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# Real Time Monitoring of a Distribution Transformer based on IoT

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## ABSTRACT

In this project represents the real time monitoring of a distribution transformation based on iot, i.e. Implemented on a mobile embedded system to measure to load current, voltage, temperature and humidity. The internet of things is an online based working of physical devices, vehicles and other objects which consists of an embedded system with sensors, actuators and network connectivity that collect and exchange data. The iot allows the objects to be sensed and/or controlled remotely across the existing network of the physical world into computer-based systems, and result in improved accuracy, efficiency and economic benefits. It is installed at the distribution transformer site. The load current, voltage, temperature and humidity of the distribution transformer is measured by the sensors are processed and recorded in the system memory. The system is programmed with a code to check the abnormal condition. The iot will help the utilities to monitor the distribution transformer in minute to minute date transfer to the user to identify the problems before any catastrophicfailure occurs. Hence the minute to minute monitoring of a distribution transformer health measuring will help us to identify or predict the unexpected situations before any fault occurs which leads to a greater economic loss.

**Keywords**: Distribution Transformer, Overheating, Arduino, Insulation, Carona.

## I. INTRODUCTION

A transformer is the one of the most common devices found in electrical system that links the circuits which are operating at different voltages. These are commonly used in applications where there is a need of ac voltage conversion from one voltage level to another. In majority of the electrical devices used in transmission/distribution, these transformers are considered as main components and economically occupy 50% of the capital investment. Whenever a distribution transformer operates under its rated condition then the life of the device will be more than the expected. Their life can be reduced when they are continuously affected with serious failures, unpredicted faults or any abnormal conditions. The major causes in failure of a distribution transformer are overloading, ineffective cooling, oil temperature, load current. In present era we required a greater number of transformers to distribute electrical power over a wide area. Hence each and every transformer health monitoring is difficult during its operation to measure all the essential parameters. The new mobile embedded system based on iot is needed to monitor the transformer and operate it at any situation and send data to the required department, which will help and guide them to protect the transformer and increases its service.

## II. MAIN CAUSES OF DISTRIBUTION TRANSFORMER

### A. OVERLOADING

Overloading in general will take years to destroy a transformer. When load is increased the windings heat up and then cool down again when it is decreased. So, it will burst when either the load is very high for a short period, but this won't generally happen. The transformer will fail mostly because of high loading over a long period of time. In short, overloading reduces the life of a transformer but not as drastically as for other equipment. Most people won't even notice the overloading for long periods. This is one the major reasons why so many transformer manufacturers in India get away with malpractices like selling under-capacity transformers. Dry type transformers generally have lower tolerance for overloading. In these transformers overloading can result in crack in the insulation, since there is no oil to cool it, resulting in failure of transformer. Overloading is still the most common reason for transformer failure in India. In some utilities, the annual failure rate for transformers is as high as 20 percent. Yes, that is for a piece of equipment whose average lifeis 25 years. Ideally the failure rate should be less than 4 percent. This really shows the condition our electrical infrastructure

### B.TRANSFORMER OIL:

Loosening of used conductors is caused by transformer overheating vibrations which produce heat is called overheating. This heat damage the insulating paper and the mineral oil used, because transformer oil is made of the combination of mineral oil or insulating oil. Transformer overheating mostly produced in liquid insulation oil. It is a different problem to slightly in transformers. A DGA (Dissolved Gas Analysis) after the test will indicate high thermal gases to generate. Methane, Ethane, and Ethylene these gases to produce by overheating of the liquid oil. These gases are formed from a breakdown voltage of the liquid oil caused by heat.

Transformer overheating to overcome than an important part of the testing of oil. After testing than transformer oil become aggressive and solid insulation is the expanding services life.

