IoT Based Transformer Monitoring System using Arduino



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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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Certification

This is to certify that this project entitled **"IoT Based Transformer Monitoring System using Arduino"** 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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We are, indeed, grateful to all those from whom we got sincere cooperation and help for the preparation of this report.

ABSTRACT

Transformers are a vital part of the transmission and distribution system. Any damages in transformer adversely affects the balance of a power system. The damages are mainly occurring due to overloading and inefficient cooling. The main objective of the real time monitoring of the health conditions of the distribution transformer using IOT technology. The parameters such as temperature, voltage, current, and oil level of a transformer are monitored, processed and recorded in servers. For this purpose, we use sensors interfaced with Arduino Mega 2560. The recorded data can be send using Wi-Fi module and accessed from anywhere around the world using IOT technology. This system will help to identify or recognize unexpected situations before any serious failure which leads to greater reliability and significant cost savings.

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Chapter 1: Introduction

1.1 Introduction

The internet of things is about connecting the unconnected things. It allows for thing to accessible from the internet that historically have not been. The internet of things is able to improve quality of life for everyone by taking advantage of these connected thing and data produced. The billions of m2m connection make possible the everything in IoT. The process element leverages the connection between data thing and people to deliver the right information. To right thing or person, at the right time, it is these billions of connections that add value. Distribution Transformers have a long life if they are operated under appraised conditions. However, their life is essentially decreased if they are overloaded, resulting in unexpected failures and loss of supply to an expansive number of customers hence affecting system unwavering quality. Overloading and ineffective cooling of transformers are the major significant reasons for failure in distribution transformers. Most power companies use Supervisory Control and Data Acquisition (SCADA) system for web-based monitoring of power transformers yet amplifying the SCADA system for online monitoring of distribution transformers is a costly suggestion.

- Distribution transformers are as of now observed physically where a man intermittently visits a transformer site for support and records parameter of significance. This type of monitoring can't give data about incidental over-load and overheating of transformer oil and windings. Every one of these variables can essentially decrease transformer life.
- Normal transformer measurement system generally detects a single transformer parameter, for example, control, frequency, temperature, voltage, and stage. While some ways could recognize multi-parameter, the time of acquisition and operation parameters is too long, and testing pace is not sufficiently quick.
- A monitoring system can only monitor the operation state or guard against steal the power, and is not able to monitor all useful data of distribution transformers to reduce costs.
- Auspicious detection data will not be sent to observing centres in time, which cannot judge distribution transformers three phase equilibrium.
- Detection system itself is not reliable. The main principal execution is the device itself instability, poor anti jamming capability, low measurement accuracy of the data.

According to the above requirements, we need a distribution transformer real-time monitoring system to detect all operating parameters operation, and send to the monitoring centre in time. It leads to Online monitoring of key operational parameters of distribution transformers can provide useful information about the health of transformers which will help the utilities to optimally use their transformers and keep the asset in operation for a longer period. This will also help identify problems before any catastrophic failure which can result in a significant cost savings and greater reliability.

1.2 Transformer Fault Analysis

The transformer contains a set of more windings around a magnetic core. Those windings are insulated to the core. Operational stresses can cause damages to the transformer winding, insulation, and the core. The transformer windings and magnetic core are subjected to a number of different forces during

operation like expansion, contraction, vibration and eddy currents. These operating limits only considered the thermal effects of transformer overload. Power transformer produce physical faults that cause insulation wear. This effect is cumulative and should be considered over the life of the system. The following are highlights of different capability limits of transformer.

- Over load.
- Over temperature.
- Over excitation.
- Oil level fault.

Because of all these problems of transformers, we face different types of problems such as.

- Input voltage.
- Input line fault.
- Output voltage.
- Output line fault.
- Transformer oil Temperature.

1.3 Background of This Project

The name of our project is **IoT Based Transformer Monitoring System using Arduino**. This is a modern project. In this proposed system we have used the Arduino Development board, sensor and Wi-Fi module. In this project the system is been totally operated by power supply. The main aim of IoT Based Power Transformer Parameter Monitoring Systems. In block diagram there are temperature sensor for transformer room temperature and humidity, transformer input voltage, Oil level and output voltage which we have used for sensing when is detected the transformer parameter monitoring Systems. Microcontroller continuously check the output of sensor and gives signal to the IoT system circuit which drives the apps.

1.4 Source of Motivation

Power distribution companies try to maximize profits by attracting customers and ensure a regular, reliable and high-quality power. Even utilities minimize their maintenance costs. The main component of the distribution company is the transformer, the distribution transformer and the high voltage wires. Reliable substations in distribution companies are numerous and even in urban or rural areas. The distribution or service transformers for these substations are in quantum of number. Substation transformers are equipped with overcurrent protection, ground protection and differential power protection, while service transformers use horn fault protection. As the amount of service transformers is optimal, regular maintenance will be difficult. In this way, most of the time troubleshooting is reactive Maintenance. The current trend is utilizing devices to highest potential and the repayment of all capital investments offered for renovation or installation. Figure shows the general problem of distribution companies.

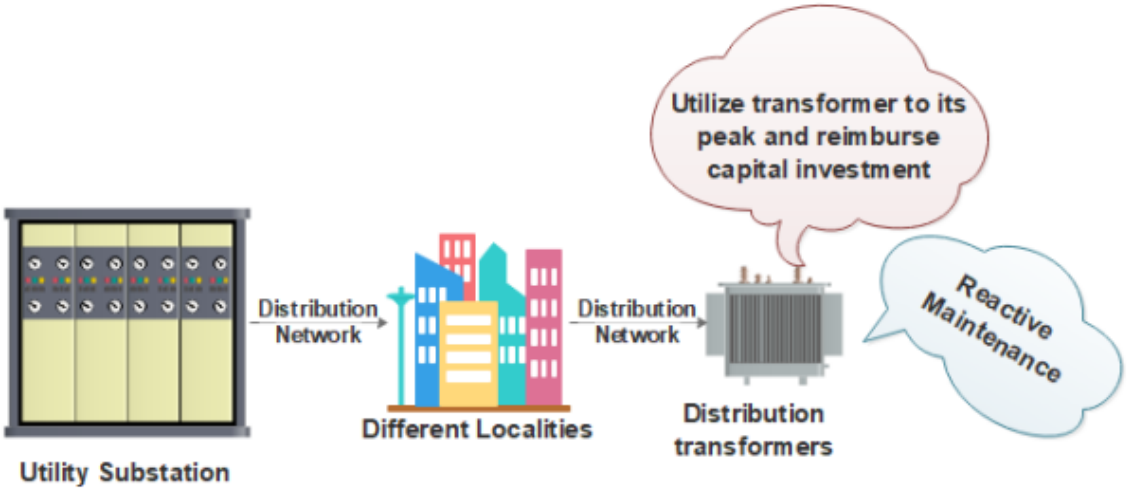


Fig-1.1: Distribution System

1.5 Objective of This Project

Our aim is to develop an IoT based remote monitoring system for transformers of an area, so that life expectancy of distribution transformer can increase with regular maintenance which could help companies to reimburse their capital investment on transformers. Remote monitoring is based on health index calculations of transformers based on parameters like current, voltage and winding temperature. Data syncing is done through a web server called as data hub, and synced data is processed in MATLAB software at a utility substation based all-in one server which calculates health of distribution transformers. Health index can be used to predict life expectancy of transformer and can prevent reactive maintenance. An overview of operation is given as in figure below:

- We will be able to monitor different systems of transformer such as voltage, Current, oil Level , transformer room temperature and humidity.
- We will be available through internet.
- IoT Monitoring System.

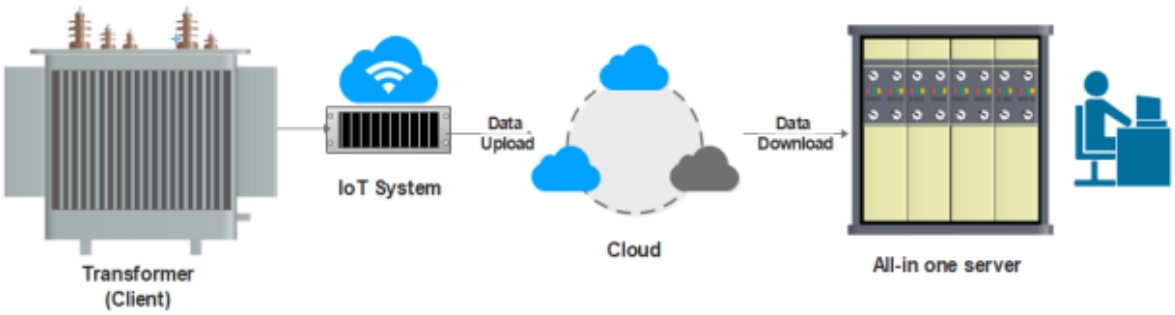


Fig-1.2: An Overview of Proposed System

1.6 Proposed Methodology

In this proposed system we have used the Arduino Development board, sensor and Wi-Fi module. In this project the system is been totally operated by power supply. The main aim of IOT Based Power Transformer Parameter Monitoring Systems. In block diagram there are temperature sensor for transformer room temperature and humidity, transformer input voltage, input frequency and output voltage which we have used for sensing when is detected the transformer parameter monitoring Systems. Microcontroller continuously check the output of sensor and gives signal to the IoT system circuit which drives the apps. In this proposed system we have used the Arduino Development board, sensor and Wi-Fi module. In this project the system is been totally operated by power supply. The main aim of IOT Based Power Transformer Parameter Monitoring Systems. In block diagram there are temperature sensor for transformer room temperature and humidity, transformer input voltage, input frequency and output voltage which we have used for sensing when is detected the transformer parameter monitoring Systems. Microcontroller continuously check the output of sensor and gives signal to the IoT system circuit which drives the apps.

- Collection of data from books and internet.
- Collection of required components from local market and online shop.
- The concept of the design is based on using a microcontroller
- for processing.
- Designing a schematic for creating the circuit board.
- Programming for the microcontroller (ATMEGA2560P) to controlled the energy saving system.
- Setting all the components in a PCB board and soldering.
- Turn on the device experimental.
- And finally, run the system using microcontroller

1.7 IoT System

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. The definition of the Internet of Things has evolved due to the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems.

