University of Engineering & Technology (UET) Taxila

Electrical Engineering Department

Industrial Automation Lab

Complex Engineering Problem

Statement**: Automating of Cement Making Process System**

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Section**: C**

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Objectives:

- Designing an effective short circuit protection scheme for a transformer.
- Ensuring reliability and sensitivity in fault detection.
- Implementing the protection scheme in hardware according to specified ratings.
- Compiling a comprehensive project report detailing the design procedure and testing results.
- Demonstrating the functionality of the implemented protection scheme through a hardware demonstration.

Introduction:

In the realm of electrical engineering, ensuring the reliable operation of power systems is paramount. One critical aspect of this is safeguarding power system equipment, such as transformers, against various faults that may occur during operation. Among these faults, short circuits pose a significant threat to the integrity and functionality of transformers. Therefore, the implementation of robust short circuit protection schemes is essential to prevent potential damage and ensure uninterrupted power supply.

The Short Circuit Protection of a Transformer project aims to address this vital aspect of power system protection. By designing and implementing a tailored protection scheme, our objective is to mitigate the risks associated with short circuit faults and enhance the reliability of transformer operation. This project encompasses a multi-faceted approach, involving theoretical research, circuit design, hardware implementation, and comprehensive documentation.

Equipment:

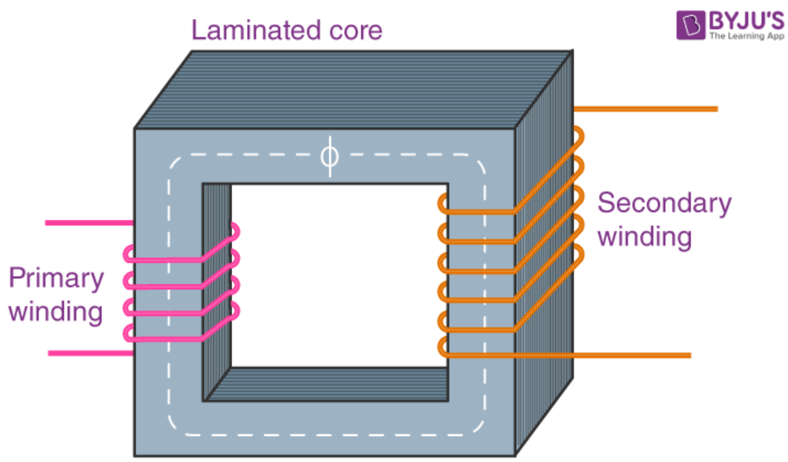
- Current Sensitive Relay (AC 180V – 440V, 5A – 70A)
- Magnetic Contactor (240V, 5.5kW, 22A)
- DC Relays (DC 28V, 10A)
- Transformer (AC 230V - 12V, 50Hz)
- 12V Power Supply (220V AC - 12V DC)
- Voltmeter (2) (20-500V)
- Ammeter (2) (0-100A)
- Bulbs (2) (AC 12V)
- Toggle Switches (3)

- Puch Button (Reset Button)
- Red LED
- Socket
- Wires
- Wooden Box
- Soldering Iron & Wire
- Screws
- Glass Sheet

Theory:

(Transformers)

A transformer is a fundamental electrical device used for transferring electrical energy from one circuit to another through electromagnetic induction. It primarily functions to change voltage levels between the primary and secondary winding while maintaining the frequency of the alternating current (AC) supply. Transformers play a crucial role in power distribution, transmission, and various electrical applications.



(Basic Operation)

Principle of Electromagnetic Induction: Transformers operate based on Faraday's law of electromagnetic induction, which states that a changing magnetic field induces a voltage in a nearby conductor. When an alternating current flows through the primary winding of a transformer, it produces a changing magnetic field, which induces a voltage in the secondary winding.

Voltage Transformation: The ratio of the number of turns in the primary winding to the number of turns in the secondary winding determines the voltage transformation ratio of the transformer. Step-up transformers increase voltage levels, while step-down transformers decrease voltage levels.

(Types of Transformers)

Power Transformers:

Description: Power transformers are large-scale transformers used for voltage transformation in high voltage transmission and distribution systems. They handle high power levels and are essential for efficient energy transmission over long distances.

Applications: Power transformers are commonly employed in electrical substations to step up voltages for long-distance transmission and step down voltages for distribution to consumers. They are also utilized in industrial settings for powering large machinery.

Distribution Transformers:

Description: Distribution transformers are smaller transformers typically used in electrical distribution networks to supply power to residential, commercial, and industrial areas. They operate at lower voltage levels compared to power transformers.

