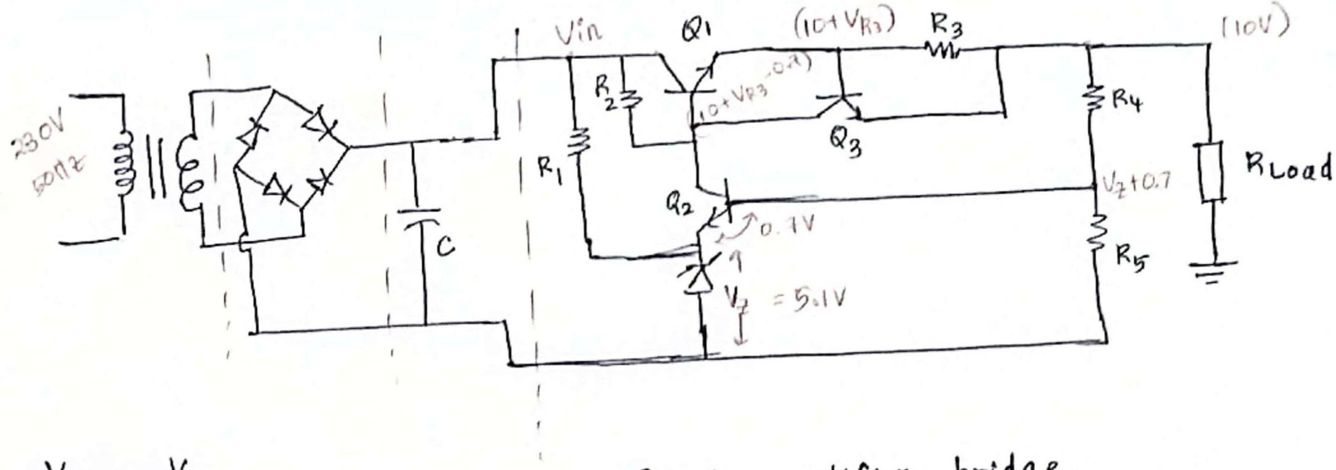


$V_{rms} = \frac{V_p}{\sqrt{2}}$

$\frac{V_p}{V_s} = \frac{N_p}{N_s} = \sqrt{\frac{L_p}{L_s}}$

$\frac{L_p}{L_s} = \left(\frac{V_p}{V_s}\right)^2 = \left(\frac{230}{15}\right)^2$

$\frac{L_1}{L_2} = \frac{2116}{9}.$

for the rectifier bridge.

$PIV = V_p(sec) - 0.7\ V$

$= 15\sqrt{2} - 0.7V$

$= 20.5132V$

$V_p(out) = V_{p(sec)} - 1.4$

$\simeq 15\sqrt{2} - 1.4$

$= 19.8132\ V.$

* we may get a peak voltage of 19.8 V accross the filter capacitor C.

Ripple calculations.

$V_{ripple} = \frac{I_{max}}{2fC}$

$I_{max} = 10\ A \Rightarrow$

$V_{ripple} = \frac{10}{2 \times 100\ C}$

$C = \frac{1}{20\ V_{ripple}}.$

for $C = 6800\ \mu F$ (which is available in market) we may expect a ripple of around 7.35 V which is acceptable for our purpose.

Calculations with zener diode.

for the proper operation of zener

$$I_K < I_Z < I_{max}$$

$$I_K < \frac{V_{in} - V_Z}{R_1} < I_{max}$$

$$\frac{1}{I_K} > \frac{R_1}{V_{in} - V_Z} > \frac{1}{I_{max}}$$

$$\frac{V_{in} - V_Z}{I_K} > R_1 > \frac{V_{in} - V_Z}{I_{max}}$$

$$R_1 < \frac{V_{in} - V_Z}{I_K} \quad \text{and} \quad \frac{V_{in} - V_Z}{I_{max}} < R_1$$

$$* \quad R_1 < \frac{(V_{in} - V_Z)_{min}}{I_K} \quad \text{and} \quad \frac{(V_{in} - V_Z)_{max}}{I_{max}} < R_1$$

$$R_1 < \frac{19.81 - 7.35 - V_Z}{I_K} \; — ① \quad \text{and} \quad \frac{19.81 - V_Z}{I_{max}} < R_1 \; — ②.$$

considering component availability and operating ranges we choose 1N 4733 A zener diode for our circuit.

for 1N 4733 A zener,

$$I_{ZK} = 1\,mA$$

$$I_{ZT} = 49\,mA$$

$$I_{Zm} = 178\,mA \quad (@\, 50^\circ C)$$

$$V_Z = 5.1V.$$

$$① \Rightarrow \quad R_1 < \frac{12.46 - 5.1}{1 \times 10^{-3}} \qquad ② \Rightarrow \quad \frac{19.81 - 5.1}{178 \times 10^{-3}} < R_1$$

$$R_1 < 7.36\,k\Omega \quad \text{and} \quad R_1 > 82.64\,\Omega.$$

But to operate in test current (49 mA),

$$R_1 = \frac{\left(19.81 - V_{ripple} \times \frac{2}{3}\right) - V_Z}{49 \times 10^{-3}} = 200.2\,\Omega. \text{ is prefered.}$$

$Q_2$ and $R_3$ are for over current protection.

We may forward bias the $Q_2$ transister when their is a current greater than 10 A to the load, to reduce the base current of $Q_1$, which will reduce the emitter current that is going through the load.

$$R_3 = \frac{0.7}{10} = 0.07\,\Omega.$$

We can neglect the base current of feedback transistor $Q_3$ and consider $R_4$ and $R_5$ resistors as potential dividers.

$$\frac{V_Z + 0.7}{R_5} \times (R_4 + R_5) = 10\text{ V}$$

$$\frac{R_4}{R_5} + 1 = \frac{10}{5.1 + 0.7} = \frac{10}{5.8}$$

$$\frac{R_4}{R_5} = \frac{4.2}{5.8}$$

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