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UIET

UTKAL INSTITUTE OF ENGG & TECHNOLOGY

LECTURE NOTES

ON

POWER ELECTRONICS & PLC

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(∵ Signal diodes are used in Communication Circuits)

Thyristors :-

i) Bell Laboratories where the first 2 fabricate a Silicon based Semiconductor device Called Thyristor, in the year 1957.

ii) Later on many other devices having characteristics similar to that of a Thyristor were developed they are: Triac, diac, SCS (Silicon Controlled Switch) UJT, GTO, RCT.

iii) SCR is the most used Commonly device in Thyristor family.

(SCR = Silicon Controlled rectifier. ⇓ most imp device of Thyristor)

iv) Thyristor belongs to a transistor family from Construction point of view.

Thyristors = Thyra(tron) + transistor.
(Semiconductor device)

Symbol of Thyristor :-

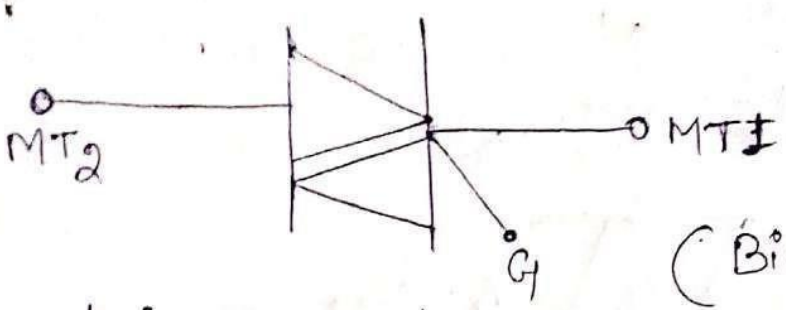
(∵ G = gate)
A = Anode,
K = Cathode.

(Unidirectional)

TRIAC :- (Triode + AC = TRIAC).

(Voltage Controlling device)

Symbol :



(Bidirectional)

∵ MT = Main Terminal.

i) A TRIAC can conduct in both the direcs.

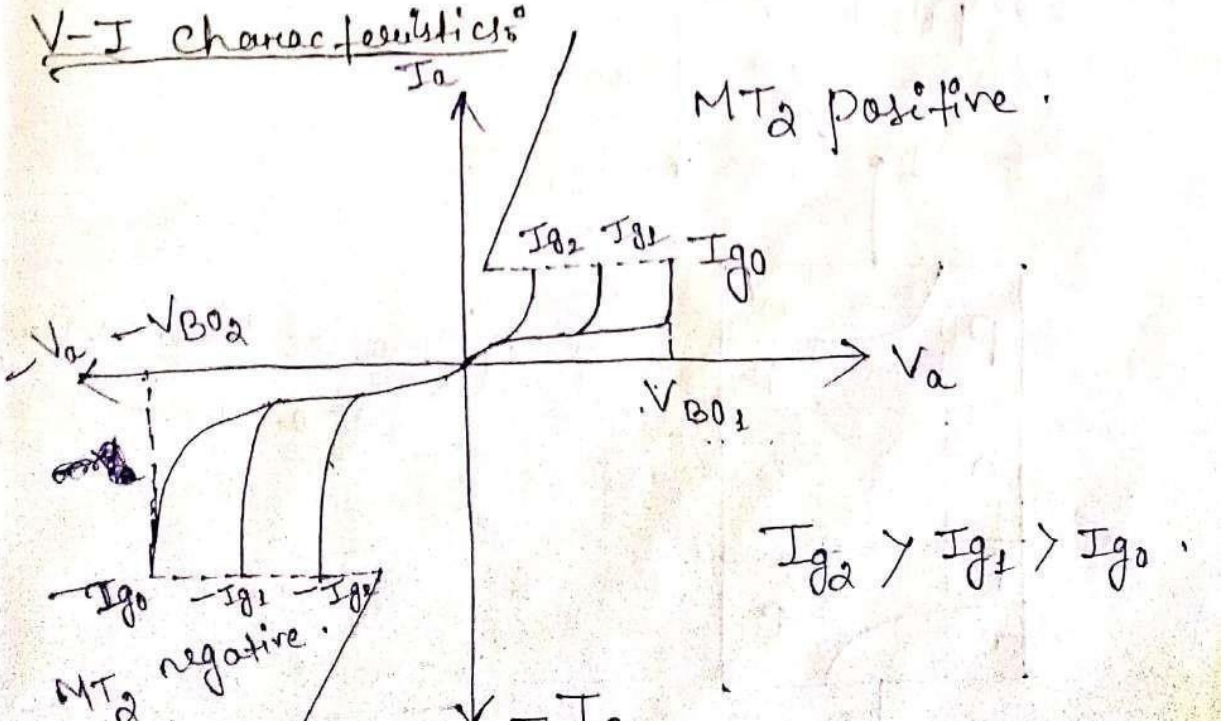
ii) A Triac is thus a bidirectional thyristor with 3-terminal.

iii) It is used extensively for the control of power in A.c circuits.

iv) As the triac can conduct in both the directions the term Anode & Cathode are not applicable to triac.

v) Its 3-terminals are usually designated as; MT_1, MT_2 & Gate.

V-I characteristics:

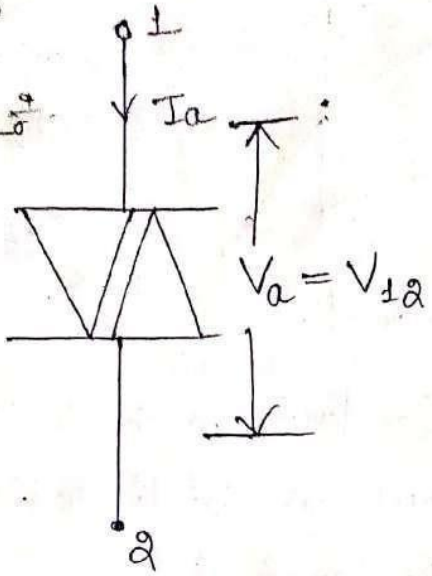


$I_{g2} > I_{g1} > I_{g0}$.

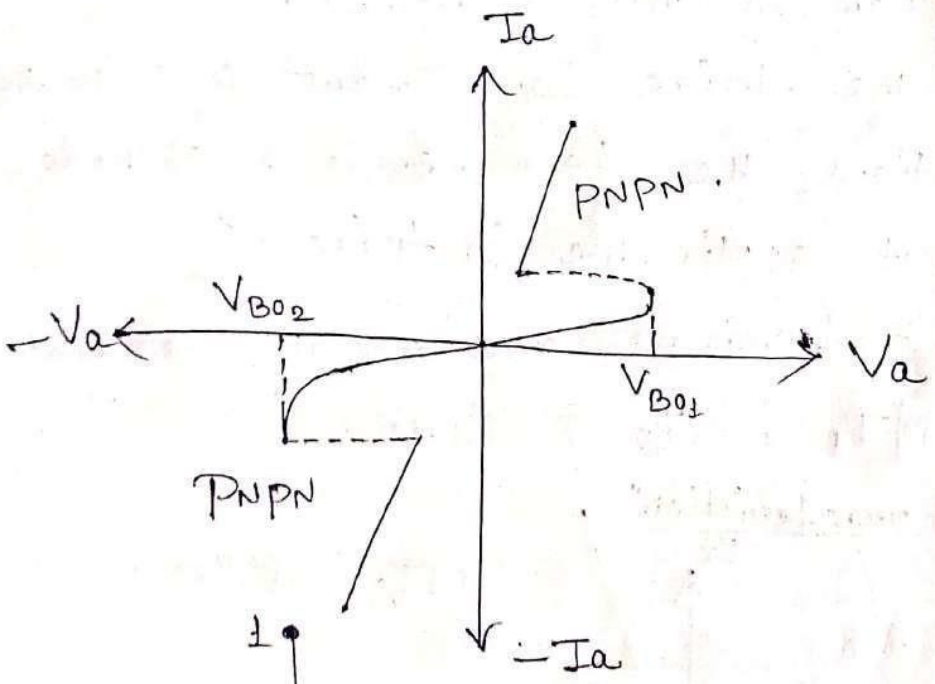
DIAC :- (Bidirectional thyristor diode)

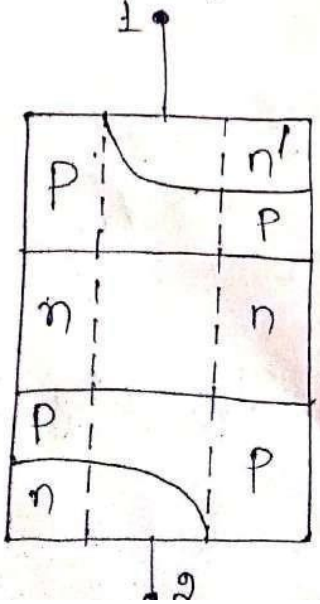
(Gateless)

Symbol :-



VI- Characteristics :-

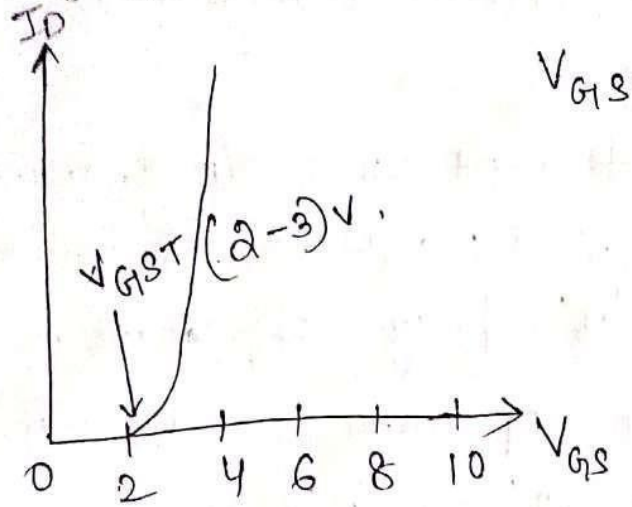




⇒ (Crossectional View of a DIAC)

