IOT IN INDIAN AGRICULTURE USING WIRELESS SENSOR NETWORKS

PROJECT REFERENCE NO.: 39S_BE_0349

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CHAPTER 01

PREAMBLE

1.1 INTRODUCTION

The projected population of India being 1500 million by 2050 and agriculture remaining as the primary source of livelihood in rural areas, the focus should be on the increase of productivity. Though our country claims to have developed in terms of science and technology, erratic power supply or complete breakdown for hours together has almost become routine today. Solar power is being increasingly utilized worldwide as a renewable source of energy. India has huge untapped solar off-grid opportunities.

Power problem to farmers for irrigation is a regular problem where still a permanent solution has not been find out. In such situation we can go for an alternate power solution-solar power. Solar light is readily available where we will not pay to it.

There will be n-number of work in field like water pumping that to in required amount depending upon crop and time. Sometime excess of water and some deficiency of water makes crop difficult to grow. In such situation automation play an important role to maintain water level without human interaction.

The farmer can water the fields from any place using GSM technique which provides an acknowledgement message about the job status such as temperature of the environment, humidity level of the soil and whether the motor runs on main power supply or with the use of solar power. It also detects the rain and protects the crops using panels. The main advantage of this project is optimizing the power usage through water resource management and also saving government’s free subsidiary electricity. This proves an efficient and economy way of irrigation and this will automate the agriculture sector.

1.2 OBJECTIVES

- The project is mainly related with off-grid application
- The objective is to supply water to the fields by using solar power as the main source
- In this the user can water fields and protect his crops from anywhere by using GSM technique
1.3 PROBLEM STATEMENT

The farm fields of farmers are situated miles away from his home. Sometimes he need to go to his field for several times in a day to start and stop the irrigation water pumps. Availability of nonstop power is a scarce in many of the villages around India, resulting several trips a day to operate the pumps. Farmer cannot come to the field always and also they cannot protect the crops from unconditional rain.

Power problem to the farmers for irrigation is a regular problem where still a permanent solution has not been found out, in the existing system power generation is carried out by the conventional energy sources.

1.4 LITERATURE SURVEY

To carry out the project in a phased manner it is necessary to conduct the literature survey. To establish communication, the concept of wireless communication is used. The fundamental concept and information about wireless communication is excellently described by Theodre S Rappaport.

Mobile computing service creation are completely discussed by Ashok K Talukder, Roopa R Yavagal in Mobile computing, Technology Applications and Service creations. The author has described about the computing between two GSM modem. Various websites have been visited like,

- www.gsmworld.com information regarding the latest developments in GSM.
- www.seeestudio.com to know about the soil moisture sensor module.
- www.electronics-tutorials.ws/io/io3.html to know about the temperature sensor types for temperature measurement.
- www.rainsensor.com to know about the rain sensor module.

The project is implemented using Embedded C language. To develop the code for establishing communication between the terminals, the books of the Complete Reference C. The information regarding programming in C was referred from Muhammed Ali Mazidi, Janice GillispieMazidi, Rollin D. McKinlay. The 8051 Microcontroller and Embedded System using Assembly and C and the 8051 Microcontroller and Embedded System, by Kenneth J Ayala. Knowledge about the usage of AT commands to exchange Short Message Service (SMS) was learnt from AT commands Manual.
CHAPTER 02

Block diagram and its Description

Figure 2.1. Block diagram

2.1 Explanation for the flow of each block

The figure 2.1 shows the block diagram of e-farming in agricultural system using smart phones.

WORKING

- When the power supply is switched on, the GSM modem gets initialized. The GSM modem communicates with the ARM LPC2148 board using AT commands
- The LCD display is connected to the ADC pins of the ARM processor, in order to display the message
• Firstly the processor checks for the availability of the solar energy with the help of LDR, the solar panel is interfaced with the stepper motor, which in turn is connected with the stepper driver
• The solar panel rotates both in clockwise and anti-clockwise 180° and stops where the maximum sun intensity is available and stores the in a battery
• The humidity sensor checks for the soil moisture content whose maximum threshold is kept at 1000°C and minimum of 300°C. When the soil moisture content is less than 300°C the pump motor will pump the water to the field
• The temperature sensor will measure the surrounding temperature of the farm
• The rain sensor will sense the heavy rain and closes the panel to protect the crop
• All the above information will be informed to the user using GSM technology

When the power supply is turned on the ARM7 LPC2148 microcontroller and the GSM modem/GPRS is initialized. After the initialization, the system ask the user either to select automatic mode or the manual mode.

When the auto mode is selected, firstly the processor checks for the availability of the solar energy with the help of LDR which is used for sensing the sunlight. Solar panel is mounted on stepper motor to expose to light according to sun movement. When no solar energy is available, the system runs on a battery. The block consists of a water level sensor which is used to sense the water level in the tank of the farm field.

Relay is connected to the pump which starts pumping water when the moisture sensor senses the land as dry. Moisture sensor is used for sensing the soil moisture of the crop land to feed them water with the help of 3-Phase power unit, whenever the land get dried below the threshold level of moisture of land which is suitable for the growth of crops. The temperature sensor senses the surrounding temperature of the farm. When it starts raining, the pump motor will stop pumping the water to the field and updates the user using GSM/GPRS technique. When there is an unconditional rain the panels provided will be closed automatically to protect the crop. An Alpha numeric LCD is used to display the data.

When the manual mode is selected, the information about the farm field will be updated to the user only when he calls to an authenticated number given.
Figure 2.2: Real time implementation of e-farming [1]

2.1 ARM7 LPC2148[2]

The LPC2148 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high speed flash memory ranging from 32 KB to 512 KB. A 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 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. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers suitable for industrial control and medical systems.

