ESS: Exercise Set 5

Peripherals

Question 1:

Two devices are communicating using asynchronous serial UART. The baudrate is 57600 bps, with 1 start bit, 8 data bits and 1 stop bit. Each device is run from its own, independent clock (oscillator).

(a) What is the throughput of the serial link (maximum number of data bits per second)?

(b) What is the maximum error that can be tolerated between the two clocks before timing errors will occur? (hint: we start timing at the start bit and need to keep clocks synchronized until the stop bit. In a noisy environment, there will be jitter on transitions, so we need to sample the last bit within ± 0.25 bits of the true position.)

(c) What is the tolerance we need on each device's clock?

(d) To generate the baudrate, we can use the following oscillators, which each contribute the following cost to the BOM:

- 64 MHz, with a tolerance of ± 50 ppm (parts per million), a unit cost of \$2.30 and a supply current of 1 mA
- 16 MHz, with a tolerance of $\pm 2\%$ and a unit cost of \$0.20 and a supply current of 0.1 mA
- 8 MHz, with a tolerance of $\pm 4\%$ and a unit cost of \$0.00 (internal RC) and a supply current of 0.01 mA

Which oscillator would be suitable for a industrial control system? Which oscillator would be suitable for a mass-produced toy?

(e) What strategies can you think of to minimize this problem?

Question 2:

A 12 bit DAC has a reference voltage of 3.3V. What digital word would result in a voltage of 1.32V? What is the relative error?

Question 3:

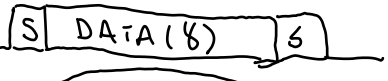
A 4 bit DAC can be used in conjunction with a comparator to digitize an analog voltage. Design an algorithm that the controller could use to find the digitized value.

Question 4:

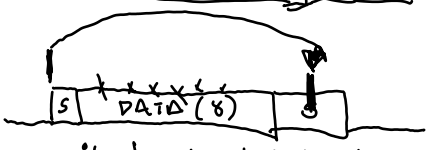
A temperature sensor has an output from 0V to 3V, where 1V corresponds to 0°C and 2V corresponds to 100°C. This signal is digitized with an ADC, with a full-scale range from 0V to 3V.

(a) Using an 8-bit ADC, what is the resolution of a voltage that can be measured?

(b) Using an 8-bit ADC, what is the resolution of the temperature that can be measured?

a) 

$\Rightarrow$ throughput: 80% × 57600 = 46 kbps

b) 

5%	3%	0.4%
Daniel	Ken	Zoltan

$\frac{\pm 0.25 \text{ bits}}{9.5 \text{ bits}} \approx \pm 2.6\%$

c) $\approx 1.3\% \approx 1\%$

d)

64 MHz:	± 50 ppm	$2.30	1 mA ⇐
16 MHz	± 2%	$10.20	0.1 mA ⇐
8 MHz	± 4%	$10.00	0.01 mA

e)

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2) $4096 = 2^{12}$

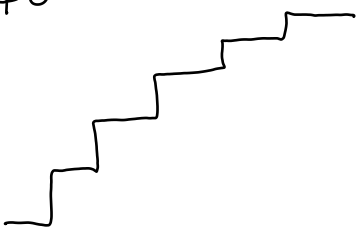
1638

$\frac{X}{4095} = \frac{1.32V}{3.30V}$

$\frac{3.3V}{4095} = V/bit$ (1sb)

$= 0.805 mV/bit$

$1638 \times 0.805 \ldots mV/bit = 1.32V$



$2^{12} = 4096$

(c) To achieve a resolution of 0.1°C, how many bits should the ADC have as a minimum?

Question 5:

A timer has a period of 1000 counts. It has a 4 channel PWM module. Draw the output waveforms for:

- Timer counter
- Ch1 with a compare value of 250
- Ch2 with a compare value of 600
- Ch3 with a compare value of 10
- Ch4 with a compare value of 2000

Question 6:

The figure shows a sinusoidal waveform that is to be digitized by a 16 level ADC. Show the reconstructed waveform for sampling rates of 10 Hz, 5 Hz, 2 Hz and 1 Hz.