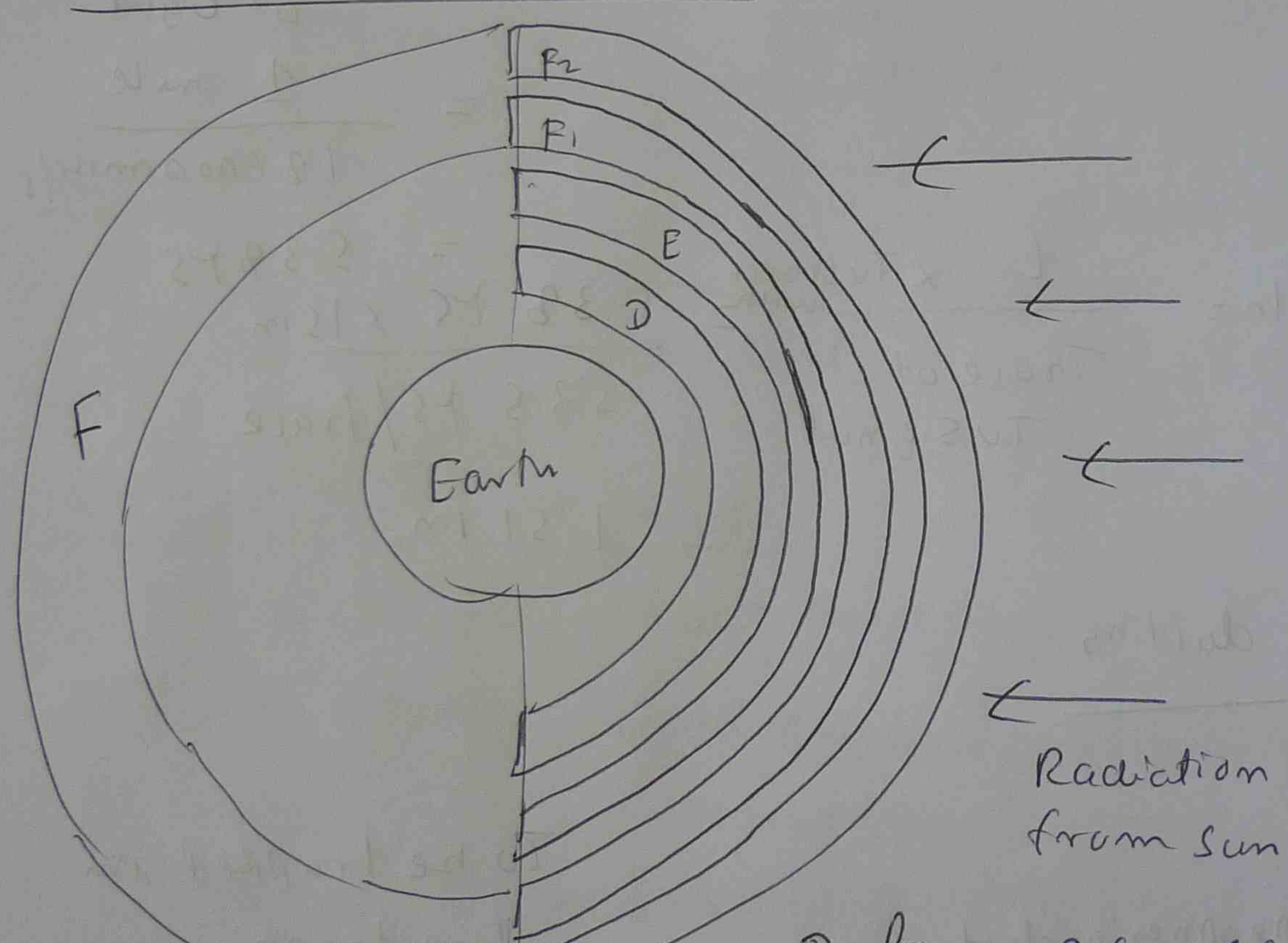


To be trapped in the trophopheric duct, the wave must be transmitted at 1/2 degree.

Sky wave propagation



Ionospheric layers



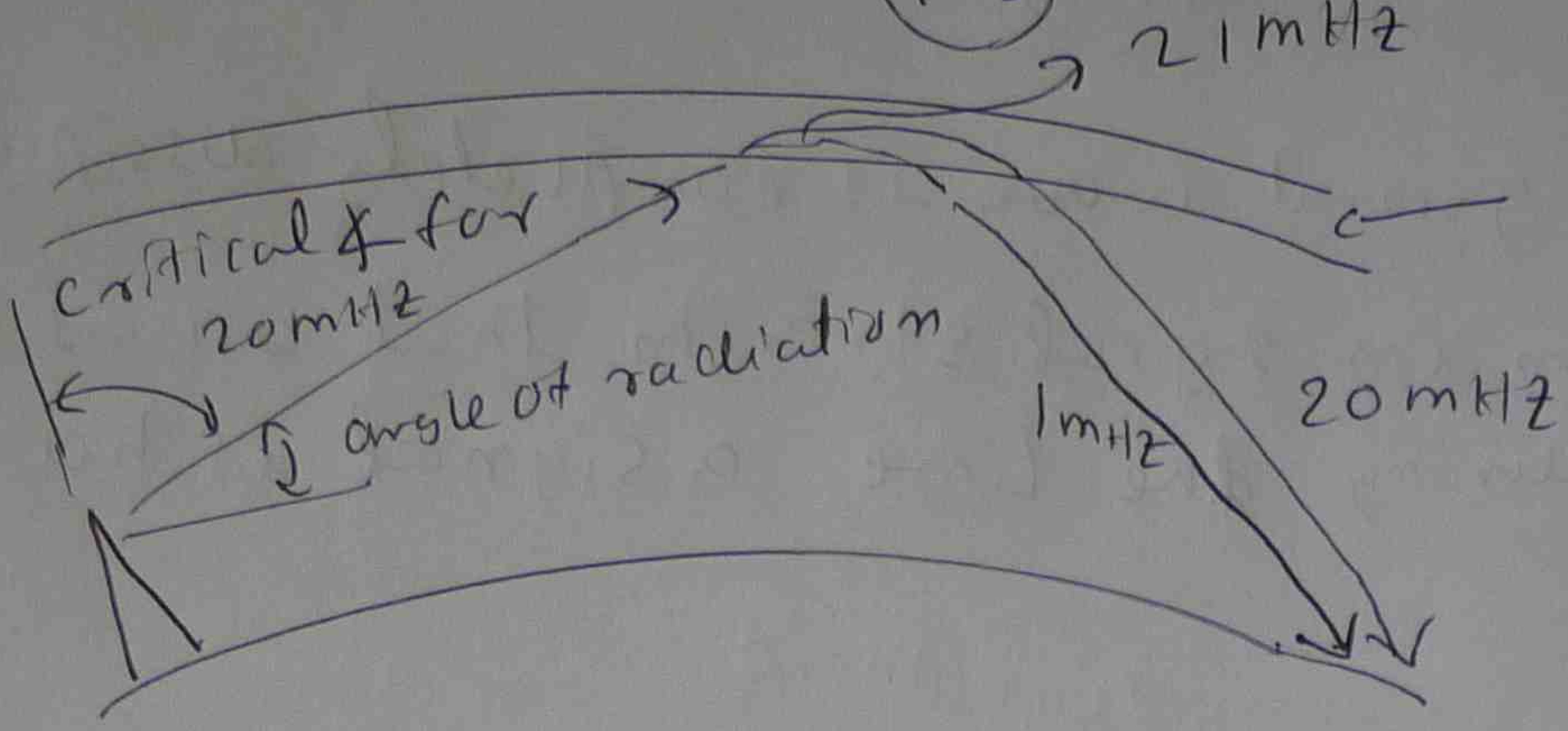
D layer 25 → 55 miles
E layer 55 → 90 miles
F_1 layer 90 — 155 miles
F_2 layer < 250 miles.

Critical frequency

The highest ~~velocity~~ frequency which will be returned to earth when transmitted under given ~~Ionos~~ ionospheric condition.

Critical angle The highest angle at which a wave of specific frequency can be propagated and still returned (refracted) from the ionosphere.

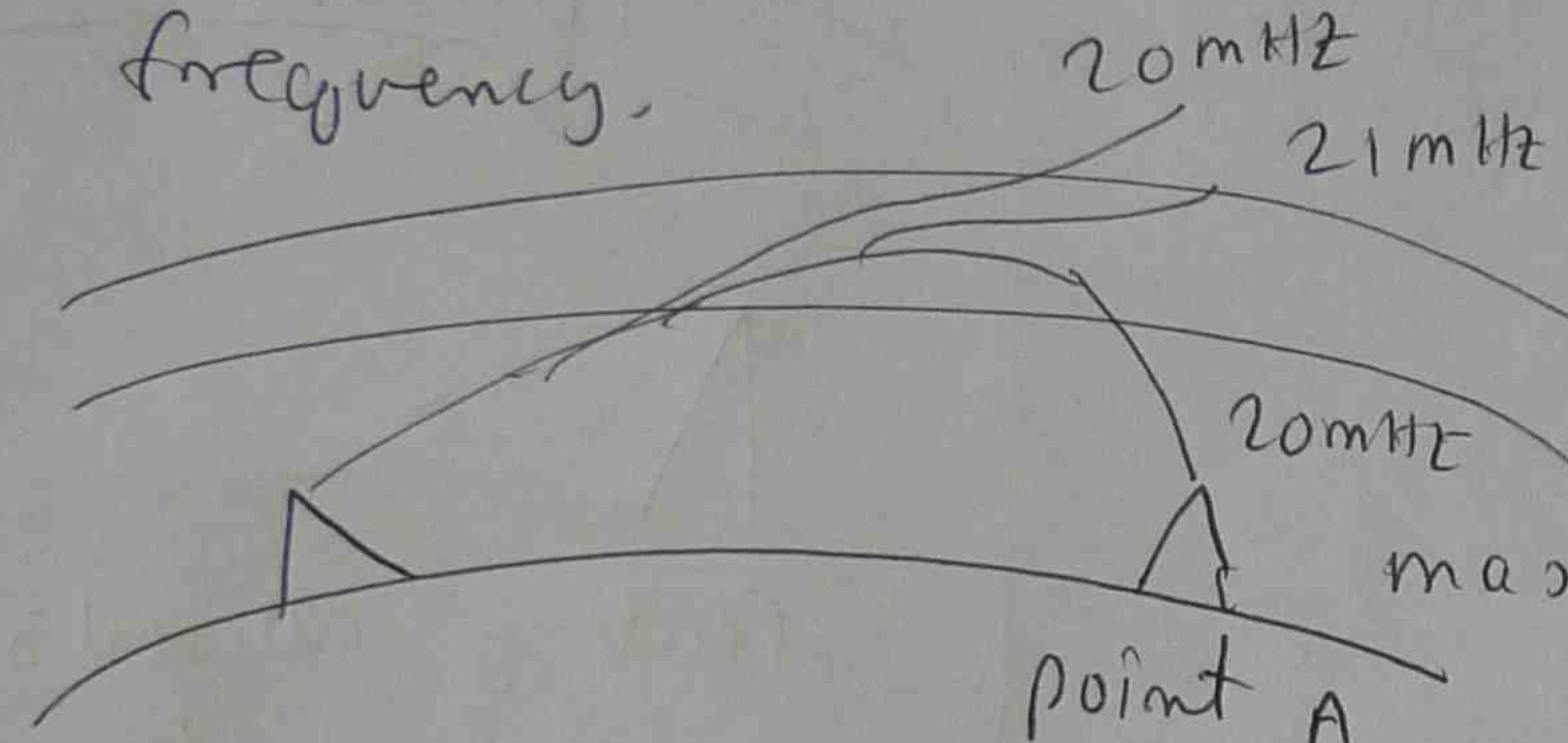
(118)



Relationship of frequency to refraction by the ionosphere

maximum usable frequency (muf)

The highest frequency which is returned to earth at a given distance is called maximum usable frequency.



maximum usable frequency for point A

Suitable radiation angles

1.5 to 3 mHz : low angle radiation for long distance

3 to 7 mHz : Good sky wave return at angle ∡ of radiation

High ∡ radiation for short/moderate range

low ∡ radiation for long distance comm;

7 → 12 mHz: ∡ of radiation from 45 to 30° for short to moderate distances.

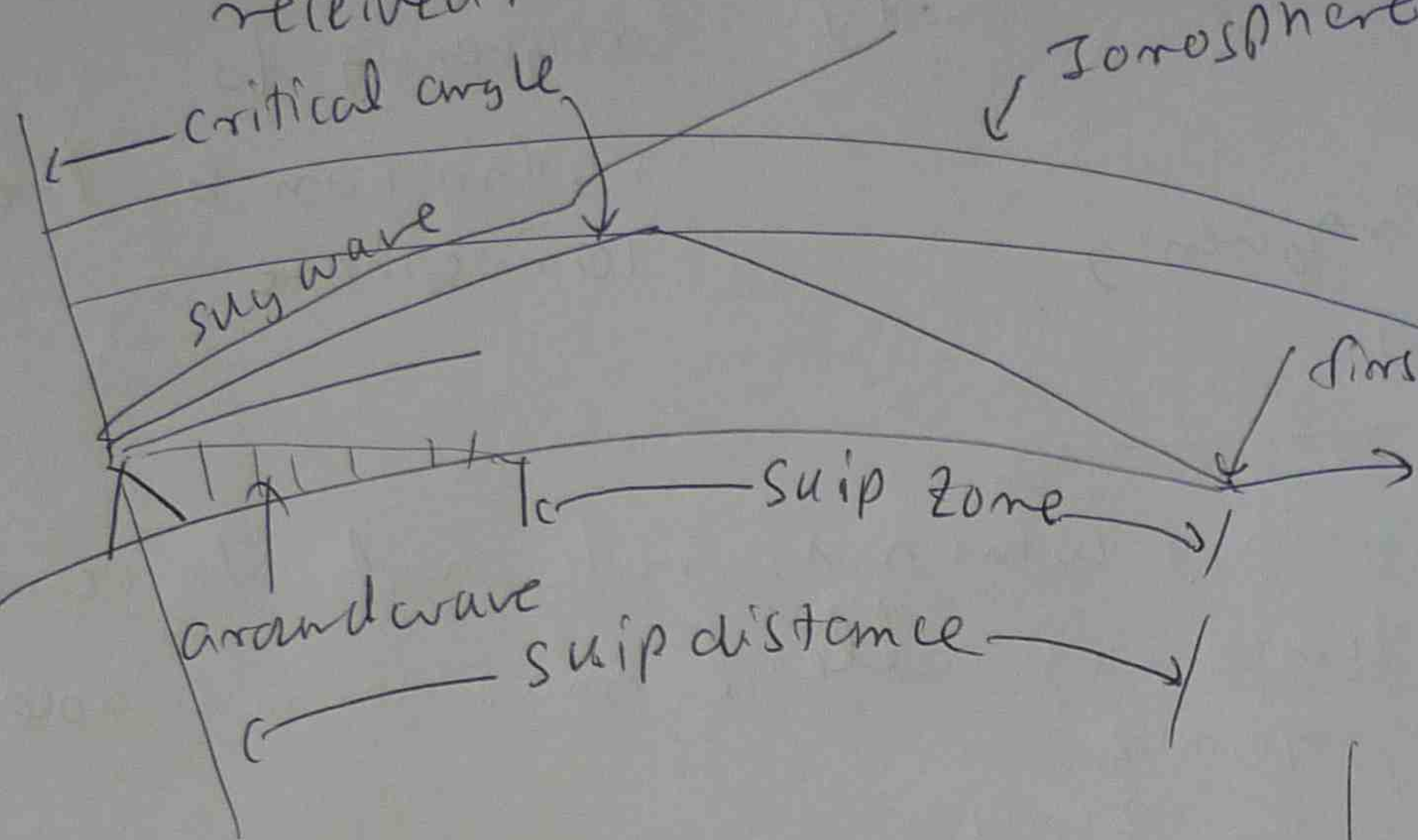
lower angles for long distance communication.

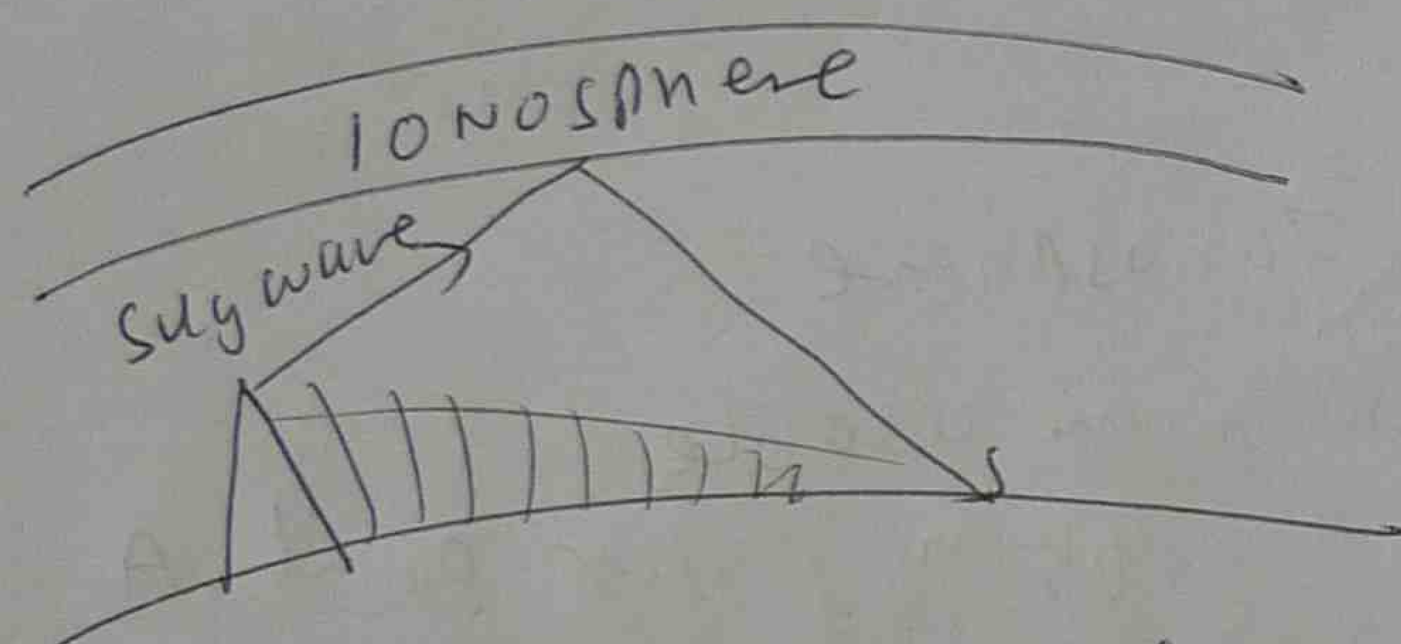
12 to 30 mHz : not useful for short distance sky wave transmission.

12 → 16 mHz ⇝ 30°

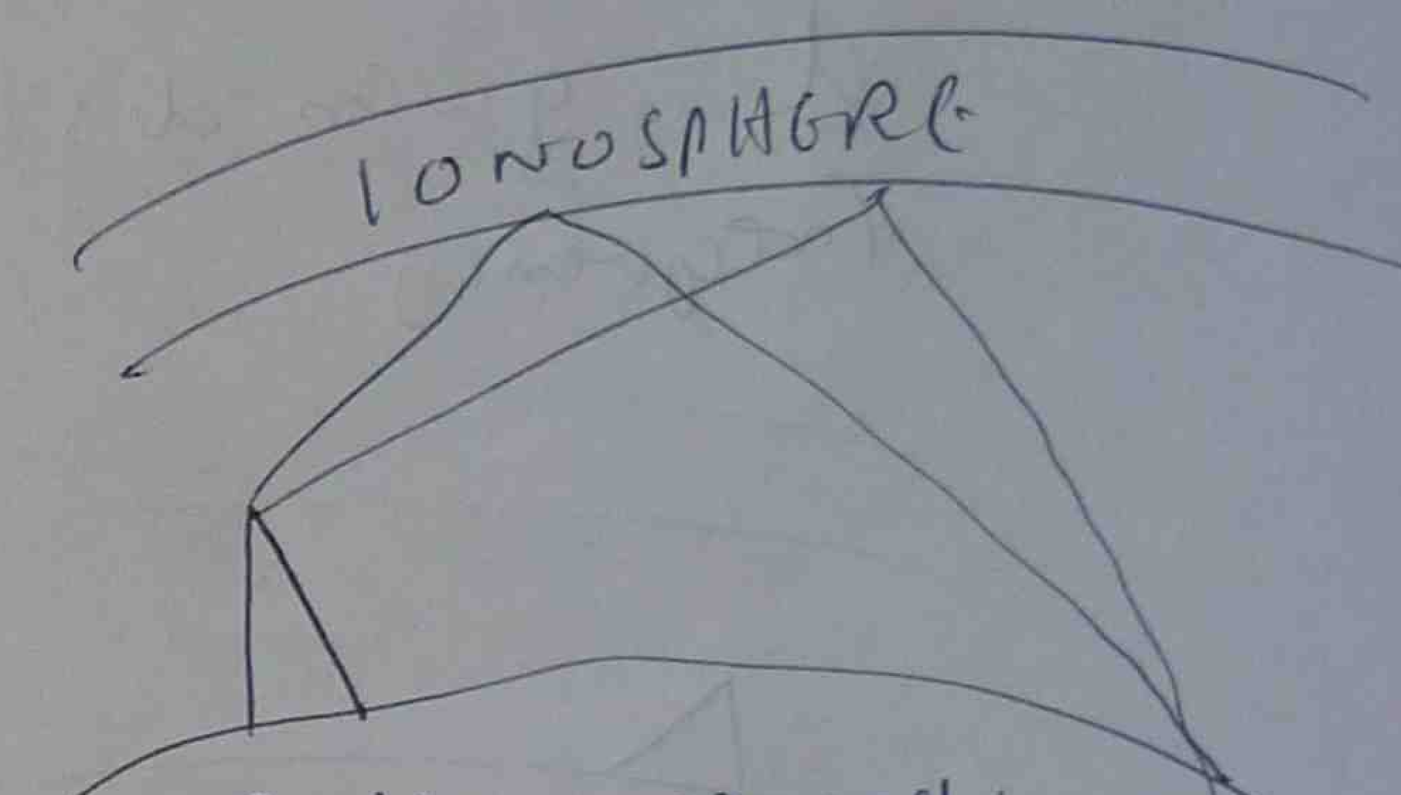
Skip zone The ground wave is completely dissipated

Fading variation in signal strength that occurs at a receiver during the time a signal is being received.



