GEBZE
TECHNICAL UNIVERSITY

ELEC334

PROJECT 2

Ebru İrem Doğan - 151024021

Eren Acarel - 161024075

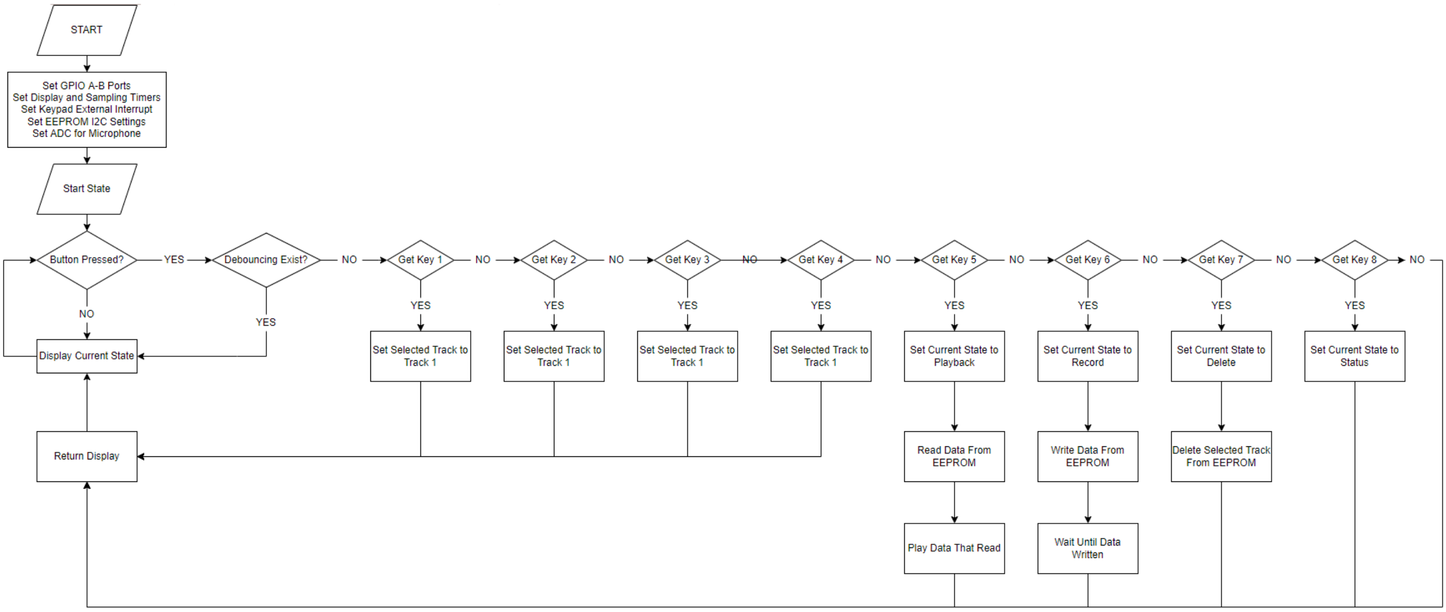
Merve Koçak – 161024018

CONTENTS

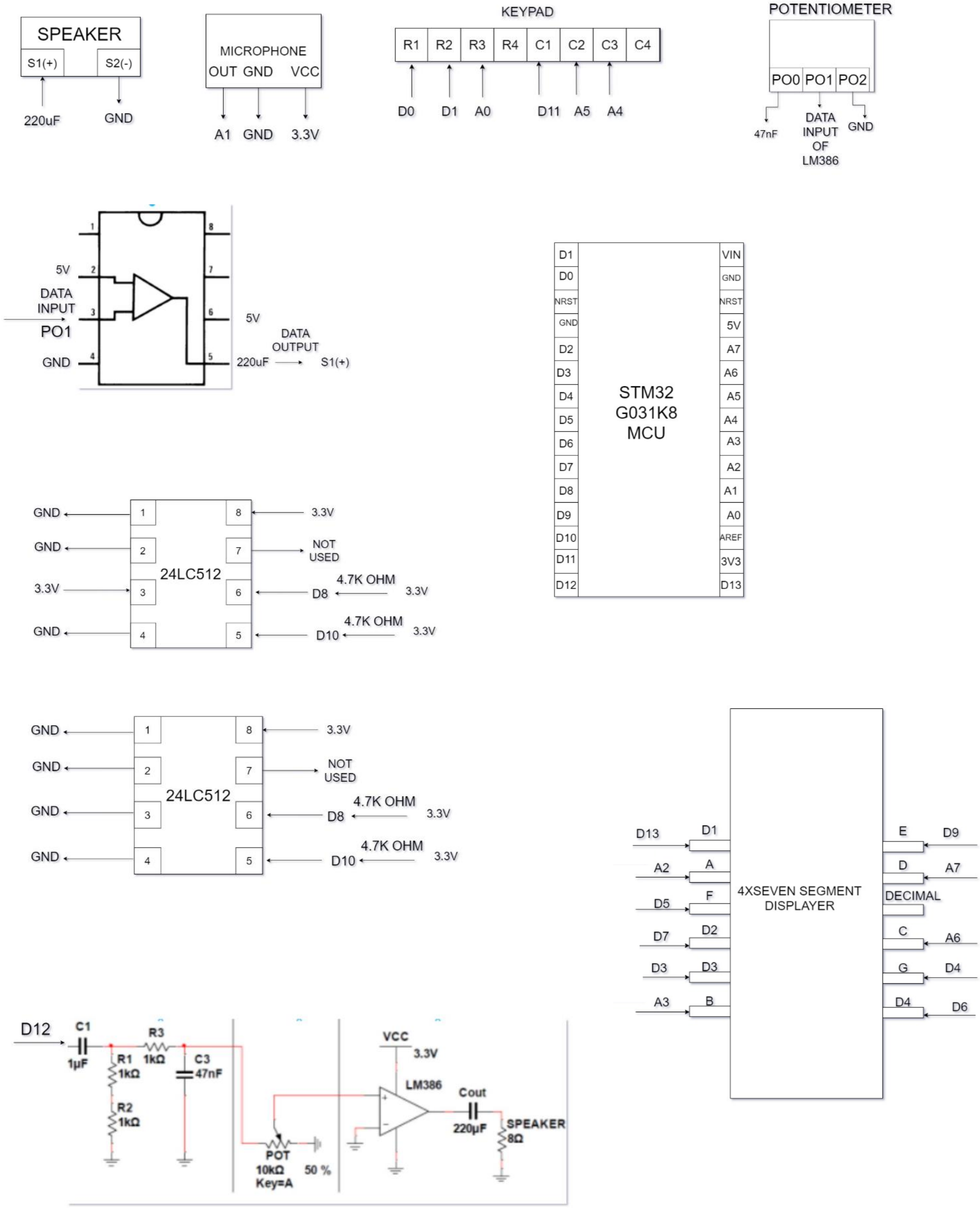
1. INTRODUCTION

In this project, we have aimed to create a digital voice recorder which can record voice that will be taken from microphone. We have used various types of modules such as Timers, PWM, ADC, External Interrupts and I2C. We have used two EEPROMs that have 64K bytes size in order to store our voice samples. A keypad used to get input from user in order to be selected operation that user wants. A speaker circuit built to play audio from EEPROMs by using PWM. ADC sampling frequency has been arranged by calculating each track that will be stored in EEPROMs size. Playing sound by using PWM has been done in two times of sampling frequency in order to obtain proper audio from speaker. EEPROMs used same I2C bus but we have communicated them with different device addresses. Lastly, in our speaker circuit, we have used a band pass and high pass filter to get less noisy audio from EEPROMs.

