Transformer Health Monitoring using Cloud Computing

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ABSTRACT

Electrical energy is the backbone of the economy of a country. Transformer is an essential equipment to get electrical energy at the desired voltage. *Transformers* are a *vital part* of the transmission and *distribution system*. The state electricity boards and utilities incur huge money to procure distribution transformers every year. These state electricity boards and utilities suffers huge losses due to the reason that the transformers are damaged on account of overloading of distribution system, non-augmentation of transformers, poor maintenance and negligence on the part of maintenance staff of the board. According to the above discussion, we need a distribution transformer real-time monitoring system to detect all operating parameters operation, and send to the monitoring centre in time. We initiated our work with selection of a 400 KVA, 11/0.433 KV Distribution Transformer to commence our work on transformer health monitoring. With the help of sensors which are mounted on transformer, we monitored the level and temperature of transformer oil. The acquired data real time data of transformer is further transmitted to the cloud server via cellular modem at set periodic intervals. This acquired real time data of transformer is finally be available at control room on the Computer / mobile of the concerned technical staff with alerts at the time of occurrence of faults. At the end, we validated the acquired real time data with the manually recorded data. Our monitoring system is capable to monitor the various key parameters of transformers. In future, if this system will be implemented by the power utilities of our country, a huge amount of money can be saved which is spent on the repair of transformers.

Keywords: Acquired, Cloud server, Monitoring, Real Time, Sensors, Transformers

I. INTRODUCTION

The Transformers are considered to be the most important part of substation and power system. Failures of transformers not only impact industries and consumers but also the economy of country affected by the same causing social and political ramifications. Transformers have expected life of 25 to 30 years but they fail in large numbers, within 3 years itself, due to various causes and factors. By determining the reasons of failure, we can take appropriate action to avoid faults at great extent and thus reduce the possibilities of fault in transformers and making the power system more reliable. A transformer is a very essential device that connects the generating stations to various types of loads. The appropriate design, manufacturing, testing, operation and protection inflate the operating life of transformer.

These days, the power utilities are quite tensed as the rate of failure of distribution transformers and service has been increased to high extent. The rate of failure of transformers in India is around 12 to 15 % which is quite higher than developed countries which is less than 1% [3]. No one wants to share responsibility of failure i.e. neither the power utilities nor the manufacturers of transformers. The manufacturers often blame the utilities for running the transformers in overload and unbalanced condition (Unbalanced loading of three phases).

It has been observed that very little efforts are made by utilities to find out the root cause of failure, which could be one of the reasons why a damaged transformer is replaced by a new one without removing the cause of damage, leading to failure immediately or within a very short period. It is necessary to identify the causes of failure without which we are unable to take corrective measures. Following are some of the most common causes of transformer failure.

1. Prolonged Overloading of transformers
2. Unbalanced Loading
3. Leakage of Oil
4. Short circuit of transformers
5. Poor maintenance and lack of monitoring of transformers by utilities.

We need a distribution transformer real-time monitoring system to detect all operating parameters operation, and send to the monitoring centre in time. It leads to online monitoring of key operational parameters of distribution transformers which can provide useful information about the health of transformers which will help the utilities to optimally use their transformers and keep the asset in operation for a longer period. This will help to identify problems before any serious failure which leads to a significant cost savings and greater reliability. Widespread use of mobile networks and GSM devices such GSM modems and their decreasing costs have made them an attractive option not only for voice media but for other wide are network application.

2. CLOUD COMPUTING

Cloud computing is a technology that uses the internet and central remote server to maintain data and applications. Cloud computing allows user to use application without installation and access their personal files at any computer with internet access. This technology allows for much more efficient computing by centralizing data storage processing. Cloud computing is broken down into three segments: “application “storage” and “connectivity” each segment serves a different purpose. Figure 2.1 represents block diagram of cloud computing system architecture.

Basically, cloud computing is a way to deliver IT services in which resources are retrieved from the server through tools and applications, as opposed to a direct connection to a server.

Rather than keeping files on a proprietary hard drive or local storage device, cloud-based storage makes it possible to save them to a remote database. As long as an electronic device has access to the web, it has access to the data and the software programs to run it. It's called cloud computing because the information being accessed is found in "the cloud" and does not require a user to be in a specific place to gain access to it.

3. PROPOSED WORK

Transformers are a crucial *part* of the transmission and *distribution system*. The state electricity boards and utilities incur huge money to procure distribution transformers every year. These state electricity boards and utilities suffers huge losses due to the reason that the transformers are damaged on account of overloading of distribution system, non-augmentation of transformers, poor maintenance and negligence on the part of maintenance staff of the board. Apart from this, there are several other drawbacks in the present system that are discussed below.

1. For proper maintenance of transformers, boards require huge man power to check each and every transformer spread over vast and remote areas where the transformers have been installed in villages, cluster of houses, in agricultural fields etc. which is not feasible for the technical line staff.
2. It involves financial cost to be incurred on travelling on vehicles to various sites where the transformers are installed.
3. The scheduled maintenance of transformers is not possible as the technical line staff is already overburdened with multiple types of duties assigned to them.
4. The critical weather conditions in various states of India make interruption for the technical staff in performing their duties.

Several research works have been done in this field to develop a solution for health monitoring of transformers to prevent premature failure of distribution transformers and improving reliability of services to the customers. We also initiated our work in the same field and completed the same with better and advantageous results.

Transformers come in variety of sizes commonly ranging from 5 KVA Distribution transformers to 2000 MVA Power Transformers. So, first we selected a 400 KVA, 11/0.433 KV Distribution Transformer to commence our work on transformer health monitoring. After selecting rating of transformer, we selected the sensors for the transformers to monitor fault parameters. One Level sensor was mounted on the top of the conservator to monitor the level of transformer oil as it is compulsory to maintain a standard level of oil in transformer. The temperature sensor was mounted on the top of tank cover to sense the oil temperature of the transformer.

Figure 3.1 represents block diagram of online transformers monitoring system with arrangement of two sensors with 400 KVA Distribution transformer. These sensors were further connected to the input of SATEC Intelligent MFT EM133 Meter which is a smart, multi-function and GSM based meter. The output terminals of the transformers are also connected to this meter to acquire various parameters of the transformer. The meter has intelligent features to monitor and acquire the real time data of the transformer. Being a GSM based meter, it further transmitted the real time data of transformer to the cloud server via cellular modem at set periodic intervals. We know that cloud computing has capability to save time especially for computational task in comparison with conventional method / calculation. This acquired real time data of transformer is finally be available at control room on the Computer / mobile of the concerned technical staff with alerts at the time of occurrence of faults. At the end, we have validated the acquired real time data with the manually recorded data.

3.1 SENSORS USED FOR MONITORING

We have used two types of sensors for our system.

