ECE 320 - Homework #6

DC to AC Converters, SCR's. Due Monday, February 29th

DC to AC Converters

1) Design an H-Bridge to drive an 8-Ohms speaker forward and back.

Input:

- 5VDC, capable of driving 3A (i.e. DC power supply on lab bench)
- 0V / 5V TTL signals capable of driving 25mA (i.e. switches on the CADET boards)

Output: 8 Ohm Speaker

Relationship: You should be able to apply +5V, -5V, or 0V across the speaker by adjusting the switches

Let I(on) = 100mA (3904 transistors are limited to 200mA)

$$R = \left(\frac{5V - 0.2V - 0.2V}{100mA}\right) = 46\Omega$$

Add a 38 Ohm resistor in series with the speaker to give 46 Ohms total. The base resistor is then

$$\beta I_b > I_c = 100mA$$

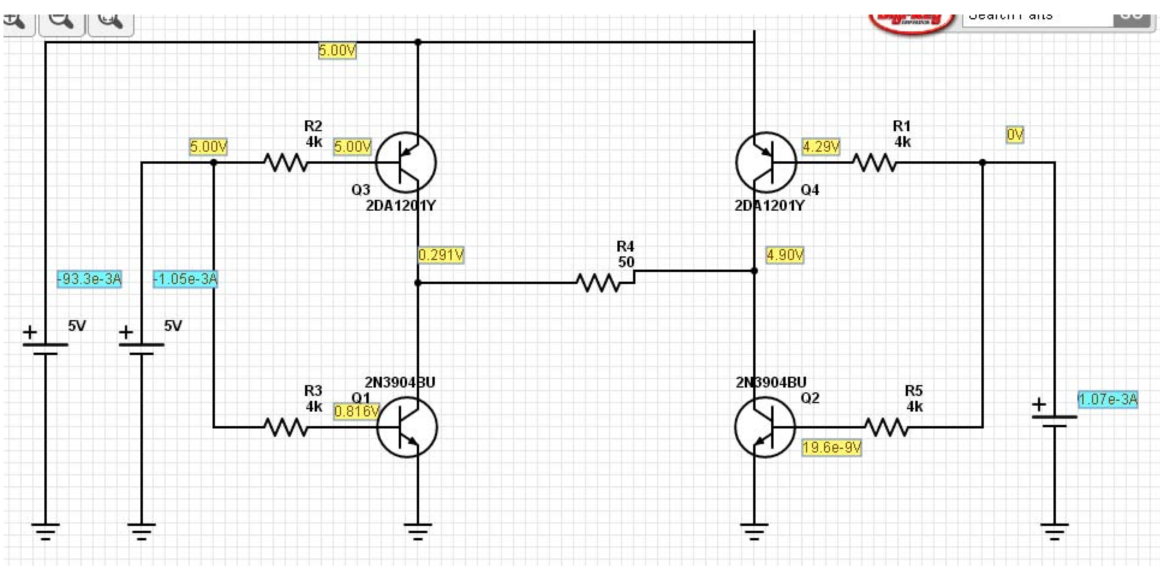
$$I_b > 1mA$$

Let

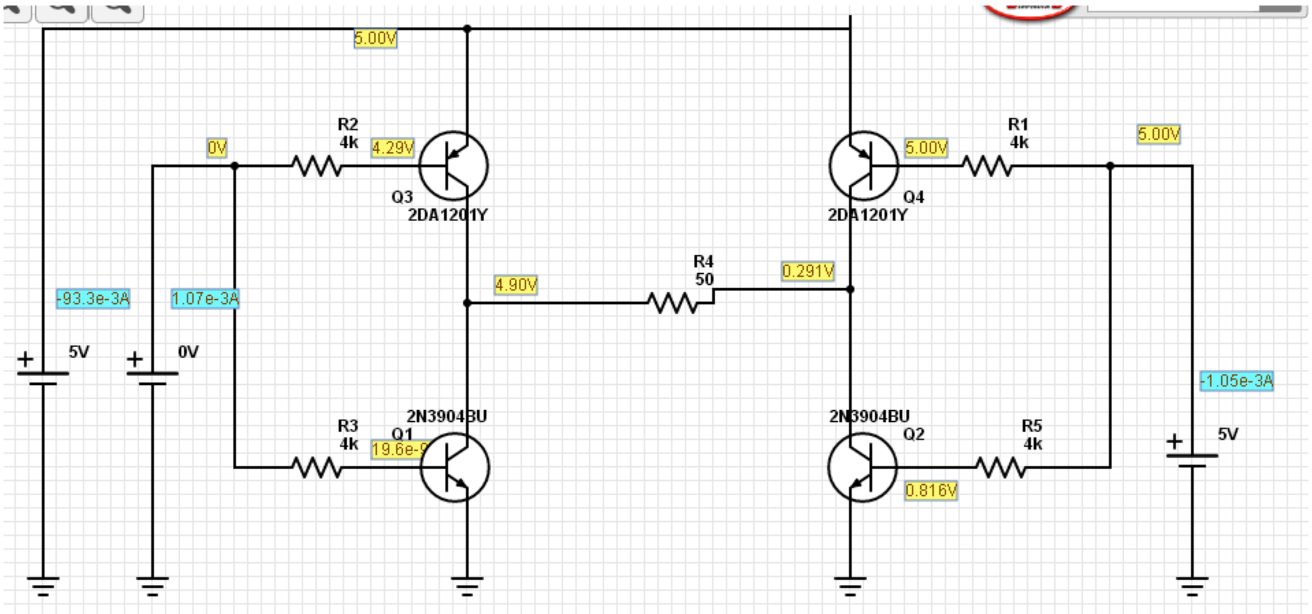
$$I_b = 2mA$$

$$R_b = \left(\frac{5V - 0.7V}{2mA}\right) = 2150\Omega$$

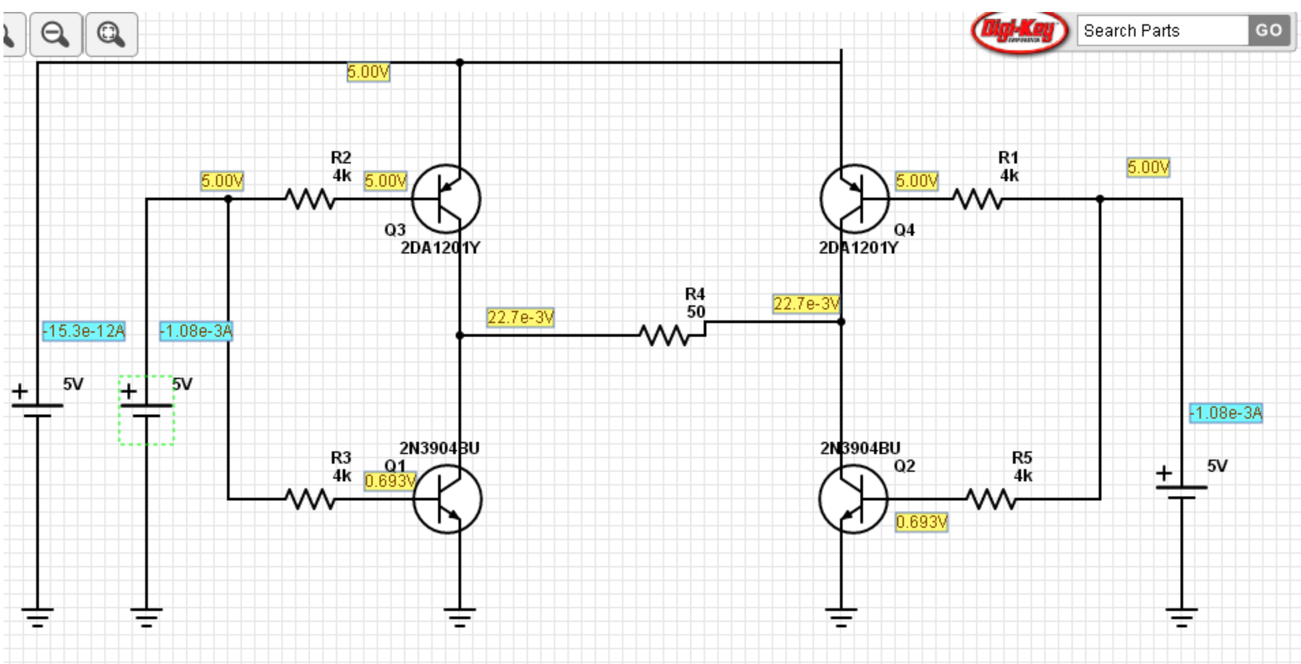
2) Check youd design in PartSim (three tests: 0V, 5V, -5V)