2. Flowchart



3. Block Diagram



4. PROJECT SETUP

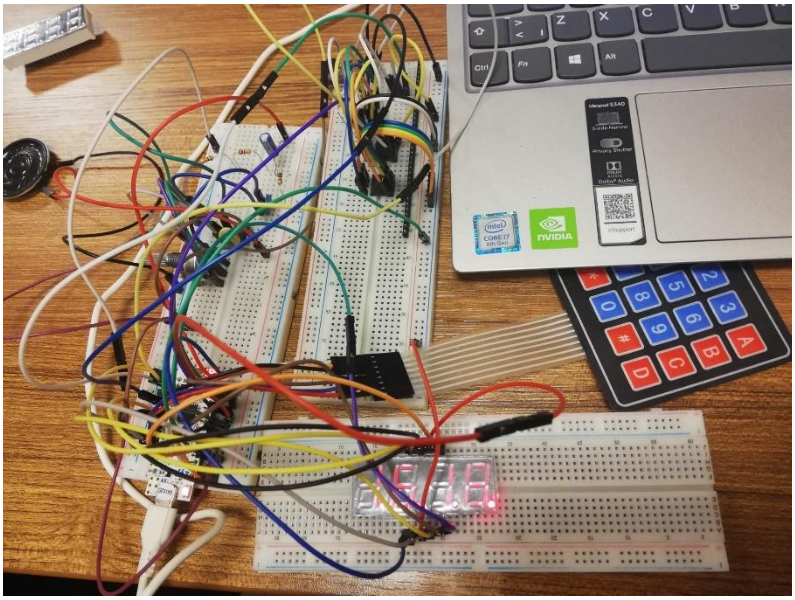


Figure 1. Circuit Setup

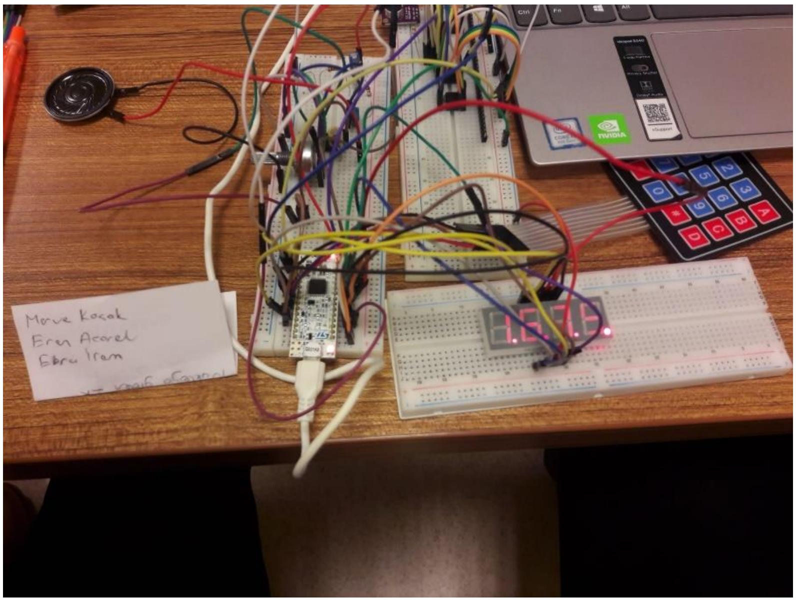


Figure 2. Test with Eren's id number

5. METHODOLOGIES FOR NUMERICAL WORKS

5.1. Calculating Auto Reload Register (ARR) Value

$$DutyCycle_{PWM}\,[\%] = \frac{CCRx}{ARRx}\,[\%]$$

When creating sound from values which we obtain from ADC, we should change duty cycle. Thus we need to specify auto-reload register value (ARR), since we have writing operations which done in 8 bit size we should get sampling values in 8 bit resolution. So as we know that $2^8 = 256$, we have to select auto-reload register value (ARR) 255 which means our max value that will be gotten from ADC.

5.2. Calculating EEPROM Track Size

As we know we have to record 4 tracks which have 5 seconds duration we can write 2 tracks to each EEPROM, but we need to calculate one track size in order to ensure about our track sharing decision. 24LC512 has 512.000 bit size so from 512.000 ⁄ 2 = 256.000 we have 256.000 bit size for each track.

5.3. Calculating Sampling Frequency

$$F_{Sampling} = \frac{F_{CLK}}{(ARR + 1)X(PSC + 1)}$$

We have selected our ARR value 255 for DAC and we know F_CLK value is equal to 16 MHz. So we have to decide F_Sampling value in that way we will end up this process with finding prescaler value (PSC) as well. Each track has 256.000 bit size so we can calculate our sampling frequency from here.

$$F_{Sampling} = \frac{256.000}{8\ bit\ resolution\ x\ 5\ seconds\ duration} = 6400\ Hz$$

6400 Hz should be our max sampling frequency, but we should choose 6300 Hz which is a little bit less than 6400 Hz value in order to avoid some error-prone writing operations. Now, we can calculate auto-reload register value (ARR) for ADC by selecting prescaler value (PSC) 1. We can do this by using this formula: $6300 = \frac{1600000}{(ARR+1)X(2)}$, from there we have found ARR value 1268.

5.4. Calculating PWM Frequency

$f_{PWM} \geq 2 * f_{Sampling}$ so our f_Sampling is equal to 6300 we should choose f_{PWM} minimum 12600 Hz and we have selected 20K Hz.

6. CONCLUSION

In this project, we have learned lots of things. To touch them briefly, we have learned how to communicate with EEPROMs on same bus and different addresses by using I2C, how to build a speaker circuit proper for audio that we have recorded, how to use ADC in order to get digital converted analog data and how to generate analog output again from data that we have stored our EEPROMs in order to hear audio that we have recorded by using microphone. Actually, reading and writing EEPROMs was not too much difficult for me. I wrote a driver to communicate with EEPROMs in order to store data that will be taken from microphone. I have achieved writing and reading operations on EEPROMs and then I tested to play these samples in order to see my system works well and it worked. After that, i arranged ADC to do sampling process and i tested this by using microphone for 5 seconds. I could store the data that i got from microphone by using ADC. By the way, i used page writing operations on EEPROMs, as said in datasheet i could write maximum 128 bytes of data to EEPROMs once. In this situation, i could record and play my voice but when i was playing audio by using PWM, i got a little bit noisy audio so i had to fix it. I realized that driving SSD makes some noise on my voice since displaying occurred in timer interrupt and it interrupts my recording so i decreased my timer count.