MOSFET :-

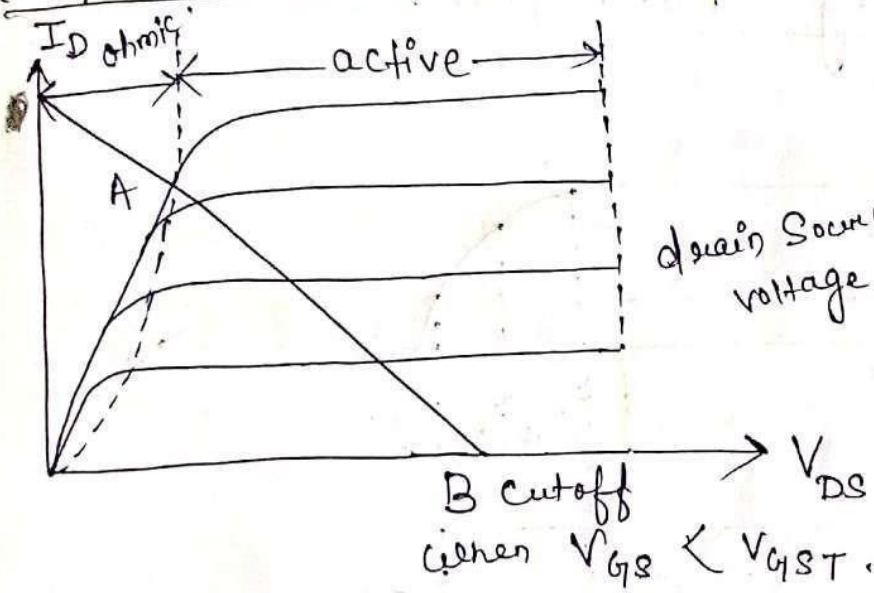
(1) Transfer characteristics :-



V_{GST} → Gate Source - Threshold voltage

$V_{GS} > V_{GST}$ (for turn on of MOSFET)

Output characteristics :-



drain Source breakover-voltage.

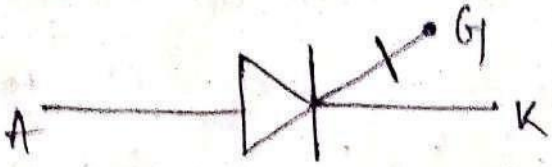
when $V_{GS} < V_{GST}$.

(i) MOSFET Output characteristics indicates the variation of drain current as a func of drain Source voltage "V_{DS}" with gate Source voltage "V_{GS}" as a parameter.

(ii) for low value of V_{DS} the graph b/w I_D & V_{DS} is almost linear. This indicates the value of on state resistance, $R_{DS} = \frac{V_{DS}}{I_D}$ is Constant.

GTO :- (Gate turn off thyristor)

Symbol :-

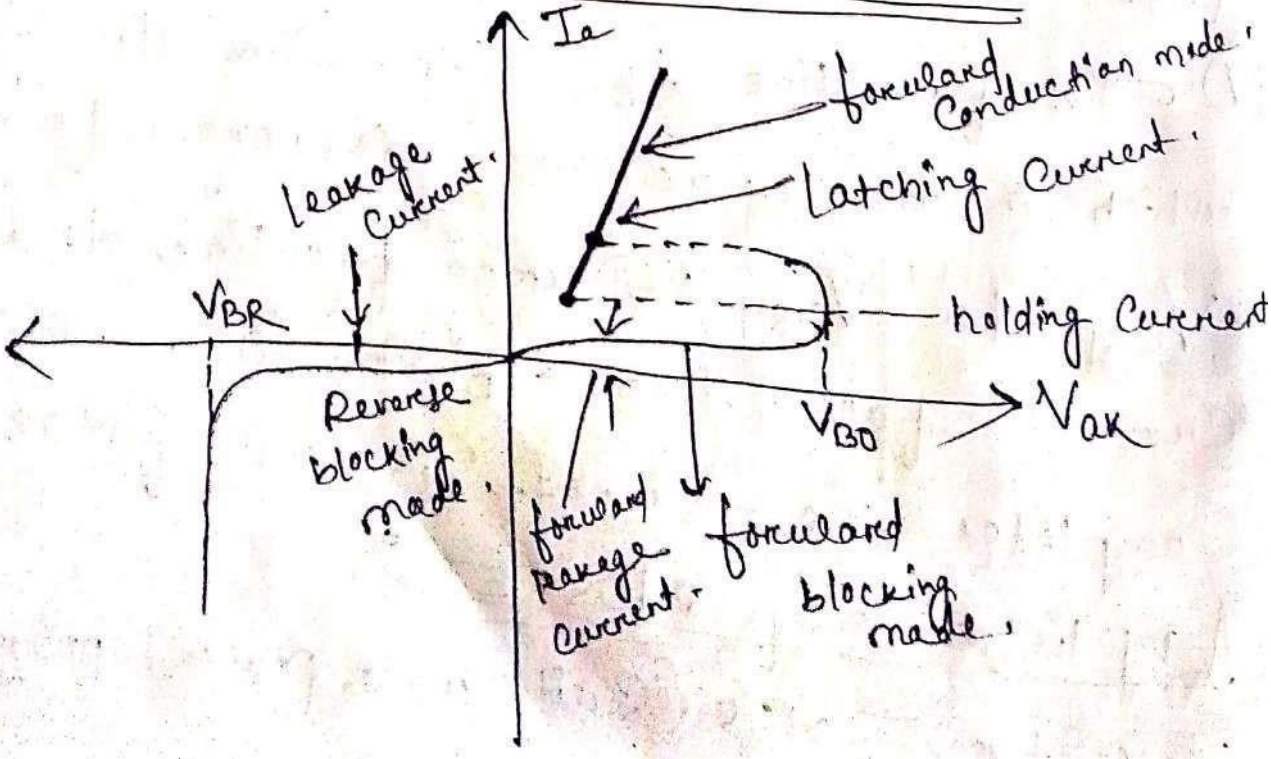


(i) GTO is a pnpn device that can be turn on by a +ve gate current & can be turn off by a -ve gate current at it's gate cathode terminal.

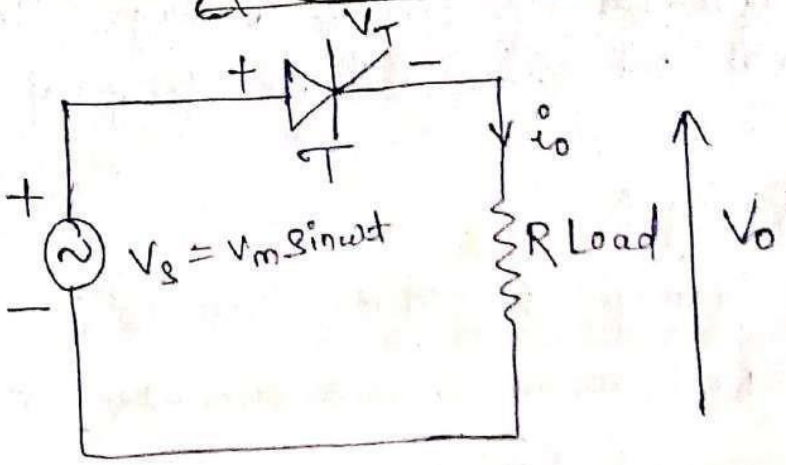
(ii) Self turn off capability of GTO makes it the most suitable device for inverter & chopper application.

This is one of the main advantage over SCR as it avoids the bulky & costly commutation circuit required in case of thyristor.

