Scientific Journal of Impact Factor (SJIF): 5.71
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 04, April -2018

PROTECTION OF TRANSFORMERS USING SENSORS

Sruti Suvadarsini Singh[1], Abir Jana[2], Abhay Kumar[3], Hrishabh Singh[4]

[1]*Assistant Professor, School of Electronics Engineering, KIIT-Deemed to be University*
[2, 3, 4] *UG Students of Electrical & Electronics Engineering, Kalinga Institute of Industrial Technology (Deemed to be University), Bhubaneswar, Odisha*

Abstract — *In case of transformers there are two over temperature relays used to protect over heating of windings and cooling oil. Similarly in the large DC and induction motors, the stator and rotor windings are provided with over temperature protection system. The Transformer windings are over heated due to over load, inadequate cooling facility so this system can protect the transformer from flashover. The motors draw over current due to rotor blockage or short circuit of the windings. The system is basically designed with a temperature sensor, which read the temperature of the winding and compares with a set point and takes a decision to trip the protective relay. This protection device is designed as a specific application programmable logic controller.*

Keywords- *OLTC, OT sensor, LM393, MOSFET, PZT Buzzer, Bistable/Latch, LEDs, 555Timer*

1. INTRODUCTION

The transformer protection system is very important aspect. Many manufacturers are focusing in to this area. The protection system avoids hazards and also provides durability to the equipment. In the electrical engineering, the protection system is one of the major fields. Over temperature protection system is a very important protection system for transformers. Normally every electrical equipment have one electrical winding or coil in which current passes in turn generate heat. Any fault in the system creates more current through the coil, as a result the coil gets heated up. Normally one full fledge transformer will have the following protective devices: Buchholz's Relay, Temperature Tripping Relay, Temperature Indicator & Alarm.[1][6]

1.1. Buchholz's Relay :

A large transformer may have two number of Buchholz's Relay. One for conservator tank oil level monitoring & other may be used to monitor the oil level of On Line Tap Changer (OLTC) chamber oil level. The Boucz's Relay have a non-potential close contact point. Whenever the oil level goes below the set level ,the Boucz's relay closes the contact by filling the gap by measuring. Normally one end of this relay is connected to a positive DC voltage and upon activation of this relay. The output of this relay will be the same DC voltage.

1.2. Temperature Tripping Relay :

This relays normally used in conjunction with thermocouple transducers. The transducers are kept inside the thermocouple. When the temperature goes beyond the set value, the relay gets closed. These are normally mursummy filled type or bimetallic strip type relays, but in principle these relays also provide a non-potential contact points. So when the relay gets closed the input dc voltage will appear at the output. There are two such relays connected in the transformer to monitor winding temperature (WT) & oil temperature (OT).

1.3. Temperature Indicator & Alarm:

This relay operates in the same principle as the temperature tripping relay, but this gets activated few degree centigrade prior to tripping relay.

Keeping all the above facts in mind this programmable logic controller is designed. In this PLC, there are 8 – channels available for protection. As discussed above the transformer requires only fine channels. Other three channels may be used for inter locking or for some advance protection.

2. DESIGN PRINCIPLE

The transformer protection system designed to protect different devices from the abnormal or fault conditions. Whenever there is a fault the transducer or the fault detector connected to that particular channel will generate a digital TTL compatible output. That is the pulse, which is sensed by the controller, and necessary task is attended as per the design. In this design the system is basically designed to protect device connected through the protective relay. There are four channels starting from CH0 to CH4 and one LED panel containing four LEDs to indicate the status of each channel. There are also four protective relays connected to the controller through the relay driver to protect the devices. On sensing

TTL compatible logic signal from the sensors the controller reacts to the single fault or combination of more than one fault and direct the relays to protect the device as per the program entered prior to the operation. The statuses of the channel are indicated in the LED panel.

The solid state relays are basically made out of a Thyrister or Power MOSFET. In our project work the solid state relay is used for operating with AC load so a Triac is used which conduct for both positive and negative half cycles with full angle of conduction. The solid state relay designed here is consisting of a semiconductor switch along with four channels of interlock. A embedded micro controller is used to control the solid state relay. Once the relay is ON then the controller scans four channels. Whenever there is a fault then automatically the controller issue signal to the TRIAC to drive the device into non conducting state, by removing the active pulse from the Gate.

