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CHAPTER III

RESEARCH METODOLOGY

This research was related to lighting control management in a room. The research was started from an idea to make a handy wireless dimmer switch panel which does not need to be wired on the wall like other wireless dimmer switch panel available in the market. Therefore, a research and several examinations were held to develop a prototype of wireless dimmer touch screen switch panel connected with ZigBee. Silicon Labs C8051F340 Microcontroller, Success Electronic Co., LTD S95361 TFT LCD Touch Display Module, and ZigBee ETRX357 built in EVB-TouchTFT400_v1.0 development board connected with ZigBee ETRX2 and a Power Source were used to build the prototype.

3.1. Design and Development of Prototype

The prototype was begun by making a general flowchart about how the system works and a circuit's block diagram about how object's main components communicate each other in the circuit. After having a brief description from the general flow chart and the circuit's block diagram about how to make the object's prototype, development of object's prototype was held.

3.1.1. Design of Prototype

3.1.1.1. General Flowchart

- *Main Function*

In the beginning, as shown in Figure 3-1, after turning on at the first time, there are some system initialization (i.e. system clock initialization, port initialization, LCD initialization, touch screen initialization, etc). Microcontroller checks if it is the first time microcontroller runs the program after reprogrammed by the developer. If it is, microcontroller

will write all the initialization needed on its flash memory, set ZigBee connection (i.e. connecting device's ZigBee to a desire PAN), set any variable value which will be needed in the device's decision-making later. If it is another run after reset executed by customers or after initialization writing process on the flash memory, microcontroller will read the flash memory and set other necessary variable values and check light bulbs' current light level by sending command through ZigBee. If the system is connected to ZigBee installed on the lamp controller and it gives feedback to the microcontroller about the bulbs' current light level, microcontroller will refresh the LCD's screen and display Main Menu page based on light bulbs' current light level. Otherwise, microcontroller will still refresh LCD's screen but it will display default light levels on Main Menu page. Either after displaying current light levels or default light levels, the system should wait for any input which is a valid touch from customers. For every first start either after reprogrammed by the developer or after reset by customers, the customers will begin from Main Menu page and Main Function ends right after customers enter Main Menu page.

- *Main Menu*

On Main Menu page (see Figure 3-2), the flow starts when customers enter the page and the system waits for customers' input on CheckTouch(), if customers pick any light switch buttons or lower/higher dimmer buttons, the system will send commands to the lamps through ZigBee and it will refresh LCD's screen and display bulbs' current light level. After that, the system will check again if there is any valid touch. If customers pick Insta-On/Off button, the system will send commands to the lamps through Zigbee to turn on/off all the lights and refresh LCD's screen to display current lights levels.

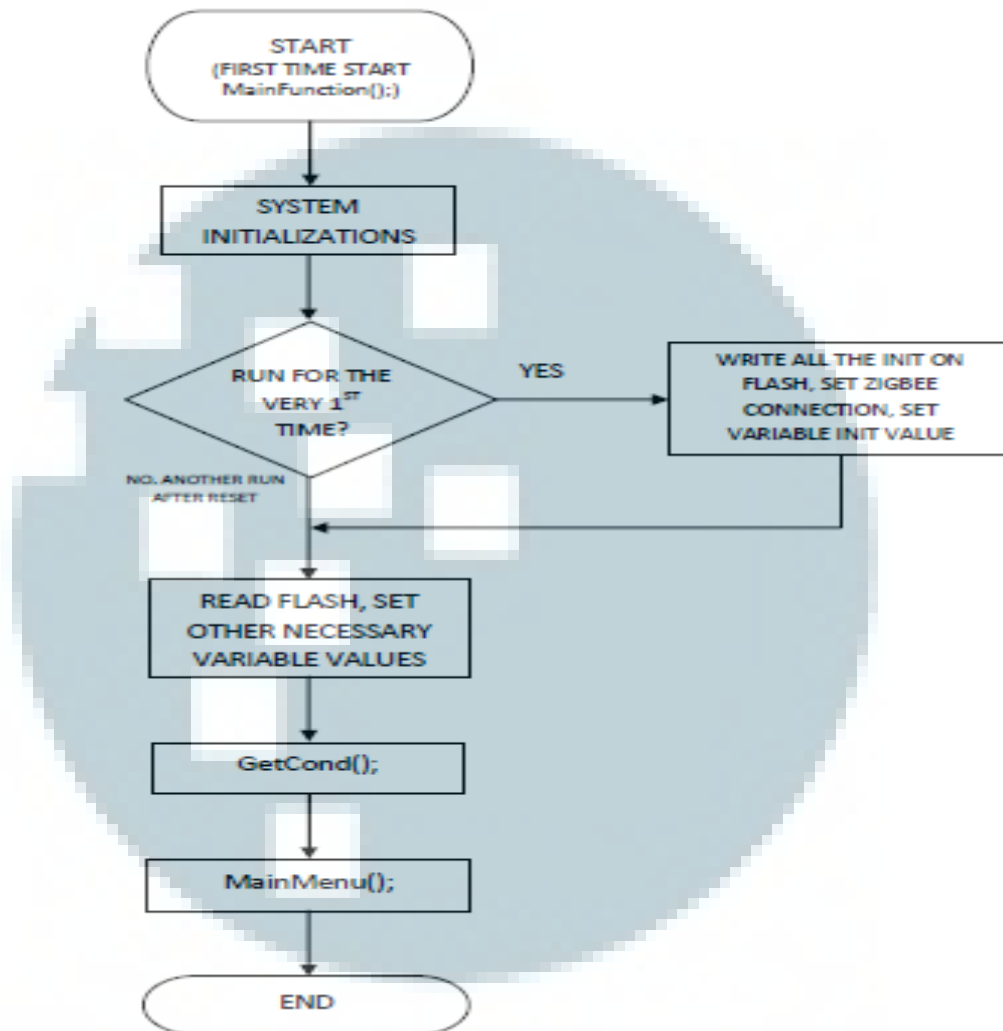


Figure 3-1 Main Function Flowchart

If customers pick Refresh button, the system will send commands to the lamps through Zigbee to get all the lights' current states and refresh LCD's screen based on the information system got just by now. If customers pick user profile button, the system will direct customers to User Profile 0/1/2 page depends on UP and flow ends. Every time customer picks either light switch buttons, dimmer buttons, InstaOn/Off button or Refresh button, the system will check the network connection on that time and collect the bulbs' information whether the connection is

still maintained and the bulbs are turned on/off or dimmed as what the customer wanted. If the connection is still maintained and the bulbs are synchronized, the system will direct the customer to Main Menu and update the display based on the bulbs' state. Otherwise, if the connection is down or error, the system will receive NACK response, direct the customer to Main Menu and display a red button on every light switch button and activate the buzzer for 100 ms. The flow ends when customers do not make any input to the system and system goes to Sleep Mode.

