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# Design of ARM Based Embedded System for Industrial Application Using TCP/IP Network

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**Abstract—**
In Embedded and real time data acquisition and control system, design and implementation of online embedded web server is challenging part. To interface real time embedded application like data acquisition, automation and control system in industries specially power generation plant. The World Wide Web is a global system of interconnected computer networks that use the standard Internet Protocol Suite (TCP/IP) to serve billion of users worldwide. This paper show the design and development of online Interactive Data Acquisition and Control system(IDACS) using ARM base Embedded web server, it can be digital distributed control system. Processing capability of a system improve by single chip IDACS. This system uses ARM7 Processor portability with Real Time operating system (RTOS) it makes the system more real time and handling various processes based on multi tasking using embedded 'C' language, Web server application is ported into an ARM processor
***Keywords-*** *ARM-TDMI, µC/OS-II, GSM , EHTERNET, MEMORY CARD, TCP/IP.*

## I. INTRODUCTION

In industries, systems are becoming very complex. Industries system needs to test the site equipments and environmental so it can track state of system in real time [4]. This system requires design which has to be flexible and adaptable, for that microcontroller based systems can be used. This is more reliable and provides high performance to the system.

Microcontroller is very practical and successfully utilized, the conventional 8 and 16-bit Microcontroller has its deficiencies when compared with 32-bit [4]. 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 successor 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.

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. The expectant response depicts the logical correctness of the result produced. The instant of the events' evolution depicts deadline for producing the result. 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. RTOS is therefore an operating system that supports real-time applications and embedded systems by providing logically correct result within the deadline required. Such capabilities define its deterministic timing behavior and limited resource utilization nature.

Real time kernel is simple and stable. RTOS can cut 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 the 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]

## 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.

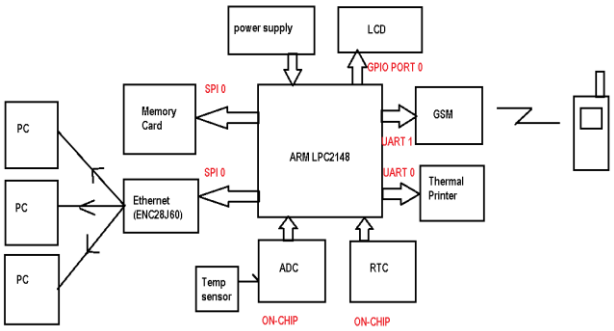


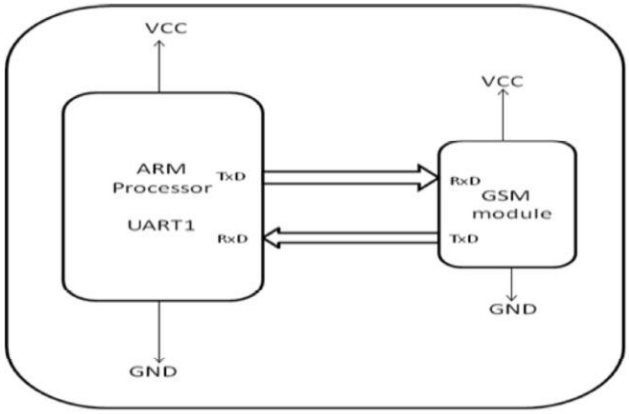

Figure 2.1: Block diagram of Proposed Architecture

The proposed embedded system uses FLASH and MMC memories for program running and data storage. The BIOS codes, user's codes and the useful data are stored in FLASH memories. RTC data is written on MMC for data logging purpose. As far as the control and acquisition system concerned, the Analog to Digital Converter (ADC) is essential components. The ADCs are applied for data acquisition. A RS-485 serial port is backed up for more widely applications.

The LCD controller can be programmed to support different requirements on the screen. LCD is connected to the General Purpose Input/output ports (GPIO) of the microprocessor. The IP address of the system is burned in a serial EEPROM. The Ethernet controller will read the IP address when reset. Ethernet is interfaced to serial peripheral interface of controller.

