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Power Transformer Monitoring and Controlling using IoT

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Abstract

Transformers are very important device for transfer of electrical energy. This paper presents a new IoT (Internet of Things) framework for condition monitoring and controlling of larger number of distribution transformers as they are one of the influential and important equipment in the power distribution network. To protect transformer against different types of faults, various methods get used. In this system, overload protection is established for protection of transformer. Relay connected to the microcontroller is used to protect transformer.

Keywords: Current Sensor, microcontroller, relay, overload, transformer, internet of things.

1. Introduction

Reliability and safety issues of power system have been more important with progress and development of national economy and power system [1]. If we look back towards our daily routine we can conclude that electricity is the inseparable part of our life and transformers plays a role of electricity carrier to us from generation stations. Transformer is the key component in electricity distribution system. Hence protection of transformer is very important. Transformers are used in many applications i.e. from small projects to the mega industries [5]. Increasing population and machinery is resulting in more and more demand of power [4]. Transformers get overloaded due to illegal use of electricity. Overload affects the efficiency of transformer and electricity distribution system. So, the designed system involves automatic isolation of load to avoid damage to the transformer due to overloading. Therefore, a proposed method is chosen to design microcontroller-based transformer for overload protection. The microcontroller-based relay provides more adjustable characteristics, high accuracy, more flexibility, increased range of setting, and reduced size, minimum cost with many functions such as self-monitoring and checking by IOT technology.

2. Problem Statement

Modern power system requires accurate, reliable technique for detection of faults, real time data monitoring and fast response speed. The reliable operation of the power system depends upon the effective functioning of the distribution transformer. Microcontroller based system has real time data monitoring, detection of abnormal condition, fast processing speed, reduced installation cost low maintenance cost and more flexibility.

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3. Block Diagram

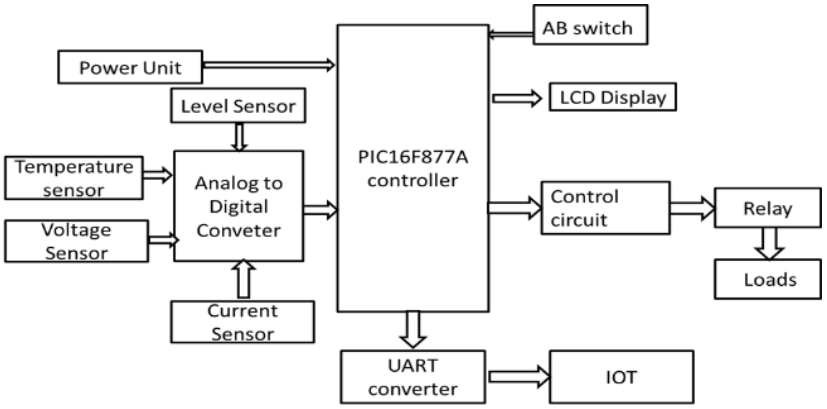

Figure 1 Block diagram of proposed method

This system is designed for online monitoring of distribution transformers parameter can provide useful Information about the transformers health which will help the utilities to optimally use their transformers and keep the asset in operation for a long time. In this system, we used three sensors for monitoring that is voltage sensor, a current sensor, and temperature sensor. Then the values of all the sensors are sent sequentially as per the frequency of multiplexing of the ADC by Microcontroller PIC16F877A and IOT Module. The power system any unbalance cortication informed IOT. AB switches open without permission informed officer using IOT. The design of a monitoring system that consists of a GSM modem that is integrated with standalone single chip embedded system to monitor and record key operation indictors of a distribution transformer like load currents, transformer oil and ambient temperatures. The paper is organized as follows; section two discusses the proposed hardware architecture. The power system any unbalance cortication informed IOT. And same time AB switch open without permission informed officer using IOT to this system.

4. Proposed Method

Avoiding equipment failures, reducing labor work, avoiding accidents due to faults, avoiding stealing of electricity etc. are the objectives of the system. We have used Proteus software for circuit simulation, PIC16F877a for programming the controller. The system is expected to isolate the load from transformer if the measured load current value exceeds the predefined value inside the controller. The system is also expected to send the values of sensed load current and load conditions to the android phone using IOT.