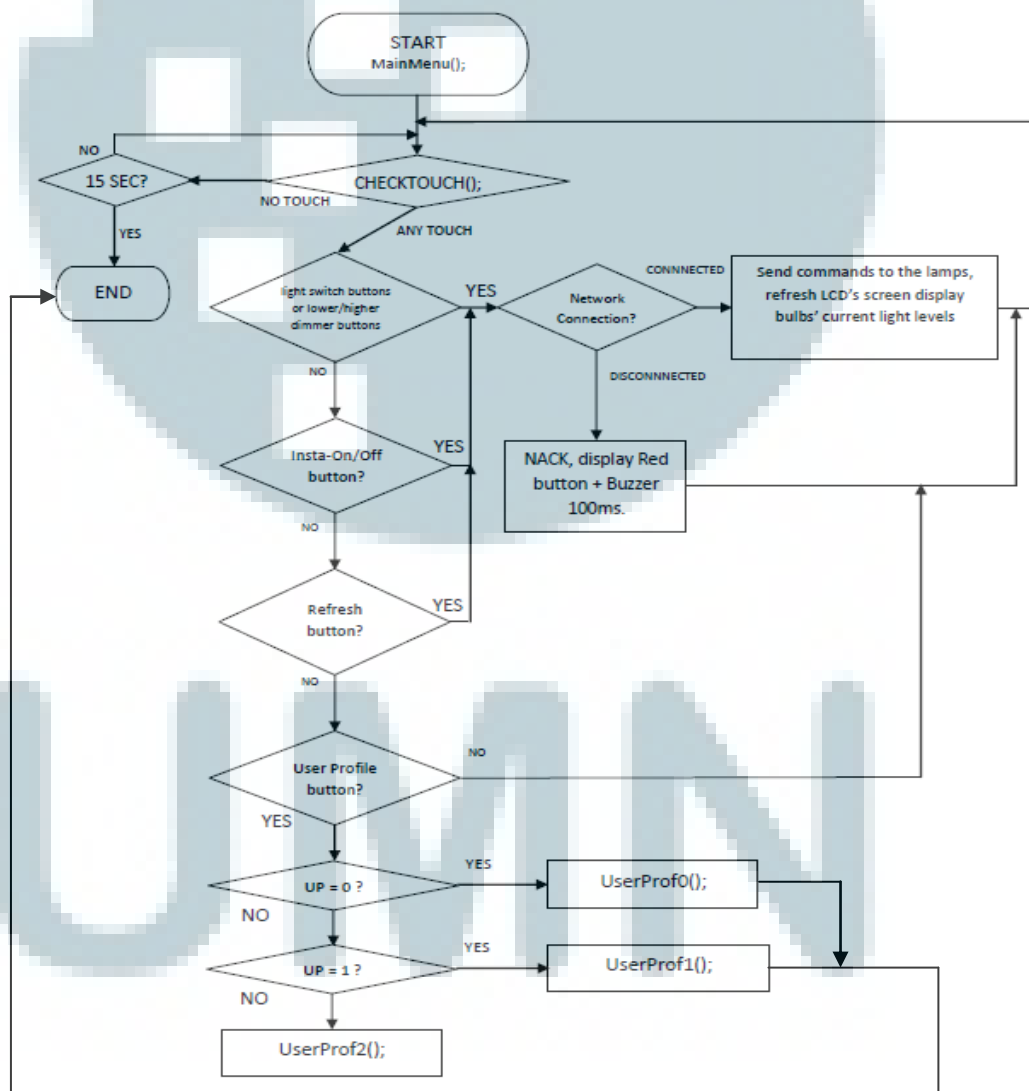


Figure 3-2 Main Menu Flowchart

- *User Profile 0*

On User Profile 0 page (see Figure 3-3), the flow starts when customers enter the page and the system waits for customers' input on CheckTouch(), if customers pick back button, the system will direct customers to Main Menu page and flow ends. If the customers pick add user profile button, the system will add one to UP variable, update the flash memory, and direct customers to User Profile 1 page and flow ends. The flow ends when customers do not make any input to the system and system goes to Sleep Mode.

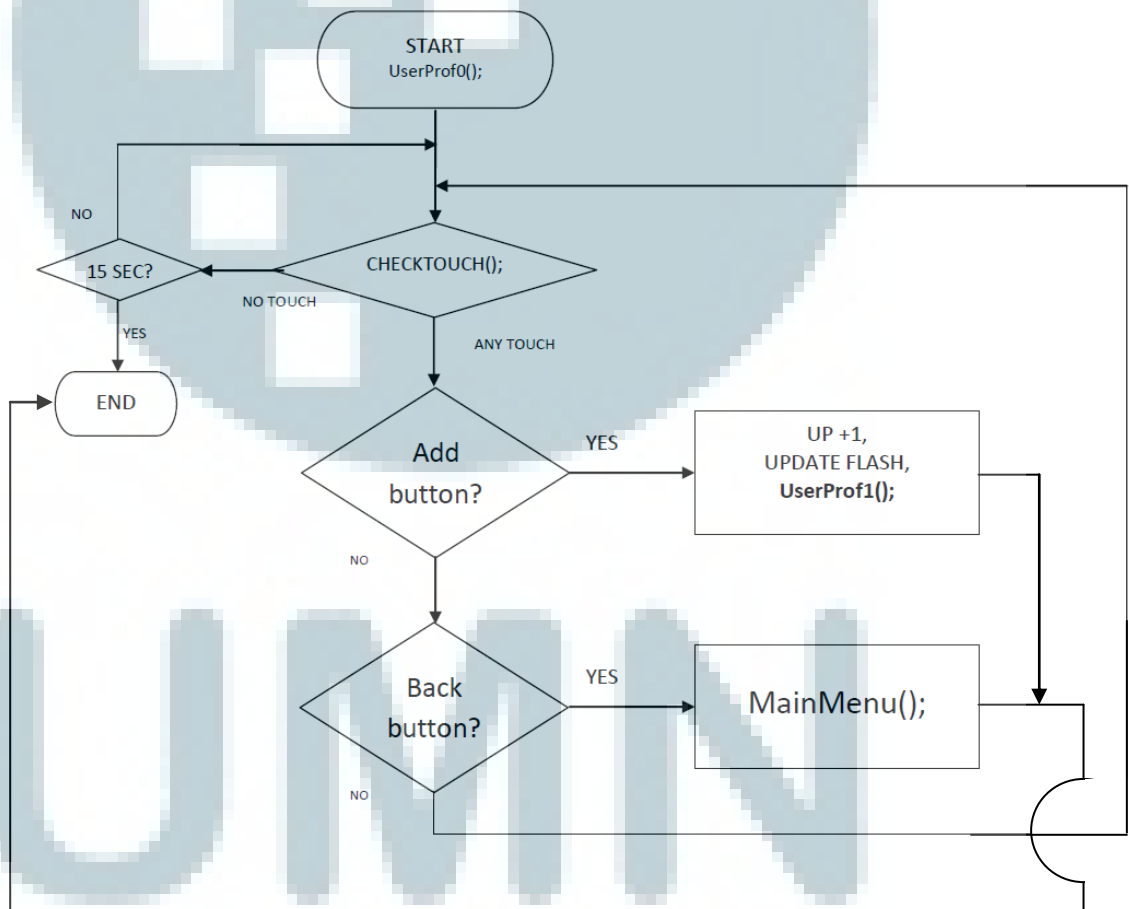


Figure 3-3 User Profile 0 Flowchart

- *User Profile 1*

On User Profile 1 page (see Figure 3-4), the flow starts when customers enter the page and the system waits for customers' input on CheckTouch().if customers pick back button, the system will direct customers to Main Menu page and flow ends. If the customers pick add user profile button, the system will add another point to UP variable, update the flash memory, and direct customers to User Profile 2 page and flow ends. If the customers pick delete button, the UP variable will become zero, update the flash memory, and the system will direct customers to User Profile 0 and flow ends. If the customers pick edit user profile button, the system will direct the customers to Edit User Profile page and flow ends. If the customer picks User Profile 1 button, the system will check the network connection on that time and collect the bulbs' information whether the connection is still maintained and the bulbs are turned on/off or dimmed as what the customer wanted on User Profile 1 preferences. If the connection is still maintained and the bulbs are synchronized, the system will direct the customer to Main Menu and update the display based on the bulbs' state and turn on the User Profile 1 indicator. Otherwise, if the connection is down or error, the system will receive NACK response, direct the customer to Main Menu and display a red button on every light switch button and activate the buzzer for 100ms and flow ends. The flow ends when customers do not make any input to the system and system goes to Sleep Mode.

