Ethernet Converting Module for Industrial Serial Interface

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Abstract – **For controlling and monitoring the electrical power system, it is needed to be stored and computated the data for many electricity parameters measured in different points of the electrical system. In many cases it is needed the information for every parameter, to be sent to a monitoring and visualization main-system device, which is usually situated on a long distance from the basic measuring module.**

The results of this project will be used in designing an intelligent module for detecting the electricity quality with integrated Ethernet interface for network communication with main-system station.

Keywords – **Industrial interface, Ethernet, UDP, TCP/IP, PST08**

I. Introduction

For controlling the quality of the electricity, it is needed to be measured as many parameters as possible from different points of the network. The main goal of this project is to be designed technical equipment for transfer the measured values from the intelligent measuring modules to the main-station server through Ethernet. At the one side of the network is the intelligent device, which communication interface is type of industrial serial interface. At the other side of the network is a main station, which can be situated on a long distance. The interface for communication is based on Ethernet.

The integrated serial digital interface in PS intelligent modules gives the possibility for network connection between them and a Personal Computer. This connection is based on RS232 interface and the maximum devices, which can be connected to RS232 port of a PC is 10.

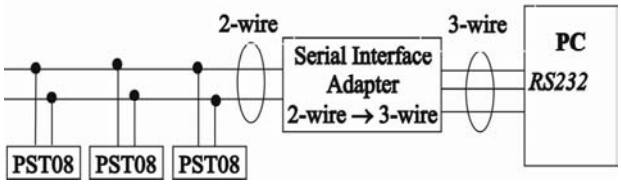

Fig. 1a. Network communication between PST08 and PC, based on the serial interface integrated in the intelligent sensors

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The maximum speed of transfer is 9600 bps, and the physical connection is made through an adapter (Fig. 1a).

The Ethernet communication interface gives the possibility to connect many of the modules in network again by using interface adapter (Fig. 1b). This network permits transfers of data with 10Mbps.

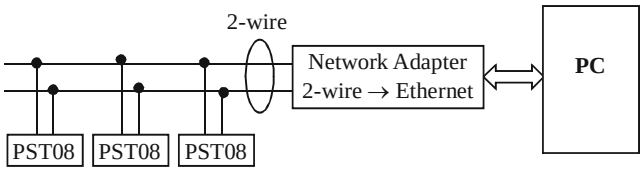

Fig.1b Ethernet network communication between PST08 and PC /2-wire serial interface converted to Ethernet/

II. Basic features of the Ethernet Converting Module

The 2-line serial interface has the following data transfer protocol: when the sensor receives command $02 (data from the measurement), the reply is:

TABLE I
Transmit data description

Byte Number	Content
0	Address
1	Command
2	40($28),
3, 4	$U1_{MS}$, $U1_{LS}$
5, 6	$U2_{MS}$, $U2_{LS}$
7, 8	$U3_{MS}$, $U2_{LS}$
9, 10	$I1_{MS}$, $I1_{LS}$
11, 12	$I2_{MS}$, $I2_{LS}$
13, 14	$I3_{MS}$, $I3_{LS}$
15, 16	P_{MS}, P_{LS}
17, 18	Q_{MS}, Q_{LS}
19, 20	Fст, Fмл
21 - 32	reserved
33, 34	φU2a, φU2b
35, 36	φU3a, φU3b
37, 38	φI1a, φI1b
39, 40	φI2a, φI2b
43, 44	CS1, CS2

The main disadvantages of the integrated digital serial interface in PST08 sensors refer to the impossibility of transferring data on a long distance. On the other side, this protocol is simple, but also non-standard. Besides that, the personal computers in now days don't have serial interface as integrated one and it is complicated to develop a network through RS232 interface, which is replaced by USB. Base on

these facts, it is decided to be used a new modern approach for network connection.

