There are only 10 types of people in the world: Those who understand binary and those who don't.
\[
d = \sum_{i=0}^{n} b_i 2^i
\]
<table>
<thead>
<tr>
<th>binary</th>
<th>decimal</th>
<th>hexadecimal</th>
</tr>
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<td>2</td>
</tr>
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<tr>
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<td>D</td>
</tr>
<tr>
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<td>E</td>
</tr>
<tr>
<td>1 1 1 1</td>
<td>15</td>
<td>F</td>
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</tr>
<tr>
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<td>0 1 2 3 4 5 6 7 8 9</td>
</tr>
<tr>
<td>notation</td>
<td>#b</td>
<td>#d</td>
</tr>
</tbody>
</table>
Memory
Memory Map

32k Flash
"Program Memory"

0x0000

instruction
(16 or 32 bit)

address
(16 bit)

CPU

data
(8 bit)

address
(16 bit)

2.5k SRAM
"Data Memory"

0x0000

0x7FFF

0x0AFF
Memory Map

2.5k SRAM
"Data Memory"

- working reg
- I/O
- ext. I/O
- SRAM

Address: 0x02A5
Value: 0x2F
Analog-to-Digital Conversion
Common ADC Architectures

**Flash**
- cascade of n comparators
- fastest (Gsps)
- low resolution (n ~ 8)
- more expensive

**Successive Approximation**
- compares input to internal DAC
- starts with MSB
- successively updates DAC to match
- mid-range speed (Mps)

**Sigma-Delta**
- oversamples then filters
- highest possible resolution
- lower-speed (<Mps)

**Integrating**
- compares against ramp reference
- counts time until compare
- lowest-speed (<100ksps)
Encoders
Optical Encoder

Quadrature Encoding

second ring
90 degree phase shift
double triggering

$V_{out}$

1
0
mx_encoder_zero(channel)
reset the encoder counter for the specified channel (1 or 2)

result = mx_encoder(channel)
read the specified encoder channel (1 or 2)
Wireless

\[ x = m\_rf\_open(\text{channel}, \text{RXaddress}, \text{packet\_length}) \]
configure the RF subsystem to listen to a desired address (0x00 to 0xFF) over a wireless channel (1-32, TX/RX must match) with a specified packet length (1-32, TX/RX must match).

\[ x = m\_rf\_read(\text{buffer}, \text{packet\_length}) \]
retrieve \text{packet\_length} bytes from the receive buffer into \text{buffer}.

\[ x = m\_rf\_send(\text{TXaddress}, \text{buffer}, \text{packet\_length}) \]
send the message contained in \text{buffer} of \text{packet\_length} (1-32, TX/RX must match) bytes to an specified address (0x00 to 0xFF).
“A designer must develop a device that, by definition, has the capabilities to meet some need that is not fully defined.”
“The best way to get a good idea is to get a lot of ideas”

-Linus Pauling
Our Brainstorming Rules

Set the Environment
Focus the Topic
Capture Everything
Be Visual
Defer Judgment
Go for Quantity