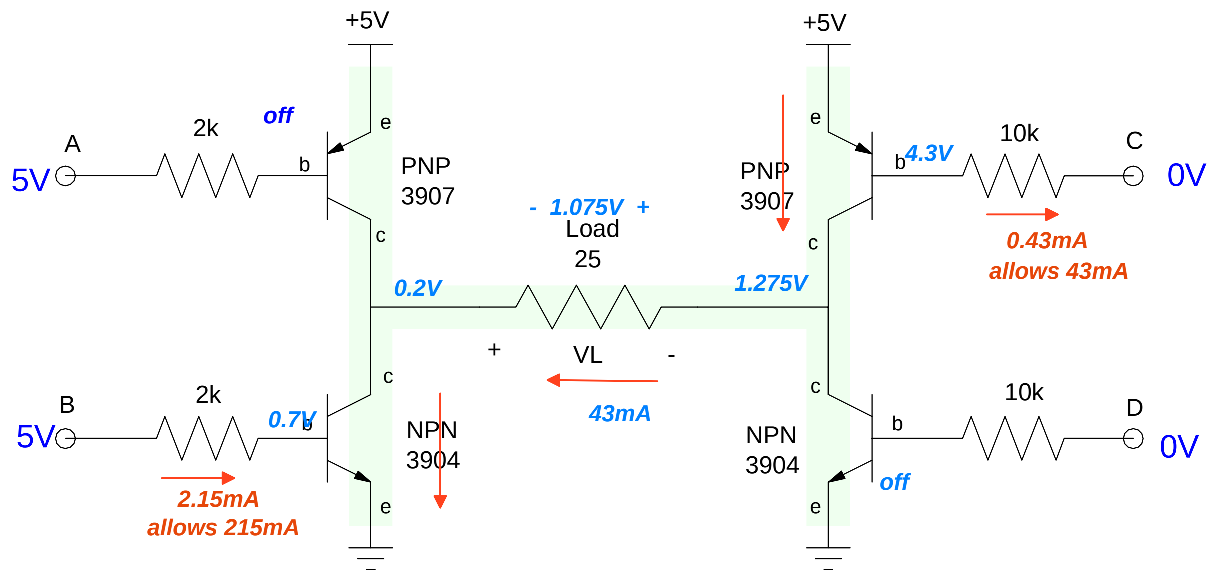
# ECE 320 - Homework #6

H-Bridge, DC to DC Converters. Due Monday, October 2nd, 2017

## H-Bridge

1) Assume $\beta$=100 (worst case) for each transistor. Determine the currents and voltages for the following H-bridge




First, compute the base currents

$$\left(\frac{5-0.7V}{2k}\right) = 2.15mA$$

$$\beta I_b = 215mA$$

This leg allows 215mA to flow

$$\left(\frac{5-0.7}{10k}\right) = 0.43mA$$

$$\beta I_b = 43mA$$

This leg allows 43mA to flow

The 25 Ohm load limits the current to

$$I_{\max} = \left(\frac{5V-0.2V-0.2V}{25\Omega}\right) = 184mA$$

The smallest current wins:

**The current through the load is 43mA**

The lower left transistor is saturated:

$$\beta I_b > I_c$$

215mA > 43mA

meaning

Vce = 0.2V

The upper right transistor is active

$$\beta I_b = I_c$$

2) Redesign the above circuit to meet the following requirements:

Input:

- Four binary signals, ABCD, each 0V/5V, capable of driving up to 25mA

Output:

- 25 Ohm load

Relationship:

- Inputs ABCD can cause the load to see
  - +200mA +/- 30mA
  - -200mA +/- 30mA
  - 0mA

