Laboratory work: DC-DC Boost converter

In this laboratory work a boost DC-DC converter is built and tested.

Preparations

The following components are required to complete the laboratory work.

- Breadboard
- Jumper cables
- Signal generator or NI myDAQ
- Passive components: inductor, electrolytic capacitor and resistor
- Active components: MOSFET, diode and driver
- Voltage source
- Oscilloscope with voltage probe
- Current probe with current amplifier
- Multimeter with a diode testing function

Assembling the prototype converter

Circuit diagram of a boost converter is shown in Fig. 1.

The MOSFET requires a driver circuit to be able to switch between conducting and non-conducting mode. Moreover, the driver circuit takes the energy it requires from the input voltage source (pins Vdd and GND).

The function generator (or NI myDAQ device) is used to generate the switch control signal. Assemble the boost converter on the breadboard according to the circuit diagram. Double-check for short circuits and polarities of the components, especially the electrolytic capacitor and diode.

Checking diode polarity:

http://en-us.fluke.com/training/training-library/test-tools/digital-multimeters/how-to-test-diodes-using-a-digital-multimeter.html

Checking MOSFET pin order (Hint: MOSFET has internal body diode from source to drain.):

MOSFET datasheet attached

Checking MOSFET for faults (if required…)

https://www.utm.edu/staff/leeb/mostest.htm

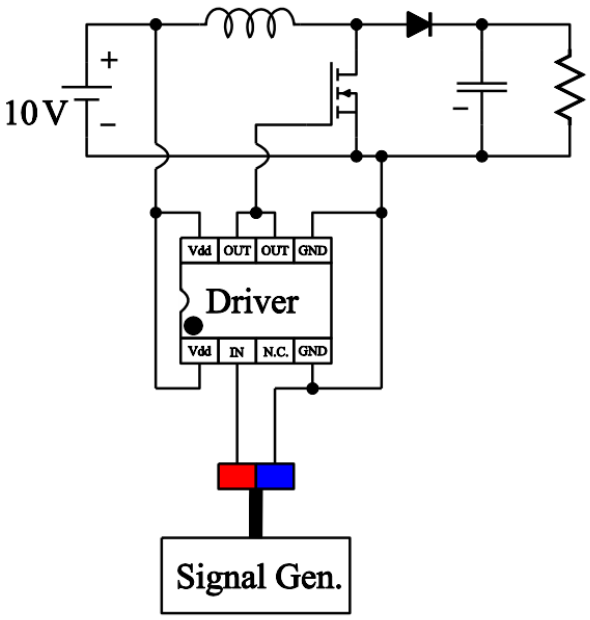

Fig. 1. Circuit diagram of a DC/DC converter **(AO0 from MyDAQ to Driver IN and AOGND to Driver GND)**

Some guidelines for assembling the prototype:

- Connections inside the breadboard are made according to Figure 2. It is suggested to use the red and blue terminals at the left side as source terminals and red and blue terminals on the right side as load terminals. I.e., the source voltage is connected to the left side and load resistor to the right side.

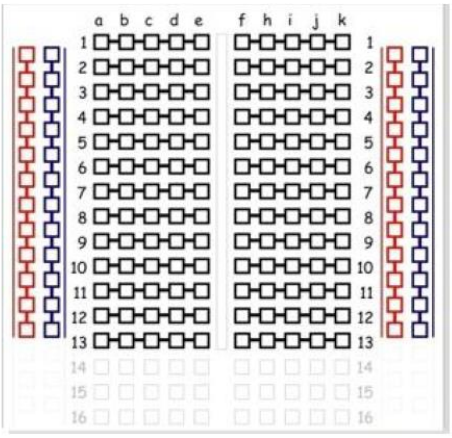

Fig. 2. Internal connections of the breadboard

- Connect the output terminals “OUT” of the driver circuit together by a short jumper as in Fig. 1. Otherwise the driver circuit won’t operate correctly. Check the attached datasheet of the driver circuit for correct pin numbers.
- Driver circuit fits best at the center of the breadboard as in Fig. 2.

- Read through the datasheet of the driver to identify the pin numbers and their functions. The type of the driver circuit is MCP1407. Connect the output terminals “OUT” of the driver circuit together by a short red jumper as in Fig. 3. Otherwise the driver circuit won’t operate correctly.
- Connect the driver circuit supply voltage pins and ground pins together using the green jumpers.
- Finally connect the driver supply voltage to the converter input terminals using the yellow and orange jumpers. Converter input terminals are marked by the red and blue terminals on the left side of the breadboard.

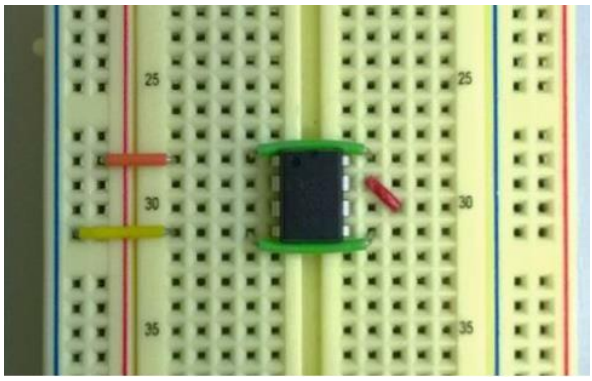

Fig. 3. Driver circuit with output pins shorted together and supply voltage connected

- Check the MOSFET datasheet for correct pin location for gate source and drain. Note that on the first page the MOSFET is viewed from the bottom side (the figure which indicates pin numbers). You can test the correct pin numbers using a multimeter in the “diode-testing mode”. The positive sensor of the multimeter (red) should be connected to the anode of the diode and the negative sensor to the cathode. The multimeter can be configured to diode-testing mode by rotating the selector switch as in Fig. 4 and by pressing the yellow button once. You should also use the multimeter to verify which terminal of the MOSFET is the source and which one is the drain. After all the converter won’t work if the MOSFET is placed in the circuit in a wrong way.

