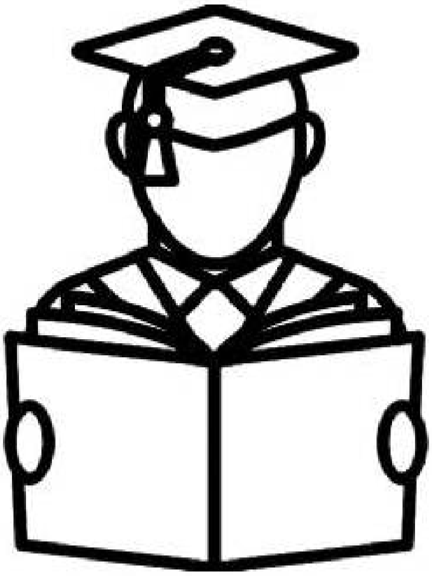


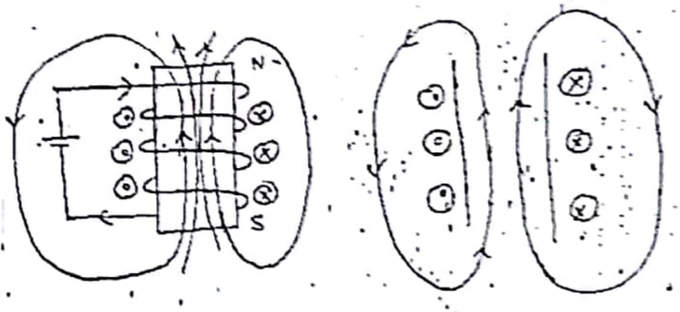
Electrical Engineering for GATE/IES

(*MADE EASY*)

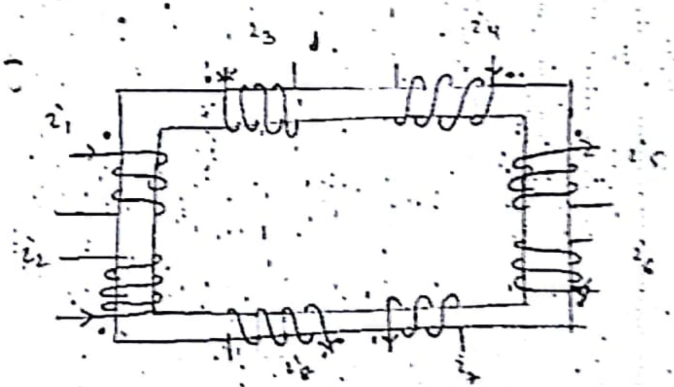
Electrical Machine

Lenz's law

- According to Lenz's law, the direction of induced emf is as such if it allow to cause a current, then the current so produced opposes the cause.



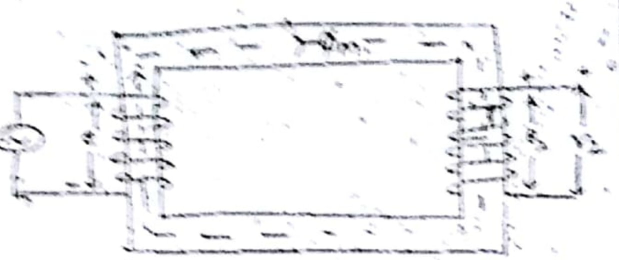
- $e = \pm \frac{d\lambda}{dt} = \pm \frac{d(N\phi)}{dt}$ where the sign depends on Lenz's law and which terminal is taken as positive.
- If the currents ~~is~~ are leaving or entering the dot simultaneously then the flux
- only the first dot is assigned. The other dots follow automatic



$$\text{Net MMF} = I_1N_1 + I_2N_2 + I_3N_3 + I_4N_4 + I_5N_5 - I_6N_6 - I_7N_7 - I_8N_8$$

- As applied to the transformer as current enters the dot, then in order to satisfy the Lenz's law, the current should leave through the dot from the secondary winding.
- Dots indicate the same simultaneous polarity in transformers.

Transformer



*

Ideal transformer

1) No losses
2) No leakage flux
3) $\mu = \infty$

- If $\phi = \phi_m \sin\omega t$

$e_1 = N_1 \frac{d}{dt}(\phi_m \sin\omega t)$

$\Rightarrow e_1 = N_1 \phi_m \cdot \omega \cos\omega t$

$\Rightarrow e_1 = N_1 \phi_m \cdot \omega \sin(\omega t + 90^\circ)$

$\Rightarrow E_1 = \frac{N_1 \phi_m \cdot \omega}{\sqrt{2}}$

$\Rightarrow \boxed{E_1 = \sqrt{2}\pi f \phi_m N_1 \Rightarrow \text{Induced Emf}}$

- $e_2 = N_2 \frac{d\phi}{dt}$

$= N_2 \frac{d}{dt}(\phi_m \sin\omega t)$

$= N_2 \phi_m \cdot \omega \cos\omega t$

$\Rightarrow e_2 = N_2 \omega \phi_m \sin(\omega t + \pi/2)$

$\Rightarrow E_2 = \frac{N_2 \phi_m \cdot \omega}{\sqrt{2}}$

$\boxed{E_2 = \sqrt{2}\pi f \phi_m N_2 \text{ (Emf induced)}}$

* Flux $\phi = \frac{\text{MMF}}{\text{Reluctance}}$

$\phi = \frac{(N_1 I_0)}{\frac{l}{\mu A}}$

$\Rightarrow N_1 I_0 = \phi \times \frac{l}{\mu A}$

$\Rightarrow \quad = 0 \qquad \mu = \infty$

$\Rightarrow \boxed{I_0 = 0 \text{ when } \phi \neq 0}$

$e_1 = +N_1 \frac{d\phi}{dt}$

where e_1 is expressed as voltage drop.

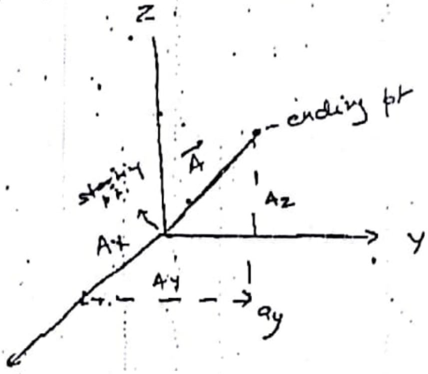
Electoomagnetic theory

1) vector analysis - G/I/P
2) Electrostatics → "
3) Magneto statics → "
4) Maxwell's eqn → I/P
5) Electoomagnetics → "
6) Transmission line → "
7) wave guides & optical fibre → "
8) Antennas ⟶ "

Inductance and Capacitance calculation — Gate/Ies/PSU
Laplace & poisson's eqn. — I.ES/PSU

Vector Analysis

$$\vec{A} = A_x \cdot \hat{x} + A_y \hat{y} + A_z \hat{z}$$



Unit vector
It is always defined in the direction of $\vec{A}$

1) $\vec{A} + \vec{B} = \vec{B} + \vec{A}$: commutative
2) $\vec{A} + (\vec{B} + \vec{C}) = (\vec{A} + \vec{B}) + \vec{C}$: Associative property
3) $K(\vec{A} + \vec{B}) = K\vec{A} + K\vec{B}$: scalar multiplications