Applications: Distribution transformers are installed on utility poles or pad-mounted in substations to step down high voltage from the transmission lines to lower voltages suitable for consumer use. They are essential for delivering electricity safely and efficiently to end-users.

Instrument Transformers:

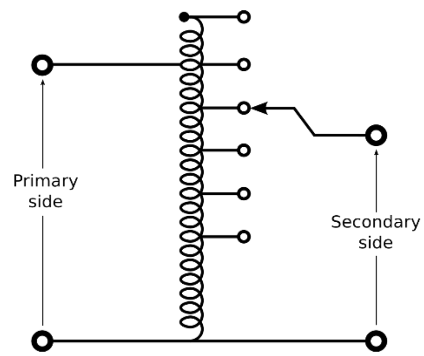
Description: Instrument transformers are specialized transformers designed for measuring voltage and current in high voltage systems. They provide accurate representations of high voltage and current levels at reduced magnitudes suitable for instrument and metering purposes.

Types: Instrument transformers include current transformers (CTs) for measuring current and voltage transformers (VTs), also known as potential transformers (PTs), for measuring voltage.

Auto Transformers:

Description: Auto transformers are transformers with a single winding tapped at various points to provide different voltage levels. Unlike conventional transformers with separate primary and secondary windings, auto transformers use a common winding for both input and output.

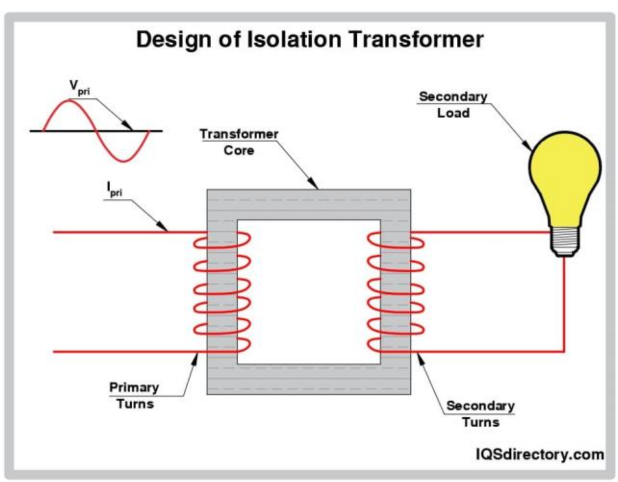
Applications: Auto transformers are used in applications where voltage transformation ratios are relatively small, such as voltage regulation in electrical systems and motor starting circuits.



Isolation Transformers:

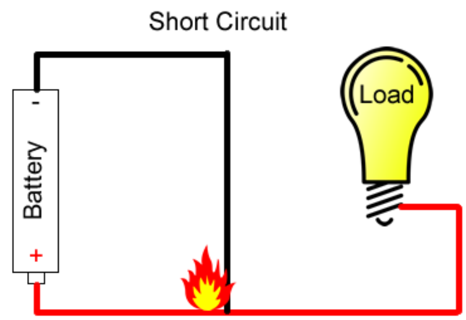
Description: Isolation transformers are transformers designed to electrically isolate the primary and secondary circuits, providing galvanic isolation. They have separate primary and secondary windings and do not have a direct electrical connection between the input and output.

Applications: Isolation transformers are commonly used in sensitive electronic equipment, such as medical devices, audio equipment, and data communication systems, to protect against electrical noise, voltage spikes, and ground loop problems.



(Short Circuit Fundamentals)

A short circuit refers to an abnormal condition in an electrical circuit where an unintended low-resistance path is created between two or more conductors, resulting in excessive current flow. This low-resistance path bypasses the intended load and can lead to potentially hazardous situations, including equipment damage, fires, and electrical hazards.



(Causes of Short Circuits)

Faults: Short circuits can occur due to faults in electrical insulation, equipment failure, or accidental contact between conductors.

Overloads: Excessive current flow caused by overloading a circuit beyond its rated capacity can lead to overheating and short circuits.

Environmental Factors: External factors such as moisture, dust, and debris can cause insulation breakdown and create short circuits.

Equipment Malfunction: Malfunctioning electrical equipment or damaged wiring can create unintended short circuits in a circuit.

(Types of Short Circuits)

Phase-to-Phase Short Circuit: Occurs when two phases of a three-phase electrical system come into contact due to insulation failure or equipment malfunction.

Phase-to-Ground Short Circuit: Involves a direct connection between one phase conductor and ground, typically caused by insulation breakdown or accidental contact.

