EEL 4742C: Embedded Systems

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12/2/2019
EEL4742-0011
Lab 11 SPI to LCD

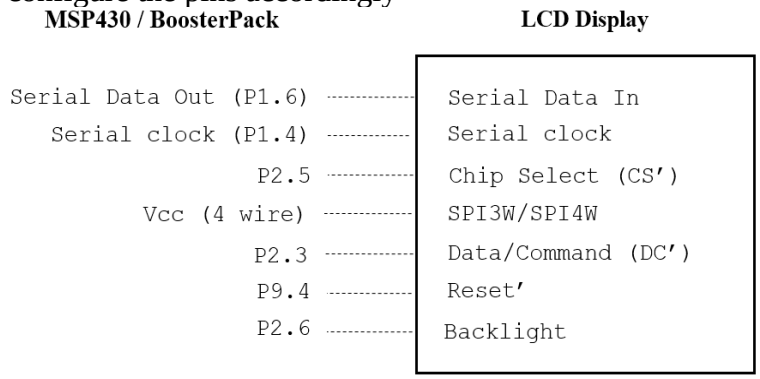
Introduction

In this lab experiment we will be programming the serial peripheral interface (SPI) and the LCD pixel display. SPI will be configured to talk to the between the LCD and the board. in part one we configured the middle driver file to configure the SPI using functions HAL_LCD_SpiInit() and HAL_LCD_PortInit() (Configuration registers found in family user guide at the end of chapter 31). Once we have configured SPI and the LCD, we can call functions from the grlib.h file to draw or write what we would like to the LCD display.

Part 11.1: Serial Peripheral Interface (SPI)

Same middle driver used for part 1 and part 2, each has its own main calling configuration functions in main.c which is in the table row below the middle driver code.
This code for main is below. The main is configured to write the given text message to the LCD.

We first configured the SPI pins following the table taken from the lab manual, we will configure the pins accordingly




```
//MIDDLE_DRIVER.c

//Christopher Badolato
//12/2/2019
//Lab 11.1
//EEL 4742 0011
//SPI AND LCD

#include "msp430fr6989.h"
#include "LcdDriver/middle_driver.h"
#include "Grlib/grlib/grlib.h"
```

```
#include <stdint.h>

void HAL_LCD_PortInit(void){
        // Configure the SPI pins
        // P1.4 pin to serial clock
    P1SEL1 &= ~BIT4;
    P1SEL0 |= BIT4;
    // P1.6 pin to SIMO
    P1SEL1 &= ~BIT6;
    P1SEL0 |= BIT6;
        //display pins
        //Set reset pin as output
    P9DIR |= BIT4;
    P9SEL1&=~BIT4;
    P9SEL0&=~BIT4;
        //data/command pin as output
    P2DIR |= BIT3;
    P2SEL1&=~ BIT3;
    P2SEL0 &=~ BIT3;
        //chip select pin as output
    P2DIR |= BIT5;
    P2SEL1&=~ BIT5;
    P2SEL0 &=~ BIT5;
    return;
}

void HAL_LCD_SpiInit(void){
        //spi config
        // Put eUSCI in reset state while modifying the configuration
    UCB0CTLW0 |= UCSWRST;
        //clock phase to capture on 1st edge, change on following edge
    UCB0CTLW0 |= UCCKPH;
        //clock polarity to inactive low
    UCB0CTLW0 &=~ UCCKPL;
        //data order to transmit MSB first
    UCB0CTLW0 |= UCMSB;
        //MCU to SPI master
    UCB0CTLW0 |= UCMST;
        //SPI to 3 pin SPI
    UCB0CTLW0 |= UCMODE_0;
        //module to synchronous mode
    UCB0CTLW0 |= UCSYNC;
        //clock to SMCLK
    UCB0CTLW0 |= UCSSEL_3;
        //Set clock divider to 1 (SMCLK is from DCO at 8 MHz; we'll run SPI at 8
MHz)
    UCB0BRW =1;
        //Exit the reset state at the end of the configuration
    UCB0CTLW0 &= ~UCSWRST;
        // chip select bit to 0
    P2OUT &= ~BIT5;
        //DC bit to 0
    P2OUT &= ~BIT3;
    return;
}
```

```
//*****************************************************************************
// Writes a command to the CFAF128128B-0145T.  This function implements the basic
SPI
// interface to the LCD display.
