Remote Monitoring and Analyzing of Low Voltage Distribution System

Abstract

Electricity distribution is the final stage in the delivery of electricity from generating power plants to end users. A distribution system's network carries electricity from the transmission system and delivers its load centers. It is the most visible part of the power supply chain, and as such the most exposed to the critical observation of its users. Thus, it is very important to have high reliability, high efficiency and high service quality in a distribution system.

In order to have such a system, improvement in some areas is important. They are, identifying the point of fault occurrence, fixing the fault in minimum time, keeping a proper data base of outage and fault occurrence, effectively monitor the voltage variation, current variation and other related parameters, identifying the voltage drop and keeping the variation within the standard level. At present, a system to monitor and control the low voltage distribution system in Sri Lanka does not exist.

In this paper, we propose a permanent solution for the above issues by monitoring the distribution network regularly. The whole system is based on GSM network and measuring devices integrated with software interface. By using this developed system, faults can be detected instantly with the exact location including GPS map. The system helps to monitor voltage and current values efficiently, improve reliability, reduce the outage time, and maintain a proper data base and forecast the load.

Keywords: Remote monitoring, Low voltage distribution, GSM communication

1. Introduction

Electricity distribution is the final stage in the delivery of electricity from generating power plants to end users. The transmission system voltage is stepped-down to lower levels by distribution substation transformers.

The primary distribution system is that portion of the power network between the distribution substation and the utilization transformers. The primary distribution system consists of circuits, referred to as primary or distribution feeders, which originate at the secondary bus of the distribution substation. The distribution substation is usually the delivery point of electric power in large industrial or commercial applications.

Electricity is one of the basic needs of people in modern world. So it is very important to have high reliability, high efficiency and high service quality in a distribution system. In order to meet these facts, following areas should be improved in a distribution system

- Identifying the faults occurred place in an instant,
- Fixing the fault in minimum time,
- Keeping proper data base of outage and fault occurrence,
- Effectively monitoring the supply voltage, current and other related parameters,
- Identifying the voltage drop and keep the variation in standard level.

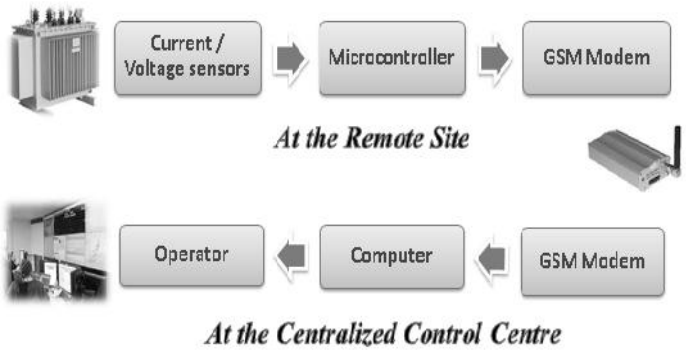

Figure 1: System Design Diagram

So it is necessary to monitor the system in a regular manner. But, it is very hard to find a proper way of monitoring the distribution system in Sri Lanka. The basic idea of the system design is shown in Figure 1.

2. General Information

Remote monitoring and analyzing system of low voltage distribution lines is being developed in order to monitor and analyze low voltage, 50 Hz; three phase distribution system from a centralized control center. We propose a software tool integrated with specific measuring devices and proper communication link.

- Designing of measuring device

Designing of measuring devices is the most important part of this project. Incorrect measuring of voltages and currents definitely misguide the objectives of the project. Hence, it is required to design a device which should be sensitive enough to capture variations of measuring parameters (current and voltages of three phases).

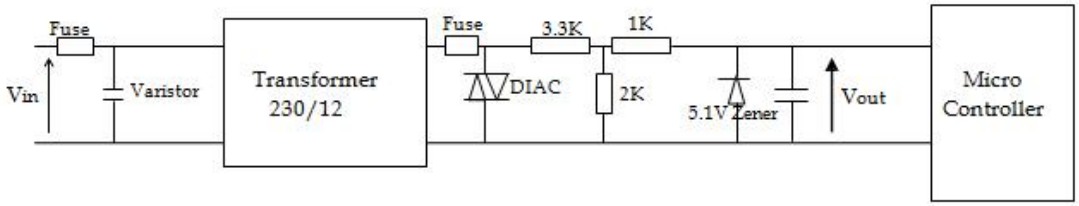

Figure 2 : Voltage Measuring Device

Linear variation between sensor output and measuring parameters are preferable as it is easy for calibrating. In order to achieve those requirements, we choose voltage transformer and current transformers with required specifications.

In Sri Lanka distribution voltage level is 230V (rms value) with 6% tolerance (216V-244V). So the voltage sensor device (voltage transformer) should be withstood for this voltage level. Hence the selected voltage transformer can withstands up to 275 V without damaging to windings and without saturation.

