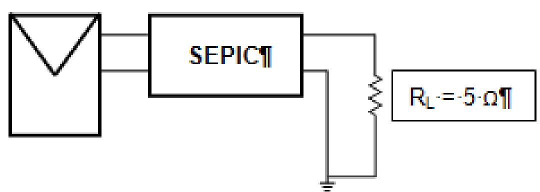
Name: Solutions

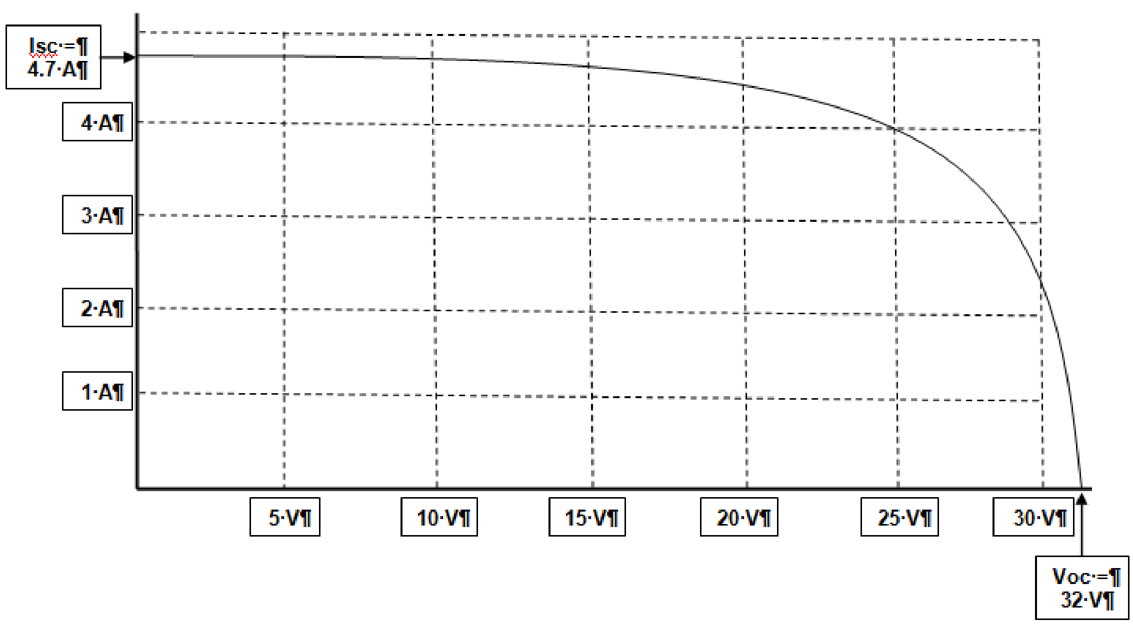
EE462L – Spring 2013, Test 2

Please, read the following notes carefully. Please, show all your work on the test sheets. A correct answer without supporting work gets no credit. One new sheet of notes is permitted. Write your name in all pages. Do not un-staple. Please **be neat**. Otherwise, you may end up loosing credit for correct answers if I cannot find or understand them. Unless otherwise noted assume that all converters operate in continuous conduction mode. You have 50 minutes to complete the test.

Problem 1 (30 points)

You're in the power lab & can't seem to find a potentiometer for use. Today is the last day to collect your solar PV data. However, you improvise by using your SEPIC in conjunction with a 5 Ω power resistor, and vary the duty cycle within acceptable limits. Below is the plot you were able to trace out for your solar PV panel.





Please mark on this plot the Req value for your SEPIC having a duty cycle (D) of 1/3, 1/2, and 2/3 and give the output power of your solar PV panel at those respective duty cycles. A blank page is included next so you can write down your answer there.

EE462L – Spring 2013, Test 2

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For a SEPIC, $R_{eq} = \frac{(1-D)^2}{D^2} R_L$

The easiest is D = 0.5, for Req = R_L = 5 Ω.

