

## ETHERNET INTERFACE FOR A SYSTEM OF AUTOMATION WITH MICROCONTROLLER

Florin RAVIGAN, Nicolae BOTEANU, Adrian Mircea DRIGHICIU

University of Craiova, Department of Engineering in Electromechanics,  
Environment and Industrial Informatics, ravigan.florin@gmail.com,  
boteanu.nicolae@gmail.com, adrighiciu@gmail.com

**Abstract** – Because the Internet is becoming more widespread, there was the possibility of communication with automation systems for configuration, reprogramming or control in real time. For this, the automation system needs a physical communication port with the network. This paper presents the design and implementation of such Ethernet interface for automation system with microcontroller. The connection between the automation system and the interface is made via an SPI(Serial Peripheral Interface) port. The main element of the interface is a chip named ENC28J60 manufactured by Microchip. It is designed to serve as an Ethernet network interface for any controller equipped with SPI. ENC28J60 meets all specifications of IEEE 802.3 having incorporated MAC and PHY modules. It also provides an internal mode DMA for fast data transfer and hardware for TCP/IP. With ENC28J60, an RJ45 connector and a few passive components we can connect a microcontroller to a 10 Mbps network. The access of ENC28J60 controller is done through configuration registers and memory. The interpretation of data to extract useful information is done by software routines. These interfaces have multiple applications: Remote monitoring of a system or industrial process, can be accessed on mobile devices with Internet connection, domestic applications.

**Keywords:** microcontroller, ethernet, interface, communication, programming.

### 1. INTRODUCTION

The paper aims to show how to make ethernet interface with microcontroller automation systems. Are given at all stages of design, implementation and programming interface. The only requirement is that the microcontroller to have SPI interface (Serial Peripheral Interface). SPI is a standard synchronous high speed interface that operates in full duplex and can operate with one master device and one or more slave devices[6].

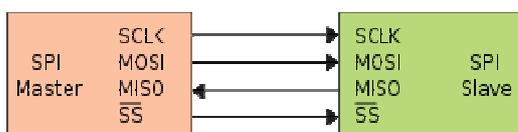


Figure 1: SPI bus

A big disadvantage of this port is that transmission can only be a short distance till to 50-100 centimeters.

### 2. THE DESIGN OF INTERFACE

#### 2.1. The network controller

The main element is the controller interface ENC28J60 made by Microchip company. It is designed to serve as an Ethernet network interface for any controller equipped with SPI. ENC28J60 meets all specifications of IEEE 802.3 having incorporated MAC and PHY modules. It also provides an internal mode DMA for fast data transfer and hardware for TCP/IP. The Enc28J60 has a clock at 25MHz.

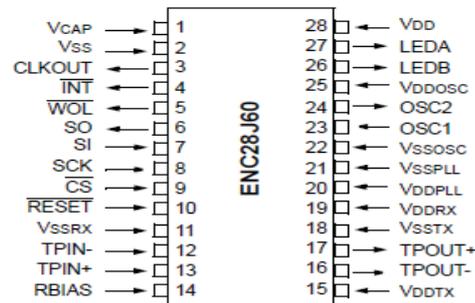


Figure 2: The ENC28J60

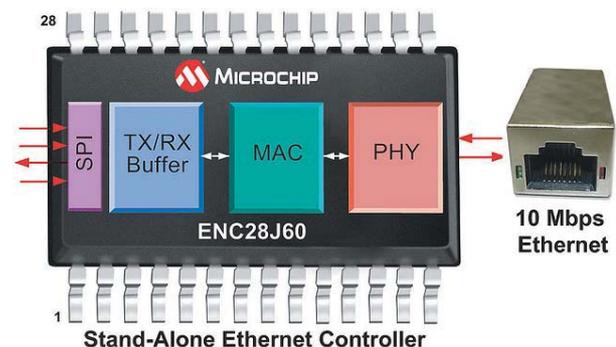


Figure 3. The ENC28J60 block diagram

With Orcad 9.2 software package was designed electronic interface scheme, which is shown below. The PCB is shown in the figure achieved being conducted on two sides.

