APPLICATION NOTE

cadence

Modeling Schottky Diodes

This document explains how the model parameters IS and N can be modified to set the forward voltage drop of a Schottky diode. Attached test case shows the simulation results of varying these parameters.

Introduction

This document explains how the model parameters IS and N can be modified to set the forward voltage drop of a Schottky diode. Attached test case shows the simulation results of varying these parameters. The project has three simulation profiles;

1. dc: DC sweep analysis of forward biased schottky diode as shown in Fig. 2.
2. IS_Variation: Nested DC sweep. Shows effect of IS variation.
3. N_Variation: Nested DC sweep. Shows effect of N variation.

Schottky Diode

Schottky diode, also known as hot carrier diode is a semiconductor diode with low forward voltage and a very fast switching action. Unlike a PN-junction diode, a Schottky Diode has a metal–semiconductor (M–S) junction in which a metal comes in close contact with a semiconductor material. Schottky diodes do not have a recovery time, as there is nothing to recover from (i.e. no charge carrier depletion region at the junction). The switching time is ~100 ps for the small signal diodes, and up to tens of nanoseconds for special high-capacity power diodes.

$$I = IS(e^{\frac{V}{NVt}} - 1) \qquad (1)$$

$$V = N.Vt.\log(I/IS + 1) \qquad (2)$$

Where

I: Forward DC current
IS: Reverse saturation current
N: Ideality factor
V: Bias Voltage
Vt = $k \cdot T/q$ (thermal voltage)
k: Boltzmann constant = 1.3806488(13) $\times 10^{-23}$ J/K.
T: analysis temperature
Q: electron charge

Developing Model

With respect to the above diode equation, we can see that the forward voltage drop, V, depends on the current, I, but only weakly. V increases by 60 millivolts for each factor of 10 that I increases. Alternatively, V increases by 60 millivolts for each factor of 10 that IS decreases. So, the forward voltage drop for your circuit's bias conditions can be set by changing IS parameter. You can change this in the diode's .MODEL statement. For Schottky diodes, values of IS are larger when compared to diffusion diodes of the same area. The model parameter N can also be used to adjust the forward voltage drop, but changing N will make the I-V curve deviate from the normal slope of a decade per 60 millivolts. We do not recommend changing N in order to model Schottky diodes. The attached test case shows the effect with DC sweep of IS and N parameters.

Simulation of schottky diode, Dmurs360t3

Fig. 1 and 2 show the circuit and the model being used for this simulation.

