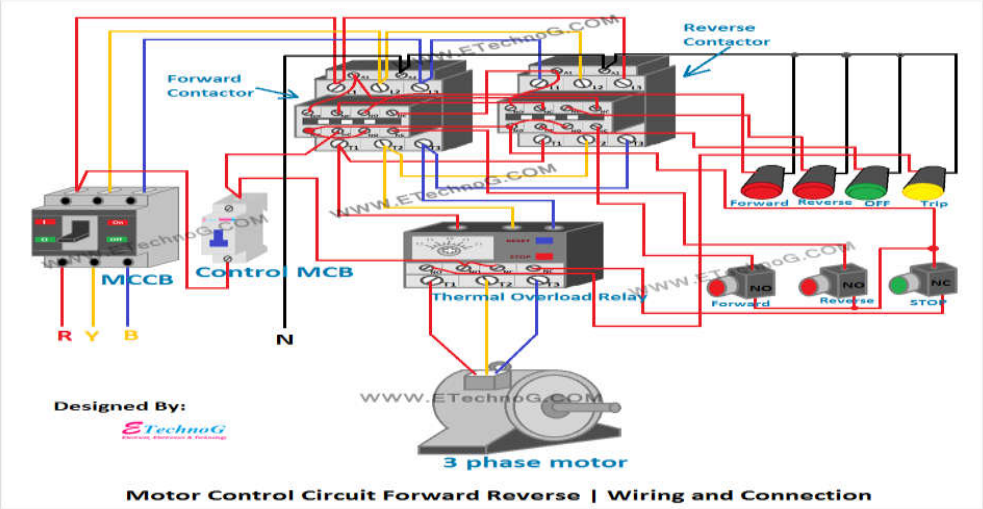
Industrial Electrical/Electronic Control Technology Level – II

Based on March 2021, Curriculum Version 1



Module Title: Perform Installation of Motor Controller System

Module code: EIS IEC2 M 09 0322

Nominal duration: 150Hour

Prepared by: Ministry of Labor and Skill

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Addis Ababa, Ethiopia

Contents

Acknowledgment

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Acronym

C B	Circuit Breaker
L2	Line1
L3	Line2
L1	Line3
L1	Line 4
N	Neutral
NC	Normally Closed Pushbuttons
NCTC	Normally-Closed, Timed- Open
NCTO	Normally-Closed, Timed-Open
NO	Normally Open Pushbuttons
NOTC	Normally-Open, Timed-Closed.
NOTO	Normally-Open, Timed-Open.
PE	Protective Conductor
VFD	A Variable-Frequency Drive
ITP	Inspection And Test Plan

Introduction to the Module

In Industrial Electrical/Electronic Control Technology filed; Performing Installation of Motor Controller System covers the skills, attitudes and knowledge required and helps to perform installation of motor controller and electrical machines and drives including electrical wiring system.

This module is designed to meet the industry requirement under Industrial Electrical/Electronic Control Technology occupational standard, particularly for the unit of competency: Performing Installation of Motor Controller System.

This module covers the units:

- Preparation of Motor controller Installation
- Electrical materials and tools
- Installation Works
- Electrical motor controller system
- Completion of work and clean-up

Learning Objective of the Module

- Plan and Prepare for Motor controller Installation
- Inspect electrical materials and tools
- Perform Installation Works
- Install electrical motor controller system
- Notify completion of work and Clean-up

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” give at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit one: Preparation of Motor controller Installation

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Wiring diagrams and layout/shop drawings
- Read and interpret drawing
- Estimation of work schedule
- Correct rating, quantity, sizes and type of control components, wiring devices and degree of protection of enclosures
- Correct size and degree of protection of enclosures
- Tools and testing instruments
- Complete data on inspection report
- Quantity, usage and specifications of materials, tools and equipment
- Requisition form of materials, tools and equipment

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Obtain wiring diagrams and layout/shop drawings
- Read and interpret drawing
- Verify estimated work schedule
- Identify correct rating, quantity, sizes and type of control components, wiring devices and Verify correct size degree of protection of enclosures
- Verify correct size and degree of protection of enclosures
- Select Tools and testing instruments
- Submit complete data on inspection report
- Verify quantity, usage and specifications of materials, tools and equipment
- Fill up requisition form of materials, tools and equipment

1.1. Wiring diagrams and layout/shop drawing

Electrical Safety

Electrical Safety in the workplace is the most important Job of an electrical worker. No matter how much training one has received or how much employers try to safeguard their workers, Electrical Safety is ultimately the responsibility of the electrical worker. The human factor associated with electrical accidents can be immeasurable. No one can replace a worker or loved one that has died or suffered the irreparable consequences of an electrical accident.

Machine safety

Machine safety is one of the key factors in ensuring that your production is efficient. Reliable systems that are simple to operate and maintain reduce the probability of accidents as well as the susceptibility of your equipment to faults.

Safety requirements of controlling electrical machines and drives in the lab

Some of the experiments involve voltages that could conceivably lead to serious

1. Injury or death. Therefore strict adherence to the following rules will greatly decrease the probability that accidents will occur. However, no set of rules can replace basic common sense, and all persons using the laboratory are encouraged to constantly Think Safety!
2. Always assume all circuits are energized unless you know with certainty that they are not.
3. Use one hand to make connections.
4. Never work on electrical circuits with wet or moist hands.
5. Do not play with equipment not directly involved in your experiment.
6. It is important for safety reasons for anyone to easily trace out your test circuit and, therefore do not work on a cluttered bench.
7. Never touch moving parts of machinery.
8. Think out ahead of time the consequences of closing or opening a switch. Never alter an energized circuit unless you are certain of the outcome.

9. If you know or suspect that an accident is about to occur, take immediate steps to prevent it but do not jeopardize your own safety in so doing.

10. When in the lab do not wear clothing or jeweler which could constitute a health hazard. Shoes, preferably rubber soled ones, must be worn in the lab. Long hair presents a hazard near moving parts of machinery. THINK SAFETY

Electrical diagrams

There are several different types of electrical wiring diagrams. They all do essentially the same thing, which is to show you how circuits are wired. However, the variation in these diagrams shows how circuits are mapped out in different ways to accomplish different ends.

A. Wiring diagram

wiring diagram is the most common form of electrical wiring diagram. Unlike a schematic, it's concerned with the connections between the different parts of a circuit or parts of an entire electrical system. Wiring and equipment on the wiring diagram is carefully laid out to show the approximate location of equipment in the circuit and thus, within the home. This makes it far more useful as a reference and guide for anyone wanting to work on a home's electrical. An electrical wiring diagram will use different symbols depending on the type, but the components remain the same. Diagrams will show receptacles, lighting, interconnecting wire routes, and electrical services within a home. This includes circuit breaker boxes and any alarms that are wired into the system. Different switches and different types of outlets all have different symbols, and you'll need to know these symbols in order to be able to read an electrical wiring diagram. Everything within a home electrical system will be shown on one of these diagrams. This is to make sure that everything will operate correctly if the diagram is adhered to and all components are functional Wiring diagram is the drawing which shows all the wiring between the parts, such as:

- Control or signal functions;
- power supplies and earth connections;
- Termination of unused leads, contacts;
- Interconnection via terminal posts, blocks, plugs, sockets, lead-throughs.

It will have details, such as the terminal identification numbers which enable us to wire the unit together. Parts of the wiring diagram may simply be shown as blocks with no indication as to the electrical components inside. These are usually sub-assemblies made separately, i.e. pre-assembled circuits or modules.

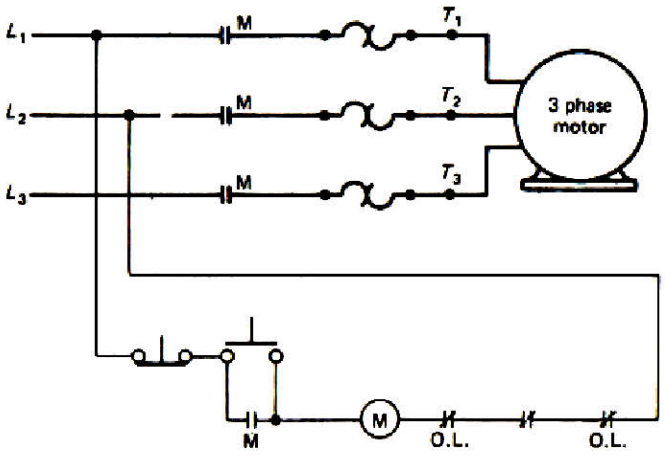


Figure1. 1 wiring diagram

B. **Schematic diagram**

Schematic diagram represents the elements of a system with abstract and graphic symbols instead of realistic pictures. A schematic diagram focuses more on comprehending and spreading information rather than doing physical operations. For this reason, a schematic usually omits details that are not relevant to the information that it intends to convey and may add simplified elements to help readers understand the features and relationships.

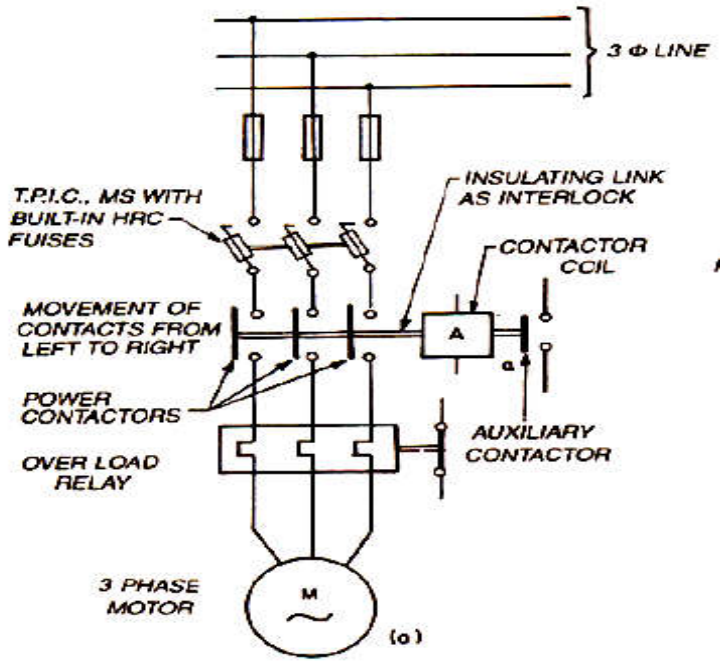


Figure1. 2 **Schematic Diagram**

C. **circuit diagram**

A **circuit diagram** (also named electrical diagram, elementary diagram, and electronic schematic) is a graphical representation of an electrical circuit. Circuit diagrams are widely used for circuit design, construction, and maintenance of electrical and electronic equipment. Circuit diagrams can be divided into two categories - pictorial circuit diagram and schematic circuit diagram.

D. **Pictorial diagrams**

Pictorial diagrams are much easier to understand than schematic circuit diagrams. By connecting realistic electrical components with the wiring, a pictorial diagram makes it easy and quick for viewers to identify the electrical components of a system immediately without professional knowledge required. It can be commonly mentioned in user's manual for normal operation. In some extent, circuit diagrams are more practical-applied.

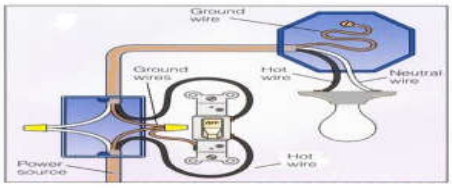


Figure1. 3 Pictorial Diagram

E. Layout diagram

It is an exact graphical representation of the layout of the various fixtures, equipment, utilities, and buildings of the plant

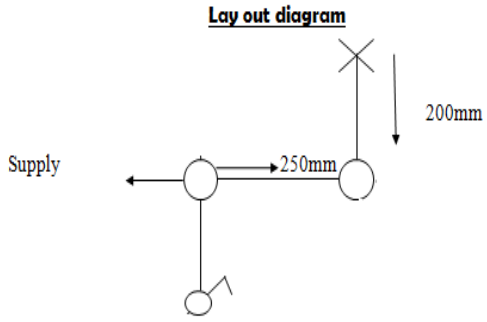


Figure1. 4 Layout diagram

1.2. Read and interpret drawing

1.2.1. Electrical symbols

Electrical symbols or electronic circuits are virtually represented by circuit diagrams. There are some standard symbols to represent the components in circuits. This article gives some of the frequently used symbols for drawing the circuits. There are many electrical and electronic schematic symbols are used to signify basic electronic or electrical device. These are mostly we used for draw circuit diagrams.

Below are different kind of symbols we mentioned category wise.

Table1. 1 Electrical symbols

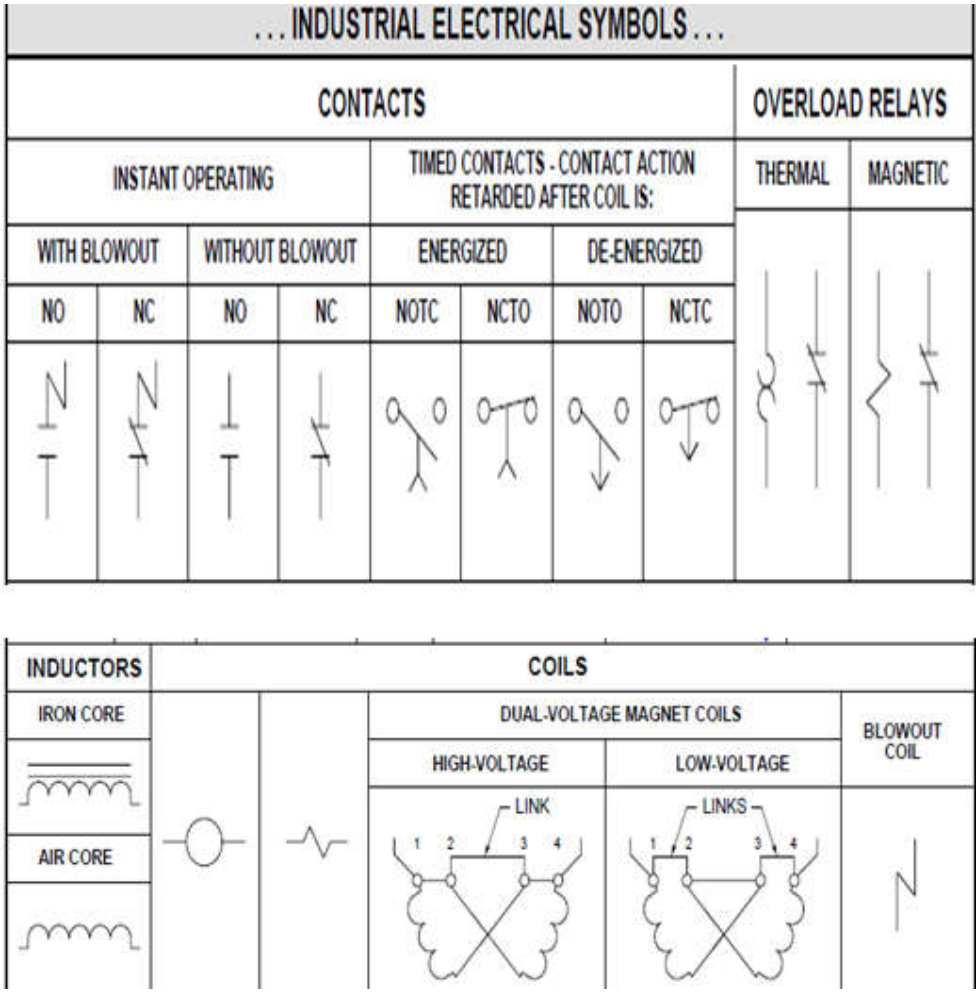
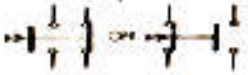
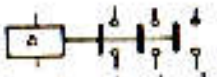
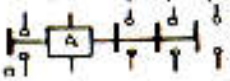
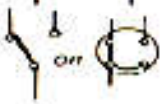
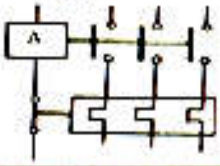
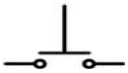

. . . INDUSTRIAL ELECTRICAL SYMBOLS . . .
CONTACTS
OVERLOAD RELAYS
INSTANT OPERATING
TIMED CONTACTS - CONTACT ACTION RETARDED AFTER COIL IS:
THERMAL
MAGNETIC
WITH BLOWOUT
WITHOUT BLOWOUT
ENERGIZED
DE-ENERGIZED
NO
NC
NO
NC
NOTC
NCTO
NOTO
NCTC
INDUCTORS
COILS
IRON CORE
AIR CORE
DUAL-VOLTAGE MAGNET COILS
BLOWOUT COIL
HIGH-VOLTAGE
LOW-VOLTAGE
LINK
LINKS
1 2 3 4
1 2 3 4

Table1. 2 Electrical symbols

Sl. No	Name of Component	Electrical Symbols
1.	Push Button Normally Open NO, S = Start Normally Closed NC, O = Off	
2.	Push Button with one NO and one NC contact operated together (1 NO + 1 NC)	
3.	Three phase induction motor (Squirrel cage)	

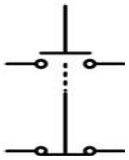
Sl. No.	Name of Component	Electrical Symbols
4.	Slip ring induction motor	
5.	Electrically operated 3-pole contactor with power contacts (three phase supply contacts) or main contacts only	
6.	Electrically operated contactor with main (three phase or power contacts) and auxiliary (control circuit) contacts	
7.	Coil of a electromagnetic relay contactor	
8.	Auxiliary contact Normally Open (NO)	
9.	Auxiliary contact Normally Closed (NC)	
10.	Two-way contactor	
11.	Limit Switch contact Normally Closed	
12.	Limit Switch Contact Normally Open	
13.	NO + NC Limit Switch Operated together	
14.	Signal Lamp	
15.	Contactor with thermal overload relay in all the three poles (phases)	

5. **Push Buttons**



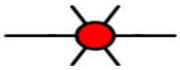
Single circuit NO

Single circuit NC

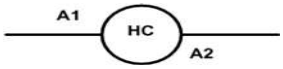


Double circuit

6. **Indicating lights**



7. **Magnetic coils**



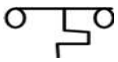
8. **Timers and transition**

TR contact
Timed to close

TR contact
Timed to open

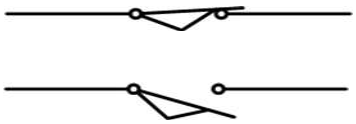
9. **Temperature actuated switch**

NC (identify will close or open on temp. Rise)

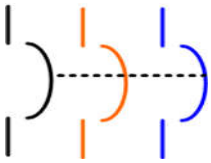


NO (identify will open or close on Temp. Rise)

10. Limit switch



11. Circuit breaker

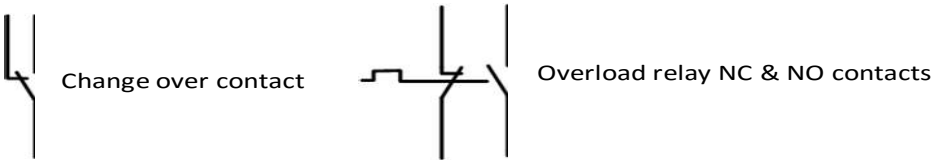


Three pole circuit breaker

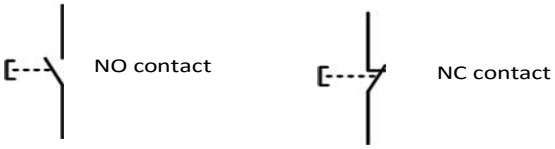
Electrical Symbols (ISO)

1. Circuit Elements

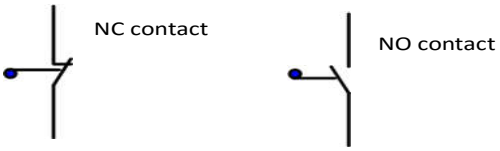
2. Delayed elements



3. Push button

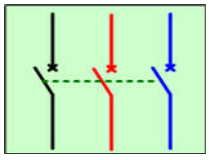


4. Limit switch

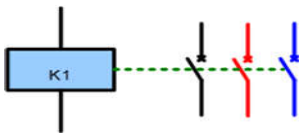


5. Device

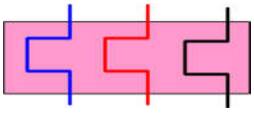
Circuit breaker – 3 pole



Contactor main contact



Overload relay contact



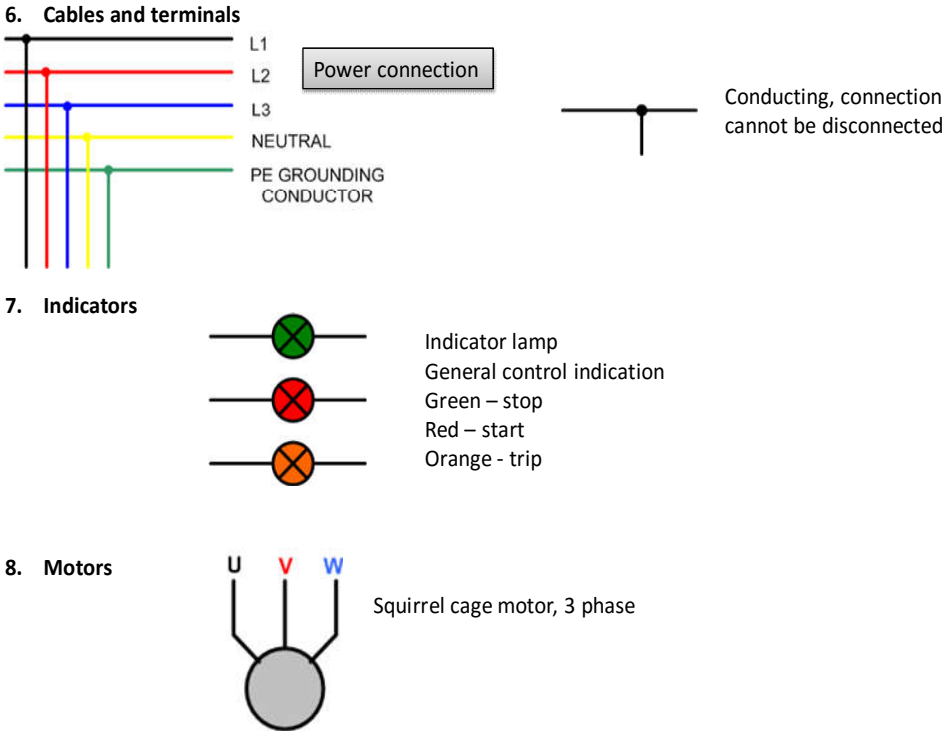
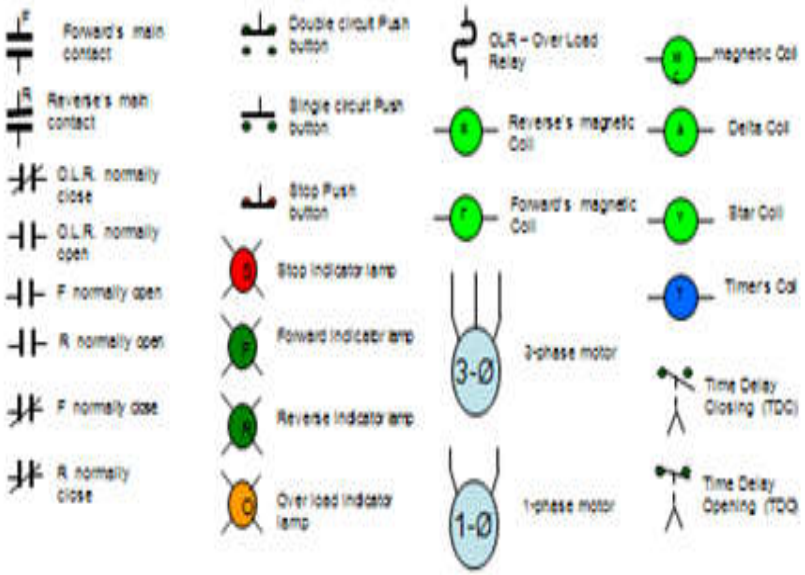


Figure1. 5 Electrical symbols

- Motor Controllers Symbols (Western Format)



Motor Controllers Symbols (European Format)

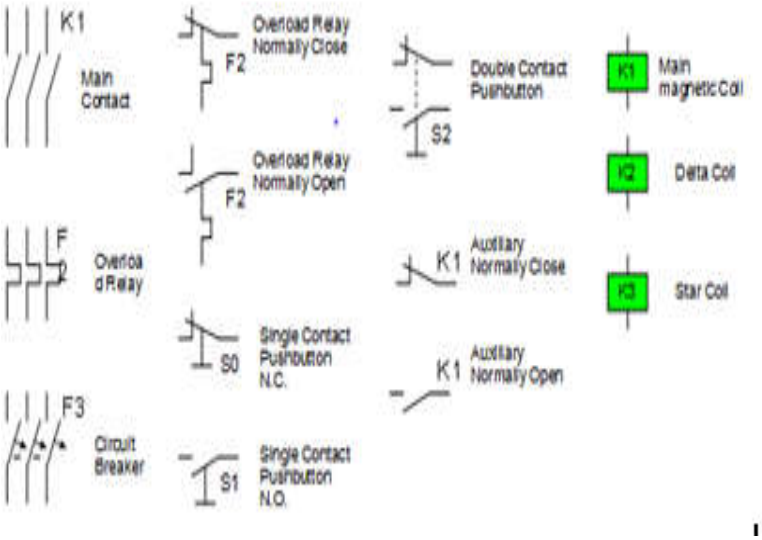


Figure1. 6 Electrical symbols

1.3. Work schedule

A work schedule refers to the specific days and hours designated to an employee for paid work. It includes the details of your specific shift, including which days of the week and hours of the day you're expected to work for a company.

A work schedule refers to the specific days and hours designated to an employee for paid work. It includes the details of your specific shift, including which days of the week and hours of the day you're expected to work for a company. Depending on your job and the business, you could work the same hours and days your entire career there or your schedule could vary based on the employer's needs.

A work schedule is important to think about when you want to achieve a harmonious work-life balance. When you're searching for a job, it's important to discuss the work schedule to find out if it fits your needs. You should make sure the schedule works around your prior responsibilities, or that you can accommodate a new work schedule. If the job description doesn't list the schedule, you can ask the hiring manager for more details.

1.3.1. The most common types of work schedules

Full time

Full-time hours are the traditional work hours most people envision when getting a job. Full-time employees often work between 30 to 40 hours throughout the week, though the standard is typically 40 hours.

Part time

People with part-time jobs usually work fewer than 30 hours per week. Part-time schedules provide greater flexibility for parents, students and others who need it.

Fixed

Fixed schedules follow a specific timetable regarding hours and days worked each week. The details of fixed work hours are agreed upon by the employer and employee before the shifts start. Fixed shifts could be for part-time or full-time schedules. If your work schedule follows a fixed format, you have the benefit of consistent, predictable shifts.

Flexible

While you are expected to work a certain number of hours on a flexible schedule, the details of your work arrangement may vary from week to week. In this situation, a manager usually creates schedules just one to two weeks in advance based on needs, meaning your shifts can vary from week to week. Flexible schedules are common in retail, restaurant and hospitality industries.

Rotating

Having a rotating shift means that your work schedule changes weekly or quarterly depending on your employer. These shifts are very common in the health care, military and construction fields, and require you to work different hours that rotate on a specific timeframe.

Split

Split shifts divide the hours you work in a day into two separate shifts. Instead of having one lunch break in the middle of the day, you have a break of at least two hours that separates your shifts. These shifts can be beneficial or challenging, depending on your individual circumstances.

1.4. Correct rating, quantity, sizes and type of control components & wiring devices

Motor control system

Motor control system control the electrical energy used to run a motor. Many of the components used to control that energy are in the motor controller, protected by a motor control enclosure.

Control Circuits

The National Electrical Code® (NEC®) defines a controller as a device or group of devices that serves to govern, in some predetermined manner, the electrical power delivered to the apparatus to which it is connected (Article 100-definitions).

A motor controller is also designed to limit the starting current and control the starting torque of the motor. A motor control system also provides protection for the motor against overload and over current motor controllers is classified as:

1.4.1. Control

Control, as applied to control circuits, is a broad term that means anything from a simple toggle switch to a complex system of components which may include relays, contactors, timers, switches, and indicating lights. Every electrical circuit for light or power has control elements. One example of a simple control circuit is a light switch used to turn lights on and off. Of course there are many other devices and equipment systems in industrial applications. Motor control, for example, can be used to start and stop a motor and protect the motor, associated machinery, and personnel. In addition, motor controllers might also be used for reversing, changing speed, jogging, sequencing, and pilot-light indication. Control circuits can be complex: accomplishing high degrees of automatic and precise machine operation

A. Manual Control

Control is considered to be manually operated when someone must initiate an action for the circuit to operate. For example, someone might have to flip the switch of a manual starter to start and stop a motor. All the basic operations, such as the closing of switches and the movement rheostat handles are by hand

B. Automatic Operation

While manual operation of machines is still common practice, many machines are started and stopped automatically. Frequently there is a combination of manual and automatic control. A process may have to be started manually, but may be stopped automatically. Basic functions of closing of switches or the movement of rheostat handles are performed by magnetic contractors.

Motor control system divided into **two** kinds of circuits:

1. The power circuit and
2. The control circuit

power circuit

Contains all of the components that carry the full voltage and current to operate the motor. Besides the contactor, these commonly include disconnects, fuses, breaker and over load heaters.Power circuits are identical for most 3-phase motor starters, so it is common not to refer to them in schematic drawings. In contrast to the control circuit, the power

circuit provides the large values of voltage and current used by the motor itself **power circuit of a three-phase motor consists of the following items:**

- 3PST three-phase disconnect
- Over current protection
- Horsepower-rated motor starter contacts
- Overload relay heaters

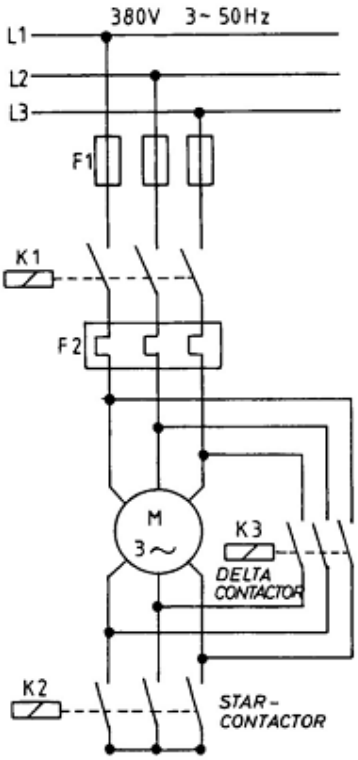


Figure1. 7 power circuit

Control circuit

Control circuit means the circuit that carries the electric signals directing the performance of a control device, but that does not carry the power that the device controls
control circuit is usually operated at a lower voltage and contains all of the components necessary to switch power to the motor on and off under the proper condition and at the proper time. These

commonly include devices like relay, field devices like start and stop push buttons, limit switches and pressure switch, indicating devices like light and alarms to help monitor the operation of the system.

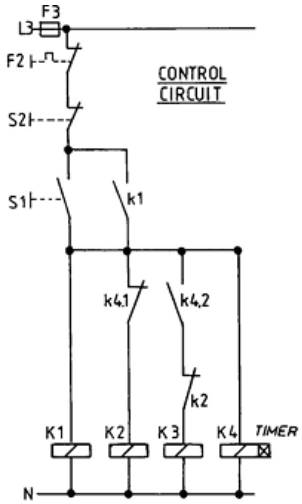


Figure1. 8 control circuit

Indicator Circuit

Indicator Circuit A galvanometer used to show when a circuit is active, and to give an approximate measurement of its strength. It is a less accurate and delicate form of instrument than the laboratory appliance

Open Circuit

An open circuit is defined as an electric circuit in which current does not flow. Current can only flow in a circuit if it finds a continuous path known as a “closed circuit”. If there’s a break anywhere in the circuit, you have an open circuit, and current cannot flow.

Hence in an open circuit, the current flowing through the circuit is zero, and voltage is present (non-zero). Now Power is equal to zero, and the current is equal to zero. Hence power is also equal to zero, and no power dissipates from an open circuit.

An open circuit implies that the two terminals are points are externally disconnected, which is equivalent to a resistance R=∞. This means that zero current can flow between the two terminals,

regardless of any voltage difference. (Note that very high voltages can cause arcs of current to flow even over large air or vacuum gaps!)

Short circuit

A short circuit implies that the two terminals are externally connected with resistance R=0, the same as an ideal wire. This means there is zero voltage difference for any current value. (Note that real wires have non-zero resistance!)

Grounding

Grounding something simply means connecting it to ground. And in electronics, ground is just a name we give to a certain point in the circuit.

Contact Resistance

Contact resistance is the resistance to current flow, due to surface conditions and other causes, when contacts are touching one another (in the closed condition of the device). This can occur between contacts of:

- Breakers
- Contactors
- Relays
- Switches
- Connectors
- Other switching devices

1.4.2. Control components & wiring devices

1. **Cam switch**

Have a group of fixed contacts and an equal number of moveable contacts. The contacts can be made to open and close in preset sequence by rotating a handle or knob, Used to control the motion and position of hoists, machine and tools.

Figure1. 9 Cam switch

2. Push buttons

A switch activated by finger pressure, two or more contacts open or close the button is depressed. Usually spring loaded so as to return to their normal position when pressure is removed.

A pushbutton is a control device used to manually open and close a set of contacts. Pushbuttons are available in a flush mount, extended mount, with a mushroom head, illuminated or non illuminated. Pushbuttons come with either normally open, normally closed, or combination contact blocks.

Figure1. 10 pushbutton

a) **Normally Open Pushbuttons**

Pushbuttons are used in control circuits to perform various functions. For example, pushbuttons can be used when starting and stopping a motor. A typical pushbutton uses an operating plunger, a return spring, and one set of contacts. The following drawing illustrates a normally open (NO) pushbutton. Normally the contacts are open and no current flows through them. Depressing the button causes the contacts to close. When the button is released, the spring returns the plunger to the open position.

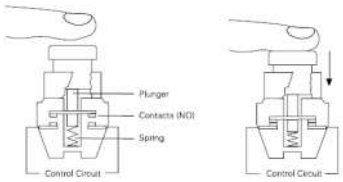


Figure1. 11 Normally Open Pushbuttons

Normally Closed Pushbuttons

Normally closed (NC) pushbuttons, such as the one shown below, are also used to open and close a circuit. In the pushbutton's normal position the contacts are closed to allow current flow through the control circuit. Depressing the button opens the contacts preventing current flow through the circuit.

These types of pushbuttons are momentary contact pushbuttons because the contacts remain in their activated position only as long as the plunger is held depressed. Pushbuttons are available with variations of the contact configuration. For example, a pushbutton may have one set of normally open and one set of normally closed contacts so that when the button is depressed, one set of contacts is open and the other set is closed. By connecting to the proper set of contacts, either a normally open or normally closed situation exists.

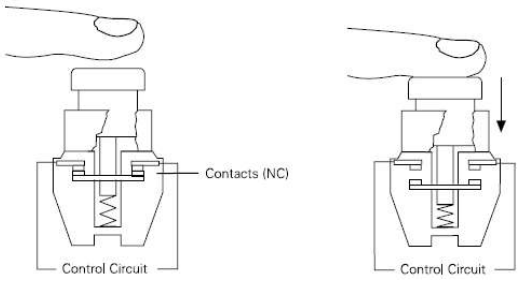


Figure1. 12 ***Normally Closed Pushbuttons***

3. Selector Switches

Selector switches are also used to manually open and close contacts. Selector switches can be maintained, spring return or key operated. Selector switches are available in two-, three-, and four-position types. The basic difference between a push button and a selector switch is the operator mechanism. With a selector switch the operator is rotated to open and close contacts. Contact blocks used on pushbuttons are interchangeable with those on used on selector switches.

Selector switches are used to select one of several circuit possibilities such as manual or automatic operation, low or high speed, up or down, right or left, and stop or run.

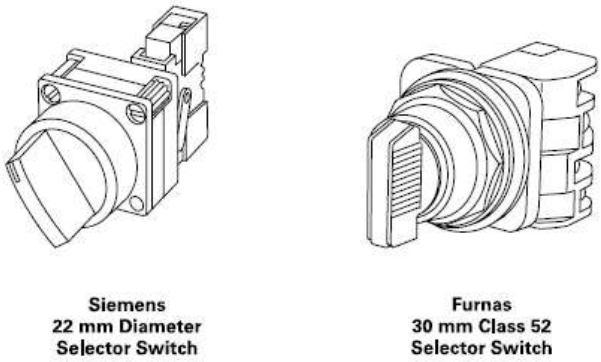


Figure1. 13 Selector Switches

4. Two Position Selector Switch

In the following example PL1 is connected to the power source when the switch is in position 1. PL2 is connected to the power source when the switch is in position 2. In this circuit either PL1 or PL2 would be on at all times. If there were only one load, then the selector switch could be used as an On/Off switch.

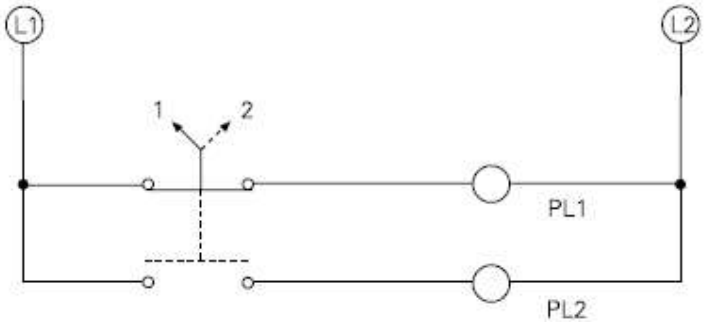


Figure1. 14 ***Two Position Selector Switch***

Contact Truth Tables

There are two accepted methods of indicating contact position of a selector switch in a circuit. The first method uses solid and dashed lines to denote contact position as shown in the previous example. In the second method truth tables, also known as target tables, are used. Each contact is marked with a letter. An "X" in the truth table indicates which contacts are closed for a given switch position. In this example contact A is closed, connecting PL1 to the power source, when

the switch is in position 1. Contact B is closed, connecting PL2 to the power source, when the switch is in position 2.

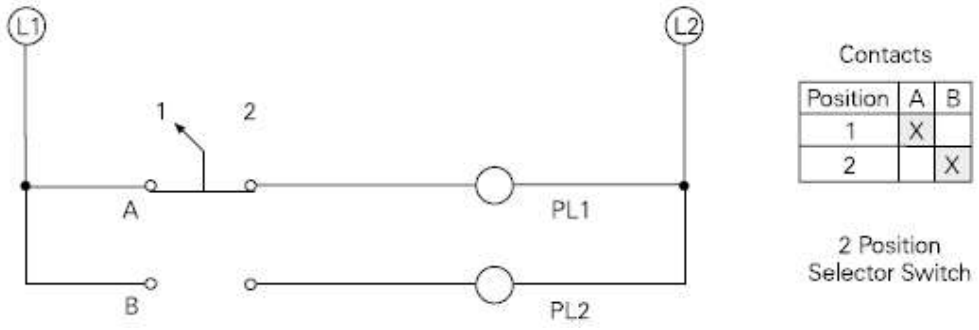


Figure1. 15 ***Contact Truth Tables***

5. Three-Position

A three-position selector switch can be used to select either of two sets of contacts or to disconnect both sets of contacts. Hand/Off/Auto is a typical application for a three-position selector switch used for controlling a pump. In the Hand (manual) position the pump will start when the Start pushbutton is pressed. The pump can be stopped by switching the switch to the off position. The liquid level switch has no effect in either the Hand or off position. When the selector switch is set to Auto, the pump will be controlled by the liquid-level switch. At a predetermined level the liquid level switch closes, starting the pump. At a predetermined level the liquid level switch opens, stopping the pump.

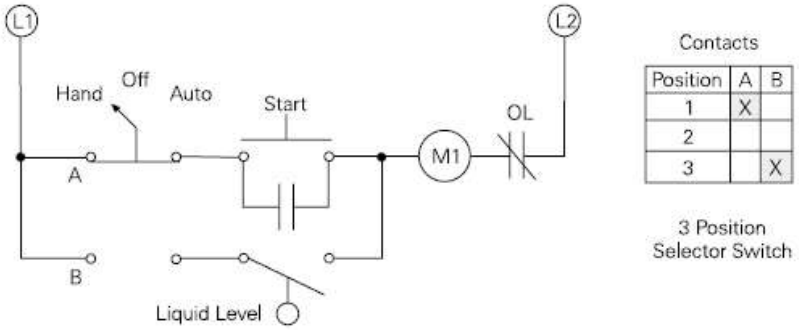


Figure1. 16 ***Three-Position***

6. **Disconnecting switches:** It isolates the motor from the power sources, selected to carry the nominal full-load current of the motor and to with stand short circuits currents for brief interval.
7. **Pilot Lights**

Pilot lights provide visual information at a glance of the circuit's operating condition. Pilot lights are normally used for "ON/OFF" indication, caution, changing conditions, and alarm signaling.

Figure1. 17 Pilot Lights

Pilot lights come with a color lens, such as red, green, amber, blue, white, or clear. A red pilot light normally indicates that a system is running. A green pilot light normally indicates that the system is off or deenergized. For example, a red pilot light located on a control panel would give visual indication that a motor was running. A green pilot light would give visual indication that a motor was stopped.

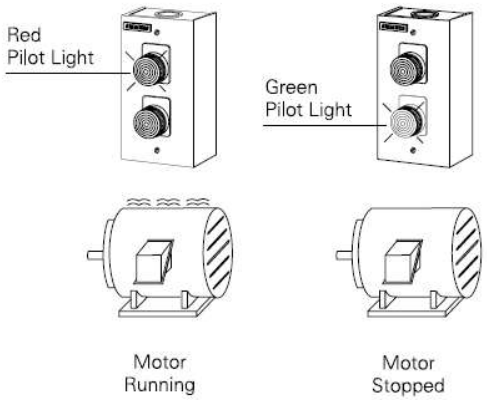


Figure1. 18 *Pilot Light*

8. Using a Pilot Light in a Control Circuit

In the following line diagram, a red pilot light is connected in parallel with the "M" electromagnetic coil.

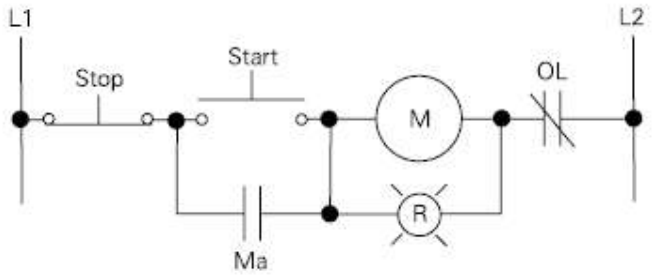


Figure1. 19 Using a Pilot Light in a Control Circuit

When the coil is energized, the light will illuminate to indicate the motor is running. In the event the pilot light burns out the motor will continue to run.

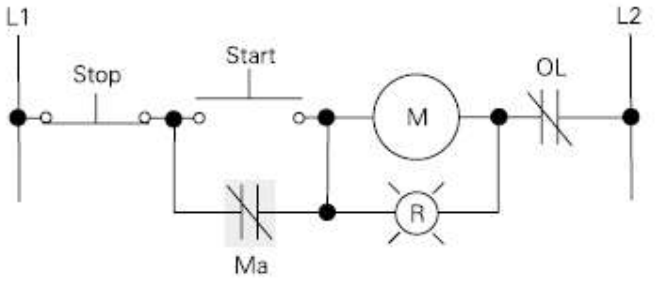


Figure1. 20 Using a Pilot Light in a Control Circuit

In the following line diagram a green pilot light is connected through a normally closed "M" auxiliary contact (Mb). When the coil is deenergized, the pilot light is on to indicate the motor is not running. Depressing the "Start" pushbutton and energizing the "M" contactor opens the normally closed "Mb" contacts, turning the light off.

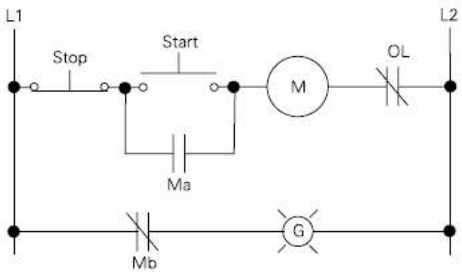


Figure1. 21Using a Pilot Light in a Control Circuit

Emergency Stop Button

This is an emergency stop button and it differs from a standard stop button as follows:

It has a large, easy to operate, mushroom shaped actuator.
This actuator must be mounted on a yellow background.

When operated, the actuator latches in the "Off " position.

The actuator is released by twisting the mushroom shaped head.

