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TRANSIENT ANALYSIS ON THE PERFORMANCE AND BEHAVIOR OF A SINGLE PHASE HALF WAVE RECTIFIER

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Abstract: Half wave rectifiers are used in small power supply due to easy circuit design and cheap in cost. Various important characteristics are required to be specified for a making a power supply. The efficiency of half wave rectifier reduces due to various losses. In this paper transient analysis is conducted on a half wave rectifier to find the various aspects on changing the load and filter capacitor. The selection of appropriate capacitor value in the filter circuit does an important role in determining the average direct current level and ripples.
Keywords: Efficiency, Filter, Rectifier, Ripple, Spice.

I. INTRODUCTION

Rectifier is an important circuit which is used in various electronic devices. Every electronic system requires power supply and diode plays an important role in this. A rectifier converts alternating current to direct current by the process known as rectification. In a half wave rectifier the diode conducts current only when it is forward biased. During the reverse biased condition the output is zero [1]. Thus a unidirectional pulsating voltage is received at the output. The rectification process alone produces DC current which is unidirectional but consist current pulses. Filters are used to make steady DC current which remains constant [2]. A half wave rectifier only provides one peak per cycle.

The important characteristics required to be specified for a making a power supply are output dc voltage, average current, peak current, peak inverse voltage, regulation factor and ripple factor. Peak Inverse Voltage is the maximum voltage that a diode has to withstand during the reverse biased period [3]. During the negative half cycle when the input voltage reaches to its maximum value V_m, the voltage across the diode also gets to maximum. PIV of half wave rectifier is

$$PIV = V_m \quad (1)$$

The current flowing through the diode will be

$$I_{MAX} = V_{SMAX}/(R_F + R_L) \quad (2)$$

The DC output current is

$$I_{dc} = V_{SMAX}/ R_L \quad (3)$$

The DC value of voltage across the load is

$$V_{dc} = V_{SMAX}/pi \quad (4)$$

The RMS value of current flowing through the diode will be

$$I_{rms} = V_{SMAX}/ 2(R_F + R_L) \quad (5)$$

The RMS value of voltage across the load will be

$$V_{Lrms} = V_{SMAX}/2 \quad (6)$$

Ripple factor is the ratio of the effective value of the ac components present in the output to the dc component in output, which is

$$\gamma = K_f^2 - 1 \quad (7)$$

Where, K_f is the form factor of the input voltage. For half wave rectifier the form factor is1.57, hence ripple factor

$$\gamma = (1.57^2 - 1) = 1.21 \quad (8)$$

Regulation is the variation of the output voltage as a function of dc load current. The percentage regulation is

$$\% Reg = [(Vno\ load - Vfull\ load)/Vfull\ load] \times 100 \quad (9)$$

The ratio of DC output power to the AC input power is called as rectifier efficiency which is denoted by η. Efficiency is given by

$$\eta = P_{dc} / P_{ac} \quad (10)$$

The efficiency of half wave rectifier efficiency is very low. The losses of transformer windings and the power dissipation in the rectifier element reduce the efficiency. Filter circuits reduces the ripples and are used to improve efficiency [4]. The maximum efficiency obtainable from a half wave rectifier is 40.6%. This paper analysis the effect of load and capacitor values on half wave rectifiers and it's applications for use in small power supplies.

II. RESEARCH METHODOLOGY

Using the linear technology spice software a new sheet is created and the half wave rectifier is drawn as shown in figure 1.

