Design of ARM Based Interactive Data Acquisition and Control System for Embedded System

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Abstract— The system of Internet Protocol Suite (TCP/IP) used by Interconnected Computer Network to allows the user to interface real time embedded applications like data acquisition, Industrial automations. The design and development of on-line Interactive Data Acquisition and Control System (IDACS) using ARM based embedded web server is approached in this paper. It can be distributed control system. On chip IDACS methods improves the processing capability of a system and improve the problem of poor real time and reliability. ARM7 Processor portability with Real Time Operating system (RTOS) it makes the system more real time and handling various processes based on multi tasking and reliable scheduling mechanisms. ARM processor using embedded ‘C’ language is applicable in this paper.

Keywords— ARM-TDMI, µC/OS-II, GSM, EHTERNET, MEMORY CARD, TCP/IP

1. INTRODUCTION

In industries, systems are becoming very complex. Interactive Data Acquisition and Control system plays the major role to control in the field of measurement and control systems. It has been designed with the help of many automation instruments and high voltage equipments. This paper approaches a new system that contains inbuilt Data Acquisition and Control system (IDACS) with on-line interaction. To test the site equipments and environmental so it can track state of system in real time [4].For that microcontroller based systems can be used, to design flexible and adaptable system. This is more reliable, avoid more complication and provides high performance to the system. The ARM for ARM processor for data acquisition and digital diagnosis. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler than those of micro programmed Complex Instruction Set Computers. This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and cost-effective processor core. Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its processor is being decoded, and a third instruction is being fetched from memory. ARM based embedded system will be more functional, reliable, cost effective, less in size and low power consumption. Microcontroller has low speed and poor memory, so it can only execute simple control tasks. A single ARM board has been act as data acquisition unit, control unit, embedded web server and self diagnosis. All processes are allocated with essential resources and associated with reliable scheduling algorithms and internet protocols followed by ARM processor. This setup reduces the complexity & size of system. A small 8-bit microcontroller has the portability with RTOS. Generally all ARM7 processors have the portability with any kind of higher end RTOS. RTOS comprises of two components, namely, “Real-Time” and “Operating System”. Real-Time indicates an expectant response or reaction to an event on the instant of its evolution. Operating System (OS) is a system program that provides an interface between hardware and application programs. OS is commonly equipped with features like: Multitasking, Synchronization, Interrupt and Event Handling, Input/ Output, Inter-task Communication, Timers and Clocks and Memory Management to fulfill its primary role of managing the hardware resources to meet the demands of application programs.

Figure 1: System Overview
Real time kernel is simple and stable. RTOS can divide a complex application into several mutually independent tasks based on task priority and it also has its own limitation [3]. RTOS, include the task management, task scheduling, interrupt handling etc. Industrial application requires multiple tasks to be executed. Controlling the industrial system, processing of data, storing of the data and transmission of data with polling technique require more time so use of multi tasking is involved. When ARM processor combined with RTOS with timing constraint can be realized for the data acquisition and transmission of data. For e.g. transmission of data using Ethernet or RS-485 which requires industries standards like modbus protocol and it will have timing constraint [2] above Fig. shows the overview of IDAC system. Every client can access the industry directly without any interaction with additional server and modules. IDACS shows intelligent data Acquisition and Control System. This system contains single ARM7 processor which is portable with RTOS. ARM processor is the heart of this work. It handles two modes at same time, DAC and Web server. During DAC mode Processor can measure signals which are coming from various external sources and applications.

II. SYSTEM OVERVIEW

A. ARCHITECTURE

Industrial system require data acquisition for which ADC is required, DAC is required for embedded control and for data backup SDRAM is required which we will contain entire log details. To communicate with desktop computer industries require modbus protocol so Ethernet control is required.

The proposed embedded system uses FLASH and MMC memories for program running and data storage. FLASH memories are used to store the BIOS codes, user’s codes and the useful data. For data logging purpose RTC data is written on MMC. As far as the control and acquisition system concerned, the Analog to Digital Converter (ADC) is essential components. For data acquisition the ADCs are applied. The LCD controller can be programmed to support different requirements on the screen. The General Purpose Input/output port (GPIO) of the microprocessor LCD is connected. A serial EEPROM is allowed to burned IP address of the system. The Ethernet controller will read the IP address when the system is reset. GSM is interfaced as it provides a wireless communication. To interface to controller using UART port Thermal printer has RS232 port. ON-Chip RTC is configured so that it gives real time clock value which is very useful for data logging and data is written on MMC.