APPENDIX A – Codes

A - main.c

```
#include "lc512driver.h"
#include "ssdconfig.h"
#include "stm32g0xx.h"
#include <stdlib.h>
#include <stdbool.h>

//FIRST EEPROM COMMUNICATION ADDRESS
#define EEPROM_ADR1 0x50 //1010(Control Byte)000(A2 A1 A0)
//SECOND EEPROM COMMUNICATION ADDRESS
#define EEPROM_ADR2 0x54 //1010(Control Byte)100(A2 A1 A0)

//Max one track size that will write to EEPROM
#define MAX_TRACK_BYTE_SIZE 32000

//Write buffer
uint8_t* buffer_write;
//Read buffer
uint8_t* buffer_read;
//Write index
uint16_t bw_index = 0;
//Read index
uint16_t read_index = 0;
//Current recorded size
uint16_t record_size = 0;
//Current write memory address
uint16_t curr_memaddr = 0;
//Current read device address
uint8_t curr_devaddr = EEPROM_ADR1;
//Able to read operation
```

```
bool can_read = true;
//Able to button press
bool canButtonPress = true;
//Debouncing counter
uint8_t buttonPressCounter = 0;
//Returning idle counter
uint16_t idle_counter = 0;
//Storing state chars to display on SSD
char disp_letters[4];
//Recorded Track size
uint8_t track_size = 0;
//Recording time duration
uint8_t record_time = 5;
//Refers to initialized address of reading memory
uint16_t read_init_memaddr = 0;
//Current reading device address
uint8_t curr_readdevaddr = EEPROM_ADR1;
//Current reading memory address
uint16_t curr_readmemaddr = 0;
//Boolean array that refers to
//whether track is recorded or not
bool playable_track[4];

//STATES
typedef enum STATE
{
	START,
	IDLE,
	RECORD,
	PLAY,
```

```
	PAUSE,
	DELETE,
	STATUS,
	FULL,
	INVALID
}STATE;

//TRACKS
typedef enum TRACK
{
	TRACK1 = 1,
	TRACK2,
	TRACK3,
	TRACK4
}TRACK;

//Selected Track
TRACK selected_track;

//Selected Current State
STATE curr_state;



//Basic common delay function
void delay(volatile unsigned int s)
{
	for (; s > 0; s--);
}

//CLEAR KEYPAD ROWS
```

```
void clearRow(void) {
	GPIOB->BRR = (1U << 6);
	GPIOB->BRR = (1U << 7);
	GPIOA->BRR = (1U << 0);
}
//SET KEYPAD ROWS
void setRow(void) {
	GPIOB->ODR |= (1U << 6);
	GPIOB->ODR |= (1U << 7);
	GPIOA->ODR |= (1U << 0);
}

//Assigning proper chars to display array
//to show current state properly
void SetStateProperty(STATE state)
{
	switch(state)
	{
		case START:
		disp_letters[0] = '1';
		disp_letters[1] = '6';
		disp_letters[2] = '7';
		disp_letters[3] = '5';
		break;
		case IDLE:
		disp_letters[0] = 'i';
		disp_letters[1] = 'd';
		disp_letters[2] = 'l';
		disp_letters[3] = 'e';
		break;
```

```
case FULL:
disp_letters[0] = 'f';
disp_letters[1] = 'u';
disp_letters[2] = 'l';
disp_letters[3] = 'l';
break;
case RECORD:
disp_letters[0] = 'r';
disp_letters[1] = 'c';
disp_letters[2] = 'd';
disp_letters[3] = IntToChar(record_time);
break;
case PLAY:
disp_letters[0] = 'p';
disp_letters[1] = 'l';
disp_letters[2] = 'b';
disp_letters[3] = IntToChar(selected_track);
break;
case STATUS:
disp_letters[0] = 'a';
disp_letters[1] = 'v';
disp_letters[2] = 'a';
disp_letters[3] = IntToChar(track_size);
break;
case DELETE:
break;

case INVALID:
disp_letters[0] = 'i';
disp_letters[1] = 'n';
```

```
            disp_letters[2] = 'v';
            disp_letters[3] = 'd';
            break;
            default:
            break;
        }
}

//TIMER3 USED BY PWM
void INIT_PWM()
{
        //Used TIM3 at D12 pin
        RCC->APBENR1 |= (1U << 1);

        //Set PB4 as alternate function
        GPIOB->MODER &= ~(3U << 2 * 4);
        GPIOB->MODER |= (2U << 2 * 4);

        //Configure PB4 pins AF0
        GPIOB->AFR[0] |= 1U << 4 * 4;

        //Sets the duty cycle
        TIM3->CCR1 = 500;

        //PWM configuration begins
        TIM3->CCMR1 |= (TIM_CCMR1_OC1M_2 | TIM_CCMR1_OC1M_1);

        //Enabling preload register
        TIM3->CCMR1 |= (TIM_CCMR1_OC1PE);
```

```
	//Enabling auto reload
	TIM3->CR1 |= TIM_CR1_ARPE;

	//Output pin active high
	TIM3->CCER &= ~(TIM_CCER_CC1P);

	//Enabling output pin
	TIM3->CCER |= TIM_CCER_CC1E;

	//Timer Prescaler Value
	TIM3->PSC = 2;

	//Auto reload value.
	TIM3->ARR = 255;

	//Start Timer
	TIM3->DIER = (1 << 0);
	TIM3->CR1 = (1 << 0);
}

//TRACK PLAYER & RECORDER
void INIT_TIMER2()
{
	RCC->APBENR1 |= (1U);

	TIM2->CR1 = 0;
	TIM2->CR1 |= (1 << 7);
	TIM2->CNT = 0;

	// 6300Hz(Sampling Freq) = 1600000 / (ARR + 1) * (PSC + 1)
```

```
	TIM2->PSC = 1;
	TIM2->ARR = 1268;

	TIM2->DIER = (1 << 0);
	TIM2->CR1 = (1 << 0);

	NVIC_SetPriority(TIM2_IRQn, 0);
	NVIC_EnableIRQ(TIM2_IRQn);
}

//DEBOUNCING & DISPLAYER TIMER
void INIT_TIMER14()
{
	RCC->APBENR2 |= (1U << 15);

	TIM14->CR1 = 0;
	TIM14->CR1 |= (1 << 7);
	TIM14->CNT = 0;

	TIM14->PSC = 1;
	TIM14->ARR = 16000;//1MS

	TIM14->DIER = (1 << 0);
	TIM14->CR1 = (1 << 0);

	NVIC_SetPriority(TIM14_IRQn, 0);
	NVIC_EnableIRQ(TIM14_IRQn);
}

//Play sound
```

```
void PlaySound(uint8_t sound)
{
	TIM3->CCR1 = (uint32_t)sound;
}

//Track and recorder interrupt
void TIM2_IRQHandler()
{
	//RECORD STATE
	if(curr_state == RECORD)
	{
		//ADC START CONVERSION
		ADC1->CR |= (1U << 2);

		//Wait until end of conversion flag is true
		while (!(ADC1->ISR & (1U << 2))) {}

		//Read data register and write it to buffer
		if (bw_index < 128)
		{
			buffer_write[bw_index] = ADC1->DR;
			++bw_index;
		}
		//Go inside after writing 128 byte to buffer
		if (bw_index >= 127)
		{
			//Write 128 byte data buffer to EEPROM
			//Page writing method used
