BUILDING ELECTRICAL INSTALLATION LEVEL-III

Based on October 2032, Curriculum Version II

Module Title: - low voltage electrical apparatus and circuits Trouble-shooting

Module code: EIS BEI3 M7 1023

Nominal duration: 80Hour

Prepared by: Ministry of Laboure and Skill

October, 2023

Addis Ababa, Ethiopia

Contents

Acknowledgment

Ministry of Labor and Skills wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

Acronym

OHS - -------------------------------- Occupational Health & Safety

OSHA-------------------------------- Occupational Health and Safety Administration

PPEs – -------------------------------Personal Protective Equipment

GFCI- -------------------------------Ground Fault Current Interrupt

RD - ---------------------------------Requirements Document

DC – ---------------------------------Direct Current

AC – ---------------------------------Alternative Current

DMM- -------------------------------digital multimeter

ELV – -------------------------------extra low voltage

CB- ----------------------------------circuit breaker

LLL----------------------------------line to line to line

LLLG--------------------------------line to line to line to ground

SOPs- --------------------------------standard operating procedures

Introduction to the Module

In Building Electrical installation filed low voltage electrical apparatus and circuits Trouble-shooting is very important for rectify faults and repair faults and report trouble-shoot It helps to know the Basic concept of trouble-shoot faults, Understand Trouble-shooting and repairing faults and report trouble-shoot and repair activities

This module is designed to meet the industry requirement under the Building Electrical Installation occupational standard, particularly for the unit of competency: low voltage electrical apparatus and circuits Trouble-shooting

This module covers the units:

- Diagnose faults
- Trouble-shoot and repair faults.
- Completion and report trouble-shoot and repair activities

Learning Objective of the Module

- Identify Diagnose faults
- Understand Trouble-shooting and repairing faults
- Complete and report trouble-shoot and repair activities

Module Instruction

For effective use this module 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" giver at the end of each unit.
5. Read the identified reference book & website.

UNIT ONE: DIAGNOSE FAULTS

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

- Basic concept of trouble-shoot faults
- Extent and nature of electrical installation
- OHS procedures & risk control measures
- Tools, Equipment and materials
- Identification of faults
- Faults symptoms and their causes
- Visual fault/breakdown inspection

Visual fault/breakdown inspectionThis unit will also assist you to attain the learning outcomes stated in the coverage. Specifically, upon completion of this learning guide, you will be able to:

- Understanding of basic concept of trouble-shoot faults
- Inspect the Extent and nature of electrical installation
- Follow OHS procedures & risk control measures
- Identify tools, Equipment and materials
- Describe the Identification of faults
- Explain the Faults symptoms and their cause
- Visual fault/breakdown inspection

1.1. Basic concept of trouble-shoot faults

Troubleshooting faults is the process of identifying and resolving the cause of a problem. It is a systematic approach to solving problems by breaking them down into smaller, more manageable parts.

Identify the problem. What is the specific problem that is occurring?

Gather information. What information is available about the problem? This may include information about the equipment involved, the environment, and the people who are using it.

Generate hypotheses. What are the possible causes of the problem?

Test the hypotheses. Test each hypothesis to determine if it is the cause of the problem.

Implement a solution. Once the cause of the problem has been identified, implement a solution to resolve it Verify the solution. Test the solution to ensure that it has resolved the problem. Troubleshooting faults can be a challenging task, but it is an essential skill for anyone who works with equipment or systems. By following the basic troubleshooting process, you can quickly and efficiently identify and resolve problems.

Document your steps. This will help you to keep track of what you have done and to avoid making the same mistakes again.

Ask for help. If you are stuck, don't be afraid to ask for help from a colleague or supervisor.

There are many different troubleshooting techniques that can be used, depending on the specific problem that is occurring. Some common troubleshooting techniques include:

Visual inspection: Look for any obvious problems with the equipment or system.

Functional testing: Test the equipment or system to see if it is working properly.

Log analysis: Review the system logs to look for any errors or warnings.

Diagnostics: Run diagnostic tests on the equipment or system to identify any problems.

1.2. Extent and nature of the electrical installation

The extent and nature of an electrical installation is determined from job specifications. These specifications typically include the following information:

The size and type of building: Larger buildings with more complex electrical needs will require more extensive electrical installations.

The number and type of appliances and equipment: The number and type of appliances and equipment that will be used in the building will determine the size and capacity of the electrical system that is needed.

The specific requirements of any specialized equipment: Some specialized equipment, such as medical equipment or industrial machinery, may have specific electrical requirements that need to be met.

Any local codes or regulations: There may be local codes or regulations that govern the installation of electrical systems. It is important to check with your local authorities to ensure that your installation complies with all applicable codes and regulations.

Once you have this information, you can begin to develop a plan for your electrical installation. This plan should include the following:

A diagram of the electrical layout: This diagram should show the location of all electrical outlets, switches, and fixtures.

A list of all electrical components: This list should include the type, size, and quantity of all electrical components that will be used in the installation.

A schedule for the installation: This schedule should include start and end dates for each phase of the installation.

Once you have developed a plan, you can begin to install the electrical system. It is important to follow the manufacturer's instructions for each electrical component and to comply with all applicable codes and regulations.

Here are some additional tips for determining the extent and nature of an electrical installation from job specifications:

Consider future needs: When planning your electrical installation, it is important to consider future needs. For example, if you are planning to add on to your home in the future, you will want to make sure that your electrical system is sized to accommodate the additional load.

Be energy efficient: When choosing electrical components, be sure to select energy-efficient options. This will help you to save money on your energy bills in the long run.

1.3. OHS procedures & risk control measures

OHS procedures and risk control measures are designed to protect employees from hazards in the workplace. These procedures and measures should be implemented in a hierarchy of controls, with the most effective controls at the top and the least effective controls at the bottom.

Examples of OHS procedures and risk control measures:

Elimination: Removing a trip hazard from a walkway.

Substitution: Using a less hazardous chemical than before.

Engineering controls: Installing guards on machinery.

Administrative controls: Developing and implementing safe work procedures.

PPE: Providing employees with safety glasses, gloves, and hard hats.

It is important to note that the hierarchy of controls is not a rigid set of rules. The best way to control

a hazard will depend on the specific situation. For example, it may not be possible to eliminate a hazard, so the next best option may be to substitute it with a less hazardous one.

1.4. Tools, Equipment and materials

The tools, equipment, and materials that you need for troubleshooting faults will vary depending on the specific problem that you are trying to solve. However, some common tools and equipment that can be used for troubleshooting faults include:

Multimeter: A multimeter is a versatile tool that can be used to measure voltage, current, and resistance.

Logic probe: A logic probe is a tool that can be used to test the state of digital signals.

Cable tester: A cable tester is a tool that can be used to test the integrity of cables.

Voltage detector: A voltage detector is a tool that can be used to detect the presence of voltage.

Hand tools: A variety of hand tools, such as screwdrivers, wrenches, and pliers, may be needed to disassemble and reassemble equipment.

Replacement parts: It is a good idea to have a supply of replacement parts on hand, so that you can quickly replace any faulty parts that you find.

Cleaning supplies: cleaning supplies, such as alcohol and contact cleaner, can be used to clean electrical components.

1.5. Identification of faults

There are a number of ways to identify faults in electrical equipment. Some common methods include:

Visual inspection: Look for any obvious signs of damage, such as burned wires, loose connections,

Functional testing: Test the equipment to see if it is working properly. For example, if you are troubleshooting a light switch, you would turn on the switch to see if the light comes on.

Log analysis: Review the equipment logs to look for any errors or warnings. For example, if you are troubleshooting a server, you would review the event logs to look for any errors that may be causing the server to crash.

An electrical fault is the deviation of voltages and currents from nominal values or states. Under normal operating conditions, power system equipment or lines carry normal voltages and currents which results in safer operation of the system. ... Those are symmetrical and unsymmetrical faults

If the correct voltage is not present, then the control fuse is open. If the fuse is open, then there is either a short circuit or ground fault. If the fuse is not open, then there is an open circuit fault. This is our first indication that the fault is an open circuit fault.

Short-circuited fault is one of the most dangerous and common faults occurring in power system, which includes three-phase short circuit, two-phase short circuit, two-phase grounding short circuit and single-phase grounding short circuit

Maintain the first test probe at the hot wire terminal of the circuit. Remove the second probe from the neutral terminal then place it on the ground terminal for the circuit. Once more the multi meter will read "OL" or infinity if the circuit is open or zero if the circuit is functioning

Types of Faults

Electrical faults in three-phase power system mainly classified into two types, namely open and short circuit faults. Further, these faults can be symmetrical or unsymmetrical faults. Let us discuss these faults in detail.

Open Circuit Faults

These faults occur due to the failure of one or more conductors. The figure below illustrates the open circuit faults for single, two and three phases (or conductors) open condition.

The most common causes of these faults include joint failures of cables and overhead lines, and failure of one or more phase of circuit breaker and also due to melting of a fuse or conductor in one or more phases.

Open circuit faults are also called as series faults. These are unsymmetrical or unbalanced type of faults except three phase open fault.