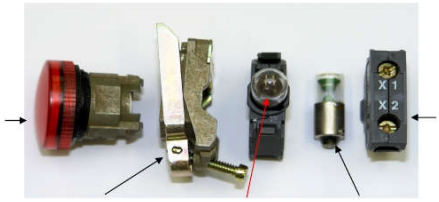


Figure1. 22 Emergency Stop Button

9. Magnetic contactor

. It is basically a large control relay designed to open and close a power circuit. It possesses a relay coil and magnetic plungers which carries a set of movable contacts. When the relay coil is energized, it attracts the magnetic plunger, causing it to rise quickly against the force of gravity. The movable contacts come in contacts with a set of fixed contacts there by closing the power circuit. When the relay coil de-energized the plunger falls there by opening and closing the respective contacts, Used to control motors from 0.5hp to several hundred horse power

A contactor is an electrically controlled switch used for switching an electrical power circuit, similar to a relay except with higher current ratings. A contactor is controlled by a circuit which has a much lower power level than the switched circuit.

Contactors come in many forms with varying capacities and features. Unlike a circuit breaker, a contactor is not intended to interrupt a short circuit current. Contactors range from those having a breaking current of several amperes to thousands of amperes and 24 V DC to many kilovolts. The physical size of contactors ranges from a device small enough to pick up with one hand, to large devices approximately a meter on a side.

Contactors are used to control electric motors, lighting, heating, capacitor banks, thermal evaporators, and other electrical loads.

A contactor has three components. The *contacts* are the current carrying part of the contactor. This includes power contacts, auxiliary contacts, and contact springs. The electromagnet (or "coil") provides the driving force to close the contacts. The enclosure is a frame housing the contact and the electromagnet. Enclosures are made of insulating materials like Bakelite, Nylon 6, and thermosetting plastics to protect and insulate the contacts and to provide some measure of protection against personnel touching the contacts. Open-frame contactors may have a further enclosure to protect against dust, oil, explosion hazards and weather.

Magnetic contactor is a type of switch which is used to control the operation of an electric motor.

Working Principle

Unlike general-purpose relays, contactors are designed to be directly connected to high-current load devices. Relays tend to be of lower capacity and are usually designed for both normally closed and normally open applications. Devices switching more than 15 amperes or in circuits rated more than a few kilowatts are usually called contactors. Apart from optional auxiliary low current contacts, contactors are almost exclusively fitted with normally open ("form A") contacts. Unlike relays, contactors are designed with features to control and suppress the arc produced when interrupting heavy motor currents.

When current passes through the electromagnet, a magnetic field is produced, which attracts the moving core of the contactor. The electromagnet coil draws more current initially, until its inductance increases when the metal core enters the coil. The moving contact is propelled by the moving core; the force developed by the electromagnet holds the moving and fixed contacts

together. When the contactor coil is de-energized, gravity or a spring returns the electromagnet core to its initial position and opens the contacts.

For contactors energized with alternating current, a small part of the core is surrounded with a shading coil, which slightly delays the magnetic flux in the core. The effect is to average out the alternating pull of the magnetic field and so prevent the core from buzzing at twice line frequency.

Because arcing and consequent damage occurs just as the contacts are opening or closing, contactors are designed to open and close very rapidly; there is often an internal tipping point mechanism to ensure rapid action.

Rapid closing can, however, lead to increase contact bounce which causes additional unwanted open-close cycles. One solution is to have bifurcated contacts to minimize contact bounce; two contacts designed to close simultaneously, but bounce at different times so the circuit will not be briefly disconnected and cause an arc.

A slight variant has multiple contacts designed to engage in rapid succession. The first to make contact and last to break will experience the greatest contact wear and will form a high-resistance connection that would cause excessive heating inside the contactor. However, in doing so, it will protect the primary contact from arcing, so a low contact resistance will be established a millisecond later.

Another technique for improving the life of contactors is contact wipe; the contacts move past each other after initial contact in order to wipe off any contamination.

Two units of contactors will alternate the working conditions. They are

- **Normally closed (NC)**
- **normally open contactor (NO)**

The basic elements of magnetic contactors are as follows.

- Iron Core The iron core is divided into two parts:
- Fixed Core Coil is energized, it becomes an electromagnet.

- Moving Core The coil is energized, the magnetic contactor closes and the moving core is pushed into the fixed core.
- Coil The coil is energized to draw the main contact, and the auxiliary contact uses the power of that coil to operate. Contact

There are mainly two types available.

Main Contact

Auxiliary Contact

Interlock

Two contactors may be interlocked so that only one will operate at any time. This may be used, for instance, when the two contactors switch a motor in different directions.

Protective units

Further add-on parts to a contactor-type control system include overload prevention devices.

A protection unit may have to be fitted, e.g. thermal overload unit.

These have three pin connectors which engage into the contactor's screw clamps.

The overload unit has a changeover contact unit in addition to the three protected connections.

Most also have a clip to secure them to the base of the contactor.

Coils are marked alphanumerically, e.g. A1, A2.

Odd numbers – incoming supply terminal.

Even numbers – outgoing terminal.

Auxiliary contacts

Auxiliary contacts are secondary switching devices that work in conjunction with primary switching equipment such as circuit breakers, relays, and contactors. These contacts are physically linked to the main switching mechanism and activate at the same time it does. They are commonly used as interlocks or retainers on the primary device's control circuit and often used to give

indication of its state of operation. Many contactors and circuit breakers feature sets of auxiliary contacts as integral parts or they may be modular snap on units which can be added or removed as required. They are available with either normally open or normally closed contact points or a combination of both.

Main circuit switching devices, such as circuit breakers and contactors, often require additional switching functions over and above those of their primary contacts. These include remote indication of their status, trip function indication, electrical interlocks, and start circuit retainers. These functions have no physical bearing on the main circuit and stand alone. In addition, the voltage used for these auxiliary circuits will typically be far lower than that of the main circuit. To achieve this simultaneous yet separate switching, auxiliary contact points activate along with the primary device. These are generally a lot smaller and rated at lower current values than those of the main device

Figure1. 23 Auxiliary contacts

Advantages of Magnetic Contactors

- Provides high safety for operators
- Provide ease of control
- Economical compared to manual controls

Disadvantages

- The coil may burn if there is no magnetic field.
- When exposed to moisture, ageing of components promotes corrosion of materials. Applications of Magnetic Contactors

The following are some of the applications of magnetic contactors.

- Magnetic Motor Starter
- Lighting Control Contactor

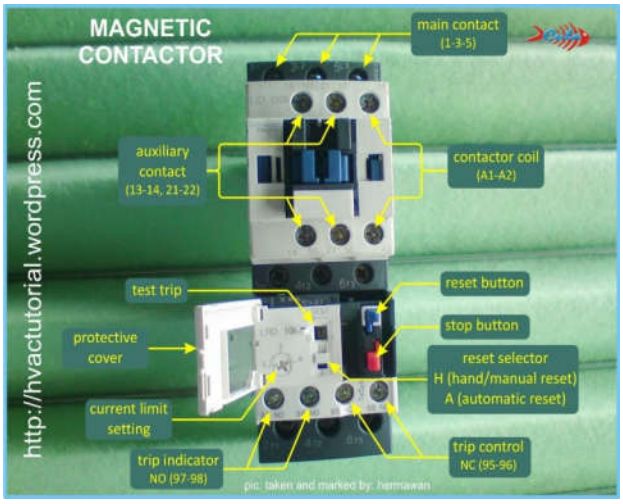


Figure1. 24 the basic parts of simple magnetic contactor

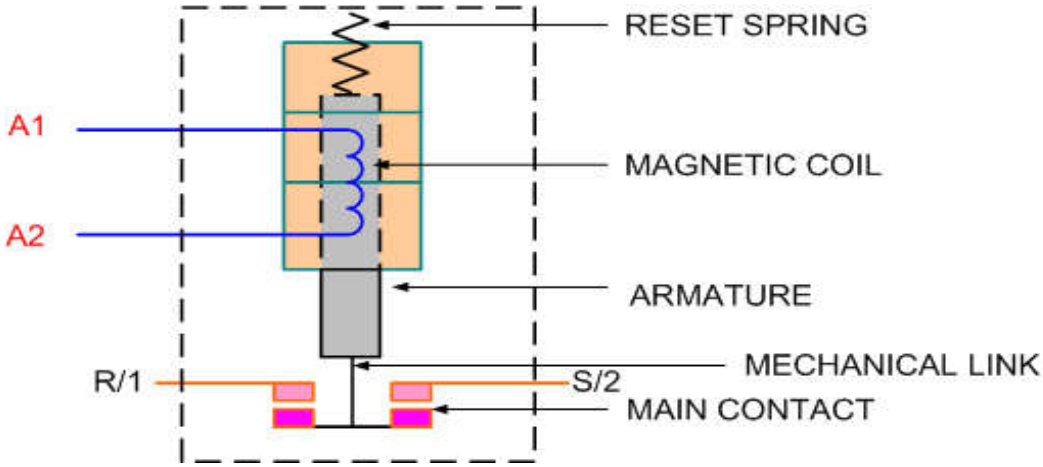


Figure1. 25 the basic parts of simple magnetic contactor

Auxiliary contact – these are sets of contact which are either normally closed (NC) or normally open (NO). They are used for maintaining contacts. Terminals are provided in each set of contacts.

Main contacts – these are sets of contacts which are primarily, used for connecting the load directly to the power lines upon closing them. They are normally opened (NO).

The magnetic coil – Also called holding coil, is used to provide necessary magnetic force which when energized causes the movement of armature.

Armature The movable magnetic iron core, is that part which is mechanically linked with the moving contacts, It moves towards the stationary magnetic core when the holding coil is energized.

Stationary iron core Like the armature produces the magnetic force which causes the attraction of the armature towards it.

Reset spring Is that part which returns the contacts to their original position through the armature mechanical link.

Mechanical link which is connected to the armature is used to open the NC contacts and close its NO contacts simultaneously upon energizing the holding coil.

Magnetic starter

A magnetic starter is a device designed to provide power to electric motors. It includes a contactor as an essential component, while also providing power-cutoff, under-voltage, and overload protection

10. Relays

A relay is a simple electromechanical switch made up of an electromagnet and a set of contacts. Relays are the switches which aim at closing and opening the circuits electronically as well as electromechanically. It controls the opening and closing of the circuit contacts of an electronic circuit. When the relay contact is open (NO), the relay isn't energize with the open contact. However, if it is closed (NC), the relay isn't energize given the closed contact. However, when energy (electricity or charge) is supplied, the states are prone to change.
A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms ,such as make contacts, break contacts, or

combinations

Relay Construction

There are four parts in every relay:

1. The Electromagnet
2. The Armature that is attracted by the electromagnet
3. A Spring
4. A Set of electrical contacts

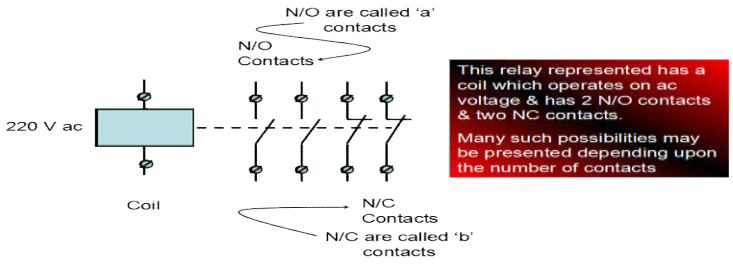


Figure1. 26 Relay Construction

Difference between Contactor and Relay

Since a contractor is required for a higher load, a relay is always cheaper than a contractor.

- A relay is normally used in appliances below 5KW, while a contactor is preferred when the appliance is heavier.
- A relay is used only in control circuit while a contactor can be used in both control and power circuits.
- In general contractors are little slower than relays

  Contactor is so designed that it can be repaired while it is not normally done in the case of relays.

11. Thermal over load relay

Thermal over load relays are economic electromechanical protection devices for the main circuit. They offer reliable protection for motors in the event of overload or phase failure. The thermal overload relay can make up a compact starting solution together with contactors.

Thermal Overload relay protect the motor from the damaging effect of drawing too much current for too long time. When this over-current are relatively high, the overloads may trip in just a few second. At very low levels of over-current, however, it may take hours for them to trip. in either case, however, the overloads open a contact interrupting power before the motor is damaged.

Some overload relays operate magnetically, but most of them operate thermally. There are two main kinds. Bi-metallic and solder pot.

All overloads have two parts, one in the power circuit, and the other in the control circuit. The overload heater is in the power circuit where they conduct the same current used to run the motor. They warm up as the motor draws current. The normally-closed overload contacts is in the control circuit where it conduct current that operates the coil of the contacts. The contact opens when current going through the motor becomes too high.Auxiliary contacts can be fitted to the top or to the sides of most contactors.

Thermal overload relays are economic electromechanical protection devices for the main circuit. They offer reliable protection for motors in the event of overload or phase failure. Starter combinations are setup together with block contactors and mini contactors.

The thermal overload relays are three pole relays with bimetal tripping elements. The motor current flows through the bimetal tripping elements and heats them directly and indirectly. In case of an overload (over current), the bimetal elements bent as a result of the heating. This leads to a release of the relay and a change of the contacts switching position (95-96 / 97-98).

Thermal relays or over load relay is a temperature sensitive device whose contacts open or close when the motor currents exceed a preset limit. The current follows through small calibrated heating elements which raises the temperature of the relay. It is an inherent time delay devices because the temperature cannot follow the instantaneous changes in current

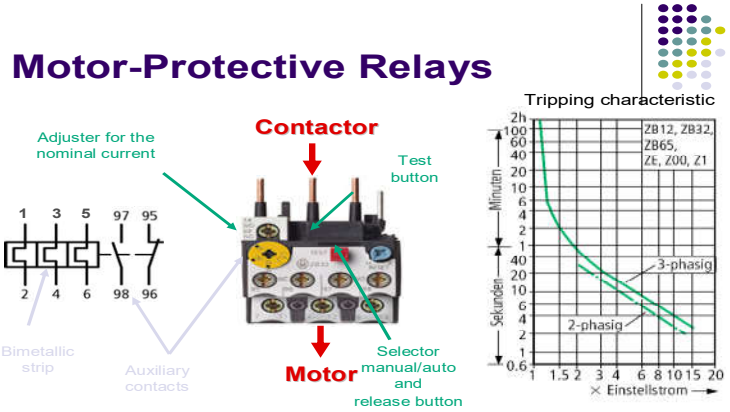


Figure1. 27 Thermal relays

Main benefits

- Reliable protection for motors
- Easy to create starters
- Optimized match to ABB contactors
- Single mounting kits and wire reset for remote control available for specific applications.

Characteristics of thermal overload relays: TF range

Trip class 10 A

Ambient air temperature - operation: -25°C … +60°C

Sealable cover for operating elements

Characteristics of thermal overload relays: T16 range

Trip class 10A

Ambient air temperature - operation: -25°C … +60°C

Characteristics of thermal overload relays: TA…DU range

Trip class 10A

Special version with trip class 20 or 30*

Ambient air temperature - operation: -25°C … +55°C

Special versions, suitable for protection of EEX e motors*

General characteristics of thermal overload relays

Manual or automatic reset selectable

Trip-free mechanism

Phase loss sensitivity acc. to IEC/EN60947-4-1

2 electrically isolated auxiliary contacts – 1 NO + 1 NC

Test and STOP function

Trip indication on the front

Temperature compensation

Useable for AC- or DC-application*

Suitable for three- and single-phase applications

All phase are equipped with bimetal tripping elements

All terminal screws are accessible from the front

12. Proximity detectors

Sealed devices that can detect objects without coming in direct contact with them, their service life is independent of the number of operations. They are wire to an external DC source and generate an alternating magnetic field by means of internal oscillators. When a metal objects comes within a few millimeters of the detector, the magnetic field decreases which in turns cause a DC motor current flows.

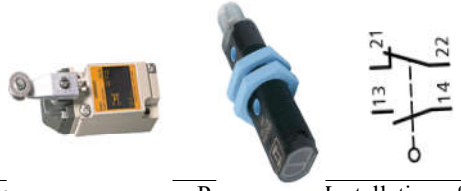


Figure1. 28 Proximity detectors

13. Cable duct

Cable duct With special DIN punching for direct mounting on the enclosure section or on surfaces such as mounting plates.

Figure1.29 Cable duct.

14. A DIN rail

DIN rail is a metal rail of a standard type widely used for mounting circuit breakers and industrial control equipment inside equipment racks. These products are typically made from cold rolled carbon steel sheet with a zinc-plated or chromated bright surface finish. Although metallic, they are meant only for mechanical support and are not used as a bus bar to conduct electric current,

though they may provide chassis grounding connection.

Figure1. 30 A DIN rail

15. cable tie

Cable tie comes with a single loop as well as an attached strap wire to provide strength. At the same time, the cable tie is made of polyethylene and has a strong tensile strength. The elastic band is used to seal the speaker rope, and the strap wire is tied to a box line or cable. This cable tie wire strap clip is suitable for fixing and the fixed part of cable ties.

Figure1. 31 cable tie

16. Conductor

Conductor is an object or type of material that allows the flow of charge (electric current) in one or more directions. Materials made of metal are common electrical conductors. Electric current is generated by the flow of negatively charged electrons, positively charged holes, and positive or negative ions in some cases. An insulator is a material which does not easily allow heat and/or electricity to pass through it. Plastic, wood, rubber and glass are examples of good insulators

17. cable gland

Cable gland is a device designed to attach and secure the end of an electrical cable to the equipment. Cable glands are commonly defined as mechanical cable entry devices

18. Time-Delay Relays

Time-delay relays can be constructed to delay armature motion on coil energization, de-energization, or both. Time-delay relay contacts must be specified not only as either normally-open or normally-closed but whether the delay operates in the direction of closing or in the direction of opening. The following is a description of the four basic types of time-delay relay contacts. Timing relays have timing ranges available from .05 seconds to 100 hours.
Time delay relays are built in these four basic modes of contact operation:
Normally-open, timed-closed. Abbreviated “NOTC”, these relays open immediately upon coil de-energization and close only if the coil is continuously energized for the time duration period. Also

called normally-open, on-delay relays.

Normally-open, timed-open. Abbreviated "NOTO", these relays close immediately upon coil energization and open after the coil has been de-energized for the time duration period. Also called normally-open, off delay relays

Normally-closed, timed-open. Abbreviated "NCTO", these relays close immediately upon coil de-energization and open only if the coil is continuously energized for the time duration period. Also called normally-closed, on-delay relays

Normally-closed, timed-closed. Abbreviated "NCTC", these relays open immediately upon coil energization and close after the coil has been de-energized for the time duration period. Also called normally-closed ,off delay relays

One-shot timers provide a single contact pulse of specified duration for each coil energization (transition from coil off to coil on).

Recycle timers provide a repeating sequence of on-off contact pulses as long as the coil is maintained in an energized state.

Watchdog timers actuate their contacts only if the coil fails to be continuously sequenced on and off (energized and de-energized) at a minimum frequency

Normally-Open, Timed-Closed Contact

First, we have the normally-open, timed-closed (NOTC) contact. This type of contact is normally open when the coil is unpowered (de-energized). The contact is closed by the application of power to the relay coil, but only after the coil has been continuously powered for the specified amount of time. In other words, the direction of the contact's motion (either to close or to open) is identical to a regular NO contact, but there is a delay in closing direction. Because the delay occurs in the direction of coil energization, this type of contact is alternatively known as a normally-open, on-delay:

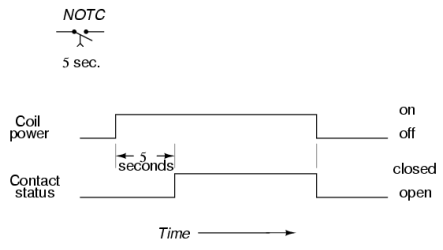


Figure1. 32The following is a timing diagram of this relay contact's operation

Normally-Open, Timed- Open Contact

The normally-open, timed-open (NOTO) contact. Like the NOTC contact, this type of contact is normally open when the coil is unpowered (de-energized), and closed by the application of power to the relay coil. However, unlike the NOTC contact, the timing action occurs upon de-energization of the coil rather than upon energization. Because the delay occurs in the direction of coil de-energization, this type of contact is alternatively known as a normally-open, off-delay:

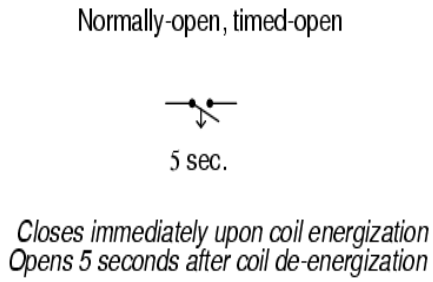


Figure1. 33 NOTC contact

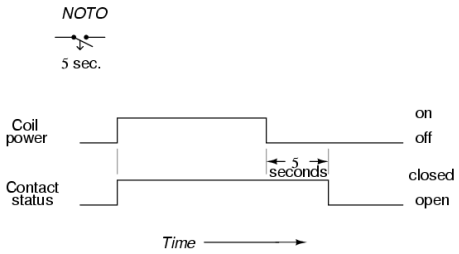


Figure1. 34 timing diagram of this relay contact's operation

Normally-closed, Timed- Open Contact

The normally-closed, timed-open (NCTO) contact. This type of contact is normally closed when the coil is unpowered (de-energized). The contact is opened with the application of power to the relay coil, but only after the coil has been continuously powered for the specified amount of time. In other words, the direction of the contact's motion (either to close or to open) is identical to a regular NC contact, but there is a delay in the opening direction. Because the delay occurs in the

direction of coil energization, this type of contact is alternatively known as a normally-closed, on-delay:

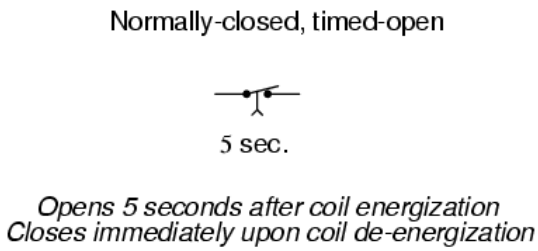


Figure1. 35NCTO contact

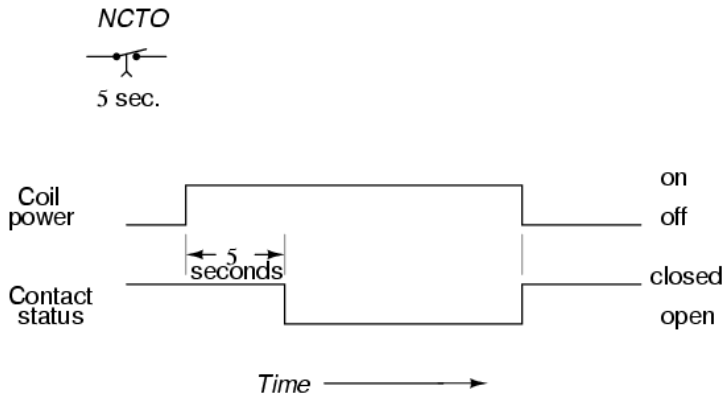


Figure1. 36 timing diagram of this relay contact's operation

Normally-closed, Timed- closed Contact

Finally, we have the normally-closed, timed-closed (NCTC) contact. Like the NCTO contact, this type of contact is normally closed when the coil is unpowered (de-energized), and opened by the application of power to the relay coil. However, unlike the NCTO contact, the timing action occurs upon de-energization of the coil rather than upon energization. Because the delay occurs in the direction of coil de-energization, this type of contact is alternatively known as a normally-closed, off-delay:

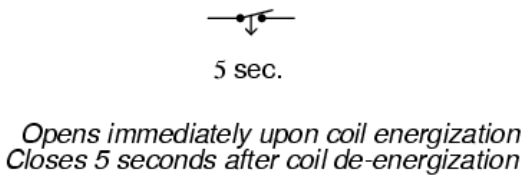


Figure1. 37 NCTO

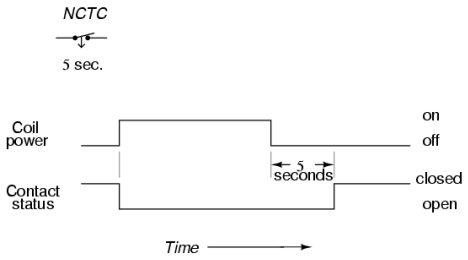


Figure1. 38 timing diagram of this relay contact's operation

Time-delay relays uses industrial control logic circuit

Time-delay relays are very important for use in industrial control logic circuits. Some examples of their use include:

Flashing light control (time on, time off): two time-delay relays are used in conjunction with one another to provide a constant-frequency on/off pulsing of contacts for sending intermittent power to a lamp.

Engine auto start control: Engines that are used to power emergency generators are often equipped with "autostart" controls that allow for automatic startup if the main electric power fails. To properly start a large engine, certain auxiliary devices must be started first and allowed some brief time to stabilize (fuel pumps, pre-lubrication oil pumps) before the engine's starter motor is energized. Time-delay relays help sequence these events for proper start-up of the engine.

Furnace safety purge control: Before a combustion-type furnace can be safely lit, the air fan must be run for a specified amount of time to "purge" the furnace chamber of any potentially

flammable or explosive vapors. A time-delay relay provides the furnace control logic with this necessary time element.

Motor soft-start delay control: Instead of starting large electric motors by switching full power from a dead stop condition, reduced voltage can be switched for a “softer” start and less inrush current. After a prescribed time delay (provided by a time-delay relay), full power is applied.

Conveyor belt sequence delay: when multiple conveyor belts are arranged to transport material, the conveyor belts must be started in reverse sequence (the last one first and the first one last) so that material doesn’t get piled on to a stopped or slow-moving conveyor. In order to get large belts up to full speed, some time may be needed (especially if soft-start motor controls are used). For this reason, there is usually a time-delay circuit arranged on each conveyor to give it adequate time to attain full belt speed before the next conveyor belt feeding it is started.

Advance time future .

The electronic-timer relays are more versatile than the older, mechanical models, and less prone to failure. Many models provide advanced timer features such as “one-shot” (one measured output pulse for every transition of the input from de-energized to energized), “recycle” (repeated on/off output cycles for as long as the input connection is energized) and “watchdog” (changes state if the input signal does not repeatedly cycle on and off).

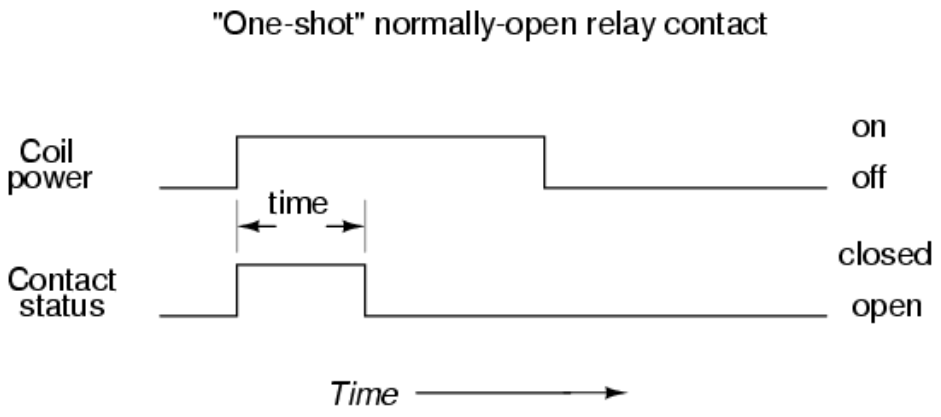


Figure1. 39 one shot normally open rely contact

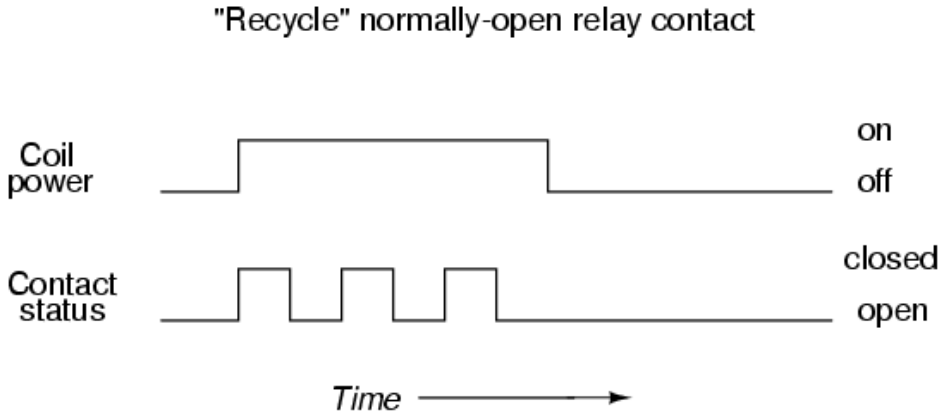


Figure1. 40 recycle normally open contact

Watch dog Timer Relay contact

The “watchdog” timer is especially useful for monitoring of computer systems. If a computer is being used to control a critical process, it is usually recommended to have an automatic alarm to detect computer “lockup” (an abnormal halting of program execution due to any number of causes). An easy way to set up such a monitoring system is to have the computer regularly energize and de-energize the coil of a watchdog timer relay (similar to the output of the “recycle” timer). If the computer execution halts for any reason, the signal it outputs to the watchdog relay coil will stop cycling and freeze in one or the other state. A short time thereafter, the watchdog relay will “time out” and signal a problem.

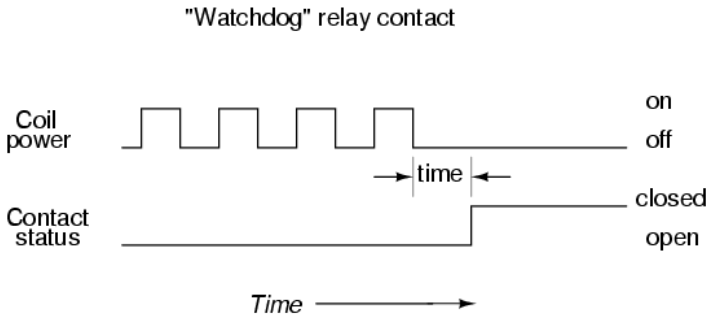


Figure1. 41watchdog Relay contact

A timing relay has two major functions: On-delay and Off-delay timing. An arrow is used to denote the function of the timer. An arrow pointing up indicates an On-delay timing action. An arrow pointing down indicates an Off-delay timing action.

On-delay and Off-delay timers can turn their connected loads on or off, depending on how the timer's output is wired into the circuit.

On-delay indicates that once a timer has received a signal to turn on, a predetermined time (set by the timer) must pass before the timer's contacts change state.

Off-delay indicates that once a timer has received a signal to turn off, a predetermined time (set by the timer) must pass before the timer's contacts change state

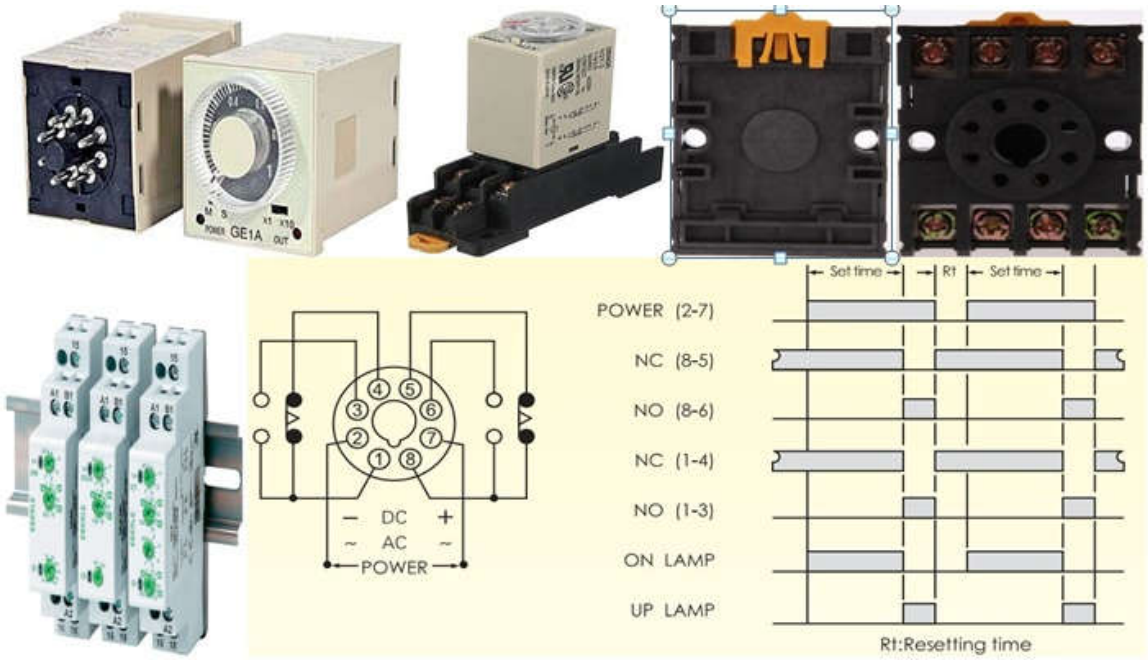


Figure1. 42 timer

On-Delay, Time Closed

The following is an example of On-delay, timed closed. For this example a set of normally open (NO) contacts is used. This is also referred to as normally open timed closed (NOTC). The timing relay (TR1) has been set for an On-delay of 5 seconds. When S1 is closed, TR1 begins timing. When 5 seconds has elapsed, TR1 will close its associated normally open (NO) TR1 contacts,

illuminating pilot light PL1. When S1 is open, deenergizing TR1, the TR1 contacts open immediately, extinguishing PL1.

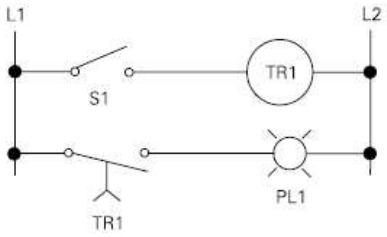


Figure1. 43 ***On-Delay, Time Closed***

On-Delay, Timed Open

The following is an example of On-delay, timed open. For this example a set of normally closed (NC) contacts is used. This is also referred to as normally closed, timed open (NCTO). PL1 is illuminated as long as S1 remains open. The timing relay (TR1) has been set for an ON delay of 5 seconds.

When S1 is closed, timing relay TR1 is energized. After a timed delay of 5 seconds, the associated normally closed TR1 contacts open, extinguishing PL1. When S1 is open, deenergizing TR1, the TR1 contacts close immediately, illuminating PL1.

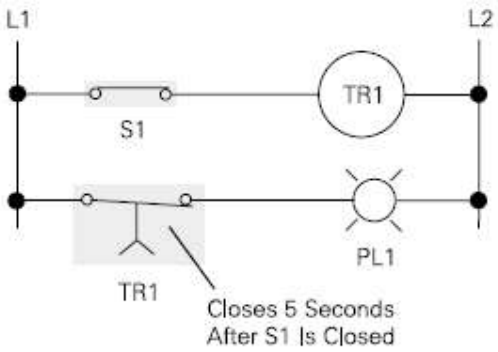


Figure1. 44 NCTO

Off-Delay, Timed Open

The following is an example of Off-delay, timed open. For this example a set of normally open contacts (NO) is used. This is also referred to as normally open, timed open (NOTO). The timing relay (TR1) has been set for an off delay of 5 seconds. Closing S1 energizes TR1 causing its associated normally open TR1 contacts to close immediately, illuminating PL1.

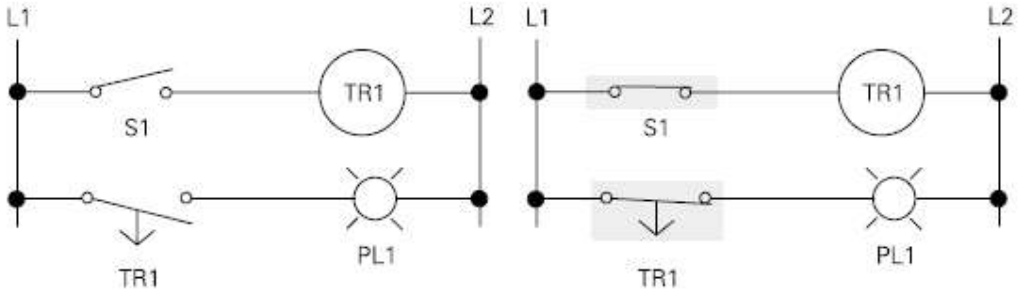


Figure1. 45 NOTO

When S1 is opened, TR1 begins timing. When 5 seconds has elapsed, TR1 will open its associated normally open contacts, extinguishing pilot light PL1.

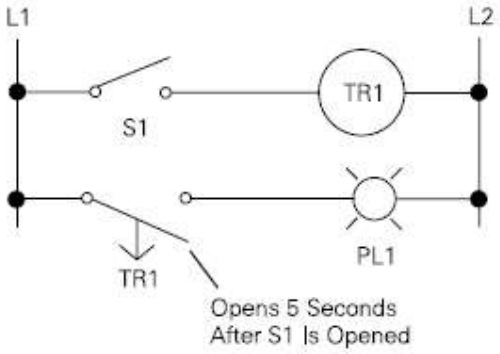


Figure1. 46 NOTO

Off-Delay, Timed Closed

The following is an example of Off-delay, timed closed. For this example a set of normally closed (NC) contacts is used. This is also referred to as normally closed, timed closed (NCTC). The timing relay (TR1) has been set for 5 seconds. PL1 is on. Closing S1 energizes TR1 causing its associated contacts to open immediately, extinguishing PL1.

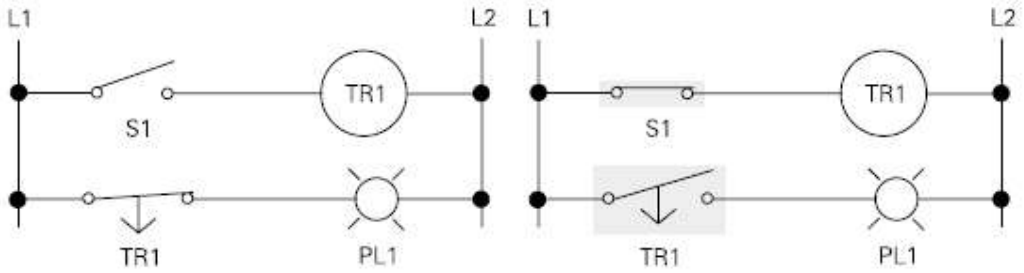


Figure1. 47 Off-Delay, Timed Closed

When S1 is opened, timing relay TR1 is deenergized. After 5 seconds, the associated normally closed contacts close, illuminating PL1.

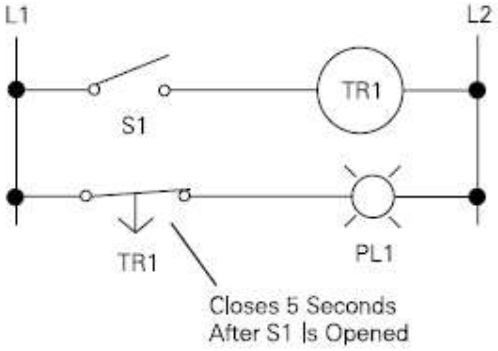


Figure1. 48 Off-Delay, Timed Closed

Instantaneous Contacts

Timing relays can also have normally open or normally closed instantaneous contacts. In the following example, when switch S1 is closed, the TR1 instantaneous contacts will close immediately, illuminating PL1. After a preset time delay the TR1 timing contacts will close, illuminating PL2.

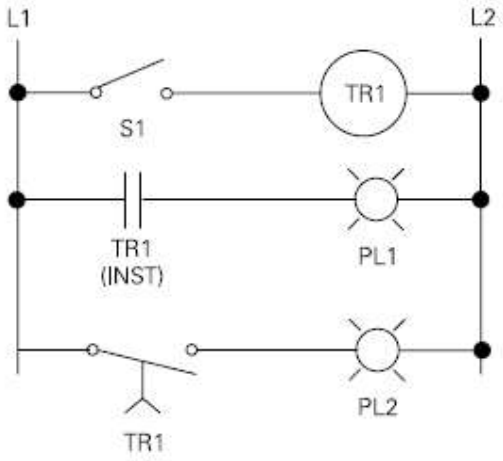


Figure1. 49 Instantaneous Contacts

19. Digital device

Digital device means an electronic device that can create, generate, send, share, communicate, receive, store, display, or process information, and such electronic devices shall include, but not limited to, desktops, laptops, tablets, peripherals, servers, mobile telephones, smart phones, and any similar storage device ...

A digital device processes electronic signals into discrete values, of which there can be two or more. Actuators Buzzers Indicating Lamps Limit switches Magnetic contactors Photo-sensors Proximity sensor Solenoid Cylinders

20. Analog signals

Analog signals **are** continuous and can be represented by a smooth wave pattern.

The major difference between both signals is that the analog signals have continuous electrical signals, while digital signals have non-continuous electrical signals Actuators Servo & Stepper Motors Frequency drives Transducers Transmitters solenoid valves

21. transmitter

Transmitter is an electronic device used in telecommunications to produce radio waves in order to transmit or send data with the aid of an antenna. The transmitter is able to generate a radio frequency alternating current that is then applied to the antenna, which, in turn, radiates this as radio waves.

22. buzzer or beeper

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, train and confirmation of user input such as a mouse click or keystroke.

23. transducer

A transducer is a device that converts energy from one form to another. Usually a transducer converts a signal in one form of energy to a signal in another.[

24. Indicator Lamp or Indicator Light

Indicator Lamp or Indicator Light is a widely used in the ship, machine tools, machine equipment, switch cabinet, power distribution cabinet. Indicator lamp, also name pilot lamp, who to indicate whether power is on or a equipement device is for showing the operating condition of some system.

25. An actuator

An actuator **is** a component of a machine that is responsible for moving and controlling a mechanism or system, for example by opening a valve. In simple terms, it is a "mover".

26. A variable-frequency drive (VFD)

A variable-frequency drive (VFD) is a type of motor drive used in electro-mechanical drive systems to control AC motor speed and torque by varying motor input frequency and, depending on topology, to control associated voltage or current variation. VFDs may also be known as 'AFDs' (adjustable-frequency drives), 'ASDs' (adjustable-speed drives), 'VSDs' (variable-speed drives), 'AC drives', 'micro drives', 'inverter drives' or, simply, 'drives'.

27. Limit switch

Limit switch is a switch operated by the motion of a machine part or the presence of an object. A limit switch can be used for controlling machinery as part of a control system, as a safety interlock, or as a counter enumerating objects passing a point.

Limit switches are used in a variety of applications and environments because of their ruggedness, ease of installation, and reliability of operation.

28. Proximity sensors

Proximity sensors are also used in machine vibration monitoring to measure the variation in distance between a shaft and its support bearing. This is common in large steam turbines, compressors, and motors that use sleeve-type bearings.

29. Solenoid valve

Valve is directly controlled by the contacts of an industrial limit switch, but more typically the limit switch is wired through a control relay, a motor contactor control circuit, or as an input to a programmable logic controller.

30. Pneumatic solenoid valves

Pneumatic solenoid valves are used to control the flow direction of compressed air. A moving part inside the valve blocks or opens the ports of the valve. The moving part is called spool or piston. The movement of the spool can be controlled in two ways: direct operation, or indirect operation.

31. hydraulic solenoid valve

A hydraulic solenoid valve is a solenoid controlled directional valve used in a hydraulic system for opening, closing or changing the direction of flow of the liquid. are widely used in industries like manufacturing, aerospace, construction and many others that require hydraulic systems.

1.5. Correct size and degree of protection of enclosures

Motor Overload Protection

Motors larger than 1 horsepower must be provided separate motor overload protection devices. The most common devices typically used include:

1. Magnetic or thermal overload devices
2. Electronic overload relays
3. Fuses

Fuse

Normally, the ampacity rating of a conductor is a circuit design limit never to be intentionally exceeded, but there is an application where ampacity exceedance is expected: in the case of fuses. A fuse is a small, thin conductor designed to melt and separate into two pieces for the purpose of breaking a circuit in the event of excessive current

A fuse is an electrical safety device built around a conductive strip that is designed to melt and separate in the event of excessive current. Fuses are always connected in series with the component(s) to be protected from over current, so that when the fuse ***blows*** (opens) it will open the entire circuit and stop current through the component(s). A fuse connected in one branch of a parallel circuit, of course, would not affect current through any of the other branches.

Cartridge type fuses are popular in automotive applications, and in industrial applications when constructed with sheath materials other than glass. Because fuses are designed to "fail" open when their current rating is exceeded, they are typically designed to be replaced easily in a circuit. This means they will be inserted into some type of holder rather than being directly soldered or bolted to the circuit conductors.

Fuse rating

after Fuses are primarily rated in terms of maximum current, but are also rated in terms of how much voltage drop they will safely withstand interrupting a circuit Fuses can be designed to blow fast, slow, or any where in between for the same maximum level of current.