			WriteMultipleByte(curr_devaddr, curr_memaddr, buffer_write, 128);
			//Increasing 128 byte recorded size of current EEPROM
```

```
record_size = (uint16_t)(record_size + 128);

//Forward 128 byte from current memory address of current EEPROM

curr_memaddr= (uint16_t)(curr_memaddr + 128);


//Decrease recording time one when we write multiples of 6400 bytes(32000/5=6400)

if(record_size == 6400 || record_size == 12800 || record_size == 19200 || record_size == 25600 || record_size == 32000)

{

    //Decrease recording time

    record_time = (uint8_t)(record_time - 1);

    //Assign current time to state char array

    disp_letters[3] = IntToChar(record_time);

}

//Go inside when we write one track to EEPROM

if (record_size >= MAX_TRACK_BYTE_SIZE)

{

    //ONE TRACK RECORDED


    //Recorded track index

    uint8_t track_recorded = 0;

    //If recorded track size is one go inside

    if(curr_memaddr == 32000)

    {

    //If we have used first EEPROM then it represents first track else third track

        track_recorded = curr_devaddr == EEPROM_ADR1 ? 0 : 2;

        //Set recorded track to true

        playable_track[track_recorded] = true;

    }

    //If recorded track size is two go inside
```

```
        else if(curr_memaddr == 64000)
        {
            //If we have used first EEPROM then it represents
            second track else fourth track
            track_recorded = curr_devaddr == EEPROM_ADR1 ?
            1 : 3;
            //Set recorded track to true
            playable_track[track_recorded] = true;
        }
        //Finish writing state, return idle state
        curr_state = IDLE;
        SetStateProperty(curr_state);
        //Reset writing index
        bw_index = 0;
        //Reset recorded size
        record_size = 0;
        //Reset record time
        record_time = 5;
        //Update track size by increasing one
        track_size = (uint8_t)(track_size + 1);
    }
    //Keep writing
    else
    {
        //Reset writing index
        bw_index = 0;
    }
    //If EEPROM is full then change EEPROM
    if(curr_memaddr >= MAX_TRACK_BYTE_SIZE * 2)
    {
        //Reset current memory address
```

```
                curr_memaddr = 0;
                //Change current device address
                curr_devaddr = curr_devaddr == EEPROM_ADR2 ?
                EEPROM_ADR1 : EEPROM_ADR2;
            }
        }
}
//PLAYBACK STATE
else if(curr_state == PLAY)
{
        //If read buffer is empty go inside
        if(can_read)
        {
            //Read 128 byte data to buffer
            ReadMultipleByte(curr_readdevaddr, curr_readmemaddr, buffer_read,
            128);
            //Ignore reading until whole buffer has been read
            can_read = false;
        }

        //If read buffer has sounds then play it
        if(read_index < 128 && !can_read)
        {
            PlaySound(buffer_read[read_index]);
            read_index++;
        }
        //If reading of current buffer finish, then go inside
        else if(read_index >= 128 && !can_read)
        {
            //If reading of last 128 byte has been occured then go inside
            if(curr_readmemaddr >= ((read_init_memaddr +
            MAX_TRACK_BYTE_SIZE) - 128))
```

```
                {
                        //Reset reading memory address
                        curr_readmemaddr = 0;
                        //Reset reading device address
                        curr_readdevaddr = EEPROM_ADR1;
                        //Reset reading index
                        read_index = 0;
                        //Finish reading and return idle state
                        curr_state = IDLE;
                        SetStateProperty(curr_state);
                        //Reset can_read bool to continue reading
                        can_read = true;
                }
                //If there are values that must read then go inside
                else
                {
                        //Forward 128 byte from current reading memory address
                        curr_readmemaddr = (uint16_t)(curr_readmemaddr + 128);
                        //Reset reading index
                        read_index = 0;
                        //Reset can_read bool to continue reading
                        can_read = true;
                }
        }
}
//DELETE STATE
else if(curr_state == DELETE && track_size > 0 && playable_track[selected_track -
1])
{
        //Return idle state after deleting
        curr_state = IDLE;
```

```
            SetStateProperty(curr_state);
            //Delete selected track
            playable_track[selected_track - 1] = false;
            //Decrease current track size one
            track_size = (uint8_t)(track_size - 1);
        }
        //INVALID OPERATION STATE
        else if(curr_state == DELETE && (track_size <= 0 || !playable_track[selected_track -
        1]))
        {
            //Set current state to invalid state
            curr_state = INVALID;
            SetStateProperty(curr_state);
        }
        //Resetting pending register to continue
        TIM2->SR &= ~(1U << 0);
}

void TIM14_IRQHandler(void)
{
        //If debouncing exist, go inside
        if(!canButtonPress)
        {
            idle_counter = 0;
