DESIGN AND IMPLEMENTATION OF A GPRS BASED FAULT LOCATOR SYSTEM

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ABSTRACT

Providing constant electricity for cities is one of the most Important issue in the electrical power distribution network companies. To make a distribution network more reliable there have been many types of automation introduced in different elements of these networks like in switches, circuit reclosers, auto reclosers, etc. These devices are connected to an automation system and then controlled from dispatching centers, remotely. The fault indicator is one of the devices that have extreme importance for a trustable power distribution network. In the case of vast distribution networks, identifying the exact place of the fault is rather time consuming and comes with a lot of difficulties like when the problem is far in the desert, crew should drive their cars along the cable network to find the fault location.

In this paper we present a GPRS based fault indicator system which automatically detect the location of fault in the distribution network. The software part of the proposed system can immediately show the fault location on the screen in the monitoring station.

INTRODUCTION

On basic distribution networks (without any automation) when a fault occurs crews must be dispatched to locate the fault, disconnect the faulted section and prepare the network for repairs. All of these times crews must spend to find the location (travelling time and reaching the site), find the fault by inspecting the circuit and travelling between switching points must be reduced. Therefore, different automation is introduced in fault indicators, like Power Line Communication (PLC) and Fixed RF Network but both of them have many disadvantageous. In case of PLC, one can mention its lack of conformity with local distribution networks, possibility of losing information as its drawbacks.In case of RF Network, having many different elements like “collector towers”, “repeaters” which increase the costs can be named as its drawbacks. The on-line power quality monitoring system in a large network is mainly to monitor the power quality of the supplied power from the power utility. With the on-line monitoring implementation, the suppliers can understand the instant power quality issue such as voltage dropping [1].

During past few years, many different fault locator systems have been introduced. Figure 1, shows some traditional fault locator systems used in the power distribution networks.

(a)

(b)

(c)

Figure1. Some traditional fault locator systems (a) Flite 11x [2] (b) Line Troll 110E [3] (c) Cable Troll2500 [4]

The main objective of the current project is to introduce an inexpensive, reliable and automatic system for determining the fault location. The proposed system has a graphical user interface to show the fault location on the screen. Furthermore it is able to send a text message to a pre-defined mobile phone number and inform the occurrence of fault in the network. Here we take advantage of the GSM/GPRS communication standard which is a high-speed data handling technique. Using GPRS one can send information to users in the “packet” form. It has many other advantageous that emphasis its usage even more such as: vast coverage, great data transmission quantity, low running expense, fast switching time and so on [5].

In the proposed system each fault indicator uses the GSM/GPRS communication standard to connect to the server. Each fault indicator has a unique IP address which is used as a unique identity (ID) and is sent along with time and date of fault to the server. The idea is depicted in Figure2.

The proposed system has two different parts including hardware and software. Hardware constitute of a contact relay, a circuit using ATMEGA 32 microcontroller and a GSM/GPRS module.

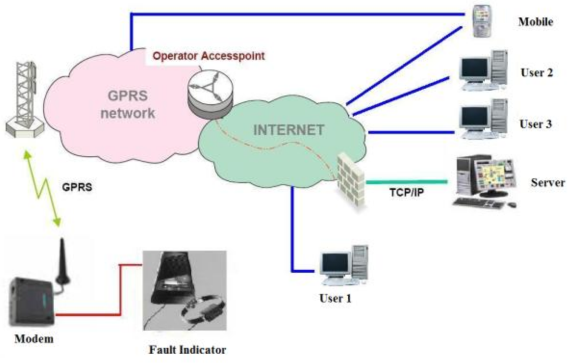

Figure 2 The proposed GPRS based fault locator system

When a fault occurs in the network, relay output contact will change its mode for one second. The microcontroller-based circuit which acts as an interface between the fault indicator and the GSM/GPRS module, will detect this change of the output mode as a one second pulse, and then send one data packet including fault indicator IP address, time and date of fault to the server. The system will continue sending the packet until it receives an acknowledgement from the server and then again it will enter the waiting mode to observe the next pulse from the relay.

Software designed for the server includes two main parts. First part is responsible to receive and store data sent from GPRS and the second part is responsible of showing it on the screen and providing report of on-line fault indicators.

SYSTEM COMPONENTS

Hardware

In the proposed system, we used the SIM300CZ as GSM/GPRS module. A PCB is designed to connect the SIM300CZ to a microcontroller. Places for SIMCARD, antenna, microcontroller and supply voltages circuits of fault detector and a back-up battery is reserved on the PCB. Figure 3 shows the final PCB designed for this module.

The SIM300CZ has 60 pines used for ground and supply voltages, serial connection and SIMCARD interface. The desired supply voltage for this module is between 3.4 to 4.5 volts with maximum current of 2 ampere. In Figure 4, the designed supply voltage circuit is shown. This module can support both 1.8v and 3.0v SIMCARDs.