Fuses are primarily rated, as one might expect, in the unit for current: amps. Although their operation depends on the self-generation of heat under conditions of excessive current by means of the fuse's own electrical resistance, they are engineered to contribute a negligible amount of extra resistance to the circuits they protect. This is largely accomplished by making the fuse wire as short as is practically possible. Just as a normal wire's ampacity is not related to its length (10-gauge solid copper wire will handle 40 amps of current in free air, regardless of how long or short of a piece it is), a fuse wire of certain material and gauge will blow at a certain current no matter how long it is. Since length is not a factor in current rating, the shorter it can be made, the less resistance it will have end-to-end.

However, the fuse designer also has to consider what happens after a fuse blows: the melted ends of the once-continuous wire will be separated by an air gap, with full supply voltage between the ends. If the fuse isn't made long enough on a high-voltage circuit, a spark may be able to jump from one of the melted wire ends to the other, completing the circuit again:

Consequently, fuses are rated in terms of their voltage capacity as well as the current level at which they will blow.

Fuses are always supposed to be placed on the "hot" side of the load in systems that are grounded. The intent of this is for the load to be completely de-energized in all respects after the fuse opens. To see the difference between fusing the "hot" side versus the "neutral" side of a load, compare these two circuits:

The most common device in use for over current protection in high-current circuits today is the circuit breaker.

Circuit breakers

A circuit breaker is a specially designed switch that automatically opens to interrupt circuit current in the event of an over current condition. They can be "tripped" (opened) thermally, by magnetic fields, or by external devices called "protective relays,"
is an electrical safety device designed to protect an electrical circuit from damage caused by an over current or short circuit. Its basic function is to interrupt current flow to protect equipment and to prevent the risk of fire. Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation
Circuit breakers are made in varying sizes, from small devices that protect low-current circuits or individual household appliances, to large switchgear designed to protect high voltage circuits feeding an entire city. The generic function of a circuit breaker, or fuse, as an automatic means of removing power from a faulty system,
specially designed switches that automatically open to stop current in the event of an over current condition. Small circuit breakers, such as those used in residential, commercial and light industrial service are thermally operated. They contain a bimetallic strip (a thin strip of two metals bonded back-to-back) carrying circuit current, which bends when heated. When enough force is generated by the bimetallic strip (due to overcurrent heating of the strip), the trip mechanism is actuated and

the breaker will open. Larger circuit breakers are automatically actuated by the strength of the magnetic field produced by current-carrying conductors within the breaker, or can be triggered to trip by external devices monitoring the circuit current (those devices being called protective relays***).***

Because circuit breakers don't fail when subjected to over current conditions rather, they merely open and can be re-closed by moving a lever they are more likely to be found connected to a circuit in a more permanent manner than fuses.

Sizing Motor Overload Protection

There are several types of devices that can be used to provide overload protection and the sizing procedure can vary depending on the type of device used.

It is important to keep differences in the procedures separate and understood well so as not to install overloads that do not provide adequate protection to the motor.

The simplest and most straightforward sizing procedures for motor overload protection are applied when sizing overload relays using the cover of the motor starter, control center, or Manufacturer's catalog.

The National Electrical Code specifies methods to calculate the maximum size motor overload protection for specific motors if a manufacturers chart is not available. Installations relying on fuses and circuit breakers as back-up overload protection must be calculated using the NEC method.

Selecting Overloads From Starter Covers or Charts

The size overloads required to protect the windings of a motor can be determined by taking the motor's full-load current rating and selecting the size overloads from the cover of a magnetic starter, a motor control center, or the manufacturer's catalog.

The following things should be kept in mind when using manufacturer's charts.

When the overload size is selected from the cover of a magnetic starter or controller, the nameplate full-load running current of the motor is used. The full-load running current is NOT increased by 125% when the overloads are selected in this manner.

The charts are usually based on only the specific manufacturer's equipment.

Sizes from the charts may be different from those of calculated values from the National Electrical Code.

Manufacturer s' charts often provide smaller rated devices than the NEC would allow as a measure of extra protection.

Manufacturers' typically list the most common sizes in their charts. Certain sizes may require calculations if the chart is not available from the manufacturer.

If the motor will operate at/near service factor, the appropriate FLA of the motor at its Service Factor should be used to select the overload size from the manufacturer's chart

1.6. Tools and testing instruments

Testing equipment

A multi meter or a multi tester, also known as a volt/ohm meter or VOM, is an electronic measuring instrument that combines several measurement functions in one unit. A typical multi meter may include features such as the ability to measure voltage, current and resistance. Multi meters may use analog or digital circuits—analog multi meters and digital multi meters (often abbreviated DMM or DVOM.) Analog instruments are usually based on a micro ammeter whose pointer moves over a scale calibration for all the different measurements that can be made; digital instruments usually display digits, but may display a bar of a length proportional to the quantity measured.

Voltmeter (Measures voltage)

Ohmmeter (Measures resistance)

Ammeter, e.g. Galvanometer or Milliammeter (Measures current)

Multimeter e.g., VOM (Volt-Ohm-Milliammeter) or DMM (Digital Multimeter) (Measures all of the above)

Clamp-on ammeter A clamp meter is a clothespin-shaped instrument that can be clamped around a live wire in order to measure the current it's carrying.

The ground resistance test set works by injecting a current into the earth between a test electrode and a remote probe, measures the voltage drop caused by the soil to a designated point, and then use Ohm's Law to calculate the resistance.

Ground resistance test sets come in a variety of styles with the most common being the 4-terminal unit for soil resistivity testing and the 3-terminal unit for fall-of-potential testing. Copper rods or similar stakes are used to make contact with the earth along with spools of small stranded wire to cover long distance measurements.

Vibration Tester

Vibration analyzers are used to identify and locate the most common mechanical faults (bearings, misalignment, unbalance, looseness) in rotating machinery. As mechanical or electrical faults develop in motors, vibration levels increase. These increases in vibration and no is levels occur at different severity of a developing fault.

Accelerometers

Accelerometers are used to take vibration measurements with the equipment in service and data is loaded into software for analysis. As the machine under test operates, the accelerometer detects its vibration along three planes of movement (vertical, horizontal and axial).

Figure1. 50 Accelerometers

Relay test

Relay test set these ae power system simulators used for testing protection devices used in industrial and power systems. Relay test sets are fitted with multiple sources to test solid-state and multi-function numerical protection, each voltage and current channel is operated independently to create different power system conditions.

High end relay test equipment can test not only simple voltage, current, and frequency relays but also complex protection schemes, such as communication-assisted line protection, and protection schemes that use IEC61850-compliant IEDs (intelligent electronic devices).

Megohmmeter

Megohmmeter Most commonly referred to as simply a "megger", a megohmmeter is a special type of ohmmeter used to measure the electrical resistance of insulators.

Resistances values by megohmmeters may range from several megohms to several million megohms (teraohms). Megohmmeters produce high voltages via battery powered internal circuitry or a manually operated generator with outputs ranging from 250 to 15,000 volts.

Megohmmeters are one of the most frequently used pieces of test equipment and can be used to measure the insulation of various types of apparatus such as circuit breakers, transformers, switchgear and cables.

1.7. Inspection report

An inspection report is a report created by a company that performs inspections for a client to describe a building or object. Inspection reports are among the most important tools for ensuring the quality of construction, facilities, and products.

An inspection report is a report generated by an insurance company regarding the details of a specific risk. Inspection reports are designed to examine the risk from a moral, physical, and financial perspective. In terms of life insurance, for example, the older a person is, and the more health problems they have, the riskier they can be to insure.

Inspection report is a report created by a company that performs inspections for a client to describe a building or object. Inspection reports are among the most important tools for ensuring the quality of construction, facilities, and products.

1.8. Quantity, usage and specifications of materials, tools and equipment specification

Specification is a detailed description of the dimensions, construction, workmanship, materials etc., of work done or to be done, prepared by an architect, engineer etc."

A specification is the document that describes in words what cannot be visualized or explained on a drawing or model. This is not only applicable to construction; the same principles apply to all industries, from aerospace and oil and gas to automobiles and manufacturing. In construction, the specification can cover everything:

- Site establishment.
- Contract type.
- Asset performance criteria.
- Systems and product quality.
- Applicable standards and how they are executed.
- Specific products to be used.

The type of specification can relate to the project or the procurement route – whether it is performance-based, prescriptive or proprietary – depending on project requirements.

- Specifications:
- Are required during the design stage.
- Form part of the contract documentation.
- Play a key role in project fulfillment.

The primary Reasons why specification is crucial

The specification provides clear instructions on project intent, performance

It can reference the quality and standards which should be applied.

Materials and manufacturers' products can be clearly defined.

Installation, testing and handover requirements can be identified.

Classification within the specification can be used to support handover and asset management.

It eliminates the need for information overload on the drawing or model, making identifying information easier.

A specification can support project costing, not only the materials and products but the performance and workmanship.

Along with the drawings, the specification forms part of the contractual documents, helping minimize project risk and providing support should there be any legal disputes.

It supports client brief interpretation and gives the client assurance that their commissioned asset is the one being delivered.

It is essential for the construction phase and an important part of the soft-landing process, subsequent asset management and the lifecycle plan.

By being clear, concise and information-rich, a specification provides answers to many onsite construction questions, saving the project team, client and contractor time and money.

After project finish, office masters can incorporate best practices and lessons learnt, improving efficiency, providing quality assurance and ensuring project consistency.

Office masters also save the team time and money because they can be developed over time and adapted to suit a project's specifics, drawing on specialist knowledge when needed.

The specification is a living document to be used by the complete project team throughout the construction phase; its value does not end at the design phase.

Along with any variations or value engineering, it becomes a part of the project audit trail and a crucial part of the handover documents, forming the basis for asset management, asset maintenance, and even feeding into staff training and human resources policies.

Specifications used to be one of the last items written before issuing a tender package; however this has changed over time, especially since the advent of BIM.

Nowadays, the best practice is to begin specification writing as early as possible in the project lifecycle. Early-stage specifications can capture information from the client review, documenting what the client is trying to achieve on the project. Early-stage work also provides a better understanding of a project's performance requirements. Any information incorporated into the client's EIR (employer information requirements) and discussions on complexes, entities, spaces, locations, elements, systems, and products contribute to the specification as it builds.

Material Specifications means the specification(s), data, impurity profile, requirement(s) and/or descriptions of the Material and the shipping and handling thereof as set forth in Exhibit A and as may be further provided by Verrica to Supplier from time to time. Material Specifications means specific and detailed information regarding the composition, shipping, handling and storage guidelines and other information necessary to properly manufacture, ship and store a Product, including, without limitation, the identity of and contact information for the Manufacturer, Part Number, sampling plan, safety considerations, expiration date and retest instructions, Supplier certificate requirements, Genzyme test requirements, and storage conditions. Material Specifications means the specifications and testing to be performed on the Materials, as specified in the Quality Agreement.
Material Specifications means the description of the Material, including requirements, tolerances, shelf life, specifications, suppliers and safety data, that are set forth in Exhibit D.

Sample Material Specifications.

Length x Width: [ ] Thickness of Material: [ ] CONSUMPTION MATERIALS: Adhesives, [ ] PRODUCTION CAPACITY: [ ] cards/hour/set (based on three rows of the module tapes) SYSTEM PARAMETERS: ---------- -- Width [ ] ---------- Thickness [ ] ---------- Height [ ] ---------- ---------- Weight [ ] ---------- ---------- Placement Area [ ] ---------- ---------- Placement Precision [ ] ---------- ---------- Power Supply [ ] ---------- ---------- Maximum Electric Current [ ] ---------- ---------- Power [ ] ---------- ---------- Frequency [ ] ---------- Condensed Air Pressure [ ] ---------- - Condensed Air Flow [ ] ---------- Condensed Air Conditions [ ] ---------- ---- WIRE IMPLANTING MACHINE FUNCTIONS: Said machine uses the [ ] [ ]ultrasound wire implanting head to implant the enamel-insulated wire accurately into the PC, adhesive coated PET, PETG and PVC material and coil into a wire coil The position, size, shape, and the circles of coil can be set up by the computer. With automatic protection device that can automatically turn off the machine in exceptional cases.

Table1 1 Sample Inspection Report Form

Inspection date:	System name:		Location
Inspection type:	Status:		Building: Room:
Last inspection date:	National Board number:	Serial number:	SLAC pressure system number:
System type *(check all that apply)*:		Year built:	
☐ Scientific ☐ Vacuum ☐ Conventional ☐ Compressed gas ☐ Cryogenic ☐ Other *(specify)*:		Manufacturer:	
Dimensions (D x L):	Thickness:	Capacity:	Surface area:
Pressure relief devices (PRD)			
Size:		Maximum allowable working pressure:	
Capacity:		Pressure test:	
Set at:		PRD test:	
Certificate issued: ☐ Yes ☐ No *(explain)*:		Pressure allowed This inspection: Last inspection:	
Conditions:			
Requirements:			
Custodian's name *(print)*:		Phone:	
Inspector's name *(print)*:		Phone:	
Inspector's signature:		Date:	

1.9. Requisition form of materials, tools and equipment

Material Requisition Form

This is a form used to request items from a company or organization's inventory so that those items can be used for a project or for providing service to a customer or client. There are various projects for which Material Requisition Forms can be used, such as workshops, marketing projects, and any other processes, such as cleaning and construction.

Since a Material Requisition Form is only used for the request of items already in stock in a company's inventory, a Purchase Requisition Form has to be used in the event that the stock of certain items or materials becomes depleted. The filled out Purchase Requisition Form or Purchase Request Form is then forwarded over to the purchasing department so

that they can place an order for the materials.

Requisition form

A requisition form is an important tool in different industries and organizations. You use it to procure goods or services from a company, a branch, a department, and more. Organizations should have their own requisition form template in case any of their employees need to make a request.

If you need to make an official request, this you can use this form which typically comes in a standardized format. You either need to fill up a piece of paper or an online form depending on what's available in your organization. This type of form, whether it's digital or physical, would include:

- Details about what you're requesting for
- The date you made the request
- The name of the person or the department making the request

Uses of a Material Requisition Form

this form can help streamline the request process so that the inventory can be checked and replenished once the stock goes down. For example, if you know that there are 10 of a certain item in the inventory, and there is a request for 10 of that item as well, then you'll know that you would need to put in a purchase order for this item. Aside from that, it relays the information of what items have to be picked from the inventory and when.

Components of a Material Requisition Form

The name of the employee and department requesting the materials

1. What the materials are for (If it is for a project or job, then the job number should be specified so that the receiving departments will be aware as to who the materials will be charged to.)

2. The date the request was placed, along with the date the materials are going to be needed

3. A description or item number of the materials requested

4. Unit or quantity of materials that have to be pulled from the stock

5. The name and signature of the authorized personnel

If the materials have to be delivered, then a delivery address should be included on the Material Requisition Form as well. And if the form will be used as a basis for a service invoice, then the cost of the materials can be included as well so it is easier to calculate the total cost for the service/s provided.

Whenever specific materials are required in a production department, **a** materials requisition form must be prepared.

Also kno**wn as a** requisition slip **or** materials requisition note**, a** materials requisition form is a document that authorizes and records the issue of materials for use.

In other words, a materials requisition form is used to draw materials from the stores, and it specifies the quantity and quality of materials required, along with the job number or work order for which it is needed.

The materials requisition form must be signed by the foreman of the department or the works manager to ensure authenticity. Furthermore, it is the responsibility of the store-keeper to issue the quantity and quality of materials specified in the form.

After receiving a materials requisition form, the store-keeper issues the required materials to the correct job and enters the details in the appropriate bin card.

The signature of the person receiving the materials against the materials requisition from the stores must also be obtained by the store-keeper.

Table1 2 materials requisition

Materials Requisition
A.B. Co. Ltd.

Department ..... Serial No. .....
Job No. ..... Date .....

Qty.	Description	Code No.	Bin Card No.	Store Ledger Folio	Rate	Amount

Authorized by ..... Received by .....
Storekeeper's Signature ..... Checked by .....
Materials Abstract Prepared by .....

The rates and amounts of materials are entered in the materials requisition form by the Costing Office. The form is prepared in duplicate. One copy is sent to the store-keeper and another is retained by the initiating department for future reference.

Material Requisition

Also known as a requisition slip or materials requisition note, a materials requisition form is a document that authorizes and records the issue of materials for use. In other words, a materials requisition form is used to draw materials from the stores, and it specifies the quantity and quality of materials required, along with the job number or work order for which it is needed.

The authenticity of the material requisition form

The materials requisition form must be signed by the foreman of the department or the works manager to ensure authenticity. Furthermore, it is the responsibility of the store-keeper to issue the quantity and quality of materials specified in the form. After receiving a materials requisition form, the store-keeper issues the required materials to the correct job and enters the details in the appropriate bin card.

Purpose of a material requisition form

A material requisition form lists the items to be picked from inventory and used in the production process or in the provision of a service to a customer, usually for a specific job.

Gate pass

A gate pass is a document issued in the name of the authority that receives materials from the storage department. It is prepared by the storekeeper.

Purpose of a gate pass

Gate passes issued by a storekeeper authorize the security officer of the storage department to allow the specified person to carry the specified materials out of the store.

Self check 1

Test I say true or false

2. Never work on electrical circuits with wet or moist hands
3. When in the lab do not wear clothing or jeweler which could constitute a health hazard
4. Electrical Safety in the workplace is the most important Job of an electrical worker

Test II: short Answer writing

Instruction: write short answer for the given question. You are provided 3 minute for each question and each point has 5Points

1. ---------- represents the elements of a system with abstract and graphic symbols instead of realistic pictures
2. ----------refers to the specific days and hours designated to an employee for paid work.

Test III: Short answer writing

Instruction: Give short answer to the following questions. Time allotted for each item is 2mniut and each question carry 4 point.

1. Write at least three types of work schedules Full time
2. Write at least two tpe of diagrams.

Operation sheet 1.1 Preparation for Motor controller Installation

Operation Title Identifying Electrical Symbol Used In Motor Controls

Instruction:

Using the Flip chart and given equipments Identifying Electrical Symbol Used In Motor Controls instructor must check the circuit before you apply power.

Purpose: When you have completed this Unit, the trainee should be able to identify the electrical symbols used in motor controls.

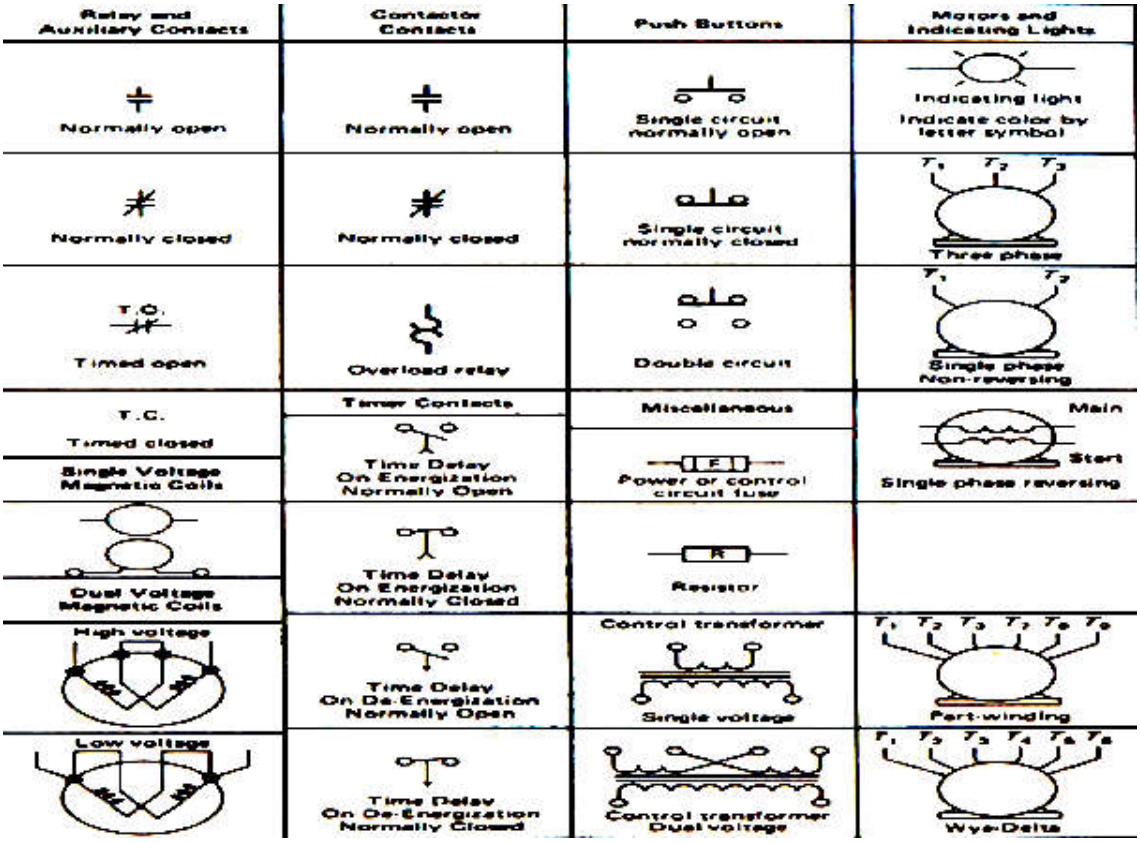
Required tools and equipment: Flip chart

Precautions: Safe handling of hand tools, testing instruments and components

Procedures:

Step 1. Prepare electrical symbols for the given task

Step2. Identify the electrical symbols used in motor controls.



Quality criteria:

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. Neatness/good looking

Operation sheet 1.2 Preparation for Motor controller Installation

Operation Title: **Thermal Overload Relay**

Instruction:

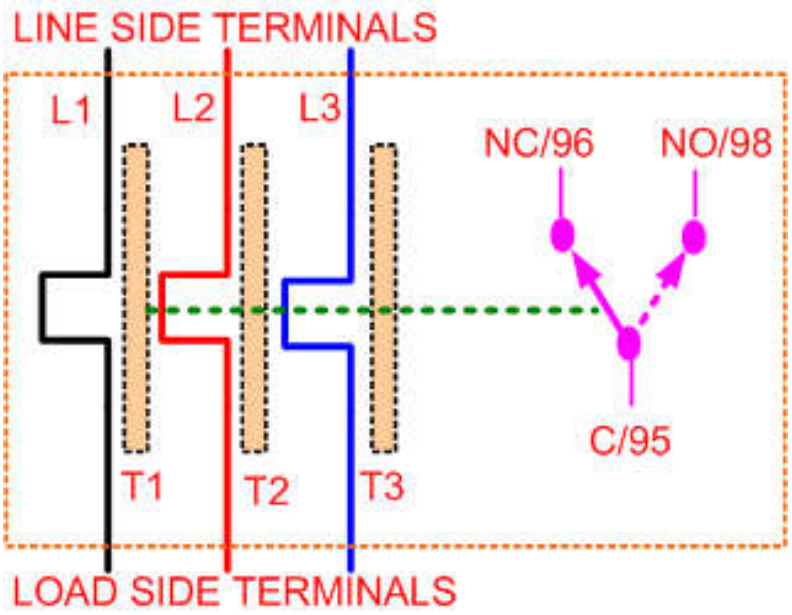
Using the given equipments to describe a thermal overload relay and identify its part The instructor must check the circuit before you apply power.

Purpose: Upon completion of this Unit, trainee should be able to describe a thermal overload relay and identify its part.

The thermal overload relay is an important part of a full voltage magnetic starter which provides protection to the motor against running and stalled overloads. Its heater is rated in ampere and adjustable. Each setting determines when the overload relay heaters will begin to heat up and bend the bi-metallic strip. The bending of the bi-metallic strip actuates or moves a level to open a NC contact or to close a NO contact.

Required tools and equipment: Flip chart Thermal overload relay

Precautions: Safe handling of hand tools, testing instruments and components



Procedures:

Step 1. prepare equipment for the given task

Step 2. describe a thermal overload relay

Step 3. identify part of thermal overload relay .

Quality criteria:

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. Neatness/good looking

Operation sheet 1.3 Preparation for Motor controller Installation

Operation Title Reading and interpreting motor controls diagram

Instruction:

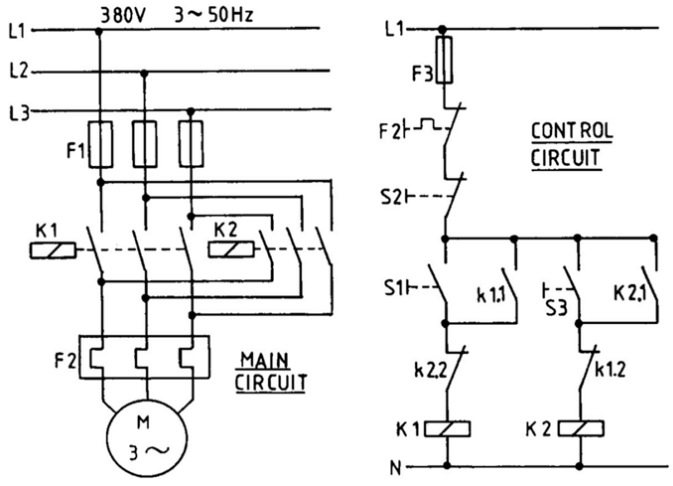
Using the given motor controls diagram read and interpret motor controls diagram the instructor must check the circuit before you apply power

Purpose: When you have completed this Unit, you will be able to read and interpret control circuit and power circuit diagram of a motor control.

Motor control plays an important part in industry today. Industries would cease to function without properly designed, coordinated, installed, and maintained control systems. Electrician's, maintenance personnel, and service technician's are required to glean control system information from engineering drawing and apply it to the actual work situation at hand. A starter that connects a motor directly across the line is called a full voltage magnetic starter, which is commonly used for squirrel-cage motors, is non reversing and provides only for starting and stopping the motor without reducing the applied voltage during starting.

Required tools and equipment: Flip chart

Precautions: Safe handling of hand tools, testing instruments and components



Procedures:

Step 1. Prepare control circuit and power circuit diagram for the given task

Step 2. Read and interpret control circuit and power circuit diagram of a motor control.

Quality criteria: Safe handling of hand tools, testing instruments and components

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. Neatness/good looking

Lap Test-1

Name: _____ Date: _____

Time started: _____ Time finished: _____

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

Task 1- identifies the electrical symbols used in motor controls.

Task 2- describe a thermal overload relay and identify its part.

Task 3- read and interpret control circuit and power circuit diagram of a motor control.

Unit Two: Electrical materials and tools

This unit to provide you the necessary information regarding the following content coverage and topics:

- Delivered materials
- Defects of electrical materials
- Inspect reports

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

- Identify Check, inspect and test delivered electrical materials
- Identify defective/Sub-standard electrical materials
- Submit inspected reports

2.1. Delivered materials

Delivered Material means the returnable metals delivered by the Supplier

Materials Inspection

Materials inspections are similar to taking a flight on an airplane. The ideal scenario for both is an uneventful outcome—they are both means to a greater end. If an issue arises, it creates a series of headaches for all parties involved. While we can't prevent issues with your next flight (at least until every airline uses MaintainX!), we can help streamline your materials inspections and build a repeatable process to success.

It is also important to be aware of industry-specific guidelines. For example, the auto industry has a QS-9000 Certification. Anyone in the auto-industry supply chain who receives materials or parts that have previously been certified might be able to run these audits less frequently.

However, if you fall into the majority, your company likely buys most supplies from uncertified sources and will want to perform random inspections to ensure your supply chain doesn't cost your business.

Key Takeaways:

Don't take your supplier quality for granted always perform random inspections.

It is important to inspect ISO-certified supplies occasionally. don't let their potential mistake become your business's mistake.

Material inspections are necessary when the supplier doesn't perform audit checks.

Purpose of Material Inspections

There are several situations where you want to be sure to carry out material inspections.

Foreign Suppliers

Chances are some of your suppliers are foreign. Many foreign countries simply don't have the same standards we have in North America.

Assuming the raw materials you source from these countries will meet the type of quality standards you have could be a grave mistake. If your organization is in the habit of renegotiating your cost down (and really, who isn't trying to do that), you may set yourself up for a situation in which the supplier can't afford to provide you with the best quality materials or parts.

Quality Fade

Quality fade, sometimes also called quality creep, is something most of us have faced, at least as consumers. We purchase a product that we've been buying for years only to find that it doesn't quite hold up and perform the way it used to.

While quality fade is known to be a problem with material sourced internationally, it is increasing domestically as well.

Over time there is a very subtle but progressive degeneration of quality. If your company isn't diligent about materials' quality management, you could miss this slow-moving trend toward substandard materials.

The Costs

Make no mistake. There will be costs involved when you implement a materials inspection strategy. Time put into effective inspection protocols and then the time required to perform them isn't free.

However, the money you ultimately save could far outweigh your initial outlay in setting up and implementing your inspection strategy.

Clearly, a material inspection is imperative to the quality-control process.

Certified Off-Site Material Testing

Since material testing is a critical step, it should be noted that in some cases it's not feasible or reliable to have certain materials tested in house. For example, is your facility set up for, and do your local employees have the training to do, a complete analysis of chemical components? This could include testing for trace contamination and the process of identifying unknown substances.

If your answer to this is “no,” then you need to have your materials checked and tested at a certified lab that can handle the job.

Methods of component or material testing include:

- Chemical analysis
- Testing physical properties and measurements
- Testing mechanical properties
- Regulatory testing

Procedure of Material Inspection

1. Pre-inspection Steps

Materials inspection is also commonly called an inbound or receiving inspection and there are some steps performed before the actual inspection.

Your receiving department will have its own process that will include things like verifying and recording the quantity received, the referencing purchase order number, and whether or not the material order is complete.

2. Photos.

It’s a very good idea to capture photos or videos upon receipt of materials. An easy way to do this is to use a tool such as MaintainX that enables you to capture photos, tag them, and store them within each inspection form.

3. Review Project Specifications

This is a critical step, and it needs to be performed before you start your physical inspection. You need to know the set specifications of your project in order to know if the materials you received fall within tolerances. Receiving a part or component whether it’s a piece of metal or a liquid chemical that falls outside of agreed-upon standards should never pass inspection.

Once you know the project's specifications required of the materials, you can confirm whether they comply with the requirements of the contract and purchase order.

4. Physical Condition of Material

Create a sampling process where you randomly pull materials and check their physical condition. How this is handled will clearly depend on the material, and it doesn't necessarily mean you have to eyeball every single piece that was delivered.

5. Make & Manufacturer

This is a fairly simple step. Confirm that what you received is from the confirmed manufacturer or trademark holder.

6. Confirm Certifications

If the materials you are receiving should meet specified standards or certifications for example, UL or CSA make sure they are appropriately marked.

7. Storage Requirements

Assuming your materials have passed inspection, check for any special storage requirements. If so, materials should be marked or tagged appropriately. It may even be wise to include a final photo requirement to show the materials in the place where they need to be—if a shipment of refrigerated produce arrives cold, but sits in receiving for 24 hours before being stored properly, this defeats the purpose of the whole inspection.

Importance of Material Testing

Whether your product is bound for an end consumer or another manufacturer in the supply chain, it's critical to test the materials coming in so the product you ship out meets quality and safety standards.

A materials inspection will help to catch defects before production starts. And remember, a business with quality material inspections is a business that grows.

Testing and Inspection

Testing and inspection of the equipment is required to ensure that the equipment will meet its design intent. The requirement for testing and inspection increases the cost of the equipment and extends the fabrication schedule. Despite these negatives, testing and inspection are an essential part of the fabrication process.

The purchaser generally requires the vendor to submit an Inspection and Test Plan (ITP) which is reviewed and approved prior to start of fabrication. Key points in the fabrication process can be identified as hold points that require approval from the purchaser before further fabrication can proceed. The hold point will generally involve inspection and testing of the equipment. Acceptance of a successful test may also be a requirement before further fabrication can occur.

The vendor is obligated to notify the purchaser in advance of a scheduled test and inspection so that the purchaser can attend and witness the procedure.

The purchaser should have the right to review the ITP and to conduct additional tests and inspections Necessary to ensure compliance with the provision of the fabrication specification. It is important the purchaser be given free access to the areas in the fabrication shop where the work is being performed in order to carry out the required tests and inspections.

The vendor must keep all documentation up to date. Mill test certificates indicating the material Specification should be available for review to ensure that the materials being used for fabrication meet the requirements of the specification.

The type and extent of testing can be specified according to the purchaser's requirements and standards. The applicable codes or standards for the type of test should be specified so the vendor understands the requirements for the test

2.2. Defects of materials and tool

Defective Parts means any part or component of the Equipment that breaks or fails to function properly within a period of three hundred and sixty five (365) days after the date of installation

Electrical defects can result in shock, injury and fires. The good news is that most electrical defects can be corrected without spending a fortune.

Contactor defect the most common situation in contactor failures is contact sticking and coil burning. The reason for contact sticking; If more current is passed through the main power contacts than it can carry, the contacts will overheat after a while and the contacts may stick as a result of this warming. Relay defects the main drawbacks are loose contacts, cracks in the contacts, or excessive size and position deviation. This will affect the contact reliability of the relay. The faults of contact components generally include contact overheating, wear, and welding

circuit breaker defect

A circuit breaker problem is misfiring of the electrical system. Miswiring or electrical wiring mistakes may cause an electrical device to not turn off properly and continue running even after the switch is shut off. Another consequence of miswiring can be electric shock. Typically the shock is not fatal but wiring inaccuracy can cause harm to individuals operating electrical appliances in the home. A problem of this magnitude will require rewiring the circuit or circuits that are affected and testing the entire electrical system to make sure it works properly. Miswiring can also cause appliances, switches and other electrical devices to not operate properly or to not work at all.

Figure 2. 1 circuit breaker defect

Timer defect a watchdog timer (sometimes called a computer operating properly or COP timer, or simply a watchdog) is an electronic or software timer that is used to detect and recover from computer malfunctions. Watchdog timers are widely used in computers to facilitate automatic correction of temporary hardware faults, and to prevent errant or malevolent software from disrupting system operation.

During normal operation, the computer regularly restarts the watchdog timer to prevent it from elapsing, or "timing out". If, due to a hardware fault or program error, the computer fails to restart the watchdog, the timer will elapse and generate a timeout signal. The timeout signal is used to

initiate corrective actions. The corrective actions typically include placing the computer and associated hardware in a safe state and invoking a computer reboot.

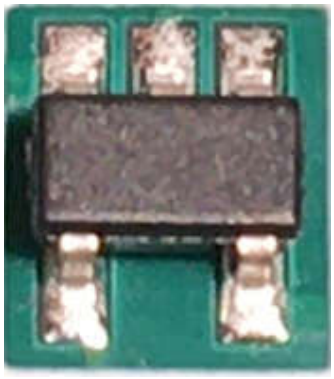


Figure 2. 2 defected Timer

Common defects in relays

Identifying relay faults and their causes enables you to fix problems quickly. The most common relay failures are:

Flashover

Flashover is the trouble where discharge between opposing conductors causes a short-circuit. This often occurs with contacts used with medium and large power. Flashover is dangerous when the current is high.

Sticking

Welding, locking, or gluing make it difficult to open contacts. Welded contacts are usually caused by high inrush currents as the contacts are closed creating molten or soft metal in the contact area. Welded contacts are also caused by high-frequency switching.

Contact wear

Contact wear is the wear of contacts due to mechanical causes, such as wear during repeated operation. Relays open and close millions of times. Sometimes this repeated operation causes contact wear.

Contact erosion

Contact erosion is the expending of contacts due to electrical, thermal, chemical, and other causes all through the repeated operation. Contacts having variable or intermittent contact resistance. This occurs particularly at low current levels because of erosion of the contact materials.

Activation

Activation is the failure where contact surfaces become dirty. Dirty contact surfaces increase the possibility of discharge.

Contact film

Metal oxide, sulfide, and other films are generated on or attached to contact surfaces and cause boundary resistance. If there is a film on the surface of contact and the contacts retouching, the film electrically breaks down and the contact resistance drops rapidly when the contact voltage exceeds a certain value.

Humming

Mechanical relays create a humming noise when turned on. Humming noise is continuous during operation. Humming occurs due to mechanical vibration caused by AC poles or a rectifier wave drive with insufficient smoothing.

Abnormal heat generation

If switching arcs occur continuously due to contact chattering, the contact parts generate an abnormal amount of heat, which can lead to contact fusing, dissolution, and welding. This leads to operation failure. Abnormal heat is also generated by wiring and installation failures.

Carbonization

During switching, carbonization occurs (carbon is generated) on the contacting surfaces. This increases contact resistance and leads to contact failure.

Burn damage

Burn damage is caused by problems such as over current, overvoltage, and vibration.

Case holes

Case surface (top and side) materials that collapse into the inside of the relay obstruct the operation of the components that move inside the relay, which may lead to outer appearance defects, operation failures, and release failures.

Case swelling

This phenomenon causes the top and sides of the case of a relay designed for use with printed circuit boards to swell.

Figure 2. 3 defected relay

Use the Correct Wire

Wire used depends on operation, building materials, electrical load, and environmental factors

Use the correct extension cord **.**Must be 3-wire type and designed for hard or extra-hard use

Figure 2. 4 Use the Correct Wire

Clue that Electrical Hazards Exist

Tripped circuit breakers or blown fuses

Warm tools, wires, cords, connections, or junction boxes

GFCI that shuts off a circuit

Worn or frayed insulation around wire or connection

Figure 2. 5Tripped circuit

Defective Cords & Wires

Plastic or rubber covering is missing from caps

Open wiring used as extension cord

Damaged extension cords & tools

Figure 2. 6Defective Cords

Damaged Cords

Cords can be damaged by aging

Door or window edges

Staples or fastenings

Abrasion from adjacent materials

Activity in the area

Improper use can cause shocks, burns or fire

Figure 2. 7damaged Cords

2.3. Inspect report

Inspection

Suppliers shall establish and maintain documented procedures for inspections and tests of the equipment during manufacturing and assembly. The procedures shall provide for the verification by inspections or tests, at appropriate points in the manufacturing and assembly process, that the characteristics of the item conform to the requirement specified for that stage of the process. In general the verification should be made as close as possible to the point of realization of the characteristic. The in-process verification may include:

- Set-up and first piece inspection.
- Inspection or test by machine operator.
- Automatic inspection or test.
- Fixed inspection stations.

Equipment shall be held until the required inspection and test has been completed.

Equipment shall not be released for further use until it has been verified and the results of the verification are satisfactory.

Final inspection

The contractor shall carry out all final inspection and testing in accordance with the quality plan and/or documented procedures to complete the evidence of the conformance of the finished equipment to the specified requirements. The quality plan and/or documented procedures for all final inspection and testing shall require that all specified inspections and tests, including those specified on receipt of equipment or in-process, have been carried out and that the results meet specified requirements.

Inspections and tests procedures shall define:

- The location where the inspection or test is to be performed (supplier premises or client organization site or CERN site).
- The parameters to be measured.
- The characteristics or functions that have to be verified.
- The acceptance criteria, including any applicable standards or codes. The requirements for special tools, fixtures, gauges, test set-ups and measuring equipment. Special instructions relative to handling and storage of the equipment.
- Guidelines for the use of sampling inspection if appropriate.
- The data and records that are required and in which form.
- When and how the inspections and tests results are to be reported to the client organization. No equipment shall be dispatched until all activities specified in the quality plan and/or documented procedures have been satisfactorily completed and the associated data and documentation are available

Self check 2

Test

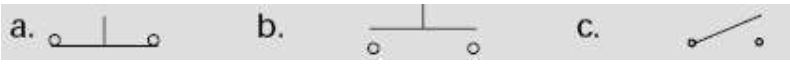
Instruction: choose the best answer

1. A control is _____ operated when someone must initiate an action for the circuit to operate.

2. Which of the following symbols represents a normally open contact?

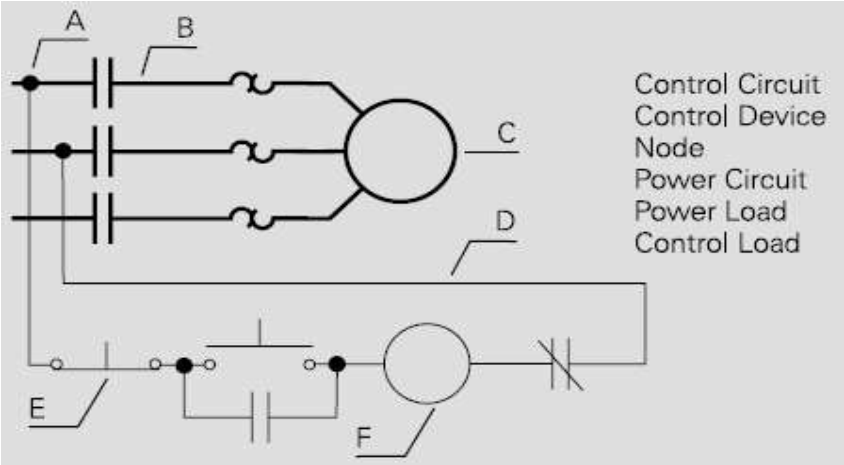
3. Which of the following symbols represents a normally closed contact?

4. Which of the following symbols indicates a normally open pushbutton?



5. Which of the following symbols indicates a mushroom head pushbutton?

6. Match the items on the line diagram with the associated list.



A _____

B _____

C _____

D _____

E _____

F _____

7. With an increase in current, heat will _____.

8. The National Electrical Code® defines over current as any current in _____ of the rated current of equipment or the ampacity of a conductor.

9. _____ occurs when electrical equipment is required to work harder than it is rated.

10. Starter with two sets of contacts would be called a_____ -pole starter.

11._____ will automatically disconnect power from the motor when incoming power drops or is interrupted.

12. Electrical defects can result in ----------, ----------and----------.

13. the most common situation in contactor failures is ----------and ----------.

14. ----------is misfiring of the electrical system.

16. ----------mistakes may cause an electrical device to not turn off properly and continue running

Test II: short Answer writing

Instruction: write short answer for the given question. You are provided 3 minute for each question and each point has 5Points.

1. Define delivered material?
2. Write down at least three methods of component or material testing?
3. What is purpose of materials inspections?

Test III: Short answer writing

Instruction: Give short answer to the following questions. Time allotted for each item is 2mniut and each question carry 4 point.

1. Defective Parts
2. Materials inspection will
3. Electrical defects
4. circuit breaker problem

Unit Three: Installation Works

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

- Conduit accessories& bending conduits
- Cable color code according to EBCS
- Installation of electrical machines and drives

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

- Identify conduit accessories& bending conduits
- Use cable color code according to EBCS
- Install electrical machines and drives

3.1. Conduit accessories and bending

Conduit Wiring

Electrical conduits are used to protect and provide the route of electrical wiring in an electrical system. Electrical conduits are made of metal, plastic, or fiber and can be rigid or flexible. Conduits must be installed by electricians as per standard regulations. For workshops and public buildings, conduit wiring is the best and most desirable system of wiring. It provides protection and safety against fire.

Figure3. 1*Conduit Wiring*

3.2. Conduit couplers

- Used to join two lengths of conduit
- Are threaded on both ends

Types of Conduits

- **Class A conduit:** Thin layered steel sheet of low gauge
- **Class B conduit:** Thick steel sheet of high gauge

Materials used in Conduit Wiring

- GI (Galvanized Iron) wire
- Elbow
- Coupling
- VIR (Vulcanized Indian Rubber) or PVC (Poly Vinyl Chloride) insulated cables
- Lock nut
- Clip
- Junction Box

Advantages of conduit wiring

- Safe
- Better appearance
- No risk of fire
- No risk of damage of cable insulation
- Safe from humidity, smoke, steam, etc.
- No risk of shock
- Long lasting

Disadvantages of conduit wiring

- Expensive
- Installation is not easy
- Not easily customizable for future use
- Hard to detect faults

Figure3. 2 different conduit

3.2. **Cable color code according to EBCS**

General specification of cables

The complete specification of a cable will give the following information:

- The size of the cable
- The type of conductor used in cables (copper or aluminum)
- Number of cores that the cable consists of (single core, twin core, twin core with ECC etc,)
- Voltage grade

- Type of insulation (taping, braiding & compounding)

Colors of conductors:

Color identification of conductors is specified in Table 3. 1, Table 3. 2

Table 3. 3 color identification of cores of Flexible Cables and Cords

Number of Cores	**Function of Core**	**Color(S) of Core**
1	Phase Neutral Protective	Brown Blue Green-and-Yellow
2	Phase Neutral	Brown Blue
3	Phase Neutral Protective	Brown Blue Green-and-Yellow
4 or 5	Phase Neutral Protective	Brown or Black Blue Green-and-Yellow

Table 3. 4 color identification of cores of non-flexible cables and bare conductors for fixed wiring

Function	**Color Identification**
Protective (including earthing) conductor	Green and Yellow
Phase of a.c. single-phase circuit	Red orYellow or Blue
Neutral of single or three-phase circuit	Black
Phase R of 3-phase circuit	Red
Phase Y of 3-phase circuit	Yellow
Phase B of 3-phase circuit	Blue
Positive of d.c. 2-wire circuit	Red
neutral of d.c. 2-wire circuit	Black
Outer(Positive or Negative) of d.c. 2-wire circuit derived from 3-wire system	Red
Positive of d.c. 3-wire circuit	Red
Middle of d.c. 3-wire circuit	Black
Negative of d.c. 3-wire circuit	Blue

General specification of cables:

The complete specification of a cable will give the following information:

i. The size of the cable
ii. The type of conductor used in cables (copper or aluminum)

iii. Number of cores that the cable consists of (single core, twin core, twin core with ECC etc,)

iv. Voltage grade

v. Type of insulation (taping, braiding & compounding)

Conduits

The commonest method of installing cables is to draw them in to a conduit. The conduit can be steel or plastic steel conduit is made in both light gauge and heavy gauge of which heavy gauge is much more frequently used.