2.1.1 Pin Diagram

Figure 2.3: Pin diagram of ARM LPC2148[3]
2.1.2 Features of ARM LPC2148[3]

- 16-bit/32-bit ARM7TDMI-S microcontroller in a tiny LQFP64 package
- 8 KB to 40 KB of on-chip static RAM and 32 KB to 512 KB of on-chip flash memory. 128-bit wide interface/accelerator enables high-speed 60 MHz operation.
- In-System Programming/In-Application Programming (ISP/IAP) via on-chip boot loader software. Single flash sector or full chip erase in 400ms and programming of 256 bytes in 1ms
- Embedded ICE RT and Embedded Trace interfaces offer real-time debugging with the on-chip Real Monitor software and high-speed tracing of instruction execution
- USB 2.0 Full-speed compliant device controller with 2 KB of endpoint RAM. In addition, the LPC2146/48 provides 8 KB of on-chip RAM accessible to USB by DMA
- One or two (LPC2141/42 vs. LPC2144/46/48) 10-bit ADCs provide a total of 6/14 analog inputs, with conversion times as low as 2.44μs per channel
- Single 10-bit DAC provides variable analog output (LPC2142/44/46/48 only)
- Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog
- Low power Real-Time Clock (RTC) with independent power and 32 kHz clock input
- Multiple serial interfaces including two UARTs (16C550), two Fast I2C-bus (400kbit/s), SPI and SSP with buffering and variable data length capabilities
- Vectored Interrupt Controller (VIC) with configurable priorities and vector addresses
- Up to 45 of 5 V tolerant fast general purpose I/O pins in a tiny LQFP64 package
- Up to 21 external interrupt pins available
- 60 MHz maximum CPU clock available from programmable on-chip PLL with Settling time of 100μs
- On-chip integrated oscillator operates with an external crystal from 1 MHz to 25 MHz
- Power saving modes include Idle and Power-down
- Individual enable/disable of peripheral functions as well as peripheral clock scaling for additional power optimization
- Processor wake-up from Power-down mode via external interrupt or BOD
- Single power supply chip with POR and BOD circuits
- CPU operating voltage range of 3.0 V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant I/O pads
2.1.3 Functional Description[3]

Architecture Overview

The ARM7TDMI-S is a general purpose 32-bit microprocessor, which offers high performance and very low power consumption. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles and the instruction set and related decode mechanism are much simpler than those of micro programmed Complex Instruction Set Computers (CISC). This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and cost-effective processor core. Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its successor is being decoded and a third instruction is being fetched from memory.

The ARM7TDMI-S processor also employs a unique architectural strategy called Thumb, which makes it ideally suited to high-volume applications with memory restrictions or applications where code density is an issue. The key idea behind Thumb is that of a super-reduced instruction set.

The ARM7TDMI-S processor has two instruction sets:

• The standard 32-bit ARM set

• A 16-bit Thumb set

The Thumb set’s 16-bit instruction length allows it to approach twice the density of standard ARM code while retaining most of the ARM’s performance advantage over a traditional 16-bit processor using 16-bit registers. This is possible because Thumb code operates on the same 32-bit register set as ARM code. Thumb code is able to provide up to 65 % of the code size of ARM, and 160 % of the performance of an equivalent ARM processor connected to a 16-bit memory system. The particular flash implementation in the LPC2148 allows for full speed execution also in ARM mode. It is recommended to program performance critical and short code sections (such as interrupt service routines and DSP algorithms) in ARM mode. The impact on the overall code size will be minimal but the speed can be increased by 30% over Thumb mode.

On-chip Flash Memory

The LPC2148 incorporate a 512 KB flash memory system respectively. This memory may be used for both code and data storage. Programming of the flash memory may be accomplished in several ways. It may be programmed In System via the serial port. The application program may also erase
and/or program the flash while the application is running, allowing a great degree of flexibility for data storage field firmware upgrades, etc. Due to the architectural solution chosen for an on-chip boot loader, flash memory available for user’s code on LPC2148 is 512 KB respectively. The LPC2148 flash memory provides a minimum of 100,000 erase/write cycles and 20 years of data-retention

**On-Chip Static RAM**

On-chip static RAM may be used for code and/or data storage. The SRAM may be accessed as 8-bit, 16-bit, and 32-bit. The LPC2148 provide 32 KB of static RAM respectively. In case of LPC2148 only, an 8 KB SRAM block intended to be utilized mainly by the USB can also be used as a general purpose RAM for data storage and code storage and execution.

**Interrupt Controller**

The Vectored Interrupt Controller (VIC) accepts all of the interrupt request inputs and categorizes them as Fast Interrupt Request (FIQ), vectored Interrupt Request (IRQ), and non-vectored IRQ as defined by programmable settings. The programmable assignment scheme means that priorities of interrupts from the various peripherals can be dynamically assigned and adjusted. Fast interrupt request (FIQ) has the highest priority. If more than one request is assigned to FIQ, the VIC combines the requests to produce the FIQ signal to the ARM processor. The fastest possible FIQ latency is achieved when only one request is classified as FIQ, because then the FIQ service routine does not need to branch into the interrupt service routine but can run from the interrupt vector location. If more than one request is assigned to the FIQ class, the FIQ service routine will read a word from the VIC that identifies which FIQ source is requesting an interrupt.

