# Pre-lab

1. TMP36 is an external temperature sensor. Briefly explain how this sensor works.

TMP36 use the fact as temperature increases, the voltage across a diode increases at a known rate. (Technically, this is actually the voltage drop between the base and emitter - the Vbe - of a transistor.) By precisely amplifying the voltage change, it is easy to generate an analog signal that is directly proportional to temperature.

2. How do accelerometer sensors work?

Accelerometers measure proper acceleration, meaning acceleration due to any force, including the force of gravity, unlike other coordinate acceleration, being the acceleration in a fixed coordinate system.

3. Is top of the stack different for push and pull operations?

No, the top of the stack is the same for push and pull operations since it applies the LIFO method (last in, first out)

4. How is the memory cell notation different for stack compared to a regular memory bank?

The SP usually starts pushing the top address of RAM, ie the stack grows down.

5. Explain what case A and case B, are when it comes to stack operations.

* Pushing when SP points at TOS
* Popping when SP Point at TOS

6. What are the RTN notation for push and pop?

Push:

(SP) <- src

SP <- SP - N

Pull:

SP <- SP + N

Dst <- (SP)

(Depending on if it is CASE A or B

7. How is a subroutine executed? Explain the roles of stack and program counter.

When reaching a subroutine, the contents of the PC is pushed onto the stack, while maintaining the address for the next instruction. After the subroutine is executed, the next instruction is called and execution is resumed.

8. What is an orthogonal CPU?

A CPU is said to orthogonal if all its registers and addressing modes can be used as operands, except for the immediate mode as a destination

9. What are the advantages and disadvantages of using an interrupt?

* Advantages:
  + Preferred when working with low power mode
  + Using interrupts leads to less CPU cycles and less power consumption
* Disadvantages:
  + susceptible to false triggering of interrupts so in noisy environments it might be better to use polling to get a more accurate functionality
  + If not handled properly, interrupt driven systems may have delayed responses to different IRQs

10. What are maskable and non-maskable interrupts?

Maskable interrupts are interrupts that can be turned off (modified), non-maskable interrupts cannot be turned off (modified)

11. Explain the 6 steps for servicing interrupts

* Finish the instruction being executed
* Save the current PC value and the SR onto the stack
* Clear the global interrupt enable flag
* Load the PC with the address of the ISR to be executed.
* Execute the corresponding ISR.
* Restore the PC and any other register that was saved onto the stack in Step

12. What is a brown-out in electrical circuit?

# 

# Lab

Q1: Parts of code responsible for capturing temperature:

void Mode4(void)

{

// One time initialization of header and footer transmit package

TX\_Buffer[0] = 0xFA;

TX\_Buffer[6] = 0xFE;

// variable initialization

ADCTemp = 0;

temp = 0;

WriteCounter = 0;

active = 1;

ULPBreakSync = 0;

counter = 0;

// One time setup and calibration

SetupThermistor();

CalValue = CalibrateADC();

while((mode == TEMP\_MEAS) && (UserInput == 0))

{

// Take 1 ADC Sample

TakeADCMeas();

if (ADCResult >= CalValue)

{

temp = DOWN;

ADCTemp = ADCResult - CalValue;

}

else

{

temp = UP;

ADCTemp = CalValue - ADCResult;

}

if((ULP==1) && (UserInput == 0))

{

// P3.4- P3.7 are set as output, low

P3OUT &= ~(BIT4 + BIT5 + BIT6 + BIT7);

P3DIR |= BIT4 + BIT5 + BIT6 + BIT7;

// PJ.0,1,2,3 are set as output, low

PJOUT &= ~(BIT0 + BIT1 + BIT2 + BIT3);

PJDIR |= BIT0 + BIT1 + BIT2 + BIT3;

// Transmit break packet for GUI freeze

if(!(ULPBreakSync))

{

TXBreak(mode);

ULPBreakSync++;

}

}

if((ULP==0) && (UserInput == 0))

{

ULPBreakSync = 0;

WriteCounter++;

if(WriteCounter > 300)

{

LEDSequence(ADCTemp,temp);