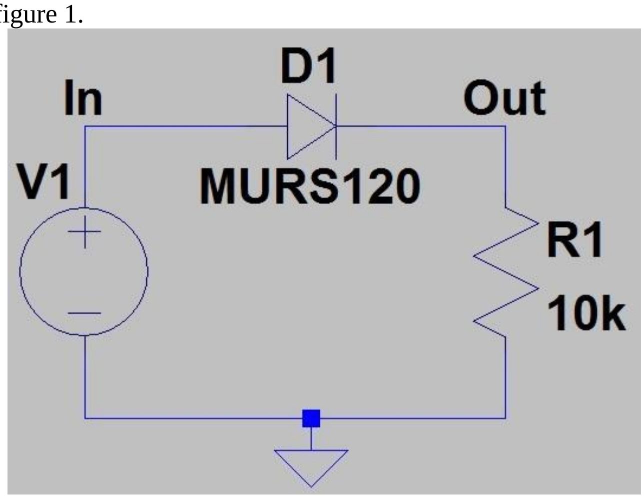

Figure 1: Half wave rectifier

The ground terminal is connected and the In/Out labels are labeled at the nodes. The resistor and diode value is selected as 10 kilo ohm and MURS120. MURS120 is an ultrafast rectifier which is ideally suited for high voltage and high frequency rectification in surface mount applications. It is compact in size and weight. The independent voltage source is selected to provide a sine wave as shown in figure 2. The DC offset [V] is for the value of DC offset voltage. To create a pure sinusoid it is kept at zero. Amplitude [V] is for the un-damped amplitude of the sinusoid. Frequency [Hz] is for the required frequency of the sinusoid in Hertz. T delay [s] is the time delay required in seconds. It is set to zero for normal sinusoid. Theta [1/s] is for the damping factor which is set to zero for the normal sinusoid. Phi [deg] is for the phase advance in degrees. If a cosine wave form is needed it is then set to 90. Ncycles is for the number of cycles of the sinusoid required. It is left blank if ongoing cycles are required [5].

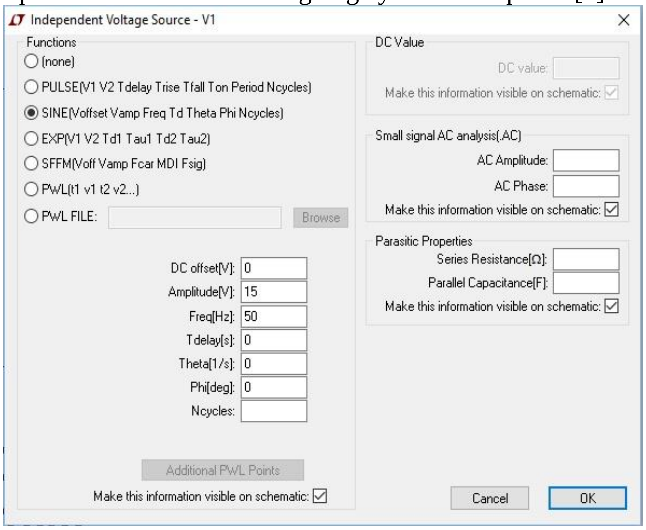

Figure 2: Independent voltage source at Sine input mode

The parameters for the input sine wave are selected by keeping the DC offset [V] at 0, Amplitude [V] at 15, Frequency [Hz] at 50, T delay [s] at 0, Theta [1/s] at 0, Phi [deg] at 0 and the Ncycles is left blank.

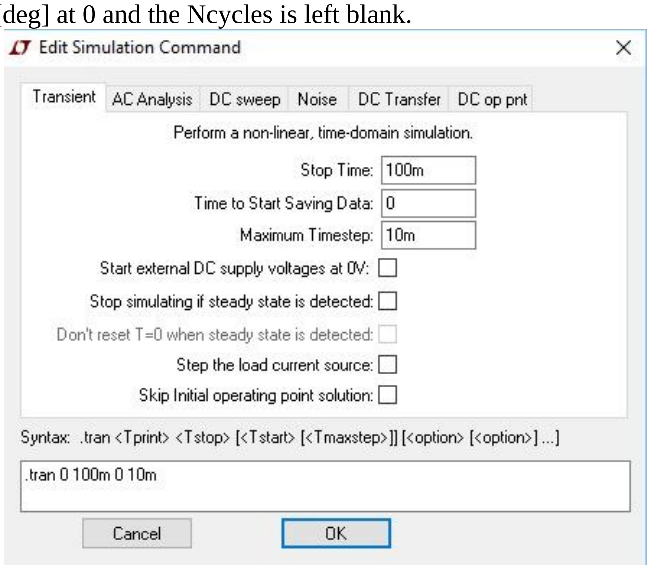

Figure 3: Transient analysis

After setting the source, the transient analysis is then selected as shown in figure 3. The number of calculations required by linear technology spice software to plot a wave form is determined by the ratio of stop time and maximum time step. If the time step is kept very small then the probe screen will be cluttered with unnecessary points which will take much amounts of time to calculations. Whereas if the time step is kept very high then important process which occurs in very short periods of time in the circuit will be missed. So a proper value must be kept [6]. The stop time is set 100m, time to start saving data at 0 and maximum time step at 10m.