//*****************************************************************************
void HAL_LCD_writeCommand(uint8_t command)
{
    // For command, set the DC' bit to low before transmission
    P2OUT &= ~BIT3;

    // Wait as long as the module is busy
    while (UCB0STATW & UCBUSY);

    // Transmit data
    UCB0TXBUF = command;

    // Set DC' bit back to high
    P2OUT |= BIT3;
}


//*****************************************************************************
// Writes a data to the CFAF128128B-0145T.  This function implements the basic SPI
// interface to the LCD display.
//*****************************************************************************
void HAL_LCD_writeData(uint8_t data)
{
    // Wait as long as the module is busy
    while (UCB0STATW & UCBUSY);

    // Transmit data
    UCB0TXBUF = data;
}
```

```
//Christopher Badolato
//12/2/2019
//Lab 11.1
//EEL 4742 0011
//SPI AND LCD

#include "msp430fr6989.h"
#include "Grlib/grlib/grlib.h"          // Graphics library (grlib)
#include "LcdDriver/lcd_driver.h"       // LCD driver
#include <stdio.h>

#define redLED BIT0
#define greenLED BIT7
#define button BIT1
```

```
void main(void){
    volatile unsigned int counter=0;
    char mystring[20];
    unsigned int n;

    WDTCTL = WDTPW | WDTHOLD;     // Stop the Watchdog timer
    PM5CTL0 &= ~LOCKLPM5;         // Disable GPIO power-on default high-impedance
mode

    P1DIR |= redLED;    P1OUT &= ~redLED;
    P9DIR |= greenLED;  P9OUT &= ~greenLED;
    P1DIR &= ~button; P1REN|=button; P1OUT|=button; // button, resistor, pullup

    // Configure SMCLK to 8 MHz (used as SPI clock)
    CSCTL0 = CSKEY;                  // Unlock CS registers
    CSCTL3 &= ~(BIT4|BIT5|BIT6);     // DIVS=0
    CSCTL0_H = 0;                    // Relock the CS registers


////////////////////////////////////////////////////////////////////////////////
/////////
    Graphics_Context g_sContext;        // Declare a graphic library context
    Crystalfontz128x128_Init();         // Initialize the display

        // Set the screen orientation
    Crystalfontz128x128_SetOrientation(0);

        // Initialize the context
    Graphics_initContext(&g_sContext, &g_sCrystalfontz128x128);

    // Set background and foreground colors
    Graphics_setBackgroundColor(&g_sContext, GRAPHICS_COLOR_BLACK);
    Graphics_setForegroundColor(&g_sContext, GRAPHICS_COLOR_WHITE);

        // Set the default font for strings
    GrContextFontSet(&g_sContext, &g_sFontFixed6x8);

        // Clear the screen
    Graphics_clearDisplay(&g_sContext);

    Graphics_drawStringCentered(&g_sContext, "Welcome to", AUTO_STRING_LENGTH, 64,
30, OPAQUE_TEXT);

    sprintf(mystring, "EEL 4742 Lab!");
    Graphics_drawStringCentered(&g_sContext, mystring, AUTO_STRING_LENGTH, 64, 55,
OPAQUE_TEXT);

    n = 1234;
    sprintf(mystring, "%d", n);
    Graphics_drawStringCentered(&g_sContext, mystring, AUTO_STRING_LENGTH, 64, 80,
OPAQUE_TEXT);

    while(1){}
```

```
}
```

