PSIM

TUTORIAL

Diode Model with Reverse Recovery

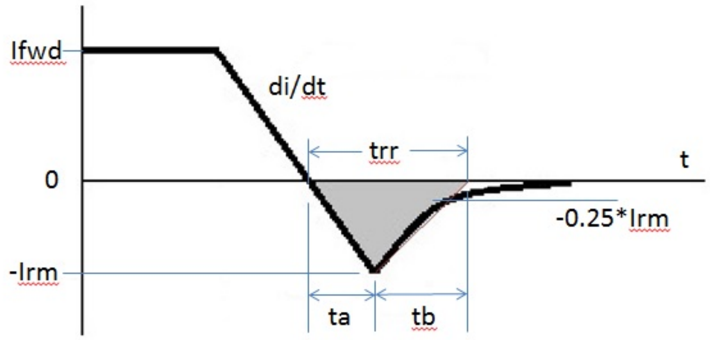
October 2016

This tutorial describes how to use the PSIM's diode model with reverse recovery.

When a diode turns off, it displays a transient reverse current. The diode model described in this tutorial takes into account the reverse recovery transient.

The reverse recovery diode model requires more parameter inputs than the ideal diode model. Some of these parameters come directly off manufacturers' datasheets, while other parameters need to be obtained by experiments. This tutorial describes how these parameters are defined.

A typical diode turn-off characteristic is shown below, with parameter definitions.



The diode model has the following parameters:

Forward Voltage	Forward voltage drop *Vfwd*, in V.
Resistance	Diode resistance *Rs*, in Ohm. Some datasheets provide this value. Others provide the forward voltage drop curve. One can obtain the resistance from the slope of the curve at the operating point, i.e. *Rs = ΔVfwd/ΔIfwd*.
Parasitic Inductance	Inductor lead parasitic inductance *Ls*, in H. Some datasheets do not include this value, and one may need to find it from the diode packaging information.
Parallel Capacitance	Parallel capacitance *Cp* between the anode and cathode. If the capacitance is 0, the capacitor is ignored and is removed from simulation. Note that the parallel capacitance will affect the reverse recovery characteristic as the capacitor current will add to the reverse recovery current. But this is a realistic effect in practice.
Forward Current	Forward conduction current *Ifwd*, in A, under test conditions of reverse recovery characteristic.
Peak Reverse Current	Peak reverse current *Irm*, in A, under test conditions
Current Slope	The di/dt slope that it takes the current to decay from the forward conduction current *Ifwd* to the reverse current peak *-Irm*, in A/sec., under test conditions. It is implied that di/dt is negative, and a positive value should be entered here (e.g. 120e6 instead of -120e6).
Reverse Recovery Time	Reverse recovery time *trr*, in sec., under test conditions

Current Flag	Current flag of the diode. If the flag is set to 1, and assuming that the diode name is D1, the diode current will be displayed as I(D1.Drr).

The reverse recovery time *trr* consists of two parts: *ta* and *tb*. During the period *ta*, the current increases from 0 to -Irm. Based on JEDEC (Joint Electron Device Engineering Council), tb is defined as the interval from the time of -Irm to the time when the straight line from -Irm through -0.25*Irm (in red in the diagram) intersects with the time axis.

In this tutorial, Fairchild's RURG3020CC diode is used to illustrate how to use the diode model.

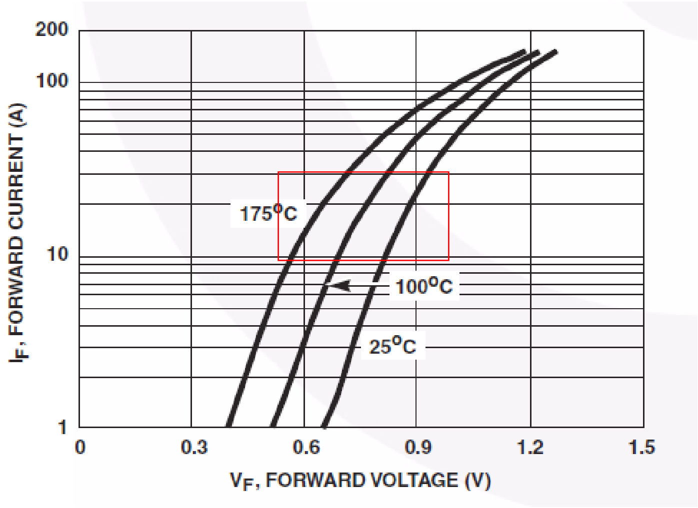
Entering Datasheet Information:

From the datasheet, we have the following parameters:

- The forward voltage drop at the rated current 30A and at 150°C is:

  Vfwd = 0.85 V

- The diode resistance is not given in the datasheet. It can be calculated from the curve of the forward current vs. forward voltage below:



  In the region of interest (highlighted in red), based on the slope of the curves, at around 10A to 30A and 100°C, the resistance is approximately:

  Rs = *ΔVfwd / ΔIfwd* = 0.007 Ohm

- The package of the diode is TO-247. A typical parasitic inductance for this type of package is around 10nH for each lead, that is:

  Ls = *2 ×10* = 20 nH

- No information is given regarding the diode capacitance. We will assume the parallel capacitance to be 0.