-5V Across the Speaker (50 Ohm resistor)



+5V across the speaker (50 Ohm resistor)



0V Across the Speaker (50 Ohm resistor)

3) Assume the H-bridge is to be used to drive an AC motor (BLDC, AC Synchronous, AC Induction motor).

3a) Explain how you convert a DC power supply into an AC voltage

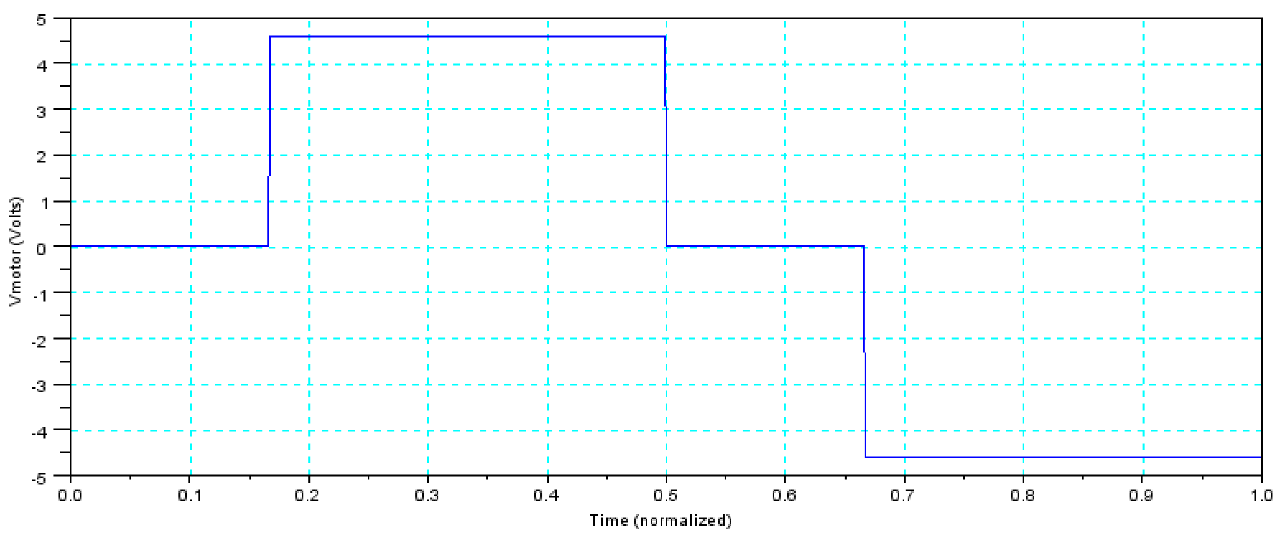
Alternate between +5V / 0V / -5V to create an approximation to a sine wave

3b) Explain how you adjust the speed of the AC motor

change the frequency of the AC waveform. Frequency = speed for AC motors

3c) Specify the AC waveform you would send to the motor at 10Hz

```
-->t = [0:0.001:1]';
-->y = 4.6*(t>1/6).*(t<1/2) - 4.6*(t>4/6);
-->plot(t,y)

-->xlabel('Time (normalized)');
-->ylabel('Vmotor (Volts)');
```



3d) Calculate the efficiency of your DC to AC converter (MATLAB helps here)

