Behavior of the Nature of Load Applied to Resonant Circuit

Prachi D. Mohite * and Dr. C. S. Thorat **
*P.E.S College Of Engineering, Aurangabad
prachi272010@gmail.com
** Government Polytechnic, Nagpur

Abstract: Switched mode converters are inherently sensitive and can interface with the equipment sharing the same supply lines. As seen from simple topologies with respect to input current signal nature can be smoothing or pulsating. A resonant circuit must be inserted between the supply output and the converter input. Sometimes the circuit will be reactive. The problem comes from the nature of the load applied to the circuit output and the converter input.
The paper will closely analyze this problem for the RLC topology and its response to load.

Keywords: circuit, damping, oscillation, resonant.

Introduction

There are many topologies available for resonant circuits. In this paper we are studying only one topology that is RLC topology. The advantages and disadvantages of using the circuit are revealed from the paper. In the study we are connecting the negative impedance load on the RLC side output to study its effects with the help of analytical method followed by the software simulation which proves the result.

Proposed work of this Research paper

RLC circuit is a close loop converter input resistance looks negative. We need to connect a low insertion loss circuit we probably choose a circuit made up of L and C elements rather than a circuit made of R and C elements. The RLC network combination forms a resonating tank.
The work is carried on the RLC circuit with its effects to load. The load taken for study purpose is the negative resistance shown by the current source and voltage source or Zout (output impedance). It supports the study of negative resistance shown by the closed loop system of the converter. The converter presents a negative input resistance which can can cancel the resonant circuit damping factor. To avoid such situation damping elements such as RLC components must be installed to calm possible oscillations.

Input RLC circuit

The input RLC circuits are the R, L and C values. In the following paper the insertion of RLC input circuit importance is shown. It shows the Zout excibited by the RLC circuit and the peaking effects of it and shown in figure 6.

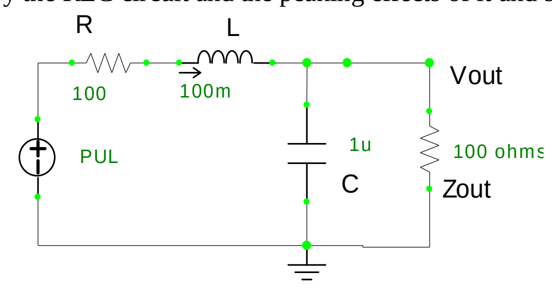

Figure 1 The RLC circuit inserted in series with the input line

The study is carried with the help of analytical method and software simulation method.

Analytical method

Analysing the load effect problem if in the close loop system the system tries to maintain the constant power . This can be seen when the system is modulate the V_{in} grows and the current diminishes so as to maintain constant power output and while a decrease in V_{in} is associated with increase in I_{in}. This shows that the converter will act as a negative resistor and in case of open loop it is not so.

$$Pin = Pout = IinVin = IoutVout$$

Let us consider μ which is inverse of dc transfer ratio

$$\frac{Vin}{Vout} = \frac{Iout}{Iin} = \mu$$

The static input resistance of the converter

$$\frac{Vin}{Iin} = Rin$$

The incremental resistance is

$$Rin\ inc = dVin/dIin$$

$$Vin = \frac{Pin}{Iin}$$

$$Pin = Pout = Rload\ I^2\ out$$

$$\frac{dVin}{dIin} = \frac{d}{dIin}\frac{Rload\ I^2\ out}{\text{Iin}}$$

$$Rin.inc = -\frac{RloadI^2\ out}{Iin^2} = -Rload\mu^2$$

From the above equation R_{load} can represent another switching regulator, a simple resistor, or a linear regulator. So the equation becomes

$$Rin.inc = -\frac{Vout}{Iout}\mu^2$$

$$Rin.inc = -\frac{V2\ out}{Pout}\mu^2 \qquad \text{Equation 1}$$

Here the R_{load} shows how it is effected from the relations shown above. The load effects can be changed by applying damping in the circuit. In this paper we take the help of the topology of RLC circuit to illustrate it.
From the equation 1 the it implies the negative resistance of load which needs a low insertion loss circuit of L and C values. The RLC combination forms the resonating tank.