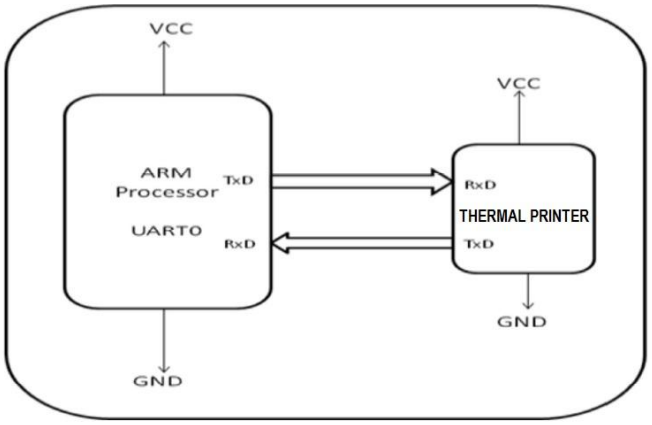
GSM is interfaced as it provides a wireless communication i.e message can be sent to particular individual instantly. Thermal printer has RS232 port available so it is interfaced to controller using UART port. ON-Chip RTC is configured so that it give real time clock value which is very useful for data logging and data is written on MMC.

### *B. GSM MODULE*




Global System for Mobile communications (GSM) is the almost popular wireless standard for mobile phones in the world. GSM module allows transmission of Short message service (SMS) in TEXT mode and PDU mode. The proposed design uses SIM 300 GSM module in text mode. This design uses SIM300 GSM module that provide 900/1800/1900MHz Tri-band for VOICE, SMS, DATA, and FAX. This module operates on AT command over TTL interface. AT command is an abbreviation 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).

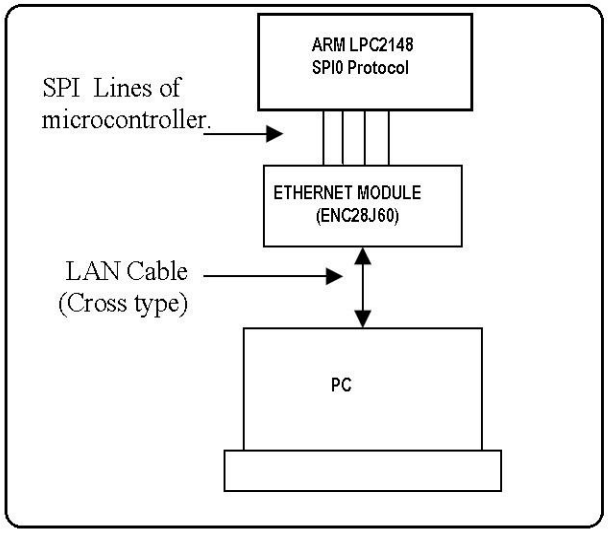
### *C. THERMAL PRINTER*




Thermal printer is very compact and portable. It is very easy to access as directly it can be interfaced to RS232. 2 inch paper width is generally present inside it. APS Thermal printer mechanism can write character Per Line: 24 and Programmable speed is upto 50 mm / sec.

Universal ESC sequence compatible. Complete text can be printed and graphic printing can be done. It has inbuilt over temperature & voltage protection and serial RS-232 interface.

*D. ETHERNET MODULE*




The ENC28J60 is a stand-alone Ethernet controller with an industry standard Serial Peripheral Interface (SPI). It is designed to serve as an Ethernet network interface for any controller equipped with SPI. The ENC28J60 meets all of the IEEE 802.3 specifications. It incorporates a number of packet filtering schemes to limit incoming packets. It also provides an internal DMA module for fast data throughput and hardware assisted checksum calculation, which is used in various network protocols. 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.

