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MOTOR PROTECTION AND MONITORING USING ADVANCE PIC MICROCONTROLLER AND WEB SERVER

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Master Thesis

Supervisor

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The thesis titled **"MOTOR PROTECTION AND MONITORING USING ADVANCE PIC MICROCONTROLLER AND WEB SERVER"** prepared and presented by **IMAD ALBAYATI** was accepted as a Master of Science Thesis in Electrical and Computer Engineering.

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Imad Burhan Kadhim Albayati

DEDICATION

I would like to dedicate this work to my first supporter my parents, my wife and my brothers. Without you, this dream would never come true. For their encouragement and support as this research achieved.

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ABSTRACT

MOTOR PROTECTION AND MONITORING USING ADVANCE PIC MICROCONTROLLER AND WEB SERVER

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Electrical Motors are generally highly susceptible to different types of abnormalities known as faults. Such incidents may occur due to several purposes more likely, overloading the supply, temperature hikes and short circuits (conductions between two poles). However, the economical drawbacks due to the faults occurrences is too high due to equipment's damages. Motors are essential part in power machines and more susceptible to unexpected faults. This project is made to establish a monitoring system to monitor the current consumption, voltage at the terminals, temperature of windings and CO2 leakage. Because of over drawing of current, motors windings and coils heat up which results ignition of other insulation existing between those coils and producing of CO2 gas. As a parameter of abnormal existence, CO_2 may indicate high oil temperature. This project proposed automatic control system as well as remote web-based monitoring system to ensure safety of motor equipment. Microcontroller 18F4620 is used to build the system. System is tested in different current levels and different raising of temperature, gas, etc. and shown noticeable performance.

Keywords: PIC, DC, Web, Machine, Fault, Short circuit.

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1 INTRODUCTION

1.1 PREFACE

The development of control system begins by advancement of micro controllers and few attempts to perform switching operation using a programmable integrated circuit. These attempts followed by development of advance programmable chips that are capable to integrate the large networks such as mobile network and cyber space with large powered elements alike transformers and motors. In this report, work is focused on integration of programmable integrated circuit with electric motor for monitoring and controlling purposes. The scope of integration of such technologies are motivated by the capability of recent microchips to perform web procedures as they can act as webservers. The risks that may rise from unfortunate event such as fault that leads to fire is critical to the lives of workers or any human available in the vicinity so the need of remotely controlled monitoring and control system has become an insisting demand. From the other hand, motors are usually cost consumer elements among the others in machinery systems so one of the major motivations of this project is cost saving and adaptation of far less expensive deice to perform a bigger task.

1.2 RESEARCH PROBLEM

Literature shows that the first step to tackle any problem is required to define the same with sufficient evidences. Motors can be formulating the heart of any factory among the other machinery. Along with the life risks that may appears because of such components fails (fault), it is also considered as one of most expensive parts of in many applications such as heavy industries. Literature survey reveals many trials to tackle the same by using the remote monitoring systems. The following points are defining the major drawbacks in the existed monitoring systems.

1. Some researchers are proposed using microcontroller to perform a remote control on the said motor without actually being in the machines room (factory). This proposal took place by using a radio frequency antenna (transmitter) to establish the signaling between the remote person and transformer room where the microcontroller circuit is installed. The main drawback of this works is seen from the sensitivity of radio frequency and the fears of fail in the transmitter tasks if the remote person is located in far place (it can work only of few meters) so in other word it is mobility resistive approach due to the unmarked quality of the used transmitter.

2. Using SMS alarm monitoring system base a microcontroller: this approach is either not up to the mark since it demands uncut network with service availability all the time. The same is

directly dependent on mobile network availably and may not be exactly suitable for Real-time monitoring.

3. Using of internet network to exchange the signaling is again challenged since internet resources cannot be granted to provide uncut services.

4. In many researches a control and monitoring system is implemented without using a straightforward graphical user interfaces which make the monitoring task more difficult.

5. The last observation that made by reviewing the literature is using of big system such as SCADA which has a perfect outcome but very expensive budget which may not be always a good solution for small scale projects such as constructions and building power monitoring systems.

1.3 PROPOSED SOLUTION

For establishment of monitoring unit, a remote monitoring unit (terminal) (RTU) is to be made using attractive web based graphical user interface (GUI) that brings all the sensors output together and represent them as straightforward values for the user continuance.

Tackling the coverage and mobility problem will be implicitly happened as this network will take care of all the terminals wherever they are depending on the strength of the coverage. For the time being, we propose using of wire network that can be in the same building of project area. The wire network is of course supported using an Ethernet cable, which can be further connected with routers in case of rerouting the information to other locations apart from the local site. Furthermore, experiments conducted to deploy a GSM module to exchange the information between the monitoring nodes and remote terminal node, reveal that only single mobile number is to be allotted as destination number where all messages will be redirected. So, only one mobile destination is to be defined and ideally one person can access the information of sensors. This approach is economical and powerful if it compared to SCADA and PLC projects. It uses all the sensors that coming user the SCADA system such as current sensors and temperature sensors, gas sensors etc. except the main core unit, which will be simply a PIC microcontroller. The input/output operations in the proposed system are limited to the number of available ports in the microcontroller unit (chip) which makes it unsuitable for large applications that required to process large number of inputs (in ordinary form).

1.4 OBJECTIVES

The general and major ideology that to be designed over this project is to develop a powerful, cost efficient and easy to use monitoring system with control capability. Some of the objectives can be listed herein:

1. Development of powerful framework that involves using of advance microchip component such as 18F generation chip termed as 18F4620.

2. To state the different method used to monitor and protect the small-scale motor system such as voltage monitoring, current monitoring, temperature monitoring, etc.

3. To present the powerful backbone that take cares of data exchanging process such as TCP/IP protocol and HTTP protocol.

4. To write the results in efficient form in order to make a useful outcomes and conclusions with light method of proposal.

1.5 THESIS ORGANIZATION

This thesis report is contained of five technical chapters appended by the conclusion and references chapters, the distribution of the thesis chapters can be stated as following:

- Chapter one entitled as "Introduction" involves the major aspects of the system and research problem formulation and accordingly the objectives are made as well.
- Chapter two entitled as "Literature survey" in which the previous research attempts in favor of monitoring and controlling systems are demonstrated with intension to support the problem statement and motivations followed to make this report.
- Chapter three entitled as "Methodology" that constructs the methods that made the backbone of this project, more likely, the structure of network and other protocols along with the corpus of microcontroller are being discussed intensively.
- Chapter four entitled as "Monitoring System Simulation" which prescribe the steps taken to build up the said monitoring and control system.
- Chapter five entitled as "Conclusion" which demonstrates the facts that obtained after fulfillment of whole projects steps. Thesis report is ended by enlisting the references

Thesis report is ended by enlisting the references that taken to design this thesis.

2 LITERATURE REVIEW

2.1 PREFACE

Generally, electrical motors are monitored periodically and sometimes continuously for prevention of any fault occurrences. It is known that fault may develop further effects, more likely may lead to crises such as big fire of explosion in the power devices. So, the use of monitoring system is essential to keep the power equipment under the control line. Efficient monitoring procedure may help to increase the life of the power equipment and optimize the system in whole which make great economical plus points. Motor is constructed from several windings, coils sharing the same core and core is made from iron or highly conducting material. It can be understood from this introduction that motors are formulating the core of electrical machines systems and such devices are more subjectable to unwanted circumstances such as over current, faults, cooling system problems that increase the temperature of transformers coils and leads a fire or explosion. In order to tackle such events, monitoring systems are designed. This chapter contains the studies that made to protect and monitor many applications for last eight years. Below, each research that made in favor of mentoring system or protection system is being summarized, each research is entitled by its own unique reference number and is stated as follow.

2.2 CONTROL SIGNALING TRANSMISSION

At [1], the efficiency of power distribution system can be limited to the permissible desired boundary by controlling the losses of this distribution system. S mentioned by the author, power distribution is encountered for various kind of losses that is directly degrade the efficiency of overall system. Author emphasized that power system should be always monitored using a powerful monitoring strategy. The monitoring procedure may pave the road for the maintenance engineers and designers to realize the weak points in the said power system and hence they can correct the fault as quick as possible. Clarification of power system faults is directly related to fast detection of that fault and fast location of it. In this study, authors have proposed using the monitoring system infrastructure by Short Message System (SMS) where information about temperature, current consumption and voltage dropping are propagated by SMS and hence the messages are carrying the information of the mentioned parameters and deliver it to the destination of control engineer PC where he can take the appropriate decision such as switch off the main or clear the fault if any.

At [2], a study is conducted in favor of power transformer cooling system, it was already declared that transformers are usually sunk in pool of oil which helps to reduce the temperature of the coils in which resulted due to the electromagnetic induction or due to the eddy currents that resulted due to core material bad quality. This study proposed sensing system that collect the information from the transformer and send it across till receiving unit that take the decision based on that information. The core that hold the transformers primary and secondary coils is places in a vacuum and this vacuum is filed by cooling oil. For some reason when temperature of this oil goes up, oil will begin to evaporate and hence different gases will be produced due to oil evaporation. This study proposed using of couple of sensors more likely temperature sensor and gas sensor to monitor the status of cooling oil. The information generated by the sensors are received by microcontroller and sent to decision making units which is in turns switch off the transformer. The decision unit is receiving the control signal generated by microcontroller by Radio Frequency (RF) signals, more likely, an RF transmitter is place at the sending microcontroller and RF receiver is place at the tripping circuit that receives the signal from the transmitter and convert it into control message that goes as an input to relay which is tripping down the transformer till the time the reason of error is cleared.

At [3], a virtually implemented alarm system was developed in Proteus software protect the transformer form overheats. This system is producing alarm messages that reveals to shut down the transformer as temperature is reached to intolerable level. In this study, a microcontroller is used to process alarm message as soon as the transformer oil level goes down. For that, level sensor is used to measure the oil level in the transformer and then send the results into microcontroller which is in turns produce the alarm to shut down the transformer. Author mentioned that implementation of such system in Proteus environment is made it easy for developers to test the performance of the system and perform profit and loss calculations. Furthermore, author mentioned that transformer is very subject able to overheat if it is placed in tough environments such as highly temperature areas so the oil level may get down due to environmental effects as well as internal physical or operational impact, so that, the oil level of the said transformer is always needing to be checked.

At [4], a transformer can be safeguarded against the faults and hence power delivery procedure can be expected with optimum performance. The main challenges of deploying the power transformers are the faults which happens in part of the system and cause large consumption of current and resulting big hick in the temperature. In this study microcontroller is used to make up a reliable monitoring system that collects the data of over current and send it to terminal computer using the serial port connection. Remote terminal computer is used to access the readings by technical or engineers in order to maintain system smoothness. Author stated in this study that monitoring system is an integral part of the power system and maintaining the reliability of the power system is a difficult task without involving powerful monitoring strategy.

