VOICE ACTIVATED DOOR

By

HAFIZAH CHE RAMLI

FINAL REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Universiti Teknologi Petronas
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

JUNE 2007

CERTIFICATION OF APPROVAL

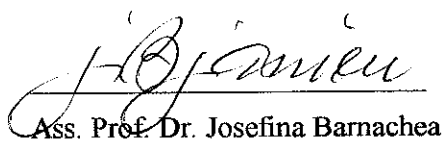
VOICE ACTIVATED DOOR

by

HAFIZAH CHE RAMLI

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Approved:



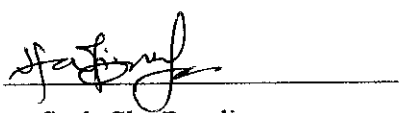
Ass. Prof. Dr. Josefina Barnachea
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

June 2007

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.



Hafizah Che Ramli

ABSTRACT

Voice activated door is a voice input environment control unit for use by individual. The system operates in response to voice command by converting the sound input energy into electrical energy. This voice activated door opens when the user gave command, "Open" through the speech recognition and it closes automatically as the user passes by the door by stepping on the touch plate (i.e. enters the room). The objective of the project is to help disable person enters a room, place or area with ease. This system also can provide a security system for entrance for some area, by using different command password for each user. Thus, only authorized person can enter the area. The designed voice activated door system consists of 3 mains parts which are speech recognition for recognizing the input sound, DC motor control circuit attach with the rack and pinion gear system to control the door operation (close /open) and touch sensor as an object detection to detect an object that enters the room, which then automatically closes the door. For better operation of the system, electric strike and cylindrical locks are used for locking system purpose, with fail secure mode. Fail secure mode will leave the door lock if power failure occurs. This will avoid from unauthorized user to come in which obeys the security objective. The voice activated door system produced is low in cost, simple and capable in helping the disable people as well as enhances the security system.

ACKNOWLEDGEMENTS

First of all I would like to thank ALLAH the Almighty, for blessing me for all the times through completing this Final Year Project (FYP). I also would like to thank my family for all their support and encouragement.

My great thank you to my project supervisor; Ass. Prof. Dr. Josefina Barnachea, for the supervision, guidance and support. Her advices and comments really help me all the way through understanding and completing this project.

A big thank you to lab technicians of Electrical & Electronics Engineering Department, Ms. Siti Hawa and Mr. Isnani, for guidance and help in troubleshooting all the circuits and fabricating the door model. Also, to lab technician of Mechanical Engineering Department, Mr. Zamil for guidance and helping me fabricate the gear system.

Last but not least, to all my friends and everyone that has been involved in helping me in my Final Year Project.

THANK YOU

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

C	- Common
DC	- Direct current
NC	- Normally Close
NO	- Normally Open
IC	- Integrated Circuit
BCD	- Binary Code Decimal
SPDT	- Single Pole Double Throw
DPDT	- Double Pole Double Throw
SR-07	- Speech Recognition Kits - 07
PCB	- Printed Circuit Board
BCD	-Binary Coded Decimal
SRAM	-Static Random Access Memory

CHAPTER 1
INTRODUCTION

1.1 Background of Study

Voice activated door is a voice input environment control unit for use by individual. The system contains, voice/speech recognition, open/close door circuitry, and door sensor (i.e. object detection sensor). The voice/speech recognition will be the main interface for the system design. Speech/voice recognition will be able to identify the person command/ words. It is a process of converting an acoustic signal, captured by a microphone or telephone to set of words. The recognized words can be the final results, for such applications as commands and control, data entry, and document preparation.

The speech recognition system commonly used in voice activated system door in the market is isolated-word speech recognition system. It requires the sound pause briefly between words. The isolated words are easy to differentiate and recognize than continuous speech. Thus, it give more precise output to the system in recognizing the speech and can achieve high performance in controlling the condition of the voice activated door system.

Present voice activated door system, uses the door opener for open/close door operation. The voice/speech recognition system is attached to the main control circuit, which mostly consists of motor and door movement mechanism to control the door operation. Programmed microcontroller is being used to control the whole system operation. For automatic closing, object detection is use. Once it senses an object passing by, the circuit will produce different voltage output and transmit a signal to the receiver which then activates the door circuitry to close the door automatically. Refer to Appendix A for flowchart of the voice activated door system.

As security purpose, another identification sensor, like fingerprint identification is use to enter higher security level area, instead of using different password for the speech recognition.

1.2 Problem Statement

Handicapped people often experience difficulty in opening door especially swing door type. Thus, this project was designed to help this people to live their life with ease. Avoiding such difficulties to open the door they just need to give specific command, (i.e. "Open") then the door will open and close automatically once they enter the room.

Besides that, it also can be implemented for security system purpose. Using the speech recognition, different command can be recorded for different person hence can be used as a password for the person to enter the area that need high level security system. Thus, this can avoid unauthorized person to enter the area as well as avoiding any break-in or burglary.

1.3 Objectives

The project objective is to assist disable people and who's having difficulties in opening door. Also, to enhance the security system level present by using the voice/speech recognition as the heart of the voice activated door for house or office. For industrial, security system of warehouse cans also being protected by using password to enter the area.

1.4 Scope of Study

The scope of this project was more on the speech recognition system understanding and implementation in the voice activated door system design. Basically, the study focuses on how to connect the speech recognition to the door control operation circuitry as well as the object detection system. The cost, time frame and the applicability of the system were given priority while designing the system. The project was accomplished within one year.

CHAPTER 2
LITERATURE REVIEW

2.1 Voice Activated Door

Several voice activated system already exist in this high technology era. There are voice activated switch, voice activated remote control, voice activated dial phone as well as voice activated door. But, mostly the voice activated present was not precise enough in distinguishing the noise from environment and words command. Thus, this project will be stressed on those parts. From the research done, literature reviews related to the project were found from previous projects, journals and article, which can be the guidelines in accomplishing this project.

According to Lisa Torvik's project, the Voice Activated Door Opener was designed for a quadriplegic to open the garage door without assistance. "This project is designed to use speech recognition of one word. The activating word that is chosen is "up". The frequency spectrum of "up" was captured on a soundboard and is the basis of this design. Filters are used to pick out three frequency bands in this spectrum. The output signals from these filters are then compared to three threshold voltages using voltage comparators. If the output signals from the filters are above the threshold voltages, the comparators go high. Monostable multivibrators are used on the output of the comparators to lengthen the high pulses. When all of the pulses from the monostable multivibrators are high at the same time, an AND gate output goes high. This high pulse activates the door opener. This device permits a physically disabled individual, without outside assistance, to gain access to a garage by using a simple voice command." [1]

Another project which has similar topic was Soni-Key Controlled Door Lock. The project was sponsored by National Science Foundation, in effort have student engineers at universities throughout US to design and construct devices for persons with disabilities. Once the project is completed, it is given to those disabled

persons as a gift to improve their life. The project was specially designed for people who have difficulty in opening a locked door because of their disabilities. It is voice activated door lock and opener, with additional attachment of fingerprint identification for security system.

There are five main components in the Soni-Key Door lock. A central control unit is located inside the house near the door operated by the Soni-Key. Microphones for voice actuation are located near the controlled door on the inside and outside the house. A fingerprint scanner is mounted on the wall outside to provide for extra security. An electronic door lock mechanism is mounted inside the door, and an automatic door opener is mounted on the top of the door. A Voice-Direct chip is utilized for voice recognition. The Little G (BL1600) microcontroller from Z-World controls the Soni-Key. The Central Control Unit process the speech signal, controls the lock open and door opener and provides a recharging circuit for the batteries that control the device.

The Soni-Key has four command operations: Lock, Unlock, Open and Close. The system operates as the person speaks a code word into the microphone. These microphones have range of approximately twenty feet. The speech pattern will be recognized by a microcontroller, Voice-Direct chip. However, if the voice communication is from outside, fingerprint recognition is required. If the fingerprint is recognized, the microcontroller will send signal to the central control unit which in turn sends an electromagnetic signal to the door latch and opens to allow the user to enter. The door still can be accessed and opened using the original key or open manually. [2]

2.2 Voice /Speech Recognition

In the near future, speech recognition will become the method of choice for controlling appliances, toys, tools, computers and robotics. There is a huge commercial market just waiting for this technology to mature. To control and command an appliance (computer, VCR, TV security system, etc.) by speaking to it, will make it easier to use, while increasing the efficiency and effectiveness of working with that device. At the most basic level, speech recognition allows the user to perform parallel tasks, (i.e. hands and eyes are busy elsewhere) while continuing to work with the computer or appliance.

By referring to the Build a Speech Recognition Circuit Article; "This circuit allows one to experiment with many facets of speech recognition technology. The heart of the circuit is the HM2007 speech recognition integrated circuit. The chip provides the options of recognizing either the .96 second word length (40 word vocabulary) or the 1.92 second word length (20 word vocabulary). For memory the circuit uses an 8K X 8 static RAM. The chip has two operational modes; manual mode and CPU mode." [3].

As for the research done from internet, another system of voice /speech recognition was found. It was Voice Direct 364 Kits. Voice Direct™ 364 Speech Recognition Kit is a low-cost kit designed to easily enable hands free speech recognition capability of consumer electronics. It can be used to voice-activate all types of ordinary consumer electronics like set top boxes, microwaves, cars, remote controls, garage door openers, alarm clocks, telephones, lights, internet appliances and many other types of electronic products. Voice Direct™ 364 features:

- ✓ continuous listening technology that allows a device to be switched on or off with just the sound of one key word or short phrase.
- ✓ works by using one key word or phrase to turn the speech recognizer on.
- ✓ employs speaker-dependent (user trained) speech recognition technology to recognize up to 60 words or phrases (15 as a stand-alone module) lasting up to 2.5 seconds each.
- ✓ prompts are available in English and German, although the technology works in any language.
- ✓ can be configured to use three continuous listening key words or phrases, each with up to five speaker-dependent sub-commands.

The Voice Direct™ 364 Kit is powered by Sensory's Voice Direct™ 364 speech recognition processor, designed for consumer telephony products and cost-sensitive consumer electronic applications. The Voice Direct™ 364 Kit is software compatible with the original Voice Direct™ kit, allowing past customers to simply replace the old module with the newer one to enable hands free usage. Running Sensory Speech™ 5.0 Technology, the latest generation offers improved recognition accuracy, faster response times, and improved noise immunity.

The Voice Direct™ 364 Speech Recognition Kit comes complete with almost everything necessary to apply speech recognition to common electronic devices. The kit includes the assembled Voice Direct™ 364 module,

- a microphone element
- speaker
- 4 micro switches
- passive component selection to configure the module
- quick setup guide.

The Voice Direct™ 364 works in an easy to use standalone pin configurable mode, but also supports slave mode operation for increased programmability and features. Sensory's Voice Direct™ 364 product line also includes speech processor ICs and modules. The Voice Direct™ 364 Speech Recognition Kit retails for $49.95. [4]

2.3 Door Control Circuit

As for door control circuit, several circuits are suitable to use to close / open the door was found. The type of door use is the automatic door which will open automatically once switch is ON when the door locked is released. The door will then be closed and locked automatically by the electrical or mechanical part construction of the door. An example for mechanical is by using spring tension attached at the door and or electrical, by using switch that will trigger once it detects that a person enters the area. Most of the automatic door can be operated manually when facing problems like no electricity or when there's system breakdown.

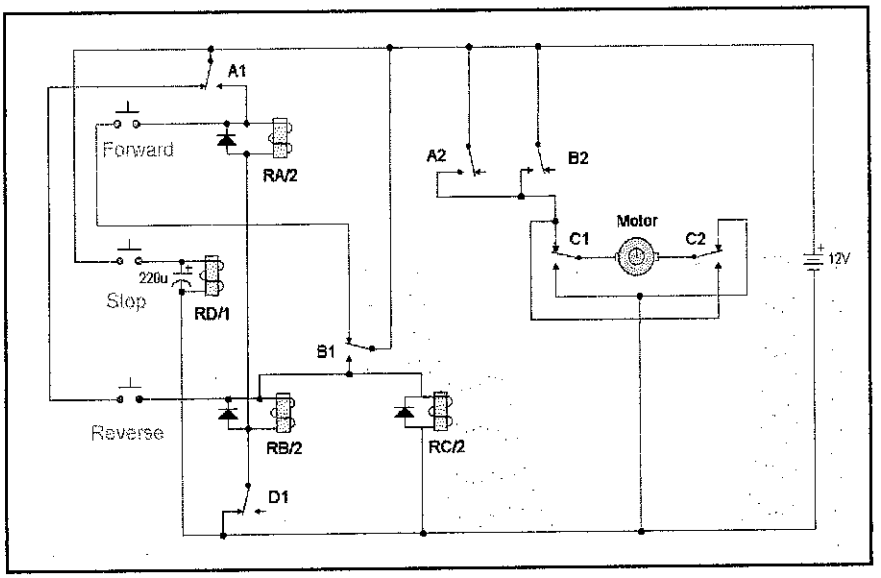


Figure 1 DC motor reversing circuit.

Figure 1 show, DC (Direct Current) [5] motor reversing circuit that can control the DC motor rotation. Relays control forward, stop and reverse action, and the motor cannot be switched from forward to reverse unless the stop switch is pressed first.

The circuit operates, when the forward button is pressed and released the motor will run continuously in one direction. The Stop button must be used before pressing the reverse button. The reverse button will cause the motor to run continuously in the opposite direction, or until the stop button is used.

2.3.1 Locking system

The door circuit also is attached with door locked, for security purpose. Several device and circuit design can be used for locking system. The two most suitable designs are by using the electromagnetic lock and electric strike attached to the latch or doorknob.

Magnetic switch

A magnetic lock is a simple locking device that consists of an electromagnet and armature plate. By attaching the electromagnet to the door frame and the armature plate to the door, a current passing through the electromagnet attracts the

armature plate holding the door shut. Unlike an electric strike a magnetic lock has no interconnecting parts and is therefore not suitable for high security applications because it is possible to bypass the lock by disrupting the power supply. Nevertheless, the strength of today's magnetic locks compare well with conventional door locks and cost less than conventional light bulbs to operate.

The magnetic lock relies upon some of the basic concepts of electromagnetism. Essentially it consists of an electromagnet attracting a conductor with a force sufficiently large enough to prevent the door from being opened. In more detailed examination, the device makes use of the fact that a current flowing through one or more loops of wire (known as a solenoid) produces a magnetic field. This works in free space, but if the solenoid is wrapped around a ferromagnetic core such as soft iron the effect of the field is greatly amplified. This is because the internal magnetic domains of the material align with each other to greatly enhance the magnetic flux density. [6]

Electric Strike

An electric strike is an access control device used for doors. It replaces the fixed strike often used with a latch bar. Like a fixed strike, it normally presents a ramped surface to the latch bar allowing the door to close and latch just like a fixed strike would. However, an electric strike's ramped surface can, upon command, pivot out of the way of the latch bar allowing the door to be pushed open without any operation of the knob.

Electric strikes generally come in two basic configurations:

- Fail-secure. Also called Fail-locked. In this configuration, applying electrical current to the strike will cause it to open. In this configuration, the strike would remain locked in a power failure, but typically the knob can still be used to open the door from the inside.

- Fail-safe. Also called Fail-open. In this configuration, applying electrical current to the strike will cause it to lock. In this configuration, it operates the same as a magnetic lock would. If there is a power failure, the door would open merely by being pushed/pulled open.

Electric strikes are sometimes equipped with buzzers which allow someone outside the door to hear when the door is open. The buzzing noise is typically simply a result of applying AC current to the strike instead of DC. [7]

2.4 Object Detection Circuit

2.4.1 Infrared object/motion detection

Infrared system has two devices: active and passive.

Active Infrared Devices

Active devices that use infrared technology have an infrared diode, which constantly or periodically emit infrared waves. Concurrently there is a receiver, which monitors the reflected wave levels .The absence of a reflected wave or a change in its properties (wavelength or amplitude) will indicate to the receiver that something has changed in the detection zone. In the case of a door sensor this change will cause a relay to trip.

Passive Infrared Devices

Passive Infrared devices monitor a certain area for the presence of infrared rays, which are emitted by humans in the form of body heat.

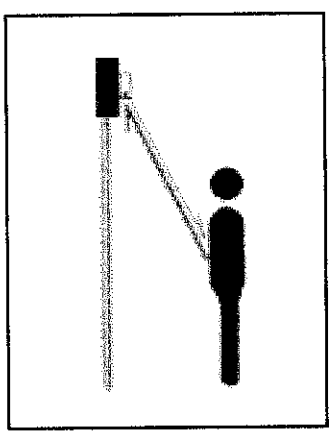


Figure 2 Infrared object detection.

2.4.2 Ultrasonic object/motion detection

Ultrasonic devices constantly emit inaudible sound waves. At the same time the device is scanning for reflected waves, which are reflected at a preset speed. The speed corresponds to the height of the door and if a faster reflected wave is detected it indicates that something or someone has entered the monitored space. This triggers the door to open.

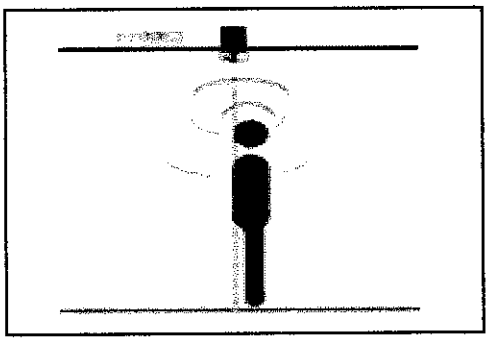


Figure 3 Ultrasonic object/motion detection

Figure 4, shows an example of the ultrasonic motion or object detection circuit. The circuit is quite complex than infrared circuit, but it is more reliable.

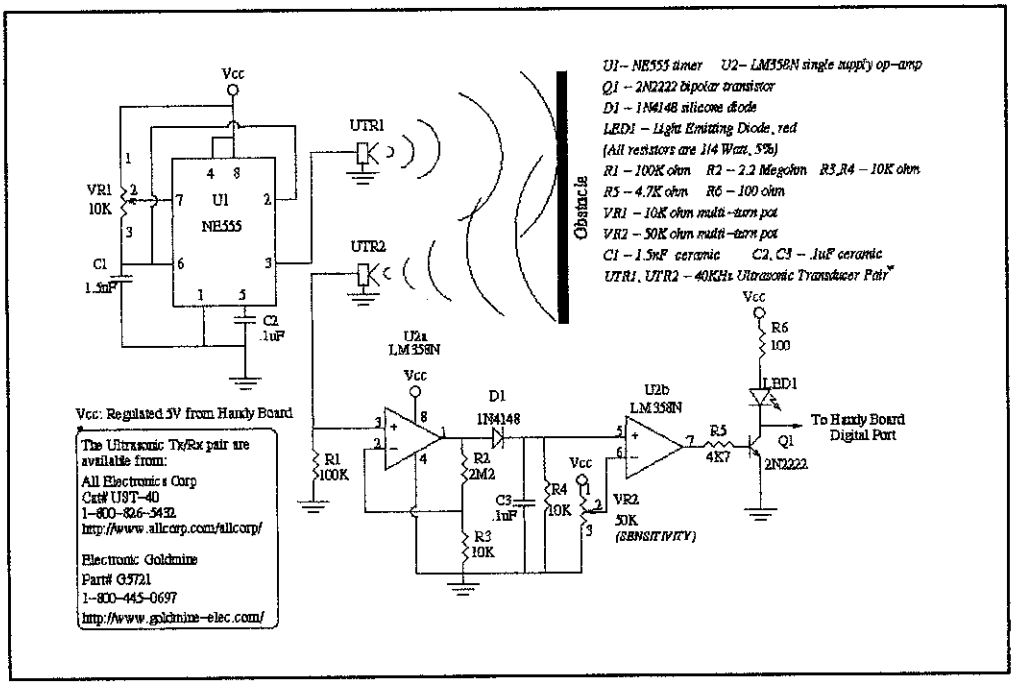


Figure 4 Ultrasonic Obstacle Detection Circuit.

"The IC U1 is a 555 timer in stable configuration to oscillate at 40 KHz. Instead of using exact values for the two resistors that is placed between pin 6 and 7, a 10K ohm potentiometer (VR1) was used. This also allows for some fine tuning of the output frequency. The output (pin 3) is then attached to a 40 KHz ultrasonic transmitter (UTR1).

The receiving circuit is a dual LM358N (U2) op-amp. An ultrasonic receiver (UTR2) is connected to pin 3, the non-inverting input of U2a which is a non-inverting amplifier with a gain of 220. The output of U2a is put through a low pass filter via D1, C3 and R4 to produce a some what stable DC voltage. This DC voltage is fed into the non-inverting input of U2b configured as a non-inverting comparator. Sensitivity of U2b is controlled by VR2 to set the threshold trigger value. The output of U2b is connected through R5 to the base of a bipolar 2N2222 transistor (Q1) acting as an inverter with a LED (LED1) to indicate if an obstacle has been detected. Finally, the collector of Q1 goes to the output" [8]

2.4.3 Touch sensor switch.

A touch switch is a switch that is turned on and off by touching a wire contact, (i.e. 2 metal plates) instead of flicking a lever like a regular switch. Touch switches have no mechanical parts to wear out, so they last longer than regular switches. Touch switches can be used in places where regular switches would not last, such as wet or very dusty areas. Examples of touch switch circuit diagram as Figure 5. [9]

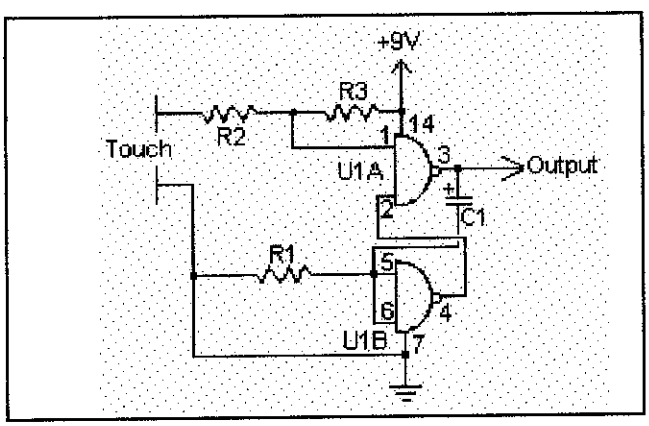


Figure 5 Touch switch circuit.

