ECE 248
HW2 Solutions

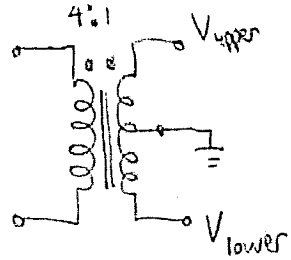
Total = 100 pts

4.9 (+9)

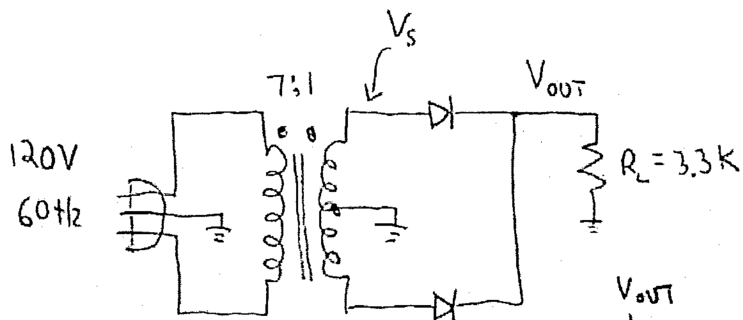
$V_{upper} = \frac{120}{4} \times \frac{1}{2} = \boxed{15\ V_{rms}}$

$V_{peak} = 15\sqrt{2} = \boxed{21.2\ V_p}$

$V_{lower} = \frac{120}{4} \times \frac{1}{2} = \boxed{15\ V_{rms}}$

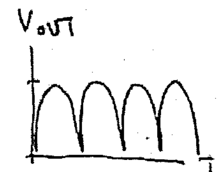


4.11 (+9)



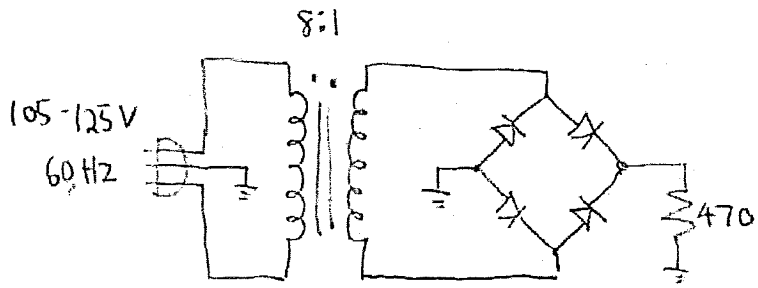
Peak $V_s = \frac{120V}{7} \times \frac{1}{2} \times \sqrt{2} = 12.1V$

Peak $V_{OUT} = 12.1 - 0.7 = \boxed{11.4\ V_p}$



Average value = DC value = $2 \times \frac{11.4}{\pi} = \boxed{7.3V}$

4.14 (+9)



Minimum DC output voltage

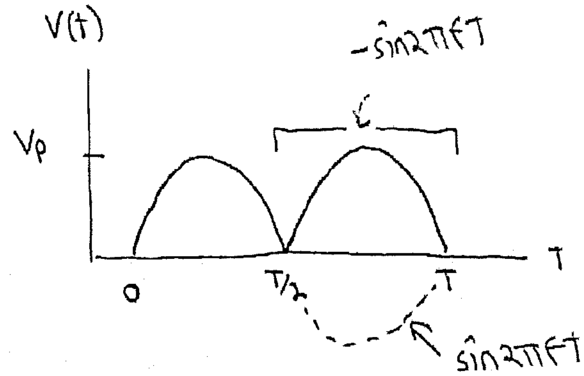
$V_{min} = \left(\frac{105}{8} \times \sqrt{2} - 1.4\right) \times \frac{2}{\pi}$

$= \boxed{10.9V}$

Max DC output voltage

$V_{max} = \left(\frac{125}{8} \times \sqrt{2} - 1.4\right) \times \frac{2}{\pi} = \boxed{13.2V}$