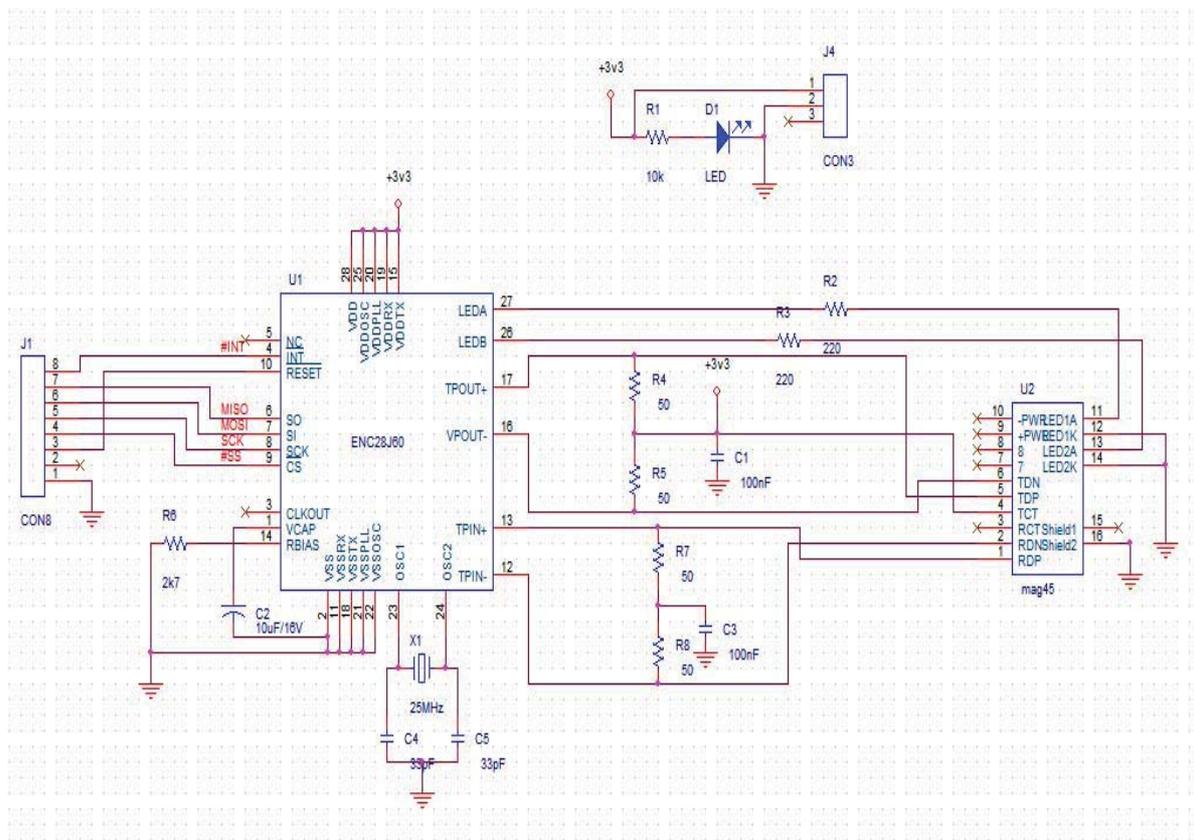


Figure 4: The electronic schematics

The LEDA and LEDB outputs of the controller can be used to view his activity. Their configuration is done through a dedicated register.

In this design these were connected to RJ45 network jack witch will be described later.

Next picture shows the footprints of the components and the placement of theses on pcb.

