How Data is actually Represented

\[ \text{Voltage} \quad 0.1 = 0 \quad 1 = 1 \]

Everything is 1's + 0's

Bytes 8-bits 0000 0000 0000 to 0-255 (unsigned) 1111 1111 0xFFF

Bytes are important because memory is BYTE addressable

Words \rightarrow \text{collection of Bytes}

4-bytes (32-bits)
8-bytes (64)
2-bytes (16)
Representing positive ints -> easy

- negative #'s
- characters
- non-integers (Reals)

Simple operations w/ bits

<table>
<thead>
<tr>
<th>input 0</th>
<th>input 1</th>
<th>AND</th>
<th>OR</th>
<th>XOR</th>
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<tbody>
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\[ a \quad b \quad + \quad b \quad + \quad 1 \quad = \quad c \quad 0 \quad \]

\[ a \quad b \quad c \quad \text{carry} \]

<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>c</th>
<th>\text{carry}</th>
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</table>
8-bit: \(11011001\) + 00110010 = Overflow
8-bits: 00001011

Negative #'s \(\rightarrow\) 2's complement
-8-7-6-5-4-3-2-1 0 1 2 3 4 5 6 7 8

2's comp
4-bits: [-8, 7]

unsigned 4-bits: [0, 15]

\[-5\ \underline{+\ 2\ +\ 0010}\ \underline{=\ -3\ \underline{+\ 1101}}\]
Subtraction?

\[
\begin{align*}
7 & \quad 0111 \\
-3 & \quad 0011 \\
\hline
4 & \quad 0100 \\
\end{align*}
\]

Overflow?

Converting from positive to negative:

\[
\begin{align*}
b & \Rightarrow -b \quad \Rightarrow \quad (\neg b + 1) \\
0011 & \Rightarrow 1101 \quad \Rightarrow \quad \neg 0011 + 1 \\
\end{align*}
\]