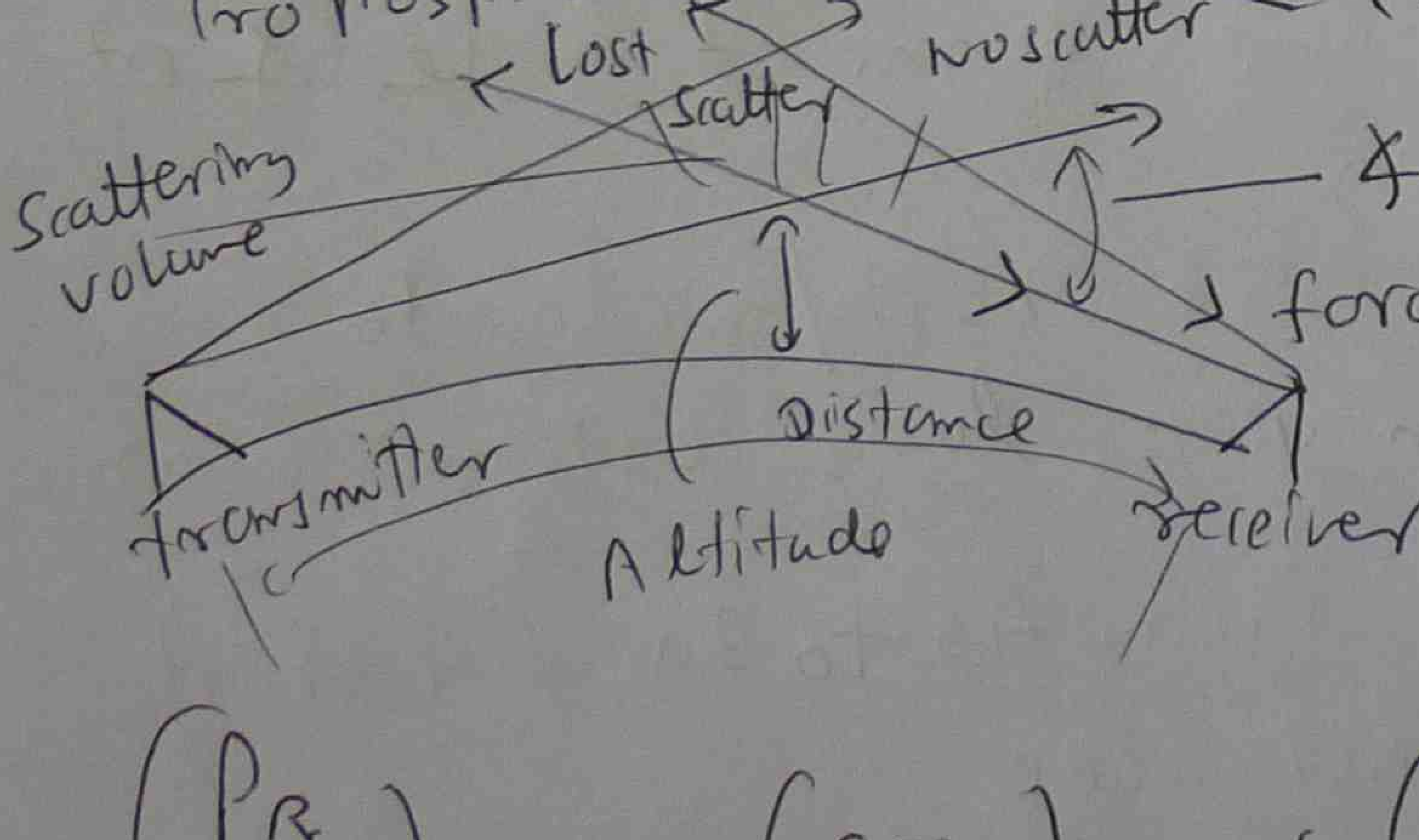


Fading caused by arrival of ground wave & sky wave at the same point out of phase



Fading caused by arrival of two sky waves at the same point out of phase.

Tropospheric scatter — space diversity — frequency diversity



Tropospheric scatter

$$\left(\frac{P_R}{P_T}\right)_{dB} = (G_T)_{dB} + (G_R)_{dB} - \left[32.5 + 20\log_{10} d + 20\log_{10} f\right] dB$$

P_R = Received power G_T = Gain of transmitting antenna

P_T = Transmitted power G_R = Gain of receiving antenna

f = freq (MHz) d = Distance (km) between antenna

Week (15) Antenna

In a transmitting system, a radio frequency signal is developed, amplified, modulated and applied to the antenna. The RF currents flowing through the antenna produce electromagnetic waves which radiate into the atmosphere. In a receiving system, electromagnetic waves "cutting" through the antenna induce alternating currents for use by the receiver.

Adequate signal strength

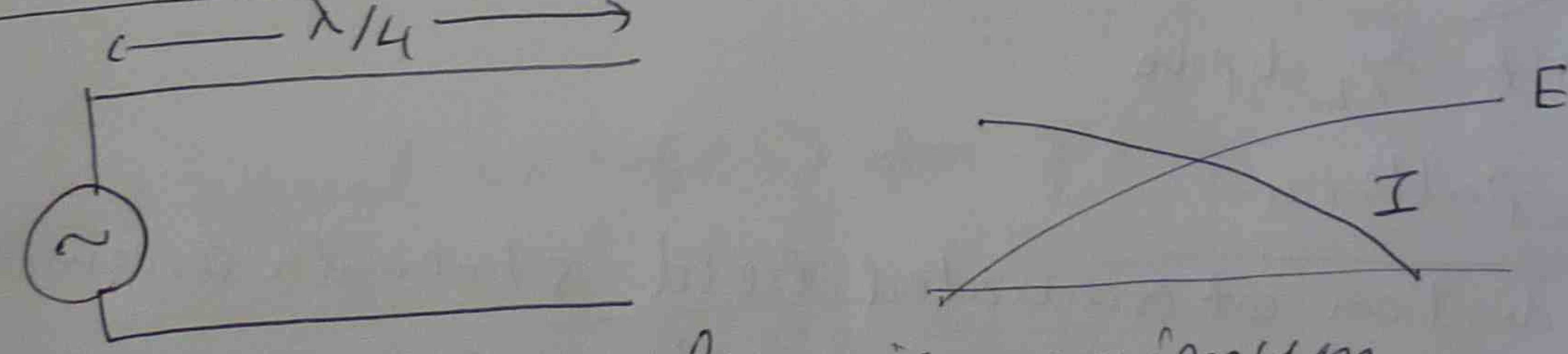
- power transmitted must be extremely high
- The efficiency of transmitting & receiving antenna must be high.

Heartz Antenna

Any antenna having a physical length that is one half wave length of applied frequency is called a Hertz antenna.

use with frequency above 2 mHZ

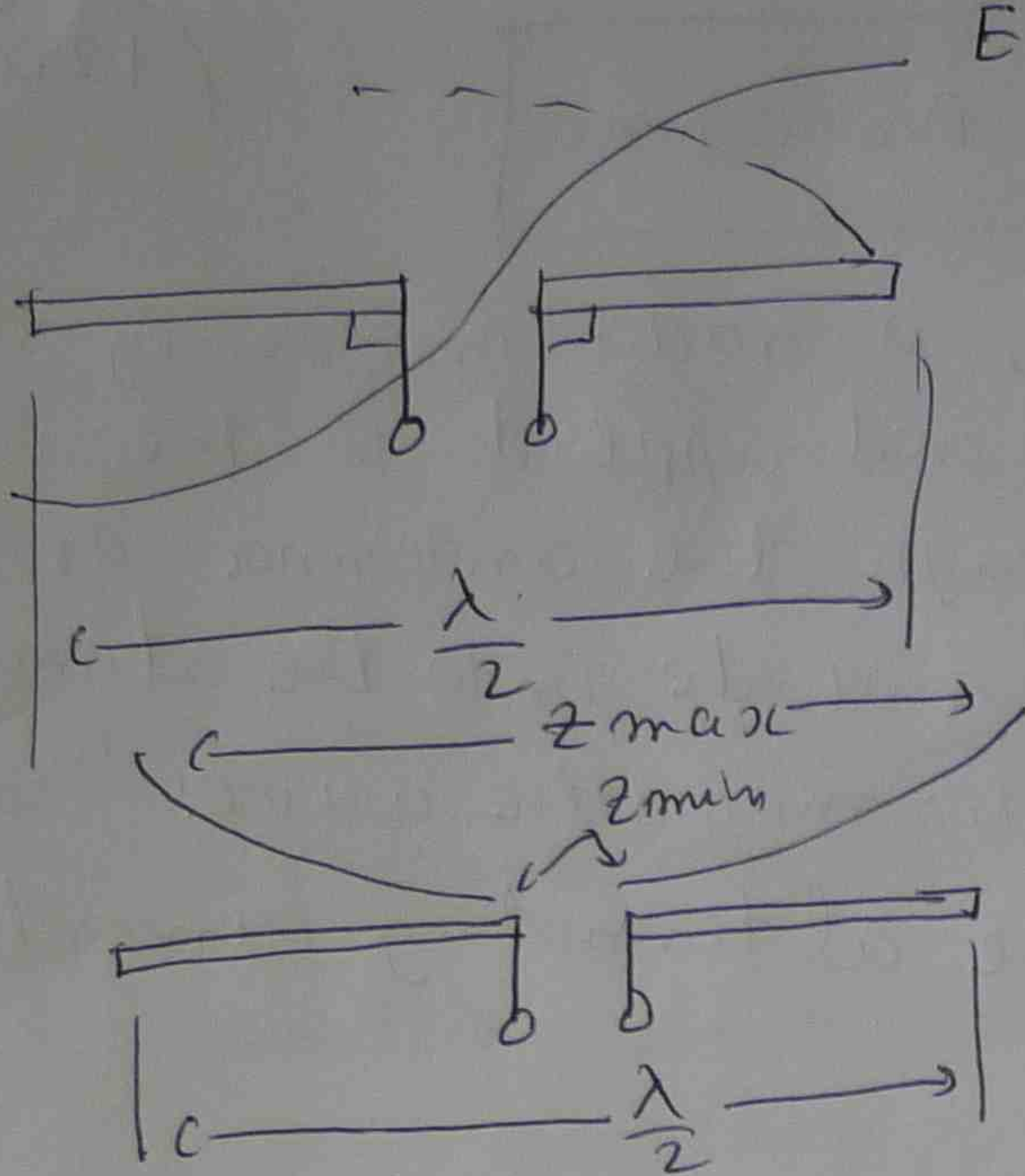
open ended quarter wave transmission line



- voltage at the end line is maximum
- current at the end line is zero.
- All energy applied to antenna would be converted to electromagnetic waves and radiated.

Half wave or Hertz antenna

Bending each line outward 90 to form a half wave (or) Hertz antenna or $\lambda/2$ dipole.



Hertz antenna impedence

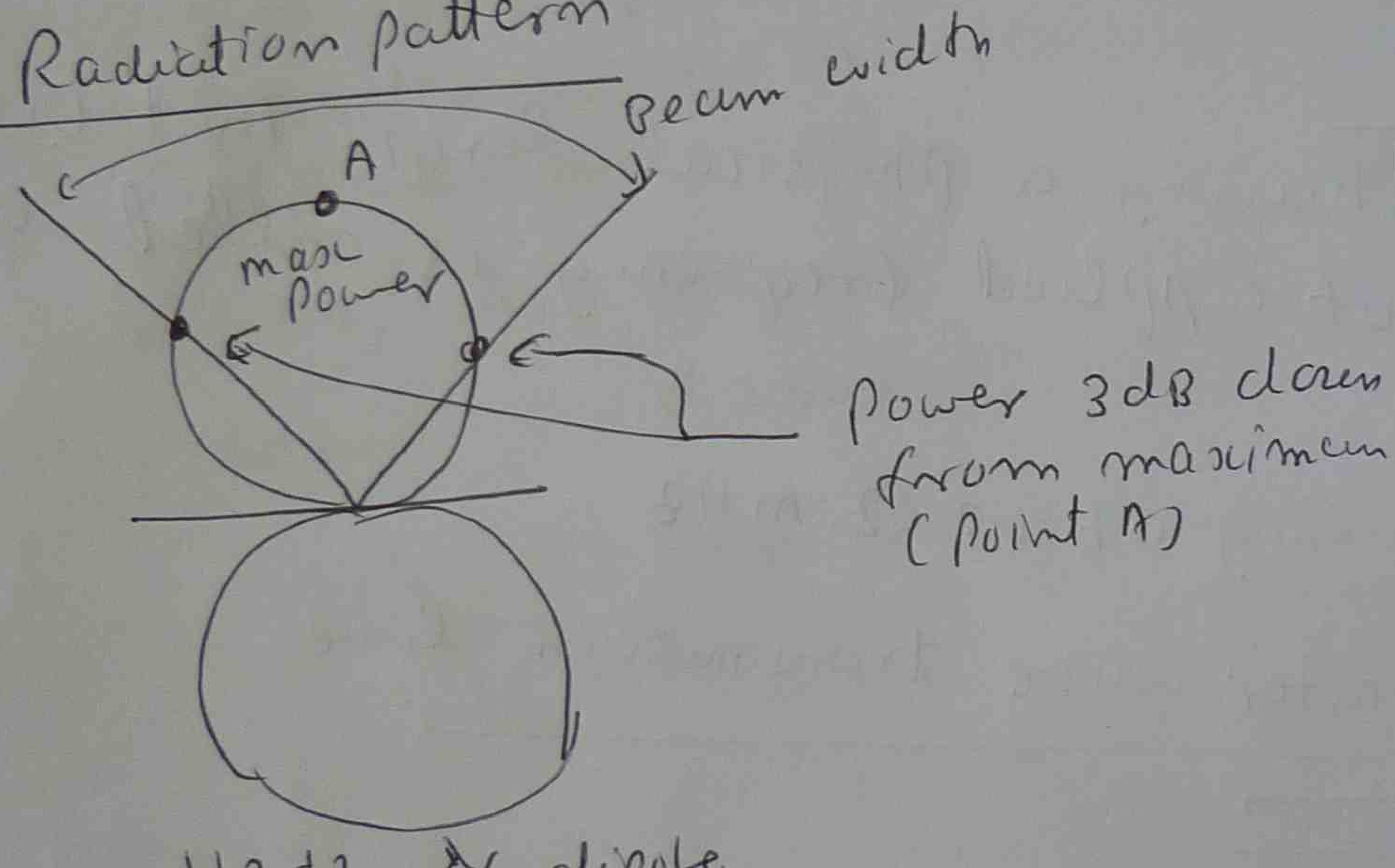
2500Ω at open end to 75Ω at source end.

Impedence along half wave antenna.

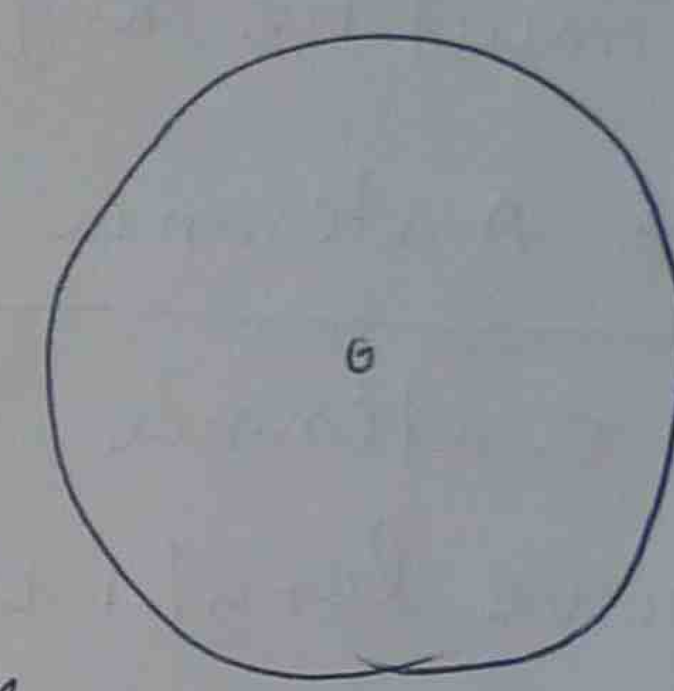
Radiation & induction field

Feeding the Hertz antenna at the center results input impedance 73 Ω.

Radiation pattern



Hertz $\lambda/2$ dipole

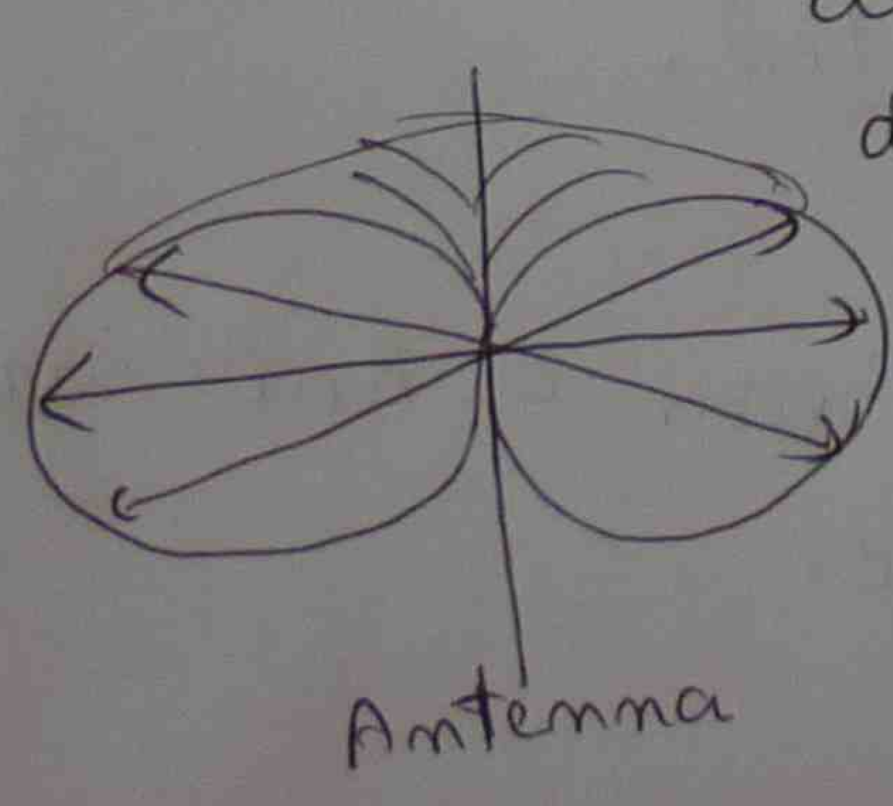


Isotropic point source.

Radiation pattern

An indication of radiated field strength around the antenna.

Directional — It concentrates energy in certain direction at the expense of lower energy in other directions.



Antenna Gain

$$P_r = \frac{P_t\ G_t\ G_r\ \lambda^2}{16\pi^2\ d^2}$$

P_r = power received (w)

P_t = power transmitted (w)

G_t = Transmitting antenna gain (ratio not dB)

G_r = receiving antenna gain (ratio not dB)

λ = wave length (m)

d = Distance between antennas (m)

Pb 1 Two $\lambda/2$ dipoles are separated by 50 km. They are aligned for optimum reception. The transmitter feeds its antenna with 10w at 144 MHz. calculate power received.

$$\lambda = \frac{v}{f} = \frac{3\times10^8}{144\times10^6} =$$

Dipole Gain $G_t = 1.64$, $G_r = 1.64$

$P_t = 10w$ $\quad d = 50\times10^3$ m

$$P_r = \frac{P_t\ G_t\ G_r\ \lambda^2}{16\pi^2\ d^2} = \frac{10\times1.64\times1.64\left(\frac{3\times10^8}{144\times10^6}\right)^2}{16\times(3.1416)^2\times(50\times10^3)^2}$$

$$= 2.96\times10^{-10}\ w$$

Received signal voltage => $P = \frac{v^2}{R}$

$$v = \sqrt{P\times R} = \sqrt{2.96\times10^{-10}\times73} = 147\ \mu V$$

Radiation resistance

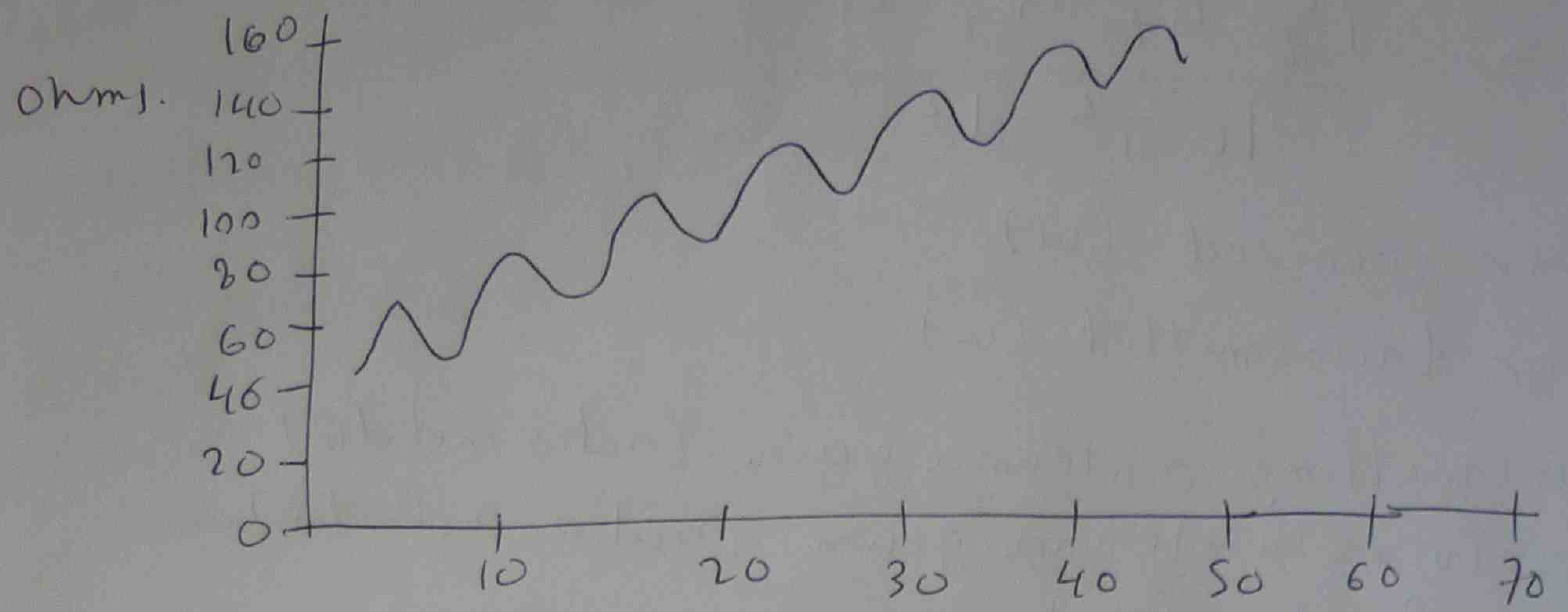
$$R_r = \frac{P}{I^2}$$

R_r = Radiation resistance (Ω)

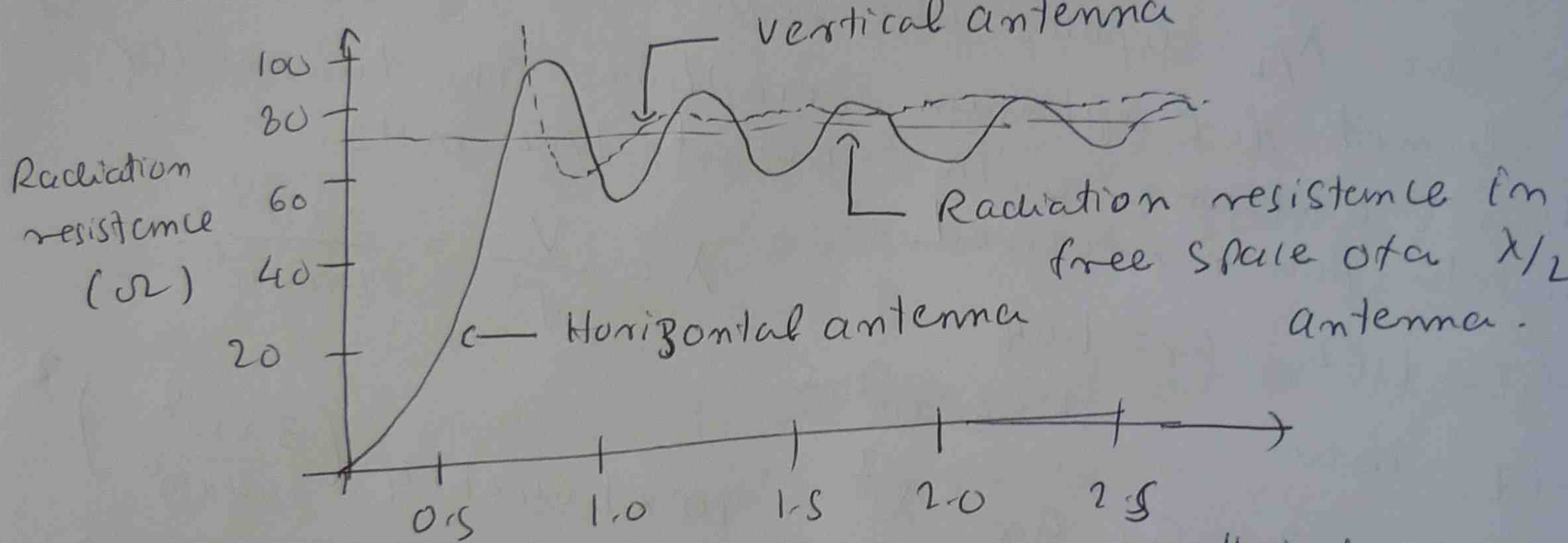
I = Effective rms value of antenna current at feed point (A)

P = Total power radiated from the antenna

Effects of antenna length



Ground effect



Radiation resistance of half wave length antennas at various heights.