Dot product of two vector $\vec{A}$ and $\vec{B}$
1) Dot product is applicable to only for vector quantities.

$$\vec{A} \cdot \vec{B} = \underbrace{|A||B|\cos\theta}_{\text{scaler}} \searrow \text{smallest angle}$$

$$\cos\theta = \frac{\vec{A} \cdot \vec{B}}{|\vec{A}||\vec{B}|} \Rightarrow \theta = n\pi \pm 18; 36$$

$$\vec{B}\cdot\vec{A} = |\vec{B}|\,|\vec{A}|\cos\theta$$

$$= \vec{A}\cdot\vec{B}$$

$\vec{A}\cdot\vec{B} = \vec{B}\cdot\vec{A}$ commutation

values

$\hat{x}\cdot\hat{x} = 1$

$\hat{x}\cdot\hat{y} = 0$

$\hat{x}\cdot\hat{z} = 0$

$\hat{y}\cdot\hat{x} = 0$

$\hat{y}\cdot\hat{y} = 1$

$\hat{y}\cdot\hat{z} = 0$

$\hat{z}\cdot\hat{x} = 0$

$\hat{z}\cdot\hat{y} = 0$

$\hat{z}\cdot\hat{z} = 1$

$$\vec{A}\cdot\vec{B} = A_x B_x(1) + A_x B_y(0) + A_x B_z(0) + A_y B_x(0) + A_y B_y(1) + A_y B_z(0) + A_z B_x(0) + A_z B_y(0) + A_z B_z(1)$$

Cross product of two vectors $\vec{A}$ and $\vec{B}$

Cross product is applicable only for vector quantity

$$\vec{A}\times\vec{B} = \underbrace{|\vec{A}|\,|\vec{B}|\sin\theta}_{\text{vector q}} \cdot \hat{a}_n \rightarrow \perp \text{ to } \vec{A} \,\&\, \vec{B}$$

direction

$$\vec{B}\times\vec{A} = |\vec{B}|\,|\vec{A}|\sin\theta \cdot \hat{a} \rightarrow \perp \text{ to } \vec{B} \,\&\, \vec{A}$$

$$= -|\vec{A}|\,|\vec{B}|\sin\theta \cdot \hat{a}_n$$

$$\vec{A}\times\vec{B} = -\vec{B}\times\vec{A}$$

values

$\hat{x}\times\hat{x} = \vec{0}$

$\hat{x}\times\hat{y} = \hat{z}$

$\hat{x}\times\hat{z} = -\hat{y}$

$\hat{y}\times\hat{x} = -\hat{z}$

$\hat{y}\times\hat{y} = \vec{0}$

$\hat{y}\times\hat{z} = \hat{x}$

$\hat{z}\times\hat{x} = \hat{y}$

$\hat{z}\times\hat{y} = -\hat{x}$

$\hat{z}\times\hat{z} = \vec{0}$

$$\vec{A}\times\vec{B} =$$

$$= (A_y B_z - A_z B_y)\hat{x} - (A_x B_z - A_z B_x)\hat{y} + (A_x B_y - A_y B_x)\hat{z}$$

Chemical Bonds

→ The binding force

- → primary → These bonds are having higher bond energy
  ex- ionic bond, covalent bond and mettalic bond.
- → Secondary → These bonds are having lesser bond energy as compared to primary binding.
  Ex- vanderwall bond & hydrogen bond.

Ionic bond

It is the bond resulting from electrostatic interaction between oppositely charge ions

» ionic bonds are formed particularly between left hand side and right hand side of periodic table. (Group 1 element are Alkali elements)

[Group-1 → Li, Na, K, Rb, Cs, Fr
Group 7 → F, Cl, Br, I]

» Alkali halides formed b/w Alkali metal & halogens are strongly ionic.

Properties Ionic solids

- → Higher ~~Halogens~~ hardness.
- → Higher melting pt.
- → higher strength
- → Brittle
- → Electrically Insulator.

ovalent Bond

It is formed by sharing of electron b/w neighbouring atoms. Covalent solids are also known as valence crystal

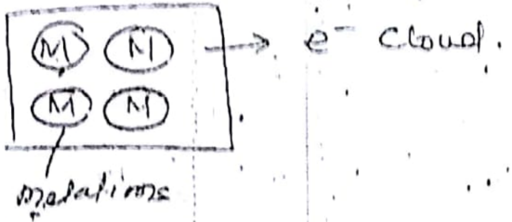
Properties of covalent solids

- » Very hard
- » Very high melting pt.
- » very brittle.
- » { Conductor → Tin.
  Semiconductor → Si, Ge
  Insulator → Diamonds }

Metallic Bonding

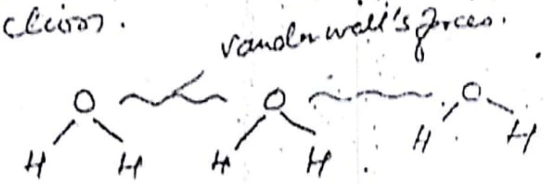
» Metallic bonds is a characteristics of element having small no. of valence electron.

» Metallic bonds can be considered as metal ions surrounded by electron clouds:



④ Vanderwall's bond

The weaker force of interaction b/w. dipoles of inert gases and polar molecules are known as vanderwall force of attraction.



Hydrogen bond is a strong type of vanderwall bond.

Atomic Arrangement in solids.

- → Crystallinity
- → Single crystal material
- → polycrystalline material
- → Amorphous material
- → Epitaxial.

* **Crystallinity**

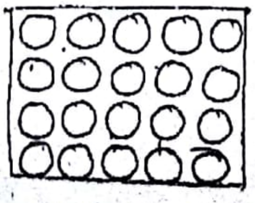
→ property of solid in which atoms or molecules are arranged in regular or periodic manner is called crystallinity.

» **Single crystal material**

Material having regular or periodic arrangement of atoms or molecules is known as single crystal material

For ex - Quartz

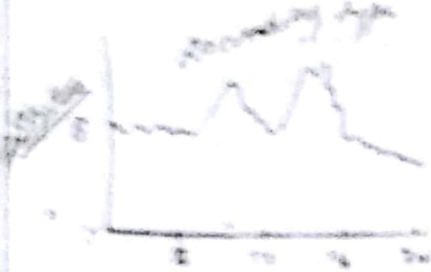
» These materials are anisotropic material

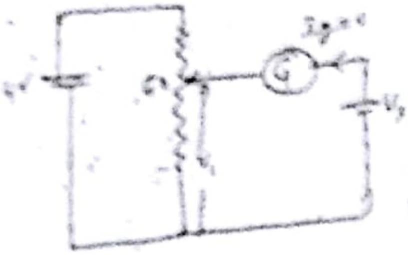


Analog meter

- Quantity to be measured
  - I
  - V
  - P
  - p.f
  - frequency
  - energy
- Principles
  - Electromagnetic
  - static
  - Thermal
  - Hall effect
  - Induction
- Representation
  - Indicating
    - Ammeter
    - voltmeter
    - wattmeter
  - Integrating
    - Energymeter
  - Recording
    - [illegible]
  - Null detector
    - potentiometer

