International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-2, December 2019

Design and Monitoring of 1kva Distribution Transformer

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Abstract: ***Transformers are vital part of transmission and distribution system. Generally, the lifetime of the transformer varies from 40 to 50 years. Regular monitoring and maintenance must be done to increase its lifetime. The existing monitoring system can acquire, process, analyse and communicate the critical parameters viz. voltage, current, frequency, temperature, oil level, etc. and sends the values to a central hub and indicates the fault to the concerned person. These parameters are required by the operators to ensure reliable power delivery and to assist the day-to-day decision-making activities. A single phase, 1 KVA, 50 Hz, 230/115 V, oil-immersed distribution transformer is designed, and the above-mentioned parameters are monitored and displayed in mobile phones/personal computers. The values from the monitoring system is displayed in website or mobile application using cloud services. With the data available, various processes can be performed to obtain information. The proposed system can be installed in any available transformers with little modification in sensors. When a severe fault occurs secondary circuit-breaker is tripped thereby isolating the transformer and an official is alerted using a text message.***

Index Terms: Cloud services, Distribution Transformer, GSM Module, Transformer monitoring system

I. INTRODUCTION

A transformer is a static device which transfers electrical energy from one circuit to another through the process of electromagnetic induction. It is most commonly used to increase (step up) or decrease (step down) voltage levels between circuits. It is widely used in transmission and distribution sector as there is a need to change the voltage levels to improve the efficiency. Transformers are generally costly equipment and should be worked within the specified limits. They also require frequent changing of coolant oil. Embedded technology is used to monitor some of the critical parameters viz., primary and secondary voltages and currents, oil level and oil temperature. The results are displayed in cloud services and a text alert will be sent in faulty conditions to the concerned person.

Revised Manuscript Received on December 30, 2019.
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II.DESIGN OF DISTRIBUTION TRANSFORMER

The transformer designed has the following specifications KVA RATING : 1 KVA

PRIMARY SIDE:
VOLTAGE : 230 V
CURRENT : 4.34 A
COIL SWG : 20 (0.9 mm2) TURNS 448
SECONDARY SIDE:
VOLTAGE : 115 V
CURRENT : 8.7 A
COIL SWG : 17 (1.42 mm2) TURNS 224

STAMPING:
TYPE 43
THICKNESS : 2 inches INSULATION : CLASS F (160 ˚C)
COOLANT : Oil immersed

III.MONITORING AND CONTROLLING OF DISTRIBUTION TRANSFORMER

The high-level design of the proposed system and the block diagram of the Monitoring and Controlling Unit are shown in the Fig 1 and Fig 2 respectively.

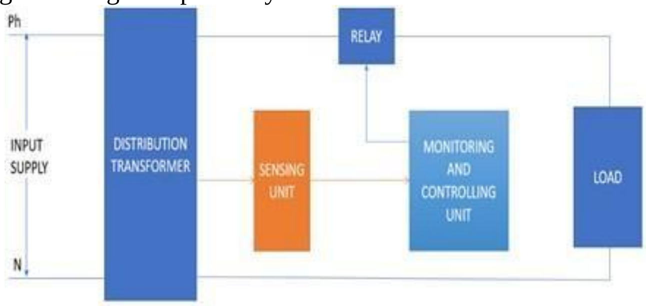

Fig -1: High Level design of the proposed system

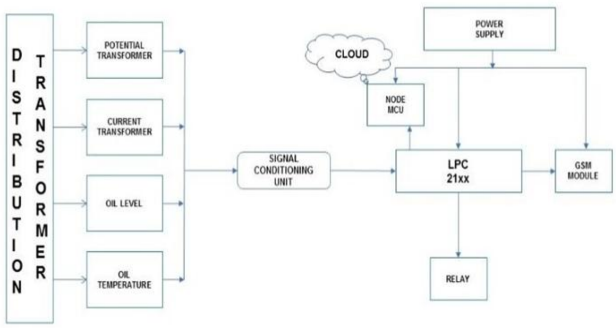

Fig -2: Monitoring and controlling unit

A. Operation of The Proposed System

The proposed system receives the primary and secondary values of voltage and current from potential and current transformers placed at the terminals of the 1 KVA distribution transformer.

The values of oil temperature is measured from temperature sensor and oil level from the float sensor. The voltage and current values are sent to a signal conditioning unit so that the values are converted into DC and limited to the range as per requirement of the microcontroller. The values from various sensors are then processed by the microcontroller and updated into the cloud via Node MCU. Text alert is sent using GSM module during certain fault conditions. The various faults that are identified in this module along with the conditions are mentioned in the Table -1.