Vectored IRQs have the middle priority. Sixteen of the interrupt requests can be assigned to this category. Any of the interrupt requests can be assigned to any of the 16 vectored IRQ slots, among which slot 0 has the highest priority and slot 15 has the lowest. Non-vectored IRQs have the lowest priority. The VIC combines the requests from all the vectored and non-vectored IRQs to produce the IRQ signal to the ARM processor. The IRQ service routine can start by reading a register from the VIC and jumping there. If any of the vectored IRQs are pending, the VIC provides the address of the highest-priority requesting IRQs service routine, otherwise it provides the address of a default routine that is shared by all the non-vectored IRQs. The default routine can read another VIC register to see what IRQs are active.
Interrupt sources

Each peripheral device has one interrupt line connected to the Vectored InterruptController, but may have several internal interrupt flags. Individual interrupt flags may also represent more than one interrupt source.

Pin Control Block

The pin control block allows selected pins of the microcontroller to have more than one function. Configuration registers control the multiplexers to allow connection between the pin and the on chip peripherals. Peripherals should be connected to the appropriate pins prior to being activated, and prior to any related interrupt(s) being enabled. Activity of any enabled peripheral function that is not mapped to a related pin should be considered undefined.

The Pin Control Module with its pin select registers defines the functionality of the microcontroller in a given hardware environment. After reset all pins of Port 0 and 1 are configured as input with the following exceptions: If debug is enabled, the JTAG pins will assume their JTAG functionality; if trace is enabled, the Trace pins will assume their trace functionality. The pins associated with the I2C0 and I2C1 interface are open drain.

Emulation and Debugging[4]

The LPC2141/42/44/46/48 support emulation and debugging via a JTAG serial port. A trace port allows tracing program execution. Debugging and trace functions are multiplexed only with GPIOs on Port 1. This means that all communication, timer and interface peripherals residing on Port 0 are available during the development and debugging phase as they are when the application is run in the embedded system itself.

Embedded ICE

Standard ARM Embedded ICE logic provides on-chip debug support. The debugging of the target system requires a host computer running the debugger software and an Embedded ICE protocol converter. Embedded ICE protocol converter converts the Remote debug protocol commands to the JTAG data needed to access the ARM core.

The ARM core has a Debug Communication Channel (DCC) function built-in. The DCC allows a program running on the target to communicate with the host debugger or another separate host without stopping the program flow or even entering the debug state.
The DCC is accessed as a co-processor 14 by the program running on the ARM7TDMI-Score. The DCC allows the JTAG port to be used for sending and receiving data without affecting the normal program flow. The DCC data and control registers are mapped in to addresses in the Embedded ICE logic.

**Embedded Trace**

Since the LPC2141/42/44/46/48 have significant amounts of on-chip memory, it is not possible to determine how the processor core is operating simply by observing the external pins. The Embedded Trace Macro cell (ETM) provides real-time trace capability for deeply embedded processor cores. It outputs information about processor execution to the trace port.

The ETM is connected directly to the ARM core and not to the main AMBA system bus. It compresses the trace information and exports it through a narrow trace port. An external trace port analyser must capture the trace information under software debugger control. Instruction trace (or PC trace) shows the flow of execution of the processor and provides a list of all the instructions that were executed. Instruction trace is significantly compressed by only broadcasting branch addresses as well as a set of status signals that indicate the pipeline status on a cycle by cycle basis. Trace information generation can be controlled by selecting the trigger resource. Trigger resources include address comparators, counters and sequencers. Since trace information is compressed the software debugger requires a static image of the code being executed. Self-modifying code cannot be traced because of this restriction.

**Real Monitor**

Real Monitor is a configurable software module, developed by ARM Inc., which enables real-time debug. It is a lightweight debug monitor that runs in the background while users debug their foreground application. It communicates with the host using the DCC, which is present in the Embedded ICE logic. The LPC21/48 contain a specific configuration of Real Monitor software programmed into the on-chip flash memory.

**2.2 HUMIDITY SENSOR[4]**

Soil moisture sensor measure the water content in soil. Measuring soil moisture is important in agriculture to help farmers manage their irrigation systems more efficiently. Not only are farmers able to generally use less water to grow a crop, but they are also able to increase yields and the quality of the crop by better management of soil moisture during critical plant growth stages.
Besides agriculture, there are many other disciplines using soil moisture sensors. Golf courses are now using sensors to increase the efficiencies of their irrigation systems to prevent over watering and leaching of fertilizers and other chemicals offsite.

The module uses LM393 comparator to compare the soil moisture level with the pre-set threshold. When the soil moisture deficit module outputs a high level, and vice versa.

**Features**
- State binary output
- Adjustable sensitivity

**Specifications**
- Input operating voltage: 3.3 to 5V

### 2.3 TEMPERATURE SENSOR[4]

Temperature sensors are vital to a variety of everyday products. For example, household ovens, refrigerators, and thermostats all rely on temperature maintenance and control in order to function properly. Temperature control also has applications in chemical engineering. Examples of this include maintaining the temperature of a chemical reactor at the ideal set-point, monitoring the temperature of a possible runaway reaction to ensure the safety of employees, and maintaining the temperature of streams released to the environment to minimize harmful environmental impact.

From a thermodynamics perspective, temperature changes as a function of the average energy of molecular movement. As heat is added to a system, molecular motion increases and the system experiences an increase in temperature. It is difficult, however, to directly measure the energy of molecular movement, so temperature sensors are generally designed to measure a property which
changes in response to temperature. The devices are then calibrated to traditional temperature scales using a standard (i.e. the boiling point of water at known pressure).

Temperature sensors are devices used to measure the temperature of a medium. There are 2 kinds on temperature sensors: 1) contact sensors and 2) noncontact sensors

**Contact Sensors**

Contact temperature sensors measure the temperature of the object to which the sensor is in contact by assuming or knowing that the two (sensor and the object) are in thermal equilibrium, in other words, there is no heat flow between them.

