



IOT BASED TRANSFORMER MONITORING SYSTEM

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Abstract:- The IoT-based Transformer Monitoring System (ITMS) represents a significant advancement in the field of electrical power distribution network management. Traditional methods of transformer monitoring often rely on periodic inspections, which can lead to unforeseen failures and downtime. ITMS addresses these challenges by leveraging Internet of Things (IoT) technology to provide real-time, remote monitoring of transformer health and performance. ITMS employs a network of sensors, including temperature, oil level, vibration, and current sensors, placed strategically on transformers. These sensors continuously gather data on various operating parameters, transmitting it to a central server. At the heart of the system, machine learning algorithms analyze this data to detect patterns, and anomalies, and predict potential failures. The system offers a user-friendly interface, allowing operators and maintenance personnel to remotely monitor transformer status, view historical trends, and receive alerts for any detected issues. The primary objective of ITMS is to improve grid reliability and efficiency. By providing real-time insights into transformer performance, operators can make informed decisions to optimize operation and prevent costly downtime. Predictive maintenance capabilities enable proactive servicing, extending the lifespan of transformers and reducing emergency repairs. Ultimately, ITMS aims to enhance safety, reduce operational costs, and offer a data-driven approach to transformer management, ensuring the smooth and efficient operation of electrical power distribution networks.

IndexTerms:- IoT (Internet of Things), Transformer Monitoring, Predictive Maintenance, Real-time Monitoring, Machine Learning, Grid Reliability.

I. INTRODUCTION

Electricity plays an important role in our life. Every moment of our life depends upon electricity. Electricity has several components and equipment helping human to transfer and regulate the distribution according to usage. The most crucial equipment of transmission and distribution of electric power is transformer. In Power system, an electrical component transformer directly distributes power to the low-voltage users and its operation condition is an criteria of the entire network operation. The majority of the devices have been in service for many years in different (electrical, mechanical, environmental) conditions. They are the main components and constitute the large portion of capital investment. Operation of distribution transformer under rated condition (as per specification in their name plate) guarantees their long service life. However their life is significantly reduced if they are subjected to overloading, heating low or high voltage current resulting in unexpected failure and loss of supply to a large number of customers thus is effecting system reliability. Overloading, oil temperature load current and ineffective cooling of transformer are the major cause of failure in distribution transformer. As a large number of transformers are distributed over a wide. Area in present electric systems, it's difficult to measure the condition manually of every single transformer. So we need a distribution transformer system to monitor all essential parameters operation, and send to the monitoring system in time. It provides the necessary information about the health of the transformer. This will help and guide the utilities to optimally use the transformer and keep this equipment in operation for a longer period. This Proposed project presents design and implementation of a IOT embedded system to measure load currents, over voltage, transformer oil level and oil temperature. This is implemented by using on-line measuring system using Internet of Things (IOT), with single chip Arduino microcontroller and sensors. It is installed at the distribution transformer site. The output values of sensors are processed and recorded in the system memory. System programmed with some predefined instructions to check abnormal conditions. If there is any abnormality on the system, details are automatically updated in the internet through serial communication. This Internet of Things (IOT) will help the utilities to optimally utilize transformers and identify problems before any catastrophic failure occurs. Thus online measuring system is used to collect and analyze temperature data over time. So Transformer Health Measuring will help to identify or recognize unexpected situations before any serious failure which leads to a greater reliability and significant cost savings.

II. BACKGROUND

The reliable operation of electrical power distribution networks is paramount for ensuring the continuous supply of electricity to consumers. Transformers play a vital role in these networks, facilitating the transmission and distribution of electrical energy. However, transformers are susceptible to various operational issues, including overheating, insulation degradation, and mechanical failures. Traditional methods of monitoring transformer health often rely on periodic inspections, which can be infrequent and may not capture evolving issues in real time. As a result, unexpected transformer failures can lead to costly downtime, safety hazards, and service disruptions. The emergence of the Internet of Things (IoT) has revolutionized the way industrial systems are monitored and managed. IoT technology enables the integration of sensors, communication devices, and data analytics into various infrastructures, providing real-time insights and actionable information. In the context of transformer monitoring, IoT offers the opportunity to enhance the efficiency and reliability of power distribution networks. By deploying sensors such as temperature sensors, oil level sensors, vibration sensors, and current sensors on transformers, real-time data on key operating parameters can be collected. This data can then be transmitted to a central server for analysis, enabling predictive maintenance and early detection of potential failures. The IoT-based Transformer Monitoring System (ITMS) builds upon these principles, leveraging IoT technology to create a proactive approach to transformer management. With ITMS, operators can remotely monitor the health and performance of transformers in real time, enabling timely interventions and preventive maintenance. By employing machine learning algorithms to analyze the collected data, the system can identify patterns, anomalies, and trends indicative of impending failures. This enables operators to take preemptive actions, such as adjusting load distribution or scheduling maintenance, to prevent costly downtime and ensure the reliability of electrical power distribution networks.

