

LABVIEW APPROACH IN MODELING DC-DC CONVERTERS

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Abstract

In a world, where the technology has an exponential growth, scientists are investigating in a much more complex way the DC-DC converters. When designing and modeling a device like is DC-DC converter, it is always most suitable to start with well known and designed converters like Buck and Boost converters. This is of great importance because LabView is visual programming oriented software, that works with Virtual Instruments and generates signals by our need, and by using this software we can test all the models that we have been worked before and see the similarity in the results.

This paper will investigate the response of the buck and boost converters, by testing them in software environment like LabView, make a comparison with previous tested results in other software. In advance, VI's will be created for using the models for other users in future that will work with similar problems.

Keywords: LabView, modeling, DC-DC converters.

INTRODUCTION

Before 30 years the mobile phones, electric cars, atm machines, heat converters and a lot of other electric devices didn't exist and all the electricity was flowing in well known way. These days, we have a lot more raised technology and to be more interesting, much more bigger problems in the field of the energy conversion than before. This is a little strange to say for lot of people that are doing their tasks every day and function normally. Let's prove what we have said. The whole industry of electric and hybrid cars are now trying to improve their battery range and battery health. Another moment is with our cellphones, that had evolved from ordinary phones, to smartphones and now our phone batteries lasts one or two days, also some of the models like "Samsung Note 7" didn't make it to the market because of the battery exploding problem. However, there are a lot of cases where the electric devices like DC-DC converters, should also evolve and go further in front of the needs of the nowadays technology.

EXPOSITION

In this paper three types of converters will be discussed. Buck, boost and buck-boost converter.

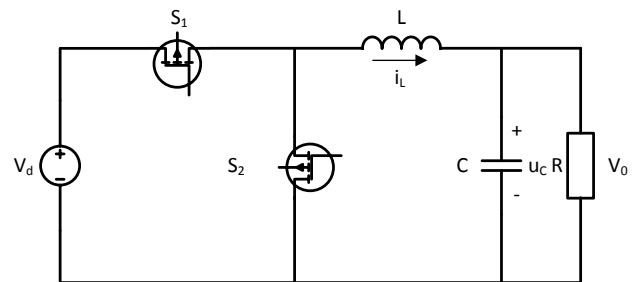


Fig. 1. Buck Converter

a. Buck Converter

On Figure 1 we can see how the buck converter works and from which components is combined. S_1 and S_2 are two semiconductor switches, the load R , filter capacitor C and filter inductance L . When working in continuous current mode, two states of the power circuit can be distinguished: first state – switch S_1 closed and S_2 open; second state – switch S_1 open and S_2 closed.

This is the most common used transformer in electronic devices. The following equation are relative to this transformer [1, 2, 3, 7, 8]:

$$\begin{cases} L \frac{di_L}{dt} = F.V_d - u_C \\ C \frac{du_C}{dt} = i_L - \frac{u_C}{R} \end{cases} \quad (1)$$

The state of the two transistors (on or off) is described using the switching function F [1,2].

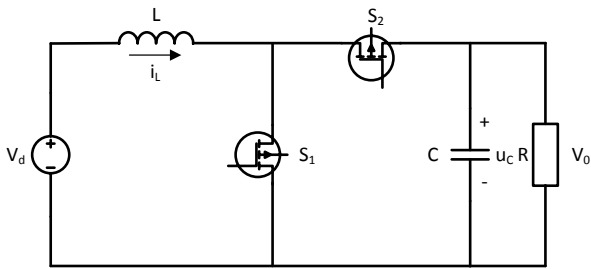


Fig. 2. Boost Converter

b. Boost Converter

On Figure 2 is presented the schema for the boost converter. Like the buck converter, the number of the elements from which is combined is with same number. When the S_1 switch is off, then the power is transferred from the power source. So, this converter is called inverse. From here, we can name this converter as an “reverse” converter and to maintain the main method of modeling, we will use the inverse function $F_{inv}=1-F$. We can mention the following system of equation for this converter [1, 2, 5, 6]:

$$\begin{cases} L \frac{di_L}{dt} = V_d - F_{inv} \cdot u_C \\ C \frac{du_C}{dt} = F_{inv} \cdot i_L - \frac{u_C}{R} \end{cases} \quad (2)$$

c. Buck-Boost Converter

On Figure 3 is presented the sheme for the buck-boost converter. This converter works in manner of that the input polarity is opposite from the output voltage and the power is transferred when the switch S_1 is off.

