



بسم الله الرحمن الرحيم



Sudan University of Science and Technology

Collage of Graduate studies

Design of a Distribution Transformer Monitoring System using Global System Mobile Technology

تصميم نظام مراقبة محول التوزيع باستخدام تقنية النظام
العالمي للهاتف السيار

A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree
of M.Sc. in Mechatronics Engineering

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2017

الآية

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

إِنَّ الَّذِينَ آمَنُوا وَعَمِلُوا الصَّالِحَاتِ يَهْدِيهِمْ رَبُّهُمْ
بِإِيمَانِهِمْ تَجْرِي مِنْ تَحْتِهِمُ الْأَنْهَارُ فِي جَنَّاتِ النَّعِيمِ
﴿٩﴾ دَعَوَاهُمْ فِيهَا سُبْحَانَكَ اللَّهُمَّ وَتَحِيَّتُهُمْ فِيهَا
سَلَامٌ وَآخِرُ دَعَوَاهُمْ أَنْ الْحَمْدُ لِلَّهِ رَبِّ الْعَالَمِينَ
﴿١٠﴾

صدق الله العظيم

سورة يونس

Dedication

To the man who worked hard to push me forward, who taught me the meaning of determination and Patience.

My Father

To the woman whose continuous support and encouragement was the motive during the challenges, who gave me the opportunity to touch each success.

My Mother

To the kind heart whose sacrificial care of me and our children made it possible to complete this work, from her I learned; where there's a will, there's a way.

My Wife

To all those whose incessant support made me achieve new heights in my life.

Family and Friends

For all those and more, I present my humble thesis.

Acknowledgment

First of all, I want to thank Allah, who give me everything and without him nothing can be done.

*I would like to express my deep appreciation and sincere gratitude to my supervisor **Dr. Abdelfatah Bilal** for his assistance, guidance and endless help throughout the steps of this thesis.*

My great thanks extend to my colleagues in The National Electricity Corporation for their valuable suggestions and information during this research.

Last but not least, a lot of thanks are due to my family for their motivation and contribution.

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Abstract

Distribution transformer is considered one the most important element in the power distribution system as it works to reduce the high voltage to the consumption voltage. To achieve maximum efficiency of these transformers and to ensure stability of the power distribution system, their operational conditions must be quite appropriate which led to perform their task efficiently throughout their life time.

This research aims to design a monitoring system for the distribution transformer by installing different sensors on it. These sensors monitor the level of transformer oil, temperature, voltage range and a magnetic sensor that monitors the transformer when it trips and gets out of service.

This monitoring system works by observing these sensors and send its readings in case of exceeding the allowable limits by using SMS to a mobile phone via GSM technology.

This system is designed in Proteus program using Atmega32 microcontroller and programmed by Bascom language.

المستخلص

يعتبر محول التوزيع من اهم عناصر منظومة توزيع القدرة الكهربائية حيث يعمل على خفض الجهد العالي الى قيمة جهد الاستهلاك. ولتحقيق الحد الاقصى من كفاءة هذه المحولات ولضمان استقرارية منظومة التوزيع لابد ان تكون الظروف التشغيلية لتلك المحولات ملائمة بحيث تؤدي مهمتها بكفاءة عالية طيلة فترة العمر الافتراضي المحدد لها.

يهدف هذا البحث الى تصميم نظام مراقبة لمحول التوزيع عن طريق وضع محساسات مختلفة. تراقب هذه المحساسات مستوى زيت المحول ودرجة حرارته وحدود جهد الاستهلاك بالاضافة الى جهاز استشعار مغناطيسي يراقب توقف المحول وخروجه خارج الخدمة.

يعمل نظام المراقبة على ارسال قراءة هذه المحساسات في حال تجاوزها الحدود المسموح بها بواسطة رسالة نصية الى هاتف نقال عبر شبكة النظام العالمي للهاتف السيار.

تم تصميم هذا النظام في برنامج بروتس باستخدام متحكم اتميجا32 وبرمجتها بلغة باسكوم.

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List of Abbreviations

ADC	Analog-to-Digital Converter
AT commands	Attention commands
ATmega	Atmel's Mega
AVR	Advanced Virtual RISC
Bascom	Basic Compiler
DC	Direct Current
DTRMS	Distributed Transformer networks Remote Monitoring System
EEPROM	Electrically Erasable Programmable Read-Only Memory
GND	Ground
GSM	Global System for Mobile Communications
HMI	Human Machine Interface
IDE	Integrated Development Environment
JTAG	Joint Test Action Group
KVA	Kilo-volt amperes
LCD	Liquid Crystal Display
LED	Light-Emitting Diode
MIPS	Million Instructions Per Second
MVA	Mega-volt amperes
NEC	National Electricity Corporation
PIC	Programmable Interface Controllers
PLC	Programmable Logic Controller
PWM	Pulse Width Modulation
RISC	Reduced Instruction Set Computing
SCADA	Supervisory Control And Data Acquisition
SMS	Short Message Service
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
USART	Universal Synchronous/Asynchronous Receiver/Transmitter
WTI	Two Wire Interface

Chapter One

Introduction

1.1 General Review:

Distribution transformers have a long service life if they are operated under good and rated conditions. However, their life is significantly reduced if they are overloaded, resulting in unexpected failures and loss of supply to a large number of customers thus effecting system reliability. Overloading and ineffective cooling of transformers are the major causes of failure in distribution transformers.

Distribution transformers are currently monitored manually where a person periodically visits a transformer site for maintenance and recording the parameters. This type of monitoring cannot provide information about occasional overloads and overheating of transformer oil and windings. All these factors can significantly reduce transformer life. This thesis aims to design a system based upon online monitoring of different operational parameters of distribution transformers which can provide useful information about the health of transformers and to assess their operation for a longer period.

Many operational problems will be identified before any catastrophic failure, thus resulting in a long life service for transformers. It is also has the advantages of significant cost savings and greater reliability.

The proposed monitoring system integrates Global System for Mobile Communications (GSM), with ATmega32 microcontroller and sensor packages. Data of operation condition of transformer receives in form of Short Message Service (SMS) using the suggested online monitoring system will help engineers to keep transformers in service for longer of time [1].

1.2 Problem statement:

Currently, a distribution transformer can be monitored manually where a person periodically visits the transformer site to do his routine check, perform maintenance tasks or even to check whether the transformer is online or tripped out. This type of monitoring cannot provide information about different types of the transformer parameters.

1.3 Objectives:

The purpose of this thesis is to design an online monitoring that monitor distribution transformers parameters and send SMS to specified mobile and activated LED in the following cases:

- When the oil temperature reaches the high degrees.
- When the oil temperature reaches high high degrees.
- When the oil level reaches the high level.
- When the oil level reaches the low level.
- When the transformer voltage is out of specified range.
- When the transformer trips.

This design will be simulated by Proteus software.

1.4 Methodology:

Monitoring system will be designed by using Atmega32 microcontroller, level and temperature sensors, GSM modem for sending SMS, Voltage sensor and LCD for local display.

Bascom – AVR will be used to program the microcontroller.

The SMS will be programmed to define the transformer by its name code and location.

1.5 Thesis Outline:

- Thesis title: Design of Distribution Transformer Monitoring System through GSM Technology
- Chapter one: contains an introduction to the importance of distribution transformers protection and how variation of their operational conditions could affect their service life time. Also this chapter contains the problem statement of the thesis and main purposes and objectives that should be achieved, in addition to the used methodology that will led to the desired objectives.
- Chapter two: gives theoretical background on the following topics:
 - General literature review on distribution transformer monitoring through GSM technology.
 - Quick preview on transformers basics which include their types, principle of operation, main parts and their power ratings.

- Description of temperature sensor LM35, its operating range, pins description, electrical connections and features.
 - Introduction to ATmega32 microcontroller which includes its pins description, configuration summary and features.
 - Brief description to the programming language – Bascom AVR – which is used to program the ATmega32 microcontroller.
 - Work principle and pins description of the Liquid Crystal Display (LCD) which is interfaced with a microcontroller to display a message or status of input/output device.
 - Introduction to GSM technology, GSM modem and AT commands which is used for sending and receiving SMS.
- Chapter three: focuses on optimum operating values that needed to accomplish the circuit design. This is done through full technical analysis to all parameters of circuit sensors.
- Chapter four: discusses and illustrates the following points:
- Proposed work accomplished with proposed block diagram.
 - Proteus software that used for circuit simulation.
 - General design procedures to design this system circuit.
 - Circuit parameters and description with detailed explanation.
 - Discuss program execution and testing of the circuit.
 - Draw a flow chart for the system.
 - Make analysis and results.
- Chapter five: present the conclusion and recommendations.

Theoretical background

2.1 Literature review:

A number of designs have been made in order to create a monitoring system for transformers: *Kumar, A., Raj, A., Kumar, A., Prasad, S. and Kumar, B.* – (2012) have presented a design and implementation of a mobile embedded system to monitor and diagnose condition of transformers, by record key operation indicators of a distribution transformer like load currents, transformer oil, ambient temperatures and voltages. The on-line monitoring system integrates a GSM Modem, with PLC (programmable logic controllers) and sensor packages. Data of operation condition of transformer receives in form of SMS (Short Message Service). *Sachan, A.* – (2012) has acquired the remote electrical parameters like Voltage, Current and Frequency and send these real time values over GSM network using GSM Modem/phone along with temperature at power station. Also his design aimed to protect the electrical circuitry by operating an Electromagnetic Relay. This Relay gets activated whenever the electrical parameters exceed the predefined values. His system also can automatically send the real time electrical parameters periodically in the form of SMS. *Surekha, N., Kumar, A. and Figueiredo, D.* – (2012) have developed a monitoring system for distribution transformers by concentrating on temperature of transformer and viscosity of oil. This system is designed based on the AVR microcontroller. Here controller is continuously reading the temperature and viscosity, and display on the LCD along with the set point. If current value is crossing the set point then device will off and LED is ON along with the fan (DC motor), and one alert message is sent to the predefined number through GSM module. *Suresh, D., Prathibha, T. and Taj, K.* – (2014) have mainly focused on monitoring of transformer oil by using PLC, SCADA with suitable sensors for sensing parameters of oil like moisture content and temperature. In addition to this, their system incorporated with the GSM module to alert the maintenance authority when the transformer under goes faulty condition. *Nagaraju, N. and Kiruthika, M.* – (2013) have designed a monitoring system that observes frequent power

disconnections, power theft, power wastage. This system sends the status of the transformer through GSM. Also, their system has ability to automatic sense ON/OFF street lights. *Pandey, R. and Kumar, D.* – (2013) have developed and constructed monitoring system called distributed transformer networks remote monitoring system (DTRMS), for monitor and record the parameters like temperature, oil level status, of a distribution transformer. The system consists of a microcontroller based circuit, with solid-state components for handling sensors, power back-up, real time clock and data communication module which based on ZigBee protocol. *Agarwal, M. and pandya, A.* – (2014) have presented design and implementation of a mobile embedded system to monitor and record key operation of a distribution transformer like overvoltage, over current, temperatures, fall of oil level. This system is designed to send SMS alerts whenever related parameter value exceeds the predefined limits. They used a PIC microcontroller for continues reading sensors parameters. *Ranvir, K., Solanke, M., Ratnaparkhi, R. and Sable, A.* – (2015) have developed an on-line monitoring and control system. The main objective of this system is to monitor the electrical parameters of a distribution transformer in a substation, and hence to guard the burning of distribution transformer due to the constraints such as overload, over temperature and high input voltage. If any of these values increase beyond the limit then the entire unit is shut down by operating an Electromagnetic Relay. This relay is activated as soon as the parameters exceed the predefined threshold values. The GSM modem is used to send the real time electrical parameters in the form of SMS. The system is designed to send a SMS alerts to the authorized person whenever the parameters (Voltage, Current and Temperature) exceeds the predefined limits. *Kharche, A., Vadirajacharya, K., Kulakarni, H. and Landage, V.* – (2012) have developed a low cost solution for monitoring health condition of remotely located distribution transformers using GSM technology. An Embedded based hardware design is developed to acquire data from electrical sensing system. It consists of a sensing system, signal conditioning electronic circuits, advanced embedded hardware for middle level computing, a powerful computer network for further transmission of data to various places. *Sarsamba, M., Yanamshetty, R. and Sangulagi, P.* – (2013) have designed a system for monitoring

Load and Power lines using SMS based on GSM Technology. This system is designed and implemented using mobile embedded system to monitor and record load fluctuations with respect to current and voltage in electric power lines and it also controls the same when line breaks during high load. This on-line monitoring system integrates a Global Service Mobile (GSM) Modem; withstand along single chip microcontroller and sensor package.

2.2 Transformer definition and operation principle:

A transformer is a static (or stationary) piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. It can raise or lower the voltage in a circuit but with a corresponding decrease or increase in current. The physical basis of a transformer is mutual induction between two circuits linked by a common magnetic flux [12].

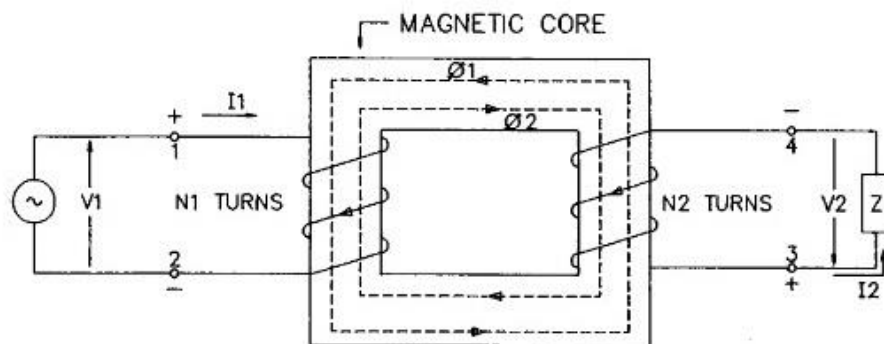


Figure 2.1: Electrical power transfer [13].

