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Customized RTU for Local and Remote Supervision

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ABSTRACT

Telemetry is the science of gathering information at some remote location to be examined and recorded [1]. When telemetry is used to both: monitor and control, SCADA (Supervisory Control and Data Acquisition System) is often used to describe the System. This paper presents a new design of SCADA that works remotely. Telemetry system consists of three parts: central unit, remote terminal unit (RTU) and communication media. The most important part of this system is a low cost RTU based on a Programmable Logic Controller (PLC), which can be customized according to the user's needs. This RTU is conceived to collect data from the field of instruments & sensors and transmits the information to SCADA installed in a central control room through wire/wireless communication systems and lines, and to receive control commands from host computer to conduct online controls in real time. The main role is accomplished by the PLC (XGT 5000) with its extended modules in order to communicate with the different system parts. The SCADA design is developed in Vijeo Designer software. Modules used are: Real Time Clock Modules to guarantee exact history of data, Communication Modules: RS485 to communicate with local SCADA, an Ethernet Module for remote SCADA, and an analogue module to extend the acquisition to analogue signals. In addition a Power Meter is added to the system to prove some featured properties of such supervisory tool. As one RTU can communicate with the remote SCADA via an IP address, multiple RTU can be used having each one a unique IP. This design is dedicated to industrial application and can be easily extended to supervise multiple modules, and hence can be used in diagnosing and monitoring machines and systems, and collecting data for fault and error prediction.

INTRODUCTION

In General, telemetry system consists of three parts, which are: central unit, RTU and communication media (Wikipedia, 2016).

The remote terminal unit is made up of three major parts: sensors, microprocessor or controller, communication tools (Wikipedia, 2016). Already designed RTU are all based on microcontrollers, which allow them to be used in general application. However, when an industry dedicated RTU is needed, the tough aspect of the industry environment should be taken in consideration. On the other hand, the PLC is the most used controller in such domain. So our contribution is to design an RTU based on PLC with all its extension modules and communication tools.

This RTU is implemented in a complete SCADA system. First this RTU is monitored by a local SCADA within the on-site supervision station, then it communicates with the remote SCADA via Ethernet to complete the supervisory system design, once the connection between the remote SCADA and one RTU is established, we can assure that the remote supervision station can be connected to multiple RTUs.

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In this paper, we will present the hardware and software design of the on-site supervision station in section 2. In section 3 the software and hardware design of the central remote unit are presented. Finally, the results are discussed in section 4 and the perspectives are suggested in the conclusion.

2. Hardware Design and Software of the on-site supervision station:

The role of the RTU is to collect data from the site, by communicating with the sensors and the different instruments present on the field. We conceived a special RTU that relies on the PLC to accomplish this task. The proposed hardware design of the R.T.U is shown in figure 1:

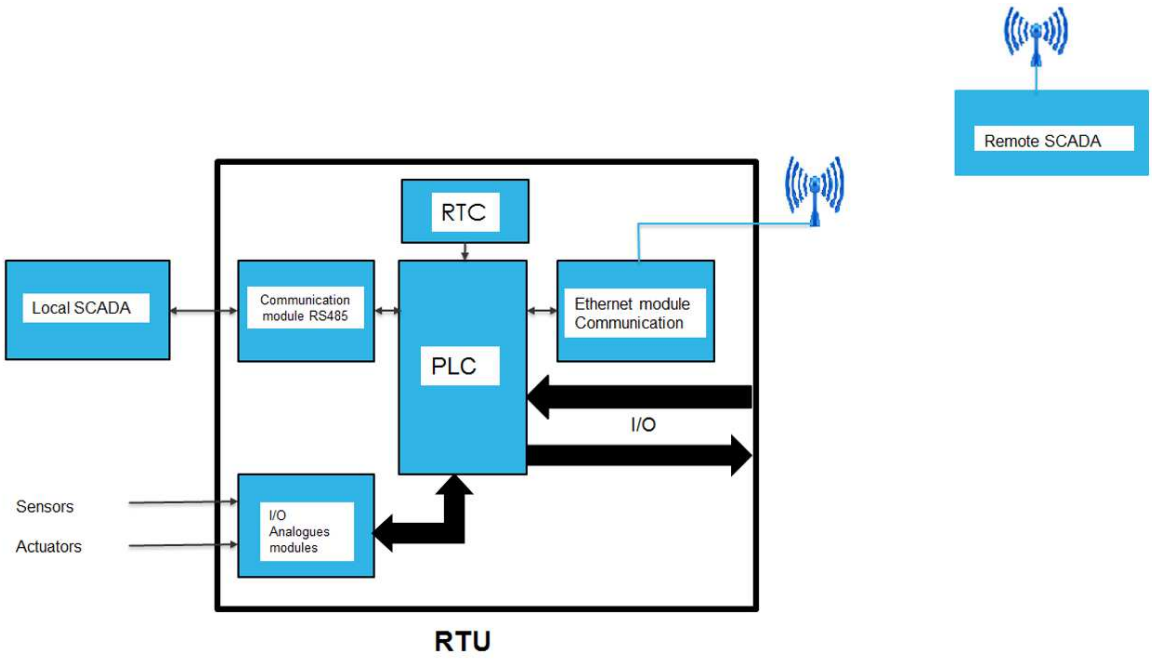

Fig. 1: The block diagram of the proposed R.T.U

I. Hardware Design:

Thus, the on-site supervision station is composed of the following components, In order to clarify the role of each component a brief definition is given about it below:

- PLC of type XGB
- Analogue and Digital Modules
- Ethernet module.
- RTC (real time clock).
- Local SCADA (runtime).

a) Plc Xgb:

PLC is the main component of the proposed RTU, it contains CPU that collect the data from the sensors, process it and give it to the communication part for delivering it to the central unit, and contains a volatile memory and nonvolatile memory for processing and storing programs and data. The used PLC in our application is PLC XGB which is manufactured by the LS Company (Korea). For more details the reader is recommended to view the reference (http://eng.lsis.biz). XGB is a modular type that can be extended by different type of modules such as the Expansion I/O module and the Communication module that are used also in this application. This property of the PLC gives the user an option to extend the capability of the RTU to manage and monitor a larger number of instruments and sensors and thus a wider field can be operated from the same station. In addition the variety of modules that can communicate with the PLC make this RTU customized to the user's need.

b) Analogue and Digital Modules:

PLC uses digital or analog input/output modules to control machines, processes, and other control modules.The used XGB comprises 12 input and 8 output digital modules and we can add analogue modules to cover the need of the system. In this application the XBO-AH02A analog I/O option board is used to add an analog input and output to the PLC. It contains one Channel Analog input, one Channel Analog output

(Voltage/Current) that provides 2 ranges (4~20mA, 0~20mA) of current I/O and one range (0~10V) of voltage I/O (http://eng.lsis.biz).

c) Ethernet Module:

XGB Fast Enet I/F modules (XBL-EMTA) is an interface module used to communicate data between higher level system such as host PC and PLC. It supports open Ethernet and provides data sending/receiving by using Modbus TCP/IP protocol (www.aspar.com). In the proposed RTU, XBL-EMTA provides the communication part that connects RTU to the remote SCADA.

This wireless connection is very important in this contribution. In fact, the remote SCADA can connect to multiple RTUs simultaneously via their Ethernet modules, having each a unique IP address. Once one connection is established between the remote supervision station and one RTU, it is guaranteed to accomplish a connection with the same protocol and using the same module among the remote SCADA and multiple RTU in multiple locations, figure x can easily clarify this concept.

d) RTC:

The RTC used in this application is the XBO-RTCA which is the compatible real clock module with the XGB PLC. Such module is needed in SCADA system to determine the exact time of any event.