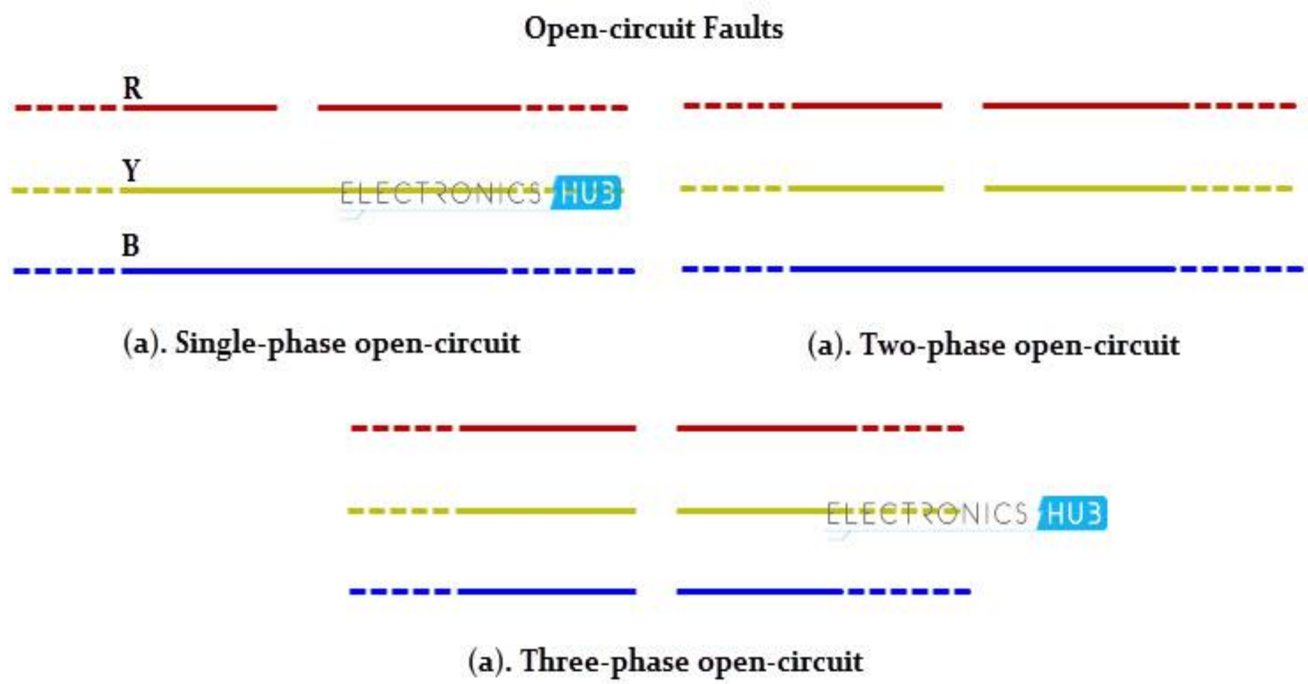

Fig 1. open circuit fault

Consider that a transmission line is working with a balanced load before the occurrence of open circuit fault. If one of the phases gets melted, the actual loading of the alternator is reduced and this cause to raise the acceleration of the alternator, thereby it runs at a speed slightly greater than synchronous speed. This over speed causes over voltages in other transmission lines.

Thus, single- and two-phase open conditions can produce the unbalance of the power system voltages and currents that causes great damage to the equipment.

Causes

Broken conductor and malfunctioning of circuit breaker in one or more phases.

Effects

- Abnormal operation of the system
  Danger to the personnel as well as animals
- Exceeding the voltages beyond normal values in certain parts of the network, which further leads to insulation failures and developing of short circuit faults.

Although open circuit faults can be tolerated for longer periods than short circuit faults, these must be removed as early as possible to reduce the greater damage.

Short Circuit Faults

A short circuit can be defined as an abnormal connection of very low impedance between two points of different potential, whether made intentionally or accidentally.

These are the most common and severe kind of faults, resulting in the flow of abnormal high currents through the equipment or transmission lines. If these faults are allowed to persist even for a short period, it leads to the extensive damage to the equipment.

Short circuit faults are also called as shunt faults. These faults are caused due to the insulation failure between phase conductors or between earth and phase conductors or both.

The various possible short circuit fault conditions include three phases to earth, three phase clear of earth, phase to phase, single phase to earth, two phase to earth and phase to phase plus single phase to earth as shown in figure.

The three-phase fault clear of earth and three phase faults to earth are balanced or symmetrical short circuit faults while other remaining faults are unsymmetrical faults.

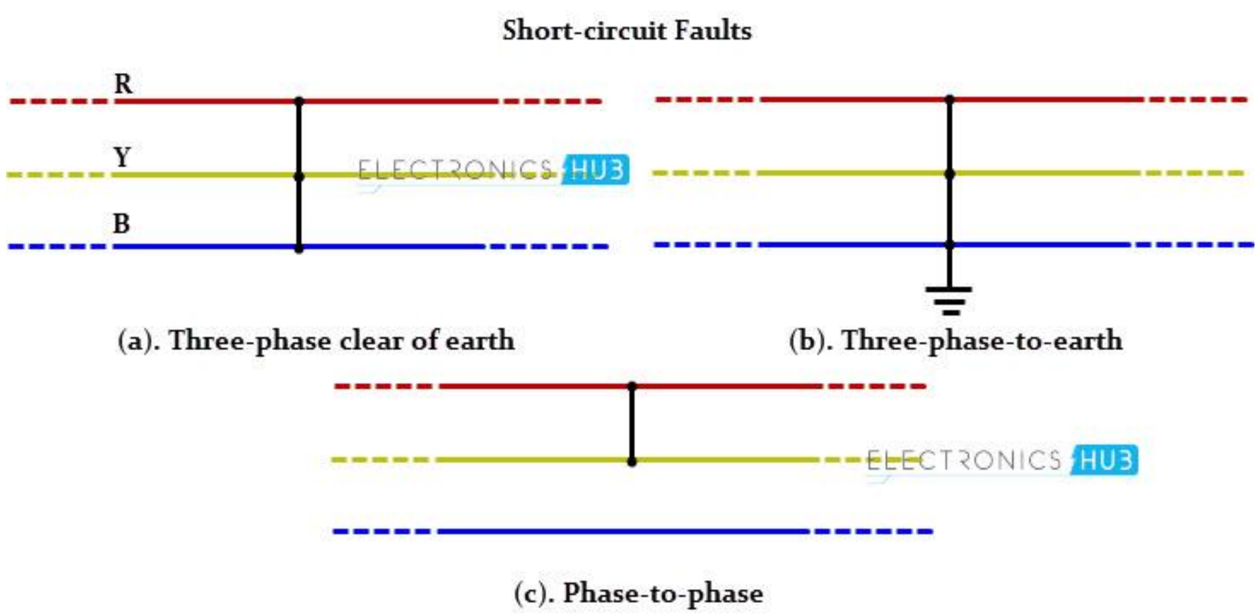

Fig2. phase to phase circuit fault

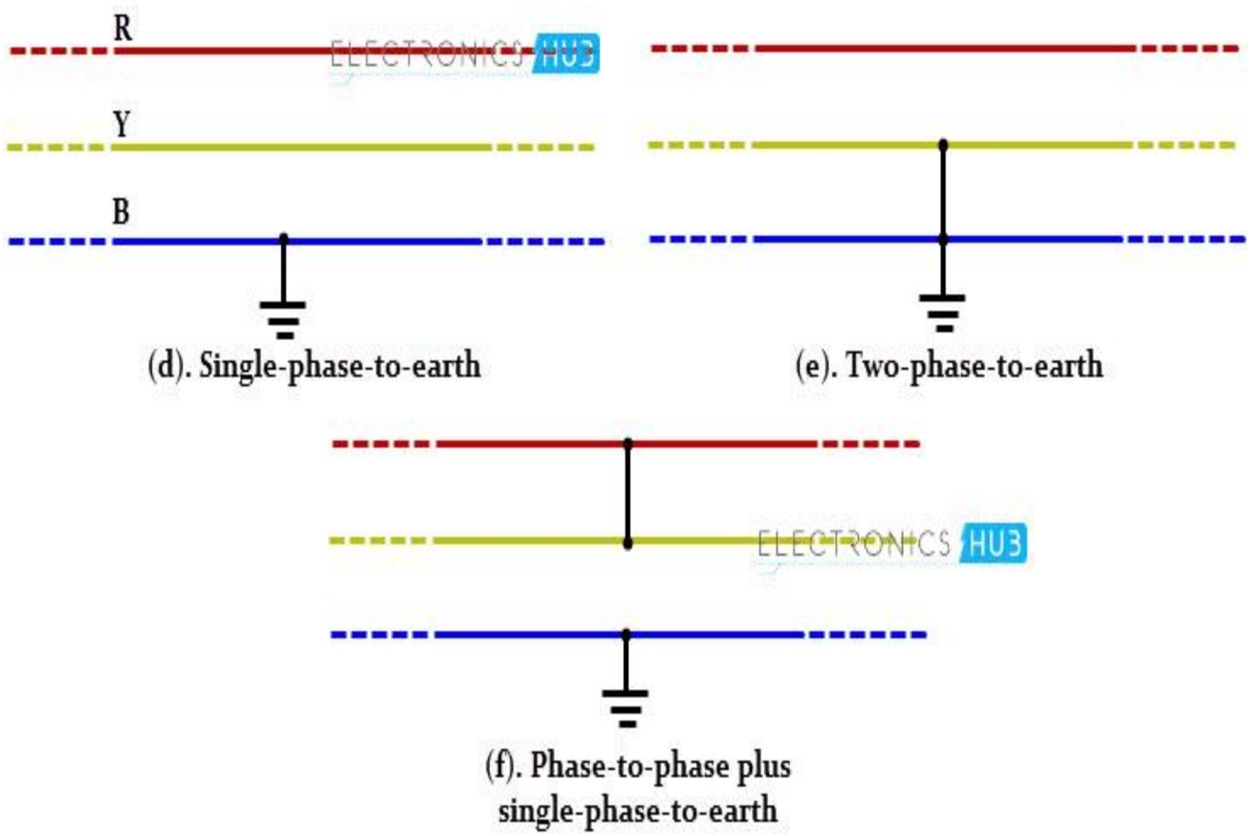

Fig3. phase to phase plus single-phase circuit fault

Causes

These may be due to internal or external effects

- Internal effects include breakdown of transmission lines or equipment, aging of insulation, deterioration of insulation in generator, transformer and other electrical equipment, improper installations and inadequate design.
- External effects include overloading of equipment, insulation failure due to lighting surges and mechanical damage by public.

Effects

- Arcing faults can lead to fire and explosion in equipment such as transformers and circuit breakers.
- Abnormal currents cause the equipment to get overheated, which further leads to reduction of life span of their insulation.
- The operating voltages of the system can go below or above their acceptance values that creates harmful effect to the service rendered by the power system.

- The power flow is severely restricted or even completely blocked as long as the short circuit fault persists.

Symmetrical and Unsymmetrical Faults

As discussed above that faults are mainly classified into open and short circuit faults and again these can be symmetrical or unsymmetrical faults.

Symmetrical Faults

A symmetrical fault gives rise to symmetrical fault currents that are displaced with 1200 each other. Symmetrical fault is also called as balanced fault. This fault occurs when all the three phases are simultaneously short circuited.

These faults rarely occur in practice as compared with unsymmetrical faults. Two kinds of symmetrical faults include line to line to line (L-L-L) and line to line to line to ground (L-L-L-G) as shown in figure below.

