Analysis of Full Bridge Rectifier with Filter Capacitor

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Abstract— Presently a day's utilization of dc-dc convertor expands step by step. Dc supply is important as a contribution to this convertor. So by and large full bridge rectifier is utilized. It changes over alternating current supply into direct current. At the yield of the full bridge rectifier we get pulsating dc supply implies it isn't pure dc like straight line. So to make it pure dc we have to utilize filter circuit. It might be L-C filter or just capacitor channel.

Keywords: Full Bridge Rectifier, L-C Filter

I. INTRODUCTION

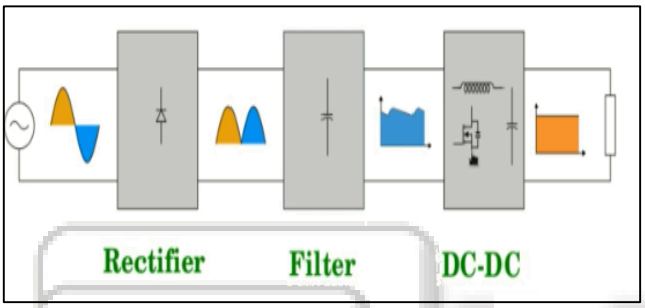

Fig. 1.1: "Block Diagram" [4]

Generally full bridge rectifier is used with filter capacitor. This configuration has some disadvantages like low power factor & it draws peaky current. On the other side it has an advantage of less component, low cost, compact & high volumetric efficiency. Here input supply is connected to full bridge rectifier, input current before the rectifier is vector sum of diode currents. Means that I= I_{d1} + I_{d4} in positive half cycle & I= I_{d2} +I_{d3} in negative half cycle. There might be a small amount of decrease in current at the output of full bridge rectifier. This happens because of diode. It consumes minor current. Output of full bridge rectifier contains some ripple. Now capacitor is connected across the load resistance so again current has two paths to flow, one through capacitor another through load resistor. Output current of Rectifier I_r = I_{avg} + I_{ac}. I_{avg} will flow into load and I ac which doesn't have average current, flow through capacitor.

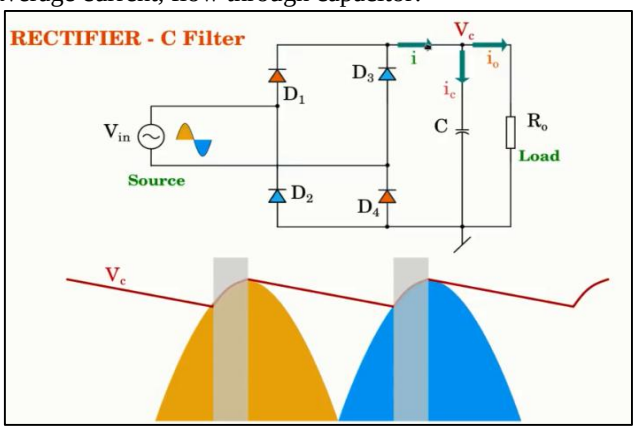

Fig. 1.2: "Circuit Diagram & Capacitor Voltage" [4]

steady state capacitor can handle pure ac current. There should not be average current flow into capacitor otherwise charge will build up in it and creates problem. Upon starting the current will flow through capacitor because capacitor act as a short circuits. When it fully charged up means gain potential, then current will flow through load resistor. So here capacitor gets charged & discharged.

II. EXPLANATION

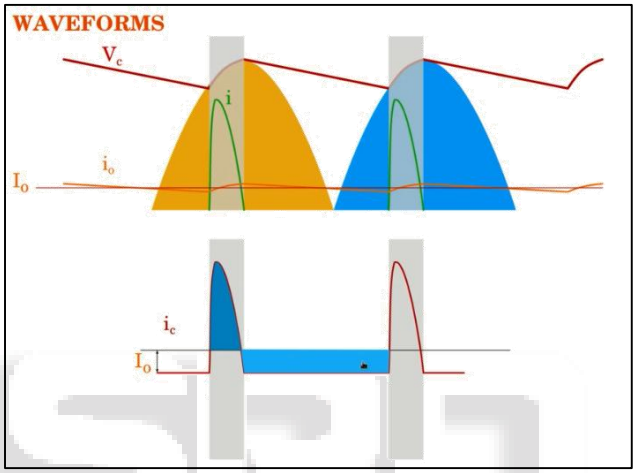

Fig. 2.1: "Waveform of Diode & Capacitor current" [4]

