

# IMPLEMENTATION OF AUTOMATIC REAL TIME SYSTEM FOR INDUSTRIAL MONITORING USING $\mu\text{C}/\text{OS-II}$

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**Abstract—** The main of this paper is to monitor the temperature and humidity values in manufacturing industries like PCB board designing industries, mobile and other electronics industries, power plant and etc. The temperature, humidity, etc., are the key issues in manufacturing electronics plant and it leads to loss in production. This paper aims to provide a solution to this problem by remote monitoring of the temperature, humidity levels of different area of the plant with the help of the Wireless Sensor Network Module and the system implemented with LPC2148 porting of  $\mu\text{C}/\text{OS-II}$  real time operating system. Here in addition, the buzzer facility is there to intimation sounds when over limit and SD card for further reference and to stores the data instantly and contiguous. These things make the electronic industries to manufacture the device ideal.

**Keywords—** LPC2148,  $\mu\text{C}/\text{OS-II}$ , WSN, RTC(DS1307), Communication Protocols, Gateway, SD card.

## I. INTRODUCTION

Recently the industries and others facing major production fault due to temperature, humidity and etc., thus temperature cause more defects like improper soldering joints, extra oxidation of boards, bridging the solder components and more issues regarding production. Even though the environment, particularly some machines like solder paste refrigerator, desiccators for storage of paste, bare PCB and boilers in power plants are respectively also have to control over these parameters.

Also some factory looking to control their machine's temperature with certain level to improve the efficiency of the particular machine, such a case some time lead unexpected accident, low product quality and more.

Hence now the monitoring and control system established with LabView tool, PLC and interfaces of microcontroller. But the authors have coming to share their ideas in this paper, to implement the monitoring and alert the temperature and humidity system with ARM with porting of  $\mu\text{C}/\text{OS-II}$ .

The system which is implemented with RTOS is having multitasking capability to monitor multiple tasks and

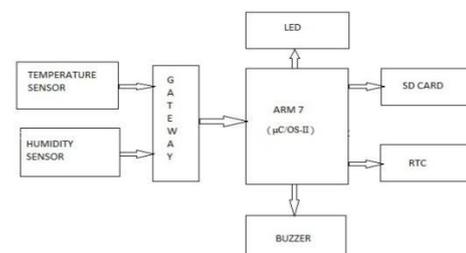
controlling it. Also the system can add more applications by patching to kernel. So the system updates also possible when it required.

The ARM Controller is latest one and it support higher end applications now a days. In here we can choose the ARM controller ported with real time operating system( $\mu\text{C}/\text{OS-II}$ ). The system connected through the wireless sensor network for monitoring remote area.  $\mu\text{C}/\text{OS-II}$  is a preemptive, hard real-time deterministic multitasking kernel for ARM Controller. The  $\mu\text{C}/\text{OS-II}$  running with Linux command and ANSI C source code for system and compilation.  $\mu\text{C}/\text{OS-II}$  can runs upto 256 tasks by patching as our requirement.  $\mu\text{C}/\text{OS-II}$  performs are inter-process communication (like semaphores, message queues and mailbox), timer management and memory management, interrupt processing and context switching. It supports for monitoring and controlling the environment by getting information from sensed value from industries at real time by guidance of the Engineers.

The complete architecture of this paper has been divided into different parts: the system hardware details, software detail, operational unit and finally the conclusion.

## II. HARDWARE DETAILS

The following figure 1 show simple working and hardware assembly of this paper



**Fig1 : Block diagram of industrial monitoring system**

The block shows experimental set up of this paper, Here the ARM processor will continuously getting input signal from

external or real time environment through gateway. The input signals are temperature and humidity which are measured real time manner, those measured are transmitted with wireless mode.

After getting the input signals, the processing unit will compares those values with fixed one. The fixed values are set upped with industry persons as their requirement level of particular industry and also the temperature and humidity fixed levels are varied at each industry. After the comparisons, if the values are exits with fixed value and then gives alerting through buzzer simultaneously the values are displayed in LED display.

Also the gathered input values are stored into SD card for future reference, the data storing is with respect to sensed time like, at that time what is temperature and humidity range.

