IMPLEMENTATION OF WEB SERVER USING ARM FOR INTELLIGENT MONITORING

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Abstract— An embedded system is a computer system designed for specific control functions within a larger system, often with real-time computing constraints But when networking technology is combined with it, the scope of embedded systems would be further more. Here design and implementation of embedded web server is presented. That can be used for electrical equipment monitoring system. In h/w design ARM MP, LPC2129 from NXP is used. Sensors are interfaced with microcontroller. Parameters like temperature, humidity, gas are measured and transmitted to PC through serial protocol SPI. The received values in PC are uploaded in internet by Ethernet cable. So by typing IP address in web browser, client can monitor all devices in industry from any remote places via its own local browser. Ethernet communication is depicted and data flow is analyzed last. When RTOS is incorporated into this system, more devices could be controlled and monitored. In industry single ARM board acts as data acquisition and control system and as a web server also, so the system is less compact with less complexity.

Keywords— ARM processor, Web server, SPI, TCP/IP, Hyper terminal, KEIL

I. INTRODUCTION

The arrival of internet reduced the whole world communication boundary to that of a single village. After the "everybody in internet wave" now obliviously follows the "everything in the internet wave" .When the embedded device are provided with internet access, it is of no doubt that demand will rise due to the remote accessing capability of the devices.

The paper includes complete implementation of an HTTP Web Server in arm ARM7 microcontroller. ARM 7 LPC 2129 development kit which contains Ethernet interface are connected to PC using RJ45 cable. Sensors are connected to ARM board. Temp., Gas, Humidity, pressure, motion, speed are must often measured parameters. Some electronic circuits, chemical reactions, biological processes perform best with in limited temperature, humidity range. It is also necessary to measure gas in environment. These parameters are mostly used in power plants, chemical industry, hospital, medicine Production Company.

In this paper embedded systems and Internet technology are combined to form a new technology - the Embedded Internet Technology, which developed with the popularization of computer network technology in recent years. The heart of communication is TCP/IP protocol. Network communication is performed by the IEEE 802.3 Ethernet standard. It is the most modern technology of embedded systems. Since ARM processor has fast execution capability and Ethernet standard can provide internet access with reasonable speed, this system is suitable for enhancing security in industrial conditions by remotely monitoring various industrial appliances.

II. EMBEDDED WEBSERVER

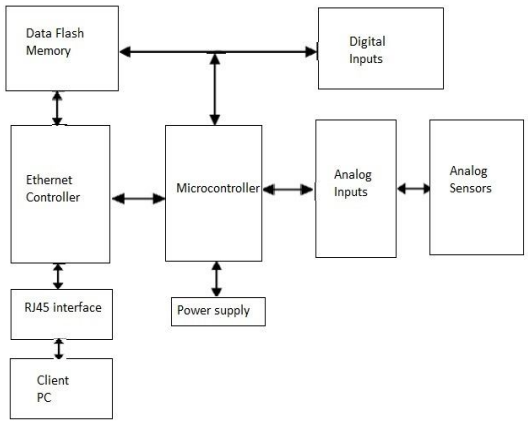

Fig. 1 Embedded Web Server Module

The implementation of embedded Internet technology is achieved by means of the embedded web server. It runs on embedded system with limiting computing resources to serve web documents including static and dynamic information about embedded system to web browser. We can connect any electronic device/equipment to web server and can obtain the real-time status information and control remote equipments without time and space restriction through web page released by embedded web server. As shown in Fig.1 Embedded server is a single chip implementation of the Ethernet networking standard. It consists of two primary elements communicating with each other: i) a server consisting of an ARM processor with an Ethernet controller and ii) a client computer which is connected to controller through this RJ45 interface. The client computer sends/receives data to/from the arm microcontroller using TCP packets. The client has to enter IP address to access this server. This request is taken by the operating system of the client

and given to the LAN controller of the client system. The LAN controller sends the request to the router that processes and checks for the system connected to the network with the particular IP address. If the IP address entered is correct and matches to that of the server, a request is sent to the LAN controller of the server and a session is established and a TCP/IP connection is establishes and the server starts sending the web pages to the client through which we can remotely monitor and control the sensor and device status respectively.