Examples (further description of each example provide below)

- Thermocouples
- Resistance Temperature Detectors (RTDs)
- Full System Thermometers
- Bimetallic Thermometers

**Noncontact Sensors**

Most commercial and scientific noncontact temperature sensors measure the thermal radiant power of the Infrared or Optical radiation received from a known or calculated area on its surface or volume within it.

An example of noncontact temperature sensors is a pyrometer, which is described into further detail at the bottom of this section.

**LM35 Sensor [4]**

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in °C). The LM35 temperature sensor measure temperature more accurately than using a thermistor. The sensor circuitry is sealed and not subject to oxidation, etc. The LM35 generates higher output voltage than thermocouples and may not require that the output voltage be amplified. It has an output voltage that is proportional to the Celsius temperature. The scale factor of LM35 is 0.1 V/°C. The LM35 draws only 60 micro amps from its supply and possesses a low self heating capability. The sensor self heating causes less than 0.1 °C temperature rise in still air.
2.4 RAIN SENSOR[5]

The rain sensor module is an easy tool for rain detection. It can be used as a switch when raindrop falls through the raining board and also for measuring rainfall intensity. The module features, a rain board and the control board that is separate for more convenience, power indicator LED and an adjustable sensitivity though a potentiometer.

The analog output is used in detection of drops in the amount of rainfall. Connected to 5V power supply, the LED will turn on when induction board has no rain drop, and DO output is high. When dropping a little amount water, DO output is low, the switch indicator will turn on. Brush off the water droplets, and when restored to the initial state, outputs high level.

Specifications

- Adopts high quality of RF-04 double sided material.
- Area: 5cm x 4cm nickel plate on side,
- Anti-oxidation, anti-conductivity, with long use time;
- Comparator output signal clean waveform is good, driving ability, over 15mA;
- Potentiometer adjust the sensitivity;
- Working voltage 5V;
- Output format: Digital switching output (0 and 1) and analog voltage output AO;
- With bolt holes for easy installation;
- Small board PCB size: 3.2cm x 1.4cm;
- Uses a wide voltage LM393 comparator

### 2.5 Liquid Crystal Display[5]

![16x2 LCD display](image)

Figure 2.7:16x2 LCD display [5]

Liquid crystal display is very important device in embedded system. It offers high flexibility to user as he can display the required data on it. But due to lack of proper approach to LCD interfacing many of them fail. LCD driver/controller is used in LCD. It is dumb it does not know to talk with microcontroller. LCD driver is a link between the microcontroller and LCD. LCD driver finds whether hardware reset is required at start up, the time of reset pulse, is it active low and which pins of LCD are to be toggled.

Major task in LCD interfacing is the initialization sequence. In LCD initialization command bytes must be sent to LCD and set the interface mode, display mode, address counter increment direction, set contrast of LCD, horizontal or vertical addressing mode, colour format. Next step after initialization is to send data bytes to required display data RAM memory location. Firstly set the address location using address set command byte and then send data bytes using the DDRAM write command. To address specific location in display data RAM one must have the knowledge of how the address counter is incremented. Incorporation of a refreshing controller in to LCD, there by relieving the CPU of the task of refreshing the LCD. In contrast LCD must be refreshed by CPU to keep displaying the data.

**Interfacing LCD with microcontroller**

Interfacing LCD with microcontroller is very easy task if the proper LCD programming algorithm is known.

LCD used here has HD44780u dot matrix LCD controller. LCD module has 8-bit data interface and control pins. One can send data as 8-bit or in pair of two 4-bit nibbles.
To display any character on LCD micro controller has to send its ASCII value to the data bus of LCD. For e.g. to display 'AB' microcontroller has to send two hex bytes 41h and 42h respectively. LCD display used here is having 16x2 size. It means 2 lines each with 16 characters.

Algorithm to send data to LCD

- Make R/W low
- Make RS=0 ;if data byte is command
- RS=1 ; if data byte is data (ASCII value)
- Place data byte on data register
- Pulse E (HIGH to LOW)
- Repeat the steps to send another data byte

LCD Initialization

Steps to initialize the LCD

1. Specify function set: Send 38H for 8-bit, double line and 5x7 dot character format.
2. Display On-Off control: Send 0FH for display and blink cursor on.
3. Entry mode set: Send 06H for cursor in increment position and shift is invisible.
4. Clear display: Send 01H to clear display and return cursor to home position

Next step after initialization is to send data bytes to required display data RAM memory location. Firstly set the address location using address set command byte and then send data bytes using the DDRAM write command. To address specific location in display data RAM one must have the knowledge of how the address counter is incremented.

16X2 LCD

16X2 LCD can be used to display 16 characters in 2 rows. It has the ability to display numbers, characters and graphics. It has an inbuilt refreshing circuit, thereby relieving the CPU from the task of refreshing. LCD discussed has total of 14 pins.
Table 2.1 LCD pin Description

<table>
<thead>
<tr>
<th>Pin</th>
<th>Symbol</th>
<th>I/O</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Vss</td>
<td>-</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>Vcc</td>
<td>-</td>
<td>+5V Power Supply</td>
</tr>
<tr>
<td>3</td>
<td>Vee</td>
<td>-</td>
<td>Power Supply to contrast</td>
</tr>
<tr>
<td>4</td>
<td>RS</td>
<td>I</td>
<td>RS = 0 to select command register</td>
</tr>
<tr>
<td>5</td>
<td>R/W</td>
<td>I</td>
<td>RS = 1 to select data register</td>
</tr>
<tr>
<td>6</td>
<td>EN</td>
<td>I/O</td>
<td>Enable</td>
</tr>
<tr>
<td>7 to 14</td>
<td>D0 to D8</td>
<td>I/O</td>
<td>8 bit data bus</td>
</tr>
</tbody>
</table>

