

IOT BASED SMART TRANSFORMER MONITORING AND ITS CONTROL

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Abstract - The aim of the project is to design a IOT based smart transformer monitoring and control system. The present monitoring system requires manpower which is the time consuming and it is difficult to predict the occurrence of faults. In this project, we designed a system which Building of an automatic system using the arduino microcontroller for the monitoring and protection of the transformer and also Making an android app fit for our purpose and synchronization of the system with the Nodemcu (wifi module) for getting notifications and real-time monitoring of the parameters of the transformer. The system would also provide the real-time monitoring of the parameters of the transformer like voltage, current ,temperature etc on the android device and personal computers and get notifications in the cases of faults.

Key Words: ArduinoUno, IOT, Voltage, Current, Temprature, NodeMCU, Buzzer

1. INTRODUCTION

Transformer is the most important device in the power system. Thus it has to be continuously monitored and kept healthy. Any fault or unbalancing in the transformer may cause the serious problems in the power system. Thus, here our objective is to build a system that would continuously monitor the transformer and do the needful in the cases of unbalancing. The system would also provide the real-time monitoring of the parameters of the transformer like voltage, current ,temperature etc on the android device and personal computers and get notifications in the cases of faults.

Our project involves two phases. (1) Building of an automatic system using the arduino microcontroller for the monitoring and protection of the transformer.(2) Making an android app fit for our purpose and synchronization of the system with the the Nodemcu (wifi module) for getting notifications and real-time monitoring of the parameters of the transformer.

The aim of this research paper is to make system easy and convenient. Automatic systems are used instead of traditional methods. Monitoring is vital for sustenance of mankind but simultaneously it is very tedious and time consuming. By introducing advanced systems, this process can become better. There is already a shortage of V&I sources and hence it becomes essential for mankind to save it. This proposed system consumes the least amount

time required for monitoring, thus saving it. This paper proposes a system which does controlling the process with the help of a IoT on mobile application, which will make easy to monitor the transformer from remote location and even decrease the requirement of manpower to look after the system as our systm is automatic.

2. METHODOLOGY

The main principle of operation of a transfor is mutual inductance between two circuits which is linked by a common magnetic flux. A basic transformer consists of two coils that are electrically separate and inductive, but are magnetically linked through a path of reluctance .

In short, a transformer carries the operations shown below:(1)Transfer of electric power from one circuit to another.(2)Transfer of electric power without any change in frequency.(3)Transfer with the principle of electromagnetic induction.(4)The two electrical circuits are linked by mutual induction.

Faults and Abnormal conditions in Transformer.Internal faults:

(1)insulation deterioration(2)winding failure(3)overheating(4)contamination of oil

Phase to phase fault is also considered an internal fault. if insulation starts to fail it can create a short circuit inside the transformer that can shut it down. A high current flow can also cause problems with winding and over heating. Mechanical faults can also happen when the cooling mechanism fails to operate properly. High current levels can also deteriorate the insulation, which is a major cause of faulting. Most of these faults can be prevented through testing and maintenance.

External faults:(1)lighting strikes(2)system overload(3)short circuit

External faults are things that happen outside the transformer, and cannot generally be prevented by maintenance. The transformers are subject to things like lightning strikes, or other damage from the outside that cannot be prevented. Since these things cannot be predicted, it is important to have a plan in place to make repairs as fast as possible. These can also be fairly minor in nature, but can cause damage to the insulation and cause problems over time to the inside of the transformer.

The greater concern is when something happens outside that shuts the transformer down immediately.

Protection That Will Be Provided In Transformer

Overvoltage and Under-voltage: occur due to fluctuation of power source through the power supply. It occurs when the input voltage from the mains exceeds or goes below a certain acceptable limit thereby causing the equivalent DC voltage to go high or low. This causes excess heating of the motor, stator and rotor losses increase and a considerable effect on machine insulation.

Overloading: Occurs when a motor is under excessive load. The primary symptoms accompanying motor overload are excessive current draw, insufficient torque and overheating. Indeed, excessive motor heat is a major cause of premature wear on electrical and mechanical components that ultimately leads to motor failure.

