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Design of Data Acquisition and Control System for Industrial Purpose

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***Abstract*—Design of ARM based data Acquisition &Control using Ethernet is proposed. This system is an intelligent for data acquisition, monitoring and output control. Proposed system designed based on ARM Processor with RTOS. An embedded system with ARM processor can be used for diverse industrial applications involved with a real time kernel for task management, multi-tasking etc. RTOS can be ported to ARM hardware, and then the system can deal with much more complicated tasks. Embedded system designed provides a generic design with all kind of data acquisition and control. System is used as an embedded web server with all data by typing the IP address user get webpage onscreen contains all the current status of the devices. The Administrator can Real-time control the devices through Ethernet Controller. Motivation behind this project involves acquiring the temperature data from a boiler or machine and in turn controlling the boilers through a Ethernet web server prior to the instrumental damages or failures**

***Index Terms*—Embedded systems, Data Acquisition, Web server, RT Linux.**

I. Introduction

Embedded systems are developing fast and have been used in control and data acquisition. As embedded system is of high performance and the cost is low, it has the tendency to play the great role of control and data acquisition. In Industries, systems are becoming very complex Industrial system needs to test the site equipment's an environmental conditions to track the state of system in real time. This system requires design, which has to be flexible and adaptable, for that microcontroller based systems can be used. These systems are more reliable and provide high performance to the system. Real-Time gives a desired response or reaction to an event on the instant of its evolution. The desired response depicts the logical correctness of the result produced. System operates in a strict time constraint. Operating System (OS) is a system program, which is an interface between hardware and application programs. Common features of OS are multitasking, Synchronization, Interrupt and Event Handling, Input/ Output, Inter-task Communication, Timers and Clocks and Memory allocation and management. This enables its primary role of managing the hardware resources to meet the demands of application programs. RTOS is therefore an operating system that supports real-time applications for embedded systems by providing logically correct result within the deadline required. Such capabilities define its deterministic timing behavior and limited resource utilization nature.

In this project, Analyzing an embedded system with an onboard Ethernet interface allowing remote device monitoring, control and data acquisition and WIFI module to give monitoring control and critical data to particular user in case of system failure. The embedded device of the system can be an important element for building networked manufacturing systems that shows a very promising prospect for industrial applications.

Data Acquisition Systems, as the name implies, are products and/or processes used to collect information to document (or) to analyze some phenomenon. The purpose of the data acquisition system is generally the analysis of the sensed and measured data at the remote location in the industry and process it and transmitting to the control room consisting of PC. The data acquisition system is normally electronics based, and it is made of hardware and software. The hardware part consists of sensors and electronics. The software part is made of the data acquisition logic and the analysis is software.

II. PROJECT DESCRIPTION

Many embedded systems have substantially different designs according to their functions and utilities. There is no single characterization for all kinds of embedded systems. Processor based real-time embedded systems are playing an important role in most control applications. An embedded system interacts continuously with its environment and carries out various tasks with certain timing constraints to meet the requirements of system performance. The processor has the dominant influence on an embedded system.

The control and acquisition system uses NXP ARM-CORTEX M3 32-bit CMOS RISC Microcontroller that is the product of Philips Ltd. The LPC-1768 microcontroller is designed to provide a cost-effective and high performance micro-controller solution for general applications. An outstanding feature of the S3C2440 is its CPU core, a 32-bit ARM-CORTEX M3 RISC processor (400MHz) designed by Advanced RISC Machines, Ltd. Hence the processor has low power consumption and small

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size with a high instruction throughput and an excellent real time interrupt response. Besides, ARM-CORTEX M3 board has abundant integrated on-chip functions such as bus interfaces, Watch Dog Timer (WDT), Real Time Clock (RTC) and so on. All these facilitated the controller's hardware and software design. Because the controller uses a pipeline to increase the speed of the flow of instructions, it allows several operations to take place simultaneously and the processing and memory systems to operate continuously. On the basis, RT-Linux operating system can be ported to the embedded system. Thus the controller based on the ARM processor can deal with much more complicated control tasks that most conventional lower computers cannot deal with. So, the smart processor can greatly optimize the controller's performance. The architecture of the control and acquisition system based on the LPC-1768 based Microcontroller is shown in Fig. 1.