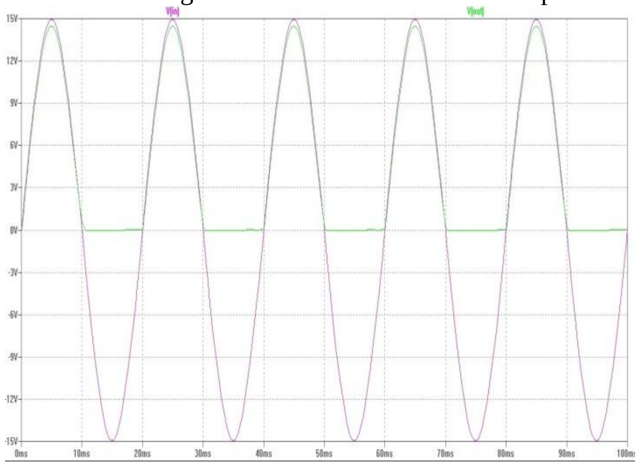

Figure 4: AC Input and pulsating DC output

Now the simulation is run by selecting input and output voltage. The input sine wave and the output pulsating DC can be seen as shown in figure 4. The output contains only the positive peaks when the diode is conducting thus providing a unidirectional pulsating voltage. By selecting the V (in) and V (out) the horizontal and vertical value can be measured as shown in figure 5.

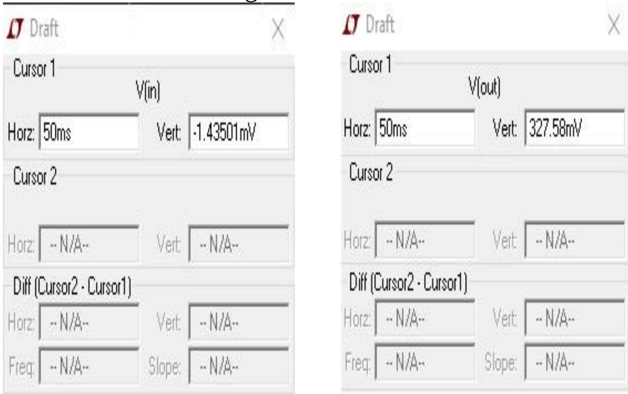

Figure 5: V in and V out

Filter circuits are needed to convert the pulsating DC to pure DC. It allows passing of the dc component to the load and blocks the ac component thus enabling the output to be a steady DC voltage [7]. The filter circuit can be constructed using capacitors and inductors. An electrolytic capacitor can be attached in parallel to work as the filter circuit which will block the DC and allows AC to pass. The capacitor gets charged during the conduction period and stores the charged energy. During the non conducting period this charged energy is delivered to the load. By this energy storage and supply process the ripples get decreased. Thus the high amount of ripple components gets bypassed through the capacitor. A series choke can also be used along with capacitor to reduce ripple and make the waveform smoother. Inductor allows dc components to pass though it and blocks the ac components. It opposes the change in current that flows through it, offering high impedance to the ripples and no impedance to the dc components. But in contemporary designs chokes are not preferred. Series inductor filter are used for high load current cases. Ripple can also be reduced by increasing the order of the filter.

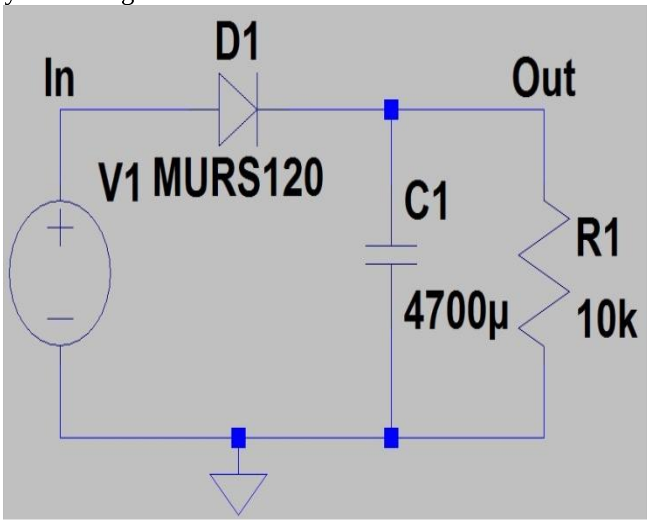

Figure 6: Half wave rectifier with filter

The half wave rectifier circuit is modified by connecting a filter capacitor of 4700µ as shown in figure 6. The pulsating DC voltage flattens due to the rapid charging of the capacitor and slow discharging. By selecting input and output voltage the simulation is then checked for the output DC. The resultant graph for the output DC is shown in the figure 7.

