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BORANG PENGESAHAN STATUS TESIS♦

JUDUL: **REMOTE DATA LOGGER WITH MULTI-SENSOR FOR GREENHOUSE**

SESI PENGAJIAN: 2011/2012

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REMOTE DATA LOGGER WITH MULTI-SENSOR FOR GREENHOUSE

LAM KHENG YIK

A report submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Engineering (Electrical and Electronic)

Faculty of Electrical and Electronic Engineering
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Date : 19 JUNE 2012

DEDICATION

Specially dedicated to

My beloved parents, siblings,

Lecturers, and all my friend

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ABSTRACT

A data logger or a data acquisition system is an electronic device common in measurement application. The basic form of data logger is to capture and store the environment parameters over a period of time with incorporating sensors. This stand alone device measure, collect and store data on the Secure Digital (SD) card. Microcontroller is used in this system to perform the job. The system is equipped with several sensors such as temperature, humidity, lights intensity and air contaminants. The data can be analyzed in standard condition or using Personal Computer (PC) for offline analysis and report. In the end, microcontroller Atmega32 system board is able to display four parameters from each sensor on Liquid Crystal Display (LCD).

ABSTRAK

Data logging atau *data acquisition system* adalah peranti elektronik yang sama dalam pengukuran. Bentuk asas data logger adalah untuk mengambil dan menyimpan parameter persekitaran sepanjang tempoh masa dengan *sensor* menggabungkan. Peranti ini langkah pendirian sahaja, mengumpul dan menyimpan data pada system ini untuk melaksanakan tugas. Sistem ini dilengkapi beberapa *sensor* seperti suhi, kelembapan udara, intensity cahaya dan bahan cemar udara. Data boleh dianalisis dalam keadaan *standard* atau menggunakan komputer peribadi (PC) untuk analisis dan laporan data. Akhirnya, *microcontroller Atmega32 system board* dapat menunjukkan bacaan daripada empat *sensors* berbeza dalam Liquid Crystal Display (LCD).

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The usage of electronic device such as data logger has been growing rapidly. It is a stand-alone device which is portable, small size, powered by battery and ability to collect data on a 24-hour operation. The basic requirement for a data logging system is acquisition, online analysis, logging, offline analysis, display and data sharing. Most data loggers collect data which may be directly transferred to a computer. It is a very common measurement application which can be programmed and record electrical parameters over a period of time with a built in a sensor. Conversion of electrical impulses from process instrument into digital data can be performed by using microcontroller in order to record and store on the storage device for further analysis. There are varieties of storage media option such as non-volatile memory, memory card, floppy disks. Personal Computer (PC) based logging systems is very popular in industrial, so mostly user will implement this system by using PC as their data storage devices to store data on a local drive.

There are a lot of different data loggers in the market with various sensors. By choosing desire parameters to be measured, input signals and number of inputs have to be considered. It is usually economical. The advantages of data loggers are in terms of ability to work at very long intervals, portable, reliability, flexibility and robustness.

Some of the criteria must be noted such as size, speed/memory, real time operation and display. Smaller size is preferred depends on the purpose of usage. Speed is important due to sampling rate from the changes of parameter. High memory offer capability to record data for a longer interval. Time provided is important for user analysis based on the data. All the parameter should be able to display on screen so user able to read the readings.

A wide-spread operation of data logging system can be found from science laboratory, hospital, manufacturing industries or weather stations. Due to independently and sensitivity variation of parameters in data logger, it can be replaced human job to measure parameter in a high risk situation. Furthermore, this system is equipped by real-time information as well as capture historical data.

1.2 Problem Statement

How to sense indoor or outdoor air problems, temperature and humidity? By solving this issue, it can be identified and possibly prevented with the help of data loggers and sensors.

How to read the data after measured by data logger?

How to arrange the result that had been captured?

1.3 Project Objective

The aim of the project is to design a stand-alone microcontroller-based remote data logger that able for measuring, monitoring and store the current parameters such as temperature, light intensity, humidity and air contaminants in Secure Digital (SD) card.

The measured data will be stored in a memory card such as SD card at the defined interval that issued by user in a actual format so it can be easily analyzed by the user. At the same time, parameter measured from sensors will display readings on Liquid Crystal Display (LCD).

The data will be stored into SD card and can be retrieved by using PC for analysis.

1.4 Project Scope

In order to develop this system, a prototype should be prepared. In order to accomplish it, scope of the project is summarized as follow:

- Develop an 8-bit microcontroller Atmega32 as the main controller for the system

- Design sensor circuits for temperature, humidity, light intensity and air contaminants

- Develop a LCD module for display information

- Design a Real Time Clock (RTC) for real-time parameter and 4x4 matrix keypad to keep track and update from time to time

- Develop a SD memory card for data media storage

- Develop a Microsoft Visual Basic (VB) program for read SD card and offline analysis

1.5 Thesis Outline

This thesis will consist of six chapters. Every chapter details will elaborate as below.

Chapter 1 gives a brief overview of the project. Objectives and scope of project also stated here to provide guideline in this chapter.

Chapter 2 involves literature review. The review of previous research papers such as AVR microcontroller module, sensors module, LCD display module, keypad module, ZigBee module and real time clock module are included here.

Chapter 3 discusses the methodology of this project. Hardware and software implementation are included in this chapter too. The discussion is based on flow chart of the system.

Chapter 4 contains the testing result and the discussion of the testing will conducted.

Chapter 5 will indicates the recommendation for future development. Besides, the conclusion of the outcome of the project included as well.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Literature review is a previous researches and studies contributed according to data logger and related field. It plays pivotal role in developing in order to study contributed work. Several papers and journals are reviewed in order to produce the ultimate design. Relevant researcher works to the project will be discussed in details.

2.2 Previous Project Work

Data logger is a stand-alone device which plays an important role especially in industries. It has become more flexibility and convenient because it helps in the situation where the information changes faster than a human can possibly collect. The following researchers topics will discussed in details below.

2.2.1 8 Channel Configurable Data Logger for Reliability Testing and Quality Assurance

In Jano Rajmond and Dan Pitica [1] research work, they are built for 8 channel configurable data logger as input channel to measure either voltage or current. The input channels are chosen by a 2:1 multiplexer in order to proceed by 10 bit build-in ADC conversion unit of the Atmega8 microcontroller. Measurement data is stored for later analysis on a PC by creating virtually unlimited space for storage. When 8 channels have been measured, it will send the packet to the PC. All steps will repeat by measure a new incoming channel according to a new channel configuration. Figure 2.1 shows the block diagram of this system.

Storage is not an issue in this project due to high capacities of memory hard disk storage in PC. The only weakness stated by researchers is the timestamp is not consistent by using software. They suggested that using real-time clock circuit to reduce error and improve the system. To make a more perfect independently system, researchers was suggested intervene the system to attract user's attention to avoid irremediable damage.

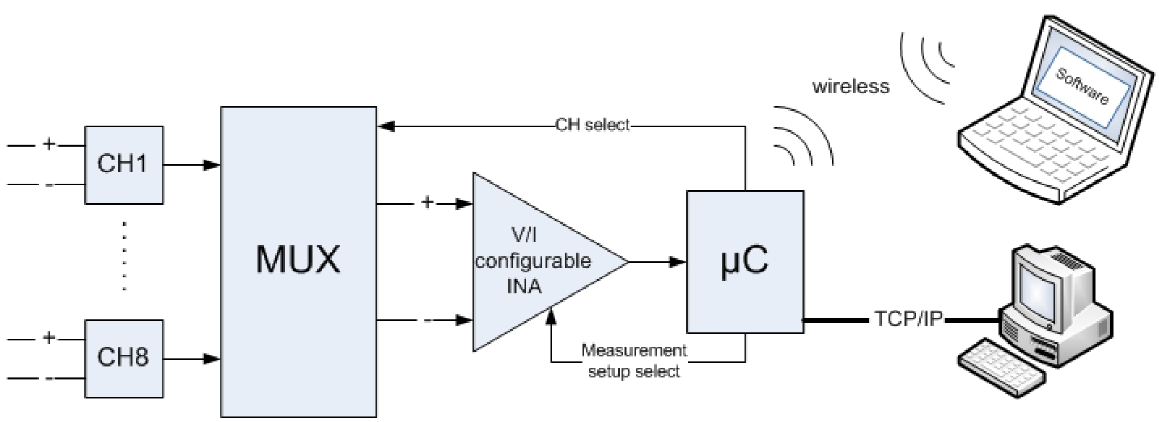

Figure 2.1: Block diagram of the 8 channels data logger

2.2.2 Microcontroller based Data Logger System

The senior students of Information Technical Division Engineering at Soonchunhyang University [2] built their project by using microcontroller Atmega128. Atmega128 supported several features in their project such as transparent D-latch, SRAM chip and RS-232 chip. Transparent D-latch is cooperating with SRAM module in order to demultiplexing address/data channels from the Atmega128. In RS-232 module, it is function as serial communication between Atmega128 with PC.

Master/slave function applied in this project. They used BIM-418-F as their RF module to wirelessly transmit and receive the signal. In master circuit, they designed main device of RS-232 module and RF module. However, slave circuit consists of RF module, LCD and power module. The parameters from sensors will be sending from master to slave circuit through RF module and display on LCD. Data transmission will be used half duplex method at speeds 40k bit/sec within distance of 30 meters in the building.

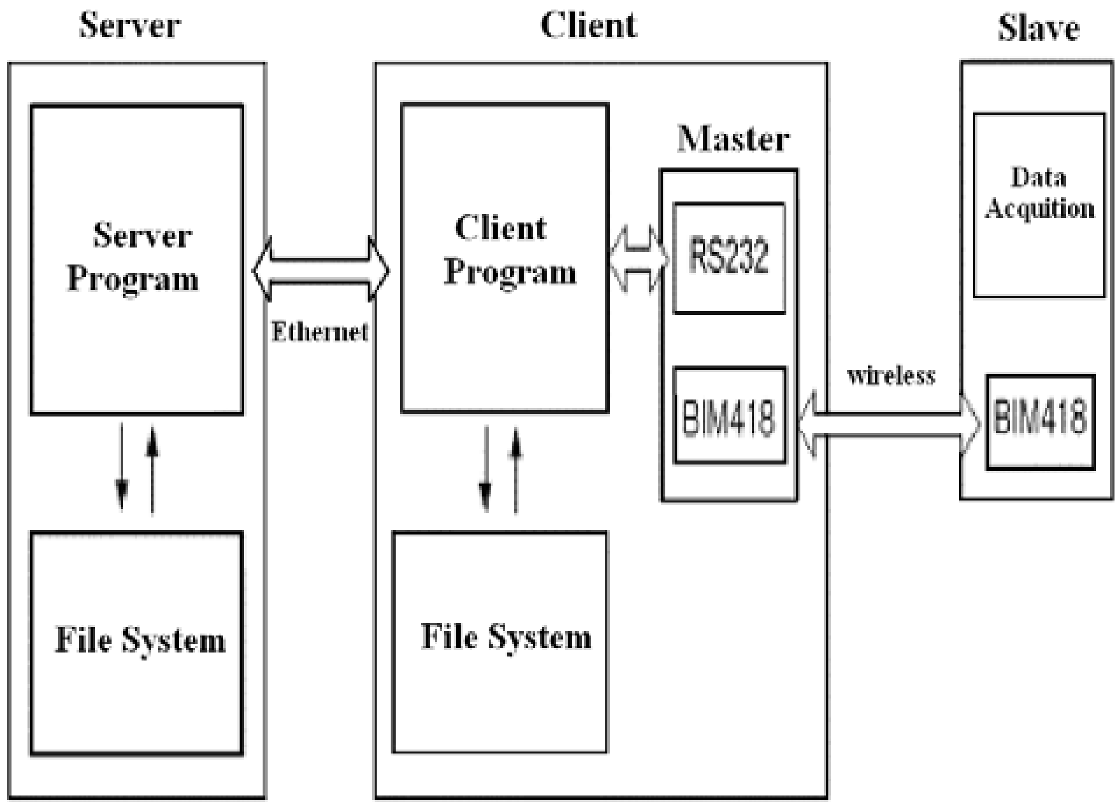

Figure 2.2: Data logger diagram consists of Master and Slave

2.2.3 CAN Based Smart Sensor Network for Indoor Air Quality Monitoring

Minu A Pillai, Sridevi Veerasingam and Taswanth Sai D [3] successfully built an indoor air quality monitoring system by using controller Area Network (CAN). CAN is a based on smart sensor network. It can provide an ideal platform for interconnecting nodes and allows each node to communicate with any other nodes.

CAN based smart sensor network developed with two transmitter nodes and one receiver nodes. Two transmitter nodes consist of air contaminants sensor (TGS 2600) and volatile of organic solvents sensor (TGS 2620) to measure sensitivity concentration in the air. For receiver node, motor control is the node which is activated or deactivates the fan to control indoor air quality.

When the system begins, both sensors will start measuring air quality based on its own function. Analog data from sensors will send to AT89C51CC03 microcontroller by using inbuilt ADC which is converting from analog to digital form. Then, microcontroller will give out digitally output to CAN transceiver so CAN used to communicate between two sensor nodes and motor control node. CAN bus interface with the sensors will transmit to the motor control node which is received by another CAN bus. If the data received is higher than defined limit, motor will activate the fan and it will start to rotate continuously. Figure 2.3 shows the overall CAN application system that has been proposed.

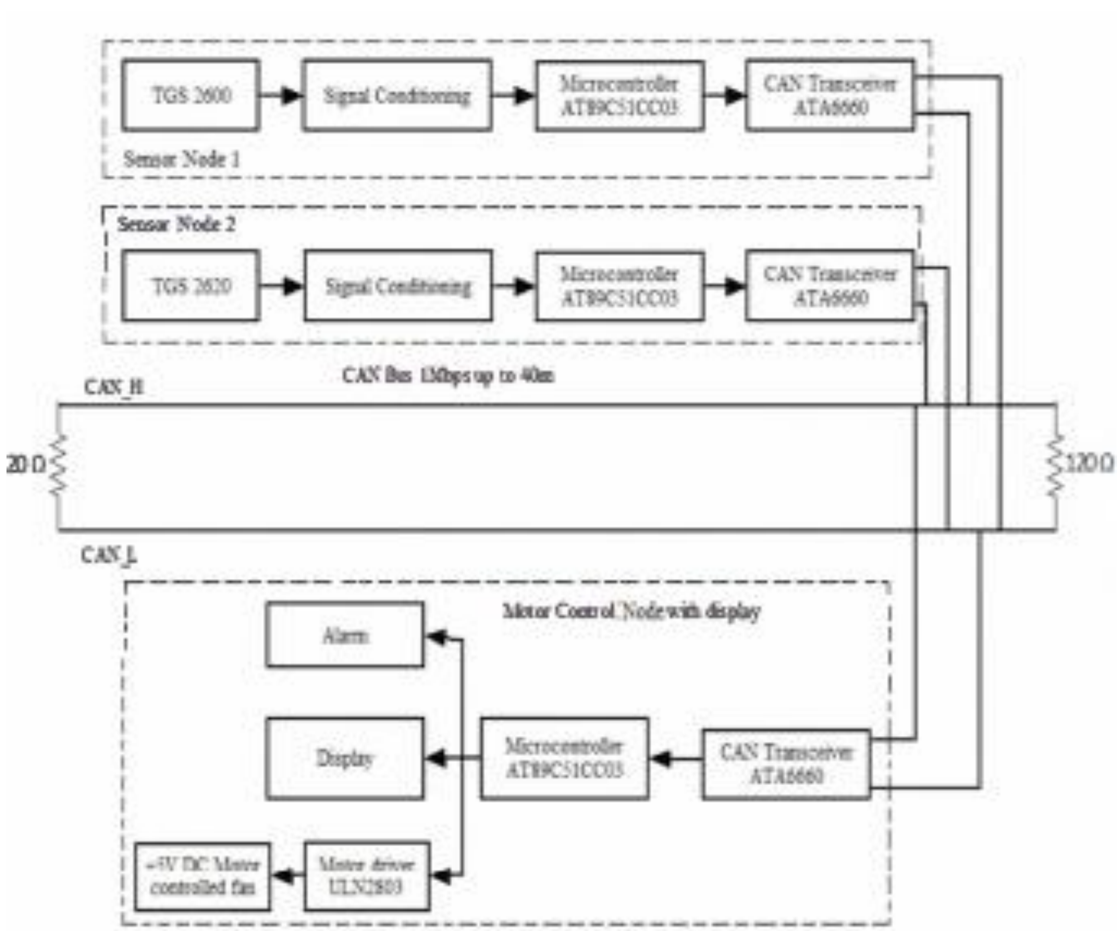

Figure 2.3: Schematic of CAN application system

2.2.4 Smart Wireless Temperature Data Logger Using IEEE 802.15.14/ZigBee Protocol

Four researchers Vivek Kumar Sehgal, Nitin, Durg Singh Chauhan and Rohin Sharma [4] have developed a temperature data logger system by using IEEE 802.15.4 ZigBee protocol. They are used 8 bit microcontroller 89C51 and temperature sensor LM35-DZ. This sensor is operating from range 0 degree Celsius to 100 degree Celsius. The measured parameter will be proceeds by ADC from microcontroller. There will be conversion data from analog form to digital form by ADC then microcontroller will transmit the data digitally through ZigBee module which is send to an assigned receiver. Another module assigned as receiver will receives the data and display on LCD. In same spot, RS-232 will transmit the data to the PC for monitoring and analysis.