9-xx (+5)



$$\langle v \rangle = \frac{1}{T}\int_0^T v(t)\,dt$$

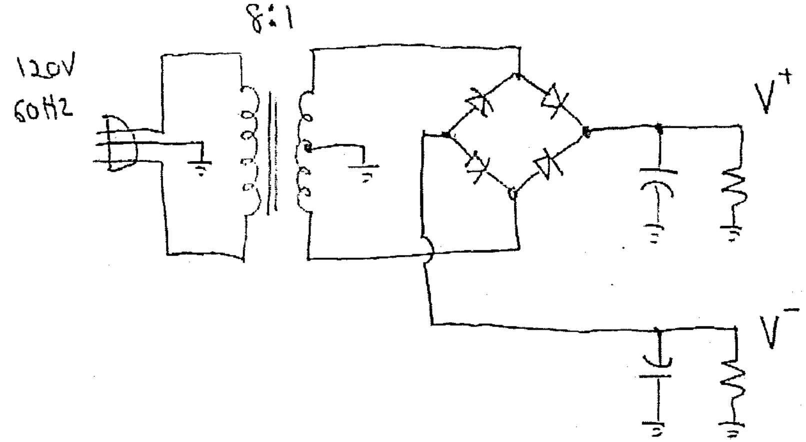
$$= \frac{1}{T}\left[\int_0^{T/2} V_p \sin 2\pi f t\,dt + \int_{T/2}^{T} V_p(-\sin 2\pi f t)\,dt\right]$$

$$= \frac{V_p}{T}\left[\frac{-1}{2\pi f}\cos 2\pi f t\Big|_0^{T/2} + \frac{1}{2\pi f}\cos 2\pi f t\Big|_{T/2}^{T}\right]$$

$$= \underbrace{\frac{V_p}{2\pi f T}}_{1}\Big[-\underbrace{(\cos\pi - \cos 0)}_{-2} + \underbrace{(\cos 2\pi - \cos\pi)}_{2}\Big]$$

$$= \frac{4V_p}{2\pi} = \boxed{\frac{2V_p}{\pi}}$$ ✓

4.45 (+9)



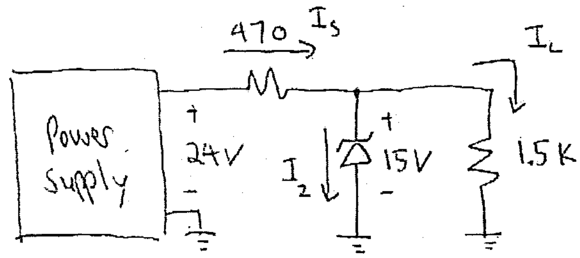
$$V^+ = \left[\frac{120}{8}\times\sqrt{2}\times\frac{1}{2}\right] - 0.7$$

$$= \boxed{9.9V}$$

$$V^- = -\left[\frac{120}{8}\sqrt{2}\cdot\frac{1}{2}\right] + 0.7$$

$$= \boxed{-9.9V}$$

5.5 (+9)



$$I_s = \frac{24-15}{470} = \boxed{19.1\ mA}$$

$$I_L = \frac{15}{1.5K} = \boxed{10\ mA}$$

$$I_z = I_s - I_L = \boxed{9.1\ mA}$$

5.6 (+9)

Max zener current involves lowest R_s and highest R_L.

$$I_{s,max} = \frac{24-15}{.95\times 470} = \underline{\underline{20.2\ mA}}$$

$$I_{L,min} = \frac{15}{1.05\times 1.5k} = \underline{\underline{9.5\ mA}}$$

$$I_{z,max} = I_{s,max} - I_{L,min} = \boxed{10.7\ mA}$$

5.7 (+9)

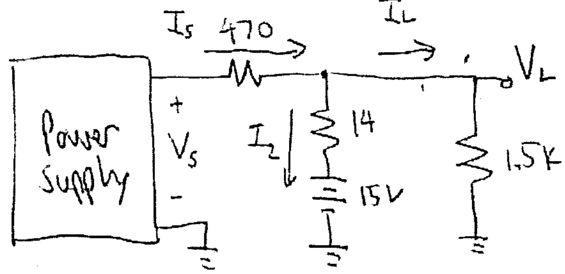
Max zener current involves highest supply

$$I_{s,max} = \frac{40-15}{470} = \underline{\underline{53.2\ mA}}$$

$$I_L = \frac{15}{1.5K} = \underline{10\ mA}$$

$$I_{z,max} = I_{s,max} - I_L = \boxed{43.2\ mA}$$

5.11 (+9)



