ENHANCEMENT OF PRODUCTIVITY FOR THE POWER NETWORK PARAMETER METER MULTIFUNCTIONAL DEVICE

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Abstract

Article covers the aspects of interaction between the Modbus communication protocol and the multifunctional metering device used in the supervisory control and data acquisition (SCADA) system for monitoring and control reasons of power network parameters. Algorithm of productivity enhancement is drawn out and implemented in real experimental conditions. Power network parameter meter multifunctional N14 device (produced by Lumel S.A.) has been chosen as research object.

Key words: SCADA system. Modbus communication protocol. Productivity.

1. Introduction

Problems concerning the productivity enhancement are very actual in modern SCADA systems. In particular this is related to the systems dedicated to the monitoring and control purpose of various technological processes, where the main attention is paid to the speed of performance and generally to the productivity of the whole system. Full automation of technological processes of production sphere on the one hand increased their quality, but on the other hand improper usage of the possibilities of the modern intellectual devices caused the system performance problems and the necessity of their improvement and perfection. Nowadays, technological solution (algorithms, used communication protocols, their realization in practice) of the processes running in any sphere, including the production field is much more behind of capacities of appliances participating in the monitoring and control of that processes and this causes the improper, incomplete usage of their possibilities and is finally affected on the performance of the technological processes.

2. Experiment

Research of power network parameter meter multifunctional N14 device interaction with Modbus communication protocol has been performed in the main frame of an experiment. The N14 meter is a programmable digital panel instrument destined for the measurement of 3-phase, 3 or 4-wire power network parameters (RMS voltage and current, active, reactive and apparent power, active and reactive energy, frequency and so on), in balanced or unbalanced systems with the simultaneous display of measured quantities and digital transmission of their values [1]. This network parameter meter enables the control and optimization of power electronic devices, systems and industrial installations. Measured parameters of power network are placed in embedded 16 and 32 bit registers. Each measured parameter is transmitted to the main device in SCADA system via the RS-485 interface and the Modbus protocol. Maximum time of response to the request is 1000 milliseconds, chosen working regime – Modbus RTU, data transmission rates are 4.8, 9.6, 19.2, 38.4 Kbit/second.

Experiment implies the readout of measured parameters in a certain interval of time using the Modbus protocol (in particular readout command #03) and the assessment of the readout time.

3. Experiment background

Modbus is an application layer communication protocol based on a client-server architecture which is widely used in industry to connect the electronic devices [2]. It uses RS-485, RS-422, RS-232 interfaces and TCP/IP networking protocol. Its working principle is based on transactions, containing the request and the reply on request. This protocol defines the main (Master) and secondary (Slave) devices in communication network, determines and terminates the connection between them, establishes the types of data transfer and error checking and recovery methods. Standard Modbus network contains only one master and maximum up to 255 slave devices, manages and controls the request and response cycles between them. In typical RTU regime data is transmitted in frames, which structure is shown on a Figure 1.

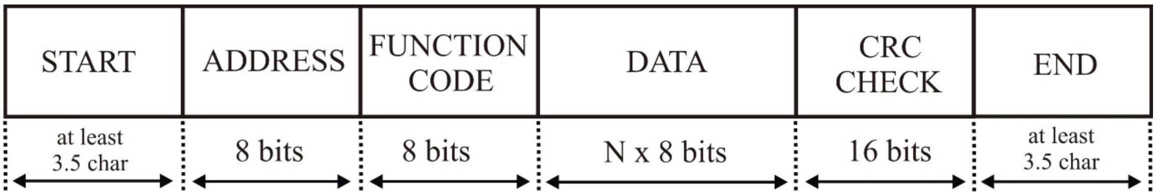

Figure 1. Data frame structure for Modbus RTU protocol

Each device participating in Modbus network has an unique, independent address in a range of 1-247. Function code identifies an action, that has to be performed (read, write and so on). Modbus RTU implies 8 data bit in 11 bit symbol, making possible data byte transfer in a symbolic shape. Each symbol has the following shape: one start bit, eight data bits (junior goes first), one parity + one stop bit, or no parity + two stop bits, (1+8+1+1=11). Device address and function code fields occupy one byte, as far as each byte is transmitted as one symbol. Checksum is presented in two bytes and is defined by CRC16 algorithm [3]. Interval between frames is regulated by the pause between the symbols. New frame must not appear earlier than 3,5•Tc, where Tc is a time of transfer for a single symbol. On one hand, signal absence for more than 1,5•Tc is counted by the receiver device as the end of frame, but on the other hand appearance earlier than 3,5•Tc is counted as an error.

In Modbus RTU data exchange is organized in a form of communication cycles. These are a kind of preparatory operations necessary for data transfer/reception. Two kind of cycles exist: master device and slave device cycles. Appliances get requests/data in the beginning of cycle and transfer in the very end (see Fig.2).

