ECE 320 - Homework #6

H-Bridge, DC to DC Converters, Fourier Transforms. Due Wednesday, February 23rd

H-Bridges:

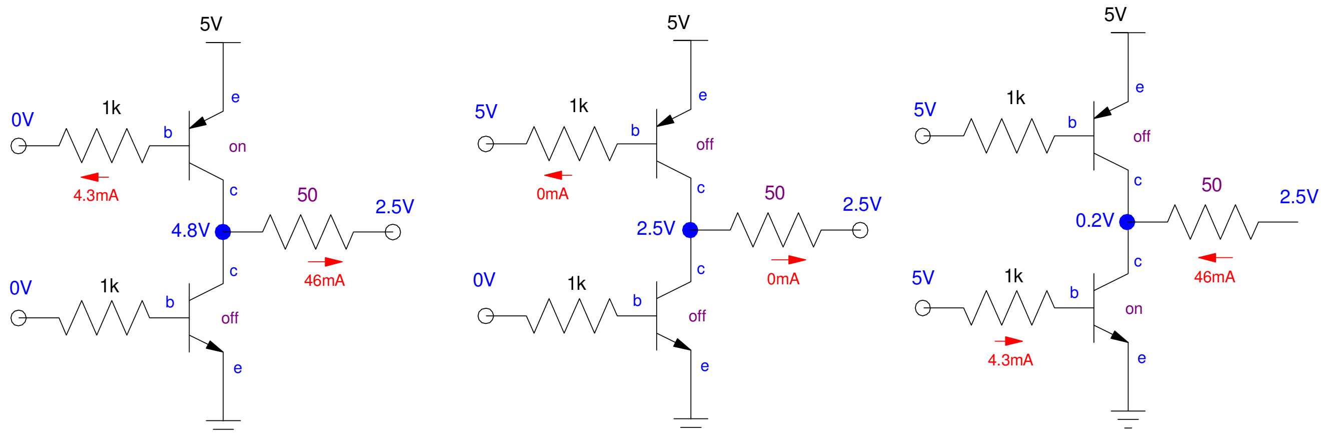
The following circuit is 1/2 of an H-bridge. (the mirror image (minus the 2.5V supply) is repeated to the right for a full H-bridge). Also note: the 50 Ohm & 2.5V source is the Thevenin equivalent of two 100 Ohm resistors (shown to the right). The circuit to the right is easier to build and is equivalent to the part shown in purple.

1) Determine the voltages and currents for the following 1/2 H-bridge for

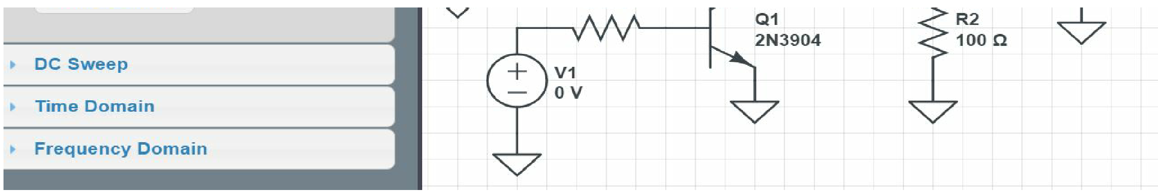
- V1 = 0V, V2 = 0V
- V1 = 5V, V2 = 5V
- V1 = 5V, V2 = 0V

Assume 3904/3906 transistors

- | Vbe | = 0.7V
- current gain = 100
- $V_{ce(sat)}$ = 0.2V



2) Check your results (votlages and currents) in CircuitLab



6) Change the duty cycle and C so that

- The DC voltage at V2 = 5.00V
- The ripple at V2 is 1Vpp

$$V_2 = \left(\frac{75}{75+10}\right) V_1$$

$$V_1 = \left(\frac{85}{75}\right) V_2 = 5.667V$$

Duty cycle

$$\alpha = \left(\frac{5.667V+0.7V}{19.8V+0.7V}\right) = 31.1\%$$

note: I'm using 19.8V in the denominator to account for the 0.2V drop across the PNP transistor when saturated