At [5], transformers of power can be protected against overload (over current consumption) by deploying of switching circuit. A standard switching circuit can be implemented using microcontroller and relay device. It is obvious that microcontrollers are used to collect their inputs form sensors and then process those inputs internally and accordingly it generates an output signal that goes again to a relay and make the relay to get triggered for opening or closing a circuit connected to it (relay) terminals. The study limps on some important part of monitoring system which is called as sensors. The measuring devices that calculates the level of some qualities such as current, temperature, pressure, voltage, etc. is called as sensors. In this study current senses are used to detect the over current and author mentioned that in order to calculate the state of overcurrent (overload conditions) current has to be monitored at the secondary side of the transformer where the load is connected. It is noteworthy that microcontroller is used over this study to deliver the monitoring information to the technical staff by using GSM model integration with microcontroller. Only current and voltage readings are measured from the transformer and directed to the maintenance staff using the GSM facility.

At [6], another approach is developed over this study to for tracking the voltage drop over transformer using of microcontroller. Study is focused on the faults that occurs in the transformer windings due to the voltage drop. Similarly, like other projects of this kind, readings of voltage over transformer terminals are measured and set through the microcomputer into the relay that can shut down the transformer. The system proposed over this study is made in Proteus simulator.

At [7], author limps on the built-in units that are manufactured along with transformer and used to access the major values such as terminal voltage and current consumption as well as the temperature of transformer windings. These devices are made to protect the transformer from any unfortunate event such as faults. Buchholz relay is one of those devices that made ready by transformers manufacturers to perform a monitoring tasks for big transformer corpus. As soon as the terminal voltage and load (demand) current are detected, a monitoring system made based on GSM module are used to grape the set of readings and send it to the terminal monitoring units. This project is proposed for updating the tap charger that used to change the switching status of transformer depending in the staff (technicians) decision once they read the values in the terminal units. The monitoring system and tap charger are acting together to protect the transformer and to deliver a good quality of service to the consumers.

At [8], at the distribution systems where electrical power is being carried and converted among high, medium and low voltage, a performance of transformers is vital to the efficiency of the overall power distribution systems, knowing that, a special care is to be taken to maintain the performance of the transformers to the designated level; said by the author. In this study, a research made to determine the necessity of online real time monitoring system and their role to deliver quality of service to the end users. The outcomes of this study revealed that online and real time monitoring system is very essential for ensuring a quality of service. This study also highlighted the of analogue to digital convertor (ADC) that is integrated with the microcontroller and used to intake the analogue inputs produced from different kind of sensors and convert it into digital equivalent reading processable by microcomputers. The study comes with implementation of triple factor monitoring system that capable to check the current, voltage and temperature. The main agenda of this study is to prevent the fire chances due to overheat and to find the relationship of current and consumption with temperature increment. Liquid level sensor is used as well to measure the level of oil in the transformer data is collected by means of sensors that are interfaced with microcontroller and sent to the monitoring room where decision can be taken base on these values.

At [9], in this study, author defined the operational parameters such as operational voltage, operational temperature and current as those values which are calculated while the device is functional. So, above operational components are monitored in this study from running 11000/220 Volt transformer. Microcomputer is used to input those readings (values) and process it and send it across to nearby monitoring unit using of transmitter. GSM module is a communication standard that reflects the very popular kind of mobile cellular network. The monitoring system of this study has resulted by integration of three components more likely, microcontroller with GSM integration, sensors array (set of sensors that detect different kinds of readings and lastly, a relay component to reveal the protection decision thorough out the network). The project is made with adding another unit called as EPROM which is made to store the information received from the sensors (temperature, current, voltage). Sensing information are exchanged between the microcontroller and monitoring unit by means of Short

Message System (SMS), that was done by defining of GSM module in microcontroller stuck and then allotment of active mobile number (GSM) and also defining of the destination mobile number that system will forward all the messages for.

The preceding part of this report involves implementation of monitoring systems by using either radio frequency spatial transmitters or using the short message system integrated in GSM module over microcontroller.

2.3 COMPUTER NETWORKS

The technology of monitoring systems is essentially contained of microcontrollers that is taking the responsibility of performing the major tasks in the system with light of sensors that provide analogue inputs. Furthermore, microcontroller may be connected directly or indirectly to decision making logic that implements the actions on the surveilled network. The means of signaling channels are either SMS with GSM stuck or radio frequency transmitters. The same was explained above. This section involves using other technologies for signaling purpose such as Bluetooth, WIFI and Zigbee. The other mentioned technologies are used as means of data exchanging between the remote monitoring terminals that located at remote location and mentoring local system that located at the project site. There are two possibilities of decision making. As literature survey revealed, either the monitoring system is taking the decision instantly by turning the main switches off and on, or monitoring system is diverting the data to the remote monitoring terminal where technicians are observing the same and taking the decision accordingly. However, below some of other researches that conducted in favor of data transmission methods in the monitoring systems:

At [10], authors proposed an application of monitoring and remote systems that is capable to control electrical applications at home remotely. The proposed system can perform the control strategy in automatic fashion and manual fashion respectively. The connection between the devices (electrical applications) and the control system is made by using the Ethernet shield that act as compatible interface with all devices, furthermore, the control system is made by deploying UNO Arduino microcomputer and wireless model for providing the connection with the remote terminal unit. This kind of systems are integrated with the so called smart homes where user can control any device at home by simply login into the web page by the internet and using the graphical objects (switches) to change open or shut the devices. Furthermore, user can login any time to check if unwanted people are presented at his home and can accordingly start alarm. Technically, Ethernet of all devices are connected with sensors such as infrared sensor or temperature sensor (for air condition status measurement), an actuator can be connected to the Ethernet shield in order to receive the signal from the main module and change the switching statue. The actuator is connecting the control unit with high voltage units and acts similarly as relay to perform switching base on triggering by external sources.

At [11], author made a smart home application using of microcontroller supported by Zigbee system to initiate the communication between different devices at home and the control system. No monitoring system is made in this project except a control system that provide the user with flexibility to switch the home applications by using a mobile phone. No remote terminal is needed to be deployed in here as user can access the devices when he is at home only. One plus point is seen in here that different devices with different current rating can be connected to the same switch without needing to use different switches which is reduced the system overall costing.

At [12], the authors of this study have proposed a mobile integrated monitoring system that able to record the ratings of functional transformer. Ambient temperature, voltage and current are been monitored using of the proposed system. The mentioned parameters are monitored using online monitoring system in real time monitoring by connecting the sensors of particular purposes with the analogue to digital convertor ports at the microcontroller circuit. An Arduino microcontroller is providing a chip with the port connections that are easily connected with the particular input. The method that enabled the used to access the monitoring system and check the readings of those sensor remotely is implemented by using a Global System of Mobile Communication (GSM). However, the readings from the sensors array are stored at the device memory and working condition of alarm system is taking place if any abnormal situation took place. Now, the abnormality can be decided base on some parameters that are already encrypted inside the microcontroller device and decided according to the engineering calculations in the transformer datasheet where the rating nominal current and voltage are set along with maximum and minimum tolerance of temperature, load, etc. the monitoring unit (microcontroller) is sending a text message SMS to the mobile number of the responsible person that tells about the system conditions and actual Real time readings of those sensors. For this monitoring system, no automatic tasks are made, it is only about monitoring and alerting tasks that reveals the unfortunate conditions (fails) upon there occurrence to the responsible person who can initiate the fail aid procedure by his own.

At [13], this study demonstrates similar project that performed using a microcontroller and local area network LAN to control the lighting system. The advance microcontrollers are made capable to connect a computer networks and act using the Ethernet integration facility in those devices. Microchip is a company, which is, designed a microcontrollers and smart chips, microcontrollers such as 16F series are capable to connect the computer network in both serial port and Ethernet port. However, control system can be made by microcontroller using the same concept by connecting a relay circuit (actuator switch) with the circuit which is willing to be under control. As new microcontrollers are providing the facility of remote networking, then it is important to discuss something about networking and web services. Web pages such as HTML can be used to access the monitoring system and monitoring system as well can send across all the required information into this web page. the web pages are accessible by unique IP address only such as 132.89.122.80 this is version Four IP address which is used to identify the monitoring network and provide access this network.

3 METHODOLOGY

3.1 PREFACE

Electrical motors are built the backbone of all life applications since electrical power is the most popular means to energize life routines such as big factories, computers, and networks and so on. Due to the paramount influences of the said motor system in human daily life and the cost of power equipment's adaptation, protection systems are involved as major parts of every factory. Protection devises are considered as integral part of power system operations due to their role in maintaining the power activity of the motors which delivering service to the end user.

The motors are paramount device in the system corpus due to their uncompromising role to transfer the energy from one section to other section in the system. It is known that power is generated from the production stations (power plants) in high voltage and it is used by the end users in low voltage i.e. 220 volts, so motors are made to maintain the potential requirements in different applications [15].

For every part of the power system, different strategies are presented for protection. Considering the variation of adaptation cost of those protection devices. The focus of this project is protection of electrical motors due to their popularity of problems in small power systems. In other word, motors are most important parts of power systems serving within buildings as well such as residential compounds, hotels, parks, etc.

Monitoring system is integral part in power system, it is essential to protect the power devices by prevention the faults in proactive manner or by elimination the further effects of fault. However, monitoring system is proposed over this study to track the transformer and send the information such as current consumption, terminal voltage, winding temperature etc. into remote terminal unit (RTU). The RTU is web-based unit that is accessible through the network using web browsers. This chapter is a demonstrating the underlying information of the network topology and the monitoring system by whole. It also describes the mode of operation of the sensing units and how sensors information is processed and sent to remote terminal unit.

3.2 MONITOR PROTOTYPE

In order to protect the machineries by whole or to protect the motors particularly, rating values of the electrical components should be maintained. The monitoring system must be capable to detect the ratings of this transformer, process the analogue value digitally (analogue to digital conversion) and send the results to remote terminal where the observer can see and take an action accordingly. Monitoring system might be integrated with control scheme in order to be more useful in case the observer or the concern person not on the site or not available eat the fault occurrence time.

Automatic control strategy is very essential to success any protection system because automatic control is time independent and totally available always and can take instant action according to a programmable scenario. Manual control is also not comprisable since new circumstances might be occurred where automatic control system is unable to perform. More likely, when demand is raised to power of the supply for some time due to some maintenance work or in case of power system upgrading. [17]

Unlikely traditional method of offline/manual control by tripping/changing the switches (open or close). Remote control online and real time is best more effective method. In this study, micro controller is proposed to act as underlying device that forms power system monitoring and controlling at same time.

The inputs this system are sensors rows which are detecting any variation in temperature, power, voltage, current, etc. and outputs of the system are accumulated to be directed into remote terminal unit (web-based monitor). System in who is web based and able to perform control strategies by software-based switches (push-bottom). The design considerations of this smart monitoring system inclusive of the virtual models required to reflect the actual circumstances of the power system can be listed as fellow:

1. Motors is simulated as power step up transformer is of 220 volts at secondary windings and supposed to step down the voltage from 11 Kilovolt.

