EE575 – Group Project Assignment B

Open-Loop Simulation of DC–DC Boost Converter

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1 Project Overview

This report presents the open-loop simulation of a 12 V to 24 V, 30 W DC–DC boost converter operating in continuous conduction mode (CCM). The objective is to verify steady-state performance, conduction mode, and ripple characteristics prior to implementing closed-loop control.

The converter is simulated using an EMT-based platform, and performance is evaluated at 10%, 50%, and 100% of the rated load.

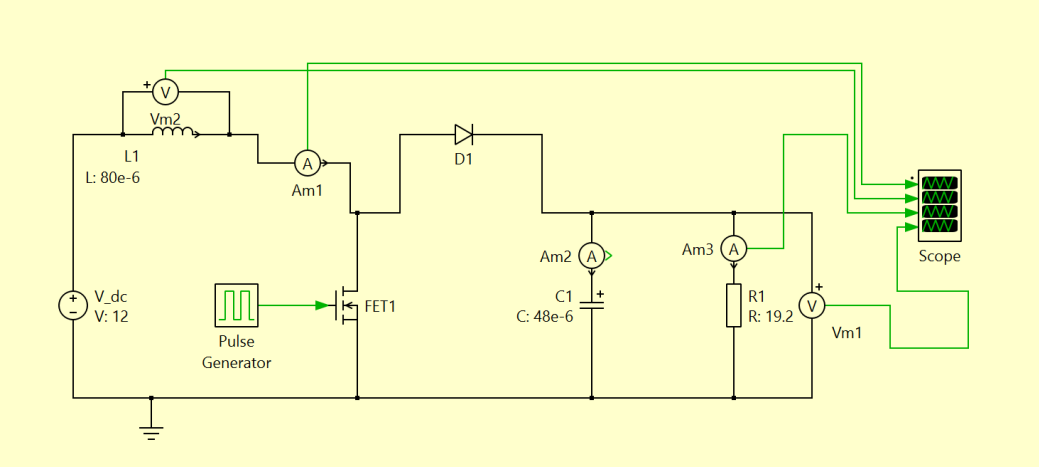

Figure 1: Block diagram of the simulated DC–DC boost converter

2 Inductor Current Waveforms

The inductor current waveforms for different load conditions are shown below. At 50% and 100% load, the current remains strictly positive, confirming CCM operation. At 10% load, the inductor current reaches zero during part of the switching cycle, indicating discontinuous conduction mode (DCM).