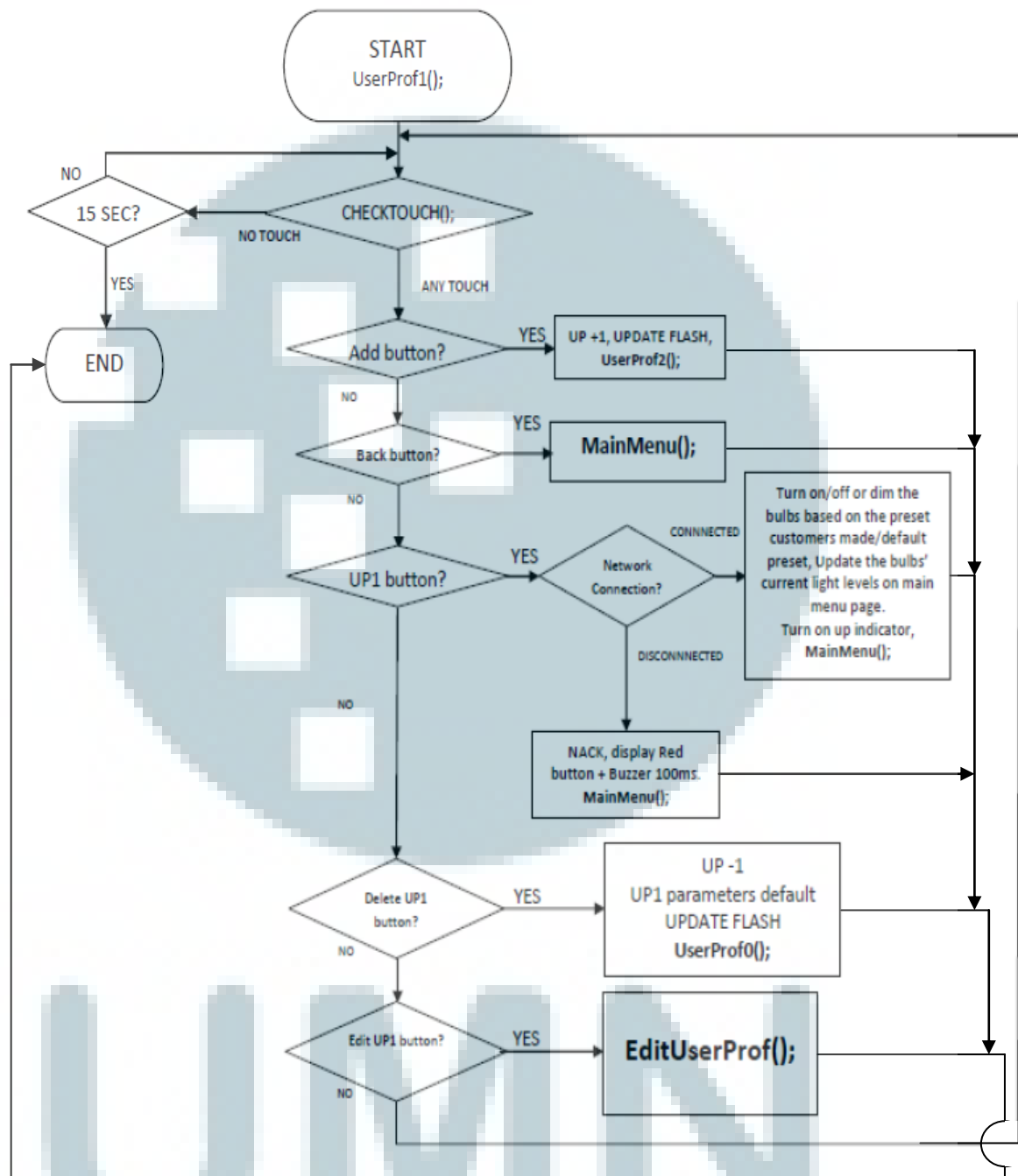


Figure 3-4 User Profile 1 Flowchart

- *User Profile 2*

On User Profile 2 page (see Figure 3-5), the flow starts when customers enter the page and the system waits for customers' input on CheckTouch(), if customers pick back button, the system will direct customers to Main Menu page and flow ends. If customers pick delete button on one of the user profiles, the system will look at which UP customers want to delete. If customers delete UP1 (user profile 1) the system will change UP1 preferences to UP2 (user profile 2) preferences and UP2 is gone. The system will update the flash memory and direct customers to User Profile 1 page. If customers delete UP2 (user profile 2) the system will just delete all of UP2 preferences, update the flash memory, and direct customers to User Profile 1 page and flow ends.

If the customer picks User Profile 1 or User Profile 2 button, the system will check the network connection on that time and collect the bulbs' information whether the connection is still maintained and the bulbs are turned on/off or dimmed as what the customer wanted on User Profile 1 or User Profile 2 preferences. If the connection is still maintained and the bulbs are synchronized, the system will direct the customer to Main Menu and update the display based on the bulbs' state and turn on the User Profile 1/2 indicator and flow ends. Otherwise, if the connection is down or error, the system will receive NACK response, direct the customer to Main Menu and display a red button on every light switch button and activate the buzzer for 100ms and flow ends. The flow ends when customers do not make any input to the system and system goes to Sleep Mode.