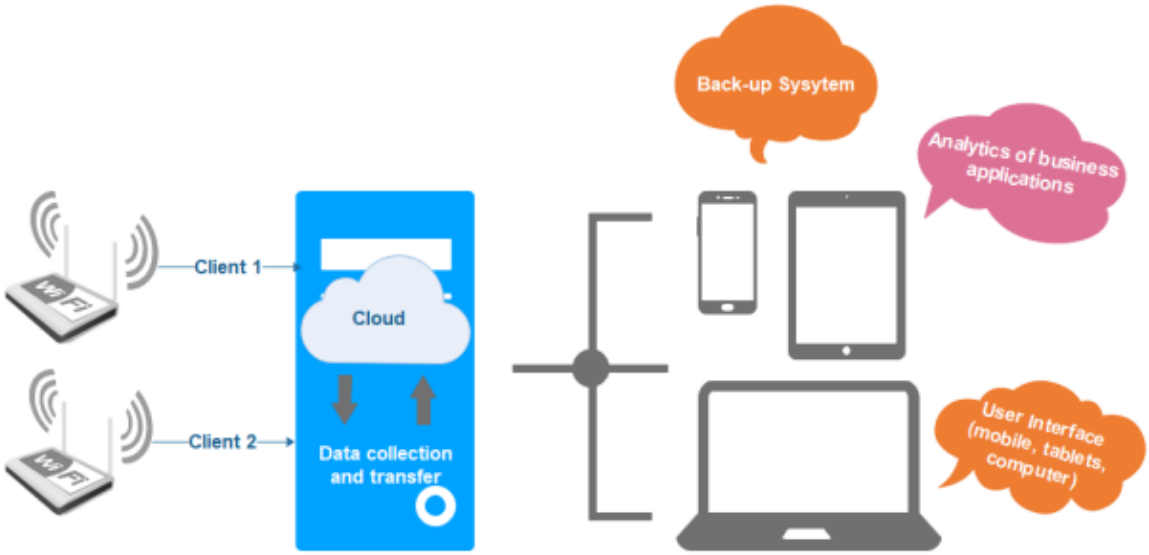


Fig-1.3: IoT System

Traditional fields of embedded systems, wireless sensor networks, control systems, automation (including home and building automation), and others all contribute to enabling the Internet of Things. In the consumer market, IoT technology is most synonymous with products pertaining to the concept of the " **Iot based Power Transformer Parameters Monitoring System",** covering devices and appliances (such as lighting fixtures, thermostats, home security systems and cameras, and other home appliances) that support one or more common ecosystems, and can be controlled via devices associated with that ecosystem, such as

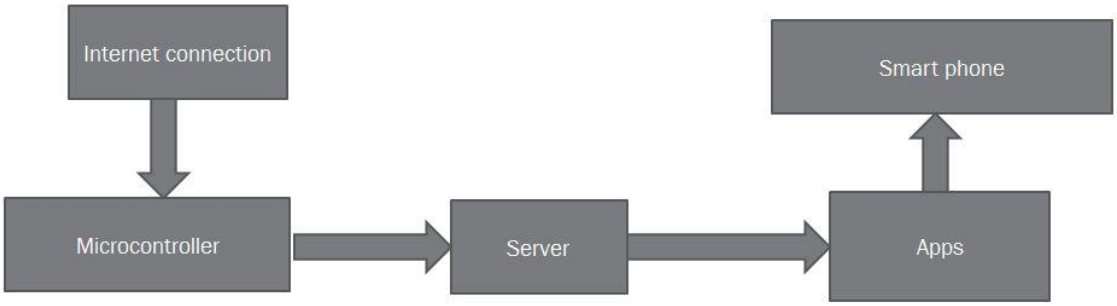


Fig-1.4: Block Diagram of IOT

Smart phones and smart speakers. There are a number of serious concerns about dangers in the growth of IoT, especially in the areas of privacy and security; and consequently industry and governmental moves to begin to address these.

Chapter 2: Theoretical Review

2.1 Introduction

Autor's in proposed a wireless transformer monitoring parameters. The most important purpose of this system is monitoring and controlling of transformer through RF module. By using a temperature sensor, microcontroller and RF transmission which is wireless communication, both monitoring and controlling can be done. The transformer has three parameters which are monitored voltage, frequency and temperature. The monitored data is then send to a remote location. The transmission between RF and client is done via controller. Sujatha et al. suggested a IOT technique. This technique can be apply successfully for special protection systems. These systems are developed earlier and are based on communication. The proposed IOT technique can increase system's reliability during network interruptions. The IOT technique is independent of the distance parameter and increases the speed of communication. To meet the reliability requirement of the network, an authenticated hardware must be designed. The data acquisition from an electrical sensing system is done by an embedded hardware. The system sends data from one network to another and measures the change in parameters of transmission so that the entire process of transmission and distribution can be fully protected. IOT supports bi-directional communication as a smart phone apps. The interpreter is used among many tools and systems is visually presented with basic software.

- Anirudh et el suggested an advanced remote monitoring system. This system is proposed for distribution transformers. These transformers uses IOT communication network so the investment and operation cost is low. The installation and use of this system is easy too. To analyze the voltage unbalance condition, a novel software (DTMAS) has been introduced which is used for three different types of distribution transformers.

- Bakare Govind et al. proposed a mobile embedded system. This system is used to monitor and record key operation indicators voltage, transformer oil temperature and frequency of a distribution transformer. The online monitoring system combine IOT, an independent single chip microcontroller and sensor packages. the installation is complete at the site of the distribution transformers and the 8-channel ADC records the defined parameters mentioned above. The processing and recording of the parameters is done in the system memory. If any anomaly occurs, the mobile phones will monitor data by the system with complete details about the abnormality according to the policies embedded to the system EEPROM. The system also sends data to a central database for processing it further through a Wi-Fi module. This mobile system will be helpful to use transformers in an optimal way and also problems will be identify earlier before the occurrence of any failure.

- Autor's in offered a past maintenance of transformers. This was built on a pre-determined schedule. As the communication technology is improving day by day, false transformer information can be received by the respective authorities remotely via IOT technology. This will help to solve the problem before converting fault in to a fatal condition. Depending upon fault analysis, transformer health monitoring kit based on a prototype model of micro-controller is developed in laboratory. Results are being updated on regular basis by using digital controller

analysis. If any abnormality occurs, information is sent to the operators via GSM technology for possible remedial action.

2.2 Benefits of IoT

Overall system and process monitoring is faster with the introduction of IoT and automation. Not only had this, but Internet of Things also improved customer's usage experience with a product or service, which provides better value and higher reliability. IoT also saves time and money of companies for the establishment of monitoring systems e.g. post-fault clearing time can reduce if such a monitoring system is used in electrical distribution networks. By the implementation of IoT based devices in offices or homes, it has been found that autonomous systems like thermostat, air-conditioners, lightning etc. make the overall daily routine faster as human can now spend more time in other tasks. An IoT based system can be operated remotely and is also easy to monitor even in extreme weather and working conditions. Thus, IoT based systems are more reliable, fast, accurate, economical and safe to use.

2.3 Internet of Things

The Internet of Things (IoT) is a new revolution for Data Transfer and Storage. Objects that make themselves recognizable and they obtain intelligence by making or enabling context related decisions to the situations. They can transfer information about themselves. They can access information that has been used by other things, or they can be components of other services. The three factors that makes IoT look forward are Sensing Nodes, Embedded Processing and Communication. This transformation is accompanied by the emergence of cloud computing capabilities supported by an increased storage capacity and high-end data processing and the Machine-to-Machine communication for data transport with complete security for data. By introducing cloud computing, we can make a full call to the storage resource pool and computing resource pool in the cloud computing architecture, and provide high reliability for IoT cloud storage service and efficient cloud computing services to users. This Machine-to-Machine service layer will provide the needed services like data transport, security, devices, management and device discovery in a harmonized manner across a vertical domain to the application layer.

2.4 Arduino Software (IDE)

The Arduino Integrated Development Environment (IDE) contains message area, the text console, text editor for writing code, a toolbar with buttons for common functions and a series of menus. It connects to Arduino and Genuine hardware upload programs written using the Arduino software (IDE) are called sketches. The programs are written in the text editor and are saved with the file extension of'. ino'. The editor has features for cutting/pasting and for saving/replacing text. The message area gives feedback and displays errors. The console displays text output by the Arduino software (IDE), including complete error message and other information. The configured board and serial port are displayed in the right hand corner of the window. The toolbar buttons permit to verify and upload programs, create, open, and save sketches, and open the serial monitor.

2.5 Android Apps

For visualization and authentication, in this research work, the team has an Android App. The Android Application does not restrict itself to Thing Speak but also has a Firebase login system. Firebase is a Google-provided API to create a database and fetch from it in real time. It also provides enhanced

security for the developed App. Also, it is used for backend support and other functionalities like data storage, user authentication and hosting. Real-time data variations are recorded automatically and updates are sent to clients. The HTTP protocol works on a simple request and response

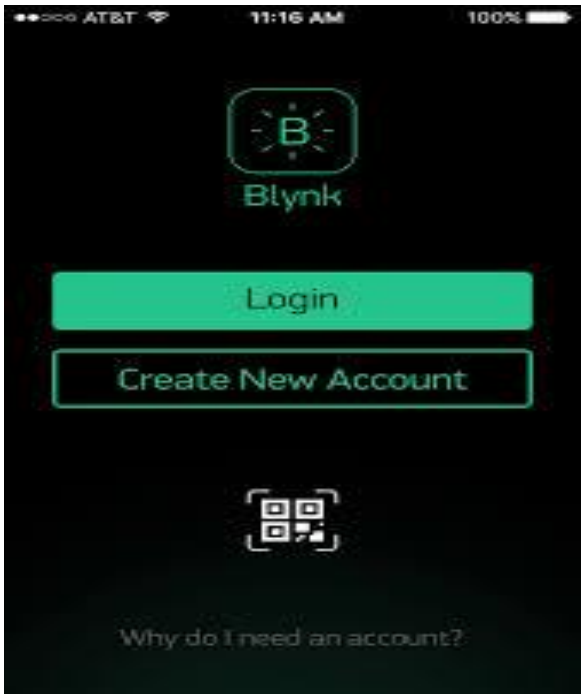


Fig-2.1 Android Apps

system but firebase is different as its real-time database uses data synchronization. It can be used for user authentication purposes as the user credentials are securely stored using bcrypt. Firebase authentication to the android studio is added using Firebase Android Studio tool. Whenever someone authenticates during the sign-in process either using an Email or Google, it handovers a firebase user object that represents that the authentication is successfully done by the user. This object contains the basic information about the user. Once the firebase API is included in Android or iOS App, firebase features like Analytics, Authentication, Storage, Messaging, Hosting, Crash reporting, Real-time Database etc.

2.6 Literature Review

In most power companies, for online monitoring of power transformers, use supervisory control and data acquisition (SCADA) system, but for online monitoring of power transformer, the extending the SCADA system is an expensive proposition. Power transformers are currently monitored manually, where a person visits a transformer site, for maintenance and taking records purpose. But main drawbacks of these systems are, it cannot provide information about overloads (Voltage & Current) and overheating of transformer oil & windings. Due to these, the transformer life is reduced.