Temperature Sensor – It is basically a device which consists of a thermocouple, thermistor or thermostat which sense the temperature. The widely utilized type of sensor are used to detect temperature or heat. These temperature sensors comes in variety as per the application of sensor. It varies from a normal ON/OFF thermostatic device which is mostly utilized for domestic water heaters to highly sensitive types that are for industrial use. There is variety of these sensors available in the market with different applications and characteristics. Basically there are two types of temperature sensors which are Contact Type Sensor and Non-Contact Type sensor.

Figure 3.2 shows contact type of sensors which needs to be physically contacted with the object which is being sensed. These sensors are used for detect temperature of solid object, liquid or gases with wide range of temperatures. The other non-contact type sensors use convection and radiation to detect temperature of liquids and gases that generally emits radiation as it heats.

Level Sensor –

A level sensor is a device used to detect the level of any liquid or fluid kept in an open or closed system. The float type sensors comes with an floating arrangement through which it detects the level of any fluid or liquid. We have installed liquid level sensor on the top of conservator which detects the level of oil in the transformer. The figure 3.3 shows float type level sensor.

4. RESULT & DISCUSSION

As discussed in our methodology, we have utilized sensors and advance SATEC Intelligent MFT EM133 Meter for monitoring of Distribution transformer. This meter will collect required parameters from the distribution transformer and transmit the same to control center via cellular modem at set periodical intervals. Alarm events will be transmitted immediately.

The figure 4.1 shows a 400 KVA distribution transformer which was used for the purpose of online monitoring. As circled in red, one Level sensor was mounted on the top of the conservator to monitor the level of transformer oil and the temperature sensor was mounted on the top of tank cover to sense the oil temperature of the transformer.

Figure 4.2 shows a metering box having SATEC Intelligent MFT EM133 Meter installed in it. It also shows connections of sensors to the input of meter and the output terminals of the transformers are also connected to acquire various parameters of the transformer.

Further, the meter monitors and acquires real time data of transformer. This acquired data will be transmitted to the cloud server which can be accessed on either desktop / laptop or our mobile phones / tablets. The user shall be provided with an id and password through which he / she can login on portal of Expert Power i.e. www.expertpowerplus.com using any standard web browser. The same is shown in the figure 4.3.

Our system can provide following parameters from distribution transformers.

1. Geographical location of transformers
2. Real time parameters via tabular and trend graphs
3. Energy parameters via tables and trend graphs
4. Alarm on event of fault
5. Generated Reports via email at set interval of time

Apart from monitoring the real time data of transformers, it is also necessary to access the geo-graphical location of a transformer. There are thousands of transformers which are installed at the remote locations which are completely out of reach for the technical team / maintenance team of utilities. At the time of occurrence of fault in transformer installed at remote location, it is first necessary of identify the geo-graphical location of that transformer so that the technical team shall reach the location and take necessary action for the same.

Our system is capable to track geo-graphical location of a transformer. Figure 4.4 shows location of our transformer which is installed in the premises of a company situated at New Focal Point, Dabwali Road, Bathinda.

The next advantage of our monitoring system is the capability to monitor the oil level and temperature. In a transformer, it's must to maintain these parameters as per standards and requirements. The main trouble is to conserve a neutral oil level in transformer to avoid over flow from the tank with respect to the change in temperature. The level of oil in transformer tank is never same or constant rather it is dependent on the function of the following parameters-

- Temperature of the transformer oil (average value).
- Ambient temperature
- Solar radiation
- Transformer loading

On the other hand, the oil temperature should also be maintained to avoid to over flow of oil from the tank. As per IS 1180 (Part 1) 2014, the specified limits of temperature rise for oil and winding over maximum ambient temperature of 50 ^{o}C are described in tabular form as Table 4.1.

Our monitoring system has the ability to diagnose the abnormality in level and temperature of transformer oil. Different figures shows the multiple conditions of transformer oil level and temperature. Figure 4.5 shows two Green signals indicating the normal oil level and temperature. Second Figure 4.6 shows one green and one red signal in the figure indicating the normal oil temperature and abnormal oil level respectively. The third Figure 4.7 shows one red and one green signal in the figure indicating the abnormal oil temperature and normal oil level respectively. Finally Figure 4.8 shows two red signals in the figure indicating the abnormal oil temperature and oil level.

Our System has feature to send mobile alerts to the concerned operator / technical staff at the time of occurrence of faults. The system will respond immediately and send alert in the form of SMS. Figure 4.9 (a) represents a figure with screen shot of SMS alert on mobile phone for low level of oil and other Figure 4.9 (b) represents a figure with screen shot of SMS alert on mobile phone for temperature above permissible limit.

In case if laptop / desktop is not available, we can also monitor the health of transformer on our mobile phones. The screen shot taken from mobile is displayed below showing real time data of transformers. It will be more convenient for the concerned operator / technical staff to monitor the real time data of transformer at any place and time on his / her mobile phone. Figure 4.10 shows a figure with screen shot of health monitoring on mobile phone.

The other feature of monitoring system is to record the various parameters of transformers. These parameters includes three phase line voltages, Currents, Active Power, Reactive Power, Apparent Power and Power Factor. We can set the time interval in our system to record data of transformer. We have recorded transformer datafor the period of 3 days at the interval of every 5 minutes. So, day wise records have been displayed below starting from 01st November, 2017 to 03rdNovember, 2017 from 9.00 am to 11.00 am. (Tables 4.2, 4.3 and 4.4)

There are several advantages of our system which makes it suitable to be adopted by utilities and others in the coming future. Some of the advantages of our system are discussed below.

1. It can save huge revenue of our country which is being spent by power utilities on repair of transformers.
2. This monitoring system is very efficient, reliable and almost maintenance free.
3. The installation process of this system is quite easy and hassle free.
4. It can save time of technical staff / lineman of utilities which is being spent on physical verification of each installed transformer.
5. It has no effect of critical weather conditions which usually interrupts the technical staff to check the transformer manually.

Although our system is very reliable and has many advantages, we have also considered disadvantages of our system. The main disadvantage of our system is the initial cost of this system which is higher. But eventually it will save huge revenue of utility and country which is spent on repair of transformers and skilled manpower. Apart from this, this system acquires extra space with the transformer.

5. COMPARISON WITH EXISTING METHODS

1. Reference to paper presented by Vadirajacharya.K et.al [11] in 2012, they have discussed on Transformer Health condition monitoring through GSM technology but they don't have feature for real time monitoring of transformer. Our system is capable to monitor real time parameters of transformers with alerts in form of SMS.

2. Reference to paper presented by A.R. Al-Ali et.al [18] in 2004 have discussed on GSM based distribution transformer monitoring system. This system is capable to monitor few parameters whereas our system can monitor multiple parameters of transformers.

