Ethiopian TVET-System

Electro Mechanical Equipment Operation and Maintenance

NTQF Level -III

Module Title: Maintaining Induction Motor Functions

TTLM Code: EIS EME3TTLM0920 v1

This module includes the following Learning Guides

LG45: Identifying types of starting motor

LG Code: EIS EME4 M11 LO1-LG 45

LG 46: Prepare circuit diagrams

LG Code: EIS EME4 M11 LO2-LG-47

LG 48: Mounting equipment and testing devices

LG Code: EIS EME4 M11 LO3-LG-48

Instruction Sheet 1	Learning Guide 45: Identifying types of starting motor

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Introduction to Induction motor and its components
- Types of Induction Motor starting and its Components
  - Dol (direct on line)
  - forwarded and reversed
  - Star- Delta
  - Auto Transformer
  - Soft starter methods

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to

- Identify components of direct on line
- Know components of forward and reverse starting method
- Identify components of Star-delta starting method
- Identify components of auto transformer starting method
- Know method of starting soft star starter

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 14.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the Self-check 1,

5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1
7. Submit your accomplished Self-check. This will form part of your training portfolio.
8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2”
10. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3”
13. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
14. If you earned a satisfactory evaluation, proceed to “Operation Sheet 1” However, if your rating is unsatisfactory, see your teacher for further instructions or go back to for each Learning Act

Information Sheet-1	Introduction to Induction motor and its components

1.1 Introduction

Induction motors are basically asynchronous AC motor where power is supplied to the rotating device by means of electromagnetic induction. They can operate on either single phase or three phase ac supply, however the single phase induction motors are suitable only for few applications. almost 85% applications the three phase induction motors are preferred. Depending on the type of rotor, the induction motor are classified into two types, slip ring induction motors and squirrel cage induction motors type.

1.2. Construction of three phase induction motors

. A 3-phase induction motor has two main parts (i) stator and (ii) rotor. The rotor is separated from the stator by a small air-gap which ranges from 0.4 mm to 4 mm.

Shaft- for transmitting the torque to the load. This shaft is made up of steel.

Bearings:- for supporting the rotating shaft.

Fan :-used for cooling purpose

Terminal box:-.used for receiving external electrical connection

Air gap:- the small distance between stator and rotor approximately varies from 0.4mm to 4 mm.

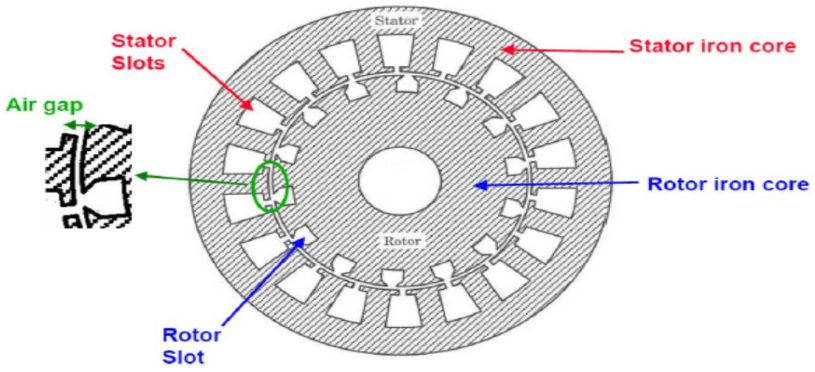


Figure 1.1.part of induction motor

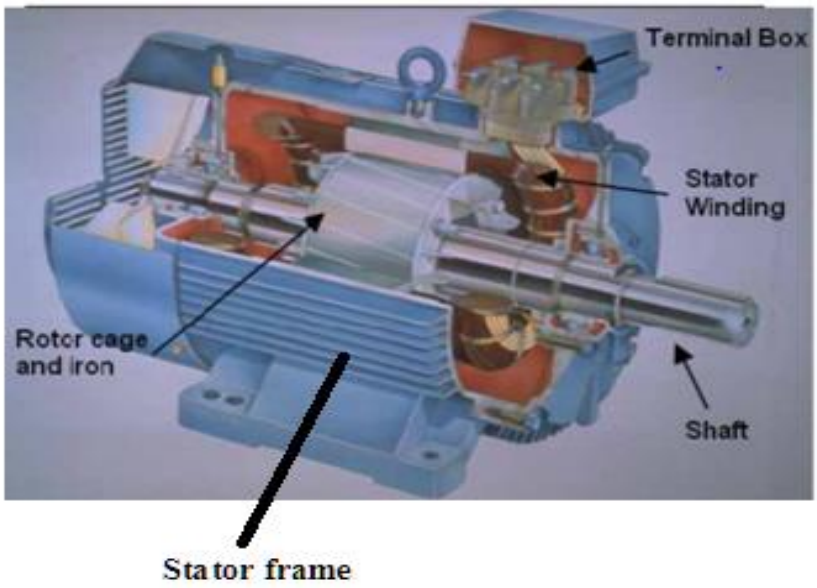


Figure1.2 Sectional view of three phase induction motor stator and rotor

Stator: As its name indicates stator is a stationary part of induction motor. It is made up of number of stampings in which different slots are cut to receive 3 phase winding circuit which is connected to 3 phase AC supply

Slots: - is the house of the conductor in which rotating magnetic field is produced after AC supply is given to them.

A stator winding: - is placed in the stator of induction motor and the three phase supply is given to it. The three phases of the winding are connected either in star or delta depending upon which type of starting method is used. The windings are wound for a definite number of poles depending upon the speed requirement, as speed is inversely proportional to the number of poles, given by the formula: Ns= 120f/p

Where Ns= synchronous speed f = Frequency p = no. of pols

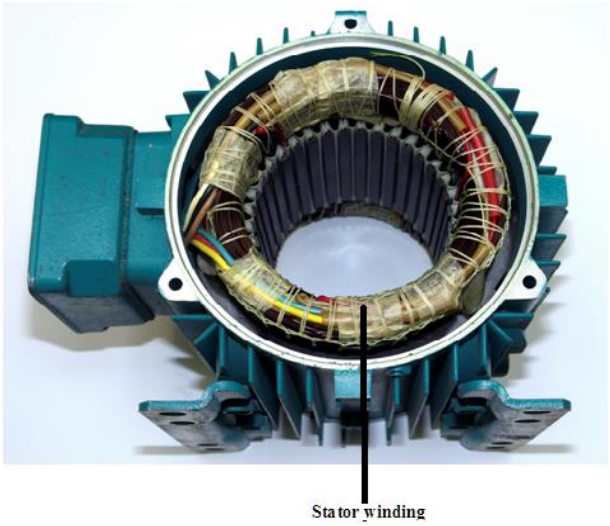


Figure 1.3. stator and its windings

Stator Frame

It is the outer most part of the three phase induction motor. Its main function is to support the stator core and the field winding. It acts as a covering and it provide protection and mechanical strength to all the inner parts of the induction motor.

Stator Core

The main function of the stator core is to carry the alternating flux. In order to reduce the eddy current loss, the stator core is laminated. These laminated types of structure are made up of stamping which is about 0.4 to 0.5 mm thick

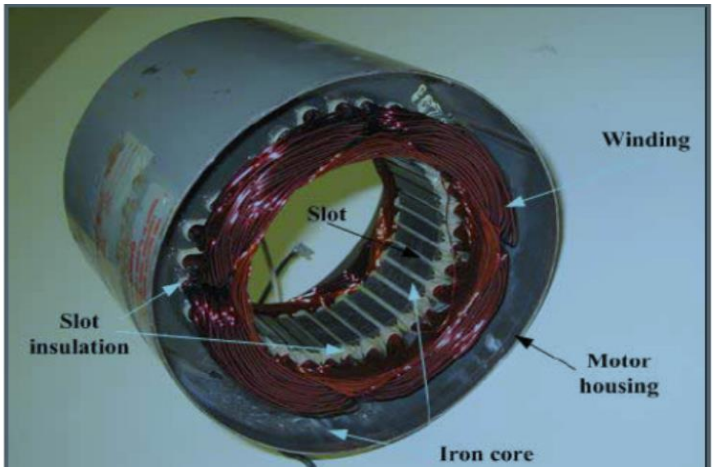
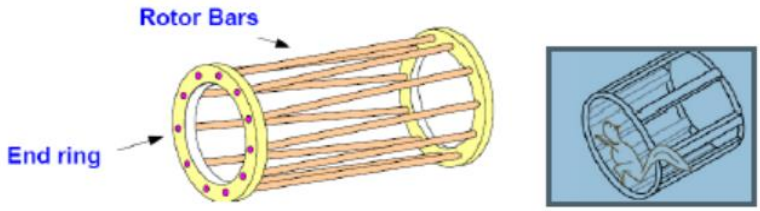


Figure 1.4. The internal components three phase motors

Rotor

The rotor is a rotating part of induction motor. The rotor is connected to the mechanical load through the shaft. Rotor consists of cylindrical laminated core with parallel slots that carry conductor bars. Conductors are heavy copper or aluminum bars which fits in each slots. The slots are not exactly made parallel to the axis of the shaft but are slotted a little skewed for the following reason, they reduces magnetic hum or noise and They avoid stalling of motor.



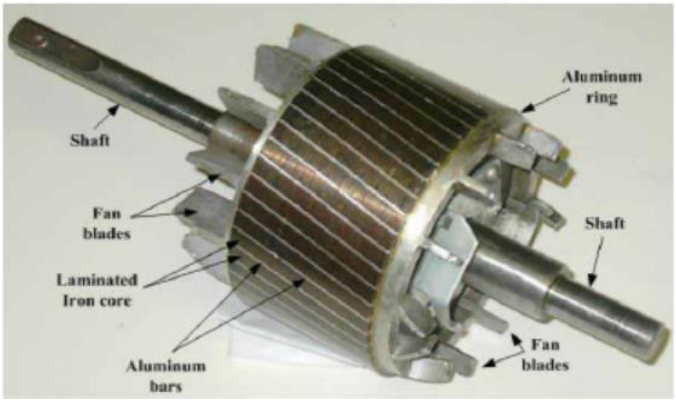


Figure 1.4 squirrel cage rotor

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is induction motor? (2pts)
2. Write the difference between stator frame and yoke? (2pts)
3. List construction parts induction motors parts (6pts)

Note: **Satisfactory rating - 10points** **Unsatisfactory - below 10 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1. ----------
2. ----------
3. ----------

Information Sheet-2	Types of Induction Motor starting and its Components

2.1 Introduction

A 3-phase induction motor is theoretically self-starting. The stator of an induction motor consists of 3-phase windings, which when connected to a 3-phase supply creates a rotating magnetic field. The magnetic field created by the rotor will interact with the rotating magnetic field in the stator and produce rotation. Therefore, 3-phase induction motors employ a starting method not to provide a starting torque at the rotor, but because of the following reasons; There are various methods of starting of an induction motor:

1.1. Direct on line starting (DOL)
1.2. Star – Delta starting
1.3. Forwarded and Reversed
1.4. Auto transformer starting
1.5. Soft-start

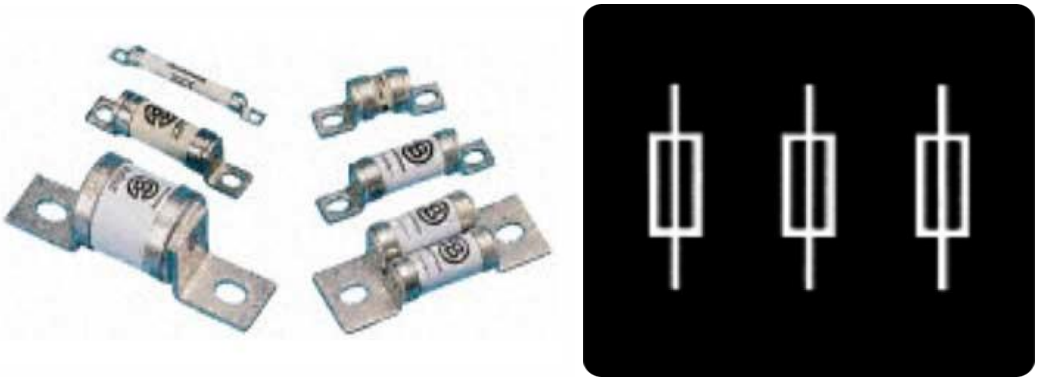
2.2. Direct on line starting (DOL)

The Direct On-Line (DOL) starter is the simplest and the most inexpensive of all starting methods and is usually used for squirrel cage induction motors. It directly connects the contacts of the motor to the full supply voltage. The starting current is very large, normally 6 to 8 times the rated current. The starting torque is likely to be 0.75 to 2 times the full load torque. In order to avoid excessive voltage drops in the supply line due to high starting currents, the DOL starter is used only for motors with a rating of less than 5KW.

