USB DOOR LOCK USING FINGERPRINT BIOMETRICS TECHNOLOGY

by

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A Design Report Submitted to the School of Electrical Engineering, Electronics Engineering, and Computer Engineering in Partial Fulfilment of the Requirements for the Degree

Bachelor of Science in Computer Engineering

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Approval Sheet

Mapua Institute of Technology

School of EECE

This is to certify that I have supervised the preparation of and read the design report prepared by **Jonnavel A. Lerit and Jan Alfred Patrick R. Torres** entitled **"USB Door Lock using Fingerprint Biometrics Technology"** and that the said report has been submitted for final examination by the Oral Examination Committee.

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As members of the Oral Examination Committee, we certify that we have examined the design report presented before the committee on **February 18, 2012,** and hereby recommended that it be accepted in fulfilment of the design requirements for the degree in **Bachelor of Science in Computer Engineering.**

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This design report is hereby approved and accepted by the School of Electrical Engineering, Electronics Engineering, and Computer Engineering in partial fulfilment of the requirements for the degree in **Bachelor of Science in Computer Engineering.**

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Above all, we thank the Almighty God who gave us the knowledge, strength, patience, perseverance, and courage in completing this design project.

ROLES AND RESPONSIBILITIES OF MEMBERS

<table>
<tr><th colspan="2">Role</th></tr>
<tr><td>Lerit, Jonnavel A.</td><td>The person responsible for designing and developing the prototype</td></tr>
<tr><th colspan="2">Responsibilities</th></tr>
<tr><td colspan="2">Search for the equipment that can be used for the prototype
Analyzed the interfacing of the fingerprint reader and the USB host device
Provides the algorithm to be used in storing the data
Finalize the design prototype</td></tr>
<tr><th colspan="2">Role</th></tr>
<tr><td>Torres, Jan Alfred Patrick R.</td><td>The person responsible for coding and testing the finished design prototype</td></tr>
<tr><th colspan="2">Responsibilities</th></tr>
<tr><td colspan="2">Code how the user will be able to store fingerprint in the fingerprint device
Test the interaction of the fingerprint reading device and the USB host device
Document the progress of the work</td></tr>
</table>

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ABSTRACT

The USB Door Lock using Biometrics Fingerprint Technology aims to interface a bio-metric reader, specifically a fingerprint scanner, and a door lock using a USB port that will secure a specific room. This device can be a replacement for keys and cards. The design is composed of the USB interfaced fingerprint reading device and a circuit to trigger the locking and unlocking of the door. Pic BASIC is used in the programming of the microcontroller unit to interact with the fingerprint reader in triggering relays for locking and unlocking of the door. With this system, securing access to establishments is guaranteed while providing convenience and efficiency in entering a room.

Keywords: Biometrics, USB, Microcontroller unit, Relay, Pic BASIC

Chapter 1

DESIGN BACKGROUND AND INTRODUCTION

Introduction

Technology is developed by people to help improve the quality of human lives, and all are using technological advances in many different ways and one of these ways is security system. When it comes to security systems, biometrics is one of the top of the choices which has brought significant changes with regards to how people gain access of rooms or establishments. The use of biometrics have changed the security system from what people conventionally used such as passwords or what a person possesses such as door keys to something a person embodies such as retinal patterns, fingerprints, or voice recognition. Fingerprint recognition is one of the most popular and successful methods used for person identification, which takes advantage of the fact that the fingerprint has some unique characteristics called minutiae; which are points where a curve track finishes, intersect with other track or branches off (Aguilar et. al., 2007).

In this design project the conventional mechanical door lock that uses metal keys is replaced with a USB door lock with fingerprint authentication using a separate fingerprint reading device for the user that will serve as the *key*.

Customer

The target customer of this design project is Casa Consuelo Dormitory owned by Realty Corporation and one of the competing dormitories residing inside Intramuros, specifically located at Lot 3 Block 41 Solana St. Intramuros, Manila. Casa Consuelo is one of many that offer affordable rooms and a secured living for its tenants.

Need

Secured rooms are important to Casa Consuelo in gaining trust from its future and existing tenants. But with several cases of theft, there is a need for better security measures within the premises of the dormitory. That is the reason why Casa Consuelo is looking to improve their existing security system of just the conventional door locks and replace is with a systems that would ensure access to be only entitled to the occupants of each room.

Solution

With the need to replace or improve the existing security system of Casa Consuelo Dormitory in its rooms, the researchers come up with the solution of replacing the conventional door lock with a USB Door Lock accessed using a separate fingerprint reading device that serves as the *key*. The proposed system will replace the existing system with an innovative new system in such a way the tenants can gain access using USB communication between the separate fingerprint reading device and the door lock that validates the captured fingerprint. This will ensure only tenants occupying the specific room can gain access prohibiting unauthorized access to the room by other tenants, guests and even the administrators of the dormitory.

Objectives

Aside from aiding the need of Casa Consuelo Dormitory in improving their rooms' security system and resolve problems of theft, this design projects also aims to create a USB door lock system with the same principle of a door lock and a key with the use of a separate fingerprint reading device. The researchers also aim that the USB door lock using biometrics fingerprint technology is reliable in validating fingerprints in accordance to the proper placement of the fingerprint to the scanner to gain access of the door and also the addition and deletion of fingerprints to the system.

Constraints

In using biometrics fingerprint technology, there are studies showing that among the different biometrics, fingerprint authentication is one of the top if not the top choice to be used for identification systems of devices. Although these studies showed the benefits and competencies in using different kind of biometrics, the limiting factor for this design project in using biometrics fingerprint technology is the acceptance of the society with fingerprint authentication. Socially, people nature does not shift to a newly introduced system quickly. That is why the group's implementation of the USB door lock using fingerprint biometric technology started with a dormitory as its client. This is not just to solve the theft problems within the dormitory and improve their security system, but also the implementation of a system using biometrics for authentication showing and focusing the benefits it can give.

Impact

With the advancement of technology, the society is becoming electronically connected to form one big global community. Surrogate representations of identity such as passwords and key cards no longer suffice making biometrics as one of the choice of form of security.

This design may further improve the security system of the dormitory and will also have an impact with the people's safety, security to be more specific. This is in terms of aiding the target customer's need of improving its rooms' security system in implementing a USB door lock with a separate fingerprint reading device for fingerprint authentication in gaining access that is only entitled to the occupants of the room. The design solution is also not comprised of harmful material that may affect the environment where the system is installed.

Differentiation

This design project is unique as it did not completely throw away the use of keys when dealing with door locks as it uses a separate USB fingerprint reading device from the USB door lock. The fingerprint reading device and the door lock communicates via a USB port placed at the door. The project also provides functions such as the addition, deletion, and verification (authenticating) of the user/owner of the room/unit. In existing USB door locks, some were needed to be interfaced with a personal computer (PC) when authenticating users, the use of keypads for personal PINS were implemented, and others were using the serial number of a flash drive. In term with technology used, this design project utilizes fingerprint technology and won't be needing to be interfaced with a PC in authenticating users or even during the addition and deletion of fingerprints. This project also features just having the USB port outside the door making it for other people to distinguish what security system it uses.

Benefits

Biometrics has brought significant changes in security systems making them more secure than before, efficient, and cheap. The target customer being a dormitory can earn trust from their existing and future occupants with the implementation of this design project featuring the an improved way of eliminating unauthorized access with the use of fingerprint biometrics providing the needed improvement on each room's security system.

Definition of Terms

1. **Biometrics** - consists of methods for uniquely recognizing humans based upon one or more intrinsic physical or behavioral traits. It is used as a form of identity access management and access control. It is also used to identify individuals in groups that are under surveillance.

2. **Fingerprint** - an impression left by the friction ridges of a human finger. It is the trace of an impression from the friction ridges of any part of a human hand.

3. **USB(Universal Serial Bus)** - an industry standard developed in the mid-1990s that defines the cables, connectors and communications protocols used in a bus for connection, communication and power supply between computers and electronic devices. USB was designed to standardize the connection of computer peripherals, such as keyboards, pointing devices, digital cameras, printers, portable media players, disk drives and network adapters to personal computers, both to communicate and to supply electric power.

4. **Minutiae** - major features of a fingerprint, using which comparisons of one print with another can be made. Minutiae include:
    - **Ridge ending** – the abrupt end of a ridge
    - **Ridge bifurcation** – a single ridge that divides into two ridges
    - **Island** – a single small ridge inside a short ridge or ridge ending that is not connected to all other ridges

- **Ridge enclosure** – a single ridge that bifurcates and reunites shortly afterward to continue as a single ridge
- **Spur** – a bifurcation with a short ridge branching off a longer ridge
- **Crossover or bridge** – a short ridge that runs between two parallel ridges

5. **Failure to Enroll Rate (FTE or FER)** - the rate of performance of biometric systems at which attempts to create a template from an input is unsuccessful. This is most commonly caused by low quality inputs.
6. **Failure to Capture Rate (FTC)** - within automatic systems, the probability that the system fails to detect a biometric input when presented correctly.
7. **Fingerprint Reader** – the device used to read/scan and store the fingerprint of a certain user
8. **Fingerprint Identification** - also known as dactyloscopy, or hand print identification, is the process of comparing two instances of friction ridge skin impressions, from human fingers, the palm of the hand or even toes, to determine whether these impressions could have come from the same individual.
9. **Fingerprint Authentication** - refers to the automated method of verifying a match between two human fingerprints. Fingerprints are one of many forms of biometrics used to identify individuals and verify their identity.

10. **Fingerprint Verification** - the comparison of a claimant fingerprint against an enrollee fingerprint, where the intention is that the claimant fingerprint matches the enrollee fingerprint. To prepare for verification, a person initially enrolls his or her fingerprint into the verification system. A representation of that fingerprint is stored in some compressed format along with the person's name or other identity.

Chapter 2

REVIEW OF RELATED DESIGN LITERATURES AND STUDIES

BIOMETRICS

In the article entitled "Biometrics", written by Dilum Bandara, a PhD Candidate in the Computer Networking Research Laboratory, Department of Electrical and Computer Engineering, Colorado State University, USA (2008), defined Biometrics as an open-minded set of technologies based on the measurement of some unique physical characteristics of an individual for the purpose of identifying an individual or verifying identity which cannot be borrowed, stolen, or forgotten. This technology measures the individual's unique physical or behavioural characteristics to recognize or authenticate their identity. Behavioural characteristics include signature, signature dynamics, voice, lip movement, keystroke analysis, and gait. Physical characteristics include hand geometry, retina, iris, facial characteristics and fingerprints.

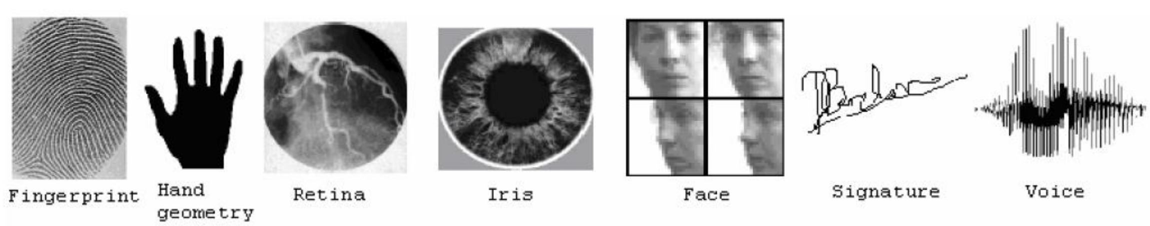


Figure 2-1 Various Biometrics Technologies

In another article entitled "Biometric Recognition: Security and Privacy Concerns" by Prabhakar, Pankanti and Jain (2003) described biometrics systems is essentially a pattern-recognition system that recognizes a person based on a feature vector derived from a specific characteristic that a person possesses. And typically operates in one of two modes: *verification*, validating a person's identity by comparing the captured biometric characteristics with the individual's biometric template, or *identification*, recognizing an individual by searching the entire template database for a match.

Several biometric characteristics can be used in various applications. Each biometric has its strengths and weaknesses, and choosing the best characteristic to use depends on the application as no single biometric can effectively meet every requirements – none is "optimal".

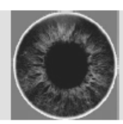
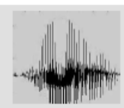
BIOMETRIC	FINGERPRINT	FACE	HAND GEOMETRY	IRIS	VOICE
					
Barriers to universality	Worn ridges; hand or finger impairment	None	Hand impairment	Visual impairment	Speech impairment
Distinctiveness	High	Low	Medium	High	Low
Permanence	High	Medium	Medium	High	Low
Collectibility	Medium	High	High	Medium	Medium
Performance	High	Low	Medium	High	Low
Acceptability	Medium	High	Medium	Low	High
Potential for circumvention	Low	High	Medium	Low	High

Table 2-1 Comparison of several biometric technologies

Table 2-1 shows the comparison of several biometrics conducted by the researchers of the article "Biometric Recognition: Security and Privacy Concerns", (2003). Ranking each characteristic based on the given categories as being low, medium or high. A low category indicates poor performance in the evaluation criterion, whereas a high ranking category indicates a very good performance. The following parameters are used: barriers to universality, distinctiveness, permanence, collectability, performance, acceptability, potential for circumvention.

Technology	Ease of Use	Accuracy	User acceptance	Security Level	Stability	Error occurrences	Cost
Fingerprint	High	High	Medium	High	Very High	Dryness, dirt	Average
Hand geometry	High	High	High	Medium	Medium	Injury, age	Average
Retina	Low	Very High	Low	High	High	Glasses	Very High
Iris	Medium	Very High	Low	Very High	High	Poor light	Average
Face Recognition	High	High	High	Medium	Medium	Age, poor light, hair	Lower
Signature	High	High	Medium	Medium	Medium	Changes over time	Average
Voice	High	High	High	Medium	Low	Health, Noise	Lower
key stroke analysis	High	High	High	Medium	Medium	Changes over time, maturity to type	Lower

Table 2-2 Comparison of Various biometric technologies

Also in a study by A.K. Jain, biometrics was ranked as shown in Table 2.2 using the parameters: universality, uniqueness, permanence, collectability, performance, acceptability, circumvention.

Analysing the comparisons, a biometric device that uses fingerprints shows more pleasing results. Also, its cost and portability are big factors why fingerprints have an edge over the other biometrics. A fingerprint scanner can be easily installed and utilized by an application and it is also very much acceptable in the industry.