3. Reference to the paper presented by SH. Mohamadi, A.Akbari [23] in 2012, they emphasized GSM

based system for the monitoring of Distribution transformers. This system diagnoses and capture parameters of distribution transformers but they have few parameters in comparison to our system. Our system is capable to monitor multiple parameters of transformers.

4. Reference to the paper presented by Sajidur Rahman et.al [24] in 2017, they proposed a method for the real time monitoring of transformers using GSM technology. This system is not capable to trace the geographical location of Distribution transformer whereas our proposed method is capable to identify the geographical location of Distribution transformer.

6. EQUATIONS

Efficiency of Transformer η = $\frac{\text{Output power of Transformer}}{\text{Input Power of Transformer}}$ ……. (1)

Efficiency η = $\frac{\text{Input – Losses}}{\text{Input}} = 1 - \frac{\text{Losses}}{\text{Input}}$ ……. (2)

7. FIGURES AND TABLES

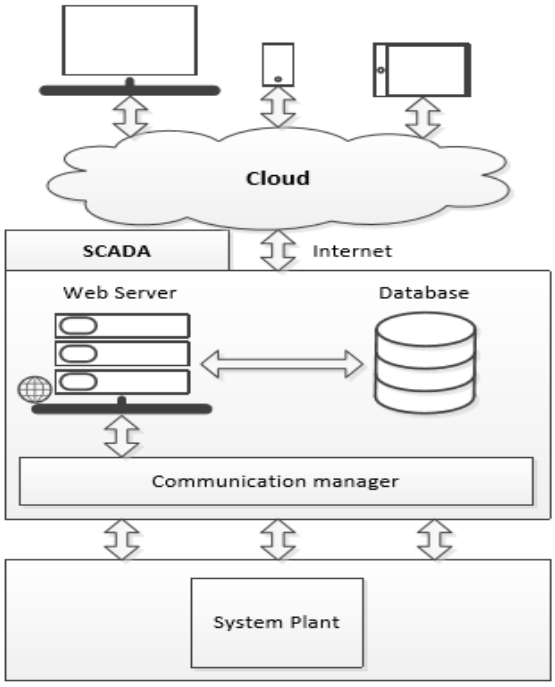

Fig.2.1 Block diagram of cloud computing system architecture

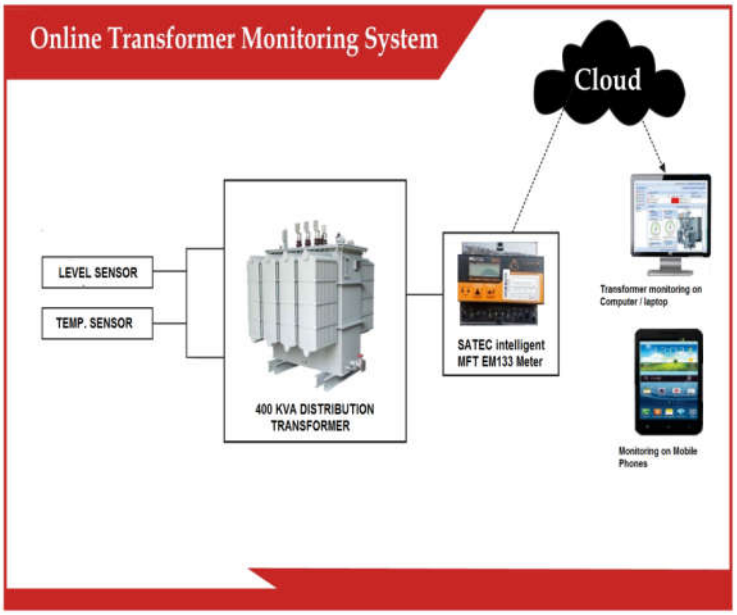

Figure 3.1 Block Diagram of Online Transformer Monitoring System

Figure 3.2 Contact Type Temperature Sensor

Figure 3.3 Level Sensor

Figure 4.1 400 KVA Distribution Transformer used for online monitoring

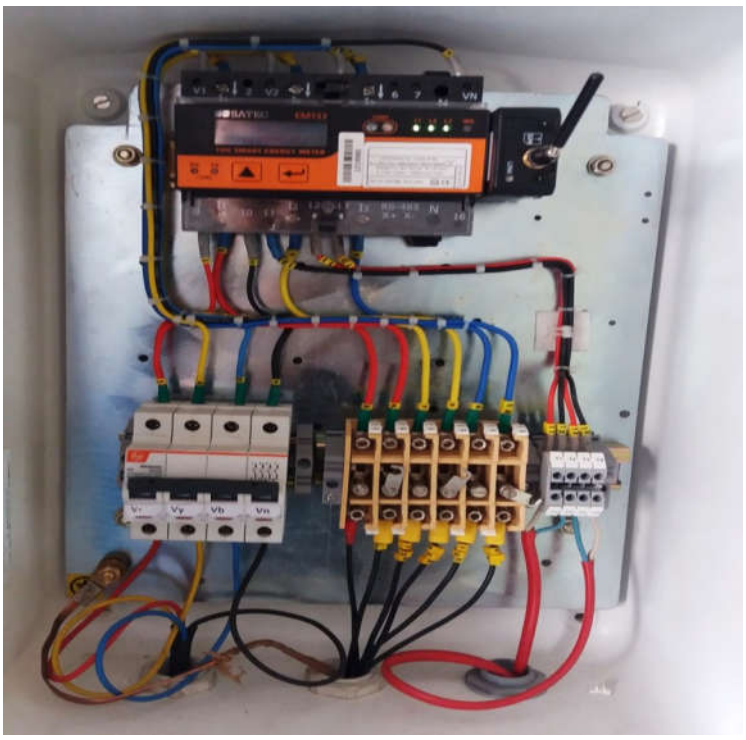

Figure 4.2 A Metering Box with SATEC Intelligent MFT EM133 Meter

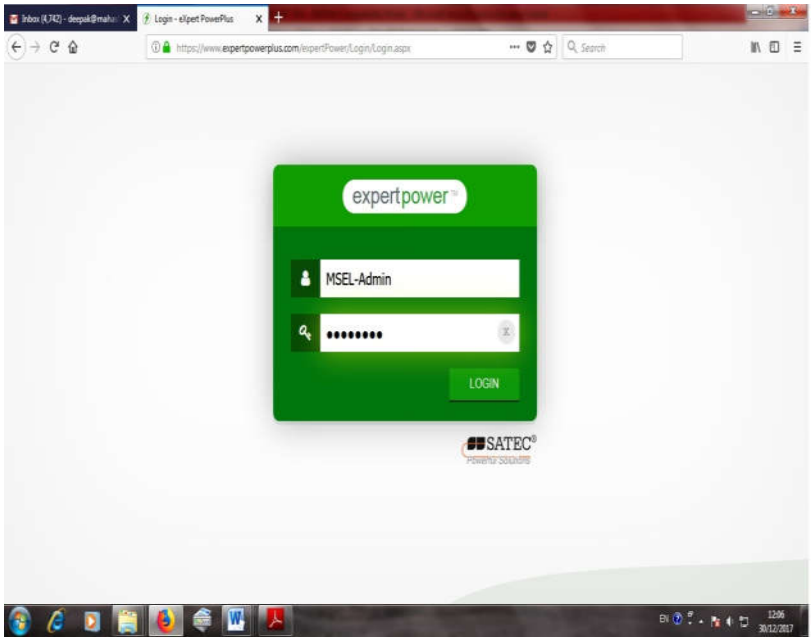

Figure 4.3 Log in page of www.expertpowerplus.com

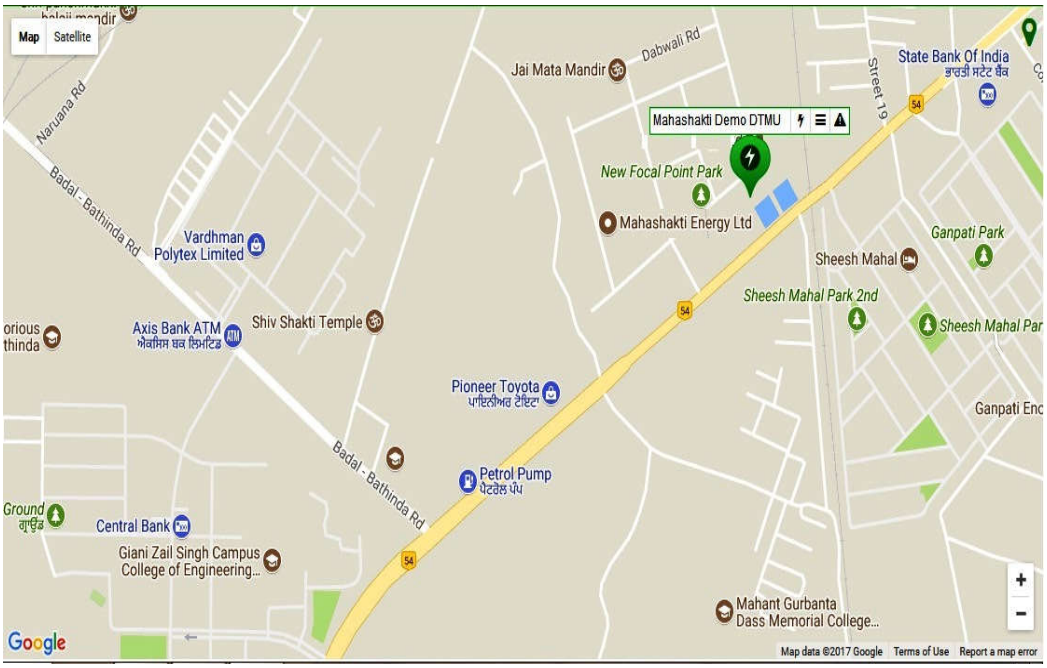

Figure 4.4 Geographical location of transformer

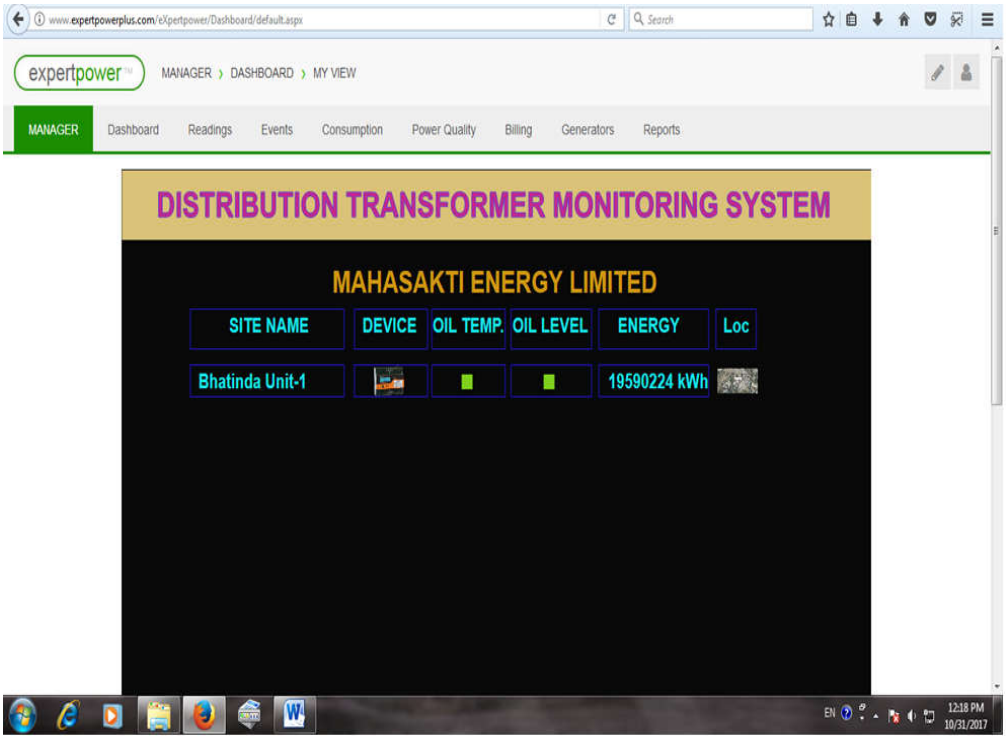

Figure 4.5 Two Green signals in the figure indicating the normal oil level and temperature.