2.2.1 Components of direct on line (DoL)

Fuse or circuit breaker, Contactors, Over Load Relay (Overload protection), Pushing Start Button, Release Start Button and Pushing Stop Button

Fuse :-is over current protective device this means that it blows the current is above the rated value .



(a) (b)

Figure 2.1 (a) Shows fuse electrical device and b shows electrical symbol

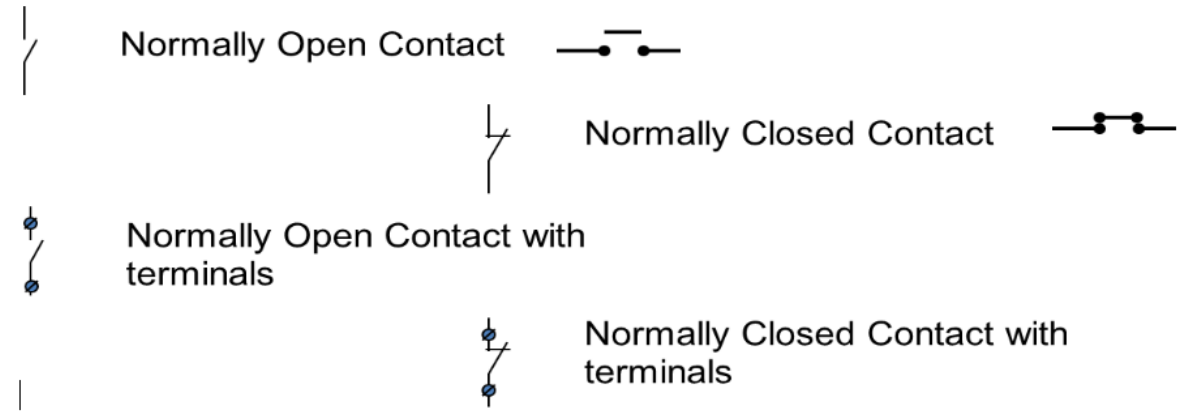
Circuit breaker (CB):- is an electrical device used to interrupt the circuit during fault condition automatically.

(a) (b)

Figure 2.2 (a) and (b) shows electrical and symbols of circuit breaker respectively

Magnetic Contactor :- is a control device that uses a small control current to energize or de-energize the load connected to it. This means that it makes the circuit while energized and break s a circuit when de energized

Contacts Symbols



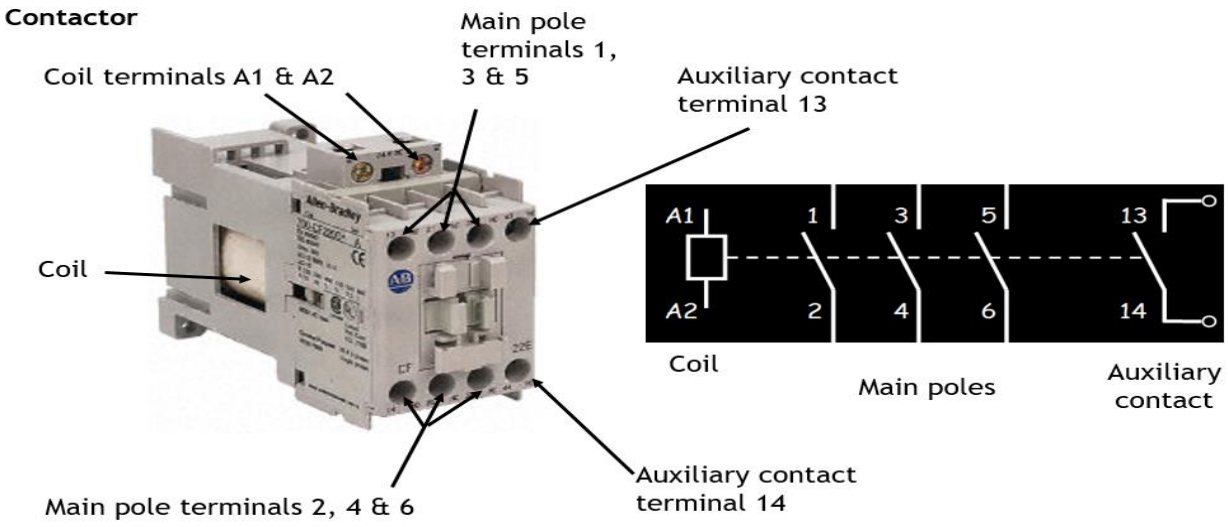


Figure 2.3 . contactor electrical device and its components

An Auxiliary contactor: -is a regular (low-power) relay - but built like a regular contactor and when used together with another contactor it is called auxiliary contactor to clarify that it is not used for switching loads but has an activation/deactivation the system it is operated by power supply of ac 220v. it has normally closed and open terminals for more information see figure 2.3 above

Thermal overload relay :- are protective devices. They are designed to cut power if the motor draws too much current for an extended period of time.

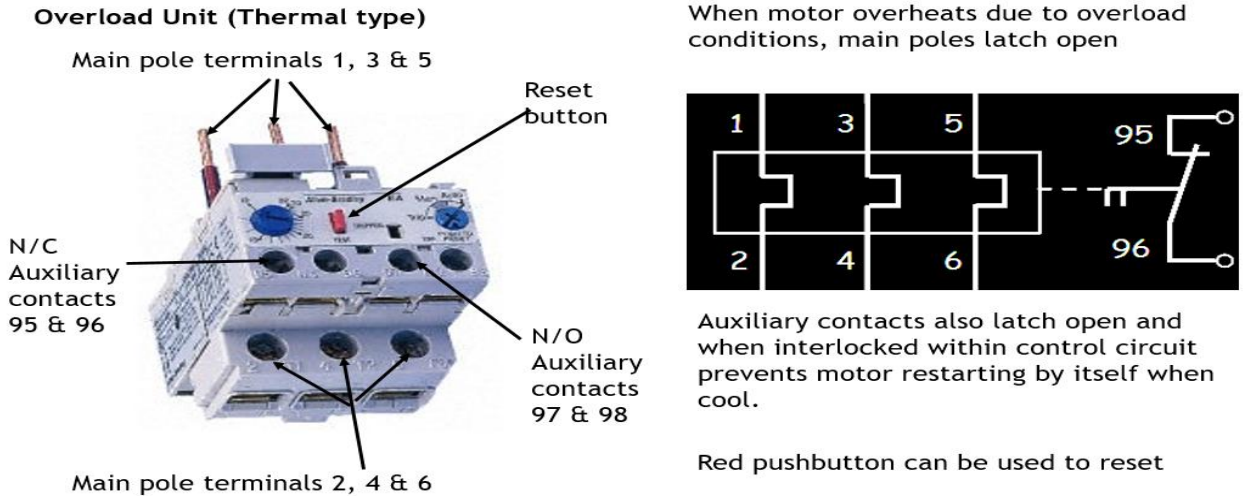
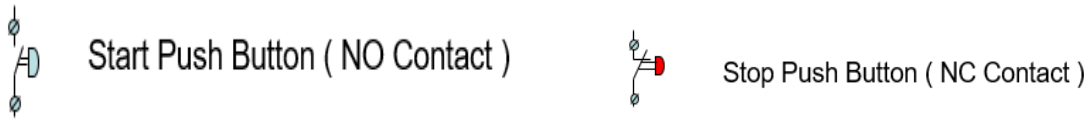


Figure 2.4. parts of thermal overload relay and its symbols

Push button :-is an electrical device used to make and break the power supply pushing on the device there are start and stop push button.

Electrical symbol



- Normally open
  - ❖ electrical contact is made when button is pressed
- Normally closed
  - ❖ electrical contact is broken when button is pressed

- Internal spring returns button to its un-pressed state

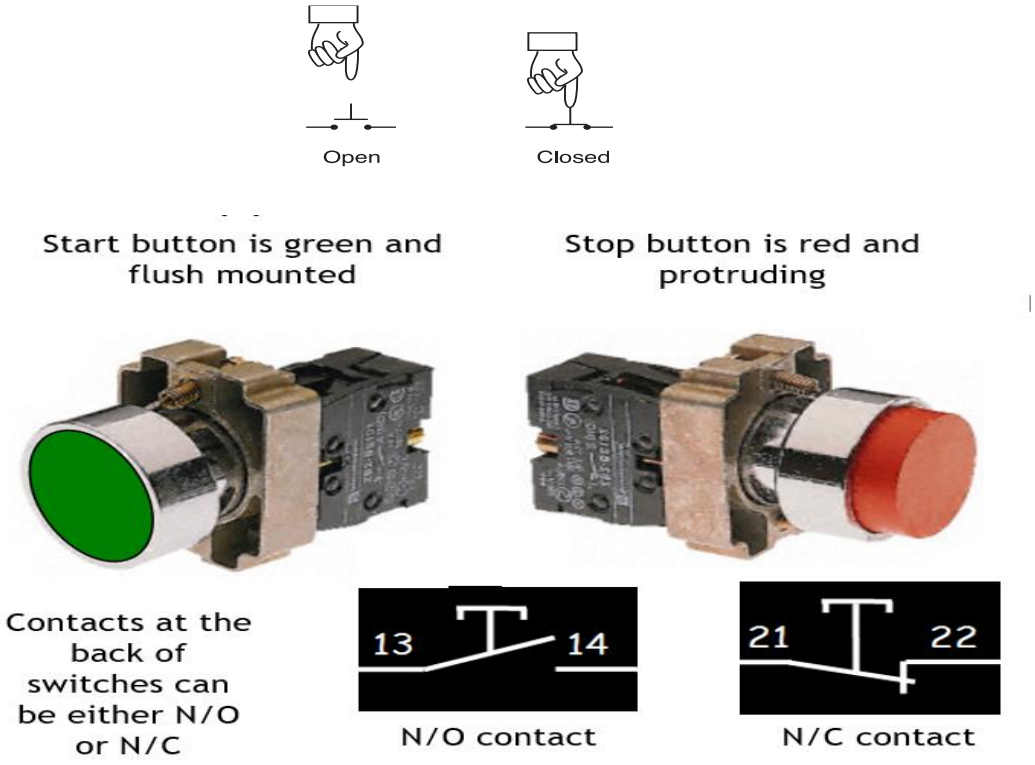


Figure 2.5 Electrical device and symbol of start and stop push button

Selector switch selector :- an electrical or a mechanical electronic device for making or breaking or changing the connections in a circuit.

