REVIEW ARTICLE

Monitoring and Control of Operational Parameters of Distribution Transformer using IoT Technology

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ABSTRACT: Distribution transformers are one of the most important equipment in power system network. Because of the large numbers of transformers are widely used in the power system, Therefore the data acquisition and monitoring is important issue in the large distribution network. The main objective of this proposed work is that distribution transformer monitoring and controlling through IoT technology. The signal is sent to control room using a IOT technique interfaced with WI FI connectivity. When the power supply is interrupted due to faults in the one transformer then load sharing is done on the other transformer through IoT technology, If any deviation in the operational parameter or any disturbance occurs, the system sends SMS (short message service) messages to the mobile phones containing information about the deviation according to some predefined instructions programmed in the micro controller to safeguard the transformer against technical problems like over working temperature, low oil level and over load. At present man power is employed and there is no accuracy, safety and reliability for distribution of power supply. Therefore proposed work is designed efficiently to overcome these problems using IoT technology.

KEYWORDS: Aurdino controller unit, rectifiers, relays, voltage regulators, sensors, distribution transformers, IoT, Wifi modems, mobile phone, Cloud and Aurdino software.

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1. INTRODUCTION

The IOT based monitoring of distribution transformer is rather useful as compared to the manual operating system. In case of manual monitoring system it is not possible to monitor the oil level, rise in oil temperature, rise in ambient temperature, over load detection etc. These problems are addressed in this proposed work. Since large numbers of distribution transformers are being employed in distribution network. Therefore it is required to take adequate initiation against problems related to power distribution area. This proposed work is designed for online monitoring of key operational parameters of distribution transformers, which will provide useful information about the overall condition of distribution transformers using IoT technique. By that information the power supplier can minimize the losses due to distribution transformer and improve the power supply quality and reliability to greater extent. When such system is adopted to each distribution transformer in the distribution network, device will keep track of each operational parameter of the transformer. If any abnormal values of parameter exist, immediately SMS will be sent to the section in charge and concerned technician. Thereafter immediate corrective measure will be taken against the problem.

2. LITERATURE SURVEY

Design and implementation of a mobile embedded system to monitor and record operational parameters of a distribution transformer such as loading condition, transformer oil level and winding temperature etc., Abnormal values of operational parameters message will be sent to mobile device using a GSM network[1]
Monitoring of loading condition of power lines and communicating to control room using SMS based GSM technology. This methodology is design and implementation using embedded system to monitor and record load fluctuations with respect to current and voltage in power lines and it isolates the power lines during abnormal loads. [2]

Online monitoring system integrates the GSM modem with a single chip microcontroller and sensors. It is implemented at the distribution transformer side. Also this system to protect distribution transformers from overheating and overloading [3]

Comparison of many combinations ways of internet of things and power, the oil based transformer monitoring system is analysed, but it has high cost, loss data and feedback control of function. This system uses a single bus multi point temperature measurement method and GSM network remote control and data processing combined, so that speed of the temperature and its analysis becomes improved also accuracy of system is also improved, reducing the cost of temperature monitoring system and using the remote control module to avoid the failure of transformers. [8]

Design and implementation of a system to monitor and record operations of a distribution transformer like over voltage, over current, temperature, rise or fall of oil level. [9]

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3. Block Diagram and Methodology

