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PLC Based Transformer Protection from Over Voltage and Under Voltage

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Abstract:- A PLC (Programmable Logic Controller) based transformer protection system is an electronic system designed to protect industrial transformers from various electrical faults and abnormalities. The system utilizes sensors to detect electrical parameters such as voltage, current, and temperature and uses a PLC to process the data and control the transformer's operation. The protection system can be programmed to detect faults such as overload, overvoltage, undervoltage, phase loss, phase reversal, and over-temperature conditions. Once a fault is detected, the PLC will automatically shut down the transformer to prevent further damage. The system provides reliable and accurate protection to the transformer, reducing the risk of costly downtime and repairs. Transformer protection from over and under voltages is a critical aspect of any transformer control system. Overvoltage can damage the transformer's insulation, bearings, and winding, while undervoltage can cause the transformer to stall or overheat. To protect the transformer from these conditions, various protection devices can be employed, including overload relays, circuit breakers, and voltage monitors. To protect against overvoltage, a voltage monitor can be installed, which will detect any voltage spikes or surges and trigger an alarm or shut down the transformer if the voltage exceeds a predetermined threshold. Similarly, an undervoltage relay can be used to protect the transformer from low voltage conditions. The undervoltage relay will monitor the voltage levels and shut down the transformer if the voltage drops below a certain level..

Key Words:-PLC (Programmable Logic Controller), SMPS, Voltage Controlled Relay, LED indicators, Transformer and Dimmer.

1. INTRODUCTION:-

1.1. Objective:-

PLC stands for Programmable Logic Controller. It is a digital computer-based device used for automation and control of industrial processes, such as machinery on a factory floor. PLCs are designed to operate in harsh environments and can withstand extreme temperatures, vibration, and electrical noise. PLCs consist of a central processing unit (CPU), memory, input/output (I/O) modules, and programming software. The CPU executes the program stored in memory, which is created using the programming software. The I/O modules are used to interface with sensors and actuators that monitor and control the process.

PLCs are commonly used in transformer protection systems to monitor and control the transformer's operation and protect it from various electrical faults and abnormalities. PLCs can be programmed to monitor parameters such as voltage, current, and temperature and respond to any deviations from the expected values. For example, a PLC-based transformer protection system can be programmed to detect overload conditions, where the transformer is drawing too much current. If an overload is detected, the PLC can automatically shut down the transformer to prevent damage. Similarly, the PLC can monitor the voltage and detect any overvoltage or undervoltage conditions that could cause damage to the transformer.

1.2. Description:-

PLCs can also be used to control the transformer's starting and stopping sequences, ensuring that the transformer is started and stopped safely and efficiently. For instance, the PLC can be programmed to gradually ramp up the transformer's speed to prevent mechanical stresses, and similarly ramp down the speed during the stopping sequence to prevent abrupt stops. Therefore there will be use of over and under voltage relay in order to protect the transformer. overvoltage and undervoltage relays are commonly used as protective devices in transformer protection systems to prevent damage to the transformer due to over and under voltage conditions.

Overvoltage relay: An overvoltage relay is a protective device that monitors the voltage level of the transformer and triggers an alarm or shuts down the transformer if the voltage exceeds a preset threshold. The overvoltage relay works by comparing the actual voltage level with the set voltage level. If the voltage exceeds the set level, the relay will activate and send a signal to the control system to shut down the transformer.

Undervoltage relay: An undervoltage relay is a protective device that monitors the voltage level of the transformer and triggers an alarm or shuts down the transformer if the voltage drops below a preset threshold. The undervoltage relay works by comparing the actual voltage level with the set voltage level. If the voltage drops below the set level, the relay will activate and send a signal to the control system to shut down the transformer.

Both overvoltage and undervoltage relays can be wired into the transformer control circuit, and they can be interfaced with a PLC to provide automatic transformer protection. The PLC can be programmed to monitor the status of the relays and take action if either an overvoltage or undervoltage condition is detected.

1.3. Focus Of The Project:-

A transformer's efficiency drops when it is overloaded. Overloading can also cause the secondary winding to overheat and burn, which can damage the transformer.

