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MICROCONTROLLER BASED SMART FAN SYSTEM

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ABSTRACT

This project will present the design, construction, development, control and evaluation of an automatic switching speed electric fan. This further step of an intelligent electric fans than before that using “intelligent technology’’ such sensing the sound of clapping and functioning by analog circuit relay from the lowest to the highest speed clapping by clapping. The microcontroller base automatic fan system presented in this project is required to fulfill the requirement of technologies “tomorrow will be more advanced than today”. The electric fan automatically switches the speed according to the environment temperature changes. This electric fan system contains combination of sensor, controller, driver and motor with integration of embedded controlled programming which means in this case using MC68HC11A1 as the main controller. This project also presents the expected performance of the automatic fan system, construction of hardware and software development to gather the performance data. Finally, this system performance will be evaluated by comparing performance data to the theoretical.

CHAPTER 1

INTRODUCTION

1.1 Project Background

Sometimes electric fan usage is wasting power because of human attitude. Human also mostly demands something that easily to be used without wasting energy. To minimize or reduce the power usage, this project developed an automatic fan system where speed is controlled by the room temperature.

1.2 Problem Statement

Most human feels the inconvenient about changing the fan speed level manually when the room temperature changes. So, the automatic fan system that automatically changes the speed level according to temperature changes is recommended to be built for solving this problem.

1.3 Project Objectives

The objectives of this project are to:

i. Enable the electric fan to automatically change the speed level according to temperature changes.
ii. Develop an automatic fan system that can change the speed level due to the environment temperature changes.
iii. Develop an automatic fan system that can preview the status of the temperature and the speed level by using Liquid Crystal Display (LCD).

1.4 Project Scopes

The system is built using:

i. MC68HC11 as the main controller.
ii. The temperature sensor as the input for the microcontroller.
iii. The DC motor as the output for the system.

1.5 Methodology

Figure 1.1 showed the methodology or work flow for the project which is involving system development from hardware and software to the integration of both elements. Then, the system is being tested to produce a certain results that will be analyzed to produce the results that compatible with the system.