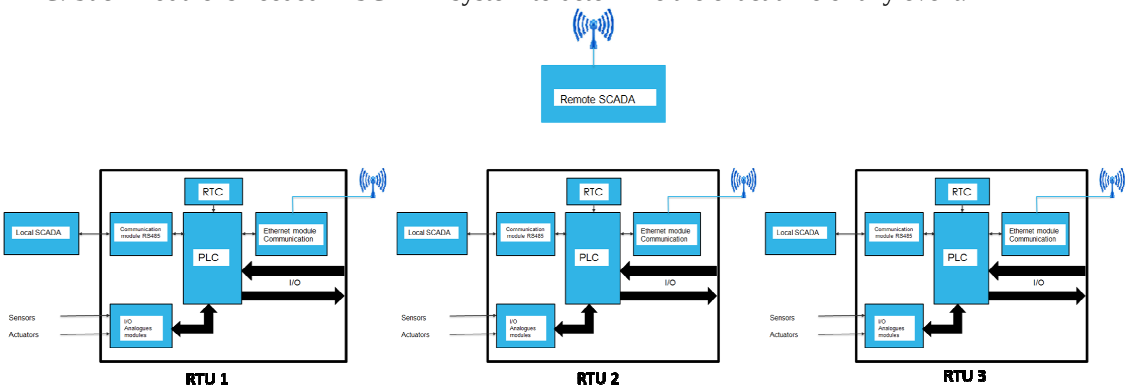

Fig. 2: Remote SCADA communicating with multiple RTUs in different Locations via Ethernet Modules

e) Local SCADA:

The local SCADA is an application developed on the on-site PC, which is connected directly to the RTU via a serial communication RS485 that is a physical layer of the protocol Modbus. The Local SCADA role is to gather data from RTU and generally provide an interface to: display information, control the remote sites, present operational status, show historical data and manage alarms. The SCADA used is developed on the software Vijeo Designer that is a state-of-the-art software application developed by Schneider electric. This software allows to create Human Machine Interfaces (HMI) and provides all the tools needed to design a project, from the acquisition of data to the creation and presentation of animated drawings.

In addition to the already listed modules, a power meter is added to communicate directly to the local SCADA to prove this option given by the local SCADA application. The used power meter is PM201 manufactured by Schneider, it measures many electrical parameters like the voltage, the current, the frequency and the energy consumption, the remaining characteristics are given in (Schneider-electric.com).

An important option in local SCADA is that we can create or calculate internal variables not provided by the RTU and other devices connected to it. It can send internal or external variables to remote SCADA, which can communicate to RTU via Ethernet module, by sending these variables to the memory of the RTU.

II. Software design of the RTU components:

The RTU components (its different modules) need to be configured properly to communicate with the controller element (PLC) in order to accomplish the RTU functionality. This can be done in these few steps:

a) Programming PLC:

The XGB PLC can be programmed by the XG5000 software developed by the manufacturer [3]. The PLC should be programmed to perform the operation of data collection via digitals and analogue modules connected to PLC, and transmit these data to communications media (serial communication and Ethernet communication).

b) Configuration serial communication Modbus RS485:

The RTU presented by its controller element, the PLC, can communicate with local SCADA (the application on the computer) via serial MODBUS communication. The XGB PLC needs a module to deal with MODBUS communication. Thus, the module (Cnet I/F) is integrated, but needs to be configured by adjusting the speed, the station number and such information (http://eng.lsis.biz).

c) Configuration Ethernet module communication:

RTU can communicate with remote SCADA via Ethernet communication, the extension module used is XBL-EMTA, which should be configure according to the TCP/IP protocol (http://eng.lsis.biz).

d) Local SCADA software:

The local SCADA analyzes and displays the data acquired from RTU and PowerMeter and can send data to remote SCADA via Ethernet module communication. The software was designed and implemented in Vijeo Designer as shown in figure 3.