Figure 2.6 Selector switch device

2.3. Star –Delta starting method

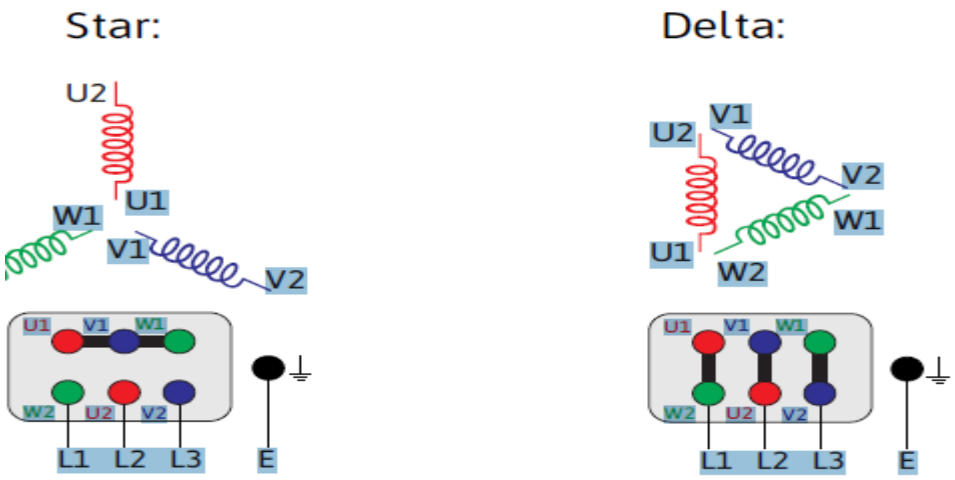


Figure 2.7.shows the terminal connection of star and delta

The voltage between phase to phase in star or delta connection is

V1-u1= 380v/400v v1-w1=380v/400v u1-w1=380v/400v

But the voltage between phase and neutral is 220v/250v

The star delta starting is a very common type of starter and extensively used, compared to the other types of the starters.

This method used reduced supply voltage in starting.it achieves low starting current by first connecting the stator winding in star configuration, and then after the motor reaches a certain speed, throw switch changes the winding arrangements from star to delta configuration. By connecting the stator windings, first in star and then in delta, the line

current drawn by the motor at starting is reduced to one-third as compared to starting current with the windings connected in delta. At the time of starting when the stator windings are start connected, each stator phase gets voltage $VL/\sqrt{3}$ where VL is the line voltage. Since the torque developed by an induction motor is proportional to the square of the applied voltage, star- delta starting reduced the starting torque to one – third that obtainable by direct delta starting. its components are the same as to listed in section 2.1 except timer

Time delay relay switch:- also called a timer switch, or simply timer) is a timer that operates an electric switch controlled by the timing mechanism. The switch may be connected to an electric circuit operating from mains power, including via a relay or contactor; or low voltage

It has different pin in its base example 8-pin, 10- pin etc

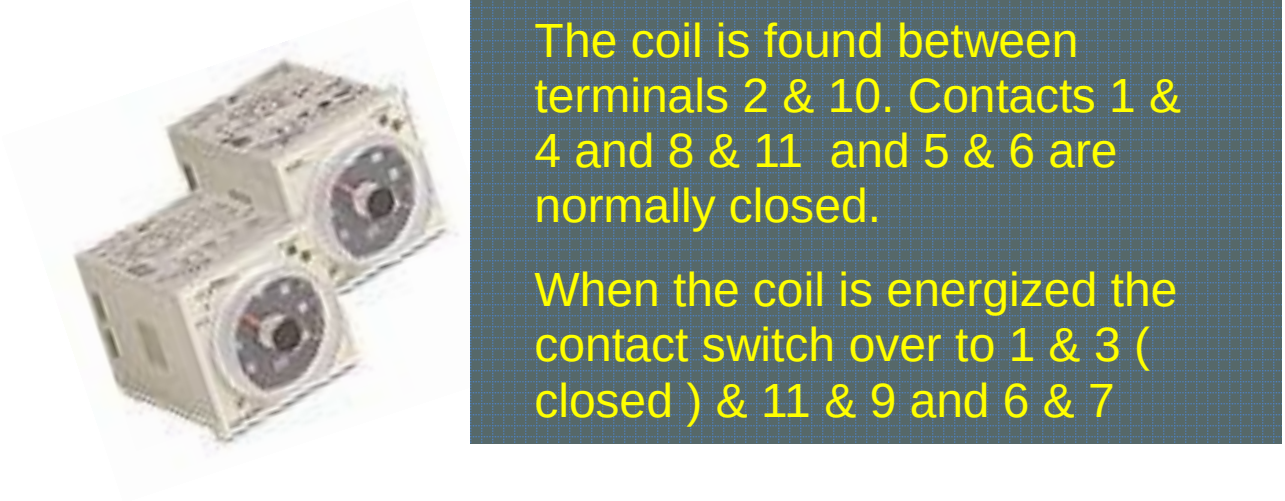


Figure 2.8 Time delay relay device

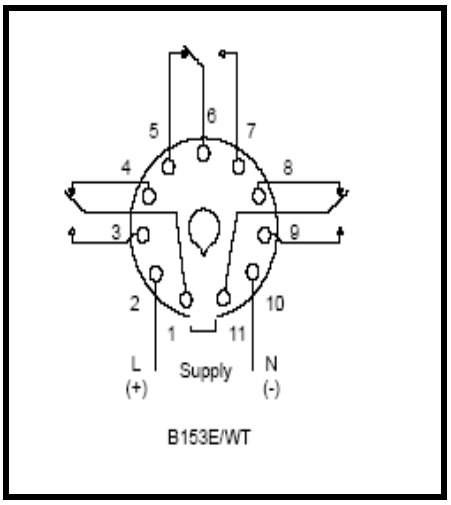


Figure 2.9 11-pin timer base format configuration

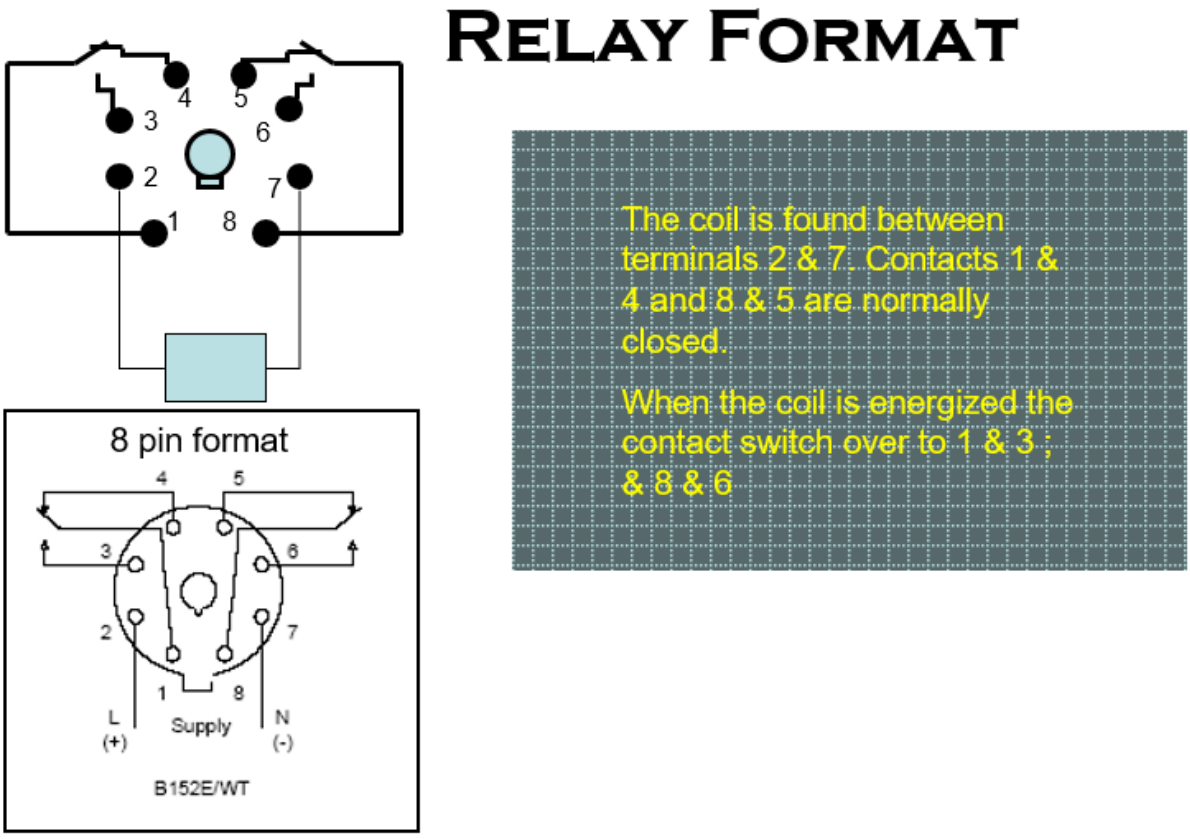


Figure 2.10 8- pin –time relay format

2.4. **Forward and Reverse motor starting:** -is used in system where forward and backward or upward and down ward movement or rotation in the system needed. To change the direction of the rotation, in three phase induction machine two of its phases needs to be exchanged, thus changing the phase sequence form, say ABC to CBA. This can be accomplished by using two contactors, one for the forward or CW rotation and one for the reverse or CCW rotation. The forward and reverse contactors are mechanically interlocked i.e., if one of them is closed the other cannot close. This is done to avoid dead short circuit in case both the contactors closing simultaneously.it components are the components listed in section 2.1 and 2.2 above see them carefully

2.5. **Auto transformer starting:** -The autotransformer reduced-voltage starter places the motor on the secondary of the autotransformer while starting. The taps on the autotransformer limit the voltage applied to the motor to 50%, 65% or 80% of the nominal voltage. The operation principle of auto transformer method is similar to the star delta starter method. The starting current is limited by (using a three phase auto transformer) reduce the initial stator applied voltage.

The auto transformer starter is more expensive, more complicated in operation and bulkier in construction when compared with the star – delta starter method. But an auto transformer starter is suitable for both star and delta connected motors, and the starting current and torque can be adjusted to a desired value by taking the correct tapping from the auto transformer

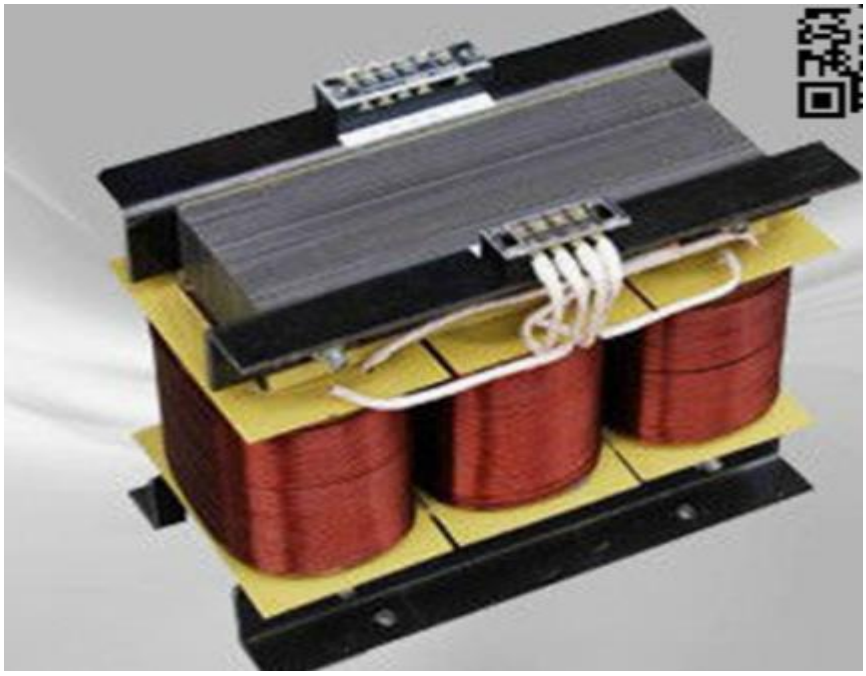


Figure2.4 Auto-transformer device

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. List the starting components of Dol (4pts)
2. Write the constructional components of induction motors (4pts)
3. What makes difference the starting components of star-delta from Dol (2pts)
4. List three phase induction motor starting method (5)

Note: **Satisfactory rating - 10 points** **Unsatisfactory - below 10 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1. ----------
2. ----------
3. ----------
4. ----------

Instruction Sheet 2	Learning Guide 46: **Prepare circuit diagrams**

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics –

- Preparing power circuit and control circuit diagram
- Identifying type of control components & wiring devices and other materials
- Connecting the circuit and wiring diagram

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to

- Prepare power circuit and control circuit diagram
- Identify type of control components & wiring devices and other materials
- Connect the circuit and wiring diagram

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 18.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page 10
5. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
7. Submit your accomplished Self-check. This will form part of your training portfolio.