There could be some issues (Surges) that increase the voltage of the low voltage distribution system. So protection system is required to protect the measuring device from that issue.There are several types of protecting devices used in this project in order to overcome this problem. Those are;

- Varistors (275V)
- Diac
- Zener Diodes (5.1V)
- Fuses (1A)

The full diagram of Voltage measuring device with protection devices is shown in Figure 2.
In Sri Lanka most of low voltage distribution lines are constructed using bare conductors. But in now a days it is being converted to Arial Bundle Conductors (ABC), because of the difficulties arise due to way leaves.

- ABC (213A)
- Fly (155A)
- Wasp (220A)

Although ABC can carries up to 213A, it cannot be loaded to high ampere rating because of heat generation will harm the conductor.

Generally, current through the low voltage conductor is lower than 200A. Hence, we use current transformer with current ratio 200/5 and class 0.5. According to type of conductor capacity, different type of current transformers should be used with various current ratios. Current through the conductor can be measured using resistor ladder.

Another main objective of this project is, identifying the faults in the system. There are few kind of faults are occurred in the system. In case any kind of fault, HRC fuses will operate and disconnect the line from transformer .The fault is identified using voltage level of the conductor. Disconnection will leads to zero voltage in the conductor and zero current through the conductor. The type of fault can be determined as a further improvement of the project.

- Over current problem

Current transformer ratio is 200/5. We can define certain tolerance level that current can increase. If secondary current exceed this tolerance level, fault can be identified as an over current fault. Meanwhile protection system should be activated and protect device from over current.

- Over voltage & Low voltage problem

As described above, over voltage faults also can be identifying by defining specific tolerance level. If voltage of the system decrease or increase this predefined voltage level, error message will send to centralized control center.

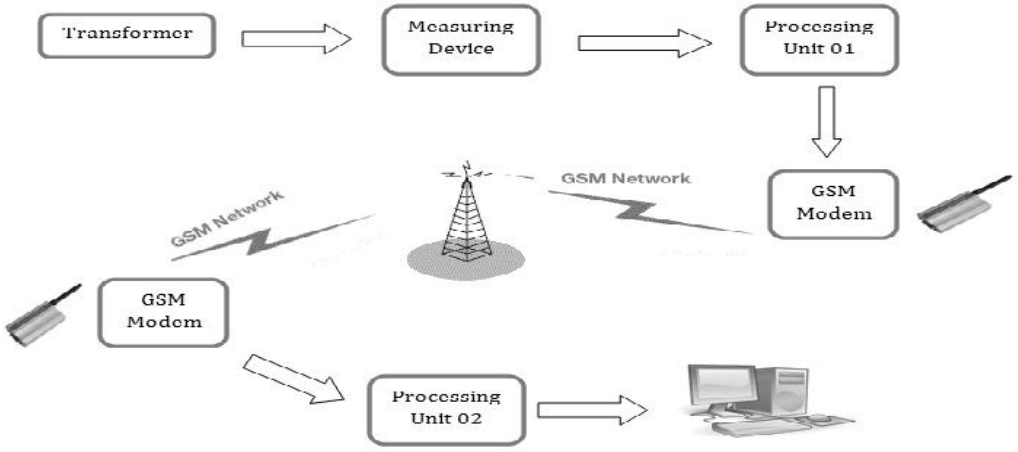

Figure 3: Communication System

- Data Communication

The communication system is also one of the major part in this project. GSM network is used to communicate (send and receive data) between Centralized control center and the measuring devices. Figure 3 is shown the flow of the communication system.

The GSM modems are placed near the distribution transformers and the centralized control center. The modems which are placed near the transformers are connected to measuring devices via controller system (16F877A microcontroller). Measured data is sent to the Centralized control center as a text message via above GSM modems.

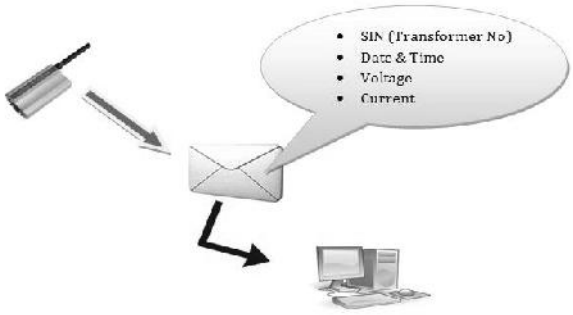

Figure 4: Contents of a Message

Then the receiver modem will catch the data and update the data base in the control center. These text messages include the latest current and voltage values measured by the measuring device, transformer number (SIN-Serial Identification Number), date and time as shown in the Figure 4. pic C language is used to command the micro controller and AT commands used to command the GSM modem.

