Real-Time Monitoring and Control System for Industry

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Abstract— Industrial automation and control systems become an integral part of industries and hence the project Real-Time Monitoring and Control System is an important system. Real-Time Monitoring and Controlling System aims to monitor the environmental parameters like Temperature, Humidity, Pressure statistics in any factory and controlling peripheral systems also transmit parameter wireless to the Monitoring room using Zigbee Technology. It uses ARM 7 based embedded technologies from NXP which is sister company of Philips and made for used in highly sensitive and critical Real Time systems.

I. INTRODUCTION

Automation and control systems are an integral part of an industry and hence the project "Real-Time Monitoring and Control System" is an important system. Real-Time Monitoring and Control System aims at monitoring the environmental parameters like temperature, Humidity and Pressure statistics in any factory and controlling peripheral systems. Monitor parameters from Monitor room using Wireless using Zigbee Technology. It uses embedded technology from NXP which is sister company of Philips and built for application in highly sensitive and critical systems.

Remotely the system allows the user to effectively monitor and control the house/office appliances and equipments via the mobile phone set by sending commands in the form of SMS messages and receiving the appliances status.

The principle in which the project is based is fairly simple. First, the sent SMS is stored and polled from the receiver mobile station and then the required control signal is generated and sent to the intermediate hardware that we have designed according to the command received in form of the sent message.

I have selected a particular SIM900 GSM module for my project. The messages are sent from the mobile set that contain commands in written form which are then processed accordingly to perform the required task. A microcontroller based system has been proposed for our project. There are several terminologies that are used extensively throughout this project paper. I have selected LM35 as Temperature Sensor. The LM35 thus has an advantage over the 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. Humidity Sensor is HR-202 which gives output in Relative Humidity. It is depend on Temperature of the room. HR-202 is liner with output voltage.

The microcontroller used here is LPC2138. It belongs to a class of 16/32 bit microcontrollers of RISC architecture & a Program Memory (FLASH) for storing a written program. Since the memory is made in FLASH technology, it can be programmed and cleared more than once & makes this microcontroller suitable for device development. It has inbuilt ADC and USART. In the receiving section, the temperature is displayed on 16x 2 LCD. If parameters beyond set limit than inform to supervise by SMS. Functional flow diagram of the system as shown in Fig.1

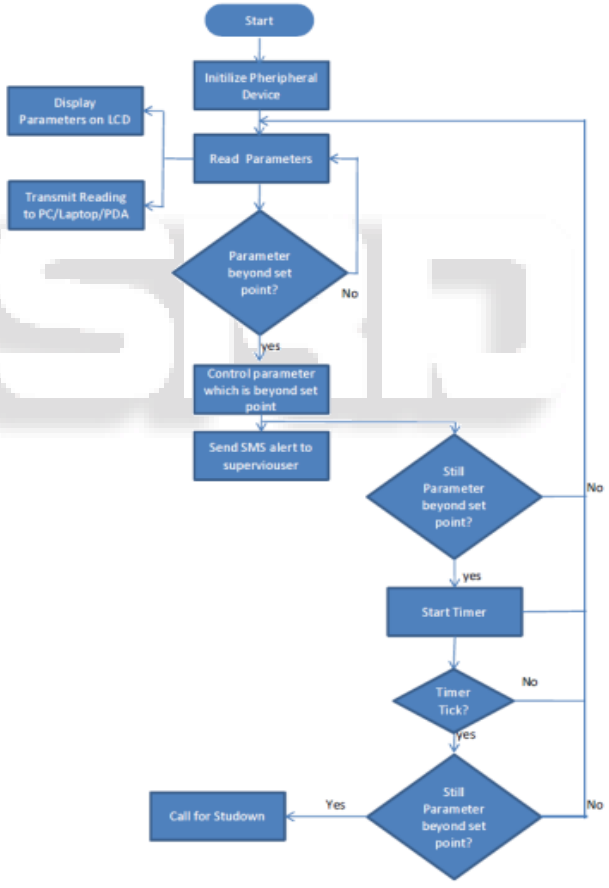

Figure.1: Functional Flow Diagram of the System

The paper covered in the following sequence. A brief introduction about the work undertaken in this paper and the relevant literatures were presented in the previous paragraphs. Block Diagram of the system describe in Section2. Description about the Microcontroller in the section 3. Section 4 depicts about the background literature of sensors and it's interfacing with Microcontroller. The ransmitter & receiver part is presented in section 5. This is followed by the conclusions, followed by the references.