Biometrics is a rapidly evolving technology widely used in forensics than access control. In a study done by A.K. Jain, S. Pankanti, S. Prabhakar, L. Hong, and A. Ross, the "Biometrics: A Grand Challenge", the researchers cited that as our society becomes electronically connected to form one big global community, it has become necessary to carry out reliable person identification often remotely and through automatic means. Surrogate representations of identity such as passwords (prevalent in electronic access control) and cards (prevalent in banking and government applications) no longer suffice. Further, passwords and cards can be shared and thus, cannot provide non-repudiation. Furthermore, the researchers concluded that existing biometric technology should not be construed that it is not useful. In fact, there are a large number of biometric solutions that have been successfully deployed to provide useful value in practical applications.

FINGERPRINT READER

Fingerprint is one of the most common biometrics used in the field of security which still faces unique challenges for acceptance especially the threat of identity theft which has been validated as a realistic vulnerability. And in the study by S. Palka and B. A. Hamilton in the "Fingerprint Readers: Vulnerabilities to Front- and Back- end Attacks", the researchers stated that the technology used for sensors and fingerprint processing has matured but vulnerabilities still persist described in their paper.

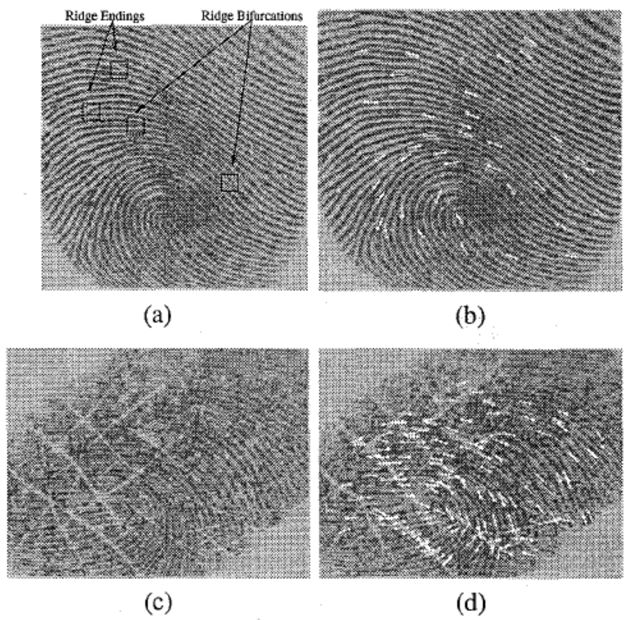


Figure 2-2 Minutia extraction: (a) good quality input image; (b) extracted minutiae; (c) poor quality input image; (d) extracted minutiae.

An automatic fingerprint identification system (AFIS) is based on a comparison of minute details of ridge/valley structures of fingerprints. A total of eighteen different types of local ridge/valley descriptions have been identified. Among them, ridge endings and ridge bifurcations (Figure 2-2(a)), which are usually called minutiae, are the two most prominent structures used in an automatic fingerprint identification system.

Prevention of identity theft is done by encrypting the biometric data gathered. After the identification of specific points of data, the match points in the database were processed using an algorithm that translates that information into a numeric value. The database value was then compared with the biometric input where the authentication is either approved or denied.

PIC-BASED DOOR LOCK SYSTEM

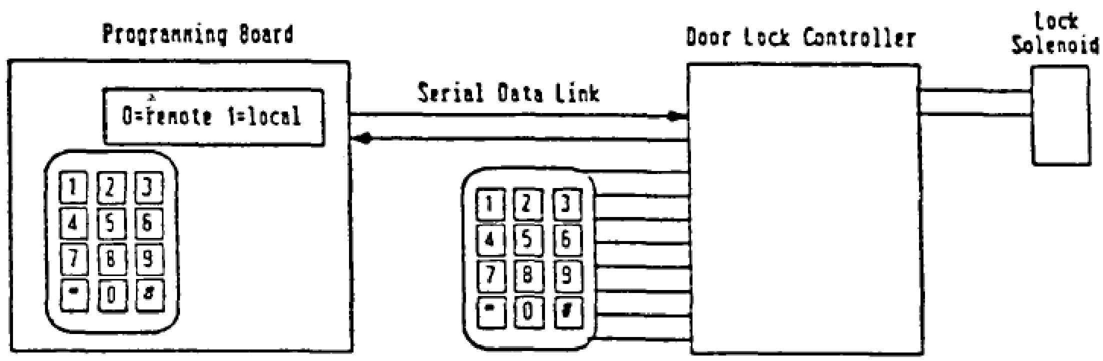


Figure 2-3 System diagrams of door lock controller and programming modules

The Microprocessor-controlled door lock system done by D. C. Poirier and S. R. Vishnubhotla, (March 1990), pointed out that maintaining an entry only to authorized persons for multi-dwelling buildings such as apartments, dormitories, etc. is a problem. The system is composed of two modules, the door lock controller board and the programming board shown in Figure 2-3.

In another study by A. Bitoon, et. Al (September 2003) regarding a PIC-based door lock system, the researchers stated that; "PIC-based door lock system provides a means of replacing old fashioned locks using keys by means of sensors and readers. With this PIC-based door lock system provides a means of replacing old fashioned locks using keys by means of sensors and readers. With this door lock system homes and establishments can avail of better safety and security. It uses components such as a keypad for password input and Programmable Integrated Circuit Microcontroller as to control the functions of the system."

Based on these studies, researchers learned that microcontrollers can also be used for locking and unlocking doors for better safety and security. Based on an article published in Blackheath, South Africa in 2006, Biometric locks provide a more secured access to homes as well as the easiest way to enter an establishment. Moreover, static pins will no longer be needed for a hassle free access to a room.

PC INTERFACED LOCK USING FLASH DRIVE AS A KEY

With the use of a USB flash drive as an alternative key for door lock, M. Balmes, et. Al (July 2009), developed a PC Interfaced Lock using Flash Drive as a Key. Using a microcontroller, a PC and with the storing capability of a flash drive, a data corresponding to its assigned room is stored and the software will validate as soon as the user inserted the flash drive. In this study, the researchers stated that, "PC Interfaced Lock using Flash Drive as a Key is a device that will replace the usual key the people are using with a USB Flash Drive".

In an article entitled "USB Auth", a project demonstrated a computerized door lock that reads the unique ID of the USB Flash Drive to gain access. This project also uses a USB as its access port and with the unique serial number of a flash drive, the PC will check if the device is on the approved list to instruct the servo to unlock the door.

With these studies, replacing a conventional door locks key is possible using USB connection between a USB flash drive and the door lock.

Chapter 3

DESIGN PROCEDURES

HARDWARE DEVELOPMENT

BLOCK DIAGRAM

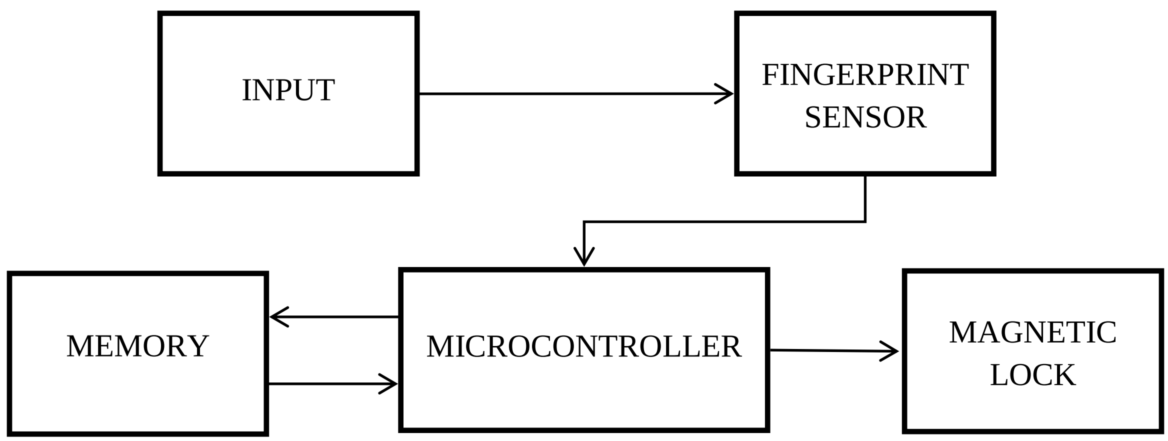


Figure 3-1 Block Diagram of the Design

The block diagram serving as the backbone of the design and figure 3-1 illustrates the block diagram used by the group. There is the Fingerprint Sensor that will wait for an input which is a fingerprint, after receiving an input the Fingerprint Sensor will then send signal to the microcontroller unit. The microcontroller unit will then pass the signal to the memory. After the memory validates the data sent to it, the memory will send back an answer to the microcontroller which will determine if the magnetic lock should open the door or not.

SCHEMATIC DIAGRAM

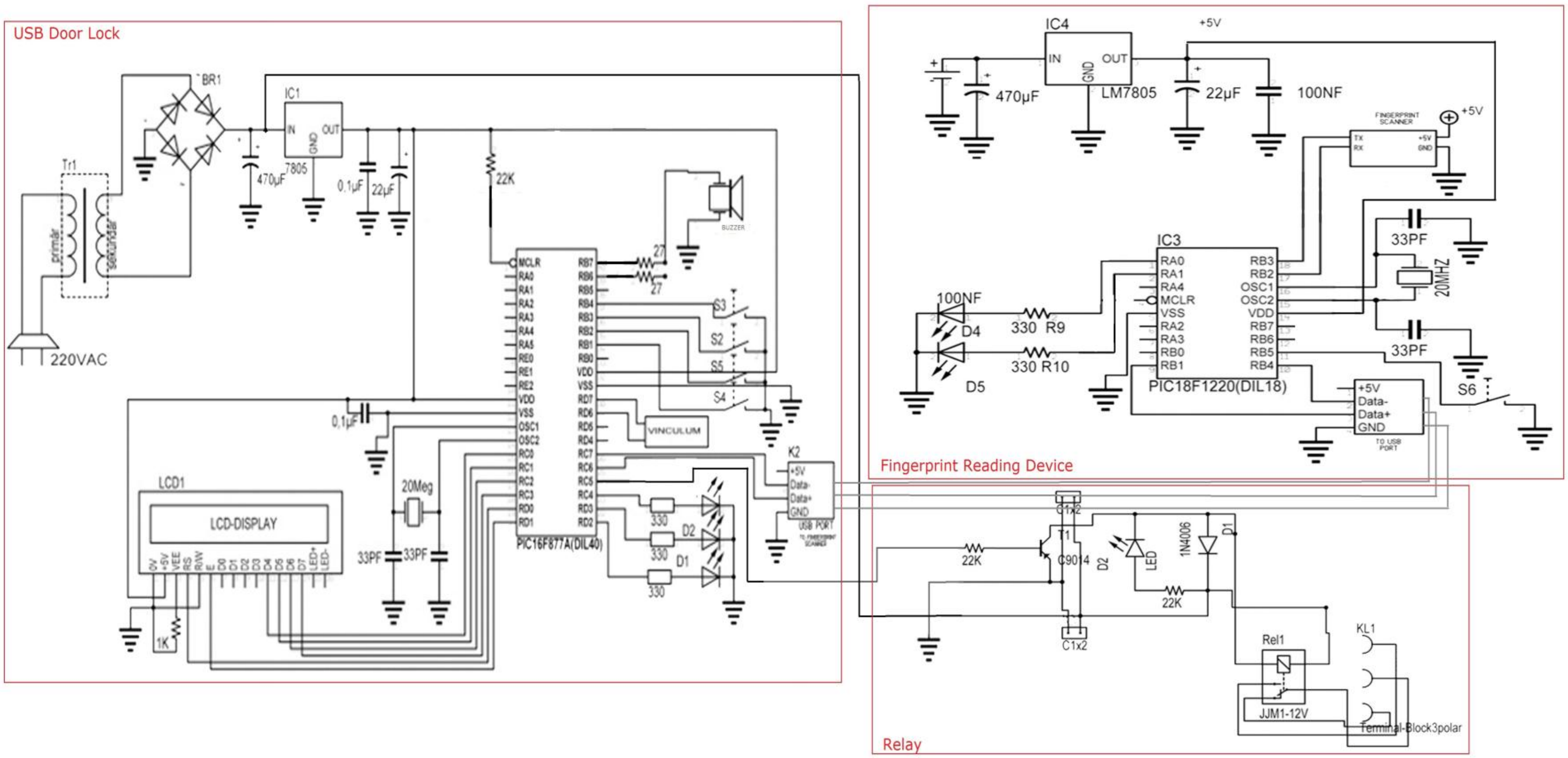


Figure 3-2 Schematic Diagram – USB Door Lock using Biometrics Fingerprint Technology

Figure 3-2 shows the schematic diagram of the USB Door Lock using Biometrics Fingerprint Technology. The schematic diagram is divided into three systems which are the USB Door Lock, Relay, and the Fingerprint Reading Device. The USB Door Lock system is the main system that is placed in the door and needs the Fingerprint Reading Device to be activated.

For the USB Door Lock system, from a 220V AC it will be regulated to 12V to be able to comply with the operating state of the PIC168F77A microcontroller unit. The operating state of the microcontroller is as referenced from its datasheet. A 470 micro-Farad capacitor is connected to the output voltage of the regulator and the ground to filter out the noise coming from the regulator.

The relay driver circuit is responsible for controlling the AC power used by the USB Door Lock system which consists of a PNP-transistor, 22 kilo-Ω resistor, 12V relay and 1N4006 diode. The 22kilo-Ω resistor allows small current to pass through the base-emitter junction. The output lines of the relay circuit are then connected to the output port RC5 of PIC168F77A, and to the 1N4006 diode and is connected to the 12V output of the regulator of door lock system and lastly it is connected to the ground. The transistor serves as a circuit that controls the state of the relay. When a small positive volt (3.3V) was applied at the base of the transistor, the collector-emitter junction connects together. Thus, the 12V power flows through the inductor part of the relay which then energizes the switch inside the relay. The state of the switch determines if the AC power flow to the AC socket. The reverse-biased diode serves as a voltage protection for the inductor part of the relay such that no current will pass through when the transistor is not active. If ever no positive voltage is applied to the base of the transistor, the transistor will not be in active state and the AC power is disconnected to the AC socket.