The actual process of transfer of electrical power from a voltage of V_1 to a voltage of V_2 is explained with the aid of the simplified transformer representation shown in Figure (2.1). Application of voltage across the primary winding of the transformer results in a magnetic field of ϕ_1 Wb in the magnetic core, which in turn induces a voltage of V_2 at the secondary terminals. V_1 and V_2 are related by the expression $V_1/V_2 = N_1/N_2$, where N_1 and N_2 are the number of turns in the primary and secondary windings, respectively. If a load current of I_2 A is drawn from the secondary terminals, the load current establishes a magnetic field of ϕ_2 Wb in the core and in the

direction shown. Since the effect of load current is to reduce the amount of primary magnetic field, the reduction in ϕ results in an increase in the primary current I_1 so that the net magnetic field is almost restored to the initial value and the slight reduction in the field is due to leakage magnetic flux.

The currents in the two windings are related by the expression $I_1/I_2 = N_2/N_1$. Since $V_1/V_2 = N_1/N_2 = I_2/I_1$, we have the expression $V_1 \cdot I_1 = V_2 \cdot I_2$. Therefore, the volt-amperes in the two windings are equal in theory. In reality, there is a slight loss of power during transformation that is due to the energy necessary to set up the magnetic field and to overcome the losses in the transformer core and windings. Transformers are static power conversion devices and are therefore highly efficient. Transformer efficiencies are about 95% for small units (15 kVA and less), and the efficiency can be higher than 99% for units rated above 5 MVA [13].

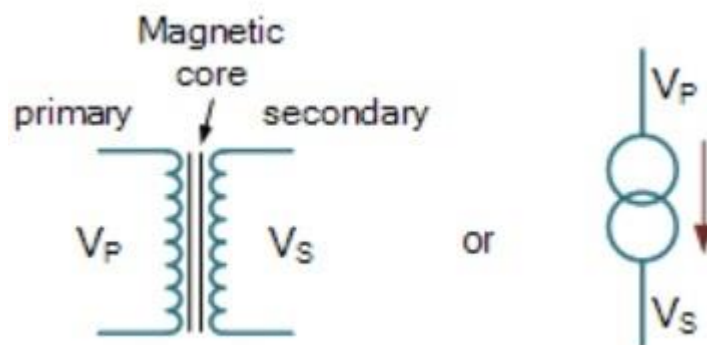


Figure 2.2: Transformer Symbols

2.2.1 Ideal transformer:

Ideal transformer model is devolved by a transformer which does not have any loss. That means the windings of the transformer are purely inductive and the core of transformer is loss free. There is zero leakage reactance of transformer. Whenever a low reluctance core is placed inside the windings, maximum amount of flux passes through this core, but still there is some flux which does not pass through the core but passes through the insulation used in the transformer. This flux does not take part in the transformation action of the transformer.

This flux is called leakage flux of transformer. In an ideal transformer, this leakage flux is also considered nil. That means, 100% flux passes through the core and links with both the primary and secondary windings of transformer. Although every winding is desired to be purely inductive but with some resistance on it which causes voltage drop and I^2R loss on it. In such ideal transformer model, the windings are also considered ideal, which means resistance of the winding is zero. Now if an alternating source voltage V_1 is applied in the primary winding of that ideal transformer, there will be a counter self emf E_1 induced in the primary winding which is purely 180° in phase opposition with supply voltage V_1 .

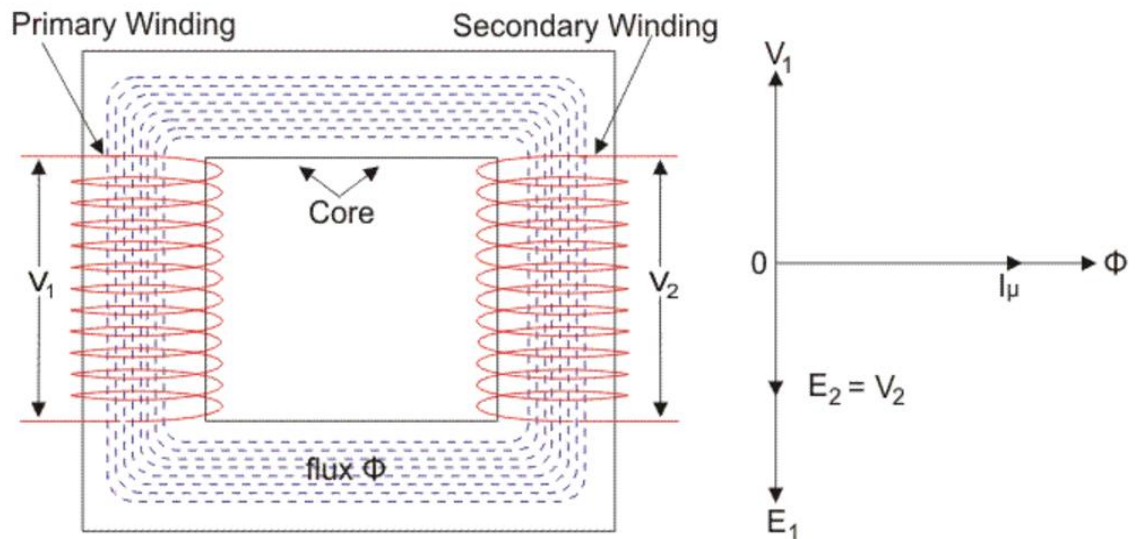


Figure 2.3: Secondary induced voltage in ideal transformer

This alternating current I_μ produces an alternating magnetizing flux Φ which is proportional to that current and hence in phase with it. As this flux is also linked with secondary winding through the core of transformer, there will be another emf E_2 induced in the secondary winding, this is mutually induced emf. As the secondary is placed on the same core where the primary winding is placed, the emf induced in the secondary winding of transformer, E_2 is in the phase with primary emf E_1 and in phase opposition with source voltage V_1 . The above chapter was about a brief discussion about ideal transformer, it has also explained the basic ideal transformer model.

The ideal transformer model neglects the following basic linear aspects in real transformers:

a) Core losses, collectively called magnetizing current losses, consisting of:

- Hysteresis losses due to nonlinear application of the voltage applied in the transformer core, and
- Eddy current losses due to joule heating in the core that are proportional to the square of the transformer's applied voltage.

b) Whereas windings in the ideal model have no resistances and infinite inductances, the windings in a real transformer have finite non-zero resistances and inductances associated with:

- Joule losses due to resistance in the primary and secondary windings
- Leakage flux that escapes from the core and passes through one winding only resulting in primary and secondary reactive impedance [13].

2.2.2 Types and applications of transformers:

Transformers are used in every power plant, all grid substations, buildings, in the industry, the underground installations, wind turbines, on platforms, marine vessels, under the sea, etc. Due to peculiarities of all these applications, many different types of transformers have been developed in the course of history.

Transformers can be classified according to different basis, like types of construction, types of cooling etc.

1. On the basis of construction:

i. Core type transformer.

Windings are cylindrical former wound, mounted on the core limbs.

ii. Shell type transformer.

The coils are former wound and mounted in layers stacked with insulation between them, as shown in Figure (2.4).

2. On the basis of number of phases:

i. Single phase transformer.

ii. Three phase transformer.

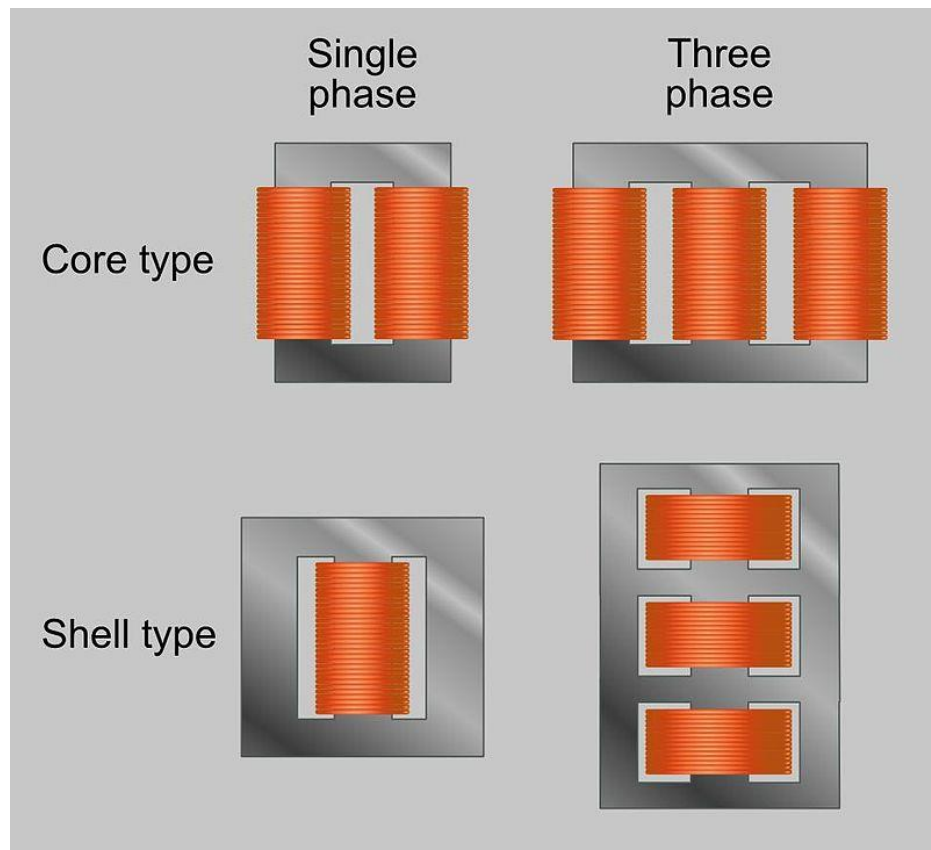


Figure 2.4: Transformer's types

3. On the basis of their purpose:

- i. Step up transformer: voltage increases (with subsequent decrease in current) at secondary.
- ii. Step down transformer: voltage decreases (with subsequent increase in current) at secondary.

4. On the basis of cooling employed:

- i. Oil-filled self-cooled type.
- ii. Oil-filled water cooled type.
- iii. Air blast type (air cooled).

5. On the basis of their use:

- i. Power transformer: used in transmission network, high rating.
- ii. Distribution transformer: used in distribution network, comparatively lower rating than that of power transformers.
- iii. Instrument transformer: used in relay and protection purpose in different instruments in industries.
 - Current transformer (CT).
 - Potential transformer (PT).

6. On the basis of their installation:

- i. Overhead type.
- ii. Pad-mounted type.

Transformers can be broadly classified, depending upon their application as given below.

1. Generator transformers:

Power generated at a generating station (usually at a voltage in the range of 11 to 25 kV) is stepped up by a generator transformer to a higher voltage (220, 345, 400 or 765 kV) for transmission. Generator transformers are usually provided with off-circuit tap changer with a small variation in voltage (e.g., $\pm 5\%$) because the voltage can always be controlled by field of the generator.

2. Unit auxiliary transformers:

These are step-down transformers with primary connected to generator output directly. The secondary voltage is of the order of 6.9 kV for supplying to various auxiliary equipments in the generating station.

3. Station transformers:

These transformers are required to supply auxiliary equipment during setting up of the generating station and subsequently during each start-up operation. The rating of these transformers is small, and their primary is connected to a high voltage transmission line.

4. Interconnecting transformers:

These are normally autotransformers used to interconnect two grids/systems operating at two different system voltages (400 and 220 kV or 345 and 138 kV). They are normally located in the transmission system between the generator transformer and receiving end transformer, and in this case they reduce the transmission voltage (400 or 345 kV) to the sub-transmission level (220 or 138 kV).

5. Receiving station transformers:

These are basically step-down transformers reducing transmission/sub-transmission voltage to primary feeder level (e.g., 33 kV). Some of these may be directly supplying an industrial plant. Loads on these transformers vary over wider limits, and their losses are expensive.

6. Distribution transformers:

Using distribution transformers, the primary feeder voltage is reduced to actual utilization voltage (~415 or 460 V) for domestic/ industrial use. A great variety of transformers fall into this category due to many different arrangements and connections. Load on these transformers varies widely, and they are often overloaded.

7. Phase shifting transformers:

These are used to control power flow over transmission lines by varying the phase angle between input and output voltages of the transformer. Through a proper tap change, the output voltage can be made to either lead or lag the input voltage. The amount of phase shift required directly affects the rating and size of the transformer.

8. Earthing or grounding transformers:

These are used to get a neutral point that facilitates grounding and detection of earth faults in an ungrounded part of a network (e.g., the delta connected systems).

9. Furnace duty transformers:

These are used to feed the arc or induction furnaces. They are characterized by a low secondary voltage (80 to 1000 V) and high current (10 to 60 kA) depending upon the MVA rating.

10. Freight loco transformers:

These are mounted on the locomotives within the engine compartment itself. The primary voltage collected from an overhead line is stepped down to an appropriate level by these transformers for feeding to the rectifiers, whose output DC voltage drives the locomotives.

11. Hermetically sealed transformers:

This construction does not permit any outside atmospheric air to get into the tank. It is completely sealed without any breathing arrangement, obviating need of periodic filtration and other normal maintenance. These transformers are filled with mineral oil or synthetic liquid as a cooling/dielectric medium and sealed completely by having an inert gas, like nitrogen, between the coolant and top tank plate.

12. Shunt Reactors:

These are used to compensate the capacitive VARs generated during low loads and switching operations in extra high voltage transmission networks, thereby maintaining the voltage profile of a transmission line within desirable limits. These are installed at a number of places along the length of the line. They can be either permanently connected or switched type. Use of shunt reactors under normal operating conditions may result in poor voltage levels and increased losses. Hence, the switched-in types are better since they are connected only when the voltage levels are required to be controlled.

