

Lab 6: Part 1

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Questions

Lab 6 Wrapup

William Watkins

1. The ADC is a 12-bit ADC. Therefore, it has $2^{12} = 4096$ bins. If the reference voltages provided are $+V_R = +5V$ & $-V_R = +1V$, the ADC is being used in bipolar mode, and the voltage bin resolution is $\Delta V_R / 2^{12} \Rightarrow 4V / 2^{12} = 0.98 \text{ mV per bin}$.

13.13.: What is SPBRG₆ reg. for band=9600, asynchronous, $F_{osc} = 16 \text{ MHz}$, & TXSTA.BRGH is cleared?

$\text{BRGH} = 0 = \text{low speed asyinc. Assume default 8-bit mode.}$

$$\text{For 8-bit, } 9600 = F_{osc} / [64(n+1)]$$

$$\rightarrow n = [F_{osc} / 9600] / 64 - 1 = 25.04117$$

$$\boxed{\text{SPBRG}_6 = 25.}$$

13.14. Calculate error in 13.13.

$$\text{Band} = 16 \text{ MHz} / [64(n+1)] = 9615.38 \text{ band}$$

$$\text{Error} = (9615.38 - 9600) / 9600 = \boxed{0.16\% \text{ error}}$$

13.15. 13.13, but assume BRGH16=1. 13.14.

$$\text{For 16-bit, } 9600 = F_{osc} / [16(n+1)]$$

$$\rightarrow n = [F_{osc} / 9600] / 16 - 1 = 103.167$$

$$\boxed{\text{SPBRG}_6 = 103}$$

$$\text{Band} = 16 \text{ MHz} / [16(103)] = 9615.38 \text{ band}$$

$$\text{Error} = (9615.38 - 9600) / 9600 = \boxed{0.16\% \text{ error}}$$

Functionality

- On power up
 - RD4 off
 - RDS on 0.5s
 - RD6 on 0.5s
 - RD7 on 0.5s
- Following occurs forever
 - RD4 blinks 100ms ON, 900ms OFF
 - LCD displays
 - $T = XX.XC$
 - $P_T = X.XXV$
 - Both update @ 5Hz
 - USART commands read/executed properly
 - 'TEMP\n' - Transmits 'XX.XC' once
 - 'POT\n' - Transmits 'X.XXV' once
 - For 5067:
 - 'CONT_ON\n' begins continuous transmission over USART
 - 'CONT_OFF\n' stops transmission
 - Data sent as ' $T = XX.XC$; $P_T = X.XXV\n$ '
 - Output 0.5Hz, 3.3V triangle wave on DAC
 - Accuracy better than 1ms

Part 1

1 ms

Part 0: Layout

- Use ~~delay_ms()~~ for LEDs on start
- ADC
 - Pin AN3 (RA3) for Temp. Sensor (LM35)
 - Use Channel 3
 - Pin AN1 (RA1) for potentiometer (PZ)
 - Use Channel 1
 - Right justified
- USART
 - USART1, 19,200 baud, 8-N-1
 - Use high-priority interrupts when a start bit is detected
 - For continuous output, set a flag & do in mainline
- SPI/DAC
 - 4096 bins \rightarrow Need to update every 0.244141 ms
 - Use CCP1 low-pr. interrupt, timer 1
 - First thing is update CCP reg. so hi-pr. doesn't send past 1 ms tolerance
- Blink LED
 - CCP2 timer 3, low-pr. interrupt

On startup

- Set RD4-7 as OUTPUT
- Configure LCD for output
- Configure ADC for input
- Configure DAC for output
- Configure USART to listen for input
- Configure Blink LED
- Configure Timer 1
- Configure Timer 3

CCP1 - SPI/DAC

best res: update every 0.244141ms (≈ 4096 bins)

- Error of 0.5ms

Acceptable: update every 0.9765625ms (≈ 1024 bins)

- 3906.25 Instruction cycles

- Use 3906 instruction cycles

- $3906 \text{ cy} \cdot \frac{250\text{ns}}{1 \text{ cy}} = 0.9765 \text{ ms}$

1 clock cycle!