Classification of conduits

a. Light gauge steel-plain (unscrewed) conduit.
b. Heavy gauge steel-screwed conduit.
c. Flexible conduit
d. PVC conduit.

a) Light gauge steel conduit:

- This type of conduit is used with special grip fittings.
- It is available with an external diameter of 12mm, 16mm19m, 25mm, 31mm, 38mm, and 50mm.

In general, light gauge is the cheapest and quickest of conduit installations but should be used where the location is dry and there is little likelihood of mechanical damage.

b) Heavy gauge screwed steel conduit:

- Though it is very expensive, this type of conduit provides a permanent installation with a maximum of protection for the cables
- The joints into fittings are by means of screw threads which provide mechanical strength and good electrical conduit:
- Are available in approximately 3meter lengths and are threaded at the two ends.

c) Flexible steel conduit:

- This usually consists of light galvanized steel strip spirally wound, and to some extent, interlocked, so as to form a tube.

- It is made in size from 19mm to 50mm internal diameter and in two grades: non water tight and water tight.
- Available in lengths up to 250 meters. So no coupling is required ands hence no threading.
- Since the conduits are flexible and are easily bent no elbow is required.
- One of the most common uses of flexible conduit is for protecting the final connections to motors. It has the additional advantage of reducing the transmission of vibration. However, the flexible conduit is costlier than the rigid conduit.

PVC conduit:

- This type of conduit wiring is finding wide applications in internal wiring because it is light in weight, shock proof, anti-termite, fire resistant, acid and alkaline resistant.
- Can be used for surface, recessed or concealed type of wiring.

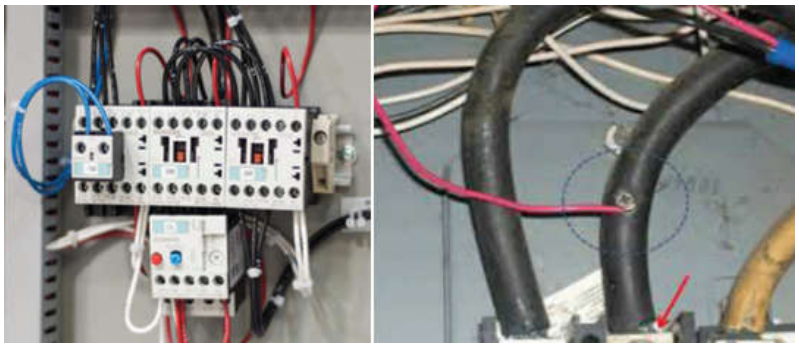


Figure 3. 1 Wiring materials

1. **Conducting Material**

a) Copper It is a good conductor of electricity. It is used in wiring materials in cables. It has low resistance and is used for conduction of electricity at high, medium and low voltage(Fig. 3). It is used in wiring and cable making.

Figure 3. 2.*Copper*

b) Aluminum It is light weight and cheaper in comparison to copper. Therefore, this type of conducting material is mostly used in electrical wiring. It is silvery–white in color and it has a soft texture. It is often used in wiring and making cable(Fig.3).

Figure 3. 3 Aluminum

2. **Insulating Materials** Insulating materials are used for insulating purpose. These types of materials are bad conductors of current. For example, rubber, paper, mica, wood, glass and cotton.

3.1.2. Wiring Accessories

Wiring accessories are used for connecting appliances.

Concealed Wiring: It is laborious to install this wiring. The layout of this wiring is done under the plaster of the wall of the building. A typical example of industrial wiring is shown below, which consists of:

a) **Circuit one:** Two group of light with two gang switches, protected by a 10A circuit breaker.
b) **Circuit two:** Two single phase socket outlets with ground protected by 16A circuit breaker.

c) **Circuit three:** Two three-phase socket outlets with ground protected by a 16A three-phase circuit breaker.

Install the circuit according to the diagram shown below using ½ inch steel conduit.

NOTE: All of the branch circuits are controlled from the power board

circuit must be checked by the instructor before you apply power.

Bends, elbows and tees: - are generally called conduit fittings.

Beds are usually used for change in direction of conduit. This should never be sharp. The minimum allowable radius of curvature is 2.5 times the outside diameter of the conduit.

Solid elbows and tees should be used only at the end of the conduit run (e.g. close behind a light fitting or accessory.).

Conduit boxes used in surface conduit wiring as well as concealed conduit wiring. Have different designs which serve the following purposes:

For providing connections to light, fan, and other points. The conduit boxes serving the purpose are known as outlet boxes because conduit terminates at the boxes.

For pulling of cables in to the conduits. The boxes serving this purpose are known as inspection boxes.

For housing junction of cables. The conduit boxes serving this purpose are known as **junction boxes.**

Lighting accessories and fittings

Switch

A switch is used to make or break an electrical circuit. It is used to switch 'on' or 'off' the supply of electricity to an appliance.

- Are used to control lighting circuits.
- Most are rated at 5/6A, but ratings at 15A are also available.
- Are available in three types: single pole, two-way and four-way (intermediate) each for control of a practical circuit arrangement.
- To allow true control of a number of different circuits from one position, switches are contained within the same unit: two-gang, six-gang, etc.
- Single chord ceiling switch is suitable for installation in the bathroom, where by one pull of the chord puts the switch ON and the following pull puts the switch off.
- Switches for water-heaters are of the double pole type and rated to carry 20A. Are also available at 32A and 45A rating, the latter being used to control cooker circuits.
- Dimmer switches are used to allow control of the level of lighting from luminaries.
- Splash-proof switches are found in situations where water is present, such as in shower rooms.

There are various switches for industrial such as

- push button switch
- Toggle Switch
- Slide Switch
- Rotary Switch

Lamp Holders

- Are designed for quick removal and replacement of the lamp and yet they must hold the lamp in firm metallic contact to prevent overheating.
- There are three main sizes of lamp holders: Bayonet-cap (B, C), the medium Edison screw (E.S) and the Goliath screw (G.E.S).

* For ordinary tungsten filament lamps up to 200W the lamp caps and lamp holders are B, C, caps, up to 300W the caps are E.S, and above 300W they are G.E.S. In any case where the lamp is to be installed, the appropriate size and type of holder must be fitted. Lamp holders may be either the insulated type of Bakelite or the brass type with porcelain interior.

Holders: A lamp holder is advice used to hold the lamp there are different lamp

- Pendant holder
- Batten holder

Figure 3. 4.Holders

A. **Socket outlet/plug:**The socket outlet has an insulated base with the moulded or socket base having three terminal sleeves (Fig. 3.4).

Figure 3. 5 Socket outlet/plug

B. Main switch: To control the electrical circuit a main switch is used. Through the main switch, the power in a building is controlled completely(Fig. 3.5).

Figure 3. 6 Main switch

C. **PVC casing-capping wiring:** PVC capping is done in order to cover the wires. It includes casing also. This casing-capping wiring is also known as open wiring, as it is done outside the wall.

Materials required for PVC casing-capping wiring include

1. wire
2. casing enclosures made up of plastic
3. capping made up of plastic
4. T. Joints VIR (Vulcanized Indian Rubber) or
   PVC (Polyvinyl chloride) insulated wire
5. junction box
6. elbow casing and capping joints

Figure 3. 7PVC casing-capping wiring

Wooden casing-capping wiring is old fashioned. Now PVC or VIR insulated wires are enclosed within the PVC casing enclosure and PVC capping is used to cover the casing.

D. Miniature Circuit Breaker (MCB)

A MCB is used in new constructions instead of the older types of fuses. Circuit breakers are small devices used to control and protect the electrical panel and the other devices from overflowing of electrical power.

Figure 3. 8Miniature Circuit Breaker

Switch and distribution board

ICTP (Iron Clad Triple Pole) Switch

It is used alongwith the energy meter to isolate the supply of electricity automatically or manually(Fig. 3.10)

Figure 3. 9 ICTP (Iron Clad Triple Pole) Switch

Distribution Board

A distribution board is a component of an electricity supply system that divides an electrical power feed into subsidiary circuits, while providing a protective fuse or circuit

breaker for each circuit in a common enclosure. A distribution board is also known as panel board, breaker panel, or electric panel

Plugs and socket outlets:

These are used to enable portable apparatus to be connected to the fixed wiring and comprises of two or three contact tubes and terminals. The plug is the movable part connected to the apparatus by flexible wire, and consists of two or three contact pins to fit in to the contact tubes.

FUSES

- Consists of a piece of copper or tin-lead alloy wire, which will melt when carrying a predetermined current. This element with contacts, carrier and base is called a fuse.
- Is placed in series with the circuit to be protected, and automatically breaks the circuit when over loaded.

The time for blowing out of a fuse depends on the magnitude of excess current. i.e. the larger the fault current the more rapidly the fuse blows.

There are three main types of fuses: the rewirable, the cartridge and high breaking capacity (HBC) fuses; the latter is a development of the cartridge type.

Three terms are used in connection with fuses.

Current rating: this is the maximum current that a fuse will carry indefinitely without undue deterioration of the fuse element.

Fusing current: this is the minimum current that will 'blow' the fuse.

Fusing Factor: this is the ratio of minimum fusing current to the current rating Fusing Factor = minimum fusing current ≥ 1 Current rating

a) Rewirable Fuses

This type of fuse consists of a porcelain (usual material) bridge and base. The bridge has two sets of contacts, which fit in to other contacts in the base. The fuse element usually tinned copper wire is connected between the terminals of the bridge. An asbestos tube or pad is usually fitted to reduce the effects of arcing when the fuse element melts.

The Rewirable fuse is a simple and relatively cheap type of over current protective device and is still widely used despite several disadvantages including:

i. The fact that it is Rewirable enables the wrong size of the fuse wire (element) to be used.
ii. Undue deterioration of the fuse element due to oxidation.
iii. Lack of discrimination. This means that normal starting surges (e.g. when motors, etc are switched on) are "seen" by the fuse as an over load and will there fore break the circuit.
iv. Damage, particularly in conditions of severe short circuit.

.

Cartridge Fuses

The obvious disadvantages of rewirable fuse led to the development and use of the cartridge type fuse. The fusing factor is about 1.5.

High Rapture Capacity (HRC) Fuses

The high breaking capacity fuse (HBC) has its fusing characteristics carefully controlled by the manufacturer. As its name implies it can safely interrupt very large currents. The fuses are often used to protect large industrial load and main cables. The cartridge barrel is of high-grade ceramic able to with stand the shock conditions when a heavy fault current is interrupted. Except for very low ratings, the fuse element is made from pure silver. The filler is powdered silica, carefully dried before use.

The HBC fuse is more expensive than the rewirable or cartridge type. The fusing factor of HBC fuse is for small loads up to 1.25A, thus a 10 A HBC fuse will blow at 12.5A. HBC fuses are discriminating which means that they are able to distinguish between a starting current taken by a motor which lasts for a matter of seconds) and a high fault or overload current (which lasts longer). Motors are normally protected against overloads by the starter trip; the fuses are required only to give protections against short circuit currents and overloads outside the capacity of thermal trip.

Circuit breakers

Is a device designed to open and close a circuit by non- automatic means and to open the circuit automatically on a predetermined over-current with out injury to itself when properly applied

within its rating. So a circuit breaker is a combination device composed of a manual switch and an over – current device.

A circuit breaker has several advantages over any type of fuse

a) In the event of fault or overload all the poles are simultaneously
b) disconnected from the supply
c) overload and time-lags are capable of adjustment within limits
d) the circuit can be closed again quickly onto the fault safely

Essentially a circuit breaker consists of a carefully calibrated bimetallic strip. As current flows through the strip, heat is created and the strip beds. If enough current flow through the strip, it bends enough to release a strip that opens the contacts, interrupting the circuit just as it is interrupted when a fuse blows or a switch opened. In addition to the bimetallic strip that operates by heat, most breakers have a magnetic arrangement that open the breaker instantly in case of short circuit. A circuit breaker can be considered a switch that opens itself in case of overload.

Circuit breakers are rated in amperes just as fuses are rated. Like fuses, breakers are tested in open air to carry 110% of their rated loads indefinitely without tripping. Most breakers will carry 150% of their rated load for perhaps a minute, 200% for about 20 sec. and 300% for about 5 sec, long enough to carry the heavy current required to start most motors.

Standard ratings: both fuse and circuit breakers are available in standard ratings of 6, 10, 16, 20, 25, 35, 50, 63, 80, 100, 125, 160, 224, 250, 300, and large sizes.

Distribution board

A distribution board is an assemblage of parts, including one or more fuses or circuit breakers, arranged for the distribution of electrical energy to final circuits or to other sub- distribution boards. It consists of a case inside which is a frame holding a number of fuse (CB) carriers behind the frame or something along side or above it, is a bus-bar to which the incoming sub-main is connected. From the bus-bar there is connection provided to one side of each fuse way (CB). Each final sub-circuit is then connected by the installer to the outgoing terminal of the fuse ways.

The standard distribution boards usually have 4, 6, 8, 12, 18 or 24 fuse ways both single phase and three phases are available. It is not necessary to utilize all the available fuse ways on a board, and in fact it is very desirable to leave several spare ways on each board for future extension.

Light source and application

Light is a form of energy that is radiated or sent out from a source in a waveform. It is part of a whole family of electromagnetic wave. Light sources can either be natural (sun) or artificial (e.g. electric lamps).

Generally, electric lamps can be classified in to:

a) Incandescent lamps
b) Discharge lamps.

a. Incandescent lamps:

When an electric current passes through a fine metallic wire, heat is produced and the temperature of the wire increases. At low temperature the wire radiates heat energy. As the temperature of the wire increases due to heating, it radiates heat as well as light energy. The incandescent lamp consists of a glass globe completely evacuated or gas filled and a fine wire known as filament within it. The materials that can be used for the filament are carbon, osmium, tantalum and tungsten. These metals are selected due to their high melting points.

There are two types of incandescent lamps:

1) Vacuum lamps:
    a. air is evacuated from the glass bulb.
    b. operates only up to around 2000^0c.
2) Gas-filled lamps:
    - The glass bulb is filled with inert gases(Ne or Ar)
    - Operates up to around 2500^0c.
    - In gas-filled lamps, the bulb is so bright that it is given an opaque coating internally.
    - The light out put of incandescent lamps is about 10 to 15 lm/W.

Thus:

- A 25W IL produces about 250 to 375 lm.
- A 40W IL produces about 400 to 600 lm.
- A 60W IL produces about 600 to 900 lm.

The average lifetime of incandescent lamps is about 2000 hrs when operating at rated voltage.

An incandescent lamp gives out light at all frequencies including dc.

Incandescent lamps suffer from two disadvantages- low efficiency and colored light. To overcome these drawbacks, the gaseous discharge lamp has been developed.

b. Discharge Lamps

It consists of a glass tube containing a gas. Gases are normally pure conductors especially at atmospheric pressure, but applications of suitable voltage called, ignition voltage, across the two electrodes can result in a discharge through the gas, which is accompanied by electromagnetic radiation. the wave length of the radiation depends up on the gas, its pressure, and the metal vapour used in the lamp.

Argon gas and sodium vapour are commonly employed in the manufacture of gaseous discharge lamps. The colour of the light obtained depends on the nature of the gas or vapour used.

e.g. Ne----------red

Mercury----------bluish white

He----------ivory

Na vapour----------yellow

Electric discharge lamps can in general be classified as cold-cathode and hot-cathode.

Cold-cathode:

- Uses a high voltage (3.5KV) for its operation.

- They are familiar as fluorescent tubes with 25mm in diameter, either straight, curved, or bent to take a certain form for general lighting purpose.
- The electrodes of this lamps are not preheated.

  e.g. Neon lamps.

Hot-cathode:

- Are commonly called fluorescent lamps.
- More commonly used type of discharge lamps.
- Are available in tube lengths of 2.5m, 1.7m 1.3m or 30cm.
- Electrodes are heated and operating voltage is low or medium.
- To assist starting the mercury vapour is mixed with argon gas.

e.g. sodium vapour lamps, fluorescent lamps, and high pressur mercury vapour lamps.

High pressure mercury vapour lamps:

It consists of a quartz tube containing mercury at high pressure and a little argon gas to assist starting. There are two main electrodes and auxiliary electrode connected through a high resistance. The auxiliary electrode is used to start the discharge. A choke is provided to limit a current to a safe value.

A capacitor is connected in parallel to the lamp to improve its power factor. The initial discharge takes place in the argon gas between the auxiliary (starting) electrode and main electrode close to it. This causes the main electrode to heat up and the main discharge between the main electrodes takes place.

The high pressure mercury vapour lamp has an efficiency of about 40-50lm/W they are manufactured in 250 and 400W ratings for use on 220-250v a.c. supply mains. Their application is mainly for industrial and street lighting, commercial and display lighting.

Low pressure mercury vapour lamps:

- Are mainly known as fluorescent lamps.
- It consists of glass tube filled with mercury vapour at low pressure.

- Is provided with two electrodes coated with electron emissive material.
- The inner wall of the tube is coated with fluorescent powder which transforms ultraviolet radiation in to visible radiation or light.

Starters

Three methods are commonly available for starting the discharge in a fluorescent tube: the thermal starter, the glow start and the quick start.

Thermal type start

The thermal type starter switch has two contacts mounted on bi-metal strips, a small heating coil being fitted very close to the bi-metal strips but not electrical contact between them. the contacts arc normally closed so that the main supply is first switched on full heating current passes through the lamp electrodes as before. The current also flows through the starter heater and so warms the bi-metal strips. After a short time the bi-metal strips warms sufficiently to bend and open the contacts thus striking the lamp. As long as the lamp remains alight current flows through the starter heater keeping the contacts apart. A small capacitor is often connected in parallel with the starter switch contacts to suppress radio interference.

Glow type star

The glow type starter switch consists of a small bulb filled with helium and containing two contacts, one of which is mounted on a bi-metal strip. The contacts are normally open so that when the main supply is first switched on full main voltage is applied to the starter contacts. This causes a glow discharge that warms the bi-metal strip making it bends, so closing the starter contacts. The closing of the starter contact allows full heating current to pass through the lamp electrodes and also extinguish the glow discharge. After a short time the bi-metal strip cools sufficiently to open the circuit thus striking the lamp. As long as the lamp remains alight the voltage applied to the starter is insufficient to initiate a glow discharge and so the starter contacts remain open until the next starting operation. A small capacitor is often connected in parallel with the starter switch contacts to suppress radio interference.

Quick type start or Instant type start

In the case of the quick start or instant starter, starting is achieved by the use of autotransformer and an earthed metal strip in close proximity to the tube.

When the supply is switched on, mains voltage appears across the end of the tube, and the small part of the winding at each end of the transformer energizes the filaments, which heat up. The difference in potential between the electrodes and the earthed strip causes ionization, which spreads along the tube.

Sodium vapor lamps:

is a double glass container, the inner glass tube filled with Neon and Argon gas and some sodium drops.

When the supply is switched on, the lamp would not start, as the supply voltage is too low to start the discharge. The leak transformer is connected across the mains produces a starting voltage of about 400v. The Neon Argon gas starts the discharge, and afterwards the sodium vaporizes and the discharge continues.

Types of cables used in internal wiring

The wires used for internal wiring of buildings may be divided in to different groups according to:

- The type of conductor
- The number of cores
- The voltage grading
- The type of insulation used.

According to the number of cores

the cables may be divided in to classes known as single core, twin core, twin core with ECC (earth continuity conductor).

According to voltage grading

the cables may be divided in to two classes:

250/440 volt and 650/1100 volt cable.

According to type of insulation cables can be classified in to:

1. **Vulcanized Indian Rubber (VIR) cables:**

   VIR cables are available in 250/440volt as well as 650/1100 volt grades and are used for general conduit wiring.

2. **Lead sheathed cables:**
   - available in 250/440 volt grade
   - are used for internal wiring where climatic condition has moisture.
   - Is a vulcanized rubber insulated conductor covered with a continuous sheath of lead . The sheath provides very good protection against the absorption of moisture and sufficient protection against mechanical injury and can be used with out casing or conduit system.
   - It is available as single core, flat twin core, flat three core and flat twin core with ECC.

3. **PVC cables:**
   - Are available in 250/440 volt and 650/1100 volt grades
   - Used in concealed type of wiring system.
   - Since PVC cables are harder than rubber, they do not require cotton taping and braiding over it for mechanical and moisture protection.

4. **Weather proof cables:**
   - Are used for outdoor wiring and for power supply
   - are not affected by heat or sun or rain.
   - Are either PVC insulated or vulcanized rubber-insulated conductors being suitably taped (only in case of vulcanized rubber insulated cable) braided and then compounded with weather resisting material.
   - Are available in 250/440 and 650/1100 volt grades.

5. **Flexible cords and cables:**

It consists of wires either silk or cotton or plastic covered, plastic cover is more popular as it is available various pleasing colors. Flexibility and strength is by using conductors having large number of strands.

Most stranded conductors are built upon a single central conductor, surrounding this conductor are layers of wires in a numerical progression of 6 in the first layer, 12 in the second layer, 18 in the third layer and so on.

3.1.2. Electrical Circuit

In an electric circuit the positive side of wire is connected to the negative side of a load, for example, bulb, TV, etc. and power supply is started by using a switch. The circuit is like an electrical house.

Types of Circuit Are **Open, Closed, Series** and **Parallel**

3.1.3. Fixing Wiring Accessories on Board

You should know the tools required for fixing the accessories on the board. You should also know the purpose of fixing the accessories. In-house wiring of the switches, holders and sockets should be fixed on wooden/sun mica boards and blocks. Therefore, it is necessary to learn how to fix these accessories. The ways to fix these accessories have been discussed in the following practical activity.

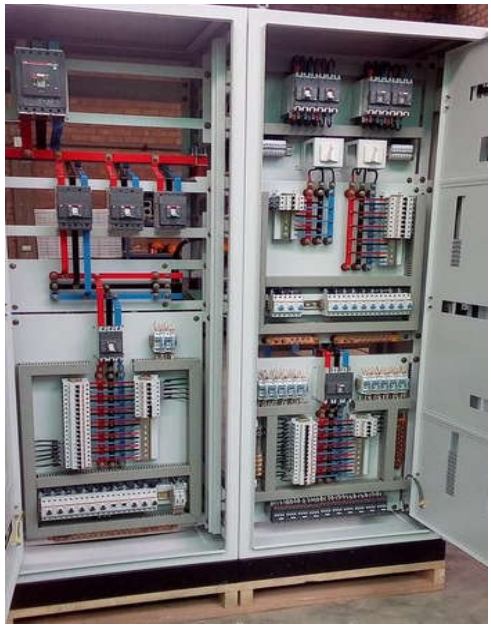


Figure 3. 10Fixing Wiring Accessories on Board

Terminal Blocks

Figure shows a simple terminal block arrangement. Individual terminals are designed to clip onto a variety of mounting rails. They are manufactured in a variety of sizes to accommodate any cable CSA. Green / Yellow earth terminals are designed to make good contact with the mounting rail on tightening of the centre screw. Other colours are available but are not essential.

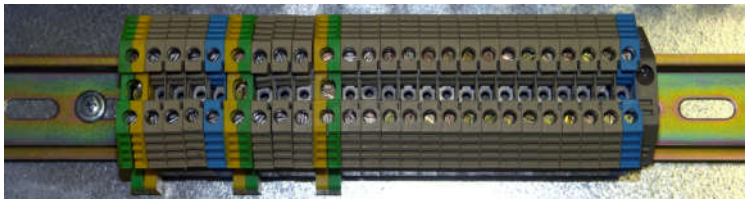


Figure 3. 11Terminal Blocks

The terminals must be installed the correct way round as each one is generally insulated on one side only. An end insulator must be installed to insulate the last terminal. An end clamp must be used to prevent the terminals from spreading apart. An earth terminal doubles as an end clamp. Terminals with solid links or fuse holders are also available.

Cable lag

Cable lags are used for connecting the cable/wire to electrical appliance, other cables, surface or mechanism these are used permanent direct-fasting method are not feasible or not required.

Figure 3. 12 Cable lag

Industrial applications

There are many small scale industrial buildings where MCBs are used instead of the old fuses. Miniature circuit breakers are largely used in restaurants, bakeries and commercial food stores.

Heaters

When heaters are used at home or in the office, the MCB can be beneficial. It is known in general that heaters can be problematic sometimes, especially with distribution of electrical power. The MCB prevents possible problems, cutting off electricity in the case of overload or fault. In this case, though, you need to choose a miniature circuit breaker of the proper capacity, enabling it to handle the load of power when needed.

3.3. Installing electrical machines and drives

Typical Motor Control Installation

Figure illustrates a typical layout where the isolator is remote from the motor

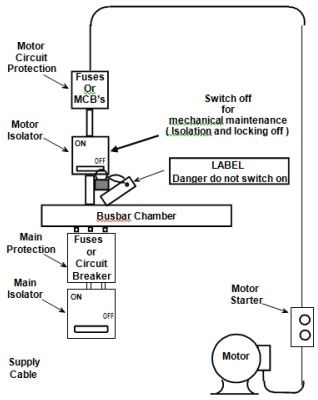


Figure 3. 13 a typical layout where the isolator is remote from the motor

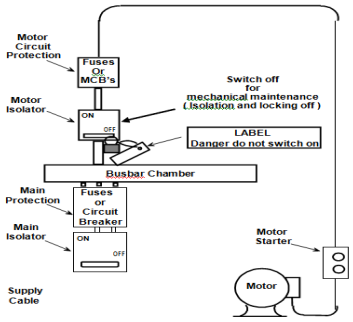
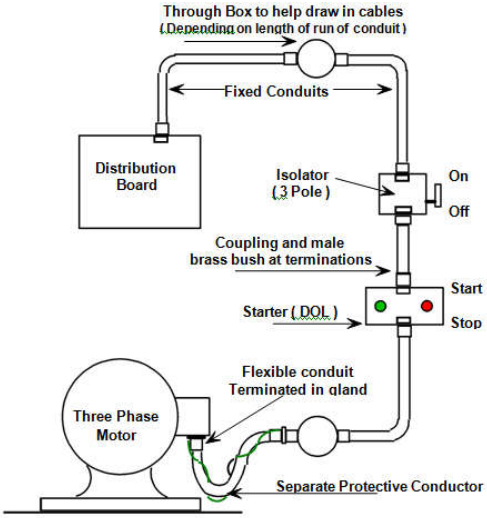


Figure 3. 14 example of a motor final circuit equipment layout.



Note: A separate earth protective conductor was fitted on the outside of the older types of flexible conduit. Therefore mechanical protection was not provided.

In modern installations it must be installed inside the flexible conduit with the power cables.

Flexible Conduit

Flexible conduit is made of interlinked metal spirals often covered with a PVC sleeving. The tubing must **not** be relied upon to provide a continuous earth path and, consequently, a separate protective conductor must be run inside the flexible tube.

Flexible conduit is used for the final connection to motors so that the vibrations of the motor / machine are not transmitted throughout the electrical installation. It also allows adjustments to be made to the final motor position for drive belt tension etc.

Assembly Instruction

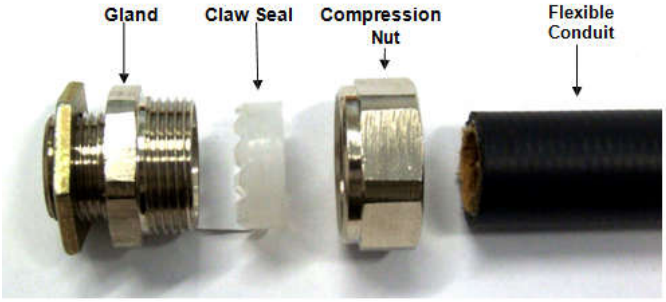


Figure 3. 15 Assembly Instruction

1. Cut the conduit square with a knife edge blade rather than a hacksaw.
2. Dismantle the gland body.
3. Fix the gland body in the enclosure entry.
4. Assemble the compression nut and claw seal loosely on the conduit end (correct way round).
5. Push the conduit down into the gland body
6. Assemble the compression nut onto the body thread while continuing to apply a force on the conduit.
7. Tighten the compression nut until finger tight.
8. Using a spanner tighten the compression nut two further turns to provide a dust and water tight seal between the conduit and gland.

Testing of Installation

The tests to be performed before a new installation or an addition to an existing installation is connected to the supply mains are as follows:

1. **Insulation Resistance**

   - The insulation resistance between the wiring and earth with all fuses (breakers) and lamps in and all switches 'ON'
   - The insulation resistance between the conductors with all lamps out and all switches 'ON'

2. Testing of polarity of non-linked single pole switches.

3. Testing of earth continuity path.

4. Testing of earth-electrode resistance.

Insulation Resistance Test

The aim of this test is to know whether the wires or cables used in the wiring are sufficiently insulated to avoid leakage current. Test is performed by a DC source not less than twice of working voltage but not exceeding 500 V. A 500 V tester, known as 'Megger' is used for this purpose.

Since installation circuits are wired in parallel, one can see that for a very large Installations an insulation resistance test at the intake position may show a low value, which isn't actually due to bad insulation. In order to overcome this problem, EELPA regulation (SECTION E-2) permits such installation to be broken down into smaller units of not less than 50 outlets.

Testing of Insulation Resistance Between the Wiring and the Earth

The resistance offered to leakage from conductors to earth is known as insulation resistance test between the wiring and earth. Before making an insulation test ensure that:

- Supply is isolated, i.e. the main switch, breaker or fuse is in OFF position.
- All protective devices are in place.
- All the switches are in ON position.
- All the lamps are in their positions or the holders are short-circuited.
- Link all the poles of the supply together i.e. line and neutral terminals are shorted on the installation side.

Self check-3

Name: _____ **Date:** _____

Test-I Matching

Instruction: select the correct answer for the give choice. You have given 1 Minute for each question. Each question carries 2 Point.

A	B
---------1. NCTC	A. Normally-closed, timed-closed
---------2. Normally-open, timed-closed.	B. NOTC
---------3. Are designed for quick removal and replacement of the lamp	C. this is the minimum current that will 'blow' the fuse
---------4. Current rating	D. Lamp Holders
	E. Weather proof cables
---------5. Fusing current	F. This is the maximum current that a fuse will carry indefinitely without undue deterioration of the fuse element.
---------6. used for outdoor wiring and for power supply	

Test **II**

Instruction: If the statement is correct write true if the statement is in correct write false

1. _____ Silver is a bad conductor of electricity.
2. _____ Switches are made of conducting material.
3. _____ PVC casing and capping are used for covering the wires.
4. ----------Is equipment that is found to be out of calibration shall be marked and removed from service until re-calibrated?
5. ---------- Is processes (including materials used) to the extent necessary to ensure conformance to the specified requirements

Test III.

Instruction: Multiple choice questions

1. ----------Pendant holder is used for

(A) fixing the bulb (b) fixing the fan

(c) For hanging the bulb (d) to hang the fan

2. ----------A two-way switch is used for

(A) Control one bulb from 2 points (b) control two bulbs from 2 points

(c) Control multiple bulbs from 2 points (d) control one bulb from one point

3. _____is used to protect and provide the route of electrical wiring in an electrical system.

(A) Heaters (b) conduit

(c) Switch (d) Electrical Circuit

4._____It is a good conductor of electricity. It is used in wiring materials in cables.

(a) Copper (b) silver

(c) Aluminum (d) None

Test IV: short Answer writing

Instruction: write short answer for the given question. You are provided 3 minute for each question and each point has 5Points.

1. Write classification of conduits
2. Write down at least three Materials required for PVC casing-capping wiring include
3. Write classification of cables According to type of insulation
4. List at list three criteria of Inspections and tests procedures selecting laboratory equipment.
6. List two types of Inspection and Test
7. What is the purpose of Conduit couplers
8. List at list three types of inspection and test records.

Operation sheet 3.1: Electrical materials and tools

Operation title: Commercial and Industrial Inspections

Purpose: checking/inspecting the delivered the Commercial and Industrial Motor by using the inspection check list

Instruction: Using the give Inspection check list for motor Control circuit do the task

Tools and requirement:

1. Paper
2. Ruler
3. Pencil
4. Scale

Steps in doing the task

1. Prepare Inspection Check List
2. Prepare Tools and Materials for Inspection
3. Identify area of Inspection
4. Inspect and test based on Inspection Check List
6. Complete Your work by confirming the recorded measurement

Quality Criteria:

1 neatness/good looking

2. Read and observe Check List

Precautions: Read and observe Check List

	Item	Inspection Activity	
☐	1.	Check motor control circuits for proper over current protection	
☐	2.	Verify that motor controllers are provided for motors and that they are of the proper type and have adequate ratings, including Short-circuit current ratings.	
☐	3.	Check MCCs for proper ratings, protection, workspace, and Dedicated space.	
☐	4.	Verify that motor disconnects are of the proper type and rating. ,	
☐	5.	Verify that controller disconnects are in sight of controllers, are Readily accessible, and have adequate workspace.	
☐	6.	Verify that motor disconnects are in sight of motors, are readily accessible, and have adequate workspace.,	

Operation sheet 3.2: Perform Installation Works

Operation title: Identify and connect the accessories with the wires

Purpose: To perform Identification and connecting accessories with the wires

Instruction: Using the give Inspection check list for motor Control circuit do the task

Tools and requirement:

1. Multimeter for measuring the current and voltage.
2. Tools like pliers, screw driver will be required

Steps in doing the task

1. Prepare Tools and Materials
2. Identify area
3. Complete and confirm Your work

Quality Criteria

1. neatness/good looking

2.Read and observe Check List

Precautions:

1.All connections should be tight.

2.Do not touch the terminals when supply is on.

Operation sheet 3.3: Perform Installation Works

Operation title: Connection of component

Purpose: To connect different types of components with wires in a junction box.

Instruction: Using the give Inspection check list for motor Control circuit do the task

Tools and requirement:

3. Multimeter for measuring the current and voltage.
4. Tools like pliers, screw driver will be required

Steps in doing the task

1. Different types of components will be connected with the help of wires in a junction box
2. Identify area
3. Complete confirm Your work

Quality Criteria:

1.neatness/good looking

2. Read and observe Check List

Precautions:

1. All connections should be tight.

2. Do not touch the terminals when supply is on.

LAP Test-2

Name: _____ Date: _____

Time started: _____ Time finished: _____

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

Task 1- Prepare Inspection check list for motor Control circuit

Task 2- Identify and connect the accessories with the wires

Task 2- Prepare different types of components with wires in a junction box

Unit Four: Install electrical motor controller system

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

- Electrical components ,machines and drives Preliminary checks/tests
- Electrical components
- Work schedule
- Unplanned events
- Quality of the work

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

- Mount electrical components ,machines and drives Preliminary checks/tests
- Wiring electrical components
- Follow work schedule Follow work schedule
- Seek further instructions in a case of unplanned events
- Undertake checks of quality of the work

4.1. Electrical components ,machines and drives Preliminary checks/tests

Install electrical motor controller system

Motor Controllers

- A motor controller is a switching device which makes the motor turn-on or turn-off.
- It is used to change the direction of the motor's rotation.
- It is utilized to protect the motor from overloading.
- It is used to minimize the motor's drawn current during starting period.
- It is used to control the speed of the motor

Install a Magnetic Contactor installing a magnetic contactor can be accomplished in a short period of time with the right preparation and tools. When a controlled remote which is necessary, a magnetic contactor is often used as it requires less power than other circuits may require. Magnetic contactors come in a variety of sizes and capacities ranging from palm size to ones that are several feet long. The primary use of a magnetic contactor is to override and detect an electrical motor overload.

Step 1 – Measure

Measure the area you plan to install the unit before you purchase it.

Step 2: Prepare the Work Area

It is always advisable when working with electricity to take caution and turn off any power unit you may come in contact with while installing any electrical device.

Step 3 :Mount the Magnetic Contactor

Mount the contactor housing into a stud whenever possible, with the manufacturer enclosed screws. If you are unable to mount into a stud use appropriate wall anchors. Pre drill a small starter hole into the drywall, and then carefully hammer in the wall anchor. This will make the housing secure and stable for the contactor to rest.

Step 4 : Prepare the Wiring

Prepare the wiring by using the wire stripper to remove approximately ½ inch of insulation from all ends of the copper wiring. Make sure to use the correct wire stripper. The best type of wire stripper has several notches in the cutting blade. Place the wire in the correct gauged notch, press down and slide off the insulation without damaging the wire.

Step 5 : Connecting the Control Wires

Slightly unscrew the termination screws from the coil solenoid. Carefully connect the stripped part of the control wire to the terminals. Make sure the connection is solid and all the strands, if any, are securely connected.

4.1.1. Motor starting Introduction motor control system

The following terminology is used with reference to the starters for induction motor

- **motor starter:** the combination of all switching and regulating means to start and stop the motor
- **Manual operation:** the operation which is called by the actuation of lever with auxiliary power.
- **Automatic operation:** the operation where the stating proceeds automatically after an initial impulse has been given by an external means.
- **Auxiliary circuit:** the circuit which includes all the conducting parts of the starter other than those of the main circuit of the starter.

Motor Starter is a device which connects with motor in series to decrease the current at starting time and increase current after starting the motor (in other words start or stop the motor) and provide overload protection.

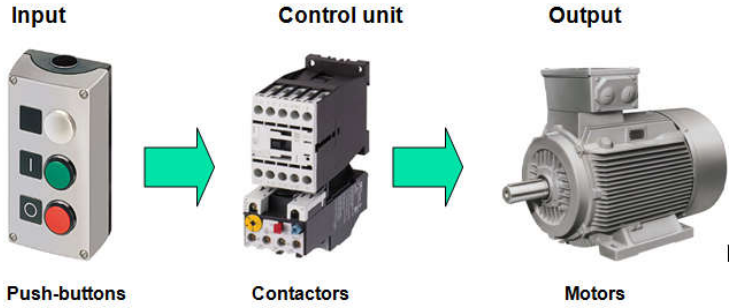


Figure 4. 1 motor control component

Three phase induction Motor Starting method

1. Magnetic starter (Direct on line)
2. Reduced voltage starting
    A. Star-Delta
    B. Primary resistor
    C. Auto transformer
    D. Part winding
    E. Soft starter
3. Wound Rotor starting
4. VFD (Variable frequency Drive)

A single-phase induction motor consists of a squirrel cage rotor and a stator carrying a single-phase winding. But, a single-phase induction motor is not self-starting like a 3-phase induction motor since it requires some starting means.

When a single-phase supply is fed to the stator winding of the single-phase induction motor, it produces a magnetic field that pulsates in strength in a sinusoidal manner. The polarity of the magnetic field reverses after each half cycle but the magnetic field does not rotate in the space.

As a result, the alternating flux cannot produce rotation in a stationary squirrel cage rotor because the magnetic flux can be resolved into two components, each one rotates in the opposite directions at the same speed. Consequently, the net flux is zero, the induced current in the rotor bars is zero, and hence, the resulting torque on the rotor conductors is zero. Therefore, a 1-phase induction motor is not self-starting.

How to Make a Single-Phase Induction Motor Self-Starting?

Somehow, by producing a rotating stator magnetic field, the 1-phase induction motor can be made self-starting. This may be accomplished by converting a single supply into two-phase supply through the use of an additional winding or auxiliary winding.

As soon as the motor attains a sufficient speed, the starting means may be removed depending on the type of the motor. Hence, the single-phase induction motors are classified and named according to the method used to make them self-starting which are given as follows

- **Split-phase Induction Motor** : These motors are started by 2-phase motor action, which is achieved by the use of a starting or auxiliary winding.
- **Capacitor Motor** : To start a capacitor motor, the two-phase motor action is achieved by the use of an auxiliary winding and a capacitor.
- **Shaded Pole Motor** : This type of single-phase induction motor is started by the motion of magnetic field produced by the means of a shading coil around the portion of the pole structure.

4.1.1.1. Direct on line starting (Full voltage motor starter with two- stop, two-start push button switch and indicating lights)

If an ac motor is started on full voltage, it will draw from two to six times its normal running current. Because the motor is constructed to withstand the shock of starting, no harm will be caused by this excessive flow of current. However, on very large motors, it is generally desirable to take some measure to reduce this starting current; otherwise, damage may be done to the machinery driven by the motor, and line disturbances may be created that affect the operation of other motors on the same line. For small motor or when the load can stand the shock of starting and no objectionable line disturbances are created, a hand-operated or an automatic starting switch can be used for control of the motor. This type of switch connects the motor directly across the line and is called an across-the-line-starter, or a full-voltage starter**.** In case of large motor, when the starting torque must develop gradually or when the high initial current will affect the line voltage, it is necessary to insert in the line some device that will reduce the starting current.

This device may be a resistance unit or an autotransformer. Controllers that use this method of starting a motor are called reduced-voltage starters. Controllers are also used to protect the motor

from overheating and overloading, to provide speed control, to provide for reversing the motor, and to provide under voltage protection

A diagram of a typical full-voltage magnetic starter equipped with three thermal overload relays and connected to a START-STOP station is shown in Figure below. In the diagrams to follow, the motor circuits are indicated by heavy lines, and the control circuits are shown by light lines. The operation of this starter is as follows:

When the START button is pressed, it completes the circuit from L) to the normally closed contacts of the STOP button through the holding coil M and normally closed contacts of the overload relays to L2. Thus, the coil is energized, and it closes contacts M and connects the motor across the line. A maintaining circuit is completed at point 2 to keep the holding coil energized after the finger is removed from the START button. Pressing the STOP button opens the coil circuit and causes all contacts to open. If a prolonged overload should occur during the operation of the motor, the overload relay contacts will open and de-energize the holding coil.

It also has a magnetic holding coil, which closes the main contacts upon being energized and also closes a normally open auxiliary or maintaining contact to maintain the current in the holding coil. The main and auxiliary contacts are generally joined by an insulating connecting bar so that all contacts will close when the holding coil becomes energized. It is obvious that any size of magnetic switch can be operated just by sending a small current through the coil. Starters are often equipped with dual-voltage coils for operation on either high or low voltage. They have two coil sections-series for high voltage; parallel for low voltage.

Direct On-Line (D.O.L.) Starting As the name suggests, the induction motor is started by connecting it directly to three-phase supply. In this method, the motor draws a high starting current (about 4 to 7 times of the rated current) and at low power factor. Therefore, DOL starting is suitable for relatively small motors (up to 10 kW).

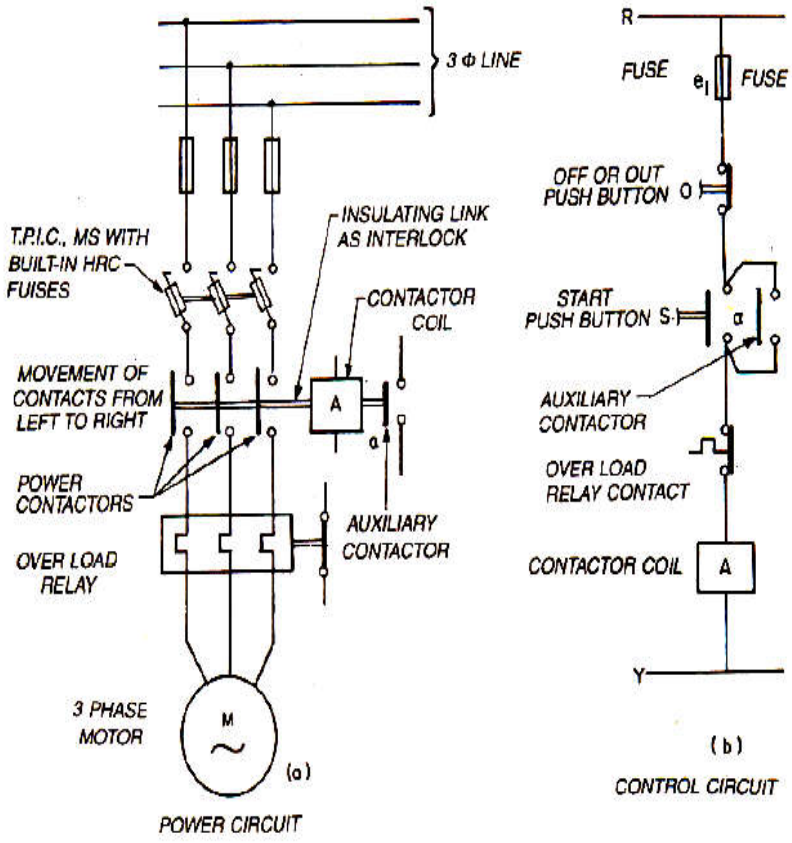


Figure 4. 2. Direct on line starting

Advantage of DOL

- Most Economical and Cheapest Starter
- Simple to establish, operate and maintain
- Simple Control Circuitry
- Easy to understand and trouble□shoot.
- It provides 100% torque at the time of starting.
- the machine to drive does not need to speed up gradually

Disadvantage of DOL

- It does not reduce the starting current of the motor.
- High Starting Current: Very High Starting Current (Typically 6 to 8 times the FLC of the motor).