In this project controlling the Physical parameter temperature and to measure the temperature value using an LM35 sensor which measures the temperature continuously. In ARM there are inbuilt ADC and DAC. The ADC to convert the analog data from the sensor and convert it to the digital value and DAC is to convert the Digital data from the microcontroller and convert it Analog form to the RS-485. The microcontroller continuously reads the temperature from the sensor and will be compared with the set point. Device 1 and 2 are the two devices which are going to control these devices may be the boilers (or) machines. The measured temperature from the measured sensor will be compared continuously with the set point if the measured temperature is below the set point the ARM CORTEX-M3 microcontroller will switch on the heater and if the temperature is above the set point it will switch on the heater with the help of in the webpage one can change the set point also based on the application. With Ethernet WIFI module, the system can communicate with desktop computers or Workstation so that the control and acquisition of a distributed industrial system can be realized within a LAN. A RS-485 serial port is backed up for more widely applications.

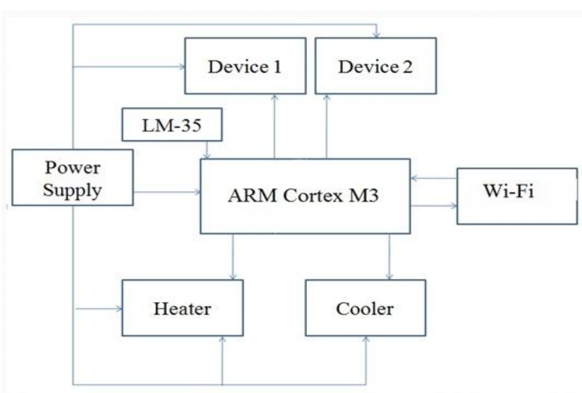

Fig 1: Block Diagram of Design of Data Acquisition System for Industrial Purpose

III. SYSTEM OVERVIEW

A. LM35 Sensor

There are so many kinds of sensors. Sensors Applications covers all major fields of applications. In this project to control temperature (physical parameters), for this purpose LM35 temperature sensor used to measure the temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single point power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy).

- Calibrated directly in ° Celsius (Centigrade)
- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy guarantee able (at +25°C)
- Rated for full −55° to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08°C in still air
- Nonlinearity only ±1⁄4°C typical
- Low impedance output, 0.1 W for 1 mA load

B. ARM Cortex-M3

The Land Tiger V2.0 NXP LPC1768 ARM development board is based on a second generation ARM Cortex-M3 microcontroller, a high-performance, low-power 32-bit microprocessor designed for embedded system applications, suitable for instrumentation, industrial communications, motor control, lighting control, alarm systems, and other fields. The board supports USB2.0 Device and Host, dual CAN interfaces, RS-485 interface and an on-board USB emulator for JLINK. The development board is supported by a rich set of example software and detailed information to facilitate the users to quickly project development.

Powerful LPC1768 MCU Cortex-M3 core:

- Clock frequency up to 100MHz.
- Includes support of eight areas of memory protection unit (MPU).
- Built-in Nested Vectored Interrupt Controller (NVIC).
- 512KB on-chip Flash program memory, supports in-system programming (ISP) and In Application Programming (IAP).

- 64KB SRAM for high-performance CPU access through the instruction bus, system Bus, data bus access.
- AHB multi-layer matrix with 8-channel general-purpose DMA controller (GPDMA).
- Supports SSP, UART, I2C, I2S, ADC, DAC, Timer, PWM, GPIO, etc., can be used for memory-to-memory transfer.
- Standard JTAG test / debug interface and a serial wire debugging and serial wire Tracking port option.
- Simulation trace module supports real-time tracking.
- 4 low-power modes: sleep, deep sleep, power-down, deep power-down.
- Single 3.3V power supply (2.4V - 3.6V).
- Operating temperature: -40° C - 85° C.
- Non-maskable interrupts (NMI) input.
- On-chip integrated power-on reset circuit.
- Built-in systems timer (SysTick), to facilitate operating system migration.

C. *WI-FI Module*

Wi-Fi, also spelled Wifi or WiFi, is a local area wireless technology that allows an electronic device to exchange data or connect to the internet using 2.4 GHz UHF and 5 GHz SHF radio waves. Many devices can use Wi-Fi, e.g., personal computers, video-game consoles, smart phones, some digital cameras, tablet computers and digital audio players. These can connect to a network resource such as the Internet via a wireless network access point. Such an access point (or hotspot) has a range of about 20 meters (66 feet) indoors and a greater range outdoors. Hotspot coverage can comprise an area as small as a single room with walls that block radio waves, or as large as many square kilometers achieved by using multiple overlapping access points.