III. SYSTEM DESIGN

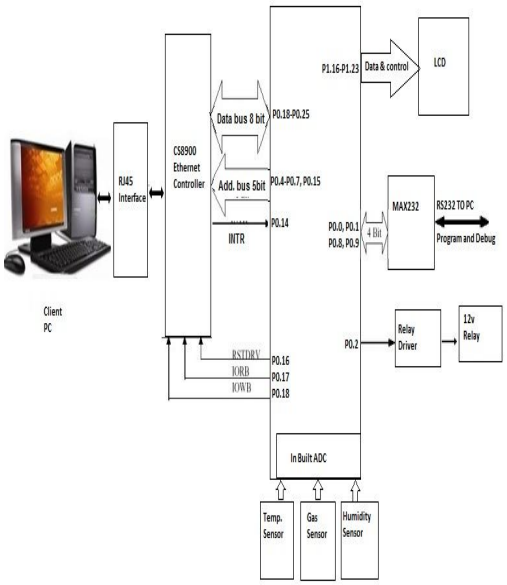

Fig. 2 Embedded Web Server Module

As shown in Fig. 2, system is mainly composed of ARM Processor module, Ethernet Module and SPI communication module. Here all the devices which we want to monitor are connected to processor through sensors. LPC2129 microcontroller interfaces with three sensors using P0.27-29 of an on chip Analog to Digital converter (ADC). Converted digital data will be sending out by DOUT pin of the chip. Port pin P1.19 of LPC2199 is used with relay driver circuit for controlling action. We have considered relay driver for experiment purpose. Ethernet data communication between microcontroller and a remote web-client is performed using the CS8900 ethernet controller. Specifically, the CS8900 receives reference commands from the remote web client and communicates the same to the microcontroller. In addition in built 10 bit adc converts sensors analog data into digital data and sends value to LCD. These measured values are transmitted to PC through serial protocol SPI. Values are uploaded on internet through Ethernet cable. So all devices are connected to PC through internet. When client types IP address on web browser, he will get web page that contains all parameters like temperature, humidity and gas.

IV. ARM LPC2129

Fig. 3 shows ARM LPC2129 development kit. Lpc2129 is 32bit ARM7TDMI-S CPU with 256 Kbytes Program Flash, 16 Kbytes on chip RAM, 2x UARTs, I2C, 2x SPI, 2x 32-bit Timers, 2x CAN, Four channel 10 bit ADC, PWM, WDT, 46 General propose 5V tolerant I/O pins, On chip crystal oscillator with operating range up to 60 MHz CS8900 Ethernet interface, Standard JTAG connector, 24LC515 EEPROM for external web storage.

Fig. 3 LPC2129 ARM development board

ARM has high speed of execution and powerful information processing capability. The capacity of multi parameter execution, multilevel monitoring and networking of ARM processor makes it suitable for wide variety of networking application.

V. ETHERNET INTERFACE DESIGN

Ethernet provides services corresponding to Layers 1 and 2 of the OSI reference model. It is standardized as IEEE 802.3 It specifies bus topology with connecting cable with both station and the actual network medium. Ethernet interface consists of MAC controller and PHY interface. MAC layer is responsible for data packaging, closing, sending and receiving. As shown in Fig. 4 LPC2129 is embedded with MAC but does not provide physical interface. So it uses CS8900 chip to provide Ethernet access channels. CS8900A is a low-cost Ethernet LAN controller for embedded applications. Its highly integrated design eliminates the need for costly external components required by other Ethernet controllers.

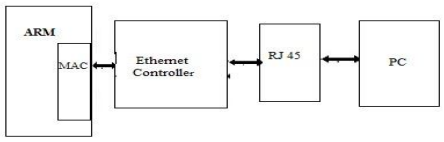

Fig. 4 ARM interfaced with Ethernet controller

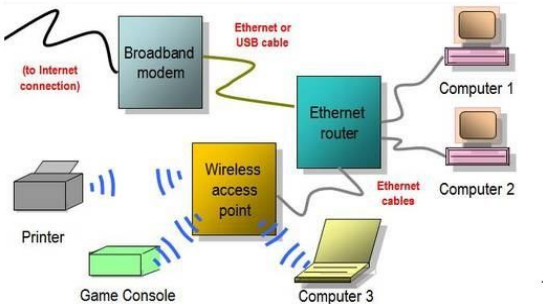

Fig. 5 Ethernet Routing

As shown in Fig.5, most (but not all) wired network routers allow up to four devices to be connected via Ethernet cable. A wireless access point consumes one of these available ports, but it then enables many (dozens of) WiFi devices to join the network. All devices connecting to an Ethernet router must possess a working Ethernet network adapter. All devices connecting a wireless access point must possess a working WiFi network adapter