Recording type





100 cm = 4 V

1 cm = 0.04 V

60 cm = 2.4 V

$V_2 = V_1 = 2.4\,V$

Indicating meters

$$\%\ \text{Relative error} = E_r = \frac{\text{Measured value} - \text{True value}}{\text{True value}} \times 100$$

$$\%\ E_r = \frac{A_m - A_t}{A_t} \times 100$$

For Example

True current = I_t = 10 A

Measured current = I_m = 12 A

$$\%\ E_r = \frac{I_m - I_t}{I_t} \times 100 = \frac{12 - 10}{10} \times 100 = 20\%$$

$\%E_r = 20\%$

$I_m = I_t + I_t(E_r)$

$I_m = 10 + 20\% \times 10 = 12\,A$

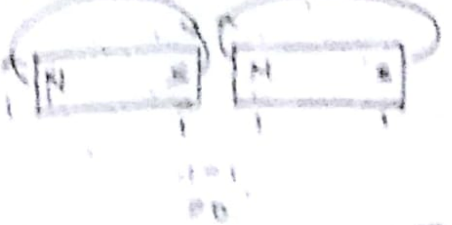
$= 10 \pm 20\%$

$$\boxed{A_{ext} = A_f(1 + R_e)}$$

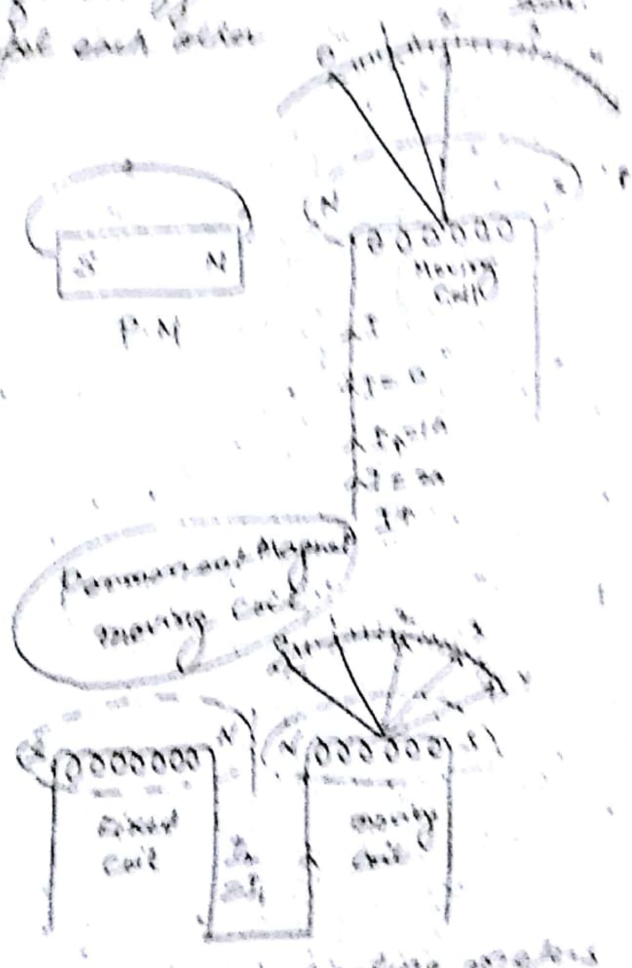
$$\Rightarrow \boxed{A_{ext} = A_f + A_f \cdot R_e}$$

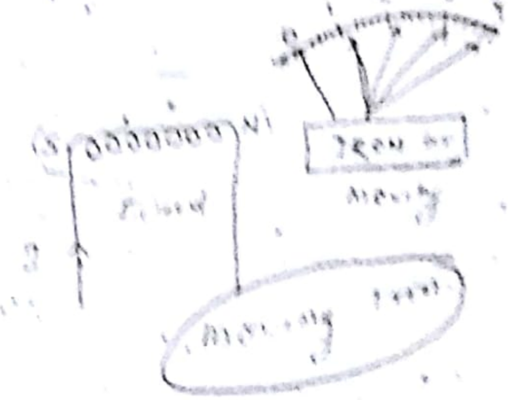
Electromagnetic Attraction meter

Energy at centre is maximum
So, for energy balance it will
repel each other



Energy at centre is minimum.
So for energy balance, it will
attract each other





Torques in indicating meters

1. Deflecting torque (T_d)
2. Controlling torque (T_c)
3. Damping torque

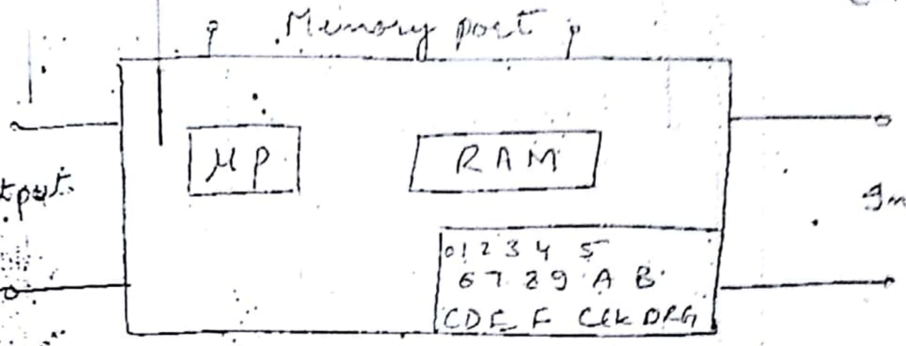
Microprocessor :-

9-1-12

IES → conventional → 40-60 marks
objective → 20-25 "

① Programming
② 1 Descriptive
③ 1 short note

MOS [illegible]



Defn

① It is an electronic chip that has computing and decision making capability

② It is a electronic integrated chip that fetch instruction from memory and execute them and provide result.

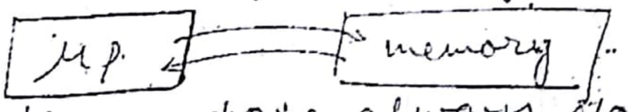
→ μp cannot perform any task on its own.

μp = [Hardware of μp + software]
↳ always installed on ROM.

· ROM is the internal part of processor.
↳ all system related information are stored in ROM

Booting cause fetch :- It comes into picture at the time of power switch ON condition.

RAM / Main memory / memory :-



- Instruction / commands are always store in memory
Note - But execution of instruction always inside the μp

μP	bit of μp.	Technology
4004	4 bit	PMOS
8008	8 bit	NMOS
8080	"	"
8085	"	"
8086	"	HMOS (High density channel)
8088	"	—
80186	16	—
80286	16	—
80386	32	—
80486	32	
80586	64	

→ Pentium
"
P-II
P-III
P-IV

pro → I-3
I-5
I-7

⇒ Total no. of data bits excute in one machine cycle is known as bit of μp.

Size of ALU also known as bit of μp.

