Design and Implementation of ARM Based advanced Industrial Control and Data Acquisition with Wireless LAN Monitoring

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Abstract   This paper describe the proposed system of design and implementation of ARM based advanced industrial control and data acquisition system with web monitoring feature. The technological advancement in the field of Electronic development, manufacturing and facilities has been one of the prime necessities in the present days. The paper focuses on new concept of smart, intelligent industrial embedded control and data acquisition system, which design based on ARM7 platform which is 32-bit embedded microprocessor. This system measures the temperature value, gas concentration, system failure and human presence in restricted zone in real time with RTC. The measured quantity can be displayed on LCD of the system, stores data in MMC card whenever any events occurs and at the same time can be transmitted through Ethernet network to remote desktop computers within the industrial area by using TCP protocol which displays data on web page. A unique IP address is assigned to the server through which it can be accessed. The system has long-distance communication facility, tends to send a text message using GSM module, which can reduce some sort of disturbances and rejection in the communication network. A memory card is interfaced to store all the information generated by the system for every second.

Keywords: RTOS, ARM7, data acquisition, TCP/IP

Cite This Article: K.S.Patle, P.B.Dahikar, and K.Y.Rokde, "Design and Implementation of ARM Based advanced Industrial Control and Data Acquisition with Wireless LAN Monitoring." *Journal of Embedded Systems*, vol. 3, no. 1 (2015): 16-20. doi: 10.12691/jes-3-1-3.

1. Introduction

As we know that, the industry societies are one of the most important subject on which human being is currently depends. The people especially in cities are working in industries for him and his family survival. So it becomes one of the most important concepts to monitor such industrial area with respect to production in industries, skill development of workers along with the health and security purpose. An Industry undergoes through various technical and non technical processes. An industrial process comprises of various factors like poisonous gaseous, human prohibited area, pressure, speed, temperature, timings, and so on. These parameters are needed to be maintained and monitor at a desired level in some interval time repeatedly and some disturbance of these levels may cause to heavy loss or severe accidents. So, in order to maintain the desired levels of these parameters, they must be monitored and accordingly controlled with respect to time.

Now a day's internet becomes an integral part of human life. So, it is clear that the internet based advance technologies are much more useful to browsing the web for various purposes. As part in advancement in technology, now web access functionality can be implemented with an embedded system to enable low cost widely accessible and enhanced user interface which tends to result in web server development. A web server provides access to the user through web page which enables to access the data from the device. This brings web services being deployed on various embedded processors such as Advanced RISC Machine (ARM) in real time context.

The web accessing facility can be applied by the Ethernet standard based device (Ethernet module). The system data can be accessed over internet by a unique IP address which is assigned to the system. The system consists of ARM7 micro controller of LPC 2148 series. The main purpose to use this controller is its advantages. Some of the main advantages are, it consumes very low power that reduces the power consumption and it is high speed controller that makes system very fast by increasing the speed of operation. The use of this system can make anyone to monitor the industrial parameters like gas concentration, humidity and temperature in the Industrial processes. For this, the proposed system consisting of gas sensor MQ4, smoke sensor MQ2 and temperature sensor LM35. The sensed data by the sensors is then being read by the microcontroller LPC2148 through its one of the ADC pins or by GPIO pins and stored in the respected data registers. These readings can be stored in the MMC card as a database and monitored on the web page over the

web. This task relates to the data acquisition. Now, in order to perform some control operations, it depends on the desired levels of the measured parameters. For an example, if temperature crosses the maximum level, the relays will be controlled by the level of the temperature. Once the level is achieved, then any one of the appliance will be get activated for certain task. This system can also able to monitor the status of the controlling devices in order to get desired result and avoid any unwanted situation.