13. Series Reactors:

These reactors are connected in series with generators, feeders and transmission lines for limiting fault currents under short circuits. Series reactors should have linear magnetic characteristics under fault conditions. They are designed to withstand mechanical and thermal effects of short circuits. Series reactors used in transmission lines have a fully insulated winding since both its ends should be able to withstand the lightning impulse voltages.

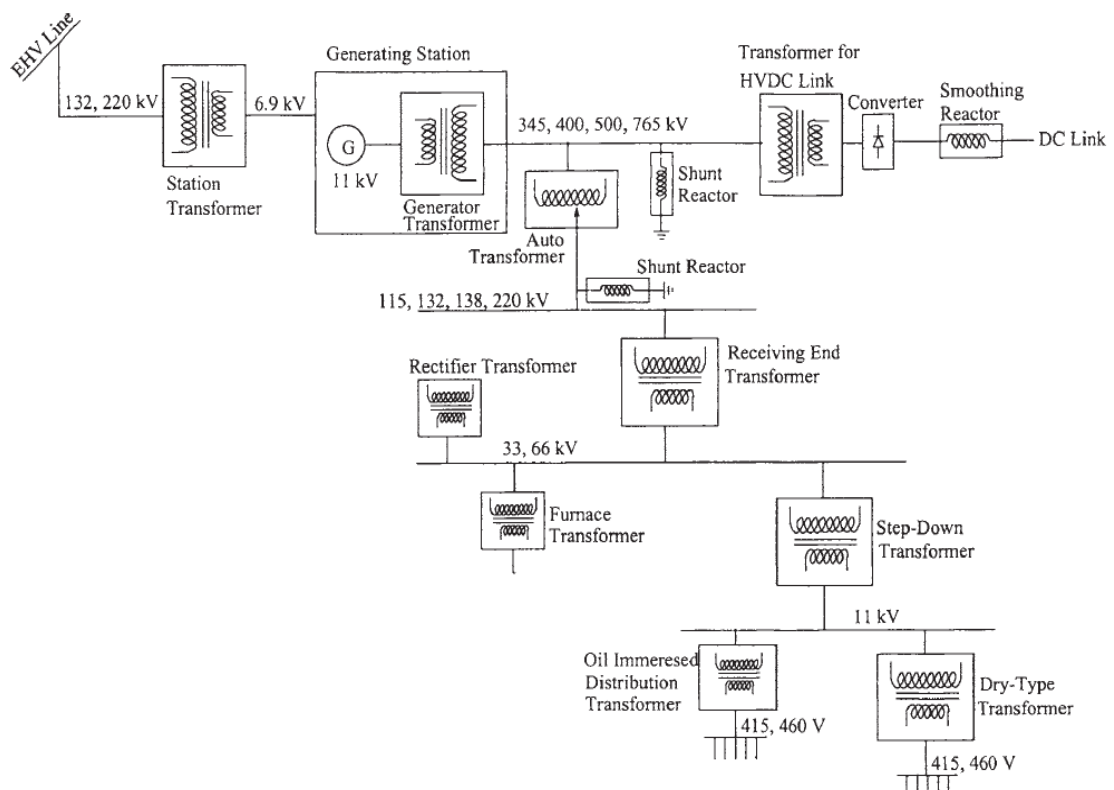


Figure 2.5: Different types of transformers in a typical power system [12], [13].

In this thesis, our target monitoring system is applied on a three phase step down distribution transformer with oil-filled self-cooled type.

2.2.3 Distribution transformer main parts:

1. Expansion oil tank (Conservator).

Installed above the main oil tank on the outer transformer frame and is connected to the main tank through a metallic tube. Oil can freely contract and expand during loading and thus the temperature of the oil increases and decreases. Loading can increase expansion up to 8%. Tank compensates any loss in oil that may occur in the main tank.

2. Radiator.

Radiator is added to increase cooling efficiency of the transformer. In this case, cooling is assumed to be “natural air” as it depends on natural circulation and air cooling the oil.

3. Temperature detector.

This detector is used to monitor oil temperature. Typically, there are mainly two types of temperature indicators used in transformer. Principally both of the instruments are the same but, one is used for oil temperature and the other is used for winding temperature.

4. Buchholz Relay:

It is placed when a conservator tank is used, as it indicated faults and errors such as oil loss when oil level goes low, improper oil flow between the oil tank and the transformer. Moreover, it shows gas emission inside transformer due to any unusual operation (excessive loading or short circuit) and can issue a control signal which can be used to disconnect the transformer. It is equipped with a release valve in case oil exceeded its level.

5. Breather unit:

As mentioned earlier, any decrease in oil is being compensated by the conservator tank which leads to decrease in oil in the conservator tank itself and thus the air gap widens in the tank and air is pulled from outside through what is known as “dehydrated breathing unit” which contains “Silica gel” that absorbs any moisture present in the oil. Silica changes its color from blue to pink if it unable to absorb moisture.

6. Main tank.

Windings are placed and soaked in oil.

7. Pressure relief device.

It reduces pressure inside the transformer through external pressure release to avoid explosion of transformer.

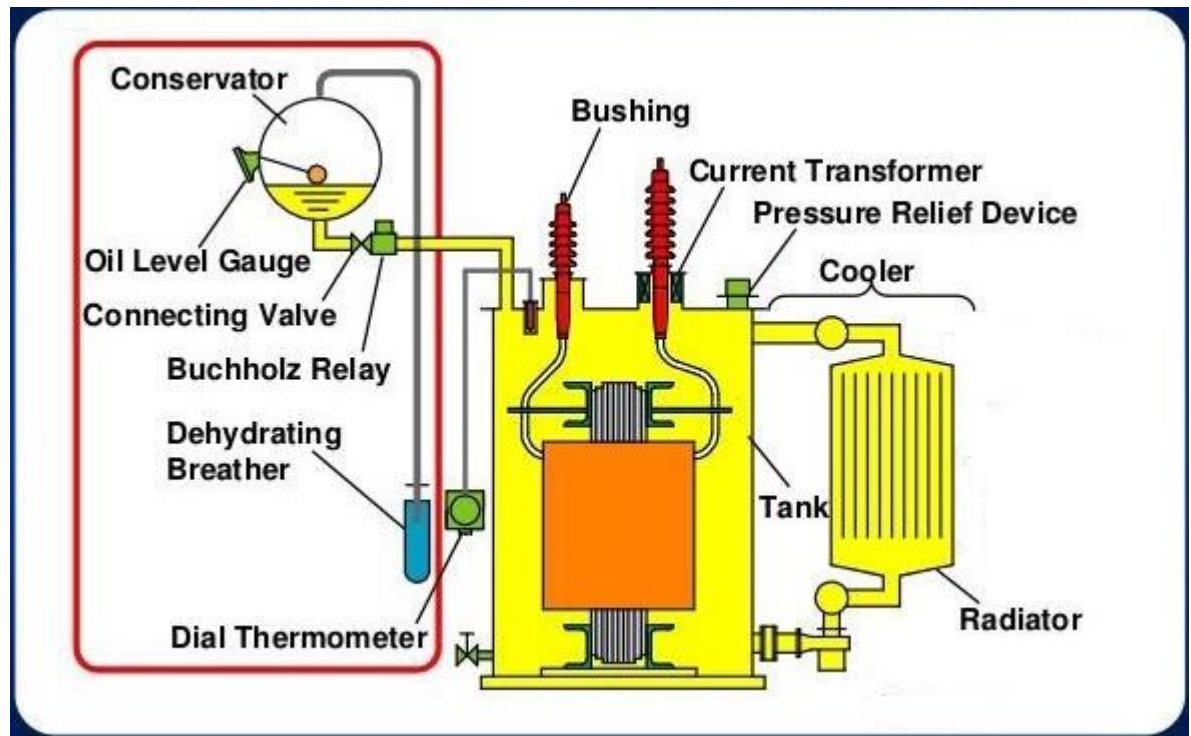


Figure 2.6: Distribution transformer main parts.

8. Oil level indicator.

This device is used to indicate the position of transformer oil level in conservator of transformer, which is a mechanical device. Decrease in oil can cause flash over if it is not refilled.

9. HV/LV bushings.

These bushings are responsible for connecting the internal windings of the transformer with the external electrical network. It isolates the internal windings from the transformer body. Bushings are fixed using flanges to avoid any humidity, dirt and dust from reaching the points of contact [14].

2.2.4 Distribution Transformer Ratings:

The capacity of a distribution transformer is determined by the amount of current it can carry continuously at rated voltage without exceeding the design temperature. The transformers are rated in kilovolt-amperes (kVA) since the capacity is limited by the load current which is proportional to the kVA regardless of the power factor. The standard kVA ratings are itemized in Table (2.1).

Table 2.1: Standard ratings of distribution transformers, kVA [15].

Overhead type		Pad-mounted type	
Single Phase	Three Phase	Single Phase	Three Phase
5	15	25	75
10	30	37.5	112.5
15	45	50	150
25	75	75	225
37.5	112.5	100	300
50	150	167	500
75	225		750
100	300		1000
167	500		1500
250			2000
333			2500
500			

2.3 LM35:

The LM35 series are integrated-circuit temperature sensors. Their output voltage is linearly proportional to the Celsius temperature with change the analog voltage of output. The operating temperature range is from -55°C to 150°C. The output voltage varies by 10mV in response to every° C rise/fall in ambient temperature. The LM35 thus has a benefit over linear temperature sensors calibrated in° K, as there is no need to subtract a large constant voltage from its output to obtain Centigrade reading. LM35 can be used with single power supplies, or with plus and minus supplies. It draws only 60 μ A from its supply, so it has very low self-heating, less than 0.1°C in still air. As shown in Figure (2.7), LM35 has three pins first pin for vcc supply 5 volt,

second one for analog output and another one for Gnd. Analog output range of LM35 is 0 volt to 1.5 volt. The +Vs can be from 4V to 20V as specified by the pin configuration. To use the sensor vcc was connected to +5V, GND to ground and the Vout to one of the ADC (analog to digital converter channel) as shown in Figure (2.7) [16].

2.3.1 Pin Diagram:

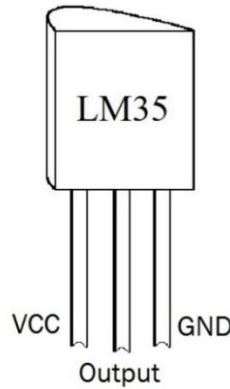


Figure 2.7: LM35 pin diagram

This type of temperature sensors have no moving parts, they are precise, never wear out, don't need calibration, work under many environmental conditions. Moreover they are very inexpensive and quite easy to use [17].

2.3.2 Electrical Connections:

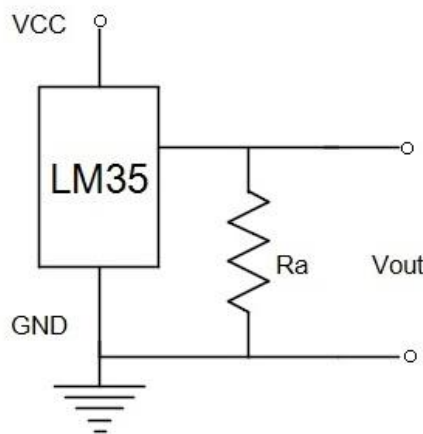


Figure 2.8: LM35 Electrical connections

$V_{cc} = 4$ to 30 v, Typical 5 v or 12 v are values used.

$R_a = V_{cc} / 10^{-6}$ - actually, it can range from $80 \text{ K}\Omega$ to $600 \text{ K}\Omega$, but most use $80 \text{ K}\Omega$.

2.4 ATmega32:

ATmega32 is an 8-bit high performance microcontroller of Atmel's Mega AVR family. ATmega32 is based on enhanced RISC (Reduced Instruction Set Computing) architecture with 131 powerful instructions. Most of the instructions execute in one machine cycle. ATmega32 can work on a maximum frequency of 16MHz. By executing powerful instructions in a single clock cycle, the ATmega32 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed [18].

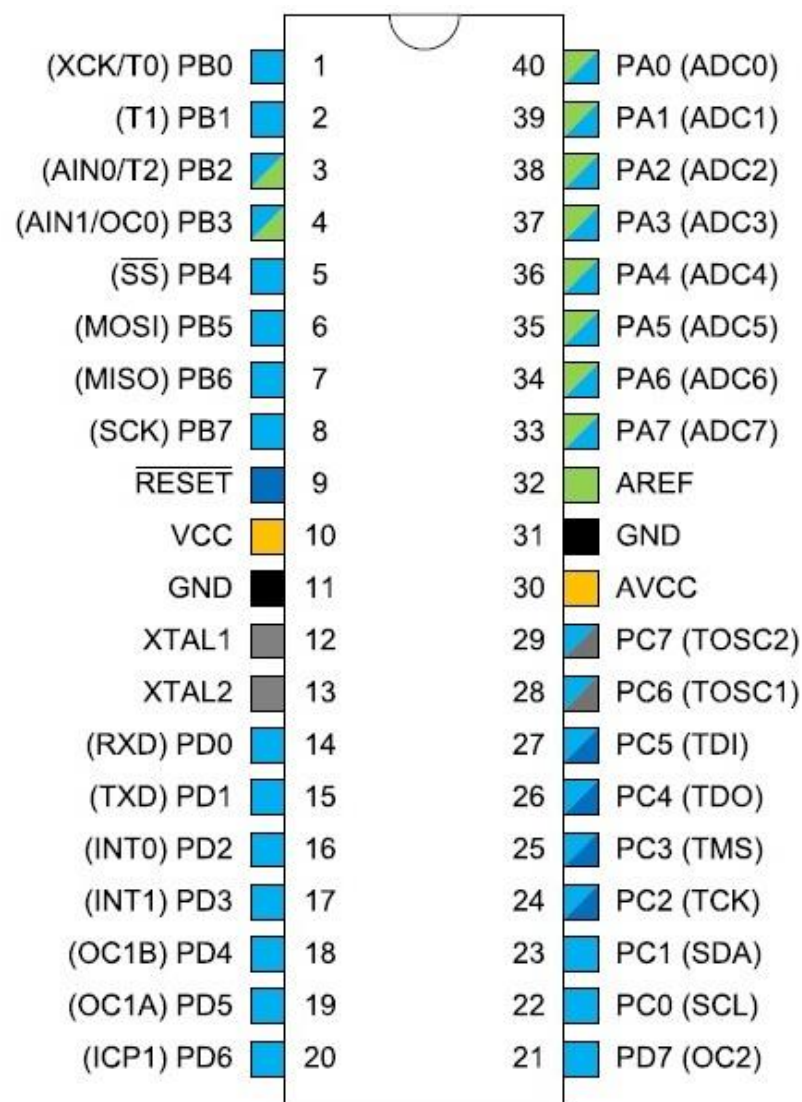


Figure 2.9: Pin out of ATmega32 [18].