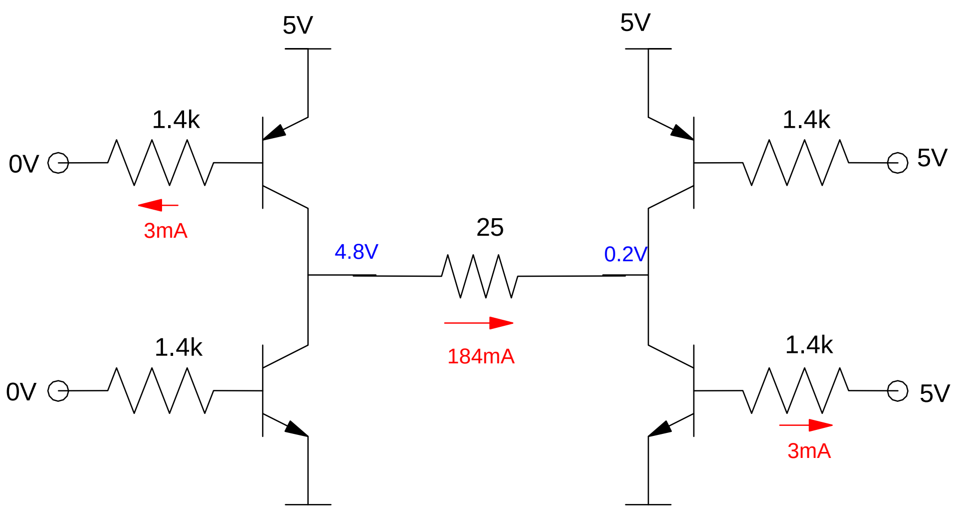
Solution:

Assume the transistors are saturated or off. The voltage drops should be 0.2V, giving

$$I_{load} = \left(\frac{5V - 0.2V - 0.2V}{25\Omega}\right) = 184mA$$

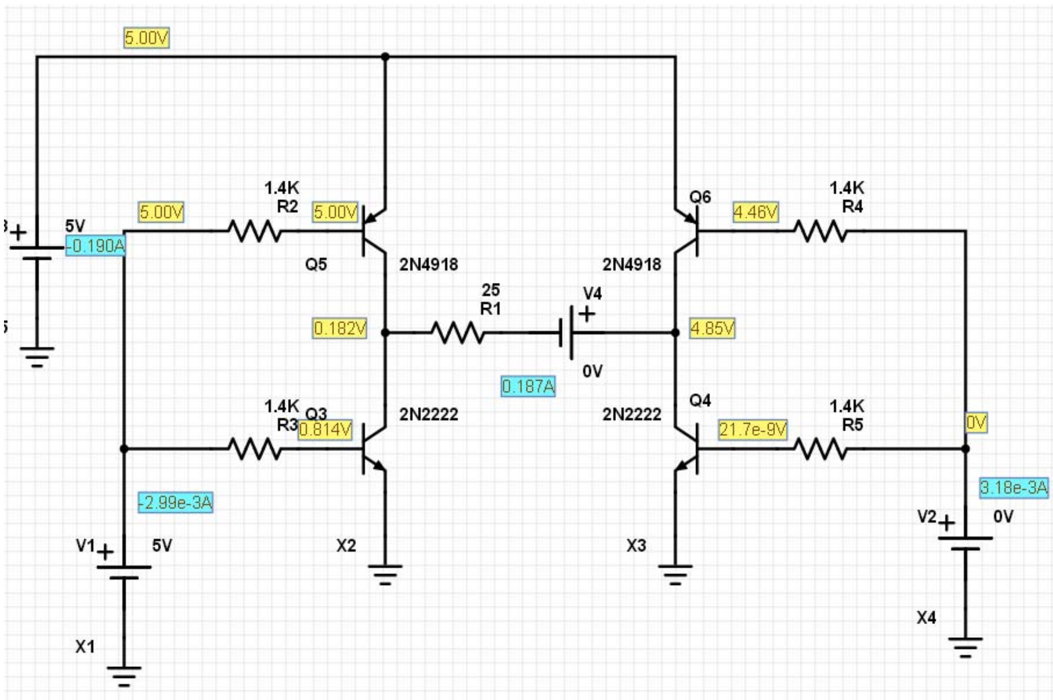
To saturate the transistors, you need at least 1.84mA flowing in the base. Let Ib = 3mA to be safe.