## III. MAIN CAUSES OF TRANSFORMER OIL OVERHEATING

A. Insulation overheating
B. Insulation liquid overheating
C. Corona overheating
D. Arcing overheating
E. Screen testing overheating
F. Insulation failure of conductor

### A. INSULATION OVERHEATING:

It is the transformer overload any reason, the transformer winding will more generate heat and cellulose insulation. The insulation overheating method mainly measures as transformer oil testing method. Testing transformer oil after showing result high carbon monoxide, high carbon dioxide and generate methane or ethylene. The transformer overloaded long time period than transformer condition deteriorating and short cellulose paper. The cellulose insulation is breaking down than produced arcing and transformer took out of services.

### B. INSULATION LIQUID OVERHEATING:

The insulation liquid overheating is a slightly different problem to create on transformer and transformer oil testing method. So, after testing are produce the transformer high thermal gases like as methane, ethane, and ethylene etc. these all result are showing than transformer overheating the liquid.These gases are breakdown than transformer is produce heat. These heating may be cause by poor

contacts and loose connection and bushing grounding stupor circulating currents.

## C. CORONA OVERHEATING:

Corona is produced and considers being partial and transformer discharge and occurring area of high electrical stress, such as sharp point along the transformer for electrical path. The transformer oil after testing being partial discharge is commonly explained intermittent.

## D. ARCING OVERHEATING:

The arcing is the most severe condition in a transformer oil testing. The normally arcing occurs after the testing transformer oil after other problems. Since, high energy require to produce arc will cause the transformer to be elevate arc occurs the area like as cellulose paper insulation, carbon dioxide, and carbon monoxide to be elevate.The transformer or transformer oil in which arcing generated many areas of like as insulation breakdown and transformer coil or cellulose paper in transformer oil etc. will result in arching. The transformer oil after testing contains no longer stress or electrical conductor to a used electrical component. The cause of transformer oil arcing loose connection but the greater significance and produced arcing due to insulation breakdown.

## E. SCREEN TESTING OVERHEATING:

The Screen testing of transformer oil than overheating is produce in the collection of physical, electrical and chemical transformer oil testing method. These screen-testing overheating in transformer oil to include like as electrical breakdown, power factor, inter facial tension, acidity, and insulation color. While large quantity of transformer oil needed for these tests. So, produce insulation liquid for services to gather the transformer oil sample, a transformer oil clean, transformer oil moisture or container must be use.

Due to overload windings get heated up and their will be a loss of energy and efficiency will be down.

## F.INSULATION FAILURE OF CONDUCTOR:

Electrical failures are the result of insulation degradation. This can be caused by thermal degradation over the life of the transformer, by thermal degradation due to excessive or frequent fault current, or by dielectric breakdown due to high voltage stress.The purpose of the insulation is to prevent the flow of electric current between points of different potential in an electrical system. Failure of insulation is one of the most common failures in electrical equipment. The commonly used insulations in a transformer are insulating fluids, conductor insulation and solid insulator.

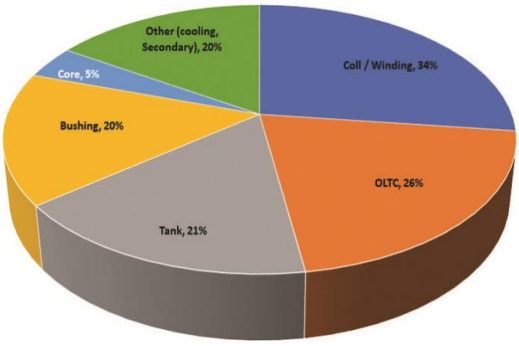


Figure 1 Transformer Fault Percentage

# IV.HARDWARE IMPLEMENTATION

## A.SOFTWARE REQUIREMENTS:

A software requirements specification is a detailed description of a software system to be developed with its functional and non-functional requirements. This developed based the agreement between customer and contractors. It may include the use cases of how user is going to interact with software system. The software requirement specification document consistent of all necessary requirements required for project development. To develop the software system, we should have clear understanding of software system. To achieve this, we need to continuous communication with customers to gather all

requirements. A good srs defines the how software system will interact with all internal modules, hardware, communication with other programs and human user interactions with wide range of real-life scenarios.

