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Advancement in the Conventional Winding Temperature Indicator/Oil Temperature Indicator of Transformer Using Internet of Things

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ABSTRACT

Internet of Things (IoT) is an Industry 4.0 Technology that is rapidly getting implemented in the industries and is replacing the conventional and obsolete parts of the machines. In a transformer, the rise in temperature of the winding and the transformer oil, which is the most common coolant, beyond a certain limit signifies that the insulation may be damaged. Conventionally, the protection scheme implied is the Oil Temperature Indicator (OTI) and the Winding Temperature Indicator (WTI). This work uses IoT to transmit and deploy alarms based on wireless and cloud technologies which significantly increased the efficiency of the protection scheme. The hardware model developed attempts to incorporate the benefits of the IoT and deploy the alarm message and alarm sound in significantly lesser amount of time and enable the required safety measures to be taken as soon as possible.

Keywords—Internet of Things (IoT), Oil Temperature Indicator (OTI), Transformer Oil

I. INTRODUCTION

Measurement of transformer oil temperature is an essential step in the current power protection scheme. An increase in the temperature of the transformer oil can lead to decrease in the dielectric strength, thereby, leading to failure of insulation in transformer windings [1]. Hence, the goal of the present work is to develop a setup that can efficiently deploy alarms (alarm buzzer as well as alert messages over Telegram application) on rise of temperature oil beyond a certain threshold temperature.

The term Internet of Things (IoT) is used to refer to the combination of real-world objects or things and the embedded technologies such as sensors and software that enable the exchange of real time data between two or more devices over the internet [2], [3], [4], [5], [6]. IoT comprises most of what is considered for Industry 4.0.

The IoT comprises of four main components –

1) Sensors
2) Connectivity
3) Data Processing, and,
4) User Interface (*here, Telegram Application*)

The sensor used is LM 35 RTD sensor, while the user interface is Telegram application and a Buzzer.

II. HARDWARE CONNECTIONS

A. LM -35 RTD Sensor

The LM-35 is a temperature sensor that operates at low voltage and offers high precision in measuring temperature in degrees Celsius. This chip outputs a voltage that increases in a linear fashion with the temperature, making it straightforward to use in various applications.

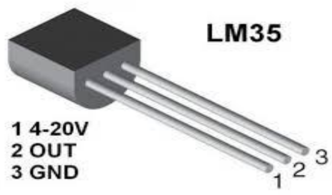

Fig.1. LM -35 Sensor

Calibration details for LM 35 Sensor:
Temperature in °C = (Sensor Value/10.24)
The LM-35 used here comes with an in-built voltage divider circuit in Fig. 2. Thus, it gets the sensor value in a suitable and usable form and it makes it easier to process the data in program code [7].

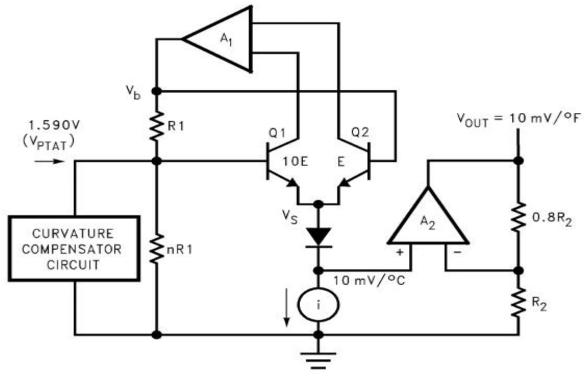

Fig.2. Circuit Diagram of LM 35 Sensor

B. IOT Module

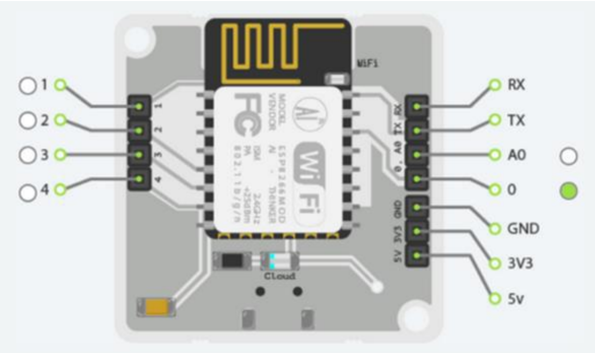

Fig.3. Bolt IOT Wi-fi module

C. BUZZER

Buzzer is an electronic device, which when supplies with power, produces sound [8]. Here, it has been used as an alarm.

