Un Interruptible Power Supplies :

Introduction :

A consistent increase in the need for reliable and quality ac power has spurred the need for uninterruptible power systems (UPS).

The requirement for an UPS is a result of the declining quality of available utility-provided power.

UPS Equipment and components :

A solid-state (or static) UPS is comprised of the following units :

1) an energy storage device (usually a battery and thus a dc source) to provide power during utility or mains interruption

2) a rectifier-charger as a means of restoring the energy to the storage device when the utility power is again available.

3) an inverter which is powered by the dc source, to provide the desired and regulated ac output

4) an automatic transfer switch which connects the load to the inverter or to the utility line, depending on the desired configuration.

Major Topologies of UPS:

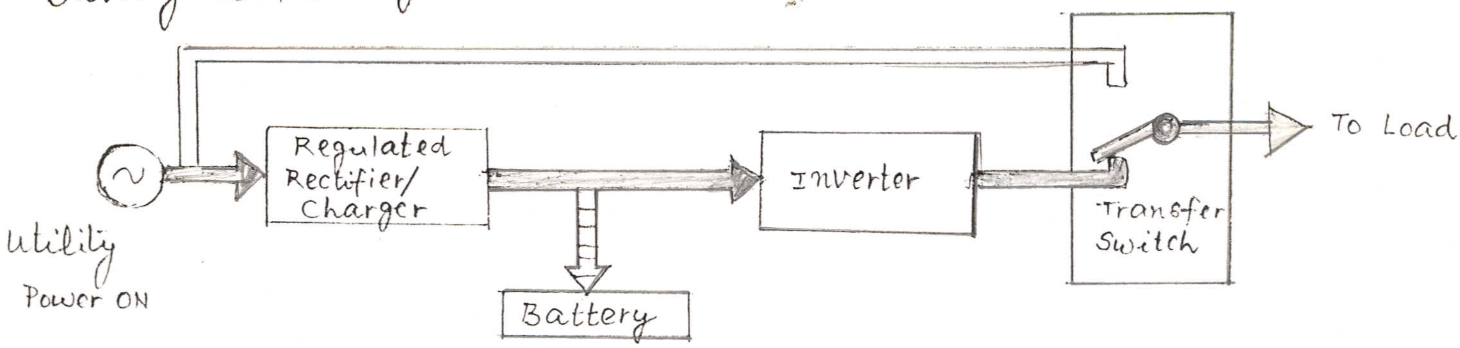
1. ON-LINE system, where the inverter powers the load continuously
2. OFF-LINE system where the utility is the primary power for the load.

Heavy lines : main path of current flow

Dashed lines : path of lesser current flow

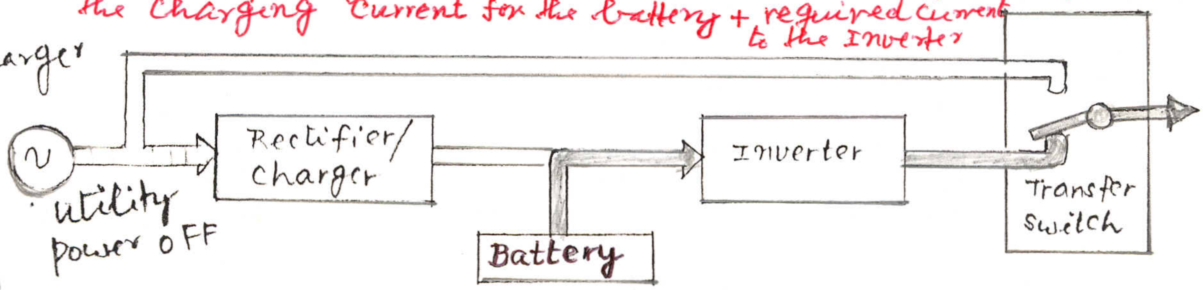
ON-LINE SYSTEM: (Floating system)

Battery is floating



(a) When utility power is ON

Rectifier/charger should have the current capability to supply the charging current for the battery + required current to the inverter