The protection of transformer is incorporated with the help of few non-potential relays. In principle these relays converts physical quantities such as temperature & liquid level into non-potential close and open contacts. This relays are supplied with a dc voltage at are end of the relay contact. On closer of the relay contact, the dc voltage appears at the other end of the relay. This action is considered & treated as logic pulse generation. As long as the logic pulse remains at high state the protective relay is considered to be in tripped condition. The relays such as the Bocuz's relay, Temperature tripping relay on this principle. Whereas Alarming relays are provided with temperature relays. When the temperature comes in the range of predefined zone, the relay gets activated & and starts alarming and it continues until tripping occurs. The temperature relays have two contacts points in series. One is connected to alarm relay & other is connected to tripping relay. Whenever the controller receives a logic high signal at any of the input channel, it indicates the type of fault or tripping on the display board .At the same time the device trips the required protective relay. This protective device works on the principle of digital logic and the controller is designed to function on receipt of logic signals. Each channels of the controller assigned for specific task so the input terminals are marked for connecting because input and output both are interconnected or related.[5]

If any time any of the sensor is occurred fault, the controller activate the relays (those are connected to the keypad of the mobile phone) to dial the key board of the mobile phone to make a call by the interfaced mobile phone to the given mobile or telephone number.

3. BLOCK DIAGRAM & CIRCUIT EXPLANATION

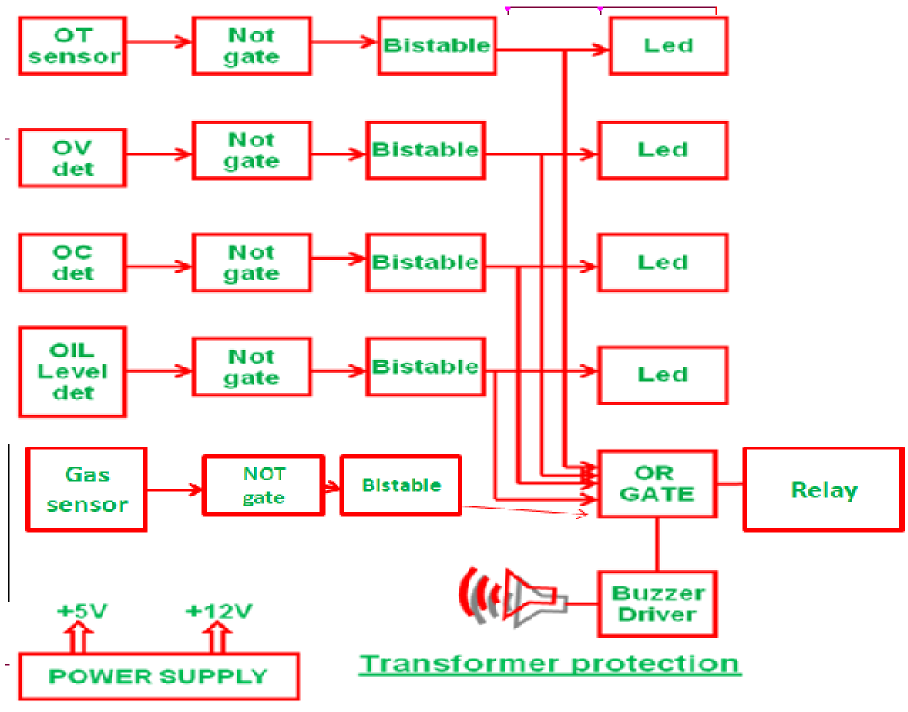


Figure 1: Block diagram of Proposed Transformer Protection System

Magnetic flux is induced in the primary coil after the application of ac signal to the primary winding of the transformer. Then due to transformer action, it is transferred to the secondary coil of the transformer. "The transformer is an electromechanical static device which transformer electrical energy from one coil to another without changing its frequency". There are four diodes connected in bridge structure. The secondary coil of the transformer is given to the bridge circuit for rectification purposes. The output of bridge rectifier circuit is not a pure dc voltage. Therefore, to fix it we have used 7805 and 7812 IC regulators. The output of the regulator circuit is connected to the LED indicator section for fault indication.

3.1 Over Temperature Detector:

The electrical windings are normally protected against over temperature. The maximum allowable temperature range for the windings may be less than 150 degree centigrade to 200 degree centigrade. In this range of temperature thermister is quiet suitable and reliable. Thermister is a semiconductor bid which has negative temperature coefficient.