B. IDACS Design:

IDACS design is the major part in hardware. ARM7 processor is a centre core of this system. The general hardware structure of the IDACS is shown in Fig.2.2. The online intelligent data acquisition and control system based on embedded ARM platform has high universality, each acquisition and control device equipped with 24-way 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.
Digital acquisitions are done by special ADC. The measured data are stored in external memory in which the memory is act as a data base during web server mode. The ARM processor directly supports the Ethernet service and RS232 communication. Hence the data has been stored and controlled by some other PCs or network via RS232 & Ethernet. ARM processor has internal I2C module. So it has the ability to communicate with any other peripherals

C. GSM MODULE

Global System for Mobile communications (GSM) is the almost popular wireless standard for mobile phones in the world. Transmission of Short message service (SMS) in TEXT mode and PDU mode GSM module is used. SIM 300 GSM module in text mode is used for the proposed design. SIM300 GSM module that provide 900/1800/1900MHz Tri-band for VOICE, SMS, DATA, and FAX which is operates on AT command over TTL interface. AT command is short form of word for Attention command that is recognized by GSM Module. This abbreviation is always used to start a command line to be send from TE (Terminal Equipment) to TA (Terminal Adaptor).

D. RS-485 COMMUNICATION:

For binary serial communications between two or more devices RS-485 is a telecommunications standard is used. It is the protocol or specifications that need to be followed to allow devices that implement this standard to communicate with each other. This protocol is an updated version of the serial protocol known as RS-232. While the original RS-232 standard allowed for the connection of two devices through a serial link, RS-485 allows for serial connections between more than 2 devices on a networked system.

The general network topology of RS485 is shown in Fig.2.3. Here N nodes are connected in a multipoint RS485 network. For higher speeds and longer lines, the termination resistances mostly 100Ω resistors are necessary on both ends of the line to eliminate reflections. RS-485 standard specifies up to 32 drivers and 32 receivers on a single (2-wire) bus. In this IDACS system the RS485 communication is used to transfers the data between remote IDACS to Embedded controller vice versa. A RS-485 network is "automatic" repeaters and high-impedance drivers and receivers such that the number of drivers and receivers can be extended to hundreds of nodes on a network. A RS-485 network can be constructed as balanced 2 wire system as well as a 4 wire system. All of the nodes will have equal ranking, if a RS-485 network is constructed as a 2 wire system. A RS-485 network constructed as a 4 wire system, has one node is point out as the master.
and the remaining nodes are pointed out as slaves. Communication in such a system is only between master and slaves but never between two or more slaves.

E. THERMAL PRINTER:

Thermal printer is very compact and portable. It is very easy to place approach as directly it can be interfaced to RS232. 24 line and Programmable speed is up to 50 mm/sec character Per Line is allowed by APS Thermal printer mechanism. Universal ESC sequence compatible. It has provision for complete text can be printed and graphic printing. It has inbuilt feature over temperature & voltage protection and serial RS-232 interface.

F. ETHERNET MODULE:

The ENC28J60 is a Ethernet module which is Ethernet controller with an industry standard Serial Peripheral Interface (SPI). To serve as an Ethernet network interface for any controller equipped with SPI Ethernet module is designed. The ENC28J60 has all of the IEEE 802.3 specifications. It incorporates a number of packet filtering schemes to limit incoming packets. An internal DMA module for fast data throughput and hardware assisted checksum calculation, which is used in various network protocols is provided by ENC28J60. 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. With the ENC28J60, two pulse transformers and a few passive components are all that are required to connect a microcontroller to an Ethernet network. The embedded system in which field signal values are displayed on Web page or collected into control center in real-time through RJ-45 with Embedded device (equipped with SPI support) on to a network.

