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Distribution Line Fault Detection & GSM Module Based Fault Signaling System

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Abstract--Any distribution network is prone to faults, and intermittency in power availability creates loss for the supplier as well as user. Majorly, a supply line can be effected by conditions of overvoltage and overcurrent, also under-voltage condition. During the occurrence of any fault, the incident goes unreported for long duration. Manual reporting can lead to long outage time. To overcome this problem, a GSM based signaling system is developed that will detect the changes in voltage-current parameter, and using a microcontroller based circuit, the faults can be classified based on comparison values obtained from rated parameters of the distribution substation. To overcome these, we are proposing a GSM based transmission line fault detection System. Whenever the preset threshold is crossed, the microcontroller instantly initiates a message to be sent to the area lineman and the Control Station stating the exact pole to pole location. This helps us to realize an almost real time system. The real intention of detecting fault in real time and protecting the transformer at the earliest is realized.
Keywords--Distribution System, Unsymmetrical Faults, Sag, Microcontroller, GSM Card

I. INTRODUCTION

Generally when a fault occurs in Distribution or Transmission line, unless it is severe it is unseen. But gradually these minor faults can lead to damage of transformer. It may also initiate fire. Present day in India, we do not have a system in hand that would let us know in real time once a fault occurs. Matter of concern is that since we do not have a real time system, this leads to damage of the underlying equipment's connected and turns out to be a threat to human around.

In order to avoid such incidents to the maximum extent, maintenance or checking of the transmission lines or distribution lines are generally carried out on a frequent basis. This leads to increased manpower requirement. The fact remains that the real intention of this is not met as many a times line failure may be due to rain, toppling of trees which cannot be predicted. Like in places where massive rainfall almost sets everything standstill. It is necessary to understand the gravity and after effects of a line failure. As a solution to these problems, a system that is working on GSM will be very useful in distribution network & transmission line which can sense the fault in the system. A microcontroller is set to compare essential line parameters with preset value stored in the monitor. Whenever the preset threshold is crossed, the microcontroller instantly initiates a message to be sent to the area lineman and the Control Station stating the value of the increased or decreased parameter, so that the type of fault and its location can be properly predicted. This helps us to realize an almost real time system.

II. POWER SYSTEM FAULTS

Faults can be defined as the flow of a massive current through an improper path which could cause enormous equipment damage which will lead to interruption of power, personal injury, or death. In addition, the voltage level will alternate which can affect the equipment insulation in case of an increase or could cause a failure of equipment startup if the voltage is below a minimum level.[2] As a result, the electrical potential difference of the system neutral will increase. The severity of the fault depends on the short-circuit location, the path taken by fault current, the system impedance and its voltage level. In order to maintain the continuation of power supply to all customers which is the core purpose of the power system existence, all faulted parts must be isolated from the system temporary by the protection schemes. When a fault exists within the relay protection zone at any transmission line, a signal will trip or open the circuit breaker isolating the faulted line. To complete this task successfully, fault analysis has to be conducted in every location assuming several fault conditions.

There are two types of faults which can occur on any transmission lines; balanced faults & unbalanced faults. In addition, unbalanced faults can be classified into single line to ground faults, double line faults and double line-to-ground faults. The most common types taking place in reality are as follow:

Line-to-ground fault: this type of fault exists when one phase of any transmission lines establishes a connection with the ground either by ice, wind, falling tree or any other incident. 70% of all transmission lines faults are classified under this category.

Line-to-line fault: as a result of high winds, one phase could touch anther phase & line-to-line fault takes place. 15% of all transmission lines faults are considered line-to-line faults.

Double line-to-ground: two phases will be involved instead of one at the line-to-ground faults scenarios. 10% of all transmission lines faults are under this type of faults.

Three phase fault due to falling tower, failure of equipment or even a line breaking and touching the remaining phases can cause three phase faults. In reality, this type of fault not often exists which can be seen from its share of 5% of all transmission lines faults.[1]

Some researchers classify fault as [3]:

Series faults which represent open conductor and take place when unbalanced series impedance conditions of the lines are present. In the real world a series faults takes place, for example, when circuit breakers controls the lines and do not open all three phases, in this case, one or two phases of the line may be open while the other/s is closed. Series faults are characterized by increase of voltage and frequency and fall in current in the faulted phases.