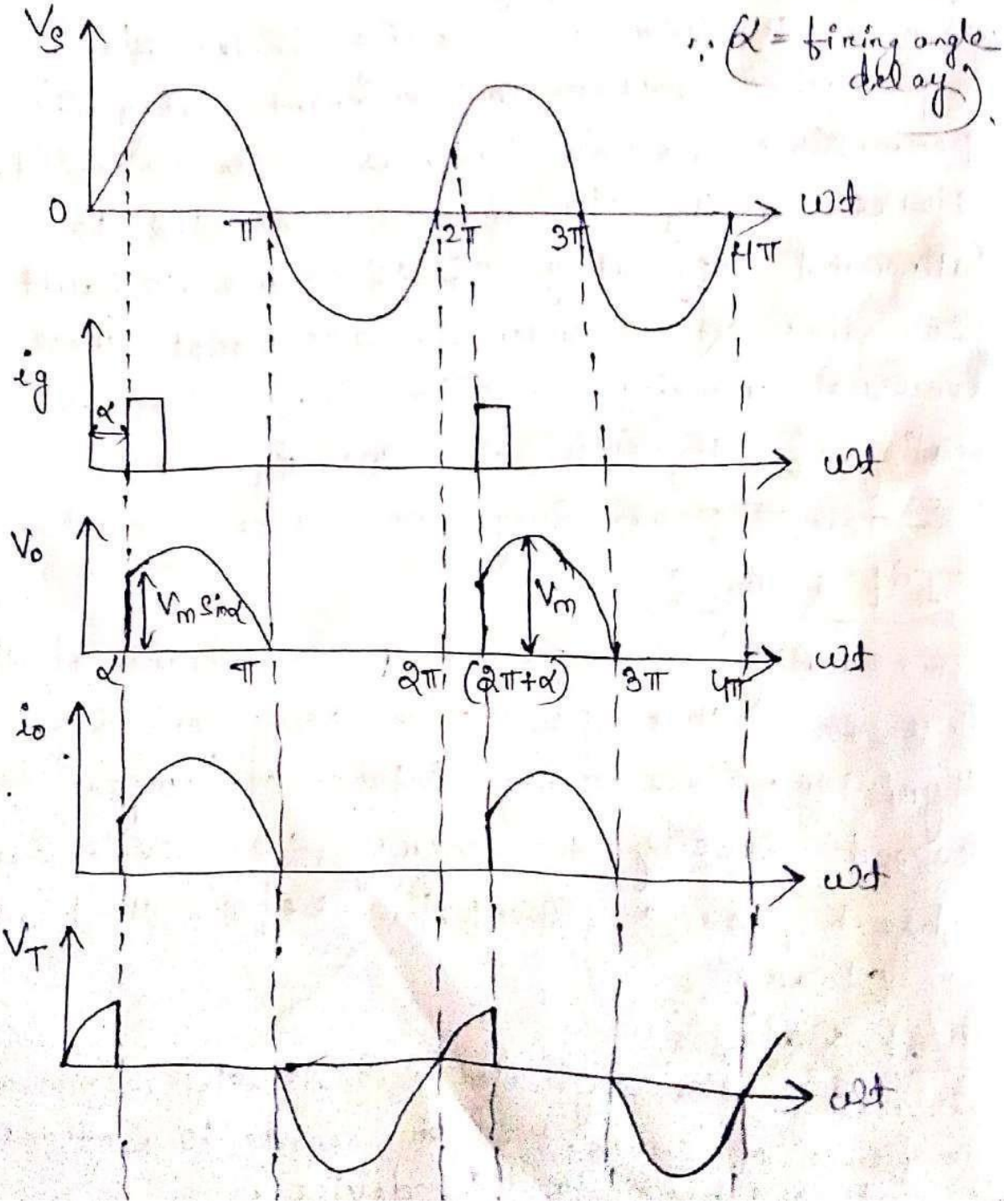
Static V-I characteristics :-



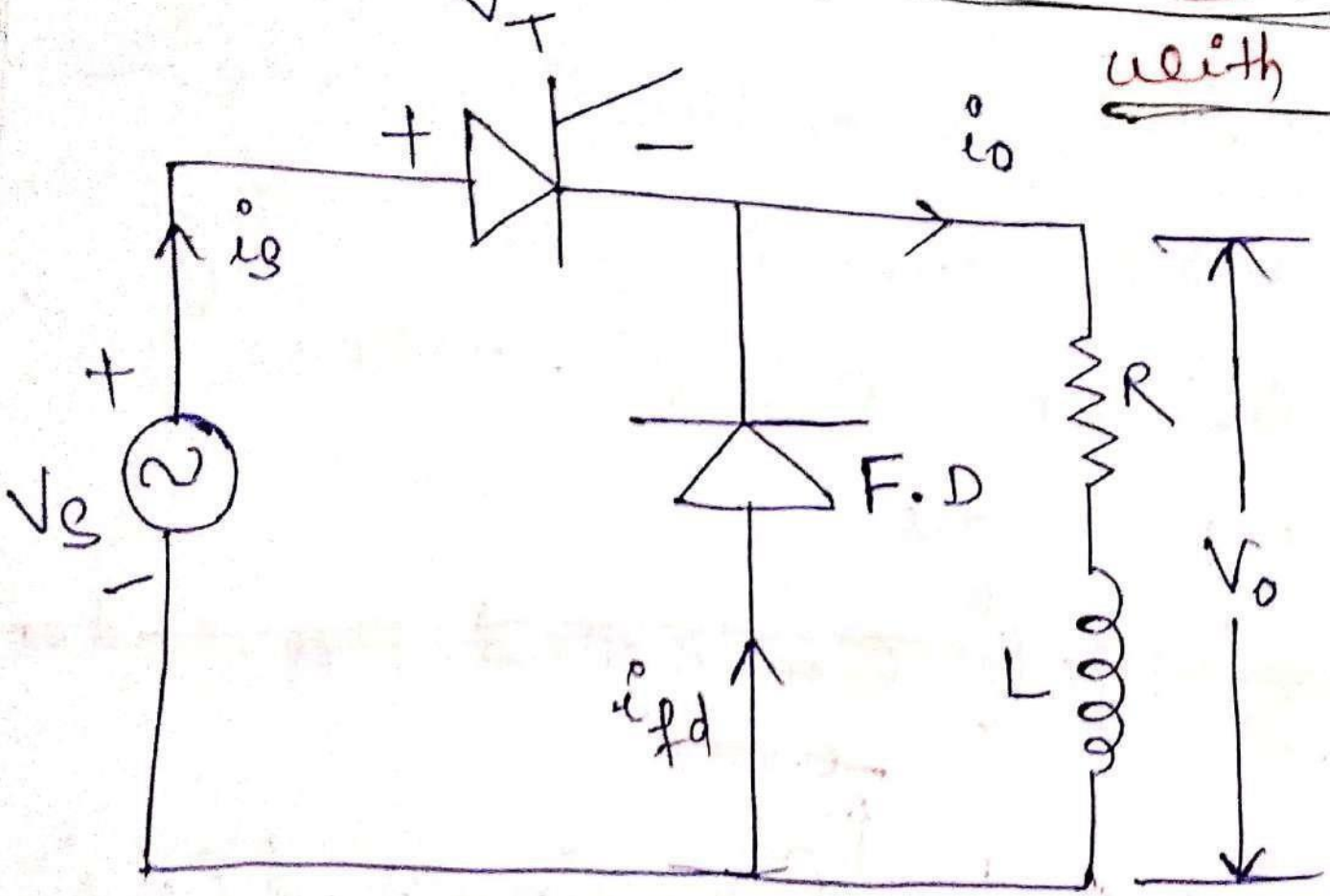
Single phase Half Wave Controlled Rectifier with R-Load :



∴ (α = firing angle delay).

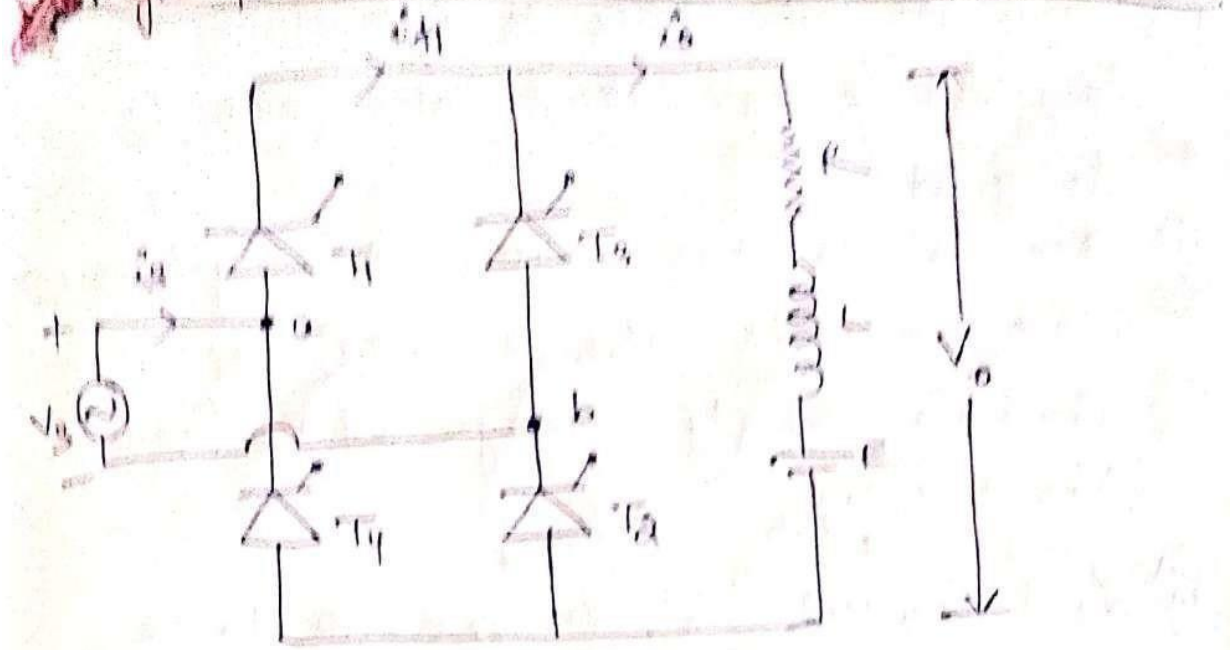


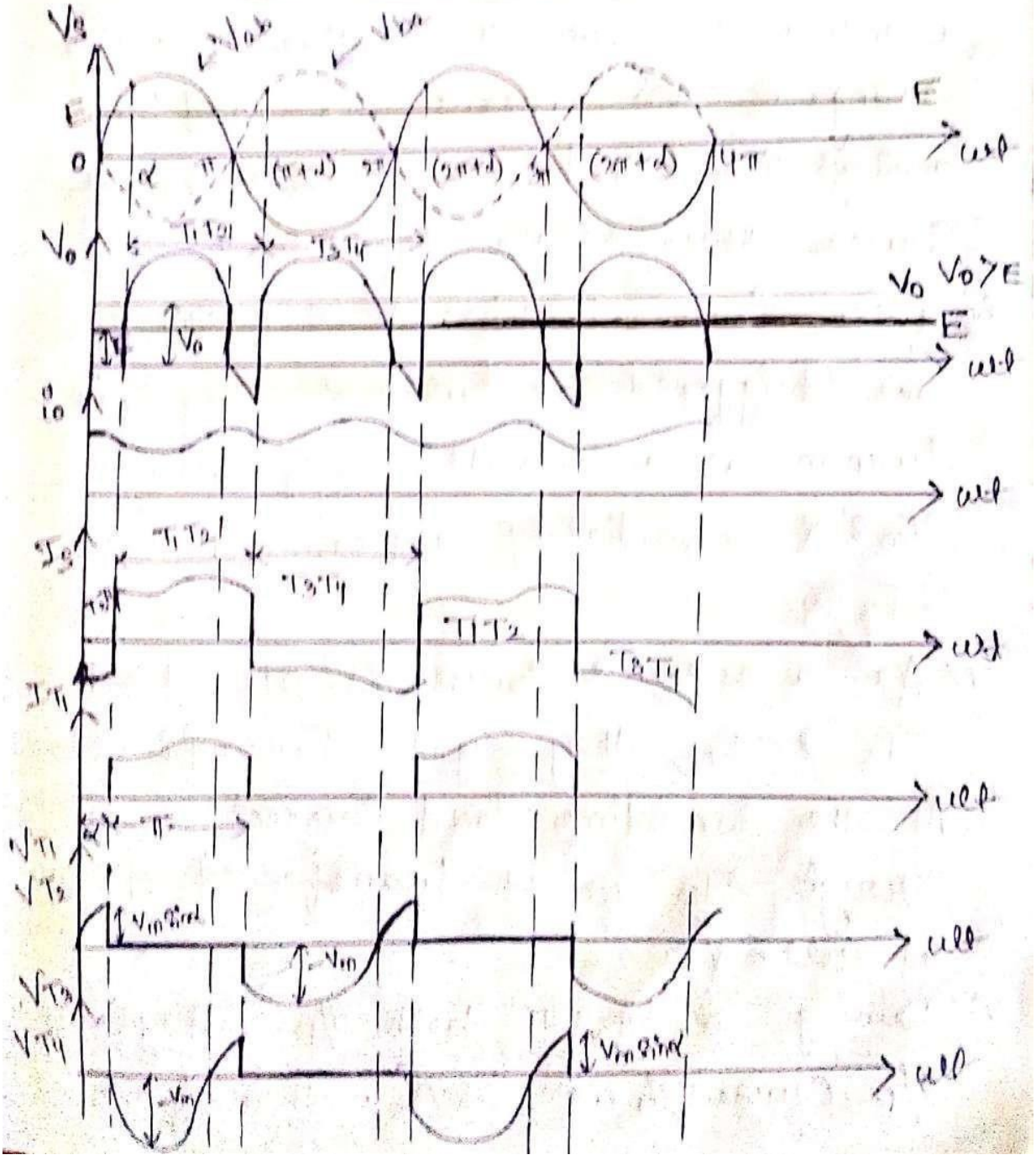
Single Phase Half wave Controlled Rectifier with RL Load & freewheeling diode :-



$$i_o = i_s + i_{fd}$$

Single Phase full Converter with R-L load:



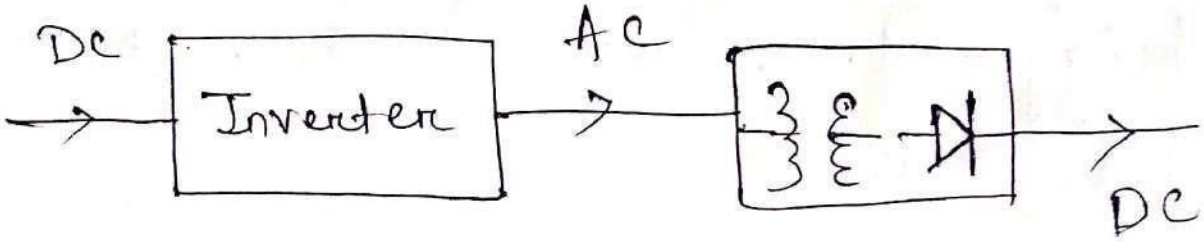


CHOPPERS :-

The Conversion of fixed d.c voltage to an adjustable d.c o/p voltage through the use of semiconductor devices can be achieved in 2-ways.

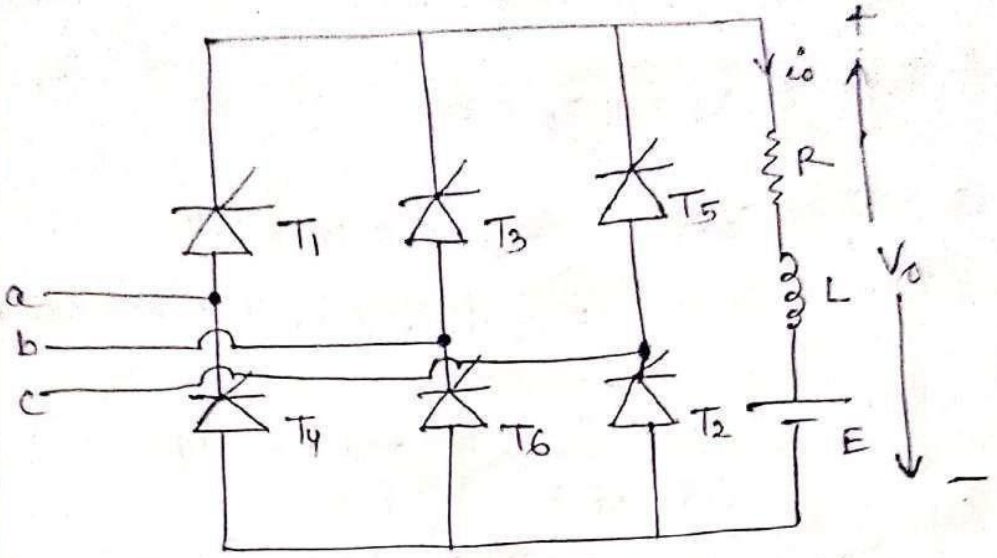
(1) By the use of Ac link chopper.
(2) " " " " D.c chopper.

(1) Ac link Chopper :-



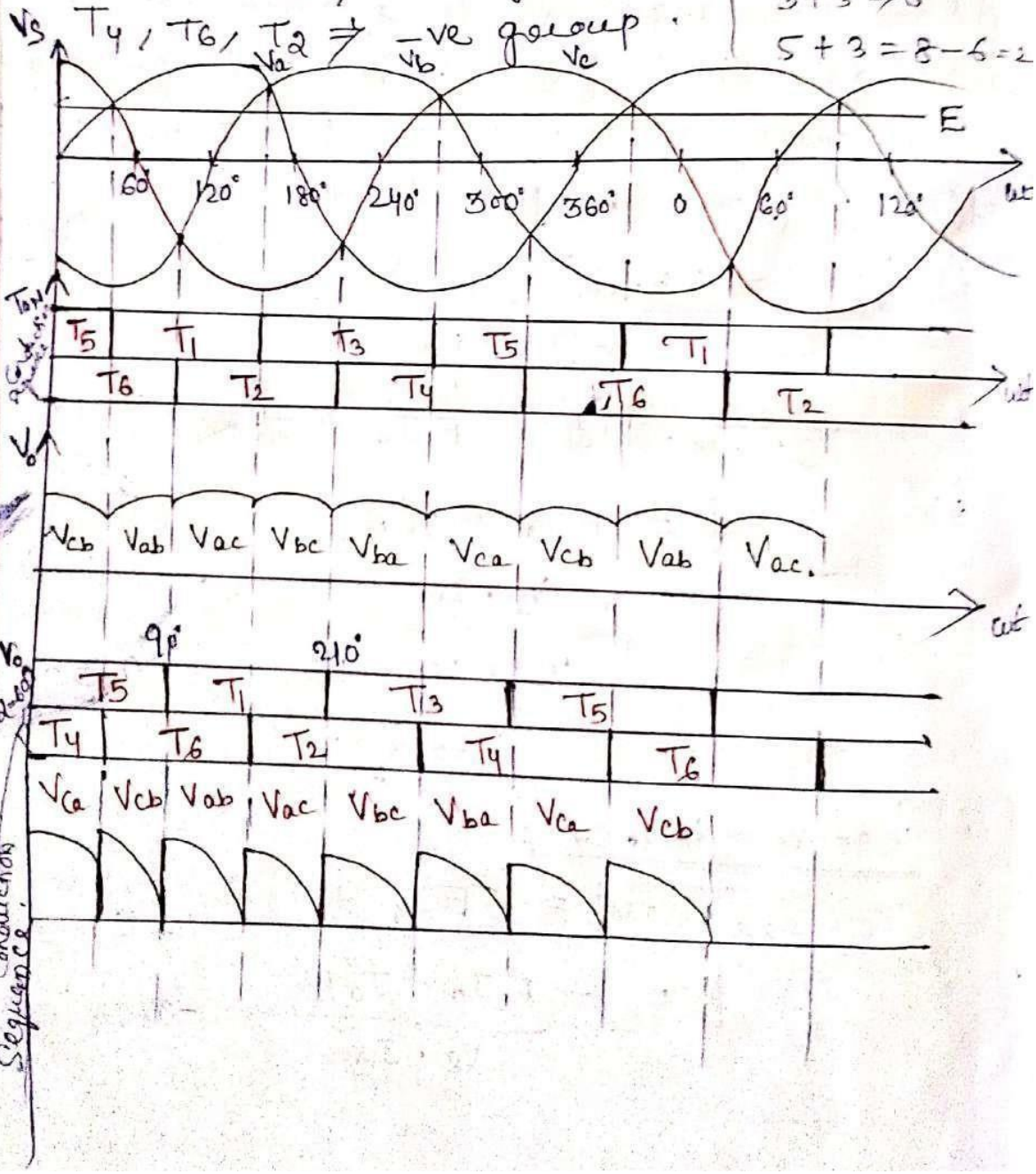
(i) In the Ac link chopper, d.c is 1st Converted into A.C by an Inverter. A.C is then Stepped up or Step down by a

3-ϕ full Converter : (Phase Voltage)