$$I_s = I_z + I_L$$

$$\frac{V_s - V_L}{470} = \frac{V_L - 15}{14} + \frac{V_L}{1500}$$

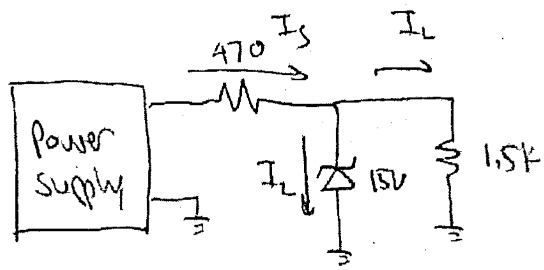
$$\frac{V_s}{470} + \frac{15}{14} = \left(\frac{1}{470} + \frac{1}{14} + \frac{1}{1500}\right) V_L = .074\, V_L$$

$$V_L = \frac{1}{.074}\left(\frac{V_s}{470} + \frac{15}{14}\right)$$

$V_s = 21.5V \rightarrow$ $\boxed{V_L = 15.1V}$

$V_s = 25V \rightarrow$ $\boxed{V_L = 15.2V}$

5.12 (+5)



Drop out occurs when $I_z = 0$

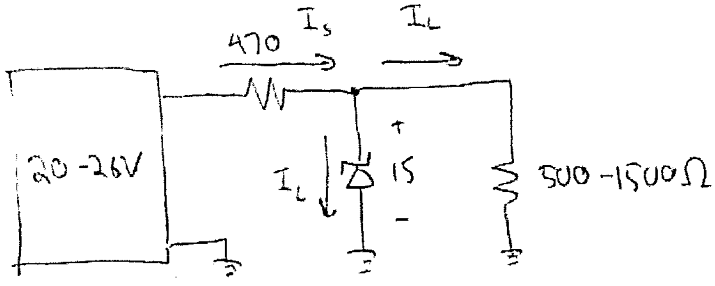
$$\rightarrow I_s = I_L$$

$$\frac{V_s - 15}{470} = \frac{15}{1500}$$

$$V_s = \left(\frac{15}{1500} + \frac{15}{470}\right) 470 = \boxed{19.7V}$$ ← Voltage regulation is completely gone.

Note: Regulation becomes poor when $I_z \lesssim 10$ mA

5.13 (+9)



worst case scenario:

$$I_Z = I_S - I_L$$

$$= \frac{20-15}{470} - \frac{15}{500}$$

$$= 10.6\text{ mA} - 30\text{ mA} = -19.4\text{ mA} < 0 !$$

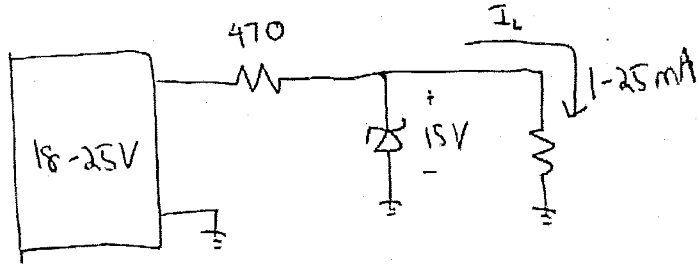
YES, the zener regulator will fail. :(

want $I_{Z,min} = 0 = \frac{20-15}{R_{S,max}} - \frac{15}{500}$

$$R_{S,max} = (20-15)\frac{500}{15} = \boxed{167\Omega}$$

← NOTE: In practice, R_s should be lower than this to keep $I_Z > 10$ mA.

5.14 (+9)



worst case scenario:

$$I_Z = I_S - I_L$$

$$= \frac{18-15}{.470K} - 25\text{ mA}$$

$$= -18.6\text{ mA} < 0 !$$

YES, the zener will fail. :(

want $I_{Z,min} = 0 = \frac{18-15}{R_{S,max}} - 25\text{ mA}$

$$R_{S,max} = \frac{3}{25\text{ mA}} = 0.12K = \boxed{120\Omega}$$

← NOTE: In practice, R_s should be lower than this to keep $I_Z > 10$ mA

D. 4-yy Diode datasheets

4-yy Suppose that the lab you are doing specifies that you use a 1N4002 diode but you only have 1N4003 diodes. Use the datasheet on the WEB site to determine if the 1N4003 diodes will work. Explain your answer.

See pages 110 to 113 in your textbook

The difference between the 1N4002 and the 1N4003 is that the 1N4002 has a PIV of 100 V and the 1N4003 has a PIV of 200V

Section 4-7 defines PIV as:

The maximum voltage across the reverse biased diode. This voltage must be below the specified PIV for the diode or the diode will be destroyed.

In the circuit in lab 1 has a Vpk of less than 5 Vpk and in lab 2 a Vpk of less than 20 Vpk so either the 1N40002 or 1n4003 will work.