

ECE 320 - Quiz #6 - Name _____

H Bridges, DC to DC Converters

H-Bridge Analysis:

1) Determine the voltages and currents for the following H-bridge. Assume ideal transistors:

PNP (KSA614)			NPN (6144)		
$ V_{be} $	$ V_{ce(sat)} $	$h_{fe} = \beta$	$ V_{be} $	$ V_{ce(sat)} $	$h_{fe} = \beta$
700mV	500mV	120	700mV	360mV	200

Determine the voltages and currents

R 1000 + 100*mo + day	I1	I2	I3	V4	V5
1514	31.00uA	3.72mA	23.25uA	5.99V T1 is active	0.36V T4 is saturated

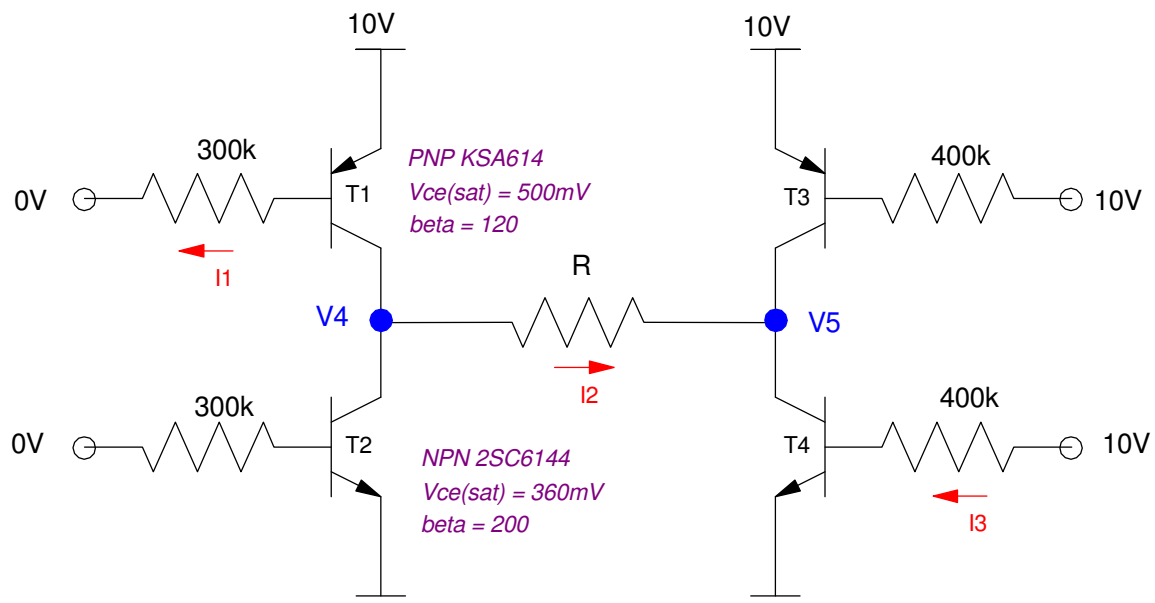
$$I_1 = \left(\frac{10V - 0.7V}{300k} \right) = 31.00\mu A \quad \text{allows } 3.72mA \text{ to flow}$$

$$I_3 = \left(\frac{10V - 0.7V}{400k} \right) = 23.25\mu A \quad \text{allows } 4.65mA \text{ to flow}$$

$$\max(I_2) = \left(\frac{10V - 0.5V - 0.36V}{1514\Omega} \right) = 6.037mA \quad \text{the smallest current wins (3.72mA)}$$

$$V_5 = 0.36V \quad \text{T1 is saturated}$$

$$V_4 = V_5 + 3.72mA \cdot 1514\Omega = 5.99V$$



H-Bridge Analysis:

2) Determine the voltages and currents for the following H-bridge. Assume ideal transistors:

PNP (KSA614)			NPN (6144)		
$ V_{be} $	$ V_{ce(sat)} $	$h_{fe} = \beta$	$ V_{be} $	$ V_{ce(sat)} $	$h_{fe} = \beta$
700mV	500mV	120	700mV	360mV	200

Let $R = 1000 + 100 * (\text{Birth Month}) + \text{Birth Day}$. May 14th would give $R = 1514 \text{ Ohms}$.