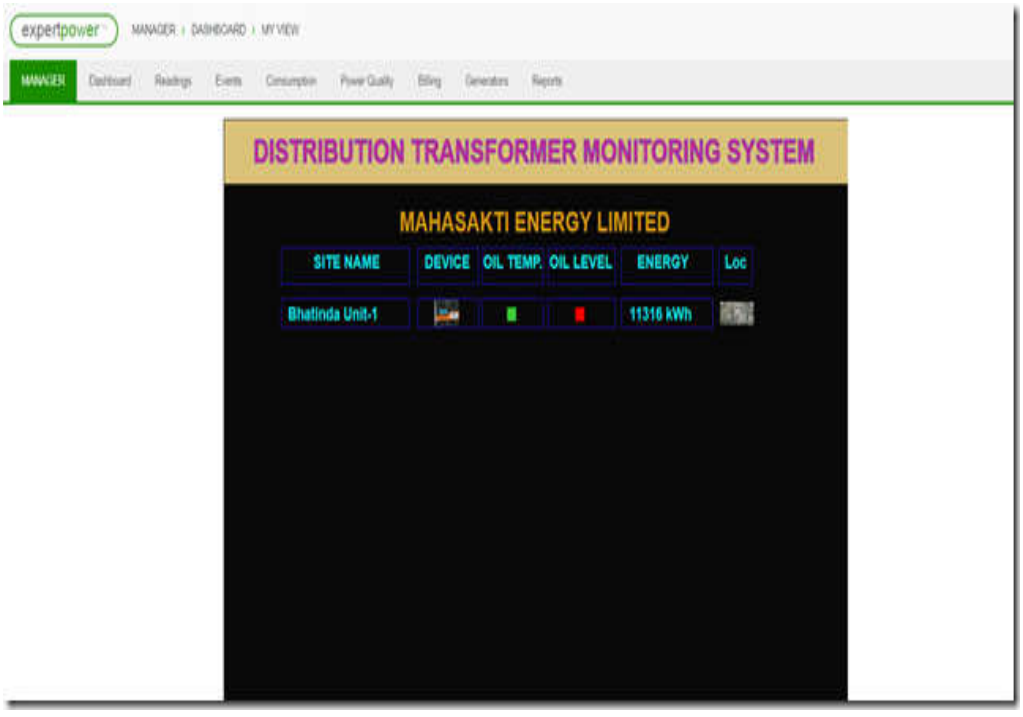

Figure 4.6 One Green and One red signal in the figure indicating the normal oil temperature and abnormal oil level respectively.

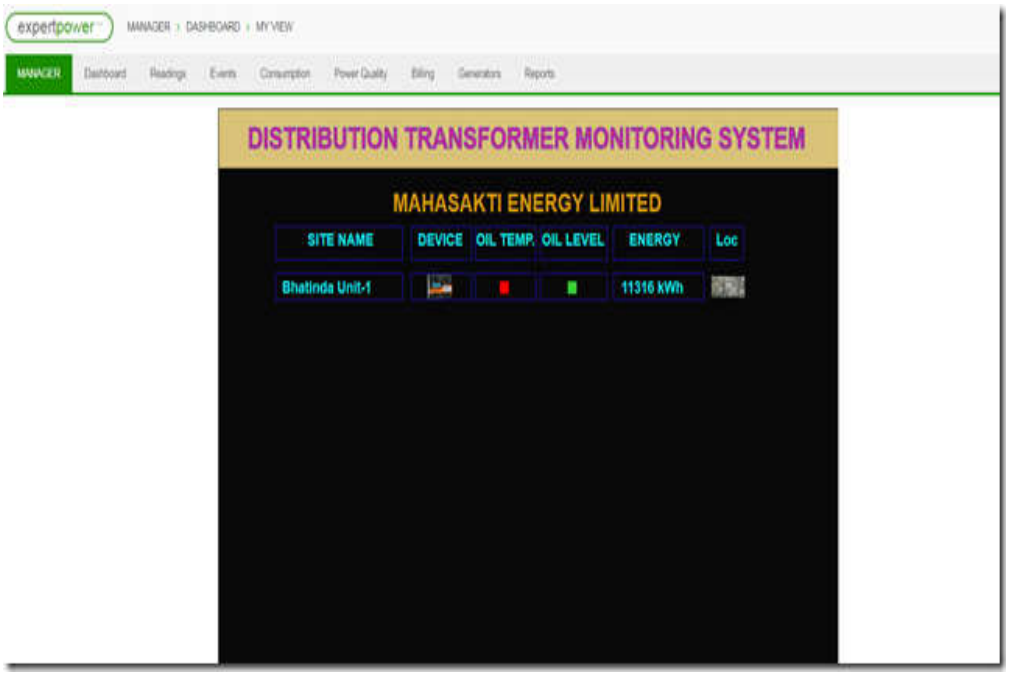

Figure 4.7 One Red and One Green signal in the figure indicating the abnormal oil temperature and normal oil level respectively.

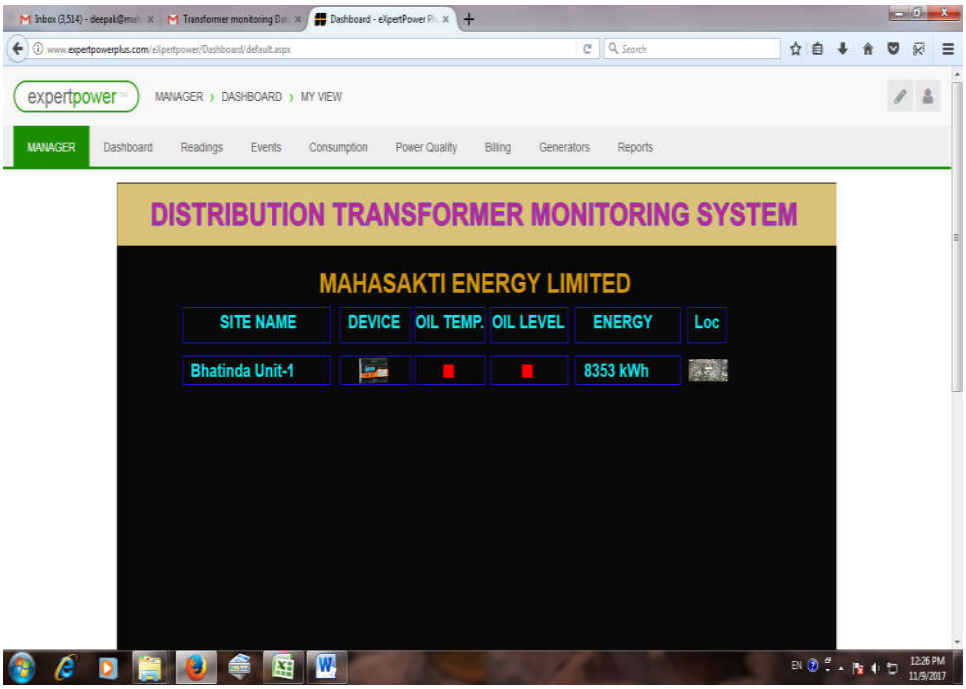

Figure 4.8 Two Red signals in the figure indicating the abnormal oil temperature and oil level

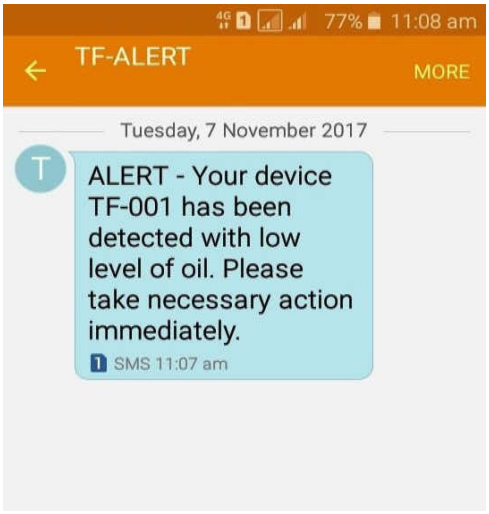

Figure 4.9 (a) shows Screen Shot of SMS alert on mobile phone for low level of oil

