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DATA LOGGING OF BOILER TEMPERATURE USING REAL TIME OPERATING SYSTEM

G. H. Rajavignesh and B. Rajasekar
Department of Electronics and Communication Engineering, Sathyabama University, Chennai, India
E-Mail: ghrajavignesh@gmail.com

ABSTRACT

This paper presents a data recorder of boiler temperature using RL-ARM Real time operating system. In order to monitor the boiler temperature, the system will record the physical values of temperature sensor from boiler in the EEPROM along with Real Time Clock (RTC) information's. So it can enable to view and access the data from wherever from the Electrically Erasable Programmable Read-Only Memory (EEPROM) using Personal Computer (PC). This system uses ARM7 Processor very portable with Real Time Operating System (RTOS) it employs the system more real time and handling various processes depends upon multi-tasking using embedded C language, data acquisition application is ported into an ARM processor. RTOS are programs that schedule execution in the suitable manner and used to manage system resources and provide a consistent function for developing application code.

Keywords: boiler temperature, ARM-TDMI, RL-ARM, I2C, UART, EEPROM, RTC.

1. INTRODUCTION

A Data Logger is also known as data recorder is an electronic machine that records the data over a period of time. Progressively they are based on a digital processor. They are normally tiny, battery operated, portable and assembled with microprocessor, internal memory used for data storage and sensor. Some data logger interface to the personal computer and make software to activate the data logger and viewing the collected data and local interface device (keypad, LCD) and it can be used as a stand-alone device. Data logger has changes in general purpose types for aspect range of measurement to very specific devices used for measuring in environment. It is used for general purpose types to be programmable however static machines have only a limited number and have no changeable parameters. Electronic data loggers are used as a replacement for chart recorders in many applications. The proper instrumentation is to initialize and control system are required to assist the operation personnel in performing dynamics and consistent operation. The systems are connected with computer and make active the data logger. Thereafter logger can be disconnected and it can be inserted in any system that can be viewed the records which stores the corresponding data in memory along with date and time respectively. The measuring of boiler temperature is very absolutely necessary apart from the collateral damages and by use of RTOS multitasking function can be performed in effective manner with simple operation.

Microcontroller is very practical and successfully applied, the conventional 8 and 16-bit Microcontroller has its insufficiencies when compared with 32-bit. The ARM (Advanced RISC Machine) architecture is based upon Reduced Instruction Set Computer (RISC) principles, and the instruction set and with related decode mechanism are very simpler than those of micro programmed Complex Instruction Set Computers. This simplicity end results in a high instructions throughput and impressive real-time interrupt response from a tiny and cost-effective processor core. ARM based embedded system will be more functional, consistent, cost effective, less in size and low power consumption. Micro-controller has low speed and poor memory, so it can only execute simple control tasks.

2. BACKGROUND REVIEW

A. RL-ARM

The Keil Real-Time Library is a collection of middle-ware component is build to work across many different microcontrollers. The Real-Time Library consist of five main components.
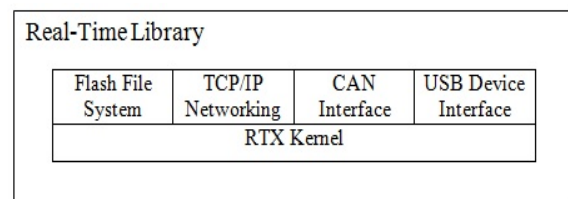

Figure-1. Structure of RL-ARM.

They are Flash file system, a TCP/IP networking suite, driver for USB and Controller area network and RTX Kernel. Each of the middleware components is structured to be used by the Keil RTX real time operating system. Flash file system includes the on-chip and external RAM and with Flash memory as well as Serial peripheral interface based Flash memory and SD/MMC memory cards. TCP/IP library supports TCP and UDP communication and also enable a microcontroller to be a server for the TELNET, HTTP and File Transfer (FTP) protocols. The USB protocol is complex and wide-ranging to support the USB protocol, and the USB host operating system. CAN interface include a basic CAN driver and hardware adaptations for several ARM based Microcontroller. RTX kernel uses the required execution priorities to select the next task to run and also provides

additional functions for inter-task communication, memory and peripheral management.

