Modelling and Optimization of DC/DC Converter for Supplying of LED Lighting

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***Abstract*—In this paper a mathematical modeling and optimization of the DC-DC converters are realized. Two different topologies Cuk and Zeta with their particularity are presented. The mathematical model and optimization are realized in MATLAB/Simulink environment.**

Keywords—DC-DC converter, LED lighting, modelling, optimization

I. INTRODUCTION

Generally, the usage of the power electronic DC-DC converter for supplying of LED lighting has significant importance. In the most cases for supplying of the lighting of smart home are used renewable energy sources such as photovoltaic panel, wind power generators and others. Due to this reason the design of the DC-DC converters is one of the major problem in this field.

In this paper the proposed solution for supplying LED lighting are presented two DC-DC converter – Cuk and Zeta. This types of converter has duality operation principle of buck-boost converter. It provides the controlled output voltage with respect to the general terminal of the input voltage. The capacitor is used for transfer the energy from input to output and also for storage.

For design of this type of converter is used standard methodology [1]. Optimal solution for determination of the accurate values of the components in the scheme is proposed in this paper. Likewise, the usage of this type of numerical optimization significantly decrease time for settlement of the transient process in the scheme.

II. MATHEMATICAL MODELLING OF CUK AND ZETA CONVERTER

A. Cuk converter

In Fig. 1. a schematic of examined Cuk converter is presented.

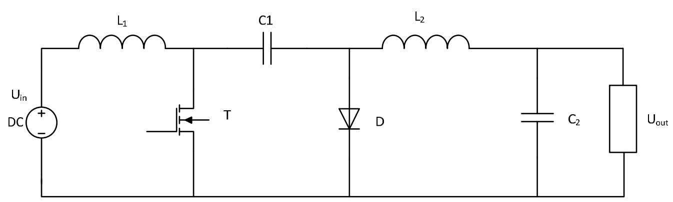

Fig. 1. Cuk converter

The mathematical model realized with the differential equations which describes the operation modes of the converter is presented in Figure 2.

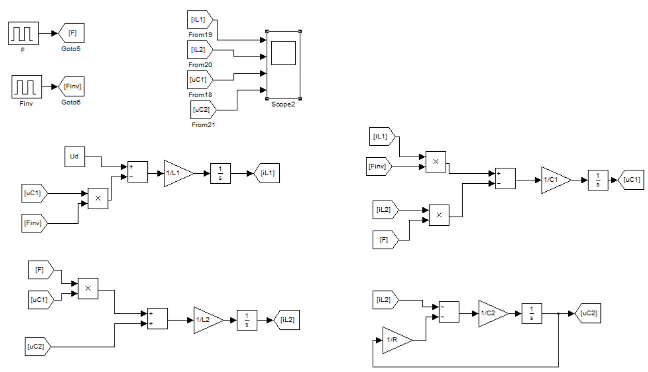

Fig. 2. Cuk converter in MATLAB/Simulink

On the base of this model is realized numerical optimization of the components of the scheme in MATLAB/Simulink. The initial values of these elements are selected after standard design and then adjusted with numerical optimization.

In order to avoid adding an additional "soft start" system. It is formulate the following optimization problem. Limiting the starting current in the load by optimizing the selection of L_1, L_2, C_1, C_2 and at the same time preventing large pulsations of the load voltage in the steady state. For this purpose, an appropriate reference trajectory is selected $i_{L1,ref}$.

The purpose is to minimize the functionality:

$$I(C_f) = \int_0^{t_{end}} \left(i_{L1} - i_{L1,ref}\right)^2 dt \underset{L1}{\rightarrow} \min \tag{1}$$

with two inequality-type constraints

$$\begin{aligned} i_{\min} - i_{L1} \le 0 \\ i_{L1} - i_{\max} \le 0 \end{aligned} \tag{2}$$

The mathematical model described by equations was developed in the MATLAB/Simulink using the switching functions the F and F_{inv}. Figure 3 shows the mathematical model implemented in MATLAB / Simulink. To optimize the proposed model, the tool "Constraint" is used. It is applied a

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numerical optimization procedure. Restrictions on the values of the elements L_1, L_2, C_1, C_2 have been added in it and their optimization has been realized.