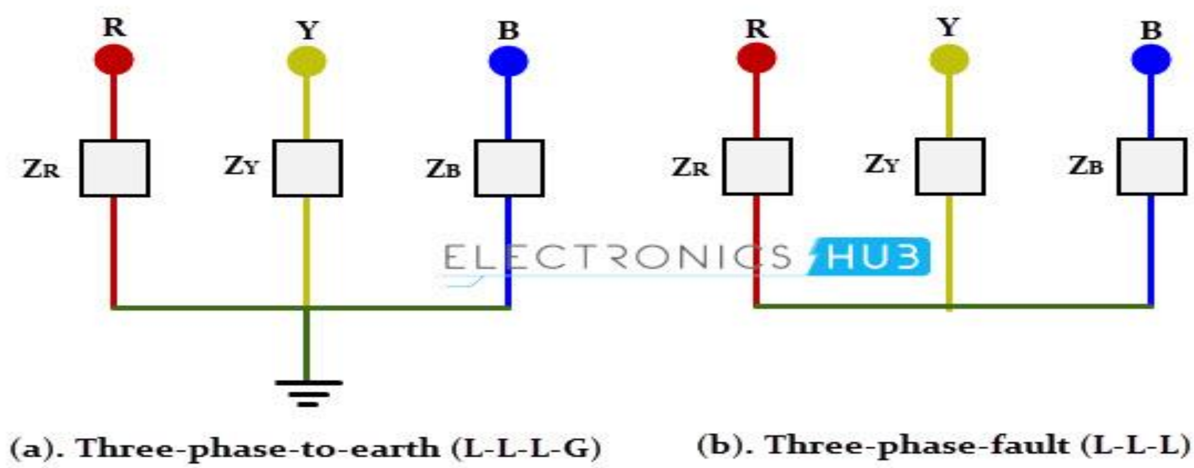

Fig4. A. three phase to phase earth B. three phase –phase fault

Occurrence of symmetrical faults is in the range of 2 to 5% of the total system faults. However, if these faults occur, they cause a very severe damage to the equipment even though the system remains in balanced condition

The analysis of these faults is required for selecting the rupturing capacity of the circuit breakers, choosing set-phase relays and other protective switchgear

Unsymmetrical Faults

The most common faults that occur in the power system network are unsymmetrical faults. This kind of fault gives rise to unsymmetrical fault currents (having different magnitudes with unequal phase displacement). These faults are also called as unbalanced faults as it causes unbalanced currents in the system.

Up to the above discussion, unsymmetrical faults include both open circuit faults (single- and two-phase open condition) and short circuit faults (excluding L-L-L-G and L-L-L).

The figure below shows the three types of symmetrical faults occurred due to the short circuit conditions, namely phase or line to ground (L-G) fault, phase to phase (L-L) fault and double line to ground (L-L-G) fault

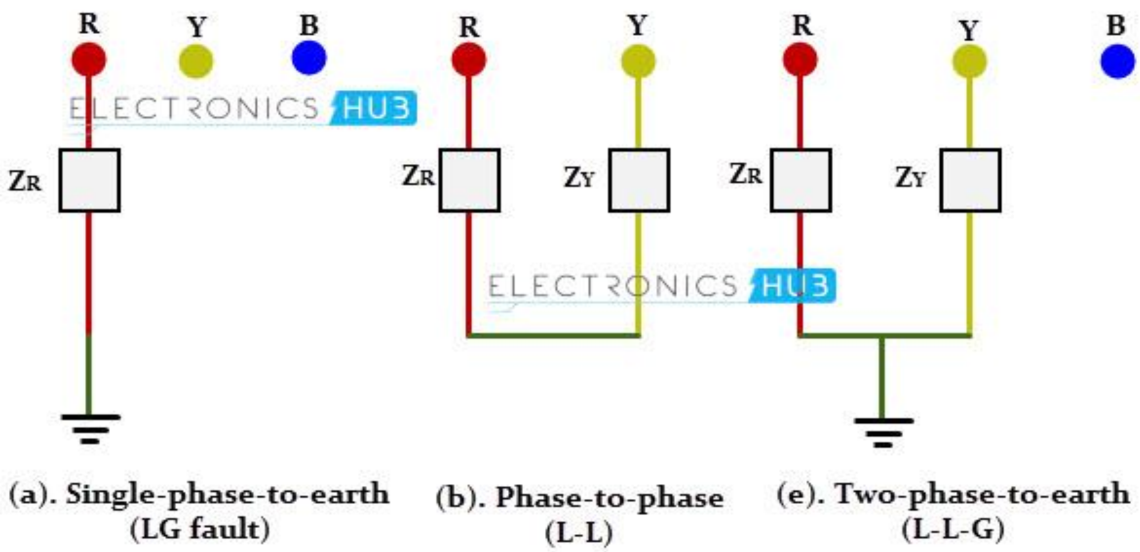

Fig5.A. single phase-to phase fault   B. Phase to phase   C. two –phase- earth

A single line-to-ground (LG) fault is one of the most common faults and experiences show that 70-80 percent of the faults that occur in power system are of this type. This forms a short circuit path between the line and ground. These are very less severe faults compared to other faults.

A line-to-line fault occur when a live conductor get in contact with other live conductor. Heavy winds are the major cause for this fault during which swinging of overhead conductors may touch together. These are less severe faults and its occurrence range may be between 15-20%.

In double line to ground faults, two lines come into the contact with each other as well as with ground. These are severe faults and the occurrence these faults is about 10% when compared with total system faults.

Unsymmetrical faults are analyzed using methods of unsymmetrical components in order to determine the voltage and currents in all parts of the system. The analysis of these faults is more difficult compared to symmetrical faults.

This analysis is necessary for determining the size of a circuit breaker for largest short circuit current. The greater current usually occurs for either L-G or L-L fault.

Protection Devices against Faults

When the fault occurs in any part of the system, it must be cleared in a very short period in order to avoid greater damage to equipment and personnel and also to avoid interruption of power to the customers.

The fault clearing system uses various protection devices such as relays and circuit breakers to detect and clear the fault.

Some of these faults clearing or faults limiting devices are given below.

Fuse

It opens the circuit whenever a fault exists in the system. It consists of a thin copper wire enclosed in a glass or a casing with two metallic contacts. The high fault current rises the temperature of the wire and hence it melts. A fuse necessitates the manual replacement of wire each time when it blows.

Circuit Breaker

It is the most common protection device that can make or break the circuit either manually or through remote control under normal operating conditions.

There are several types of circuit breakers available depending on the operating voltage, including air brake, oil, vacuum and SF6 circuit breakers. For more information on circuit breakers, follow the link attached.

Protective Relays

These are the fault detecting devices. These devices detect the fault and initiate the operation of the circuit breaker so as to isolate the faulty circuit. A relay consists of a magnetic coil and contacts (NC and NO). The fault current energizes the coil and this causes to produce the field, thereby the contacts get operated.

Fig 6. protective relay

Some of the types of protective relays include

- Magnitude relays
- Impedance relays
- Directional relays
- Pilot relays
- Differential relays

Lighting Arrestor

Surges in the power system network caused when lightning strikes on transmission lines and equipment. This causes high voltage and currents in the system. These lighting faults are reduced by placing lighting arrestors at transmission equipment

In order to control workplace hazards and eliminate or reduce the risk, you should take the following steps:

- Identify the hazard by carrying out a workplace risk assessment;
- Determine how employees might be at risk;
- Evaluate the risks;
- Record and review hazards at least annually, or earlier if something changes.

1.6. Faults symptoms and their cause

Visual faults breakdown or inspection refers to a systematic examination of equipment, machinery, structures, or work areas to identify visual defects, faults, or deficiencies that may compromise safety or performance. This type of inspection relies on visual observation and can help detect issues that are visible to the naked eye. Here is a breakdown of the visual fault's breakdown or inspection process:

Preparation: Before starting the inspection, gather relevant information about the equipment or area to be inspected. This may include equipment manuals, maintenance records, safety guidelines, and any specific inspection checklists or procedures.

Safety Measures: Ensure proper safety measures are in place. This may involve wearing appropriate personal protective equipment (PPE), such as safety glasses, gloves, or hard hats, and following any necessary lockout/tagout procedures.

Visual Observation: Conduct a thorough visual examination of the equipment, machinery, or work area. Pay attention to details and look for signs of wear, damage, corrosion, leaks, lose or missing components, or any other visual abnormalities. Inspect from different angles and distances to ensure comprehensive coverage.

Checklists and Guidelines: Utilize checklists, guidelines, or standard operating procedures (SOPs) specific to the equipment or area being inspected. These documents can serve as a reference to ensure all critical components or areas are inspected and help identify common faults or issues.

Documentation: Document any observed faults or deficiencies. Take notes, photographs, or videos as necessary to provide clear evidence of the identified faults. Include details such as the location, description, severity, and potential impact of each fault.

Actionable Steps: Determine the appropriate course of action for each identified fault. This may involve immediate corrective measures, scheduling repairs or maintenance, notifying relevant personnel, or initiating further investigations if necessary.

Priority and Severity: Assess the priority and severity of each identified fault. Determine which faults pose the highest risk to safety, operations, or compliance and prioritize their resolution accordingly.

Reporting and Communication: Compile the inspection findings into a comprehensive report. Clearly communicate the identified faults, their potential impact, and recommended actions to relevant stakeholders, such as supervisors, maintenance personnel, or safety committees.

Follow-Up and Verification: Ensure that the recommended actions are implemented within the specified timeframe. Conduct follow-up inspections or verifications to confirm that the identified faults have been properly addressed and resolved.

Continuous Improvement: Use the inspection findings to identify trends, recurring faults, or systemic issues. Analyze the data to implement preventive measures, such as improving maintenance procedures, enhancing training programs, or modifying equipment design to minimize the occurrence of similar faults in the future.

1.7. Visual fault/breakdown inspection

A visual fault/breakdown inspection is a systematic examination of electrical equipment to identify any visible signs of damage or defects. This type of inspection can be performed on a variety of electrical equipment, including:

Electrical panels

- Circuit breakers
- Fuses
- Switches
- Outlets
- Wiring
- Lighting fixtures
- Motors
- Transformers
- Generators

To perform a visual fault/breakdown inspection, the following steps should be taken:

Disconnect the power to the equipment being inspected.

