Design & Implementation of Microcontroller based Automated Smart Grid System

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Declaration

It is declared hereby that this thesis paper or any part of it has not been submitted to anywhere else for the award of any degree.

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This is to certify that this project entitled "**Design & Implementation of Microcontroller based Automated Smart Grid System**" is done by the following students under my direct supervision. This project work has been carried out by them in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering, Sonargaon University (SU) in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering.

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ABSTRACT

Transformers of substation are one of the most important equipment in the power system network. Because of a large number of transformers and various components over a wide area in power systems, data acquisition, condition monitoring, automatic controlling are important issues. The project aims to design a monitoring and protection system for the transformer with the help of GSM technology. The present monitoring system requires manpower which is time-consuming and it is difficult to predict the occurrence of faults. In this project, we designed a system that continuously monitors the transformer parameters such as load current, voltage, and oil temperature with the help of sensors. These values are displayed continuously on the LCD. If any abnormalities occur in the transformer then the relay tripping system is active, and an alert message with the parameter values are sent to the monitoring center using the GSM module which is integrated with the Arduino board. This system will help the transformer to operate smoothly and identify problems before any catastrophic failure.

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CHAPTER I

INTRODUCTION

1.1 Introduction

Most power generation systems are located far from the user's area, so they must be capable of transmitting electricity from the power plant to the user's area in the most reliable and economical way. Past research has pointed out that using high-voltage power lines to send power is the best solution. Therefore, starting from the power plant, the power will be boosted to like 132 kV, 161kV or 400 kV by the transformer, and then transmitted. When the power reaches the destination, it will be reduced to the rated low voltage for distribution to customers. This implies that transformers meet a major role in electricity transmission. In the absence of own generators in facility infrastructure companies, factories, hospitals, and towns, transformers are important step-up and step-down devices in power transmission systems. These transformer users often face challenges including how to reduce the manual maintenance costs of transformer maintenance, mastering transformer temperature, obtaining real-time operating data, remotely monitoring transformers, or data collection and analysis. Transformer is a kind of static element device. Its main function is to convert electric energy from one circuit to another without any direct electrical connection. With the mutual inductance between the two windings, the transformer can also be used as a circuit isolation element. The transmission line is composed of one or more conductors, and its main design function is to transmit power or electrical signals over a long distance with minimal loss and distortion, as shown in Figure1.1.

In the power supply system, circuit breakers, fuses and electromechanical relays are mostly used as power system protection, but it turns out that using these protections is not reliable. Most of the current commercial activities use manual monitoring of transformer operation, especially manual and regular on-site inspection of transformer stations for maintenance and recording of important parameters. This type of monitoring cannot provide information about the potential hazards of incidental overload and overheating of transformer oil and windings. The aforementioned factors will seriously shorten the life of the transformer, and this issue deserves special attention.

On the technical idea, the power system monitoring of parameters like ambient temperature, load current, oil level of a transformer and voltages in a power system is an essential way of reducing power loss effectively. Supervisory control and data acquisition (SCADA) system are used for online monitoring of transformers within

company but extending the SCADA system for monitoring of distribution transformers at remote area is an expensive proportion due to long distance.

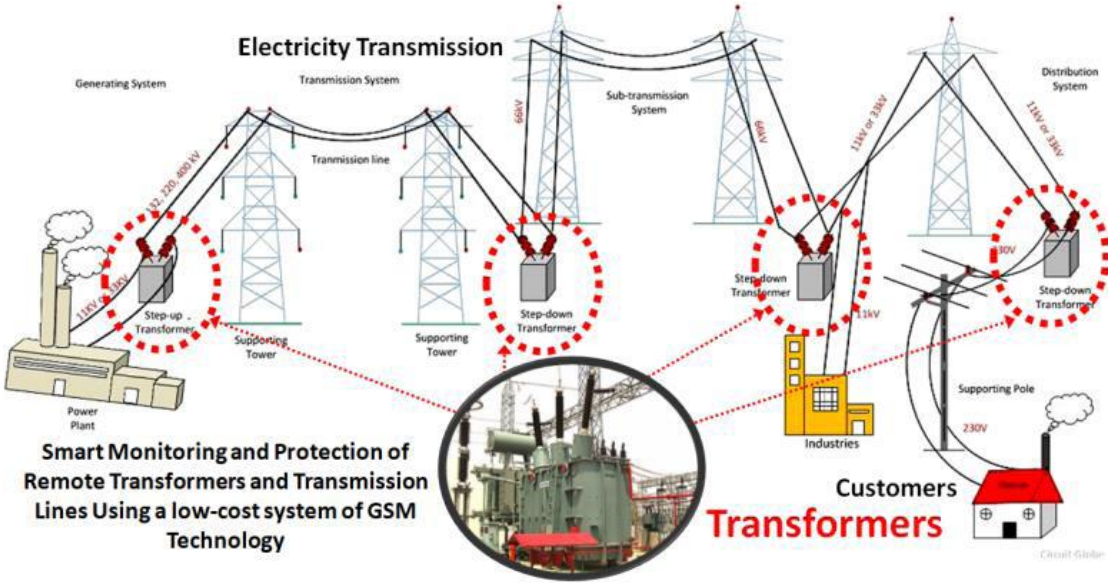


Figure 1.1: Electricity supply system

Distributed control systems (DCS) and internet-based communications are having their own limitation. The current poor monitoring of transformers has led to several challenges that confront power transformers. Some of these include overheating, overloading and overvoltage. The improper monitoring and control of these parameters can lead to flashover between terminals, deterioration of insulation of transformer oil, burning of winding insulation, shortening of transformer life span and total breakdown of the power transformer. These can cause interruptions in the supply of power to consumers and subsequently an unreliable power system. Unfortunately, some of these parameters are not adequately monitored due to the remoteness of some of these power transformers and coupled with the fact that personnel have to travel long distances to transformer sites in order to monitor them.

However, there is therefore the need for a novel technique to monitor these remote transformers. That is why we have engineered a system by using global service mobile (GSM) to monitor and protect transformer at remote areas. A low-cost GSM based monitoring system was designed to monitor temperature, oil level and three phase voltage balancing and to shut down the transformer if the temperature increases above a set threshold in this study. The temperature and oil level of a loaded transformer was measured at different load and fault condition. This is an important contribution of this study.

The major purpose of this project is to design a wireless monitoring and protection system and implement it on transformers. Data will collect through various sensors that measure supply voltage, load current, and transformer oil temperature. An

Arduino Uno will use to collect all the data from the sensors and send it to the user using a GSM module. It also isolates the transformer from the feeder line, when any fault occurs.

1.2 Objectives of the Project

- To design an embedded system that monitors the transformer's input voltage, load current, oil temperature, and automatically trips when preset values are exceeded.

