Ethernet based Addressable Industrial Process Control Modules

R. P. Chaudhari¹, Swapnil R. Nardange²
¹,²Department of Electronics Engineering, Government college of Engineering, Aurangabad, INDIA

ABSTRACT
Developments in technology and the marketplace now make it possible for embedded systems to communicate in local Ethernet networks as well as on the Internet. Network communications can make an embedded system more powerful and easier to monitor and control. Ethernet solves the problem of remote communication with the embedded application. Challenges like application monitoring, control, diagnostics and data logging can all be accomplished from a remote, centralized location. With the ability to access the application remotely, corporations can eliminate the need to send a service person to the application and thus save labor time and money. The presented system enables Ethernet connectivity to the digital and analog signals in the industries so that they can be accessed from internet. This system use Atmega328p microcontroller to store the source code, web pages. An Ethernet controller chip, ENC 28J60 is used to handle the communication and is interfaced with the host microcontroller using SPI pins. There are several I/O pins available at the microcontroller which are used to interface with the relays, opto-isolator for controlling the industrial processes.

Keywords— Atmega328p, Ethernet controller ENC 28J60, SPI, relays.

I. INTRODUCTION
For many years, embedded systems and Ethernet networks existed in separate worlds. Ethernet was available only to desktop computers and other large computers. Embedded systems that needed to exchange information with other computers were limited to interfaces with low speed, limited range, or lack of standard application protocols.

But developments in technology and the marketplace now make it possible for embedded systems to communicate in local Ethernet networks as well as on the Internet. Network communications can make an embedded system more powerful and easier to monitor and control. Ethernet solves the problem of remote communication with the embedded application. Challenges like application monitoring, control, diagnostics and data logging can all be accomplished from a remote, centralized location. With the ability to access the application remotely, corporations can eliminate the need to send a service person to the application and thus save labor time and money.

There are compelling reasons behind considering Ethernet for remote communication. Ethernet is the most widely deployed network in offices and industrial buildings. Ethernet's infrastructure, interoperability and scalability ensure ease of development. Once equipment is connected to a Ethernet network, it can be monitored or controlled through the Internet removing any distance barrier that may have inhibited remote communication previously.

II. FUNDAMENTAL COMPONENTS
This section gives information about various components related to the system and various options available for using them. Some of the important components and protocols are listed below.
- Ethernet
- Ethernet control module
- SPI interface
- I/O system

A. Ethernet
Ethernet is a data link and physical layer protocol defined by the IEEE 802.3 specification. Ethernet is versatile enough to suit many purposes. Ethernet can transfer any kind of data, from short messages to huge files. An Ethernet communication can take advantage of existing higher-level protocols such as TCP and IP, or it can use an application-specific protocol. Ethernet doesn't require a large or fast
computer. With the addition of an Ethernet controller chip, even an 8-bit microcontroller can communicate in an Ethernet network.

Normal IEEE 802.3 compliant Ethernet frames are between 64 and 1518 bytes long. They are made up of five or six different fields: a destination MAC address, a source MAC address, a type/length field, data payload, an optional padding field and a Cyclic Redundancy Check (CRC).

![Figure 1. Ethernet control module](image1)

**B. Ethernet Control Module**

The ENC28J60 is a stand-alone Ethernet controller with an industry standard Serial Peripheral Interface (SPI). It has on-chip 10 Mbps Ethernet Physical Layer Device (PHY) and Medium Access Controller (MAC), providing reliable packet-data transmission/reception based on an industry-standard Ethernet protocol.

The PHY contains analog circuitry to encode and decode the data on the twisted pair interface while the MAC contains digital circuitry to control when to transmit, handle automatic retransmission when a collision occurs, calculates and validates CRCs (Cyclical Redundancy Check), and do other necessary tasks.

**C. Serial Peripheral Interface (SPI) standard**

The SPI has a 4-wire synchronous serial interface. Data communication is enabled with a low active Slave Select or Chip Select Signal (SS) or (CS). Data is transmitted with a 3-wire interface consisting of wires for serial data input (MOSI), serial data output (MISO) and serial clock (SCK).