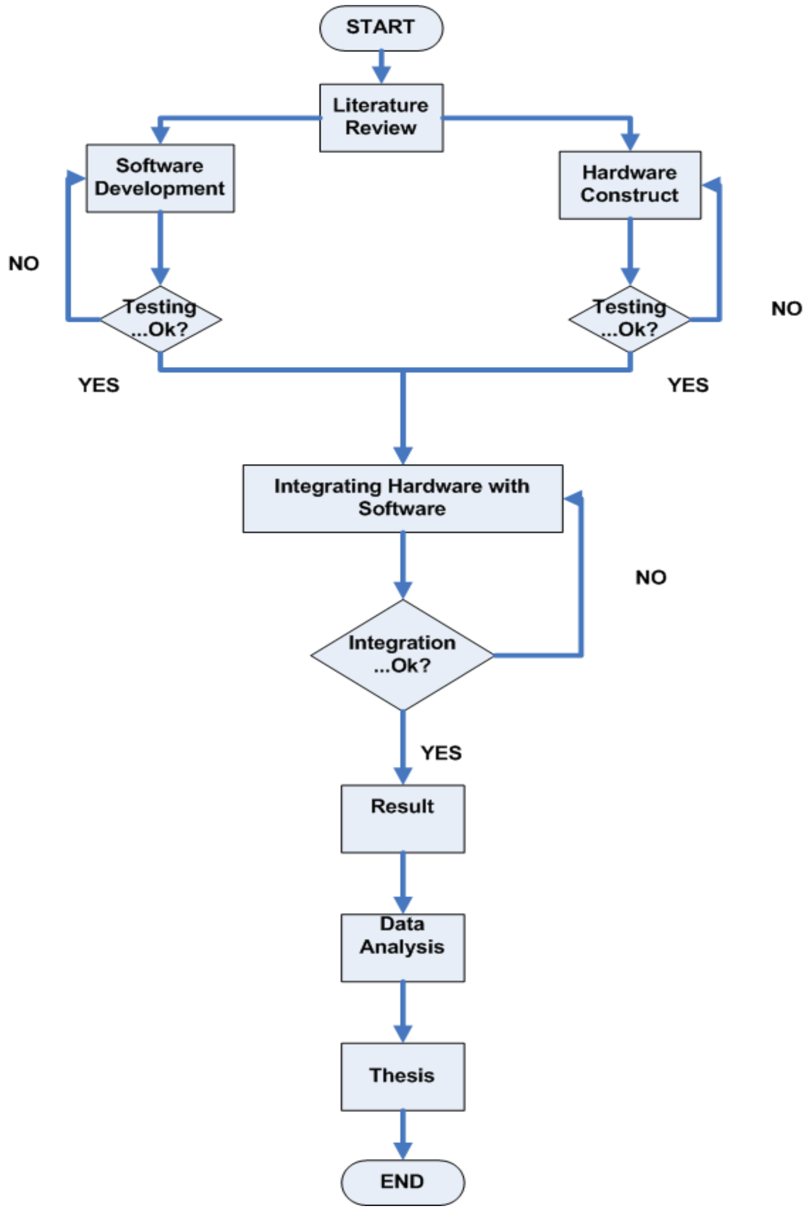

Figure 1.1 the Work Flow of the Project

1.6 Reviews of Thesis Contents

The thesis is organized as follows:

Chapter 1: This chapter explained about project background, objective, scope and also the problem statement.

Chapter 2: Describe about types of microcontrollers, sensors, ways that been used for previous similar system that using same alternative.

Chapter 3: Examines a model for smart/automatic fan system. Review details about the hardware construction part by part, controller, input and output part, also development level to level programming.

Chapter 4: Describe about the experimental results, expected performance and performance limits that can be achieve by the system.

Chapter 5: Provides conclusions, recommendations for further work or future expectations and cost that involved for the system.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews about previous system that been developed and has similarities with the automatic fan system plus the components that will be used in developing this system.

2.2 Available Fan Controlling System

2.2.1 Temperature-Based Fan Control Using the MAXQ2000 Microcontroller

The system is using MAXQ2000 as the controller. The thermistor in the Figure 2.1 as the temperature sensor senses the environment temperature change and produces the output, the fan speed is adjusted equal to the range that been set. “Once the temperature is read, the pulse width modulation (PWM) duty cycle is adjusted based on the temperature reading" [Maxim, 2005].

There are two thresholds in the program, the minimum temperature and the maximum temperature. "If the temperature is below the minimum temperature threshold, the fan will be turned off. If the temperature is above the maximum temperature threshold, the fan is set to its maximum speed. If the temperature is between the minimum threshold and the maximum threshold, the speed is proportional to the fractional distance between the two temperature thresholds" [Maxim, 2005].

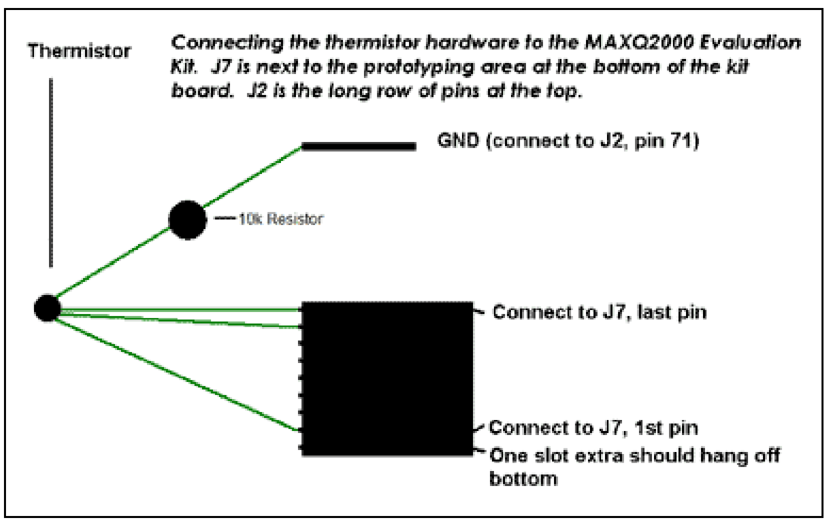

Figure 2.1 Connection thermistor to the MAXQ2000 evaluation kit [Maxim, 2005].

Figure 2.2 showed one of the ways PWM generated from microcontroller connected with output circuit. The output circuit can be either one or two MOSFETs as the driver.

