

EE 371 Test 4
Monday December 5, 2005
2 pages, 4 questions, 40 points, 15% of Final Grade

Please put your name on the outside of the paper also Name _____ Key _____

1. A microcontroller similar to the HCS12 has a 12-bit successive approximation A/D. It is clocked by a 1 MHz clock.

- a. Excluding any clock periods required for sampling, how many A/D clocks are required to convert an analog value to a digital value. (2 points)

1 clock per bit = 12 clocks

- b. Assuming the sampling time is 4 A/D clocks, what is the maximum frequency that can be sampled without aliasing effects? (2 points)

**4 clocks for the sample time and 12 clocks for the conversion time = 16 μ s conversion time
 $f_{MAX} = 1/(2 * \text{Conversion time}) = 31.25 \text{ kHz}$**

- c. If aperture time effects are taken into account, what is the maximum frequency that can be sampled such that the aperture time error is $< \pm 1/2 \text{ LSB}$? (2 points)

**$t_{AP} = 4 \mu\text{s}$
 $f_{MAX} = 1/(2 * \pi * t_{AP} * 2^{12}) = 9.71 \text{ Hz}$**

2. An A/D is required to digitize a 17 kHz signal with peak amplitude of 450 mV_{p-p} with noise of 2 mV_{p-p}. Specify an A/D to do this. (2 points each)

- a. Conversion time? $\leq 1/(2 f) = 29.4 \mu\text{s}$

- b. Number of bits? $450/2 = 225 \rightarrow 8 \text{ bits}$

- c. Aperture time? $t_{AP} = 1/(2 * \pi * f * 2^8) = 36.6 \text{ ns}$

3. Consider interrupt vectors.
- What is an interrupt vector? (3 points)
The starting address of the particular ISR stored in a specific memory location.
 - In the CodeWarrior system, how do you initialize the interrupt vector? (5 points)
XDEF the ISR label in the source file
In the linker parameter file set
VECTOR ADDRESS 0x- - - - ISR_LABEL
 - What happens if you do not initialize the interrupt vector properly? (Note: “The program doesn’t work” is not a sufficient answer.) (5 points)
The processor will fetch the improperly initialized vector and try to start executing code at that address. Anything can happen; mostly bad things.
4. The HCS12 timer is being clocked by an 8 MHz clock. A time delay of 10.6 millisecond is required between Point A and Point B in the program. Assume the timer is enabled and running and that you do not need interrupts.
- What is your strategy to generate the time delay? (5 points)
10.6 ms requires 84,800 clock cycles at 8 MHz which is greater than 65,536. So need two successive delays of 42,400 cycles using an output compare channel.
 - Give a design using pseudo-code comments (no program code) to accomplish the 10.6 ms delay between Point A and Point B. (10 points)
 ; Point A

; Get the current TCNT value
; Add 42,400 to it
; Save in TCn register
; Reset the OCnF flag
; Wait until OCnF flag is set
; Add 42,400 to TCn
; Reset the OCnF flag
; Wait until OCnF flag is set
 ; Point B