A REAL-TIME IMPLEMENTATION OF SMART AUTOMATION SYSTEM AND DIGITAL CIRCULAR BOARD USING ANDROID, GLOBAL SYSTEM FOR MOBILE, ADVANCED REDUCED INSTRUCTION SET COMPUTER MACHINES-7 BASED TECHNOLOGIES

KIRAN SS¹*, MURALI KRISHNA P², PHANI KUMAR S³, JAWAHAR A¹

¹Department of ECE, Sanketika Institute of Technology and Management, Visakhapatnam, Andhra Pradesh, India. ²Department of EEE, National Operation and Maintenance Company Limited, Saudi Arabia. ³Department of Mechanical, Anil Neerukonda Institute of Technology and Sciences, Visakhapatnam, Andhra Pradesh, India. Email: sskiran88k@gmail.com

ABSTRACT

The project presents a digital circular board and a smart automation system for hospitals, railway stations, bus stops, institutions, and industries using Android, global system for mobile (GSM) module, and advanced reduced instruction set computer Machines 7 (ARM-7). This idea provides the users with a simple and fast way to keep up important circulars in liquid crystal display (LCD). The message can be sent through an Android application using proposed system to the GSM SIM900 module. Similarly, a smart automation system has been developed to control appliances such as lights, fans, machines and digital boards in hospitals, railway stations, bus stops, institutions, and industries. These appliances can be switched ON or OFF using the Android application, the appliances can be controlled and notices or circulars can be put up in an LCD display from any location in the world. The project consists of a 32-bit ARM-based microcontroller LPC2148 development board, GSM SIM900 module, an LCD. The proposed system is flexible, durable without any risk of getting hacked. Such a system has a low cost of installation and maintenance.

Keywords: Circular digital board, LPC2148 development board, global system for mobile SIM900, Android, Relay, ARM 7.

INTRODUCTION

Using Advanced reduced instruction set computer (RISC) Machines (ARM 7) LPC2148 designed global system for mobile (GSM)-based smart home and digital notice board, in this paper controlling home appliances and send message to digital notice board [1]. Some of the home automation systems developed earlier includes a PIC16F887 IC integrated with GSM module enabling short message system (SMS)-based automation [2]. However, unlike this project, it did not use any android application in it and involved extra task of writing message. In [3] Elkamouchi also gave a prototype of smart automation home and used sensors and actuators for the home appliances to get them connected to microcontroller. Another smart home was built in [4], studied a multilevel home security system [5]. Observed wireless home and industrial automation security system using GSM [6]. Using GSM-based anti-theft security system using Atmel commands in [7] and referred some national and international conferences and journal published papers for the designing of smart automation systems and digital notice boards.

Introduction about project

In this project, hardware capable of controlling all appliances and displaying notices electronically using an android application has been built. Hence, the hardware can perform broadly two functions. For controlling appliances, the system can be used in much different kind of situations where a user can switch on/off any home appliance connected to it from anywhere using an android application installed in a smart phone. To display notices or circulars, a user can use the same application to type a notice and click on the send button to get it displayed. Both the functionality can be used only if sufficient balance amount is left in the user's SIM card since each access transacts a fixed amount for SMS. The hardware consists of an ARM-based microcontroller LPC2148 that communicates to the application through a GSM mobile communication network module which uses a SIM card to receive messages. LPC2148 itself retrieves message and sends signal to switch on/off a device or display a notice. A GSM-based system is flexible, durable without any risk of getting hacked. Such a system has a low cost of installation and maintenance.

Introduction to embedded systems
What is embedded system?

An embedded system is a combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a specific function. An embedded system is a microcontroller-based, software driven, reliable, real-time control system, autonomous, or human or network interactive, operating on diverse physical variables and in diverse environments and sold into a competitive and cost conscious market.