A PLC-based transformer overload and under load protection system uses sensors to detect transformer faults, including overload, overvoltage, under-voltage, phase to phase fault, and over temperature faults. Relays are then used to isolate the transformer from service and protect it from damage.

PLC-based transformer overload and under load protection systems are useful in remote areas, at night, and in bad weather conditions. They are also safe to operate during maintenance work.

The focus of the project for PLC based transformer overload and under load protection is to develop a system that can protect transformers from damage caused by overload and under load conditions. The system should be able to detect faults quickly and accurately, and it should be able to isolate the transformer from service quickly and safely. The system should also be easy to install and maintain, and it should be cost-effective.

2. DELTA PLC :-

Delta PLC is a programmable logic controller (PLC) developed and manufactured by Delta Electronics, a Taiwanese company that specializes in power electronics, industrial automation, and energy management solutions. Delta PLCs are designed for use in a wide range of industrial applications, such as packaging, material handling, and process automation. The PLCs feature a modular and scalable design, which allows for easy expansion and customization to meet specific application requirements.

Delta PLCs come with a range of advanced features, such as high-speed processing, multiple communication interfaces, and support for various programming languages, including ladder diagram (LD), function block diagram (FBD), and structured text (ST). Delta PLCs are also equipped with a range of built in I/O modules that can be easily configured to interface with various sensors and actuators. Delta PLCs are known for their high reliability, durability, and performance. They are designed
to operate in harsh industrial environments and are capable of withstanding extreme temperatures, humidity, and vibration.
Delta Electronics also provides comprehensive technical support, training, and maintenance services to ensure that customers can maximize the benefits of their PLCs.

Figure-1 DELTA Programmer Logic Controller

2.1. Configurations of DELTA PLC

The Delta PLC DVP14SS2 has the following:-

- Configurations Processor: 32-bit RISC CPU, with a clock speed of 600 MHz
- Program memory: 14K steps
- Data memory: 6K words
- Input points: 8 digital inputs (24VDC), 4 analog inputs (0-10VDC)
- Output points: 6 digital outputs (relay, transistor, or mixed), 2 analog outputs (0-10VDC)
- Communication ports: 1 RS-232 port, 1 RS-485 port
- Programming languages: Ladder Diagram (LD), Function Block Diagram (FBD), Structured Text (ST)
- Operating temperature range: -10°C to 55°C
- Power supply: 24VDC (±20%)
- Dimensions: 90mm x 70mm x 60mm (H x W x D)
- Weight: Approximately 200g

The DVP14SS2 is a compact and versatile PLC, suitable for a wide range of industrial applications. Its built-in I/O modules, high-speed processing, and multiple communication interfaces make it easy to integrate into existing systems and communicate with other devices.

3. PLC COMMUNICATION :-

Delta PLCs support various communication protocols and interfaces for communication with other devices, such as HMIs, SCADA systems, and other PLCs. Here are some common communication methods for Delta PLCs: -

- RS-232: Delta PLCs have one built-in RS-232 communication port, which can be used to communicate with a PC or other devices that support RS-232 communication.
- RS-485: Delta PLCs also have one built-in RS-485 communication port, which can be used for serial communication over longer distances and with multiple devices.
- Ethernet: Delta PLCs support Ethernet communication using the Modbus TCP protocol, which enables communication with other
- Modbus-compatible devices, such as HMIs or SCADA systems.
- CANOpen: Some Delta PLC models also support the CANOpen communication protocol, which is commonly used in industrialautomation for communication with other devices, such as sensors, transformers, and other PLCs.

To establish communication with a Delta PLC, the appropriate communication cable and software drivers may need to be installed, depending on the communication method used. Once the communication is established, data can be exchanged between the PLC and the other devices according to the communication protocol used.

Figure-2 PLC Communicator

The specific communication cable required for a Delta PLC with an 8-pin connector will depend on the communication protocol and the specific model of the PLC. However, the general guidelines are considered. For serial communication via the RS-232 port, you will need an 8-pin to 9-pin serial cable to connect the PLC to a computer or other device with a 9-pin serial port. From 9pin to we need to utilise the USB cable, which does the conversion. To connect a device with a 9-pin serial port to a computer with a USB port, you will need a USB to serial adapter cable.