Note - 8088 externally 8 bit, internally 16 bit μp.

$$BICMOS = \overset{\text{operates active region}}{\underset{\downarrow\ \text{speed}}{BJT}} + \overset{\text{saturation region}}{\underset{\downarrow\ \text{power dissipation requirement}}{CMOS}}$$

$$\downarrow FOM_{\text{better}} = \underbrace{\text{Pro delay}}_{\text{less}} \times \underbrace{\text{Power dissipation}}_{\text{less}}$$

<u>Pipeline</u> - It is a line which allows fetching of one bit while the execution of former was taking place.

Advantage - speed gets improved

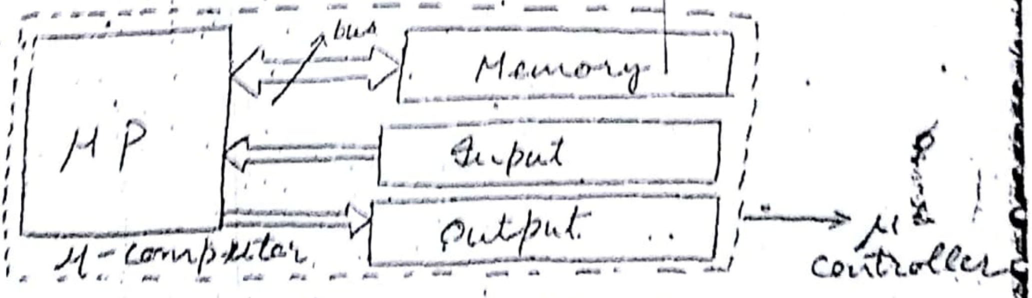
⇒ Why 8085 has name 8085

$\underset{\text{decage}}{80}$ $\underset{\text{bit}}{8}$ $\underset{\text{5 Volt power supply}}{5}$

① <u>Microcomputer</u> :- If all task of CPU performed by μp. then such type of computer is known as μ-computer.

μ computer = μp + Input + Output + Memory.

8051 μ-controller
↓
8 bit
256 kb has its own memory



Note :- μ-computer on single chip or single platform is known as μ-controller.

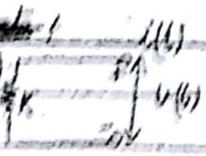
<u>Bus</u> - It is group of (parallel combination of) metal wires that is used for interfacing b/w the devices.

ASIC = Application specific integrated chip.
= μ controller is a example of ASIC

Networks

Components of Electrical Circuit :

1. Resistor. (Linear and bilateral element)



It will follow ohm's law and current will flow in either direction

$$\boxed{\begin{array}{l} v(t) = R \cdot i(t) \\ i(t) = \frac{1}{R} v(t) \end{array}} \rightarrow \text{in time domain}$$

$$\boxed{\begin{array}{l} V(s) = R \cdot I(s) \\ I(s) = \frac{1}{R} V(s) \end{array}} \rightarrow \text{in } s\text{-domain}$$

$s = \sigma + j\omega$, complex frequen

$$\boxed{\begin{array}{l} V = RI \\ I = \frac{1}{R} V \end{array}} \rightarrow \text{for sinusoidal excitation}$$

$s = j\omega$.

⇒ For a linear element, the terminal voltage $v(t)$ & terminal current $i(t)$ are proportional to each other and therefore there variation is linear either in the time domain or in S-domain or in both domains.

⇒ In a bilateral element the current through the elemen flows in either direction irrespective of the type of the polarity of the terminal voltage.

⇒ For non-~~linear~~ sinusoidal input the analysis can be done either in time domain or in S-domain

⇒ For sinusoidal excitation, the analysis is done either in frequency domain or in the phasor form

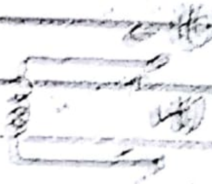
⇒ While analysing the problem in laplace domai

1. Any differential Nr. Integral eq^n is transformed to a linear eq^n, the analysis of which is simpler.
2. The initial conditions if any are automatically taken care off.

 ⇒ electrolytic (Unilateral)

 ⇒ Capacitor (bilateral)

2. **Inductor** – $v(t) = L\frac{d\,i(t)}{dt}$



$i(t) = \frac{1}{L}\int_0^t v(t)\,dt$ → in time domain

$Z_L = sL$
$Y_L = \frac{1}{sL}$

$V(s) = sL \cdot I(s)$ → in s-domain
$I(s) = \frac{1}{sL} \cdot V(s)$ (assuming zero ICs)

$Z_L = j\omega L$
$Y_L = \frac{1}{j\omega L}$

$V = j\omega L \cdot I$ → for sinusoidal excitation
$I = \frac{1}{j\omega L} \cdot V$ $(s = j\omega)$

3. **Capacitor** – $i(t) = C\frac{d\,v(t)}{dt}$

$v(t) = \frac{1}{C}\int_0^t i(t)\,dt$ → in time domain

$Z_C = \frac{1}{sC}$
$Y_C = sC$

$I(s) = sC \cdot V(s)$ → in s-domain
$V(s) = \frac{1}{sC} \cdot I(s)$ (assuming zero initial current)

$Z_C = \frac{1}{j\omega C}$
$Y_C = j\omega C$

$I = j\omega C \cdot V$ → for sinusoidal excitation
$V = \frac{1}{j\omega C} \cdot I$ $(s = j\omega)$

	L	C
$s = 0$	SC	OC
$s = \infty$	OC	SC

4. **Transformer** $\frac{V_2}{V_1} = \frac{n_2}{n_1}$

$\frac{I_2}{I_1} = \frac{n_1}{n_2}$ $n_2 > n_1$, step up T/F
$n_2 < n_1$, step down T/F

If $n_1 = 10$, $n_2 = 100$
$\frac{V_2}{V_1} = \frac{n_2}{n_1} = 10 \Rightarrow \frac{I_2}{I_1} = \frac{n_1}{n_2} = \frac{1}{10}$

Power Electronics

Def:- It deals with control and conversion of high power applications. we use various power semiconductor devices like

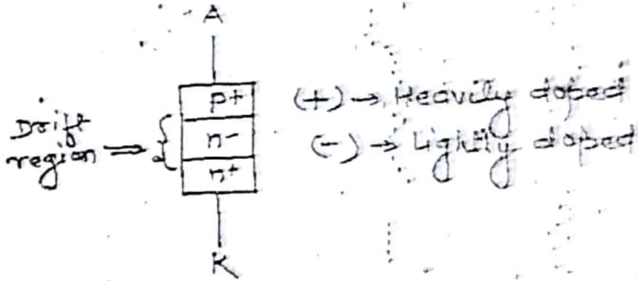
i) power diodes
ii) power transistors
iii) Thyristors.