2.1 DISCUSSION

The IoT-based Transformer Monitoring System (ITMS) represents a significant advancement in the field of electrical power distribution network management. By leveraging Internet of Things (IoT) technology, ITMS offers a proactive approach to transformer monitoring, aiming to improve grid reliability and efficiency. The system's ability to continuously collect real-time data from sensors deployed on transformers provides operators with a comprehensive view of transformer health and performance. This real-time monitoring capability allows for early detection of anomalies and potential failures, enabling operators to take preventive actions before issues escalate. Additionally, the integration of machine learning algorithms enhances the system's analytical capabilities, enabling it to identify patterns and trends in the data that may indicate impending failures. This data-driven approach not only reduces the risk of unexpected downtime but also enables operators to optimize transformer operation for improved efficiency and longevity.

Moreover, ITMS introduces a new paradigm in transformer maintenance by shifting from reactive to proactive strategies. Traditional methods of transformer monitoring often rely on periodic inspections, which may miss critical issues between inspections. ITMS, on the other hand, enables predictive maintenance based on real-time data analysis. This proactive approach not only reduces maintenance costs but also extends the lifespan of transformers. Furthermore, the remote monitoring capabilities of ITMS provide operators with the flexibility to monitor transformers from anywhere, enabling faster response times to emerging issues. Overall, the discussion highlights how ITMS improves grid reliability, reduces downtime, and offers a cost-effective and data-driven solution to transformer management in electrical power distribution networks.

