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Monitoring and Protection of Distribution Transformer Using GSM Module

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Abstract:

The aim of the project is to design a monitoring and protection system for distribution transformer with the help of GSM and GPS technology. The present monitoring system requires manpower which is time-consuming and it is difficult to predict the occurrence of faults. In this project, we designed a system which continuously monitors the transformer parameters such as load current, voltage, oil level and ambient temperature with the help of sensors. These values are displayed continuously on the LCD display and it is recorded in the system memory. If any abnormalities occur in the transformer then an alert message with the parameter values are sent to the monitoring centre along with the location by means of GSM and GPS which are integrated with the Arduino board. This system will help the transformer to operate smoothly and identify problems before any catastrophic failure.

Keywords **—Distribution transformer, sensors, Arduino controller, GSM, GPS.**

I. INTRODUCTION

In power system, distribution transformer is an electrical equipment which supplies power from the generating station to consumers directly. Distribution transformer has a long service if they are operated under rated conditions. Their life is significantly reduced if they are subjected to overloading and voltage unbalance for a long time, also low oil level and high winding temperature leads to insulation failure resulting breakdown. Overloading and ineffective cooling of transformers is the major cause of failure in distribution transformer [1][2]. Distribution transformersare currently monitored manually which cannot provide information about occasional overloads and overheating of transformer oil and windings [3]. Most power companies use Supervisory Control and Data Acquisition (SCADA) system for online monitoring of power transformer extending the SCADA System for online monitoring of distribution transformer at the remote area is an expensive proposition due to long distance [4].

According to the above requirements, we need a distribution transformer real-time monitoring system to detect all operating parameters such as winding and oil temperature, oil level, load current, and voltage output continuously and sent to the monitoring centre in time.

II. METHODOLOGY

1. Existing System

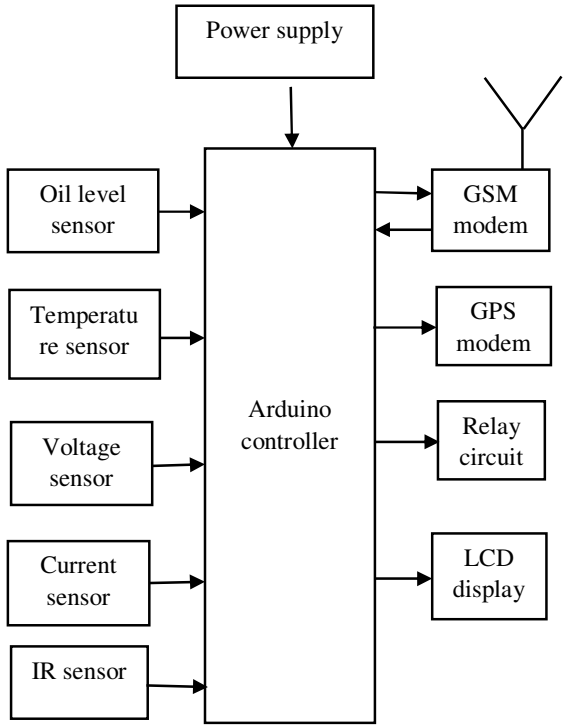
For decades, fuse, circuit breakers and electromechanical relays were used for the protection of power system. But, they operate only after the fault occurs. The failure of the transformers inthe remote area is unnoticed. If the transformers are working without the parameter values monitoring leads to breakdown during abnormality and lifetime of transformers are reduced.

Fig.1. Linemen trying to measure the various parameters of the transformer.

2. Proposed System

This system can detect faults during under voltage, over current, low oil level, high winding temperature and isolate the transformer from the source. It can communicate which transformer is under fault by obtaining its location using GPS and what type of fault has been occurred to authorized persons (lineman, engineer, substation, powerhouse etc.,) via SMS using GSM technology. This is wireless communication and for this, we can use the existing mobile phone towers. We can easily communicate with more than one person if necessary. This project will reduce the failure level.

