

E85: Digital Design and Computer Engineering

Problem Set 1

1) Number system finger exercise. Don't use a calculator to automate these parts, though you can use it if you want help with multiplication or addition or to check answers. If you find any parts difficult or time-consuming, make up some more problems until number systems feel easy.

- A) Write the powers of 2 from 2^0 to 2^{16} . Commit these numbers to memory because you will use them frequently in digital design.
- B) Base conversions. If you do these properly, you shouldn't have any difficult arithmetic when converting between bases 2, 8, and/or 16.
 - i. Convert the following numbers to base 2.
 13_{10} , 1000_{10} , 654_8 , $FEED_{16}$
 - ii. Convert the following numbers to base 10.
 1001_2 , 1100100_2 , 654_8 , $BEEF_{16}$
 - iii. Convert the following numbers to base 16.
 1001_2 , 1100100_2 , 654_8 , 17_{10} , 200_{10} , 1000_{10}
- C) Number systems
 - i. Convert the following numbers to 8-bit 2's complement and sign-magnitude format:
 69_{10} , -2_{10} , -37_{10}
 - ii. Convert the following 6-bit 2's complement numbers to base 10:
 100100_2 , 011111_2
 - iii. Convert the following 6-bit sign-magnitude numbers to base 10:
 100100_2 , 011111_2
 - iv. Write the most positive and most negative 8-bit numbers in binary and decimal for each of the following formats: unsigned, 2's complement, sign-magnitude.
- D) Arithmetic:
 - i. Assuming unsigned format:
 - a) Compute $1010_2 + 0111_2$. Convert the addends and the sum to decimal and check your results.
 - b) Extend 101111_2 to 8 bits. Convert the input and result to decimal and check your result.
 - ii. Repeat the question above assuming 2's complement format.

2) Logic gates

Write the symbol, Boolean equation, truth table, and Verilog code for a 3-input NAND gate.

3) Impact on Society

Research and write a paragraph about how digital systems have transformed another discipline of engineering within your lifetime. Provide quantitative data about at least one specific impact, such as cost, reliability, etc. Cite your sources.

4) AI Question (Optional)

This question must be solved by AI. You may start by photographing or pasting in the prompt below. 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. If you are unsatisfied with the initial answer, explain how you modified the prompt and whether you obtained better results.

- a) Convert the following numbers to base 10: 1100100_2 , $BEEF_{16}$.
- b) What is the most positive unsigned 8-bit number?
- c) What is the most positive 2's complement 8-bit number?
- d) Sketch a CMOS transistor-level diagram for a 4-input NOR gate. (When I asked this in August 2024, the first answer ChatGPT gave me was incorrect, and when I reminded it of the function of a NOR gate, it revised the answer to be correct.)

How long did you spend on this problem set? The amount of time will not affect your grade but will help calibrate the workload for the future. You will get one point for reporting the time.