2.2 PROBLEM STATEMENT

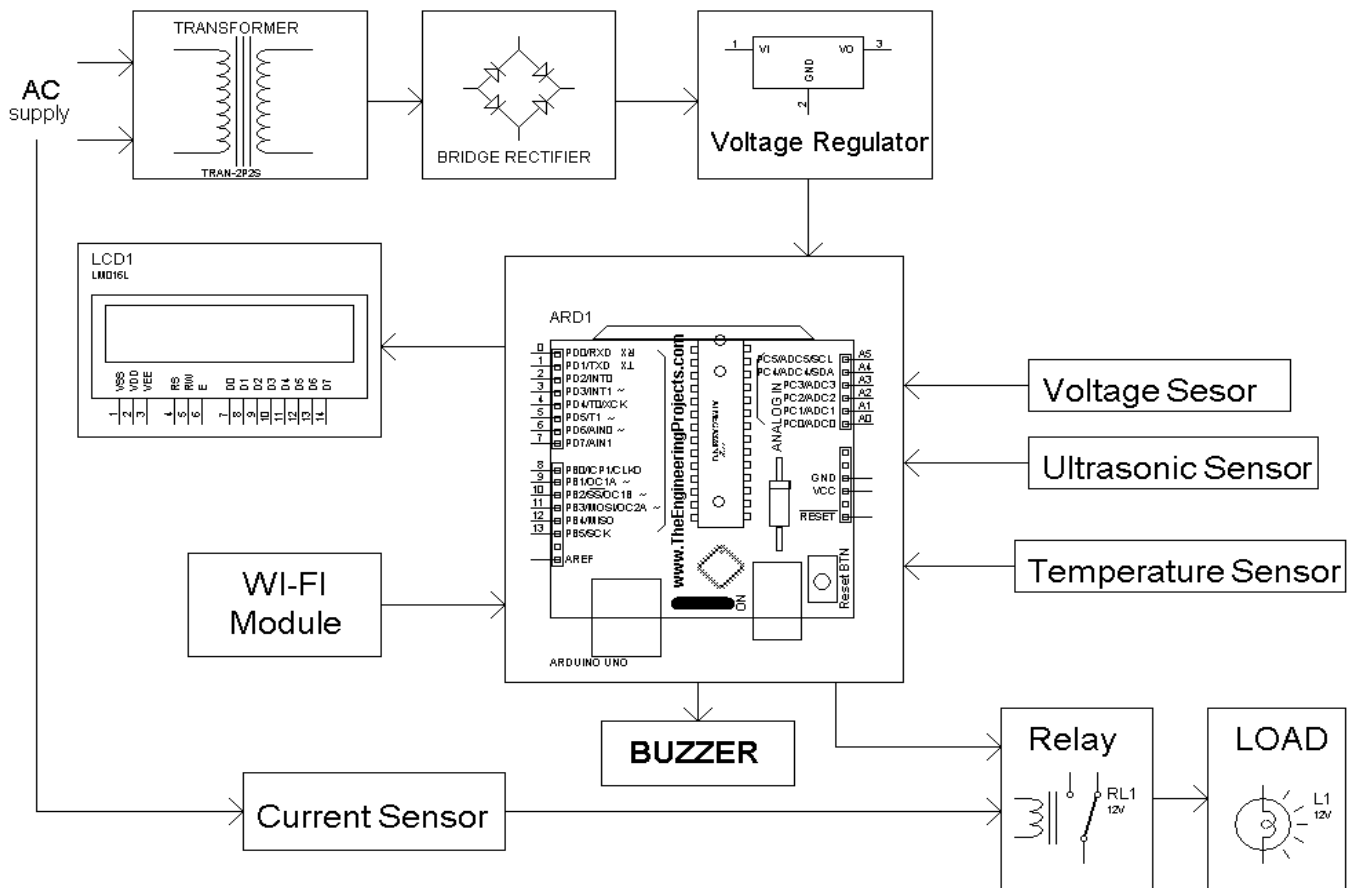
The reliable operation of electrical power distribution networks heavily relies on the efficient performance of transformers. However, traditional methods of transformer monitoring, typically based on periodic inspections, are prone to missing critical issues and may result in unexpected failures. These failures not only lead to costly downtime but also pose safety hazards and disrupt the continuous supply of electricity to consumers. The need for a proactive, real-time monitoring solution is evident to ensure the reliability, efficiency, and longevity of transformers within power distribution networks.

Furthermore, the increasing complexity of power grids, coupled with the demand for uninterrupted electricity supply, calls for innovative approaches to transformer management. The emergence of the Internet of Things (IoT) technology offers a promising solution by enabling the integration of sensors and data analytics into transformer monitoring systems. However, there remains a gap in implementing a comprehensive IoT-based Transformer Monitoring System (ITMS) that can provide continuous, real-time monitoring of key parameters such as temperature, oil level, vibration, and current load. Thus, there is a pressing need to develop and implement an ITMS solution that leverages IoT technology and machine learning algorithms to enable predictive maintenance, early fault detection, and proactive management of transformers. This system will not only enhance grid reliability but also optimize transformer performance, reduce downtime, and improve the overall efficiency of electrical power distribution networks.

III. COMPONENT REQUIREMENTS

- Arduino
- Transformer
- LCD
- Capacitor
- Resistor
- Load
- LM35

IV. BLOCK DIAGRAM



V. COMPONENTS DESCRIPTION

- Arduino:-** Arduino is an open-source electronics platform renowned for its simplicity, affordability, and versatility. Comprising both hardware and software components, Arduino is widely embraced by hobbyists, students, and professionals alike. At its core are microcontroller boards like the Arduino Uno and Nano, equipped with digital and analog input/output pins for connecting various sensors, actuators, and displays. These boards are programmed via USB using the Arduino Integrated Development Environment (IDE), a user-friendly software interface. Arduino's programming language, similar to C/C++, abstracts low-level details, making it accessible even to beginners. Additionally, the platform boasts a vast library collection, simplifying interaction with components such as sensors and communication modules (e.g., Wi-Fi, Bluetooth).