Antenna efficiency

$$\eta = \frac{P_{transmitted}}{P_{input}} = \frac{R_r}{R_r + R_d}$$

Arcing effects – corona discharge
R_d = Lumped value of resistance R_d

Physical length = 95% of calculated length.

Pb 2

It is desired to build a $\lambda/2$ dipole to receive a 100 MHz broadcast. Determine the optimum length of the dipole.

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{100 \times 10^6} = 3\,m$$

~~Physical~~ Electrical length $= \frac{\lambda}{2} = \frac{3}{2} = 1.5\,m$

Length of antenna $= 0.95 \times$ Electrical length

$= 0.95 \times 1.5 = 1.43\,m$

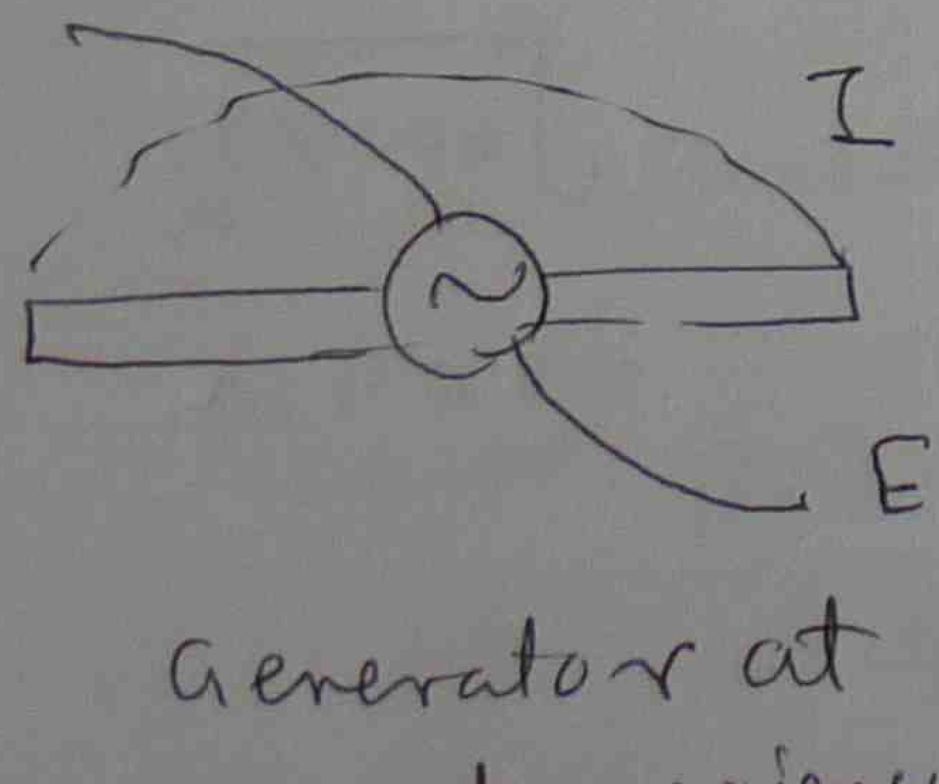
Antenna feed lines

If energy is applied at the geometrical centre of an antenna, the antenna is said to be center fed.

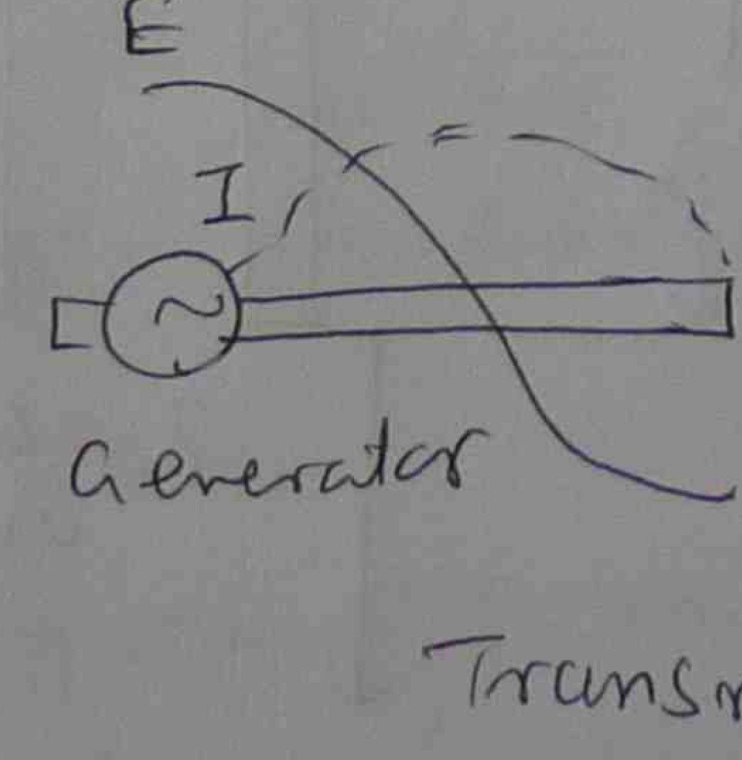
If energy is applied to the end of an antenna, it is known as an end fed antenna.

Resonant feed line

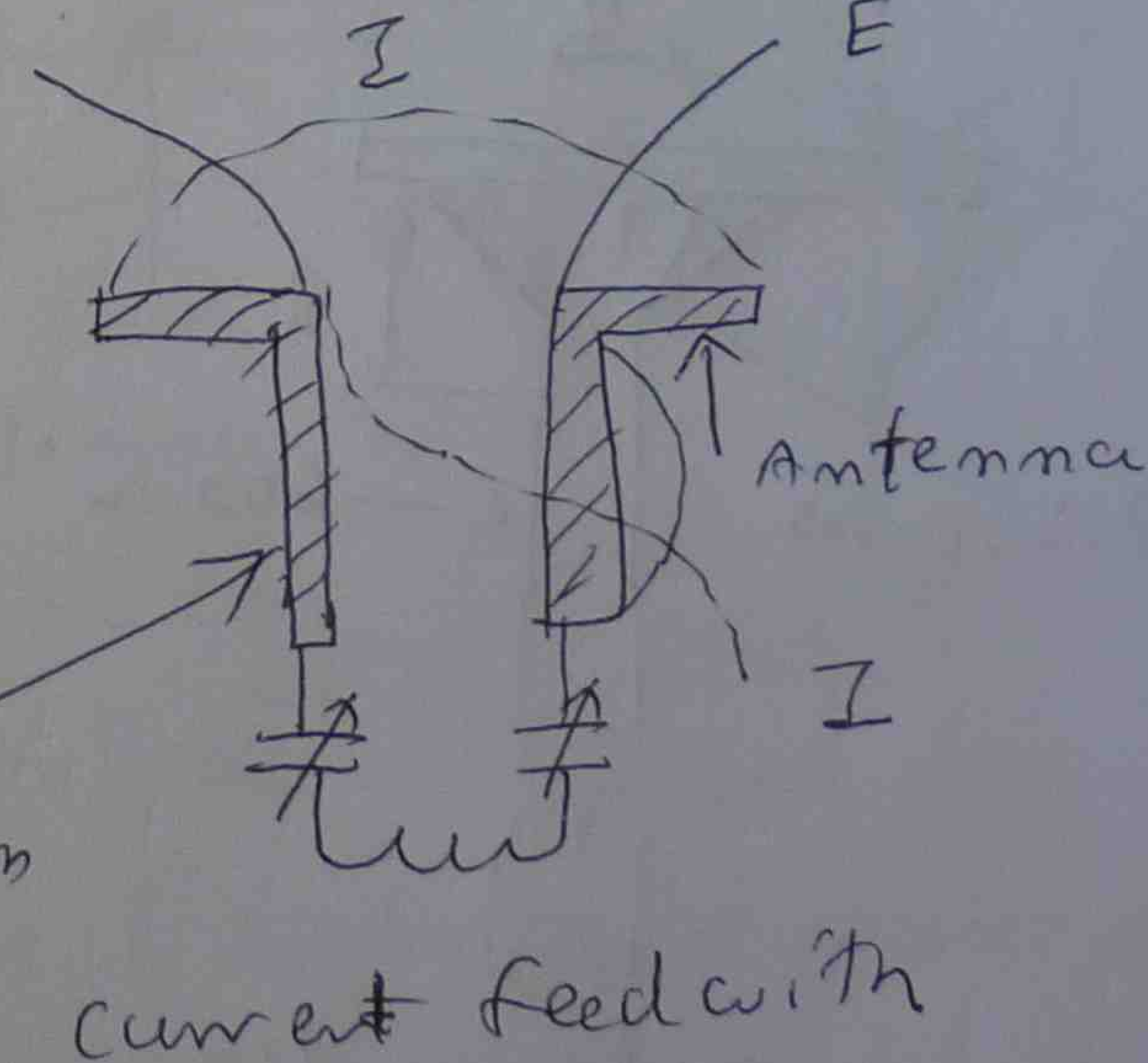
The transmission line is connected to the center of antenna.



Generator at current maximum means current feed



Transmission Line



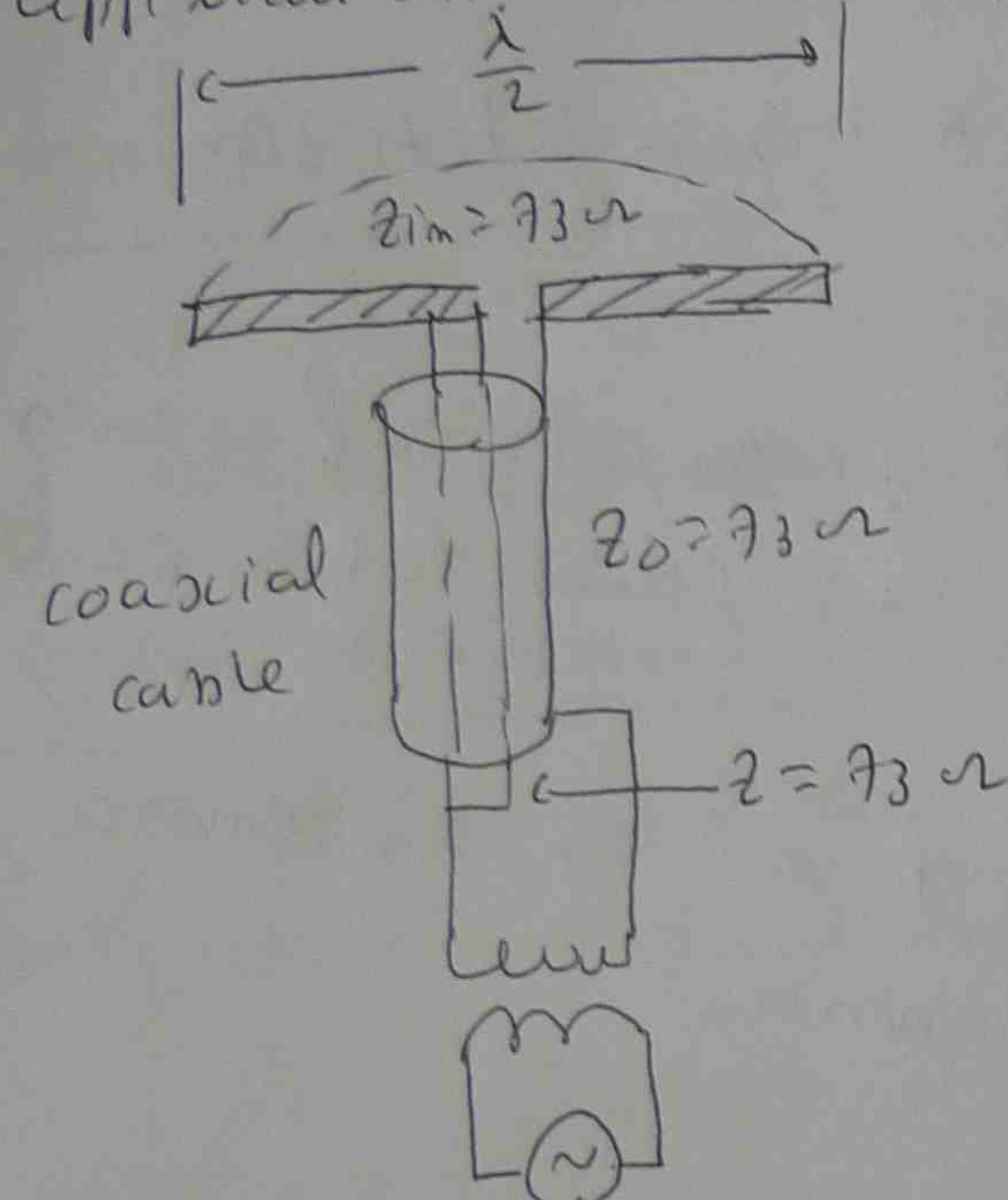
current feed with resonant line

Non resonant feed line

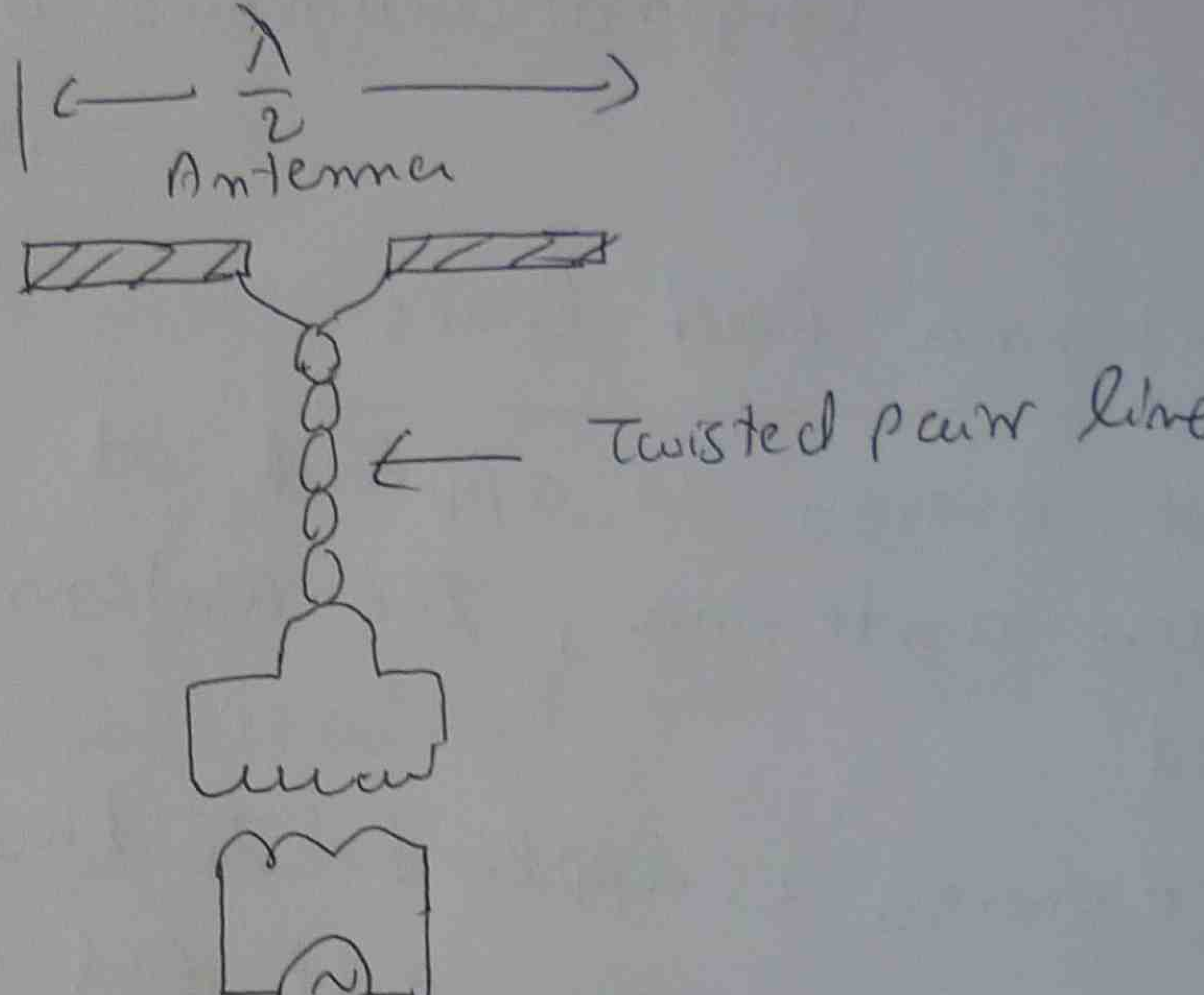
open wire line, shield pair, coaxial line, twisted pair line. $Z_0 \simeq 70\,\Omega$

Delta match

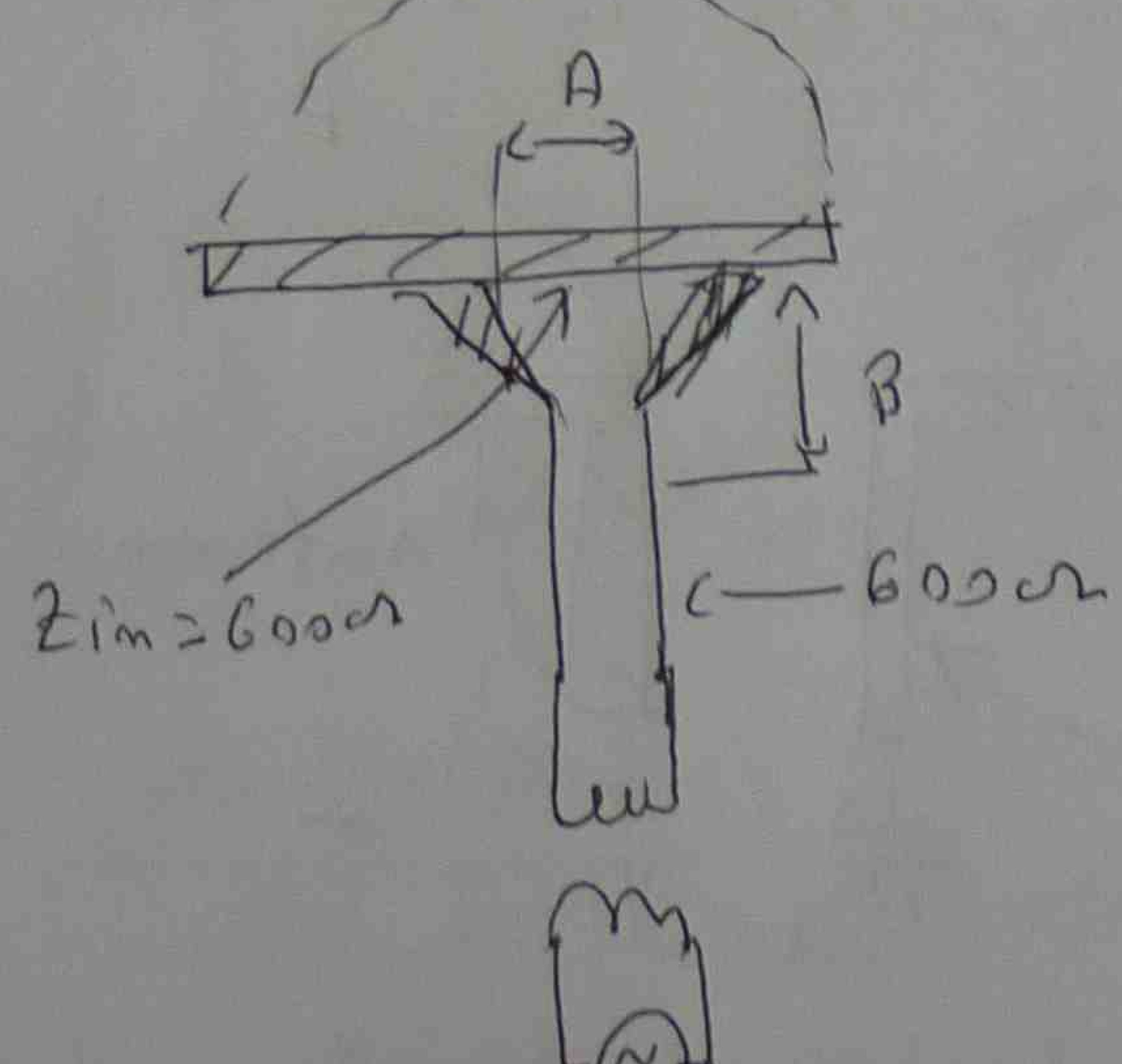
When a line does not match the impedance of the antenna, it is necessary to use special impedance matching techniques used in Smith Chart application



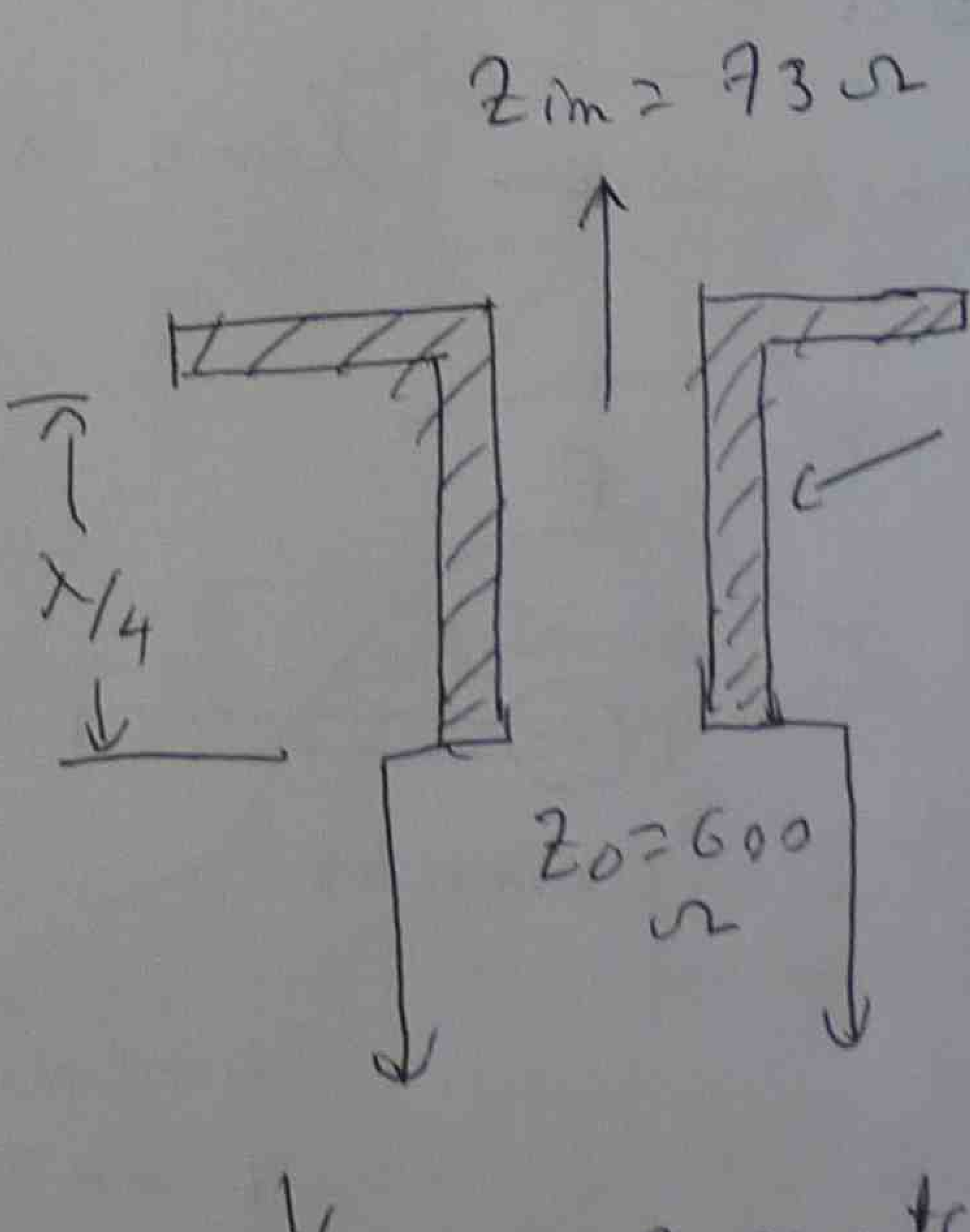
coaxial feed cable



Twisted pair feed



deltamatch



$Z_0' = \sqrt{Z_0 R_L}$

$= \sqrt{600\,\Omega \times 73\,\Omega}$

$= 209\,\Omega$

1/4 wave matching transformer

Feeding antenna with non resonant lines.

