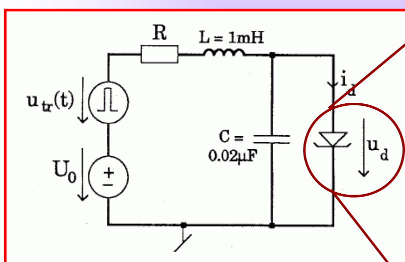
7th Homework – Solution

- 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.

Free-running Tunnel Diode Circuit I

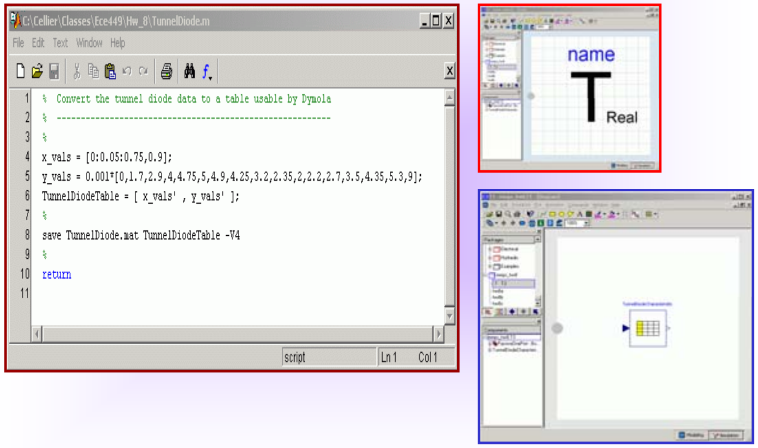
- Given the following electronic circuit:



Voltage u_d [V]	Current i_d [mA]
0.00	0.00
0.05	1.70
0.10	2.90
0.15	4.00
0.20	4.75
0.25	5.00
0.30	4.90
0.35	4.25
0.40	3.20
0.45	2.35
0.50	2.00
0.55	2.20
0.60	2.70
0.65	3.50
0.70	4.35
0.75	5.30
0.90	9.00

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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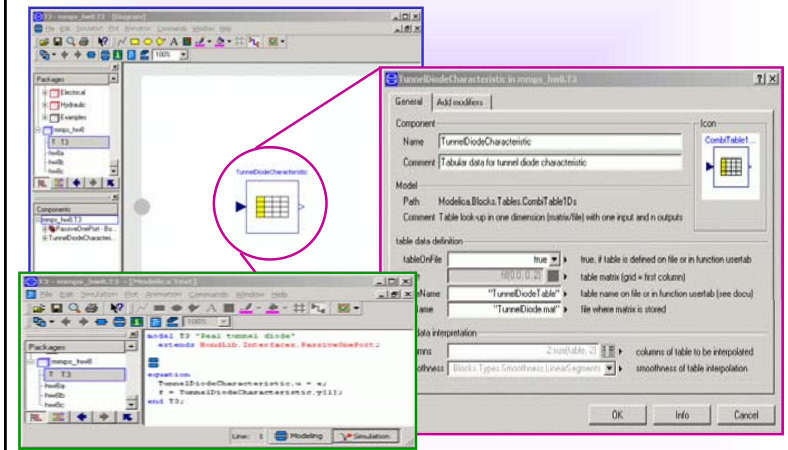

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Free-running Tunnel Diode Circuit III