2. Current consumption circuit is to be modeled as three gated sections each section is connected with toggle switch. On changing the switching condition, new load is added to the circuit and hence current consumption is increased [18].

3. Current consumption by the load is to monitored using current sensor. More likely, current is a device interfaced serially with the load so that the flow of current from supply into load is measured by this sensor. The output of current sensor is DC +0 to +5 volts which is heading into micro controller input port for further operations.

4. Gas sensor is a special device that sense the gas leakage from the transformer (which stands for motor), it detects the CO_2 produced as windings temperature increased and cooling material of the said coils are began to ignite. The reason of CO_2 production in the transformer of its vicinity might be due to ignition of any other materials such as cables or circuit breaker of any other similar stuff. This sensor is also providing an output oscillated from zero volt to five volts DC in accordance with amount of gas emission.

5. Temperature sensor which detect any hike of temperature in the transformer windings or the cooling oil which is surrounding those windings. Temperature of windings is raising either due to over current computation or because of cooling oil shortage or due to some internal fault. The temperature sensor is also generating an output oscillated from zero to five volts with respect to the temperature level.

6. Cooling devises (supplementary), which are used to control the temperature hike once it occurs. Air fans which a known capacity are usually installed at the vicinity of power transformer and used whenever monitoring systems indicates a temperature hike.

7. Alarm system that may be used if any uncontrolled circumstances occurs in the transformer room. It is actually sound alarm system which produces a deep sound (beeps) to alert of fine occurrence and claims for evacuation.

8. Microcontroller is paramount part of this system which process all the inputs and send it to the web browser at the remote terminal unit. For fulfillment of projects prerequisites, the microcontroller must compatible with the web services. In other word, microcontroller should able to translate the data into web contain and exchange the web overheads through a computer network.

9. Network requirements is about output interfaces (ports) support in the microcontroller which make it feasible to link network devises. Ethernet controller is likely to be linked with microcontroller and hence, the last will be able to broadcast the sensors contains into web network [19].

3.3 INTEGRATED FUNCTIONS

While developing the monitoring system, manual control strategies are integrated as well to act alongside with automatic control strategy. As was declared earlier, at some circumstances more likely, to upgrade power system (adding more loads, more breakers, etc.) or in uncontrolled situations such as fire occurrences or faulty of any sensing unit at the monitoring system, power system may require to be controlled manually. In order to fulfil those requirements, the following function is developed as software defined Buttons.

A. Button (1) which made in the remote terminal unit, this bottom is made to force shutdown the power system.

B. Button (2) is made to insert new load to the system which is equivalent to 10 A.

C. Button (3) is made to insert new load to the system which is equivalent to 10 A.

D. Cooling fans, on temperature hike, one fan is automatically to start in order to reduce the temperature. If the temperature is continued to increase, second fan will commence working alongside with first fan as an attempt to reduce the temperature.

F. Beep buzzer is used to alert of uncontrolled temperature and indicates fire possibility.

It is noteworthy to state that: if load insertion continued until the load is said over (overload), the power supply is going shut down automatically and display a message on the remote terminal unit revealing over load occurrence to the system observer. Similarly, when temperature is hiked, a message indicating that is sent to remote terminal but system supply is not turning off automatically. Instead, supplementary cooling system is starting automatically and if that fails to reduce the temperature, beep alarm will begin.

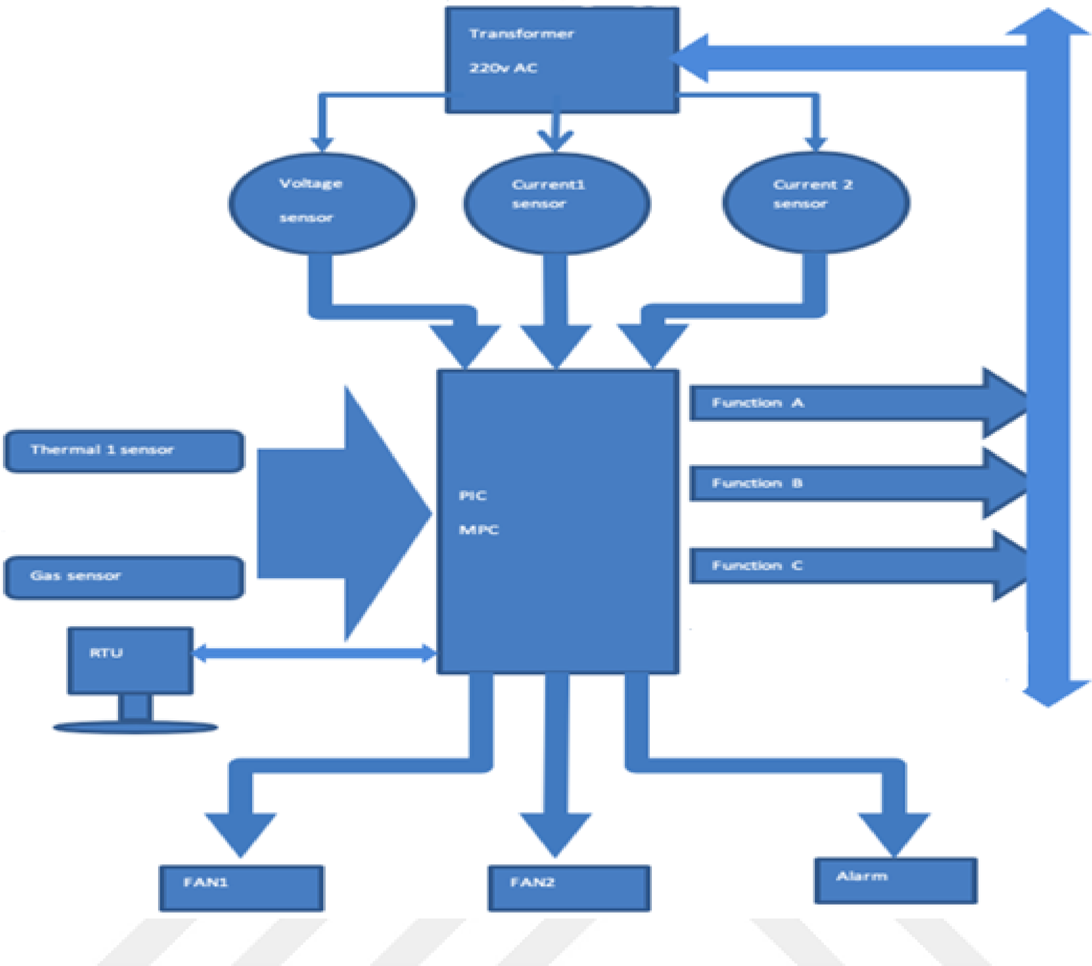

Figure 3.1: Overall structure of monitoring/control system.

Figure 3.1 depicts the entire monitoring system; it shows the input ports and output ports as well as the interface of remote monitoring system.

3.4 OVERLOAD PLATFORM

In order to simulate the current circuit in virtual environments, several conditions must be implemented in power system. A noteworthy that current sensor can sustain for 30 A of current as per the simulator. Current is increasing as the motor loading increasing so the current simulation sub-system can be illustrated with the help of transformer as the following.

So, the output of the power transformer must be scaled down to match the current sensor tolerance. It has been decided to design three gates of current circuit where each gate is corresponding to 10 A so that current circuit by hole will be able to consume 30 A. Over current is take place once the current raised into 30 A. Figure 3.2 is demonstrating the over current scenario.

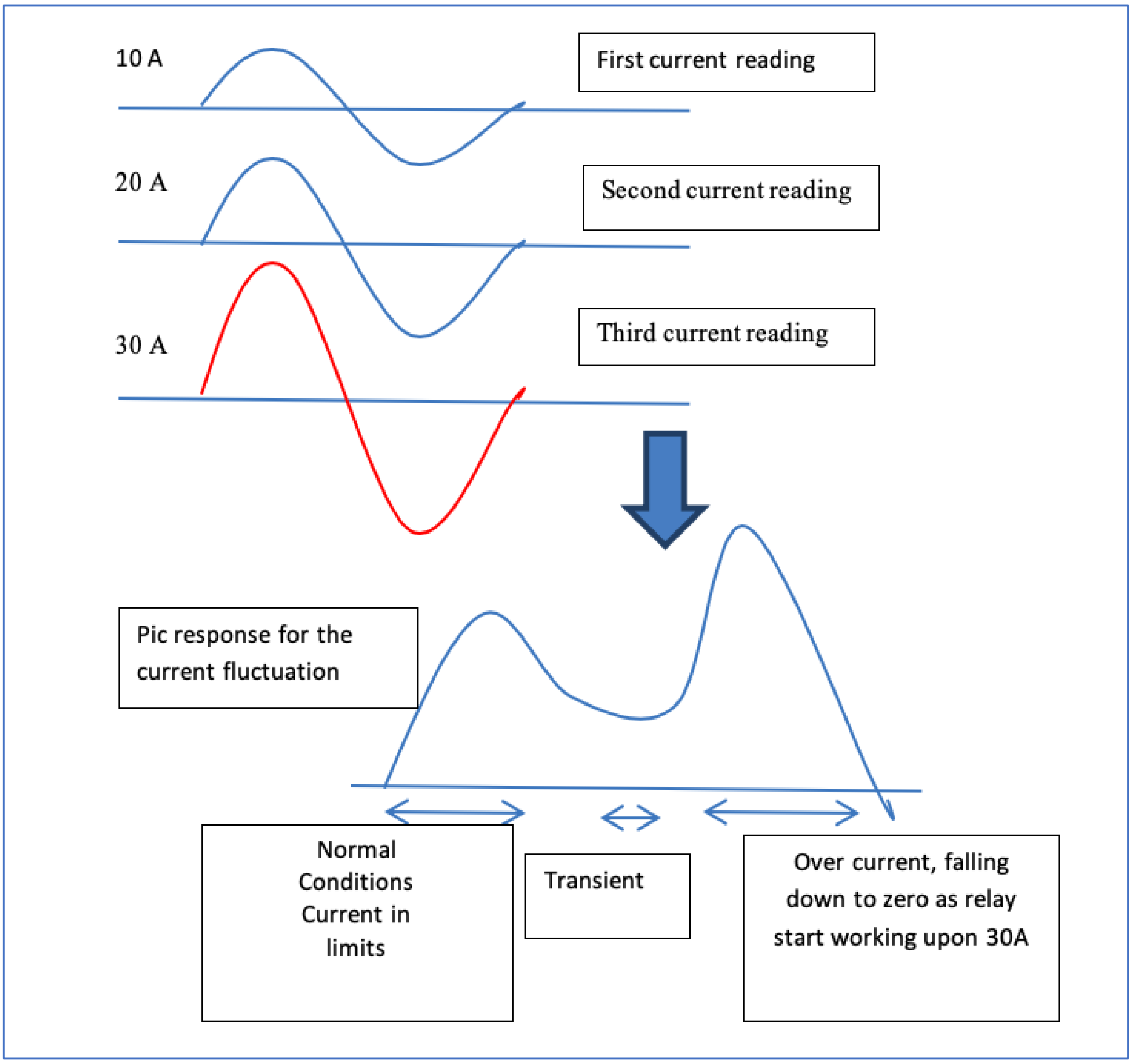

Figure 3.2: Microcontroller response to the current fluctuation.

