SCADA SYSTEM SIMULATION USING THE TINY TIGER 2 DEVELOPMENT BOARD

AGAPE C.P., KILYENI ST., BARBULESCU C.
Politehnica University Timisoara, Power Systems Department,
Power Systems Analysis and Optimization Research Center
agape_cosmin@yahoo.com, stefan.kilyeni@upt.ro, constantin.barbulescu@upt.ro

Abstract - This paper presents a new design for a surveillance and control system of a medium voltage cell. The accent is on the acquisition of information of the consumer's state, the instantaneous current consumption, power and voltage apparent to the consumer. The proposed design is based on Wilke Technology development board at its basis being a Tiny-tiger 2 Multitasking Microcontroller. This computer has 2 MByte or 4 MByte Flash for programming, and 1 MByte SRAM with backup input for data. On the software's behalf we managed to create a Delphi Interface which communicates with the serial port on the development board. The interface takes information about the consumer and its capacity to load with voltage.

Keywords: Delphi-interface, Hardware design, Smart Grid, microcontroller, SCADA, withdrawable cell.

1. INTRODUCTION

The teletransmission and control systems are in a permanent modification and improvement of their performances, reliability and safety of operation. All the command and control systems were developed to integrate a unique system in order to cover a larger and larger area. The command and control systems must ensure the necessary information volume for the leaded system which offers information to the dispatcher in real time in order to ensure the safe operation of the grids. The data volume taken from the grids and transmitted to the superior levels (to the dispatchers) must offer a complete, relevant and correct information for the superior teletransmission and control, so that they can take a decision, in case it is needed, upon the functioning parameters and the safety of the monitored grids. The teletransmission and control systems are, thus, created to prevent the possible high costs of that the next level implies.

The command and control of data acquisition systems give the dispatchers the opportunity to foresee certain phenomena, through the analysis and processing of the collected data, leading to the most important financial savings. There can be acquired analog and binary signals or numerical data flows of diverse equipment.

In this paper we tried to develop a simulator in order to survey and monitor a medium voltage line load. The information received from the development board is analyzed and shown with the help of a graphic interface developed in Delphi.

2. SCADA SYSTEM

The experiment simulation analysis is an important means of SCADA systems. Simulating real cases offers flexibility and extensibility to the power systems. SCADA systems have become increasingly complex, constantly evolving and solving different types of problems: from the level of communication between devices to the issues of information analysis, security and safety installation. Power systems must be highly reliable and safe given the potential, the importance and the complexity of the equipment. Lately, within SCADA systems, a particular emphasis has been laid on the information encryption and on the increasing security of the systems [1][2].

SCADA systems are based on open architecture, redundancy and multiple configuration possibilities. SCADA solutions are developing along with the process and can be continually adapted according to the needs. The benefits are seen through the productivity and quality growth, as well as in the considerable cost savings. The term SCADA usually refers to a command center that monitors and controls an entire production space. Most of the operations are executed automatically by RTU (Remote Terminal Unit) or by PLC (Programmable Logic Controller). On a large scale, SCADA systems are defined as computerized devices, used in monitoring and managing the situations in the field, so that the information they provide can be analyzed in real time by a dispatcher [3], [4], [5].

There are developed a wide range of SCADA systems. It offers the capacity to purchase / process / interpret and visualize data from the entire area which we want to monitor in real time. Therefore, the best SCADA-type solution, used and proven in nearly every possible industry and application, is ensured [6].

Using the control and data acquisition systems (SCADA), the energy dispatch is carried at world standards. Through this energy dispatch is monitored everything related to electrical equipment, from the producer to the final user: electricity transmission substations, electric transformer substations, circuit breakers, separators.

Within this paper, the simulation of a SCADA system using Delphi programming environment was experimented. In order to collect the data from the field, a development board based on Tiny Tiger 2 microcontroller was used. Moreover, the emphasis was put on the acquisition of analog data concerning the consumption, instantaneous power and the loading capacity of the system.