$$R_b = \left(\frac{5V - 0.7V}{3mA}\right) = 1433\Omega$$

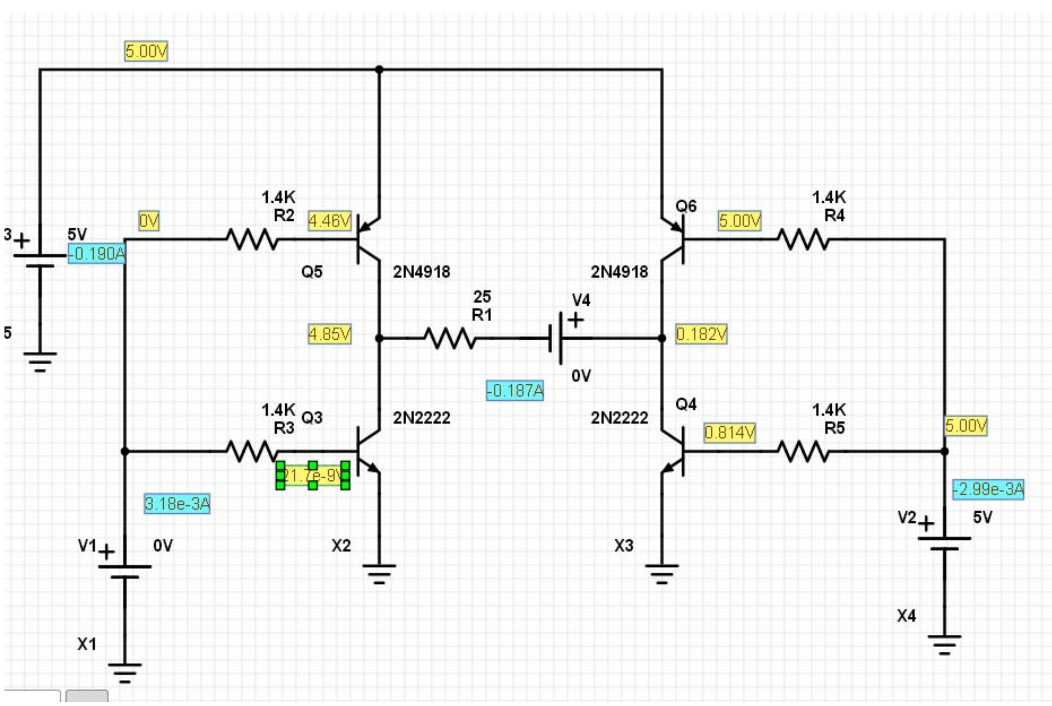


3) Check your design in PartSim (or similar program) for the three modes of operation in the requirements

Forward: +184mA (computed), +187mA (simulated)