[1] Monika Agarwal, This paper represents that they are designing a system where there exits communication between system and operator. For this we are using Transformer, microcontroller, logic

level converter and GSM i.e. global system for mobile communication modem. This GSM modem helps to monitor transformer health by sending message to the system.

[2] Hongyan Mao, This paper represents a large number of power distribution transformer stations and they are far away from city, wireless GPRS transmission provides a good communication solution to supervise power distribution transformer stations. The scheme of remote wireless monitoring system for power distribution transformer station based on GPRS wireless network was designed in this paper. A control terminal system implement was mainly given, which adopted LPC2132 as main processor, GR47 as the date communication module. The monitor terminal software and flow chart were also designed. At last, the way of configuring the GPRS module to connect network is analyzed.

[3] Pathak A.K, This paper represents a design and implementation of a mobile embedded system to monitor and record key parameters of a distribution transformer like load currents, oil level and ambient Modem, with a standalone single chip microcontroller and different sensors. It is installed at the distribution transformer site and the above parameters are recorded using the analog to digital converter (ADC) of the embedded system. The obtained parameters are processed and recorded in the system memory. If any abnormality or an emergency situation occurs the system sends SMS (short message service) messages to the mobile phones containing information about the abnormality according to some predefined instructions programmed in the microcontroller. This mobile system will help the transformers to operate smoothly and identify problems before any catastrophic failure.

2.7 Motivation for Project

A poorly motivated team has been known to unravel even the best project plan. A good project manager needs to know how to harness the initial excitement that comes with starting a project and use it to maintain motivation – leading to success throughout the project's lifecycle. We now know that contemporary project managers need to be more than just schedulers and contract managers. They need excellent skills in managing those complex human elements that have the potential to bring any project down.

2.8 Time Plan

The following tables define the main tasks in the project introduction and project itself.

T1	Project Definition	1 Week
T2	Collecting data	11 Weeks
T3	Analysis	7 Weeks
T4	Theoretical calculation	4 Weeks
T5	Documentation	10 Weeks
T6	Prepare for presentation	2 Weeks

Table- 01: Time Scheduled Table for Project Introduction

The time of the project introduction is scheduled over 16 weeks, table 2 shows how the work was scheduled over this time:

Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
T1																
T2																
T3																
T4																
T5																
T6																

Table-02: Time Plan Table for Project Introduction

The following table defines the main tasks in the project:

T1	Collecting data	3 Week
T2	Implementation	10 Weeks
T3	Analysis	5 Weeks
T4	Building and testing the system	8 Weeks
T5	Documentation	10 Weeks
T6	Prepare for presentation	2 Weeks

Table-03: Time Scheduled Table for Project

The time of the project is scheduled over 16 weeks, table 4 shows how the work was scheduled over this time:

Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
T1																
T2																
T3																
T4																
T5																
T6																

Table-04: Time Plan Table for Project

Chapter 3: Project Implementation

3.1 Introduction

Power transformers, which perform the function of transforming the voltage levels, are one of the most important electrical equipment's that are used in power transmission systems. Hence, it is mandatory to perform power transformer maintenance; as they are normally scattered geographically, it is impractical to do periodical monitoring due to insufficient manpower. As the reason above, transformer failure may occur which causes the transformer from network unexpectedly power shutdown. To overcome this shutdown from transformer failure of the adapter, a system for transformer monitoring and self-protection was proposed in case the maintenance is delayed.

In this paper, the transformer room temperature and humidity, input voltage, output voltage and frequency within the transformer were monitored, in addition to monitoring the rate of loading on the transformer. By using the internet of things (IoT), a self-protection system is designed and implemented for the transformer. Where, if the transformer is not serviced quickly, the transformer will separate loads of low importance (workshops, Homes, etc) and it will keep the loads of high importance (hospitals,…) .and if the transformer is unable to feed the loads of high importance, in this case the transformer will separates all loads and stay in no-load status where the transformer monitor its parameter by itself, if all parameters of the transformer return to the normal level, the transformer automatically returns the loads in order of priority. All these components have been grouped and combined into one device. In addition the device is powered using an AC-DC adapter by an external power source.

3.2 Block Diagram of This Project

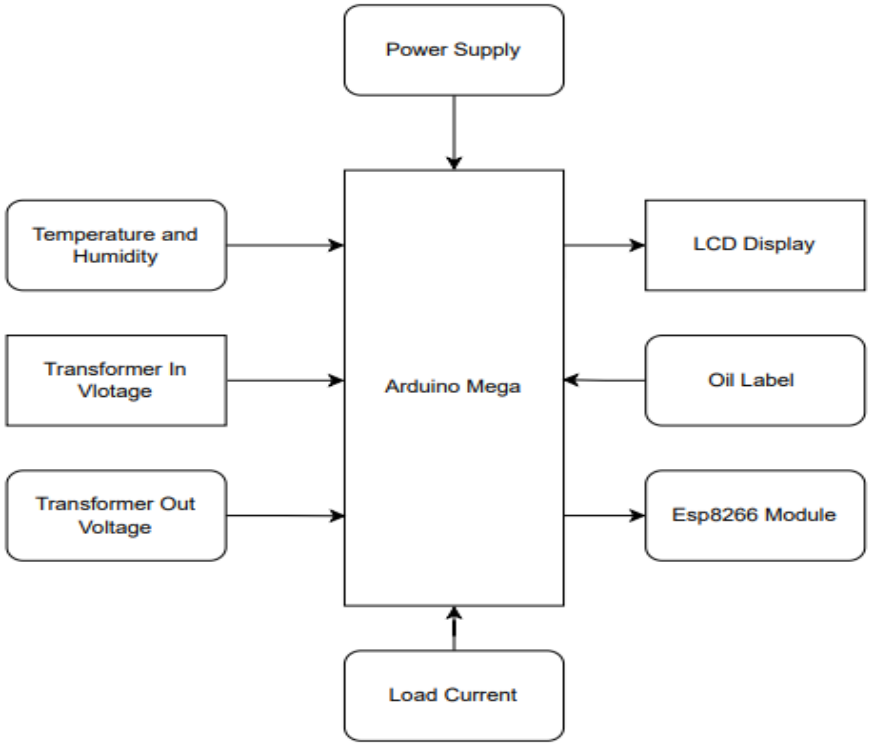


Fig- 3.1 Block Diagram

3.3 Circuit Diagram of This Project

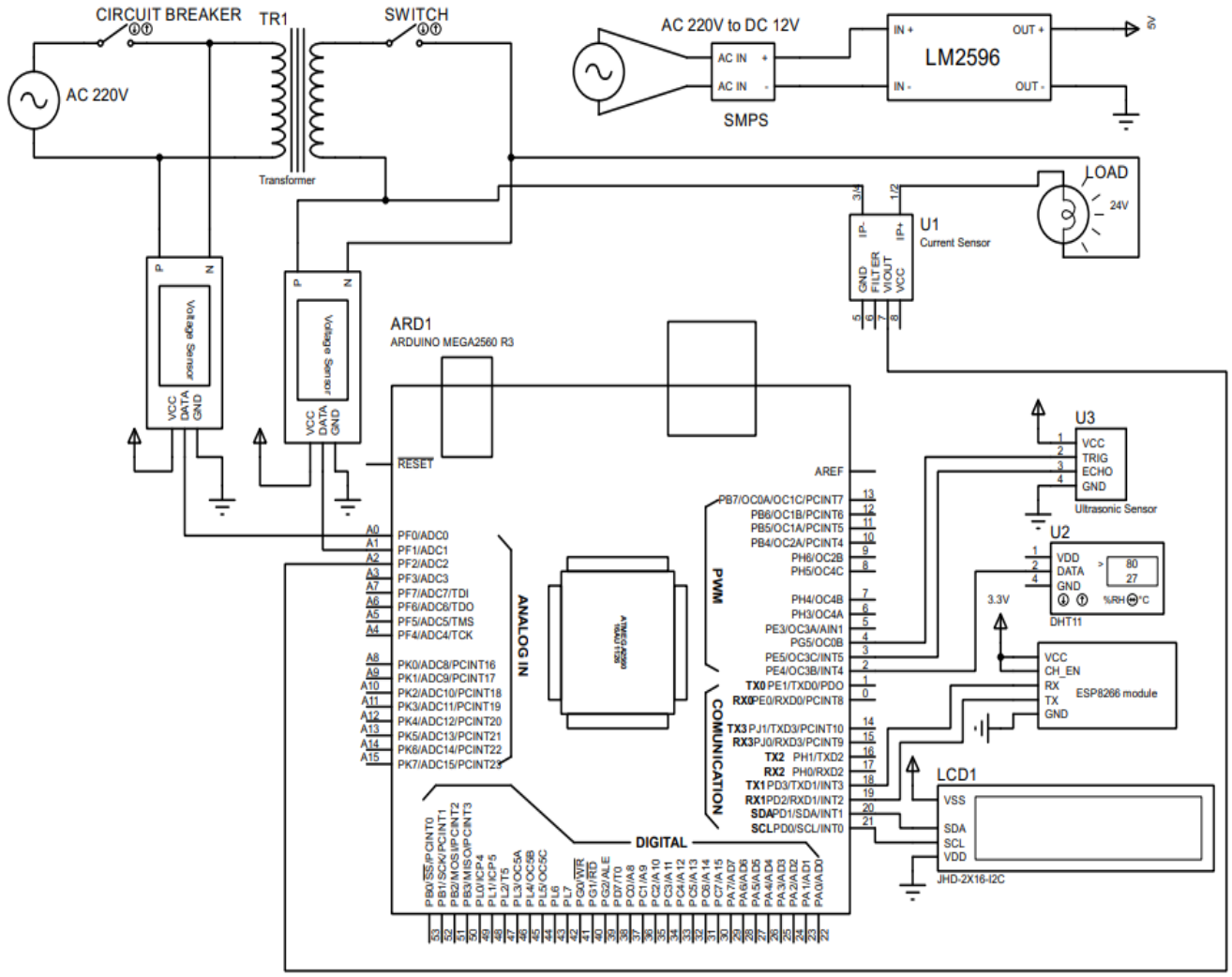


Fig-3.2: Circuit Diagram

3.4 The list of devices used in the project is given below

- Arduino MEGA.
- LM2596 Voltage Converter.
- LCD Display.
- SMPS.
- Wi-Fi Module.
- Voltage Sensor.
- Optocoupler
- Transformer.
- Ultrasonic Sensor.
- DHT-11 Sensor.
- Current Sensor.

3.5 Arduino MEGA

The Arduino Mega is a microcontroller board based on the ATmega2560 . It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller.