To connect to a Wi-Fi LAN, a computer has to be equipped with a wireless network interface controller. The combination of computer and interface controller is called a station. All stations share a single radio frequency communication channel. Transmissions on this channel are received by all stations within range. The hardware does not signal the user that the transmission was delivered and is therefore called a best-effort delivery mechanism. A carrier wave is used to transmit the data in packets, referred to as "Ethernet frames". Each station is constantly tuned in on the radio frequency communication channel to pick up available transmissions.

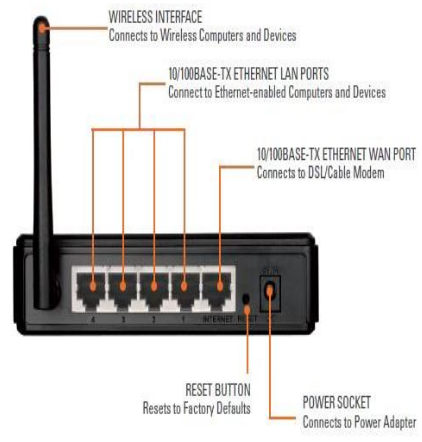

Fig 2: Wifi Router

D. *Ethernet*

The Ethernet block contains a full featured 10 Mbps or 100 Mbps Ethernet MAC (Media Access Controller) designed to provide optimized performance through the use of DMA hardware acceleration. Features include a generous suite of control registers, half or full duplex operation, flow control, control frames, hardware acceleration for transmit retry, receive packet filtering and wake-up on LAN activity. Automatic frame transmission and reception with Scatter-Gather DMA off-loads many operations from the CPU.

The Ethernet block is an AHB master that drives the AHB bus matrix. Through the matrix, it has access to all on-chip RAM memories. A recommended use of RAM by the Ethernet is to use one of the RAM blocks exclusively for Ethernet traffic. That RAM would then be accessed only by the Ethernet and the CPU, and possibly the GPDMA, giving maximum bandwidth to the Ethernet function. Ethernet standards support

- Supports 10 or 100 Mbps PHY devices including 10 Base-T, 100 Base-TX, 100 Base-FX, and 100 Base-T4.
- Fully compliant with IEEE standard 802.3.
- Fully compliant with 802.3x Full Duplex Flow Control and Half Duplex backpressure.
- Flexible transmit and receive frame options.

IV. SOFTWARE DEVELOPMENT

Embedded Software development is always been a unique software cycle, where a development of application over a hardware to function as user requirement is an advancement of software development techniques. Here, in this project the framework is developed using ‘Embedded C’ programming language on ‘KEIL IDE’ Environment. The key modules involved in framework are discussed below.

A. TCP/IP Model

TCP/IP is based on a four-layer reference model. All protocols that belong to the TCP/IP protocol suite are located in the top three layers of this model. As shown in the following illustration, each layer of the TCP/IP model corresponds to one or more layers of the seven-layer Open Systems Interconnection (OSI) reference model proposed by the International Standards Organization (ISO).

You can configure TCP/IP on servers running Windows Server 2003 by using the following methods:

1) AUTOMATIC CONFIGURATION:-

TCP/IP uses Automatic Private IP Addressing (APIPA) by default to provide automatic configuration, using the IP address range 169.254.0.1 to 169.254.255.254 and the subnet mask 255.255.0.0. There is no automatic configuration of a default gateway, DNS server, or WINS server since APIPA is designed for networks that consist of a single network segment and that are not connected to the Internet.

2) DYNAMIC CONFIGURATION:-

By using DHCP, TCP/IP configuration is done dynamically and automatically when the computer is started. Dynamic configuration requires the configuration of a DHCP server. By default, computers running Windows Server 2003 operating systems are DHCP clients. By properly configuring the DHCP server, TCP/IP hosts can obtain IP address, subnet mask, default gateway, DNS server, NetBIOS node type, and WINS server configuration information. Dynamic configuration (using DHCP) is recommended for medium-to-large TCP/IP networks.

3) ALTERNATE CONFIGURATION:-

Alternate configuration enables a computer to use an alternate, manually configured IP address configuration in the absence of a DHCP server. You can use an alternate configuration when a computer is used on more than one network, at least one of the networks does not have a DHCP server, and automatic configuration is not wanted.

