

GUI FOR THE DESIGN OF RESONANT CONVERTERS

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Abstract

The paper deals with the design of power supplies based on resonant converter using Matlab GUI environment. The resonant converter is composed by LC components forming a resonant tank. The tool use basic equation for the design of resonant components for the variable topology of resonant converter. The window of GUI (Graphic User Interface) consist of the input selection for the input values (eg. Power, Input voltage, etc.) and output selection. Calculating of the different kind of resonant filter can be select in pop-up menu. Depending on the catalog values can be the resonant component values retroactively recalculated.

1 Introduction

In the 1980s, much research was focused on the use of resonant converters. The concept was to incorporate resonant tanks in the converters to create oscillatory (usually sinusoidal) voltage and/or current waveforms so that zero-voltage switching (ZVS) or zero-current switching (ZCS) conditions could be created for the power switches. Reduction of switching loss and continual improvement of power switches allow the switching frequency of the resonant converters to reach hundreds of kilohertz (typically 100 to 500 kHz). Consequently, the size of magnetic components can be reduced and the power density of the converters increased. Various forms of resonant converters have been proposed and developed.

New generations of soft-switched converters that combine the advantages of conventional PWM converters and resonant converters were developed. These soft-switched converters have switching waveforms similar to those of conventional PWM converters except that the rising and falling edges of the waveforms are “smoothed” with no transient spikes. Unlike the resonant converters, new soft-switched converters usually utilize the resonance in a controlled manner. Resonance is allowed to occur just before and during the turn-on and turnoff processes so as to create ZVS and ZCS conditions. After the switching loss and stress have been reduced, soft-switched converters can be operated at the very high frequency (typically 500 kHz to a few megahertz). Soft-switching converters also provide an effective solution to suppress EMI and have been applied to dc-dc, ac-dc and dc-ac converters.

2 Resonant converter

Many applications when load has to be supplied from HF transformer with stiff harmonic voltage due to synchronization, constant frequency, and precise phase control. It can be provided by different type of converters.

One method for taking advantage of the oscillations caused by an LC circuit for reducing the switching losses in a dc-dc converter. The basic division of resonant circuits is to parallel and serial connection of the accumulation elements. The multi-resonant converters is the combination of the parallel and serial connections of the resonant circuits. The resonant components design of the multi-resonant converter can be simplified using MATLAB software. One of the novel types of converters are LCLCL converter based on LLC resonant scheme, and LCTL inverter consists of DC/DC buck converter, LCLC resonant filter and HF transformer. The HF transformer can also be connected after the LCLC filter, if necessary. The converter is usually used as power supply for either HV rectifiers or HF cycloconverters or matrix converters, for motor- or constant frequency applications.



Figure 1: Block diagram of the resonant converter

In case of demand of the harmonic sinusoidal voltage for critical load, the resonant converter supposes to be use. The resonant components are tuned to basic harmonic. The resonant filter can be supplied by either single-phase voltage inverter in full- or half- bridge connection. The resonant frequency of resonant components should be the same as basic fundamental frequency of the converter. So, based on Thomson relation

$$\omega_{res} = \sqrt{\frac{1}{L_1 C_1}} = \sqrt{\frac{1}{L_2 C_2}} \quad (1)$$

or, respectively

$$\rightarrow L_1 \omega_{res} = \frac{1}{\omega_{res} C_1} = L_2 \omega_{res} = \frac{1}{\omega_{res} C_2} \quad (2)$$

where ω_{res} is equal $2\pi x$ fundamental frequency of the converter.

3 GUI application for the design of variable topology

The graphic user interface (GUI) is a part of the MATLAB software package. The GUI I a graphical display in one or more windows containing controls, called components that enable a user to perform interactive tasks. The user of the GUI does not have to create a script or type commands at the command line to accomplish the tasks. Unlike coding programs to accomplish tasks, the user of a GUI need not understand the details of how the tasks are performed. The components can include menus, tool bars, push buttons, radio buttons, list boxes, and sliders—just to name a few. GUIs created using MATLAB tools can also perform any type of computation, read and write data files, communicate with other GUIs, and display data as tables or as plots.

