J.O TECHNICAL INSTITUTION

LEADWAY TO ELECTRICAL/ELECTRONICS DESIGNS & AUTOMATION

A Practical reservoir for all electrical & electronics students

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PREFACE

Often times, most people imagine that working on the electrical circuit of any kind is an extremely complicated business, but the circuitry is in fact based on very simple principles.

Before any electrical appliance can work, the power must have a complete circuit, the electricity must be able to flow along a wire from its source to the appliance and then back to the source along another wire, if the circuit is broken at any point, the appliance will stop working.

The switch is used for breaking the circuit and restoring it. When the switch is closed, the circuit is complete and the bulb or other appliance operates. Turning the switch off makes a gap in the circuit so the electricity stops flowing. Although a break in either of the two wires would stop the power flow, a switch must always be wired so that it interrupts the live wire i.e the one that takes power to the appliance. In this way the appliance is completely dead when the switch is off. If the switch is wired to interrupt the neutral wire, which takes the electricity back to its source, the appliance will stop working but element in it will still remain 'live' which can be dangerous.

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CHAPTER 1

INDUSTRIAL SWITCH GEARS

Switch gears are used to ON and to OFF a circuit. They can also be used to protect a circuit against overload and short circuit .

Types of switch gears used in industries are

1. Switches
2. Isolators
3. Relays
3. Contactors
4. Fuses

SWITCHES

Switches are only used to ON (close) a circuit so that electrical current can flow or to OFF (open) a circuit in order to interrupt flow of current.

TYPES OF SWITCHES

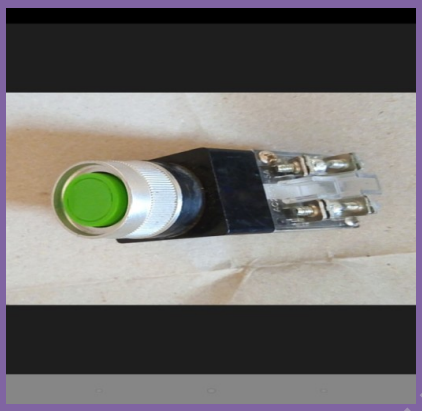
- Selector switch
- Push button switch
- Limit switch
- Float switch
- Proximity switch

PUSH BUTTON SWITCH

This is the type of switch mostly used in the industry for starting electrical motors, circuits and other machines at remote locations. Push button switches always have auxiliary contacts attached with them and a restoring spring that brings the switch back to its original position immediately after it is pushed/pressed in. Auxiliary contacts are of two types; Normally open contacts (NO) or Normally closed contact (NC) .

We have two types of push button switch

i : START PUSH BUTTON SWITTCH; Here the switch is OFF (OPEN) by default and it will remain in this state until it is pressed (pushed in).Normally open (NO) auxiliary contact is attached behind this switch so that when it is pressed (pushed in), the normally open (NO) contacts changes to normally closed (NC) and when released the push button returns to its original position by the aid of the restoring spring and the auxiliary contact also returns to its default normally open (NO) state.



STOP PUSH BUTTON SWITCCH ;Here the switch is ON (CLOSED) by default and it will remain in this state until it is pressed (pushed in).Normally closed (NC) auxiliary contact is attached behind this switch so that when it is pressed (pushed in), the normally closed (NC) contact changes to normally open (NO) and when released, the push button returns to its original position by the aid of spring and the auxiliary contact also returns to its default normally closed (NC) state.

LIMIT SWITCHES

Limit switches have one pair of normally open (NO) contact and one pair of normally closed (NC) contact; and a lever/arm (which is the switch).Connections are made to the auxiliary contacts (either the NO or NC or even to both pairs) .When the lever/arm is pressed the status of the contacts changes. The switch contact NC changes to NO and the switch contact NO changes NC.

FLOAT SWITCH

Float switch enables us to monitor the level of liquid in a storage tank, the float switch sensor is calibrate to reflect position as VERY LOW,LOW,MMEDDIUM, HIGH AND VERY HIIGH. Float switch can be connected to an MMI/HMI (man machine interface or human machine interface) so that its result (i.e the level of liquid in the storage vessel) can be read by an operator or personnel monitoring the tank. it can also be connected to a relay, an alarm or a plc (programmable logic controller) in such a way that other actions might be carried out depending on the level of liquid in the storage tank.

HOW FLOAT SWITCHES WORK

Float switches have two basic parts; an internally calibrated sensor part that is dipped into the storage vessel, and the communication port where wires can be connected from the float switch to HMI, relay, alarm, etc. The communication port is the transmission port of the float switch .it transmits the result of the float switch through wires that are connected to it onto the specific components (like relays, alarm etc) that requires its signal to function. The sensor part of the switch could be calibrated to reflect positions such as LOW,MEDDIUMM, and HIGH. Also a small ball is attached to the sensor. this ball could move from the lowest point of the sensor stick to the highest point-acting like a pointer or an indicator describing the level of the liquid inside the tank in which the float switch is dipped into. There is an internal connection between the communication port and the sensor region. If this is the case then communication port of the switch would have 4 contact points that would reflect LOWW,MEDIUM,HIGH and the pointer (which is labeled /called com.). The COM contact in the communication port is connected internally with the small ball (pointer). Similarly the other 3 contacts on the communication port will all have an internal connection with their respective regions on the sensor part of the switch. For instance contact marked LOW on the communication port has an internal connection with the low region on the sensor part etc.

A DC voltage of say 12V or 24V (The actual voltage is usually specified on the body of the switch) is supplied to the COM wire, while the other 3 wires would have no voltage supplied to them. In the event that the liquid is at its LOW point, the COM ball

sensor will be at LOW part of the sensor, thus making contact with it and as such the LOW wire would now have the same voltage with the COM wire. While the other wires would have 0 voltage in them. And when ever the level of the liquid increases, the ball will keep moving up (owing to the up trust of the liquid on it) and when ever it gets to the region that has been calibrated as medium on thee sensor, the com and the medium wire will now have the same voltage mean while the other wires will have 0V.

NOTE; This is the mode of operation of a float switch. When ever the water in the tank is empty, the floater will be in the vertical position .when this happens the LOW wire becomes shorted with the COM wire. But when the tank is getting filled, the floater will be tending to float on the liquid(with the yellow part lying horizontally on the liquid) and the COM and the MEDIUM wire becomes shunted together, and when the tank is almost completely filled ,the HIGH wire becomes shunted with the com wire.

PREECCAUITION: Never connect AC voltage to the com wire as this could be very dangerous especially in cases where the storage vessel is made of metal and liquid inside it is a conductor of electricity.

PRESSURE SWIITCH: The pressure switch has a lever and a switch part. The configuration only changes when a pressurized stream of air, water, or other kinds of gases flows across the levers of the pressure switch.

PRESSURE SWITCH USUALLY HAS THE FOLLOWING COMPONENTS:

1: SWITCH CONTACTS; Pressure switches usually have 3 switch contact points (NO,NC, and C)

2: AJUSTABLE KNOB: This is the part of the pressure switch that is used for adjusting the pressure range.

3: A DIAPHRAGM : This is the part of the pressure switch which responds to the pressure change. This is usually attached to the switch contacts, such that whenever the diaphragm moves the switch operates.

4: PRESSURE RANGE INDICATOR: This is the part that reflects the pressure calibration. It is attached to the diaphragm. It represents the various positions that the pressure switch could be set for it to function.

PROXIIMITY SWITCH;

Proximity switch operates whenever a certain substance is brought close to them. The configuration of the switch contact changes only as a result of some substances that are brought close to its surface and when this substances are taken away from its surface, the switch contacts returns back to its default state.

Types of proximity switch commonly in use involves those that responds to light change (i.e they respond whenever the surface close to them is bright, but whenever the surface becomes dark owing to the presence of obstacles in front of it, the switch will operate) and those that respond to metallic surfaces.

The proximity switch has basically 3 parts

i: A sensor part that senses the required surface.

ii : 3 wires that are connected to the switch contacts.

iii : An indicator light (which goes off and on as the switch functions)

Like the float switch, it operates only with DC voltage (it may be 5v, 12v,24v) .The wire of proximity switch include, COM (usually colored red),NC (usually colored black),and NO (usually colored green). The main internal component of the proximity switch is a transistor. Proximity switch used in the industry are of two types; PNP and NPN; but PNP is commonly in use. A detail on how a proximity switch can be connected is always drawn on a label that is attached to it. For the PNP proximity, the com wire is connected to the 12v or 24v supply (With respect to the specified voltage by the manufacturer), while the NC is connected to 0V and NO is the wire that conveys the result/output of the switch. But for NPN type proximity switch, the COM wire will be connected to 0V, while the NC wire will be connected to 24v and the NO will still be the output wire.

CIRCUIT BREAKER

They are like the common switch in terms of function. But with the different of protecting the circuit or the load to which they are connected to in the case that the circuit or load is over loaded or when there happens to be a short circuit problem that could have destroyed the load or circuit or possibly result to fire outbreak. It has two sides, the upside or the mains side and the down side or the load side. The main side is where you connect your incoming power supply, while the down side is where you connect your load to. So that when the breaker closes, supply can flow from the power supply to the load.

Circuit breakers do not protect the circuit from unnecessary voltage rise (surge).it only interrupts unnecessary current rise beyond the ratting of the breaker. Some circuit breakers usually have the reset button attached to them. This reset button can be used to check the functionality of the circuit breaker as well as reset it whenever the breaker trips on overload or as a result of some serious short circuit condition. A normal breaker in an ON position should trip (OFF) the moment the reset /test button is pressed. Otherwise the breaker is not healthy and should not be used as it is a potential hazard to both the property it protects and even the personnel that works close to it.

TYPES OF BREAKERS

1. Miniature circuit breaker (MCB)
2. Insulated case circuit breaker (ICCB)
3. Mounded case circuit breaker (MCCCB)
4. Draw out circuit breaker

MINIATURRE CERCUIT BREAKER

The miniature circuit breaker can either be a single pole ,double pole, triple pole or four poles.

Mcbs are usually rail mounted or screw mounted.

Some miniature circuit breakers have test/reset point with which we can check the functionality of the mcb. To check the functionality of mcb, put the breaker in its ON position and then press the test//reset button. if the breaker trip, then it means it is still functional otherwise it is bad.

All normal mcbs have their normal maximum continuous current ratings specified on them. But some operate at a given range and they will have knob through which the current rating of the breaker can be adjusted to the desired maximum current. Example an mcb may be of a capacity of 32A, but it could have an adjuster that would have a range of 25A -32A. Thus the breaker (32A rated breaker) can be effectively put to use where 25A is suppose to be the maximum current.

Though mcbs does not give protection against voltage rise, however all mcbs usually have a maximum voltage ratings that the contacts of the mcb can withstand and this value is equally specified on the mcb (usually not exceeding 600v,, hence the name miniature circuit breaker) exceeding the voltage rating will not only destroy the it but can possibly cause fire outbreak.

Though under continuous usage, breakers should not be loaded beyond 80% of their specified rating, however breakers can safely carry excess current of their ratings to as much as 115% without tripping for a very short time. This property of circuit breaker is important where breakers are used to protect induction motors that require huge currents during start up, but the current dies down quickly as the motor starts running.

MOULDED CASE CIRCUIT BREAKERS (MCCB) & INSULATED CASE CIRCUIT BREAKERS (ICCB)

These could be of 3 poles (used for red, yellow, blue phases respectively) or 4 poles (red, yellow, blue and neutral connection respectively) except those that are used for dc application that would have only 2 poles (i.e +ve and –ve terminals).

Most of the MCCBs usually have a test/reset button provision .

MCCB break both overload current, and short circuit.

Some MCCB have provision where the current rating can be adjusted especially the big ones ..

MCCB usually have lots of symbols for different currents it brakes and the particular voltage it can operate on, especially for the very big ones. Some of the denotations and their meanings are

In = Rated maximum current

Ue = Ratted voltage

Ith/It = Trip current of overload relay settings

Ib = Maximum load current setting

Iz = Maximum permitted current in the circuit

Im = Short circuit current settings

Icu or Iccn = Rated short circuit breaking

Ui = Rated insulation voltage

Uimp = Rated impulse withstand voltage

Ies = Rated service short circuit breaking capacity

Iew = Rated short time withstand current

RACK/DRAW OUT CERCUIT BREAKER

These circuit breakers are very large in size. When trying to close a circuit whose operational voltage is 4kv and above, there would be a huge spark. Circuit breakers which are meant for this function (i.e closing the circuit) usually have capacity of quenching the huge arc or spark in a very short time.

THINGS YOU MUST KNOW ABOUT CIRCUIT BREAKERS

1: Do not load circuit breakers beyond 80% of its maximum continuous current rating (because the rating that is specified on the body of the breaker was achieved in an ideal laboratory condition which may not be similar with the utilization condition of your area) example circuit breakers rated 100A should not be loaded beyond 80A.

2: Try to ensure even distribution of the total load among all the 3 phase wires that are connected to a circuit breaker. Otherwise this could lead to the burning of the cables of the overloaded phase (and the burning usually begin from the terminal of the circuit breaker where the wires are terminated) and the heat could eventually burn the circuit breaker where the wires are connected to. To cross check that there is fairly even distribution of load across the 3 phases, a clamp meter can be used to check the current in each of the phases and subsequent adjustment of the amount of load per phase can be effected to ensure faire load distribution among the 3 phases.

When circuit breakers suddenly trip, before restarting the circuit breaker check for the cause of the trip (most times its either overload or short circuit problem) and clear the fault .And after clearing the fault and the breaker fails to start, allow it to cool very well before retrying to start it (this phenomenon is common with MCB that trips on overload). But do not reset a breaker immediately whenever you find out that it is very hot, as an explosion may occur.

When circuit breaker acts as protection for induction motor, the breaker size should be chosen as so to account for the starting current of induction motor (which is usually 2 to 3 times full load current of the motor).example a motor whose full load current is

10A,the circuit breaker that will be used to act as protection should be of range of 20A to 30A ,but not less than 20A in order to avoid nuisance tripping of the breaker during start up and to prolong the life off the circuit breaker.

Whenever connections are made to a circuit breaker, ensure that you screw properly so that the contacts are tightly holding the wires in order to prevent loose connection. The consequence of loose connection can lead to arcing that will spoil the circuit breaker and after some time the carbon deposited on the contacts will prevent current from flowing through that particular phase, thus making a 3 phase power system to be supplying 2 phase power – This is called single phasing.

FUSES

This is the commonest of all type of switch gear already discussed. They possess a wire element that melts when a current beyond their ratting is applied across them. Fuses have a larger tolerant limit (time delay) than the circuit breaker. For example if a 7A is applied in a circuit that has a 4A rated fuse, the fuse will not melt immediately ,it will take some minutes before the fuse will burn.

TYPES OF FUSE

a. Re- wirable fuse
b. Cartridge fuse

RELAYS

Relays are switches that use small electrical power to control large electrical power. what All relays work on the principle of electromagnetism (they are electromagnetic switches) with the exception of a few like some overload relays and solid state relays (SSR). Inside these relays (that work on electromagnetism),there is a coil that is energized when its operating voltage (usually small voltage of say AC 220V or DC voltages of 24v or 12v) is supplied to it. When the coil is energized it attracts all

metallic contacts that are close to it, thus changing the previous state of the contacts; those that were NC becomes NO, and those that were NO becomes NC..

Kinds of relays commonly found in industries includes

a. Pin relays
b. Card/reed relay
c. Solid state relay
d. Overload relay

PIN RELAYS: This type of relays have 2 sections – the base section/terminal section and the electrical section/switch section.the base section is the part of the relay where wires can be connected to while the electrical section is the part of the relay that houses the pins (the NO and NC switches as well as the coil of the relay) the pins could be 6,8,12 etc. depending on the manufactures choice. The pins are actually electrical contacts .some of the contacts carry NO while others are NC. Supply to the relay could be 12V, 24V, 220V AC, depending on the specification

NOTE; the power specification for relay coil is different from those specified for its contacts.

CARD/REED RELAY;

This is just a circuit board/card that has many relays mounted on them.

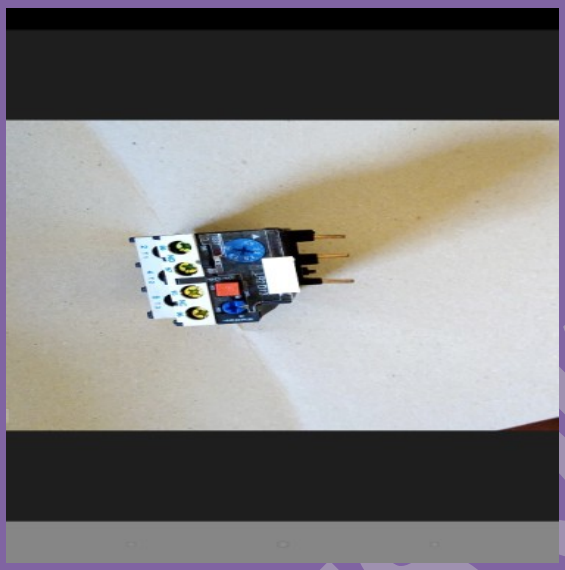
SOLID STATE RELAY (SSR)

These are purely electronic relays. They are made of semiconductors like thyristors, triac, diodes and transistors. They don't have any movable parts (mechanical part), as they are purely electronic. They have the advantage of fast response. They are energized only by DC voltage (12V or 24V).they usually have 4 contact points; 2 for input to the relay (example a 24v relay will have an input wire supplying 24v and 0V) and the other 2 contacts will be for NO and C contact points.

Thus whenever the required dc voltage is supplied to the relay coil, the contacts closes NO contacts changes to NC and when supply is removed, the relay opens again(the contacts returns back to its default NO position)

OVERLOAD RELAY ; This kind of relay protects circuit against over load .it is usually employed in electrical motors to protect them against overload. They can be likened to bimetallic strip that bends when they are heated to a certain temperature

thereby causing some switches to open or close at the right temperature, and by the aid of a spring can be restored back to its previous position.



THIS IS WHY ELECTRICAL MOTORS NEED TO BE PROTECTED AGAINST OVER LOAD CONDITION

Electrical motors are made of primarily two sets of winding (on the stator and rotor) , and these windings has a maximum temperature that they can withstand in the cause of operation and beyond which they will burn out. When electrical motors are overloaded, the current in the electrical motor builds up (owing to huge hindrance of movement of the rotor caused by the load thus causing more current to be drawn from the power system by the stator winding in other to maintain its torque

Over load relays usually have a current range that they can operate on ,and could be adjusted with a screw driver to any particular set point within the range (such that beyond this set the relay will trip thus protecting the motor.

There are different types of over load relay, however the most common ones that are widely used in the industry are, this type of overload that cannot work on its own. It is usually attached to a Contactor. For connection purposes, it has two sections where connection can be made.- (main contacts and the auxiliary contacts).It equally have 3 pins, these pins are tucked directly into the contactor. Such that electrical power flows from the contactor through it (i.e the pins) and then to its main contacts (where electrical motor is connected to)

HOW OVERLOAD WORKS

The purpose of overload is to protect electrical motor windings from rising beyond a certain value. All overload relays usually have a current range, which is the range of current that they can protect. The full load current of the load that the over load relay is meant to protect is what determines the right choice of over load relay and the right set point to keep it. Example if a motors full load current is 5A as given from its name plate, Then an overload relay with a range between 2.0 – 8A can be chosen and then it must be set (by adjusting with a screw driver) at 5A or value slightly less than 5A (because over load relay does not trip instantly when the current is reached; It incorporates some time delay before it trips. Beside electrical motors under normal operation consumes less current than the value of the current specified on the name plate of the motor) For optimal protection of the motor, it is safer to set the overload relay slightly less than the value of the current on the name plate

Over load relays have a stop button and a reset button as well as normally open aux contact (NO) conventionally labeled as 97 & 98 and normally close (NC) conventionally labeled as 95 & 96 on the body of the over load relay. The reset button can be pressed in or out in order to alter the configuration of the auxiliary contacts. When the reset button is pressed in, the NC contact (95 & 96) will retain been closed while the NO contacts (97 & 98) will still be open. This can be checked with the aid of a millimeter. (test the continuity).

CONTACTORS

This type of switch gear is used to CLOSE and OPEN a circuit. but unlike the circuit breakers or fuses, they don't protect the circuit they open or close. They work exclusively on the principle of electromagnetism.

WHAT CONTACTORS ARE MADE OF

1: Contactors have 3 pairs of main contacts-one of the pairs at the top and another at the bottom of the contactor. The contacts at the top are labeled L and the contacts underneath are labeled T as follows

Line side (Top) of contactor label 1L1 3L2 55L3

Tension//load side (Bottom) of contactor label 2T1 4T2 6T3

The power supply wire is connected to the line side of the contactor (at the top side) and the wires to be connected to the load is connected to the Tension/Load side (at the bottom side) of thee contactor.

2: Inside a contactor there is a coil and pair of armature (the coil surrounds one of the pairs of the armature while the other pairs of armature has the main and aux contacts of the contactor attached to it). When electrical power is supplied to the coil, only then will the armature that the coil surround become magnetic and as such attracts the main and the aux contacts thereby changing their previous default configurations; the supply contacts (1L1 3L2 & 5L3) will now be closed with the load contacts (2T1 4T2 & 6TT3) Previously NO aux contact will change to NC ,and previously NC aux contact will change to NO. Thee contactor coils can be energized either by an AC or DC voltages, depending on the specifications given by the manufacturer. Contactors energized by AC voltages could either be single phase (220V) or 2 phase (415V) power supply, which is always specified on the body of the contactor. The points where the supply to the coil is given on the contactor is always labeled A1 & A2 respectively.

3: There is a restoring spring that helps to bring the contactor back to its original position after the coils are de-energized.

ISOLATORS

Isolators are used to isolate an electric power supply from a load or to isolate two different electric power supplies (circuit).

CHAPTER 2

MACHIINE PANEL

Machine panel could be simple or complex depending on the type of machine and the function of the machine..sometimes it could be a group of machines forming a system in order to carry out a specific tax all the machines could obtain their power supply from a common panel.

COMPONENTS THAT YOU CAN SEE IN MOST STANDARD INDUSTRIAL ELECTRICAL PANELS AND THEIR FUNCTIONS

1: **TERMINAL BLOCKS**: It serves as the purpose of receiving electrical power into the panel as well as sending electrical power out of the panel to the different sub machines and components.(like heater ,pumps, limit switch, sensor, etc) that are connected/mounted in the main machine. The electrical power that is supplied to supply to most machines arrive first at the terminal blocks before it is distributed.

2: **PANEL MAIN ISOLATOR SWIITCH/ROTTARY SWIITTCH;** this is the main switch you must turn ON first before you get the indication that there is power in the panel. It is most times; located by the side or in the front of the panel or any part of the panel.

Sometimes this switch could have 3 different status position; and thus could be used in situation like OFF mode, **AUTO**, and **MANUAL** modes respectively by turning the switch to the desired position hence it is called rotary switch.

3 : **EMERGENCY STOP PUSH BUTTON** : when this switch is pressed it brings all operation that was going on to a halt. After pressing the emergency STOP push button in, It remains in until it is turned anticlockwise and it then becomes released and springs out again to its previous position. The emergency stop push button is often a safety mechanism that is incorporated in circuits. The button has a restoring spring and an NC contact attached to it .so whenever the button is pressed the contacts changes to NO and when released (with the aid of the spring) it restores back to its NC state.

4 : **CIRCUIT BREAKER / FUSE;**

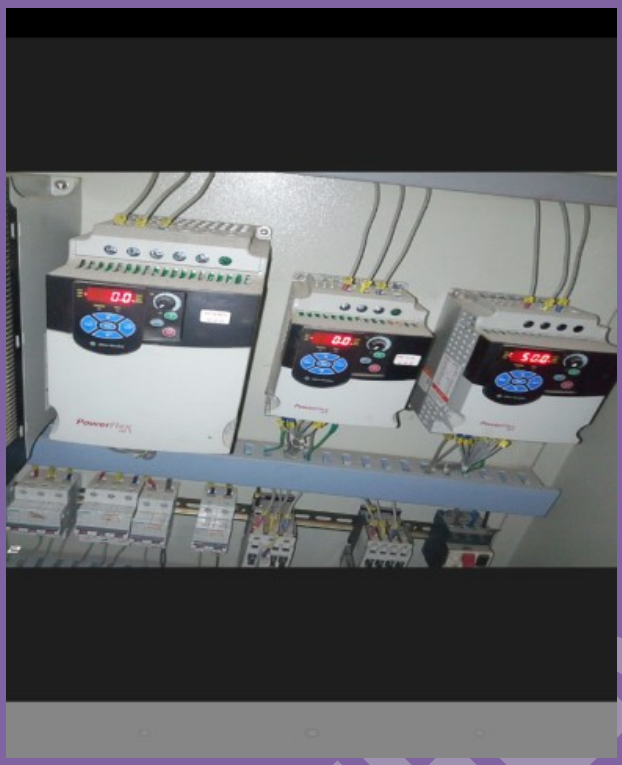
6 : **HMI/MMI**; This is a short form for human machine interface./man machine interface. This is where the output performance of thee particular machine, sensor, or relay is displayed. Some HMI also have provision for input to be given to alter the machine performance. The power to HMI/MMI are mostly DC (12V OR 24V) only very few are powered by AC single phase(230v live and neutral wire.)

7 : **SMPS**; The full meaning is switched mode power supply. This is the device (that acts as a rectifier) that is used in an electrical panel to convert single phase AC voltage to 24V DC that is often required to power relays and other electronic instruments(like him) within and outside panel

8 : **CURRENTT TRANSFORMERS**: They are used to measure the value of current in different wires or bus bars. They are placed in machine panel for metering purpose.

9 : **PLC** : This stands for programmable logic controller. They are the brain behind industrial automation. they have input ports, a central processing unit. Most plc are being powered by a pure single phase AC 220V while others are powered by DC voltage (12v or 24v).

10 : **VFD** : This stands for variable frequency drive. They are used to vary the speed of induction motors. VFD can be used to control the speed of induction motor from zero speed to full speed, it does that by varying the frequency of the supply that is sent to the motor .choosing a VFD depends on the power rating of the motor whose speed is to be controlled, as well as the voltage requirement of the motor.



11 **:** **TIMER** : They are used to control time in a circuit .For instance in **STAR/DELTA** starter, the timer is used to control the amount of time in which the motor runs in STAR before changing to DELTA. Timers have contacts for power supply (Labeled A1 & A2), they also have other set of contacts (**NO** & **NC**) for input and output wires and a knob for adjusting the time. Then when electrical power is supplied to the timer, its auxiliary contacts will continuously remain in their default

(NO & NC) state until when the timer gets to the set time and then the status of its auxiliary contacts will change (from NO & NC to NC & NO respectively).

12 : **EXTRACTOR FAN**; In machine panel, extractor fans are used to induce fresh air from the atmosphere into the panel. Also at the downside of the panel there will always be an opening to exhaust hot air generated from the heat build up inside the panel to the atmosphere .

13 : BUZZER: This is an alarm that is triggered when an unusual or dangerous condition occurs or is about to occur in a circuit. They can be powered by AC or DC VOLLTTAGEE.

SOLENOIDS; solenoids work on the principle of electromagnetism. Whenever electrical supply gets to the coils of these solenoids, they will exhibit magnetic property and therefore attracts any metal round the region of their magnet. .when a solenoid is used together with a valve, the valve will be termed a solenoid valve. The coil is energized by either AC OR DC voltage.

PNEUMATIC PANEL : This is subset of the main electrical panel. They contain solenoids, pressure switches, filters and pressure gauges.

CHAPTER 3

UNDERSTANDING AND INTERPRETING ELLECTTRICAL CIRCUIT DIAGRAM

The best and general way of representing all the connections that was made in any electrical panel is by circuit diagram. You have to get good understanding of the panel circuit diagram in order to attend to challenging problems and to make wise modifications.

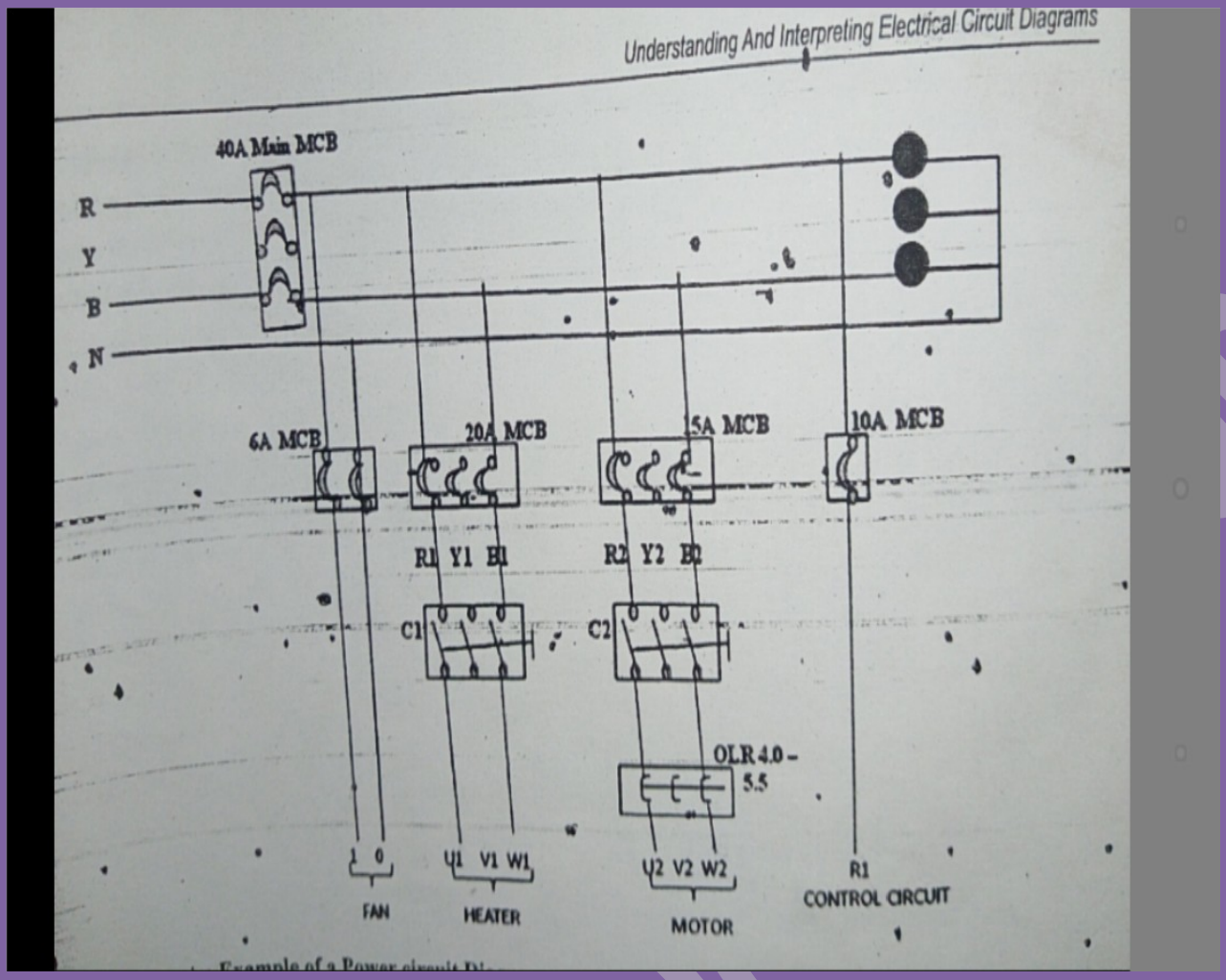
You must understand a good number of electrical symbols (especially all that applies to interpreting electrical circuit).

And owing to the complexity off some machines, it is difficult to have all the details of its electrical diagram in one sheet of paper, so in order to represent electrical diagram of machineries completely, circuit diagrams are sub categorized into.

a. Power circuit dig
b. Control circuit dig
c. Pneumatic air circuit dig (where different air pressures are involved)
d. PLC circuit digs (where plc is involved)

POWER CIRCUIT DIAGRAM : This diagram simply shows the main electrical (AC or DC) power connection to the various motors, lights and other components that constitute the circuit through different switch gears. It tells if 2 wires (single phase) or 3 wires (3 phase only) or 4 wires (3 phase and neutral) or 5 wires (3 phase, neutral and ground).