Microcontroller is very practical and successfully to utilize in such system, the conventional 8 and 16-bit Microcontroller has its deficiencies when compared with 32-bit [1,2]. The ARM architecture is Reduced Instruction Set Computer (RISC), and the instruction set and related decode mechanism are much simpler than those of micro program of Complex Instruction Set. As a result of this simplicity in the instruction set results in fast throughput from a small and cost-effective processor. The architecture of the processor introduces the pipeline techniques as a result of this all parts of the processing and a memory system operates simultaneously and continuously. This mechanism allows the fetching, decoding and execution of the instruction simultaneously. ARM based embedded system will be more functional, reliable, cost effective, compact in size and also low power consumption [2,3].

RTOS stands for Real-Time Operating System. Real time kernel is simple and stable. RTOS divides the complex application into number of mutually independent tasks based on its priority [6]. The difference between simple programming concept and RTOS programming is that, the response of the RTOS programming is much satisfactory than that of the simple programming concept. Real-Time gives an expected response to an event with respect to its time interval and production of the result depicts deadline for instant of the events' evolution. Operating System (OS) is a system program that makes device user friendly and provides an interface between hardware and application programs. Synchronization, Multitasking, Event Handling, Input/ Output, interrupt and Inter-task Communication are the common features of Operating system. RTOS is therefore an operating system that supports real-time applications and embedded systems by providing logically correct result within the deadline. Such capabilities shows that, why the RTOS is superior to that of the simple programming concept and shows its deterministic timing behavior and limited resource utilization nature [6,7].


Figure 1.1. Real time embedded system with RTOS

Industrial application also 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 [7].

2. System Overview

2.1. Architecture

The developed system comprises of three main sub blocks viz. data acquisition and monitoring, industrial controlling and processing unit.

The data acquisition and monitoring comprises many sensor modules which performs all the measurement and acquisition task require for industrial purpose. The system consisting of sensors like LM 35 temperature sensor, Gas sensors MQ4, smoke sensor MQ2 which sense hazardous gaseous and smoke in the industrial area, proximity sensor to observe human movement and transformer module to check machine is ON/OFF. So, all such sensors are used in the system to acquire the data from the industrial environment for further processing and controlling. The MMC card is interface with system to store the acquired information from the sensor. The industrial controlling is done through the programming, developed for the system on the basis of the various parameters which has been sensed by the system. For ex. The controlling of the appliances based on the temperature level and gas detection. There are some other modules are interface with system like GSM module to send text massage, MMC card to store data, Ethernet module to communicate with all the PC's in LAN network, LCD module to display data and relay modules for controlling purpose. All the above sensors and controlling elements are interface with the processing unit and the processing unit is based on the ARM 7 microprocessor which is a 32 bit RISC Processor. Figure below shows the entire system block diagram
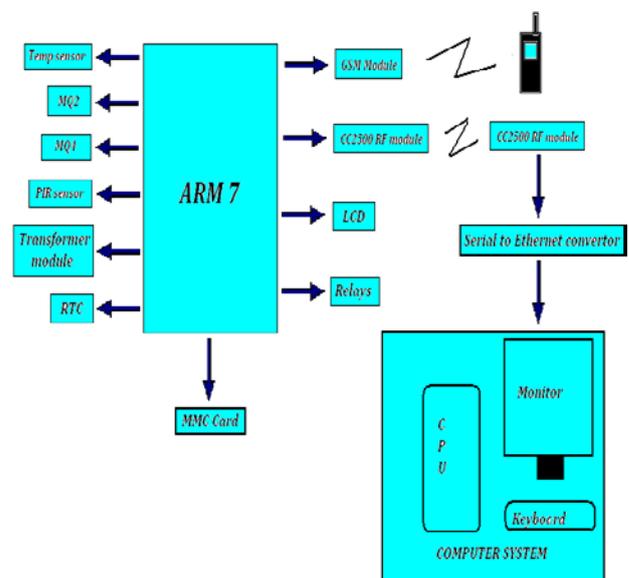