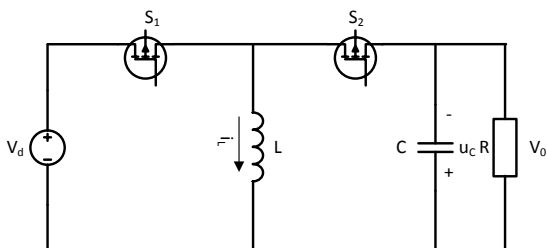


Fig. 3. Buck-Boost converter

The system of differential equations that this function generates are:

$$\begin{cases} L \frac{di_L}{dt} = F \cdot V_d - u_C \\ C \frac{du_C}{dt} = i_L - \frac{u_C}{R} \end{cases} \quad (3)$$

MODELING

Equation systems 1, 2, and 3 are implemented in the LabView visual programming environment. Fig. 4 shows the block diagram realizing the model of the buck transducer.

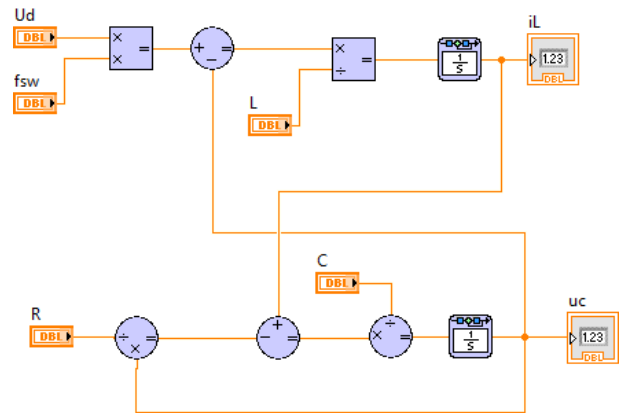


Fig. 4. Model of Buck converter in LabView

In an analogous manner, the following figures 5 and 6 show the realized models of the other two transformers – Boost and Buck-Boost.

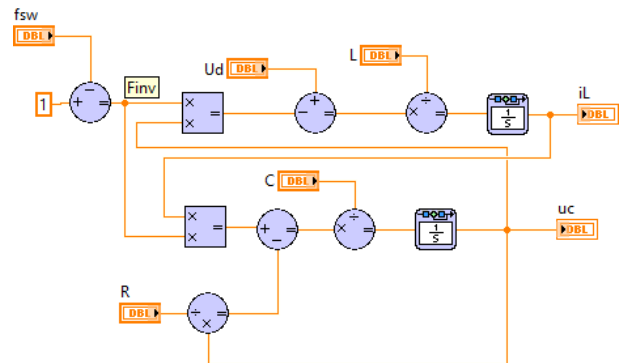


Fig. 5. Model of Boost converter in LabView

Simple mathematical operators who perform collection, multiplication, and integration are used for modeling purposes. To solve the equation systems, the numerical method of the Runge–Kutta is used.

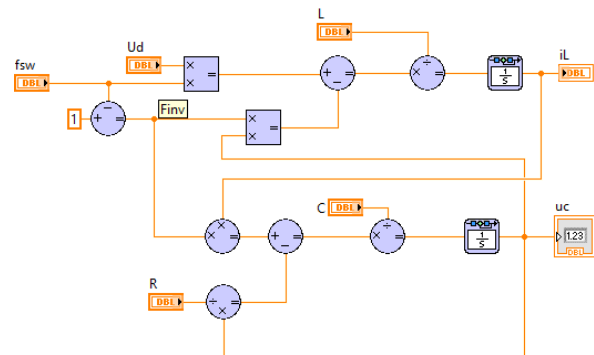


Fig. 6. Model of Buck-Boost converter in LabView

The switching function F is realized by means of a rectangular pulse generator. With it, besides the control frequency, the duty cycle D is also set.