During the process in this system, researchers faced some challenges. They found out if ZigBee module placed in a long range distance between transmitter and receiver, there will be error occurred. In order to solve the issue and make this system to be more perfect, researchers has been suggested that is built a memory database by using chip memory and connected remotely to the PC through wireless link. Besides, they also stated system can be more stable and efficiency by using PID control algorithm. In future work, they will build their system to compatible with different network protocols. Figure 2.4 shows the block diagram of ZigBee transmission and Figure 2.5 shows the block diagram of ZigBee receiver.

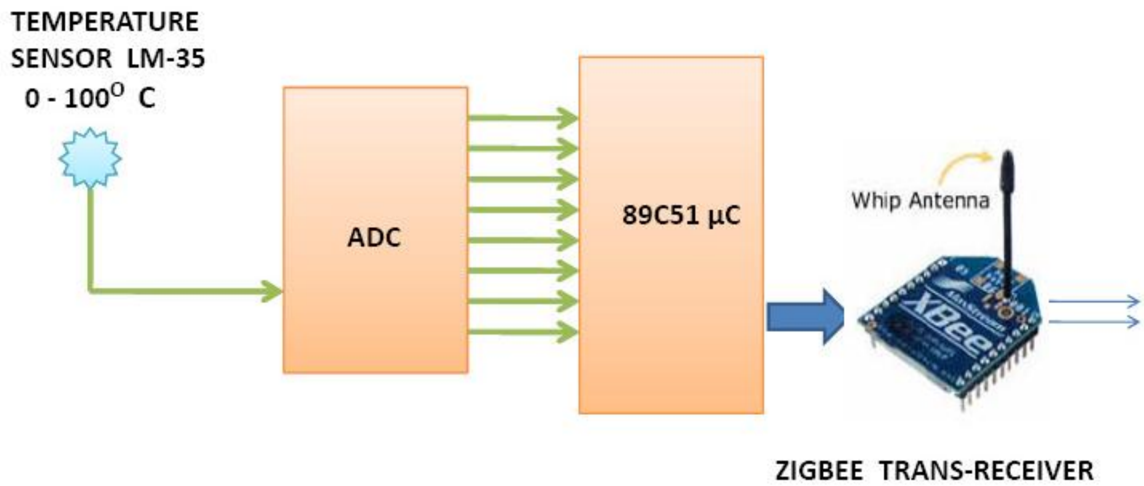

Figure 2.4: Block diagram for ZigBee transmitter

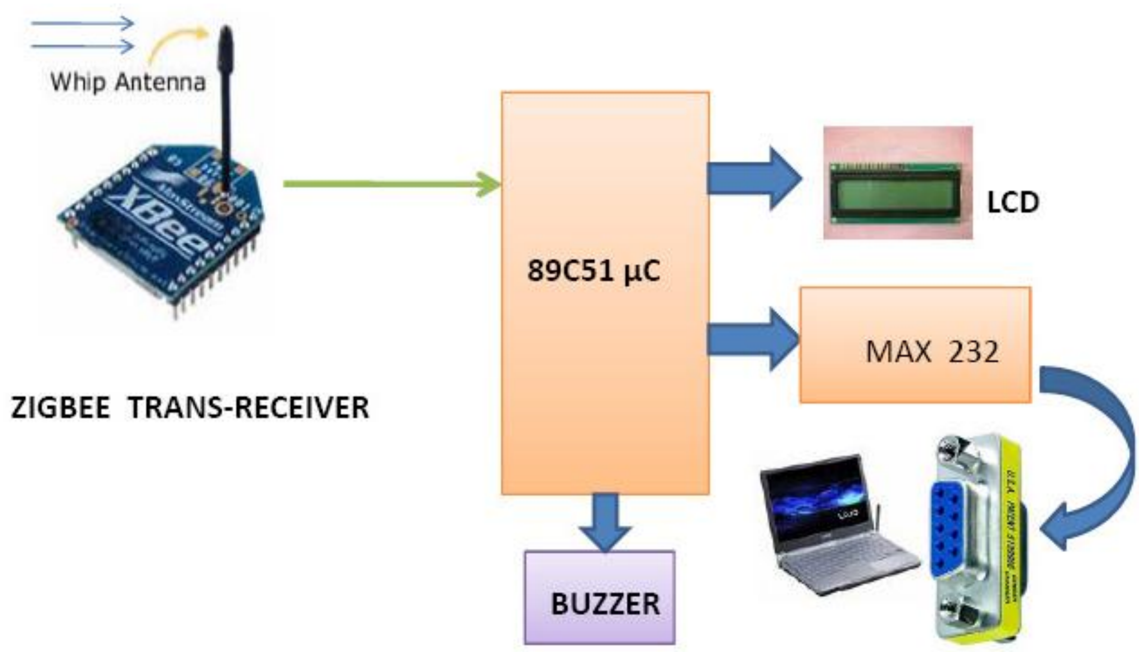

Figure 2.5: Block diagram for ZigBee receiver

2.2.5 Development of an Indoor Environment Monitoring System with Secure Digital (SD) Card Storage

The most important for monitoring system is the need to store the results in memory storage for future graph analysis. Most of the systems have chosen to store into PC due to its unlimited memory. Some of the researchers prefer to store the parameters into Electrically Erasable Programmable Read-Only Memory (EEPROM) memory chip. However, for researchers Cheng Wei Peh, Vee Khee Wong and Ying Khai [5], they have chosen SD card in their system as memory storage. the block diagram of indoor monitoring system is shown in Figure 2.6.

The main purpose in this system is to develop a monitoring environment variation system. They are using 8-bit PIC18F4620 microcontroller with external crystal 10MHz act as a main controller system following by some module such as sensors, LCD and SD card. LCD will be display parameter from sensors via RS232 port. The main circuit is using LM7805 voltage regulator to generate 5V which is compatible to microcontroller, sensors and LCD.

SD card is operating under Serial Peripheral Interface (SPI) mode. The library file of microcontroller is used to provide an interface to File Allocation Table (FAT)-12 and FAT-16. By using Java program which is Graphical User Interface (GUI), it can allowed to access and analyze data file recorded in the SD card.

Researchers stated that the microcontroller used in this system is not sufficient that expected due to insufficient of the remaining memory space to apply in other system function. Master Synchronous Serial Port (MSSP) in microcontroller cannot be use simultaneously between I2C and SPI; it can only choose one feature to function in one time. In this reason, Real Time Clock (RTC) which is using I2C feature to provide accurate timing information affected. If the system using SPI feature for SD card for storage purpose, it is impossible to use I2C in the same time. In order to solve this problem, researchers suggested that system can upgrade by using bit banging method from programming effort.

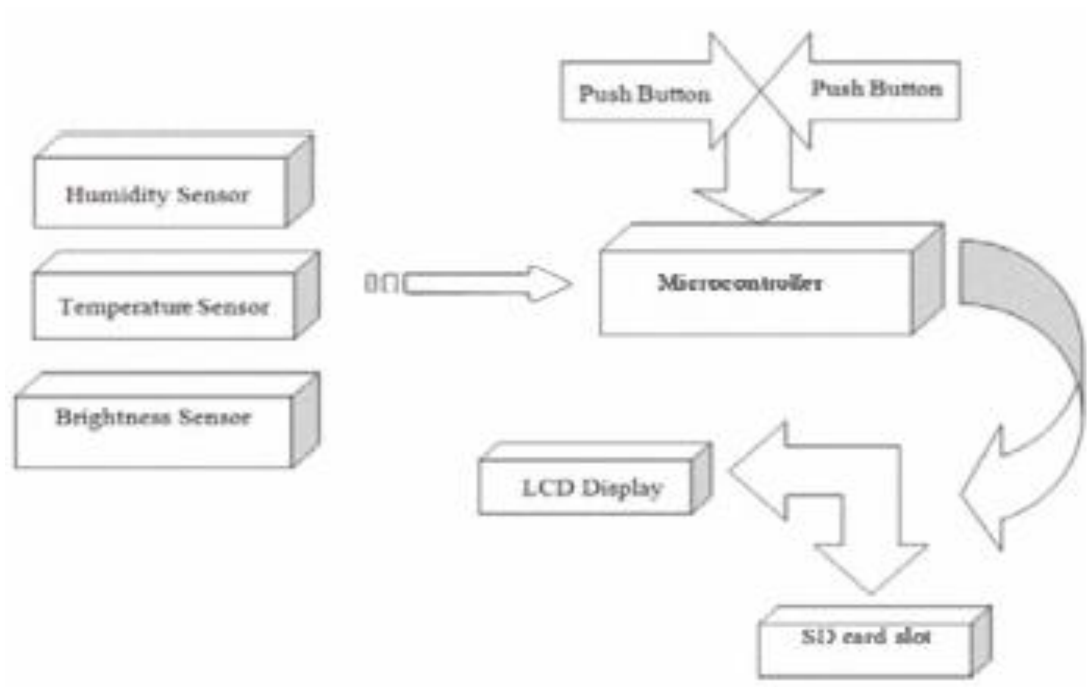

Figure 2.6: Block diagram of indoor monitoring system

2.2.6 A Simple Low Cost Data Acquisition System for Remote Sensing of Relative Humidity and Temperature

The researchers have presented a simple technique in combining analog circuit and digital circuit theory together with programming technique to control the hardware for remote sensing of temperature and relative humidity. In Figure 2.7 as shown, a capacitance relative humidity sensor was used in order to converts this capacitance into voltage proportional to relative humidity. In temperature sensor, thermistor Bridge with Whetstone is used and produce a differential output voltage changed with temperature changes. Figure 2.8 shows the linearizing network for temperature sensor. All these sensed signals in analog form will converted to digital signal in order to store data into PC. Data from PC is then viewed and analysis. In PC, Visual C++ software is used to download and upload data from the data logger for analysis. Figure 2.9 as shown is the block diagram of complete system.

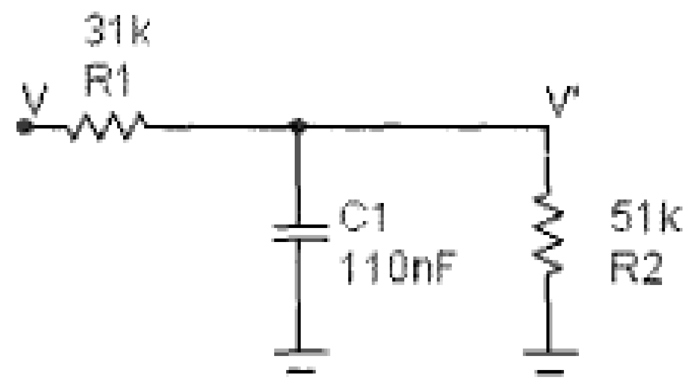

Figure 2.7: Linearizing circuit for sensing relative humidity

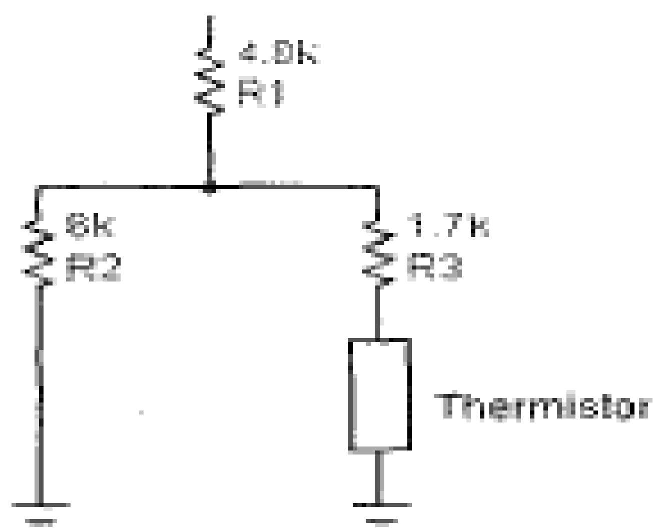

Figure 2.8: Linearizing network for temperature sensor

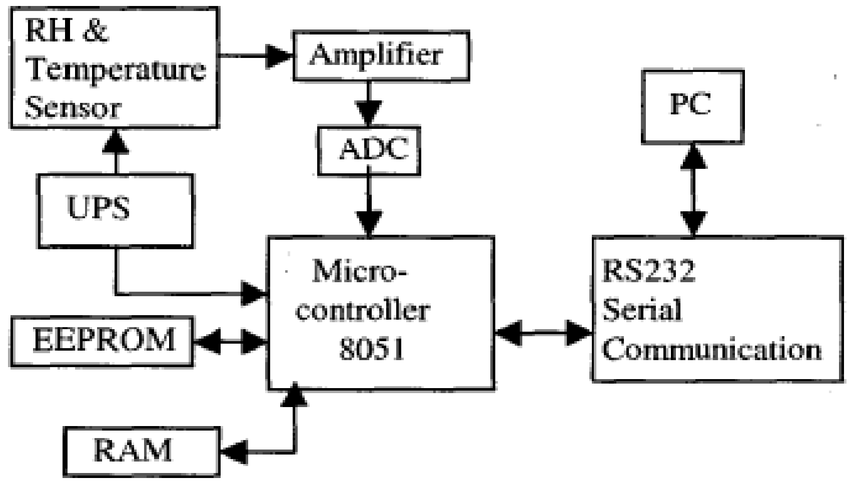

Figure 2.9: Block diagram for complete system

2.2.7 SoSE Oriented Multipurpose Human-Data Acquisition System Based on MEMS Sensors

Takayuki Fujita, Kazusuke Maenaka, Katsuhisa Yamamoto, and Sayaka Okochi [7] presents the data of human activities and circumstances for the system-of-systems engineering (SoSE) with human centered systems. This project is using Micro Electro Mechanical Systems (MEMS) sensors device to monitor the human accidents or problems. It can measure various parameters and store into micro SD card. The device is put on the left chest in order to do an experiment. Several motions are done such as walking, running, and climbing to observe the changes of the parameters. Finally, all data are collected and analysis based on the acceleration from the user. In order to improve the system, this device has to further miniaturization by using MEMS technology and some energy harvesting modules to obtain the power from the light source or human movement.

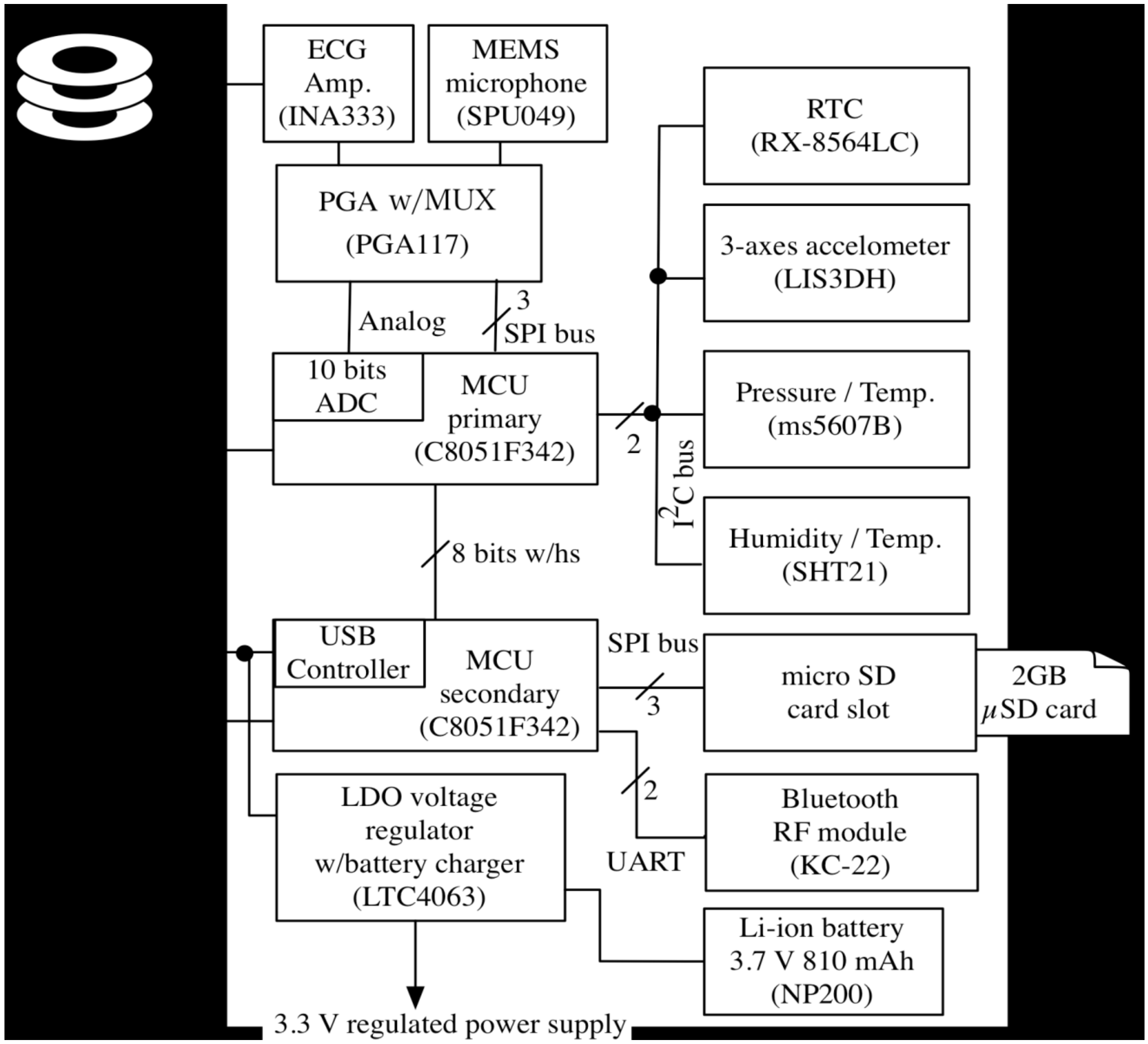

Figure 2.10: Block diagram of the prototype system

2.3 Conclusion

According to previous researches contribution, it can be concluding that in order to produce an ultimate design, some of the device must include in this system. There are microcontroller Atmega32, sensors, LCD, keypad, RTC, XBEE and SD card.