PIN count: Atmega32 has got 40 pins. Two for Power (pin no.10: +5v, pin no. 11: ground), two for oscillator (pin 12, 13), one for reset (pin 9), three for providing necessary power and reference voltage to its internal ADC, and 32 (4×8) I/O pins.

About I/O pins: ATmega32 is capable of handling analogue inputs. Port A can be used as either digital I/O lines or each individual pin can be used as a single input channel to the internal ADC of ATmega32, plus a pair of pins AREF, AVCC & GND together can make an ADC channel.

No pins can perform and serve for two purposes (for an example: Port A pins cannot work as a Digital I/O pin while the Internal ADC is activated) at the same time. It's the programmer's responsibility to resolve the conflict in the circuitry and the program.

Digital I/O pins: ATmega32 has 32 pins (4ports×8pins) configurable as Digital I/O pins.

Timers: 3 timer/counters, two 8 bit (timer0, timer2) and one 16 bit (timer1).

ADC: It has one successive approximation type ADC in which total 8 single channels are selectable. They can also be used as 7 (for TQFP packages) or 2 (for DIP packages) differential channels. Reference is selectable, either an external reference can be used or the internal 2.56V reference can be brought into action. There external reference can be connected to the AREF pin.

Communication Options: ATmega32 has three data transfer modules embedded in it. They are

- Two Wire Interface
- USART
- Serial Peripheral Interface

Analog comparator: On-chip analog comparator is available. An interrupt is assigned for different comparison result obtained from the inputs.

External Interrupt: 3 External interrupt is accepted. Interrupt sense is configurable.
Memory: It has 32Kbytes of In-System Self-programmable Flash program memory, 1024 Bytes EEPROM, 2Kbytes Internal SRAM. Write/Erase Cycles: 10,000 Flash / 100,000 EEPROM.

Clock: It can run at a frequency from 1 to 16 MHz. Frequency can be obtained from external Quartz Crystal, Ceramic crystal or an R-C network. Internal calibrated RC oscillator can also be used.

More Features: Up to 16 MIPS throughput at 16MHz. Two cycle on-chip multiplication. 32×8 General Purpose Working Registers

Debug: JTAG boundary scan facilitates on chip debug.

Programming: Atmega32 can be programmed either by In-System Programming via Serial peripheral interface or by Parallel programming. Programming via JTAG interface is also possible. Programmer must ensure that SPI programming and JTAG are not being disabled using fuse bits; if the programming is supposed to be done using SPI or JTAG.

2.4.1 Configuration Summary:

Table 2.2: ATmega32 configuration summary [18].

Features	ATmega32
Pin count	32
Flash (KB)	32
SRAM (KB)	2
EEPROM (KB)	1
General Purpose I/O pins	23
SPI	1
TWI (I2C)	1
USART	1
ADC	10-bit, up to 76.9ksps (15ksps at max resolution)
ADC channels	8
AC propagation delay	Typical 400ns
8-bit Timer/Counters	2
16-bit Timer/Counters	1
PWM channels	4
RC Oscillator	+/-3%
Operating voltage	2.7 - 5.5V
Max operating frequency	16MHz
Temperature range	-55°C to +125°C
JTAG	Yes

2.5 Bascom:

Bascom-AVR is the original Windows Basic Compiler for the AVR series of microcontrollers. It is a very powerful and easy to use compiler developed by Atmel. Bascom-AVR has four programs in one package, it is known as an IDE (integrated development environment); it includes the Program Editor, the Compiler, the Programmer and the Simulator all together. Such a development environment supports the whole process from coding and testing a program to programming the used microcontroller [19]. In this thesis Bascom commands are written and burned into microcontroller flash memory in such a way that the designed circuit can accomplish its tasks and achieve the objectives.

2.6 LCD (Liquid Crystal Display):

The display used in this thesis is 16x2 LCD which means 16 characters per line by 2 lines, each character is displayed in 5x8 pixel matrix.

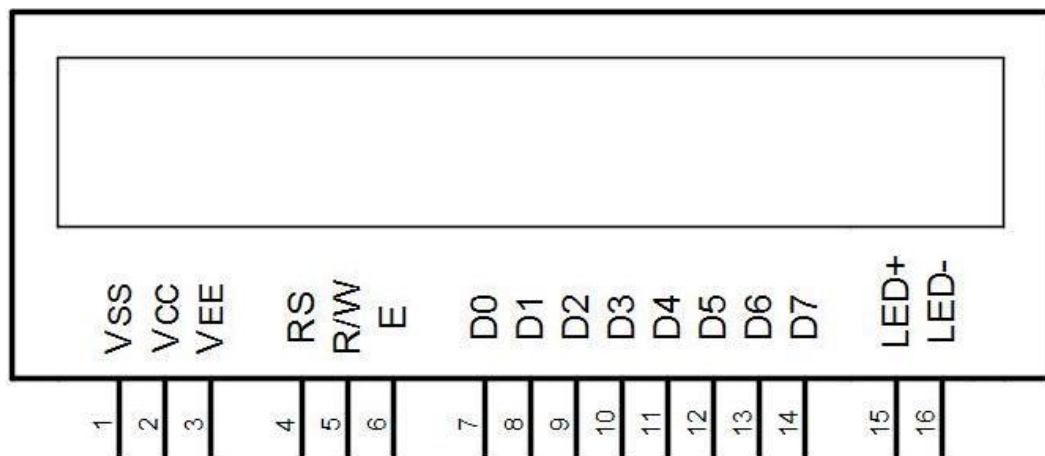


Figure 2.10: Pin Diagram of LCD.

This LCD has two registers, namely, Command and Data:

- The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc.

- The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

Table 2.3: LCD 16x2 pins description [20].

LCD 16x2 pins description		
Pin No	Name	Function
1	V _{SS}	Ground (0V)
2	V _{CC}	Supply voltage; 5V (4.7V – 5.3V)
3	V _{EE}	Contrast adjustment; through a variable resistor
4	Register Select	0=Instruction Input 1=Data Input
5	Read/write	0=Write to LCD 1=Read From LCD
6	Enable	Sends data to data pins when a high to low pulse is given
7	DB0	8-bit data pins
8	DB1	
9	DB2	
10	DB3	
11	DB4	
12	DB5	
13	DB6	
14	DB7	
15	Led+	Backlight V _{CC} (5V)
16	Led-	Backlight Ground (0V)

There are three control lines in LCD 16x2: **EN**, **RS**, and **RW**.

The **EN** line is called "Enable" This control line is used for telling the LCD that the data is sending. For sending data to the LCD, the program should make sure that the line is low (0) and then set the other two control lines or put data on the data bus. When the other lines are ready completely, bring **EN** high (1) and should wait for specific required time, then end by bringing it low (0) again.

The **RS** line is "Register Select" line. When RS is low (0), the data is treated as a command or special instruction (such as clear screen, position cursor, etc.).

When the RS is high (1), the data sent is text data which is displayed on the screen. For example, to display the letter "B" on the screen you would set RS high.

The **RW** line is "Read/Write" control line. When RW is low (0), the information on the data bus is written to the LCD. When RW is high (1), the program is effectively questioning (or reading) the LCD. Only one instruction ("Get LCD status") is read command. All the others are write commands, so RW will always be low. Table (2.3) shows pin description of LCD [20].

2.7 GSM:

GSM – Global System for Mobile Communications – is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile phones, first deployed in Finland in July 1991. As of 2014, it has become the default global standard for mobile communications - with over 90% market share, operating in over 219 countries and territories.

A GSM modem is a specialized type of modem which uses a wireless technology. It can accept a SIM card, and operates over a subscription to different GSM network operators, just like a mobile phone. The modem can either be connected to PC serial port directly or to any microcontroller. These modems are more frequently connected to computers which allow the computers to communicate with the mobile network. They are most probably used for sending/receiving SMS. The purpose of GSM modem is to send the monitoring parameters values of transformer to authorized person number in NEC.

Whenever temperature or oil level changes than set point then microcontroller sends signals to GSM modem. These signals include AT commands for GSM modem and the SMS to the authorized person.

Unlike mobile phones, a GSM modem doesn't have a keypad and display to interact with. It just accepts certain commands through a serial interface and acknowledges for those. These commands are called as AT commands. There is a list of AT commands to instruct the modem to perform its functions. Every command starts with

"AT". That's why they are called as AT commands. AT stands for attention.

Below in Table (2.4), are some of the necessary AT Commands for sending and receiving SMS.

Table 2.4: AT Commands and its description [21].

Command	Description
AT	It is the Prefix of every command sent to the modem. It is also used to test the condition of the modem.
AT+CMGF=1	It is used to instruct the modem to operate in text mode. AT+CMGF=0 will instruct the modem to operate in PDU mode.
AT+CMGS	Command to send SMS from the GSM Modem.
AT+CMGD=1	Command to delete the SMS at the index 1.
AT+CSMINS?	Command to check if the Modem has a SIM inserted in it.
AT+CREG?	Command to check if the SIM is registered with the network.

Optimum operating values

This chapter will discuss the optimum operating values of distribution transformer. These values would help to define the acceptable working range for the monitoring system and the out ranged values that leads to send SMS to NEC engineer.

3.1 Technical parameters analysis:

3.1.1 Temperature rise in oil:

The temperature in the oil starts increasing as working time of transformer increases .The faults occurs in the transformer if the temperature of oil start rising above 65 C. As load to the transformer increases that increases the temperature of the oil due to drawn of large currents. If the temperature rises above 90C the over load fault may occur. The average temperature rise in the oil should not exceed above the 110 C. If it rises above this temperature it causes insulation failure in oil and gases starts dissipating [5]. Regarding to these limitations of oil temperature, 90C will be assumed as high temperature that need to send SMS to NEC engineer and activate a local LED, while 65C will be assumed that need just a local LED alarm.

3.1.2 Magnetic oil level indicator:

The magnetic oil level indicators are used to give a visual indication of the oil level inside the conservator by a graduated dial with arrow plus electric signals, when the oil inside the conservator reaches the max or min level. The movement of the float rod and the pointer takes place thanks to magnetic coupling and reaches a 120° angle. In this way, for every variation of the oil inside the conservator tank the movement of the float cause the rotation of the magnet joint with consequent variation of the indication on the dial of the gauge. The pointer indicates the level that the oil should reach. The electronic version of the oil level gauge provides an analogical and a digital signal proportional to the oil level inside the conservator. These signals can be remote to: PLC, PC, integrated monitoring system, Remote Indicator [22].



Figure 3.1: Magnetic oil level indicator.

In this thesis an electronic version is used to give a digital signal that determine the max/min level of oil, these signals can be taken from micro-switches as shown in the following wiring diagram:

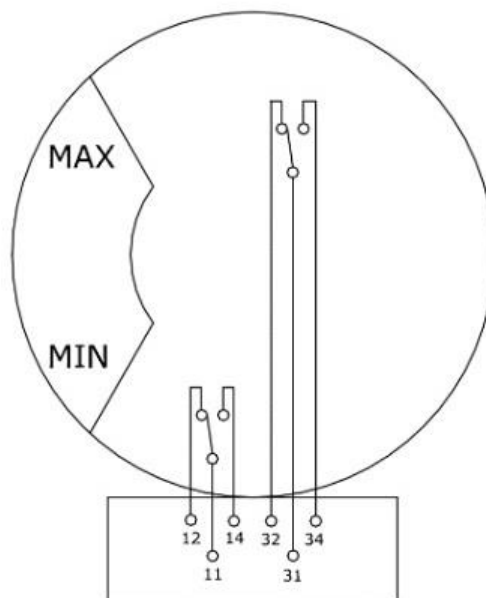


Figure 3.2: Micro-switches wiring for Max/Min oil level [22].

When transformer is working near its maximum rating, the oil temperature starts to increase which will expand the oil volume. This expansion may let the oil reach its maximum limit. Conversely, if there is substantial oil loss or leakage, oil may reach its minimum limit. For the importance of these two levels, the proposed monitoring system will send a SMS to NEC engineer whenever one of them reach its limit.

3.1.3 Voltmeter:

A voltmeter, also known as a voltage meter, is an instrument used for measuring the potential difference, or voltage, between two points in an electrical or electronic circuit. Some voltmeters are intended for use in direct current (DC) circuits; others are designed for alternating current (AC) circuits. Specialized voltmeters can measure radio frequency (RF) voltage.

A basic analog voltmeter consists of a sensitive galvanometer (current meter) in series with a high resistance. The internal resistance of a voltmeter must be high. Otherwise it will draw significant current, and thereby disturb the operation of the circuit under test. The sensitivity of the galvanometer and the value of the series resistance determine the range of voltages that the meter can display.