II. BLOCK DIAGRAM & DESCRIPTION

As shown below Fig.1, use controller LPC2138 which is connected with one 2.4 GHz RF Zigbee module for transmit data wireless to the PC for display values of parameter in laptop/PC for monitoring purpose and second GSM module connected with controller for send emergency alert to the supervisor. In one port of LPC2138 connected peripherals for control parameters and sensors for measurement parameters.LCD 16x2 for display current temperature and set temperature point with set precision values.

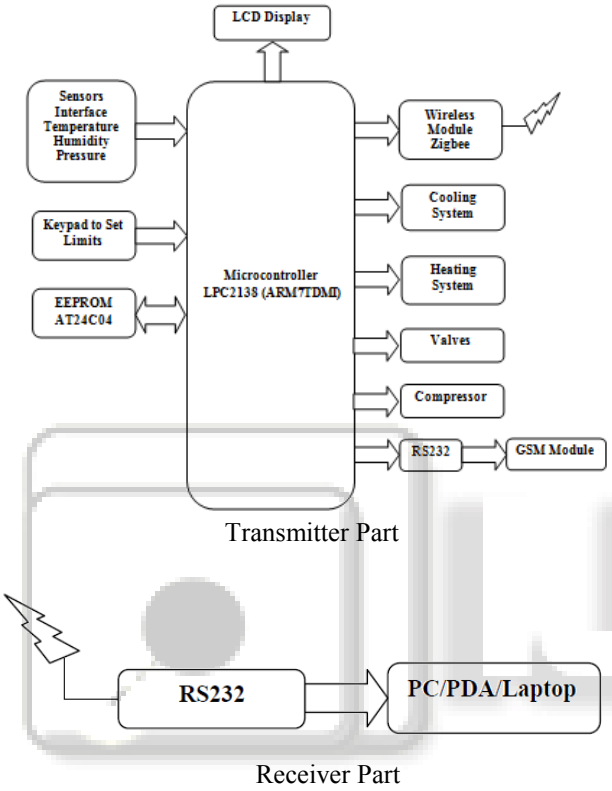

Figure. 2 : Block Diagram of Whole System

GSM Module used as SIM900 by SIM Technology. Block diagram shows other peripherals are used for controlling temperature if high than cooling and if low than heater are connected with microcontroller. For monitoring purpose used wireless technology Zigbee to transmit parameter value to the PC/PDA/Laptop.

III. DESCRIPTION ABOUT THE MICROCONTROLLER

This section gives a brief idea about the LPC2138 microcontroller, its core features, block diagram, pin diagram and its description.

Key features common for LPC213x

- 16/32-bit ARM7TDMI-S microcontroller available in various packages with 64 pins.
- LPC2138 have of 32 kb on-chip static RAM and 512 kB of on-chip flash program memory.
- LPC2138 have easy to load program in his on-chip flash program with help of In-System Programming or In-Application Programming (ISP/IAP) via on-chip boot loader software.
- LPC2138 also support RTOS like EmbeddedICE and offer real-time debugging with the on-chip RealMonitor software with high-speed tracing of instruction execution.
- LPC2138 have 2 ports with 8-channel 10-bit ADCs so we can connect 14 analog inputs with it.
- LPC2138 have one single 10-bit DAC.
- LPC2138 have two 32-bit timers, PWM and watchdog timers
- LPC2138 have RTC (Real time clock) with is independent of power and work on 32 kHz clock input.
- LPC2138 have two UART ports, two I2C ports, SPI Port. LPC2138 gives 5 V tolerant to general purpose I/O pins
- LPC2138 have vectored interrupt controller with configurable priorities of interrupts and serves interrupt according to specific vector addresses.
- It can be work on up to 60 MHz maximum CPU clock and On-chip integrated oscillator operates with external crystal in range of 1 MHz to 30 MHz and with external oscillator up to 50 MHz
- LPC2138 have auto power saving modes, idle and Power-down modes.
- LPC2138 operating voltage range from 3.0 V to 3.6 V with 5 V tolerant I/O pads.