2.5 Theory of the Project

From the literature reviews done, the voice activated system theory applied, will be the basic theory of the voice/ speech recognition to detect the code words. Most common voice/speech recognition found in the market uses the Voice Direct™ 364 and Speech Recognition Kit (SR-07) using of HM2007 speech recognition IC. List of advantages and disadvantages of the voice/speech recognition system was done to choose which system is better for the system design. The differences and evaluations were based on the elements listed in Appendix D. SR-07. Voice Direct™ 364 is better than speech recognition in terms of cost and sizing, but the speech recognition SR-07 is better in terms of features, memory, specification, recognition style and applications. Thus, the speech recognition SR-07 is more applicable and reliable for designing the voice activated door.

Open/close door operation, consists of mechanical parts and electrical parts. The electrical part is the motor control circuit and mechanical part is the door movement mechanism. Several circuit designs can be used to control the motor direction to move the door. i.e. H-bridge (half-bridge transistor) motor control circuit and DC motor reversing control circuit using relays. DC motor reversing control circuit was chosen for this system since it is more simple, approach than H-bridge which uses transistor. The basic concept locking system of door operation is similar to the electrical automatic door using electric strike and magnetic switch for locking purpose.

As for the object/motion detection, three most popular sensors are applicable for the system. There are ultrasonic object detection, infrared sensor and touch switch sensors. From these three sensors, touch switches sensor can be used in places where regular switches would not last, such as wet or very dusty areas. Thus the touch switch sensor theory; contacts of two metals, is more reliable to be applied for the object/motion detector parts. Nevertheless it is cheaper simple and suitable than others.

CHAPTER 3
METHODOLOGY/ PROJECT WORK

3.1 General Project Methodology

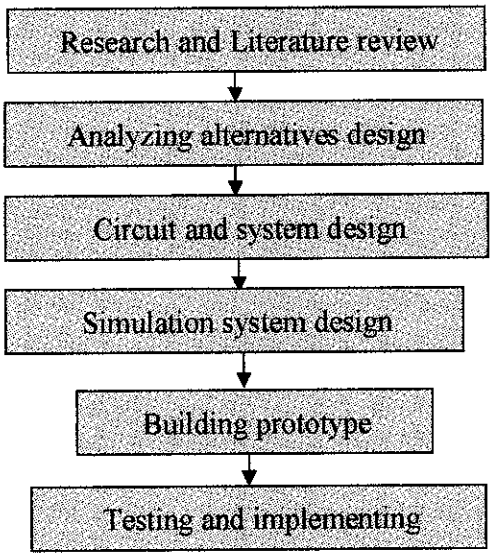


Figure 6 Project Process Flow.

The project started with some research and literature review related to the voice activated door system. The readings made guided the author to analyze the suitable alternatives and theory for designing the voice activated system, door operational system controller and object detection system. Next stage, circuit design and simulation were done for the system to work by using the Multisim7 (EWB) and PSPICE software. For the door operation mechanism design, AutoCAD was used in designing suitable approach for the system.

Testing and troubleshooting of the circuit were done by soldering the components circuit to the breadboard and Vera board and testing the circuit functionality one by one before connecting it together to troubleshoot and testing the whole system process for smooth operation. The final touch up of the project was

building a miniature model with the operation mechanism. The compatibility of the electrical and mechanical part of the system designed was checked and troubleshoots. (Refer to Appendix B and C for the Gantt chart).

3.2 Project Work

Figure 7, shows the summary of the Voice Activated Door System project work based on the methodology and process flow of the project.

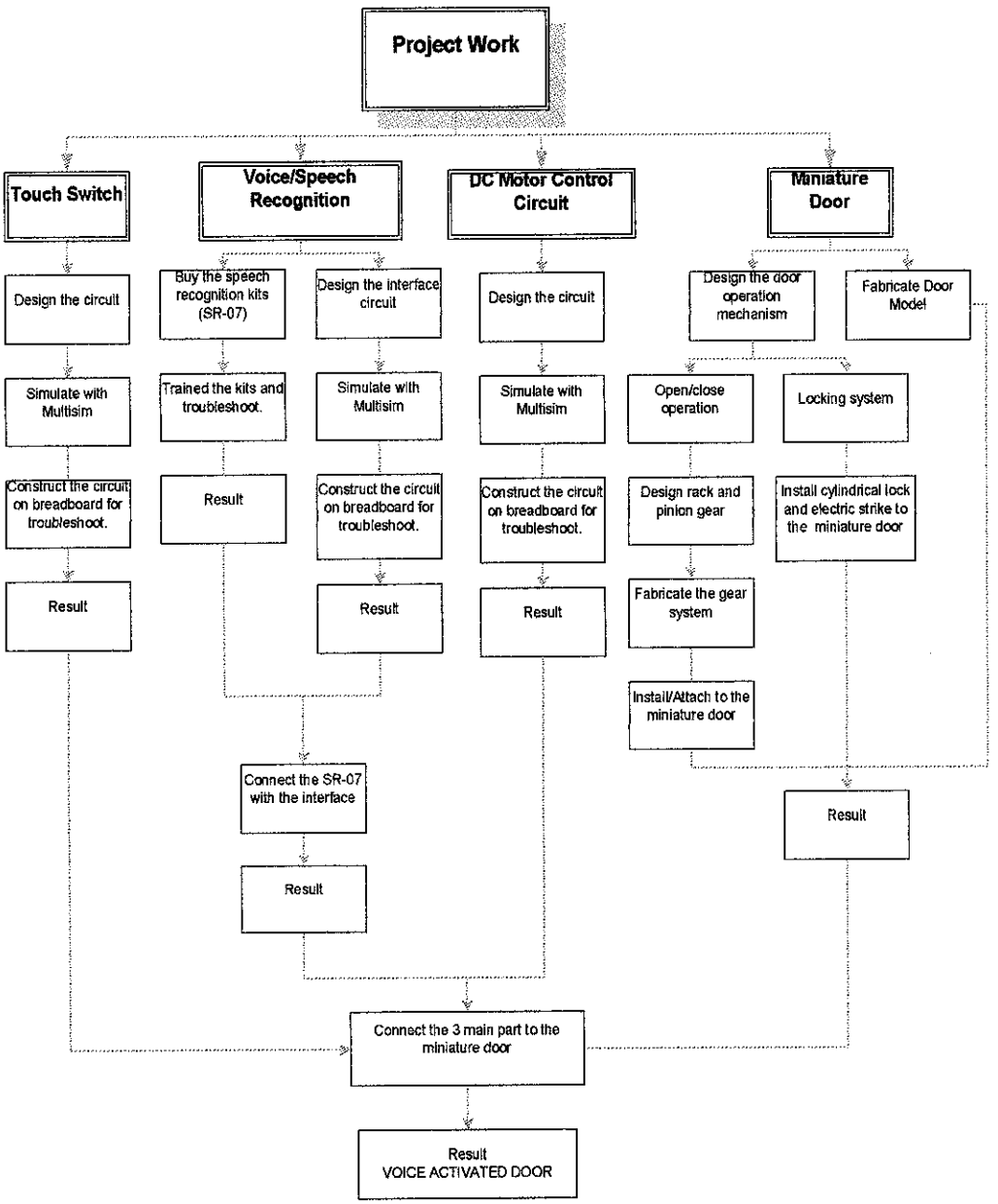


Figure 7 Block Diagram of Project Work

3.2.1 Voice/Speech Recognition

The SR-07 speech recognition kit consists of HM2007 chip; which is a CMOS voice recognition large scale integration (LSI) circuit. The chip contains analog front end, voice analysis, regulation, and system control functions. The chip can recognize either the .96 second in a word length (40 word vocabulary) or the 1.92 second in a word length (20 word vocabulary) that need to be trained first to responds accurately for speaker dependent type. For speaker independent type, the speech recognition only responds to words regardless of who speaks. The chip is connected to 8K X 8 static RAM that function as memory store. Refer Appendix E for the speech recognition kit (SR-07) board.

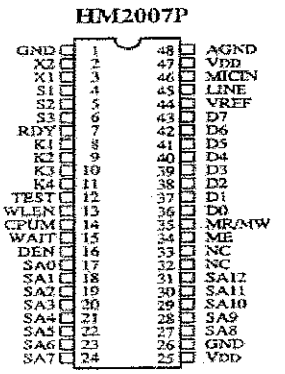


Figure 8 HM2007 chip pin configuration.[10]

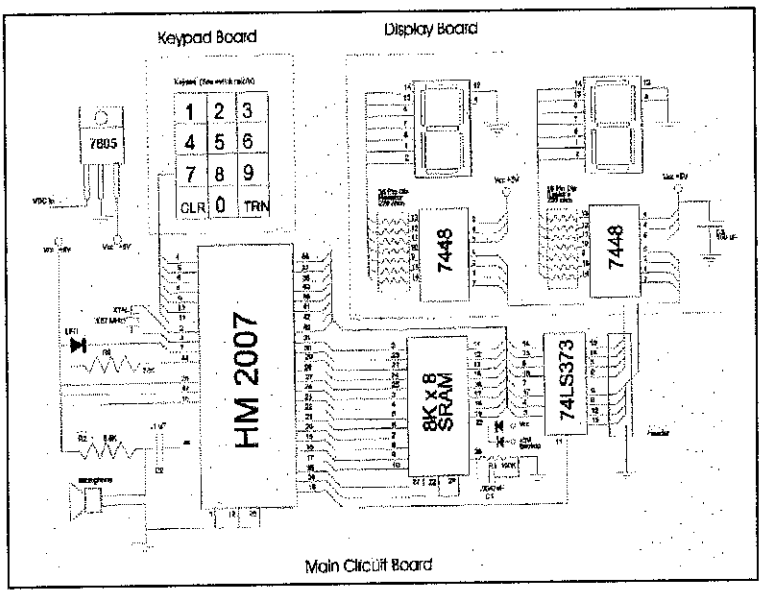


Figure 9 SR-07 kit schematic diagram.[11]

The keypad and display board are used to communicate and program the HM2007 CMOS chip. Refer Appendix F for Datasheet of HM2007. The microphone is plug to the microphone jack in position about 1" away from mouth. When the circuit is turned on, "00" is displayed in the digital display and the LED (READY) is ON (lit) and the circuit waits for a command. The HM2007 chip needs to be trained and programmed first with the words that as command/password used for activating the system. By following the manual [11], the chip was trained to recognize the command words.

Train instruction.

"1" is pressed (display shows "01" and LED turns off) on the keypad, then the TRN (Train) key is pressed (LED turn on) to place circuit in training mode, for word one. The target word said into the microphone clearly. The LED blinking OFF then ON when the circuit accepts ten signal input. The word is then identified as the "01" word. If LED did not flash, start over by pressing "1" and then "TRN" key.

To continue training new words in the circuits, press "2" then TRN to train second word and so on. The circuit will accept and recognized 20-40 words depending on the circuit setting. For this system, the circuit is set to recognize 20 words (each with length of 1.92 seconds) by placing jumper wire on the two-pin WD header.

To test the words trained, repeat a trained word into the microphone. The number of words will be displayed on digital display if it recognizes the word.
The chip provides error code:
55 = word to long 66 = word to short 77 = no match

Clearing Memory, Changing Words and Erasing Words.

To erase all words in memory "99" is press and then "CLR" (Clear). The numbers will quickly scroll by on the digital display as the memory erased. The trained words can be changed by overwriting the original word by simply pressing the desired key of the specific words. If it is to be erased without replacing the word with another word press the word number then press "CLR".

Interface circuit for Speech Recognition Kit (SR-07)

The interface circuit is connected to the 10 pin Right Angle interface header on the circuit boards. This header is also used for connecting the digital display board for training command word and testing the main board. The interface circuit is consisting of 4028, BCD to decimal decoder IC that has ten output lines that correspond to the respective word store number. The corresponding line number of the 4028 will be high and will be connected to the NPN transistor and simple relay, to control the DC motor control circuit to move forward. The interface circuit is adapted from the example of the SR-07 kit manual and modified by adding timer circuit to control the door operation time between the NPN transistor and DPDT relay. It is to ensure the door operation reach fully open position by setting the timer circuit according to the time taken.

The timer circuit output of the interface circuit is connected by replacing the stop switch with the normally close (NC) and common (C) relay contact which is parallel to the NC and common relay contact of the touch sensor circuit. For the normally open (NO) contact, it is connected to the forward switch DC motor control circuit.

The motor stops according to the time set for the interface circuit to maintain its high output state before de-energized the relay. The time is set about, 5.17 seconds based on the calculation below:

$$T = 1.1\ R1\ C1 \qquad (1)$$

Where; $R1 = 10\text{kohm}$ $C1 = 470\text{uF}$

The time will change according to the door movement required for the door to fully open when the gear is attached.

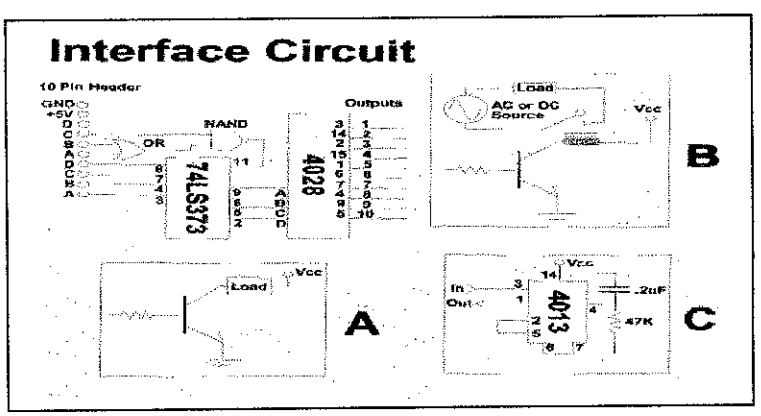


Figure 10 Interface circuit (Adapted from reference [11])

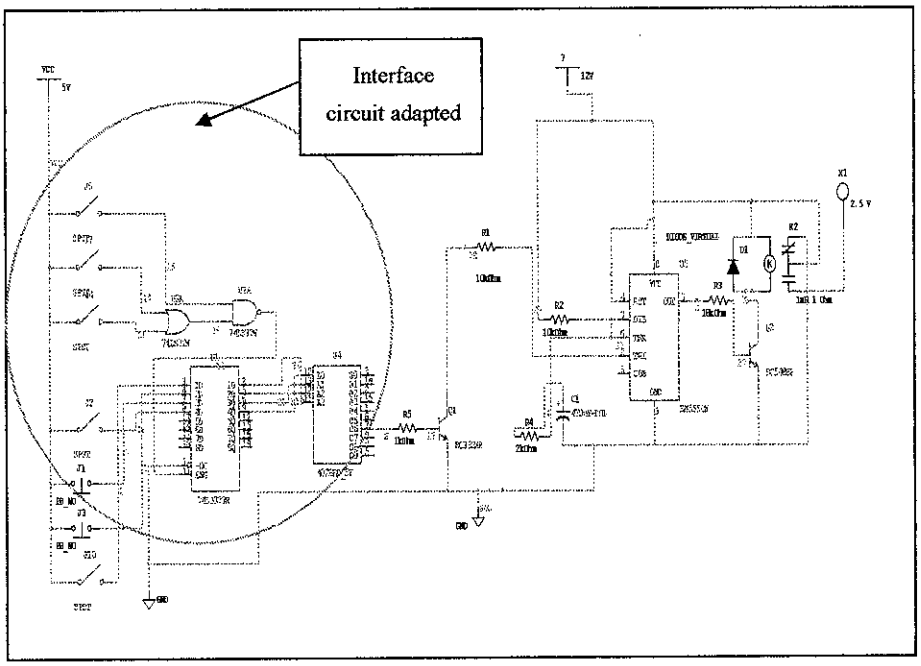


Figure 11 Interface Circuit Design.

3.2.2 Touch switch sensor.

Figure 12 is the adapted circuit from Kit 137, Touch switch [12]. This kit uses 12V relay to do the switching once the plate being touch or energized.

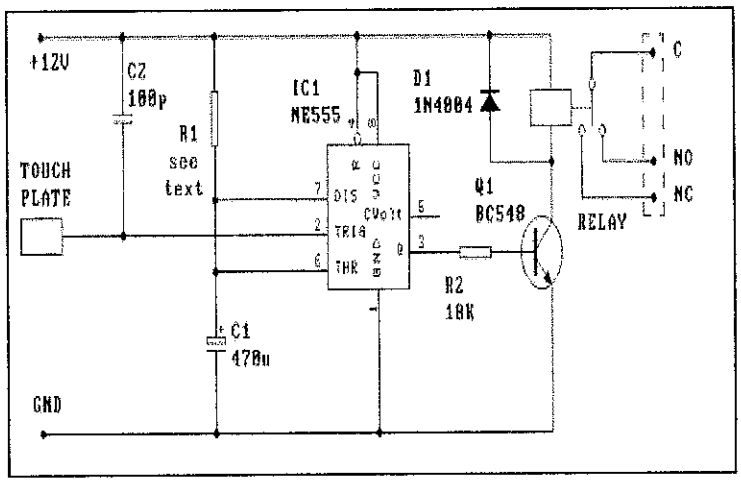


Figure 12 Kit 137, Touch Switch Schematic Diagram.

Table 1 List component of Kit 137, Touch switch circuit.

Components	Value / Type	Unit
Relay	SPDT , 12V	1
Resistor	R1, 10kΩ R2, 18 kΩ	2
Diode	1N4004	1
Capacitor	Electrolytic C1 : 470uF Ceramic, C2 : 100pf	2
Transistor	Q1, BC 548 (NPN type)	1
IC	Timer, LM555	1
Powers supply	12 V	1

The used touch plate is about 30 cm length x 2 cm width. The touch sensor is constructed to the Vera board. Each wiring continuity of all components were checked to ensure correct connectivity. The touch sensor connects to the DC motor control circuit by replacing the reverse switch with the NO and C relay contact. The timer circuit output of the touch sensor is connected by replacing the stop switch with the NC and common relay contact. The motor stops according to the time set for the touch sensor to activate. For this troubleshoot, the time is set about, 5.17 seconds based on below calculation:

$$T = 1.1\ R1\ C1 \qquad (1)$$

Where; $R1 = 10\text{kohm}$ $C1 = 470\text{uF}$

The time will change according to the door movement required for the door to fully close when the gear is attached. The circuit was constructed according to the schematic in Figure 12.

3.2.3 DC Motor Control Circuit

The type of DC motor used is 12V DC gearbox combination brushed nylon geared with rated load speed 60rpm and rated load torque 300mNm. The DC motor reversing circuit adapted from Andy Collinson, DC Motor Reversing Circuit [5] as shown in Figure 13, for controlling the movement of the motor. This circuit works by relay contact that will activate the motor direction. Relays control forward, stop and

reverse action, and the motor cannot be switched from forward to reverse unless the stop switch is pressed first. Table 2 shows the list of components needed in the circuit. The circuit was constructed to the Vera board. Each wiring of all components continuity were checked to ensure it was connected correctly.

Table 2 List of component for DC motor reversing circuit.

Components	**Value / Type**	**Unit**
Relay	DPDT , 12V	4
Pushbutton	Non-latching	3
Diode	1N4002	3
Capacitor	220uF	1
Powers supply	12 V.	1

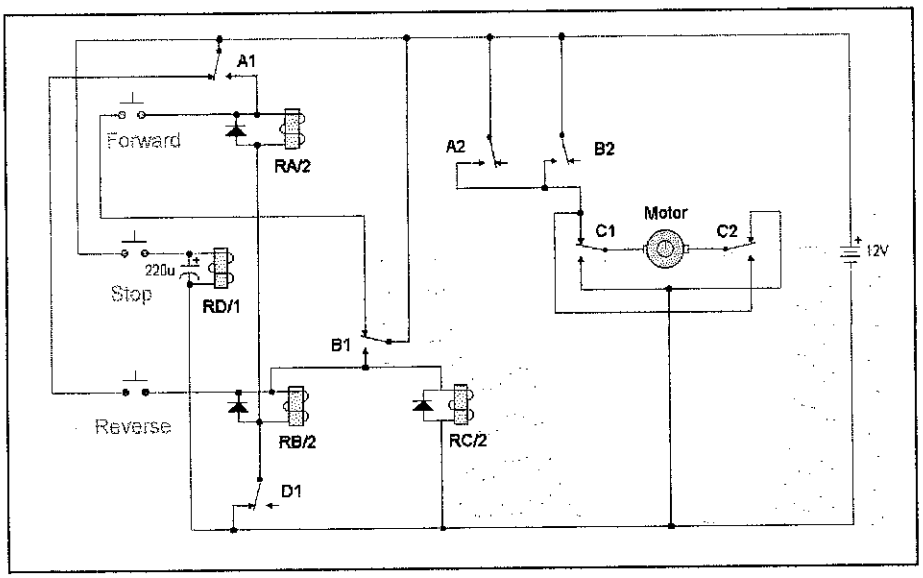


Figure 13 DC motor reversing circuit.