- Mechanically Harsh: Thermal Stress on the motor, thereby reducing its life.
- Voltage Dip: There is a big voltage dip in the electrical installation because of high in-rush current affecting other customers connected to the same lines and therefore not suitable for higher size squirrel cage motors
- High starting Torque: Unnecessary high starting torque, even when not required by the load, thereby increased mechanical stress on the mechanical systems such as rotor shaft, bearings, gearbox, coupling, chain drive, connected equipments, etc. leading to premature failure and plant downtimes**.**

4.1.1.2. Direct switching (starting) of 3-phase ac motors

Motor protector Switch Starter

The Motor protector Switch Starter is a simple type of switch that connects the motor directly to the line. Pressing the switch causes the contacts inside the switch to make and connect the motor across the line.] o break apart and open the circuit to the motor. The Mot oad condition occurs.

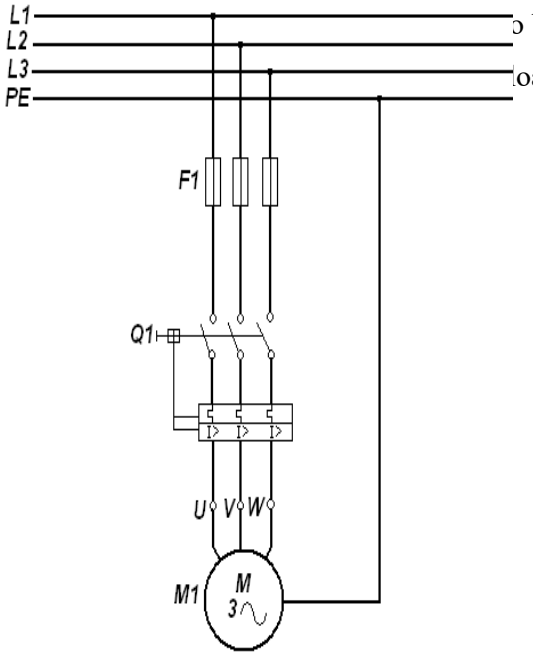


Figure 4. 2 Motor protector Switch Starter

Pushbutton Switch Starter

The pushbutton switch starter is switch that connects the motor directly to the line. Two pushbuttons are located on the switch, one for starting and the other for stopping the motor. Pressing the START button causes the contacts inside the switch to make and connect the motor across the line. Pressing the STOP button causes the contacts to break apart and open the circuit to the motor.

Pushbutton Stations

Magnetic starters are controlled by means of pushbutton stations. The most common station has START and STOP buttons, as shown in Figure below. When the START button is pressed, two normally open contacts are closed; and when the STOP button is pressed, two normally closed contacts are opened. Spring action returns the buttons to their original position when finger pressure is removed.

To operate a magnetic switch by a START-STOP station, it is necessary to connect the holding coil to the station contacts so that when the START button is pressed, the coil will become energized; and when the STOP button is pressed, the holding-coil circuit is opened.

Figure 4. 3 Pushbutton Stations

4.1.1.3. Installing ON-OFF control circuits with manual switches (Rotary) for 3 phase Squirrel cage motors on an installation chassis

Rotary Switches are hand operated electro-mechanical devices used for switching circuits and selecting functions. Rotary switches can be two-position, on-off, or they can have multiple discrete stops. Key specifications include number of poles, number of positions, construction type, mounting type, and panel cut-out diameter for panel mount switches. Rotary switches are used to

provide a visually verifiable means of switch position, allowing operators to tell with a glance whether a circuit is energized or not. They are also called Paddle Switches.

Advantages and disadvantages of direct-on-line control with manual switch

Advantages: Simple structure, low-cost in systems with small powers and single machines, easy to handle.

Disadvantages: No central control possible, no automation possible, no emergency off in the event of a fault.

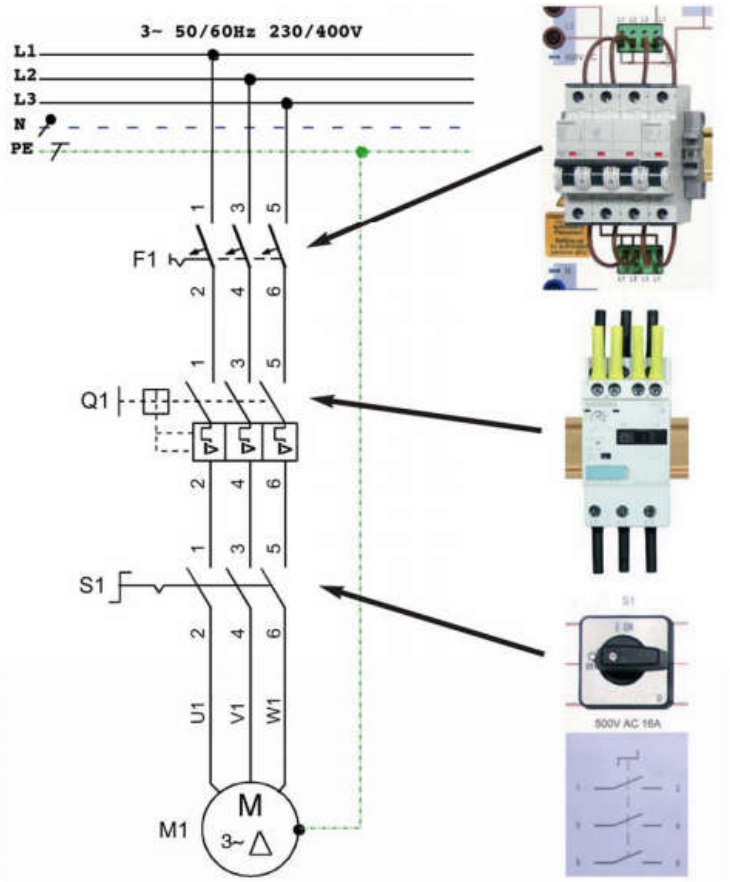


Figure 4. 4 Direct-on-line control with manual switch

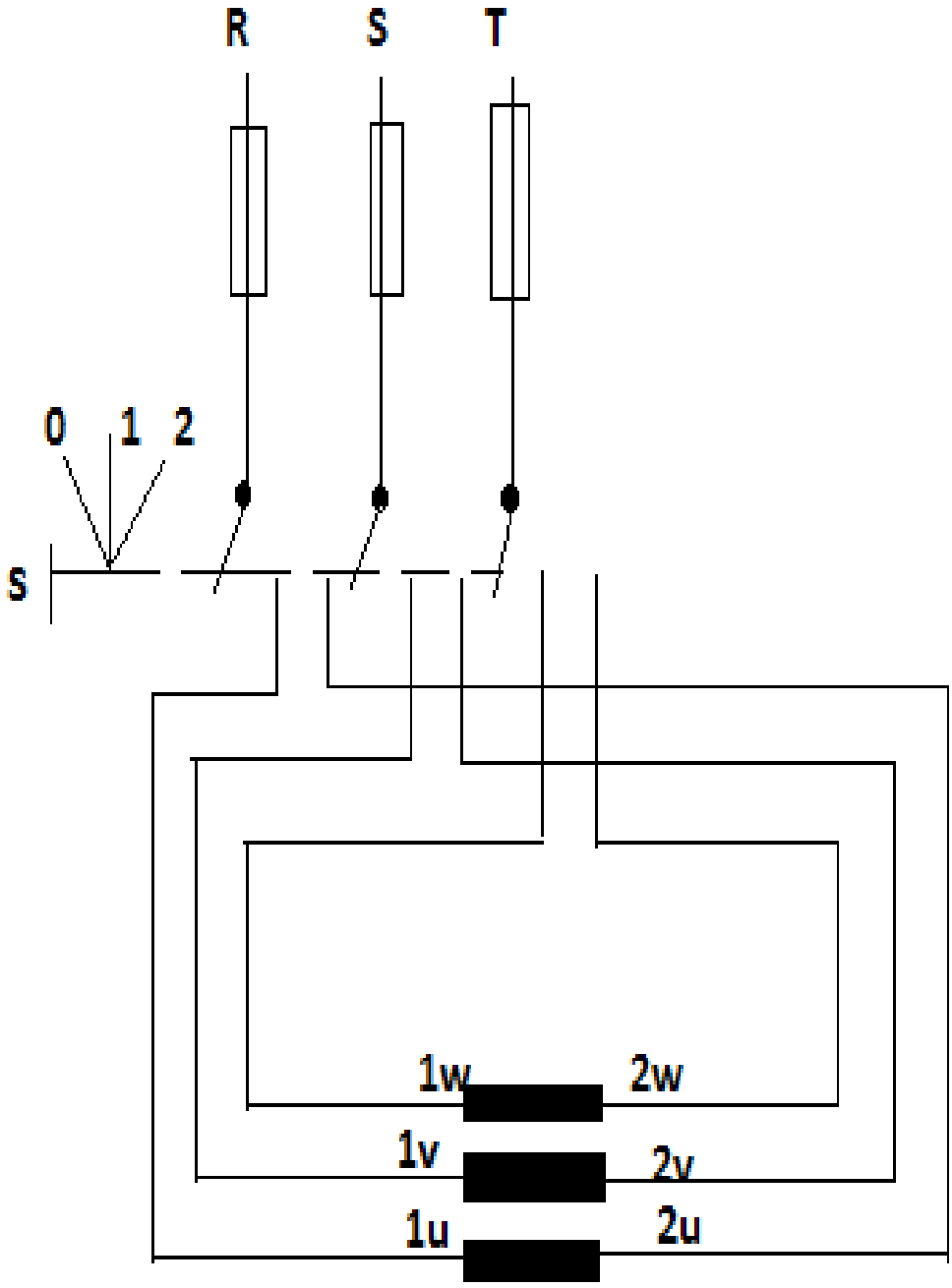


Figure 4. 5 Direct-on-line control with manual switch

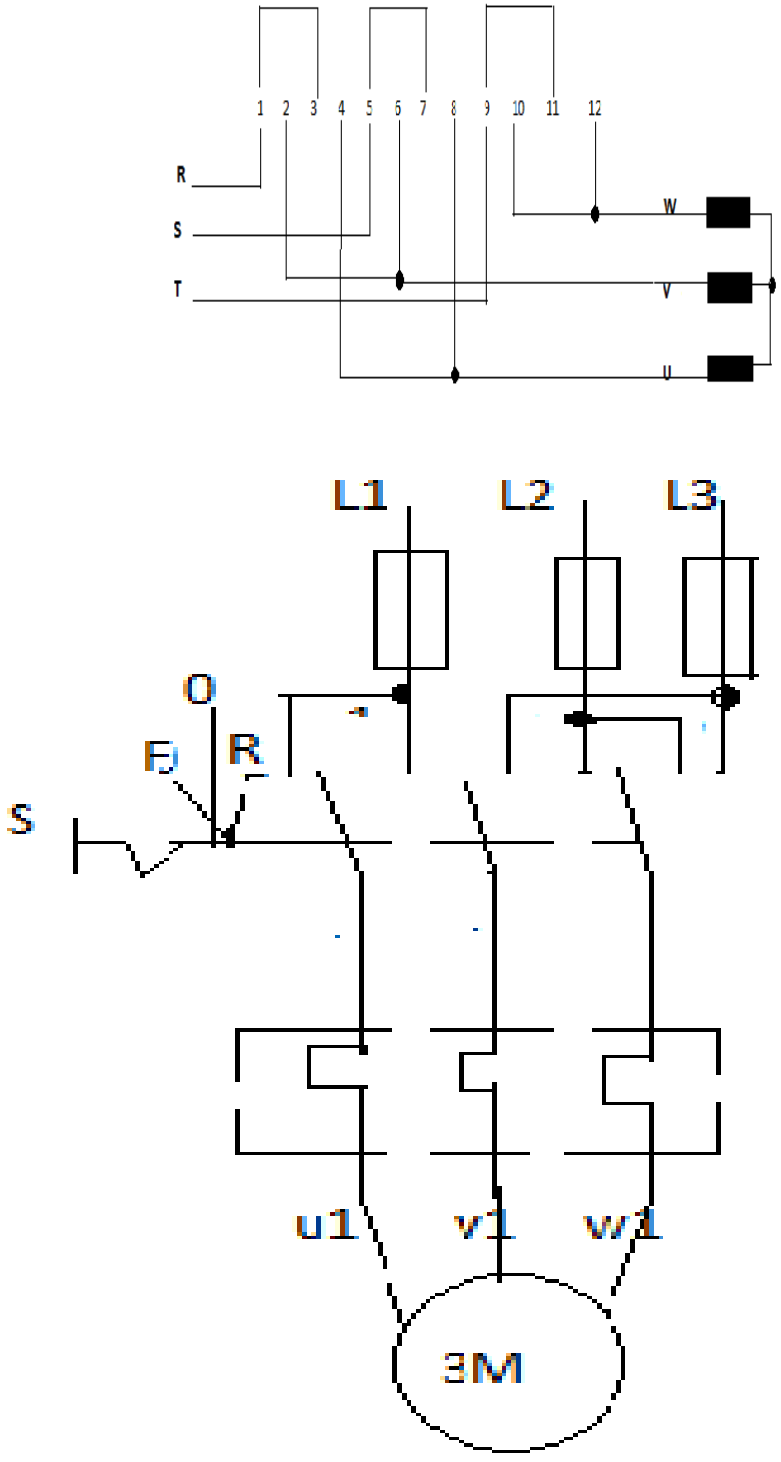


Figure 4. 6 Forward with reversing circuit with manual switch

2/4 pole two speed control circuit three phase motor

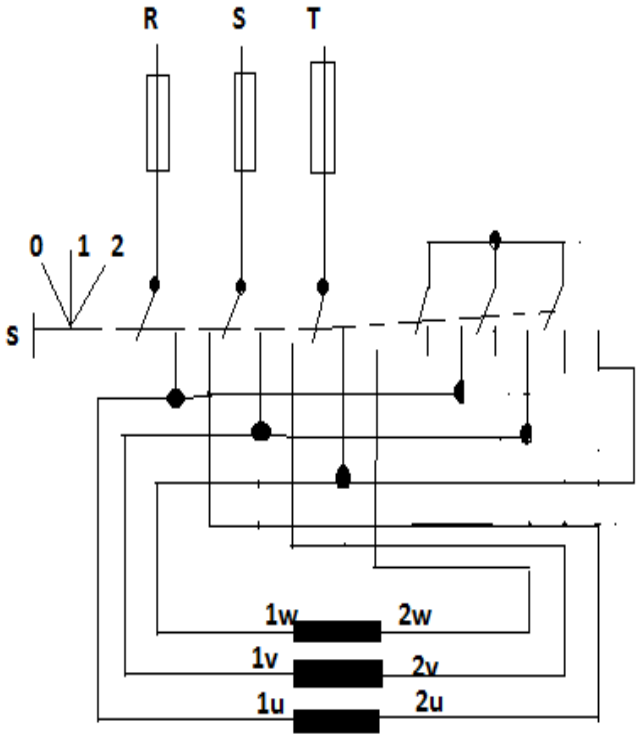
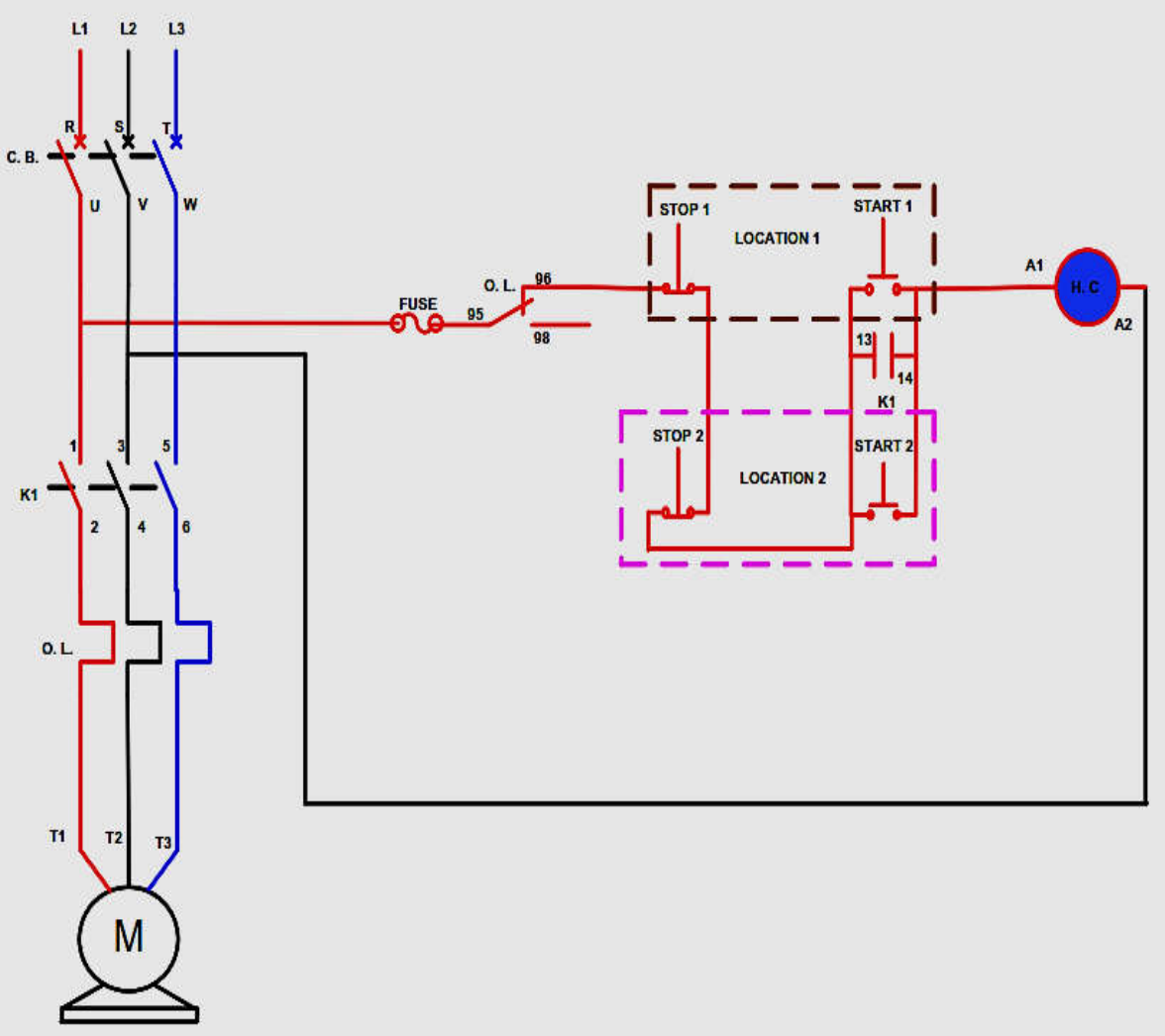


Figure 4. 7 2 /4 pole two speed control circuit three phase motor

4.1.1.4. Multi station Starter

It is sometimes necessary to operate a reversing magnetic controller from more than two places. Fig show two stations can be connected for that purpose.



4.1.2.2.Forward/Reverse Motor direction changing circuit

Direction changing circuits allow the direction of the rotation to be changed from clockwise to anti-clockwise (or vice versa). For example by pressing a push button Care must be taken, that both types of commands do not reach the motor simultaneously.

There must be an interlocking mechanism of either the contactors or the push button controls or even by both. To change the direction a three phase induction machine rotation, two of its phases needs to be exchanged, thus changing the phase sequence form, say l_1,l_2,l_3 to l_3, l_2 l_1,. This can be accomplished by using two contactors, one for the forward or CW rotation and one for the reverse or CCW rotation.

Two sets of main and auxiliary contacts are used. One set closes when forward operation is desired; the other set closes for reverse rotation. These contacts are connected in such a manner that two line wires feeding the motor are interchanged when the reverse contacts close. In this system, additional normally closed auxiliary contacts are used to prevent the forward and reverse contactors from being energized at the same time

Electrically Interlocked Reversing Starter

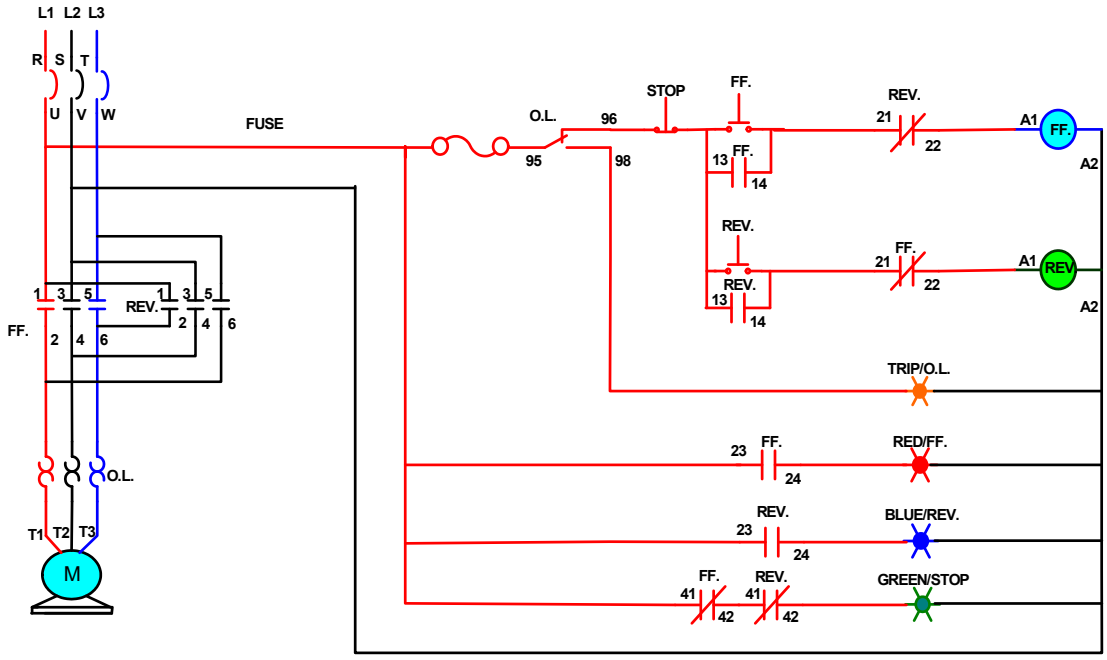


Figure 4. 1 Forward and Reversing Full Voltage Across the Line (FVAL) motor starter with auxiliary contact interlocking and complete indicating lights

Immediate forward-reverse starter mechanical interlocked Reversing Starter

A momentary contact pushbutton station that permits immediate reversal of direction without first pushing the STOP button. Note that this is also electrically and/or mechanically interlocked. Note also that the FORWARD and REVERSE buttons each have a normally closed and normally open contact.

At the same time the normally closed forward contacts are broken, preventing a circuit to the reverse coil. When the forward contactor coil is energized, the forward maintaining contacts are closed, keeping the coil energized, and the forward normally closed auxiliary contacts in series with the reverse coil are

opened, preventing the reverse coil from becoming energized. To reverse the motor, press the REVERSE button. This opens the circuit to the forward coil and closes the circuit to the reverse coil. Operation,

In operation, pressing push-button two (S2) energizes the coil K1, which closes the contacts for forward operation of the motor. Auxiliary contacts of K1 also close, maintaining (holding) the current through coil K1 when the button is released.

Pressing push-button three (S3) energizes the coil K2, which closes the contacts for reverse operation of the motor. Auxiliary contacts of K2 also close, maintaining (holding) the current through coil K2 when the button is released.

Pressing the STOP button S1 opens the circuit, which result in deenergizing of both coils K1 and K2, so that opening contacts K1 and K2 and the motor stops.

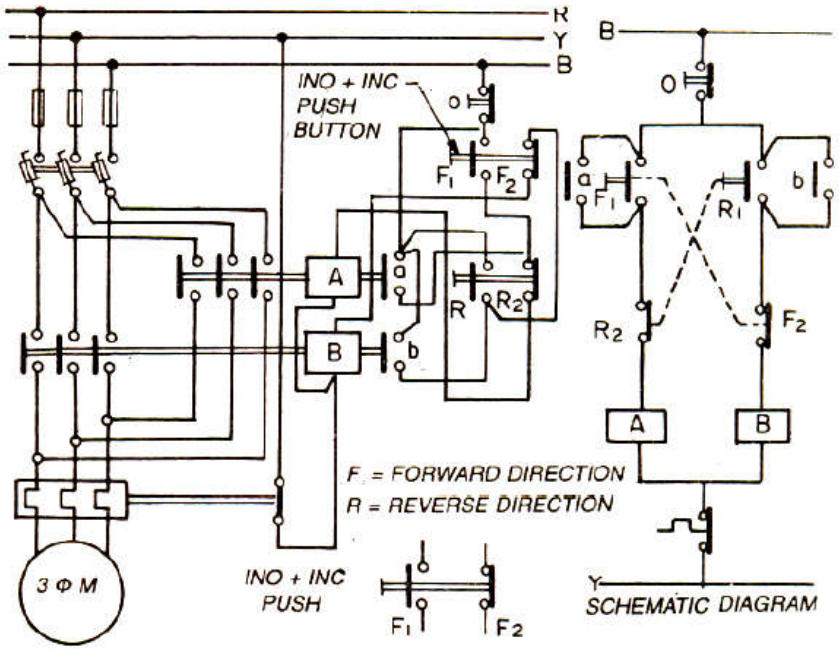


Figure 4. 2 mechanical interlocked Reversing Starter

Combination of Electrically Interlocked and Mechanical interlocked Reversing Starter

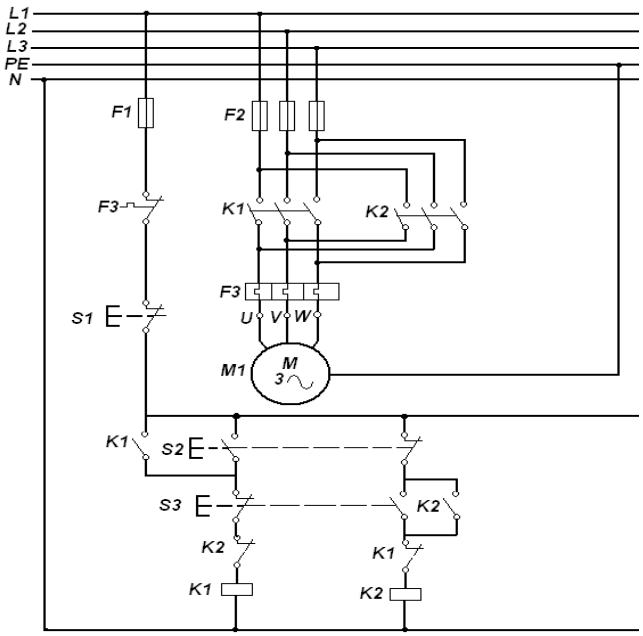


Figure 4. 3.Forward and Reversing Full Voltage Across the Line (FVAL) motor starter with pushbutton and auxiliary contact interlocking, and complete indicating lights

Stoppage on reversing by three position switch

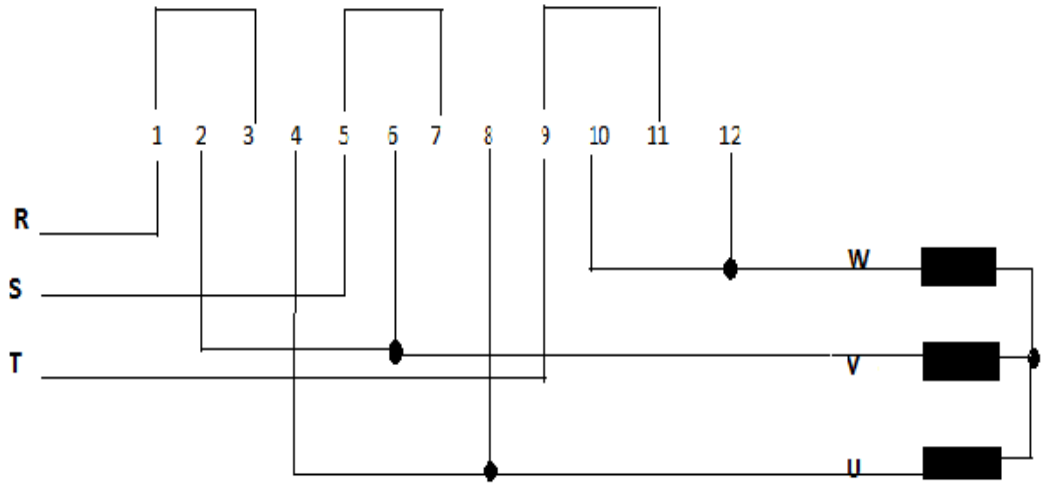


Figure 4. 8Stoppage on Reversal by three position switch

Reduced-Voltage Starters

If a squirrel-cage motor is connected directly across the line, the starting current will be several times the normal running current. In very large motors this abnormal flow may be injurious to the driven machinery.

On small motors this injurious effect is seldom noticeable, so that across-the line starters may be used safely. For the large motor, however, it is sometimes necessary to use a starter that will hold the starting current at a safe value.

The need for these starters depends a great deal on the construction of the motor and the use to which it is put. The following controllers will be treated in this section: primary-resistance starters, autotransformer starters, wye-delta starters, and solid-state starters.

Wye-Delta Starters

In star-delta starting method of squirrel cage induction motor, the motor started in star and run in delta, i.e. the stator winding of the motor is designed for delta operation and is connected in star during starting. When the motor attains sufficient speed, the connections are changed to delta.

The six leads of stator winding of the motor are connected to a change-over switch. At the time of starting, the change-over switch is switched to 'Star' which connects the stator windings in star. Thus, each phase gets $V/\sqrt{3}$ volts, where V is the three phase line voltage. This reduces the starting current. When the motor attains 80% of rated speed, the changeover switch is switched to 'Delta' which connects the stator windings in delta. Now, each phase gets full line voltage

The principle disadvantage of this method is large reduction in stating torque due to reduced voltage in the star connection at the instant of starting. The star-delta starting is used for medium size motors up to 25 hp.

What is the Function of motor starters?

1. Start and stop the **motor**

2. Limit inrush current where necessary

3. Permit automatic control when required

4. Protect **motor** and other connected equipment from sustained overload, no voltage, under voltage, single phasing, etc.

Comparison between Star and delta connections and How Star-Delta starter works?

Star connections

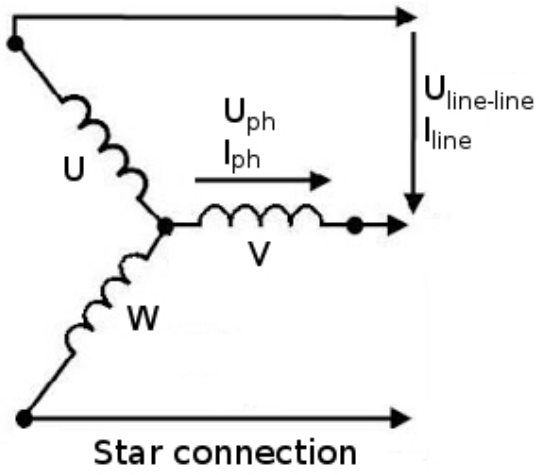
In each 3-phase alternator, six terminals come out from 3 coils placed at 120˚ apart from each other. If any three ends starting or finishing are connected at one point and we get supply from the other three-point the connection is called a star. The junction point is called the Star point or neutral point.

Star connection is used where we require a Neutral terminal to obtain Phase voltage

In a star-connected system $\mathbf{V_L=\sqrt{3}V_{ph}}$,

In a star Connected system $\mathbf{I_L=I_{phase}}$.

Star-connected systems require less insulation level and are used where a low starting current is required.



Advantages of star connections

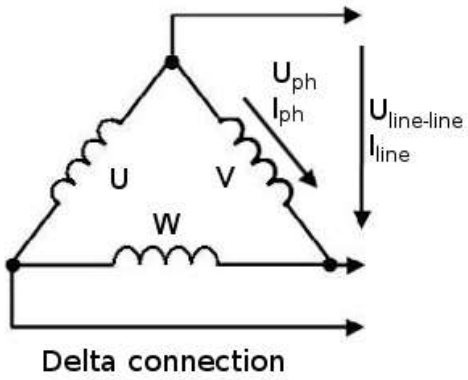
- Used for high voltage
- Common neutral point
- Good for unbalanced loading
- Each phase is a separate circuit
- Dual voltage applications
- Star connection can distribute the load evenly
- Star connection- alternator requires low insulation
- Star connection -alternator requires a low number of turns than delta for the same voltage
- Ability to spread the load between the phases
- Availability of single phase at a lower voltage
- The neutral point can be earthed

Disadvantages of star connections

- Less torque
- Construction involves combining 3 single phases into 1
- Secondary distribution, light-duty applications
- Construction cost is more expensive

Delta connections

In each 3-phase alternator, six terminals are so connected that the end of the first coil (assumed) is connected to the start of the second coil and the end of the second coil is connected to the start of the third coil and the end of the third coil is connected with the start of the first coil, the connections are called delta connected. The supply is taken from those connection points.



Delta connection

	Star	Delta
Voltage	$V_{Line} = \sqrt{3} \times V_{Phase}$	$V_{Line} = V_{Phase}$
Current	$I_{Line} = I_{Phase}$	$I_{Line} = \sqrt{3} \times I_{Phase}$

Power in both cases is the same√3V *I* COS ϕ.

Line voltage = Phase Voltage so, the Insulation level is high.

For high starting torque, a delta connection is required.

Advantages of Delta connections

- More torque
- Efficient
- Simple motor design
- Heavy-duty application
- Protection is simple and less costly
- Used in rotatory conveyors

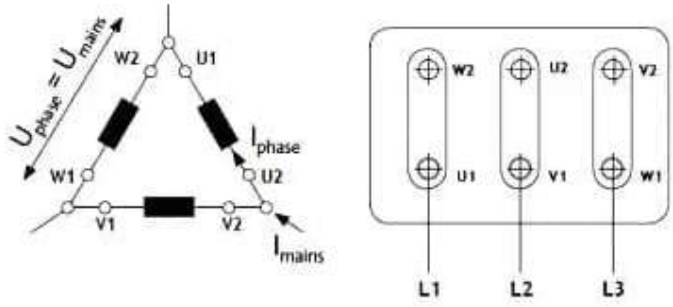
- While using delta connection, less current per winding for the same power output
- Major applications in power generation, transmission, and distribution
- The transformer secondary provides all the 3 phases
- Construction cost is low

Disadvantages of Delta connections

- No common neutral point
- Detecting earth ground faults is difficult
- Low voltage connection

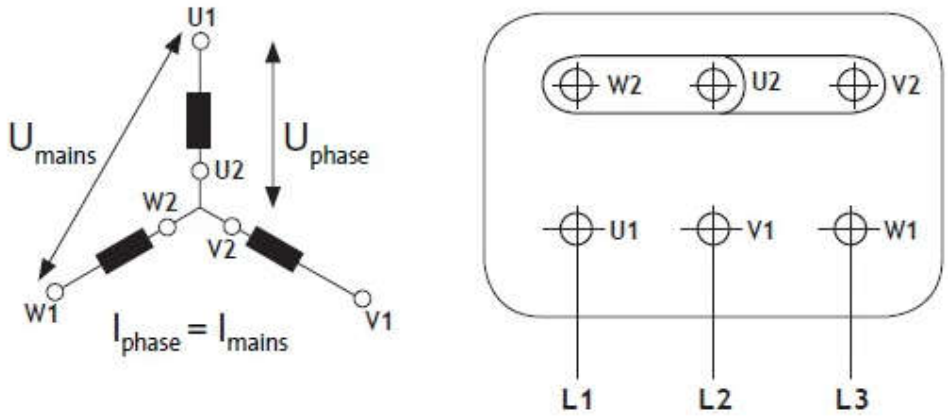
Delta connection in a 3phase induction motor terminal

A delta connection in 3 phase induction motor is, the opposite end of three windings are connected (or) the end of each winding is connected with the starting point of another winding and three wires are taken out from the winding joints.



Star connection in a 3phase induction motor terminal

A star connection in 3 phase of induction motor in which the three winding each one end is connected in common junction and another end is connected to line voltage or supply voltage separately.



Purpose of star delta starter

Star delta starter is used to reduce the current flow at the starting of the three-phase induction motor to avoid sparking, overheating, coil burning, etc. In the star connection, the supply voltage is lower than the delta connection.

So basically, the star delta starter has both the star and delta connection arrangement and also it has a timer. So, at the starting time, the motor is connected to the Star connection. After a few seconds which is already set in the timer that will connect the motor from the star to the delta connection.

So, at the initial starting stage-star connection helps to reduce the starting current and in the running condition, the delta connection helps to gather enough torque and speed for the motor.

Application of Star-Delta starter

Star delta starter is preferred for low to medium voltage and low torque squirrel cage induction motor, centrifugal compressors, large and high-power induction motors.

Suitable for applications where the required starting current is low and also the line current drawn must be minimum.

Commonly implemented in industries like- Textile, Food and Beverage, Sugar plants, Paper and Printing, Cold storage, etc.

Advantages of Star-Delta Starter

- Star delta starter provides more electrical safety and a greater life span to the induction motors.
- It is comparatively cheaper than other reduced voltage methods of starting of induction motor.
- Reduce the flow of current at starting which avoids the chances of sparking, overheating, burning of the coil, etc.
- It helps to gather more speed and torque to the induction motor at running conditions.
- Torque and current characteristics of star delta starter are better than other methods of starting.
- Starting current is 1/3 times of direct On-Line (DOL) starting current.
- No tap changing device is required to use
- It produces high torque per ampere of line current
- The design and operation of the star delta starter are simple and rugged.

Disadvantages of Star-Delta starter

Star delta starter can only be useful for 6 terminal delta connected induction motors where all 6 terminals can be accessed.

As the initial starting current compared to nominal current is 1/3 times high, starting torque is also reduced to 1/3 times. Hence it provides only 33% starting torque and if the load connected to the motor requires higher starting torque, then very high transient and stress are produced while changing from star to delta connection. It causes many electrical and mechanical break-down to occur.

It requires more cables from the star delta starter to the motor compared to the DOL starter.

Star delta starter will fail to start the motor if load connected with the motor has load torque higher than 50% of motor rated torque.

In this method of starting during the transition from star to delta, if the motor does not reach at least 80% of its rated speed then the current peak will be high same as in the DOL starter. It causes harmful effects on the contacts of contractors. Hence it would not be reliable.

If the motor too heavily functions then there will not be enough torque to accelerate the motor up to the desired speed before switching over to the delta position.

Star-delta motor control power circuit

Illustrated on the star-delta circuit diagram above, the three-phase line voltage L1, L2, L3 is supplied from the main circuit breaker down to the main magnetic contactor and finally to the three primary terminals of the motor coils U1, V1, W1. Meanwhile, the closing of the star contactor shorts the other three secondary terminals of the motor terminals U2, V2, W2.

The control circuit of the star-delta motor controller is specifically configured to produce the operational transfer sequence that switches the motor terminal from star connection to delta connection.

The main magnetic contactor is kept energized as long as the motor is running, only interchanging the activation between the star contactor and the delta contactor. Once the timer reaches the specified time, it activates the delta contactor to close its contact while at the same time disconnecting the star contactor. This second sequence eventually disconnects the motor terminals from their previous state of star connection and reconfigures them into a delta connection, connecting the reference voltage L1 to the motor terminals U1 and V2, reference voltage L2 to motor terminals V1 and W2, and reference voltage L3 to motor terminals W1 andU2. The star contactor serves to initially short the secondary terminal of the motor U2, V2, W2 for the start sequence during the initial run of the motor from standstill. This provides one third of DOL current to the motor, thus reducing the high inrush current inherent with large capacity motors at startup.

Controlling the interchanging star connection and delta connection of an AC induction motor is achieved by means of a star delta or wye delta control circuit. The control circuit consists of push button switches, auxiliary contacts and a timer.

Control Circuit of Star-Delta Starter

The ON push button starts the circuit by initially energizing Star Contactor Coil (KM1) of star circuit and Timer Coil (KT) circuit.

When Star Contactor Coil (KM1) energized, Star Main and Auxiliary contactor change its position from NO to NC.

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.

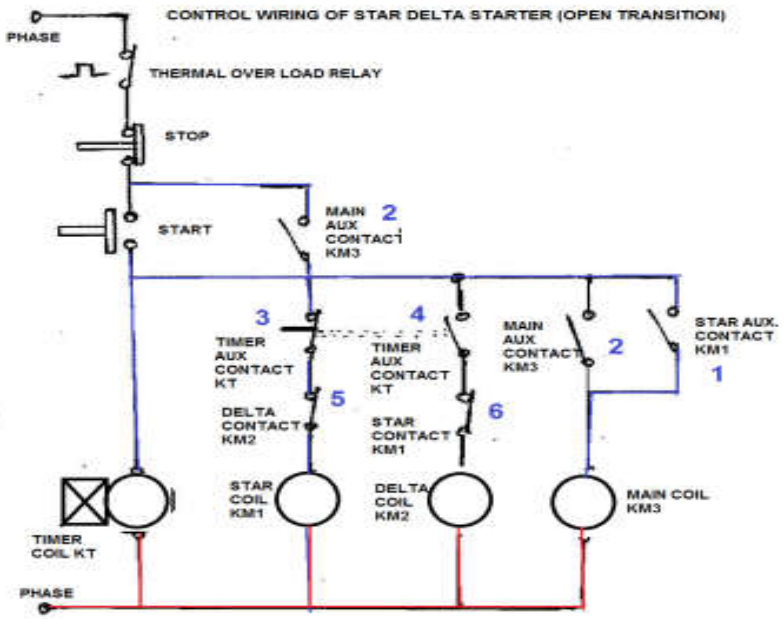


Figure 4. 9Control Circuit of Star-Delta Starter

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.

A normally close auxiliary contact from both star and delta contactors (5&6)are also placed opposite of both star and delta contactor coils, these interlock contacts serves as safety switchesto prevent simultaneous activation of both star and delta contactor coils, so that one cannot be activated without the other deactivated first. Thus, the delta contactor coil cannot be active when the star contactor coil is active, and similarly, the star contactor coil cannot also be active while the delta contactor coil is active.

The control circuit above also provides two interrupting contacts to shutdown the motor. The OFF push button switch break the control circuit and the motor when necessary. The thermal overload contact is a protective device which automatically opens the STOP Control circuit in case when motor overload current is detected by the thermal overload relay, this is to prevent burning of the

motor in case of excessive load beyond the rated capacity of the motor is detected by the thermal overload relay.

At some point during starting it is necessary to change from a star connected winding to a delta connected winding. Power and control circuits can be arranged to this in one of two ways open transition or closed transition.

In Open transition there are four states:

OFF State: All Contactors are open.

Star State: The Main [KM3] and the Star [KM1] contactors are closed and the delta [KM2] contactor is open. The motor is connected in star and will produce one third of DOL torque at one third of DOL current.

Open State: This type of operation is called open transition switching because there is an open state between the star state and the delta state. The Main contractor is closed and the Delta and Star contactors are open. There is voltage on one end of the motor windings, but the other end is open so no current can flow. The motor has a spinning rotor and behaves like a generator.

Delta State: The Main and the Delta contactors are closed. The Star contactor is open. The motor is connected to full line voltage and full power and torque are available

In Close transition there are Four states:

OFF State. All Contactors are open

Star State. The Main [KM3] and the Star [KM1] contactors are closed and the delta [KM2] contactor is open. The motor is connected in star and will produce one third of DOL torque at one third of DOL current.

Star Transition State. The motor is connected in star and the resistors are connected across the delta contactor via the aux [KM4] contactor.

Closed Transition State. The Main [KM3] contactor is closed and the Delta [KM2] and Star [KM1] contactors are open. Current flows through the motor windings and the transition resistors via KM4.

Delta State. The Main and the Delta contactors are closed. The transition resistors are shorted out. The Star contactor is open. The motor is connected to full line voltage and full power and torque are available. .

Safety Interlock Switches

Observe carefully from the control circuit diagram the presence of interlocking contacts placed before the coils of both the star contactor and the delta contactor. These interlock switches serve as safety features so that one contactor cannot actuate without the other one deactivated. Simultaneous activation of both star and delta contactors could destroy the motor. The delta contactor will not activate unless the star contactor is deactivated, and conversely, the star contactor will not activate unless the delta contactor is deactivated.