- To construct the proposed real-time based monitoring and protection scheme to get optimum performance with GSM system.

1.3 Project Report Organization

This project book is arranged into the following chapters:

- Chapter 1 gives a brief introduction to the background of the project, objectives, and report organization.

- Chapter 2 focuses on the various types of transformer faults protection scheme.

- Chapter 3 focuses on the design of real-time based monitoring and efficient transformer protection system with GSM communication. Also discusses the performances of the implemented prototype system.

- Chapter 4 concludes the overall discussion project and future recommendation are also presented in this chapter.

- Chapter 4 includes the result and discussion of this proposed system.

- Chapter 6 describe the conclusion about our coal mine safety system.

CHAPTER II

THEORETICAL ASPECTS

The factors that are considered on a transformer protection scheme depend on the application size and importance of the transformer concerned. In order to mitigate against the harmful effects of thermal stress and fault induced electrodynamics forces, it is advisable to ensure that the protection scheme employed keeps to the minimum possible, the disconnection time in the event of a fault occurring within the transformer. Small distribution transformers can be protected satisfactorily, from both technical and economic considerations, by the use of fuses or over current relays. This results in time-delayed protection in order to satisfy the need for downstream co-ordination requirements. Time delayed fault clearance is however unacceptable on larger power transformers used in distribution, transmission and generator applications, due to system operation/stability and cost of repair/length of outage considerations.

2.1 Transformer Protection Scheme

The challenges associated with transformers require efficient means of protection. With the advent of static relays it is now the norm for a modern relay to be designed to provide all of the required protection elements in a single package, whilst in electromechanical relay types that would require several different relays each with its own connections to perform a unique function. This created a problem of larger overall CT burdens. See figure 2.1 .The advantages of static relays is their speed of operation, portability, accuracy, less burden on the CTs and great flexibility in terms of being programmable. Below is a diagram figure 2.1 showing the basic protection set-up, including the elements involved in the protection of power systems equipment which are current transformers (CTs), voltage transformers (VTs), relay and circuit breaker.

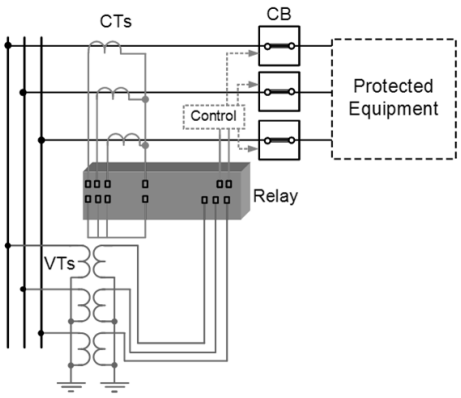


Figure 2.1: Basic protection setup

2.1.1 Current Transformer

A current transformer is a device used to reduce the magnitude of fault current in the primary circuit to values which can be managed by the protection relays [8]. It provides an interface of the primary circuit and the control circuit. It should be able to insulate the control circuit from the high voltages of the primary circuit. Protection CT has low saturation points in order to protect the relays for excessive currents. Protection CTs are usually required to operate above full load currents of system but under these conditions it's no longer accuracy that is critical but the ability to be able to handle high magnetizing currents on switching on of highly inductive loads but at the same time able to distinguish inrush currents from fault currents. Current transformers secondary are not to be open-circuited when the primary current in which they are connected is carrying load.

2.1.2 Voltage Transformer

A voltage transformer is essentially similar in most respects to a power transformer [9]. The only notable difference being that it has lower power rating. It is thus rated in VA while the larger power transformer is rated in at least KVA .Their purpose is to reduce the high voltage of the primary system to smaller values of voltage, the standard output being 110V which relays can easily handle without the need of the very high voltage required for the primary circuit. They are used to transform voltage of up to 36KV to 110V.Above 36KV it does not make economic sense to use them. At above 36KV it becomes necessary to use Capacitor Voltage Transformers as they become the cheaper option. Voltage transformer secondary circuits are not supposed to be shorted out when their primary circuit are connected as this results in very high currents flowing resulting in them overheating. This is in contrast to current transformers which are not supposed to have their secondary circuits open circuited on load.

2.1.2.2 Capacitor VTs

Capacitor voltage transformers (CVTs) employ a series string of high voltage capacitors to provide a voltage divider network. They are used in systems with voltages higher than 36KV. A suitable voltage is tapped off the voltage divider network. This voltage is then supplied to a voltage transformer which then gives the standard output of 110V which can then be used to supply relays requiring them. They are also used in the tuning circuit of wave traps used in power line carrier systems. The results in the use of technologies such as teleportation.

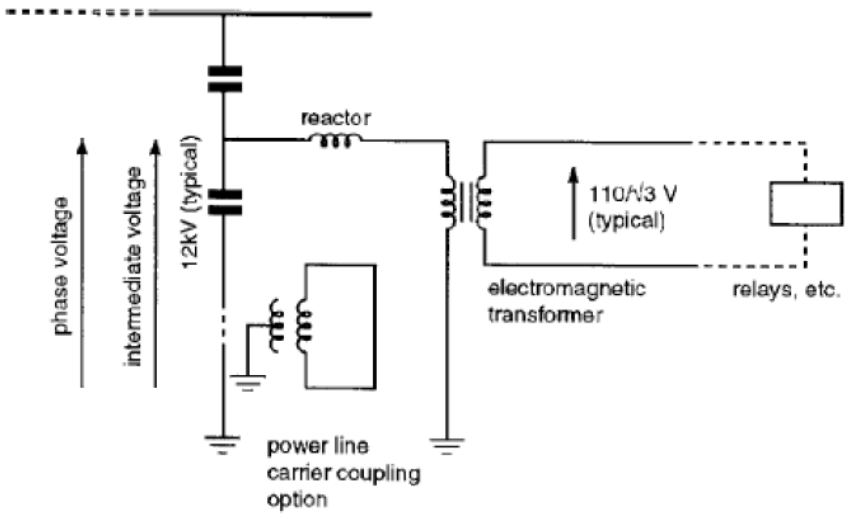


Figure 2.2: Protection relay

In order to affect control of circuit breakers relays are employed .Different kinds of relays are designed to measure specific elements of the power systems .Some relays respond to current, others measure impedance whilst other respond to changes in frequency or voltages. They normally have normally open contacts and normally closed contacts. When a certain pre-set value is reached relay will operated and close its normally open contacts whilst at the same time opening their normally closed contacts.