3.2.4 Miniature Door

The miniature door model was fabricated based on common door model design. It is 1ft 8 inch in length x 1ft 2 in inch width. Several design of door controlling unit can be used to control the close / open door operation mechanism. One of it is by using DC motor, gear and door linkage. The mechanism operation design was done by using the AutoCAD. There are two designs for the door control

system which are, screw system; Figure 19 in Appendix G and rack and pinion system; Figure14.

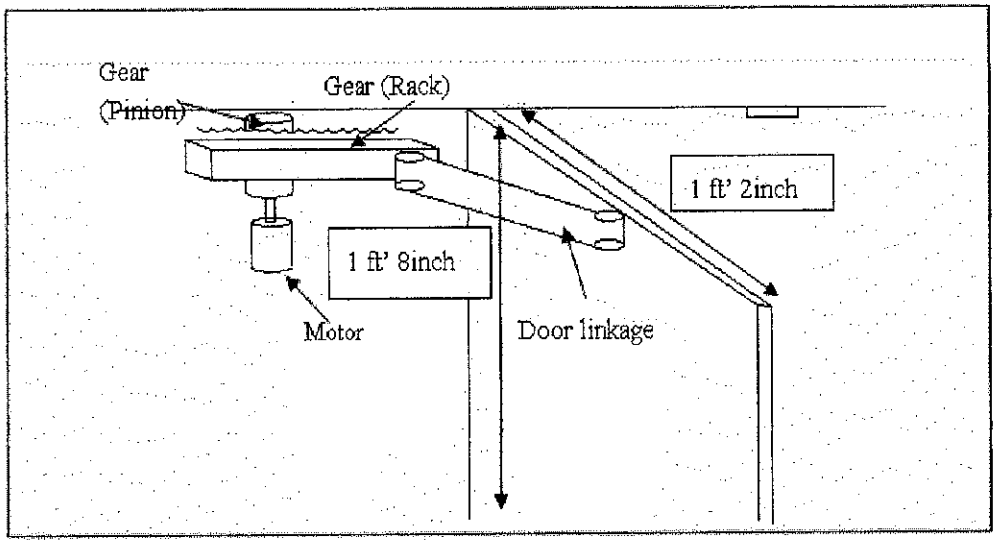


Figure 14 Rack and pinion System.

From the comparison made, the rack and pinion system, was chosen since it is more reliable and easy to fabricate and to install than the screw system. Rack and pinion system is gear system for linear motion. The gear was fabricated using the Wire Cut Machine that being programmed to cut the gear by following the specification of the gear. The specification [13] is;

For Pinion Gear:

Module [M] = pitch diameter / no. of teeth (2)

= 24mm/12

= 2

No. of teeth [N] = 12 (3)

Pressure angle = 20° (4)

For Rack Gear:

Module [M] = length of the rack/ no. of teeth (5)

= 126mm/63

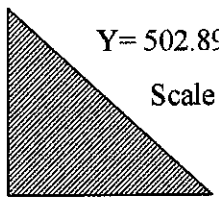
= 2

No. of teeth [N] = 63

Pressure angle = 20°

The specification is found by assuming first the pitch diameter is 24mm, and number of teeth 12, which gives the module equal to 2.The pressure angle, is chosen to be 20 ° since most gear are standardized to be at 20 ° and 25 °. The rack gear specification must be the same in module and pressure angle. The length of the rack is determined by calculating the distances needed to move the door for fully open and closes. By using the Theorem Pythagoras, the distance should be about 502.8943mm. To minimize the length so that the rack will not be too long the distance is scaled to 1:4. Hence, the length of the rack is 126mm.

$$Y = \sqrt{X_1^2 + X_2^2} \quad (6)$$



Y= 502.8943mm

Scale 1:4 = 126mm: 503mm

X1= 355.60mm

X2= 355.60mm

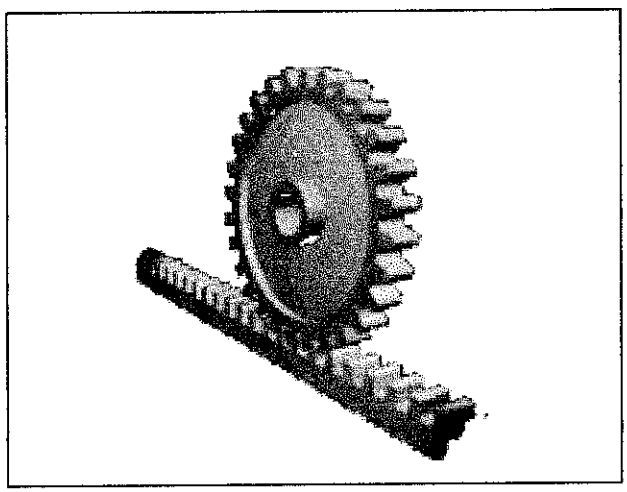


Figure 15 Rack and Pinion Gear.

For the miniature door automated locking system, electric strike cylindrical lock is used. Electric Strike is mounted into the door frame. It will capture the latch portion of the cylindrical lock mounted to the door. When power is applied (speech recognition recognized the command word), the throat of the strike opens releasing the latch of the lock. For the cylindrical and electric strike installation, the manual in Appendix H is being referred. The system used *Fail Secure* mode means, when

power fails (is off), the door is locked. The electric strike consists of solenoid, the "motor" that drives an electric strike. When activated, the solenoid moves the keeper. Keeper is the ''jaw''; this moving part of the strike opens or closes when the strike is activated. When open, the lock latch is allowed to pass from the electric strike, allowing the door to be opened.

CHAPTER 4

RESULTS AND DISCUSSION

This system consisted of 3 main parts: 1) Voice/speech recognition, 2) Door control operation and 3) Object/motion detection circuit.

4.1 Voice/speech Recognition

The HM2007 can be run in either manual mode or Central Processing Unit (CPU) mode. For manual mode, a keypad is used to control the operation of voice recognition board. For instance, to record a command to be recognized in a specific memory slot, the user will press a 2-digit number, which is the command identifier, on the keypad and then press the 'train' button. To clear a command, the user will press the command identifier and then press the 'clear' button. In this case, the K-bus and S-bus of the voice chip were used as inputs to accept the input from the keypad and the D-bus are used as outputs to the microprocessor. The D-bus output, 'Word AB', is the binary form of the memory identifier. The first four bits represent the first digit, while the last four represent the last digit. An illustration of the D-bus output is shown in Table 3 [10].

Table 3 Content of D-bus Output.

D7	D6	D5	D4	D3	D2	D1	D0	Description
0	0	0	0	0	0	0	0	Power On
A				B				Word AB
0	1	0	1	0	1	0	1	Voice Too Long
0	1	1	0	0	1	1	0	Voice Too Short
0	1	1	1	0	1	1	1	No Match

In recognition mode, the chip compares the user input analog signal from the microphone with those stored in the SRAM. If it recognizes a command, an output of the command identifier will be sent to the microprocessor through the D0 to D7 ports of the chip. Whenever recording and recognition process is successful, the ready pin on the chip will be set to low and then back to high. An LED is placed in the ready pin to notify the user of a successful operation.

In this system, when the main circuit is switch ON the SR-07 circuit is constantly listening for commands using the microphone that is attached to the PCB mount microphone jack on the circuit board. Once a programmed command / password is recognized by the circuit the HM2007 sends the serial signal to the interface circuit to activate the DC motor control circuit to move forward. Refer to Appendix I for interface circuit prototype.

In testing the SR-07 kit, accuracy and consistency are huge concern because of the way the HM2007 functions. In order for a voice to be recognized, it almost has to be said in the exact tone, pronunciation and at the same distance away from the microphone as the original recording. When the chip was tested, this proved to be a very complicated task and accuracy and consistency were major problems. To overcome this problem, the trained voice was recorded to achieve the accuracy of detection. The result is better than using unrecorded voice. Table 4 show the possible combination of the serial signal get with different signal of voice trained.

Table 4 Results Combinations of the Serial Signal (With different signal voice trained).

Command /Description	Serial Bits								Display
	D7	D6	D5	D4	D3	D2	D1	D0	
Power ON	0	0	0	0	0	0	0	0	00
Open (Test 1)	0	0	0	0	0	0	0	1	01
Open (Test 2)	0	0	0	0	0	1	0	0	04
Open (Test 3)	0	0	0	0	0	1	1	0	06
Word too long	0	1	0	1	0	1	0	1	55
Word too short	0	1	1	0	0	1	1	0	66
Not match	0	1	1	1	0	1	1	1	77

4.2 Object/Motion Detection

4.2.1 Touch switch sensor.

When the power is supplied, current flows through R1 and charges C1 until the voltage across C1 equals one third of the supply voltage, which is 4V. Pins 1 and 7 are shorted together by an internal resistor in the 555 so current flows through R1 to ground. Nothing happens until the IC is triggered. This is done by putting a low voltage input on pin 2, the trigger input. When this happens an internal resistor turns off and the current flow from pin 7 to pin 1 is stopped. This causes C1 to charge. At the same time the voltage at the output of pin 3 which had been at zero rises quickly to 9V. This is the beginning of the output pulse.

Charging of C2 continues until it reaches two-thirds of the supply voltage, 8V. As soon as it reaches 8V two things happen: The output voltage on pin 3 drops almost instantly to zero ending the pulse. Secondly, the internal transistor turns back on and the path between pins 1 and 7 opens up again. C1 is rapidly discharged back to one third of the supply voltage. Then the internal transistor turns off and the timer is ready to be triggered again. The trigger input, pin 2, is normally held at the positive voltage input by the internal circuit in the 555. It is connected to the input of a very sensitive comparator which triggers the timer when its voltage is brought below one-third of the supply voltage.

The touch plate material is copper plated board. Once the copper plate is touched, it will induced the mains-supply frequency which alternate the 50 Hz or 60 Hz. Touching the plate with a finger is enough to cause the timer to be triggered. Now when this happens and pin 3 goes high, the transistor Q1 is turned on. Current flows through Q1 and causes current to flow through the relay and produce output 12V which will activate the motor to move reverse which perform the closing operation of the door. The motor will stop according to the time set for the touch sensor to activate, which is 5.17 seconds, when the door is in fully close position. Pin 2 is very sensitive, so to reduce its sensitivity to electromagnetic interference C2 has been connected between it and the positive rail [12]. Refer Appendix J for touch switch operation for sensing condition.

4.3 Door Control Operation

4.3.1 DC Motor Control Circuit

As the power supply is ON and command word detected, the output from the interface circuit, from the NO contact of the relay will give 12V to the forward switch, which energize relay A/2 and then will activate the forward operation of the circuit as Relay C/2 is NC contact. The output from the NC contact of the relay of the timer circuit is connected parallel to the stop switch. Once the timer is off after 5.17 seconds, the motor will stop as Relay D/1 energized, and the door is fully open. When the person touches the touch plate, the touch sensor circuit operates and gave 12 V output, voltage that will energize Relay B/2 and Relay C/2. The reverse part of the motor control circuit operates. After 5.17 second, the door is fully close; NC contact of the relay connected to the output timer will activate and energized Relay D. As Relay D energizes, its contact D1 breaks power to relay B/2, which in turn breaks power to relay C/2 via the NO contact of B1 and of course the motor will stop. The capacitor across relay D is there to make sure that relay D will operate at least longer than the time relays A, B and C take to release. Refer Appendix K for DC motor control circuit board

The motor control circuit functions as required after several reconstructions and troubleshooting. A modification of the circuit was made, by connected the NC C1 and NC C2 of the relay to ground. The circuit functions well according to its operation.

4.3.2 Miniature Door

The operation started when code words recognize by the speech recognition, it will produce electric strike to the striker that locked the door. The throat of the strike opens releasing the latch of the lock. At the same time, the Relay A/2 NO contact will close and the motor forward part will activate which move the motor forward. The motor is attached with gear and door linkage. The gears attached to the motor will move, which made another gear that is attached to the door linkage move. When the motor moves forward, the gears attached to the motor will move reverse. Thus, the

door will open. The timer switch will cut off, Relay D/1 NC activates and motor will stop moving once the door reaches it fully open position.

Once a person step on the touch plate, the Relay B/2 will NO then will activate the motor reverse part. Once the motor reverses, the gear will move forward which then will close the door until it reached its fully close position. Then the timer switch will cut off, Relay D/1 NC activates and the motor will stop. The door automatically closes as the throat of the strike closes. Refer to Figure 14 for the system design. The door moves in one direction only, which means if the person is outside (coming in) the room, the door swings outwards when opened, and if the person is inside the room (coming out) the door swings towards when opened. Appendix L shows the miniature door model.

4.4 Overall System Design.

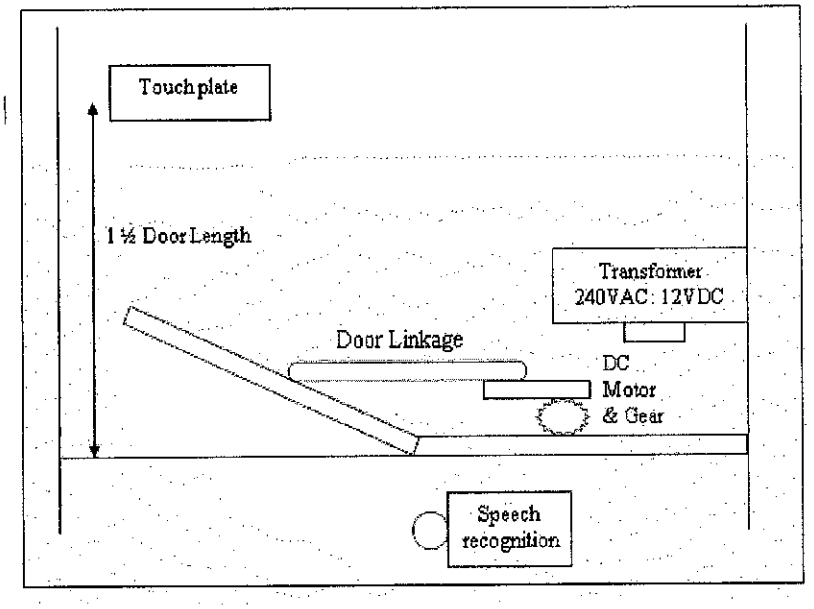


Figure 16 Overall system design (Actual)

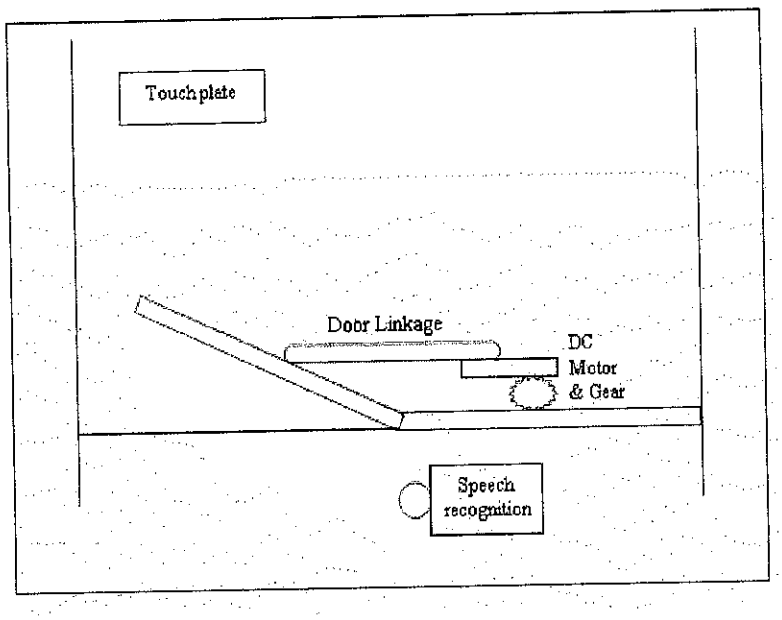


Figure 17 Overall system design (Prototype)

Basically, the overall design system is the same both prototype and actual design. For actual design, transformer is needed when using power supply from main source. The transformer will step down the voltage supply from 240VAC to 12 VDC using rectifier circuit to supply source to the control circuit that needs 12VDC and 5 VDC by using regulator to vary the voltage input for each circuit. Refer to Appendix M for the overall circuitry of the system design.

For safety, the door system designed uses the fail-secure operation mode of the electric door strike. In the fail secure mode, a loss of power leaves the door strike in the locked condition. This mode can avoid the door from being opened by unauthorized person. This automatic door also can be opened and closed manually by key only if there is no electricity or if the system breakdown. The manual operation is the same as non-automated door operation, since the system use common cylindrical locked that is commonly used for housing or room door. Refer to Appendix N for the overall system model.

The resulting voice activated door system designed consisted of three mains parts:

1) Voice/speech recognition – recognize input sound.

2) Door control operation - consists of electrical and mechanical parts for locking and open/close operation.

3) Object detection (Touch switch) – to detect object enters the room, in order to automatically close the door. Refer to the Appendix O for the block diagram of the voice activated door system design.

4.5 Tools

The tools used in this project are microphone to give signal input to the speech recognition system, control circuit for the door (open/close operation), as well a as software for circuit simulation process. The hardware tools, are gear set (Rack and Pinion), 12 VDC motor, door linkage, and touch plate as the touch sensor.

4.6 Cost

The cost for the whole system of the voice activated door is estimated to be around RM 835. This includes the speech recognition kit, the door model, the door control operation, and the touch switch circuit for the object or motion detector.

Table 5 List of parts and equipment/circuitry

Parts	Circuitry / Equipment	Quantity	Cost (RM)
Door control Circuit	Speech recognition kits.	1	582
	Motor Control circuit.	1	60
	Timer	2	
	Touch switch	1	
	Touch plate	1	
	Interface circuit	1	
Door Control Operation	DC Motor	1	50
	Gear	1 set	20
	Door Linkage	1	-
	Electric Strike	1	58
	Cylindrical Locks	1	15
Door Model		1	50
TOTAL			**835**

CHAPTER 5
CONCLUSION AND RECOMENDATIONS

The voice activated door system designed is controlled by speech recognition kit that consist of HM2007 chip that had been programmed with the trained command word ("Open") to open the door. The door operation is controlled by the DC motor control circuit connected with timer to ensure the door is operating at its fully open and close condition. Touch plate is the device that activates the door operation automatically closes once the person enters and steps on the touch plate. Electric strike and cylindrical lock attached to the door are performed by automatic door lock system when power is supplied. If power failure occurs, the door can be opened and close manually by key.

The voice activated door system produced is low in cost, simple and importantly capable in helping the disable people. It also enhances the security system of a house, or office. As for industrial, security of warehouse also can be protected using this system.

Recommendations, for the purpose of safety, the designed door should not be opened manually while there is electricity. In other words, the door cannot be opened manually unless there is an electricity problem or system breakdowns. A door alarm can be attached with the magnetic switch in order to detect the door when it is opened manually. The system designed also, can be opened manually by authorized person, if in case of chip is not functioning. As recommendation, each user must have a spare key to help them open the door if facing this situation. Another recommendation, the motor torque should suit the door torque and weight so that it is sufficient enough to drive the door (pull/push) open/close.

REFERENCES

1. Lisa Torvik, University of Wyoming, NSF 1993 Engineering Senior Design Projects to Aid the Disabled, *Voice Activated Door Opener*, http://nsf-pad.bme.uconn.edu/1993/chapter_19.pdf#search=%22chapter%2019%20voice%20activated%20door%20opener%22 , (10/08/2006)

2. Ethan Phelps, William R. Pruehsner, John D. Enderie, (University Of Connecticut), *Soni-Key Voice Controlled Door Lock*, http://ieeexplore.ieee.org/iel5/6792/18228/00842431.pdf#search=%22NSF%20%2B%20%22Automatic%20door%20opener%22%22 (9/09/2006)

3. TROPER ELECTRONIC SDN BHD., *Speech Recognition Kits*, http://www.troper.com/speech_recognition_kits (12/08/2006)

4. Sensory,Inc. , *Sensory Release Hands-Free Voice Direct™ 364 Speech Recognition Kit*, http://www.sensoryinc.com/html/company/pr00_7.html (3/09/2006)

5. AndyCollinson, *DC Motor Reversing Circuit* http://www.mitedu.freeserve.co.uk/Circuits/Switching/reverse.htm (10/09/2006)

6. *Magnetic Lock*, http://en.wikipedia.org/wiki/Magnetic_lock (16/10/2006)

7. *Electric Strike*, http://en.wikipedia.org/wiki/Electric_strike (16/10/2006)

8. Dave Chu, Concordia University, *Autonomous SUMO robot projects*, "Obstacle Detection Sensors" http://users.encs.concordia.ca/~dave/project/elec.html#%20%20%20Obstacle%%2020detection%%2020sensor (17/8/2006)

9. Aaron Cake, *Touch switch*, http://www.aaroncake.net/circuits/touch.htm (15/09/2006)

10. *HM2007*, Data Sheet.