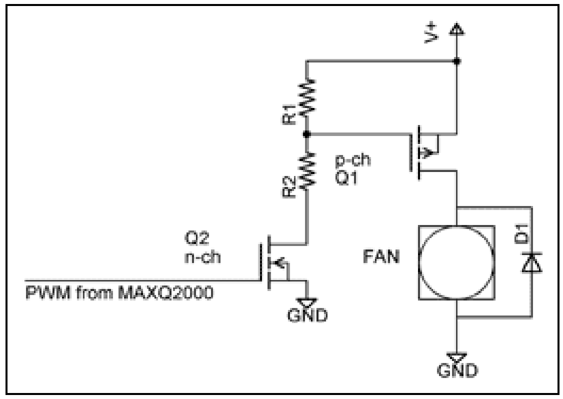

Figure 2.2 a possible hardware setup for connecting the PWM output to the fan [Maxim, 2005].

2.2.2 Digital I/O Temperature Sensors

This system is controlling a fan while monitoring remote temperature is the chief function of the IC shown in Figure 2.3. Users of this part can choose between two different modes of fan control. In the PWM mode, the microcontroller controls the fan speed as a function of the measured temperature by changing the duty cycle of the signal sent to the fan.

This permits the power consumption to be far less than that of the linear mode of control that this part also provides. Because some fans emit an audible sound at the frequency of the PWM signal controlling it, the linear mode can be advantageous, but at the price of higher power consumption and additional circuitry. The added power consumption is a small fraction of the power consumed by the entire system, though.

‘’This IC provides the alert signal that interrupts the microcontroller when the temperature violates specified limits. A safety feature in the form of the signal called "overt" (an abbreviated version of "over temperature") is also provided. Overt could be used to shut down the system power supplies directly, without the microcontroller, and prevent a potentially catastrophic failure’’ [Maxim, 2001].

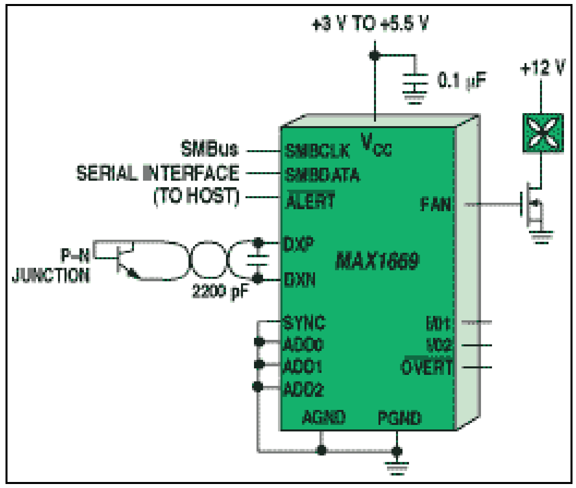

Figure 2.3 A fan controller/temperature sensor IC uses either a PWM- or linear-mode control scheme [Maxim, 2001].

2.3 Components

A system is constructed with a certain components that every component has it own function integrated to each others for completing the hole system to functioning. The components should have the input, controller and the output. In this system, the input is a temperature sensor, the controller is a microcontroller and the output is a DC motor and also LCD for status monitoring.

2.3.1 Temperature Sensor

Measurement of temperature is critical in modern electronic devices, especially expensive laptop computers and other portable devices with densely packed circuits which dissipate considerable power in the form of heat. Knowledge of system temperature can also be used to control battery charging as well as prevent damage to expensive microprocessors.

"Accurate temperature measurements are required in many other measurement systems such as process control and instrumentation applications. In most cases, because of low-level nonlinear outputs, the sensor output must be properly conditioned and amplified before further processing can occur" [Kester & else, 1999].

2.3.1.1 Types of Temperature Sensors

Except for IC sensors, all temperature sensors have nonlinear transfer functions. In the past, complex analog conditioning circuits were designed to correct for the sensor nonlinearity. These circuits often required manual calibration and precision resistors to achieve the desired accuracy. Today, however, sensor outputs may be digitized directly by high resolution ADCs. Linearization and calibration is then performed digitally, thereby reducing cost and complexity [Kester & else, 1999].

