A FUNCTIONAL MODEL FOR A STANDALONE FINGERPRINT RECOGNITION SYSTEM

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Abstract: The paper describes a functional model for a standalone fingerprint recognition system, representing a minimum implementation to demonstrate the functionality of such system. For simplicity, the model uses only a fingerprint recognition module and a demonstration board with a PIC microcontroller. The development tools were that common used by the PIC microcontroller family.

Key words: *fingerprint recognition system, fingerprint recognition module, embedded system, microcontroller.*

I. INTRODUCTION

A functional model for a standalone fingerprint recognition system is presented, based on BioFlex 4 [1] fingerprint recognition module for the registration and identification of the fingerprints and based on PIC18F452 [2] microcontroller for the communication protocol management with the BioFlex 4 module.

This application was achieved as part as AMPRENTA project, within the Excellence Scientific Research Program of Ministry of Education and Scientific Research.

The functional model represents a minimum implementation (hardware and firmware) to demonstrate the functionality of a standalone fingerprint recognition system.

For the hardware implementation simplicity of the functional model, the PICDEM 2 PLUS demonstration board was used [3].

II. THE BIOFLEX 4 MODULE

The BioFlex 4 (figure 1) is a typical fingerprint recognition embedded system. It consists of the powerful processor and the capacitive fingerprint sensor. The BioFlex 4 executes the algorithm for fingerprint verification/ identification, communication with host and also interfaces to fingerprint sensor.

The main features of the BioFlex 4 are presented in the table 1.

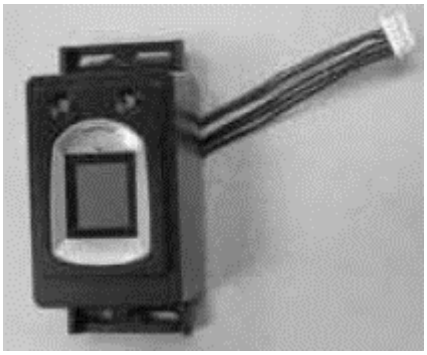

Figure 1. The BioFlex 4 Module

The parameters of the serial communication with host system are: 8 data bits, one stop bit, no parity, 9600/ 19200/ 57600/ 115200 bps baud rate, no flow control.

The BioFlex 4 module commands are presented in the table 2.

Table 1. The BioFlex 4 main features

Fingerprints store capacity in authentication mode (1:1)	999
Fingerprints store capacity in identification mode (1:N)	30
Sensor type	Semiconductor
Host interface	RS-232 (TTL)
Fingerprint sensor resolution	508 dpi
Sensor chip size	12,8 mm x 10 mm
Sensor area	11,8 mm x 9,6 mm
Pixels numbers	236 x 192
Gray level	256 (8 bits/ pixel)
Minutia size	512 bytes
False rejection rate	1/100
False acceptance rate	1/1000000
Finger allowable rotation	± 15°
ESD	18-20 kV
Scanning speed	0.2 s
Matching speed	0.1 s
1:1 recognition response time	Max. 2 s
Module dimension	20 x 58 x 30 mm
Weight	Max. 300g
Sensor temperature	-40°C~70°C
Power supply voltage	5Vcc
User's management interface	2 three colors LEDs

Table 2. The BioFlex 4 commands

A	Device version identification
B	Upload fingerprint raw image to host
C	Capture fingerprint

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Table 2. The BioFlex 4 commands (cont.)

DEL	Delete all templates in flash memory slot
E	Capture and enroll into flash memory slot
I	Identify against in flash memory slot 001...099
K	Write RAM data to flash memory slot location
L1...9	Security level setup
M	Download template to RAM
O	Verify against in flash memory slot in location
R	Capture and enroll template into RAM
S	Upload the enrollment table to host
T	Upload the template from flash memory slot to host
V	Verify against in RAM
X	Delete template in flash memory slot
Y	Delete template in RAM
0001. .9999	Change template identity
J	Upload a condensed fingerprint raw image to host
F	Change UART baud rate and control LED on/off

The BioFlex 4 responds to all commands with a text string followed by CR and LF:

Start mb: sb CR LF,

Result mb: rb CR LF,

where *sb* and *rb* can take different values, depending on the result.

After 30 s of inactivity, the BioFlex IV will enter in deep sleep mode automatically. The deep sleep mode can be terminated only by power resetting (figure 2).

