Université libre de Bruxelles
Ecole Polytechnique de Bruxelles

MECA-H312 : Power Electronics - Practical Work sessions

Simulations :
Buck and Boost converters (ideal components)
Part 2

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Groupe 6

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MATLAB files and data

All MATLAB files and data are available on this group's GitHub page : `https://github.com/ArnaudSaison/Power_Electronics_ELEC-H312_groupe6/tree/main/SimBB-Buck%20and%20Boost%20converters`.

1. Buck (with ideal components)

1.4 Discontinuous conduction mode (DCM)

a) We set the resistance at 40 Ω which gives Figure 1.1.

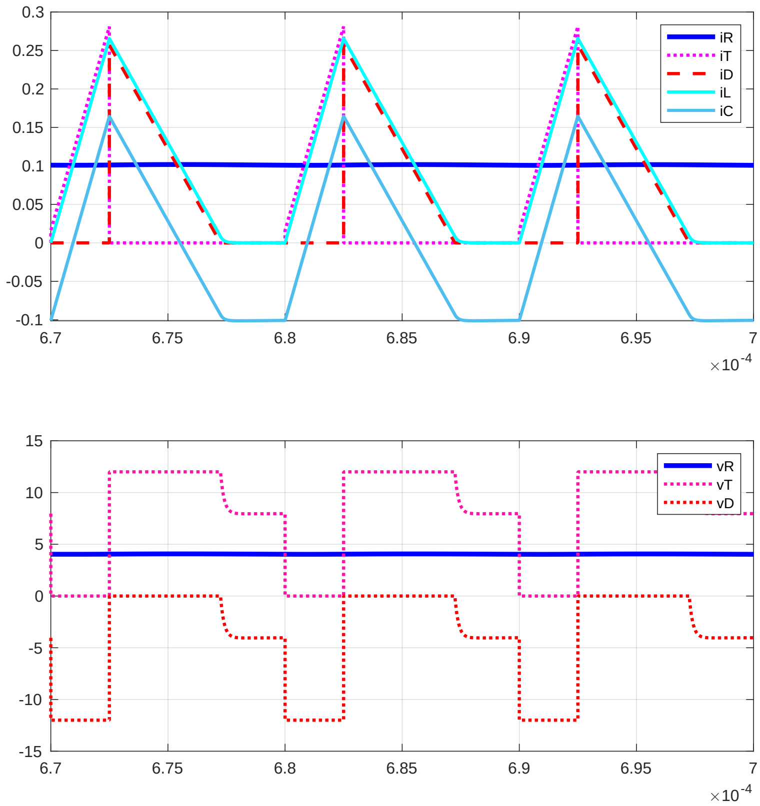

FIGURE 1.1 – Result with 40 Ω load resistance

Thanks to the *Mean* block and a *Display*, we measure $I_R = 0.1012$ A. This value can then be plugged into Equations 1.1 and 1.2. **The computed average output voltage $\mathbf{V_R}$** is consistent with the measured average = 4.049 V (same method as for I_R).

$$V_R = \frac{D^2}{\left(D^2 + \frac{1}{4} * I_{R/I_{Rref}}\right)} * V_I = 3.9683 \text{ V} \tag{1.1}$$

$$I_{Rref} = \frac{V_I}{8 * L * f_s} \tag{1.2}$$

The **peak inductor current $\mathbf{I_L}$max** is analytically computed with Equation 1.3 and corresponds to the experimental value of 0.26 A.

$$I_{L\,\mathrm{max}} = D * (V_i - V_R) * \left(\frac{1}{L}\right) * \frac{1}{f_s} = 0.2677 \text{ A} \tag{1.3}$$

The **fraction of non-conduction characterized by $\mathbf{\Delta_1}$ and $\mathbf{\Delta_2}$** is computed with equations 1.4 and 5 and approximately corresponds to the experimental values $\Delta_{1\mathrm{exp}} = 4.8e - 6 * f_s = 0.48$ and $\Delta_{2\mathrm{exp}} = 2.7e - 6 * f_s = 0.27$.

$$\Delta_1 = D * \left(\frac{V_i - V_O}{V_R}\right) = 0.5060 \tag{1.4}$$

$$\Delta_2 = 1 - D - \Delta_1 = 0.2440 \tag{1.5}$$

b) Figure 1.2 shows the results for $R = 200\ \Omega$. These results correspond to the analytical values (see Table 1.1).

c) Figure 1.2 shows the results for $R = 2000\ \Omega$. The seems to be an error in the simulation, generating values with up to an order of magnitude difference (see Table 1.1).