B. Real time operating system

An RTOS (Real Time Operating System) will be effective to perform the real time applications to be designed and expanded more easily while meeting the performances required. The main functions of RTOS are multitasking, scheduling, interrupt handling, inter task communication and resource allocation.
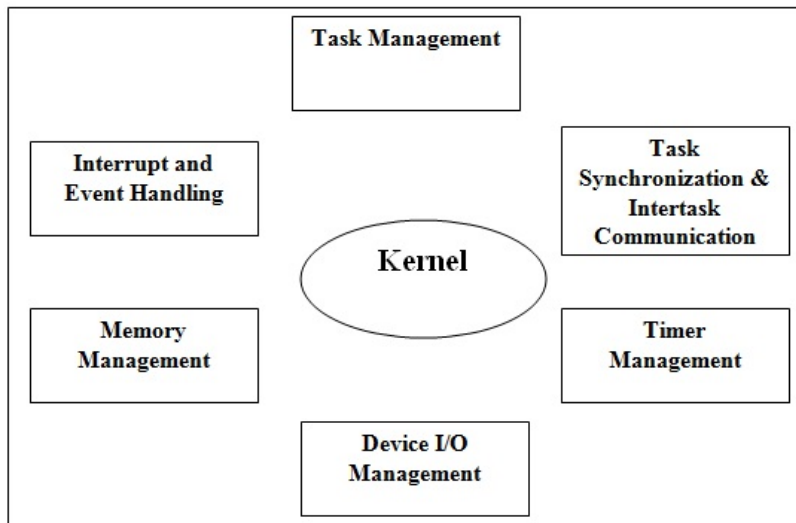

Figure-2. RTOS Kernel services.

Multitasking is sharing of CPU between several independent tasks. Scheduling is also called as dispatcher and it is part of kernel for determining which task will run task. Inter process communication enables sharing of data among tasks through allocation of memory space and transmission of data. Interrupts handling is used to block the highest priority tasks. The advantages are low cost, high performance devices with large amount of internal memory and it consume less time.

3. HARDWARE IMPLEMENTATION

The basic block diagram of the Data logger based on ARM7 is shown in Figure-3. This work implements a Data Acquisition System with RL-ARM using ARM microcontroller. The LPC2148 are peculiar to 16/32 bit ARM7TDMI-S microcontroller CPU with present real-time emulation and embedded trace support, process together with 128/512 kilobytes of embedded high speed flash memory. LPC2148 microcontroller circuit board consists of ADC, UART, I2C, EEPROM and I/O Ports. It has a separate power supply.
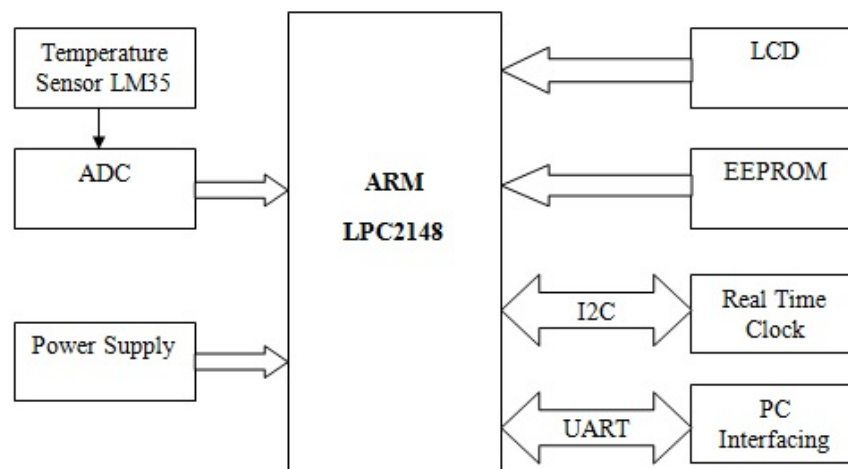

Figure-3. Block diagram of data logger based on ARM7.