The normally open contacts are then used to supply specified power to closing coils of circuit breakers to close them or to trip coils of circuit breakers in order to open them. The protection relay is expected to be very fast in terms of speed of operation in order to ensure that faults are not sustained on the power system equipment. They are also expected to be sensitive and selective so that they can pick up small changes in the power system elements. Relays have what are called targets, these are basically a means of displaying to the operator whether a relay has operated or not.

2.1.3 Over Current Protection

Over current protection is mainly concern with protecting equipment from the effects of very high current which flow in the event of a short circuit occurring in a circuit. They are basically current operated devices.

Over current protection is not unit protection so intentional time delays can be introduced in order to allow coordination with downstream devices. These relays can self-reset in that they revert to their original state once the over current condition is removed from the power system. Only the target would need manual resetting.

2.1.4 Restricted Earth Fault Protection

REF is used to provide unit protection of earth fault on transformer windings [8]. The winding to be protected is placed within boundaries marked by CTs. Three CTs are installed in the three phases of the power supply and their sum output is fed to a CT connected to the Neutral point of the star transformer winding to be protected. REF is a form of unit protection.

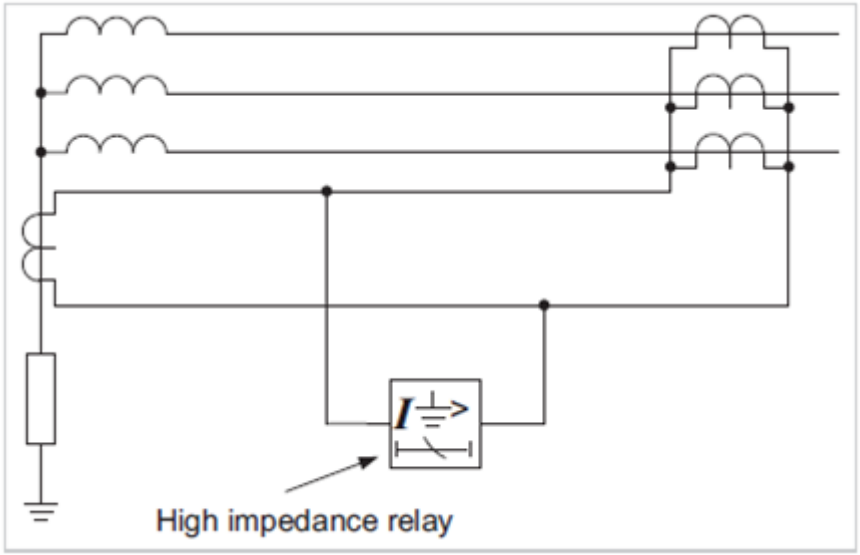


Figure 2.3: Restricted Earth Fault scheme

2.1.5 Differential Protection Scheme (DIFF)

This is unit protection which makes use of comparisons of currents from the HV lines and the LV by connecting a set of CT's at the HV phases with the corresponding ones at the LV side and having differential relays across these currents, this creates a balanced circulation in the phase CT"s, thus at normal operation no currents flow into

the differential relay, a fault in the zone defined by the line CT‟s disturbs this equilibrium permitting a differential current to pass through the differential relay which then operates.

Principles of High and Low Impedance differential schemes
A relay or a relay circuit whose voltage setting is not less than the calculated maximum voltage which can appear across its terminals under the assigned maximum through fault conditions(relay impedance is higher than the impedance of the secondary circuit of a saturated CT is referred to as a high impedance relay. It can be applied in the following situations;

- Protection co-ordination is difficult / impossible using time delayed elements
- Fast fault clearance is critical

It can be used on all items of plant in one form or another to form a defined zone of protection dictated by CT location.

Low impedance relay has impedance which is less than the total impedance of the secondary circuit of current transformer which is in saturation and the voltage setting in less than the calculated maximum voltage which appears at its terminals. Where relay impedance alone is too low to ensure stability then the relay circuit impedance can be increased through the addition of an external resistor connected in series with the relay.

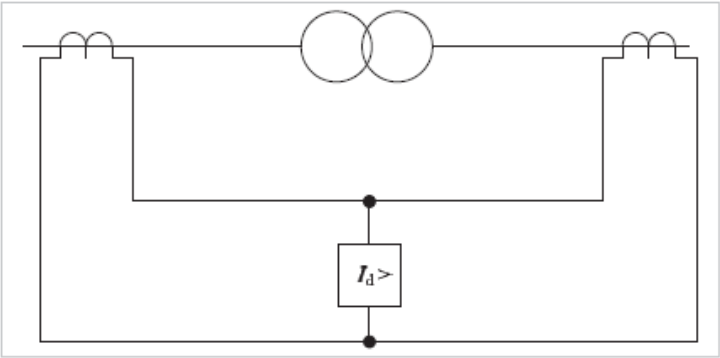


Figure 2.4: Differential protection scheme

2.1.6 Buchholz Protection

Buchholz protection can only be applied on all transformers fitted with a conservator tank. The Buchholz relay is itself contained in a housing which is connected in the middle of the pipe to the conservator .All faults that occur on device immersed in oil will cause heating of the oil which result in the decomposing of the to release methane and other gases. The percentage composition of the gases can then be used to determine the nature of fault. For example damage to paper insulation of a transformer winding will give different gas ratios as compared to direct oil

decomposition. A developing fault e.g. loose connection will release gas slowly whilst a heavy fault will release the gas very rapidly in the form of a surge.

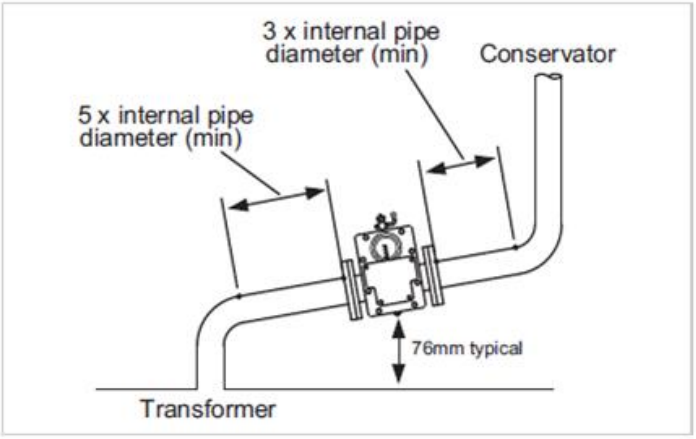


Figure 2.5: Buchholz Relay

Buchholz: this is a relay connected between conservator and main tank or at the top most point in the OLTC tank. It has contacts which make when the oil equilibrium is disturbed in the tank; the protection appears in two forms. Buchholz gas, this initiates an alarm when gas collects in the buchholz chamber after being generated from oil or insulation breakdown from winding faults or gas which would have been trapped in the tank during filling. These gases pile up in the chamber and produce a lowering of oil level which affects float switches that subsequently closes contacts signaling an alarm. Buchholz Surge causes a trip; this would have been generated from a more severe fault like arcing which then causes violent oil movements which affect higher float switches in the chamber thus making the trip contacts. The gas in the buchholz chamber is collected and analyzed and various interpretations come from the relative proportions of the gases hydrogen, acetylene, nitrogen, Carbon Monoxide, Carbon Dioxide, methane, Oxygen.

