Power Engineering Laboratory (MSc)

Buck Converter Lab – Dr. Paul Judge

Week 2

Welcome to the second week of the power electronics components of this module. This will involve a mixture of experimental work and simulation work using LTspice. You may wish to prioritise the experimental work during the allocated lab session and work on the LTSpice exercises in your own time outside of the lab.

Guidance on PowerPoint:

20% of the marks for the overall Buck Converter Lab are allocated to a PowerPoint which you will use to record your results. One joint PowerPoint should be submitted per group of students. This single PowerPoint covers both Week 2 & Week 3 of the lab and will be due on the 1st of November.

- The purpose of the PowerPoint is as an aid for you during the viva examination. It should be neatly presented and without massive amounts of text.
- You should also not use more than the number of slides allocated for each section in the PowerPoint.
- You should only include the results you think are the most interesting. I expect students to have varying results between groups and to not all have decided to include the same figures & graphs in each set of slides.
- In some of the later sections you will be asked to investigate a particular feature or phenomenon in the buck converter. In these sections it will be up to you as the student to decided what to include on the PowerPoint slides for these sections. You will get marks for things you discover and will not lose marks for missing things.
- Remember that during the viva you will be presenting your results on a laptop screen and not on a large projector – format your slides so that text and figures are readable under this format.
- Students may use a maximum of four slides at the very end of their presentation to present whatever material they like. It is suggested that you use this to present things you have discovered that fall outside the given exercises, or as additional slides for exercises where you feel that the allocated number of slides did not give you enough space. These slides are not mandatory.

Efficiency Measurements (45 Mins Target)

1. Set input power supply to 10 V and the converters output voltage to 3.3V. Using the 10 Ohm Rheostat record the power in, power out and efficiency of the Buck converter as you vary the output current in the range from 0.5 – 4 A. **(1 Slide)**
2. Compare the efficiency results you achieve experimentally with those you can measure using the LTSpice model of the converter **(1 Slide)**

3. Investigate how the switching frequency of the converter impacts the efficiency of the converter **(1 Slide).**
4. Investigate how the input to output voltage ratio impacts the converters efficiency **(1 Slide).**
5. Using LTSpice investigate how changing the gate resistor used with the MOSFETs would impact the converters efficiency. (**1 Slide**)
6. Using LTSpice Investigate the impact of the gate resistor on the switching performance of the MOSFETs (hint: measure the voltage across each MOSFET and the current flowing through each MOSFET) **(1 Slide)**
7. Move the 'SyncBuck' shunt pins on the board from the 'ON' position to the 'OFF' position. Make sure that the board is powered off when you do this. Investigate how and why this impacts the efficiency of the converter. **(2 Slides)**

Duty Cycle, Inductor Current Ripple and Capacitor Ripple Measurements (45 Mins Target)

For each of the following results you should compare your measurements against the theoretical curves you expect. You may perform these measurements with the 'SyncBuck' pins in the 'ON' position. It is up to students to decide what exact input and output voltage conditions tests are performed at.

1. Investigate the relationship between the input voltage, the output voltage, and the duty cycle when the converter is in continuous operation mode **(1 Slide).**
2. Investigate the relationship between the inductor current ripple magnitude and the 1) input to output voltage ratio, 2) the load current and the 3) the converters switching frequency, when the converter is operating in continuous mode. **(3 Slides)**
3. Investigate the relationship between the output capacitor ripple and: 1) the input voltage magnitude, 2) output current magnitude and the 3) converters switching frequency when the converter is operating in continuous mode. For measuring the capacitor voltage ripple you will need to set the coupling of the probe to 'AC'. This will filter out the dc component on the capacitor voltage ripple and allow you measure the capacitor ripple that is imposed on top. You should also note that the voltage measurement point 'Vout+' will be the sum of the capacitor voltage and the voltage across the Rsense resistor. You can use the math function on the oscilloscope to subtract the voltage across Rsense from the measurement (make sure the channel measuring this voltage is also in 'AC' coupling mode). **(3 Slides)**
4. The output capacitor can be switched between two values using the 'CapSelect' pins. Investigate if this switch in capacitor size has the impact you expect on the capacitor voltage ripple. **(1 Slide)**

Discontinuous Operation (30 Mins Target)

You should perform this section with the 'SyncBuck' pin the 'OFF' position. It is up to students to decide what exact input and output voltage conditions tests are performed at.

1. Using the 33 Ohm resistor bring the inductor current to the boundary condition. Keep increasing the load resistance and observe the converter waveforms. What do you observe, is anything different from the theoretical waveforms we examined in the notes? **(1 Slide)**
2. Investigate the relationship between the output current, the duty cycle and value of Δ as the converter is driven further into discontinuous mode. **(2 Slides).**

Exploration Questions (20 Mins Target)

Disconnect one of the probes from its BNC adapter (ask a T&D for help if you are unsure). You can use this probe as a rudimentary electric field probe by waving it over the PCB. Investigate where on the PCB you can detect the most radiated electric field. Try doing this when the converter is in both continuous and discontinuous modes. **(1 Slide)**

Compare the quality of the measurements you can achieve using the probe BNC adapter against using the probe tip with a ground lead (ask a T&D for help). What does this tell you about measurements in power electronic circuits? **(1 Slide)**

What happens to the converter when the input voltage goes beyond the specified 7-20V input **(1 Slide).**