Unbalancing: Three phase induction motors are designed and manufactured such that all three phases of the winding are carefully balanced with respect to the number of turns, placement of the winding, and winding resistance. When line voltages applied to a polyphase induction motor are not exactly the same, unbalanced currents will flow in the stator winding, the magnitude depending upon the amount of unbalance. A small amount of voltage unbalance may increase the current an excessive amount. The effect on the motor can be severe and the motor may overheat to the point of burnout. The voltages should be evenly balanced as closely as can be read on the usually available commercial voltmeter.

IoT (INTERNET OF THINGS)

The Internet of things (IoT) is the extension of Internet connectivity into physical devices and everyday objects. Embedded with electronics, Internet connectivity, and other forms of hardware (such as sensors), these devices can communicate and interact with others over the Internet, and they can be remotely monitored and controlled.

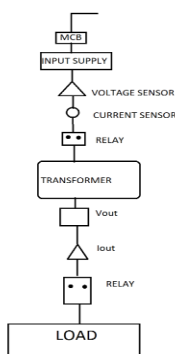


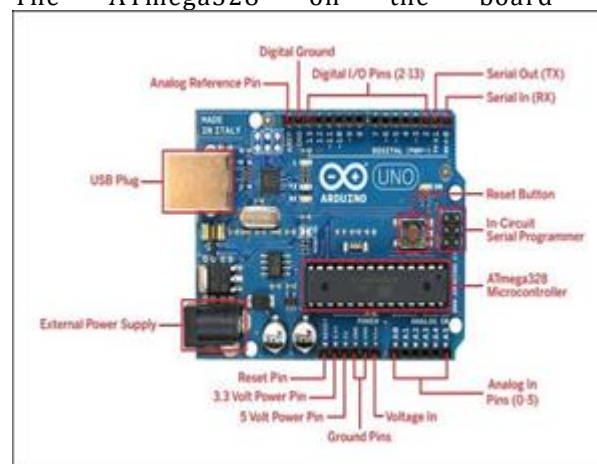
Fig -1: Block diagram of system

3. COMPONENTS OF THE SYSTEM

3.1: ARDUINO UNO



The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available. The word "uno" means "one" in Italian and was chosen to mark the initial release of the Arduino Software. The Uno board is the first in a series of USB-based Arduino boards, and it and version 1.0 of the Arduino IDE were the reference versions of Arduino, now evolved to newer releases. The ATmega328 on the board comes



preprogrammed with a bootloader that allows uploading new code to it without the use of an external hardware programmer. While the Uno communicates using the original STK500 protocol,

it differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Specifications:

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g



2.3: VOLTAGE SENSOR

In voltage sensors, the measurement is based on the voltage divider. Mainly two types are of voltage sensors are available- Capacitive type voltage sensor and Resistive type voltage sensor.

Capacitive Voltage Sensor

As we know that a capacitor comprises of two conductors or simply two plates and in between these plates, a non-conductor is kept. That non-conducting material is termed as dielectric. When an AC voltage is provided across these plates, current will start to pass owing to either the attraction or the repulsion of electrons by means of the voltage present on the opposite plate. The field among the plates will create a complete AC circuit without any hardware connection. This is how a capacitor works.

Next, we can discuss about the voltage division in two capacitors which are in series. Usually in series circuits, high voltage will develop across the component which is having high impedance. In the case of capacitors, capacitance and impedance (capacitive reactance) are always inversely proportional.

The relation between voltage and capacitance is

Q → Charge (Coulomb)

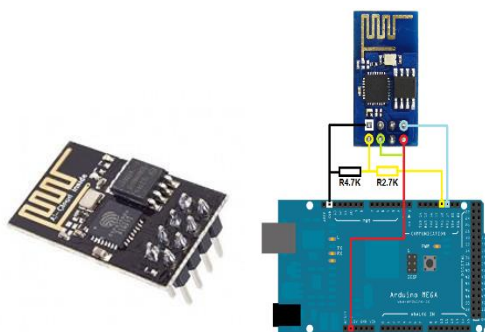
C → Capacitance (Farad)

XC → Capacitive reactance (Ω)

f → Frequency (Hertz)

From the above two relations, we can clearly state that the highest voltage will build up across smallest capacitor. The capacitor voltage sensors work based on this simple principle. Consider we are holding the sensor in our hand and then placing the tip of it near a live conductor. Here, we are inserting the sensing element of high impedance into a series capacitive coupling circuit. In this moment, the tip of the sensor is the smallest capacitor which is coupled to the live voltage. Thus the whole voltage will develop across the sensing circuit and it can detect voltage and indicator like light or buzzer sound is turned on.