CHAPTER 3

HARDWARE DESIGN

3.1 Hardware Overview

This chapter emphasizes on the greenhouse concept in order to monitor, measure and record environmental parameters. In general, this system consists of 7 main modules and connections as shown in Figure 3.1. Those modules are

- Microcontroller Atmega32 module
- Temperature, humidity, light intensity and air contaminants sensor module
- Liquid crystal display (LCD) module
- Real time clock module
- Keypad module
- XBEE module
- SD card module

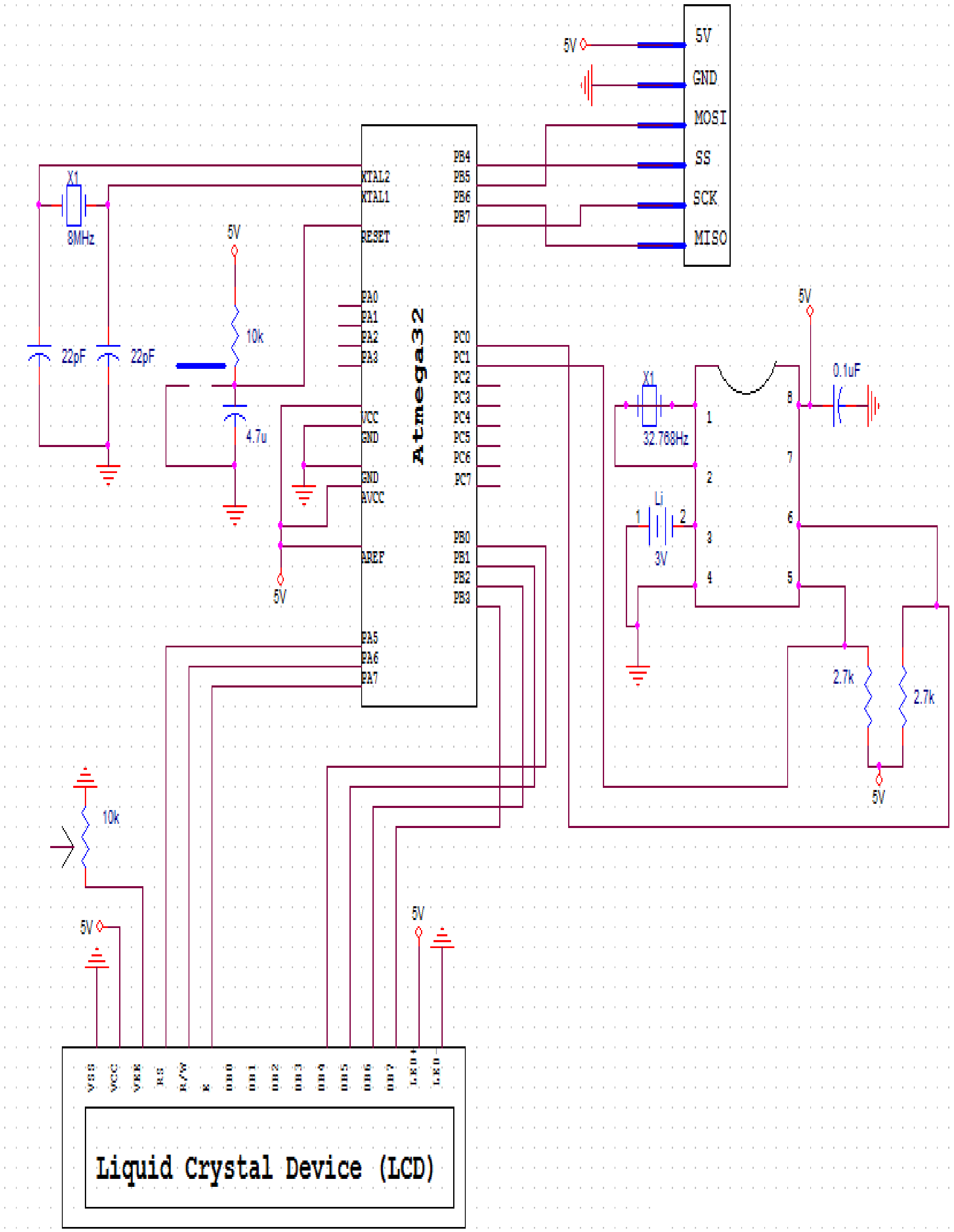

Figure 3.1: Schematic diagram of microcontroller Atmega32 system board

3.2 Microcontroller System

Embedded microcontroller is assigned to perform a task. Many manufactures have designed a high-end embedded processor where the normal processor is used to optimize processor for embedded systems. They are five major 8-bit microcontrollers which are Freescale Semiconductor's (formerly Motorola) 68HC11, Intel's 8051, Atmel's AVR, PIC from Microchip Technology and Zilog's Z8. In this system, Atmel's AVR family Atmega32 is chosen. This is due to the fact that it meets the computing needs for the task at efficiently and cost effectively in categories of speed, packaging, power consumption, and amount of Random Access memory (RAM) and Read-Only Memory (ROM) on the chip, number of I/O pins and the timer on the chip. Software and hardware development tools availability such as compiler, assemblers, debuggers and emulators. Besides, simple architecture and language of Atmega32 is the criteria to be considered.

The block diagram for microcontroller system is shown in Figure 3.2. .It consists of clock circuit, power supply, reset circuit, In-System Programmable Flash Program memory, EEPROM and Static Random-Access memory (SRAM). Power module provides 5V supply to the system while reset circuit is used to immediately reset I/O ports to their initial state. Clock circuit is needed to perform 8MHz pulses for system operates. The job of In-System Programmable Flash Program memory, EEPROM and SRAM are assigned to store program respectively.

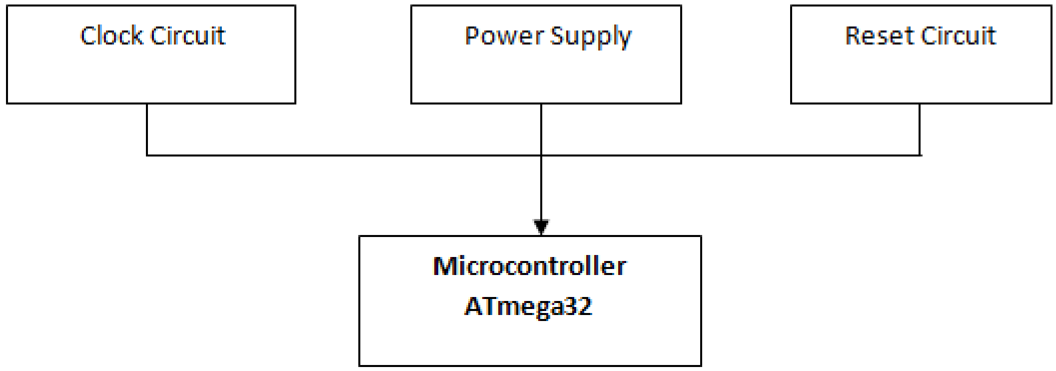

Figure 3.2: Block diagram of microcontroller board module

3.2.1 Power Supply Circuit

LM7805 of voltage regulator is used as power supply to provide a 5V to the microcontroller Atmega32. These regulators can provide local-on-card regulation, eliminating the distribution problems associated with single point regulation. Each type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. This is shown in Figure 3.3.

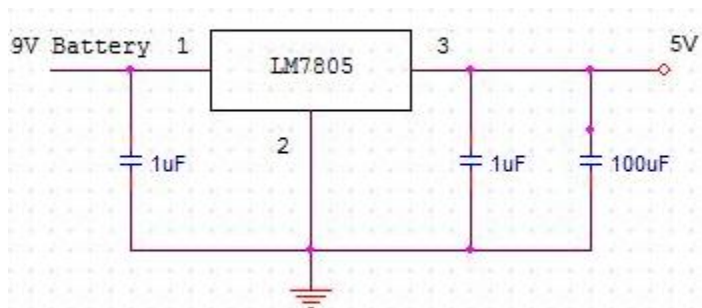

Figure 3.3: Power supply circuit

3.2.2 Reset Circuit

Reset module is used to reset the Atmega32 controller so it can be initialized properly. If reset button is pressed as shown in Figure 3.4, all I/O registers are set to their initial values, and the program starts execution from the Reset Vector.

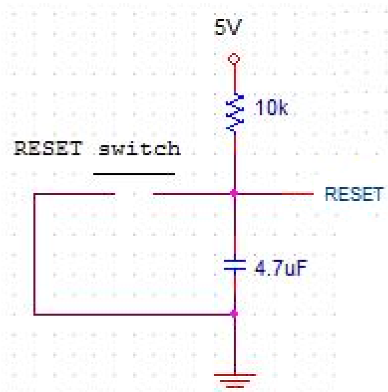

Figure 3.4: Reset circuit

3.2.3 Clock Circuit

The clock circuit shown in Figure 3.5 is used 8MHz of crystal oscillator. XTAL2 and XTAL1 are used to connect crystal to internal clock circuit to generate clock for the microcontroller Atmega32 to operate. The oscillator output will oscillate with a full rail-to-rail swing on the output.

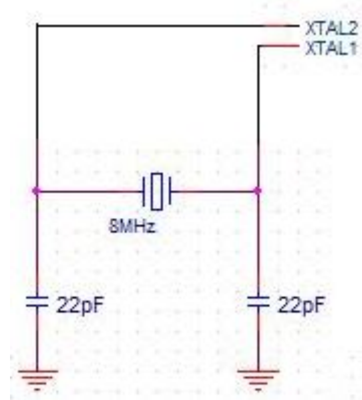

Figure 3.5: Clock circuit

3.3 Sensor Module

There are 4 types of sensors used to measure the environment parameters. They are temperature, humidity, light intensity and air contaminants sensors.

3.3.1 Temperature and Humidity Sensors

HSM-20G is compatible with all types of microcontroller and Figure 3.6 shows the connection for HSM-20G sensors circuit by using 5V supply. HSM-20G is a sensor which is combination of temperature and humidity. It is small size and easily to conceal. Voltage analog output for humidity is in percentage of relative humidity (%RH) and temperature is in degree Celsius (℃). They are connected to PA0 and PA1 in microcontroller Atmega32 respectively.

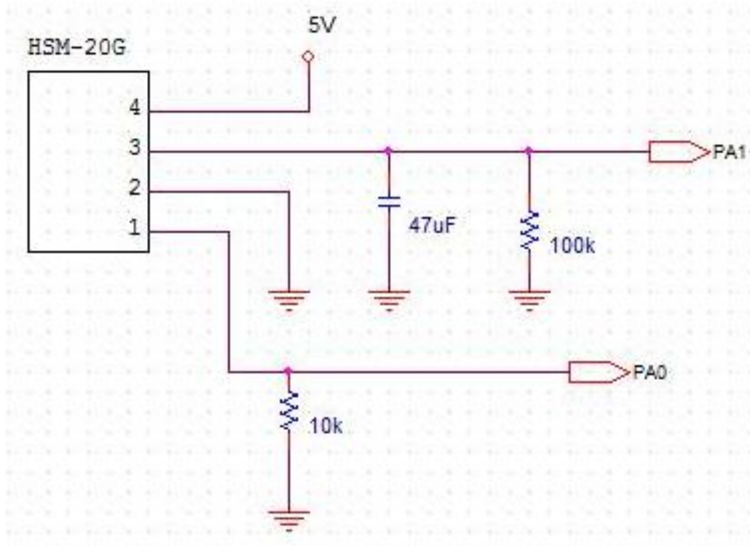

Figure 3.6: HSM-20G temperature and humidity sensors circuit

3.3.2 Light Intensity Sensor

A simple circuit connection for light intensity sensor using TSL 250R is shown in Figure 3.7. The measurement is performed through PA2 of the microcontroller Atmega32 and the output of the conversation will be display in unit micro-watt per centimeters square ($\mu W/cm^2$). In this case, the output voltage is directly proportional to the light intensity (irradiance) on the photodiode.

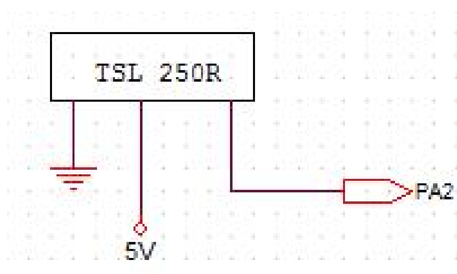

Figure 3.7: TSL 250R light intensity sensor circuit

3.3.3 Air Contaminants Sensor

The TGS 2600 sensor is suitable for indoor air quality monitoring. It is designed for controlling the concentration of air contaminants. It is connected to PA3 in microcontroller Atmega32 for measurement and display in unit parts per million (ppm). The connection between microcontroller Atmega32 and TGS 2600 is shown in Figure 3.8.

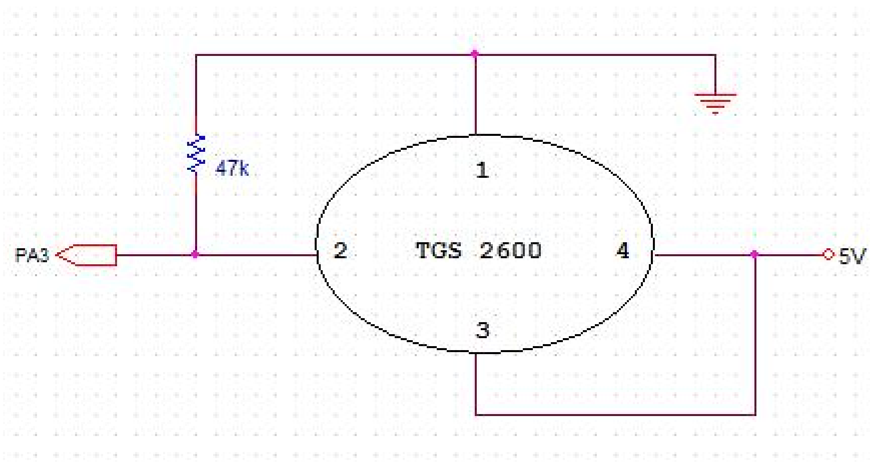

Figure 3.8: TGS 2600 air contaminants sensor circuit

3.4 LCD Module

Figure 3.9 shows a simple circuit connection for the JHD162A LCD. The LCD consists of 16pins such as for data input (DB0-DB3), register select (RS), enable (E), read/write (R/W) and power supply. Enable (E) is used to supply a high-to-low pulse in order for the LCD to latch in the data present at the data pins. Read/write (RW) is used to allow write information to the LCD or read information from it. The control register (DB0-DB3) are used to send information to the LCD or read the content of the LCD's internal registers. 2x16 LCD must be initialized before the command and data are sending to the LCD. LCD is built with 5x7 dot matrix character with cursor.

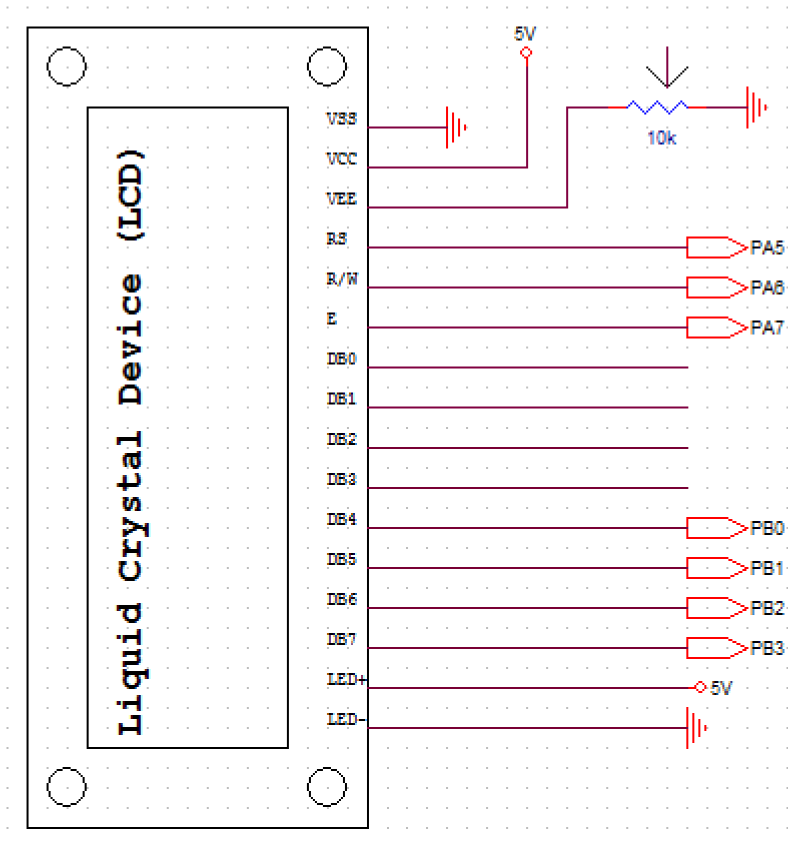

Figure 3.9: LCD circuit

3.5 Real Time Clock Module

DS1307 chip is a widely used device that provides accurate time and date information for many applications. It is also used for stores the current days, date and time in seconds, minutes and hours information in registers. It is a low power, full BCD clock/calendar plus 56 bytes of nonvolatile SRAM. The interface between real time clock (RTC) and microcontroller Atmega32 is shown in Figure 3.10. It allows reading the time keeping in registers. Address and data are transferred serially via a 2-wire bidirectional bus through an Inter-Integrated Circuit Communications (I2C). Time keeping operation continues while the part operates from the backup supply which is 3V from lithium battery.