- Interfacing

In the data transferring process, measured data is transferred from measuring device to the GSM modems. First the measured data is sent to the microcontroller and then data is processed and converted to a SMS. After that the SMS is sent to the GSM modem which is placed in the control center through the GSM modem at the site. Interfacing between microcontroller and GSM modem is done by using Max232 integrated circuit and RS 232 protocol as shown in Figure 5.

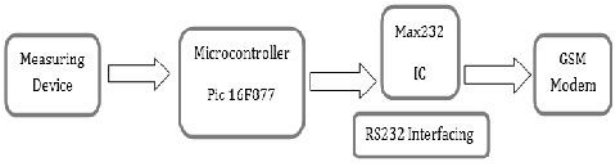

Figure 5: Interfacing at the Measuring Device

The data which are transferred from the site GSM modem to the control centre GSM modem should be displayed through the computer. The interface between modem and the computer is done using RS232 protocol as shown in Figure 6.

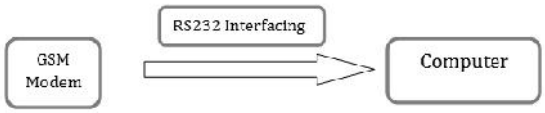

Figure 6: Interfacing at the Control Center

RS-232 (Recommended Standard 232) is the traditional name for a series of standards for serial binary single ended data and control signals connecting between a DTE (Data Terminal Equipment) and a DCE (Data Circuit- terminating Equipment).

It is commonly used in computer serial ports. Many modern personal computers have no RS-232 ports and must use an external converter to connect to older peripherals.

■ Graphical User Interface

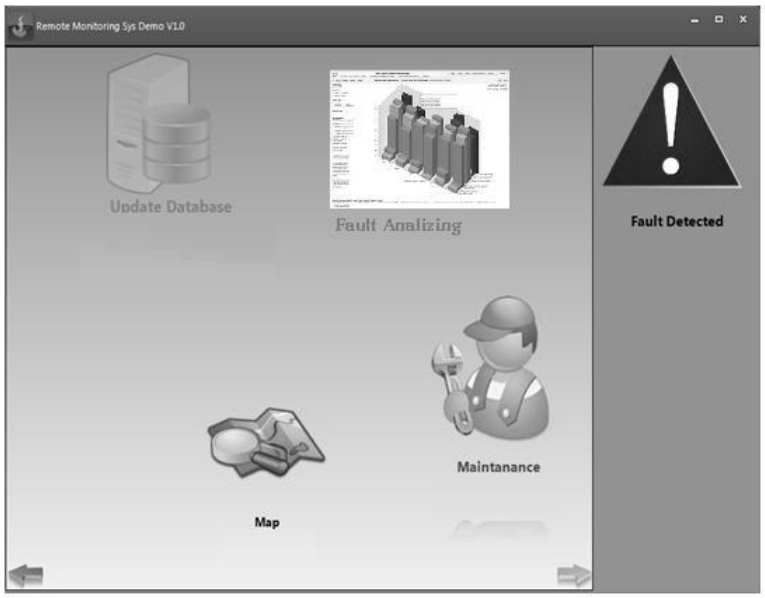

Figure 7: Graphical User Interface

Graphical User Interface is the final step of this project. The data which measured in the Low Voltage system distribution network feeders are transferred to the Control Center and those data are transferred to the computer placed in there. Those data is used to update the database

in the Centralized Control Center. Basic developed interface is shown in Figure 7.

When the system identified that there is a fault in the network, the Fault indicator will appeared and shows that there is a fault in the system. This will help control center operator to identify the fault in an instant. Controller will be able to check the exact place and can schedule the related operation for the workers. Also it will provide GPS map to the operators.

Graphical User Interface facilitates user to easy monitoring and analyzing of the low voltage distribution system.

Throughout GUI, operator can,

- Monitor current status of the system (Voltage & Current of each transformer per hour)
- Efficient fault detecting

Faults can be detected instantly and the exact transformer, feeder and the phase can be identified by using this GUI. Following figure shows example of fault detection. The red colored one is the phase with fault as shown in Figure 8.