Figure 4.9 (b) shows Screen Shot of SMS alert on mobile phone for temperature above permissible limit

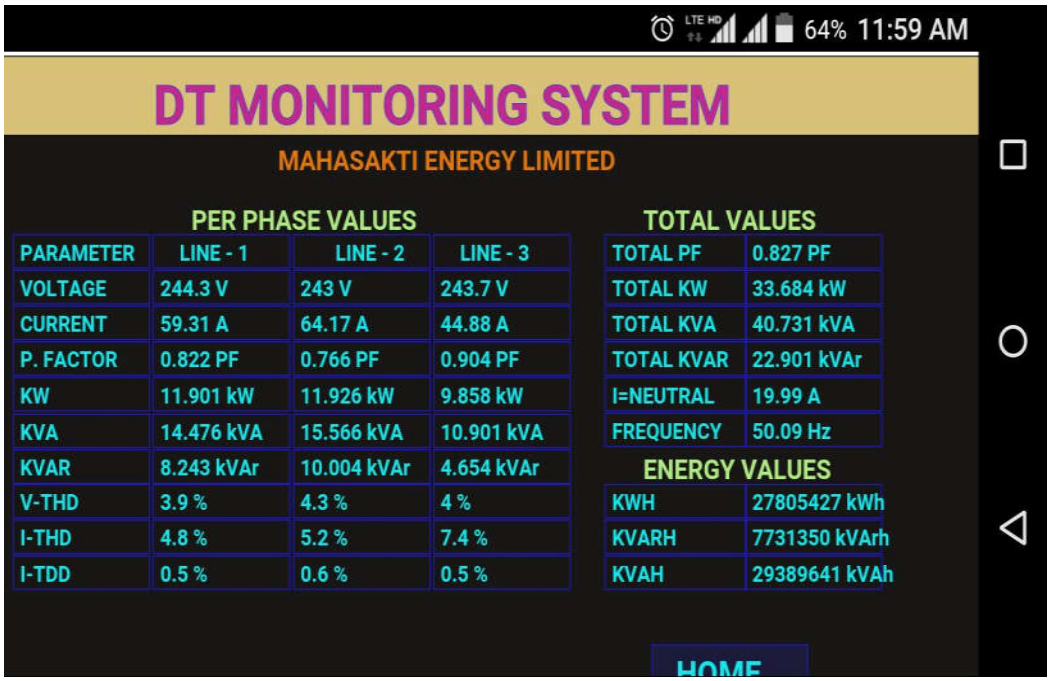

Figure 4.10 Screen Shot of health monitoring on mobile phone

Parameter	Upto 200 KVA	Above 200 KVA & upto 2500 KVA
For Transformer Oil	35 ºC	40 ºC
For Transformer Winding	40 ºC	45 ºC

Table 4.1 Limits of Temperature Rise for Oil and Winding over maximum Ambient Temperature of 50 ºC as per IS 1180 (Part 1) 2014

Record Time	Voltage LN, V			Current, A			Active Power, kW			Reactive Power, kvar			Apparent Power, kVA			PF		
	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
01/11/2017 09:00:18	248.50	247.90	248.40	61.52	41.65	42.56	14.27	8.92	9.74	5.46	5.16	4.05	15.28	10.31	10.55	0.93	0.87	0.92
01/11/2017 09:05:33	247.60	247.00	247.60	63.19	43.89	43.27	14.39	9.10	9.77	6.11	5.85	4.35	15.64	10.82	10.69	0.92	0.84	0.91
01/11/2017 09:10:13	247.30	246.60	247.20	67.05	43.00	42.72	15.09	9.05	9.69	6.83	5.48	4.15	16.56	10.57	10.54	0.91	0.86	0.92
01/11/2017 09:15:07	246.70	246.20	246.00	119.99	81.97	84.29	28.90	19.56	20.50	6.40	4.94	3.11	29.60	20.17	20.73	0.98	0.97	0.99
01/11/2017 09:20:05	246.20	245.30	245.50	113.70	83.29	82.34	27.55	19.71	20.02	4.98	5.32	2.78	27.99	20.42	20.21	0.98	0.97	0.99
01/11/2017 09:25:05	245.80	245.10	245.20	61.96	48.59	51.82	14.31	10.25	12.16	5.19	6.01	3.64	15.22	11.89	12.70	0.94	0.86	0.96
01/11/2017 09:30:10	245.50	244.50	245.00	49.00	40.01	34.83	10.98	8.01	7.68	4.90	5.58	3.69	12.02	9.76	8.52	0.91	0.82	0.90
01/11/2017 09:35:07	245.00	243.70	244.10	46.36	41.26	41.00	10.53	8.12	9.48	4.18	5.87	3.09	11.33	10.02	9.97	0.93	0.81	0.95
01/11/2017 09:40:05	244.30	243.50	243.50	83.60	69.08	65.07	19.36	15.04	15.23	5.38	6.69	3.79	20.10	16.46	15.69	0.96	0.91	0.97
01/11/2017 09:45:16	244.40	243.10	243.30	66.76	51.95	53.87	15.24	10.77	12.55	5.80	6.56	3.73	16.30	12.61	13.09	0.94	0.85	0.96
01/11/2017 09:50:07	243.90	242.80	243.20	69.06	53.92	55.18	15.26	10.68	12.65	7.12	7.53	4.44	16.83	13.07	13.41	0.91	0.82	0.94
01/11/2017 09:55:36	244.80	244.00	244.40	62.76	48.92	53.64	14.45	10.29	12.61	5.18	6.01	3.51	15.35	11.91	13.09	0.94	0.86	0.96
01/11/2017 10:00:26	245.60	244.70	245.00	64.69	50.29	53.46	14.87	10.48	12.54	5.56	6.41	3.72	15.87	12.28	13.08	0.94	0.85	0.96
01/11/2017 10:05:26	244.80	244.00	244.40	62.76	48.92	53.64	14.45	10.29	12.61	5.18	6.01	3.51	15.35	11.91	13.09	0.94	0.86	0.96