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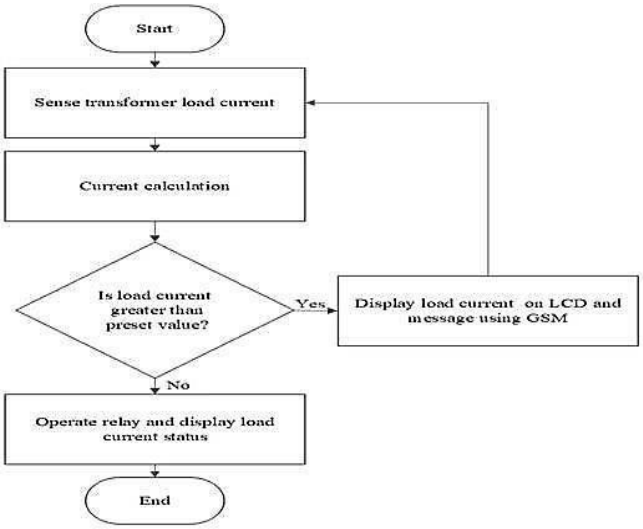

Figure 2 Flowchart for transformer load conditions

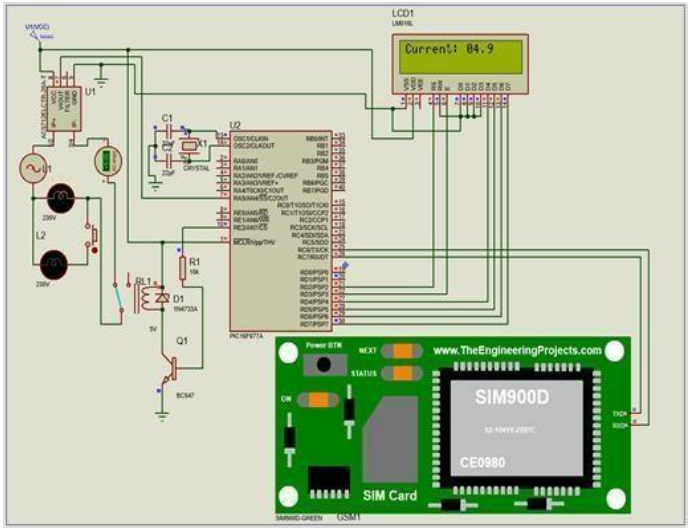

Figure 3 Circuit diagram

In the circuit diagram shown above alternator is used to generate 230V supply. Two lamps are connected in parallel which acts as loads to the alternator which represents the distribution transformer in the system. The current sensor is connected in series with the loads alternator and relay to measure the amount of load current. Output of current sensor (analog) is given to the microcontroller to convert it into the digital values. Further LCD is connected to microcontroller to display load current values and IOT to send data and status of load to android phone. Relay is connected to one of the port pins of microcontroller to control the load. This circuit is designed to monitor overloading and to protect transformer from damage by overloading. Here, Reference value of load is set. If load exceeds reference value then microcontroller send trip signal to transistor and relay will trip within microseconds. As relay will trip, transformer will be disconnected from load. At the same time IOT will send information to the prescribed web page.

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Components Used

- Transformer
- Power Supply Circuit
- Current Sensor
- Voltage Sensor
- Relay
- ADC Converter
- Internet of Things
- Microcontroller

Principle Components

Microcontroller

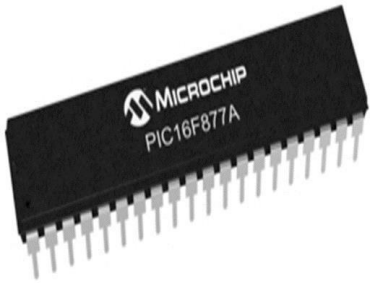

Figure 4 Microcontroller PIC16F877A

PIC16F877A is the brain of this protection circuit. This microcontroller has on chip ADC which converts analog values to digital values. This sampled value compared with pre-set values and decision is taken according to programming, hence microcontroller is decision making device. As compared to microprocessor microcontroller have simple structure and fast responding capacity. Power consumption is less for PIC16F877A microcontroller. It has wide range of temperature so it can be used in most of the systems. Along with specifications mentioned above the microcontroller have few more specifications as mentioned below:

- Voltage - Supply (Vcc/Vdd): 4 V ~ 5.5 V
- Core Size: 8-Bit
- Speed: 20MHz
- Data Converters: A/D 8x10b
- Connectivity: I²C, SPI, UART/USART
- Program Memory Size: 14KB (8K x 14)
- EEPROM Size: 256 x 8
- RAM Size: 368 x 8
- Operating Temperature: -40°C ~ 85°C (TA)
- Voltage Sensor.

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Voltage sensor is the electrical device which produces an analog output which is proportional to AC input. Sensor can measure voltage up to 440 V.

Voltage sensor -General Specifications

- Active High Shutdown Pin
- 100 kHz Wide Bandwidth
- Unity Gain 1V/V

Current Sensor

Current sensor is the electrical device which produces an analog output which is proportional to AC input. Sensor can measure current up to 20A.

ACS712 20A Current Sensor - General Specifications

- Bidirectional current sensing up to 20A
- Electronic isolation by Hall Effect
- Adjustable bandwidth
- Wide operating temperature range
- ACS712 20A Current Sensor - Technical Specifications:
- Operating Voltage: 3-5V
- Internal Resistance: 1.2mΩ
- Operating Temperature: -40ºC – 85ºC

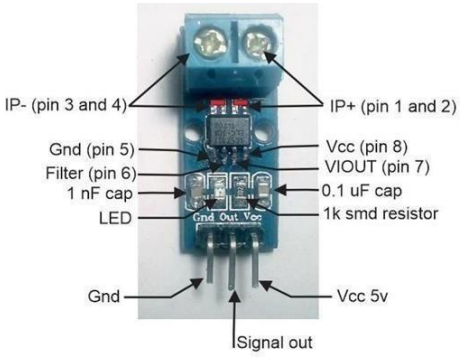

Figure 5 Current sensor (ACS712-20A module)

Relay

It is an electrically operated switch. When current exceed their limits, coil actuates which operate either to close open contacts or to open close contacts. It gives high reliability, safe disconnection from the main supply. It has longer life.

Specifications of Relay are:

- Supply Voltage: 3.75 to 6 V

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- Supply Current with Relay De-Energized: 2 mA
- Supply Current with Relay Energized: 70 to 72 mA
- Input Control Signal: Active Low
- Input Control Signal Current: 1.5 to 1.9 mA
- Relay Max Contact Voltage: 250 VAC or 30 VDC
- Relay Max Contact Current: 10 A
- Relay is used just like a switch to isolate load from transformer and it get operated by the microcontroller.

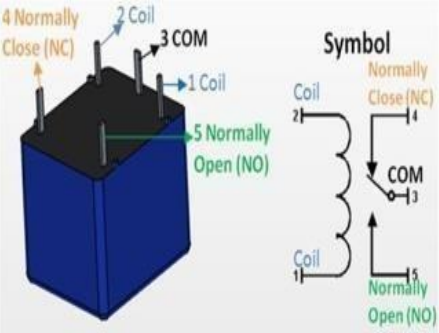

Figure 7 Relay

4.2.4 16×2 LCD

It has (16×2=32) 32 characters in total and each character is made of 5×8-pixel dots. Specifications of 16x2 LCD are:

- Built-in controller (ST7066 or Equivalent)
- +5V power supply only
- Negative voltage optional for +3V power supply
- 1/16 duty cycle
- White LED backlight not available.