Shunt Faults are the most common type of fault taking place in the field. They involve power conductors or conductor-to-ground or short circuits between conductors. One of the most important characteristics of shunt faults is the increment the current suffers and fall in voltage and frequency.

III. METHODS OF FAULT LOCATION

Faulted lines must be repaired and returned to service in the shortest possible times to provide reliable service to the customers. Several methods of locating transmission line faults have been developed to achieve this objective. The primitive method of fault location was to visually inspect the line [2]. The procedure involved patrolling the line by foot or automobile and inspecting the line with or without the aid of binoculars.

Sectionalizing the line and energizing it in pans has been used to reduce the length of the line that must be inspected. Surge-operated targets placed on line towers, and tracer currents have been used to further assist in locating faults. These procedures are slow, inaccurate and expensive, and are unsafe during adverse weather conditions. Other methods, proposed in the past used, include the use of annunciator ammeters. Magnetic links and automatic oscillographs. These methods are also not used widely because they require considerable preparatory work and skill; they are time-consuming and accuracy of the results is low. [4]

To estimate the locations of faults on radial distribution systems, the following methods, which are based on measurement at one terminal of the line mentioned below [4]:

Reactive component method.

Takagi algorithm.

Richards and Tan algorithm.

Girgis algorithm.

A. Reactive Component Method

Estimates the apparent reactance of the line from its terminal to the fault and converts the calculated reactance to distance.

B. Takagi Algorithm

In this method, the line fundamental frequency voltages and currents measured at a line terminal before and during the fault. This approach uses the Thevenin's equivalent of the faulted system and obtains estimate of distance to a fault.

C. Richards And Tan Method

It considered the fault location problem as a parameter estimation of a dynamic system and compared the response of the physical system with that of a lumped parameter model. The Thevenin equivalent model used in this method includes system resistances and inductances and an unknown fault resistance.

The parameters of the model are varied until the observed voltages and currents match adequately with those obtained from the response of the model. An optimization technique is used to determine the fault resistance and fault location. The method needs an accurate network model including transmission lines and sources. The technique needs a lot of iteration, is computationally expensive and cannot be easily applied at every line terminal.

d) Girgis Algorithm: The method suggested a fault location technique for rural distribution feeders. This technique estimates the fundamental frequency voltage and current phasors on the detection of a disturbance. Changes in the amplitudes of the current phasors are used to classify the fault type and faulted phases. The voltage and current phasors of the faulted phase are used to compute the apparent impedance.

IV. FAULT ESTIMATION & DETECTION

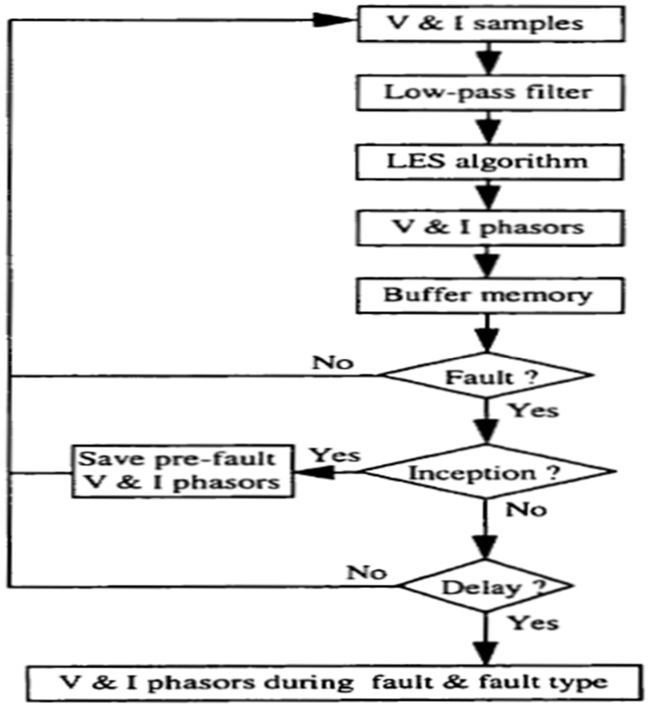

Fig 1 – Flowchart for Fault Detection

The method adopted to detect the fault in line needs real time reading of line current and voltage parameters, also the instant calculation of result based on algorithm used. The technique consists of few major steps, after fault is detected:

The fundamental frequency components of the pre-fault voltage and current phasors at the required point is recorded.

