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Ethernet Controlled Home Automation

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Abstract - *This paper presents very intelligible and sparing way to provide Ethernet connectivity to embedded systems. TCP/IP stack which is a vital element of the system software. ATmega328p microcontroller is used in this system to store the main application source code, web pages. For the purpose to handle the Ethernet communications, an Ethernet controller chip, ENC28J60 is used. They are interfaced with the host microcontroller using SPI pins. To interface with sensors and relays for the purpose of monitoring and controlling, I/O pins available at the microcontroller are used. Nowadays, most of the internet connections use Ethernet as a medium for data exchange. In home appliances or in industries, most of the time we need to control different parameters using microcontrollers. Once Ethernet is enabled which is used to interface to such systems, so that we can communicate with them remotely over the internet.*

Key Words: TCPI/P stack; ATmega328p; Ethernet controller; serial peripheral interface (SPI).

1. INTRODUCTION

Nowadays, for monitoring and to control the home or industrial devices, we are using many Networked embedded systems [1]. In this paper, we present the design of a system for Internet-based data-transfer system and operate by using Advanced RISC Machine i.e ARM processor which has in-build web server application with. An industrial grade RTOS for hard time applications is an OS on which the main core of the system is an embedded hardware runs. There is no need for for server software and maintenance in the proposed system. The proposed system reduces the controlling and operational costs while handling with a large amount of data [2]. Inbuilt web access functionality in a device which is low cost widely accessible and enhanced user interface functions for the device. For accessing to the user interface functions for the device, a web server is used through a device web page. A web server can be installed into any devices and gets connectivity to the Internet so the device can be controlled from remote places through the browser in a computer.

3. SYSTEM ARCHITECTURE DESCRIPTION

This part provides information regarding various components of the system available to serve particular purpose. Some of the important protocols and components are listed below

2.1 Potential Transformers

PTs or VTs are the generally used devices. These devices are standard transformers with one primary with one or two secondary windings. These devices have an iron core and the primary and secondary are coupled magnetically. The top side winding is built with more copper turns than other side. Any voltage applied on the primary winding is mutually reflected on the secondary windings in direct amount to the turns ratio.

2.2 Current Transformer

A current transformer (CT) is a kind of instrument transformer proposed to supply a current in its secondary winding in equal amount to the current flowing in its primary. They are often used in metering in the electrical power industry where they facilitate the safe measurement of large currents, often in the presence of high voltages. The current transformer safely isolates measurement and control circuitry from the high voltages typically present on the circuit being measured.

2.3 Microcontroller

Microcontroller is a core of this system. For this proposed embedded system AVR 8 is suitable microcontroller. Atmega 328p controller used in this system. The main features of ATmega 328p are as follows,

ATmega 328p microcontroller board based on an 8-bit AVR CPU with real-time emulation and commonly used in many systems, that combine microcontrollers with high-speed flash memory ranging from 32 kB to 512 kB. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30% with minimal performance penalty. The ATmega48PA/88PA/168PA/328P 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 ATmega48PA/88PA/168PA/328P achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed.

- High Performance, Low Power AVR® 8-Bit Microcontroller
- Advanced RISC Architecture

– 131 Powerful Instructions – Most Single Clock Cycle Execution

– 32 x 8 General Purpose Working Registers

– Fully Static Operation

– Up to 20 MIPS Throughput at 20 MHz

– On-chip 2-cycle Multiplier

• High Endurance Non-volatile Memory Segments

– 4/8/16/32K Bytes of In-System Self-Programmable Flash program memory

(ATmega48PA/88PA/168PA/328P)

• Peripheral Features

– Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode

– One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture

Mode

– Real Time Counter with Separate Oscillator

– Six PWM Channels

• Special Microcontroller Features

– Power-on Reset and Programmable Brown-out Detection

– Internal Calibrated Oscillator

– External and Internal Interrupt Sources

– Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby, and Extended Standby

• I/O and Packages

– 23 Programmable I/O Lines

– 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF

• Operating Voltage:

– 1.8 - 5.5V for ATmega48PA/88PA/168PA/328P

• Temperature Range:

– -40°C to 85°C

• Speed Grade:

– 0 - 20 MHz @ 1.8 - 5.5V

• Low Power Consumption at 1 MHz, 1.8V, 25°C for ATmega48PA/88PA/168PA/328P:

– Active Mode: 0.2 mA

– Power-down Mode: 0.1 µA

– Power-save Mode: 0.75 µA (Including 32 kHz RTC)

3. ETHERNET

Ethernet is a diverse and huge family of frame-based networking technologies for local area networks. The name is based on physical phenomenon of the ether. It defines a number of signaling and wiring standards for the physical layer in the network. It accesses network media through means of Media Access Control (MAC)/Data Link Layer with a common addressing format. Physical layer Ethernet stations communicate to each other on top by exchanging data packets which are the small blocks of data that are individually sent and delivered. Ethernet is standardized as IEEE 802.3 [3]. The ethernet is a link layer protocol in the TCP/IP stack. It describe how networked devices on the same networked segment and how to put data out on the network connection. This has been in use from 1980 to the present, which replaced competing LAN standards like token ring.