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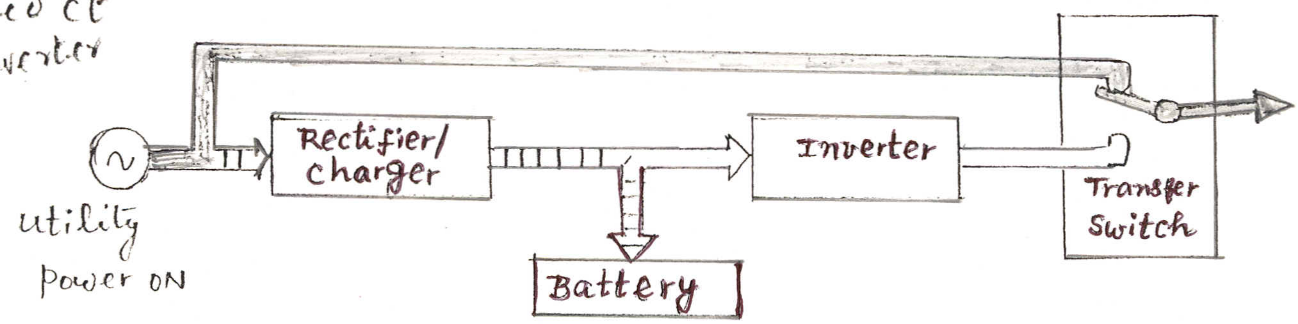
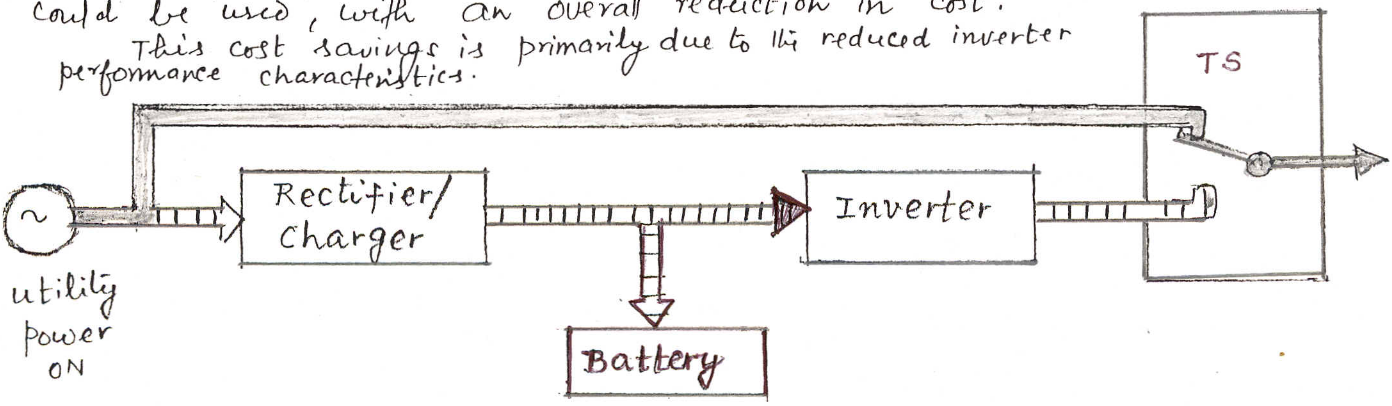
(b) When utility power is off:



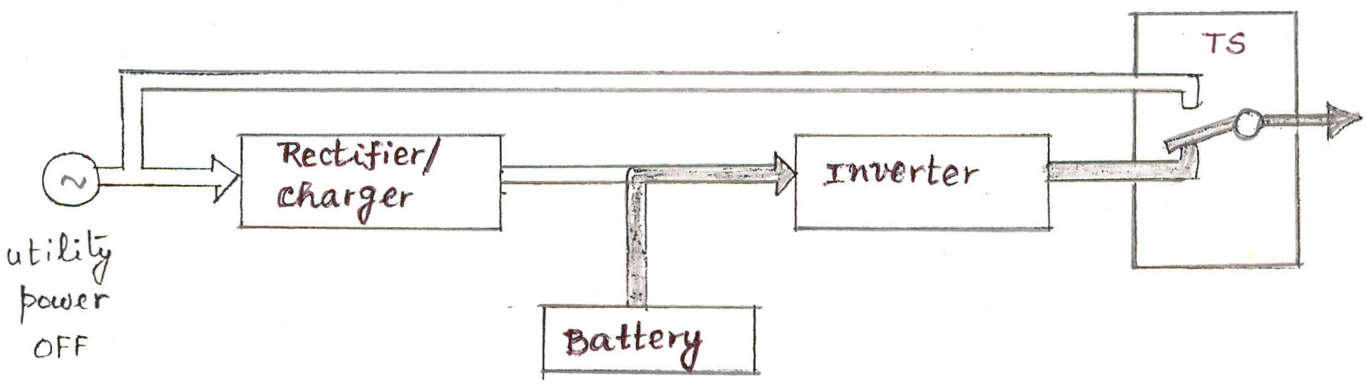
(c) When the inverter ceases to function

OFF-LINE SYSTEM: For conditions where utility power is clean and is not subject to abnormal voltage excursions, an OFF line system could be used, with an overall reduction in cost.
This cost savings is primarily due to the reduced inverter performance characteristics.



(a) when the utility power is ON

TS : Transfer Switch



(b) when the utility power fails

Note: Transfer Switches are SPDT power devices (TRIACS & antiparallel SCRs) which switch the load from the inverter output to the utility line or vice-versa.

Transfer switches

It may be electromechanical or static (solid-state). EM switches such as relays and contactors are relatively slow and the transfer time is typically more than one cycle of the utility line.

