MONITORING & CONTROLLING OF SUBSTATION (TRANSFORMER) USING PLC

Submitted in partial fulfillment of the requirements
of the degree of

Bachelor's in Electrical Engineering

by

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Certificate

This is to certify that the project entitled **"Monitoring and Controlling of Substation (Transformer) Using PLC"** is a bonafide work of **"DhanseWasimIqbal"** (12EE13), **"Siddiqui Abdul Halim"** (13EE68), **"PatvekarMustakeem"** (13EE67), and **"KondkariRehan"** (12EE26), submitted to the University of Mumbai in partial fulfillment of the requirement for the award of**"Bachelor's Degree"** in **"Electrical Engineering"**.

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Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Acknowledgement

It is indeed a matter of great pleasure and proud privilege to be able to present this project on "**Monitoring and Controlling of Substation (Transformer) Using PLC**".

The completion of the project work is milestone in student life and its execution is inevitable in the hand of guide. We take this opportunity to express our deep and sense of gratitude to our guide **PROF. IFTEKAR PATEL** for his valuable guidance and inspiration in spite of his busy schedule. He devoted himself in completing our task with the admirable excellence. He has taken keep and personal interest in giving us constant encouragement and timely suggestion also to our **HOD PROF. SAYED KALEEM** for cheerful encouragement and notable guidance.

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Abstract

Electrical power system is a technical wonder. Electricity and its accessibility are the greatest engineering achievement of the 20th century. A modern society cannot exist without electricity. Generation, transmission lines and distribution system are the main components of power system.

Today's world most of the systems are operate on automation. Because of that the automotive system is most efficient. Automation means use of Programmable Logic controller (PLC) & Supervisory control and data acquisition (SCADA) instead of electromechanical devices. Substation (Transformer) automation using PLC means controlling & monitoring electrical parameter (like Voltage, Current, temperature, oil level) and controlling if any fault occurs (like open circuit, short circuit, overvoltage, oil level, &temperature, etc.) in substation transformer.

The fault free operation of transformer gives more impact on economic and safety in power supply to utilities and industrial and domestic consumers. A sudden breakdown/fault in a power transformer will affect unexpected production interruption, down time of equipment's in industries and the repair/replacement of transformer; it may lead to huge investment and expenses. The insulating oil in a transformer can tell a lot about the actual state of transformer and its longevity.

Main concept of our project is to control and monitor substation (transformer) using PLC. Here PLC is a medium between electrical system to take inputs and outputs bits. We can say that the system is one of the most cost effective solutions for improving reliability, increasing utilization, increasing efficiency and costs saving.

PLC on the other hand is like the brain of the system, it is possible to control and operate the power system remotely. Task like oil level control, short circuit, open circuit etc.

In short, our project is an integration of network monitoring & controlling electrical parameters of transformer using PLC

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Abbreviations and Notations

AC	Alternating current
DC	Direct current
IED	Intelligent Electronic device
LED	Light Emitting Diode
PDF	Portable Document Format
PC	Personal Computer
PCB	Printed Circuit Board
RTU	Remote Terminal Units
PLC	Programmable Logic Controller
RLY	Relay
IC	Integrated Circuit
IEC	International Electro Technical Commission
RLL	Relay Ladder logic
HMI	Human Machine Interface
CPU	Central Processing Unit
RAM	Random Access Memory
ROM	Read Only Memory
PS	Power Supply
NO	Normally Open

NC	Normally Closed
HMI	Human Machine Interfaced
GUI	Graphical User Interfaces
PCB	Printed Circuit Board

1 Introduction

1.1 Programmable Logic Controller

Much attention has been given to the use of PLCs (Programmable Logic Controllers) in substation and distribution automation applications in recent years. Innovative engineers and technicians have been actively seeking new applications for PLCs in substations and SCADA (Supervisory Control and Data Acquisition) systems. The manufacturers of PLCs have responded by developing new products that meet the unique requirements of substation automation and SCADA applications. PLCs are very cost competitive with traditional RTUs and have many benefits in substation automation applications. PLCs have an important place in substation automation and their use in substation applications will grow.

As the use of PLCs in substation automation applications increases, and the demand for substation and distribution automation increases, utility engineers are seeking ways to implement applications. With deregulation, utilities are decreasing engineering staff levels.

Utility engineers are required to field more projects with fewer available resources. The services of outside control system integrators, engineering firms or consultants are often called upon to meet the needs of the utilities. Selection of an outside firm is an important task of the utility engineer and the selection of the particular outside firm can determine the success or failure of a project.

1.2 History of PLC Use in Substations

The Hydramatic Division of General Motors Corporation specified the design criteria for the first programmable controller in 1968. The first PLCs only offered control relay functionality and were programmed in RLL (Relay Ladder Logic). PLCs offered the automobile industry quick change for year to year model changes. In addition, PLCs were modular and easily understood by plant floor personnel.

The first programmable controllers were known as PCs; the acronym PLC for programmable logic controller, was actually a trade name used by Allen-Bradley. With the introduction of personal computers known as PCs the term PLC became the common term to avoid confusion.

By 1971 PLCs were coming into wide spread use in industries outside the automotive industry. Still providing control relay replacement only, they were found in industries such as food and beverage, pharmaceutical, metals, manufacturing and pulp and paper.

The introduction of microprocessors changed the PLC industry. PLCs have been reduced in size from the size of an apple crate to smaller than a loaf of bread. Some PLCs are smaller than a deck of cards. Processing power increased and PLCs are now capable of the most complex program algorithms. Originally PLCs were programmed only in RLL; they can now be programmed in several styles and types of programming languages such as SFC (sequential function chart), state language, control block languages and statement languages such as Basic. With the growth in technology, PLCs are now capable of advanced data manipulation, communications and process control.

PLCs were first used by the utility industry in generating stations. This is undoubtedly because of the similarity of generating station applications to industrial applications in which PLCs were already being applied.

Private industry has been applying PLCs in substations for many years. Exxon has applied PLCs in refinery substations for load shedding and load restoration (called re-acceleration because of the connected motor loads) since the early 1980s. PLCs have been used in emergency power systems in commercial buildings and hospitals for many years for switching, load shedding and restoration and emergency generator control.

1.3 Benefits of using PLCs in substation automation

Reliability, a large installed base, extensive support resources and low costs are some of the benefits of using PLCs as a basis for substation automation and SCADA systems.

PLCs are extremely reliable. They have been developed for application in harsh industrial environments. They are designed to operate correctly over wide temperature ranges and in very high electromagnetic noise and high vibration environments. They can operate in dusty or humid environments as well. The number of PLCs (in the millions) which have been applied in various environments has allowed the designers of PLCs to perfect the resistance to the negative effects of harsh environments.

The large installed base of PLCs offers the advantages of reduced costs, readily available and low cost spare parts and trained personnel to work on PLCs. The large installed base also allows the manufactures more opportunity to improve design and offer new products for more varied applications.

PLCs have extensive support throughout the US and most of the world. PLC manufactures have extensive of field offices, distributors and authorized control system integrators. Most technical schools and colleges offer courses in PLC application, programming and maintenance.

In many, if not all, applications PLCs offer lower cost solutions than traditional RTUs for SCADA systems. They offer lower cost solutions than traditional electromechanical control relay systems for automated substation applications. With the lower cost solutions PLC based systems offer in substation and distribution automation applications along with the other benefits, it is no surprise that there is so much interest in the application of PLCs in substation.