IV. LITERATURE SURVEY ABOUT SENSORS AND INTERFACING WITH MICROCONTROLLER

A sensor is a device that measures a physical quantity and converts it into an equivalent digital signal. The basic parameters which are measured in the climate monitoring are temperature, relative humidity. For this, temperature and humidity are used.

A. *Temperature Sensor*

LM35 IC which was manufactured by National Semiconductors is used to measure temperature. The temperature sensor has three terminals as shown in Fig.2. The data pin is connected to the chanel-3 of the inbuilt ADC using port pin P0.30. The sensor gives electrical output proportional to the temperature (^oC). The general equation used to convert output voltage to temperature is

$$T\ (^oC) = V_{out} * (100^o C / V_{cc})$$

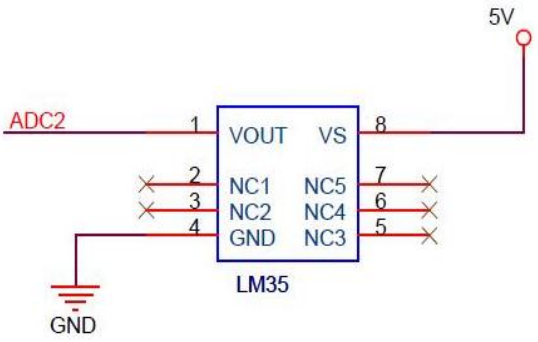

Figure. 3 : Pin connection of Temperature sensor

B. *Humidity Sensor*

HR202 humidity sensor is used to measure humidity. Humidity is an important factor in personal comfort and in quality control for materials, machinery etc.

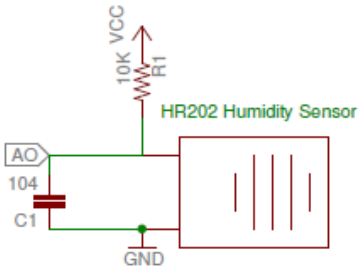

Figure.4 : Pin connection of Humidity Sensor

C. *Pressure Sensor*

I was selected SPD015GA Pressure sensor which gives output proposal to Voltage with respect to applied pressure. SPD015GA, G is indicate Gauge and A for Absolute. So output of this sensor without applied pressure gives atmospheric pressure and by default offset without applied pressure is 0.5V when 5V supply. If supply can be 2.7V to 5V so according to applied supply offset value is change. SPD015GA can be measure up to 15 PSI pressure.

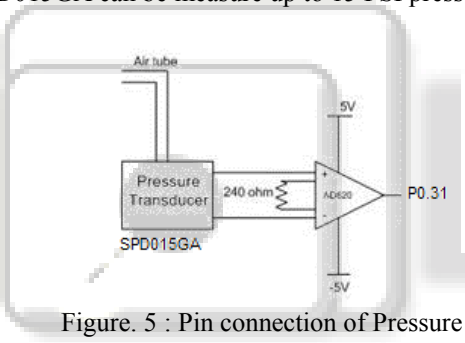

Figure. 5 : Pin connection of Pressure Sensor

D. *LCD Interfacing to Microcontroller*

A liquid crystal display (LCD) is use to display temperature, Relative Humidity and Pressure. Its major features are its lightweight construction, and portability. Four data lines are used to send data on to the LCD. When RS=0 and EN pin is made high to low command is sent to LCD. When RS=1 and EN pin is made high to low data is sent to LCD. VEE is used to adjust contrast.