The Figure 3.2 shows how microcontroller will response to the three current scenarios. The graph shows three regions of operation, the first region is normal current action where load within the tolerance of the controller (tolerance of the designated power system), second region is transient action region where current consumption changed from minimum tolerance to the maximum tolerance, lastly, the third action region is over current action where current consumption reaches to threshold tolerance [20] [21].

4 EMPIRICAL MODEL

4.1 OUTLINE

This chapter involves practical steps to implement the proposed monitoring and control system. It is however implemented using a flexible software supports virtual electronics implementation with microcontroller's compatibility. Circuit along with whole sensors are connected in the Proteus software. Another software was used to enable network connectivity along the virtual devices such as Winpcap 4.1.3 and VMware for virtual network implementation. System is totally implemented and tested under various circumstances.

Remote terminal unit is made to be accessible through external web browser at any terminal within the network subset. The data from all sensors are preprocessed at microcontroller unit and sent to remote terminal unit.

Data heading from microcontroller towards remote terminal is required a proper interfacing between the microcontroller's end and terminal computer's end. In order to do so; A computer network should be form between microcontroller and all terminals desired to have access to the system.

In the coming sections of this chapter, tools and materials used to build the system are explained with details. Furthermore, the simulation procedure of load circuit and how load is controlled by the remote terminal unit. In the last section of this chapter, a discussion is made on how implanted system works by whole.

4.2 EQUIPMENTS AND MATERIALS

For fabricating the so-called monitoring and control system, Proteus Electronics was found as best available option to handle project re-equipment's. First of all, electronics tools such as transistors, resistors, DC power supplies, capacitors, etc. are required to form the system. However, more materials are needed to form the monitoring system such as sensors alike current sensor, temperature sensor and gas sensor are essentially needed. Proteus Electronics is supporting Microchips devices such as PICs of different families and network supports such as serial interfacing and Ethernet interfacing.

The tools used in the project is listed herein along with technical explanation of each and how it was useful in the proposed system.

4.3 MATHEMATICAL MODEL

Let:

Current sensor output is X_1

Voltage sensor output is X_2

Gas sensor output is X_3

Thermal sensor output is X_4

The microprocessor (MP) operations is to be represented by f_x

$$f_x = \mathrm{H}(X_1, X_2, X_3, X_4) \quad (4.1)$$

Where H is the transfer function that applied by MP unit on the incoming inputs.

$$H(X_1) = (X_1 * 1023)/5000 \quad (4.2)$$

$$H(X_2) = (X_2 * 220/5) \quad (4.3)$$

$$H(X_3) = (X_3 * 220)/5 \quad (4.4)$$

$$H(X_4) = (X_4 * 5)/1024 \quad (4.5)$$

The equations above can be written in general form as:

$$\mathrm{H}(\mathrm{m}) = \begin{cases} \frac{(m*1023)}{5000} & if\ m = x1 \\ m * \frac{220}{5} & if\ m = x2 \\ \frac{(m*220)}{5} & if\ m = x3 \\ \frac{(m*5)}{1024} & if\ m = x4 \end{cases} \quad (4.6)$$

The current (is simulated to be increased manually using the bottoms integrated with the remote terminal unit. Hence, the operations representing the current consumption could be expressed as:

Let y is logical controller which has values in [0, 1]. However, there will be two logical controllers for current circuit $y1$ and$y2$. Another logical controller is made to shut down the motor in case that is demanded by situation, this controller is called$y3$.

Another transfer function will be representing the MP output operations is called as$L$. R, R1 and R2 are the resistors used to control the current.

$$L(s) = \begin{cases} \frac{v}{\frac{1}{R}+\frac{1}{R1}} & if\ y1 = 1 \\ \frac{v}{\frac{1}{R}+\frac{1}{R1}+\frac{1}{R2}} & if\ y2 = 1 \\ v = 0 & if\ y3 = 1 \end{cases} \tag{4.7}$$

Ultimately, the MP response for the temperature hike can be expressed by the following formula:

$$T(c) = \begin{cases} f1 = 1 \ ||\ f2 = 0 & if\ c = 55 \\ f1 = 1 \ ||\ f2 = 1 & if\ c = 66 \\ f1 = 0 \ ||\ f2 = 0 \ \ ||\ v = 0 & if\ c = 100 \end{cases} \tag{4.8}$$

Where the v is the main voltage supply and c=x3 is the temperature value. T(c) is the MP response for the temperature hike. F1, f2 is the logical controller of fan 1 and fan 2 respectively.

4.4 MICROCONTROLLER PIC 18F4620

This model from microcontroller (PIC) is employed in this project to accommodate all signals (outputs) from sensors. This integrate circuit can be programmed so that it can convert all the analogue signals from different sensors into digital form. This device is manufactured by Microchip and contained a reliable feature to support networking tasks and controlling tasks as well. This device can work as miniature webserver which provides all the web services available in any web server over TCP/IP network. From the other hand, PIC 18F microcontroller can be used as GSM device as well to support mobile signaling.

Forty ports as available in this device and it can be run using single DC power supply with five volts. It supports both internal clock and crystal external clock with speech up to 30 Megahertz. USB port is also supported by this microcontroller in order to program the device by connecting it to the programming adaptor easily.

In order to use this device, Proteus library is providing this version of microcontroller directly so, it can be drug from the library into workspace. The essential step that to be done prior to use this device is port definition.

Device must be having clear information about the port dedication. That means, input and output ports are to be defined correctly during programing the device. Micro C compiler is used to compile the code as soon as all the required functions are implemented in that code.

Table 4.1 is tableting the details of each port in microcontroller corpus. The virtual environment of Proteus is not insisting to demanding empowering the integrate circuits by connecting DC power supply to the particular power-in ports. As this device is having more than one power-in port, only one power supply is used to provide V_{cc} voltage input (five volts DC voltage).

Another paramount step to be taken to ensure the smooth operation of this device is accurate definition of clock frequency. In case of our application a crystal clock oscillator is used with twenty-Megahertz frequency. The mentioned clock frequency is found very much suitable in our application as device take very less time to detect the input variation. PIC of interest is depicted in Figure 5.1 as it looks in Proteus workspace.

Table 4.1: Ports assignment in microcontroller unit.

Port Label	Interfacing object
AN0	Current sensor of the primary windings (first analogue input)
AN1	Current sensor of the secondary windings (third analogue input)
AN2	Terminal voltage sensor (second analogue input)
AN3	The input from gas sensor
AN4	----
AN5	Oil temperature coming from the temperature sensor of the transformer
RB0	----
RB1	Fan 1
RB2	Fan 2
RB3	Main circuit breaker (automatic shut-down)
RB4	---
RB5	Circuit breaker 1
RB6	Circuit breaker 2
RB7	---

RC0	Ethernet reset
RC1	Ethernet chip select
RC2	-----
RC3	Clock
RC4	Serial out
RC5	Serial in
RC6	Universal port transmitter
RC7	Universal port receiver
RD0	Interrupt
RE3	Microcontroller power in

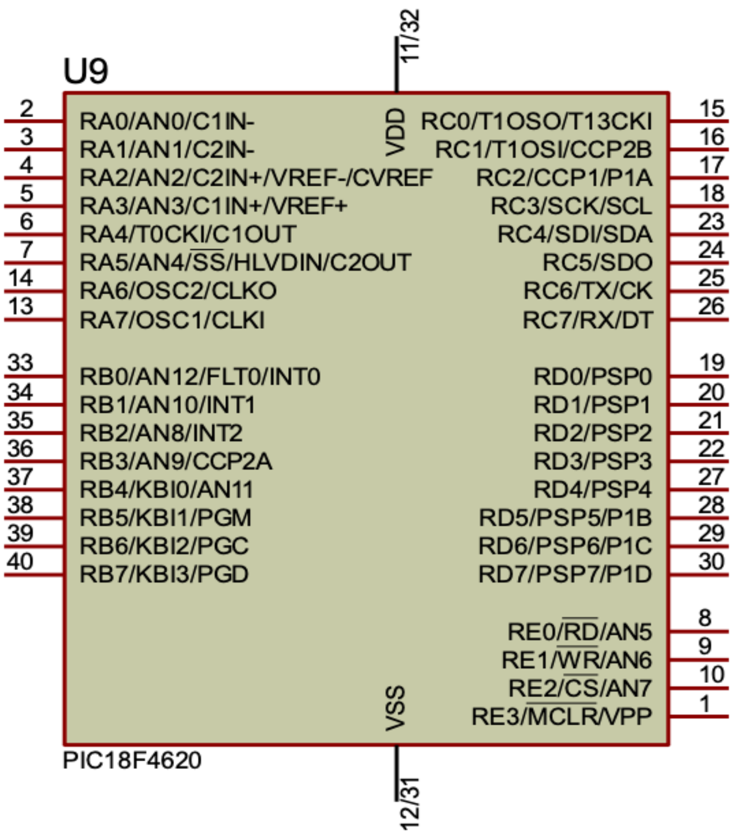

Figure 4.1: The actual appearance of PIC as in simulator's workspace.

4.5 MOTOR SUBSYSTEM

Step down transformer is picked-up from Proteus library and supplied with input voltage 11 Kilovolts to represent a motor circuit. The output of this transformer is kept to 220 volts at fifty Hertz frequency. In order to have a hold of the transformer input, the main source the power the primary windings of the transformer is cut by a switch transistor as demonstrated in Figure 4.2. Switch transistor is controlled by microcontroller. A software defined button was made at the remote terminal unit web page and used to power off (shut-down) the supply remotely.

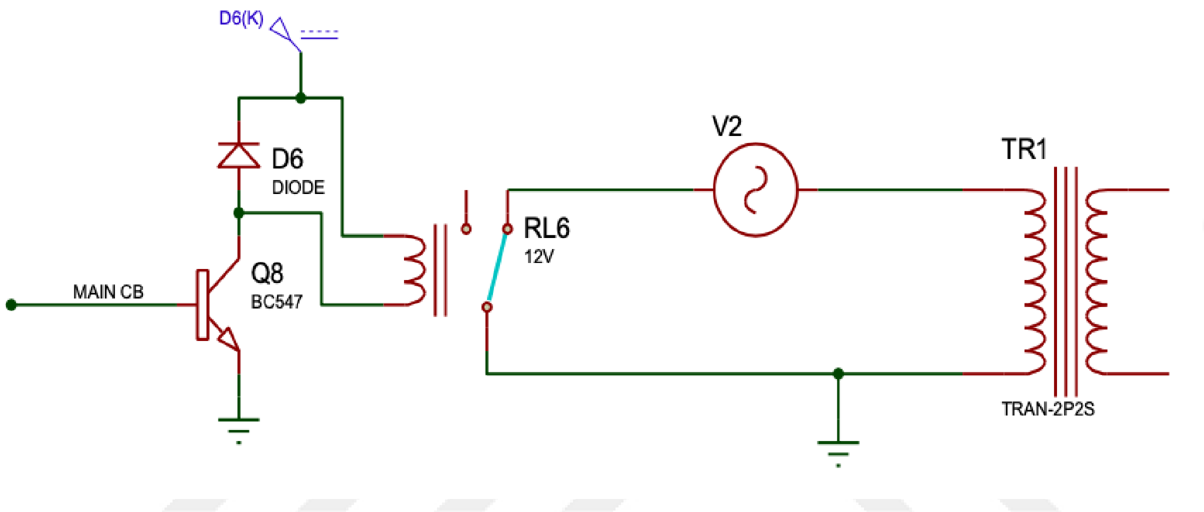

Figure 4.2: Transformer's main feeder remote control circuit.