- 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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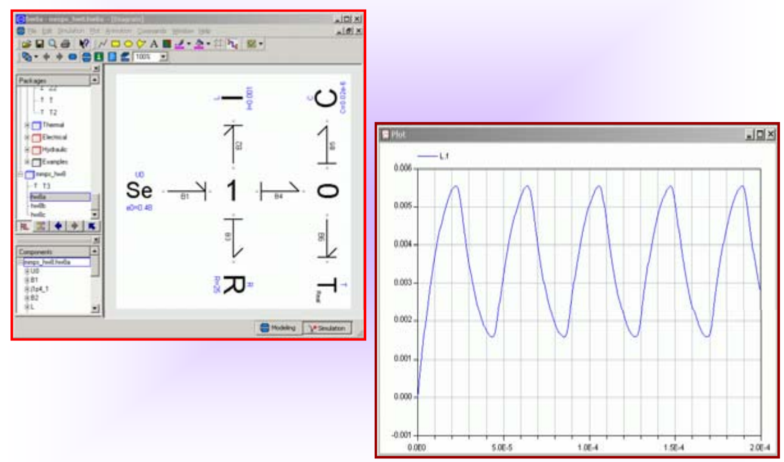

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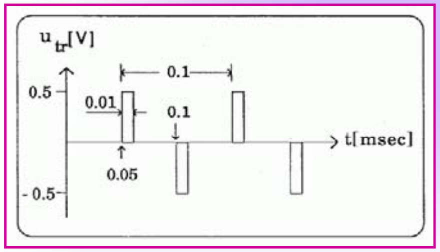
Pulsed Tunnel Diode Circuit I

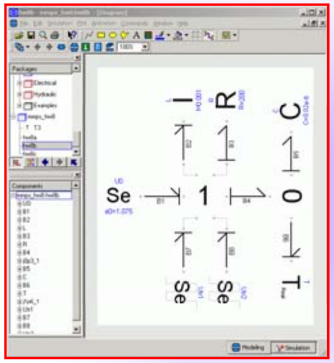
- In a second experiment, we include the following pulsed trigger signal, U_{tr}.



- 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.

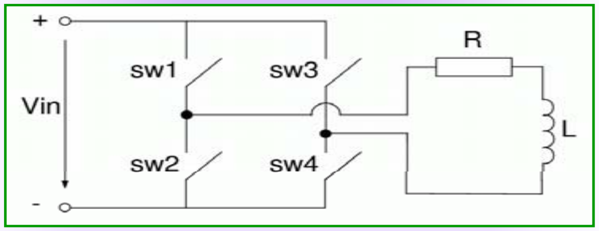
Pulsed Tunnel Diode Circuit II

- 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.



Fly-back Power Converter Circuit I

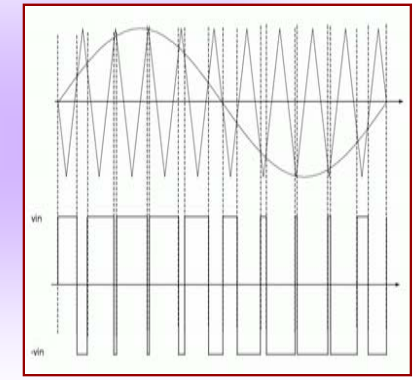
- Given the electronic circuit:



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

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 ***-Vin***.
- The logic is explained in the graph to the right.



Fly-back Power Converter Circuit III

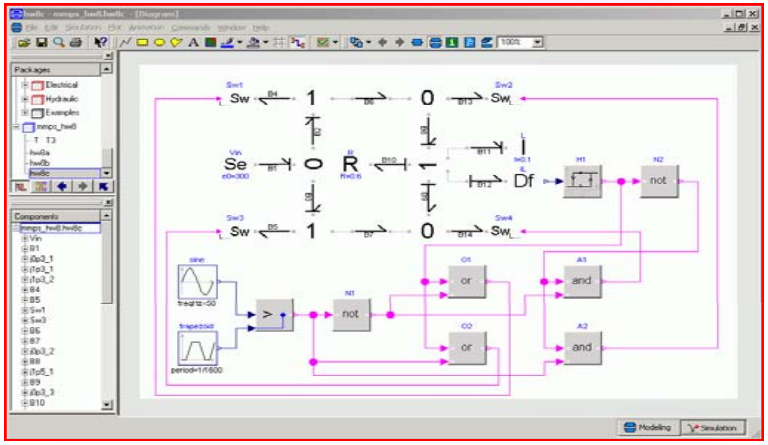
- If the sine-wave signal is larger than the triangular signal, switches #1 and #4 must be closed, whereas switches #2 and #3 must be opened.
- If the sine-wave signal is smaller than the triangular signal, switches #2 and #3 must be closed, whereas switches #1 and #4 must be opened.