11. *Speech Recognition Kit SR-07*, Manual. (1/12/ 2006)

12. *Kit 137, Touch Switch*, http://www.paia.com/KRUKits/K137/k137.pdf (9/2/2007)

13. David H. Myszka (2005). *Machines & Mechanisms: Applied Kinematic Analysis (3rd edition)*. Pearson Prentice Hall (2/2/2007)

14. *Access Control Application,*
http://www.usbuildersupply.com/AccessControl/access_control.htm
(12/3/2007)

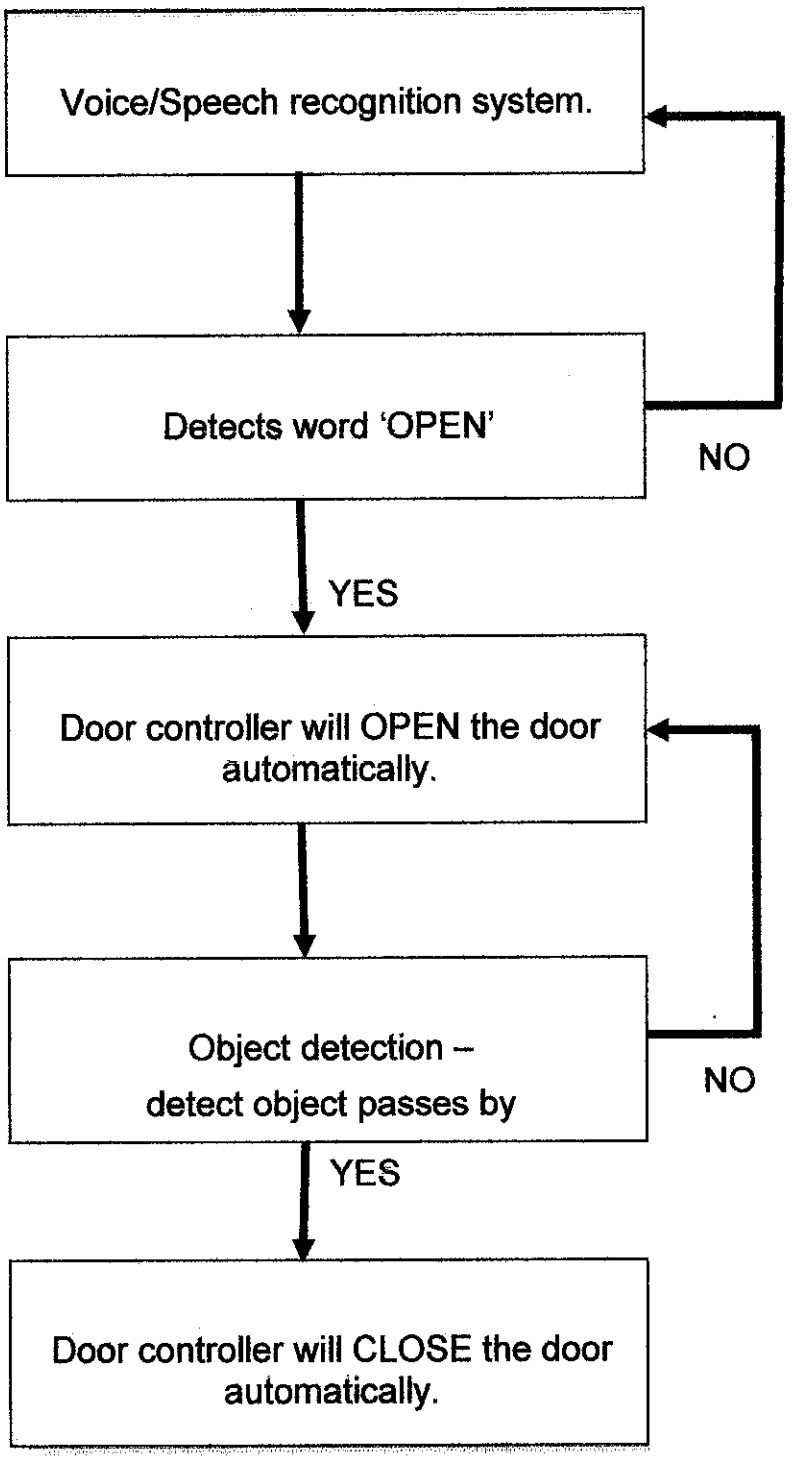
15. *Electric Strikes Installation Instruction manual,* GK-300 Series ANSI Sized Electric Strikes.
(14/3/2007)

16. *Instructions for installation of locksets,* Cylindrical Lock Manual
(14/3/2007)

APPENDICES

APPENDIX A

FLOWCHART OF VOICE ACTIVATED DOOR SYSTEM



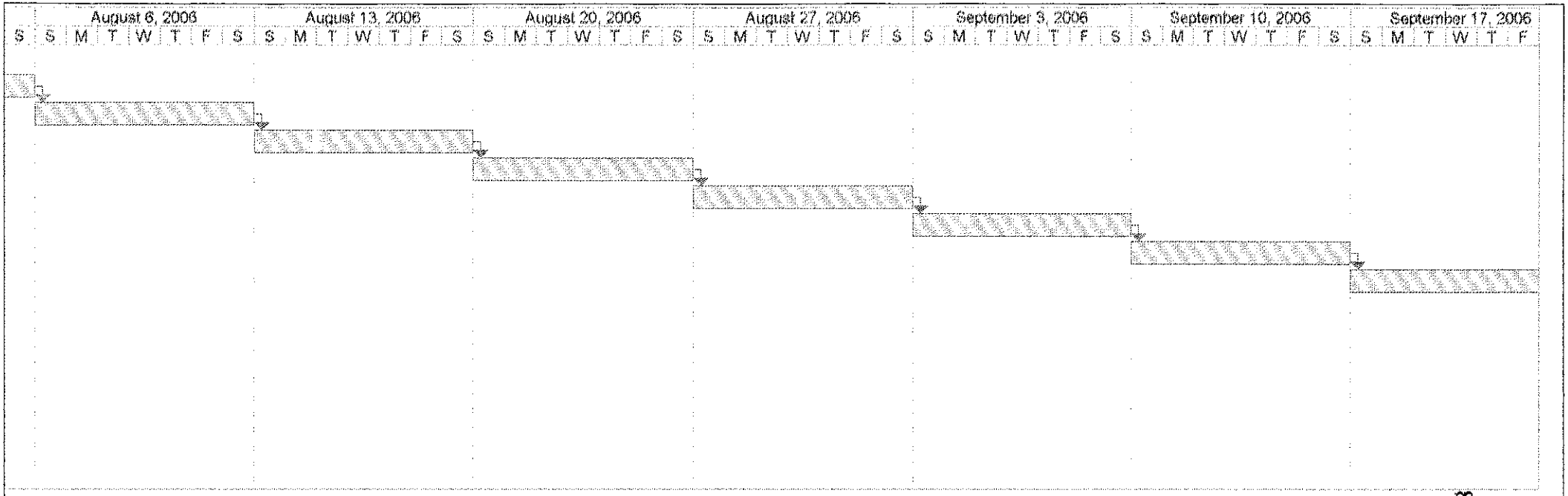
APPENDIX B

PROJECT GANTT CHART-SEMESTER 1

ID	Task Name	Duration	Start	Finish
1	FYP title selction / allocation process	5 days	Mon 7/24/06	Fri 7/28/06
2	Research on the internet on project title	7 days	Sun 7/30/06	Sat 8/5/06
3	Research on the internet on project title & Log Book	7 days	Sun 8/6/06	Sat 8/12/06
4	Prepare and Submit Log Book (8/14) & Prelinminary report (8/18)	7 days	Sun 8/13/06	Sat 8/19/06
5	Research on the internet for system design & Prepare and submit Log Book (8/21)	7 days	Sun 8/20/06	Sat 8/26/06
6	Design system & Prepare and submit Log Book (8/28)	7 days	Sun 8/27/06	Sat 9/2/06
7	Design system & Prepare and submit Log Book (9/4)	7 days	Sun 9/3/06	Sat 9/9/06
8	Research system design & choose which system is better (Semester Break)	7 days	Sun 9/10/06	Sat 9/16/06
9	Research on the internet & Prepare and submit Log Book (9/18) and Progress report (9/22)	7 days	Sun 9/17/06	Sat 9/23/06
10	Circuit design simulation & Prepare and submit Log Book (9/25)	7 days	Sun 9/24/06	Sat 9/30/06
11	Circuit design simulation & Prepare and submit Log Book (10/2)	7 days	Sun 10/1/06	Sat 10/7/06
12	Circuit design simulation; Prepare and submit Log Book (10/9); Prepared Draft Report	7 days	Sun 10/8/06	Sat 10/14/06
13	Submit Draft report (10/16) ; Prepared interim report	7 days	Sun 10/15/06	Sat 10/21/06
14	Prepared interim report	7 days	Sun 10/22/06	Sat 10/28/06
15	Submitt Interim Report (10/30) & Prepared Oral Presentations	7 days	Sun 10/29/06	Sat 11/4/06
16	Oral Presentations	5 days	Mon 11/6/06	Fri 11/10/06

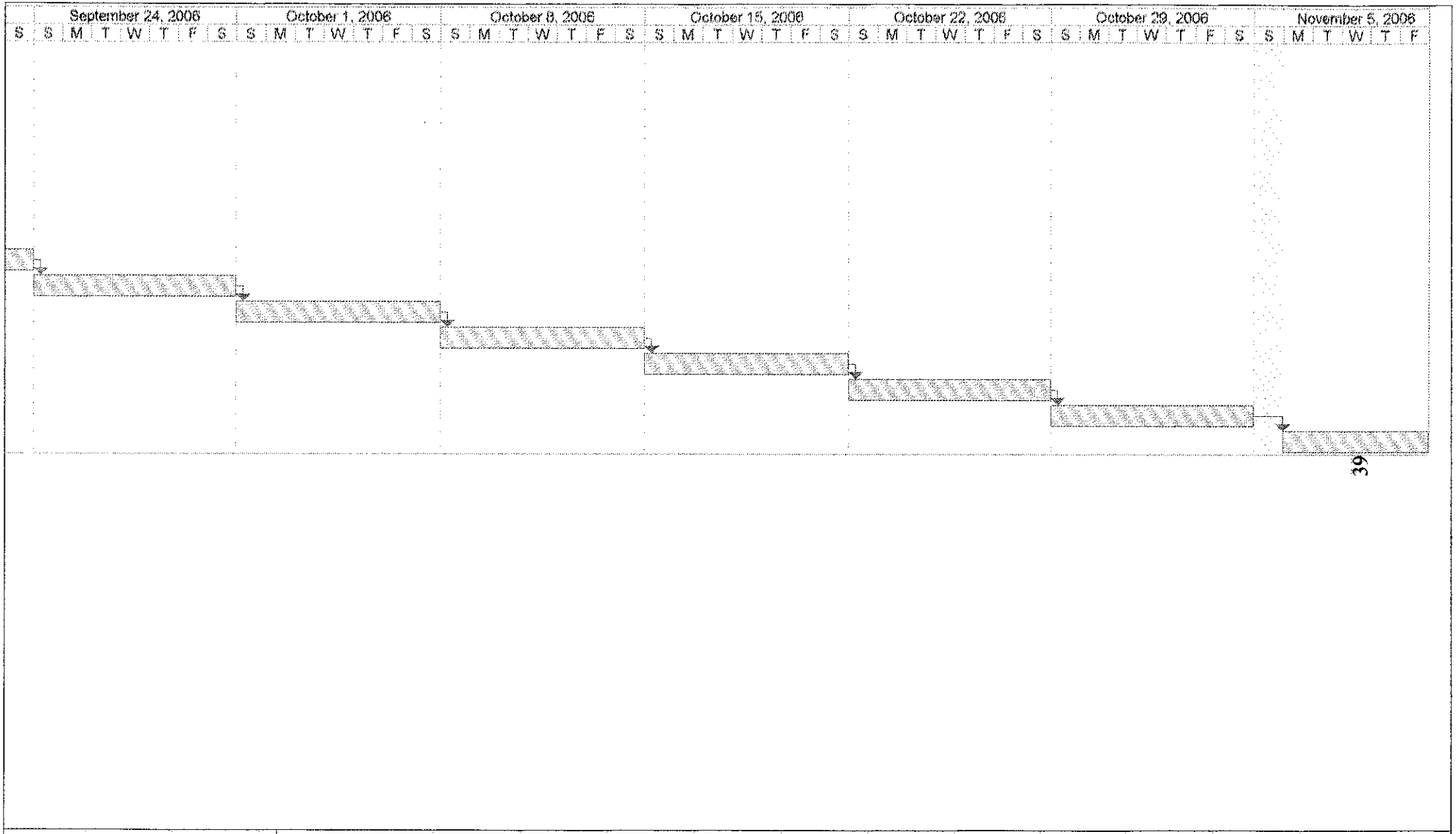
Project: gantt_chart_fyp1
Date: Sat 6/16/07

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline



Project: gantt_chart_fyp1
Date: Sat 6/16/07

Task		Milestone		External Tasks	
Split		Summary		External Milestone	
Progress		Project Summary		Deadline	



Project: gantt_chart_fyp1
Date: Sat 6/16/07

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

APPENDIX C

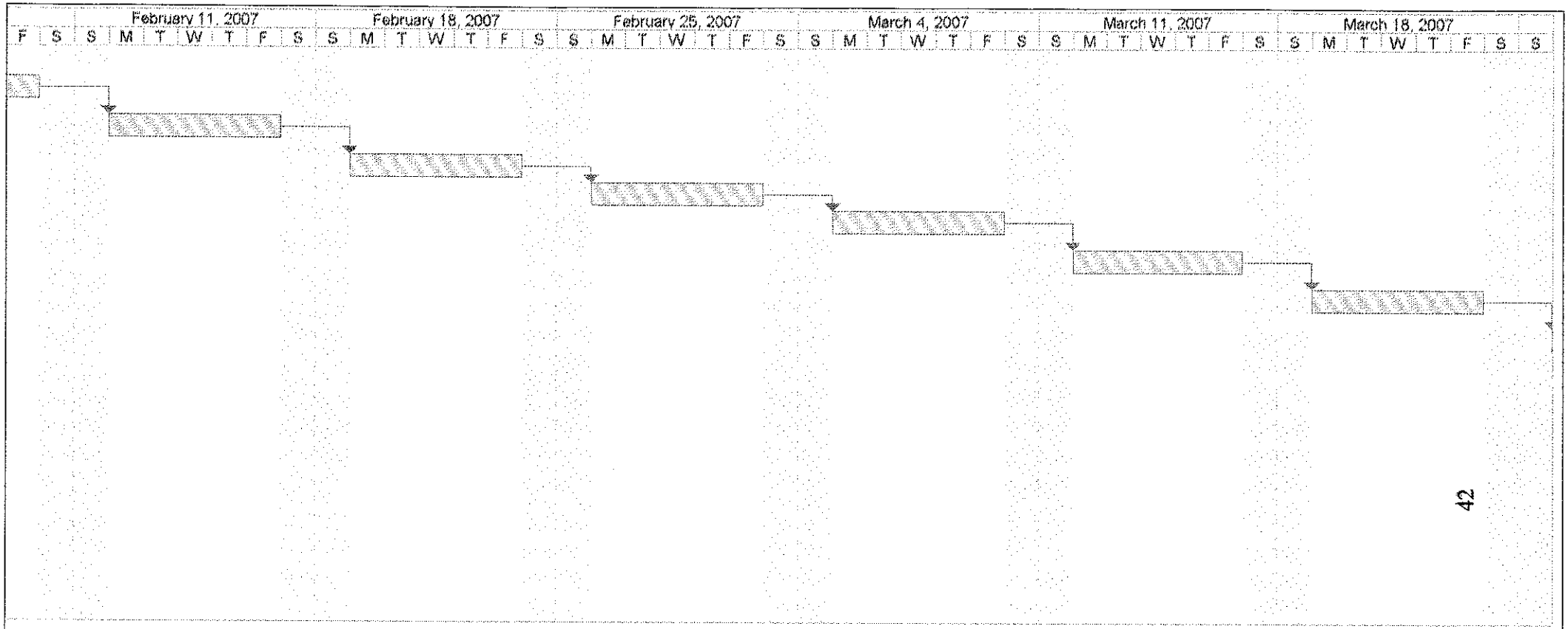
PROJECT GANTT CHART-SEMESTER 2

ID	Task Name	Duration	Start	Finish
1	Constructing touch switch circuit	5 days	Mon 1/29/07	Fri 2/2/07
2	1) Constructing touch switch circuit 2)Constructing motor control circuit 3) Build miniature door (Log book Week 2)	5 days	Mon 2/5/07	Fri 2/9/07
3	1) Constructing touch switch circuit 2)Constructing motor control circuit 3) Build miniature door (Logbook week 3 & Progress report)	5 days	Mon 2/12/07	Fri 2/16/07
4	1)Constructing motor control circuit 2) Build miniature door (Logbook week 4)	5 days	Mon 2/19/07	Fri 2/23/07
5	1)Constructing motor control circuit 2) Build miniature door (Logbook week 5)	5 days	Mon 2/26/07	Fri 3/2/07
6	1) Constructing the voice speech recognition 2) finishing the door model (attach gear and DC motor) (Log book week 6)	5 days	Mon 3/5/07	Fri 3/9/07
7	1) Constructing the voice speech recognition 2) finishing the door model (attach gear and DC motor)	5 days	Mon 3/12/07	Fri 3/16/07
8	1) Constructing the voice speech recognition 2) Connecting all 3 parts of the design. 3) Troubleshoot the system. (Log book week 7 & progress report)	5 days	Mon 3/19/07	Fri 3/23/07
9	1) Constructing the voice speech recognition 2) Connecting all 3 parts of the design. 3) Troubleshoot the system (Logbook week 8)	5 days	Mon 3/26/07	Fri 3/30/07
10	1) Troubleshoot the system (Logbook week 9)	5 days	Mon 4/2/07	Fri 4/6/07
11	1) Prepare Draft report 2) Prepare final report	5 days	Mon 4/9/07	Fri 4/13/07
12	1) Prepare Draft report 2) Prepare final report	5 days	Mon 4/16/07	Fri 4/20/07
13	1) Prepare Draft report 2) Prepare final report (draft report)	5 days	Mon 4/23/07	Fri 4/27/07
14	1) Prepare Final Report 2) Prepare technical report	5 days	Mon 4/30/07	Fri 5/4/07
15	1) Prepare Final Report 2) Prepare technical report (Final Report Soft Cover)	5 days	Mon 5/7/07	Fri 5/11/07
16	1) Preapre oral presentation 2) Final report hard cover (technical report)	15 days	Mon 5/14/07	Fri 6/1/07
17	Oral Presentation	5 days	Mon 6/4/07	Fri 6/8/07
18	Final report (Hard Cover)	10 days?	Mon 6/11/07	Fri 6/22/07

January 28, 2007 | February 4, 200
M T W T F S S M T W T

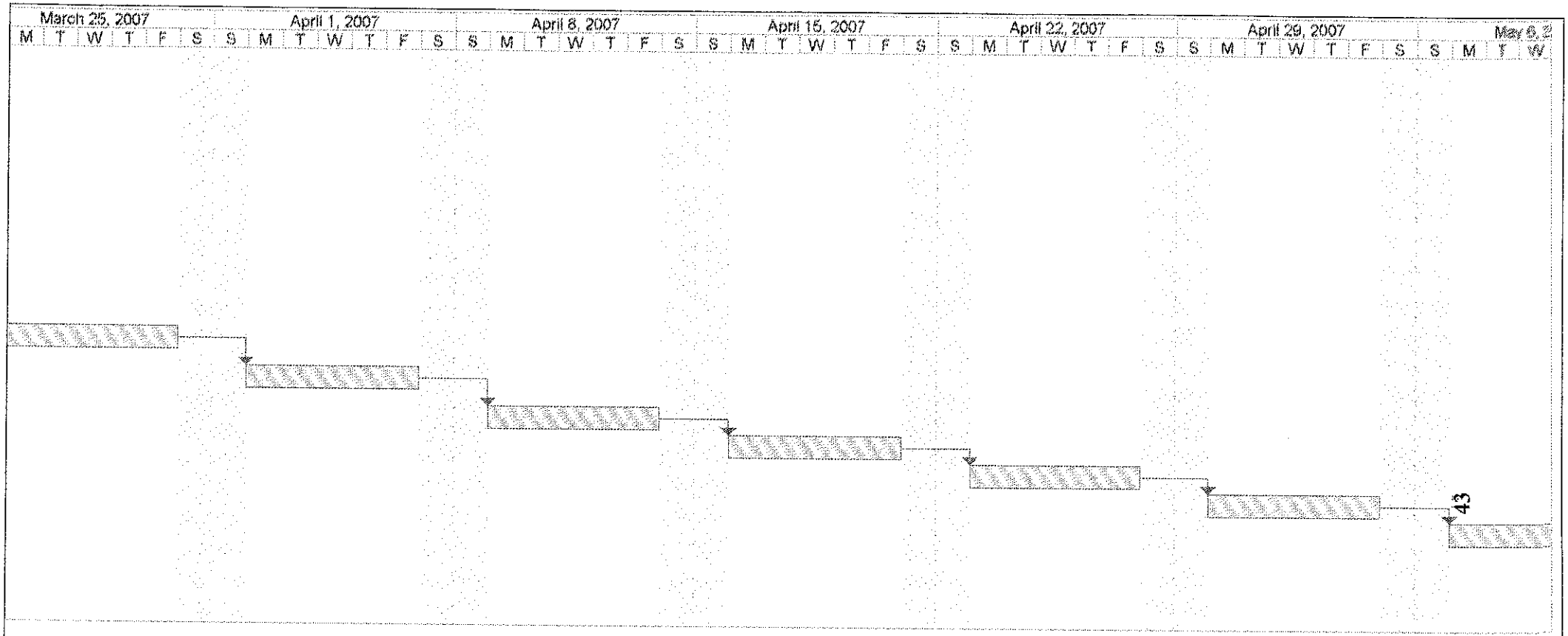
Project: gantt_chart_fyp2
Date: Sat 6/16/07