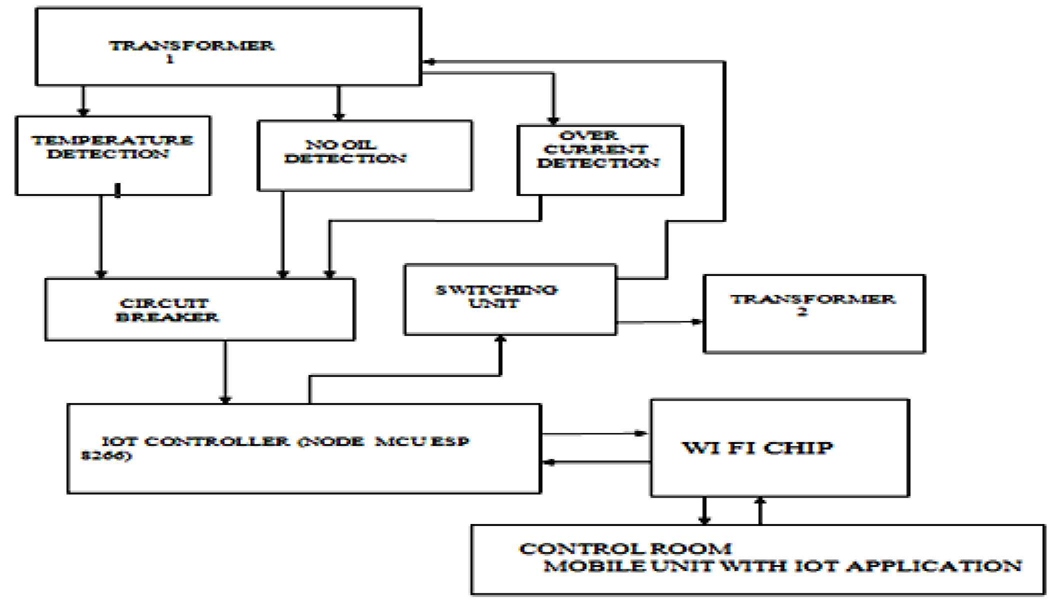

Fig 1: Block Diagram

3.1 Mode of Operation

Temperature sensing unit

To protect the transformer against over temperature sensing circuit is designed with Thermistor, OP_AMP, which sense the working temperature of pump. The Thermistor is used as a "thermal sensitive resistor". The Thermistor resistance is very high at normal temperature. Here the OP_AMP is used as a voltage comparator. As soon as temperature increases its resistance decreases which increases the voltage at Pin No 3 i.e. non-inverting terminal of the OP_AMP. Now because of this condition the potential difference between two inputs at comparator also changes and the output of the comparator goes from its low to high state to activate (Saturate) the transistor. The collector of the transistor further drives the signal to microcontroller .As long as the temperature is maintained high the OP_AMP output remains in the same state. When pump temperature falls down on Thermistor, its resistance goes to increase. This shows a decrease in voltage at Pin No 3. Because of this condition the OP_AMP i.e. comparator output changes from its high to low state. At this instant the transistors goes to cut-off and the collector signal connect to switching unit which disables the transformer to prevent the damages.

3.2 Oil Level Detection Circuit

For the sensing of oil level in the transformer can be possible with contact type sensor which goes to detects the level of the oil and also indicate the leakage conditions also. The copper conducting probe detects the level of the oil by providing the number of sensors at different intervals. When the oil level falls below the safe limit the circuit breaker stops the functioning of the transformers and prevents the damages to the transformer. The circuit is designed with op amp IC 741.

3.3 Over Load Detection Circuit

The over current can be detected with transistorised circuit which goes to detect the excess current flow. The excess current flow indirectly give the indication of power theft in the areas if the area usage exceeds the limit of current this leads to damage the transformer and also leads to excess heating also. As the transistor base circuit detects the excess current the circuit breaker breaks and stop the working of transformer which prevents the damages. The level of current sensing for every transformer cab be possible to set separately also. The opto-coupler in the circuit provides the isolation in from transformer input supply to electronic circuit.

The signals from all the sensors are fed to IOT controller which is inbuilt flash memory and the program is written in the memory unit. When any of the sensor gets activated this data reads through controller port and push the stack pointer to fetch the signal and send serially from serial via WI FI chip. As soon as the message appears in user mobile, IOT application environment with pop up message and alert indication were given. In response to this message the control room operator sends the required action buttons through IOT application platform. Now the required action string reaches to the hardware unit through server and reaches to IOT module and the switching action takes place.