Based on the basic equations for design of variant topologies of the resonant converter has been created the GUI application. The window of application (Fig. 2) includes input part, part of output calculations and graphic part with waveforms. The input part (Fig. 3a) contains required values to obtaining the resonant components values. Choosing the type and size of the load is possible as well (Fig. 3b). The load may be purely inductive (L) or purely resistant (R) or the combination of RL . It is depend of requirements of the converter. In the pop-up menu can be selected the physical units of the entered values. Last part of the input values is quality factor ($q_{1,2}$). Default value of $q_{1,2}$ is 1 but number is possible to edit as is design required.

After entering the input values and selecting the chosen resonant converter topology (LLC, LCLC, LCL2C2) and by pressing button "Calculate" program displays the values of resonant components. The program does not include the catalog values of capacitors. Therefore, is necessary to find correct catalog values and then is program retrospective capable to recalculate the values of the inductor depend of catalog value of capacitor. The quality factor ($q_{1,2}$) will be recalculated as well. The two different topologies cannot be selected in same time.

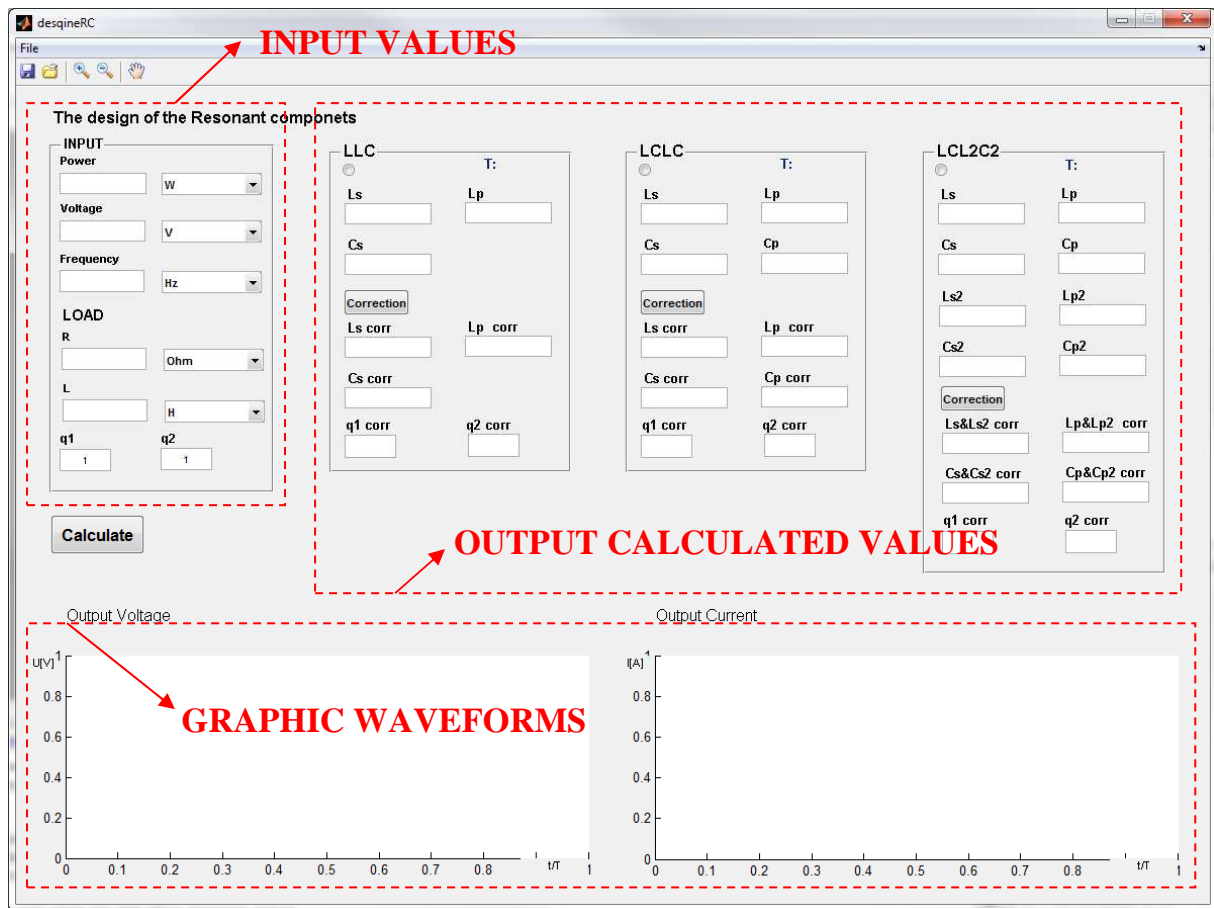


