Conceptual Framework for Fault Detection and Fault Location in Overhead Power Transmission Lines

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Abstract: The electricity has been distributed from one place to other through overhead transmission lines. It has been commonly used method since very long time. The faults may creep in at any point and at any time. Electricity comes under the essential services and therefore the faults or failures must be treated as critical issues. The most important part of addressing the issue is to find position and location of the fault so that speedy and accurate recovery is ensured. Traditionally the human interface has been there to find the faults and failures in the transmission lines nonetheless the technology may save substantial time and ensure effective utilization of the resources. One of the objectives of the paper is to find certain viable and implementable yet powerful strategies for detection of the faults and failures in the power transmission.

Keywords: Detection of Failure, Fault Detection, Smoke Detection, Transmission Line Failures

1. Introduction

In order to transmit electrical power from the place of production to the place of use, a network of wires (or grid) is used. This network may have a finite number of power stations, the transmission lines (withstanding high voltages) and the distribution lines meant for distributing electricity to the end user. It has been proved that low voltage cannot be efficiently and effectively carried to long distances, because of the huge power loss. As a result the electricity so generated is first stepped up through a step up transformer, before the transmission takes place [1]. The power so stepped up is then transmitted to various substations through a network of transmission lines. When such a power is received at the substation then this high voltage power is brought down by a step down transformer so that it could be used for different applications as per the needs. After the power is received at the substation and it is stepped down, such low voltage electricity could be used by the end users for various applications and appliances. Though the electricity could be transmitted through overhead transmission lines or underground transmission lines, the overhead transmission lines are mostly used for transmitting power to various places. As per an estimate in India, 70 percent of total power transmission is carried by overhead transmission lines. India being an agrarian economy, the major income is made through agriculture or industries. The fault free and continuous power supply is the need of hour. To have constant and consistent power supply, the power carrying lines must be properly maintained and monitored with due care. In India the power loss due to the transmission is 22.5%, whereas in the case of USA, for example it is just 5% [2]. If we raise the voltage 10 times it will reduce the current by factor of 10 and therefore the power losses are reduced by 1/100, with the condition that the current carrying conductors used in both cases are of same size. Considering the dimensions of conductor (its area of cross section) is reduced by 1/10 in order to match the reduced current value, the power losses are still at a reduced by 1/10. However the periodic and timely regular maintenance is taken, some unforeseen problems or issues could be there because of tree fall, storm, cyclones, unplanned and risky construction [3]. There could be soil erosion and corrosion by the wind passing through the sea especially in the transmission line that are mounted and fixed near the sea beaches. It is true that technical manpower is there for the maintenance of the transmission lines; at times it is practically difficult technically less feasible and time taking activity. In most of the cases the technician or the power engineers have to climb up the posts just to track and locate an electrical fault [4].

One reason for faults in the transmission lines may be due to sparking due to the failure of the insulators at the towers. Technically, to find out a fault and locating a failure in the transmission lines between the transformer and the end user is easy in comparison to the fault tracing in the transmission lines for long distances (upto thousands of kilometers) and covering very big number of towers. Therefore, a technical solution that is efficient and effective is required to be devised so that this problem could be overcome. In this paper, it has been an endeavour to suggest two solutions for detecting and locating the transmission line failures. One of them is based on IoT (Internet of Things) and other ones are based on voltage drop along lines [5].

2. L:iterature Survey

Certain relevant research papers and articles are examined and reviewed before a formal study has been conducted. Faults in overhead transmission lines are simplest to diagnose as the problem is quite often known and obvious, such as a tree could have fallen over the line, or some pole is damaged and the conductors carrying the electrical current are spread ground [6]. The faults may occur because of four reasons viz. weather conditions, equipment failure, human errors or smoke of fires. The climatic conditions such as lightning, thunderstorms, heavy rains, etc may harm overhead transmission lines and as a consequence they may interrupt regular power supply and thus disrupt electrical power supplies [7]. The electrical power equipments such as alternators, transformers, motors etc may cause faults because of short circuit mainly due to dysfunctional, insulation problems and ageing of wires and cables. These may result in flow of very high current through the circuitry or therefore damages it badly. The electrical faults could also be caused because of mishandling of the equipments by human beings [8]. This also includes the selection of inappropriate and improper rating of equipments. One of the critical reasons of overhead transmission line failure is air ionization caused by smoke particles that surround transmission lines. This results in a flashover or spark. This spark further causes the insulators to lose insulting properties under the effects of high voltages [9]. Whenever a fault is detected in the transmission lines, it may create very low resistive and impedance circuit path. As a result very high current starts flowing in the circuit and eventually the relays are tripped, the insulators and related components are damaged and sometimes the equipment is blown off. Because of the faults the personnel who work in the close vicinity may receive the shocks [10]. How deadly or severe the shock would be that solely depends on the intensity of the current and the level of at the location of the fault. It may even cause the death of the personnel. Such flow of heavy currents because of short circuiting may result in the complete damage of the equipments [11].

