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Research Article

# Design and Development of ARM7 Based Real-Time Industry Automation System using Sensors & GSM

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**Abstract**

Automation is the current need of industries. There are number of technologies that are growing to achieve the good automation in the plant. One of the recently popular technologies is the automation using sensors and actuators. Here in this paper development of ARM7 and uC/OS-II RTOS based real-time industry automation system using GSM communication is presented. The proposed system is having centralized controller, sensors and relays. Centralized module is the main unit that collects the information from plant sensors and gives this information to the end user using GSM communication. Also whenever needed it control the production automatically by switching the relays and actuators. The ARM7 LPC2148 is used as monitoring and controlling unit for different parameters. Some time more than processes need to be monitor and control in real-time. To control the process in real-time uC/OS-II Real- Time Operating System and needful files are dumped in to ARM controller. ARM7 LPC2148 controller is programmed using Embedded C language. Results obtained show the usefulness and effectiveness of the system as planned.

**Keywords:** Automation; Sensors; Relays; GSM; RTOS

## Introduction

Automation is need of any industry to control industrial machinery and processes, reducing the need for human interference. With technology growing at a fast rate, automated machine status tracking system of completely automated processes is today's need that will be used in a variety of ways to track and display machine information or status in Real-time on hand held devices with wireless technology like Zigbee/GSM/GPRS [1]. Currently available system are not fully automatic, these need to monitored time to time. Presently SCADA like systems are used for automation purpose but the problem is that such systems cannot be controlled from remote location. Also the shop floor data is not available to the higher authority persons like Manager, MD etc. In industry environment some process are completely automated for e.g. Sterlite industry is making the production of fiber optic cables, once the process started it runs continuously for months. In such processes some parameters like temperature, pressure, gas leakage, production achieved etc need to be controlled in real-time from remote location.

There are few skilled persons in the industry; they need to touch in every moment about the parameters such as temperature, pressure, gas leakage, production achieved etc. By assuming this a automation system is developed in a such a way that even if concern person is not present at field, he can become aware, update and control the status of that particular plant with the help of GSM communication. Different sensors are mounted to get the data from plant environment. Sensor signals are given to the ARM controller for signal conditioning and according to the need controller is programmed and produces the control signals to control the operation .In this system two or more tasks need to be controlled and monitor at same time. In such system uC/OS-II RTOS is implemented to manage resource allocation to user in orderly and controlled manner by enabling the assignment of priority and priority conversion [2].

Different researchers have worked and many methods have been suggested on the industrial automation and control using different communication technologies, out of them some are still working to improve more and more. Vehbi C. Gungor et al. proposed [3] that different communications technologies supported by two main communications media, i.e., wired and wireless, can be used for data transmission between smart meters and electric utilities. G.M. Sultan Mahmud Rana et al. designed and implemented [4] a cost effective home security system using the GSM technology. The system is designed to detect burglary, leaking of harmful gas. Ajith Kumar et al. suggested an article An Industrial Perspective on Wireless Sensor Networks-A Survey of Requirements, Protocols, and Challenges, focused on the use of WSN in industrial applications [5]. The better and effective industrial communication is characterized by the fact that interaction and control must take place in real time, with hard time requirements [6]. By considering the above work and need of industries an industrial application oriented automation system is developed and implemented for sponsoring industry i.e. "Yeshshree Press Comps Pvt. Ltd., Aurangabad" Upcoming challenges and future scope are discussed at the end of paper.

## Methodology

The proposed work includes the collection of data from different sensors like temperature sensor, inductive sensor, IR sensor etc are placed in the production working environment. Out of all some sensors gives the analog data and some gives digital pulses, analog signals undergo signal conditioning to convert it to digital. The controller used is ARM7 LPC2148 which belongs from ARM family. Relays are used for controlling and switching purpose. Controller takes the sensor values and displays it on LCD and as also at the same




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time send it at remote location to alert user through GSM in the form of SMS. If sensor value exceeds than predefined then user can control the process by passing the commands the through SMS and action can be controlled using relay switching. For execution of operation in Real-Time uC/OS-II RTOS is ported and dumped into LPC2148.

## Block Diagram Description

The proposed work is divided into two parts. First part consists of collection of data from different sensors like LM35 temperature sensor, inductive sensor and IR sensor etc. These sensors are mounted at different desired location in the plant to measures the parameters like temperature, metal detected, non-metallic abject detected, production achieved etc in real-time and gives this data to ARM7 LPC2148. In Second section microcontroller collects the all the sensor values and compare it with predefined values in the program. If the sensor values exceeds than predefined then it takes the necessary action to control the parameters by switching the relays i.e. ON/OFF. At the same time controller send the SMS to alert the user who is at remote location. User may send the control command using SMS to control the parameter if needed. LCD is used to display the parameter details according to priority assigned to the task using uC/OS-II RTOS (Figure 1 and 2).

## Hardware Description

Proposed block diagram of the system is shown in the Figure 1 consists of different sensors, ARM7 LPC2148 [MCU], GSM modem, uC/OS-II RTO files, LCD display and power supply.