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline



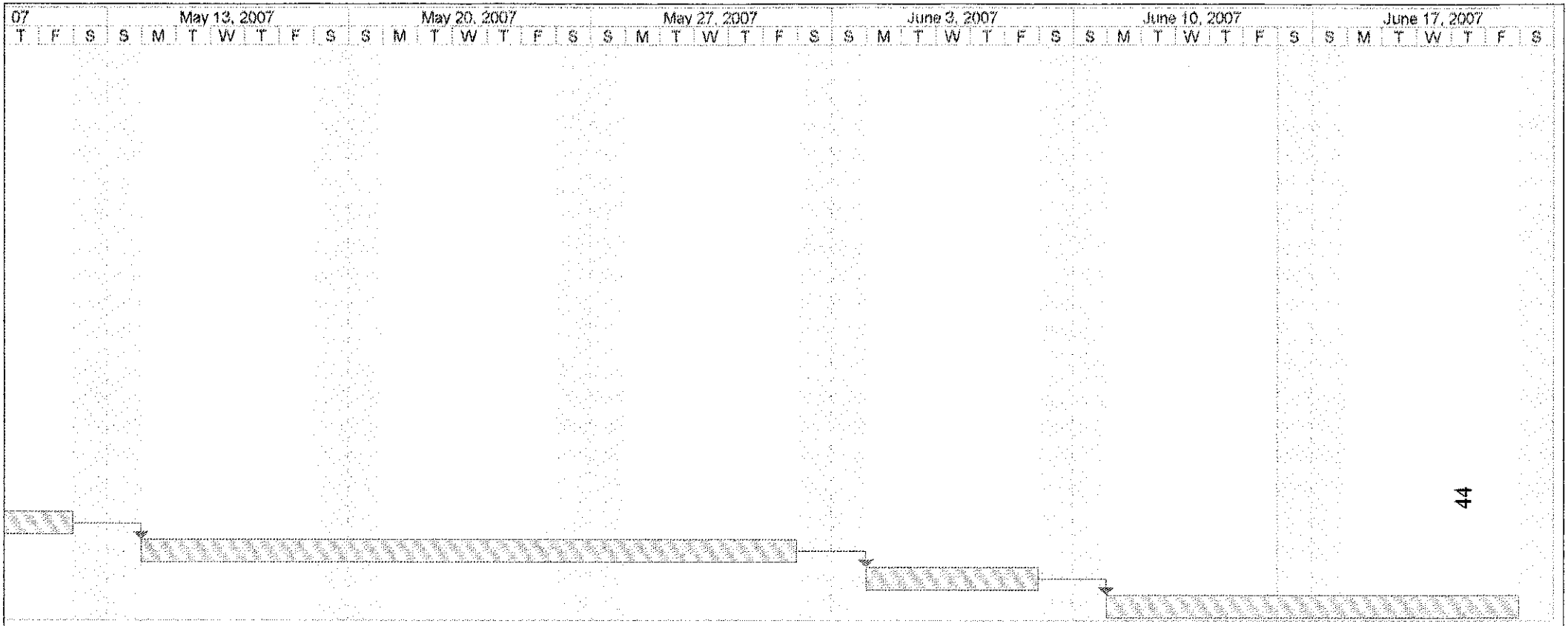
Project: gantt_chart_fyp2
Date: Sat 6/16/07

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline



Project: gantt_chart_fyp2
Date: Sat 6/16/07

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline



Project: gantt_chart_fyp2
Date: Sat 6/16/07

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

APPENDIX D

COMPARISION TABLE VOICE/SPEECH RECOGNITION

Table 6 Comparison Table Voice/Speech Recognition

	VOICE DIRECT ™ 364	SR-07 SPEECH RECOGNITION KIT
Features	• Speaker-Dependent and Continuous Listening speech recognition technologies. • Minimal external components. • Over 99% recognition accuracy with proper design • Phrase recognition up to 2.5 seconds • User-friendly speech prompting	▪ Self-contained stand alone speech recognition circuit. ▪ Modular circuit design for easy embedding of base circuit into other designs. ▪ User programmable. ▪ Multi-lingual. ▪ Non-volatile memory back up. ▪ Easily interfaced to control external circuits & appliances.
Memory	VOICE DIRECT™ 364 can recognize 15 words in stand-alone mode, but has only 8 outputs, some decoding circuitry is required if The application requires more than 8 words to be recognized.	Use HM2007 chip .This circuit allows the user to choose either the .96 second word length (40 word vocabulary) or the 1.92 second word length (20 word vocabulary). For memory the circuit uses an 8K X 8 static RAM.
Applications	Ordinary consumer electronics (i.e., set top boxes, microwaves, cars, remote controls, garage door openers, alarm clocks, telephones, lights, internet appliances and many other types of electronic products).	• Command and control of appliances and equipment • Telephone assistance systems • Data entry • Speech controlled toys • Speech and voice recognition security systems

Continue Table 6 Comparison Table Voice/Speech Recognition

Recognition style	Continues listening speech technologies.	Recognition style: can recognize three styles of speech: ▪ Isolated ▪ Connected ▪ Continuous
Recognition memory erase	Individual words or sets cannot be erased or overwritten. But the entire set o words can deleted.	Individual word or set can be erased one by one and also entire set or all the memory.
Speech recognition specification	Employs speaker-dependent (user trained) speech recognition technology	Speaker dependent • 95% accuracy for word recognition. • The system only responds accurately only to the individual who trained the system. Speaker independent • System trained to respond to a word regardless of who speaks. • High accuracy can still be maintained within processing limits.
Sizing	3" x 3 "	3" x 6"
Life time	Not stated	Not stated
Cost	$49.95	$95.95

APPENDIX E

SPEECH RECOGNITION KITS (SR-07)

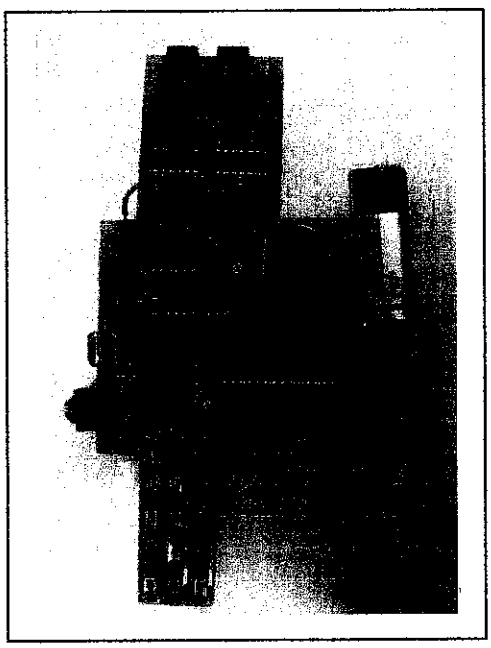


Figure 18 Speech Recognition kit (SR-07) board.

APPENDIX F

DATA SHEET HM2007

GENERAL DESCRIPTION

HM2007 is a single chip CMOS voice recognition LSI circuit with the on-chip analog front end, voice analysis, recognition process and system control functions. A 40 isolated-word voice recognition system can be composed of external microphone, keyboard, 64K SRAM and some other components. Combined with the microprocessor, an intellengent recognition system can be built.

FEATURES

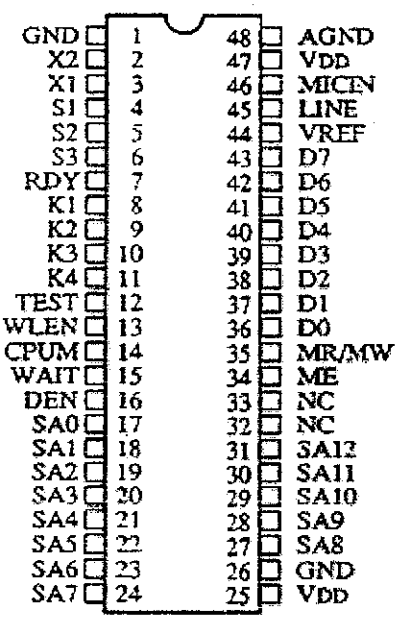
- Single chip voice recognition CMOS LSI.
- Speaker-dependent isolates-word recognition system.
- External 64K SRAM can be connected directly.
- Maximum 40 words can be recognized for one chip.
- Maximum 1.92 sec of word can be recognized.
- Multiple-chip configuration is possible.
- A microphone can be connected directly.
- Two control mode is supported: Manual mode and CPU mode.
- Response time : less than 300 ms.
- 5V single power supply.
- 48-pin PDIP, 52 pin PLCC, 48 pad bare chip.

John Rivco

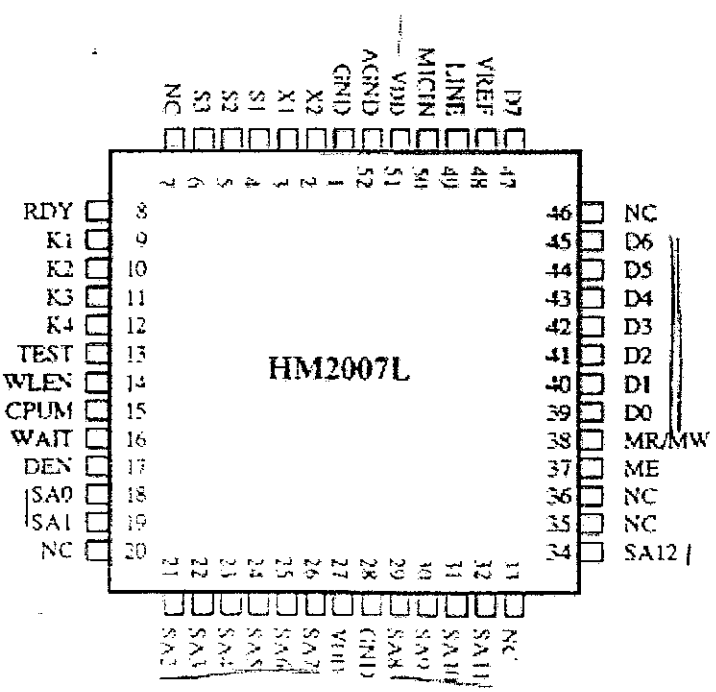
1-800-230-4535

PIN CONFIGURATIONS

HM2007P



HM2007L



PIN DESCRIPTIONS

Symbol	Pin No. PDIP 48L	Pin No. PLCC 52L	I/O	Function
Vref	44	48	I	The voltage reference input of internal ADC. Supply the reference voltage of the internal A/D converter.
LINE	45	49	O	For testing only.
MICIN	46	50	I	Microphone connect pin. A microphone should be connected via a coupling capacitor and resistor.
V_{DD}	47	51		Positive power supply.
AGND	48	52		Analog Ground.
GND	1	1		Negative power supply.
X2,X1	2,3	2,3	I	Crystal connect pin. A 3.58 MHz crystal is connected to these pin.
S1,S2	4,5	4,5	I/O	Keypad scaning pin for manual mode and the read/write
S3	6	6		control Pins in the CPU mode.
RDY	7	8	O	Voice input ready indicator. Active low output.When HM2007 is ready for the voice input in training or recognition mode,a low signal is sent.If the chip is busy, a high signal is sent.
K1,K2 K3,K4	8-11	9-12	I/O	The keypad input pin in the manual mode and the bidirectional data bus (K-bus)in the CPU mode. In the manual mode , the four pins combined with S1 to S3 form the keypad scaning circuit. Maximum12 keys can be scanned. In the CPU mode. the data bus direction is determined by the S2 and S3.A high level signal that appears in the pin S2 will place the content of internal register onto to the data bus.(K-bus). The data may be come from the status register or the output buffer which is selected by the pin S1. If S1 is high, output buffer is selected, otherwise, the status register is selected. A high level signal that appears in the pin S3 will place the content of K-bus into the input register. Note that user can not place high level signal on S2 and S3 simultaneously.
TEST	12	13	I	"H":test mode. "L":Normal mode.
WLEN	13	14	I	Word length select pin. Selecting the voice length to be recognized. When set to high, 1.92 sec is selected. Internally pull low for 0.9 sec is selected. Note that when 1.92 sec is selected,only 20 words maximum can be recognized if 8K-byte memory is used.
CPUM	14	15	I	CPU mode select pin. Internally pull low for manual mode. When set to high,CPU mode is selected.

Symbol	Pin No. PDIP 48L	Pin No. PLCC 52L	I/O	Function
WAIT	15	16	I	Waiting control input. Active low input. When this pin is set to "L" and manual mode is selected, HM2007 will enter the waiting state and do not accept voice input until this pin back to "H". For CPU mode, when HM2007 is ready to get voice input, if this pin is set to "L", HM2007 will skip the voice input process and enter the get-command process.
DEN	16	17	O	Data enable signal. When the recognition or training process is complete, the chip will place its response on the data bus D0 to D7 and which can be latched onto external devices by this pin.
SA0,SA1	17-24	18,19	O	External memory address bus.
SA2-SA7		21-26		The bus is used as an external memory address when ME pin
SA8-SA11	27-31	29-32		is active.
SA12		34		
V_{DD}	25	27		Positive power supply.
GND	26	28		Negative power supply.
NC	32,33	35,36		
		7,20		
		33,46		
ME	34	37	O	Memory enable pin. Active low output. This pin will send the memory enable signal to the external SRAM. This pin can be connected directly to the CE pin of 6264 SRAM.
MR/MW	35	38	O	Memory read/write select pin. Read/write control signal of the external SRAM. This pin can be connected directly to the R/W pin of 6264 SRAM.
D0-D6	36-42	39-45	I/O	External memory data bus(D-bus).
D7	43	47		The bus is used as an external memory I/O bus when ME pin is active and used as output response bus when DEN pin is active.

FUNCTION DESCRIPTIONS

There are two operation mode which are provided by HM2007.

A). Manual mode.

In this operation mode, a keypad, a SRAM and other components may be connected to HM2007 to build a simple recognition system (See application circuit).
The type of SRAM can be used is a 8K-byte memory.

a). Power on.

When the power is on,HM2007 will start its initialization process. If WAIT pin is "L", HM2007 will do the memory check to see whether the external 8K byte SRAM is perfect or not.
If WAIT pin is "H", HM2007 will skip the memory check process.
After the initial process is done, HM2007 will then move into recogition mode.

b). Recognition Mode.

i). WAIT pin "H"

In this mode, the RDY is set to low and HM2007 is ready to accept the voice input to be recognized.
When the voice input is detected, the RDY will return to high and HM2007 begins its recognition process.It is recommended that user train the word pattern before the beginning of the recognition operation, otherwise the result will be unpredictable.
After the recognition process is completely, the result will appear on the D-bus with the pin DEN active.
Table 1 shows the list of the output content.
The data on the data bus is a decimal code in binary format.

D7	D6	D5	D4	D3	D2	D1	D0	Description
0	0	0	0	0	0	0	0	Power on
		A				B		Word AB
0	1	0	1	0	1	0	1	Voice too long
0	1	1	0	0	1	1	0	Voice too short
0	1	1	1	0	1	1	1	Not Match

Table 1 : Content of the D-bus output.

Note 1 : A is the binary code in the range 0 to 4, and B is the binary code in the range 0 to 9.

Note 2 : If WLEN is high, the maximum word length is 1.92 sec.

ii).WAIT pin "L"

In this mode, no voice input is accepted until WAIT pin back to "H" state.

c). Training or clearing one pattern

Two operation are included during this time, 1) clearing trained pattern and 2).training new pattern.
To clear or train the voice pattern, one must select the word number to process first. The number of word is composed of two digits. The two digits are entered into HM2007 through keypad one digit a time. If more than two digits are entered, only the last two digits are valid. When number key is pressed, the number of key will be echoed to the D-bus.

When the word number is entered, press the function key to choose the operation function. If function key CLR is pressed, the corresponding word pattern will be cleared and then HM2007 will return its recognition mode. If the function key TRN is pressed, HM2007 will begin its training process. At the beginning of training process, if WAIT pin is "H", HM2007 will send a low level signal to RDY to indicate that HM2007 is ready to accept voice input. If WAIT pin is "L", no voice input will be detected until WAIT pin back to "H". After available voice input to HM2007, HM2007 will return to its recognition mode and send a low level signal to RDY to indicate that HM2007 is ready for voice input to do the recognition process.

For example,

2 4 TRN → training the 24th pattern.
0 1 CLR → clearing the first pattern.
1 3 2 6 TRN → training the 26th pattern.

d). Clear all pattern.

If the number key 99 is entered and the CLR is pressed, all the patterns in the memory will be cleared by HM2007.

B). CPU control mode.

The CPU mode provides several functions: RECOG, TRAIN, RESULT, UPLOAD, DOWNLOAD, RESET and which will be described later. In this mode, the K-bus is used as a bidirectional data bus between the external controller and HM2007 and S1 to S3 as the R/W control pins.

Table 2 is the summary of the CPU command. The command contains two parts. 1). the command code and 2). the number of the word to be processed if needed.

command	code	word #(L)	word #(H)
RECOG	0001		
TRAIN	0010	B3 B2 B1 B0	0 0 B5 B4
RESULT	0100		
UPLOAD	0101	B3 B2 B1 B0	0 0 B5 B4
DOWNLOAD	0110	B3 B2 B1 B0	0 0 B5 B4
RESET	0111		

Table 2. Command for CPU mode.

There are three registers in HM2007, one input buffer register, one status register and one output buffer register. The first is a write-only register and the last two are read-only registers. If S1 pin is high, the data read from the K-bus will come from the output buffer register. If S1 pin is low, the data read from the K-bus will come from the status register. S2 and S3 are R/W control signals. If S2 is high, it's in a read cycle and the external controller can read data form the K-bus. If S3 is high, it's in a write cycle and external controller can write data into the input buffer. Note that S2 and S3 can not be high simultaneously and the state of S1 will be ignored during a write cycle.

The status register as shown, reflect the current status of HM2007 for the CPU control mode.

~~S3~~	~~S2~~	~~S1~~	~~S0~~
X	X	ST1	ST0

Status Register

ST1	ST0	Operating state:
0	1	Ready to get voice input.
1	0	Ready to get command.
1	1	1. The first nibble of the output data is available on the output buffer during a read cycle. 2. HM2007 is ready to get first nibble of the input data during a write cycle.
0	0	1. The second nibble of the output data is available on the output buffer during a read cycle. 2. HM2007 is ready to get second nibble of the input data during a write cycle.

a). Power on

When power is on, the chip will perform its initialization process, the same as manual mode and then make the status register to be (10) to wait the external command.

b). Recognition

When HM2007 receives the command RECOG, the chip will begin its recognition process. The external device can be polling the status flag to monitor the operation state of HM2007. When the operation state is changed to (01), and WAIT pin is "L", HM2007 will back to the operation state (10) and then ready for receive another command. When the operation state is change to (01) and WAIT pin is "H", it is ready to get voice input and then do the recognition process. When the operation state is changed back to (10) again, then the recognition process is completed and HM2007 is ready to get another command. The programming flow chart is shown in Fig. 1.

c). Resulting

After recognition, the recognition result is ready in the buffer. The external device can send the RESULT command to obtain the recognition result. When the data in the buffer has been read the operation state will be turned back (10) and waiting for another command.

When the RESULT command is sent, four continuous read actions must be done by the external device to get the result sent by HM2007. The result contains two parts, each parts needs two read actions. The first part is the word number(B5-B0) and the second part is the matching score (V7-V0).

Table 3 shows the output format of the result and the programming control flow chart is shown in Fig 2.

1st read	2nd read	3rd read	4th read	Result
B3 B2 B1 B0	0 0 B5 B4	V3 V2 V1 V0	V7 V6 V5 V4	Word # and Score.

Table 3.

d). Training Pattern

When HM2007 receives the command code TRAIN, the chip needs two more words to specify the number of pattern to be trained.The first word is the low 4 bit of the word number and the second word is the high 2 bits of the word number.
If the number of the pattern is valid and WAIT pin is "H", HM2007 will begin its training process for the corresponding word. If WAIT is "L", HM2007 will skip the training process. After the training process, the operation state will change back to (10) and wait for next command. Fig 3 shows the control flow of the training process.

e). Upload pattern

When HM2007 receives the command code UPLOAD,the chip needs two more words to specify the number of pattern to be uploaded.The first word is the low 4 bits of the word number and the second word is the high 2 bits of the word number.
In the uploading process,HM2007 will send the pattern length first in two words(low 4 bits first, then high 4 bits), and then the data of the pattern frame by frame and each frame is consisted of eight words (4 bits). Fig 4 shows the control flow chart of the uploading process.Note that when the external device get the data which is sent by HM2007, it's user's responsibility to designate a memory space to save them, otherwise, the data will be lost and no use of this command.

f). Download pattern

The download pattern process is same as the upload pattern process except that the direction of the data flow is reversed. After receiving the DOWNLOAD command and the word number, HM2007 begin to read data from external device. The first two words of the data will be treated as the pattern length and the following data will be stored as pattern frame by frame. Fig 5 shows the control flow of the downloading process.

g). Reset

When Reset command is received by HM2007, the chip will clear all the patterns in the memory. Fig 6 shows the control flow of reset process.