8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2” in page 13.
10. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
11. Read the information written in the “Information Sheets 3 . Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page 11.
13. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page 17, However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
15. Read the “Operation Sheet 1” and try to understand the procedures discussed.
16. If you earned a satisfactory evaluation proceed to “Operation Sheet 2” in page 18. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
17. Read the “Operation Sheet 2” and try to understand the procedures discussed.
18. Do the “LAP test” in page 19(if you are ready). Request your teacher to evaluate your performance and outputs. Your teacher will give you feedback and the evaluation will be either satisfactory or unsatisfactory. If unsatisfactory, your teacher shall advice you on additional work.

Information Sheet-1	Preparing power circuit and control circuit diagram

1.1 Introduction to Power circuit and control circuit

A control circuit :-is a special type of circuit used to control the operation of a completely separate power circuit . Control wiring is wire that carries a low voltage signal to a relay, contact or terminal point. Usually and 24 or 12 volts but is considered low having anything under 48 volts .

A power circuit is defined as any circuit used to carry electricity that operates a load. and the circuit control is part of the power circuit when the device is operate.

1.2. power circuit and control circuit diagram of direct on line (DOL)

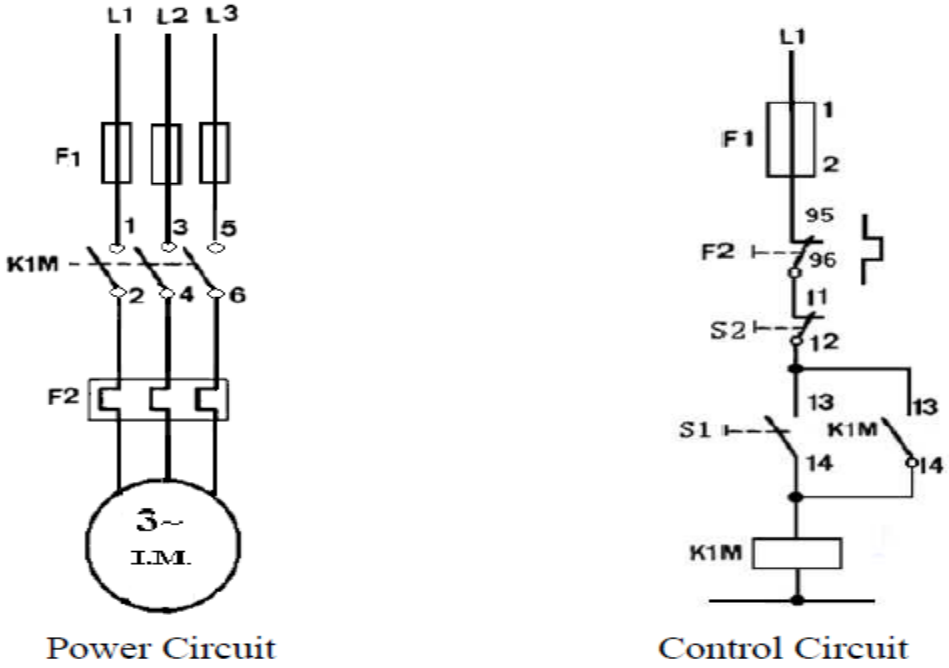


Figure 1. 1. schematic diagram of power and control circuit of DOL

Where L1, L2, L3 shows line voltage

Voltage between L1-L2=380V/400V, L1-L3=380V/400V, L2-L3= 380V/400V

Voltage between phase –neural 220v/250v

F1- fuse/circuit breaker, F2= thermal over load relay, S1= start push button

S2= stop pushbutton, K1M= main magnetic contactor (power contactor)

Working principle

The DOL starter consists of a coil operated contactor K1M controlled by start and stop push buttons.

When you press the start push button S1, the contactor coil K1M is energized from line L1.

The three mains contacts (1-2), (3-4), and (5-6) in fig. (1) are closed energized. Then motor is connected to the supply. When the stop push button S2 is pressed, the supply through the contactor K1M is disconnected/de energized. Since the K1M is de-energized, the main contacts (1-2), (3-4), and (5-6) are opened. The supply to motor is disconnected and the motor stops.

1.**3. power circuit and control circuit diagram of star -delta**

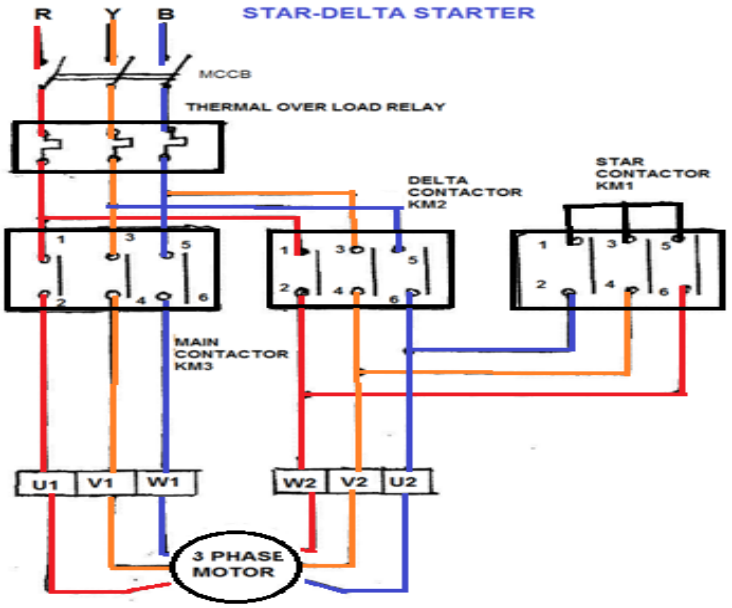


Figure 1. 2. power circuit of star-delta wiring diagram

Where R, Y, B power line source voltage

V1, U1, W1, = the primary terminal of the motor

V2, U2 , W2, = the secondary terminal of the motor

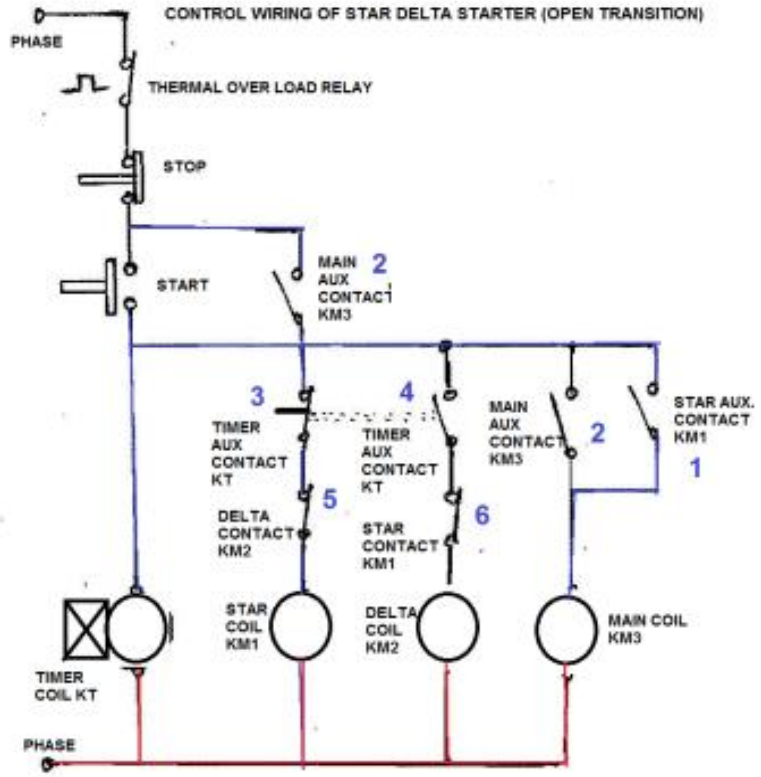


Figure 1. 3. control circuit - wiring diagram of star- delta

Working principle

- The main circuit breaker serves as the main power supply switch that supplies electricity to the power circuit.
- The main contactor connects the reference source voltage R, Y, B to the primary terminal of the motor U1, V1, and W1.
- When you press the start push button in the control circuit the Main Contactor (KM3) and the Star Contactor (KM1) are closed /energized initially, and then after a period of time, the star contactor(KM1) is opened or de energized, and then the delta contactor (KM2) is closed/energized . The control of the contactors is by the timer (K1T) built into the starter. When Star Auxiliary Contactor (1)(which is placed on Main Contactor coil circuit)became NO to NC it's complete The Circuit of Main contactor Coil (KM3) so Main Contactor Coil energized and Main

Contactor's Main and Auxiliary Contactor Change its Position from NO To NC. This sequence happens in a friction of time.

- After pushing the ON push button switch, the auxiliary contact of the main contactor coil (2) which is connected in parallel across the ON push button will become NO to NC, thereby providing a latch to hold the main contactor coil activated which eventually maintains the control circuit active even after releasing the ON push button switch.
- When Star Main Contactor (KM1) close its connect Motor connects on STAR and it's connected in STAR until Time Delay Auxiliary contact KT (3) become NC to NO.
- Once the time delay is reached its specified Time, the timer's auxiliary contacts (KT)(3) in Star Coil circuit will change its position from NC to NO and at the Same Time Auxiliary contactor (KT) in Delta Coil Circuit(4) change its Position from NO To NC so Delta coil energized and Delta Main Contactor becomes NO To NC. Now Motor terminal connection change from star to delta connection and the motor runs at full speed.

