

Journal of the Arkansas Academy of Science

Volume 57

Article 30

2003

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Recommended Citation

Hossain, Maruf; Cilio, Edgar; McNutt, Ty R.; Lostetter, Alexander B.; and Mantooth, Alan H. (2003) "Parameter Extraction Software for Compact Diode Model," *Journal of the Arkansas Academy of Science*: Vol. 57 , Article 30.

Available at: <http://scholarworks.uark.edu/jaas/vol57/iss1/30>

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Parameter Extraction Software For Compact Diode Model

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Introduction

A reliable device model is crucial for the development and implementation of a circuit design. However, the creation of a high quality model requires a significant amount of time and money. The software package presented in this paper seeks to minimize the time and money invested in the realization of a high quality model for SiC Schottky, Merged PiN Schottky, and PiN Power diodes based on McNutt and Mantooth's Comprehensive SiC Diode model (McNutt et al., 2001, 2002). This software can be used for extraction of any other device model parameters with little modification (Ma et al., 1994; Krishna et al, 1995., Bai et al., 2001; Laux et al., 1991).

The software package is a user-friendly three-step algorithm that provides the user with efficient parameter extraction of the device. Initially, the *Slope Calculation* program determines the on-state resistance of the diode. Secondly, the ONSTMSR program carries out the on-state parameter calculation; and lastly, the TPE program performs the extraction of the transient parameters. All of the programs have been created with LabWindows/CVI with the exception of TPE, which utilizes LabWindows/CVI and Saber.

On-state Resistance Calculation.--*Slope Calculation* determines the on-state resistance of the diode. Measured data of the voltage across the diode and the current going through it have to be supplied in any type of data file. The *Slope Calculation* software analyzes the data, plots the voltage against the current, and displays the resulting curve as detailed in Fig. 2. In order to find the on-resistance, *Slope Calculation* allows the user to find the slope and inverse slope at any given point in the curve. The value obtained for the inverse slope is the on-state resistance of the diode. Figure 1 shows the output of a test run. *Slope Calculation* software allows the user to calculate the on-state resistance, for diodes and transistors. Figure 1 shows the calculation of slope for a transistor. From this figure it can be seen that the software has four check boxes at the top to allow the user to plot four different curves at the same time or any number of plots in which the user might be interested. The user can use

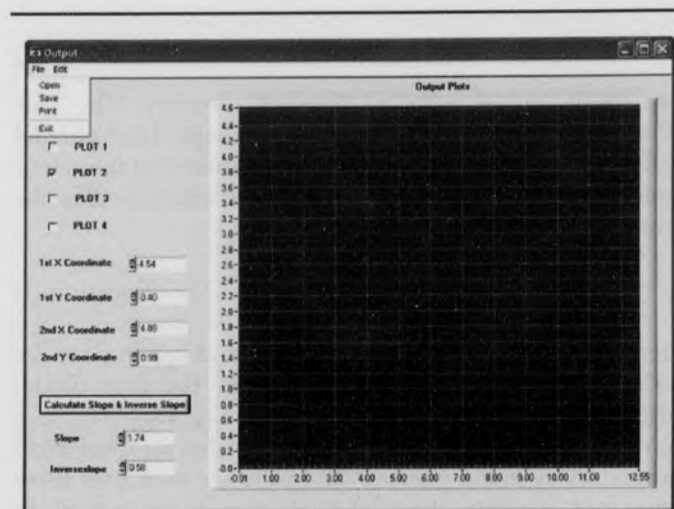


Fig. 1. Output from slope calculation software.

the two cursors to obtain two sets of data points. Those points are shown in their specific spaces called 1st X coordinate, 2nd X coordinate, 1st Y coordinate, and 2nd Y coordinate. The user is given the value of slope and inverse slope by pressing the calculate slope and inverse slope buttons. Notice that the best value for the on-state is obtained at the point where the curve starts increasing linearly. This value of resistance will be used by ONSTMSR.