2.3.1.1.1 Resistance Temperature Devices (RTDs)

"Resistance Temperature Devices (RTDs) are accurate, but require excitation current and are generally used in bridge circuits. Unlike a thermocouple, however, an RTD is a passive sensor and requires current excitation to produce an output voltage. The RTD's low temperature coefficient of 0.385%/°C requires similar high-performance signal conditioning circuitry to that used by a thermocouple; however, the voltage drop across an RTD is much larger than a thermocouple output voltage" [Kester & else, 1999].

2.3.1.1.2 Thermistor

Thermistors have the most sensitivity but are the most non-linear. However, they are popular in portable applications such as measurement of battery temperature and other critical temperatures in a system.

"Similar in function to the RTD, thermistors are low-cost temperature-sensitive resistors and are constructed of solid semiconductor materials which exhibit a positive or negative temperature coefficient. Although positive temperature coefficient devices are available, the most commonly used thermistors are those with a negative temperature coefficient" [Kester & else, 1999].

2.3.1.1.3 Thermocouples

"Thermocouples are small, rugged, relatively inexpensive, and operate over the widest range of all temperature sensors. They are especially useful for making measurements at extremely high temperatures (up to +2300°C) in hostile environments. They produce only millivolts of output, however, and require precision amplification for further processing" [Kester & else, 1999].

2.3.1.1.4 Semiconductor

"Modern semiconductor temperature sensors offer high accuracy and high linearity over an operating range of about –55°C to +150°C. Internal amplifiers can scale the output to convenient values, such as 10mV/°C. They are also useful in cold-junction- compensation circuits for wide temperature range thermocouples" [Kester & else, 1999].

2.3.1.2 Temperature Sensors Key Features

There are certain features that should be considered when choosing the temperature sensor for any use. The features are showed in the Figure 2.4.

TYPES OF TEMPERATURE SENSORS

THERMOCOUPLE	RTD	THERMISTOR	SEMICONDUCTOR
Widest Range: –184°C to +2300°C	Range: –200°C to +850°C	Range: 0°C to +100°C	Range: –55°C to +150°C
High Accuracy and Repeatability	Fair Linearity	Poor Linearity	Linearity: 1°C Accuracy: 1°C
Needs Cold Junction Compensation	Requires Excitation	Requires Excitation	Requires Excitation
Low-Voltage Output	Low Cost	High Sensitivity	10mV/K, 20mV/K, or 1µA/K Typical Output

Figure 2.4 Types of Temperature Sensors [3]

2.3.2 Controller

Controller is the main part of the system where all the process flow will be controlled by this hardware accordingly to the embedded programming in it. Microcontroller is chosen for the system as the controller. The functions of the microcontroller are limited by manufacturers or the types of certain model. The microcontroller that been used in the system is manufactured by Motorola and every families of the microcontroller have same or differences features.

2.3.2.1 MC68HC11A Families

The Motorola families that been chosen for the system is from MC68HC11A Families. The families can be divided into three types which are MC68HC11A8, MC68HC11A1, and MC68HC11A0 with high-performance microcontroller units (MCUs) are based on the M68HC11 Family.

"This high speed, low power consumption chips have multiplexed buses and a fully static design. The chips can operate at frequencies from 3 MHz to dc. The three MCUs are created from the same masks; the only differences are the value stored in the CONFIG register, and whether or not the ROM or EEPROM is tested and guaranteed" [Motorola, 2000].

2.3.2.1.1 MC68HC11A Families Features

The Figure 2.5 showed the pins assignment of MC68HC11A and Figure 2.6 showed the component in the MC68HC11A.The features on MC68HC11A Families are:

i. M68HC11 CPU
ii. Power Saving STOP and WAIT Modes
iii. 8 Kbytes ROM
iv. 512 Bytes of On-Chip EEPROM
v. 256 Bytes of On-Chip RAM (All Saved During Standby)
vi. 16-Bit Timer System
vii. 3 Input Capture Channels
viii. 5 Output Compare Channels
ix. 8-Bit Pulse Accumulator
x. Real-Time Interrupt Circuit
xi. Computer Operating Properly (COP) Watchdog System
xii. Synchronous Serial Peripheral Interface (SPI)
xiii. Asynchronous Nonreturn to Zero (NRZ) Serial Communications Interface (SCI)
xiv. 8-Channel, 8-Bit Analog-to-Digital (A/D) Converter

xv. 38 General-Purpose Input/Output (I/O) Pins

xvi. 15 Bidirectional I/O Pins

xvii. 11 Input-Only Pins and 12 Output-Only Pins (Eight Output-Only Pins in 48-Pin Package)