The fingerprint reading device is the one responsible for collecting user's fingerprints. It is regulated by a 5V output voltage. An oscillator of 20 mega-Hertz is connected to one of the microcontroller's pin for the purpose of timing frequency.

The formula used in getting the value of the capacitor in the relay circuit is:

$$C = \frac{5xI}{V\ x\ f} = \frac{5\ x\ 7.59x10^{-4}}{5.7\ x\ 20x10^{6}} = 33.29\ \text{pF}$$

Where:

C= computed capacitance in farads (F),

I = measured output current from the supply in amps (A),

V = measured supply voltage in volts (V),

f = frequency of the AC supply in hertz (Hz)

The base resistor of each transistor circuit is obtained using the formula:

$$Rb = \frac{Vb - Vbe}{Ib} = \frac{5.7 - 0.7}{2.27x10^{-4}} = 22.02\text{k}\Omega$$

Where:

Rb = computed base resistor in ohms

Vb = the base voltage in volts (V)

Vbe = the difference from the base voltage to the base emitter

Ib = measured base current in amperes (A)

SOFTWARE DEVELOPMENT

PROGRAM FLOW CHART

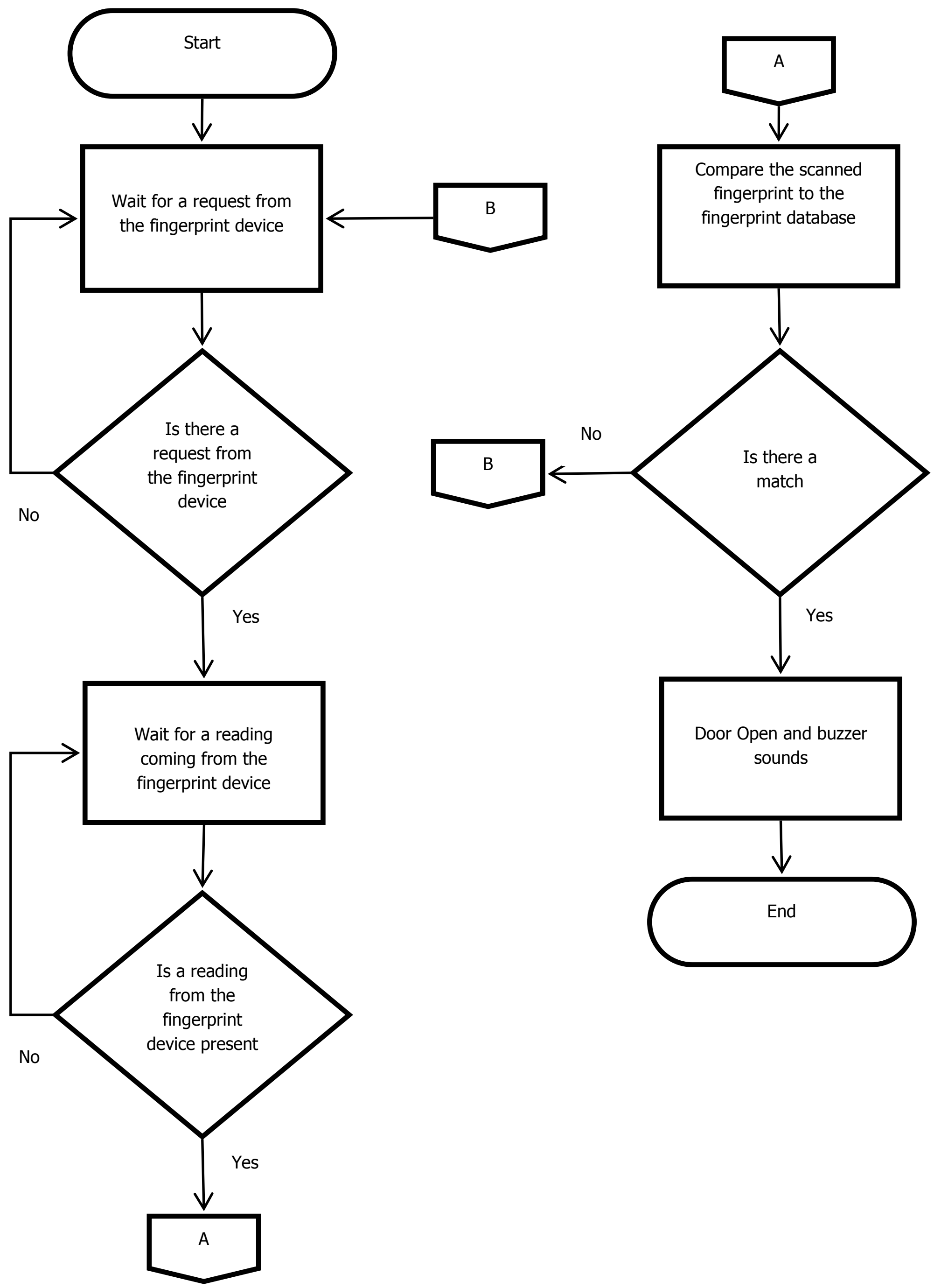


Figure 3-3 Door Access Flow Chart of Enrolled and Not enrolled users

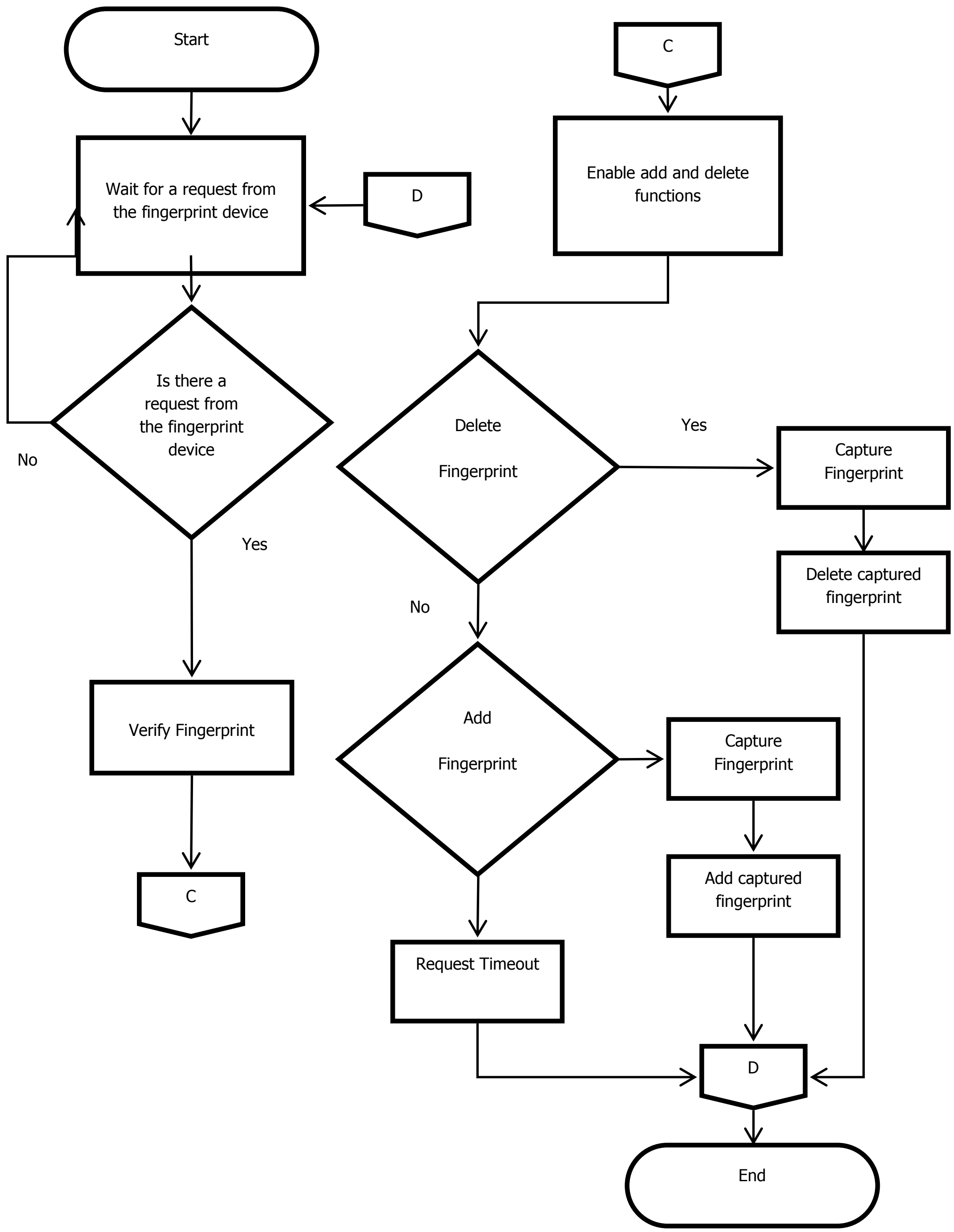


Figure 3-4 Door Access Flow with Administrator Rights

The following figures, referring to figure 3-3 and figure 3-4, are the flow charts of the prototype being design. It shows the processes of the verification and enrolment features of the USB Door Lock System using Biometrics Fingerprint Technology. The system starts up as soon as it is plugged in and immediately initializes all the variables needed to clear unwanted data that may cause system failure. The system also waits for the request from the fingerprint reading device before making any actions in which verification of fingerprint is always the first thing to do. Whether the user wants to open the door or enroll a new fingerprint, the system will always verify first if the requesting user's fingerprint is enrolled. Unlocking the door just requires the user to verify itself and as soon as the system recognizes that the requesting user's fingerprint is enrolled, the door lock will open and immediately sound the buzzer prompting that the door is open signifying that the door is open for attacks and must be close to activate the locking system again. The enroll feature happens only when the user is inside the room or establishment, assuming the requesting user's fingerprint is indeed enrolled in the system. After verification of the user's fingerprint, the system will prompt that the user is logged in and the enroll feature is now enabled. Upon enrolment, it will again verify the fingerprint to be enrolled by capturing three samples of the fingerprint and add it into the system prompting the fingerprint number for both the door lock system and the fingerprint device.

The system was made possible with the use of Maxis Biometrics SM630 fingerprint module equipped with an optical fingerprint sensor, high performance DSP processor and Flash and can perform fingerprint deletion, fingerprint verification and fingerprint addition. The SM630 module algorithm was specially designed according to the image generation theory of the optical fingerprint collection device which has excellent correction and tolerance to deformed and poor-quality fingerprint. In which fingerprint recognition or authentication's two major classes of algorithms, minutia and pattern, was used together with the optical sensor. Optical sensor imaging involves capturing a digital image using visible light when the finger is placed in the touch surface where beneath that surface is a light-emitting phosphor layer responsible in illuminating the surface of the finger and when the light reflected from the finger passes through the phosphor layer to an array of solid state pixels that captures a visual image of the fingerprint.

Fingerprint matching is key for this design to be operational and matching algorithms are used to compare previously stored templates of fingerprint against candidate fingerprints for authentication purposes. The pattern-based or image-based algorithms compare the basic fingerprint patterns such as the arch, whorl and loop between a previously stored template and a candidate fingerprint. For this algorithm to work properly, it requires that the images must be aligned in the same orientation and doing this, the algorithm finds a central point in the fingerprint image. With this algorithm, the template contains the type, size, and orientation of patterns within the aligned fingerprint image. Thus, the candidate fingerprint image is graphically compared with the template to determine the degree to which they match.

PROTOTYPE DEVELOPMENT

Figure 3-5 USB Host Kit

The VNC2 USB Host kit with a preloaded Vinculum Disk and Peripherals firmware enables the researchers to incorporate USB host functions and interface it with a host microcontroller which enables the prototype to communicate through a universal serial bus.

Figure 3-6 Biometric Fingerprint Reader

The biometric fingerprint reader serves as the main device for the verification of fingerprints and it has a DSP controller for easy integration with a microcontroller unit.

Figure 3-7 Microcontroller Units

The microcontroller unit is in charge of receiving data from the VDIP USB Host and also sends out signal to the relay to control the solenoid and buzzer upon locking and unlocking of the door.

Figure 3-8 Relay Modules

The relay is used for triggering the state of a component in the device which waits for the microcontroller unit to send a signal to the relay to activate a component. This module would trigger the solenoid whether to open the door or not.

Figure 3-9 Universal Serial Bus

Universal Serial Bus ports are used to accept request from the fingerprint reading device and transfer it to the microcontroller unit. USB 2.0 connection is used to allow simplified attachment of peripherals and cater the growing usage of USB connection.

Figure 3-10 Solenoids

The solenoid is used as a lock for the door in the system. It is considered as an output for the circuit as it waits a signal from the relay to latch its state.

Figure 3-11 Switches

The switches serve as the mode selector for both the system and the fingerprint device. It enables the user to select whether to verify, add or delete a fingerprint.

Figure 3-12 Resistors

Resistors are used for balancing the flow of current and are also used for pull-ups to produce proper input going through the system.

Figure 3-13 Connecting Wire

The connecting wire serves as an extension to isolate and extend the range of the components like the solenoid and the USB ports,

COMPONENT	PRICE (PHP)	QUANTITY	PRICE (PHP)
Fingerprint Reader	4500.00	1	4500.00
PIC1220	205.00	1	205.00
PIC16F877A	250.00	1	250.00
18 Pins IC Socket	7.00	1	7.00
20mHZ Crystal Oscillator	30.00	1	30.00
Push-on switch	15.00	4	60.00
2 Pins Connector	10.00	1	10.00
LCD	780.00	1	780.00
VDIP USB Host	798.00	1	798.00
Buzzer	30.00	1	30.00
Fingerprint Device Casing	35.00	1	35.00
Door Lock Casing	180.00	1	180.00
3A Transformer	375.00	1	375.00
750mA Transformer	175.00	1	175.00
Bridge Rectifier	30.00	1	30.00
Battery Holder	15.00	1	15.00
Magnetic Lock	1500.00	1	1500.00
0.1 Capacitor	5.00	2	10.00
Total			8990.00

Table 3-1 Component Price Listing

Chapter 4

TESTING, PRESENTATION, AND INTERPRETATION OF DATA

Functionality Test

The system can verify whether the scanned fingerprint is enrolled or not and has add and delete fingerprint functions for registered fingerprints. The researchers tested the features of the USB door lock system: Verify and Enroll fingerprints.