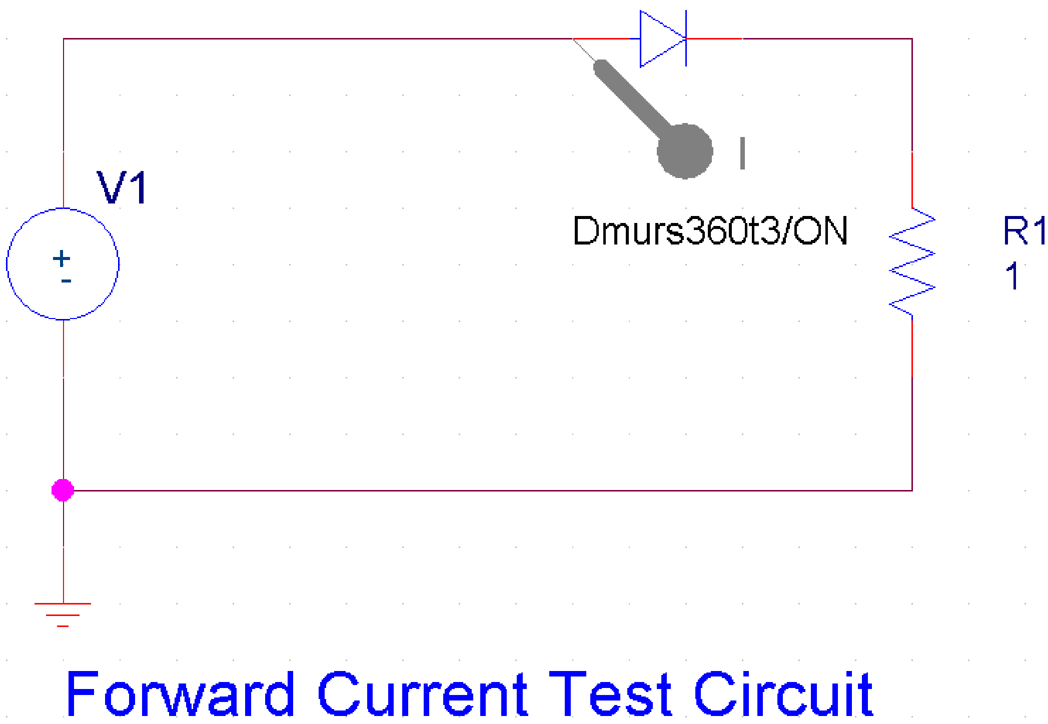

Figure 1: Circuit diagram in Allegro Design Entry CIS (Capture CIS)