- Remove any covers or panels that obstruct the view of the internal components.
- Inspect the equipment for any signs of damage, such as:
- Burned wires
- Loose connections
- Cracked insulation
- Rust or corrosion
- Overheating
- Discoloration
- Swelling
- Leaking fluids

If any signs of damage are found, the equipment should be taken out of service and repaired or replaced.

It is important to note that a visual fault/breakdown inspection is not a substitute for a comprehensive electrical inspection. A comprehensive electrical inspection should be performed by a qualified electrician on a regular basis to ensure the safety and reliability of your electrical system.

Fig 7. visual fault inspection

Table 1- report format

ELECTRICAL INSPECTION REPORT AND CERTIFICATION FORM

(Excluding the Grounding Electrode System, Swimming Pools and Hazardous Locations)

PROJECT INFORMATION

Permit No.: ______________ Floor: ________ Suite: ________ Tax Map ID: ______________

Project Name: ______________________ Project Owner: ______________________

Street Address: ______________________ City: ______________, VA ZIP: ______________

CERTIFICATION INFORMATION

Company Name: ____

Address: ____________________________________ Suite: ______________

City: ______________________ State: ______ ZIP: ________ Telephone: ______________

INSPECTION INFORMATION

Concealment Inspection for the following (Choose One): ☐ Deck/Slab ☐ Concrete/Masonry Wall ☐ Ditch/Trench ☐ Pole Bases ☐ Ufer Ground ☐ Other: ____________

Inspection Complete?	Yes	No
Job identification properly posted?		
Approved construction documents on site?		
Construction documents revision required?		
Work conforms to permit?		
Work conforms to code?		

Inspection Complete?	Yes	No	NA
Equipment listed and approved?			
Equipment grounding conductors installed?			
Equipment is protected from the elements?			
Depth of cover is approved?			

CERTIFICATION

I hereby certify that I am the person which holds the Virginia Master Electrician Tradesman Certification for the Electrical Contracting Firm that holds the permit for the project. I have read the 2012 edition of the Virginia Uniform Statewide Building Code (VUSBC), Chapter 66 of the Code of the County of Fairfax, Virginia and the 2011 National Electrical Code (NEC); and I am thoroughly familiar with the provisions contained therein.

I further hereby certify that I personally inspected the installation at the location described above in accordance with the Approved Construction Documents, VUSBC, NEC, and Chapter 66 of the Code of the County of Fairfax, Virginia; and the following is my report:

Brief but descriptive details of work installed: ____

____

Inspection report ____

____

Signature of Certifier: ______________ Name of Certifier (please print): ______________

License Number: ______________ Expiration Date: ______________ Date: ______________

Self-check #1

I. Choose the correct answer from the give alterative

1. Which of the following is NOT a step in troubleshooting electrical faults?
   A. Identifying the fault C. Testing the circuit
   B. Repairing the fault D. Replacing the circuit
2. Which of the following is NOT a safety precaution to take when troubleshooting electrical faults?
   A. Wearing safety glasses C. Working on live circuits
   B. Using insulated tools D. Turning off the power to the circuit
3. Which of the following is a common cause of electrical faults?
   A. Loose connections C. Faulty wiring
   B. Overloaded circuits D. all
4. Which of the following is NOT a visual symptom of an electrical fault?
   A. Scorched wires C. Burning smell
   B. Tripped circuit breaker D. Loose connections

II Matching:

. Direction: Match Column A with Column B. Write the letter only.

<u>**Colmen A**</u>	<u>**Colmen B**</u>
1. No power to the circuit	A. Open circuit
2.Circuit breaker trips frequently	B. Short circuit
3. Tingling sensation when touching the circuit	C. Ground fault
4. Sparks and smoke from the circuit	D. Overloaded circuit
5.To protect your eyes from flying debris	E. Wear safety glasses
6.To prevent electrical shock	F. Use insulated tools
7.To avoid working on live circuits	G. Turn off the power to the circuit

III Short answer

1.What is the importance of troubleshooting electrical faults?

2.What are some of the challenges of troubleshooting electrical faults?

UNIT TWO: TROUBLE-SHOOTING AND REPAIRING FAULTS

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

- Circuits/Machines/plants
- Equipment and associated
- Circuit Testing procedure of Trouble-shooting
- Methods and technique of trouble-shooting
- Circuit and wiring diagrams
- Critical aspects of trouble-shooting

Visual fault/breakdown inspectionThis 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:

- Inspect Circuits, Machines and plants
- Repair equipment and associated
- Identify Circuit Testing procedure of Trouble-shooting
- Inspect methods and technique of trouble-shooting
- Understand Circuit and wiring diagrams
- Identify Critical aspects of trouble-shooting

2.1. Circuits, Machines and plants

To troubleshoot and repair faults in electrical circuits, machines, and plants, it is important to follow safety guidelines.

Identify the problem: What is the specific problem that is occurring? Is there no power? Is the machine not working properly? Is the plant not producing the desired output?

Gather information: What information is available about the problem? This may include information about the equipment involved, the environment, and the people who are using it.

Generate hypotheses: What are the possible causes of the problem? Consider all of the factors that could be contributing to the problem, such as the equipment, the environment, and the people who are using it.

Test the hypotheses: Test each hypothesis to determine if it is the cause of the problem. This may involve inspecting the equipment, running diagnostic tests, or changing the operating conditions.

Implement a solution. Once the cause of the problem has been identified, implement a solution to resolve it. This may involve repairing the equipment, changing the operating conditions, or training the people who are using the equipment.

Verify the solution. Test the solution to ensure that it has resolved the problem.

Here are some additional tips for troubleshooting circuits, machines, and plants:

Be systematic. Don't just start tinkering with things randomly. Follow a logical process to identify and resolve the problem.

Document your steps. This will help you to keep track of what you have done and to avoid making the same mistakes again.

Ask for help. If you are stuck, don't be afraid to ask for help from a colleague or supervisor.

It is important to note that some troubleshooting tasks can be dangerous, especially if you are working with high-voltage electricity or with moving machinery. It is important to follow all safety precautions and to wear appropriate personal protective equipment (PPE) when troubleshooting circuits, machines, and plants

- Inspect single phase motor and control for any obvious damage. Look for loose connections, burnt wires, or damaged components.

Fig 8. Check single phase motor

Make sure that all of the components in the control circuit are working properly. You can use a multimeter to test the components.

Troubleshooting steps

Check the power supply. Make sure that the motor is plugged in and that the power switch is turned on.

Check the fuse or circuit breaker. If it is blown or tripped, reset it or replace the fuse.

Check the wiring. Make sure that all of the connections are tight and that there are no breaks in the wires.

Check the contactor. Disconnect the power to the motor and then use a multimeter to check the continuity of the contactor contacts. If the contacts are not closed, the contactor is faulty and needs to be replaced.

Check the overload relay. Disconnect the power to the motor and then use a multimeter to check the continuity of the overload relay contacts. If the contacts are not closed, the overload relay is faulty and needs to be replaced.

Check the motor windings. If the motor windings are open or shorted, the motor will not start.

Troubleshooting and repairing a faulty contactor in a three-phase motor control:

Identify the problem: The first step is to identify the problem with the contactor. This can be done by checking for the following symptoms:

- The motor is not starting up.
- The motor is running intermittently.
- The motor is running slowly.
- The motor is making unusual noises.
- The contactor is hot or sparking.

Inspect the contactor: Once you have identified the problem, inspect the contactor for any signs of damage, such as:

- Burned or melted contacts.
- Cracked or broken housing.
- Loose or corroded connections.

Test the contactor: If the contactor is damaged, it will need to be replaced. However, if the contactor is not damaged, you can test it to see if it is working properly. To do this, you will need to use a multimeter or voltage tester.

To test the contactor with a multimeter:

- Set the multimeter to DC voltage.
- Connect the positive lead of the multimeter to the coil terminal of the contactor.
- Connect the negative lead of the multimeter to the frame of the contactor.
- Apply power to the contactor.
- The multimeter should read the voltage of the power supply.

To test the contactor with a voltage tester:

- Connect the voltage tester to the coil terminal of the contactor.
- Apply power to the contactor.
- The voltage tester should light up if the contactor is working properly.

Repair or replace the contactor: If the contactor is not working properly, it will need to be repaired or replaced. If the contactor is damaged, it will need to be replaced. However, if the contactor is not damaged, you may be able to repair it by cleaning the contacts or tightening the connections.

Here are some additional tips for troubleshooting and repairing a faulty contactor in a three-phase motor control:

- Always disconnect the power supply before troubleshooting or repairing the contactor.
- Be careful when handling the contactor, as it may be hot.
- Use the proper tools and safety gear when working on the contactor.
- If you are not comfortable troubleshooting or repairing the contactor yourself, contact a qualified electrician.
- faulty contactor in a three-phase motor contr.

Causes of electrical faults in three phase motors

There are a number of causes of electrical faults in three-phase motors, including:

Open and partially open circuit phase winding: This fault occurs when one or more of the phase windings in the motor is broken or damaged. This can be caused by a variety of factors, such as overheating, vibration, and moisture.

Short and partially short circuit phase winding: This fault occurs when two or more of the phase windings in the motor come into contact with each other. This can be caused by a variety of factors, such as insulation failure, loose connections, and damaged windings.

Open circuit rotor: This fault occurs when one or more of the rotor bars in the motor is broken or damaged. This can be caused by a variety of factors, such as overheating, vibration, and mechanical stress.

Burnt out phase winding: This fault occurs when one or more of the phase windings in the motor overheats and burns out. This can be caused by a variety of factors, such as overloading, poor ventilation, and insulation failure.

Coil shorted to frame: This fault occurs when one or more of the coils in the motor comes into contact with the frame of the motor. This can be caused by a variety of factors, such as insulation failure, loose connections, and damaged windings.

Example

A three-phase motor in a factory is not working properly. The motor is making a loud noise and is not rotating at its normal speed. The electrician is called to troubleshoot the problem. The electrician discovers that one of the phase windings in the motor has burned out.

Fig 9. Check three-phase motor

Safety considerations

It is important to follow all safety precautions when working with electrical systems. When working with three-phase motors, it is also important to be aware of the risks of electrocution. Always disconnect the power supply before working on a three-phase motor.

preventing electrical faults in three-phase motors

Here are some preventing electrical faults in three-phase motors:

- Use motors that are properly sized for the load.
- Avoid overloading motors.
- Make sure that motors are properly ventilated.
- Avoid installing motors in hot or humid environments.
- Use surge protection devices to protect motors from voltage spikes.
- Make sure that all connections are tight and secure.
- Have your three-phase motors inspected and serviced by a qualified electrician on a regular basis.