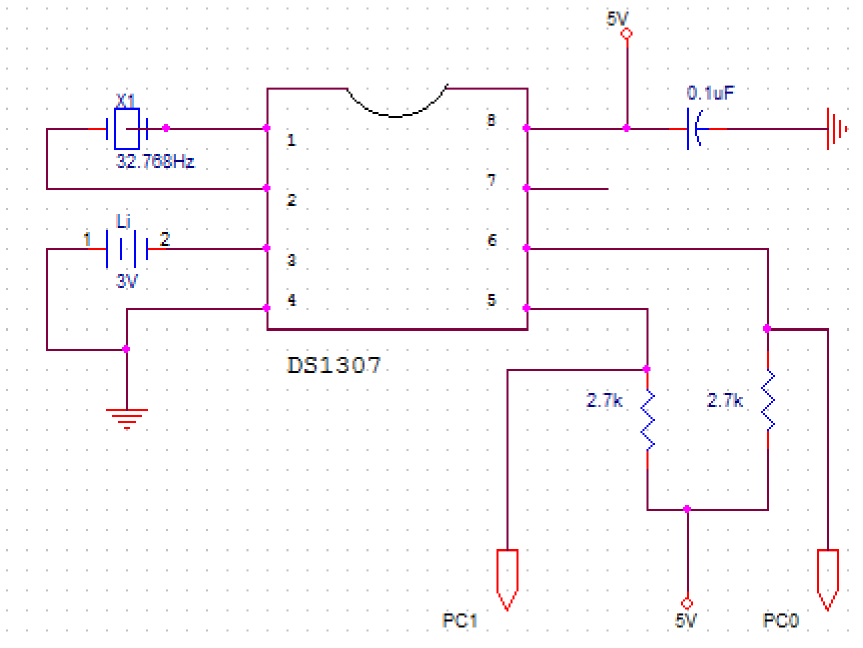

Figure 3.10: Real time clock circuit

3.6 Keypad Module

A 4x4 matrix keypad is deployed to set current date and time for real time clock. The interfacing of keypad with microcontroller Atmega32 is shown in Figure 3.11. It is function of the microcontroller to scan keypad continuously to detect and identify the key pressed. MM74C922N keypad encoders function as converted 8 bits data input into 4 bits data output. In this way, the system becomes more simple and effective in program. Table 3.1 shows the data bits for keypad when button is pressed.

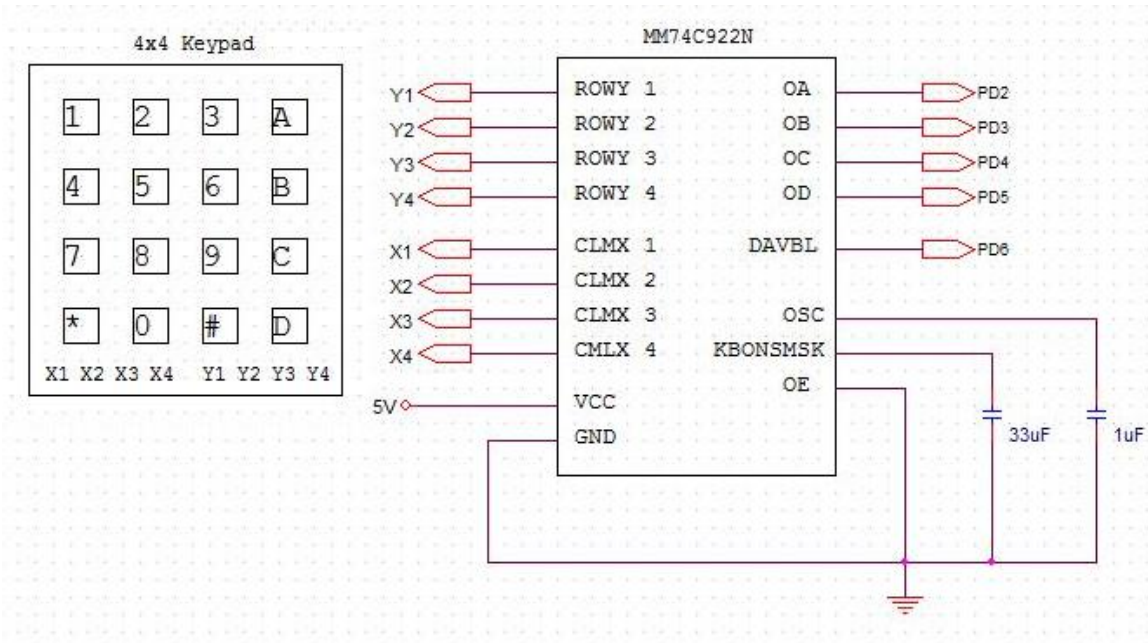

Figure 3.11: Keypad circuit

Table 3.1: Description of Data Bits for Keypad

Key Pressed	PD5	PD4	PD3	PD2	PD6
1	0	0	0	0	DA = 1
2	0	0	0	1	DA = 1
3	0	0	1	0	DA = 1
A	0	0	1	1	DA = 1
4	0	1	0	0	DA = 1
5	0	1	0	1	DA = 1
6	0	1	1	0	DA = 1
(space)	0	1	1	1	DA = 1
7	1	0	0	0	DA = 1
8	1	0	0	1	DA = 1
9	1	0	1	0	DA = 1
/	1	0	1	1	DA = 1
:	1	1	0	0	DA = 1
0	1	1	0	1	DA = 1
#	1	1	1	0	DA = 1
D	1	1	1	1	DA = 1

3.7 XBEE Module

XBEE is a part of IEEE 802.15.4 for the physical and link layers for Low-Rate Wireless Personal Area Network (WPAN). It can be used for transmit wirelessly to assigned destination address within the range distance. It requires low power consumption so it can last for a longer period of time. In this way, it made XBEE be more advanced designed as remote monitoring and control application in order to remotely operated switches where the end devices are battery powered. The connection of XBEE with microcontroller Atmega32 is shown in the Figure 3.12.

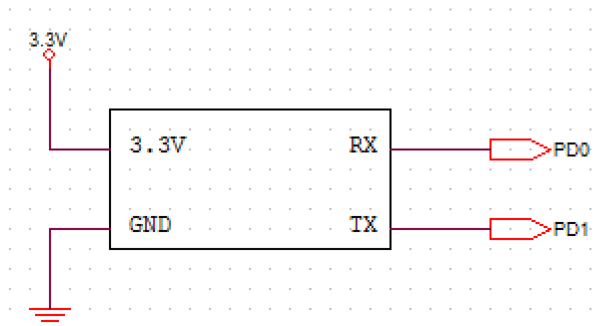

Figure 3.12: XBEE circuit

3.8 SD Card Module

The microcontroller Atmega32 is connected with the SD card via Serial Peripheral Interface (SPI) mode. This module is used as storage media for a portable device, in a form that can access by a PC. It allows high-speed synchronous data transfer between the Atmega32 and SD card device. It is designed for minimum power consumption as required by devices. This two way communication is the most effective and simple way for data transferring with low in cost and power consumption.

SPI bus is a master/slave interface which is master drives the serial clock. When using SPI, full duplex technology is used where both information are send and received simultaneously. The interconnection between microcontroller Atmega32 and SD card is shown in Figure 3.13.

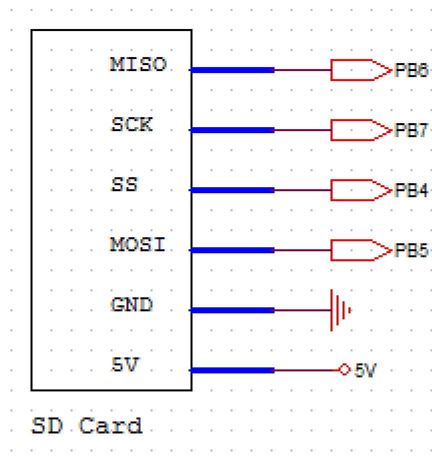

Figure 3.13: SD card circuit

CHAPTER 4

SOFTWARE DEVELOPMENT

4.1 Introduction

In this chapter, the software development is discussed elaborately. All the codes are written in C-language for flexibility and performance. The programs then are compiled by using AVR GCC compiler in order to produce hex files. This hex file is downloaded into the Flash of the microcontroller Atmega32. The size of the hex file produced by the compiler is one of the main concerns of microcontroller programmers because microcontroller Atmega32 has limited on-chip Flash.

4.2 Microcontroller System Testing

Microcontroller Atmega32 is the main control unit and responsible in the data logging system operation. A simple test is required to perform a simple free running test of Light-Emitting Diode (LED) as shown in flow chart of Figure 4.1. This program performs a simple blinking on LEDs. Initially, value $55 is loaded into Port B. Four LED will turn on and another four LED will turn off. A delay of one second is generated to allow LEDs to turn on for one second. Then, the value of $AA are loaded into Port B to observe another four LEDs turn on and off. This program is repeated to perform a dancing LEDs process.

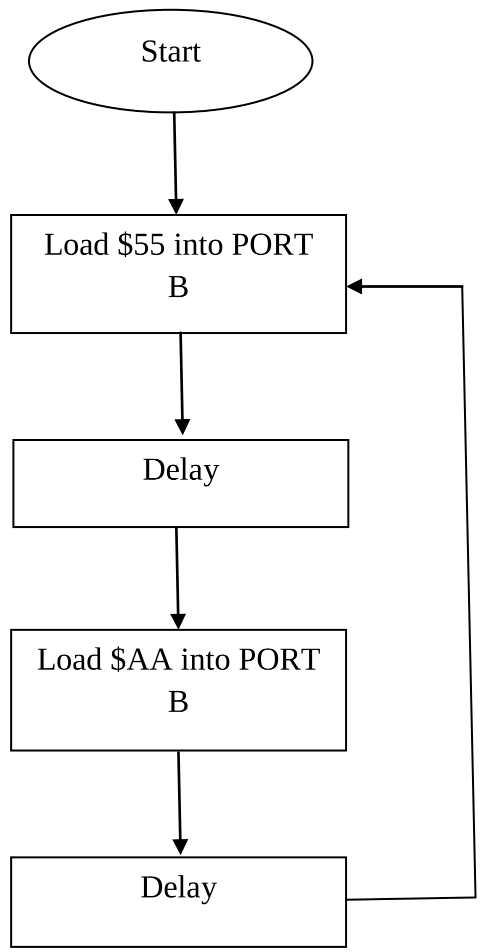

Figure 4.1: Flow chart of microcontroller module testing using LED blinking program

4.3 Sensor Module Testing

Several sensors are involved in the system and each sensor is tested independently. The result conversation is displayed on LCD. Figure 4.2 is a simple flow chart of sensor testing. Initially, initialize of (Analog-to-Digital Converter) ADC in voltage reference (V_{ref}) needed to set REFS1=0 and REFS0=1 which is same as VCC supply. Before proceed to conversation, register ADMUX of MUX4:0 bits are set in order to select ADC input channel. This process will proceed to start conversation by writing one to the ADC Start Conversion (ADSC) bit of register ADCSRA. While ADC Interrupt Flag (ADIF) goes to high, conversation is completed and allow to read A/D Result Low Byte (ADCL) and A/D Result High Byte (ADCH) registers to get the digital data output. This process will be repeated by selected channel again.

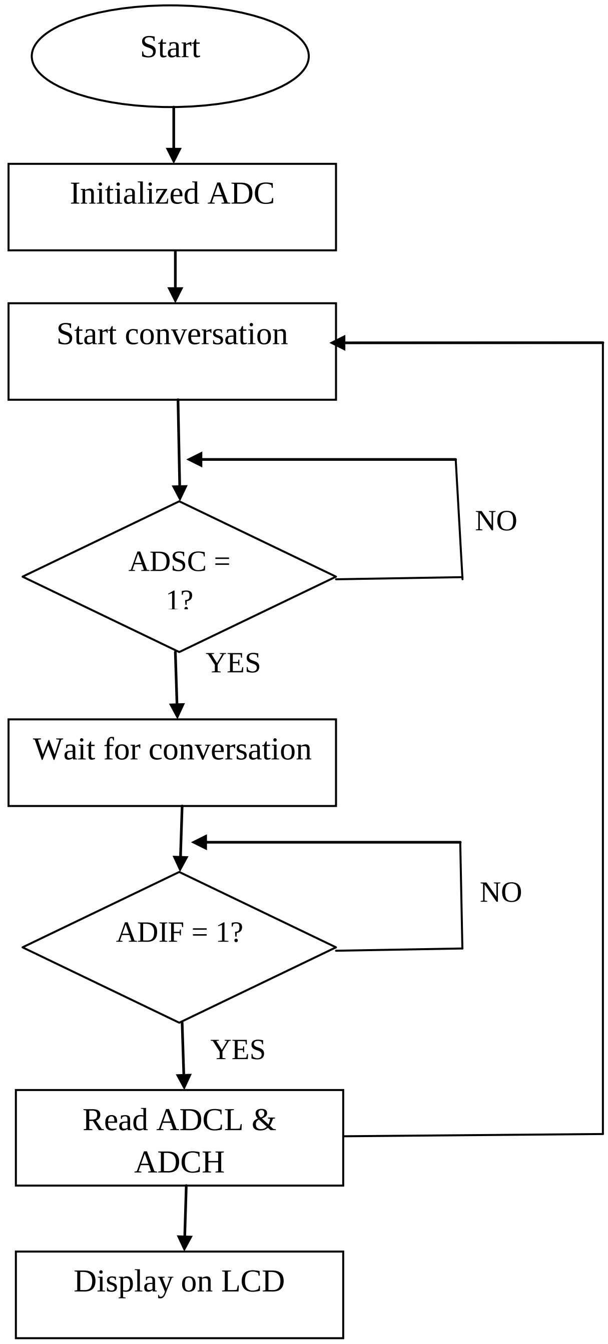

Figure 4.2: Flow chart of sensor module testing

4.4 LCD Module Testing

Figure 4.3 is a simple flow chart of the LCD testing. To send data and commands to LCD, LCD has to be initialized, send any of the commands to the LCD, and send character to be shown on the LCD. To initialize the LCD for 5x7 matrix, the sequence of commands should be sent to the LCD such as 0x0E, 0x01, and 0x06. Before shift the cursor to right, set for 2ms delay for it. In order to initialize 4-bit operation mode in LCD, a series of 0x33, 0x32, and 0x28 are sent. While sending commands to the LCD, a high-to-low pulse to the E pin is set to enable the internal latch of the LCD. Lastly, make pins RS=1 and R/W=0 to send data to the LCD. A simple character is written to show on the LCD.

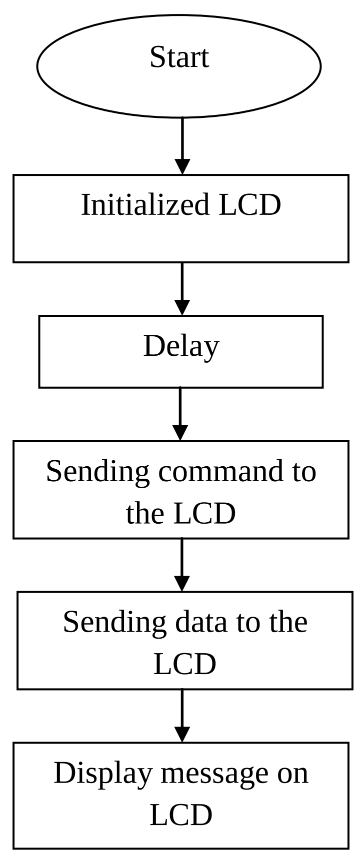

Figure 4.3: Flow chart of LCD module testing

4.5 Keypad Module Testing

A simple keypad module testing is developed and simplified as shown in flowchart of Figure 4.4. When a key pressed, output will be determined by keypad encoder which is MM74C922. When Data Available (DA) found to be high, the data will load from keypad encoder and send through Atmega32. The key pressed will be display on LCD.