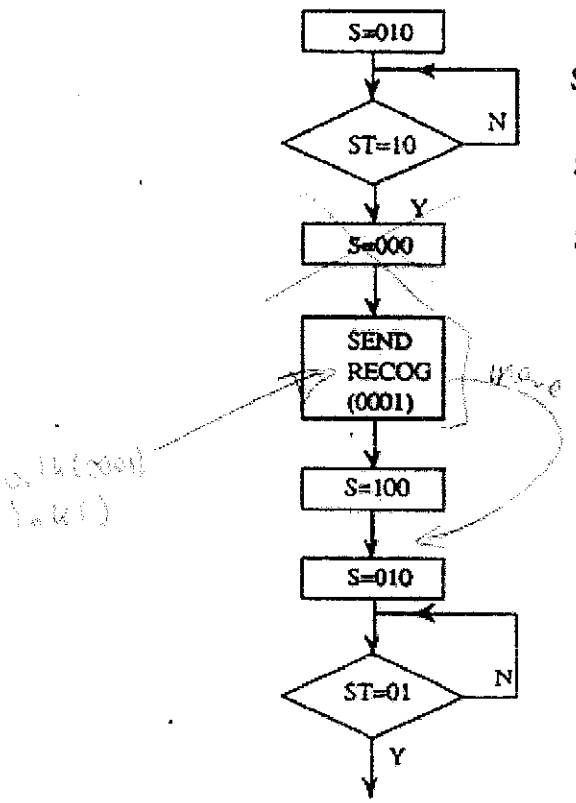
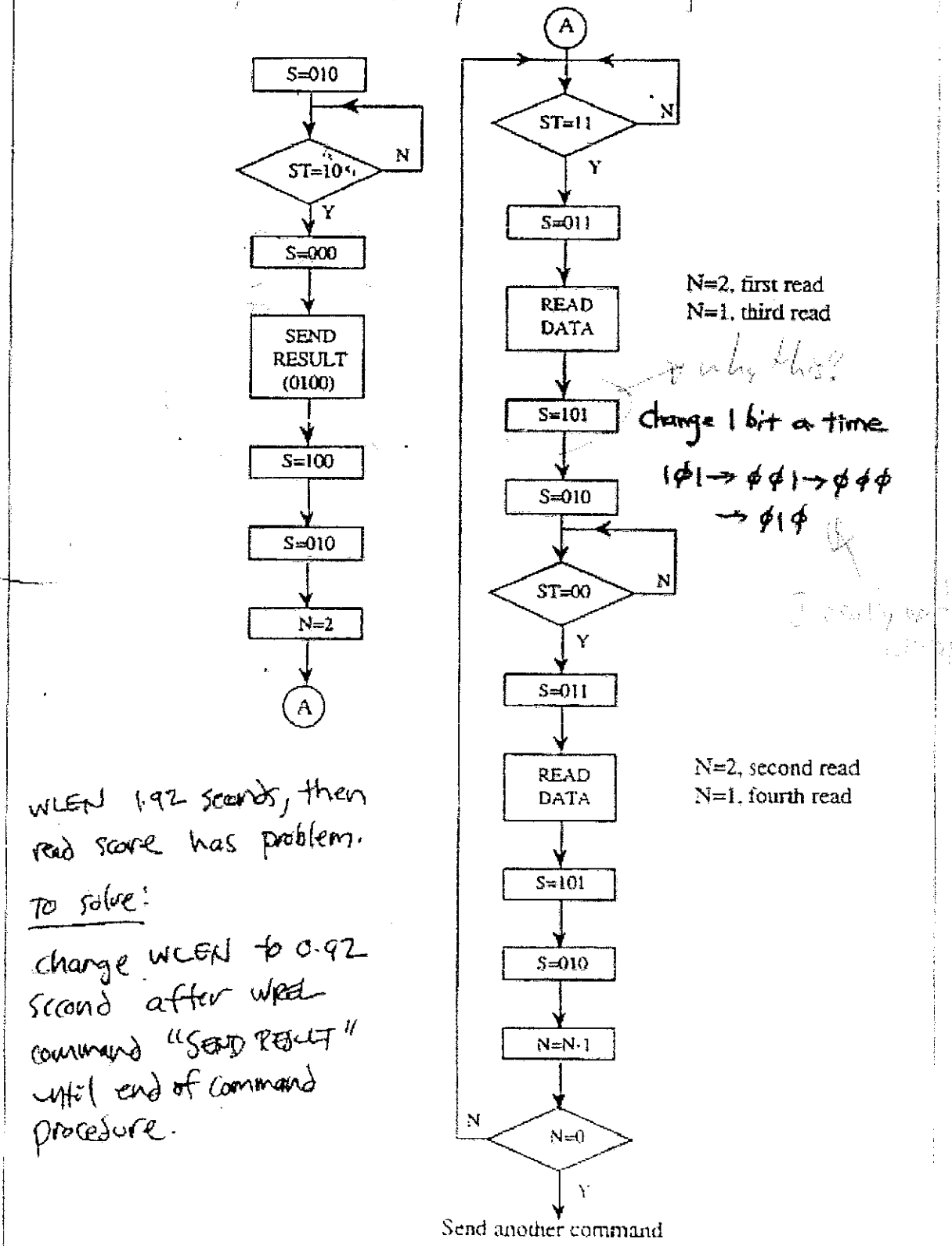


Fig 1. Control flow of the CPU mode for recognition.



WLEN 1.92 seconds, then read score has problem.

To solve:

change WLEN to 0.92 second after WRD command "SEND RESULT" until end of command procedure.

Fig 2. Control flow of the CPU mode for resulting

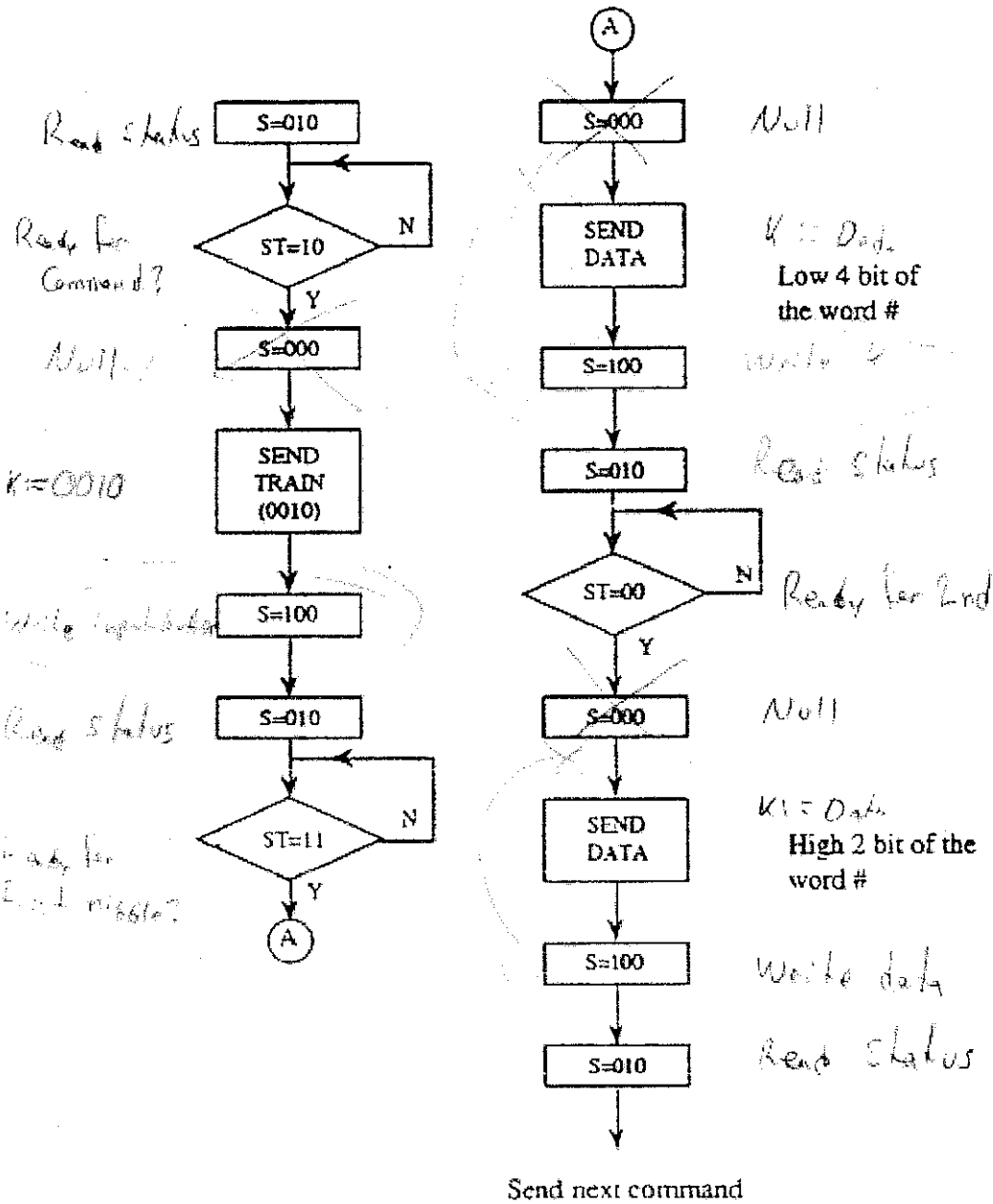


Fig 3. Control flow of the CPU mode for training.

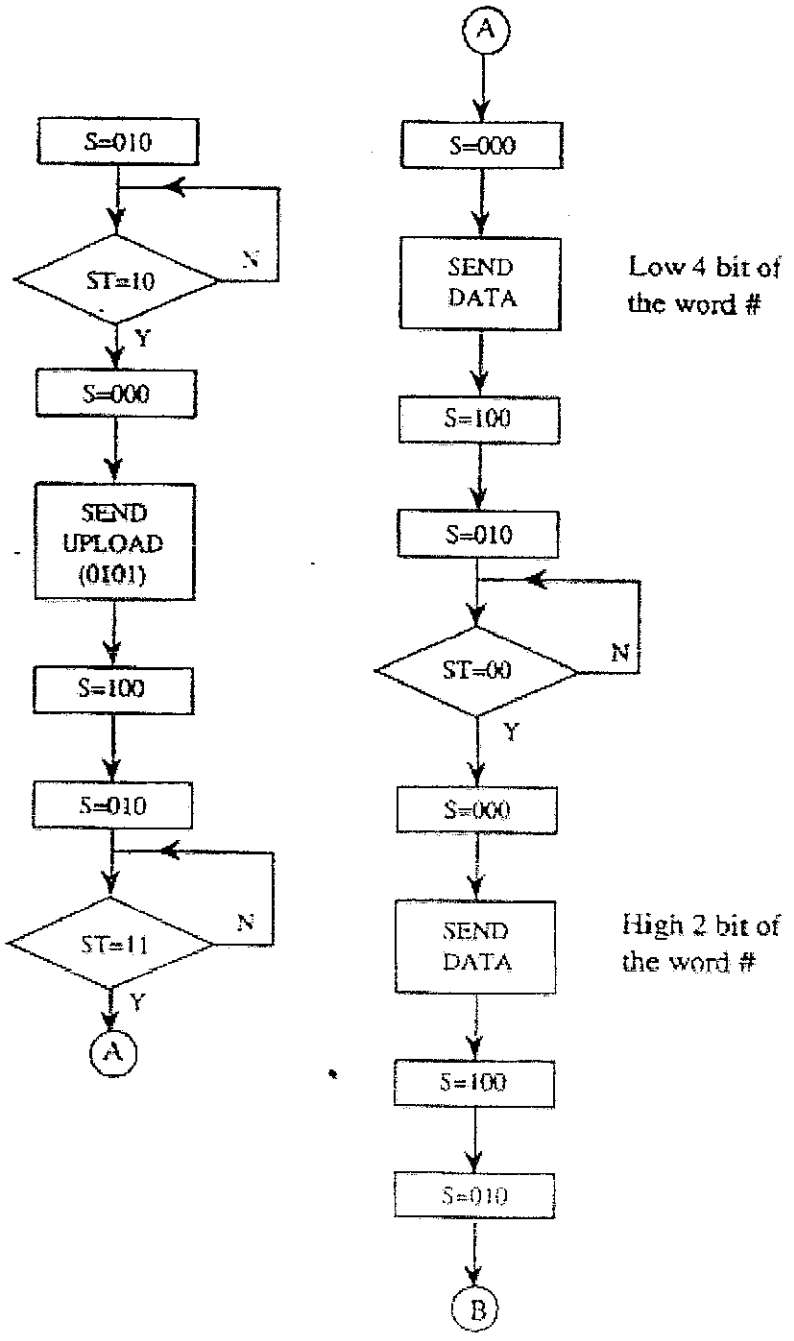


Fig 4 Control flow of the CPU mode for uploading.

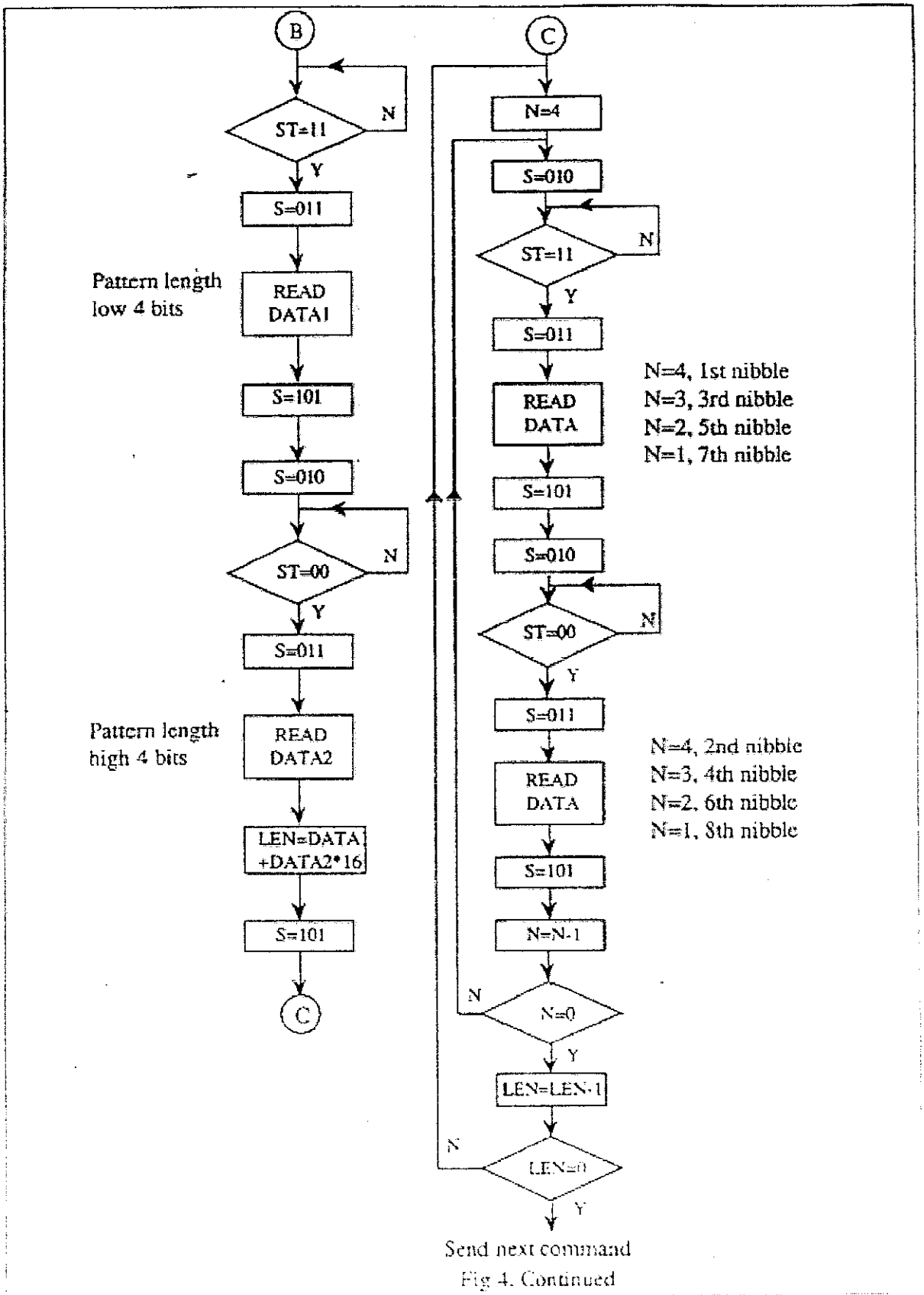


Fig 4. Continued

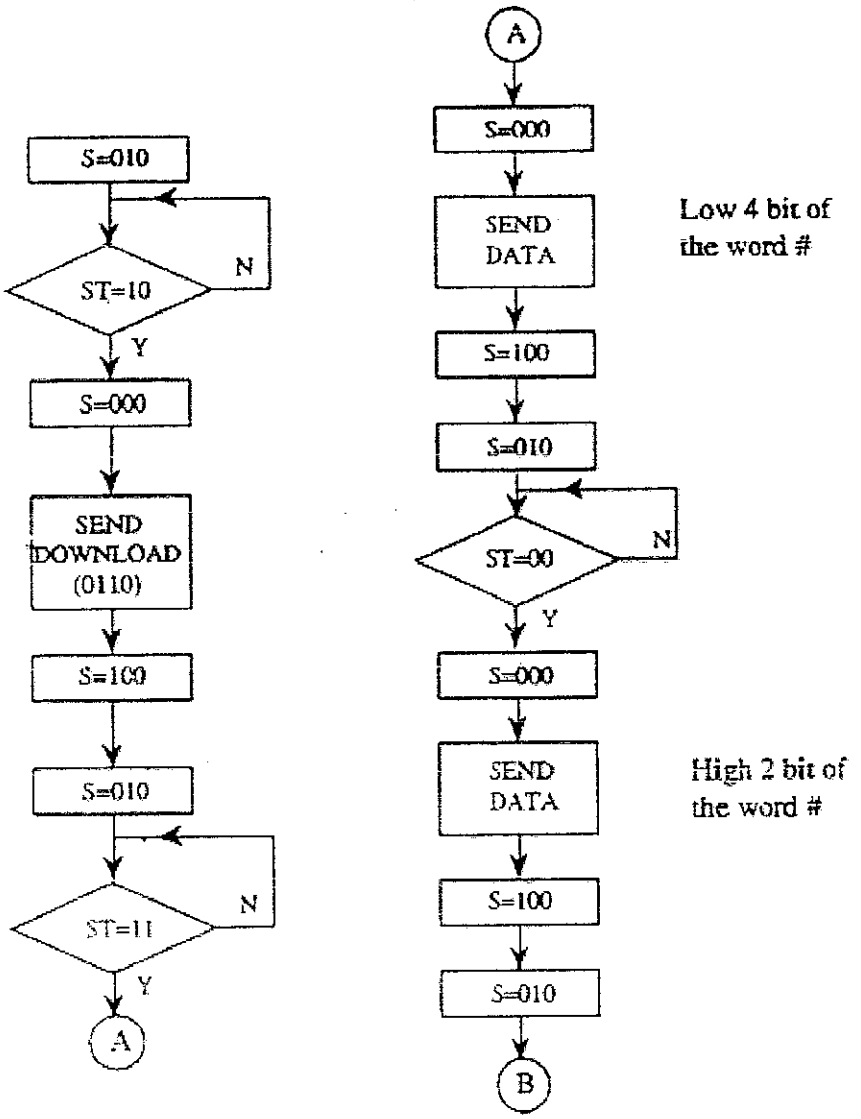


Fig 5. Control flow of the CPU mode for downloading.

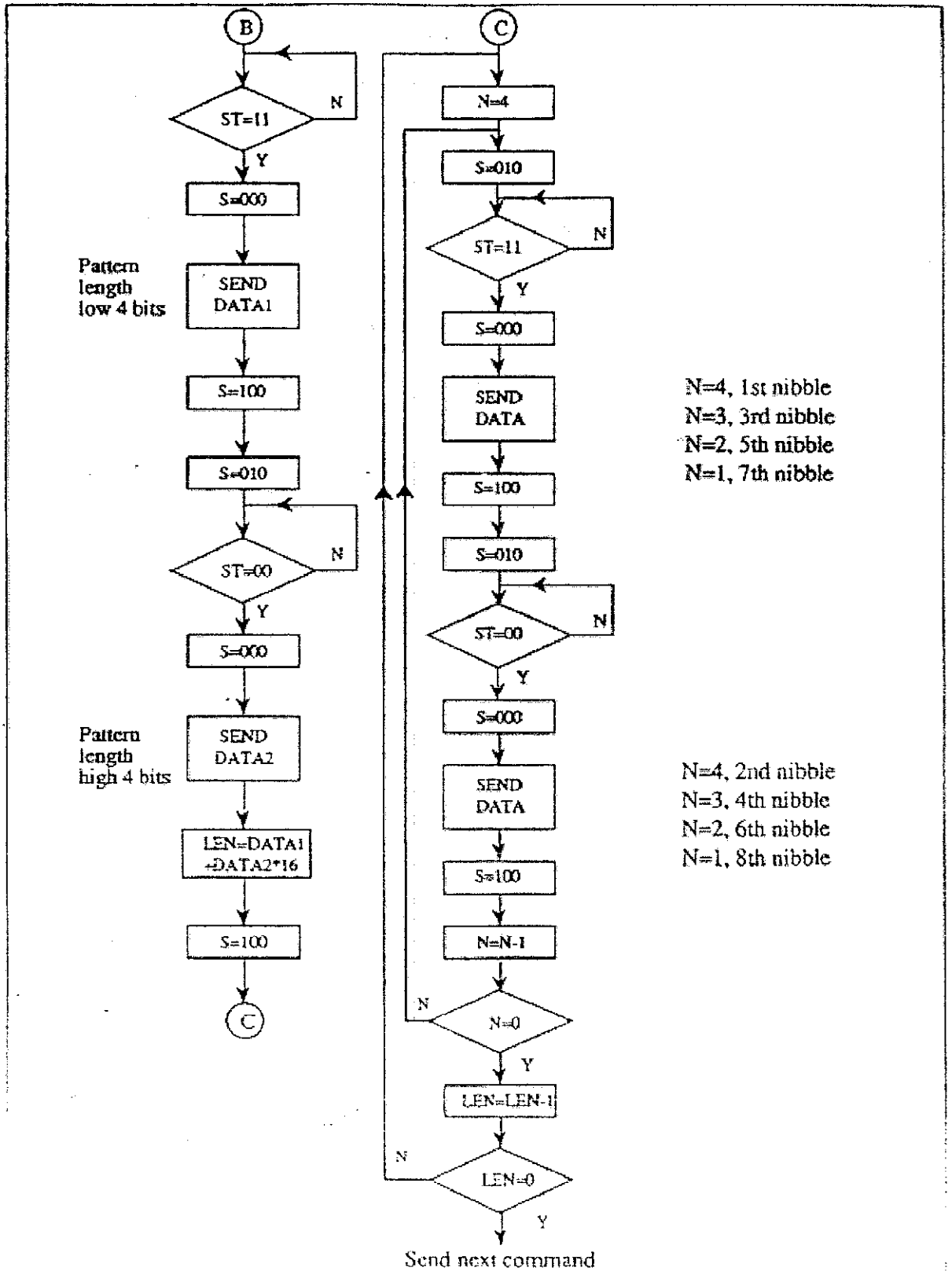


Fig 5. Continued

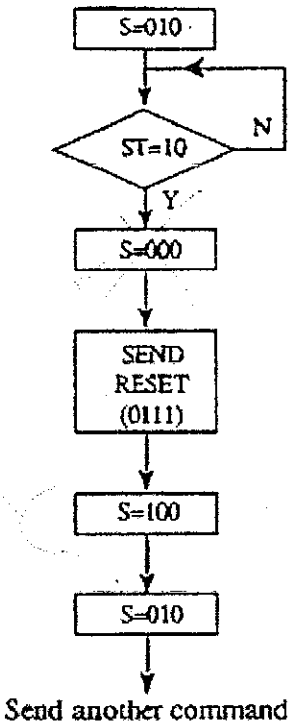


Fig 6. Control flow of the CPU mode for reset.