This cable typically has a USB connector on one end and a 9-pin serial connector on the other end. Before purchasing a USB to serial adapter cable, make sure it is compatible with your computer's operating system and supports the serial communication protocol used by your device. Some USB to serial adapter cables may also require installation of drivers before use, so be sure to check the manufacturer's instructions before connecting it to your computer. To connect a Delta PLC to a computer via USB, you will need a USB to serial cable that is compatible with the Delta PLC's serial communication protocol.

Figure-3 Serial Communication To RS232 PLC Cable

Delta offers several USB to serial cables that are compatible with their PLCs, such as the DVPACAB2A30, which is a USB to RS-232 communication cable. This cable has a USB connector on one end and a 9-pin serial connector on the other end, which can be connected to the Delta PLC's RS-232 communication port. Before purchasing a USB to serial cable for your Delta PLC, make sure it is compatible with your specific PLC model and the communication protocol you intend to use. Additionally, you may need to install drivers for the USB to serial cable before use, depending on your computer's operating system.

4. INTERFACING DELTA PLC AND WPL SOFTWARE:-

4.1 WPL software:-

WPLSoft is a software tool provided by Delta for programming and configuring Delta PLCs. It is a free software package that can be downloaded from Delta's website and is compatible with various models of Delta PLCs.

WPLSoft provides a user-friendly interface for creating and editing ladder logic programs, configuring system settings, and monitoring real-time data from the PLC. It supports various communication protocols such as RS-232, RS-485, and Ethernet, and allows users to communicate with the PLC and upload/download programs and data.

4.1 Self commutated inverters:-

Such inverters are more complicated and use switching devices (IGBT and MOSFET) that can control the switch-on and switch-off time and adjust the output signal to that of the grid. The self-commutated inverters are the predominant technology in PV power sources because of their ability to control the voltage and current output signal (AC side), regulate the power factor and reduce the harmonic current distortion.

Figure-4 WPLSoft for PLC Software

4.2 Interfacing WPL soft and PLC:-

WPLSoft is a software tool provided by Delta that allows you to program and configure Delta PLCs. Interfacing a Delta PLC with WPLSoft can be done using a communication cable and configuring the communication settings in both the PLC and the WPLSoft software.

Here are the general steps for interfacing a Delta PLC and WPLSoft:

Connect the Delta PLC to the computer using the appropriate communication cable, such as a USB to serial cable or a RS-232/RS-485 cable.

Install the WPLSoft software on your computer and open it.

In WPLSoft, go to "Options" and select "Communication Settings."

Choose the appropriate communication protocol and settings for your Delta PLC, such as the communication port, baud rate, and parity.

Click "OK" to save the communication settings.

In WPLSoft, go to "PLC" and select "Online."

Choose the appropriate communication port and click "Connect" to establish communication with the Delta PLC.

Once the communication is established, you can program and configure the Delta PLC using the WPLSoft software.

Note that the specific steps and communication settings may vary depending on the Delta PLC model and the communication protocol used. Make sure to refer to the manufacturer's instructions and documentation for more detailed information on interfacing your Delta PLC with WPLSoft.

5. COMPONENTS USED :-

5.1 MCB (Miniature Circuit board):-

An MCB is an electrical switching device that automatically cuts off the flow of electricity in the event of an overload or short circuit. It is used as a safety device to protect electrical circuits from damage and prevent electrical fires.

MCBs are commonly used in residential, commercial, and industrial applications. They are designed to be compact and take up less space than traditional circuit breakers. MCBs are available in different sizes and amperages to accommodate different electrical loads.