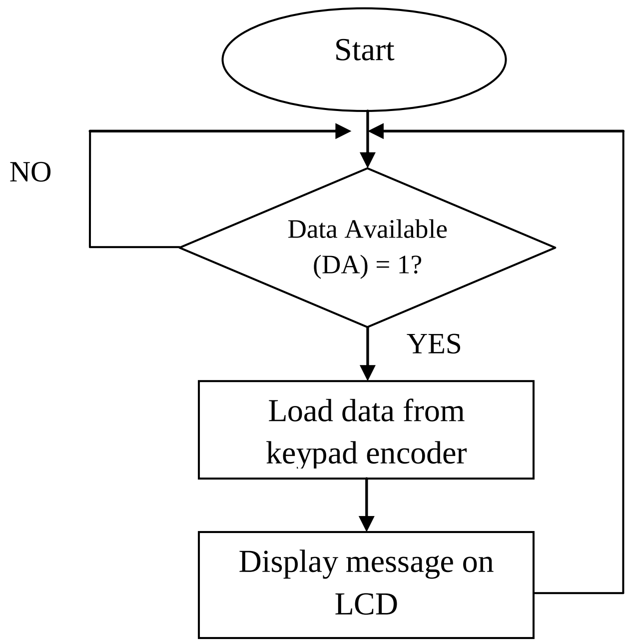

Figure 4.4: Flow chart of keypad module testing

4.6 Real Time Clock Module Testing

SCL and SDA from microcontroller Atmega32 pins are interface with the DS1307 device. Like LCD, the RTC needs to be initialized where every parameter such as day, date, and time information are set in accordance to the system requirement.

Once the initialization process is completed, the microcontroller Atmega32 can obtain the time information from the RTC. Initially, after sending a START condition, transmit the address of DS1307 of value 0b1001101 to indicate a write operation. Besides, I2C has to be initialized. By setting time and date into control register of the DS1307, information are read and stored into variables before they are displayed on the LCD display from time to time. There is a register pointer that specifies the byte that will be accessed in the next read or write command. After each read or write operation, the content of the register pointer is automatically incremented. It is useful in multi-byte read or write. A simple flowchart is shown in Figure 4.5.

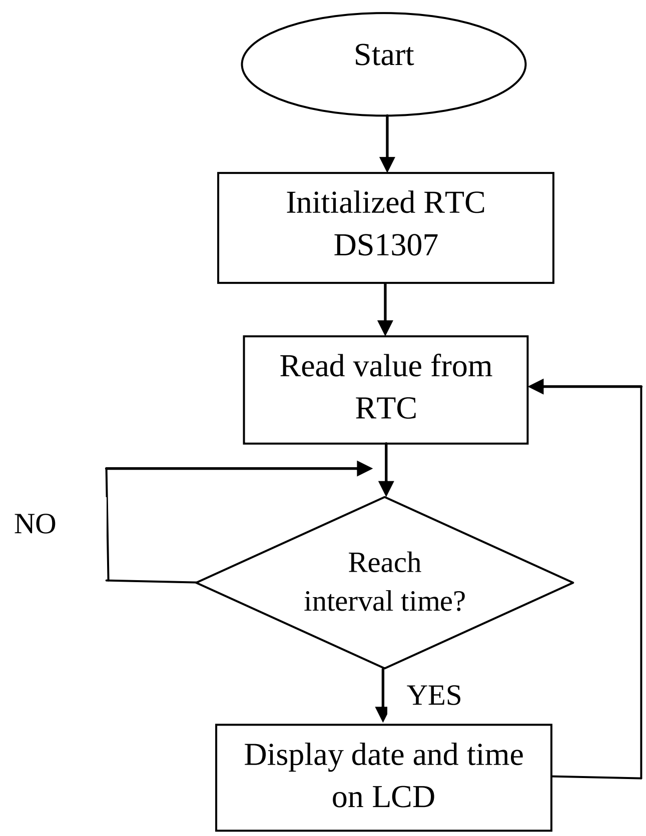

Figure 4.5: Flow chart of real time clock module testing

4.7 SD Card Module Testing

Memory card are commonly used for store digital information in electronics devices. Figure 4.6 shows the flow chart of saving save into SD card device. Initially, SPI has been initialized. The values of the SPE, MSTR, and SPR0 bits in SPCR are set to access SPI mode as master. However, SPSR is set as zero due to initialization of SPI mode. SD card is initialized as well by sent reset and go idle command. While SD card insert into device, it will create a file inside memory card with predefined format file name. During the system is logging, it will continuously to append the same file.

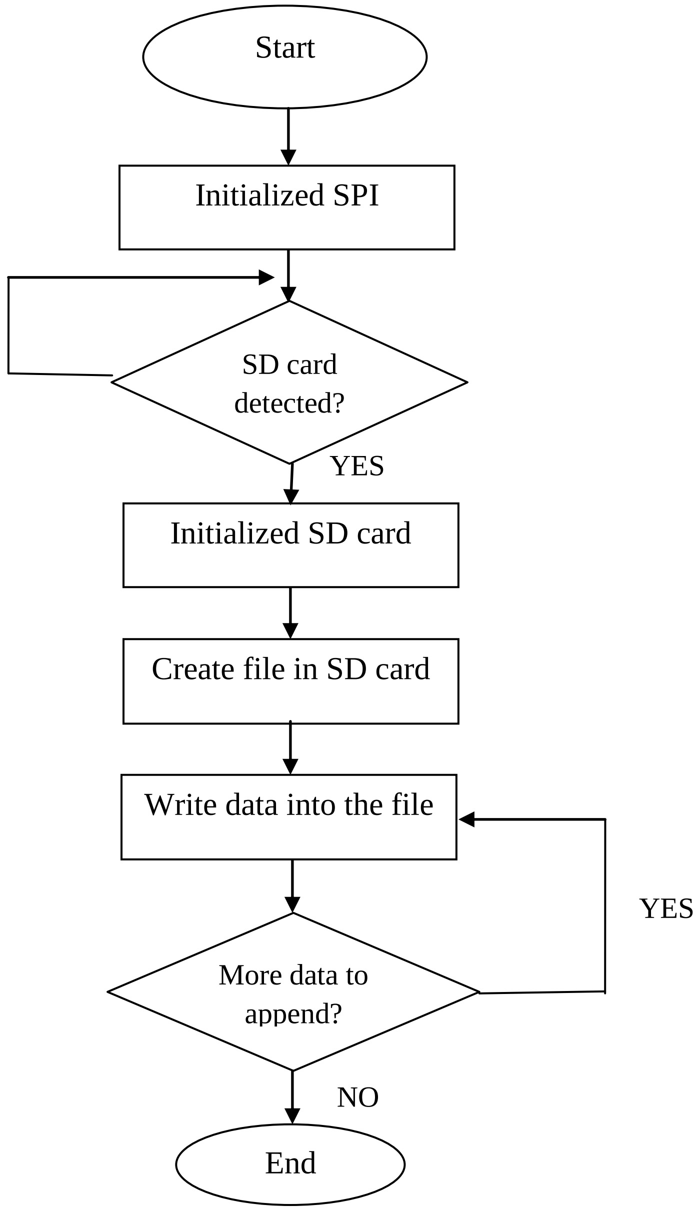

Figure 4.6: Flow chart of SD card module testing

CHAPTER 5

TESTING AND RESULT

5.1 Introduction

In this session, tests are conducted on each individual module to ensure the module function properly before these modules are integrated into the complete system. There are six modules involved:

- Microcontroller system
- Sensor module
- LCD module
- Real time clock module
- Keypad module
- SD card module

5.2 Microcontroller System Testing

Based on Figure 4.1, in order to test the microcontroller free running test of LEDs, the program as shown in Figure 5.1 is developed. Initially, the LEDs are changing blinking for each second delay. The blinking style is similar as dancing mode. If based on the program, four LEDs will turn on and another four LEDs will turn off and vice versa. This is proven that the expected outcome is correctly and microcontroller Atmega32 is functioning well.

```
#include <avr/io.h>
#include <util/delay.h>

void delay_ms(int d)
{
	_delay_ms(d);
}

int main(void)
{
	DDRB = 0xFF;
	while(1)
	{
		PORTB = 0x55;
		delay_ms(1000);
		PORTB = 0xAA;
		delay_ms(1000);
	}
	return 0;
```

Figure 5.1: Microcontroller system testing program

5.3 LCD Module Testing

The flow chart of the LCD is shown in Figure 4.3. A program is developed to display characters on LCD screen. Initially, program has to set initialization for LCD in order to using 2lines and 5x7 matrix (Db4-DB7, 4-bits), clear and on display screen, and shift cursor to right. In command setting, it is used to send high and low nibble to DB4-DB7. Data setting is same case with command setting, data coding is functional as send data to data port. By setting a location in LCD, 2 lines of characters are written and display on the location been called. When the system is on, first line of LCD will shows a string of character "4 bit LCD coding" and second line will shows "SUCCESS!". Both displayed on the LCD as shown in Figure 5.3. In this case, LCD is successfully display the character and next will proceed to display parameters.

```
#include <avr/io.h>
#include <util/delay.h>

#define LCD_APRT     PORTA
#define LCD_ADDR     DDRA
#define LCD_APIN     PINA
#define LCD_BPRT     PORTB
#define LCD_BDDR     DDRB
#define LCD_BPIN     PINB
#define LCD_RS       5
#define LCD_RW       6
#define LCD_EN       7

void delay_us(int d)
{
	_delay_us(d);
}

void lcdCommand(unsigned char cmnd)
{
	LCD_BPRT = cmnd & 0xF0;     //send high nibble to D4-D7
	LCD_APRT &= ~(1<<LCD_RS);
	LCD_APRT &= ~(1<<LCD_RW);
	LCD_APRT |= (1<<LCD_EN);
```

Figure 5.2: LCD module testing program

```
        delay_us(1);
        LCD_APRT &= ~(1<<LCD_EN);
        delay_us(100);
        LCD_BPRT = cmnd<<4;         //send low nibble to D4-D7
        LCD_APRT |= (1<<LCD_EN);
        delay_us(1);
        LCD_APRT &= ~(1<<LCD_EN);
        delay_us(100);
}

void lcdData(unsigned char data)
{
        LCD_BPRT = data & 0xF0;
        LCD_APRT |= (1<<LCD_RS);
        LCD_APRT &= ~(1<<LCD_RW);
        LCD_APRT |= (1<<LCD_EN);
        delay_us(1);
        LCD_APRT &= ~(1<<LCD_EN);
        LCD_BPRT = data<<4;
        LCD_APRT |= (1<<LCD_EN);

        delay_us(1);
        LCD_APRT &= ~(1<<LCD_EN);
        delay_us(100);
}

void lcd_init()
{
        LCD_ADDR = 0xFF;
        LCD_BDDR = 0xFF;
        LCD_APRT &= ~(1<<LCD_EN);
        lcdCommand(0x33);
        lcdCommand(0x32);
        lcdCommand(0x28);    //LCD 2line, 5x7 matrix
        lcdCommand(0x0E);    //display on, cursor on
        lcdCommand(0x01);    //clear LCD
        delay_us(2000);
        lcdCommand(0x06);    //shift cursor right
}

void lcd_gotoxy(unsigned char x, unsigned char y)
{
        unsigned char firstCharAdr[] = {0x80,0xC0,0x94,0xD4};
        lcdCommand(firstCharAdr[y-1] +x-1);
```

Figure 5.2: LCD module testing program (Continue)

```
        delay_us(100);
}

void lcd_print(char*str)
{
        unsigned char i=0;
        while(str[i] !=0)
        {
                lcdData(str[i]);
                i++;
        }
}

int main(void)
{
        lcd_init();
        lcd_gotoxy(1,1);
        lcd_print("4 bit LCD coding");
        lcd_gotoxy(1,2);
        lcd_print("SUCCESS!");
        while(1);
        return 0;
}
```

Figure 5.2: LCD module testing program (Continue)

Figure 5.3: Characters display on LCD

5.4 Sensor Module Testing

In this sensor module, two parts of testing are done which is manual testing and microcontroller based testing. The purpose of both testing is to ensure the functionality of sensors. Multi-meter in laboratory is used in manual testing to observe the condition of environment varies. If the parameter from sensor increases, the value of voltage is increased. For example, in testing of humidity sensor, it will converts air humidity into voltage measurement. The method been used in this testing is blowing from mouth. Initially, humidity was measured and read as shown in Figure 5.4. If the blowing continuously, multi-meter shows the voltage will increased as shown in Figure 5.5. The higher humidity detected, the higher voltage been measured. Manual testing is proceeds by using light intensity sensor. The method been using in this testing is used blocking method. Initially, voltage value displayed on multi-meter screen as shown in Figure 5.6 without blocked. Once the sensor has been blocked by my finger, voltage was dropped until 0.36V as shown in Figure 5.7.

