Real Time Condition Monitoring of Transformer

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***Abstract*—Energy is the basic necessity of human beings, without continues supply of electrical energy nations couldn't progress. Electricity generation includes number of cycles, process and components. Each of these has its own significance and importance. Due to the fact that nowadays, mostly generated electrical energy comes from limited fossil fuel; therefore, need of utilizing them efficiently is very important. There are number of approaches, practices that has been implemented in order to generate and manage sustainable energy. Out of the various causes of energy shortage, one cause is the low efficiency of the components that are utilizes to generate it. This paper focuses on the method of enhancing the efficiency of one of the similar components used in power generation system i.e. transformer through continues condition monitoring and real-time data screening.**

***Index Terms*—condition monitoring, energy efficiency, transformer data monitoring, sustainability**

I. Introduction

Energy plays a vital role in economic growth of any nation. Nowadays, it is counted among the most important necessities of human life. We are so much accuse of it that we need it in every aspect of our life starting from sleeping to working. With the current industrialization, industries is continuously upgrading itself to fulfill the demands of modern needs as well as to survive in global market; this industrialization and automation also needs electrical energy for its successful implementation. According to Pakistan Institute for Development Economics (PIDE); industrial sector losses approx. 3.5 labor per day due to this insufficiency in energy. This has yielded a massive increase in production cost i.e. around 27% in 2014-2015 [1]. This power shortage is a causes a loss of around 21% to local manufacturing sector.

We cannot address the issue by only increasing the energy production; but several research and studies should be conducted to spread the awareness regarding the efficient and sustainable use of this energy [2]-[6]. By means of proper energy management we can only control the overflowing problem on power shortage. Energy management can be carried through several means out of which one is to make the components involving in its production cycle efficient by minimizing power loss. According to research, transformer accumulates for about 10%-12% of power loss during power generation cycle [7]-[10]. Beside power losses on more factor yields its low efficiency is its low life duration. The transformer fiascos insights display that a large portion of the failures have happened before coming to their appraised life because of absence of appropriate upkeep or impromptu utilization, according to Lahore Electric Supply Corporation (LESCO) they have faced a cost of 20 million in repairing 1000 transformer that were damaged due to indecorous management of load voltage [11].

Transformer is an essential component which is used to regulate, increase and decrease the electrical voltages. Its function depends upon the number of primary and secondary windings. This paper briefly discusses about the methods of real-time condition monitoring of transformer in order to decrease the risk of its failure and increase its life. For effective condition monitoring of any system, one need to determine the causes of its failure. The factors the leads towards its failure are: overloading which results in increased winding temperature and improper means of electricity purloin. Commercially, there are some companies who have come up with a device to monitor its parameters but there are certain drawbacks associated with them which failed to increase its efficiency. The reason of it is that, though these devices can detect multi parameters but the time which it consume while acquisition is high enough [12].

This paper proposed the installation of smart grid system with conventional transformer so as to enable intelligent condition monitoring with and drastic command over its power system control. Smart grid allows the effective monitoring and gives the indicator if any of its set parameter limit exceeds, it immediately reports the operator regarding the outrageous limit of component. When transformer is connected to traditional grid, it is very tricky to diagnose the fault if there is any. This research focuses on a solution to minimize the transformer damages by analyzing its parameter.

II. Experimental Setup

A. Component Description

There are number of software's that has been used in the designing and implementation of transformer condition monitoring system. Each of this software has its own requirement and importance. Software's that are used in applications are: Solid works, Arduino IDE and HTML. These software's control different hardware's as per user's requirement. Main hardware components include: sensors, microcontroller and GPS.