Determine the voltages and currents

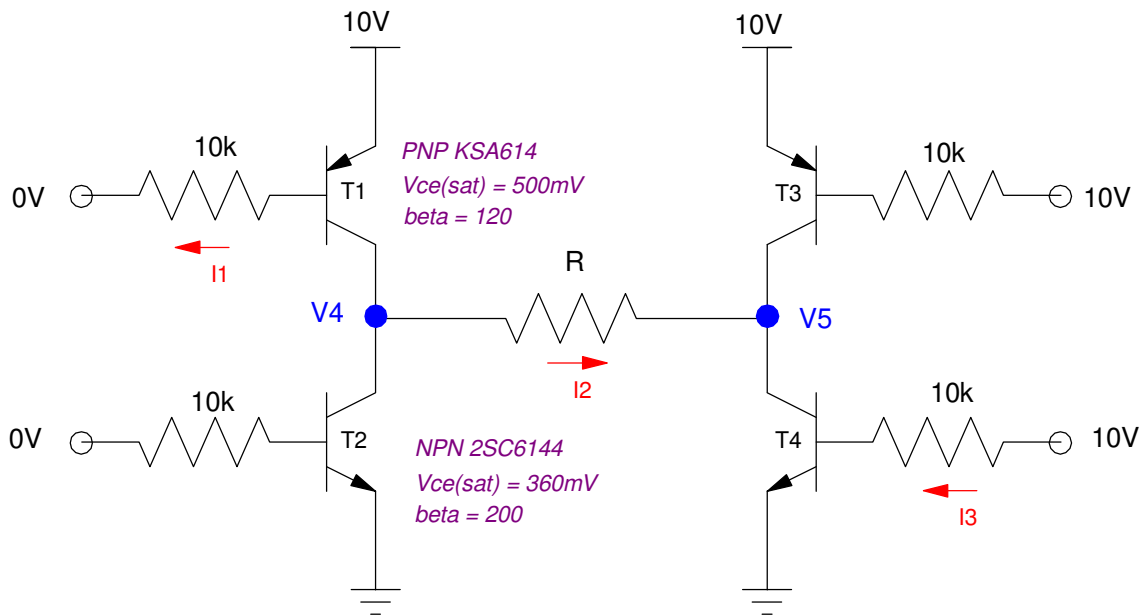
R <small>1000 + 100*mo + day</small>	I1	I2	I3	V4	V5
1514	930μA	6.037mA	930μA	9.50V T1 is saturated	0.36V T4 is saturated

$$I_1 = \left(\frac{10V - 0.7V}{10k} \right) = 930\mu A \quad \text{allows } I_2 = 111.6mA \text{ to flow}$$

$$I_3 = \left(\frac{10V - 0.7V}{10k} \right) = 930\mu A \quad \text{allows } I_2 = 186.0mA \text{ to flow}$$

$$\max(I_2) = \left(\frac{10V - 0.5V - 0.36V}{1514\Omega} \right) = 6.037mA$$

I_2 is the smallest of these three (6.037mA)