1.4 Block Diagram

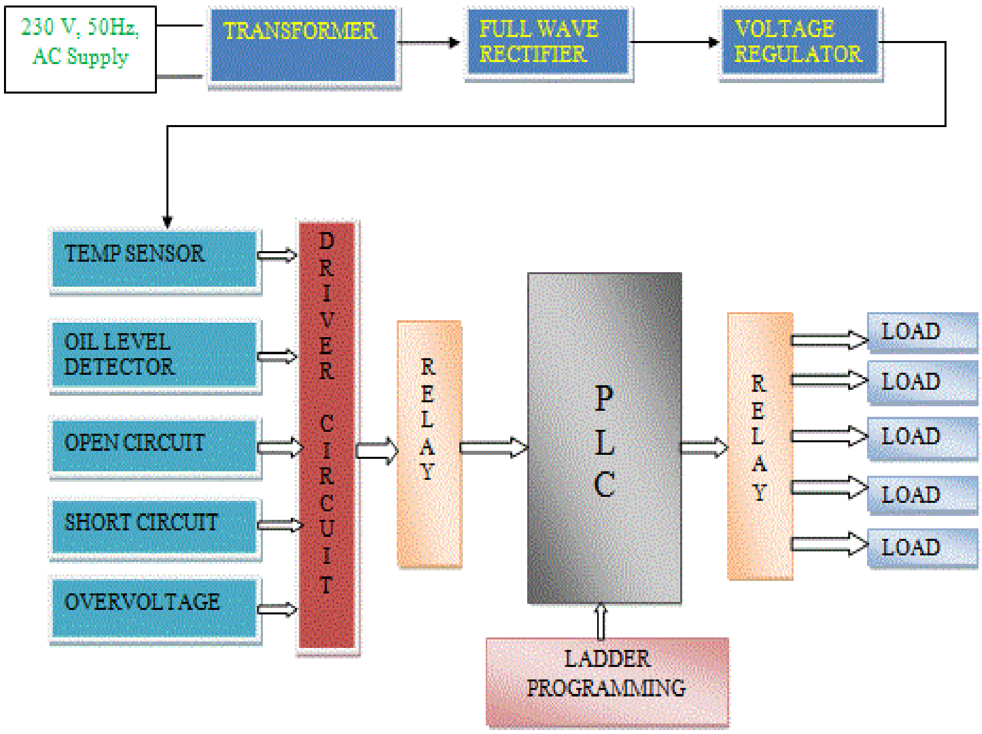


FIGURE 1-1 BLOCK DIAGRAM

1.5 Transformer Automation

In modern age, PLC automation has been placed on power reliability and economy. A power transformer is a very valuable and important link in a power transmission system. A monitoring is essential to evaluate transformer performance and safe operating conditions. High reliability of the transformer is essential to avoid disturbances in transmission of power. Due to wide range of PLC automation, the various types of fault in power transformer can be detected and diagnosed by using PLC system. Some papers show that transformer protection a challenge to researchers.Ruchita R. Katkamwar, Shweta K.Nyahare, presented a paper on A Review on Different Types of Protection of Transformer Using PLC, proposed the design and implementation automatic control circuit using PLC and also monitors control electrical parameter of transformer.

A high quality power transformer properly designed and supplied with suitable protective relays and monitors is very reliable. When a fault occurs in a transformer of electrical substation, the damage is normally severe due to high rating of power. The ultimate aim is that to minimize the response time after occurring fault. To operate a power distribution system with a transformer out of service is always very difficult. The impact of a transformer fault is more serious than a transmission line outage. There are various types of fault which occurs on transformer. These faults are mainly internal and external faults of power transformer. The main concern of this paper with transformer protection is rescued the transformer against internal faults as well as ensuring security of the protection scheme for external faults. Overloading of power transformers beyond the nameplate rating can cause a rise in temperature of both transformer oil and windings. Overloading is nothing but it is an over current fault which occurs on secondary side of distribution transformer. If the winding temperature rise exceeds the transformer limits, the insulation will deteriorate and may fail prematurely.

Power system faults external to the transformer zone can cause high levels as well as low level of voltage on transformer. It leads to over voltage fault and under voltage fault. The fault impedance of power line being low, the fault currents are relatively high. During the occurrence of faults, the power flow is diverted towards the fault and the supply to the neighbouring zone is affected and voltages become unbalanced [6]. A comprehensive transformer protection scheme needs to include protection against transformer overload, over voltage fault and low voltage fault as well as protection for internal faults.

2 Review of Literature

There have been so many researches done in its theoretical & application field which are briefly discussed in this chapter

[1] V.K. Mehta, Rohit Mehta, *Principles of Power System*,4th revised edition 2008.

[2] G. Keerthana, S. Sanmathy, presented controlling and monitoring generator transformer by using PLC, and proposed protection for transformer increase efficiency & using plc process becomes more flexible, reliable and PC friendly.

[3] Wael Al-Hasawi, Mahmoud Gilany, proposed technique for identifying open and short circuit sections in distribution networks.

[4] John McDonald, *Substation Automation Basics*, presented the basics of Substation Automation Using PLC SCADA.

[5] Santosh B.Belekar, Abhijit A. Desai, Mehharaj H. Parit, Prof. AnupDakre, presented PLC SCADA Based Monitoring & Control proposed that PLC works as a mediator PC at second level whereas PLC will collect data related to electrical parameter

[6] Ruchita R.Katkamwar,Shweta K.Nyahare, presented a paper on A Review on Different Types of Protection of Transformer Using PLC, proposed the design and implementation automatic control circuit using PLC and also monitors control electrical parameter of transformer

[7] D S Suresh, Prathibha, KouserTaj, presented Oil based Transformer Health Monitoring System Using PLC proposed condition monitoring of transformer oil by using PLC, suitable sensors for sensing parameters of oil like moisture content, temperature can be found.

[8] Dayananda S.K, Harshavardhan C.R, Sharath A.M, Shivaraju T, presented, planned distribution system for protection of transformer by using plc proposed Embedded system designed to developed for monitoring and controlling electrical appliance mainly Transformers Temperature.

[9] Satya Kumar Behera, Ravi Masand, Prof. S.P.Shukla, presented A Review of transformer Protection By using PLC System, proposed PLC automation to monitor as well as diagnose condition of transformers and also help to detect the internal fault as wellas external fault of transformer.

[10] Sageer Ali Khan presented “Transformer Protection Using plc” proposed protection of transformer from severe faults & also measure electrical parameters

From the reading of the above literatures it was found that it is good to find the global optimum solution to a problem associated.

3 Programmable Logic Controller

3.1 PLC

FIGURE 3-1 DELTA PLC

A **programmable logic controller**, **PLC**, or **programmable controller** is a digital computer used for automation of typically industrial electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLCs are used in many machines, in many industries. PLCs are designed for multiple arrangements of digital and analog inputs and outputs, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. A PLC is an example of a "hard" real-time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.

3.2 Features

- Compact PLC
- Configurable LED display
- Window based software
- program for configuration

3.2.1 Size

Control panel with PLC (grey elements in the centre). The unit consists of separate elements, from left to right; power supply, controller, relay units for in- and output

The main difference from other computers is that PLCs are armoured for severe conditions (such as dust, moisture, heat, cold), and have the facility for extensive input/output (I/O) arrangements. These connect the PLC to sensors and actuators. PLCs read limit switches, analog process variables (such as temperature and pressure), and the positions of complex positioning systems. Some use machine vision On the actuator side, PLCs operate electric motors, pneumatic or hydraulic cylinders, magnetic relays, solenoids, or analog outputs. The input/output arrangements may be built into a simple PLC, or the PLC may have external I/O modules attached to a computer network that plugs into the PLC.

3.2.2 Scan time

A PLC program is generally executed repeatedly as long as the controlled system is running. The status of physical input points is copied to an area of memory accessible to the processor, sometimes called the "I/O Image Table". The program is then run from its first instruction rung down to the last rung. It takes some time for the processor of the PLC to evaluate all the rungs and update the I/O image table with the status of outputs.[5] This scan time may be a few milliseconds for a small program or on a fast processor, but older PLCs running very large programs could take much longer (say, up to 100 ms) to execute the program. If the scan time were too long, the response of the PLC to process conditions would be too slow to be useful.

As PLCs became more advanced, methods were developed to change the sequence of ladder execution, and subroutines were implemented. This simplified programming could be used to save scan time for high-speed processes; for example, parts of the program used only for setting up the machine could be segregated from those parts required to operate at higher speed.

Special-purpose I/O modules may be used where the scan time of the PLC is too long to allow predictable performance. Precision timing modules, or counter modules for use with shaft encoders, are used where the scan time would be too long to reliably count pulses or detect the sense of rotation of an encoder. The relatively slow PLC can still interpret the counted values to control a machine, but the accumulation of pulses is done by a dedicated module that is unaffected by the speed of the program execution.

3.2.3 System scale

A small PLC will have a fixed number of connections built in for inputs and outputs. Typically, expansions are available if the base model has insufficient I/O.

Modular PLCs have a chassis (also called a rack) into which are placed modules with different functions. The processor and selection of I/O modules are customized for the particular application. Several racks can be administered by a single processor, and may have thousands of inputs and outputs. A special high speed serial I/O link is used so that racks can be distributed away from the processor, reducing the wiring costs for large plants.

3.2.4 User Interface

PLCs may need to interact with people for the purpose of configuration, alarm reporting, or everyday control. A human-machine interface (HMI) is employed for this purpose. HMIs are also referred to as man-machine interfaces (MMIs) and graphical user interfaces (GUIs). A simple system may use buttons and lights to interact with the user. Text displays are available as well as graphical touch screens. More complex systems use programming and monitoring software installed on a computer, with the PLC connected via a communication interface.