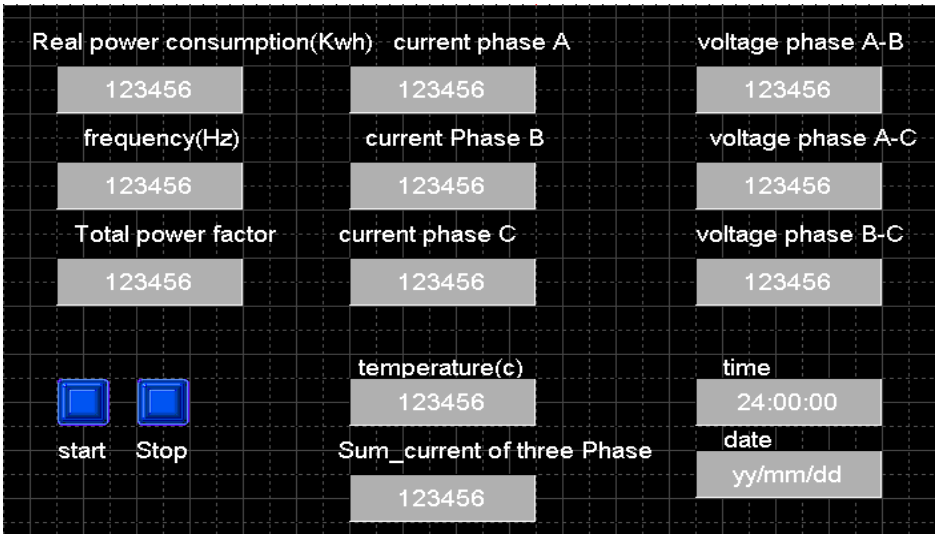

Fig. 3: Local SCADA Interface

3. The design of Remote SCADA (central unit):

The main function of the central unit is to receive, process store and display the data received from RTU. The implemented hardware consists of PC with static IP address.

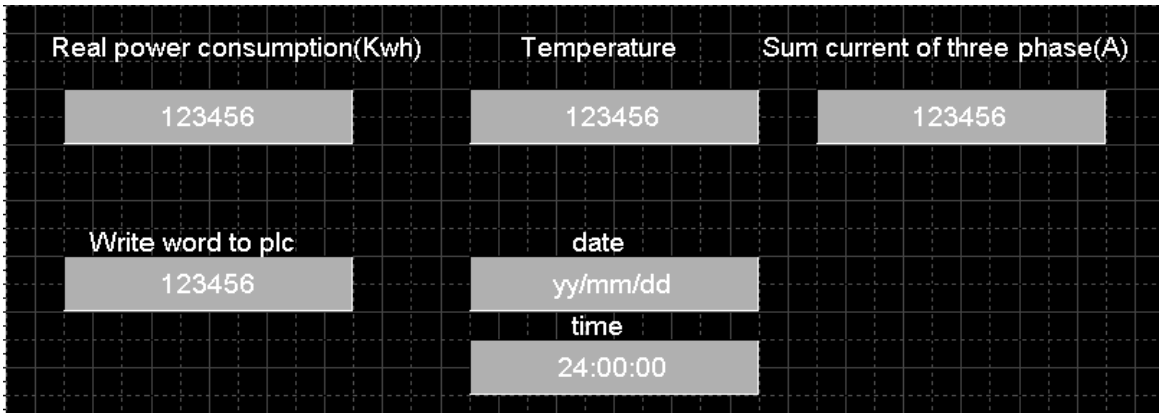

Fig. 4: Remote SCADA

As already mentioned the local SCADA acquires data from PLC and other components, new variables can also be calculated via the program of this entity. Thus, it contains larger amount of data than the RTU and its controller (PLC).But the local SCADA cannot communicate directly with the remote central unit, the communication should be via the RTU. So, all the data sent from the local SCADA to the Remote SCADA will pass via the internal memory of the controller of the RTU (PLC).

As the remote central unit supervises many entities at the same time, each entity is an RTU in a specific location, logically, the remote SCADA shouldn't receive all the data contained by the local SCADA, so, the parameters displayed by the software of the remote SCADA are the most essential ones of those displayed by the local SCADA.

RESULTS AND DISCUSSIONS

This new design of a remotely supervisory system is applied in a small experiment where a low cost and modular RTU is implemented to communicate with local and remote SCADA.