A moving coil galvanometer can be used as a voltmeter by inserting a resistor in series with the instrument. The galvanometer has a coil of fine wire suspended in a strong magnetic field. When an electric current is applied, the interaction of the magnetic field of the coil and of the stationary magnet creates a torque, tending to make the coil rotate. The torque is proportional to the current through the coil. The coil rotates, compressing a spring that opposes the rotation. The deflection of the coil is thus proportional to the current, which in turn is proportional to the applied voltage, which is indicated by a pointer on a scale.

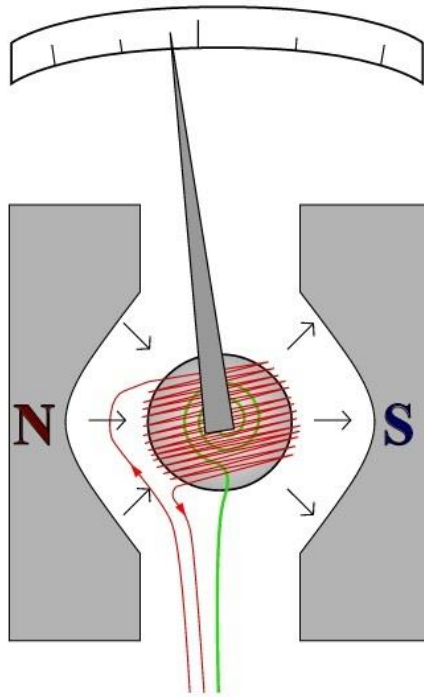


Figure 3.3: A moving coil galvanometer

Voltmeters operating on the electrostatic principle use the mutual repulsion between two charged plates to deflect a pointer attached to a spring. Meters of this type draw negligible current but are sensitive to voltages over about 100 volts and work with either alternating or direct current.

A digital voltmeter shows voltage directly as numerals. Some of these meters can determine voltage values to several significant figures. Most commercially manufactured voltmeters have several scales, increasing in powers of 10; for example, 0-1 V, 0-10 V, 0-100 V, and 0-1000 V.

A digital voltmeter (DVM) measures an unknown input voltage by converting the voltage to a digital value and then displays the voltage in numeric form.

DVM measurement accuracy is affected by many factors, including temperature, input impedance, and DVM power supply voltage variations. Less expensive DVMs often have input resistance on the order of 10 M Ω . Precision DVMs can have input resistances of 1 G Ω or higher for the lower voltage ranges (e.g. less than 20 V).

3.1.4 Equipment performance under different voltage values:

Most equipment is designed to operate optimally at a particular voltage. When voltage deviates from the 'nominal' voltage, performance is affected, depending on technology used. For example; in lighting lamps, if the voltage is low, light output drops dramatically. If it's high, output increases dramatically but lamp service life falls considerably.

Motors are also designed for nominal voltages. If subjected to high voltages, the magnetic flux in the steel circuit will saturate and cause heating of the steel laminations. Under low voltage conditions, motors will need to draw higher currents to achieve the required torque.

Nominal voltage: The nominal voltage identifies the reference voltage level of a supply system.

Highest / Lowest voltage of a system: These terms are used for the highest/lowest value of voltage which occurs under normal operating conditions at any time and at any point on electric system.

Standardization of nominal voltage and tolerances: Although many regions have its own standard for nominal operating voltage and tolerances, there are no internationally agreed rules that define a nominal voltage or tolerances. For example: Electricity supplies within the European Union are providing nominally 230 V $\pm 10\%$.

In the United States and Canada, national standards specify that the nominal voltage at the source should be 120 V and allow a range of 114 V to 126 V (-5% to $+5\%$).

In 2000, Australia converted to 230 V as the nominal standard with a tolerance of (-6% to $+10\%$) [23].

In this thesis, the nominal voltage will be assumed as 230V with voltage tolerance from 210 up to 250V.

3.1.5 Reed switch:

A reed switch is a small device that operated by an applied magnetic field. When the device is exposed to a magnetic field, the two contacts inside the switch pull together and the switch closes. When the magnetic field is removed, the reeds separate and the switch open [24]. Here, in this thesis, reed switch is used to sense magnetic field in transformer line. If the transformer trips, the magnetic field will remove and the ATmega32 microcontroller will send SMS that transformer was tripped. Figure (3.4) shows reed switch symbol.

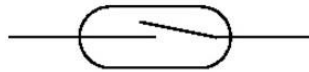


Figure 3.4: Reed switch symbol

Monitoring system implementation & results

4.1 Proposed Work:

Most people in residential areas are not aware about the power cuts that are caused due to disconnections in the distribution transformers. The problem can be solved if a person had noticed and make a call to the National Electricity Corporation (NEC) and define in which transformer this power cut happened. Otherwise, main parameters in transformer like oil level, oil temperature and voltage output range need to be known for NEC engineers. Monitoring transformers for such parameters when they are out ranged can prevent faults that are costly to repair and result in a loss of service as well as result in a loss of service life time [6].

In order to overcome the mentioned problems, a low cost system is proposed for determining the health condition of transformer by using the parameters of oil level, oil temperature, output voltage range and check power availability. Then send a SMS alerts through GSM modem to the authorized person whenever these parameters exceeds the predefined limits. Figure (4.1) below shows proposed block diagram for the circuit.

The block diagram shown in Figure (4.1) is proposed to implement in a real circuit. The sensed signals – signals from and to microcontroller – are represented with thin arrows. While power for sensors and other devices are represented by thick arrows. To receive stable power of 5 Vdc, the Ac power should be converted to Dc and regulated as shown in Figure (4.1). Also a battery is suggested for continuous supply of power in case of transformer trips. All sensors need Dc power source to give the sensed signals to microcontroller except voltage sensor which uses the Ac power directly from transformer and convert it to its equivalent Dc value.

4.1.1 Proposed Block Diagram:

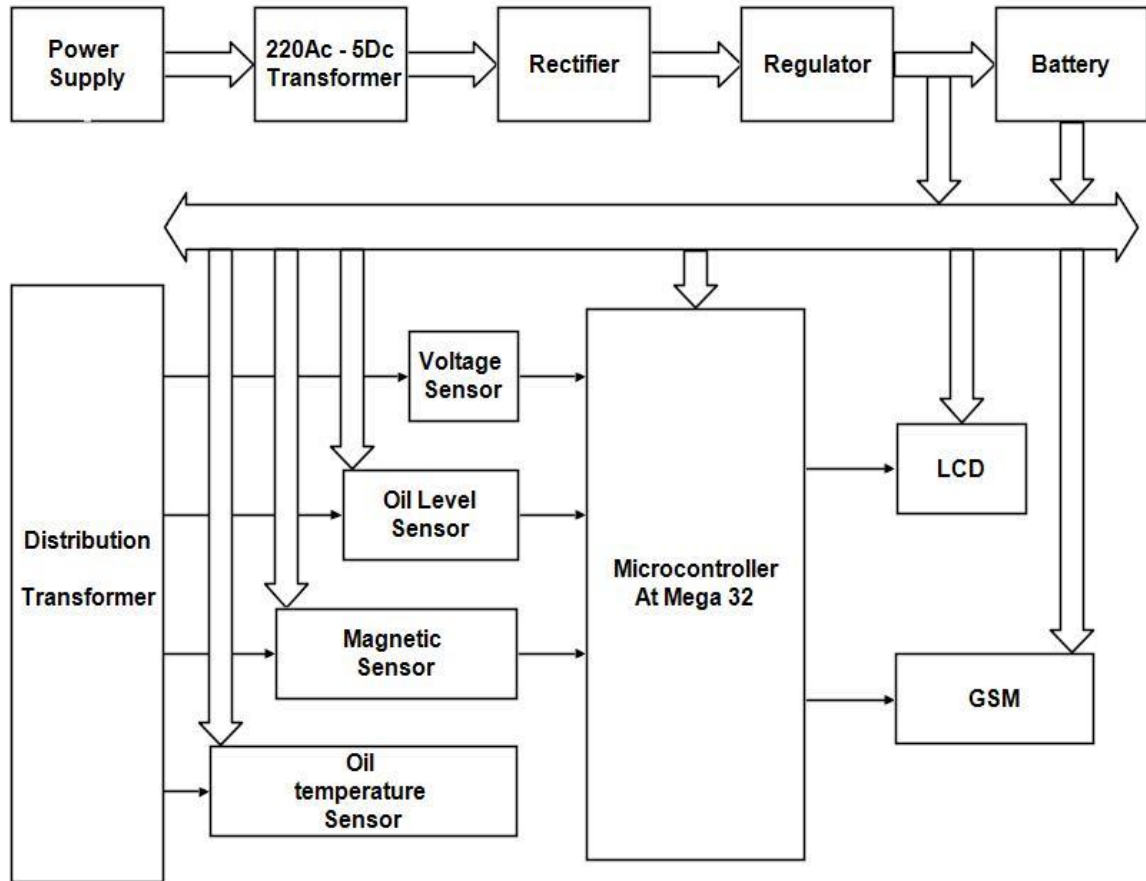


Figure 4.1: Proposed Block Diagram

4.2 Proteus simulator:

The proposed design of a distribution transformer monitoring system consists from a microcontroller connected to a group of sensors, LCD, GSM modem and a LED. This circuit can be easily simulated with specialist software called Proteus. Proteus is the best simulation software for various designs of microcontrollers. It was the first product to bridge the gap between schematic and Printed circuit board (PCB) for embedded design, offering system level simulation of microcontroller based designs inside the schematic package itself. It's easy to change hardware design by rewiring the schematic, changing component values for resistors, capacitors etc. and deleting or adding new components to the design. This gives a total freedom to experiment with different ideas and to find the optimal design solution

for a project. The schematic serves as a virtual prototype for the firmware and it's quick and easy to make changes to either [25].

4.3 Design Procedures:

The design procedures for the proposed monitoring system based on ATmega32 microcontroller is described as follows:

- Initialize the input and output ports of the microcontroller.
- Define the interfacing parameters for LCD and Data Registers.
- Assign a value for the circuit elements such as temperature sensors, variable voltages.
- The functions defined for particular outputs or SMS content and time.
- The displaying function is called and the parameter values are displayed [3].

4.3.1 Initializing input/output ports:

In this system, AVR ATmega32 microcontroller is used because of its features. It is low power high performance device, has RISC architecture. It is faster than 8051 and PIC [4]. Here temperature sensor (LM35), LCD, oil level sensors, GSM module, reed switch and voltage sensor (to simulate variation in main transformer voltage) are interfaced with this microcontroller unit.

AVR ATmega32 has four ports A, B, C and D. These ports are configured as follows:

- Port A: use to connect analog sensors.

Pin (0): configured as analog input from temperature sensor LM35.

Pin (1): configured as analog input from voltage sensor.

- Port B: used to interface LCD.

Pin (0): configured as register select on LCD (RS).

Pin (2): configured as Enable on LCD (E).

Pins (4 ~ 7): four pins configured as LCD output data.

Figure (4.2) shows a typical LCD interface with microcontroller.

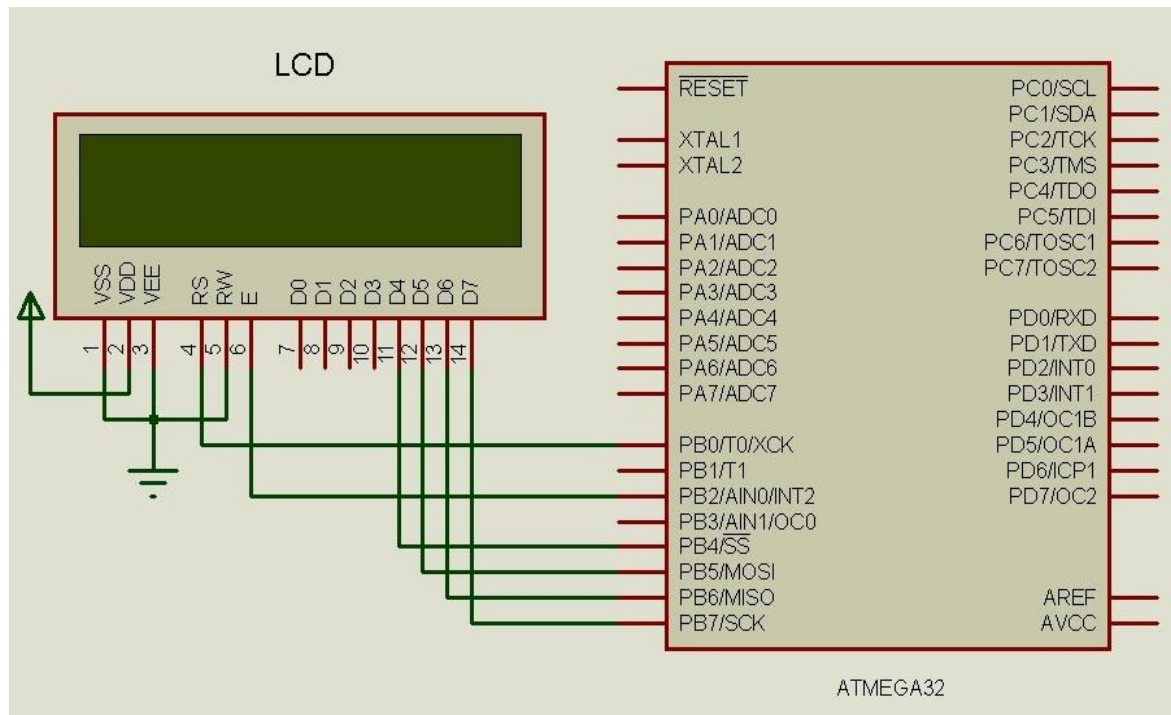


Figure 4.2: LCD interfacing with ATmega32 microcontroller.

➤ Port C: use for both analog inputs and outputs.

Pin (0): configured as digital input from reed switch.

Pin (1): configured as digital input from low oil level indicator.

Pin (2): configured as digital input from high oil level indicator.