3.2.5 Communications

PLCs have built-in communications ports, usually 9-pin RS-232, but optionally EIA-485 or Ethernet. Modbus, BACnet, or DF1 is usually included as one of the communications protocols. Other options include various fieldbuses such as DeviceNet or Profibus. Other communications protocols that may be used are listed in the List of automation protocols.

Most modern PLCs can communicate over a network to some other system, such as a computer running a SCADA (Supervisory Control and Data Acquisition) system or web browser.

PLCs used in larger I/O systems may have peer-to-peer (P2P) communication between processors. This allows separate parts of a complex process to have individual control while allowing the subsystems to co-ordinate over the communication link. These communication links are also often used for HMI devices such as keypads or PC-type workstations.

Formerly, some manufacturers offered dedicated communication modules as an add-on function where the processor had no network connection built-in.

3.2.6 Programming

PLC programs are typically written in a special application on a personal computer, then downloaded by a direct-connection cable or over a network to the PLC. The program is stored in the PLC either in battery-backed-up RAM or some other non-volatile flash memory. Often, a single PLC can be programmed to replace thousands of relays.

3.3 Block Diagram of PLC

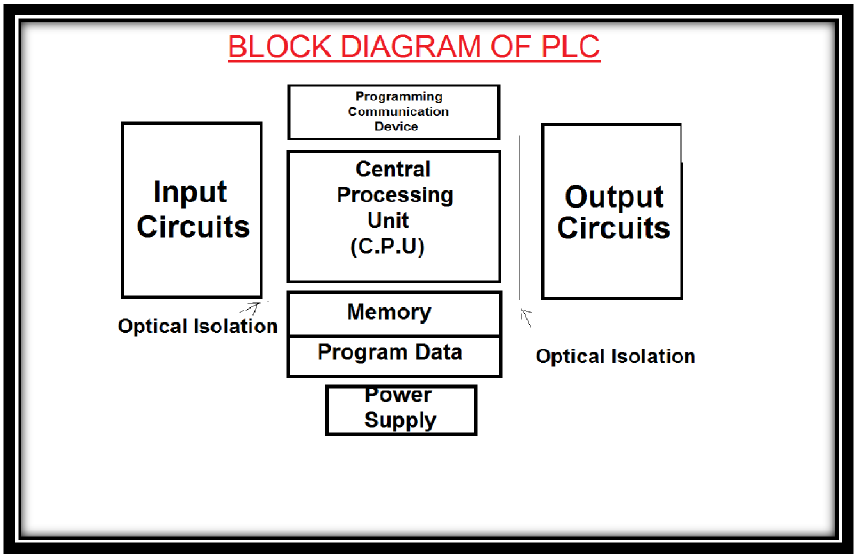


FIGURE 3-2 BLOCK DIAGRAM OF PLC

A Programmable Controller is a specialized computer. Since it is a computer, it has all the basic component parts that any other computer has; a Central Processing Unit, Memory, Input Interfacing and Output Interfacing. A typical programmable controller block diagram is shown above.

3.3.1 Central Processing Unit (CPU)

1. It interprets the program commands retrieved from memory and acts on those commands.
2. In present day PLC's this unit is a microprocessor based system.
3. The CPU is housed in the processor module of modularized systems.

3.3.2 Memory

Memory in the system is generally of two types: ROM and RAM.

1. The ROM memory contains the program information that allows the CPU to interpret and act on the Ladder Logic program stored in the RAM memory.
2. RAM memory is generally kept alive with an on-board battery so that ladder programming is not lost when the system power is removed.

3. This battery can be a standard dry cell or rechargeable nickel-cadmium type.
4. Newer PLC units are now available with Electrically Erasable Programmable Read Only Memory (EEPROM) which does not require a battery.
5. Memory is also housed in the processor module in modular systems.

3.3.3 Input units

Input signals are of two types: Discrete signals and Analog signals.

Discrete signals behave as binary switches, yielding simply an On or Off signal (1 or 0, True or False, respectively). Push buttons, limit switches, and photoelectric sensors are examples of devices providing a discrete signal. Discrete signals are sent using either voltage or current, where a specific range is designated as On and another as Off. For example, a PLC might use 24 V DC I/O, with values above 22 V DC representing On, values below 2VDC representing Off, and intermediate values undefined. Initially, PLCs had only discrete I/O.

Analog signals are like volume controls, with a range of values between zero and full-scale. These are typically interpreted as integer values (counts) by the PLC, with various ranges of accuracy depending on the device and the number of bits available to store the data. As PLCs typically use 16-bit signed binary processors, the integer values are limited between -32,768 and +32,767. Pressure, temperature, flow, and weight are often represented by analog signals. Analog signals can use voltage or current with a magnitude proportional to the value of the process signal. For example, an analog 0 to 10 V or 4-20 mA input would be converted into an integer value of 0 to 32767.Current inputs are less sensitive to electrical noise (i.e. from welders or electric motor starts) than voltage inputs.

3.3.4 Output units

Operate much the same as the input units with the exception that the unit is either sinking (supplying a ground) or sourcing (providing a voltage) discrete voltages or sourcing analog voltage or current.

1. These output signals are presented as directed by the CPU. The output circuit of discrete units can be transistors for TTL and higher DC voltage or Triacs for AC voltage outputs.

2. For higher current applications and situations where a physical contact closure is required, mechanical relay contacts are available.
3. These higher currents, however, are generally limited to about 2-3 amperes.
4. The analog output units have internal circuitry which performs the digital to analog conversion and generates the variable voltage or current output.

3.3.5 Extending PLC

1. Every PLC controller has a limited number of input/output lines.
2. If needed this number can be increased through certain additional modules by system extension through extension lines.
3. Each module can contain extension both of input and output lines.
4. Also, extension modules can have inputs and outputs of a different nature from those on the PLC controller (ex. in case relay outputs are on a controller, transistor outputs can be on an extension module).

3.3.6 Application

1. HVAC
2. Moulding injection machine
3. Packing Machine
4. Logistic System

3.4 Terminal Connections

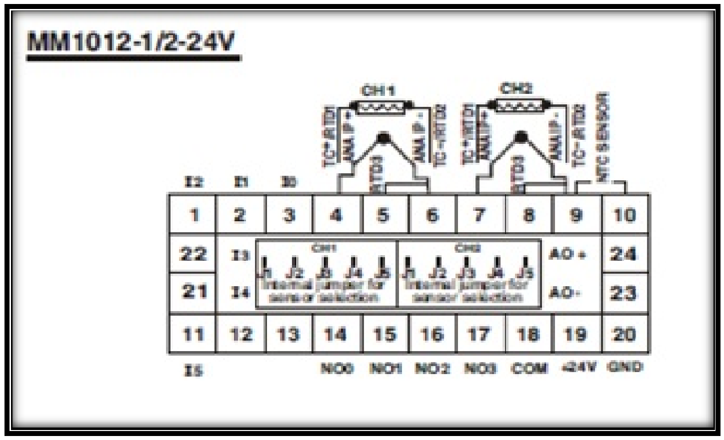


FIGURE 3-3 TERMINAL CONNECTIONS OF PLC

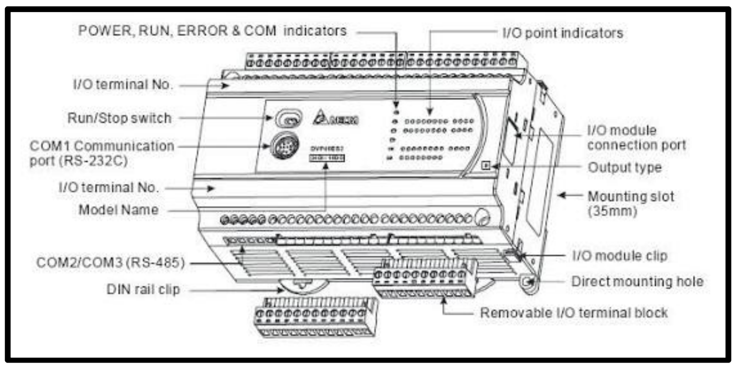


FIGURE 3-4 INSTRUCTION FEATURES OF PLC

Functional Features	
Timer Operational Modes	On Delay, Off Delay, Pulse, Special [Up/Down] Timer
Timer Resolution	1 ms (Accurate only for 1 msec Timer block)
Timer Display Format	Sec, Min, Hr, Day, Min.Sec, Hr.Min, Day.Hr.
Counter	Up Counter, Down Counter, Up/Down Counter, Special Up Down Counter
Other Blocks	PID Control with Autotune, Analog input, Rampsoak, FTC, Analog Output, Hysterisis, Scaling.
Memory Retention	10 years (4k memory)
RTC	No
Supply Voltage	
Supply Voltage [As per product selection]	180 - 270V AC, 50Hz 18 - 30V DC
Environmental Specifications	
Temperature	Operating : 0 to 50 °C Storage : -20 to 60 °C
Humidity (non-condensing)	95% RH
Weight	258gms

FIGURE 3-5 FUNCTIONAL FEATURE OF PLC

3.4.1 Specifications:

1. MPU points :16/ 20 / 24 / 32 / 40 / 60
2. Program Capacity: 16K steps
3. Max. I/O points: 256 inputs points + 16 Outputs, or 256 Output points+ 16 inputs points
4. Password protection: Password for subroutine, User ID, restriction on trial times
5. Highly efficient instruction efficient instruction execution
6. Built-in with 3 COM ports: 1 RS-232 and 2 RS-485ports, all are able to operate independently

DVP-EX2 MPU is built in with 12- bit 4AD/ 2DA and offers analog / temperature modules of 14-bit resolution.