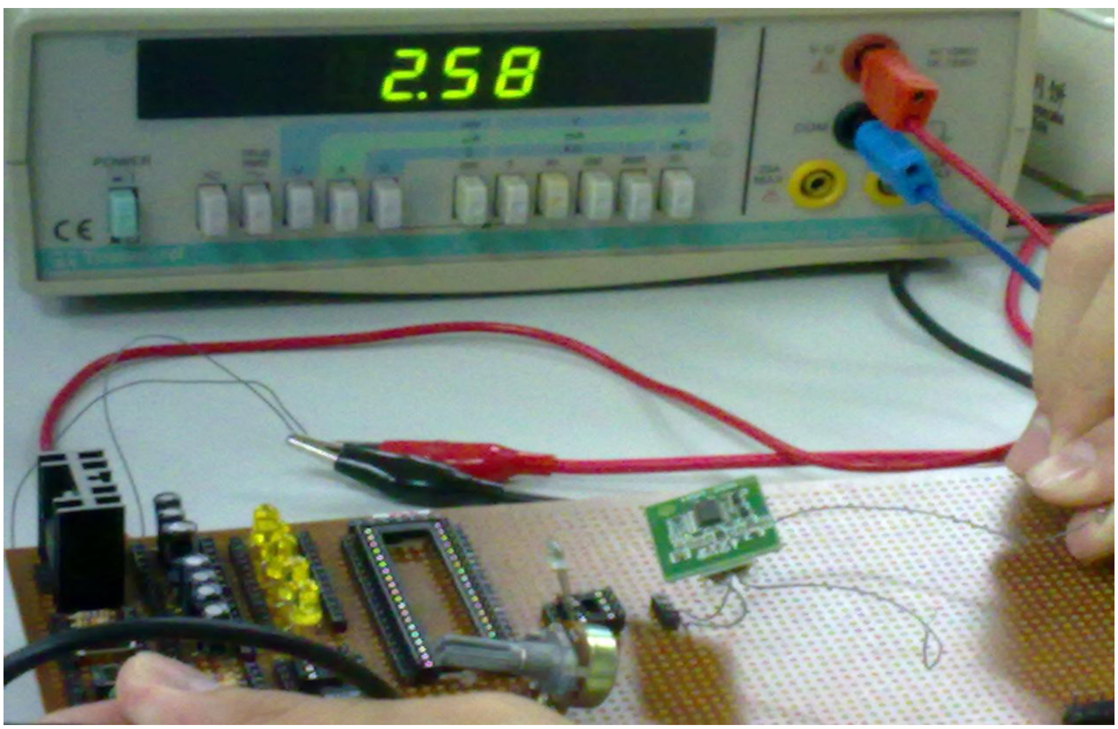

Figure 5.4: Initial value for humidity sensor

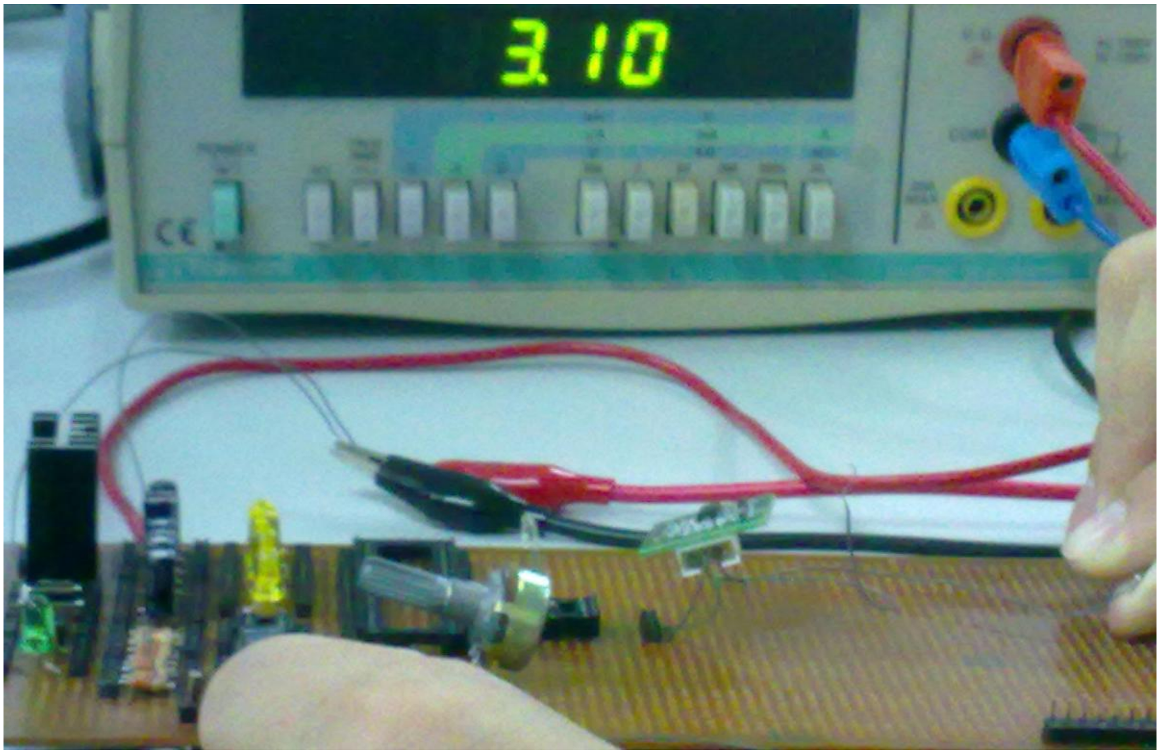

Figure 5.5: Changes of air humidity for humidity sensor

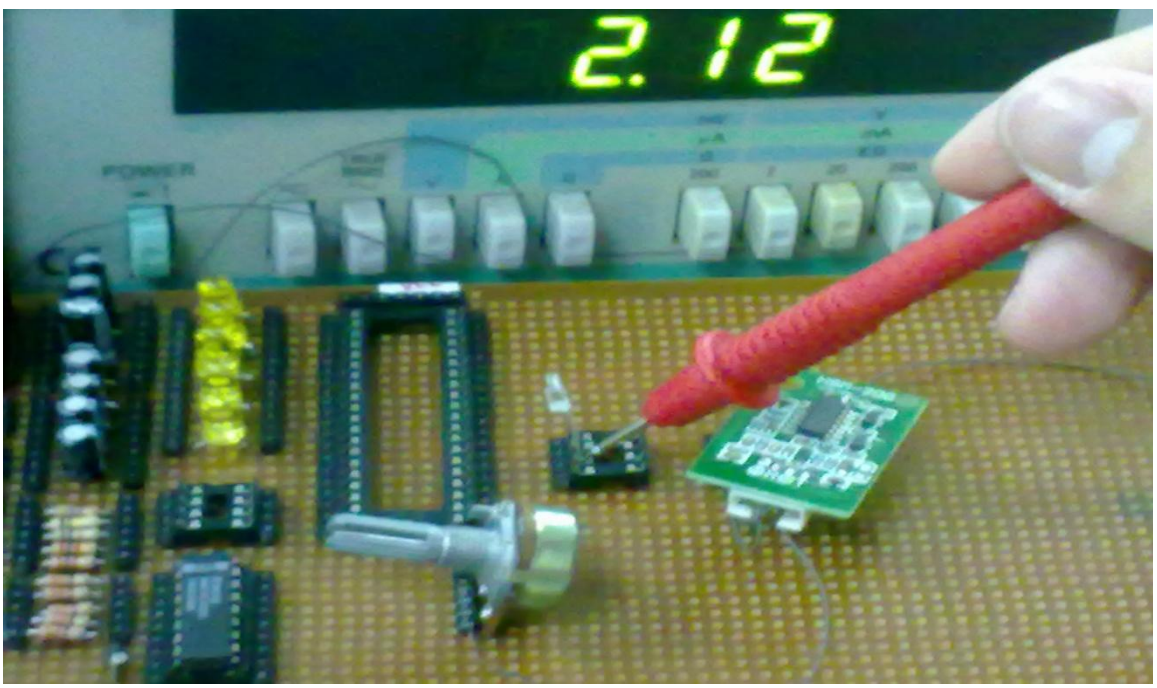

Figure 5.6: Initial value for light intensity sensor

Figure 5.7: Changes of intensity for light intensity sensor

In next part, testing by using microcontroller Atmega32 based testing was done. Testing on sensors connection for the temperature, humidity, light intensity and air contaminants sensor are carried out based on Figure 3.5, Figure 3.6 and Figure 3.7. A simple program is written in order to test each sensor. The output of sensor will display on LCD and shows the value of the conversation in decimal. LED is used in this testing to observe the condition of environment varies. If the parameter from sensor increases, the decimal value is increased. For example, if the environment temperature is raised, the degree Celsius will be increases and displayed on LCD. The entire sensor module program are shown in Figure 5.8, 5.9, 5.10, and 5.11.

```
#include <stdio.h>
#include <avr/io.h>
#include <util/delay.h>

void delay_us(int d)
{
	_delay_us(d);
}

int main(void)
{
	int value;
	float analog;
	char converter;
	DDRA = 0xF0;
	DDRD = 0xFF;
	lcd_init();
	ADCSRA = 0x87;
	ADMUX = 0x60;
	delay_us(10);
	lcd_gotoxy(1,1);
	lcd_print("Temperature: ");
	lcd_gotoxy(13,1);
	lcd_print("C");
	while(1)
	{
		ADCSRA |= (1<<ADSC);
		while((ADCSRA&(1<<ADIF))==0);
		PORTD = ADCH;
		value = ADCH;
		analog = 0.5 * ADCH;
		converter = analog;
		delay_us(100);
		char buffer[3];
		itoa(converter,buffer,10);
		lcd_gotoxy(11,1);
		lcd_print(buffer);
	}
	return 0;
}
```

Figure 5.8: Temperature sensor testing program

```
#include <stdio.h>
#include <avr/io.h>
#include <util/delay.h>

void delay_us(int d)
{
	_delay_us(d);
}

int main(void)
{
	int value;
	float analog;
	char converter;
	DDRA = 0xF0;
	DDRD = 0xFF;
	lcd_init();
	ADCSRA = 0x87;
	ADMUX = 0x61;
	delay_us(10);
	lcd_gotoxy(1,1);
	lcd_print("Humidity: ");
	lcd_gotoxy(13,1);
	lcd_print("%");
	while(1)
	{
		ADCSRA |= (1<<ADSC);
		while((ADCSRA&(1<<ADIF))==0);
		PORTD = ADCH;
		value = ADCH;
		analog = 0.5 * ADCH;
		converter = analog;
		delay_us(100);
		char buffer[3];
		itoa(converter,buffer,10);
		lcd_gotoxy(11,1);
		lcd_print(buffer);
	}
	return 0;
}
```

Figure 5.9: Humidity sensor testing program

```
#include <stdio.h>
#include <avr/io.h>
#include <util/delay.h>

void delay_us(int d)
{
	_delay_us(d);
}

int main(void)
{
	int value;
	float analog;
	char converter;
	DDRA = 0xF0;
	DDRD = 0xFF;
	lcd_init();
	ADCSRA = 0x87;
	ADMUX = 0x62;
	delay_us(10);
	lcd_gotoxy(1,1);
	lcd_print("Light: ");
	lcd_gotoxy(10,1);
	lcd_print("uW/cm2");
	while(1)
	{
		ADCSRA |= (1<<ADSC);
		while((ADCSRA&(1<<ADIF))==0);
		PORTD = ADCH;
		value = ADCH;
		analog = 0.5 * ADCH;
		converter = analog;
		delay_us(100);
		char buffer[3];
		itoa(converter,buffer,10);
		lcd_gotoxy(11,1);
		lcd_print(buffer);
	}
	return 0;
}
```

Figure 5.10: Light intensity sensor testing program

```
#include <stdio.h>
#include <avr/io.h>
#include <util/delay.h>

void delay_us(int d)
{
	_delay_us(d);
}

int main(void)
{
	int value;
	float analog;
	char converter;
	DDRA = 0xF0;
	DDRD = 0xFF;
	lcd_init();
	ADCSRA = 0x87;
	ADMUX = 0x63;
	delay_us(10);
	lcd_gotoxy(1,1);
	lcd_print("Air_Cont: ");
	lcd_gotoxy(13,1);
	lcd_print("ppm");
	while(1)
	{
		ADCSRA |= (1<<ADSC);
		while((ADCSRA&(1<<ADIF))==0);
		PORTD = ADCH;
		value = ADCH;
		analog = 0.5 * ADCH;
		converter = analog;
		delay_us(100);
		char buffer[3];
		itoa(converter,buffer,10);
		lcd_gotoxy(11,1);
		lcd_print(buffer);
	}
	return 0;
}
```

Figure 5.11: Air contaminants sensor testing program

5.5 Keypad Module Testing

A simple manual testing on keypad module was done based on the flow chart shown in Figure 4.4. In Figure 5.12, when button 1 pressed, the fifth LED lights on but four LEDS remain off. Once released the button, fifth LED lights off. This is proceed by pressed button D on keypad, it shows all LEDs lights on before released the button. This is shown in Figure 5.13. From both testing, if pressed the button on keypad, fifth LED lights on because it is Data Available (DA) found from keypad encoder. If referred to data sheet, button 1 output is 0000, so it will not light on the LED. But for button D, the output is 1111 and will lights on all LED.

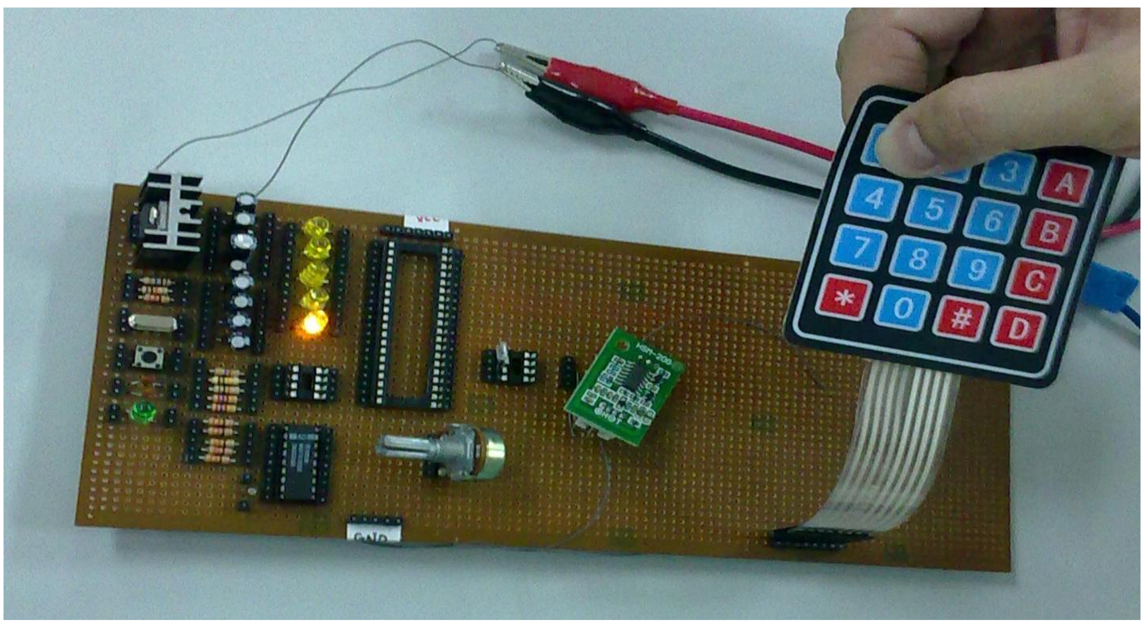

Figure 5.12: Button 1 pressed on keypad

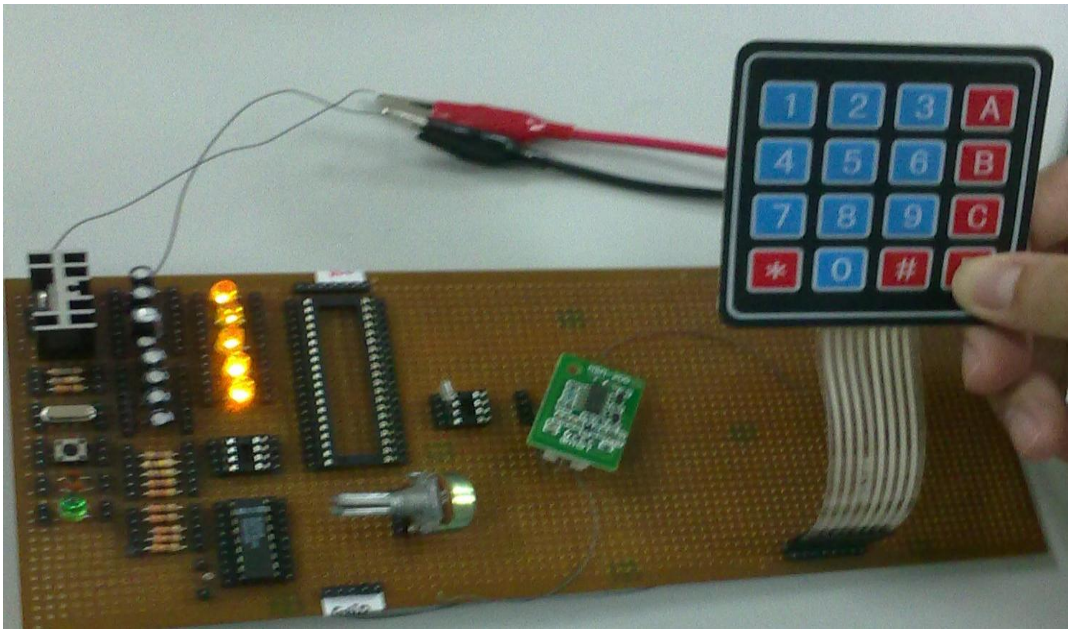

Figure 5.13: Button D pressed on keypad

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This project has accomplished. However, main objective does not achieve due to unsuccessful to store result into SD card. In general, data logging system is successfully measure environment parameter and display the reading on LCD.

In order to achieve the main objective of data logger system, this system has to develop a SD card system for storage purpose. This is because all the information and data logged must save into SD card for offline analysis and plot the data.

6.2 Recommendation

In order to make this system more effectively, there are some of recommendations need to be improved on this system.

- Analogue signal from all sensors can be transmitted to microcontroller via wirelessly transmission to observe the changes of parameters.

- LCD display can replaced by Graphic LCD or touch screen LCD to read more parameters on it.

- SD card device can improve by replaced with USB data storage as the SD card may obsolete in future.

6.3 Commercialisability

Remote data logger with multi-sensor by greenhouse can be used in industrial process, instrumentation controls and laboratory to record data. This is due to the consideration of save labor costs and environment safety and user friendly.

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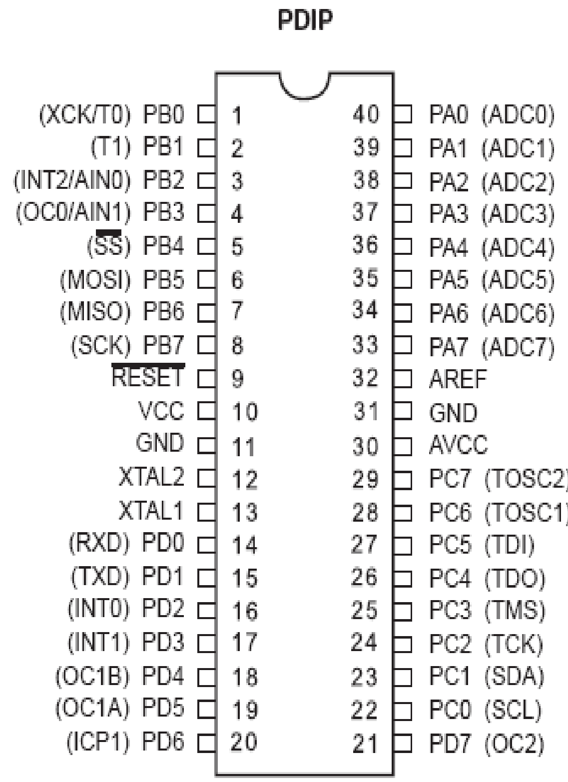
APPENDIX A

