

USING VIRTUAL INSTRUMENTATION IN DISTRIBUTED CONTROL SYSTEMS

Nicolae Patrascoiu, Ph.D., Assoc.Professor, University of Petrosani, Romania
 Ioana Camelia Barbu, Ph.D. Lecturer, University of Petrosani, Romania
 Cecilia Roşulescu, professor, Grigore Geamanu School

ABSTRACT: In this paper we propose an application written in LabVIEW through which a number of acquisition modules are controlled and these modules realize the initial data processing. Control consists in selection for each of these modules, their inputs selection and retrieves information from them. The physical connection is made by RS-485 bus and the transmission protocol used is MODBUS.

KEYWORDS: data acquisition, RS-485, MODBUS, LabVIEW

1. INTRODUCTION

The notion of distributed control system (or DCS) shall, in the broadest sense, any system of control of a dynamic process characterized by the fact that control elements are located spatially adjacent of the controlled subsystems and these control elements are interconnected in a communication network that allows the monitoring and supervision process.

SCADA is used also to define de control into a distributed system and is an acronym for *Supervisory Control and Data Acquisition* which means level supervisory control and data acquisition system.

Supervisory control level is defined in opposition to real-time control and consists, for example, in charging the set-point values of some smart regulators, whose job is to maintain, in real time, the measured values of some process parameters at levels as close to the prescribed values.

The general scheme of a distributed control system with SCADA supervision is shown in Fig.1. We note the presence of several process units or distinct subprocesses, each with sampling devices and transmitting measured data (sensors, conditioning circuits and transmission), actuators (pumps, motors, heaters, etc.) in real-time controls (usually PLC, PID "smart" controllers or RTU), all interconnected by a communication bus to a central monitoring and supervision equipment equipped with an HMI (Human-Machine Interface) that usually is a computer equipped with special software and communication control which can be LabVIEW.

Should be noted that some parameters can be passed directly to supervisory equipment, located in the control room, by means of devices called RTU (Remote Terminal Units). The RTU devices can transmit commands to the PLC or directly to actuators associated to the real-time process control, and these commands sometimes have greatest priority against commands from the local control loop in real time.

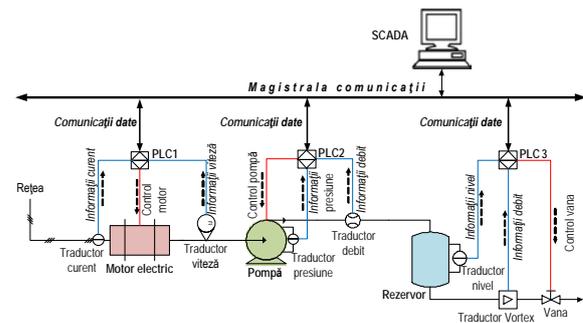


Fig.1. Distributed control system with SCADA

2. HARDWARE STRUCTURE

An RTU unit (sometimes called telemetry unit) is a unit of data acquisition and control system independent in general based on microprocessor or microcontroller which monitors and controls equipment located at a location away from the this unit. Its primary role is to retrieve data and transfer them to the main unit and also to control process equipment located away from the main unit. In general, RTU equipment have the facility to be dynamically configured and programmed from the main unit but the configuration and programming operations can be achieved also through a local programming device. Although usually RTU communicates with the main unit, it is also possible to carry out a communication peer-to-peer to other RTU. RTU unit can also act as a relay unit RTU unit can also act as a relay unit (sometimes called storage and retransmission unit) to another RTU unit, which cannot be accessed directly from the main unit.

Hardware structure of an RTU unit typically includes the following components:

- processing Unit (microprocessor or microcontroller) and associated memory;

- communication interface;
 - power supply;
- which may be added one or more of the following functional blocks:
- analog inputs/outputs;
 - digital inputs/outputs;
 - counter/timer.

A typical configuration of a unit is shown in Fig.2.

