1. SHORT ANSWER:

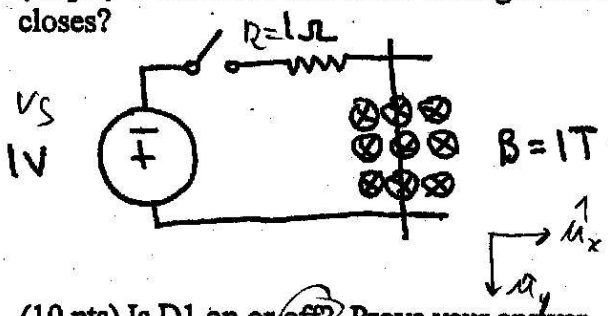
a. (10 pts) For a transistor to be in the active region, the base-emitter junction must be Forward biased and the base-collector junction must be Reverse biased.

b. (10 pts) A three-phase 11.5KV **delta connected generator** delivers 100 MVA to a load. What is the magnitude of the generator phase current?

Assuming an evenly balanced load, 1/3 of the power will be delivered by each line, or 33.3 MVA

So $I_L = \frac{\sqrt{3}(33.3\,MVA)}{(11.5\,kV)} = 5.02\,kA$ $\quad I_\phi = \frac{I_L}{\sqrt{3}} = 2.90\,kA$

c. (10 pts) What is the direction and magnitude of the force on the 1M conductor when the switch closes?



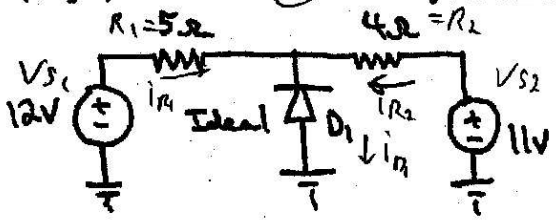
$\vec{F} = i\vec{L} \times \vec{B}$

$= \frac{V_s}{R}(-1m\,\hat{u}_y) \times (1T\,\hat{u}_z)$

$= \frac{1V}{1\Omega}(-1m)(1T)\,\hat{u}_x$

$= -1N\,\hat{u}_x$ (left)

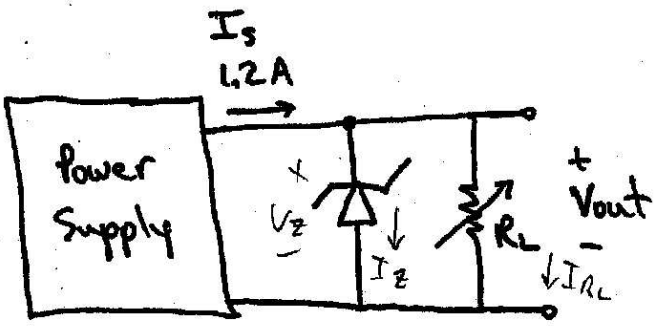
d. (10 pts) Is D1 on or off? Prove your answer.



If on, then $i_{R_1} + i_{R_2} = i_{D_1} = 0$

$\frac{V_{S1}}{R_1} + \frac{V_{S2}}{R_2} = \frac{12V}{5\Omega} + \frac{11V}{4\Omega} \neq 0$ Contradic so D_1 is

e. (10 pts) If Is = 1.2A and the Zener is rated 14V, 5W, what is the maximum value of R_L to maintain 14V at output?



$I_{Z,max} = \frac{P_{Z,max}}{V_{Z,max}} = \frac{5W}{14V} = 357$

$I_{R_L} = I_S - I_Z \geq 1.2A - 357mA$
$= 843mA$

$\frac{V_{R_L}}{R_L} = I_{R_L} \geq 843mA$

$R_L \leq \frac{V_{R_L}}{843mA} = \frac{14V}{843mA} = 16.6$

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2. (30 pts) A 440Vrms (line-to-line), 60 Hz, three-phase Y connected **Induction Motor** draws 16.8 Arms at a p.f. of 80% lagging. The stator copper losses are 350W, the rotor copper losses are 120W, and the rotational losses are 400W. Assume no other losses.

