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Permanent Switchboard Monitoring using Embedded Web Server

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1. Extended Abstract

Electrical systems are necessary in each kind of building such as homes, factories, hospitals and so on. In many cases electrical systems manage critical applications, like freezer temperature, incubator internal temperature and so on. All these systems contain devices that are sensitive to voltage variations, current deviations and to all the power quality measurable quantities. In scientific literature we can find that one of the possible solution for data acquisition is based on permanent monitoring systems: for our purpose we refer to the switchboards components. Benefits of such systems are numerous, first the opportunity to prevent any fault that could affect the switchboard. In fact, these systems are able to detect malfunctions due to several causes. For example, a faulty switch can provide a lower voltage to an electrical engine: the switch is open, but the engine does not work properly.

The overall prototype architecture can be split in two main parts: a local network and a remote one.

The local network acts as a transducer between all the devices composing the switchboard and the embedded web server. The first issue that we consider refers the voltage conversion: for each line of any switchboard device we can measure a low voltage up to about 400V. So we have to reduce this value in order to keep it compatible with the maximum voltage allowed by the RCMs. Moreover we have to handle the three lines, producing a scaled DC voltage proportional to the real one. Then, the produced voltage must be converted into a digital value using an Analog to Digital Converter. All the data are then collected into a serial network. based on the EIA 485 protocol. So, the voltage measures are sent encapsulated into an EIA 485 frame. The EIA 485 protocol allows many topologies implementation, but the daisy chain connection is the preferred. This because in all the switchboards assemblages there are many wires to be connected and other topologies, first a star topology, will produce an increase of the wires number. Using this serial bus, the transducer is connected to an embedded web server implemented using the RCM3xxx (Rabbit Core Modules) produced by Rabbit Semiconductors. The RCM3xxx are based on a 8-bit Rabbit processor with 20 MHz clock. Depending on the specific type of the modules, also processor with a 44.2MHz clock can be used. RCMs are tolerant to a wide number of analog lines that arrive to 5V. They have 3.3V CMOS compatible serial ports, too. So, these modules can be easily connected to SPI (Serial Peripheral Interface) and I2C (Inter Integrated Circuit) devices. Referring to the memories, the RCMs have a 512kB flash memory, 512kB program execution SRAM, 512kB data SRAM. The operating code data can be stored permanently into the flash memory using a Dynamic C FAT (File Allocation Table) file system. Since a so small flash can be a lack in a web server implementation, it is possible to extend the amount of memory using a serial flash that can be bought separately. The serial flash can have a size of 4MB or 8MB. The RCMs programming language is the Dynamic C, very close to the ANSI C.

The server can be connected to the Internet in a wired and/or wireless way using the IEEE 802.3 (Ethernet) and the IEEE 802.11 (Wi-Fi) protocols. Finally, the web server uses standard TCP/IP protocols, such as HTTP to manage the web pages and SMTP to dispatch automatic alarm notifications via e-mails.

In the remote network each user can perform a permanent monitoring using one of the available web browsers, such as Internet Explorer, Mozilla Firefox, and so on. The proposed prototype has embedded server pages that are stored into the flash of the embedded web server. The employed web pages are both static and dynamic. Static HTML pages are used in order to view contents that do not change, providing only an informational view, while dynamic pages are used to manage data that can vary. The dynamic update is performed a using CGI function.

Specially, the developed prototype includes the following pages:

1) Login form
2) Home Page
3) Switchboard Information and Configuration
4) On line monitoring
5) Event Log repository

The home page must contain all the links to the other web pages stored into the embedded web server. The home page can only be accessed after an authorization procedure using the HTTP protocol.

The switchboard Information and Configuration contains all the necessary information about the switchboard, such as layout dimensions, electrical schemas, and so on. All these data are collected into a static HTML page that will be uploaded during the programming stage.

Relating to the on line monitoring, a dynamic page must be created in order to have an instant view on the load measured on each switchboard component. To facilitate the analysis of the acquired voltage, all the malfunctioning must be detected in a very easy way: this is achieved by the usage of a color legend. Each color is associated to a specific error: connection failure, voltage deviation, and not available data.

Finally, the log event page is composed by a textual file that is stored permanently into the embedded flash. This file contains all the information related to any malfunctioning. It reports the ID of the switchboard device, the timestamp of the event notification and the sensed voltage. This file is very useful to detect also the duration of each event in order to provide the right classification among the power quality quantities.

We can assert that the proposed prototype can be very useful in Power Quality contests because a permanent supervising of an electric switchboard allows a correct usage of each switch, in a such way any anomalous behaviour can be revealed. This grants the manufacturer an immediate action in order to repair the faults that can occur and a consequently longer life cycle of each switch. The proposed system can also be extended in order to allow the full control of the switchboard. Moreover, further development can involve this kind of prototype, first a secure channel creation that will lead to the data integrity. Also an integration with the PQDIF or a XML language will permit a more powerful user interface without any increase in the server complexity. In this way it is possible to consider other Power Quality quantities that can be evaluated thanks to post acquisition elaborations. So, the prototype will be a valid diagnosis instrument.

The prototype is based on open and standard protocols. This key feature allows low cost realization because no royalty must be paid due to the use proprietary protocols. The architecture can also be easily extended for an higher number of devices.

This prototype can be developed using other technologies. Regarding the security issue, the prototype take into account only a cypher authentication. So, all the data can be protected using a SSL (Secure Sockets Layer) communication. This protocol allows security and data integrity over the Internet and it is included into the RCMs supported protocols.