Pin (3): configured as digital output for a LED.

➤ Port D: use to interface GSM modem.

Pin (1): configured as serial output for the GSM modem.

4.3.2 Circuit parameters:

Here are a summary of sensors' parameters as discussed in chapter three:

- Oil temperature sensor :
 - 65 °C for high temperature alarm.
 - 90 °C for high high temperature alarm.
- Voltage sensor (variable voltage transformer):
 - A range out of (210 ~ 250) V will be treated as alarm of out ranged voltage.
- reed switch:
 - A push button with low activated is used to simulate reed switch.
- Oil level sensors:
 - A push button with high activated is used to simulate low oil level sensor.
 - A push button with high activated is used to simulate high oil level sensor.
- GSM modem:
 - Used as output device and will send a predefined SMS in different cases of input sensors. These messages will be discussed in details later in circuit description.
- LED:
 - Used as output device for local alarm and it will activate at different cases of input sensors which will discussed in details later in circuit description.

Table 4.1: shows different output actions depending on different inputs values

Sensor description	Sensor input	Output action
High oil temperature	65°C	Activate LED
High high oil temperature	90°C	Send SMS + Activate LED
Lower voltage range	210V	Send SMS + Activate LED
higher voltage range	250V	Send SMS + Activate LED
reed switch	"0" activated	Send SMS + Activate LED
Low oil level	"1" activated	Send SMS + Activate LED
High oil level	"1" activated	Send SMS + Activate LED

4.4 Circuit description:

Figure (4.3) shows the proposed transformer monitoring system when simulated by Proteus software.

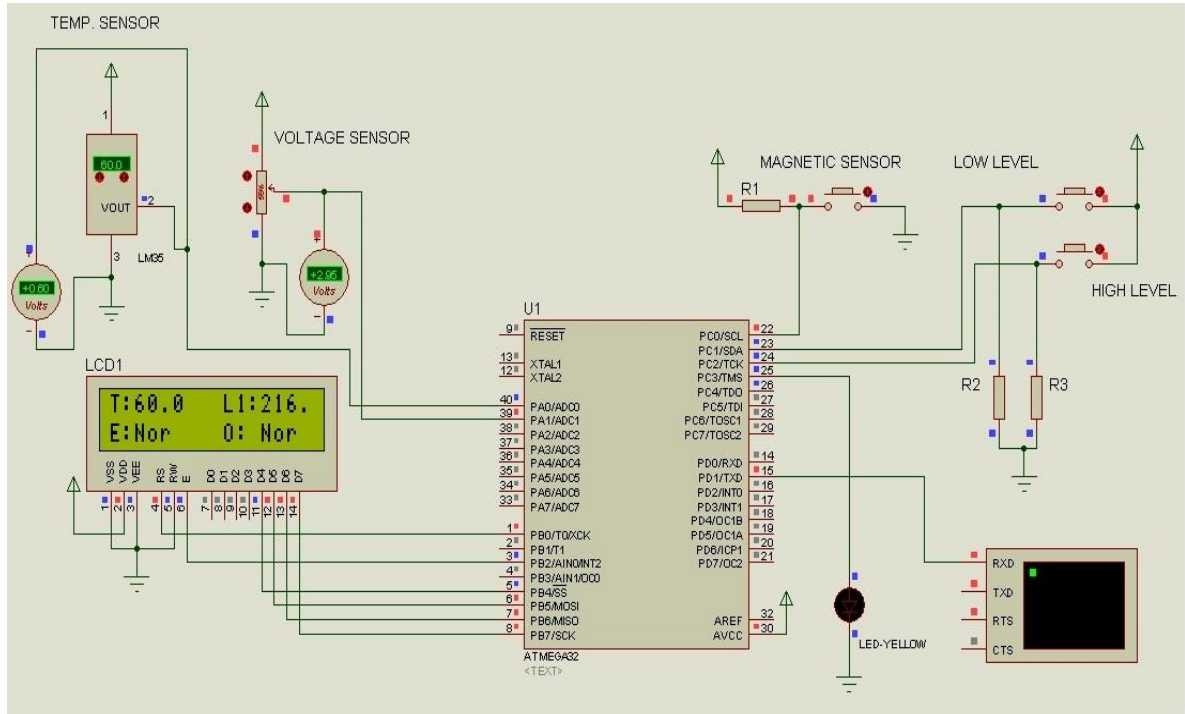


Figure 4.3: Transformer monitoring system.

Let us assume that the distribution transformer is located in block 2 and its number is 6, so all the text messages that will be sent by the GSM module should contain these information (location + transformer number) as well as specific problem that caused the system to send this message.

From Figure (4.3), the microcontroller read the transformer oil temperature, voltage sensor value, reed switch and oil level sensor, then compare them with values which shown in Table (4.1), and show there reading on LCD. If these values within the specified limits, no action will be taken in either LED or GSM module as shown in LCD reading in Figure (4.3).

- T refers to oil temperature which is 60° C and not reaches 65 ° C, so it's normal.
- L1 refers to the line voltage of transformer (represented by variable resistance) which indicates 216 V. This reading is acceptable because it's inside the defined range (210 ~ 250) V.
- E refers to presence or absence of power in transformer which is sensed by reed switch. Here reed switch is represented by push button switch. Now power is available, so it's indicates 'nor'.
- O refers to oil level in transformer. The low/high level of oil is represented by two push button switches. Now neither low nor high push button switches are pressed, so it's indicates 'nor'.

An example of sending SMS and activating LED, when a low level push button is pressed, the microcontroller compares this state with its stored states. Referring on Table (4.1), the microcontroller will activate LED and send a text message through GSM modem says that: "Oil level is low in block 2 Tran No:6" and LCD will display "low" as shown in Figure (4.4).

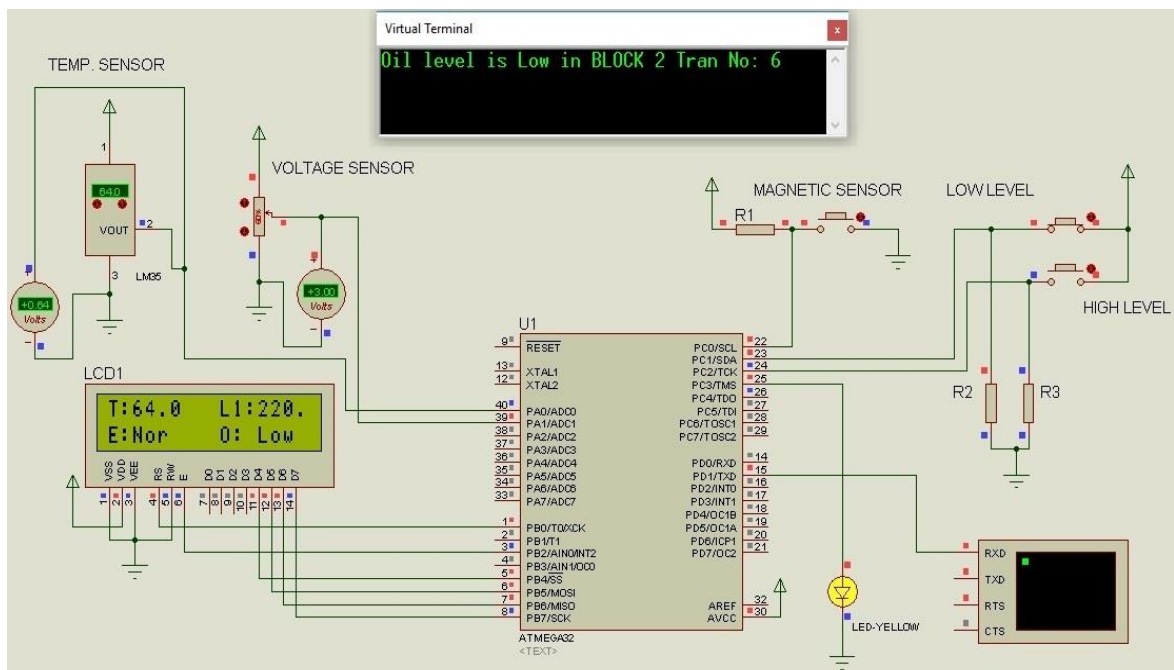


Figure 4.4: Transformer monitoring system when oil low level sensor is activated.

There are five states that microcontroller will send a SMS as follows:

- When there is no power as sensed by reed switch, the text message will be “Power Off in BLOCK 2 Tran No: 6”
- When oil level is low, the text message will be “Oil level is Low in BLOCK 2 Tran No: 6”
- When oil level is high, the text message will be “Oil level is High in BLOCK 2 Tran No: 6”
- When the oil temperature is high high, the text message will be “High Oil Temp in BLOCK 2 Tran No: 6”
- When the voltage is out of range (210 ~ 250), the text message will be “Voltage out of range in BLOCK 2 Tran No: 6”

4.5 Program execution and testing:

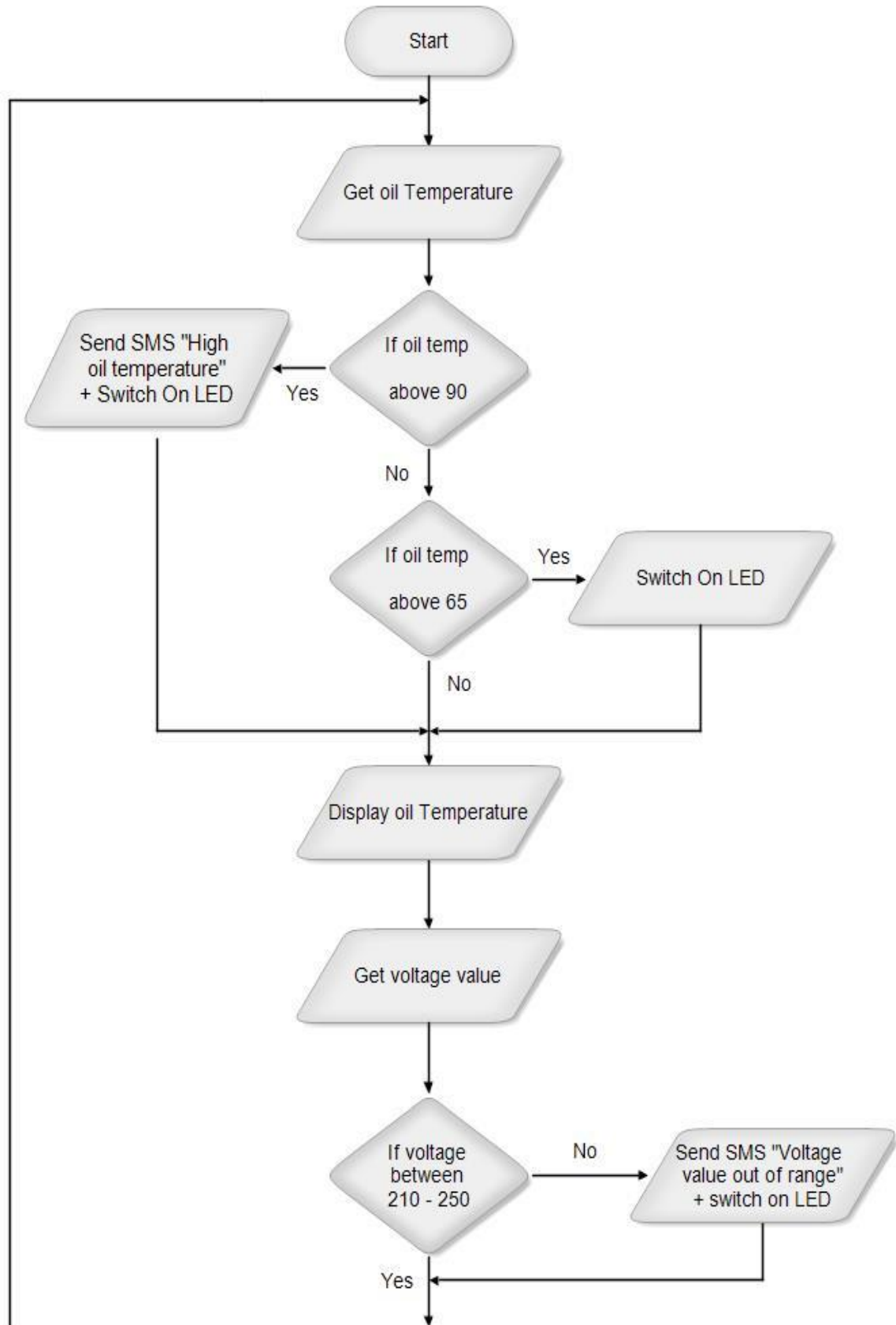
The system is based on microcontroller programming. The program for microcontroller is written in Bascom programming environment. It is written and burned into microcontroller then saved as Hex file. Program hex file is compiled in microcontroller flash compiler. This compiler converts program into machine language code as well as check program for error if any error found notifies and these errors are corrected manually. Then it successfully executed in compiler. After successful program burning, microcontroller ATmega32 becomes ready for use.