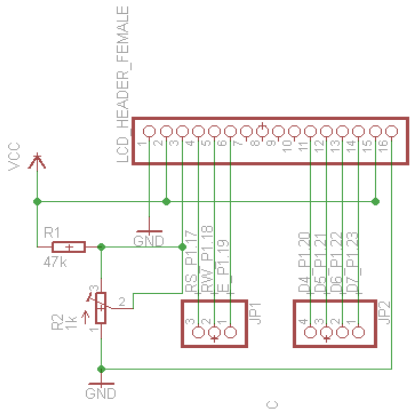

Figure. 6 : LCD interfacing

E. *PC Interfacing using RS-232 with Zigbee*

PC is interfaced with Receiver using MAX-3232 and Zigbee. MAX3232 used to convert the logic level to the RS-232 logic level. RS-232 has not required clock along with data lines. There are two data lines Tx and Rx for the serial communication. To convert logic level to RS-232 standard, MAX-3232 IC is used. The MAX-232 operates from a single 3.3V power supply with 0.1µF charge-pump capacitor.

F. *AT24C04 EEPROM Interfacing*

The EEPROM stores data coming from analog to digital converter channels of the microcontroller. The serial clock (SCL) and serial data (SDA) are the two pins used for writing and reading data from EEPROM.

The memory required for storing data which consists of temperature, relative humidity and light intensity with respect to date and time is eleven bytes. Like this last twenty three values are stored in the EEPROM. Total of 253 bytes is used for storing these values. The EEPROM of ATMEL Company is used. This is programmed to store data for every one minute. The supply voltage is given 5V DC and the ground pin is grounded. The interfacing of EEPROM to the microcontroller is shown below.

Serial Clock (SCL): The Serial Clock if positive edge than clock data into each EEPROM device and if negative edge than clock data out of each device.

Serial Data (SDA): The SDA pin bidirectional for serial data transfer. This pin is open-drain driven and may be wire or wired with any number of other open drain or open collector devices.

Device/Page Addresses (A0, A1, A2): The A0, A1, A2 pins are device address inputs that are hardwired or left not connected for hard compatibility.

Write Protect (WP): The write protect input, when tied to GND, allows normal write operations. When WP is tied to VCC, all write operations to the memory are inhibited. If left unconnected, WP is internally pulled down to GND.

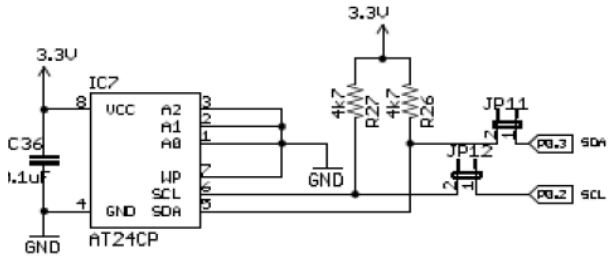

Figure.7 : Pin Connection of AT24C04 with Microcontroller

– *Protocol used for Interfacing ARM Device*

Inter-Integrated Circuit generically referred to as "two-wire interface" is a multi-master serial single ended computer bus invented by Philips in the year 1982 that is used to attach low-speed peripherals like EEPROM to the microcontroller. Each device connected to the bus has a unique address and only one device is connected. Data is

divided into 8-bit bytes to be transmitted. A few control bits for controlling the communication start, end, direction and for an acknowledgment mechanism are used. The active wires i.e. serial clock (SCL) and serial data (SDA) are both bi-directional. Here LPC2138 microcontroller which is having inbuilt I2C protocol which is completely interrupt driven acts as master and EEPROM as slave. Pulling such a line to ground is decoded as a logic ZERO, whereas releasing the line and letting it float is a logic ONE. Actually, a device on an I2C bus "only drives zeros."

– *Writing Byte into I2C Device*

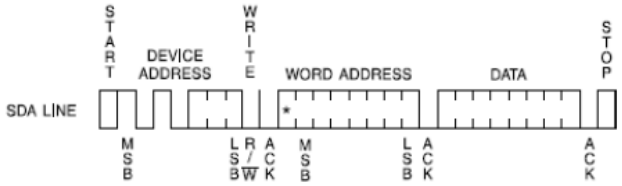

Figure. 8(a) Write Byte Operation

For writing a byte on the SDA line first a start bit to the slave device i.e. EEPROM and the device address with write bit is sent. The serial interrupt is set. Slave device sends an acknowledgement. Then serial interrupt is cleared. Master sends word address. Serial interrupt is set. Slave sends acknowledgement and serial interrupt is cleared. Master sends the data to be stored in slave device. Serial interrupt is set. Slave send the acknowledgement and serial interrupt is cleared. Master sends the stop bit. After this process the byte is written into EEPROM.