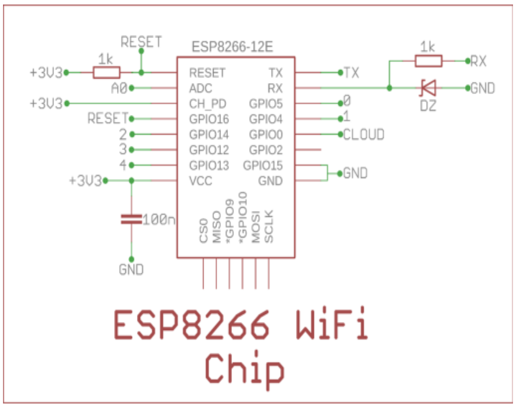

Fig.4. ESP8266 Chipset used in IOT Module

D. WTI & OTI (*Winding Temperature Indicator and Oil Temperature Indicator*)

For the protection of transformers various types of protection schemes and data observation are being used as given in Table I. For overheating protection of winding and transformer oil winding temperature indicator (WTI) and oil temperature indicator (OTI) are used respectively.

Table I: Winding Temperature Indicator

WTI Alarm	85^0 C
WTI Trip	95^0 C
Oil Temperature Indicator	
OTI Alarm	80^0 C
OTI Trip	90^0 C

III. COMPLETE BLOCK DIAGRAM AND WORKING OF PROPOSED SCHEME

As depicted in Fig.5 complete block diagram of proposed scheme followed the steps as mentioned below:

Step-1: Power supply and Internet connectivity is provided to ESP8266 (chip).

Step-2: LM-35 (Temperature Sensor) and Buzzer (alarm) interfaced with ESP8266 chipset

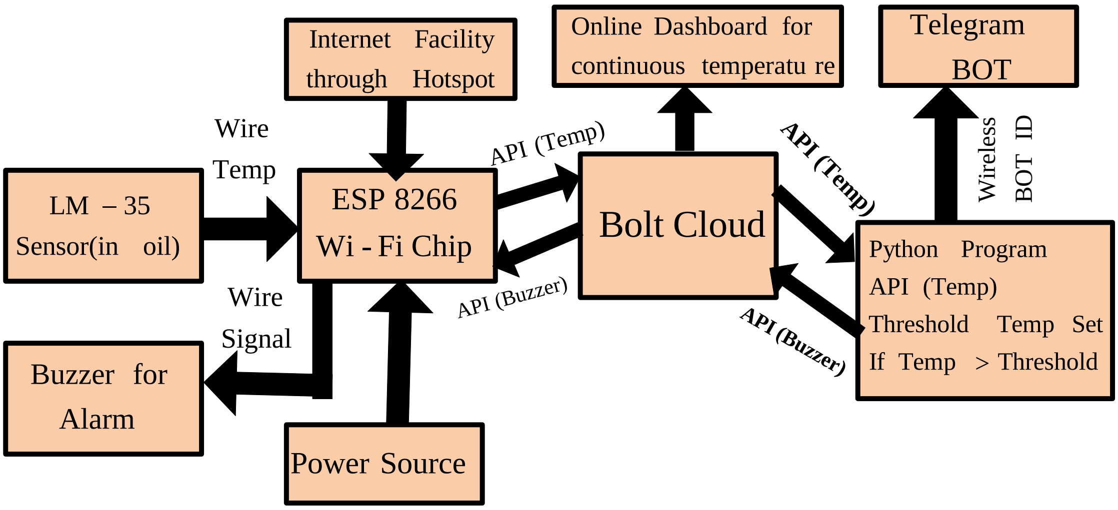

Fig.5. Complete block diagram of the proposed scheme.

(a) Coded on BOLT cloud to let the chip know which pins are used for which input or output device.
(b) Hardware connections are made.

Step-3: Sensor takes in data (temperature) and send to ESP8266 which sends to BOLT cloud.

Step-4: Python program used to access the temperature data from BOLT cloud using application programming interfaced (APIs) in which calculation is done so that signal is sent.

(a) To BOT (over telegram) when Temp > Threshold.
(b) API sent to BOLT cloud to trigger buzzer.

