

SEMIS – An Interactive Tool for Selecting the Right Device for Your Application

SEMIS is a web-based simulation tool available through the ABB Semiconductors webpage. It helps its users to evaluate the performance of ABB semiconductor products for common converter applications. The tool is compatible with all web browsers.

It is user friendly and allows for quick results through simple steps.

In this way, a preliminary component selection is possible. ABB provides the semiconductor models for simulation based on data sheet values. This allows engineers to get reliable results on the performance of ABB products.

By Vasilis Kappatos, Anup Kavi and Evgeny Tsyplakov, ABB Switzerland Ltd., Semiconductors and Madhan Mohan, ABB Global Industries and Services Ltd.

Semiconductors Simulation (SEMIS) is a web-based tool developed by ABB, which is using the PLECS software. It is intended to assist engineers at an early design phase in selecting the semiconductor device best fitting their application in respect to thermal losses. For a system designer it is important to choose the appropriate semiconductor according to the parameters of the application without having to spend too much time and effort.

SEMIS offers a user friendly interface for parameter set up and provides a comprehensive steady state analysis for the selected ABB semiconductors. Simulation results are obtained in both graphical and arithmetical form. Time based graphs such as semiconductor current, output voltage, output current and temperatures are presented. The arithmetical results are listed in tables and among others indicate the estimated semiconductor switching and conduction losses as well as the junction temperatures. Input and output values for voltage and current are also available. Multiple device selection and simulation for the same conditions is possible for direct product comparison. Figure 1 provides an overview of SEMIS' interface.



Figure 1: SEMIS interface overview

Features and functionality

Converter models

SEMIS aims to include the most common converter applications where the ABB semiconductor products are deployed. The first beta version is already available at the ABB Semiconductors website. It is a 2-level Voltage Source Inverter (VSI) feeding an RL-load. ABB HiPak IGBT modules can be selected for the simulation from a drop list. In the near future new circuits will be introduced for 3-level VSI with IGBT and IGCT based converters, which are currently under development (Figure 2).

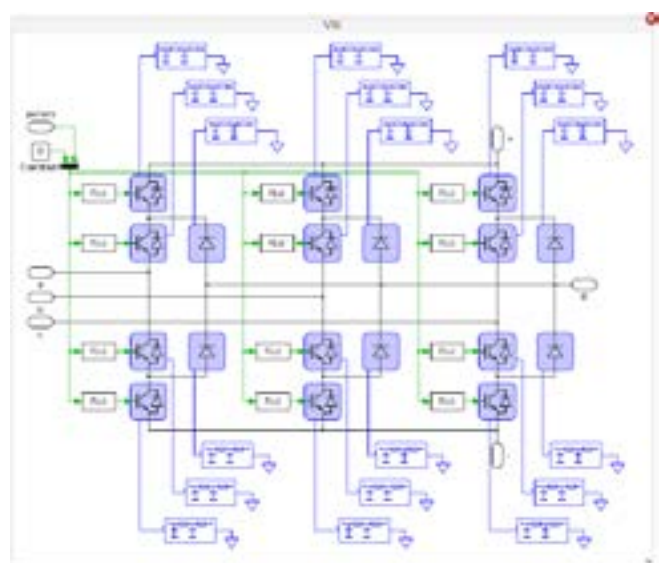


Figure 2: Upcoming 3-level inverter SEMIS thermal model

Thermal Model

In order to calculate the thermal behavior and junction temperatures, an accurate thermal description of the simulated semiconductor is needed. The thermal chain network considers the different packaging concepts (modules or press-pack products). Figure 3 shows the equivalent thermal model for IGBT modules available on the beta version. The values that are attributed for thermal resistance (R_{th}) correspond to the data sheet parameters of the selected product.