The power circuit diagram only give details of how to supply electrical power to different components. But it does not give any description on how these components can be put ON or OFF.



EXPLANATION OF THE CIRCUIT DIAGRAM

1 observe that the main supply is 4 wires,3 phase. From the diagram it seems that no ground / earthling is in the installation..but in actual fact there will always be one. The earth wire could actually be tied to the body of the panel and from the body of the panel connection can be made to the different loads that will require it.

2 The supply is protected by the 62A circuit breaker, such that in the event of problems (short circuit or overloading) with the supply wires, the circuit breaker

responds to protect the other small circuit breakers and also offers secondary protection for the other loads (since each of the loads gets their primary protection from their respective circuit breakers)

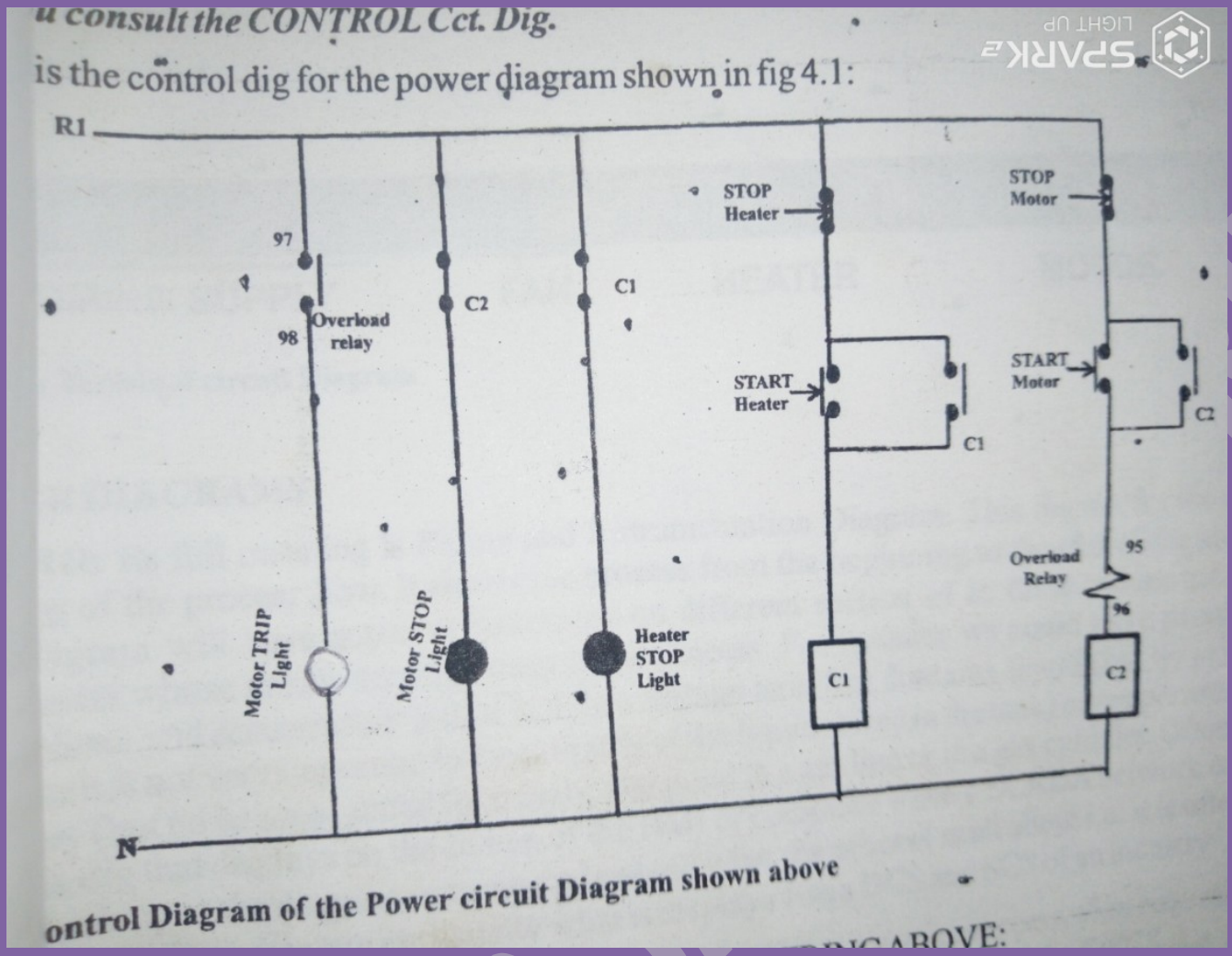
3 Observe the 3 different breakers have been used primarily to protect the different loads (fan, heater, motor). The breakers are chosen in consideration of the maximum current demand expected from their respective circuit breakers.

4 Observe that no overload relay was attached to the heater contactor. this is because heaters don't require overload protection.

5 Also observe that only a one pole circuit breaker of rating 15A was used for the control circuit. This circuit breaker serves the purpose of protecting the relay coils, and other auxiliary contacts that gets supply from the control circuit.

6 Observe that there are 3 indication lights (for red, yellow and blue phases respectively) that indicate that the panel is on whenever the main breaker is put ON .each of the 3 phases light has a particular phase wire and a neutral wire connected to it. So whenever any of the light fails to glow, it tells us that there is no current in that phase connected to the light or that the light itself is bad.

CONTROL CIRCUIT DIAGRAM; having seen how electrical power is connected from the respective group of switch gears to the particular components, then we look at how the components are being organized to function i.e the sequence inn which they are operated. To achieve this ,we access the control diagram, It talks about how the timers, start buttons, stop buttons, relays and auxiliary contacts are being connected to control the mode of operation of the components that have been previously powered as shown / explained in the power cct dig. Remember that these powered components will not get electrical power supply and as such will not function until the main contacts of the switch gears (like circuit breaker , fuses, contactors etc) interconnecting the switch gears and the components that they provide power to being controlled to close..So the control circuit connections are done on start switches, stop switches, relays and auxiliary contacts of contactors and overload relays. It is the control circuit most times that we get to adjust the mode of operation of machineries..



EXPLANATION OF THE CONTROL CIRCUIT WIRING ABOVE

From the control diagram observe that the wire R1 which is after the control cct. Breaker in the power circuit is what is used in giving supply to all the components that make up the control circuit. Until one puts on the control MCB, you cannot start the heater or the motor.

Observe that contactor C1 is used for the heater, while C2 was used for the electrical motor.

Also observe that when C1 and C2 are in block forms, they indicate that they are the perspective contactor coils for the two contactors. While the other contacts of the respective contactors (i.e C1 & C2) are the auxiliary contacts of the respective contactors whose number whose number they bear.

Observe that 1 NO contacts and 1 NC contacts from the motor contactor was used.1 NO and 1 NC from the heater contactor was also used and 1 NO and 1NC contacts of overload was used.

Observe that since no overload relay was used with the heater, there is no reflection of the over load relay in its control circuit diagram. Don't forget that the overload relay which is used with the motor contactor in the control cct..dig . above is the auxiliary contact of the overload (precisely contacts 95 & 96)

Observe that once the control MCB is ON, and all things are functioning properly, the 2 (red) lights for heater stop and motor stop respectively will be ON while the lights for motor trip will be off. This is because both red lights are supplied from the NC contacts of thee 2 different contactors, while the trip light is supplied from the NO contact of the overload relay. On normal operation the 97 & 98 contact of the overload relay will continuously be on NO until the motor is overloaded and it changes to NC (and then the trip light glows) indicating that the motor has tripped as a result of an overload condition ,mean while contacts 95 & 96 will change to NO and it will remain in this state continuously until the relay is reset.

If the motor and the heater are started, observe that the two red lights will now be off as the contacts NC through which the power is supplied to them will now change to NO as the contactors are now energized .And when any of the motor or heater is stopped, the contacts return to their default state and the red light will be on again indicating that the particular device is off.

CHAPTER 4

CONNECTIONS/STARTING/RUNNING MODES OF ELECTRICAL MOTORS & MAINTENANCE

DC MOTORS

Irrespective of the different types of DC motors, they are all connected in the same manner. From the output of the motor terminal, would be two wires where the right magnitude (either 12v,24v etc depending on the size of the motor) of the DC supply voltage is connected to it (+ve and –ve terminals)

When connecting DC motor pay attention to the polarity of the plug or lead. Make sure to connect the **+ve** lead to the positive terminal of the supply and ***–ve*** lead to the terminal marked -ve. Interchanging the polarity will cause the motor to run run /turn in the wrong direction.

AC INDUCTION MOTOR

3 PHASE INDUCTION MOTOR TERMINALS

This motors have 3 phase voltage (red , yellow, and blue phase) from the mains supply that is supplied to the stator winding via the electrical terminal of the motor. owing to the mechanical construction of the motor winding ,it starts rotating in as much as the stator winding has been supplied by the voltage that is stated on the name plate of the motor.

So on the terminals from where this electrical power is fed to the stator, there are 6 terminals (which are actually 3 pairs of coils) which are labeled as U1 , V1 ,W1 on one side andU2, V2 and W2 on the other side.

U1 & U2 is one coil; U1 is the start of the coil and U2 the end

V1 & V2 is one coil. V1 is the start of the coil and V2 the end

W1 & W2 is one coil; W1 is the start of the coil and W2 is the end.

BASIC CONNECTION MODES OF 3 PHASE INDUCTION MOTTOR

DELTA CONNECTIONS ; When electrical motor is connected in delta form, at its terminal is a small metal used to shunt the terminals in a vertical arrangement. It is such that the metal would shunt U1 and V2; V1 and W2; and W1 and U2respectivelly.

When the electrical motor is connected in delta the normal voltage from the line (i.e from your supply) is being supplied to the motor . i.e if your normal supply voltage per any pair phase (red/yellow or yellow/blue or red/blue)is 415v;then this would be the voltage that would be on the motors terminal (i.e in between two different winding) when the supply is switched ON. After shunting the terminals vertically as shown above, you can now connect your power supply cable to any side of the coils either on u1,v1,w1 or v2,u2,w2.

STAR CONNNECTION MODE; In this mode the small metals are used to shunt the whole aspect of one section of the motor terminal and the power supply cable to the motor must be connected only to the other side of the terminal and never to the shunted star joint side. We can choose to shunt any aspect of the coil terminal (u1,v1,w1, or v2,u2,w2) and then put the supply cable via the other side of the coil (but not on the same shunted side)..

When the motor is connected in star mode, the shunted terminals forms the star point so that the voltage on each winding is 1/root3 of the supply voltage unlike in the delta connection mode. Example if the mains voltage is 415v then the voltage that appears on any pair of thee coils would be 240V .i.e 415*1/rooot3.

ELECTRICAL MOTOR STARTERS

Irrespective of connecting the electrical motor in star or delta mode; there will always be a switch or group of switch gears that must be closed in order for current to flow from the mains supply wire into the wires that is connecting the motor and then into the motors stator.

Electrical motors are properly connected with the following components; circuit breakers/fuses, contactors, overload relay, and start / stop push button switches.

In industrial application we would often come in contact with the following starters or drives

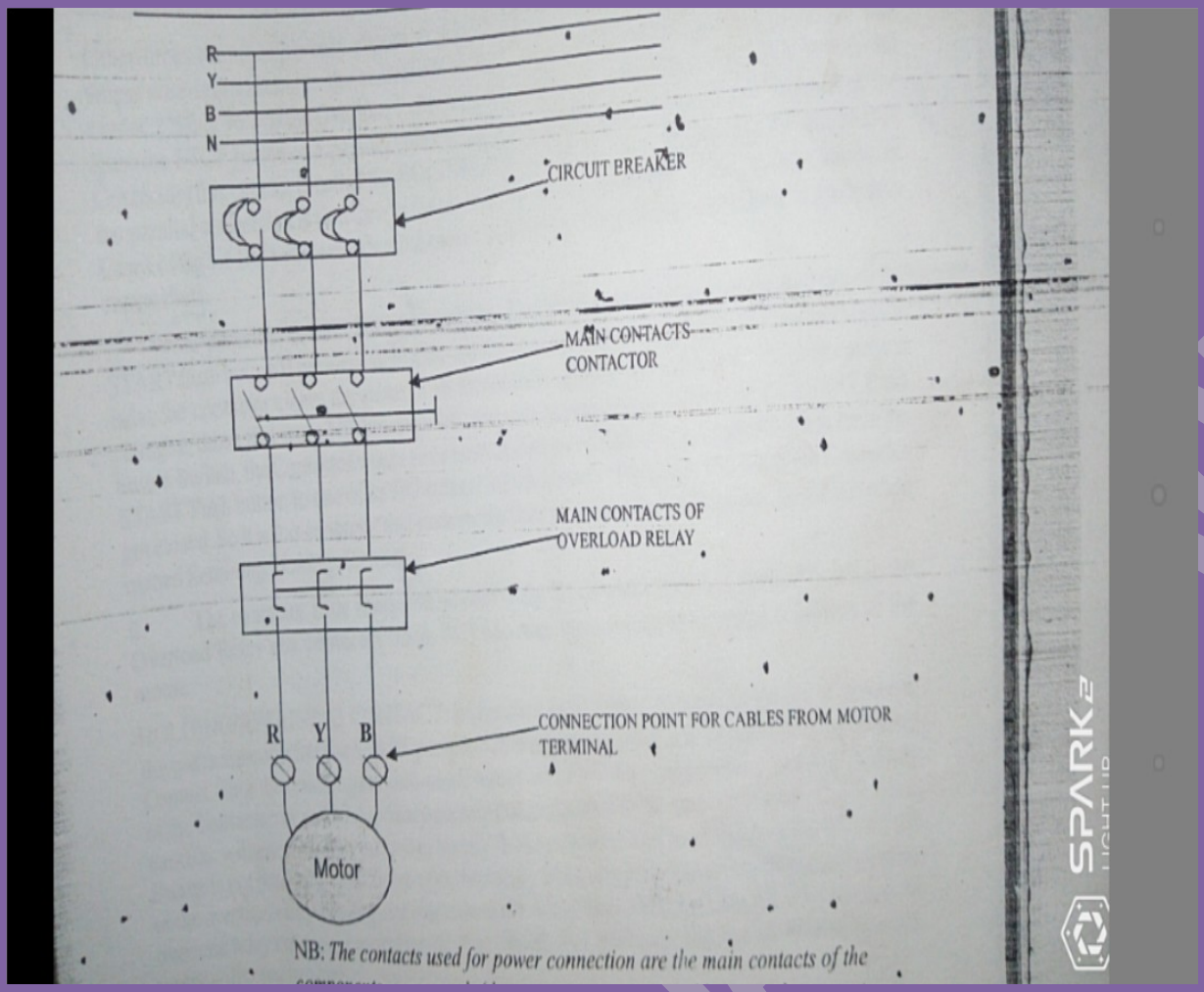
1. Direct online starter (DOL)
2. Forward and reverse starters
3. Star/delta starters
4. Variable frequency drive

DIRECT ONLINE STARTER CONNNECTIOON MODE OF ELLECTRICAL MOTOR

This type of connection involves connection of the induction motor directly across the supply voltage (3 phase).with this kid of connection in the even of starting of the motor, there is an in rush of full current that is required to give the motor maximum torque.

In order to carry out this connection to the motor, several switch gears are placed in between the supply line and the motor terminals to protect the motor from problems off short circuit, overload, moreover connection can be done such that the motor can be started from distance far from its point of installation.

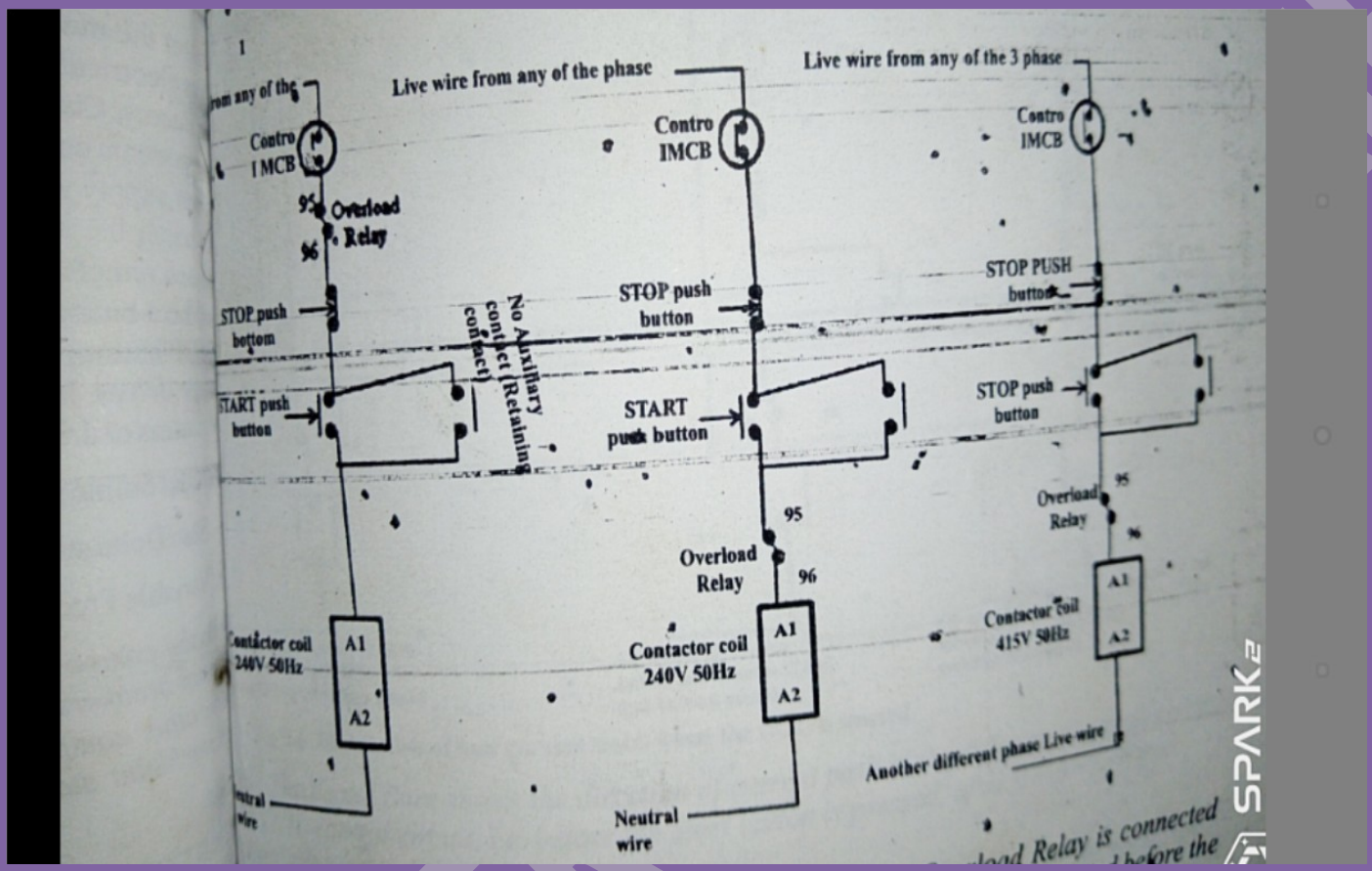
DOL POWER CIRCUIT DIAGRAM; this shows how the main power gets to the motor from the supply line(mains).It tells various switch gears that the power goes through .it is usually from circuit breakers (or fuses) to contactors, overload relays and then to the terminals of thee motor..



CONTROL CIRCUIT DIAGRAM; Even after connecting the electrical power from the mains up to the motor terminal as described in the power circuit diagram above and then close breaker ,the motor will not start as the contactor is not closed. so the electrical power will flow up to the supply part of the contactor, but cannot go to the load part of the contactor until the contactor is closed .and the contactor will not be closed until a (properly connected) start button is pressed. So it is the control circuit diagram that tells us how the start and stop button is connected properly with the auxiliary contacts of the contactor and the over load relay for proper operation of the motor .

For the contactor to become closed, the required supply voltage that is needed to energize the coils of a contactor must be supplied to it.

Observe that in the control diagram you will never find electrical motor in it (unlike in the power circuit diagram).All we are concerned here is to make a wiring that will enable the contactor to be closed when we press the start button and to be opened when the stop button is pressed.



From one of the 3 phases (where our load is 3 phase load) a single wire is connected to the control MCB/fuse (though sometimes may be absent) and from the MCB to the stop button and from the stop button to a parallel connection of start button and an no aux contact of the contactor (this contact is called the HOLDING /RETAINING CONTACT),and the resultant of the parallel connection is sent to an NC aux contact (95 % 96) of an over load relay and from this NC aux contact of the relay a wiring is made to any of the coil terminals (A1 & A2) of the contactor. Meanwhile a neutral wire will be connected to remaining terminal of the contactor coil.

The contactor doesn't energize until the start push button is pressed and when the start push button is pressed current should flow immediately to the contactor coil to energize it.(as the contactor closes the status of its contact changes ,those that were no becomes nc and vice versa).

The function of the holding /retaining contact is to ensure continues supply of power to the contactor coil after the start push button is released .

STAR DELTA CONNECTION MODE

This is a form of reduced voltage starting of induction motor .it is usually used to start induction motors that are of very large size (say from 7.5kw motors and above)

If Induction motors as large as 10kw and above were to be started normally in DELTA mode, this would draw very large current from the power system at start up for some seconds and this could affect other loads like lightings that are connected from the same power supply with the motor. Besides the windings of the motor would become weak quickly owing to the large current that results at start – up of large motors with the normal line voltage (usually 415).

on other hand if we decide to connect the motor in STAR, it would just be good in starting the motor normally without much stress on the power system or the motors winding ,but the full speed output from the motor will be lesser than the required output from the motor owing to the reduced voltage created by running the motor in STAR mode.

COMPONENTS NEEDED TO CARRY OUT STAR DELTA CONNECTION

A : 3 no of contactors -2 of which must have at least one pair of NO and NC auxiliary contacts each. While the third one must have at least 2 pairs of NO of auxiliary contacts

and a pair of NC auxiliary contacts .we call one the line contactor and the other we call the DELTA contactor while the other we call the STAR contactor.

B : one timer

C : One overload relay

D : One start and one stop push button switches

Control cable

Control MCB/fuse

HOW TO CONNECT MOTOR TO AN ALREADY WIRED STAR DELTA STARTER. Most times ,the star/delta starter panel or circuit would have been connected and all you need to do is to connect the mains power cables to the (input of) starter and another set of cables (the output) from the starter to the motor terminals. The mains power cables (input) is usually 3 phase (red ,yellow & blue) and a neutral; this can be connected appropriately in the input section of the starter easily. But on the output of the starter ,we require 6 cables to be connected from it to the motor terminal. The thing now becomes how to connect the cables from the panel to the motor terminal to achieve the desired result.

HOW MANY CABLES ARE CONNECTED TO THE MOTOR TERMINALS

Before going ahead to explain how the contactors work in achieving the star /delta starting mechanism, it is very important to remind us that 6 cables will be connected to all 6 output terminals of the motor-3 cables on each side of the coils (I,e 3 cables would be connected at the end of the coil – v2,w2 and u2). Where do these 3 different pairs of cables (i.e 6 cables) come from. One of the 3 pairs of cables (red, yellow, and blue phase) would come from the first contactor (LINE/MAIN contactor),and the other 3 cables will come from the second contactor (DELTA contactor),to make up the 6 cables that are connected to the motor terminal. Meanwhile the remaining contactor only takes care of forming the star joint hence its named a STAR contactor.

WHAT IS THE ORDER ARRANGEMENT OF THE CABLES IN ORDER TO ENSURE SMOOTH OPERATION;

The order of arrangement of the 6 cables on the motor terminal from the star/delta panel should be such that an orderly sequence is maintained. Take note that 6 cables could be just 2 different pairs of cables having 3 strands (red, yellow, blue and red2,yellow2 and blue2) each, i.e one cable would have red, yellow and blue wires while the other will have its own red, yellow and blue wires inside it. Altering or connecting the motor in the wrong sequence would not only cause the motor not function properly ,but could lead to the tripping of the circuit breakers/blowing fuse(where the breaker/fuse are rightly sized) or burning of the motor coils (where the breakers are over sized or faulty such that they fail to function when needed) or gradual weakening of the motors insulation.

In order to achieve an orderly sequence, you must choose where to start the cable termination from, it is either you terminate the cables on the motor terminals first, after which you terminate the other end of the same cable onto the star/delta panel or vice versa. below is a detailed guide on how to achieve proper sequencing based on the two possible ways.

A : In the first way, we can choose to connect the cables first on the motor terminal then after which we terminate the other end of the cables on the contactors (or on the terminal block which already have 6 provisions where we can connect the load- which is 2 pairs of 3phases from the out let of the contactors).on the motor terminal, ensure that similar windings have the same phase /cable (color of cable) connected to them i.e u1 and u2 could have the red1 & red2 phase/cable connected to them respectively. V1 and V2 yellow1 & yellow 2 phase/cable respectively;w1 and w2 blue1 & blue2 phase/cable respectively .then on the terminal block in connecting the cables ,if we connect red1 on the red phase then we must connect red2 on the yellow phase; while if we connect yellow1 on the yellow phase then we must connect yellow2 to the blue phase; and finally we connect blue1 on the blue phase and then connect blue2 to the red phase.

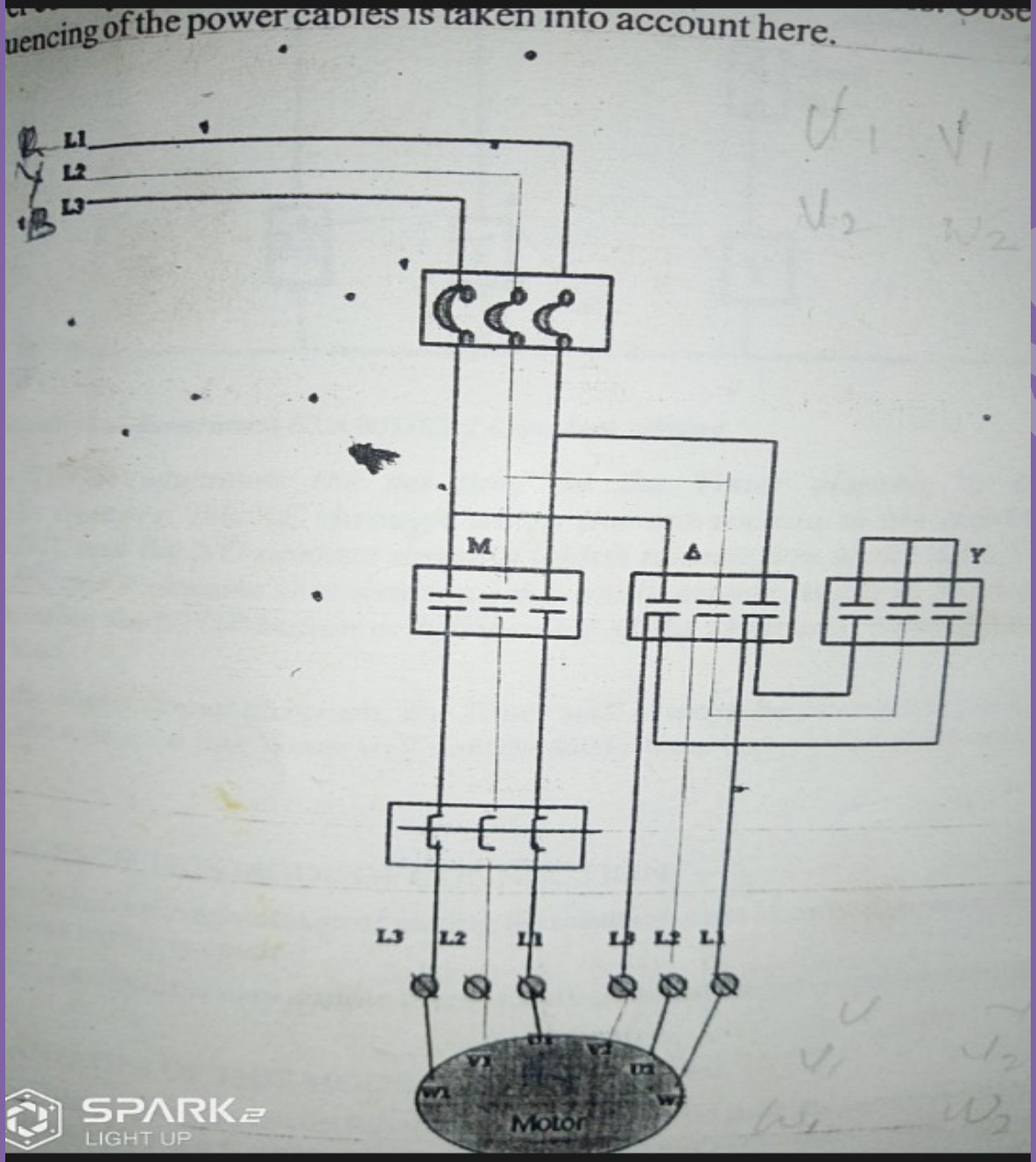
B : In the second way, we can choose to connect the cables first at the terminal block of the star/delta starter or on the outlet of the contactors, after which we can then terminate the cables on the motor terminals. but before connecting the cables on the terminal block, ensure that the cables (phases) on the terminal blocks are arranged orderly i.e

red1,yellow1,blue1, red2 ,yellow2,blue2. So you can choose to place any of the two sets of cables first on any side of the motor terminals first, after which you place the other set on the other side of the terminal while obeying the law of sequencing .in our case if we place red1,yellow1,blue1 on u1,v1,& w1 respectively, then we must place red2,yellow2 blue2 on v2,w2,& u2 respectively. Observe that we have left one phase gap after placing the first cable before placing the next one.

HOW TO WIRE A STAR DELTA STARTER PANEL FROM THE ORIGIN

A : **POWER CIERCUIT**: The power circuit connection of the star/delta starting mechanism can only be achieved in one way .to achieve this the following items are needed ;a circuit breaker (fuse),3 main contactors ,and an overload relay. The circuit breaker serves the purpose of protecting the motor against short circuit and other problems that could occur in the main line that supplies the motor ,while the 3 contactors controls the start ,run ,and the stopping of the electrical motor whenever the start or stop button is pressed, and the overload relay like we know protects the motor against excessive current resulting from overload of the electrical motor (build of excessive current owing to lack of free movement of the rotor).

uencing of the power cables is taken into account here.



EXPLANATION OF THE POWER CONNECTION OF THE STAR/DELTA PANEL ;The 3 phase main cables (R,Y,B) brings in power from the supply to the motor via 3 sets of contactors. First contactor is called the line/main contactor, the second contactor which is called the delta contactor and the third contactor is called the STAR contactor as usual. The overload relay is connected to the main contactor /line contactor. The 3 phase wires first enter the line contactor at its line terminals (l1 , l2, & l3) from this same terminal it is looped to the delta contactor such that contactors are connected parallel. At the load end of the line/main contactor will be the over load relay which is stocked into it and on the outlet of the relay will be a At the load end of the line/main contactor will be the over load relay which is stocked into it and on the outlet of the relay will be a 3 phase wires that could be going to any of the 3 pairs of the motors winding (say u1,v1 & w1 for instance). while from the load side of the delta contactor, 2 pairs of 3 phase wires is connected to it; one pair goes to the other 3 pairs of the winding left (9 which will now be u2,v2,w2) while the other pair is connected to the load side of the star contactor. And on the line (upper part) of the star contactor all 3 terminals are shorted (forming the star joint). The pix below shows the power connection of thee star/delta connection mode of electrical motor.

Observe that the overload relay has been connected to the line/main Contactor and not the delta contactor. This is because whenever there is any interruption of power to the main Contactor, every other contactor will be de energized and the motor will stop. But the motor will not stop if there is an interruption of power supply to the delta contactor. and its redundant having an overload on both contactors as well.

Remember that the difference switch gears have to be properly rated in relation to the load (which is the function of the motors capacity i.e full load current) they are meant to protect for optimum function of the circuit .)