Figure-5.1 MCB (Miniature Circuit board)

5.2 SMPS (Switched-Mode Power Supply):-

SMPS stands for Switched-Mode Power Supply, which is a type of power supply that converts electrical power efficiently from one form to another. The output of an SMPS can be regulated or unregulated, depending on the application. The output of an SMPS can be regulated or unregulated, depending on the application. 1A refers to the output current rating of the SMPS, which is 1 ampere. This means that the SMPS is capable of supplying up to 1 ampere of current to the load it is connected to. SMPSs are commonly used in electronic devices that require a stable and reliable source of power. They are known for their high efficiency and compact size, making them ideal for use in small electronic devices such as laptops, routers, and LED lighting. The output voltage and current rating of an SMPS can vary depending on the application, and it is important to select the correct SMPS based on the power requirements of the device being powered.

Figure-5.2 SMPS (Switched-Mode Power Supply)

5.3 Single Channel Relay:-

A single-channel relay can be used in a PLC project for various applications such as controlling the on/off function of a transformer, turning on or off a heater or cooling system, or switching power to a specific device.

To use a single-channel relay in a PLC project, the relay is typically connected to one of the PLC's digital outputs, which is used to control the relay's state. When the PLC output signal is received by the relay, it energizes an electromagnet that closes or opens the relay's contacts, which in turn either allows or stops the flow of electricity to the connected device or circuit.

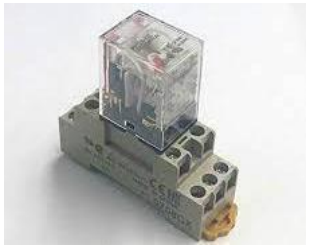


Figure-5.3 Single Channel Relay

5.4. Single phase contractor:-

A single-phase contactor is an electrical switch that is used to control and switch power to single-phase electric transformers or other electrical loads. It is designed to handle the high electrical loads of a single-phase system and is commonly used in various industrial and commercial applications.

Figure-5.4 Single phase contractor

The basic components of a single-phase contactor include a set of contacts that are mechanically linked together, a coil that creates an electromagnetic field, and a housing or enclosure that protects the components from damage. Single-phase contactors come in various sizes and configurations, depending on the application and the electrical load that they are designed to handle. It is important to select the correct contactor for the specific application and to ensure that it is installed and wired correctly to ensure safe and reliable operation.

5.5 Single Phase Transformer**:-**

A transformer is a type of electrical device designed to operate on an alternating current (AC) power supply. Unlike rotary transformers that can operate with a rotating magnetic field generated by a multi-phase power supply, transformers require a special starting mechanism to produce a rotating magnetic field to initiate operation. The transformer has two main parts: the stator and the rotor. The stator is a stationary component that consists of a core made of laminated steel sheets wrapped with conductive wire to create an electromagnetic field. The rotor is a rotating component mounted on a shaft and composed of a laminated steel core with conductive elements.

Figure-5.5 Single Phase Transformer

5.6 Under voltage and over voltage relay:-

An under voltage relay is a protective device that is designed to monitor the voltage of an electrical system and trip a circuit breaker or switch if the voltage drops below a certain threshold. It is commonly used to protect sensitive equipment from damage caused by voltage fluctuations or brownouts. The threshold voltage for an under voltage relay is typically set at 80% to 90% of the nominal voltage of the system. If the voltage drops below this threshold, the relay will activate and trip the circuit breaker or switch, shutting down the equipment connected to the system.

Figure-5.6 Under voltage and over voltage relay

5.7 Voltage dimmer:-

A voltage dimmer is a device that is used to control the amount of voltage that is delivered to a load, such as a light bulb or electric transformer. It is also known as a voltage regulator or a dimmer switch. Voltage dimmers work by adjusting the voltage that is supplied to the load, which in turn changes the amount of power that is consumed by the load, and thereby controls its brightness or speed.

Voltage dimmers can be used for a variety of applications including:

Lighting control: Voltage dimmers can be used to control the brightness of incandescent, halogen, and some LED light bulbs. This is often used in

residential and commercial applications for energy savings and improved comfort and ambience.

Fan speed control: Voltage dimmers can be used to control the speed of electric fans by varying the voltage supplied to the fan transformer.

Heating control: Voltage dimmers can be used to control the power supplied to heating elements, such as those in electric stoves, ovens, and heaters. This can be used to control the temperature and reduce energy consumption.