4 Implementation of Project

4.1 Circuit Diagram

4.1.1 Symbol and Component use in Diagram

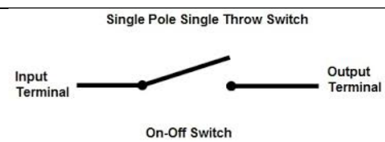
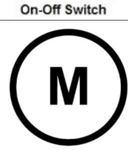
	Buzzer
	Toggle Switch
	Motor

TABLE 4-1 SYMBOL OF COMPONENTS

4.1.2 Layout Notation Used

RLY	Relay
D	LED
NC	Normally closed
NO	Normally open

TABLE 4-2 LAYOUT NOTATION

4.1.3 Input &Outputs use in PLC

Inputs	Outputs
Temperature Sensor (LM35)	Fan
Oil level Sensor (Floating Sensor)	Buzzer
Open Circuit	Motor
Short Circuit	
Overvoltage (Potentiometer)	

TABLE 4-3 INPUT OUTPUT DEVICES

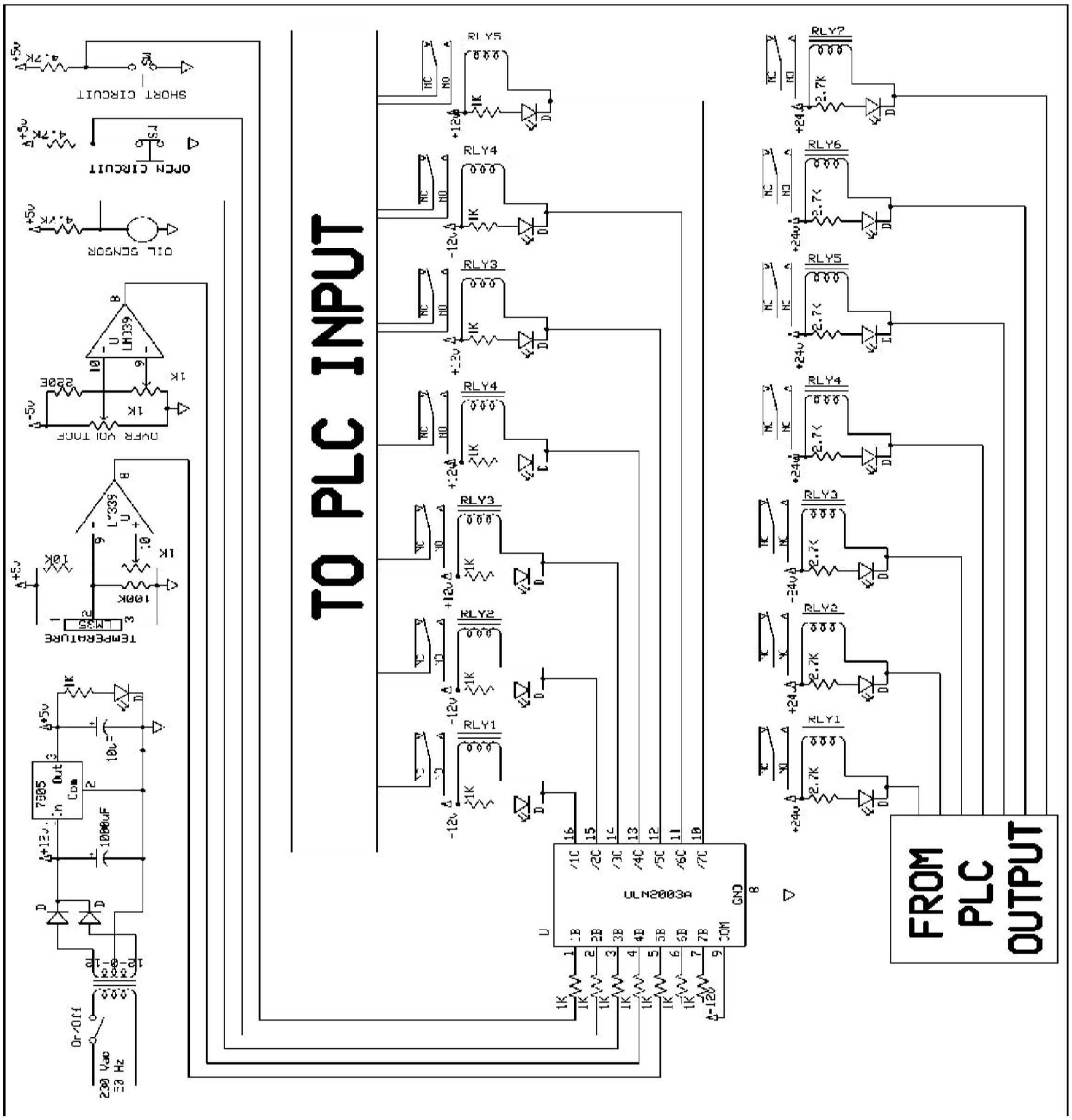


FIGURE 4-1 CIRCUIT DIAGRAM

4.2 Circuit Working

Step 1: Switch ON the power supply.

Step 2: Power supply is given to PLC & Centre tapped transformer.

Step 3: Centre tapped transformer step down 230V AC to 12V AC.

Step 4: This 12V AC is converted into 12V DC & 5V DC by Signal conditioning.

Step 5: 12V DC goes to coil of input relays & 5V goes to sensors.

Step 6: Sensor will sense the Unhealthy condition and it will send signal to PLCaccording to thatsignals PLC give the outputto the actuator.

4.3 Component List

Sr. No.	Component	Rating/Size	No. of Units	Price (Rupees)
01	PLC (DVP16ES2)		1	11250
02	Transformer	12-0-12	1	450
03	Input Relays	12V	7	280
04	Output Relays	24V	7	300
05	DC Motors		3	250
06	Buzzer	12V	1	119
07	Layout Sticker		1	200
08	Indicator LEDs	5mm	15	100
09	Wooden Board		1	200
10	Resistors	1K 2.7K 4.7K 10K 100K 220K	17 7 3 1 1 1	150

11	Capacitor	1000µF 10µF	2	40
12	Connecting wires		As Required	150
13	Temperature sensor	LM35	1	50
14	Floating sensor		1	156
15	Potentiometer Pot		3	30
16	IC	LN7805 LM339 ULN2803A	1 2 1	55 12 18
17	Battery	9V	3	150
	Total			15900

TABLE 4-4 COMPONENT LIST

4.4 Data sheet

4.4.1 Relay Module

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. It was invented by Joseph Henry in 1835. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier.

FIGURE 4-2 RELAY

When a current flow through the coil, the resulting magnetic field attracts an armature that is mechanically linked to a moving contact. The movement either makes or breaks a connection with a fixed contact. When the current to the coil is switched off, the armature is returned by a force approximately half as strong as the magnetic force to its relaxed position. Usually this is a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low voltage application, this is to reduce noise. In a high voltage or high current application, this is to reduce arcing.

If the coil is energized with DC, a diode is frequently installed across the coil, to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a spike of voltage and might cause damage to circuit components. Some automotive relays already include that diode inside the relay case. Alternatively, a contact protection network, consisting of a capacitor and resistor in series, may absorb the surge. If the coil is designed to be energized with AC, a small copper ring can be crimped to the end of the solenoid. This "shading ring" creates a small out-of-phase current, which increases the minimum pull on the armature during the AC cycle.