Quarter wave matching

$$Z_0' = \sqrt{Z_0 R_L}$$

Z_0' = Characteristic impedance of (quarter wave section) of the matching line

Z_0 = Impedance of the feed line

R_L = Resistive impedance of radiating current

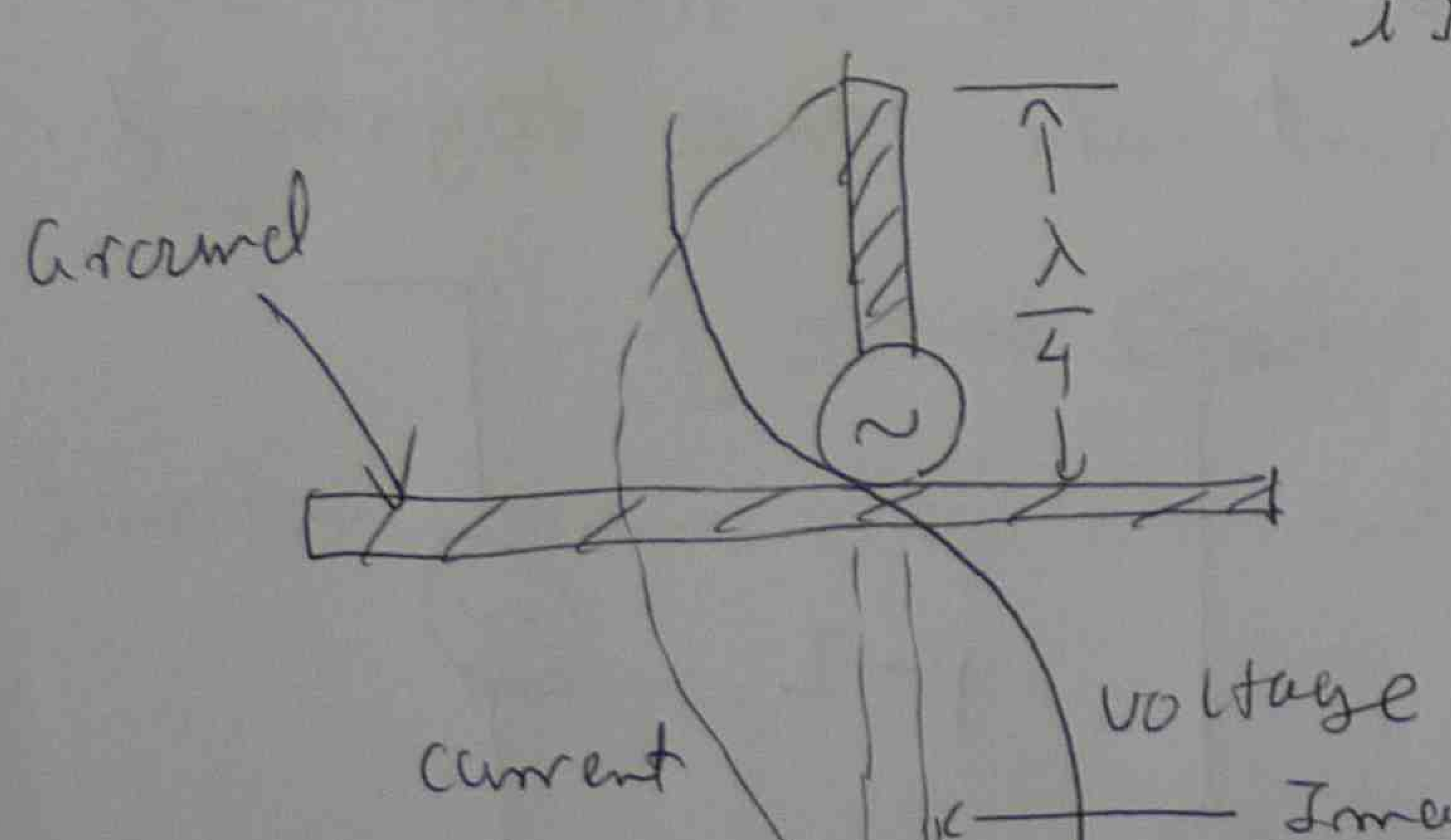
Marconi antenna

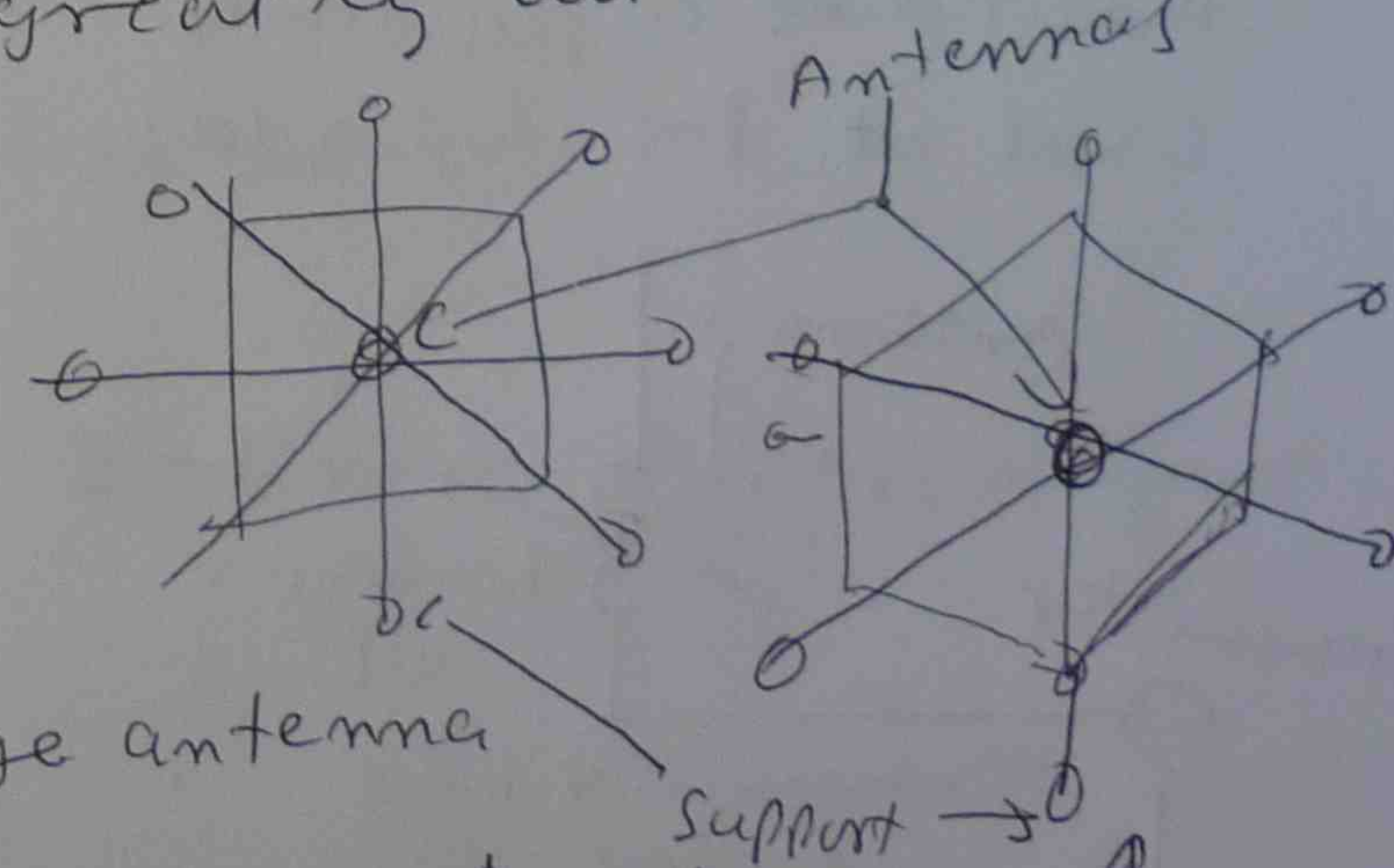
Marconi antenna is used primarily with frequencies below 2 MHZ.

Effects of ground reflection

The transmitter is connected between the antenna and ground. Actual length of antenna is 1/4 wave length.

$Z_{in} = 36.6\Omega$ The reflected wave from ground is greatly attenuated

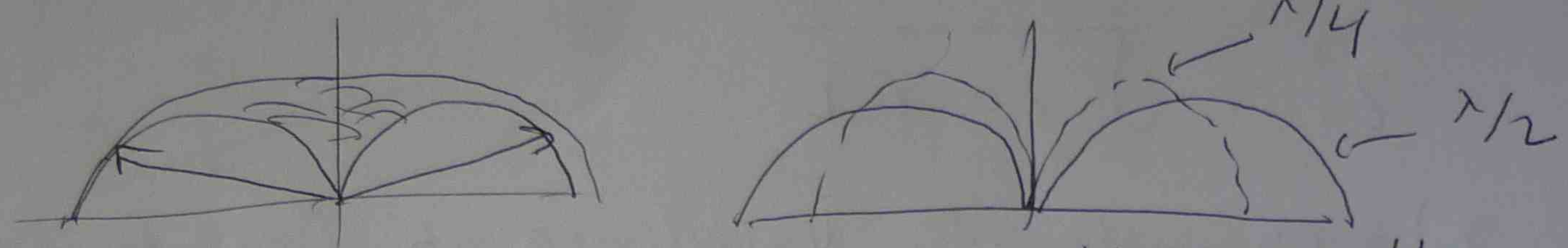




Counter poise

When an actual ground connection cannot be used for high resistance of soil, counter poise (a structure made of wire erected a short distance ~~for~~ above ground & insulated from ground is to be used.

Radiation pattern



vertical antenna radition patterns.

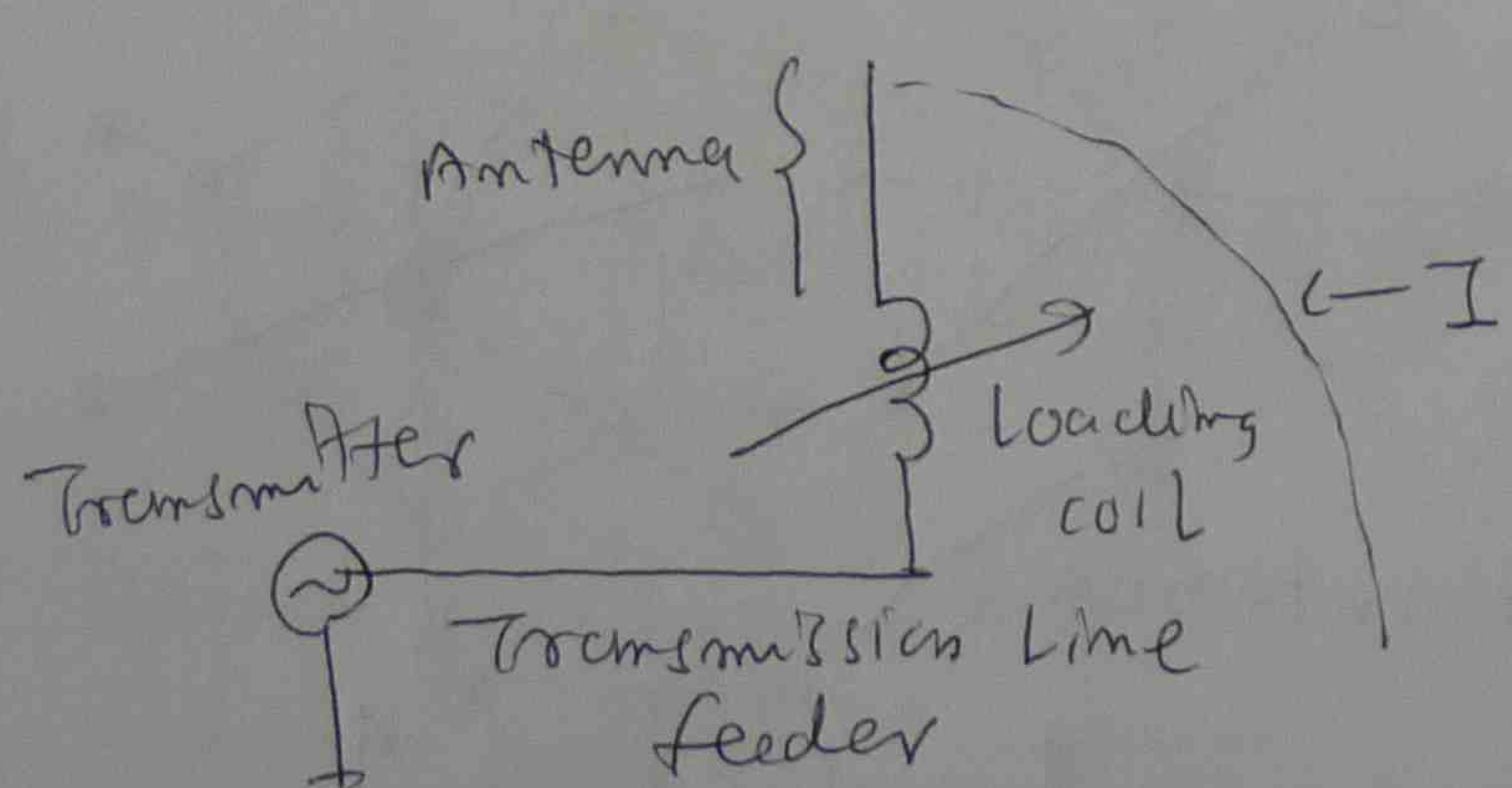
Loaded antenna

In many low frequency applications, it is not practical to use an antenna that is a full quarter wave length. This is especially true for mobile transceiver application. marconi antennas less than a quarter wave length have an input impedence that is highly capacitive and they become inefficient radiator. The reason for this is that a highly reactive load cannot accept energy from the transmitter.

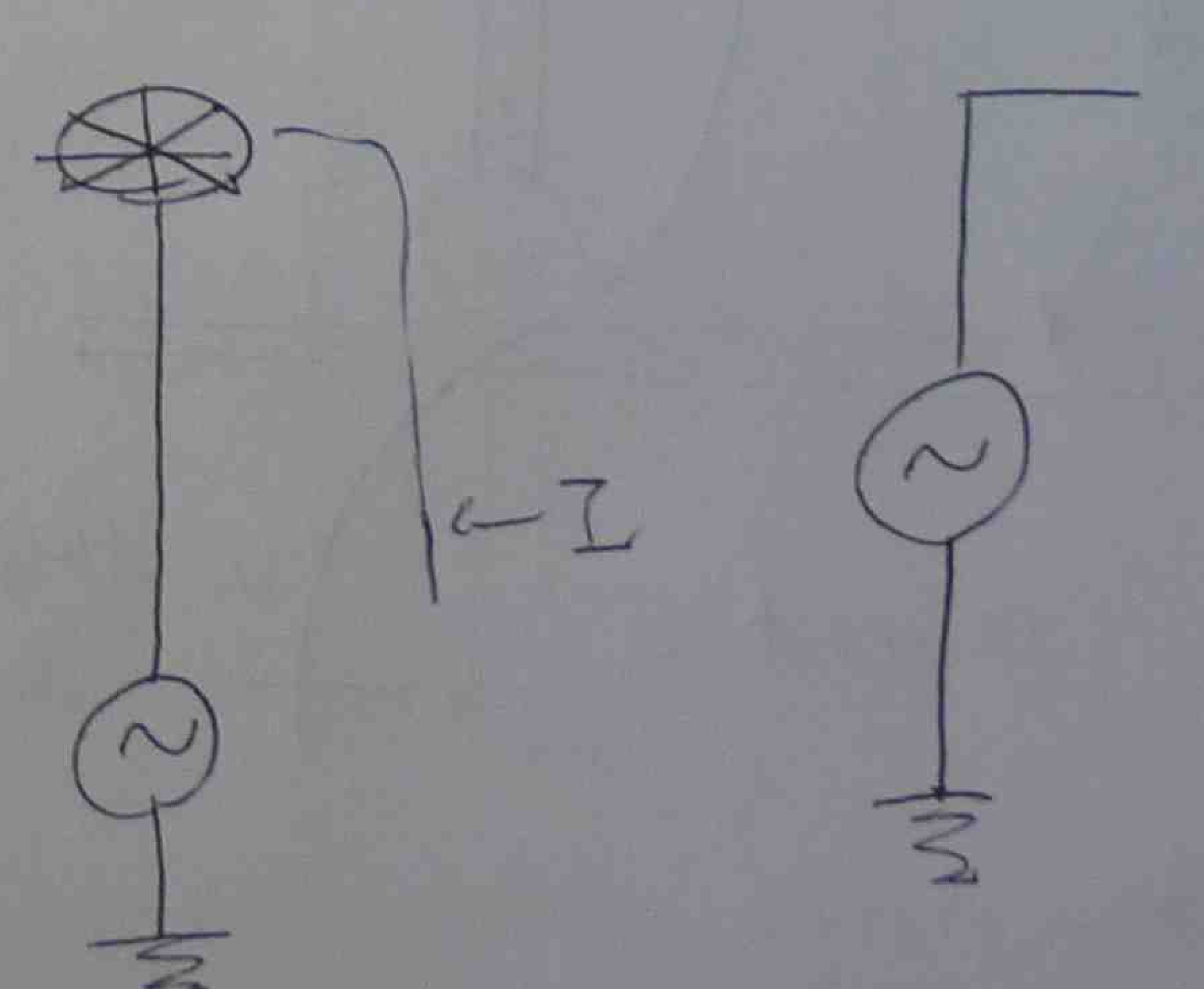
$\frac{\lambda}{8}$ marconi antenna $\longrightarrow$ $Z_{in} = 8 - j500\ \Omega$

Effective heigut of antenna should be $\frac{\lambda}{4}$

Additional capacitance reduces X_0. metallic spoke wheel at the top adds shunt capacitance to ground.



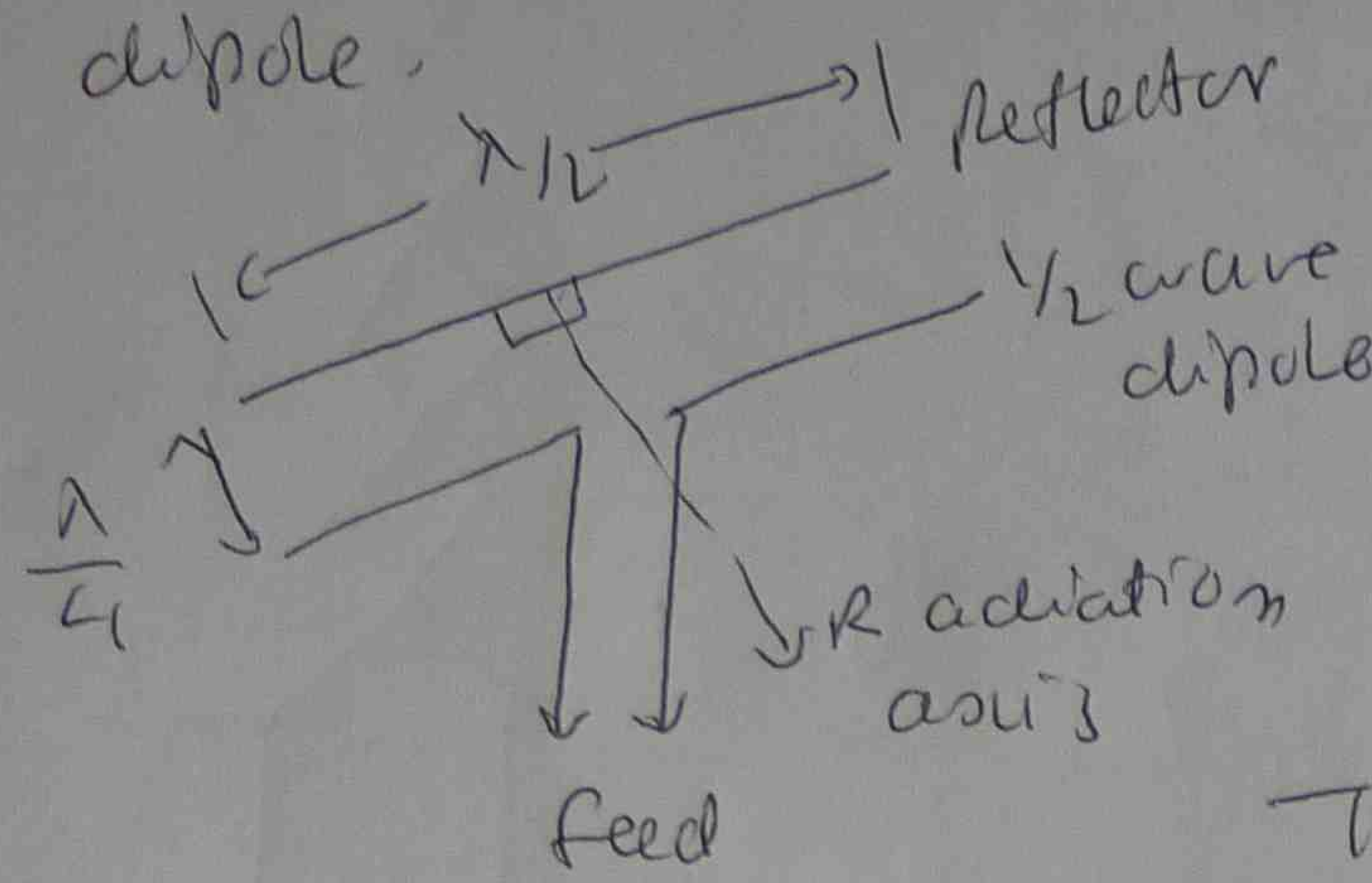
marconi antenner with loading coil

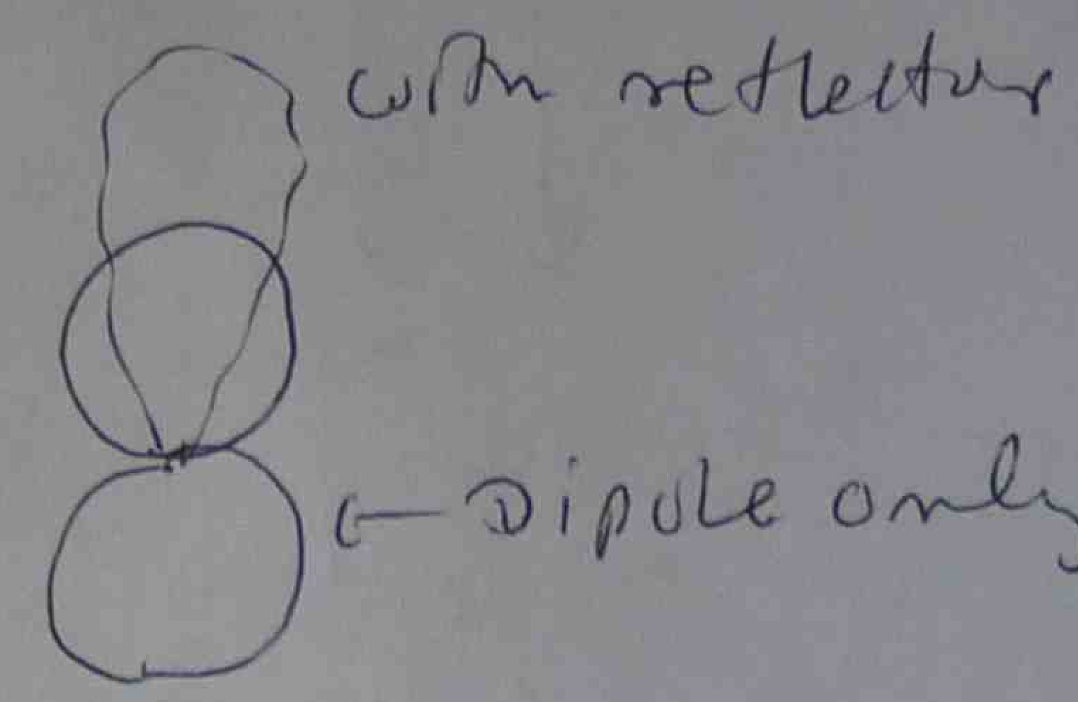


Top loaded marconi antennas

Antenna arrays

1/2 wave element located a 1/4 wave length behind the dipole.