Transformer control: Voltage dimmers can be used to control the speed of single-phase AC transformers by varying the voltage supplied to the transformer.

Voltage dimmers can be controlled using various methods, such as rotary knobs, slide switches, touchpads, and remote controls. It is important to choose the appropriate dimmer for the application, taking into account factors such as the load type, load power, voltage range, and control method.

Figure-5.7 Voltage dimmer

5.8 NO and NC push buttons:-

NO and NC are abbreviations used in reference to the contact configuration of a push button switch.

NO stands for Normally Open and NC stands for Normally Closed. These terms describe the state of the contacts when the button is not being pressed.

In a NO push button switch, the contacts are open (not connected) when the button is not being pressed. When the button is pressed, the contacts close (connect) to complete the circuit. This is also called a "make" contact.

In a NC push button switch, the contacts are closed (connected) when the button is not being pressed. When the button is pressed, the contacts open (disconnect) to break the circuit. This is also called a "break" contact.

Push button switches can be either momentary or latching. A momentary switch returns to its original state when the button is released, while a latching switch stays in the last position until it is manually reset.

NO and NC push buttons can be used in a variety of applications, such as control panels, machinery, and automation systems, to provide start/stop or on/off control.

Figure- 5.9 NO and NC push buttons

6. PROJECT LADDER DIAGRAM :-

A ladder diagram is a graphical programming language used for programming PLCs (Programmable Logic Controllers). It is based on the principle of electrical ladder diagrams used in relay-based control systems.

A ladder diagram consists of two vertical rails, which represent the power supply, and horizontal rungs, which represent the controlled logic. The

rungs are connected to the vertical rails through contacts and coils, which represent inputs and outputs.

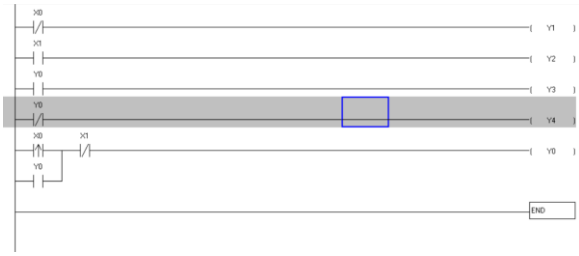


Figure.6 Project Ladder Diagram

000000	LDI	X0
000001	OUT	Y1
000002	LD	X1
000003	OUT	Y2
000004	LD	Y0
000005	OUT	Y3
000006	LDI	Y0
000007	OUT	Y4
000008	LDP	X0
000011	OR	Y0
000012	ANI	X1
000013	OUT	Y0

Here

X0 = Start push button

X1 = Stop push button

Y0 = Transformer load

Y1 = Start Push button indication

Y2 = Stop Push button indication

Y3 = Transformer ON indication

Y4 = Transformer OFF indication

7:FUNCTIONAL BLOCK DIAGRAM :-

It represents the connections of the project**.**

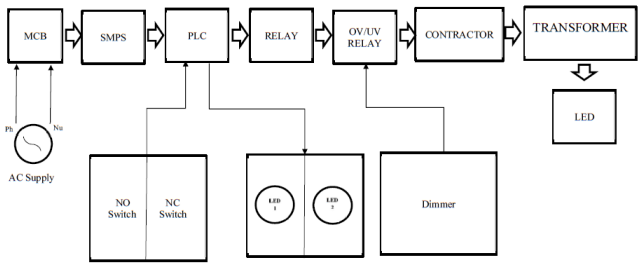
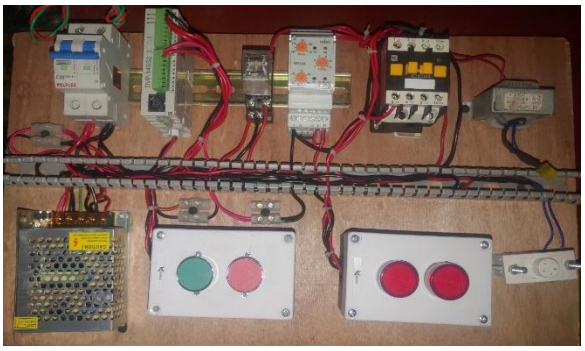