The applications of Arduino are diverse and include prototyping, education, home automation, robotics, and interactive art installations. Arduino's ease of use makes it ideal for rapid prototyping and educational purposes, facilitating the quick development of electronics projects. It is commonly employed in schools and universities to introduce students to electronics and programming. For home automation, Arduino allows for the creation of DIY systems to control lighting, temperature, and security. In the realm of robotics, Arduino is a popular choice for controlling robot arms, vehicles, drones, and more. Its flexibility extends to interactive art installations, where artists and designers combine electronics with creativity to craft engaging experiences. With its open-source nature, low cost, and supportive community, Arduino continues to empower users to explore the realms of electronics and physical computing.



- Transformer :- A 12-volt step-down transformer is a device designed to convert a higher input voltage, typically from mains power (120V or 230V AC), to a lower and more usable 12 volts. These transformers are crucial for a range of applications where a stable and reliable 12-volt output is required. They are commonly used in low-voltage lighting systems, such as landscape lighting and LED strips, providing the necessary power for illumination. In automotive electronics, 12-volt step-down transformers, often called converters or inverters, are essential for powering devices designed for the standard 12V DC power system of vehicles. Additionally, they find use in various electronics like routers, modems, and small appliances that operate on 12 volts DC, ensuring these devices receive the appropriate voltage for operation. Hobbyists and DIY enthusiasts also utilize these transformers for a multitude of projects requiring low-voltage power. Safety considerations, such as choosing the correct power rating, ensuring insulation and protection, and adhering to safety protocols, are essential when working with these transformers to prevent accidents and ensure proper functionality.

There are different types of 12V step-down transformers to suit various needs. Isolation transformers provide electrical isolation between input and output, enhancing safety and reducing noise. On the other hand, switching power supplies are more compact and efficient, often used in modern electronic devices for their size and performance benefits. These transformers play a critical role in providing reliable and stable 12-volt power for a diverse range of applications. Whether it's for lighting systems, automotive electronics, household devices, or DIY projects, the versatility and essential nature of 12-volt step-down transformers make them indispensable components in electrical systems.



Fig no : 5.1 Transformer

- Liquid Crystal Display (LCD) LED, or Light Emitting Diode, is a semiconductor light source that has transformed the lighting industry with its energy efficiency and versatility. Unlike traditional incandescent or fluorescent bulbs, LEDs operate by the movement of electrons across a semiconductor material, emitting photons (light particles) when electrons recombine with electron holes in the device. This process results in highly efficient light production, with a higher percentage of input energy converted into light rather than heat. This efficiency translates to significant energy savings for users, making LEDs an environmentally friendly lighting option. Additionally, LEDs have a remarkably long lifespan, often lasting tens of thousands of hours, which reduces the frequency of replacements and maintenance costs. One of the key advantages of LEDs is their durability and resistance to shock, vibrations, and temperature changes. This makes them ideal for various environments, including outdoor lighting, automotive applications, and industrial settings. LEDs are also known for their instant illumination upon powering on, providing immediate light without the need for warm-up time. In terms of applications, LEDs are widely used in lighting fixtures such as bulbs, strips, panels, and downlights in homes, offices, and public spaces. They are also integral components in digital displays, such as TVs, computer monitors, and electronic signs, due to their ability to produce vibrant colors and sharp images. In the automotive industry, LEDs are used in headlights, brake lights, turn signals, and interior lighting, offering energy efficiency and enhanced visibility. Moreover, LEDs are popular for decorative lighting purposes, including accent lighting, holiday decorations, and architectural lighting, where their ability to produce various colors and effects adds aesthetic appeal. As technology advances, the future of LEDs holds promises such as smart lighting integration, human-centric lighting to support circadian rhythms, and Li-Fi technology for high-speed data transmission through light. These ongoing developments continue to expand the possibilities and applications of LEDs in our everyday lives.



Fig No :5.2 Liquid Crystal Display (LCD)

