International Journal of Engineering and Techniques - Volume 3 Issue 5, Sep - Oct 2017

RESEARCH ARTICLE OPEN ACCESS

A Technical and Business Approach on Warning and Monitoring System for Insulation Resistance of Cables with Equipment Designed with GSM Modules

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Abstract:

The imposition by standards and norms of insulation resistance measurement becomes one of the most important tests of electrical safety. These tests are required to prevent any accidents caused by electrical shock, equipment damage or trigger fires. The method of testing the insulation resistance of an equipment, transformer, motor or cable is to measure the resistance that must be below the normative values. Management of network costs with this equipment and networks without it(e.g. [1]).

Keywords — **Insulation resistance of cables, GSM, costs.**

I. INTRODUCTION

The cable insulation resistance measuring equipment is composed of modules that contain microelectronic technology, programmable complex circuits. Thanks to this technology, it is possible to read values but also to calculate these data received in real time to warn of the error. Checking insulation resistance is done over a period of time (usually run for 8 hours). The possibility offered by this equipment is to inform the specialists by checking at any time the insulation resistance values.

The use of Global Systems for Mobile Communications (GSM) makes it possible to develop a whole system that includes many equipment, unlike other systems that limit the number of such devices. The mode of data transmission is through 3G / 4G data communications (e.g. [2]).

The advantage of this type of data transmission is the very high coverage area compared to other systems that can't transmit over a very long distance. All the interrogated data transmitted is stored in a database specifically created for this purpose.

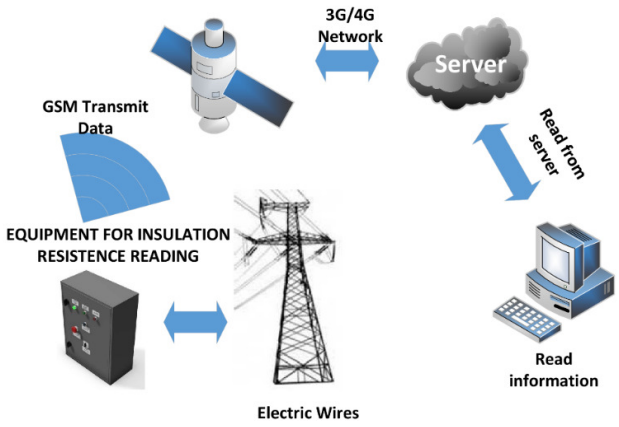

Fig. 1Overview of how the module works

II. GSM COMMUNICATION SYSTEM FOR TRANSMITTING DATA ON CABLE INSULATION RESISTANCE

The equipment has several interconnected modules for insulating resistance reading. The communication between these modules is achieved by using the RS485 serial interface and the Universal synchronous / asynchronous receiver / transmitter (USART) standard.

Use of the device without the gsm module is an advantage because it offers the possibility todecrypt stored information over a certain period of time without using 3G / 4G data communications. This operation can be performed using a RS485 interface cable and a laptop with the software specializing in decoding the received data (e.g. [3]).

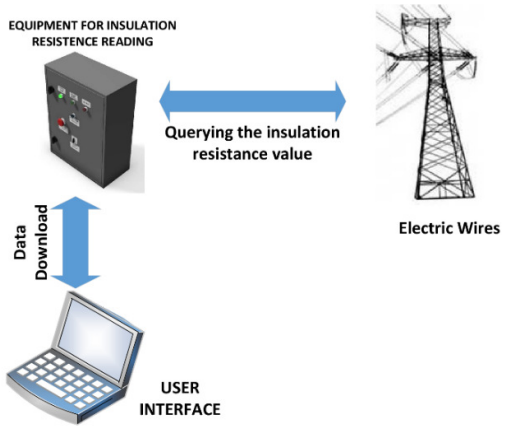

Fig. 1Data transmission between device and user

A. ***Description of the communication protocol in the equipment used to read the insulation resistance of the cables***

The communication is a serial communication type 8N1, which is described in the following table:

TABLE I

RS485 isolated network	
Characteristics	
Number of START bits	1 bit
Number of data bits	16 bits
Number of parity bits	0 bits
Number of STOP bits	2 bit
Speed of communication	9600 bps

Performing the communication functions of the module refers to the provision of a required number of events stored in the internal memory that includes the possibility to request from a certain event with the number "x" to the event with the number "y" or the events at the date "x " at date" y ". Sending the last stored event number, providing the date and time of the system, providing the current insulation value, setting the time and date sent according to the received data, resetting the locally displayed transient events, performing the equipment functionality test, displaying the equipment identification number and providing information about its status.

All this information is received as a response only when a request is made to the equipment. These equipments have a passive role.

B. ***Description of the interconnection of the modules in the GSM communication equipment, for the insulation resistance of the cables***

Construction of electronic equipment is done by using modules with microelectronic technology. The central unit of this equipment is a complex circuit that contains a 32-bit microcontroller with ARM cortex-M3 core (e.g. [4]).

The function of this microcontroller is to create a bridge between the slave module microcontroller that interrogates the value of the cable insulation resistance, calculating this value and sending the value further to the master.

The role of the "slave" module is to calculate, analyze and transmit the value of the cable insulation resistance by algorithms that use the functions specific to this case.

The master module has the role of interrogating the slave module, displaying the insulation resistance value on the cables, and sending the warnings or errors that occurred in the process.

These errors and warnings appear on an alphanumeric LCD (Liquid Crystal Display), but they are also stored in an external eeprom memory where they can be checked in the next period.