3.4. power circuit and control circuit diagram of Auto- transformer starting

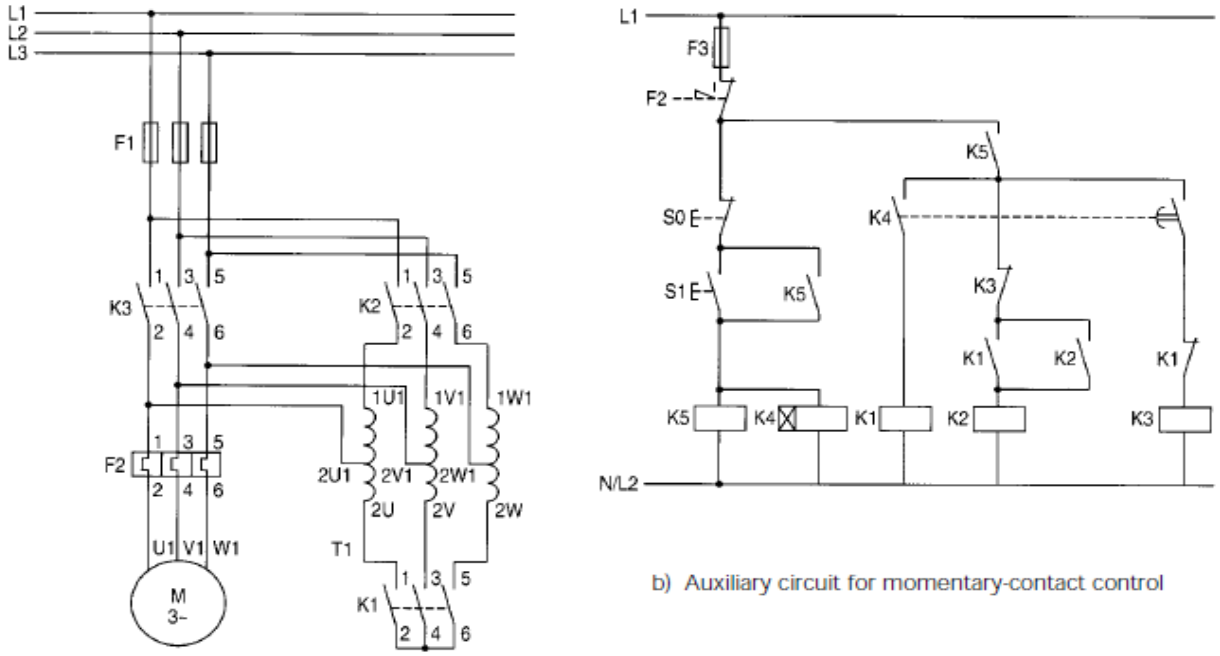


Figure1. 4. (a) show power circuit of auto-transformer

(b) shows control circuit of auto-transformer

Where

S0 = 'OFF' Push button S1 = 'ON' Push button K1 = Star contactor

K2 = Transformer contactor, K3 = Main contactor K5 = Contactor relay (2NO + 2NC)

K4 = Time relay, F1 = Main circuit fuses, F2 = Overload relay, F3 = Control circuit fuse

Working principle

The operation principle of auto transformer method is similar to the star delta starter method. The starting current is limited by (using a three phase auto transformer) reduce the initial stator applied voltage.

The auto transformer starter is more expensive, more complicated in operation and bulkier in construction when compared with the star – delta starter method. But an auto transformer starter is suitable for both star and delta connected motors, and the starting current and torque can

be adjusted to a desired value by taking the correct tapping from the auto transformer.

3.5. power circuit and control circuit diagram of forward and reverse starting

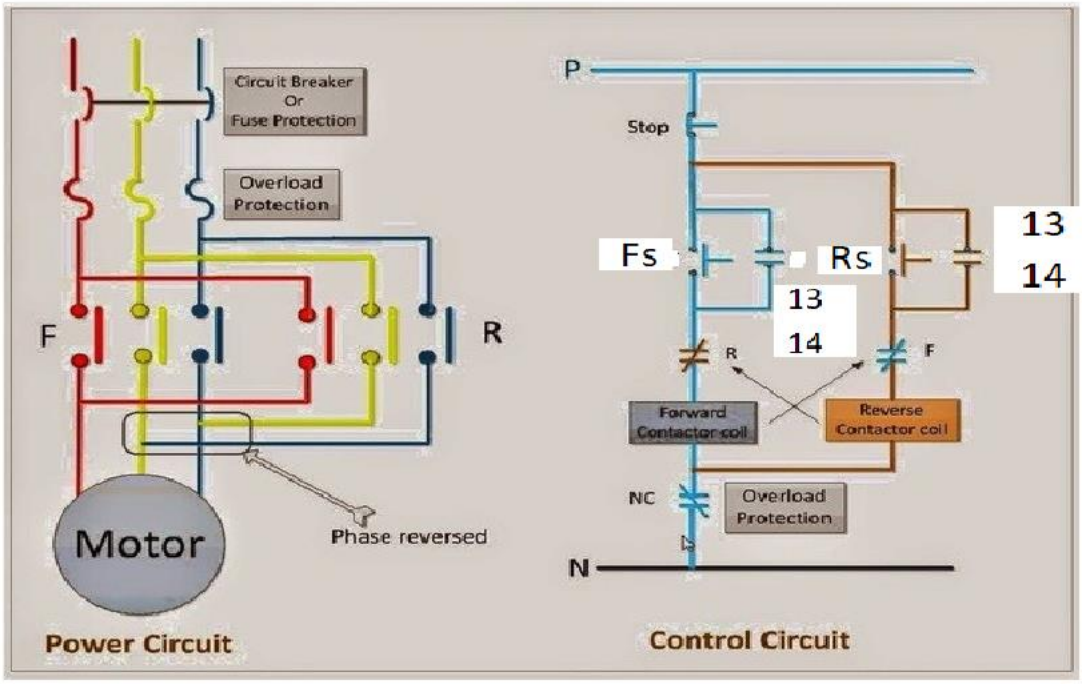


Figure 1. 5. power circuit and control circuit diagram of forward and revers starting

Where

F= forward main magnetic contactor R= reverse main magnetic contactor

Fs =forward start push button Rs= reverse start push button

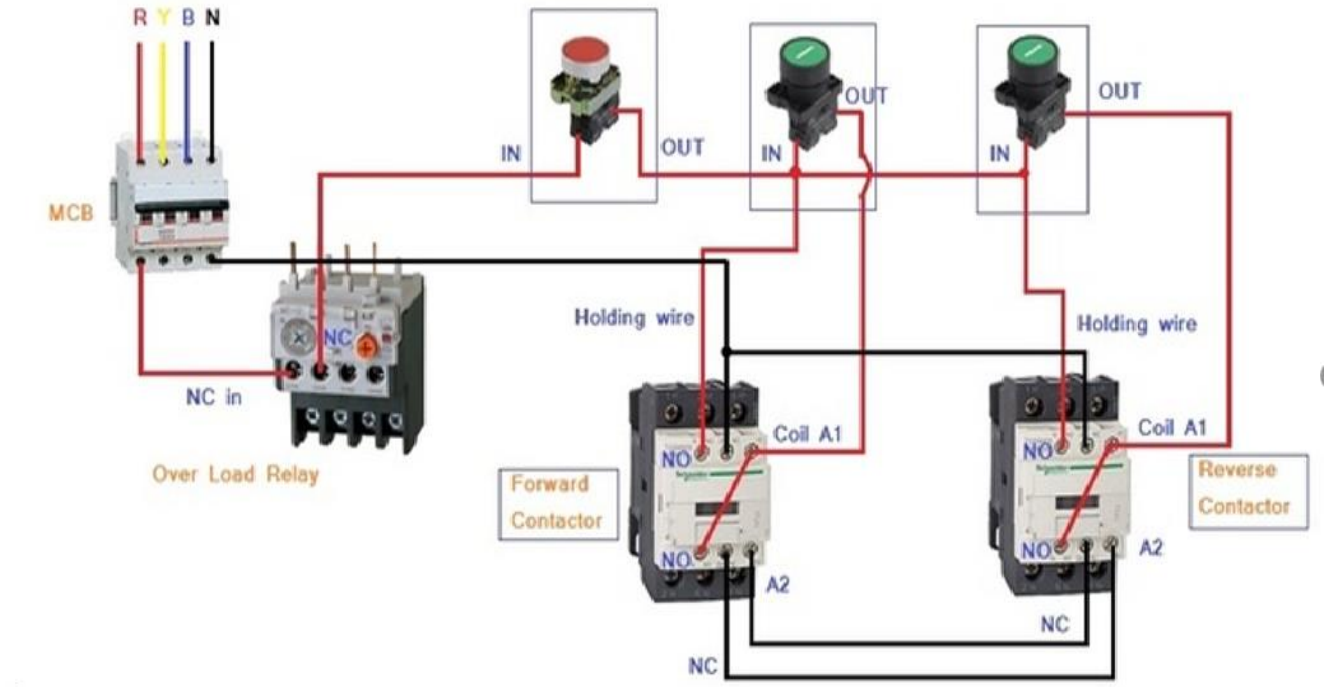


Figure1. 6. forward and reverse control wiring diagram

Working principle

When you press Fs figure 5. Of control circuit forward contactor be become energized and then the motor runs forward direction until you press stop push button when you press stop push button the motor become de energized when you press Rs the reverse contactor become energized .and then the runs in the reverse direction of the forward start until you press stop push button .

Self-Check -1	Written And Tracing Wiring Diagram Test

Directions: Answer all the questions listed below. Use the proper materials for the drawing of wring diagram.

1. Write elements of power circuit and control circuit components in Dol wiring diagram (5pts)
2. Trace the power and control circuit of
   a. Dol (5pts)
   b. Star-delta (5pts)

Note: **Satisfactory rating - 10points** **Unsatisfactory - below 10 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

1. _____
   _____
2. _____
   _____
   _____
   _____

Information Sheet-2	Identifying type of control components & wiring devices and other materials

2.1. Introduction

There are different types of control components In different types of motor starting method and also the wiring device and the materials used may not be the same.

2.2. direct on line power and control component and wiring device

power components of DOL are:- , main circuit breaker(3phase MCB), main magnetic contactor and thermal overload relay

control components of DOL are:- single phase circuit breaker (1MCB), start stop push button , normally open auxiliary contactor of 3 phase MCB