Procedure for the verification feature:

1. First, plug the system and make sure it is functioning properly without errors seen in the LCD.
2. Turn on the fingerprint reading device.
3. Insert the device into the system.
4. Push the verify button and wait for the fingerprint scanner to light up.
5. Once the scanner lights up scan the fingerprint and wait if the door opens or not.
6. Repeat step 3 every time a user access the door lock.

Procedure for the enrollment feature:

1. First, plug the system and make sure it is functioning properly without errors seen in the LCD.

2. Turn on the fingerprint reading device.

3. Make sure you are inside the room or establishment then insert the device into the system.

4. Push the verify button in the system and in the device, respectively, and wait for the fingerprint scanner to light up.

5. Once the scanner lights up scan the fingerprint and wait if the LCD indicates that the user is logged in.

6. Push the add button and wait until the device lights up.

7. Scan the new fingerprint thrice and wait until the LCD indicates the fingerprint number for both the system and the fingerprint reading device.

8. Repeat step 3 every time new a user or fingerprint is to be enrolled.

The following tables illustrate how the features of the USB Door Lock System must be tested to ensure all functionalities are working properly.

TRIAL	**VERIFICATION**	**STATUS**
1	VERIFIED	UNLOCKED
2	VERIFIED	UNLOCKED
3	VERIFIED	UNLOCKED

4	VERIFIED	UNLOCKED
5	VERIFIED	UNLOCKED
6	VERIFIED	UNLOCKED
7	VERIFIED	UNLOCKED
8	VERIFIED	UNLOCKED
9	NOT VERIFIED	LOCKED
10	NOT VERIFIED	LOCKED
11	NOT VERIFIED	LOCKED
12	VERIFIED	UNLOCKED
13	VERIFIED	UNLOCKED
14	VERIFIED	UNLOCKED
15	VERIFIED	UNLOCKED
16	VERIFIED	UNLOCKED
17	VERIFIED	UNLOCKED
18	VERIFIED	UNLOCKED
19	VERIFIED	UNLOCKED
20	NOT VERIFIED	LOCKED
21	NOT VERIFIED	LOCKED
22	VERIFIED	UNLOCKED
23	VERIFIED	UNLOCKED
24	VERIFIED	UNLOCKED

25	VERIFIED	UNLOCKED
26	NOT VERIFIED	LOCKED
27	VERIFIED	UNLOCKED
28	VERIFIED	UNLOCKED
29	VERIFIED	UNLOCKED
30	VERIFIED	UNLOCKED

Table 4-1 Verify Enrolled Fingerprint

Based on the results, the USB Door Lock System design prototype accurately verifies if the captured or scanned fingerprint in enrolled or not in the database. There were some instances that even if the finger is enrolled, the system won't unlock the door since the verification depends on how that specific finger was scanned during its enrollement to the system as the fingerprint reading gathers three samples of scanned fingerprint template for accuracy in which the researchers consider misplacement of fingerprint into the fingerprint reader as the cause of the problem.

TRIAL	VERIFICATION	STATUS
1	NOT ENROLLED	LOCKED
2	NOT ENROLLED	LOCKED
3	NOT ENROLLED	LOCKED
4	NOT ENROLLED	LOCKED

5	NOT ENROLLED	LOCKED
6	NOT ENROLLED	LOCKED
7	NOT ENROLLED	LOCKED
8	NOT ENROLLED	LOCKED
9	NOT ENROLLED	LOCKED
10	NOT ENROLLED	LOCKED
11	NOT ENROLLED	LOCKED
12	NOT ENROLLED	LOCKED
13	NOT ENROLLED	LOCKED
14	NOT ENROLLED	LOCKED
15	NOT ENROLLED	LOCKED
16	NOT ENROLLED	LOCKED
17	NOT ENROLLED	LOCKED
18	NOT ENROLLED	LOCKED
19	NOT ENROLLED	LOCKED
20	NOT ENROLLED	LOCKED
21	NOT ENROLLED	LOCKED
22	NOT ENROLLED	LOCKED
23	NOT ENROLLED	LOCKED
24	NOT ENROLLED	LOCKED
25	NOT ENROLLED	LOCKED

26	NOT VERIFIED	LOCKED
27	NOT VERIFIED	LOCKED
28	NOT VERIFIED	LOCKED
29	NOT VERIFIED	LOCKED
30	NOT VERIFIED	LOCKED

Table 4-2 Verify Not Enrolled Fingerprint

Based on the results for the verification of not enrolled fingerprints, the USB door lock system design prototype accurately verify that the captured or scanned fingerprint is not in the memory or enrolled into the system. This proves that the design can secure places where it will be installed with 100% accuracy in verifying intruders or untrusted access.

TRIAL	MODE	STATUS
1	ADD TEMPLATE	ENROLLED
2	ADD TEMPLATE	ENROLLED
3	ADD TEMPLATE	ENROLLED
4	ADD TEMPLATE	ENROLLED
5	ADD TEMPLATE	ENROLLED
6	ADD TEMPLATE	ENROLLED
7	ADD TEMPLATE	ENROLLED
8	ADD TEMPLATE	ENROLLED
9	ADD TEMPLATE	ENROLLED

10	ADD TEMPLATE	ENROLLED
11	ADD TEMPLATE	ENROLLED
12	ADD TEMPLATE	ENROLLED
13	ADD TEMPLATE	ENROLLED
14	ADD TEMPLATE	ENROLLED
15	ADD TEMPLATE	ENROLLED
16	ADD TEMPLATE	ENROLLED
17	ADD TEMPLATE	ENROLLED
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20	ADD TEMPLATE	ENROLLED
21	ADD TEMPLATE	ENROLLED
22	ADD TEMPLATE	ENROLLED
23	ADD TEMPLATE	ENROLLED
24	ADD TEMPLATE	ENROLLED
25	ADD TEMPLATE	ENROLLED
26	ADD TEMPLATE	ENROLLED
27	ADD TEMPLATE	ENROLLED
28	ADD TEMPLATE	ENROLLED
29	ADD TEMPLATE	ENROLLED
30	ADD TEMPLATE	ENROLLED

Table 4-3 Enroll New Fingerprint

Based on the gathered data for enrolling a new fingerprint template into the system, new fingerprints can be accurately enrolled into the system given that the user has admins rights the user's fingerprint is already enrolled where testing results for verifying enrolled fingerprints are shown in Table 4-1.

Impact Analysis

This design may further improve the security system of the dormitory and will also have an impact with the people's safety, security to be more specific. This is in terms of aiding the target customer's need of improving its rooms' security system in implementing a USB door lock with a separate fingerprint reading device for fingerprint authentication in gaining access that is only entitled to the occupants of the room. The design solution is also not comprised of harmful material that may affect the environment where the system is installed.

Chapter 5

CONCLUSION AND RECOMMENDATION

Conclusion

There is a lot of existing door locks using biometric fingerprint technology and most of them integrate the fingerprint device into the door lock itself. In which the researchers of this USB Door lock separates the fingerprint reading device and preserving the principle of having a tangible device to be used as the key. This paper also achieved its objective that a fingerprint reader and a microcontroller controlled door lock can be interfaced to use USB as its main connection. This design also proves that it can improve the level of security of establishments using the mechanical door locks through the uniqueness each person's fingerprint. The testing process proves that the system can accurately identify and compare fingerprint templates at a high rate whether it is to enrol a new fingerprint template or just verify if the captured template is in the memory or already enrolled. Through the use of this design, people will have an easier way of having a convenient, secured, and authorized entrance in a certain room or establishment as there would be no keys, passwords or cards will be used. Owners would just register trusted fingerprints that could enter its premises. With this system, it can automate door locks and help people especially security guards and utility men, administrators and owners to secure its premises.

Recommendation

This design project can be further improved through a more intensive development and additional features. The design aims to prove that USB door locks using biometrics fingerprint technology can accurately verify users and secure places.

First, further studies can improve the source of power especially the fingerprint reading device as it is for now battery operated. Another improvement is providing the main owner to have the capability to delete users without the verification of their fingerprints. It is also recommended to have an override button inside the room or establishment for a more convenient way of going out of the place. In addition, the researchers recommend having a delete all except the main owner in case the fingerprint numbering is messed up. Also, an additional feature of having a keypad for proper identification of the fingerprints being stored which can be a preparation in case the main owners have the capability to delete fingerprints without the verification or consent of the user's fingerprint being deleted. Additional recommendations would be utilizing a larger memory and an additional timer for dormitories with curfew hours which would disable and enable door access.

Lastly, the researchers would like to recommend reducing the size of the devices most especially the fingerprint reading device. This is to improve portability and also additional security.

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APPENDIX

A. OPERATION'S MANUAL

1. SYSTEM REQUIREMENTS

The "USB DOOR LOCK USING BIOMETRICS FINGERPRINT TECHNOLOGY" only works if the door lock system and the fingerprint reading device is turned on and the device communicates with the system through inserting it into the USB port.

2. INSTALLATION PROCEDURE

The following procedures must be followed to ensure the system works properly.

Turning on the door lock system:

1. Plug the system into an outlet.
2. Make sure the LCD displays no error.

Inserting the fingerprint reading device:

1. Make sure there is a battery is connected into the device.
2. Push the button to start up the device. Never turn on the device while it is inserted into the door lock system.
3. Wait until the blinking light stops.
4. Insert the device into the door lock system.

3. USER'S MANUAL

3.1 Plug the system into an outlet.

3.2 Make sure the LCD displays no error.

3.3 Make sure there a battery is connected into the fingerprint device.

3.4 Push the button to start up the device.

3.5 Wait until the blinking light stops.

3.6 Insert the device into the door lock system.

3.7 Push the verify button to access the door lock.

3.8 Wait until the fingerprint scanner lights up.

3.9 Place the fingerprint properly into the scanning glass.

3.10 Finish the verification and check if the door unlocks.

4. TROUBLESHOOTING GUIDES AND PROCEDURES

4.1 After turning the door lock system, check if the LCD displays an error. If yes, re-plugged the door lock system until the LCD indicates that the system is working properly

4.2 After switching on the fingerprint reading device, check if the LED lights up and blink three times. If not, push off the power button and power it on again.

5. ERROR DEFINITIONS

5.1 Door lock system LCD displays and error – there is a problem during the initialization of the VDIP USB Host

5.2 Fingerprint reading device LED does not light up – there is a problem with the push button upon triggering the device to operate

B. PICTURES OF PROTOTYPE

C. DATA SHEETS

e-Gizmo

VNC2 USB Host

Hardware Manual Rev 1r0

These days, just about anything that can be connected to a PC do so using a USB port. Before USB came into existence, adding peripherals to a PC is a job that requires the service of a skilled technician. With USB connectivity, attaching new peripherals became just as easy as plugging an appliance into an AC outlet. Any PC owner can install new USB peripherals, no special skills needed.

Not surprisingly, PC owners now have a huge selection of USB peripheral devices to choose from. From basic devices such as USB mouse and keyboards, to advance laboratory measuring equipment; even machines. And with equally countless of USB manufacturers competing to sell you the same products, prices goes as low as it can be.

With plentiful and sometimes dirt cheap USB devices all around the place, one may expect to see DIY microcontroller experimenters using these devices in their projects. But that is not what is happening. Experienced experimenters know all too well the reasons why. One is the heavy and lengthy programming code involved just to get the microcontroller to talk with USB devices. Layers upon layers of procedures and protocols are required. Even if the programmer has the patience (and all the time in the world) to do the coding, popular 8-bit microcontrollers simply lacks the processing power and memory capacity required to do such low level USB tasks.

Fortunately, one company, Future Technology Devices International FTDI, finally provided an easy with the introduction of their Vinculum chip. The second generation Vinculum II chip is a user programmable USB host chip with two integrated USB ports. FTDI provides a free software developer's kit and libraries for advance users who may want to customize the VNC2, and build a dedicated function USB host in no time at all.

For the rest of us who just want an easy to use, general purpose USB host, FTDI has prepared a general purpose USB firmware for us, the Vinculum Disk and Peripherals firmware V2DAP. This firmware is preloaded with the Vinculum USB Host kit as sold by e-Gizmo. With this kit, microcontroller experimenters can now easily incorporate USB hosts function with their circuits working with a number of USB devices, such as USB flash disk (BOMS devices), joystick (HID devices), including devices using FDTI USB to serial bridge chips and CDC devices.

e-Gizmo USB Host kit is built around FDTI Vinculum VNC2 chip, and is preloaded with V2DAP firmware.

Features

Chip: VNC2-48Q
USB Ports : Two USB Type A sockets
Interface: UART,SPI jumper selectable
Debugger Port: 1
I/Os: 25
Power Input: 5VDC
DC Power Output: 3.3V @ 100mA
Preloaded Firmware: V2DAP
PCB Size: 51W x 51L mm

HARDWARE REFERENCE

The following section briefly describes the pin-out and jumper configurations of the VNC2 USB Host. For a more complete description, please refer to the Vinculum VNC2-48 Development Module Datasheet. Downlink link to this document is listed in page 8 of this manual.