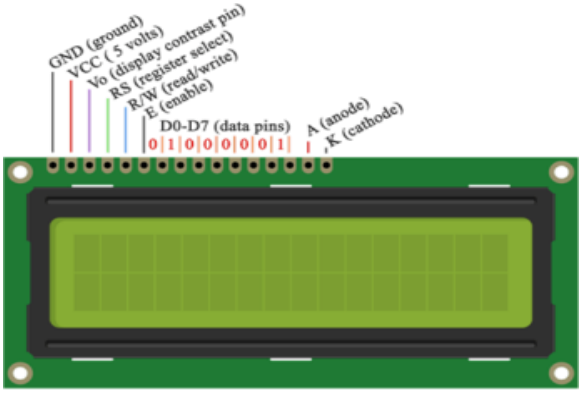

Figure 6 16×2 LCD

4.2.5 Wi-Fi- Module

The ESP8266 Wi-Fi module is one of the leading platforms in internet of things. It is

connected to micro control board to access the web. The Wi-Fi module is a very cheap and available in low cost. However this module is already preloaded in firmware with set up 9600 baud rate. This module consists of 8 pins Tx, Rx, Vcc, reset, CH-EN CPIO-0, 1 pin.

The CPIO pin is connected to receiver pin through USB board. They communicate pic16c877a configuration is employed to attach with Wi-Fi module. It requires 3.3v only. The main exciting feature of ESP8266 module that can be programmed using the pic16c877a IDE which makes it a lot more user friendly.

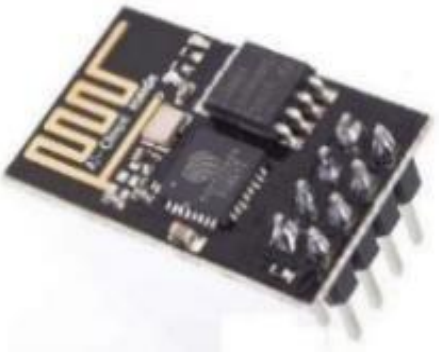

Figure 8 Wi-Fi module (ESP8266)

5 Implementation & Methodology

For continuous monitoring the transformer is connected with oil level sensor, temperature sensor, current sensor and voltage sensor to measure the parameter of the transformer. When the supply is given to the transformer, it began to operate. The sensor will start to sense the parameter of the transformer and the sensed data were given to the controller pic16c877a. The parameters of the transformer were monitored continuously. From the controller, the data were uploaded in the cloud using Wi Fi modulo 8266. Wi Fi modulo is operated with the help of an internet. Here we used GOOGLE platform for upload, view and for controlling. The data or parameter of transformer is viewed through mobile. When any parameter values exit its value or range, an intimation will received through mobile app and also can control through it. The relay was connected between the transformer and controller. When the parameter of the transformer exits its limited range or value, the motor get trip through the relay.

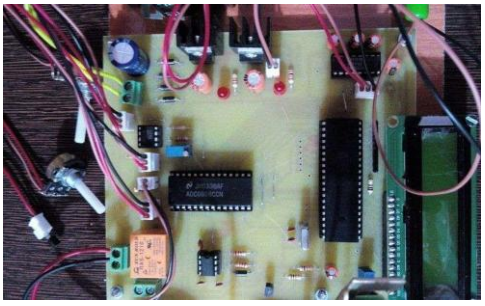

Figure 8 Hardware Kit

6 Results and Discussions

After testing of proposed system, it provides following results:

- Current>20A=Current Fault
- Voltage>440V=Voltage Fault
- Temperature>500C=Temperature Fault
- Oil Level <30ML = Oil Level Fault

Therefore any abnormality condition occurred in above rated condition, these changes shown in LCD at RTU side, also same data monitored at monitoring node send via IOT system on webpage. All above results for normal conditions of parameters are displayed on webpage.

7 Conclusion

This system provides transformer protection using microcontroller-based relay. For transformer current sensing circuits were designed and results have been verified with proteus simulation. Proposed method is economical and compact in size.

8 Future Scope

The system has following future scopes which makes system more reliable and effective:

- System will be capable of communicating in both directions.
- System will be able to measure more transformer parameters.
- Data at monitoring station will get updated whenever requested by monitoring person.

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