At any while the motor is running, the motor's control circuit can easily be disconnected by pressing the OFF push button switch. This deactivates all three magnetic contactor units, immediately removing the supply voltage to the motor. The motor will slow down until its rotating inertia runs out and it comes to a full standstill.

Another disconnecting contact connected in the control circuit is the thermal overload relay. This automatic contact will disconnect the circuit upon detection of a motor overload. This means that when the load carried by the motor exceeds its rated capacity, the high current in the motor heats up the metallic plates in the thermal overload relay, which mechanically releases its contact to open the motor's control circuit.

Star-delta switching by Hand operated Push-buttons

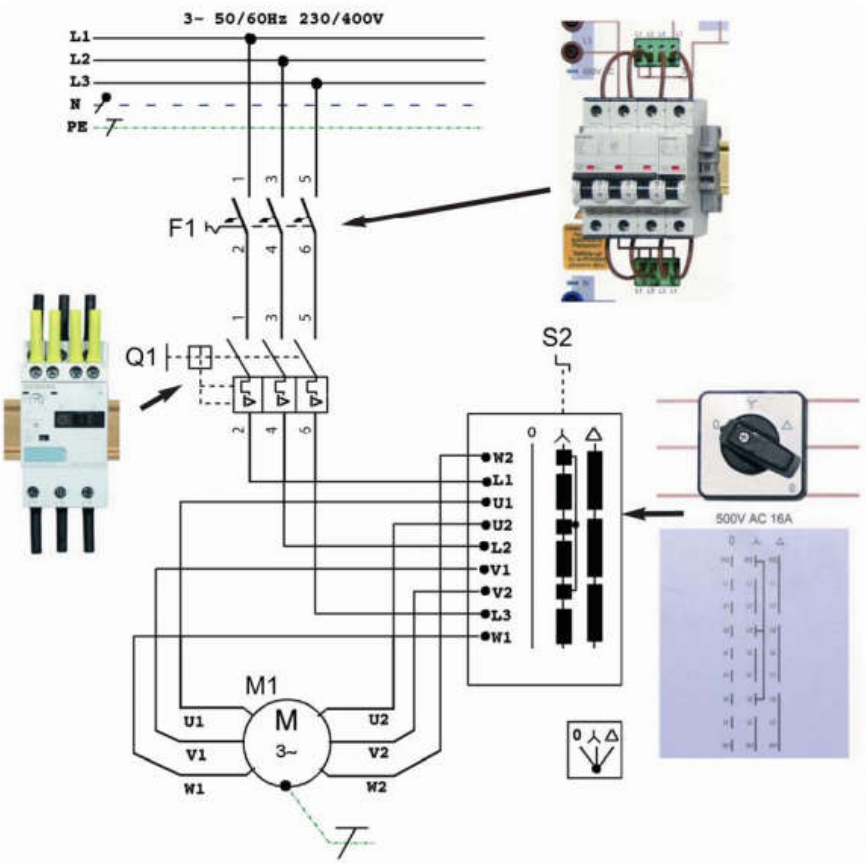


Figure Star-delta switching by Hand operated Push-buttons

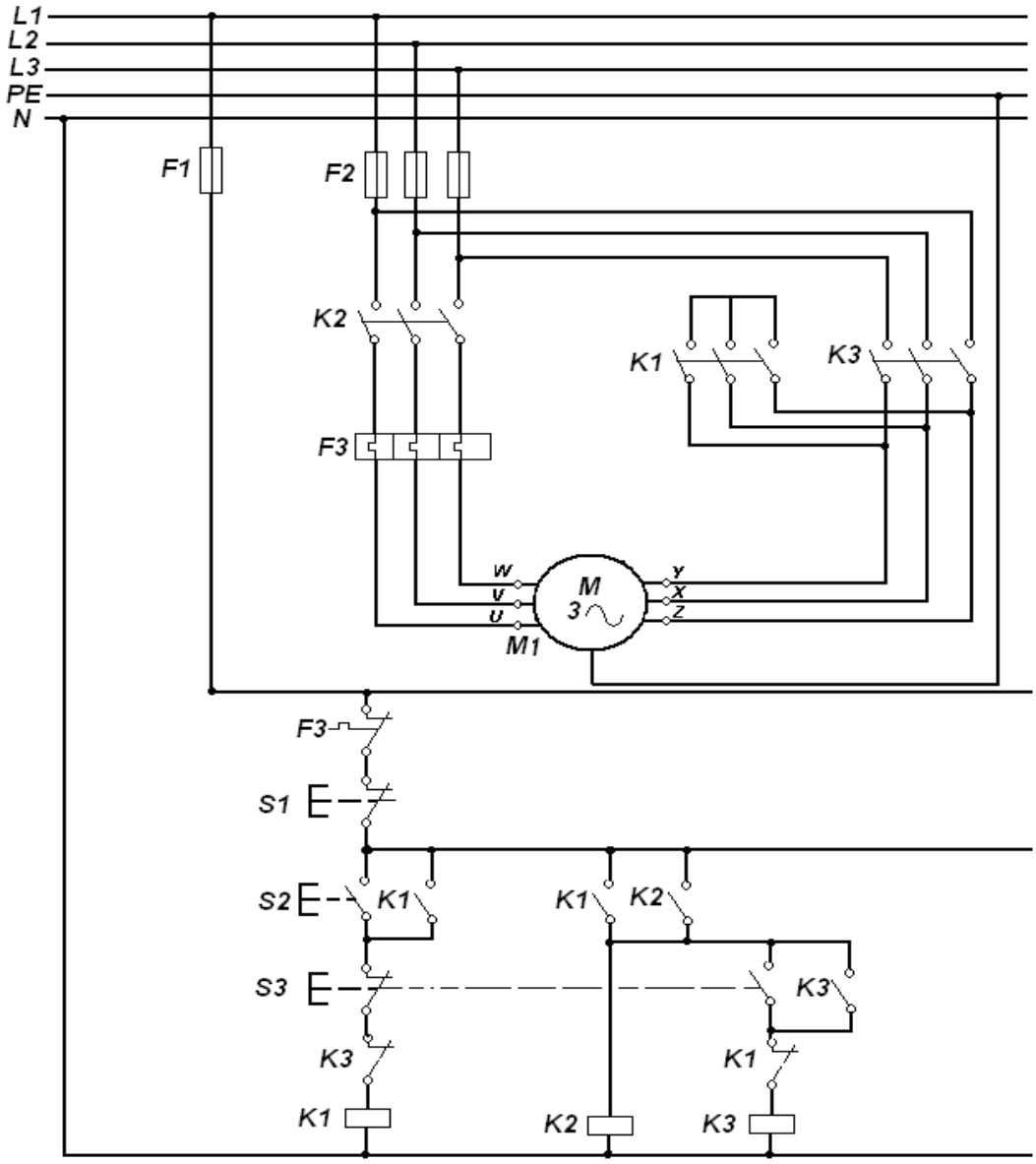


Figure 4. 10 Star-delta switching by Hand operated Push-buttons

Starting up three-phase current asynchronous motors with a star-delta reverser switch A mobile drive mechanism, i.e. one that can change its location, is equipped with a three-phase asynchronous motor and all the necessary operating devices such as main fuses, motor circuit breakers and control switches. The drive mechanism is connected to the mains by a flexible cable and should be switchable in both directions of rotation.

Circuit diagram

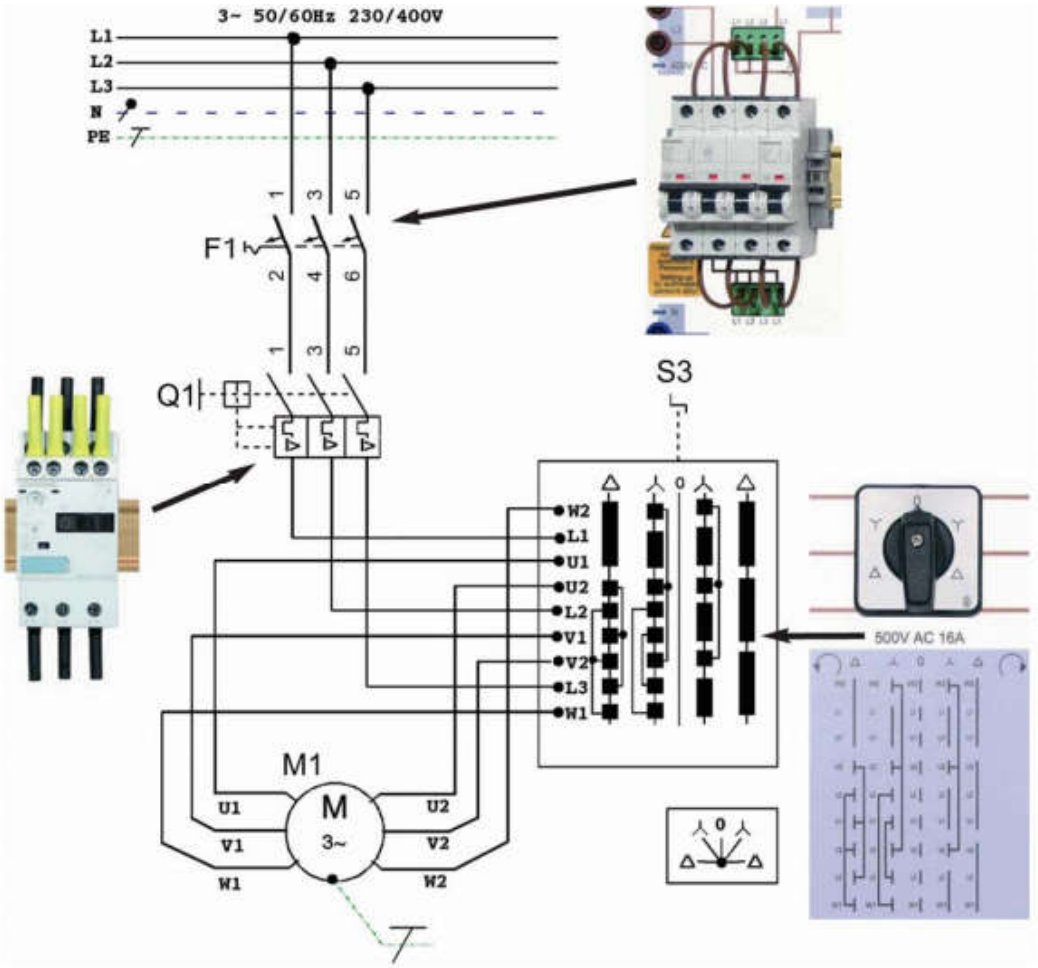


Figure 4. 4 Starting up three-phase current asynchronous motors with a star-delta reverser switch

Functional description

Set up the circuit completely and test the function. Describe the function of the circuit.

Switching on in direction 1 – right-hand rotation: By turning the switch S3 from position 0 to position Y, the connections L1-U1, L2-V1and L3-W1 are connected. At the same time the connections W2, U2 and V2 are all connected to the star point. The motor M1 starts up with a rated power reduced by factor3 in direction 1 (right-hand rotation). On reaching the startup conditions, switch S2 is turned to position Δ, the motor M1 runs at full rated power.

Switching off: By turning the switchS3 from position Δ(in special cases also from position Y only) through position Y to position 0, the connections between the given terminals are broken and the motor is switched off.

Switching on in direction 2 – left-hand rotation: By turning the switch S3 from position 0 to position Y, the connections L1-U1, L2-W1and L3-V1 are connected. At the same time the connections W2, U2 and V2 are all connected to the star point. The motor M1 starts up with a rated power reduced by factor3 in direction 2 (left-hand rotation). On reaching the startup conditions, switch S2 is turned to position Δ, the motor M1 runs at full rated power.

State the advantages of using a star-delta reverser switch.

The star-delta reverser switch allows universal use of a three-phase current motor or a mobile drive mechanism. The motor can always be switched in the desired direction of rotation regardless of the connections in the mains socket used

Automatic Star-delta switching by time-lag relay

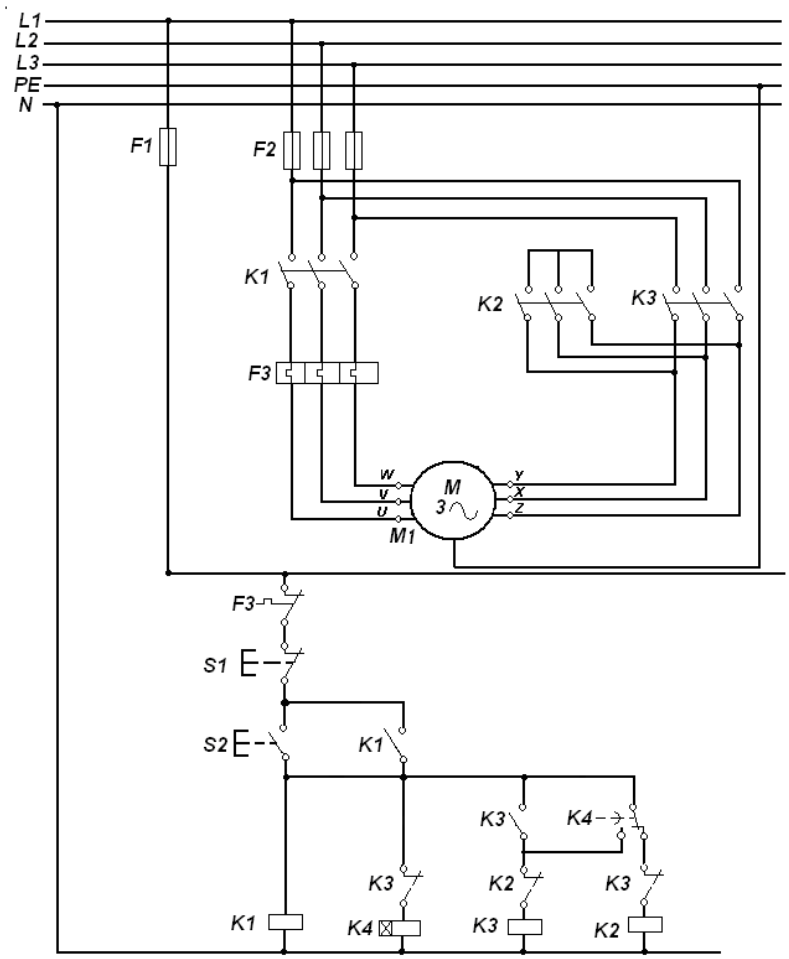


Figure 4. 11Automatic Star-delta switching by time-lag relay

Automatic Star-delta switching by time-lag relay, reversal only after stoppage

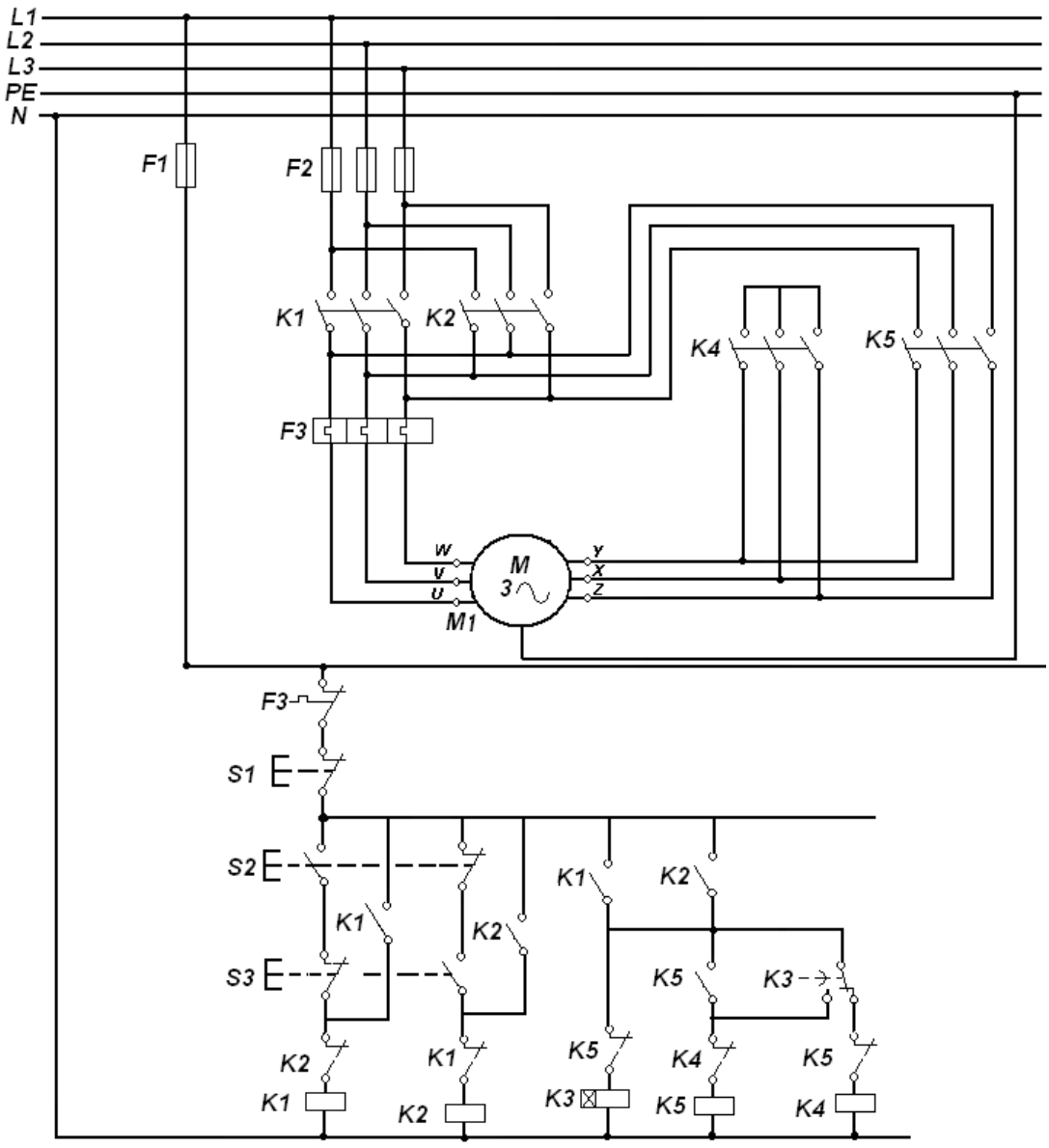


Figure 4. 12Automatic Star-delta switching by time-lag relay, reversal only after stoppage

Multi-Speed and Reversing Starters

Full-voltage AC magnetic multi-speed controllers are designed to control squirrel-cage induction motors for operation at two, three, or four different constant speeds, depending on motor construction. The speed of a constant-speed motor is a function of the supply frequency and the number of poles and is given in the following formula:

$$\text{Synchronous Speed in RPM} = \frac{120 \times \text{Frequency}}{\text{Number of Poles}}$$

The speed in RPM is the synchronous speed or the speed of the rotating magnetic field in the motor stator. Actual rotor speed is always less due to slip. The design of the motor and the amount of load applied determine the percentage of slip. This value is not the same for all motors. A motor with four poles on a 60 hertz AC line has a synchronous speed of 1800 RPM. This means that, after allowing for slip, the motor is likely to run at 1650 to 1750 RPM when loaded.

$$1800 = \frac{120 \times 60}{4}$$

An induction motor with two poles on a 60 hertz AC line, however, would run at twice that speed. When motors are required to run at different speeds, the motor's torque or horsepower characteristics will change with a change in speed. The proper motor must be selected and correctly connected for the application. In these applications, there are three categories.

Constant Torque (CT)

Variable Torque (VT)

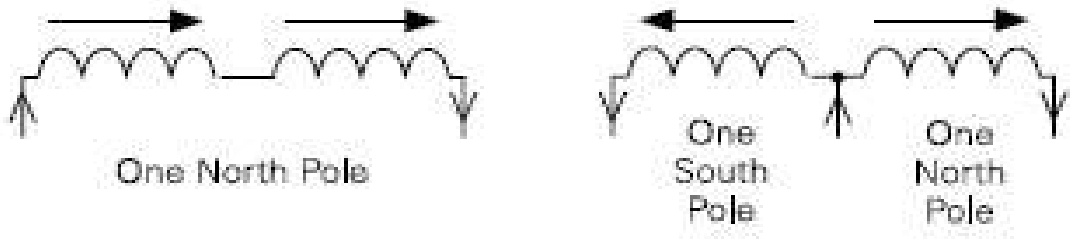
Constant Horsepower (CHP)

Separate-Winding

There are two basic methods of providing multi-speed control using magnetic starters: separate-winding motors and consequent-pole motors. Separate-winding motors have a separate winding for each speed. The speed of each winding depends on the number of poles. The low-speed winding is wound for more poles than the high-speed winding. The motor cost is higher than consequent pole, but the control is simpler.

There are many ways multi-speed motors can be connected depending on speed, torque, and horsepower requirements

Consequent-pole motors have a single winding for two speeds. Taps can be brought from the winding for reconnection for a different number of poles. Two-speed, consequent-pole motors have one reconnectable winding. Low speed of a two speed, consequent-pole motor is one half the speed of high speed. Three-speed motors have one reconnectable winding and one fixed winding. Four-speed motors have two reconnectable windings



Starting up three-phase asynchronous motors with two speeds using pole switches A suction device for pollutants is to be switchable between two speeds according to requirements. A three-phase asynchronous motor in Dahlander circuit is used. The motor is controlled by an appropriate manual control switch.

Circuit diagram

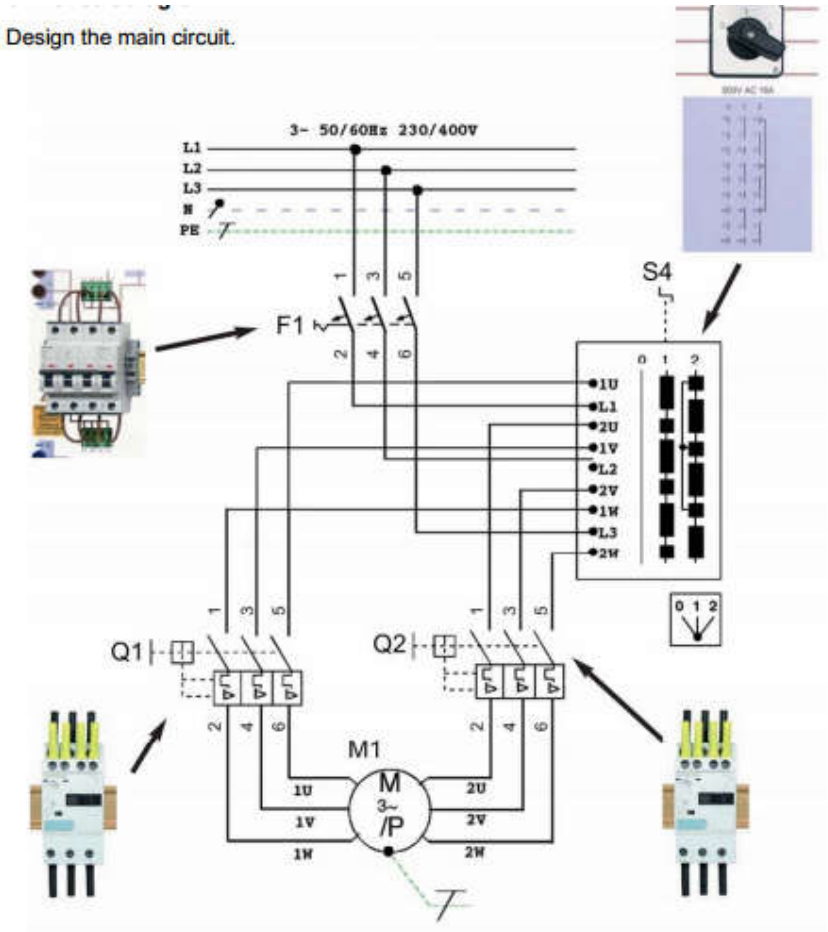


Figure 4. 13 Starting up three-phase asynchronous motors with two speeds using pole switches

Functional description

Set up the circuit completely and test the function. Describe the function of the circuit.

Switching on, speed range 1 – low speed: By turning the switch S4 from position 0 to position 1, two windings per line are connected in series and the three lines in delta circuit. The motor M1 runs in the lower speed range with a high number of poles.

Switching off: By turning switch S4 from position 1 to position 0 the motor M1 is disconnected from terminals L1, L2 and L3. The motor is switched off.

Switching on, speed range 2 – high speed: By turning the switch S4 from position 0 through **position 1 to position 2,** two windings per line are connected in parallel (double star). The motor M1 runs in the high speed range with a low number of poles.

State the advantages of a three-phase current motor in Dahlander circuit.

The Dahlander circuit allows doubling of the speed by halving of the number of poles.

The torque stays the same in both speed ranges. The motor performance remains almost constant Controlling three-phase current asynchronous motors with separate windings by pole switches A machine tool is to be operated at two speeds according to operating requirements. A three-phase current asynchronous motor with separate windings is used. The motor is controlled by an appropriate control switch.

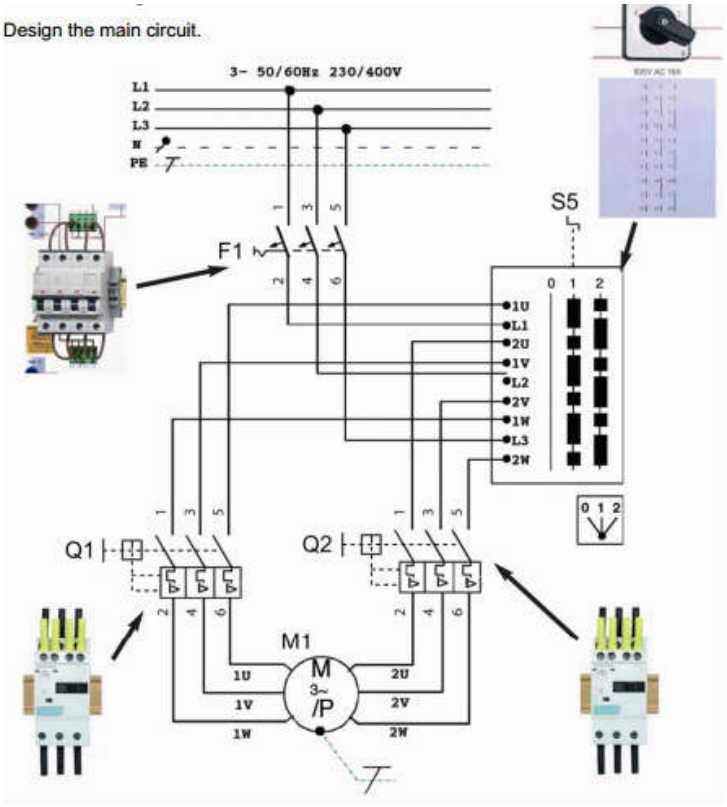


Figure 4. 14Controlling three-phase current asynchronous motors with separate windings by pole switches

Functional description

Set up the circuit completely and test the function. Describe the function of the circuit. Switching on, speed range 1 : lower speed: If switch S5 is turned from position 0 to position 1, the connections L1-1U, L2-1V and L3-1Ware connected. The motor runs in the lower speed range. The windings are switched in star circuit, there is a high number of poles. Switching off: By turning the switch S5 from position 1 to position 0, motor M1 is disconnected from the terminals L1, L2 and L3. The motor is switched off. Switching on, speed range 2 : higher speed:If switch S5 is turned from position 1 to position 2, the connections L1-2U, L2-2V and L3-2W are connected. The motor runs in the higher speed range. The windings of the second group are switched in star circuit with a low number of poles.

State the advantages of a three-phase current motor with two separate coils.

Three-phase current motors with separate stator windings and different numbers of poles allow two speeds in any integer ratio to each other. The powers produced by the motor behave about the same as the corresponding speeds but the torque is roughly the same for both speeds.

Give reasons for using two motor circuit breakers in this circuit.

Since the current consumption is different for the two speeds, a motor circuit breaker

set to the respective necessary rated current is required for each circuit type Δ/YY Manual pole changing using drum controller.

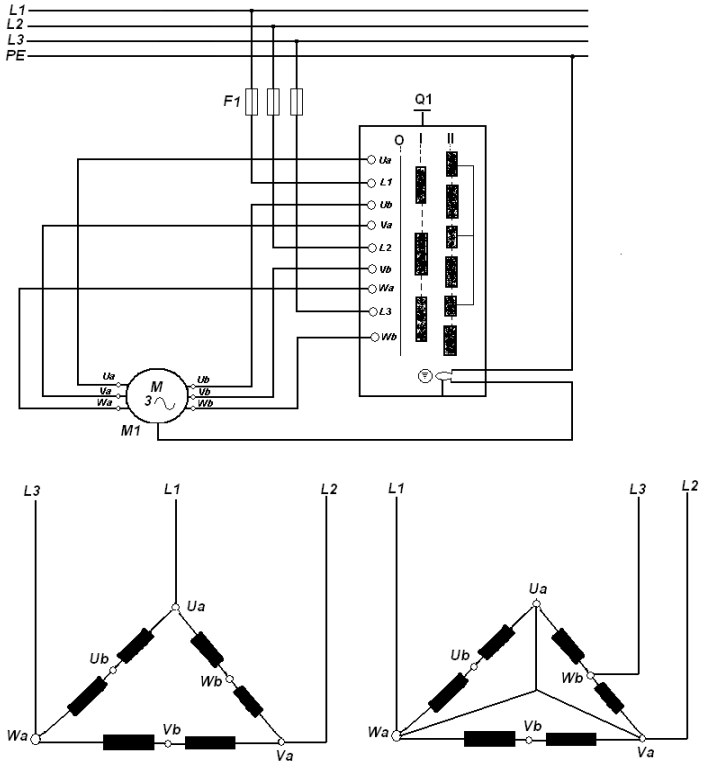
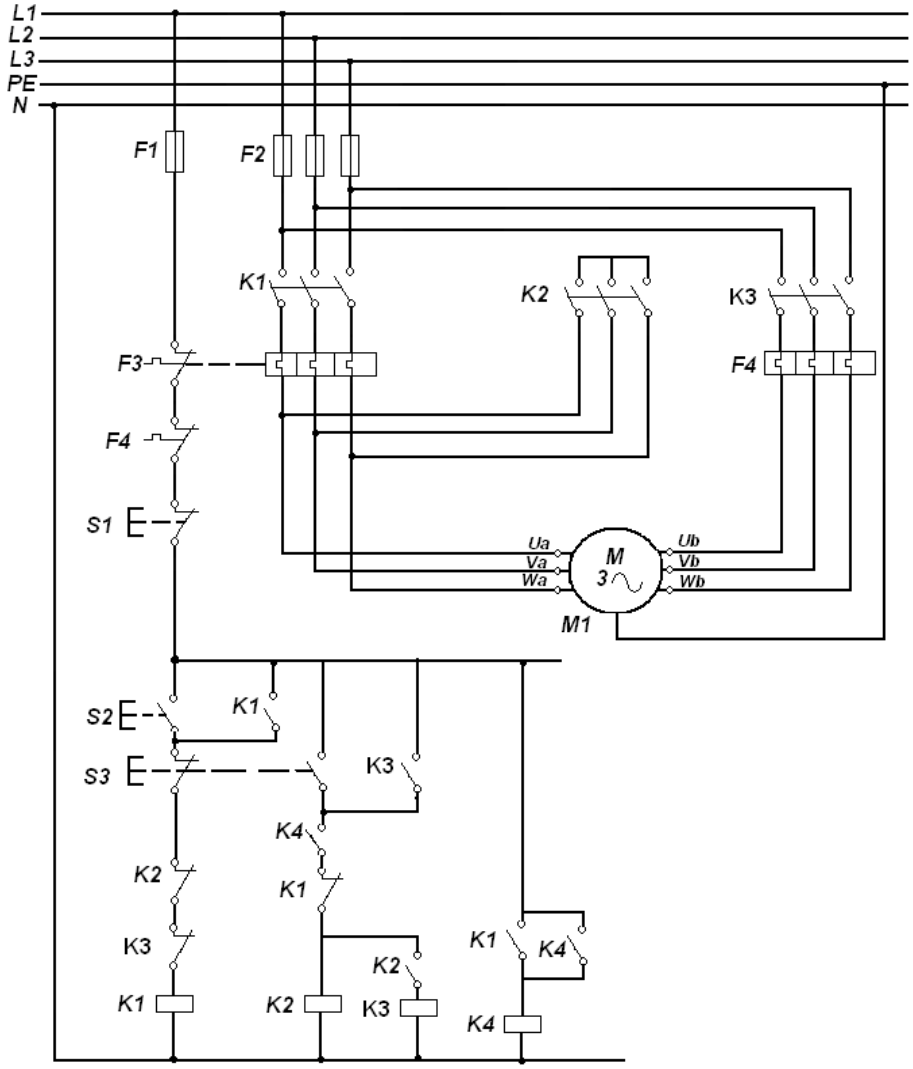


Figure 4. 15 Δ/YY Switch-over to low speed.



Stator Resistance Starting

In this method, external resistance is connected in series with each phase of the stator winding during starting. The external resistance causes voltage to drop across it so that reduced voltage available across the motor terminals. Hence, the starting current is reduced. The starting external resistances are gradually cut out in steps from the stator circuit, as the motor accelerates. When the motor attains the rated speed, the starting resistances are completely cut out and full line voltage is applied across the motor terminals.

This method has two drawbacks. First, the reduced voltage during starting reduces the starting torque and hence increases acceleration time. Secondly, a lot power is wasted in the starting resistances.

Rheostat type Primary Resistance starter.

There are two types of primary resistance starters: manual resistance starters of the rheostat type and automatic resistance starters.

The rheostat type of starter (old) for a three-phase motor is shown in. It can also be used for a repulsion-induction motor. The resistances are connected in two of the three phase lines. The arm of this rheostat consists of two sections insulated from each other. Under each section, a metal strip usually made of copper, rides on contacts that are connected to taps on the resistances.

As the arm is moved, sections of resistance are cut out, increasing the speed of the motor. The starter is so constructed that equal amounts of resistance are removed from each line as the arm is moved. Some starters are equipped with a holding coil to keep the arm at the last contact point, and the rheostat is used only for starting. In other cases, the arm can be set in any position for speed regulation.

The starting torque is cut down considerably when a resistance starter is used, because the voltage drop due to the resistance converts most of the energy needed for starting into heat.

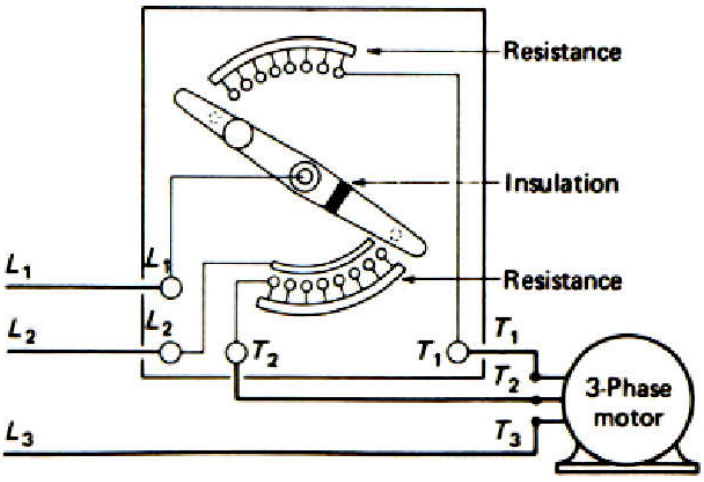


Figure 4. 16Rheostat type of starter

Magnetic primary-resistance starter.

Three resistance units are used in this starter. The diagram shows two sets of contacts. When the contacts marked S are closed, a resistance unit is placed in series with each line lead feeding the motor, thereby causing it to start slowly and on reduced voltage. After a definite time, another set of contacts, R, also closes, cutting out the resistance and placing the motor directly across the line.

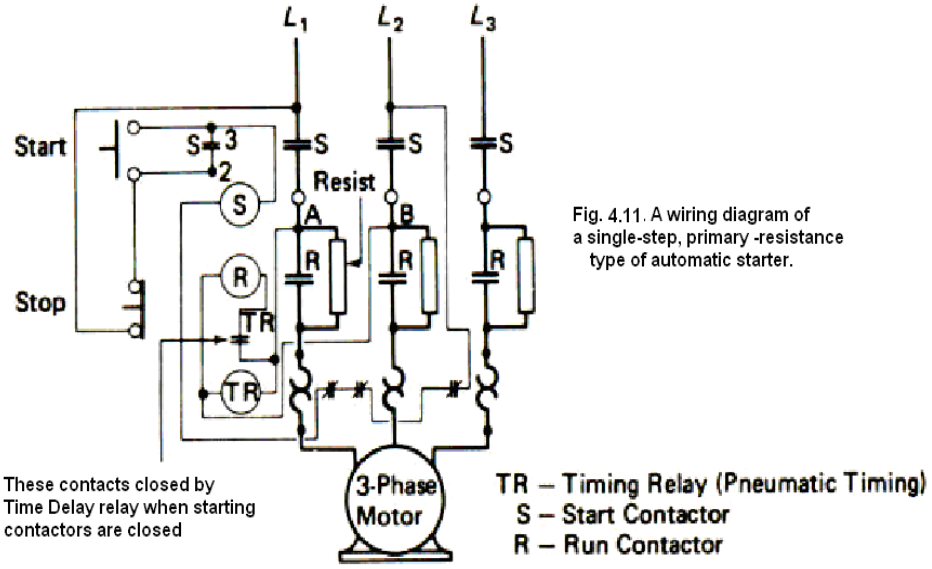


Fig. 4.11. A wiring diagram of a single-step, primary -resistance type of automatic starter.

Figure 4. 17 Magnetic primary-resistance starter

An elementary diagram of this starter is shown in Figure 4-12. Its operation is as follows: When the START button is pressed, the circuit is completed from LJ through coil S to line L2. Coil S is energized, closing the starting contacts, and the motor starts slowly. When the starting contacts close; the auxiliary interlock contacts also close to maintain a circuit through coil S. At the same time, the coil TR of a time-delay relay connected across A and B is energized, setting in motion a timing mechanism.

After a predetermined time, contacts TR close, and a circuit is completed through coil R. This coil becomes energized and causes running contacts R to close. These cut out the resistance and connect the motor across the line. Pressing the STOP button opens all circuits through the holding coils, thus all contacts to the motor are opened.

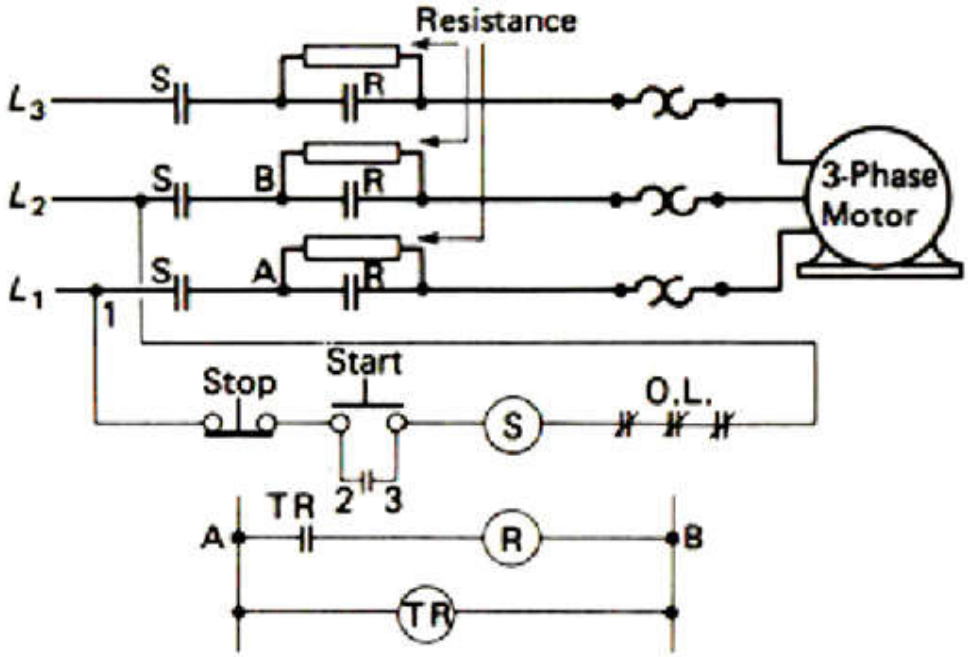


Figure 4. 18 Magnetic primary-resistance starter pneumatic timer

Figure shows a General Electric reduced-voltage, magnetic, primary-resistance starter. This magnetic primary resistor consists of a three-pole start contactor, a three-pole run contactor, a pneumatic timing relay, a single-step primary resistor, and two or three bimetallic overload relays.

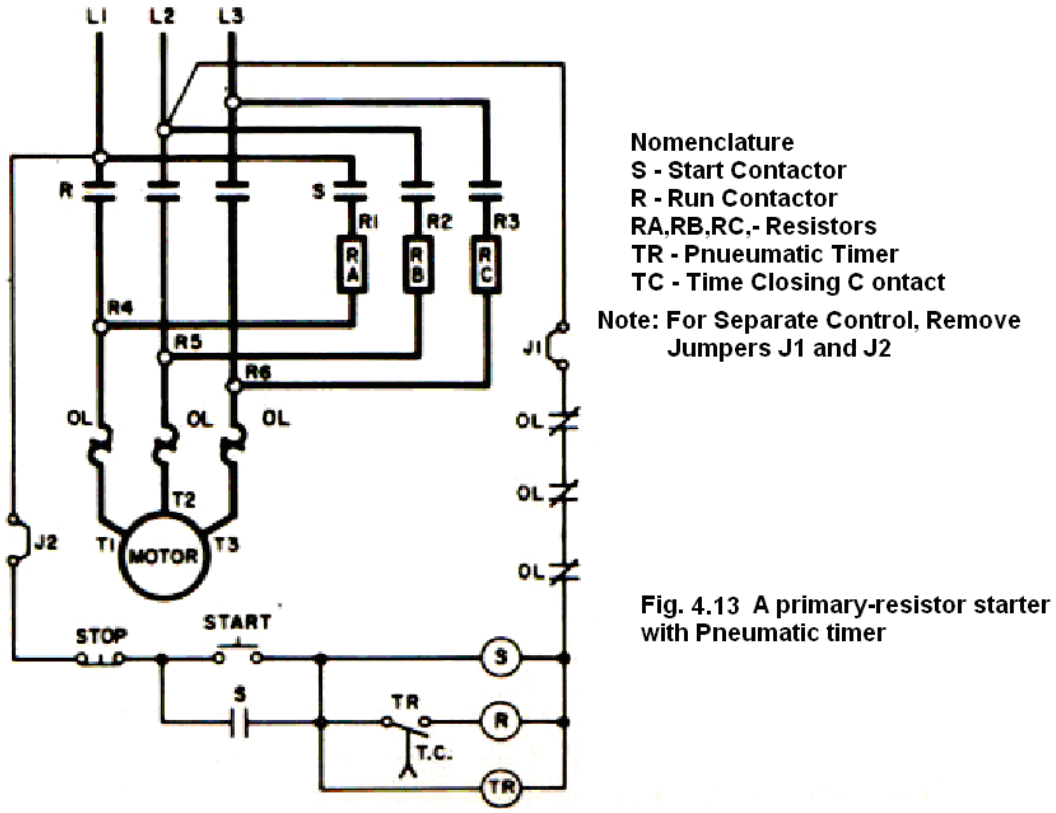


Fig. 4.13 A primary-resistor starter with Pneumatic timer

Figure 4. 19Magnetic primary-resistance starter pneumatic timer

Pressing the START button energizes the start-contactor coil. The start contactor closes, placing the motor on reduced voltage. The resistors in series with the line reduce the starting current drawn from the line. At the same time the timing relay coil is energized, and after a definite time delay, the run-contactor coil is energized, closing the run contactors. The resistors are now bypassed, thus sending full voltage to the motor. Pressing the STOP button deenergizes all the contactors and stops all power to the motor.

Autotransformer Starting

In this method, an autotransformer is used to reduce the starting voltage of the induction motor. The tapings of the autotransformer is so set that when it is in the circuit, 60 to 80 % of the line voltage is applied to motor during starting and then connecting it to the full-line voltage as the motor attains a sufficient speed.

At the instant of starting, the change-over switch is connected to 'Start'. This supplies the reduced voltage to the motor through the autotransformer. Consequently, the starting current is limited to safe value. When the motor attains about 80% of rated-speed, the change-over switch is now thrown to 'Run'. This removes the autotransformer from the circuit and full line voltage is applied across the motor terminals.

The autotransformer starting has many advantages such as low power loss, low starting current etc. This method is used for large motors over 25 hp.

Automatic stator starter circuit with transformer starter.