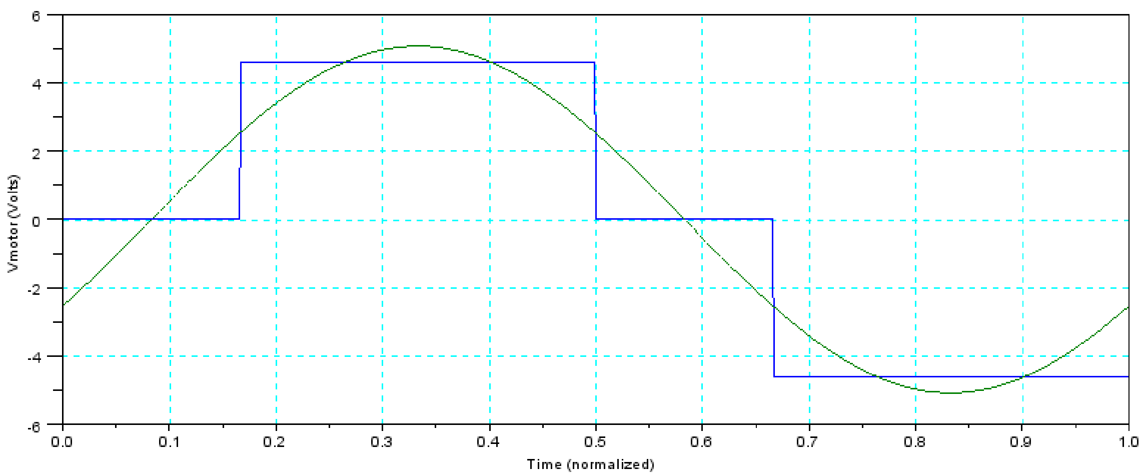
Compute the 1st term of the Fourier Series (the component of y(t) at the 1st harmonic)

```
-->a1 = sum(y .* sin(2*%pi*t) / sum( (sin(2*%pi*t)).^2))

    4.3953242

-->b1 = sum(y .* cos(2*%pi*t) / sum( (cos(2*%pi*t)).^2))

  - 2.5295233

-->y1 = a1*sin(2*%pi*t) + b1*cos(2*%pi*t);
-->plot(t,y,t,y1)
```

The efficiency is the ratio of the energy in the 1st harmonic vs. the whole waveform:

```
-->Pout = mean(y1.^2)

    12.852228

-->Pin = mean(y .^ 2)

    14.09962

-->eff = Pout / Pin

    0.9115301
```

This DC to AC converter is 91% efficient



AC approximate wave (blue) and its 1st harmonic (green)

SCR: AC to DC Converter

4) Design a full-wave AC to DC converter using diodes and SCRs.

Input: 12V peak, 60Hz, AC signal capable of driving 1A (i.e. AC wall transformer room 235 / 237)