Three-Phase Short Circuit: Involves simultaneous short circuits between all three phases of a three-phase electrical system, resulting in a significant fault current.

Line-to-Line Short Circuit: Refers to a short circuit between two line conductors, often seen in transmission and distribution systems.

(Effects of Short Circuits)

Equipment Damage: Short circuits can cause damage to electrical equipment, including transformers, circuit breakers, motors, and conductors, due to excessive current flow and overheating.

Fire Hazard: The high temperatures generated by short circuits can ignite nearby combustible materials, leading to fires and property damage.

Power Interruptions: Short circuits can disrupt power supply to electrical systems, causing downtime, production losses, and inconvenience to consumers.

Electrical Hazards: Short circuits pose electrical shock hazards to personnel working on or near affected equipment, especially in industrial and construction settings.

(Detection and Protection)

Protective Relays: Specialized devices called protective relays are used to detect abnormal conditions, including short circuits, and initiate protective actions such as circuit interruption.

Overcurrent Protection: Overcurrent protective devices such as fuses and circuit breakers are employed to interrupt the flow of excessive current during short circuit conditions, preventing further damage to equipment and mitigating hazards.

Selective Coordination: Coordination between protective devices ensures that only the nearest device to the fault operates to isolate the faulted section while maintaining continuity of service in unaffected areas.

(Transformer Short Circuit Protection and Protection Scheme)

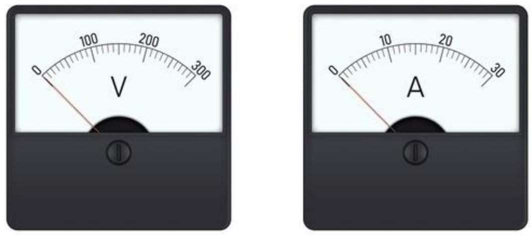
In transformer applications, short circuit protection is essential to safeguard the transformer from damage and ensure the safety of the surrounding electrical system. The protection scheme typically involves the use of protective relays, circuit breakers, and other auxiliary devices to detect short circuit faults and isolate the affected section of the circuit. In this scenario, we are implementing a protection scheme using an AC current-sensitive relay and a magnetic contactor on the primary side of the transformer, along with voltmeters and ammeters on both sides of the transformer. Additionally, we have two loads on the secondary side of the transformer that can be turned on and off, and a control circuit consisting of two DC (12V) relays.

(Component Used)

AC Current-Sensitive Relay: This relay is designed to detect abnormal currents, such as those occurring during a short circuit, and initiate protective actions.

Magnetic Contactor: The contactor serves as a switching device to interrupt the primary current flow in response to a signal from the AC current-sensitive relay.

Voltmeters and Ammeters: These instruments are installed on both the primary and secondary sides of the transformer to monitor voltage and current levels, providing essential feedback for the protection scheme.



Loads on Secondary Side: The loads connected to the secondary side of the transformer represent the consumer load, which may vary in magnitude and can be turned on or off as needed.

DC Relays: The DC relays in the control circuit are used to control the operation of the magnetic contactor based on signals received from the AC current-sensitive relay.

(Protection Scheme Operation)