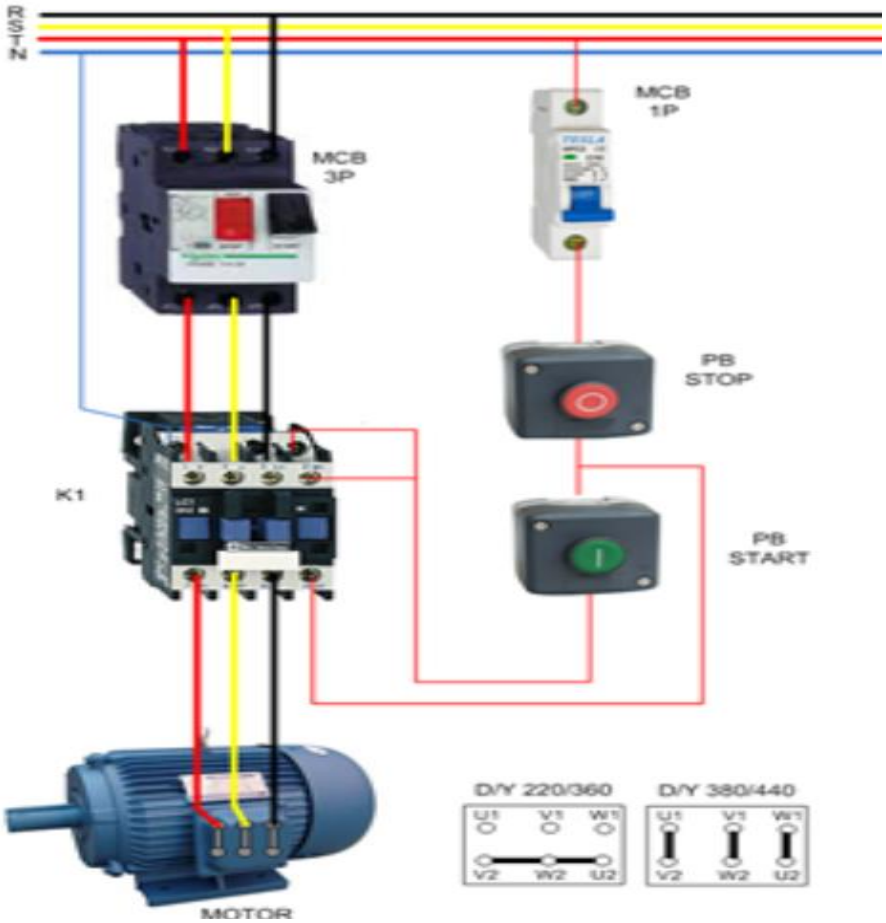


Figure 2.1.DOL power circuit and control circuit components of wiring device

2.3. Star delta control component and wiring device

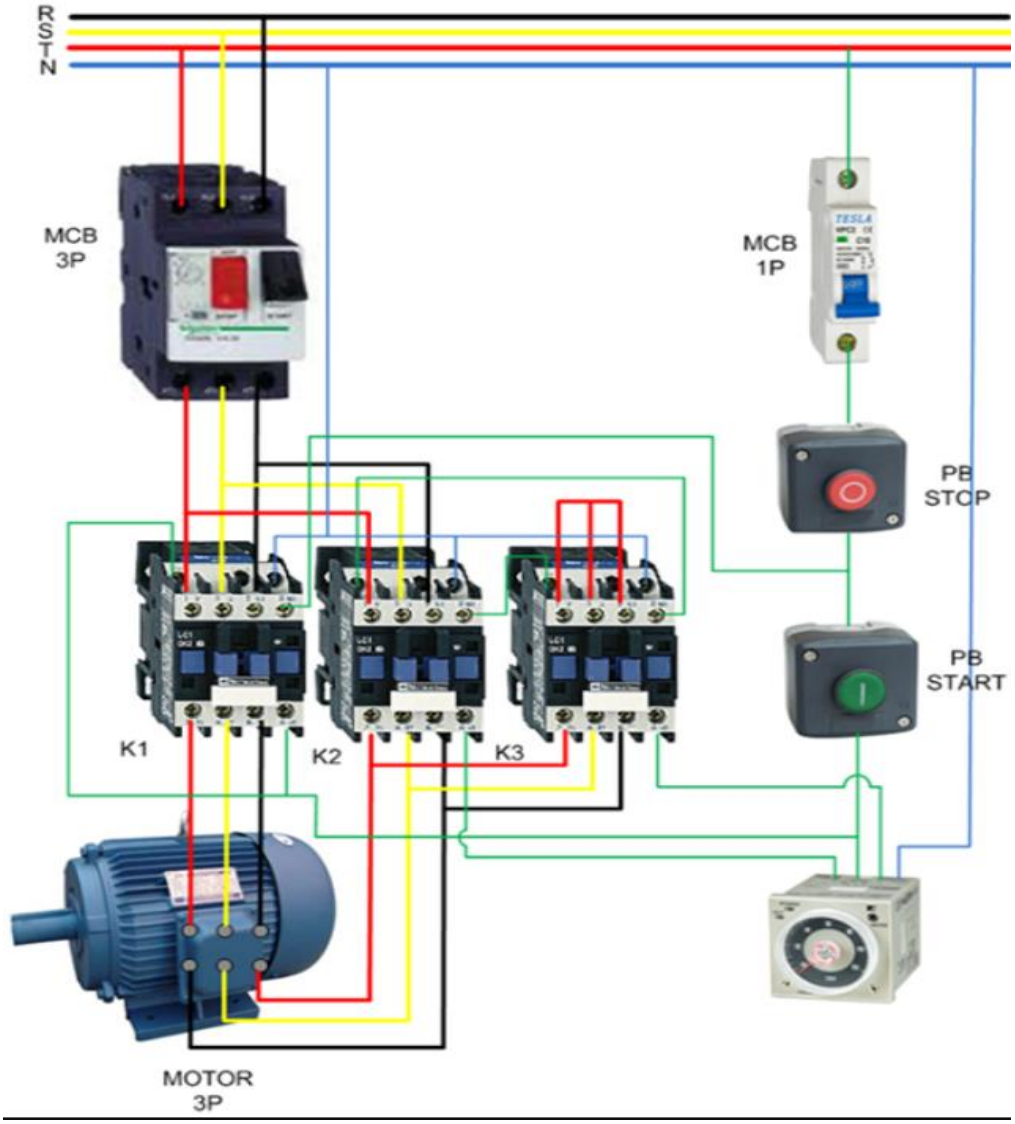


figure 2.2. star-delta power circuit and control circuit components of wiring device

power components of star-delta 3phase-MCB, line magnetic contactor(K1), delta magnetic contactor(k2), star-magnetic contactor (k3)

star-delta control components are single phase breaker(1pMCB), stop and start pushbutton and time delay relay and for more information, refer information sheet 1 of LG-29 LO

Self-Check -2	Multiple choice test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. ---------- One of the following is not the components of Dol control device
   A. Single phase circuit breaker
   B. Fuse
   C. Timer
   D. contactor
2. ----------The device used to convert star-connection to delta connection in automatic star-delta starting with in specified period is
   A. transformer
   B. Auto-transformer
   C. Time delay relay
   D. All
3. ----------The push button required in forward and reverse starting
   A. One
   B. Three
   C. Four
   D. Two

Note: **Satisfactory rating – 5 points** **Unsatisfactory - below 5 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

1._____

__

2._____

__

Information Sheet-3	Connecting the circuit and wiring diagram

3.1 Introduction

Different type of motor starting mechanism has different circuit and wiring diagram configuration.

Circuit: - is the complete path of electric current through the wiring diagram. whereas wiring is the inter connection of device with conductor in power and control circuit to make the system energize or de energize. Or A circuit diagram is a graphical representation of an electrical circuit

Wiring diagram: is the diagram that indicates the actual material and the circuit connection used in sequential order to execute our work activates. A wiring diagram usually gives information about the relative position and arrangement of devices and terminals on the devices, to help in building or servicing the device

Power circuit diagram of start –delta

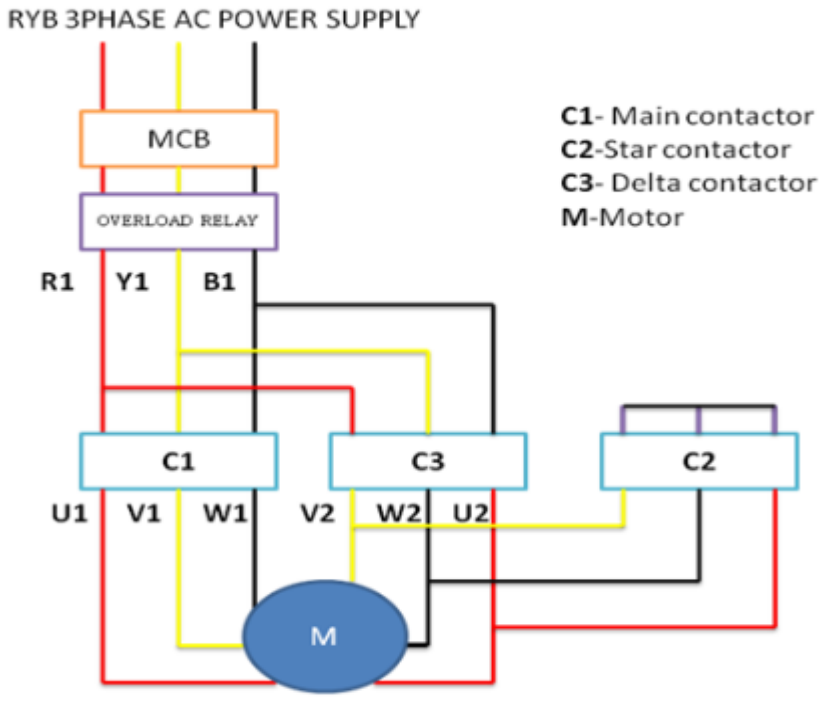


Figure 3.1 power circuit diagram of star- Delta .

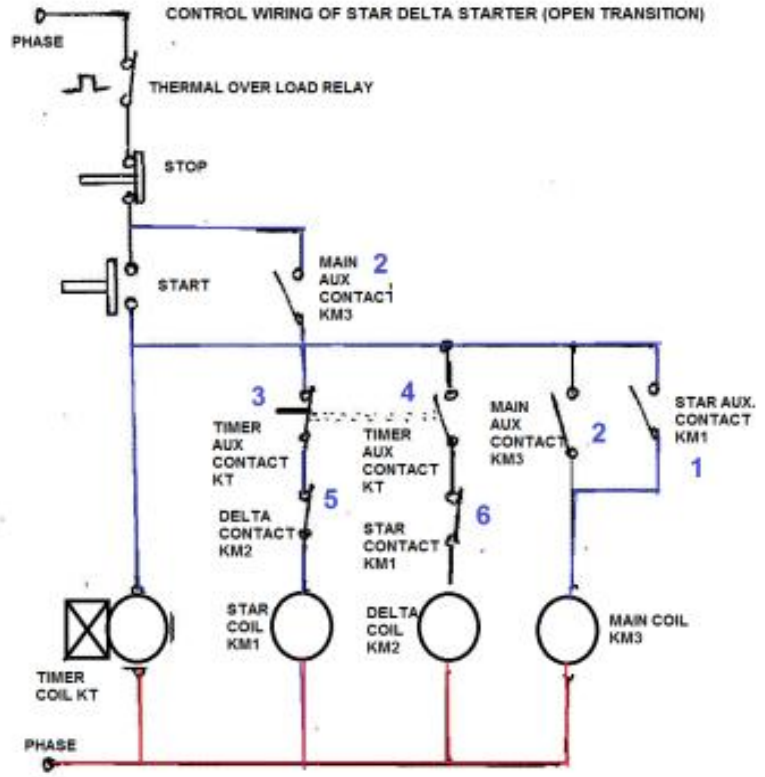


Figure 3.2. power and control wiring diagram of star-delta

Common Procedure for connecting the circuit and wiring diagram

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Write the difference between circuit diagram and wiring diagram
2. What makes difference the control circuit diagram of Dol and star-delta
3. Sketch the power and control circuit wiring diagram of star-delta

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer Questions

1._____

__

2._____

__

Operation Sheet 1	preparing power and control circuit of DOL

Techniques for preparing power and control circuit of DOL

Step 1- wear PPE.

Step 2- Draw the wiring diagram of power and control circuit of Dol

Step 3- select the necessary tools and materials required for construction of Dol.

Steps 4- check the functionality of each device before mounting it

Step-5 Construct the circuits

Step 6-connect the motor to circuit

Step 7- test the motor /the circuits

Operation Sheet 2	Connecting control component and wiring device of motor start

Techniques for preparing power and control circuit of star-delta or any

Step 1- Wear PPE.

Step 2- Draw the wiring diagram of power and control circuit of (star-delta) or any

Step 3- Select the necessary tools and materials required for construction of star-delta any Steps 4- Check the functionality of each device before mounting it

Step-5 Construct the circuits

Step 6-Connect the motor to circuit

Step 7- Test the motor /the circuits

.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4 hours.

Task 1. Construct direct on line wiring power and control device

- Draw power and control circuit
- Prepare proper device and materials
- Select proper tools
- Construct the device

Instruction Sheet 1	Learning Guide 47: Mounting equipment and testing devices

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics –

- Tools and testing instruments
- Identifying defective/Sub-standard electrical materials
- Cleaning work areas

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Select Tools and testing instruments
- Identify defective electrical materials
- Clean work areas.

