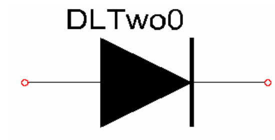
DiodeLevel-2



Author: Xiaobin Wang
Date: 2002-07-10
Executable file name: DiodeLevel2.vtm
Version number: 1.0

Description

This is a level-2 physics-based diode model. It includes the transient characteristics of diode such as forward overshoot and reverse recovery. It also contains the effects of emitter recombination and junction capacitance.

Validity Range and Limitations

The model can be widely used to model the diode used in power electronic application, conducted EMI or any other situation in which waveform is sensitive.

Connections

Terminals	Description
Terminal 0 and Terminal 1	The direction of current, and voltage is defined form terminal 0 to terminal 1.

Adjustable Parameters

Table 1. The following parameters are adjustable

Name	Description	Valid Range	Default Value	Units
BreakdownVoltage	Breakdown voltage of the device	> 0	1200.0	V
InitialTemperature	Initial Temperature of the diode	>0	300	K
BuiltInPotential	Zero-biased junction built-in potential	>0	0.6	V
Junction Capacitance	Zero-biased junction capacitance	>0	1.0e-12	F
SaturationCurrent	Saturation Current of the diode	>0	1.0e-9	A
EmitterSaturation	Emitter region saturation current	>0	5.0e-22	A
LifeTime	Carrier lifetime	>0	5.0e-6	s
TransitTime	Transit time for carriers transit half the distance of i-region	>0	2.0e-6	s
InitialResistance	Initial resistance of i-region	>0	500	Ω
ContactResistance	Ohmic contact resistance	>0	1.0e-3	Ω
DampingCoefficient	Damping coefficient for NR iteration	0~ 1.0	0.1	N/A

Output Variables

Table 2. The following parameters are output to scope

Name	Description	Units
Voltage	Voltage across the diode	V
Current	Current through the diode	A

Model Assumptions

It is assumed that the hole and electron mobility are equal, so that the charge distribution is symmetric, and allows the analysis to be simplified to only half the structure.

Mathematical Description

The switching characteristics of the diode can be described by the charges, current components and voltages. The basic equations are:

$$i_M = \frac{q_E - q_M}{T_M} \qquad (1)$$

$$\frac{q_E - q_M}{T_M} = \frac{dq_M}{dt} + \frac{q_M}{\tau} \qquad (2)$$

$$q_E = Is \times \tau \times \left[\exp\left(\frac{v_E}{V_T} \right) - 1 \right] \qquad (3)$$

$$iE = I_{SE} \left[\exp\left(\frac{2v_E}{V_T} \right) - 1 \right] \qquad (4)$$

$$v_M = \frac{V_T \times T_M \times R_{M0} \times i}{q_M \times R_{M0} + V_T \times T_M} \qquad (5)$$

$$v = 2v_E + 2v_M + Rs \times i \qquad (6)$$

$$i = i_E + i_M + 2C_j \frac{dv_E}{dt} \qquad (7)$$

$$C_j = C_{j0} \times \left(1 - 2v_E / \Phi_b \right)^{-0.5} \qquad \text{for} \qquad 2v_E >= 0.5 \times \Phi_b \qquad (8)$$

$$C_j = \sqrt{2} \times C_{j0} \times \frac{(2v_E)}{\Phi_b} + \frac{1}{\sqrt{2}} \times C_{j0} \qquad \text{for} \qquad 2v_E < 0.5 \times \Phi_b \qquad (9)$$

Where,

i– total current through the diode
v -- voltage across the diode
q_E—the charges at junction boundaries
q_M –- charges at i-region
v_M —voltage across half of the i -region
vE –- voltage across two junctions
iE — emitter region recombination current
i_M—diffusion current
T_M—transit time
τ– carrier lifetime
I_S – Saturation current
I_{SE}– emitter region saturation current
R_{M0}—initial resistance in the i-region
Rs–contact resistance
V_T– thermal potential
Cj – junction capacitance
Cj0—zero-biased junction capacitance
Φb– zero biased built-in potential of one junction

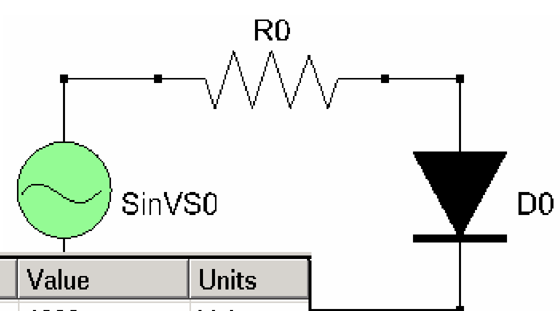
Model Validation

N/A

Example Application

One application example is shown in Fgure1.

The parameters for the diode model are shown in Table 3.
Table3. The parameters for

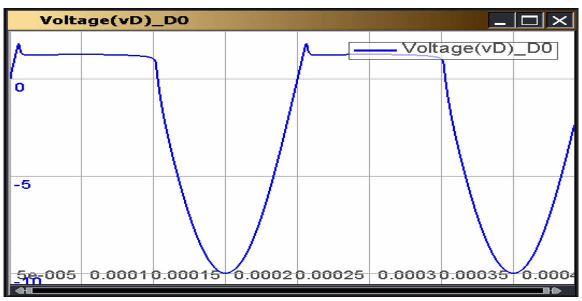


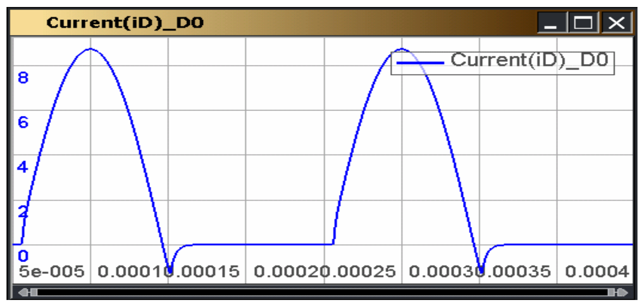
Parameter	Value	Units
BrekDownVoltage	1200	Volt
InitialTemperature	300	Kelvin
BuiltInPotential	0.6	Volt
JunctionCapacitance	1.0e-10	Farad
SaturationCurrent	1.0e-9	Ampere
EmitterSaturation	5.0e-22	Ampere
Lifetime	5.0e-6	Second
TransitTime	2.0e-6	Second
InitialResistance	500	Ohm
ContactResistance	1.0e-3	Ohm
DampingCoefficient	0.1	N/A

t with a
urce:
mplitude=10V;

the Diode

The VTB simulation results were shown in Figure2. The transient characteristics of the diode such as forward overshoot and reverse recovery was represented in the waveforms.





Fgiure2. An example of switching waveform of the diode model

References

[1] Cliff L. Ma and P.O. Lauritzen, “A simple power diode model with forward and reverse recovery”, IEEE Transactions on power electronics, Vol 8, No.4, Oct. 1993. pp342-346.