In order to monitor the current drawn from the transformer, a current sensor is implemented as in Figure 4.3. ACS 712 current sensor is implemented in series with the source and empowered with single power supply of five volts DC voltage. Furthermore, a capacitor filter is connected on the output port in order to remove the noise in the readings (output sensing DC signal). The value of the capacitor is made equal to microfarad.

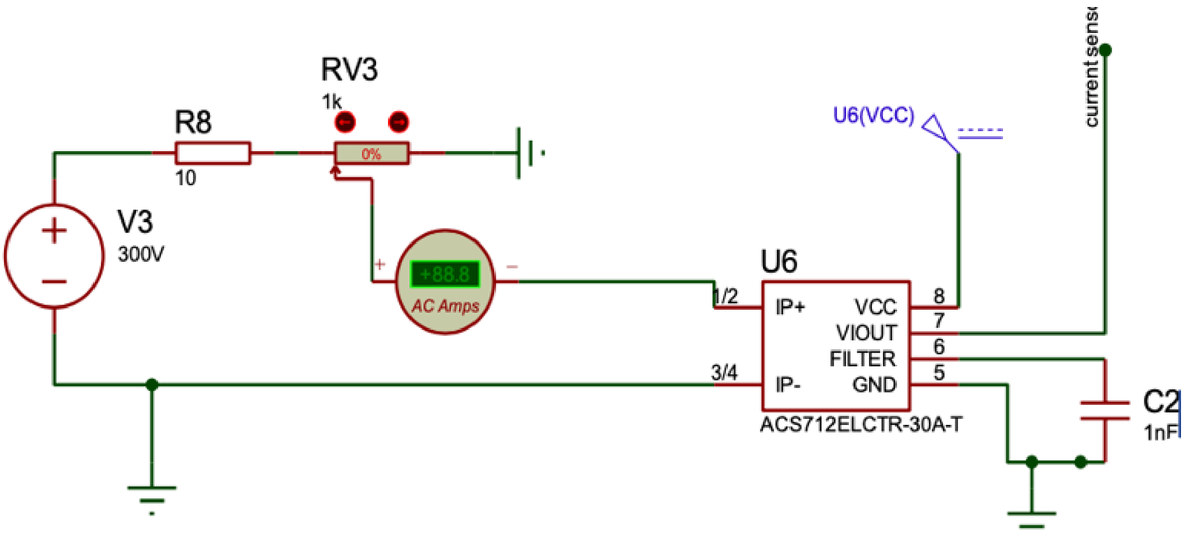

Figure 4.3: Current sensor circuit interfaces.

The consumed current can be simulated as three gates circuit as shown in figure 4.4, this circuit is made to increase the current withdrawn from the transformer secondary windings. A three resistors were used and reach resistor is cur by remote controlled switch as in Figure 4.5. The switches are controlled from the remote terminal unit by software defined switches. Current sensor is connected at the beginning of the circuit to detect any changes in the current.

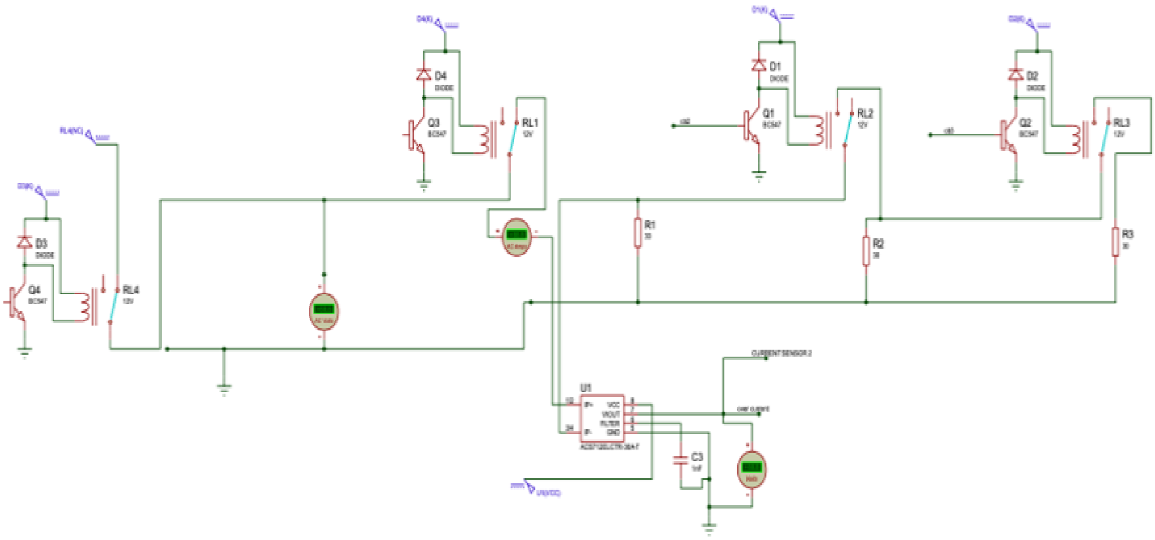

Figure 4.4: Secondary windings current circuit.

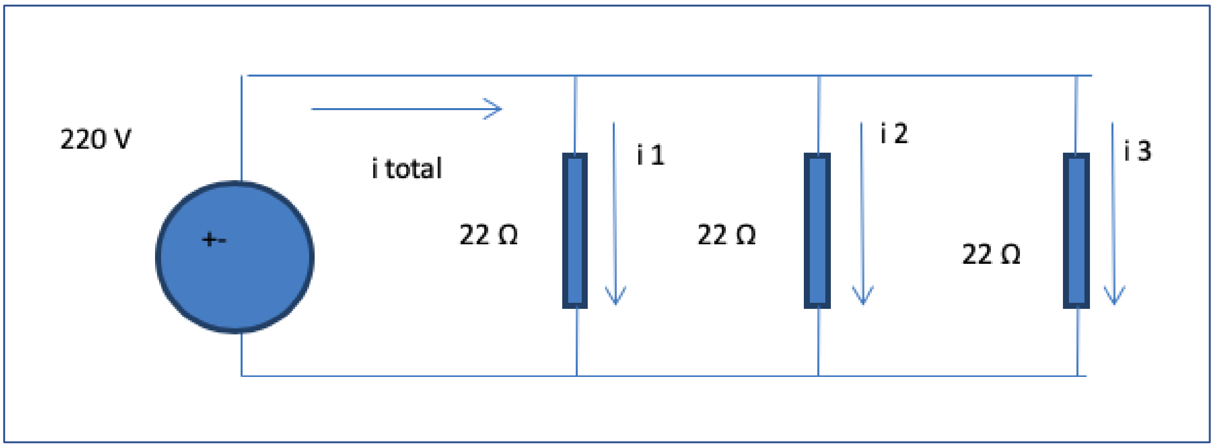

Figure 4.5: Circuit analysis of current branches.

Figure shows three branches as three resistors of twenty-two Ohms are connected in parallel with source so that each branch will consume ten amperes only. The total current consumption is made equal to thirty amperes because of the current sensor available on Proteus library can sense only 30 amperes.

$$I_i = \frac{V}{R} \tag{4.9}$$

$$I_1 = \frac{220\,Volt}{22\,Ohm}$$

$$I_1 = 10\,Ampere$$

Since same value of resistors are connected in parallel, current in second and third branches are same as current in the first branch.

$$I_1 = I_2 = I_3 \tag{4.10}$$

Applying of Kirchhoff's current law on the three branches of above circuit will yield the total current may be consumed if three branches are connected.

$$I_{sum} = I_1 + I_2 + I_3 \tag{4.11}$$

$$I_{sum} = 10 + 10 + 10$$

$$I_{sum} = 30 \text{ Ampere}$$

4.6 TEMPERATURE AND GAS SENSORS

LM 35 is temperature sensor provided in Proteus library as Figure 4.6 depicts. This sensor is used to monitor windings temperature. Practically, it is a surface mounted device and can be placed near the windings on the transformer corpus. This device is empowered by five volts single DC power supply. In virtual model (Proteus version), temperature can set manually using (+ and -) buttons on the device block. Totally, three ports can be seen in Proteus version of LM 35 corresponded to input power supply, ground (earthing connection) and output port. Device can produce a range of five volts corresponding to the detected temperature.

From the other hand, since Proteus library is not involving any gas sensor, and the concept of sensors by whole is known to us more likely production of DC voltage ranging from zero to five volts with accordance to the indicated signal, gas sensor is simulated using a DC supply and resistor. Resistor can be manually adjusted (rheostat). The output (terminal voltage across the resistor) is fed into microcontroller and stands for gas sensor equivalent circuit as depicted in Figure 4.7.

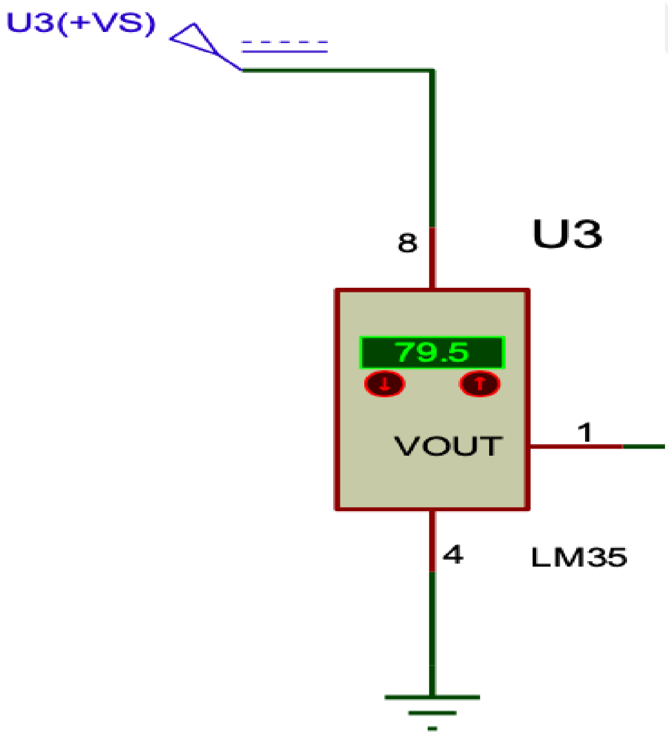

Figure 4.6: LM 35 Virtual temperature sensor.