4. CIRCUIT IMPLEMENTATION

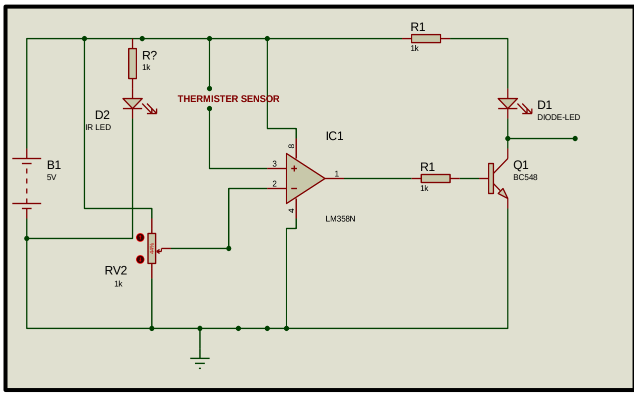

Fig 2: Circuit Diagram of Temperature Sensing

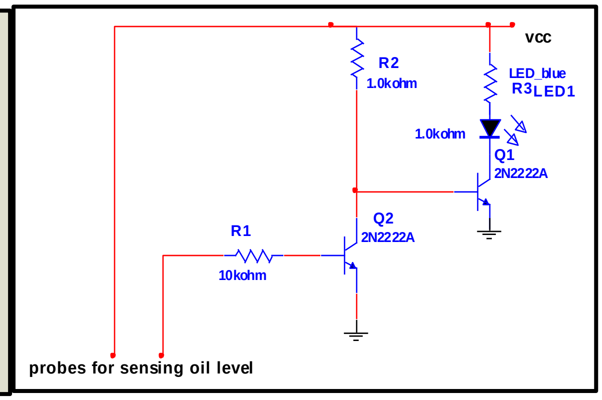

Fig 3: Circuit Diagram of Oil Level Sensing

4.1 Temperature Sensing Circuit

A temperature Sensing circuit is designed with thermistor sensor and OP_AMP(IC LM358), and Transistor as given in fig 2. The thermistor sensor converts the temperature variations in to difference in the resistance. The resistance variation is inversely proportional to temperature. Here the OP_AMP is used as a voltage comparator. The sensor is connected to the non-inverting terminal Pin No 3 of the OP_AMP to provide the potential difference. The inverting terminal Pin No 2 of the OP_AMP get the potential difference & variable resistor (10 KΩ), to adjust the Reference Voltage or a set value of the parameter. The LED connected at the collector gives an indication of sensing temperature when it exceeding the threshold value.

When the temperature value exceeds the predefined safe value Because of this condition the voltage at Pin No 3 i.e. non-inverting terminal of the OP_AMP changes and its output goes high which in turn activate (Saturate) the transistor. This signal is given connected to buzzer, transmitter, relay or microcontroller unit to take further actions like alert indication, exhaust fan system , cooling system etc.

4.2 Oil Level Sensing Circuit

The circuit of fig 3 is used to sense the presence of oil in the transformer. This circuit indicates if the oil level goes low or the absence of oil in transformer is indicated. The circuit consists of probes for sensing the oil which is dipped in the oil at a certain level. Whenever there is presence of oil, oil acts as conducting medium between the probes and the circuit is completed and base voltage is applied to the transistor (q2) and transistor gets saturated, the collector of that transistor is given to the base of the other transistor, that base of (q1) gets the more negative voltage compare to the +ve voltage from the vcc supply because of this the transistor q1 is in cut-off state and led is in off state.

If the oil level goes lower than the required level the probes become open and the q2 transistor is in cut off state (transistor does not saturate) and the more positive signal enters into the q1 transistor and it gets saturated and the LED glows to indicate the absence or lower level of the oil at the transformer. Indication is made with led only if there is low level or absence of oil at the transformer.