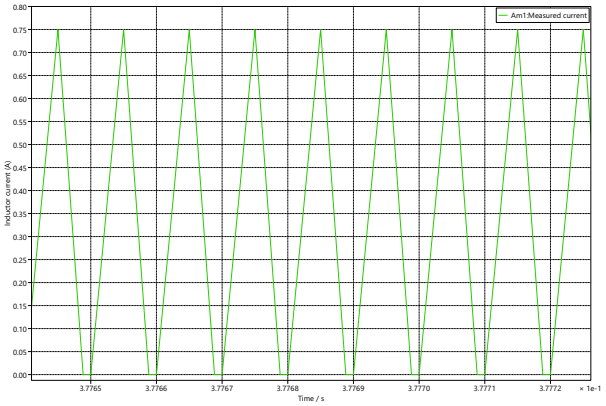

Figure 2: Inductor current waveform at 10% load

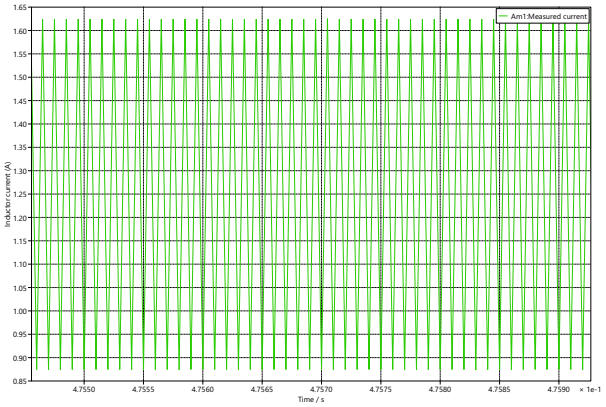

Figure 3: Inductor current waveform at 50% load

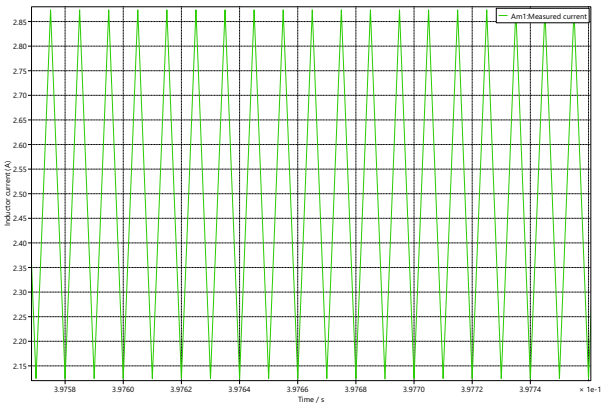

Figure 4: Inductor current waveform at 100% load

3 Inductor Voltage Waveforms

The inductor voltage waveforms reflect the expected switching behavior of a boost converter. During the switch ON interval, the inductor voltage is approximately equal to the input voltage. During the OFF interval, the voltage reverses polarity and equals $V_o - V_{in}$, confirming correct energy transfer to the output.

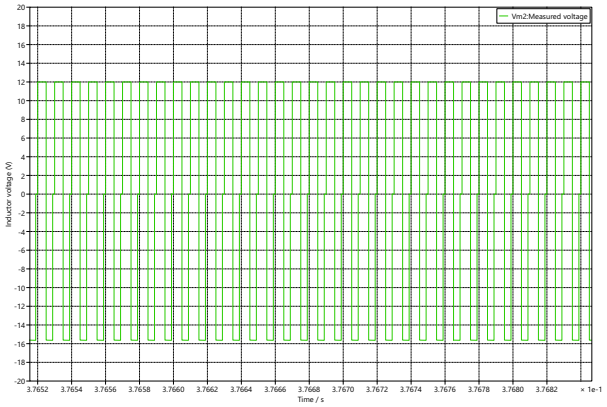

Figure 5: Inductor voltage waveform at 10% load

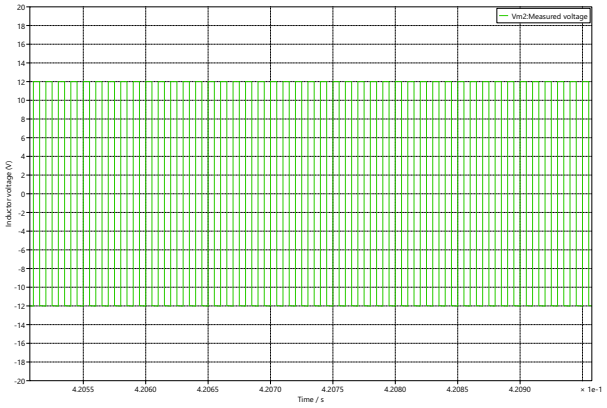

Figure 6: Inductor voltage waveform at 50% load

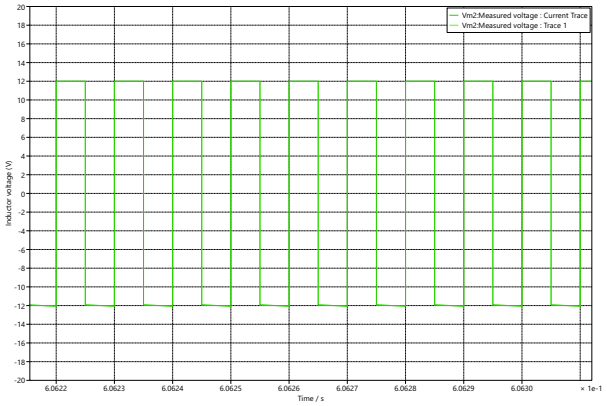

Figure 7: Inductor voltage waveform at 100% load

4 Output Voltage and Ripple

The output capacitor voltage under different load conditions is shown below. In all cases, the output voltage settles rapidly to 24 V, and the peak-to-peak ripple remains well below the specified 2% limit, validating the selected output capacitance values.