TERMINALS & INDICATORS

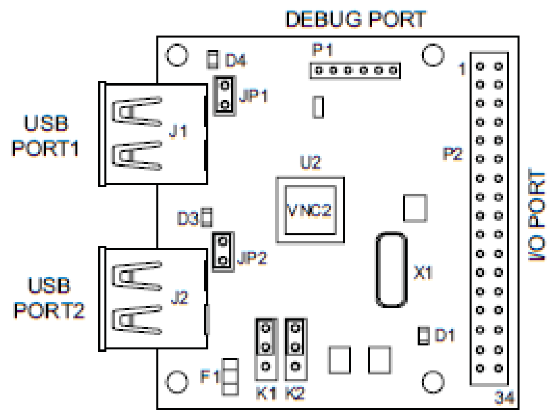


Figure 1. *VNC2 USB Host component layout showing only the LED indicators, USB and I/O ports, plus a few more components.*

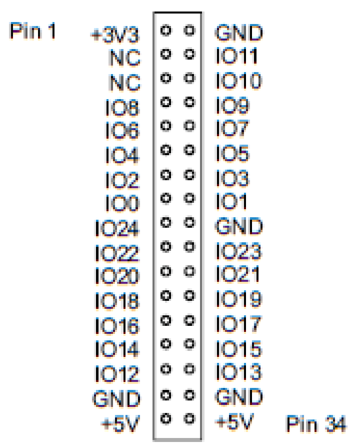


Figure 2. *I/O Port pin-out. Some of the I/Os -depending on the mode selected - are used by the V2DAP firmware for some specific function.*

Table 1 LED Indicators

COMP	ID	Description
D1	POWER	+5V Power Indicator
D3	USB2/P2	USB PORT2 selected
D4	USB1/P1	USB PORT1 selected

Table 2. I/O PORT P2

PIN	ID	VNC2 ID	REMARKS
1	+3V3		+3V3 OUT
2	GND	GND	
3	N.C.		key/no connection
4	IO11	BCBUS3	5V safe I/O, SPI_MSS
5	N.C.		key/no connection
6	IO10	BCBUS2	5V safe I/O, SPI_MMISO
7	IO8	BCBUS0	5V safe I/O, SPI_MCLK
8	IO9	BCBUS1	5V safe I/O, SPI_MMOSI
9	IO6	BDBUS6	LED D3, SPI_MISO
10	IO7	BDBUS7	5V safe I/O, SPI_SS
11	IO4	BDBUS4	5V safe I/O, SPI_CLK
12	IO5	BDBUS5	LED D4, SPI_MOSI
13	IO2	BDBUS2	5V safe I/O
14	IO3	BDBUS3	5V safe I/O
15	IO0	BDBUS0	5V safe I/O
16	IO1	BDBUS1	5V safe I/O
17	IO24	ACBUS4	5V safe I/O
18	GND	GND	Ground
19	IO22	ACBUS2	5V safe I/O
20	IO23	ACBUS3	5V safe I/O
21	IO20	ACBUS0	5V safe I/O,TX_Active
22	IO21	ACBUS1	5V safe I/O
23	IO18	ADBUS6	5V safe I/O, DCD
24	IO19	ADBUS7	5V safe I/O, RI
25	IO16	ADBUS4	5V safe I/O, DTR
26	IO17	ADBUS5	5V safe I/O, DSR
27	IO14	ADBUS2	5V safe I/O, RTS
28	IO15	ADBUS3	5V safe I/O, CTS
29	IO12	ADBUS0	5V safe I/O, TXD
30	IO13	ADBUS1	5V safe I/O, RXD
31	GND	GND	PWR Ground
32	GND	GND	PWR Ground
33	+5V	PWR	+5V Power input
34	+5V	PWR	+5V Power input

MODE CONFIGURATION

The VNC2 USB Host kit with V2DAP firmware can be interfaced to the host microcontroller three ways – by UART, SPI, or parallel FIFO. FIFO, however, is not supported in this kit when loaded with the V2DAP firmware. Advanced user may create his own firmware (or modify V2DAP) to implement FIFO if needed.

UART is by far the most popular interface. Most microcontroller supports UART interface. It is easy to use and supported by most C compilers I/O functions (e.g. printf()), but is generally slower compared to SPI and FIFO. In most applications, however, this is seldom an issue.

SPI, on the other hand, is fast, and is best used with microcontrollers with built-in SPI peripherals. Not all C compilers can readily redirect I/O functions to SPI, however. In some cases, users have to write his own code in order to transfer data via SPI.

Figure 3 illustrates the jumper settings corresponding to each mode. Each mode uses a set of I/O for its physical interface. These reserved I/Os are shown in Figure 4 labeled with their assigned functions. All unused I/Os are available for user defined functions.

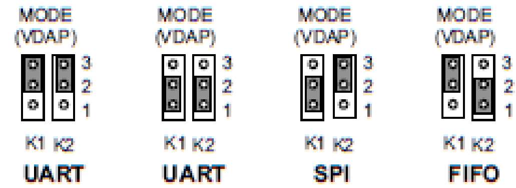


Figure 3. *Jumper configurable settings. FIFO is not available by default with the VDAP2 firmware.*

Table 3. Jumper Settings

Note: These settings are valid for V2DAP & VNC1 compatible firmware only.

K1	K2	MODE
2-3	2-3	UART
1-2	1-2	UART
1-2	2-3	SPI
2-3	1-2	FIFO (see text)

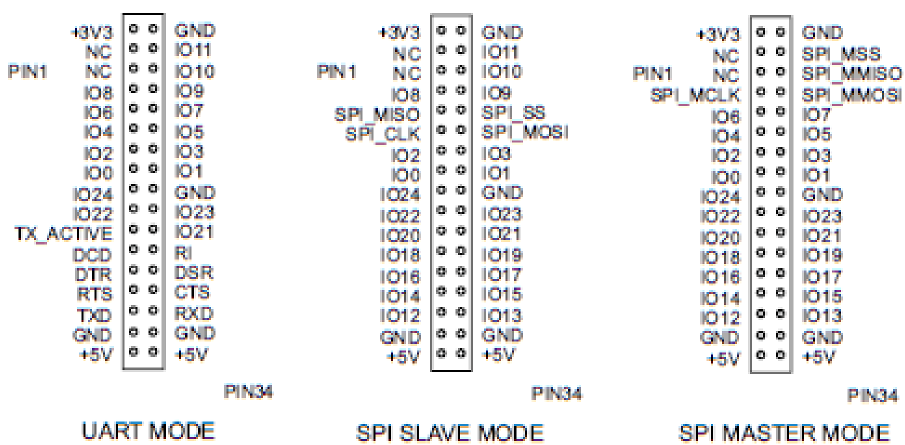


Figure 4. *Equivalent I/O pins assignment under UART and SPI Mode. SPI can be configured to work as a master or a slave. All other unused I/Os in a particular mode are available for user applications.*

Table 4. UART Mode I/O Assignment

PIN	ID	FUNCTION	TYPE	DESCRIPTION
21	IO20	TX_ACTIVE	Output	Enable Transmit Data for RS485 interface
22	IO21			
23	IO18	DCD	Input	Data Carrier Detect control input
24	IO19	RI	Input	Ring Indicator Control input
25	IO16	DTR	Output	Data Terminal Ready output, Data Acknowldge output
26	IO17	DSR	Input	Data Set Ready input, Data Request Input
27	IO14	RTS	Output	Request to Send Control output
28	IO15	CTS	Input	Clear to send Control Input
29	IO12	TXD	Output	Data Tx Output
30	IO13	RXD	Input	Data Rx Input

Table 5. SPI SLAVE Mode I/O Assignment

PIN	ID	FUNCTION	TYPE	DESCRIPTION
9	IO6	SPI_MISO	Output	Master In Slave Out, Data from slave to master
10	IO7	SPI_SS	Input	Slave chip select, active low
11	IO4	SPI_CLK	Input	Slave Clock Input
12	IO5	SPI_MOSI	I/O	Master Out Slave In, Data from master to slave

Table 6. SPI MASTER Mode I/O Assignment

PIN	ID	FUNCTION	TYPE	DESCRIPTION
4	IO11	SPI_MSS	Output	Master slave select, active low
5	N.C.			
6	IO10	SPI_MMISO	Input	Master In Slave Out, Data from slave to master
7	IO8	SPI_MCLK	Output	Master Clock output
8	IO9	SPI_MMOSI	Output	Master Out Slave In, Data from master to slave

SM630 Fingerprint Verification Module User Manual

2008-07-01

V1.0

Chapter 1 System Overview

SM630 background highlight optical fingerprint verification module is the latest release of Miaxis Biometrics Co., Ltd. It consists of optical fingerprint sensor, high performance DSP processor and Flash. It boasts of functions such as fingerprint Login, fingerprint deletion, fingerprint verification, fingerprint upload, fingerprint download, etc. Compared to products of similar nature, SM630 enjoys the following unique features:

- **Self-proprietary Intellectual Property**

  Optical fingerprint collection device, module hardware and fingerprint algorithm are all self developed by Miaxis.

- **High Adaptation to Fingerprints**

  When reading fingerprint images, it has self-adaptive parameter adjustment mechanism, which improves imaging quality for both dry and wet fingers. It can be applied to wider public.

- **Low Cost**

  Module adopts Miaxis' optical fingerprint collection device, which dramatically lowers the overall cost.

- **Algorithm with Excellent Performance**

  SM630 module algorithm is specially designed according to the image generation theory of the optical fingerprint collection device. It has excellent correction & tolerance to deformed and poor-quality fingerprint.

- **Easy to Use and Expand**

  User does not have to have professional know-how in fingerprint verification. User can easily develop powerful fingerprint verification application systems based on the rich collection of controlling command provided by SM630 module. All the commands are simple, practical and easy for development.

- **Low Power Consumption**

  Operation current <80mA, specially good for battery power occasions.

- **Integrated Design**

Fingerprint processing components and fingerprint collection components are integrated in the same module. The size is small. And there are only 4 cables connecting with HOST, much easier for installation and use.

- **Perfect Technical Support**

Miaxis is the leading company in the fingerprint verification industry. It has an excellent customer service team ready to offer powerful technical support in user development.

Chapter 2 Technical Specifications

Operating Voltage:

4.3V～6V

Rating Voltage:

6.5V（exceeding this value will cause permanent damage to the module）

Operating Current：

<80mA（Input voltage 5V）

Fingerprint Template：

768 templates

Search Time：

<1.5s（200 fingerprint, average value in test）

Power-on Time：

<200ms（Time lapse between module power-on to module ready to receive instructions）

Tolerated Angle Offset：

±45°

User Flash Memory：

64KByte

Interface Protocol:

Standard serial interface （TTL level）

Communication Baud Rate:

57600bps

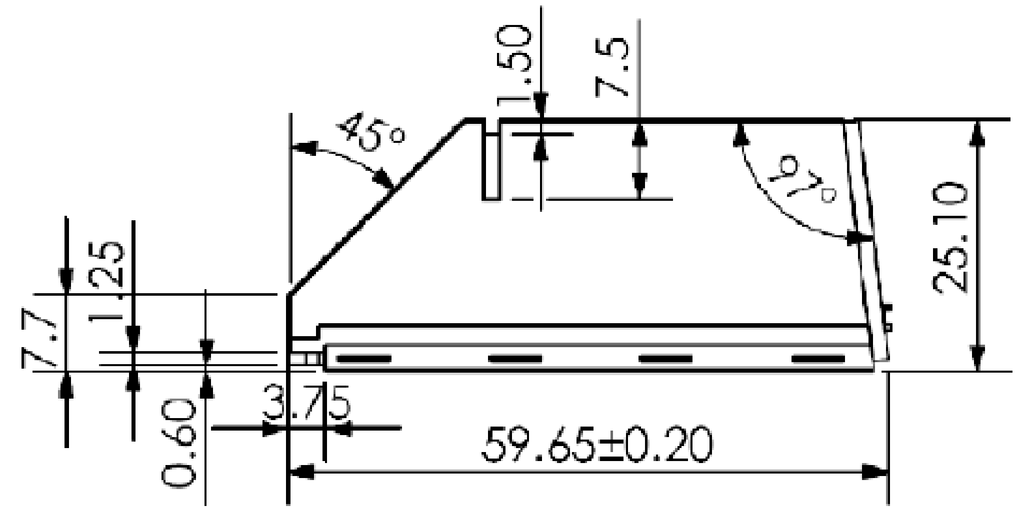
Operating Environment:

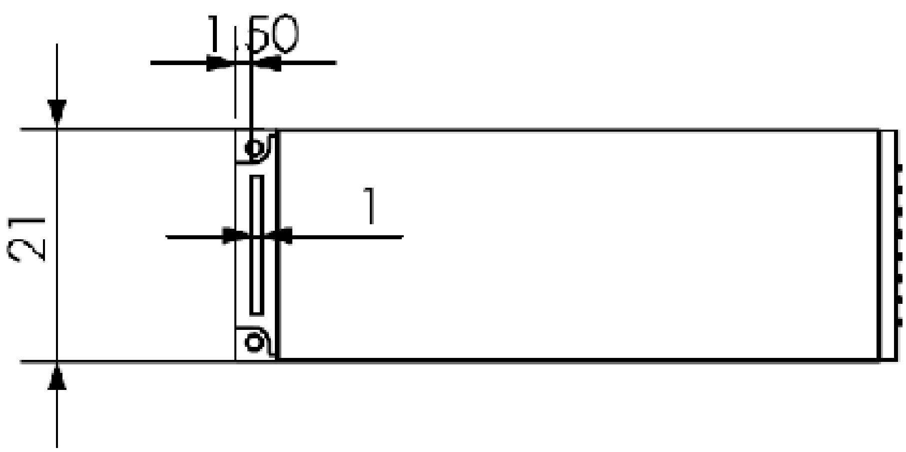
Temperature: -10℃～+40℃

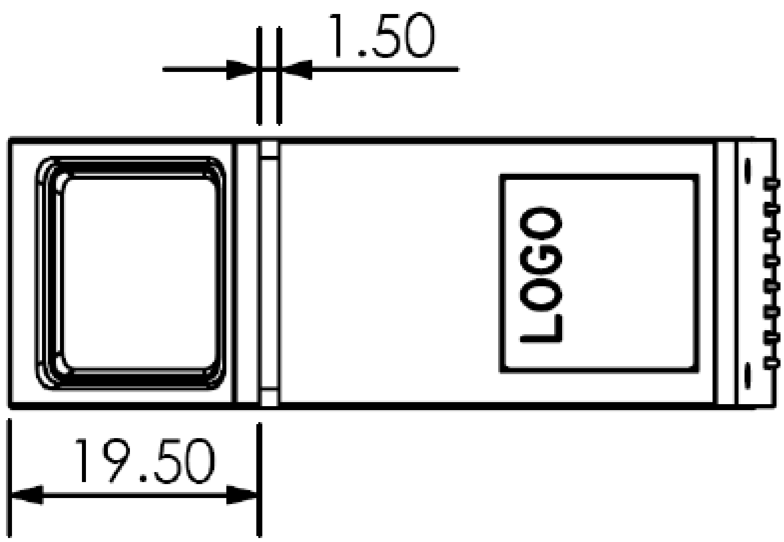
Relative humidity: 40％RH～85％RH（no dew）

Chapter 3 System Specification & Interface

3.1 Dimension



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LOGO
19.50

3.2 Electrical Interface

Module is connected to HOST via 4PIN cable. The PIN definition is as follows:

No.	PIN Definition	Remarks
1	Power supply ＋	Power supply＋
2	Module Tx	Open-drain output, need to use pull-up resistance in application (Typical value: 10KΩ)
3	Module Rx	Wide voltage input, 7V affordable
4	Power supply	Power supply －

Notes:

The PIN close to the edge of circuit board is PIN4: Power supply －.