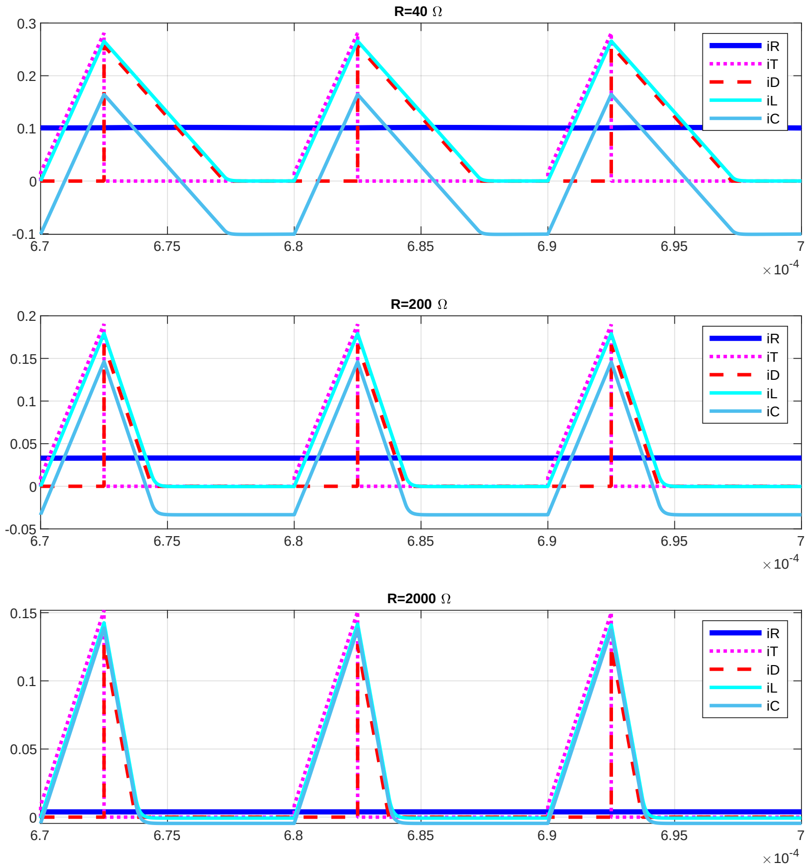

FIGURE 1.2 – Result with 40 Ω, 200 Ω and 2000 Ω load resistances

Load resistance	**40 Ω**	**200 Ω**	**2000 Ω**
V_R	3.9683	7.2141	11.1357
$V_{R\text{ exp}}$	4.049	6.634	7.776 ?
I_{Lmax}	0.2677	0.1595	0.0288
$I_{Lmax\text{ exp}}$	0.26	0.18	0.1466 ?
Δ_1	0.5060	0.1658	0.0194
$\Delta_{1\text{ exp}}$	0.48	$\approx 20\%$	$\approx 10\%$?
Δ_2	0.2440	0.5842	0.7306
$\Delta_{2\text{ exp}}$	0.27	$\approx 60\%$	$\approx 70\%$

TABLE 1.1 – Comparison of output variables for different load resistances

1.5 More steady-state current and voltages waveform (CCM and DCM)

a) See Figure 1.3.