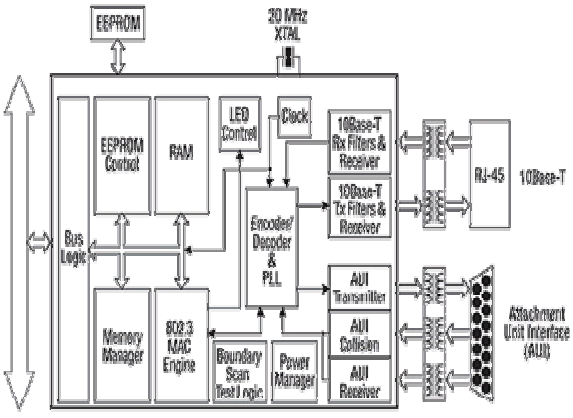

Fig. 6 CS8900 Ethernet Controller diagram

In this design, External Ethernet controller is interfaced with processor. As shown in Fig. 6, The CS8900A includes on-chip RAM, 10Base-T transmit-and-receive filters and direct ISA-Bus interface with 24 mA drivers. Here external bus is used. If parallel bus is used, then network traffic is slow. So in this system, SPI protocol is used for serial communication between processor and Ethernet controller. This controller has internal DMA module for fast data throughput and hardware assistated IP checksum calculations. The data of Ethernet is grouped into bytes often called frames.

As shown in Fig. 6, An IEEE 802.3 Ethernet frame consists of a 14 byte header, 46 to 1500 bytes of data, and an optional 4 byte cyclic redundancy check. 14 byte header consists of 6 byte source address,6 byte destination address and 2 byte/length field. The start of the frame is preamble which is of 7 bytes length. It contains sets of 0□s and 1□s arranged alternately. The frame terminates with a 32-bit checksum that performs CRC checking to identify if any error is present. All the stations see the frames regardless of whether they represent an intended destination. If so, frame is passed to higher protocol for processing.

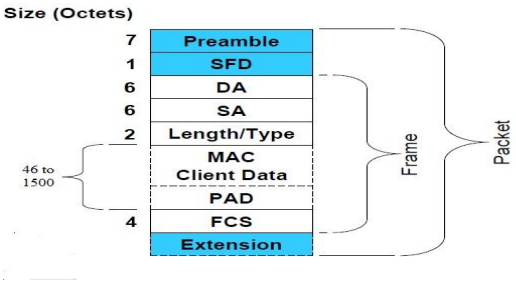

Fig. 6 IEEE 802.3 Frame Format

SFD=start frame delimiter , DA=destination add.
FCS=Frame check sequence SA= Source add.

VI. TCP/IP PROTOCOL

The software running on the embedded web server follows the same layered structure as used in the TCP/IP protocol suite. The TCP/IP protocol suite allows computers of all sizes, running different operating systems, to communicate with each other. The TCP/IP protocol suite is a combination of different protocols at various layers as shown in Fig. 7

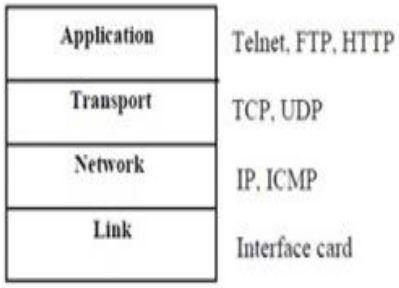

Fig. 7 Layers of TCP/IP protocol suit

Every layer acts independently from each other. The Link Layer normally includes the device driver in the operating system and the corresponding network interface (card) in the computer. An Ethernet controller driver controls the Ethernet interface. The network layer controls the communication between hosts on the Ethernet. The Address Resolution Protocol (ARP) at network layer translates IP addresses to Ethernet MAC addresses. Internet Protocol (IP) delivers packets to Transmission Control Protocol (TCP), UDP, and Internet Control Message Protocol (ICMP), the ICMP answers to

PING requests. TCP/UDP delivers data to the applications. HTTP runs on the top of TCP/IP protocol. It is set of the rules for transferring files like text, image, sound and other multimedia file on the World Wide Web. When Web. The applications can communicate with the transport layer through buffers with data and variables with control information. As soon as a Web user opens their Web browser, the user is indirectly making use of HTTP. When you are set up with direct access to the Internet, your computer is provided with a copy of the TCP/IP program.