            //Decreasing button counter time
            buttonPressCounter++;
            //Checking whether buttonPressCounter has reached zero or lower than zero
            if (buttonPressCounter >= 100)
            {
                //Resetting debouncing preventer elements so that any button press can
                be read
```

```
			buttonPressCounter = 0;
			canButtonPress = true;
		}
	}
	//If there are no button press go inside
	else if(curr_state != RECORD && curr_state != PLAY && curr_state != PAUSE && curr_state != IDLE)
	{
		//Increase returning idle counter
		idle_counter++;
		//If returning idle counter reachs 10000
		//then return idle state(1MS TIMER CLOCK * 10000 = 10 SEC)
		if(idle_counter >= 10000)
		{
			//Reset returning idle counter
			idle_counter = 0;
			//Set current state to idle state
			curr_state = IDLE;
			SetStateProperty(curr_state);
		}
	}

	//Displaying on SSD
	uint8_t offset = 0;
	int iterator;
	for(iterator = 3; iterator >= 0; --iterator)
	{
		//Display one of current state letters
		DisplayChar(disp_letters[iterator]);
		//For displaying smoothness
		delay(40);
```

```
			//Turn off all ssd leds
			ResetDisplay();
			//Shift digit section
			ShiftDigit((unsigned int)offset);
			//Increase offset from rightmost digit on SSD
			offset = (uint8_t)(offset + 1);
		}
		//Resetting pending register to continue
		TIM14->SR &= ~(1U << 0);
}

void EXTI4_15_IRQHandler(void)
{
  //COLUMN 1
  if (((GPIOB->IDR >> 5) & 1))
  {
		 //If debouncing does not exist go inside
		if(canButtonPress)
		{
			clearRow();
			//SELECT TRACK 1
			GPIOB->ODR ^= (1U << 7);
			if(((GPIOB->IDR >> 5) & 1))
			{
				//BUTTON(1)
				canButtonPress = false;
				selected_track = TRACK1;
			}
			GPIOB->ODR ^= (1U << 7);
```

```
            //SELECT TRACK 4
            GPIOB->ODR ^= (1U << 6);
            if((((GPIOB->IDR >> 5) & 1)))
            {
                //BUTTON(4)
                canButtonPress = false;
                selected_track = TRACK4;
            }
            GPIOB->ODR ^= (1U << 6);

            //SELECT DELETE STATE
            GPIOA->ODR ^= (1U << 0);
            if((((GPIOB->IDR >> 5) & 1)))
            {
                //BUTTON(7)
                canButtonPress = false;
                curr_state = DELETE;
                SetStateProperty(curr_state);

            }
            GPIOA->ODR ^= (1U << 0);
            setRow();
        }
        EXTI->RPR1 |= (1U << 5);
    }
    //COLUMN 2
    if (((GPIOA->IDR >> 11) & 1))
    {
        //If debouncing does not exist go inside
        if(canButtonPress)
```

```
{
        clearRow();
        //SELECT TRACK 2
        GPIOB->ODR ^= (1U << 7);
        if (((GPIOA->IDR >> 11) & 1) && curr_state != PLAY)
        {
                //BUTTON(2)
                canButtonPress = false;
                selected_track = TRACK2;
        }
        GPIOB->ODR ^= (1U << 7);

        //SELECT PLAYBACK STATE
        GPIOB->ODR ^= (1U << 6);
        if((((GPIOA->IDR >> 11) & 1)) && selected_track > 0)
        {
                //BUTTON(5) PLAY
                canButtonPress = false;
                //PAUSE STATE CONTROLLER
                bool pass_init = true;
                //If play button pressed when playing then set current state
                //to pause state
                if(curr_state == PLAY && playable_track[selected_track-1])
                {
                        //Pause state exist
                        pass_init = false;
                        curr_state = PAUSE;
                        SetStateProperty(curr_state);
                }
                //If play button pressed when pausing then set current state
```

```
//to play state
else if(curr_state == PAUSE && playable_track[selected_track-1])
{
	//Pause state exist
	pass_init = false;
	curr_state = PLAY;
	SetStateProperty(curr_state);
}
//Initialize track that will be played
//If pause state exist then do not initialize
//to prevent resetting memory
if(pass_init && playable_track[selected_track-1])
{
	//Selecting from first EEPROM
	if((selected_track == TRACK1 && playable_track[0]) ||
	(selected_track == TRACK2 && playable_track[1]))
	{
		//Set reading device address to first EEPROM address
		curr_readdevaddr = EEPROM_ADR1;
		//Set reading memory address to selected track beginning
		address
		curr_readmemaddr = selected_track == TRACK1 ? 0 :
		32000;
		//Set current state to playback state
		curr_state = PLAY;
		SetStateProperty(curr_state);
	}
	//Selecting from second EEPROM
	else if((selected_track == TRACK3 && playable_track[2]) ||
	(selected_track == TRACK4 && playable_track[3]))
	{
		//Set reading device address to second EEPROM address
```

```
}

                        curr_readdevaddr = EEPROM_ADR2;

                        //Set reading memory address to selected track beginning address

                        curr_readmemaddr = selected_track == TRACK3 ? 0 : 32000;

                        //Set current state to playback state

                        curr_state = PLAY;

                        SetStateProperty(curr_state);

                    }

                    //Set initializing address to beginning of reading current memory address

                    read_init_memaddr = curr_readmemaddr;