PARAMETERS	ACTUAL VALUE	PRESET VALUE
Winding temp	65 deg. C	80 deg. C
Output voltage	108.57V	195V
Load current	5A	8A
Oil level	5%	2%



PARAMETERS	ACTUAL VALUE	PRESET VALUE
Winding temp	65 deg. C	80 deg. C
Output voltage	230V	195V
Load current	5A	8A
Oil level	5%	2%

Fig.2. Block diagram of transformer monitoring and protection with GSM technology.

III. Parameter Analysis

Table.1. Parameters during normal condition.

1. Voltage Analysis

The Voltage unbalance is a condition which the three-phase voltages differ in amplitude or are displaced from their normal 120-degree phase relationship or both of these situations occur simultaneously[5]. Voltage unbalance will occur in power systems as well as distribution systems, especially those systems with a large number of single-phase consumers. Considering the significant effect of the voltage unbalance on transformers lifetime and system reliability.

Table.2. Parameters during under voltage.

NEMA Definition

According to NEMA definition of voltage unbalance also known as the Line Voltage Unbalance Rate (LVUR), is given by %LVUR=Max(|VAB-VLav|,|VBC-VLav|,|VCA-VLav|) *100 / VLav.

The average line voltage designed as follows,

VLav = [VAB+ VBC+ VCA /3]

Here VAB, VBC, VCA are line voltages.

IEC Definition

The "IEC definition" of voltage unbalance defined as the ratio of the negative sequence voltage component to the positive sequence voltage component and given by %VUF = (negative sequence voltage component/Positive sequence voltage component) *100.

2. Overload Analysis

An overloading can occur when at least one of the phase currents exceeds its rated value. In distribution transformers, overloading is a complicated problem (an important tissue) that needs an overall understanding of loads behaviours, effective parameters in transformers and environmental conditions. Whereas the load variation in the distribution system is so much more than transfer system, then one phase could be in overloading condition in a longer time. A longtime overloading beyond standard duration causes serious damages to the transformer and will reduce its lifetime. Considering the importance of the value and duration of transformer overloading, we can use following standards to determine allowable values. In which is according to ANSI standard, the approximate value of the overloading peak that transformer can endure while not affect its lifetime, has been shown. The environmental temperature is assumed to be 30. But the loading capability for each degree of temperature rise above 30 will reduce to 1.5 percent. Also, by decreasing the temperature, it will increase as 1 percent for every one degree [6].

PARAMETERS	ACTUAL VALUE	PRESET VALUE
Winding temp	65 deg. C	80 deg. C
Output voltage	230V	195V
Load current	8.02A	8A
Oil level	5%	2%

Table.3. Parameters during overload.

3. Temperature Analysis

Temperature is one the most important factor that reduces transformers lifetime. Thus, using transformers in an optimum and standard temperature will help to keep transformers working for a longer time.

PARAMETERS	ACTUAL VALUE	PRESET VALUE
Winding temp	105.87deg. C	80 deg. C
Output voltage	230V	195V
Load current	5A	8A
Oil level	5%	2%

Table.4. Parameters during high temperature.

IV. DESIGN AND IMPLEMENTATION

1. Software Implementation:

The Software Implementation is done by means of Arduino software. Programming of Arduino and Interfacing of sensors with Arduino are the main part of software implementation. The programming part is done by using the "C" language. The hardware circuit gets initialized as soon as the power supply is given to it. LCD display is interfaced with the Arduino so that it displays the parameter values like voltage, current, temperature and oil level. When any problem occurs in the transformer it will be displayed on the LCD and it sends the values to the monitoring centre through GSM module. The location is also sent to the monitoring centre through GPS module.

2. Hardware Implementation:

The main components used for designing the system are sensors, Arduino, GSM, GPS. Power is supplied to all the components by means of a battery. The required parameter values are obtained by using sensors. Arduino is programmed in such a way that it displays the obtained values in the LCD display and compares the values with the pre-set values. The values are sent to the monitoring centre by means of GSM. The location of the transformer is obtained by means of GPS.

Fig.4. Hardware kit of transformer monitoring and protection.