Here the aim is to detect temperature beyond 200 degree centigrade, for that a temperature sensor is used as a thermistor. For sensing the temperature and comparing it, an voltage comparator (LM393) is used. This compares the two input voltage and gives the corresponding outputs according to the temperature. The temperature sensor itself converts the sensed temperature to its corresponding voltage.

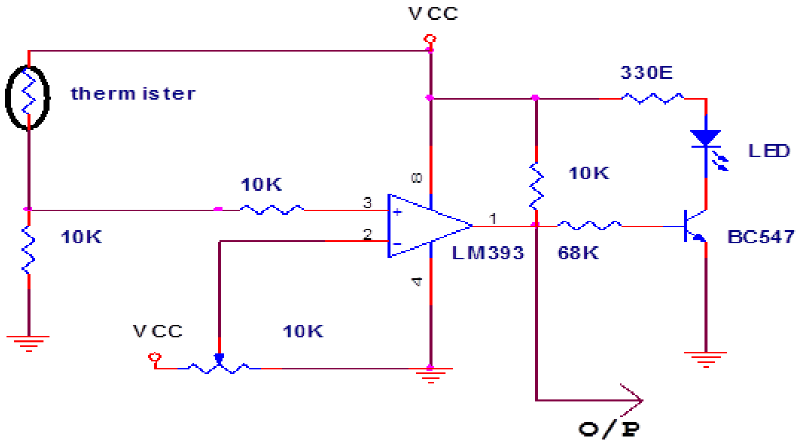
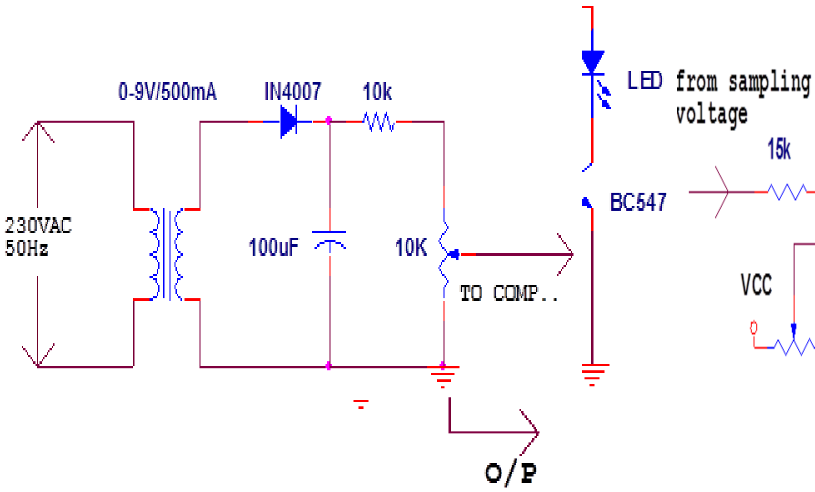


Figure 2. Temperature Detector Circuit

3.2 Over Voltage Detector:

Detection of the line varying voltage is discussed here.



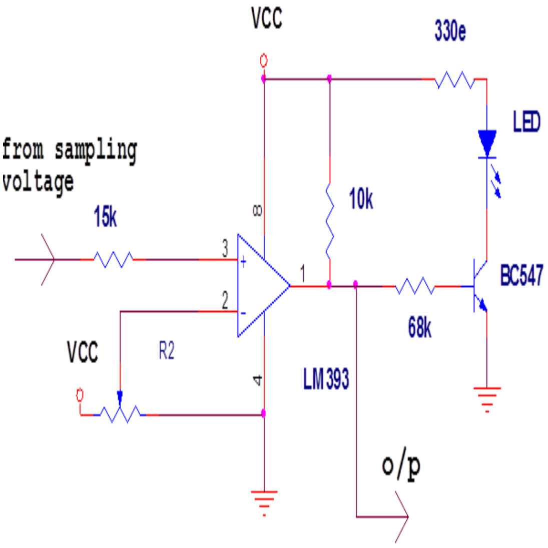


Figure 3. Voltage Signaling Circuit **Figure 4. Voltage Comparator Circuit**

A step down transformer is used to convert the 230V ac line voltage to be step down. If the line voltage varies, the step down voltage also varies in accordance with the input voltage. If the primary winding of the transformer voltage is more the flux induced is more and the secondary voltage will be more.