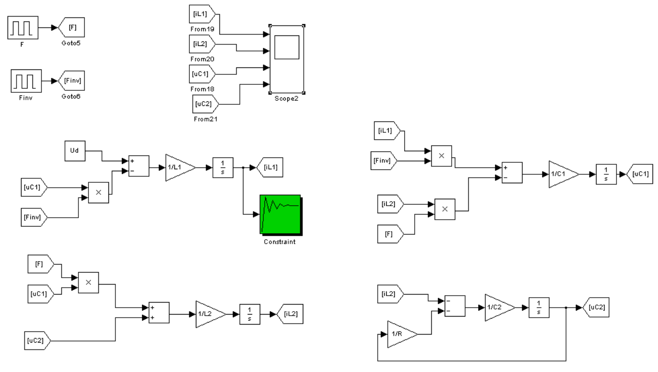

Fig. 3. Mathematical model with optimization

TABLE I. PARAMETERS

Parameters	Values
Input voltage	10[V]
Inductance L_1	100[µH]
Inductance L_2	100[µH]
Capacitance C_1	2.2[µF]
Capacitance C_2	100[µF]
Load	10[Ω]
Switching frequency	200[KHz]

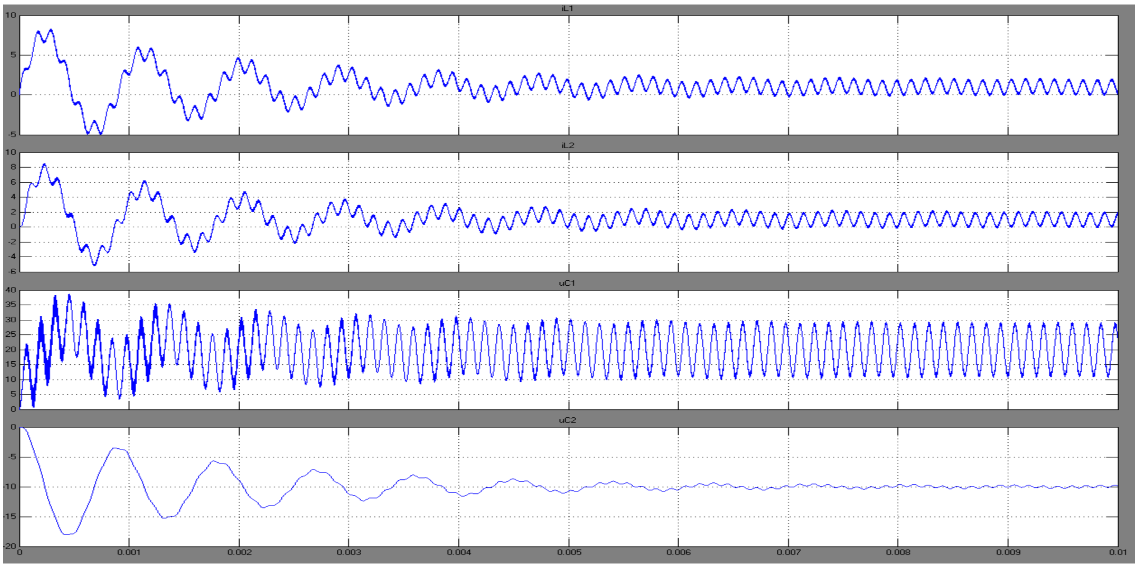

