Data Acquisition and Control System for Real Time Applications

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Abstract—This paper proposes an Embedded Ethernet which is nothing but a processor that is capable to communicate with the network. This helps in data acquisition and status monitoring with the help of standard LAN. Currently device with processor is widely used in industrial field. The Embedded Ethernet provides web access to distributed measurement/control systems and provides optimization for instrumentation, educational laboratories and home automation. However, a large number of devices don't have the network interface and the data from them cannot be transmitted in network. A design of ARM Processor based Embedded Ethernet interface is presented. In this design, data can be transmitted transparently through Ethernet interface unit to remote end desktop computer. By typing the IP address of LAN on the ARM9 board, the user gets sensor values on the PC screen at remote station. This provides the status of the devices at remote field. The user can also control the devices interfaced to the ARM9 Board by pressing the button displayed on the GUI of the remote Desktop PC.

Key words: ARM9 Processor, Embedded Ethernet, Linux, TCP/IP.

I. INTRODUCTION

Due to development in communication and network technology, the industrial control need can be completed via network is a trend now. The main purpose of the design is to make traditional monitoring systems that have the capabilities of remote monitoring or data transmission by introducing Ethernet interface in it. So an ARM processor based Embedded Ethernet interface system is designed. In the system the data can be transmitted transparently between host and serial device and the host can communicate with any serial device connected with Ethernet without knowing each other’s physical location. When the serial device needs to establish communication with a new host, what you can do is just to connect the host to Ethernet. A web server can be embedded into any appliance and connected to the Internet so the appliance can be monitored and controlled from remote places through the browser in a desktop. Temperature, Pressure, displacement, motion and sound are the most often measured environmental quantities. Among these environmental quantities, temperature is the most often measured parameter in industries. For example, some processes work only within a narrow range of temperatures; certain chemical reactions, biological processes, and even electronic circuits perform best within limited temperature ranges. So, it is necessary to measure the temperature and control if it exceeds some certain limit to avoid any misbehavior of the systems.

II. SYSTEM DESIGN

In this, all the design aspects including the block diagram, functional description of the system are discussed in detail.

A. System Architecture

Following Fig. 1Shows the proposed system of Data Acquisition and Control Systems (DACS) with Embedded Web Server. The ARM processor manages all the tasks such as measuring analog signals, conversion of signals, database updating and connecting/communicating with new users etc. In this architecture the client PC is connected to the Internet through a browser and gets access to the embedded Web server. Using this way remote login and controlling is possible. But for demonstration purpose and for prototype design; the system is designed which is limited over the LAN only. That means ARM9 Board with sensors and relays can be accessed over the LAN only.

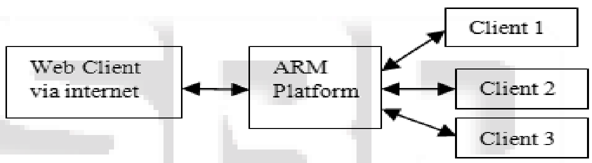

Fig. 1: Embedded Web Server Architecture

B. Hardware Design of the System

ARM core is the center core of this system. The general hardware structure of the IDACS is shown in Fig.1.The online intelligent data acquisition and control system based on embedded ARM platform has high universality, acquisition and control device is equipped with acquisition/control channels and isolated from each other. Each I/O channel can select a variety of electrical and non-electrical signals like current, voltage, resistance etc.

Samsung Company brings out a 32bit RISC microcontroller called S3C2440X, which is designed for hand-held devices and general applications; it is cost-effective, low-power, and high-performance microcontroller. To reduce total system cost, the S3C 2440X includes the following components i.e. MMU to handle virtual memory management, LCD Controller (STN & TFT), NAND Flash Boot Loader, System Manager (chip select logic and SDRAM Controller), 3-ch UART, I/O Ports, RTC, and Touch Screen Interface, the main frequency of S3C2440 up to 400MHz etc. S3C2440X reduces the whole cost of the system and enhances integration and dependability of the system. The S3C2440 CPU chip has two types of boot modes: booting from the NAND flash and booting from the NOR flash. Steppingstone buffer is present in SDRAM to support boot loader in the NAND Flash. When the system is started, the first 4Kbyte content in NAND Flash is loaded to the

Steppingstone buffer and gets executed. During Start up, the contents of the NAND Flash are copied to the SDRAM. Main program then executes from the SDRAM.