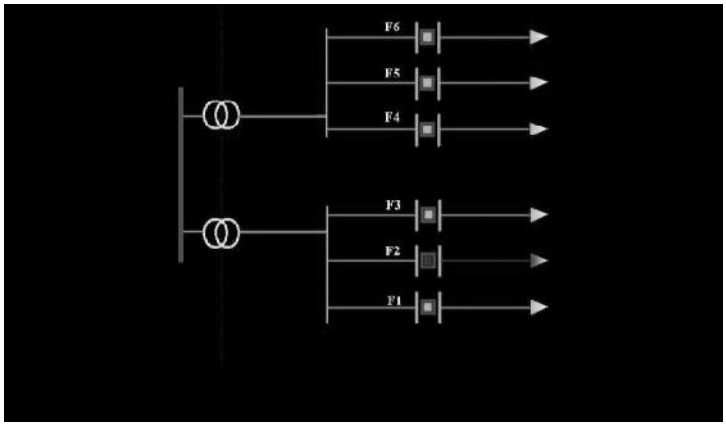

Figure 8 – Interfacing at the Control Center

- Fault analyzing

The faults occurred in the system are recorded in the data base. Those faults are analyzed by feeder wise, transformer wise and time wise by system and display using GUI. Figure 9 is shown, faults analyzed by transformer wise for a period of time.

- Maintain proper database Data base keeps records of following details,
  - SIN
  - Transformer Capacity
  - Transformer Location
  - GPS Location

- Fault Time

GPS Map is used to identify the exact place of the fault occurred, GPS map is given the exact position of transformer with GPS coordinates.

According to our proposal following objectives can be achieved.

- Easily detection of faults in distribution system.
- Outage reduction.
- Efficient monitoring.
- Phase balancing.
- Maintaining proper data base.
- Load forecasting.
- Improve reliability.

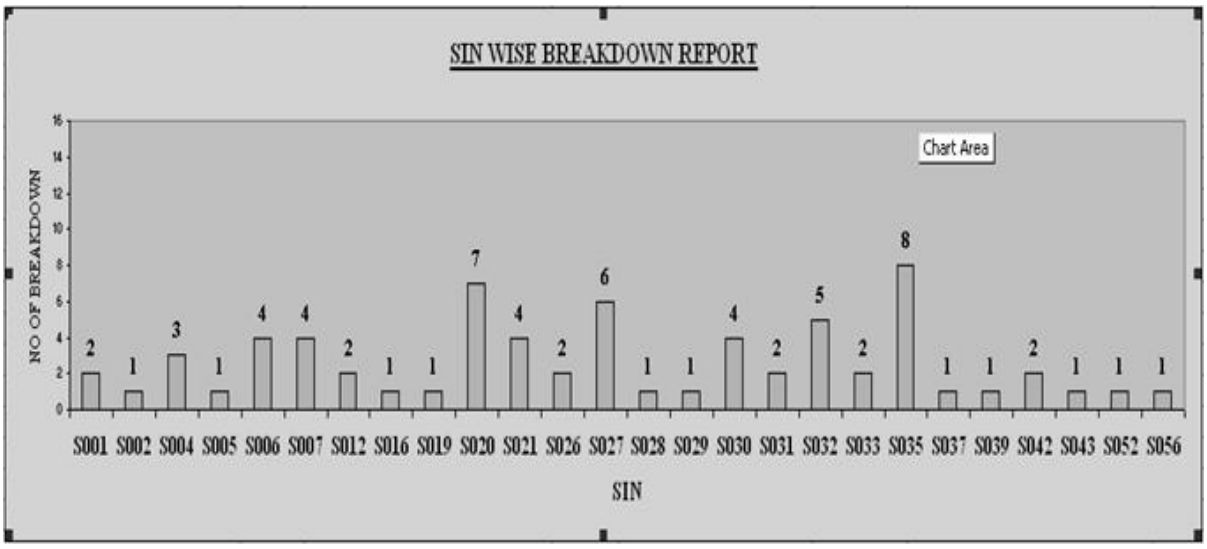

Figure 9: Transformer Wise Faults Analyzing

3. Conclusion

In the modern world electricity is one of the basic needs of human beings. People take more and more uses from electricity every time every day. So they can't do their day today works without electricity. So, people don't like to be without electricity, at least for one moment. Although people need electricity always, there are some power failures always. Therefore, power distribution companies need some precautions, to minimize the outage time of their users. In this project we present a permanent solution for minimizing outage time by monitoring the distribution network regularly. Also we supply some advanced features like ability to keep a proper data base. Fault analyzing, etc. The whole system based on GSM network and measuring devices (voltage and current transformers). By using the developed system power distribution companies can supply a more reliable power supply to their

consumers. Considering all aspects the REMOTE MONITORING AND ANALYZING SYSTEM is a low cost reliable solution to reduce the outage time of end user consumers.

References

1) Kandy City Automation Project, Ceylon Electricity Board (On going project).

2) Kundasale Area Automation Project, Ceylon Electricity Board(On going project).

3) AT Commands for GSM/GPRS Wireless Modems, Reference Guide, Revision C, Multi Tech Systems.

4) SMS and the PDU format, [online] Available: http://www.dreamfabric.com/sms