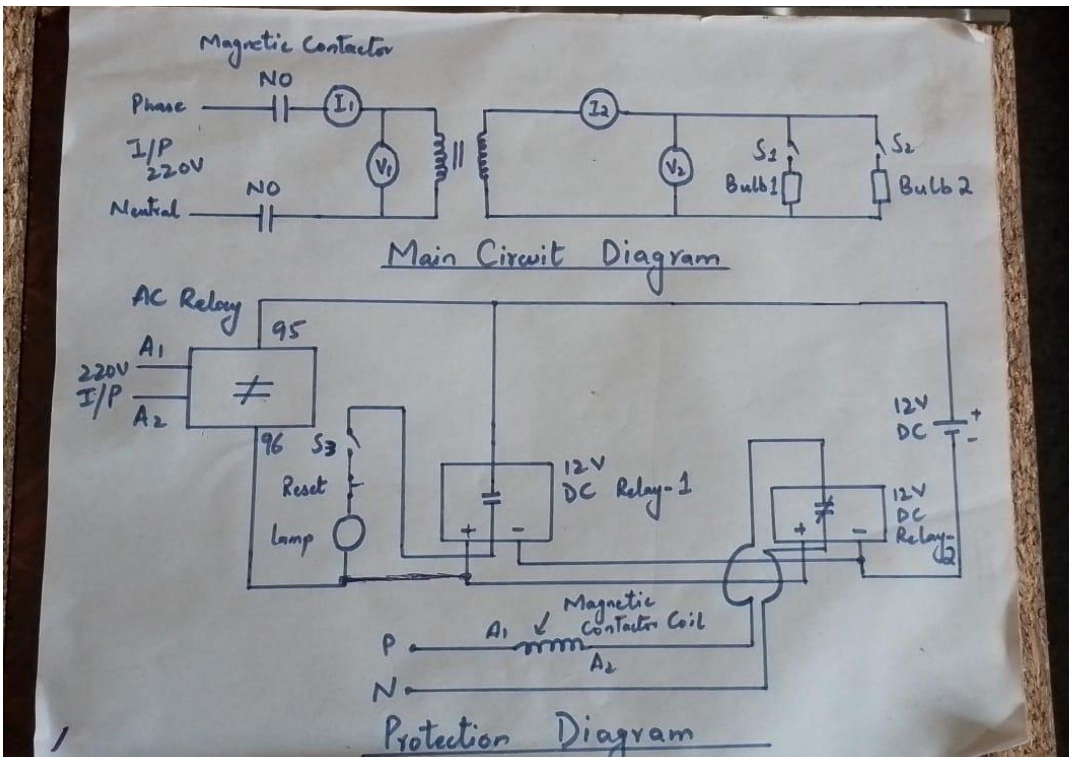
Detection of Short Circuit: When a short circuit occurs in the transformer circuit, the AC current-sensitive relay detects the abnormal current flow and sends a signal to the control circuit.

Activation of Magnetic Contactor: Upon receiving the signal from the AC current-sensitive relay, the control circuit energizes one of the DC relays, which in turn activates the magnetic contactor on the primary side of the transformer.

Isolation of Faulted Section: The magnetic contactor interrupts the primary current flow, effectively isolating the transformer from the short circuit fault. This prevents further damage to the transformer and associated equipment.

Monitoring and Feedback: Throughout the protection scheme operation, voltmeters and ammeters on both sides of the transformer continuously monitor voltage and current levels, providing feedback on the status of the circuit and the effectiveness of the protection scheme.

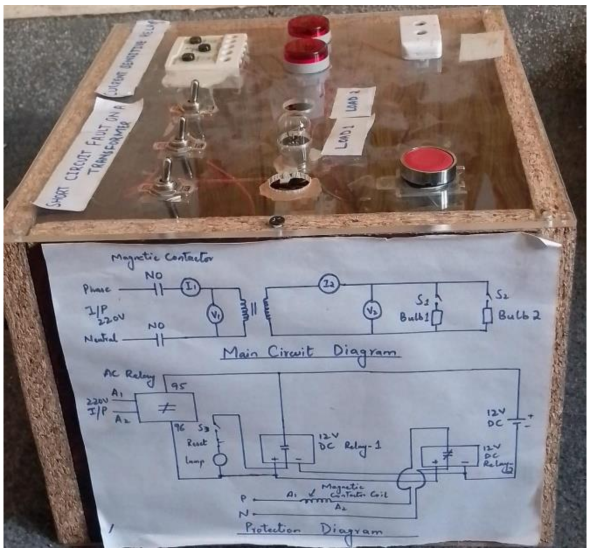
Circuit Diagram:



Working:

An AC current-sensitive relay is positioned on the primary side of the transformer, continuously monitoring current flow. In the event of a short circuit, where current surpasses a predefined threshold, the relay triggers a response. This prompts one of the two DC relays in the control circuit to activate. Activation of a relay prompts the magnetic contactor on the primary side to open its contacts, halting current flow to the transformer. Meanwhile, voltmeters and ammeters on both primary and secondary sides provide real-time readings of voltage and current levels. The loads on the secondary side, representing consumer loads, can be toggled on or off as required. This comprehensive setup ensures rapid short circuit detection and isolation, safeguarding the transformer and associated equipment from damage while maintaining operational flexibility.

Hardware:



Conclusion:

In conclusion, the experiment demonstrates an effective short circuit protection scheme for a transformer, utilizing an AC current-sensitive relay and magnetic contactor on the primary side, alongside voltmeters, ammeters, and controllable loads on the secondary side. This scheme promptly detects short circuit faults, triggers appropriate protective actions, and isolates the transformer from potential damage. The integration of monitoring instruments ensures real-time assessment of voltage and current levels, enhancing system reliability. Overall, this experiment showcases a practical and reliable solution for safeguarding transformers against short circuit faults, contributing to the safety and stability of electrical systems.