# Pset 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.

| *Power* | *Value* |
|---|---|
| 0 | 1 |
| 1 | 2 |
| 2 | 4 |
| 3 | 8 |
| 4 | 16 |
| 5 | 32 |
| 6 | 64 |
| 7 | 128 |
| 8 | 256 |
| 9 | 512 |
| 10 | 1024 |
| 11 | 2048 |
| 12 | 4096 |
| 13 | 8192 |
| 14 | 16384 |
| 15 | 32768 |
| 16 | 65536 |

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.
$1001_2$, $1100100_2$, $654_8$, $17_{10}$, $200_{10}$, $1000_{10}$

10 A

11 B

12 C

13 D

14 E

15 F

1. 1101
   01111101000
   $428_{10}$ = 110101100

$$65261_{10} = 1111111011101101_2$$

2. $2^3 + 1 = 9$
   $2^2 + +2^5 + 2^6$ = 100
   $6 * 64 + 5 * 8 + 4 = 428$

$$11 * 16^3 + 14 * 16^2 + 14 * 16 + 15 = 48879_{10}$$
$$= 1011111011101111$$

3. 1. 9
   2. 64
   3. 1 A C
   4. 11
   5. C8
   6. 3E8

- I realized just after finishing this that I could have done it much simpler by breaking base 16 into 4 digits in base two, and base 8 into 3 digits. That is silly, but oh well.

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C) Number systems

i. Convert the following numbers to 8-bit 2's complement and sign-magnitud format:
$69_{10}$, $-2_{10}$, $-37_{10}$

$69_{10}$) sign-magnitude = 01000101

two's compliment format = 01000101

$-2_{10}$) sign-magnitude = 10000010
two's compliment format = 11111110

$-37_{10}$) sign-magnitude = 10100101
two's compliment format = 1011011

ii. Convert the following 6-bit 2's complement numbers to base 10:
$100100_2$, $011111_2$

$100100_2$ is -28
011111 is 31

iii. Convert the following 6-bit sign-magnitude numbers to base 10:
$100100_2$, $011111_2$

-4
31

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.

Binary:
unsigned)
Positive: 11111111 = 255

Most Negative: 00000000 = 0

2's compliment)

Positive: 011111111 = 127

Most Negative: 10000000 = -128

Sign Magnitude)

Positive: 011111111 = 127

Most Negative: 11111111 = -127

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.

$$
\begin{array}{ll}
A & \\
1010 & 10 \\
+0111 & +7 \\
=10001 & =17
\end{array}
$$

$$
\begin{array}{ll}
B & \\
00101111 = 32+8+4+2+1 & =47 \\
101111 & =47
\end{array}
$$

ii. Repeat the question above assuming 2's complement format.

$$
\begin{array}{ll}
A & \\
1010 & -6 \\
0111 & +7 \\
=0001 & =1
\end{array}
$$

2) Logic gates

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

$$y = (\tilde{a} + \tilde{b} + \tilde{c})$$

$nand\ \ g_1(y_1, a, b, c)$