Data Sheets

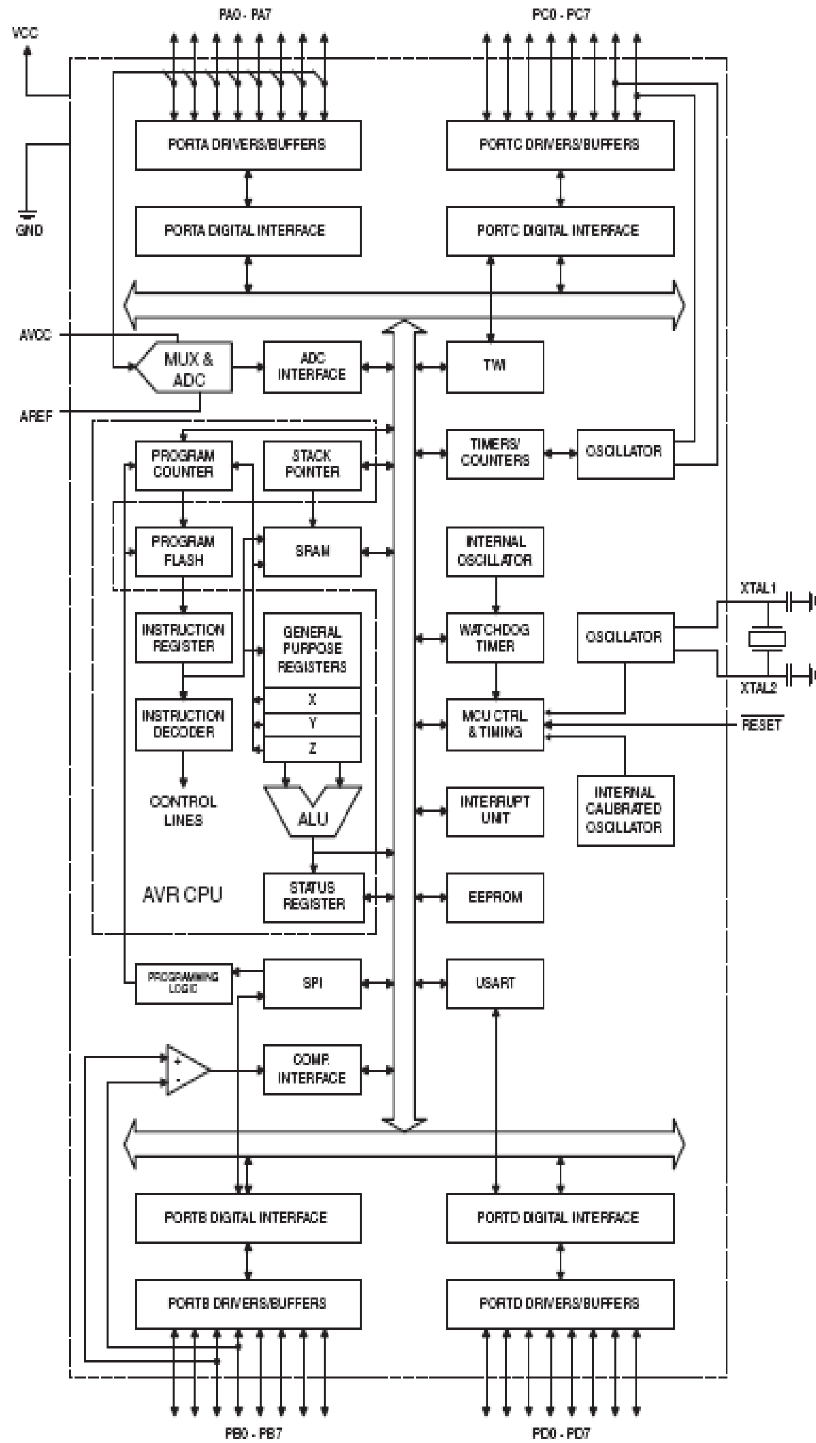
Pin Configurations

Figure 1. Pinout ATmega32

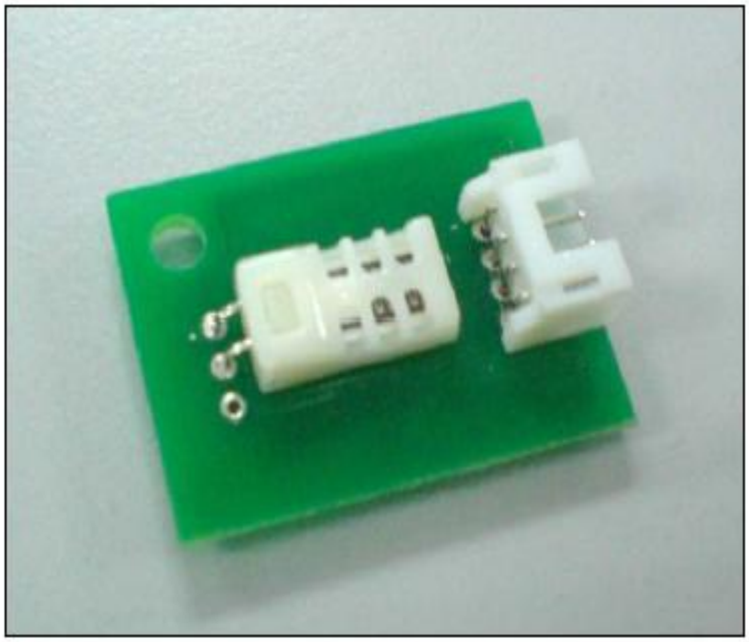


Block Diagram

Figure 2. Block Diagram



SN-HMD
Humidity Sensor



User's Manual

V1.2

April 2009

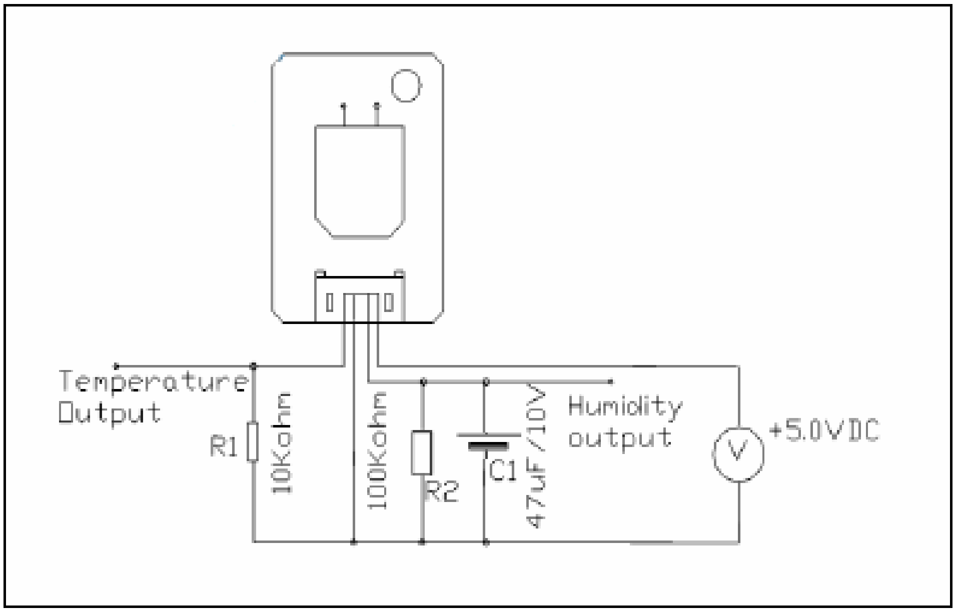


Figure 4.1

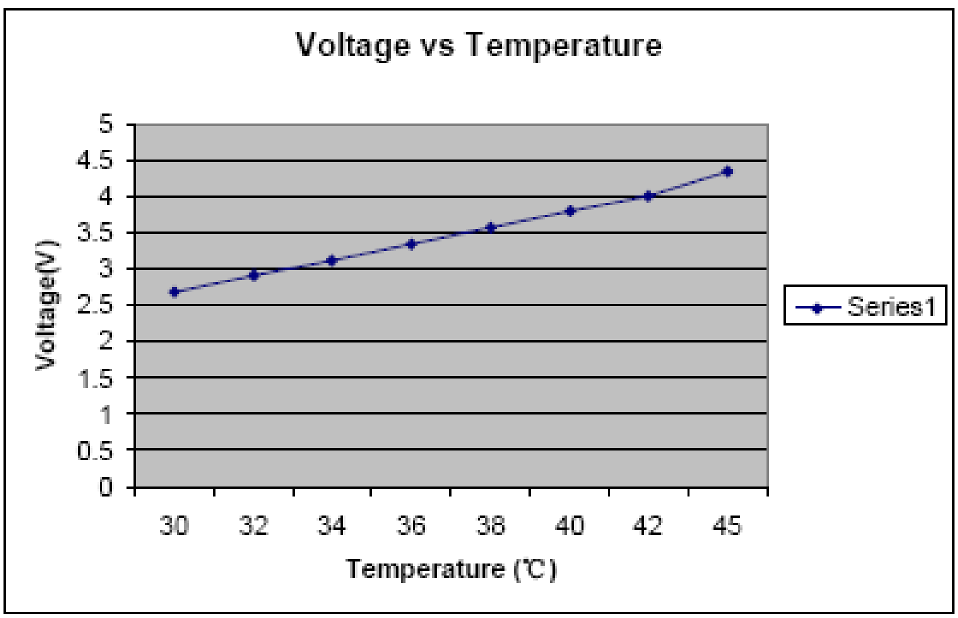


Figure 4.2

Figure 4.3 shows the relationship between output voltage and humidity while Table 4.1 shows the standard characteristics of the humidity sensor.

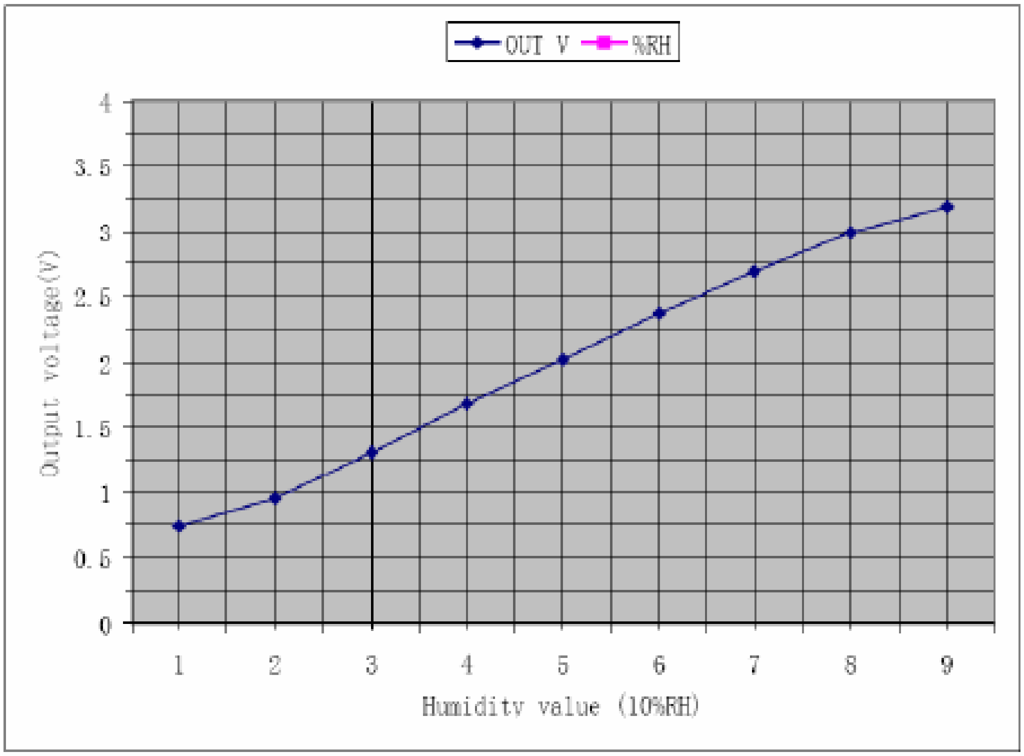


Figure 4.2

%RH	10	20	30	40	50	60	70	80	90
OutpotV	0.74	0.95	1.31	1.68	2.02	2.37	2.69	2.99	3.19

Table 4.1

JHD162A SERIES

CHARACTERISTICS:

DISPLAY CONTENT: 16 CHAR x 2ROW

CHAR. DOTS: 5 x 8

DRIVING MODE: 1/16D

AVAILABLE TYPES:

TN, STN(YELLOW GREEN、GREY、B/W)

REFLECTIVE、WITH EL OR LED BACKLIGHT

EL/100VAC, 400HZ

LED/4.2VDC

PARAMETER (V_{DD}=5. 0V±10%, V_{SS}=0V, T_a=25℃)

Parameter	Symbol	Testing Criteria	Standard Values Min.	Typ.	Max	Unit
Supply voltage	V_{DD}-V_{SS}	-	4.5	5.0	5.5	V
Input high voltage	V_{IH}	-	2.2	-	V_{DD}	V
Input low voltage	V_{IL}	-	-0.3	-	0.6	V
Output high voltage	V_{OH}	-I_{OH}=02mA	2.4	-	-	V
Output low voltage	V_{OL}	I_{OL}=1.2mA	-	-	0.4	V
Operating voltage	I_{DD}	V_{DD}=5.0V	-	1.5	3.0	mA

FAIRCHILD
SEMICONDUCTOR™

October 1987
Revised January 1999

MM74C922 • MM74C923
16-Key Encoder • 20-Key Encoder

General Description

The MM74C922 and MM74C923 CMOS key encoders provide all the necessary logic to fully encode an array of SPST switches. The keyboard scan can be implemented by either an external clock or external capacitor. These encoders also have on-chip pull-up devices which permit switches with up to 50 kΩ on resistance to be used. No diodes in the switch array are needed to eliminate ghost switches. The internal debounce circuit needs only a single external capacitor and can be defeated by omitting the capacitor. A Data Available output goes to a high level when a valid keyboard entry has been made. The Data Available output returns to a low level when the entered key is released, even if another key is depressed. The Data Available will return high to indicate acceptance of the new key after a normal debounce period; this two-key roll-over is provided between any two switches.

An internal register remembers the last key pressed even after the key is released. The 3-STATE outputs provide for easy expansion and bus operation and are LPTTL compatible.

Features

- 50 kΩ maximum switch on resistance
- On or off chip clock
- On-chip row pull-up devices
- 2 key roll-over
- Keybounce elimination with single capacitor
- Last key register at outputs
- 3-STATE output LPTTL compatible
- Wide supply range: 3V to 15V
- Low power consumption

Ordering Code:

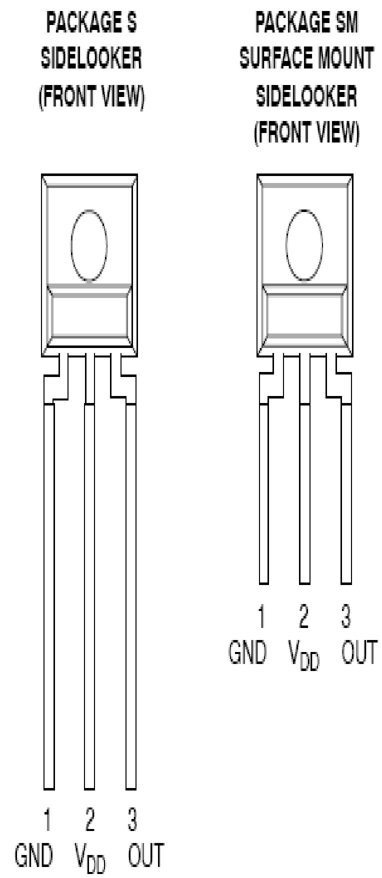
Order Number	Package Number	Package Description
MM74C922N	N18A	18-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide
MM74C922WM	M20B	20-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300" Wide
MM74C923WM	M20B	20-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300" Wide
MM74C923N	N20A	20-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide

TAOS TEXAS ADVANCED OPTOELECTRONIC SOLUTIONS®

TSL250R, TSL251R, TSL252R
LIGHT-TO-VOLTAGE OPTICAL SENSORS

TAOS028H – SEPTEMBER 2007

- **Monolithic Silicon IC Containing Photodiode, Operational Amplifier, and Feedback Components**
- **Converts Light Intensity to a Voltage**
- **High Irradiance Responsivity, Typically 137 mV/(μW/cm²) at λ_p = 635 nm (TSL250R)**
- **Compact 3-Lead Clear Plastic Package**
- **Single Voltage Supply Operation**
- **Low Dark (Offset) Voltage....10 mV Max**
- **Low Supply Current......1.1 mA Typical**
- **Wide Supply-Voltage Range.... 2.7 V to 5.5 V**
- **Replacements for TSL250, TSL251, and TSL252**
- **RoHS Compliant (–LF Package Only)**



Description

The TSL250R, TSL251R, and TSL252R are light-to-voltage optical sensors, each combining a photodiode and a transimpedance amplifier (feedback resistor = 16 MΩ, 8 MΩ, and 2.8 MΩ respectively) on a single monolithic IC. Output voltage is directly proportional to the light intensity (irradiance) on the photodiode. These devices have improved amplifier offset-voltage stability and low power consumption and are supplied in a 3-lead clear plastic sidelooker package with an integral lens. When supplied in the lead (Pb) free package, the device is RoHS compliant.

FIGARO

PRODUCT INFORMATION

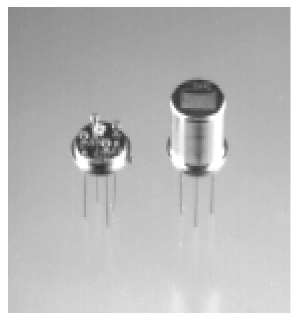
TGS 2600 - for the detection of Air Contaminants

Features:

* Low power consumption
* High sensitivity to gaseous air contaminants
* Long life and low cost
* Uses simple electrical circuit
* Small size

Applications:

* Air cleaners
* Ventilation control
* Air quality monitors



The sensing element is comprised of a metal oxide semiconductor layer formed on an alumina substrate of a sensing chip together with an integrated heater. In the presence of a detectable gas, the sensor's conductivity increases depending on the gas concentration in the air. A simple electrical circuit can convert the change in conductivity to an output signal which corresponds to the gas concentration.

The TGS 2600 has high sensitivity to low concentrations of gaseous air contaminants such as hydrogen and carbon monoxide which exist in cigarette smoke. The sensor can detect hydrogen at a level of several ppm. Figaro also offers a microprocessor (FIC93619A) which contains special software for handling the sensor's signal for appliance control applications.

Due to miniaturization of the sensing chip, TGS 2600 requires a heater current of only 42mA and the device is housed in a standard TO-5 package.

