Lecture 16

H-Bridge
DC Motor Direction Control

- Half Bridge
  - 2 switches and 2 power sources
- H-Bridge
  - 4 switches and 1 power sources
Half Bridge 1
Half Bridge 1

Switch
Half Bridge 2

NPN BJT
H-Bridge 1

Switch
H-Bridge 2

Switch
H-Bridge 3

Switch
H-Bridges with NPN BJT 1

<table>
<thead>
<tr>
<th>Pin5</th>
<th>Pin6</th>
<th>Motor</th>
<th>Notes</th>
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<tbody>
<tr>
<td>High</td>
<td>Low</td>
<td>forward</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>backward</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>No motion</td>
<td></td>
</tr>
<tr>
<td>High*</td>
<td>High*</td>
<td>*</td>
<td>Forbidden</td>
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H-Bridges with NPN BJT 2

A 1k 2N2222 PNP 1N4002 NPN 1k 2N2222 B

12V

TIP42: PNP
TIP120: NPN

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>Action</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>stop</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>forward</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>reverse</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>PROHIBITED</td>
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H-Bridge: How It Works

Set High

Set Low
H-Bridge: How It Works

Set Low

Set High
H-Bridges with Relays
H-Bridge ICs

- LMD 18200
- LMD 18201
- LM 15200
- SN754410NE
Micro Dual Serial Motor Controller

- Using one serial output from the BASIC Stamp module, this motor controller can independently set each motor to go forward or backward at any of 127 speeds.
- To control additional motors, you can connect multiple motor controllers to the same serial line.
# H-Bridge Experiments

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Lecture 17

RC filter
Linear Differential Equation

\[ a_n \frac{d^n y}{dt^n} + a_{n-1} \frac{d^{n-1} y}{dt^{n-1}} + \cdots + a_0 y = \]

\[ b_m \frac{d^m u}{dt^m} + b_{m-1} \frac{d^{m-1} u}{dt^{m-1}} + \cdots + b_0 u \]
First-Order System

\[ n \geq m, n = 1 \quad a_1 \frac{dy}{dt} + a_0 y = u \]

Applying Laplace Transform

\[ \frac{1}{U(s)} = \frac{1}{a_0 \tau s + 1} \quad \Rightarrow \quad Y(s) = \frac{1}{a_0 \tau s + 1} \]

\[ y(t) = (y(0) - y_\infty) e^{-\frac{t}{\tau}} + y_\infty \]

\[ \tau = \frac{a_1}{a_0} \]

\[ y_\infty = \frac{A}{a_0} \]

\[ u(t) = A \text{ for } t \geq 0 \]

\[ u(t) = 0 \text{ for } t < 0 \]
Passive RC Low-Pass Filter

\[ \frac{V_o(s)}{V_i(s)} = \frac{1}{RCs + 1} \]
Bode Plot

- Bode plot is a very useful graphical approach is to analyze and design feedback loops.
- It consists of plotting two curves, the log of gain, and phase, as functions of the log of frequency.

\[ G(s) = \frac{V_o(s)}{V_i(s)} \]
\[ s = j\omega \]
\[ G(j\omega) = \frac{V_o(j\omega)}{V_i(j\omega)} \]
\[ G(j\omega) = |G(j\omega)| e^{-j\varphi(\omega)} \]
\[ L(j\omega) = 20 \log\left(\frac{V_o}{V_i}\right) \text{dB} \]
\[ \varphi(j\omega) \]

\( L(j\omega) \) is log of gain, unit is \( \text{dB} \)
\( \varphi(j\omega) \) is phase
Bode Plot of Low-Pass Filter

-3dB

Cutoff frequency
• Cut off frequency is the frequency that the power of the output signal is attenuated to half of its input value

\[
\frac{A_o}{A_i} = \sqrt{\frac{P_o}{P_i}} = \sqrt{\frac{1}{2}} \approx 0.707
\]

\[
dB = 20 \log_{10} \sqrt{\frac{1}{2}} = -3 \text{dB}
\]

\[\text{Example:}\]

\[
G(s) = \frac{V_o(s)}{V_i(s)}
\]

\[
G(j\omega) = \frac{1}{RCj\omega + 1}
\]

\[
|G(j\omega)| = \frac{1}{\sqrt{(RC\omega_c)^2 + 1}} = \sqrt{\frac{1}{2}}
\]

\[
\frac{P_o}{P_i} = |G(j\omega)|^2 = \frac{1}{2} = \frac{1}{(RC\omega_c)^2 + 1}
\]

\[
=> 2 = (RC\omega_c)^2 + 1
\]

\[
\omega_c = \frac{1}{RC}
\]
Passive RC High-Pass Filter

\[ \frac{V_o(s)}{V_i(s)} = \frac{RC_s}{RC_s + 1} \]
Bode Plot of High-Pass Filter

-3dB

Cutoff frequency