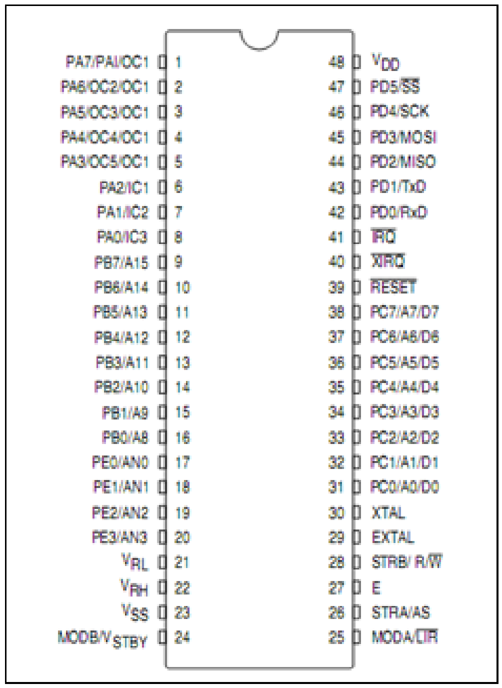

Figure 2.5 48-Pin DIP Pin Assignments [Motorola, 2000].

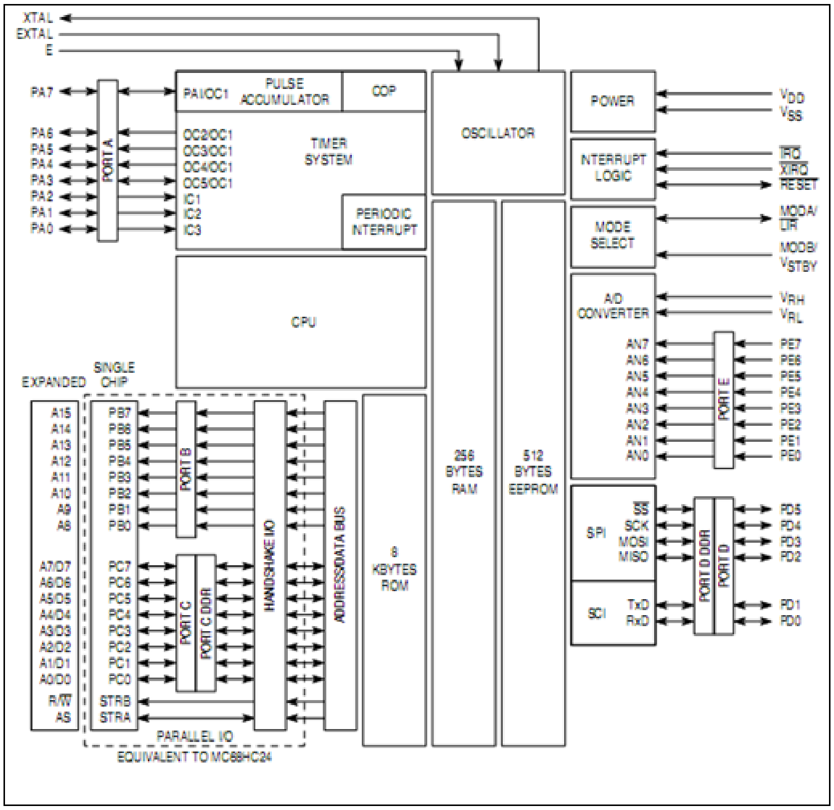

Figure 2.6 MC68HC11A8 Block Diagrams [Motorola, 2000].

2.3.3 Output

2.3.3.1 DC Motor

The DC Motor is a perfect choice for the system because the motor easy to be driven by the voltage, low torque so the current needed to drive the motor is low, high rpm and the speed change can be seen clearly.

2.3.3.1.1 Motor Driver

IRF640N MOSFET is chosen for the motor driver. There are many advantages to using MOSFETs as the driver. MOSFET is:

i. Voltage controlled devices.
ii. Compatible with the microcontroller because microcontroller can directly drive the MOSFETs.
iii. Less temperature dependant and harder to false trigger due to the threshold voltage required to turn the MOSFET on.
iv. Better to use in high frequency operations to minimize switching losses.