Figure 2: The window of GUI

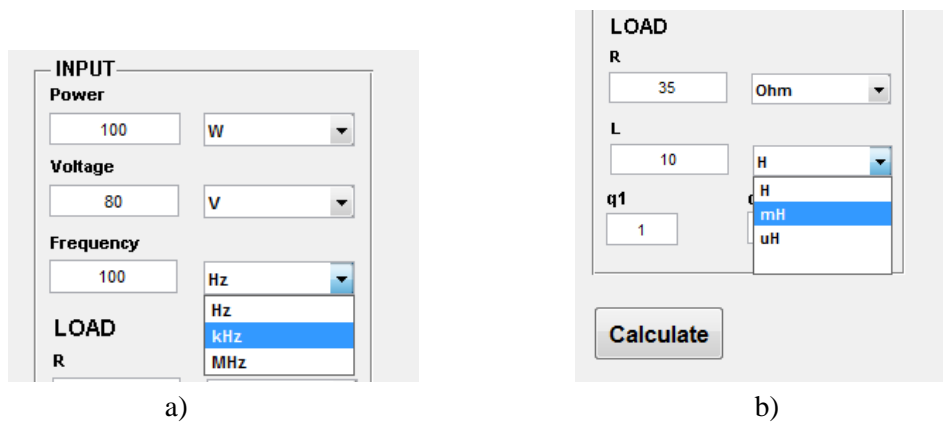


Figure 3: a) input part, b) type and size of load

After entering input data GUI displays the values of the resonant components before chosen topology. Following fig. shows print screen of calculation of LCLC resonant components.

The design of the Resonant componets

INPUT		LLC		LCLC		LCL2C2	
Power	100 W	T:		T:		T:	
Voltage	80 V	Ls	Lp	Ls	Lp	Ls	Lp
Frequency	100 kHz	Cs		Cs	Cp	Cs	Cp
LOAD		Correction		Correction		Correction	
R	35 Ohm	Ls corr	Lp corr	Ls corr	Lp corr	Ls2	Lp2
L	10 mH	Cs corr		Cs corr	Cp corr	Cs2	Cp2
q1	1	q1 corr	q2 corr	q1 corr	q2 corr	Correction	
q2	1			q1 corr	q2 corr	Ls&Ls2 corr	Lp&Lp2 corr
						Cs&Cs2 corr	Cp&Cp2 corr
						q1 corr	q2 corr

Calculate

Figure 4: Calculation of chosen topology

So, graphic waveforms will be:

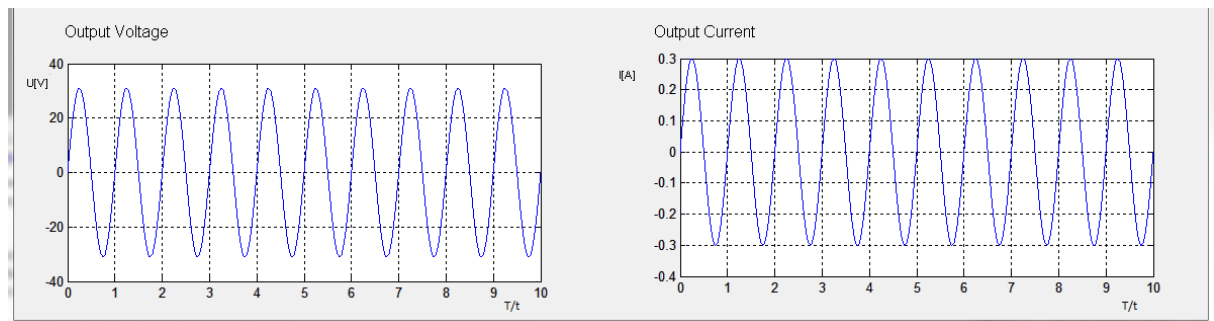


Figure 5: Waveforms of output voltage and current in the steady state

If are the resonant parts designed correct the output voltage and current will be smoothed sinus. Otherwise the non-smoothed waveform(s) will displayed. Depend of output load the phase shift of the current can be obtained. As a verification of the designed topology and componets is possible to create schematic circuit in MATLAB Simulink. The chosen topologies has been simulated in Simulink environment and following figure show results.