                }

            }

            GPIOB->ODR ^= (1U << 6);


            //Set current state to status state

            GPIOA->ODR ^= (1U << 0);

            if ((((GPIOA->IDR >> 11) & 1)))

            {

                //BUTTON(8)

                canButtonPress = false;

                curr_state = STATUS;

                SetStateProperty(curr_state);

            }

            GPIOA->ODR ^= (1U << 0);

            setRow();

        }

        EXTI->RPR1 |= (1U << 11);

    }

    //COLUMN 3

    if (((GPIOA->IDR >> 12) & 1))
```

```
{
      //If debouncing does not exist go inside
    if(canButtonPress)
    {
        clearRow();
        //SELECT TRACK 3
        GPIOB->ODR ^= (1U << 7);
        if (((GPIOA->IDR >> 12) & 1))
        {
            //BUTTON(3)
            canButtonPress = false;
            selected_track = TRACK3;
        }
        GPIOB->ODR ^= (1U << 7);

        //SELECT RECORD STATE
        GPIOB->ODR ^= (1U << 6);
        if ((((GPIOA->IDR >> 12) & 1)))
        {
            canButtonPress = false;
            //BUTTON(6)
            //If EEPROMs are not full
            if(track_size < 4)
            {
                //Set current state to current state
                curr_state = RECORD;
                SetStateProperty(curr_state);
                //Check selected track is recorded
                if(!playable_track[0] || !playable_track[1])
                {
```

```
                //Set device address to first EEPROM address
                curr_devaddr = EEPROM_ADR1;
                //Set reading memory address
                curr_memaddr = !playable_track[0] ? 0 : 32000;
            }
            //Check selected track is recorded
            else if(!playable_track[2] || !playable_track[3])
            {
                //Set device address to first EEPROM address
                curr_devaddr = EEPROM_ADR2;
                //Set reading memory address
                curr_memaddr = !playable_track[2] ? 0 : 32000;
            }
        }
        //If EEPROMs are full change current state to current state
        else
        {
            curr_state = FULL;
            SetStateProperty(curr_state);
        }
    }
    GPIOB->ODR ^= (1U << 6);

    //EMPTY KEY
    GPIOA->ODR ^= (1U << 0);
    if ((((GPIOA->IDR >> 12) & 1)))
    {
        //BUTTON(9)
        canButtonPress = false;
    }
```

```
            GPIOA->ODR ^= (1U << 0);
            setRow();
        }
        EXTI->RPR1 |= (1U << 12);
  }
}
//ADC INITIALIZATION
void ADCInit()
{
        //PA1 USED FOR ADC

        //GPIOA-B PORT ENABLED
        RCC->IOPENR |= (3U);

        //ADC CLOCK ENABLED
        RCC->APBENR2 |= (1U << 20);

        //ADC VOLTAGE REGULATOR ENABLED
        ADC1->CR |= (1U << 28);
        //WAIT AT LEAST 20US, AS SAID IN LECTURE
        delay(300000);

        //8 BIT RESOLUTION SELECTED
        ADC1->CFGR1 |= (1U << 4);

        //ADC CALIBRATION ENABLED
        ADC1->CR |= (1U << 31);
        //WAIT UNTIL END OF CALIBRATION FLAG IS SET
        while (!(ADC1->ISR & (1U << 11)));
```

```
	//ADC SAMPLING TIME SELECTED MAX 3.5 ADC CLOCK CYCLE
	ADC1->SMPR |= (1U);

	//ADC CHANNEL 1 SELECTED
	ADC1->CHSELR |= (1U << 1);

	//ADC ENABLED
	ADC1->CR |= (1U);
	//WAIT UNTIL ADC GETS READY
	while (!(ADC1->ISR & 1U));
}

//KEYPAD & SSD INITIALIZER
void Keypad_SSD_GPIO_Init(void)
{
	//Set B6 B7 A0 as output rows
	GPIOB->MODER &= ~(3U << 2 * 6);
	GPIOB->MODER |= (1U << 2 * 6);

	GPIOB->MODER &= ~(3U << 2 * 7);
	GPIOB->MODER |= (1U << 2 * 7);

	GPIOA->MODER &= ~(3U << 2 * 0);
	GPIOA->MODER |= (1U << 2 * 0);

	//Set B5 A11 A12 as input column
	GPIOB->MODER &= ~(3U << 2 * 5);
	GPIOB->PUPDR |= (2U << 2 * 5);

	GPIOA->MODER &= ~(3U << 2 * 11);
```

```
GPIOA->PUPDR |= (2U << 2 * 11);

GPIOA->MODER &= ~(3U << 2 * 12);
GPIOA->PUPDR |= (2U << 2 * 12);

//SSD B0 PORT
GPIOB->MODER &= ~(3U << 2 * 0);
GPIOB->MODER |= (1U << 2 * 0);
GPIOB->ODR |= (1U << 1 * 0);

//KEYPAD +5V PORTS
GPIOB->ODR |= (1U << 6);
GPIOB->ODR |= (1U << 7);
GPIOA->ODR |= (1U << 0);

//Set external interrupt for keypad
EXTI->EXTICR[1] |= (1U << 8 * 1);//B5
EXTI->RTSR1 |= (1U << 5);
EXTI->IMR1 |= (1U << 5);

EXTI->EXTICR[2] |= (0U << 8 * 3);//A11
EXTI->RTSR1 |= (1U << 11);
EXTI->IMR1 |= (1U << 11);

EXTI->EXTICR[3] |= (0U << 8 * 0);//A12
EXTI->RTSR1 |= (1U << 12);
EXTI->IMR1 |= (1U << 12);

NVIC_SetPriority(EXTI4_15_IRQn, 0);
NVIC_EnableIRQ(EXTI4_15_IRQn);
```

```
}

int main(void)
{
	//Allocating 128 byte data on heap memory for write buffer
	buffer_write = (uint8_t*)malloc(sizeof(uint8_t) * 128);
	//Allocating 128 byte data on heap memory for read buffer
	buffer_read = (uint8_t*)malloc(sizeof(uint8_t) * 128);

	//Set playable track bools to false not to play or delete
	playable_track[0]=playable_track[1]=playable_track[2]=playable_track[3]=false;

	//Set current state START
	curr_state = START;
	//Set current state properties
	SetStateProperty(curr_state);

	//Initializing ADC
	ADCInit();
	//Initializing PWM
	INIT_PWM();
	//Initializing EEPROMs
	INIT_EEPROM_512();
	//Initializing TIMER14
	INIT_TIMER14();
	//Initializing KEYPAD & SSD
	Keypad_SSD_GPIO_Init();
	//Initializing TIMER2
	INIT_TIMER2();
```

```
	while (1)
	{

	}
	//Releasing memory
	free(buffer_read);
	free(buffer_write);
}
```