2.1.7 Overload Protection

Windings of power transformers must never be allowed to overheat as this leads to significant reduction in the lifespan of the transformers. A maximum temperature rise of 95°C is normally accepted to be the normal value pf temperature beyond which insulation of transformers will rapidly deteriorate. Winding temperature is normally used as the basis for transformer overload protection. A true representation of the load current is represented as a temperature through the use of thermal imaging. Thermal imaging involves connecting a CT on the winding whose temperature is to be measured and then connect the secondary of this CT to a heater to heat up oil on a pouch on the transformer. A temperature sensor or thermometer is then used to determine the winding temperature. A protective relay or tilt mercury switches are then used to trip appropriate circuit breakers.

2.2 Transformers Thermal Performance

Winding temperature trip, Oil temperature trip (WTT, OTT) are temperature caused trips from thermometers and CTs which measure the temperature of the oil and winding respectively. The trip will be initiated when certain temperatures are reached and these are generally set to be 115°C and 95°C respectively, these temperature increases are caused by mainly overloading the transformers, for prolonged times and they usually trip the LV breaker if the grading is proper.

OLT (Oil Level Trip): Oil level trip is a measurement of the level in the main or OLTC tank, when it goes below a certain level trip signals are sent as operating at lower oil levels is detrimental to the transformer, as insulation will be lower and cooling would be compromised.

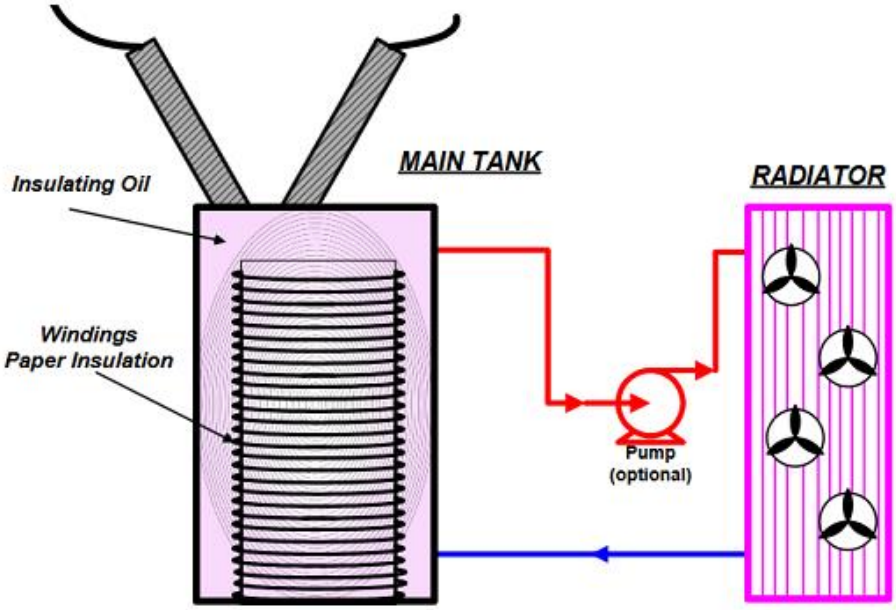


Figure 2.6: Transformer cooling system representation

Transformer rating is determined by basing on how much power the transformer can deliver continuously when being operated at its rated voltage and frequency. The transformer rating limit is determined by the thermal capability of the materials used to construct the transformer namely the core materials, and insulating oil used for coil. Load losses are the main contributors as the source of transformer heating current loss.

Ambient temperature measurement is used as a reference point to ensure that the transformer is protected regardless of outside temperature condition. The simplest method for cooling transformers is transferring heat from the core and windings to the

insulating oil. Natural circulation of the oil transfers the heat to external radiators. The radiators provide an increased the surface area for cooling of the transformer tank. Pumps may be used to increase the rate of flow of transformer oil, thereby increasing the cooling efficiency of the radiators. In non-directed flow transformers, the pumped oil flows freely through the tank. In directed flow transformers, the pumped oil is forced to flow through the windings. Forced air cooling is also another technique commonly used to provide better cooling of large transformers. Fans are employed to blow air at high pressure onto the surface of the radiators, which can double the efficiency of the radiators. For some large power transformers, water cooling may replace large radiators.

Large power transformers may also have additional ratings for multiple stages of forced cooling normally, only two stages are applied, providing transformer ratings equivalent to 133% and 167% of the self cooling rating.

Both the IEEE and the IEC established standard designations for the various cooling modes of transformers. The IEEE has adopted the IEC designations. The designation completely describes the cooling method for the transformer, and the cooling method impacts the response of the transformer insulating oil to overload conditions.

Table 2.1: Lists the common transformer cooling designations.

Old IEEE Cooling Designations		**IEC Equivalent**
Self-cooled	OA	ONAN
Forced air cooled	FA	ONAF
Directed-flow forced liquid cooled	FOA	ODAF
Water cooled	OW	OFWF
Forced liquid and water cooled	FOW	OFWF