HARDWARE

ARM-based LPC2148 development board
It is an ARM development board which consists of 32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package. The microcontroller in it is LPC2148. There are light emitting diodes (LEDs), a 2×16 alphanumeric liquid crystal display (LCD) also available in the development board. Other than these are, two UART, USB 2.0, JTAG, VGA, POWER JACK, BUZZER, SD/MMC, and buttons and based on Table 1 we can select ARM Development Board LPC2148 of our proposed system. In table we can explain memories, memory architectures, power supply, LCD, graphical display, communication protocols, and popular microcontroller of following development boards.

Bar Graph 1 explains different types of microcontrollers based on the four modules in that first module indicates the type of the controller like is it 8-bit or 16 bit, the second module indicates the size of the RAM in the form of the KBs, the third module shows that operating voltage of the microcontrollers in the form of volts and fourth module shows that operating frequency of the microcontrollers in the form of MHz frequency.

The ARM7TDMI is a member of the ARM family of general purpose 32-bit microprocessors, which offer high performance for very low-power consumption and price. The ARM architecture is based on RISC principles, and the instruction set and related decode mechanism are much simpler than those of microprogrammed complex instruction

set computers. This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and cost-effective chip.

The ARM7TDMI processor architecture as shown in Fig. 1 employs a unique architectural strategy known as thumb, which makes it ideally suited to high-volume applications with memory restrictions, or applications where code density is an issue.

LPC2148 Development Board-LPC214X as shown in Fig. 2 is an evaluation board for LPC2148 ARM7TMDI-based microcontroller. The LPC2148 microcontroller has 512 KB of internal flash and 32+8K RAM.

The LPC2141/42/44/46/48 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-SCPU 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. 128-bit wide memory interface and a 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.

Due to their tiny size and low-power consumption, LPC2141/42/44/46/48 pin configuration 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 I2C-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. In our proposed system particularly selected ARM LPC2148 based of their special features explained in following Table 2.
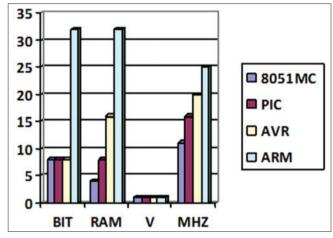
GSM SIM900 module
A GSM SIM900 module has been interfaced with the 32-bit ARM processor based LPC2148 microcontroller. It is connected to LPC2148 through a USB to RS232 driver. The module contains a SIM card holder;

RS232-based serial port for connection, an antenna for sending/receiving signals to the SIM and a LED as a status for power, signal, and incoming call. It supports features such as voice, data/fax, GPRS, and SMS at both 900 MHz and 1800 MHz. Serial port baud rate is adjustable from 1200 to 115200 BPS (bauds per second). It receives only incoming calls to its SIM from the users through the antenna.

16×2 alphanumeric LCD display
This LCD has been used to display the notice sent by the user. It is a 16X2 screen which means it can display 16 alphanumeric characters in each line and there are two lines for display in total which sums up to a maximum of 32 characters being displayed at a time. It has 8 data pins since each character is of 8 bits and three other pins, namely, enable, read/write and register select. Whenever the enable pin is low, LCD is OFF, and it is ON if the pin is high. The read/write pin, if high, reads the data from LCD and if low, writes data in it. The register select pin decides the type of data transferred through the data pins. If it is high, a character is written in LCD and if low, command is sent to LCD.