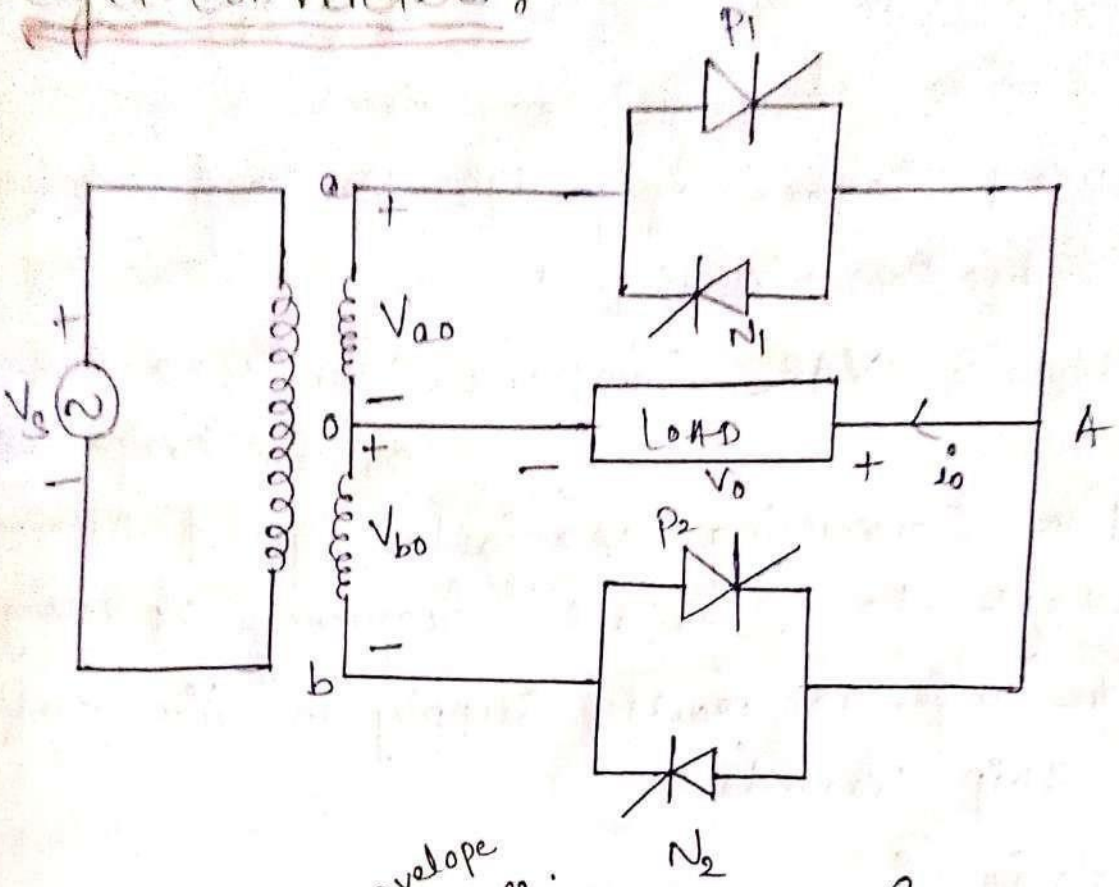


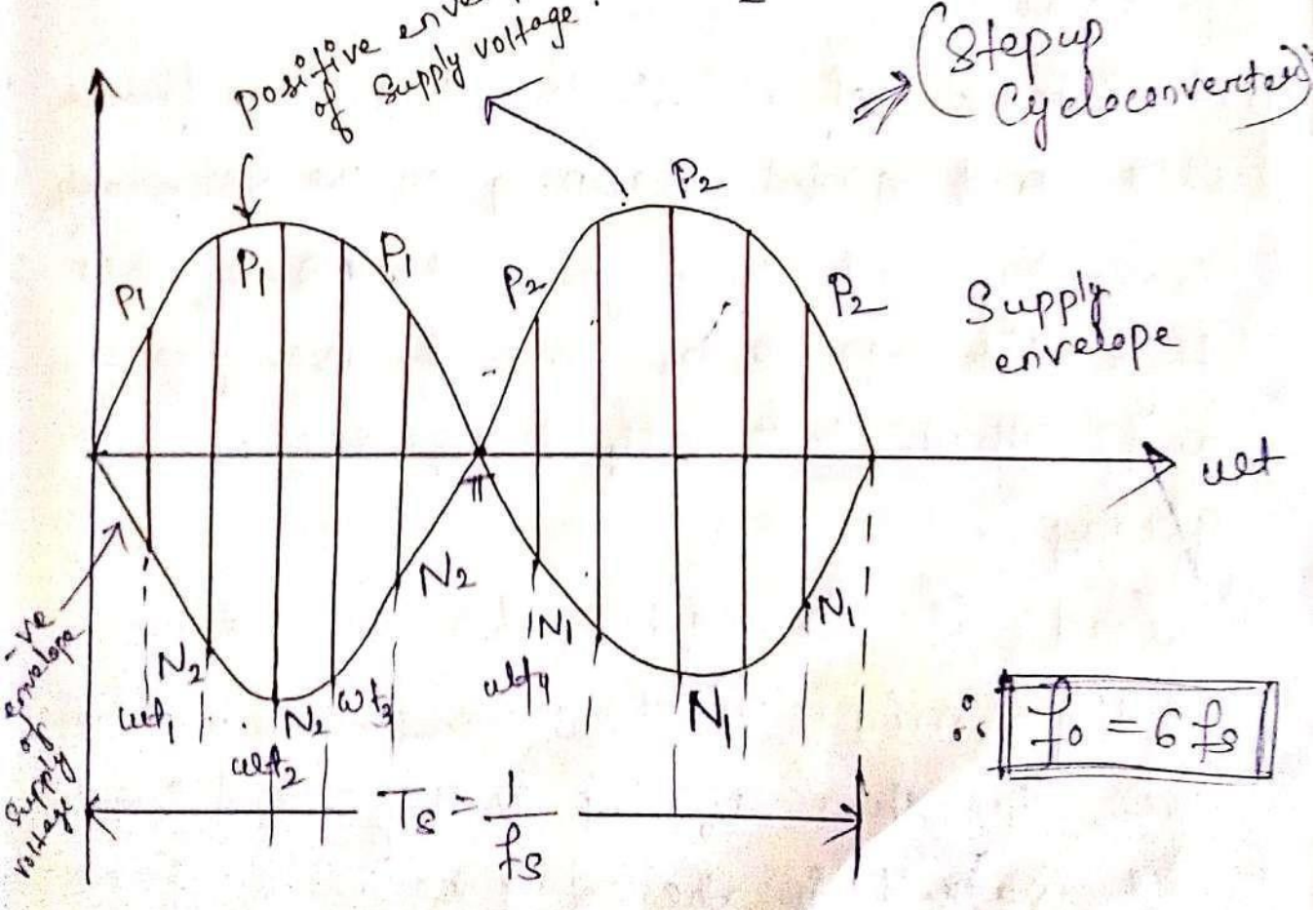
T1, T3, T5 ⇒ +ve group.
T4, T6, T2 ⇒ −ve group.

1+3 = 4
3+3 = 6
5+3 = 8−6 = 2



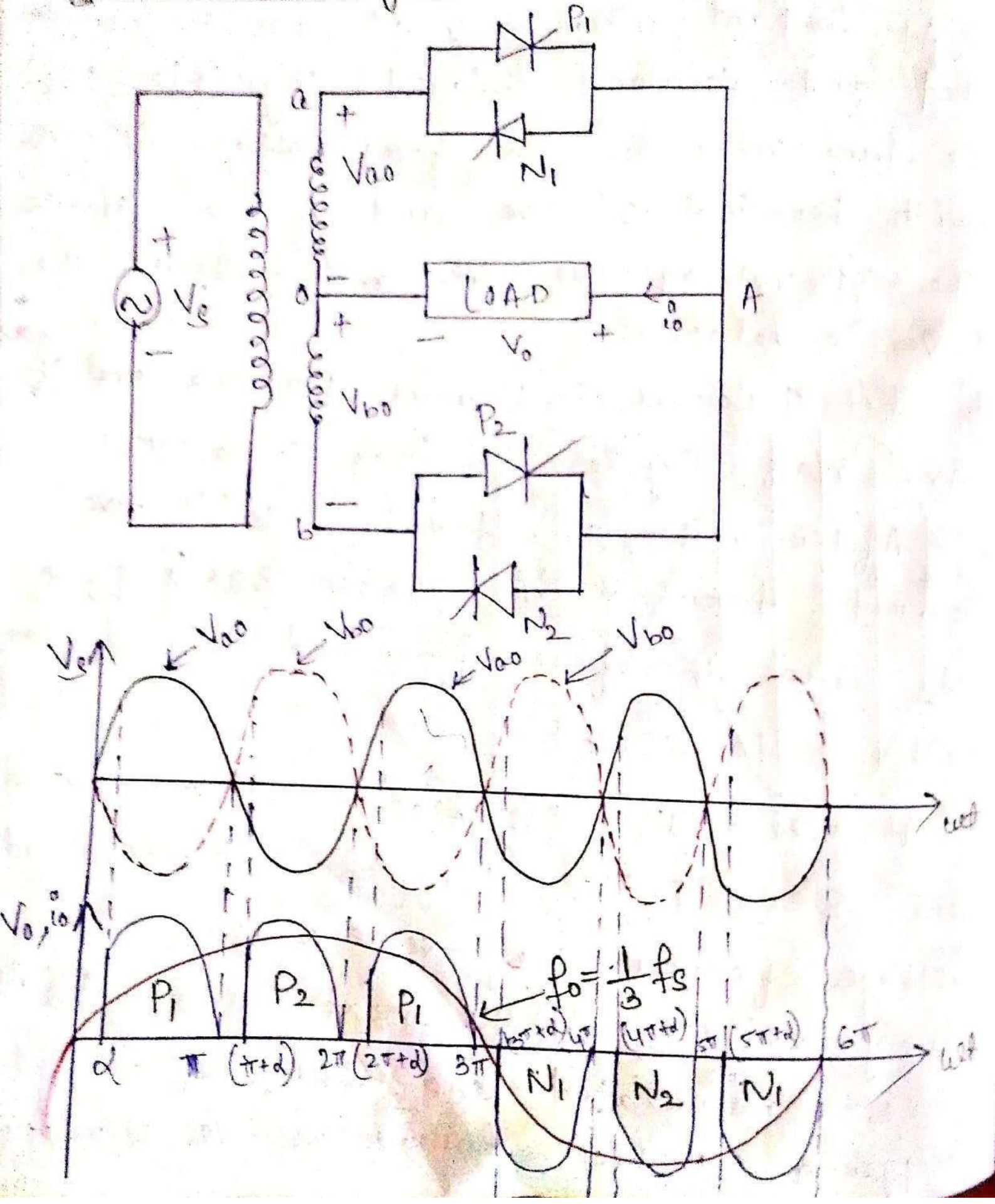
Cycloconverters :-





(i) A device which converts i/p power at one frequency to o/p power at a diff^t frequency with one stage conversion is called a cycloconverter.

Step down cycloconverter



Inverters :-

Inverters are used to convert d.c supply into A.C supply. we find its application in many fields like;

(1) UPS.
(2) HVDC transmission.
(3) In all industrial and domestic applications. etc.

Inverters are basically divided into 2-types.

(1) VSI or voltage Source Inverters
(2) CSI (Current Source Inverter)

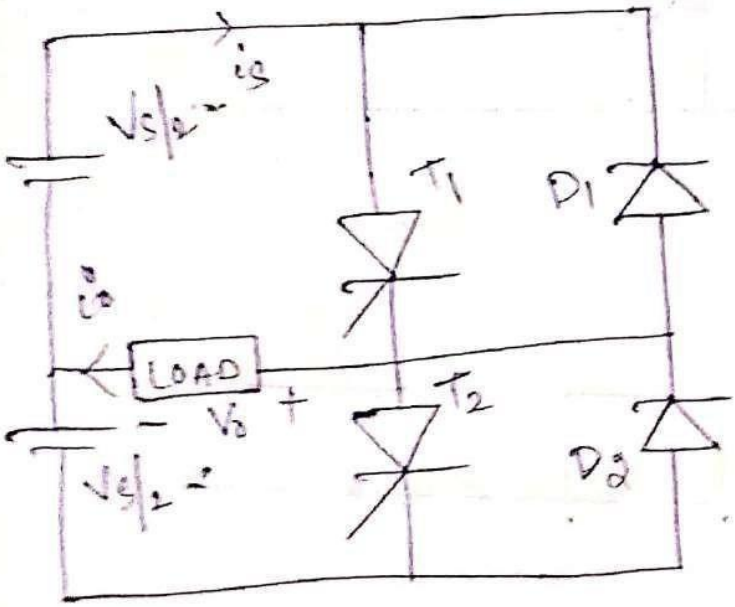
(1) VSI has stiff d.c voltage source at its i/p terminals. whereas

Single Phase Bridge Inverters

Single phase bridge inverters are of 2-types.