CHAPTER III

SYSTEM DEVELOPMENT

3.1 System Block Diagram

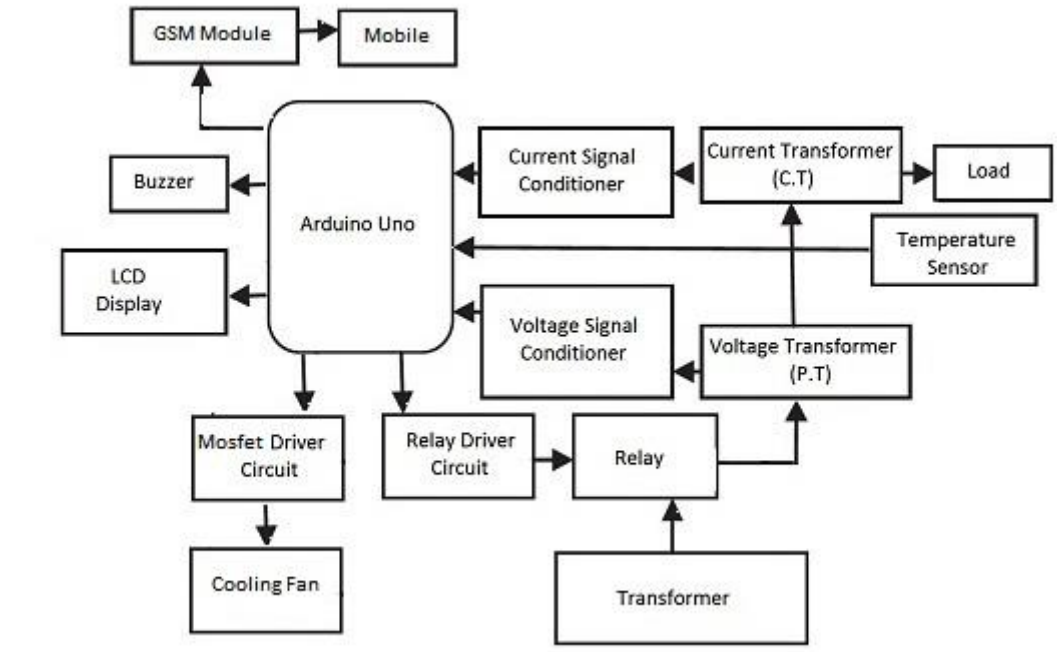


Figure 3.1: Block diagram of the proposed transformer protection system

Methodology of purposed protection scheme is shown in figure 3.1 with the help of block diagrams. The brain of the scheme is Arduino board. Detailed description and circuit of each block is given below. In this model, three transducers are used which are followed as Voltage transducer, Current transducer and Temperature transducer. These transducers are analog transducers. The analog sensors produce a continuous output signal or voltage which is generally proportional to the measuring quantity. This system can detect faults during under-voltage, over-current, and high winding temperature and isolate the transformer from the source. It can communicate transformer is under fault by obtaining what type of fault has been occurred to authorize persons (lineman, engineer, substation, powerhouse, etc.) via SMS using GSM technology. This is wireless communication and for this, we can use the

existing mobile phone towers. We can easily communicate with more than one person if necessary. This project will reduce the failure level.

3.1.1 Voltage Transducer

A voltage transducer is an element of electrical circuitry that both measures and monitors the levels of current and voltage dispersed and dispensed through the network depending on whether the current is AC or DC. When the power supplied to the circuit is AC, a voltage transducer will monitor and measure the current more readily than the voltage while voltage transducers work mainly in conjunction with DC power sources and the measurement capabilities of different voltage transducers differ widely due to the many ranges of their application, from computer circuitry to large transformer circuits. In this project, a potential transformer is used to measure the voltage and it is placed in parallel to the load. This transformer is acting like a voltage sensor. The primary side voltage of P.T is 220V and the secondary side voltage is 6V. Using bridge rectifier 1N4007 AC voltages is converter into DC voltage and attached to the analog pin of the Arduino. A variable resistor is used for calibration purposes.

3.1.2 Current Transducer

A current sensor is a device that detects electrical current (AC or DC) in a wire and generates a signal proportional to its variable parameters. The generated signal could be analog voltage or current or even digital output. This can be then utilized to display the measured current in an ammeter or can be stored for further analysis in a data acquisition system or can be utilized for control purposes. An input current signal is scaled down through interposing the current transformer (CT). The scaled-down signal is fed to a precision rectifier stage then this output is processed to provide DC Voltage/ Current output signal proportional to input AC Current and the output signal is calibrated for RMS value. In this project, ACS712 Hall Effect current sensor is used to measure the system current and it is placed in series to the load. The sensor secondary side is attached to the analog pin of the Arduino. A variable resistor is used for calibration purposes.

3.1.3 Temperature Transducer

A temperature sensor is an electronic device that measures the temperature of its environment and converts the input data into electronic data to record monitor or signal temperature changes. Non-contact temperature sensors are usually infrared (IR) sensors. In this project, LM35 has used as a temperature sensor to measure the transformer rising temperature.

3.1.4 Relay Circuit

The purpose of the relay is to disconnect the load in abnormal conditions. The relay circuit is connected to Arduino Board with using of opto-coupler (PC817). Opto-coupler is used for the isolation purpose and it protects the microcontroller from high voltage spikes. As the Arduino output pin becomes high, the relay circuit will operate and trips the load. The relay circuit is also shown in figure 3.2.

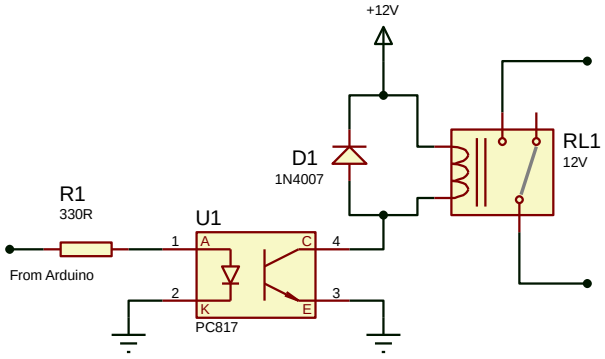


Figure 3.2: Opto isolated relay driver circuit

3.1.5 GSM Module

GSM (Global System for Mobile Communications) module is a chip or circuit that will be used to establish communication between a mobile device or a computing machine and a GSM system. There are different kinds of GSM modules available in the market. We are using the most popular module based on SIM800L**.** This means the module supports communication in 800MHz band. The communication between Arduino and GSM module is serial. We may connect the Tx pin of GSM module to Rx pin of Arduino and Rx pin of GSM module to Tx pin of Arduino. Now connect the ground pin of Arduino to ground pin of GSM module. The modem needs AT commands, for interacting with a controller, which are communicated through serial communication. These commands are sent by the controller. The MODEM sends back a result after it receives a command. Different AT commands supported by the MODEM can be sent by the controller to interact with the GSM.

3.1.6 Power Supply Unit

The power supply uses a step-down transformer to step down the input mains voltage to a voltage level suitable for the electronics within the device. A centre tapped transformer, with two diodes for full wave rectification is used to convert the ac voltage to a pulsating dc voltage followed by a filter, comprising of a capacitor to filter out (smooth) the pulsation.

