INNOVATIONEERING

Power Cut-off Notifier and Transformer Fault Predictor

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1.0 Project Abstract

Power cut-off is one of the major problems in our country, most of them are because of transformer failures. The user does not have any idea about the problem, its current status, etc. and even technicians know the problem only when people inform them about it. Due to regular transformer failures, power transmission and distribution companies experience significant loss, so we intend to reduce this loss.

We will be providing an ML and IoT based solution. We are Monitoring the transformer parameters along with a web-based app and for the miscommunication between user and office we will be providing a simple GUI in the web-based app where users can send messages to SEB(State Electricity Board) office with just a click and the location will be reported to the technicians. Also, with an additional feature of predicting the fault and probable defects that may take place in the future with the help of the *ML(machine learning)* model which would be using sensors, connected to the device through *IoT*. All these things integrated into a web-app for both users and the SEB staff.

With our device, the efficiency in detecting and resolving the problem would increase by up to 20% as all the delay in the process would be removed. In terms of cost, the setup of the transformer takes approx 5-6 lakhs and also the lifespan is approx 5-10 years but with just investing some more we can increase the life span by 20-25% by predicting the problems earlier.

The efficiency and cost matter a lot in real life as electricity is an indispensable part of our lives.

2.0 Market Analysis (Background)

1) Customer Need Identification :

As in the current scenario, we can see the power cut-off in various regions. Even the SEB people come to know about the problem (after the feeder) when people report them personally, also due to various reasons people calling at the same time the line is also busy most of the time and creates confusion. Thus the time for repairs is also increased. Hence there is a need for organizing the way of managing the communication between people and the electricity board members.

2) Product Differentiation w.r.t. Existing solutions:

Some companies which have a similar product as of our solution, but they do not have all possible parameters that detect the defects in the transformer. Also, companies do not predict the transformer defect and there is only an information alert to the customers. In our device, all these parameters are well analyzed, so the user will get an update about all such information integrated with machine learning tools. Predicting future issues of the transformer before the problem takes place will help to increase the lifespan of the transformer. Some existing companies, the list is given in the references section.

3) Understanding your customer & user:

Our solution would consist of a device that would inform the SEB office about the cutoff and also be predicting some fault problems and causes at the transformer level with the machine learning model that will be built from collecting the sensor data. So the *main users* would be all the people and the staff of SEB who would use the website for knowing their problem and staff would update all the things. And the power transmission & distribution companies, SEBs and transformer manufacturing companies would be our customers who would pay for the product which would be made available for the users.

People would be updated for power cut-offs, and the staff would be updated about the transformer failures through our website.

4) TAM, SAM (Total & Service addressable market):

The product would be used by most of the people as everyone has electricity in their houses. The TAM would be the electricity boards available for the direct revenue generation and also we would be having the users in this as we have our website which can be sold for Ads in it. These two things would be the main source of revenue generation. So according to Wikipedia (Link in references), we have 47 + 11 government(state+central) organizations providing power distribution in various places and also some private organizations. There are 1.3 billion people in India, so if we look at the SAM for using our service users must have a smartphone. The smartphone users in India are approximately 300 million people who can use the service. In India, 90% of the organization and companies do not have this kind of system involved in it.

5) Distribution Channel Identification:

As our product is for the power suppliers and transformer manufacturing companies, we can directly contact the service providers of the company. This would be most beneficial rather than open marketing as our target customers will be very specific. And also through social media apps which would cost bare minimum.

3.0 Problem Statement

People are facing a big issue during power-cut that is they are completely in the dark about the status of electricity when it will be back as without electricity nothing is possible and the current communication is not well organized so we intend to provide a solution for that.

Due to which there will not be any hassle while taking the problem and also the repair times will also get reduced.

4.0 Research

Proposed solution

The solution that we are proposing is that we would give control to users regarding the power cut. That is the user should be able to easily inform the office regarding the problem. This can be achieved with our web-based app where the user can message the SEB office with just a click. The user would Register his account with the electricity bill and when there is a power cut he would just press a button to send a predefined message. So if we receive a group of messages from a region we directly know the location of the problem.