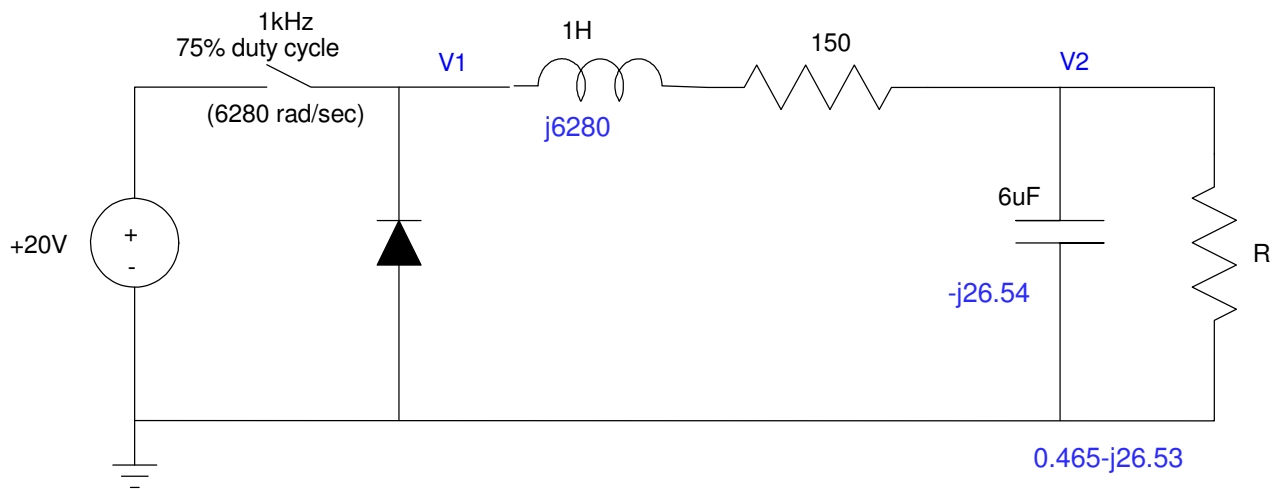


DC to DC Converter

3) Determine the voltages at V1 and V2 (both DC and AC). Assume

- $R = 1000 + 100 \cdot (\text{Birth Month}) + \text{Birth Day}$. May 14th would give $R = 1514$ Ohms.

R	V1		V2	
1514	V1(DC)	V1(AC)	V2(DC)	V2(AC)
	14.83V	20.7Vpp	13.49V	0.088Vpp



$$V_1(DC) = 0.75 \cdot 20 + 0.25 \cdot (-0.7) = 14.83V$$

$$V_2(DC) = \left(\frac{1514}{1514+150} \right) 14.83V = 13.49V$$

$$V_1(AC) = 20.7V_{pp}$$

$$V_2(AC) = \left(\frac{0.465-j26.53}{(0.465-j26.53)+(150+j6280)} \right) (20.7V_{pp})$$