(1) Single phase Half Bridge Inverter.
(2) " " full " "

(1) Single phase Half Bridge Inverter :-



(1-ϕ half-bridge-inverter)

Fig (a)

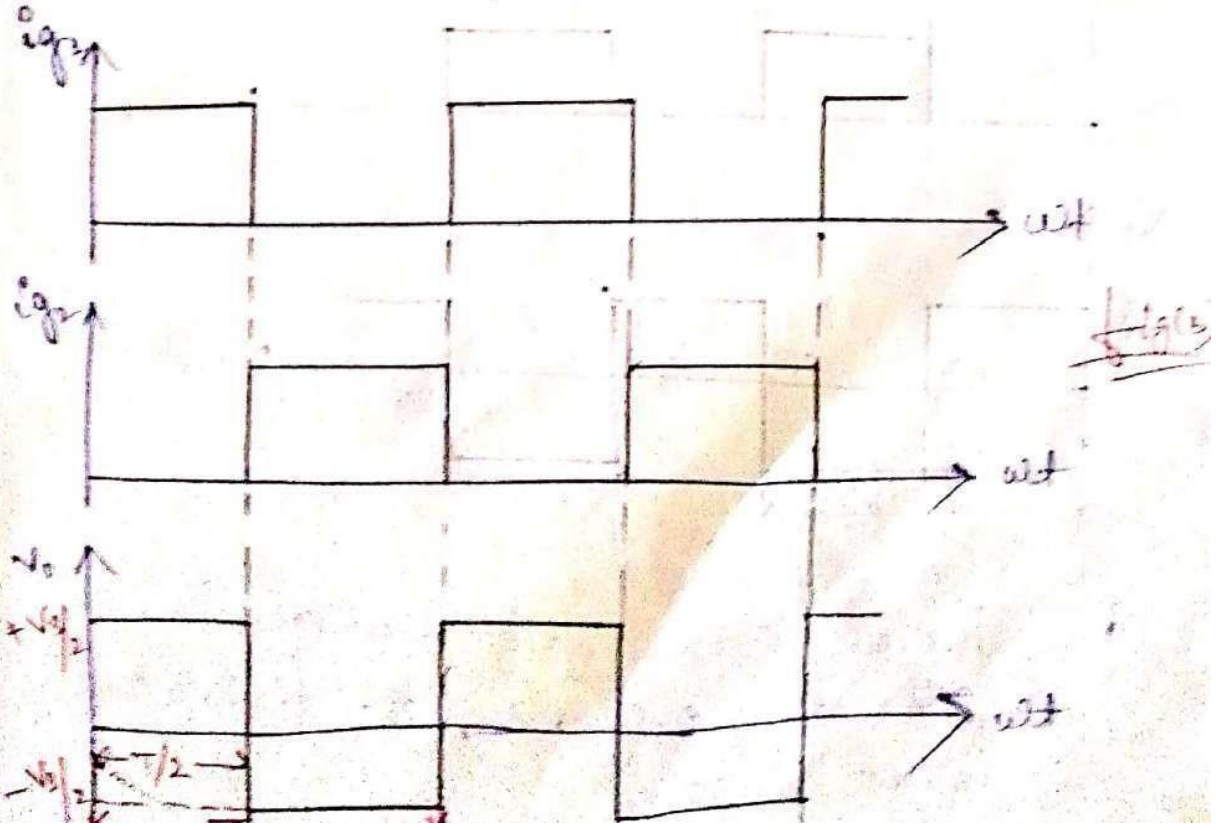


Fig (b)

CSI (Current Source inverter):-

(i) The Current Source inverter doesn't required any feedback diode. whereas these are required in Case of voltage source inverter.

(ii) Hence Commutation ckt is simple in Case of CSI.

(iii) As power semiconductors in a CSI have to withstand reverse voltages. Hence devices such as; GTO, Power Transistors, Power MOSFETS Cannot be used in a CSI. The devices like; SCR, & IGBT whose reverse voltage withstanding Capability is more will be used in a CSI.

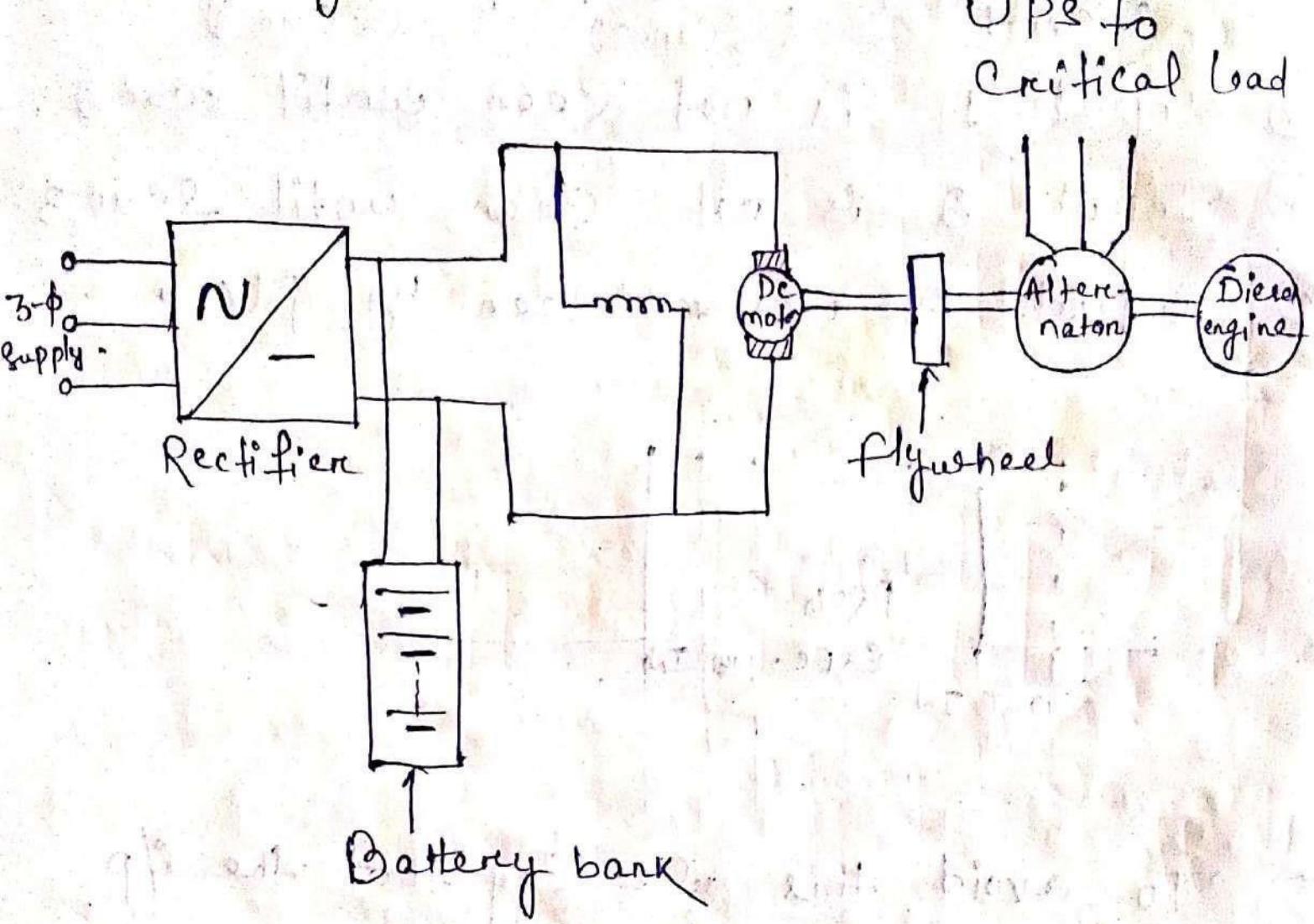
iv) The CSI finds they are used in the following applications.

(a) Speed Control of A.C Motors.
(b) Induction Heating.
(c) Reactive power Compensation.
(d) Synchronous motor starting.