Chapter 4 Communication Protocol

4.1 Command

No.	Name of Command	Command Code
1	Add fingerprint	0x40
2	Delete fingerprint	0x42
3	Search fingerprint	0x44
4	Empty fingerprint database	0x46
5	Search information in fingerprint database	0x4B
6	Download fingerprint template	0x50
7	Upload fingerprint template	0x52
8	Read ID number	0x60
9	Read user Flash	0x62
10	Write user Flash	0x64
11	Read product logo	0x80

4.2 Response Code

No.	Name of Command	Response Code
1	Receive correct	0x01
2	Receive error	0x02
3	Operation successful	0x31
4	Finger detected	0x32
5	Time out	0x33
6	Fingerprint process failure	0x34
7	Parameter error	0x35
8	Fingerprint matching with this ID found	0x37
9	No matching fingerprint with this ID	0x38
10	Fingerprint found	0x39
11	Fingerprint unfound	0x3A

4.3 Coding Method

The communication between HOST and Module must be coded as Communication Packet.

One communication packet includes the following:

Packet Head（2 bytes）

Packet flag（1 byte）

Packet length（1 byte）

Packet Content（N bytes）

Check sum（1 byte）

Packet head：0x4D 0x58

Packet flag：

0x10：command packet

0x20：data packet

0x21：last packet

0x30：response packet

Packet length：

Length of the Content in packet

Packet content：

Content of packet

Check sum：

Low 8 bytes of the SUM from packet head to check sum.

4.4 Brief Work Flowchart

Module waits for command from HOST after it is powered on. Module will respond by a Rx correct packet after receiving the correct command. Module will perform operations according to the command and will return corresponding information after the operation is successful. When the Module is performing operation, it will not respond to other command given by HOST. If the check sum for the received command is wrong, the module will send back receive error response.

Module receive correct packet:

0x4D + 0x58 + 0x30 + 0x01 + 0x01 + 0xD7

Module receive error packet:

0x4D + 0x58 + 0x30 + 0x01 + 0x02 + 0xD8

MICROCHIP

PIC16F87XA

28/40/44-Pin Enhanced Flash Microcontrollers

Devices Included in this Data Sheet:

- PIC16F873A
- PIC16F874A
- PIC16F876A
- PIC16F877A

High-Performance RISC CPU:

- Only 35 single-word instructions to learn
- All single-cycle instructions except for program branches, which are two-cycle
- Operating speed: DC – 20 MHz clock input
  DC – 200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  - Capture is 16-bit, max. resolution is 12.5 ns
  - Compare is 16-bit, max. resolution is 200 ns
  - PWM max. resolution is 10-bit
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I^2C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP) – 8 bits wide with external $\overline{RD}$, $\overline{WR}$ and $\overline{CS}$ controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

Analog Features:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (V_{REF}) module
  - Programmable input multiplexing from device inputs and internal voltage reference
  - Comparator outputs are externally accessible

Special Microcontroller Features:

- 100,000 erase/write cycle Enhanced Flash program memory typical
- 1,000,000 erase/write cycle Data EEPROM memory typical
- Data EEPROM Retention > 40 years
- Self-reprogrammable under software control
- In-Circuit Serial Programming™ (ICSP™) via two pins
- Single-supply 5V In-Circuit Serial Programming
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving Sleep mode
- Selectable oscillator options
- In-Circuit Debug (ICD) via two pins

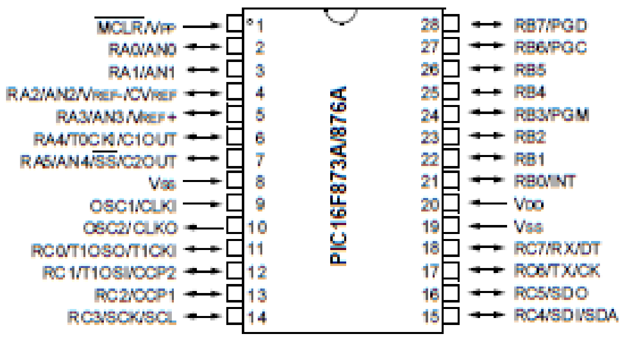
CMOS Technology:

- Low-power, high-speed Flash/EEPROM technology
- Fully static design
- Wide operating voltage range (2.0V to 5.5V)
- Commercial and Industrial temperature ranges
- Low-power consumption

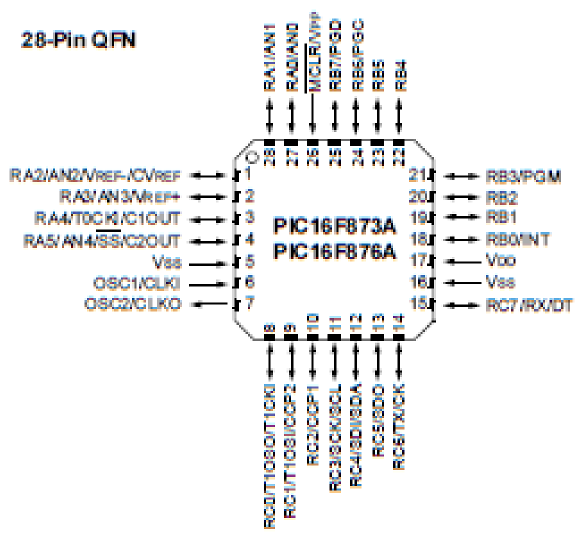
Device	Program Memory		Data SRAM (Bytes)	EEPROM (Bytes)	I/O	10-bit A/D (ch)	CCP (PWM)	MSSP		USART	Timers 8/16-bit	Comparators
	Bytes	# Single Word Instructions						SPI	Master I^2C			
PIC16F873A	7.2K	4096	192	128	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F874A	7.2K	4096	192	128	33	8	2	Yes	Yes	Yes	2/1	2
PIC16F876A	14.3K	8192	368	256	22	5	2	Yes	Yes	Yes	2/1	2
PIC16F877A	14.3K	8192	368	256	33	8	2	Yes	Yes	Yes	2/1	2

Pin Diagrams

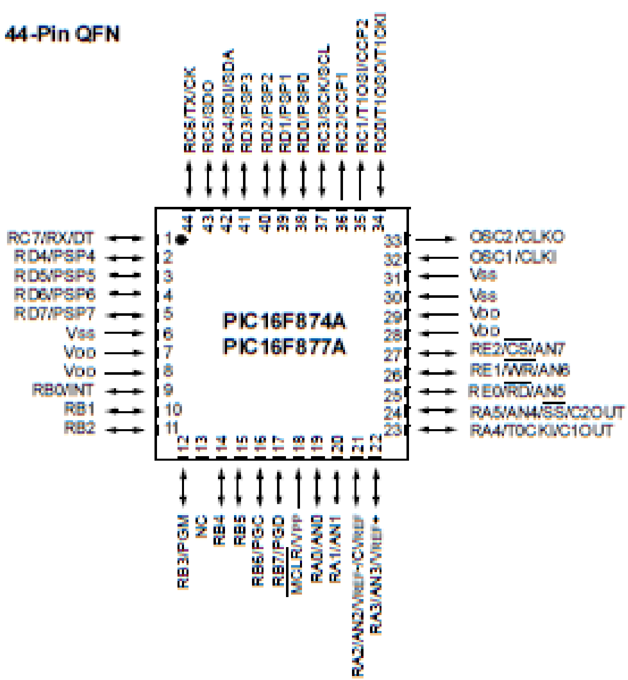
28-Pin PDIP, SOIC, SSOP



28-Pin QFN

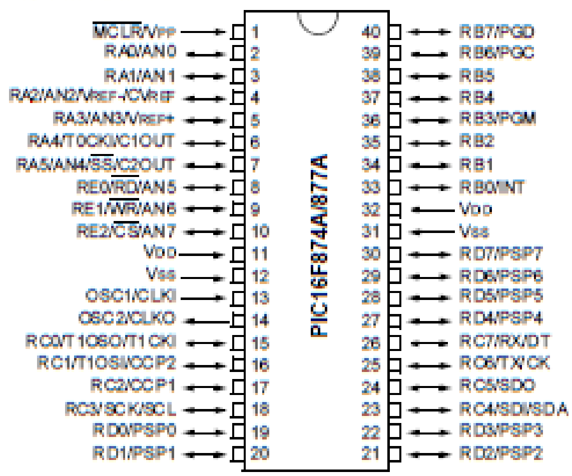


44-Pin QFN

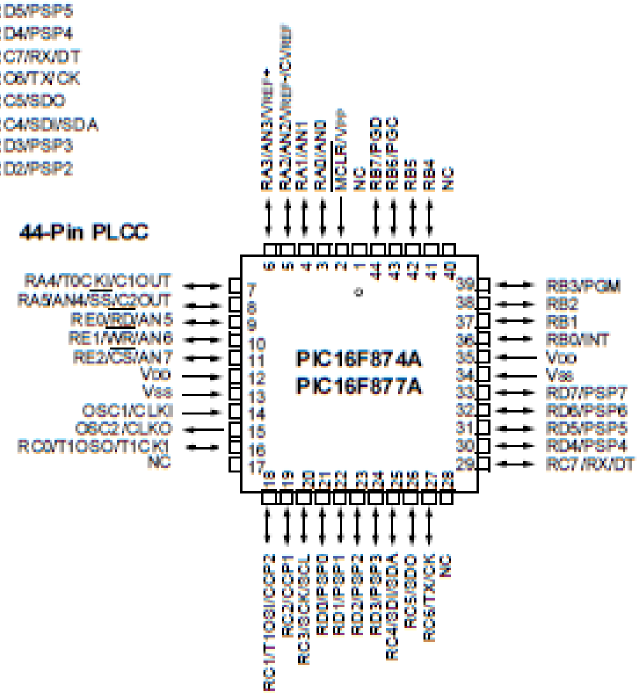


Pin Diagrams (Continued)

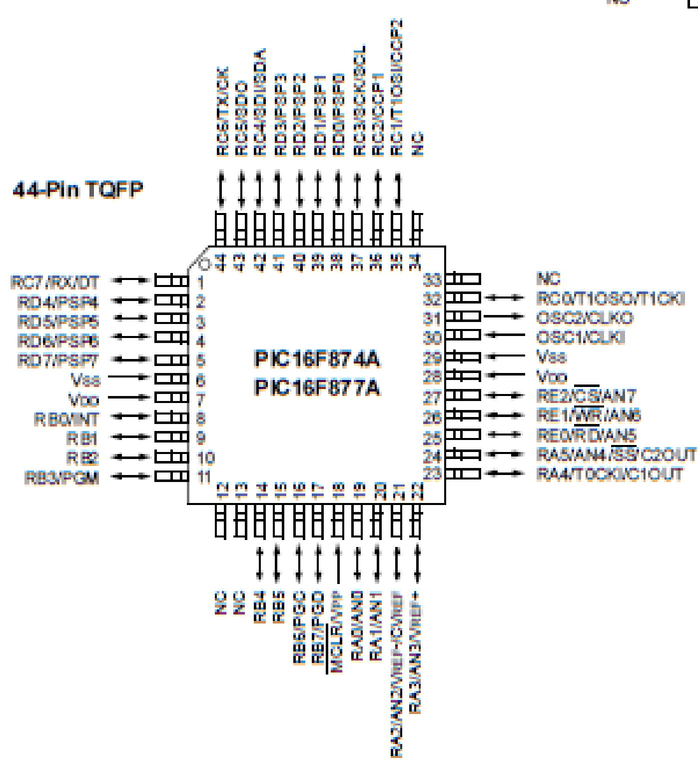
40-Pin PDIP



44-Pin PLCC



44-Pin TQFP



PIC18F1220/1320 Rev. B4 Silicon/Data Sheet Errata

The PIC18F1220/1320 Rev. B4 parts you have received conform functionally to the Device Data Sheet (DS39605**C**), except for the anomalies described below.

All of the issues listed here will be addressed in future revisions of the PIC18F1220/1320 silicon.

The following silicon errata apply only to PIC18F1220/1320 devices with these Device/ Revision IDs:

Part Number	Device ID	Revision ID
PIC18F1220	00 0111 111	00100
PIC18F1320	00 0111 110	00100

The Device IDs (DEVID1 and DEVID2) are located at addresses 3FFFFEh:3FFFFFh in the device's configuration space. They are shown in hexadecimal in the format "DEVID2 DEVID1".

1. Module: Core (DAW Instruction)

The DAW instruction may improperly clear the Carry bit (STATUS<0>) when executed.

Work around

Test the Carry bit state before executing the DAW instruction. If the Carry bit is set, increment the next higher byte to be added, using an instruction such as INCFSZ (this instruction does not affect any Status flags and will not overflow a BCD nibble). After the DAW instruction has been executed, process the Carry bit normally (see Example 1).

EXAMPLE 1: PROCESSING THE CARRY BIT DURING BCD ADDITIONS

```
MOVLW   0x80        ; .80 (BCD)
ADDLW   0x80        ; .80 (BCD)

BTFSC   STATUS, C   ; test C
INCFSZ  byte2       ; inc next higher LSB
DAW
BTFSC   STATUS, C   ; test C
INCFSZ  byte2       ; inc next higher LSB

This is repeated for each DAW instruction.
```

Date Codes that pertain to this issue:

All engineering and production devices.

2. Module: EUSART

The auto-baud measurement may not determine the correct baud rate if the ABDEN bit is set while the RB4/RX pin is low.

Work around

If the wake-up function is being used (WUE is set), wait for the RB4/RX pin to go high following a Break signal before setting the ABDEN bit.

If the wake-up function is not being used, ensure that RB4/RX is Idle (high between bytes) before setting the ABDEN bit.

Date Codes that pertain to this issue:

All engineering and production devices.

3. Module: Data EEPROM

When writing to the data EEPROM, the contents of the data EEPROM memory may not be written as expected.