Static switches such as triacs and back to back SCRs can switch within less than 1/4 cycle and transfer time is a function of the control circuit sensing impending loss of voltage.

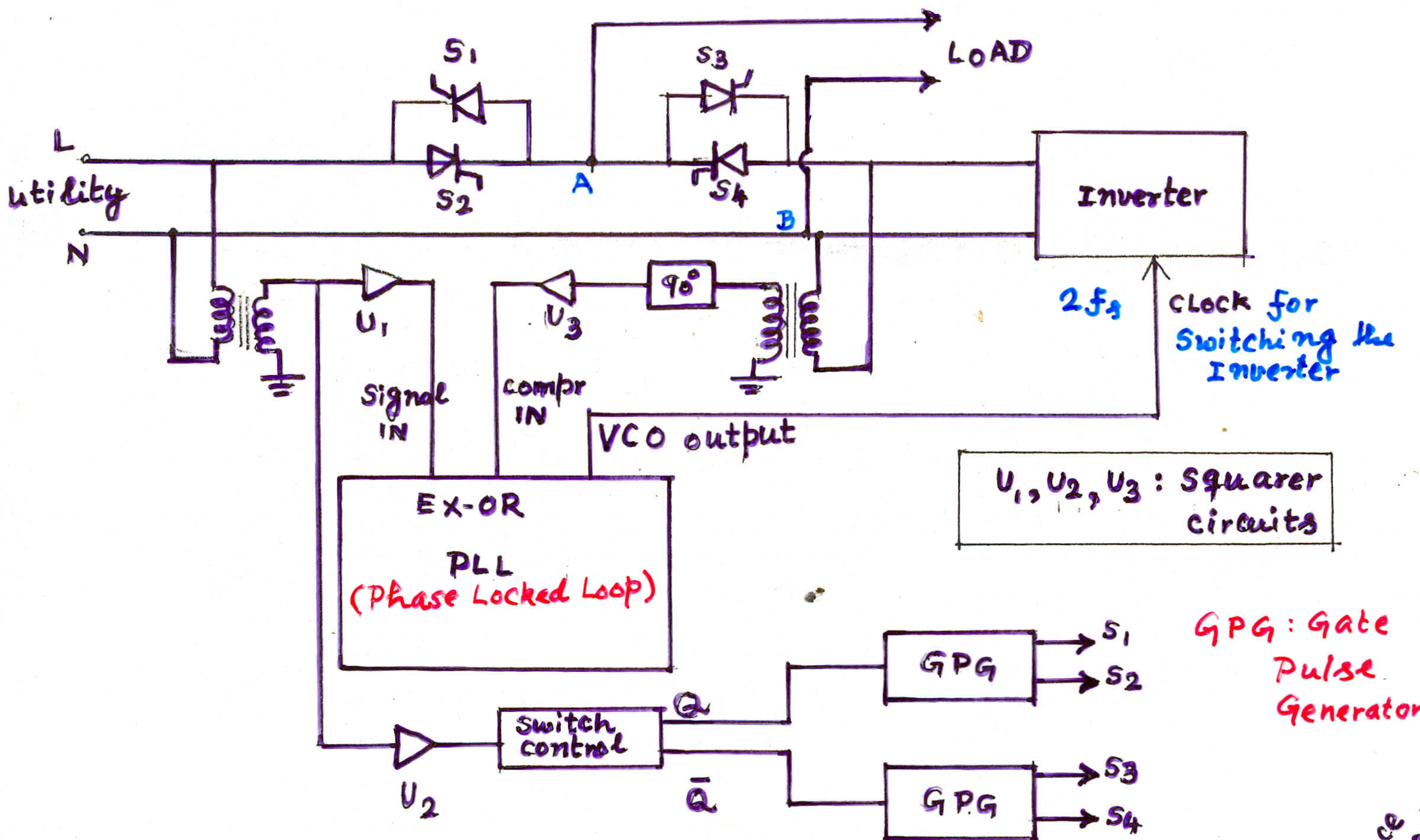
Phase synchronization:

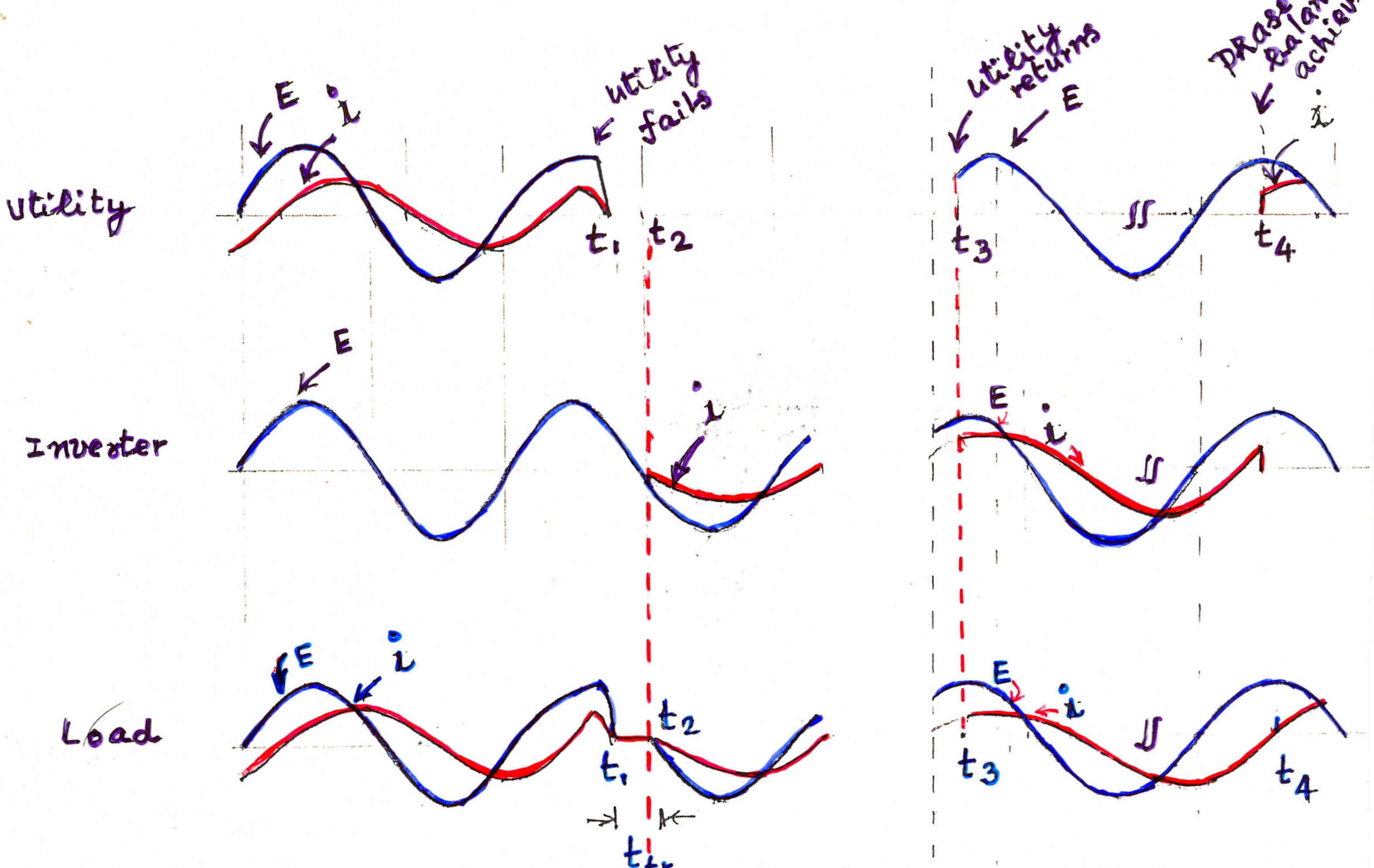
Synchronization of the phase and thus the frequency of the utility and the inverter is an important consideration in transfer switch operation.

If an imbalance in phase or frequency is present when the switch is activated, transient conditions may occur, depending on the type of load.

One method of accomplishing synchronization is with a Phase Locked Loop (PLL).

Phase synchronization with PLL





Note: The inherent nature of the EX-OR produces a symmetrical square wave of twice the input frequency when the signal and the comparator inputs are at 90°.

Thus the 90° shift from the (inverted) output of the inverter will cause the VCO input signal to maintain the phase of the utility and the inverter within a few degrees.

Working:

Initially S_1 and S_2 are gated on and the utility powers the load.

At t_1 the utility fails; the switch control then removes the gate signal from S_1 and S_2 and applies a gate signal to S_3 and S_4 after a delay time T_{tr}.

At t_2, S_3 and S_4 conduct and within less than 1/4 cycle, the voltage and current are again applied to the load.

At t_3 the utility is again present. However the inverter and the utility may not be instantaneously in phase.

The PLL then compensates the VCO input for phase synchronization at the predetermined frequency slew rate which will not adversely affect the load.