On-state Parameter Calculation.--This software carries out the results of *Slope Calculation* software and uses this to extract the parameter of any diode. Figure 3 shows an on-

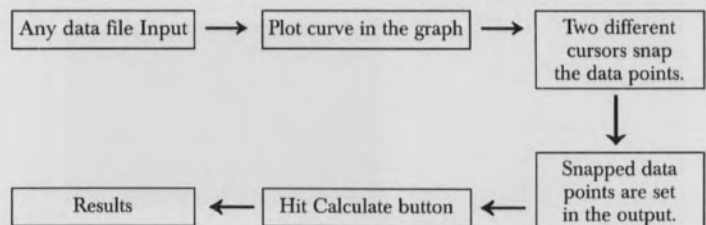


Fig. 2. Flow chart of slope calculation software.

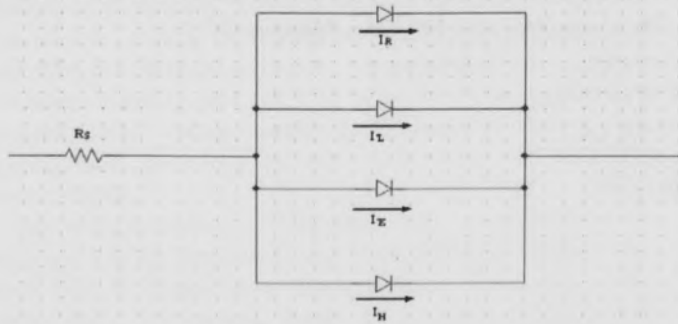


Fig. 3. On state diode model with no forward recovery.

state diode model with no forward recovery. The four different current components flow through four parallel diodes. This software extracts eight parameters of these four diodes. To extract the parameters, the software uses the formula

$$I = I_S (e^{v_j/n \cdot v_t}) \quad \text{Equation (1)}$$

where v_j is the voltage across the diode, and I_S and n are the model parameters and are different for the four diodes illustrated in Fig. 3. The parameters are I_{SR} , I_{SSL} , I_{SE} , I_{SH} , n_R , n_L , n_E , and n_H . The user inputs the value for these eight parameters as initial guesses. The software then uses these values and calculates the total diode current for each diode voltage using equation (1). These current and voltage values are then plotted in the graph. Whenever the plot of the sum of all currents and voltages matches the measured current and voltage plot, the user gets the parameters from the output shown in Fig. 4. This software also allows users to

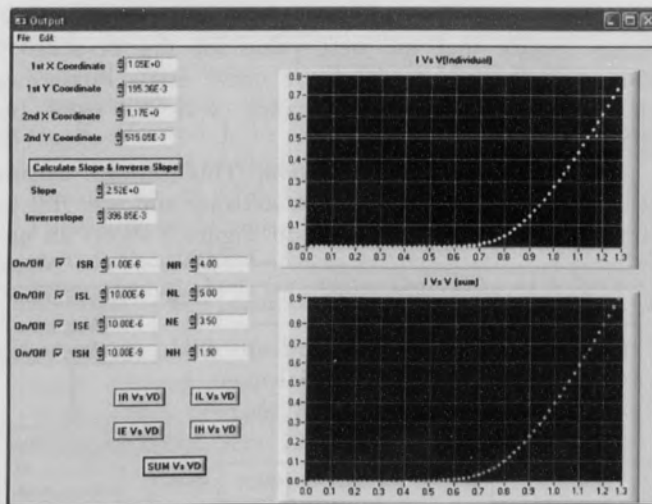


Fig. 4. Output from On-state parameter extraction software.