Fig. 5. Multimeter diode testing mode

- Try to implement the prototype to as small space as possible. You can cut legs of passive components to a desired length.

- Check the polarity of the electrolytic capacitor and diode before you connect them in the breadboard.
- Negative terminal of the capacitor is marked by '-' which should be connected to negative output terminal of the converter.
- Cathode of the diode is marked in the diode case and should be pointing toward the output capacitor
- Remember to connect also the load resistor.
- You may cut the component legs to a desired length to implement the converter in a smaller space.

Testing the prototype

Be careful while connecting the source to the breadboard not to cause short-circuit.

- Set the myDAQ device to generate a pulse waveform at the analog output 'AO0' with 40% duty ratio at 10 kHz. The amplitude of the pulse should be 5 V with a DC-offset of 2,5 V.
- Connect the voltage sensors of myDAQ to the output terminals of boost converter. Use the multimeter of myDAQ to measure the output voltage of the boost converter.
- Test the converter by connecting the battery to the input. The multimeter should give a value close to 12,5 volts.
- Do not test the converter with duty ratio higher than 95 % as you risk short-circuiting the source.

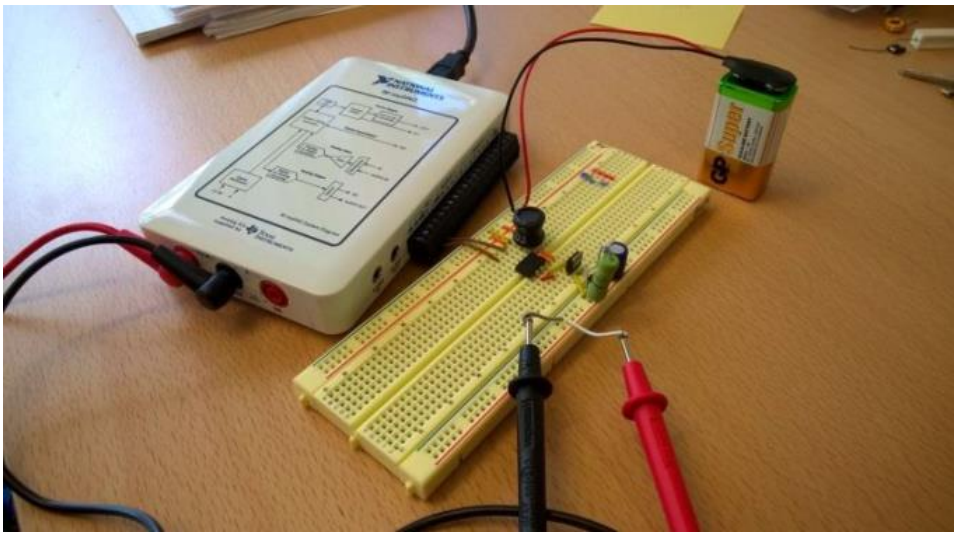

Fig. 6. Measurement setup

Measurements

- Determine the output voltage of the boost converter as a function of duty ratio. Vary the duty ratio from 10% to 95% with 5% resolution and take a note on the output voltage values using the multimeter.

- Try to listen if the converter makes any noise and take a note on the duty ratio values at which the noise is largest.

Laboratory report

Consider at least the following points and questions:

- Give a short description was done in the laboratory work.
- Attach the pictures to the final report.
- What is the conduction time of the diode in a switching ratio when the pulse is applied to the gate of the MOSFET?
- How does the conduction time of diode change if you increase the width of the pulse?
- Use MATLAB to plot the output voltage as a function of the duty ratio. Axes have to be labelled 'Duty ratio' and 'Output voltage (V)'. Plot the ideal output voltage of the boost converter in the same figure the source voltage (Vin=9V) and the same duty ratio values. Mark the two curves by using legends 'Measured' and'Ideal'. Scale the y-axis so that the figure is easy to read, e.g., between 5 and 35 volts.
- Use the figure to estimate maximum obtainable output voltage of the boost converter. Explain why the curve does not increase to infinity similarly as the ideal curve.

Useful commands in MATLAB for plotting data are collected below. You can find out more about these functions by typing, e.g., 'help plot' in the MATLAB command screen.

```
plot()

figure()

x=[0.1:0.05:0.95]

y1=[8 8.5 9 9.7 …]

y2=[8 8.8 9.5 10 …]

figure(1),plot(x,y1,x,y2) //plots two curves in figure 1

xlabel('Name')

ylabel('Name')

xlim([0 1])

ylim([0 10])

legend('curve1','curve2')
```