ECE4055 Electrical Energy – Power Electronic Applications
Semester 2 – 2014

Laboratory Assignment – Simulation of Switching Converters

Introduction

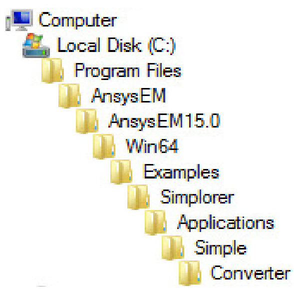
In this experiment, simulations will be carried out using the Simplorer simulation software. Exploration of the buck and boost converter topologies will be carried out, for both continuous and discontinuous conduction modes of operation. Students will be expected to verify correct operation of the converters under all conditions of operation.

A very useful resource for the use of this simulation software is the Simplorer *Getting Started Guide* (SimplorerGSG.pdf) which can be found within the Simplorer help system. For convenience, it is also posted on the ECE4055 Moodle site.

Buck converter operation

(i) Start by locating the pre-loaded set of converter model files and copy them into a working folder of your own. You will operate on the model files from your own working folder during the course of this experiment.

You can find the preloaded models in the *Converter* folder as below:



(ii) Start the Simplorer software.

(iii) Select the "Open an Existing Simulation Model" option

(iv) Make sure you are looking in the correct folder (the working folder you defined above).

(v) Select buck.asmp

Using this as a starting point, set up the buck converter simulation in compliance with the following parameters:

L = 50uH
C = 22uF
f_s = 50 kHz
R_L = 5 Ohm
D = 0.5
DC supply = 12 volt

Start with a total simulation interval of 1.0 msec

[Side note: you can also start the Simplorer software, running buck.asmp , by navigating to buck.asmp in your working folder using Windows Explorer, double-clicking on on the file, and this will automatically start Simplorer and load the buck converter model].

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(vi) Under these conditions, does the converter operate in continuous conduction mode (CCM), or discontinuous conduction mode (DCM). Demonstrate that your answer is sensible in relation to the theory – carry out the calculations to verify this.

(vii) What is the value of V_o under this operating condition, this make sense?

(viii) Predict the value of load resistance that would take the inductor current to the borderline between CCM and DCM. Verify this result by simulation.

(ix) Return the load resistance value to 5 Ohm; determine *analytically* the value of inductance that would result in the converter operating on the borderline between continuous and discontinuous conduction modes, with D = 0.5. Compare this with the simulated result. Consider using initial conditions in order to help your traces settle more quickly.

(x) Now replace the square wave controller (D = 0.5) with a PWM controller to allow operation of the converter at D values ranging from $0 \rightarrow 1$.

(xi) With conditions set as in part (vii) above, run the simulation at D = 0.2, and at D = 0.8 What happens, and why does it happen? Verify that the output voltages make sense in both cases. Can you use the relationship
$V_o = DV_i$
in both cases?

(xii) Is there a tendency for oscillation in the output? If so, what is the frequency of this oscillation, and where does it come from?

Boost converter Operation

(i) The procedure carried out above for the buck converter is now to be replicated for the boost converter.

(ii) Use the model boost.asmp as the starting point for your modeling.

(iii) As with the buck converter, carry out the duty cycle variation in order to explore the behaviour of the boost converter as it changes between CCM and DCM

Assessment

The work carried out in this laboratory is to be compiled into a complete set of results demonstrating the outcomes of each of the cases prescribed in the procedure, along with calculations verifying the behaviour of the converters as outlined in the above procedure. One report is to be submitted by each group.