Figure 2.1. block diagram of the system

The sensors in the system like LM35, MQ2 and MQ4 are of analog in nature. So these sensors are connected to

processor through its internal inbuilt ADC module which acquires the analog value from the sensors and converts into digital equivalent value for the further processing. The proximity sensor gives output in two state viz. logic 1 and logic 0. So it is interfaced with the GPIO (General purpose input output) of the processor. Similarly transformer module also connected to GPIO. The GSM module SIM 900 is used in the system to send the text massage. This module is interfaced with system through UART with 9600 baud rate. LCD is connected to the general purpose input/output ports (GPIO) of the microprocessor. It is used to display the various conditions occurring and reading of the sensors that are used in the industrial environment. The system has facilities of RTC since all the observations are made with reference to the RTC. The MMC card is interfaced with system to store acquire data for future purpose as a record of the environmental conditions in the industries. MMC card is interfaced through SPI bus. Ethernet module is interfaced to the controller through UART. This is an embedded TCP/IP server which has a configurable fixed IP address and a UART connected virtually over Ethernet/LAN [8,9,10]. This allows data to be displayed on the web page after typing the IP address in the address bar. This facility makes system more reliable in the industries. GSM is interfaced with system as it provides a wireless communication i.e message can be sent to particular individual instantly after any emergency cause in the industry.

2.2. GSM Module

GSM stands for Global System for Mobile communications; it is the most popular wireless communication medium used in the world for faithful and fast communication. GSM module allows transmission of Short message service (SMS) in TEXT mode. The proposed design uses SIM 300 GSM module in text mode. It is connected with the system through UART with 9600 baud rate. The Tx pin of the Microcontroller is connected to the Rx pin of the GSM module and vice-versa.
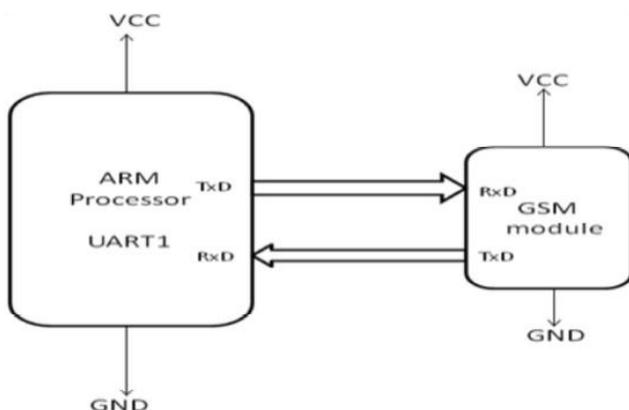
Figure 2.2. Interfacing of SIM300 GSM module with ARM processor

The SIM300 GSM module provides 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).

2.3. SeRial to Ethernet Convertor Module

This is an embedded TCP/IP server which has a configurable IP address and a UART connected virtually over Ethernet/LAN.
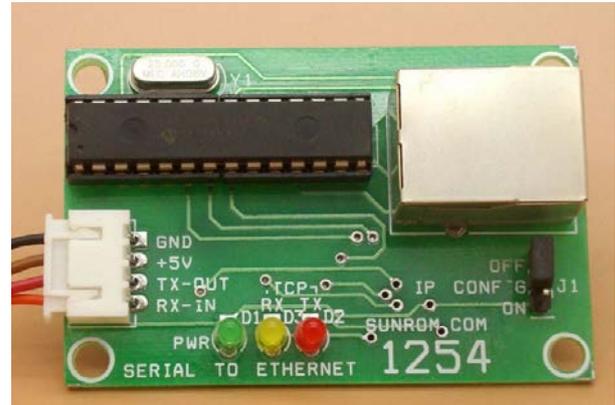
Figure 2.3. Serial to Ethernet convertor module used in the system.

It is very easy to interface with microcontroller having UART at 3V or 5V level. For that microcontroller required to configure at baud rate of 9600 [11].