Work around

Either of two work arounds can be used:

1. Before beginning any writes to the data EEPROM, enable the LVD (any voltage) and wait for the internal voltage reference to become stable. LVD interrupt requests may be ignored. Once the LVD voltage reference is stable, perform all EEPROM writes normally. When writes have been completed, the LVD may be disabled.
2. Configure the BOR as enabled (any voltage). Select a threshold below VDD to allow normal operation. If VDD is below the BOR threshold, the device will be held in Brown-out Reset.

Date Codes that pertain to this issue:

All engineering and production devices.

4. Module: EUSART

The auto-baud measurement may not determine the correct baud rate if the resulting measurement could overflow the SPBRG register when measuring slow baud rates. In such cases, SPBRGH:SPBRG will contain 0x00FF.

Work around

Either or both of the following work arounds may be used:

1. Use a faster baud rate that can not result in auto-baud measurements greater that 0x00FF.
2. Clear the BRGH bit (TXSTA<2>). This divides the bit clock by 64 rather than dividing it by 16.

Date Codes that pertain to this issue:

All engineering and production devices.

5. Module: Reset

It has been observed that in certain Reset conditions, including power-up, the first `GOTO` instruction at address 0x0000 may not be executed. This occurrence is rare and affects very few applications.

To determine if your system is affected, test a statistically significant number of applications across the operating temperature, voltage and frequency ranges of the application. Affected systems will repeatably fail normal testing. Systems not affected will continue to not be affected over time.

Work around

Insert a `NOP` instruction at address 0x0000.

Date Codes that pertain to this issue:

All engineering and production devices.

Clarifications/Corrections to the Data Sheet

In the Device Data Sheet (DS39605**C**), the following clarifications and corrections should be noted.

1. Module: CCP

In **Section 14.0 "Timer3 Module"**, bit 6 of the T3CON register was incorrectly defined as "unimplemented". The correct definition for T3CON<6> is T3CCP2 and is shown in **bold** below.

REGISTER 14-1: T3CON: TIMER3 CONTROL REGISTER

R/W-0	**R/W-0**	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
RD16	**T3CCP2**	T3CKPS1	T3CKPS0	T3CCP1	$\overline{\text{T3SYNC}}$	TMR3CS	TMR3ON
bit 7							bit 0

bit **6**, 3 **T3CCP2:T3CCP1:** Timer3 and Timer1 to CCP Enable bits

`1x` = Timer3 is the clock source for compare/capture CCP module
`01` = Reserved
`00` = Timer1 is the clock source for compare/capture CCP module

2. Module: Data EEPROM Memory

In Table 22-1 on page 254 of the Device Data Sheet, the typical value for parameter D122, Data EEPROM Erase/Write Cycle Time (TDEW) has changed. The new value is 5.5 ms and is shown in **bold** below.

TABLE 22-1: MEMORY PROGRAMMING REQUIREMENTS

DC CHARACTERISTICS			**Standard Operating Conditions (unless otherwise stated)** Operating temperature -40°C ≤ TA ≤ +85°C for industrial				
Param No.	**Sym**	**Characteristic**	**Min**	**Typ†**	**Max**	**Units**	**Conditions**
D122	TDEW	Erase/Write Cycle Time	—	**5.5**	—	ms	

D. OTHERS (Program Listing)

Fingerprint Reading Device

```
'Transmitter Module

Device 18F1220
Declare Xtal 20


Config_Start
OSC = HS        ; XT 4MHz
FSCM = On       ; Fail-Safe Clock Monitor enabled
IESO = On       ; Internal External Switch Over mode enabled
PWRT = OFF      ; Disabled
BOR = OFF       ; Disabled
WDT = OFF       ; Disabled
WDTPS = 32768   ; 1:32768
MCLRE = OFF     ; Disabled
STVR = On       ; Enabled
LVP = OFF       ; Disabled
Debug = OFF     ; Disabled
CP0 = OFF       ; Disabled
CP1 = OFF       ; Disabled
CPB = OFF       ; Disabled
CPD = OFF       ; Disabled
WRT0 = OFF      ; Disabled
WRT1 = OFF      ; Disabled
WRTB = OFF      ; Disabled
WRTC = OFF      ; Disabled
WRTD = OFF      ; Disabled
EBTR0 = OFF     ; Disabled
EBTR1 = OFF     ; Disabled
EBTRB = OFF     ; Disabled
Config_End

Declare FSR_CONTEXT_SAVE = On
Declare Watchdog = Off
Declare Hserial_Baud = 9600
Declare Hserial_RCSTA = %10010000
Declare Hserial_TXSTA = %00100100
Declare Hserial_Clear = On
Declare Unsigned_Dwords = On

Symbol myLEDGreen = PORTA.1
```

```
Symbol myLEDRed = PORTA.0

preProg:

Dim dummy As Byte
Dim dCom[2] As Byte

Dim userID As Word
Dim uiH As userID.HighByte
Dim uiL As userID.LowByte
Dim reqByte[8] As Byte
Dim repByte[8] As Byte
Dim idx As Byte, sampleCount As Byte
Dim idStat As Byte
Dim FPCSum As Byte
Dim devID As Byte
Dim uIDCtr As Byte
Dim vUsers[128] As Byte

ADCON1 = $FF
TRISA = $FC
TRISB = $F9

DelayMS 500

reqByte[0] = $F5
reqByte[1] = $0C
reqByte[2] = $00
reqByte[3] = $00
reqByte[4] = $00
reqByte[5] = $00
reqByte[6] = $0C
reqByte[7] = $F5

'GoSub hwd_Diagnostics

devID = 1
myLEDGreen = 0
myLEDRed = 0
userID = 0
idStat = 0
uIDCtr = 0

For idx = 0 To 127
```

```
    vUsers[idx] = ERead idx
    DelayMS 10

Next idx

For idx = 0 To 127

    If vUsers[idx] = 255 Then
       uIDCtr = idx
       Break
    EndIf

Next idx

For idx = 1 To 6

    myLEDGreen = ~myLEDGreen
    DelayMS 500

Next idx

myLEDGreen = 0

While 1 = 1

        If PORTB.5 = 1 Then

        DelayMS 50
        While PORTB.5 = 1
        Wend
        DelayMS 50

        txRetry:

        HSerOut["U"]

        DelayMS 50

        HSerOut ["CON"]

        HSerIn 3000, txRetry,[Str dCom\2]

        If dCom[0]="V" Then
```

```
'verify

myLEDGreen = 0
myLEDRed = 0
idStat = 0
GoSub checkFP

If idStat  = 1 Then

   myLEDGreen = 1
    myLEDRed = 0

Else

   myLEDGreen = 0
    myLEDRed = 1
    userID = 255

EndIf
 HSerOut["OK_",uiL,devID]
HSerIn[Wait("OK")]
DelayMS 1500


ElseIf dCom[0]="R" Then

'register
       myLEDGreen = 0
myLEDRed = 0

idStat = 0
GoSub checkFP

If idStat  = 1 Then
   'existing user
    myLEDGreen = 1
    myLEDRed = 0

Else
   'register this user first
    myLEDGreen = 0
    myLEDRed = 1
```

```
      For idx = 0 To 127

         If vUsers[idx] = 255 Then
           uIDCtr = idx
            Break
        EndIf

     Next idx
      'get first unoccupied memory

      userID = uIDCtr + 1
      GoSub changeFP

      If userID <> 255 Then
        EWrite uIDCtr,[1]
         vUsers[uIDCtr] = 1
         DelayMS 10
      EndIf

   EndIf

   'userID = dCom[1]



    HSerOut["OK_",uiL,devID]
   HSerIn[Wait("OK")]
   DelayMS 1500


ElseIf dCom[0]="E" Then

   'erase fingerprint
         myLEDGreen = 0
 myLEDRed = 0

   idStat = 0
   GoSub checkFP

   If idStat  = 1 Then
     'existing user
      myLEDGreen = 1
      myLEDRed = 0
           GoSub deleteFP_Single
```

```
            EWrite uiL - 1,[255]
            vUsers[uiL - 1] = 255
            DelayMS 10

      Else
        'register this user first
        userID = 255

      EndIf

       HSerOut["OK_",uiL,devID]
      HSerIn[Wait("OK")]
      DelayMS 1500


    ElseIf dCom[0]="D" Then

      'erase fingerprints
            myLEDGreen = 0
     myLEDRed = 0
       GoSub clearFP
       userID = 0
       uIDCtr = 0

       For idx = 0 To 127

         EWrite idx,[255]
         vUsers[idx] = 255
         DelayMS 10

       Next idx

       HSerOut["OK_",uiL,devID]
      HSerIn[Wait("OK")]
      DelayMS 1500

  EndIf



     myLEDGreen = 0
     myLEDRed = 0

  EndIf
```

```
Wend

Return

hwd_Diagnostics:

While 1 = 1

   HSerIn [Str dCom\2]
   HSerOut[Str dCom\2]

   If dCom[0]="V" Then

      'verify

      myLEDGreen = 0
      myLEDRed = 0
      idStat = 0
      GoSub checkFP

      If idStat  = 1 Then

         myLEDGreen = 1
          myLEDRed = 0

      Else

         myLEDGreen = 0
          myLEDRed = 1


      EndIf

   ElseIf dCom[0]="R" Then

      'register
      userID = dCom[1]
      GoSub changeFP

      HSerOut[255]
```

```
    ElseIf dCom[0]="D" Then
    'erase fingerprints

            GoSub clearFP
      HSerOut[255]

    ElseIf dCom[0]="X" Then

      Break

    EndIf


Wend

Return

checkFP:

        idStat = 0

    'indicate via LED

                        reqByte[1] = $0C
                reqByte[2] = $00
                        reqByte[3] = $00
                        reqByte[4] = $00
                        reqByte[5] = $00
                        reqByte[6] = $0C
                        'GoSub getCS

                                For idx=0 To 7

                                        SerOut PORTB.2,33,[reqByte[idx]]

                                Next idx



                        SerIn PORTB.3,32,[Str repByte\8]

                        uiH = repByte[2]
                        uiL = repByte[3]
```

```
                FPCSum = 0
        FPCSum = FPCSum ^ $0C
        FPCSum = FPCSum ^ repByte[2]
        FPCSum = FPCSum ^ repByte[3]
        FPCSum = FPCSum ^ repByte[4]
        FPCSum = FPCSum ^ $00


        If repByte[4]<>5 And repByte[6]=FPCSum Then

          idStat=1

        ElseIf repByte[4]=5 And repByte[6]=FPCSum Then

          idStat=0

                Else

                  idStat=2

                EndIf


Return

deleteFP_Single:

reqByte[1] = $04
   reqByte[2] = uiH
   reqByte[3] = uiL
   reqByte[4] = $00
   reqByte[5] = $00
   GoSub getCS

      For idx=0 To 7

            SerOut PORTB.2,33,[reqByte[idx]]

      Next idx

      'wait for scanner

      myLEDGreen = 0
      myLEDRed = 0
```

```
        For idx = 1 To 10

          myLEDRed = ~myLEDRed
          DelayMS 500

        Next idx

    myLEDGreen = 1
        myLEDRed = 0



Return

changeFP:

        'delete previous

        reqByte[1] = $04
    reqByte[2] = uiH
    reqByte[3] = uiL
    reqByte[4] = $00
    reqByte[5] = $00
    GoSub getCS

        For idx=0 To 7

                SerOut PORTB.2,33,[reqByte[idx]]

        Next idx

        'wait for scanner

        myLEDGreen = 0
        myLEDRed = 0

        For idx = 1 To 10

          myLEDRed = ~myLEDRed
          DelayMS 500

        Next idx
```

```
myLEDGreen = 1
    myLEDRed = 0


    startGettingSamples:

    sampleCount=1

    For sampleCount=1 To 3


            reqByte[1] = sampleCount
        reqByte[2] = uiH
            reqByte[3] = uiL
            reqByte[4] = $01
            reqByte[5] = $00

            GoSub getCS


                For idx=0 To 7

                    SerOut PORTB.2,33,[reqByte[idx]]

                Next idx

            SerIn PORTB.3,32,[Str repByte\8]

     repByte[4]=repByte[4]<<1

            If repByte[4]>0 Then

            myLEDGreen = 0
            myLEDRed = 1
            DelayMS 2000
            myLEDGreen = 0
            myLEDRed = 0

              userID = 255
              Break
            EndIf

    Next sampleCount
```

```
        myLEDGreen = 0
        myLEDRed = 0

Return

clearFP:

        reqByte[1] = $05
    reqByte[2] = $00
    reqByte[3] = $00
    reqByte[4] = $00
    reqByte[5] = $00
    reqByte[6] = $05
        'GoSub getCS


        For idx=0 To 7

                SerOut PORTB.2,33,[reqByte[idx]]

        Next idx

        myLEDGreen = 0
        myLEDRed = 0

        For idx = 1 To 10

          myLEDRed = ~ myLEDRed
          DelayMS 500

        Next idx

        myLEDGreen = 1
        myLEDRed = 0

        DelayMS 2000

    myLEDGreen = 0
        myLEDRed = 0

    Return

getCS:
```

```
 reqByte[6] = 0
 reqByte[6] = reqByte[6] ^ reqByte[1]
 reqByte[6] = reqByte[6] ^ reqByte[2]
 reqByte[6] = reqByte[6] ^ reqByte[3]
 reqByte[6] = reqByte[6] ^ reqByte[4]
 reqByte[6] = reqByte[6] ^ reqByte[5]

Return

End
```