VII. SPI COMMUNICATION

Serial to Peripheral Interface (SPI) is a hardware/firmware communications protocol developed by Motorola. sometimes SPI is also called a "four wire" serial bus. It is developed primarily for the communication between host processor and peripherals at high speed. The SPI bus, which operates at full duplex is a synchronous type data link setup with a Master / Slave interface and can support up to 1 mega baud or 10Mbps of speed. Both single-master and multi-master protocols are possible in SPI. Due to this high-speed aspect, the bus lines cannot be too long, because their reactance increases too much, and the Bus becomes unusable.

An SPI protocol specifies 4 signal wires. 1.) Master Out Slave In (MOSI) - MOSI signal is generated by Master, recipient is the Slave. 2.) Master In Slave Out (MISO) - Slaves generate MISO signals and recipient is the Master. 3) Serial Clock (SCLK or SCK) - SCLK signal is generated by the Master to synchronize data transfers between the master and the slave. 4) Slave Select (SS) from master to Chip Select (CS) of slave - SS signal is generated by master to select individual slave/peripheral devices. The SS/CS is an active low signal. Among these four logic signals, two of them MOSI & MISO can be grouped as data lines and other two SS & SCLK as control lines.

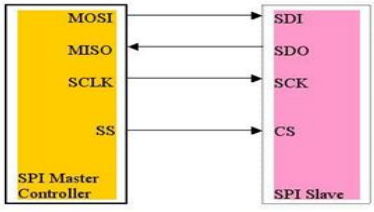

Fig. 8 SPI implementation

During each SPI clock cycle, a full duplex data transmission occurs:1) the master sends a bit on the MOSI line; the slave reads it from that same line 2) the slave sends a bit on the MISO line; the master reads it from that same line. In our system, to enable serial communication, arm kit is connected to PC via COM1 port at baud rate of 2400 using RS232 serial communication standard. So values of sensors are transferred to PC.

VIII. SOFTWARE LEVEL COMPILATION

The firmware development for the system operation is done in Embedded C language in KEIL software we have to create code for four modules. First is adc module that code can convert sensor data into digital data. Second is uart module in which data can be transferred to pc via serial protocol. Third is LCD module, which shows values. Three module compilation is done in KEIL software as shown in Fig. 10. Fourth module is to transfer data into website. Fourth module compilation is done in visual studio software. It is also used to design website as shown in Fig.12. These modules coding is dumped into ARM development kit by using Keil Ulink USB-JTAG Debugger. The Keil ULINK family of adapters connect the USB port of the PC to the JTAG port of your target board allowing to download and debug embedded programs running on target hardware. There are many different technologies to achieve dynamic Web page, commonly used with CGI, ASP, PHP, and JSP and so on. The ASP improves the speed of communication between devices and web server. ASP provides an access to execute external program for Web server, this server technology can be made to interact between the browser and server. ASP programs can be written by any programming language for example VB, VC, or C. Here VB is used to create dynamic webpage. Dynamic Webpage is shown in Fig 12.