Thus the power supply may be completely disrupted because of the equipment failure. Because of the short circuit there may be outbreak of heavy fire that may damage the equipments. The faults disturb all the interconnected activities from the point of fault [12]. Thus the loss of time and other resources could be manifold. It may not be considered that the fault has just disturbed the power supply at the origin of the fault but it has also the extended effects in the related and interconnected activities. The short circuit may result in sparks that may further give birth to fire which may spread to neighboring buildings and they may be heavily damaged [13]. We may find the location of the faults in the transmission lines if we de-energize the circuit, or we may supply in the circuit with less power. The location of the fault may be determined by either of the two methods, first one being terminal method in which the currents and voltages are measured at extremes of the transmission cable [14]. If there is perceived difference between the desired and measured values of currents and voltages then it is established that there was a fault. The second method is known as tracer method in which an inspection is conducted across the transmission cable [15]. In most of the cases location of fault is determined just through close inspection of the cables. The transmission line is critical part of electrical power supply system [16]. Therefore the faults and failures do affect entire power supply system. In present era the requirement of power by the society has grown multifold and the lifestyle

has grown the requirement of power exponentially. The importance of study of location of fault its detection can be very well understood by the fact that almost 85-87% of the faults and failures occur in transmission line only [17]. Because of the faults there is huge energy loss that the present day corporate entities are confronting with. The only way out to this could be to devise some technique to offer a solution to problem of fault detection in the transmission lines. This can then be intimated to the concerned authorities about the specific location of such a fault [18].

To ascertain the location of fault and its detection requires the sensors to measure the voltage across power supply line and finds if some variation in the voltage is found. If faults are detected, they may be fixed by means of relays. Entire system may be integrated through IoT techniques so that the concerned personnel are intimated in time and the corrective action could be taken. The internet that is primarily providing effective communication and networking among various devices and physical entities or which are known as 'Things', is the major area of study that is known in turn as the 'Internet of Things' or in short IoT [19]. IoT will change almost everything including the human behavior and lifestyle. loT is has brought the revolution in terms of technology and human approach. IoT can therefore be applied to the area of fault detection and correction in case of transmission lines as well. There could be number of points to be considered while designing a power supply system. The fundamental to a power supply system is the ease of control in the system. The next consideration could be the ability to detect a fault in power line and all the interconnected devices could be easily monitored, and controlled [20]. The power supply system must be economical and it should not incur huge expenses. The corporate entities worldwide and in India, in particular have been consistently and continuously using modern technologies. In any of such endeavours the reliability transmission system is the top priority [21]. To meet the objective a GSM module based technology could be used that helps in detection of the fault and also determination of its location. GSM and GPS based system could be used to appropriately locate the fault position. This may ensure an immediate attention of the technical personnel to fix the faults [22].

3. Present Scenario

Transformer is critical part in the transmission of power. The proper functioning of transformer for effective power transmission is very crucial, that can be ensured through continuous monitoring. The continuous monitoring and proper maintenance ensures and increases the life and thus enhances the performance of a transformer. Transformer, commissioning is a costly proposition and the failure of a transformer cannot be fixed immediately in comparison to other equipments and components of power transmission system. [23]. A method could be proposed to use GSM and microcontroller in order to monitor the function of the transformer and if it is found the same is communicated to the concerned personnel. In such technologies usually a comparator is used that compares the input and output voltages of the transformer. When a significant voltage drop is detected it may be forwarded through SMS (Short Message Service) to the concerned officials. This method may be proposed for detecting leakage and theft of power in transmission line. This is implemented using GSM and microcontroller. The whole system encompasses two subsystems. One subsystem may be used for detecting the line failure while the other one may be used to identify theft [24]. The line failure is detected by finding the difference in voltage between the power transmitted and the power received. On the other hand the theft could be detected by measuring the total power consumed and then comparing it with the total power transmitted. If there is any difference in the measured parameters then it is immediately informed to the concerned officers. In the entire system wireless sensors and their networks are used for finding and locating the faults in the transmission line. At regular intervals, it measures the power difference and intimates about the deviation, if any to the concerned officials [25].