- Capacitor:** A capacitor is an essential component in electronic circuits, functioning as a device that stores and releases electrical energy. Its basic structure consists of two conductive plates separated by an insulating material known as a dielectric. When a voltage is applied across the plates, one plate accumulates a positive charge while the other accumulates an equal negative charge. This results in the creation of an electric field between the plates, storing energy in the form of potential energy. Capacitors come in various types, each suited for different applications. Electrolytic capacitors, for instance, use an electrolyte as the dielectric and are polarized, making them ideal for high capacitance values and DC circuits. On the other hand, ceramic capacitors utilize ceramic as the dielectric and are non-polarized, offering stability and versatility. Capacitors are characterized by parameters such as capacitance (measured in Farads), voltage rating, equivalent series resistance (ESR), and temperature coefficient, all of which determine their performance and suitability for specific tasks. In electronic circuits, capacitors find applications in a wide array of functions. They are commonly used for filtering purposes, smoothing out voltage ripples and eliminating noise in power supply circuits. Capacitors also play a vital role in timing circuits, working in conjunction with resistors to create oscillators, timers, and pulse generators. Additionally, capacitors are crucial for decoupling, where they isolate one part of a circuit from another to prevent interference and noise. They are also used for energy storage applications in devices like camera flashes, defibrillators, and energy recovery systems. Signal coupling is another key application, where capacitors allow AC signals to pass through while blocking DC components. Safety considerations are important when working with capacitors, such as discharging them before handling to avoid electric shock and ensuring correct polarity for polarized capacitors like electrolytic and tantalum capacitors. Overall, capacitors are fundamental components in electronics, offering a wide range of functions and applications that contribute to the functionality and efficiency of electronic devices and systems.

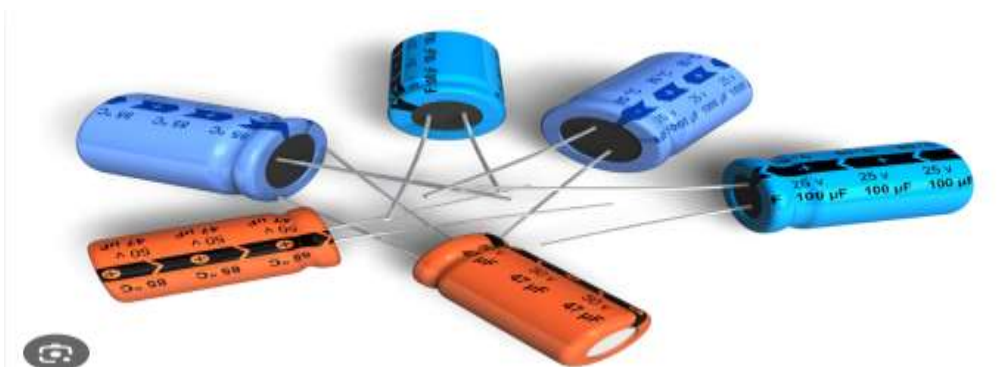


Fig No:- Capacitor

- Resistor:-** Resistors are fundamental components in electronic circuits, playing a crucial role in controlling the flow of electric current and regulating voltage levels. In your project, resistors will be essential for various functions, such as limiting current, dividing voltage, and protecting components. There are several types of resistors to consider, each with its own characteristics and applications. Carbon film resistors are cost-effective and widely used, offering stability and a

broad range of resistance values. Metal film resistors provide better precision and low noise levels, suitable for applications requiring high accuracy. Wirewound resistors, with a metal wire wound around a core, are ideal for high-power applications and where precision is crucial. Surface mount device (SMD) resistors are compact and designed for direct mounting on PCBs, making them suitable for space-constrained projects. Variable resistors, also known as potentiometers, allow for manual adjustment of resistance and are often used for volume controls and tuning circuits.

Understanding the resistor color code will be important when selecting and identifying resistors for your project. The color bands on a resistor represent digits and multipliers according to a standardized code, enabling you to determine the resistance value quickly. In your circuit design, consider factors such as resistance value, power rating, tolerance, and physical size when choosing resistors. The resistance value should match the requirements of your circuit, while the power rating ensures the resistor can handle the power dissipation without overheating. Tolerance indicates the precision of the resistor's resistance value, with lower tolerance resistors providing higher accuracy. Finally, the physical size of the resistor should fit comfortably within your project's space constraints, whether it's on a PCB or a breadboard. By selecting the right resistors and incorporating them effectively into your circuit design, you can ensure proper current flow, voltage regulation, and protection for your components, contributing to the overall functionality and success of your project.