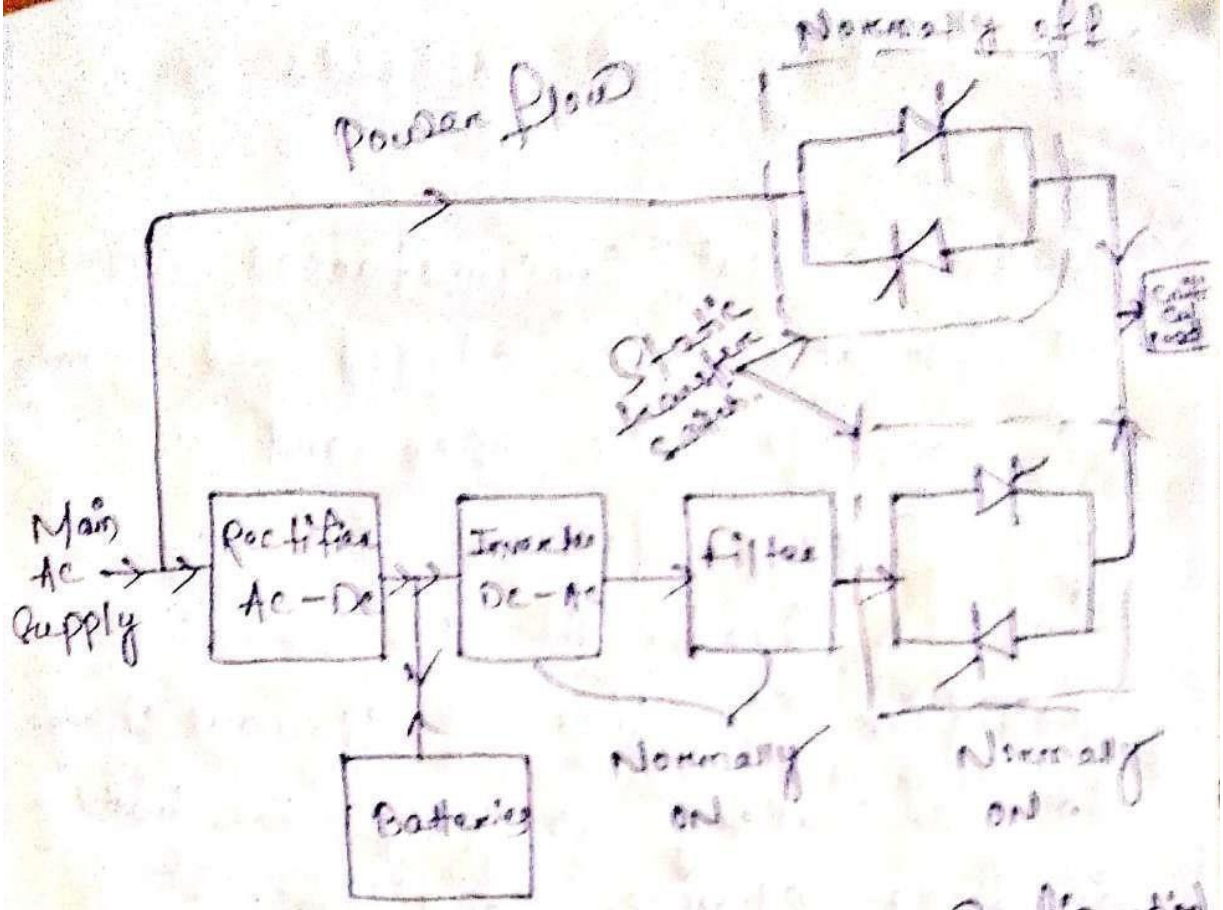
Single Phase CSI with Ideal Switches:-

UPS :- (Uninterruptable Power Supply)

Rotating type Ups :-



(i) There are several applications where even a temporary power failure can cause a great deal of public inconvenience leading to large economic losses.



(No-break Static UPS Configuration)

III ON-line UPS

SHORT Break / off line UPS :-

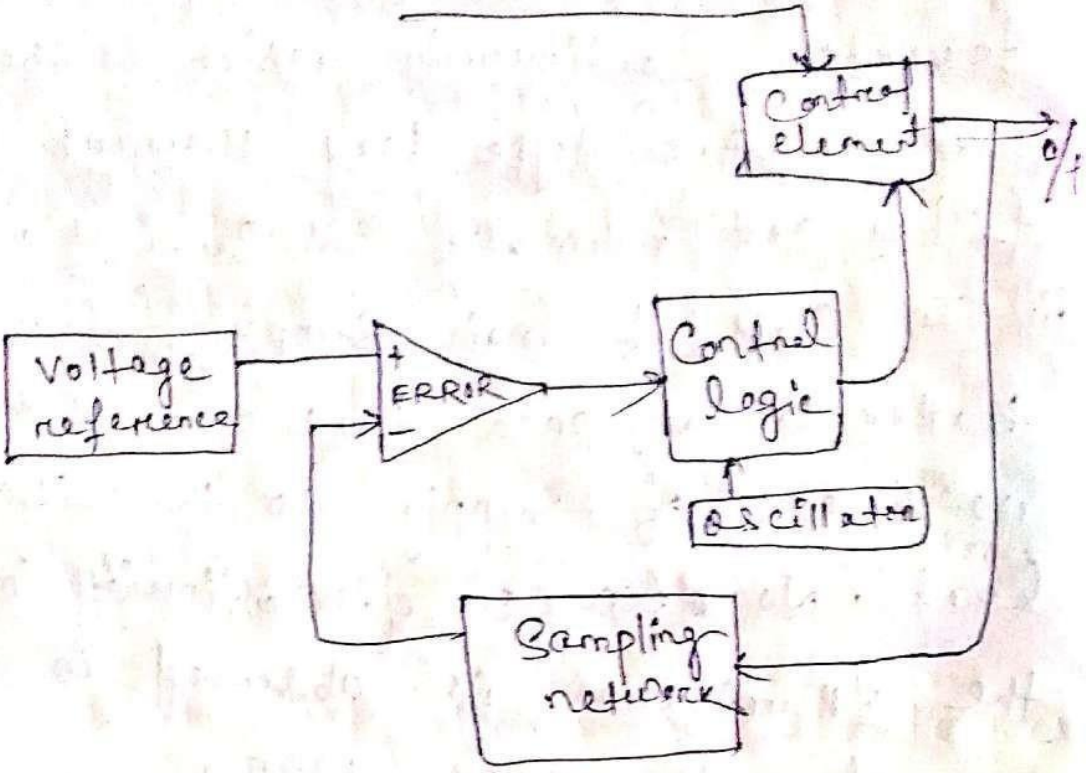
(i) In situation where short interruption (4-5 milli sec) in Supply can be tolerated the short break UPS can be used.

(ii) In this system main A.C Supply is rectified to d.c. This d.c output from the rectifier charges the batteries and is also converted to A.C by an Inverter.

(iii) After passing through the filter A.C Can be delivered to the load in

SMPS :- (Switchmode power Supply)

Block diagram of SMPS :-



(i) DC to dc Converters and d.c to A.c Converters belongs to this Category. The various types of voltage regulator used in linear power supplies fall under this Category.

(ii) The i/p d.c supply is chopped at a higher frequency around 15 – 50 KHz using an active device like; BJT, Power MOSFET &

Application of SMPS :-

It is used in almost all electron system. like ; TV, Computers, frize, washing machine etc.

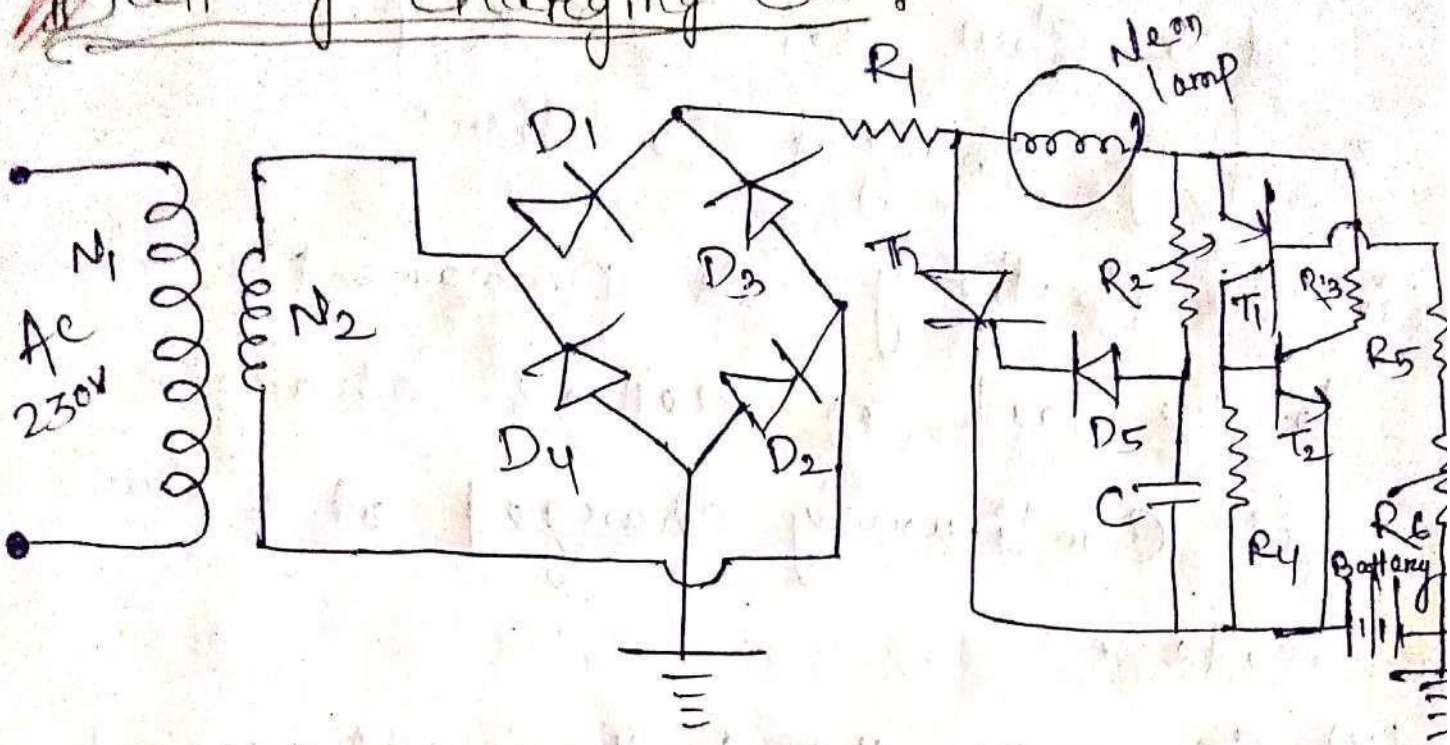
Advantages of SMPS :-

(1) Less size & weight.

(2) Efficiency is higher as compared to normal power supply.

(3) Cost is less as in case of normal power supplies when we need to use higher capacity

Battery Charging Ckt :-



(Battery Charging Circuit)

(i) It is necessary to charge a battery to restore it's fully charged condition. During charging a current is send through the battery in a direction opposite to that when the battery is being used.

(ii) The charging current is generally obtained from the bridge rectifier. The ckt should give an indication

New Chapter

Programmable logic Controllers (PLC)

(R-Dick Morley, 1964)

Introduction :-

(*) A PLC (Programmable logic Controller) is a device that was invented to replace the necessary Sequential relay circuits for machine Control.

(*) The PLC works by looking at it's inputs and depending upon their State, during on/off outputs. The user enters a program, usually via - Software, that gives the desired results.

PLC examples :-

(i) Lets assume that when a Switch turns on we want to turn a Solenoid on for 5-Seconds and then turn it off regardless of how long the Switch is on for.

(ii) We can do this with a Simple external timer. But what if the process

included 10 switches and Solenoids) we would need 10 external timers. what if the process also needed to count how many times the switches individually turned on? we need a lot of external counters.

PLC Need:

(i) The bigger the process the more is need for a PLC.

