Electronic Devices and Circuits Lab
Experiment 5- Group 2

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Aim-

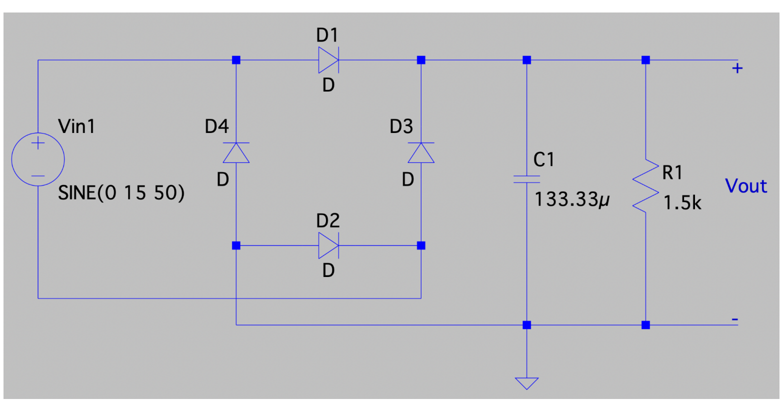
1) To design a Bridge Rectifier such that the ripple voltage is less than 15% with the lowest possible capacitance value.
2) To design a voltage regulator based on a Zener Diode with output voltage as 8V ($\pm$ 0.2 V). Given conditions are I_L(min) = 0mA, I_L(max) = 100mA, I_Z(min) = 0.1*I_Z(max).
3) To compare the ripple voltage in the circuit with and without the regulator.

The above circuits are given an AC supply with 15V peak and frequency of 50Hz. The load resistance can vary between 500Ω to 1500Ω. Forward bias voltage of the diode is 0.75V.

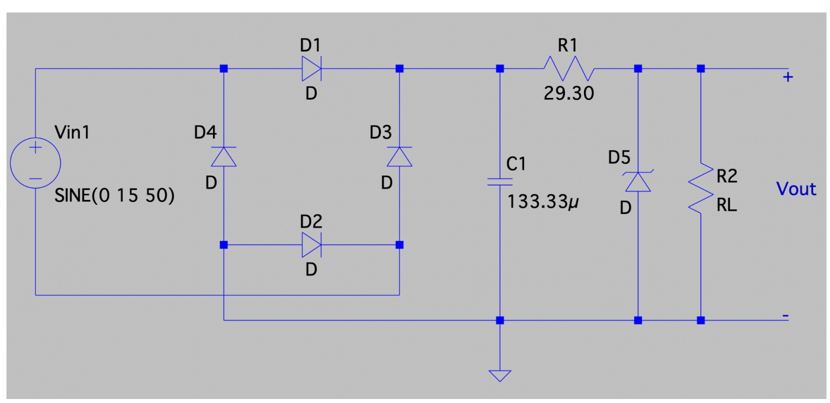
Theory-

From Experiment 4, we saw that the corrected voltage went to 0V twice in one cycle. This causes the appliance to turn off twice in one cycle which is problematic. So to correct this we can use a capacitor in parallel to the output to prevent the voltage from falling to 0V, i.e. it discharges when the voltage starts to reduce thereby maintaining a constant voltage. In other words, the capacitor acts as a Low Pass filter which tries to average out the voltage to a constant value.

But even after this correction there is a ripple in the voltage (as seen in the output graph). To convert the ripple voltage completely to DC voltage we can use a zener diode with V_{BR} = 8V. The zener diode regulates the voltage to a constant one when used in reverse bias. The zener diode has a very thin depletion region due to heavy doping and so it is used in reverse bias. When the reverse bias voltage exceeds the breakdown voltage (also called as zener breakdown), the I-V curve is such that a very small change in voltage gives rise to a very large change in current flowing through the diode. So the voltage across the zener diode remains constant near breakdown voltage even if the applied voltage exceeds it.



Bridge Rectifier with Capacitor



With Regulator

Procedure and Calculations-

For Bridge Rectifier with Capacitor

The maximum voltage across capacitor will be V_{max} = 15V - 2*(0.75V) = 13.5V due to the two diodes in the bridge rectifier being in forward bias.

The relation between V_r and V_{max} is $Vr = \frac{Vmax}{2fRC}$

Given that $V_r \leq 15\%$ of V_{max} , we can calculate the capacitance by-

$$\frac{Vmax}{2fRC} \leq 0.15 * Vmax$$

Using f = 50Hz we get - $C \geq \frac{1}{15R}$

It has been given that R can vary from 500Ω to 1500Ω, so maximum RHS is achieved when R=500Ω. Substituting that we get $C \geq 133.34\mu F$

So the minimum value of capacitance is $133.34\mu F$.