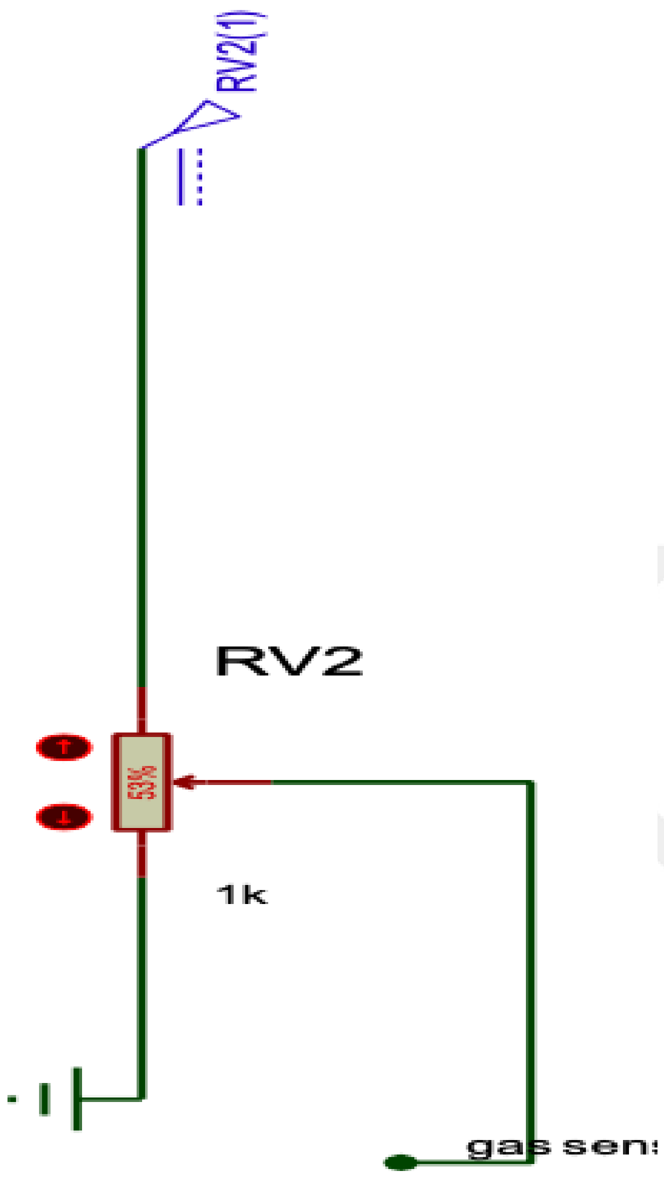

Figure 4.7: Gas sensor equivalent circuit.

4.7 REMOTE TERMINAL UNIT

Basically, monitoring system demands sending information about the objects it is been monitored into the observer. Observer can either access the sensing information locally by checking the on-site meters or screens or otherwise, information can be sent to him. Remote monitoring system is served in power system monitoring and other industrial applications by providing the infrastructure to view the sensing information at remote terminal units such as computers or tablets.

That ensures efficiency of monitoring and flexibility of work. In this project, microcontroller is designed to work as miniature webserver to provide web service such as sending information through a computer network. A remote terminal unit is connected with this network and observer can access the information at any time by using web browser.

HTML web page is designed to view all the sensors information and alert messages to the observer. Figure 4.8 demonstrates the web page at remote terminal unit. The remote monitoring a controlling is featured as follow:

1. Prevention of risks might be happened to the observers due to unexpected event such as fire.

2. Flexibility in monitoring which means that observed can use any tablet or even mobile phone to access the network where sensors information is available.

3. Permittivity of instant actions implementations using remote control facility.

Remote terminal unit is made to have several functions to be done remotely whenever it deems required. These functions are integrated with fore software embedded buttons as described hereinafter, all the functions are made to control the terminal current consumption and one function is made to shut down the power feeder if the emergency raised for that.

Those functions are integrated with switch transistors and used to toggle the switch at any time a button is pressed. Current related functions are used to integrate more loads to the circuits (insertion of new resistor to the circuit) and hence, since resistor cause current consumption, current sensor may detect any changes in current level and send the information to the microcontroller which is in turn sending it to the remote terminal webpage. The functions are further explained in Table 4.2.

Table 4.2: Software integrated control functions implemented in RTU.

Button label	Description
Fn 1	To shut down the main feeder in events alike uncontrolled fault or system upgrading.
Fn 2	To insert resistive load of 22 Ohm to the secondary windings of transformer which lead to draw of ten amperes from the transformer.
Fn 3	To insert one more resistive load of 22 Ohm in parallel fashion with the previous load which leads to draw twenty amperes from the transformer.
Fn 4	To insert one more resistive load of 22 Ohm in parallel fashion with the previous load which leads to draw thirty amperes from the transformer.

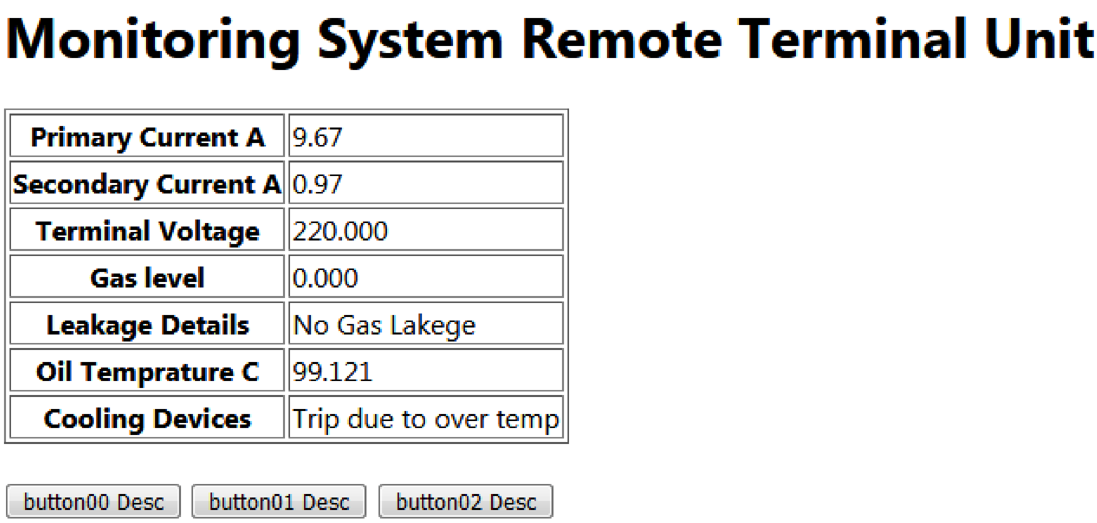

Figure 4.8: Remote terminal unit web page.

4.8 COOLING SUPPLEMENTARY SYSTEM

As was prescribed in previous sections upon temperature hike, a cooling system may work side by side with cooling oil (which is part of most of transformers) to suppress temperature. Temperature treatment is automated in the microcontroller so that any detection of abnormal temperature will lead to start the fans. Two tans are to be started sequentially to reduce the temperature. Otherwise, more likely if temperature insisted to be on higher side, alarm is starting automatically to alert the people in the vicinity to vacant the place. This supplementary system is said to be functional at the time of temperature hike and work to support transformer in build cooling system.

In this project fans are made working if temperature crossed certain level as the following:

1. To begin fan (1) if temperature reaches to fifty-five centigrade.

2. To begin fan (2) along with fan (1) if temperature reaches to sixty-six centigrade.

3. To continue working with both fans 1 and 2 and watch the temperature for some time.

4. For certain time and if the temperature reached to one-hundred centigrade, both fans to be shut down and alarm to be begin. Figure 4.8 demonstrates the supplementary cooling units (subsystem).

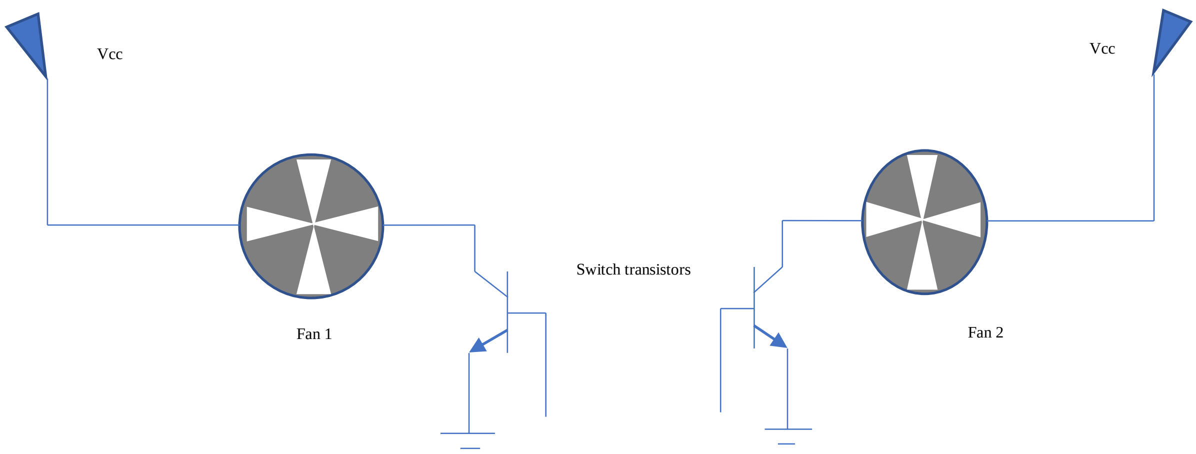

Figure 4.9: Supplementary cooling subsystem.

4.9 NETWORK INITIATION

Microcontroller in programmed in such way to provide web services and allotted an IP address similar to (192.168.100.200). Ethernet board is deployed and interfaced with the micro controller using the SPI ports. The virtual Ethernet controller is allotted an IP address similar to the IP address of virtual computer.

Two virtual computers are created using VMware and hence, those virtual computers are received data from microcontroller unit with help of Winpcap software. ENC 24J60 is sourced out from Proteus library and connected as in Figure 4.9 with two indicators light emitting diodes to track the speed of data exchange. The noteworthy is that ENC24J60 chip is not required any power source (virtual device not needs to be empowered).