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Two sensors are used in this system i.e. current sensor and temperature sensor. Both of these sensors are deployed to extract some particular and useful data real time so as to avoid possible failures of transformer and increase its efficiency. These sensors send useful information to microcontroller and then as per designed algorithm MCU compare the real time data with the standard one in order to take decision. The current sensor is used to acquire the working current of load so that accurate real time power consumption can be calculated. The current sensor that is used in this system is Hall affect ACS712ELC which has been selected due to its characteristic of low noise output signal, low output error i.e. 1.5%, little operating voltage and zero magnetic hysteresis [13]. Alongside with current sensor, temperature sensor is also made a part of this system. Among various causes of failure, one is that there is a rapid increase of temperature in transformers winding if applied load limit exceeds. This rise in temperature causes transformer to malfunction, increases internal corrosion and also sometimes is a reason of high power losses. This ultimately decreases the efficiency and life of transformer. In order to get rid of this problem, temperature sensor is deployed so as to monitor the data continuously and take necessary action when needed. The selected sensor for this purpose is MLX90614 due to the characteristics; that, it is used in various industrial application such as boilers etc. hence; it is robust and has high precision [14].

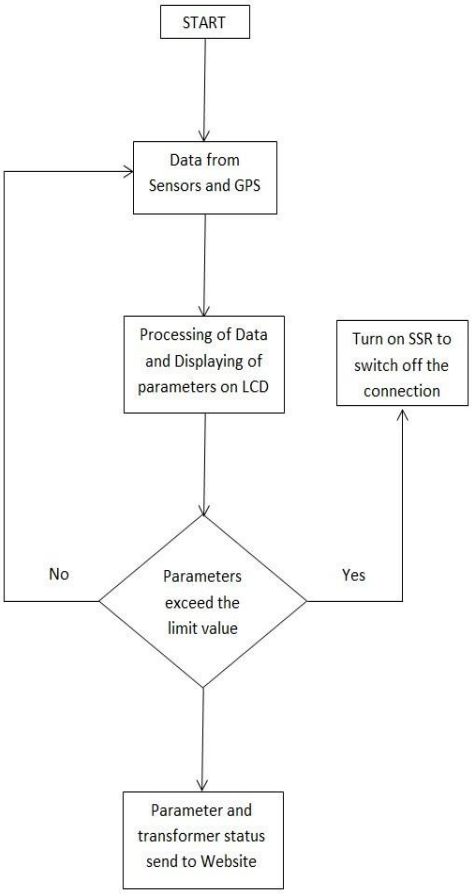


Figure 1. Flow diagram

Microcontroller is made hub of information where all the extracted data is shared and useful decisions took place. The microcontroller which is used here is Arduino mega2560. Arduino 2560 is an integrated board which has several input and output pins to connect multiple input and output devices and a microcontroller that analyze the data and take decisions as per uploaded algorithm/program. Detailed algorithm is shown in Fig. 1. The reason of choosing Arduino over others is its ease of use, user friendly GUI and easy to program interface. With Arduino, WI-Fi shield Esp8266 is used to transmit the analyzed results wirelessly on a website where user can monitor it anytime, anywhere on his fingertips. This website is a user control interface where he can monitor parameter continuously real-time and can also take decisions such as emergency stop etc. block diagram of overall system is shown in Fig. 2.

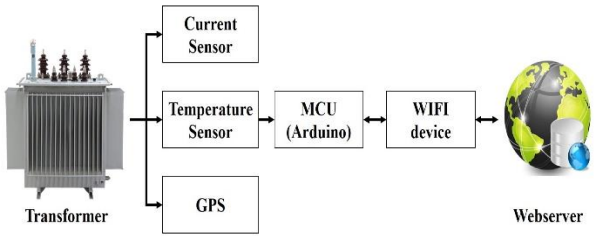


Figure 2. Block diagram

Global Positioning System (GPS) is used to locate the co-ordinates of the transformer. It'll help user locate the faulty transformer and repair it at earliest. This facility is embedded in the system to increase its overall efficiency by reducing the operation time which eventually reduces the problem faced by its consumer due to shortage of electricity.