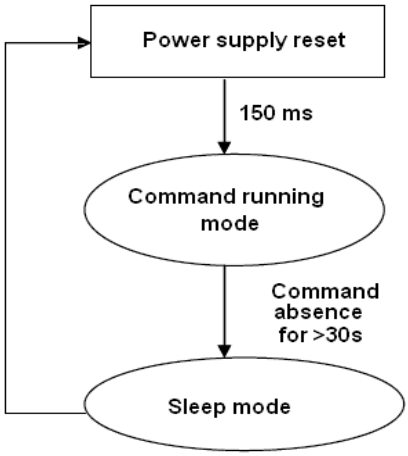

Figure 2. The sleep mode

Testing software is attending on the BioFlex 4 for firmware updating and module testing. The graphic interface of this software is show in figure 3. The testing software assures the serial port and the baud rates selecting, the module version identification, the fingerprint capture in normal or condensed format, saving and identification of captured fingerprints.

Figure 3. The Aimgene test software

Complementary testing software was supplementary developed for programming the PC and module baud rates, for sending of any command to the module, for displaying the telegrams transmitted or received on serial communication, for saving the captured fingerprints as BMP files and for displaying a BMP file (figure 4).

Figure 4. The Seektron test software

Supplementary information about the BioFlex 4 module is presented in [4].

III. THE DEMONSTRATION BOARD PICDEM 2 PLUS

For the standalone fingerprint recognition system development, the demonstration board PICDEM 2 PLUS (figure 5) was used.

The PICDEM 2 PLUS board consists of the next principal hardware elements:

1) 18, 28 and 40-pin DIP sockets;
2) on-board +5V regulator for direct input from 9V, 100 mA AC/DC wall adapter or 9V battery, or hooks for a +5V, 100 mA regulated DC supply;
3) RS-232 socket and associated hardware for direct connection to an RS-232 interface;

4) In-Circuit Debugger connector;
5) 5 kΩ potentiometer for devices with analog inputs;
6) three push button switches for external stimulus and reset;
7) green power-on indicator LED;
8) four red LEDs connected to port B;
9) jumper to disconnect LEDs from port B;
10) 4 MHz crystal oscillator;
11) unpopulated holes provided for crystal connection;
12) 32.768 kHz crystal for Timer1 clock operation;
13) jumper to disconnect on-board RC oscillator;
14) 32k x 8 Serial EEPROM;
15) 2x16 alphanumeric LCD display;
16) piezoelectric buzzer;
17) prototype area for user hardware;
18) TC74 thermal sensor.

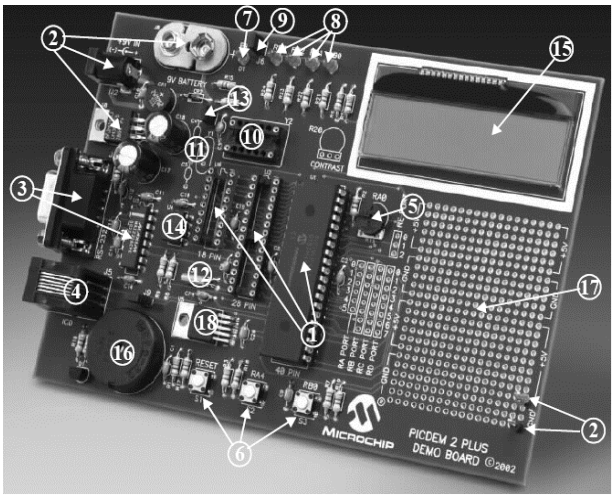

Figure 5. The demonstration board PICDEM 2 PLUS

IV. THE STRUCTURAL DIAGRAM

A structural diagram of the fingerprint recognition system based on the PIC18F452 microcontroller is show in figure 6.

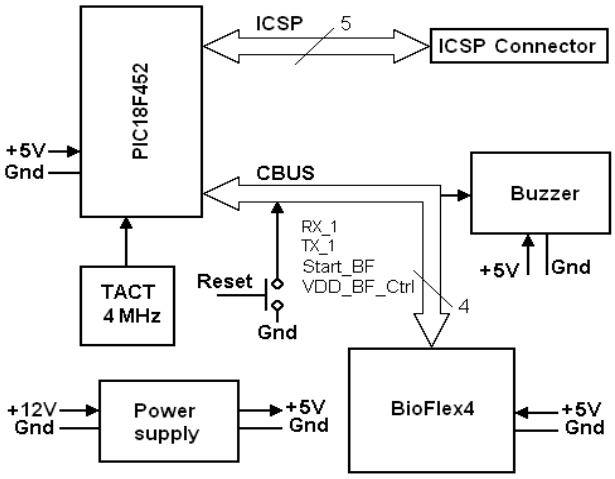

Figure 6. The structural diagram

Four signals are connected from PIC to BioFlex 4: two for the serial communication, one for the finger presence switch and one for the power reset MOSFET.