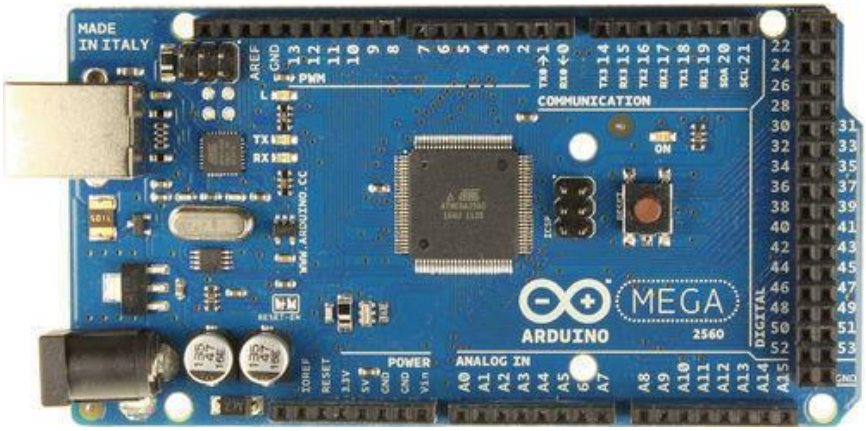


Fig-3.3: Arduino MEGA

Technical Specifications:

- Microcontroller : ATmega2560
- Operating Voltage : 5V
- Input Voltage (recommended) : 7-12V
- Input Voltage (limit) : 6-20V
- Digital I/O Pins : 54 (of which 15 provide PWM output)
- Analog Input Pins : 16
- DC Current per I/O Pin : 20 mA
- DC Current for 3.3V Pin : 50 mA
- Flash Memory : 256 KB of which 8 KB used by bootloader
- SRAM : 8 KB
- EEPROM : 4 KB
- Clock Speed : 16 MHz
- Length : 101.52 mm
- Width : 53.3 mm
- Weight : 37 g

Applications:

- Arduboy, a handheld game console based on Arduino.
- Arduinome, a MIDI controller device that mimics the Monomer.
- Ardupilot, drone software and hardware.
- ArduSat, a cubesat based on Arduino.
- C-STEM Studio, a platform for hands-on integrated learning of computing, science, technology, engineering, and mathematics (C-STEM) with robotics.
- Data loggers for scientific research.

- OBDuino, a trip computer that uses the on-board diagnostics interface found in most modern cars.
- OpenEVSE an open-source electric vehicle charger.
- XOD, a visual programming language for Arduino.

3.6 LM2596 Voltage Converter

The LM2596 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 3-A load with



Fig: 3.4 LM2596 Voltage Converter

excellent line and load regulation. These devices are available in fixed output voltages of 3.3 V, 5 V, 12 V, and an adjustable output version. Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation, and a fixed frequency oscillator. The LM2596 series operates at a switching frequency of 150 kHz, thus allowing smaller sized filter components than what would be required with lower frequency switching regulators. Available in a standard 7-pin TO-220 package with several different lead bend options, and a 7-pin TO-263 surface mount package.

3.7 LCD Display

LCD20*04 or 20 character-type liquid crystal display, is a kind of dot matrix module to show letters, numbers, and characters and so on. It's composed of 5x7 or 5x11 dot matrix positions; each position can display one character. There's a dot pitch between two characters and a space between lines, thus separating characters and lines. The model 20*04 means it displays 4 lines of 20characters.

Generally, LCD20*04 has parallel ports, that is, it would control several pins at the same time. LCD20*04 can be categorized into eight-port and four-port connections. If the eight-port connection is used, then all the digital ports of the Sun Founder Uno board are almost completely occupied. If you want to connect more sensors, there will be no ports available. Therefore, the four-port connection is used here for better application.

Pin	Function
VSS	connected to ground
VDD	connected to a +5V power supply
VO	to adjust the contrast
RS	A register select pin that controls where in the LCD's memory you are writing data to. You can select either the data register, which holds what goes on the screen, or an instruction register, which is where the LCD's controller looks for instructions on what to do next.
R/W	A Read/Write pin to select between reading and writing mode
E	An enabling pin that reads the information when High level (1) is received. The instructions are run when the signal changes from High level to Low level.
D0-D7	to read and write data
A	Pins that control the LCD backlight. Connect A to 3.3v.
K	Pins that control the LCD backlight. Connect K to GND.

Tabel-01: LCD Display Outline

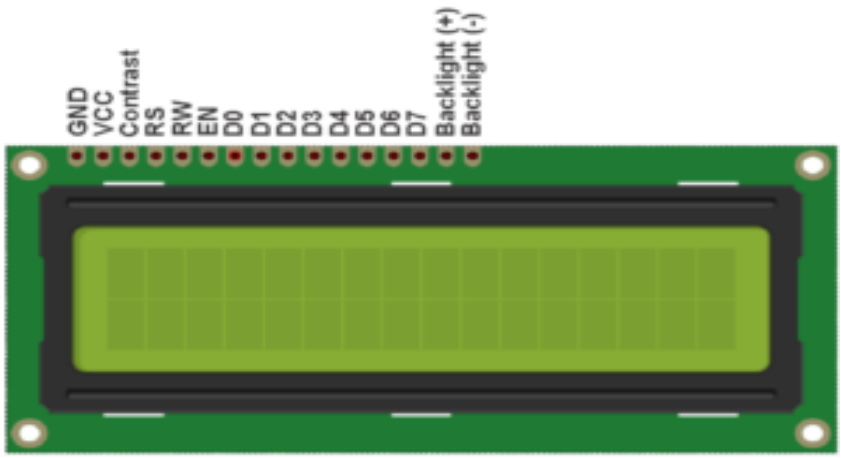


Fig-3.5: LCD Display

3.8 SMPS

A switched-mode power supply (switching-mode power supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently.

Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power, see AC adapter) to DC loads, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. The switched-mode power supply's higher electrical efficiency is an important advantage.

Switched-mode power supplies can also be substantially smaller and lighter than a linear supply because the transformer can be much smaller. This is because it operates at a high switching frequency which

ranges from several hundred kHz to several MHz in contrast to the 50 or 60 Hz mains frequency. Despite the reduced transformer size, the power supply topology and the requirement for electromagnetic interference (EMI) suppression in commercial designs result in a usually much greater component count and corresponding circuit complexity.

Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight is required. They are, however, more complicated; switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor.



Fig-3.6: Switched Mode Power

Technical Specifications:

- Input Voltage: AC 85-265V
- Output Voltage: DC 12V
- Current: 10A
- Size:128mm*98mm*40mm
- Shell Material: Metal case / Aluminum base
- Protection: Shortage Protection, Overload Protection, Over Voltage Protection
- Widely used in Industrial automation, LED display, communications, etc.
- Safety Compliance: CCC/ FCC / CE
- Working Temperature: 0~40℃
- Storage Temperature: -20~60℃
- Ambient Humidity: 0~95% Non-Condensation

3.9 Wi-Fi Module

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by manufacturer Express if Systems in Shanghai, China. The chip first came to the attention of Western makers in August 2014 with the ESP-01 module, made by a third-party manufacturer Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at first there was almost no English-language documentation on the chip and the commands it accepted.

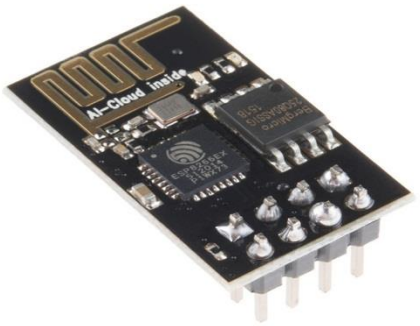


Fig-3.7: Wi-Fi Module

The very low price and the fact that there were very few external components on the module, which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and the software on it, as well as to translate the Chinese documentation. The ESP8285 is an ESP8266 with 1 MiB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi.The successor to these microcontroller chips is the ESP32, released in 2016.

Features: Processor L106 32-bit RISC microprocessor core based on the Tensilica Xtensa Diamond Standard 106Micro running at 80 MHz

Memory:

- 32 KiB instruction RAM
- 32 KiB instruction cache RAM
- 80 KiB user-data RAM
- 16 KiB ETS system-data RAM
- External QSPI flash: up to 16 MiB is supported (512 KiB to 4 MiB typically included)
- IEEE 802.11 b/g/n Wi-Fi
- Integrated TR switch, balun, LNA, power amplifier and matching network
- WEP or WPA/WPA2 authentication, or open networks
- 16 GPIO pins
- SPI
- I^2C (software implementation)
- I^2S interfaces with DMA (sharing pins with GPIO)
- UART on dedicated pins, plus a transmit-only UART can be enabled on GPIO2
- 10-bit ADC (successive approximation ADC)

Pinout of ESP: The pinout is as follows for the common ESP-01 module:

- VCC, Voltage (+3.3 V; can handle up to 3.6 V)
- GND, Ground (0 V)
- RX, Receive data bit X
- TX, Transmit data bit X
- CH_PD, Chip power-down
- RST, Reset
- GPIO 0, General-purpose input/output No. 0
- GPIO 2, General-purpose input/output No. 2

3.10 Voltage Sensor

A voltage sensor is a sensor is used to calculate and monitor the amount of voltage in an object. Voltage sensors can determine both the AC voltage or DC voltage level. The input of this sensor can be the voltage whereas the output is the switches, analog voltage signal, a current signal, an audible signal, etc. Sensors are basically a device which can sense or identify and react to certain types of electrical or some optical signals. Implementation of voltage sensor and current sensor techniques have become an excellent choice to the conventional current and voltage measurement methods.

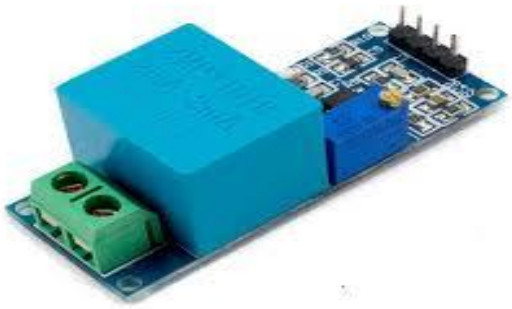


Fig-3.8: Voltage Sensor

Specification:

Drive Voltage: 5VCharacteristics: Analog output Up to 250V AC detection range Calibration potentiometer.

Chipset: ZMPT101B.

Mounting holes: M2 46/16mmPin pitch: 2.54Connectors: Screw Terminals.

Operating Temperature: -40°C to 85°C (unconfirmed)

This module is ideally suited to measuring an AC voltage. When connected to the screw terminals the sensor will sample the input and output an analog voltage, in the region of 0 - 5V. This makes it easy to use in power monitoring applications and checking supplies.

3.11 Optocoupler

These are High Density Mounting Type Photocouplers used in Computer terminals, System appliances, measuring instruments, Registers, copiers, automatic vending machines, Electric home appliances, such as fan heaters etc.

Features:

Current transfer ratio (CTR:MIN.50% at IF=5mA Vce=5V)

High isolation voltage between input and output (Viso:5300Vrms).