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.MODEL Dmurs360t3/ON d
+IS=3e-07 RS=0.0493239 N=2.2 EG=0.5
+XTI=0.5 BV=600 IBV=1e-05 CJO=1.36534e-10
+VJ=0.781554 M=0.743776 FC=0.5 TT=5.54918e-08
+KF=0 AF=1
```

Figure 2: PSpice Model parameters

Do a DC sweep of above circuit, sweeping V1 linearly from 0.1 to 3.5 with an increment of 0.001. Fig. 3 shows the simulation results. Value of IS is 3e-07 and N is 2.2.

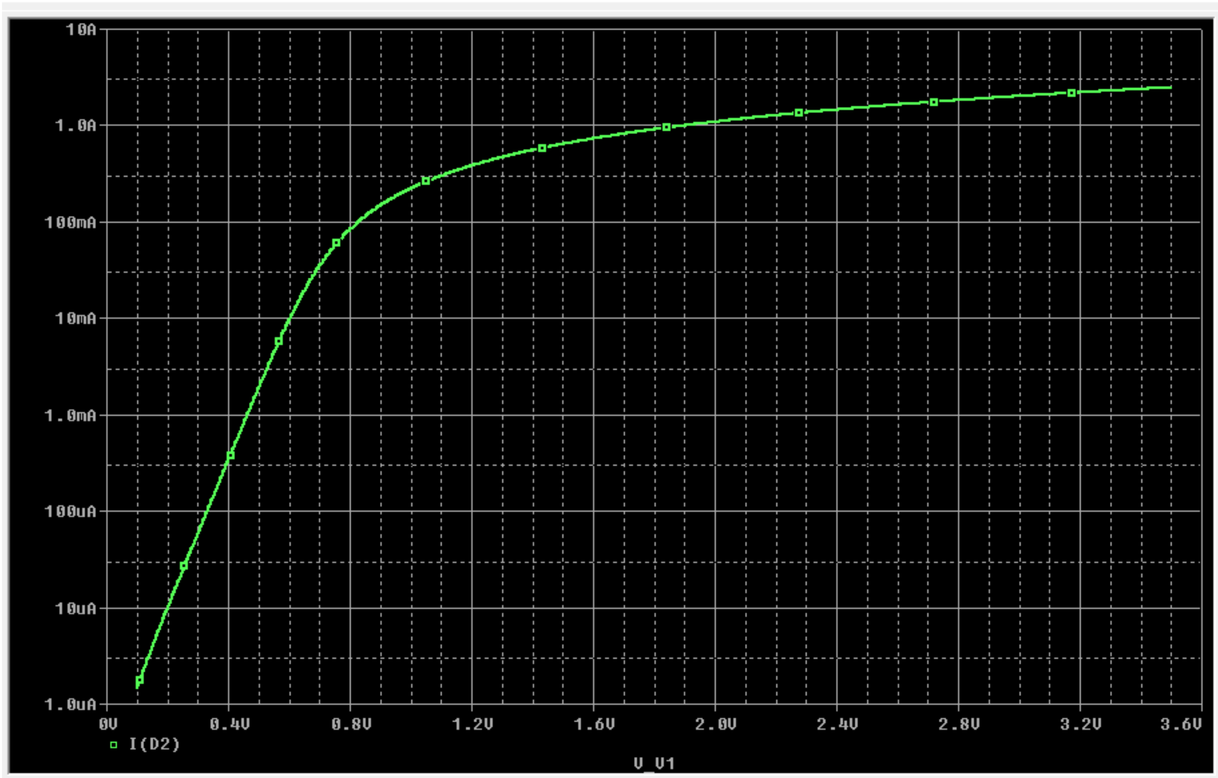

Figure 3: Simulation results – IS=3e-07, N=2.2

Effect of varying Parameter 'IS'