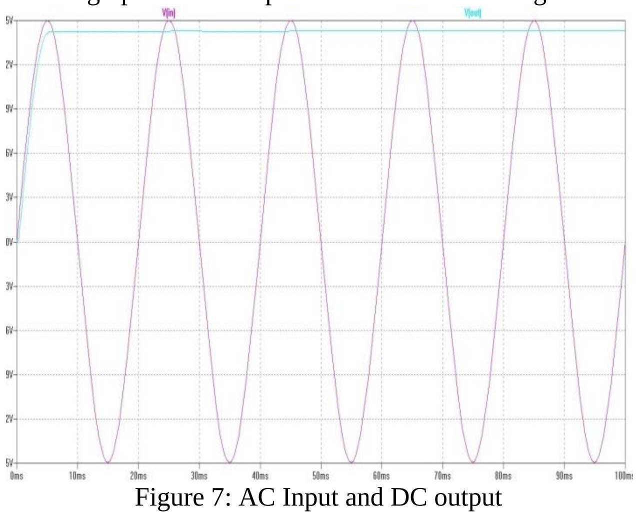

Figure 7: AC Input and DC output

By varying the values of capacitor and load resistor the various effects on the output DC can be tested. The discharge time constant will be high if the value of the load resistance is large, thus the capacitors time to discharge will get over soon. This will increase the output voltage and lower the amount of ripples in the output. Whereas if the load resistance is small, the discharge time constant will become less and there will be more ripples with a decrease in the output voltage. The capacitor value plays an important role in determining the average DC level and ripples. If a high value is selected the amount of charge it store will be high and the discharging amount will be less. Due to this the ripples will be very less but the average dc level will become high [8].

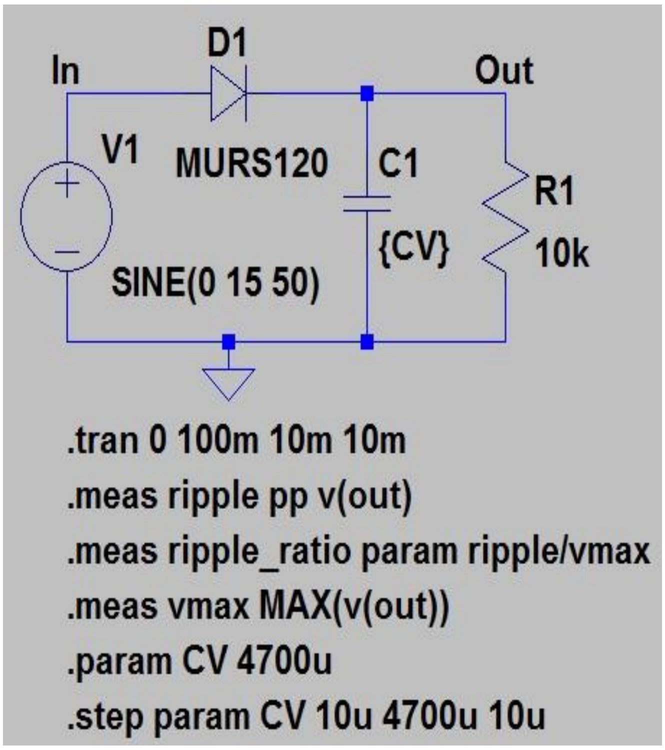

Figure 8: Modified circuit with parameters

Now the circuit is modified as shown in figure 8 to calculate the ripple ratio in function of the value of the capacitor. By selecting input and output voltage the simulation is then checked for the output. The resultant graph shows the ripple as shown in the figure 9. Ripple occurs due to the incomplete suppression of the alternating waveform. Ripple current is undesirable and to make the rectifier more effective, its value should be smallest. The ripple factor of half wave rectifier is about 1.21.