Table 2.2 LCD Command Codes

<table>
<thead>
<tr>
<th>Code(HEX)</th>
<th>Command to LCD Instruction Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Clear display screen</td>
</tr>
<tr>
<td>2</td>
<td>Return home</td>
</tr>
<tr>
<td>4</td>
<td>Decrement cursor (shift cursor to left)</td>
</tr>
<tr>
<td>6</td>
<td>Increment cursor (shift cursor to right)</td>
</tr>
<tr>
<td>80</td>
<td>Force cursor to the beginning of first line</td>
</tr>
<tr>
<td>C0</td>
<td>Force cursor to the beginning of second line</td>
</tr>
<tr>
<td>38</td>
<td>2 lines and 5x7 matrix</td>
</tr>
</tbody>
</table>
IOT in Indian Agriculture using Wireless sensors

Internal structure of LCD module

![Internal structure of LCD module](image)

Figure 2.8: Internal structure of LCD module[5]

LCD is connected to the microcontroller through the controller interface. LCD has an internal memory which stores the lookup table for all the characters. Any ASCII value of a character that is passed to the LCD module is compared with the lookup table in the memory and that value is displayed.

2.6 GSM

Global System for Mobile communications is the most popular standard for mobile phones in the world. Its promoter, the GSM Association, estimate that 82% of the global mobile market uses the standard. GSM is used by over 2 billion people across more than 212 countries and territories. Its ubiquity makes international roaming very common between mobile phone operators, enabling subscribers to use their phones in many parts of the world. GSM has used a variety of voice codecs to squeeze 3.1 kHz audio into between 5.6 and 13 kbit/s. Originally, two codecs, named after the types of data channel they were allocated, were used, called Half Rate (5.6 kbit/s) and Full Rate (13 kbit/s). These used a system based upon linear predictive coding (LPC). In addition to being efficient with bit rates, these codecs also made it easier to identify more important parts of the audio, allowing the air interface layer to prioritize and better protect these parts of the signal.

SUBSCRIBER IDENTITY MODULE

One of the key features of GSM is the Subscriber Identity Module (SIM), commonly known as a SIM card. The SIM is a detachable smart card containing the user’s subscription information and
phonebook. This allows the user to retain his or her information after switching handsets. Alternatively, the user can also change operators while retaining the handset simply by changing the SIM. Some operators will block this by allowing the phone to use only a single SIM, or only a SIM issued by them; this practice is known as SIM locking, and is illegal in some countries. A subscriber can usually contact the provider to remove the lock for a fee, utilize private services to remove the lock or make use of ample software and websites available on the Internet to unlock the handset themselves. While most web sites offer the unlocking for a fee, some do it for free. The locking applies to the handset, identified by its International Mobile Equipment Identity (IMEI) number, not the account (which is identified by the SIM card). It is always possible to switch to another (non-locked) handset if such a handset is available.

**GSM MODEMS**

A modem is a communication device that converts binary into analog acoustic signals for transmission over telephone lines and converts these acoustic signals back into binary form at the receiving end. Conversion to analog signal is known as modulation; conversion back to binary signal is known as demodulation. Low-speed modems are designed to operate asynchronously. Each data frame conforms an asynchronous transmission mechanism.

High-speed modems as well as leased-lines modems use synchronous transmission. The two modems use a common time base and operate continuously at substantially the same frequency and the phase relationship by circuit that monitors the connection. A half-duplex modem must alternately send and received signals. Half-duplex allows more of the channel bandwidth to be put to use but slows data communications. A full-duplex modem can simultaneously handle two signals using two carriers to transmit and receive data. Each carrier uses a half of the bandwidth available to it and its modulation.

![GSM SIM900A modem](image)

*Figure 2.9: GSM SIM900A modem [6]*
GSM IN INDIA

![GSM India Pie Chart]

Figure 2.10: GSM in India [5]

GSM SERVICES

- Tele-services
- Bearer or Data Services
- Supplementary service

Tele-services

Telecommunication services enables voice communication via mobile phones and offers services like Mobile telephony and Emergency calling.

Bearer or Data services

- Include various data services for information transfer between GSM and other networks like PSTN, ISDN etc at rates from 300 to 9600 bps.
- Short Message Service (SMS): Up to 160 character alphanumeric data transmission to/from the mobile Terminal.
- Unified Messaging Services (UMS)
- Group 3 fax
- Voice mailbox
- Electronic mail
Supplementary services

- Call Waiting - Notification of an incoming call while on the handset
- Call Hold - Put a caller on hold to take another call
- Call Barring - All calls, outgoing calls, or incoming calls
- Call Forwarding - Calls can be sent to various numbers defined by the user
- Multi Party Call Conferencing - Link multiple calls together
- CLIP - Caller line identification presentation
- CLIR - Caller line identification restriction
- CUG - Closed user group

WORKING

Sending SMS Messages from a microcontroller using a GSM Modem:

A GSM modem is a wireless modem that works with GSM wireless networks. A wireless modem is similar to a dial-up modem. The main difference is that a wireless modem transmits data through a wireless network whereas a dial-up modem transmits data through a copper telephone line. Most mobile phones can be used as a wireless modem.