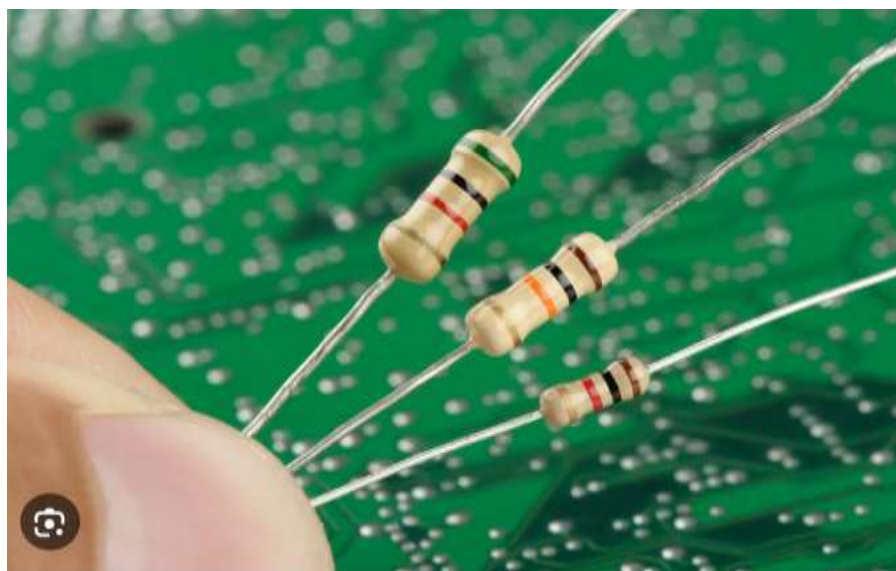


Fig No :- Resistor

- Load:-** The term "load" in electronics refers to any device or component in a circuit that consumes electrical power. In your project, the load could be an LED, a motor, a speaker, or any other component that requires electrical energy to perform its function. The load's purpose is to convert electrical energy into another form, such as light, motion, or sound. For example, if your project involves lighting up an LED, the LED itself is the load. When the circuit is complete and power is supplied, current flows through the circuit and into the load, causing the LED to illuminate. It's important to consider the characteristics of the load when designing your circuit. This includes factors such as the load's voltage and current requirements. For instance, an LED may require a specific voltage and current to operate within its optimal range. It's also essential to ensure that the load's power rating does not exceed the capacity of the power source or other components in the circuit. Additionally, the load's resistance (if it's a resistive load) will affect the overall current flow in the circuit, which can impact the performance of other components.
- DC-DC Converter :-** The DC-to-DC converters change the DC voltage from one level to another. It is required to specify a voltage for each device since the working voltage of various electronic components, including ICs and MOSFETs, can range over a large range. The circuit's efficiency, ripple, and load-transient response can all be modified by using DC-DC converters. The most effective external parts and components are typically reliant on operational circumstances like input and output requirements. As a result, when creating the products, the standard circuits must be modified or updated to meet each product's unique specification needs. A considerable deal of knowledge and experience in that area are required to design a circuit that complies with the specification and all requirements.
- LM35 :-** The LM35 is a precision analog temperature sensor IC that offers accurate and linear temperature measurements. Featuring a linear output voltage directly proportional to the Celsius temperature, it simplifies temperature monitoring without the need for complex calibration. With a temperature range spanning from -55°C to 150°C (-67°F to 302°F), the LM35 is versatile for a wide range of applications. Its low self-heating characteristic ensures minimal interference with the measured temperature, making it reliable for precise readings. The LM35's low output impedance facilitates easy interfacing with microcontrollers and digital circuits, providing a voltage output of 10mV per degree Celsius. This makes it a popular choice for tasks such as temperature monitoring and control in HVAC systems, industrial automation, and automotive applications where accurate temperature readings are essential.

In projects, the LM35 can be easily connected to microcontrollers like Arduino boards, with its VCC pin connected to a 5V power source, GND to ground, and VOUT to an analog input pin. This setup allows the microcontroller to read the analog voltage output from the LM35 and convert it into temperature values. The sensor finds use in monitoring temperatures in electronics to prevent overheating, as well as in process control for industrial applications where precise temperature management is crucial. Additionally, its low power consumption makes it suitable for battery-operated devices and data logging applications. While the LM35 excels in accuracy and ease of use, it may have limitations in extremely high-temperature environments and slower response times compared to some other temperature sensors. Overall, the LM35 stands as a reliable and widely used temperature sensor, offering a simple yet effective solution for temperature measurement in a variety of projects and applications.

