

# E85: Digital Design and Computer Architecture

## Problem Set 6

### 1) Number Systems

- a) Write -9.0625 as a 12-bit fixed-point number with 7 integer and 5 fractional bits.
- b) Compute the sum of the following IEEE single-precision numbers by hand.  
 $0x41200000 + 0x40D80000$

### 2) Building Blocks

You need to blink 27 LEDs in a mesmerizing pattern to create a nifty display for the next Hackathon. You want to generate the pattern with a microcontroller that only has two free pins available. Design some hardware that could go on a breadboard to receive inputs from these two pins and control the LEDs. Assume you have any reasonable gates, registers, and other building blocks available.

### 3) FPGA Configuration

How many Altera Cyclone IV logic elements (LEs) are required to build each of the following functions? Explain.

- a) 2-input OR
- b) 8-input AND
- c) arbitrary FSM with 3 states, 1 input and 1 output
- d) 8-bit counter with reset and enable

### 4) Datasheets

Answer the following questions to familiarize yourself with the STM32F042K6T6 microcontroller that we will be using. See the stm32f042 datasheet on the class web page. For each question, note the page number and symbol for the specification that informs your answer.

- a) What is the range of allowable digital supply voltages for normal operation?
- b) If you accidentally connect a 5 V supply to the  $V_{DD}$  pin, should you expect it to survive?  
For the remainder of this question, assume 3.3 V operation.
- c) What is the typical  $V_{DD}$  power consumption in normal operating mode at  $f_c = 48$  MHz with all features running full-bore? How long could the chip run off a 300 mAh battery?
- d) What is the typical  $V_{DD}$  power consumption in standby mode with all features turned off? How long could the chip remain in standby using a 300 mAh battery?
- e) What is the range of ambient temperatures over which the microcontroller will work reliably?

- f) What is  $V_{IL}$  and  $V_{IH}$  for a generic digital I/O pin?
  - g) What are  $V_{OL}$ , and  $V_{OH}$  for a digital CMOS I/O pin, assuming a maximum output current of 8 mA?
  - h) If you use an I/O pin to drive an LED, what is the maximum current you can expect to provide? What resistor should you choose to achieve that current?
  - i) What is the maximum input leakage current for a pin, assuming the input voltage does not exceed  $V_{DD}$ ? If you were to connect a DIP switch to the pin with a pullup resistor, how large could the resistor be before the leakage causes the input pin to reach an invalid logic level?
  - j) How much Flash memory for programs is on the chip?
  - k) How much SRAM for data storage is on the chip?
  - l) How many bits of resolution does the ADC have? How many external input channels can it read? What is the maximum sampling rate?
- 5) Impact on Society: Explain the impact of the C programming language on modern society. When did C become widely used? What languages were dominant before the rise of C, and how did C improve on them? For what kinds of programming is C typically used today? Why does E85 teach C instead of another contemporary language (e.g. Python, C++, Java)? Name at least one major drawback of the C language that has a concrete impact on geopolitics.
- 6) How long did you spend on this problem set? This will not count toward your grade but will help calibrate the workload.