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Advanced Techniques for Prevention of Electrocutions, Power Theft and fault reader using GSM for FACTS

[1]Anusha A M, [2]Ashwini, [3]Sarvesh Naik, [4]Mr. Harshith K
[123] Students E&EE Dept. SIT Mangalore,
[4]Asst. Professor SIT Mangalore

Abstract: **Electrical accidents to lineman are rising during electric line repair due to lack of communication between the maintenance staff and electric line man. The main purpose of this project is to save line man by making a protective system controlled through fingerprint scanner. In this proposed system if there is any fault in the line, the line man senses his finger due to which main line is switched off. Once the line is locked with his finger print, he works on line solving the problem and once his work is done he again senses his finger and switch on the electrical line. This can be achieved by interfacing relay as well as biometric fingerprint sensor with the arduino. In this proposed scheme, identification of location of the fault can be done very quickly by using voltage and current sensor to continuously monitor the line parameters. These sensors are interfaced with the arduino board. The arduino is programmed to detect the abnormal conditions such as open circuit, short circuits, under and over voltages and to send a message to the concerned authority via GSM. A smart GSM based fault detection and location system is used to adequately and accurately indicate and locate the exact spot where fault had occurred. This will ensure a shorter response time for technical crew to rectify these faults and thus help save transformers from damage and disasters.**

1. INTRODUCTION

Transmission lines are among the power system components with the highest fault incidence rate, since they are exposed to the environment. The faults that occur due to lightning, storms, vegetation fall, fog and salt spray on dirty insulators are beyond the control of man. Utility work is essential for keeping electricity running into our homes, but it is also highly dangerous. Linemen risk falls, electric shocks, burns and other injuries while on the job every day and these incidents can even be fatal. There are reportedly 1400 deaths in the last three years across India due to electricity related accidents. In 2014 the total number of accidental deaths by electrocutions in India was 9606. The top 10 states/UTs in terms of accidental deaths by electrocution in India during 2014 were: Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Gujarat, Chhattisgarh, Andhra Pradesh, Telangana, Tamil Nadu and Karnataka. Electricity is the fourth-leading cause of death in the world. Therefore the protection of the linemen and the transmission line is highly needed. The main cause for electrical accidents to the linemen is due to lack/miscommunication between maintenance staff and electrical line man [1-3].

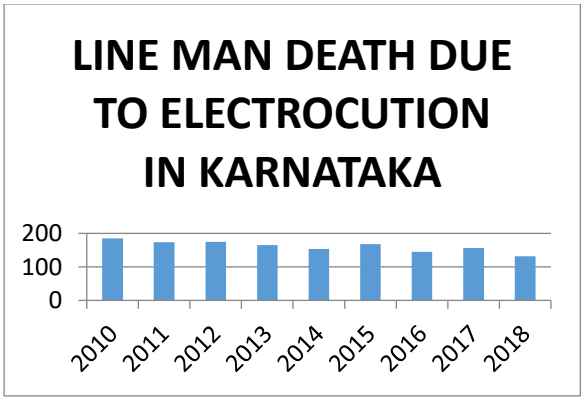

Fig 1.1 Line man death due to electrocutions in Karnataka

The Electric Power System is divided into many different sections. One of which is the transmission system, where power is transmitted from generating stations and substations via transmission lines into consumers. Both methods could encounter various types of malfunctions is usually referred to as a "Fault". Fault is simply defined as a number of undesirable but unavoidable incidents can temporarily disturb the stable condition of the power system that occurs when the insulation of the system fails at any point. Moreover, if a conducting object comes in contact with a bare power conductor, a short circuit, or fault, is said to have occurred. The causes of faults are many, they include lighting, wind damage, trees falling across transmission lines, vehicles or aircraft colliding with the transmission towers or poles, birds shorting lines or vandalism.