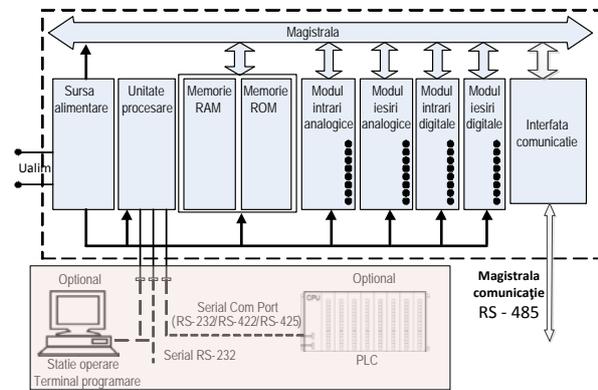


Fig.2. Typical configuration of a RTU unit

Through the virtual instrument that is presented in this paper are controlled the RTU units represented by modules type SM 1 and type P120.

The SM1 module, shown in Fig. 3., has two analog input channels and is designed to convert standard signals: voltage (0 ... 10 V) or current (4 ... 20 mA) or resistance (0 ... 400 Ω) or temperature signals (collected with Pt100 RTD) into the numerical data which are accessible via bus RS-485 or RS-232. The module has ports to connect to these buses and uses for data communication the MODBUS protocol.

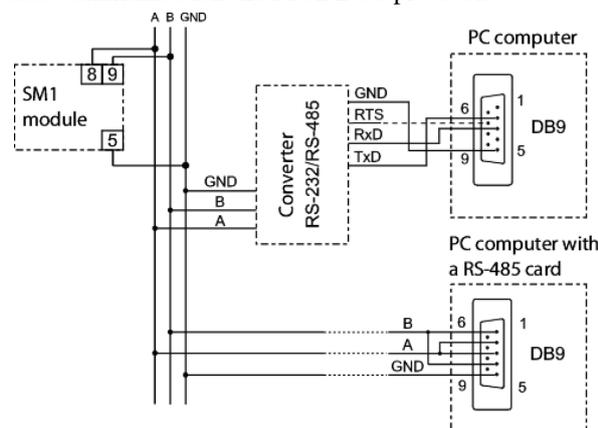


Fig.3. Connecting of module SM1

The module SM1 can be connected to an RS-485 serial bus via lines A and B (pins 8 and 9 of connector) to communicate with computer systems or other devices that act as master in a network through asynchronous communication protocol MODBUS.

For module SM1 MODBUS protocol was implemented according to the PI-MBUS-300 Rev. G of the Modicon Company.

So, for communication via RS485 serial bus and MODBUS protocol is necessary to set the following parameters:

- Module Address 1 ... 247;
- Transfer rate: 2400, 4800, 9600, 19200, 38400, 57600, 115200 bits/sec.;
- Maximum Response Time: 300 msec.
- mode: ASCII, RTU;
- Units of information: ASCII: 8N1, 7E1, 7O1;
RTU: 8N2, 8E1, 8O1, 8N1;

If the connection of the module to the computer is performed by the RS-232 serial bus are set automatically following communication parameters:

- Transfer rate of 9600 bits / s,
- Mode: RTU: 8N1,
- Address: 1.

Implementation of MODBUS protocol is achieved by using the following functions:

Table 1

Function code (hex)	Significance
03 (03 h)	Read n – registers
06 (06 h)	Write single register
16 (10 h)	Write n – registers
17 (11 h)	Slave identification

Based on table of module SM1 registers which can only be read is observed that the values of the two inputs registers can be found at the addresses 7006 and 7008 respectively if are used two successive 16-bit registers or at the address 7503 and 7504 if are used two 32-bit registers.

The module P120, Fig. 4, is a programmable digital transducer that can convert the number of pulses, number of turns, number of hours of operation, frequency, period and speed of rotation in a unified current signal 4 ... 20 mA or signal DC voltage signal.