For realization of network connection between PST08 sensors and a PC, without making changes of the electrical circuit of the sensors, the only decision is to be used the digital serial interface integrated in the intelligent modules, but the data from it to be converted to another protocol suitable for transferring data faster and on a long distance. After this conclusion, it was decided to be designed an adapter module for converting the serial data into Ethernet packets. The Ethernet network is now very popular and it is not expensive to be made. The basic components needed for developing this kind of communication is an Ethernet controller, HUB or Switch and the physical connection – UTP/FTP cable and RJ45 plug and connector. After the investigation, it was made a conclusion that it is appropriate to be used RTL8019 integrated circuit produced by the Taiwan Company **Realtek**. This Ethernet controller is intended for 10Mb/s networks with 8-bit ISA interface. For controlling this IC it is needed an 8-bit data signal, address signals and IOW, IOR and Reset signals. IOW and IOR signals are for allowing writing and reading to/from the RTL8019 registers. For this purposes it is very convenient to be used an 8-bit microcontroller for realization of the physical and software interface between the serial data from the sensor and the Ethernet controller. For 8-bit microcontroller is chosen the PIC16F877 MCU produced by **Microchip**. This MCU has enough I/O pins for the purposes and its program FLASH memory and data EEPROM memory are enough for development. The main purpose of the microcontroller is to collect data from the serial interface, to store the information and after that to prepare Ethernet packets for sending through RTL8019.

For communication over IP protocol every device in the network has own MAC (6 Bytes) and IP (4 Bytes) address. When two devices want to communicate the sender has to note source and destination MAC and IP addresses.

For communication over Internet Protocol, the minimal service is UDP, adding only optional checksumming of data and multiplexing by port number. TCP (Transmission Control Protocol) is a connection-oriented transport service; it provides end-to-end reliability, resequencing, and flow control.

TCP enables two hosts to establish a connection and exchange streams of data, which are treated in bytes.The delivery of data in the proper order is guaranteed. TCP enables two hosts to establish a connection and exchange streams of data, which are treated in bytes. TCP can detect errors or lost data and can trigger retransmission until the data is received, complete and without errors. But in this case it is needed more resource from the MCU placed on the adapter module.

The adapter module connected with PST08 is similar to **gateway,** which makes possible communication between two devices with different standards and protocols. In this case, a command is sent from the main station in the network. Every adapter has an individual IP address, which corresponds to every intelligent sensor. It means that it is needed an adapter for every sensor. To be connected with a PC, the adapter modules have to be connected to a HUB or Switch. The adapter module recognizes the IP address sent from the main station and it sends a command to PST08 for data request. The sensor begins transmitting data to the adapter, where the PIC16F877 stores the data in its data EEPROM memory. The microcontroller prepares the packets for transmitting to the main station through Ethernet over UDP protocol (first tests are over UDP) or TCP. The software on a high level, installed on the PC, helps for collecting, storing and visualizing data in convenient for the user way. It is very important the transferred data to be protected against hacker attacks. All the commands and data have their own specific coding for transferring over UDP type of protocol. The Ethernet Converting Module can switch on its IP address by receiving command from the main station device. This command is transferred over ARP protocol.

III. ELECTRICAL CIRCUIT DESCRIPTION OF THE CONVERTER BOARD

From the designed electrical circuit shown in fig. 3 it can be found the following modules integrated in it:

- Serial interface communication;
- Microcontroller for communicating with Industrial Serial Interface of PST08 and driving the Ethernet controller;
- Ethernet controller for network communication over ARP, UDP and ICMP Internet Protocols.

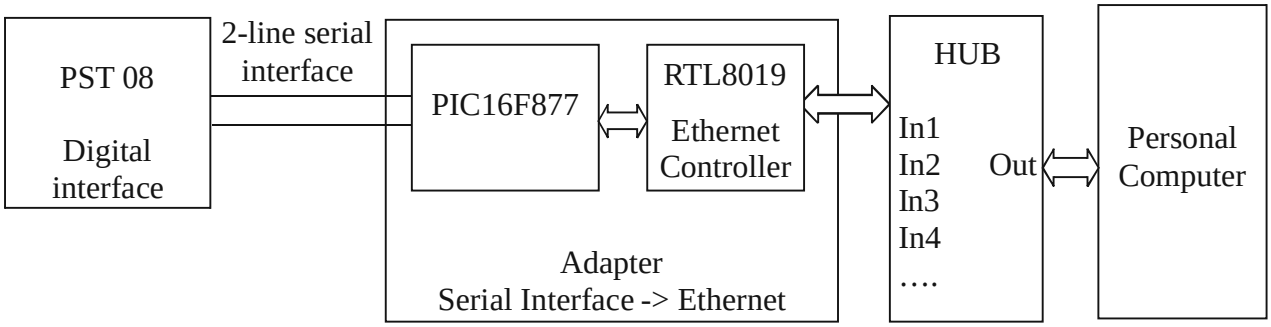

Fig. 2 Functional block diagram of the network system

1. Serial interface communication circuit is based on T1, T2 transistors and U3, U4 optocouplers. There are two lines from the side of microcontroller - Tx line – for transmitting data from the converter board to PST08; Rx line – for receiving data from PST08 to converter board.