Fault Finding – Three Phase Motors

Problem	Possible Cause	Tests	Solution
Motor will not start.	Fault with supply. Motor or load locked up. Wrong connections in control circuit.	Check for correct voltage at motor terminals. Make sure motor and load are free to turn. Check to ensure contactors operate.	Fit new fuses, reset circuit breakers, etc. Remove clamps, locks, etc. Sort out control circuit.
Supply or started trips out at start.	Wrong or loose connections. Motor overloaded. Inertia of load to high. Low Voltage due to volt drop in cables Overload or circuit breaker incorrectly set or sized.	Check all connections are properly connected. Check load performance data against motor performance data. Measure voltage at motor terminals while motor starting. Check settings of overload and CB & allow for starting current.	Fix up connections. Change motor for correct size. Change cables for correct size. Correct setting of overload or breaker or change.
Motor starts but has no torque. Motor does not reach full speed or takes a long time to accelerate.	Incorrect connection. Delta wound motor connects in star. Star/Delta starter staying in Star. Inertia of load to high. Motor overloaded. Low voltage due to volt drop in cables.	Check connection diagram and nameplate data. Check load performance data against motor performance data. Measure voltage at motor terminals while motor starting	Sort out and correct connections. Check timer and starter control circuit. Change motor for correct size. Change cables for correct size.
Motor Overheating.	Motor overloaded.	Check load performance data.	Fix problem with load or fit

	Ineffective cooling. Wrong connection. Delta wound motor in star. Supply voltage unbalanced.	Check fan and air flow. Look for buildup of dirt. Check connection diagram and nameplate data. Measure phase to phase voltage accurately	larger motor. Clean motor. Sort out cooling of air flow. Sort out connections. Restore supply to all phases. Balance supply.
No load amps in excess of Full load amps	Incorrect connection Star wound motor connection Delta. Voltage in excess of nameplate. Motor supplied for different voltage or frequency.	Check connection diagram and nameplate data. Measure voltage at motor terminals. Compare supply voltage and frequency to nameplate.	Sort out and correct connections at motor terminals. Correct supply voltage Change motor for correct voltage and frequency
Mechanical Noise or Vibration. Noisy bearings. Bearings overheating.	Thrust from load or misalignment. Damaged bearings, too much grease, no grease, or foreign matter in grease. Rotor pulling or foreign matter in air gap. Out of balance load, coupling or pulley. Excessive belt pull. Motor foundations not rigid.	Check gap between coupling halves and alignment. Turn shaft slowly by hand and feel for roughness or stiffness. Check for bent shaft or fan rubbing. Run motor disconnected from load and then with pulley or coupling removed. Run motor without belts. Check design and construction foundations	Re-align couplings Clean bearing housing, change bearings and repack with fresh grease. Fix up out of balance items. Loosen belt tension. Increase strength of foundations
Motor amps in excess of nameplate full load amps on	Motor overloaded. Low supply voltage.	Check load and performance data.	Fix problem with load or fit larger motor.

load	Wrong voltage or frequency. Wrong Connections. Motor 'Single-Phasing'. Supply voltage unbalanced. Motor Speed not matched to load.	Measure voltage at motor terminals Check nameplate. Check nameplate . Check volts and amps in all three phases. Measure motor speed and check load speed requirements.	Fix problem, maybe with larger cables. Correct voltage or frequency. Sort out and correct. Restore balanced supply to all three phases. Change motor for correct motor speed.
Excessive electric noise	Wrong connections. Wrong voltage. Motor 'Single-Phasing'.	Check connections Check voltage with nameplate Check volts with amps in all three phases.	Fix up connections Correct voltage. Restore supply to all three phases.
Unbalanced amps in different phases when motor loaded	Unbalanced supply voltage	Measure phase to phase voltage accurately	Balance supply or accept unbalance
Motor runs in wrong direction	Wrong connections.	Watch shaft rotation	Swop and two phases of supply.

Synchronous machines

Synchronous machines are electrical machines that operate at a constant speed, synchronized with the frequency of the electrical system to which they are connected. They can be used as either motors or generators.

Synchronous motors are used in a variety of applications, including industrial drives, power generation, and transportation. They are known for their high efficiency and ability to provide constant torque over a wide speed range.

Synchronous generators are used to generate electrical power in power plants. They are also used in wind turbines and other renewable energy systems.

Fig 10. Synchronous machine

Common problems with synchronous machines include:

Overheating: This can be caused by overloading the machine, poor ventilation, or a failure of the cooling system.

Vibration: This can be caused by a misalignment of the machine, a loose bearing, or a damaged rotor.

Noise: This can be caused by a vibration, a rubbing of parts, or a failure of a bearing.

Electrical problems: These can include short circuits, open circuits, or a failure of the insulation.

Here are some tips for troubleshooting synchronous machines:

- Check the machine for signs of overheating, vibration, noise, and electrical problems.
- Inspect the machine for any obvious damage.
- Check the alignment of the machine.
- Check the bearings for wear and tear.
- Check the insulation for damage.

Additional of Problem Synchronous machine will not start.

Possible causes:

- Power failure
- Blown fuse
- Tripped circuit breaker
- Open circuit in the wiring
- Faulty exciter
- Faulty synchronizing system
- Faulty rotor windings
- Faulty stator windings

Troubleshooting:

Check the power supply: Make sure that the synchronous machine is plugged in and that the power switch is turned on.

Check the fuse or circuit breaker: If it is blown or tripped, reset it or replace the fuse.

Check the wiring: Make sure that all of the connections are tight and that there are no breaks in the wires.

Check the exciter: Disconnect the power to the synchronous machine and then use a multimeter to check the output of the exciter. If the output is not correct, the exciter is faulty and needs to be repaired or replaced.

Check the synchronizing system: Disconnect the power to the synchronous machine and then use a multimeter to check the continuity of the synchronizing system wiring. If the wiring is not continuous, the synchronizing system is faulty and needs to be repaired or replaced.

Check the rotor windings: Disconnect the power to the synchronous machine and then use a multimeter to check the continuity of the rotor windings. If the windings are not continuous, the rotor windings are faulty and need to be repaired or replaced.

Check the stator windings: Disconnect the power to the synchronous machine and then use a multimeter to check the continuity of the stator windings. If the windings are not continuous, the stator windings are faulty and need to be repaired or replaced.

Repairing the fault: Once you have identified the cause of the fault, you can proceed to repair it. If the fault is in the wiring, simply tighten the connections or repair the broken wires. If the fault is in the exciter, synchronizing system, rotor windings, or stator windings, replace the faulty component.

DC machines

DC machines are electric machines that convert DC electrical energy into mechanical energy or vice versa. They are used in a wide variety of applications, including electric vehicles, industrial robots, and machine tools.

Ward-Leonard control: Ward-Leonard control is a classic method of DC machine control that uses two motor-generator sets to control the speed and torque of a DC motor.

Thyristor control: Thyristor control is a more modern method of DC machine control that uses thyristors to control the voltage and current applied to the DC motor.

Microprocessor control: Microprocessor control is the most advanced method of DC machine control and allows for precise control of the speed and torque of the DC motor.

Inspect the machine and control for any obvious damage. Look for loose connections, burnt wires, or damaged components.

Fig 11. Check DC machine

If you are unable to identify the problem, you may need to consult a qualified electrician.

- If the machine is not starting, check the starter. Make sure that the starter is turned on and that the starter contacts are closing.
- If the machine is running but not at full speed, check the machine control circuit. Make sure that the machine control circuit is providing the correct voltage and current to the machine.
- If the machine is overheating, check the ventilation around the machine. Make sure that the machine is not being blocked by any objects.
- If the machine is making strange noises, check the bearings. Make sure that the bearings are lubricated and that they are not worn out. Inspect the transformer and auxiliary for any obvious damage.

Transformer and auxiliary component:

A transformer is a static electrical device that transfers energy from one circuit to another through electromagnetic induction. A varying current in the first circuit (the primary) creates a varying magnetic field in the transformer, which in turn induces a varying current in the second circuit (the secondary). Transformers can be used to increase or decrease voltage, and they are also used to isolate circuits from each other.

Fig 12. Test secondar voltage transformer

Auxiliary transformer

An auxiliary transformer is a type of transformer that is used to provide a secondary voltage source for auxiliary equipment. Auxiliary equipment includes things like cooling fans, pumps, and control systems. Auxiliary transformers are typically smaller than power transformers, and they are often located inside the same enclosure as the equipment they are powering.

Examples of transformers and auxiliary components

Transformers:

Power transformers: These are used to transmit and distribute electricity over long distances.

Distribution transformers: These are used to step down the voltage from power transformers to a level that is safe for use in homes and businesses.

Electronic transformers: These are used in a variety of electronic devices, such as computers and televisions.

Auxiliary components:

Auxiliary transformers: These are used to provide a secondary voltage source for auxiliary equipment.

Cooling fans: These are used to keep electronic equipment from overheating.

Pumps: These are used to circulate fluids in a variety of applications, such as heating and cooling systems.

Control systems: These are used to monitor and control electrical systems.

Troubleshooting transformers and auxiliary components

There are a number of things that can go wrong with transformers and auxiliary components. Some common problems include:

- Overheating
- Overloading
- Short circuits
- Ground faults
- Insulation failure

Here are some tips for troubleshooting transformers and auxiliary components:

Check the temperature of the transformer. If it is overheating, it may be overloaded or have a ventilation problem.

Check the load on the transformer. If it is overloaded, it may need to be replaced with a larger transformer.

Check for short circuits and ground faults. These can be detected using a variety of test instruments.

Inspect the insulation for signs of damage. If the insulation is damaged, it may need to be replaced.

Repairing the fault:

Once you have identified the cause of the fault, you can proceed to repair it. If the fault is in the wiring, simply tighten the connections or repair the broken wires. If the fault is in the transformer bushing, conservator, breather, tap changer, or windings, replace the faulty component.

Causes of faults in ELV lighting devices,

There are a number of causes of faults in ELV lighting devices, including:

Transformer (iron core or electronic): Transformers can fail due to a number of reasons, such as overloading, overheating, or voltage spikes.