Fig. 4 Simulation results without optimization

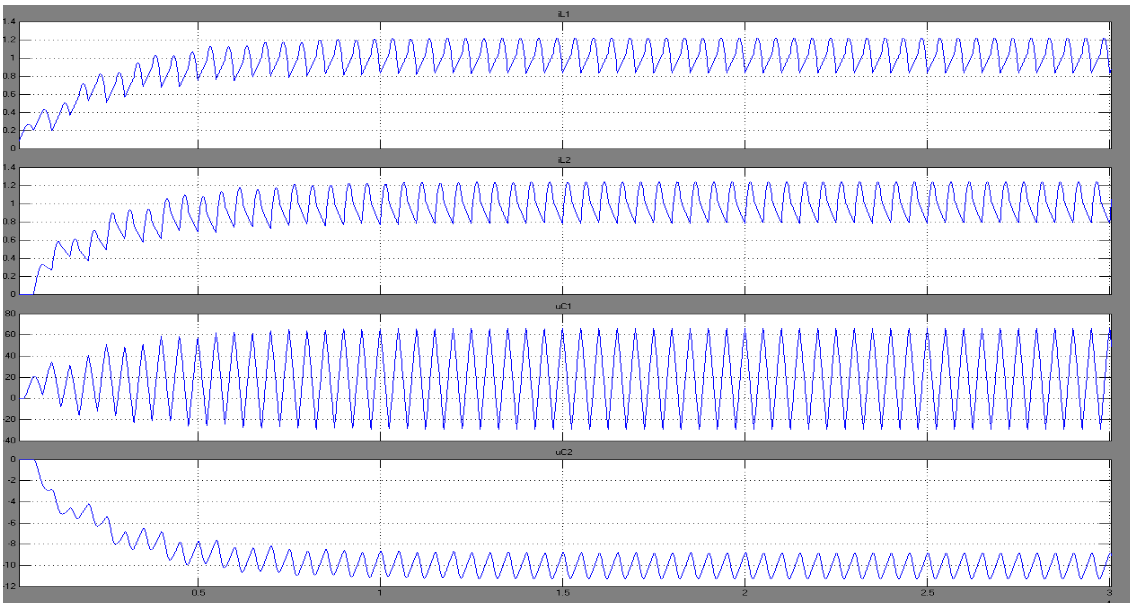

Fig. 5 Simulation results with optimization

B. Zeta converter

In Figure 6 a model of a Zeta DC-DC converter is presented. The mathematical model realized with differential equations in MATLAB/Simulink is proposed in Figure 7.