ABSOLUTE MAXIMUM RATINGS

Items	Sym.	Limitation Min.	Max.	Unit
Supply Voltage	V_{DD}	-0.3	+6.0	V
Input Voltage	Vin	-0.3	V_{DD}+0.3	V
Operating Temperature	Top	-20	+70	°C
Storage Temperature	Tstg	-55	+125	°C

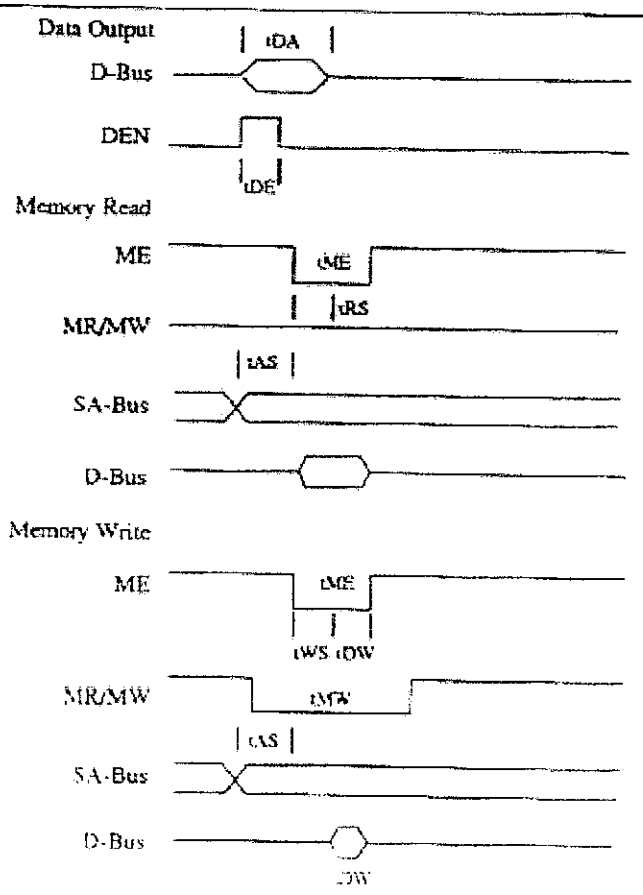
DC ELECTRICAL CHARACTERISTICS (T_A=25°C, V_{SS} = 0V)

Items	Sym.	Min.	Typ.	Max.	Unit	Conditions
Supply Voltage	V_{DD}	4.0	5.0	5.5	V	
Operating Current	I_{DDO}	-	6	15	mA	V_{DD}=5V, no load
Output Drive Current	I_{OH}	0.5	1.5	-	mA	Vo=4.6V
Output Sink Current	I_{OL}	0.5	1.5	-	mA	Vo=0.4V
Output Current of RDY	I_{RDY}	5.0	8.0	-	mA	V_{RDY}=3.35V
Input Leakage Current	I_{LKG}	-	0.1	1.0	μA	Vi=4.6V
Input Current (Pull Down)	I_i	50	200	300	μA	Vi=4.6V

AC ELECTRICAL CHARACTERISTICS

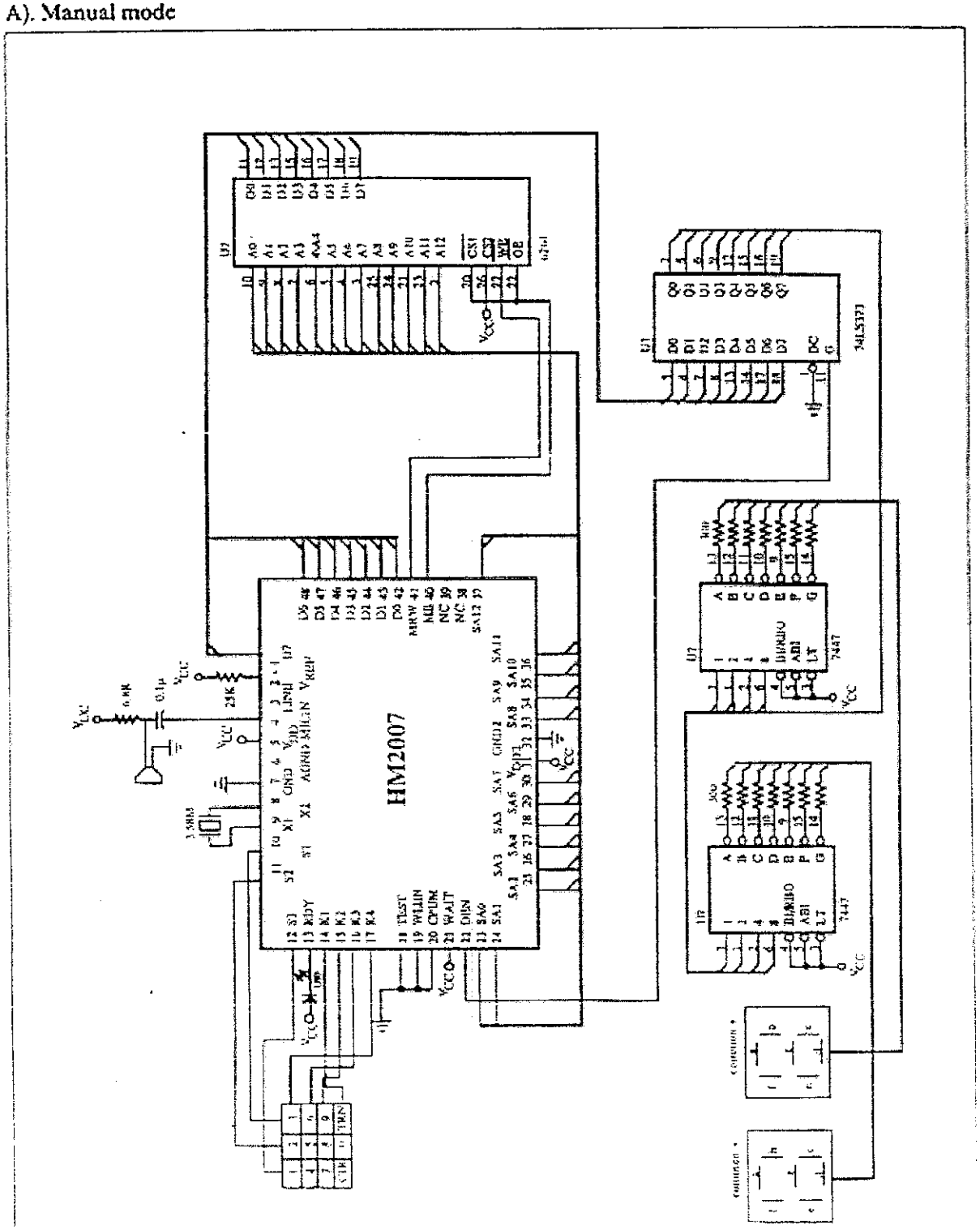
Items	Sym.	Min.	Typ.	Unit
Data Output				
Output Data Enable Width	tDE	240	280	ns
Output Data Holding Time	tDA	440	480	ns
Memory Read				
Memory Enable Width	tME	520	560	ns
Address Setup Time to Memory Enable	tAS	240	280	ns
Memory Enable to Data Reading Starting	tRS	240	280	ns
Memory Write				
Memory Enable Width	tME	520	560	ns
Memory Write Signal Width	tMW	1080	1120	ns
Address Setup Time to Memory Enable	tAS	240	280	ns
Memory Enable to Data Writing Starting	tWS	240	280	ns
Data Write Period	tDW	240	280	ns

Timing Diagram

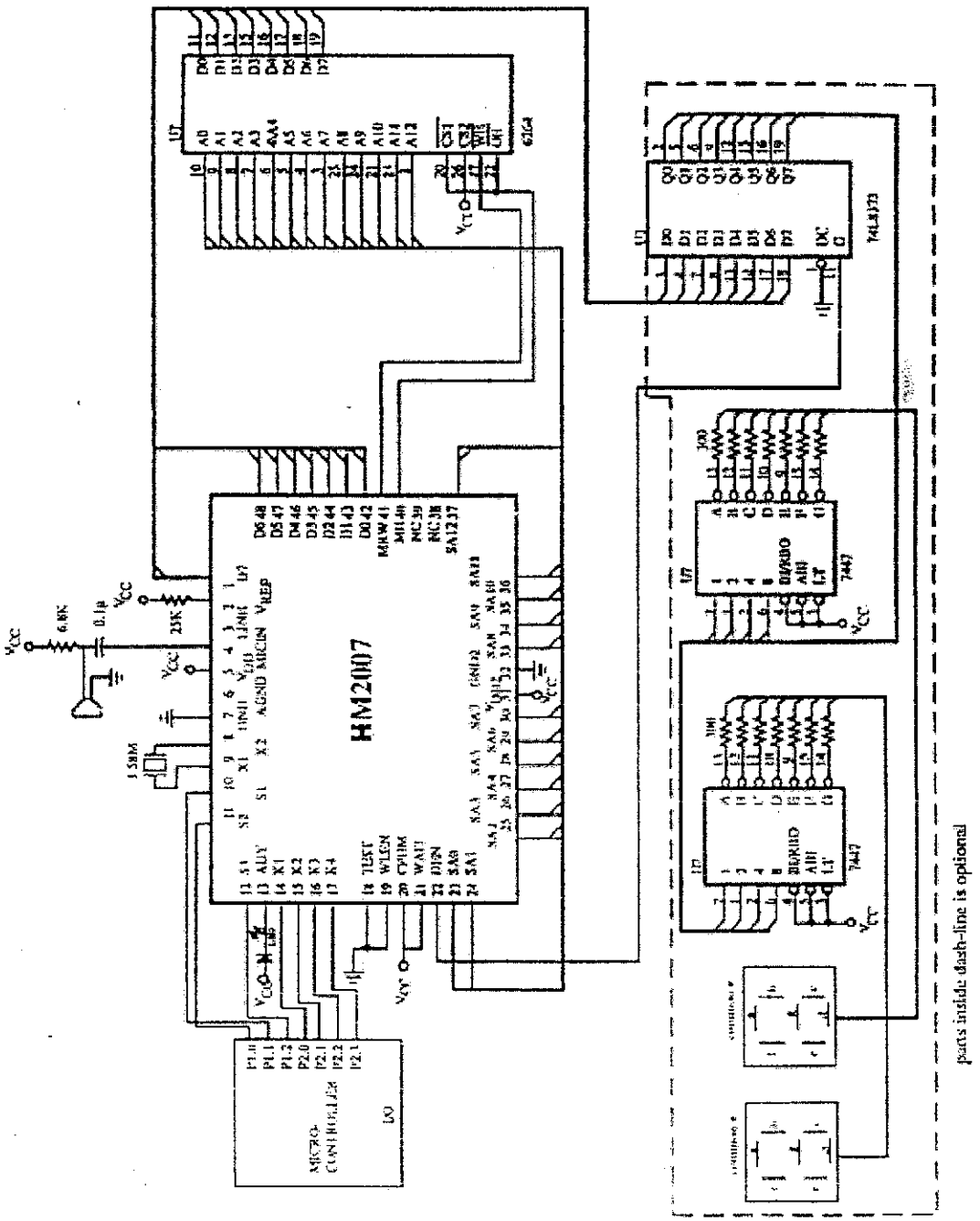


APPLICATION CIRCUIT

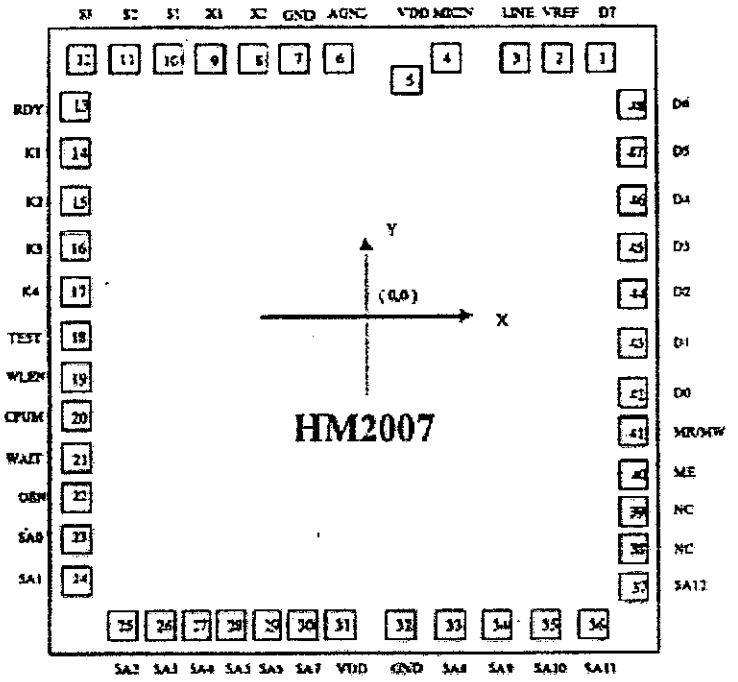
A). Manual mode



B). CPU mode



PAD DIAGRAM



Chip Size : 3970 µm x 3890 µm

Pad No.	Name	X	Y
1	D7	1722.6	1719.6
2	V_{REF}	1503.8	1720.0
3	LINE	1220.6	1720.0
4	MICIN	838.2	1720.0
5	V_{DD}	618.3	1666.1
6	AGND	-7.1	1647.1
7	GND	-296.2	1645.2
8	X2	-597.7	1720.1
9	X1	-922.9	1720.0
10	S1	-1204.1	1720.0
11	S2	-1485.3	1720.0
12	S3	-1766.5	1720.0
13	RDY	-1799.6	1468.0
14	K1	-1799.6	1198.4
15	K2	-1799.6	937.8
16	K3	-1799.6	668.8
17	K4	-1799.6	408.2
18	TEST	-1800.0	184.8
19	WLEN	-1800.0	-94.9
20	CPUMP	-1800.0	-408.2
21	WAIT	-1800.0	-721.2
22	DEN	-1799.6	-1046.4

Pad No.	Name	X	Y
23	SA0	-1799.6	-1316.0
24	SA1	-1799.6	-1576.6
25	SA2	-1459.7	-1759.6
26	SA3	-1186.1	-1759.6
27	SA4	-922.1	-1759.6
28	SA5	-648.5	-1759.6
29	SA6	-384.5	-1759.6
30	SA7	-110.9	-1759.6
31	V_{DD}	180.1	-1760.1
32	GND	409.4	-1760.0
33	SA8	723.9	-1759.6
34	SA9	987.9	-1759.6
35	SA10	1261.5	-1759.6
36	SA11	1525.5	-1759.6
37	SA12	1799.6	-1592.3
38	NC	1800.0	-1267.1
39	NC	1800.0	-983.9
40	ME	1799.6	-761.9
41	MR/MW	1799.6	-488.3
42	D0	1799.6	-224.3
43	D1	1799.6	49.3
44	D2	1799.6	313.3
45	D3	1799.6	586.9
46	D4	1799.6	850.9
47	D5	1799.6	1124.5
48	D6	1799.6	1388.5

Unit : μm

Note : The substrate must be connected to V_{SS} in PCB layout artwork.

APPENDIX G

DOOR OPERATION CONTROL SYSTEM

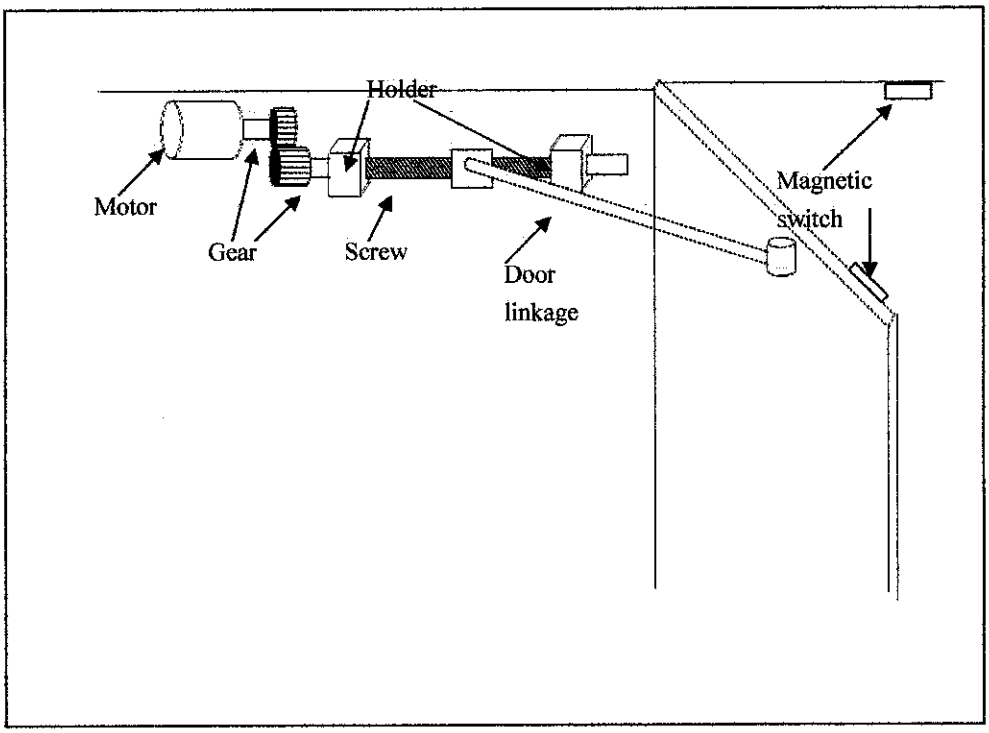
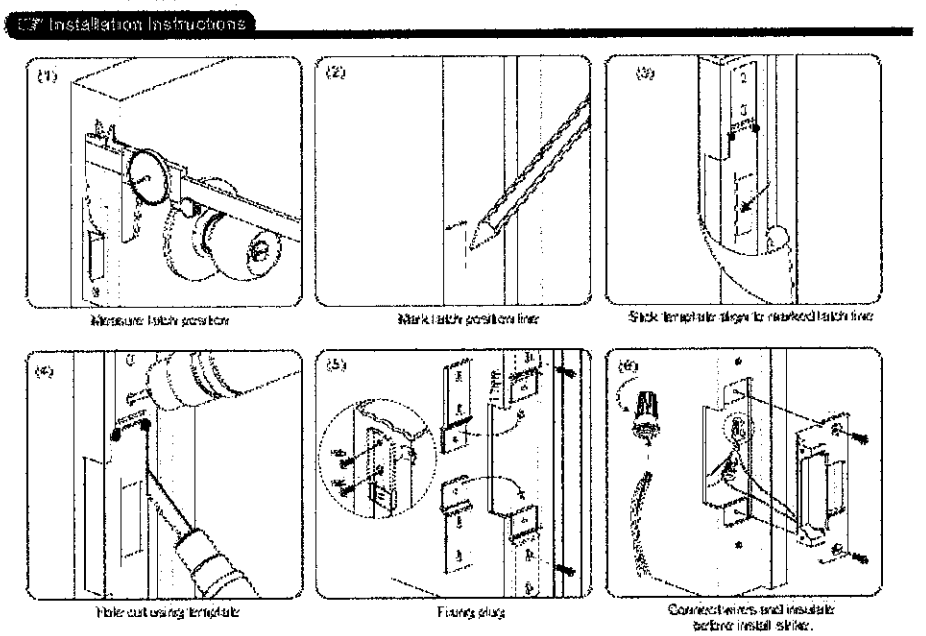


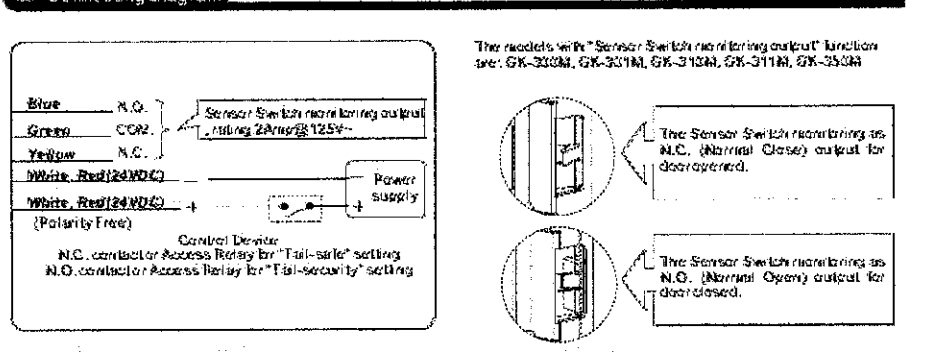
Figure 19 Screw system.