Along with we will try even before the user messages a problem, we would be using a device that would contain sensors to get the parameters of the environment and the transformer and would train a machine learning model that would predict the problems to the technicians on the web-based app.

Innovativeness of the Proposed Solution

In case of a power cut, maybe due to short circuit, rain or any other obstacle. People first report it to SEB, and then further actions are taken. In our solution, with just a press of button people can inform the SEB office. Also, it monitors all the parameters that affect the transformer and predict the failures of the transformer using the machine learning model. This module predicts failures, and then sends alert messages about the emergency condition to the SEB so that we can increase the lifespan of the transformer significantly.

All the information will be available on the user-defined dashboards. And that too for everyone from the staff members to the people who are living in that region.

This module is cost-effective and can also be implemented in all possible areas, the major use can be seen in the areas where there are a lot of industries. When we look for other similar products, there is no communication between the control panel and the users. Here, the control unit will update the information about repairs, the damage and how much time it will require to regain the power, and it will be visible to the users on the dashboard.

Impact of the proposed solution

In India, the failure of a distribution transformer is a very common phenomenon.
The failure rate of these transformers(in Govt. SEBs): 16%
The failure rate of these transformers(international): 1 to 2%
The average lifespan of these transformers: 6-8 years
Price of distribution transformers in India: above 5 lacs

Distribution Transformer failure can cause significant loss to the power and transmission companies and SEBs in India. Our aim is to avoid transformer failures and increase their lifespan significantly. Using this product the transformer failures will decrease and increase in the life of the transformer, which is beneficial for the companies economically. Thus power transmission companies and SEBs can transmit power efficiently. We are also establishing a strong network between the power suppliers and the users, which will benefit almost everyone effectively.

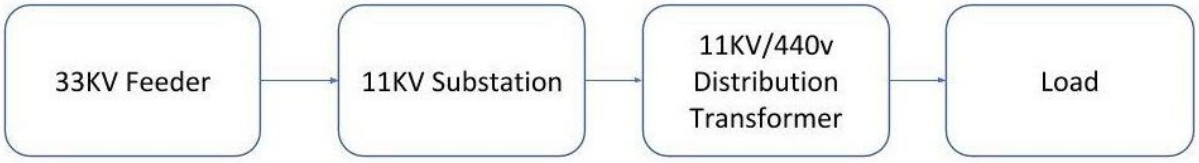
Also, this module can be a part of the smart grid. The smart grid is an electricity supply network that uses digital communications technology to detect and react to local changes in usage. This module can increase the efficiency of the grid which would help India to reduce an economic loss (especially in an industrial area).

4.0 Technical details

Our Product's aim is to monitor distribution transformers using machine learning and IoT. This will help to improve the health of the transformer and also to establish good communication between power suppliers and people by reducing the time for repairs.

The devices are mounted on the double pole structure of the transformer, so it does not require any major change in the current structure of the setup.

As there are various levels through which the power is transmitted from the station, substations, feeders, transformers on double pole structures, then to our houses by poles. Till the feeder, substation level, there are people available to repair the faults there, so we were trying to automate things at and after the transformer level.



In our module, we have used the distribution side current by converting AC to DC. Also, the protection of the module has been taken care of by adding a circuit breaker to the circuit. The continuous power supply after a power cut-off(approx,15-20 mins), is given by UPS which would help the module to send the data to the server and switching off the module.

We are using a Machine Learning model to monitor the Distribution Transformer. To build this model, we require to collect the data which affects the transformer's health. The transformer monitoring system consists of various sensors that can be placed on the transformer for its monitoring in real-time.

In the Transformer monitoring system, we are using the current sensor, voltage sensor, oil temperature sensor, winding temperature sensor, oil level sensor, humidity sensor and Raspberrypi 3B+ microcontroller for the prototype. This project uses the GSM module for wireless transmission of data.

The system collects the data from the sensors, and this collected data is sent to an analysis model via wireless communication using the GSM module. The collected data will be uploaded on the server for further data analysis using a machine learning algorithm. We would mostly be using Random Forest as it is currently one of the best methods of training the model, but we would also check if we can increase the accuracy of the model with other algorithms also. This data will be also available on the staff panel on our website.