The optocouplers in the electrical circuit shown in fig.4 are needed because of galvanic insulation between the receiving-transmitting lines of the adapter board and the PST08 Industrial Serial Interface (ISI). That is why it is used two 5V power supply lines, obtained from two different coils of a transformer. The connection of the converter board with ISI of PST08 is realized with CON2 connector. There are two lines named "+" and "–".

2. Microcontroller used in this circuit is PIC16F877-20I/PQ. The package is 44-pin QFP, and the integrated modules very useful for this project are 8Kwords (1 word is 14-bit) program memory, 368 bytes data RAM memory, 256 bytes EEPROM data memory and the hardware Universal Synchronous Asynchronous Receiver Transmitter (USART). The work of the microcontroller is organized as follows: 8-lines Port D of the microcontroller is connected to 8 data pins of RTL8019 Ethernet controller. For driving the RTL8019 IC it is needed also driving IOW, IOR and RESET signals and A0-A4 addressable lines. The EEPROM data memory is used for storing the basic MAC and IP addresses and the data coming from the PST08. The MAC address is unique for every adapter module, but the IP address can be changed through ARP protocol. In first place the PICMicro is waiting for a command from the main station over UDP, ICMP or ARP protocols. If the command is to change the IP address, the microcontroller takes the needed data which includes the new 4 bytes IP address, stores it in the EEPROM data memory, and resets. After reset the adapter module has new IP address. If the received packet is a command for asking data from PST08, the microcontroller stores the Ethernet packet in the RAM data memory takes the command from it and sends it through Tx line of the USART module. The ISI interface is so organized that if there is no connection between the converter board and the PST08, the byte transmitted by PICMicro Tx line is not received on Rx line. The microcontroller is making checking if every transmitted byte is received properly by the PST08. If it is not, the PICMicro is sending warning to the main station over UDP interface. If PST08 is received everything properly, the adapter module is waiting for coming data on Rx line of the PICMicro. One cycle of coming data is 44 bytes (table 1). All these bytes are stored in the EEPROM data memory. After all 44 bytes are received, the PICMicro prepares the UDP packet for transmitting the data to the main-station. In this case the data EEPROM memory is used for storing only 2x44 bytes data coming from PST08, which means that it stores only 2 measurement results. All of the statistics is made in the high level software installed on the main-station.

3. Ethernet controller RTL8019

The PICMicro is driving only the first 5 address lines, and the other are connected to GND and VCC as shown in fig. 3. For indication of network communication state it is used 2 LEDs – LED0 for indication of LINK presence; LED1 for Carrier Sense LED (LED_CRS = LED_TX + LED_RX). The physical connection for Ethernet communication is based on UTP/FTP cable with RJ-45 connector. In the electrical circuit in fig. 3 is shown the CON8 connector, which in this case is with integrated transformer. If the RJ-45 connector does not have integrated transformer it can be used external one. The interface is differential and it is needed TPTX+ and TPTX- lines for transmission and TPRX+ and TPRX- lines for receiving.

Another module in the electrical circuit is the "Prog" connector. This connector is used for In-Circuit Serial Programming Debugging of the PICMicro.

IV. RESULTS

After the tests made with the Ethernet communication between PST08 and main-station PC, it was found that this electrical circuit is enough for realizing an ARP, ICMP and non-standard UDP protocols. The connection is reliable and the transfer of data is fast enough for these purposes.

V. CONCLUSIONS

Ethernet communication is fast enough, it gives a possibility for collecting, storing and visualizing data on a PC screen situated on a long distance from the destination points, in this case the intelligent sensors. For reliable connection it is recommended to be used TCP, but the UDP is also convenient.

