2. Simulation

The studied electrical circuit has two modes, depending on the state of the transistor: transistor is saturated and conducting electrical current; transistor is blocked, no current flowing through it.

Model

The **model** of a physical system or phenomenon is a simplified representation of it, which is capable of catch the essential aspects of interest of the structure and behavior, from control point of view.

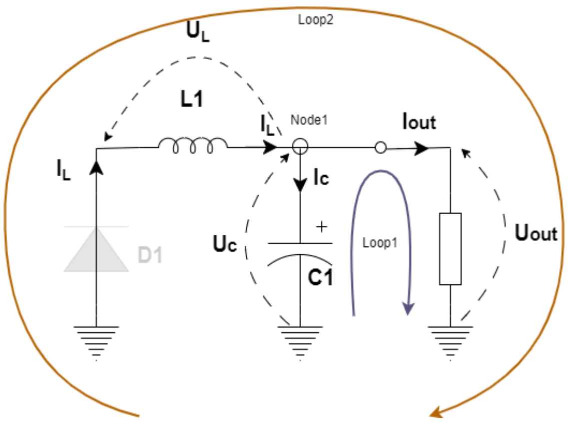
As the motivation for studying Power Electronics is the “switching mode” control, we consider some simplifying hypotheses:

a) The commutation of the switching component is ideal, with 0 internal resistance during conduction, infinite resistance during blocking mode. Switching time, as time spent in the active region is considered as well 0.
b) The external voltage source is considered ideal, without internal resistance.
c) The passive elements (R, L, C) have linear characteristics, are invariant in time and without parasitic elements.

The used model type is Switched mode model, where we describe every different configuration given by switches states. In this case, we study two different scenarios.

Transistor not conducting

In this case, the path of the current flowing through the inductor is closed with the diode. The equivalent circuit looks like this.



After Kirkhoff's laws:

Loop1: $-U_L - U_{out} = 0$

Loop2: $U_C - U_{out} = 0$

Node1: $I_L = I_C + I_{out}$

$-dI_L/dt*L - U_{out} = 0$

$U_C - U_{out} = 0$

$I_L = dU_c/dt*C + U_{out}/R$

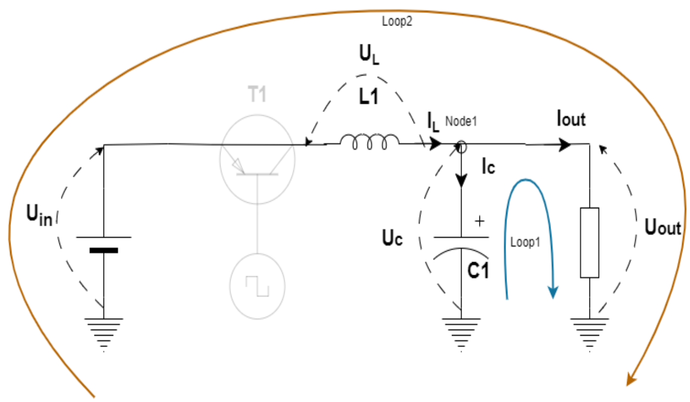
$dI_L/dt = -U_C/L$

$dU_c/dt = (I_L - U_C/R)/C$

$U_{out} = U_C$

Transistor conducting

In this case, the inductor current flows through the transistor, diode is remaining closed. The equivalent circuit looks like this.



After Kirkhoff's laws:

Loop1: $U_{in} - U_L - U_{out} = 0$

Loop2: $U_C - U_{out} = 0$

Node1: $I_L = I_C + I_{out}$

$U_{in} - dI_L/dt*L - U_{out} = 0$

$U_C - U_{out} = 0$

$I_L = dU_c/dt*C + U_{out}/R$

$dI_L/dt = (U_{in} - U_C)/L$

$dU_c/dt = (I_L - U_C/R)/C$

$U_{out} = U_C$

Summarizing the two systems of equation, we can obtain a generic one, introducing **μ**:

$dI_L/dt = (U_{in} * \boldsymbol{\mu} - U_C)/L$

$dU_c/dt = (I_L - U_C/R)/C$

$U_{out} = U_C$

Where μ = 1 shows, the transistor is conducting. μ = 0 means, the transistor is blocked.

Task

Implement the system of equation described before in MATLAB-Simulink.

Input of the system is **μ,** output is $\mathbf{U_{out.}}$ Load resistance is calculated from output maximum current and output voltage.

Generate a PWM signal with the requested frequency and calculated duty cycle as input in the model.

a) Using the calculated C and L values, plot out the coil current and output voltage, and measure the current and voltage ripple. Compare with the given value.
b) Change C and L values to the chosen components' nominal value (the value from datasheet). How does this affect the current and voltage ripple? Plot the coil current from a) and b) on the same graph, the output voltage from a) and b) on an other graph.
c) Change the input PWM signal to a constant which value is the duty cycle calculated in the Part1 of the project(between 0 and 1). How the system responds? Measure overshoot (if exists) and settling time.