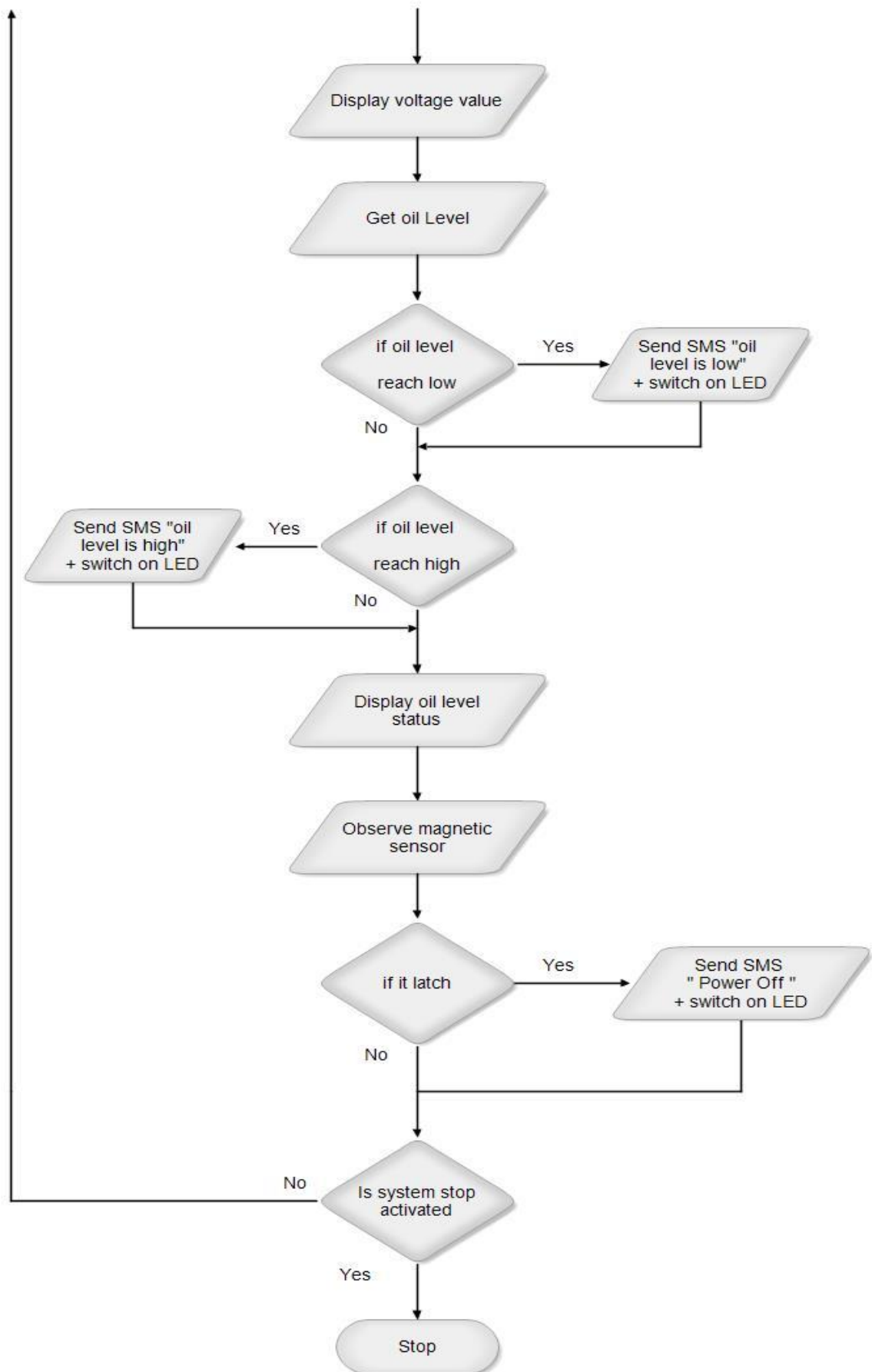
In testing, after successful program burning, microcontroller should be provided with following four parameter of transformer:

1. $210V < \text{Voltage} < 250V$.
2. Temperature $< 90^{\circ}\text{C}$.
3. Low level $< \text{Oil level} < \text{high level}$.
4. Reed switch is not activated.

Therefore any change occurred in above rating during running of system model will be shown in LCD and same data is obtained in SMS.

4.6 Flow Chart:





4.7 Analysis and results:

In the circuit diagram the microcontroller will receive the input analog signals and will convert into digital signals in the microcontroller and the result of transformer condition will be displayed on the display screen. Initially the rated value of the transformer will be set and if any of values reaches above that value then the LED will be activated and at the same time SMS will be sent to the mobile user whose number is feed into the GSM modem.

To view different conditions from the circuit, let assume that the transformer tripped which sensed by magnetic sensor. In circuit, when this sensor is pressed the text message will be “Power Off in BLOCK 2 Tran No: 6” and LCD will indicates “E: P Off” as shown in figure (4.5).

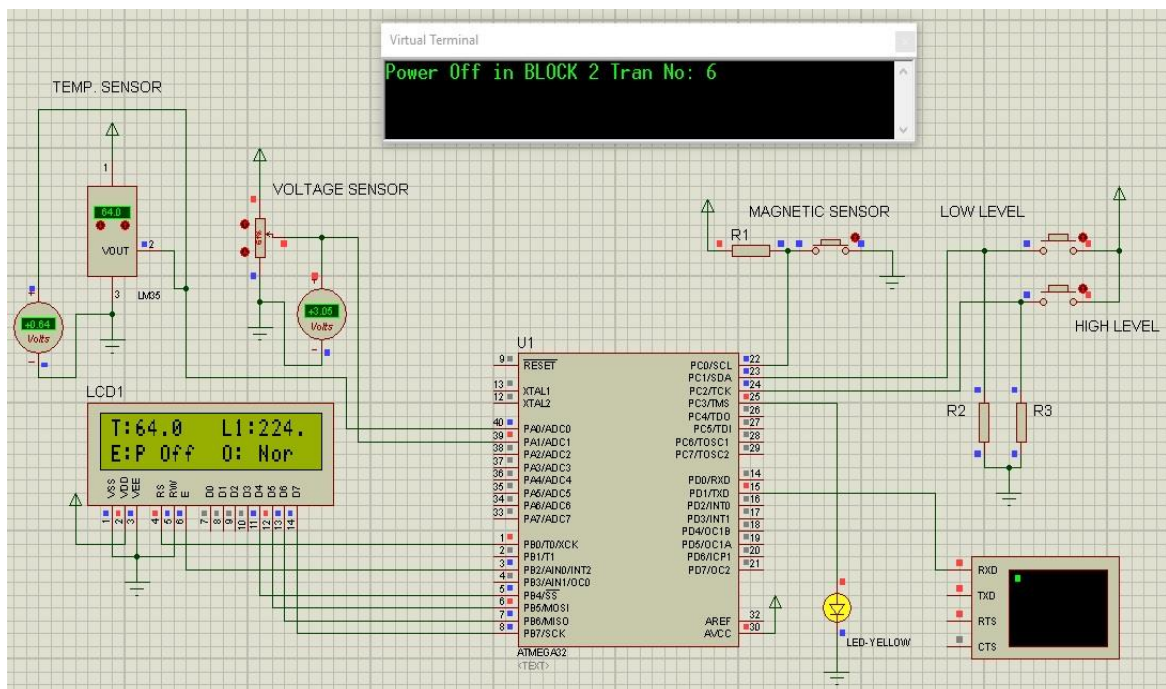


Figure 4.5: System and SMS status when the transformer trips.

If oil level in transformer is low, the Low Level sensor will sense it which represented by Low Level push button in the circuit. The text message will be “Oil level is Low in BLOCK 2 Tran No: 6” and LCD will indicates “O: Low” as shown in figure (4.6).

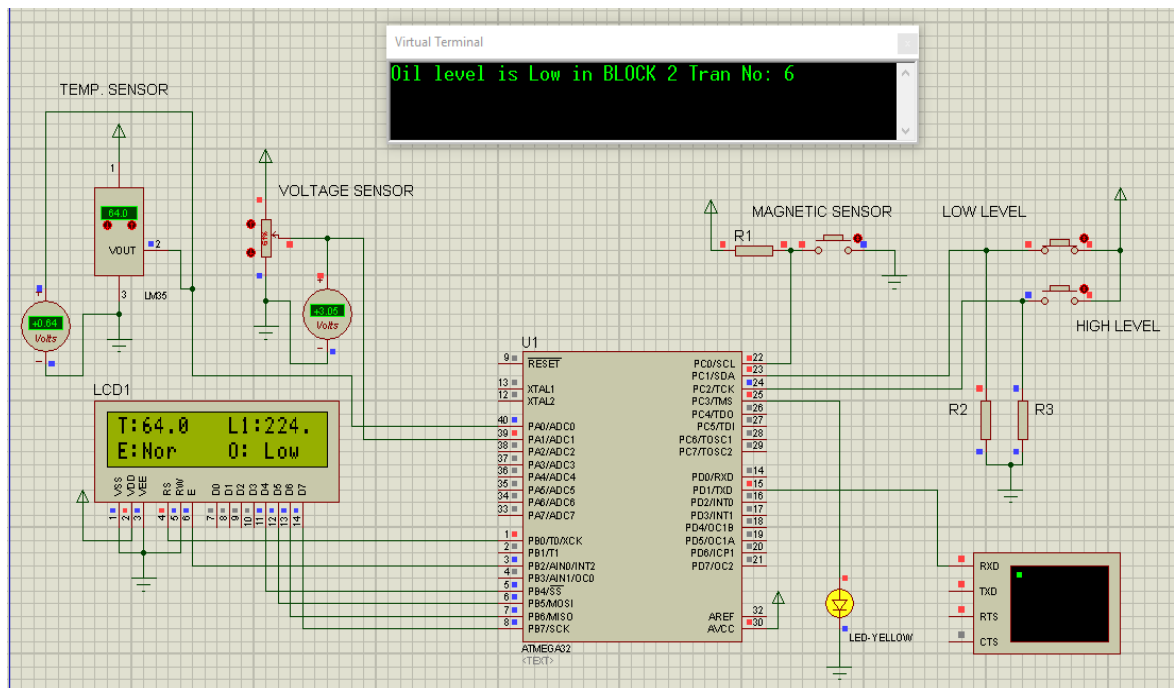


Figure 4.6: System and SMS status when the oil in transformer is low.

If oil level in transformer is high, the High Level sensor will sense it which represented by High Level push button in the circuit. The text message will be “Oil level is high in BLOCK 2 Tran No: 6” and LCD will indicates “O: High” as shown in figure (4.7).

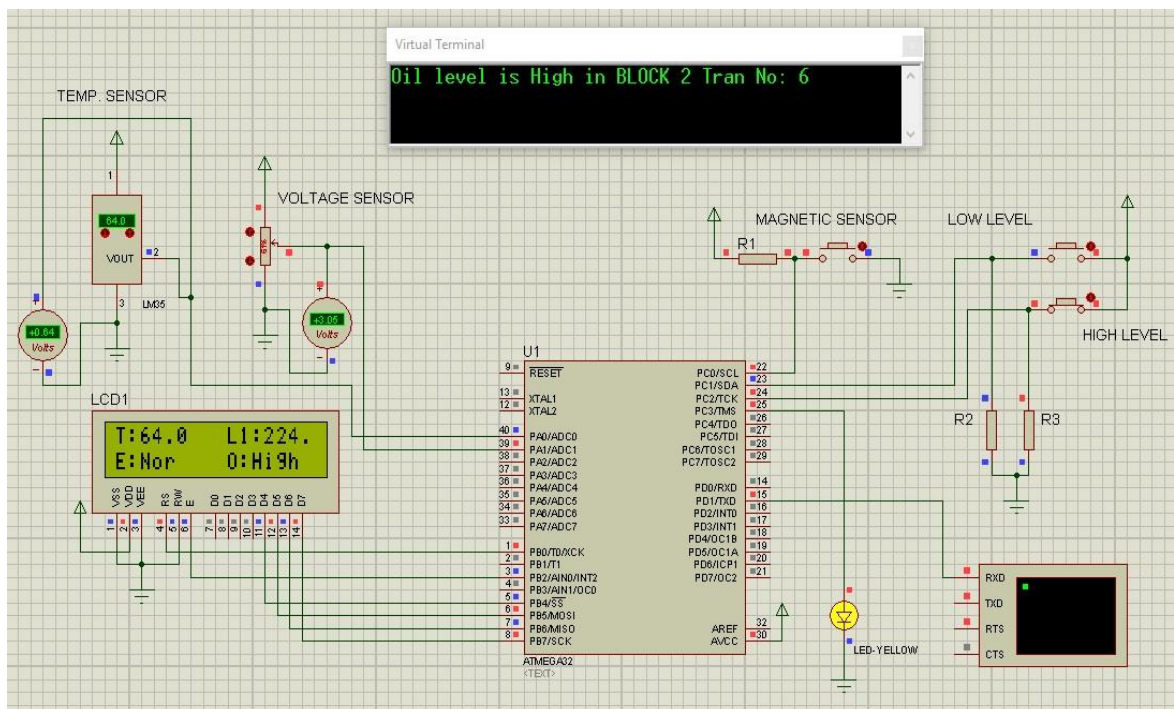


Figure 4.7: System and SMS status when the oil in transformer is high.

If the oil temperature in the transformer is more than 90°C the LM35 will sense it which represented by Temp. Sensor in the circuit. The text message will be “High Oil Temp in BLOCK 2 Tran No: 6” and LCD will indicates the actual value of the temperature “T: 92” as shown in figure (4.8).