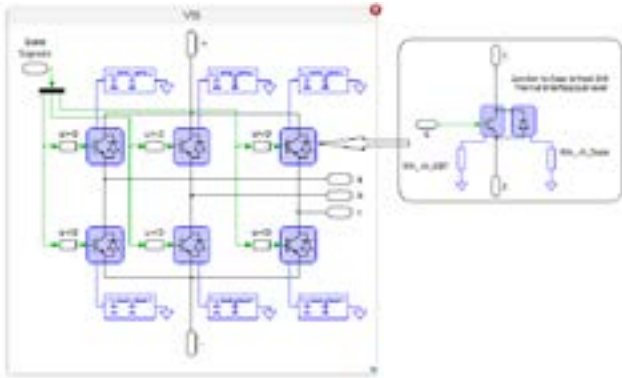


Figure 3: Converter and semiconductor thermal model

In SEMIS the thermal resistance between heat sink and ambient temperature $R_{th}(h-a)$ is provided for a single switch per heat-sink position, therefore the user needs to properly adjust the value of the thermal resistance of the selected heat sink to match the amount of switches in the semiconductor package. For example, a heat sink with an $R_{th}(h-a)$ of 10 K/kW is used with a HiPak1 IGBT module. This module consists of two switches as shown in Figure 4.

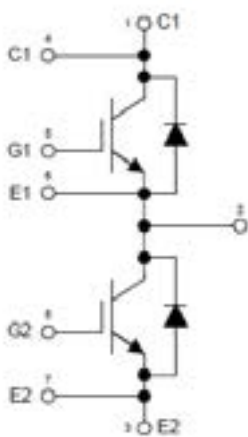


Figure 4: Dual switch IGBT module HiPak1

Each IGBT switch will get only half of the heat sink property and the effective R_{th} should be doubled, i.e. 20 K/kW. In other words the user needs to multiply the heat sink value $R_{th}(h-a)$ with a factor of 2 to account for each switch separately. For ABB's HiPak IGBTs the possible electrical configurations are: single switch module, dual switch module, half bridge and chopper module. The above consideration applies to the dual and half bridge modules. Moreover, if multiple modules are put in parallel to the same heat sink then the same consideration needs to be accounted. Figure 5 shows how a dual IGBT switch in a half bridge configuration is modelled in SEMIS.

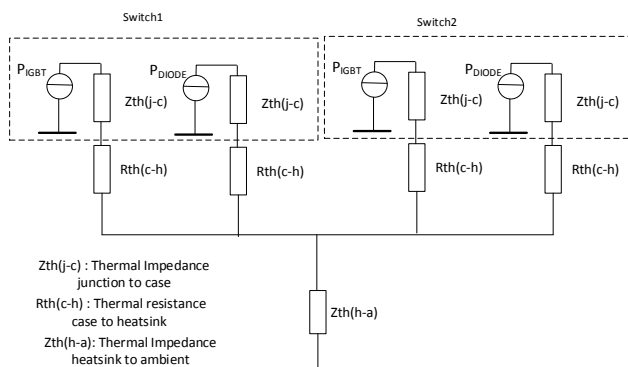


Figure 5: Dual switch IGBT thermal model

Working with SEMIS

SEMIS provides to the user a number of inputs for setting the conditions of the simulation similar to the actual application as shown in Figure 1. Electrical values for the load and control parameters for the switching of the semiconductor elements are such examples. The system designer can set optionally a desired Real Power or phase current rating as well as a Power Factor (PF) for the load on the AC side. For the control part, different Pulse Width Modulation (PWM) strategies are provided. The selection is done easily by clicking the various sections on the circuit and filling in the fields. The semiconductor selection is short listed depending on the selected blocking voltage rating and desired electrical configuration (e.g. single switch etc.). Figure 6 shows a functional flowchart of SEMIS.