3.2: ESP8266 WIFI MODUL



(Fig 5 ESP8266 [https:// www.google.com](https://www.google.com))

The ESP-01 ESP8266 Serial WIFI Wireless Transceiver Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much WiFi-ability as a WiFi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community.

Resistive Voltage Sensor

There are two ways in converting the resistance of the sensing element to the voltage. First one is the simplest method that is to provide a voltage to the resistor divider circuit comprises of a sensor and a reference resistor which is represented below. resistive voltage sensor

The voltage that is developed across the reference resistor or sensor is buffered and then given to the ADC. The output voltage of the sensor can be expressed as

The drawback of this circuit is the amplifier present here will amplify the whole voltage developed across the sensor. But, it is better to amplify only the voltage change due to the change in resistance of the sensor. This is achieved by the second method implementing the resistance bridge which is shown below.

resistive voltage sensor

Here, the output voltage is

When $R1 = R$, then output voltage becomes approximately

$A \rightarrow$ Gain of Instrumentation Amplifier.

$\delta \rightarrow$ Change in the resistance of the sensor analogous to some physical action.

In this equation, gain have to be set high because only the voltage change due to the change in resistance of the sensor is being amplified.

resistive voltage sensor.

Application of Voltage Sensor

- Power failure detection.
- Load sensing.
- Safety switching.
- Temperature control.
- Power demand control.
- Fault detection etc.

3.4: CURRENT SENSOR (ACS712)



ACS712 Current Sensor is the sensor that can be used to measure and calculate the amount of current applied to the conductor without affecting the performance of the system.

ACS712 Current Sensor is a fully integrated, Hall-effect based linear sensor IC. This IC has a 2.1kV RMS voltage isolation along with a low resistance current conductor.

Working Principle

Current Sensor detects the current in a wire or conductor and generates a signal proportional to the detected current either in the form of analog voltage or digital output.

Current Sensing is done in two ways – Direct sensing and Indirect Sensing. In Direct sensing, to detect current, Ohm's law is used to measure the voltage drop occurred in a wire when current flows through it.

A current-carrying conductor also gives rise to a magnetic field in its surrounding. In Indirect Sensing, the current is measured by calculating this magnetic field by applying either Faraday's law or Ampere law. Here either a Transformer or Hall effect sensor or fiberoptic current sensor are used to sense the magnetic field.

ACS712 Current Sensor uses Indirect Sensing method to calculate the current. To sense current a liner, low-offset Hall sensor circuit is used in this IC. This sensor is located at the surface of the IC on a copper conduction path. When current flows through this copper conduction path it generates a magnetic field which is sensed by the Hall effect sensor. A voltage proportional to the sensed magnetic field is generated by the Hall sensor, which is used to measure current.

The proximity of the magnetic signal to the Hall sensor decides the accuracy of the device. Nearer the magnetic signal higher the accuracy. ACS712 Current Sensor is available as a small, surface mount SOIC8 package. In this IC current flows from Pin-1 and Pin-2 to Pin-3 and Pin-4. This forms the conduction path where the current is sensed. Implementation of this IC is very easy.

ACS712 can be used in applications requiring electrical isolation as the terminals of the conduction path are electrically isolated from the IC leads. Thus, this IC doesn't require any other isolation techniques. This IC requires a supply voltage of 5V. Its output voltage is proportional to AC or DC current. ACS712 has a nearly zero magnetic hysteresis.

3.5: Relay



A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have double throw (changeover) switch contacts as shown in the diagram

Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits, the link is magnetic and mechanical. The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA, enough to supply a relay coil directly.