Bar Graph 1: Different types of microcontrollers chart

Table 1: Comparison between different types of development boards

S. No.	Features	8051 development board	PIC development board	AVR development board	ARM development board LPC2148
1	Memory	ROM, SRAM, FLASH 128 B of internal, 4K-64 RAM	SRAM, FLASH, 4K-64K RAM	Flash, SRAM, EEPROM, 4K+64K RAM	Flash, SDRAM, EEPROM, 512 KB of internal flash, 32+8K RAM
2	Memory Architecture	Von Neumann architecture	Harvard architecture	Modified	Modified Harvard architecture
3	Power supply	12 V Ac or Dc	12 V Ac or Dc	5 V, 12 V supply's	DC 9-12 V with power LED
4	2×16 character	Available	Available	Available	Available
5	128×64 graphical	Not available	Not available	In direct interface	Direct interface
6	Communication Protocols	UART, USART, SPI, I2C	PIC, UART, USART, LIN, CAN, Ethernet, SPI, I2S	UART, USART, SPI, I2C, CAN, USB, Ethernet	UART, USART, LIN, I2C, SPI, CAN, USB, Ethernet, I2S, DSP, SAI IrDA
7	Popular microcontrollers	AT89C51, P89v51, etc.	PIC18fXX8, PIC16f88X, PIC32MXX	Atmega 8, 16, 32, Arduino Community	LPC2148, ARM Cortex-M0 to ARM Cortex-M7

LED: Light-emitting diodes

Table 2: Comparison between different types of development boards' special features

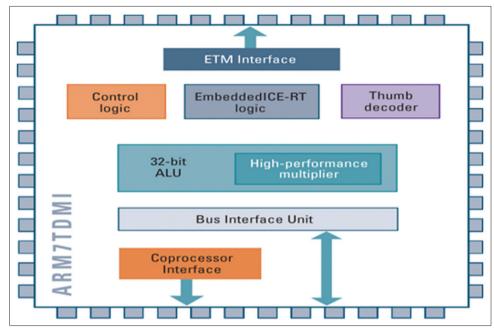| 8051 development board	PIC development board	AVR development board	ARM development board LPC2148
8-Bit controller, a serial port for ISP, 24Cxx I2C EEPROM, Matrix Key Pad, 7 Seg Mulitplexed Display, 8 LED array, RTC DS1307, INT keys	8-Bit controller, an RS232 serial port, RTC DS1307, 8 LED array, Matrix Key Pad, INT keys	8-Bit controller, RS232 serial Port, 7Seg Multiplexed Display, 24Cxx I2C EEPROM, RTC DS1307, 8 LED array, Matrix Key Pad, INT keys	32-Bit controller, RS232 connectors-2 nos, JTAG connector, SD/MMC connector, USB B-type connector, I2C based EEPROM, 8 Led Arrays, INT keys

LED: Light-emitting diodes

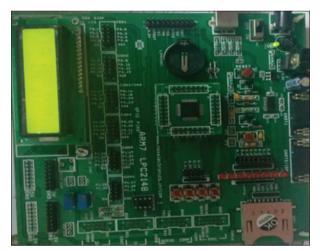**Fig. 1: ARM7TDMI processor architecture**

Fig. 2: LPC2148 development board

Relay

A relay to drive a dc motor has been used. To control a circuit by a low-power signal with electrical isolation between control and controlled circuits, the relay is used. Relay isolates low current circuit from the high current circuit and the low current circuit either makes or breaks the high current path through the switch.

USB 2.0 to Rs232 serial Db9 driver

The GSM module has a db9 port and therefore, to connect it to ARM development board, the USB to RS232 driver used.

Android application

An application named home automation has been used to switch on/off dc motors using on/off button and another button for typing and sending a notice to be displayed in the LCD.

SYSTEM DESCRIPTION

The proposed system block diagram as shown in Fig. 3, which takes message from the Android application sends to controller through GSM modem, as per the input signals devices should be controlled and displayed text in the LCD. The microcontroller receives an SMS through the GSM module on occurrence of one of the two events: (a) When a notice is sent by a user through the application; (b) user clicks on ON/OFF button in the application.

Digital circular board

- When the SIM inserted in the GSM module receives a notice as an SMS from a user, it saves the SMS, and the data are transferred to LPC2148 through DB9 port of GSM to USB port of ARM development board connected by USB to RS232 driver
- On receiving data from the GSM, LPC2148 sends a write command to the 16×2 alphanumeric LCD followed by transfer of data to the 8 data pins of the LCD
- The application named Home Automation is used to send message that gets displayed in the LCD.