### ARM7 LPC2148 microcontroller

ARM7 LPC21487 is one of the widely used micro-controller based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded support. LPC2148 is RISC based processor that uses fewer transistors than other typical processors. Hence it leads to low cost and low power consumption. In this work some sensors such as LM35 temperature sensor gives the analog data that need to be convert in to digital. Its 10-bit A/D converter provide digital output with respect to the voltage given by LM35 with conversion times as low as 2.44 us per channel. The power supply operating voltage range is from 3.0V to 3.6V. The main reason behind selection of ARM7 is its support for uC/OS-II RTOS for real-time execution of tasks. Programming of is done using embedded C-Language with the help of Keil IDE software tool.

### uC/OS-II RTOS

uC/OS-II RTOS is a real-time operating system which is used to perform a task within particular time interval. Compared to OS and RTOS, RTOS supports only multitasking and time scheduling tasks. uC/OS-II allows multiple tasks to run at the same priority level [7]. If we implement without uC/OS-II it is less accurate and time delay will be more, and it cab possible to perform one task at a time. In normal operation system performs a task one by one. So to overcome this problem I am implementing uC/OS-II for number of tasks as displaying temperature on LCD display, object detection by IR sensor, metallic Object detection by inductive sensor, switching relays etc. Priorities are assigned to tasks to get access of resource. Inter-task or inter process communication in C/OS takes place using Semaphores, Message mailbox and Message queues. Tasks and Interrupt service routines (ISR) can interact with each other through an ECB (event control block).

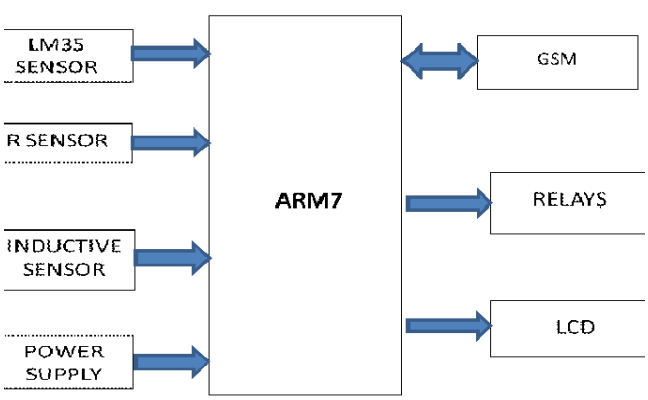


**Figure 1:** Block Diagram of proposed system.

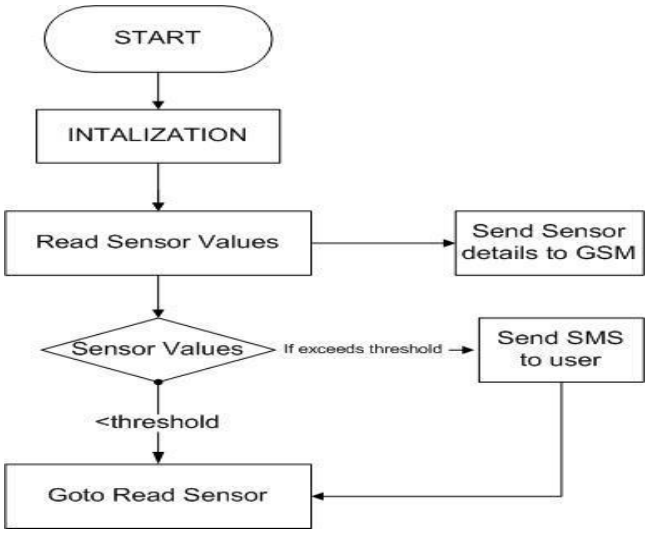


**Figure 2:** Flow chart of the system.

### 2*16 LCD display

Matrix LCD display [2*16] is employed in this work to display the necessary parameters. Once the minimum required voltage is applied to the electrodes, the liquid molecules will be aligned on selected directions. Here display is used as resources for different tasks. uC/OS-II gives the access of LCD to highest priority task at a time according to the priority assigned to the tasks.

### GSM SIM900A modem

In this work i have selected GSM SIM900A because of its baud rate and low power consumption. ARM controller within very short time period read the sensor values and creates SMS AT (Attention) commands. These commands will be send to GSM modem connected to controller. Modem executes the commands to send/receive SMS alert to user at remote location. Some sample commands used to GSM are "AT+CMGL" List message, "AT+CMGR" Read message, "AT+CMGS" Send Message [8].