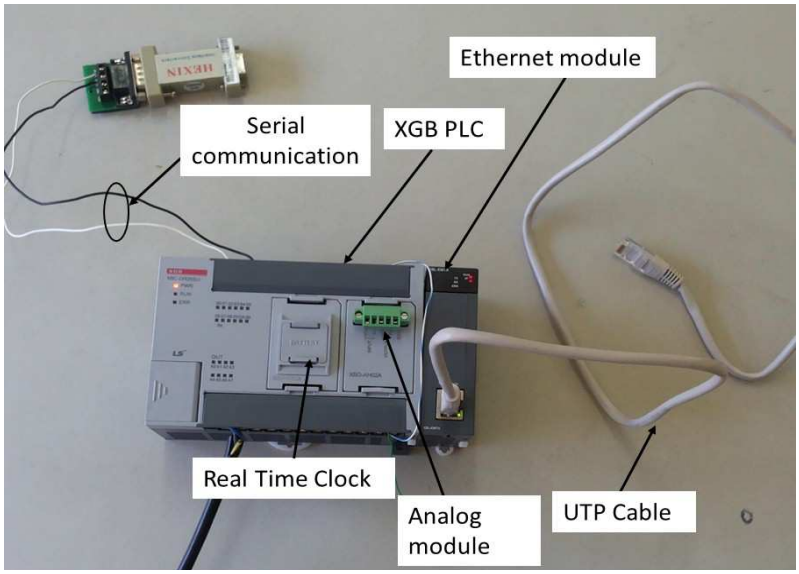

Fig. 5: the designed and successfully Implemented RTU

The serial communication is added to this unit to communicate with the PC where the local SCADA application is running. While the Ethernet module is used to guaranty the wireless communication with remote central unit. Figure (6) shows a connection between R.T.U and local SCADA over a serial communication and between RTU and remote SCADA over a LAN. A router was added to allow access to LAN and internet Networks.

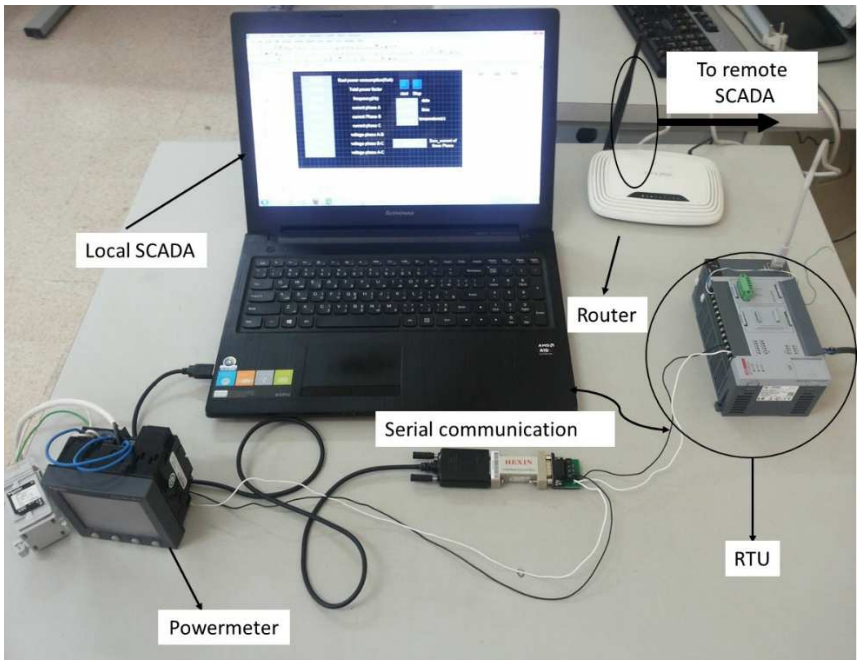

Fig. 6: Local SCADA Communicating with the RTU and the Power Meter

As shown in figure 6, the local SCADA communicates with the RTU and the PowerMeter(PM210). In fact, we can add other components communicating with the local SCADA to have more measurements and thus collect more data from the supervised system. Consequently, the on-site supervising station is extendable to cover all the need of any user. Within the RTU, the PLC collects data from all the sensors and the modules connected to it. In this application, the data delivered by the RTU are:

-temperature from the analog module
-actual time and date from the RTC
-start and stop output control from the PLC

The powermeter component delivers many parameters. In our experiment, we have chosen:

-real power consumption
-frequency
-total power factor
-the current and the voltage in each phase.

The local SCADA collects the data from the RTU and additional components, and can calculate new variables deduced from the collected data. In this application, we have added the sum of current in the three phases.