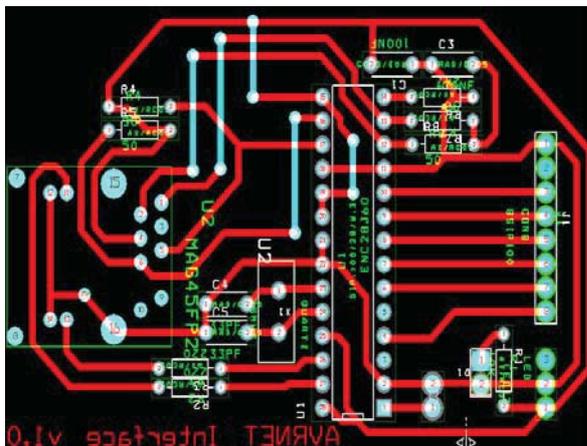


Figure 5: The PCB

Because the 50Ω is not a a standard value, the resistors R4, R5, R7, R8 are 51Ω.

## 2.2.The Magjack connector

To connect the circuit to a computer network requires a circuit consisting of coils, diodes and resistors to ensure the electrical parameters of the line, controller protection and the possibility of using PoE (Power-Over-Ethernet).

For this, it has been identified the connector presented bellow.

It has integrated magnetic system and can use Power over Ethernet technology, providing speeds of 10/100Mbps[1][2].

Connector has built two green LEDs that can be used to display various information ENC28J60 controller (using the register PHLCON: PHY control register LED modules):

- transmit activity;
- receive activity;
- collision activity;
- link status;
- transmit and receive activity;
- link status and receive activity;

- link status and transmit activity;
- duplex status and collision activity.

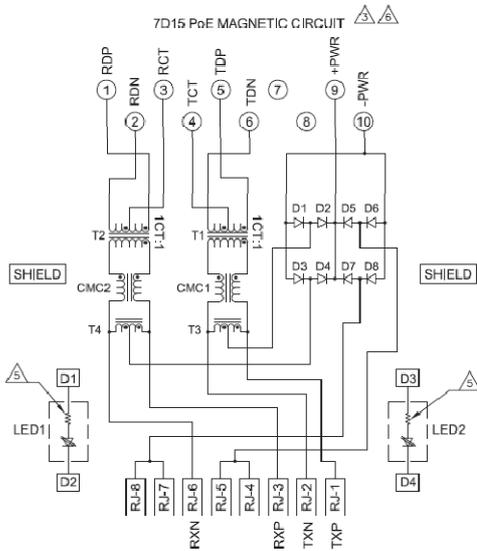


Figure 6: The schematics of connector

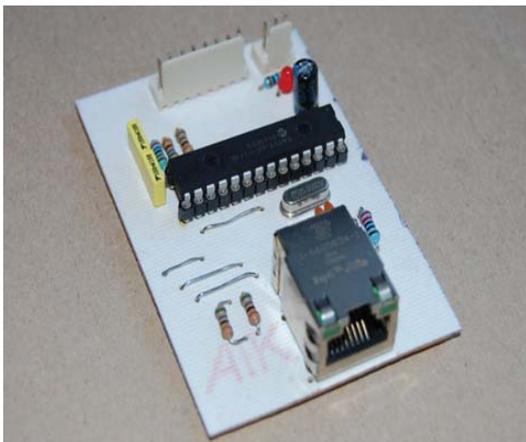


Figure 7: The build of ethernet interface

### 3. THE AUTOMATION SYSTEM

Automation system was developed using a Atmel AVR microcontroller family: ATMEGA8. In fact, he was made a minimal automation system to allow testing[6][8].

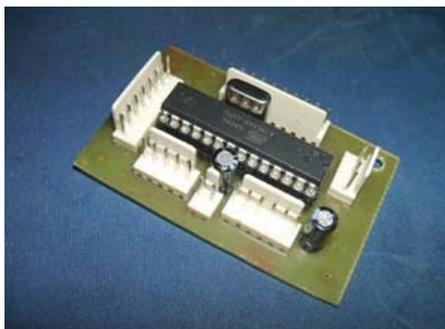


Figure 8: The automation system

The schematic of the automation system is presented below in figure 9.