It may be mentioned here that the proposed suggestion could be considered for detecting asymmetrical faults. Surveys of the research papers and articles in context of power transmission failure have been conducted as well. On the basis of the aforementioned survey it may be inferred that GSM-SMS has been greatly proposed for the communication channel. Nonetheless, the obstruction caused by the nature for tapping and communicating useful information by the transducer or sensor has not been dealt with. While using, Artificial Intelligence techniques it has been revealed that it immensely requires training data which is very difficult to avail. In this concept paper, an efficient and effective solution is proposed based on Internet of Things (IoT). Some other techniques have been considered using other modes of communication [26].

4. Suggestive Solutions

It may be stated that different approaches could be considered in order to deal with the faults and failures in the transmission line and power theft. We shall be describing them in detail in the following sections.

A. IoT Based Models

As far as the discussion goes and it has also been experienced that the power transmission infrastructure is under high risk and uncertainty caused by many types of natural and interfering physical activities and events that may negatively affect performance and efficiency of power grid. Though we have fault or failures indicator techniques that may be the reliable means to find and locate the permanent faults, the technical personnel still has to be there at the place of fault and inspect closely the devices for longer duration so as to find and fix the failures of the transmission lines . As a suggestion, Raspberry pi to be installed along-with an inbuilt server which should be connected at the output of the transformers. Whenever a problem is encountered say because of the short circuit, the output voltage of the transformer will become very high (along-with low current) and the open circuit will have the low voltage at the (equivalently high current). This change in the voltages can be monitored effectively by using a webpage. The Current transformer and Voltage transformer have been used to measure the deviations in the current and the voltage. The sensor has been attached with the transformer for the data upload on the Webpage. Entire set up is connected with the Wi – Fi, so that the data is uploaded on the secure web page in real time mode. The uninterrupted power supply must be in place for Raspberry pi [27].

B. GSM Based Techniques

GSM Modules have been commonly used as communication tools in majority of the nations across the world. The GSM module is applied to have a proper communication between the microprocessor and the GSM system. The GSM modem is assembled along with a power supply unit and communication interfaces (such as USB, etc) for computer. In order to activate the communication with the network, one SIM card is required just like the one that is used in mobile phones. It does have an IMEI number just like the mobile phones for unique identification. AT commands are needed for the GSM Module, in order to interact with micro processor or micro controller. These commands are forwarded by the controller or the processor. Whenever a fault occurs or detected by the sensors, the information immediately is communicated to the decision making authorities through SMS. The authority then notifies concerned person or technician to rectify the problems in the area [28].

C. The Architecture of Suggestive Models

In these models various types of sensors are attached to the microcontroller, which after processing the useful data, detects for any problem or failures like short circuit sparks, power theft, line failures etc. in the transmission line. If any unusual condition is found, the microcontroller then forwards the same to the respective officials for further decisions. In order to communicate, we may use GSM module. After receiving the SMS, the officials may take appropriate actions. We have already

mentioned that by this method, the real location of failure can be ascertained. It would be more appropriate to use multiple sensors because values from one sensor may not be accurate and sometimes it may be misleading [29].

D. Other Solutions and Possibilities

To detect the faults in the transmission lines, it would be better approach sometimes that we measure the differences in voltages between the entry and exit nodes in the transmission tower. It is not much in use as it is expensive and we have to install Current Transformer (CT) at every possible vulnerable point. The communication about fault and failures can be achieved through the existing electrical conductor as a medium of transmission. The communication for sending the faults can be achieved by sending such messages at a different frequency than that one used for power transmission. At the reception the filters can be used to draw the messages. The fiber-optic cables can be used for the sake of communication between the points of fault and the control room. This may be achieved without much expenditure and without much technical troubles. The organization may choose appropriate method for communication by giving due considerations to the cost factors [30].

5. Conclusion and Further Scope

It has been attempted to suggest certain novel and appropriate approaches for finding and locating the failures in the network of transmission grid. The aforementioned methods could also be used for locating electricity thefts as well. Primarily two approaches viz., IoT and GSM have been discussed with proper use of sensors for identifying the reasons that may lead to network failures. In every approach, the detected problematic issues are duly forwarded through SMS to the respective authorities so that they may take timely decisions. The future of this approach depends on the advancement of communication system in the country and the govt. policies towards it.

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