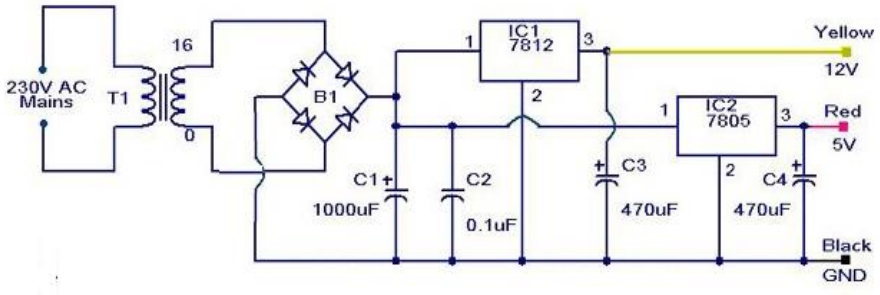


Figure 3.3: Typical positive regulated power supply circuit

3.2 Complete Circuit

Figure 3.4: Complete circuit diagram of the proposed transformer protection system

The transformer is an electrical device that is used to step down or step up the voltage without a change in frequency. Normally distribution transformer steps down the voltage of 11kV to 440V. But faults and excessive increases in load can lead to malfunction, insulation breakdown, and complete failure of transformer that can cause the blackout. In this project, a protection system has been designed in such a way that the designed system is monitoring the real-time based, operating parameters of the transformer continuously and these parameters are displayed on the LCD. In the LCD unit, we can view the continuous parametric information of the transformer. In this project work, a P.T is used to step down the line voltage for measuring purposes, and for sensing the line currents one Hall-Effect current sensor is used. C.T is connected in series and P.T is connected in parallel to the terminals of the transformer. LM35 sensor is used to measure the temperature of transformer oil. Relays are used to perform the tripping operation, and the GSM module is used to send SMS to user/responsible personnel. Voltage, current, and temperature are measured using analog to digital converter of the microcontroller. Analog to digital converter converts the values of analog voltage, current, and temperature value to the digital value respectively. Then according to the code, values are compared with the preset values in the controller if excess in any parameter occurs a relay would trip the transformer upon exceeding the limit of current with SMS notification. If temperature increases from the pre set value, a fan would be turned on using the proper driver circuit. The voltage, temperature, and current values are displayed on the LCD.

3.3 Software Implementation

The Software Implementation is done by means of Arduino software. Programming of Arduino and Interfacing of sensors with Arduino are the main part of software implementation. The programming part is done by using the "C" language. The hardware circuit gets initialized as soon as the power supply is given to it. LCD display is interfaced with the Arduino so that it displays the parameter values like voltage, current, and temperature. When any problem occurs in the transformer it will be displayed on the LCD and it sends the values to the monitoring centre through GSM module.

3.4 Required Components

3.4.1 NodeMCU

There are open-source prototype board designs for the NodeMCU open-source firmware. NodeMCU is a combination of the node and MCU (micro-controller unit) The related development kits are not technically considered to be part of the NodeMCU, but rather the firmware is. There are two versions of NodeMCU that are currently available: ESP-12 in version 0.9 and ESP-12E in version 1.0, where E stands for enhanced.

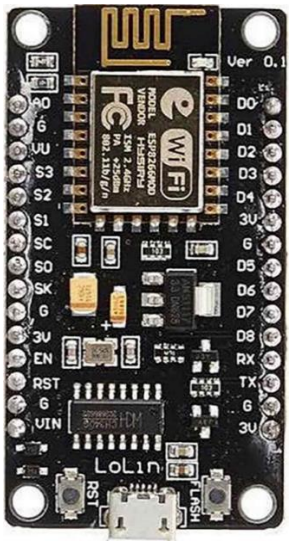


Figure 3.4: NodeMCU WiFi module

3.4.2 SMPS 12V

The disadvantages of LPS such as lower efficiency, the need for large value of capacitors to reduce ripples and heavy and costly transformers etc. are overcome by the implementation of Switched Mode Power Supplies.



Figure 3.5: SMPS (12V, 5A)

The working of SMPS is simply understood by knowing that the transistor used in LPS is used to control the voltage drop while the transistor in SMPS is used as a controlled switch.

Working:

The working of SMPS can be understood by the following figure.

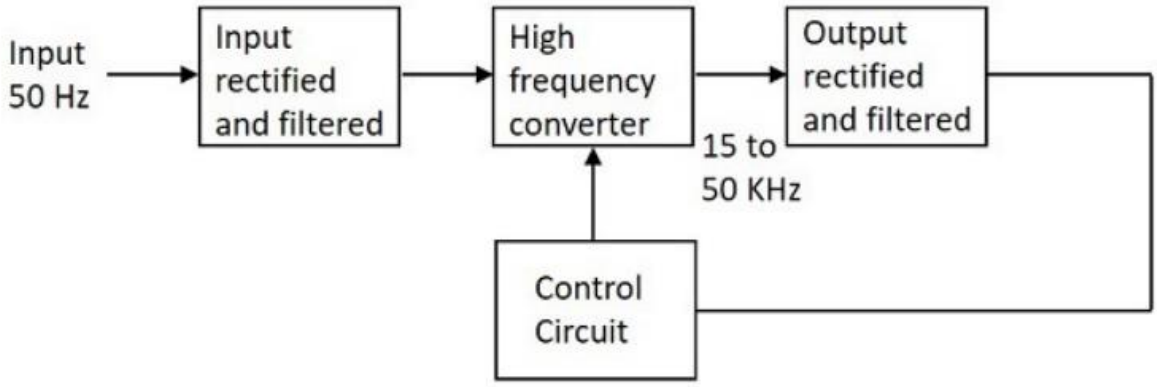


Figure 3.6: Working Procedure of SMPS (5V, 5A)

Let us try to understand what happens at each stage of SMPS circuit.

Input Stage

The AC input supply signal 50 Hz is given directly to the rectifier and filter circuit combination without using any transformer. This output will have many variations

and the capacitance value of the capacitor should be higher to handle the input fluctuations. This unregulated dc is given to the central switching section of SMPS.

Switching Section

A fast switching device such as a Power transistor or a MOSFET is employed in this section, which switches ON and OFF according to the variations and this output is given to the primary of the transformer present in this section. The transformer used here are much smaller and lighter ones unlike the ones used for 60 Hz supply. These are much efficient and hence the power conversion ratio is higher.

Output Stage

The output signal from the switching section is again rectified and filtered, to get the required DC voltage. This is a regulated output voltage which is then given to the control circuit, which is a feedback circuit. The final output is obtained after considering the feedback signal.

Control Unit

This unit is the feedback circuit which has many sections. Let us have a clear understanding about this from the following figure.