Smart home automation

- On clicking an ON/OFF button, an SMS is generated and sent by the smart automation to the SIM in GSM module
- The GSM module transfers the data to LPC2148 as explained earlier
- On receiving the data, LPC2148 sends a signal (logic 0 or logic 1) to the relay driver which turns the motors on/off as per the message.

INTERFACING DESCRIPTION

LPC2148 and GSM module interfacing

Microcontroller LPC2148 and the GSM SIM900 module communicate through any one of the two UART devices which are 16C550 present in the LPC2148 chip. In proposed system, the interface of LPC2148 with GSM module as shown in Fig. 3. UART0 has been used to connect to the GSM module. Among all the 64 pins of the microcontroller, pin P0.0 is the TXD0 (transmit) pin and pin P0.1 is the RXD0 (receive) pin. The RXD0 and TXD0 pins of LPC2148 are connected to the Tx and Rx of the GSM module, respectively with jumper wires. The UART is initialized for communication to happen. The frequency of crystal oscillator (Fosc) is 12 MHz and to maintain a frequency of 60 MHz for the CPU (Fcclk) through phase locked loop (PLL) output, the multiplier is set as M=5 and the following registers are configured:

PLL0CON=0×01 PLL0CFG=0×24 the sequence fed is: PLL0FEED=0×AA PLL0FEED=0×55

Hence, the peripheral clock frequency Fcclk is set as Fcclk/4. The baud rate generated is 9600 bauds per second. To communicate with GSM, attention (AT) commands are sent to GSM module through UART of LCP2148. Hence, initially to ensure successful connection with GSM module, the data "AT" is sent through UART. If in return "OK" is received by UART from GSM, then the connection is successful else not. After ensuring connection established, the GSM modem is set to text mode to read the SMS in text mode otherwise it gets displayed in binary mode. Hence, the string "AT+CMGF=1" is send to GSM module which sets the SMS at index 1 in text mode. Since it is known that the latest SMS is always stored at index 1, the data sent are "AT+CMGF=1" where 1 is the index number of the message. Next, to read the message and send it for display, the string "AT+CMGR=1" is sent to GSM. This string is sent to read the message at index number 1 as it is the latest SMS received by the SIM in GSM. Finally, after the message is read, it is sent to LCD in 4-bit mode and displayed.

LPC2148 and LCD interfacing
The 16×2 LCD has eight data pins and three special pins, namely, read/write (R/W), enable (E), and register select (RS). It can be used in 4-bit or 8-bit mode to transfer data or command. In 8-bit mode, all the eight data lines of LCD are connected to eight I/O pins of LPC 2148 along with three other pins also connected to the microcontroller, but in 4-bit mode, only four data lines are connected to the microcontroller. Here, 4-bit mode has been used to display and in proposed system the interface of LPC 2148 with LCD shown in Fig. 4 for displaying digital circular.

In 4-bit mode, the data lines D0-D3 of LCD are not connected, and D4-D7 is connected to pins P0.19-P0.22 of LPC2148. The R/W, E, and RS pins are connected to pins P0.16, P0.17, and P0.18 pins of LPC2148, respectively. Initially, the LCD is initialized and then the data is sent to it to get it displayed. RS pin, if high, selects the data register and LCD interprets any data sent to it as data to be displayed, and if RS pin is low, command register is selected, so the data sent to LCD is interpreted as a command by the LCD. The enable pin is used to enable transfer of command or data to LCD from the microcontroller.

LCD initialization
For initialization, the pins R/W is kept low (write), RS is kept low (command register selected) and then command is sent through the 4-bit mode. But to place the command into command register, E pin is transitioned from high to low each time a byte is sent to the LCD. The commands sent for initialization in hexadecimal are, 28H, 20H, 06H, 01H, and 80H.

Sending data to LCD
Sending of data involves following steps:
• R/w is set low (write operation selected)
• RS is set high (data register selected)
• The data byte is sent through the 4 data lines
• E pin is transitioned from high to low for data to be placed into data register

The above steps are repeated to send other bytes of data.