At the peak of waveform, capacitor has a maximum voltage Vm1 indicates that it's fully charged up. After that it decreases linearly for some time means it's discharging into load resistance. During discharging, input voltage is less than capacitor voltage Vm2but there is no current flowing from capacitor to source because diodes are in reverse bias condition. Consider this energy loss given to load. From graph we can define time for this process (π-α). value of capacitor we can find by energy equation 1/2CV2.

$$\text{Duty Ratio} = \frac{\text{Turn on Time}}{\text{Total Time}} = \frac{\pi-\alpha}{\pi}$$

$$\frac{1}{2}CVm1^2 - \frac{1}{2}CVm2^2 = \left(\frac{\pi-\alpha}{\pi}\right)Po\frac{T}{2}$$

$$\frac{1}{2}C\,(Vm1^2 - Vm2^2) = \left(\frac{\pi-\alpha}{\pi}\right)\frac{Po}{2f}$$

$$C\left(\frac{Vm1+Vm2}{2}\right)(Vm1-Vm2) = \left(\frac{\pi-\alpha}{\pi}\right)\frac{Po}{2f}$$

$$Vo = \frac{Vm1+Vm2}{2} \qquad \Delta Vr = Vm1 - Vm2$$

$$\text{So} \qquad C * Vo * \Delta Vr = \left(\frac{\pi-\alpha}{\pi}\right)\frac{Vo*Io}{2f}$$

$$C = \left(\frac{\pi-\alpha}{\pi}\right)\frac{Io}{2f*\Delta Vr}$$

Io is the value of load current, Capacitor value should be sufficient to particular load current. ΔVr indicates ripple voltage. It should be as small as possible and to decrease this value of capacitor needs to be increased. Generally capacitor value is taken as three times as it is found by above equation. E.g. if capacitor value is 10μf capacitor from above equation then we have to take 30μf.

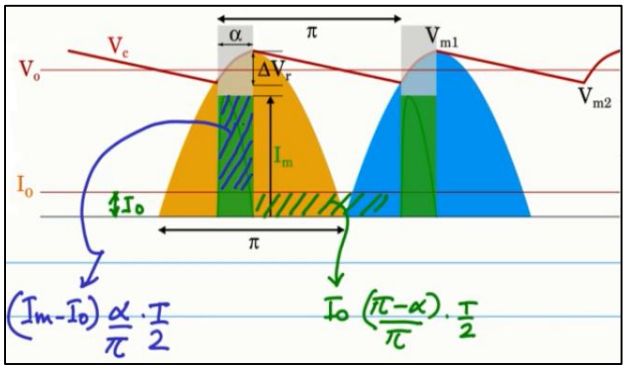

Fig. 2.2: "Waveform of Diode & Capacitor current"[4]

$Vm2 = Vm1 \cos\alpha$

$\alpha = \cos -1\ (Vm2 \div Vm1)$

$Vm1 = Vrms * \sqrt{2}$

$Vm2 = Vm1 - \Delta Vr$

$$Icrms = \sqrt{(Im - Io)^2 \ \frac{\alpha}{\pi} + Io^2 \ \left(\frac{\pi-\alpha}{\pi}\right)}$$

Voltage rating of capacitor = $Vrms * \sqrt{2}\ (1 +- \frac{\%Tol}{100})$

Diode rating:-

$PIV = Vrms / \sqrt{2}(1 +- \frac{\%Tol}{100})$

$Idavg = Im * (\alpha / 2\pi)$ here diode current repeats after two cycle.

$Idmax = Im$

This process will continue until the next peak occurs when input voltage is higher than capacitor voltage. During charging, current flows through diode so it is limited by diode itself until and unless we put any series resistance to prevent high capacitor charging (initial) current. This high starting current sometimes called current surge. Sometimes if turn on occurs after zero crossing, then capacitor is completely discharged so it has a zero voltage and supply has already some voltage greater than zero. This potential difference is very large, so very high current will flow.it may damage the diodes. It is necessary to prevent this current surge. Some series resistance is used to prevent this initial current surge

III. FUTURE SCOPE

Rs is used to limit the starting current for an instance when switch is not on at t=0 sec or nonzero crossing. But it creates some amount of power loss.one possibility is that remove Rs after capacitor build up the charge but it is not practical solution. We can replace Rs resistor with Thermistor. It has a negative temperature co-efficient means as the temperature increases resistance value will become low.