Table -1 Faults identified in the module

S.No	Fault	Condition for occurrence
1.	Overvoltage	>115% of rated voltage
2.	Undervoltage	<85% of rated voltage
3.	Winding fault	V_S = (0.95-1.05) * V_P* Turns ratio
4.	Overload	110% of rated current
5.	Short-circuit	>150% of rated current
6.	Low oil	Oil level < 50% of tank capacity
7.	High temperature	Coolant temperature > 40° C

IV.SIMULATION

The simulation of the firmware dumped in the microcontroller is executed in the Simulink. It is divided into two parts as shown in the Fig -3.

- Logic
- Dashboard

LOGIC produces the processed values that is to be displayed in Thingspeak. It is further split into three subsystems- Voltage Measurement, Current Measurement and Temperature. In these subsystems, the various processes are done to the input signal to get the apt values that are to be sent. Further the calculation to find the faults are also included within these subsystems. This screen is shown in Fig -4.

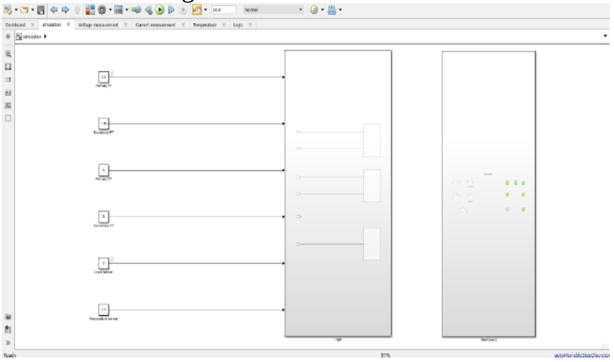

Fig -3: High Level Design

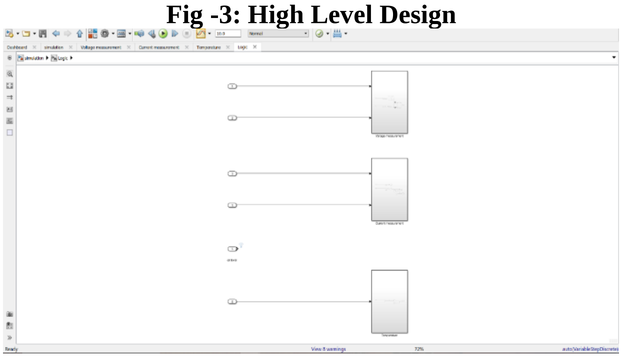

Fig -4: Screenshot of LOGIC

DASHBOARD shows the output screen which is a loose mimic of the output screen in Thingspeak. It has five gauges that show the primary and secondary voltages and current values and oil temperature and seven lamps.

The seven lamps are for seven faults that are identified in this module- Overvoltage, Undervoltage, Winding problem, Overload, Short-circuit, Low Oil level and High coolant temperature. The screenshot of the dashboard is in shown in Fig -5.

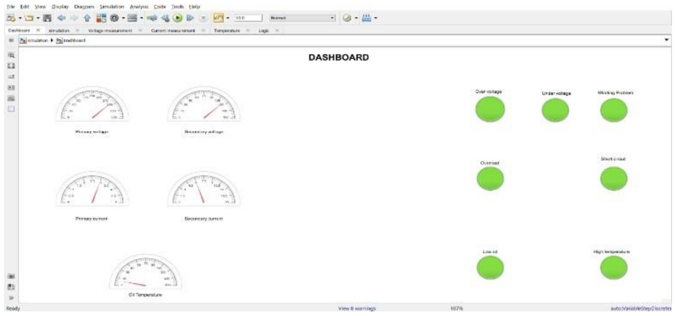

Fig -5: Screenshot of DASHBOARD

The following table 2 shows the different inputs given to the logic. The input values are assumed to be the input voltages available from the sensors.

Table -2: Simulation inputs

PARAMETER	INPUT VALUE
Primary Voltage	2.3
Secondary Voltage	1.15
Primary Current	2.88
Secondary Current	2.88
Oil Level	0
Oil Temperature	0.1

The parameter values are displayed using gauges. The lamps are included to show the faults. When a fault occurs, the lamp glows red. The comparison between the expected output and the observed output is shown in table 3

Table -3: Comparison between Expected Output and Obtained Output

PARAMETER	EXPECTED OUTPUT	OBTAINED OUTPUT
Primary Voltage	230	230
Secondary Voltage	115	115
Primary Current	4.8	4.8
Secondary Current	9.6	9.6
Oil Temperature	10 °C	10 °C
Overvoltage	Unlit	Unlit
Undervoltage	Unlit	Unlit
Winding problem	Unlit	Unlit
Overload	Lit	Lit
Short-circuit	Unlit	Unlit
Low Oil Level	Unlit	Unlit
High Temperature	Unlit	Unlit

The screenshot of the simulation output is shown in Fig 6.