### 2.1 ARM PROCESSOR

ARM designs microprocessor technology that lays at the heart of advanced digital products, from mobile phones, digital cameras to games consoles and automotive systems. It is leading intellectual property (IP) provider of high-performance, low-cost, power-efficient RISC processors, peripherals and system-on-chip (SoC) designs through involvement with organizations such as the Virtual Socket Interface Alliance (VSIA) and Virtual Component Exchange (VCX). ARM also offers design and software consulting services.

ARM7 processor family continues to be used today for simple 32-bit device, newer digital designs are increasingly making use of the newer, more powerful and feature-rich ARM processors which offer significant technical enhancements over the ARM7 family. System designers wishing to upgrade from ARM7 benefit from a robust ARM processor roadmap providing multiple upgrade options, including the latest Cortex processors. In most cases migration is straightforward, brings significant benefits in PPA, features and efficiency.

ARM's architecture is compatible with all four major platform operating systems: Symbian OS, Palm OS, Windows CE,  $\mu$ C/OS-II and Linux. As for software, ARM also works closely with its partners to provide optimized solutions for existing market segments.

### 2.2 LPC-2148

The LPC2148 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine the microcontroller with embedded high-speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the

alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty.

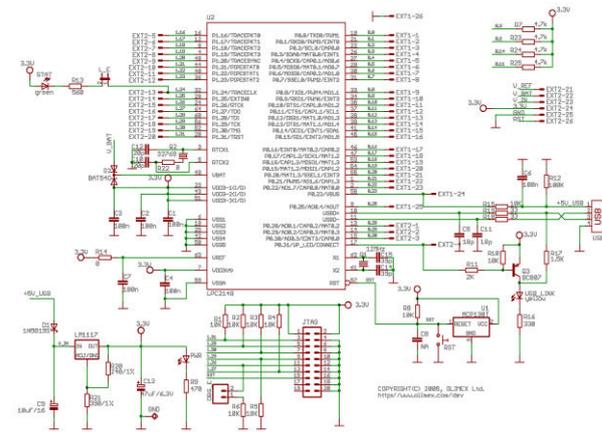


Fig 2 : LPC 2148 board schematic diagram

Due to their tiny size and low power consumption, LPC2148 are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I<sup>2</sup>C-bus and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single ordinal 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers suitable for industrial control and medical systems.

### 2.3 TEMPERATURE SENSOR

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature.



Fig 3 : Temperature sensor

The LM35 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 required any external

calibration or trimming to provide typical accuracies of  $\pm 1/4^{\circ}\text{C}$  at room temperature and  $\pm 3/4^{\circ}\text{C}$  over a full  $-55$  to  $+150^{\circ}\text{C}$  temperature range. Low cost is assured by trimming and calibration at the wafer level.

## 2.4 HUMIDITY SENSOR



Fig 4 : Humidity sensor

Humidity is the presence of water in air. The amount of water vapor in air can affect human comfort as well as many manufacturing processes in industries. The presence of water vapor also influences various physical, chemical, and biological processes. Humidity measurement in industries is critical because it may affect the business cost of the product and the health and safety of the personnel. Hence, humidity sensing is very important, especially in the control systems for industrial processes and human comfort. Controlling or monitoring humidity is of paramount importance in many industrial & domestic applications. In semiconductor industry, humidity or moisture levels needs to be properly controlled & monitored during wafer processing

## 2.5 GATEWAY

The wireless gateways from Comcast provide the functionality of a Wi-Fi router and voice modem in a single device. The wireless gateway functions such as firewall, port forwarding, port blocking, diagnostic tools and Wi-Fi Protected Setup. It gives a secure wireless home network and connects your computers, laptops, and other Wi-Fi electronic products (such as game systems, tablets, or mobile phones). The wireless gateway function in here is to receive the task from sensors and pass the task to ARM Processor.

## 2.6 RTC (DS1307)

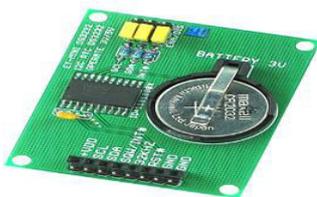


Fig 5 : Real Time Clock

The DS1307 is serial Real time clock(RTC) counts seconds, minutes, hours, day of the week, date, month and year. The purpose of an RTC or a real time clock is to provide precise time and date which can be used for various applications. RTC

is an electronic device in the form of an Integrated Chip (IC) available in various packaging options. It is powered by an internal lithium battery. As a result of which even if the power of the system is turned off, the RTC clock keeps running. It plays a very important role in the real time systems like digital clock, attendance system, digital camera etc.

