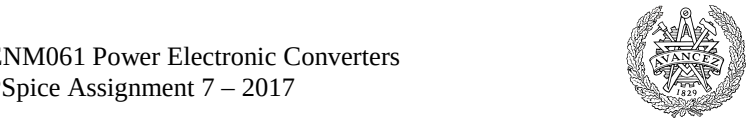
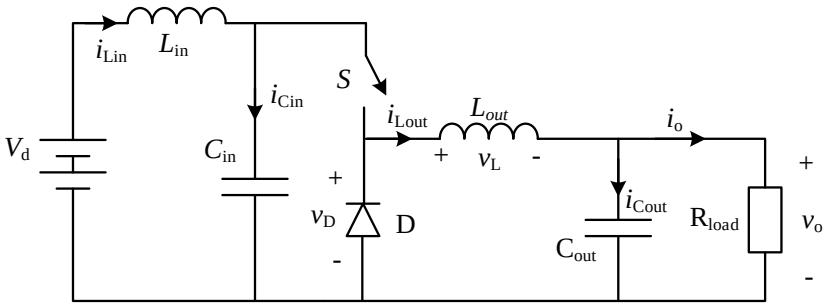


Assignment 7
Converter enhancements: Loss Analysis and control

The questions marked HA are home assignments to be completed before the laboratory starts.



Nominal values	
Source voltage (V_d)	15V
Output Inductance (L)	2.2μH
Output Capacitance (C)	150μF
Load Resistance (R_{load})	2Ω
Switching frequency	300kHz
Duty ratio (D)	0.667

Fig. 1. A buck converter with input (L_{in}, C_{in}) and output (L_{out}, C_{out}) filters.

Source files: *assignment_7a.opj*
assignment_7b.opj

Task/Questions:

HA 1: For the operating point above, sketch the currents through the input filter and the output filter (i_{Lin}, i_{Cin}, i_{Lout}, i_{Cout}). Assume that the current drawn from the source is a pure DC-current (L_{in} large).

1. Run the circuit with ideal components (*assignment_7a.opj - buck1*) and analyse the current through the input and output filter (i_{Lin}, i_{Cin}, i_{Lout}, i_{Cout}). Do the waveforms agree with the home assignments?
2. In the measurements, the losses for each component are calculated automatically (the table in the probe window). By adding a trace *W*, the losses in each component can be evaluated directly. Analyse the curve traces *W(S1)* and *W(d1)*, when do the losses occur? Comment on the losses in the switch (*S1*), the diode (*d1*), the capacitors (*Cin, Cout*) and the inductors (L_{in}, L_{out}). What is the total efficiency of the converter?

HA 2: Explain how to calculate the power dissipation in output capacitor for ESR of R_{ESR}.

3. Run the circuit with real component models (*assignment_7a.opj - buck2*). How will the losses change?

HA 3: If the current in a real inductor increases very high, what will happen to the inductance value?

4. Increase the switching frequency to 600kHz. What happened with the overall efficiency? Why? Compare the losses with the losses obtained in task 3.
5. Change the switching frequency back to 300kHz. Replace the ideal diode with the diode *diode_RR* from the library *pwr_elec*. Make sure that you change the name of the new diode to *d1* in order to keep the measurements. What happens with the current through the diode when it drops to zero? Compare the losses with the losses obtained in task 3.
6. Run the circuit with real component models and a synchronous switch (*assignment_7b.opj – buck4*). What do the resistances in the thermal network (*Rthcs* and *Rthsa*) represent? What are the resulting temperatures in the thermal network (*Tj*, *Tcase* and *Tsink*)?
7. Change the thermal resistance *Rthsa* to 53K/W. What are the resulting temperatures in the thermal network (*Tj*, *Tcase* and *Tsink*)? At t=5ms, there is an increase of the output current from the converter. What happens with the temperature in the component?
8. Run the circuit with a controller (*assignment_7b.opj - buck5*). What happens at t=1.2, 2 and 3 ms? How does the controller compensate for changes in the system?