### 1. Arduino:

The Arduino integrated development environment (ide) is a cross-platform application (for windows, macos, linux) that is written in functions from c and c++. It is used to write and upload programs to arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.The arduino ide supplies a software library from the wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the gnu toolchain, also included with the ide distribution. The arduino ide employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the arduino board by a loader program in the board's firmware.

### 2. C language:

C is a general-purpose, procedural computer programming language supporting structured programming, lexical variable scope, and recursion, while a static type system prevents unintended operations. By design, c provides constructs that map efficiently to typical machine instructions and has found lasting use in applications previously coded in assembly language. Such applications include operating systems and various application software for computers, from supercomputers to embedded systems.C is an imperative procedural language. It was designed to be compiled using a relatively straightforward compiler to provide low-level access to memory and language constructs that map efficiently to machine instructions, all with minimal runtime support. Despite its low-level capabilities, the language was designed to encourage cross-platform programming. A standards-compliant c program written with portability in mind can be compiled for a wide variety of computer platforms and operating systems with few changes to its source code. The language is available on various platforms, from embedded microcontrollers to supercomputers.

## B. HARDWARE REQUIREMENTS:

The hardware requirements may serve as the basis for a contract for the implementation of the system and should therefore be a complete and consistent specification of the whole system. They are used by software engineers as the starting point for the system design. It shows what the systems do and how it should be implemented. The minimum hardware requirements are as listed below.

1) Arduino nano
2) Current sensor
3) Temperature sensor
4) Rectifier
5) Relay
6) Transformer
7) NodeMCU esp8266
8) Power supply

### 1. Arduino nano:

The arduino nano is a small, complete, and breadboard-friendly board based on the atmega328 (arduino nano 3.0) or atmega168 (arduino nano 2.x). It has more or less the same functionality of the arduino duemilanove, but in a different package. It lacks only a dc power jack, and works with a mini-b usb cable instead of a standard one. The nano was designed and is being produced by gravitech. The arduino nano can be powered via the mini-b usb connection, 6-20v unregulated external power supply (pin 30), or 5v regulated external power supply (pin 27). The power source is automatically selected to the highest voltage source. The atmega168 has 16 kb of flash memory for storing code (of which 2 kb is used for the bootloader); the atmega328 has 32 kb, (also

with 2 kb used for the bootloader). The atmega168 has 1 kb of sram and 512 bytes of eeprom (which can be read and written with the eeprom library); the atmega328 has 2 kb of sram and 1 kb of eeprom.
Each of the 14 digital pins on the nano can be used as an input or output, using pinmode (), digitalwrite (), and digitalread () functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 ma and has an internal pull-up resistor (disconnected by default) of 20-50 kohms. In addition, some pins have specialized functions: serial: 0 (rx) and 1 (tx). Used to receive (rx) and transmit (tx) ttl serial data. These pins are connected to the corresponding pins of the ftdi usb-to-ttl serial chip. External interrupts: 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachinterrupt () function for details.
Pwm: 3, 5, 6, 9, 10, and 11. Provide 8-bit pwm output with the analogwrite () function.

The nano has 8 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default, they measure from ground to 5 volts, though is it possible to change the upper end of their range using the analog reference () function. Additionally, some pins have specialized functionality:

Reset. Bring this line low to reset the microcontroller.
The arduino nano has a number of facilities for communicating with a computer, another arduino, or other microcontrollers. The atmega168 and atmega328 provide uart ttl (5v) serial communication, which is available on digital pins 0 (rx) and 1 (tx). An ftdi ft232rl on the board channels this serial communication over usb and the ftdi drivers (included with the arduino software) provide a virtual com port to software on the computer. The arduino software includes a serial monitor which allows simple textual data to be sent to and from the arduino board. The rx and tx leds on the board will flash when data is being transmitted via the ftdi chip and usb connection to the computer (but not for serial communication on pins 0 and 1). The atmega168 and atmega328 also support i2c (twi) and spi communication. The arduino software includes a wire library to simplify use of the i2c bus; see the documentation for details. To use the spi communication, please see the atmega168 or atmega328 datasheet.