CONTROL CIRCUIT DIAGRAM.

Here the following items are needed,; timer, a start button, a stop button, and at least a pair of both auxiliary contacts (NO & NCC) on all 3 contactors described above.

TIPS TO ALWAYS REMEMBER HOW THE CONTROL WIIRE GOES IN A STAR/DDELTA STARTER.

Remember that the star Contactor is required to start the first and then the main contactor should follow almost immediately (to ensure that the star joint is formed before supply gets to the motor).And as long as the star contactor is energized, the delta contactor can never be energized. And when the timer times up, the star contactor will be de energized and the delta contactor becomes energized; and as long as the delta contactor is energized the star contactor can never be energizd. So we say that the star and delta contactors are electrically interlocked. Also when the timer times up, since it has no function in the running of the circuit, it is wired such that no power supply gets to it again.

The main contactor NO auxiliary contact serves as the retaining /holding contact (after the start push button is released) for all –main contactor, star contactor, timer, and delta contactor.

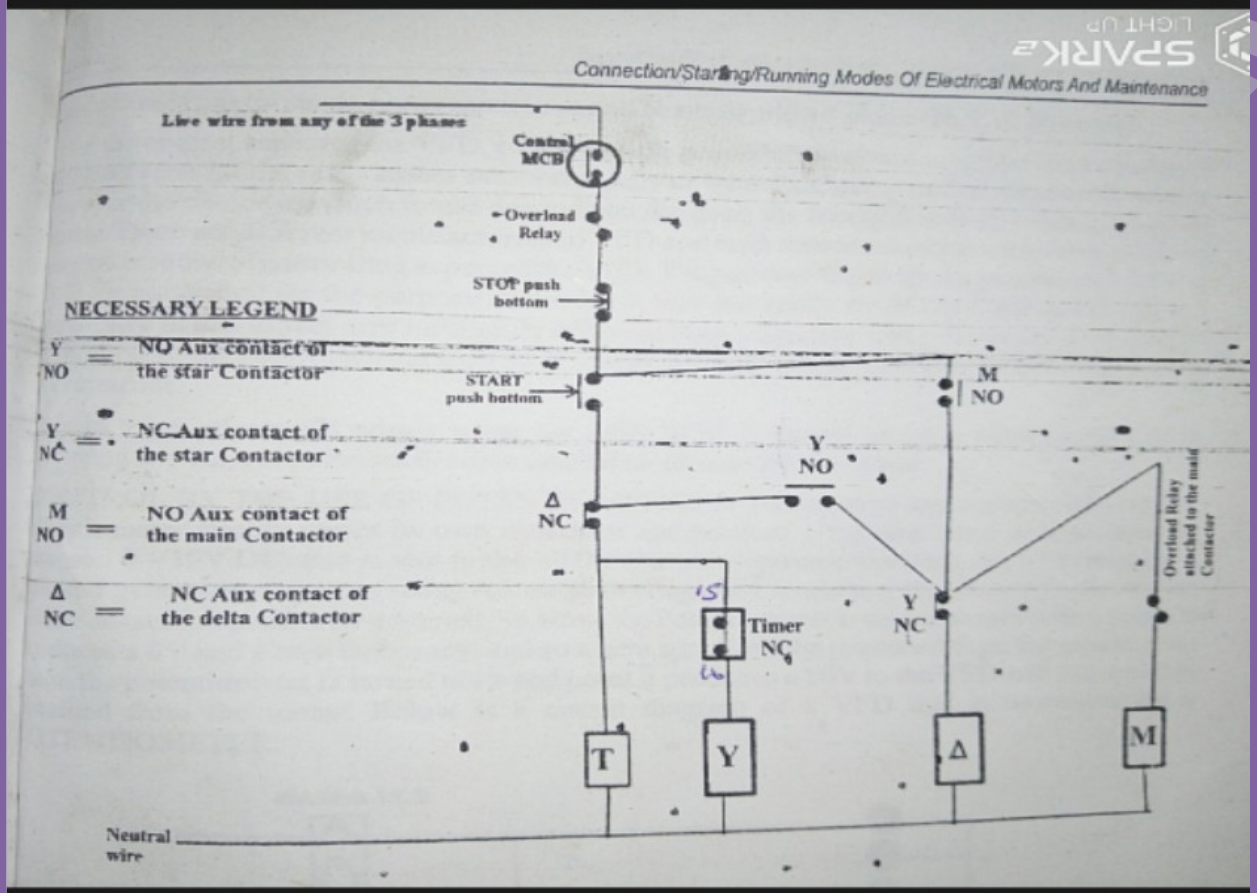
Secondly,to achieve the electrical interlock between the star and the delta contactor , the star contactor is connected such that electrical power gets to it through the NC contact of the delta contactor. And the power gets to the delta contactor through the NC auxiliary contact of the star contactor. So when star contactor is energized its NC auxiliary contact changes to NO, thereby preventing supply from getting to the delta contactor. And when the timer times up, the star contactor becomes de energized, immediately the delta contactor becomes energized and so the star contactor cannot be energized as long as the delta contactor is energized.(since the supply gets to the star contactor through the NC contact of the delta contactor)

Also since we don't want the main contactor to close (energize) until the star joint is formed,(i.e we want the star contactor to close first before the main contactor will be closed).in order to achieve this ,an NO auxiliary contact of the star contactor is meant to supply power to the main contactor coil, thus until the star contactor closes no supply gets to the main contactor

In order to preserve the life of the timer, the connection is done such that whenever the timer times up, it is automatically disconnected from the circuit (i.e no electrical power

will flow through any of its contact).to achieve this, the timer is connected parallel to the star contactor, so that whenever it is de energized, the timer becomes de energized as well.

Since the main contactor NO contact is the retaining/ the holding contact for all contactors, so whenever the main contactor coil is de energized the other contactors I,e both the main and the star contactor (before timer times up) or the main and delta contactor (after the timer times up) will be de-energized. Because of this the overload relay is tucked into the main contactor and its auxiliary contact NC is connected such that it is in series with the main contactor coil. So in event of overload, the overload NC contact opens (changes to NO)and the whole contactors will open.


Live wire from any of the 3 phases
Control MCB
Overload Relay
STOP push bottom
START push bottom
NECESSARY LEGEND
Y NO = NO Aux contact of the star Contactor
Y NC = NC Aux contact of the star Contactor
M NO = NO Aux contact of the main Contactor
Δ NC = NC Aux contact of the delta Contactor
M NO
Y NO
Δ NC
Y NC
15
Timer NC
T
Y
Δ
M
Overload Relay attached to the main Contactor
Neutral wire

SOME IMPORTANT INFORMATION/PRECAUTION NECESSARY IN CARRYING OUT STAR DELTA CONNECTION OR TROUBLE SHOOTING PROBLEMS ASSOCIATED WITH IT.

Failure to adhere to the rules of proper sequencing could cause the motor to run properly in star mode but trip the CB or blow the fuse (which is used to protect the motor) in attempt to switch to delta mode (owing to the large current that results from improper sequencing off the cables)

Sometimes after connecting the motor in star/delta mode correctly and the motor is started, the motor starts properly in star and when it changes to delta, it trips off the breaker (even when the control wiring is correct).in this case reduce the starting time of the timer. This happens because as the motor starts for prolong time on star, the torque dies down owing to the reduced current and voltage, and when the timer changes for the motor to run in delta, in attempt for the motor to pick up (with already fully loaded) there would be huge instantaneous current build that is capable of tripping the circuit breakers.

CHOICE OF SWITCH GEAR RATINGS NEEDED FOR STAR/DELTA CONNECTTION.

The switch gears that are used in star/delta connection of electrical motors need to be carefully selected in order to avoid underrating or overrating which in both cases are not good for the functioning of the motor and the switch gears themselves. Underrating will lead to quick damage of the switch gears while over rating will make the switch gears fail in their function of protecting the electrical motor against circumstances (like overloading and short circuiting) that could destroy it. So the switch gears used in star/delta connection are chosen based on the following considerations

CIRCUIT BREAKERS OR FUSE : Since it is meant to protect the motor from faults happening within it as well as to protect the motor from faults (majorly short circuit)

that could happen from the mains line supplying the motor, they are usually rated to be of the same capacity of the motors full load current with some slight allowance given in the positive sense. Remember that the motor does not take huge current at start unlike THE MOTORS connected in DOL, so if the motors full load current is 50A,then use CB of 60A.

CABLE SIZE; The cables here are of two categories; the power supply cable and the load cable. The main power supply cable is usually 3 phase cable. But the load cable are 2 pairs of 3 phase cables i.e 6 cables which goes into the motors terminal from the load end of delta and the main contactor. It is advisable that the main power supply cables (3 in numbers) should have the amp range slightly higher than the motors full current while the load cables (6 in number) should have an amp range capacity up to the motors full load amp range. But the load cable can be made to be some amp range capacity less than the motors full load current.(but above half its value).this is because the total current is divided between the two contactors unlike the DOL connection.

Example a 40A rated motor would have its current split between the delta and the main contactors (20A each) and so is the current that will flow through the cables that are connected to these contactor respectively. So ensuring that the load cables is of the capacity of motors full current, will take into account temperature rise and other possible insulation weaknesses that could result in huge current applicatioin.

CONTACTOR : 3 contactors are used in star/delta connection, but the 3 contactors are not of the same size. Observe that the main motor contactor and thee delta contactors are the contactors that carry the power supply to the motor, while the star contactor only forms the star joint; so only small current goes through it (which is mainly the back/reverse current from the motor) and so should be smaller than the other two. so the sizes of contactors should be chosen as.

A main contactor = 0.58 x full load current

B delta contactor = 0.58 x full load current

C star contactor = 0.34 x full load current

OVERLOAD RELAY; in setting the overload relay a balance needs to be strike between the motors starting current (which is 1/root3 of the line current) and the running current; since half of thee running current goes through the overload relay as the overload relay is connected to the main contactor ,while the other half of the current flows through the delta contactor .thus it will be very misguiding to set the overload relay at the same value of the motors full load amps. So the overload relay should be set at 0.58 x full load current.

VARIABLE FREQUENCY DRIVE:

This is an electronic drive that is used to control the speed of the electrical motors by varying the frequency and voltage simultaneously.

Like other starters stated above, it has the power and the control aspects. they have thee ability of regulating the speed of the (induction) electrical motor from zero speed to full speed. There are no much protocols in connecting the power wires from supply to it and from it to the load (motor).It comes with a label which indicates the section in which the input supply is connected to (the label may bear U1,,VV1,W1 && R,Y,BB,&E),,and a label indicating where the load is connected to (it may be u2,,vv2,w2) .or sometimes for the smaller VFD, they could actually have a single phase input (live and neutral) and a 3 phase (R,Y,B) output.

For the control aspect of the VFD ,two forms are possible, the speed could be controlled by a POTENTIOMETER (also called manual n mode) or by a plc (also called automatic mode).

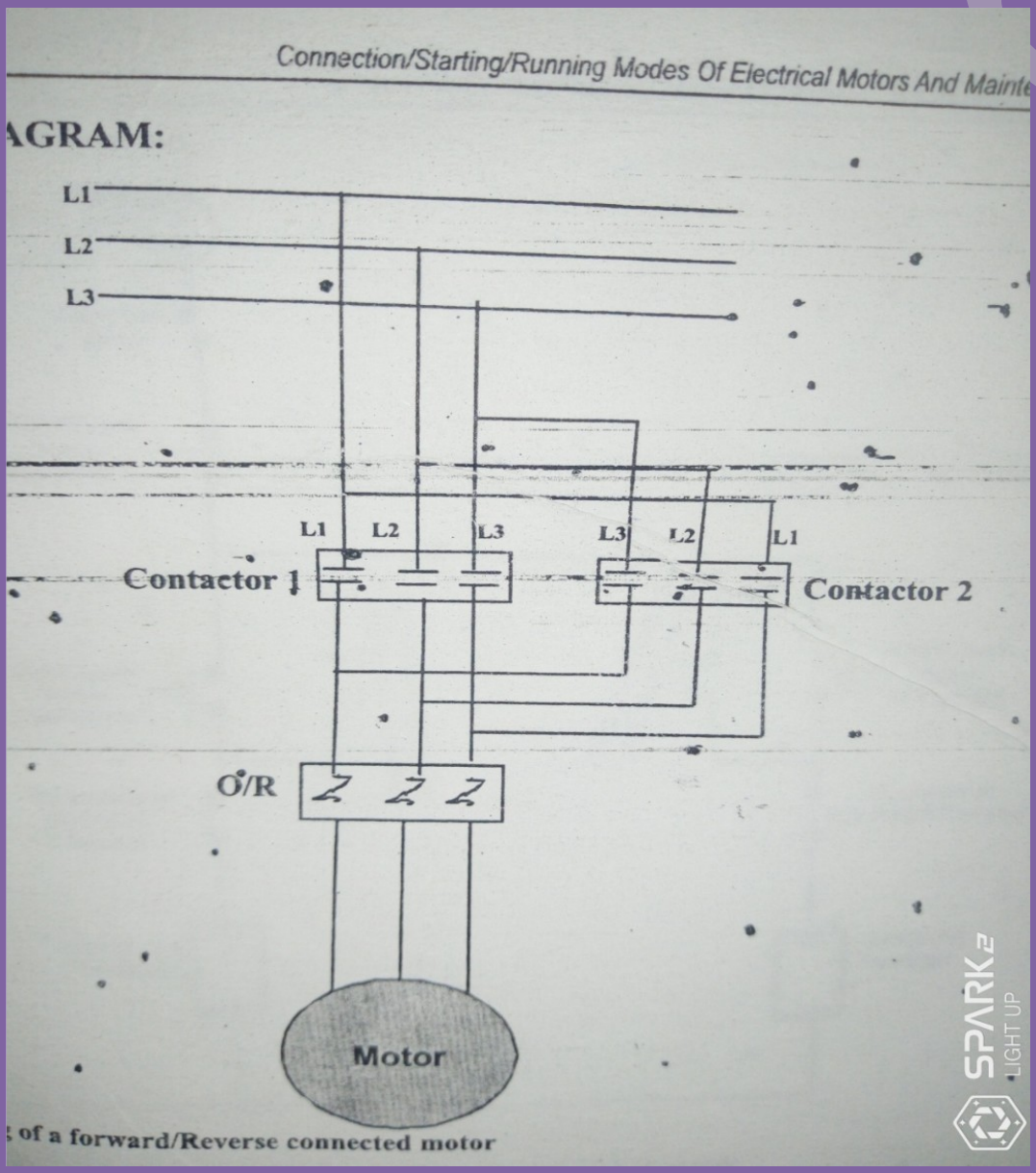
FORWARD/REVERS CONNECTION OF ELECCTRICAL MOTOR

In this mode, the main motor itself can be connected in STAR or DELTA mode and the right voltage be made available according to the specifications on the motors name plate. But in order to connect the motor so that when we press one button it turns clock wise direction and after it stoped,on pressing another button the motor will turn in counter clockwise direction.

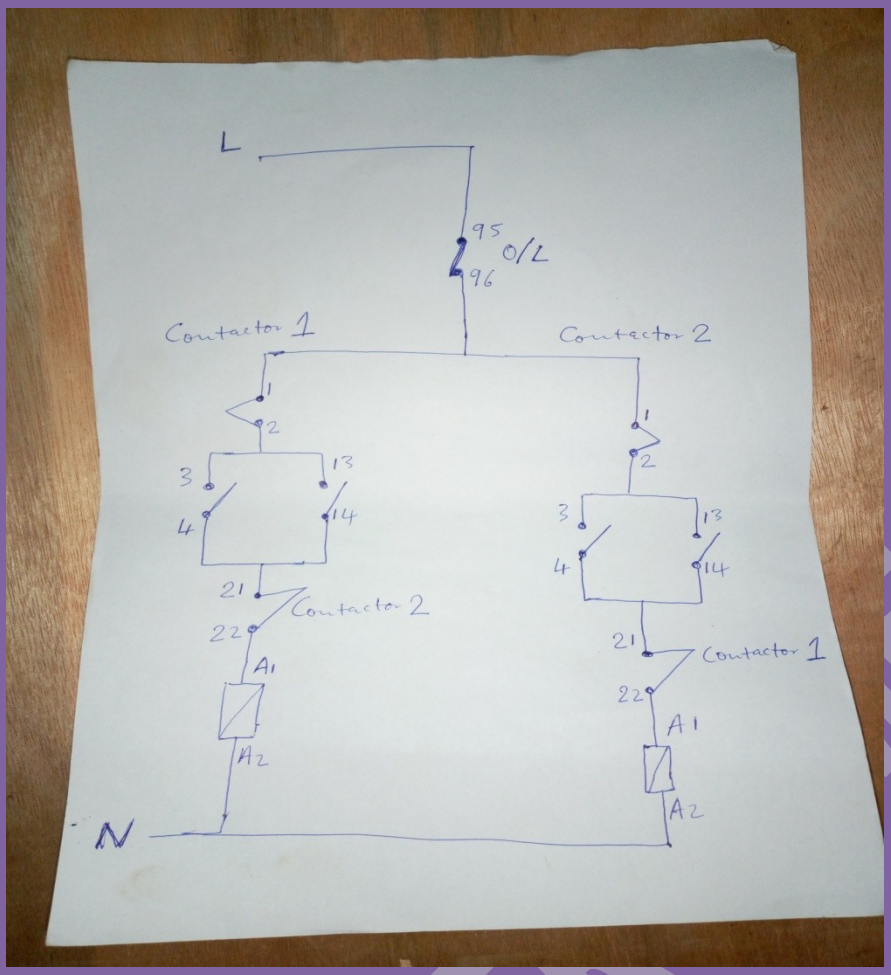
The following items are needed.

a. 2 nos of contactors
b. 1 overload relay

THE POWER CIRCUUIT DIAGRAM



THE CONTROL CIRCUUIT DIAGRAM



From the power circuit diagram above you can observe that the order of input supply to the two contactors are different; in contactor 1 we have RYB OR L1,L2,LL3 (counting from left to right), while inn contactor 2 we have BRY OR L3,L2,L1 (also counting from left to right). Consequently the output from each of the contactors will be different ,since it is only one contactor that is meant to be ON at a time (because in a real practical scenario you cannot walk forward and backward simultaneously) then the output from contactor 2 is fed to the output of contactor 1 which can be considered as the main contactor (as it is the one in which the overload relay is tucked into). So whenever contactor 1 is on, the motor will turn in a particular direction ,and when we put contactor 1 off and then put contactor 2 on, the motor will turn in a different direction (owing too change of two of the phases i.e R & B).How can we energize

contactor 1 or 2 at intervals without both of them closing the same time which is catastrophic.

CHAPTER 5

ELECTRICITY

Electricity is a kind of energy, a very versatile kind of energy that we can make in all sorts of ways ansd use in many more.

Electricity is all about making electromagnetic energy flow around a circuit so that it will drive something like electric motor or a heating element , powering appliances such as electric kettles, etc.

Generally, electrical appliances need a great deal of energy to make them work so they use quite large electric currents.

ELECTRONICS

Electronics is a much more subtle kind of electricity in which tiny electric current (and, in theory, single electrons) are carefully directed around much more complex circuits to process signals (such as those that carry radio and television programs) or store and process information.

Think of something like a micro a microwave oven and its easy to see the difference between ordinary electricity and electronics.

In microwave, electricity provides the power that generate, high energy waves that cooks your food, electronics controls the electrical circuit that does the cooking.

Electronics is the science of controlling electrical energy electrically, in which the electrons have a fundamental role.

Electronics deals with electrical circuits that involves active electrical components such as transistors, diodes, integrated circuits associated passive electrical components, and interconnection technologies.

CURRENT

Electric current is defined as the movement of electrons (negatively charged atoms) round the circuit. It measures the number of electrons that travel through wire.

Voltage

This is a measure of potential difference between one place and another

AMPERE

This is defined as the current which when maintained in two straight parallel conductors of infinite length, negligible circular cross section and placed one meter apart in a vacuum would produce a force of 2x10exponet -7 Newton per meter length in-between this conductors.

VOLT

This is a potential difference obtained when a current of 1A in a conductor desipates a power of 1watt between the terminals of this conductor.

ELECTROMOTIVE FORCE (E M F)

This can be defined as a force that sets electrons in motion, thereby producing current in a circuit.

SOURCES OF ELECTROMOTIVE FORCE (EMF)

1. Photoelectric devices; example, photocell.
2. Movement of conductor and magnetic flux. Example generators (i.e variation of a magnetic flux linked in a coil).
3. Temperature difference between junctions of dissimilar materials.
   Example, thermocouple. (thermoelectric devices)
4. Immersion of electrodes of different materials in an electrolyte.
   Example, primary and secondary cells.

RESISTANCE;

This can be defined as the measure of the opposition of the circuit component, to the passage of electric current through them.

OHMS

This is the resistance of circuit in which 1amps of electric current generates a heat of 1 watts.

CONDUCTANCE

This is the degree to which an object conducts electricity, calculated as the ratio of the current which flows to the potential difference present.

This is the reciprocal of the resistance and is measured in SIEMENCE or MHOS

DIFFERENCE BETWEEN CURRENT AND VOLTAGE

The difference between current and voltage is often compared to water traveling through a pipe

The current measures how much water travels through the pipe.
Sometimes you have a big pipe and sometimes you have a little pipe.
But neither matters for the current .
The current simply measures how much water goes through it.

LIKE WISE “CURRENT”, it measures the number of electrons that travel through a wire.

THE VOLTAGE is a measure of how hard the water is being pushed through the pipe.
If you have got a huge pump driving water through a pipe, the water is pushed through hard.
If the pump isn’t working well, it isn’t .
VOLTAGE is a measure of potential difference between one place and another.

DIFFERENCE BETWEEN KILOWATTS (KW) AND KILO-VOLTS-AMPERE (KVA)

We have heard of kilowatts (KW): its what we learnt at school, its how our electrical items at home are rated and it’s the unite we see on our electricity bill. So what the difference between KW and KVA? And more impotently, how do we convert between the two?.
KVA ; apparent power: it tells you the total amount of power in use I a system. In a 100% efficient system KW =KVA.
However, electrical systems are never 100% efficient and therefore not all the systems apparent power is being used for useful work output.

KW: actual power

KW is the amount of power that is converted into useful output. KW is therefore known as the actual power or working power.

POWER FACTOR: a measure of electrical efficiency.

You can convert KVA and KW if you know the efficiency of the electrical system. Electrical efficiency is expressed as a power factor between 0 and 1, the more efficiently the KVA is being converted into useful KW. Generators have a power factor of 0.8.

The formula for converting KVA into KW is:

Apparent power (KVA) X power factor (pf) = actual power (KW)

E.g. 100KVA X 0.8 = 80 KW.

The formula for converting KW into KVA is:

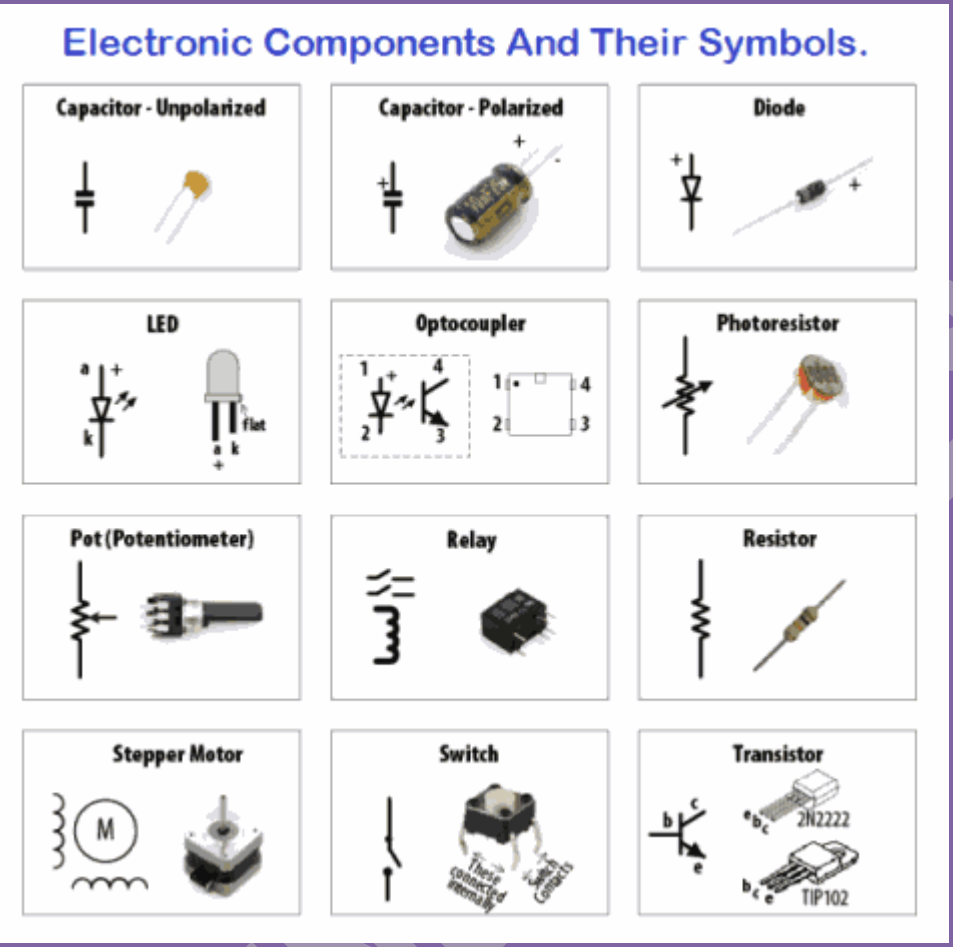
Actual power (KW) / power factor (pf) = apparent power (KVA)

E.g. 100KW / 0.8 = 125 KVA.

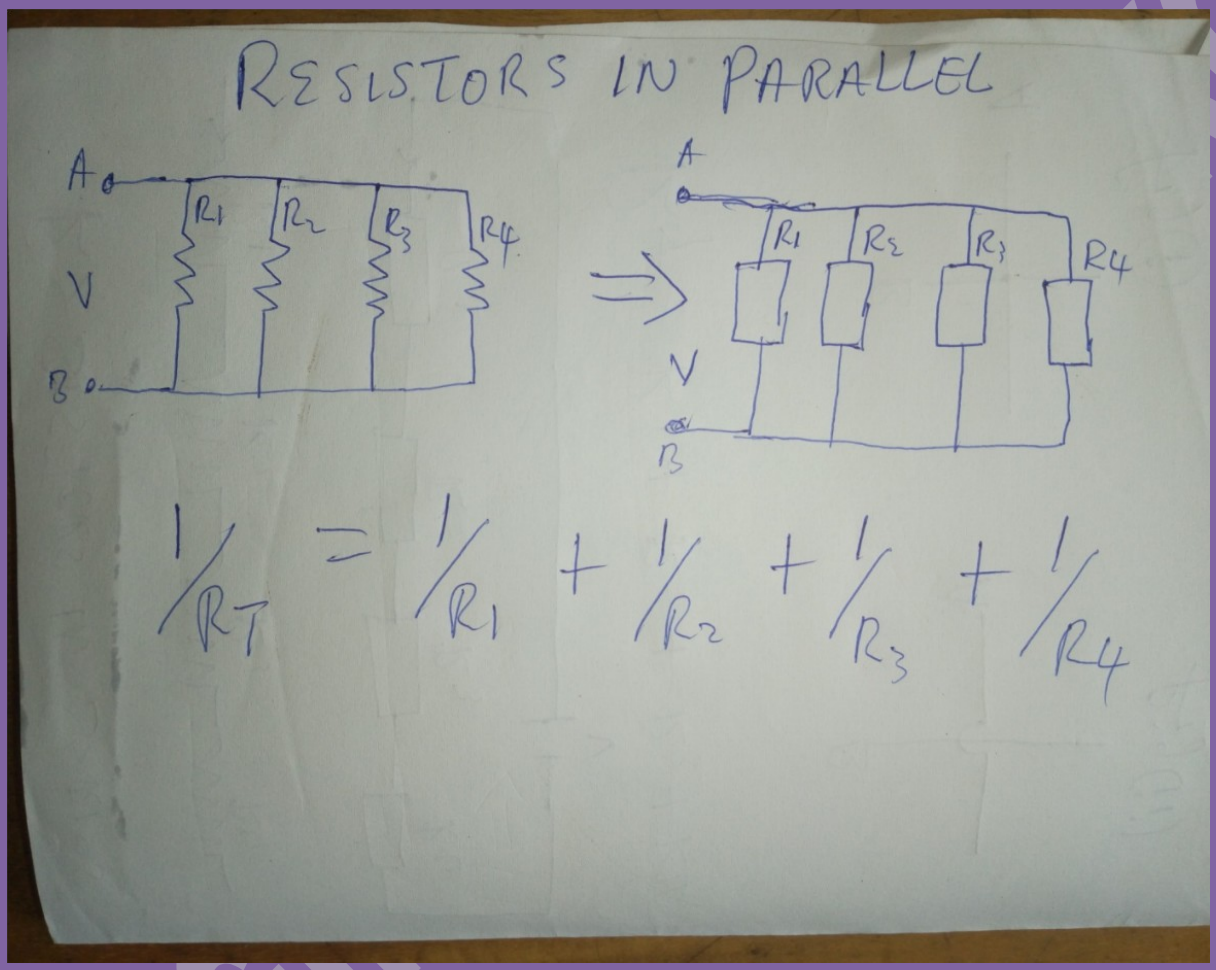
CHAPTER 6

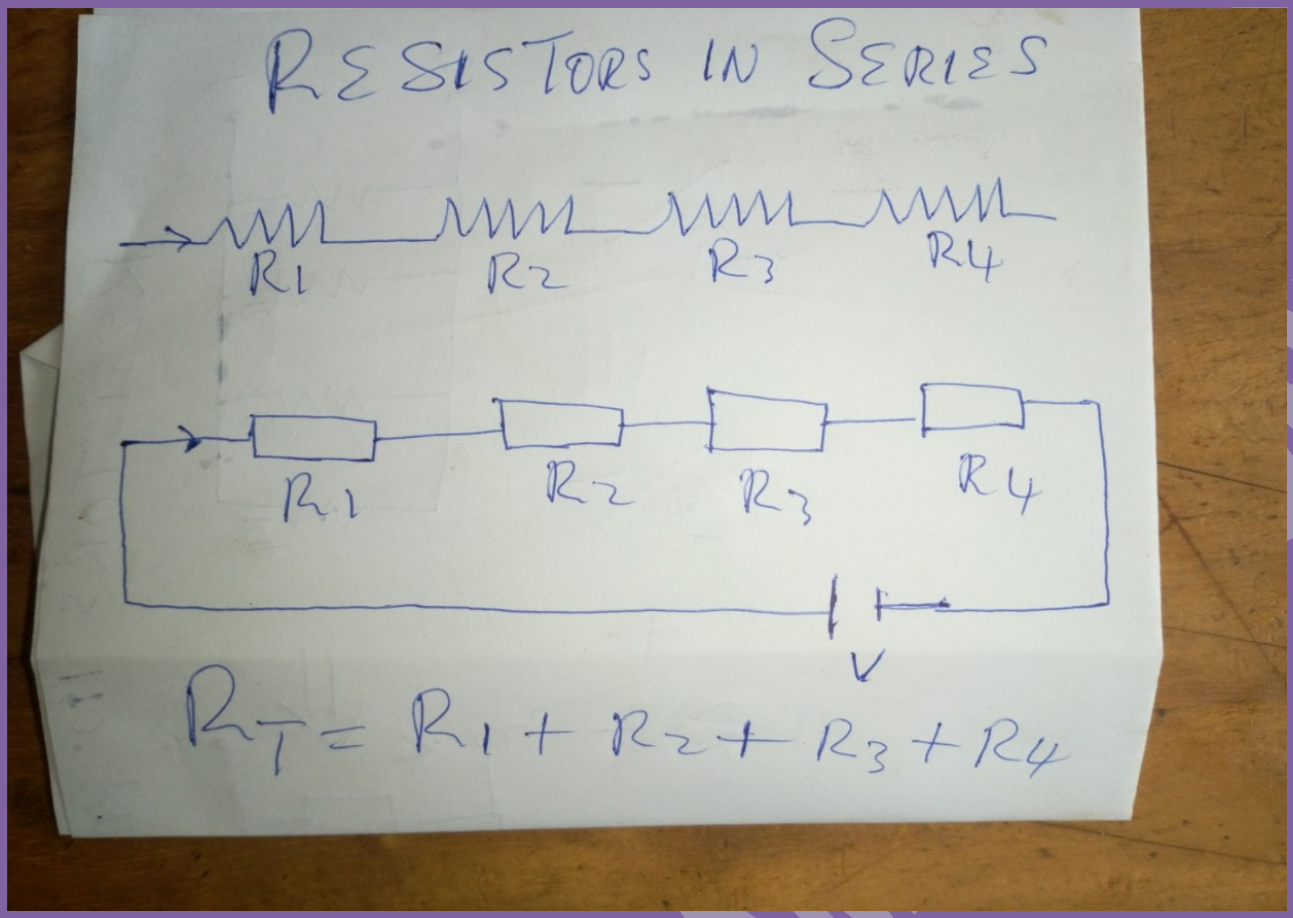
A-Z KNOWLEDGE OF ELECTRONICS CIRCUIT DIAGRAMS