– *Reading Byte from I2C Device*

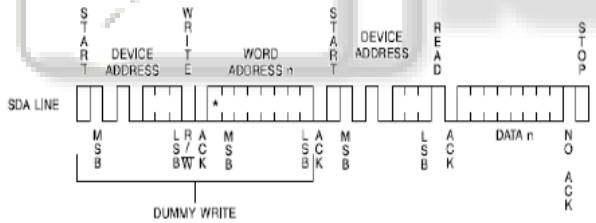

Figure. 8(b) Read Byte Operation

For reading the data stored in EEPROM, a start bit is sent on the SDA line. Device address and the read bit are sent to the slave device. Serial interrupt is set. The slave device sends an acknowledgement to the master. Then serial interrupt is cleared. Then data is read from EEPROM and a stop bit is sent by the microcontroller. After this process the data is read from EEPROM.

G. *Introduction to ZIGBEE*

Figure. 9: ZIGBEE chip

Zigbee is supports wireless network protocol specifically designed for wireless transmission as shown in Fig. 6. Zigbee is a consortium of software, hardware and services companies that have developed a common standard for wireless, networking of sensors and controllers. While other wireless standards are concerned with exchanging large amounts of data, Zigbee is for devices that have smaller throughout needs. The other driving factors are low cost, high reliability, high security, low battery usage, simplicity and interoperability with other Zigbee devices.

Compared to other wireless protocol that Zigbee wireless protocol offers low complexity. In health care, Zigbee can be used for patient monitoring process control, assuring compliance with environmental standards and energy management. They will be used for controlling our home entertainment systems, lights, garage door openers, alarms, panic buttons and many other uses.

Zigbee looks rather like blue tooth but is simpler, has a lower data rate and spends most of its time in snoozing. The operational range for it is 10 to 75 meters compared to 10 meters for blue tooth (without a power amplifier). Zigbee sits below blue tooth in terms of data rate.

– *How does ZIGBEE work?*

Zigbee hardware typically consists of an eight bit microcontroller combined with a miniature transceiver a small amount (example 32 KB) of flash memory and RAM. Most of the Zigbee stack is provided in ASIC. Zigbee operates with ISM 2.4 GHz frequency band and is pin for pin compatible with digi's Zigbee product. There are three radio frequencies used for Zigbee radio frequency communications 2.4 GHz with 16 channels and a data rate of 250 kbps for worldwide coverage, 868 MHz with a single channel and a data rate of 20 kbps in Europe and 915 MHz with 10 channels and a data rate of 40 kbps in America. For comparison even at 250 kbps the data throughput is only about one tenth that of blue tooth. Another wireless networking solution but more than sufficient for monitoring and controlling usage. Broadcast range for Zigbee is approximately 70 meters. Theoretically Zigbee networks can contain up to 64 k (65,536) network nodes.

V. TRAMSMITTER AND RECEIVER

I mentioned in introduction of this paper. I have two parts in project.

1) Transmitter part: Microcontroller LPC2138 and wireless transmission done in this part and SMS sending if cross temperature set range in this part. This part is totally embedded system Design. Screenshot shows of whole system.

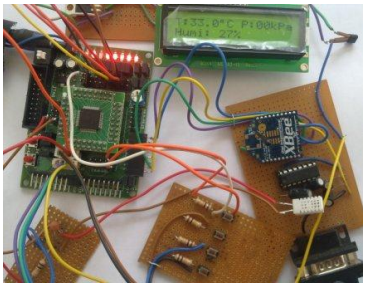

Figure.10 : Hardware Screenshot use as Transmitter part

2) Receiver Part: Laptop/Personal Computer. In this part only Monitoring API which is made in .NET Technology using Language C#.net. We can also check graph of the Temperature and Humidity with real time plotting.