The inquiry of the information equipment is done through the GSM module using the 3G / 4G communication data.

Figure 3 describes how to interconnect the modules inside the cable insulation resistance checking equipment.

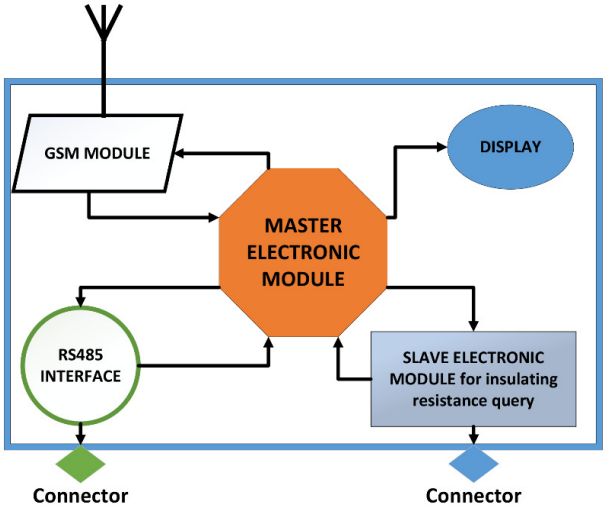

Fig. 3Module block diagram

C. ***Central data processing unit, ARM Cortex-M3 microcontroller***

The necesity to use a microcontroller as the central unit of the equipment is the accuracy and the way to calculate the values received on the analog pins, which hold resolutions up to 16 bits. The large number of communication interfaces owned by the microcontroller is an advantage in connecting multiple modules in this equipment (e.g. [5]).

The protocol used between the master module and the slave module is specifically designed for this equipment. The purpose of creating this special protocol is the security provided in the data transmission.

The ASCII "GET" characters are used to request certain information, and ASCII "SET" characters are used to set certain information. At the termination of the transmitted or received data string, the end characters "STOP" are used, followed by a byte representing the check of the data string, called checksum.

III. COST APPROACH TO LOSSES IN ELECTRICITY NETWORKS USING EQUIPMENT TO CHECK THE INSULATION RESISTANCE OF CABLES

Due to the factors that reduce the insulation resistance, it is necessary to query the insulation resistance of the cables. The main causes of insulation loss are:

- Natural aging of the insulation
- Forced or accidental aging of insulation due to very high operating temperatures
- Air humidity, which condenses weakens the insulation resistance, favoring the overflow phenomenon
- Dust deposits
- Mechanical factors (e.g. [6]).

All these emerging issues, lead to material losses or electricity, raising the cost of electricity companies. Illegal networking of consumers brings major losses to the company. For this reason, the equipment reduces losses by announcing the company, and the time until the damage is detected is considerably reduced (e.g. [7]).

The example of a loss reduction calculation due to this equipment is made using two scenarios showing the financial situation of an electricity supplier before installing the equipment (Scenario 1) and after purchasing and using the insulation resistance monitoring equipment (scenario 2).

We admit that the majority revenues of the electricity supply company are collected from two clients, the annual amount being 12672 $, and the total annual revenues of the company are worth 12972 $. The production of electricity for these two customers amounts to an annual cost of 6335,75 $. Major costs occur when the insulation resistance of cables is weakened, by losing electricity, until the problem is detected and corrected (e.g. [8]).

Due to the installation and use of the equipment, the losses are reduced to 5%, justified loss and recorded in the time frame until the equipment is installed, the low isolation resistance and the intervention team movement.

The net profit earned by the electricity utility is 49.19% (e.g. [9]).

	Scenario 1			Scenario 2					
Revenue	collecting the equivalent of the electricity supplied to customers		other incomes	collecting the equivalent of the electricity supplied to customers			other incomes		
USD	12672 $		300 $	12672 $			300 $		
Total revenue	12972 $			12972 $					
Costs	cost of electricity supplied	costs of loss of electricity due to weakening of insulation resistance	other expenses	cost of electricity supplied	costs of loss of electricity due to weakening of insulation resistance	purchase of equipment	installation of equipment	maintenance of equipment	other expenses
USD	6336 $	2700 $	150 $	6336 $	135 $	525 $	125 $	52,5 $	150 $
Total expenses	9186 $			7323,5 $					
Gross profit	3786 $			5648,5 $					
Net profit	3180,24 $			4744,74 $					

IV. CONCLUSIONS

Checking and monitoring cable insulation resistance is necessary to avoid problems arising from factors that cause it to drop. The detection of the decrease in insulation resistance can be observed in real time and immediate intervention on the problem, reduces the costs of the losses incurred.

The technology used in GSM communications is a great advantage in transmitting information in real time due to its high coverage area and communication speed.

Downloading a history, in .txt format, of a file that can be accessed with any operating system of the device is the ability to access problems that occur during a long period of time but also to permanently monitor the condition of the cables in a particular location.

The profits of an electricity supplier are considerably rising as a result of using this monitoring and warning device to lower the insulation resistance of the cables.

ACKNOWLEDGMENT

This research has been carried out in order to detect as soon as possible the losses of electric power due to the weakening of the cable insulation resistance and the notification of an intervention team to solve the problem. It has also been studied from a hardware point of view to see if it is feasible and necessary but also economically to see if it is profitable for the end-user, namely the power supply company.

Due to the fact that all things start to be linked through the Internet of Things and this solution was thought to transmit data with the help of GSM modules, which makes it fit into the great IoT concept.

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