The sample voltage can be regulated by varying the load resistance. The step down transformer samples the line voltage at a reduced signal voltage

$$Vac = (N2/N1)*V_L \text{ -------------------- } (1)$$

The capacitor voltage in figure 3 represents the line voltage. The time constant of the circuit is the product of capacitance with the load resistance. The resulting voltage is fed to the comparator.[2]

3.3. Over Current Detector:

This circuit is designed to detect the over current. A current transformer circuit is used to detect very low current. The output of the current transformer circuit is ac voltage. This ac voltage is proportional to the load current. Therefore, the current transformer voltage varies according to the load current.

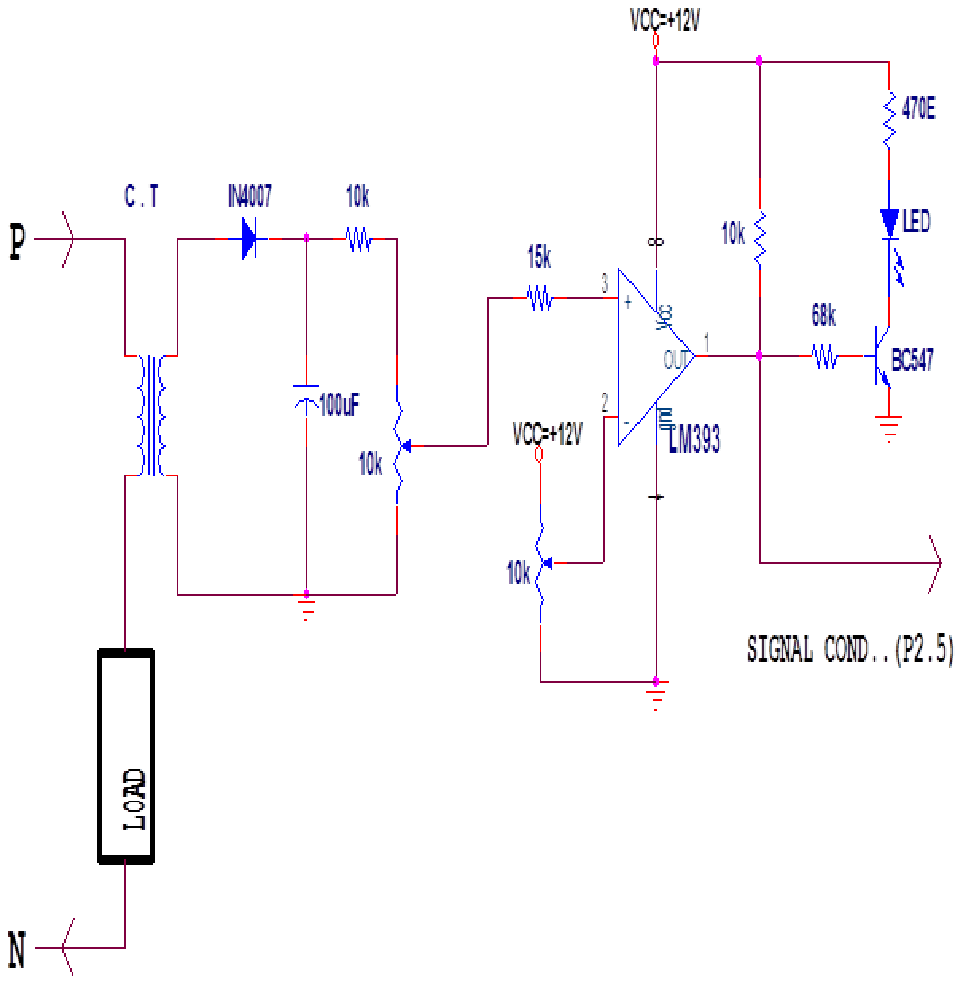


Figure 5. Current Detector Circuit

The main supply voltage i.e. 230V ac is the line voltage which is given between the primary of the current transformer and a load (15W) to the neutral. The voltage at the secondary coil is induced from the current in the primary coil of the current transformer circuit. The ratio of the primary coil turns and the secondary coil turns is kept as 1:200. The output voltage of the current transformer circuit is dependent on the primary flux density.

The figure 5 shows a half-wave rectifier, which converts ac to dc voltage. In this circuit the importance of designing the rectifier is at the priority to achieve the accuracy and precession.