Output: 5V DC signal, capable of driving 100mA

Tolerance: Output ripple < 100mVpp @ 100mA

The signal at the load is

$$5 = \frac{1}{T}\int_{\theta}^{\pi+\theta} 10.6\sin(t)dt$$

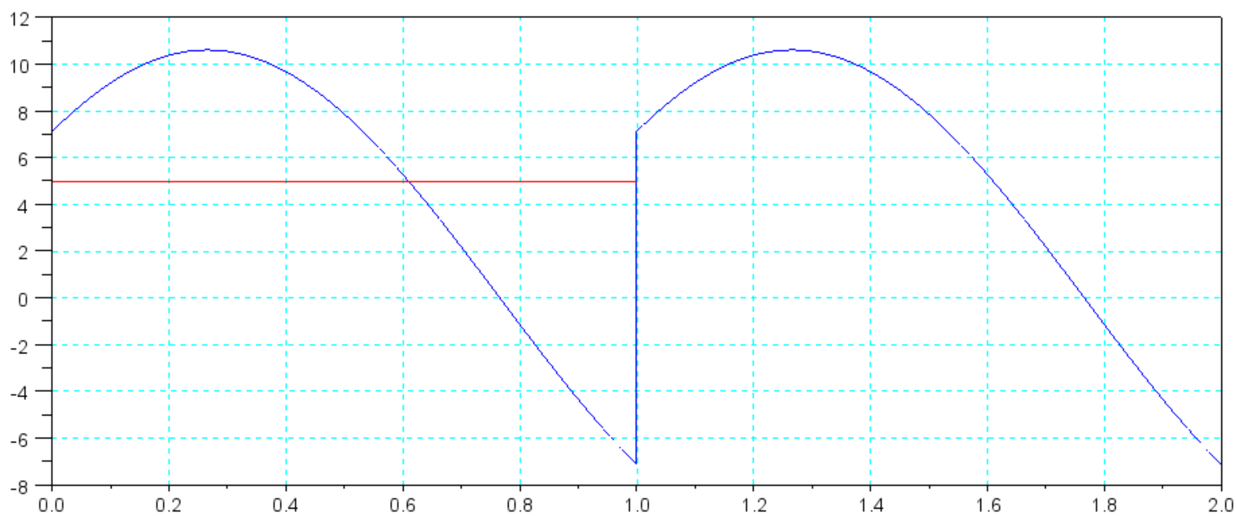
$$\left(\frac{5\pi}{10.6}\right) = (-\cos(t))_{\theta}^{\pi+\theta}$$

$$\left(\frac{5\pi}{10.6}\right) = \cos(\theta) - \cos(\pi+\theta)$$

$$\left(\frac{5\pi}{10.6}\right) = 2\cos(\theta)$$

$$\theta = 42.19^0$$

```
-->t = [0:0.001:1]';
-->y = 10.6*sin(%pi*t + 42.19*%pi/180);

-->plot([t; t+1],[y; y])
-->xgrid(4)
-->plot(t,mean(y),'r')
```