By analogy with the functions of the original electromagnetic device, a solid-state relay is made with a thyristors or other solid-state switching device. To achieve electrical isolation an opt coupler can be used which is a light-emitting diode (LED) coupled with a photo transistor.

4.4.1.1 Basic Design and Operation

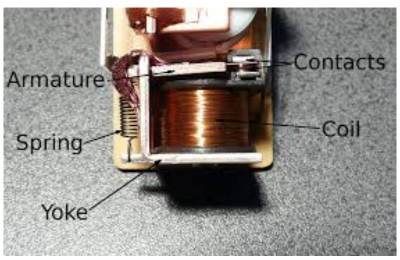


FIGURE 4-3 RELAY WORKING

A simple electromagnetic relay consists of a coil or wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts (there are two in the relay pictured). The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that

When the relay is energized there is an air gap in the magnetic circuit. In this condition, one of the sets of contacts in the relay is pictured is closed, and the other set is open. Other relays may have more or fever sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the printed circuit board (PCB) via yoke, which is soldered to the PCB.

When an electric current is passed through the coil it generates a magnetic field that activates the armature, and the consequent movement of the movable contacts either makes or breaks (depending upon construction) a connection with contact. If the set of contact was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection and vice versa if the contact were open. When the current to the coil is switched off, the armature is returned by a force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in high voltage or current application it reduces arcing.

4.4.2 LEDs

Light Emitting Diodes are great for projects because they provide visual entertainment. LEDs use a special material which emits light when current flows through it. Unlike light bulbs, LEDs never burn out unless their current limit is passed. A current of 0.02 Amps (20 mA) is good range for LEDs.

FIGURE 4-4 LEDS

They have positive leg and a negative leg just like regular diodes. To find the positive side of an LED, look for a line in the metal inside the LED. It may be difficult to see the line. This line is closed to the positive side of the LED. Another way of finding the positive side is to find a flat spot on the edge of the LED. This flat spot is on the negative side.

When current is flowing through an LED the voltage on the positive leg is about 1.4 volt higher than the voltage on the negative side. Remember that there is no resistance to limit the current so a resistor must be used in series with the LED to avoid destroying it.

It has high brightness panel LED indicators light in various colours like red , yellow, blue, green, white. Various volt ranges in led indication lights. Long life working. Different Volt is available 24V, 110V, 220V.

4.4.2.1 Features

1. Power: 24V
2. Colour: Green, Red, Yellow
3. Multi segment
4. Long life: 50,000 hours
5. 230 V AC
6. Current Rating: 20mA
7. 24V &110 V AC/DC

4.4.3 Transformer

FIGURE 4-5 TRANSFORMER

It is a general purpose chassis mounting main transformer. Transformer has 230 V primary winding & centre tapped secondary winding. The transformer has flying colored insulated connecting leads (Approx. 100 mm long). The transformer act as step down transformer reducing AC-230V to AC-12 V.

The transformer gives two outputs of 24V, 12V, and 0V. The transformer construction is written below with details of solid core and winding.

The transformer is a static electrical device that transfers energy by inductive coupling between its winding circuits. A varying current in the primary winding creates a varying magnetic flux in the transformers core and thus a varying magnetic flux through the secondary winding. This varying magnetic flux induces a varying electromotive force (E.M.F) or voltage in secondary winding

The transformer has cores made of high permeability silicon steel. The steel has a permeability many times that of free space and the core thus serves to greatly reduce the magnetizing current and confine the flux to a path which closely couples the windings.

4.4.3.1 Features of 12-0-12 (24V) 5A Transformer

1. Soft Iron Core
2. Amp Current Drain

4.4.3.2 Application of 12-0-12 (24V) 5A Transformer

1. DIY projects Requiring In-Application High Current Drain
2. On Chassis AC/AC converter
3. Designing a battery charger

4.4.4 Toggle Switch

FIGURE 4-6 TOGGLE SWITCH

A toggle switch is a class of electrical switches that are manually actuated by a mechanical lever, handle, or rocking mechanism. Toggle switches are available in many different styles and sizes and are used in numerous applications. Many are designed to provide the simultaneous actuation of multiple sets of electrical contacts, or the control of large amounts of electric current or main voltages.

The word toggle is reference to a kind of mechanism or joint consisting of two arms, which are almost in line with each other, connected with an allow like pivot. However, the phrase toggle switch is applied to a switch with a short handle and a positive snap action whether it actually contains a toggle mechanism or not. Similarly, a switch where a definitive click is heard is called a positive on- off switch multiple toggle switches may be mechanically interlocked to prevent forbidden combinations

Switches are devices that create a short circuit or an open circuit depending on the position of the switch for a light switch ON means short circuit. when the switch OFF that means there is an open circuit. When the switch is ON it look and act like a wire. When the switch is OFF there being no connection.

4.4.5 Potentiometer Pot

FIGURE 4-7 POT

A potentiometer, informally a pot, is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat. The measuring instrument called a potentiometer is essentially a voltage divider used for measuring electric potential (voltage); the component is an implementation of the same principle, hence its name.

Potentiometers are commonly used to control electrical devices such as volume controls on audio equipment. Potentiometers operated by a mechanism can be used as position transducers, for example, in a joystick. Potentiometers are rarely used to directly control significant power (more than a watt), since the power dissipated in the potentiometer would be comparable to the power in the controlled load

4.4.5.1 Description

1. Horizontal Adjustable Resistor
2. Suitable for PC, electronic projects and DIY projects
3. Working Voltage: 50V

4.4.5.2 Specifications

1. Colour: Blue + White
2. Material: PBT
3. Rated power: 0.1W

5 Integrated Circuit

5.1 LN7805

Voltage Regulators

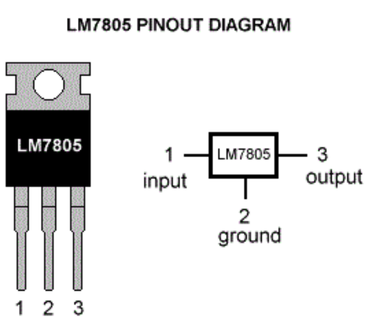


FIGURE 5-1 LM7805

1. Output Current up to 1.5 A
2. Internal Thermal-Overload Protection
3. High Power-Dissipation Capability
4. Internal Short-Circuit Current Limiting
5. Output Transistor Safe-Area Compensation

The 78xx (sometimes L78xx, LM78xx, MC78xx...) is a family of self-contained fixed linear voltage regulator integrated circuits. The 78xx family is commonly used in electronic circuits requiring a regulated power supply due to their ease-of-use and low cost. For ICs within the family, the xx is replaced with two digits, indicating the output voltage (for example, the 7805 has a 5-volt output, while the 7812 produces 12 volts).

This series of fixed-voltage integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 1.5 A of output current.

The internal current-limiting and thermal-shutdown features of these regulators essentially make them immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents, and also can be used as the power-pass element in precision regulators.

5.1.1 Advantages

78xx series ICs do not require additional components to provide a constant, regulated source of power, making them easy to use, as well as economical and efficient uses of space. Other voltage regulators may require additional components to set the output voltage level, or to assist in the regulation process. Some other designs (such as a switched-mode power supply) may need substantial engineering expertise to implement.

5.1.2 Disadvantages

The input voltage must always be higher than the output voltage by some minimum amount (typically 2.5 volts). This can make these devices unsuitable for powering some devices from certain types of power sources (for example, powering a circuit that requires 5 volts using 6-volt batteries will not work using a 7805).

5.2 LM339

In electronics, a comparator is a device that compares two voltages or currents and outputs a digital signal indicating which is larger. It has two analog input terminals and one binary digital output. The output is ideally

FIGURE 5-2 LM339

V_o = 1, if V+ > V-

=0, if V+ < V-

A comparator consists of a specialized high-gain differential amplifier. They are commonly used in devices that measure and digitize analog signals, such as analog-to-digital converters (ADCs), as well as relaxation oscillators.

A dedicated voltage comparator will generally be faster than a general-purpose operational amplifier pressed into service as a comparator. A dedicated voltage comparator may also contain additional features such as an accurate, internal voltage reference, an adjustable hysteresis and a clock gated input. A dedicated voltage comparator chips such as LM339 is designed to interface with a digital logic interface (to a TTL or a CMOS). The output is a binary state often used to interface real world signals to digital circuitry (see analog to digital converter). If there is a fixed voltage source from, for example, a DC adjustable device in the signal path, a comparator is just the equivalent of a cascade of amplifiers.