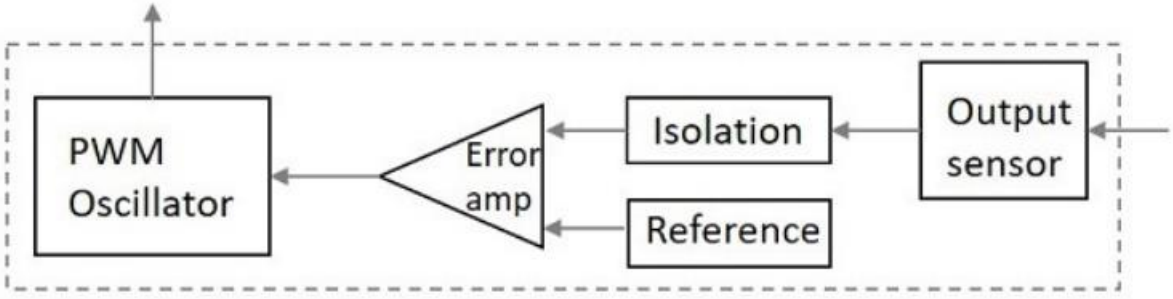


Figure 3.7: Control Unit

The above figure explains the inner parts of a control unit. The output sensor senses the signal and joins it to the control unit. The signal is isolated from the other section so that any sudden spikes should not affect the circuitry. A reference voltage is given as one input along with the signal to the error amplifier which is a comparator that compares the signal with the required signal level.

By controlling the chopping frequency the final voltage level is maintained. This is controlled by comparing the inputs given to the error amplifier, whose output helps to decide whether to increase or decrease the chopping frequency. The PWM oscillator produces a standard PWM wave fixed frequency.

We can get a better idea on the complete functioning of SMPS by having a look at the following figure.

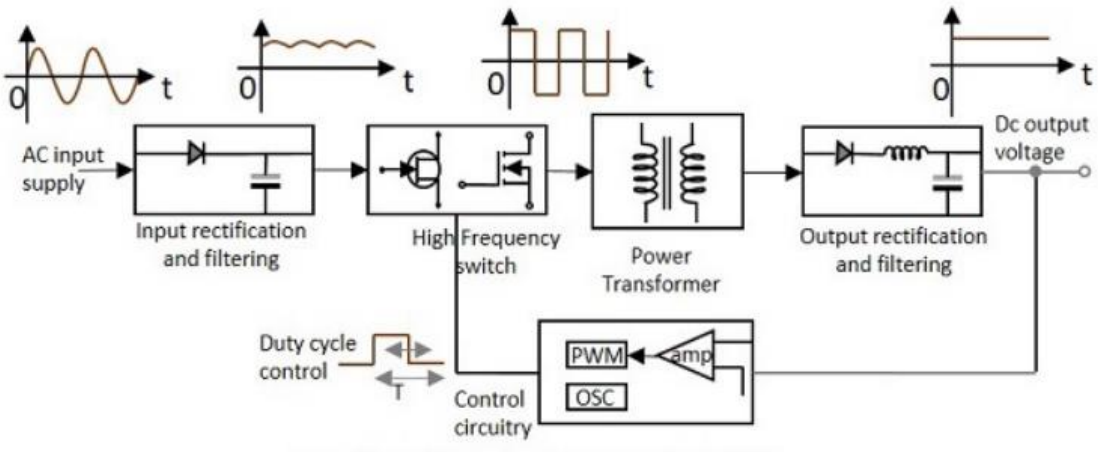


Figure 3.8: Functional Block Diagram of SMPS

The SMPS is mostly used where switching of voltages is not at all a problem and where efficiency of the system really matters. There are few points which are to be noted regarding SMPS. They are

- SMPS circuit is operated by switching and hence the voltages vary continuously.
- The switching device is operated in saturation or cut off mode.
- The output voltage is controlled by the switching time of the feedback circuitry.
- Switching time is adjusted by adjusting the duty cycle.
- The efficiency of SMPS is high because, instead of dissipating excess power as heat, it continuously switches its input to control the output.

Disadvantages

There are few disadvantages in SMPS, such as

- The noise is present due to high frequency switching.
- The circuit is complex.
- It produces electromagnetic interference.

Advantages

The advantages of SMPS include,

- The efficiency is as high as 80 to 90%
- Less heat generation; less power wastage.
- Reduced harmonic feedback into the supply mains.
- The device is compact and small in size.
- The manufacturing cost is reduced.
- Provision for providing the required number of voltages.

Applications

There are many applications of SMPS. They are used in the motherboard of computers, mobile phone chargers, HVDC measurements, battery chargers, central power distribution, motor vehicles, consumer electronics, laptops, security systems, space stations, etc.

Types of SMPS

SMPS is the Switched Mode Power Supply circuit which is designed for obtaining the regulated DC output voltage from an unregulated DC or AC voltage. There are four main types of SMPS such as:

- DC to DC Converter
- AC to DC Converter
- Fly back Converter
- Forward Converter

The AC to DC conversion part in the input section makes the difference between AC to DC converter and DC to DC converter. The Fly back converter is used for Low power applications. Also there are Buck Converter and Boost converter in the SMPS types which decrease or increase the output voltage depending upon the requirements. The

other type of SMPS include Self-oscillating fly-back converter, Buck-boost converter, Cuk, Sepic, etc.

3.4.3 ACS712 Current Sensor

The ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device consists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy after packaging. Typical applications include motor control, load detection and management, switched-mode power supplies, and over current fault protection.

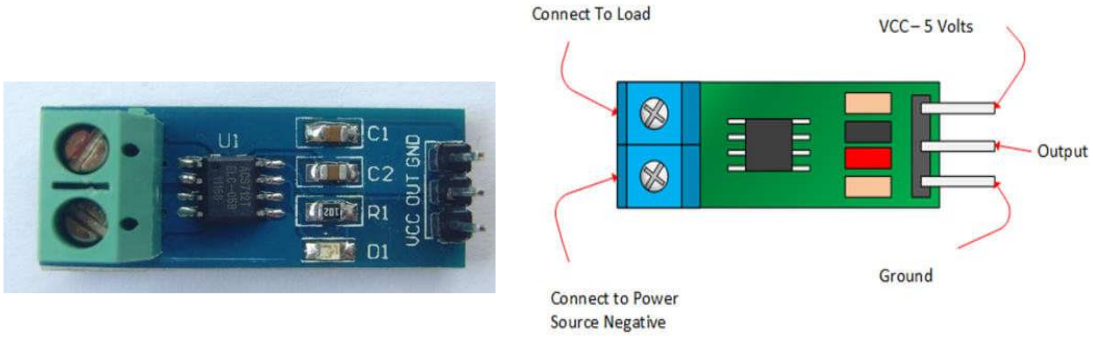


Figure 3.9: ACS-712 Hall Effect current sensor

3.4.4 Buzzer

For alarm purposes a lot of electric bells, alarms and buzzers are available in the market that has got different prices and uses. The buzzer being used in this project is a 5-12 V buzzer and has got enough alarm sound to be used in a fire alarm system. Louder buzzer would have been even better but then their operating voltages are high as we had a supply of maximum up to 12V available with us on the board.



Figure 3.10: Typical buzzer arrangement.