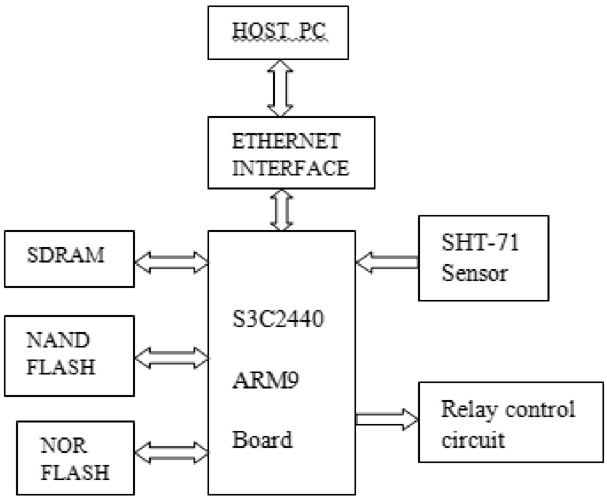

Fig. 2: General Structure of the Remote DACS

C. Software Design of the System

It includes the following steps:

1) Transplant U-Boot

At first, cross-compiling environment is built, which is a code generated from one platform and used in another platform. For this system, it is generated in PC and can run on the development board. Arm-linux-4.4.3 is used as the cross compilation tool-chain. Transplanted U-boot will be done after installing the cross compilation tool-chain and configuring the development environment. U-Boot is at the boot loader stage. Boot loader is the first software code after system powers up. It initializes the hardware equipment and builds up the map of memory space. Then the hardware and software environment of the system may be suitable for the OS Kernel boot. This system adopts u-boot-1.1.6. Download and decompress source code. Modify source code in order to support MINI 2440 development board, and add the boot function of NAND Flash. Compiling u-boot-1.1.6 generates a binary file u-boot.bin. Download it to MINI 2440 development board through Jtag interface.

2) Transplant Linux kernel

OS kernel is the center of the operating system. A complete operating system includes more tools, libraries, application programs and kernel source. Linux kernel source can be downloaded from Internet free of charge. This system uses Linux-2.6.32 kernel source. Firstly, customize Linux kernel source and modify the source code. Add processor support, Nand flash chip support and Yaffs file system support. Dispose the program module in order to support the hardware module of MINI 2440 development board. Then, cross-compile the kernel source to generate zImage. At last, download the mapping file to NAND Flash memory.

3) Load file system

By building, canceling, reading and writing, modifying and copying files, file system can access files by name and make access control. After Linux system startup, root file system must be mounted firstly. If not mounted from designated equipment, the system will be treated as making mistakes and quit startup. This system adopts Yaffs file system. As a kind of JFS designed for NAND flash memory in embedded system, Yaffs has the characteristics of high efficiency, short mount time and small memory requirement.

4) Application program

This system adopts Qtopia as the platform for application program. As a general application platform designed by Troltech and used in those consumer electronics with embedded Linux operating system, Qtopia contains complete application layer, flexible user interface, window operating system, and application program startup and development framework. Qtopia-2.2.0 is adopted, which is the most advanced edition in PDA Qtopia. Qtopia-2.2.0 possesses PDA function. Besides this system has the function of wireless communication, including making calls, short message management, telephone directory management and network data deliver. GUI graphical interface is designed by QT Creator. QT Creator, a kind of design tool with visualized user interface, can improve the development speed of QT application program. Three interfaces are designed in the wireless communication module, containing calling, short message management and network data deliver. Following lines of the code are used to send the SMS if temperature goes beyond the set value that is 60^0C.

```
/* write the basic AT */
ret = write(CommFd, "AT\r", 3);
/* Enter in Text Mode */
ret = write(CommFd, "AT+CMGF=1\r", 10);
/* Read the Number */
str  = LineEdit3->text();
/* Read the sms */
str2 = "ALERT!!! Temperature Overshoot!!!!";
sprintf(buf2,"AT+CMGS=\"%s\";\r\n%s",str.data(),str2.data
());        buf2[strlen(buf2)+1] = '\0';
            buf2[strlen(buf2)] =(char)0x1A;
/* send the message */
ret = write(CommFd, buf2, strlen(buf2)+1);
```