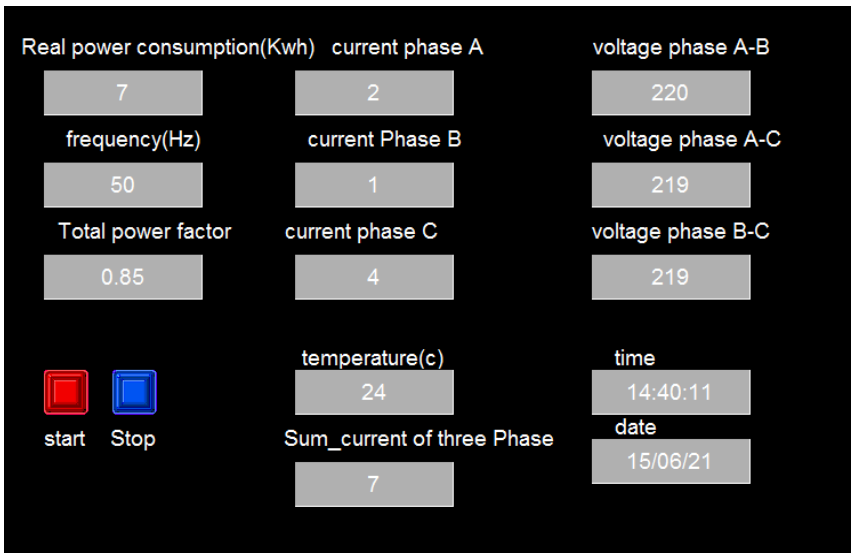

Fig. 7: Result on local SCADA interface

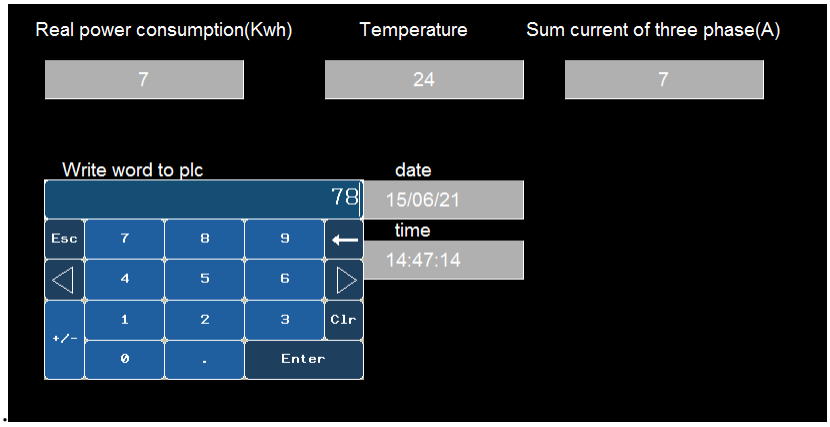

Fig. 8: Result on remote SCADA interface

The remote SCADA communicates with the RTU to collect data, sent from local SCADA, and to send back the corresponding commands. The collected data sent from local to remote SCADA, via the RTU, can be either coming from RTU or PM210 or internal variables created in Local SCADA. In our application, the parameters displayed in the remote SCADA are only five, which are the most important to be monitored. In fact, the remote SCADA, as mentioned before, can be connected to more than one RTU and thus supervises multiple working system in the same time. This can add to this supervisory design system wideness and extensibility: one remote

supervision system can monitor and control multiple systems simultaneously in different locations which are all distant from the supervision station.

Conclusion:

In this paper a telemetry system was designed and implemented: it is based on an RTU that communicates with a local and a remote SCADA. The remote terminal unit is based on a PLC with some additional modules: it is characterized by its low cost, its modular aspect, and its dedication to industrial application. The local SCADA supervises the system by communicating with the RTU and other components, and the remote SCADA receives data from local SCADA and controls the system via RTU. This design allows the user to monitor and manipulate industrial systems locally and remotely using simple and cheap devices, with the possibility to extend the supervision (distant or on-site) on multiple systems working at the same time. Finally, this supervisory system can be used to study systems and machines behavior, and collected data that can be processed in different ways, so they can lead us to study and predict errors and then prevent systems from failure.

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