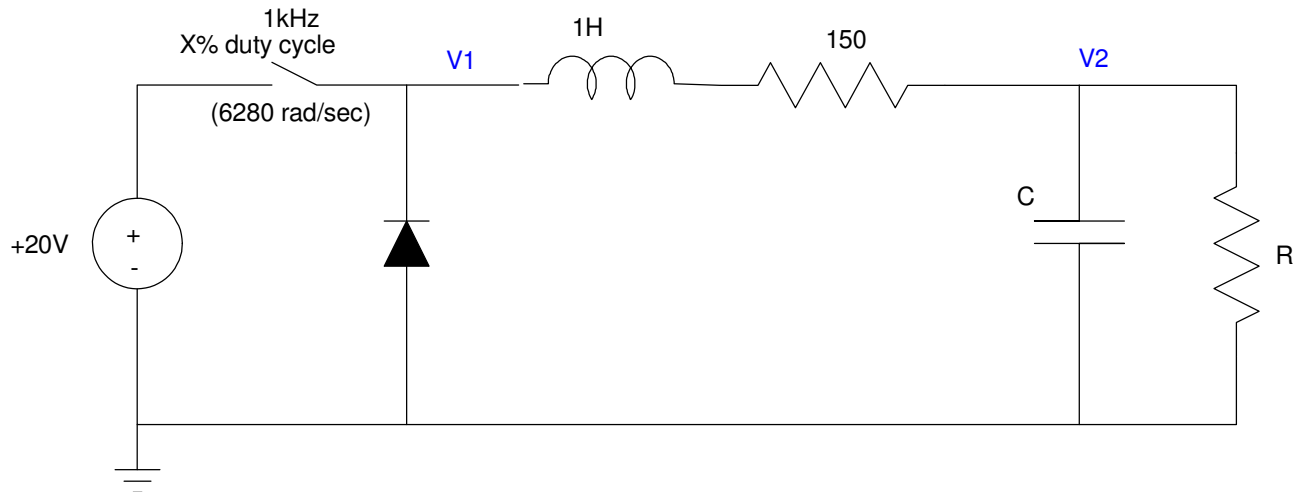
$$V_2(AC) = 0.088V_{pp}$$

DC to DC Converter: Design

4) Determine the duty cycle and C so that

- $V_2(\text{DC})$ is 12.50V
- $V_2(\text{AC}) = 1.00\text{V}_{pp}$
- $R = 1000 + 100 * (\text{Birth Month}) + \text{Birth Day}$. May 14th would give $R = 1514$ Ohms.

$V_1(\text{DC})$	$X\%$ (duty cycle) $V_2(\text{DC}) = 12.50\text{V}$	C $V_2(\text{AC}) = 1.00\text{V}_{pp}$	R $1000 + 100 * \text{Mo} + \text{Day}$
13.738V	69.8%	508nF	1514



$$V_1(\text{DC}) = \left(\frac{1514+150}{1514} \right) 12.50\text{V} = 13.738\text{V}$$

$$13.738\text{V} = \alpha \cdot 20\text{V} + (1 - \alpha)(-0.7\text{V})$$

$$\alpha = \left(\frac{13.738\text{V} + 0.7\text{V}}{20\text{V} + 0.7\text{V}} \right) = 69.8\%$$

Assume $C = 0$

$$V_2(\text{AC}) = \left(\frac{1514}{1514 + (100 + j6280)} \right) (20.7\text{V}_{pp}) = 4.833\text{V}_{pp}$$

To reduce this to 1V_{pp}, the impedance of the capacitor needs to be

$$\left| \frac{1}{j\omega C} \right| = \left(\frac{1\text{V}_{pp}}{4.83\text{V}_{pp}} \right) 1514\Omega = 313.24\Omega$$

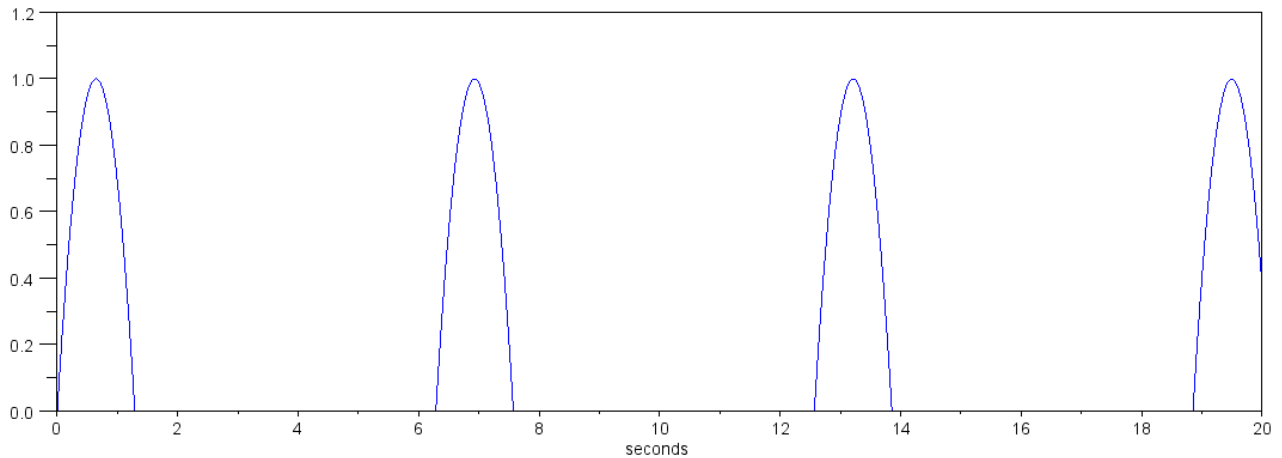
$$C = 508\text{nF}$$

Fourier Transform

5) (Matlab recommended) Determine the DC term and the first two harmonics for the following waveform