Hardware flow control (RTS/CTS)

To control the process of sending and receiving data, two signals (RTS and CTS) are used. When sending data must be stopped, the CTS is deactivated. When receiver is activated a signal is sent which means receiver can accept data again. The default mode for data communication in SIM300CZ is the hardware flow control which can be switched to software easily using the AT command.

Figure 3 Designed PCB

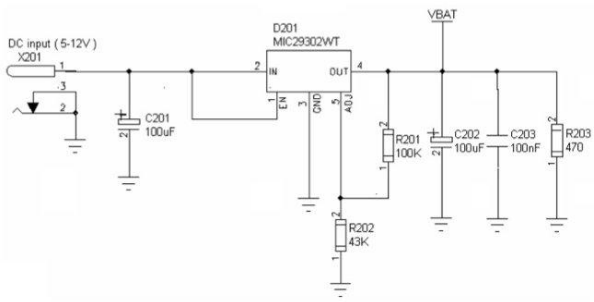

Figure 4 Designed supply voltage

Software flow control (Xon/Xoff flow control)

In the software flow control, for holding or starting the sending process a pre-defined character is sent. For holding it is (Xoff) decimal 19 and for starting (Xon) it is decimal 17.

This kind of controlling is used in 3-wired serial communication.

Software

Software developed for this system includes two parts. The first part includes the software written for microcontroller for communication between fault indicators and SIM300CZ and also sending data through SIM300CZ. Second part includes the software written for server to receive data and showing the fault location on screen. For communication with GSM/GPRS module we should use the AT command and serial port of microcontroller.

Using a suitable flow control mechanism is one of the important matters when communicating with GSM/GPRS module. It means that when the receiver buffer is filled with data, sender recognizes this and holds the sending process until it acknowledges the empty space in the receiver buffer. Basically, there are two kinds of flow control available: software and hardware flow control. Our SIM300CZ support both kinds.

Microcontroller software flow chart

As mentioned earlier, for identifying each fault indicator there is a known number devoted to it. This number is saved in the microcontroller and one can set it by programming the IC. Figure 5 shows the flowchart of the written program in the microcontroller.

As can be seen in this figure, interrupts must be activated at the beginning. Also, serial communication is set here. In the next step it is checked if the connection to the GPS/GPRS module is functioning properly or not. When it is confirmed that communication is correctly set, using some AT commands the GSM/GPRS module is biased. In the next step, the connection to GSM and GPRS network is checked and if it were not connected then an error message would be issued which would run an alarm in the microcontroller circuit. In case the module is connected to the network, system would send its IP along with the fault indicator code for the server. After this stage microcontroller will wait until one of its pins, which is connected to the fault indicator changes its mode. This change of mode is a one second pulse, which is issued when a fault is detected. At this time, a packet including fault indicator code, time and date of its activation is sent to the server. The same data can be sent to pre-defined numbers as an SMS. This process is continued until an acknowledge signal is received, which will put this system again in waiting mode.

Server's software

Server's software includes two main parts. The first part is in charge of receiving and storing the sent data by GPRS module. The second part is responsible for screening the fault and providing reports from fault indicators. In server side, using socket programming a port is dedicated to receive data. For managing received data, a protocol is designed which determine data format in the received packet. To make the communication more secure and avoid data loss, TCP protocol is used in carrier layer. Figure 6 shows the format of sent data.

Codes related to screening and providing report of the fault indicators have access to a database and use a graphical environment which in our case it has a map of Mashhad city.

Figure 7 shows how the software looks on screen. In this picture all the fault indicators are in the normal mode and shown in yellow color. As soon as a fault happen in the network a data packet of data including a unique code, time and date of error is sent to the server via GPRS module and immediately the yellow spots on the screen will start to blink in red.