To send SMS messages, first place a valid SIM card into a GSM modem, which is then connected to microcontroller by RS232 cable. The instructions used for controlling the GSM modem are called AT commands. GSM modems support a common set of standard AT commands. One use of the extended AT commands is to control the sending and receiving of SMS messages. The following table lists the AT commands that are related to the writing and sending of SMS messages:

Table 3.1: GSM AT Commands [6]

<table>
<thead>
<tr>
<th>AT command</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>+CMGS</td>
<td>Send message</td>
</tr>
<tr>
<td>+CMSS</td>
<td>Send message from storage</td>
</tr>
<tr>
<td>+CMGW</td>
<td>Write message to memory</td>
</tr>
</tbody>
</table>
AT command | Meaning
--- | ---
+CMGD | Delete message
+CMGC | Send command
+CMMS | More messages to send

It sends the characters that are typed to the GSM modem. It then displays the response it receives from GSM modem on the screen.

### Characteristics of GSM Standard

- Fully digital system using 900,1800 MHz frequency band
- TDMA over radio carriers(200 KHz carrier spacing
- 8 full rate or 16 half rate TDMA channels per carrier
- User/terminal authentication for fraud control
- Encryption of speech and data transmission over the radio path
- Full international roaming capability
- Low speed data services (up to 9.6 Kb/s)
- Compatibility with ISDN
- Support of Short Message Service (SMS)

### Advantages of GSM over Analog system

- Capacity increases
- Reduced RF transmission power and longer battery life
- International roaming capability
- Encryption capability for information security and privacy
- Compatibility with ISDN, leading to wider range of service

### GSM Applications

- Mobile telephony
- GSM-R
• Value Added Services
• Telemetry System
  ▪ Fleet management
  ▪ Automatic meter reading
  ▪ Toll Collection
  ▪ Remote control and fault reporting of DG sets

**GSM Module**

The GSM Modem comes with a serial interface through which the modem can be controlled using AT command interface. An antenna and a power adapter are provided. The basic segregation of working of the modem is as under

• Voice calls
• SMS
• GSM Data calls
• GPRS

**Applications and Facts about GSM Data Calls**

• Devices that have communication on serial port either on PC or in the embedded environment
• Devices that want to communicate with a remote server for data transfer
• This capability of data transfer can help in reducing processing requirements of the device
• The basic aim is to provide a wireless solution keeping the existing firmware intact
• The clients firmware continues to work without any modifications (no changes in the existing software required)
• GSM data calls can be a good solution where data has to be transmitted from a hand-held device to a central server
• The interface on two sides can be between PC’s as well as embedded devices
• Calls can be established by the terminals at either side to start data calls
• The Modem remains transparent during data transfer after the call is established
• Call establishment utility to be provided in case PC terminals
• Call establishment to be automated in case of embedded terminals. GSM converter can be an option where intelligence of establishing calls has to be put in case of embedded devices.
Dial-Up Networks Using GSM Data Calls: Dial up networking is a utility available with Windows through a person can dial the Data call number of this modem from any PC and share the file system on either PC’s. This can be a good utility where both terminals are PC based. Sharing the file system remotely enables monitoring of devices remotely. Thus the modem can act as a piece of device which acts as a spy in the system. Can be a good debugging utility wherein a person can configure/monitor a remote PC based system and even rectify it. Some companies do sell their products with a GSM modem inside it just for this handy feature which allows them to configure the machines sitting anywhere in the world. Since the connection can have upper layer protocols like TCP/IP in this connection it becomes more reliable and useful

GSM Converter: GSM converter will be an add-on device to be attached between a terminal which wants data transfer and the GSM modem. This GSM converter will take care of call establishment where the embedded device cannot make a call. The converter will remain transparent through-out the call once call is established. The GSM converter will be a very small piece of hardware possibly embedded inside the cable itself.

![Figure 2.11: Basic Architecture of GSM Module [3]](image)

SIM900A [7]

Description

GSM/GPRS Modem-RS232 is built with Dual Band GSM/GPRS engine- SIM900A, works on frequencies 900/ 1800 MHz. The Modem is coming with RS232 interface, which allows to connect PC as well as microcontroller with RS232 Chip(MAX232). The baud rate is configurable from 9600-115200 through AT command. The GSM/GPRS Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS, Voice as well as DATA transfer application in M2M interface.
GSM/GPRS Modem Features

- High Quality Product (Not hobby grade)
- Dual-Band GSM/GPRS 900/ 1800 MHz
- RS232 interface for direct communication with computer or MCU kit
- Configurable baud rate
- Wire Antenna ( SMA connector with GSM Antenna Optional )
- SIM Card holder.
- Built in Network Status LED
- Inbuilt Powerful TCP/IP protocol stack for internet data transfer over GPRS.
- Normal operation temperature: -20 °C to +55 °C
- Input Voltage: 12V DC

2.7 RELAY [7]

Relays are devices which allow low power circuits to switch a relatively high Current/Voltage ON/OFF. A relay circuit is typically a smaller switch or device which drives (opens/closes) an electric switch that is capable of carrying much larger current amounts.

Interfacing Relay with LPC2148

To control the relay operations by using LPC2148 Primer Board. Here we are using two Relays. The relay consists of a coil and a switch. When the coil is energized, the switch closes, connecting the two contacts together. ULN2803 is used as a driver for port I/O lines, drivers output connected to relay modules. Connector provided for external power supply if needed.

Relay Module : Port P1 pins (Realy1 – P1.20) and Relay2-P1.21) for relay module, make port pins to high, relay will activated.

2.8 STEPPER MOTOR [7]

A stepper motor is a brushless, synchronous electric motor that converts digital pulses into mechanical shaft rotation. Every revolution of the stepper motor is divided into a discrete number of steps, and the motor must be sent a separate pulse for each step.