The arduino nano can be programmed with the arduino software (download). Select "arduino diecimila, duemilanove, or nano w/ atmega168" or "arduino duemilanove or nano w/ atmega328" from the tools > board menu (according to the microcontroller on your board). The atmega168 or atmega328 on the arduino nano comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original stk500 protocol (reference, c header files). You can also bypass the bootloader and program the microcontroller through the icsp (in-circuit serial programming) header; see these instructions for details.

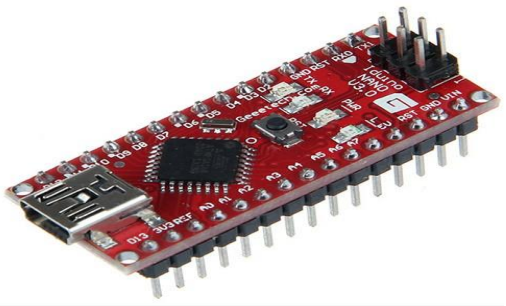

Figure.2 Arduino nano

**2. Current Sensor:**

Acs712 is a economical and precise solutions for ac or dc current sensing in industrial, commercial, and communications systems. The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, switched-mode power supplies, and overcurrent fault protection. The device is not intended for automotive applications.

Figure 3 Current Sensor

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 that 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.

The acs712 is provided in a small surface-mount soic8 package. The leadframe is plated with 100 percent matte tin, which is compatible with standard lead (pb) free printed circuit board assembly processes. Internally, the device is pb-free, except for flip-chip high-temperature pb-based solder balls, currently exempt from rohs. The device is fully calibrated prior to shipment from the factory. The features are as below

Device bandwidth is set via the new filter pin

5 μs output rise time in response to step input current.

Total output error 1.5% at ta = 25°c

Small footprint, low-profile soic8 package

1.2 mω internal conductor resistance

2.1 kvrms minimum isolation voltage from

Pins 1-4 to pins 5-8

Output voltage proportional to ac or dc currents

Low-noise analog signal path

5.0 V, single supply operation

66 to 185 mv/a output sensitivity

Factory-trimmed for accuracy

Extremely stable output offset voltage

Nearly zero magnetic hysteresis

Ratiometric output from supply voltage 80 khz bandwidth

**3. Temperature Sensor:**

This dfrobot dht11 temperature & humidity sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an ntc temperature measurement component, and connects to a high- performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.

Figure 4 Temperature and Humidity sensor

Communication process: serial interface

Single-bus data format is used for communication and synchronization between MCU and dht11 sensor. One communication process is about 4ms. Data consists of decimal and integral parts. A complete data transmission is 40bit, and the sensor sends higher data bit first. Data format: 8bit integral rh data + 8bit decimal rh data + 8bit integral t data + 8bit decimal t data + 8bit check sum. If the data transmission is right, the checksum should be the last 8bit of "8bit integral rh data + 8bit decimal rh data + 8bit integral t data + 8bit decimal t data".

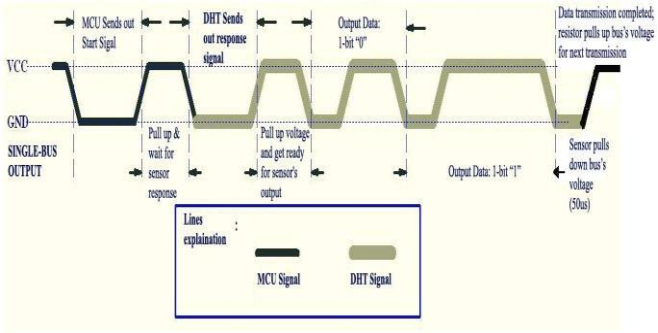


Figure 5 Communication process between MCU and DHT11

When mcu sends a start signal, DHT11 changes from the low-power-consumption mode to the running-mode, waiting for mcu completing the start signal. Once it is completed, dht11 sends a response signal of 40-bit data that include the relative humidity and temperature information to mcu. Users can choose to collect (read) some data. Without the start signal from mcu, dht11 will not give the response signal to mcu. Once data is collected, dht11 will change to the lowpower-consumption mode until it receives a start signal from mcu again.