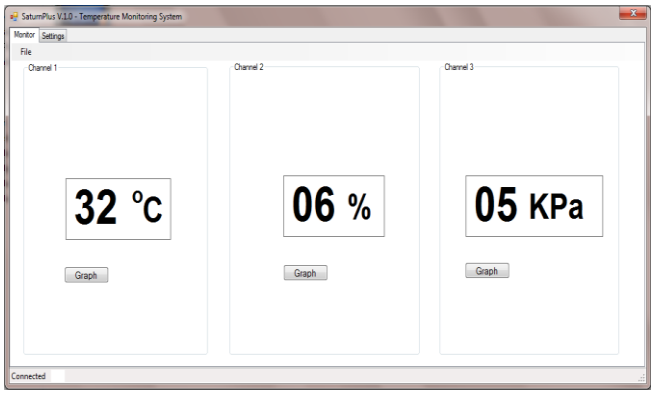

Figure. 11 : Monitoring Screen

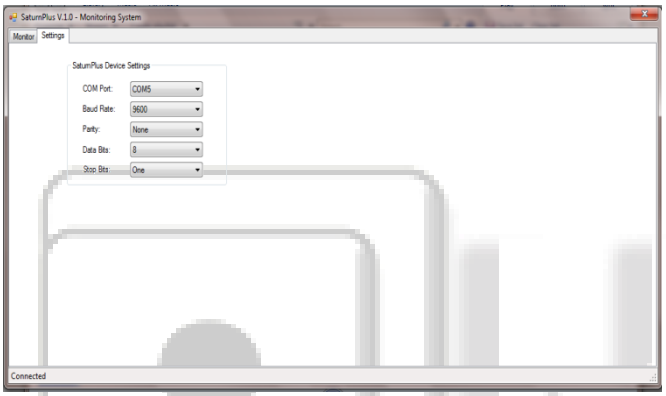

Figure.12 : Setting Screen

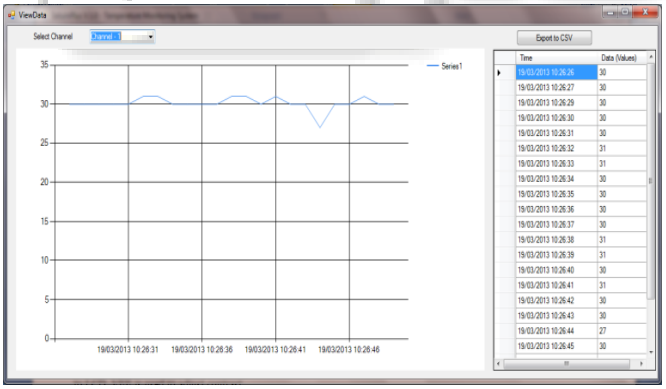

Figure.13 : Real Time Graph Plotting for Temperature (Channel-1)

So we can also see real time graph for channel-2 and channel-3. SaturnPlus also supports Database management with real time and date. We can also open previous database files and observed it.

– *Applications*

- Industrial Application
- Wireless data logging applications
- Wireless telemetry for transmitting sensor data
- Climate Monitoring system for Forest

V. CONCLUSIONS

Real-Time Monitoring & Control System is a project based on microcontroller, due to which hardware requirement is reduced. Modifying the software will be enough for further enhancement of our project. In a dynamic scenario wherein the breed and nature of real time systems are subjected to promising changes, this project is aimed adding the fundamental functionality of interfacing them with varying ambience enabling them to be stable and reliable.

The development of wireless solution within the standard organization and industrial filed has the advantage of bringing several views together to define a better solution. The quick development in the industrial standard is due to the active participation of technology. The purpose of Zigbee development is in industrial application to maintaining simplicity and the essential requirements that will leverage a successful standard.

By doing this project, I was better able to understand the various facets of doing an embedded system project which is emerging as one of the most 'in demand' technologies right now. I come to know about Zigbee technology and how it improves existing system used in industries.

For monitoring part is improve by use of SaturnPlus application where It can be show real time graph and also have database management system to store data of sensors.

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