

7th Homework

- In this homework, we shall model and simulate a discontinuous system as well as train the incorporation of tabular functions.
- We shall first model an electrical oscillatory circuit containing a tunnel diode.
- We shall then model a fly-back electronic power converter circuit with current overprotection.

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- Free-running tunnel diode circuit
- Pulsed tunnel diode circuit
- Fly-back electronic power converter circuit

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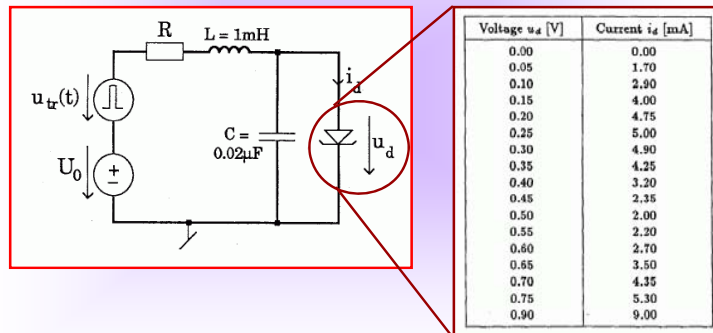
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Free-running Tunnel Diode Circuit I

- Given the following electronic circuit:



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Free-running Tunnel Diode Circuit II

- Let us set $U_{tr} = 0$. We select a resistor with a value of $R = 25 \Omega$. We choose a DC bias of $U_0 = 0.48 V$.
- Create a bond graph (without wrapping) of the circuit. Use causal bonds whenever possible.
- Create a model **T3** representing the tunnel diode. The tabular function is incorporated by dragging the corresponding table-lookup block into the diagram window.
- Use Matlab to save the table onto a binary file, and reference that table from within the parameter window of the table-lookup block. Make sure to assign the correct causality to the table-lookup function. You can determine the correct causality from the bond graph of the overall circuit.

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Free-running Tunnel Diode Circuit III

- Now create a model of the overall circuit (without wrapping) in Dymola using the **BondLib** library as well as the previously coded **T3** model.
- Simulate the circuit across **0.2 msec** of simulated time.
- Plot the current through the tunnel diode.
- Interpret the results obtained.

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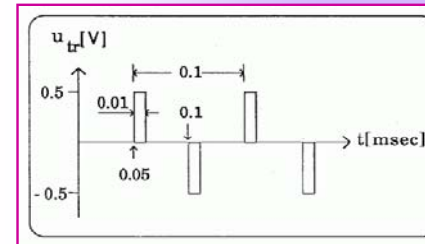
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Pulsed Tunnel Diode Circuit I

- In a second experiment, we include the following pulsed trigger signal, U_{tr} .



- You can easily create the trigger voltage out of the superposition of two of the pulsed voltage sources provided in the standard bond graph library.

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Pulsed Tunnel Diode Circuit II

- For this experiment, we select a resistor with a value of **$R = 200 \Omega$** . We now choose a DC bias of **$U_0 = 1.075 V$** .
- Simulate the modified circuit across **0.2 msec** of simulated time.
- Plot the current through the tunnel diode.
- Interpret the results obtained.

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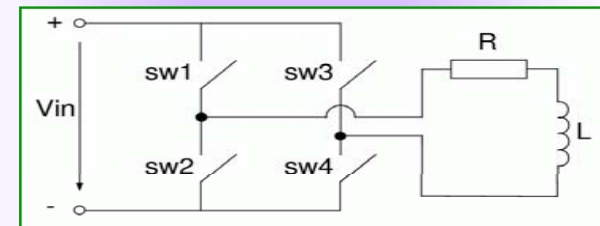
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Fly-back Power Converter Circuit I

- Given the electronic circuit:




- The purpose is to create an inductor current that is approximately sinusoidal.

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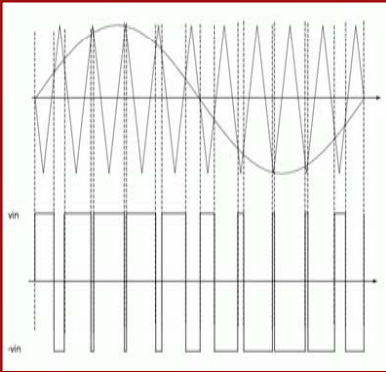
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Mathematical Modeling of Physical Systems

Fly-back Power Converter Circuit II

- To this end, we use pulse width modulation.
- The four switches are controlled in such a way that sometimes V_{in} is being applied to the RL circuit, and at other times $-V_{in}$.
- The logic is explained in the graph to the right.



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Mathematical Modeling of Physical Systems

Fly-back Power Converter Circuit III

- If the sine-wave signal is larger than the triangular signal, switches #1 and #4 must be closed, whereas switches #2 and #3 must be opened.
- If the sine-wave signal is smaller than the triangular signal, switches #2 and #3 must be closed, whereas switches #1 and #4 must be opened.

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Mathematical Modeling of Physical Systems

Fly-back Power Converter Circuit IV

- We also want to implement a over-current protection circuit.
- When the inductor current becomes larger than 11.05 A , switches #2 and #4 must be closed, and switches #1 and #3 must be opened, irrespective of what the previous logic indicated.
- When the inductor current becomes smaller than 10.95 A , the previous logic takes precedence once again.
- The hysteresis around the threshold current of 11.0 A is necessary to avoid chattering.

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Mathematical Modeling of Physical Systems

Fly-back Power Converter Circuit V

- Without the hysteresis, the switches would switch back and forth with infinite frequency. This phenomenon is called chattering.
- Create a bond graph model of the fly-back converter circuit. Use causal bonds wherever the causality is fixed, and use a-causal bonds elsewhere.
- Make use of four “leaky” switches to avoid divisions by zero.
- Program the logic of the four switches graphically using the standard *Modelica* blocks library.

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Fly-back Power Converter Circuit VI

- Simulate the circuit across *1 sec* of simulated time using $R = 0.6 \Omega$ and $L = 100 \text{ mH}$.
- Plot the inductor current over the entire period, and also over two smaller time windows, namely at an early period, when the over-current protection is active, and during steady-state operation.