**Node mcu esp8266:**

Nodemcu is a low-cost open source iot platform.[4][5] it initially included firmware which runs on the esp8266 wi-fi soc from espressif systems, and hardware which was based on the esp-12 module. As arduino.cc began developing new mcu boards based on non-avr processors like the arm/sam mcu and used in the arduino due, they needed to modify the arduino ide so that it would be relatively easy to change the ide to support alternate toolchains to allow arduino c/c++ to be compiled for these new processors. They did this with the introduction of the board manager and the sam core. A "core" is the collection of software components required by the board manager and the arduino ide to compile an arduino c/c++ source file for the target mcu's machine language. Some esp8266 enthusiasts developed an arduino core for the esp8266 wifi soc, popularly called the "esp8266 core for the arduino ide".[18] this has become a leading software development platform for the various esp8266-based modules and development boards, including nodemcus.

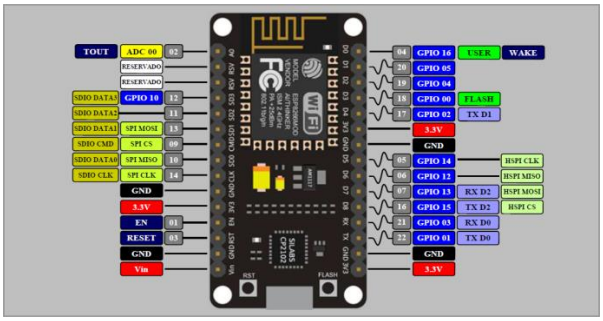


Figure 6 Node MCU

**4. Rectifier:**

A bridge rectifier is an alternating current (ac) to direct current (dc) converter that rectifies mains ac input to dc output. Bridge rectifiers are widely used in power supplies that provide necessary dc voltage for the electronic components or devices. They can be constructed with four or more diodes or any other controlled solid-state switches.Depending on the load current requirements, a proper bridge rectifier is selected. Components' ratings and specifications, breakdown voltage, temperature ranges, transient current rating, forward current rating, mounting requirements and other considerations are taken into account while selecting a rectifierpower supply for an appropriate electronic circuit's application.

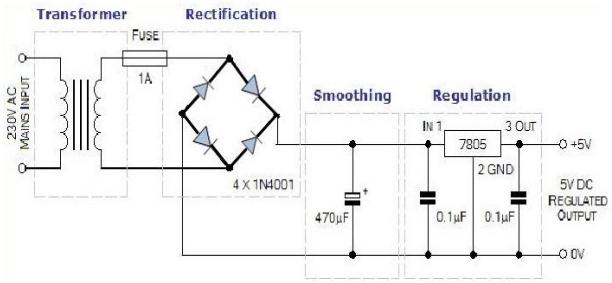


Figure 7 Rectifier circuit

**5. Relay:**

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals.The single channel relay module is a convenient board which can be used to control high voltage, high current load such as motor, solenoid valves, lamps and ac load. It is designed to interface with microcontroller such as arduino, pic and etc.

The relays terminal (com, no and nc) is being brought out with screw terminal. It also comes with a led to indicate the status of relay.

Specification: Digital output controllable

Rated through-current: 10a (no) 5a (nc)

Control signal: ttl level

Max. Switching voltage 250vac/30vdc

Max. Switching current 10a

Size: 43mm x 17mm x 17mm

### 6. Transformer:

A transformer is a electrical device that transfers electrical energy from one electrical circuit to another circuits. A varying current in any one coil of the transformer produces a varying magnetic flux in the transformer's core, which induces a varying electromotive force across any other coils wound around the same core. Transformers are most commonly used for increasing low ac voltages at high current (a step-up transformer) or decreasing high ac voltages at low current (a step-down transformer) in electric power applications.

