

GSM based Smart Home and Digital Notice Board

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Abstract—The project presents a digital notice board and a home automation system using a GSM SIM900 module. The idea behind this project is to provide its users with a simple, fast and reliable way to put up important notices in an LCD where the user can send a message to be displayed in the LCD. The message can be sent through an android application designed in this project, to the GSM SIM900 module which has a SIM card inside it. Similarly, a home automation system has been developed where home appliances like light, fan etc. can be switched on or off using the same android application designed in this project. So, using the android application, the home appliances can be controlled and notices can be put up in an LCD display from any location in the world. It uses a microcontroller for system control, GSM technology for communication and sends SMS containing the message through the android application. The project consists of a 32-bit ARM based microcontroller LPC2148, GSM SIM900 module, an LCD, a motor and an android application for user interface with the hardware. The device can be used anywhere irrespective of the place of deployment provided mobile network connectivity is available.

Keywords: LPC2148, GSM SIM900, android, relay, microcontroller, security

I. INTRODUCTION

In this project, a hardware capable of controlling home appliances and displaying notices electronically using an android application has been built. So, the hardware can perform broadly two functions. For controlling home appliances, the system can be used in many 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 smartphone. In order to display notices, 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. The motivation behind such a project is mainly to reduce physical effort for operating appliances especially for aged people. Also, it might help a person to save energy by switching off appliances on being out of home or to switch on appliances to get services like washing clothes, cooling room, heating water done by the time he reaches home. Another reason for this project is overusage of paper in educational institutions for printing notices. Due to mushrooming paper usage day by day, lot of trees are being cut which is harmful for the environment. So, if notices are displayed everywhere electronically, it would

reduce paper usage and make communication easier and faster. A GSM based system is flexible, durable without any risk of getting hacked. Such a system has a low cost of installation and maintenance.

The other sections of the paper are organized as follows: Section-II is a discussion about earlier works in this field, Section-III briefs the devices of the system, Section-IV gives the outline of the system operation and Section- V explains the application.

II. RELATED WORK

Some of the home automation systems developed earlier includes a PIC16F887 IC integrated with GSM module enabling SMS based automation [1]. However, unlike this project, it did not use any android application in it and involved extra task of writing message. In [2], Elkamouchi also gave a prototype of Smart home and used sensors and actuators for the home appliances to get them connected to microcontroller. Another smart home was built in [3], where Xbee was used for communication instead of GSM. In 2011, a wireless remote power controller was built in [4], which could control power consumption in a home through TC35 module. Han in [5], built a smart home energy management system using IEEE 802.15.4 and Zigbee module for communication. A computerised system was developed in [6], where a GSM was interfaced with a desktop computer. Home appliances had wired connection with desktop and users were connected through Wi-Fi. Doors and Windows were monitored in [7] using PIC18F452 with security that required ID for entering through the door. Some important GSM based antitheft and security systems have been developed in [8], [9], [10], [11], [12], [13], [14], [15] in recent years that has urged us to take up such a project.

III. COMPONENTS

The components used in the project are:-

A. ARM processor with development board

It is a ARM development board which consists of 32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package. The microcontroller in it is LPC2148. There are LEDs, a 2*16 alphanumeric 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.

B. 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 an LED as a status for power, signal and incoming call. It supports features like 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.

C. 16*2 Alphanumeric LCD display

This LCD has been used to display the notice sent by the user. It is a 16*2 screen which means it can display 16 alphanumeric characters in each line and there are two lines for display in total which sums upto 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.

D. Relay

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

E. 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 has been used.

F. DC Motor

A 500 rpm 12V DC motor have been used for home automation purposes.

G. 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.

H. Smartphone with android operating system

A smartphone Moto E 2nd generation with android version 4.2 Jelly Bean has been used for running the android application named Home Automation.

IV. SYSTEM DESCRIPTION

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 application; (b) user clicks on ON/OFF button in the application.

A. Digital Notice 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 is 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.