The SCADA surveillance and control systems applied in the electric power processes are exquisitely complex and integrate at a software level the entire necessary function range of the operative management:

- operative tracking;
- operative archiving;
- energetic balance sheets;
- operator guide;
- diagnosis;

SCADA systems are structured differently, every developing system having its advantages and disadvantages. Therefore, for this project we have chosen a SCADA system based on the structure from Fig. 1.

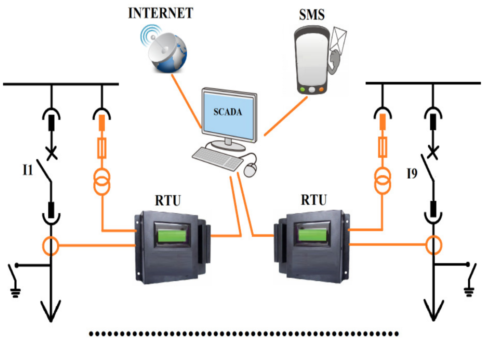

Fig. 1. A SCADA system structure

3. HARDWARE EXTENSION

In the Politehnica University Timişoara there are Tiny Tiger2 development boards, based on the second generation of Tiny Tiger 2. The development board is provided with a series of numerical inputs and outputs. It also has four analogical inputs, through which the voltage can be measured, and four numerical inputs, through which the current can be measured. Both numerical and digital inputs and outputs can be extended through the development of the extension boards, which can be attached to the Tiny Tiger 2 board. For this application, the advantages offered by the Tiny Tiger 2 board were sufficient to measure the current and voltage of the three phases of a real power system.

The main source of information related to electric network is current and voltage transformers. There are several types of voltage transformers working at various voltages in secondary. According to the manufacturer of the voltage transformer (voltage transformer for measuring the voltage from a high power line), the output voltage for measurement, the exit side of transformer can be between 100 and 110 V or between 100/√3 and 110/√3V [7].

For this application, a voltage divider was used, by means of which, at the analogical input of the microcontroller, a maximum voltage of 5V was reached. In what concerns the current transformers, according to the type of construction and the working voltage in their secondary, the current reaches a maximum of 1A or 5A. In this case, the use of a divider was taken into account, in order to reduce the current of the secondary up to the value accepted by the microcontroller. Taking into consideration that making tests in real life at this voltages is very hard, instead of using real high and medium voltages, we have chosen to simulate the high voltage measurement devices with LM 317. In order to simulate current and voltage variations, a scheme based on the integrated circuit LM 317 was developed, which helped us simulate the voltage variation on the three phases of the power circuit. The LM 317 integrated circuit is a circuit designed for voltage adjustments, being designed to support a 1.5A load current. Using the LM 317 integrated circuit, the voltage can vary between 1.2 and 37 V. The voltage is adjusted by using a resistive divider [8].

In figure 2, the scheme of the small simulator created to reduce the voltage and current is represented.