To bring the ripple down to 1Vpp

6uF results in 2.174Vpp ripple

$$C = \left(\frac{2.174V_{pp}}{1V_{pp}}\right) 6\mu F = 13.04\mu F$$

7) Check your results for problem #6 in CircuitLab

- max(V2) = 5.435v
- min(V2) = 4.558V
- V2(DC) = 4.997V
- V2(AC) = 0.877Vpp

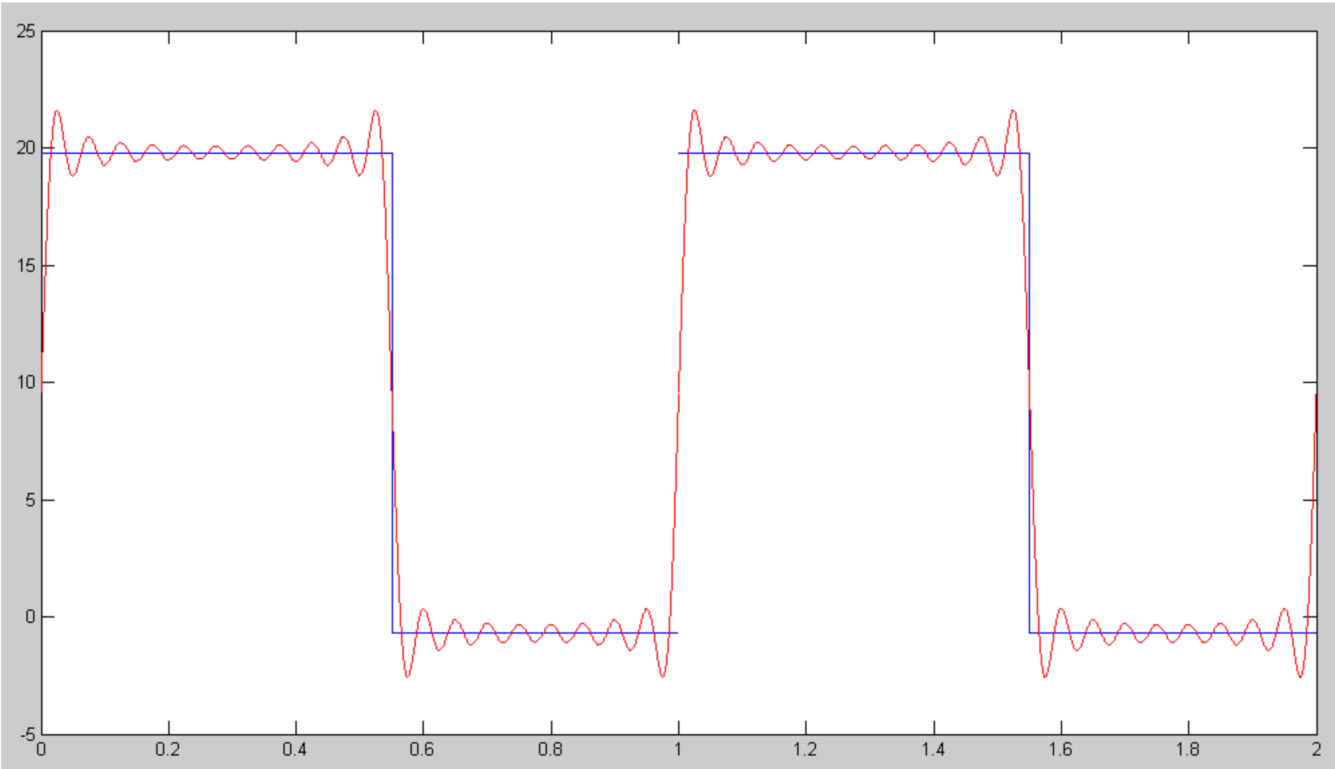
Fourier Transforms

8) Going back to problem #4, determine the Fourier Transform for V1 out to the 3rd harmonic (3kHz)

```
>> t = [0:0.0001:1]';
>> V1 = 19.8 * (t<0.55) - 0.7*(t >= 0.55);
>>
>> X0 = mean(V1)

X0 =   10.5739

>> X1 = 2*mean(V1 .* exp(-j*2*pi*t))

X1 =  -2.0124 -12.7307i

>> X2 = 2*mean(V1 .* exp(-j*4*pi*t))

X2 =   1.9178 - 0.6218i

>> X3 = 2*mean(V1 .* exp(-j*6*pi*t))

X3 =  -1.7564 - 3.4549i
```

$$V_1(t) \approx 10.5739$$
$$-2.01\cos(\omega_0 t) + 12.73\sin(\omega_0 t)$$
$$+1.92\cos(2\omega_0 t) + 0.62\sin(2\omega_0 t)$$
$$-1.75\cos(3\omega_0 t) + 3.45\sin(3\omega_0 t)$$

$$\omega_0 = 6280\frac{rad}{\sec}$$



V1(t) (blue) and its Fourer approximation taken out to the 20th harmonic (red)

9) Using the Fourier Transform approximation for V1, determine V2 out to the 3rd harmonic (3kHz)

```
>> %  DC
>> X0 = mean(V1);
>> G0 = 75 / 85;
>> Y0 = G0 * X0;

Y0 =    9.3299

>> % 1st harmonic

>> X1 = 2*mean(V1 .* exp(-j*2*pi*t));
>> w = 6280;
>> L = j*w*0.05;
>> C = 1/(j*w*6e-6);
>> R2 = 1/(1/75 + 1/C);
>> L = 0.05;
>> C = 6e-6;
>> R2 = 1/( 1/75 + j*w*C );
>> R1 = 10 + j*w*L;
>> Y1 = (R2 / (R1 + R2))*X1

Y1 =  -0.2703 + 1.0747i

>> Y1pp = 2*abs(Y1)

Y1pp = 2.2163


>> % 2nd harmonic

>> X2 = 2*mean(V1 .* exp(-j*4*pi*t));
>> w = 6280 * 2;
>> R2 = 1/( 1/75 + j*w*C );
>> R1 = 10 + j*w*L;
>> Y2 = (R2 / (R1 + R2))*X2

Y2 =  -0.0425 + 0.0051i

>> % 3rd harmonic

>> X3 = 2*mean(V1 .* exp(-j*6*pi*t));
>> w = 6280 * 3;
>> R2 = 1/( 1/75 + j*w*C );
>> R1 = 10 + j*w*L;
>> Y3 = (R2 / (R1 + R2))*X3

Y3 =   0.0122 + 0.0344i
```

$$
\begin{aligned}
V_2(t) \approx \; & 9.3299 \\
& -0.270\cos(\omega_0 t) - 1.075\sin(\omega_0 t) \\
& -0.043\cos(2\omega_0 t) - 0.005\sin(2\omega_0 t) \\
& +0.012\cos(3\omega_0 t) - 0.034\sin(3\omega_0 t)
\end{aligned}
$$

Note:

- In CircuitLab, V2(AC) = 2.174Vpp, which closely matches the 1st-harmonic Y1pp.
- The harmonics past the 1st harmonic are almost zero. Ignoring them doesn't change the results that much.