B. Home Automation

- On clicking an ON/OFF button, an SMS is generated and sent by the application Home 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.

V. SYSTEM DESCRIPTION

A. Microcontroller 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 this project, 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 12MHz and to maintain a frequency of 60MHz for the CPU (Fclk) through phase locked loop (pll) output, the multiplier is set as M=5 and the following registers are configured:-

PLL0CON=0x01

PLL0CFG=0x24

The sequence fed is:-

PLL0FEED=0xAA

PLL0FEED=0x55

Hence, the peripheral clock frequency Fpclk is set as Fclk/4. The baud rate generated is 9600 bauds per second using the formula, baud rate B,

$$B = \frac{Fpclk \text{ in Hz}}{16(256(DLM) + DLL)(1 + D/M)} \quad (1)$$

where registers U0DLL = 97 ; U0DLM = 1 ;

MULVAL = 15 ; DIVADDVAL = 0

Here, in formula, DLL stands for U0DLL, DLM stands for U0DLM, M for MULVAL and D for DIVADDVAL.

On setting the baud rate at 9600 bps, the UART gets ready to communicate with the GSM module. To communicate with GSM, Attention (AT) commands are sent to GSM module through UART of LCP2148. So, 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. So, the string "AT+CMGF=1" is sent 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 is "AT+CMGF=1" where 1 is the index number of the message. Next, in order 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.

B. Microcontroller 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 LPC2148 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.

In 4-bit mode, the data lines D0-D3 of LCD are not connected and D4-D7 are 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 microcontroller. The command/data transfer is enabled when E pin gets a transition from high to low. The R/W pin, if high gives read operation and gives write operation otherwise.

1) *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.

2) *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.

Thus in this way, the LCD is interfaced with LPC2148. The message displayed in the LCD can be seen in figure 1.



Fig. 1. Snapshot of Digital Notice Board

C. Microcontroller and Relay 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 5V whereas relay requires 12V 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 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 (5V) 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.

D. Android Application (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
- Notice board

The homepage is shown in figure 2. So, the functionality of the application can be broadly divided into two parts:-

1) *Fan control:*

- On clicking the fan control option in homepage, there are two options visible, fan off and fan on as shown in figure 3.

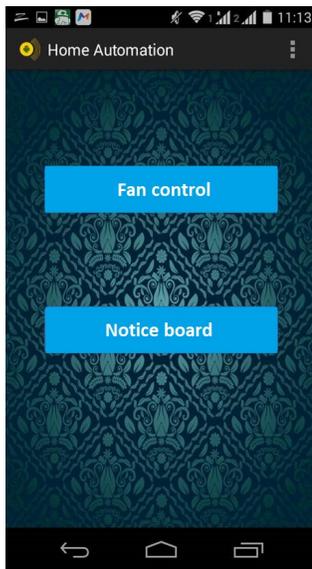


Fig. 2. Homepage

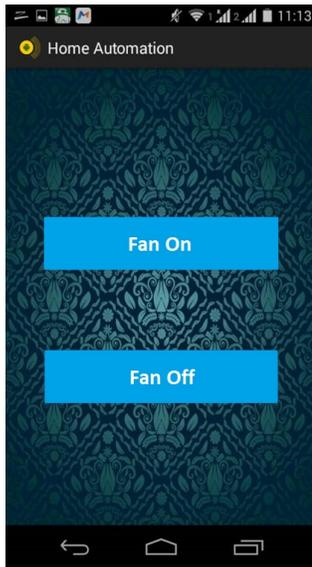


Fig. 3. Fan control page

- 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 as shown in figure 4.
- 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 as

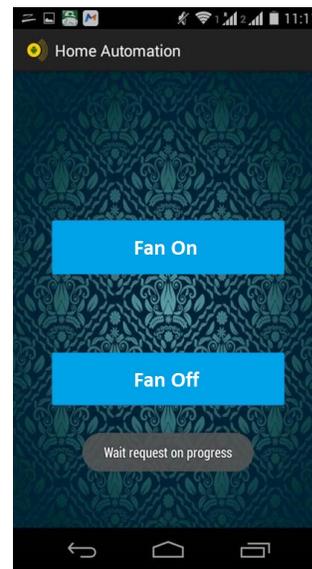


Fig. 4. Fan on/off request in progress

shown in figure 5 , depending on what option is clicked. Thus, the home appliances are controlled in this way using the application.