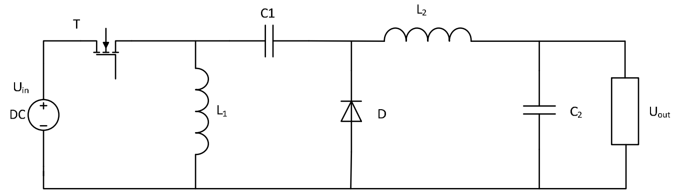

Fig.6. Zeta converter

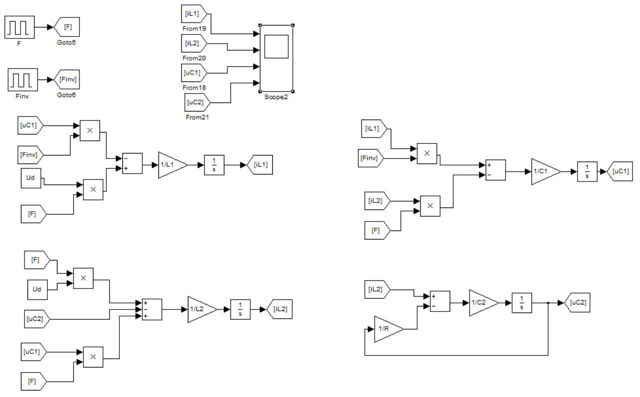

Fig.7. Zeta converter in MATLAB/Simulink

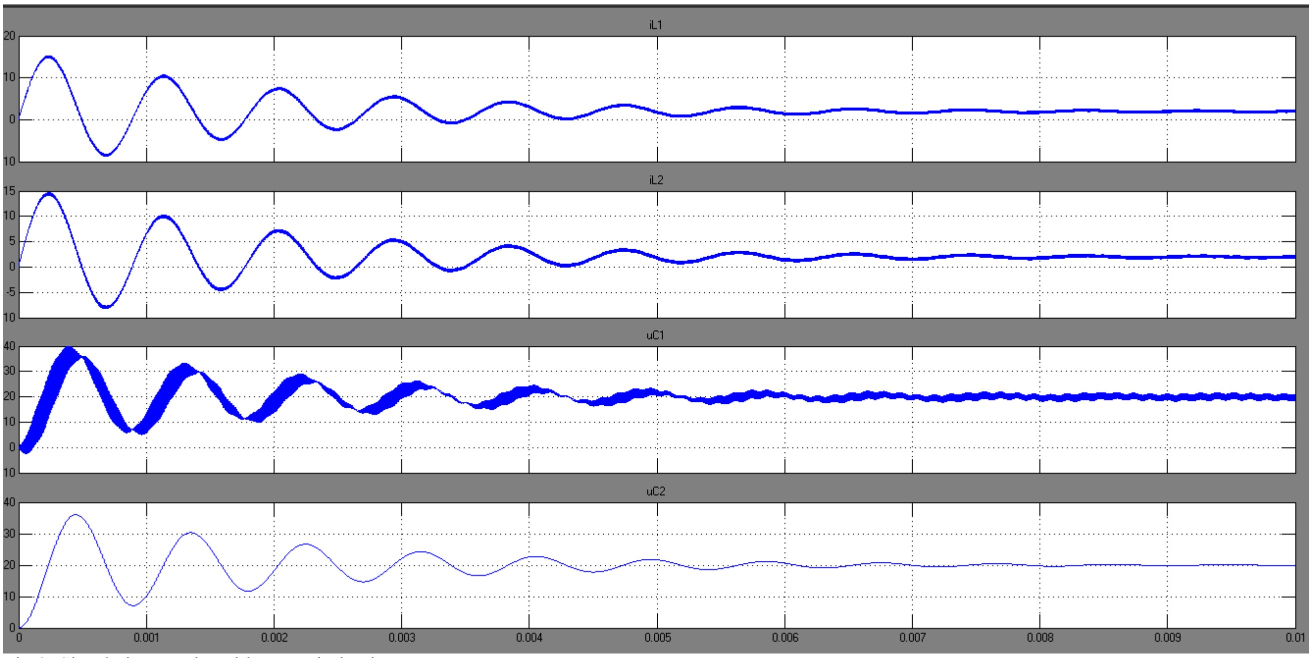

Fig.8. Simulation results without optimization

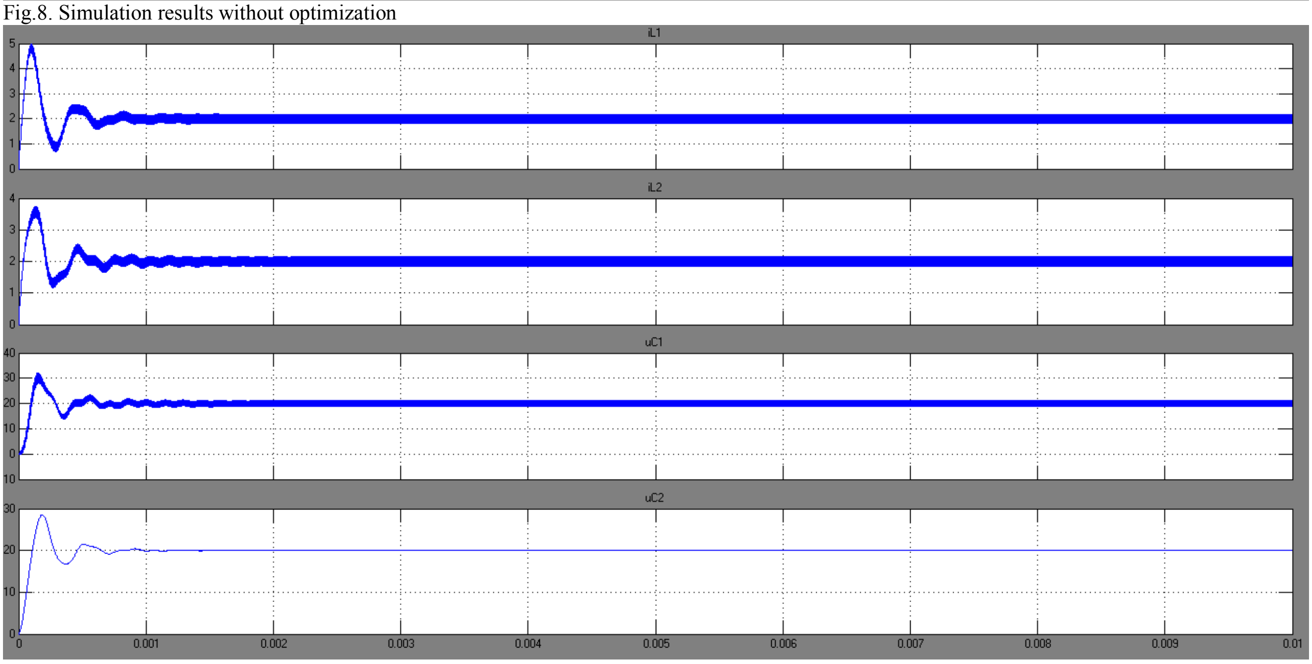

Fig.9. Simulation results with optimization

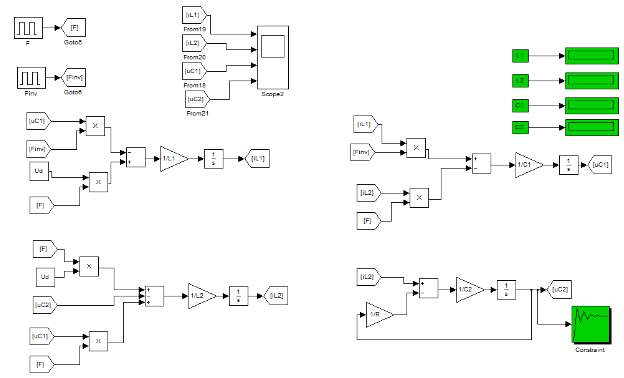

Fig.9. Mathematical model with optimization

III. Simulation Results

In Fig. 4 the simulation results of the realized model without optimization of the components is presented. It can be observed the curve of the current through the inductor L_1 and L_2.

In Fig. 5 the simulation results with optimization are presented. In this case the transient process significantly decrease according to the results from Fig. 4.