Voltage drops: If the voltage at the ELV device is too low, the device may not work properly or may fail altogether.

Heat: ELV devices can be sensitive to heat, and overheating can cause them to fail.

Over-voltage: If the voltage at the ELV device is too high, the device may be damaged or destroyed.

Poor connections: Loose or corroded connections can cause a variety of problems with ELV devices, including flickering, dimming, and complete failure.

Incompatible dimmers: Using an incompatible dimmer with an ELV device can damage or destroy the device.

Example

An ELV lighting system in a house is not working properly. The homeowner has tried replacing the bulbs, but the problem persists. The homeowner then calls an electrician to troubleshoot the problem. The electrician discovers that the transformer for the ELV system has failed. The electrician replaces the transformer and the ELV system starts working properly again.

preventing faults in ELV lighting devices

Here are some tips for preventing faults in ELV lighting devices

Use a transformer that is properly sized for the load.

- Avoid overloading the transformer.
- Make sure that the ELV devices are properly ventilated.
- Avoid installing ELV devices in hot or humid environments.
- Use surge protection devices to protect the ELV devices from voltage spikes.

- Make sure that all connections are tight and secure.
- Use compatible dimmers with ELV devices.
- Have your ELV lighting system inspected and serviced by a qualified electrician on a regular basis.

2.2. Equipment and associated

The correct operation of a circuit or equipment is essential to ensure safety and reliability. Switching and control circuit arrangements are used to control the flow of electricity in a circuit. They can be used to turn equipment on and off, to select different operating modes, or to protect equipment from damage.

Here is an example of a switching and control circuit arrangement for a simple lighting circuit:

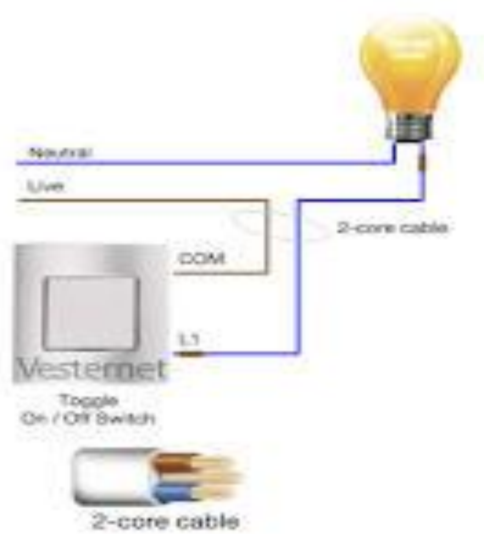

fig. 13. simple lighting circuit

The switching and control circuit arrangement in this example consists of a single-pole, single-throw (SPST) switch. The switch is connected in series with the light bulb and the power supply. When the switch is turned on, current flows through the circuit and the light bulb turns on. When the switch is turned off, the circuit is interrupted and the light bulb turns off.

Troubleshooting. simple lighting circuit

Here are some common problems that can occur with a simple lighting circuit and how to troubleshoot them:

Light bulb does not turn on:

- Check the light bulb to make sure it is not burned out.
- Check the switch to make sure it is turned on.
- Check the wiring connections to make sure they are tight and secure.

If the problem persists, use a voltage tester to check the voltage at the light bulb socket. If there is no voltage, the problem may be with the power source or the wiring.

Light bulb flickers:

- Check the wiring connections to make sure they are tight and secure.
- Check the switch to make sure it is making good contact.
- If the problem persists, the problem may be with the light bulb itself.

Light bulb burns out prematurely:

- Check the voltage at the light bulb socket. If the voltage is higher than the voltage rating of the light bulb, it will cause the light bulb to burn out prematurely.
- Check the ventilation around the light bulb. If the light bulb is not properly ventilated, it will overheat and burn out prematurely.

motor control circuit

motor control circuit arrangements can be much more complex than the simple example above. For example, a motor control circuit arrangement for a motor control circuit might include a contactor, a starter, and a variety of other components.:

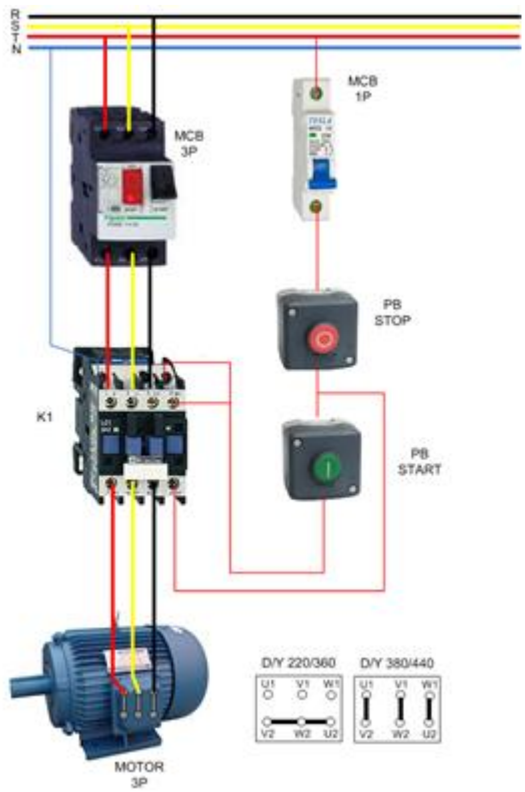

Fig 14. Check motor control circuit

Troubleshooting motor control circuit

Here are some common problems that can occur with a motor control circuit and how to troubleshoot them:

Motor does not turn on:

- Check the switch to make sure it is turned on.
- Check the wiring connections to make sure they are tight and secure.
- Use a voltage tester to check the voltage at the motor contactor terminals. If there is no voltage, the problem may be with the power source or the wiring.
- If there is voltage at the motor contactor terminals, check the motor contactor to make sure it is operating properly.

Motor runs but is noisy:

- Check the motor bearings to make sure they are lubricated properly.
- Check the motor shaft to make sure it is not bent or damaged.
- Check the motor belts or chains to make sure they are properly tensioned.

Motor overheats:

- Check the motor ventilation to make sure it is not blocked.
- Check the motor load to make sure it is not overloaded.
- Check the motor bearings to make sure they are lubricated properly.

Operator faults:

- Accidentally turning off a switch or breaker
- Using incorrect wiring procedures
- Overloading a circuit
- Incorrect connections:
- Loose or corroded connections
- Incorrectly sized wires
- Incorrectly wired outlets or switches

Open-circuits:

- Broken wires
- Blown fuses or tripped breakers
- Faulty devices

Short-circuits:

- Exposed wires touching each other
- Damaged insulation
- Faulty devices

Device faults (mechanical):

- Worn or broken parts
- Malfunctioning switches
- Overheated components

Supply faults:

- Low or high voltage
- Power outages
- Faulty wiring at the service panel

Here are some images of common faults with circuits and equipment:

fig 15. faults with circuits

If you experience any of the following symptoms, it is important to have the circuit or equipment inspected by a qualified electrician:

- Tripping breakers or blown fuses
- Dimming lights
- Sparks or arcing
- Burning smell
- Overheated devices
- Equipment that does not work properly

Circuit protective device

- Symptom: Circuit breaker trips or fuse blows.
- Causes: Overcurrent, short circuit, ground fault, faulty device.

Appliance does not operate:

- Symptom: Appliance does not turn on or does not work properly.
- Causes: Open circuit, faulty device, power supply problem.

Single phase motor does not develop enough torque to drive the load:

- Symptom: Motor runs but does not have enough power to turn the load.
- Causes: Low voltage, overloaded motor, faulty motor.

Three phase motor does not develop enough torque to drive the load:

- Symptom: Motor runs but does not have enough power to turn the load.
- Causes: Unbalanced voltage, overloaded motor, faulty motor.

Motor overload

- Symptom: Motor overload protection device.
- Causes: Overloaded motor, faulty motor, ventilation problem.

troubleshooting electrical faults

Here are some tips for troubleshooting electrical faults:

- Identify the symptoms. What is the problem that you are experiencing? Is it a tripped circuit breaker, a non-working appliance, or a motor that is not developing enough torque?
- Check the circuit protective devices. Are any circuit breakers tripped or fuses blown? If so, reset the circuit breaker or replace the fuse.
- Check the power supply. Is there power at the outlet or switch? If not, check the service panel to make sure that the main breaker is not tripped.
- Check the connections. Are all of the connections tight and secure? Loose connections can cause a variety of problems, including overheating, sparking, and equipment failure.

2.3. Circuit Testing procedure of Trouble-shooting

Check the devices themselves. If you have checked all of the above and the problem persists, it is likely that one of the devices on the circuit is faulty. Try disconnecting the devices one by one until you find the faulty device Identify the symptoms. What is the problem that you are experiencing? Is it a tripped circuit breaker, a non-working appliance, or a motor that is not developing enough torque?

Visually inspect the circuit. Look for any obvious signs of damage, such as loose connections, burned wires, or scorched components.

Test the circuit for voltage. Use a voltmeter to measure the voltage at different points in the circuit. If the voltage is below or above normal, this could be a sign of a problem.

Test the circuit for continuity. Use a continuity tester to check for continuity of the circuit. If there is no continuity, this means that there is a break in the circuit.

Test the circuit for ground faults. Use a ground fault tester to check for ground faults in the circuit. If there is a ground fault, this means that there is a current leakage from the circuit to ground.

2.4. Methods and technique of trouble-shooting

There are a number of different methods and techniques that can be used for troubleshooting electrical systems. Some of the most common methods include:

Visual inspection: This involves inspecting the electrical system for any obvious signs of damage, such as loose connections, burned wires, or scorched components.

Voltage testing: This involves using a voltmeter to measure the voltage at different **points in** the electrical system. This can help to identify problems with the power supply or with individual components.

Continuity testing: This involves using a continuity tester to check for continuity in the electrical system. This can help to identify breaks in the wiring or in individual components.

Ground fault testing: This involves using a ground fault tester to check for ground faults in the electrical system. This can help to identify problems with the wiring or with individual components.

Signal tracing: This involves using a signal tracer to track the signal through an electrical system. This can help to identify problems with the wiring or with individual components.

In addition to these general methods, there are also a number of specific troubleshooting techniques that can be used for different types of electrical systems. For example, there are specific troubleshooting techniques for AC circuits, DC circuits, electronic circuits, and power systems.