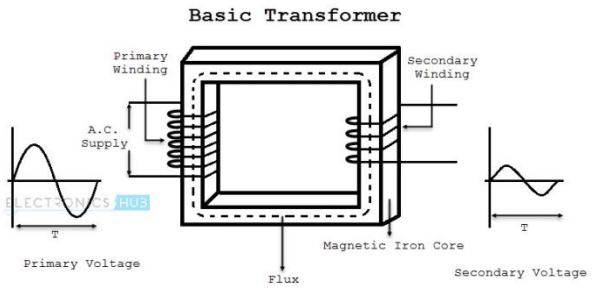


Figure 8 Transformer Design

The basic architecture design is shown below

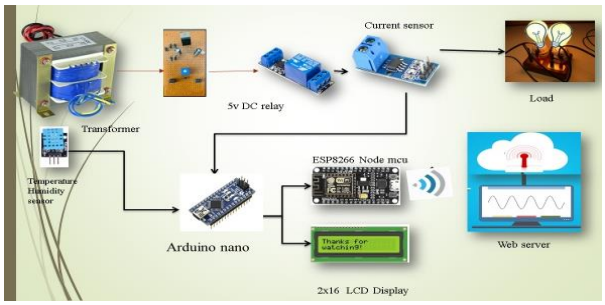


Figure 9 Architecture design

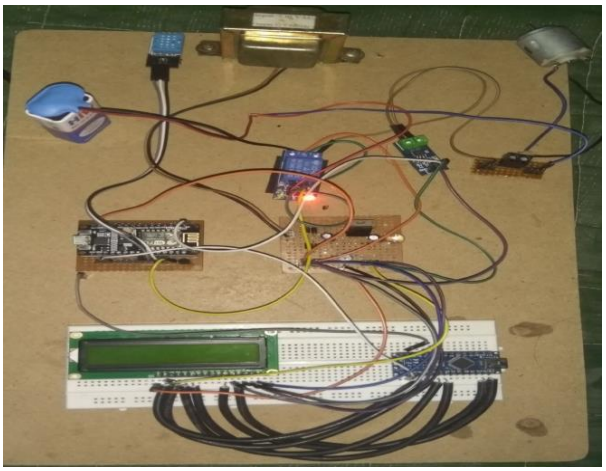

Figure 10 Experimental Model

## IV. EXPERIMENTAL RESULTS & CONCLUSION

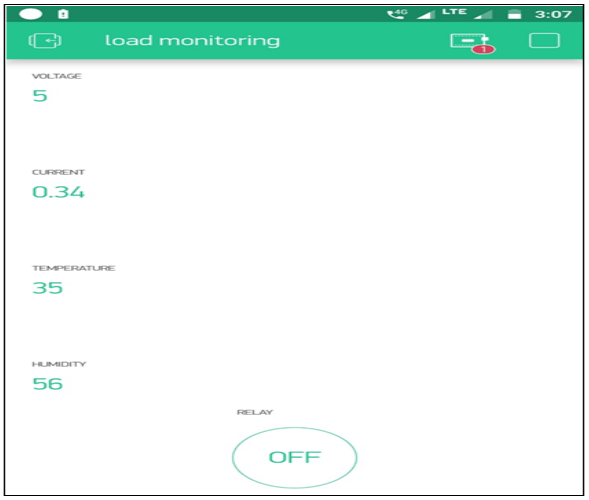


Figure 11 Parameters of Transformer

By applying the above-mentioned technique, we can sense all the parameters mentioned and control the distribution transformer from being damaged in the faulty conditions and increase its service of life. The health monitoring is done properly with accuracy, sensitivity of the sensors is very high during normal and faulty conditions.It is mainly used for identification of unpredictable situations which causes a serious failure, loss of life who works in the yard and economically loss. Transformer health is automatically updated through a webpageand can be controlled.

## V. ACKNOWLEDGMENT

We express our sincere thanks to the support given by the management in completing our project. We express our sincere gratitude & deep sense of respect to my project guide Mrs.U.Subha, Dr. G. Joga Rao, HOD of EEE department and Project coordinator Mr.G.S.N.M Venkatesh. We also thankful to all staff members of Electrical department for their support to complete of this project.

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