Model Documentation of the Boost Converter

1 Nomenclature

1.1 Nomenclature for Model Equations

L	inductivity of the inductor
C	capacity of the capacitor
R	resistance of the load
U_E	input voltage
i_L	current through the inductor
u_C	voltage over the capatitor
d	duty ratio of the switch

1.2 Circuit Diagram

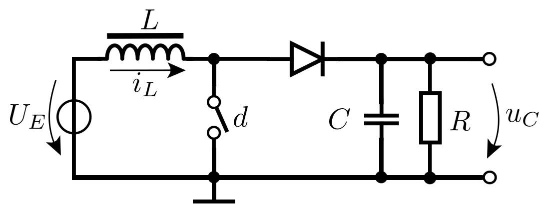

Figure 1: Circuit

2 Model Equations

State Vector and Input Vector:

$$\underline{x} = (x_1\ x_2)^T = (i_L\ u_C)^T$$
$$\underline{u} = d$$

System Equations:

$$\dot{x}_1 = -(1-u)\frac{1}{L}x_2 + \frac{U_E}{L} \tag{1a}$$

$$\dot{x}_2 = (1-u)\frac{1}{C}x_1 - \frac{1}{RC}x_2 \tag{1b}$$

Parameters: L, C, R, U_E
Outputs: $x_2 = u_C$

2.1 Assumptions

1. The switching frequency is high enough, to prevent the inductor from fully discharging beween charging stages.

2.2 Exemplary parameter values

		Symbol	Value
Inductiviy	L	0.00018	H
Capacity	C	$2.0 \cdot 10^{-5}$	F
Resistence	R	10	Ω
Input Voltage	U_E	24	V

3 Derivation and Explanation

Using PWM (puls width modulation), instead of only discrete values $d \in \{0, 1\}$ representing an *open* or *closed* switch, any value of the interval $[0, 1]$ can be modeled. This is done by using the averaged values for states and inputs:

$$\bar{d} = \frac{1}{T} \int_t^{t+T} d(\tau) d\tau$$

$$\bar{x}_i = \frac{1}{T} \int_t^{t+T} x_i(\tau) d\tau \quad i = 1, 2$$

with the switching period T. For $T \to 0$, which is achieved by a high enough switching frequency, an averaged model can be obtained.

4 Simulation

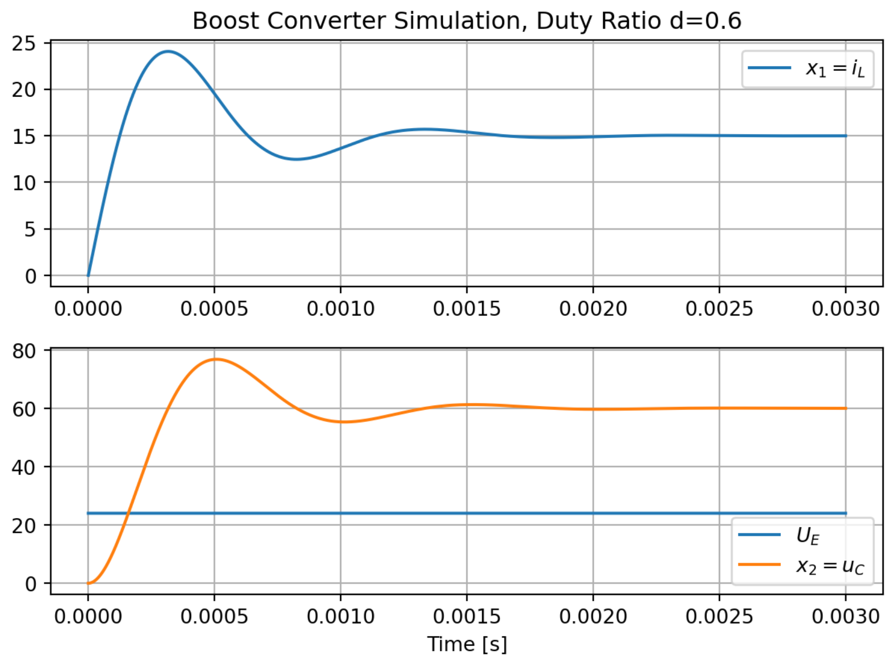

Figure 2: Simulation of the boost converter.

References

[1] K. Röbenack, Nichtlineare Regelungssysteme: Theorie und Anwendung der exakten Linearisierung. Berlin, Heidelberg: Springer Berlin Heidelberg, 2017. doi: 10.1007/978-3-662-44091-9.

[2] Sira-Ramirez, H.: A geometric approach to pulse-width modulated control in nonlinear dynamical systems. IEEE Trans. on Automatic Control, 34(2):184–187, Februar 1989.

[3] R. H. G. Tan and L. Y. H. Hoo, DC-DC converter modeling and simulation using state space approach, in 2015 IEEE Conference on Energy Conversion (CENCON), Oct. 2015, pp. 42–47. doi: 10.1109/CENCON.2015.7409511.