cf p 764

a. Determine the following:

i. (10 pts) Input power (Pin): Pin = 10.2 kW

$P_{in} = (V_{in})(I_{in})pf = 3\left(\frac{440V}{\sqrt{3}}\right)(16.8\,A)(0.8)$

ii. (10 pts) Developed power (Pdev): Pdev = 9.77 kW

$P_{dev} = P_{in} - P_{stat} - P_{rot,cu}$

$= 10.2\,kW - 350W - 120W$

iii. (5 pts) Output Power (Pout): Pout = 9.37 kW

$P_{out} = P_{dev} - P_{rot,cu} - P_{rot}$

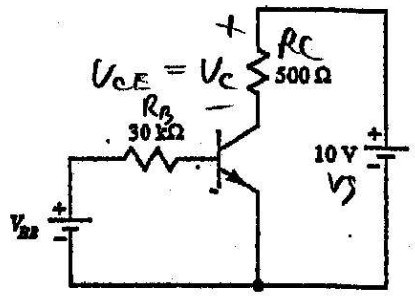
$= 9.89\,kW - 400W$

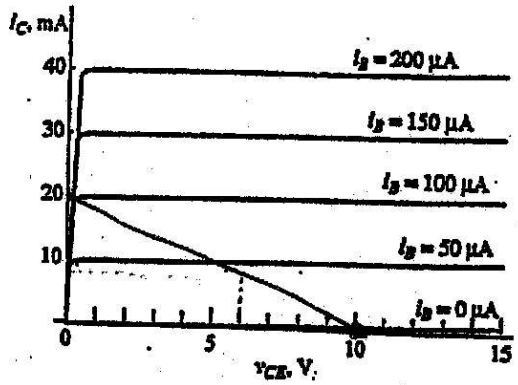
iv. (5 pts) Efficiency: η= 91.5%

$\eta = \frac{P_{out}}{P_{in}} = \frac{9.37\,kW}{10.2\,kW}$

3. (50 pts) Given the **common emitter BJT** circuit shown and the associated output characteristic. Perform the calculations indicated. Assume Beta = 200.

cf
p575, 579





a. (20 pts) Plot the load line on the characteristic curve.

$V_C = V_S - i_C R_C$

b. (15 pts) Find the required base current to give a V_{CE} = 6V.

$i_C = 8\,mA \qquad i_B = \frac{i_C}{\beta} = \frac{8\,mA}{200} = 40\,\mu A$

c. (15 pts) What value of V_{BB} is required to saturate the transistor for this circuit. Assume at saturation that V_{CE} will = 0.2V.

$V_C = V_S - i_C R_C$

$0.2V = 10V - i_C(500\,\Omega)$

$i_C = 19.6\,mA$

$i_B = \frac{i_C}{\beta} = \frac{19.6\,mA}{200} = 98\,\mu A$

$V_{BE} = V_{BB} - i_B R_B$

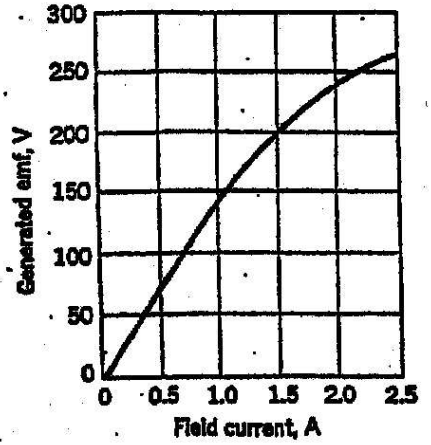
$V_{BB} = V_{BE} + i_B R_B$

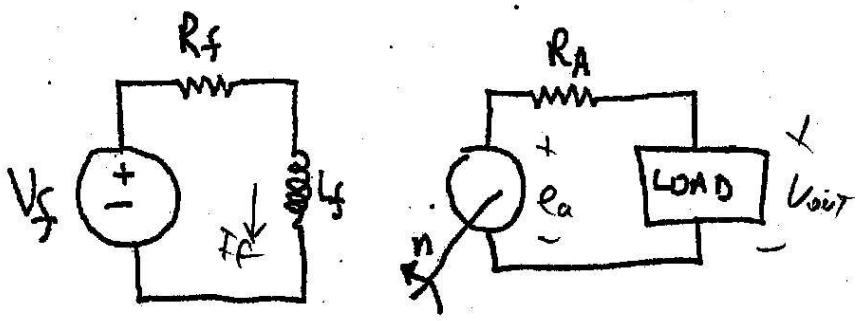
$= 0.7V + (98\,\mu A)(30\,k\Omega)$

$= 3.64\,V$

4. (30 pts) The constant-speed magnetization chart for a 25-hp 250V **DC generator** running at 1100 rpm is shown. This machine is **separately excited** and has an armature resistance of 0.12 ohms.

cf p 729, 730





a. (20 pts) If the armature current is limited to 75A, and the field current is adjusted to 1.5A, what is the maximum power out of the generator. Pout = 14.3 kW = 19.2 hp

b. (10pts) What is the new shaft speed.