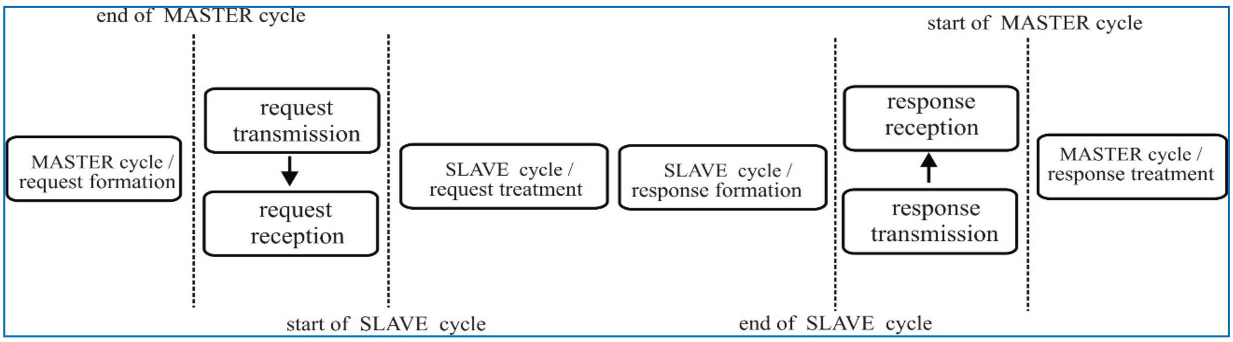

Figure 2. Communication cycles used in Modbus protocol

Many researchers of Modbus protocol think that master and slave communication cycles have the fixed duration [4], despite of the Modbus command being processed. Research work carried out by us gives an obvious answer to an actual question, if its possible to reduce the communication cycle duration for different Modbus commands or not.

4. Experiment technics

In conducted experiment personal computer has a role of a master device and multifunctional N14 node of the slave one. Connection between them is realized through the RS-485 interface, that is connected to the USB port of the PC via special convertor. RS-485 represents the most spread and popular standard for physical layer based connections. Physical layer is a connection channel and signal transmission media, based on a data differential transfer (balanced) method [5]. In this particular case one signal is transmitted through the two connection lines. One line (conventionally A) is used for original signal transfer and another one (conventionally B) – for inversed signal transfer. In other words, one line is for "1" and another one for "0" or vice versa.

Figure 3 represents the readout time distribution for one 16 bit integer type register of power network parameters meter N14 multifunctional device, containing the value of power network frequency. This register is accessed in a loop of one second time interval.

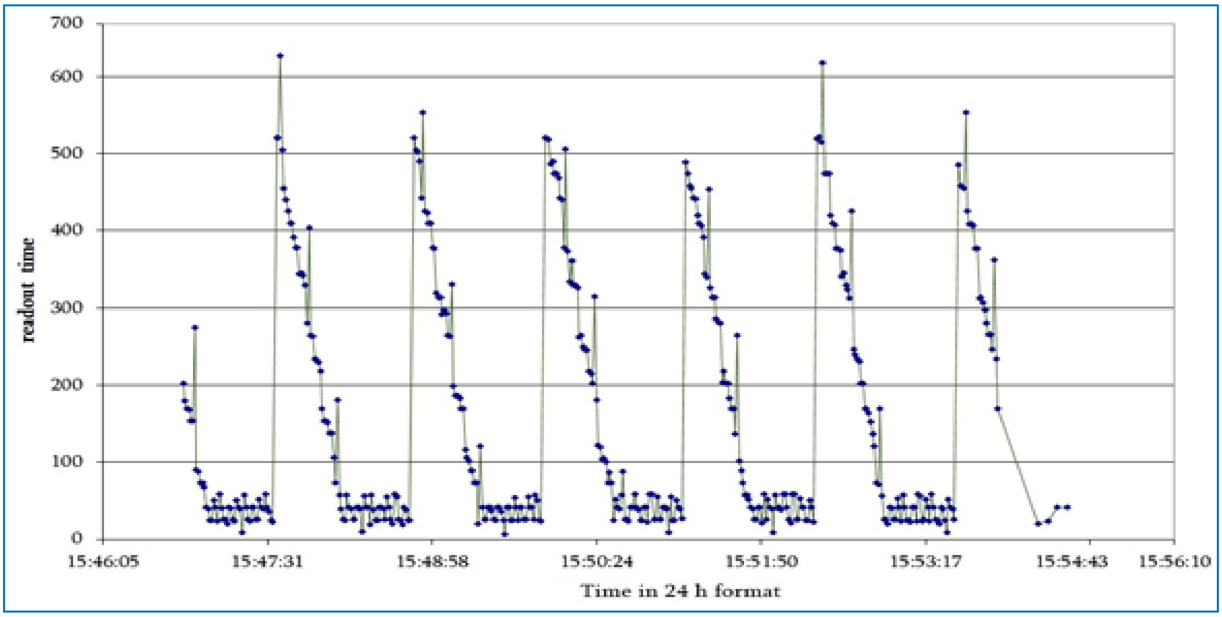

Figure 3. One 16 bit integer type register readout time (milliseconds) distribution for N14 power network parameter meter device