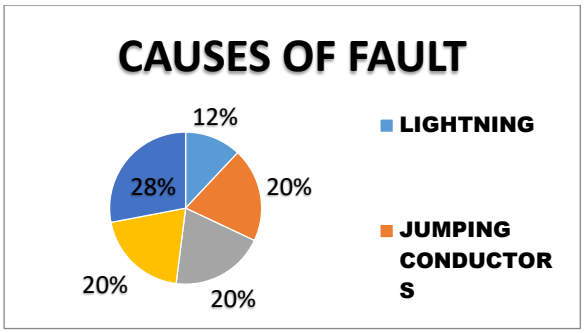

Fig 1.2 Causes of fault

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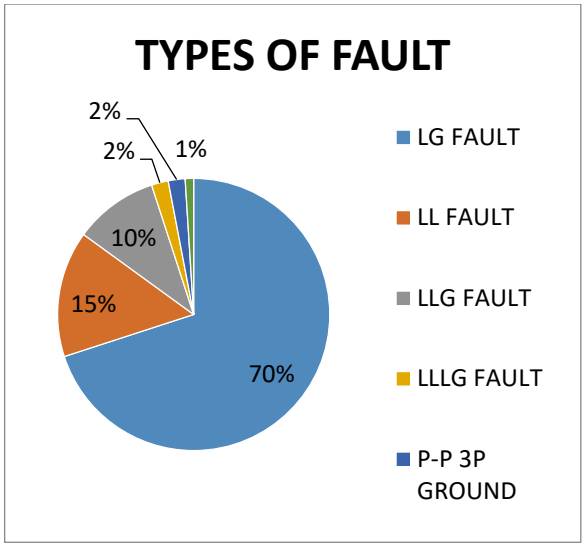

Fig 1.3 Types of fault

2. BLOCK DIAGRAM

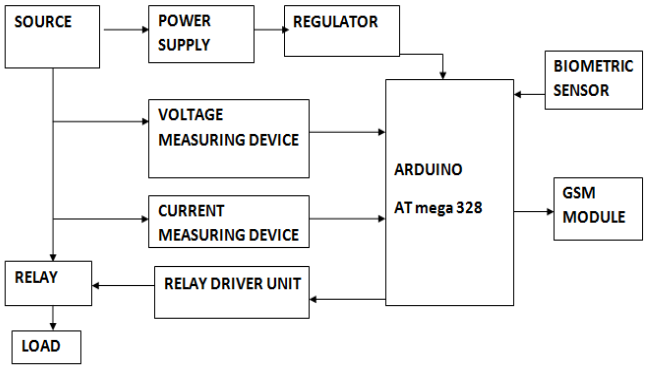

Fig 2.1 Block diagram of the proposes scheme

The main functional unit of this project is the Arduino. The arduino needs 5V power supply for its functioning. This voltage can be given either from main source using suitable voltage regulator or by a 5V DC power supply. There are different sensors used viz.., voltage sensors, current sensors, biometric sensors. These sensors are interfaced with the arduino, which is able to read the parameters obtained by the sensors. The arduino is programmed to detect the faults and abnormal voltage conditions. If the voltage/current parameters are not in the permissible limits, the proposed system will give the signal to the relay which then disconnects the system and prevents further faults and accidents. Meanwhile the GSM module will send the exact location of the fault to the concerned authority. The biometric sensor is used to make the protective system controlled through fingerprint scanner [4]. The transmission line can be locked and unlocked with the fingerprint. Description of the hardware components used are as follows:

Source: This is the standard single phase voltage with one 230V power line and one neutral wire with 50Hz frequency.

Power supply: This is the external power supply which is provided to give supply to the arduino board as well as to the GSM module.

Regulator: Since the arduino works only on 5V DC supply, the AC supply has to be converted to DC and the voltage level has to be maintained at 5V. This is done by regulator.

Voltage measuring unit: Voltage sensors are used to continuously measure the voltage parameters. This is interfaced with the arduino. This information can be used to identify the faults as well as under and over voltage conditions.

Current measuring unit: Current sensors are used to monitor current parameters. This unit is also interfaced with the arduino.

Biometric fingerprint sensor: This sensor is used to enroll the fingerprint of the linemen and to give access to open and close the line with his previously enrolled fingerprint. This device is also interfaced with the arduino.

GSM module: The location of the fault is sent to the concerned authority by GSM module. This module is interfaced with the arduino and is able to send the message according to the information sent by the arduino.

Relay driver unit: This unit takes the information from the arduino and sends the proper signal to the relay to ON/OFF the supply to the load.

Relay: This unit takes the signal from the relay driver unit and automatically disconnects the supply to the load during fault condition and connects it when the fault is cleared.

Load: Load is any electrical device which operates on 230V AC power supply.

Arduino: This is an open source hardware and software user community to which all the sensors and GSM module are interfaced. This is programmed in such a way that it reads all the information obtained from the sensors and is able to identify the fault and abnormal conditions. This also sends the signal to the GSM module to send the exact location of the fault. This sends the ON/OFF signal to the relay driver unit [5].

3. BIOMETRIC SENSOR

Biometric sensor refers to a science involving the statistical analysis of biological characteristics. Thus, we should refer to biometric recognition of people, as those security applications that analyze human characteristics for identity verification or identification. However, we will use the short term “biometrics” to refer to “biometric recognition of people”. Biometric recognition offers a promising approach for security applications, with some advantages over the classical methods, which depend on something you have (key, card, etc.), or something you know (password, PIN, etc.). A nice property of biometric traits is that it is based on something you are or something you do, so you do not need to remember anything neither to hold any token.