Some components that made up electronics circuit includes

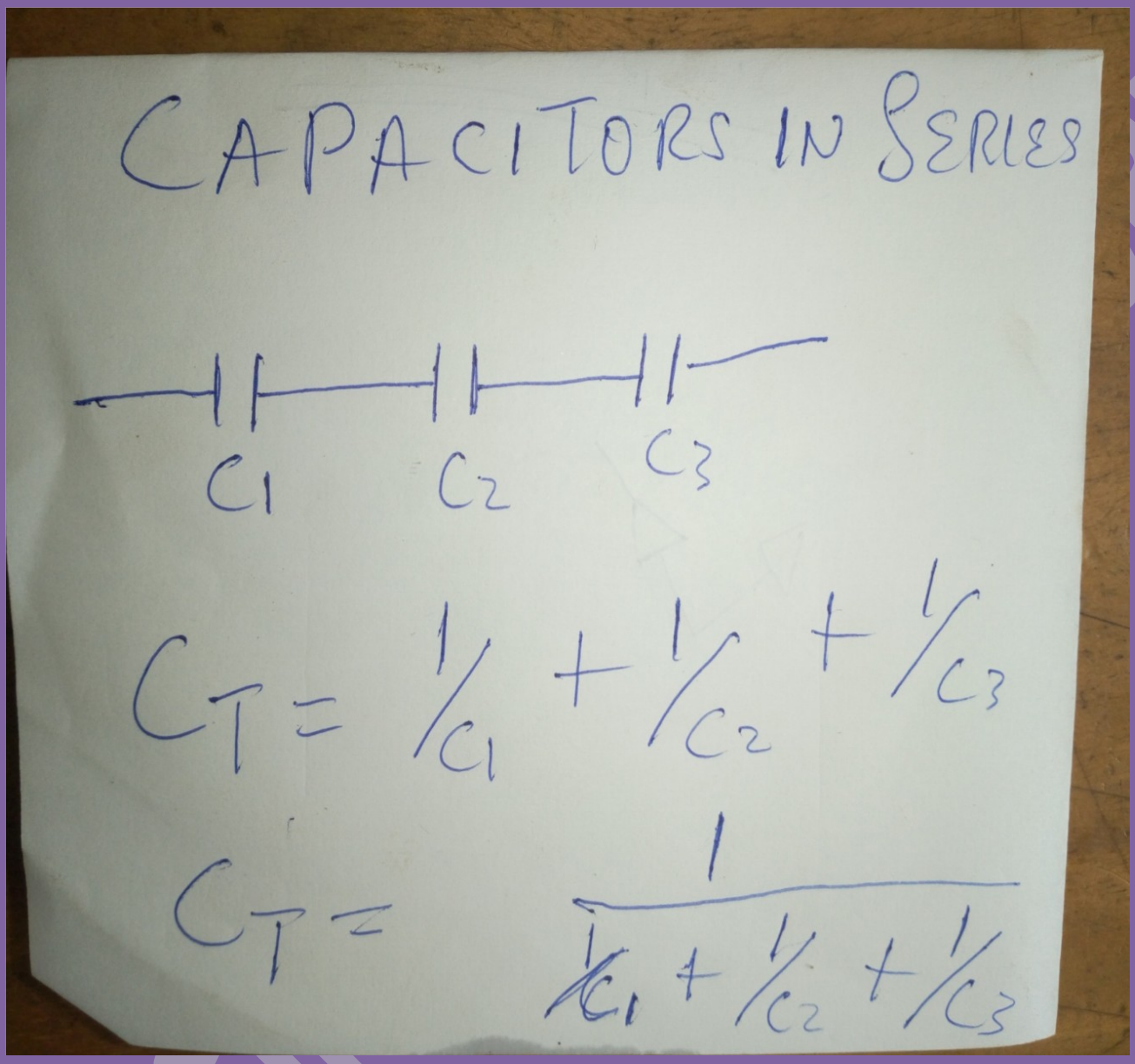


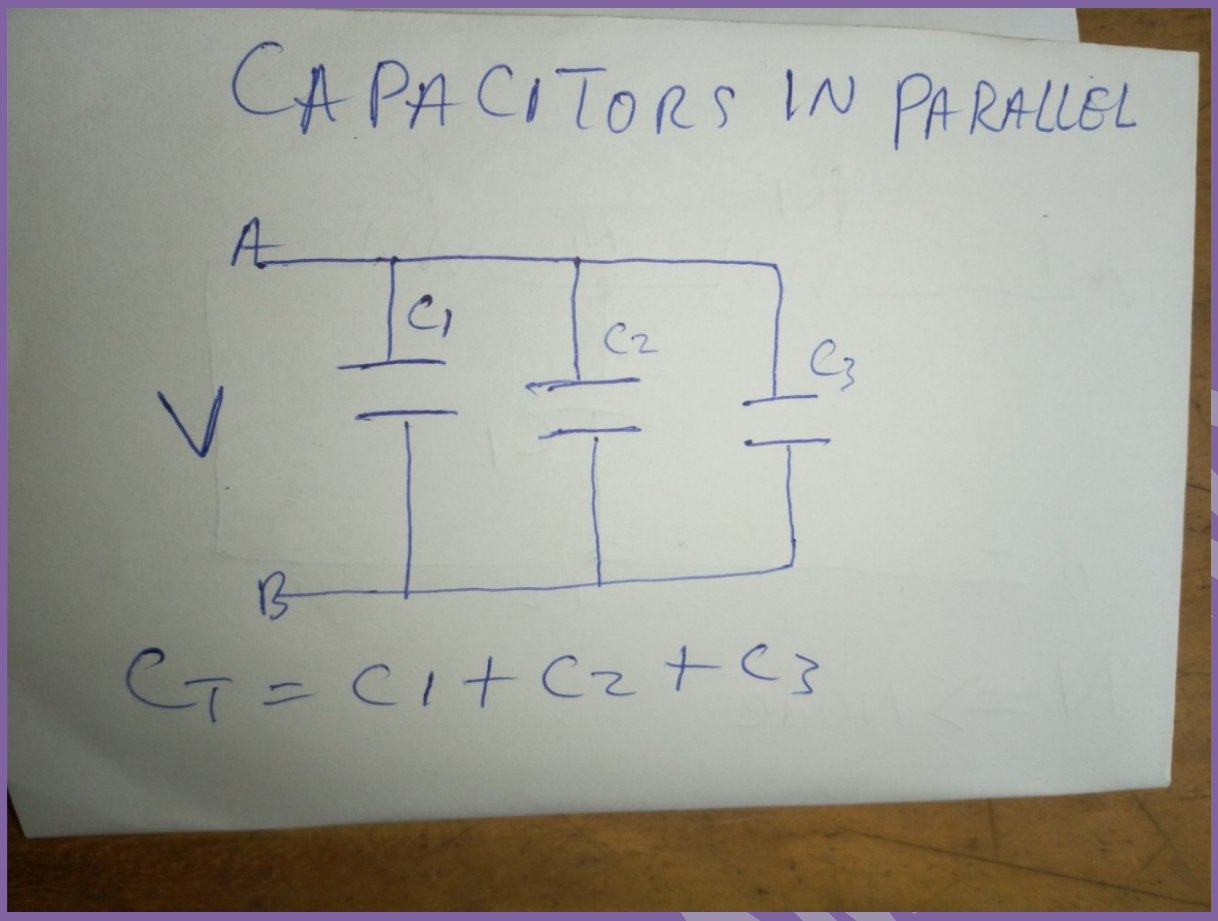
RESISTOR





A resistor is a two is a passive two terminal electrical component that implement the electrical resistance as a circuit element. It is used to oppose or limit the flow of current. The S.I unit is ohm.





A capacitor is a passive two terminal electrical component used to store energy in an electric field. They are also used for filtration . capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass.

DIODES

A diode is a two terminal electronic component with asymmetric transfer characteristics with low (ideally zero) resistance to current flow in one direction and high { ideally infinite) resistance in the other direction.

The most common function of a diode is to allow an electric current to pass in one direction while blocking current in the opposite direction.

MOV

Metal oxide varistor. It protects the circuit against power surge (increase in power)

BLEADING RESISTOR

Is used to discharge capacitor. With it, your power supply / driver circuit will always go to 0V a few seconds you shut power off.

ZENER DIODE

A zener diode is a special type of rectifying diode that can handle breakdown due to reverse breakdown voltage without failing completely.

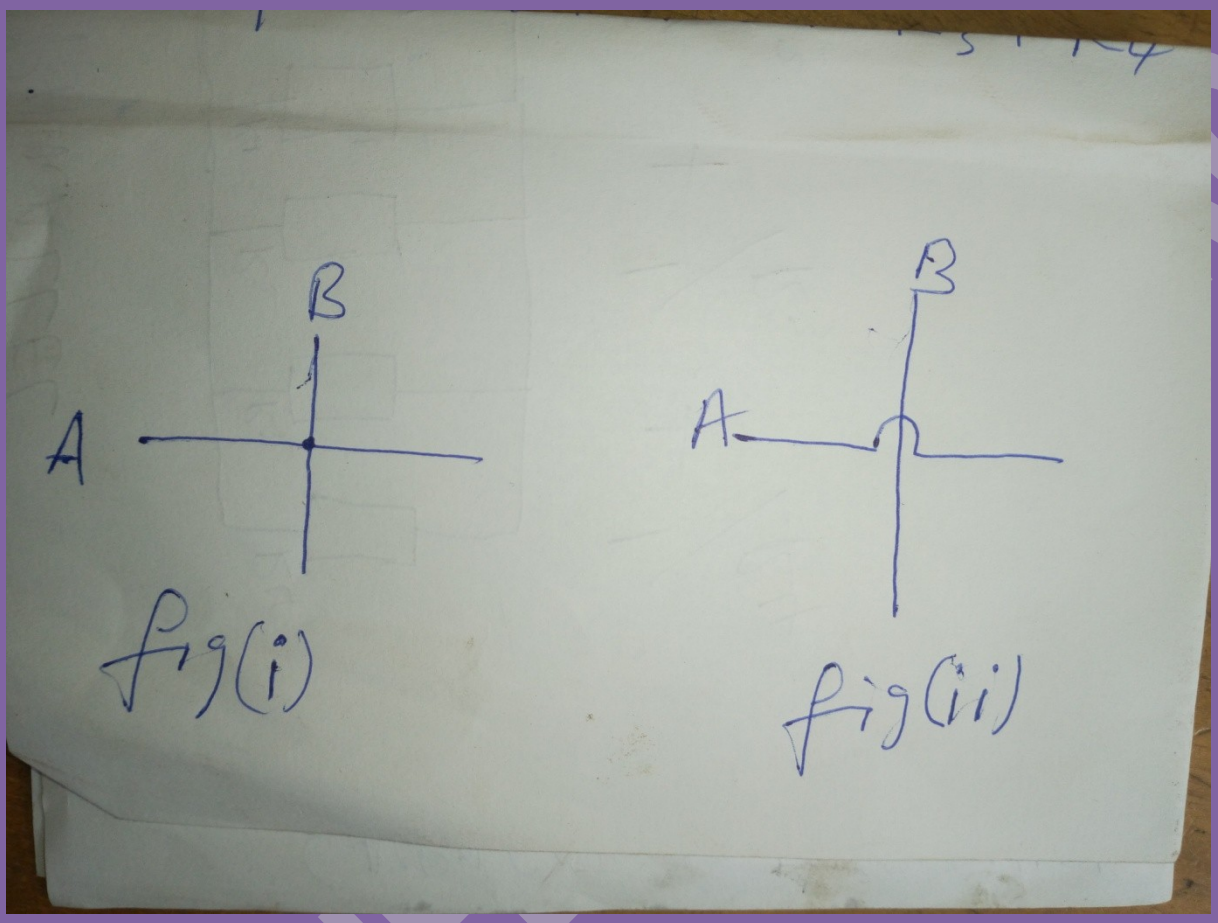
It is used to regulate the voltage.

RECTIFIER

A rectifier is an electronic device that converts AC which periodically reverses direction to direct current DC, which flows in only one direction. This process is known as rectification.

We have half wave and full wave rectifiers, but for the building of LED drivers, we will be using full wave rectifier.

INTERPRETING CIRCUIT DIAGRAMS



Letters A and B represents wires in the figure (i) and (ii) above .

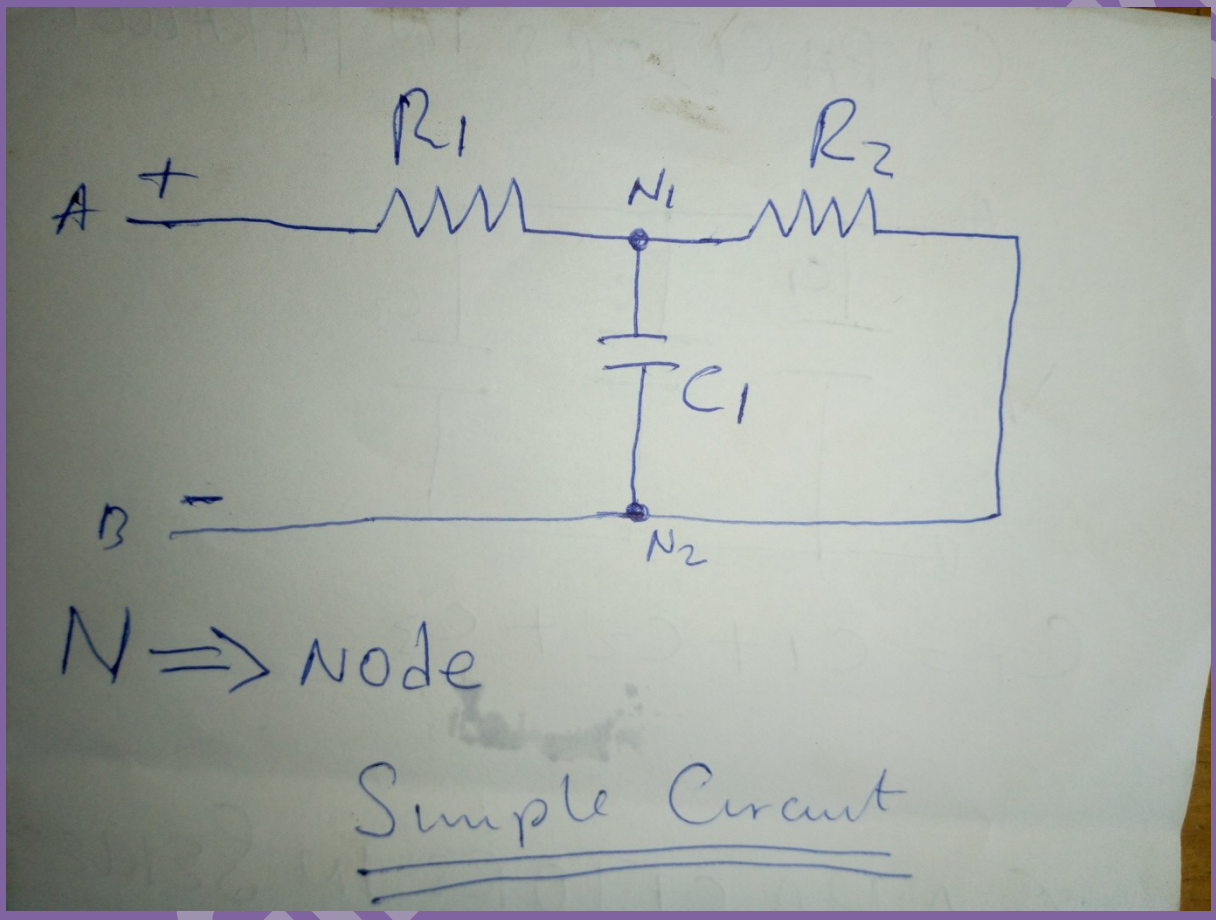
In figure (i), wires A and B are joined together .

In figure (ii), wires A and B are not connected / joined together .

So when ever you see these kind of line crossing of figure (i), know that they are joined together .

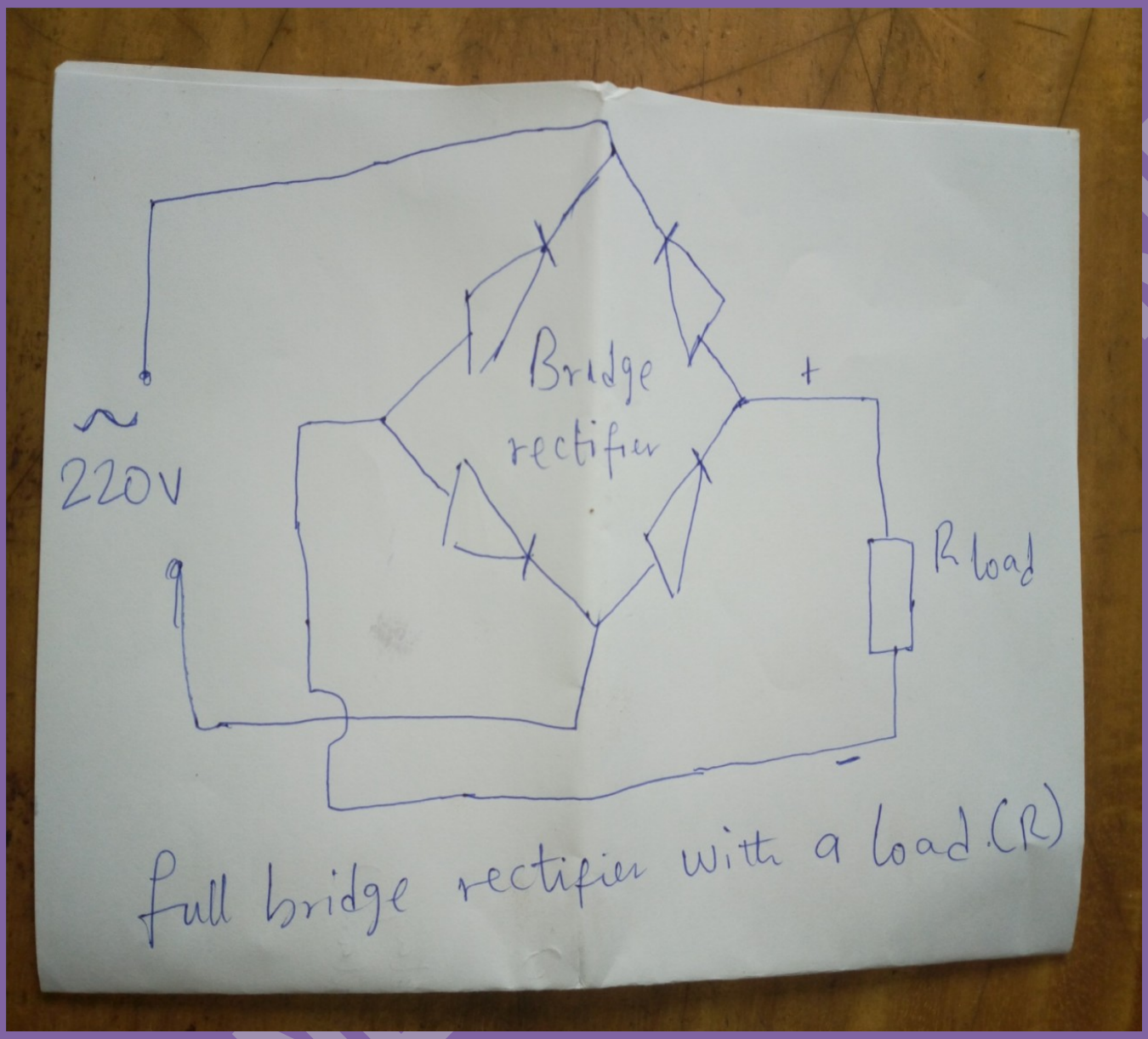
And whenever you see these kind of line crossing of figure (ii), know that they are not connected / joined together .

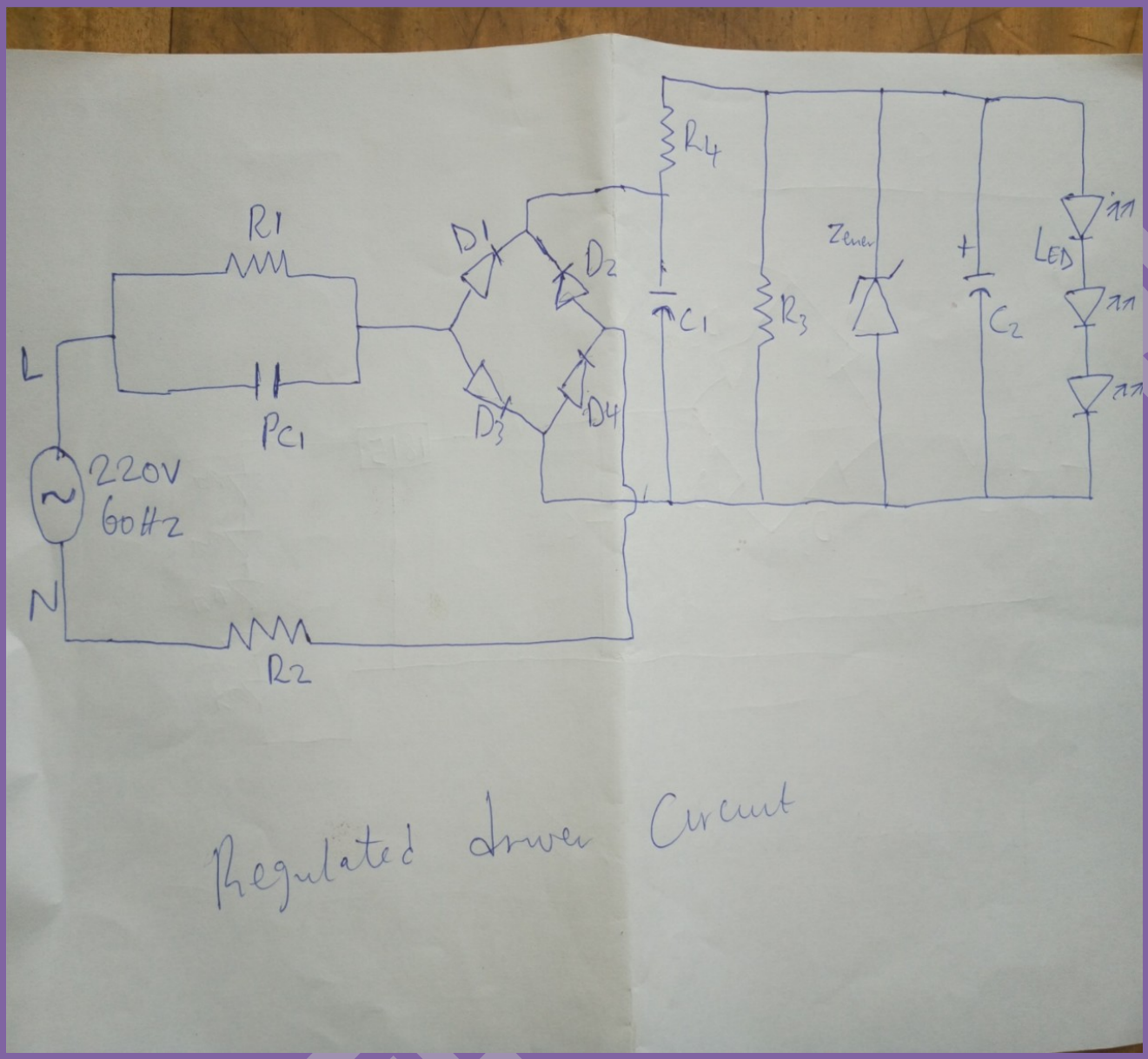
Lets analyze this simple circuit



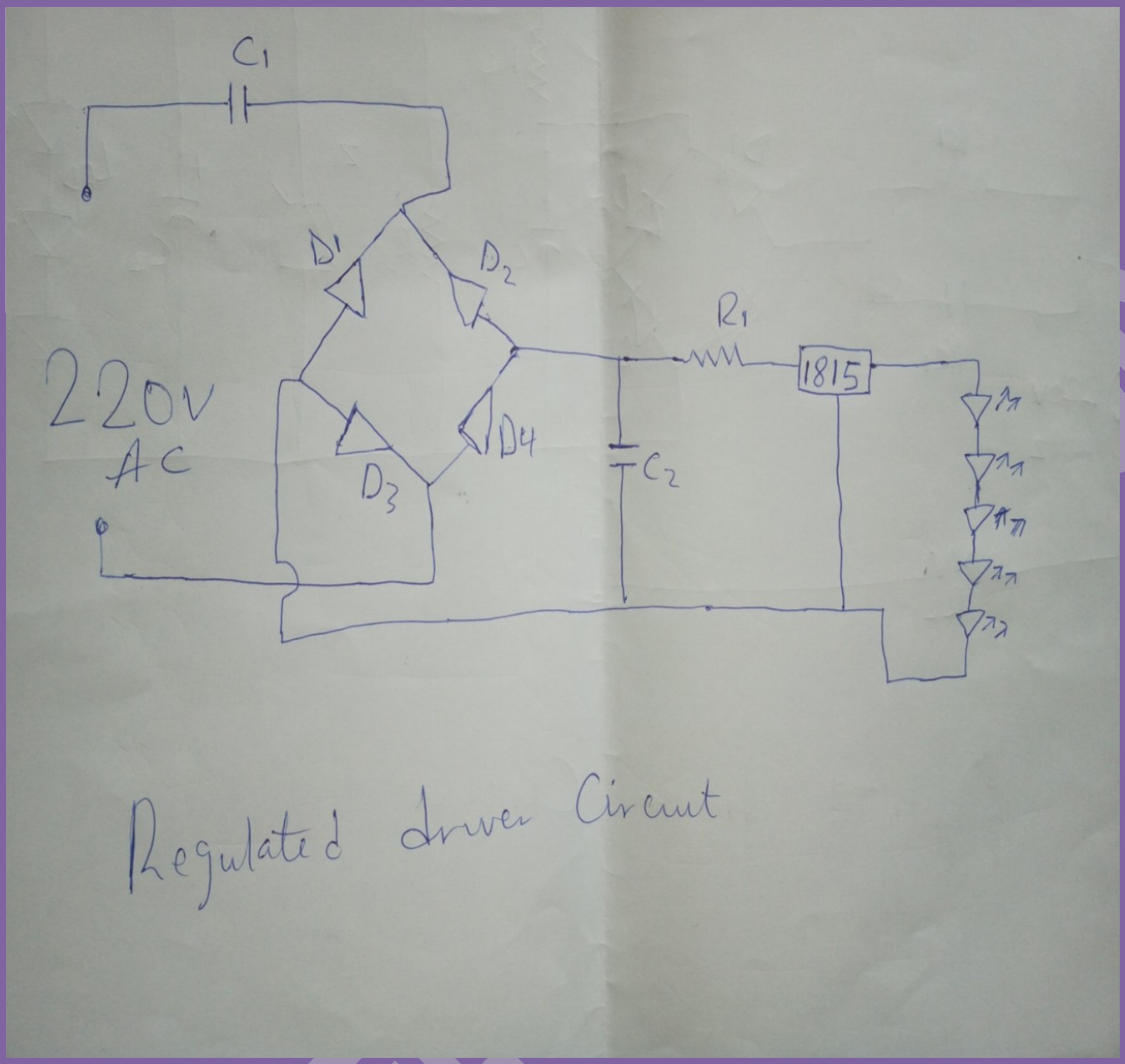
This circuit above implies that one leg of R1 is connected to the line A which is the positive line of the circuit , the second leg of R1 is connected together with one leg of R2 and one leg of C1 at point N1. While the second leg of R2 connects together with the second leg of C1 at point N2 and together they (R1 &R2) are connected to line B which is the negative of the circuit .

Note , R is resistor while C capacitor .