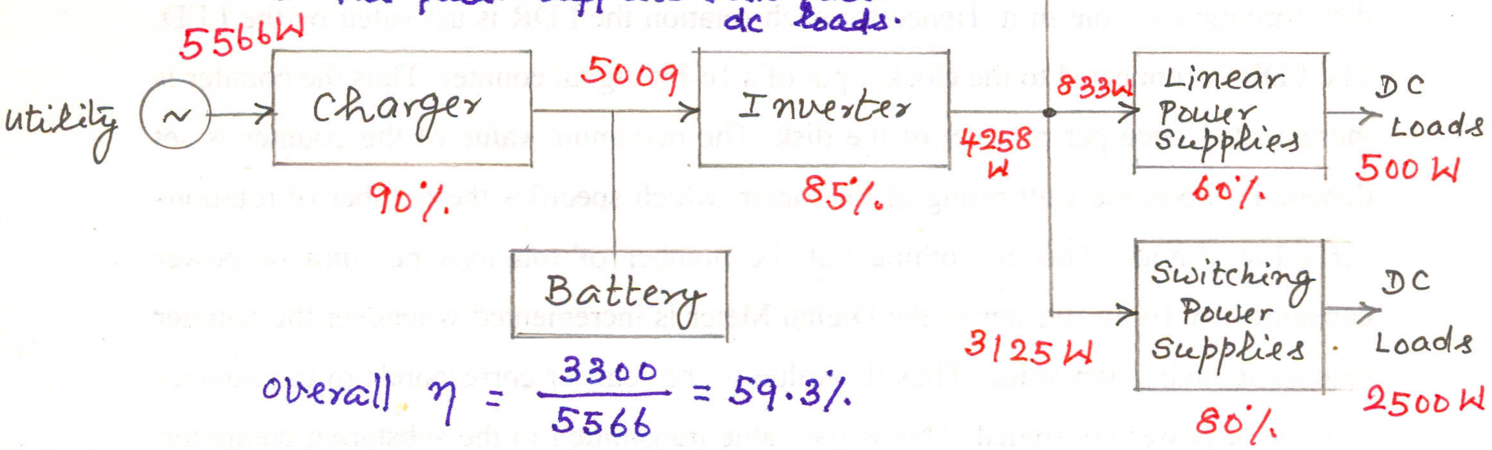
At time t_4, phase balance is achieved. S_1 & S_2 are then gated on, while the gate signals are removed from S_3 & S_4.

This mode can be 'make before - break' which eliminates any disturbance in the load.

The transformer and motor loads do not experience abrupt phase displacement or reversal as might be the case without PLL.

Complete UPS system analysis

(i) Topology : 1. utility ac rectified to charge battery and supply power to inverter
2. Invr. provides ac output to power supplies
3. The power supplies then power the dc loads.

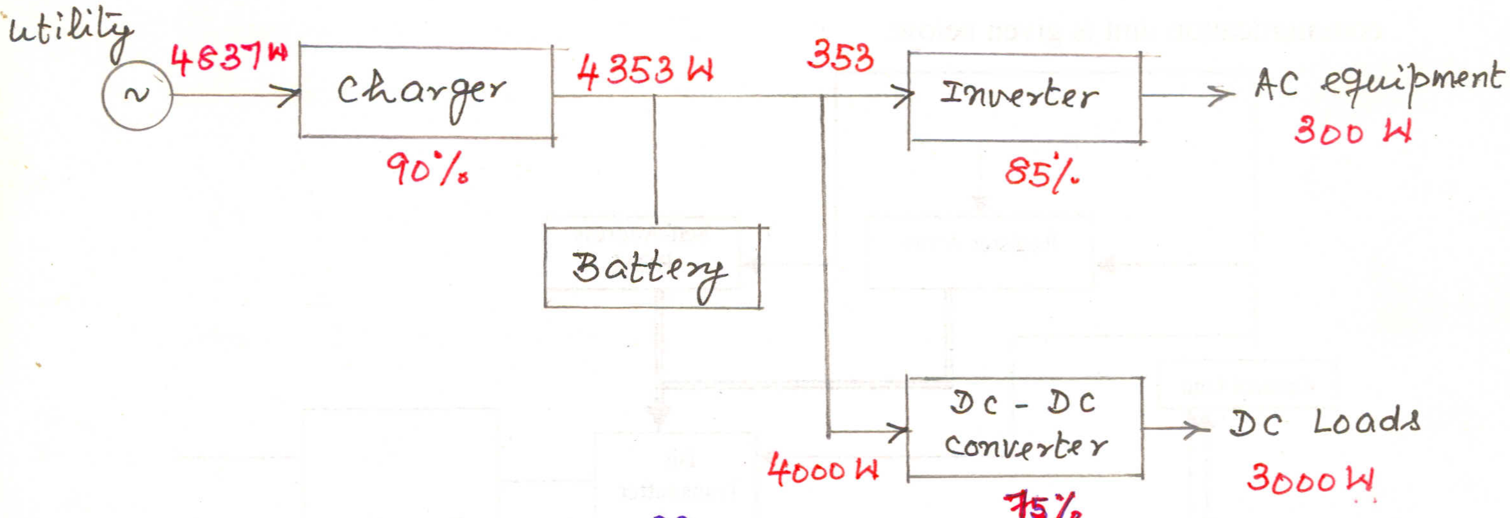


overall $\eta = \frac{3300}{5566} = 59.3\%$

(Power loss = 2266 W)

[The losses cause a burden on the air conditioning unit]

Topology II : The same output power requirements except
(i) the power supplies are replaced by converters and
(ii) only a low power inverter is required for ac loads



overall $\eta = \frac{3300}{4837} = 68.2\%$

(Power loss = 1537 W)

Savings = 2266 W − 1537 W = 729 W!