When the voltages are nearly equal, the output voltage will not fall into one of the logic levels, thus analog signals will enter the digital domain with unpredictable results. To make this range as small as possible, the amplifier cascade is high gain. The circuit consists of mainly Bipolar transistors. For very high frequencies, the input impedance of the stages is low. This reduces the saturation of the slow, large P-N junction bipolar transistors that would otherwise lead to long recovery times. Fast small Schottky diodes, like those found in binary logic designs, improve the performance significantly though the performance still lags that of circuits with amplifiers using analog signals. Slew rate has no meaning for these devices. For applications in flash ADCs the distributed signal across eight ports matches the voltage and current gain after each amplifier, and resistors then behave as level-shifters.

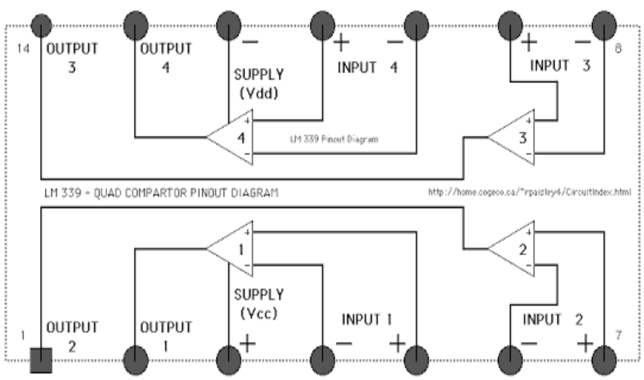


FIGURE 5-3 BLOCK DIAGRAM OF LM339

The LM339 accomplishes this with an open collector output. When the inverting input is at a higher voltage than the non-inverting input, the output of the comparator connects to the negative power supply. When the non-inverting input is higher than the inverting input, the output is 'floating' (has a very high impedance to ground). The gain of op amp as comparator is given by this equation V(out)=V(in).

5.3 ULN2803A

The ULN2803 or ULN2803A octal Darlington driver is a very useful chip used for interfacing up to 8 low-powered microcontroller output pins to higher current and voltage devices.Each channel of the chip contains a back-emf snubbing diode, so it is perfect for driving relays and motors.

5.3.1 Features

1. 500mA Rated Collector Current (Single Output)
2. High voltage Output
3. Output Clam Diodes
4. Inputs Compatible with Various
5. Types of Logic
6. Relay Driver Application
7. Compatible with ULN2800 Series

5.3.2 Applications

1. Relay Drivers
2. Hammers Drivers
3. Line Drivers
4. Lamp Drivers

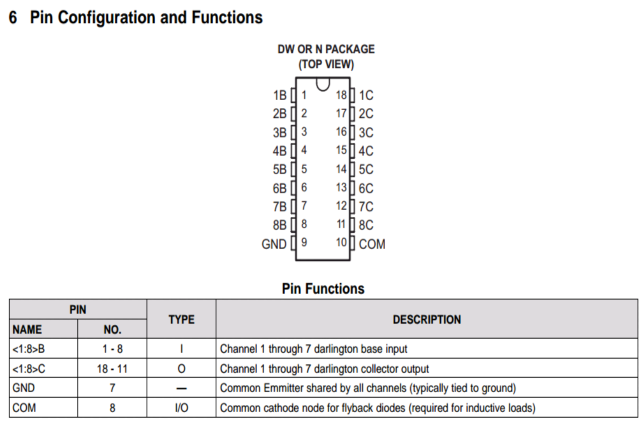
5.3.3 Description

The ULN2803A device is a high-voltage, high-current Darlington transistor array. The device consists of (Single Output) eight NPN Darlington pairs that feature high-voltage Output with Common Cathode Clamp Diodes for switching inductive loads. The collector-current rating of each Darlington pair is 500 mA. The Darlington pairs may be connected in parallel for higher current Types of Logic Capability Applications include relay drivers, hammer drivers, • Compatible with ULN2800A Series lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. The twoapplications ULN2803A device has a 2.7-kΩ series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices.

5.3.4 Device Information

PART NUMBER	PACKAGE (PIN)	BODY SIZE
ULN2803	SOIC (18)	11.50mm&*7.50mm
	PDIP (18)	22.48mm*6.35mm

TABLE 5-1 ULN2803



PIN		TYPE	DESCRIPTION
NAME	NO.		
<1:8>B	1 - 8	I	Channel 1 through 7 darlington base input
<1:8>C	18 - 11	O	Channel 1 through 7 darlington collector output
GND	7	—	Common Emmitter shared by all channels (typically tied to ground)
COM	8	I/O	Common cathode node for flyback diodes (required for inductive loads)

FIGURE 5-4 PIN CONFIGURATION OF ULN 2803A

6 Sensors

6.1 Temperature Sensor (LM35)

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in ^{o}C). The LM35 - An Integrated Circuit Temperature Sensor

6.1.1 Why Use LM35s to Measure Temperature?

You can measure temperature more accurately than a using a thermistor. The sensor circuitry is sealed and not subject to oxidation, etc. The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified.

6.1.2 What Does an LM35 Look Like?

Here it is:

FIGURE 6-1 LM35

6.1.3 What Does an LM35 Do? How does it work?

It has an output voltage that is proportional to the Celsius temperature. The scale factor is .01V/°C. The LM35 does not require any external calibration or trimming and maintains an accuracy of +/-0.4°C at room temperature and +/- 0.8°C over a range of 0°C to +100°C. Another important characteristic of the LM35DZ is that it draws only 60 micro amps from its supply and possesses a low self-heating capability. The sensor self-heating causes less than 0.1°C temperature rise in still air.

The LM35 comes in many different packages, including the following:

1. TO-92 plastic transistor-like package,
2. T0-46 metal can transistor-like package
3. 8-lead surface mount SO-8 small outline package
4. TO-202 package. (Shown in the picture above)

6.1.4 How Do You Use an LM35?(ElectricalConnections)

Hereisacommonlyusedcircuit.Forconnectionsrefertothepictureabove.

Inthiscircuit,parametervaluescommonlyusedare:

1. V_c = 4 to 30v
2. 5vor12varetypicalvaluesused.
3. $R_a = V_c / 10^{-6}$
4. Actually, it can range from 80 K to 600 K, but most just use 80 K

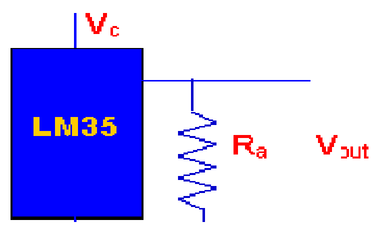


FIGURE 6-2 CONNECTION OF LM35

6.1.5 WhatCanYouExpectWhenYouUseanLM35?

1. You will need to use a voltmeter to sense Vout.
2. The output voltage is converted to temperature by a simple conversion factor.
3. The sensor has a sensitivity of 10mV / °C.
4. Use a conversion factor that is the reciprocal, that is 100 °C/V.

5. The general equation used to convert output voltage to temperature is:

   Temperature (^oC) = Vout * (100 $^oC/V$)

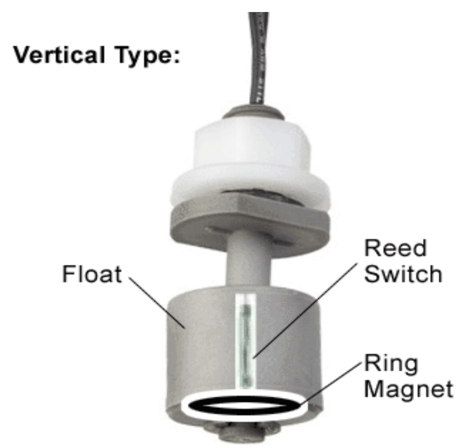
   So if Vout is 1V, then, Temperature = 100 ^oC

6. The output voltage varies linearly with temperature.

6.2 OilLevelDetector(Floatingsensor)

FIGURE 6-3 OIL LEVEL DETECTOR

Liquidlevelfloats,alsoknownasfloatballs,arespherical,cylindrical,oblongorsimilarlyshapedobjects,madefromeitherrigidorflexiblematerial,thatarebuoyantinwaterandotherliquids.Theyarenon-electricalhardwarefrequentlyusedasvisualsight-indicatorsforsurfacedemarcationandlevelmeasurement.Theymayalsobeincorporatedintoswitchmechanismsortranslucentfluid-tubesasacomponentinmonitoringorcontrollingliquidlevel.