The output is 5V @ 100mA

Rload = 50 Ohms

For a ripple of 100mVpp

Input ripple = 17.71Vpp

```
-->V1pp = max(y) - min(y)
    17.71886
```

$$100mV_{pp} = \left(\frac{50}{50+j\omega L}\right)17.71V_{pp}$$

$$|50 + j\omega L| = 8859\Omega$$

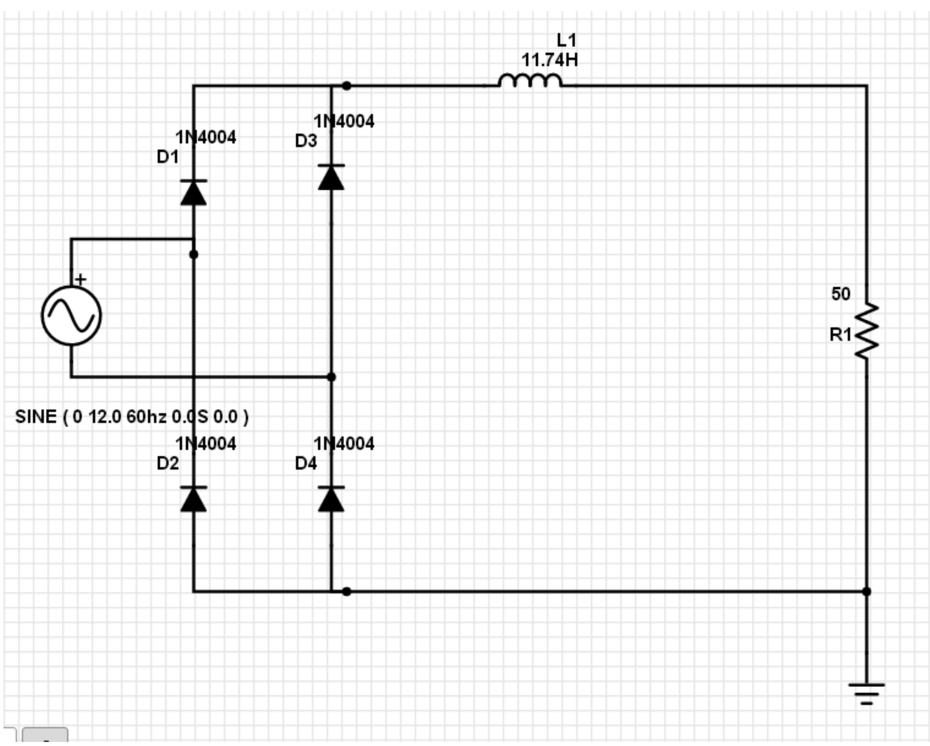
$$50^2 + (\omega L)^2 = 8859^2$$

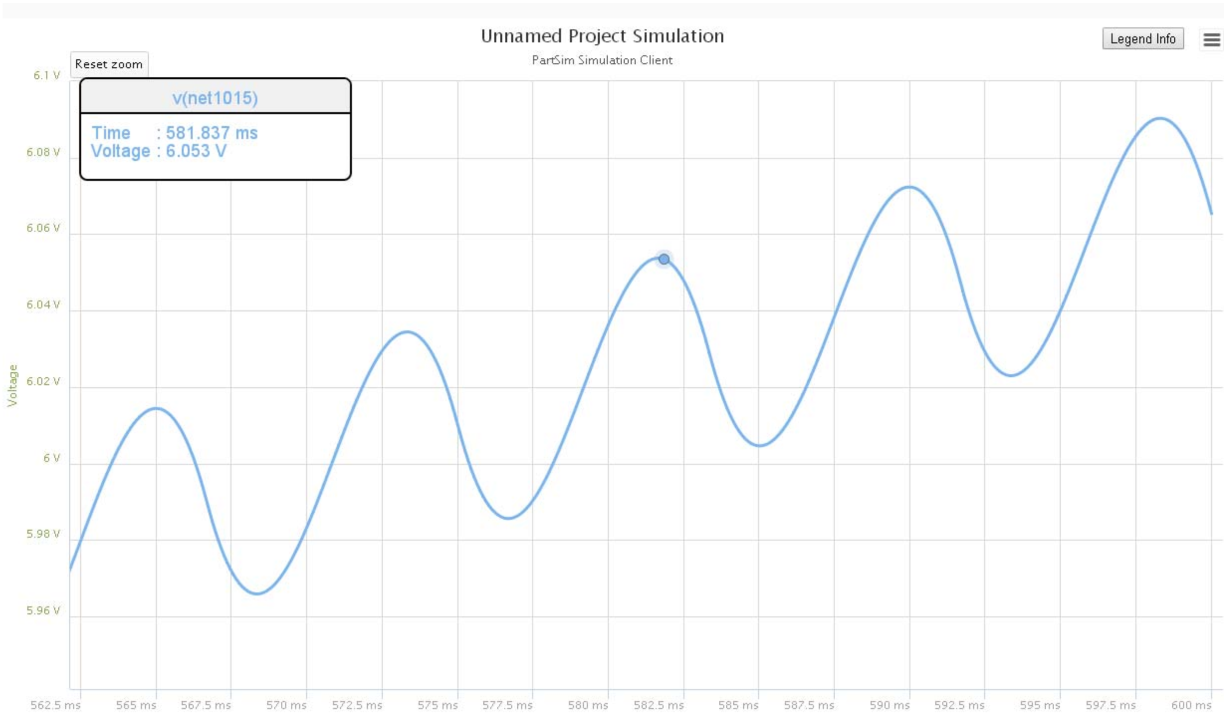
$$\omega L = 8859\Omega$$

$$\omega = 2 \cdot 377 \qquad \text{(120 Hz)}$$

$$L = 11.74H$$

PartSim Check (Firing Angle = 0 degrees)





Riple = 70mV (100mV expected)

Note: The peak-to-peak ripple is slightly off due to approximating the input ripple at 120Hz to be 17.18Vpp. This way you calculate the 1st harmonic is what we did for computing efficiency (i.e. Fourier Trasnsforms). If you used Fourier transforms, you would get closer answers, for a lot more work.

Lab:

5. Build the H-bridge and verify your computations for problem 1.