CHAPTER 6

WEB SERVER BASED DAQ SYSTEM AND CONTROL

6.1 INTRODUCTION

Web-based user interfaces are state of the art of network based embedded systems. It makes configuration, control and monitoring of a device from every PC, smart phone or tablet device running a Web browser possible. The Web server offer services through the Web that brings availability and accessibility of services on the internet backbone. A Web server is composed an OS that leads the Web pages or the application and even the memory of a special hardware. Currently the hardware DAQ system has quasi Real-time data transferring capability (Li et al 2010). The Embedded Web Server is a practical approach of the implementation of TCP/IP protocols on a microcontroller. By implementing the TCP/IP stack on a microcontroller the user can control and monitor device status through a Web page (Robson et al 2006).

The function of a Web server is to serve Web pages, authentication and accessing of Web pages. The actual Web page is loaded into a standard Web browser. The system should be always connected over Ethernet/LAN. The Web page is accessed by giving the IP address provided to the Embedded Web server. It has certain requirements which include low resource usage, high reliability, security and portability which differ from general Web server technologies. It also has some design issues in case of HTTP and embedded API (Chi Chung Ko et al 2001). The proposed work provides DAQ and
control through the Web server with high secure substantiation system. DAQ has been made through a designed hardware support of ARM7 and necessary interfacing.

6.2 RELATED BACKGROUND

The term Web server can refer to either the hardware or the software that helps to deliver Web content accessed through the Internet. A Web server can be either implemented into the OS kernel or in user space. Usually it works faster because as part of the system it can directly use all the hardware resources it needs such as non paged memory, CPU time-slices and network adapters or buffers (Sandeep & Malyadri 2012).

Web servers that run in user mode have to ask the system for permission to use more memory or CPU resources. Not only do these requests to the kernel which takes time but they are not always satisfied because the system reserves resources for its own usage and has the responsibility to share hardware resources with all the other running applications. Also applications cannot access the system’s internal buffers which cause useless buffer copies that create another handicap for user mode Web servers. As a consequence the only way for a user mode Web server to match kernel mode performance is to raise the quality of its code to much higher standards similar to the code used in Web servers run in the kernel (Mo Guan & Minghai Gu 2010).

The Apache HTTP Server commonly referred to as Apache is a Web server software program prominent for playing a key role in the initial growth of the World Wide Web. In 2009 it became the first Web server software to improve on the 100 million Website milestones (Mo Guan & Minghai Gu 2010). Apache was the first viable alternative to the Netscape Communications Corporation Web server. Typically Apache is run on a Unix-like OS and was developed for use on Linux.
Apache is developed and maintained by an open community of developers under the support of the Apache Software Foundation. The application is available for a wide variety of systems including UNIX, FreeBSD, Linux, Solaris, Novell NetWare, OS X, Microsoft Windows, OS/2, TPF and eCom Station. Apache is open source software and it was originally based on NCSA HTTP code. The NCSA code has since been removed from Apache due to a rewrite. Since April 1996 Apache has been the most popular HTTP server software in use. As of December 2012 Apache was estimated to serve 63.7% of all active Web sites and 58.49% of the top servers across all domains (Robson et al 2006).

6.3 EMBEDDED WEB SERVER USING LABVIEW

LabVIEW is a programming environment in which creates programs using a graphical note by the way it alters from habitual programming languages similar to Java, C or C++, wherein the program through text. Laboratory experiments play a vital role in engineering and science education. Computerization has changed the structure of these laboratories there is an ease of use of various interfacing tools to access laboratory setup remotely through the computer connected surroundings (Benetazzo et al 2000). These accessing can be made possible through internet. A Web server is a vital entity which can be connected using online services. Both static and dynamic images of a front panel VI can be viewed remotely. The Web server allows the user to view the front panel of an application as well as provided an ability to control the VI. It can be controlled by giving the command remotely using a browser for the specified application (Chandra & Venugopal 2012).
6.3.1 Hardware Implementation

The hardware design of the proposed DAQ system comprises LPC2129 target board which is based on ARM7 core (Yujun Bao & Xiaoyan Jiang 2010). This board is implemented using LPC2129 as a CPU and ARM7 as a core.