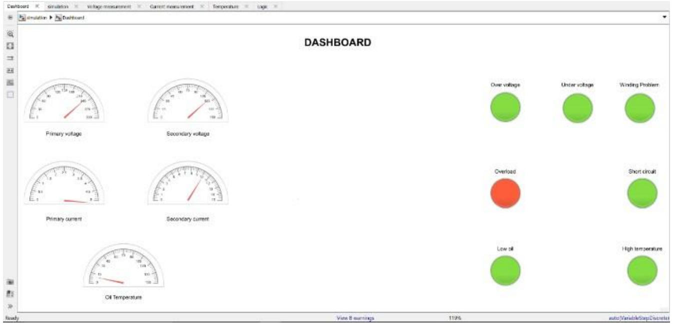

Fig -6: Screenshot of simulation output

V.HARDWARE

The snapshot of the hardware setup is shown in the Fig 7.

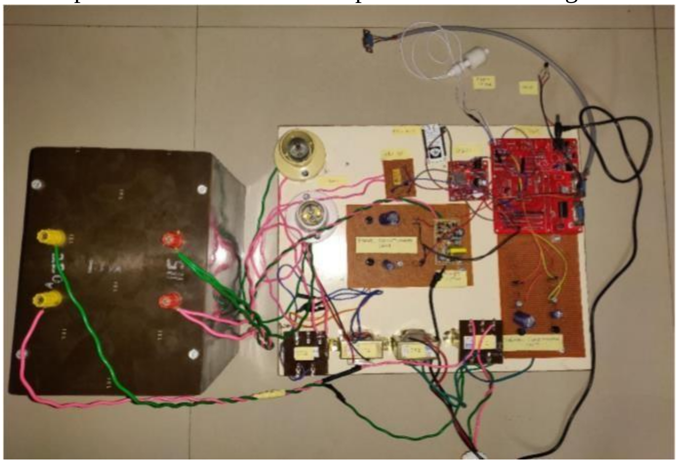

Fig -7: Snapshot of the hardware setup

The screenshot of text alert output is shown in the Fig 8.

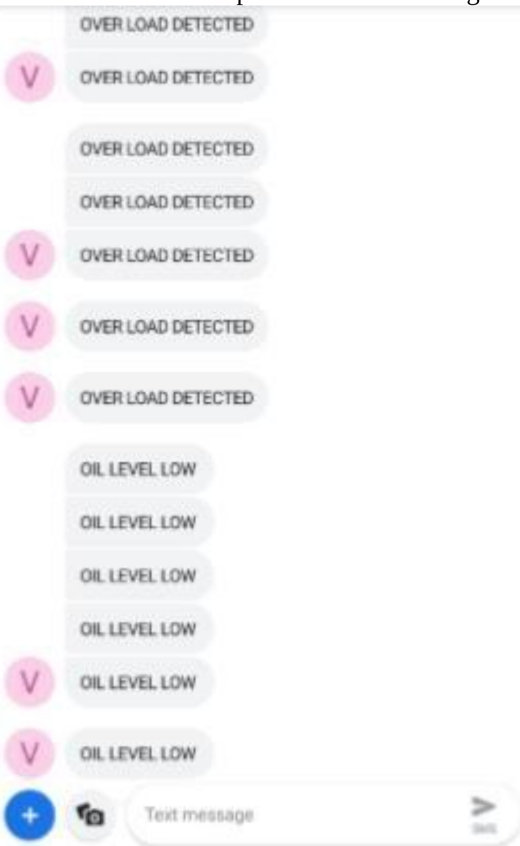

Fig -8: Screenshot of text alert

The screenshot of the output in Thingspeak is shown in the Fig 9.

Fig -9: Screenshot of output in Thingspeak

VI.CONCLUSION

Transformers are an integral part of Transmission and Distribution sectors. Proper maintenance of transformer can increase the lifetime of the transformer. Having a monitoring and controlling system helps in timely maintenance of the transformer. The parameter values displayed can be viewed anywhere and anytime if the person has reliable internet connection. The text alert that is given during the certain faults aids in speedy recovery from faulty conditions thus maintaining the environment and condition of the transformer.

VII.FUTURE SCOPE

1. Prediction of period in which oil levels must be changed
2. Embedded solution to perform Dissolved Gas Analysis in a remote transformer without human intervention
3. Development of a website which shows transformer in various locations and ability to monitor the parameters of the transformers displayed

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