Damping the circuit

Linear regulators are quiet by nature (no switching elements) switch mode converters are inherently noisy. A filter must be placed in front of the regulator to reduce the harmonics content conducted over the power cord. However the filter resonates and its presence can conflict with the converter.This converter actually presents a negative input resistance which can cancel the filter damping factor. To avoid this situation damping elements such as RC components must be installed to calm possible oscillations.
To damp the circuit means to reduce the quality coefficient Q in such a way that the peaking no longer risk the stability. A good solution consists of inserting R_{damp} in parallel with the output load , this technique is called parallel damping. To avoid increasing the dc consumption a capacitor C_{damp} is placed in series with the R_{damp} and stops the dc component. Usually C_{damp} is choosen as C_{damp} =10 C1
The following table gives the values selected for circuit in RLC input.

Table 1 The values for the RLC circuit

Component	Values
c1.capacitance	1u
cdamp.capacitance	10u
l1.inductance	100u
r_r1.resistance	100m
r_r2.resistance	0.5
rdamp.resistance	9.52
PWl	150 volts

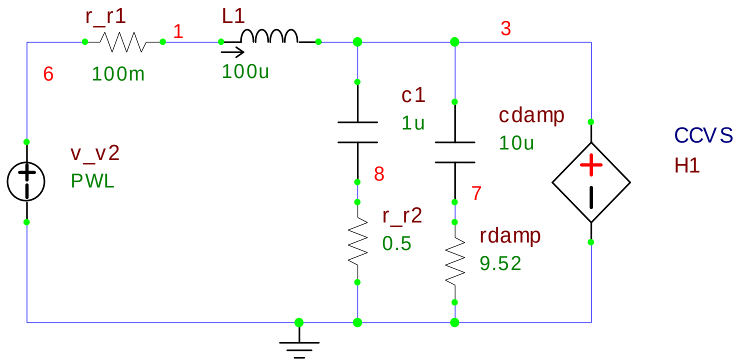

Figure 2. RLC circuit showing the insertion of R_{damp} and C_{damp} showing parallel damping

The input represents a rectified ac voltage moving from 150V down to 100V in successful steps. This situation can arise if a perturbation or a serve loading occurs on a distribution network. Unfortunately, the negative loading will affect the damping ratio, and oscillations will occur as shows. When we decrease the input voltage, the feedback loop adjusts the loading current which affects the damping factor. As long as stays positive, oscillations decay. However, for a null, oscillations are permanent. The situation becomes worse as becomes negative. A diverging situation takes place bound by clamping effects brought by protection elements. If no precaution is taken, a heavy smoke ends the oscillating process.

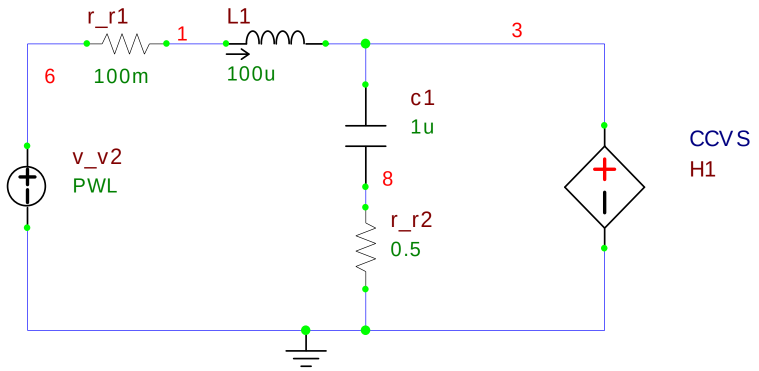

Figure 3 RLC circuit with no damping components

Software Simulation Results

The simulation results are obtained from the above circuit and it shows that no oscillations are there which is the result of damping the circuit the figure shows the signals of Vin followed by Vout. This perfect quantity is obtained by the selection of the values of Cdamp at 10u