The load resistance helps to regulate the sample voltage value. The importance of this design is to sample the load current accurately and produce a dc voltage as a copy of the ac load current. The Current Transformer circuit samples the load current as a reduced ac signal voltage given as

$$Vac = (N2/N1)*\phi_m*K \text{ ------------------------ } (2)$$

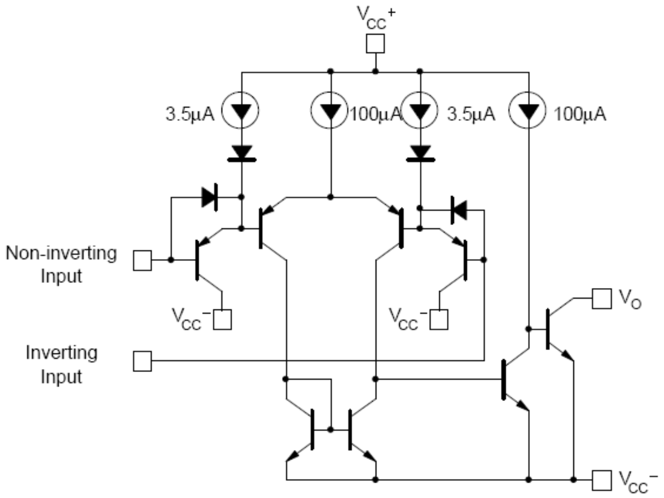


Figure 6. Current Comparator Circuit

The sampling voltage output goes to the input of the comparator circuit. If the voltage at inverting terminal is greater than that of the non-inverting terminal, then the output of the comparator will be LOW this indicates the line voltage is within the range. If the current increases, then the voltage will increase correspondingly. That voltage goes to the input of the non-inverting terminal of the OPAMP (LM393) which is configured as the voltage comparator circuit.

The comparator shown in figure 6, voltage of 3.5V is applied to the inverting terminal. Here, the non- inverting terminal is getting greater voltage than the inverting terminal. Which means the output of the comparator circuit goes to saturation (HIGH) indicating that over current has occurred. The comparator circuit's output is connected to a LED indicator section to indicate the high or low condition.[3][4]

3.4. Oil Level Detector:

In this section we have to indicate the level of the oil in the tank and also to protect the transformer. We have arranged a plastic bulb and two contact points for this section. A plastic bulb is floated on the level of the oil and one of the contact points is connected with the bulb. Whenever the OIL level goes below the lower level of the transformer, the bulb goes down and the contact point will closed and the transistor gets a high voltage at the base i.e. the transistor moves to saturation(ON) condition, the current will flow from collector to emitter junction and the output is taken at the emitter junction. That output is given to the controller terminal for further processing according to the design.

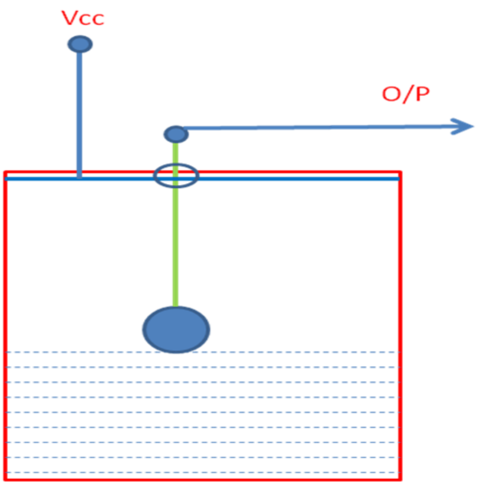


Figure 7. Oil Level Detector

3.5. LPG Gas Leakage Detector:

This is a section on LPG leakage detection and controlling system. The proposed system is very useful for home and industrial environment. The system detects the LPG leakaging and control the exhaust fan automatically. The main part of the project is the GAS sensor and a controller circuit. The GAS sensor communicates with the controller through a voltage comparator circuit to adjust the response time. The output of the sensor is feed to a comparator designed using Op-Amp. The comparator input from the voltage divider network is compared with a reference voltage correspond to the voltage of set GAS intensity.