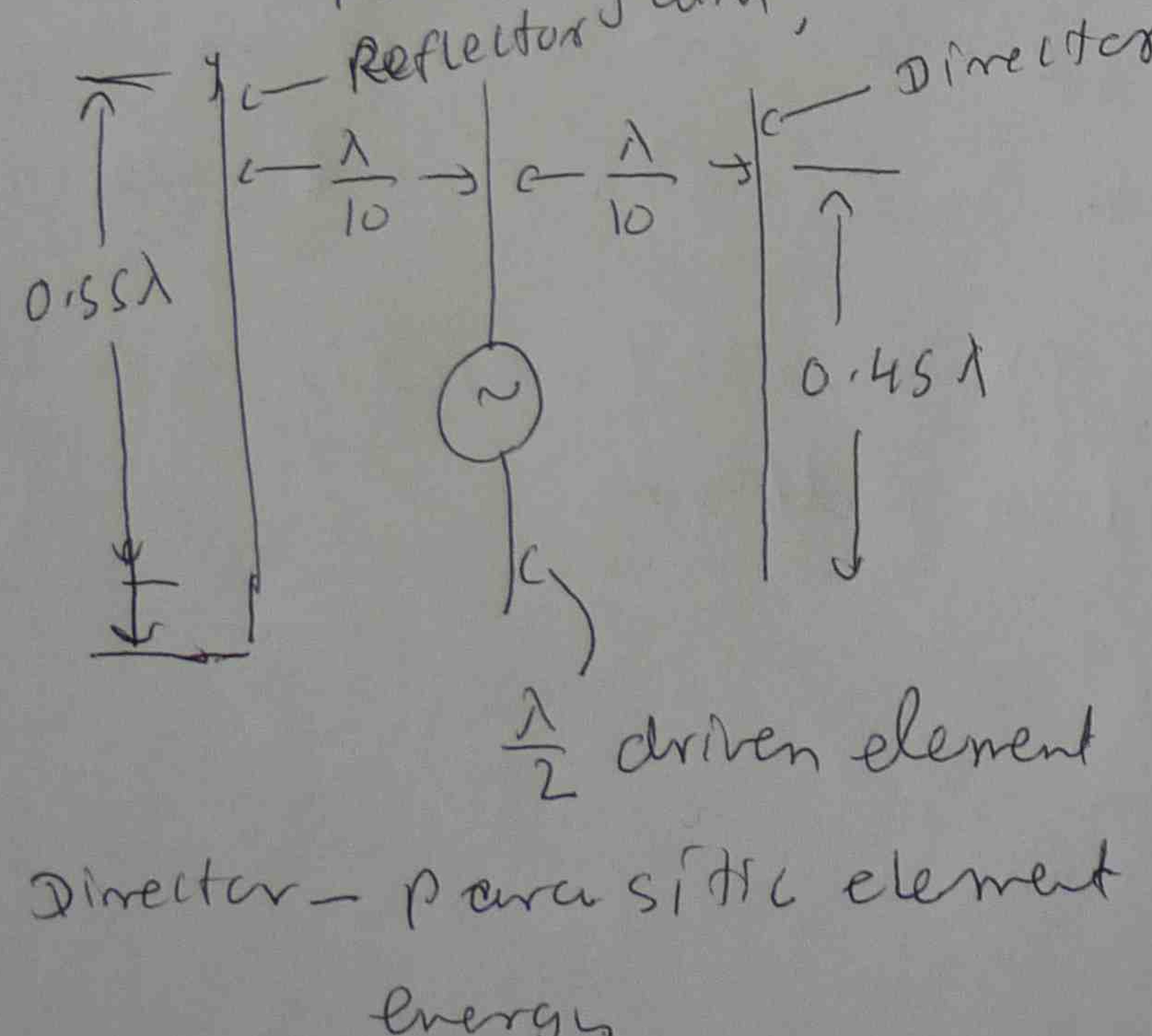


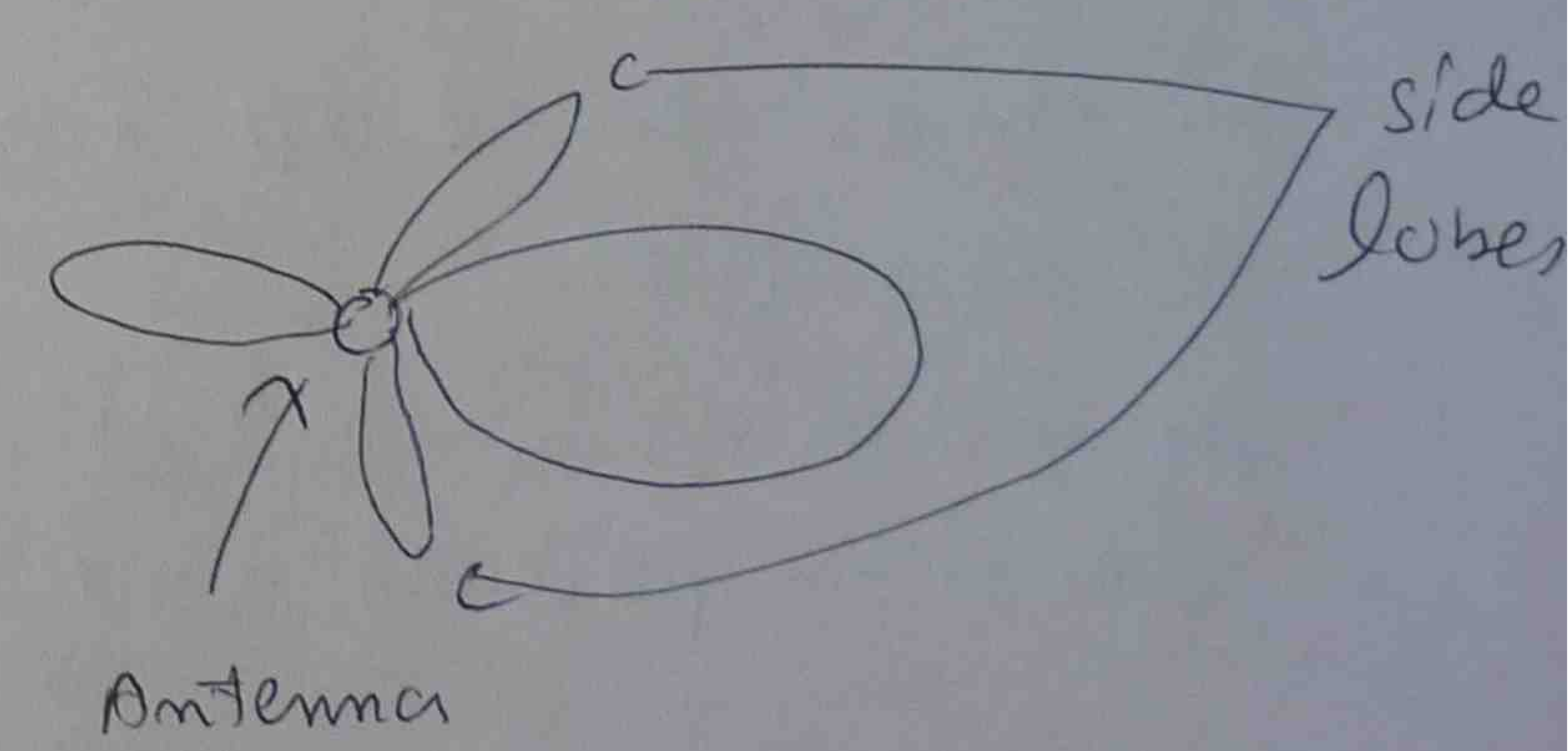


The energy from the reflector gets back to the driven element in phase and thus reinforces propagation in that direction.

Yagi-Uda antenna

7 dB power gain,

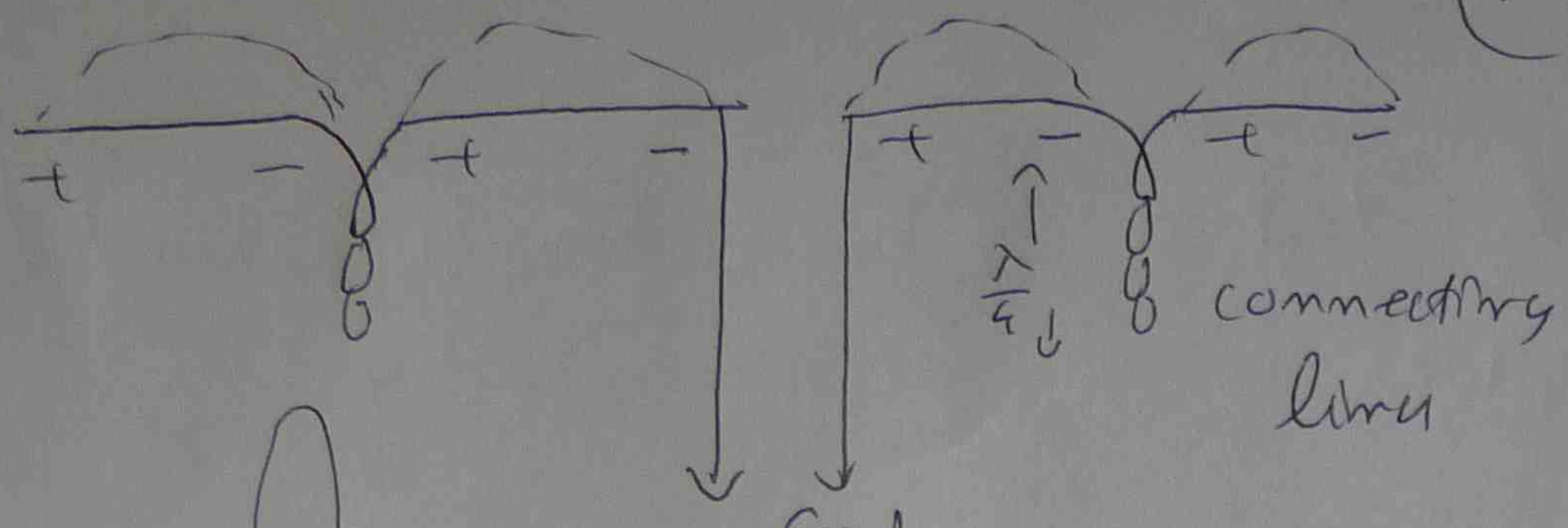




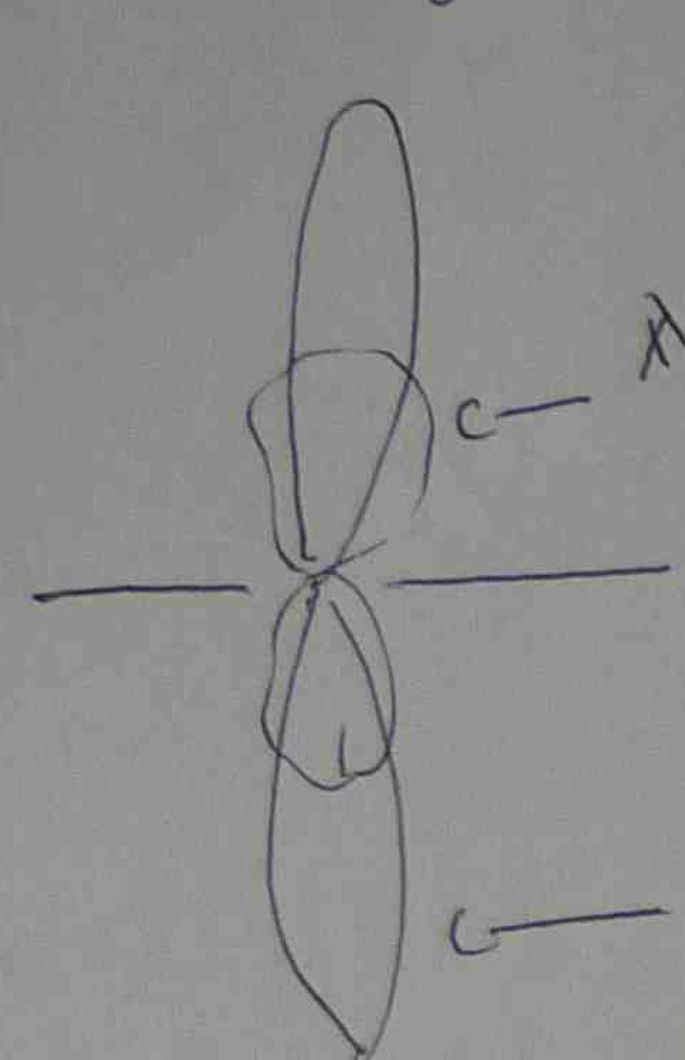
Director – parasitic element to direct electromagnetic energy

Driven collinear Array

A driven array is a multielement antenna in which all of the elements are excited through a transmission line.

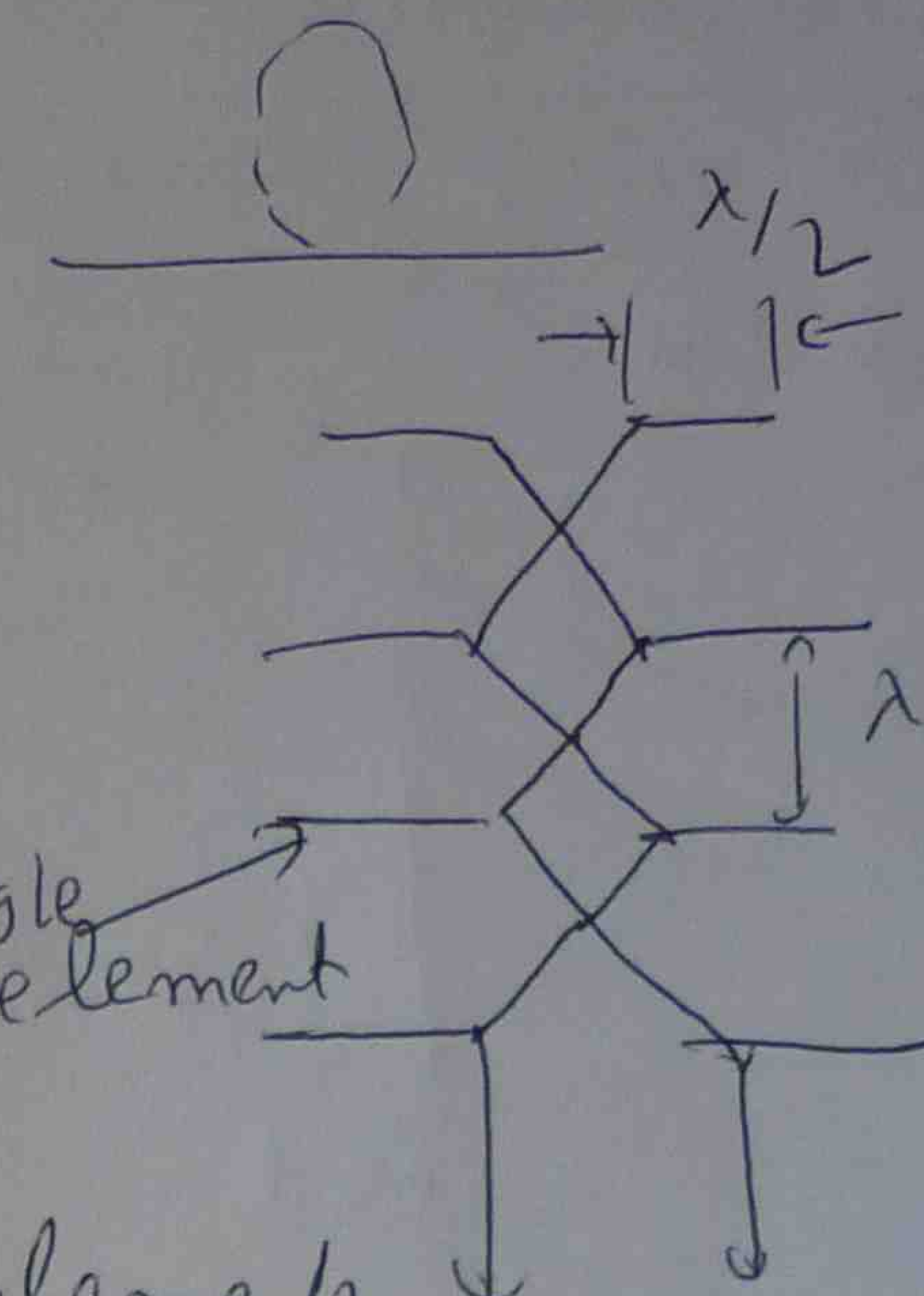


feed



λ/2 dipole radiation pattern

collinear array radiation pattern



feed

8 elements broadside array

If a group of 1/2 wave elements are ~~broad~~ mounted vertically, one over the other, a broad array is formed.

Marconi arrays

AM transmitters utilize two or more ~~m~~ Marconi antennas lined up in a row with equal spacing between them.

Phased array – controlling phase. It results a wide variety of possible radiation patterns.

Special purpose antennas

- Long periodic antenna
- Loop antenna
- Ferrite loop antenna
- Fold dipole antenna
- Slot antenna.

Week 16 Fibre Optics

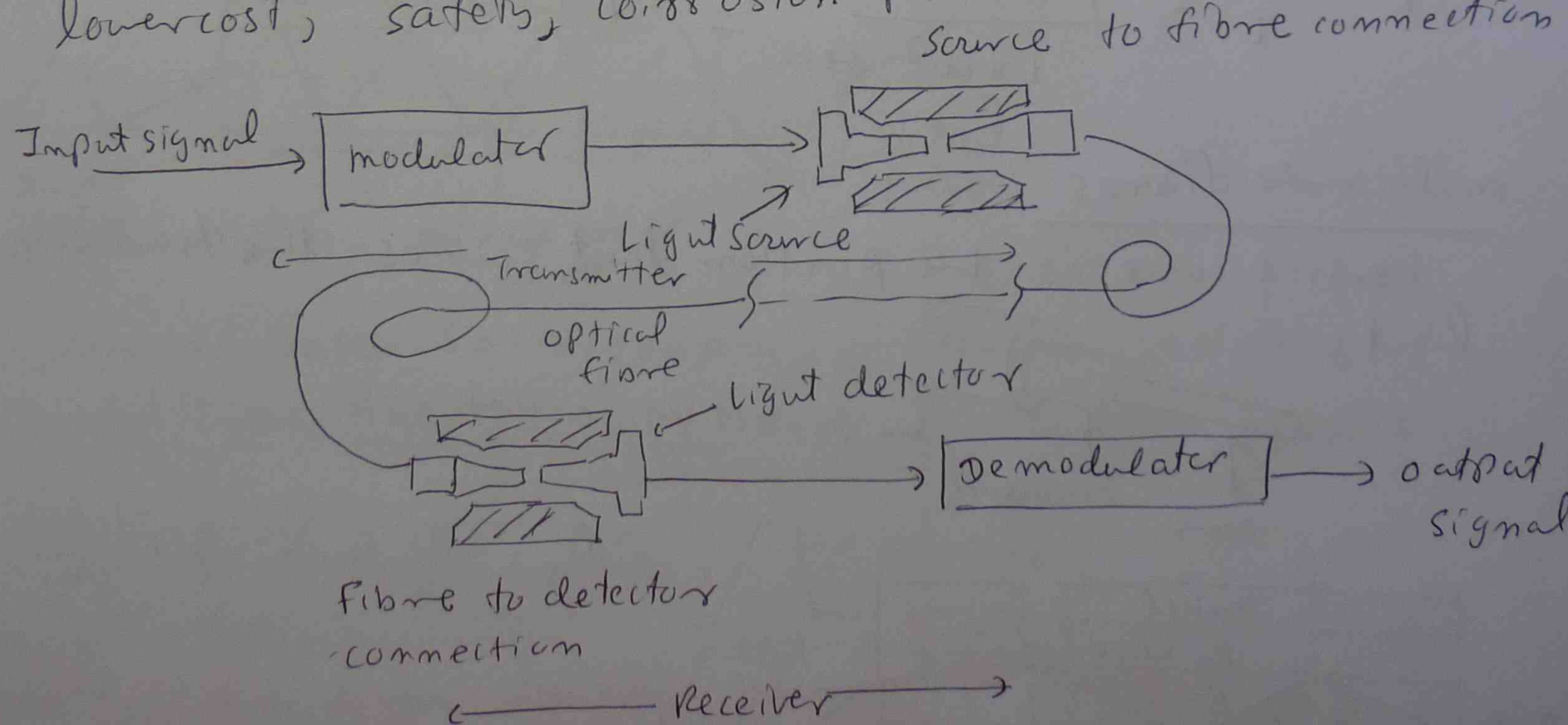
Fibre optics communication

1. A fiber optic transmission cable to carry the signal
2. Infrared radiation from light emitting diode (LED)
3. A photosensitive detector to convert the optical signal back in to electrical signal at receiver, Detectors are p-i-n or avalanche photodiode.
4. Efficient optical connectors at the light source to cable interface and at the cable to photodetector interface
5. standard communications electronics prior to the light source and following the photo detector.