6.3.2 Hardware Implementation and Interfacing Using LPC2129 Microcontroller

DAQ was made through a designed hardware support of ARM7 and necessary interfacing. System generated arbitrary password will be sent through a GSM modem connected with server. The principle behind the ARM architecture is based on RISC standards. The RISC instruction sets and interrupt mechanisms are easier than CISC. This results, increase in instruction throughput and stimulating Real-time interrupt response from a tiny and cost-efficient processor core. With pipeline techniques, all elements of the processing and memory systems can function constantly and fast manner (Shaik 2011). The LPC2129 incorporates a 128kB and a 256kB flash memory system respectively. Flash memory can be used for programming and carry out in several ways. It may be programmed in system by means of the serial port. Whereas the application is running, the application program may also erase and/or reprogram the flash memory, allowing an immense level of flexibility in data storage field.

With their packed in 64 pin pack, utilizes less power, different timers, 4 channels of 10 bit ADC, 2 numbers of advanced CAN channels, PWM channels and 46 GPIO lines with multiplexed interrupt pins, these microcontrollers are most widely used for industrial automotive and control applications as well as medical applications.
In the proposed system the control unit module is being used to control input voltage and load. It consists of interface circuit to drive relay unit for driving motor and load. A low voltage DC motor is used to drive or change the input voltage. Input or control signal for DC motor will be driven from ARM processor. Interface module contains a switching circuit to control relay unit. The polarity of the DC supply governs the direction of rotation of the motor which tends to elevate or reduce the input voltage. The motors are powered by the DC supply of ±12V which make easy the control of input voltage to the DC machines. Figure 6.1 explicit the hardware design of the proposed DAQ system.

![Figure 6.1 Hardware design of the proposed DAQ system](image)

A pair of digital outputs is required for the control of the input voltage to any one of the motor windings. Another sole characteristic provided in this test method is the facility to control the load remotely. The voltage measurement and current measurement are made through corresponding sensors. The analog values of these sensors will be converted as a digital data using inbuilt ADC of LPC2129. Various analog channels are
used namely channel 0, channel 1 and channel 2 for various data measurement. The speed will be calculated by using a proximity sensor. The input pulse of proximity sensor will be captured for a particular period of time. From the measured value the DC motor speed will be calculated. These input signals are further processed using LabVIEW functions to read the real value of the experiment. Figure 6.2 illustrates a flowchart representation of DAQ system.

![Flowchart representation of data acquisition system](image)

**Figure 6.2** Flowchart representation of data acquisition system

The measured data are sent to the server through RS232. RS232 is a protocol for serial data communication and control signals. Widely a CPU serial port uses this. The protocol provides the timing of signals and unique electrical sequences, the importance of signals and the considerable size. Figure 6.3 shows the complete hardware module and interface circuits of the overall system.
Figure 6.3 Complete hardware modules with GSM modem and interface circuit module

The overall hardware assembly of the proposed DAQ system is represented in Figure 6.4.

Figure 6.4 Overall hardware assembly of the proposed DAQ system
6.3.3 Web server Development

The main aim of the proposed work is to measure current, voltage and the speed of the DC motor for laboratory experiment applications. DC motors are commonly used to operate machinery in a variety of applications. Experiments using DC motors are very common and important in engineering studies. Remote access of these DC motors requires a safe design module and interfacing circuits. A Web server is a vital entity which can be connected using online services. Both static and dynamic images of a front panel VI can be viewed remotely. The Web server allows the user to view the front panel of an application as well as provided an ability to control the VI. This can be controlled by giving the command remotely using a browser based on the specific requirements.

6.3.4 Software Implementation

The user can monitor and control the system using a LabVIEW application or front panel remotely using a browser. The flowchart gives various operations of the LabVIEW Web server. After the deployment of Web server on LabVIEW the module will be published on the internet. In order to publish the internet server requires a Web publishing tool. The front end design of the LabVIEW Web server contains authentication system. The user must provide a Username and Password for accessing the Web page. Those Username and Password will be verified with a database which is configured in the Web server. As it matches the server generates a random password for a particular user and corresponding generated password will be sent to user through GSM module. Received random Password to be entered and the Web server will be again verified and further process will be obtained. Figure 6.5 illustrates a flowchart for authentication mechanism by using one time random Password.
LabVIEW provides a random number generation module which creates a binary exactness, floating point number between 0 and 1. The number engendered is larger than or equivalent to 0 but less than 1 and the allocation is homogeneous. In the proposed work, random number generation module will be multiplied by 1000 to get three digit temporary passwords. Figure 6.6 shows the random number generator.
GSM modem will be connected through serial communication. Since this system needs two COM ports for serial communication some server may in need of serial to USB port converter. The measured data are obtained through serial port communication. In order to collect data via serial communication the LabVIEW uses VISA Toolkit. Previous to collecting data the user must state or select the input. With this the user can observe the data by means of current, voltage, speed of a DC motor and load status to select the corresponding input, particular data will be sent through serial communication.