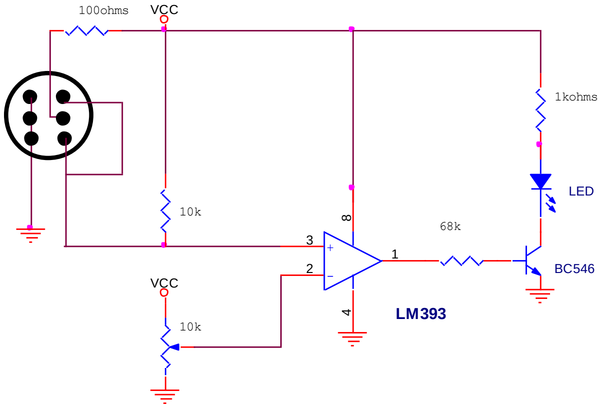


Figure 8. LPG Gas Leakage Detector

The transistors can be used as switches for computers and control applications. It is not only used as amplifier. The bistable/latch is the electronics device which stores the state even if the input is withdrawn. So this can be started as a single memory unit. The latch can be designed in many ways by using a discreet component or flip-flop or a IC known as 555 timer, The Latch designed using 555 timer IC is quite stable. The indicator section consists of LEDs. The driver circuit for the indicator section is designed so that the LEDs glow when current flows through it.

The OR gate is also called as "any or all" gate. The OR gate is the combinational logic circuit which has only one output and may have any number of inputs. The output is 1 when any one or more than one of the input is 1 and the output is 0 only when all the input is 0. One audible piezo electric buzzer is interfaced with the controller. Here, whenever there is any fault appears in any of the channel, then the controller activates the buzzer.