In applications where time stamp is needed, RTC is a good option. Using RTC for designing such application has always been a good designer's choice although the beginning might be a bit difficult. While designing any real time system which deals with time, there are two ways of handling the time factor. One is to generate the time, internally which is done by programming the timers of the controller and the other is to use an RTC. The RTC is low power, 56 bytes of non-volatile RAM for data storage, 2 serial interface wire in bi-directional and 8 pin Dual Inline Package. The battery backup mode is less than 500nA and it has automatic power switching to battery when power fails at  $25^{\circ}\text{C}$ . The RTC operates in industrial temperature range from  $40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ . It is used in TV, VCR and phonenummer recall. The DS1307 RTC is connected to ARM controller using I<sup>2</sup>C bus with time counters refer Table 1.

Table 1. Cycle Length of the Time Counters, Clock Modes

UNIT	COUNTING CYCLE	CARRY TO NEXT UNIT	CONTENT OF THE MONTH COUNTER
Seconds	00 to 59	59 to 00	-
Minutes	00 to 59	59 to 00	-
Hours(24)	00 to 23	23 to 00	-
Hours(12)	12AM 01 AM to 11 AM 12PM 01 PM to 11 PM	- - - 11PM to 12AM	-
Date	01 to 31 01 to 30 01 to 29 01 to 28	31 to 01 30 to 01 29 to 01 28 to 01	1,3,5,7,8,10,12 4,6,9,11,
Months	01 to 12	12 to 01	-
Years	01 to 03	-	-
Weekdays	0 to 6	6 to 0	-
Timer	00 to 99	No carry	-

## 2.7 SD Card

The SD-memory card is non-volatile flash memory, portable device used in mobile, computer and other consumer appliances. It gives high security, memory size can vary depends on cost, used in audio and video recording.

The SD-memory card is a Secure Digital Input Output (SDIO) card, it support data protection, avoid the duplication sensed value in same timing and security systems based on identification cards in International standard ISO-7816. An embedded version of MMC is eMMC, according to the

JESD84-A43. The interfacing of SD card with ARM using Serial Peripheral Interface (SPI) bus and operates in 3.3volts.It offers up to 8-bit wide interface and can be applied in SD-memory card compatible hardware interfaces. While the SD-memory card adds an advanced data storage functions to an application and easily accessible.

### 2.8 BUZZER

Buzzer is an audio signaling device and it is mechanical, electromechanical or piezoelectric. It is used as alarm device in timing manner and confirmation of user input from personnel computer or other devices by making sound. Buzzer is connected to ARM using one wire connecting wire.



Fig 6 : Buzzer

### 2.9 LED display

Light emitting diodes (LEDs) are semiconductor light sources and it has two terminals. The light emitted from LEDs varies from visible to infrared and ultraviolet regions. They operate on low voltage and power. LEDs are one of the most common electronic components and are mostly used as indicators of circuit. LED display the monitoring value of temperature and pressure in real time environment.

## III. SOFTWARE DETAIL

It is a written description of a software product, that a software designer writes in order to give a software development team overall guidance to the architecture of the software project. An SDD usually accompanies an architecture diagram with pointers to detailed feature specifications of smaller pieces of the design. Practically, a design document is required to coordinate a large team under a single vision. A design document needs to be a stable reference, outlining all parts of the software and how they will work.

### 3.1 $\mu$ C/OS-II

$\mu$ C/OS-II is a portable, ROMable, scalable, preemptive, real-time deterministic multitasking kernel for microprocessors, microcontrollers and DSPs. Offering unprecedented ease-of-use,  $\mu$ C/OS-II is delivered with complete 100% ANSI C source code and in-depth documentation.  $\mu$ C/OS-II runs on the largest number of processor architectures, with ports available for download from the Micrium Web site.

$\mu$ C/OS-II manages up to 250 application tasks.  $\mu$ C/OS-II includes: semaphores; event flags; mutual-exclusion semaphores that eliminate unbounded priority inversions; message mailboxes and queues; task, time and timer management; and fixed sized memory block management.