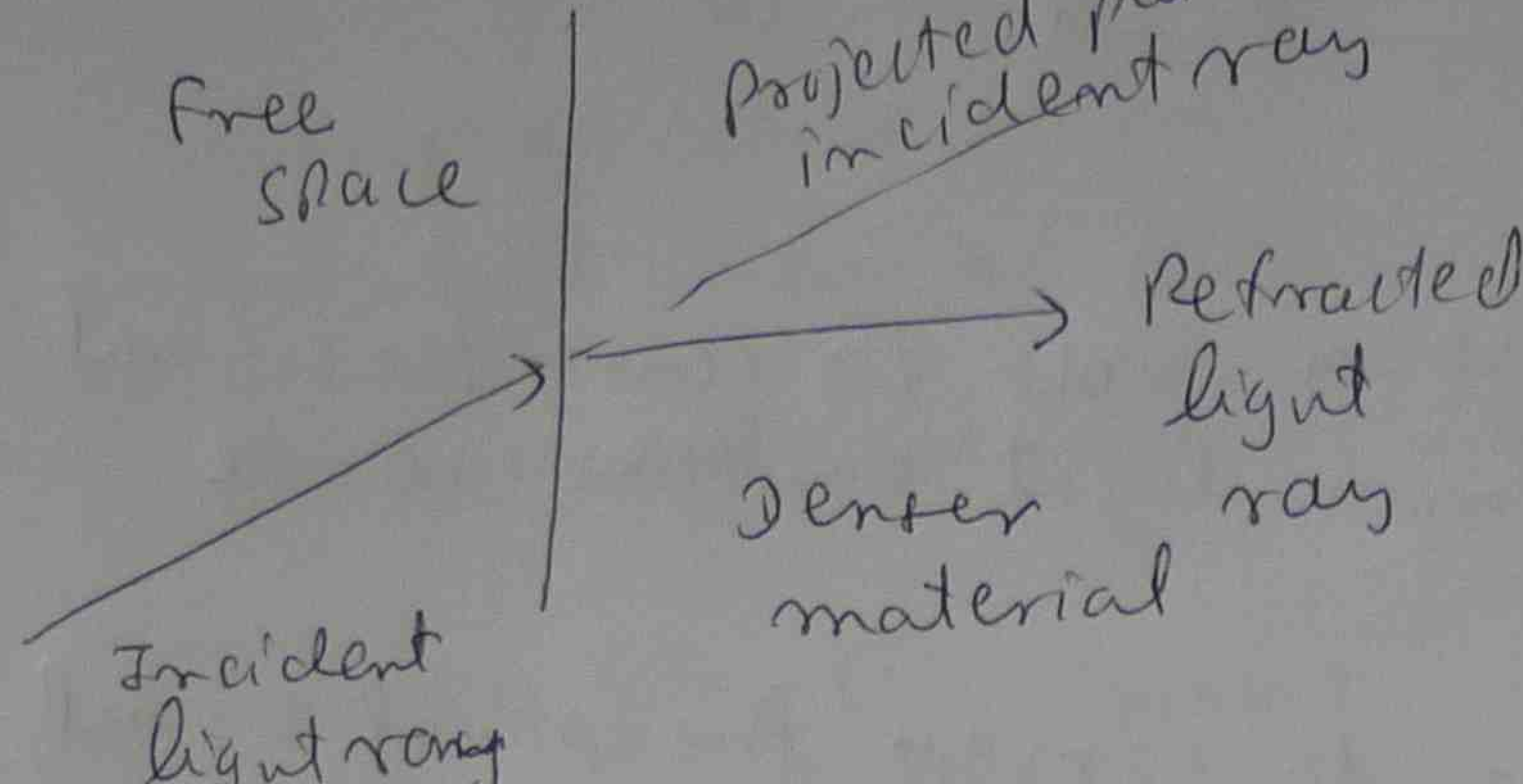
optical wave guide propagate the light signal.

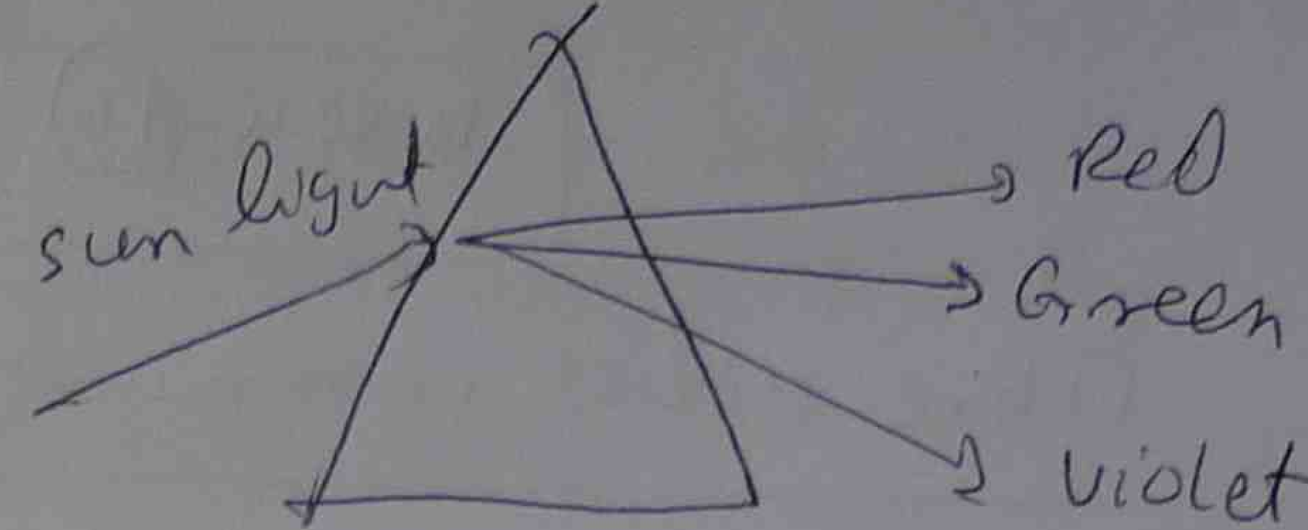
Advantage

lighter weight, Immunity to electromagnetic interference, lower signal attenuation, virtual eliminationof cross talk, lowercost, safety, corrosion prevented.



Refraction of light





Pb (1) calculate the wave length of red and violet light

Red $\lambda = \frac{c}{f} = \frac{3 \times 10^8}{3.6 \times 10^{14}} = 8.3 \times 10^{-7}\ m = 0.83\ \mu m$

violet $\lambda = \frac{c}{f} = \frac{3 \times 10^8}{7 \times 10^{14}} = 0.43$ micron

Pb (2) calculate the energy of one photon for infrared light energy at 1.55 microns. calculate the power in a 1ms pulse of this energy.

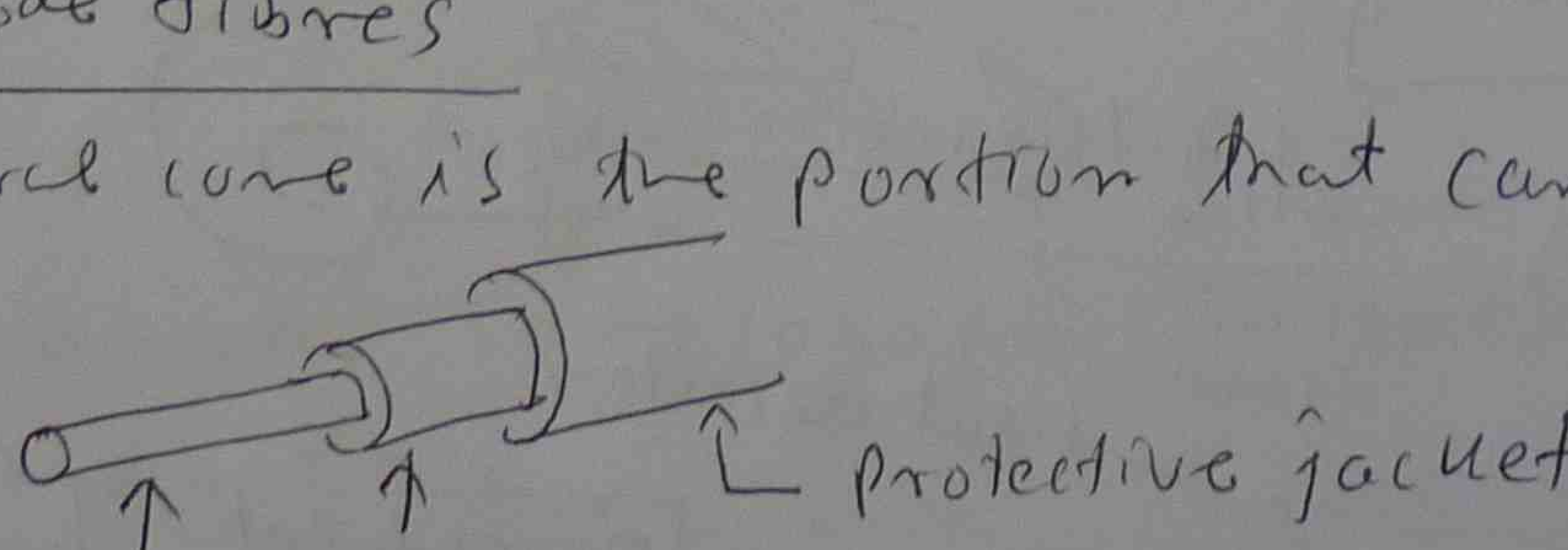
$u = hf = \frac{hc}{\lambda}$ h = planck's constant $= 6.63 \times 10^{-34}$ J-s

$= \frac{6.3 \times 10^{-34} \times 3 \times 10^8}{1.55 \times 10^{-6}\ m} = 1.22 \times 10^{-19}\ J$

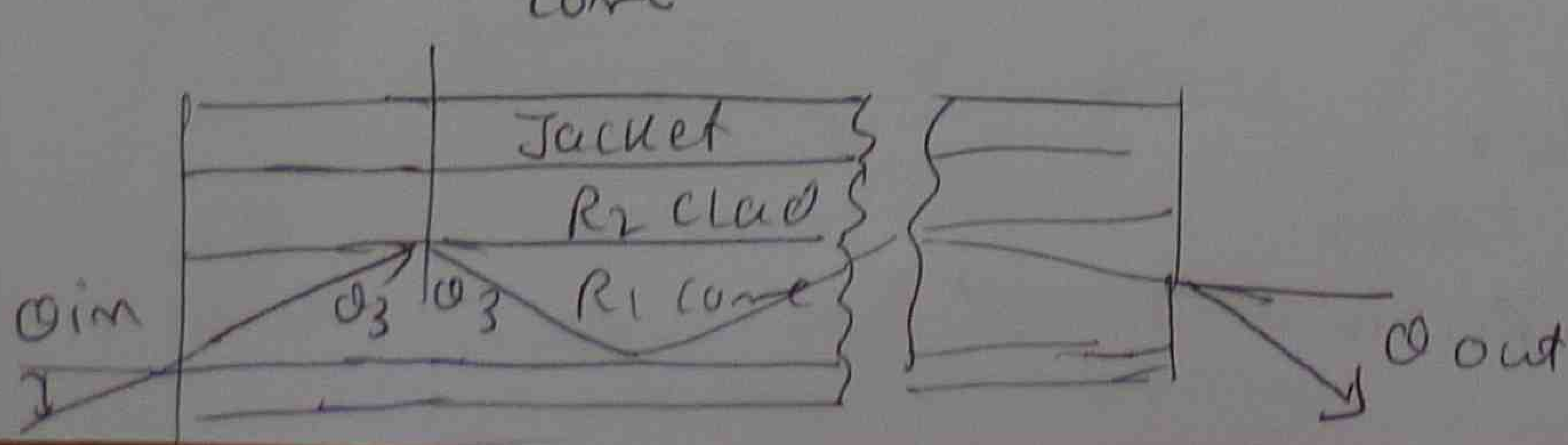
$P = \frac{u}{t} = \frac{1.22 \times 10^{-19}}{1 \times 10^{-3}\ sec} = 1.22 \times 10^{-16}\ W$

multimode fibres

central core is the portion that carries the transmitted light,



$\theta_c = \theta_3\ (\min) = \sin^{-1} \frac{n_2}{n_1}$



Pb 3, An optical fiber and its cladding have refractive indexes of 1.535 and 1.490 respectively. Calculate N.A and θ_{in} (max).

N.A – numerical aperture.

$$NA = \sin\theta_{in}(\max) = \sqrt{n_1^2 - n_2^2}$$

$$= \sqrt{1.535^2 - 1.49^2} = 0.369$$

$$\theta_{in}\max = \sin^{-1} NA = \sin^{-1} 0.369 = 21.7^\circ$$

Optical fibers

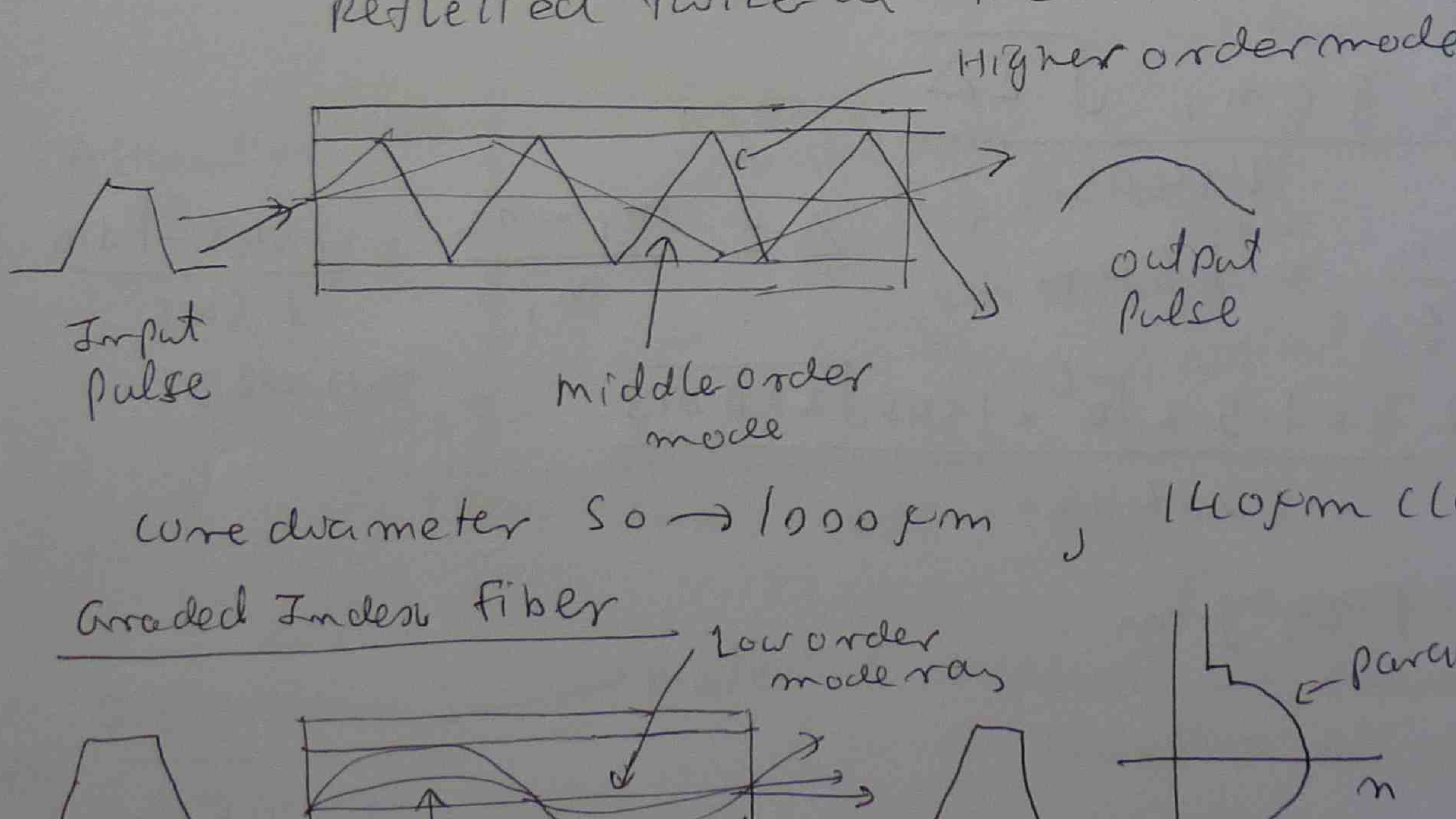
Choice criteria
(1) Signal losses
(2) Ease of light coupling and interconnection
(3) Bandwidth.

Lowest order mode

Travelling along the axis of fiber

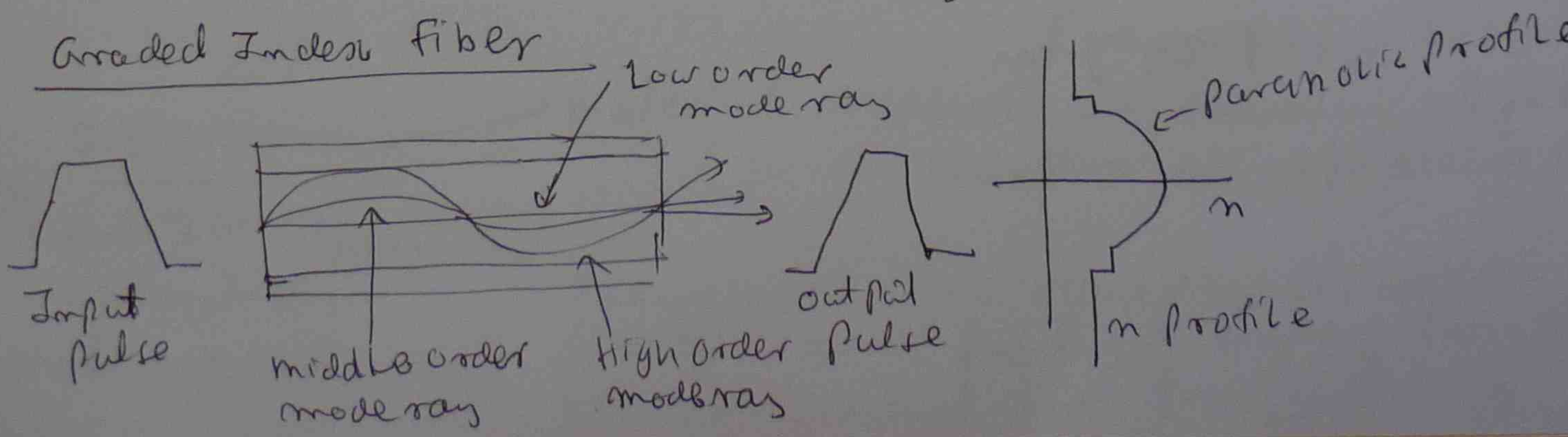
middle order mode

Reflected twice at the interface.



core diameter 50 → 1000 μm, 140 μm cladding

Graded Index fiber



The index of refraction is tailored to follow the parabolic profile. overcome the pulse dispersion problem.

Low order mode → Travel through a constant density materials.

High order mode → Lower density material farther from the core axis.

Graded index multicore - 50 μm diameter & 125 μm cladding to send upto 140 mb/sec over 20 km range.

Single mode fibers

cut off wave length λ_c

$$\lambda_c = \frac{2\pi a n_1 \sqrt{2\Delta}}{2.405}$$

where $\Delta = \frac{n_1 - n_2}{n_1}$

a = core radius.

Pb (4) Determine the cut off wave length for a fiber with a 3 μm diameter core. The core and cladding indexes of refraction are 1.545 and 1.510 respectively.

$$\lambda = \frac{2\pi a n_1 \sqrt{2\Delta}}{2.405}$$

$a = \frac{3\mu m}{2} = 1.5\mu m$

$\Delta = \frac{n_1 - n_2}{n_1} = \frac{1.545 - 1.510}{1.545}$

$= 0.023$

$$\lambda_c = \frac{2\pi \times 1.5 \times 10^{-6} \times 1.545\sqrt{2 \times 0.023}}{2.405}$$

$= 1.29\ \mu m$

Fiber attenuation and dispersion

P = optical power at distance l from transmitted Power Pt

$$P = P_t \times 10^{-\frac{A}{10}}$$

A: fibre attenuation dB/km

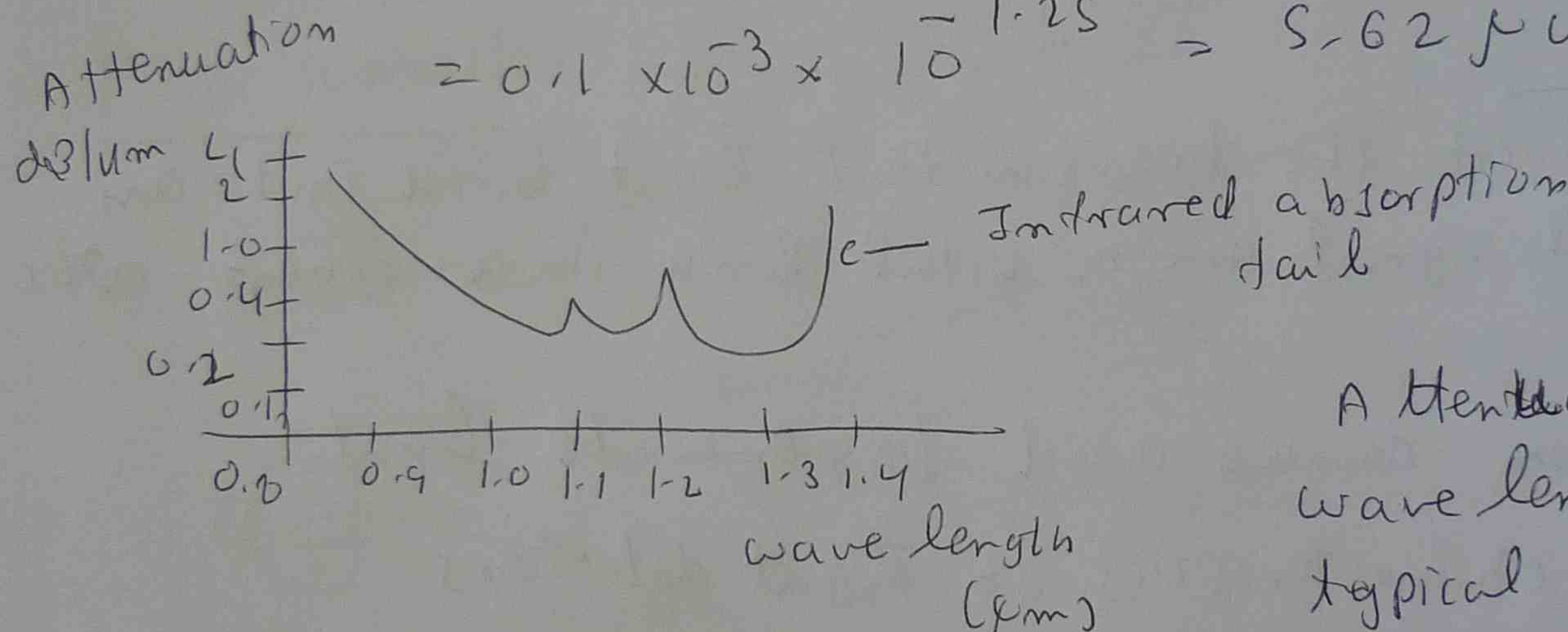
Pb 5

Calculate the optical power 50km from a 0.1mW source on a single mode fiber that has 0.25 dB/km loss.