Note : (i) 300 W inverter is certainly less expensive than 4.3 KW inverter
(ii) charger rating is reduced to 4353 W from 5009 W
(iii) Energy saving from power system point of view.

Elevator DOOR CONTROLLERS

One important example of door control is the opening and closing of elevator doors.

This type of control may appear to be trivial, but the required specifications and constraints on the door movement make the design of the controller assembly hard.

i) Opening speed is faster than the closing speed. During the first 5 cms of opening, the speed should not exceed 40% of full speed.

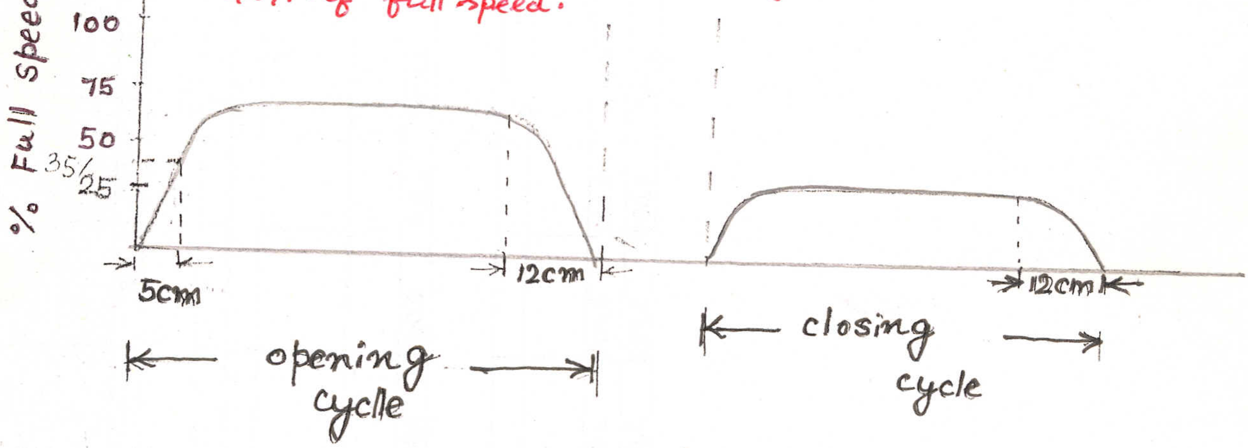


Fig.1 Speed - distance characteristics

ii) When the doors are within 12 cms of fully open or fully closed position, the speed should begin to drop, in preparation for a stop when the limits are reached.

iii) Upon any obstruction in the doorpath during closing, an immediate reversal of door motion must occur. i.e., atleast the doors must stop instantaneously.

Soft start and dynamic braking arrangement are provided in the control circuit for controlled opening and closing of the door at the beginning and end of its travel.

Fig.1 illustrates the complete speed - distance characteristics of a typical door.

As may be seen from the diagram that the opening speed is faster than the closing speed.

During the first 5cm of opening, the speed should not exceed 40% of full speed.

When the doors are within 12cm of fully open or fully closed position, the speed should begin to drop, in preparation for a stop when the limits are reached.