Fig-3.9: Optocoupler

3.12 Transformer

Transformer of identical inductance, giving approximately equal voltage and current levels in both circuits. Equality of voltage and current between the primary and secondary sides of a transformer, however, is not the norm for all transformers. If the inductances of the two windings are not equal.
Notice how the secondary voltage is approximately ten times less than the primary voltage (0.9962 volts compared to 10 volts), while the secondary current is approximately ten times greater (0.9962 mA compared to 0.09975 mA). What we have here is a device that steps voltage down by a factor of ten and current up by a factor of ten: (Figure below)

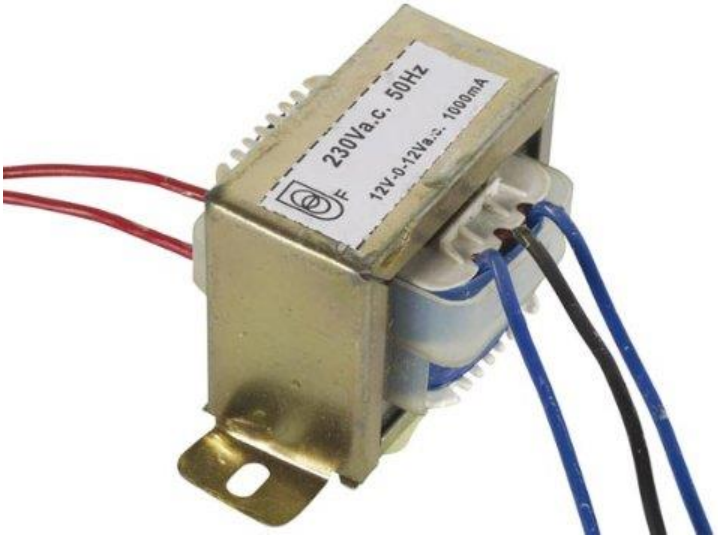


Fig-3.10: Transformer

This is a very useful device, indeed. With it, we can easily multiply or divide voltage and current in AC circuits. Indeed, the transformer has made long-distance transmission of electric power a practical reality, as AC voltage can be “stepped up” and current “stepped down” for reduced wire resistance power losses along power lines connecting generating stations with loads. At either end (both the generator and at the loads), voltage levels are reduced by transformers for safer operation and less expensive equipment. A transformer that increases voltage from primary to secondary (more secondary winding

turns than primary winding turns) is called a step-up transformer. Conversely, a transformer designed to do just the opposite is called a step-down transformer.
Transformer cross-section showing primary and secondary windings is a few inches tall (approximately 10 cm). This is a step-down transformer, as evidenced by the high turn count of the primary winding and the low turn count of the secondary. As a step-down unit, this transformer converts high-voltage, low-current power into low-voltage, high-current power. The larger-gauge wire used in the secondary winding is necessary due to the increase in current. The primary winding, which doesn't have to conduct as much current, may be made of smaller-gauge wire.

In case you were wondering, it is possible to operate either of these transformer types backwards (powering the secondary winding with an AC source and letting the primary winding power a load) to perform the opposite function: a step-up can function as a step-down and visa-versa. However, as we saw in the first section of this chapter, efficient operation of a transformer requires that the individual winding inductances be engineered for specific operating ranges of voltage and current, so if a transformer is to be used "backwards" like this it must be employed within the original design parameters of voltage and current for each winding, lest it prove to be inefficient (or lest it be damaged by excessive voltage or current!).

Transformers are often constructed in such a way that it is not obvious which wires lead to the primary winding and which lead to the secondary. One convention used in the electric power industry to help alleviate confusion is the use of "H" designations for the higher-voltage winding (the primary winding in a step-down unit; the secondary winding in a step-up) and "X" designations for the lower-voltage winding. Therefore, a simple power transformer will have wires labeled "H1", "H2", "X1", and "X2". There is usually significant to the numbering of the wires (H1 versus H2, etc.), which we'll explore a little later in this chapter.

The fact that voltage and current get "stepped" in opposite directions (one up, the other down) makes perfect sense when you recall that power is equal to voltage times current, and realize that transformers cannot produce power, only convert it. Any device that could output more power than it took in would violate the Law of Energy Conservation in physics, namely that energy cannot be created or destroyed, only converted. As with the first transformer example we looked at, power transfer efficiency is very good from the primary to the secondary sides of the device.

3.13 Ultrasonic Sensor

Ultrasonic transducers and ultrasonic sensors are devices that generate or sense ultrasound energy. They can be divided into three broad categories: transmitters, receivers and transceivers. Transmitters convert electrical signals into ultrasound, receivers convert ultrasound into electrical signals, and transceivers can both transmit and receive ultrasound.

This HC-SR04-Ultrasonic Range Finder is a very popular sensor that is found in many applications where it requires measuring distance and detecting objects.

The module has two eyes like projects in the front which forms the Ultrasonic transmitter and Receiver. The HC-SR04 ultrasonic sensor uses sonar to determine the distance to an object like bats or dolphins do.

This Ultrasonic Sensor module is a transmitter, a receiver, and a control circuit in one single pack!! It has very handy and compact construction. It offers excellent range accuracy and stable readings in an

easy-to-use package. Its operation is not affected by sunlight or black material like Sharp rangefinders are (although acoustically soft materials like cloth can be difficult to detect).

The Trigger and the Echo pins are the I/O pins of this module and hence they can be connected to the I/O pins of the microcontroller/Arduino. When the receiver detects the return wave the Echo pin goes high for a particular amount of time which will be equal to the time taken for the wave to return to the sensor.

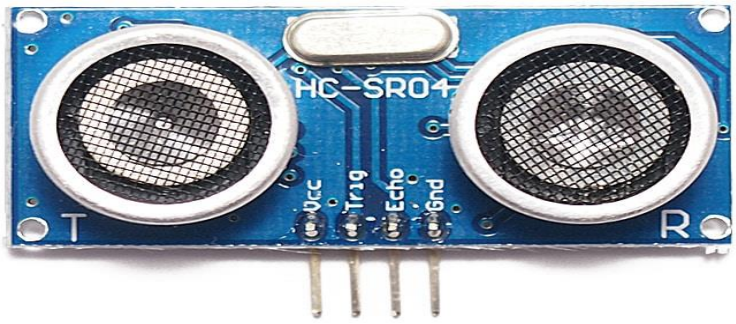


Fig-3.6: Ultrasonic Sensor

Technical Specifications:

- Operating Voltage: 5 V
- Sonar Sensing Range: 2-400 cm
- Max. Sensing Range: 450 cm
- Frequency: 40 kHz

3.14 DHT-11 Sensor

The DHT11 Humidity & Temperature Sensor Module is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and outputs a digital signal on the data pin (no analog input pins needed). Its very simple to use, and libraries and sample codes are available for controller. This DHT11 Humidity & Temperature Sensor Module makes is easy to connect to microcontroller as it includes the pull-up resistor required to use the sensor. Only three connections are required to be made to use the sensor – Vcc, Gnd, and Output. We have also included the required to connect the DHT11 to a microcontroller.

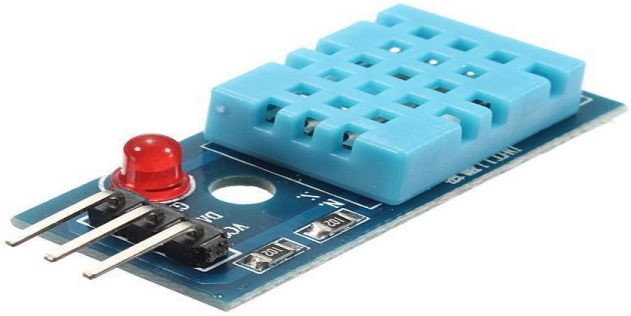


Fig-3.6: DHT-11 Sensor

Technical Specifications:

- Input Supply Voltage (VDC): 3.3 ~ 5.
- Supply Current (mA): measurement 0.3mA standby 60μA.
- Temperature measurement range: 0~50 degrees.
- Temperature measurement error: ±2 degrees.
- Humidity measurement range: 20%~95%RH.
- Humidity measurement error: ±5%RH.

3.15 Current Sensor

This current sensor board is based on the Allegro ACS712ELCTR-30A bi-directional hall-effect current sensor chip that detects positive and negative flowing currents in the range of minus 30 Amps to positive 30 Amps. The board operates at 5V DC and the current flow through the sensor is converted to an output voltage starting at 1/2Vcc (or 2.5V) for no current flow and moves up 66mV per amp for positive current or down -66mV per amp for negative current.



Fig-3.12: Current Sensor

Description:

- The current sensor chips: acs712elc-20a;
- Pin 5 V power supply on board power indicator;
- The module can measure the positive and negative 20 amps, corresponding to the analog output of 100mv / a;
- No test current through the output voltage is VCC / 2;
- PCB board size: 31 (mm) x13 (mm);