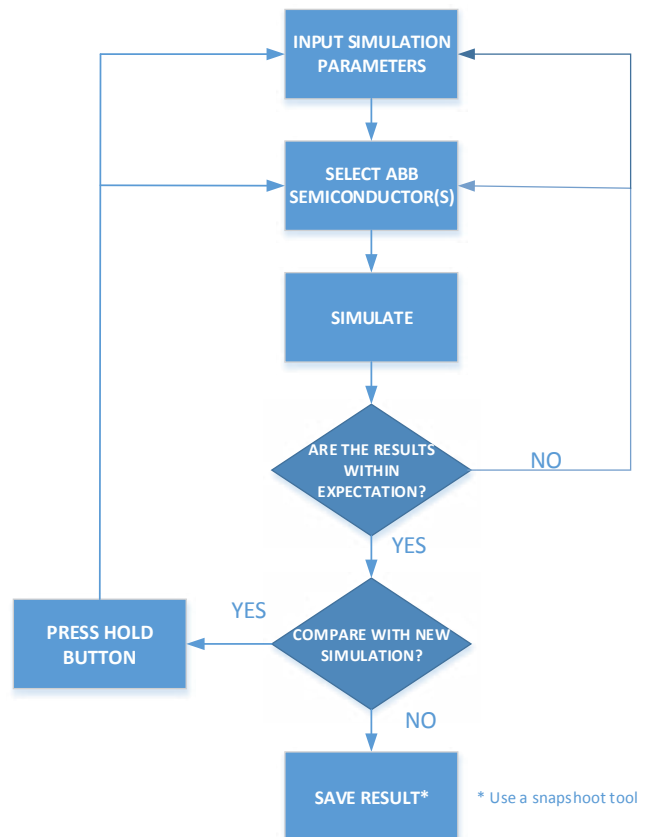


Figure 6: SEMIS functional flowchart

Output results

SEMIS simulation results are time based graphs and tables with arithmetical values. The semiconductor losses are analytically calculated as switching and conduction losses. They are also presented on converter level, accounting for the total losses on all elements. Having the input power also available in the results, SEMIS calculates the total semiconductor losses as percentage of the absorbed power from the converter. In this way, the user gets an indication of the impact of the semiconductor selection in the overall efficiency of the converter. The semiconductor junction temperature T_j is another parameter included in the results allowing for assessing the thermal limits of operation. If permissible limits are exceeded for the junction temperature T_j or if the applied voltage is out of the recommended limits of the product to be simulated, then alert messages are prompted. Figure 7 shows the different types of representations for the simulation results in the currently available beta version.

As mentioned, SEMIS is based on the PLECS software. Subsequently it adopts the ideal switch model for the semiconductor behavior where the losses are calculated through a look up table based on the ABB data sheet specifications for switching and conduction losses. Figure 8 shows this concept (courtesy of PLEXIM).



Figure 7: SEMIS simulation results

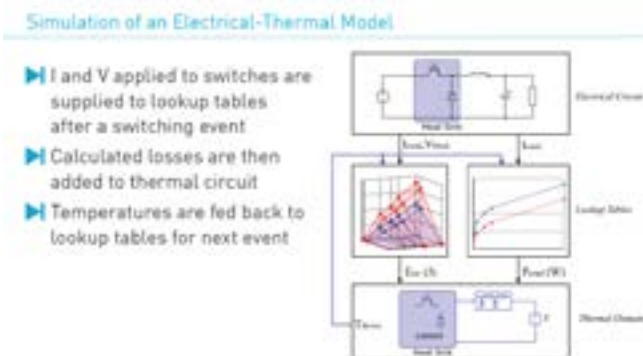
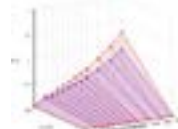


Figure 8: Look up table method (courtesy of PLEXIM)

ABB Device Models

SEMIS uses the look up tables, which have been created from the ABB Semiconductor's data sheets. For each product available for simulation, a dedicated look up table has been prepared for referencing the switching and conduction losses. These files are in the XML format and are available for downloading from the ABB Semiconductors website. An example on the content of such a look up table is shown in Figure 9.

Turn-On Losses



Thermal Impedance

	1	2	3	4
0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000

Figure 9: Indicative data in device look up table

SEMIS next steps

The SEMIS simulation tool has been initially introduced through a beta version, which is to be updated to the final version soon. The basic platform will be the same and it will only differentiate in the sense that additional features will be included such as allowing for simulating an active load.

Upcoming converter models will include:

- Thermal simulation of a 3-level VSC with ABB HiPak IGBTs
- Thermal simulation of 3-level VSC with ABB asymmetric IGCTs
- More ABB semiconductor models will also become available in the XML format from the ABB website for PLECS users.

To start using SEMIS and downloading the available product models visit the ABB Semiconductors webpage:

www.abb.com/semiconductors