A – lc512driver.c

```
#include "lc512driver.h"

//Initializing EEPROM
void INIT_EEPROM_512()
{
	//PB8-PB9 pins will activate
	//alternate function 6

	//PB8 as AF6
	GPIOB->MODER &= ~(3U << 2*8);
	GPIOB->MODER |= (2U << 2*8);
	GPIOB->OTYPER|= (1U << 8);

	//choose AF from mux
	GPIOB->AFR[1] &= ~(0xFU << 4*0);
	GPIOB->AFR[1] |= (6 << 4*0);

	//PB9 as AF6
	GPIOB->MODER &= ~(3U << 2*9);
```

```
	GPIOB->MODER |= (2U << 2*9);
	GPIOB->OTYPER|= (1U << 9);

	//choose AF from mux
	GPIOB->AFR[1] &= ~(0xFU << 4*1);
	GPIOB->AFR[1] |= (6 << 4*1);

	//enable I2C1
	RCC->APBENR1 |= (1U << 21);

	I2C1->CR1 = 0;
	I2C1->CR1 |= (1 << 7);//ERR1, error interrupt

	//TIMING REGISTERS FOR STANDART MODE
	I2C1->TIMINGR |= (3 << 28);//PRESC
	I2C1->TIMINGR |= (0x13 << 0);//SCLL
	I2C1->TIMINGR |= (0xF << 8);//SCLR
	I2C1->TIMINGR |= (0x2 << 16);//SDADEL
	I2C1->TIMINGR |= (0x4 << 20);//SCLDEL

	I2C1->CR1 = (1U << 0);//PE=0

	NVIC_SetPriority(I2C1_IRQn,0);
	NVIC_EnableIRQ(I2C1_IRQn);
}

//Writing single byte
void WriteSingleByte(uint8_t devAddr, uint16_t destAddr, uint8_t data)
{
	//Data sheet pattern applied
```

```
        //Write operation
        I2C1->CR2=0;
        //Slave address
        I2C1->CR2 |= ((uint32_t)(devAddr << 1));
        //Number of bytes that will send
        I2C1->CR2 |= (3U << 16);
        I2C1->CR2 |= (1U << 25);//AUTOEND
        I2C1->CR2 |= (1U << 13);//Start condition

        while(!(I2C1->ISR & (1 << 1)));//TXIS
        I2C1->TXDR = (uint32_t)(destAddr >> 8);//transmit data register

        while(!(I2C1->ISR & (1 << 1)));//TXIS
        I2C1->TXDR = (uint32_t)(destAddr & 0xFF);//transmit data register

        while(!(I2C1->ISR & (1 << 1)));//TXIS
        I2C1->TXDR = (uint32_t)data;//transmit data register
}

//Writing 128 bytes
void WriteMultipleByte(uint8_t devAddr, uint16_t startAddr, uint8_t* data, uint8_t size)
{
        //Avoid writing more than 128 byte and less than 0 byte
        if(size > 128 && size <= 0)
        {
                return;
        }
        //Data sheet pattern applied
        //Write operation
        I2C1->CR2=0;
```

```
	//Slave address
	I2C1->CR2 |= ((uint32_t)(devAddr << 1));
	//Number of bytes that will send
	I2C1->CR2 |= ((uint32_t)(2U + size) << 16);
	I2C1->CR2 |= (1U << 25);//AUTOEND
	I2C1->CR2 |= (1U << 13);//Start condition

	while(!(I2C1->ISR & (1 << 1)));//TXIS
	I2C1->TXDR = (uint32_t)(startAddr >> 8);//transmit data register

	while(!(I2C1->ISR & (1 << 1)));//TXIS
	I2C1->TXDR = (uint32_t)(startAddr & 0xFF);//transmit data register

	uint8_t i;
	for(i = 0; i < size; i++)
	{
		while(!(I2C1->ISR & (1 << 1)));//TXIS
		I2C1->TXDR = (uint32_t)data[i];//transmit data register
	}
}

//Reading single byte
void ReadSingleByte(uint8_t devAddr, uint16_t resAddr, uint8_t* data)
{
	//Data sheet pattern applied
	//Write operation
	I2C1->CR2 = 0;
	//Slave address
	I2C1->CR2 |= ((uint32_t)(devAddr << 1));
	//Number of bytes that will send
```

```
        I2C1->CR2 |= (2U << 16);
        I2C1->CR2 |= (1U << 13);//Start condition

        while(!(I2C1->ISR & (1 << 1)));//TXIS
        I2C1->TXDR = (uint32_t)(resAddr >> 8);//transmit data register

        while(!(I2C1->ISR & (1 << 1)));//TXIS
        I2C1->TXDR = (uint32_t)(resAddr & 0xFF);//transmit data register

        while(!(I2C1->ISR & (1 << 6)));//TC

        //read operation(read data)
        I2C1->CR2=0;
        I2C1->CR2 |= ((uint32_t)(devAddr << 1));
        I2C1->CR2 |= (1U << 10);//READ MODE
        I2C1->CR2 |= (1U << 16);//NUMBER OF BYTES
        I2C1->CR2 |= (1U << 15);//NACK
        I2C1->CR2 |= (1U << 25);//AUTOEND
        I2C1->CR2 |= (1U << 13);//start condition
        while(!(I2C1->ISR & (1 << 2)));//wait until RXNE=1
        *data = (uint8_t)I2C1->RXDR;

}

//Reading 128 bytes
void ReadMultipleByte(uint8_t devAddr, uint16_t resAddr, uint8_t* data, uint16_t size)
{
        //Data sheet pattern applied
        //Write operation
        I2C1->CR2 = 0;
```

```
//Slave address
I2C1->CR2 |= ((uint32_t)(devAddr << 1));
//Number of bytes that will send
I2C1->CR2 |= (2U << 16);
I2C1->CR2 |= (1U << 13);//Start condition

while(!(I2C1->ISR & (1 << 1)));//TXIS
I2C1->TXDR = (uint32_t)(resAddr >> 8);//transmit data register

while(!(I2C1->ISR & (1 << 1)));//TXIS
I2C1->TXDR = (uint32_t)(resAddr & 0xFF);//transmit data register

while(!(I2C1->ISR & (1 << 6)));//TC

//Read operation
I2C1->CR2=0;
//Slave address
I2C1->CR2 |= ((uint32_t)(devAddr << 1));
I2C1->CR2 |= (1U << 10);//READ MODE
//Number of bytes that will send
I2C1->CR2 |= ((1U * size) << 16);
I2C1->CR2 |= (1U << 25);//AUTOEND
I2C1->CR2 |= (1U << 13);//Start condition

uint16_t i;
for(i = 0; i < size; ++i)
{
	while(!(I2C1->ISR & (1 << 2)));//wait until RXNE=1
	data[i] = (uint8_t)I2C1->RXDR;
}
```

```
	I2C1->CR2 |= (1U << 15);//NACK
}
```