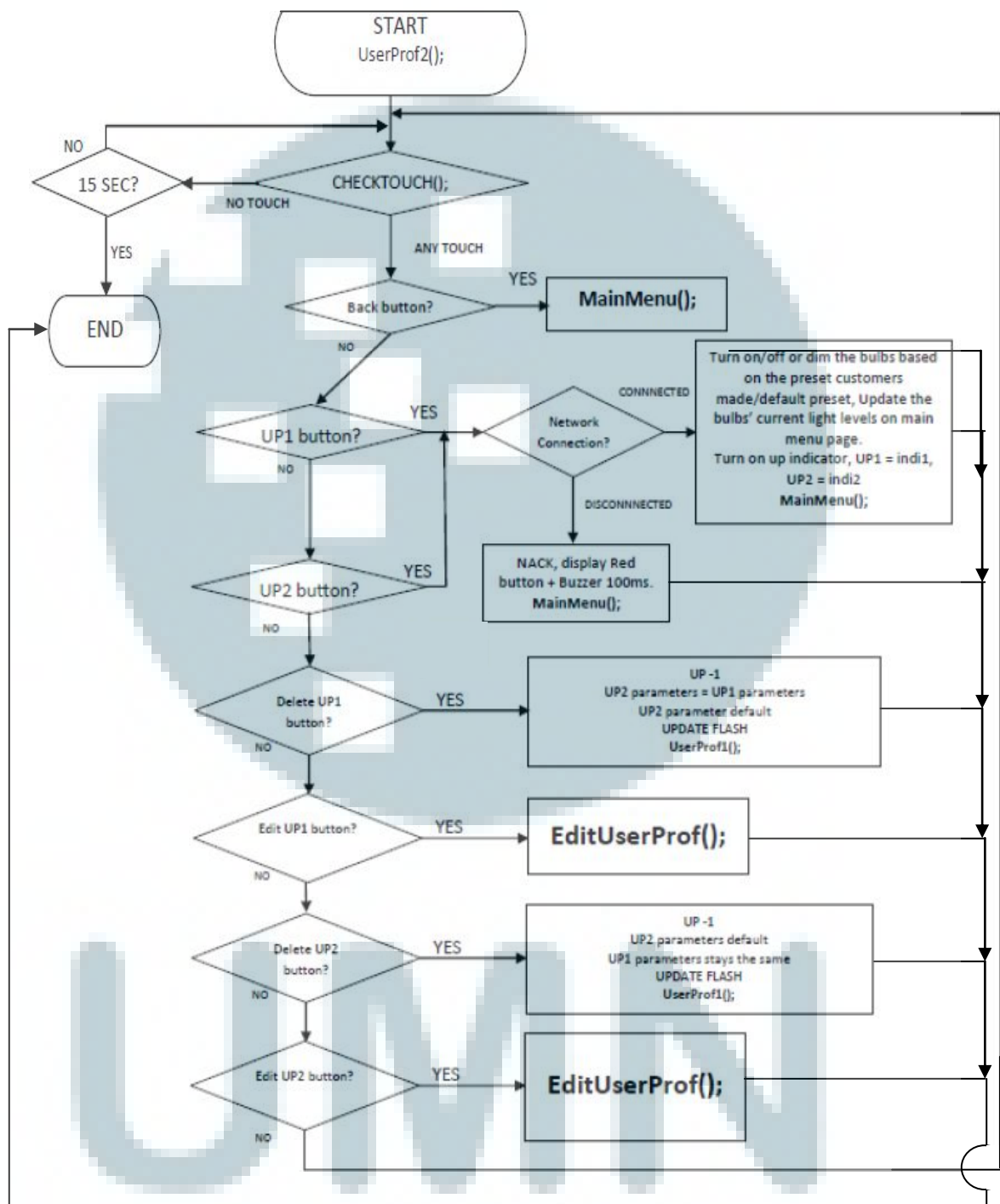


Figure 3-5 User Profile 2 Flowchart

- *User Profile Edit*

On Edit User Profile page (see Figure 3-6), the flow starts when customers enter the page and the system waits for customers' input on CheckTouch(), the system will update UP1/UP2's temporary variables whenever customers pick light switch buttons or lower/higher dimmer buttons. Either UP1 or UP2, UP1/UP2's temporary variables' default value is full brightness. Therefore, if customers press Reset button all the temporary variables' value either on UP1 or UP2 will be reset to its default value. If customers want to cancel the setting, the system will restore default UP1/UP2 temporary variables and the system will look at UP and direct customers to User Profile 1 page if UP = 1 or User Profile 2 page if UP = 2 and flow ends. If customers pick Confirm button, the system will update UP1/UP2's preference variables with UP1/UP2's temporary variables made earlier and then the system will look at UP and direct customers to User Profile 1 page if UP = 1 or User Profile 2 page if UP = 2 and flow ends. The flow also ends when customers do not make any input to the system and system goes to Sleep Mode.

- *Reset*

As shown in Figure 3-7, the flow starts when reset system occurs, if any reset occurs, the system will retrieve all the information needed (i.e. UP1's parameters, UP2's parameters, and current total of active user profile) from flash memory after any needed device's initialization and prepare the device until its stable state to be able to receive customers' input. The flow ends when the system finishes reset system and customers enters Main Function.

- *Sleep Mode*

The flow starts the system is idle for more than 15 seconds, the system will go on Sleep Mode (see Figure 3-8). The sleep mode will turn

off the ZigBee on the device, put the LCD and the microcontroller on sleep. The system will keep remain on Sleep Mode until the Reset button is pressed. When the Reset button is pressed, the system will re-initialize the microcontroller, LCD, ZigBee and all the variables and direct the customer to Main Menu page. The flow ends when customers press Reset Button.

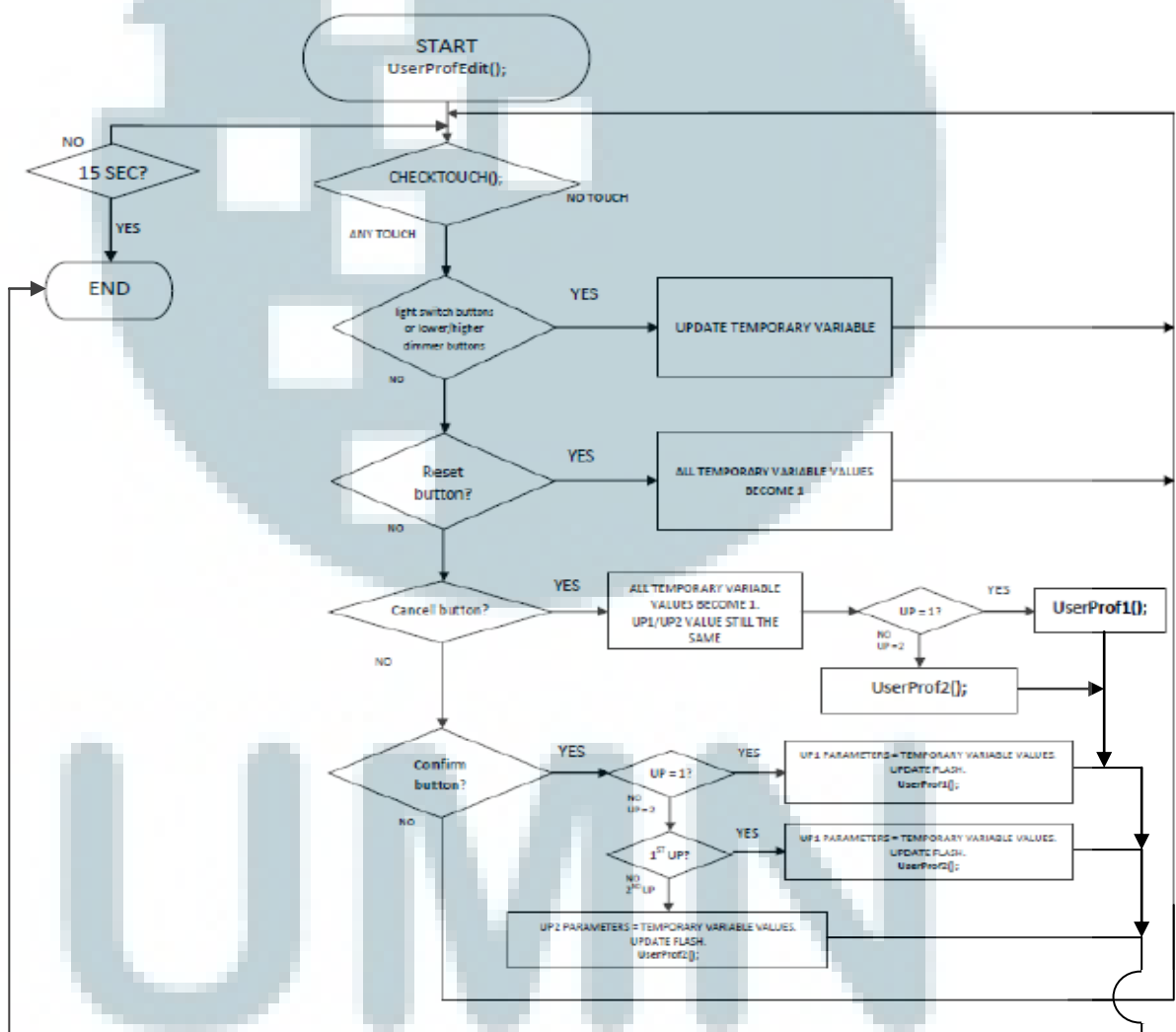


Figure 3-6 User Profile Edit Flowchart

Either on Main Menu page, User Profile 0 page, User Profile 1 page, User Profile 2 page, or Edit User Profile page, any valid touch detected by system will produce a “beep” sound from buzzer to indicate the system is active and the touch is valid. If the customer does not pick any of the buttons (i.e. customers touch the other side of the page which does not have any commands), the system will not give any actions and will wait for any other valid-touch from customers.