4) MANUAL CONFIGURATION:-

By manually configuring the properties of the TCP/IP protocol through the properties of a network connection (in Network Connections), you can assign an IP address, subnet mask, default gateway, DNS server, and WINS server. Manual configuration is required in a network with multiple network segments when no DHCP server is present.

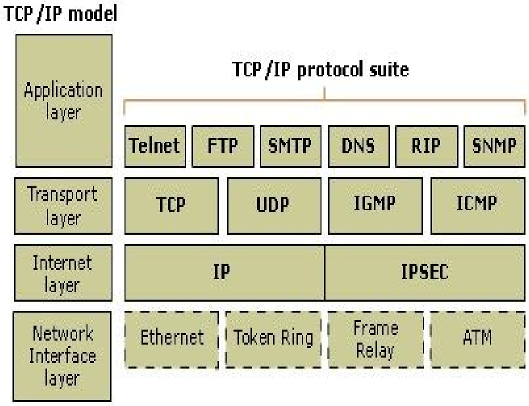

Fig 3:Block Diagram Of TCP/IP Protocol

B. Common Gate Interface

Common Gateway Interface (CGI) is a standard method used to generate dynamic content on Web pages and Web applications. CGI, when implemented on a Web server, provides an interface between the Web server and programs that generate the Web content. These programs are known as CGI scripts or simply CGIs; they are usually written in a scripting language, but can be written in any programming language. The scripting language used in this project is java script language.

The common gateway interface provides a consistent way for data to be passed from the user's request to the application program and back to the user. This means the person who writes the application program makes sure it gets used no matter which operating system server uses windows or any other operating system. It's simply a basic way for information to be passed from the Web server about your request to the application program and back again.

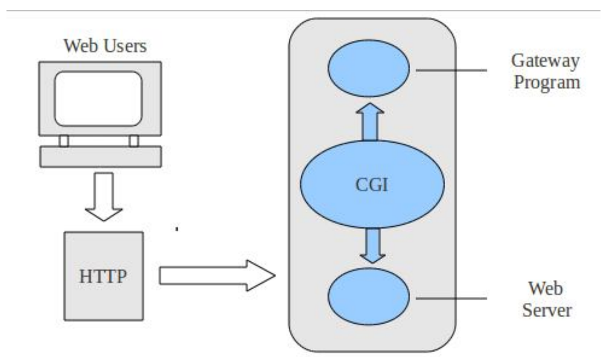

Fig 4: Block diagram of CGI interfacing

C. Real Time Linux

RT Linux is a hard real-time RTOS microkernel that runs the entire Linux operating system as a preemptive process. It is one of the hard real-time variants of Linux, among several, that makes it possible to control robots, data acquisition systems, manufacturing plants, and other time-sensitive instruments and machines.

The key RT Linux design objective was to add hard real-time capabilities to a commodity operating system to facilitate the development of complex control programs with both capabilities. For example, one might want to develop a real-time motor controller that used a commodity database and exported an operator interface. Instead of attempting to build a single operating system that could support real-time and non-real-time capabilities, RT Linux was designed to share a computing device between a real-time and non-real-time operating system so that the real-time operating system could never be blocked from execution by the non-real-time operating system and components running in the two different environments could easily share data. As the name implies RT Linux was the first computer designed to use Linux as the non-real-time system but it eventually evolved so that the RT Core real-time kernel could run with either Linux or BSD UNIX.

The key RT Linux design objective is that the system should be transparent, modular, and extensible. Transparency means that there are no inoperable black boxes and the cost of any operation should be determinable. Modularity means that it is possible to omit functionality and the expense of that functionality if it is not needed. The base RT Linux system supports high speed interrupt handling and no more. And extensibility means that programmers should be able to add modules and tailor the system to their requirements. It has simple priority scheduler that can be easily replaced by schedulers more suited to the needs of some specific application. When developing RT Linux, it was designed to maximize the advantage one would get from having Linux and its capabilities available.

RT Linux is structured as a small core component and a set of optional components. The core component permits installation of very low latency interrupt handlers that cannot be delayed or preempted by Linux itself and some low level synchronization and interrupt control routines. This core component has been extended to support SMP and at the same time it has been simplified by removing some functionality that can be provided outside the core.