- Error b/m updates: $0.9765\text{ms} - 0.9765625\text{ms} = -6.25 \cdot 10^{-5}\text{ms}$

- Error across 2_s (for 4.5Hz signal)

$$-6.25 \cdot 10^{-5}\text{ms} \cdot 2048 = -0.128\text{ms} < 1\text{ms} \text{ req'd} \checkmark$$

Bin values

- Range: $0V - 3.3V$

- Bins available: 4096

- Each bin incremented by 0.805mV

- Only using 1024 bins - $0 \rightarrow 4 \rightarrow 8 \rightarrow 12 \text{ etc}$

EUSKART

band = 19244

SPBRG = 12 \rightarrow band = 19230.8

Error = 0.16%

Lab 6 Part 2 Questions

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1. $R_1 + R_2 = 2.5V \Omega$

a) $3.3V \cdot 0.2S = \boxed{0.825V}$

b) $0.825V - \frac{1b\text{in}}{0.806mV} = 1023.57 = \text{bin } 1023$
 $= \boxed{\text{bin } 0 \times 3FF}$

c) $0 \times 333 = \text{bin } 819$

$7^{12} \text{ bins} = 4096 \text{ bins}$

0.806mV
bin

bin 819 = 0.659 V

$$V_{out} = V_{in} \cdot \frac{R_2}{R_1 + R_2}$$

$$R_2 = \frac{V_{out}}{V_{in}} (R_1 + R_2) = \frac{0.659V}{3.3V} \cdot 2.5V \Omega = 0.49V \Omega = 499 \Omega$$

$$R_1 = 2.5V \Omega - R_2 = 2.5V \Omega - 499 \Omega = 2000.76 \Omega$$

$\boxed{R_2 = 499 \Omega}$

$\boxed{R_1 = 2000.76 \Omega}$

2.

a) From section 6.8 of the data sheet, the sensor gain is typically $10 \text{ mV}/^\circ\text{C}$ for the LM35D.

b) Per section 6.3, the specified operating temperature for the LM35D is: 0°C to 100°C .

c) 25°C

$$\rightarrow 25^\circ\text{C} \cdot \frac{10 \text{ mV}}{^\circ\text{C}} = \boxed{250 \text{ mV}}$$

With 3.3V , $1 \text{ bin} = 0.806 \text{ mV}$

$$\begin{aligned} \rightarrow \frac{250 \text{ mV}}{0.806 \text{ mV}} &= 314.174 \Rightarrow \text{bin} \# = 314 \\ &= 0b000100110110 \\ &= \boxed{0x136} \end{aligned}$$

5Q67 Question

1. Bin resolution is $\frac{0.846 \text{ mV}}{\text{bin}}$. Using the nominal

slope of $\frac{10 \text{ mV}}{^{\circ}\text{C}}$, this converts to a bin

$$\text{resolution of } \frac{0.846 \text{ mV}}{\text{bin}} \cdot \frac{1^{\circ}\text{C}}{10 \text{ mV}} = \boxed{\frac{0.0846 \text{ } ^{\circ}\text{C}}{\text{bin}}}.$$

Extra Credit

$$1. \quad T_{\min} = 0^\circ\text{C} \quad T_{\max} = 35^\circ\text{C}$$

$$\text{ADC}_{\min} = 0 \text{ V} \quad \text{ADC}_{\max} = 3.3 \text{ V}$$

$$T_{V,\min} = 0 \text{ mV} \quad T_{V,\max} = 350 \text{ mV}$$

a) $V_{\text{off}} = 0 \text{ V}$. The range is already shifted down to 0 V as the minimum value.

$$\frac{3.3 \text{ V}}{350 \text{ mV}} = 9.42857 = A$$

$$b) \quad \frac{35^\circ\text{C}}{3.3 \text{ V}} = \frac{10.646^\circ\text{C}}{1 \text{ V}}$$

$$\rightarrow \frac{10.646^\circ\text{C}}{1 \text{ V}} \cdot \frac{0.806 \text{ mV}}{5 \text{ mV}} = \frac{0.0085^\circ\text{C}}{5 \text{ mV}}$$