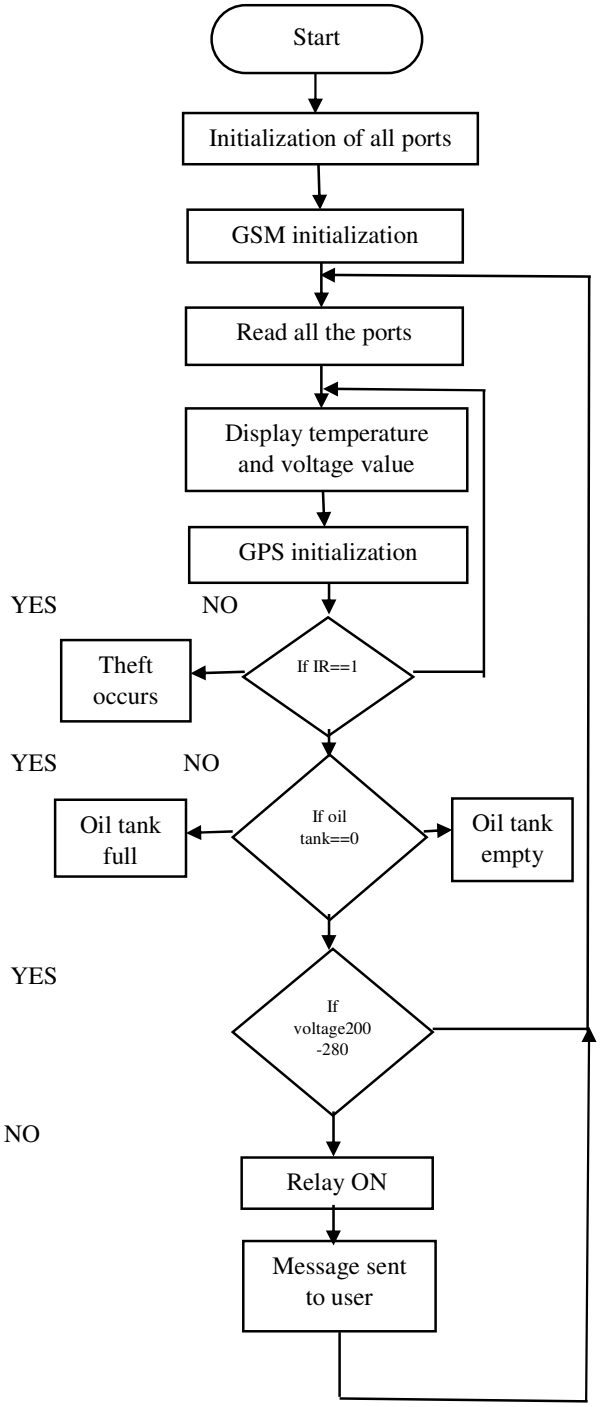


Fig.3. Software flow of monitoring and protection of distribution transformer

3. Components Used

i. Microcontroller

Arduino UNO SMD R3: In our project,analog pins are interfaced with various sensors,Digital pins are interfaced with LCD display and buzzer.Universal Serial Bus(USB) is used for loading program from personal computers.

ii. Sensors

A sensor is a device, module or subsystem whose purpose is to detect events or changes in its environment and send the information to another electronic device to which it is integrated.

1. LM 35 temperature sensor- to measure the temperature of windings and oil temperature. Its output pin is connected to analog pin (A0) of Arduino board.
2. ACS 712 current sensor–to measure the output current from the transformer. It is connected to analog pin (A1) of Arduino board.
3. Voltage sensor module – used to measurethe output voltage of the transformer.It is connected to analog pin (A2) of Arduino board.
4. Ultrasonic sensor – used to measure the oil level. It is connected to analog pin (A3) of Arduino.
5. LM358 IC 2 for IR transmitter and receiver pair- to detect the theft of power.