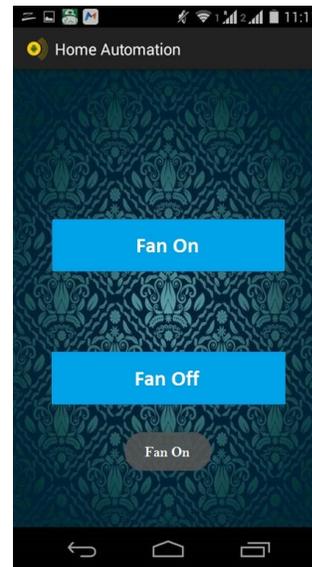


Fig. 5. Fan on

2) Notice board:

- On clicking the notice board option in homepage, a blank text area appears with initially a message "Write notice" written in it as shown in figure 6.
- The notice to be displayed is typed in the text area. For example, "RPC Project Presentation at 4:30 pm" is to be displayed which is typed in the text area as shown in figure 7.
- After typing the message, the send notice option below the screen is clicked to send it.

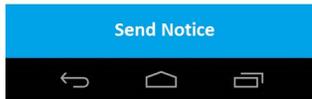
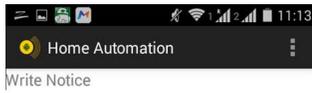


Fig. 6. Notice typing screen

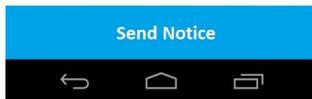
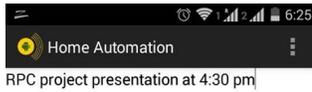


Fig. 7. Notice written

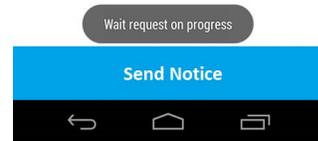
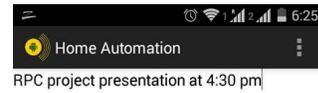


Fig. 8. Notice sending in progress

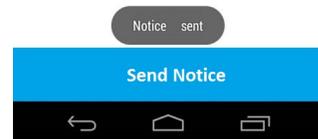
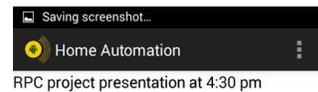


Fig. 9. Notice sent

- 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 shown in figure 8.
- As soon as the message gets delivered, "Notice sent" message pops up as shown in figure 9. Thus, the notices can be delivered this way through the application to get them displayed.

VI. ADVANTAGES

A. Digital notice board

- It can reduce use of papers and hence deforestation can be turned into afforestation.
- It can reduce physical effort of printing and distributing paper based notices.

- It can spread among more people in lesser time since large screen display is used.

B. Home Automation

- Can reduce physical effort for aged people.
- Can save time since user can access devices when he is not at home.
- Energy consumption can be managed more efficiently.

VII. CONCLUSION

The project established a digital notice board and home automation using 32-bit microcontroller and GSM successfully. It is cheap, quick, reliable and secured for any organisation that requires to circulate notices regularly and reduces physical

effort as well as ensures energy consumption management for any user. Although only fan has been driven through the system, in future, other devices like microwave, washing machine can also be operated while the user is aged or not at home.

VIII. FUTURE IMPLICATIONS

High power consuming devices like air conditioner, microwave geyser, washing machine can be monitored using LPC2148. The android application can be further enhanced in such a way that it would provide status of appliances whether on or off. The security of the application can be enhanced by introducing a password system to send message. Such enhancements can increase the system's robustness and flexibility.

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