Features:

- 12V DC SPDT Relay
- Rated up to 7A @240VAC
- Fully Sealed

3.6 THERMOCOUPLE

A Thermocouple is a sensor used to measure temperature. Thermocouples consist of two wire legs made from different metals. The wires legs are welded together at one end, creating a junction. This junction is where the temperature is measured. When the junction experiences a change in temperature, a voltage is created. The voltage can then be interpreted using thermocouple reference tables to calculate the temperature.

There are many types of thermocouples, each with its own unique characteristics in terms of temperature range, durability, vibration resistance, chemical resistance, and application compatibility. Type J, K, T, & E are "Base Metal" thermocouples, the most common types of thermocouples. Type R, S, and B thermocouples are "Noble Metal" thermocouples, which are used in high temperature applications (see thermocouple temperature ranges for details).

Thermocouples are used in many industrial, scientific, and OEM applications. They can be found in nearly all industrial markets: Power Generation, Oil/Gas, Pharmaceutical, BioTech, Cement, Paper & Pulp, etc. Thermocouples are also used in everyday appliances like stoves, furnaces, and toasters. Thermocouples are typically selected because of their low cost, high temperature limits, wide temperature ranges, and durable nature.

3.7 BUZZER



A buzzer or beeper is an audio signalling device,[1] which may be mechanical, electromechanical, or piezoelectric (piezo for short). Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

3.8 MCB (Miniature Circuit Breaker)



Miniature circuit breaker (MCB) automatically switches off electrical circuit during an abnormal condition of the network means in overload condition as well as faulty condition. Nowadays we use an MCB in low voltage electrical network instead of a fuse. The fuse may not sense it but the miniature circuit breaker does it in a more reliable way. MCB is much more sensitive to overcurrent than fuse. Handling an MCB is electrically safer than a fuse. Quick restoration of supply is possible in case of a fuse as because fuses must be re-wirable or replaced for restoring the supply. Restoration is easily possible by just switching it ON. Let's look at the working of the miniature circuit breaker.

The working principle of MCB

Whenever continuous overcurrent flows through MCB, the bimetallic strip is heated and deflects by bending. This deflection of bimetallic strip releases a mechanical latch. As this mechanical latch is attached with the operating mechanism, it causes to open the miniature circuit breaker contacts, and the MCB turns off thereby stopping the current to flow in the circuit. To restart the flow of current the MCB must be manually turned ON. This mechanism protects from the faults arising due to overcurrent or overload. But during short circuit condition, the current rises suddenly, causing electromechanical displacement of plunger associated with a tripping coil or solenoid. The plunger strikes the trip lever causing immediate release of latch mechanism consequently open the circuit breaker contacts. This was a simple explanation of a miniature circuit breaker working principle.

An MCB is very simple, easy to use and is not generally repaired. It is just easier to replace. The trip unit is the main part, responsible for its proper working. There are two main types of trip mechanism. A bi-metal provides protection against overload current and an electromagnet provides protection against short-circuit current.

MCB operation

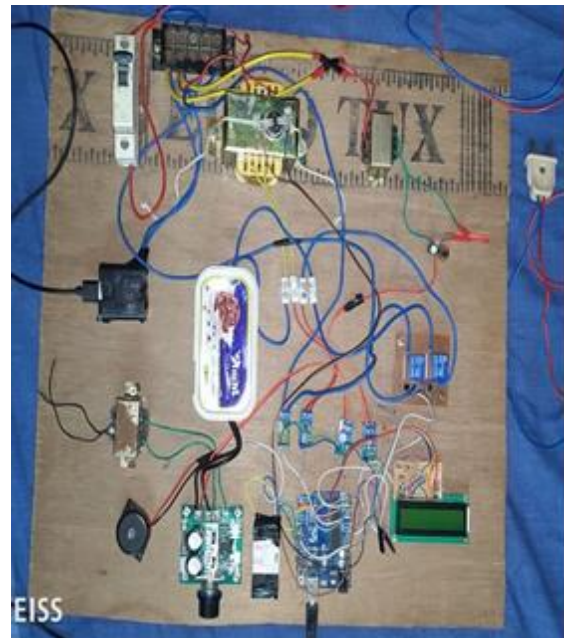
If the circuit is overloaded for a long time, the bi-metallic strip becomes overheated and deformed. This deformation of Bi-metallic strip causes, displacement of latch point. The moving contact of the MCB is arranged by means of spring pressure, with this latch point, that a little displacement of latch causes, release of spring and makes the moving contact to move for opening the MCB.