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 ***10.95A***, the previous logic takes precedence once again.
- The hysteresis around the threshold current of ***11.0 A*** is necessary to avoid chattering.

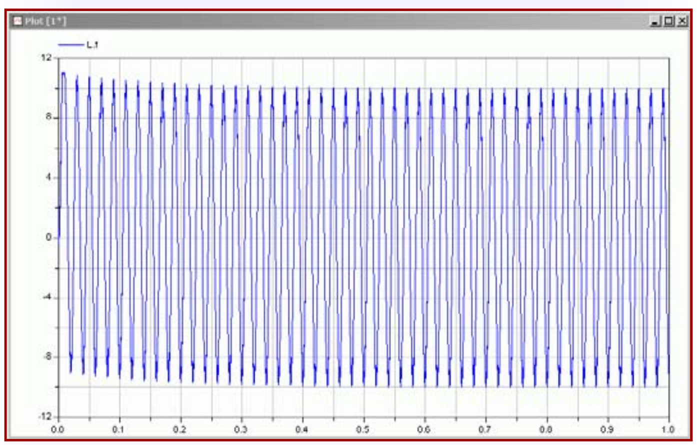
Fly-back Power Converter Circuit V

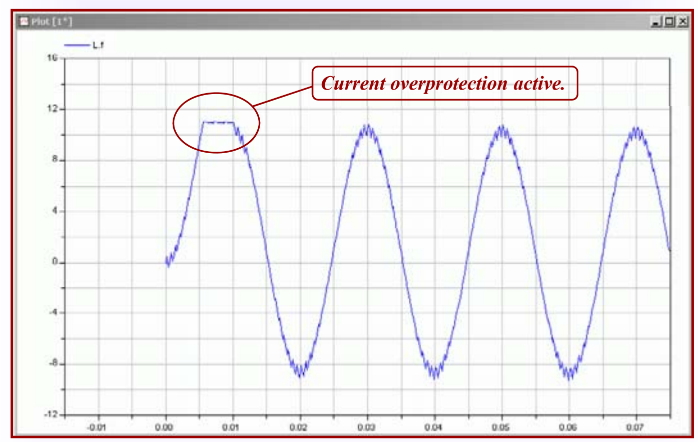
- Without the hysteresis, the switches would switch back and forth with infinite frequency. This phenomenon is called chattering.
- Create a bond graph model of the fly-back converter circuit. Use causal bonds wherever the causality is fixed, and use a-causal bonds elsewhere.
- Make use of four "leaky"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

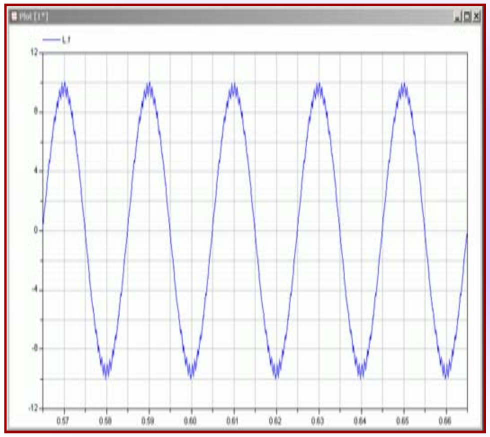


Fly-back Power Converter Circuit VI

- Simulate the circuit across *1 sec* of simulated time using $R = 0.6\ \Omega$ and $L = 100\ mH$.
- 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.







- The current is almost sinusoidal.
- There are only a few high-frequency components that could easily be filtered out using a low-pass filter.