DC nested sweep is done to vary the Model parameter 'IS'. Secondary sweep is done for IS values of 3e-04, 3e-06 and 3e-08. Simulate profile 'IS_variation' in attached test case.

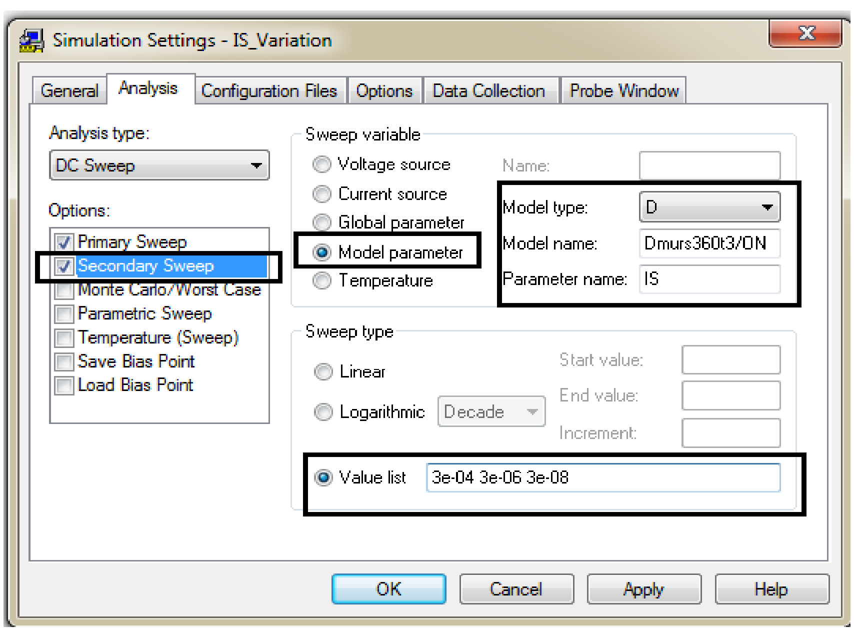

Figure 4: Simulation setting for DC nested sweep- varying model parameter IS

Fig. 5 shows the effect of varying IS parameter. You can see that as IS decreases, for the same Forward Current (I) we get greater Forward bias Voltage (V).

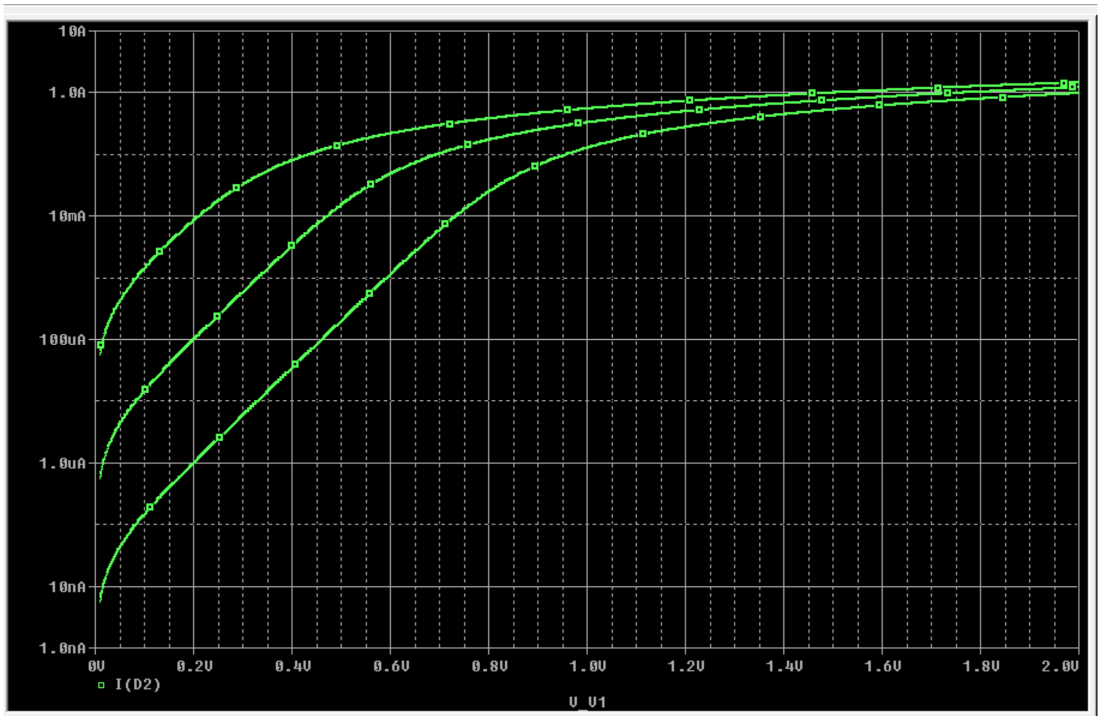

Figure 5: Effect of varying IS parameter value for a schottky diode

Effect of varying Parameter 'N'