Example:

A homeowner is having problems with their kitchen lights. The lights are flickering and sometimes they don't turn on at all. The homeowner decides to troubleshoot the problem themself.

The homeowner then uses a ground fault tester to check for ground faults in the electrical system. There are no ground faults.

The homeowner is now stumped. They have checked all of the obvious things and they still can't figure out why the lights are flickering and sometimes not working in the wiring box behind the light switch. The electrician tightens the connection and the lights start.

The homeowner decides to call a qualified electrician. The electrician comes to the house and inspects the electrical system.

Fig 16. Testing circuit breaker

troubleshooting electrical systems:

Start by identifying the symptoms of the problem: What is not working? What are the symptoms of the problem? Once you have identified the symptoms, you can begin to narrow down the possible causes.

Gather information: This includes gathering information about the electrical system, the components involved, and the environment. You should also gather information about the symptoms of the problem, when it started, and any changes that have been made to the system recently.

Form a hypothesis: Based on the information you have gathered you can begin to form a hypothesis about the cause of the problem. This is your best guess about what is wrong with the system.

Test the hypothesis: Once you have a hypothesis, you need to test it to see if it is correct. This may involve performing experiments, making measurements, or inspecting the system.

Analyze the results: Once you have tested your hypothesis, you need to analyze the results to see if they support your hypothesis. If the results do not support your hypothesis, you need to go back and form a new hypothesis.

Fix the problem: Once you have identified the cause of the problem, you can fix it. This may involve repairing a component, replacing a component, or making changes to the system.

2.5. Circuit and wiring diagrams

Circuit diagrams and wiring diagrams are important tools for troubleshooting electrical installations in buildings. Circuit diagrams show how the electrical components in a circuit are connected, while wiring diagrams show the physical layout of the electrical wires and devices. To troubleshoot an electrical problem in a building, it is helpful to have a circuit diagram and wiring diagram for the circuit in question. This will help you to identify the components that are involved in the circuit and to trace the path of the electrical current.

Here are some troubleshooting electrical installations in buildings using circuit diagrams and wiring diagrams:

Identify the circuit that is affected by the problem. To do this, you can use the circuit diagram to trace the path of the electrical current from the power source to the load (e.g., light bulb, outlet, etc.).

Once you have identified the circuit, use the wiring diagram to locate the electrical components in the circuit. This will help you to identify the component that is causing the problem.

Once you have identified the component that is causing the problem, you can troubleshoot the component to determine the specific cause of the problem. This may involve using a variety of test instruments, such as a multimeter or a voltage tester.

Once you have determined the specific cause of the problem, you can repair the problem or replace the component if necessary.

Here are some examples of how to use circuit diagrams and wiring diagrams to troubleshoot common electrical problems in buildings:

Problem: A light bulb is not working.
Troubleshooting:

- Use the circuit diagram to identify the circuit that the light bulb is on.
- Use the wiring diagram to locate the light bulb socket and the switch that controls the light bulb.
- Check to make sure that the switch is turned on.
- Check the light bulb to make sure that it is not burned out.

- If the light bulb is not burned out, use a voltage tester to check the voltage at the light bulb socket. If there is no voltage, the problem may be with the switch, the wiring, or the power source.
- If there is voltage at the light bulb socket, the problem may be with the light bulb itself.

Problem: A circuit breaker is tripping frequently.

Troubleshooting:

- Use the circuit diagram to identify the circuit that the circuit breaker is protecting.
- Use the wiring diagram to locate all of the electrical components on the circuit.
- Check all of the electrical components on the circuit for signs of damage or overheating.
- If you cannot find any signs of damage or overheating, you may need to reduce the load on the circuit by unplugging some of the electrical devices that are connected to it.
- If the circuit breaker continues to trip after you have reduced the load, you may need to replace the circuit breaker.

basic fluorescent light circuit

Fluorescent lamp: The fluorescent lamp is a glass tube that is filled with a low-pressure mercury vapor. When an electric current is applied to the lamp, the mercury vapor emits ultraviolet light. This ultraviolet light causes the phosphor coating on the inside of the lamp to glow, which produces visible light.

Ballast: The ballast is a transformer that provides the high voltage and current needed to start and operate the fluorescent lamp. The ballast also regulates the current flowing through the lamp to prevent it from overheating.

Starter: The starter is a switch that is used to start the fluorescent lamp. When the power is turned on, the starter closes and allows current to flow through the lamp. Once the lamp is started, the starter opens and disconnects itself from the circuit.

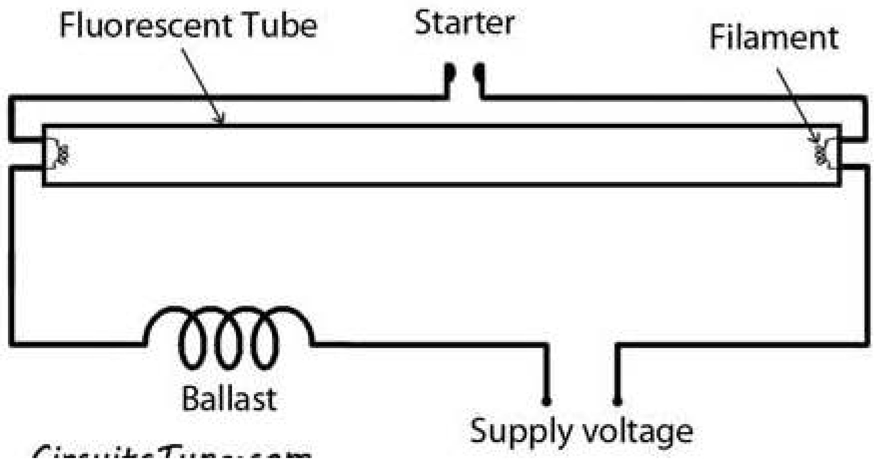

Fig 17. Fluorescent lamp.

Problem: Fluorescent lamp does not turn on.

Troubleshooting

- Check the light bulb to make sure it is not burned out.
- Check the switch to make sure it is turned on.
- Check the wiring connections to make sure they are tight and secure.
- Use a voltage tester to check the voltage at the light bulb socket. If there is no voltage, the problem may be with the power source or the wiring.
- If there is voltage at the light bulb socket, check the ballast to make sure it is operating properly.

Problem: Fluorescent lamp flickers or buzzes.

Troubleshooting

- Check the wiring connections to make sure they are tight and secure.
- Check the ballast to make sure it is operating properly.
- Check the starter to make sure it is operating properly.
- Check the light bulb to make sure it is not burned out.

Problem: Fluorescent lamp burns out prematurely.

Troubleshooting

- Check the voltage at the light bulb socket. If the voltage is higher than the voltage rating of the light bulb, it will cause the light bulb to burn out prematurely.

- Check the ventilation around the light bulb. If the light bulb is not properly ventilated, it will overheat and burn out prematurely.
- Check the ballast to make sure it is operating properly.

Some common faults & rectification of fluorescent lamp

No	**Faults**	**Rectification**
1	Lamp doesn't glow but flicks Cause: - lamp is defective - Low voltage - Defective starter	Replace after testing Check up the voltage Test the starter.
2	Lamp doesn't start Cause: - Open circuit in the filament Loose or broken connections	a) Test the filament. b) Test the wire & tighten the loose connections.
3	Lamp burns out often Cause: - High voltage	Check the voltage
4	Lamp filament glow but not light up. Cause: - short circuit of the starter contacts Capacitor short circuited	test the starter test and replace condenser
5	Lamp burns out often Cause: - low voltage Spoiled chock Loose connection in the holder and starter	check the voltage check the chock Check the lamp holder, connections, & the starter contact.
6	Blackening of the lamp at the ends after short use, Cause: - High voltages Choke coil is shorted	checks and reduce the voltage test and replace the choke

2.6. Critical aspects of trouble-shooting

- **Identifying the problem**: What is happening? What are the symptoms?
- **Gathering information**: What are the possible causes of the problem? What have you tried so far?
- **Developing a hypothesis**: What is the most likely cause of the problem?
- **Testing the hypothesis**: Try to fix the problem based on your hypothesis.
- **Evaluating the results**: Did your solution fix the problem? If not, go back to step 3.

Here is an example of troubleshooting a broken toaster:

- **Identify the problem**: The toaster is not turning on.
- **Gather information:** The toaster is plugged in and the outlet is working. I have tried turning the toaster on and off multiple times.
- **Develop a hypothesis**: The toaster may be broken because of a power cord issue or an internal problem.
- **Test the hypothesis**: First, I will try plugging the toaster into a different outlet. If that does not work, I will try replacing the power cord. If that still does not work, I will need to open up the toaster and inspect the internal components.
- **Evaluate the results**: If plugging the toaster into a different outlet fixes the problem, then the issue was with the original outlet. If replacing the power cord fixes the problem, then the issue was with the power cord. If neither of those solutions work, then the issue is likely with an internal component of the toaster and I will need to take it to a repair shop.

I Self-check-2

I. Choose the best answer from the give alterative

1.Which of the following is NOT a type of circuit?

A. AC circuit C. Series circuit

B. DC circuit D. Parallel circuit

2.Which of the following is NOT a type of electrical machine?

A. Motor C. Transformer

B. Generator D. Battery

3.Which of the following is NOT a type of electrical plant?

A. Power plant C. Transmission line

B. Substation D. Distribution line

4.Which of the following is NOT a piece of electrical equipment?

A. Circuit breaker C. Switch

B. Fuse D. Battery

5.Which of the following is NOT a critical aspect of troubleshooting?

A. Identifying the fault C. Testing the circuit

B. Repairing the fault D. Understanding the circuit

II Matching:

Direction: Match Column A with Column B. Write the letter only.

Column A	Column B.
1. measure the voltage across a component	A. Voltage test
2.measure the current flowing through a component	B. Current test
3. check if a circuit is complete	C. Continuity test
4. divide the circuit into smaller sections and test each section individually	D. Process of elimination
5. replace suspected faulty components with known good components	E. Division of the circuit
6. measure the voltage, drop across components to identify the faulty component	F. Substitution method
7.systematically eliminate possible causes of the fault until the fault is found	G. Voltage drop method

III Short answer:

1.What is the purpose of circuit and wiring diagrams?

2.What are some of the challenges of troubleshooting complex electrical systems?