2.3.3.2 Liquid Crystal Display (LCD)

LCD is used to display character in the ASCII code form which is mean the data for character that been sent by the controller to the LCD should be in 8-bit ASCII representation. The characters that will be displayed on the LCD panel should be characters that available in the LCD datasheet characters table. Most of the LCDs are using the Hitachi driver. The system is using the LCD to preview the current temperature value and motor speed level.

CHAPTER 3

SYSTEM DESIGN

3.1 Introduction

This chapter explains about system design through construction of the hardware and development of software. In addition, the chapter elaborates the hardware and the software stage by stage. All the operations of hardware and software are also included in this chapter. The system for the automatic fan is showed in Figure 3.1 with simple block diagram representation.

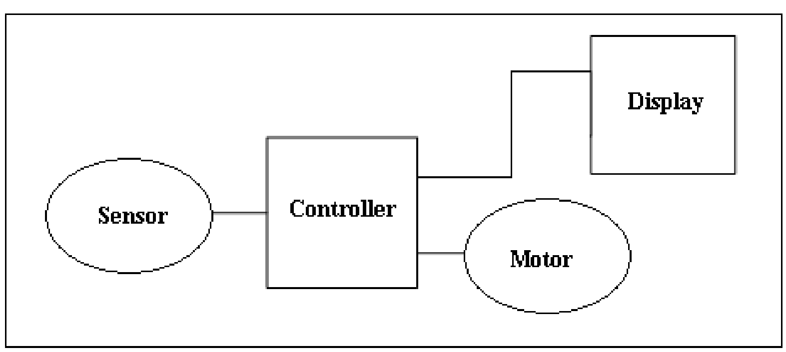

Figure 3.1 Block Diagram of Simple System Design for an Automatic Fan System

The sensor basically will be the input that will be triggered the controller to control the motor by certain condition or programming. The controller is set to decide how the output will be produced from the motor and will be displayed at the display part.

As the system requires the use of microcontroller, the design consists of two parts, hardware and software. Hardware is constructed and integrated module by module, hardware to software for easy troubleshooting and testing.

3.2 System Architecture

The system architecture of the automatic fan can be divided into 4 main modules. They are:

i. Microcontroller Module
ii. Sensory Module
iii. Liquid Crystal Display (LCD) Module
iv. Motor Module

The integration of the modules are producing the system which is roughly can be divided into two phase where the first phase is the smart fan system and the second phase is the monitoring system. Figure 3.2 is shown the separated phase through the boxes. The microcontroller, sensory and motor modules are in the first phase of the system and LCD Module is in the second phase monitoring system.

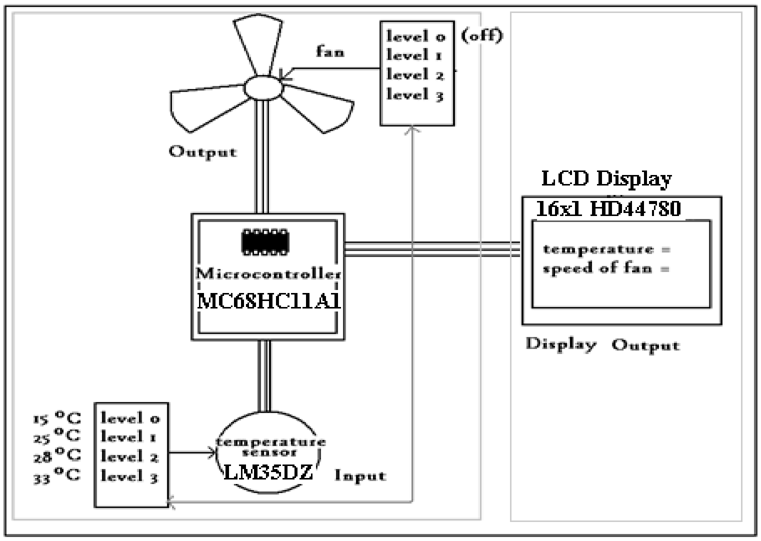

Figure 3.2 Block Diagram of Automatic Fan System

The automatic fan system will produce the output in four different levels that are the same level with input is senses. Each level of the senses by the input will triggered the same level of output and the status of the output and temperature view on the LCD panel. The Figure 3.3 showed the process of the automatic fan system.

