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IoT Based Transformer Monitoring and Control

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***Abstract*—Transformers are very important device for transfer of electrical energy. 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. Simulation circuit is designed in proteus software and programming is done in MPLAB software.**

***Index Terms*— Current Sensor, GSM Module, Microcontroller, Relay, Overload, Transformer.**

I. 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 GSM technology.

II. 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.

III. Block Diagram

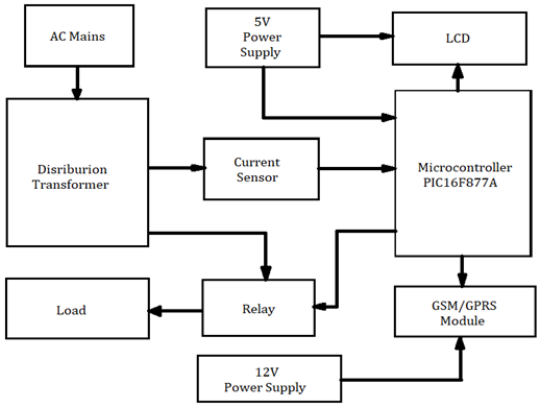

Fig. 1. Block diagram of IoT based transformer monitoring and control

Current sensor senses the amount of load current at the secondary of the distribution transformer. Output of the current sensor gets processed by the controller to find out the load current value.

If the load current exceeds the pre-set value inside the controller relay gets operated immediately. This results into isolation of load from transformer which brings down the load current to zero. So, the transformer gets protected from damage due to overloading.

The load current values continuously get transferred to the LCD and android application for monitoring. The GPRS enabled GSM module sends current values to android application.

IV. 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, PIC kit2 for programming the controller and Eagle software for designing PCB layout.

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 GSM module.

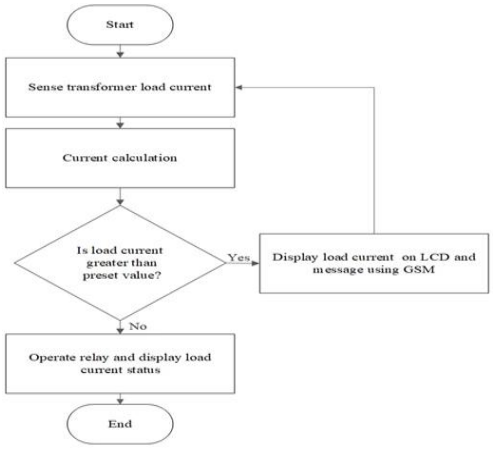

Fig. 2. Flow chart for transformer load conditions

V. Circuit Diagram

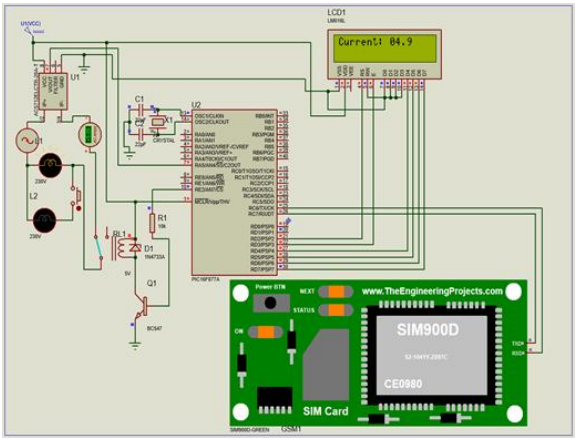

Fig. 3. Circuit diagram

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 GSM 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 GSM module will send information to the prescribed mobile numbers.

A. Components Used

- Step Down Transformer: (230/12V)
- Power Supply Circuit.
- Current Sensor.
- Relay
- Diode
- Transistor
- Resistor
- GSM Module (SIM900A)
- Microcontroller

VI. Principle Components

A. Microcontroller

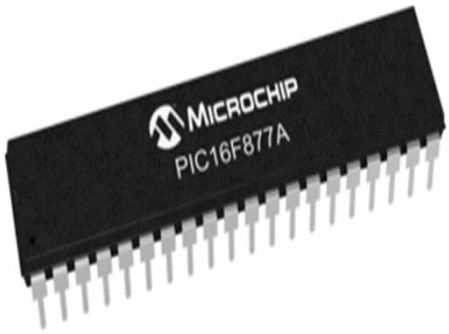

Fig. 4. PIC16F877A

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)

B. GSM Module

GSM module need 12V, 2A supply for its proper functioning. It can be used for SMS, voice, data, fax with low power consumption. It delivers GSM/GPRS 900/1800MHz Performance. PIC microcontroller sends actual load value to authority by using GSM.