Normal condition statements are used to detect the failure of the transformer. The control unit will have access to the status of the transformer all the time. So when any of the parameters of the transformer changes to an unusual range, the control unit will know it and then they can take further precautions to stop the transformer failure.

Hardware components:

Module: Data Acquisition and Fault Predictor (DAFP)

1. Rpi 3B + (Microcontroller)
2. Circuit Breaker
3. Voltage Stabilizer
4. SMPS(Switch Mode Power Supply)
5. UPS/Battery

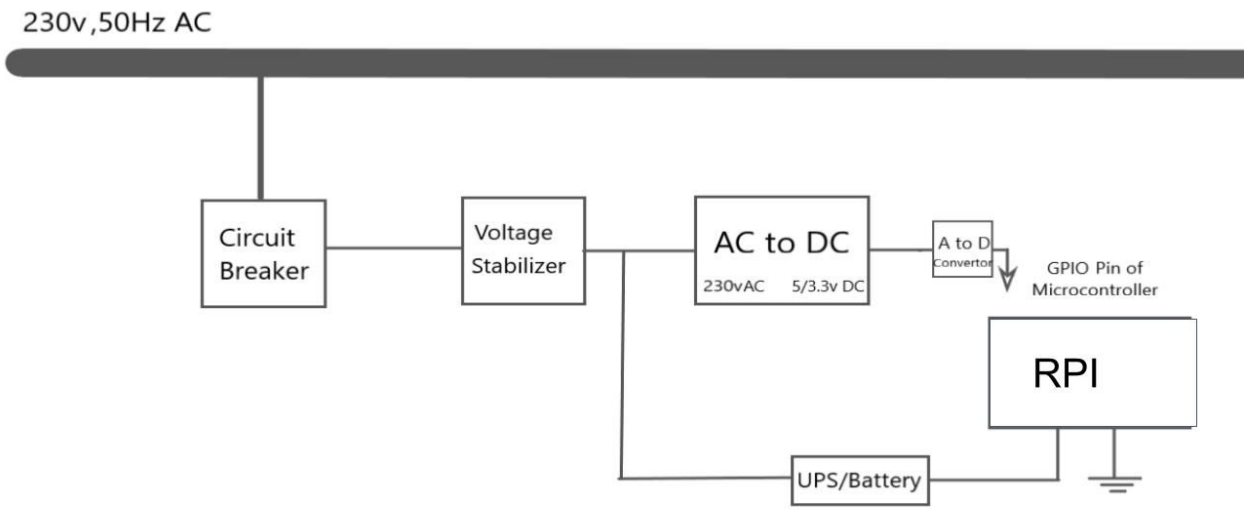
Sensors

6. Voltage Sensor
7. Current Sensor (ACS712 Current Sensor)
8. Oil level sensor (Float level sensor)
9. Oil temperature sensor (DS18B20 Waterproof Temperature Sensor Probe)
10. Winding temperature sensor(LM35 Temperature sensor)
11. Humidity sensor (DHT22/AM2302 Digital Temperature & Humidity Sensor)
12. Gas sensor (MQ135)
13. GSM (SIM800L)

Proposed Methodology:

I. Electrical unit :

This part is used to provide power supply to the sensors and microcontroller after distribution transformer i.e., load side. This module will be connected in parallel combination with the lines(one phase).



Power Source

Our design consists of the following parts:

Circuit Breaker: The circuit breaker is used to trip the DAFP module in case of faults such as a short circuit.

Voltage Stabilizer: A voltage stabilizer is used for stabilizing the voltage in the range of "180v-270v" to 230v.

SMPS(Switch Mode Power Supply)/AC to DC Converter: Switch Mode Power supply/AC to DC Converter is used to convert 230v AC to 5 volts.

UPS/Battery: In a power failure, the breaker trips the circuit due to Undervoltage/overvoltage, the UPS(Uninterrupted Power Supply)/Battery is used to supply power to the microcontroller.