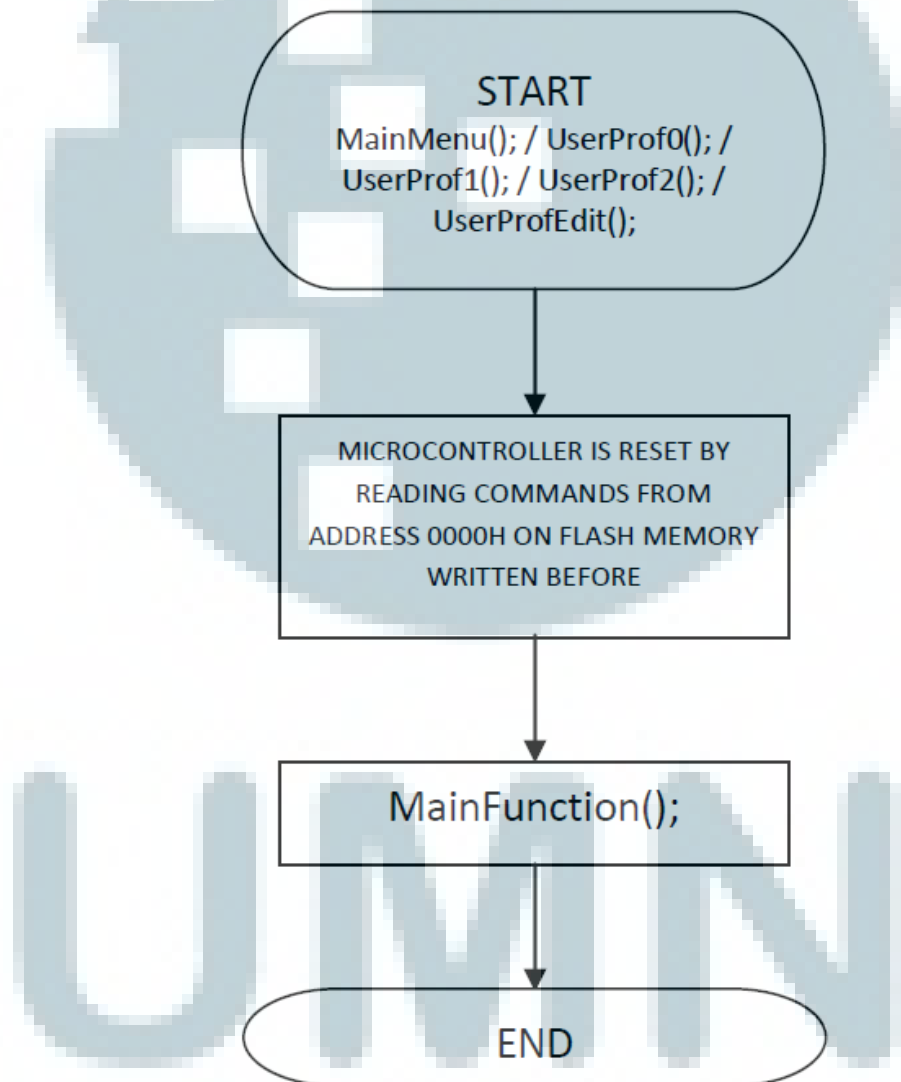


Figure 3-7 Reset Flowchart

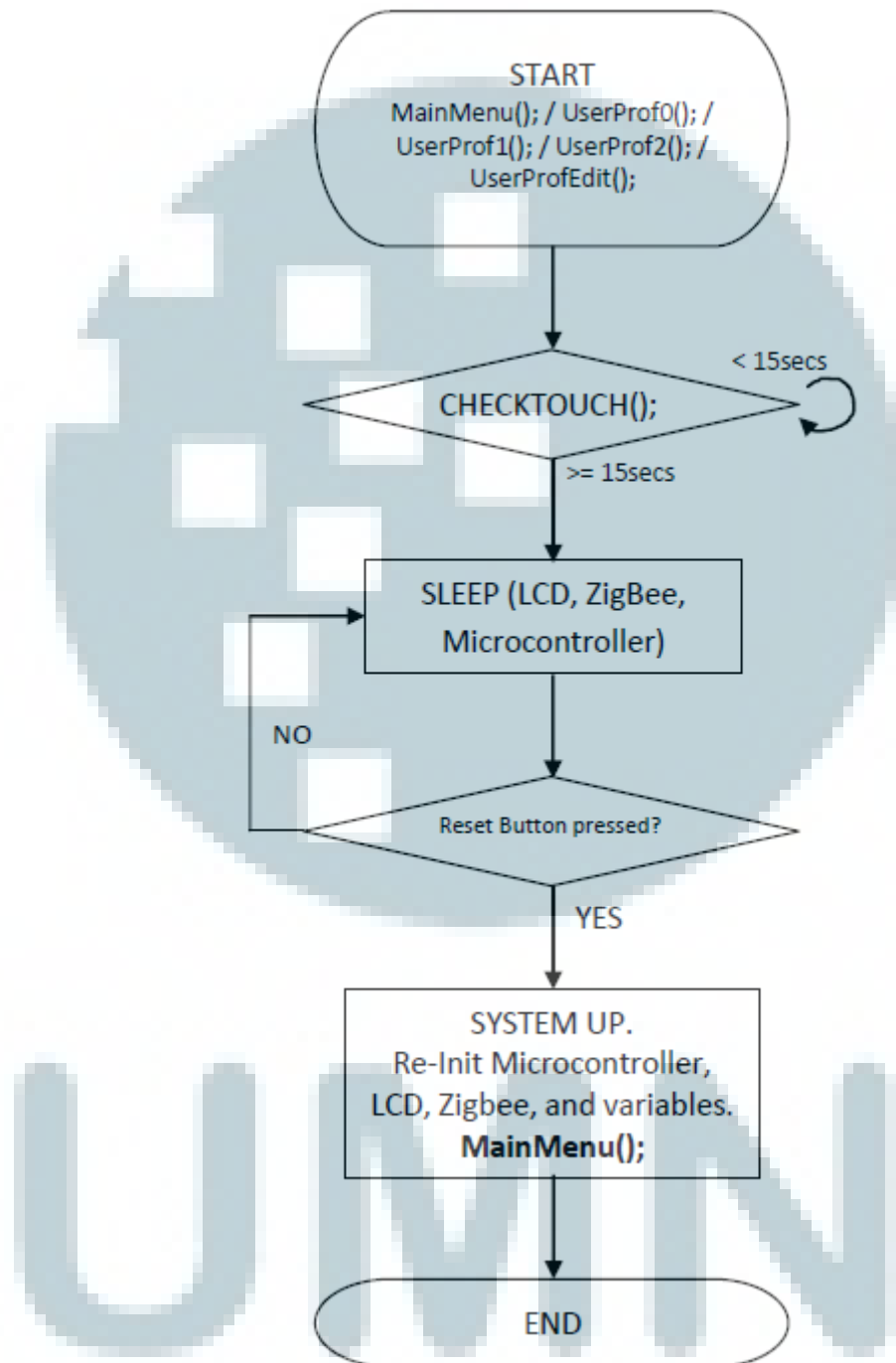


Figure 3-8 Sleep Flowchart

3.1.1.2. Circuit Block Diagram

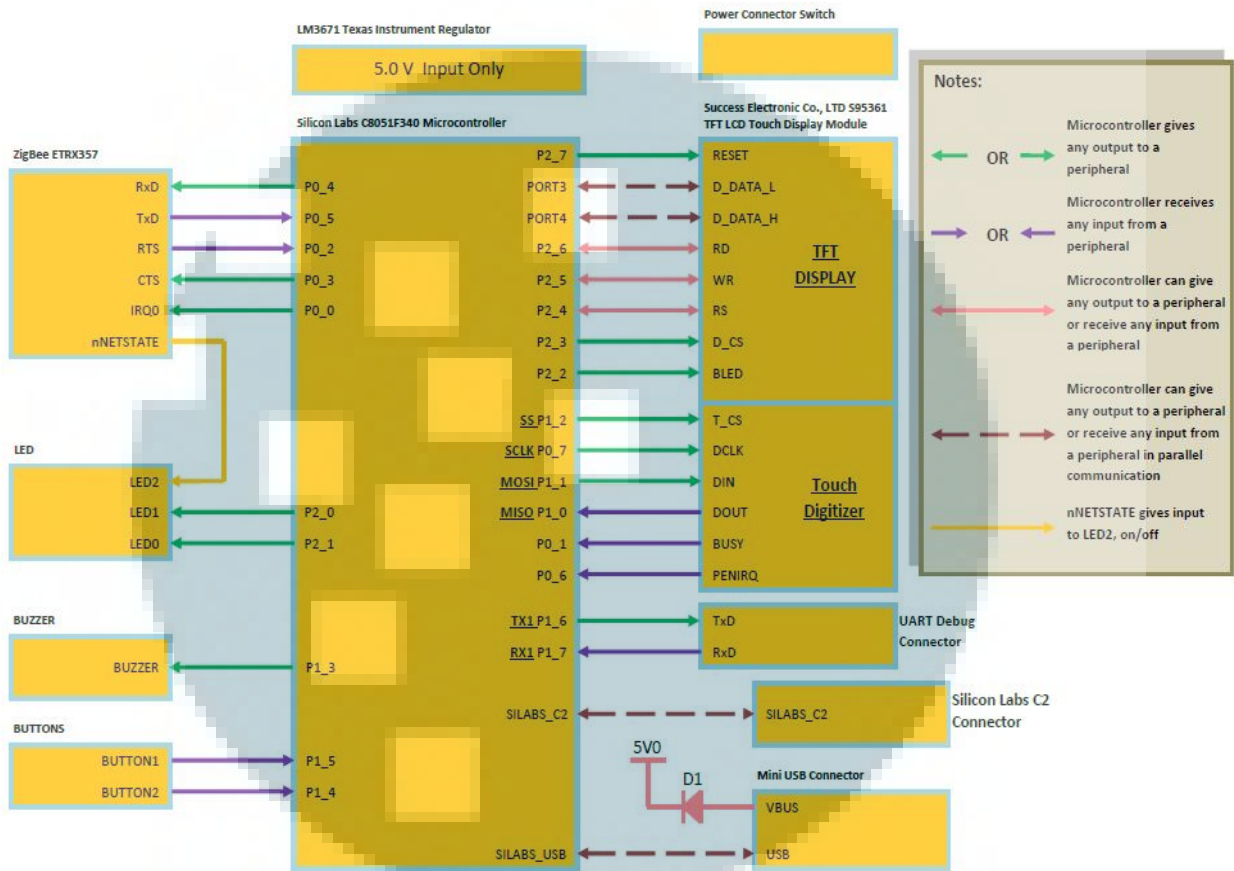


Figure 3-9 EVB-TouchTFT400_v1.0 Development Board Circuit Block Diagram

Figure 3-9 shows EVB-TouchTFT400_v1.0 development board circuit block diagram. There are ten parts in EVB-TouchTFT400_v1.0 development board connected to the Silicon Labs C8051F340 microcontroller:

- Success Electronic Co., LTD S95361 TFT LCD Touch Display Module

TFT LCD Touch's pins which maintain TFT Display (i.e. Reset, RD (Read Signal), WR (Write Signal), RS (COMMAND AND DATA REGISTER SELECT PIN), D_CS (CHIP SELECT), and BLED (Backlight)) are connected to most pins on the second port of Silicon

Labs C8051F340 microcontroller. Data is transferred through 16-bit parallel pins (i.e. D_DATA_L (8-bit) and D_DATA_H (8-bit)) bi-directionally connected to port 3 and port 4 Silicon Labs C8051F340 microcontroller. Pins for Touch Digitizer which are for Chip Select (T_CS), DIN and DOUT connected to port 1 Silicon Labs C8051F340 microcontroller. Clock (DCLK), Busy, and PENIRQ pins connected to port 0 Silicon Labs C8051F340 microcontroller because DCLK, Busy, and PENIRQ have higher priorities for interrupt sequences.

- **LM3671 Texas Instrument Regulator**

LM3671 is a step-down DC-DC converter for powering low voltage circuits from 2.5V to 3.3V from a single Li-Ion cell battery. The input voltage range is from 2.7V to 5.5V. It provides up to 600 mA load current. By using this regulator, a 5V input will be converted to a 3.3V output that can be used for EVB-TouchTFT400_v1.0 development board.

- **ZigBee ETRX357**