3.16 Project Implementation

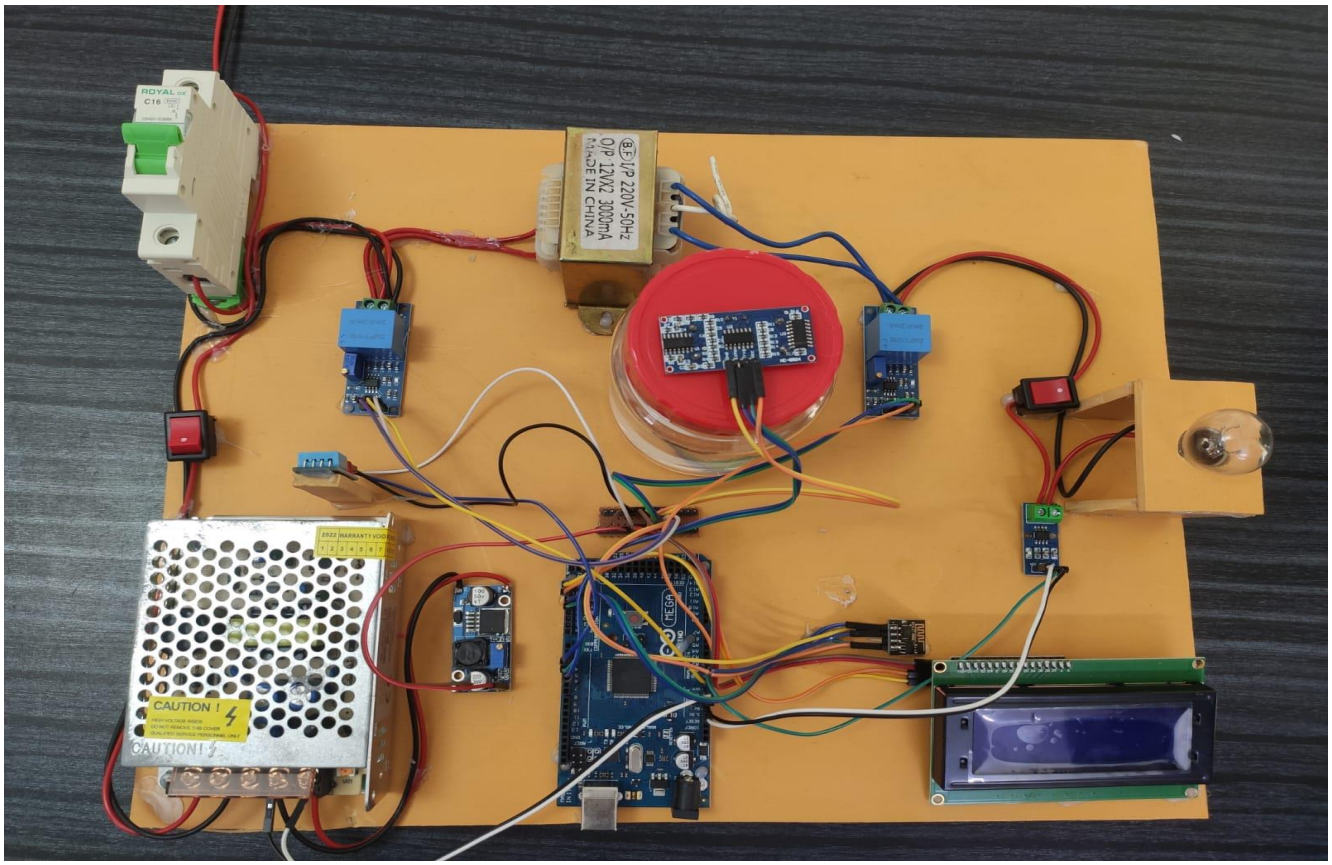


Fig-3.14: Project Picture

3.15 Result

In this project we will monitor Transformer Parameter as the transformer room temperature and humidity , transformer input voltage , output voltage, Oil level and current .We can see all the project data in an LCD display. Our project operates through the Internet, In the project we can monitor the data of various sensors used which can be monitored from anywhere on the Internet. We used Arduino as the controller and we created the C language as a programming language and uploaded it to the controller.

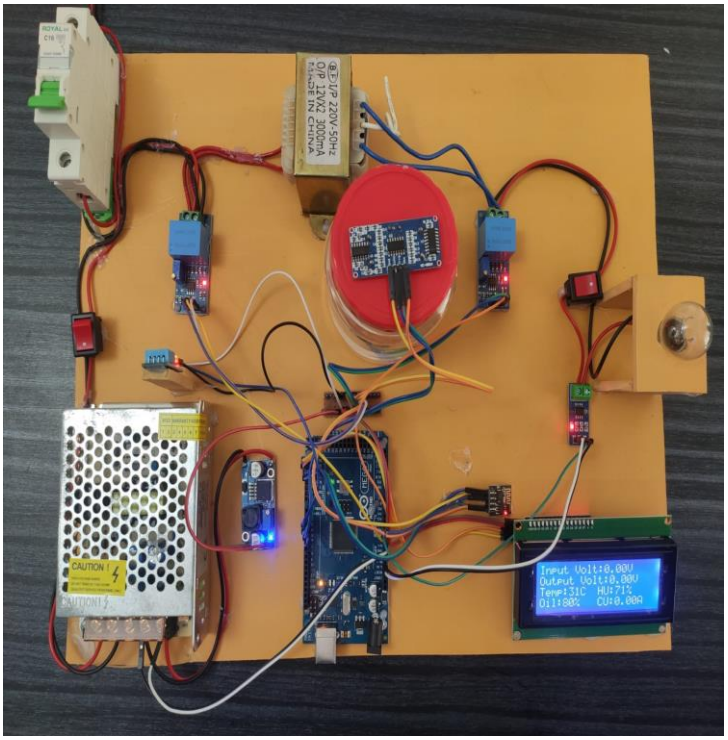


Fig-3.15: LCD Display Result -01

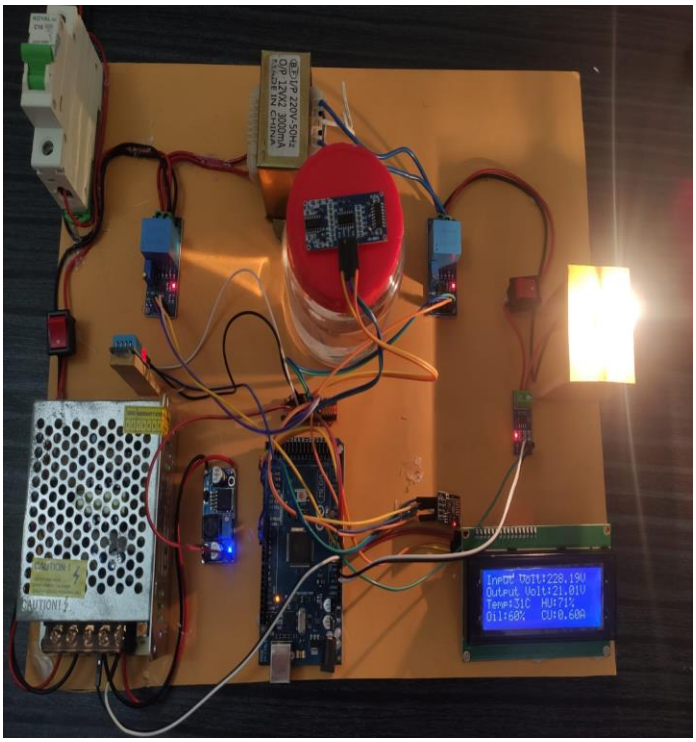


Fig-3.15: LCD Display Result -02

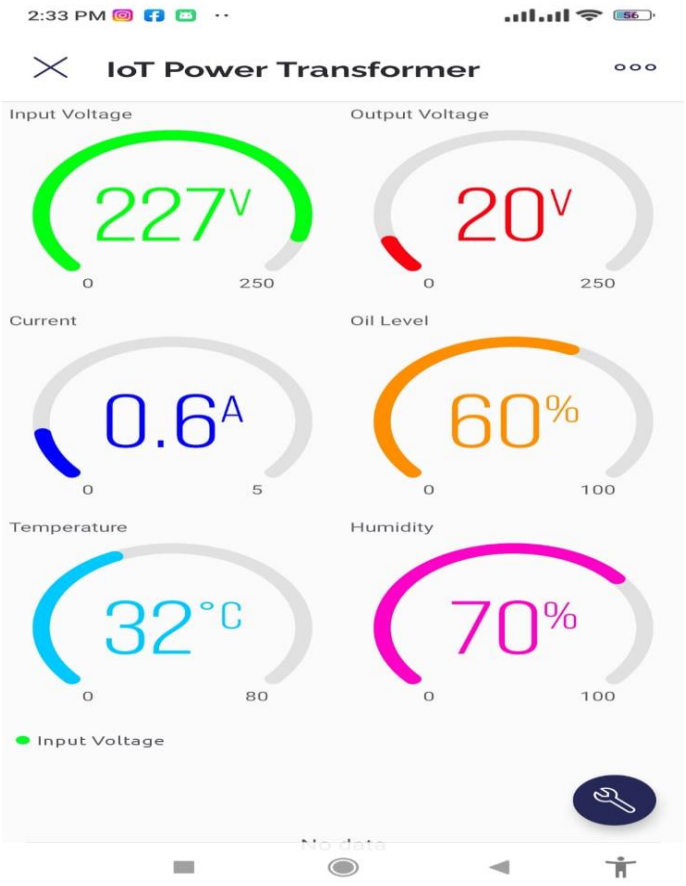


Fig-3.15: IoT monitoring System

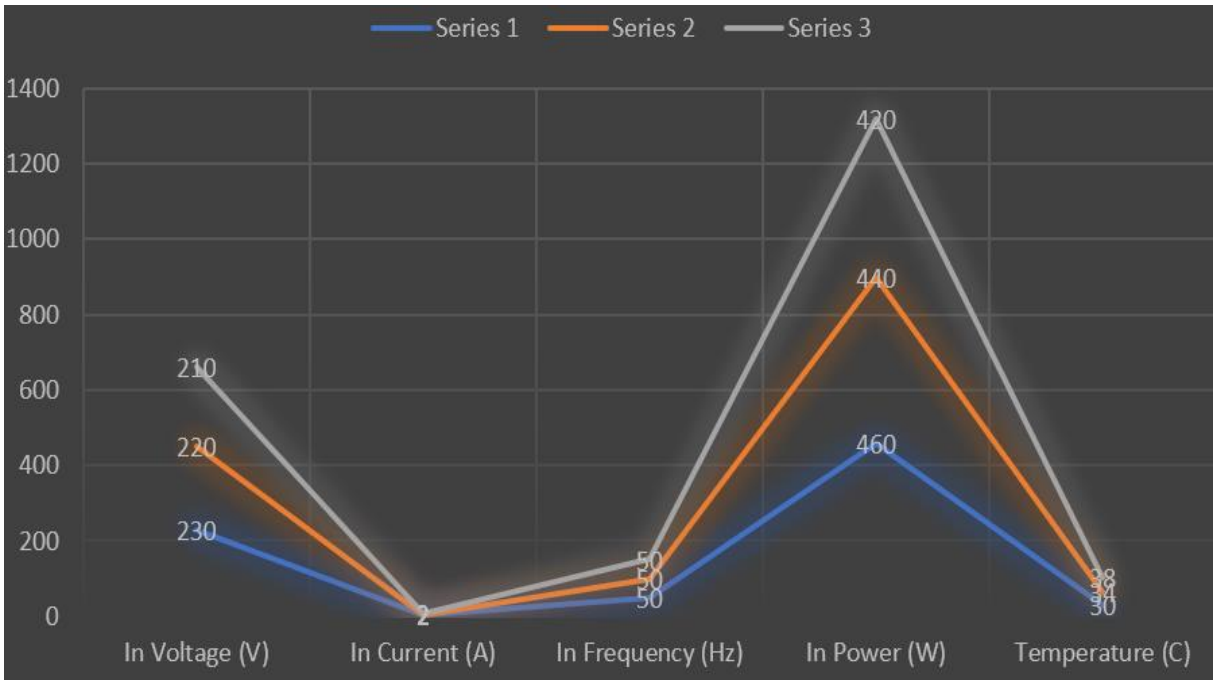


Fig-3.16: Input Data Graphs Chart



Fig-3.17: Output Data Graphs Chart

3.16 List of Components with Price

SL NO	Components Name	Quantity	Unite Price	Total Price (BDT)
1	Arduino MEGA	1	2,500	2,500
2	Buck Module	1	200	200
3	LCD Display	1	10,50	1,050
4	SMPS	1	1,100	1,100
5	Wi-Fi Module	1	450	450
6	Voltage Sensor	2	550	1,100
7	Transformer	1	550	550
8	DHT-11 Sensor	1	450	450
9	Optocoupler	1	50	50
10	2 Pin Plug	1	30	30
11	Board	1	400	400
12	Male to Male Jumper Wires			200
13	Male to Female Jumper Wires			200
14	Female to Female Jumper Wires			200
15	Ultrasonic Sensor		350	350
16	Others		4,000	4,000
Totally Cost				12,830Tk

Table 02 -List of Components with Price

Chapter 4: Software Simulation

4.1 Introduction

Software part is one of the main part of the project, controlling & protection system. The Algorithm is based on different conditions & measuring parameters. Total function of the system is controlled by the software. The code is written on C.