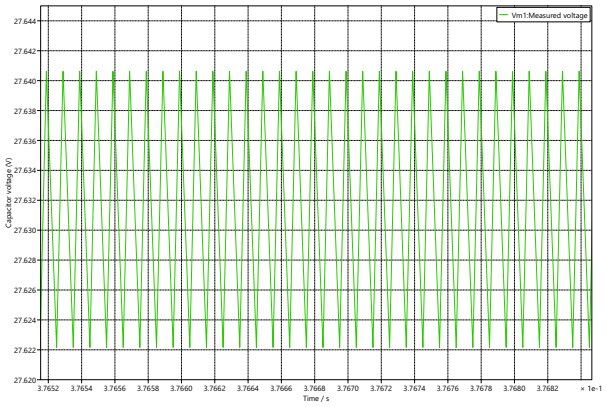

Figure 8: Output voltage waveform at 10% load

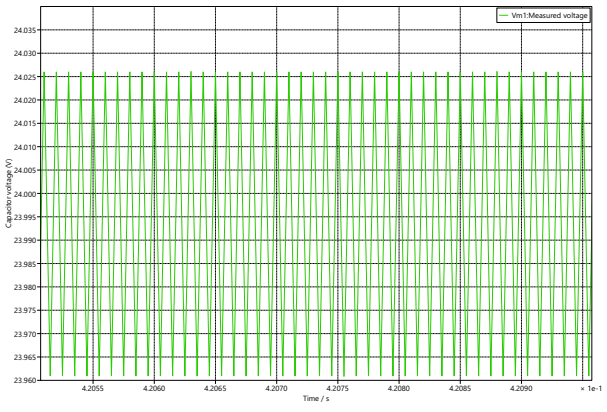

Figure 9: Output voltage waveform at 50% load

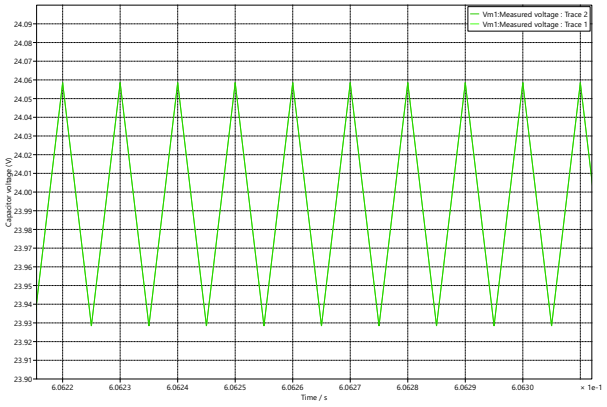

Figure 10: Output voltage waveform at 100% load

5 Summary and Key Observations

The open-loop simulation results confirm the correct operation of the designed 12 V–24 V, 30 W DC–DC boost converter. At medium and full load conditions, the converter operates in continuous conduction mode, with the inductor current remaining positive throughout the switching cycle. At light load, the converter enters discontinuous conduction mode due to insufficient average inductor current, which is consistent with theoretical predictions. The output voltage ripple remains well below the 2% design limit across all operating conditions, demonstrating the adequacy of the selected inductor and output capacitor values. These results provide a reliable basis for the implementation of a closed-loop voltage controller in the next stage of the project.

Load	$i_{L,\mathrm{pk}}$ (A)	$v_{O,\mathrm{pp}}$ (V)	Ripple (%)
10%	0.75	0.0184	0.07
50%	1.6245	0.0651	0.27
100%	2.874	0.1302	0.54

Table 1: Summary of simulated current and voltage ripple values