RESULTS

Numerous experiments have been carried out with these models. To get a comparison and a community of results, the same circuit parameters are used: input voltage $V_d = 20V$; $L = 0.2mH$; $C = 10\mu F$; $R = 10\Omega$; switching frequency $100kHz$, $D = 0.5$.

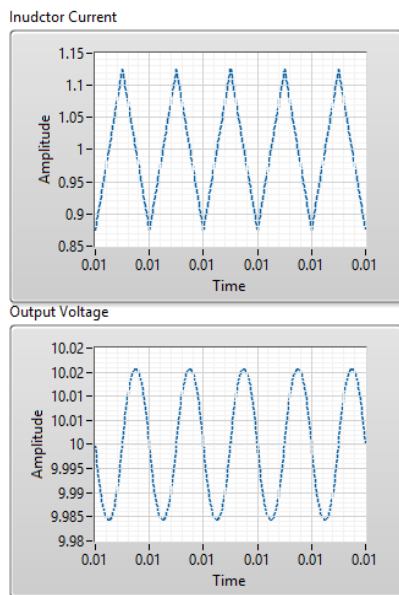


Fig. 7. Results from Buck converter in LabView

Figure 7 shows the results of a study-state operating mode of the Buck converter.

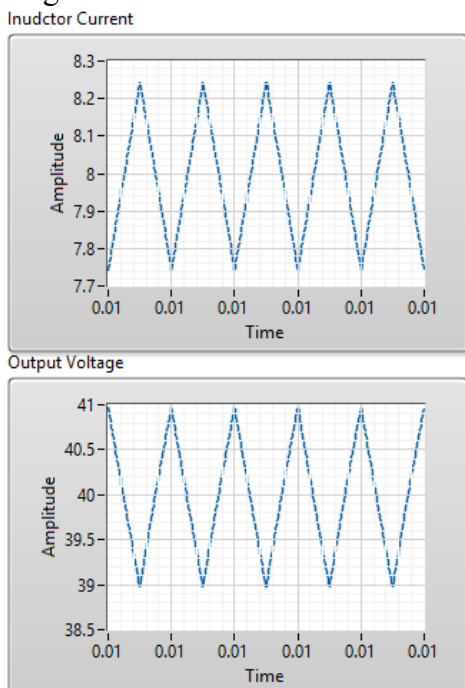


Fig. 8. Results from Boost converter in LabView

Figure 8 shows the results of a study-state operating mode of the Boost converter.

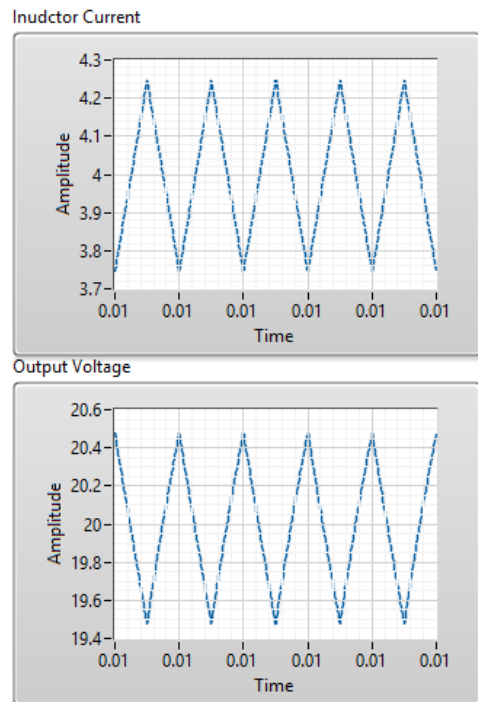


Fig. 9. Results from Buck-Boost in LabView

Similar results for the operation of the Buck-Boost converter are given in Figure 9.