$$x(t) = \max(0, 3 \sin(t) + 4 \cos(t) - 4)$$

$$x(t) \approx a_0 + a_1 \cos(t) + b_1 \sin(t) + a_2 \cos(2t) + b_2 \sin(2t)$$



In Matlab

```
>> t = [0:0.001:2*pi]';  
>> x = max(0, 3*sin(t) + 4*cos(t) - 4);  
>> a0 = mean(x)  
0.1356  
  
>> a1 = 2*mean(x .* exp(-j*t))  
0.2081 - 0.1561i  
  
>> a2 = 2*mean(x .* exp(-j*t * 2))  
0.0642 - 0.2200i  
  
>> a3 = 2*mean(x .* exp(-j*t * 3))  
-0.0645 - 0.1716i
```

real means cosine

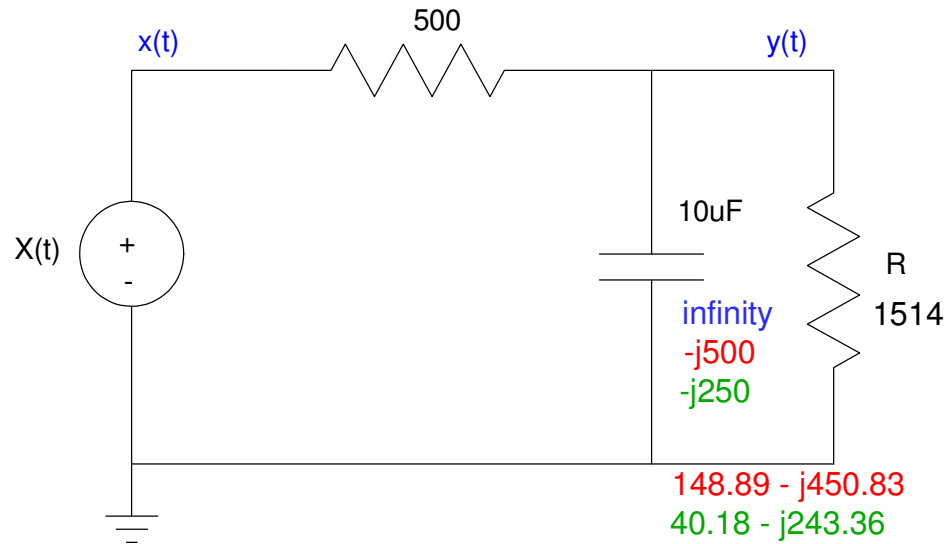
-imag means sine

$$\begin{aligned} x(t) \approx & 0.1356 \\ & +0.2081 \cos(t) + 0.1561 \sin(t) \\ & +0.0642 \cos(2t) + 0.2200 \sin(2t) \\ & -0.0645 \cos(3t) + 0.1716 \sin(3t) \end{aligned}$$

Fourier Transform

6) Determine $y(t)$ given that

- $x(t) = 10 + 6 \sin(200t) + 7 \cos(400t)$
- $R = 1000 + 100 * (\text{your birth month}) + (\text{your birth date}).$



Use superposition

DC: (blue)

$$x(t) = 10$$

$$Y = \left(\frac{1514}{1514+500} \right) 10 = 7.517$$

200 rad/sec (red)

$$X = 0 - j6 \quad \text{real} = \text{cosine}, \quad -\text{imag} = \text{sine}$$

$$Y = \left(\frac{(148.89 - j450.83)}{(148.89 - j450.83) + (500)} \right) (0 - j6) = -2.166 - j2.882$$

400 rad/sec (green)

$$X = 7 + j0$$

$$Y = \left(\frac{(40.18 - j243.36)}{(40.18 - j243.36) + (500)} \right) (7 + j0) = 1.614 - j2.427$$

so

$$y(t) = 7.517 - 2.166 \cos(200t) + 2.882 \sin(200t) + 1.614 \cos(400t) + 2.427 \sin(400t)$$