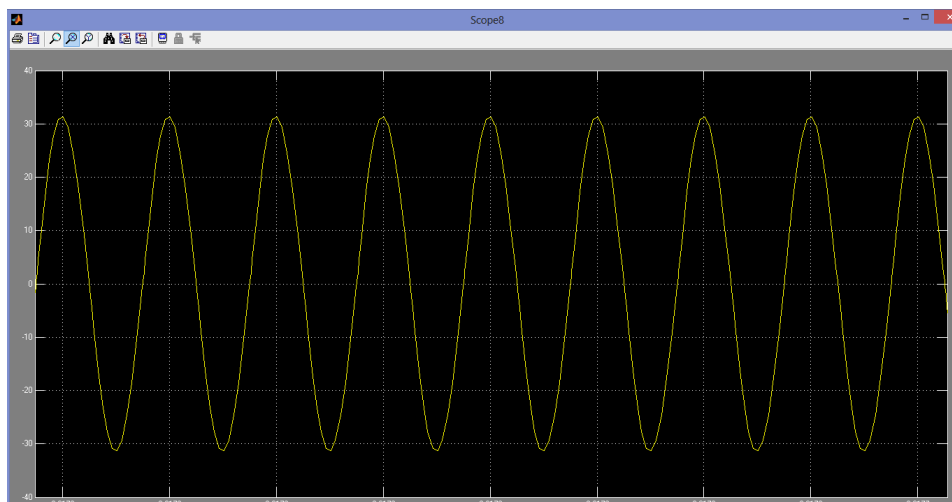


Figure 6: Output voltage (Simulink simulation)

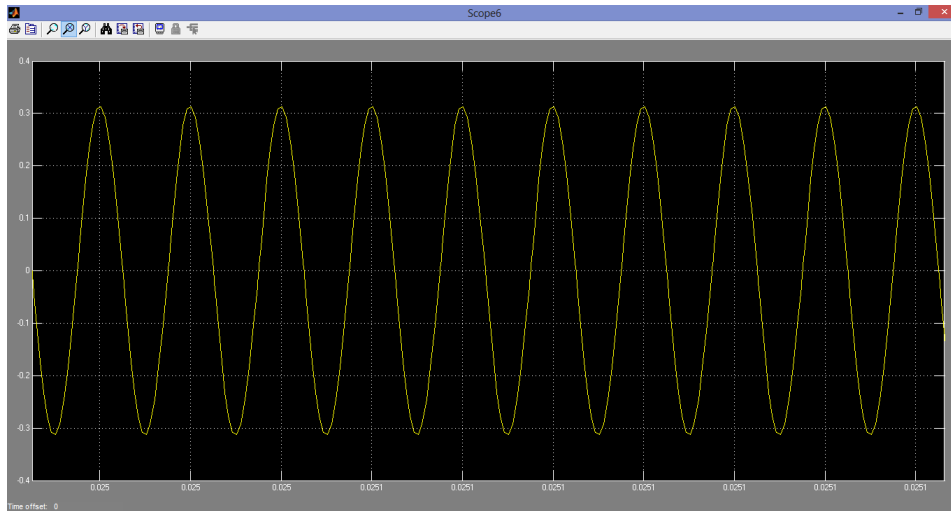


Figure 6: Output current (Simulink simulation)

From the fig. 5 and 6 is visible that the simulation results correspond with the GUI outputs.

4 Conclusion

In the paper has been presented universal application for the design of variable topologies of resonant converters. The paper does not include detailed design of presented topologies. The results of the designed components has been compared with the simulation results. As show figures 5 and 6 the results are same in both examples. The application will be used for simplifying design of resonant components and can be extensioned. The software offer many possibilities and tool-boxes to create sophisticated graphic user interfaces for variety of the applications. The GUI package as a part of MATLAB software can be used for many similar applications like was presented in the paper.

References

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