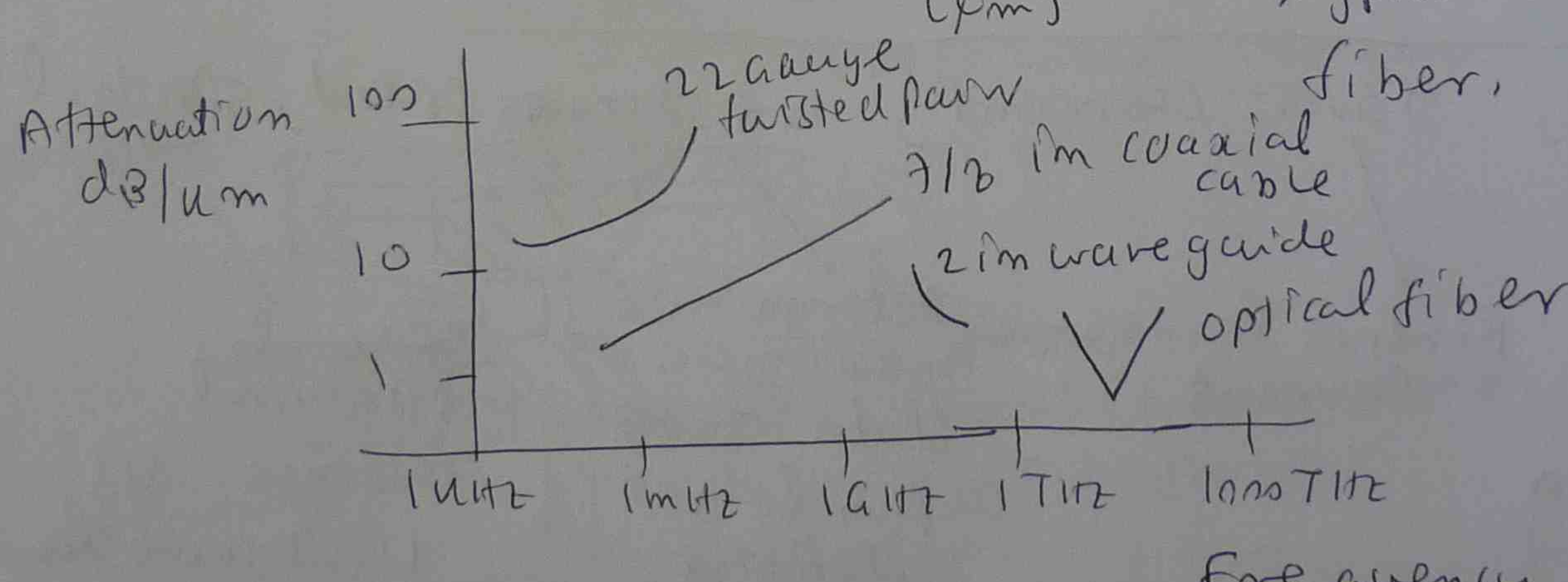
$$P = P_T \times 10^{-\frac{A}{10}}$$

$$= 0.1 \times 10^{-3} \times 10^{-\left(\frac{0.25 \times 50}{10}\right)}$$

$$= 0.1 \times 10^{-3} \times 10^{-1.25} = 5.62\ \mu W$$



Attenuation vs wave length for typical high quality fiber.



Dispersion → material dispersion — caused by slight variation of refractive index

Dispersion → wave guide dispersion — caused by a portion of the light energy travelling in the cladding.

BW limit 20MHz/km of length for multicore fibre

20% of energy contained

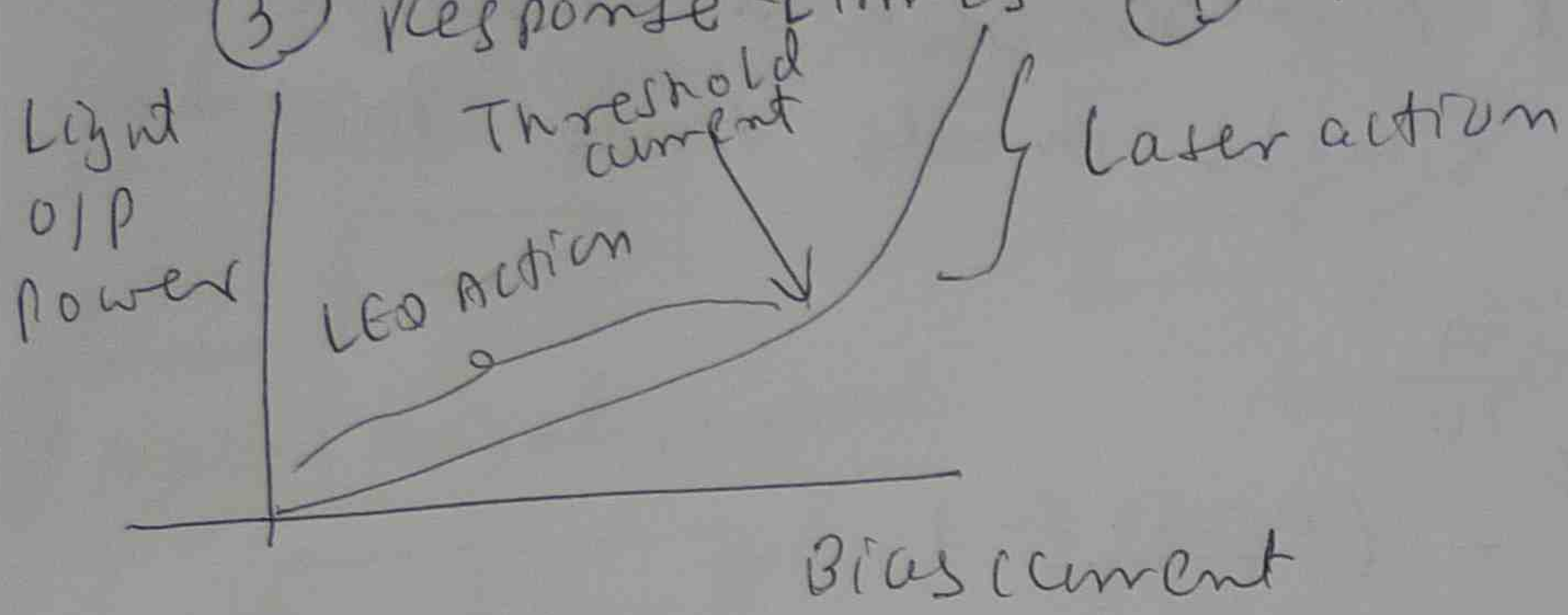
(135)

Light source for fibre optic communication system

- → Diode Laser (DL)
- → High radiance light emitting diode (LED)

Characteristics

① Power level ② Temperature sensitivities ③ Response times ④ Life times ⑤ characteristics of failure.



Detectors

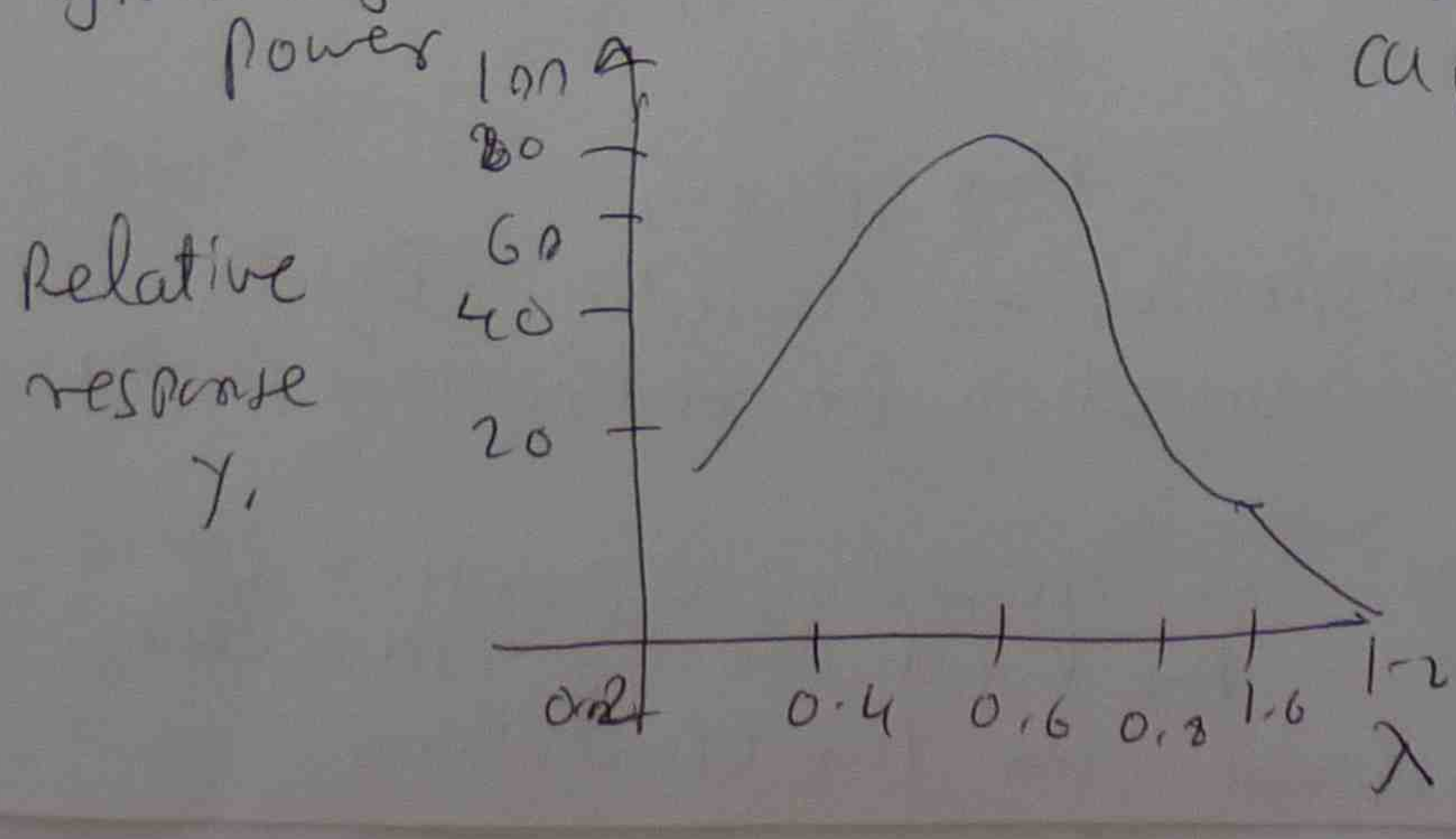
To convert the transmitted light back into an electrical signal are a vital link in a fiber-optic system.

p-n Junction can be used to generate light.

Important characteristics of light detectors

Responsivity, Dark current, response speed, spectral response

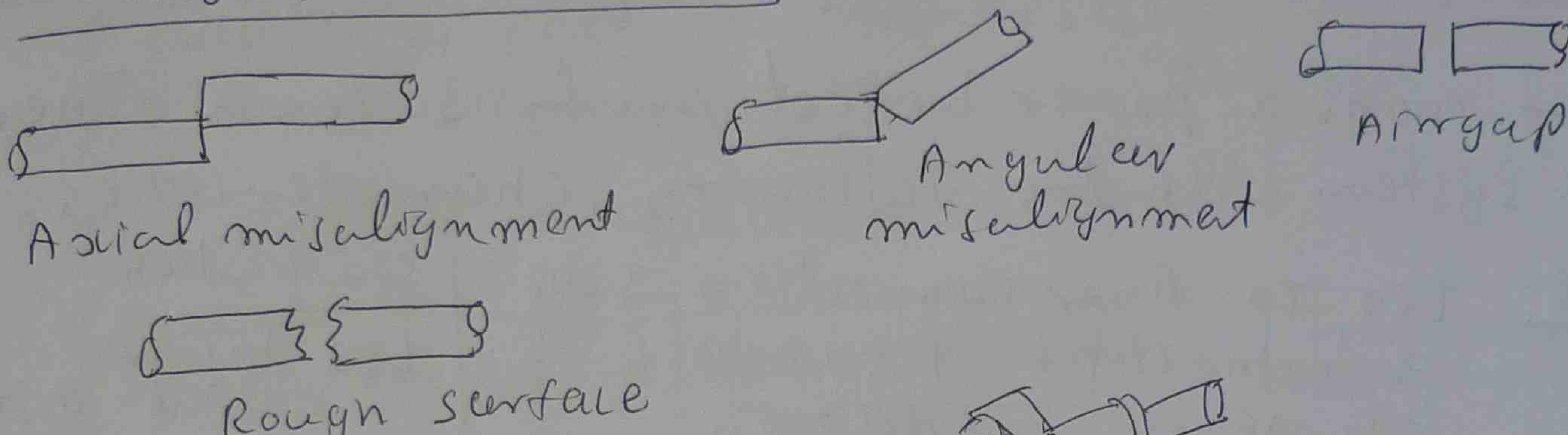
- Responsivity → measure of O/P current for a given light power
- Dark current → Reverse leakage current
- Response speed → Determine maximum data rate capability of detector
- Spectral response → ~~spectral~~ spectral response VS Light wave length



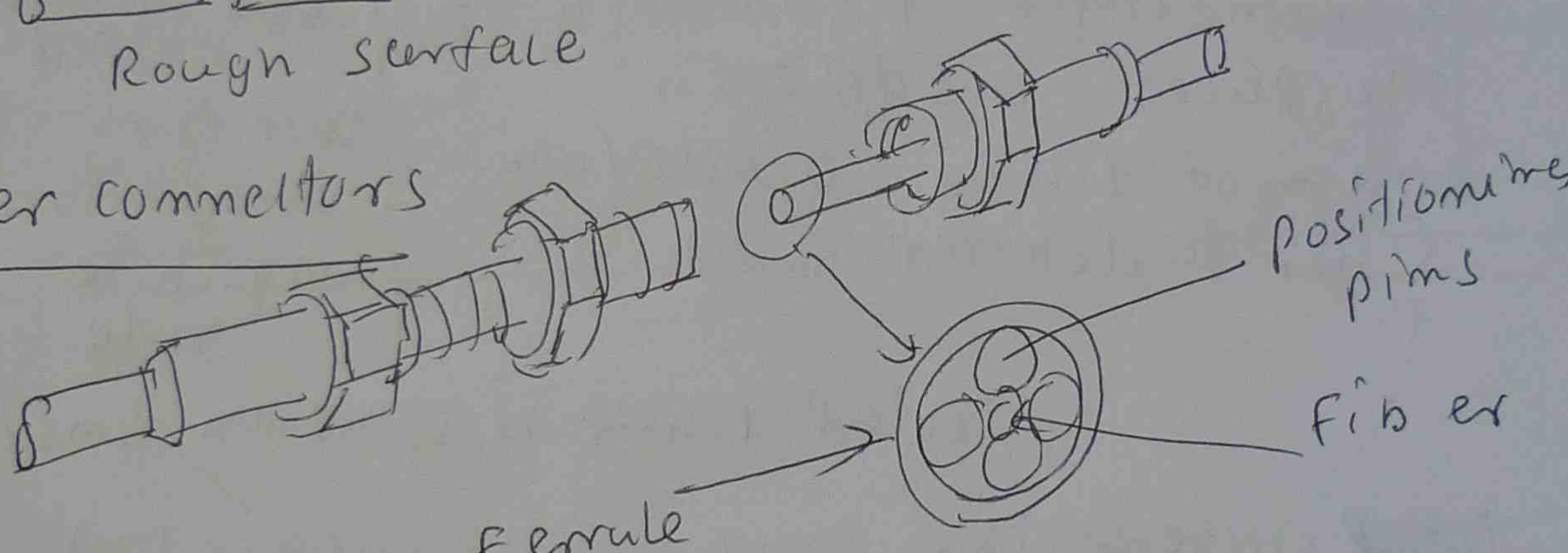
Fibre connection

- making connections from light source to fibre, ~~fibre~~ fiber to fiber and fibre to detector are critical in system.
- The connection must lose as little light as possible.

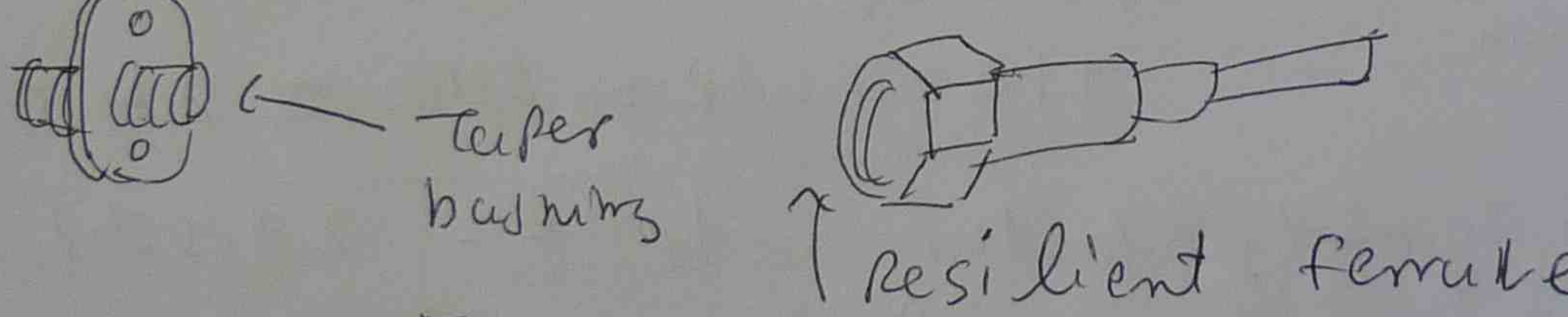
source of connection lose



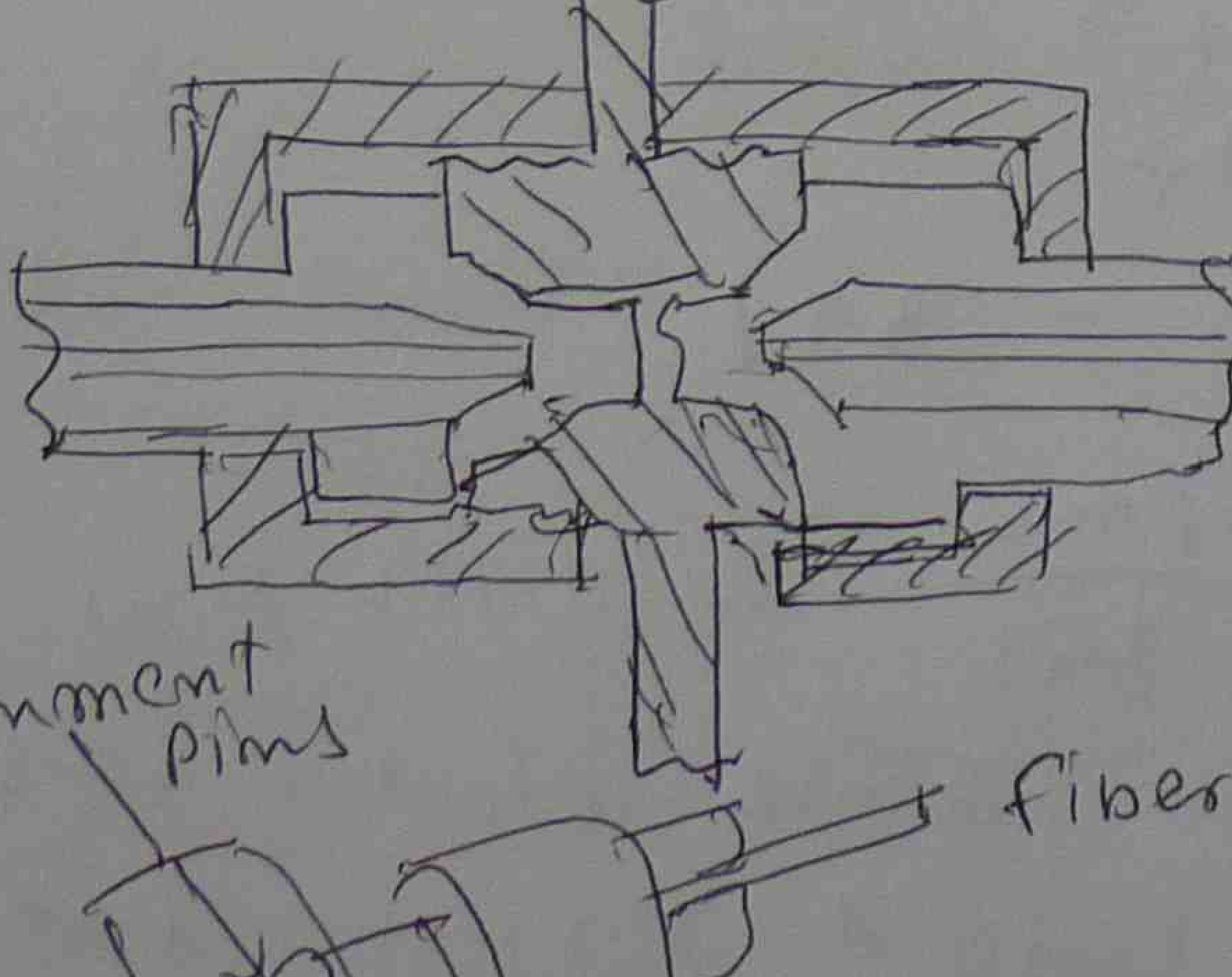
Fiber connectors



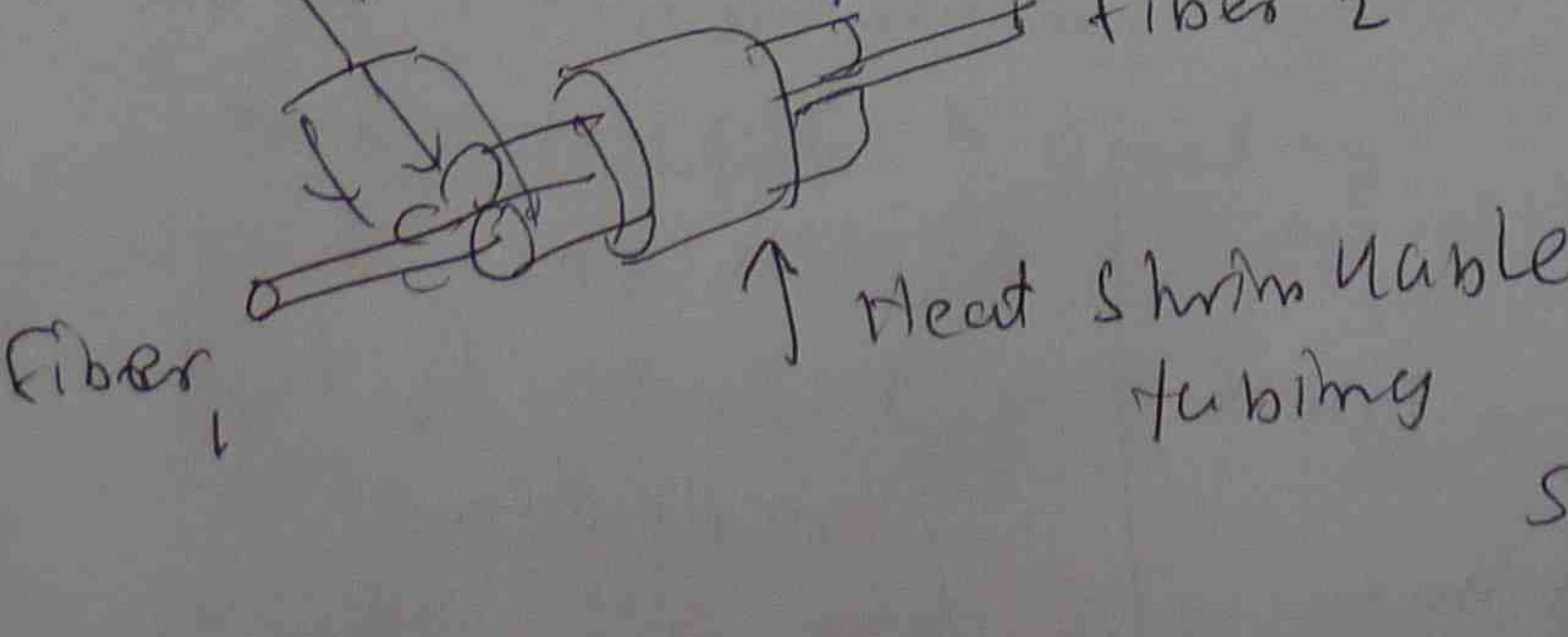
V groove



connector techniques



~~Fer~~ Ferrules compressed into bushing



Inspection port allows alignment of the fibers to be checked.

specially epoxy is applied between fibers through the port.

