

CAMBRIDGE UNIVERSITY ENGINEERING DEPARTMENT

Part IIA Laboratory Report

3B3 DC-DC Converters

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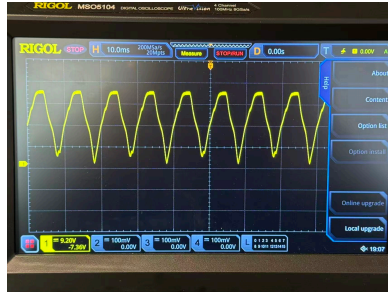
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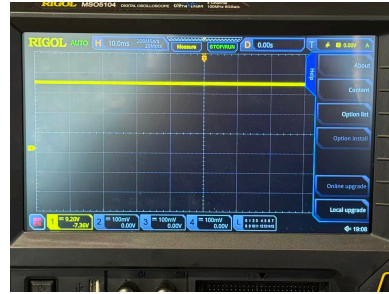
Date of Experiment: Nov 2025

Exercise 1: Diode Bridge AC-DC Rectifier

The scope readings for exercise 1 are shown by Figure 1.



(a) Reading of 1-2



(b) Reading of 1-3

Figure 1: Scope readings of Exercise 1

Exercise 2: DC-DC Buck Converter

The testing schematic of the DC-DC Buck Converter is shown by Figure 2.

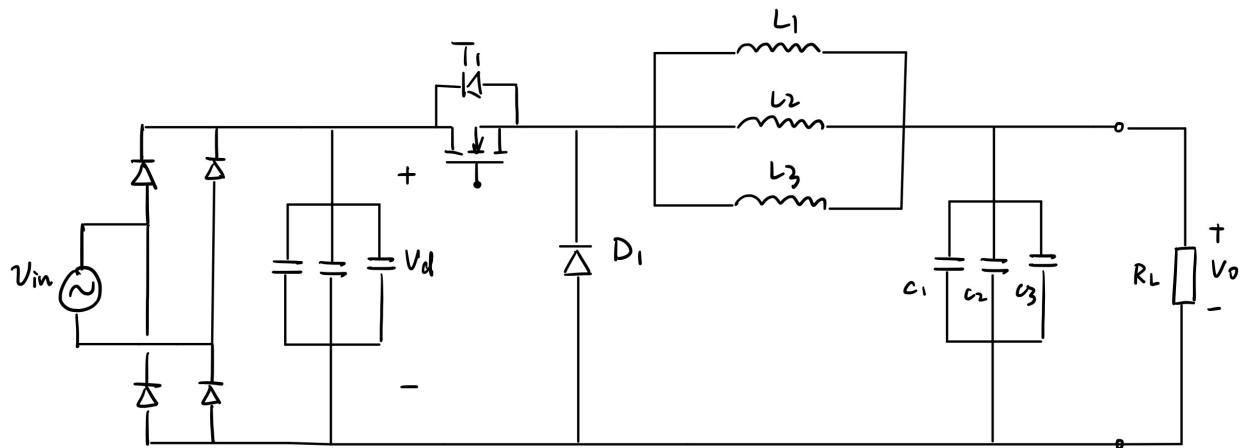


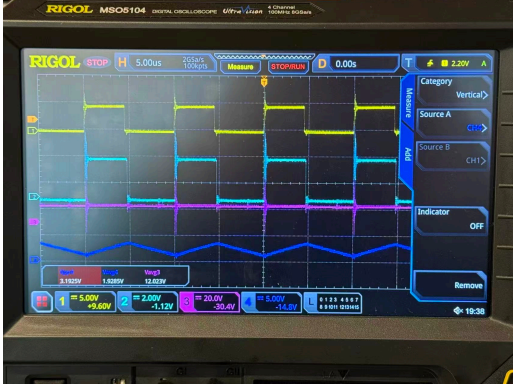
Figure 2: Schematic of DC-DC Buck Converter

The measurements are carried by four channels of the oscilloscope.

1. CH1: Gate pulse voltage v_G

2. CH2: Diode voltage v_D
3. CH3: Output DC voltage V_o
4. CH4: Inductor current i_L

Note that CH4 measures the current via a current probe and shows the reading in V on display.



(a) Reading with $V_o = 12V$



(b) Reading with $V_o = 18V$

Figure 3: Scope readings of section 2-2

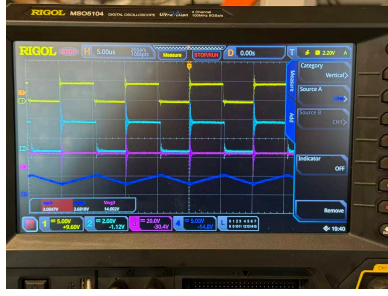
In Section 2-2, scope readings are taken with $V_o = 12V$ and $V_o = 18V$. Duty ratio $D = 0.45$ for $V_o = 12V$, $D = 0.68$ for $V_o = 18V$.

According to theory, the voltage transfer ratio of a buck converter $M(D) = \frac{V_o}{V_d} = D$. So, the theoretical values of the two measurements should be $\frac{12}{30} = 0.4$ and $\frac{18}{30} = 0.6$ respectively.

We can see that the measured duty ratios are about 10% larger than the theoretical values for both cases. This is due to non-ideal parts of circuits, mainly the extra voltage drop due to the diode and the parasitic resistance of the inductor.

Thus, for both ON and OFF states of the transistor, the DC output $= V_o - \Delta V$ is kept constant actually. $V_o = DV_d$ should be larger than theoretical value of compensate this effect. As result, duty ratio is measured to be larger.

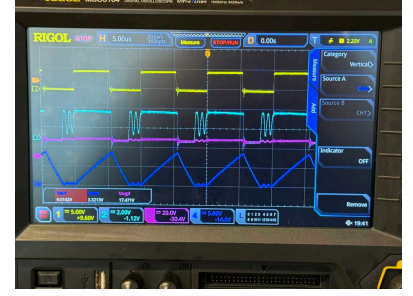
In the next session, load resistor and inductors are explored by switching more inductors on. The reading of scope is shown in Figure 4.



(a) Reading with L_3 ON



(b) Reading with L_3 and L_2 ON



(c) Reading with L_3 , L_2 , and L_1 ON

Figure 4: Scope readings of section 2-3

To find the load resistance $R_L = \frac{V_o}{I_o}$, output current I_o should be obtained from the readings of CH4, which measures the inductor current i_L . By making the assumption that the output smoothing capacitor is large enough that all ripple current goes into the capacitor, $I_o = i_{Lavg}$. This average value is obtained by the oscilloscope.

Exercise 3: DC-DC Boost Converter