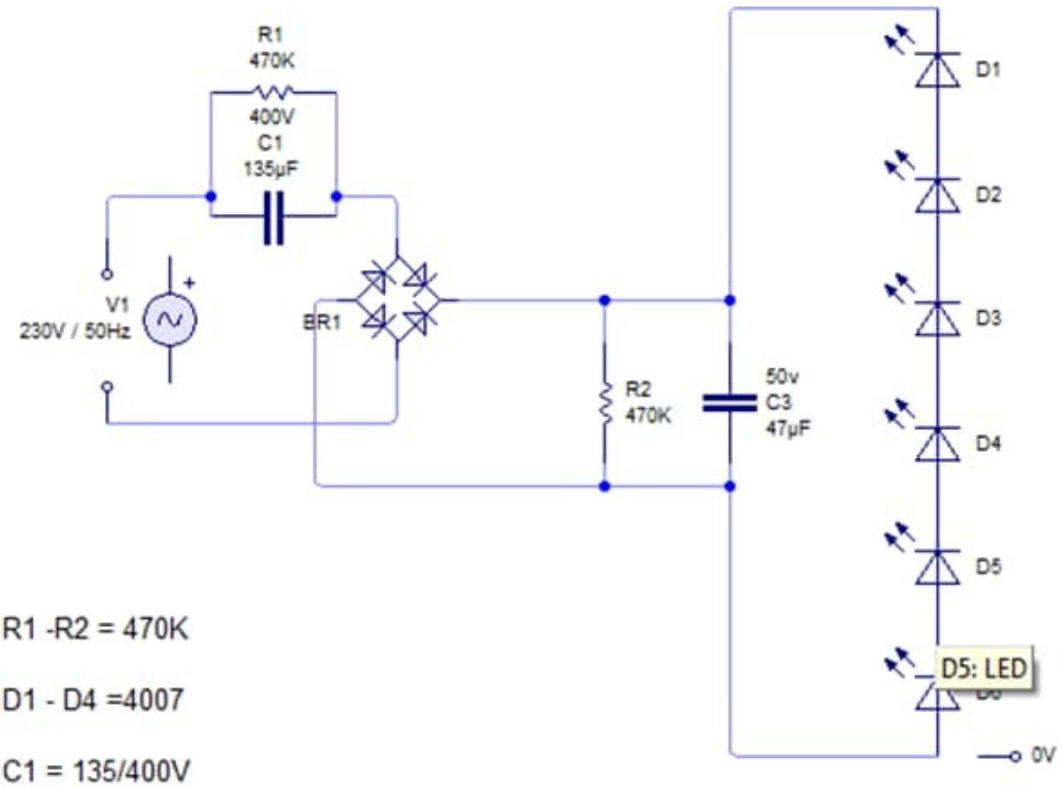




Regulated driver Circuit



Regulated driver Circuit



R1 -R2 = 470K

D1 - D4 =4007

C1 = 135/400V

C2 =47UF/50V

LED

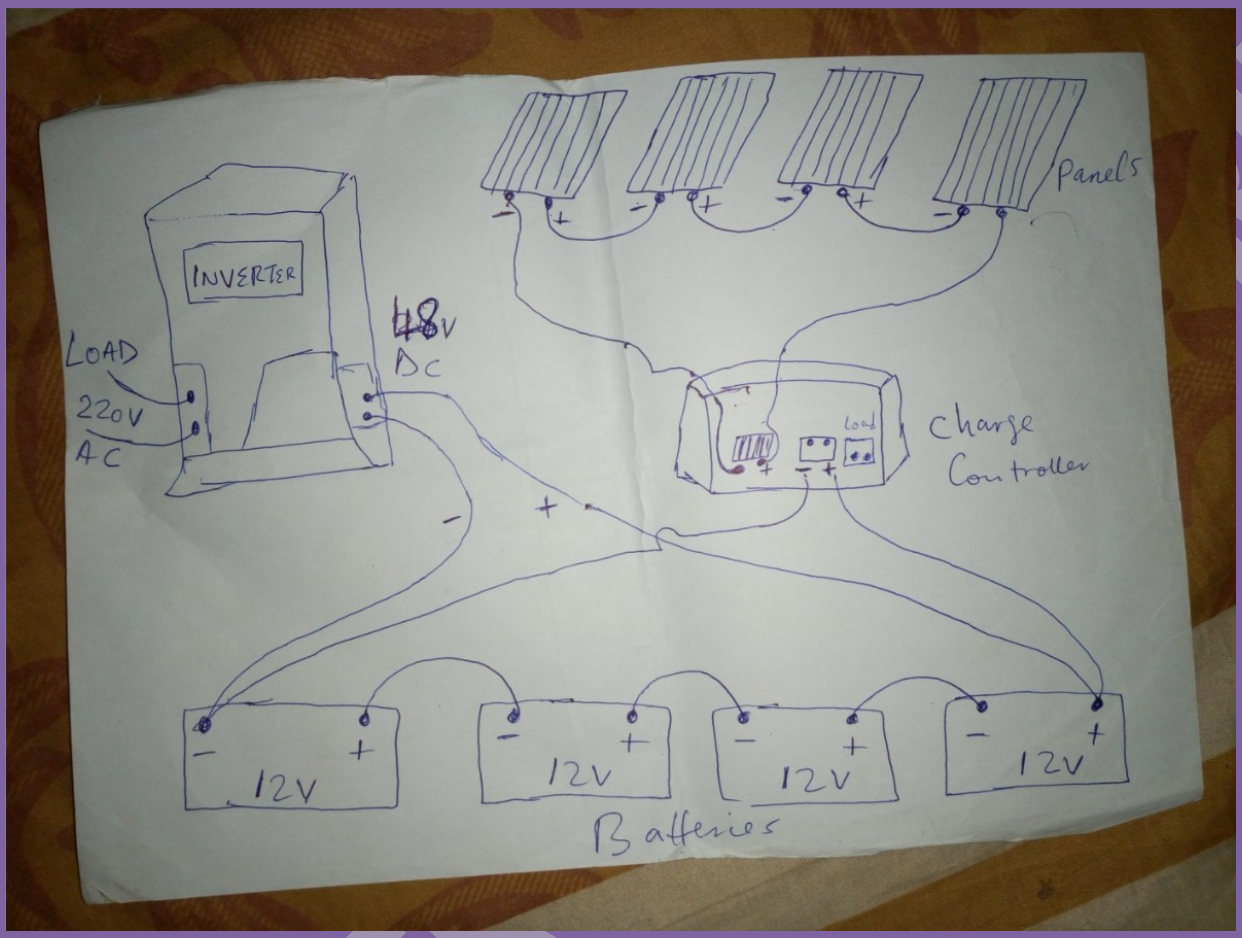
Fig iii. Unregulated driver circuit

CHAPTER 7

A COMPLETE GUIDE ABOUT SOLAR PANEL INSTALLATION. STEP BY STEP PROCEDURE WITH CALCULATION & DIAGRAMS

Complete solar panel installation design & calculation with solved examples – step by step procedure

Fig i. Solar panels / inverter installation



SOLAR SYSTEM

Solar power : this article is about generation of electricity using solar energy. Solar power is the conversion of sun light into electricity either directly using (pv), or using concentrated solar power (csp).

INVERTER

A power inverter or an inverter , is an electronic device or circuitry that changes direct current (DC) to alternating current (AC).

The input voltage ,output voltage and frequency ,and overall power handling depends on the design of the specific design or circuitry . the inverter does not produce any power , the power is provided by the DC source

SOLAR PANEL

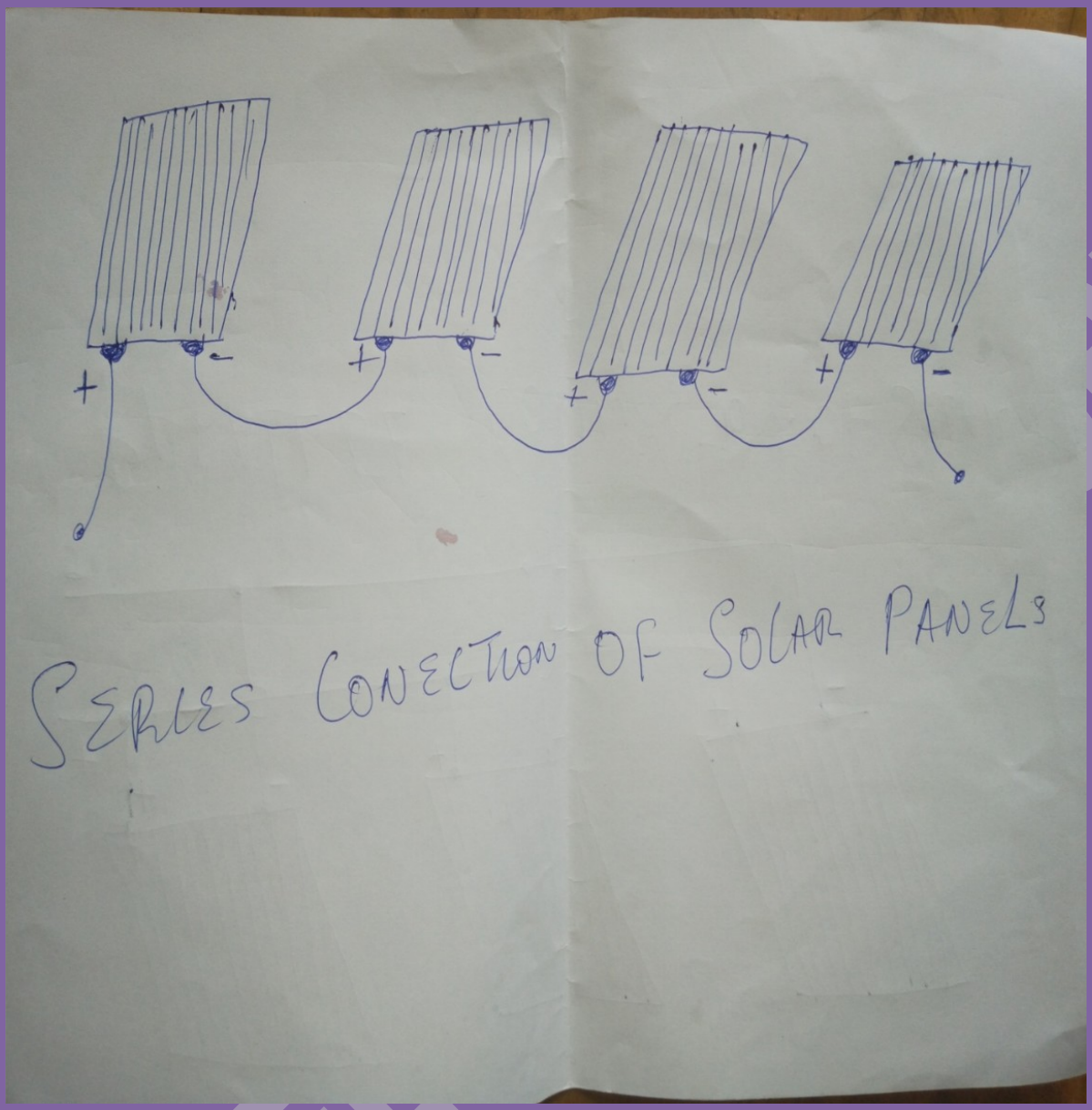
Photovoltaic solar panels absorb sunlight as a source of energy to generate electricity .

A photovoltaic (pv) modules is a package connected assembly of typically 6x10 photovoltaic solar cells.

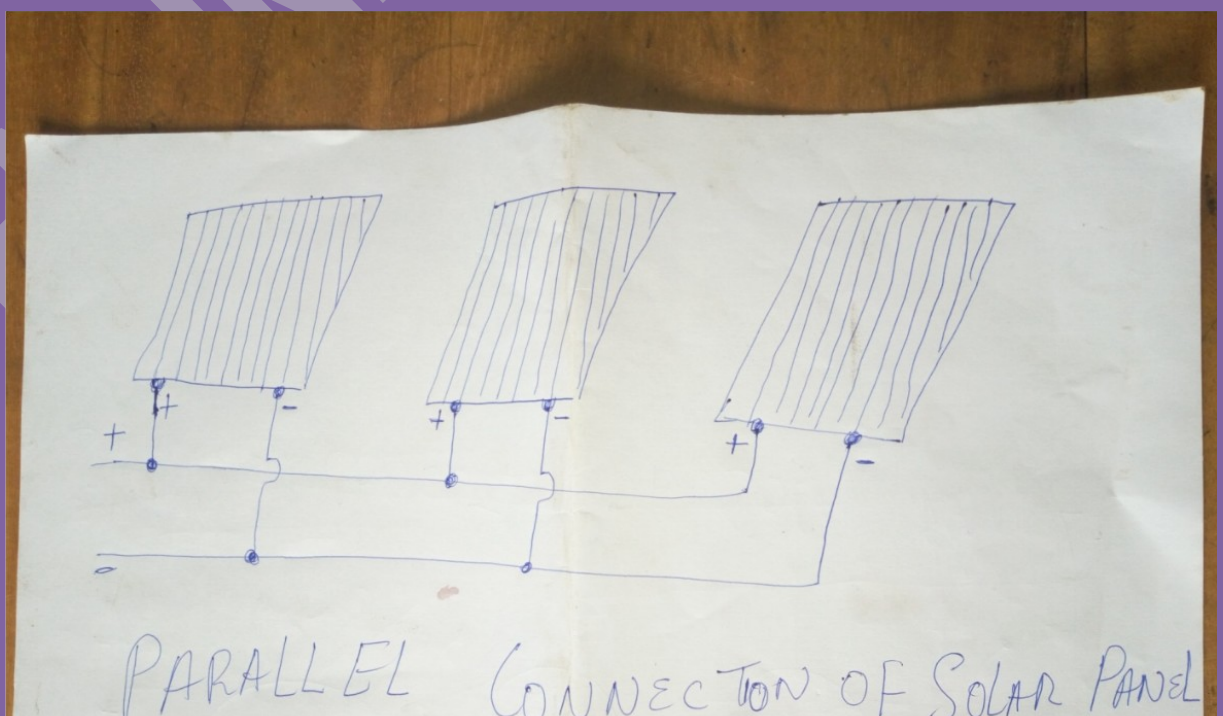
Solar panels are those devices which are used to absorb the suns rays and convert them into electricity or heat .

A solar panel is actually a collection of solar (or photovoltaic) cells ,which can be used to generate electricity through photovoltaic effect .

Photovoltaic is the science behind the most popular form of harnessing solar energy . a photovoltaic system uses solar panels to capture sunlight photons.



SERIES CONECTION OF SOLAR PANELS



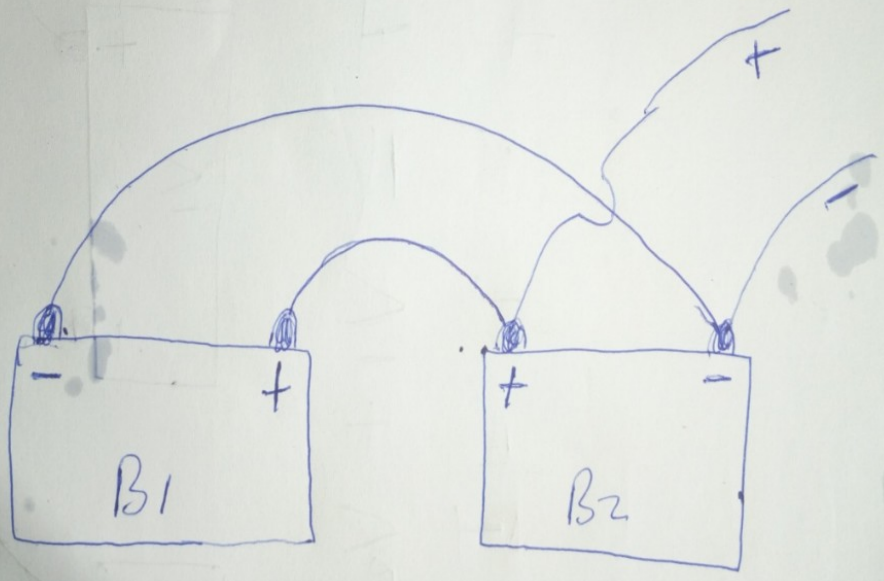
PARALLEL CONNECTION OF SOLAR PANEL

SOLAR CHARGE CONTROLLER

A solar charge controller is a major component of a solar power system. It regulates the voltage and current coming from a solar panel ,making sure it is within safe limit to charge the battery without over charging or damaging it .

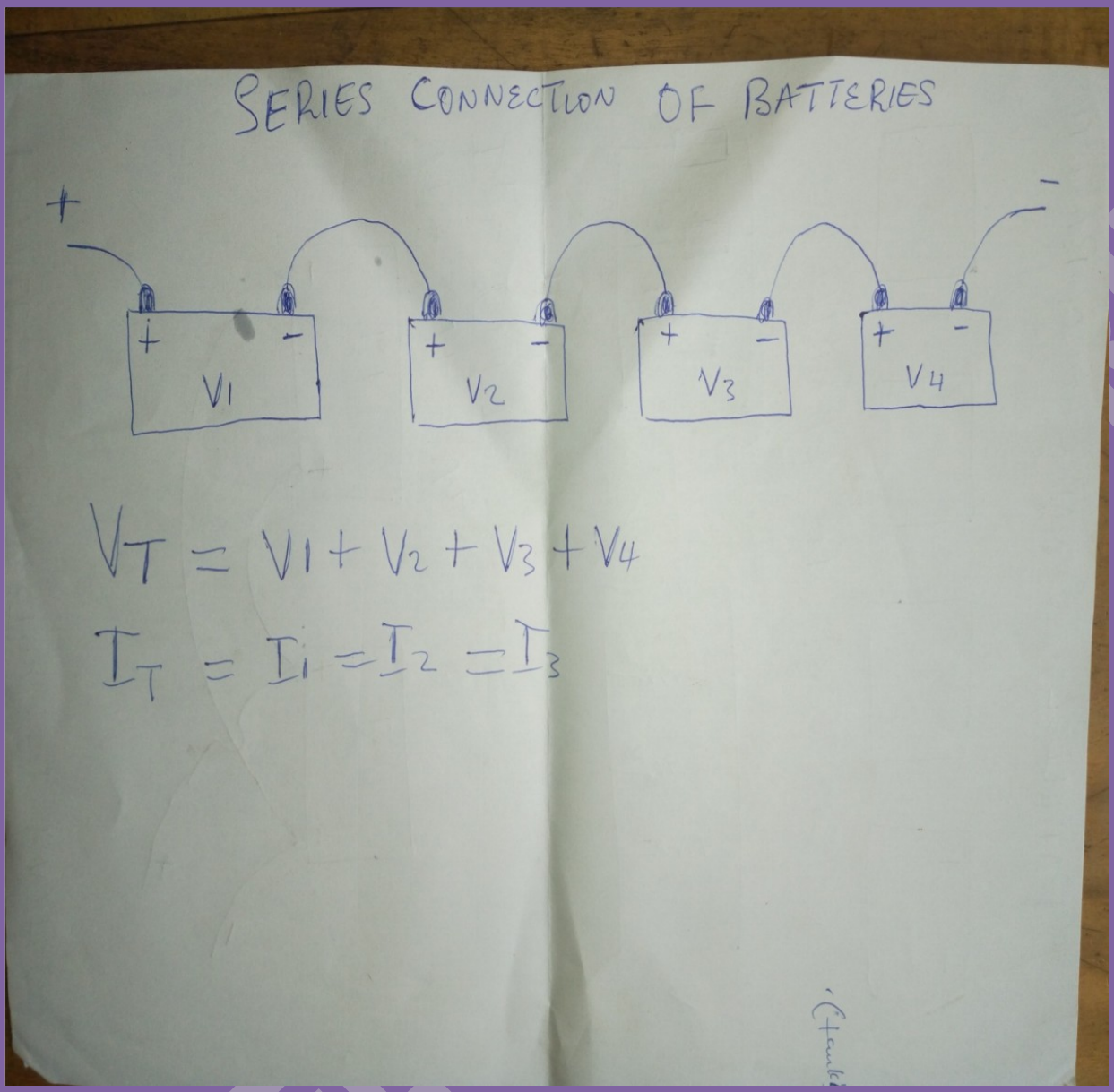
BATTERY

PARALLEL CONNECTION OF BATTERIES



$V_T = V_1 = V_2$

$I_T = I_1 + I_2$



The runtime of an inverter is dependent on the battery power and the amount of power being drawn from the inverter at a given time .

In solar system installation we use deep cycle batteries . these are batteries . This batteries have the ability to discharge up to 80% of the stored energy before recharging without any effect on the lifespan of the battery .

Photovoltaic converts light into electric current using the photoelectric effects

CALCULATIONS ON SOLAR SYSTEM INSTALLATION

Below is a DIY (do it yourself) complete note on solar panel design installation, calculation about number of solar panels, batteries rating / back up time, inverter/UPS rating, load and required power in watts. Anyone who follows the steps below can install and connect solar panels in home.

Here, you will be able to

1. To calculate the no of solar panel (with rating)
2. To calculate the rating of batteries for solar panel system
3. To calculate the rating of solar panel
4. To calculate the backup time of batteries
5. To calculate the required and charging current for batteries
6. To calculate the charging time for batteries
7. To calculate the rating of charge controller
8. How much watt solar panel we need
9. Connect solar panel in series or parallel
10. How to select the proper solar panel home
11. UPS / Inverter Rating for load requirement and much more

Example

Suppose, we are going to install a solar power in our home for a total load of 800w where the required backup time of battery is 3 hours (you may use your own as it is just for sample calculation)

Load = 800 watts

Required backup time for batteries = 3 hours

What we need to know

1. Inverter / UPS rating = ?
2. No of batteries for backup power = ?
3. Backup hours of batteries = ?
4. Series or parallel connection of batteries?

5. Charging current for batteries =?
6. Charging time for batteries = ?
7. Required no of solar panel = ?
8. Series or parallel connection of solar panel = ?
9. Rating of charge controller = ?

Solution

INVERTER / UPS RATING

Inverter / UPS rating should be greater than 25% of the total load (for the future load as well as taking losses in consideration)

800 x (25/100) = 200W.

Our load + 25% Extra Power = 800 + 200 = 1000 watts

This is the rating of the UPS (inverter) i.e. We need 1000w UPS / Inverter for solar panel installation according to our need (based on calculations)

Required No of Batteries

Now the required back up time of batteries in Hours = 3 Hours

suppose we are going to install 100Ah, 12V batteries,

12V x 100Ah = 1200 Wh

Now for one Battery (i.e the Backup time of one battery)

1200 Wh/ 800 W = 1.5 Hours

But our required backup time is 3 Hours.

Therefore , 3/1.5 = 2 i.e we will have to connect two (2) batteries each of 100Ah, 12V

Backup Hours Of Batteries

If the number of batteries are given, and you want to know the Backup Time for these given batteries, then use this formular to calculate the backup hours of batteries

1200 Wh x 2 Batteries = 2400Wh
2400 Wh / 800 w = 3 HOURS

In the first scenario, we will use 12V inverter system, therefore we will have to connect (2) batteries (each of 12v, 100 Ah) in parallel.

But the question is battery charging time

SERIES OR PARALLEL CONNECTION FOR BATTRIES

Why batteries in parallel, not in series?

Because this is a 12V inverter system, so if we connect these batteries in series instead of parallel, then the rating of batteries become

V1 + V2 = 12V + 12V = 24V while the current rating would be the same i.e. 100Ah.

Good to know: in series circuits, current is same in each wire or section while voltage is different. i.e. voltage are additive

e.g V1+V2+V3…..Vn

That's why we will connect the batteries in parallel, because the voltage of batteries (12V) remains the same, while its Ah (Ampere hour) rating will be increased.

i.e the system will become 12V and 100Ah + 100Ah = 200Ah

GOOD TO KNOW : In parallel connection, voltage wii be different i.e current is additive

e.g. I1 +I2+I3….In

we will now connect 2 batteries in parallel (each of 100Ah, 12v)

i.e. two 12V, 100Ah batteries will bw connected in parallel

=12V, 100Ah + 100Ah = 12V, 200Ah (parallel)

GGOD TO KNOW : Power in watts is additive in any configuration of resistive circuit.

P Total = P1 + P2 + P3….Pn (Negleting the 40% installation loss)

CHARGING CURRENT FOR BATTERIES

Now the required charging current for these two batteries

(charging current should be 1/10 of batteries Ah)

200Ah x (1/10) = 20A

CHARGING TIME REQUIRED FOR THE BATTERY

Here is the formula of charging Time of a Lead acid battery.

Charging time of battery = Battery Ah / Charging current

T = Ah / A

For example, for a single 12V, 100Ah battery, the charging time would be

T = Ah / A = 100Ah / 10A = 10 Hrs (Ideal case)

Due to some losses, (it has been noted that 40& of losses occurred during the battery charging), this way, we take 10 – 12 A,this way, the charging time required for a 12V, 100Ah battery would be

100Ah x (40/100) = 40 (100Ah x 40% of losses)

The battery rating would be 100Ah + 40 Ah = 140 Ah (100Ah + losses)

Now the required charging current for the battery would be

140Ah / 12A = 11.6 Hours.

REQUIRED NUMBER OF SOLAR PANELS (Series or parallel)?

Now the required No of solar panels we need for the above system is as below

Scenario 1 : DC Load is Not Connected = Only Battery Charging

We know the famous power formular (DC)

P = VI ……(Power = Voltage x Current)

Putting the values of batteries and charging current

P = 12V X 20A

P = 240 Watts

These are the required wattage of solar panel (only for battery charging, and then battery will supply power to the load i.e direct load is not connected to the solar panels)

Now

240W/60W = 4 Solar panels.

Therefore, we will connect 4 Solar panels (each of 60W, 12V, 5A) in parallel.

The above calculation was only for battery charging (and then battery will supply power to the desired load) to AC electrical appliances which will get power through inverter and DC loads via charge controller (via charged batteries).

SCENARIO 2: DC Load is connected as well as Battery Charging

Now suppose there is a 10A direct connected load to the panels through inverter (or may be DC load via charge controller).

During the sunshine, the solar panel provide 10A to the directly connected load + 20A to the battery charging

i.e. solar panels charge the battery as well as provide 10A to the load

in this case, the total required current (20A for Batteries charging and 10 A for directly connected load)

in this case above, total required current in Amperes,

20A + 10A = 30A

Now, I = 30A, then required power

P = V X I = 12V X 30A = 360Watts

i.e we need 360watts system for the above explained system (this is for both Direct load and batteries charging).

Now the number of solar panels we need

360 / 60w = 6

Therefore we will connect 6 No of solar panels in parallel (each of 60w, 12V, 5 A).

RATING OF CHARGE CONTROLER

As we have calculated above that the charging current for 200Ah battery is 20 – 22 Amperes (22A For battery charging + 10A for direct DC Load), therefore we can use a charge controller about 30 – 32 Amps.

Note : the above calculation is based on ideal case, so its recommended to always choose a solar panel some bigger then we need, because, there are some loses that occurs during battery charging via solar panel as well as the sunshine is not always in ideal mood.

PROCEDURES OF INSTALLING SOLAR PANELS AND INVERTERS

1 **MOUNT THE SOLAR PANEL.**

Nail or screw the solar panel firmly to the roof.

To have maximum harvest of sun rays by solar, please place it where you can have direct sunlight.

When solar panel is exposed to a direct sunlight, it should give at least 26V if you use your millimeter or voltmeter to measure its voltage.

2. CONNECT YOUR CHARGE CONTROLLER

The current we get from Solar panels will not remain constant through out the day, so therefore, you should not connect solar photo voltaic modules directly to charge your battery as it will damage your battery over time.

3. CONNECT THE BATTERY TO INVERTER

At the back of your inverter, you will see where 12V DC input is indicated, connect the positive (+) terminal of the battery to the positive (+) terminal of the inverter and the negative (-) terminal of the battery to the negative (-) terminal of the inverter.

Please the inverter should remain off at the point

4. CONNECT BATTERY TO CHARGE CONTROLLER

The charge controller has positive (+) and negative (-) terminals for battery.

Connect positive (+) from charge controller to the positive of the battery and negative (-) from the charge controller to the negative (-) of the battery.

5. LOAD YOUR HOUSE.

Caution

Please get an electrician to to separate the load intended for the inverter, so that the inverter will not be strained or damaged when house is powered.

a. Power the inverter, use your voltmeter to check the voltage from the inverter outlet, that should be 230V.
b. Turn the inverter OFF.
c. Turn OFF all your appliances

d. Connect the inverter outlet to your house power mains
e. ON the inverter

CHAPTER 8

PRODUCTION OF LED BULB

LED : light emitting diode (LED) is a semiconductor light source that emits light when current flows through it.

An LED is a special type of diode used as an Optoelectronic device. Like a PN junction diode, it conducts when forward biased. However, a special feature of this device is its ability to emit energy in the visible band of the electromagnetic spectrum i.e. visible light.

An LED lamp is a light – Emitting Diode (LED) product which is assembled into a lamp [or light bulb] for use in lighting fixtures.

A major concern to drive an LED is to provide an almost constant current input. Often, an LED is driven using batteries or control devices like microcontrollers. However, these have their own disadvantages, for example – low battery life etc.

A feasible approach would be driving the LED using AC to DC power supply. Though AC to DC power supply using transformer is quite popular and widely used, for applications like driving loads like LED, it proves to be quite costly and moreover it is not possible to produce a low current signal using transformer.

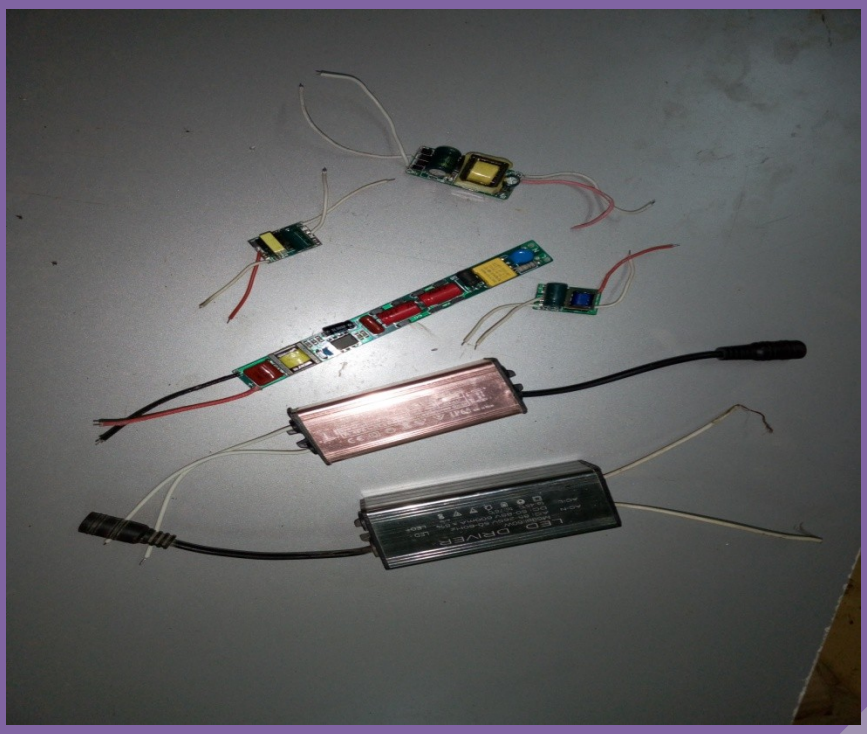
Keeping in mind all the factors, here we designed a simple circuit driving an LED from 230V AC. This is accomplished using a capacitor based power supply. This is a low cost and efficient circuit and can be used at homes.

LED Lamps have a life span and electrical efficiency which are several times greater than incandescent lamps and are significantly more efficient than most fluorescent lamps, with some chips able to emit more than 300 lumens per watt.

ABOUT LED DRIVER.

LED drivers are the essential components of LED lamps or luminaries. A good LED driver can guarantee a long life for an LED system and provide additional features such as dimming and control.

The LED drivers can easily be put inside lamp or luminaries, which is called a built in type, or be put outside, which is called an independent type



Lets say you want to power 5watts LED,

NOTE , one watt of LED has a biasing voltage of 3V . and if 5watts is 10 LEDs in number, (i.e 1/2 watts each)

Which means that there will be voltage drop of 0.6v in every LEDs.

So if for instance you want to power the 5watts LED bulb, what you need is

That is for the LED calculation

3V X5 = 15V
Voltage drop across each LED = 0.6
0.6 X 5 = 3V
Therefore,
15V + 3V = 18V

So therefore you need about 17v to 18V output from the driver to power 5watts LED bulb.

.

LED lamps are more efficient than compact fluorescent lamps and offer life span of 30,000 or more hours.

Incandescent lamps have a typical life of 1000 hours and,

Compact fluorescent have a life span of 8000 hours.

So LED is the best.

LED DRIVER CIRCUIT CALCULATIONS

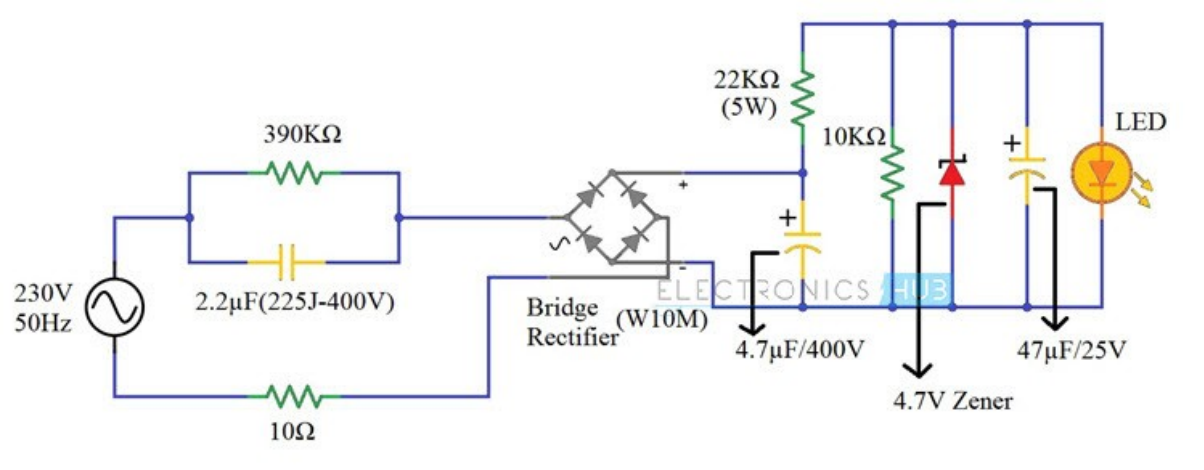
230v LED Driver Circuit Principle

The basic principle behind the 230V LED Driver circuit is transformer less power supply. The main component is the X-rated AC capacitor, which can reduce the supply current to a suitable amount. These capacitors are connected line to line and are designed for high voltage AC circuits.

The X – Rated Capacitor reduces only the current and the AC voltage can rectified and regulated in the later parts of the circuit. The high voltage and low current AC is rectified in to high voltage DC using a bridge rectifier. This high voltage DC is further rectified using a Zener diode to a low voltage DC.

Finally, the low voltage and low current DC is given to an LED.