Single-board microcontroller (Raspberry Pi): All the sensors and the GSM module will be connected to it with which we would be monitoring all the data parameters.

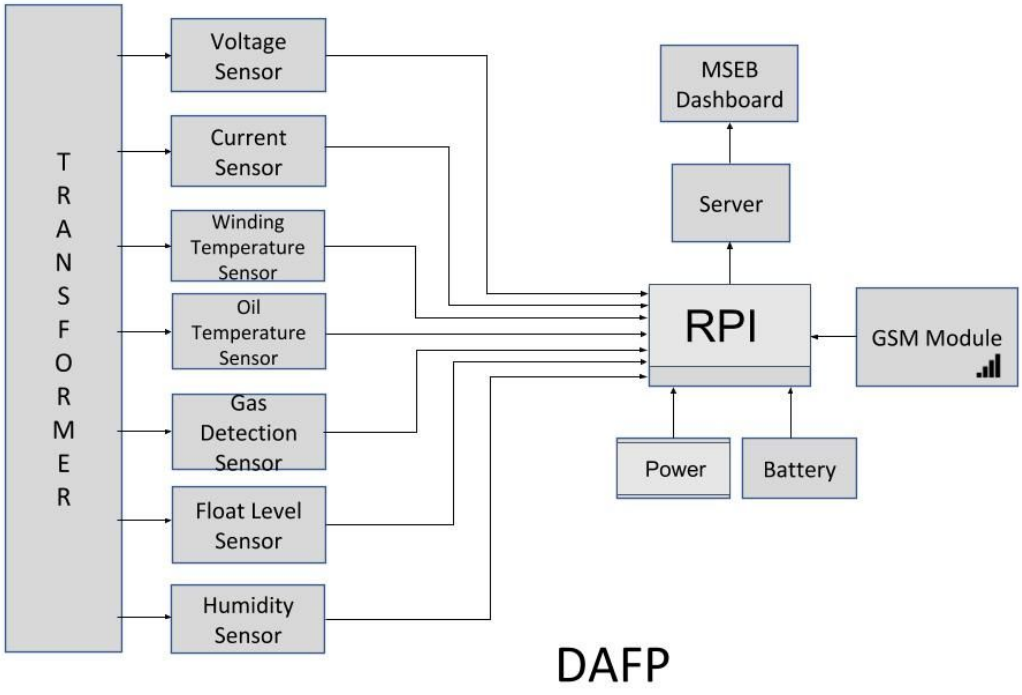
II. Data collection and transmission unit:

Module: Data Acquisition and Fault predictor (DAFP)

All the sensors such as temperature sensor, humidity sensor, voltage, and current sensor, etc. are mounted on the transformer and are integrated with Raspberry Pi Model 3B+ along with the GSM module in this prototype. Every distribution transformer in the area is provided with such a model where various sensors' real-time data along with the transformer's identity.

Voltage and Current sensor: Measure the voltage and current output in the *PCMN module*.

Winding temperature sensor: Measure the temperature in the transformer windings. The rise in voltage temperature increases the voltage of the windings which is not good for the health of the transformer.



Oil Temperature sensor: The transformer is filled with oil. It measures the temperature of the transformer oil.

Float level sensor: The level of oil in the transformer is measured with this. Very low oil levels in the transformer will result in overheating of the windings and the very high oil level can cause over-pressurization when oil expands.

Humidity Sensor: The humidity sensor is mounted outside of the transformer to measure the humidity in the environment.

Gas Detection Sensor: This sensor will measure the gas present in the oil tank.

GSM module: The collected data from all the sensors is transmitted using the GSM module. The data is transmitted periodically or if there is a significant change in the parameters of the transformer.

III. Data analysis and prediction:

The sensor data which will be collected would be used in building the machine learning model. We would also be providing the panel in staff console so that they could label the problems that occurred in case of repairing so we would be using supervised learning for better accuracy of the model. We would look at all different possible models that we can build form the given data, and then after studying the accuracy, precision and how well the model performs on the unknown data will be our deciding factor to choose a

particular model over the other. All the model building and integrating work would be done in the admin panel where the data scientists could work for getting the best performance from results.