Access interval of one second is an optimal value, because according to the factory documentation N14 device needs maximum one second for the response preparation and transfer to the recipient (device issuing the request). In the meanwhile for the device its extremely important to manage to react on all the requests coming from other members of Modbus network. As it is seen from Figure 3, maximum value of device reaction/response time reaches about 630 milliseconds and minimum response time values fluctuate in 20-65 millisecond diapason. The same figure makes clear, that during the experiment the particular register readout lasted for 10 minutes with one second access time interval. For more details, the experiment has also been carried out in conditions when simultaneously several registers were readout for different (9600 and 19200 bit/second) throughput. The overall result picture remained the same and important changes didn't occur.

Each point in Figure 3 corresponds to the time equal to the device response time plus the answer cycle. In particular, the answer cycle implies the reception of request by the slave/dependent device, its processing and the execution of an action considered by the function code field of the request message. As it's seen from carried out experiment, response cycles of slave/dependent device are not of the same duration. Time interval between the readout peak time is equal to 90 seconds and is symmetrically repeated. In the very beginning of measurement, device response time is dramatically increased up to 630 milliseconds, during the next 45 seconds stable decrease of this value and during the forthcoming 45 seconds low values (20-65 milliseconds) are observed. Then the same process is repeated cyclically.

5. Performance enhancement algorithm

Experiment shows that in the beginning of measurements, device response/ readout time can be any of shown in Figure 3. It can be in a low ranges or on a peak or in decreasing phase. In the first case, everything is clear, optimal time of readout is already caught and the only task is to maintain it for the whole measuring time. Solution for this is to access the device register only in 100 seconds time interval and the constant low rates of response time is guaranteed. In a case different from scenario one, different kind of data readout algorithms have to be processed.

For a better illustration, readout time decreasing phase shown on Figure 3 was divided in A (630 milliseconds), B (400 milliseconds), C (180 milliseconds), D (50 milliseconds) points (see Fig.4), i.e. three zones (AB, BC, CD). The main goal is to come down to the D-type points (<100 milliseconds), that correspond to the low readout time values.

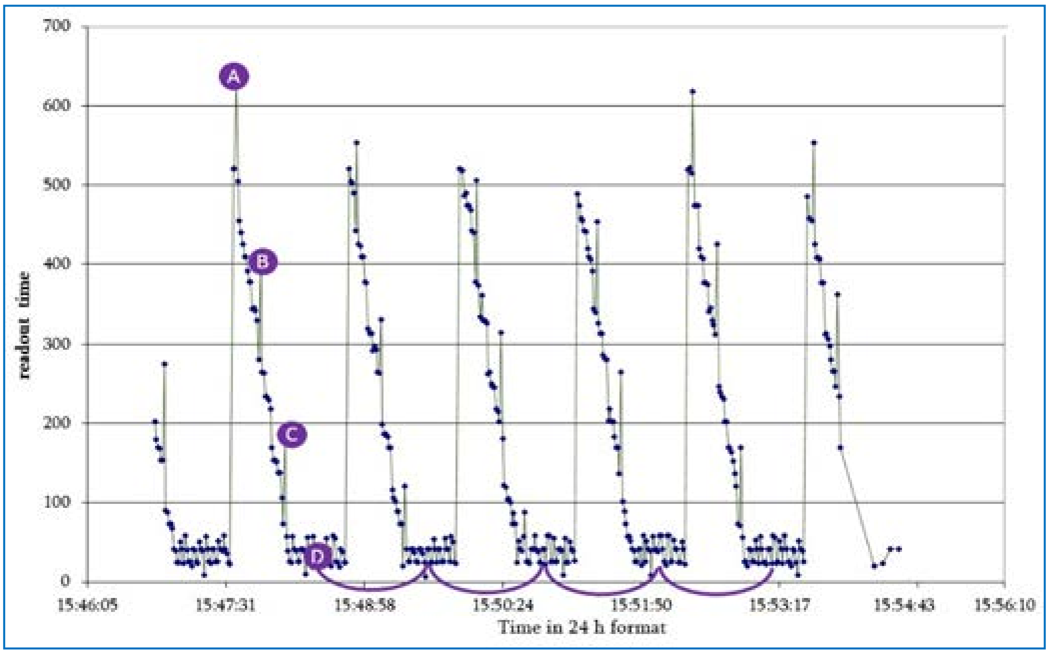

Figure 4. N14 metering device response time distribution

Using the software product written by us in order to serve this experiment, it was measured that the distance from A-B zone to D-type points is 50 seconds, from B-C zone – 25 seconds and from C-D zone – 15 seconds. Experimentally proved that once the lowest readout response time values are reached, i.e. D –type points, measurements have to be continued in 100 seconds interval, which guarantees the same type (low values) response times during every access to the device. This means it becomes possible to get the intended data from the Modbus network device in a minimum time, that solves the problems concerning the system performance issues, therefore proves that master/slave communication cycles don't have the same duration and can be optimized, i.e. reduced according to the demands of the task to be performed.