Operation sheet 1. Steps how to Troubleshooting Electrical apparatus

Steps how to Troubleshooting Electrical apparatus

The following steps will guide you through the preparation and termination process for UTP cable. Following these guidelines will help give you the optimum performance from the twisted pair cabling.

Step 1: Gather the information

step 2. Understand the malfunction

step 3. Identify which parameters need to be evaluated

step 4. Identify the source of the problem

step 5. Correct/repair the component

step 6. Verify the repair

step 7. Perform root cause analysis

Operation sheet 2 Steps how to find Electrical apparatus fault

Steps how to find Electrical apparatus fault

Step 1: Notify what exactly is the problem.

Step 2: Gather more details, eliminate variables.

Step 3: Reproduce the problem.

Steps4: Develop hypothesis of root cause.

Step 5: Attempt a fix based on findings.

Step 6: maintain the fault

Lap test

Name………………………………. ID…………………………….

Date…………………………………….

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 1 hour. The project is expected from each student to do it.

Task: 1. Troubleshooting Electrical apparatus?

Task: 2. Find the faults of Electrical apparatus?

Task: 3. Fix and troubleshoot circuit breaker (CB)?

UNIT THREE: COMPLETION AND REPORT TROUBLE-SHOOT AND REPAIR ACTIVITIES

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

- justification for repairs to apparatus.
- Documentation and reporting
- Clean and a safe work area

Visual fault/breakdown inspectionThis 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:

- Protect justification for repairs to apparatus.
- Write documentation and reporting
- Clean and a safe work area safe

3.1. justification for repairs to apparatus

Troubleshooting is a form of problem solving, often applied to repair failed products or processes on a machine or a system. In general, troubleshooting is the identification or diagnosis of "trouble" in the management flow of a system caused by a failure of some kind.

There are several justifications for repairs to apparatus in an electrical installation. Here are some common reasons why repairs may be necessary:

Safety: The primary concern when it comes to electrical installations is safety. If any apparatus within the installation is damaged or malfunctioning, it can pose a significant risk of electrical shocks, fires, or other accidents. Repairing the faulty apparatus ensures that the electrical system operates safely and minimizes the risk of harm to people and property.

Compliance with regulations: Electrical installations are subject to various regulations and codes to ensure they meet specific safety standards. If any apparatus within the installation is not functioning correctly or is outdated, it may not comply with the applicable regulations.

Repairing or replacing the faulty apparatus ensures that the installation remains compliant with the relevant codes and standards.

Performance and efficiency: Faulty apparatus can lead to a decrease in the performance and efficiency of the electrical system. For example, damaged wiring or connectors may lead to voltage drops, power losses, or poor electrical connections. By repairing or replacing the faulty components, the electrical system can operate at its optimum level, ensuring reliable performance and efficient energy usage.

Preventive maintenance: Regular maintenance and repairs are essential to prevent more significant issues from arising in the future. By addressing minor problems promptly, you can avoid costly breakdowns, extensive repairs, or complete system failures. Repairing the apparatus in a timely manner helps maintain the integrity and reliability of the electrical installation.

Equipment lifespan: Apparatus within an electrical installation has a specific lifespan, and their performance may deteriorate over time. Repairs may be necessary to extend the life of the apparatus, especially if replacement is not immediately feasible or cost-effective. Repairing or refurbishing the existing apparatus can help ensure its continued functionality until a more comprehensive upgrade can be implemented.

Cost savings: Repairing faulty apparatus is often more cost-effective than replacing the entire system. By identifying and fixing the specific issues, you can minimize expenses while still maintaining the functionality and safety of the electrical installation. This is particularly relevant in situations where the faulty apparatus is a component of a larger system that does not require replacement.

In summary, the justification for repairs to apparatus in an electrical installation revolves around safety, compliance, performance, preventive maintenance, equipment lifespan, and cost savings. By addressing and resolving issues promptly, you can ensure the optimal functioning and longevity of the electrical system while maintaining a safe environment.

3.2 Documentation and reporting

It is important to document and report all troubleshooting and repair activities. This documentation should include the following information:

- The date and time of the troubleshooting and repair activities
- The name of the person who performed the troubleshooting and repair activities
- A description of the problem
- A description of the troubleshooting and repair steps that were taken
- The results of the troubleshooting and repair activities

This documentation can be used to track the history of the apparatus and to identify any recurring problems. It can also be used to train other personnel on how to troubleshoot and repair the apparatus.

Example:

A technician troubleshoots and repairs a broken toaster. The technician documents the following information:

- Date and time: -----------------
- Technician name: ------ ----------------
- Description of the problem: The toaster oven is not turning on.
- Description of the troubleshooting and repair steps: The technician checked the power cord and found that it was damaged. The technician replaced the power cord and the toaster turned on.
- Results: The toaster oven is now working properly.

The technician also takes a photo of the damaged power cord and attaches it to the documentation.

.

Fig 18. Toaster oven

3.3. Clean and a safe work area

A clean workplace means more than just having a sparkling, fresh building. A clean workplace also ensures the safety and health of employees and visitors.

Workplace injuries can be prevented by taking action to ensure a clean, safe work environment

Here are some tips to help make your workplace safe.

- Understand the risks. ...
- Reduce workplace stress. ...
- Take regular breaks. ...
- Avoid stooping or twisting. ...
- Use mechanical aids whenever possible. ...
- Protect your back. ...
- Wear protective equipment to suit the task. ...
- Stay sober.

10 Easy Workplace Safety

1. Train employees well.

Comprehensive training is a must for preventing workplace injury. Make sure that all of your employees have access to – and complete – all safety training for their positions.

2. Reward employees for safe behavior.

Rewards are an easy way to encourage workplace safety. Giving out small rewards to employees who follow safety policies keeps them engaged, which can make a big difference in reducing workplace injuries.

3**. Partner with occupational clinicians**.

As mentioned above, occupational medicine clinicians can provide valuable insight into workplace injury and prevention. These clinicians can help you prevent work injuries by visiting your worksite and identifying areas where there's a high risk for employee injury. Physical and occupational therapists can also improve workplace ergonomics and develop human performance evaluations to help you screen candidates for physically demanding roles and aid in the return-to-work process.

4**. Use labels and signs**.

Labels and signs are a cheap and effective way to quickly communicate important information. They're usually simple and rely on pictures to detail hazards and proper procedures. These tools are good reminders and warnings for even the most experienced worker.

5. **Keep things clean**.

A messy workplace can lead to unnecessary accidents. Make sure boxes are stacked safely and spills are cleaned up quickly. Conduct regular inspections to check for potential dangers such as tangled cords, messy floors, and disorganized tools. Programs like 5S often provide beneficial improvements in organization that can lead to reduced clutter.

6. Make sure employees have the right tools and have regular equipment inspections.

The right tools and equipment create a better product and a safer work environment. It's also important that all equipment is cleaned, serviced, and inspected regularly. Machine malfunctions are one of the most dangerous workplace hazards.

7. **Encourage stretch breaks.**

Stretch breaks are an easy way to improve workplace ergonomics and employee health. Taking even five minutes to stretch can ease muscle tension and loosen joints, reducing the potential for repetitive motion injuries. Active movements have been shown to be more effective than passive stretching alone.

8. **Implement safety protocols from the start.**

Workplace safety starts from day one, which means hiring qualified people who pay attention to detail. A safe workplace starts with employees who follow safety requirements and perform their jobs per the established procedures. Some employers work with physical therapists to analyze the physical demands of each job role. The findings are used to create functional job analyses and post-offer pre-placement functional testing.

9. **Keep an open dialogue**.

Make it easy for your employees to come to you with health and safety concerns. They can report hazards right away and identify potential areas of concern you may not have noticed. Appoint or nominate a safety captain who is empowered to communicate concerns identified by employees to leadership on a consistent basis.

10. Have regular meetings on workplace safety.

It never hurts to be over-prepared. Regular meetings to review safety rules and discuss prevention keep workplace safety top of mind so that when something does happen, everyone knows what to do right away.

As an employer, it's your responsibility to protect your employees and provide a safe workplace. Use these ten tips to get started, and partner with Concentra® to help make your workplace safe, healthy, and productive.

Self-check 3

I. Choose the best answer from the give alterative:

1. Which of the following is NOT a valid reason for repairing apparatus?
   A. restore the apparatus to its original condition
   B. ensure the safe and reliable operation of the apparatus
   C. To comply with safety regulations
   D. To save money

2.Which of the following documentation should be included in a justification for repairs to apparatus?

A. description of the apparatus
B. description of the fault
C. Recommendation for the repair
D. All of the above

II. Matching:

Direction: Match Column A with Column B. Write the letter only.

<u>Column A</u>	<u>Column B.</u>
1. justify the cost of the repair	A. Apparatus name
2 identify the apparatus that needs to be repaired	B. Repair cost
3. describe the work that needs to be done	C. Repair description
4.explain why the apparatus needs to be repaired	D. Reason for repair

III Short answer:

Why is it important to document and report on repairs to apparatus?

What are some of the challenges of documenting and reporting on repairs to apparatus?

Reference Materials

1. Electrical Motor Controls for Integrated Systems" by Gary Rockies and Glen Mazur (Latest edition: 2021)
2. Industrial Electricity and Motor Controls" by Rex Miller and Mark Miller (Latest edition: 2020)
3. Electrical Wiring Commercial" by Ray C. Mullin and Phil Simmons (Latest edition: 2018)
4. Practical Troubleshooting of Electrical Equipment and Control Circuits" by Mark Brown (Latest edition: 2016)
5. Electricity and Controls for HVAC-R" by Stephen L. Herman (Latest edition: 2014)

Developer's Profile

No	Name	Qualification (Level)	Field of Study	Organization/ Institution	Mobile number	E-mail
1	Mengistu Abiyu	MSc	Industrial Automation & Control Management	Lideta Manufacturing College	0913948480	menabiy@gmail.com
2	Samuel Bekele	MSc	Industrial Automation & Control Management	Haramaya PTC	910082977	samuelbekele460@gmail.com
3	Yidnekachew Seboka	BSc	Electrical Automation & Control Technology	Akaki PTC	920137899	www.yidne23@gmail.com
4	Zegeye Girma	BSc	Electrical Automation & Control Technology	Addis Ketema In.College	926805563	zegeyegirma2@gmail.com
5	Bacha Wake	MSc	Industrial Automation & Control Management	Hawassa Tegibarid PTC	987065251	bachawake@gmail.com