19. Motor Interfacing

- Motor physics
- Transistor-level interface

Pinky, are you pondering what I'm pondering?

Ya Brain, who plugged this typewriter into our TV?
Digital Interfacing

$V_{OL}$ is defined as the voltage at maximum $I_{OL}$

<table>
<thead>
<tr>
<th>Family</th>
<th>Example</th>
<th>$I_{OH}$</th>
<th>$I_{OL}$</th>
<th>$I_{IH}$</th>
<th>$I_{IL}$</th>
<th>fan out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard TTL</td>
<td>7404</td>
<td>0.4 mA</td>
<td>16 mA</td>
<td>40 µA</td>
<td>1.6 mA</td>
<td>10</td>
</tr>
<tr>
<td>Schottky TTL</td>
<td>74S04</td>
<td>1 mA</td>
<td>20 mA</td>
<td>50 µA</td>
<td>2 mA</td>
<td>10</td>
</tr>
<tr>
<td>Low Power Schottky</td>
<td>74LS04</td>
<td>0.4 mA</td>
<td>4 mA</td>
<td>20 µA</td>
<td>0.4 mA</td>
<td>10</td>
</tr>
<tr>
<td>High speed CMOS</td>
<td>74HC04</td>
<td>4 mA</td>
<td>4 mA</td>
<td>1 µA</td>
<td>1 µA</td>
<td></td>
</tr>
<tr>
<td>LM3S/LM4F 2mA-drive</td>
<td>LM3S811</td>
<td>2 mA</td>
<td>2 mA</td>
<td>2 µA</td>
<td>2 µA</td>
<td></td>
</tr>
<tr>
<td>LM3S/LM4F 4mA-drive</td>
<td>LM3S811</td>
<td>4 mA</td>
<td>4 mA</td>
<td>2 µA</td>
<td>2 µA</td>
<td></td>
</tr>
<tr>
<td>LM3S/LM4F 8mA-drive</td>
<td>LM3S811</td>
<td>8 mA</td>
<td>8 mA</td>
<td>2 µA</td>
<td>2 µA</td>
<td></td>
</tr>
</tbody>
</table>

Electrical specifications

- See Chapter 24 of TM4C123
- 5V tolerant?
- PD0, PD1 $\leftrightarrow$ PB7,PB6

All GPIO signals are 5-V tolerant when configured as inputs except for PD4, PD5, PB0 and PB1, which are limited to 3.6 V.
Motor Physics

Electrical Model

Wire

Electromagnet

Magnetic Field, B

Electrical Current, I

North South

F

Coil

Stator

Rotor

South Magnet

North Magnet

I

I

I

I

Brush

Brush

Commutators

April 5, 2014

Jonathan Valvano

EE445M/EE380L.6
Darlington Transistor

- TIP120 (NPN)
- $h_{fe} = 1000$
- $I_{ce} = 3A$

$\begin{align*}
I_b &= I_{coil} / h_{fe} = 1A/1000 = 1mA \\
R_b &\leq (V_{OH} - V_{be}) / I_b = (3-2.5)/1mA = 0.5 \Omega \\
R_b &= 100 \Omega \\
V_{CE} &\text{ depends on current}
\end{align*}$
MOSFET Interface

- $V_{GS}$ turns on
- $V_{DS}$ small
- $I_{DS}$ large
H-bridge Interface

• Both directions
• $V_{OH} = +V-1.4$, $V_{OL} = 1.2$
H-bridge Interface

- PWM controls power
- Out controls direction

See L6203.pdf
H-bridge Interface

• One Port is PWM controlling power
• Other port controls direction
Servo Motor

- Simple digital interface (built in controller)
- Duty cycle controls angle
Servo Interface

- Needs its own +5V regulator
- Duty cycle controls angle

![Diagram of servo interface with components and waveforms]
Servo Software

- Duty cycle controls angle

<table>
<thead>
<tr>
<th>Position</th>
<th>Pulse Width</th>
<th>Example Pulse</th>
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</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>0.5ms</td>
<td></td>
</tr>
<tr>
<td>Center</td>
<td>1.5ms</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>2.5ms</td>
<td></td>
</tr>
</tbody>
</table>

April 5, 2014

Jonathan Valvano
EE445M/EE380L.6
Summary

• Be careful of the currents
• Sensors are noisy
• Time lag makes it unstable
• Component testing
• Visualization and and control