All of these components were embedded on a platform designed on solid works. The detailed mechanical design has been shown in Fig. 3.

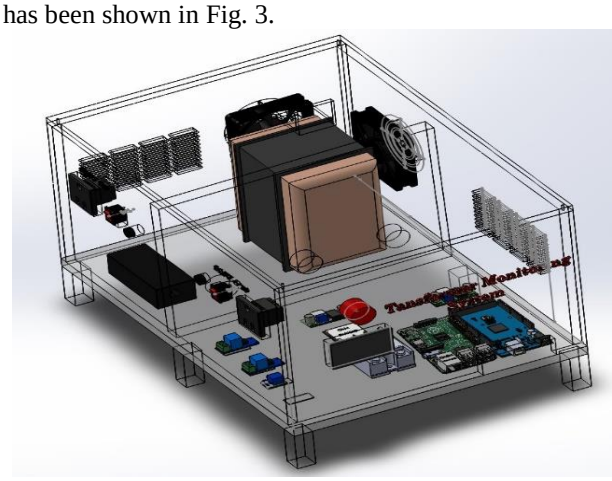


Figure 3. Solid works design

B. Methodology

This system will utilize a few parameters of the transformer to screen and control them. It utilizes the GPS to identify its position on the guide to advise which transformer has fizzled. The current and voltage sensors will extract the readings of input and output currents and

voltage, so that input and yielded wattage could be calculated and screened. Also, temperature sensor sends it analog signal at set interval to analog to digital converter which is then after converting into digital signal is fed into MCU for further processing and screening.

All of this collected data is forwarded to MCU i.e. Arduino which wirelessly directs it onto a web-server. This web-server enables user to visualize all of these results real-time and take possible actions if needed. MCU compares the real-time data with the allowed one continuously and if the allowed load exceeds it send command to the actuator to break the contact.

The webserver is used to restore the connection when the parameters get back to normal or maintenance is done. An emergency stop switch is likewise given on the site with a specific end goal to stop the transformer association amid crisis. Addition to it, user can also screen power factor, real power and apparent power that transformer is delivering real-time. All of this parameters are calculated using equations, the parameters to these equations are given through sensors and it's analyzed at MCU.

$$\text{Real Power} = \text{Voltage}_{\text{Inst}} * \text{Current}_{\text{inst}} \quad (1)$$

$$\text{Apparent Power} = \text{Voltage}_{\text{RMS}} * \text{Current}_{\text{RMS}} \quad (2)$$

$$\text{Power Factor} = \frac{\text{Real Power}}{\text{Apparent Power}} \quad (3)$$

III. Results and Discussion

By measuring the transformer parameters, for example, transformer temperature and power consumed vs power supplied by the system to its load along with handling, sending and receiving of data wirelessly on webserver, it is conceivable to successfully screen circulation transformers and furthermore to watch utilization rate per day. This prototype model shown in Fig. 4 contains four 110W bulbs as the output load. The farthest point esteem is set as 4Amps. At the point when every one of the bulbs are turned on the load current exceeds its set limit of 4Amp, the MCU senses a surpassing readings and strong state transfer is turned on which breaks the association. All of this information can be visualize on webserver in form of graphical charts and tables as shown in Fig. 5, Fig. 6 and Fig. 7 and Table I.