All pins needed to maintain how ZigBee ETRX357 works (i.e. Receiver (RxD), Transmitter (TxD), Request to Send (RTS), Clear to Send (CTS), and IRQ0) connected to port 0 Silicon Labs C8051F340 microcontroller. RTS indicates either ZigBee can receive bytes from Silicon Labs C8051F340 microcontroller or its input buffer is temporarily full. CTS will determine if Silicon Labs C8051F340 microcontroller is ready to receive bytes from ZigBee. nNETSTATE is connected to LED2 as an indicator whether ZigBee is on or off. ZigBee ETRX357 and Silicon Labs C8051F340 microcontroller communicate through UART0 in Silicon Labs C8051F340 microcontroller.

- LED.

There are three LEDs utilized in EVB-TouchTFT400_v1.0 development board (i.e. LED0, LED1, and LED2) but only two LEDs are available (i.e. LED0 and LED1) since LED2 is used for nNETSTATE on ZigBee ETRX357. LED2 will be on whenever ZigBee ETRX357 is on and vice versa. LED0 and LED1 are connected to pin P2_0 and pin P2_1 on Silicon Labs C8051F340 microcontroller. All LEDs are active low.

- Buzzer

A buzzer is connected to pin P1_3 on Silicon Labs C8051F340 microcontroller. Buzzer is active low.

- Buttons

There are two buttons available as an input media (i.e. BUTTON1 and BUTTON2). BUTTON1 and BUTTON2 are connected to pin P1_5 and P1_4 on Silicon Labs C8051F340 microcontroller. All buttons are active low.

- UART Debug Connector

UART Debug Connector makes UART 1 is available to be used in Silicon Labs C8051F340 microcontroller. TxD UART Debug Connector is connected to TX1 Silicon Labs C8051F340 microcontroller on pin P1_6 while RxD UART Debug Connector is connected to RX1 Silicon Labs C8051F340 microcontroller on pin P1_7.

- Silicon Labs C2 Connector

C2 connector is needed to link USB Debug Adapter to EVB-TouchTFT400_v1.0 development board. The USB Debug Adapter will provide the interface between the PC's USB port and the Silicon Labs C8051F340 microcontroller's in-system debug or programming

circuitry (Silicon Laboratories 2013). There are ten pins in the connector (see Figure 3-10). The adapter is powered from USB connection to the PC. The adapter is able to provide power to the EVB-TouchTFT400_v1.0 development board up to 100mA by default settings and minimum 32kHz system clock.