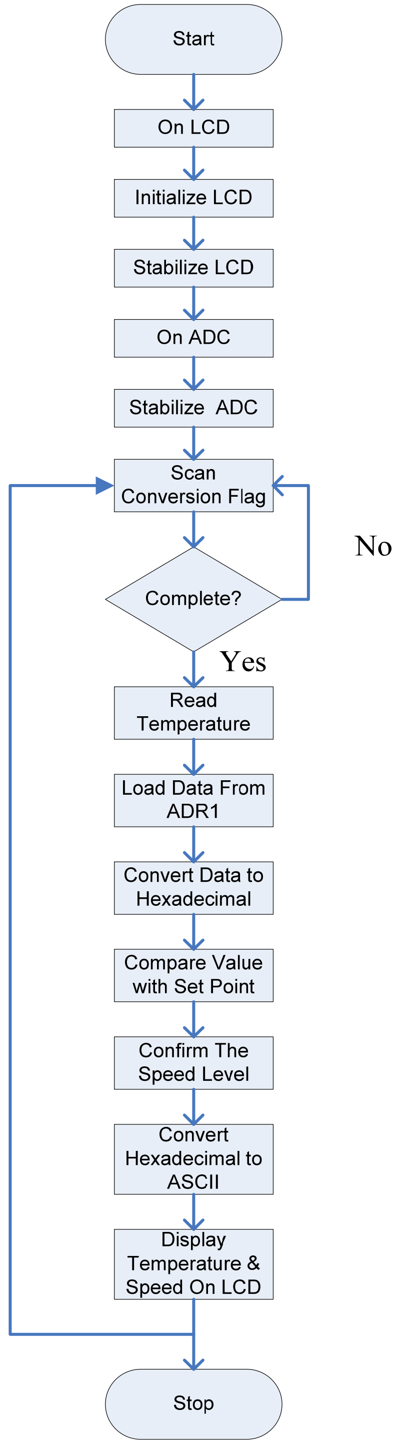

Figure 3.3 the Complete Flow Chart of Automatic Fan System

3.2.1 Microcontroller Module

The MC68HC11A1P is chosen as the controller for the project since it offers various functions and applicable for the system also it is the most produced microcontroller for the market.

MC68HC11A1P is 8-bit family from Motorola and can operate with four modes. They are Bootstrap mode, Special Test mode, Single-chip mode and expanded mode. Bootstrap mode is used for the system because this project does not require extra I/O ports and additional memory. This module consists of MC68HC11A1P as the controller, power circuit, reset circuit, clock circuit and EIA232 module as shown in Figure 3.4.

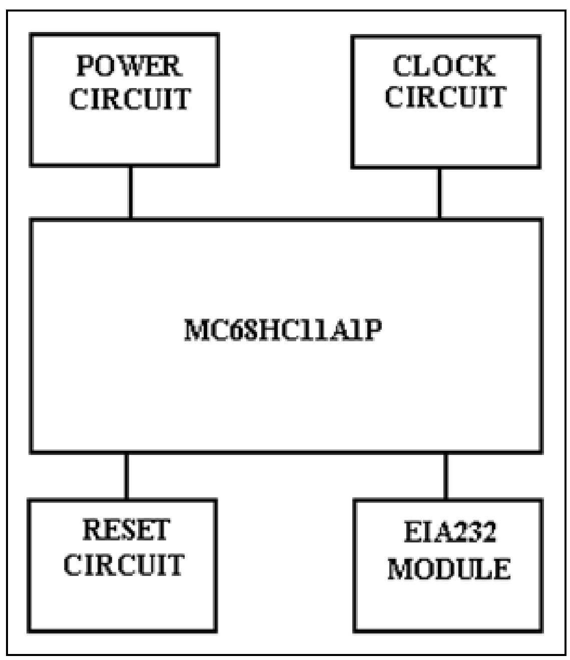

Figure 3.4 Microcontroller Module

MC68HC11A1P consist four mode of operation which are available for the microcontroller unit (MCU). They are single chip, expanded, bootstrap, and special test. For this system, the bootstrap mode is used because the system does not use large scale of memory. To set it become bootstrap mode, both pins MODA and MODB at pin 24 and 25 must be grounded to get logic '0'. The Figure 3.5 showed the connection of mode that been used for this system.