### LM35 Temperature sensor

The LM35 series are precision integrated-circuit temperature

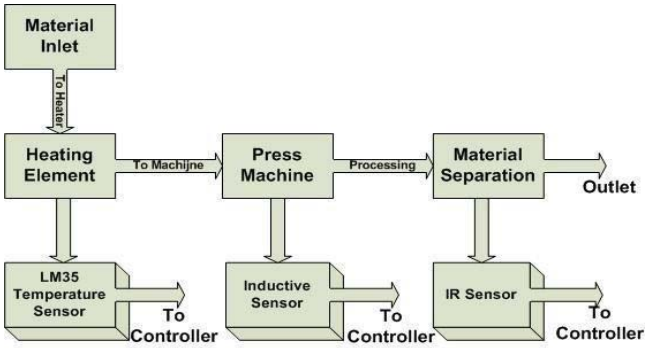


**Figure 3:** Industrial Automation System.

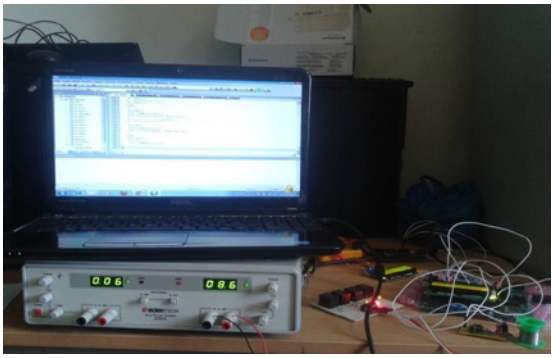

**Figure 4:** System setup in the LAB.

devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device does not require any external calibration or trimming to provide typical accuracies at room temperature. The range of LM35 is from minus 55 Degree centigrade to plus 150 centigrade [7]. Output of the LM35 is analog which is given to the inbuilt ADC 0.1. After converting the analog voltage, output value is showed on LCD display.

### Inductive sensor

Proximity (inductive) sensor is an electronic proximity sensor, which detects metallic objects without touching them. Hence it can be particularly useful for applications where access presents challenges or where dirt, oil and water etc are prevalent. Inductive proximity sensors emit an alternating electro-magnetic sensing field. When a metal target enters the sensing field, eddy currents are induced in the target, reducing the signal amplitude and triggering a change of state at the sensor output. As the output of inductive sensor is in the form of pulses it does not require any digitization.

### IR sensor

IR detectors are specially filtered for Infrared light; they are not good at detecting visible light. IR detectors are digital out - either they detect 38KHz IR signal and output low (0V) or they do not detect any and output high (5V). When an object is close to the sensor, the light from the LED reflects off the object and into the light sensor. This results in a large jump in the intensity, and considered as object detected. When the object is far away from the sensor there is no reflection of back light hence it give high output.

## Application Specific Diagram

The system developed can be implemented in the industry for specific application as shown in Figure 3. The system is used in the automobile plant where the one part of the vehicle is to be made by molding metal. From inlet metal plates are forwarded towards heater through conveyor belt to heat at specific Figure 3.

Once the metal plates reaches at the heater point heater will be started by controller, temperature will start rising. LM35 will analyze the temperature values in real-time and given to controller to compare it with predefined required values. At the same time temperature is shown on LCD display. Once the values exceeds than predefined one, heater will be OFF by cutting its supply using relay switching.

Heated object is forwarded towards press machine to make die of it. At press machine inductive sensor is mounted which detects the presence of object. When the as soon as the metallic object is sensed by the sensor it gives signal to controller and same time it is displayed on the LCD. Controller will make press machine ON to produce stroke and make that object into die.

Ready die object is forwarded towards outlet, at the end IR sensor is kept to detect the presence of the object, as the object is detected it gives low signal to the controller, accordingly controller will make request to the pick and-place robot to pick the object aside. In this application GSM is used to send SMS to user regarding to production details. User may stop the whole process by sending command to controller to cutting main power supply.

## Results

In this work, the sensors are successfully and interfaced with the ARM7LPC2148. The data or values received from the sensors were displayed on the 16X2 LCD display and also controlling the implemented corresponding devices according to the plant operation on the basis of received data. The snapshots and figures show the optimized results. Figure 4 shows proposed system setup made in the lab before implementing in the plant. Figure 5 shows the results of temperature measured and presence of metal object detected by inductive sensor. Figure 6 shows the results of temperature measured and presence of the object detected by IR sensor. Figure 7 show the snapshot of the SMS received to the user informing production details.

## Conclusion and Future Scope

The sensor based automation system can collect sensor data


**Figure 5**: Temperature measured and metal object detected.

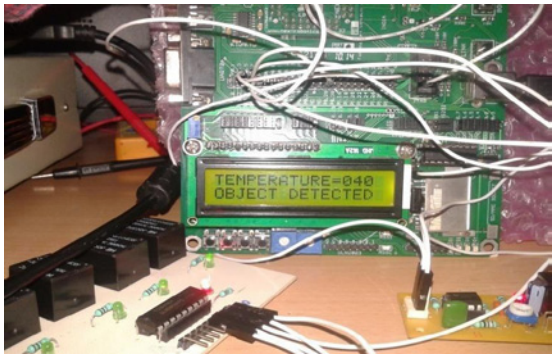


**Figure 6:** Temperature measured and object detected by IR Sensor.


**Figure 7**: SMS received to User showing production details.

intelligently. It was designed based on ARM LPC2148 and uC/OS-II RTOS and the application of wireless communication. It is very suitable for real-time and effective requirements in data acquisition system in industrial environment. Different types of sensors can be used as long as they are connected to the system. We can monitor the plant environment through GSM.

As the number of input to the ARM controller is limited, for industry purpose we can use the PLC controller for higher inputs/outputs. It is possible to develop android application for automation systems with the help of Internet communication.

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