The electrical circuit shown in fig. 3 will be upgraded by using newer PICMicro with more EEPROM and RAM data memory. It can be used also another type of Ethernet controller which is specialized for Embedded Systems applications by SPI interface (For example this is the future product of Microchip – ENC28J60 – 10Mbits/s Ethernet controller). In this case it is not needed so many pins of the microcontroller.

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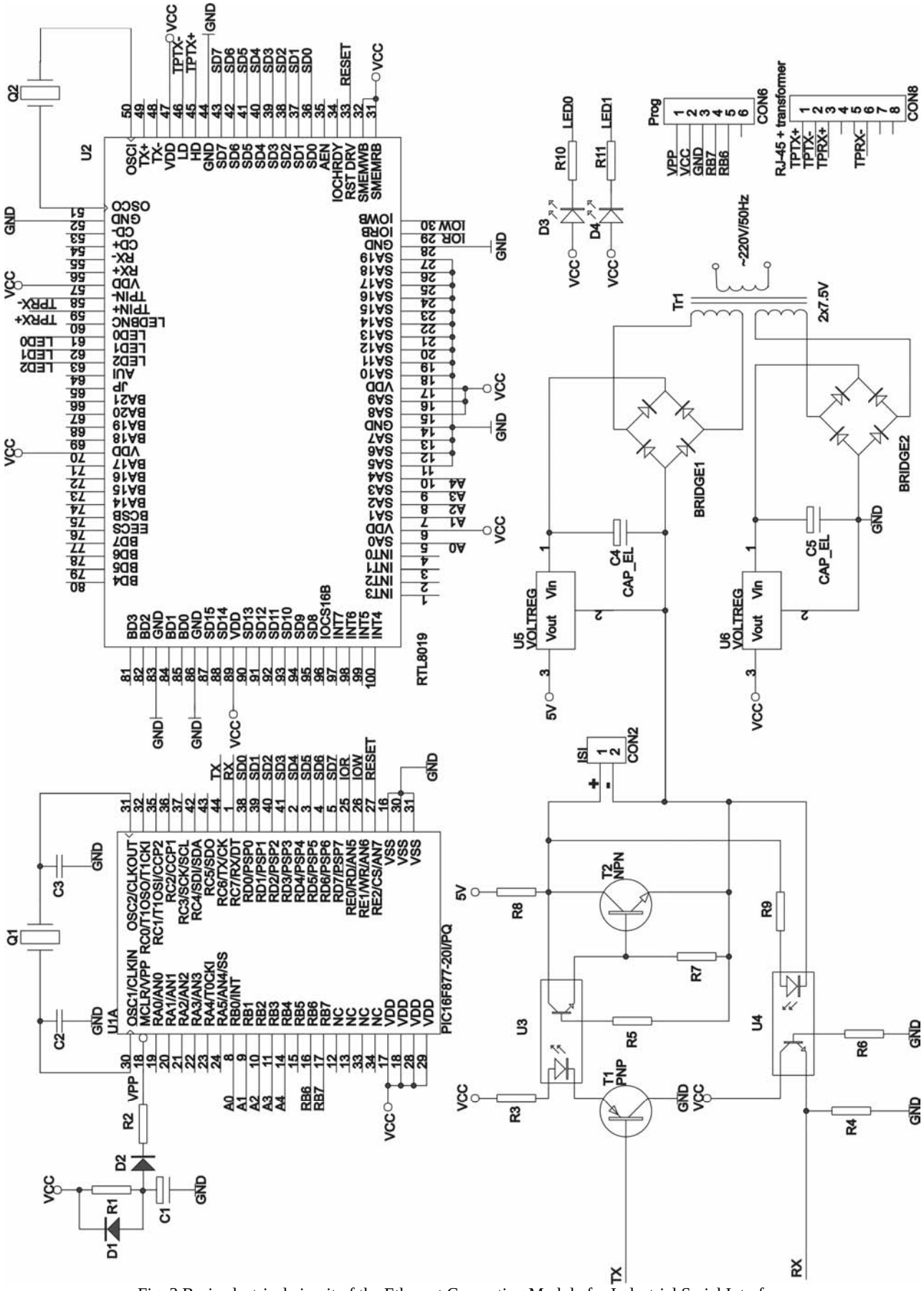

Fig. 3 Basic electrical circuit of the Ethernet Converting Module for Industrial Serial Interface