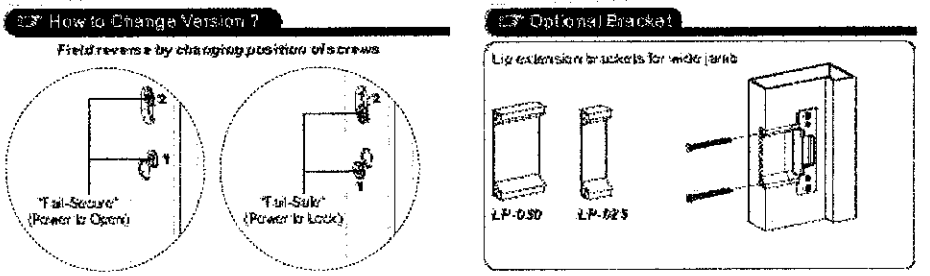
APPENDIX H

INSTRUCTION MANUAL FOR LOCKING DEVICES

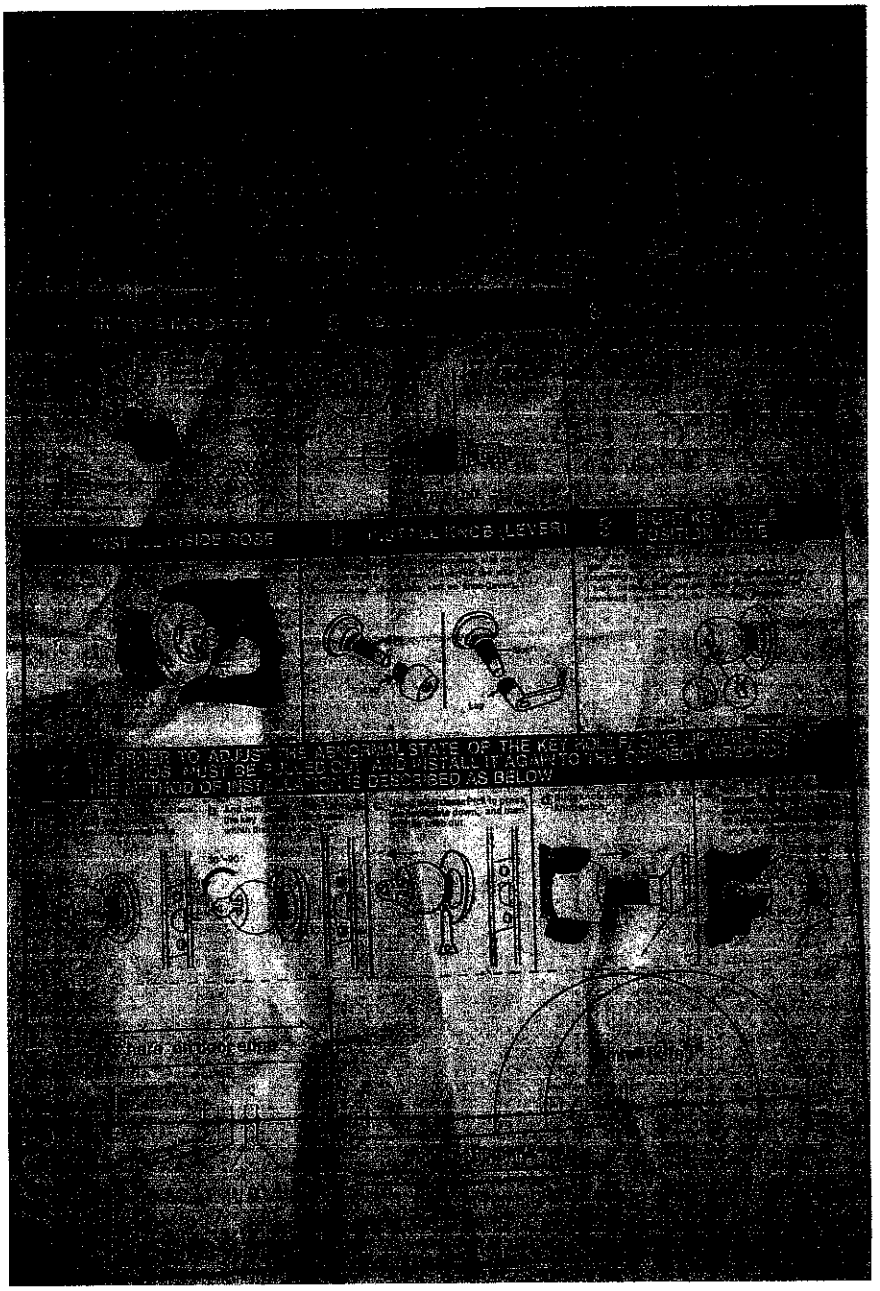
- Electric Strikes Installation Instruction manual (GK-300 Series ANSI Sized Electric Strikes) [15]







- Instruction for installation of lockset (Cylindrical Lock manual) [16]



APPENDIX I

INTERFACE CIRCUIT

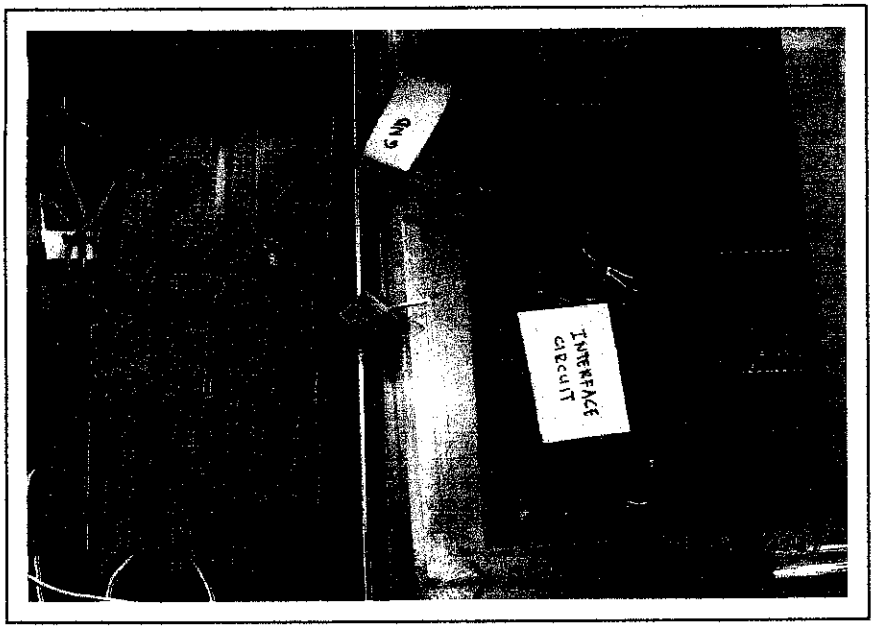


Figure 20 Interface Circuit (with timer circuit).

APPENDIX K

DC MOTOR CONTROL CIRCUIT

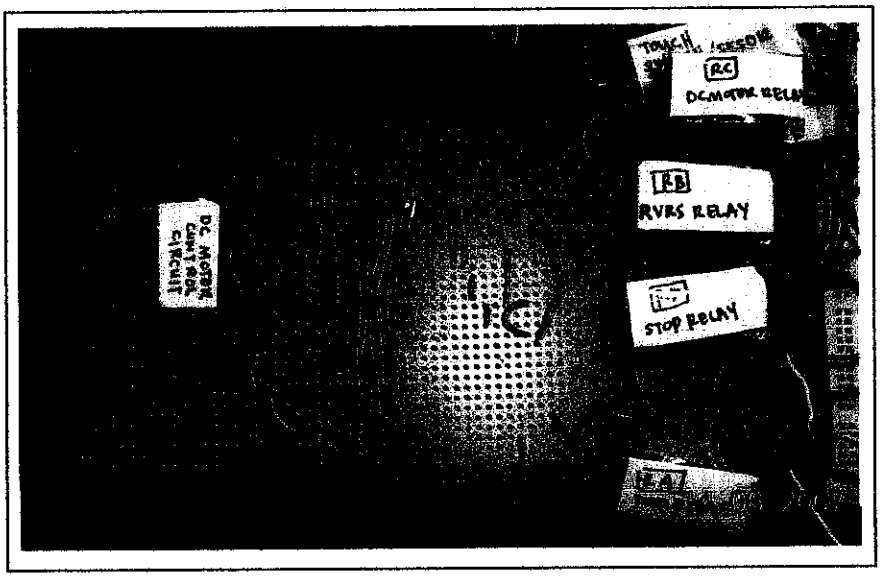


Figure 23 DC Motor Control Circuit.

APPENDIX L

MINIAUTURE DOOR

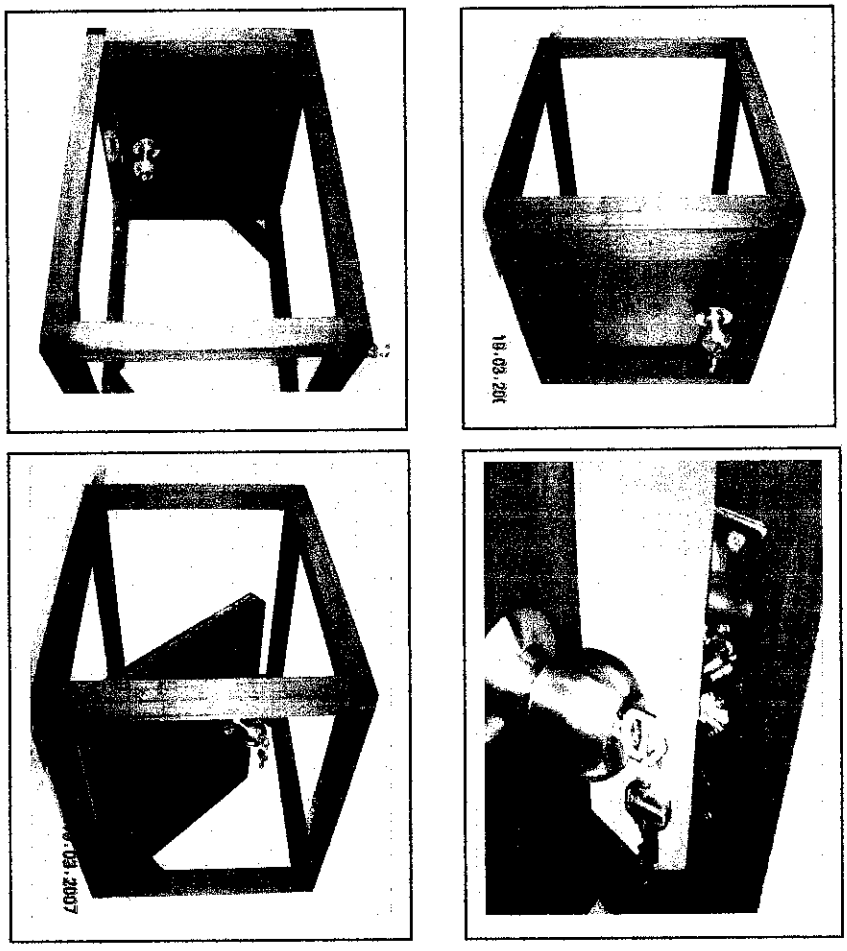


Figure 24 Miniature Door (Open operation)

APPENDIX M

OVERALL CIRCUITRY OF THE VOICE ACTIVATED SYSTEM

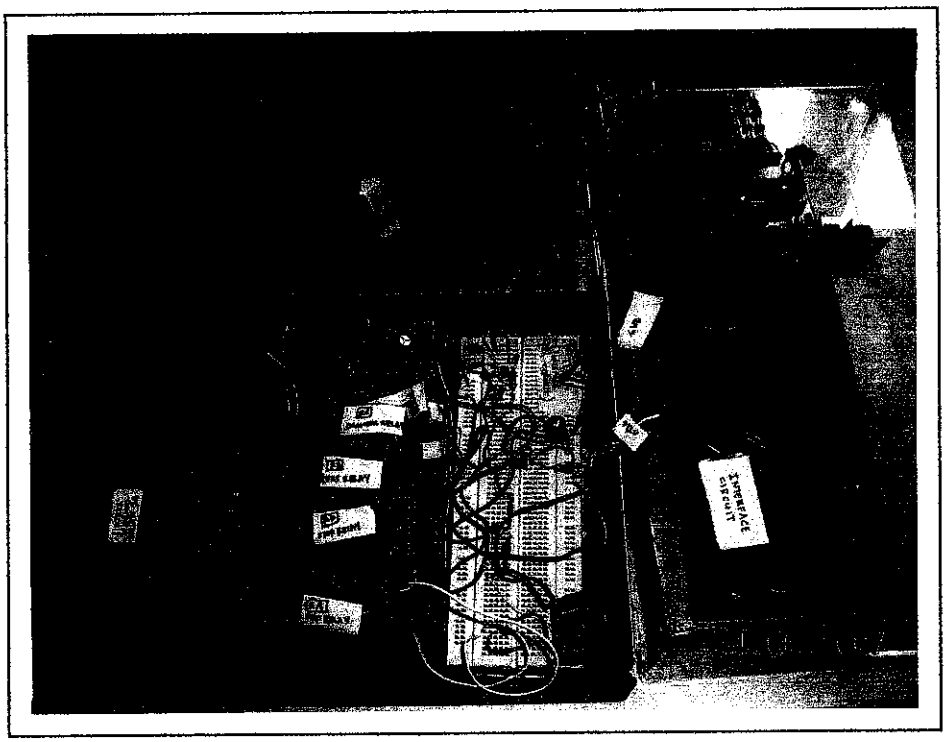


Figure 25 Overall Circuitry of the Voice Activated System design.

APPENDIX N

OVERALL VOICE ACTIVATED SYSTEM DESIGN (MODEL)

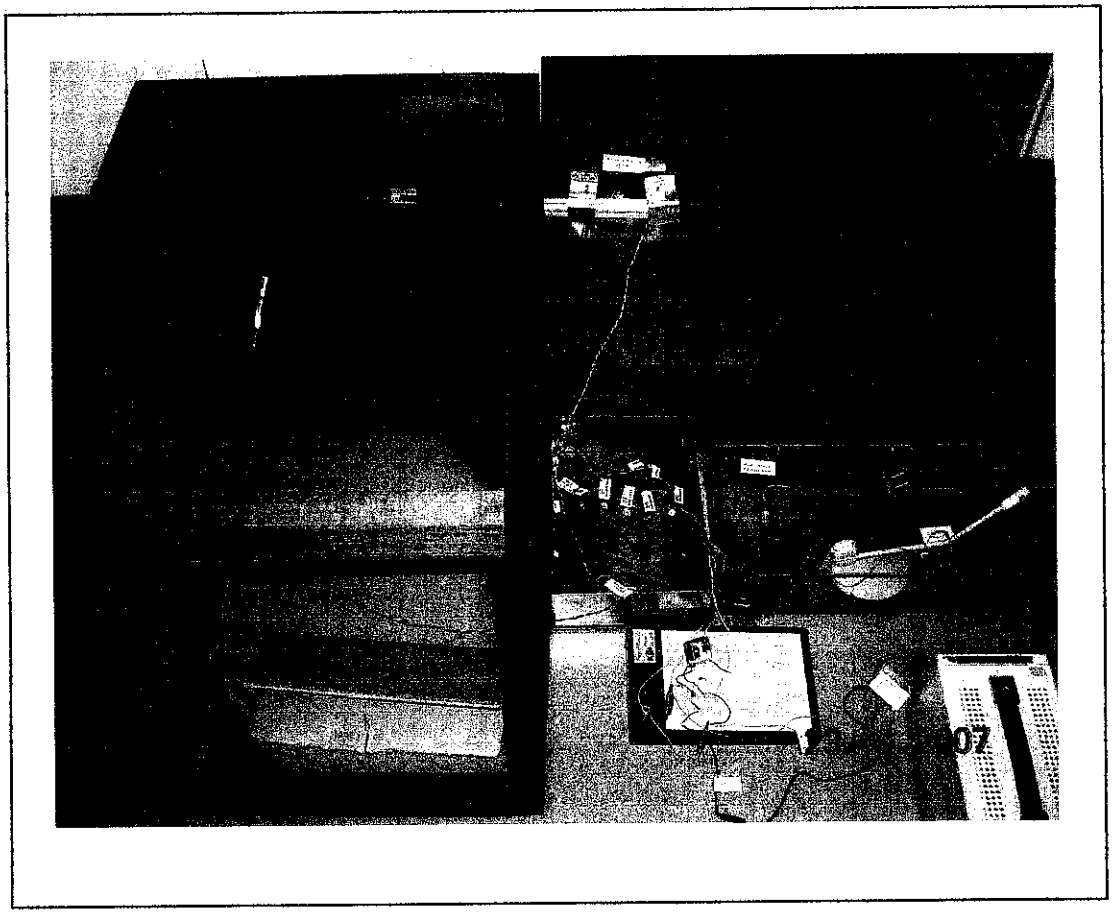


Figure 26 Overall Voice Activated System Design (Model)

APPENDIX O

VOICE ACTIVATED DOOR SYSTEM DESIGN

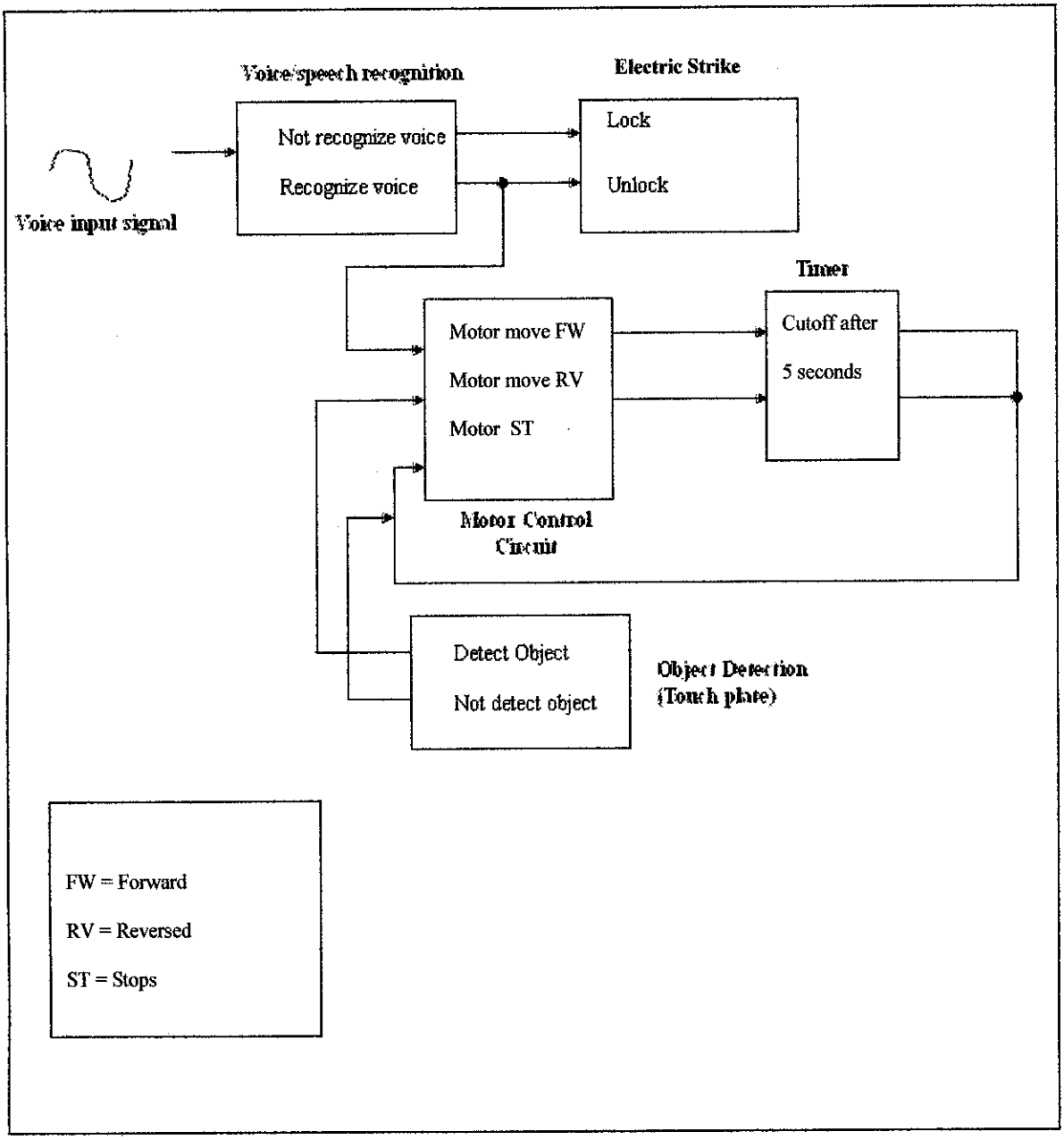


Figure 27 Voice Activated Door System Block Diagram.