Once the data are acquired through graphical code those will be represented in different forms by making use of meters and waveform charts. At each execution of code an output will be represented through these modules. The array element is used to mention periodic values. Data are measured continuously for a time interval period of 500ms. A While loop is responsible for obtaining the data continuously. This process is repeated until the sign out Boolean function is received.

### 6.4 EXPERIMENTAL RESULTS

This application creates a virtual DAQ through low power high end processor. As a result any laboratory can be experimented virtually through an online server. Remote laboratories across the countries can also be experimented or their data can be shared virtually through remote servers. Low power processor ARM7 LPC2129 has been used so the power consumption will be less. Figure 6.7 represents the client side Web page access on the browser.
Figure 6.7 Web page displaying with control parameter and authentication system

Figure 6.8 shows the SMS format of the randomly generated password.

Figure 6.8 Random number password SMS format
Current status of the system is displayed in the module as in Figure 6.9. With this the user can get the information about the status of the load.

![Display unit of current status](image)

**Figure 6.9 Display unit of current status**

This application creates a virtual data acquisition through low power high end processor. As a result, any laboratory can be experimented virtually through an online server. Remote laboratories across the countries can also be experimented or their data can be shared virtually through remote servers.

### 6.5 WEB SERVER USING WINDOWS COMPACT EDITION (WinCE)

This is another approach of DAQ system using Web server. Here, ARM9 embedded Web server using WinCE simulation tools is proposed (Mason 2002). An embedded Web server is here to provide a remote access to the device from a Web browser, a Web server has to be embedded in a device. It can be utilized to serve the embedded Web documents which include Static
and Dynamic information about the embedded systems. The user can create a Windows Embedded CE powered device that functions as a Web server and enables clients to retrieve Web based files and also makes use of the Internet for communication between client devices, network printers, scanners and other shared equipment. Setting up a Web server requires special security considerations. The Windows CE based Web server implementation enables us to monitor, configure and remotely control a device or computer through the use of a Hypertext Transfer Protocol (HTTP) server (Robson et al 2006).

### 6.5.1 Hardware Implementation

The hardware design and development of online Interactive Data Acquisition and Control System (IDACS) using an ARM based embedded Web server are also implemented. As a result this provides a need for Web services being deployed on various embedded processors such as Advanced RISC Machine (ARM). Single chip IDACS improves processing capabilities and rectifies the problem of poor reliability in Real-time context (Alkar & Karaca 2009). This system uses ARM9 Processor which is a Real-time processor that handles various processes based on multitasking and reliable scheduling mechanisms. The Web server application is ported into an ARM processor using VB, Web pages are written in Visual Studio it is beneficial for Real-time IDACS, Mission critical applications, ATM networks and Power plants.

IDACS design begins with the measurement of physical properties such as temperature, pressure and force. Irrespective of the type of physical properties to be measured the first step is to transform those properties to be measured into a unified form that can be sampled by the DAQ system. This task can be performed by the device called sensors. These sensors measure the differing properties suited to detect its associated properties. The DAQ systems have various signal conditioning mechanisms that adequately modify
the electrical signals into its equivalent voltage signals which can be digitized using an ADC. A sensor which is a type of transducer that converts a physical property into a corresponding electrical signal (e.g., a voltage or current) or in many cases into corresponding electrical characteristics (e.g., resistance or capacitance) which is easily be converted into an equivalent electrical signal.

To develop an embedded Web server the following components are used,

- Mini2440 ARM9 Processor
- 10KΩ Thermistor
- MPX2010 Pressure sensor
- Voltage and Current transformer.

**Mini2440:** The friendly ARM Mini2440 is a single board computer based on Samsung S3C2440 ARM9 microprocessor. The board measures 10cmX10cm ideal for learning about ARM systems are integrated into the numerous products. The Samsung S3C2440 supports two start-up modes: one is from NAND flash start-up and other from NOR flash start-up. The chip select memory space allocation is differed for different start-up modes.

**Startup Mode Selection:** To choose the development board startup mode S2 DIP switch governs the target board tips to choose the development board startup mode.