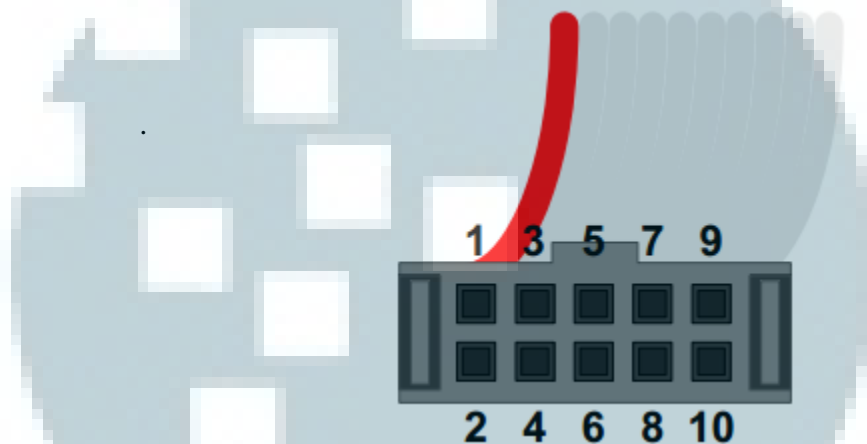


Figure 3-10 Silicon Labs C2 Connector Pins

- **Mini USB Connector**

Mini USB Connector is bi-directionally connected to SILABS_USB. The diode connected on pin VBUS Mini USB Connector shown in Figure 3-8 is utilized to protect the circuit from load current collision that might happen since there is another power supplied from USB beside power supplied on Silicon Labs C8051F340 microcontroller.

- **Power Connector Switch**

Power Connector Switch is a switch to choose the power source either battery or USB.

3.1.2. Development of Prototype

3.1.2.1. Managing Menus and Features on Success Electronic Co., LTD S95361 TFT LCD Touch Display Module

Success Electronic Co., LTD S95361 TFT LCD Touch Display Module allows the developer to display any images by converting a JPEG or JPG picture to a 16-bit TrueColor C array and save it in a global constant. In this research, another program was used to convert every image to be able to be displayed on the LCD. Whenever an image will be displayed, the system sets the address coordinates, calls its C array global constant, and takes it through asynchronous 16-bit parallel communication. Since the display image method is based on coordinate, it is important to clear the display by rewriting the background color every time the system changes page to avoid images (i.e. buttons) collision.

There are two main pages that are **Main Menu** and **User Profile** in the system. **Main Menu page** contains four light switch buttons that are used for light indicators too, either the light is off (black), full brightness (bright green), or dimmed (light green). There are lower brightness button on the left in every light switch button and higher brightness button on every its right side. There are also Insta-On/Off button on the right top of the page to instantly turn on/off all the lights, Refresh button on the left bottom of the page and User Profile button on the right bottom of the page. Refresh button is used to resynchronize the system with the lights' current state. User Profile button is used to direct the customers to User Profile page. **User Profile page** contains four pages depends on how many user profiles had been created by customers. If there is no user profile made by the customers before, system will direct the customers to User Profile 0 page. If there is a user profile made by the customers before, system will direct the customers to User Profile 1 page. If there are two user profiles made by the customers before, system will direct the customers to User Profile 2 page. The fourth User Profile page is Edit User Profile page which is used to edit User Profiles preferences from the customers. Every User

Profile page, there is a Back button that will direct the customers to Main Menu page. **On the User Profile 0 page**, there is an Add button to add a new user profile. By pressing Add button, the system will direct the customers to User Profile 1 page. **On the User Profile 1 page**, there is a user profile available. When the user profile is chosen, by default all the light will turn full brightness, unless the customers have edited its preferences earlier and when the customers go back to the Main Menu page, all the light indicators are turned full brightness. If the customers had edited User Profile 1 preferences earlier, the lights and LCD display would have turn based on customers' User Profile 1 preferences. Besides editing the User Profile preferences, system allows the customers to delete the user profile. To delete the user profile, customers can press a “trash can” button beside the user profile button. It will automatically direct customers to User Profile 0 page. To edit the user profile, customers can choose a “pencil” button besides the delete button. The edit button will direct customers to User Profile menu. To add another user profile, the customers can pick Add button on the right bottom of the page. It will direct the customers to User Profile 2 page. **User Profile 2 page** has similar abilities with User Profile 1 that customers can choose, edit, and delete the user profiles. However, customers cannot add more user profile after having two user profiles. When customers want to delete one of edited user profiles on User Profile 2 page, customers can press any delete “trash can” buttons beside the user profile buttons. If customers delete the user profile 1, then customers will be directed to User Profile 1 page with a user profile with user profile 2 preferences. Therefore, if customers want to add another user profile, the new user profile will be user profile 2 since automatically user profile 2 becomes user profile 1 and user profile 2 was vacant. **On the Edit User Profile page**, the menu appearance is similar like in Main Menu page with four light switch buttons and lower/higher dimmer buttons. But the switch buttons and lower/higher dimmer buttons in this page will not affect the lights directly because the switch buttons and lower/higher dimmer buttons in this page are purposed to set the user profile's preferences while the default value of the preferences is full brightness. If the user

profile's preferences have been done selected, customers can choose confirm (✓) button at the right bottom of the page and it will direct customers to User Profile 1 page if UP is 1 or User Profile 2 page if UP is 2 with the light's preferences chosen by the customers earlier. Therefore, if customers press the user profile button, the lights will turn on/off/dimmed based on the preferences user profile 1 or user profile 2 has. If customers want to cancel the settings on User Profile page, customers can choose cancel (X) button on the left bottom of the page and it will direct customers to User Profile 1 page if UP is 1 or User Profile 2 page if UP is 2 with default light brightness or previous lights preferences. Apart from the user profiles had made by customers, the customers are still able to change the light preferences manually by pressing switch buttons and lower/higher dimmer buttons on the Main Menu page even though they have set and chose any user profile.

3.1.2.2. Coordinating LCD Display with Touch Screen

Touch screen feature has been built in the Success Electronic Co., LTD S95361 TFT LCD Touch Display Module. Firstly, to make the touch screen working properly, it is important to know the LCD's coordinate patterns. One LCD's coordinate patterns to another's can be different. LCD's coordinate patterns can be seen through UART terminal connected with UART in microcontroller. An FTDI (Future Technology Devices International) was used as a physical media to tap data detected from touch screen on the LCD. Therefore, FTDI's Rx (receiver) pin should be connected to touch screen's DOUT (output) pin while FTDI's Tx (transmitter) pin should be connected to microcontroller's UART1 Rx pin. UART terminal will take out and display information sent through UART buffer received by UART1 Rx pin. LCD's width and height resolution should be set first. LCD's coordinates are symbolized by X and Y. X can be width and Y is height and vice versa. It is important to acknowledge minimum and maximum detectable areas (i.e. X_{min} , X_{max} , Y_{min} , and Y_{max}) at first. Besides that, raw coordinates which are symbolized by px_post and py_post can be gotten by just touching the point that is needed to be

calculated its real coordinates. Both minimum/maximum detectable areas and raw coordinates will be shown in hexadecimal in UART terminal. These raw coordinates, minimum/maximum detectable areas, and width-height resolution will be used for offset coordinates calculation. Offset coordinates are the real coordinates that will be used to locate customers' valid touch. Every valid touch customers made will have an offset coordinate. The microcontroller will check every given offset coordinate whether the given offset coordinate is on the range of any buttons' offset coordinates.

For example, it is known that the width resolution (W_{res}) is 320, height resolution (H_{res}) is 240, X_{min} is 20 (0x0014), X_{max} is 243 (0x00F3), Y_{min} is 16 (0x0010), and Y_{max} is 237 (0x00ED). A button "Z" has four points detectable area (see Figure 3-11)

A: 217 (0x00D9) as px_{post} and 139 (0x008B) as py_{post} .

B: 217 (0x00D9) as px_{post} and 110 (0x006E) as py_{post}

C: 237 (0x00ED) as px_{post} and 139 (0x008B) as py_{post}

D: 237 (0x00ED) as px_{post} and 110 (0x006E) as py_{post}

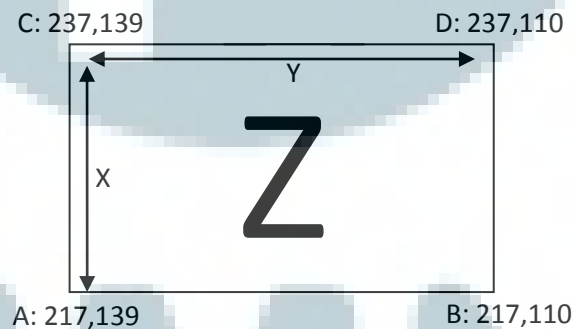


Figure 3-11 Button "Z" Detectable Area

To get an offset coordinate, there is a calculation to process raw coordinates toward LCD's resolution and minimum/maximum detectable area.