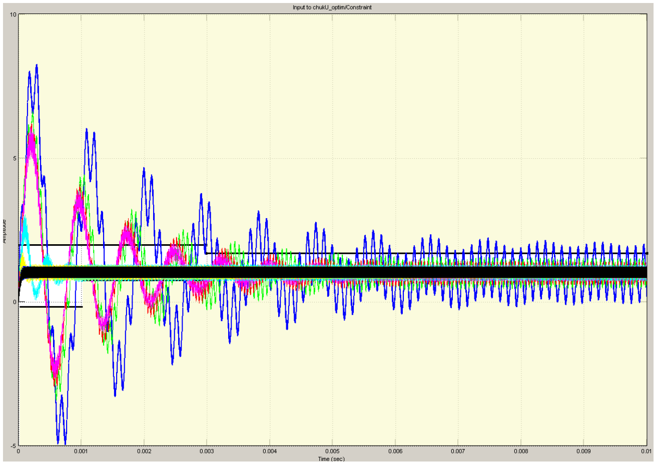

Fig. 10. Results from optimization

In Figure 8 and Figure 9 respectively are presented the simulation results without optimization and with optimization of the electronic components. In Figure 10 are presented the results from optimization process.

IV. Conclusion

In the presented study an optimization with different values was made. It can be observed that there is a significant improvement in the transient process which allows the usage of the DC-DC converter for LED lighting applications. Adjusting the dynamic process of the proposed system is the main advantage of this study, which allows optimizing the value of passive components such as capacitors and inductors.

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