The fundamental frequency components of voltage and current phasors at faulty point during the fault occurrence is estimated and the fault type is determined after a pre-set time has elapsed. These actions are taken on-line.

The pre-fault and fault data, along with line and load parameters, are used in an off-line mode to estimate the location of the fault.

To Estimating the faulted section, sequence voltages and currents at node, before and during the fault are calculated from the estimated phasors.

The type of fault and the phasors of the sequence voltages and currents are used to obtain this estimate.

An impedance, measured at the terminal, could point to multiple locations in the system if it has laterals.

V. HARDWARE IMPLIMENTATION

Whenever there is an abnormality in distribution transformer, it's symptoms are visible in its physical parameters like Winding temperature, Oil temperatures, Ambient temperature, Load current, Moisture in oil, Dissolved gas in oil, Bushing condition, LTC monitoring etc.

To monitor these parameters and its immediate processing, a system consisting of embedded circuits, GSM modem, mobile users, GSM networks and sensors, which is installed at transformer side which reads and measures the physical quantity from the distribution transformer and then it converts it into the analog signal. The embedded module is located at the transformer site. It is utilized to acquire, process, display, transmit and receive the parameters to & fro the GSM modem. The second is the GSM module. It is the link between the embedded system and the public GSM network. The third is utility module that has a PC-based server located at the utility control center. The server is attached to GSM modem and received transmits SMS from/to the transformer site via the GSM module.[5]

A GSM modem is a wireless modem that works with GSM wireless networks. To send SMS messages, first place a valid SIM card into a GSM modem, which is connected to microcontroller by RS-232 cable. After connecting a GSM modem to a microcontroller, you can control the GSM modem by sending instructions to it.

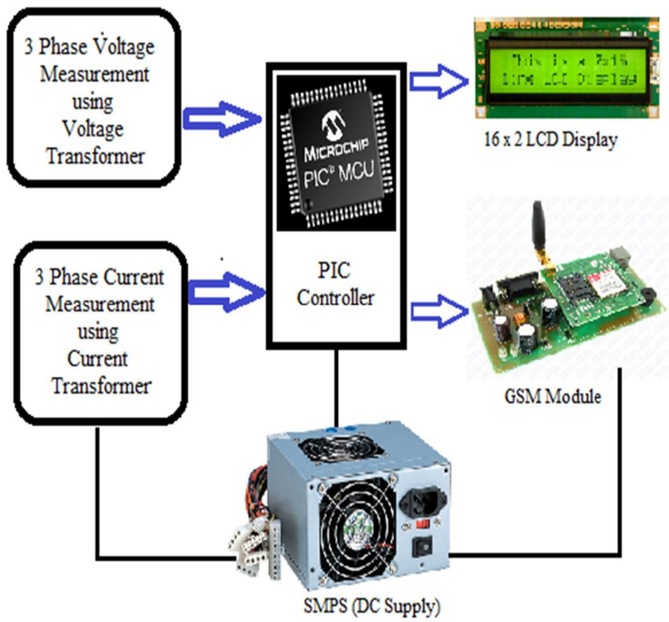

Fig 2 – Basic Block Diagram of the Monitoring Circuit

The above figure depicts the basic operations followed in the monitoring distribution transformer via GSM technology. The following steps constitutes the process of data monitoring & processing [5]:

First sensors which are installed at the transformer site sense the various parameters of transformers and convert into analog signal to be processed in signal conditioning circuits

Signal conditioning circuit consisting of opamps and resistors manipulates the analog signal to a compatible value so that can be read by the embedded circuit

Next the signal is passed through microcontroller. The ADC is used to read the parameters.

Built-in EEPROM is used to host the embedded software algorithm that takes care of the parameters acquisition, processing, displaying, transmitting and receiving.

The built in EEPROM is used to save the online measured parameters along with their hourly and daily averages.

The GSM modem is interfaced with the microcontroller through RS 232 adapter by which it upload and download SMS messages that contain information related to the transformer parameters and status.

This GSM modem then sends this SMS to mobile users containing information about parameters value of the distribution transformers.