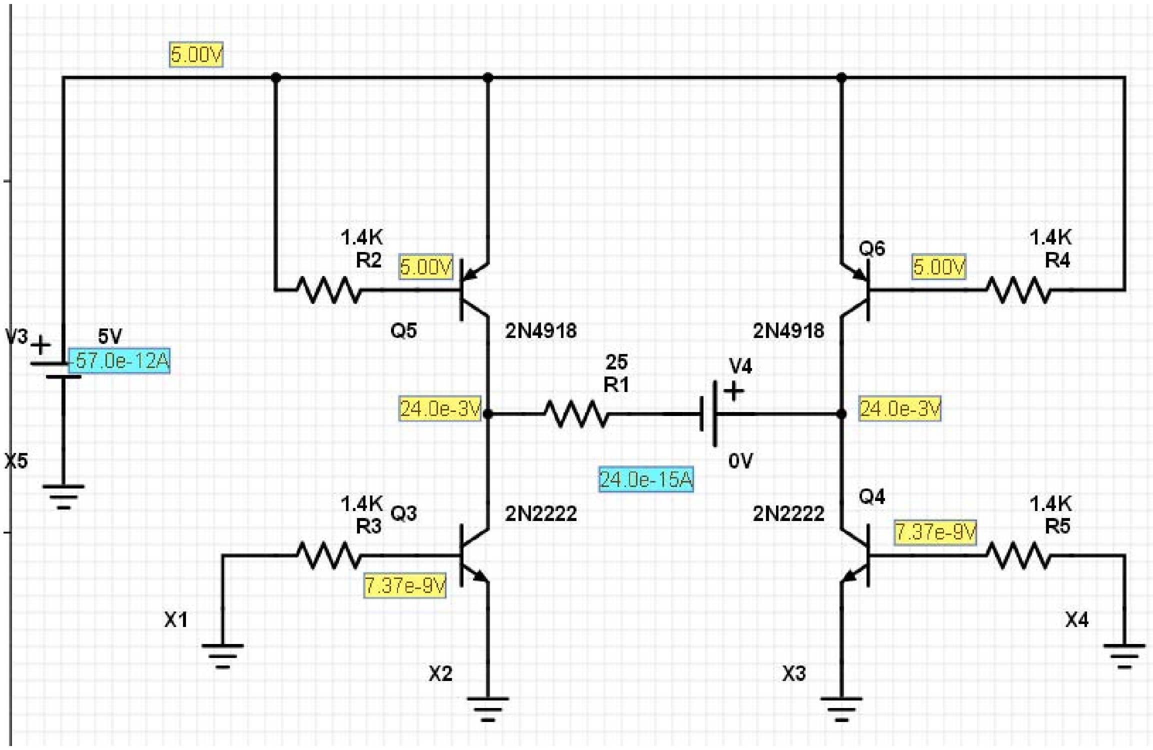



Reverse: -184mA (comptued), -187mA (simulated)



Off: All transistors turned off

- 0mA computed
- 0.024pA simulated

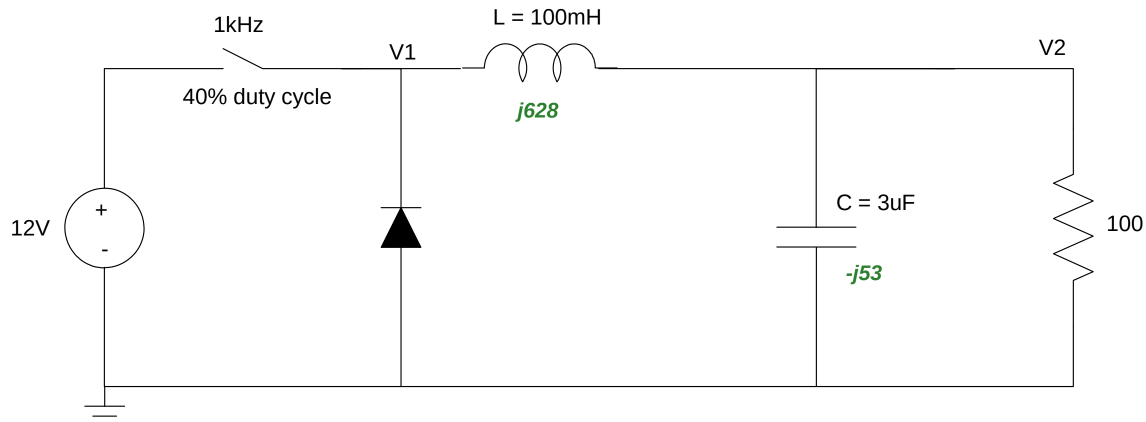



**Lab)**

4) Build your redesigned circuit in lab and verify its operation. For the load, use

- A DC motor, or
- An 8 Ohm speaker (with 16 Ohms added to it)

## DC to DC Converter




**Analysis:**

5) For the above DC to DC converter, determine

V1: DC Value

$$V_{1dc} = 0.4 \cdot 12V + 0.6 \cdot (-0.7V) = 4.38V$$

V1: AC Value

$$V_{1pp} = 12.7V_{pp}$$

V2: DC. Same as V1

$$V_{2dc} = 4.38V$$

V2: AC

$$V_{2pp} = \left(\frac{-j53||100}{-j53||100+j628}\right)V_{1pp}$$

$$V_{2pp} = (0.0798) \cdot 12.7V_{pp}$$

$$V_{2pp} = 1.0131V_{pp}$$

**Design:**

6) Redesign the above DC to DC converter to meet the following requirements:

- Input: +12VDC, capable of 3A
- Output: 100 Ohm resistor
- Relationship: The voltage at V2 under load is +5V with 100mVpp ripple.