Signal Electronics

It deals with control of low power applications. various semiconductor devices such as

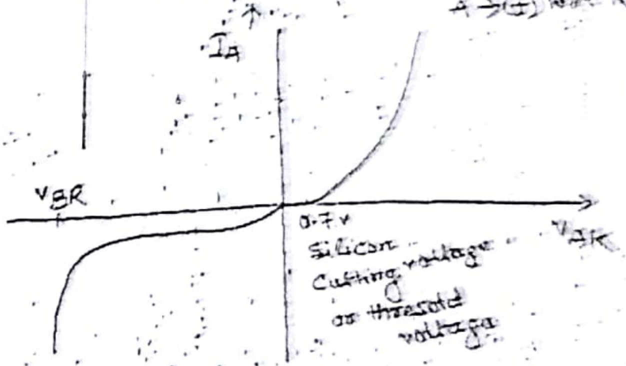
i) Signal diode
ii) Signal transistors etc

power diodes



V-I characteristics of signal diode

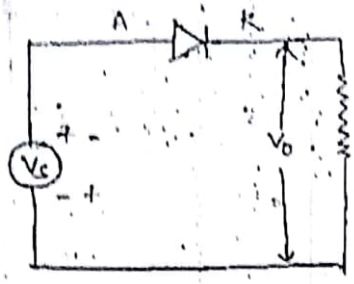
A → (+) wrt K [Forward biased]



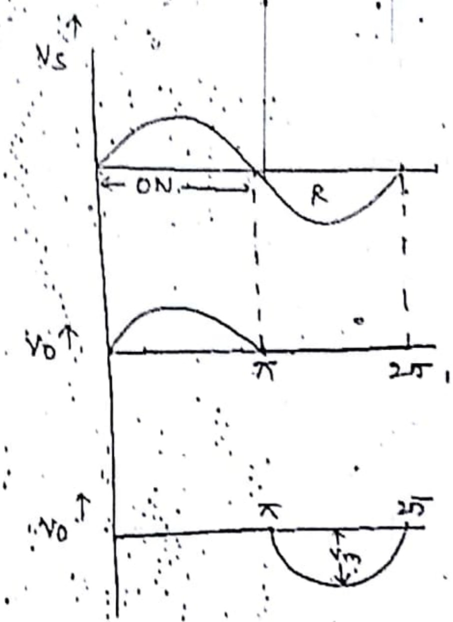
- * cutting voltage or thresold voltage is the minimum forward voltage required to turn on the device.
- * Leakage current is due to minority carrier
- * Reverse voltage should always be less than V_{BR} otherwise it will conduct in both ways.
- * power loss is comparably high in power diode than signal diode

Peak Inverse voltage (PIV)

* It is the maximum reverse voltage applied across the device when it is OFF state applied by the source



PIV = V_m

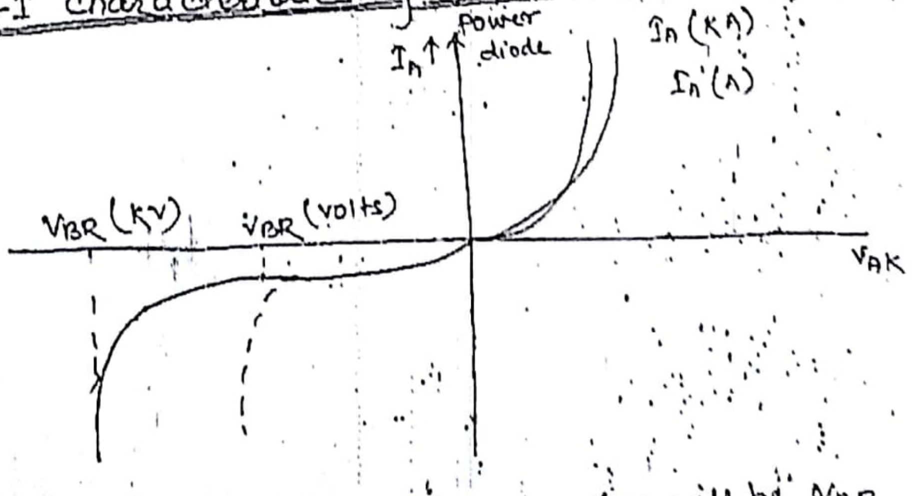


Difference between PIV and VBR

The PIV of a device must always be less than V_{BR} so that the diode is having a capacity to block the reverse voltage.

$$V_{BR} > PIV$$

V-I characteristics of power Diode



* Higher the drift region, greater will be V_{BR}

purpose of Drift region

Drift region increases the reverse voltage blocking capability of a diode.
Higher the thickness of drift region, higher the V_{BR} and reverse voltage blocking capacity.

Power Systems

1. Network Matricos
2. Short ckt Studies
3. Load Flow Studies
4. Power System Stability
5. Switchgear and Protection
6. Econonic Dispatch problem

⇒ Network Matrices:

Leaving out the generators, a power system is a big size passive network

For such a network, we need to develop network matrices

Network matrices provides the properties of of the network and such matrices are required for conducting various types of studies on power systems

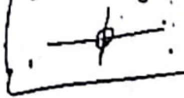
Frames of Reference

Bus frame

$V_{Bus} = Z_{Bus} I_{Bus}$

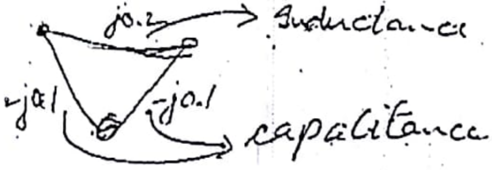
$I_{Bus} = Y_{Bus} V_{Bus}$

Bus → junction

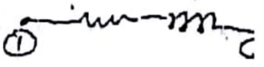


Loop frame

$I_{loop} = Y_{loop} V_{loop}$



Branch fra



Network Matricos can be formulated based on a particular frame of reference

Loop frame and Branch frame are rearly used and Bus frame ~~of~~ is popularly used.

Based on Bus frame, we have two types.

On Bus frame.

Bus Admittance matrices (Y_{Bus}) [used in Load Flow studies)

Bus Impedance Matri (Z_{Bus}) (used in short ckt stu

Direct Inspection method [this method is used when the elements are not having Mutual coupling]

Singular Transformation Method [this method is used when the elements are having Mutual coupling]

$$\boxed{Y_{Bus} = A^T [Y] A}$$

Inverse Method

$Z_{Bus} = Y_{Bus}^{-1}$

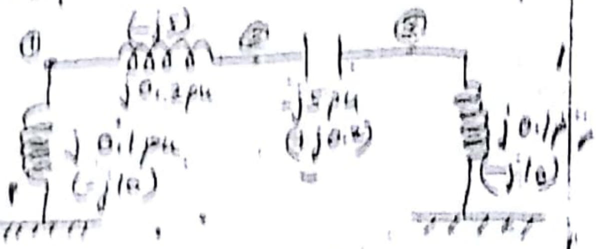
Z_{Bus} building Algorithm.