(ii) Simply program the PLC to count it's inputs and turn the Solenoids on for the specified time.

(iii) The primary reason for designing PLC was eliminating the large cost involved replacing the complicated relay based machine control systems.

Inside PLC:

The PLC mainly consists of;

(i) A CPU

(ii) Memory Areas, and

(iii) Appropriate circuits to receive input/output data.

Components in a PLC System :-

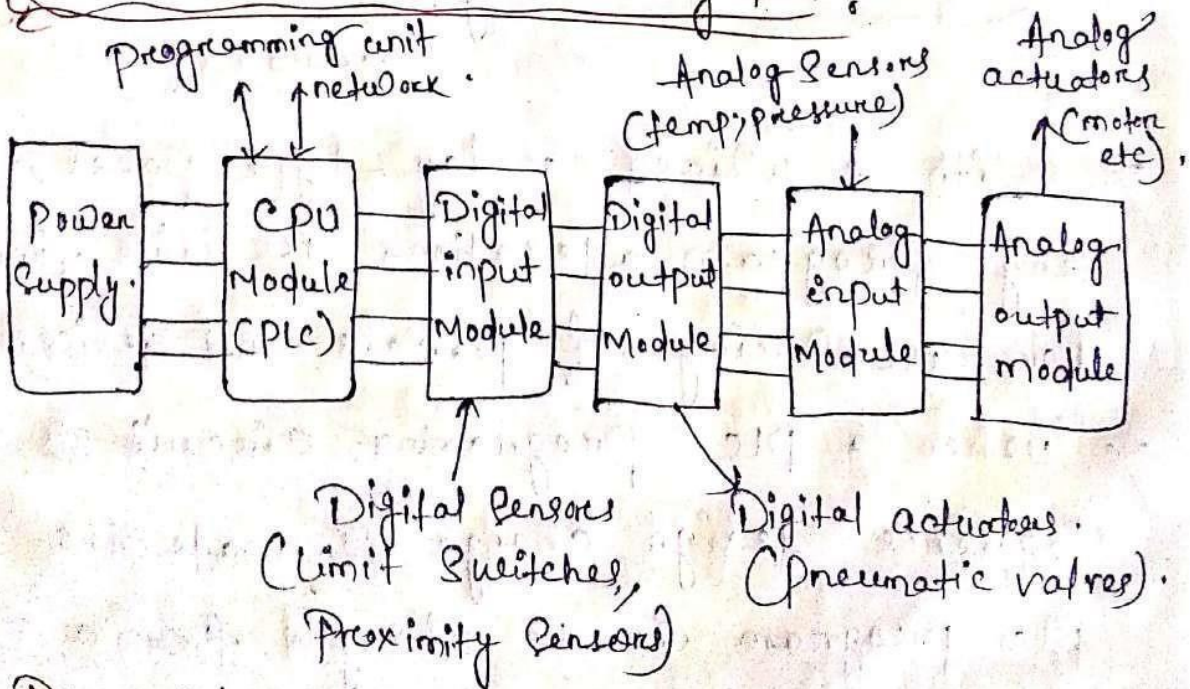
(i) CPU module, containing the processor and memory.

(ii) Input and output Modules to allow the PLC to read Sensors and Control actuators. A wide variety of types are available.

(i) Power Supply for the PLC and often Sensors and low power actuators connected to I/O Modules.

(ii) A rack or bus so the PLC can exchange data with I/O Modules.

PLC in a automated System :-



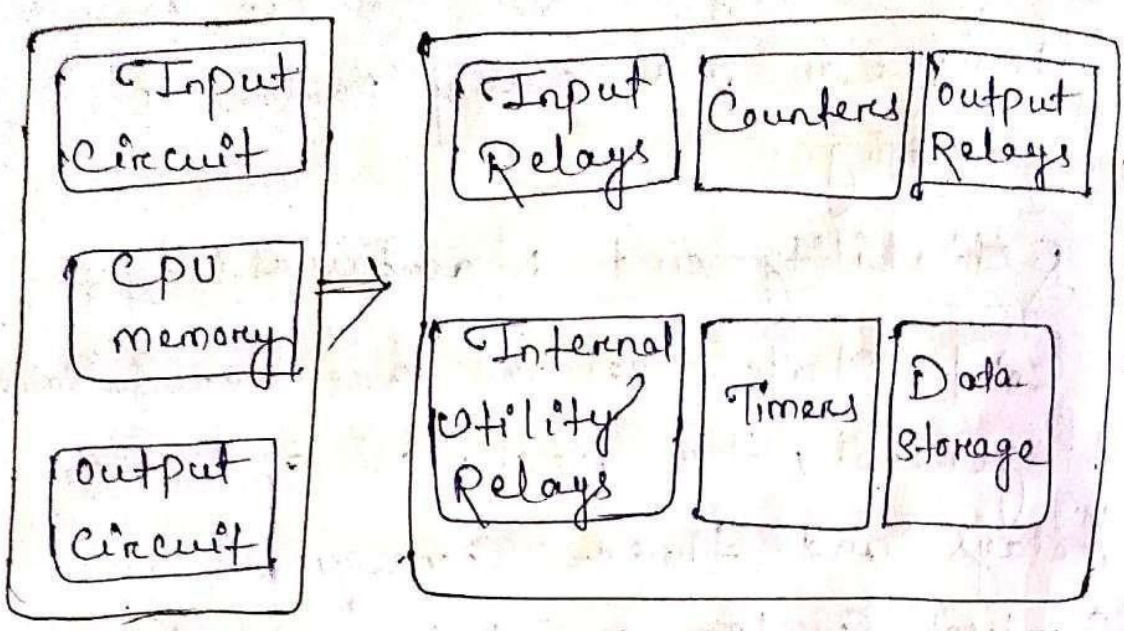
PLC Advantages :-

(a) Flexibility :-

⇒ In the past each different electronically Controlled production machine required its

Various parts of PLC :-

Block Diagram :-



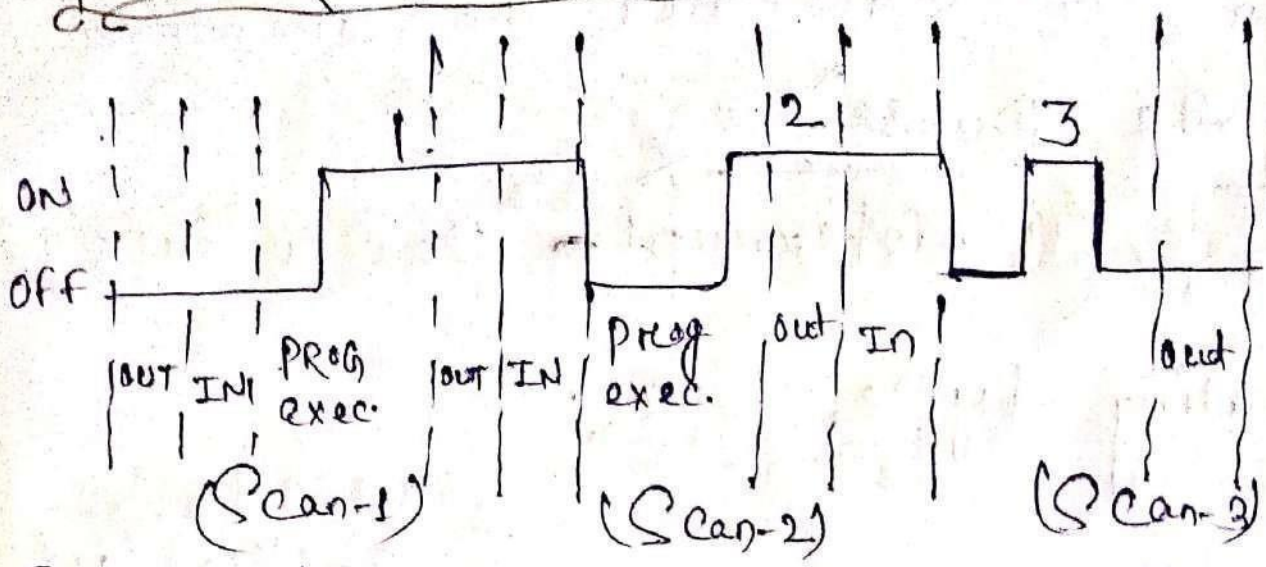
Input Relays (Contacts) :-

⇒ These are connected to the outside world. They physically exist and receive signals from switches, sensors etc. ~~not~~ Typically they are not relays but rather they are transistors.

(*) Internal Utility Relays :-

⇒ These do not receive signals from the outside world nor do they physically exist. They are simulated relays and are what enables a PLC to eliminate external relays.

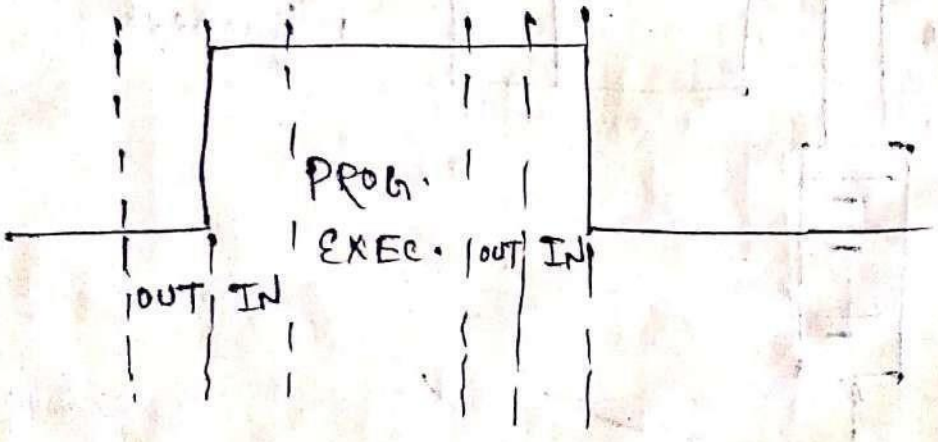
PLC - Response Time Concern :-



(1) Input 1 is not seen until Scan 2.

(2) Input 2 is not seen until Scan 3.

(3) Input 3 never seen by PLC.



⇒ To avoid this we say that the i/p should be ON for at least, input delay time + one Scan time.

⇒ But what if it was not possible for the i/p to be on this long?

↳ Then the PLC doesn't see the input turn on.