E85: Digital Design and Computer Engineering
Problem Set 6

1) Number Systems
   a) Write –9.0625 as a 12-bit two's complement 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 arbitrary patterns with a microcontroller that only has two free pins available. Design some hardware that could go on a breadboard or FPGA to receive inputs from these two pins and control the LEDs. Assume you have any reasonable gates, registers, and other building blocks available. (You are responsible only for the digital hardware, not for the microcontroller software.)

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 Freedom E310 microcontroller that we will be using. See the FE310-g002 Datasheet on the class web page. For each question, note the page number and symbol for the specification that informs your answer.

   a) What voltage level is used to supply the core (VDD)? What about the I/O pins (IVDD)?
   b) What is the typical power consumption to run the core at 16 MHz (IVDD)? What about at 250 MHz?
   c) What is V_{IL} and V_{IH} for a generic digital I/O pin?
   d) What are V_{OL}, and V_{OH} for a digital I/O pin, assuming the drive strength is set to low (DS = 0) for a maximum output current of 1 mA?

e) If you use an I/O pin to drive an LED, what is the maximum current you can expect to provide with DS = 1? What resistor should you choose to achieve that current?

f) 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?

g) How much SRAM for data storage is on the chip?

h) What is the maximum frequency clock frequency for the core?

5) Impact on Society: Research and describe the environmental life cycle of an integrated circuit. Where does electronic waste end up?

6) AI Question (Optional)
This question must be solved by AI. Report what the AI produces, whether you believe it is accurate or a hallucination, and whether the solution is similar, better, or worse than what you would have done yourself in a reasonable amount of time.

Solve problem 1(b) with AI.

How long did you spend on this problem set? This will not count toward your grade but will help calibrate the workload. Cite your sources.