A. Temperature sensor

LM35 is the temperature sensor developed from National Semiconductor. This sensor output voltage is linear relatively proportional to the Celsius. It maintains an proper value of +/-0.4 ℃ at room temperature and +/-0.8 ℃ over a range from 0 ℃ to +100 ℃. Also the temperature from surrounding monitored through temperature sensor. The consistent temperature level will be logged at limited intervals and will be transferred to the main station. The temperature sensor which could give a proper linear output value of sensed temperature of the location for monitoring and controlling.

B. LCD

The LCD (Liquid Crystal Display) controller can be programmed used to support different requirements on the screen. LCD 16x2 display module (i.e., degree to Fahrenheit) is connected to the General Purpose Input/output ports (GPIO) of microprocessor.

C. UART

UART is a Universal Asynchronous Receiver Transmitter protocol has been used to communicate with PC where it can read the back the data's where it's stored in the EEPROM with higher baud rate.

D. Inter integrated circuit (I2C)

It has been used to access the EEPROM. I2C (Inter-IC) bus is a bidirectional two wire serial bus system that provides a communication link between integrated circuits. Data is exchanged between these devices.

E. Microcontroller to LM35 interface

At first, the microcontroller is interfaced to the temperature sensor such as LM35. This LM35 produce an analog signal corresponding to the temperature values. Then the analog signal is converted into required digital signal by use of ADC process and then the digital value is read by microcontroller. Microcontroller is programmed to read this corresponding digital value to the temperature and it is stored in embedded microcontroller. Data can be displayed in the LCD by required program coding to the microcontroller.

4. SOFTWARE IMPLEMENTATION

The software section is consist of two software involved namely KEIL µVISION, FLASH MAGIC.

A. KEIL µvision

Keil IDE is used for execution and implementation. Keil IDE is an windows operating system software program that operates on a personal computer to build applications for ARM microcontroller and digital signal controller. It is also called as Integrated Development Environment (IDE) since it make available a single integrated environment is used to develop code for embedded microcontroller. Keil adds many new features to the Editor like Text Template, Quick Function Navigation, Syntax Colouring with brace highlighting,

Configuration Wizard is used for dialog based startup and debugger setup.

B. Flash magic

NXP Semiconductors produces a range of microcontroller that contain both on-chip Flash memory and the ability to be reprogrammed by using In-System Programming technology. Flash Magic is Windows software developed from the Embedded Systems Academy that permits easy access to all the ISP features are provided by the devices.
These features include:

- Erasing the Flash memory (individual block or the whole device)
- Programming and reading the Flash memory
- Implementing a blank check on a section of Flash memory
- Direct load of new baud rate such as high speed communications
- Sending commands to place device in the Boot loader mode

Flash Magic will provides a clear and simple user interface to these features and more as described in the following section. In Windows, only one application may have access the Communication Port at any one time and preventing other applications from using the Communication Port. Flash Magic only obtains access to the selected Communication Port when Internet Service Provider (ISP) operations are being performed. This process that other applications that need to use the Communication Port, such as debugging tools and may be used while Flash Magic is loaded.

C. Tera term

It is an open-source, free, software implemented, and terminal emulator such as communications program. It emulates with different types of computer terminals and also supports telnet, Secure shell 1 and 2 and serial port connections.