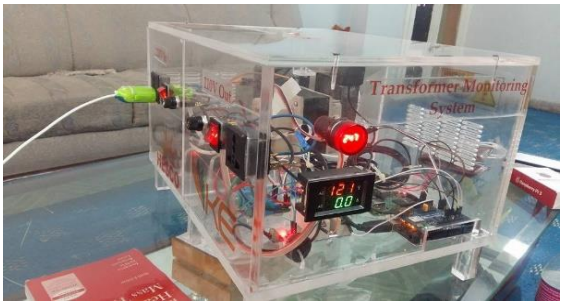


Figure 4. Prototype model

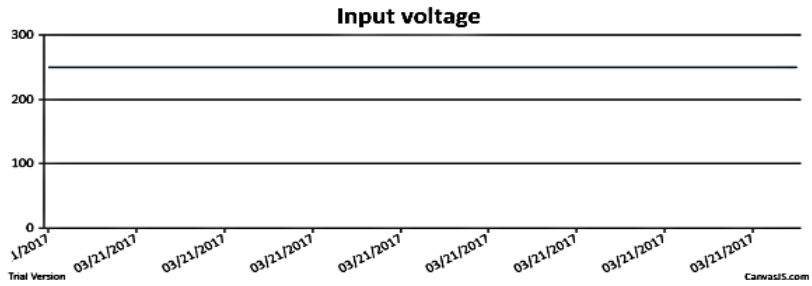
ID	Longitude	Latitude	Ambient Temp	Transformer Temperature	Input Voltage
1523	67.030197	24.820250	25.70	22.26	250
1522	67.030197	24.820250	25.62	22.26	250
1521	67.030197	24.820251	25.66	22.34	250
1520	67.030197	24.820244	25.70	22.34	250
1519	67.030182	24.820240	25.70	22.42	250
1518	67.030182	24.820196	25.66	22.42	250
1517	67.030182	24.820215	25.52	22.48	250
1516	67.030167	24.820241	25.56	22.52	250
1515	67.030167	24.820238	25.62	22.56	250
1514	67.030167	24.820249	25.52	22.60	250

ID	Output Voltage	Vrms	Power Factor	Power	Time Spent
1523	114.90	11.12	0.01	0.17	03/21/2017 11:21:51
1522	114.98	11.12	0.11	1.50	03/21/2017 11:21:44
1521	116.08	11.12	0.0	0.38	03/21/2017 11:21:38
1520	117.46	11.12	0.17	2.92	03/21/2017 11:21:32
1519	116.84	11.12	0.03	0.61	03/21/2017 11:21:25
1518	105.46	11.12	0.76	491.27	03/21/2017 11:21:19
1517	116.40	11.12	0.03	0.33	03/21/2017 11:21:12
1516	116.21	11.12	0.15	1.65	03/21/2017 11:21:08
1515	117.78	11.12	0.11	1.37	03/21/2017 11:21:00
1514	116.96	11.12	0.07	0.81	03/21/2017 11:20:53

Figure 5. Real-time readings

TABLE I. Results and Analysis

S.No	Input Voltage (V)	Output Voltage (V)	Load Current (A)	Transformer Status
1	220	117	0.9	On
2	220	115	1.8	On
3	220	115	2.7	On
4	220	115	3.6	On
5	220	110	4.4	Off