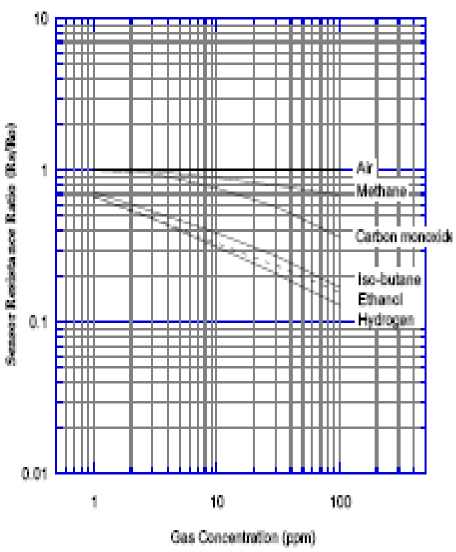
The figure below represents typical sensitivity characteristics, all data having been gathered at standard test conditions (see reverse side of this sheet). The Y-axis is indicated as *sensor resistance ratio* (Rs/Ro) which is defined as follows:

Rs = Sensor resistance in displayed gases at various concentrations
Ro = Sensor resistance in fresh air

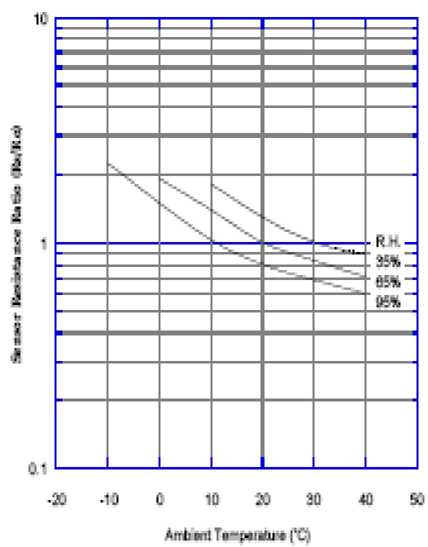
The figure below represents typical temperature and humidity dependency characteristics. Again, the Y-axis is indicated as *sensor resistance ratio* (Rs/Ro), defined as follows:

Rs = Sensor resistance in fresh air at various temperatures/humidities
Ro = Sensor resistance in fresh air at 20°C and 65% R.H.

Sensitivity Characteristics:



Temperature/Humidity Dependency:



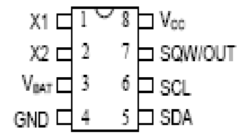
www.dalsemi.com

DS1307
64 X 8 Serial Real Time Clock

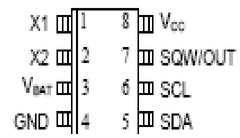
FEATURES

- Real time clock counts seconds, minutes, hours, date of the month, month, day of the week, and year with leap year compensation valid up to 2100
- 56 byte nonvolatile RAM for data storage
- 2-wire serial interface
- Programmable squarewave output signal
- Automatic power-fail detect and switch circuitry
- Consumes less than 500 nA in battery backup mode with oscillator running
- Optional industrial temperature range -40°C to +85°C
- Available in 8-pin DIP or SOIC
- Recognized by Underwriters Laboratory

PIN ASSIGNMENT



DS1307 8-Pin DIP (300 mil)



DS1307Z 8-Pin SOIC (150 mil)

PIN DESCRIPTION

V_{CC}	- Primary Power Supply
X1, X2	- 32.768 kHz Crystal Connection
V_{BAT}	- +3V Battery Input
GND	- Ground
SDA	- Serial Data
SCL	- Serial Clock
SQW/OUT	- Square wave/Output Driver

ORDERING INFORMATION

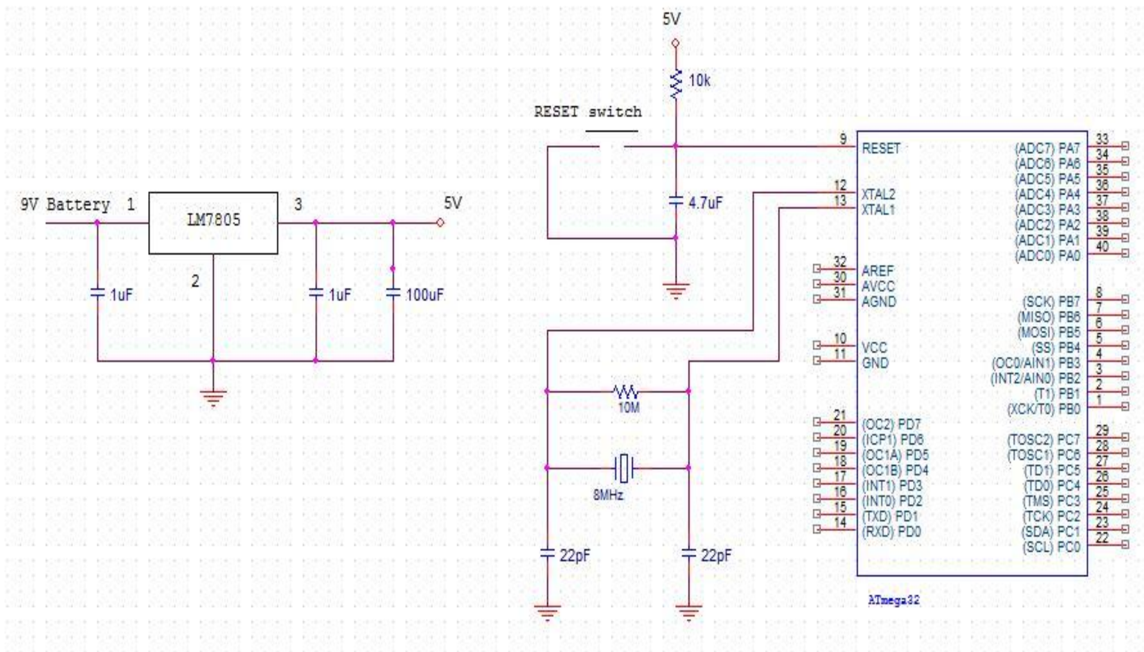
DS1307	8-Pin DIP
DS1307Z	8-Pin SOIC (150 mil)
DS1307N	8-Pin DIP (Industrial)
DS1307ZN	8-Pin SOIC (Industrial)

DESCRIPTION

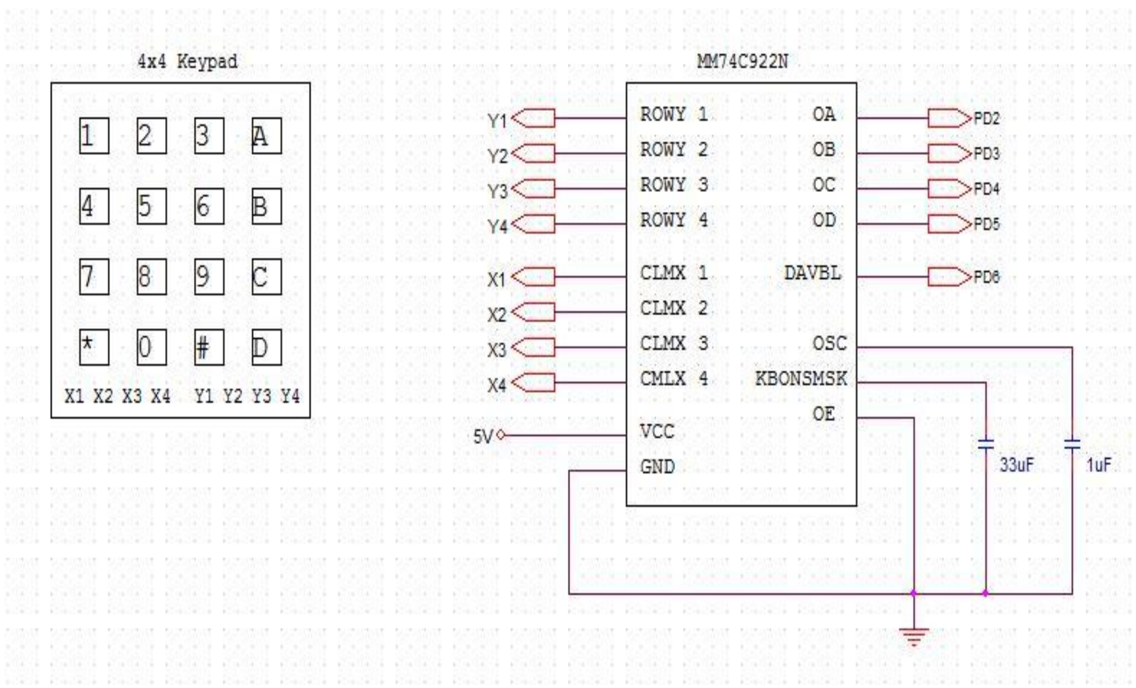
The DS1307 Serial Real Time Clock is a low power, full BCD clock/calendar plus 56 bytes of nonvolatile SRAM. Address and data are transferred serially via a 2-wire bi-directional bus. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with less than 31 days, including corrections for leap year. The clock operates in either the 24-hour or 12-hour format with AM/PM indicator. The DS1307 has a built-in power sense circuit which detects power failures and automatically switches to the battery supply.

APPENDIX B

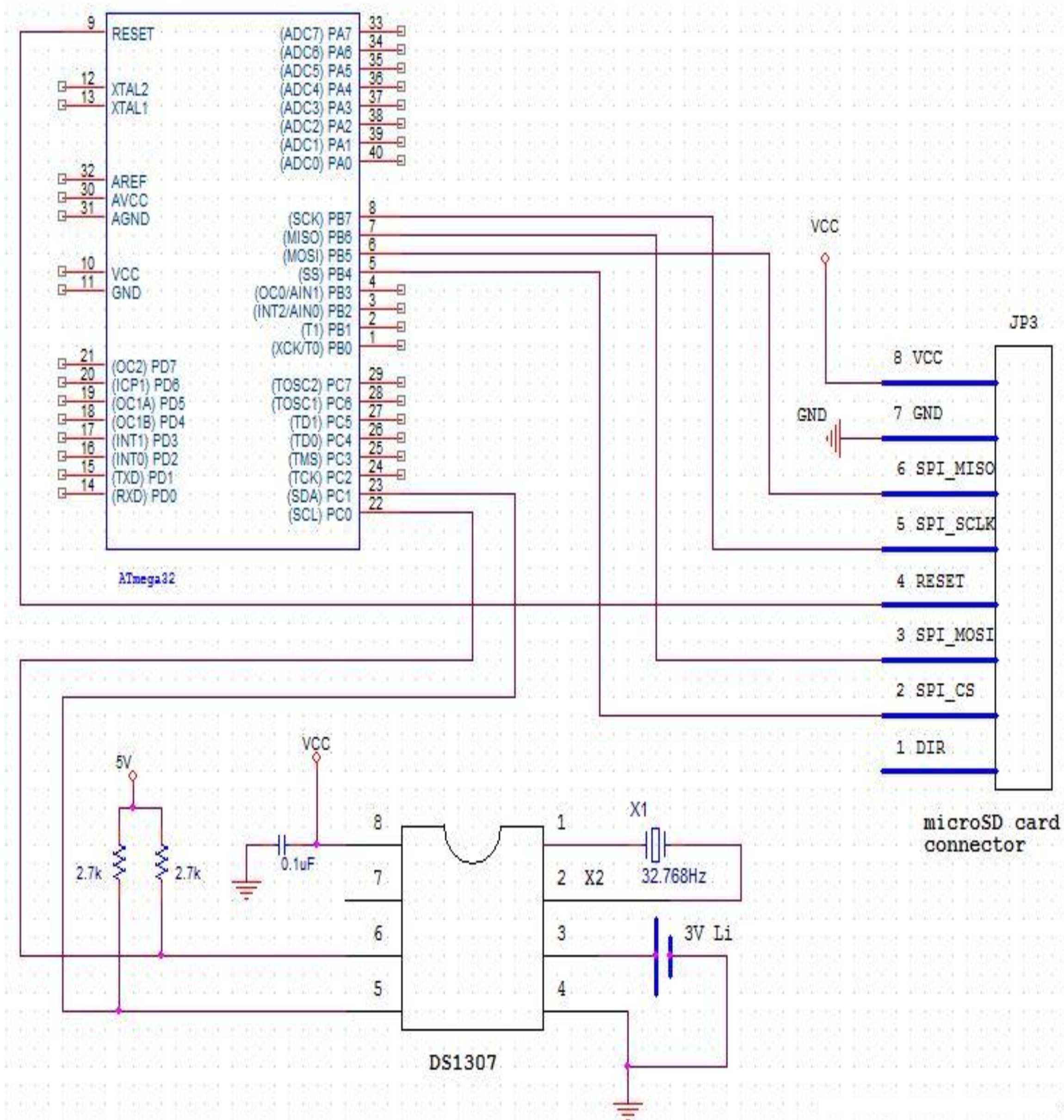
Schematic Circuit Diagram



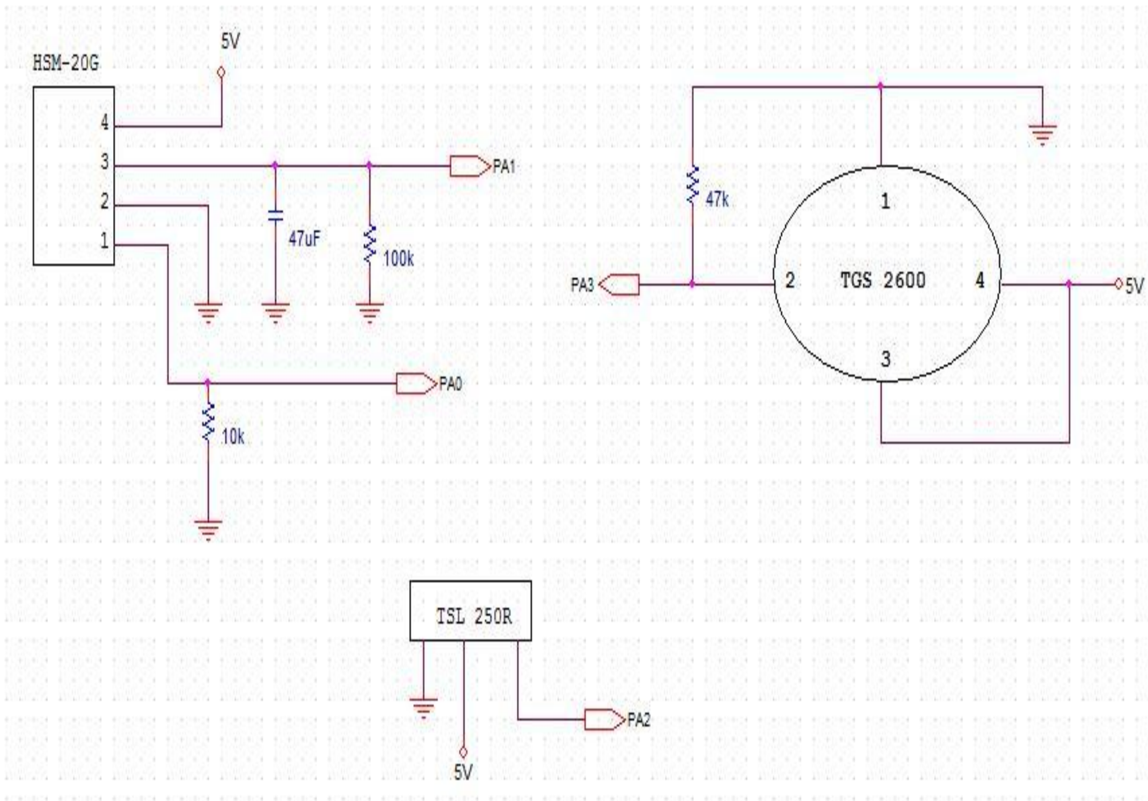
Main Circuit Diagram



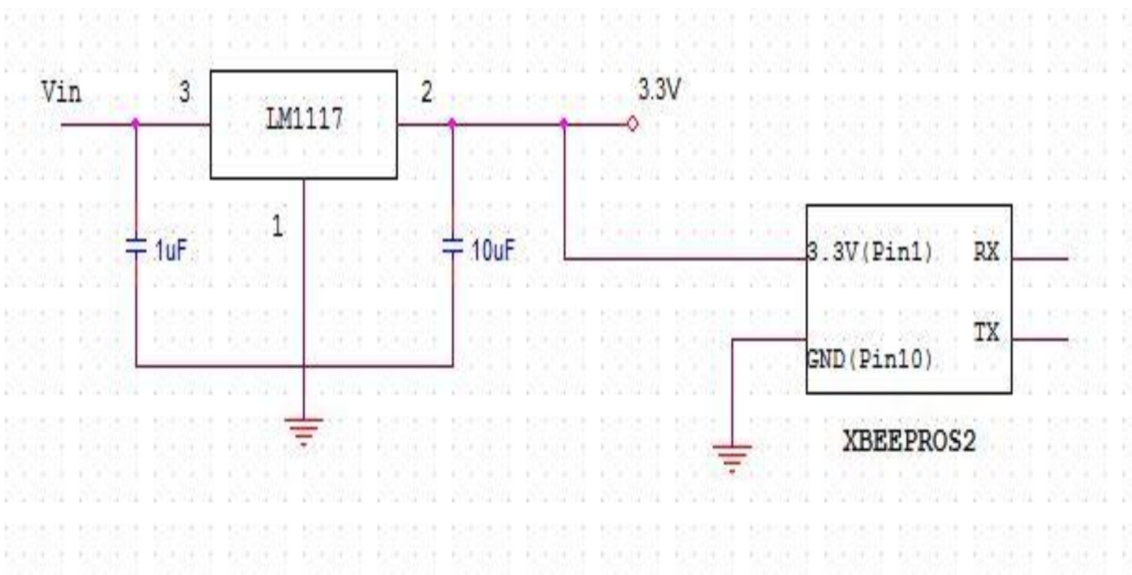
Keypad Diagram



RTC and micro SD card diagram



Sensors Diagram



ZigBee Diagram