$\mu$ C/OS-II's footprint can be scaled (between 5 Kbytes to 24 Kbytes) to only contain the features required for a specific application. The execution time for most services provided by  $\mu$ C/OS-II is both constant and deterministic; execution times do not depend on the number of tasks running in the application.

Software certification is vital in order to demonstrate the reliability and safety of software systems.  $\mu$ C/OS-II is currently implemented in a wide array of high level of safety-critical devices, including:

- Those certified for Avionics DO-178B
- Medical FDA pre-market notification (510(k)) and pre-market approval (PMA) devices
- SIL3/SIL4 IEC for transportation and nuclear systems, 99% compliant with the Motor Industry Software Reliability Association (MISRA-C:1998) C Coding Standards

## IV. COMMUNICATIONS PROTOCOL

All communications between devices require that the devices agree on the format of the data. The set of rules defining a format is called a protocol. Communication protocols cover authentication, error detection, correction, and signaling. They can also describe the syntax, semantics, and synchronization of analog and digital communications. There are thousands of communication protocols that are used everywhere in analog and digital communications. It supports both wired and wireless communication.

### 4.1 SPI BUS

SPI (Serial Peripheral Interface) bus is a low power, full duplex, master-slave interfacing bus. It is solid role in embedded systems whether it is system on chip processors, both with higher end 32-bit processors such as those using ARM, MIC or Power PC and with other microcontrollers such as the AVR, PIC etc. These chips usually include SPI controllers capable of running in either master or slave mode. In-system programmable AVR controllers can be programmed using an SPI interface. Chip or FPGA based designs sometimes use SPI to communicate. So, SPI is a common technology used nowadays for communication with peripheral devices where we want to transfer data speedily and within real time constraints. There are many serial interfaces right from more code telegraphy,

RS232, USB, Fire wire, Ethernet and many more. Each serial interface offers advantages or disadvantages for many designs, depending on criteria such as needed data rate, space availability, and noise considerations. It is simple 4 wire serial communication bus and it operates on 10MH. In SPI data is shifted in/out one at a time and transmit data from master device to/from one or more slave devices over short distances. It is high speed data transferring bus and no limit upto 8 bit transfer. The SPI bus is straightforward and versatile, enabling simple and fast communication with a variety of peripherals. A high speed multi-IO mode host adapter and some invaluable tool in debugging, as well as adding SPI communication capabilities to any test system.

#### 4.2 I<sup>2</sup>C BUS

**Two wires:** serial data (SDA) and serial clock (SCL). All I2C master and slave devices are connected with only those two wires. Each device can be a transmitter, a receiver or both. Some devices are masters – they generate bus clock and initiate communication on the bus, other devices are slaves and respond to the commands on the bus. In order to communicate with specific device, each slave device must have an address which is unique on the bus. I2C master devices (usually microcontrollers) don't need an address since no other (slave) device sends commands to the master .It supports both Multi-master and Multi-slave, so it can detect the collision easily. It supports 7 and10-bit addressing and each device connects to the bus using software with unique address. The maximum speed of the I<sup>2</sup>C bus is 3.4Mbits/sec and it varies depends on the modes of application. I<sup>2</sup>C bus is simple and flexible used in many applications.I2C bus is transferred in 8-bit packets (bytes). There is no limitation on the number of bytes, however, each byte must be followed by an Acknowledge bit. This bit signals whether the device is ready to proceed with the next byte. For all data bits including the Acknowledge bit, the master must generate clock pulses. If the slave device does not acknowledge transfer this means that there is no more data or the device is not ready for the transfer yet. The master device must either generate Stop or Repeated Start condition.

#### V. CONCLUSION

In this paper, the authors are develops the idea to monitor the temperature and humidity value using wireless sensor in Real time. In this paper the existing model has to monitor the temperature and humidity value using microcontroller. The result of this paper is more secure to keep the monitoring data in real time  $\mu$ C/OS-II. In future, ability to add some more tasks to monitor, such as employee authentication checking, data logging of cctv camera and etc. The values of the monitoring data in real time are displayed on the LED and Buzzer for intimation of warning.

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