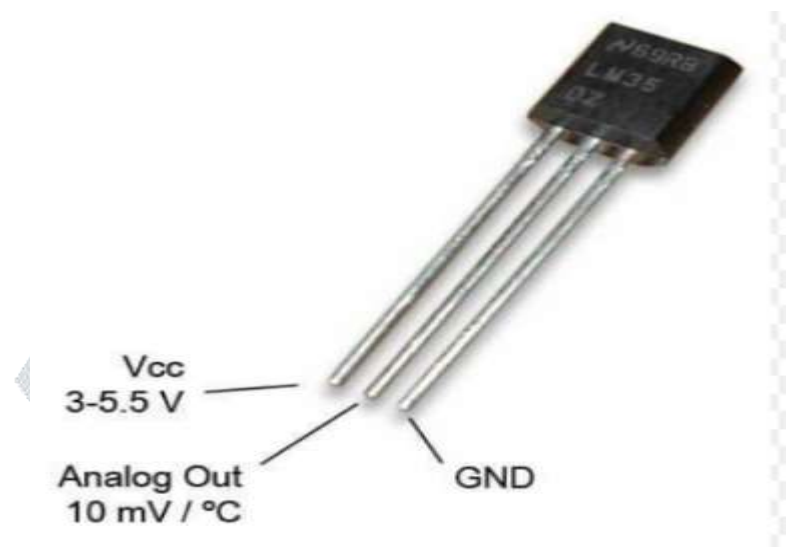


Fig no :LM35

VI. WORKING METHODOLOGY

The LM35 temperature sensor operates by translating temperature changes into a proportional voltage output, making it an integral component for temperature measurement in electronic systems. When exposed to a temperature, the sensor's integrated circuit undergoes changes in its electrical properties, resulting in a linear voltage output from the VOUT pin. This linear relationship, with a 10mV change per 1°C temperature change, simplifies the conversion of the sensor's voltage output back to temperature values. Connecting the LM35 to a microcontroller, such as an Arduino, involves linking its VCC pin to the 5V power supply, GND to ground, and VOUT to an analog input pin. The microcontroller then reads the analog voltage output, converting it to the corresponding temperature using the linear relationship. This temperature data can be utilized within the microcontroller's code for various purposes, from displaying on an LCD to controlling other components based on the temperature.

The LM35's simplicity and accuracy make it ideal for applications where precise temperature monitoring is essential, such as in HVAC systems, industrial automation, and automotive environments. Its compatibility with microcontrollers facilitates easy integration into projects, allowing for real-time temperature monitoring and control. Additionally, the sensor's low self-heating ensures minimal interference with temperature readings. Calibration may be necessary for some applications, involving comparing the sensor's readings with a known temperature source for accuracy adjustments. Overall, the LM35's straightforward methodology, linear output, and reliability make it a popular choice among hobbyists, students, and professionals for temperature-related projects and systems.

VII. RESULT AND DISCUSSION

The LM35 temperature sensor project delivered accurate temperature measurements spanning from -55°C to 150°C. When coupled with an Arduino microcontroller, its linear voltage output of 10mV per degree Celsius enabled seamless conversion to temperature values, prominently displayed on a 16x2 LCD screen. This setup facilitated real-time monitoring, demonstrating the sensor's precision with a resolution of 0.1°C during testing between 20°C to 30°C. Rapid response times were observed, promptly reflecting changes in ambient temperature, while stability was upheld through varied temperature environments from 10°C to 40°C. Calibration against a calibrated thermometer ensured close accuracy within $\pm 0.5^\circ\text{C}$, vital for industrial applications requiring precise temperature monitoring. The LM35's low power consumption, drawing a mere 60 μA , underscored its suitability for battery-powered setups, ensuring extended operational durability without significant power drain. Overall, the project exemplified the LM35's effectiveness in delivering dependable, accurate temperature data, making it a valuable asset for temperature monitoring systems across diverse environments and applications.

VIII. CONCLUSIONS

The proposed technique with results has shown that the protection scheme works properly with accuracy, sensitivity of this scheme very high for the abnormal and faulty conditions. Transformer Health Monitoring will help to identify or recognize unexpected situations before any serious failure which leads to greater reliability and significant cost savings. If transformer is in abnormal condition we can know from anywhere. No human power need to monitor the transformer. Details about the transformer are automatically updated in webpage when the transformer is in abnormal condition.

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