230v LED Driver Circuit Diagram



Components Required

- 2.2µF Polyester Film Capacitor (225J – 400V)
- 390KΩ Resistor (1/4 Watt)
- 10Ω Resistor (1/4 Watt)
- Bridge Rectifier (W10M)
- 22KΩ Resistor (5 Watt)
- 4.7µF / 400V Polarized Capacitor
- 10KΩ Resistor (1/4 Watt)
- 4.7V Zener Diode (1N4732A) (1/4 Watt)
- 47µF / 25V Polarized Capacitor
- 5mm LED (Red – Diffused)

How to Design a 230V LED Driver Circuit?

First, a 2.2µF / 400V X – Rated Capacitor is connected in line with the mains supply. It is important to pick a capacitor with voltage rating greater than the supply voltage. In our case, the supply voltage is 230V AC. Hence, we used a 400V rated capacitor.

A 390KΩ resistor is connected in parallel with this capacitor to discharge it when the supply is turned off. A 10Ω resistor, which acts as a fuse, is connected between the supply and bridge rectifier.

The next part of the circuit is a full wave Bridge Rectifier. We have used a single chip rectifier W10M. It is capable of handling currents up to 1.5 Amperes. The output of the Bridge Rectifier is filtered using 4.7µF / 400V Capacitor.

For regulating the DC output of the Bridge Rectifier, we are using a Zener Diode. A 4.7V Zener Diode (1N4732A) is used for this purpose. Before the Zener Diode, we have connected a series resistor of 22KΩ (5W) for limiting the current.

The regulated DC is given to the LED after filtering it out using 47µF / 25V Capacitor.

How the 230V LED Driver Circuit Works?

A simple, transformer less 230V LED Driver Circuit is built in this project. The main components of this project are the X – Rated Capacitor, the Zener Diode and the resistor which limits the current in the Zener Diode. Let us see the working of this project.

First, the 2.2µF X – Rated Capacitor (225J – 400V) will limit the AC current from the mains supply. In order to calculate this current, you have to use the Capacitive Reactance of the X – Rated Capacitor.

The formula for calculating the Capacitive Reactance is given below.

$$Capacitive\ Reactance\ X_C = \frac{1}{2\pi FC}$$

So, for 2.2µF Capacitor, X_C can be calculated as follows.

$$X_C = \frac{1}{2\pi * 50 * 2.2 * 10^{-6}} = 1447.59$$

So, from Ohm's Law, the current that the capacitor allows is given by

I = V/R.

Hence, the current through the capacitor is = 230/1447.59 = 0.158 Amperes = 158mA.

This is the total current that enters the bridge rectifier. Now, output of the Bridge Rectifier is filtered using a Capacitor. It is important to select an appropriated voltage rating for this capacitor.

The input to the Bridge Rectifier is 230V AC, which is the RMS Voltage. But the maximum voltage at the input of the Bridge Rectifier is given by

$V_{MAX} = V_{RMS} \times \sqrt{2} = 230 \times 1.414 = 325.26$ V.

Hence, you need to use a 400V rated filter capacitor. The Rectified DC voltage is around 305V. This must be brought down to a usable range for lighting up the LED. Hence, the Zener Diode is used in the project.

A 4.7V Zener Diode is used for this purpose. There are three important factors associated with the Zener Diode that is acting as a regulator: A Series Resistor, Power Rating of that Resistor and the Power Rating of the Zener Diode.

First, the Series Resistor. This resistor will limit the current flowing through the Zener Diode. The following formula can be used in selecting the series resistor.

$$R_S = \frac{V_{IN} - V_Z}{I_L + I_Z}$$

Here, V_{IN} is the input voltage to the Zener Diode and is = 305V.

V_Z is the Zener Voltage (which is same as the load voltage V_L) = 4.7V.

I_L is the load current i.e. the current through the LED and is = 5mA.

I_Z is the current through the Zener Diode and is = 10mA.

Therefore, the value of the Series Resistor R_S can be calculated as follows.

$$R_S = \frac{305-4.7}{5*10^{-3}+10*10^{-3}} = 20020\Omega$$

Now, the Power Rating of this Resistor. The Power Rating of the series resistor is very important as it determines the amount of power the resistor can dissipate. To calculate the power rating of the Series Resistor R_S, you can use the following formula.

$$Power\ Rating\ of\ R_S = \frac{(V_{IN}-V_Z)^2}{R_S} = \frac{(305-4.7)^2}{20020} = 4.5W$$

Finally, the Power Rating of the Zener Diode. You can use the following formula to calculate the Power Rating of the Zener Diode.

$$Power\ Rating\ of\ Zener\ Diode = \frac{(V_{IN}-V_Z)*V_Z}{R_S} = \frac{(305-4.7)*4.7}{20020} = 0.07W$$

Based on the above calculations, we have chosen the series resistor of 22KΩ Resistance rated at 5W and a 4.7V Zener Diode rated at 1W (actually, a quarter Watt Zener would suffice).

The rectified and regulated voltage with limited current is given to the LED.

To produce LED bulb

ITEMS

1. LEDs
2. Drivers (chokes)
3. PCB Plates (Printed Circuit Board)
4. Screws
5. Heat paste
6. Housing
7. Aluminum base
8. Aluminum pin
9. Cover
10. Sol tape

TOOLS

1. Soldering iron
2. Soldering lead
3. Screw driver
4. Plier

PROCEDURE

1. Gather the items together on a table
2. Solder the LEDs on the appropriate marked positions on the PCB plate. Minding the polarities (i.e +ve & --ve)

3. Place the soldered LED plate on top of the Housing and insert the Driver's output cable inside the hole of the housing, to solder with the LED plate on top of the housing

NOTE mind the polarity of the drivers output cable and the plate (i.e. solder +ve of driver's output cable to +ve of the LED plate, and –ve of the drivers output cable to the -ve LED plate).

4. Sol tape the back of the drive of the to avoid short circuit
5. Insert the input cables (+ve & --ve) inside the Aluminum base. (pay less attention to the polarity of the drivers input cable). The base could be pin or screw.
6. Apply heat paste at the black of the LED plate for proper heat description
7. Screw the LED plate on top of the housing and Cover.
8. You can now test your bulb with lamp holder.

NOTE : The same procedure applies to other categories of LED lights (like Spot lights, Flood lights, Street lights, Panel lights, Tube light etc).

Only that all these lights mentioned doesn't use Aluminums base.

They only have two cables (+ve & --ve) that can be connected to the lighting point supply cables.

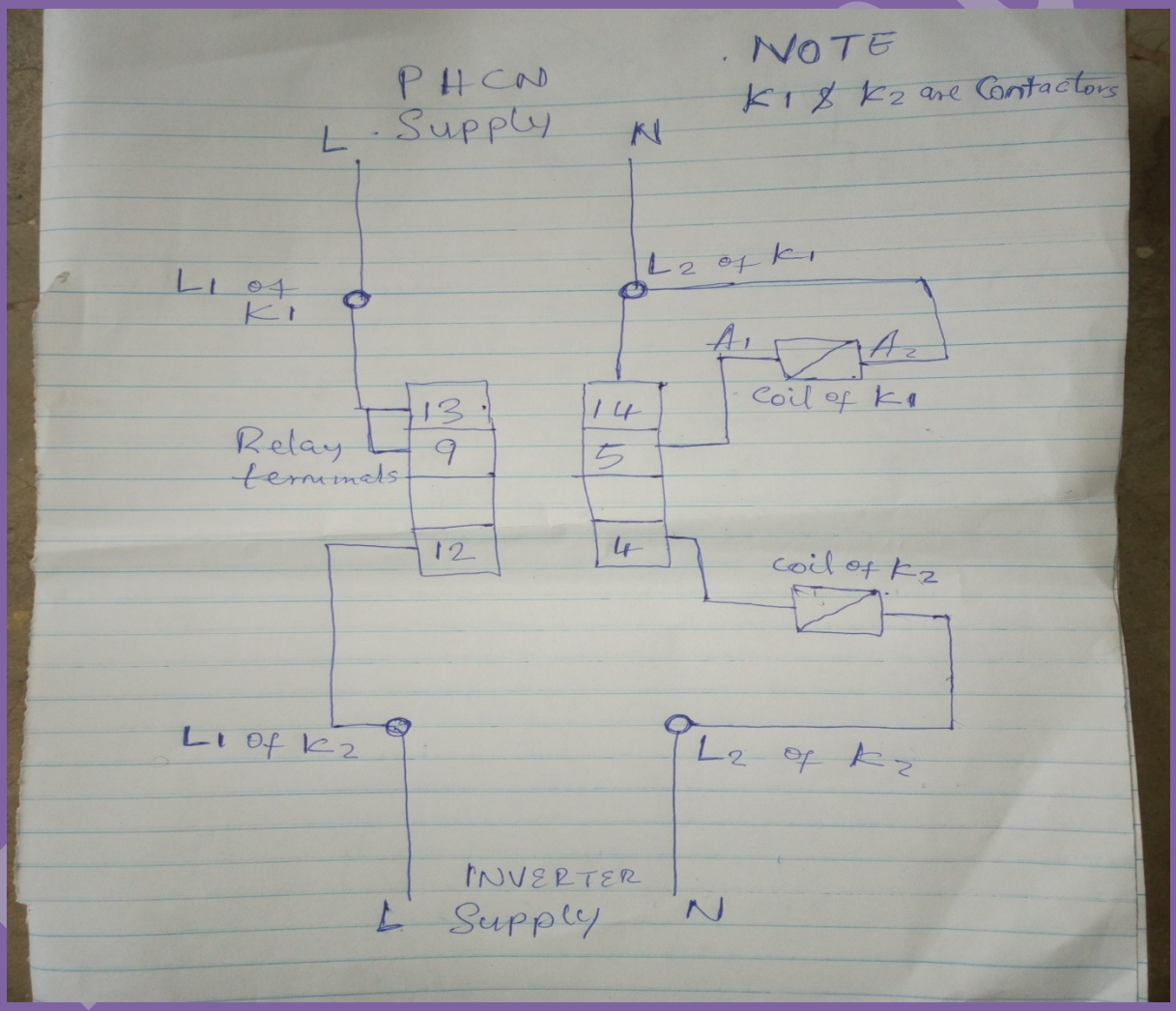
CHAPTER 8

AUTOMATION

Automation is the use of electronics and computer –controlled devices to assume control of processes .

The aim of automation is to boost efficiency and reliability . In most cases , however , automation replaces labor .

1. DESIGN OF AN AUTOMATIC CHANGE OVER



Items

a. 2 magnetic contactors

b. 1 magnetic relay
c. 2 supply wires (live & neutral each)

Suppose we use the first magnetic contactor for **PHCN** and we label it K1.

Then we use the second magnetic contactor for **generator** and we label it K2.

Follow this procedure

Supply cable for PHCN has 2 wires (live & neutral),

1. Add a wire to the live wire (red) of the PHCN supply cable and connect to L1 of K1 magnetic contactor.
2. Add another wire to the neutral wire (black) of the PHCN supply cable and connect to L2 of K1 magnetic contactor.
3. Connect the 2 wires (live & neutral) that were added to PHCN supply wires to the input supply terminals of the relay coil (live & neutral respectively).

Note : at this point, when you ON the PHCN supply, the supply will pass through L1 & L2 of K1 contactor and then enter the coil of the relay, the relay then becomes ON.

Also, note that contactor coil (A1 & A2) needs to be energized with 220V (sometimes 110V) before it can work.

4. Connect a wire to the neutral point of the K1 contactor (L2) and terminate it (connect the end part of it) to the A2 (neutral coil terminal) of the same contactor K1.
5. Connect a wire to the normally open (**NO**) of the relay (it might be 1 & 5) and terminate (connect) it to the positive coil terminal (A1) of the PHCN contactor K1.

At this point, when you ON the supply of PHCN, contactor K1 will ON, when you remove the NO wire from relay, the contactor K1 will OFF.

Now we connect the generator supply cable.

The generator supply cable has 2 wires (live & neutral)

6. Add a wire to the live (red) supply wire of the generator and Connect to the L1 of the generator contactor K2.
7. Add a wire to the neutral (black) supply wire of the generator and connect to L2 of the K2 contactor.
8. Connect the added wire (neutral) of the generator to the A2 (coil) terminal of the contactor K2.
9. Connect the added live wire of L1 to the normally closed (**NC**) of the relay (it could be 4 & 12 terminals), and terminate it to the A1 (positive terminal) of the magnetic contactor K2.

Now At this point, when K1 is ON, K2 will automatically be OFF. And when K2 is ON, K1 will automatically be OFF.

This is achieved through the work of the magnetic relay.

So when you power the 2 supplies (PHCN & GENERATOR), only one contactor will be ON and one will be OFF.

There is no way two of them will be ON the same time, one must be OFF when the other one is ON vice versa.

10. Link the output terminals (T1 & T2) of the K1 & K2 together, i.e T1 of K1 should be connected to T1 of K2. And T2 of K1 should be connected to the T2 of K2.

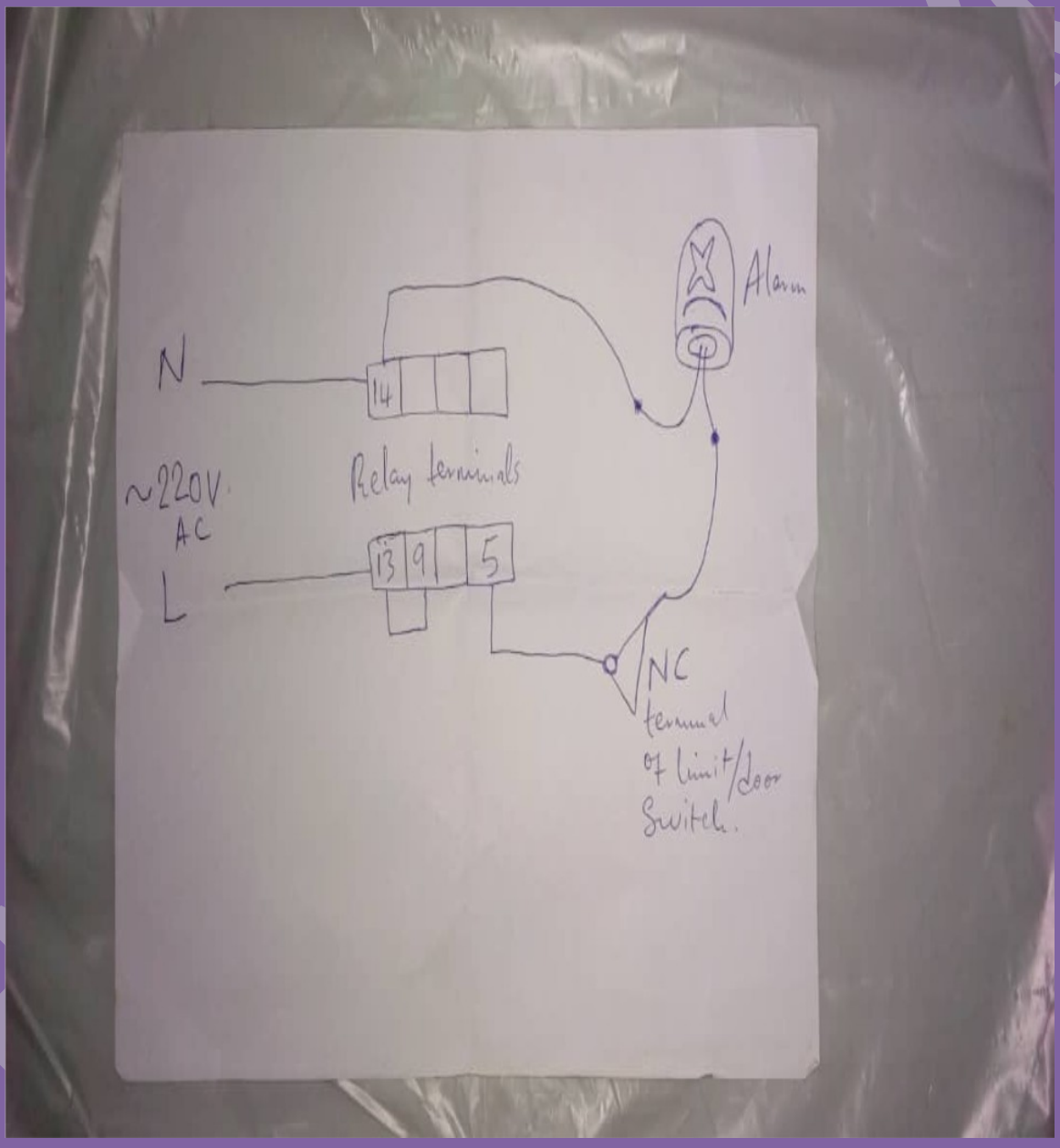
What I mean here is that, we connect the generator output live (red) to the PHCN output live (red), then we connect the generator neutral (black) to the PHCN neutral (black).

Now we connect the load

Connect your load to any of the contactor output terminals (T1 & T2), as we have looped the outputs together.

Your load could be bulb or other loads, but be mindful of the capacity your load in order not to exceed the capacity rates of your contactors and relays.

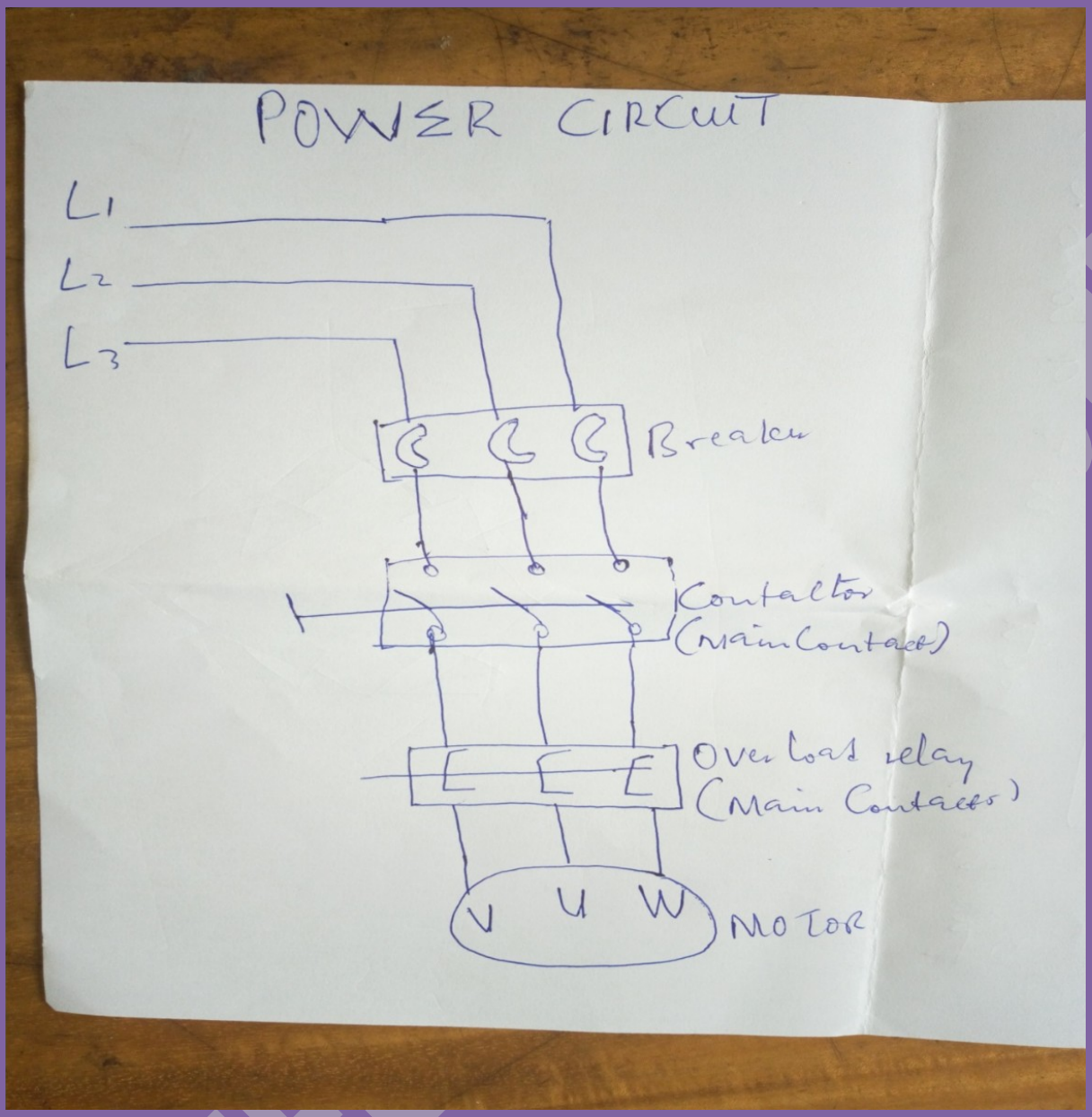
2. SIMPLE SECURITY ALARM SYSTEM

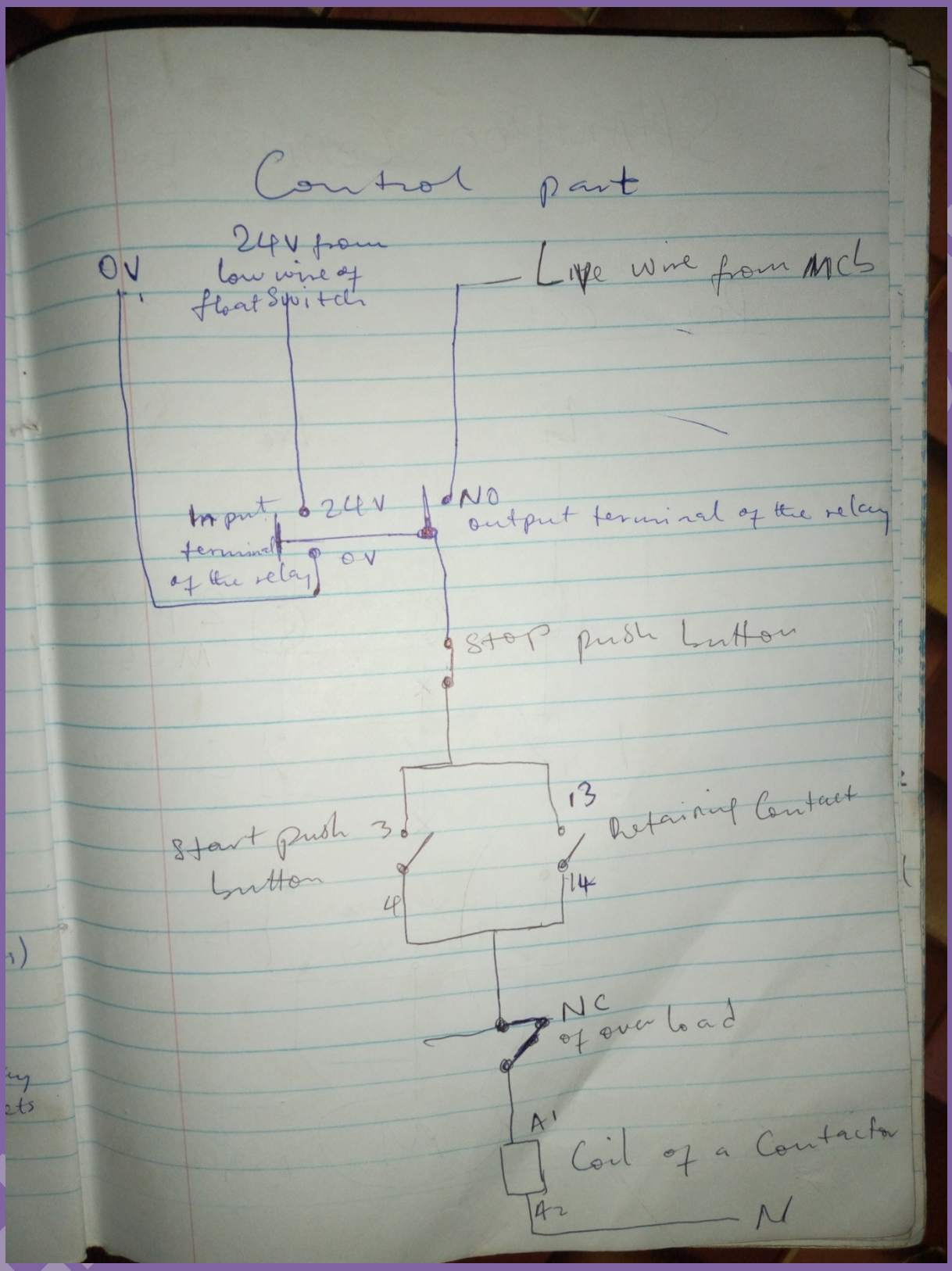


Procedure of connection

The power supply (the life and neutral) entered the relay coil. Then a wire was connected from the live wire of the supply to the no.9 terminal of the relay . the no.9 terminal is in normally open (NO) to the terminal no.5. connect terminal no.5 to the one of the terminal of the normally closed (NC) of the door switch .then the second terminal of the normally closed (NC) of the door switch , use it to supply one leg wire of the alarm , then connect the second leg of the alarm to the neutral point of the relay coil. Power the circuit .

3. WATER LEVEL CONTROL CIRCUIT USING FLOAT SWITCH

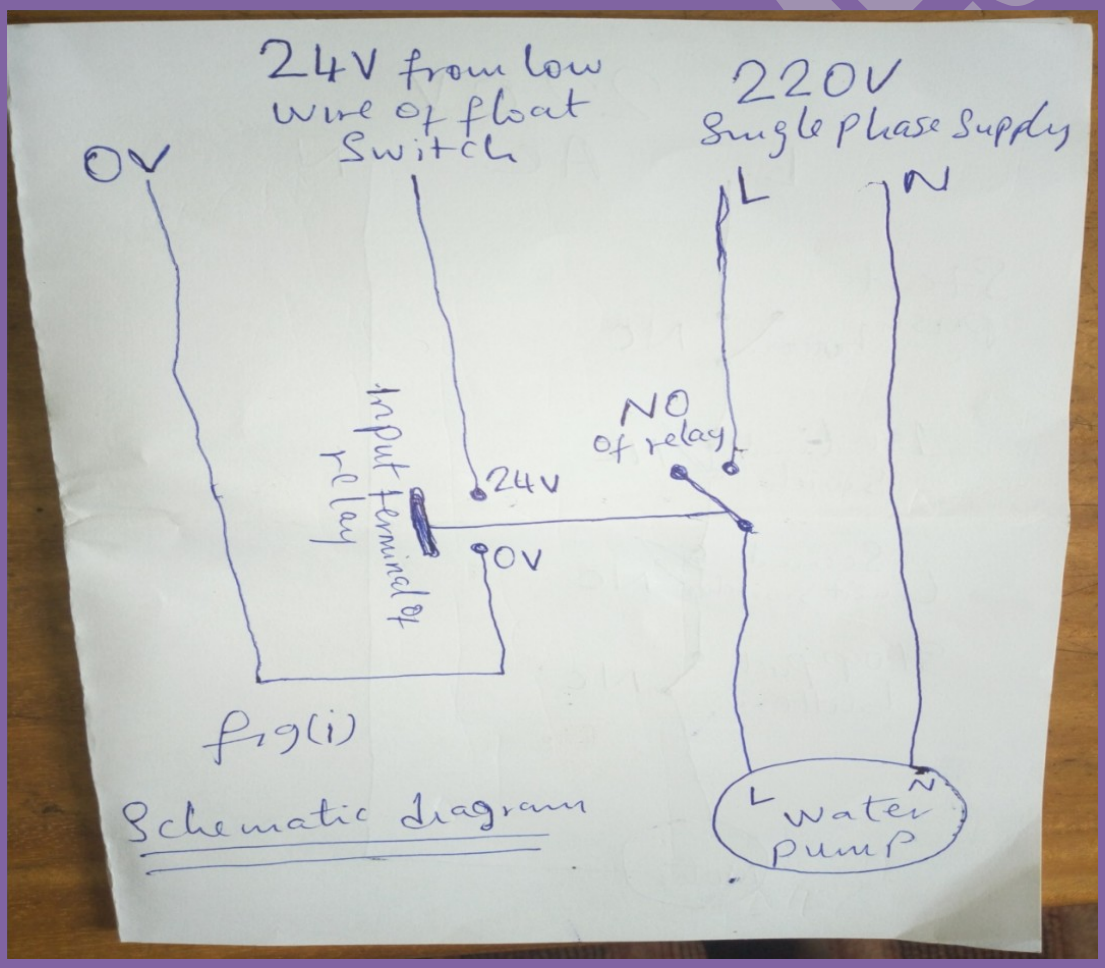

POWER CIRCUIT
L1
L2
L3
Breaker
Contactor
(Main Contacts)
Overload relay
(Main Contacts)
V
U
W
MOTOR

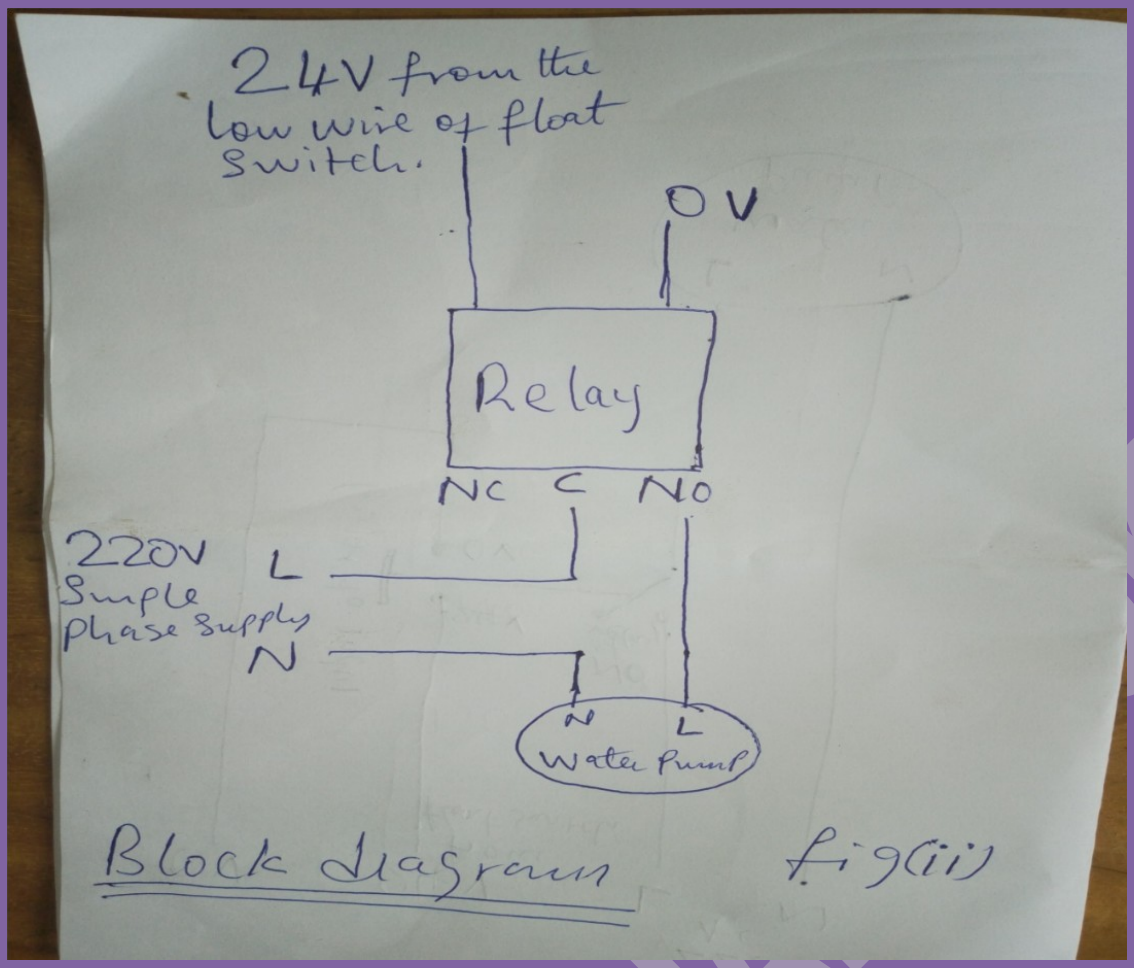

Control part
0V
24V from low wire of float Switch
Live wire from MCB
Input terminal of the relay
24V
0V
NO output terminal of the relay
STOP push button
13
Start push button
3
Retaining Contact
4
14
NC of over load
A1
Coil of a Contactor
A2
N

Switch gears

a. Breaker (mcb)
b. Float switch
c. Contactor
d. Overload relay
e. Start push button
f. Stop push button
g. Water pump

4. Assuming a water pump is a single phase pump that requires only live and neutral connection to function .we want the pump to pump the water whenever the level of the water in the tank is low.