IV. Server-side and website:

Now that we have the data of sensors and the flags for the particular region which show the electricity status of that particular region from that transformer signal. All sensor data will be used for building the machine learning model which would try to predict if there would be a cause of the problem and if possible tell the cause.

The Website would mainly be divided into 3 parts

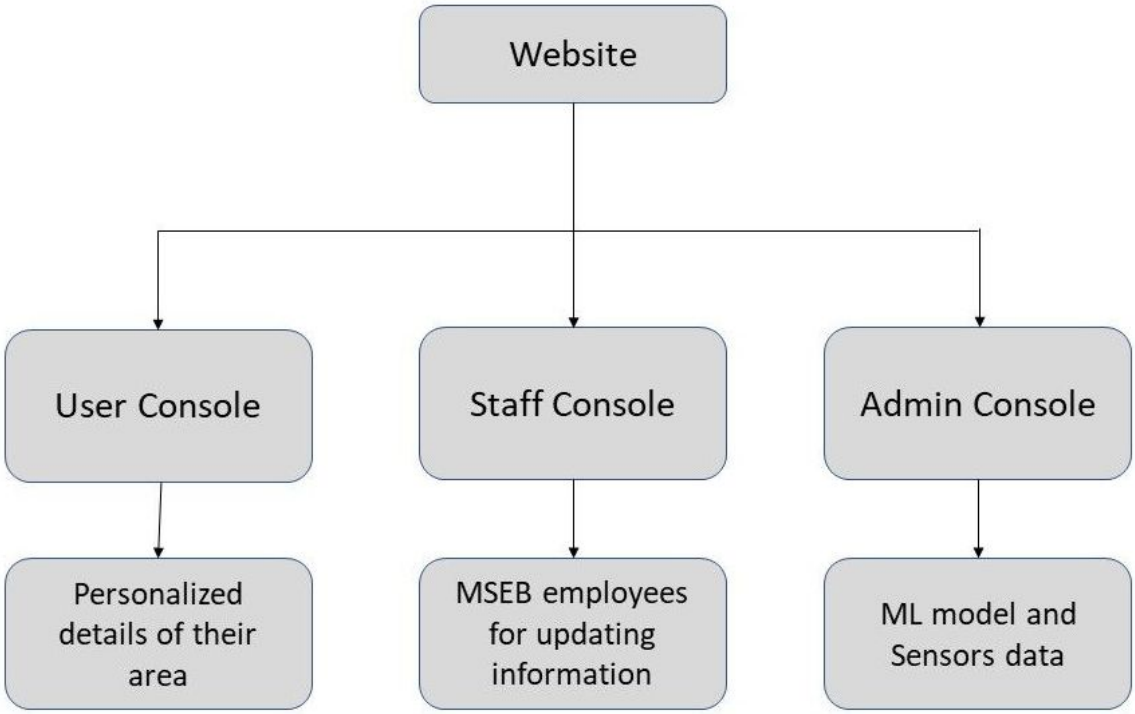
1) User/Customer console
2) SEB console of staff
3) Admin console

The main website would have 3 different logins for all three as mentioned above and also a registration for the new user. As there would be new users who would like to use the services of notification.

User console would contain the basic things, while register we would ask the basic info of the user and his electricity bill details so that we can verify the authenticity of the user. Once the user is verified he can use all the functionality. As there is power cut-off there would be an electricity status present on the website where the user just needs to press the button as we are giving this for only registered users, so we have all the details for that particular person that is the number and exact location of the transformer.

And to cross verify the problem that there is power cut due to transformer fault is that the SEB office would be notified only when there is a number of such requests generated from a particular region. Which is a necessary primary check.

Similarly, we will be having the SEB console and ADMIN console the SEB console will be used by the staff for updating the details like repairing time, status and some other things. And admin console will be used by developers for doing tasks and training the model and various things for development.



5.0 Future Scope and Applications

This is a solution which would be used where ever the electricity is present and this would increase the lifespan of the transformer. In the future, we can automatically detect the power cut-off at the transformer level without the need of users to update the information.

References:

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