For example point "A":

X offset (x_{off})

$$\begin{aligned} & ((px_{post} - X_{min}) * W_{res}) / (X_{max} - X_{min}) \\ & ((217 - 20) * 320) / (243 - 20) \end{aligned}$$

$$\begin{aligned}
 &63040 / 223 \\
 &283 \\
 &0x011B \\
 &Y \text{ offset } (y_{\text{off}}) \\
 &((py_{\text{post}} - Y_{\text{min}}) * H_{\text{res}}) / (Y_{\text{max}} - Y_{\text{min}}) \\
 &((139 - 16 * 240) / (237 - 16)) \\
 &29520 / 221 \\
 &134 \\
 &0x0086
 \end{aligned}$$

The offset coordinate for point “A” in button “Z” is **0x011B, 0x0086**.

The other points’ offset coordinate according to the same calculation’s method are:

B: 0x011B, 0x0066

C: 0x0137, 0x0086

D: 0x0137, 0x0066

The offset coordinates’ range for button “Z” is between 0x011B and 0x0137 for the X coordinate and between 0x0066 and 0x0086 for the Y coordinate (see Figure 3-12).

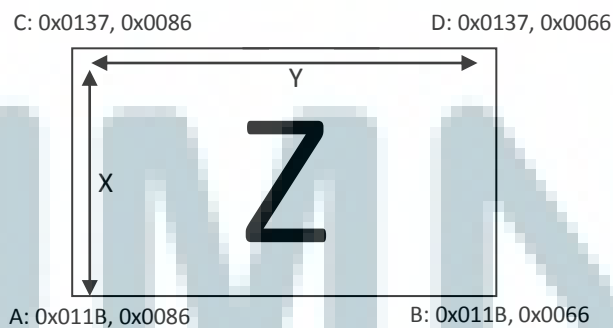


Figure 3-12 Button “Z” Coordinate Range

Therefore, by keeping the offset coordinate of button “Z”, the microcontroller will be able to acknowledge if someday the customers press the button and execute any actions according to the tasks it has.

3.1.2.3. Coordinating Menus and Features on LCD Display with Light Bulbs Connected with ZigBee

In order to be able to control the light bulbs, the LCD switch panel should be connected to ZigBee. There were two connections that had to be established, LCD to ZigBee connected with the microcontroller and ZigBee connected with the microcontroller to ZigBee attached to the lamp controller.

The connection between the LCD and ZigBee can be established by hardware through the microcontroller. The connection can be tested by using UART terminal through UART0. To make sure whether the ZigBee had been connected to the microcontroller yet, a check exist command and a display network information command were sent through program. If the ZigBee is connected, UART terminal will show ZigBee's product identification and network information. To check whether the ZigBee is also connected to the LCD yet, every ZigBee's command that is executed whenever any buttons on the LCD touched will be shown in UART terminal.

To make ZigBee ETRX357 on the device be able to communicate with ZigBees ETRX357 attached to each lamp controller, all ZigBees should be in the same PAN (Personal Area Network). ZigBee ETRX2 is the PAN Coordinator. Therefore, some commands were sent to both ZigBees to be able to join the PAN. For ZigBee on the device, the commands were sent through programming on UART0, while for ZigBees attached to each lamp controller the commands were sent through UART terminal by attaching one by one every ZigBee on a converter. The following commands on Table 3-1 are used to check the connection and establish all ZigBees ETRX357 connection to ZigBee ETRX2 PAN:

Table 3-1 ZigBee commands to check the connection and establish all ZigBees ETRX357 connection to ZigBee ETRX2 PAN

Commands	Function
ATI	To display product identification information
AT+N	To display network information
AT+PANSCAN	To scan all the available PAN
AT+JPAN:11,2829 or AT+JPAN:11,CDB7FD25DAEE177C	To join ZigBee ETRX2 PAN

Value “11” and “2829” in **AT+JPAN:11,2829** are gotten from **AT+PANSCAN** reply which is **+PANSCAN=11,2829,CDB7FD25DAEE177C**. “11” means Coordinator’s channel, “2829” means Coordinator’s PID, and “CDB7FD25DAEE177C” means Coordinator’s EPID. To join PAN, Coordinator’s channel and PID/EPID are needed to be sent in AT+JPAN command.

The connection between Zigbee on the device and the ZigBee attached to every lamp controller was established by sending ZigBee’s address and commands through UART0 programming on microcontroller. Each lamp controller is connected with a ZigBee and a dimmer. A lamp controller can handle 1/2/4 channels, depends on light bulbs’ wattage. A maximum wattage the dimmer can handle is 200W. If the dimmer has reached 200W, customers have to add another dimmer and lamp controller to avoid overheat on the dimmer. In this research, a lamp controller handled one bulb. Therefore, there were four lamp controllers with four ZigBee addresses used.

UART terminal can be used to see whether the connection is success yet. UART terminal will show a reply response from the ZigBee attached to the lamp controller whenever ZigBee on the device sends any commands to it. Table 3-2 shows some commands used to check the connection and control the light bulbs:

Table 3-2 ZigBee commands to check the connection and control the light bulbs.

Commands	Function
ATI	To display product identification information
AT+N	To display network information
AT+UCAST: (ZIGBEE DESTINATION ADDRESS), (COMMAND)	To transmit a unicast command

AT+UCAST : (ZIGBEE DESTINATION ADDRESS), (COMMAND) command was used to transmit a command to turn on/off and dim the lights and a command to request the lights' current status from ZigBee attached to the lamp controller.

For example:

To turn on a light bulbs in the lowest brightness,

AT+UCAST:000D6F0001600C04,0001000153

ZIGBEE DESTINATION ADDRESS

ZIGBEE DATA

To request a light bulb's current status,

AT+UCAST:000D6F0001601272,0181000100

ZIGBEE DESTINATION ADDRESS

ZIGBEE DATA

To make the lights dimmed smoothly, a command can be sent once to the lamp controller,

AT+UCAST:000D6F0001600C04,000200020F0A

ZIGBEE DESTINATION ADDRESS

config
tconfig

ZIGBEE DATA

Config bits on commands above manage channel's dimmer and transition mode while TConfig bits manage Timer multiplier for Channel 1 and 2. But since there is just one channel available in a lamp controller, Channel 2's bits will always be read as 0.

3.1.2.4. Managing Sleep Mode in Microcontroller

There is a sleep mode feature provided by the system developed. If the customers do not perform any touch to the LCD for more than 15 seconds, the system will go on a Sleep Mode until there is a button pressed from the customers. A sleep mode on the system includes a sleep mode on LCD and ZigBee and an idle mode with a transition to low frequency system clock on the microcontroller. Whenever the customers press a Reset button, the system will re-initialize the microcontroller, LCD, ZigBee and all the variables and direct the customers to the Main Menu page.

3.1.2.5. Managing System's Synchronization

To manage the system's synchronization, the microcontroller will always send bulbs' state request commands to the lamp controllers every time it sends commands to turn on/off or dim the bulbs. If the lamp controllers do not respond the request commands from the microcontroller, the microcontroller will receive NACK response. The system will display red buttons on Main Menu page and activate a buzzer for 100ms. If the lamp controllers do respond the request commands from the microcontroller, the microcontroller will process the responses and update the display on Main Menu page based on the responses.