Requirements

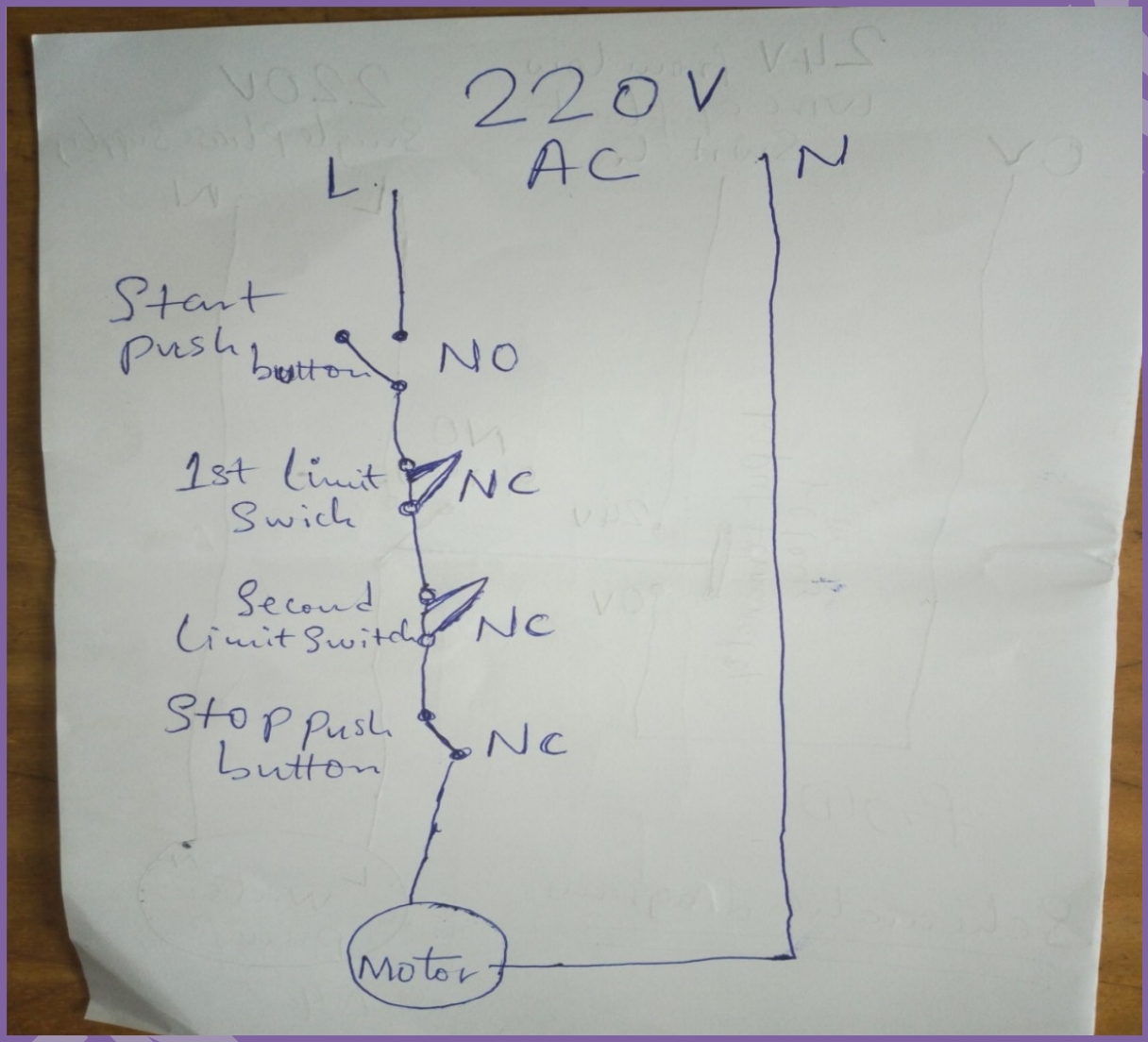
Float switch

Dc Relay

Water pump

24v battery

5. **We want a situation whereby the lift/elevator will move up continuously and eventually stop when it gets to the maximum height. Also in the same way I want it to move downward continuously until it gets to the minimum height then it stops.**



6. USING LEVEL CONTROL SENSOR TO MONITOR THE WATER IN THE TANK

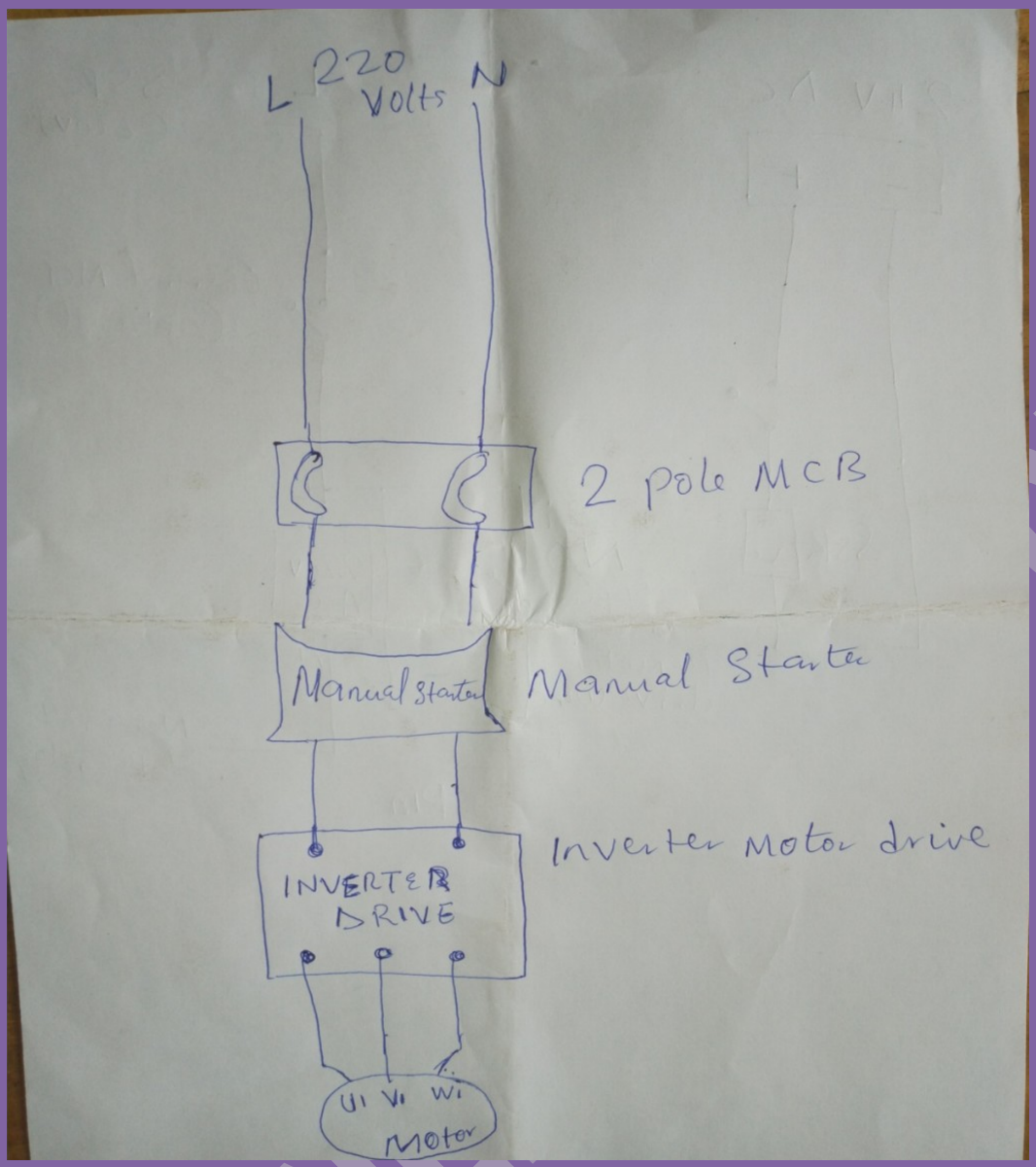


Fig (i) Power connection

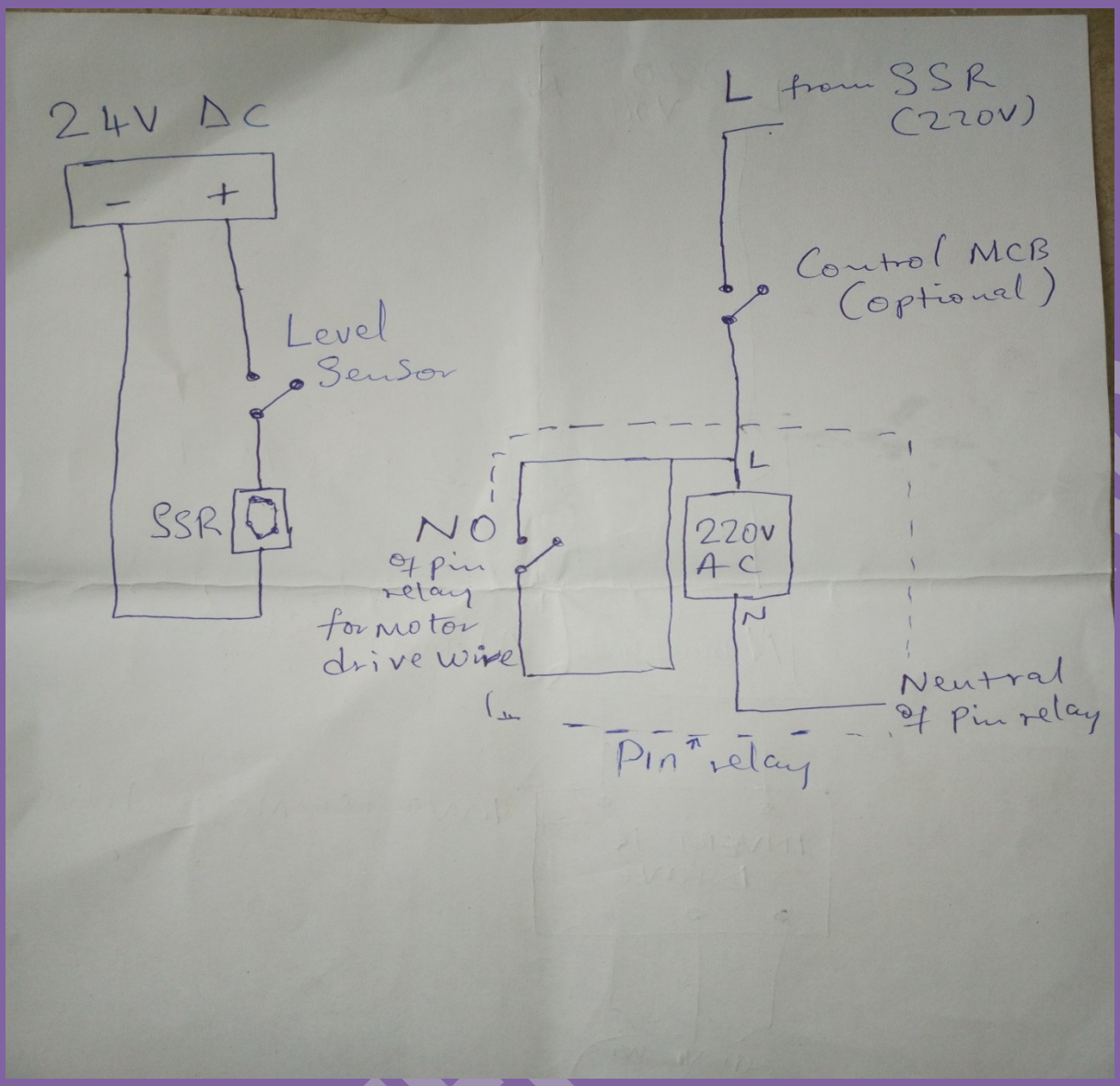


Fig (ii) Control connection

CHAPTER 10

ELECTRICAL DESIGN OF BUILDINGS (USING AUTOCAD)

Computer can be seen as an electronic machine which can perform logical / arithmetic operation on data. the data can be numbers, letters or symbols which the computer adds, subtracts, divides, multiplies, sorts or compares. It can also be defined as electronic, mechanical or electromechanical devices that can perform automatically and at high speed a sequence of logical, arithmetic or textual operations according to instructions given to it in the form of a prearranged program.

The invention of computer technology has improved scientific research in many areas of specialization. This has helped in the application of computer in different fields, which one is the computer aided design (CAD) as in drafting and design.

Auto CAD software is a type of CAD software products for 2-D (2 dimensional) and 3-D (3 dimensional) design and drafting, developed and sold by Autodesk Inc. AutoCAD software is the leading computer aided used by architects, engineers and draughts people worldwide).

Electrical drafting and design is used to communicate to people (contractors, sub-contractors, owners of buildings, etc) what a job looks like on starting to completion through drawing. The designer follows industry standards and become familiarized with both mechanical and architectural style of dimensioning.

Measurement in a building should be taken into consideration (electrical measurement). If not really been looked into by surveyors or sub-contractors (what to measure and how to measure), brings a measure problem when handled by inexperienced surveyors, sub-contractors and owners of buildings. The owner of the job in question will have to give the quantity surveyors the vital information on measurement through consulting engineers or architects..

In electrical work, detailed specification drawing should contain , layout of the installation, lighting drawing, that is conduit layout, power drawings, telephone

layout and heating layout. The D.Bs should be shown in the power drawing, the equipment layout in plant or machine rooms. Schematic layout of the equipment legend which indicates what each sign or symbol in the drawing work represents.

The drawing should be studied carefully to make sure that everything in the drawing is been done correctly and all signs and symbols in the drawing is being treated in the legend. In case there is anything confusing in the drawing, it should be taken to the engineer for explanation instead of going on with the job without knowing what is on the drawing.

AUTOCAD is a general purpose computer aided drafting application program designed with an open architecture, for use on single user desktop personal computers and graphic workstations. It was developed in the early 1980s by Autodesk Inc. AutoCAD is the leading computer aided design software used by architects, engineers and draughts people world wide. It has really changed drafting and design, and has brought it to a higher level in engineering and many fields of application. The old way of drafting and design which was free hand sketching provided a slow and maybe rough works and I feel it still happens to people using it now.

The original concept of AutoCAD in the 1980s was to promote customization and feature extensibility and was what made it especially appealing to customers. It is a suit of CAD software products for 2D and 3D design and drafting developed and by Autodesk Inc.

AutoCAD helps to modify the size, shape and location of objects easily. You just need to enter a command and select the objects to modify or vice versa. You call also recalculate objects by changing coordinate value in the properties windows

AutoCAD screen is made up of two windows, the graphic window where drawing are created and the text window at the base of which the command line is located. The text window is suited behind the graphic window and contains a history of the executed commands.

The latest command in use is always displayed at the base of the text window called the command line. AutoCAD window has some features which are title bar

that displays the name of the application and the current drawing being edited, the menu bar which contain the default AutoCAD menus and the menus are available from the menu bar at the top of the AutoCAD drawing area, tools bars, draw and modify tool bars, the command prompt, the command window, the status bar, tool palettes, etc.

AutoCAD concepts and procedures are used in the creation of increasingly complex 2 dimensional technical drawings. Modern AutoCAD includes a set of basic modeling and 3D tools, but lacks some of the more advanced capability of solid modeling applications.

The invention of computer has improved scientific research in many areas of interest thus giving rise to its application in drafting and design known as computer aided design (CAD), has made things easier and reduced the difficulty in performing various design tasks.

So many software used cannot be listed here but the basic one needed is AutoCAD. AutoCAD currently runs on Microsoft desktop operating system. it exists in fourteen languages.

The technology has existed for some time and is widely used in developed countries. Research has shown that it is technically feasible, some of the benefits of this technology includes the automatic generation of the quantity take off's directly from design drawings, improved coordination of construction disciplines and improved communication between design and construction. AutoCAD is used extensively in engineering, architecture, surveying, urban and regional planning, geology and geography.

FEATURES OF AUTOCAD

1. Create the design of your dreams or your client with creation, edition and navigation tools that take your vision to a new level of precision and aesthetic presentation.
2. Visualize your design like never before with lighting effects, materials libraries, walk through animations and stunning rendering capabilities.

3. Document your design quickly and easily with sectioning and flattening tools, dynamic blocks and enhanced tables. Create clear and accurate sets of construction document.
4. Share and design information across extended teams with powerful tools for exchanging data.
5. Migrate easily with tool that help you upgrade while preserving customization of tool bars and menus.

FEATURES OF AUTOCAD WINDOW

1. The title bar; displays the name of the current drawing being edited.
2. The menu bar; Menus are available from the menu bar at the top of the AutoCAD drawing area
3. The toolbar; This can be docked or floating depending on the choice of displays. Toolbars contain buttons that start commands. when you move the pointing device over a tool bar, the tool tip displays the name of the button.
4. Graphic window; this is the working area in AutoCAD where drawings are created.
5. The command window; displays a history of executed commands and options. It runs behind the graphic window.
6. The command prompt; the current command issued is displayed at the text window called command line.
7. The crosshair; its controlled by the pointing device (usually a mouse). It is used to select the commands.
8. The status bar; displays the coordinate location of the crosshair and the current settings of grid,snap and other drawing aids.

HOW THE BUILDING DRAWING AND THE ELECTRICAL SYMBOLS ARE CREATED USING AUTOCAD

When you start AutoCAD, the start up dialog box is displayed. The dialog box provides you with four ways to start a drawing.

YOU CAN

A. Open an existing drawing,

B. Start a drawing from scratch
C. Start a drawing from based on a template
D. Use wizards to help you set up your drawing.

TO START AUTOCAD

1. From the start menu (Microsoft window) choose programs. Then choose AutoCAD from the menu.
2. In the start dialog box, choose one of the following:

The start dialog box is displayed when you first start AutoCAD session, the **CREATE NEW DRAWING** dialog box is displayed. After you use AutoCAD for a while, you may want to turnoff displays of these dialog boxes. If you turn them off, choosing file new automatically creates a new drawing based on your last from the scratch selection [English or Metric]. Choosing file open displays the select file dialog box, where you can select AutoCAD drawing and templates. To turn off displays of the startup dialog box in the startup dialog box, clear show dialog .

TO DISPLAY THE STARTUP BOX

1. From the tool menu, choose options
2. In the options dialog box, choose the system tab
3. Choose general options, select show startup dialog.
4. Choose ok.

i OPEN A DRAWING

Open a drawing you select from a list of the four most recently opened drawings. Also displays the brows button that you choose to look for another file.

ii STARTING DRAWING FROM SCRATCH

starting a drawing from scratch is quickly way to being a menu drawing. When you select this drawing startup method, you can select one or two measurement systems on which to choose the new drawing.

ENGLISH : Create a new drawing based on the AutoCAD measurement system. The drawing based on acad. Dwt templates and the default drawing boundary, called the drawing limit is 12x9 inches.

MWTRIC: creates a new drawing based on the metric measurement system. The drawing based on the AutoCAD ISO, dwt template, and the default drawing is 429x297.

TO CREATE A NEW DRAWING USING START FROM SCRATCH

1. In the startup dialog box, choose from scratch (if AutoCAD) is already started, from scratch in the create New Drawing dialog box
2. Select opens based or metric, and then choose ok, the drawing opens based on the English (acdidust) or metric (acadiso. Dwt) template and with the name drawing 1. Dwt
3. From the file menu, choose save as.
4. In the SAVE DRAWING AS dialog box under file Name, enter a name for the drawing and choose save. AutoCAD automatically appends the drawing extension (dwg) to the new file name

COMMAND LINE NEW

System variables MEASUREMENT sets initial drawing MEASUREMENT sets drawing units as English or Metric for the current drawing.

STARTING DRAWING WITH SETUP WIZARDS

AutoCAD setup wizards start the same setting used when you start a drawing from scratch, that is English or metric then customize other settings depending on the wizard you choose.

The quick set up wizard sets the drawing units and drawing area. Choices for drawing units include Decimal, Engineering, Architectural, Fractional, and Scientific. You also specify the width and length of the drawing area to establish the drawing boundary, or limits. The area the limits the limit is the final plotted sheet size.

With the advance setup wizard, you can specify the same settings as the Quick setup wizard (drawing units and drawing area), and you can specify several angle settings,including the angle of measurement. The direction of the zero,and the direction in which AutoCAD measures angles from the zero angle.

TO START A DRAWING USING A WIZARD

A. In the startup dialog box, choose use a wizard (if AutoCAD is already started, from the file menu, choose use a wizard in the create New Drawing dialog box)
B. Under select a wizard, select Quick setup or Advance setup and choose ok.
C. Complete the wizard pages using the Next and Back button to move forward and backward.
D. On the last page choose finish.

The wizard starts your drawing session command line NEW.

USING TEMPLATES

When you start a new drawing, you can use a template (DWT) file containing settings for specific drawing purposes. You can use templates supplied with AutoCAD or create your own templates. Any existing drawing can serve as a template; all drawing settings are made in the new drawing. Although you can save any drawing as a template, you should prepare templates to include settings and drawing element consistent with your office or project standards such as

1. Unit type and precision
2. Drawing limits
3. Snaps, grid and ortho settings
4. Layer organization
5. Title blocks, boarders and logos
6. Dimension and text styles

7. Line-types and line-weight

If you start a drawing from scratch, AutoCAD uses either the acad, Dwt templates (inches) or acadiso. Dwt templates (millimeters) when you create a new drawing based on an existing template and make changes, the changes in the new drawing do not affect the template.

STARTING A DRAWING USING TEMPLATES

A. In the startup dialog box, choose use a template (if AutoCAD is already started) from the file menu,choose new, and then choose use a template in create new drawing dialog box.
B. Under select template,select a template from the list or choose browse to select another file.
   A preview image of the template appears at the right,and a description appears near the bottom of the dialog box.
C. Choose ok.

AutoCAD opens the drawing as drawing Dwg. Command line new.

SCALING

When you draft on paper, you determine the scale before you start drawing. This scale comprises the size of the drawn object to the actual size of the object the drawing represents. For example, each quarter inch in an architectural drawing might equal one root in a plan of a house. The scale you choose must allow the drawing of the object to fit on the paper.

In AutoCAD, this process is reversed. You draw with a unit type you specify (architectural, decimal, and so on) or with the default unit type (decimal). Each unit on the screan represents whatever you want it to be: an inch, a millimeter, a kilometer. Therefore, if you are drawing a motor part,one unit might equal a millimeter. If you are drawing a map, one unit might equal one kilometer. When you print or plot, you can set different scales for different sections of a drawing. You don’t need to think about setting a scale until you are ready to

print or plot your drawing. Although you don't specify the scale of your drawing until you plot, you can enter in advance the scaled size for

a. Text (if draw in model space)
b. Dimensions (if drawn in model space)
c. Non- continuous line type
d. Hatch patterns
e. Views (in layout viewpoint only)

Scaling these elements ensures that they arc at the correct final drawing.

SETTING DRAWING UNITS

Every object you draw is measured in units. You determine the values of the units within AutoCAD before you draw. You can set the unit type and number of the decimal places for objects, lengths and angles. You can also specify the unit for blocks and other content you insert from AutoCAD design center.

Drawing unit settings control-how AutoCAD interprets your coordinates and angle entries and how it displays coordinates and units in the drawing and in dialog boxes.

Setting drawing units does not automatically set units for dimensions. You generally set drawing units and dimensions unit to the same type and precision, but you can set different values for dimension units.

LINES

A line, the most basic object, can be one segment or a series of connected segments. With line, you can create a series of continuous line segments. Each single line segment can be edited separately from the other line segments in a series. You can close a sequence line segments so that the first and last segments are joined.

TO DRAW LINES

a. From the draw menu, choose line.

b. Specify the start point. You can use the pointing device or enter a coordinate on the command line.
c. Complete the first line segment by specifying the end point. To undo the previous line segment during the LINE command, enter U or choose undo on the toolbar.
d. Specify the endpoint of any additional line segments.
e. Press ENTER to end or C to close a series of line segments.
f. MODIFICATION
g. With AutoCAD, you can easily modify the size, shape and location of objects. You can either enter a command first then select the object to modify, or you can select the objects first and then enter a command to modify them. Double clicking on object displays the properties window or, in some case a dialog box that is specific to that type or objects.

CORRECTION

With AutoCAD, you can back-track your recent actions using one of the several methods.

SINGLE ACTION

The simplest method or backtracking is to use undo the standard toolbar or the U command to undo a single action. Many commands include their own U (UNDO) options so that you can correct mistakes without leaving the command. When you are creating lines and poly lines, for example enter U to undo the last segment.

SEVERAL ACTIONS

Use the mark option of UNDO to mark an action as you work. You can then use the back option of UNDO to undo all actions that occurred after the marked option. Use the begin and END options of UNDO to undo actions you have defined as a group.

You can also undo several actions at once with the Undo list on the standard toolbar.

REVERSE UNDO EFFECT

You can reverse the effect of a single U or UNDO command by using REDO immediately after using U or UNDO. You can also redo several actions at once with the redo list on the standard toolbar.

ERASE

You can erase any object that you draw. If you accidentally erase the wrong object,you can use the OOPS command to restore it.

COMMAND CANCELLATION

You can cancel a command without completing it by pressing ESC. To change the cancel key segment,clear the windows standard accelerator keys option in the options dialog box, user preferences tab.

ADVANTAGES OF AUTOCAD

1. It is easy to modify and edit the drawing
2. It is not time consuming
3. It is neat
4. It is the best way of drawing.

ELECTRICAL DRAWING FOR A DOMESTIC BUILDING

The increased demand of sophisticated and labour saving devices and other electrical gadgets has added complexity in electrical system and the need for greater number of practical workmen,technicians and designers who must know how to produce and interprete electrical drawings, wiring diagrams and other supplementary information found in working drawing and specifications has become pressing.

Drawing being an important method of communication should possess those attribute that will make it suitable for intended purpose .

Thus an ideal electrical drawing should be clear , concise , accurate and easily understandable . there should be sufficient data and legend for the electrical symbols used in the drawing .

The purpose `of electrical diagram is to effectively communicate information about about the electrical system or circuit in a simple format of lines and synbols. However, the electrical drafter must organize the information in a logical orderly manner.

When building drawing is completed by the architect or building technologist, a floor of the building is given to an electrical engineer for electrical design/drawing,which will serve as a guide for the electrical construction work in the building

Here many factors are put together into consideration/these factors are as follows

1. The number of points/outlets in each of the rooms; bedroom siting room, kitchen, toiletroom, lobby, passage/corridor and security light.
2. The position of these fittings/outlets
3. The switch positions.

NUMBER OF POINTS / OUTLETS

Before you embark on design work in the building, it is necessary to sort for the client's brief which will enable you to his desires concerning the illumination / outlets required.

In general the following is suggested in a simple bungall

a. SITTING ROOM

Four pieces of decorative/ordinary wall brackets.

Four pieces of 13A switch socket outlet

One Air conditioner

One ceiling fan, if the sitting room is so large,more than one fan is required.

2 DINNING ROOM

In a small dining room,the following are needed.

Two decorative wall brackets

Two pieces of 13A switch socket outlets

One ceiling fan

3 MASTERS BEDROOM

Two decorative / ordinary wall brackets

Two pieces of 13A switch outlets

One Air conditioner

One ceiling fan

4 MADAM'S BEDROOM

Two pieces of wall brackets

Two pieces of 13A switch socket outlets

One Air conditioner

One ceiling fan

5 CHILDREN'S ROOM

Two pieces of wall brackets

Two pieces of 13A switch socket outlets

Normally ceiling fan and air conditioner are not required in the childrens room unless the children are grown up

6 TOILET/ BATHROOM

One ceiling bowl fitting

One water heater

7 KITCHEN

One ceiling fitting

Two pieces of 13A switch socket outlet

1 cooker control unit

One Extractor fan

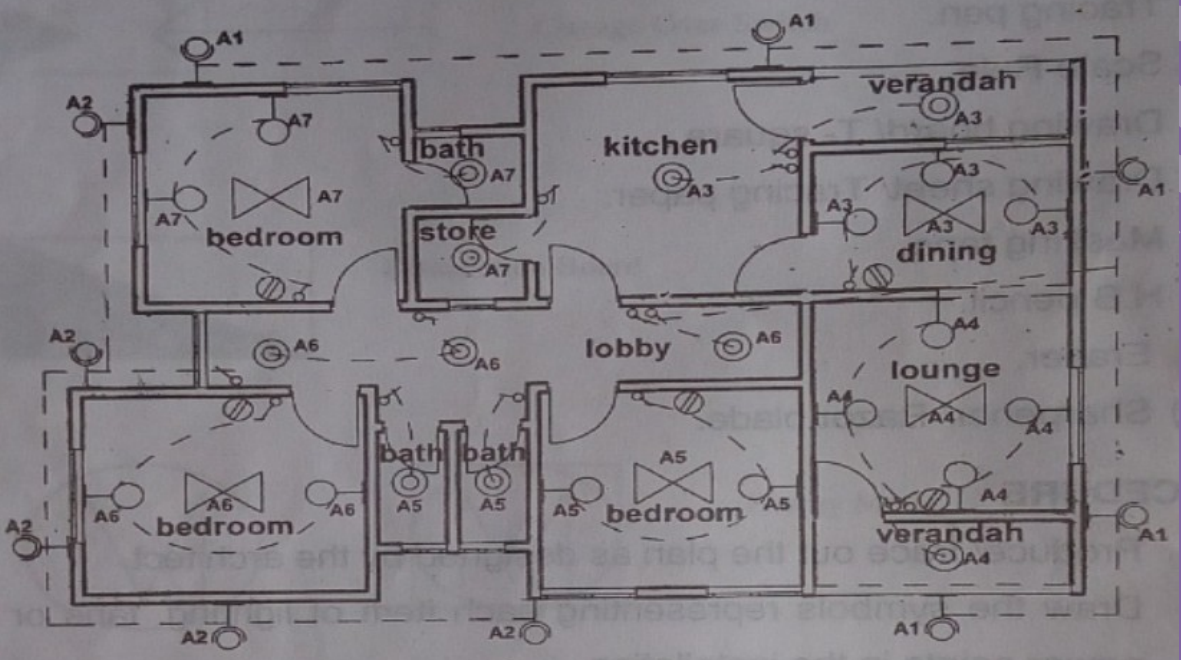
Always remember security light.