System — Telementry
— fiber optic sensors
— communications.

power budget

$$Z = \frac{1}{5 B \Delta_t}$$

Z = maximum fiber length (km)

B = maximum bit rate (mb/s)

Δ_t = dispersion (μs/km)

pb 6 make a power budget analysis for a fiber optic system with the following characteristics.

Losses
- LED to fiber connection 5 dB
- 3 connectors 1.5 dB each
- six splices 0.5 dB each
- 10 km of fiber 0.6 dB/km
- fiber to detector 6 dB

Specification
- LED power output 0.1 mW
- detector sensitivity 2 μW
- max. bit rate 5 mb/s

Total fiber dispersion 4 ns/km

sum of Total system attenuation $= 5dB + 3(1.5dB) + 6(0.6dB) + 10 \times 0.6dB + 6dB = 24.5 dB$

Assume 5 dB safety factor total = 29.5 dB

$$29.5 dB = 10 \log \frac{P_t}{P_r}$$

$$\frac{P_t}{P_r} = \log^{-1} \frac{29.5}{10} = 891$$

$$P_r = \frac{P_t}{891} = \frac{0.1 mW}{891} = 0.112 \mu W$$

Since detector sensitivity is 0.1 μW, the system should operate satisfactorily without repeater

$\Delta t = \mu s/km$

$\Delta t = 4 \times 10^{-3} \mu s/km$

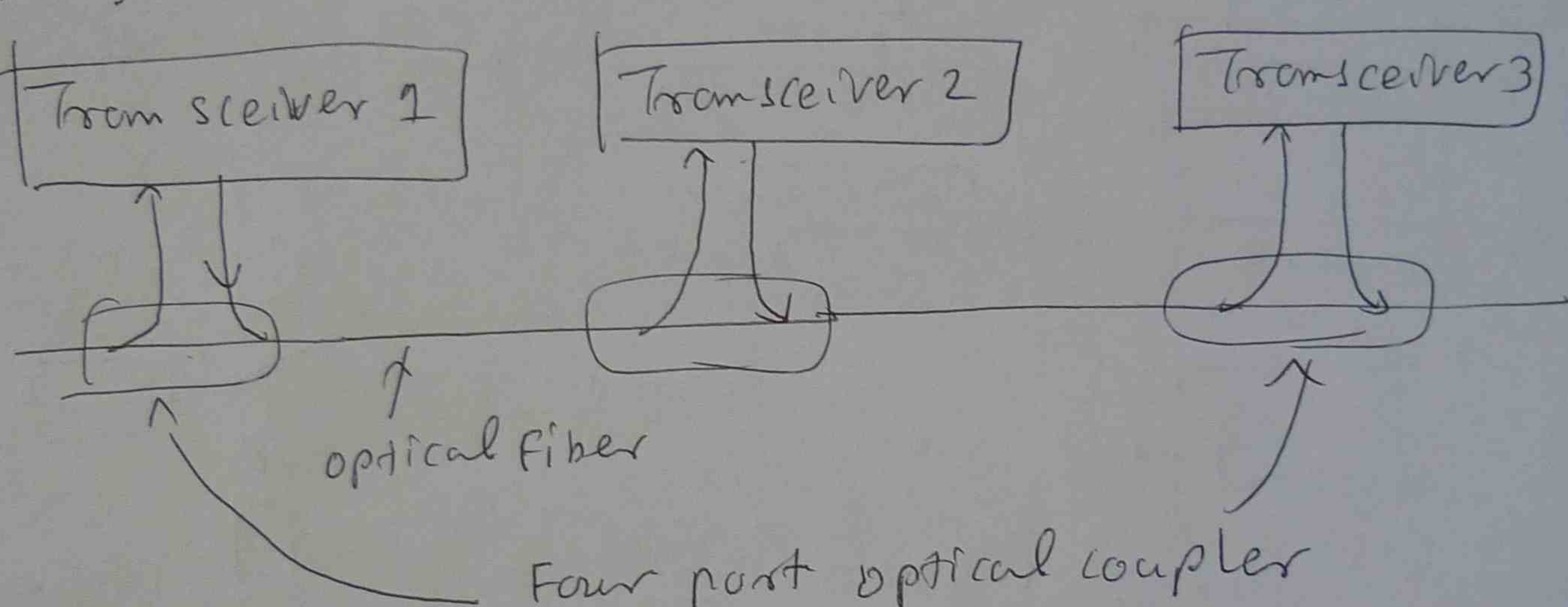
$= 0.004$

$$Z = \frac{1}{5 B \Delta t} = \frac{1}{5 \times 5 \times 0.004} = 10 km$$

System length is equal to maximum dispersion length (10 km) some testing will be necessary.

Fiber optic LANs

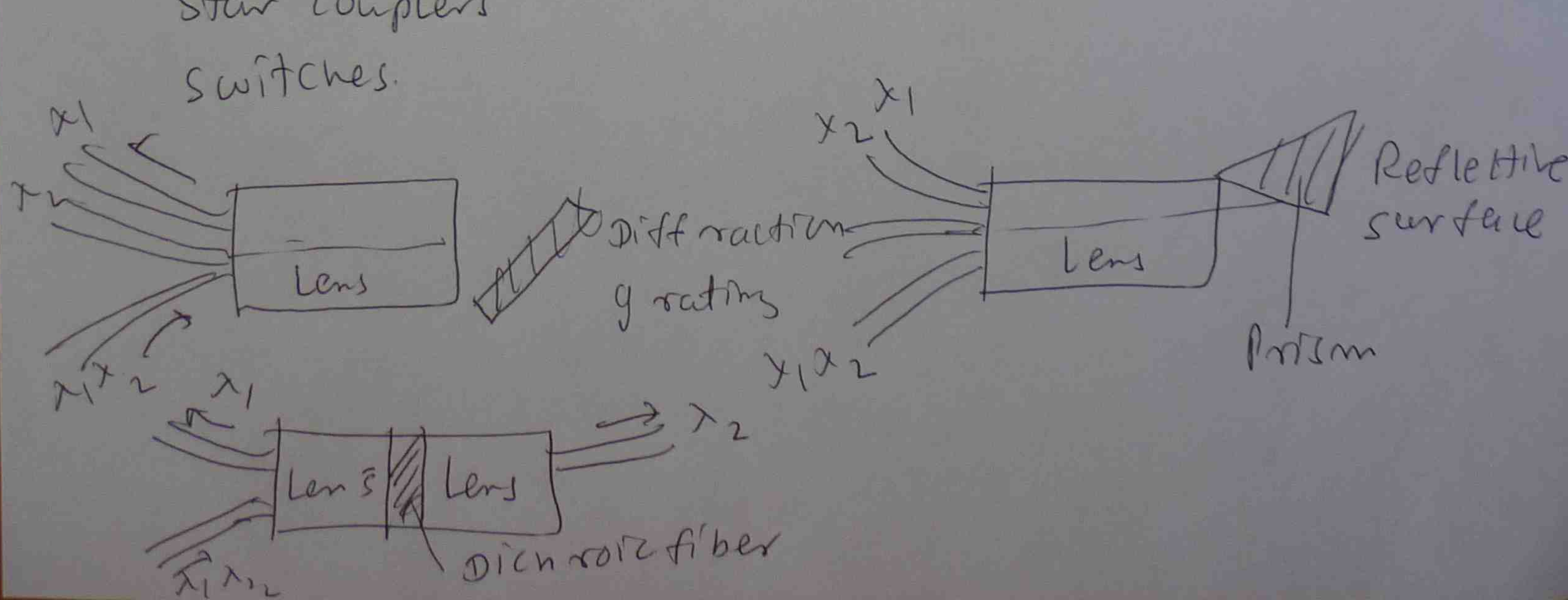
LAN configuration → ring, bus, star topologies.
Ring network has a serial connection between each node.
Fiber optic transmission system can be incorporated in each of topologies.
A passive 4 port coupler is used to transmit or receive information on the bus.
Ring network uses active elements at each node.

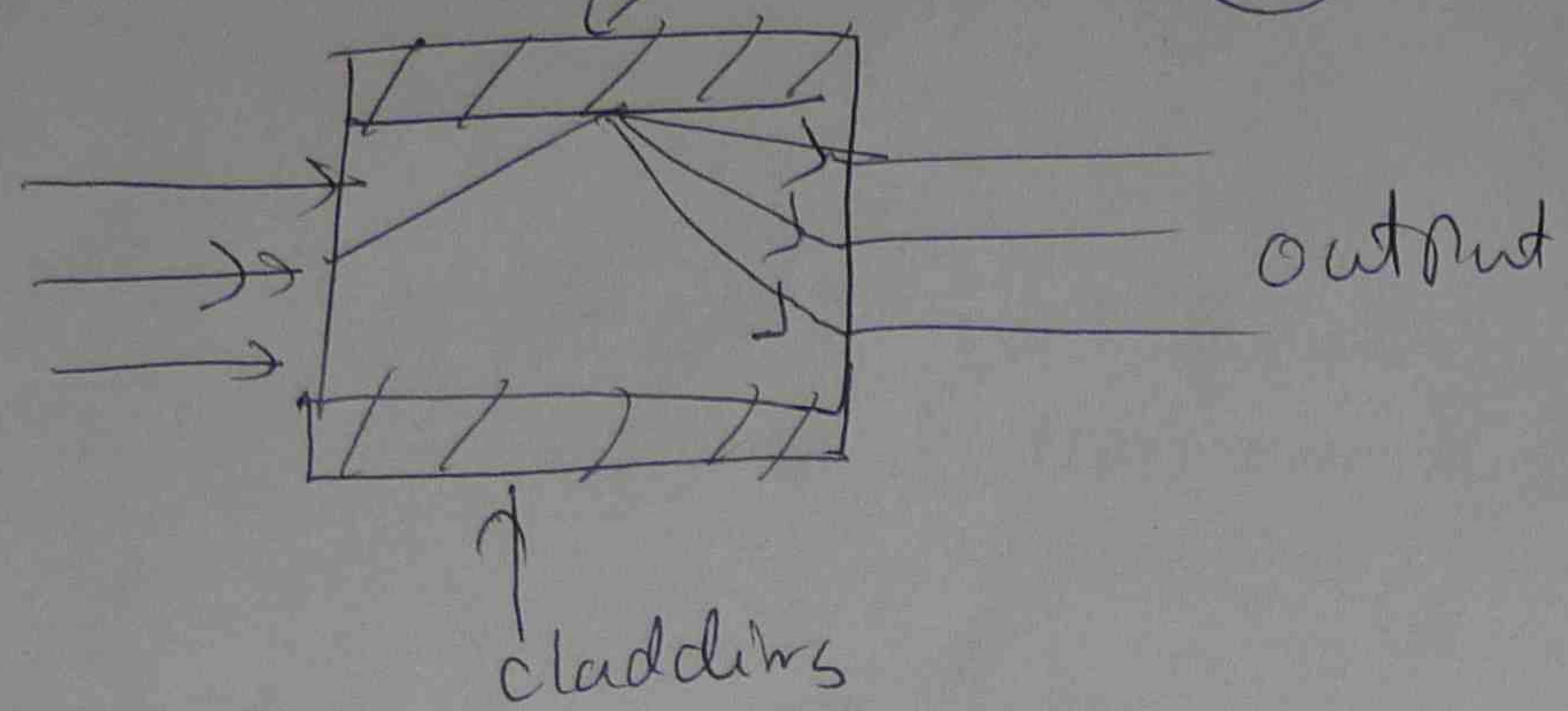


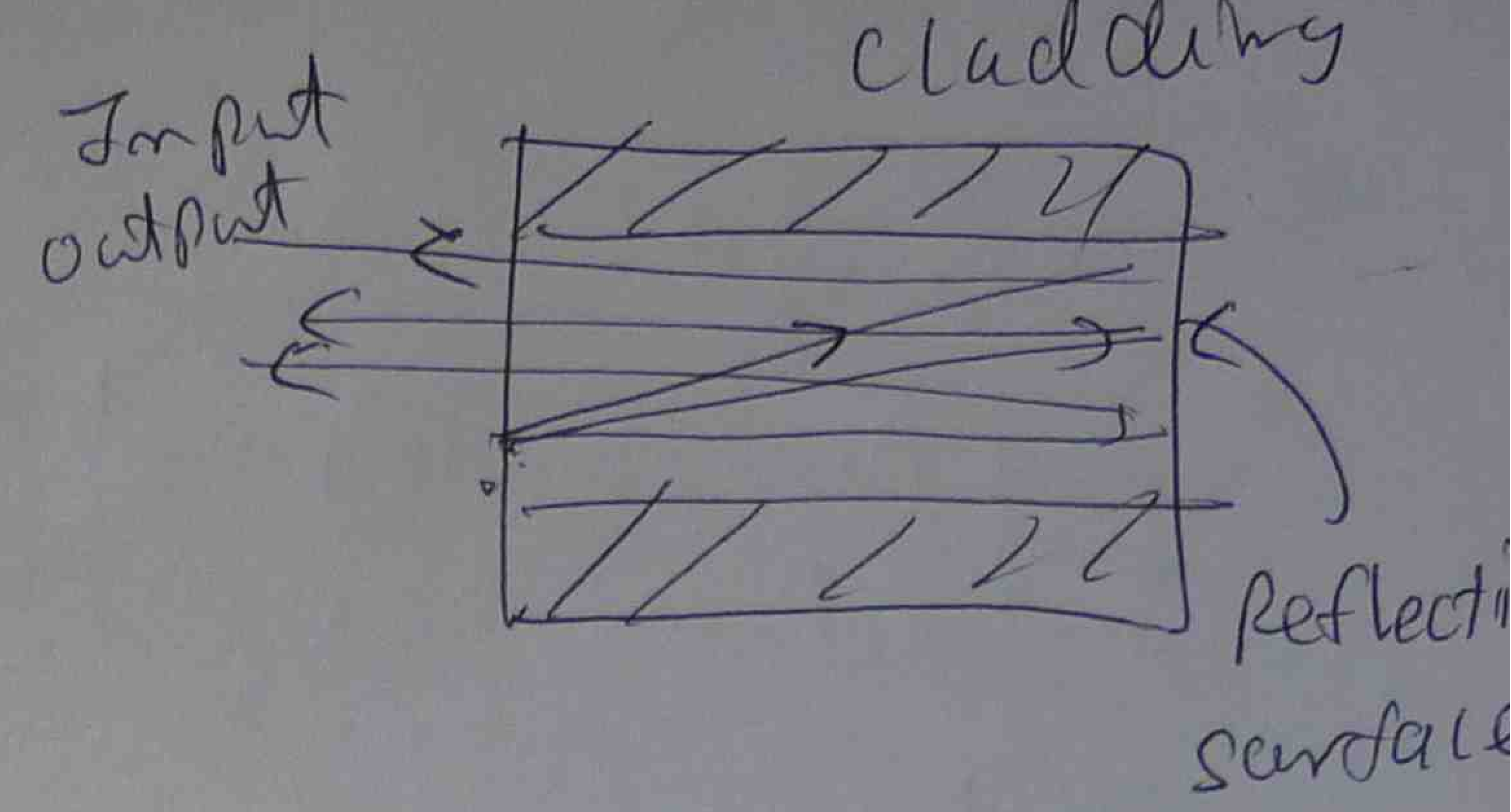
component of fiber LANs

couplers (dependent & invariant wave length dependent couplers)

Star couplers
switches.

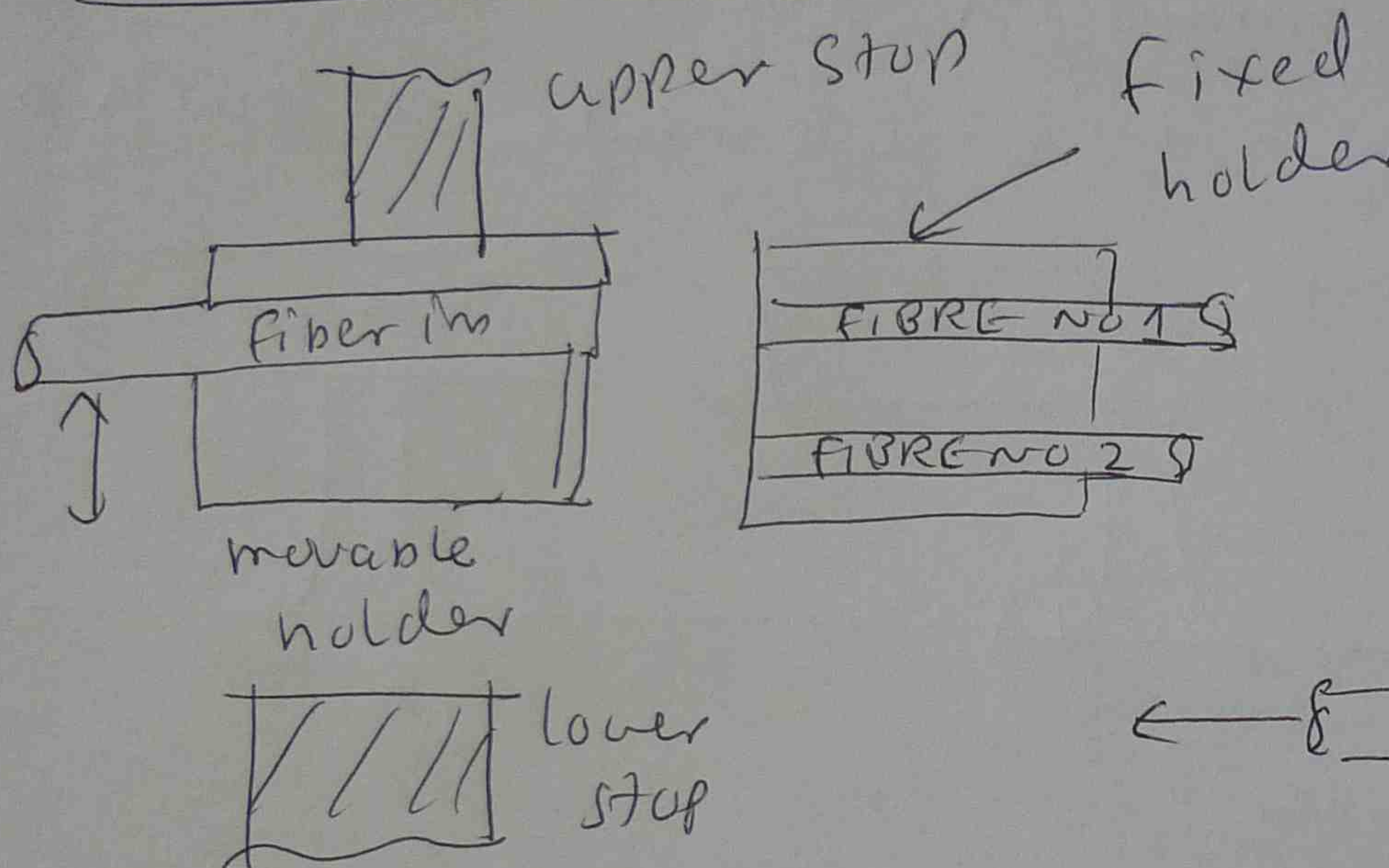




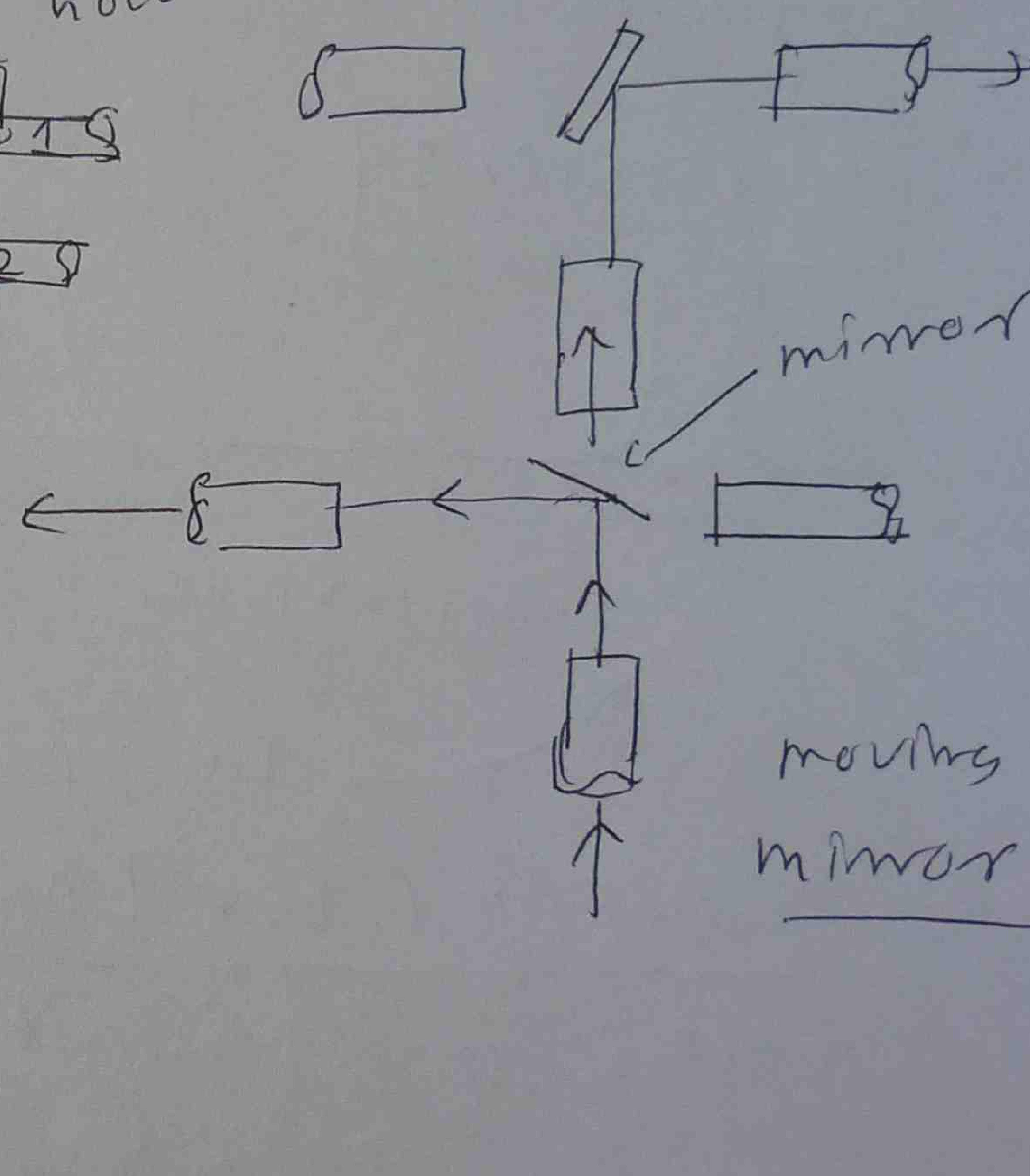


Star coupler

<u>optical switches</u> — moving fibre / moving mirror



<u>moving fibre</u>



<u>moving mirror</u>