Figure 5 demonstrates the block-scheme of implemented algorithm based on which data readout was conducted from the power network parameter meter N14 multifunctional device to the personal computer. This algorithm has been well-implemented in a software and its efficiency is confirmed based on real measurements.

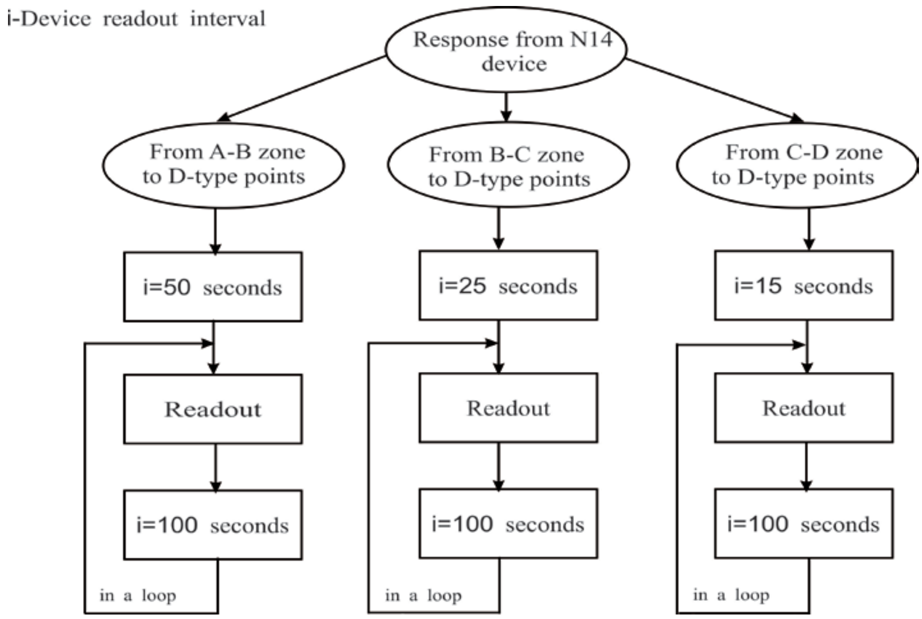

Figure 5. N14 device readout algorithm block-scheme

6. Conclusion

Development trends of modern technologies reveal, that current performance of Modbus communication protocol necessarily needs to be enhanced, because it's far behind the capabilities of the intellectual devices widely used in modern supervisory control and data acquisition systems. This problem finally causes the improper usage of their diverse possibilities and leads to the low performance of the system.

Experiment carried out in the frame of this article obviously demonstrates, that through the software or hardware modifications and implementation of the corresponding algorithms it's possible to increase the overall performance of SCADA system. However it's apparent that further and deep effects request internal modernization of current communication protocols and their practical implementation towards nowadays requirements.

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ელექტროქსელის პარამეტრების გამზომი მულტიფუნქციური ხელსაწყოს წარმადობის ამაღლება

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რეზიუმე

განხილულია ელექტროქსელის მონიტორინგის და მართვის SCADA სისტემაში გამოყენებული მულტიფუნქციური გამზომი ხელსაწყოს ოდბუს საკომუნიკაციო პროტოკოლთან მუშაობის საკითხები. დამუშავებულია ხელსაწყოს წარმადობის ამაღლების ალგორითმი. გამოკვლევის ობიექტის სახით აღებულია ელექტროქსელის პარამეტრების ანალიზის მულტიფუნქციური ხელსაწყო 14 (მწარმოებელი LUMEL S.A.).

ПОВЫШЕНИЕ ПРОИЗВОДИТЕЛЬНОСТИ МУЛЬТИФУНКЦИОНАЛЬНОГО ИЗМЕРИТЕЛЬНОГО ПРИБОРА ИЗМЕРЕНИЯ ПАРАМЕТРОВ ЭЛЕКТРОСЕТИ

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Резюме

Рассмотрены вопросы работы коммуникационного протокола Modbus мультифункционального измерительного прибора в системе SCADA мониторинга электросети и управления. Разработан алгоритм увеличения производительности прибора. В качестве объекта исследования выбран мультифункциональный анализатор параметров электросети N14 (производитель LUMEL S.A.).