01/11/2017 10:10:06	244.40	243.90	243.70	94.66	64.53	72.05	22.28	14.17	17.10	6.20	6.81	3.92	23.13	15.72	17.55	0.96	0.90	0.98
01/11/2017 10:15:07	244.90	244.40	244.50	76.83	53.72	60.56	18.14	11.85	14.45	4.98	5.61	3.16	18.81	13.11	14.79	0.96	0.90	0.98
01/11/2017 10:20:06	244.60	243.40	243.00	90.46	88.42	81.13	20.12	18.64	17.21	9.20	9.84	8.78	22.12	21.08	19.32	0.91	0.88	0.89
01/11/2017 10:25:07	243.80	242.90	243.20	81.71	59.09	65.03	18.84	12.59	15.26	6.34	6.81	4.01	19.88	14.31	15.78	0.95	0.88	0.97
01/11/2017 10:30:21	243.70	242.90	242.90	84.14	62.98	64.40	18.89	12.72	14.83	7.96	8.47	4.95	20.49	15.28	15.63	0.92	0.83	0.95
01/11/2017 10:35:08	244.10	243.40	243.50	92.33	71.84	69.35	19.70	13.53	15.48	10.83	10.98	6.64	22.48	17.42	16.85	0.88	0.78	0.92
01/11/2017 10:40:57	243.30	242.20	242.30	85.67	76.37	62.88	17.12	13.60	13.34	11.65	12.34	7.23	20.71	18.37	15.17	0.83	0.74	0.88
01/11/2017 10:45:21	243.00	241.90	242.30	67.66	60.13	53.31	13.30	10.30	11.37	9.60	10.18	6.06	16.40	14.48	12.88	0.81	0.71	0.88
01/11/2017 10:50:12	243.20	242.30	243.00	88.16	79.46	54.46	18.83	12.85	11.78	10.10	14.21	5.92	21.37	19.16	13.18	0.88	0.67	0.89
01/11/2017 10:55:06	243.40	242.50	243.40	109.07	94.07	65.86	24.30	17.59	15.00	10.65	14.47	5.61	26.53	22.77	16.01	0.92	0.77	0.94
01/11/2017 11:00:25	244.90	244.20	244.20	80.87	70.54	59.64	17.28	13.64	13.44	9.61	10.46	5.51	19.77	17.19	14.53	0.87	0.79	0.93

Table 4.2 shows reading for Day 1 (01st November, 2017) Time – 9.00 am to 11.00 am

Record Time	Voltage LN, V			Current, A			Active Power, kW			Reactive Power, kvar			Apparent Power, kVA			PF		
	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
02/11/2017 09:00:19	246.10	245.00	245.60	85.33	65.05	53.52	20.56	15.20	12.81	3.87	3.87	2.09	21.16	15.79	13.41	0.98	0.97	0.99
02/11/2017 09:05:13	243.40	242.50	243.00	98.53	76.33	71.65	23.54	17.58	16.99	4.47	5.07	2.09	24.14	18.77	17.58	0.98	0.96	0.99
02/11/2017 09:10:55	244.10	242.20	243.10	73.45	68.17	59.76	17.58	15.79	14.60	4.47	5.07	2.09	18.18	16.39	14.60	0.97	0.95	0.99
02/11/2017 09:15:43	243.20	241.50	242.50	79.93	72.13	63.13	18.18	15.79	14.60	6.85	6.85	3.87	19.37	17.58	15.20	0.93	0.92	0.97
02/11/2017 09:20:51	243.50	242.20	242.70	79.09	69.49	62.05	18.18	15.79	14.60	6.26	5.66	2.68	19.37	16.99	15.20	0.95	0.94	0.98
02/11/2017 09:25:04	240.70	239.60	240.10	82.69	74.53	65.05	18.18	16.39	15.20	7.45	7.45	3.87	19.97	17.58	15.79	0.93	0.91	0.97
02/11/2017 09:30:58	242.40	240.80	241.40	78.49	72.73	63.73	18.18	16.39	15.20	5.66	6.26	2.68	18.77	17.58	15.20	0.96	0.93	0.99
02/11/2017 09:35:10	241.40	239.80	240.50	79.21	71.53	63.37	18.18	15.79	15.20	6.26	6.26	3.28	19.37	16.99	15.20	0.94	0.93	0.98
02/11/2017 09:40:18	243.90	242.80	243.20	69.06	53.92	55.18	15.26	10.68	12.65	7.12	7.53	4.44	16.83	13.07	13.41	0.91	0.82	0.94
02/11/2017 09:45:21	251.20	249.90	248.20	72.25	83.17	53.04	14.01	16.99	11.62	11.03	12.22	6.26	18.18	20.56	13.41	0.78	0.81	0.88
02/11/2017 09:50:43	247.30	246.60	247.20	67.05	43.00	42.72	15.09	9.05	9.69	6.83	5.48	4.15	16.56	10.57	10.54	0.91	0.86	0.92
02/11/2017 09:55:27	242.10	241.30	241.30	80.17	57.48	66.13	18.77	12.22	15.20	5.66	5.66	3.87	19.37	14.01	15.79	0.95	0.90	0.97
02/11/2017 10:00:52	242.50	241.50	242.00	69.25	51.12	48.48	15.79	10.43	11.03	6.26	6.26	3.87	16.99	12.22	11.62	0.93	0.86	0.94
02/11/2017 10:05:12	241.00	239.80	240.40	76.57	56.52	51.12	16.99	11.62	11.62	7.45	6.85	3.87	18.18	13.41	12.22	0.92	0.85	0.94

02/11/2017 10:10:07	242.10	241.40	241.80	67.45	50.16	45.84	15.20	10.43	10.43	5.66	6.26	3.28	16.39	12.22	11.03	0.93	0.87	0.95
02/11/2017 10:15:18	242.60	241.90	242.40	67.21	49.56	43.20	15.20	10.43	9.83	5.07	5.66	3.28	16.39	12.22	10.43	0.94	0.88	0.95
02/11/2017 10:20:12	244.10	243.10	244.00	65.65	46.08	41.16	15.20	9.83	9.83	4.47	4.47	2.09	15.79	11.03	9.83	0.96	0.91	0.98
02/11/2017 10:25:22	240.70	239.60	240.10	82.69	74.53	65.05	18.18	16.39	15.20	7.45	7.45	3.87	19.97	17.58	15.79	0.93	0.91	0.97
02/11/2017 10:30:02	241.40	239.80	240.50	79.21	71.53	63.37	18.18	15.79	15.20	6.26	6.26	3.28	19.37	16.99	15.20	0.94	0.93	0.98
02/11/2017 10:35:09	244.90	244.20	244.20	80.87	70.54	59.64	17.28	13.64	13.44	9.61	10.46	5.51	19.77	17.19	14.53	0.87	0.79	0.93
02/11/2017 10:40:18	248.50	247.90	248.40	61.52	41.65	42.56	14.27	8.92	9.74	5.46	5.16	4.05	15.28	10.31	10.55	0.93	0.87	0.92
02/11/2017 10:45:11	243.80	242.90	243.60	51.84	37.92	41.16	11.03	7.45	9.24	5.66	5.07	3.28	12.81	9.24	9.83	0.90	0.83	0.95
02/11/2017 10:50:02	246.20	245.70	247.00	37.20	26.64	20.88	8.64	5.66	4.47	3.28	3.28	2.09	9.24	6.26	5.07	0.93	0.84	0.93
02/11/2017 10:55:21	247.50	246.60	247.30	39.48	29.40	35.76	9.24	5.66	8.64	3.87	4.47	2.09	9.83	7.45	8.64	0.93	0.82	0.97
02/11/2017 11:00:05	247.00	246.50	247.00	40.44	28.08	35.40	9.24	5.66	8.64	3.28	3.87	2.09	9.83	6.85	8.64	0.94	0.80	0.97