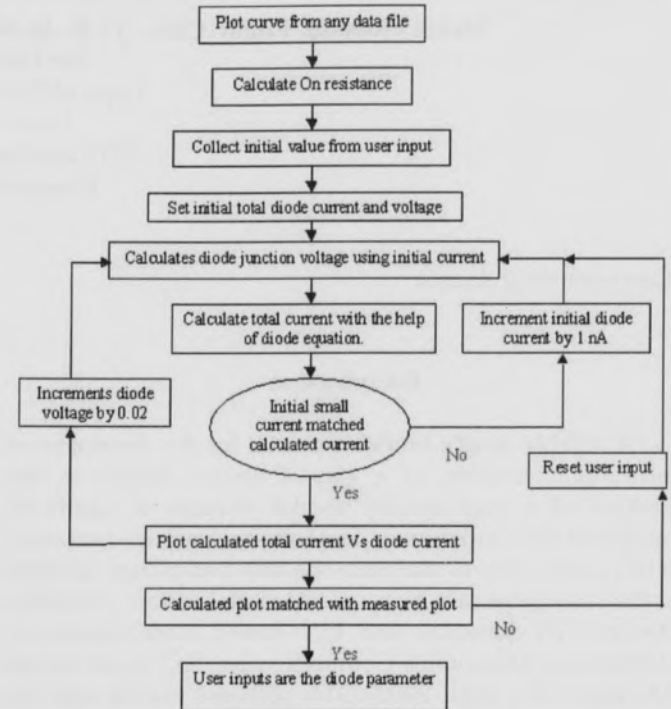


Fig. 5. Flow chart of on-state parameter calculation software.

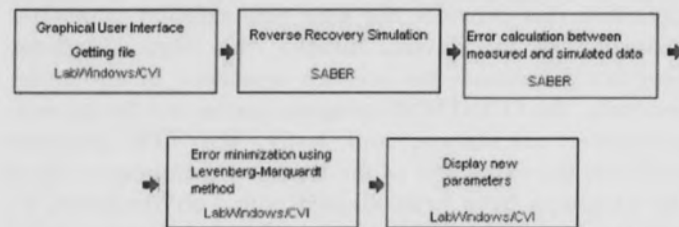


Fig. 6. Flow chart of transient parameter extraction software.

select the number of parallel diodes needed for their diode model. Figure 5 shows the flowchart for the on-state parameter calculation software. From the flowchart, it can be seen that any data file is plotted in the graph first. Then the slope calculation software calculates the on-resistance. On-resistance is the inverse slope of the curve. Next the user inputs some initial values for I_{SR} , I_{SSL} , I_{SE} , I_{SH} , n_R , n_L , n_E , and n_H to the specific box of the output. The software collects that input and uses it to calculate the diode current by Equation (1). In the process, the software calculates the diode junction voltage using the initial diode currents. After each calculation, the software plots one point of current and voltage. After each plot, the total diode voltage (V_D) is incremented by 0.02V. After plotting the entire curve, the software compares the computed plot with the experimental plot. If these two plots match, the user input values are determined to be the model parameters. Otherwise, the user

changes the input value, and the process is repeated.

Transient Parameters Extraction.--TPE extracts the parameter of the diode during the reverse recovery. This software is still under development. Nevertheless, the outline of this routine has been determined and will be implemented as described in this section. LabWindows/CVI delivers the user-interface component of the program. Initially, measured transient data of a diode reverse recovery circuit is provided to Saber. Saber will simulate the reverse recovery circuit and compare it to the measured data. Using the Levenberg-Marquardt (McNutt, 2002) optimization routine, the difference between the measured data and the simulated data will be minimized. After the minimization, the extraction software will provide the new set of parameters. During the entire process, Saber will work in batch mode. LabWindows/CVI will communicate with Saber and export parameter values and display them. Figure 6 describes the data flow manipulation that TPE will perform.

Conclusions

Parameter extraction software has been presented in this paper. This software can accurately model SiC Schottky, Merged PiN Schottky, and PiN Power diodes based on McNutt and Mantooth's Comprehensive SiC Diode model (McNutt, 2001). The parameter extraction is carried out in three different phases: on-state resistance extraction, on-state parameter extraction, and transient parameter extraction. The software presented here provides the user a friendly environment, while delivering accurate, reliable parameters that can be use for circuit design in differing applications.

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