iii. GSM

Global System for Mobile communication (GSM) modem allows the computer to communicate over the mobile network through calls, SMS and MMS messages. Tx pin of GSM module to Rx pin of Arduino and Rx pin of GSM module to Tx pin of Arduino are interconnected. Ground pin of Arduino is connected to ground pin of GSM module.

iv. GPS

The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information. Connect GPS Module to Arduino UNO as following

- VCC to 5V
- GND to GND
- RX to 9
- TX to 10

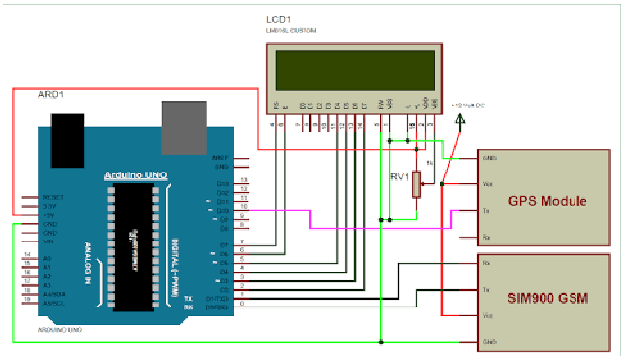


Fig.4. Interfacing GSM, GPS and LCD display in Tinker CAD

v. LCD Display

LCD (liquid crystal display) is the technology used for displays in notebook and other smaller computers. To wire LCD screen to Arduino board, connect the following pins:

- LCD RS pin to digital pin 12
- LCD Enable pin to digital pin 11
- LCD D4 pin to digital pin 5
- LCD D5 pin to digital pin 4
- LCD D6 pin to digital pin 3
- LCD D7 pin to digital pin 2

Additionally, wire a 10k pot to +5V and GND, with its wiper (output) to LCD screens VO pin (pin3). A 220ohm resistor is used to power the backlight of the display, usually on pin 15 and 16 of the LCD connector.

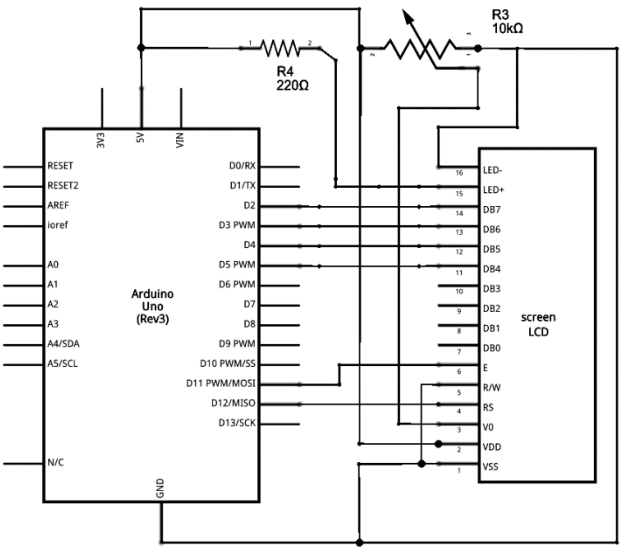


Fig.5. Circuit diagram of interconnection of LCD display with Arduino

V. RESULT:

The temperature of the windings is raised above 130-degree Celsius which is an abnormal condition. Thesensor senses the condition and it places the high signal on A0 pin and then the Arduino transmits the signal to GSM and GPS which in turn sends the message to the programmed number.

By the same way, oil level was lowered manually and the message was received and the fault was displayed on the LCD display.

A server module can be included in this system for receiving and storing transformerparameters information periodically about all the distribution transformers of a particularutility in a database application. This database will be a useful source of information on the utility transformers. Analysis of these stored data helps the utility in monitoring the operational behaviours of their distribution transformers and identify faults before any catastrophic failures thus resulting in significant cost saving as well as improving system reliability.

VI. CONCLUSION:

The complete design of the model is given and the circuit of monitoring and protection of distribution transformer is successfully implemented and the desired result is obtained. Manually the oil level was made low below the limit instantly our monitoring system detects the fault and trips the circuit along with sending a message to the specified number.

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