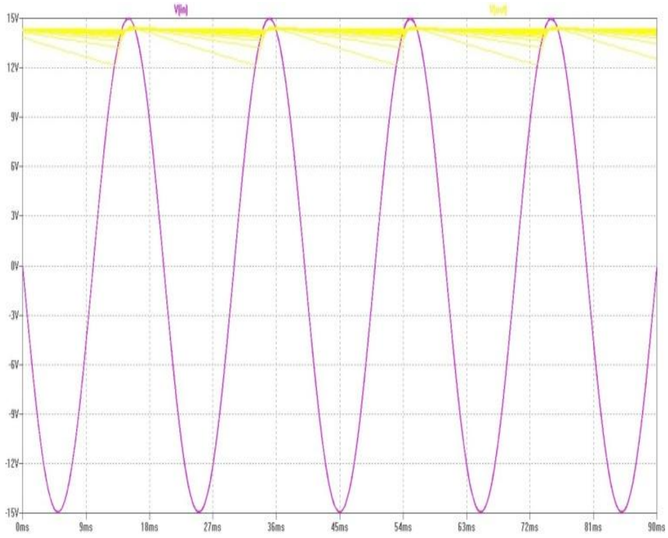

Figure 9: Ripple

Now the spice error log is selected from the view tab. From the error log the desired value of ripple ratio can be selected to plot. When the trace is added, the graph is formed as shown in figure 10 which shows the ripple ratio.

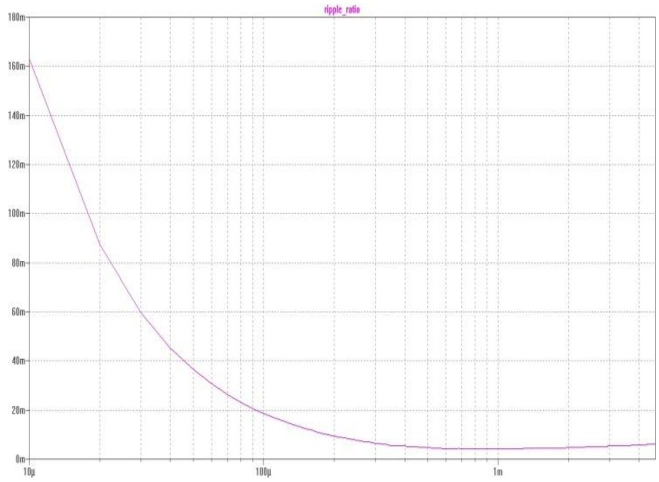

Figure 10: Ripple ratio

III. RESULT

On simulating the half wave rectifier at 15V AC input the output DC is received. The effects on output have been seen by changing the value of load and capacitor. It has been found that proper value of filter capacitor should be selected to reduce the ripples. Since the maximum obtainable efficiency from a half wave rectifier is only 40.6%, hence its application is limited for use in small power supplies only.

IV. CONCLUSION

In this research the response and performance of a half wave rectifier circuit with a single capacitor filter has been calculated at various aspects. Since the power is delivered only during one half cycle of the input alternating voltage, the rectification efficiency becomes quite low. Further the transformer losses and power dissipation in the rectifier reduces the efficiency. The simulation results shows that half wave rectifier produce more ripple, hence efficient filtering is required to eliminate the harmonics of the AC frequency from the output. It has been found that when the capacitor value is increased, better and pure DC is achieved. The selection of proper capacitor value does a significant role in determining the average DC level and ripples. Half wave rectifier can be used in non critical applications like battery charging, detection or basic power supply.

REFERENCES

[1]. Johannes Max Schaefer. Rectifier circuits theory and design, Wiley, 2007.
[2]. Arthur Williams, Fred Taylor. Electronic Filter Design Handbook, McGraw-Hill, 2006.
[3]. Salivahanan. Electronic Devices and Circuits, Tata McGraw Hill, 2008.
[4]. William H. Hayt, Jack E. Kemmerly. Engineering Circuit Analysis. McGraw-Hill, 2006.
[5]. Linear Technology website http://www.linear.com.
[6]. Gilles Brocard. The LTSpice IV Simulator Manual, Methods and Applications, Swiridoff Verlag, 2013.
[7]. R. M. Marston. Passive and Discrete Circuits, Newnes, 2008.
[8]. Cletus J. Kaiser . The Capacitor Handbook A Comprehensive Guide For Correct Component Selection In All Circuit Applications. C J Publishing, 2 edition, 2011.

BIOGRAPHY

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