LPC2148 and relay with load interfacing
In this project, single relay is used to drive a fan using dc motor. The relay requires a driver IC ULN2803 to make interfacing possible between the low logic level digital circuitry in LPC2148 and the high voltage level required by the relay. LPC2148 gives output of 5 V whereas relay requires 12 V to operate, hence, ULN2803 is required. ULN2803 IC has eight inputs and eight corresponding outputs.

It consists of eight Darlington pair of NPN transistors. Here, a single relay has been used so input pin P0 of ULN2803 is connected to pin P1. 20 of LPC2148 and the corresponding output pin of ULN2803 is connected to the relay. The DC motor used to drive the fan is connected to the relay. There is an input in the relay which is connected to a triggering coil. When

Fig. 3: Interface with global system for mobile module

Fig. 4: Interface with liquid crystal display

the coil gets energized, relay turns on and the switch inside it closes so the positive terminal of output gets connected to +12V and if relay is off (coil de-energized), positive output terminal gets grounded. The ULN2803 input pin P0 is supplied a logic 1 (5 V) by the pin P1.20 of LPC2148 to turn it on and drive the relay which in turn drives the motor to rotate the fan.

Android application (smart home automation)

The android application designed, acts as a communication interface between the SIM in GSM module and the user. The interface is quiet

user-friendly and easy to access. On opening the application, its homepage provides two functionalities.

Fan control

- On clicking the fan control option in homepage, there are two options visible, fan off and fan on
- To switch on the fan, fan on option is clicked and similarly to switch it off; fan off is clicked
- After clicking fan on/off, the application takes few seconds to send an SMS during which, "Wait request on process" message gets displayed in lower part of the screen
- On clicking fan on/off, the application automatically sends an SMS with a message written "ON" in it if fan on is clicked or "OFF" if fan off is clicked
- The GSM receives the message and delivers it to LPC2148 which, on retrieving the message, reads it and sends signal accordingly to switch on/off the motor
- As soon as the message is sent completely by the application, a message, Fan on/off gets displayed depending on what option is clicked. Thus, the home appliances are controlled in this way using the application.

Circular board

- On clicking the notice board option in homepage, a blank text area appears with initially a message "Write notice" written in it
- The notice to be displayed is typed in the text area. For example, "paper presentation at 4:30 pm" is to be displayed which is typed in the text area
- After typing the message, the send notice option below the screen is clicked to send it
- After clicking, while the phone delivers the message, at that time, the message, "wait request in progress" gets displayed in the lower part of screen

As soon as the message gets delivered, "Notice sent" message pops up. Thus, the notices can be delivered this way through the application to get them displayed.

SOFTWARE

KEIL software

In our proposed system, we can write the code in Keil software for the purpose of Simulation, Compilation, Debugging, Execution, and conversion of HEX CODE, Keil development tools for the ARM microcontroller architecture support every level of software developer from the professional applications engineer to the student just learning about embedded software development. The industry-standard Keil C compilers, macro assemblers, debuggers, real-time kernels, single-board computers, and emulators support all 8051 derivatives and help you get your projects completed on schedule.

Android software

Android software development is the process by which new applications are created for the Android operating system. Applications are usually developed in Java programming language using the Android software development kit, but other development environments are also available.

Flash magic

Flash magic is a PC tool for programming flash-based microcontrollers from NXP using a serial or Ethernet protocol while in the target hardware. Double click on desktop ICON. Flash magic provides a clear and simple user interface to these features and more as described in the following sections. Under windows, only one application may have access the COM port at any one time, preventing other applications from using the COM port. Flash magic only obtains access to the selected COM port when internet service provider operations are being performed. This means that other applications that need to use the COM port, such as debugging tools, may be used while flash magic is loaded. Note that in this manual third party compilers are listed alphabetically. No preferences are indicated or implied.

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