Liquidlevelfloats,orfloatswitches,usetheprincipleofmaterialbuoyancy(differentialdensities)tofollowfluidlevels.Solidfloatsareoftenmadeofplasticswithadensitylessthanwaterorotherapplicationliquid,andsotheyfloat.Hollowfloatsfilledwithairaremuchlessdensethanwaterorotherliquids,andareappropriateforsomeapplications.

FIGURE 6-4 PARTS OF OIL LEVEL DETECTOR

StainlessSteelMagneticfloatsaretubedmagneticfloats,usedforreedswitchactivation;theyhaveaho llowtubedconnectionrunningthroughthem.Thesemagneticfloatshavebecomestandardequipment wherestrength,corrosionresistanceandbuoyancyarenecessary.

Liquidleveldetectioncontinuestoincreasinglyselecttheliquidlevelreedsensorbecauseofitsfavora blecharacteristicandversatiledesigncapabilitiesovertheothertechnologies

7 Software

7.1 Programming of PLC

7.1.1 Ladder Logic

Ladder logic was originally a written method to document the design and construction of relay racks as used in manufacturing and process control. Each device in the relay rack would be represented by a symbol on the ladder diagram with connections between those devices shown. In addition, other items external to the relay rack such as pumps, heaters, and so forth would also be shown on the ladder diagram. See relay logic ladder logic has evolved into a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay logic hardware ladder logic is used to develop software for programmable logic controller (PLCs) used in industrial control applications. Thee name is based on the observation that programs in this language resemble ladders with two vertical rails and a series of horizontal rungs between them. While ladder diagrams were once the only available notation for recording programmable controller programs, today other forms are standardized in IEC 61131-3.

7.1.2 Overview

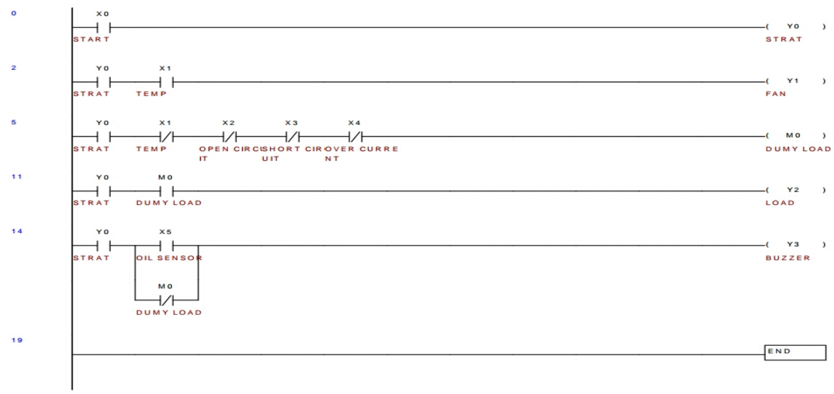


FIGURE 7-1 LADDER DIAGRAM

Parts of the ladder diagram, including contacts and coil, compares, timers and monostable multivibraters

Ladder logic is widely used to program PLCs where sequential control of a process or manufacturing operation is required. Ladder logic is useful for simple but critical control systems or for reworking old hardwired relay circuits. As programmable logic controllers became more sophisticated it has also been used in very complex automation systems. Often the ladder logic program is used in conjuction with a HMI program operating on computer workstation.

The motivation for representing sequential control logic in a ladder diagram was to allow factory enginners and technicians to develop software without additional training to learn a language such as FORTRAN or other general purpose computer language. Development and maintenance was simplified because of the resemblance to familiar relay hardware systems.Implementations of ladder logic have characteristics, such as sequential execution and support for control flow features, that make the analogy to hardware somewhat inaccurate. This argument has become less relevant given that most ladder logic programmers have a software background in more conventional programming languages.

Manufactures of programmable logic controllers generally also provides associated ladder logic programming systems. typically the ladder logic languages from two manufacturers will not be completely compatible; ladder logic is better thought of as aset of closely related programming languages rather than one language.(The IEC 61131-3 standard has helped to reduce unnecessary differences, but translating programs between systems still requires significant work). Even different models of programmable controllers within the same family may have different ladder notation such that programs cannot be seamlessly interchanged between the models.

Ladder logic can be thought of as a ruled based languages rather than a procedural language. A “rung” in ladder represents a rule.

When implemented with relays and other electromechanical devices, the various rules “execute’ simultaneously and immediately. When implemented in a programmable logic controller, the rules are typically executed sequentially by software , in a continuous loop (scan). By executing the loop fast enough , typicaaly many times per second, the effect of simultaneous and immediate execution is achieved, if considering intervals greater than the “scan time” required to execute all the rungs of the program.

7.2 Project PLC Programming

7.2.1 Software Name: WPLSoft 2.41

FIGURE 7-2 WPL SOFTWAR LOGO

WPLSoft is a program editor of Delta DVP series PLC for WINDOWS computers. In addition to general PLC programming and WINDOWS editing functions (e.g. Cut, paste, copy, multi-window displays, etc.), WPLSoft also provides various comment editing as well as other special functions (e.g. register editing and settings, file accessing and saving, contacts monitoring and setting, etc.).

System requirements for installing WPLSoft on your computer:

	System Requirements
Operation System	Windows 95/98/2000/NT/ME/XP/VISTA/Win7
CPU	Pentium 90 and above
Memory	128MB or above (256MB and above is recommended)
Hard Disk	Capacity: 50MB or above CD-ROM drive(for installing WPLSoft)
Monitor	Resolution: 640×480, 16 colors or above, It is recommended to set display setting of Windows to 800×600.
Mouse	General mouse or the device compatible with Windows
Printer	Printer with driver for Windows
RS-232	At least one of COM1~COM8 connected to PLC
Compatibility	All Delta DVP series PLC

FIGURE 7-3 SYSTEM REQUIREMENTS

7.2.2 Software Features

1. User friendly ladder editor
2. Simple, intuitive & fast software for simple ladder application
3. Program password protection
4. On-line and Off-line Simulation possible
5. Project Upload from Target

Icon	Name	Function
	PID	Auxiliary function of the PID instruction
	High Speed Counter	Auxiliary function of the high-speed counter
	High Speed Pulse Output	Auxiliary function of the high-speed pulse output
	Communication Program	Auxiliary function of the communication program
	Positioning Control	Auxiliary function of the position control
	Auxiliary Setup for Extension Modules	Auxiliary setup for the extension modules
	Sending Message Setup	Auxiliary function for the sending of the message by GSM MODEM
	2-axis Motion Control	2-axis motion of the EH2/SV series PLC
	Temperature Monitor	Monitoring the temperature through the communication.
	Interrupt Service	Auxiliary function of the interrupt service
	Extension Module	Monitoring the extension module through the communication
	AIO modules	Setting the AIO modules
	LoadCell modules	Setting the LoadCell modules