3.4.5 NPN Silicon Transistors (BC547N)

In this project we have used BC547N NPN Silicon Transistor, which is a highly performance switching device. Its Collector-Base Voltage is 50 V, maximum, collector to emitter voltage is 45 v maximum, Emitter to base voltage is 5 V, collector current is 100 mA, when input signal is zero, maximum collector power dissipation is 500 milliwatt. Its switching frequency is 300 MHz; This Transistor is used in my project as a high power IGBT / N-MOS gate driver circuit component. A typical BC547N NPN Silicon Transistor is shown in the following Figure 3.9.

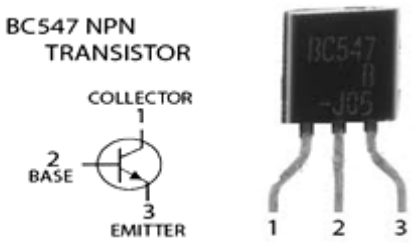


Figure 3.11: Typical BC547N silicon transistor.

3.4.6 Liquid Crystal Display (HD44780)

The embedded project becomes spicy with the addition of alphanumeric LCD that facilitates the user instructions as well as project response in alphanumeric form which makes the application professional and easy to use. It not only enhances the presentation aspects but eases the debugging process by setting single stepping, breakpoints and interrupts wherever required. HD44780 Character LCD is a popular industry standard liquid crystal display (LCD) display device designed for interfacing with microcontrollers. It has capability to display in 16 × 2 configurations. These LCDs are found in many appliances such as copiers, fax machines, laser printers, industrial test equipment, networking equipment such as routers and storage devices, etc. to name a few. Manufacture's data sheet and even many web pages cover the commands for the LCD. By adding a shift register a two wire interface for the LCD is also been developed.

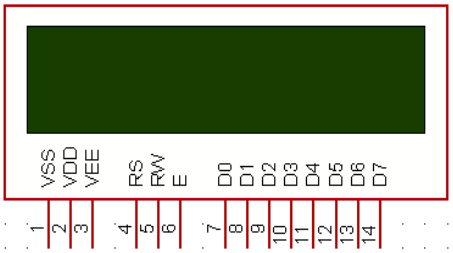


Figure 3.12: HD44780 liquid crystal display (LCD).

3.4.7 Power MOSFET (IRFZ44N)

As illustrate in Figure 3.11, this power MOSFET has limitations operation in terms of voltage, current and power dissipation. The power absorbed by the gate drive circuitry should not significantly affect the overall efficiency. The power MOSFET current rating is related with the heat dissipated in the device. This rating will be taken in consideration for designing appropriate circuit to protect power MOSFET against high voltage and current, thus cause heat generation. While considering protection of power MOSFET against over voltage, a distinction has to be made between slowly varying over voltage and short time surge. It is about 55Vdc the maximum rating of drain to source breakdown voltage. Gate voltage must be 15-20V higher than the drain voltage. Being a high side switch, such gate voltage would have to be higher than the rail voltage, which is frequently the higher voltage available in the system. Continuous drain current 49A at 25 degree centigrade.



Figure 3.13: IRFZ44N typical T220 package

3.4.8 Electromagnetic Relay

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

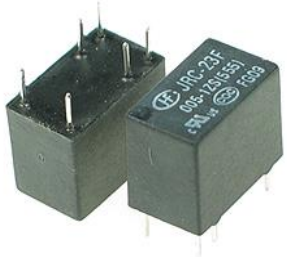


Figure 3.14: Electromagnetic relays

3.4.9 Temperature Sensor

This is a waterproofed version of the DS18B20 Temperature sensor. Handy for when you need to measure something far away, or in wet conditions. While the sensor is good up to 125°C the cable is jacketed in PVC so we suggest keeping it under 100°C. Because they are digital, you don't get any signal degradation even over long distances! The DS18B20 provides 9 to 12-bit (configurable) temperature readings over a 1-Wire interface, so that only one wire (and ground) needs to be connected from a central microprocessor. Usable with 3.0-5.5V systems.
Because each DS18B20 contains a unique silicon serial number, multiple DS18B20s can exist on the same 1-Wire bus. This allows for placing temperature sensors in many different places. Applications where this feature is useful include HVAC environmental controls, sensing temperatures inside buildings,equipment or machinery, and process monitoring and control.



Figure 3.15: Water proof temperature sensor

3.4.10 SIM800L GSM Module

SIM800L is a miniature cellular module which allows for GPRS transmission, sending and receiving SMS and making and receiving voice calls. Low cost and small footprint and quad band frequency support make this module perfect solution for any project that require long range connectivity.



Figure 3.16: Typical SIM800L GSM module

3.6 Hardware Implementation

The main components used for designing the system are sensors, Arduino, and GSM. Power is supplied to all the components by means of a battery. The required parameter values are obtained by using sensors. Arduino is programmed in such a way that it displays the obtained values in the LCD display and compares the values with the pre-set values. The values are sent to the monitoring centre or user by means of GSM.

////////////// Hardware full over view will be added here /////////////////

Figure 3.17: Complete hardware and testing circuit

3.7 Experimental Results

Table 3.1: Experiment results according to designed algorithm

DETECTORS	STEPS	LCD	RELAY FUNCTION	SMS NOTIFICATION
VOLTAGE DETECTOR (P.T)	V < =230 volt	**NORMAL CONDITION** (With R.M.S. values)	INACTIVE	No SMS
	V > 230 volt	OVER VOLTAGE	ACTIVE	**OVER VOLTAGE**
	V < =180 volt	UNDER VOLTAGE	ACTIVE	**UNDER VOLTAGE**
CURRENT DETECTOR (C.T)	I < = 4 AMP	**NORMAL CURRENT** (With R.M.S. values)	INACTIVE	No SMS
	I > 4 AMP	OVER LOAD	ACTIVE	**OVER LOAD**
TEMPERATURE DETEECTOR (LM35)	T > 65°C	HIGH TEMPERATURE	ACTIVE	**HIGH TEMPERATURE**
	25°C < = T	NORMAL CONDITION (With temperature value)	INACTIVE	No SMS

CHAPTER IV

CONCLUSION

4.1 Conclusion

Compared with manual monitoring, transformer status monitoring using GSM is more useful and reliable. The reason is that it is not always manual to monitor the load current, ambient temperature, under voltage, and over voltage. However, the system can immediately take measures to prevent the catastrophic failure of the transformer after receiving the abnormal message. The results of this research are very convenient to prevent transformer failure, so the economic cost of replacing the transformer is saved.

4.2 Future Works

- In addition, the study design can also plan for large-scale power outages in advance, thereby reducing the total load reduction time.
- Also, implement this protection system for the power generation system.
- This work can also be done using PLCs, and a similar technique can also be applied for the construction of numerical relays.

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APPENDIX

A. Programming Codes for Proposed Project

The End