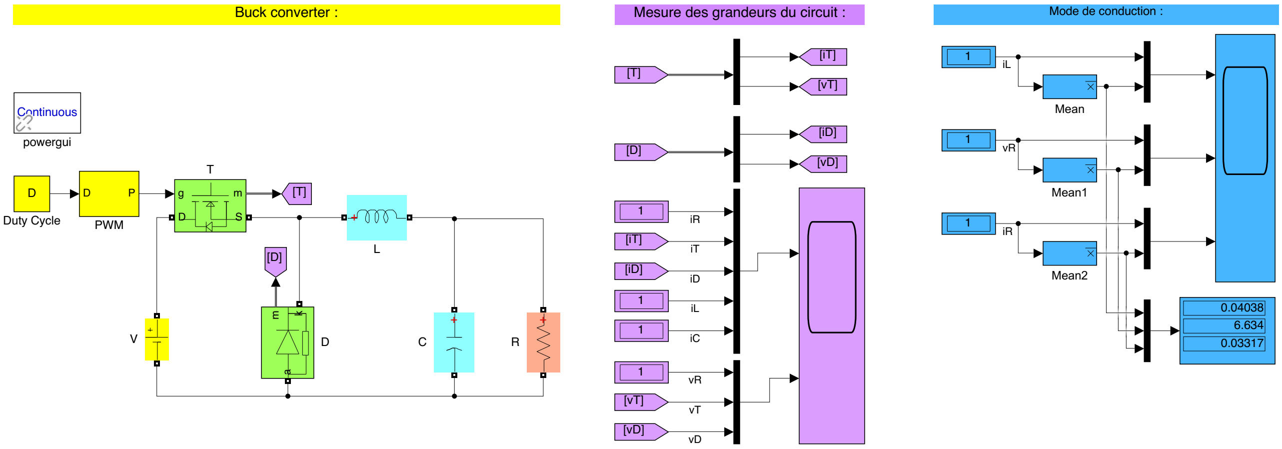

FIGURE 1.3 – Full Simulink model

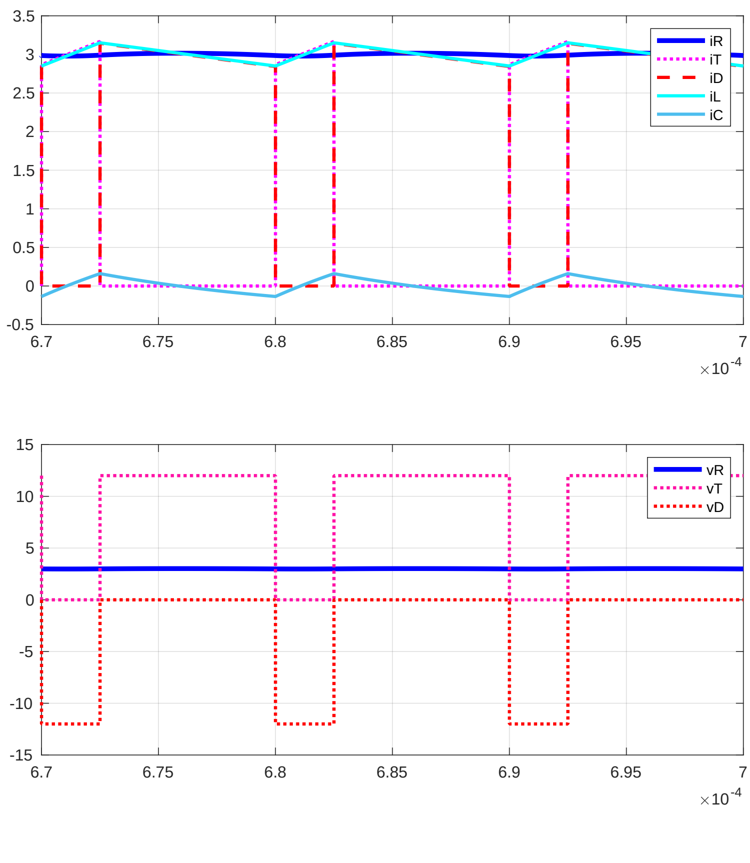

FIGURE 1.4 – Simulation with 1 Ω load resistance : CCM

b)

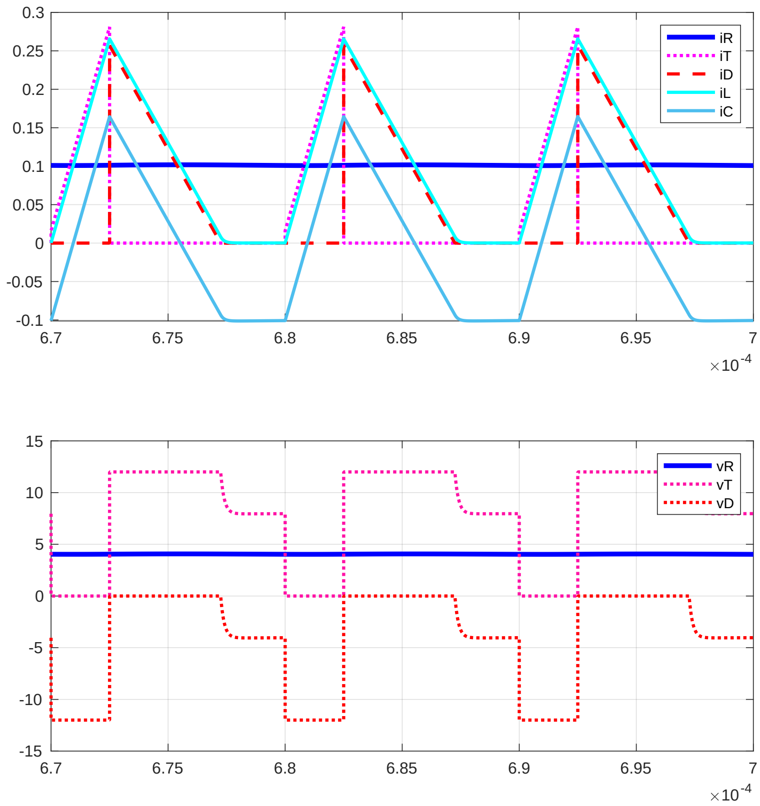

FIGURE 1.5 – Simulation with 40 Ω load resistance : DCM

c)