(i) Code for 'conf.py' file :-

```
bolt_api_key = "5c8a45e5-804b-4798-9717-6d5fd94a0cc5"
device_id = "BOLT2706650"
telegram_chat_id = "@mad_bolt"
telegram_bot_id = "bot1754814225:AAFEchAPI5HWDg9BdzkA1C96mypWM-QYZK8"
threshold = 102.4
```

The conf.py is the configuration file for the project. It describes the following data components: -

a) API Key for two-way communication with the Cloud Server.

b) Device Id to recognize the ESP-8266 Chipset and transmit data/signal to it.

c) Telegram Bot Id to communicate with the Telegram Bot and Telegram Chat Id to enable the Bot write on the Telegram Interface (Telegram group).

d) Threshold determines the sensor value beyond which the alarm shall be given over the telegram interface/buzzer.

Note :- This is NOT in °C. Appropriate Conversion Formula for conversion is mentioned in the project description.

The telegram_alert.py is the program file which needs to be run for the project hardware's to communicate with each other and also takes care of the orchestration or order in which the execution is to be carried out.

Firstly, import the required in-built libraries provided by the Python programming community to use in built functions. Also, import the aforementioned configuration file.

Next, defined the function get sensor value from pin to extract data from the ESP 8266 chipset. Moreover, defined a try - catch block for exception handling in the process.

The next function send telegram message enables to send any required message to the Telegram.

The following code is the project logic which converts the extracted sensor value to °C value and defines the comparison logic between threshold described in the configuration file and the sensor value received.

Note :- The comparison has been done in form of sensor value which is not in °C but the value that has been sent to Telegram is in °C. The conversion formula has been used after comparison and before transmission of data.

Flexibility in the code :-

a) The time period can be altering at which the value is being extracted from the chipset. A more precise operation shall require quick extraction, which may increase the cost of operation.

b) The threshold value can be mutated according to the need of operating values, but attention should be given that the value defined for threshold must NOT be °C but according to the sensor requirements.

IV. EXPERIMENTAL HARDWARE SET-UP

The hardware set up is as depicted in the following image. The Bolt IoT Wi-fi module is interfaced with the Buzzer, and the LM-35 sensor has been programmed for both of the devices to work simultaneously according to their needs.

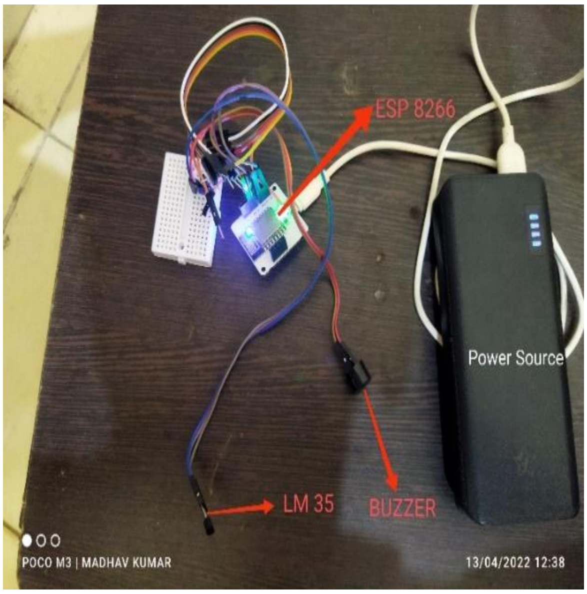

Fig.6. Hardware Set – Up

V. EXPERIMENTAL SET-UP

The final experimental set up is depicted in the following image which consists of the ESP 8266 hardware set-up integrated with LM 35 sensor dipped in transformer oil. Provisions have been made to heat the oil and alcohol thermometer is used for the manual temperature reading.