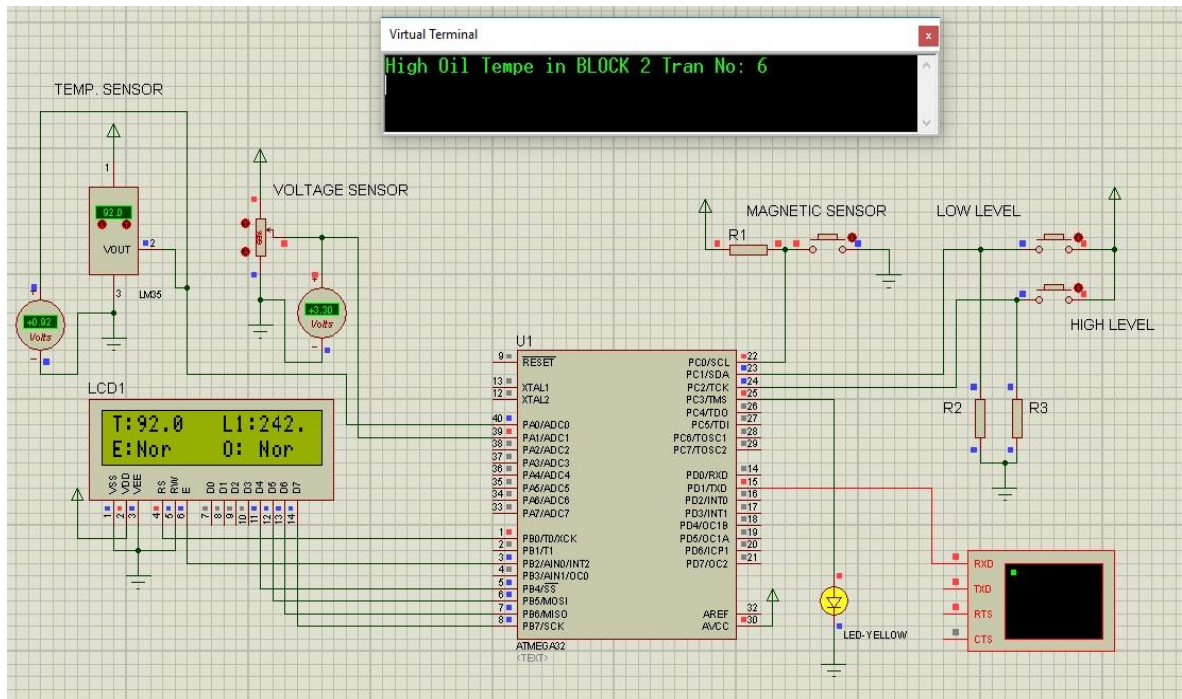


Figure 4.8: System and SMS status when the oil temperature in transformer is out of range.

If the voltage is out of range (210 ~ 250), the voltage sensor will sense it which represented by voltage sensor in the circuit. The text message will be “Voltage out of range in BLOCK 2 Tran No: 6” and LCD will indicates the actual value of the voltage “L1: 253” as shown in figure (4.9).

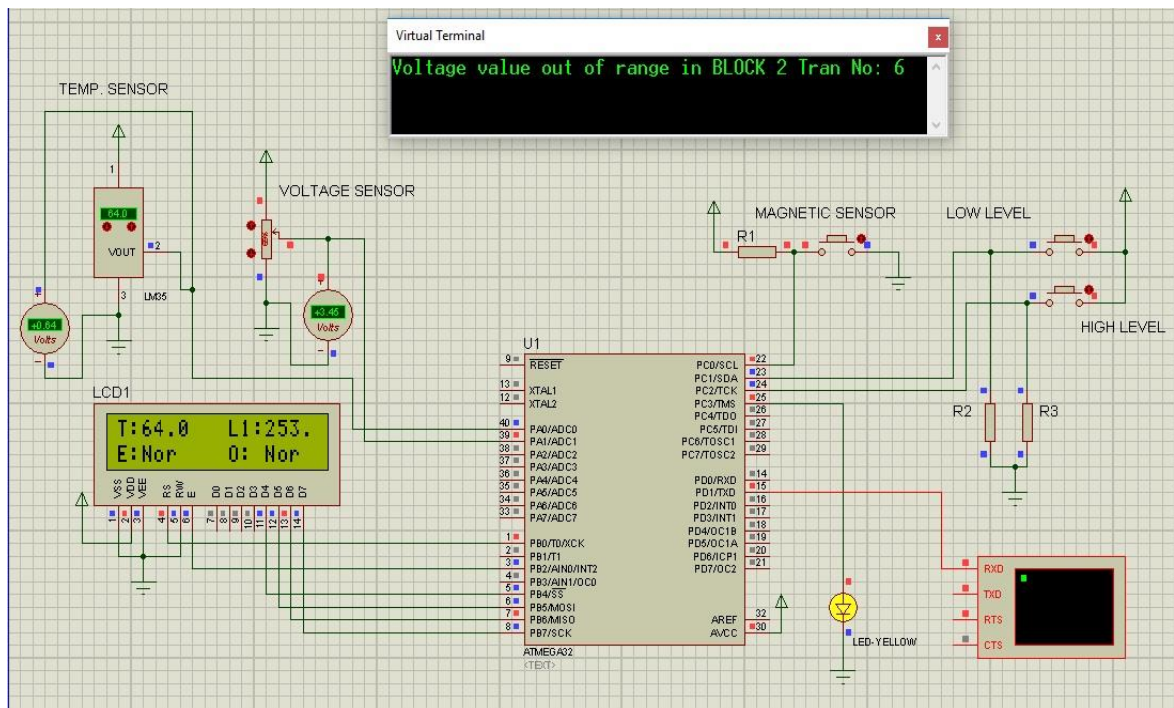


Figure 4.9: System and SMS status when the transformer voltage is out of range.

Conclusion and recommendations

5.1 Conclusion:

The GSM based monitoring of distribution transformer is quite useful as compared to manual monitoring and also it is reliable as it is not possible to monitor always the oil level, oil temperature rise, load voltage variation and transformer trip manually. In the past, maintenance of transformers was done based on a pre-determined schedule. With the advancement of communication technology now it is possible to receive fault information of transformer through GSM technology remotely to the authorities so one can able to take possible solution before converting fault in to fatal situation.

By knowing the values of the violating the parameter, the NEC engineer can take necessary step, so as to avoid the damage to the equipment. Thus this is the convenient way of avoiding the catastrophic failure and the damage to the equipment and to save the cost of replacing the transformer.

This monitoring leads to accurate and reliable operations, reduce human efforts, increase transformer life time, reduce faults and increase stability, provide fast and easy monitoring with more efficient way and It increases the efficiency of the system.

5.2 Recommendations:

- For further extension to this design, a current sensor could be added to measure transformer's current and then monitor its overload value.
- This design could be improved by adding control actions in case of any up normal conditions which need fast response by a mean of controller.
- Link all transformers to SCADA system could a suitable option to view them in Human Machine Interface (HMI) with their parameters.
- A server module can be included to this system for receiving and storing transformer parameters information periodically about all the distribution transformers of a particular utility in a database application. This database will be a useful source of information on the utility transformers.

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Appendix (I)

Program code

```
$regfile = "m16def.dat"
```

```
$crystal = 8000000
```

```
$baud = 9600
```

```
Config Adc = Single , Prescaler = Auto , Reference = Avcc
```

```
Enable Interrupts
```

```
Enable Adc
```

```
Start Adc
```

```
Config Lcd = 16 * 2
```

```
Config Lcdpin = Pin , Db4 = Portb.4 , Db5 = Portb.5 , Db6 = Portb.6 , Db7 =  
Portb.7 , E = Portb.2 , Rs = Portb.0
```

```
Cls
```

```
Cursor Off
```

```
Config Pinc.0 = Input
```

```
Config Pinc.1 = Input
```

```
Config Pinc.2 = Input
```

```
Config Pinc.3 = Output
```

```
Dim T1 As Word
```

```
Dim D As Byte
```

```
Dim Temp1 As Single
```

```
Dim A1 As Word
```

```
Dim V As Single
```

```
Locate 1 , 4
```

```
Lcd "WELL COME"
```

```
Wait 1
```

```
Cls
```

```
Do
```

T1 = Getadc(0)

Temp1 = T1

Temp1 = Temp1 / 2.05333

'2.05333 is used for scaling. When 5 V represent 1023 on micro - output, 1.5 V represent 308 which should be scaled to 150 degree.

Temp1 = Round(temp1)

Locate 1 , 1

Lcd "T:" ; Temp1

A1 = Getadc(1)

V = A1 / 2.79

'2.79 is used for scaling. When 5 V represent 1023 on micro - output, 2.79 V represent 366 which should be scaled to 366 as maximum volt.

V = Round(v)

Locate 1 , 10

Lcd "L1:" ; V

If Pinc.0 = 0 Then

Locate 2 , 1

Lcd "E:P Off"

End If

If Pinc.0 = 1 Then

```
Locate 2 , 1  
Lcd "E:Nor  "  
End If
```

```
If Pinc.1 = 0 And Pinc.2 = 0 Then  
Locate 2 , 10  
Lcd "O: Nor"  
End If  
If Pinc.1 = 1 Then  
Locate 2 , 10  
Lcd "O: Low"  
End If
```

```
If Pinc.2 = 1 Then  
Locate 2 , 10  
Lcd "O:High"  
End If
```

```
If Temp1 >= 65 And Temp1 < 90 Or Pinc.1 = 1 Or Pinc.2 = 1 Or Pinc.0 = 0  
Or V > 250 Or V < 210 Then  
Portc.3 = 1  
End If
```

```
If Temp1 < 65 And Pinc.1 = 0 And Pinc.2 = 0 And Pinc.0 = 1 And V < 250  
And V > 210 Then
```

Portc.3 = 0

D = 2

End If

If Temp1 >= 90 Or Pinc.1 = 1 Or Pinc.2 = 1 Or Pinc.0 = 0 Or V > 250 Or V < 210 Then

Decr D

Waitms 10

End If

If D = 0 Then

If Temp1 >= 90 Then

Print "High Oil Tempe in BLOCK 2 Tran No: 6"

End If

If Pinc.1 = 1 Then

Print "Oil level is Low in BLOCK 2 Tran No: 6"

End If

If Pinc.2 = 1 Then

Print "Oil level is High in BLOCK 2 Tran No: 6"

End If

If V > 250 Or V < 210 Then

Print "Voltage value out of range in BLOCK 2 Tran No: 6"

End If

If Pinc.0 = 0 Then

Print "Power Off in BLOCK 2 Tran No: 6"

End If

End If

Loop

Appendix (II)

LM35 data sheet:

Features

- Calibrated directly in ° Celsius (Centigrade)
- Linear + 10 mV/°C Scale Factor
- Low cost due to wafer-level trimming
- 0.5°C ensured accuracy (at +25°C)
- Rated for Full -55°C to +150°C Range
- Low Self-Heating
- Low impedance output, 0.1W for 1 mA Load
- Operates from 4 to 30 Volts
- suitable for Remote Applications
- Less than 60 mA current drain

Absolute Maximum Ratings

Supply Voltage	+35V to -0.2V
Output Voltage	+6V to -1.0V
Output Current	10 mA
Storage Temp:	
TO-46 Package,	-60°C to +180°C
TO-92 Package,	-60°C to +150°C
SO-8 Package,	-65°C to +150°C
TO-202 Package,	-65°C to +150°C
Lead Temp:	
TO-46 Package, (Soldering, 10 seconds)	300°C
TO-92 Package, (Soldering, 10 seconds)	260°C
TO-202 Package, (Soldering, 10 seconds)	230°C
SO Package (Note 12):	
Vapor Phase (60 seconds)	215°C
Infrared (15 seconds)	220°C
ESD Susceptibility (Note 11)	2500V
Specified Operating Temperature Range: T Min to T Max (Note 2)	
LM35, LM35A	-55°C to +150°C
LM35C, LM35CA	-40°C to +110°C
LM35D	0°C to +100°C

ATmega32 data sheet:

Pin Description

VCC: Digital supply voltage.

GND: Ground.

Port A (PA7:PA0): Port A serves as the analog inputs to the A/D Converter.

Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B (PB7:PB0): Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port C (PC7:PC0): Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PC5 (TDI), PC3 (TMS) and PC2 (TCK) will be activated even if a reset occurs. The TD0 pin is tri-stated unless TAP states that shift out data are entered.

Port D (PD7:PD0): Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D

pins are tri-stated when a reset condition becomes active, even if the clock is not running.

RESET: Reset input. A reset is generated if a low level occurs on this pin for longer than the minimum pulse length; even if the clock is not running. Pulses are not guaranteed to generate a reset.

XTAL1: Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2: Output from the inverting Oscillator amplifier.

AVCC: AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter.

AREF: AREF is the analog reference pin for the A/D Converter [18].

Features

- High-performance, Low-power Atmel® AVR® 8-bit Microcontroller
- Advanced RISC Architecture
 - 131 Powerful Instructions – Most Single-clock Cycle Execution
 - 32 x 8 General Purpose Working Registers
 - Fully Static Operation
 - Up to 16 MIPS Throughput at 16 MHz
 - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory segments
 - 32Kbytes of In-System Self-programmable Flash program memory
 - 1024Bytes EEPROM
 - 2Kbyte Internal SRAM
 - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
 - Data retention: 20 years at 85°C/100 years at 25°C(1)
 - Optional Boot Code Section with Independent Lock Bits

In-System Programming by On-chip Boot Program

True Read-While-Write Operation

- Programming Lock for Software Security

- JTAG (IEEE std. 1149.1 Compliant) Interface

- Boundary-scan Capabilities According to the JTAG Standard
 - Extensive On-chip Debug Support
 - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface

- Peripheral Features

- Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes

- One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode

- Real Time Counter with Separate Oscillator

- Four PWM Channels

- 8-channel, 10-bit ADC

- 8 Single-ended Channels

- 7 Differential Channels in TQFP Package Only

- 2 Differential Channels with Programmable Gain at 1x, 10x, or 200x

- Byte-oriented Two-wire Serial Interface

- Programmable Serial USART

- Master/Slave SPI Serial Interface

- Programmable Watchdog Timer with Separate On-chip Oscillator

- On-chip Analog Comparator

- Special Microcontroller Features

- Power-on Reset and Programmable Brown-out Detection

- Internal Calibrated RC Oscillator

- External and Internal Interrupt Sources
- Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
- I/O and Packages
 - 32 Programmable I/O Lines
 - 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF
- Operating Voltages
 - 2.7V - 5.5V for ATmega32L
 - 4.5V - 5.5V for ATmega32
- Speed Grades
 - 0 - 8MHz for ATmega32L
 - 0 - 16MHz for ATmega32
- Power Consumption at 1 MHz, 3V, 25° C
 - Active: 1.1mA
 - Idle Mode: 0.35mA
 - Power-down Mode: < 1μA