n_{shaft} = _____

At $I_f = 1.5A$, $e_a = 200V$

then $V_{out} = e_a - I_a R_a$

$= 200V - (75A)(0.12\Omega)$

$= 191V$

$P_{out} = V_{out} I_{out}$

$= (191V)(75A)$

$= 14.3 kW \left(\frac{1 hp}{746 W}\right)$

$= 19.2 hp$

Initially $P_{out} = (25 hp)\left(\frac{746 W}{hp}\right)$

$= 18.7 kW$

$I_a = \frac{P_{out}}{V_{out}}$

$= \frac{18.7 kW}{250V}$

$= 74.6A$

$e_{a_1} = V_{out} + I_a R_a$

$= 250V + (74.6A)(0.12\Omega)$

$= 259V$

$e_a = k\phi\omega$

$\frac{e_{a1}}{e_{a2}} = \frac{\omega_1}{\omega_2} = \frac{n_1}{n_2} \Rightarrow n_2 = \frac{e_{a2}}{e_{a1}} n_1 = \frac{200V}{259V}(1100 rpm) = 850 rpm$

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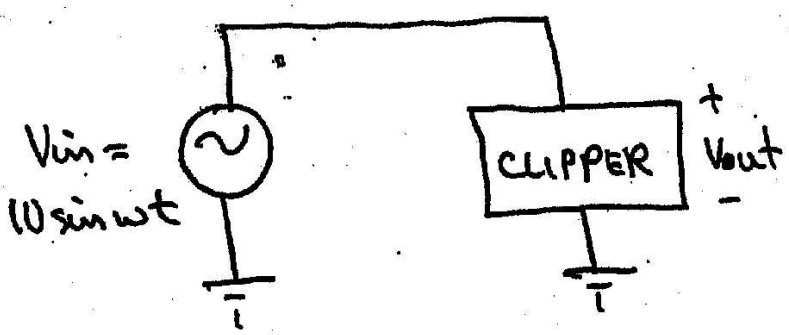
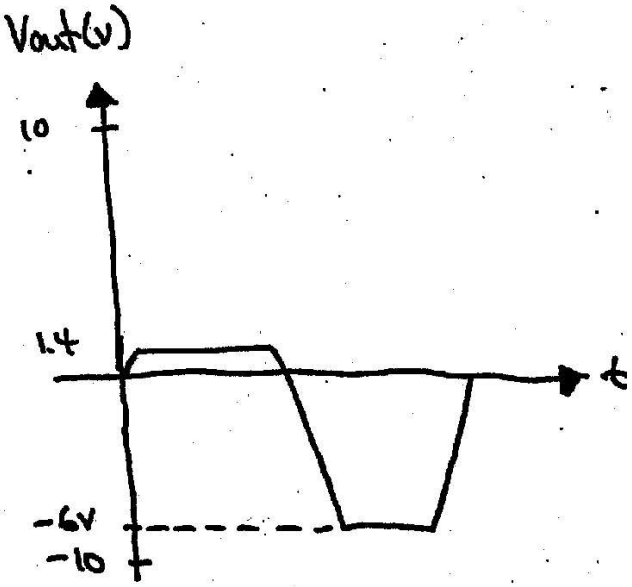
5. (40 pts) Design the clipper for the circuit below using all 3 non-ideal diodes and only 1 Zener diode from the parts list below. The desired output is shown. Redraw your design and circle the Zener that you chose.

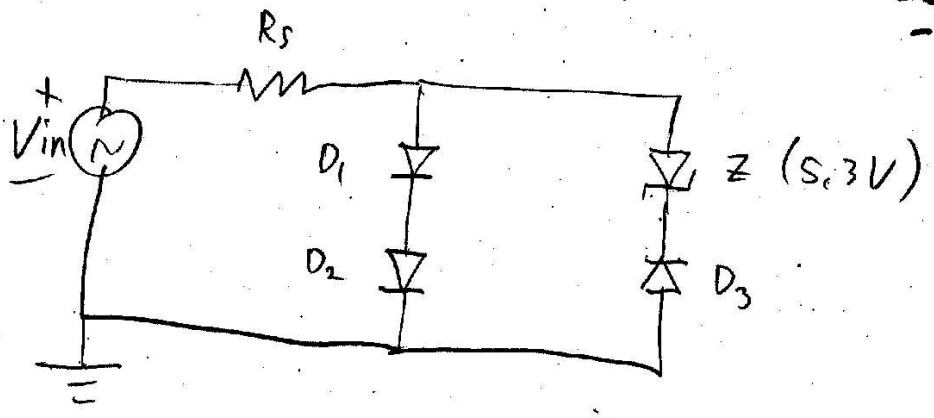
CF P447

Parts List:

Item	Quantity	Description
Non Ideal Diode	3	+ 0.7V −
7.4 V Zener	1	
6.7 V Zener	1	
5.3 V Zener	1	





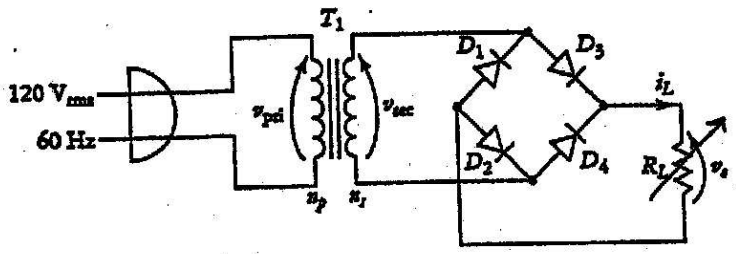


0V

6.(40 pts) In the rectifier shown, assume np/ns = 18/5 and the diodes are ideal ~~with a 0.7 V voltage~~ drop upon conduction. The load resistor (R_L) is variable.

cf. p443, 691, 409

18 : 5

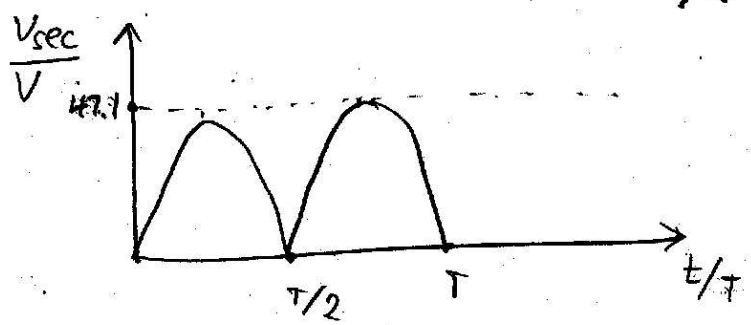


$$\frac{V_p}{n_p} = \frac{V_s}{n_s}$$

$$V_s = \frac{n_s}{n_p} V_p$$

$$= \frac{5}{18}(120V)(\sqrt{2})$$

$$= 47.1V$$



$$V_{sec,avg} = \frac{1}{T/2}\int_0^{T/2} V_{sec}(t)\,dt$$

$$= 2(60Hz)\int_0^{1/120Hz} V_{pk}\sin(2\pi f t)\,dt$$

$$= -\frac{(120Hz)(47.1V)}{2\pi(60Hz)}\cos(2\pi f t)\Big|_0^{1/120Hz}$$

$$= -\frac{47.1V}{\pi}\left[\cos(\pi) - \cos 0\right]$$

$$= \frac{2(47.1V)}{\pi}$$

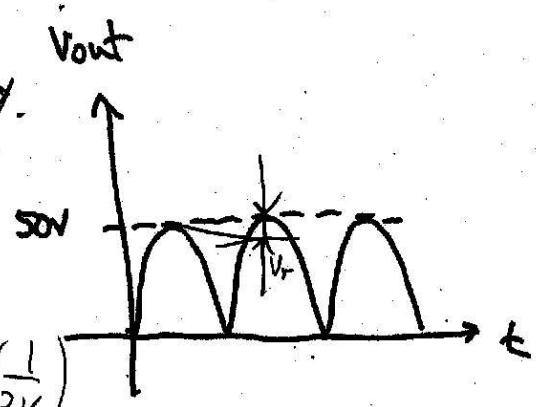
$$= 30.0\ V$$

a. (30 pts) With R_L = 50 ohms, find $V_{O_{avg}}$

b. (10 pts) If the rectifier is adjusted so that Vo is as shown, what is the smoothing capacitor (in parallel with R_L) required to maintain an average load current of 5 mA with a peak to peak ripple voltage < 4%. (Assume half the ripple is above the average and half is below the average).

$$i_{R_L}(t) = \frac{V_{R_L}(t)}{R_L}$$

If the ripple voltage is 4%, so is the ripple current.



So $V_r = (4\%)(50V) = 2V$

$$\Delta Q = C\Delta V = i_{avg}\Delta t$$

$$C = \frac{(i_{avg})(T/2)}{\Delta V} = (5mA)\left(\frac{1}{120Hz}\right)\left(\frac{1}{2V}\right)$$

$$= 20.8\ \mu F$$