Table 4.3 shows reading for Day 2 (02ndNovember, 2017) Time – 9.00 am to 11.00 am

Record Time	Voltage LN, V			Current, A			Active Power, kW			Reactive Power, kvar			Apparent Power, kVA			PF		
	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
03/11/2017 09:00:55	249.70	248.60	249.50	59.88	40.44	42.72	14.01	9.24	9.83	4.47	4.47	3.28	15.20	9.83	10.43	0.95	0.90	0.95
03/11/2017 09:05:06	247.30	246.60	247.20	67.05	43.00	42.72	15.09	9.05	9.69	6.83	5.48	4.15	16.56	10.57	10.54	0.91	0.86	0.92
03/11/2017 09:10:27	249.30	248.60	248.70	80.41	66.13	63.25	18.77	14.01	15.20	6.26	8.05	3.87	19.97	16.39	15.79	0.95	0.86	0.97
03/11/2017 09:15:59	249.50	247.90	249.00	60.25	66.85	47.88	11.62	12.22	10.43	9.83	11.03	5.07	15.20	16.39	11.62	0.77	0.74	0.90
03/11/2017 09:20:43	252.30	252.00	250.10	66.76	51.95	53.87	27.55	19.71	20.02	4.98	5.32	2.78	27.99	20.42	20.21	0.98	0.97	0.99
03/11/2017 09:25:59	250.20	248.90	247.50	63.13	76.69	47.64	12.22	15.20	10.43	9.83	11.03	5.66	15.79	18.77	11.62	0.78	0.81	0.88
03/11/2017 09:30:00	251.20	249.90	248.20	72.25	83.17	53.04	14.01	16.99	11.62	11.03	12.22	6.26	18.18	20.56	13.41	0.78	0.81	0.88
03/11/2017 09:35:03	242.40	240.80	241.40	78.49	72.73	63.73	18.18	16.39	15.20	4.18	5.87	3.09	11.33	10.02	9.97	0.96	0.93	0.97
03/11/2017 09:40:06	254.10	253.20	250.90	82.45	72.37	63.13	19.97	15.79	15.20	6.26	9.24	3.28	21.16	18.18	15.79	0.95	0.86	0.98
03/11/2017 09:45:47	251.60	250.70	248.90	78.01	71.53	50.76	18.18	14.60	11.62	7.45	10.43	4.47	19.37	18.18	12.81	0.93	0.81	0.94
03/11/2017 09:50:49	250.70	249.50	250.20	87.61	61.33	62.53	20.56	14.01	15.79	2.68	3.87	0.30	21.16	14.60	15.79	0.99	0.96	0.98
03/11/2017 09:55:05	247.00	246.40	246.60	97.93	68.29	67.93	22.35	14.60	15.79	9.24	8.64	5.07	24.14	16.99	16.99	0.93	0.86	0.95
03/11/2017 10:00:27	246.90	245.80	246.00	75.13	55.08	61.21	18.18	12.22	14.60	3.87	5.66	2.68	18.77	13.41	15.20	0.98	0.91	0.98
03/11/2017 10:05:26	244.80	244.00	244.40	62.76	48.92	53.64	14.45	10.29	12.61	5.18	6.01	3.51	15.35	11.91	13.09	0.94	0.86	0.96

03/11/2017 10:10:06	244.40	243.90	243.70	94.66	64.53	72.05	22.28	14.17	17.10	6.20	6.81	3.92	23.13	15.72	17.55	0.96	0.90	0.98
03/11/2017 10:15:17	244.90	244.40	244.50	76.83	53.72	60.56	18.14	11.85	14.45	4.98	5.61	3.16	18.81	13.11	14.79	0.96	0.90	0.98
03/11/2017 10:20:09	246.40	245.20	246.10	66.73	56.76	43.92	15.20	12.22	10.43	5.66	6.85	2.68	16.39	14.01	11.03	0.94	0.87	0.96
03/11/2017 10:25:07	243.80	242.90	243.20	81.71	59.09	65.03	18.84	12.59	15.26	6.34	6.81	4.01	19.88	14.31	15.78	0.95	0.88	0.97
03/11/2017 10:30:15	244.10	243.10	244.00	65.65	46.08	41.16	15.20	9.83	9.83	4.47	4.47	2.09	15.79	11.03	9.83	0.96	0.91	0.98
03/11/2017 10:35:22	244.10	243.40	243.50	92.33	71.84	69.35	19.70	13.53	15.48	10.83	10.98	6.64	22.48	17.42	16.85	0.88	0.78	0.92
03/11/2017 10:40:07	243.30	242.20	242.30	85.67	76.37	62.88	17.12	13.60	13.34	11.65	12.34	7.23	20.71	18.37	15.17	0.83	0.74	0.88
03/11/2017 10:45:13	243.00	241.90	242.30	67.66	60.13	53.31	13.30	10.30	11.37	9.60	10.18	6.06	16.40	14.48	12.88	0.81	0.71	0.88
03/11/2017 10:50:09	243.20	242.30	243.00	88.16	79.46	54.46	18.83	12.85	11.78	10.10	14.21	5.92	21.37	19.16	13.18	0.88	0.67	0.89
03/11/2017 10:55:06	243.40	242.50	243.40	109.07	94.07	65.86	24.30	17.59	15.00	10.65	14.47	5.61	26.53	22.77	16.01	0.92	0.77	0.94
03/11/2017 11:00:14	246.20	244.00	245.50	14.52	27.72	13.32	3.28	5.66	2.68	0.89	3.87	1.49	3.28	6.85	3.28	0.95	0.81	0.83

Table 4.4 shows reading for Day 3 (03rdNovember, 2017) Time – 9.00 am to 11.00 am

8. CONCLUSION AND FUTURE SCOPE

The Transformers are considered to be the heart of substation and power system. The Failure of transformers not only slams industries and consumer but also impacts on the country's economy. Transformers have expected life of 25 to 30 years but they fail in large numbers, within 3 years itself, due to various causes and factors. By identifying the sources of failure, we can move forward to take necessary action to overcome it. Online Health monitoring system can be used so that a transformer may last upto its expected life without failures.

8.1 FUTURE SCOPE –

1. All the utilities are quite troubled just because of huge rate of failure of distribution transformers. The rate of failure transformers in our country is around 12 to 15 % which is quite higher in comparison to other developed nation which is even less than 1%.
2. In future, if this system will be implemented by the power utilities of our country, a huge amount of money can be saved which is spent on the repair of transformers.
3. This money can be utilized for the development and growth of our nation that helps it to become strong and also to the sustain that development.

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