G. Hardware Clk Rate:

<table>
<thead>
<tr>
<th>MODULE</th>
<th>ON-CHIP PROTOCOL</th>
<th>CLK RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM</td>
<td>UART 1</td>
<td>9600BPS</td>
</tr>
<tr>
<td>THERMAL PRINTER</td>
<td>UART 0</td>
<td>9600BPS</td>
</tr>
<tr>
<td>MEMORY CARD</td>
<td>SPI 0</td>
<td>62.5KHz</td>
</tr>
<tr>
<td>ETHERNET (ENC28J60)</td>
<td>SPI 0</td>
<td>2MHz</td>
</tr>
<tr>
<td>TEMP SENSOR</td>
<td>ADC 0</td>
<td>1MHz</td>
</tr>
</tbody>
</table>
III. RTOS

RTOS (µC/OS-II) manages up to 250 application tasks (6). RTOS can be ported to ARM hardware, and then the system can deal with much more complicated tasks. Real-Time (RT) indicates an hoping response or reaction to an event on the instant of its evolution [6]. And Operating System (OS) is a system program that provides an interface between hardware and application programs.

With memory footprint is about 20KB and source code is about 5,500 lines, mostly in ANSI C, very small real-time kernel is RTOS (µC/OS-II). Depending on the processor, on an ARM (Thumb mode) µC/OS-II can be reduced to as little as 6K bytes of code space and 500 bytes of data space (excluding stacks).

IV. MERIT OF THE SYSTEM

A. Existing System:
The use of single chip Data acquisition system (DAS) method in Instrumentation and Automation control system has limited in processing capacity and also has the problem of poor real time and reliability. General web server requires more resources and large amount of memories. This system can only measure the remote signals and it cannot be used to control the process.

B. Proposed System:
By the substitution of embedded ARM processor for single chip, limited processing capacity and the problem of poor real time and reliability of DAS system has been overcome to realize interactive data acquisition and control (IDACS). Through reliable protocols and communication network, this IDACS system can able to measure the remote signals and can control the remote devices. This system uses RTOS (µC/OS-II) Multi-tasking operating system to measure and control the whole process. The embedded web server mode requires less resource usage, high reliability, security, controllability and portability.

V. IMPLEMENTATION

The heart of the system is a real-time kernel that uses preemptive scheduling to achieve multitasking on hardware platform. The previous sections dealt with µCOS_II porting to the application desired. This section deals with the implementation of hardware and software. Porting of µC/OS-II we can perform simple tasks like Temperature sensor like RTD or Thermocouple or any analog signal (i.e., ADC), 16x2 LCD (i.e., degree to Fahrenheit for temperature and Kg/cm² for pressure), UART (i.e., sending msg through GSM), Ethernet (i.e. to communicate with desktop PC) MMC (i.e., memory card for data backup), Thermal printer (i.e. for printing real time RTC value).
VI. SOFTWARE

For implementation Keil IDE is used. To develop applications for ARM microcontroller and digital signal controller, Keil IDE is a windows operating system software program that runs on a PC. IDE means Integrated Development Environment; it provides a single integrated environment to develop code for embedded microcontroller. Keil-µVision4 IDE (Integrated Development Environment) is a Windows based front end for the C Compiler and assembler. Keil-µVision4 is used for writing embedded C programs. Embedded C is a high level language, which includes many aspects of the ANSI (American National Standard Institute) C programming language. Standard libraries are altered or enhanced to address the peculiarities of an embedded target processor.

VII. CONCLUSION

The Design of ARM based industrial embedded system using RTOS offers to developing fast and efficient an application. The system can be used to perform real-time controls where there have standard electrical and Electronics interface. This system can applied to chemical, petroleum, power generation system, automobiles and so on. Using the Ethernet port of the embedded system, networked control and acquisitions can be achieved through an industrial Ethernet LAN. Since the embedded system is able to deal with Multi-Tasks and can run operation systems, field operations, supervisions and managements. This embedded ARM system can adapt to data acquisition and control system like reliability, cost, size, remote access. This system uses the portable Thermal Printer for printing real time data and GSM Module for long distance communication and MMC card for data backup that provides an alternative interface for conventional control and acquisition applications. Thus the embedded system is compact system that is useful for industrial applications.

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