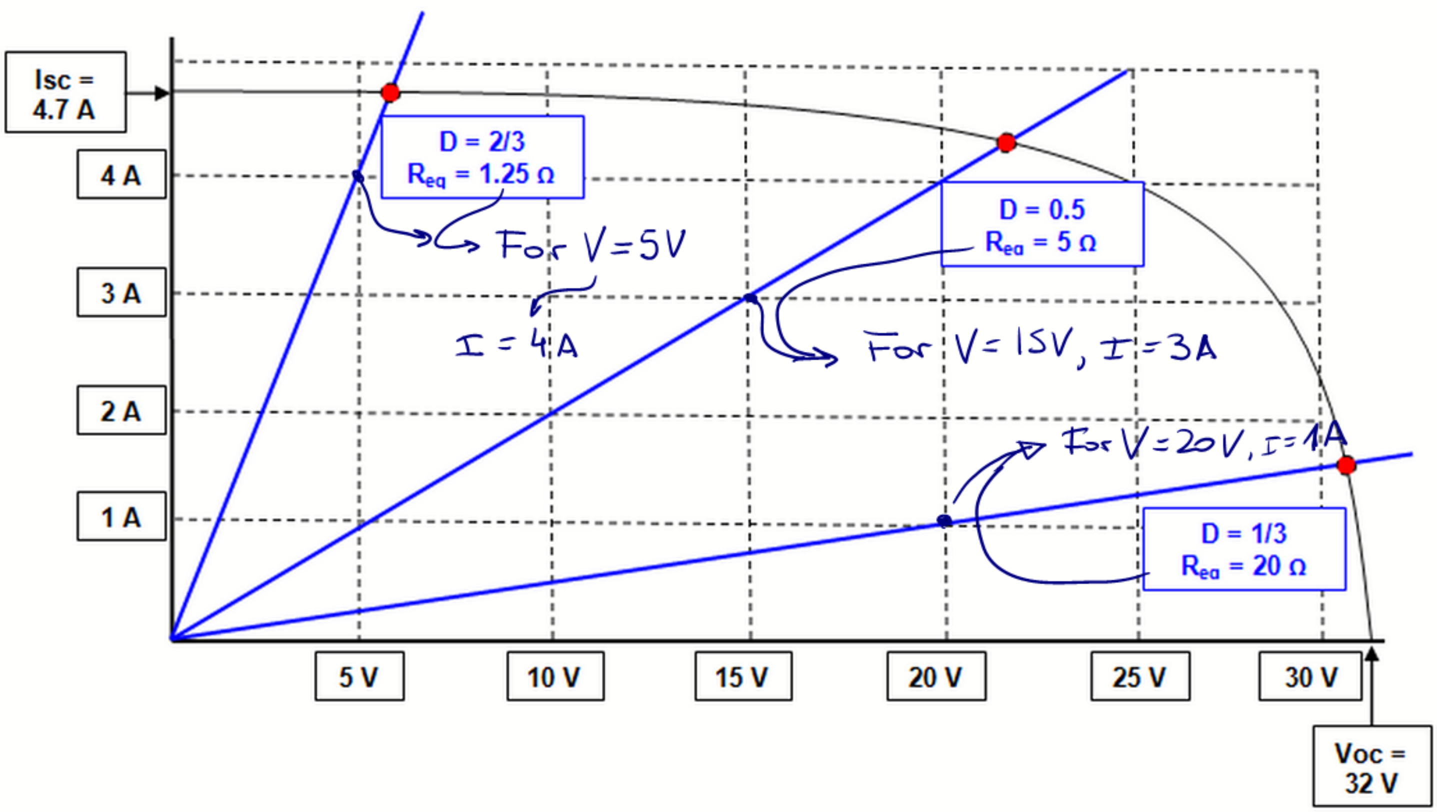
For D = 1/3,

$$R_{eq} = \frac{(1-D)^2}{D^2} R_L = \frac{(1-0.333)^2}{0.333^2}(5\Omega) = 20\Omega$$

For D = 2/3,

$$R_{eq} = \frac{(1-D)^2}{D^2} R_L = \frac{(1-0.667)^2}{0.667^2}(5\Omega) = 1.25\Omega$$

Now, those slopes can be constructed for their respective duty cycles & the points of intersection are shown below:



Now, by inspection, the solar PV panel's output power is approximated for those respective duty cycles:

P(D=2/3) ≈ (4.7 A)(6 V) = 28.2 W
P(D=0.5) ≈ (4.3 A)(22 V) = 94.6 W
P(D=1/3) ≈ (1.6 A)(31 V) = 49.6 W

EE462L – Spring 2013, Test 2

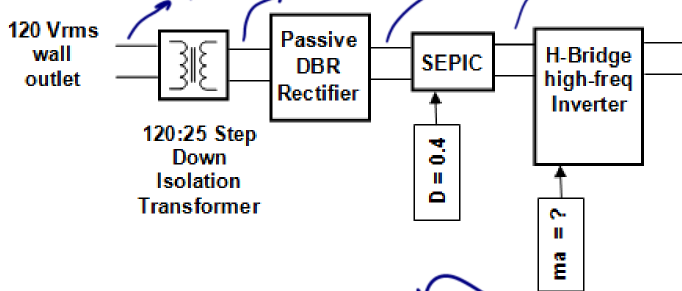
Problem 2 (40 points)

You're operating an H-Bridge in its linear region, with the following setup. You ensure m_f is set to 30, while $V_{control}$ is fed from a benchtop waveform generator, set to sine wave, 1 kHz. At the output of the H-Bridge, you measure the fundamental frequency to be $10V_{rms}$. Please sketch an approximate FFT plot for the H-Bridge output, assuming output filters aren't present and that the scale of the horizontal axis in the plot is from 0 Hz to the frequency corresponding to 3 times f_{tri}. You don't need to make the sketch at an exact scale, but be sure to indicate relevant values in both the vertical and horizontal axis. The table below may be helpful as well as considering that the dB level difference with respect to that of the fundamental is

3x30kHz=90kHz

$$\Delta dB_{harmonic,i} = 20\log_{10}\left(\frac{V_{harmonic,i}}{V_{fundamental}}\right)$$

120√2 peak 25√2 peak 25√2=35.35 Vdc



$\frac{35.35 \times 0.4}{0.6} = 23.57V_{dc}$

10Vrms

$m_a = \frac{\sqrt{2}\,10}{23.57} = 0.6$

Because of given 1kHz

30×2+1=61 kHz
30×2−1=59 kHz
57kHz, 63 kHz

Frequency	m_a = 0.2	m_a = 0.4	m_a = 0.6	m_a = 0.8	m_a = 1.0	
	Amplitude of component for varying values of m_a					
f_{cont}	0.200	0.400	0.600	0.800	1.000	
$2f_{tri} \pm f_{cont}$	0.190	0.326	0.370	0.314	0.181	$2f_{tri}$ cluster
$2f_{tri} \pm 3f_{cont}$		0.024	0.071	0.139	0.212	
$2f_{tri} \pm 5f_{cont}$				0.013	0.033	
$4f_{tri} \pm f_{cont}$	0.163	0.157	0.008	0.105	0.068	$4f_{tri}$ cluster
$4f_{tri} \pm 3f_{cont}$	0.012	0.070	0.132	0.115	0.009	
$4f_{tri} \pm 5f_{cont}$			0.034	0.084	0.119	
$4f_{tri} \pm 7f_{cont}$				0.017	0.050	

$$\Delta dB_{harmonic,i} = 20\log_{10}\left(\frac{V_{harmonic,i}}{V_{fundamental}}\right)$$