The current coil or trip coil is placed so that during short circuit fault the magneto-motive force (mmf) of the coil causes its plunger to hit the same latch point and make the latch to be displaced. Again, when operating lever of the miniature circuit breaker is operated by hand, that means when MCB goes off position manually, the same latch point is displaced as a result moving contact separated from fixed contact in the same manner.

It may be due to deformation of a bi-metallic strip, or increased mmf of a trip coil or maybe a manual operation, the same latch point is displaced and same deformed spring is released, which ultimately responsible for movement of the moving contact. When the moving contact separated from fixed contact, there may be a high chance of arc. This arc then goes up through the arc runner and enters arc splitters and is finally quenched. When we switch it on, we reset the displaced operating latch to its previous on position and the MCB is ready for another switch off or trip operation.

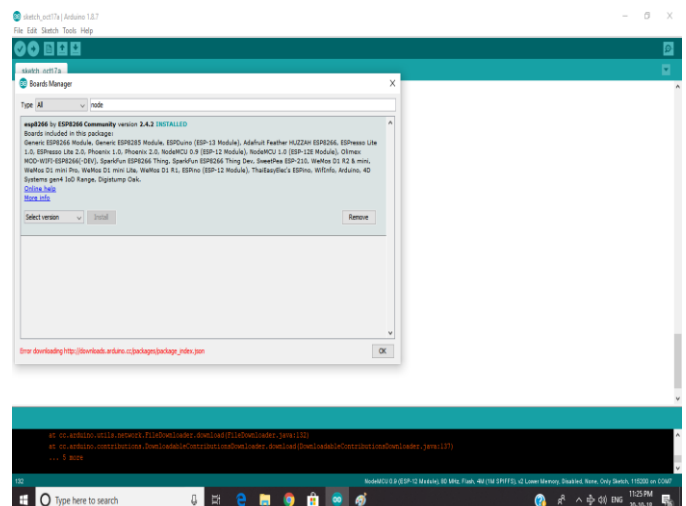
4. RESULTS AND DISCUSSIONS

4.1: HARDWARE :



4.2: Interfacing of ESP8266 With Arduino ide

STEP 1: First download the Arduino software application from the site arduino.cc which is freely available. It is an open source application. If the internet system is reliable then one can code online also.



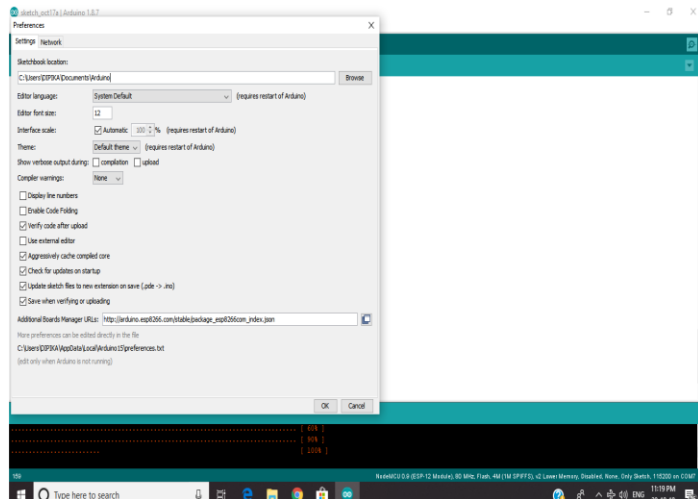
(Fig 14 ArduinoIDE Preference)

STEP 2: Once Arduino IDE is downloaded install the application. STEP 3: The open arduino IDE go to Files>Preferences in the Arduino IDE and copy the below code for additional board manager:

http://arduino.esp866.com/stable/package_esp866com_index.json

Interfacing ESP8266 and Arduino IDE

Step 4: Then go to tools>board>board Manager then navigate to esp866 by esp866 community and install the software for arduino