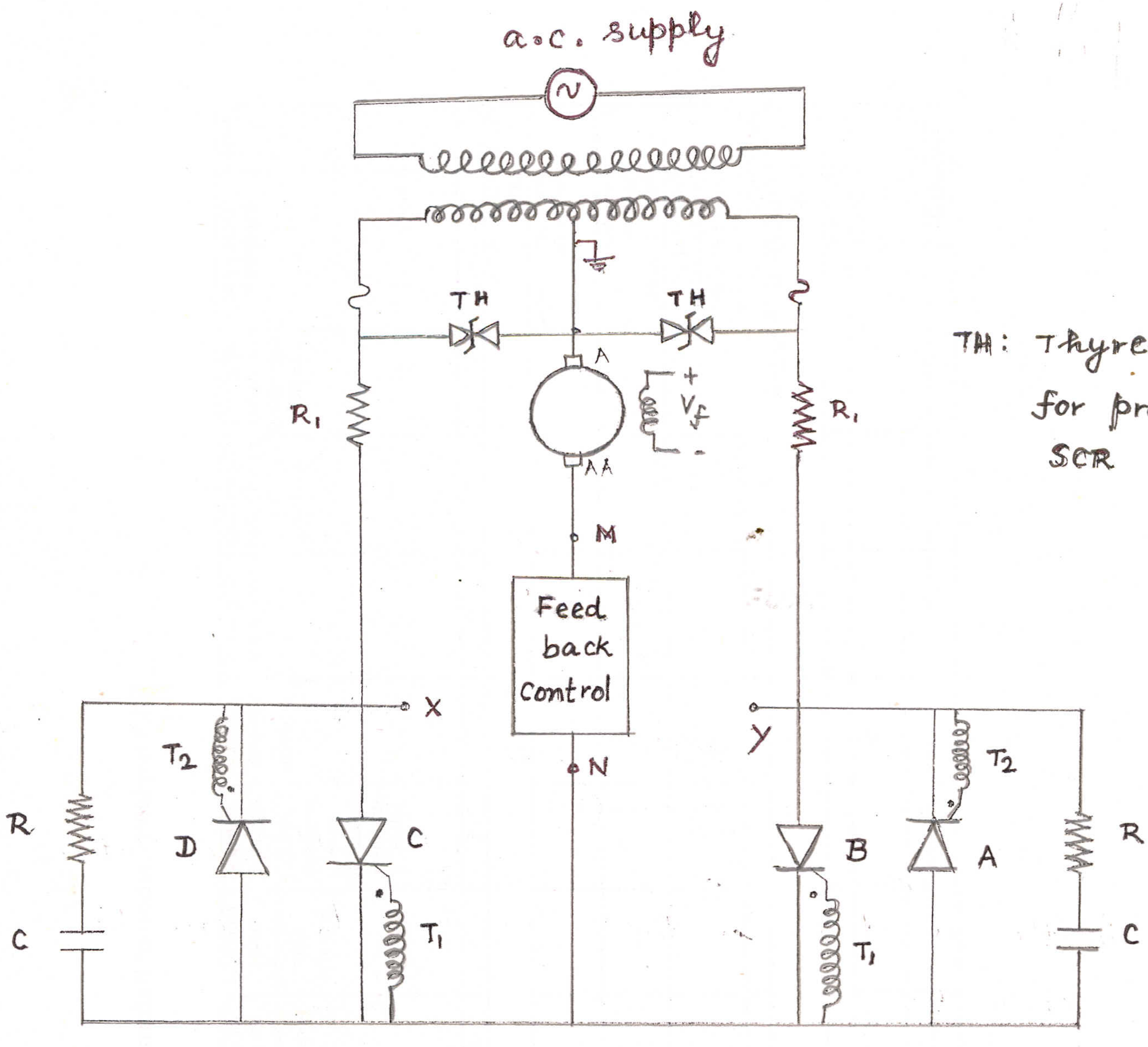
Further requirements of the control are as follows:

upon sensing any obstruction in the door path during closing, an immediate reversal of door motion must occur. The prime concern here is that the doors atleast stop instantaneously.

The control circuit used is shown in Fig. 2.

In this circuit, the field is supplied directly by full wave rectified d.c.

Reversible drive is obtained by firing SCR pairs A & D or B & C. This is done by coupling the pulse transformers T_2 or T_1 respectively to the UJT oscillator via the open or close switches shown in Fig. 3.



TH: Thyrector diodes for protection of SCR

Fig. 2 MOTOR CONTROL CIRCUIT

Across X Y : Control circuit (See Fig.3)

Across MN : Feedback circuit (See Fig.4)