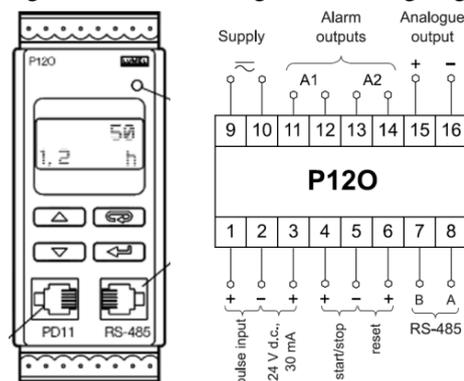


Fig.4. Connecting of module P120

It is preprogrammed to perform certain functions but it can be reprogrammed by the user via the RS-485 interface through a specialized programmer PD14 or keyboard so that it can add new features.

Like SM1 module and P120 module can connect to a RS485 bus via lines A and B (pins 7 and 8 of connector) to communicate with computer systems or other devices that act as master in a network through asynchronous communication protocol MODBUS.

slave devices and this choice is made by means of a **Tab** control and a **Case** structure.

For the AUTOMAT operation mode the slave device addresses are generated consecutively from address 1 to address that corresponds to the number of measuring points. This number is set by the user by control **Number of measurement points** on the front panel.

To increment the number representing the slave address is used the counter variable *i* of a **While loop**. The stop condition of this loop is by achieving the number *N* of the measurement points. By stopping the **While loop** after each reading cycle full of all slave devices is possible by the user switching to MANUAL tracking or remain in AUTOMAT tracking.

We consider a distributed control system structure containing four slave devices connection. The selection of the each device is made through a **Case** structure with 4 cases which correspond to the addresses of devices to which is added the address 0 for Broadcast call type.

Because each of the SM1 modules have two inputs is used in cases 1, 2 and 3 a **For** loop and each loop having two cycles. The counter variable of each loop is used to select one of the two inputs of modules SM1. It is not used in the address of the number 4 module, which is a P120 module because this has a single input.

Reading value is done via the **MB Serial Master Query Read Holding Registers** function that corresponds to the code 03 of the MODBUS protocol specifications.

Measured values, as well at the most RTU devices from the structure of SCADA systems are in floating point format according to IEEE 754 standard because these values are the real numbers.

The decimal value *F* of a real number, expressed as a floating-point in single-precision can be calculated by the formula:

$$F = (-1)^S \cdot 2^{(E-127)} \cdot (1 + M/2^{23}) \quad (1)$$

where *E* is the decimal value of the exponent and *M* is decimal value of the mantissa. In this the virtual instrument for conversion from IEEE 754 format to decimal format is implemented the expression (1) by means of **IEEE754 to Decimal SubVI**.

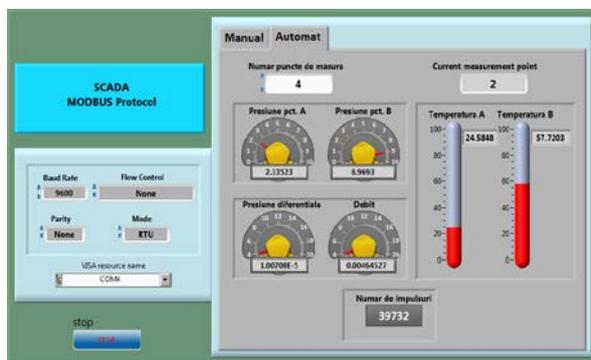


Fig.7. Front panel for AUTOMAT tracking mode

For display on the front panel of the measured values was chosen one indicator corresponding to each

device and also for each entry of the every device. In Fig.7. is show the complete front panel corresponding to AUTOMAT tracking mode.

Also on the front panel is presented and the setting mode of the parameters of serial communication between devices connected on the RS485 bus. It can be seen choosing the choice of RTU working mode, the 8N1 communication format and the 9600 bps (baud) for transfer rate. Once initialized the communication parameters they will be changed only by the restart of the virtual instrument.

4. CONCLUSIONS

The solution proposed in this paper for control the different devices connected through RS485 serial bus and MODBUS protocol can be extended up to 247 devices.

The virtual instrument proposed also has the advantage of simplicity and flexibility.

The simplicity is due to the fact that the link between devices and between every device and the master is achieved by a twisted pair. The flexibility is due to the fact that the number of devices can be from one to 247 and also every of these can be locate anywhere up to 1200 meters around the master device or computer.

5. REFERENCES

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