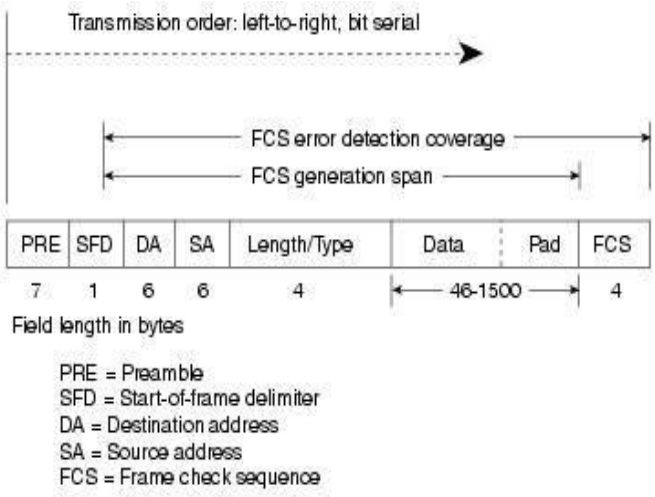

Fig -1: Basic Ethernet Frame Format

3.1 Transmission Control Protocol

TCP was uniquely made to provide a reliable end to end byte stream above an unreliable internetwork [5]. This protocol is different from a single network as its different parts have different topologies, bandwidths, delays, packet sizes, and other parameters.

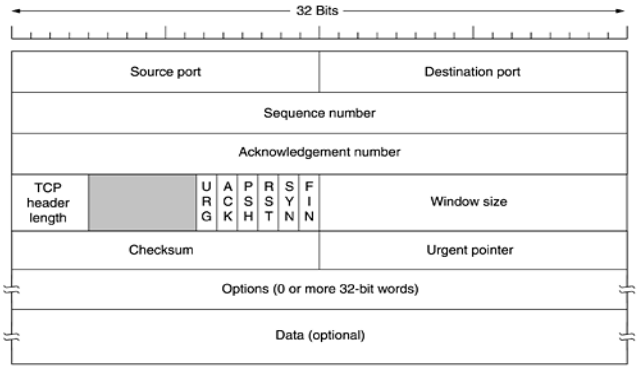

Fig -2: TCP Frame Format

TCP compatible system has a TCP transport entity, a user process, either a library procedure or part of the kernel.

It controls TCP streams and connects to the IP layer. TCP accepts user data links from local operations and breaks them up into parts not exceeding 64 KB (in practice, often 1460 data bytes in order to fit in a single Ethernet frame with

the IP and TCP headers). It sends each part as a separate IP datagram. When TCP containing datagram's data arrive at a machine, they are forwarded to the TCP entity, which built the original byte links.

3.2 Internet Protocol (IP)

Communication in the Internet proceeds as follows. First data is taken by the transport layer and divide them up into datagram's. In theory, datagram's can be ranged up to 64 Kbytes each, but in practical they are ranged not more than 1500 bytes as they have to fit in one Ethernet frame. Each datagram is forwarded through the Internet, as they are supposed to be fragmented into smaller units. When all the parts finally get to the destination system, the network layer reassembled them into the original datagram. Then the transport layer takes this datagram and inserts it into the receiving process input link. In general, it is considered to be more than six.

3.3 The IP Protocol

The study of network layer in internet is considered to be start from the format of the IP datagram [4]. A header part and a text part are the main parts of IP datagram. The header consists of a 20- byte fixed part and also has variable length part which is optional. The transmission is done in big-endian order: from left to right, with the high-order bit of the Version field going firstOn little endian machines, software conversion is required on both transmission and reception.