2.4. MMC Card

The memory card is interfaced with the system as a data logger. It is interfaced with microcontroller using SPI bus. The SPI module in the ARM 7 microcontroller is configured as per the MMC cord configuration. This module has SCL, SDA, SDO, SDI which is useful for clock of the SPI module, acknowledgement, data out and data in respectively.
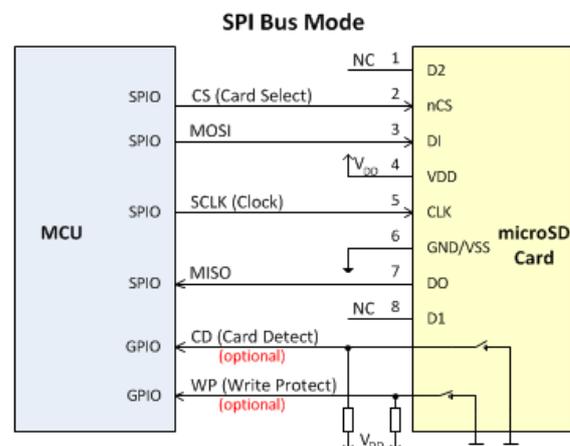

Figure 2.4. SD card interfaced via SPI bus

3. Experimental Work

The system implementation is deals with hardware and software part. The heart of the system is a real-time kernel that uses preemptive scheduling to achieve multitasking on hardware platform. The number of task in the system is depends on the requirement of the industrial area or depending on the required application. In the system, μC/OS-II developed to perform simple tasks like temperature measurement, gas detection, smart industrial control, display control, data logging, long distance communication and web server management. All the

sensors, displays, actuators (relays), storage media and communication media are handled over µC/OS-II.

Figure 3.1. Designed sytem

4. Software Implementation

IDE is used here for the programming of the microcontroller is µVision IDE from Keil. The µVision IDE from Keil combines project management, make facilities, source code editing, program debugging, and complete simulation in one powerful environment. The µVision development platform is easy-to-use and helping you quickly create embedded programs that work. The µVision editor and debugger are integrated in a single application that provides a seamless embedded project development environment. 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 [12].
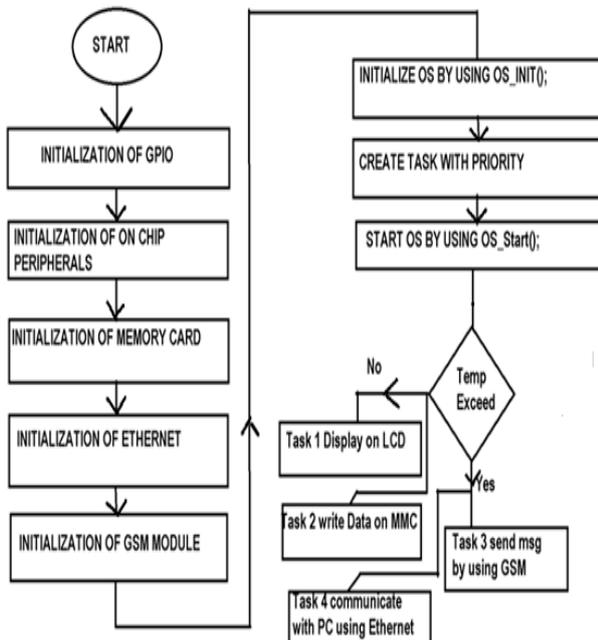
Figure 4.1. Flow chart of Hardware & µCOS_II implementation