$\Delta dB = 20\log\left(\frac{0.37}{0.6}\right) = -4.2\,dB$

$\Delta dB = 20\log\left(\frac{0.071}{0.6}\right) = -18.53\,dB$

Name: ____

EE462L – Spring 2013, Test 2

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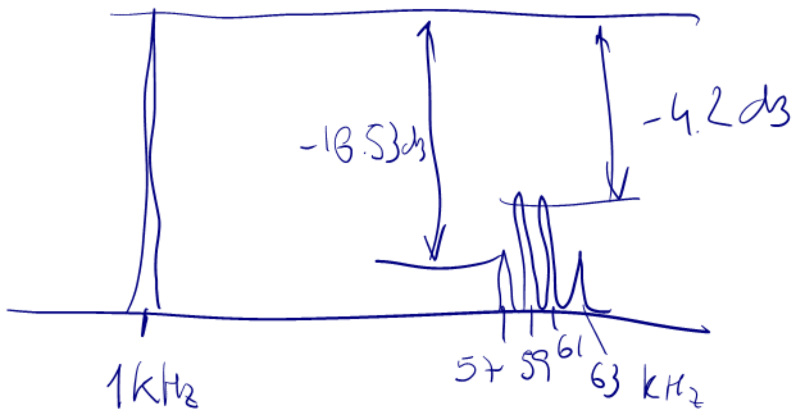
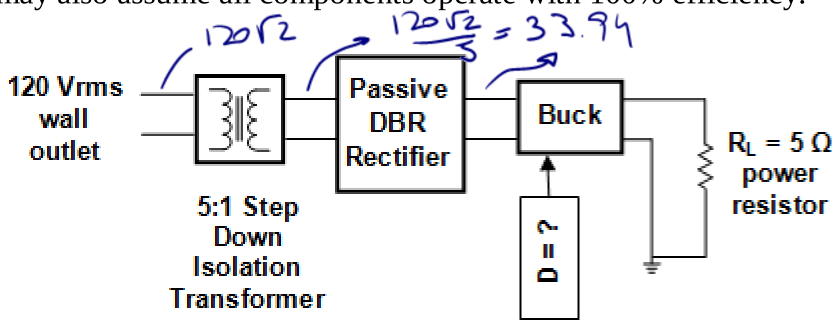


EE462L – Spring 2013, Test 2

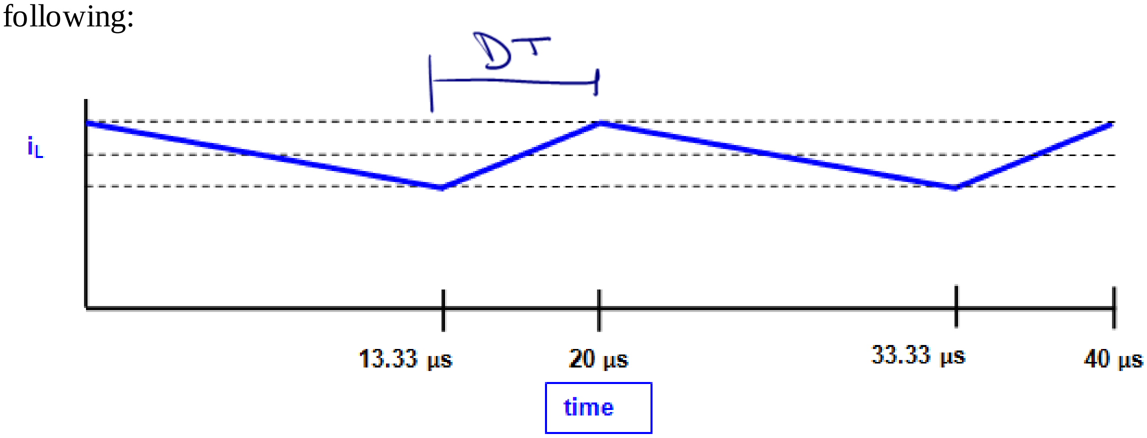
Problem 3 (30 points)

You go into the Power Lab, and cannot find a Variac station open. Determined to complete your lab testing, you decide to use the following combination of components (daisy-chained together) knowing you can simply adjust the Buck's duty cycle to affect its output voltage, accordingly.

- You may assume your DBR's output capacitor is sufficiently large enough such that there is negligible voltage ripple into your Buck.
- You may also assume all components operate with 100% efficiency.



On an oscilloscope, you pull up your Buck inductor's current waveform and notice the following:



a) What is D? What is the switching frequency?
b) What is V_{out}?
c) Is your circuit operating in discontinuous conduction mode (DCM)?
d) What is the power output of the Buck converter?
e) What is the average inductor current?
f) What is the average current for the output capacitor of the buck converter?
g) What is the average current flowing from the DBR into the buck converter?

EE462L – Spring 2013, Test 2

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a) $D = \frac{20 - 13.33}{20} = \frac{1}{3}$

b) $V_{OUT} = 33.94 \frac{1}{3} = 11.31$

c) No. $i_L(t) > 0 \ \forall t$

d) $P_{OUT} = \frac{V_{OUT}^2}{R} = \frac{11.31^2}{5} = 25.6W$

e) $I_L = I_{OUT} = \frac{P_{OUT}}{V_{OUT}} = 2.26A$

f) $I_C = 0$ (average current in steady state for capacitors is 0)

g) $I_R = \frac{P}{V_{in_{buck}}} = \frac{25.6}{33.94} = 0.75A$