Relay Interface

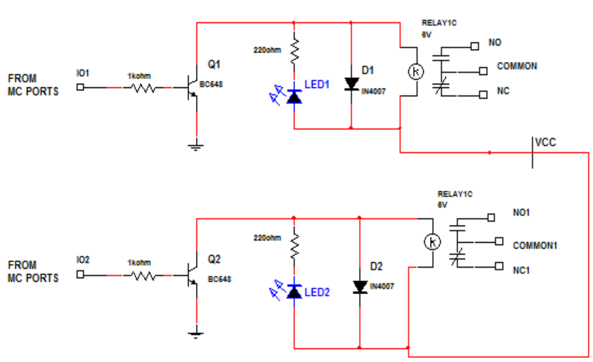

Fig 4: Circuit Diagram of Relay Interfacing for Protection

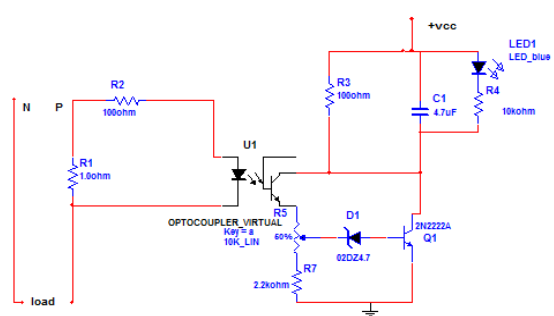

Fig 5 .Circuit Diagram of Overload Detection

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Over Load Detection

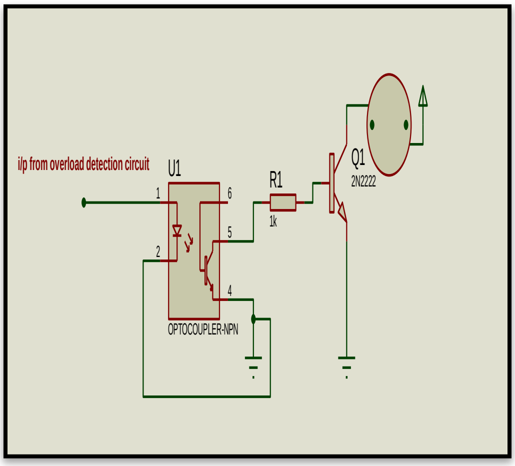

Fig 6: Circuit Diagram Of Over Load Detection

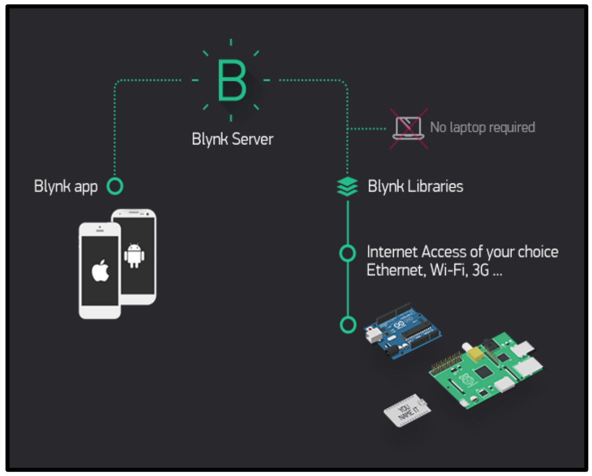

Fig 7: Model Of Blynk's Application

The circuit diagram shows the connection of Relay Driver Circuit. When the logic signal from controller or any other circuits like timers pamps is applied to base of the transistor through resistor 1KOhm .When base signal is high, transistor saturates and it energizes the relay. The transistor act as a small signal amplifier resistor of 1KOhm is used to provide proper emitter base voltage to turn the transistor to ON state from OFF state.

Relay is an electromechanical switch & it works on the principle of energizing an electromagnet. It consists of primary coil, 2 contacts, one is normally open contact "NO" & the other is normally closed contact "NC"& pole normally identified a common. When relay is in off state the pole (common) is connected to normally closed (NC contact). The load may be a fan or dc motor or heater coil, when transistor starts conducting current starts flowing through the coil. Which develops its own magnetic flux when the strength of current is suitable; whenever a sufficient flux is produced it attracts the pole to make contact with normally open position 'NO'. Hence the load connected to it performs its operation until the contact is broken. A diode connected in parallel across the primary coil is to eliminate the effect of back EMF on the transistor. Relays have great application in industry. Using the principle of energizing an Electromagnet we can handle large voltages & current application without the risk of shocks.