// Every 300 samples

// Transmit 7 Bytes

// Prepare mode-specific data

// Standard header and footer

WriteCounter = 0;

TX\_Buffer[1] = 0x04;

TX\_Buffer[2] = counter;

TX\_Buffer[3] = 0x00;

TX\_Buffer[4] = 0x00;

TX\_Buffer[5] = 0x00;

TXData();

}

}

}

// turn off Thermistor bridge for low power

ShutDownTherm();

}

Q2: Parts of code responsible for Accelerometer use:

void Mode3(void)

{

// One time initialization of header and footer transmit package

TX\_Buffer[0] = 0xFA;

TX\_Buffer[6] = 0xFE;

// variable initialization

active = 1;

ADCTemp = 0;

temp = 0;

WriteCounter = 0;

ULPBreakSync = 0;

counter = 0;

// One time setup and calibration

SetupAccel();

CalValue = CalibrateADC();

while ((mode == ACCEL\_MEAS) && (UserInput == 0))

{

// Take 1 ADC Sample

TakeADCMeas();

if (ADCResult >= CalValue)

{

temp = DOWN;

ADCTemp = ADCResult - CalValue;

}

else

{

temp = UP;

ADCTemp = CalValue - ADCResult;

}

if((ULP==1) && (UserInput == 0))

{

// P3.4- P3.7 are set as output, low

P3OUT &= ~(BIT4 + BIT5 + BIT6 + BIT7);

P3DIR |= BIT4 + BIT5 + BIT6 + BIT7;

// PJ.0,1,2,3 are set as output, low

PJOUT &= ~(BIT0 + BIT1 + BIT2 + BIT3);

PJDIR |= BIT0 + BIT1 + BIT2 + BIT3;

// Transmit break packet for GUI freeze

if(!(ULPBreakSync))

{

TXBreak(mode);

ULPBreakSync++;

}

}

if((ULP==0) && (UserInput == 0))

{

ULPBreakSync = 0;

WriteCounter++;

if(WriteCounter > 300)

{

LEDSequence(ADCTemp,temp);

// Every 300 samples

// Transmit 7 Bytes

// Prepare mode-specific data

// Standard header and footer

WriteCounter = 0;

TX\_Buffer[1] = 0x03;

TX\_Buffer[2] = counter;

TX\_Buffer[3] = 0x00;

TX\_Buffer[4] = 0x00;

TX\_Buffer[5] = 0x00;

TXData();

}

}

}

// end while() loop

// turn off Accelerometer for low power

ShutDownAccel();

}

Q3:

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\* main.c

\* User Experience Code for the MSP-EXP430FR5739

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#include "msp430fr5739.h"

#include "FR\_EXP.h"

const unsigned char LED\_Menu[] = {0x80,0xC0,0xE0,0xF0, 0xF8, 0xFC, 0xFE, 0xFF};

// These golabal variables are used in the ISRs and in FR\_EXP.c

volatile unsigned char mode = 0;

volatile unsigned char UserInput = 0;

volatile unsigned char ULP =0;

volatile unsigned int \*FRAMPtr = 0;

volatile unsigned char active = 0;

volatile unsigned char SwitchCounter=0;

volatile unsigned char Switch1Pressed=0;

volatile unsigned char Switch2Pressed=0;

volatile unsigned int ADCResult = 0;

void main(void)

{

WDTCTL = WDTPW + WDTHOLD; // Stop WDT

SystemInit(); // Init the Board

StartUpSequence(); // Light up LEDs

// Setup ADC data storage pointer for Modes 3&4

FRAMPtr = (unsigned int \*) ADC\_START\_ADD;

while(1)

{

// Variable initialization

active = 0;

Switch2Pressed = 0;

ULP = 0;

// Wait in LPM4 for user input

\_\_bis\_SR\_register(LPM4\_bits + GIE); // Enter LPM4 w/interrupt

\_\_no\_operation(); // For debugger

// Wake up from LPM because user has entered a mode

// switch(mode)

// {

// case MAX\_FRAM\_WRITE:

// Mode1();

// break;

//

// case SLOW\_FRAM\_WRITE:

// Mode2();

// break;

//

// case ACCEL\_MEAS:

// Mode3();

// break;

//

// case TEMP\_MEAS:

// Mode4();

// break;

//

// default:

// // This is not a valid mode

// // Blink LED1 to indicate invalid entry

// // Switch S2 was pressed w/o mode select

// while((mode > 0x08)&& (UserInput == 0))

// {

// P3OUT ^= BIT7;

// LongDelay();

// }

// break;

// }

}

}

// Interrupt Service Routines

/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*//\*\*

\* @brief Port 4 ISR for Switch Press Detect

\*

\* @param none

\*

\* @return none

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/

#pragma vector=PORT4\_VECTOR

\_\_interrupt void Port\_4(void)

{

// Clear all LEDs

PJOUT &= ~(BIT0 +BIT1+BIT2+BIT3);

P3OUT &= ~(BIT4 +BIT5+BIT6+BIT7);

switch(\_\_even\_in\_range(P4IV,P4IV\_P4IFG1))

{

case P4IV\_P4IFG0: // Button 1

DisableSwitches();

Switch2Pressed = 0;

UserInput = 1;

P4IFG &= ~BIT0; // Clear P4.0 IFG

PJOUT = LED\_Menu[SwitchCounter];

P3OUT = LED\_Menu[SwitchCounter];

// P3OUT = LED\_Menu[SwitchCounter];

SwitchCounter++;

if (SwitchCounter>7)

{

SwitchCounter =0;

// Switch1Pressed++;

}

StartDebounceTimer(0); // Reenable switches after debounce

break;

case P4IV\_P4IFG1: // Button 2

DisableSwitches();

Switch2Pressed = 1;

UserInput = 1;

P4IFG &= ~BIT0; // Clear P4.0 IFG

// P3OUT = LED\_Menu[SwitchCounter];

SwitchCounter--;

if (SwitchCounter<0)

{

SwitchCounter =7;

// Switch1Pressed++;

}

PJOUT = LED\_Menu[SwitchCounter];

P3OUT = LED\_Menu[SwitchCounter];

StartDebounceTimer(0); // Reenable switches after debounce

break;

default:

break;

}

}

/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*//\*\*

\* @brief Timer A0 ISR for MODE2, Slow FRAM writes, 40ms timer

\*

\* @param none

\*

\* @return none

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/

#pragma vector = TIMER0\_A0\_VECTOR

\_\_interrupt void Timer\_A (void)

{

\_\_bic\_SR\_register\_on\_exit(LPM4\_bits);

}

/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*//\*\*

\* @brief ADC10 ISR for MODE3 and MODE4

\*

\* @param none

\*

\* @return none

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/

#pragma vector=ADC10\_VECTOR

\_\_interrupt void ADC10\_ISR(void)

{

switch(\_\_even\_in\_range(ADC10IV,ADC10IV\_ADC10IFG))

{

case ADC10IV\_NONE: break; // No interrupt

case ADC10IV\_ADC10OVIFG: break; // conversion result overflow

case ADC10IV\_ADC10TOVIFG: break; // conversion time overflow

case ADC10IV\_ADC10HIIFG: break; // ADC10HI

case ADC10IV\_ADC10LOIFG: break; // ADC10LO

case ADC10IV\_ADC10INIFG: break; // ADC10IN

case ADC10IV\_ADC10IFG:

ADCResult = ADC10MEM0;

\*FRAMPtr = ADCResult;

FRAMPtr++;

// Pointer round off, once 0x200 locations are written, the pointer

// rolls over

if (FRAMPtr > (unsigned int \*)ADC\_END\_ADD)

FRAMPtr = (unsigned int \*) ADC\_START\_ADD;

\_\_bic\_SR\_register\_on\_exit(CPUOFF);

break; // Clear CPUOFF bit from 0(SR)

default: break;

}

}

/\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*//\*\*

\* @brief Timer A1 ISR for debounce Timer

\*

\* @param none

\*

\* @return none

\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*/

#pragma vector = TIMER1\_A0\_VECTOR

\_\_interrupt void Timer1\_A0\_ISR(void)

{

TA1CCTL0 = 0;

TA1CTL = 0;

EnableSwitches();

}