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Fig 3.1 Biometric sensor module

3.1 Verification and identification

Biometric systems can be operated in two modes, named identification and verification. We will refer to recognition for the general case, when we do not want to differentiate between them. However, some authors consider recognition and identification synonymous.

Identification: In this approach no identity is claimed from the user. The automatic system must determine who the user is. If he/ she belongs to a predefined set of known users, it is referred to as closed set identification. However, for sure the set of users known by the system is much smaller than the potential number of people that can attempt to enter. The more general situation where the system has to manage with users that perhaps are not modeled inside the database is referred to as open-set identification. Adding a "none-of-the-above" option to closed-set identification gives open-set identification. The system performance can be evaluated using an identification rate. Verification: In this approach the goal of the system is to determine whether the person is the one that claims to be. This implies that the user must provide an identity and the system just accepts or rejects the users according to a successful or unsuccessful verification. Sometimes this operation mode is named authentication or detection. The system performance can be evaluated using the False Acceptance Rate (FAR, those situations where an impostor is accepted) and the False Rejection Rate (FRR, those situations where a user is incorrectly rejected), also known in detection theory as False Alarm and Miss, respectively. There is a trade-off between both errors, which has to be usually established by adjusting a decision threshold. The performance can be plotted in a ROC (Receiver Operator Characteristic) or in a DET (Detection error trade-off) plot. DET curve gives uniform treatment to both types of error, and uses a logarithmic scale for both axes, which spreads out the plot and better distinguishes different well performing systems and usually produces plots that are close to linear. Note also that the ROC curve has symmetry with respect to the DET, i.e. plots the hit rate instead of the miss probability. DET plot uses a logarithmic scale that expands the extreme parts of the curve, which are the parts that give the most information about the system performance.

3.2 How does biometric sensor work?

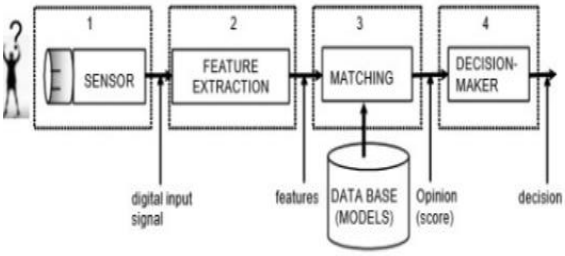

Fig 3.2 Block diagram of biometric sensor

Usually biometric systems require two consecutive steps: Enrollment: In a similar fashion as humans do, the system needs a learning procedure, before being able to recognize. The purpose of enrollment is to have user's characteristics registered for later use. The procedure consists of the following steps: a) the input signal is acquired by means of a biometric scanner. If possible, the quality of the sensed signal is checked. If it is below a threshold, a new acquisition is performed. b) Some measurements are extracted from this signal by means of digital signal processing. c) Measured parameters of previous step are used to work out a model for the given user. Sometimes, the whole set of extracted features are stored, and used as model. This model will be compared with the features extracted from input signals on recognition mode. The proportion of individuals for whom the system is unable to generate repeatable templates is defined as Failure to Enroll (FTE) rate. FTE includes those unable to present the required biometric feature, those unable to produce an image of sufficient quality at enrolment, as well as those unable to reproduce their biometric feature consistently. Recognition: Once the user is enrolled, the system can work in identification or verification mode and the systematic explained in previous sections one-to-many comparisons for identification, and one-to-one for verification using the claimed identity by the user [6].