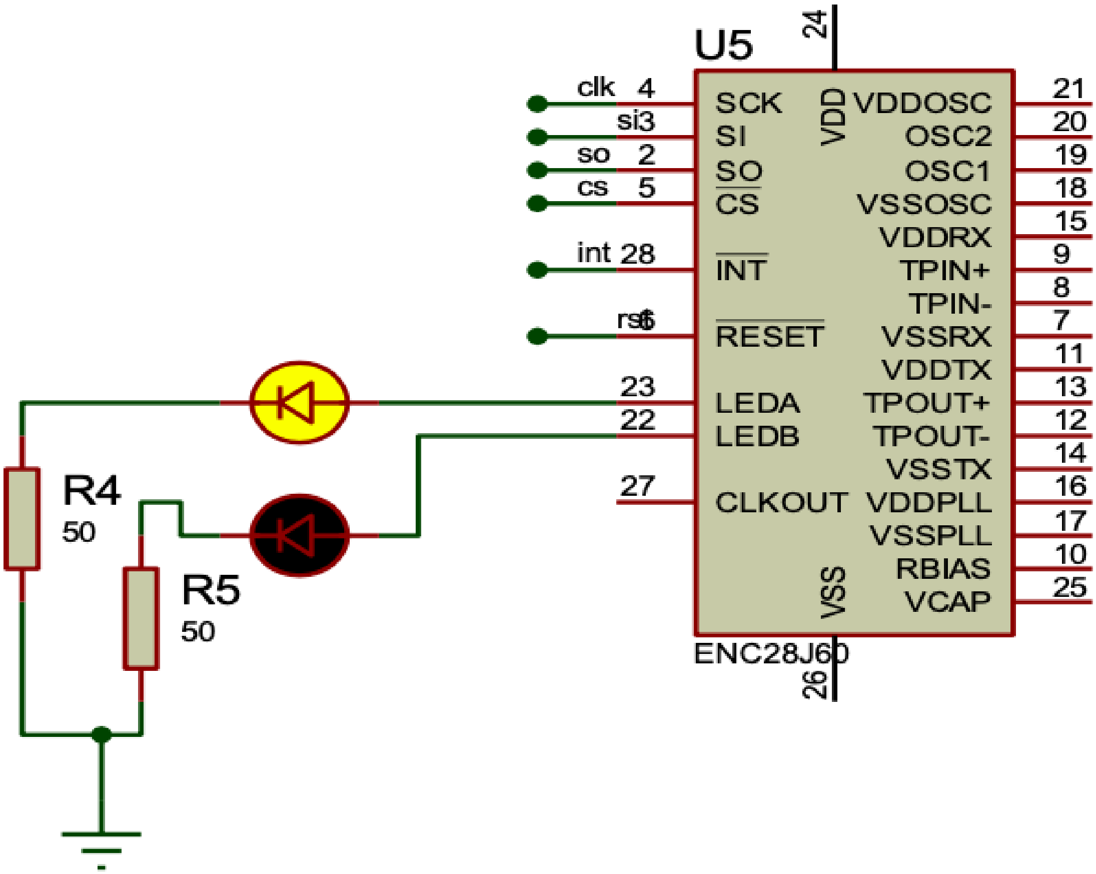

Figure 4.10: Ethernet board circuit interfacing.

IP address settings is critical to success of this project, so IP addressed should be allotted with care. Figure 4.10 is demonstrating the best way to allot IP address to different network sections such as microcontroller, virtual machine, ENC board, and remote terminal unit.

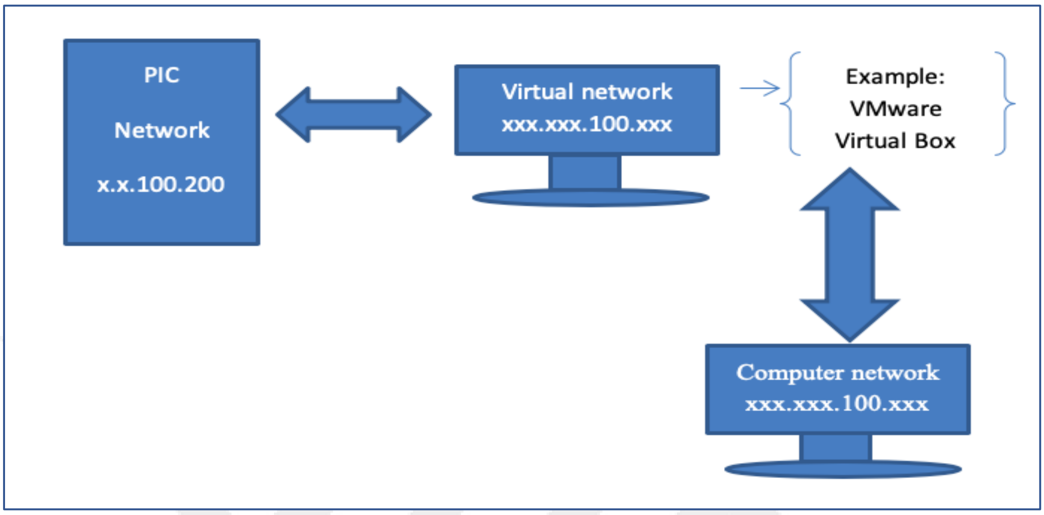

Figure 4.11: Network interfacing method.

After fabricating all the equipment's in the simulator, the output circuit will be taking the shape as in Figure 4.12.

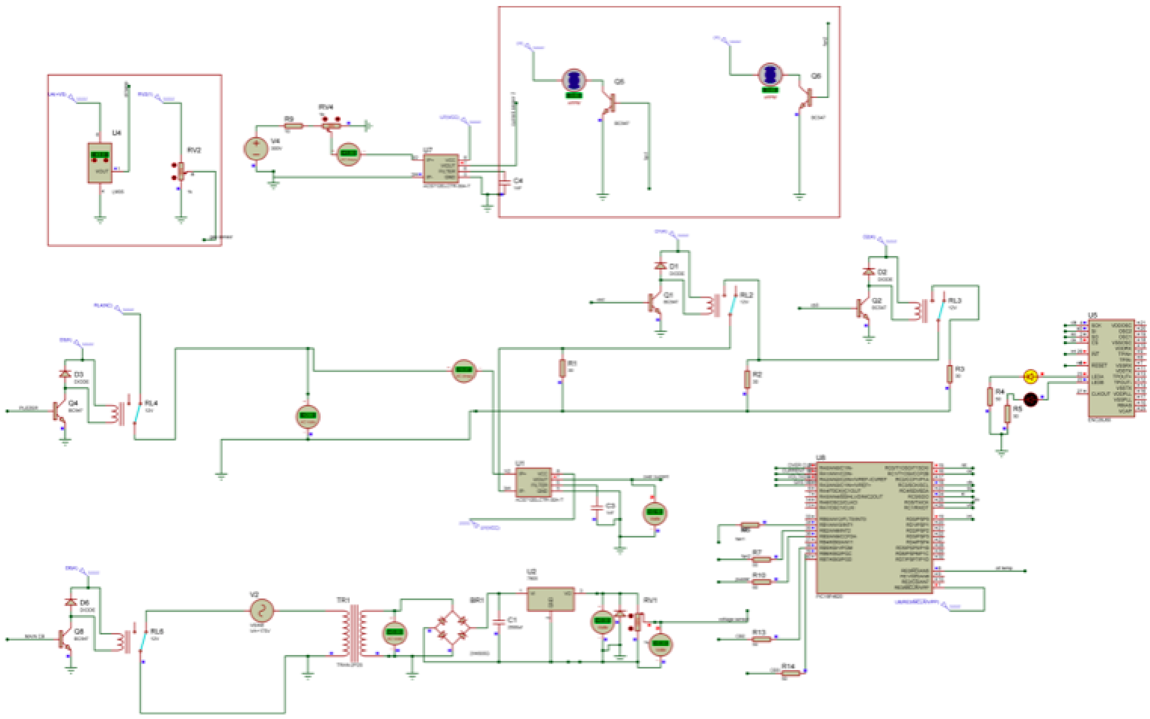

Figure 4.12: Model fabrication, figure demonstrates entire model's components.

4.10 PERFORMANCE

Electrical motors are vital equipment in each machinery and factory setup, this device is working to convert the electrical energy into mechanical energy that used to transfer the movement from one place to another inside the factory. Electrical motors can be used as well for small applications inside the residential buildings for example using the motor in the elevators. Due to the important role of electrical motor, motors are subjectable to fault due to overload. Motors are constructing of coils connected around the rotor part of the motor. Those coils (windings) can goes into fault condition if the any of the windings goes faulty. In this project, the fault possibility in the motor system was prevented by implementing a robust monitoring system based on microcontroller. Motor circuit is represented in the Proteus software and the other protection and monitoring devices are also implemented. The sensing signals from the motor are sent into the microcontroller as the sensors are detecting it from the motor's body. Several sensors are used such as temperature sensor, gas sensor, current sensor and voltage sensor to indicate any error in those parameters for functioning motor. As current withdrawn by motor is increased (due to overload on the motor shift) temperature of the windings is also increasing causing the windings to warm the insulations and then to ignite themselves. Due to ignition inside the motor, gases such as CO_2 may start to propagate hence, the following sensors are important to avoid this episode: current sensor, thermal (temperature) sensor and gas sensor. Voltage is also being monitored through the motor terminals so that the losses of the motors will remain at the controllable limit. The use of web-based microcontroller to protect this device is facilitate the process of monitoring and controlling as the remote surveillance and control can be ensured.

5 CONCLUSION

This project involves designing of smart monitoring and control system governing of DC motor. However, a PIC microcontroller was used for underlying the proposed system and hence, the following contributions were made.

System used in [3] was proposed to control the temperature and current of small power substation station using a thermal and current sensor. The microcontroller used in this study was generating a control signals that directly (automatically) control the temperature and current without existence of any monitoring technique. System proposed in this project has a dynamic web based monitoring facility that displays all the sensing information obtained from the remote sensors.

Study of [5] proposed using GSM to transfer the control and monitoring signals, this technique is susceptible of coverage issues as well as the charges applied on using the GSM service y the network service provider. In the proposed project, a local network is used which works continuously without any charges and not coverage problem.

The current trend of electrical system control including machine monitoring systems that designed in the project involved adopting a PIC microcontroller to control and monitor a motor. The data was exchanged from the remote terminal system to the microcontroller unit and vice versa through the web network. However, the system involved several sensors for tracking the temperature, current, voltage and gas level, there were a limited number of input/output ports in the current microcontroller unit and so it is with most of the existed microcontroller units. The proposed future development is interconnecting several of microcontroller units in such way data transferring from one unit to another unit which is more useful in complex systems such as power substation. The use of network of microcontrollers may provide larger number of input/output ports which enhance the monitoring and control capability.