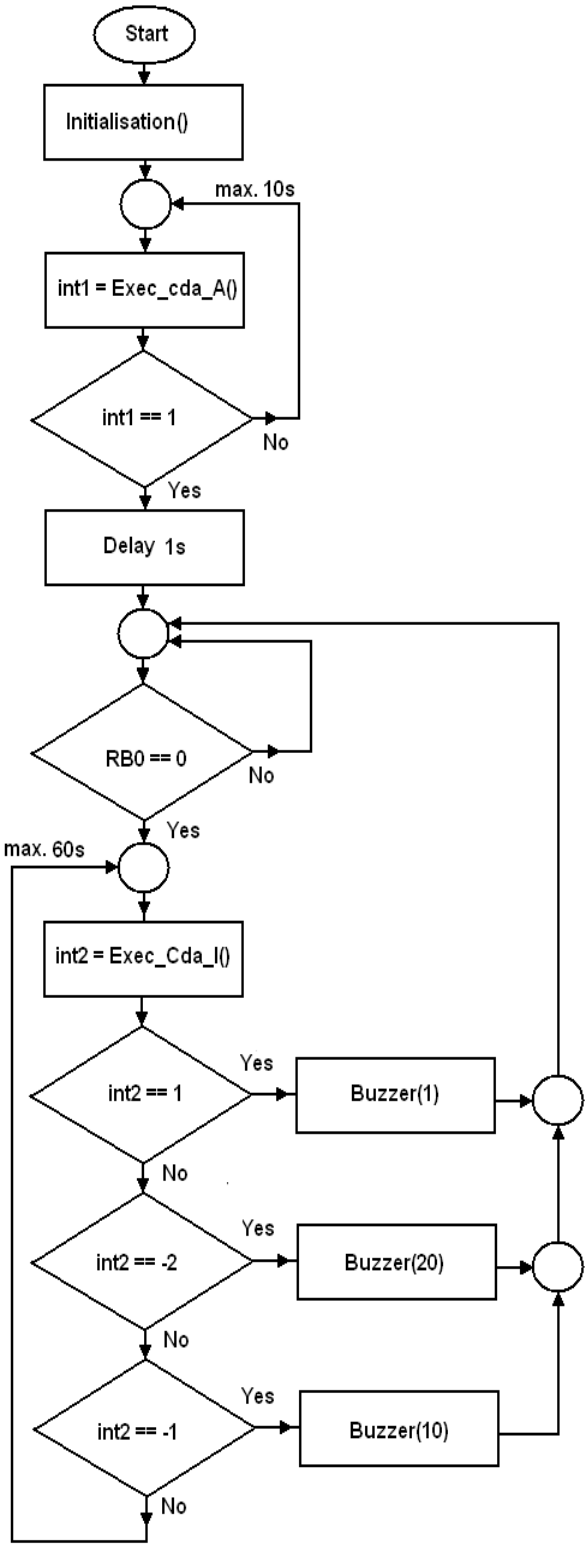

Figure 7. The logical diagram of the firmware

V. FIRMWARE CONSIDERATIONS

The firmware was developed using the C18 compiler from MicroChip [5].

A logical diagram of the firmware is show in figure 7.

It is presumed the BioFlex 4 flash memory was uploaded with the template files of the fingerprints for the persons who will use the application.

After PIC18F452 initialization, the A command (module version identification) is running as a start test.

After the successfully running of the A command and a 1 s delay, the RB0 bit which read the finger presence switch is testing.

To the finger presence on the fingerprint sensor, the I command (identify against in flash memory slot 001...099) is running. Three situations are possible, as the BioFlex 4 module is responding:

- Success, case signalized by buzzer commanding with f1 frequency signal.
- Failure, the finger presence switch is on, but the finger touches not the fingerprint sensor surface, case signalized by buzzer commanding with f2 frequency signal.
- Failure, the finger presence switch is on, the finger touches very well the fingerprint sensor surface, case signalized by buzzer commanding with f3 frequency signal (f1 < f2 < f3).

VI. CONCLUSIONS

The functional model represents a standalone fingerprint recognition system based on the BioFlex 4 module and PIC18F452 microcontroller.

The model implements only the fingerprint identification function. The BioFlex 4 module assures the fingerprint recording and identification and the PIC18F452 microcontroller manages the communication protocol with the BioFlex 4 module.

For the hardware implementation simplicity, the demonstration board PICDEM 2 PLUS was used.

MPLAB IDE v7.50 [6, 7] was the integrating development environment used, with the MPLAB C18 C compiler.

For simplicity reason too, the system response to the identification command was implemented by buzzer commanding with 3 different signal's frequencies.

During the tests performed, the model has demonstrated o very reliable fingerprint identification.

By means of BioFlex 4 all commands implementation and replacement of the demonstration board with the strict necessarily hardware, this functional model can be used to integrate the biometric security in a wide range of applications.

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