⇒ Y_{Bus} formation :

Direct inspection method :

⇒ Leaving out the reference bus (0), the no. of buses = 3

∴ size of Y-bus is 3×3 matrix.



$$Y_{Bus} = \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} \\ Y_{21} & Y_{22} & Y_{23} \\ Y_{31} & Y_{32} & Y_{33} \end{bmatrix}$$

$Z = R \underset{\to C}{\overset{\to L}{\pm}} jX$

$Y = G \underset{\to C}{\overset{\to L}{\mp}} jB$

Convert all reactances into susceptances

$x \longrightarrow B$

$j0.1 \longrightarrow \frac{1}{j0.1} \times \frac{-j}{-j} = -j10$

$-j5 \longrightarrow \frac{1}{-j5} \times \frac{j}{j} = +j0.2$

Signal and Systems

…(10-12 mark)

⇒ Chapters

① Laplace Transform
② Discrete Time system
③ Z-Transform
④ Fourier Series
⑤ RMS / power signals
⑥ Basic system properties

Books

① Schaum's Series
② B. P Lathi
③ Oppenheim
④ Simon Haykins

Questions

① Workbook
② Kanodia } → Part I ↓ 4, Part II ↓ 5

Syllabus:-

1. Signal classification and different operations on signals
2. Basic system properties
   - → Dynamic / static
   - → Causal / Non Causal
   - → Linear / Non-Linear
   - → Time variant / invariant
   - → stable / unstable
3. Linear - Time invariant (LTI) system
4. Fourier Series
5. Fourier Transform
6. Laplace Transform

(1 – 6) → Continuous time system

7. Sampling theorem
8. Discrete time system
9. Z-transform

(7 – 9) } → Discrete time system

→ Signal classification and different Operations on signals

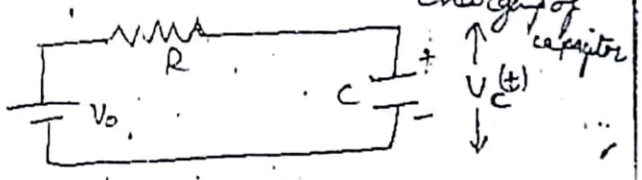
Signal :– A signal is function representing physical quantity or variable and contains information about nature or behaviour of phenomenon.

→ Mathematically, signal is represented as a function of independent variable.

Eg :- $V_c(t) = V_0\left[1 - e^{-t/RC}\right]$

independent variable

exponential

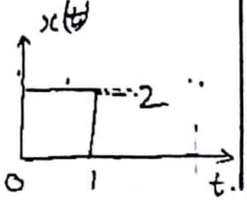


System :- System is interconnection of devices or/ component that converts signal from one form to another.

Different operations on signals :-
- ↳ shifting
- ↳ Scaling
- ↳ Reversal

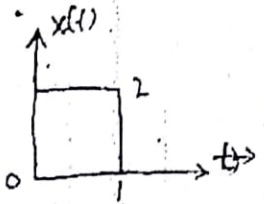
Shifting → Time shifting
↳ Amplitude shifting

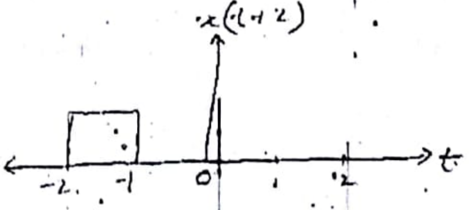
Time shifting → $x(t) \longrightarrow x(t+K)$



(i) Case 1 :- $K > 0 \Rightarrow K = 2$

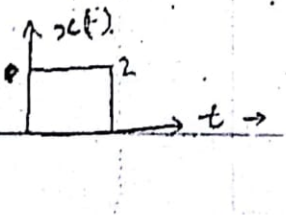
$x(t) \longrightarrow x(t \textcircled{+} 2) \longrightarrow$ Time advance, left shifting

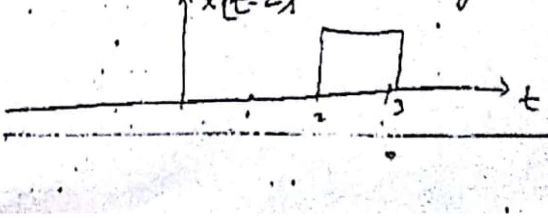




(ii) Case 2 :- $K < 0 \Rightarrow K = -2$

$x(t) \longrightarrow x(t+K) = x(t \textcircled{-} 2) \longrightarrow$ Time delay, right shift





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Analog Electronics:

⇒ **Topics**

① Semiconductor physic

② PN junction diode

→ Special diodes

→ Tunnel diode

→ UJT

→ Zener diode

→ Schottky diode

→ Photodiode

Applications

Rectifiers

filters

Clippers

clampers

③ BJT

1) BJT biasing

2) Small signal Amplifier

Frequency response of an BJT amplifier

3) large signal Amplifier (power amplifier)

4) multistage amplifier

④ FET / MOSFET

→ FET biasing

→ FET small signal Analysis

Feedback

⑤ Feedback amplifier

oscillator

Op Amp

Ⓐ Differential amplifiers

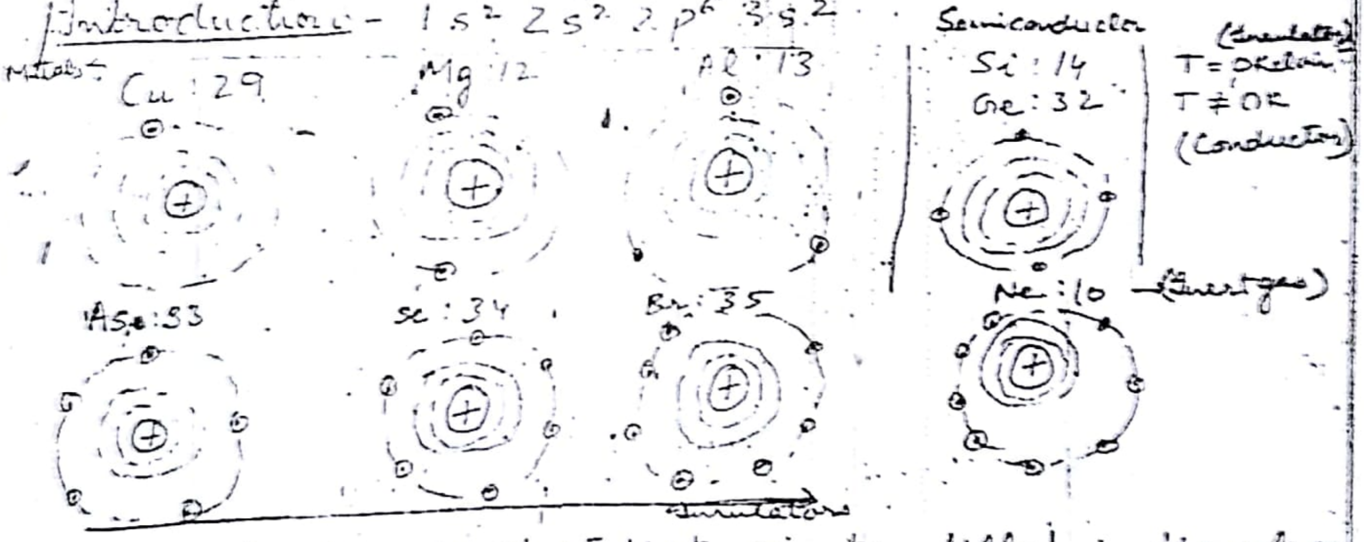
Ⓑ OpAmp applicat

Ⓒ Filter design

Ⓔ 555 timer

⇒ Semiconductor Physics:-

Introduction - $1s^2\ 2s^2\ 2p^6\ 3s^2$



Eg:- The maximum no of e^- that can be filled in the valence shell of an atom will be

ⓐ $4e^-$ ⓑ $6e^-$ ⓒ $7e^-$ ⓓ None ($8e^-$)
(Afbau's Principle)

Eg:- The no of electrons that can be filled in the valence shell of a semiconductor will be

$\boxed{4\ \text{electrons}}$

⇒ **Examples of Semiconductors:-**

Si, Ge, GaAs → Compound Semi-conductors

Single Crystalline structure

Eg: Why Si and Ge are generally preferred compared to GaAs?