5. PROPOSED METHODOLOGY

The proposed methodology has an effective for boiler temperature to ensure the safe operation and equipment to improve the efficiency. The temperature sensor from the boiler that is connected to the ARM7 controller to make required process and then the system will store physical values of temperature in the EEPROM with respect to Real Time Clock (RTC)'s data. The I2C bus is bidirectional device and for Inter-integrated circuit control using only two wires are a serial clock line and a serial data line. Each device has unique address and it can be operated in as either a receiver-only device. Transmitters and receivers can operate in either master or slave mode it depending upon whether the chip has to initiate a data transfer or is only addressed. Inter Integrated Circuit (I2C) has been performed to access the EEPROM. LCD display GUI (Graphical User Interface) is used for

instant display of RTC time and sensor data's. The Keil RTX is supremacy and stable Real-Time Operating System design for ARM processor based microcontroller used is LPC2148. A new project code is created in Keil IDE (Integrated Development Environment) by selecting the microcontroller from the device database. This corresponding step is essential to develop with right complier and debugger. The essential configuration settings for RTOS like time slice for each task and stack size are modified through the RTX_Config.c file which is added to the project. The RTX kernel involves a scheduler that runs program code as tasks. Totally three tasks are created by assigning individual task ID's. Normally RTOS-based program is made up of a number of tasks, which are controlled by the RTOS scheduler. The scheduler allots time segment for each task and executed by multitasking. All tasks are assigned with the same priority. Since all tasks have equal priority they are allotted run time in a round robin fashion. However when a task becomes ready to run with a high priority then the RTX scheduler will de-schedule the currently running task and start the high priority task running. This is called pre-emptive priority-based scheduling. The microcontroller is connected with a PC (Personal Computer) through UART0 port where it can read the back the data's where its recorded in the EEPROM with higher baud rate. The hex file generated is downloaded to the microcontroller using flash magic tool. The functions of tasks are explained separately.

A. Task 1

The first task is created and used to start additional tasks required for the application. While the first task may continue to run, it is good programming style for this task to create the necessary additional tasks and then self-delete itself in order to reduce context switching overhead. The *os_sys_init (task1)* function starts RTX but only starts the first task running. After the operating system has been initialized, control will be passed to this task.

B. Task 2

This task is used to perform ADC process and RTC operation. This task is used to measure the temperature value from the temperature sensor. The outcome of temperature sensor is analog output where the analog value of the ADC is read, converted into digital value and displayed in the LCD. It also used to measures the passage of time to maintain a calendar and clock. The RTC (Real-Time Clock) is used to provide a set of parameters to measure time when normal or idle operating mode is selected. The RTC consumes use little power and making it suitable for battery operated systems where the CPU is not running continuously.

Figure-4. Temperature value displayed in LCD.

Simultaneously it process both the operation where the value of temperature from LM35 with respect to date and time respectively.

C. Task 3

This task is used to store the physical values in EEPROM through I2C. Inter-IC bus is a synchronous protocol that allows a master device to originate

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communication with a slave device. The letter 'S' indicates that the operation is in working condition for storing the accurate values in EEPROM.
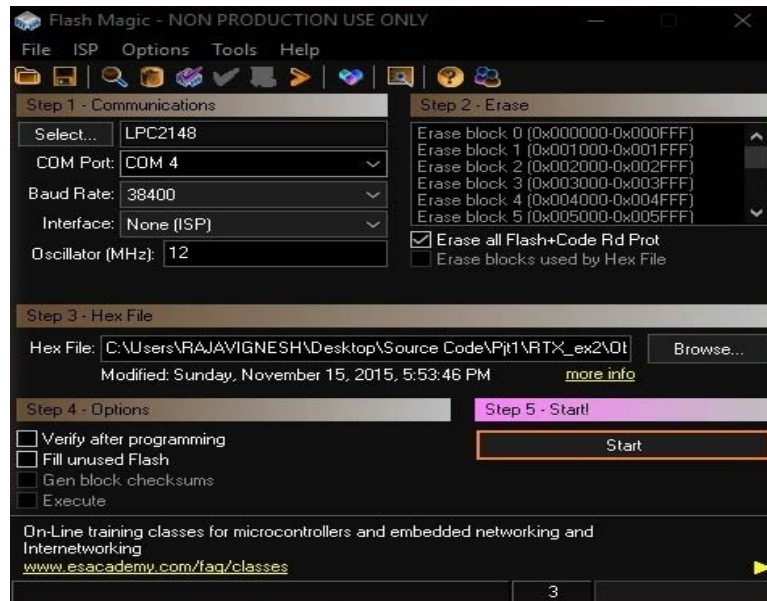