Part 11.2: Using the Graphics Library

Part 11.2 is similar to the part 1, we will just change our drawing functions to do what we would like and be creative. We will be using the same middledriver.c to configure the graphics and LCD screen.

1. Set a new background color
2. Set a new foreground color
3. Draw at least one of each: an outline circle, a filled circle, an outline rectangle, a filled rectangle and a horizontal line.
4. Use at least three different colors on your screen (open the file grlib.h in the project to see the available colors)
5. Draw an image on the first screen (use the image in the file logo.c)
6. Setup an incrementing 8-bit counter on the second screen (it should continue counting after rollback to zero)
7. Pushing the button transitions back and forth between the two screens
8. Set the GPIO pin P2.6 to high to engage the highest brightness level
9. Use two fonts on the screen (the project contains fonts in the folder GrLib/fonts)

I was having difficulty getting the UCF image to display.

```
//Christopher Badolato
//12/2/2019
//Lab 11.2
//EEL 4742 0011
//SPI AND LCD

#include "msp430fr6989.h"
#include "Grlib/grlib/grlib.h"          // Graphics library (grlib)
#include "LcdDriver/lcd_driver.h"       // LCD driver
#include <stdio.h>

#define redLED BIT0
#define greenLED BIT7
#define button BIT1

volatile unsigned int counter=0;

//*********************************
// Configures ACLK to 32 KHz crystal
void config_ACLK_to_32KHz_crystal(){
        // By default, ACLK runs on LFMODCLK at 5MHz/128 = 39 KHz
        // Reroute pins to LFXIN/LFXOUT functionality
    PJSEL1 &= ~BIT4;
    PJSEL0 |= BIT4;
        // Wait until the oscillator fault flags remain cleared
    CSCTL0 = CSKEY; // Unlock CS registers
    do {
        CSCTL5 &= ~LFXTOFFG; // Local fault flag
```

```
        SFRIFG1 &= ~OFIFG; // Global fault flag
    } while((CSCTL5 & LFXTOFFG) != 0);
        CSCTL0_H = 0; // Lock CS registers
    return;
}


void main(void){
    char mystring[20];
    unsigned int n = 0;
        //create a new rectangle objects
    Graphics_Rectangle newRectangle, rectangle2;
    newRectangle.xMax = 44;
    newRectangle.yMax = 0;
    newRectangle.xMin = 0;
    newRectangle.yMin = 22;

    rectangle2.xMax =  100;
    rectangle2.xMin =  54;
    rectangle2.yMax =  64;
    rectangle2.yMin =  54;
        //new ucf image object
    tImage newImage;


    WDTCTL = WDTPW | WDTHOLD;     // Stop the Watchdog timer
    PM5CTL0 &= ~LOCKLPM5;         // Disable GPIO power-on default high-impedance
mode
    P1DIR |= redLED;    P1OUT &= ~redLED;
    P9DIR |= greenLED;  P9OUT &= ~greenLED;
    P1DIR &= ~button; P1REN|=button; P1OUT|=button; // button, resistor, pullup
    // Configure SMCLK to 8 MHz (used as SPI clock)
    CSCTL0 = CSKEY;                 // Unlock CS registers
    CSCTL3 &= ~(BIT4|BIT5|BIT6);    // DIVS=0
    CSCTL0_H = 0;                   // Relock the CS registers

////////////////////////////////////////////////////////////////////////////////
/////////
    Graphics_Context g_sContext;        // Declare a graphic library context
    Crystalfontz128x128_Init();         // Initialize the display
        // Set the screen orientation
    Crystalfontz128x128_SetOrientation(0);

        // Initialize the context
    Graphics_initContext(&g_sContext, &g_sCrystalfontz128x128);


        //used timer interrupts to incement counter
    config_ACLK_to_32KHz_crystal();
    TA0CTL = (TASSEL_1|ID_0|MC_2|TACLR|TAIE);
    TA0CTL &= ~TAIFG;
    _enable_interrupts();

        //turn brightness on high
    P2OUT |= BIT6;
```

```
        //I was having difficulty displaying the image, it wouldn't let me
reference tImage &logo4BPP_UNCOMP
    Graphics_drawImage(&g_sContext, &newImage, 0, 0);

        // Set background and foreground colors
    Graphics_setBackgroundColor(&g_sContext, GRAPHICS_COLOR_ROYAL_BLUE);
    Graphics_setForegroundColor(&g_sContext, GRAPHICS_COLOR_PLUM);
        //set the font
    GrContextFontSet(&g_sContext, &g_sFontCmtt12);
        // Clear the screen
    Graphics_clearDisplay(&g_sContext);
        //was having difficulty displaying
    Graphics_drawImage(&g_sContext, &newImage, 0, 0);
        //write my name
    Graphics_drawStringCentered(&g_sContext, "Chris Badolato", AUTO_STRING_LENGTH,
64, 30, GRAPHICS_COLOR_LIGHT_YELLOW);
        //draw left circle
    Graphics_drawCircle(&g_sContext, 11, 11, 10);
        //draw right circle
    Graphics_drawCircle(&g_sContext, 33, 11, 10);
    Graphics_fillCircle(&g_sContext, 33, 11, 10);
        //draw unfilled rectangle aroudn circles
    Graphics_drawRectangle(&g_sContext, &newRectangle);
        //draw filled center rectangle
    Graphics_drawRectangle(&g_sContext, &rectangle2);
    Graphics_fillRectangle(&g_sContext, &rectangle2);
        //change the font before showing the counter.
    GrContextFontSet(&g_sContext, &g_sFontFixed6x8);

    while(1){
            // every second the incrementor will be increased and redisplayed on
the LCD.
        n = counter;
        sprintf(mystring, "%d", n);
        Graphics_drawStringCentered(&g_sContext, mystring, AUTO_STRING_LENGTH, 64,
40, GRAPHICS_COLOR_LIGHT_YELLOW);
    }
}

#pragma vector = TIMER0_A1_VECTOR // Link the ISR to the vector
__interrupt void T0A1_ISR() {
            // Toggle both LEDs
        counter++;
        if(counter >= 32768){
            counter = 0;
        }
        P9OUT ^= greenLED;
        P1OUT ^= redLED;
            // Clear the TAIFG flag
        TA0CTL &= ~TAIFG;
}
```

Student Q&A

1. Is the SPI implemented as half-duplex or full duplex in this experiment?

SPI can be configured to full duplex but in this experiment, we are using half-duplex

2. What SPI clock frequency did we set up?

8 MHz clock frequency

3. What is the maximum SPI clock frequency that is supported by the eUSCI module? Look in the microcontroller's data sheet in Table 5-18.

eUSCI input clock frequency maximum = 16 MHz

4. Is the display driver software specific to a display model or could it work with any display? Explain.

The driver is not specific to the display model, we need to only change the SPI configuration to match the device we are trying to project images to.

5. Is the graphics library (e.g. grlib) specific to a display model or could it work with any display? Explain.

It could work on any display, we need only change the parameters of the functions we are calling as well as the SPI configuration.

Conclusion

In conclusion, in this experiment we configured the serial peripheral interface to display on the Booster Pack LCD. First, we simply displayed a given program after configuring the middleDriver functions that will configure the LCD and SPI. In the second part of the lab we created our own design with the grlib functions such as, drawing shapes, changing fonts