4.2 Project Flow Chart

In any programming related project there is a part named “flowchart” is must. As per rules we made our project flowchart then wrote our proposed project program. There are several parts of our project thus many flowcharts we made.

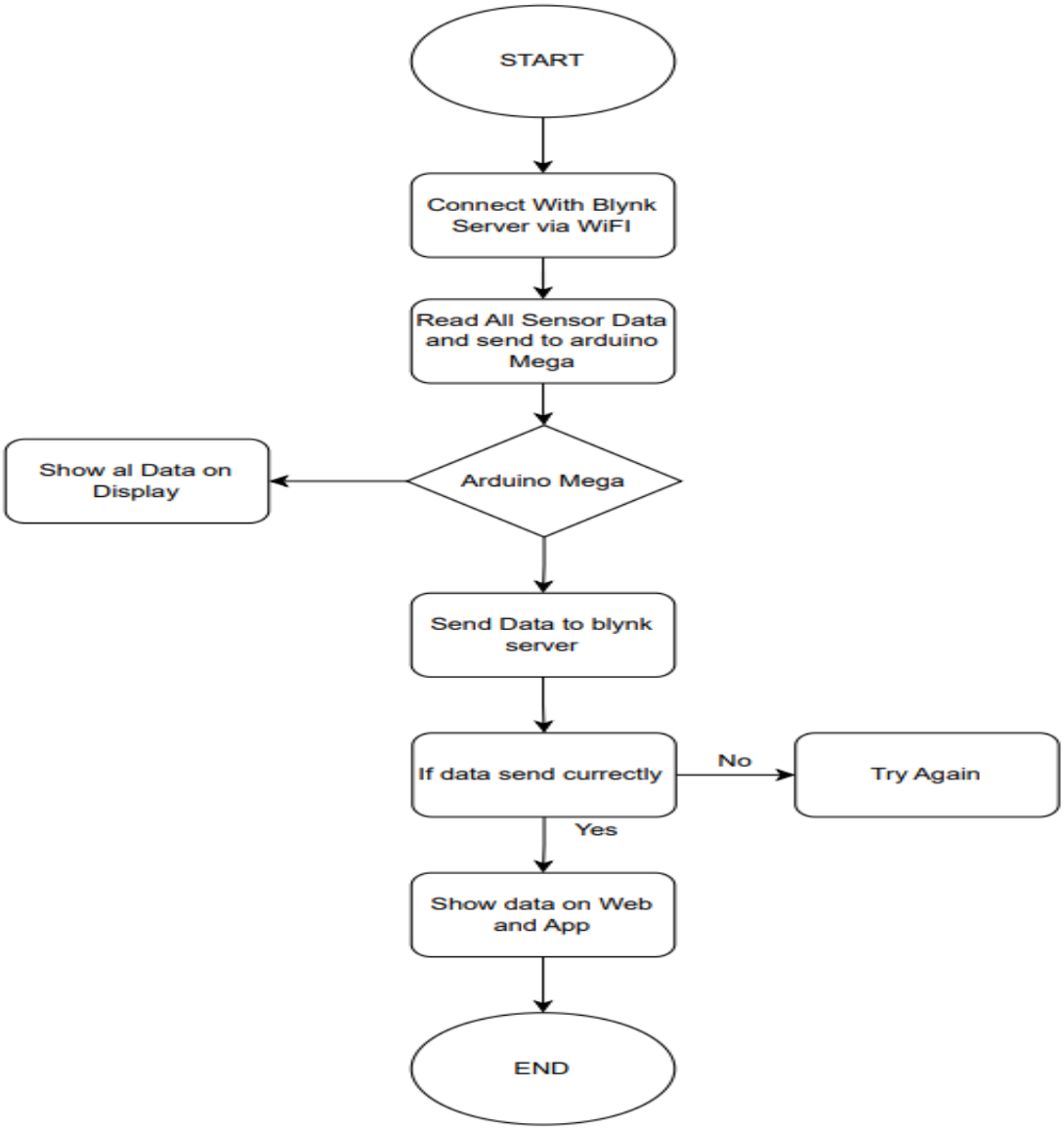


Fig-4.1: Project Flow Chart

4.3 Software Tools

The software that is used to program the microcontroller is open-source-software and can be downloaded for free on www.arduino.cc. With this “Arduino software” we can write little programs with the microcontroller. These programs are called “Sketch”.

In the end the sketches are transferred to the microcontroller by USB cable. More on that later on the subject “programming”.

Installation

Now one after another the Arduino software and the USB driver for the board have to be installed.

Installation and setup of the Arduino software

1. We have downloaded the Arduino software from www.arduino.cc and installed it on the computer (This was NOT connected to the PC). After that we opened the software file and installed the program named arduino.exe.

Two set ups on the program are important and should be considered.

a) The board that we want to connect has to be selected on the Arduino software. The “Arduino Uno” is here known as “Arduino / Genuine Uno”.

b) We have to choose the right “Serial-Port”, to let the Computer know to which port the board has been connected. That is only possible if the USB driver has been installed correctly. It can be checked this way:

At the moment the Arduino wasn’t connected to the PC. If we now choose “Port”, under the field “Tool”, we will already see one or more ports here (COM1/ COM2/ COM3…). The quantity of the shown ports doesn't depend on the quantity of the USB ports on the computer. When the board gets connected to the computer, we will find one more port.

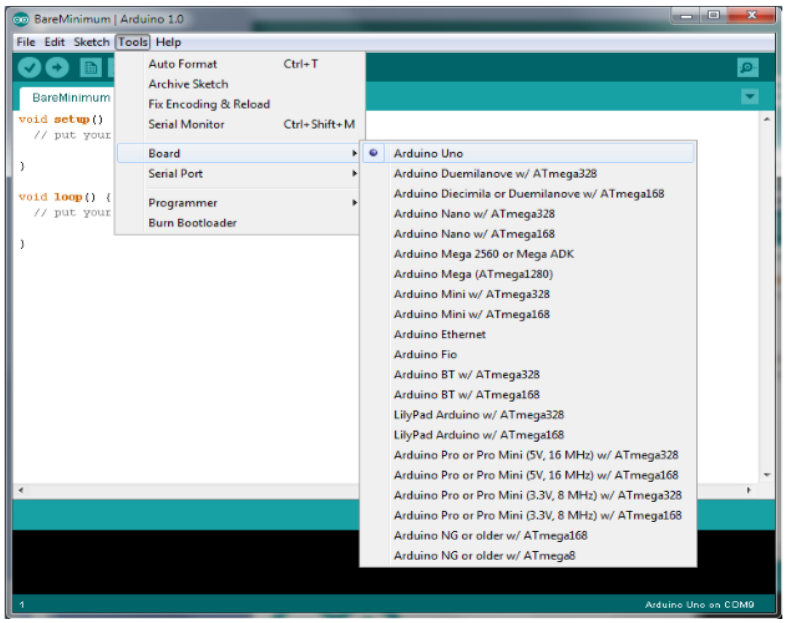


Fig- 4.2: Program installation process

4.4 Programming

The development cycle is divided into 4 phases:

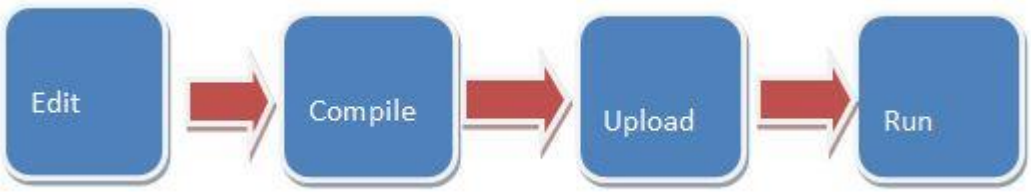


Fig-4.3: Flowchart of the compiling process

Compile: Compile means to translate the sketch into machine language, also known as object.

Code Run: Arduino sketch is executed as soon as terminates the step of uploading on the board.

4.5Arduino Program Development

- Based on C++ without 80% of the instructions.
- A handful of new commands.
- Programs are called 'sketches'.
- Sketches need two functions:
- void setup ( )
- Void loop ( )
- Setup ( ) runs first and once.
- loop ( ) runs over and over, until power is lost or a new sketch is loaded.

4.6 Proteus8.1

Proteus 8 is best simulation software for various designs with microcontroller. It is mainly popular because of availability of almost all microcontrollers in it. So it is a handy tool to test programs and embedded designs for electronics hobbyist. You can simulate your programming of microcontroller in Proteus 8 Simulation Software. After simulating your circuit in Proteus 8 Software you can directly make PCB design with it so it could be a all in one package for students and hobbyists. So I think now you have a little bit idea about what is proteus software. Proteus 7.0 is a Virtual System Modeling (VSM) that combines circuit simulation, animated components and microprocessor models to co-simulate the complete microcontroller based designs. This is the perfect tool for engineers to test their microcontroller designs before constructing a physical prototype in real time. This program allows users to interact with the design using on-screen indicators and/or LED and LCD displays and, if attached to the PC, switches and buttons. One of the main components of Proteus 7.0 is the Circuit Simulation -- a product that uses a SPICE3f5 analogue simulator kernel combined with an

event-driven digital simulator that allow users to utilize any SPICE model by any manufacturer. Proteus VSM comes with extensive debugging features, including breakpoints, single stepping and variable display for a neat design prior to hardware prototyping. In summary, Proteus 7.0 is the program to use when you want to simulate the interaction between software running on a microcontroller and any analog or digital electronic device connected to it.