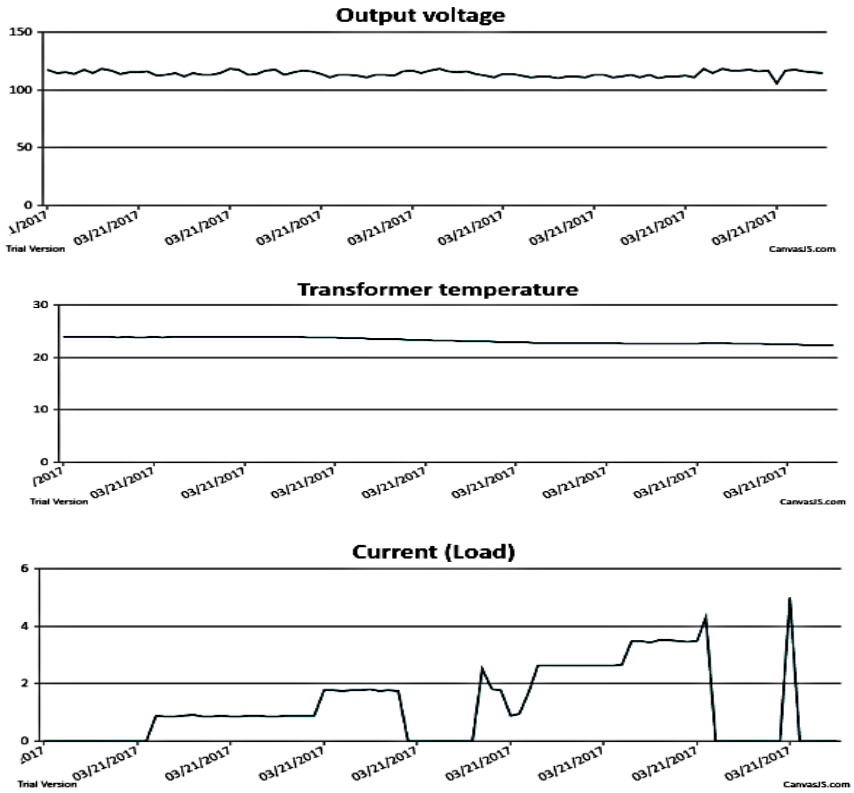


Figure 6. Graphical representation of data

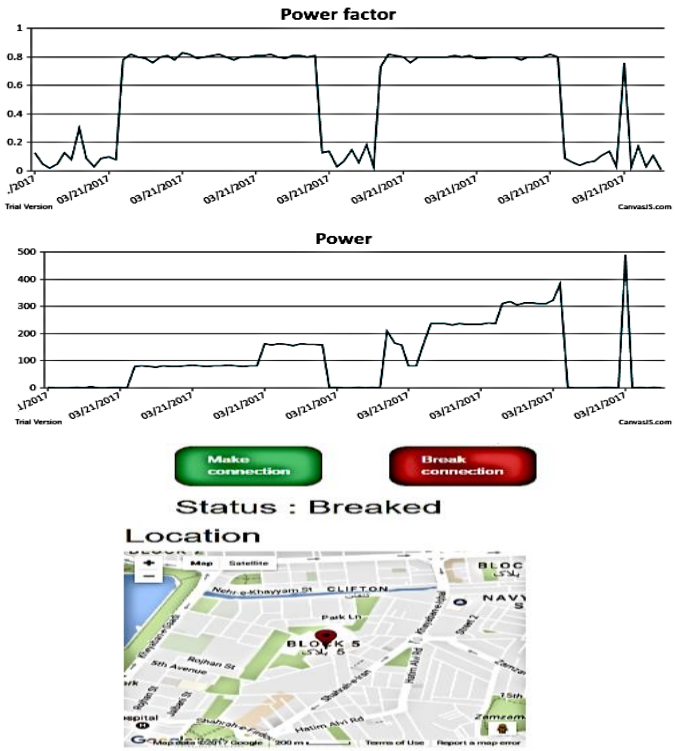


Figure 7. Graphical representation of data

The chart demonstrates that the transformer temperature increments because of 2 factors: the encompassing temperature and the expansion in stack current that makes the winding temperature rise, all the while expanding the transformer temperature.

IV. Conclusion

The proposed system plans to diminish the transformer misfortunes that power generation companies, countenances mostly during peak hours where

consumption of electricity is high and so as the load on transformers. Underdeveloped countries encountering energy shortages; whereas, in modern era, life highly depends on availability of electricity. This system plays a vital role in increasing the life-cycle of power distribution network by continues condition monitoring of transformer's critical parameters, which yields to its failure such as temperature, power consumption and power factor. The imperfections to the dispersion system are instantly perceived by utilizing this framework and it is conceivable to furnish clients with the best and quickest administrations.

We have given our best to lessen the transformer issue that the nation had confronted before. This system will cost around $400 which is lesser than taken a toll for repairing the transformer. This venture can be progressed by getting the transformer perusing for misfortunes. Additional work possible on the power issues are limiting the power misfortunes because of wires, winding losses as heat energy disperses into the air.

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