DC nested sweep is done to vary the Model parameter 'N'. Secondary sweep is done for N values of 2.2, 2.4, 2.6, 2.8 and 3. Simulate profile 'N_variation' in attached test case.

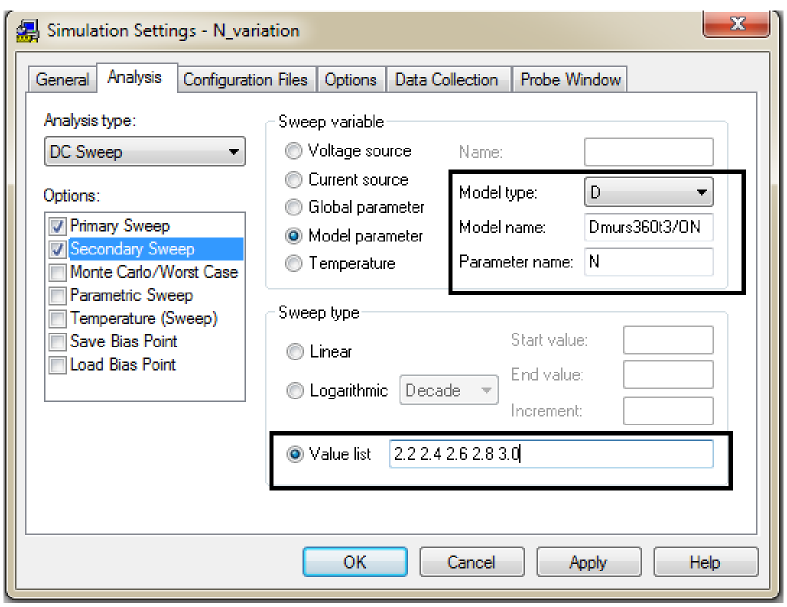

Figure 4A: Simulation setting for DC nested sweep- varying model parameter N

Fig. 7 shows the effect of varying N parameter. You can see that slope of the forward current changes with changing N.

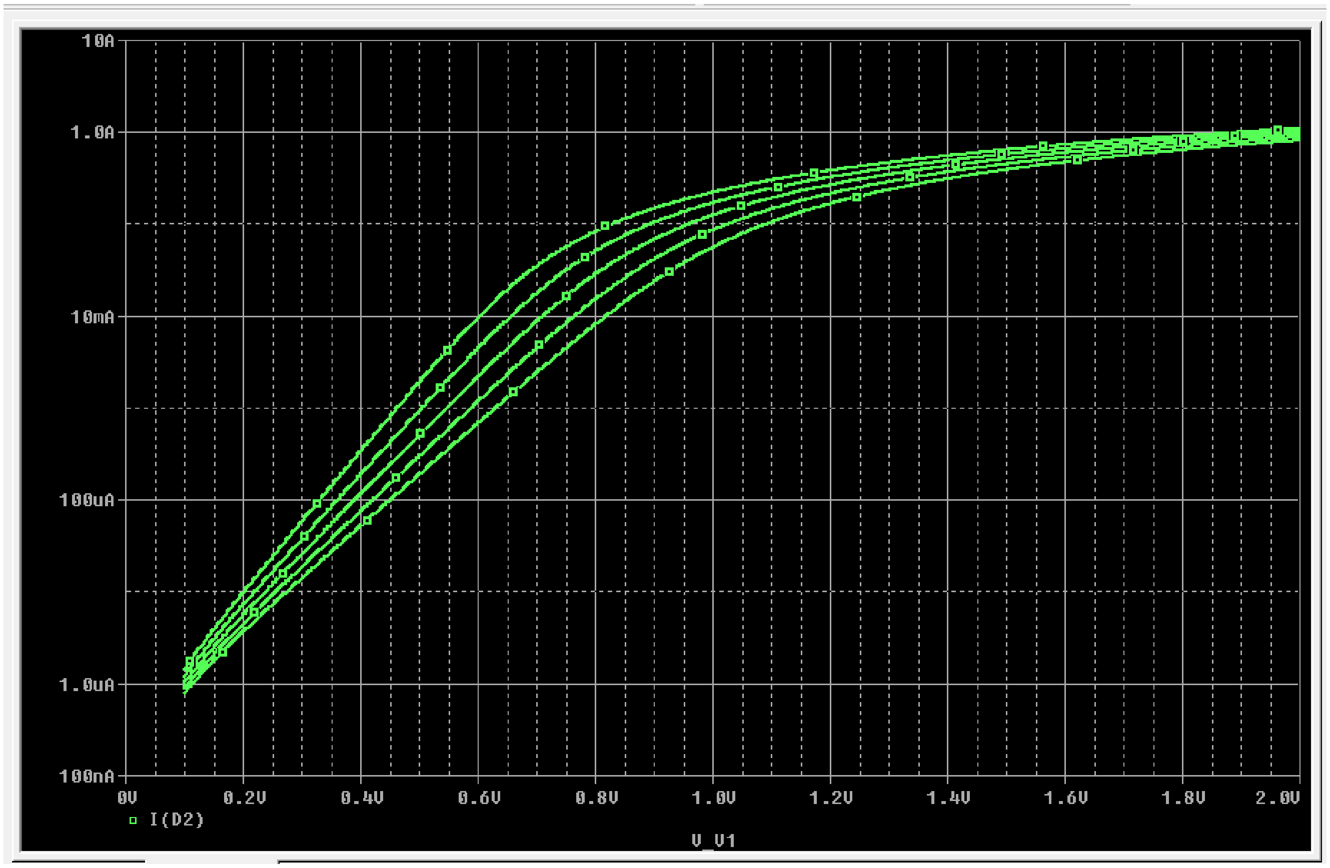

Figure 7: Effect of varying N parameter value for a schottky diode

References

[1] D. A. Hodges and H. G. Jackson, Analysis and Design of Digital Integrated Circuits, McGraw-Hill.