(Fig 15 Arduino Board Manager) Implementation of ESP8266

Interfacing ESP8266 and Arduino IDE

4.3 VOLTAGE AND CURENT MEASURING

(PRIMARY AND SECONDSARY SIDE)

For measurement of primary side voltage :The supply given to the primary side of the main transformer is also given parallel to a 0-6V transformer. Thus the supply voltage is stepped down to 6V, it is then rectified through the bridge recitifier and given to the voltage sensor. The voltage sensor senses the voltage and sends the data to the arduino board. Any changes in the supply voltage will be directly senses by the voltage sensor. Thus the voltage of primary side is measured.

Note :

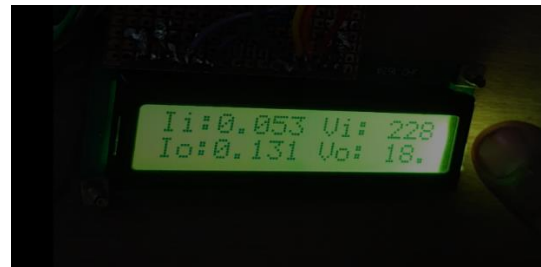
- to vary the primay side voltage auto transformer can be used.
- The limit for notification to the user is set to 250V and for tripping of the of circuit is 255V.
- The input voltage required by the voltage sensor is (5V DC) is given directly from the Arduino board.

For measurement of current :

The current sensors are connected in the series on both the sides (primary and secondary). The maximum limit of ACS712 is 30 Amp. The analog output of the current sensor is given to the Arduino board.

Note :

- The variation in current is obtained by the varying the load connected.
- Here, the current limit for notifying the user is 1.7 Amp and for the tripping of the circuit is 2.0Amp.
- The input voltage required by the current sensor is (5V DC) is given directly from the Arduino board.



Monitoring of voltage and current (primary and secondary)



Notification through buzzer at set threshold (1.70 Amp)

4.4 PROTECTIONS

The protections provided in the circuit are 1. Over and under voltage 2. Over current

5. PROJECT EVALUATION AND CONCLUSION

5.1: COST ANALYSIS

5.2: Future Scope

- More sensors can be added for inclusion of more faults.
- Data base can be used for machine learning algorithms.
- Further project work (Mobile application and cloud storage of data) is going to be done using **adafruit.io** and **mqtt protocol** .

(A) BUDGET FOR PERMANENT EQUIPMENT (IN RUPEES) (IN RUPEES)		
ITEM		BUDGET
1	Transformer	750
2	Current Sensors	250*2=500
3	Relay(10A)	35*2=70
4	Arduino Uno board	350
5	ESP8266	300
6	voltage sensors	250*2=500
7	Temparture Sensor	200
LOAD (SPEED CONTROLLER)		350
12V TRANSFORMER		50
LED DISPLAY		375
MCB		340
BUZZER		70
MISCELLANEOUS EXPENSES		1000
TOTAL		4850

BIOGRAPHIES



Monika Thakor has recently completed her Bachelors in Electrical Engineering from Gujarat Technological University. Various other types of projects have been done by her. she have been participated in IEEE projects events as branch coordinator.



Yash shah has finished his Bachelors in Electrical Engineering from GTU. He is an expert in technological aspects of field.



Bhavin Parmar has ended his Bachelors in Electrical Engineering from GTU. He has great technical and software programming skill.



Hitarth Joshi has done his Bachelors in Electrical Engineering from GTU. He has participated in making many projects throughout his study.



Hardik Shah has an Associate Professor at A.D. Patel institute of Technology with more than 17 years of experience in Academics. He is PHD in Electrical with Automatic control and Robotics.

5.3: Conclusion

The proposed system can monitor as well protect the transformer from faults, the protections included are over and under voltage, over current and ov temperature . The system monitors the operation of transformer with help of IoT on mobile application, which will make easy to monitor the transformer from remote location and even decrease the requirement of man power to look after the system as our system is automatic.

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