This circuit presented here can be used to detect over load condition resister 1ohm 10W is used as a over load sensing element. When the load exceeds the maximum rated value it draws current in excess of its rated value. This causes the potential drop across resister to increase. An optocoupler is used to sense this voltage drop.
The optocoupler will isolate the ac mains from the faulty circuit. When the load exceeds 500 watts, the transistor inside the optocoupler senses this voltage and its collector current increases proportionally. When the current reaches the required designed value, voltage drop across resistor –preset combination also increases. Overload limiting point can be set by preset. When the potential is greater than zener diode, it causes forward biasing of transistor .this results in conduct and this o/p now connects to the next optcoupler stage to run buzzer. The second optocoupler i/p signal is connected from the collector of the first transistor. The buzzer is connected across the second transistor collector which generates the buzzer sound when there is over load detected.

5. Mobile application

5.1 Working of BLYNK software

A prototyping board on Smartphone where tools can be drag and drop the sliders, displays, graphs and other functional widgets. These widgets can control Arduino and get data from it.

Blynk works over the internet. Main requirement is that hardware should fetch the internet by choosing either Ethernet, Wi-Fi or may be this new ESP8266, Blynk will replace all these functional features are more efficient and faster response.

5.2 Blynk's architecture

Currently, Blynk libraries work with this stuff:

i. USB
ii. Ethernet shield
iii. WiFi shield
iv. Arduino with Ethernet
v. Arduino YÚN (testing in progress)
vi. ESP8266
vii. Raspberry Pi (Blynk will communicate with Pi's GPIOs)
viii. More Arduino compatible shields and boards

Fig 8: Wi-Fi Module (Node MCU)