Learning Instructions:

15. Read the specific objectives of this Learning Guide.
16. Follow the instructions described in number 3 to 20.
17. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
18. Accomplish the “Self-check 1” in page 5.
19. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
20. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
21. Submit your accomplished Self-check. This will form part of your training portfolio.

22. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
23. Accomplish the “Self-check 2” in page 7.
24. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
25. Read the information written in the “Information Sheets 3 . Try to understand what are being discussed. Ask you teacher for assistance if you have hard time understanding them.
26. Accomplish the “Self-check 3” in page 11.
27. Ask from your teacher the key to correction (key answers) or you can request your teacher to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
28. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page 12. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
29. Read the “Operation Sheet 1” and try to understand the procedures discussed.
30. If you earned a satisfactory evaluation proceed to “Operation Sheet 2” in page 13. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
31. Read the “Operation Sheet 2” and try to understand the procedures discussed.
32. If you earned a satisfactory evaluation proceed to “Operation Sheet 3” in page 14. However, if your rating is unsatisfactory, see your teacher for further instructions or go back to Learning Activity #1.
33. Read the “Operation Sheet 3” and try to understand the procedures discussed.
34. Do the “LAP test” in page 15 (if you are ready). Request your teacher to evaluate your performance and outputs. Your teacher will give you feedback and the evaluation will

be either satisfactory or unsatisfactory. If unsatisfactory, your teacher shall advice you on additional work.

Information Sheet-1	Tools and testing instruments

1.1 Tools

Tools: - refer to the small materials used for working, commonly by using your hand and with the force of your arm, wrist or hand. This is called as hand tools

Some hand tools vary according to its use or purpose. Some are categorized depending on its purpose. Categories may be classified into:

- Cutting tools
- Hammering tools
- Leveling Tools
- Measuring tools
- Driving tools
- Holding tools

Examples of electrical cutting tools are:- pliers, electrical knife ,saw, nippers etc.

Pliers: - are electrical hand tools used to cutting and twisting electrical wire. Use only pliers with insulated handles when working on electrical parts. Cutting pliers are mostly used when working on wirings. There are different types cutting pliers.

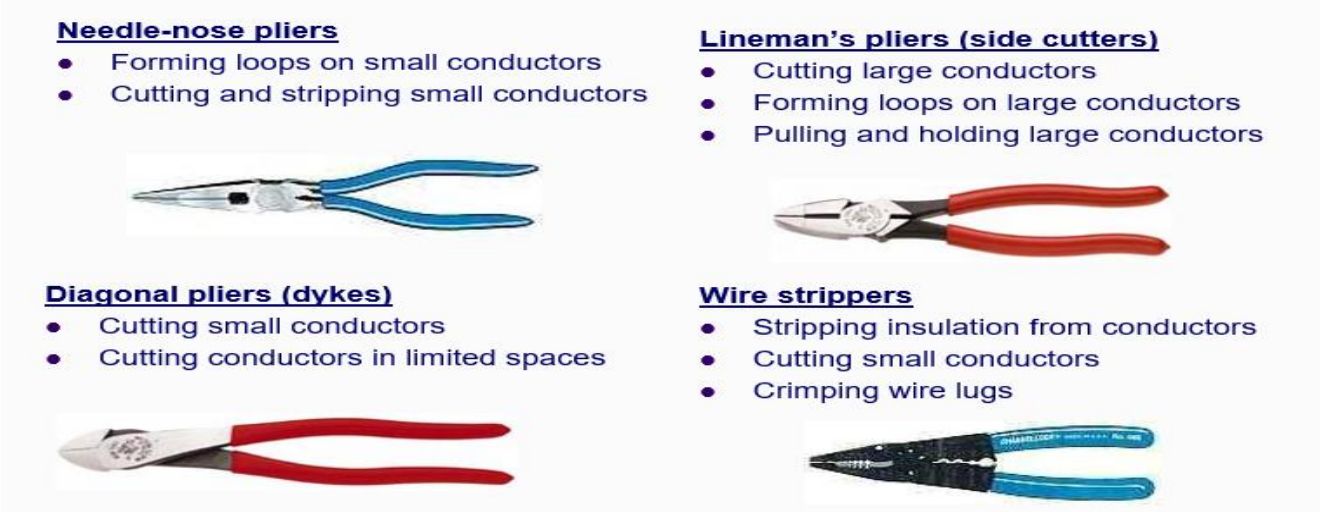


Figure 1.1 different types of electrical cutting pliers

Screwdrivers: - are used to tight or loose different shape of screws. There are different types of screw drivers flat head screw drivers, Phillips head screw drivers

Flat-head screwdriver: used to Installing and removing slot-head screws

Fig 1.2 flat head screw driver

Phillips head screw drivers: - used to installing and removing Philips-head/cross head screws

Fig 1.3 Phillips head screw drivers

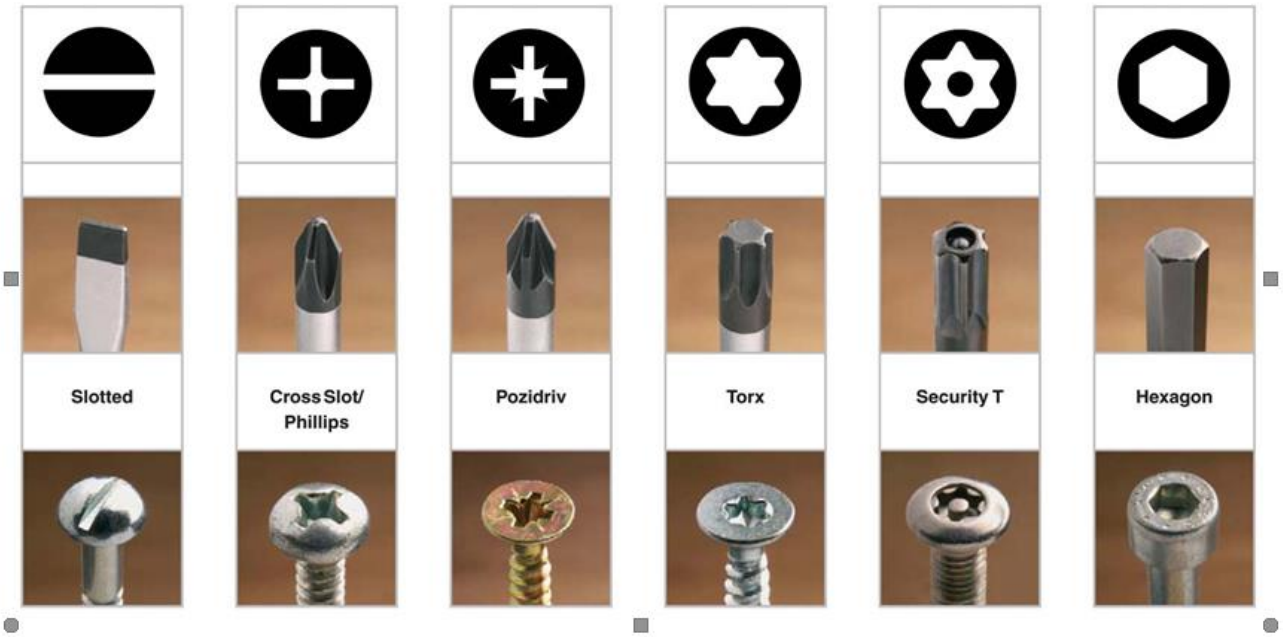


Figure1.4. Different heads of screw and its drivers

wrench or spanner: - is a tool used to provide grip and mechanical advantage in applying torque to turn objects. There are different Types of wrenches open-end, box-end, combination box/open end, adjustable, socket wrenches.

open-end wrench: - A one-piece wrench with a U-shaped opening that grips two opposite faces of the bolt or nut .it is often double-ended, with a different-sized opening at each end. It allows a greater range of movement in enclosed spaces by flipping the wrench over

Fig 1.5 open wrench

Box-wrench: - A one-piece wrench with an enclosed opening that grips the faces of the bolt or nut. The recess is generally a six-point or twelve-point opening for use with nuts or bolt heads with a hexagonal shape.

can be used in a tight space where a socket wrench cannot go. Box wrenches are usually 12-point and provide a powerful non damaging grip and the nut or bolt.

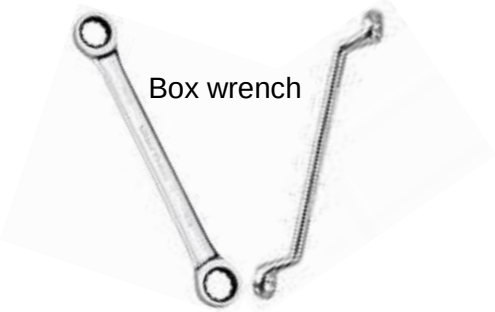


Fig 1.6 box wrench

Combination wrench: - A double-ended tool with one end being like an open-end wrench or open-ended spanner, and the other end being like a box-end wrench. Both ends generally fit the same size of bolt.

Fig 1.7 combination wrench

An adjustable wrench :- is an open-end wrench with a movable jaw, allowing it to be used with different sizes of fastener head (nut, bolt, etc.) wrench.

Fig 1.8 adjustable wrench

A wire stripper:- is a small, hand-held device used to strip the electrical insulation from electric wires.

Fig 1.9 wire stripper

Electrician knives: - This tool is used primarily for cutting of papers, cardboards and the like. Also used for cutting or stripping off the insulation of the wire.

Fig 1.10 Electrician knives

Electrical hand drill: - is a fastening tool used to secure screws or bolts. It can also be used with a drill bit to tighten fasteners

Fig 1.11 Electrical hand drill

Measuring tools: -Steel tape/ruler is used for measuring linear measurements. Such as electrical fixtures and centering lighting fixture boxes. Measuring wall height and depth as well as wire length represent just some of the common electrical works.

Fig 1.12 Measuring tools

Hack saws: -is cutting tools used to cut metal that is too heavy for snips or bolt cutters. Thus, metal bar stock can be cut readily with hacksaws.

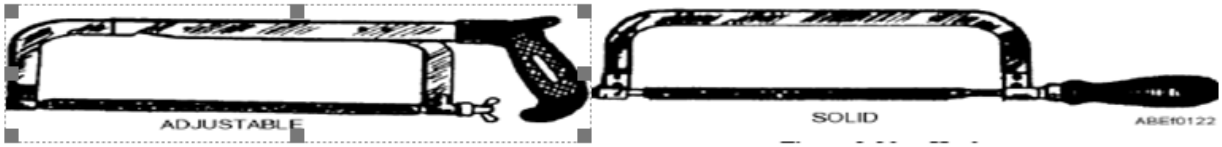


Fig 1.13 hack saw

1.2. Testing instruments: are electrical device used to test or measure electrical quantities. -almost all industrial machines, home appliances etc. are working on electrical energy, it is must to inspect and test the electrical energy for its quality before energizing machines/appliances. Example of testing instruments are voltage tester screwdriver

, analog and digital multimeter, etc.

1.2.1. VOLTAGE TESTER SCREWDRIVER:

A test light, test lamp, voltage tester, or mains tester is a very simple piece of electronic test

equipment used to determine the presence or absence of an electric voltage in a piece of

equipment under test.