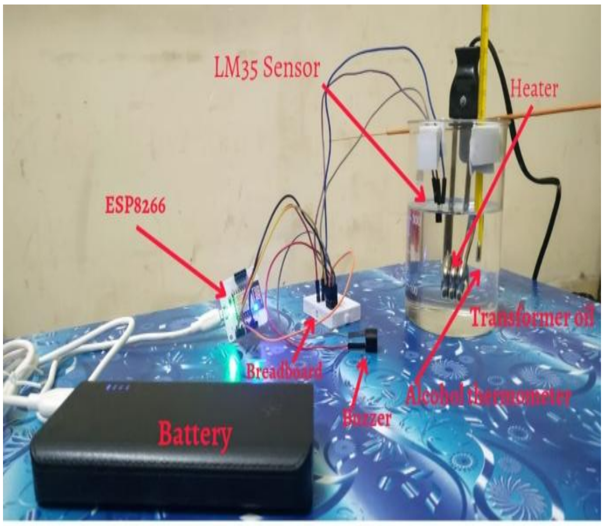

Fig.7. Experimental Set-Up

VI. EXPERIMENTAL DATA

A set of experimental readings were noted down at intervals of time to compare between the temperature of transformer oil via Alcohol Thermometer and the temperature reading provided by the hardware set up as given in Table II. Moreover, as per given data in Table II a graph is plotted as shown in Fig.8.

Table II: Experimental Data on Transformer Oil

Threshold Set= 10 ^{0}C				Testing Date :- 05-05-2022	
Sl. No.	Temperature Reading from LM 35 Sensor(in ^{0}C)	Temperature Reading on Thermometer (in ^{0}C)	Error (in ^{0}C)	Time	Alarm Status
1	35.44	37	1.56	0 sec	ON
2	39.45	40	0.55	20 sec	ON
3	41.5	42	0.5	30 sec	ON
4	47.16	45	-2.16	50 sec	ON
5	54.78	55	0.22	60 sec	ON
6	58.88	58	-0.88	70 sec	ON
7	61.42	63	1.58	80 sec	ON
8	67.67	69	1.33	90 sec	ON

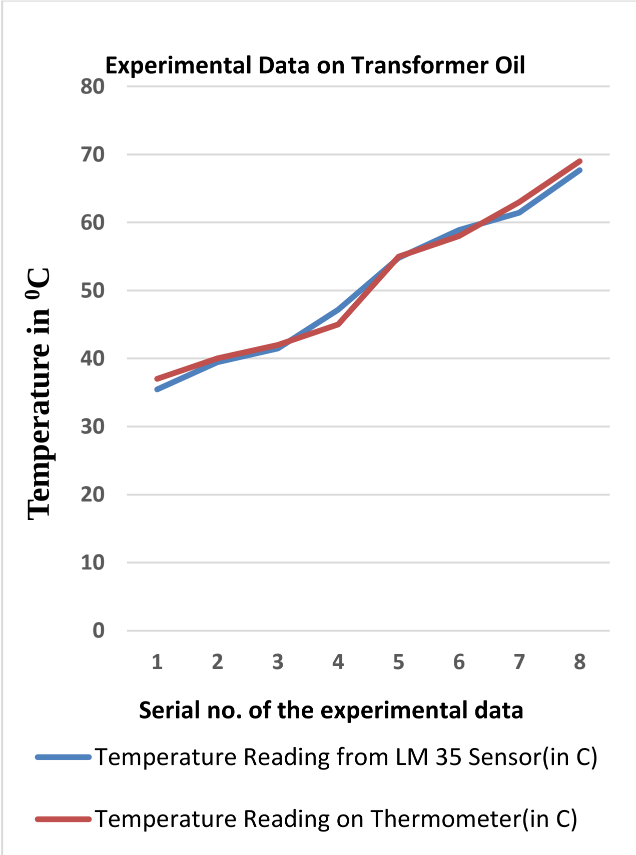

Fig.8. Experimental test results on transformer oil.

VII. CONCLUSION

This paper presents a set up for measuring the transformer oil temperature using differential measurement approach. For this purpose, LM 35 sensor, a highly accurate sensor has been used. The temperature reading on the thermometer is found very close to that of the reading received over Telegram from the sensor. The buzzer alerts are received with high efficiency and accuracy and promises the replacement for conventional WTI/OTI.

Also, the Bolt IoT wi-fi module (ESP 8266) used here has 5 GPIOs which can be used to extend the services to more than one output device like Alert Led, cooling fan, tripping circuit etc. The overall structure of the setup is favorable commercially for industries as well.

Moreover, this IoT based structure will result in receiving alarms on the web application for any defilements in the rated values of parameters, so that a speedy action can be taken to avoid any risky failures in the distribution network.

VIII. REFERENCES

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