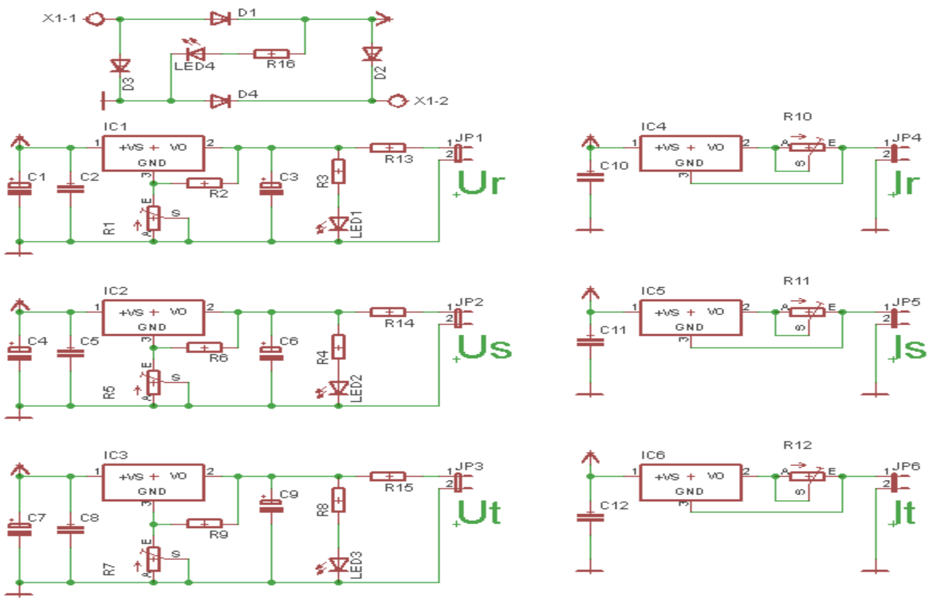

Fig. 2. Hardware design

Therefore, following the integrated circuit connection, according to the annexed scheme, a variation in voltage between 0 and 6 V resulted. In order to supply the circuit, a voltage of 6 V AC was used. The diodes D1, D2, D3, D4, from the annexed scheme, were used to create a rectifier bridge so that it converts the alternating current coming from the transformer, into continuous current. The condensers C1, C2, C3, C4, C5, C6, C7, C8 and C9 are meant to independently filter the AC current into DC [8].

The potentiometers R1, R5 and R7 have the role of varying the output voltage U_r, U_s and U_t depending on the change of the resistors, while the potentiometers R10, R11 and R12 have the role of varying the output current Ir, Is and It, depending on the variation of the resistors. The output voltages U_r, U_s and U_t are given by the ratio between the resistors R1-R2, R5-R6 and R7-R9 [8].

The variation of output voltage is determined by using the following formula:

$$U_{out} = 1,25 \cdot \left(1 + \frac{R_1}{R_2}\right) + I_{adj} \cdot R_2 \quad (1)$$

where: U_{out} – output voltage;
R_1, R_2 – resistance values;
I_{adj} – is typically 50 μA (negligible in most applications).

For the variation of the output current; to be more specific, for the simulation of current reduction, the integrated circuits IC4, IC5 and IC6 were used, according to figure 2. The current variation is determined according to this formula [7]:

$$I_{out} = \frac{U_{ref}}{R} \quad (2)$$

where: I_{out} – output current;
R – resistance value;
U_{ref} – 1.25 V for LM315.

4. SOFTWARE

In order to get closer to a real SCADA system, an interface that communicates with Tiny Tiger 2 board through the RS232 serial port was developed within the Delphi program. This interface gets information about the voltage on the three phases, the current on the three phases and the apparent power. The software shows the load on each line, main current and instantaneous power. The interface is shown by Delphi program like in fig. 3.

Through the interface it is evidenced the state of the cell, respectively the state of the circuit breaker and of the CLP. Also, the measured values for the voltage, current and apparent power for the three phases R, S and T are displayed. On the right side, the loading in percentage of the three phases is displayed.

The protection function is taken over by the development board Tiny Tiger 2, the interface having only the role of information display. The information is transmitted on the serial port, the interface analyzes them, displays them and, if necessary, notifies the operator, regarding the possible overruns or critical situations of loading phases, so that the operator immediately takes the appropriate measures in order to avoid the triggering of the protections.

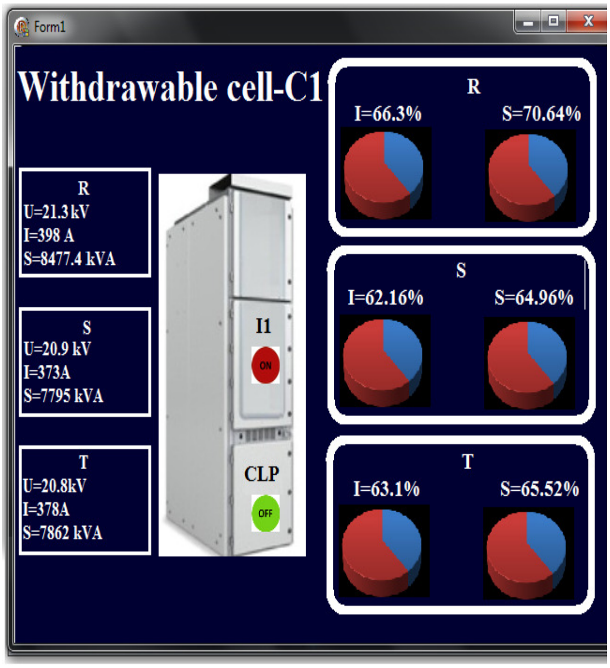

Fig. 3. Delphi Interface

The block scheme of the interface soft is shown in the figure 4.