Interfacing of Stepper motor with ARM LPC2148: The ARM7 LPC2148 board has four numbers of I/O port lines, connected with I/O Port lines (P1.16 – P1.19) to rotate the stepper motor. ULN2803 is
used as a driver for port I/O lines, drivers output connected to stepper motor, connector provided for external power supply if needed. Stepper Motor can connect JP17 or J6 connector.

The Interfacing stepper motor control with LPC2148 program is very simple and straightforward, which control the stepper motor in clockwise, counterclockwise and also a particular angular based clockwise by using switches. The I/O port lines are used to generate pulses for stepper motor rotations.

2.9 SOLAR PANEL[7]

Solar panel refers to a photovoltaic module. This module uses light energy (photons) from the sun to generate electricity which ranges from 100 to 320 watts. Photovoltaic cell performs basically 3 operations:

- The absorption of light, generating either electron-hole pairs or excitants
- The separation of charge carriers of opposite types
- The separate extraction of those carriers to an external circuit

![Solar panel](image)

Figure 2.12: Solar panel[7]

PV Modelling

Typically a solar cell can be modeled by a current source and an inverted diode connected in parallel to it. It has its own series and parallel resistance. Series resistance is due to hindrance in the path of flow of electrons from n to p junction and parallel resistance is due to the leakage current. When IR radiation hits the surface of solar PV cell, an electrical field is generated inside the cell. As seen in Fig.3 this process separates positive and negative charge carriers in an absorbing material (joining p-type and n-type). In the presence of an electric field, these charges can produce a current that can be used in an external circuit. This generated current depends on the intensity of the incident radiation. The higher the level of light intensity, the more electrons can be unleashed from the surface, the more current is generated.
The most important component that affects the accuracy of the simulation is the PV cell model. Modelling of PV cell involves the estimation of the I-V and P-V characteristics curves to emulate the real cell under various environmental conditions. An ideal solar cell is modelled by a current source in parallel with a diode.

The current source $I_{pv}$ represents the cell photo current, $R_{sh}$ and $R_s$ are used to represent the intrinsic series and shunt resistance of the cell respectively. Usually the value of $R_{sh}$ is very large and that of $R_s$ is very small, hence they may be neglected to simplify the analysis.

2.10 LDR [8]

LDR is a Light Dependent Resistor which mainly used for smoke detection, automatic lighting control, burglar alarm system and batch counting. LDR have a particular property in that they remember the lighting conditions in which they have been stored. This means the effect can be minimised by storing the LDRs in light prior to use. Light storage reduces equilibrium time to reach steady resistance values.
2.11 WATER PUMP

![Water pump image](image)

Figure 2.16: Water pump [8]

A water pump is any device for moving water, it exists in an enormous variety of styles. Some uses of water pumps include:

- Obtaining water from ground wells for drinking, cooking, and other purposes
- Moving water in active solar heating systems

2.12 BATTERY

An electrical battery is a combination of one or more electrochemical cells, used to convert stored chemical energy into electrical energy. Since the invention of the first Voltaic pile in 1800 by Alessandro Volta, the battery has become a common power source for many household and industrial applications. According to a 2005 estimate, the worldwide battery industry generates US$48 billion in sales each year, with 6% annual growth.

Batteries may be used once and discarded, or recharged for years as in standby power applications. Miniature cells are used to power devices such as hearing aids and wristwatches; larger batteries provide standby power for telephone exchanges or computer data centres.

2.13 DC MOTOR AND DRIVER

A DC motor is a class of electrical machines that converts direct current electrical power into mechanical power.

L293 Quadruple Half-H Drivers

The L293 and L293D devices are quadruple high current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V.

Figure 3.8 below depict a typical setup for using the L293 device as a controller for DC motors. Note that the L293 device can be used as a simple driver for a motor to turn on and off in one direction, and can also be used to drive a motor in both directions.
Table 2: Unidirectional DC Motor Control

<table>
<thead>
<tr>
<th>EN</th>
<th>3A</th>
<th>M1</th>
<th>4A</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>H</td>
<td>Fast motor stop</td>
<td>H</td>
<td>Run</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>Run</td>
<td>L</td>
<td>Fast motor stop</td>
</tr>
<tr>
<td>L</td>
<td>X</td>
<td>Free running motor stop</td>
<td>X</td>
<td>Free running motor stop</td>
</tr>
</tbody>
</table>

L = low, H = high, X = don’t care

Table 3: Bidirectional DC Motor Control

<table>
<thead>
<tr>
<th>EN</th>
<th>1A</th>
<th>2A</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>L</td>
<td>H</td>
<td>Turn right</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>L</td>
<td>Turn left</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>L</td>
<td>Fast motor stop</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>H</td>
<td>Fast motor stop</td>
</tr>
<tr>
<td>L</td>
<td>X</td>
<td>X</td>
<td>Free running motor stop</td>
</tr>
</tbody>
</table>
SOFTWARE REQUIREMENTS

2.14 KEIL µVISION3

The µVision4 IDE is a Windows-based software development platform that combines a robust editor, project manager and make facility. µVision3 integrates all tools including the C compiler, macro assembler, linker/locator, and HEX file generator. The µVision3 IDE offers numerous features and advantages that help you quickly and successfully develop embedded applications. They are easy to use and are guaranteed to help you achieve your design goals.