A - lc512driver.h

```
#ifndef LC512DRIVER_H_
#define LC512DRIVER_H_
#include "stm32g0xx.h"

//Initializing EEPROM
void INIT_EEPROM_512();
//Writing single byte
void WriteSingleByte(uint8_t devAddr, uint16_t destAddr, uint8_t data);
//Writing 128 bytes
void WriteMultipleByte(uint8_t devAddr, uint16_t startAddr, uint8_t* data, uint8_t size);
//Reading single byte
void ReadSingleByte(uint8_t devAddr, uint16_t resAddr, uint8_t* data);
//Reading 128 bytes
void ReadMultipleByte(uint8_t devAddr, uint16_t resAddr, uint8_t* data, uint16_t size);

#endif /* LC512DRIVER_H_ */
```

A – ssdconfig.h

```
#ifndef SSDCONFIG_H_
#define SSDCONFIG_H_
#include "stm32g0xx.h"
#include <string.h>

 //Segments BEGIN
```

```
//To light A LED
void SetSegmentA() {
	GPIOA->MODER &= ~(3U << 2 * 4);
	GPIOA->MODER |= (1U << 2 * 4);
}
//To light B LED
void SetSegmentB() {
	GPIOA->MODER &= ~(3U << 2 * 5);
	GPIOA->MODER |= (1U << 2 * 5);
}
//To light C LED
void SetSegmentC() {
	GPIOA->MODER &= ~(3U << 2 * 6);
	GPIOA->MODER |= (1U << 2 * 6);
}
//To light D LED
void SetSegmentD() {
	GPIOA->MODER &= ~(3U << 2 * 7);
	GPIOA->MODER |= (1U << 2 * 7);
}
//To light E LED
void SetSegmentE() {
	GPIOA->MODER &= ~(3U << 2 * 8);
	GPIOA->MODER |= (1U << 2 * 8);
}
//To light F LED
void SetSegmentF() {
	GPIOA->MODER &= ~(3U << 2 * 9);
	GPIOA->MODER |= (1U << 2 * 9);
}
```

```
//To light G LED
void SetSegmentG() {

	GPIOA->MODER &= ~(3U << 2 * 10);
	GPIOA->MODER |= (1U << 2 * 10);
}
//Segments END

//Numbers BEGIN
//To light Number 0
void SetNumberZero()
{
	SetSegmentA();
	SetSegmentB();
	SetSegmentC();
	SetSegmentD();
	SetSegmentE();
	SetSegmentF();
}
//To light Number 1
void SetNumberOne()
{
	SetSegmentB();
	SetSegmentC();
}
//To light Number 2
void SetNumberTwo()
{
	SetSegmentA();
	SetSegmentB();
```

```
        SetSegmentD();
        SetSegmentE();
        SetSegmentG();
}
//To light Number 3
void SetNumberThree()
{
        SetSegmentA();
        SetSegmentB();
        SetSegmentC();
        SetSegmentD();
        SetSegmentG();

}
//To light Number 4
void SetNumberFour()
{
        SetSegmentB();
        SetSegmentC();
        SetSegmentF();
        SetSegmentG();
}
//To light Number 5
void SetNumberFive()
{
        SetSegmentA();
        SetSegmentC();
        SetSegmentD();
        SetSegmentF();
        SetSegmentG();
```

```
}
//To light Number 6
void SetNumberSix()
{
	SetSegmentA();
	SetSegmentC();
	SetSegmentD();
	SetSegmentE();
	SetSegmentF();
	SetSegmentG();
}
//To light Number 7
void SetNumberSeven()
{
	SetSegmentA();
	SetSegmentB();
	SetSegmentC();
}
//To light Number 8
void SetNumberEight()
{
	SetSegmentA();
	SetSegmentB();
	SetSegmentC();
	SetSegmentD();
	SetSegmentE();
	SetSegmentF();
	SetSegmentG();
}
//To light Number 9
```

```
void SetNumberNine()
{
	SetSegmentA();
	SetSegmentB();
	SetSegmentC();
	SetSegmentD();
	SetSegmentF();
	SetSegmentG();
}
//To light Negative Sign
void SetNegativeSign()
{
	SetSegmentG();
}
//Numbers END

//Letters Begin
//To light Letter A
void SetLetterA()
{
	SetSegmentA();
	SetSegmentB();
	SetSegmentC();
	SetSegmentE();
	SetSegmentF();
	SetSegmentG();
}
//To light Letter B
void SetLetterB()
{
```

```
        SetSegmentC();
        SetSegmentD();
        SetSegmentE();
        SetSegmentF();
        SetSegmentG();
}
//To light Letter C
void SetLetterC()
{
        SetSegmentD();
        SetSegmentE();
        SetSegmentG();
}
//To light Letter D
void SetLetterD()
{
        SetSegmentB();
        SetSegmentC();
        SetSegmentD();
        SetSegmentE();
        SetSegmentG();
}
//To light Letter E
void SetLetterE()
{
        SetSegmentA();
        SetSegmentD();
        SetSegmentE();
        SetSegmentF();
        SetSegmentG();
```

```
}
//To light Letter I
void SetLetterI()
{
	SetSegmentE();
	SetSegmentF();
}
//To light Letter N
void SetLetterN()
{
	SetSegmentC();
	SetSegmentE();
	SetSegmentG();
}
//To light Letter V
void SetLetterV()
{
	SetSegmentC();
	SetSegmentD();
	SetSegmentE();
}
//To light Letter O
void SetLetterO()
{
	SetSegmentC();
	SetSegmentD();
	SetSegmentE();
	SetSegmentG();
}
//To light Letter U
```

```
void SetLetterU()
{
	SetSegmentB();
	SetSegmentC();
	SetSegmentD();
	SetSegmentE();
	SetSegmentF();
}
//To light Letter F
void SetLetterF()
{
	SetSegmentA();
	SetSegmentE();
	SetSegmentF();
	SetSegmentG();
}
//To light Letter L
void SetLetterL()
{
	SetSegmentD();
	SetSegmentE();
	SetSegmentF();
}
//To light Letter P
void SetLetterP()
{
	SetSegmentA();
	SetSegmentB();
	SetSegmentE();
	SetSegmentF();
```

```
	SetSegmentG();
}
//To light Letter R
void SetLetterR()
{
	SetSegmentE();
	SetSegmentG();
}
//Letters End

//To turn leftmost digit when shifter reachs to rightmost digit
void TurnBeginning()
{
	//B0
	GPIOB->MODER &= ~(3U << 2 * 0);
	GPIOB->MODER |= (1U << 2 * 0);
	GPIOB->BRR = (1U << 0);
	GPIOB->ODR |= (1U << 0);
	//B1
	GPIOB->MODER &= ~(0U << 2 * 1);
	GPIOB->BRR = (1U << 1);
	//B2
	GPIOB->MODER &= ~(0U << 2 * 2);
	GPIOB->BRR = (1U << 2);
	//B3
	GPIOB->MODER &= ~(0U << 2 * 3);
	GPIOB->BRR = (1U << 3);
}

//To shift digits that will be displayed
```

```
void ShiftDigit(unsigned int currIndex)
{
	if (currIndex >= 3)
	{
		TurnBeginning();
		return;
	}
	GPIOB->MODER &= ~(0U << 2 * (currIndex));
	GPIOB->MODER &= ~(3U << 2 * (currIndex + 1));
	GPIOB->MODER |= (1U << 2 * (currIndex + 1));
	GPIOB->BRR = (1U << currIndex);
	GPIOB->ODR |= (1U << (currIndex + 1));

}

//To display numbers
void DisplayChar(char ch)
{
	switch (ch)
	{
	case '0':
		SetNumberZero();
		break;
	case '1':
		SetNumberOne();
		break;
	case '2':
		SetNumberTwo();
		break;
	case '3':
```

```
        SetNumberThree();
        break;
case '4':
        SetNumberFour();
        break;
case '5':
        SetNumberFive();
        break;
case '6':
        SetNumberSix();
        break;
case '7':
        SetNumberSeven();
        break;
case '8':
        SetNumberEight();
        break;
case '9':
        SetNumberNine();
        break;
case 'a':
        SetLetterA();
        break;
case 'b':
        SetLetterB();
        break;
case 'c':
        SetLetterC();
        break;
case 'd':
```

```
        SetLetterD();
        break;
    case 'e':
        SetLetterE();
        break;
    case 'i':
        SetLetterI();
        break;
    case 'n':
        SetLetterN();
        break;
    case 'v':
        SetLetterV();
        break;
    case 'o':
        SetLetterO();
        break;
    case 'u':
        SetLetterU();
        break;
    case 'f':
        SetLetterF();
        break;
    case 'l':
        SetLetterL();
        break;
    case 'p':
        SetLetterP();
        break;
    case 'r':
```

```
            SetLetterR();
            break;
        default:
            break;
        }
}

char IntToChar(uint8_t digit)
{
        switch (digit)
        {
          case 0:
            return '0';
          case 1:
            return '1';
          case 2:
            return '2';
          case 3:
            return '3';
          case 4:
            return '4';
          case 5:
            return '5';
          case 6:
            return '6';
          case 7:
            return '7';
          case 8:
            return '8';
          case 9:
```

```
                return '9';
            default:
                break;
            }
        return '0';
}

//Clearing displayer
void ResetDisplay()
{
        uint8_t index;
        for(index = 4;index < 11;index++)
        {
                GPIOA->MODER &= ~(3U << 2 * index);
                GPIOA->MODER |= (3U << 2 * index);
                GPIOA->ODR &= ~(1U << index);
        }

}
#endif /* SSDCONFIG_H_ */
```