- Switch S2 “NOR” side logo, the system will start with NOR flash.
- Switch S2 “NAND” side logo, the system will start with NAND flash.
The NOR flash and NAND flash of the development board has been burned into the same bios from the S2 has been receiving side of NAND flash the system boot from start up operation of NAND the flash system.

**A/D Output:** In Mini2440 totally there is a 4 ADC channel that can be led out, which are located on the CON4 GPIO. The ADC chip should be synchronized with the processor’s clock while communicating with ARM processor.

**Thermistor:** A thermistor is a type of negative temperature co-efficient resistor whose resistance decreases with increasing temperature. Its application areas are used as current limiters, temperature sensors, self-resetting, over current protectors and self-regulating heating elements. It differs from various temperature detectors in the form of materials used and its range of temperature sensing. In particular thermistor typically achieves a higher precision within a limited temperature range typically $-90^\circ C$ to $130^\circ C$. Figure 6.10 represents the Block diagram of proposed WinCE based embedded system.

![Figure 6.10 Block diagram of an embedded system](image)
**MPX2010-Pressure Sensor:** The MPX2010 family of pressure sensors appeals to measure small gauge, vacuum or applications presents design in challenges for these sensors. For very low pressure sensing, large amplification is required. Two pairs of Operational Amplifiers (Op-Amp) were packed in single 14 pin quad package. The first gain stage is accomplished by feeding both pressure sensor outputs (Vs- & Vs+) into the non-inverting inputs of the Op-Amps.

**Voltage and Current Transformer:** Voltage and current transformers are also called as instrument transformers. These transformers are necessary to protect the devices in the circuit from the heavy current flow. It is also necessary for isolating, protecting, control and measuring equipments from the high voltage and current of a power system and for supplying the equipment with the appropriate values of current and voltage.

### 6.5.2 Software Implementation of the System

The software system designed for the distributed I/O WinCE based embedded Web server DAQ system is open source software which includes the functions such as task management, system management, timer management, information management and queue management (Lili Liu et al 2011). The above mentioned management functions can be serviced as though GUI core functions.

#### 6.5.2.1 Embedded web server process structure

The architecture diagram of an overall system design is shown in Figure 6.11 which illustrates the way to communicate between a Web server layer and the other layers. It uses different communication methods and protocols that are connected with the embedded Web server by bus structure. It adopts master and the slave access mode during communication between
them. The embedded Web server is master machine as well as local equipments are slave machines. Each of equipment has its unique address. Its status flag is set as WAIT once reset. The communication process described here uses an embedded Web server which transmits the access address via serial protocol. Each of the equipment receives the access address and establishes the connection with embedded Web server. In the communication process the equipment’s status is set as UNWAIT. The status will be reset as WAIT since the communication process gets over.

The Monitoring Server Module exchanges the information with SQL which associates into traditional Web through TCP/IP protocol (Robson et al 2006). In order to simultaneously support the two data dynamic interactive mechanism the Monitoring Server Module respectively listens to control and monitoring requests via controlling port and monitoring port at the same time.
Receiving the control request on controlling port Monitoring Server Module may create a new thread to response. Consequently the new thread analyzes request string to get an equipment number and command and then invokes Equipment Controlling Module to execute. Receiving monitoring request on monitoring port Monitoring Server Module may establish the special socket for communication and store it into correlative queue according to status type. After that Monitoring Server Module is always in wait status until receiving a new status arriving message from the Status Acquisition Module. Once receiving the message Monitoring Server Module traverse the corresponding queue according to status type and sends information to the relevant client.

The Embedded Web server processes an HTTP request in discrete steps as though it is a Finite State Machine (FSM). Figure 6.12 shows the embedded Web server process structure. To enhance multiple connections in a single threaded environment multiple FSM uses a lightweight task structure that is run by a scheduling system. The above task structure consists of the following heuristics,

- A pointer which holds the function being run by the system.
- A variable holds the state of the function
- A flag that indicates the states being run or blocked by the Finite State Machine (FSM).