D. Flowchart Representation of DHCP Server functionality

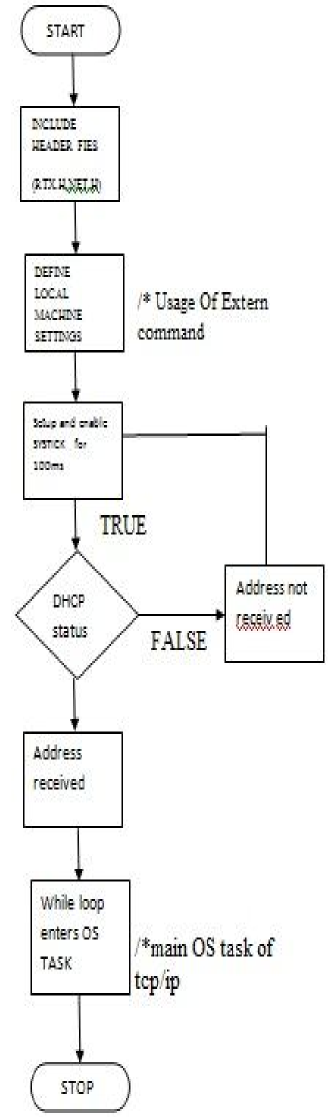

Fig 5: Flow chart of DHCP Server

In this system, programming model is developed using RT Linux the above flowchart shows the functionality of DHCP server in executing the user defined tasks using TCP/IP protocol .the following steps explains the flow chart

1) Including Header files of RT Linux introduces RT Linux into programming model.
2) Defining the local settings of the external machine settings.
3) Introducing the delay of 100ms searches the DHCP server for address, if true goes to next step or else reverts back.
4) If Address received then the main OS task starts enters into while loop of TCP/IP.
5) After execution, the program terminates.

V. RESULTS

Design of ARM based data Acquisition & Control using TCP/IP Network offers necessary mighty functions to develop fast and efficient application. The system can be used to perform real-time controls like standard electrical interface. High precision data acquisition can be realized by the embedded system. Using the Ethernet port of the embedded system, network's acquisition can be achieved through an industrial Ethernet LAN. The hardware and software provide a platform for diverse control and acquisition applications, including industrial process controls and factory automations. Since the embedded system is able to deal with Multi- Tasks and can run operation systems, field operations, supervisions and managements can be done by the lower embedded devices, hence the upper PC or workstation in the industrial LAN will do fewer works, which lowers the concentration degree of the whole system. This enhances the reliability of the control and acquisition system and reduces the risks.

VI. FUTURE SCOPE

Our technology choice for both wireless data communication and fast wired communication and control the device using web server by centralized monitoring system. The future work can be implemented by introducing artificial intelligence by making system more reliable for user interface such as automated voice recognition system. As system is generic solution it becomes easy to provide machine to machine communication and entire embedded. This design can be used widely in remote data acquisition and control system in industry.

VII. CONCLUSION

In this project the design of ARM Cortex-M3 processor for industrial application, utilizes and analyze hardware configuration and software implementation. This design brought compactness to the system. In this Project we are implementing a WEB server with 32 bit ARM Processor – LPC 1768 ARM based Micro controller. Data acquisition plays an important role in real-time controls and online supervisions. Many important data should be stored as a record for the future. Using the Ethernet port of the embedded system, networked control and acquisitions can be achieved through an industrial Ethernet LAN. The hardware and software provide a platform for diverse control and acquisition applications, including industrial process controls and factory automations.

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REFERENCES

[1] A Hand Book on Data Acquisition by Measurement Computing Corporation.

[2] Gan-ping Li "Design of an Embedded Control and Acquisition System for Industrial Local Area Networks Based on ARM" *IEEE,2010: 24 -27*.

[3] S.Vitturi "On the use of Ethernet at low level of factory communication systems", Computer standards & interfaces, *2001, (23): 267 – 277.*

[4] G. Hima Padmaja and G. Sreenivasa Rao" Industrial remote data acquisition and control system based on embedded ARM9 platform integrated with mobile communication" *International Journal of Scientific & Engineering Research, Volume 4, Issue 6, June-2013.*

[5] LPC1768 Microcontroller Data sheets and Technical Manuals.

[6] www.fsmlabs.com/ and www.tldp.org/HOWTO/**RTLinux**-HOWTO-2.html for knowledge on RTLINUX.

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