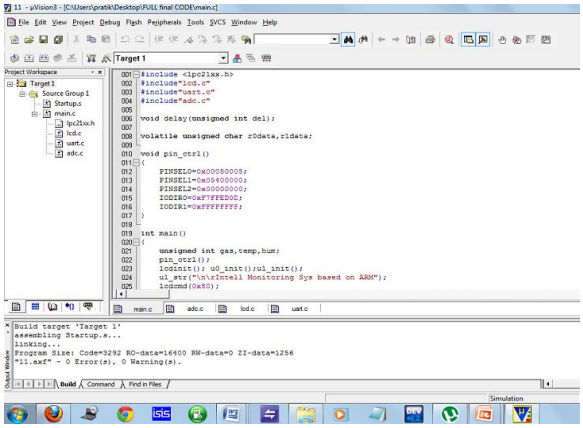

Fig. 10 Code compilation in keil software

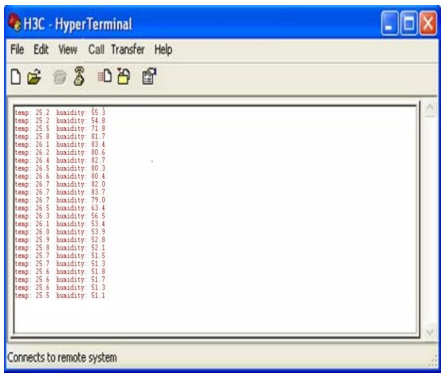

Fig. 11 Hyper terminal in PC

HyperTerminal is terminal emulator capable of connecting to systems through TCP/IP Networks, Dial-Up Modems, and COM ports. First install Hyper terminal software, then Go to Start-> Programs-> Accessories-> Communications-> HyperTerminal HyperTerminal Window will open. If we connect hardware with the com port of PC, temperature, gas, and humidity values are continuously transferred to this window as shown per Fig.11 through serial communication SPI protocol. This needs serial data transfer program which is dumped in hardware.

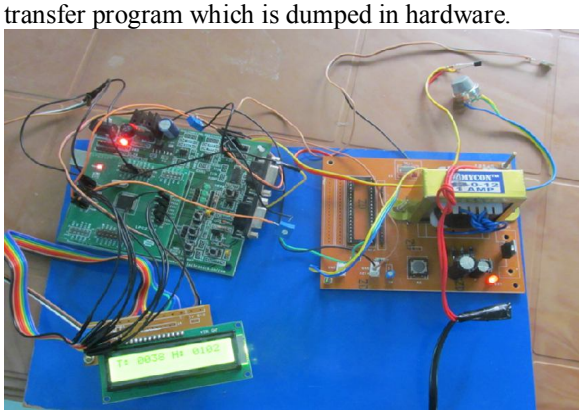

Fig 12 Hardware Part

Fig. 12 shows interfacing of ARM processor, sensors and LCD. Here 3 sensor are interfaced with ARM processor. LCD shows output. If we connect this hardware with Com port of PC through RS232 interface, These values will be transferred to HyperTerminal on PC as shown in Fig 11. If we connect ethernet interface with this hardware, Values will be transferred on website. Fig 13 shows output on website.

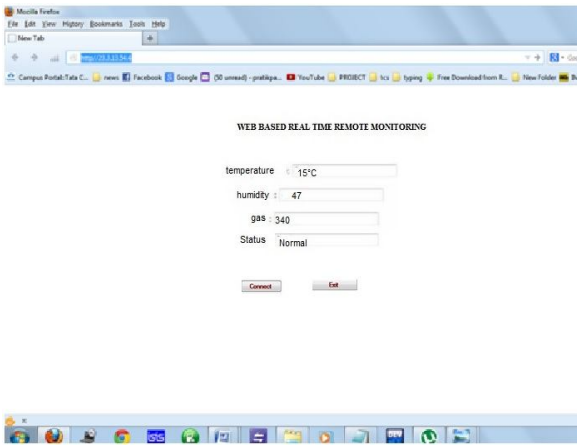

Fig. 13 Values are transferred on Website

CONCLUSION

Implementation of web server using ARM for intelligent monitoring is a new method to monitor a environment which designed here for the prototype. By using 32-bit ARM Microcontroller, the embedded system becomes highly precise and gives better performance over traditional 8/16-bit Microcontrollers. The system can also communicate with PC through RS-232 Serial Port. It supports online-supervision and control not only within Private Network (LAN) but also in Public Network (Internet). The whole system has low-cost, good openness and portability, and is easy to maintain and upgrade. It is possible to interface different kind of sensors with these modules and make various applications. So it can monitor embedded system operation state through Internet, achieving network monitoring purposes. Hence for our future we make the system for industrial, domestic environment monitoring, for Ocean environment monitoring, Educational Institution, electric power, petroleum etc.

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