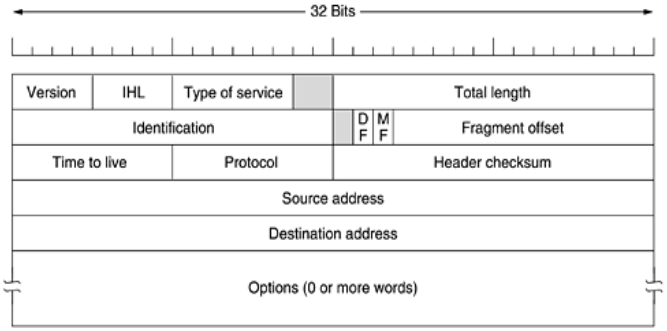

Fig -3: The IPv4 (Internet Protocol) header

3.4 Hypertext Transfer Protocol

The World Wide Web is HTTP (Hypertext Transfer Protocol) transfer protocol [6]. It is an application level protocol. It is a stateless, generic, object oriented protocol that can be utilized for many tasks like distributed object management systems and name servers, through extension of its request methods (commands). Client-server relationship is used in this and is based on TCP as a stream-oriented transport layer. HTML documents are mainly used in today's life is to transfer multimedia contents between Internet servers and clients. This works on the principle of request and response. The simple way to understand this is a case in that a client forms a connection to a server and then requests a content referred by a Uniform Resource Identifier (URL). The path and name of the resource are specified by the URL.

3.4 ENC28J60 Ethernet Controller

The ENC28J60 is referred as a stand-alone Ethernet controller which has industry standard Serial Peripheral Interface (SPI) [7]. This controller is purposefully designed to serve as an Ethernet network interface for any controller equipped with SPI. All the IEEE 802.3 specifications are followed by the ENC28J60. It consist a number of packet filtering schemes which is used to limit incoming packets. It also serves an internal DMA module for fast data throughput and hardware assisted checksum calculation, which is used in various network protocols.

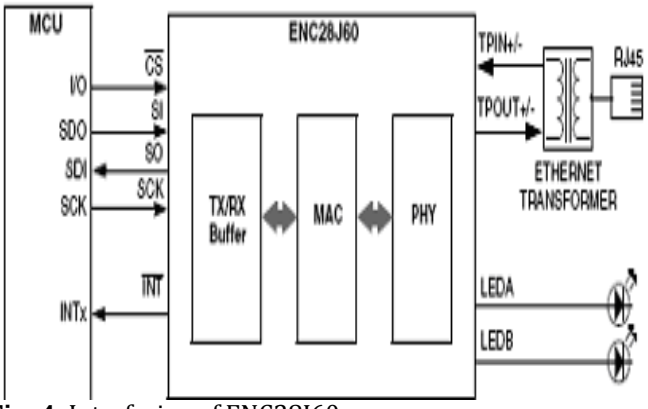

Fig -4: Interfacing of ENC28J60

4. SOFTWARE DEVELOPMENT

In an Ethernet network, an Ethernet controller chip and its driver is the interface to the network. The program code is embedded in the Ethernet driver that manages communications between and a higher level in the network protocol stack. For ethernet enabled internet communication, Transmission Control Protocol/Internet Protocol (TCP/IP) software is necessary and this stack occupies the Host MCU. According to the host microcontroller used in the system, microchip's TCP-IP stack is configured. Drivers for the ENC28J60 and a TCP/IP are provided by Microchip stack which also includes an HTTP web server. Web pages should be stored in external or internal EEPROM. These Web pages can be accessed using internet browser in the computer. It is accesses by the IP address assigned to the system. The uniquely assigned system IP address and server IP address can be configured by making changes in the program according to the aim of the system implementation.

4.1 IDE for Microcontroller's Program Development

For developing and debugging embedded code applications, Keil uVision4 is the Integrated Development Environment (IDE) used. Keil uVision4 IDE is an easy to use and user friendly interface environment to write, debug and built C/C++ or assembly code. For programming flash based microcontrollers, Flash Magic is a PC tool is used. There are several steps to dump program into Microcontroller.

5. CONCLUSION

Embedded web servers are the main and one of the important parts of an embedded network. Ethernet enabled system in our project can be used to change the status of the various devices connected to the system by means of Internet. The Embedded web server design consists of a whole web server with TCP/IP support through Ethernet interface. The embedded software environment is used for automatic configuration of the web server uniquely in the network. The complete source code written in C-language is included in embedded web server reference design. This comprehensive model of the Embedded Web Server has been designed using AVR, which makes use of only 3.3V Power Supply. Our design is a quick initiate to embedded web servers.

5.1 Future Scope

By the extra arrangement of wireless circuitry to the sensor module, this embedded system web server's capabilities like range can be improved. The facility to send e-mail alerts to a mobile phone or to the local police station on occurrence of break-in into the house in the case of home security system. In the case of a process control environment to abnormalities in the body parameters of a patient in ICU and the concerned plant engineer will alert the doctor wherever he is. Intelligent home automation will be the most practical application of this system and require a higher end microcontroller to communicate with the other devices in the network.

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