5. Simulation Result

The different types of results are on Keil uvision4 software, HyperTerminal and on PC are shown below.
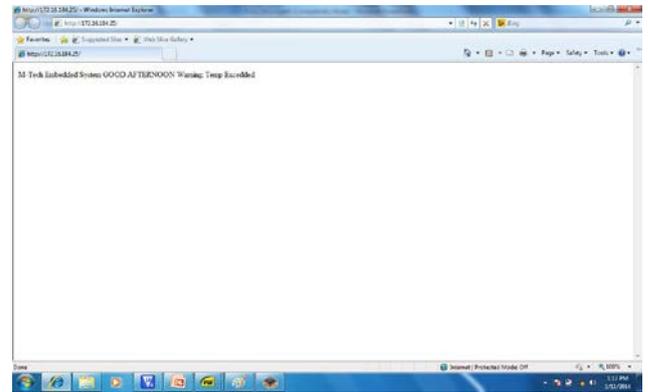
Result :- Results of Ethernet on web page
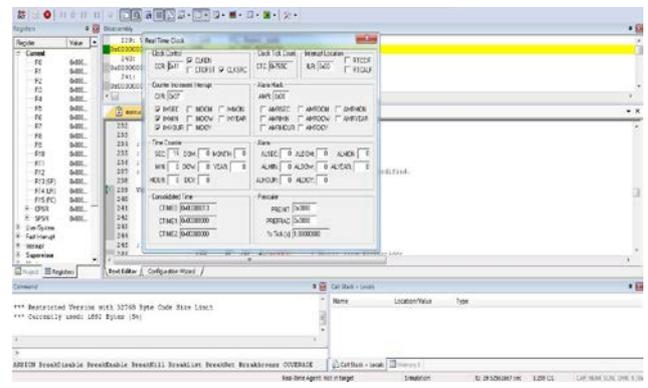
Result:- RTC Configuration
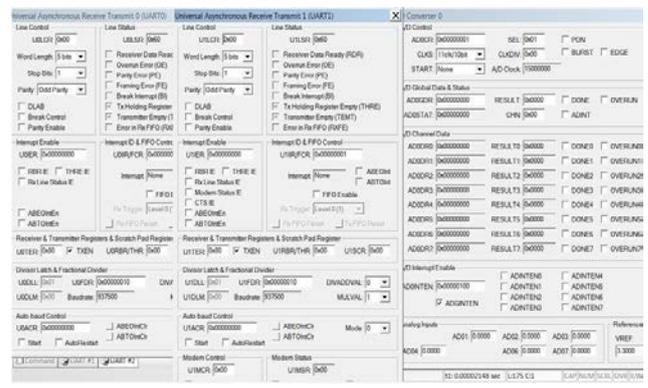
Result :- UART and ADC0 Configuration
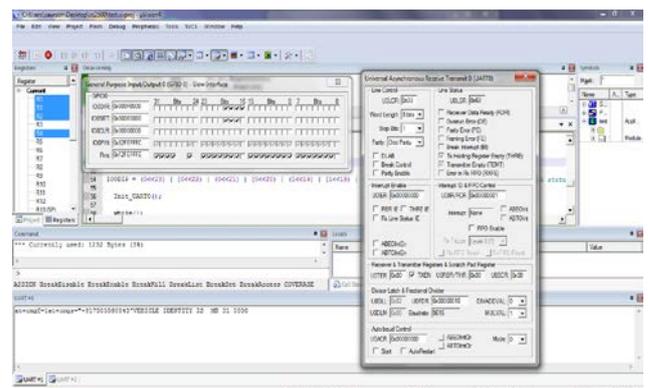
Result:- Simulation Result of UART and GSM SIM 300

Result:- Result on LCD screen

6. Conclusion

The ARM based advanced industrial control and data acquisition system has been designed with web monitoring feature. This system measures the temperature value, gas concentration in real time with RTC, system failure and human presence in restricted zone very effectively and precisely. The measured data has been displayed on LCD with good resolution. The system has long-distance communication facility, which tends to send a text message using GSM module, which can reduce some sort of disturbances and rejection in the communication network. A memory card is interfaced to store all the information generated by the system for every second. The data is transmitted through Ethernet network to remote desktop computers within the industrial area by using TCP protocol which displays data on web page.

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