*E. Hardware Clk Rate*

| MODULE | ON-CHIP PROTOCOL | CLK RATE |
|---|---|---|
| GSM | UART 1 | 9600BPS |
| THERMAL PRINTER | UART 0 | 9600BPS |
| MEMORY CARD | SPI 0 | 62.5KHz |
| ETHERNET (ENC28J60) | SPI 0 | 2MHz |
| TEMP SENSOR | ADC 0 | 1MHz |

## III. RTOS

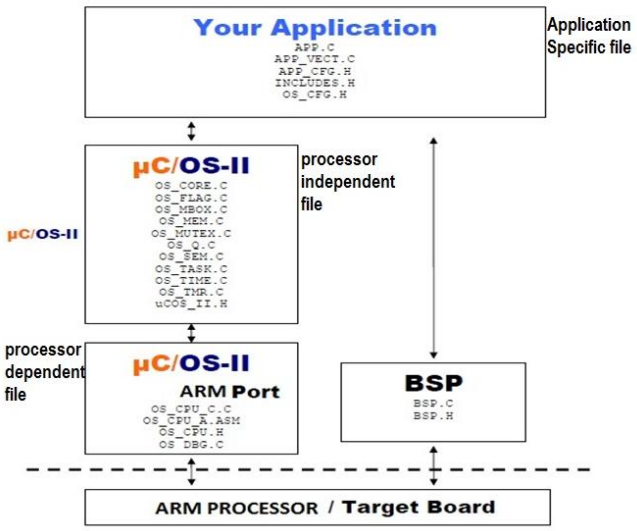



Fig 3.1 Hardware & µC/OS-II Interface

RTOS(µC/OS-II) manages up to 250 application tasks(6). RTOS can be ported to ARM hardware, then the system can deal with much more complicated tasks. Real-Time (RT) indicates an expectant 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.

RTOS(µC/OS-II) is a very small real-time kernel with memory footprint is about 20KB and source code is about 5,500 lines, mostly in ANSI C. µC/OS-II can be scaled to only contain the features you need for your application and thus provide a small footprint. 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). The execution time for most of the services provided by µC/OS-II is both constant and deterministic.

## IV. 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.

Depending on the required application the number of tasks may vary. Porting of µC/OS-II we can perform simple tasks like Temperature sensor (i.e., ADC), 16x2 LCD (i.e., degree to Fahrenheit), 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 ).

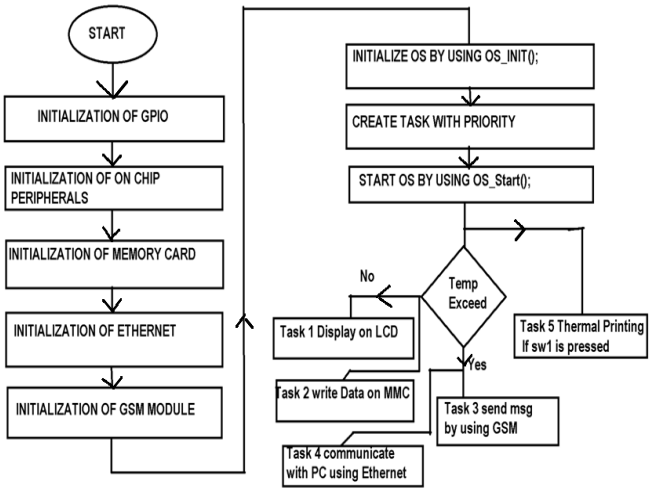



Fig.4.1 Flow chart of Hardware & µCOS_II implementation

## V. SOFTWARE

Keil IDE is used for implementation. Keil IDE is a windows operating system software program that runs on a PC to develop applications for ARM microcontroller and digital signal controller. It is also called Integrated Development Environment or IDE because 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. KeilµVision4 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.

## VI. CONCLUSION

The Design of ARM based industrial Embedded system using RTOS offers necessary mighty functions to developing fast and efficient an application. The system can be used to perform real-time controls where there have standard electrical interface. High precision data acquisition can be realized by the embedded system as well. 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. 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. In addition 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.

## ACKNOWLEDGMENT

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