ELECTRICAL DRAWING OF A 3-BEDROOM FLAT

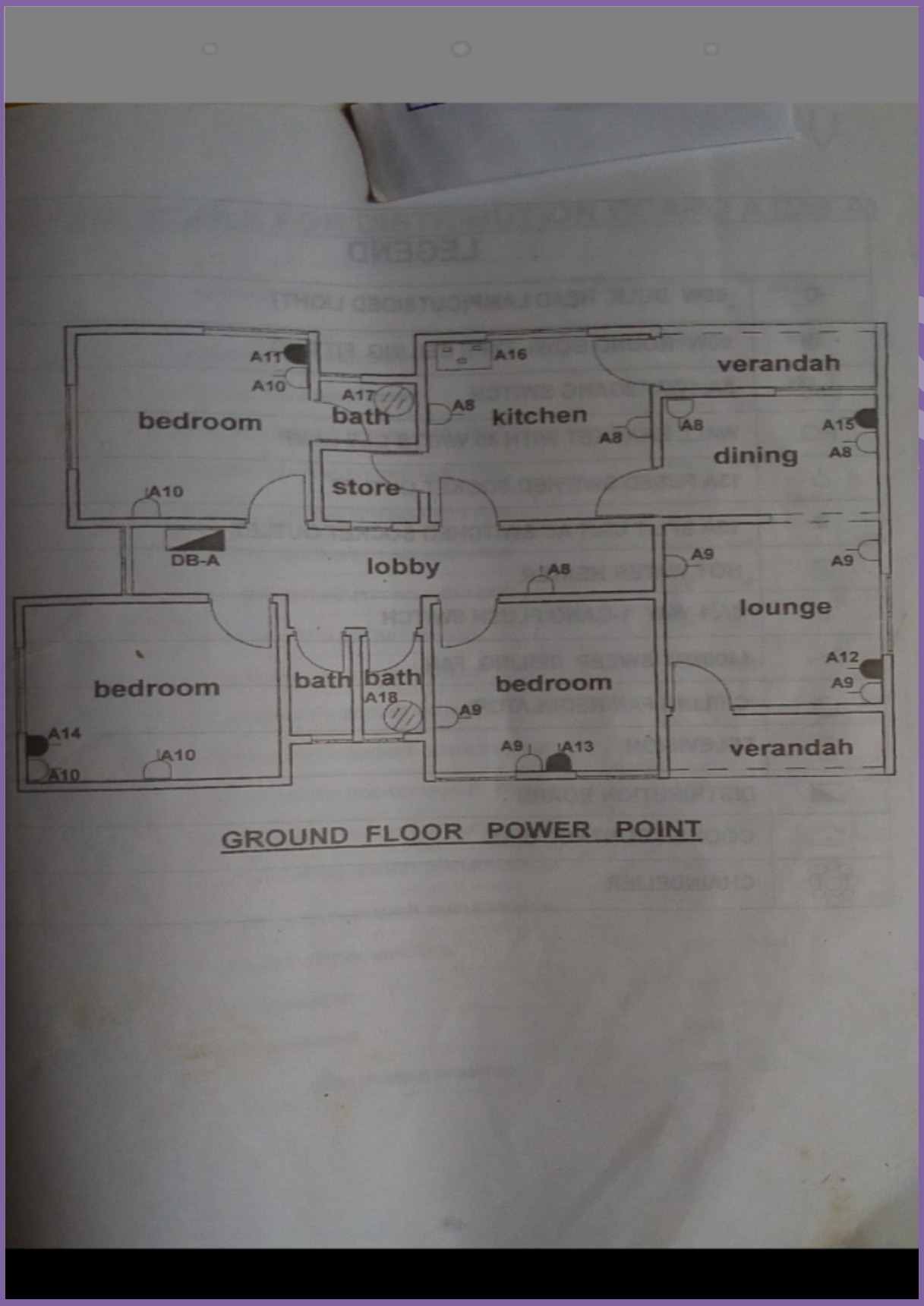
We need to do the following

1. Produce/ trace out the plan as designed by the architect.
2. Draw the symbols representing each item of lighting, fans or power points in the installation.
3. Group the fittings/power points into circuits
4. Prepare the load schedule / load balancing of the supply among the three phases.
5. Estimate the size of the DB required for the installation
6. Calculate the size in KVA of generator to be used when the public power supply fail.

DIAGRAM



GROUND FLOOR LIGHTING POINT



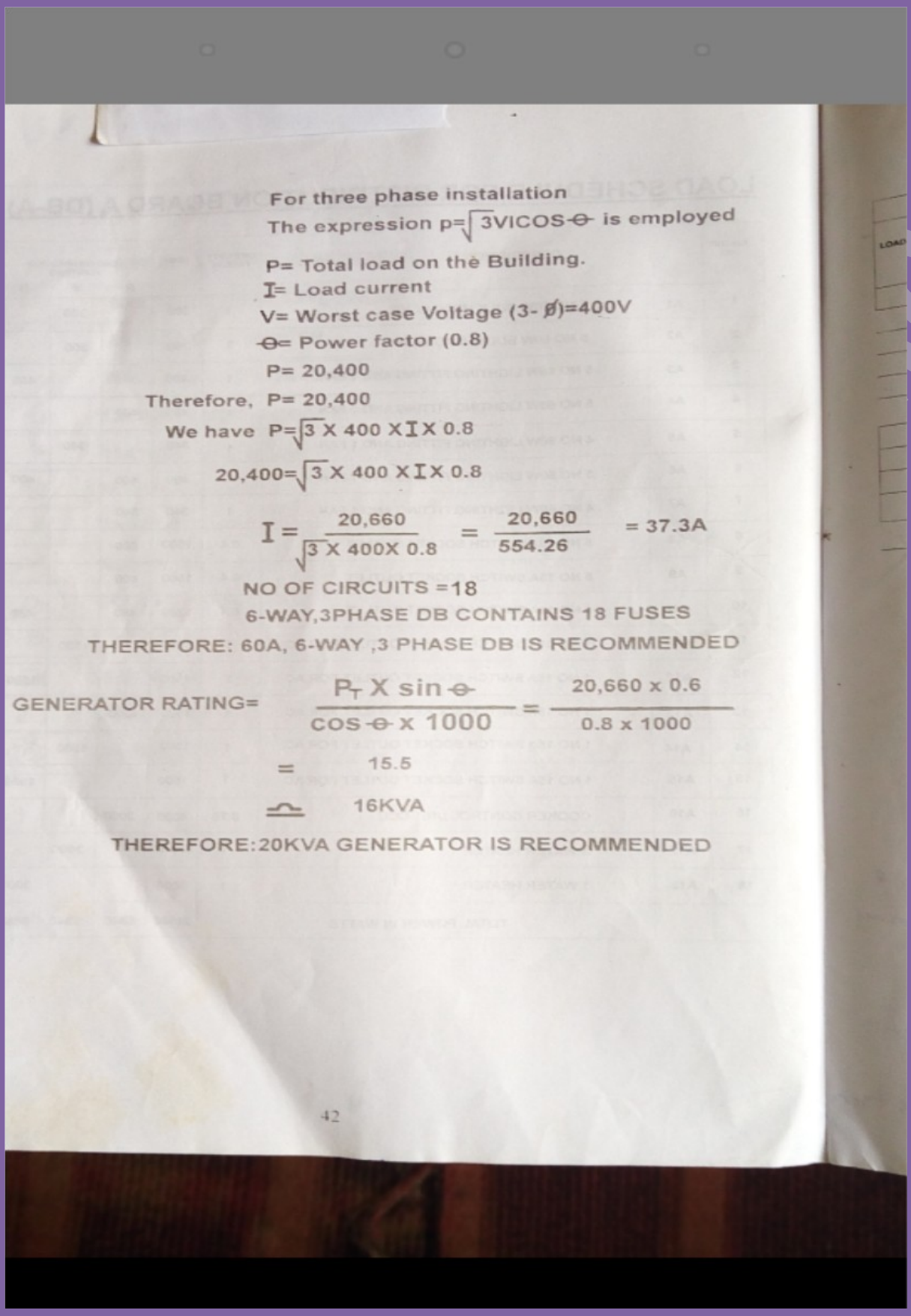
GROUND FLOOR POWER POINT

LEGEND	
	60W BULK HEAD LAMP(OUTSIDED LIGHT)
	60W ROUND BOWL TYPE CEILING FITTING
	5A,1WAY,2GANG SWITCH
	WALL BRACKET WITH 40 WATTS GLS LAMP
	13A FUSED SWITHED SOCKET OUTLET
	15A SPLIT UNIT AC SWITCHED SOCKET OUTLET
	HOT WATER HEATER
	5A 1-WAY 1-GANG FLUSH SWITCH
	1400MM SWEEP CEILING FAN
	CEILING FAN REGULATOR
	TELEVISION
	DISTRIBUTION BOARD
	COOKER CONTROL UNIT
	CHAINDELIER

LOAD SCHEDULE FOR DISTRIBUTION BOARD A (DB-A)

CIRCUIT NO	DESCRIPTION		DIVERSITY FACTOR	LOAD	LOAD DISTRIBUTION POINTS(W)		
					R	Y	B
1	A1	5 NO 60W BULK HEAD LAMP	1	300		300	
2	A2	5 NO 60W BULK HEAD LAMP	1	300		300	
3	A3	5 NO 60W LIGHTING FITTING AND 1 FAN	1	400			400
4	A4	5 NO 60W LIGHTING FITTING AND 1 FAN	1	400	400		
5	A5	4 NO 60W LIGHTING FITTING AND 1 FAN	1	340		340	
6	A6	5 NO 60W LIGHTING FITTING AND 1 FAN	1	400	400		400
7	A7	4 NO 60W LIGHTING FITTING AND 1 FAN	1	340	340		
8	A8	5 NO 13A SWITCH SOCKET OUTLET	0.4	1500	600		
9	A9	5 NO 13A SWITCH SOCKET OUTLET	0.4	1500	600		
10	A10	4 NO 13A SWITCH SOCKET OUTLET	0.4	1200	480		480
11	A11	1 NO 15A SWITCH SOCKET OUTLET FOR AC	1	1500		1500	
12	A12	1 NO 15A SWITCH SOCKET OUTLET FOR AC	1	1500			1500
13	A13	1 NO 15A SWITCH SOCKET OUTLET FOR AC	1	1500	1500		
14	A14	1 NO 15A SWITCH SOCKET OUTLET FOR AC	1	1500		1500	
15	A15	1 NO 15A SWITCH SOCKET OUTLET FOR AC	1	1500			1500
16	A16	COOKER CONTROL UNIT CCU	0.75	4000	3000		
17	A17	1 WATER HEATER	1	3000		3000	
18	A18	1 WATER HEATER	1	3000			3000
		TOTAL POWER IN WATTS		24180	6840	6940	6880

GENERATOR RATING / DB RATING CALCULATIONS



For three phase installation

The expression $p=\sqrt{3}VICOS\theta$ is employed

P= Total load on the Building.

I= Load current

V= Worst case Voltage (3- ø)=400V

θ= Power factor (0.8)

P= 20,400

Therefore, P= 20,400

We have $P=\sqrt{3} \times 400 \times I \times 0.8$

$20,400=\sqrt{3} \times 400 \times I \times 0.8$

$$I = \frac{20,660}{\sqrt{3} \times 400 \times 0.8} = \frac{20,660}{554.26} = 37.3A$$

NO OF CIRCUITS =18

6-WAY,3PHASE DB CONTAINS 18 FUSES

THEREFORE: 60A, 6-WAY ,3 PHASE DB IS RECOMMENDED

$$\text{GENERATOR RATING} = \frac{P_T \times \sin\theta}{\cos\theta \times 1000} = \frac{20,660 \times 0.6}{0.8 \times 1000}$$

$= 15.5$

$\simeq$ 16KVA

THEREFORE:20KVA GENERATOR IS RECOMMENDED

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WIRING NOTE

1. All lighting fittings and fan points shall be wired and connected to the sub-circuit in the distribution board and the circuit shall be wired with 2x1.5mm pvc cable
2. All lighting switch shall be as specified on the drawings and they shall be mounted at height of 1350mm above the finished floor level
3. All 13A switch socket outlet bearing the same number shall be ring circuit and wired with 3x2.5mm pvc insulated cable mounted at a height of 450mm above the finished floor level except otherwise indicated.
4. All 15A switch socket or switch fuse for AC shall be wired with 3x4mm pvc cable and be connected direct to sub circuit for AC unit.
5. All wiring shall be of concealed system (pvc)
6. All materials shall be as specified and or approved equal.
7. All installation shall comply with I.E.E regulation (latest edition)
8. All water heater and cooker units shall be connected direct to distribution board with approved materials
9. Positions of parts are schematic only. They should not be scaled
10. All ambiguities shall be reffered to the electrical design engineer.
11. Draw boxes shall be provided for every 9000mm run of conduit pipe or in such places where it will be difficult to draw the cable without abrasion to insulation.

ESTIMATION OF ELECTRICAL INSTALLATION

Estimating means to determine the quantities of various items required to execute a job and to assess the cost of the execution. The cost is determined by consulting the price catalogue and schedule of labour rates. The various steps to form an estimate are:

1. Check out a list of items and quantities required.
2. Consult the rate catalogue for pricing the various items

3. Asses the exact number of workmen required to complete the job and after consulting the schedule of labour rates, add the labour cost to the estimate under preparation. It should be noted that number of workmen required is dependent upon the time limit fixed to complete the service.
4. Add supervision charges and executor's profit
5. In case of govt, organization, where the work is to be executed by the contractor, the tenders are floated only after correctly specifying the description of each item, to avoid any misunderstanding while execution.

PRICE CATALOGUE

It is in the form of a booklet in which rates of various terms are indicated. The price catalogue is required to be amended as and when there is variation in the market.

DOMESTIC WIRING ESTIMATE

This is the last stage in the presentation of electrical design/drafting. It is the process of extracting the quantity of each item of an installation as obtained from the architectural drawing presentation. This helps the contractor to produce the bill of quantities with respect to the net price of each item, the total price of all the items and equipments involved in the installation. The cost or estimation of labour is also considered. it is good to make estimation work in a tabular form.

After obtaining the blue prints from the architect. The electrical engineering or the electrical contractor goes through the plans and collects the specification of the electrical wiring asked for. then he prepares an estimate, which must comprise the estimates for.

1. Accessories required and their cost.
2. Wiring materials (conduit and cables) and their cost
3. Labour

Under accessories comes an estimate for the number and types of switches, sockets, lamp holders, ceiling roses etc. usually specified in the drawing and

the estimator is simply to add. Under wiring material comes in the length of the conduit or PVC casing-capping or wooden battern required for the completion of the wiring.

Labour is the most difficult part to be assessed. There are many factors upon which labour cost depend, such as nature of construction of building, its distance from the normal working point and the type of wiring to be adopted. Usually labour can be determined by calculating man days and multiplying by the charges per day.

PROCEDURE TO BE FOLLOWED WHILE ESTIMATING FOR THE INTERNAL WIRING

1. System and method of wiring
2. No of sub circuits to be wired
3. Sizes of cable from main distribution board to final sub-circuits
4. Sizes and length of conduit
5. Cost of materials including transport
6. Labour for wiring
7. Tools charges if any, contingencies
8. Overhead charges,
9. Special fittings if any.

POINTS TO BE ADHERED TO WHILE PREPARING THE ESTIMATE

1. Length of conduit required can be calculated by going through the plan of the building. These are available in bundles.
2. Allow 10% of total length for wastage ; take the length of conduit after allowance for wastage in any system.
3. To calculate the length of wire,take the length of conduit after allowance for wastage. The length of wire can be taken as 2.5 times the length of conduit for looping system and 2 times for junction box system.

4. For material handling(i.e transport charges of materials to the site) will usually be judged by the route length and available cargo movers. It should not be more than 5% of material cost
5. Overhead charges will generally be assumed as 10% to 15% of the total cost
6. Any wiring system has to last for 25 years. Hence high quality materials are to be used, high quality workmanship must be executed through qualified contractors.
7. For loads above 4KW, 3phase supply must be arranged
8. Provide lighting arresters for high-rise buildings
9. Provide earth leakage circuit breakers for loads exceeding 5kw
10. Insist on safety precautions as contained in the IEE regulation.

CONDUCTOR SIZE CALCULATION FOR INTERNAL DOMESTIC WIRING

The important point to be considered is the current carrying capacity, the voltage drop is usually very small magnitude and will not have much effect for domestic wiring. For multistory buildings, factories and industries, the voltage drop is required to be ascertained. If the voltage drop is much, the household appliance and motors will not work.

It should be noted that maximum voltage drop should not be more than as given below

LIGHTING CIRCUIT : In any circuit at,

1. At 200V, voltage drop should not be more than 5V
2. At 210V supply, voltage drop should not be more than 5.1 volts
3. At 220V supply, voltage drop should not be more than 5.4 volts
4. At 230 volts supply, voltage drop should not be more than 5.6 volts
5. At 240 volts supply, voltage drop should not be more than 5.8 volts
6. At 250 volts supply, voltage drop should not be more than 6.0 volts.

From the above it will be seen that the permissible voltage drop in any lighting circuit is 2% of the supply voltage plus one volt.

For industrial loads, the maximum voltage drop at the extreme end equipment or motor should not be more than 5% of the declared supply voltage.

Considering the load in amperes and voltage drop , suitable size of wire with required insulation is selected. In similar fashion flexible cord is selected .

Example

A room is to be wired for single –phase A.C supply directly taken from mains, which has declared voltage of 200 volts. The length wire from the mains switch to light and plug points is 30 meters if the wire is to carry 5amps, determine the size of conductor

SOLUTION

Permissible voltage drop = 200x2/100 +1 = 5volt

The minimum size of wire is 1.5mm (1/1.40) should be in position to carry 5amps safely. Now it will be seen that there will be a drop of 1 volt after every 2.3 meters for 10ampers loading.

Therefore voltage drop at 10amps = 30/2.3

Voltage drop at 5amps = 30/2.3 x 5/10

= 6.52V.

Hence this is not suitable, now considering the next higher size i.e 2.5sq mm (1/1.80) wire

Voltage drop at 15amps = 30/2.5

Therefore voltage drop at 15amps

= 30/2.5 x 5/15 = 4V

This is within permissible limit. This wire having size 2.5 sqmm (1/1.80) is suitable

Table 4.1

Current ratings and voltage drop for vulcanised rubber PVC or polythene insulated or tough Rubber PVC lead sheathed single core aluminium wires or cables

Size of Conductor		2 Cables d.c. or Single-phase a.c.		3 or 4 cables of balanced 3-phase		4 Cables d.c.	
Normal area sq. mm.	Number and diameter of wire in mm.	Current rating in amperes	Approx. length of run for volt-drop in metres	Current rating in amperes	Approxi. length of run for 1 volt drop in metres	Current rating in amperes	Approx. length of run for 1 volt drop in metres
1.5	1/1.40	10	2.3	9	2.9	9	2.5
2.5	1/1.80	15	2.5	12	3.6	11	3.4
4.0	1/2.24	20	2.9	17	3.9	15	4.1
6.0	1/2.80	27	3.4	24	4.3	21	4.3
10.0	1/3.55	34	4.3	31	5.4	27	5.4
16.0	7/1.70	43	5.4	38	7.0	35	6.8
25.0	7/2.24	59	6.8	54	8.5	48	8.5
35.0	7/2.50	69	7.2	62	9.3	55	9.0
50.0	7/3.0] 19/1.80]	91	7.9	82	10.1	69	10.0

Example

EXAMPLE

A three phase 3-wire connection is to be given to a premise in which an electric motor 50 hp is to be installed, 40 meters of wire run from the main switch is required for this purpose. Determine the size of the wire to be used if available voltage is 400 volts.

SOLUTION

Assuming P.F. as 0.8

Current drawn by the motor

50x746/square root (3X400X0.8) = 67.30amps

If 3-core cable is used, then on referring table

It will be seen that 70sqmm (19/2.24) PVC cable will be in position to carry the motor safely. The permissible voltage drop

=400x5/100 = 20volts

Voltage drop at 82amps

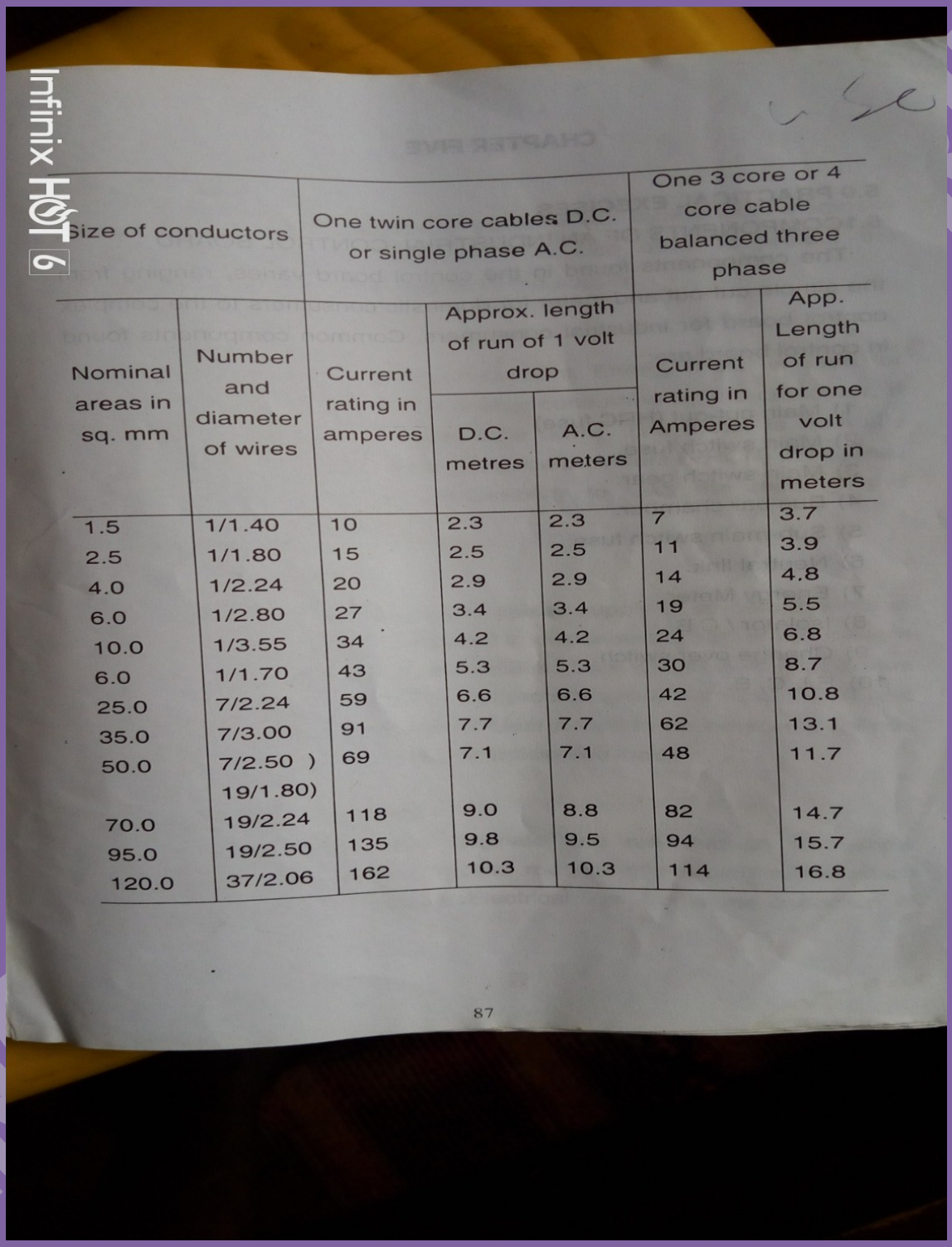
= 40/14.7

Voltage drop at 67.30

=40/14.7 x 67.30/82 = 2.21volts

As the drop is within permissible limit, hence 3-core PVC cable size 70sqmm (19/2.24) is suitable.

Current ratings and voltage drop for vulcanized rubber, pvc or polythene insulated or tough rubber, pvc lead sheathed twin, three or four core aluminum wires or cables



Size of conductors		One twin core cables D.C. or single phase A.C.			One 3 core or 4 core cable balanced three phase	
Nominal areas in sq. mm	Number and diameter of wires	Current rating in amperes	Approx. length of run of 1 volt drop		Current rating in Amperes	App. Length of run for one volt drop in meters
			D.C. metres	A.C. meters		
1.5	1/1.40	10	2.3	2.3	7	3.7
2.5	1/1.80	15	2.5	2.5	11	3.9
4.0	1/2.24	20	2.9	2.9	14	4.8
6.0	1/2.80	27	3.4	3.4	19	5.5
10.0	1/3.55	34	4.2	4.2	24	6.8
6.0	1/1.70	43	5.3	5.3	30	8.7
25.0	7/2.24	59	6.6	6.6	42	10.8
35.0	7/3.00	91	7.7	7.7	62	13.1
50.0	7/2.50) 19/1.80)	69	7.1	7.1	48	11.7
70.0	19/2.24	118	9.0	8.8	82	14.7
95.0	19/2.50	135	9.8	9.5	94	15.7
120.0	37/2.06	162	10.3	10.3	114	16.8

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CHAPTER 11

EARTHING

It is common knowledge that electric current flows through the part of least resistance that leads to the earth or ground and any current flowing on the body of an unearthed device due to a live wire in contact with the body of the device will cause anyone in contact with it to experience an electric shock (the human body acting as the path of least resistance to the earth), hence the importance of earthing.

EARTHING OF ELECTRICAL DEVICES

All electrical devices in an electrical installation must be properly earthed to the ground to prevent An electrical shock to prospective operators or maintenance personnel. Electrical devices such as gear switch; changeover; protection panel; distribution board; pumps and the Gen-set. A proper earthing is made by connecting the chassis of all electrical devices to ground using a minimum of 10mmsq copper cable with a log, to the earth bar. Tight connections of the earth terminals will improve the quality of the earthing installation.

PROTECTION AGAINST LIGHTING

Lightning is an emission of a high density of electrically negative charges accumulated in rain clouds, this discharge of electrical charges are attracted to earth (being a reservoir of electrical charges) and will follow through the highest installation as a conductive path of least resistance to earth, this path could include tall buildings, telecommunication towers and other structures directly linked to the earth.

Apparently we realize the importance of a protection against this lightening discharge, and can be achieved by the installation of a THUNDER ARRESTER.

THUNDER ARRESTER INSTALLATION

It is a fact that lightening are electrical charges that discharge from rain clouds to earth, through the highest installation or structure having the path of least resistance. With this knowledge we can now protect our structures and in turn our electrical installation from a lightening strike.

This is achieved by erecting a better conductor of electric current as compared with other structures on site as the highest point of our installation.

A good protection against lightning is made by erecting a thunder arrester as the highest point of our installation and connecting it to earth using a 25mmsq pure copper tape and earth mat of minimum dimensions of 2x2 feet buried to a minimum depth of 4 feet under ground level. A measurement point must be made to allow for measurement of resistance of the thunder arrester installation. The idear is to create a safe path of minimum resistance for the discharge of a lightning strike to the earth.

EARTHING SPECIFICATIONS

1. The thunder arrester should be the highest point of the electrical installation.
2. The 25mmsq copper tape for the thunder arrester should be fastened to the wall with clips
3. An earth test should be done after earthing installation is completed
4. Earth resistance should be less than 5 ohms.

EARTHING OF INSTALLATIONS

Earth is defined as a connection to the general mass of the earth. A conductor or other metal is said to be earthed when it is effectively

connected to the general mass of the earth by means of a metal rod. Earthing means all the processes involved in achieving a good earth. Earthing is carried out to ensure that all the metal parts of all electrical equipment and other current carrying parts cannot have a potential above earth in the event of a fault which might otherwise cause danger of electric shock.

PROCEDURE

1. For domestic installation a pit of 4 x 4 x 4 feet is provided for earthing.
2. The earth rod is driven vertically into the ground in a damp position, and earth continuity conductor connected to it.
3. Place charcoal and animal dung
4. Pour enough water to the pit
5. Hold the earth wire neatly on the wall to the consumers earth terminal, and get it properly connected
6. Cover the pit very well.

THUNDER PROTECTION IN A DOMESTIC WIRING

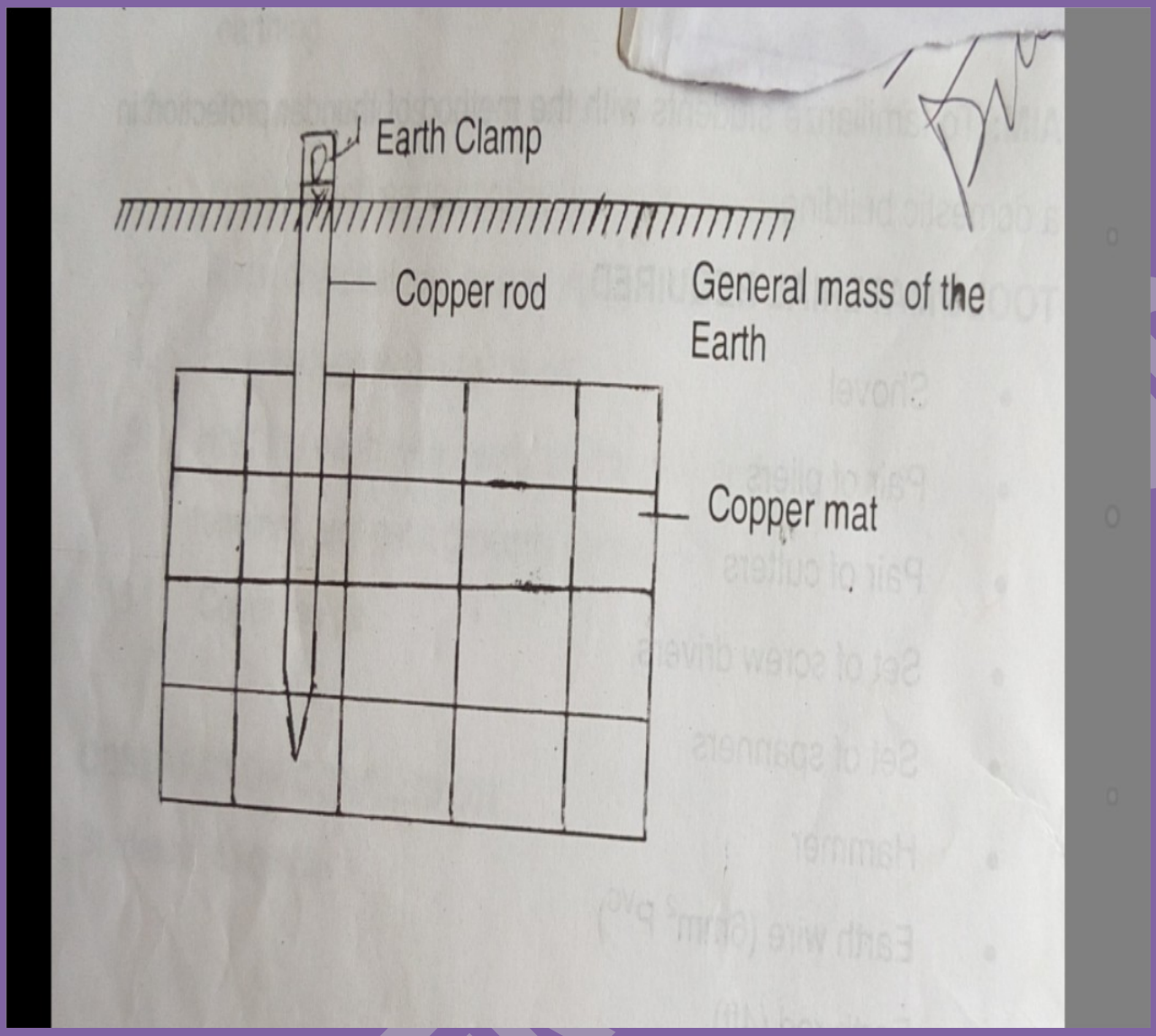
Materials required

1. Earth wire (6mmsq pvc)
2. Earth rod (4ft)
3. Charcoal
4. Animal dung
5. Water
6. Copper tape/clip
7. Arrester (arrow)
8. Copper nails

DIAGRAM

PROCEDURE

1. For domestic installation a pit of 4 x 4 x 4 feet is provided for thunder protection.
2. The earth rod is driven vertically into the ground in a damp position
3. A bare copper conductor plate or strip (lattice plate) is laid in a shallow trench in a suitable position preferable damp arear.
4. The lead should be about 3 inches above the pit level which must be damp at all times for the earth to be effective.
5. Place animal dung and charcoal
6. Pour enough water to the pit.
7. Link the copper tape to the copper basket and ensure a firm contact
8. Hold the copper tape neatly on the wall to the zinc layout and affix neatly on the base of the arrow/pointer.
9. Cover the pit very well.



SAFETY PRECAUTIONS

There is need for safety while working on your electricity system. Also you must take steps to safeguard yourself and others who will later be using the system. Faulty wiring and appliances are dangerous and can be lethal. Whenever you are dealing with electricity, the rule must be **'safety first'**. The following rules must also be observed.

1 Never inspect or work on any part of an electrical installation without first switching off the power at the consumer unit and removing the relevant circuit fuse and circuit breaker from the unit.

2 Always unplug a portable appliance or light before doing any work on it

3 Always double check all your work especially connections before you turn the electricity on again

4 Always use the correct tools for an electrical job and use good quality equipment and materials.