![Figure 2. Serial peripheral Interface](image2)

**III. HARDWARE ARCHITECTURE**

This system utilizes a Stand-Alone Ethernet Controller IC which handles most of the network protocol requirements. The IC communicates directly to the microcontroller using a standard SPI interface. The system hardware includes an Ethernet controller IC ENC28J60, RJ45 socket with link/activity lights, Ethernet transformer, host microcontroller (ATmega328p) and input/output devices like opto-coupler and relays for monitoring and controlling purpose. This system enables user to connect a particular embedded device (equipped with SPI support) on to a network. By using this Ethernet enabled digital I/O control system, applications like Embedded Web server can be easily developed.

**A. RJ-45 Connector Socket**

Ethernet uses a bus (old coaxial cable) or star topology (standard UTP cable). Most Ethernet networks use unshielded twisted pair (UTP) cable. Category 5 (CAT5) cable is widely used, but other variations are available. EIA/TIA specifies RJ-45 connectors – properly called 8P8C (ISO 8877) for UTP (unshielded twisted pair) cable. A standard LAN cable can be connected here using RJ-45 connector.

**B. Ethernet Transformer**

On the TPIN+/TPIN- and TPOUT+/TPOUT- pins of ENC 28J60, 1:1 center taped pulse transformers, rated for Ethernet operations, are required. When the Ethernet module is enabled, current is continually sunk through both TPOUT pins. When the PHY is actively transmitting, a differential voltage is created on the Ethernet cable by varying the relative current sunk by TPOUT+ compared to TPOUT-. A common-mode choke on the TPOUT interface, placed between the TPOUT pins and the Ethernet transformer, is not recommended. If a common-mode choke is used to reduce EMI emissions, it should be placed in between the Ethernet transformer and pin1 and pin2 of RJ45 connector. Many Ethernet transformer modules include common mode chokes inside the same device package.
C. ENC28J60

The ENC28J60 is a stand-alone Ethernet controller with an industry standard Serial Peripheral Interface (SPI). It is designed to serve as an Ethernet network interface for any controller equipped with SPI. The ENC28J60 meets all of the IEEE 802.3 specifications.

It incorporates a number of packet filtering schemes to limit incoming packets. It also provides an internal DMA module for fast data throughput and hardware assisted checksum calculation, which is used in various network protocols. Communication with the host controller is implemented via an interrupt pin and the SPI, with clock rates of up to 20 MHz. Two dedicated pins are used for LED link and network activity indication [5]. A typical application using the device (IC) is shown in Figure 4. With the ENC28J60, two pulse transformers and a few passive components are required to connect a microcontroller to an Ethernet network.

D. MCU ATmega328p

The ATmega328 is a 28 pin micro-controller from Atmel AVR family. It has 32Kbytes of flash memory which is sufficient to accommodate our configured main application source code. It is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328p achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

E. Monitor and control Unit

By creating the web page, we can directly access the system. To monitor and control the all the system simultaneously we create the Frames on the same web page.

IV. SOFTWARE REQUIREMENT

In this system, I am not using any TCP/IP stack. Web page is stored in the external or internal EEPROM. These pages can be accessed by internet browser by assigning the IP address assigned to the
particular system. Each system has their particular IP and MAC address.

Arduino 1.6.1 is used for the developing and debugging the prom ram. HTML and Java Script language is used in the programming language.

![Arduino Window](image)

**Figure 5** Arduino window after successful building of program

V. **CONCLUSION**

Ethernet based addressable industrial process control modules is designed to monitor and control multiple devices at the same time. This system is small, cheap, and flexible so can communicate with the remote application.

As the Ethernet network is already setup in the building so this system can easily mounted anywhere. It can be used for Industrial as well as for non-industrial purposes. This Ethernet embedded system paves the number of application in the monitoring and controlling section.

**REFERENCES**