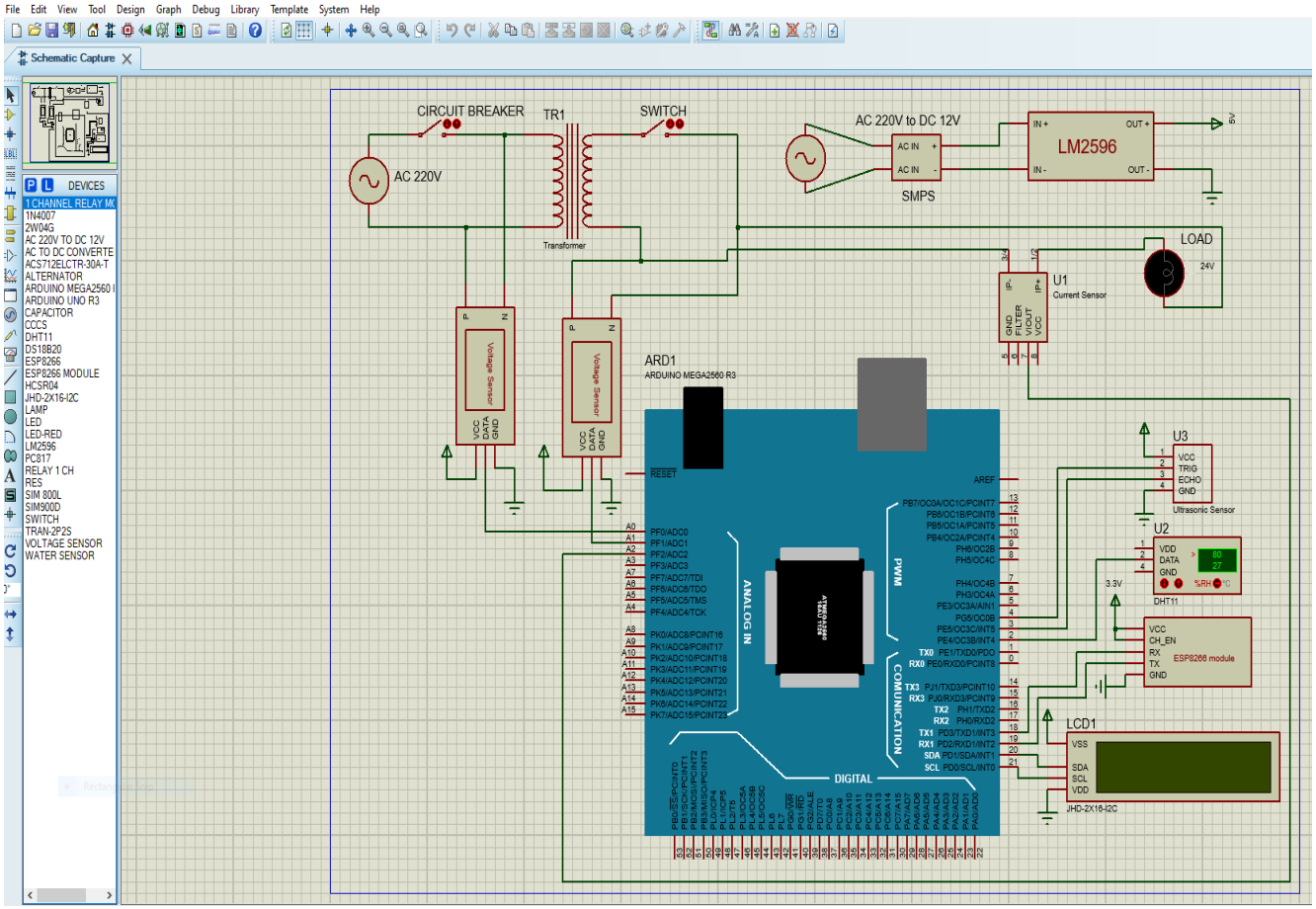


Fig-4.4: User interface of proteus 8.1

Chapter 5: Discussion and Conclusion

5.1 Discussions

An IoT based transformer monitoring system for power transformer was designed, implemented and tested. A server module can be added to this system to periodically receive and store transformer parameters information about all the power transformers in a database application. After receiving message on any abnormality we can take immediate action to prevent any catastrophic failures of power transformers. We need not have to check all power transformers and corresponding phase currents and voltages and thus we can recover the system in less time and faults before any uncertain failures thus resulting in significant cost saving as well as improving system reliability.

5.2 Advantages

- Easy to Install.
- Updates On mobile phone directly.
- Remote monitoring system.
- This project can be used for the safety of transformers in urban as well as rural areas.
- This project can also be used for power transformers inside university campus or inside any company's premises.

5.3 Future works

In future we can add many other faults also in this project. We will also continue to try for solving these problems for the following issues in the future through IoT based systems: "Transformer failure due to external faults such as lightning strike, switching operation, system etc".

5.4 Conclusions

The Electricity plays an important role in our life. Every moment of our life depends upon electricity. Electricity has several components and equipment helping human to transfer and regulate the distribution according to usage.The most crucial equipment of transmission and distribution of electric power is transformer. Operation of distribution transformer under rated condition (as per specification in their name plate) guarantees their long service life. However, their life is significantly reduced if they are subjected to overloading, heating low or high voltage current resulting in unexpected failure and loss of supply to a large number of customers thus is affecting system reliability. Overloading, oil temperature and ineffective cooling of transformer are the major cause of failure in distribution transformer. As a large number of transformers are distributed over a wide area in present electric systems, it's difficult to measure the condition manually of every single transformer. So, we need a distribution transformer system to monitor all essential parameters operation, and send to the monitoring system in time. It provides the necessary information about the health of the transformer. This will help and guide the utilities to optimally use the transformer and keep this equipment in operation for a longer period. The main aim of the project is to acquire real-time data of transformer remotely over the internet falling under the category of Internet of Things (IOT).

Reliability and safety issues of power system have been more important with progress and development of national economy and power system.If we look back towards our daily routine we can conclude that electricity is the inseparable part of our life and transformers plays a role of electricity carrier to us from generation stations.Transformer is the key component in electricity distribution system. Hence protection of transformer is very important. Transformers are used in many applications i.e. from small projects to the mega industries. Increasing population and machinery is resulting in more and more demand of power.Transformers get overloaded due to illegal use of electricity. Overload affects the efficiency of transformer and electricity distribution system. So, the designed system involves automatic isolation of load to avoid damage to the transformer due to overloading. Therefore, a proposed method is chosen to design microcontroller-based transformer monitoring.The microcontroller-based relay provides more adjustable characteristics, high accuracy, more flexibility, increased range of setting, and reduced size, minimum cost with many functions such as self-monitoring and checking by IoT technology.

Transformers are among the most generic and expensive piece of equipment of the transmission and distribution system. Regular monitoring health condition of transformer not only it is economical but also adds to increased reliability. The IOT based Parameter monitoring of power transformer is useful as compared to manual monitoring and also it is reliable as it is not possible to monitor always. Transformer is undergoing fault from the data sent to internet. We can recover the system in less time.

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Appendix:

Program for Arduino MEGA:

```
#define BLYNK_PRINT Serial

#include <ESP8266_Lib.h>

#include <BlynkSimpleShieldEsp8266.h>

//#include <SoftwareSerial.h>

#include "EmonLib.h"             // Include Emon Library

#include <Wire.h>

#include <LiquidCrystal_I2C.h>

#include <OneWire.h>

#include <DallasTemperature.h>

EnergyMonitor emon1;             // Create an instance

EnergyMonitor emon2;

float involt;

float outvolt;



// for esp8266

//SoftwareSerial EspSerial(7, 8); // RX, TX

char auth[] = "VdWQfw_Wb4x1aRwoKAKHG-GYDlSGDWc_";

char ssid[] = "student";
```

```
char pass[] = "iotstudent";

#define ESP8266_BAUD 9600

ESP8266 wifi(&Serial1);

LiquidCrystal_I2C lcd(0x27, 20, 4);

//ds18b20 veriable

#define ONE_WIRE_BUS 2

OneWire oneWire(ONE_WIRE_BUS);

DallasTemperature sensors(&oneWire);

float temp;

// define for Frequency

int input = 12;

int high_time;

int low_time;

float time_period;

float freq;

float frequency;

float value;

float supplyVoltage;

float supplyVoltage1;

int infalt = 3;

int outfalt = 4;
```

```
int tempf = 5;

int mainline = 6;

int oilsen = A2;

int oillev;



//flag

int flag = 0;

int flag1 = 0;

int flag2 = 0;

int flag3 = 0;

void setup() {

  pinMode(input, INPUT);

  pinMode(oilsen, INPUT);

  pinMode(infalt, OUTPUT);

  pinMode(outfalt, OUTPUT);

  pinMode(tempf, OUTPUT);

  pinMode(mainline, OUTPUT);



  digitalWrite(mainline, HIGH);

  Serial.begin(9600);

  lcd.begin();
```

```
  lcd.backlight();

  emon1.voltage(0, 552.25, 1.7);  // Voltage: input pin, calibration  234.26, phase_shift

  emon2.voltage(1, 90.25, 1.7);  // Voltage: input pin, calibration  234.26, phase_shift

  Blynk.begin(auth, wifi);
}

void loop() {

  emon1.calcVI(20, 1000);        // Calculate all  2000. No.of half wavelengths (crossings), time-out
  emon2.calcVI(20, 1000);        // Calculate all  2000. No.of half wavelengths (crossings), time-out
  //  //emon1.serialprint();           // Print out all variables (realpower, apparent power, Vrms, Irms, power
factor)

  oillev = analogRead(oilsen);
  //  Serial.println(oillev);
  oillev = map(oillev, 160, 300, 0, 100);

  if (oillev < 0)
```

```
{
  oillev = 0;
}

if (oillev > 100)
{
  oillev = 100;
}
supplyVoltage   = emon1.Vrms;             //extract Vrms into Variable
supplyVoltage1   = emon2.Vrms;             //extract Vrms into Variable
//  temp sensor
sensors.requestTemperatures();
temp = sensors.getTempCByIndex(0);

if (supplyVoltage < 100.00)
{
  supplyVoltage = 0.0;
}
if (supplyVoltage1 <= 25.0)
{
  supplyVoltage1 = 0.0;
```

```
}


if (frequency >= 60.0)
{
  frequency = 0.0;
}
Blynk.virtualWrite(V0, supplyVoltage); //virtual pin V0
Blynk.virtualWrite(V1, supplyVoltage1); //virtual pin V1
Blynk.virtualWrite(V2, amp); //virtual pin V2
Blynk.virtualWrite(V3, temp); //virtual pin V3
Blynk.virtualWrite(V4, oillev); //virtual pin V4
//  delay(1000);
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Input Volt:");
lcd.print(supplyVoltage);
lcd.print("V");


lcd.setCursor(0, 1);
lcd.print("Output Volt:");
lcd.print(supplyVoltage1);
```

```
  lcd.print("V");



  lcd.setCursor(0, 2);

  lcd.print("Current:");

  lcd.print(amp, 1);

  lcd.print("A");

  lcd.setCursor(0, 3);

  lcd.print("Temp:");

  lcd.print(temp, 1);

  lcd.print("C");

  lcd.setCursor(12, 3);

  lcd.print("Oil:");

  lcd.print(oillev);

  lcd.print("%");


}
```