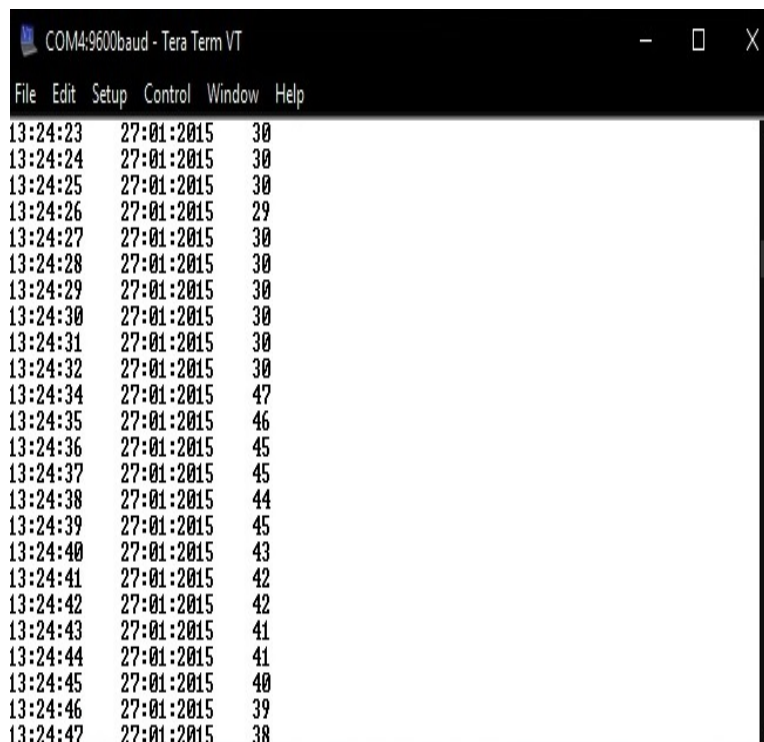**Figure-5.** Hex file generated to microcontroller using Flash Magic.

Figure-6. Output viewed through Tera Term.

The user communication is established through the tera term program available in the PC. The output values can be viewed by using tera term.

6. EXPERIMENTAL RESULTS

The proposed method was tested on LPC2148, a 32 bit ARM7TDMI-S microcontroller. The system is simple to install and easy to maintain with accurate time and memory management. It can be performed in real time

with each function getting ensured time slices to execute. This method can also be enhanced by modifying the tasks to be executed in a round-robin fashion, pre-emptive, and cooperative multitasking of program tasks. Thus Data Acquisition System using RTOS has shown that it is more effective to achieve better control results.

7. CONCLUSIONS

In this paper, we presented a data acquisition system for boiler temperature using RTOS offers necessary functions to develop the system fast and efficient an application. The system can be used for performing the real time controls where there have standard electrical interfaces. High precision data acquisition system can used to attain by the embedded system. The hardware and software has provided a platform for diverse control and acquisition applications. Since the embedded system is capable to deal with Multi-Tasks and can function as field controls, operating systems, and management. The system can be contacted to the Personal Computer interface and compute the humidity value, temperature and other data. The Data Acquisition System is an unique tool for storing of data and analyse experimental data that having the clear capability to present the real time results, with sensors and able to respond to parameters that show the advantages over the traditional methods. Thus by making the above changes we can reduce the cost and complexity of the whole system and we can also improve the performance of the instruments by using ARM processors.

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