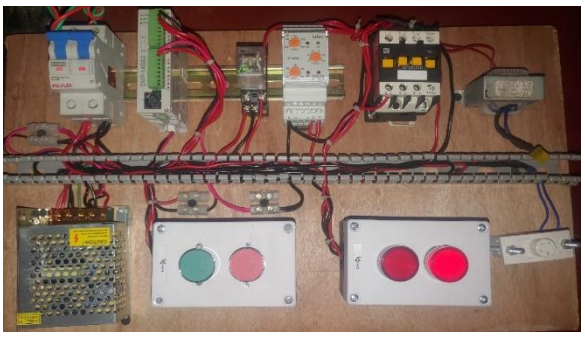
Figure.7 Project Ladder Diagram

8. PROJECT RESULTS :-

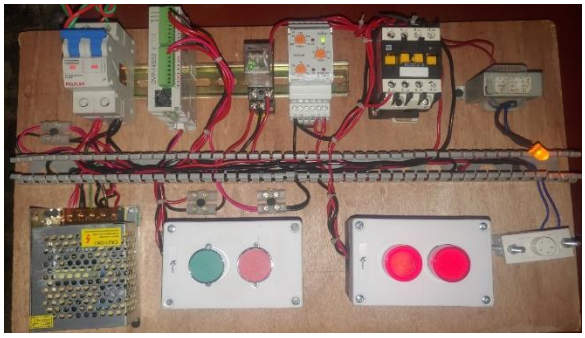
8.1 Project Hardware Setup:-



8.2 Hardware Setup Working on Abnormal Voltage:-



8.3 Hardware Setup Working on Defined Voltage:-



9. FUTURE SCOPE:-

In the future, we can expect to see continued development of PLC based transformer protection systems that are more intelligent, efficient, and user-friendly. Here are some potential areas of future work:
Artificial intelligence (AI) and machine learning (ML): The incorporation of AI and ML algorithms into transformer protection systems could enable more accurate fault detection and prediction, as well as optimized performance and energy efficiency.
Internet of Things (IoT) connectivity: The integration of IoT technologies could enable transformer protection systems to communicate with other systems and devices, providing more comprehensive monitoring and control.
Wireless communication protocols: The use of wireless communication protocols, such as Bluetooth or Wi-Fi, could simplify installation and reduce costs by eliminating the need for wired connections.
Energy management: As energy efficiency becomes increasingly important, transformer protection systems may incorporate features to optimize transformer performance and reduce energy consumption, such as load monitoring, energy usage tracking, and power factor correction.
User interface: Improved user interfaces could make transformer protection systems easier to configure, monitor, and troubleshoot, enabling faster and more efficient system operation. This could include the use of touchscreens, augmented reality, or other advanced technologies.

10. CONCLUCION:-

Protecting a 1-phase transformer from overvoltage and undervoltage using a PLC-based system is an important project for ensuring the longevity and reliability of the transformer. By implementing a PLC based system, we can monitor the voltage levels and trigger appropriate responses to prevent damage to the transformer.
The system can be designed to monitor the voltage levels continuously and compare them against preset thresholds. If the voltage level exceeds the upper threshold, the system can trigger an alarm or shut down the transformer to prevent damage due to overvoltage. Similarly, if the voltage level falls below the lower threshold, the system can take appropriate action to prevent damage due to undervoltage. The project can be implemented using a variety of PLCs, sensors, and relays, depending on the specific requirements of the application. The key to success in this project is careful planning and design to ensure that the system is reliable, accurate, and easy to maintain.

11. REFERENCES:-

1. "Industrial Automation: PLCs, Sensors and SCADA" by Seyed Kamaleddin Yadavar Nikravesh and Omid Mirmotahari
2. "PLC Programming using RS Logix 500" by Gary Dunning
3. "Electric Transformers and Drives: Fundamentals, Types and Applications" by Austin Hughes and Bill Drury
4. "Industrial Control Electronics" by Terry L.M. Bartelt
5. "Electrical Power Systems Quality" by Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, and H. Wayne Beaty