4. DESCRIPTION OF THE FLOW CHART:

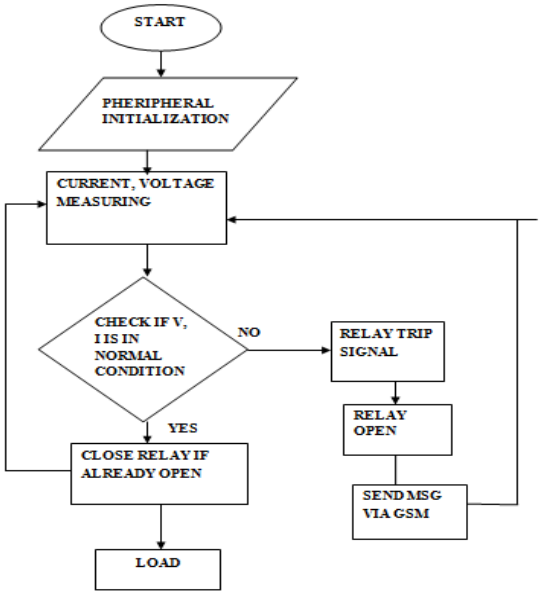

Fig 4.1 Description of the flow chart

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The program has two sections
1) Void setup- Initialization of all the modules should be done in this section.
2) Void loop- The rest of the programming statements comes under loop section this will execute the statements continuously in a loop manner.
The execution flow begins with start (Fig.4.1) from start, the signal flows to the peripheral initialization. In the peripheral initialization the ports of following devices are initialized: Relay, Sensors, GSM module.
The signal from the peripheral initialization is fed to the arduino. The conditional statements are used to identify the over voltage, under voltage and faulty conditions. The reference voltage values should be written in the conditional statements. In case of the abnormal conditions, the GSM module should be activated. The mobile number of the concerned authority to whom the message should be sent must be mentioned in the conditional statements. If these statements are executed then send HIGH signal to the respective relay, otherwise send LOW signal.

5. CIRCUIT DIAGRAM OF THE PROPOSED SCHEME:

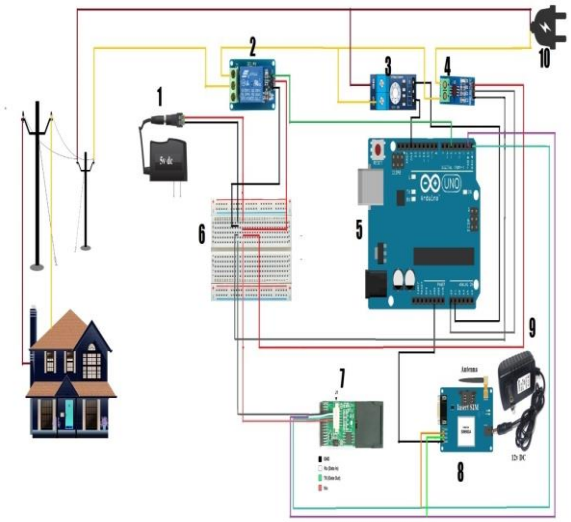

Fig 5.1 Circuit diagram

Number	Component name
1	5V Adapter
2	Relay
3	Voltage sensor
4	Current sensor
5	Arduino ATmega328
6	Bread board
7	R305Biometric sensor
8	GSM module
9	12V, 2A Adapter

The arduino needs 5V power supply for its proper functioning, this power is fed from external battery. The Vin terminal of the arduino is connected to the positive terminal of the battery and the GND is connected to the negative terminal of the battery. The voltage sensor has two ends, one of which has 'S' and '-' terminal, these are connected to Analog input (in the code it is A0) and GND terminal of the arduino respectively. The current sensor should be connected in between the lines such that the current should flow through it. It also has two ends in which one side is connected to the analog input of the arduino (A1) and the other side is connected in between the transmitting line. The biometric finger print sensor has four terminals. The Rx and Tx terminal of the sensor is connected to the Tx and Rx terminal of the arduino. It also needs external power supply. Hence, the positive and negative terminal of the sensor is connected to 5V and GND of the arduino. The GSM module has 10 pins, out of which first three pins are GND, Txd and Rxd. These pins are connected to the GND, Rx and Tx terminals of the arduino respectively. The antenna should be connected to the antenna port to fetch the network. The 2G/3G SIM should be inserted in the SIM slot provided in the GSM. The 12Volt, 2Amps adaptor is used to power the GSM module. The two electromagnetic relays are used in this proposed device, the relay module has three terminals viz.., Vin, GND and the input terminal. The Vin and GND terminal of the relay is connected to the power supply to energize the coil, the input terminal is connected to the digital pin of the arduino (D5 as mentioned in the programmes). In this project the relay 1 is connected to the digital pin 5 and relay 2 is connected to the digital pin 6 of the arduino. The normally closed terminal of the relay is connected to the load and the common terminal is connected to the 230V AC supply.