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7 APPENDIX

c micro main program ➔

```
<include <test002.h#

<include <assert.h#
<include <ctype.h#
<include <errno.h#
<include <float.h#
<include <limits.h#
<include <locale.h#
<include <math.h#
<include <setjmp.h#
<include <stddef.h#
<include <stdlib.h#
<include <stdlibm.h#
<include <string.h#
<include <stdio.h#
<include <stdint.h#

INT_PSP#
(void  PSP_isr(void
}

{


(unsigned int8 http_format_char(char* file, char id, char *str, unsigned int8 max_ret
}
؛(setup_adc(ADC_CLOCK_INTERNAL
؛(setup_adc_ports(ALL_ANALOG

؛(set_adc_channel(0
؛(delay_us(10
؛unsigned int cur1=0
؛()cur1=read_adc

؛(set_adc_channel(1
؛(delay_us(10
؛unsigned int cur2=0
؛()cur2=read_adc

؛(set_adc_channel(2
؛(delay_us(10
؛unsigned int volt=0
؛()volt=read_adc

؛(set_adc_channel(3
```

```
؛(delay_us(10
؛float gas=0
؛()gas=read_adc

؛(set_adc_channel(5
؛(delay_us(10
؛unsigned int temp=0
؛()temp=read_adc

**************************************************//


current sensor1 //

؛[char strcur1[25

؛float u
؛float h=0
؛(u=cur1*(5.0/1023.0
}(if(u==2.50
؛h=0
؛( sprintf(strcur1,"%g",h
{
} else
؛h=u-2.50
؛(h=(h/0.068
؛( sprintf(strcur1,"%g",h
{

current sensor2 //

؛[char strcur2[25

؛float x
؛float i=0
؛(x=cur2*(5.0/1023.0
}(if(x==2.50
؛i=0
؛( sprintf(strcur2,"%g",i
{
} else
؛i=x-2.50
؛(i=(i/0.068
؛( sprintf(strcur2,"%g",i
{

voltage sensor//


؛[char strvolt[25
```

```
؛float m
؛float v

؛(v =volt*(5.0/1023.0
؛m=v*44
}(if ( v>2.6
{؛( sprintf(strvolt,"%.3g",m
}(if( v<=2.5
؛float m=0
{؛( sprintf(strvolt,"%.3g",m

gas sensor//


؛[char strgas[25
؛[char strgs [25
؛float ga=0

؛(ga =gas*(5.0/1023.0

؛( sprintf(strgas,"%.3g",ga

؛int gaa=0
؛(gaa= ceil (ga
}(if (ga>0
؛( "sprintf(strgs,"%s","Caution Gas Lakege
{
} else
؛( "sprintf(strgs,"%s","No Gas Lakege
{



temprature sensor for oil//


؛[char stroil[25
؛[char stroilo[25
؛float tempo=0


؛tempo=(temp*5.0)/10.24
؛( sprintf(stroil,"%.3g", tempo


in case of higher temp//
؛int rou=0
؛(rou= ceil (tempo

} (switch (rou
```

```
:case 55
؛(output_high(PIN_B1
؛(output_low(PIN_B2
؛(output_low(PIN_B3

؛( "sprintf(stroilo,"%s","First Fan is ON
؛break
: case 65
؛(output_low(PIN_B1

؛(output_high(PIN_B2
؛(output_high(PIN_B1
؛( "sprintf(stroilo,"%s","TWO Fans are ON
؛break
:case 100
؛(output_low(PIN_B1
؛( "sprintf(stroilo,"%s","Trip due to over temp
؛(output_low(PIN_B2

؛(output_high(PIN_B3
؛break
:default

؛(output_low(PIN_B1
؛(output_low(PIN_B2
؛(output_low(PIN_B3
؛( "/sprintf(stroilo,"%s","Temp is being observed
{ ؛break



؛str = 0*

(if (id == 0
}
؛(strncpy(str,strcur1, max_ret
{
(if (id == 1
}
؛(strncpy(str,strcur2, max_ret
{
(if (id == 2
}
؛(strncpy(str,strvolt, max_ret
{
(if (id == 3
}
؛(strncpy(str,strgas, max_ret
{
(if (id == 4
```

```
}
؛(strncpy(str,strgs, max_ret
{
(if (id == 5
}
؛(strncpy(str,stroil, max_ret
{
(if (id == 6
}
؛(strncpy(str,stroilo, max_ret
{

؛((return(strlen(str
{

(void http_exec_cgi(char* file, char *key, char *val
}
.TODO: This is a callback function to the HTTP stack */
This function is called with each key/value pair read in
the GET/POST request before any web data is sent to the
web browser. 'key' matches the name of the field and
.val' is the value it was changed to'
:Example
؛(int8 v = atoi(val
(if (stricmp(key,led1_key)==0
؛(LedSet(0, v
/*
(if (strcmp(key, "button00") == 0
}
؛(output_high(PIN_B4
{
(if (strcmp(key, "button01") == 0
}
؛(output_high(PIN_B5
{
(if (strcmp(key, "button02") == 0
}
؛(output_high(PIN_B6
{

{


(void IPAddressInit(void
}
MAC address of this unit//
؛MY_MAC_BYTE1=MY_DEFAULT_MAC_BYTE1

؛MY_MAC_BYTE2=MY_DEFAULT_MAC_BYTE2

؛MY_MAC_BYTE3=MY_DEFAULT_MAC_BYTE3
```

؛MY_MAC_BYTE4=MY_DEFAULT_MAC_BYTE4

؛MY_MAC_BYTE5=MY_DEFAULT_MAC_BYTE5

؛MY_MAC_BYTE6=MY_DEFAULT_MAC_BYTE6

IP address of this unit//

؛MY_IP_BYTE1=MY_DEFAULT_IP_ADDR_BYTE1

؛MY_IP_BYTE2=MY_DEFAULT_IP_ADDR_BYTE2

؛MY_IP_BYTE3=MY_DEFAULT_IP_ADDR_BYTE3

؛MY_IP_BYTE4=MY_DEFAULT_IP_ADDR_BYTE4

network gateway//

؛MY_GATE_BYTE1=MY_DEFAULT_GATE_BYTE1

؛MY_GATE_BYTE2=MY_DEFAULT_GATE_BYTE2

؛MY_GATE_BYTE3=MY_DEFAULT_GATE_BYTE3

؛MY_GATE_BYTE4=MY_DEFAULT_GATE_BYTE4

subnet mask//

؛MY_MASK_BYTE1=MY_DEFAULT_MASK_BYTE1

؛MY_MASK_BYTE2=MY_DEFAULT_MASK_BYTE2

؛MY_MASK_BYTE3=MY_DEFAULT_MASK_BYTE3

؛MY_MASK_BYTE4=MY_DEFAULT_MASK_BYTE4

{

()void main

}

؛(setup_adc_ports(AN0_TO_AN6

؛(setup_adc(ADC_CLOCK_INTERNAL|ADC_TAD_MUL_0

؛(enable_interrupts(INT_PSP

```
؛(enable_interrupts(GLOBAL

؛()IPAddressInit
؛()TickInit
؛(enable_interrupts(GLOBAL
؛()StackInit
(while(TRUE
}

TCP/IP code //
؛()StackTask

؛()StackApplications

TODO: User Code//
{

{
```

```
<html>

<head>

<"script type="text/javascript>

/////////////////////////////////////////////////////////////////////////

////                                                      ////

//// .AJAX routines for rx/tx of data without having to reload page  ////

////                                                      ////

//// Written by CCS, Inc.                 http://www.ccsinfo.com  ////

////                                                      ////

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////            ،licensed users of the CCS C compiler.  No other use ////

////       reproduction or distribution is permitted without written ////

////                                          .permission ////

/////////////////////////////////////////////////////////////////////////

؛var ajaxGet

؛var t

؛var waiting = 0

؛var tValid = 0

؛"" = var nextCgi
```

```
؛"" = var lastCgi

؛var ios6workaround = 0


()function setStartTime

}

؛tValid = 1

؛(t = setTimeout('ajax()', 500

{


()function ajax

}

(if (waiting

}

؛--waiting

(if (waiting == 0

}

("" =! if (lastCgi

}

("" == if (nextCgi

؛nextCgi = lastCgi

else

؛nextCgi = lastCgi + "&" + nextCgi

{
```

```
{
{

(if (!waiting
}
؛()ajaxGet=GetXmlHttpObject

(if (ajaxGet==null
}
؛("!alert ("Your browser does not support AJAX
؛return
{

waiting = 5;  //wait 2.5 seconds for a response

؛(ajaxGet.open("POST", "index.xml", true

؛ajaxGet.onreadystatechange = stateChanged

("" =! if (nextCgi
}
؛(ajaxGet.send(nextCgi
؛lastCgi = nextCgi
```

```
؛"" = nextCgi

{

else

}

؛(ajaxGet.send("IGNOREDTAG="+ios6workaround


(if (++ios6workaround > 255

؛ios6workaround = 0

{

{


؛()setStartTime

{


(function sendCgi(cmd, value

}

("" =! if (nextCgi

؛"&" =+ nextCgi


؛nextCgi += cmd + "=" + value

{


(function GetElementNodeValue(xmlDoc, id
```

```
}

؛return xmlDoc.getElementsByTagName(id)[0].childNodes[0].nodeValue

{


(function GetElementAttributeValue(xmlDoc, element, attribute

}

؛var n

؛var i


؛n = xmlDoc.getElementsByTagName(element)[0].attributes.length


(++for (i=0; i<n; i

}

(if (xmlDoc.getElementsByTagName(element)[0].attributes[i].name == attribute

}

؛return xmlDoc.getElementsByTagName(element)[0].attributes[i].value

{

{


؛"" return

{


(function UpdateExistingTable(xmlDoc
```

```
}
؛var i = 0


(؛؛)for
}
؛var id = "dyn"+i
؛++i
((if (document.getElementById(id
}
؛(document.getElementById(id).innerHTML = GetElementNodeValue(xmlDoc, id
{
else
؛break
{
{


()function stateChanged
}
(if (ajaxGet.readyState==4
}
؛(UpdateExistingTable(ajaxGet.responseXML.documentElement


؛waiting = 0
```

```
{
{

()function GetXmlHttpObject
}
(if (window.XMLHttpRequest
}
code for IE7+, Firefox, Chrome, Opera, Safari //
؛()return new XMLHttpRequest
{
(if (window.ActiveXObject
}
code for IE6, IE5 //
؛("return new ActiveXObject("Microsoft.XMLHTTP
{
؛return null
{
<script/>


<title>Monitoring System Remote Terminal Unit </title>
<head/>
```

```
<"؛(")body onload="setStartTime>

<H1>Monitoring System Remote Terminal Unit </H1>

<TABLE BORDER=1>
<TR>
<TH>Primary Current A</TH>
<TD id="dyn0"></TD>
<TR/>
<TR>
<TH>Secondary Current A</TH>
<TD id="dyn1"></TD>
<TR/>
<TR>
<TH>Terminal Voltage</TH>
<TD id="dyn2"></TD>
<TR/>
<TR>
<TH>Gas level</TH>
<TD id="dyn3"></TD>
<TR/>
<TR>
<TH>Leakage Details</TH>
```

```
<TD id="dyn4"></TD>

<TR/>

<TR>

<TH>Oil Temprature C</TH>

<TD id="dyn5"></TD>

<TR/>

<TR>

<TH>Cooling Devices</TH>

<TD id="dyn6"></TD>

<TR/>

<TABLE/>


</BR>


<FORM>

INPUT TYPE="button" NAME="button00" ONCLICK="sendCgi('button00','1')" >
<"VALUE="button00 Desc

INPUT TYPE="button" NAME="button01" ONCLICK="sendCgi('button01','1')" >
<"VALUE="button01 Desc

INPUT TYPE="button" NAME="button02" ONCLICK="sendCgi('button02','1')" >
<"VALUE="button02 Desc

<FORM/>
```

<body/>

<html/>