1.6 Complete output-voltage-current curve with a MATLAB script

The script below gives us multiple output-voltage-current curves depending on the duty cycle. Each curve follows a variation of the load resistance with an imposed duty cycle. Figure 1.6 shows the different curves, appearing as a function of the duty cycle. The script allows us to calculate the output current and voltage that are respectively the x-axis and the y-axis (see GitHub link).

As the Figure 1.6 shows, for a short value of resistance, we are in a continuous conduction mode and as the resistance grows, we tend to zero output current normalized and enter the discontinous conduction mode.

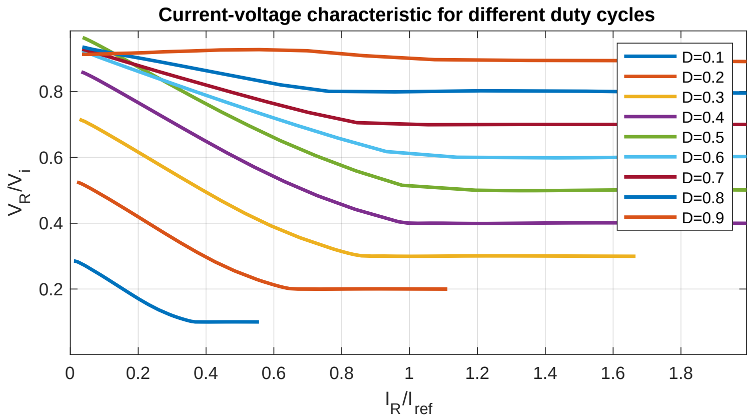

FIGURE 1.6 – Multiple output-voltage-current curves

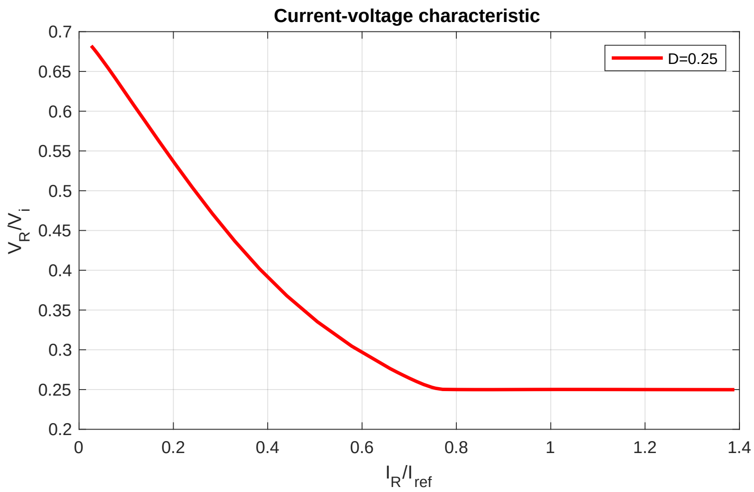

FIGURE 1.7 – Current-voltage characteristic for duty cycle of 0.25

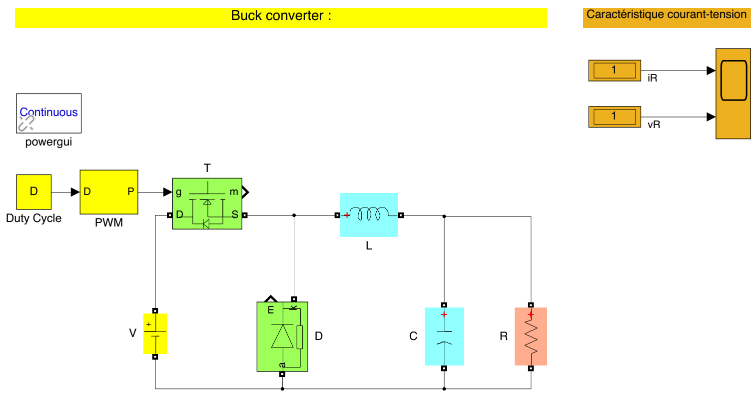

FIGURE 1.8 – Simplified model used to compute the current-voltage characteristics