Features

- The µVision3 Simulator is the only debugger that completely simulates all on-chip peripherals
- Simulation capabilities may be expanded using the Advanced Simulation Interface
- µVision3 incorporates project manager, editor, and debugger in a single environment
- The µVision3 Device Database automatically configures the development tools for the target microcontroller
- The µVision3 IDE integrates additional third-party tools like VCS, CASE, and FLASH/Device Programming
- The ULINK USB-JTAG Adapter supports both Debugging and Flash programming with configurable algorithm files
- The Code Coverage feature of the µVision3 Simulator provides statistical analysis of your program's execution

2.15 PROLOAD V5.4

PROLOAD is a user friendly software interface for programmer boards from Sunroom Technologies. PROLOAD gets its name from "Program Loader" term. It takes in compiled HEX file and loads it to the hardware. Any compiler can be used. The source code can be in Assembly or C, as all of them generate compiled HEX file.
CHAPTER 03

HARDWARE AND SOFTWARE REQUIREMENTS

3.1 HARDWARE REQUIREMENTS

- Microcontroller ARM7 LPC2148 (1)
- Humidity sensor (1)
- Temperature sensor (1)
- Rain sensor (1)
- Alphanumeric LCD (1)
- GSM modem (1)
- GSM mobile (1)
- Relays (2)
- Stepper Motor and Driver (1)
- Solar panel (1)
- LDR (2)
- Water pump (1)
- Dry null indicator (1)
- DC motor and Driver (1)

3.2 SOFTWARE REQUIREMENTS

- Embedded C
- KEIL μversion4 software
- PROLOAD V5.4
CHAPTER 04

FLOWCHART

The below figure shows how the prototype works.
CHAPTER 5

Results and Discussion

![Snapshot of the project module](image1)

Figure 5.1: Snapshot of the project module

This Model involves sensors, LCD display, GSM and ARM processor. All the sensors will give analog output but processor will accept only the digital data. So to connect all the sensors to the ADC channel pins which are in-built to the processor. LCD will be on field display purpose. GSM module will contain a Subscriber Identity Module (SIM) user can communicate with this SIM-Number. When the particular command activated or given by the user, immediately the corresponding sensor will activates and reads the present reading and immediately sends results to the same user mobile and displays in the LCD panel in the field. Immediately user will take the necessary action if required.

Temperature, Humidity, Soil moisture, Rain sensor are used. All these devices are connected to the ARM processor. GSM is used for communication purpose, with the help of AT (attention)-Commands can communicate with the components.

![GSM initialisation](image2)

Figure 5.2: GSM initialisation

Figure 5.2 shows the initialization of GSM, it is the first step as soon as the power is switched on the GSM gets initialized. The GSM modem is connected with the ARM processor via UART. This message will be displayed on the LCD screen.
Figure 5.3: Mode selection

Figure 5.3 shows the mode selection, as soon as the GSM is initialized the system asks for the user to select either auto mode or manual mode. The user will be provided by two switches may select the option depending on his requirement.

Figure 5.4: Checking for solar energy

Figure 5.4 shows the checking of availability of solar in the land. LDR detects the sunlight, if sunlight is present then user gets the message as solar is available otherwise no.

Figure 5.5: Three phase line and water level checking

Figure 5.5 shows the three phase line and water level checking. The system will check for three-phase line, if there is no solar energy then the motor works on mains which works on three phase line.

It will check the water level in the tank, if the water level is below medium then the motor will turn on.
Figure 5.6: Measuring of moisture level.

Figure 5.6 shows the measuring of moisture level in the soil. Moisture sensor measures the moisture level in the soil. If the moisture level is normal then that indicates there is sufficient amount of water is present in the soil, if the moisture level is below the normal value it indicates that the land is dry, in that case the user need to turn on the motor to water the field.

Figure 5.7: Measuring of temperature

Figure 5.7 shows the measuring of temperature in the land. Temperature sensor measure the temperature of the particular field and the information will send to the user in the form of SMS.

Figure 5.8: Opening and Closing of panels

Figure 5.8 shows the opening and closing of panels to protect the crops from the rain. If the rain sensor detects rain then the panels will get close to protect the crops from rain otherwise the panels will remain open.
CHAPTER 06

Applications and Advantages

6.1 APPLICATIONS

User can monitor their Large fields, forests, gardens from anywhere, this can be used in agricultural fields which is very helpful and useful for the farmers, as solar energy is plenty and renewable, people can depend upon this energy thus by saving the other non-renewable energy sources, it optimises the power usage through water resource management and also saving government’s free subsidiary electricity and this proves an efficient and economy way of irrigation and this will automate the agricultural sector.

6.2 ADVANTAGES

Helps in utilising non-renewable sources by using solar energy, there is no need of employees, it saves water and user time, it protects the crops and it is compact and low cost Protection for water pumps during dry null.
CHAPTER 07

Conclusion

The project is thus carried out using ARM7TDMI core with the help of GSM technologies. This project finds application in domestic agricultural field. In civilian domain, this can be used to ensure faithful irrigation of farm field, since we have the option of finding out moisture level of soil in a particular area[6]. The automated irrigation system implemented was found to be feasible and cost effective for optimizing water resources for agricultural production. This irrigation system allows cultivation in places with water scarcity thereby improving sustainability. The farmer can monitoring from any place, and also can protect his crop. The user can send a SMS message from anywhere in the world to operate this equipment. The security feature in the software will make sure that it works only with pre-assigned phone numbers.
REFERENCES


ACRONYMS

**ARM**-Advanced Risc Machine
**CISC**-Complex Instruction Set Computer
**GSM**-Global System for Mobile Communication
**GPRS**-General Packet Radio Service
**GPS**-Global Positioning System
**LCD**-Liquid Crystal Display
**LDR**-Light Dependent Resistor
**LED**-Light Emitting Diode
**LPC**-Linear Predictive coding
**RISC**-Reduced Instruction Set Computer
**SIM**-Subscriber Identity Module
**UART**-Universal Asynchronous Receiver Transmitter