For Bridge Rectifier with Capacitor and Regulator

It is given that the load must be maintained at 8V so the breakdown voltage of the zener diode will be 8V. Applying KVL in the circuit we get

$$Vps = I * R1 + Vz$$

where V_{ps} is the output voltage of the bridge rectifier, I is the current flowing through R_1, R_1 is a series resistance which prevents the capacitor from discharging instantaneously through the diode and V_z is voltage across the zener diode.

Also $I = Iz + Il$, where I_z is current flowing through the diode and I_L is the load current.

Here V_Z = 8V as load must be maintained at this voltage.

At maximum V_{ps} (= 13.5V)-

$$Rs = \frac{Vps, max - 8}{Iz, max + Il, min} \text{ ...... eq(1)}$$

At minimum V_{ps} (= 13.5 - (0.15*13.5) = 11.48V)-

$$Rs = \frac{Vps, min - 8}{Iz, min + Il, max} \text{ ...... eq(2)}$$

Equating the above equations and using the given conditions, we get that $I_{Z, max}$ = 187.71 mA. Substituting this into equation 1 we get R_s = 29.30Ω .

Comparing the ripple voltages

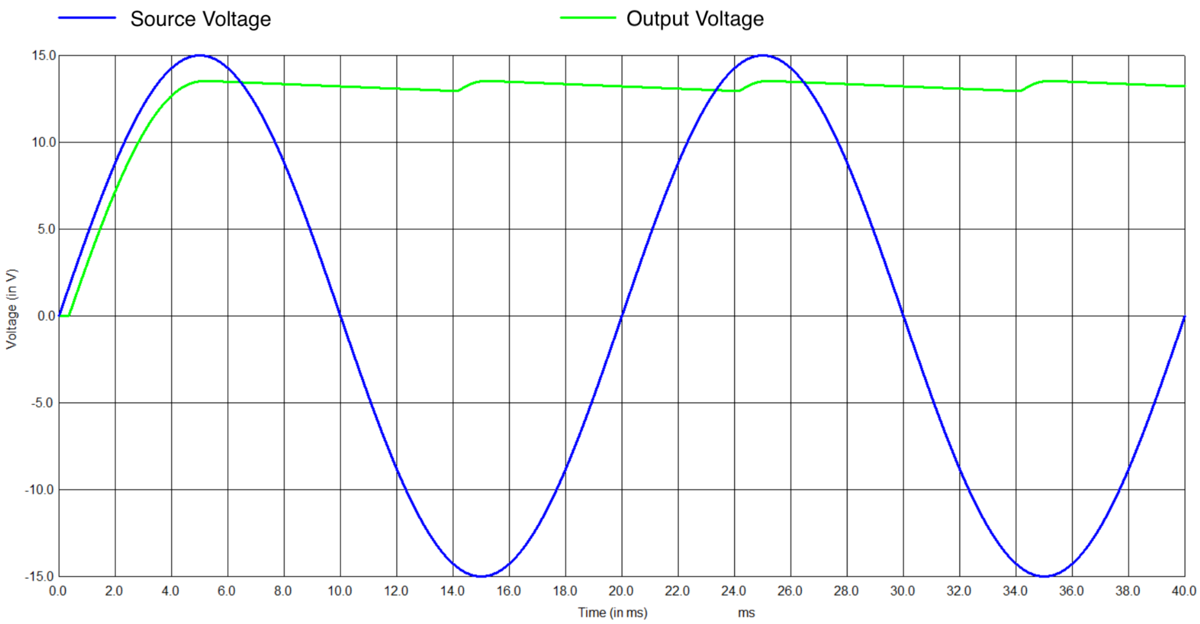
In the bridge rectifier circuit without voltage regulator, the capacitor discharges through R_L only but in the circuit with regulator the capacitor discharges only through R_s and the diode. In the former circuit the resistance is much higher ($R_L > R_s$) so the capacitor discharges slower than the latter circuit. This causes the ripple voltage in the first circuit to be lesser than the ripple voltage in the second case.

Conclusions-

1) Capacitor can be used as a Low Pass filter to average out the output voltage from the bridge rectifier.
2) To correct the ripples from the capacitor, we can use a Zener diode in reverse bias to obtain a perfect DC voltage.
3) We set the breakdown voltage of the zener diode to be the same as the desired output voltage.

Plots-

For Bridge Rectifier with Capacitor-



For Bridge Rectifier with Capacitor and Regulator-