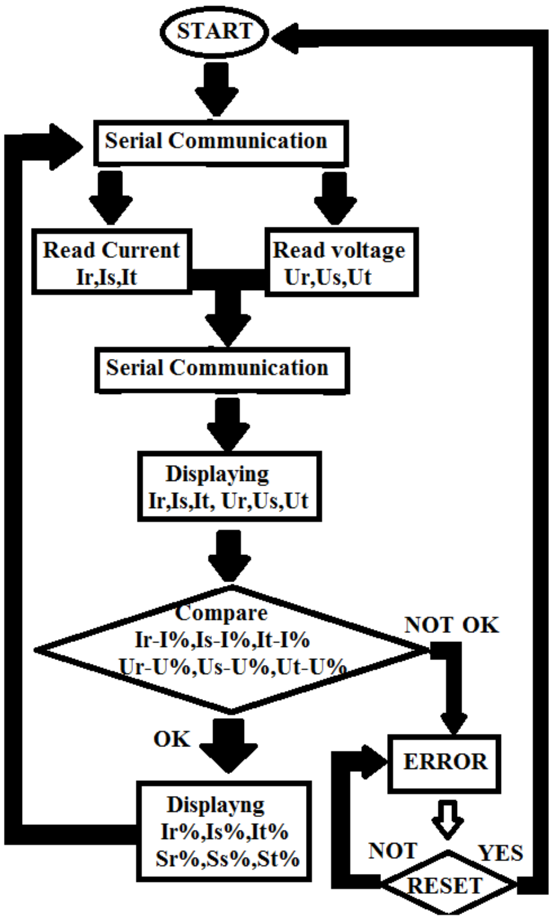

Fig. 4. The software structure

5. CONCLUSION

This paper proves the possibility of accomplishing a surveillance and control system with the help of a development system based on the Tiny Tiger 2 mC. The Tiny Tiger 2 Board is a smart equipment, with a system based on Tiny Tiger 2 Microcontrollers, and a 8 Bit Microcontroller. It is a less compact equipment consisting of a central PCB in which you can attach circuit boards. It was proved that, with the help of the Development Board, you can act and monitor the commutation equipment.

Moreover, we tried to demonstrate the possibility of monitoring the consumers parameters, the current voltage and the apparent power transported through the cells.

The Tiny Tiger 2 Mother Board system works very well on extensions, being adequate to the complex applications specific to the energetic grid, which imply the acquisition and processing of a big volume of data referring to consumption, powering of the lines and the equipment's status.

At the same time, it was proven the facilitation of the communication which offers flexibility and accommodation in an easy way to the SCADA system requirements of the Tiny Tiger 2 Mother Board.

REFERENCES

[1] Wang Chunlei,Fang Lan ; Dai Yiqi-A Simulation Environment for SCADA Security Analysis and Assessment, Proceedings of the 2010 International Conference on Measuring Technology and Mechatronics Automation (ICMTMA), Vol. 1, pp. 342-347

[2] Bruce, A.G.-Reliability analysis of electric utility SCADA systems, IEEE Transactions on Power Systems, Vol. 13, Issue 3, pp. 844-849

[3] www.elsaco.com/

[4] http://www.briltech.ro/management_si_control_sisteme_scada.aspx

[5] http://scada.imperialelectric.ro/scada-hmi

[6] http://www.energobit.com

[7] http://www.syscom.ro

[8] http://www.schneider-electric.com/products/ro/ro/3300-transformator-de-masura-mt/

[9] LM317 3-Terminal Adjustable Regulator, SLVS044W – september 1997–revised october 2014