FIGURE 7-4 SOFTWARE FUNCTION

7.3 Project Ladder Diagram

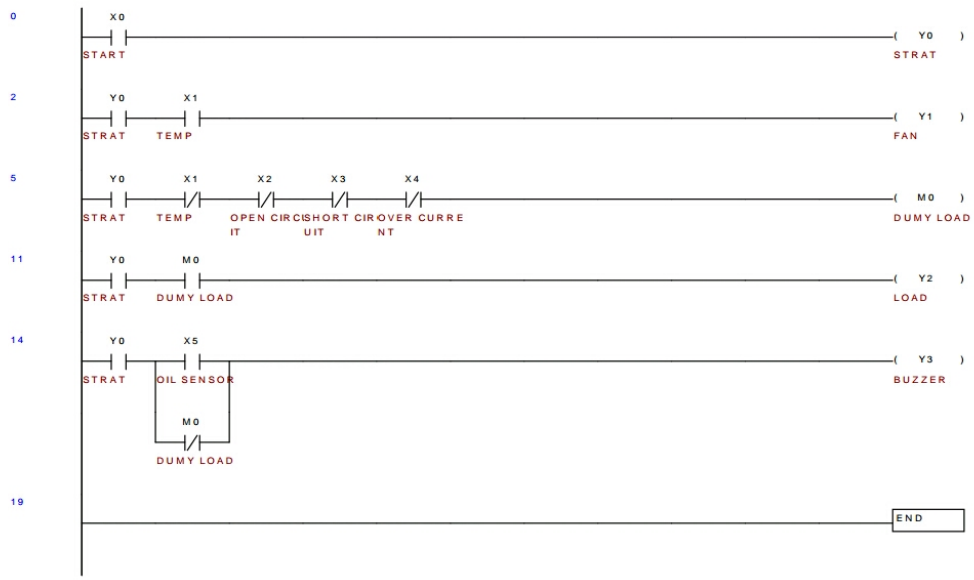


FIGURE 7-5 LADDER DIAGRAM OF PROJECT

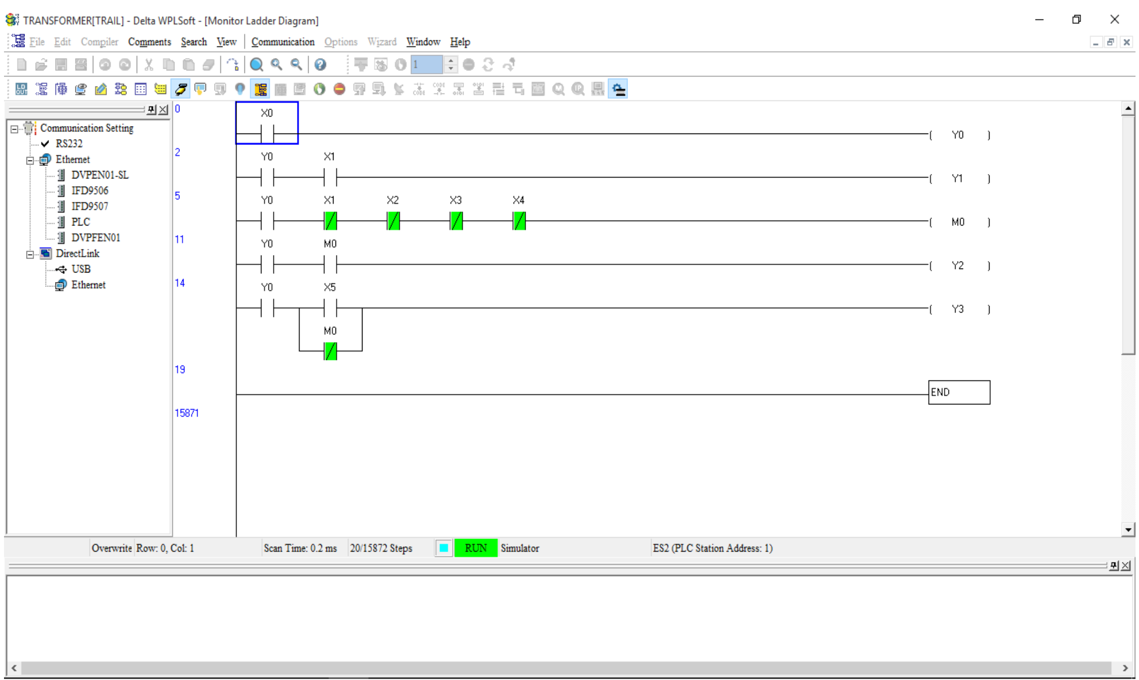


FIGURE 7-6PROJECT LADDER UNDER RUN CONDITION

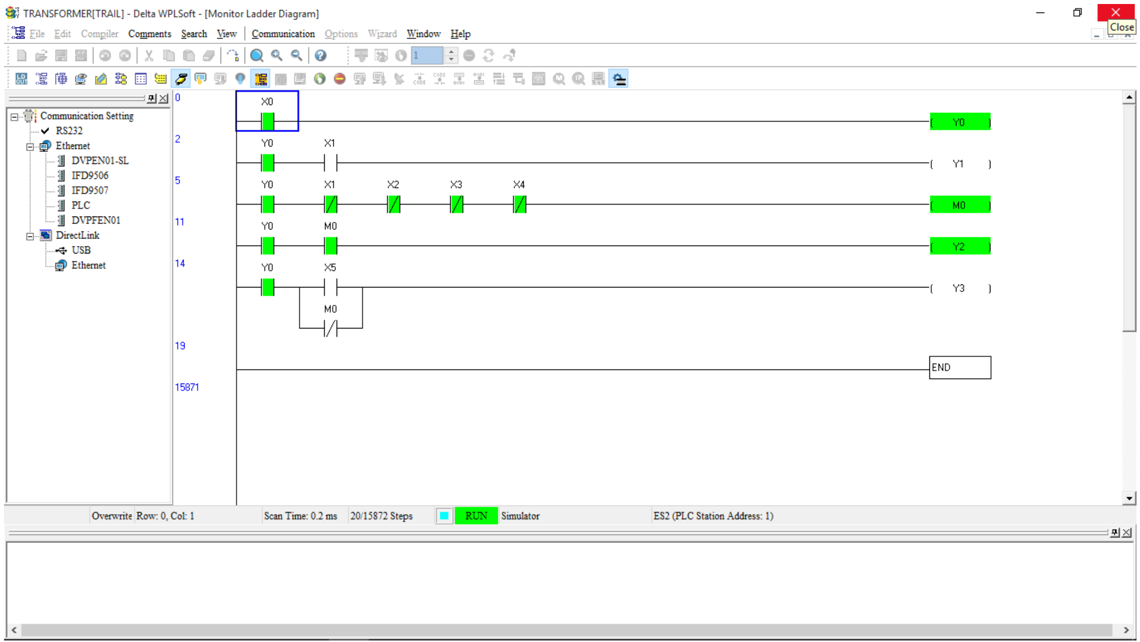


FIGURE 7-7PROJECT LADDER UNDER RUN CONDITION (NORMAL MODE)

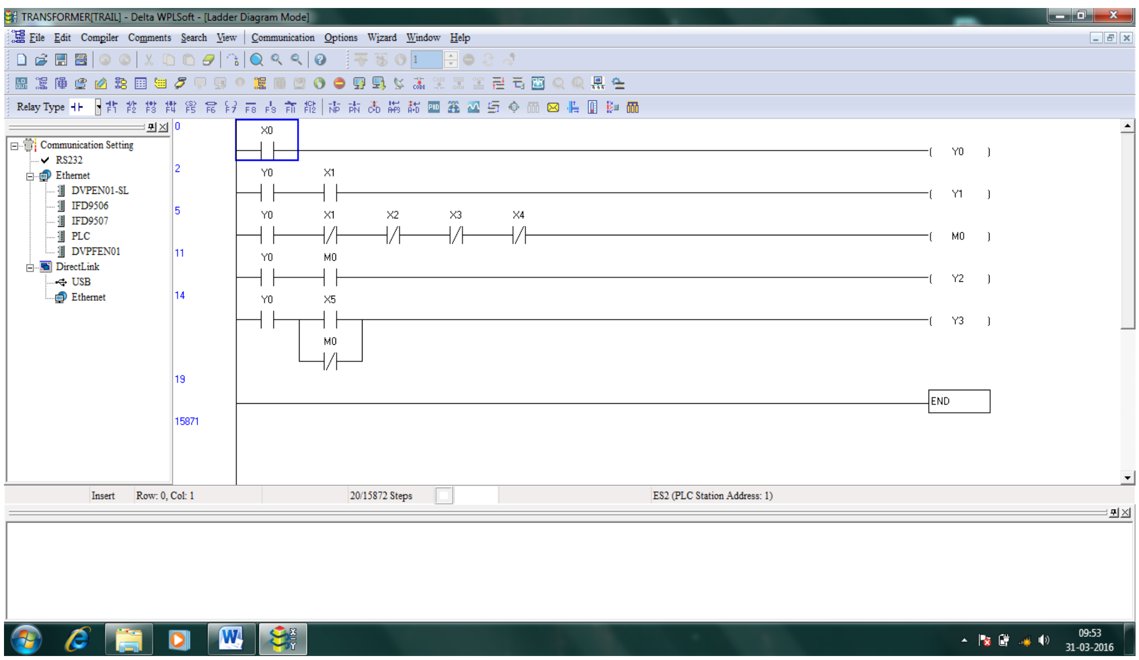


FIGURE 7-8PROJECT LADDER UNDER RUN CONDITION (OFF MODE)

8 Conclusion

In this project we have presented a design of a system based on PLC that is used to monitor and control the voltage, current, oil level and temperature of a substation distribution transformer in both sides. The proposed PLC system which has been designed to monitor the transformer's essential parameters continuously monitors the parameters throughout its operation. When the PLC recognizes any increase or decrease in the level of voltage, current, temperature or oil level values the unit has been made to cut supply load or shutdown in order to prevent it from further damages with the help of relays in system. The system not only controls the distribution transformer in the substation by shutting it down, but also displays the values through LEDs. This claims that the proposed design of the PLC systems makes the distribution transformer more Robust against some key power quality issues which makes the voltage current or Temperature to peak. Hence the distribution is made more secure, reliable and highly efficient by means of the proposed system.

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