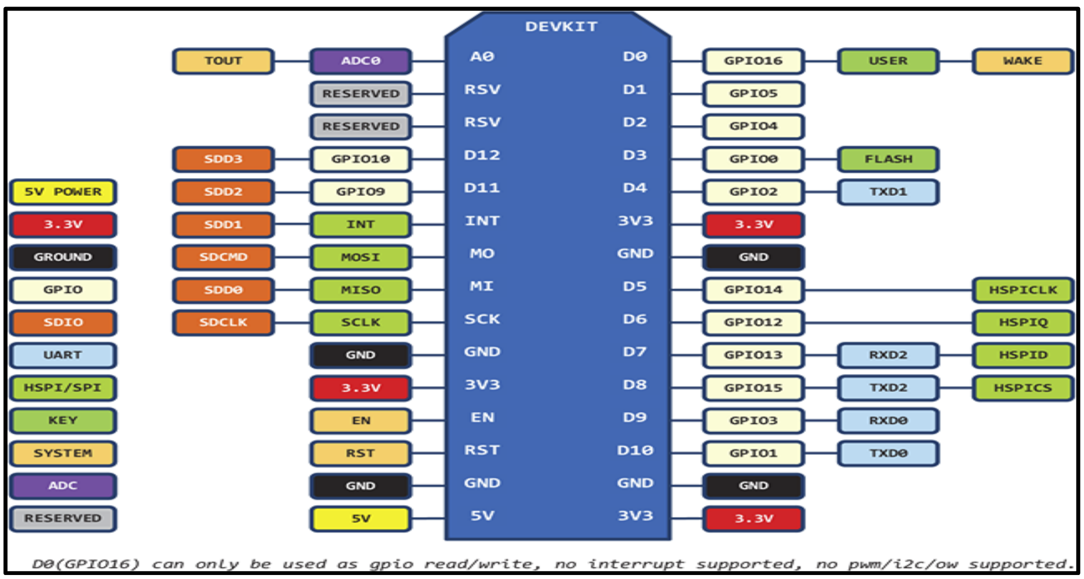

Fig 9: Pin configuration of Node MCU

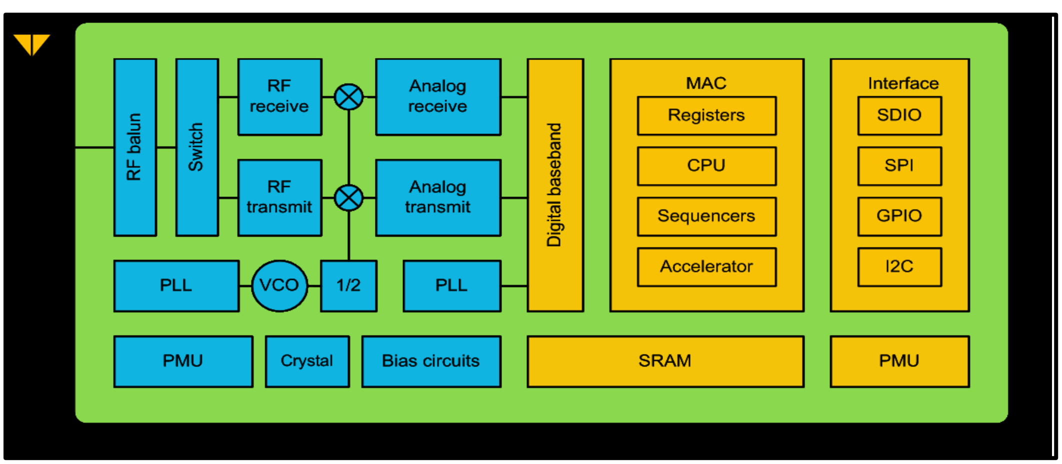

Fig 10: ESP8266EX Block Diagram

Node MCU is an open source IOT platform, which runs on the ESP8266 Wi-Fi . The term "Node MCU" by default refers to the firmware. The firmware uses the Lau scripting language. It is based on the Lau project, and built on the Espressif Non-OS SDK for ESP8266Node MCU was produced after the ESP8266 However. the ESP8266 is a Wi-Fi SOC integrated with a TensilicaXtensa LX106 core, widely used in IOT applications.

Node MCU is able to support the MQTT IOT protocol, using Lua to access the MQTT broker. Arduino.cc began developing new MCU boards based on non-AVR processors like ARM/SAM MCU and used in the Arduino Due, It need little modification for the Arduino IDE so that it would be compatible to change the IDE to support other alternate tools. A "core" is the collection of software components required by the Board Manager and the Arduino IDE to compile an Arduino C/C++ source file down to the target MCU's machine language. ESP8266 have developed an Arduino core for the Wi-Fi SOC. This is also known as the "ESP8266 Core for the Arduino IDE" and it has become one of the leading software development platforms for the various ESP8266 based modules and development boards, including Node MCUs. For more information on all things ESP8266, check out the ESP8266 Community Forum on GitHub.

5.3 ESP8266 Chip

Espressif Systems Smart Connectivity Platform (ESCP) ESP8266 CHIP is efficient wireless SOCs, designed for space application and power constrained mobile application. It works as a standalone application, with the lowest cost, and minimal space requirement.ESP8266EX provides good WiFi networking solution,it can be used to host the application or to access the WiFi networking functions from other processor also.

ESP8266EX hosts the application by booting up directly from an external flash. ESP8266EX is efficient integrated WiFi chip.