From the analysis of the graphical results it can be concluded that the models are working and reliable because they have results that are the same as the theoretical extracts made in the specialized literature [2, 8, 9].

Another research task is to study the influence of the inductance value L on the type of transient processes and the dynamics of the base DC-DC converters. For example, this is done only for the Buck DC-DC converter, the results obtained being valid for the other schemes under consideration.

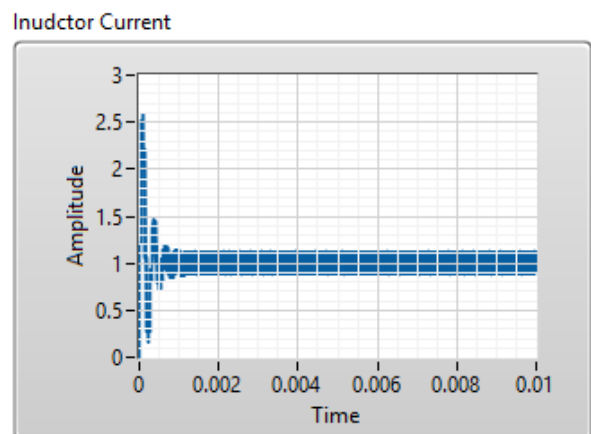


Fig. 10. Results from Buck converter $L=0.2mH$

Figure 10 shows the kind of transition process at the inductance value L used above. It is obvious that at this value of L there is a resonant transition process with little fading and long duration.

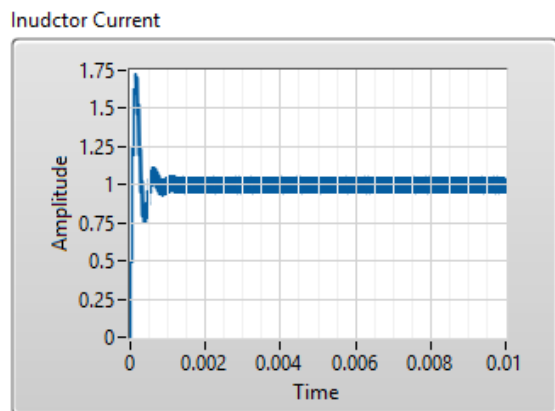


Fig. 11. Results from Buck converter $L=0.5mH$

Fig. 11 shows results with a higher inductance value. It is obvious that the nature of the transition process is retained, and its attenuation is less than that of the previous case.

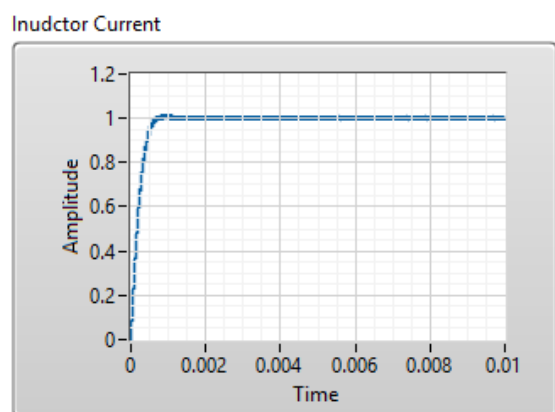


Fig. 12. Results from Buck converter $L=3mH$

Similarly, a series of numerical experiments were conducted to obtain an aperiodic transition process. These results are shown in Figure 12. Obviously, the duration of the transition process and hence the dynamics of the scheme are significantly better than the other cases considered.

CONCLUSION

The work deals with the modeling of basic circuits of DC-DC converters in the middle of the LabView. The models are verified using

theoretical calculations and experimental models.

With the developed models, studies have been conducted to determine the optimal value of inductance L so as to produce a transient start-up process with minimal duration and aperiodic shape. In this way a model based design of this type of circuit is realized, which is very suitable for use in the educational process.

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