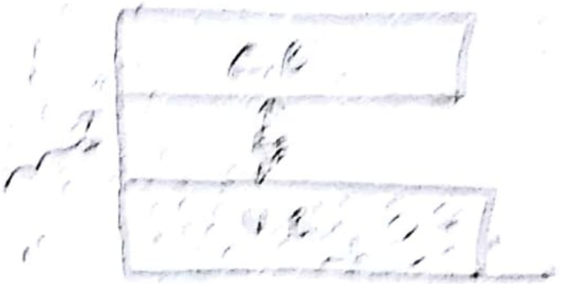
At T = 0 Kelvin

Eg

Ge → 0.785 eV

Si → 1.21 eV

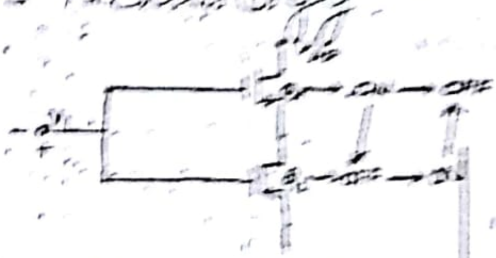
GaAs → 1.52 eV



⇒ As the energy gap value for silicon and germanium is less compared to Gallium Arsenide, we expect more conduction is possible in case of Si and Germanium

Eg: Why GaAs is used in the CMOS Technology

① The mobility of charge carriers in case of GaAs > mobility of charge carriers in case of Si and Ge



② The temperature with standing capability is more for GaAs (Eg is more) μ = mobility

Typical Values

Ge → 100°C

Si → 200°C

GaAs > 200°C

Eg: Why mobility of electrons is greater than mobility of holes ($\mu_e > \mu_h$)

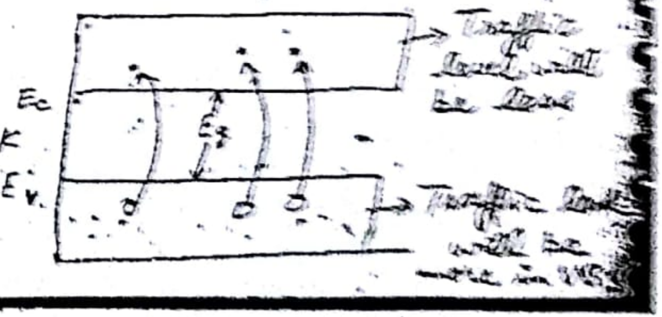
ⓐ The traffic level in C.B < in VB

ⓑ The traffic level in CB > in VB

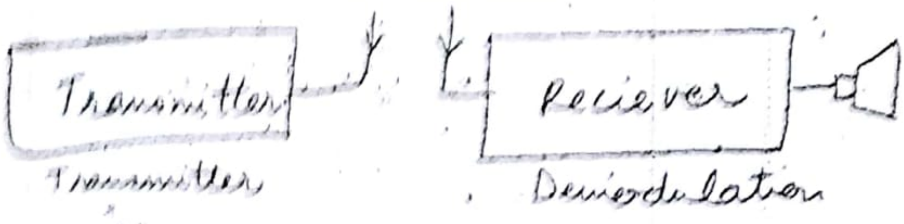
ⓒ The " " " CB = " VB

ⓓ None

⇒ The effective mass of a hole is greater than effective mass of an electron!



Communication



Information signal $f = 50Hz - 20KHz$ (audio signal)

AM signal $f = 535\ KHz - 1605\ KHz$

FM signal $f = 88\ MHz - 108MHz$ } Broad cast range

FDM - Frequency division Multiplexing

Height of antenna

Case I $f = 20\ KHz$

$\lambda = \frac{c}{f} = \frac{3\times10^8}{20\times10^3}$

$l \sim \frac{\lambda}{4}, \frac{\lambda}{2}$

--- very large

Case II $f = 100MHz$

$\lambda = \frac{c}{f} = \frac{3\times10^8}{100\times10^6}$

$= 3m$

$l \sim \frac{\lambda}{2} \cong 1.5m$

→ An audio signal can not be transmitted over long distance since the signal at this frequencies a attenuated first. Therefore this frequency component in the audio range are translated to high freq range. This process is called modulation

→ To recover the original signal from the high freq signal is called demodulation so that one can liste to that signal in the audio range

↳ The modulation process is always followed by a demodulation ~~potess~~ process

⇒ Advantages of Modulation

↳ A practical length of an antenna is required sinc the audio frequencies have been translated to high frequency component.

→ Long distance ~~to~~ communication is possible

→ By increasing signal power of the Transformer we can ~~&~~ adjust the signal to noise ratio can be adjusted and therefore required range of trans-mission is obtained as per our requirement

→ Frequency division multiplexing is possible and therefore large no. of signal can then be transmitted over a communication channel

⇒ Analog modulation

→ AM → amplitude modulation

→ Angle Modulation
- → FM → frequency modulation
- → PM → phase modulation

⇒ AM

(audio signal) modulating signal → $V_m(t) = V_m \cos \omega_m t$ → sinusoidal

(Single tone mod) $\omega_m = 2\pi f_m$

$f_m = 50\,Hz - 20\,kHz$

↳ $V_m(t) = f(t)$ — General signal

(Multi tone mod)

carrier $V_c(t) = V_c \cos \omega_c t$; $\omega_c = 2\pi f_c$

$f_c = 535\,KHz - 1605\,KHz$

→ In Amplitude modulation, amplitude of the carrier is varied in accordance with the instantaneous value of the amplitude of modulating signal keeping freq. and phase of the carrier fixed.

Single tone mod.

$V_m(t) = V_m \cos \omega_m t$; $V_c(t) = V_c \cos \omega_c t$

$\underbrace{V_{AM}(t)}_{\text{modulated signal}} = (V_c + K_a V_m(t)) \cos \omega_c t$

where K_a → constant [sensitivity of AM signal

unless specified $K_a = 1$.