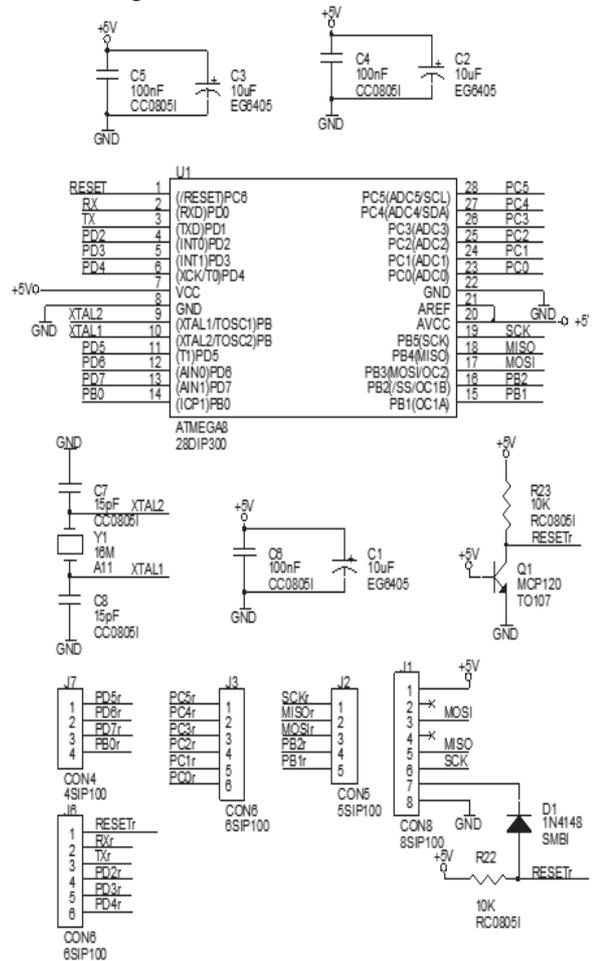


Figure 9: The electronic schematic of automation system

In short, ATMEGA 8 is a microcontroller with a clock frequency of 16MHz, with 8Kb of flash memory which is an integrated SPI port. How to connect the pins with Enc28j60 ATMEGA8 controller is shown in the table below.

Atmega8	Ethernet interface
INT0	/INT
MISO	MISO
MOSI	MOSI
SCK	SCK
SS	/CS
+3.3V	/RESET
GND	GND

In the interconnection circuit is no conversion from 3.3V to 5V because the pins of ENC28J60 is a 5V voltage tolerant as the description from datasheet[7]. After interconnection, the structure looks like following figure.

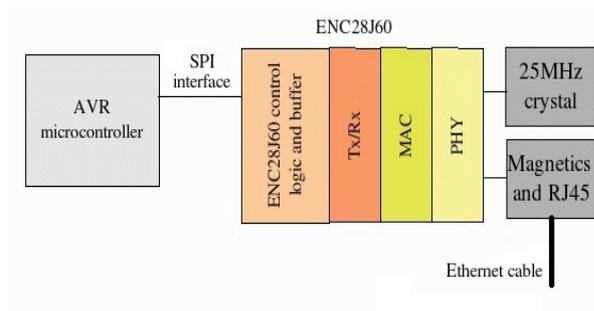


Figure 10. The system's structure

## 5. THE HARDWARE TESTING

To test the system hardware has made a dirt compound a computer connected to a network router. At the same router connected to the microcontroller system.

Note that the two have formed a local network equipment in which each received a static IP address. ENC28J60 controller can not be obtained automatically from the router IP address.

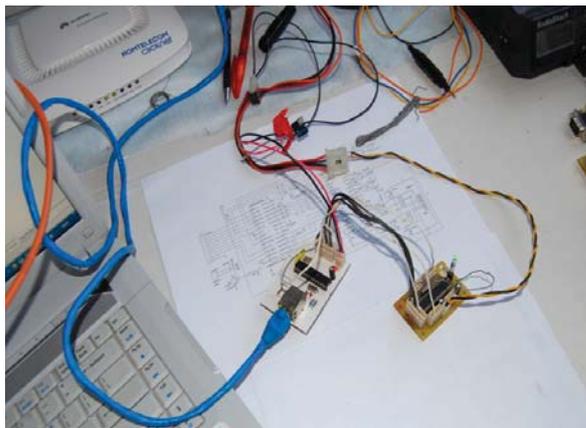


Figure 11. The ethernet interface connected at microcontroller

The ENC28J60 use involves setting a fixed IP address for it, a network mask and gateway address. That address is written in main procedure of software package as a unsigned integer on 8 bits array variable. Same way must be declared the net mask, gateway and DNS servers. Another important variable is the listen port: 80 for TCP and 1200 for UDP.