1.2.1. Continuity Test:

Continuity refers to being part of a complete connected or not connected whole. In electrical applications, when an electrical circuit is capable of conducting current, It is also said to be closed if not conducting said to open. In short, by performing continuity test, we can determine the following

i) existence of continuity in the electrical wiring circuit

ii) existence of any open circuit in the circuit

iii) existence of any short circuit in the circuit

Continuity testers are simple devices designed to verify a complete electrical path through an object. Best examples are analog and digital multimeter

Open circuit test and Short circuit test: Multimeter can be used for this test. For this, multimeter should be set in resistance mode of measurement. To check the existence of any

open circuit or short circuit between any two points in the wiring circuit, the electrical supply to

the circuit should be switched off first. Then put the multimeter probes between the two testing

points in the circuit. If multimeter reads infinitive (∞) ohm at any range, it indicates open circuit. If multimeter reads zero (0) ohms at any range, it indicates short circuit

Multimeter: -is an instrument used to measure electrical quantities and test the continuity of electrical circuit whether it broken or not. See figure 1.3 A and B

Figure 1.14A Analog multimeter

figure 1.5.B Digital multimeter

Camp meter*:* - is an electrical test tool that combines a basic digital multimeter with a current sensor. Clamps measure current. Probes measure voltage

Fig 1.16 clump meter

Insulation Tester : is an electrical device used to test the insulation of materials . best example is Megger .

A Megger insulation resistance tester is especially useful when you have carried out electrical work on your home and want to make sure you didn't damage insulation or make a wiring mistake. Which uses an applied DC voltage (typically either 250Vdc, 500Vdc or 1,000Vdc for low voltage equipment <600V and 2,500Vdc and 5,000Vdc for high voltage equipment) to measure insulation resistance in either kΩ, MΩ or GΩ. The measured resistance is intended to indicate the condition of the insulation or dielectric between two conductive parts, where the higher the resistance, the better the condition of the insulation. Ideally, the insulation resistance would be infinite, but as no insulators are perfect, leakage currents through the dielectric will ensure that a finite (though high) resistance value is measured.

Phase sequence: - is the sequence in which three phase voltages attain their positive maximum values is defined as the phase sequence. It refers to the relation between the voltages or currents in three phase system. Consider the three phases as red-R, yellow-Y and blue-B phases.

Phase sequence meter: - is used for detecting the sequence of the supply in three-phase electric circuits. Since the direction of rotation of three phase electric motors can be changed by changing the phase sequence of supply.

Figure 1.17phase sequence meter

Self-Check 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. ---------- one of the following is not hand tools
   - E. Screw driver
   - F. wrenches
   - G. knife
   - H. multimeter

2. 2. ---------- An electrical hand tool used to determine the presence or absence of an electric voltage in a piece of equipment under test.
   - E. Test light
   - F. Voltmeter
   - G. Wrench
   - H. none

3. ---------- measuring instrument used to measure the the insulation resistance is known as
   - A . Megger
   - B. Multimeter
   - C. Clamp meter
   - D. A and B

Note: **Satisfactory rating – 3points** **Unsatisfactory – below3 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Answer sheet

1. __
2. ___
3. ____

Information Sheet-2	Identify defective electrical materials

2.1. Introduction to Electrical Maintenance

Electrical maintenance covers all aspects of testing, monitoring, fixing, and replacing elements of an electrical system. Usually performed by a licensed professional with a complete knowledge of the National Electric Code and local regulations, electrical maintenance covers Electrical motor, Generators, Lighting systems any electrical device …etc

Electrical equipment defects can result in serious injuries, such as electrocution, burns, and electric shock. In some cases, electrical equipment defects can even result in death. The failure of a single component in the electrical system can cause extensive downtime or data loss.

Before you start any type of electrical work, you must follow these following safety precautions:

- Switch off the main power at the consumer unit/fuse box. Isolate the circuit you plan to work on by removing the circuit fuse. Put this in your pocket to avoid accidental replacement or switch off the breaker and lock it if you can
- Attach a note to the unit to advise you are working on the circuit
- Check the circuit is dead with a socket tester or voltage tester/meter for lighting circuits

Defective components can by identified by testing instruments such as multimeter, and megger by troubleshooting method. defective components can be caused by excessive electrical power to the components

Figure 2.1 defective test multimeter

As we say ,defective component can be recognized by ohmmeter we can see one of two things if the digital multimeter/ohmmeter dial is on the wrong resistance setting

1 or open loop(OL)

If the display reads 1 or OL the setting is to low turn the multimeter dial to the next highest resistance setting. continue increasing the setting until you have reading a full number .

Less than 1

If the number on the screen is less than 1 the setting is to high .Turn the multimeter dial to the next to lowest setting to get accurate reading .continue until you have reading that a full number.

2.2. Ways to recognize Faults.

1. infinity resistance (∞): - if the display shows 1 or OL no matter the resistance setting you have most likely got a fault defective device/components on your hands. Infinity reading means open /broken device.

2. low resistance (zero ohm reading) if the display shows zero reading at lowest range it indicates that the components are short circuit in parts.

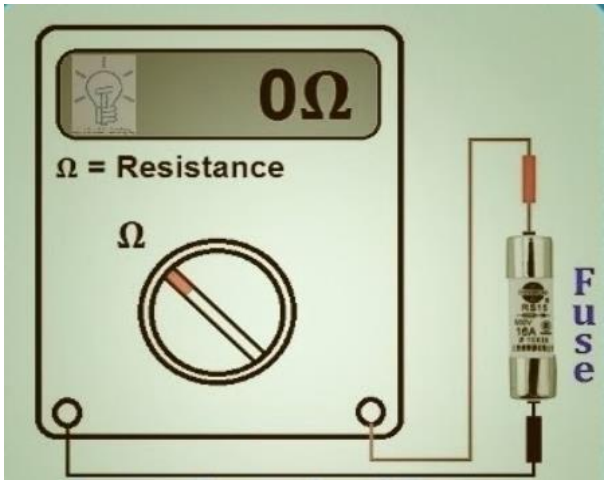


Figure 2.2 testing electrical component and device

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. ---------- Defective components can be identified by
   A. digital multimeter
   B. ohmmeter
   C. test light
   D. All.
2. ----------defective components are caused by
   A. power interruption problem
   B. excessive current flow
   C. Limited date of the components
   D. All of the above
3. ----------. When you check the component, if the ohmmeter reads infinity at any range what can you say about the component
   A. Open circuit component(broken)
   B. Short circuit (blow)
   C. Damaged component
   D. A and c

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer sheet

1._____

2._____

3._____

Information Sheet-3	Cleaning work areas

3.1. Cleaning of worksite, tools and equipment

Electrical equipment should be kept clean for maximum efficiency and service longevity. Keeping electrical equipment clean is an important part of any **electrical preventive maintenance program**, but using the wrong cleaning methods *could be costly.* Cleaning involves sweeping floors, dusting furniture and other surfaces, mopping or washing floors, polishing surfaces, articles and accessories, tools and device, rearranging cleaned areas and putting things in their specific place.

We can say that cleaning is a process of removing dust, dirt or any other undesirable materials like colors, spots, contents of an ashtray, etc. What happens if cleaning is not done on a regular basis? Yes, your house will become the breeding ground of insects such as cockroaches, spiders, ants, flies and mosquitoes. It will look dirty and will be most uncomfortable. Living in such circumstances can also lead to diseases such as asthma, bronchitis, etc. Thus, cleaning is necessary for a general presentable appearance and also to ensure good hygienic conditions.

What do you understand by dust and dirt? 'Dust' collectively refers to the loose particles, which are very easily moved by air and settle on any surface. It is easily removed with the help of a dry cloth. 'Dirt' refers to dust which sticks to any surface with the help of moisture or grease. It is more difficult to remove dirt as compared to dust. Dirt has to be removed either with a detergent or any other cleaning agent.

3.2. Methods of cleaning

Dusting :-You are already familiar with the term 'dust'. But how do you remove dust? When any surface is wiped with a piece of dry cloth, (duster), it carries the loose dust with it and the process is known as dusting. This should be done with a clean soft cloth.

Figure 3.1 Dusting with a cloth

Sweeping: -When a sweeper or a brush is used to carry the dust laterally along the room, the process is known as sweeping. While sweeping any vertical surface as walls, you should remember to start from the top and sweep downwards. Similarly, for lateral sweeping as for floors, start from one end of the room and move to another, preferably a door, and carry the dust all along or collect in a dust pan. All the movable articles kept on the floor should be lifted, swept under, and kept back in place.

Polishing: -When some reagent is rubbed on a surface to bring out the shine, the process is known as polishing and the reagent applied is known as the 'polish'. Similarly, many other articles/ decorative items made of brass, wood, marble etc, may be polished

3.3. Cleaning Equipment

Following are some of the equipment which you will come across during the process of cleaning.

Dusters - These are mostly made of soft cotton, flannel or artificial feathers mounted on a stick. These are used to clean loose dust and are also used for wiping various surfaces. It should be washed and dried after use.

Dust pans- these are made of either plastic or metal and have flat surfaces, rounded at the sides. After sweeping, dirt and dust is collected directly into these with the help of a sweeper and carried to a wastepaper basket.

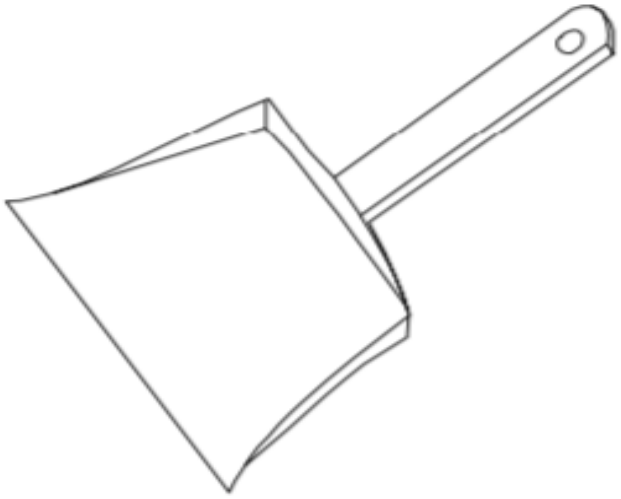


Figure 3.2. A dust pan

Brushes-are available in various sizes and shapes and are made of different materials. Different brushes are used for specific jobs. Brushes with nylon or plastic bristles are used for cleaning carpets or furniture, round feather brushes are used to remove dusts, metal brushes are used to clean wire mesh in the windows

Figure 3.3. Various types of brushes

Vacuum cleaner- it works on electricity and has a fan. This sucks in the dirt and dust from the surfaces and stores it in a disposable bag inside. This bag should be emptied regularly.

Figure 3.4. A vacuum cleaner

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is cleaning?
2. What is the importance of cleaning tools and materials?
3. Write at list three methods of cleaning

Note: **Satisfactory rating - 3 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

Short Answer sheet

1._____

_____

2._____

_____

3._____

_____

Operation Sheet 1	Identifying defective electrical components Techniques

Techniques to identify defective electrical components

1. Check the your multimeter functionality (turn on power)
2. Disconnect the power source before checking, servicing, repairing or installing electrical equipment and devices.
3. Turn “ON” your multimeter and set to the lowest resistance setting. The resistance settings are the ones measured in Ohms.
4. Test your multimeter is working by pressing the probes together. The multimeter screen should read 0.00 also known as short circuit (inexpensive meters may read close to this from resistance of their leads). When the probes part the screen should read 1 or OL, also known as open circuit.
5. Find the two connections where wires connect to your part.
6. Push the metal parts of your multimeter probes firmly onto these connections, one probe on each connection.
7. Keep the probes still until you get a reading on the multimeter screen. Take note of the reading.

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 2 hours.

Task 1. Identify defective components of control panel

- Prepare instruments to appropriate function switch and range switch
- Check your probe
- Turn off the power supplied to control panel
- Trace the fault.