$V_{AM}(t) = V_c(1 + m_a \cos \omega_m t) \cos \omega_c t$ ↳ AM signal

$m_a = K_a \frac{V_m}{V_c} = \frac{V_m}{V_c}$ → if $K_a = 1$

Control System

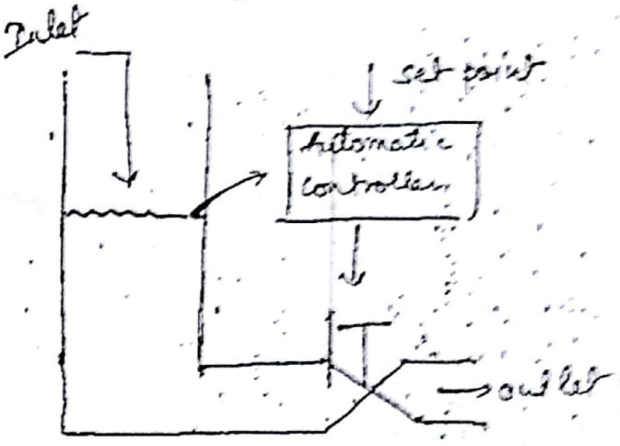
Introduction to control system

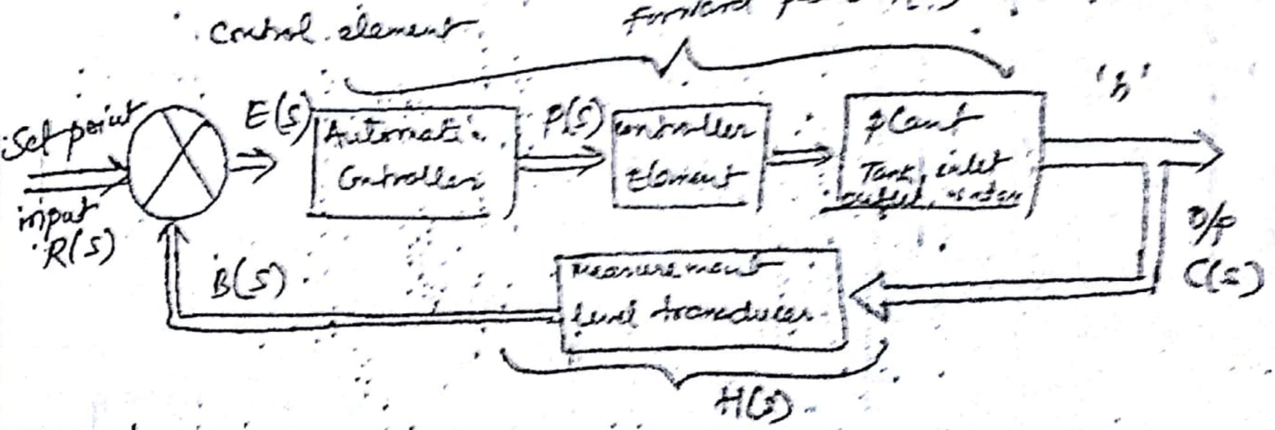
1) Consider the liquid level control system whose control objective is to maintain the water level in the tank at a height 'h'.

2) Controller is an automatic device with error signal 'E(s)' as input and Controller o/p 'P(s)' affecting the dynamics of the plant to achieve the control objective. Therefore Controller output p is equal to f(e) where e = error.

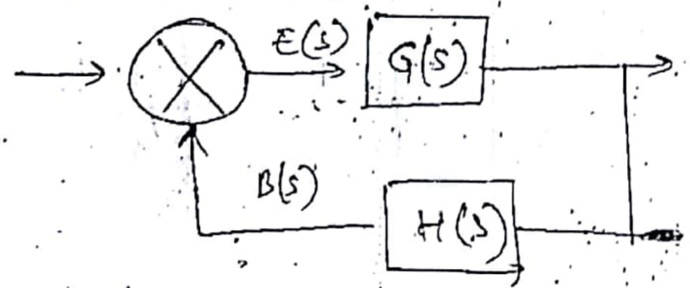
3) The different modes of controller output can be proportional, proportional + integral and proportional + integral + derivative.

4) There are two basic control loop configurations ~~[illegible]~~
 a) closed loop or feedback control system.
  i) In this configuration the changes in the o/p are measured through feedback and compared with the input or set point to achieve the control objective.
  ii) Feedback implies measurement (sensors or transducers.)

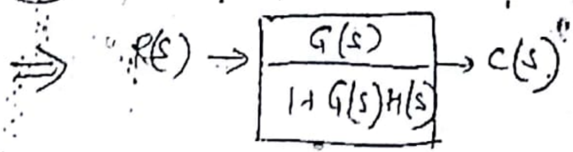




Control canonical from



E.g. Mathematical from



$$* \quad E(s) = R(s) - B(s)$$

$$\frac{C(s)}{R(s)} = R(s) - C(s)H(s)$$

$$C(s) = G(s)\cdot R(s) - G(s)H(s)C(s)$$

$$\Rightarrow \quad C(s)\{1+G(s)H(s)\} = G(s)R(s)$$

$$\Rightarrow \quad \boxed{\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)\cdot H(s)}}$$

Open loop control system

1) They are conditional control system formulated under the basic condition that the system is not subjected to any type of disturbances.

2) In this configuration, the feedback or measurement is not connected to forward path or controller.

3) Feedback in open loop system except for displaying the information about the o/p have no major significance. This insignificantness of feedback is termed as elimination or removal of feedback.

4) Open loop systems are more stable than closed loop system (without disturbances) b'coz the effect of feedback is that it introduces delays or lags thus making the overall speed of response of closed loop system slow compared to open loop system response.

* ~~[illegible]~~ Electronics *

Digital

	NAND	NOR
Not	1	1
And	2	3
OR	3	2
Ex-or	4	5
Ex-Nor	5	4

X	Y	f_0	f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8	f_9	f_{10}	f_{11}	f_{12}	f_{13}	f_{14}	f_{15}
0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
0	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
1	0	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1

Bole's logical ideas are categorised into two ways

1) Two functions that produced the constant 0 & 1
2) Four " that produces unirary ~~[illegible]~~ op^n (complement, transfer)
3) Ten f^{ns} with binary ~~[illegible]~~operators like (and, or), (Nand; Nor) (Xor, Xnor) (inhibitation, implication)

$f_0 = 0 \Rightarrow$ Null op^n

$f_1 = x.y \Rightarrow$ And op^n

$f_2 = xy'$ inhibition

x/y | (x but not y)

$f_3 = x$ transfer

$f_4 = x'y$ inhibition

y/x (y but x)

$f_5 = y$

$f_6 = x'y + xy' = x \oplus y$ (Ex-OR)

$f_7 = x+y = $ OR gate

$f_8 = (x+y)'$ NOR

$x \downarrow y$

$f_9 = xy + x'y'$ - ExNOR (also known as Equivalance gate or coincidance logic

$x \odot y$ (x equals y)

$f_{10} = y' = $ complamentary op^n

$f_{11} = x+y' = $ implication.

$x \subset y$ (If y then x & If x then y)

$f_{12} = x' = $ complamentary op^n

$f_{13} = x'+y = $ Implication op^n $(x \supset y)$ If (x then y)

$f_{14} = (xy)' = x \uparrow y$ (NAND)

$f_{15} = 1$ [Identity operation]