The scheduling system allocates an available FSM for an accepted connection and checks each FSM to see if it is blocked or runnable and to move the FSM.
6.5.3 Experimental Setup

The experimental setup of the embedded Web server which consists of the target board Mini2440 is connected to the sensor inputs via A/D Converter. The server PC connected with ARM Mini2440 which updates the sensor information and stores in a buffer. The sensor information includes temperature, pressure values, load voltage and load current. A small load of 100W bulb is connected with the experimental setup. Figure 6.13 shows the experimental setup of ARM embedded Web server based on IDACS system. WinCE 6.0 embedded OS is ported with ARM9 processor for Web server applications. The code is loaded on the target and the target is configured over the network to work as embedded Web server.
6.6 EXPERIMENTAL RESULTS

The server sends a response by providing user login information when a client enters the correct user ID and Password. The server provides the sensor information’s and can monitor from anywhere using TCP/IP Protocol. The output of four channels input signal and the status is shown in the Figure 6.14.

From this figure user can get the status information about the temperature, pressure, current and voltage through the sensors and the control information from client to server.
6.6.1 Testing of the Embedded Web server

Initially, the target system is tested for the working on an operating system that can be done by booting the target system using a hyper terminal. Henceforth the embedded Web server responds to the clients request by typing the IP address of the server in the client’s browser. Then the controller sends the request to the router which 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 controller of the server and a session is established, using a TCP/IP connection and the server starts sending the Web pages to the client (Nakul Padhye 2012).

6.7 PARAMETRIC COMPARISON OF DIFFERENT EMBEDDED PROCESSORS

In Table 6.1 the implementation of Web server application in two different processor and parameter comparison is presented.

Table 6.1 Parametric comparison of different processors implemented on the Web server application

<table>
<thead>
<tr>
<th>Parameters/ Embedded Processors</th>
<th>AT89C51 (HongLi Zhu &amp; Liyuan Bai 2009)</th>
<th>LPC2148 (Shaik 2011)</th>
<th>MINI2440</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Bits</td>
<td>8</td>
<td>16/32</td>
<td>16/32</td>
</tr>
<tr>
<td>No. of Sensors</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Protocol</td>
<td>ZigBee</td>
<td>TCP/IP</td>
<td>TCP/IP</td>
</tr>
<tr>
<td>Sampling Rates (KSPS)</td>
<td>10 KSPS</td>
<td>400 KSPS</td>
<td>500 KSPS</td>
</tr>
<tr>
<td>Throughput Rate</td>
<td>4 KBPS-16 KBPS</td>
<td>400 Kbps</td>
<td>1.9 MbPS</td>
</tr>
<tr>
<td>Operating Frequency (MHz)</td>
<td>Upto 11.0592 MHz</td>
<td>10 MHz to 30 MHz</td>
<td>Upto 200 MHz</td>
</tr>
<tr>
<td>Operating Temperature (°C)</td>
<td>-55°C to +125°C</td>
<td>-40°C to +85°C</td>
<td>0°C to 70°C</td>
</tr>
<tr>
<td>Maximum Operating Voltage (V)</td>
<td>6.6 V</td>
<td>3.6 V</td>
<td>5 V</td>
</tr>
</tbody>
</table>
From Table 6.1, it is observed that compared to AT89C51 and LPC2148, Mini2440 has better additional features with respect to a number of sensors, number of bits, sampling rate, and throughput. It consumes less power compared to AT89C51 and LPC2148 processors.

6.8 SUMMARY

This chapter summarizes the two different proposed techniques. It introduces the embedded Web server implemented with the following two simulation tools and processor cores,

- ARM7 Embedded Web server using Lab VIEW
- ARM9 Embedded Web server using WinCE

Both implementations are application oriented which is used for e-learning using LabVIEW with authentication for security purpose and industrial automation system is done using ARM processor which provide the single board solution.

The proposed architecture methodology reveals that the embedded remote monitoring system based on the Internet because the system adopts embedded Web server as a central monitoring node the system is provided with not only excellent cost performance but also running steadily and reliably. An embedded device with a standard Web browser can be accessed, controlled and managed by the remote users over the traditional internet. Moreover utilization of dynamic monitoring Web based on SQL server improves the response capability and brings convenience for complex monitoring Web design. The system has achieved the design of data collector successfully by debugging of the hardware and software.
Remote laboratories across the countries can also be experimented or their data can be shared virtually through remote servers. Since low power processor ARM7-LPC2129 is being used, power consumption will be reduced. NI has provided its very own module for DAQ since each module cost high; instead a specific design has been implemented with low cost and high end processing. The application hardware which is proposed is in DC machine experimentation in engineering studies even this can be modified for other laboratories such as Digital Circuits, Electronic Circuits and DSP Simulation respectively. This application is designed with high secured access to the Web server through a random password generator which ensures the user secured access to laboratory in case any scientific experiment data sharing made between countries top scientist.