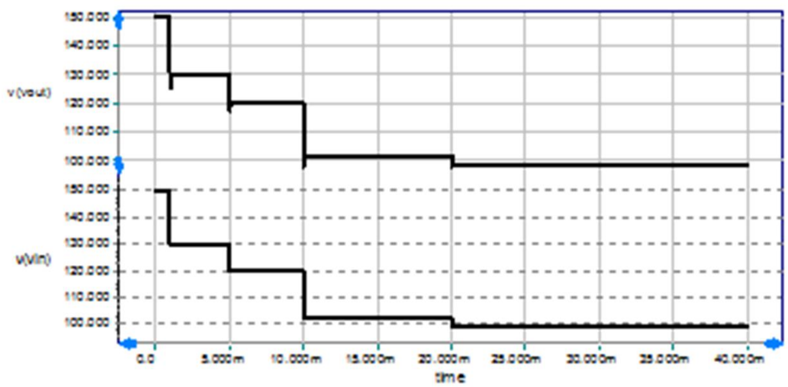

Figure 4 Simulation result showing the absence of oscillations

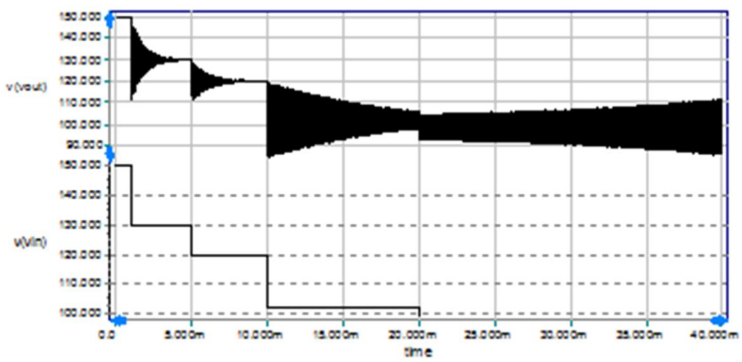

Figure 5 Simulation result showing the absence of damping components

Also it can be justified that the oscillation result in smoke if no damping is provided which is provided shown in figure 5. The figure 6 shows the values selected for Cdamp which removes the peaking effect and hence damping is taking place

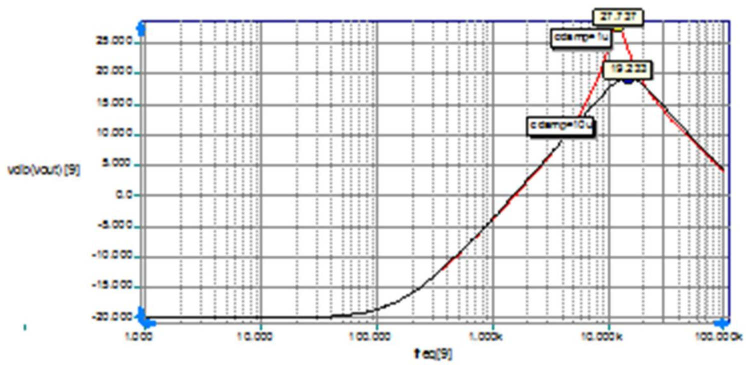

Figure 6 Variations of C_{damp} from minimum to maximum values

Experimental setup

The experimental circuit consists of the elements mentioned in circuit of figure 1. The values are taken from the simulation block and sweeped with the following values in table 2 which gives the observation result. From it it is seen that the out impedance value of -166 ohms gives steady state values and when it further applied with the cdamp and rdamp component it gives no oscillations and nullifying the peaking effect.

Table 2 Readings shown for RLC circuit

Sr.no	R_r1	R_r2	C1	L1	cdamp	Rdamp	Z out
1	100m	500m	1u	100u	0	0	-50
2	100m	500m	1u	100u	0	0	-166
3	100m	500m	1u	100u	0	0	-175
4	100m	500m	1u	100u	10u	9.52	-166

Conclusion

From the results confirms the absence of peaking. A damping capacitor of 10 times the original values can sometimes be unacceptably large. Also capacitor values down to four times the circuit is properly damped and instabilities are cured. From the behavior from the output also we see that the unwanted oscillations disappear.

Acknowledgment

I thank my Principal Dr.A.P.Wadekar of P.E.S College of Engineering, Aurangabad for valuable support. I also thank my Head of Department, Dr.B.N. Chaudhari of Electrical Department of P.E.S College of Engineering Aurangabad for providing me motivation and rendering help at every instance. I thank my colleagues at my research Centre of NIELIT Aurangabad for co-operating.

References

[1] R.Kielkowski, inside spice Mc Graw-Hill, 1998
[2] A Vladimirescu, The SPICE book, John Wiley and Sons, New York, 1993.
[3] R Pease, Analog Trouble shooting, Newness, 1991