Let's take cold value of thermistor is 10 ohm which limits current and charge the capacitor. During this process resistance gets heated up so its value will become 0.5 ohm. So it will not affect the normal current flowing through the circuit. Approximately 5 to 10 msec time require decreasing in value of resistance.

In between if supply gets cut off then thermistor will not come to its initial value quickly and supply comes back again before it comes to its initial 10 ohm value then again there will be large current flow. There is another two possible ways to prevent the surge current. One is we can put switch across Rs and turn it on & off using relay mechanism. Second is Surge limiter using MOFET.

IV. SIMULATION AND RESULT

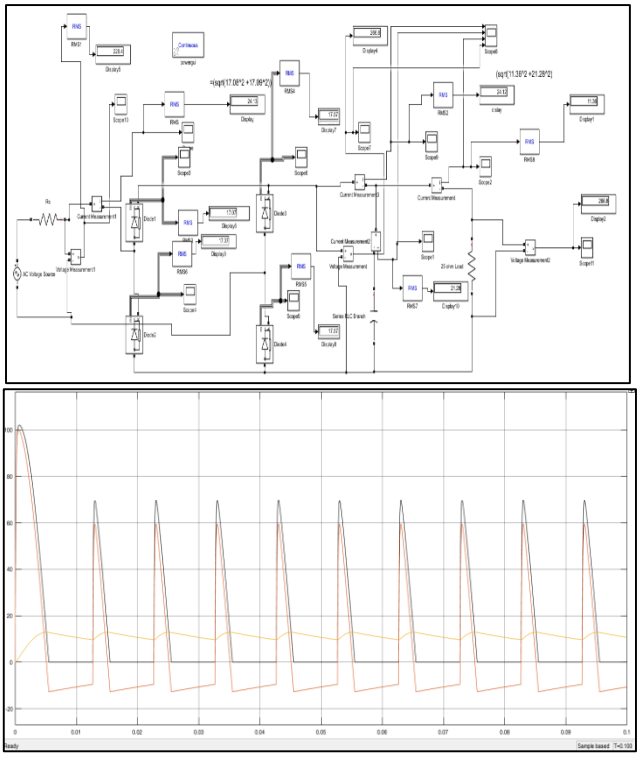

Fig. 4.1: Matlab simulation Circuit and result of Current Waveform

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REFERENCES

[1] Jesus Doval-Gandoy, Carlos Castro, and Moises C. Martínez, "Line Input AC-to-DC Conversion and Filter Capacitor", IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 39, NO. 4, JULY/AUGUST 2003

[2] Sudeep Pyakuryal, Mohammad Matin, "Filter Design for AC to DC Converter", International Refereed Journal of Engineering and Science (IRJES) ISSN (Online) 2319-

183X, (Print) 2319-1821 Volume 2, Issue 6 (June 2013), PP. 42-49

[3] Kun Zhao, "Rectifier capacitor filter stress analysis when subject to regular voltage fluctuations", University of Wollongong, kz664@uowmail.edu.au Phil Ciufo University of Wollongong, ciufo@uow.edu.au Sarath Perera University of Wollongong, sarath@uow.edu.au

[4] NPTEL Online Courses Design & Simulation of DC-DC Converters using open source tools https://nptel.ac.in/courses/117108124/

[5] Intan Shafinaz Abd. Razak, Raja Intan Zarina, Raja Zaki Hashim and Shahril Nizam Mohamed Soid, "A Design of Single Phase Bridge Full-wave Rectifier" , Electrical Engineering Department,Polytechnic Tuanku Sultanah Bahiyah, Kulim Hi-Tech Park, Malaysia b Kedah Mechanical Section, Universiti Kuala Lumpur Malaysian Spanish Institute, Kulim Hi-Tech Park, 09000 Kulim, Kedah, MalaysiaConference paper – September 2016 ResearchGate