4. PRACTICAL IMPLEMENTATION

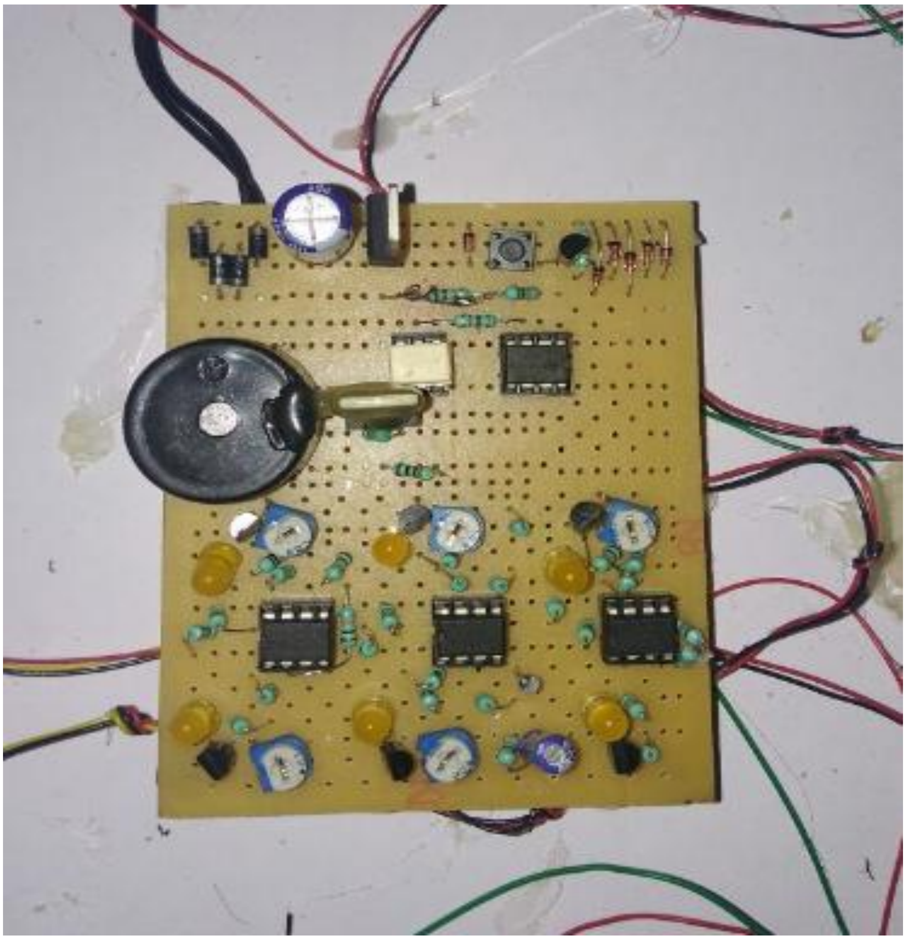


Figure 8a

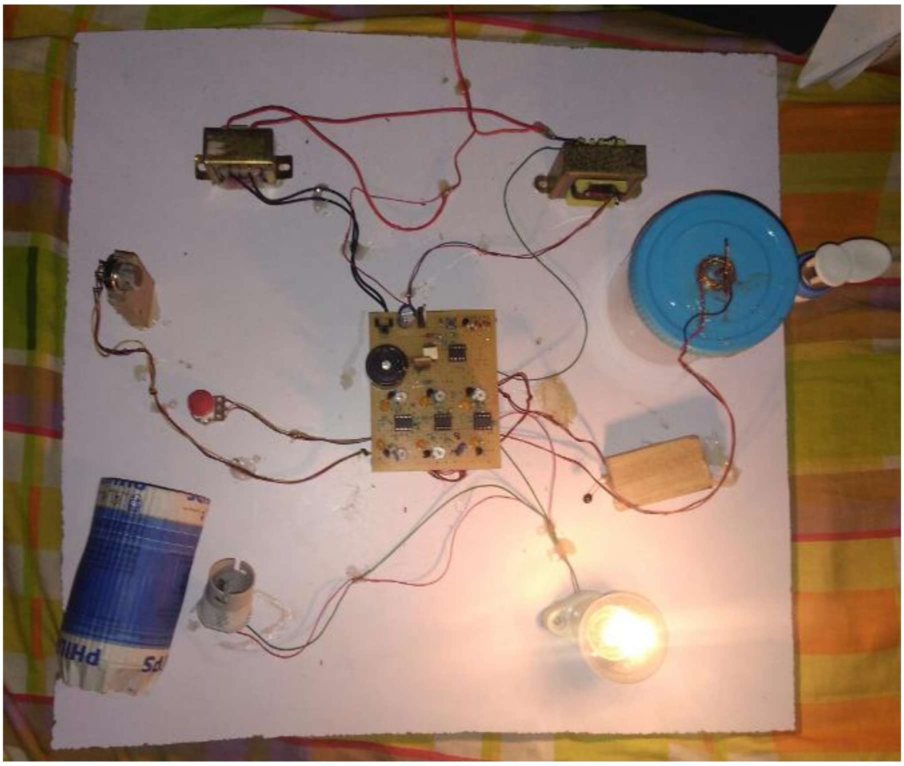


Figure 8b.

Figure 8a, 8b: Hardware Implementation of the proposed structure

5. CONCLUSION

This device designed for field application. The following sensor and transducers are connected to sense the different physical and electrical parameters,

1. Over Voltage detector
2. Over temperature
3. Over Current detector
4. Trace passing sensor

It was observed that the response is very fast and the system functions very much reliable to protect the devices. We observed that the Protection device designed here working properly which can be helpful for proper utilization of transformer without wasting the resources.

6. FUTURE EXPANSION

This device is basically an four Channel Logic controller. In future we can control it by using a microcontroller, which acts and operates according to the program loaded on the Microcontroller. The Microcontroller is a smart device so many functions can be incorporated without much change of hardware.

As the central device is a micro controller the status of different channels can be networked so that an ethernet enabled protection system or PLC can be developed. Also the inter networked PLC s can be used in cascaded format to increase device compatibility and dependability. The Present device is designed for 8 channels, whereas this can be expanded up to 256 channels without much modification in hardware and software.

This programmable Logic Controller operates with only digital input and digital outputs. Where as in the same principle, by using external ADC And DAC or by changing the processor to one having internal ADC and DAC built-in, analog input and output channels can be added up. The present days Microcontroller are very powerful and they have an option of In System Programming (ISP). This indicates that using this option this PLC can be made field Programmable.

REFERENCES

[1] Satya Kumar Behera, Ravi Masand, Dr. S. P. Shukla, "A Review of Transformer Protection by Using PLC System", IJDACR-Volume 3, Issue 2, September 2014.

[2] Rohan Perera & Bogdan Kasztenny, "Application Considerations When Protecting Lines With Tapped and In-Line Transformers", previously presented at2014 Texas A&M Conference for Protective Relay Engineers, © 2014 IEEE

[3] Manoj Tripathy , R. P. Maheshwari & H. K. Verma (2005) "Advances in Transformer Protection: A Review, Electric Power Components and Systems", 33:11, 1203-1209, DOI: 10.1080/15325000590951618

[4] A Unique Transformer Protection which Eliminates Over-Voltage, Over-Fluxing, and CT Saturation Protection B AI-Fnkhri. Senior Member. IEEE 2002

[5] Songlin Chen, Haiying Li, Yuping Zheng, Guorong Shen, "New Scheme for Transformer Protection", Print ISBN**:** 0-7803-7459-2, IEEE Xplorer, 10th December 2002

[6] T.S.Madhavrao, "Power System Protection n-Static Relays", TMH Publication.