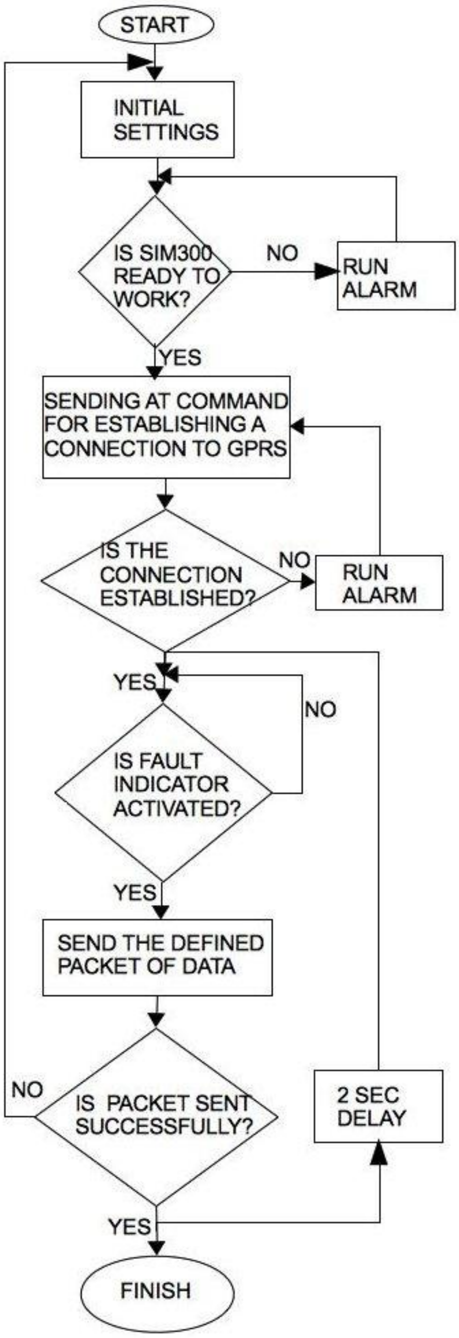

Figure 5 Flowchart of microcontroller software

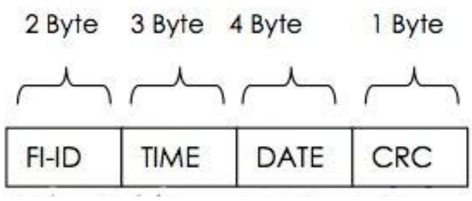

Figure 6 Formats of sent data

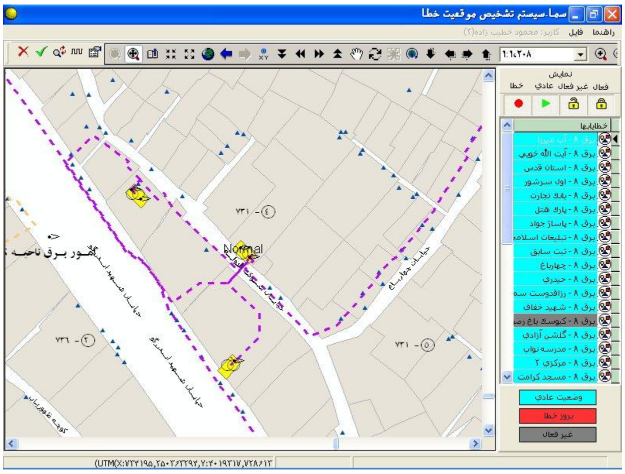

Figure 7 Screen view of the used software

IMPLEMENTATION RESULTS

The proposed system was installed on the 20 KV network in the city of Mashhad. According to the reports provided by crew and staff in the monitoring office the time to locate and fix a fault using this system has reduced from 60 minutes to 20 minutes.

Also it is observed that the overall outage of the system can be approximated by the following equation, which after calculation shows 55% decreases of the outage.

$$\frac{NewFaultIndicationTime}{Old\,FaultIndicationTime} * \frac{2}{3} + \frac{1}{3} \approx OutageAverageTime * \frac{5}{9}$$

According to [6], there is a basic relationship for annual crew time saving for interruption related benefits explained in EPRI, which follows:

Benefits = fn [(number of faults on the feeder, number of switches to be operated, switching time per switch, crew hourly rates) × (time for automated system to switch, control operator hourly rate)] PVF_N.

Where PVF_N is the present value factor [6]. According to [6] the above definition would shrink down to the following formula:

$$Benefit = \lambda(L)[(\frac{MNST}{Fault})(CR) \times (\frac{FAST}{Fault})(OR)] \times PVF_N$$

Where λ is the feeder annual outage rate/unit circuit length, L = circuit length, MNST = manual switching time, which includes travel time to switch location, CR = Crew hourly rate (including vehicle cost), FAST = feeder automation switching time, OR = operator hourly rate (including control room overhead costs), PVF = present value factor, and N = Year.

According to the available documents in the Mashhad Electric Energy Distribution Company, the real world numbers 51,600 was returned which shows the annual benefit.

Beyond all of the financial values added to the system, it worth to mention how much this system has been successful in reducing number of destructive tests. We don't need to the destructive tests to find the fault location.

CONCLUSION

In case of vast distribution networks, identifying the exact place of the fault is rather time consuming and comes with a lot of difficulties like when the problem is far in the desert, crew should drive their cars along the cable network to find the fault location. In this paper we present a GPRS based fault locator system for determining the location of fault in the power distribution systems. The proposed system can automatically detect the fault in the network. After fault detection, it can send a TCP/IP packet which gives us useful information about fault happened in the network. Implementation results confirm that the proposed system has significant result in reducing the outage average time. Furthermore the total benefit has been increased.

ACKNOWLEDGMENT

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