This is the small function that is written in main program for sending SMS through SIM 900 GSM Modem. In program we have used following lines of code to declare the Ethernet port number at the server side.

```
int portno = 8889, fd, fd1;   // Declaration of port number.
server_address.sin_port = htons(portno);  //server port no.
server_len = sizeof(server_address); //length of the server address.
```

III. TEMPERATURE,HUMIDITY MEASUREMENT AND ITS CONTROL

SHT-71 Sensor is used to measure the temperature and humidity simultaneously. SHT7x (including SHT71 and SHT75) is Sensirion’s family of relative humidity and temperature sensors with pins. The sensors integrate sensor elements plus signal processing in compact format and provide a fully calibrated digital output. A unique capacitive sensor element is used for measuring relative humidity while temperature is measured by a band-gap sensor. The interface with the SHT is similar to the Philips I2C protocol in having a unidirectional clock (SCK) and a bidirectional data lead (DATA), but the actual protocol is quite different.

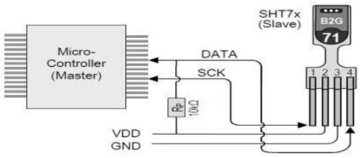

Fig. 3: Typical Application Circuit With Pull up Resistor(Rp).

To initiate each communication session, the device is reset by bringing DATA high (high impedance) and providing nine clock pulses. As with the I2C protocol, the DATA lead is bidirectional and thus the two states are open (high Z) with an external 4.7K pull up resistor providing the logic one and ground acting as a logic zero. Application program has been written at both the ends which will automatically detects the rise in temperature and sends SMS on a number provided in the GUI designed on the ARM board as well as it makes buzzer ON so that worker can immediately detects the rise in temperature at the field side. We can make ON the fan for cooling purpose connected at field side through the GUI designed at the PC side.

IV. RESULTS AND DISCUSSIONS

Following fig. 4 and 5 shows execution results of ARM Embedded web server based on DACS system.

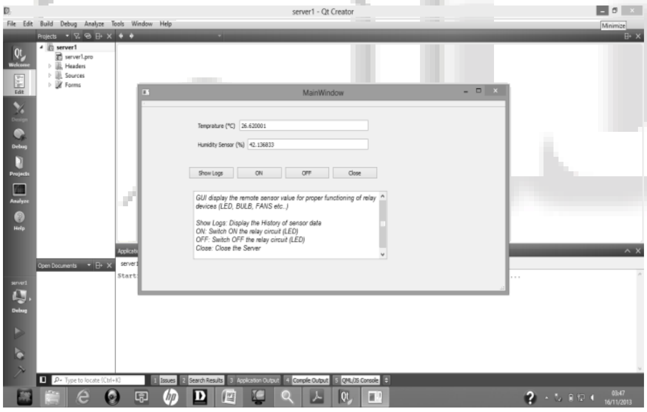

Fig. 4: Temperature And Humidity Measurement at PC Side.

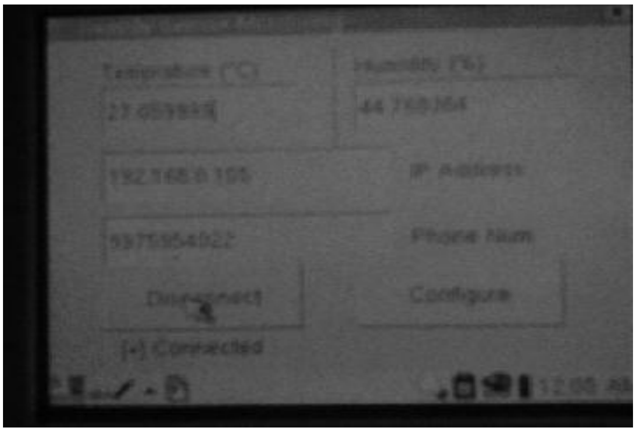

Fig. 5: Temperature And Humidity Measurement at ARM Board Side.

Fig. 6: Components Of DAC System.

V. CONCLUSION

In this application, a low-cost, Network based data acquisition and control system has been designed and implemented. Compared with other applications, this system has advantages in terms of allowing direct bidirectional communication and reducing overhead, which can be vitally important for some real-time applications. Thus the system provides higher demand of data accuracy and reliability of the control system. The embedded system implements the application as a center processing task, which can adapt the strict demands of application system well to the function, reliability, cost, size and power consumption etc.

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