USB Doorlock System

```
Remarks    On
Device 16F877A
Declare Xtal 20
Declare Watchdog = OFF
Declare FSR_CONTEXT_SAVE = On
All_Digital = True

Declare Unsigned_Dwords On

Declare LCD_DTPin PORTC.0
Declare LCD_RSPin PORTD.0
Declare LCD_ENPin PORTD.1
Declare LCD_Lines 2
Declare LCD_Interface 4

Hserial_Baud = 9600
Hserial_RCSTA = %10010000
Hserial_TXSTA = %00100100
Hserial_Clear = On

Symbol INTF = INTCON.1  ' RB0 External Interrupt Flag
Symbol INTE = INTCON.4  ' RB0 External Interrupt Enable
Symbol GIE = INTCON.7   ' Global Interrupt Enable

Symbol myLEDGreen = PORTD.2
Symbol myLEDRed = PORTD.3
Symbol myLEDYellow = PORTC.4
Symbol myLock = PORTC.5
Symbol myBuzzer = PORTB.7
Symbol Btn01 = PORTB.1
```

```
Symbol Btn02 = PORTB.2
Symbol Btn03 = PORTB.3
Symbol doorSW = PORTB.4

Dim reqFlag As Bit



On_Interrupt GoTo iHandler



GoTo mainCode

  iHandler:

    Context Save

    If INTF = 1 Then

      While GIE = 1

        GIE = 0

      Wend

      INTE = 0

      reqFlag = 1

    EndIf

  Context Restore

mainCode:

Dim SrceSize As Dword
Symbol sz01 = SrceSize.Byte0
Symbol sz02 = SrceSize.Byte1
Symbol sz03 = SrceSize.Byte2
Symbol sz04 = SrceSize.Byte3
Dim charPTR As Dword
Dim userOK As Bit
Dim uiL As Byte
```

```
Dim devID As Byte
Dim stID As Byte, stDevID As Byte
Dim gCtr As Byte
Dim modType As Bit
Dim isLogged As Bit

OPTION_REG = $02
TRISA = $FF
TRISB = $7F
TRISC = $80
TRISD = $A0
TRISE = $07

myBuzzer = 0
myLock = 0
myLEDGreen = 0
myLEDRed = 0
myLEDYellow = 0
modType = 0
isLogged = 0

DelayMS 500

'dCom defaults as V - ID Verification

AdminDetect:

Cls
Print At 1,1,"CHECKING FLASH"
Print At 2,1,"DRIVE MEMORY.."

SerIn PORTD.7,84,10000,S_DRV_ERROR,[Wait(">")]
DelayMS 1000
SerOut PORTD.6,84,[13]
SerIn PORTD.7,84, 3000,S_DRV_ERROR,[Wait(">")]
SerOut PORTD.6,84,["IPA",13]
SerIn PORTD.7,84, 3000,S_DRV_ERROR,[Wait(">")]

reqFlag = 0

INTE = 1
INTF = 0
GIE = 1
```

```
Cls

While 1 = 1

   Print At 1,1,"DOOR LOCK SYSTEM"
   Print At 2,1,"STATUS: "
   Print At 3,1,"ISLOGGED: "

   If isLogged = 1 Then

      Print At 3,11,"YES"

   Else

      Print At 3,11,"NO "

   EndIf

   If doorSW = 1 Then

      DelayMS 50

      GoSub clsLower

      myLEDGreen = 0
      myLEDRed = 0

      While doorSW = 1

         Print At 2,9,"OPENED"
         Print At 3,1,"WARNING! THE DOOR"
         Print At 4,1,"IS OPEN!"
         myLEDRed = ~myLEDRed
         myBuzzer = ~myBuzzer
         DelayMS 500

      Wend

      myLEDRed = 0
      myBuzzer = 0
      GoSub clsLower

   ElseIf doorSW = 0 Then
```

```
    Print At 2,9,"CLOSED"

  EndIf


  If Btn01 = 1 Then

    DelayMS 50

    While Btn01 = 1
    Wend

    DelayMS 50
    'add fingerprint

    While GIE = 1
      GIE = 0
    Wend

    If isLogged = 1 Then

    myLEDYellow = 1
    GoSub clsLower
    Print At 3,1,"INSERT FP DEVICE"
    Print At 4,1,"THEN PRESS BUTTON"

    HSerIn 10000, bypassAdd,[Wait("CON")]
    HSerOut["RR"]
    HSerIn[Wait("OK_"),uiL,devID]

    If uiL = 255 Then

      GoSub clsLower
      Print At 3,1,"AN ERROR OCCURED."
      Print At 4,1,"TRY AGAIN."

      myLEDRed = 0
      myLEDGreen = 0

      For gCtr = 1 To 6

        myLEDRed = ~myLEDRed
        DelayMS 500
```

```
    Next gCtr

    GoTo endAdd


EndIf
modType = 0
GoSub keyModify
HSerOut["OK"]
GoTo endAdd

bypassAdd:

GoSub clsLower
Print At 3,1,"PROCESS FAILED."
Print At 4,1,"DEVICE TIMEOUT."

myLEDRed = 0
myLEDGreen = 0


For gCtr = 1 To 6

    myLEDRed = ~myLEDRed
    DelayMS 500

Next gCtr

Else

Cls
Print At 1,1,"YOU MUST LOG IN"
Print At 2,1,"AS ADMINISTRATOR"
Print At 3,1,"TO CONTINUE."

DelayMS 3000



EndIf

endAdd:

GoSub clsLower
```

```
    myLEDRed = 0
    myLEDGreen = 0
    myLEDYellow = 0
    reqFlag = 0
    INTF = 0
    INTE = 1
    GIE = 1

ElseIf Btn02 = 1 Then

    DelayMS 50

    While Btn02 = 1
    Wend

    DelayMS 50
    'delete fingerprint

    While GIE = 1
        GIE = 0
    Wend

    If isLogged = 1 Then

    myLEDYellow = 1
    GoSub clsLower
    Print At 3,1,"INSERT FP DEVICE"
    Print At 4,1,"THEN PRESS BUTTON"

    HSerIn 10000, bypassDel,[Wait("CON")]
    HSerOut["EE"]
    HSerIn[Wait("OK_"),uiL,devID]
    modType = 1
    GoSub keyModify
    HSerOut["OK"]
    GoTo endDel

    bypassDel:

    GoSub clsLower
    Print At 3,1,"PROCESS FAILED."
    Print At 4,1,"DEVICE TIMEOUT."

    myLEDRed = 0
```

```
myLEDGreen = 0


For gCtr = 1 To 6

    myLEDRed = ~myLEDRed
    DelayMS 500

Next gCtr

Else

Cls
Print At 1,1,"YOU MUST LOG IN"
Print At 2,1,"AS ADMINISTRATOR"
Print At 3,1,"TO CONTINUE."

DelayMS 3000

EndIf

endDel:

GoSub clsLower
myLEDRed = 0
myLEDGreen = 0
myLEDYellow = 0
reqFlag = 0
INTF = 0
INTE = 1
GIE = 1

ElseIf Btn03 = 1 Then

  DelayMS 50

  While Btn03 = 1
  Wend

  DelayMS 50

  'verify fingerprint

  While GIE = 1
```

```
    GIE = 0
Wend

myLEDYellow = 1
GoSub clsLower
Print At 3,1,"INSERT FP DEVICE"
Print At 4,1,"THEN PRESS BUTTON"

HSerIn 10000, bypassIDF,[Wait("CON")]
HSerOut["VV"]
HSerIn[Wait("OK_"),uiL,devID]
GoSub keySeeker
HSerOut["OK"]
GoTo showIDF

bypassIDF:

GoSub clsLower
Print At 3,1,"PROCESS FAILED."
Print At 4,1,"DEVICE TIMEOUT."

myLEDRed = 0
myLEDGreen = 0


For gCtr = 1 To 6

    myLEDRed = ~myLEDRed
    DelayMS 500

Next gCtr

GoTo endIDF

showIDF:

GoSub clsLower
Print At 3,1,"USERID: ",Dec3 uiL
Print At 4,1,"DEV.ID: ",Dec3 devID

If userOK = 1 Then

myLEDRed = 0
myLEDGreen = 0
```

```
For gCtr = 1 To 10

    myLEDGreen = ~myLEDGreen
    DelayMS 500

Next gCtr

If isLogged = 0 Then

   isLogged = 1

Else
   isLogged = 0

EndIf


Else

myLEDRed = 0
myLEDGreen = 0

For gCtr = 1 To 10

    myLEDRed = ~myLEDRed
    DelayMS 500

Next gCtr

isLogged = 0


EndIf


endIDF:
GoSub clsLower
myLEDRed = 0
myLEDGreen = 0
myLEDYellow = 0
reqFlag = 0
INTF = 0
INTE = 1
```

```
   GIE = 1

ElseIf reqFlag = 1 Then

   HSerIn[Wait("CON")]
   HSerOut["VV"]
   HSerIn[Wait("OK_"),uiL,devID]
   HSerOut["OK"]

   GoSub keySeeker

   If userOK = 1 Then

      GoSub clsLower
      Print At 3,1,"ACCESS ALLOWED"
      Print At 4,1,"USER VERIFIED"
      GoSub operateDoor

      myLEDRed = 0
      myLEDGreen = 0
      myLEDYellow = 0

      For gCtr = 1 To 6

         myLEDGreen = ~myLEDGreen
         DelayMS 500

      Next gCtr


   Else

      GoSub clsLower
      Print At 3,1,"ACCESS DENIED"
      Print At 4,1,"UNAUTHORIZED."

      myLEDRed = 0
      myLEDGreen = 0
      myLEDYellow = 0

      For gCtr = 1 To 6

         myLEDRed = ~myLEDRed
         myBuzzer = ~myBuzzer
```

```
            DelayMS 500

          Next gCtr

        EndIf

        GoSub clsLower
        isLogged = 0
        myLEDRed = 0
        myLEDGreen = 0
        myLEDYellow = 0
        reqFlag = 0
        INTF = 0
        INTE = 1
        GIE = 1

    EndIf

Wend

keySeeker:

          SrceSize = 0
          SerOut PORTD.6,84,[13]
          SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
          SerOut PORTD.6,84, ["IPA",13]
          SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
          SerOut PORTD.6,84, ["DIR LOG.TXT",13]
          SerIn PORTD.7,84, 3000,missingLOGR, [Wait("$"), Hex sz01,
Wait("$"), Hex sz02, Wait("$"), Hex sz03, Wait("$"), Hex sz04]
          SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
          GoTo logROK
          missingLOGR:
          GoSub createLOGF
          logROK:
          SerOut PORTD.6,84, ["OPR LOG.TXT",13]
          SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]

          charPTR = 0
          userOK = 0
```

```
        If SrceSize > 0 Then

        Dec SrceSize

        For charPTR = 0 To SrceSize Step 2

            SerOut PORTD.6,84, ["SEK ",Dec charPTR,13]
            SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
            SerOut PORTD.6,84, ["RDF 1",13]
            SerIn PORTD.7,84, 3000,S_DRV_ERROR, [stID,Wait(">")]
            SerOut PORTD.6,84, ["SEK ",Dec charPTR + 1,13]
            SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
            SerOut PORTD.6,84, ["RDF 1",13]
            SerIn PORTD.7,84, 3000,S_DRV_ERROR, [stDevID,Wait(">")]


            If stID = uiL And stDevID = devID Then
             userOK = 1
              Break

           EndIf

        Next charPTR

         EndIf

           SerOut PORTD.6,84, ["SEK ",Dec SrceSize,13]
            SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
            SerOut PORTD.6,84, ["CLF LOG.TXT",13]
            SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]

Return

keyModify:
        SrceSize = 0
        SerOut PORTD.6,84,[13]
        SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
        SerOut PORTD.6,84, ["IPA",13]
        SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
        SerOut PORTD.6,84, ["DIR LOG.TXT",13]
        SerIn PORTD.7,84, 3000,missingLOGM, [Wait("$"), Hex sz01,
Wait("$"), Hex sz02, Wait("$"), Hex sz03, Wait("$"), Hex sz04]
        SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
        GoTo logMOK
```

```
missingLOGM:
   GoSub createLOGF
logMOK:
SerOut PORTD.6,84, ["OPR LOG.TXT",13]
SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]

charPTR = 0

If SrceSize > 0 Then

Dec SrceSize

For charPTR = 0 To SrceSize Step 2

     SerOut PORTD.6,84, ["SEK ",Dec charPTR,13]
     SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
     SerOut PORTD.6,84, ["RDF 1",13]
     SerIn PORTD.7,84, 3000,S_DRV_ERROR, [stID,Wait(">")]
     SerOut PORTD.6,84, ["SEK ",Dec charPTR + 1,13]
     SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
     SerOut PORTD.6,84, ["RDF 1",13]
     SerIn PORTD.7,84, 3000,S_DRV_ERROR, [stDevID,Wait(">")]

     If stID = uiL And stDevID = devID Then

      If modType = 1 Then

         'delete entry

          SerOut PORTD.6,84, ["CLF LOG.TXT",13]
          SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
          SerOut PORTD.6,84, ["OPW LOG.TXT",13]
          SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
          SerOut PORTD.6,84, ["SEK ",Dec charPTR,13]
          SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
          SerOut PORTD.6,84,["WRF 2",13,0,0]
          SerIn PORTD.7,84, 2000,S_DRV_ERROR,[Wait(">")]
          SerOut PORTD.6,84, ["SEK ",Dec SrceSize + 1,13]
          SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
          SerOut PORTD.6,84, ["CLF LOG.TXT",13]
          SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]

       EndIf
```

```
        GoTo endKM

       EndIf

    Next charPTR

    EndIf


        'Print At 3,1,Dec3 uiL
         'Print At 4,1,Dec3 devID

         'While 1 = 1
         'Wend

         If modType = 0 Then

           'add entry
            SerOut PORTD.6,84, ["CLF LOG.TXT",13]
            SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
            SerOut PORTD.6,84, ["OPW LOG.TXT",13]
            SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
            SerOut PORTD.6,84,["WRF 2",13,uiL,devID]
            SerIn PORTD.7,84, 2000,S_DRV_ERROR,[Wait(">")]
            SerOut PORTD.6,84, ["CLF LOG.TXT",13]
            SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
         EndIf

      endKM:


Return

createLOGF:


  SerOut PORTD.6,84, ["OPW LOG.TXT",13]
  SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]
  SerOut PORTD.6,84, ["CLF LOG.TXT",13]
  SerIn PORTD.7,84, 3000,S_DRV_ERROR, [Wait(">")]

Return

clsLower:
```

```
Cls
Print At 1,1,"DOOR LOCK SYSTEM"
Print At 2,1,"STATUS: "

If doorSW = 1 Then

   Print At 2,1,"STATUS: OPENED"

Else

   Print At 2,1,"STATUS: CLOSED"

EndIf

Return




operateDoor:

   myLock = 1
   DelayMS 500
   myLock = 0

Return

S_DRV_ERROR:

Cls
Print At 1,1,"DRIVE ERROR."

While 1 = 1
Wend


End
```