Duty Cycle: 44.88%

$$12V \cdot X - 0.7V \cdot (1 - X) = 5V$$

$$X = \frac{5.7}{12.7} = 0.488$$

For the ripple to go from 12.7Vpp to 0.1Vpp,

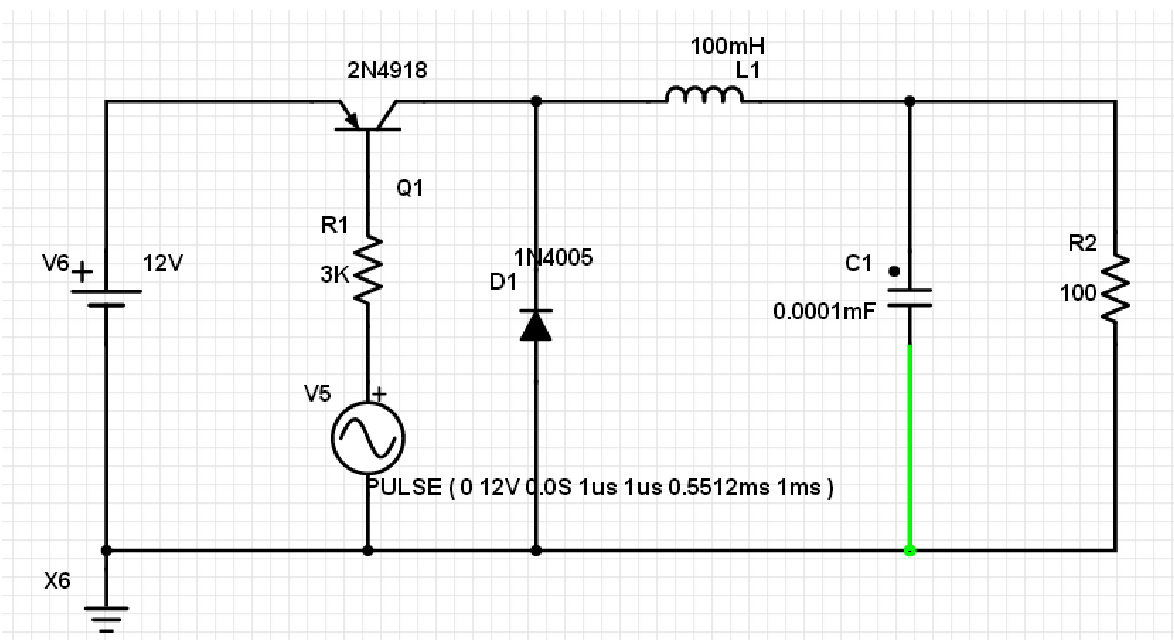
$$\left(\frac{\frac{1}{\omega C}}{\omega L}\right) = \frac{0.1V_{pp}}{12.7V_{pp}}$$

$$\omega^2 LC = 127$$

Let L = 100mH

C = 32uF

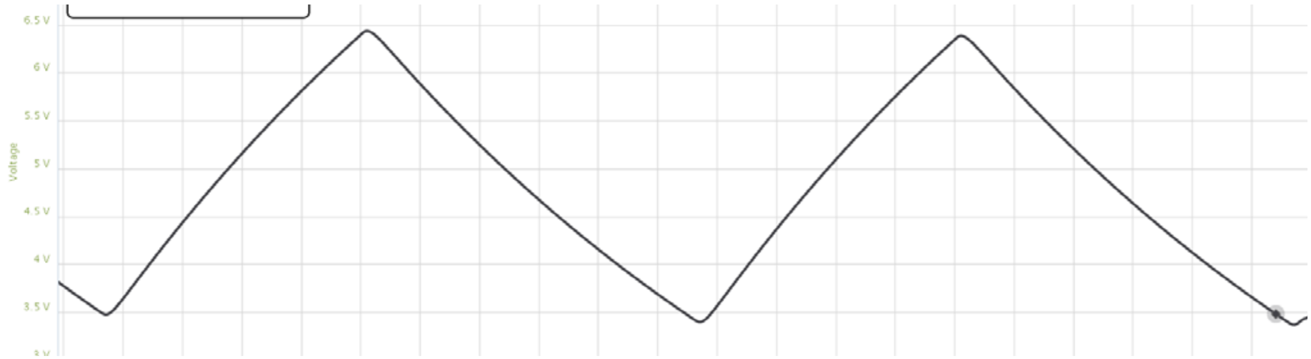
7) Check your design in PartSim:




Use a PNP transistr and a pulse generator to create the pulse input. Note that the transistor is on when the base voltage is 0V, so the on-time is 55.12% (transistor is on 44.88%)

C = 0.0001mF:  This shows the ripple due to the inductor alone (mostly).

- The DC voltage is 5.00V as desired
- The ripple is 3.03Vpp




C =  32uF

PartSim crashes

C = 10uF:  400mVpp ripple (but C is 3.2x too small, so the ripple should be 3.2x larger than expected)