6. METHODOLOGY

The set up or field device consists of 3 major components, Sensors, GSM modem and Arduino. Prevention of accidents caused to linemen during line clearance can be avoided by using finger print of the person who deal with the transmission lines. The biometric device is used to record the fingerprint. This device is also interfaced with arduino which stores the pattern and gives signal to the relay in the substation to open the circuit breaker and once the rectification of the faulty line is done the line is unlocked by the same fingerprint. The arduino compares the fingerprint, if it matches with the previously used fingerprint to lock then the transmission line can be charged by the person in the substation. All these workings are mainly depends on the Arduino programming. The location of the fault can also be easily identified by using sensors. The voltage and the current sensors used in the project uses Hall Effect methodology to measure the units. Hall Effect is nothing but the production of a potential difference across an electrical conductor when a magnetic field is applied in a direction perpendicular to the flow of current. The primaries of the Current and Voltage sensors which are connected to the line sense the corresponding current and voltage values of the system and feed the output to the ADC of the arduino which converts the signal to a digital form in order to be processed by the CPU of the processor. The Arduino serves as the central point of the set up. It contains a set of programming codes which have been stored in the EEPROM which enables it to classify the fault type based on the voltage and current values. Based on the program, the microcontroller compares these values to see whether they are within the range required. If the voltage and current values are out of

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range as compared to the reference, it gives an indication of a fault and under/over voltage conditions. Meanwhile the signal from the arduino is sent to the relay kit which is placed in the DTC, the relay coil get demagnetized and hence breaks the contact between normally closed and common terminal. Thus prevents further flow of faulty current in the line. At this instance the GSM module will be activated when there is an occurrence of a fault and it will automatically send the location of the faulty place as well as abnormal conditions. The RS-232 serves as the connector between the arduino's serial communication port and the modem. The device is placed in the distribution transformer centers of the transmitting line.

7. RESULT DISCUSSION

In this work implementation of a protective device, the experiment was done with Regulated DC Power supply to detect the voltage below 15V as under voltage condition and above 20V as over voltage condition. The GSM module successfully sent the information about the abnormal condition to the concerned people. During fault condition, the circuit will remain in open condition. In this condition the relay in the DTC will act and prevents the further flow of current. Meanwhile the location of the fault is also sent via GSM. The entire distribution area is divided into two sections as section A and section B. whenever the fault occurs in section A, the corresponding location name is sent through the GSM. Similarly if the fault occurs in section B, the message "Fault in Section B" is sent. In order to demonstrate transmission protective system using biometric fingerprint scanner, 230Volt, 50Hz, AC supply is made to control through biometric fingerprint scanner along with electromagnetic relay. Initially the fingerprint was enrolled which was later used to control the transmission line. Whenever the enrolled fingerprint was scanned, the arduino sent a signal to the relay. The relay then acted and break the entire circuit, the same fingerprint was later used to make the continuous connection of the transmitting line.

8. ADVANTAGES

Highly Reliable: Our system including hardware as well as software is highly reliable. This system will satisfactorily perform the tasks for which it was designed for a specific time and in a specified environment.

Fit and forget system: Once the hardware, software and interfacing is done and it is installed in the proper location, then you hardly know it is there. It does not require repeated maintenance. One can completely forget the system once it is installed properly.

Able to work in all atmospheric condition: The sensor used in our proposed system is able to work in -20 degree C as well as up-to 48 degree C. Therefore the operation of the system will not be affected due to the changes in the environment.

Highly sensitive: The system is highly sensitive, since the sensors used to monitor the line parameters are able to identify even a small change in the voltage and current values in the range of millimetres. The biometric sensor used has the verification speed of 0.3 seconds and scanning speed is 0.5 seconds. This makes the system highly sensitive.

Low cost: Our proposed system is highly economical since the Government of Karnataka has already installed a modem in each Distribution Transformer Centres to avoid power theft. The same modem can be used to send the messages to the concerned authority along with the sensors. Hence the overall cost can be reduced.

Scalability: Arduino program can be erased and reprogrammed. Hence the system has the ability to be enlarged to accommodate growth.

Online real-time data acquisition: Instantaneous acquisition of data is possible.

9. CONCLUSION AND FUTURE SCOPE

The proposed system will provide a reduction in the time required to locate a fault by automatically providing accurate fault location information especially in the distribution lines. The system will also be useful to detect and locate faulted segments on their transmission lines and, therefore, minimize power disruptions to distribution substations and help save expensive transformers. Charging of transmission line due to miscommunication between linemen and the concerned people who operates in the substation can be avoided which may otherwise leads to death of the linemen. Faults can be easily identified and corrected and hence the time requirement for rectifying is less, therefore interruption of power supply is minimized. Our project is able to minimize the losses that occurs to the power sector industries and hence able to increase the overall GDP of the country by 1.5%. The proposed system can be redesigned with PLC & SCADA for increased networks as well as for HT lines. This will enable the communication between the substations as well. Also the controlling of relay operations at various DTC through mobile can be made possible by developing an app for the arduino and the relays, thereby control of power flow of different areas can be done sitting at one place.

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