VI. CONCLUSION

The system is effective in the sense that a complete online monitoring of the distribution transformer is achieved through this system. Also, the concluding result regarding the fault is deducted based on tested variations in parameters. But the difficult part is to include all the sensing parameters for the fault analysis as it makes the programming complex. The use of GSM modem helps in effective message signaling to the required receiver.

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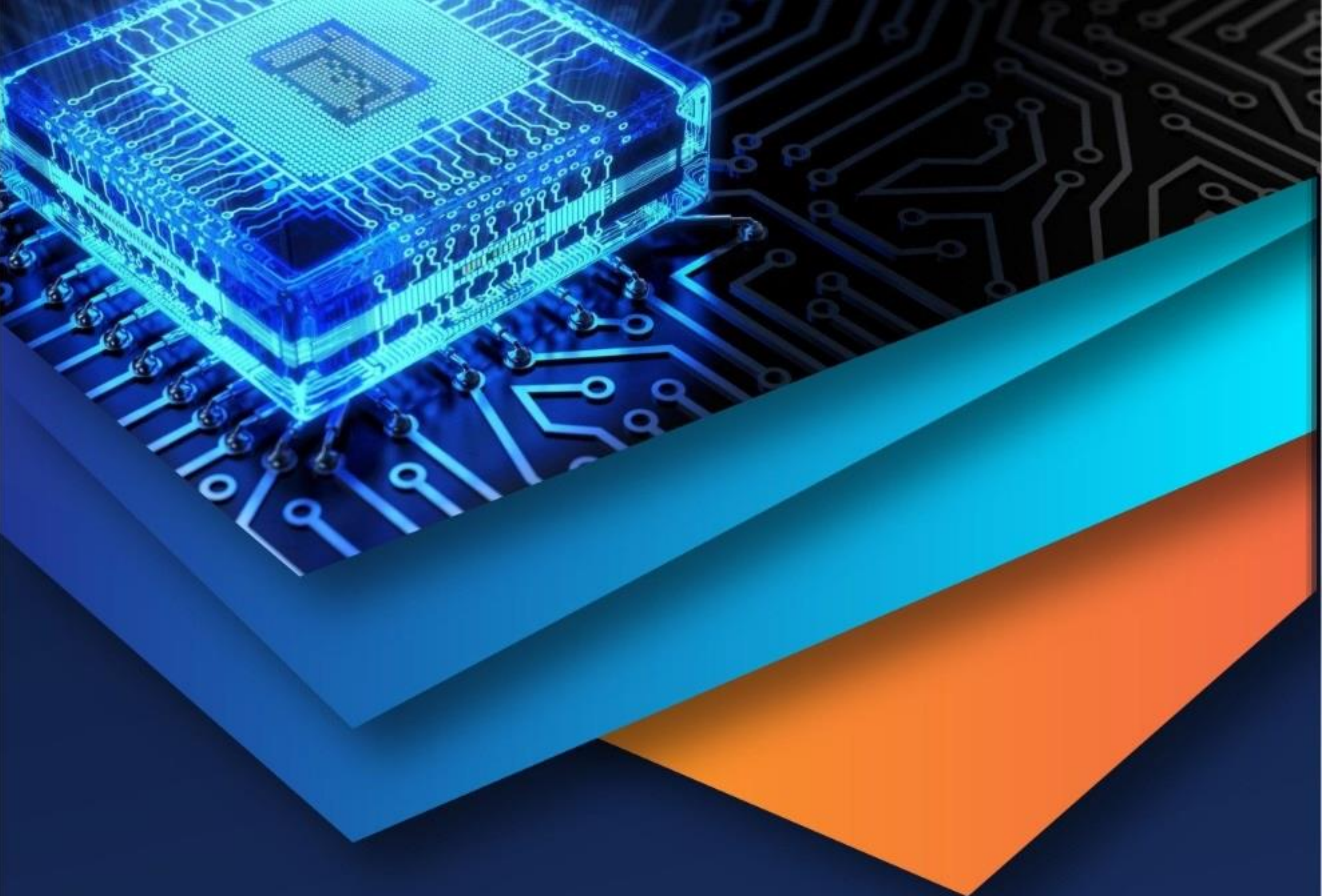

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