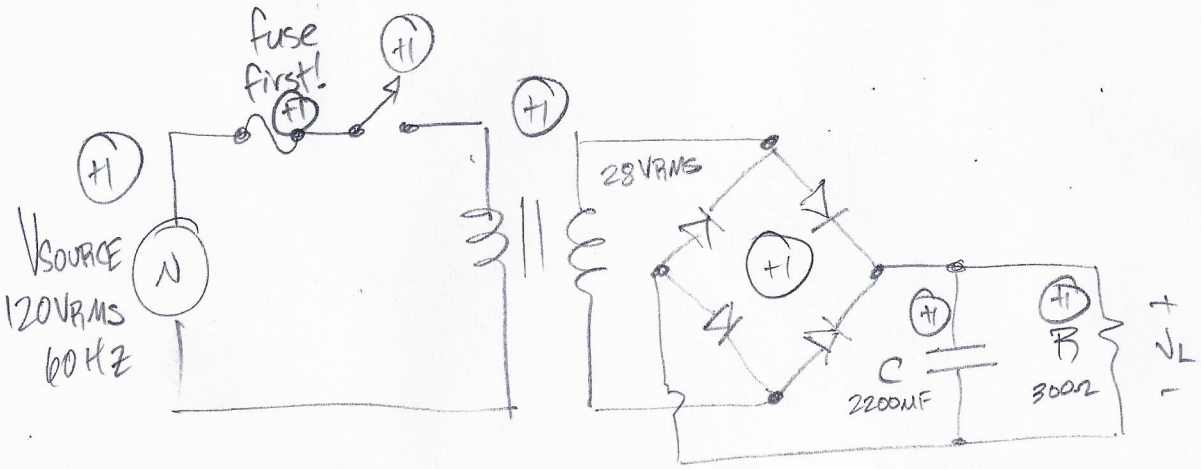
EE 3310/5310 • Exam I • 9 September 2022 NAME SOLUTION

1) Draw a complete schematic for a linear power supply using the following components:
   - 120-V_{RMS}, 60-Hz sinsusoidal voltage source
   - Line fuse and SPST on/off switch
   - Ideal transformer with 28-V_{RMS} secondary voltage
   - Full-wave bridge rectifier using silicon diodes
   - 2,200-µF smoothing/filter capacitor
   - 300-Ω load resistance



What is the turns ratio of this transformer? Is it a stepup or a stepdown?

$$\frac{V_P}{V_S} = \frac{120}{28} \approx 4.3:1$$ (+1)

stepdown (+1)

What is the required PIV rating for the diodes in the bridge rectifier, and what 1N400X-series part will work?

$PIV > V_{peak} = 28\sqrt{2} \approx 39.6\,V$ (+2)

∴ 1N4001 @ 50V is adequate (+1)

also use 50V capacitor (+1)

Determine the peak rectified voltage and approximate load current. (Don't calculate ripple yet.)

$$V_{peak} = V_S\sqrt{2} - 1.4 = 28\sqrt{2} - 1.4 = 38.20\,V$$ (+2)

$$I_L \sim \frac{V_{peak}}{R_L} = \frac{38.20}{300} = 0.1273$$

or 127.3 mA (+2)

Calculate the peak-to-peak ripple voltage and final average DC output voltage. What percentage of the DC voltage is the ripple, and is this "acceptable?"

$$V_{ripple} = \frac{I_L}{2fC} = \frac{0.1273}{2 \cdot 60 \cdot 2200 \times 10^{-6}}$$

$$= 0.4822$$

or 482.2 mV p-p (+2)

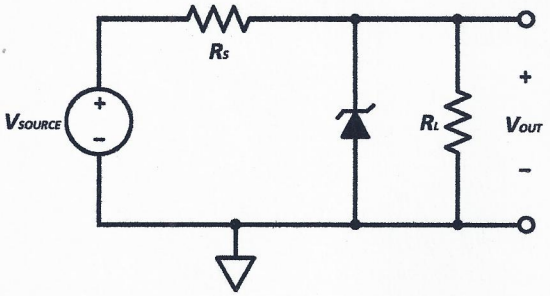
$$V_L = V_{peak} - \tfrac{1}{2} V_{ripple}$$

$$= 38.2 - \tfrac{1}{2} \cdot 0.4822 = 37.96\,V$$ (+2)

$$\frac{0.4822}{38.2} = 0.0126 \text{ or } 1.26\%$$ (+1)

(yes, acceptable)

2) What is this circuit called? What type of diode is used, and in what mode does it operate?



shunt voltage regulator (+1)

Zener diode (+1)

reverse - breakdown (+1)

V_{SOURCE} varies from 8.0 to 8.5 V, while R_L varies from 100 Ω to ∞ (open circuit). If the 1N5341B is rated at 6.2 V, calculate R_S such that the diode has a minimum current of 2 mA under all conditions. Choose the nearest E24 value and determine a suitable power rating.

- lowest Zener current occurs when V_{SOURCE} is LOW and I_L is HIGH

$$I_{L(max)} = \frac{V_L}{R_{L(min)}} = \frac{6.2}{100} = 0.062\,A \quad (+2)$$

- to keep 2mA in Zener, we therefore need

$$I_S = I_{L(max)} + I_{Z(min)}$$
$$= 0.062 + 0.002 = 0.064\,A \quad (+2)$$

$$R_S = \frac{V_{SOURCE(min)} - V_{OUT}}{I_S} = \frac{8 - 6.2}{.064} = 28.125\,\Omega \quad (+2)$$

Use $R_S = 27\,\Omega$ (+1)

$$P_{RS(max)} = \frac{(V_{SOURCE(max)} - V_{OUT})^2}{R_S} = \frac{(8.5 - 6.2)^2}{27} = 0.1959 \quad (+2)$$

Use $\frac{1}{4}$ W or $\frac{1}{2}$ W to be safe (+1)

Is the 1N5341B's power rating of 5 W sufficient under all operating conditions?

- max. power occurs @ $V_{SOURCE(max)}$ & $I_{L(min)}$

$$I_{L\,min} = \frac{6.2}{\infty} = 0$$

$$\therefore I_{Z\,max} = \frac{8.5 - 6.2}{27} = 0.08519\,A \quad (+2)$$

$P_Z = 6.2 \cdot 0.08519 = 0.5281$ W (+1)

yes 5W is ok!