Few more features of the GSM are:

- Tri-Band GSM: 900/1800/1900MHz or Quad-Band GSM: 850/900/1800/1900MHz

- GPRS multi-slot: class 10/8
- GPRS mobile station: class B
- Control via AT commands (GSM 07.07, 07.05)

In this system GSM is used to send load current values at the secondary of the transformer to monitoring station [5].

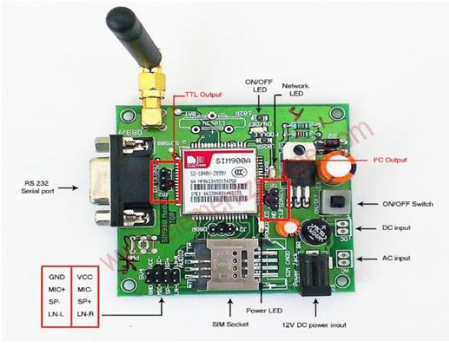

Fig. 5. GSM module SIM900A

C. Current Sensor

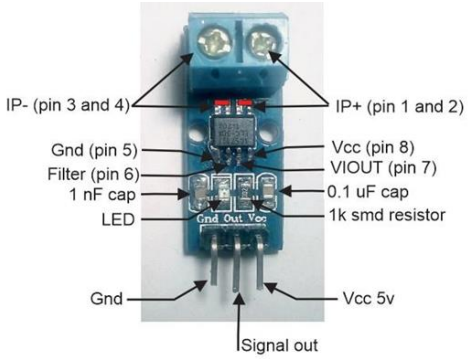

Fig. 6. Current sensor (ACS712-20A module)

Current sensor is the electrical device which produce 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

D. 16x2 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
- Interface: 6800, option SPI/I2C (RW1063 IC)

It is used to display condition of overload as per this we can take necessary action.

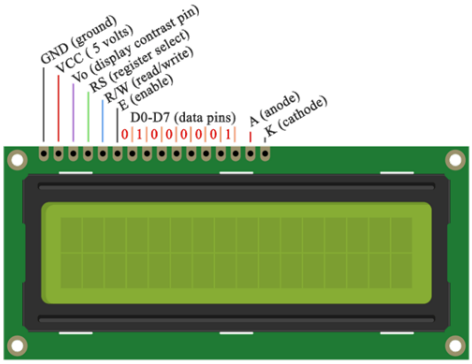

Fig. 7. 16x2 LCD

E. Relay

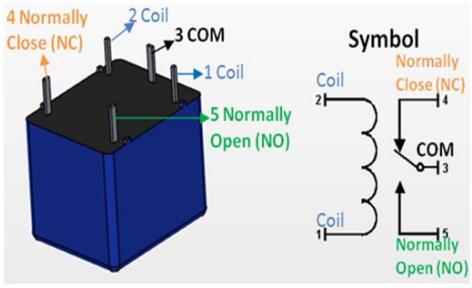

Fig. 8. Relay

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
- 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 [3].

F. PCB Layout

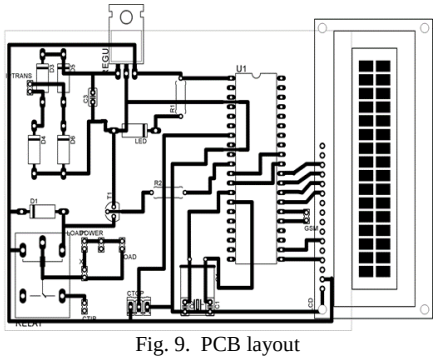

Fig. 9. PCB layout

A printed circuit board supports and connects components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a non-conductive substrate. Components get soldered onto the PCB to connect them electrically to provide them a mechanical support.

VII. Conclusion

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

VIII. 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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