  Cp = 0

- The datasheet gives the reverse recovery characteristics as:

t_{rr}	I_F = 1 A, dI_F/dt = 100 A/µs	-	-	45	ns
	I_F = 30 A, dI_F/dt = 100 A/µs	-	-	50	ns
t_a	I_F = 30 A, dI_F/dt = 100 A/µs	-	20	-	ns
t_b	I_F = 30 A, dI_F/dt = 100 A/µs	-	15	-	ns

The information that we need is highlighted in the red box. We have:

Ifwd = 30 A

di/dt = 100e6 A/sec.

From ta and tb, we can calculate the reverse recovery time as:

trr = ta + tb = 20 + 15 = 35 ns

The peak reverse current is not given in this datasheet. But it can be easily calculated from the time ta and the current slope di/dt as:

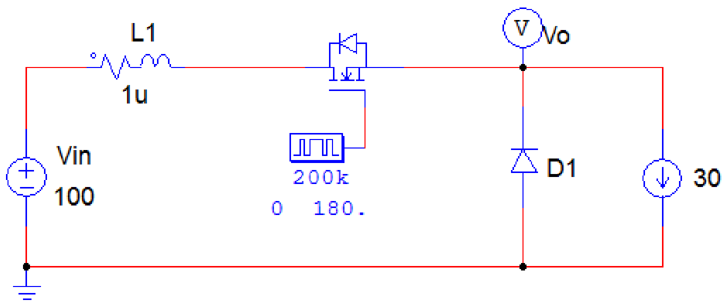
Irm = di/dt * ta = 100e6 * 20e-9 = 2 A

Some datasheet may not provide ta and tb, but trr and peak reverse current Irm directly, in which case no calculation is needed.

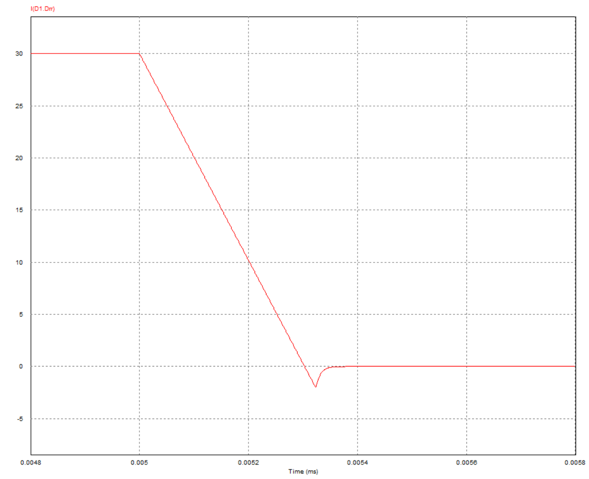
Verifying the Model:

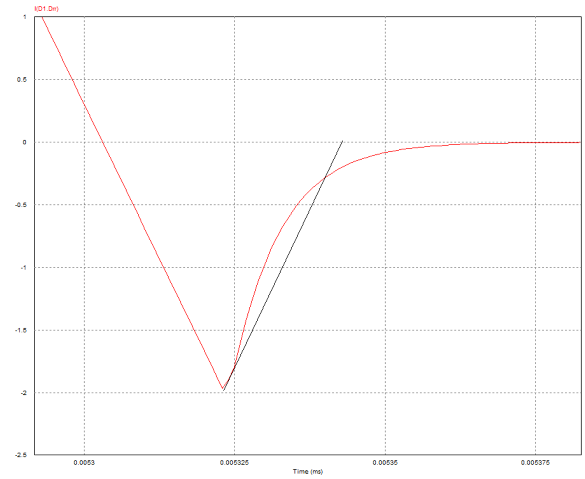
The parameters will be entered into the diode model to simulate the diode turn-off characteristic.

The figure below shows the test circuit. The diode D1 has the parameters as discussed above. The input source Vin and the inductance L1 are set in such a way that the current slope di/dt is the same as the value in the model parameter. The load current is also set to be the same as the forward current.



The simulation waveform is shown below on the left, with the enlarged reverse recovery waveform on the right.





From the simulation waveform, the reverse peak current is around 2A, and the reverse recovery time trr is around 39 ns, which are close to the datasheet result.

The accuracy of this model relies on the accuracy of the parameters. One may need to adjust the parameters, specifically the reverse recovery time trr, to have a better fit between the simulation waveform and the experimental result.