## 6. THE SOFTWARE PACKAGE

The software package contains two components:

- One for the automation system ethernet interface;
- one client to access the system.

Several forms client application CAN take. Among these are:

- Application command prompt type;
- GUI Application for Windows;
- accessible HTML page in a browser;
- Application for Windows Mobile;
- Java Midlet for mobile phones;
- Application for smart phone with Android operating system.

Two versions were developed: an HTML page served by accessing microcontroller IP address even his own, and an application for smartphones with Android operating system.

The router used to connect computer and microcontroller system is Huawei HG520s. Microcontroller has been allocated via the address 192.168.0.138.

Below are some images rendered page served by the system microcontroller.

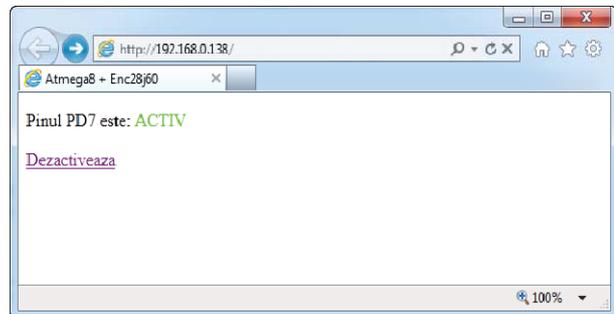


Figure 12. The web page served when the system is active

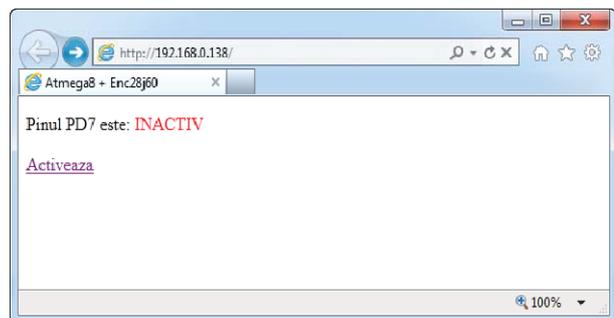


Figure 13. The web page served when the system is inactive

It also implemented a UDP protocol that allows using a tool called udpcom-xp.exe to send test orders and on / off commands for pin PD7.

For Android operating system has been developed an application that lets you connect to the IP address of the system and transmit this data packet to activate pin PD7.

Controlled pin status is displayed via a radio button element type.

At the bottom of the application is by pressing a button that switches the data packets transmitted: one for activation and one for off.

Packets consist of two bytes. To activate the package is: 0011 1100 00001111 and for inactivate: 1100 0011 11110000. These are encapsulated in TCPIP package is transmitted through the Internet.