5.4 FEATURES

i. 802.11 b/g/n
ii. Integrated low power 32-bit MCU
iii. Integrated 10-bit ADC
iv. Integrated TCP/IP protocol stack
v. Integrated PLL, regulators, and power management units
vi. Supports antenna diversity
vii. WiFi 2.4 GHz, support WPA/WPA2
viii. Support STA/AP/STA+AP operation modes
ix. STBC, 1x1 MIMO, 2x1 MIMO
x. A-MPDU & A-MSDU aggregation & 0.4s guard interval
xi. Deep sleep power <10uA, Power down leakage current < 5uA
xii. Wake up and transmit packets in < 2ms
xiii. Standby power consumption of < 1.0mW (DTIM3)
xiv. +20 dBm output power in 802.11b mode
xv. Operating temperature range -40C ~ 125C
xvi. FCC, CE, TELEC, WiFi Alliance, and SRRC certified

The ChipESP8266 (presently ESP8266EX) is a chip with which manufacturers are making wirelessly networkable micro-controller modules. More specifically, ESP8266 is a system-on-a-chip (SOC) with capabilities for 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2), general-purpose input/output (16 GPIO), Inter-Integrated Circuit (I^2C), analog-to-digital conversion (10-bit ADC), Serial Peripheral Interface (SPI), I^2S interfaces with DMA (sharing pins with GPIO), UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2), and pulse-width modulation (PWM). It employs a 32-bit RISC CPU based on the TensilicaXtensa LX106 running at 80 MHz (or over clocked to 160 MHz). It has a 64 KB boot ROM, 64 KB instruction RAM and 96 KB data RAM. External flash memory can be accessed through SPI.

The Modules Various vendors have consequently created a multitude of modules containing the ESP8266 chip at their cores. Some of these modules have specific identifiers, including monikers such as "Wi07c" and "ESP-01" through "ESP-13"; while other modules might be ill-labeled and merely referred to by a general description — e.g., "ESP8266 Wireless Transceiver." ESP8266-based modules have demonstrated themselves as a capable, low-cost, networkable foundation for facilitating end-point IOT developments. Espressif's official module is presently the ESP-WROOM-02. The AI-Thinker modules are succinctly labeled ESP-01 through ESP-13. Node MCU boards extend upon the AI-Thinker modules. Olimex, Adafruit, Sparkfun, WeMos, ESPert (ESPresso) all make various modules as well. See the ESP8266 article on Wikipedia for more information about popular ESP8266 modules.

6. RESULTS AND DISCUSSION

Figures show the circuit of Oil level sensing unit which consists of probes for sensing the oil which is dipped in the oil at a certain level. Whenever there is presence of oil, oil acts as conducting medium between the probes and the circuit is completed and base voltage is applied to the transistor (q2) and transistor gets saturated, the collector of that transistor is given to the base of the other transistor, that base of (q1) gets the more negative voltage compare to the +ve voltage from the vcc supply because of this the transistor q1 is in cut-off state and led is in off state.

If the oil level goes lower than the required level the probes become open and the q2 transistor is in cut off state (transistor does not saturate) and the more positive signal enters into the q1 transistor and it gets saturated and the LED glows to indicate the absence or lower level of the oil at the transformer. Indication is made with led only if there is low level or absence of oil at the transformer. The signal from IOT is given to Blynk application through Wi-Fi module in the form of a pop-up notification to notify the operator as the oil level went low as shown in Fig 6.2.