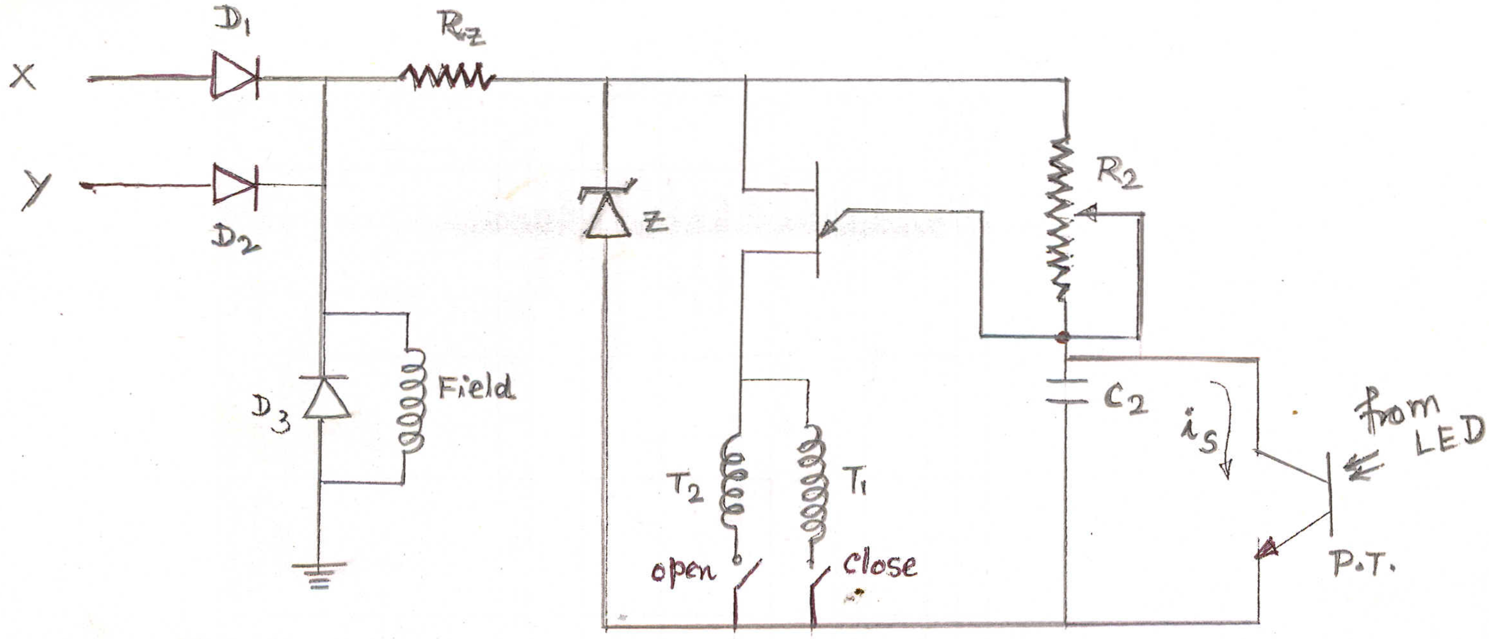


Fig. 3 Control circuit indicating the open and close switches

For sudden change over of these switches, plugging action occurs in the armature as the rotor tries to reverse the direction of rotation.

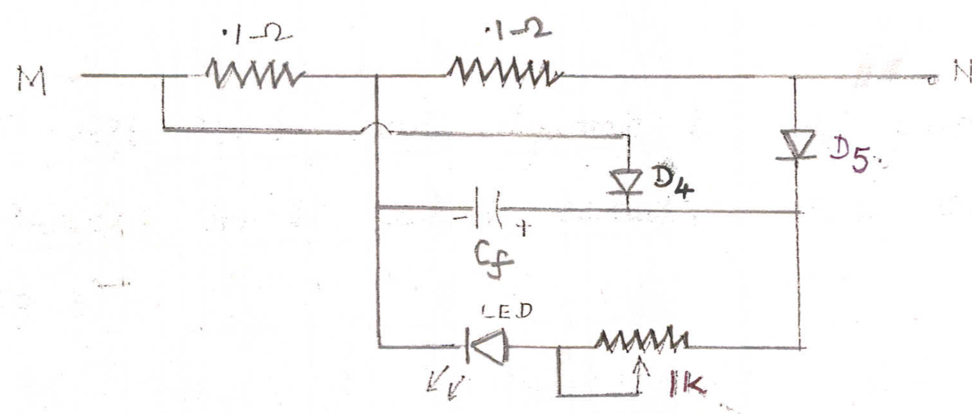
Precaution must be taken to ensure that the change over requires more than half a cycle or 10 msec for a 50 Hz supply.

This ensures that opposite pairs of SCRs will not fire during the same cycle thereby avoiding a direct short circuit on the supply.

A soft start and dynamic braking arrangement are also provided in the control circuit. (These are not shown in Fig. 3)

This provides for controlled opening and closing of the door at the beginning and end of its travel.

Fig. 4 Feed back circuit for current limit



The voltage across the ·1-Ω resistor is averaged by the capacitor C_f.

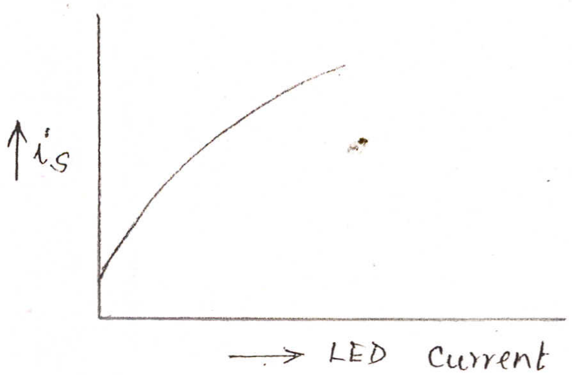
This average voltage is proportional to the load current during both modes of operation.

If M is +ve (load current flows through MN), the capacitor C_f is charged with right side +ve, through D4.

If N is +ve (load current flows through NM during reverse rotation of the motor), the capacitor C_f is again charged with right hand side +ve through D_5.

Thus there is a current through LED, which is directly proportional to the load current (motor current).

The transfer characteristic of the photomode is shown in Fig. 5.



This graph gives the relationship between the LED current and the shunt current i_s which flows through the transistor PT connected across C_2. This current will determine the corresponding change in the charging of C_2 and hence the firing angle.

When the current limit is reached, the shunting of the charging current through C_2 is complete.

This level can be adjusted by the 1K pot in the LED circuit.