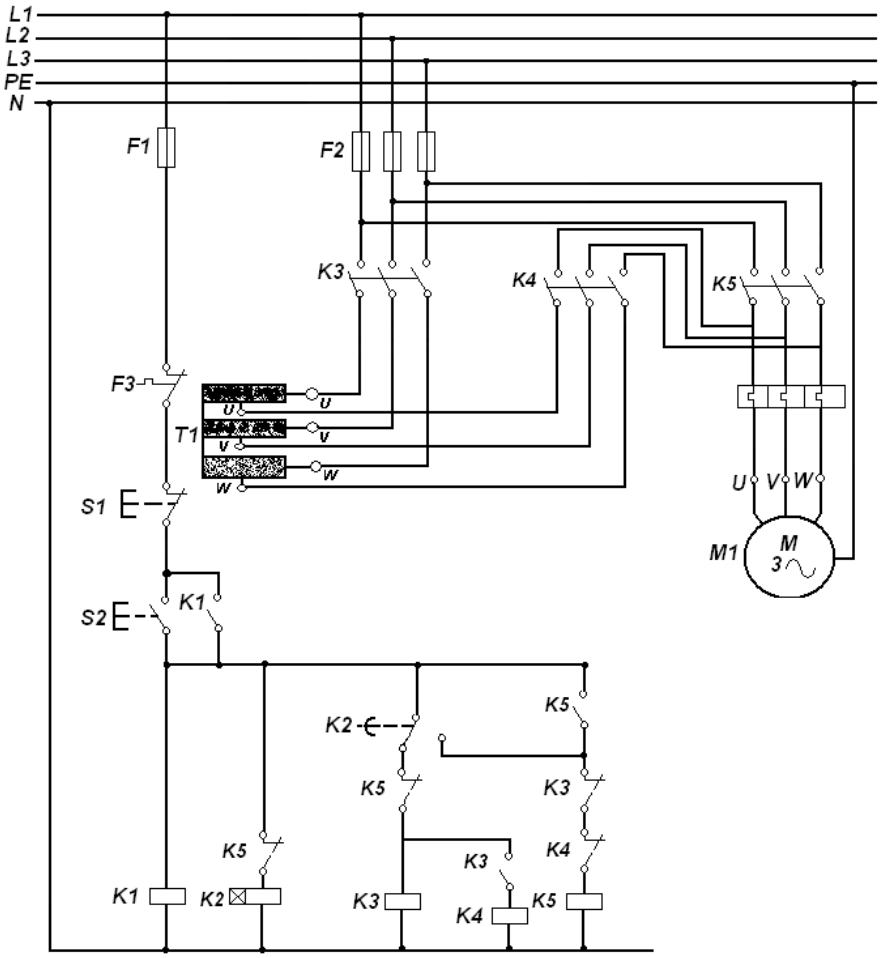


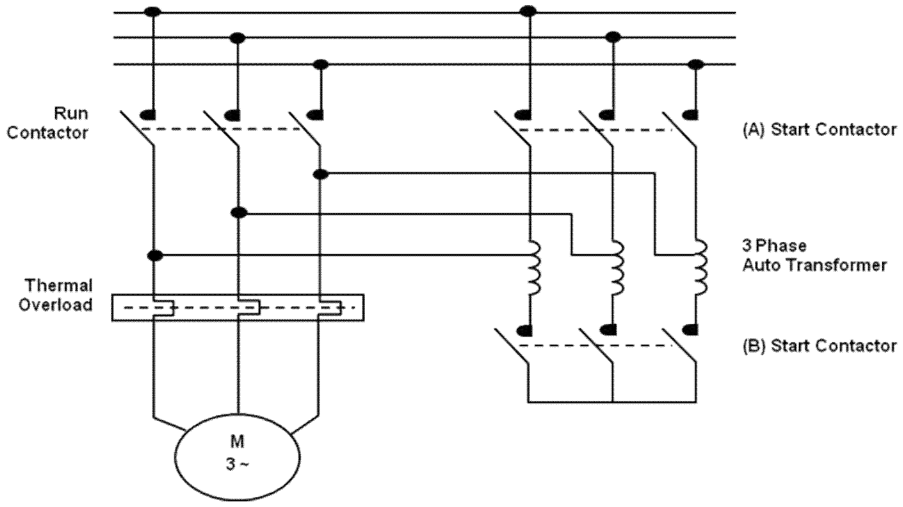
Figure 4. 20 Automatic stator starter circuit with transformer starter.

Autotransformer Starter Starting Method

This is another starting method that reduces the starting current and starting torque but contrary to Star-Delta starting where this starting method needs three wires and three terminals on the motor.

When the motor reaches the 80 to 95% of the nominal speed, the star contactor opens. Then the line contactor closes and the autotransformer contactor opens. The motor is never disconnected from the power supply during starting (closed transition) and reduces transient phenomena.

The process is run at a reduced voltage which depends on the transformation ratio.



Variable Frequency Drive

- The Variable Frequency Drive is a particular kind of adjustable-speed drive that is used to control the speed of an AC motor.
- Commonly used in a myriad of applications, a Variable Frequency Drive can be found operating ventilation systems, pumps, conveyors and machine tool drives.

Advantages of a Variable Frequency Drive

- Process temperature can be controlled without a separate controller
- Low maintenance

- Longer lifespan for the AC motor and other machinery
- Lower operating costs
  Equipment in the system that cannot handle excessive torque is protected
- energy saving
- Protection from electrical faults like short circuit in i/p or o/p circuits Etc.
- FWD/ Rev operations
- Speed control
- Smooth startup and controlling brake operations.
- controlled acceleration and deceleration which can be set by VFD parameters.
- There is no disadvantage of using VFD. Cost is the only factor.

DC Braking

The DC braking mode stops the rotating magnetic field and applies a constant DC voltage to the motor windings, helping stop the motor. Up to 250% of the motor's rated current can be applied. This is similar to removing your foot from the accelerator and applying the brakes to bring the car to a stop quickly.

The following Fig Shows DC Braking operated by time-lag relay .The time lag relay, K3, determines the duration of the DC braking action.

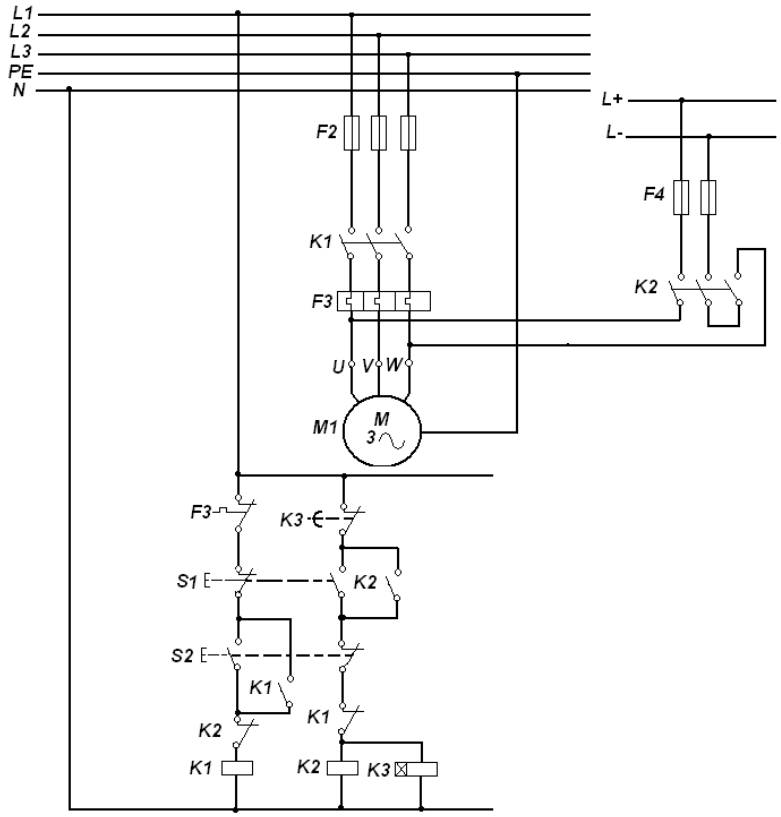


Figure 4. 21 DC Braking

Starting single phase series Motors

The construction of a single phase series motor is similar to a small DC motor. The rotor and stator are made of laminated alloyed sheet metal in order to avoid the formation of harmful eddy current. Small single phase series motors run in one direction only since their construction does not enable the use of reversing poles. The symmetrical arrangement of the series windings and the use of capacitors serve to eliminate radio interference.

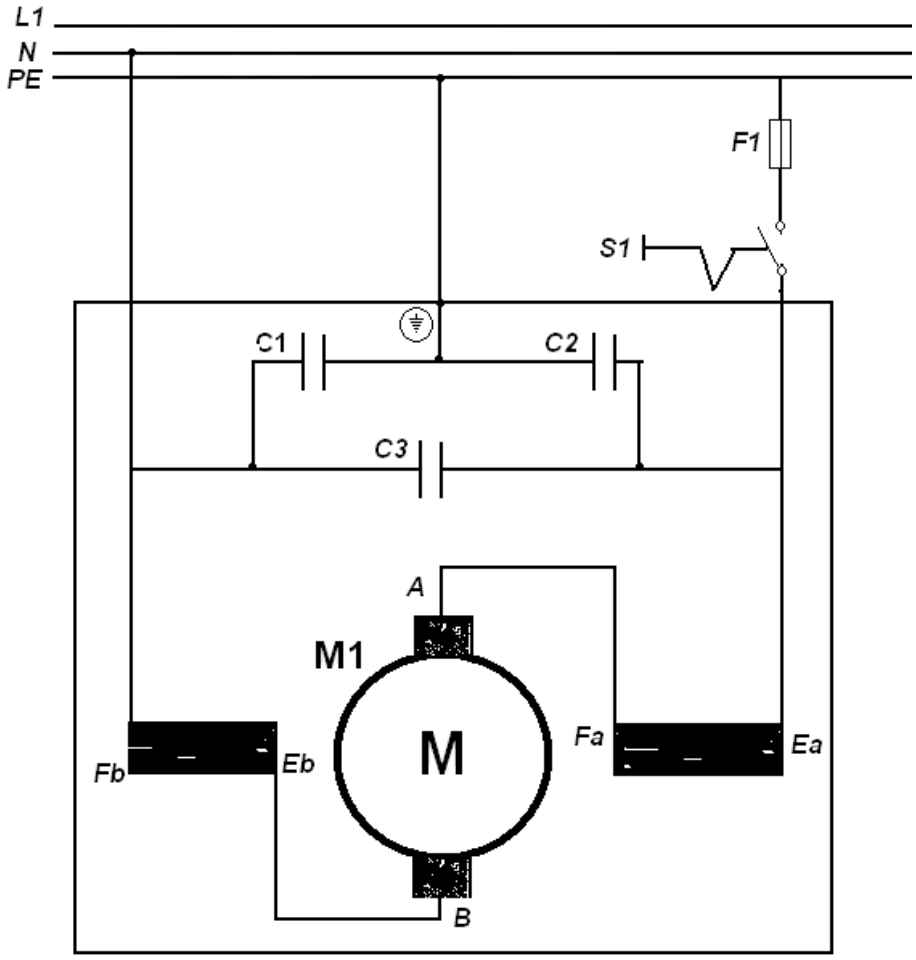


Figure 4. 22 Starting single phase series Motors

Controlling single phase series motor using Barkhausen circuit.

The Barkhausen circuit is often used for controlling the speed of single phase series motor. Resistor R1 (potentiometer) serves as a series resistance for regulating the speed as rotor shunt resistor.

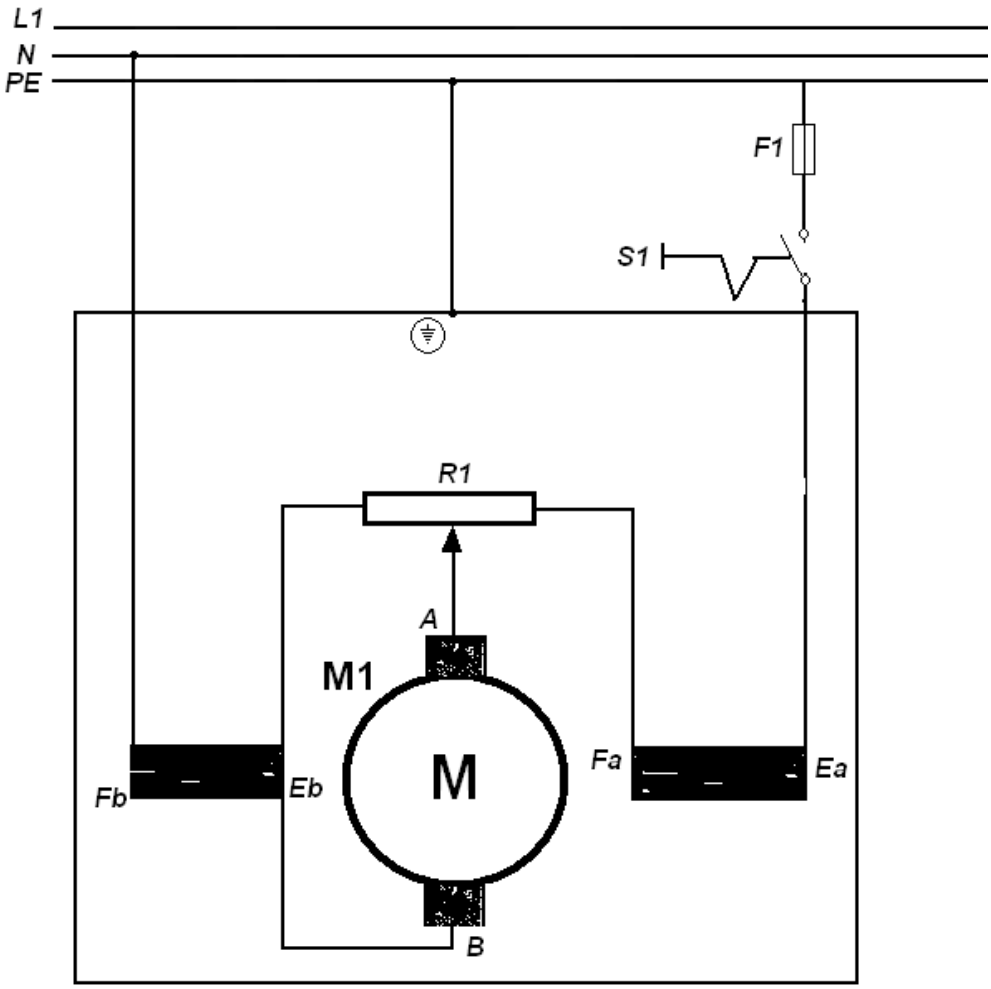


Figure 4. 23 Controlling single phase series motor using Barkhausen circuit

Wound motor starting (liquid Resistance Starter)

A slip ring motor cannot be started direct on-line with its rotor windings short-circuited; otherwise it would cause unacceptable current peaks. Resistors must therefore be inserted in the rotor circuit and then gradually short-circuited, while the stator is powered at full mains voltage. The resistance inserted in each phase is calculated to ascertain the torque-speed curve with strict accuracy. The result is that it has to be fully inserted on starting and that full speed is reached when it is completely short-circuited.

Preliminary checks**:** Check for application coding errors. Check that you sufficient resources are defined for the application,

4.2. Wiring electrical components

Electricity requires an electric path to flow and there are many conducting materials used for this purpose. There are many semi conducting materials which are used to reduce the voltage and also drop the current flow. There are non-conducting materials which are used as insulation during working on live-lines. In this unit we will study how the household or industrial wiring is done and what materials are essential for household or industrial wiring. We will also study the different types of wiring and how they is done. **For more information refer to unit three.**

4.3. Work schedule

Work schedule refers to the specific days and hours designated to an employee for paid work. It includes the details of your specific shift, including which days of the week and hours of the day you're expected to work for a company **For more information refer to unit one.**

4.4. Unplanned Event

An unexpected occurrence that is not normal behavior or anticipated condition for the process **for more information refers to M6.**

4.5. Quality of work

Quality work is the service/task one completes successfully within the estimated time, with the end output satisfying the expectations of everyone involved, including oneself. Work quality is the standard of work that an employee or team delivers consistently. Some work

quality examples include time management, communication and professional knowledge. These factors help to measure the performance of employees, departments or programs in a company

Following are some of the ways to produce quality work.

Figure 4. 24produce quality work

1. **Hold yourself to the highest standard**

Quality work starts from commitment and determination to do the job to the best of your abilities. When you hold yourself to the highest standard, you will get the motivation to compete with yourself and raise the bar. This constant quest for perfection can help you produce quality work consistently. Further, when you make yourself accountable for the quality of your work, you will gain the ability to work unsupervised without the necessity to be guided by someone constantly, which is an essential quality in the post-pandemic world.

2. **Walk the extra mile**

You can ensure the quality of the work you do as an individual. But when your work contributes only a part to a bigger task or goal that your team/organization has undertaken, you have to take up additional responsibilities, help your colleagues to do their part better and inspire the team

to produce quality work together. When you take up additional tasks and do more work than what is assigned to you, you can improve the overall quality of your team's output.

3. **Recognize mistakes and take corrective action**

Quality of work is ensured when you constantly put your work under rigorous scrutiny. Analyzing your own work, identifying mistakes and correcting them at the early stage are important to producing quality work. In contrast, if mistakes remain undetected or swept under the carpet, then they will come back to you and massively impact your productivity.

4. **Work with your team**

Team work ensures quality. You cannot meet the organizational goals and targets single-handedly; for that, you need your team. Moreover, at times, you may need some expertise outside your skillset to complete a task; you may need a helping hand to complete a complicated task; or you may even be packed with too much workload that you may need to delegate some of your own work to someone else in order to meet the deadline. So, it is extremely important to develop cohesiveness with your team and motivate them to constantly meet your quality standards. This will help you do quality work and increase productivity.

5. Stay focused and follows your schedule

You can produce quality work when you stay focused on your work, avoiding distractions and digressions. If you lose focus, then there are more chances of making mistakes. So, you have to focus on the work in hand and stick to your plan and schedule. When you delay your work and do not stick to your plan of the day, you may miss your deadlines. This will reduce the amount of time you have to do your work. When you do not have enough time, the quality of work takes a hit. So, it is crucial to plan the day, make a schedule, stay focused and meet all the deadlines, if you strive to do quality work.

Completing Quality Work with Profit.co

The Profit.co task management module offers teams the organization and collaborative space they need to keep doing quality work. Departments and teams can collaborate in designated Workspaces and create customizable Boards for individual functions or projects.

Leave all the necessary details for an initiative right on the task itself, including the deadline, priority-level, assignee, and direct links to documents or uploads from Google Drive. Individuals can leave comments directly on the task, so all necessary communication can stay where the work is, and managers can ensure that important tasks are moving forward with the highest quality possible.

Self-Check 4

Test I: test

Direction: Write on the blank space/List down the following

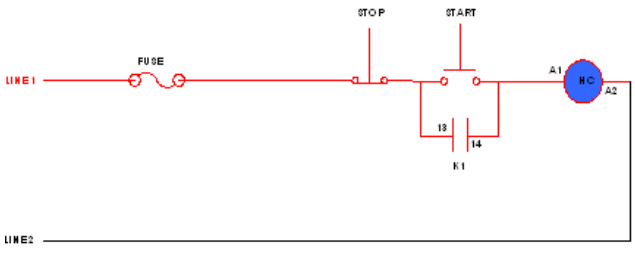
1. ---------is the most important purpose of an electrical worker.
2. ----------is operated manually.
3. ----------which prevents automatic restarting of equipment after a power failure,

Test II: say "**True**" if the statements given are correct and "**False**" if the statements are wrong.

1. To avoid electrical hazards, the floor and work place has to be insulated..
2. It is not strictly forbidden to work with any electrical part while it is live.
3. Disconnecting switches used to isolate the machinery from power source.
4. Circuit breaker trips automatically when the current exceeds predetermined limits.

Test III: Answer the following questions accordingly

1. Define automatically reversing the direction rotation of machinery. 2. Write at least four components used in control systems and explain the basic operation. 3. What happens if the Motor is connected to Delta connection at starting? 4. What happens if the motor is always connected to the Star Connection? 6. What is the Difference between Star Delta Starter and DOL Starter? 6. Explain briefly autotransformer starting method thee phase motor 8. Write the advantages of star-delta starting of three phase induction motor. Answer the question based on your schematic diagrams give below.

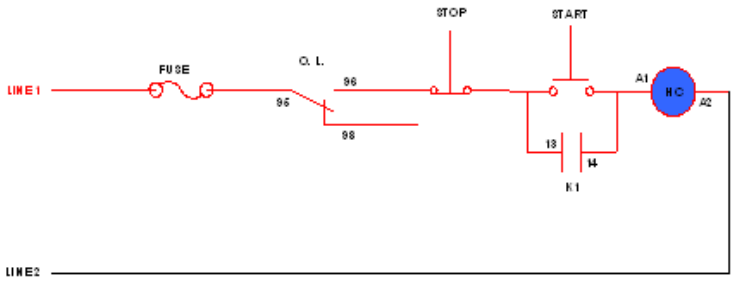


a) What happen to the Auxiliary and Main Contact when holding coil is energized? What happen to the Holding coil when the stop push button is pressed? What happen to the Holding coil when you pressed the start push button switch?

b) What happen to the Holding coil when you released the start push button switch?

c) What happen to the Holding coil when you pressed the start push button switch?

d) What happen to the Holding coil when you released the start push button switch?



a) What happen to the Holding coil when you manually tripped the Thermal Overload Relay when the Holding coil is energized?

b) Can you start/energized the Holding coil when the Thermal Overload Relay is tripped? Why?

c) What will you do in order to make the circuit functional

Operation sheet 4.1 Install electrical motor controller system

Operation Title: D.O.L. Starter

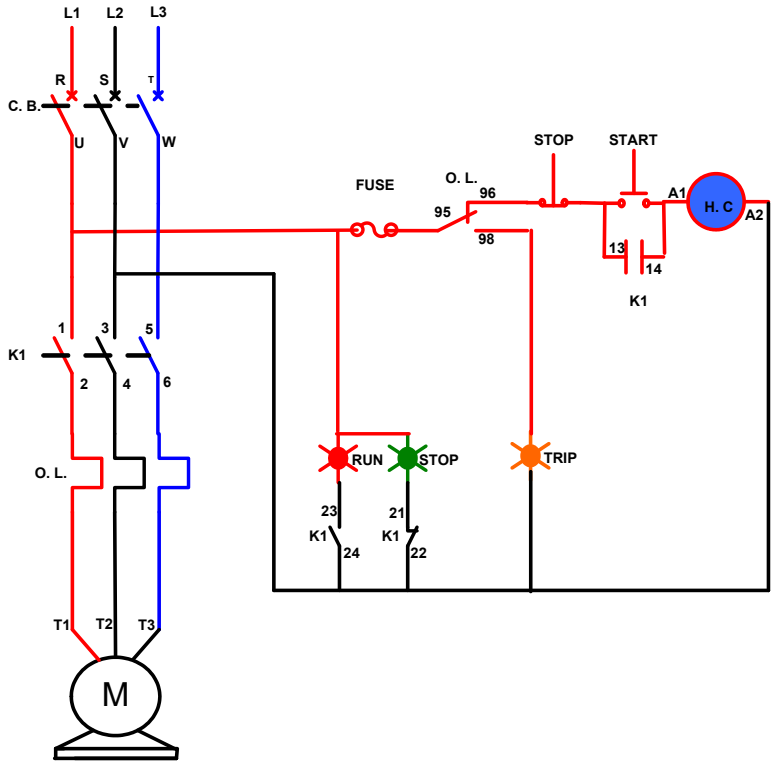
Purpose: - A three-phase induction motor- is to be-started and stopped direct-on line with the help of two push buttons. Provide overload and short circuit protection to the motor and draw the control circuit and complete wiring diagram.

Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components.

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter.

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.2: Install electrical motor controller system

Operation Title: - Motor controlled from two locations

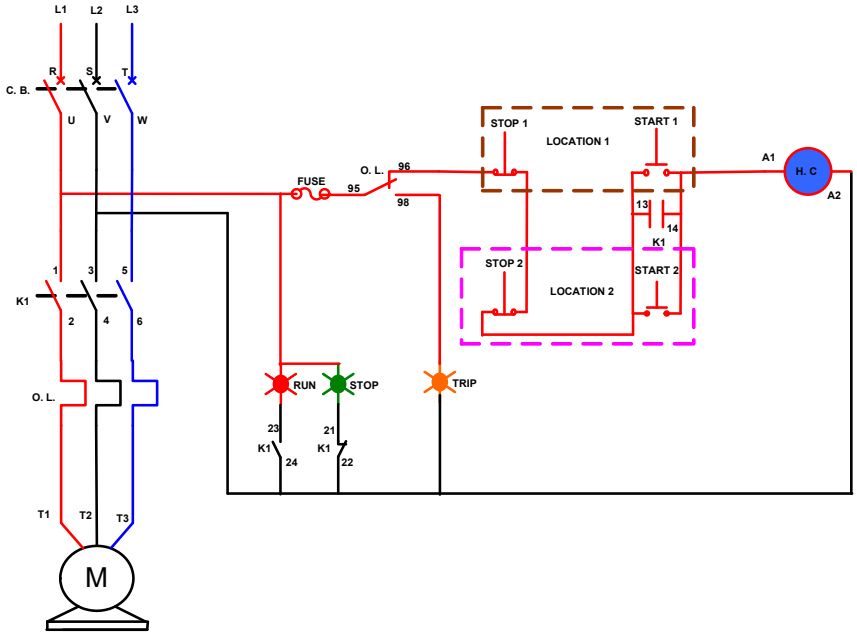
Purpose: - A three-phase induction motor is to be started and stopped direct on line (D.O.L.) from two different locations through push buttons such that the motor can be started from one location and stopped from the other or vice versa.

instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components.

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps, Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter, 3ϕmotors

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.3 Install electrical motor controller system

Operation Title: Forward Reverse Controller electrical interlock

Purpose: - Upon completion of this unit, trainee should be able to discuss the operation of Forward Reverse Controller.

.

Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components To reverse a three phase motor with a magnetic starter, two sets of main line Contactors are used with suitable controls.

Tools: Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps ,Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter .

Steps in doing the task: -

1. Select the required motor starter components on the circuit trainer, such as push-button stations, magnetic contactors, etc.
2. Connects the components which corresponds to the diagram shown on figure By interconnecting the terminals of the motor starter components with connecting cords. When you have completed the connections of the circuit, check the circuit with

   VOM and use it as an Ohmmeter.

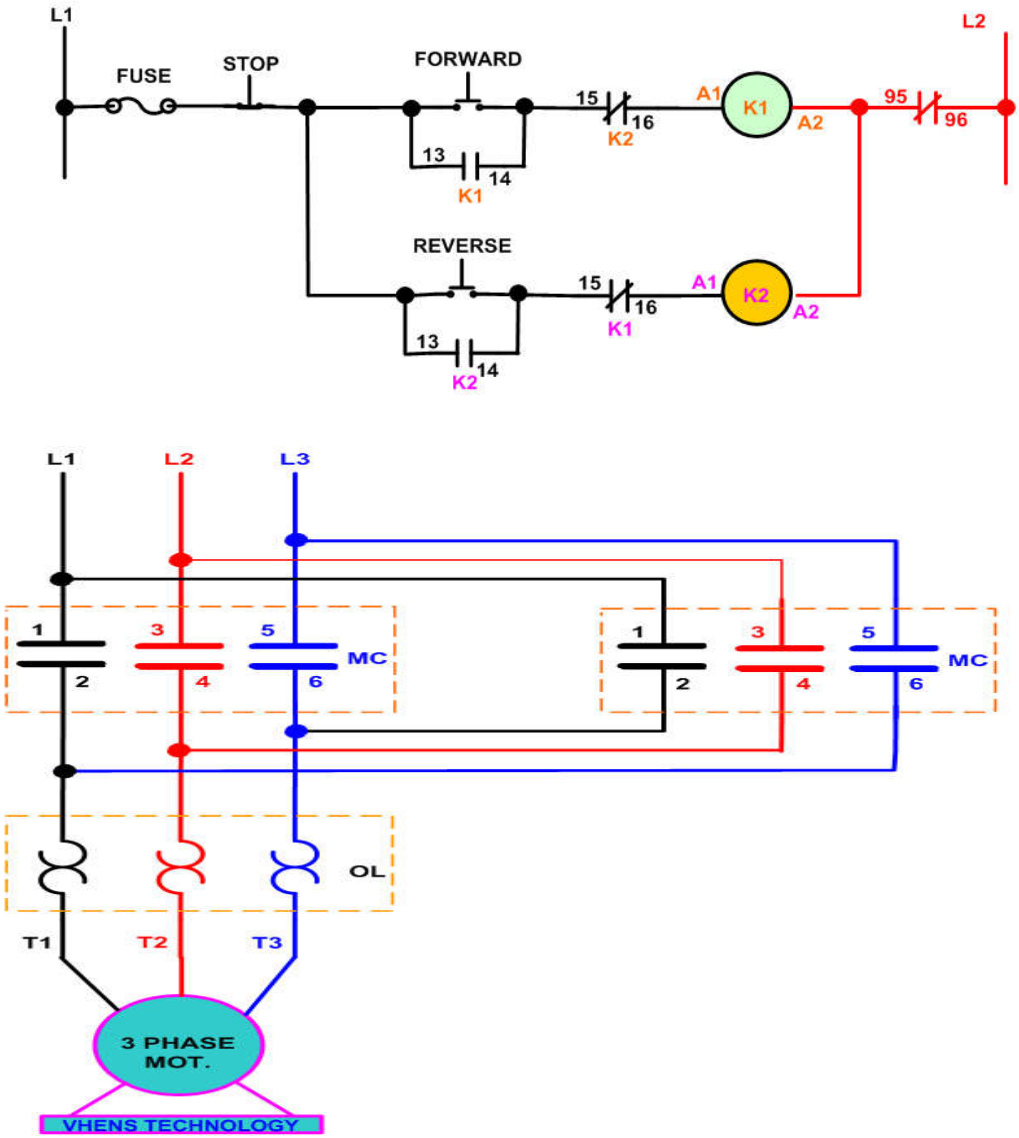
   Note: If the meter deflects to zero, then the circuit is shorted.

   Remedy – examine the circuit connections.
3. If the pointer doesn't deflect and remains at infinity position, it is an indication of open circuit.

Remedy – examine the circuit connections for broken wires or poor connections.

If the meter registers a resistance that is equal to the resistance of the coil of the contactor, the circuit is GOOD. (Approximately 200-500 ohms)

4. After checking with VOM, connect the circuit to the electrical supply of the circuit trainer and tests its operation..
5. Do commissioning of an electrical motor circuit.
6. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions:

1. Turn off the power and disconnect the cord before making any adjustment on the circuits.
2. Each time you make a measurement, be sure to check ranges. Measurement with erroneous range setting or beyond the measuring range is hazardous.
3. Do not start the motor without circuit breaker
4. Do not start the motor without permission of instructor.
   . If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily".
5. Never test a cutting edge with your fingers, test on a scrap material instead.
6. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.
7. Be sure your hands are dry when you are working with electricity. You may get electrical shock.
9. During set-up and testing of the devices, observe all necessary safety regulations, the laboratory regulations and the necessary protective measures!
10. Only wire the laboratory test when deenergized!
11. Only use safety test leads!
12. Observe rotating motor shafts

Operation sheet 4.4 Install electrical motor controller system

Operation Title: - Instant reversal of magnetic starter Combination of Electrically Interlocked and Mechanical interlocked Reversing Starter

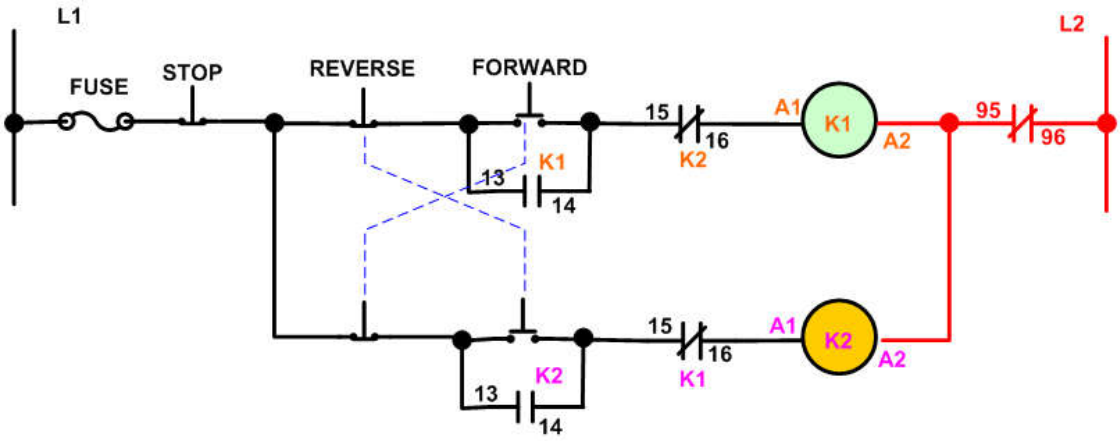
Purpose: - A momentary contact push-button station that permits immediate reversal of direction without first pushing the stop button is shown in figure

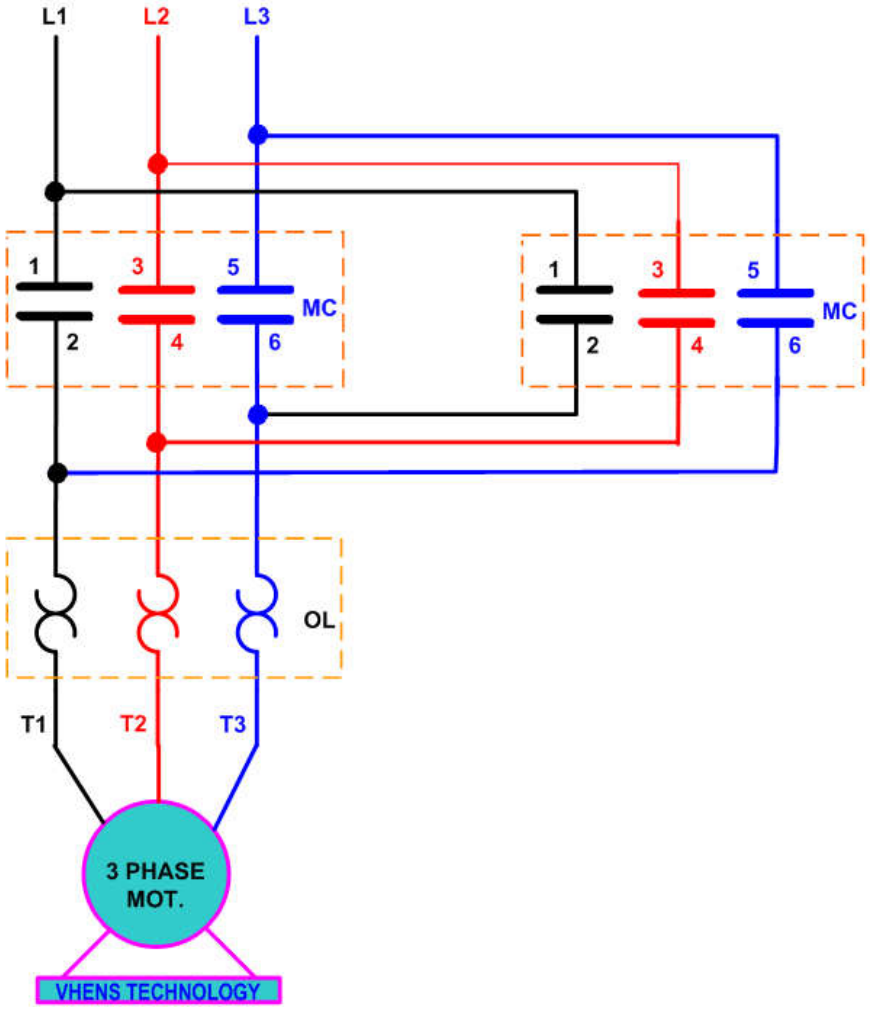
Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps, Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter, 3ϕmotors

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.


L1
FUSE
STOP
REVERSE
FORWARD
15
16
K2
A1
K1
A2
95
96
L2
13
K1
14
15
16
K1
A1
K2
A2
13
K2
14


L1
L2
L3
1
3
5
MC
2
4
6
1
3
5
MC
2
4
6
OL
T1
T2
T3
3 PHASE
MOT.
VHENS TECHNOLOGY

Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4. 5 Install electrical motor controller system

Operation Title: - Forward and Reversing Full Voltage Across the Line (FVAL) motor starter with pushbutton and auxiliary contact interlocking,, and complete indicating lights

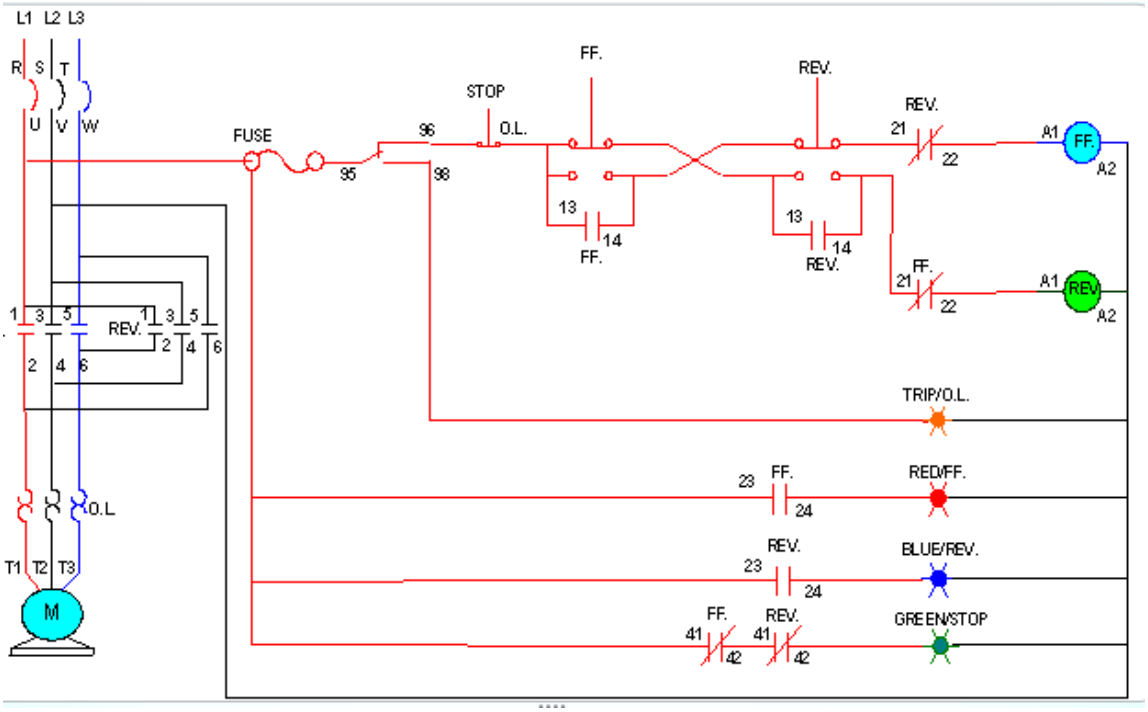
Purpose: - The motor should have forward rotation and should reverse its direction for next manually.

Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components.

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter.

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.6 Install electrical motor controller system

Operation Title: Timer Controlled Automatic Forward and reverse Full Voltage Across the Line (FVAL) motor operation

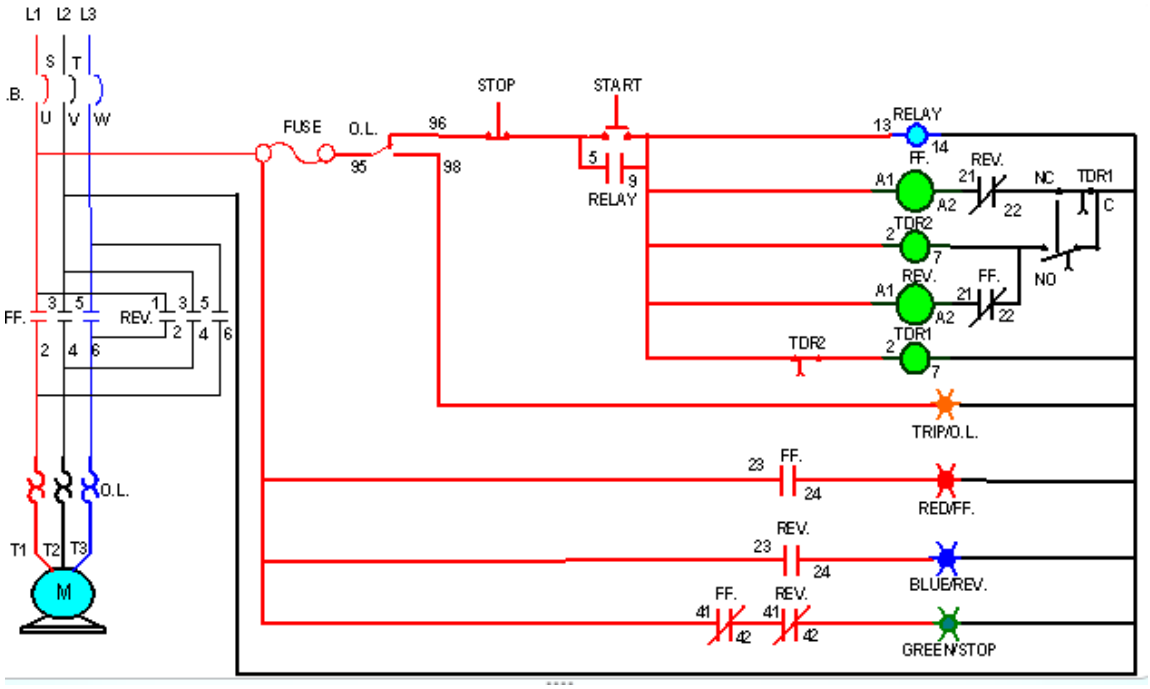
Purpose: - motor should have stay five minutes forward rotation and should automatically reverse its direction for next five minutes. Again the motor should change over to forward direction after five minutes. The process of forward and reverse rotation should continue till the motor is switched off.

Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components.

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps, Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter, 3ϕmotors

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4. 7 Install electrical motor controller system

Operation Title: - Start Forward-Reverse-Forward-Reverse and so on Automatically Using Timers

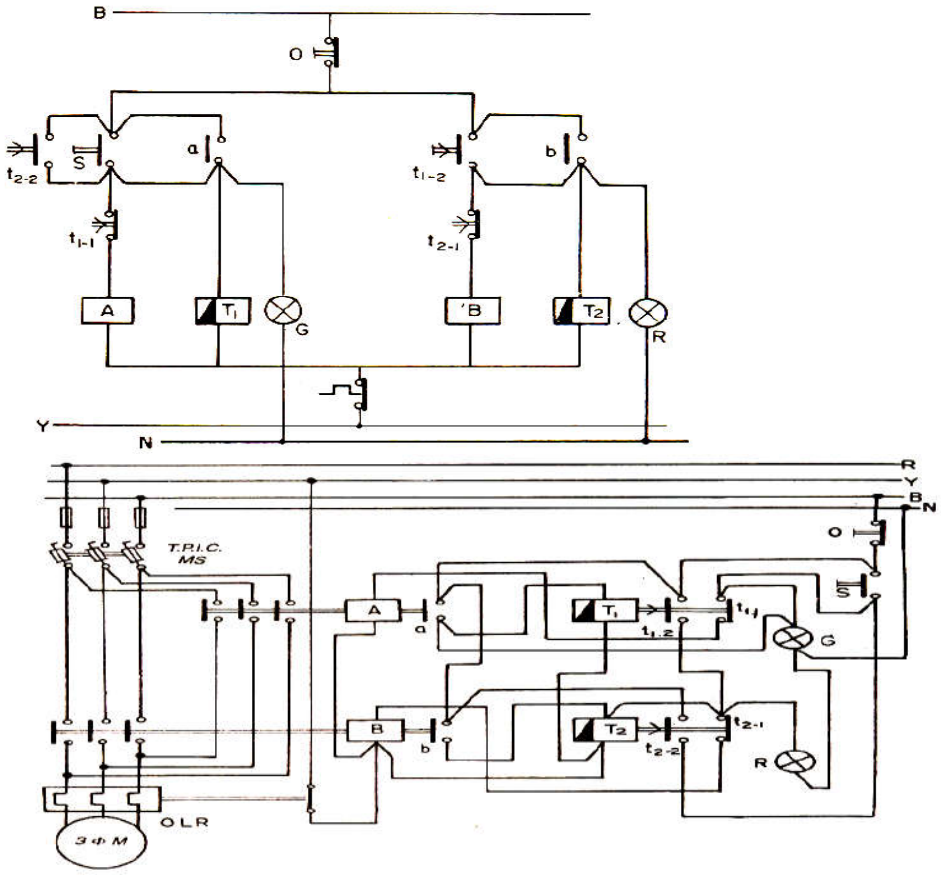
Purpose: - motor should have stay two minutes forward rotation and should automatically reverse its direction for next five minutes. Again the motor should change over to forward direction after two minutes. The process of forward and reverse rotation should continue till the motor is switched off.

Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps, Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter, 3ϕmotors

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.8 Install electrical motor controller system

Operation Title: - Sequence Starting of Two Motors Manually

Purpose: - Two motors are to be started in sequence. When first motor is started, then only the second motor can be started. The second motor can be started only when first motor is running. The second motor can be stopped but when first motor is stopped, both the motors should stop.

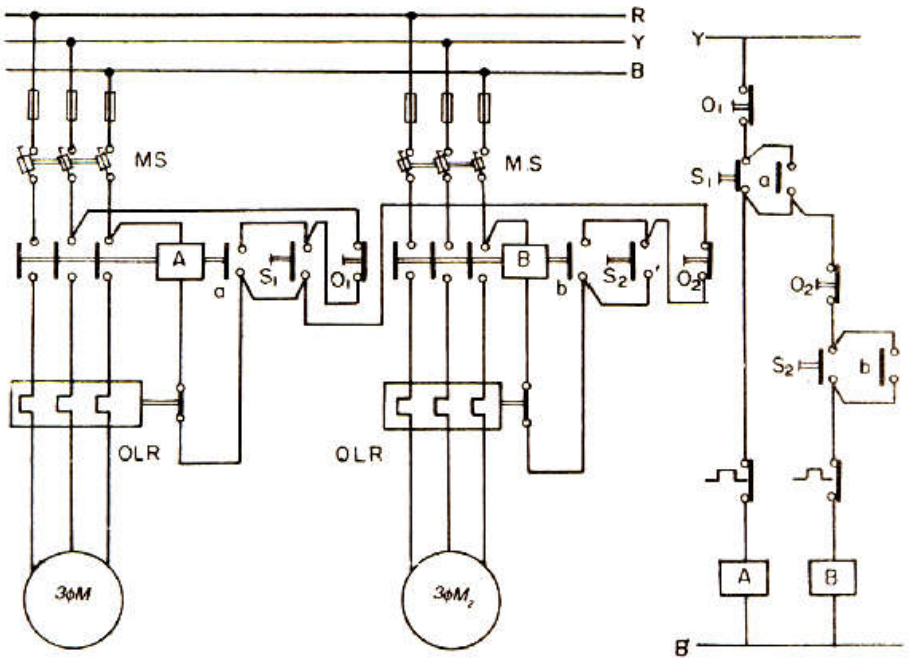
Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components.

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter.

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.

10 Connect both power and control circuit as shown in the



Quality criteria:-

1 Reading the circuit properly.
2 Safety procedures were followed
3 All hand tools were cleaned
4 the motor operate correctly
5 neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.9 Install electrical motor controller system

Operation Title: - Sequence Starting of Two Motors automatically with time delay

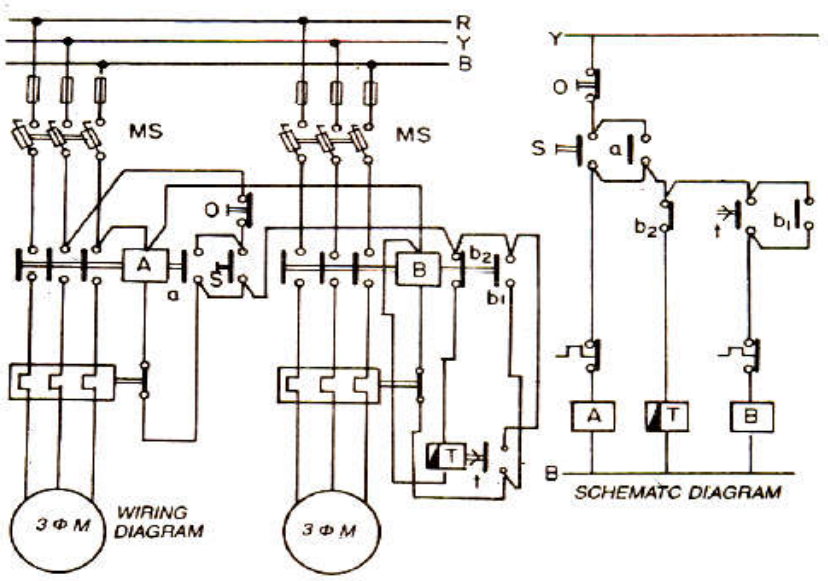
Purpose: - Two 3 phase induction motors are to be started in sequence (i.e. 'one after the other) direct on line automatically by pressing single push button. When starts push button is pressed, motor No.1. Should start and after a pre-set time, motor No.2 should automatically start. When OFF push button is pressed, both the motors should stop simultaneously. There is no separate start or OFF pushbutton for second motor and as such, it cannot be started unless motor No.1 is first started

Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components.

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps, Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter, 3ϕmotors

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

6. Reading the circuit properly.
7. Safety procedures were followed
8. All hand tools were cleaned
9. the motor operate correctly
10. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.10 Install electrical motor controller system

Operation Title: - Automatic Star – Delta Starter with contactors

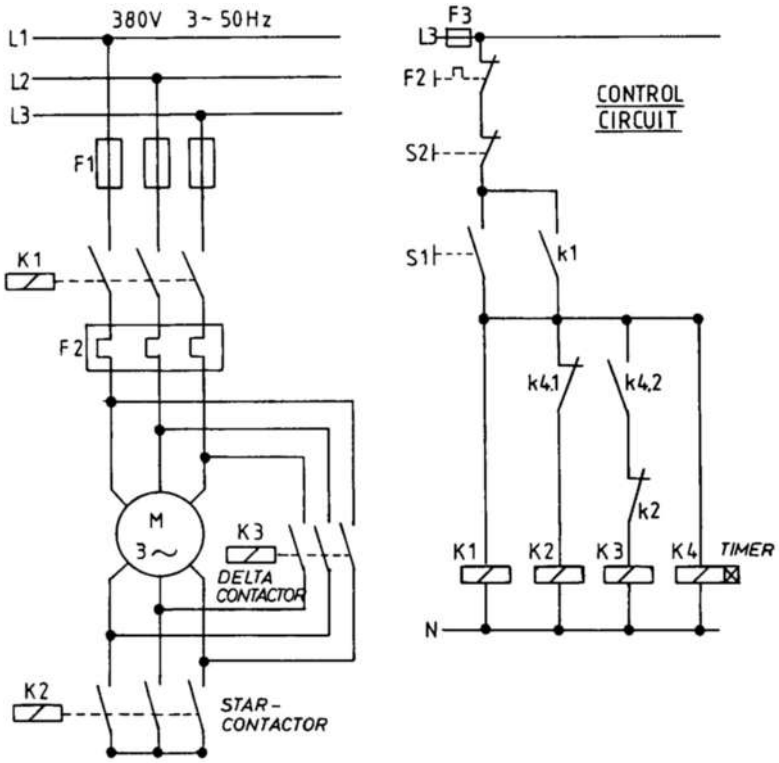
Purpose: - To start three phase induction motor safely by decreasing the starting current of the motor. In Star – Delta Starter the line voltage is reduced to 220v from 380v. This means 58% of the line voltage is reduced there by reducing the starting current. After it is changed to delta, the motor takes full voltage i.e 380v.

Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components.

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps, Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter, 3ϕmotors

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.11 Install electrical motor controller system

Operation Title: - manual Star – Delta Starter with contactors

Purpose: - The Star-Delta-Starter supplies at the starting moment the motor with 220V. After the motor has been speeded up, the voltage supply is set to 380 V. the motor starts with 1/3 of the final running power

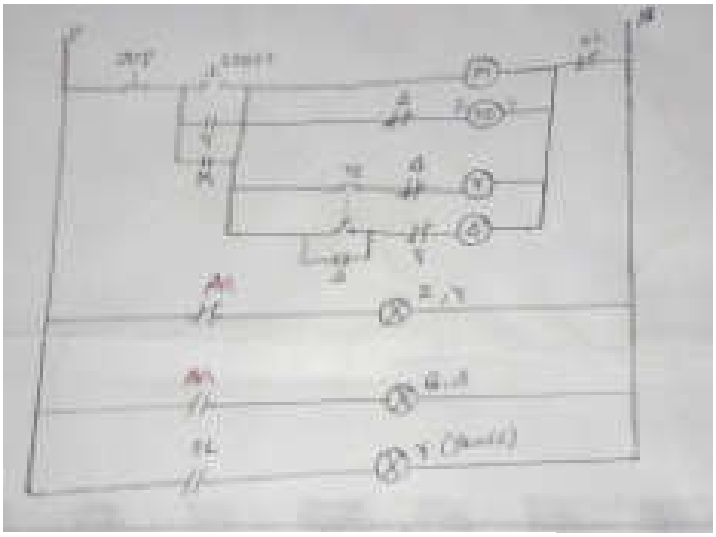
Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components

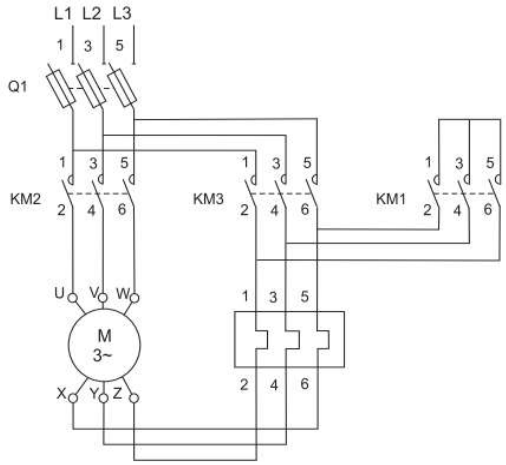
Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps ,Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter

.

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.





Quality criteria:-

1 Reading the circuit properly.
2 Safety procedures were followed
3 All hand tools were cleaned
4 the motor operate correctly
5 neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools

"temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.12 Install electrical motor controller system

Operation Title: - Resistor aided Reduced voltage motor starter, (Momentarily on Timer) with indicating lights

Purpose: reduced-voltage, magnetic, primary-resistance starter. This magnetic primary resistor consists of a three-pole start contactor, a three-pole run contactor, a pneumatic timing relay, a single-step primary resistor, and two or three bimetallic overload relays.

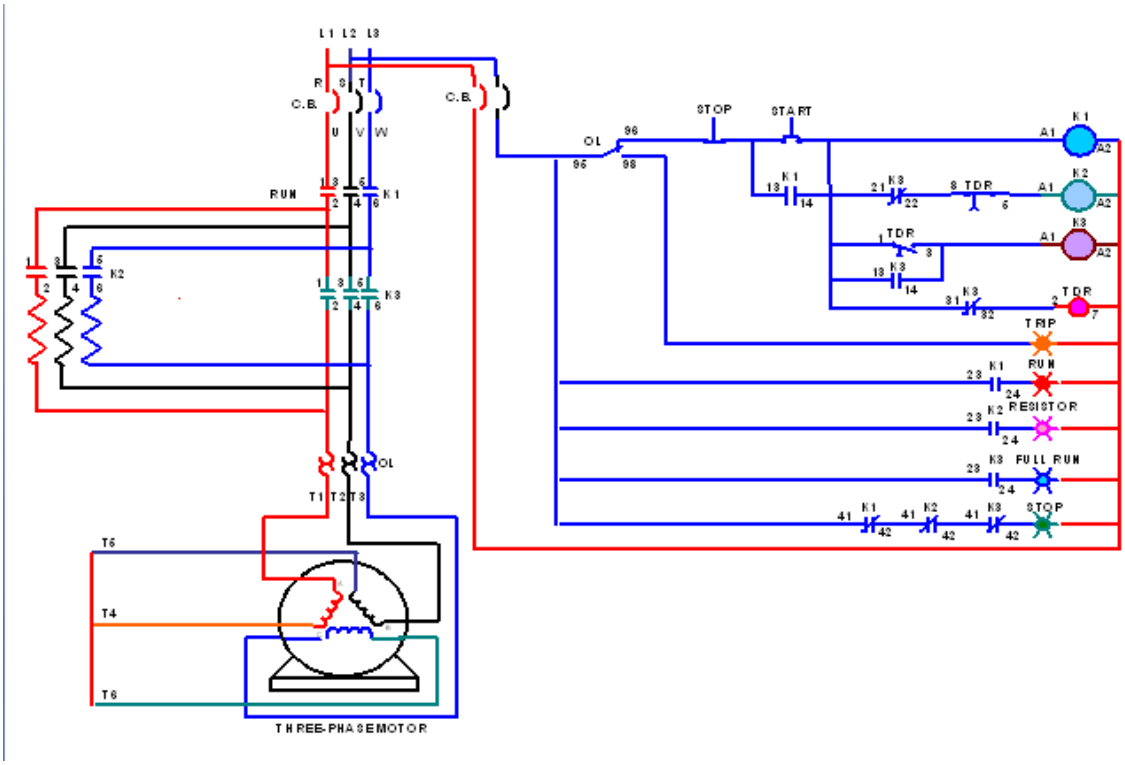
Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps ,Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter

.

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.13 Install electrical motor controller system

Operation Title: - Secondary Resistance close Transition, Reduced voltage motor starter, (Momentarily on Timer) with indicating lights

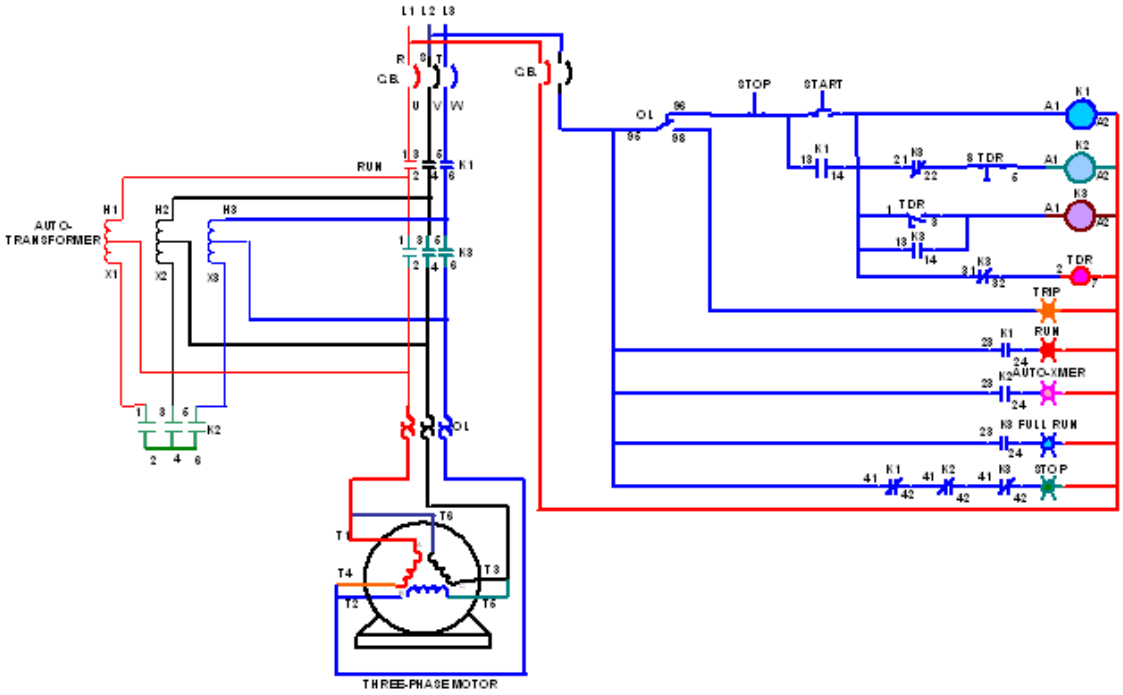
Purpose: - reduced-voltage, magnetic, secondary resistance starter. This magnetic primary resistor consists of a three-pole start contactor, a three-pole run contactor, a pneumatic timing relay, a single-step primary resistor, and two or three bimetallic overload relays.

Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps, Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter, 3ϕmotors

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.14: Install electrical motor controller system

Operation Title: - Auto-Transformer Reduced voltage (Delta) motor starter, (Momentarily on Timer) with indicating lights

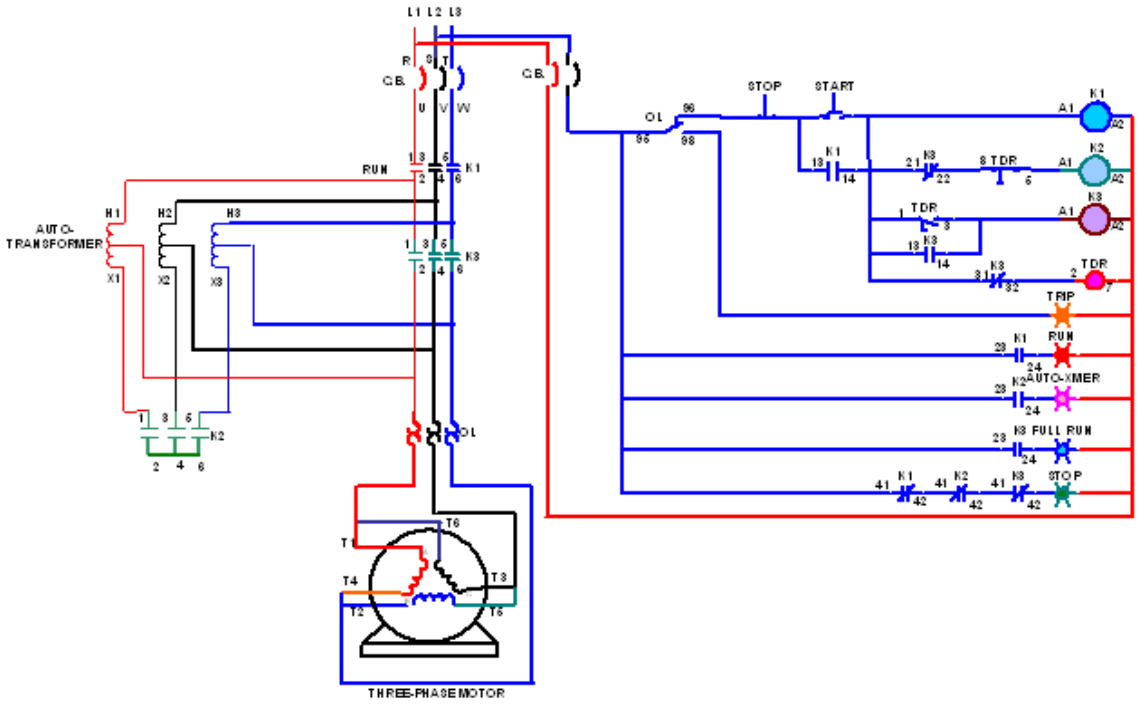
Purpose: - an autotransformer is used to reduce the starting voltage of the induction motor. The tapings of the autotransformer is so set that when it is in the circuit, 60 to 80 % of the line voltage is applied to motor during starting and then connecting it to the full-line voltage as the motor attains a sufficient speed.

Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps, Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter, 3ϕmotors

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.15 Install electrical motor controller system

Operation Title: Dynamic Breaking Full Voltage Across the Line (FVAL) motor starter with indicating lights

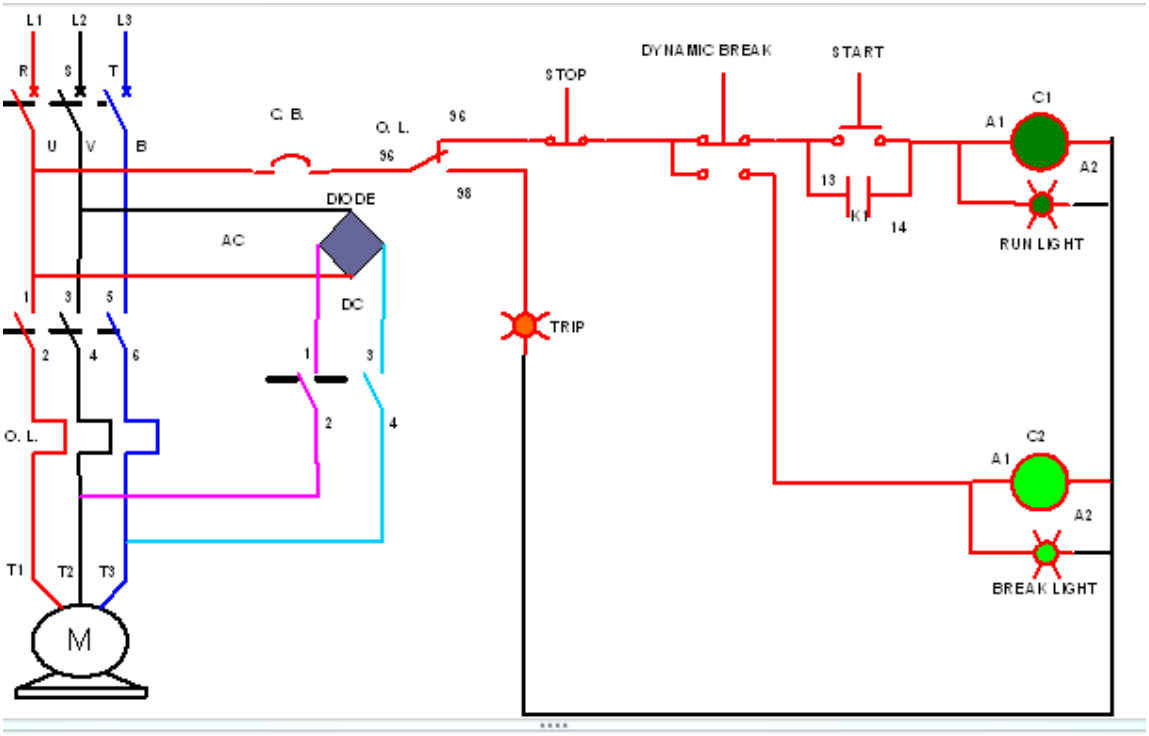
Purpose: - A system of braking (as in electric trains or machinery) in which the driving motor is converted into a generator and is driven by the kinetic energy of the vehicle thus exerting a retarding force.

Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps, Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter, 3ϕmotors

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.16 Install electrical motor controller system

Operation Title:16 Dahlander pole changing two speed circuit

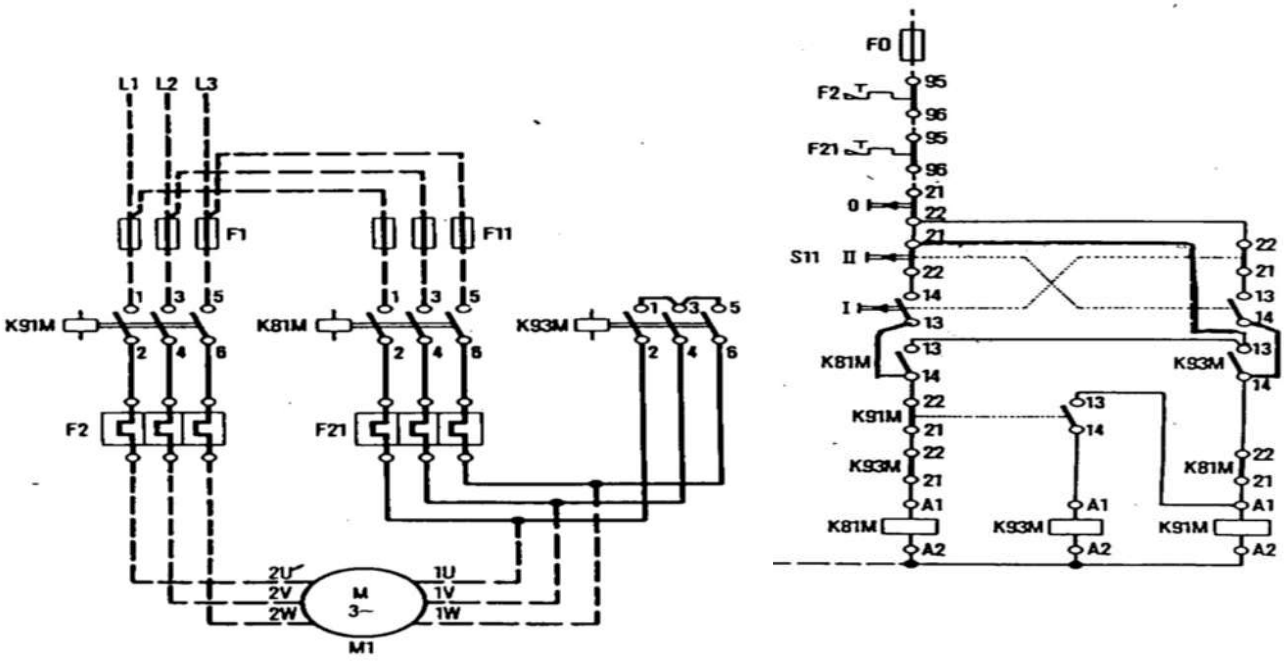
Purpose: - To understand how three phase induction motor is starting using different/variable speed.

Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps, Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter, 3ϕmotors

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Operation sheet 4.17 Install electrical motor controller system

Operation Title: Reversible Wye-Delta motor starter, (Momentarily on Timer) with indicating lights

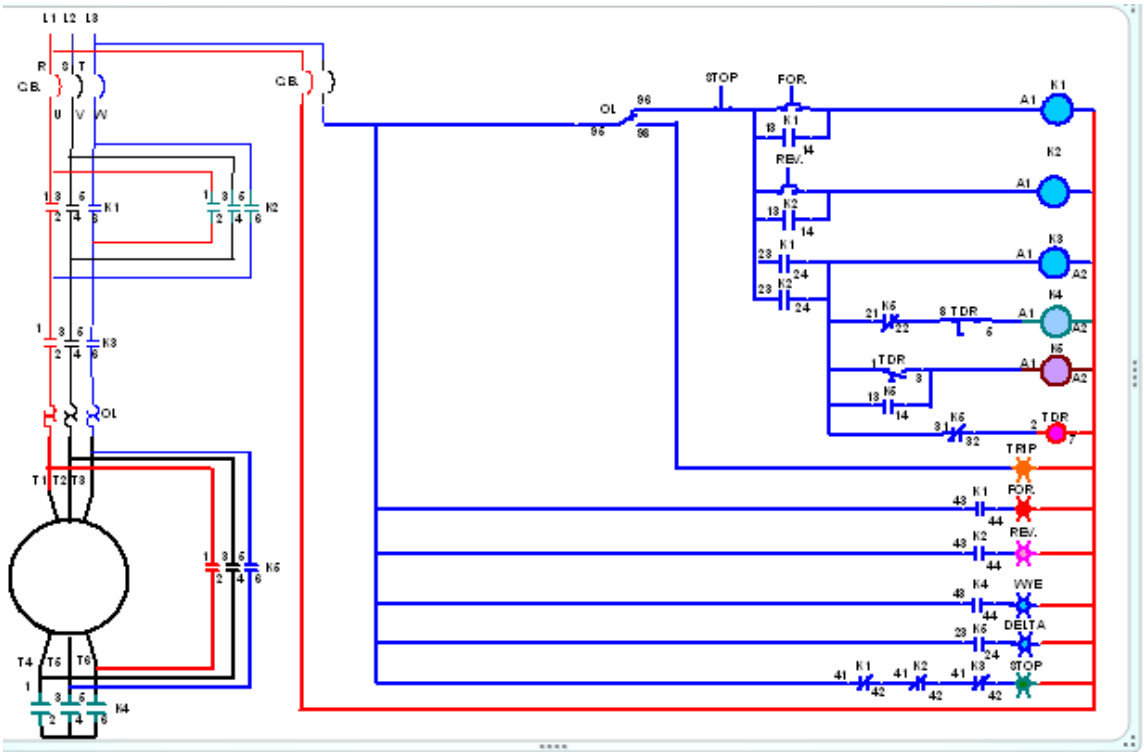
Purpose: - Star delta starter is used to reduce the current flow at the starting of the three-phase induction motor to avoid sparking, overheating, coil burning, etc. In the star connection, the supply voltage is lower than the delta connection

Instruction: Using the figure below construct control circuit and power circuit by interconnecting motor starter components

Tools: - Circuit breakers or Fuses, Magnetic Contactors, Relays, Power Cabinet, Pilot lamps, Push buttons, Insulators, Cable duct, Din rail, Wire strap, Conductors, Disconnecting switches, pliers, screw drivers, multi meter, 3ϕmotors

Steps in doing the task: -

1. Read the given drawing
2. Prepare cables/ wires and mounting rail according to the given figure.
3. Install cables, wires, mounting rail and push button holder (if any) on the installation board according to the installation drawing.
4. Fix or mount contactor, over load relay, circuit breakers, and push buttons and block terminals according to drawing.
5. Perform the wiring of the circuit according to drawing.
6. Connect the power supply cables.
7. Test the correct function of the circuit by operating it with push button.
8. Test the out put on the motor terminals by use of multimeter.
9. Do commissioning of an electrical motor circuit.
10. Connect both power and control circuit as shown in the figure.



Quality criteria:-

1. Reading the circuit properly.
2. Safety procedures were followed
3. All hand tools were cleaned
4. the motor operate correctly
5. neatness/good looking

Precautions: - Do not start the motor without circuit breaker. Do not start the motor without permission of instructor. If a tool is defective, remove it from service, and tag it clearly "Out of service for repair". Replace damaged tools immediately and do not use defective tools "temporarily". Never test a cutting edge with your fingers, test on a scrap material instead. Never use any tool, hand or power tool unless you are trained to do so and are familiar with its use Keep cutting edges sharp.

Lap Test-4

Name: _____ Date: _____

Time started: _____Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 8 hour.

Task -1: Installing manual control switch D.O.L. Starti*n*g method of thee phase induction motor

Task -2: Installing Motor controlled from two locations

Task -3: Set up the circuit completely, test the function and describe the function of the forward Reverse Controller electrical interlock

Task -4: Installing Instant reversal of magnetic starter Combination of Electrically Interlocked and Mechanical interlocked Reversing Starter

Task -5: Installing Forward and Reversing Full Voltage Across the Line (FVAL) motor starter with pushbutton

Task -6: Installing Timer Controlled Automatic Forward and reverse Full Voltage Across the Line (FVAL) motor operation

Task-: 7 Installing Instating Start Forward-Reverse-Forward-Reverse and so on Automatically Using Timers

Task -8: Installing Sequence Starting of Two Motors Manually

Task -9: Installing Sequence Starting of Two Motors automatically with time delay

Task-10: Installing Automatic Star – Delta Starter with contactors

Task -11: Installing manual Star – Delta Starter with contactors

Task -12: Installing Resistor aided reduced voltage motor starter, (Momentarily on Timer) with indicating lights

Task -13: Installing Secondary Resistance close Transition, Reduced voltage motor starter, (Momentarily on Timer) with indicating lights

Task -14: Installing Auto-Transformer Reduced voltage (Delta) motor starter, (Momentarily on Timer) with indicating lights

Task -15: Installing Dynamic Breaking Full Voltage across the Line (FVAL) motor starter with indicating lights

Task -16: Installing Dahlander pole changing two speed circuit

Task-17: Installing Reversible Wye-Delta motor starter, (Momentarily on Timer) with indicating lights

Unit Five: completion of work and Clean-up

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

- Completion of work
- Performance tests
- Work area and disposing materials

Materials storage

- Test installed electrical machines and drives
- Surplus materials to warehouse

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

- Notify completion of work to immediate superior
- Make Performance tests
- Clear work area and disposing materials
- Checking, maintaining Materials storage
- Testing installed electrical machines and drives
- Return Surplus materials to warehouse

5.1. Notify completion of work

Works completion means completion of the entire contracted work. Exhaustion of quantity of any particular item mentioned in the bid document shall not imply completion of work or any component here. Written notice issued by the owner of a project (or his or her agent) to notify concerned parties that all work on the project has been completed. This notice also sets the period within which concerned parties may exercise their lien rights against one another. Or notice of completion.

A document recorded by a property owner to notify potential Mechanics Lien claimants that a specific construction project has been completed. The effect of a properly recorded Notice of Completion is to reduce the time in which a subcontractor, material supplier or general contractor can record a Mechanics Lien against a private works construction project. .

Final completion

At the end of the defects liability period, or when the contractor believes the defects liability period has come to an end, he must submit a notice to the principal agent who is obliged to inspect the works within the period specified in order to determine whether any defects are present. Should any defects be identified, the principal agent is obliged to provide the contractor with a defects list, which have arisen during the defects liability period and which the contractor must rectify in order to achieve final completion of the works.

Practical completion, works completion and final completion deal exclusively with the construction period. Once the contractor has achieved final completion he still retains certain obligations in relation to the latent defects liability period. The latent defects liability period commences when construction begins and ends 5 years after the date when final completion was achieved.

Documenting Work Completed

Documentation is an important part of almost every workplace. Good documentation can do the following:

- Provide information for customers
- Provide information for upcoming shifts / other employees
- Avoid duplication of work
- Satisfy regulator bodies (warranties, state agencies etc.)
- Satisfy employers

A person who documents their work appropriately appears professional to customers, coworkers, and employers. Good documentation shows that you have done good work

5.2. Performance tests

Performance testing, a non-functional testing technique performed to determine the system parameters in terms of responsiveness and stability under various workload. Performance testing measures the quality attributes of the system, such as scalability, reliability and resource usage Performance Testing **is** a software testing process used for testing the speed, response time, stability, reliability, scalability and resource usage of a software application under particular workload. The main purpose of performance testing is to identify and eliminate the performance bottlenecks in the software application. It is a subset of performance engineering and also known as "Perf Testing".

The focus of Performance Testing is checking a software program's

- Speed – Determines whether the application responds quickly
- Scalability – Determines maximum user load the software application can handle.
- Stability – Determines if the application is stable under varying loads

Types of Performance Testing

- **Load testing –** checks the application's ability to perform under anticipated user loads. The objective is to identify performance bottlenecks before the software application goes live.
- **Stress testing –** involves testing an application under extreme workloads to see how it handles high traffic or data processing. The objective is to identify the breaking point of an application.

- **Endurance testing –** is done to make sure the software can handle the expected load over a long period of time.
- **Spike testing –** tests the software's reaction to sudden large spikes in the load generated by users.
- **Volume testing** – Under Volume Testing large no. of. Data is populated in a database and the overall software system's behavior is monitored. The objective is to check software application's performance under varying database volumes.
- **Scalability testing** – The objective of scalability testing is to determine the software application's effectiveness in "scaling up" to support an increase in user load. It helps plan capacity addition to your software system.

Common Performance Problems

Most performance problems revolve around speed, response time, load time and poor scalability. Speed is often one of the most important attributes of an application. A slow running application will lose potential users. Performance testing is done to make sure an app runs fast enough to keep a user's attention and interest. Take a look at the following list of common performance problems and notice how speed is a common factor in many of them:

- **Long Load time –** Load time is normally the initial time it takes an application to start. This should generally be kept to a minimum. While some applications are impossible to make load in under a minute, Load time should be kept under a few seconds if possible.
- **Poor response time –** Response time is the time it takes from when a user inputs data into the application until the application outputs a response to that input. Generally, this should be very quick. Again if a user has to wait too long, they lose interest.
- **Poor scalability –** A software product suffers from poor scalability when it cannot handle the expected number of users or when it does not accommodate a wide enough range of users. Load Testing should be done to be certain the application can handle the anticipated number of users.
- **Bottlenecking –** Bottlenecks are obstructions in a system which degrade overall system performance. Bottlenecking is when either coding errors or hardware issues cause a decrease of throughput under certain loads. Bottlenecking is often caused by one faulty

section of code. The key to fixing a bottlenecking issue is to find the section of code that is causing the slowdown and try to fix it there. Bottlenecking is generally fixed by either fixing poor running processes or adding additional Hardware.

Performance Testing Process

The methodology adopted for performance testing can vary widely but the objective for performance tests remain the same. It can help demonstrate that your software system meets certain pre-defined performance criteria. Or it can help compare the performance of two software systems. It can also help identify parts of your software system which degrade its performance.

Below is a generic process on how to perform performance testing

5.3. Work area and disposing materials

Waste disposal, the collection, processing, and recycling or deposition of the waste materials of human society.

Waste is classified by source and composition. Broadly speaking, waste materials are either liquid or solid in form, and their components may be either hazardous or inert in their effects on health and the environment. The term ***waste*** is typically applied to solid waste, ewage (wastewater), hazardous waste, and electronic waste.

Electronic waste or e-waste is electronic equipment that has ceased to be of value to users or that no longer satisfies its original purpose as a result of either redundancy, replacement, or breakage. Electronic waste includes both “white goods” such as refrigerators, washing machines, and microwave ovens and “brown goods” such as televisions, radios, computers, and cellular telephones. E-waste differs from traditional municipal waste. Although e-waste contains complex combinations of highly toxic substances (such as lead and cadmium in computers and cellular telephones) that pose a danger to health and the environment, which should be treated as

hazardous materials with respect to their disposal, it also contains non recyclable parts that enter the municipal solid waste stream.

5.4. Materials storage

Safe and efficient materials storage depends on good co-operation and co-ordination between everyone involved including, client, contractors, suppliers and the construction trades.

On all projects the arrangements for materials storage should be discussed and agreed between contractors and the project client. Larger notifiable projects should have arrangements for materials storage included in the Construction phase plan.

Top tips for materials storage on smaller projects

- **Storage areas** designate storage areas for plant, materials, waste, flammable substances eg foam plastics, flammable liquids and gases such as propane and hazardous substances eg pesticides and timber treatment chemicals;
- **Pedestrian routes** do not allow storage to 'spread' in an uncontrolled manner on to footpaths and other walkways. Do not store materials where they obstruct access routes or where they could interfere with emergency escape;
- **Flammable materials** will usually need to be stored away from other materials and protected from accidental ignition;
- **Storage at height** if materials are stored at height eg on top of a container, make sure necessary guard rails are in place if people could fall when stacking or collecting materials or equipment;
- **Tidiness** -keep all storage areas tidy, whether in the main compound or on the site itself; and

Deliveries plan deliveries to keep the amount of materials on site to a minimum. Waste management

There is other legislation governing the proper disposal of waste, ranging from low risk waste through to hazardous waste. These laws are enforced by the Environment Agency and Local Authorities.

However, all waste produced can also present a real safety hazard to workers on site if it is not properly managed throughout the project. You need to decide at an early stage:

- **How** wastes streams produced during building work will be managed in a timely and effective way; and
- **Who** is responsible for collecting and disposal of specific wastes produced on site. Problems often arise when company and individual duties are not made clear before work starts.

Top tips for waste management on smaller projects

- **Flammable materials** - make sure that all flammable waste materials (such as packaging and timber offcuts) are cleared away regularly to reduce fire risks;
- **Work areas** - make clearing waste a priority for all trades. Check that everyone is aware of what is required that it is being done;
- **Skips** - waste materials need storing safely before their removal from the site so make sure that you allow sufficient space for waste skips and bins etc. Plan where the skips can be positioned and how often they will need to be collected;
- **Waste within buildings** - consider waste generated inside the building and whether you need to provide wheeled bins or chutes etc. to enable it to be brought out of the building safely

5.5. Test installed electrical machines and drives

Electrical machines such as motor, generator, and transformer are tested to evaluate their performance characteristics such as their efficiency, voltage regulation etc. These tests requires loading of electrical machines using passive elements such as resistance, inductance and capacitance. During testing of any machine, huge amount of energy consumption take place especially when machine needs to be kept under test for a long duration of time. Hence the energy cost associated is also high for testing large rated machine. This paper proposes a pair of power electronic converter (rectifier and inverter set) that act as a load which can be resistive, inductive or capacitive in nature. The converter is also capable of regenerating the consumed power during testing of machines and feed the power back to the grid. The converter set is made to act as loader

and regenerator by controlling the active and reactive power independently from machine to converter and from converter to grid. To obtain a decoupled control of active and reactive power flow, the control scheme is implemented in d-q reference frame using vector control approach. Based upon the value of active and reactive power reference, the converter is modeled to emulate any kind of resistive, inductive, capacitive or any combination of these loads. The propose model can also be used for power factor improvement.

Final testing

The contractor shall carry out all final inspection and testing in accordance with the quality plan and/or documented procedures to complete the evidence of the conformance of the finished equipment to the specified requirements. The quality plan and/or documented procedures for all final inspection and testing shall require that all specified inspections and tests, including those specified on receipt of equipment or in-process, have been carried out and that the results meet specified requirements. Inspections and tests procedures shall define:

- The location where the inspection or test is to be performed (supplier premises or client organization site or CERN site).
- The parameters to be measured.
- The characteristics or functions that have to be verified.
- The acceptance criteria, including any applicable standards or codes. The requirements for special tools, fixtures, gauges, test set-ups and measuring equipment. Special instructions relative to handling and storage of the equipment.

5.6. Surplus materials to warehouse

Surplus materials

Surplus-material means material excavated in accordance with these specifications from any of the classes specified and which is temporarily surplus to the fill requirements and shall be carted to a designated stockpile for re-use later elsewhere in the Works, or to an approved spoil tip.

Clean work area

Work station is defined as an area, in an office, outfitted with equipment and furnishings for one or more workers. Normally leather goods are operated in awork shop therefore t he work station for a leather goods worker would be the workshop. It is necessary for a worker to p repare his work station and the pieces to bedone but before doing so a worker should be well aware of the safety rules andregulations.

Housekeeping

Good housekeeping involves every phase of industrial operations and shouldapply throughout the entire premises, indoors and out. It is more than merecleanliness. It requires orderly conditions, th e avoidance of congestion, andattention to such details as an orderly layout of the whole workplac e, the markingof aisles, adequate storage arrangements, and suitable provision for cleaning and maintenance.

Elements of a Good Housekeeping

The following are the basic elements of a good housekeeping:

- **Aisles**: Wide enough for traffic movements, marked off by floor lines from work positions and storage areas.
- **Space:** Insuring sufficient room for the individual to work.
- **Storage**: Adequate and convenient space for materials and tools.
- **Materials Handling**: Layout planned for materials flow, with efficient methods and equipment.
- **Ventilation**: Good general ventilation plus local exhaust ventilation to remove air contaminants at the source.
- **Floors and Walls**: They need to be constructed with materials that are easy to clean and if needed easy to repair.
- **Lighting** Welldistributed artificial light and effective use of available daylight.
- **Amenities**: Clean, up-to date washrooms and lockers for clothing, and clean and inviting lunch room for employees to eat their meals.
- **Waste Removal**: Adequate facilities to prevent congestion and disorr.

Returning Surplus Materials

How to Handle Surplus Materials after an Installation Is Completed

The Installed Sales contract has been updated with a new Certificate of Completion (COC), which explains the customer's options for handling surplus materials left over from an Installed Sales project. The customer must decide how they want to handle surplus materials, and indicate their choice by initialing beside it on the COC.

Only unused receipted surplus materials may be offered to customers, as clarified below.

- Customer has the option to receive some or all unused, receipted surplus materials from their installation Customer does NOT have the option to receive items not listed on the installed sales contract or receipt

Note: It is still the installer's responsibility to remove and properly dispose of scraps and waste materials as part of the normal job site clean-up.

Self check-5

Test I:

Instruction: If the statement is correct write TRUE if the statement is in correct write FALSE

_____1. waste materials are either liquid or solid in form air contaminants at the source.

_____ 2. Flammable materials will usually need to be stored away from other materials and protected from accidental ignition

.

_____3.Work station is defined as an area, in an office, outfitted with equipment and furnishings for one or more workers

_____ 4. Spike testing – tests the software's reaction to sudden large spikes in the load generated by users.

Test II: short Answer writing

Instruction: write short answer for the given question. You are provided 3 minute for each question and each point has 5Points

1.---------- involves testing an application under extreme workloads to see how it handles high traffic or data processing..

2. ----------is used to determine the software application's effectiveness in "scaling up" to support an increase in user load.

3. Most performance problems revolve around----------, ----------, ---------- and ----------

4. ----------is the initial time it takes an application to start.

4. List the achievement of final completion by the contractor

Test III: matching

Instruction: select the correct answer for the give choice. You have given 1 Minute for each question. Each question carries 2 Point.

A	B
---------1. Electronic waste	A. microwave ovens
---------2. waste materials	B. solid in form
---------3. performance problems revolve around	C. response time
---------4. done to make sure the software can handle the expected load over a long period of time.	D. Endurance testing

Part IV: Short answer writing

Direction: Give short answer to the following questions. Time allotted for each item is 2mniut and each question carry 4 point.

1. List the achievement of final completion by the contractor:
2. List two types of Restoring Equipment to Service.
3. List Elements of a Good Housekeeping

Reference

1. *Basics of Motor Control Centers. Centers. series, Siemens*
2. *Industrial Motor control Laboratory*
3. *stephen-herman,7th Edition Industrial Motor Control*
4. *Thomas E. Kissell, 1st Edition Modern Industrial Electrical Motor Controls: Operation, Installation and Troubleshooting*

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MINISTRY OF LABOR AND SKILLS

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