OIL LEVEL DETECTION

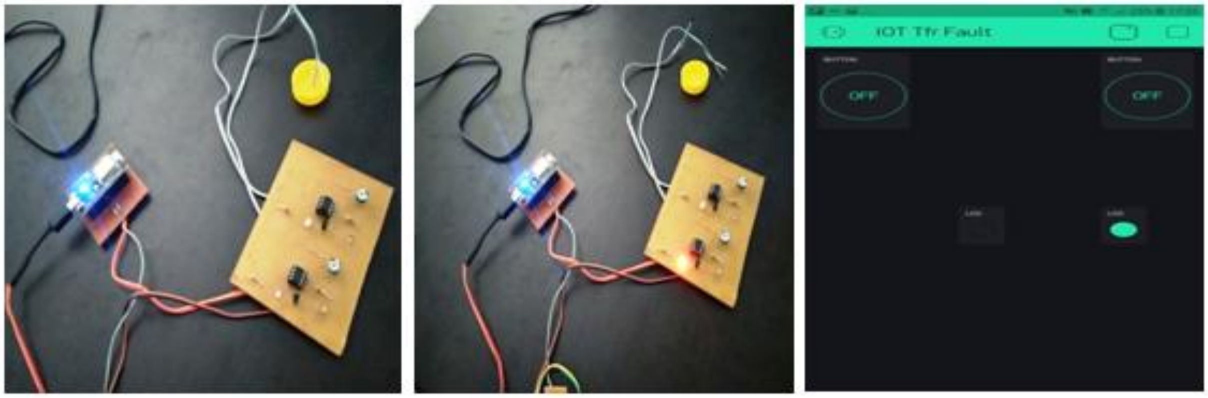

Fig 11: Output Oil Level Sensing Unit with IOT Interfacing

TEMPERATURE LEVEL DETECTION

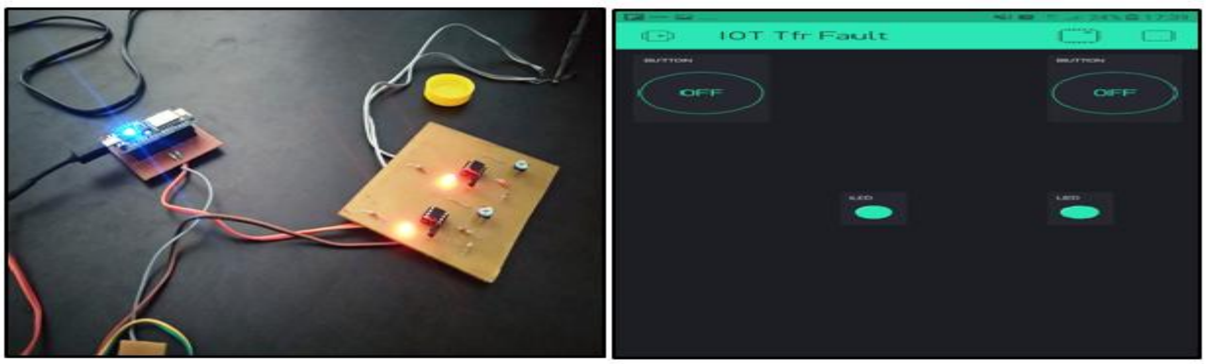

Fig 12: Output Temperature Sensing Unit

Figures shows the Temperature sensing unit which is used to detect the over temperature in the transformer by using IOT technology.The resistance variation is inversely proportional to temperature. Here the OP_AMP is used as a voltage comparator. The sensor is connected to the non-inverting terminal Pin No 3 of the OP_AMP to provide the potential difference. The inverting terminal Pin No 2 of the OP_AMP get the potential difference & variable resistor (10 KΩ), to adjust the Reference Voltage or a set value of the parameter. The LED connected at the collector gives an indication of sensing temperature when it exceeding the threshold value.

When the temperature value exceeds the predefined safe value Because of this condition the voltage at Pin No 3 i.e. non-inverting terminal of the OP_AMP changes and its output goes high which in turn activate (Saturate) the transistor. This signal is given to the Blynk application through Wi-Fi module in the form of pop-up notification to notify the operator that the temperature of the transformer has increased.

7. ADVANTAGES

i. Transformers can be operated in a safe condition.
ii. Transformer failure rate will be decreased.
iii. Quality and reliability of power supply will be improved.
iv. Maintenance cost will be reduced.
v. Distribution system losses will be minimized.
vi. Revenue generation could be improved.

8. CONCLUSION

This proposed work will addresses the problems in the present working scenario in an efficient manner. This review focuses much on the distribution transformer condition round the clock continuously. Monitoring the operational parameters of distribution transformer, results in the distribution of good quality of power supply, reliability and low maintenance.

By adopting proposed technology, it is possible to monitor the operational parameters like temperature, overload and oil level detection using IOT technology. This IOT based monitoring of distribution transformer health is quite efficient as compared with manual monitoring. Since the technology will track the transformer status round the clock and SMS will be sent to the concerned person if any abnormal situation occurs in the transformer and distribution system.

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