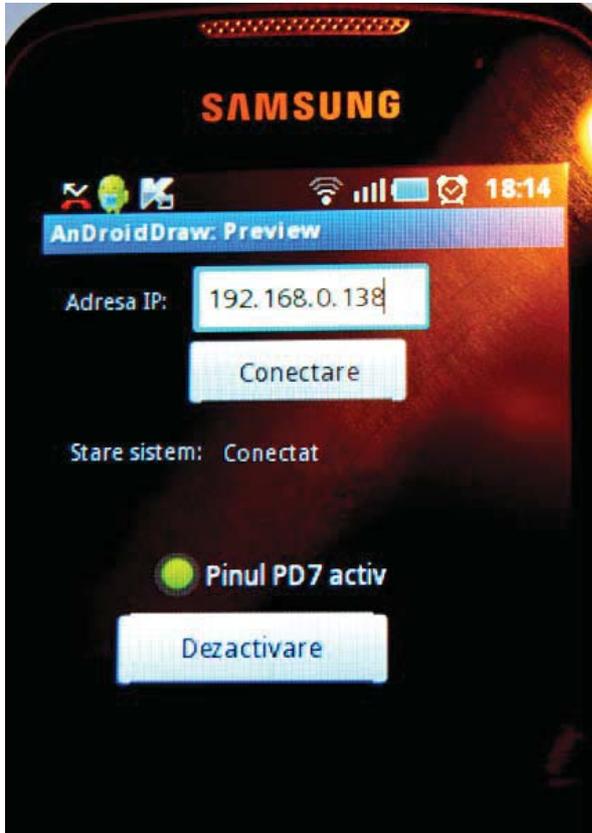


Figure 14. The application for Android OS

The microcontroller software development was done in C and compiled with the programming environment called Atmel AVR Studio 4[5].

The program is designed to consist of two main segments:

- Ethernet communication to achieve;
- system management and implemented control algorithm realized by mcu.

In the present study to further comment on the development of network communication routines.

To achieve the objective programs designed and tested in the virtual environment provided by Proteus program. After validation program has been adapted and tested microcontroller.

Here are the steps algorithm to achieve the program[4]:

- microcontroller to configure ports;
- to configure the microcontroller SPI communication;

- to set the configuration registers of the circuit ENC28J60(addresses, port);
- is expected to receive a network packet;
- Package type is detected;
- If the protocol is IP header is extracted it;
- if the type is TCP packet handler is calling the package.

This routine transmits corresponding HTML page and running and switch pin 7 of port D. Our stack is a collection of different modules. Some modules (such as IP, TCP, UDP and ICMP) must be called when a corresponding packet is received. Any application utilizing our stack must perform certain steps to ensure that modules are called at the appropriate times. This task of managing stack modules remains the same, regardless of main application logic.

To decode the package it was developed a stacktask. StackTask is implemented as a cooperative task; when given processing time, it polls the MAC layer for valid data packets. When one is received, it decodes it and routes it to the appropriate module for further processing.

The steps used by stacktask are shown in the algorithm below.

```

If a data packet received then
Get data packet protocol type
  If packet type is IP then
    Fetch IP header of packet
    Get IP packet type
    If IP packet type is ICMP then
      Call ICMP module
    Else if IP packet type is TCP then
      Call TCP module
    Else if IP packet type is UDP then
      Call UDP module
    Else
      Handle not supported protocol
  End If
End If

```

Figure15. The algorithm for package decoding

All simulations were made using Proteus ISIS software which gives us the possibility to build the circuit and run in virtual space the executable code written in C language.

#### 4. CONCLUSIONS

The interface now offers an effective solution, making low-cost (about 10euro), robust in operation. Following tests were carried out revealed the following conclusions:

-interface has a low price made the aprox.10 € and can be used for more microcontrollers with SPI (Atmel, PIC);

C-routines developed are robust and stable, with the executable code size 7.02kb;

-system can be used for monitoring and remote control is accessible through any Internet connection;

-ENC28J60 can not be used for DHCP in the router assigned it with a fixed IP address;

if using a router, it must allow portforwarding (port forwarding to a specific IP address).

Directions below:

can design the circuit that includes both circuits on the same PCB;

-you can use another microcontroller with flash memory more (Atxmegal28A1 witch is 3.3V compliant);

-can develop a system with SD card reader or USB interface for external hard drive can be a web server.

-can connect to the microcontrollers or microprocessors and other thereby improving data processing speed[3].

Ordering system can be used remotely via the Internet to different facilities or equipment used for household use.

Ex: air conditioning, home lighting, irrigation, temperature control in an enclosure, etc.

## References

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[4] \*\*\* - [www.tuxgraphics.org](http://www.tuxgraphics.org)

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[7] \*\*\* - [www.microchip.com](http://www.microchip.com)

[8] \*\*\* - [www.atmel.com](http://www.atmel.com)