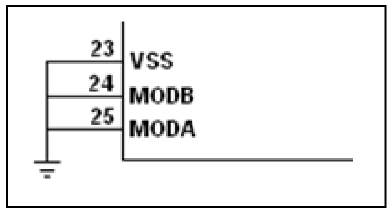

Figure 3.5 Connections to Activate Bootstrap Mode Operation

3.2.1.1 Power Circuit

Same as mostly ICs, microcontroller needed 5V as the input voltage. Figure 3.6 is showed that the circuit is used to provide a 5V supply to microcontroller. The voltage regulator 7805 is used to maintain the output voltage while the capacitors serve to filter some of the fluctuations in the power supply voltage. A LED is used to indicate the power circuit is functioning.

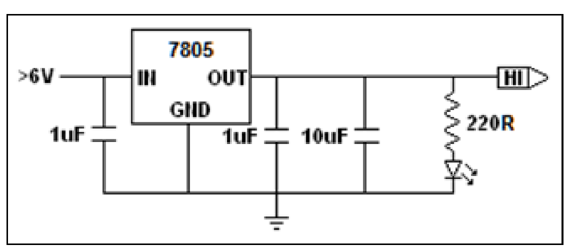

Figure 3.6 Power Supply Modules

3.2.1.2 Reset Circuit

Figure 3.7 is a simple RESET circuit. The output of the reset circuit connected to the microcontroller through pin 39. The pin 39 on the microcontroller only triggered the reset when the input is low. RESET is the power-on reset signal.

When the push button is not pressed, the 47K pull-up resistor keeps the signal high. Pressing the push button causes the pin to be pulled low, thus forcing a reset. The value of RC must be chosen properly so that the value must be grater than 6 clock cycle to distinguish from internal RESET.

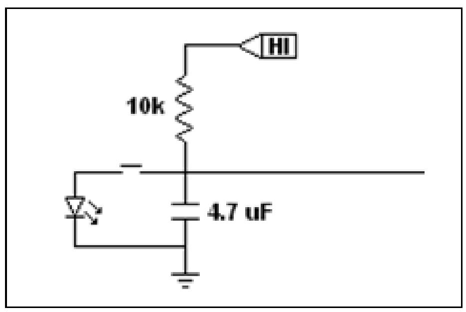

Figure 3.7 RESET Circuit

3.2.1.3 Clock Circuit

The clock signal is a periodic sequence of pulses. The MC68HC11A1P can generate its own internal clock signal. In order to generate clock for the microcontroller, the output of the clock circuit must be connected to the MC68HC11A1P XTAL and EXTAL on pin 29 and 30. A crystal, 10M resistor and 2 capacitors 22pF are require for the connection as shown in Figure 3.8.

The internal clock frequency is one-fourth of that supplied to the crystal pins. In this project, to design a clock frequency we are using 8 MHz crystal. Hence, the clock speed (frequency) is 2 MHz and often referred as E clock. The E clock can be measured on MC68HC11A1P pin 27 by using an oscilloscope or any frequencies measurement devices.

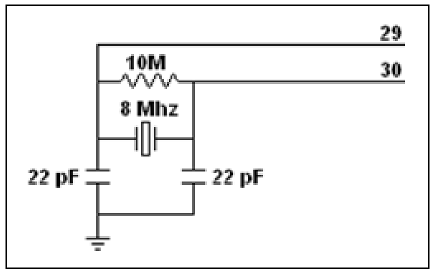

Figure 3.8 a Clock Circuit

3.2.1.4 EIA232 Module

EIA232 module is used to allow data to be transmitted for a long distance. Since the microcontroller in TTL compatible, a line driver such as MAX233A is needed to allow data to be transmitted at a longer distance. MAX233A is used as the connector for both MC68HC11A1P and computer sides. Communication computer to microcontroller can be made and vice versa.

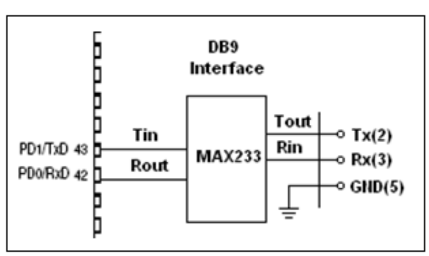

Figure 3.9 Line Drivers MAX233A