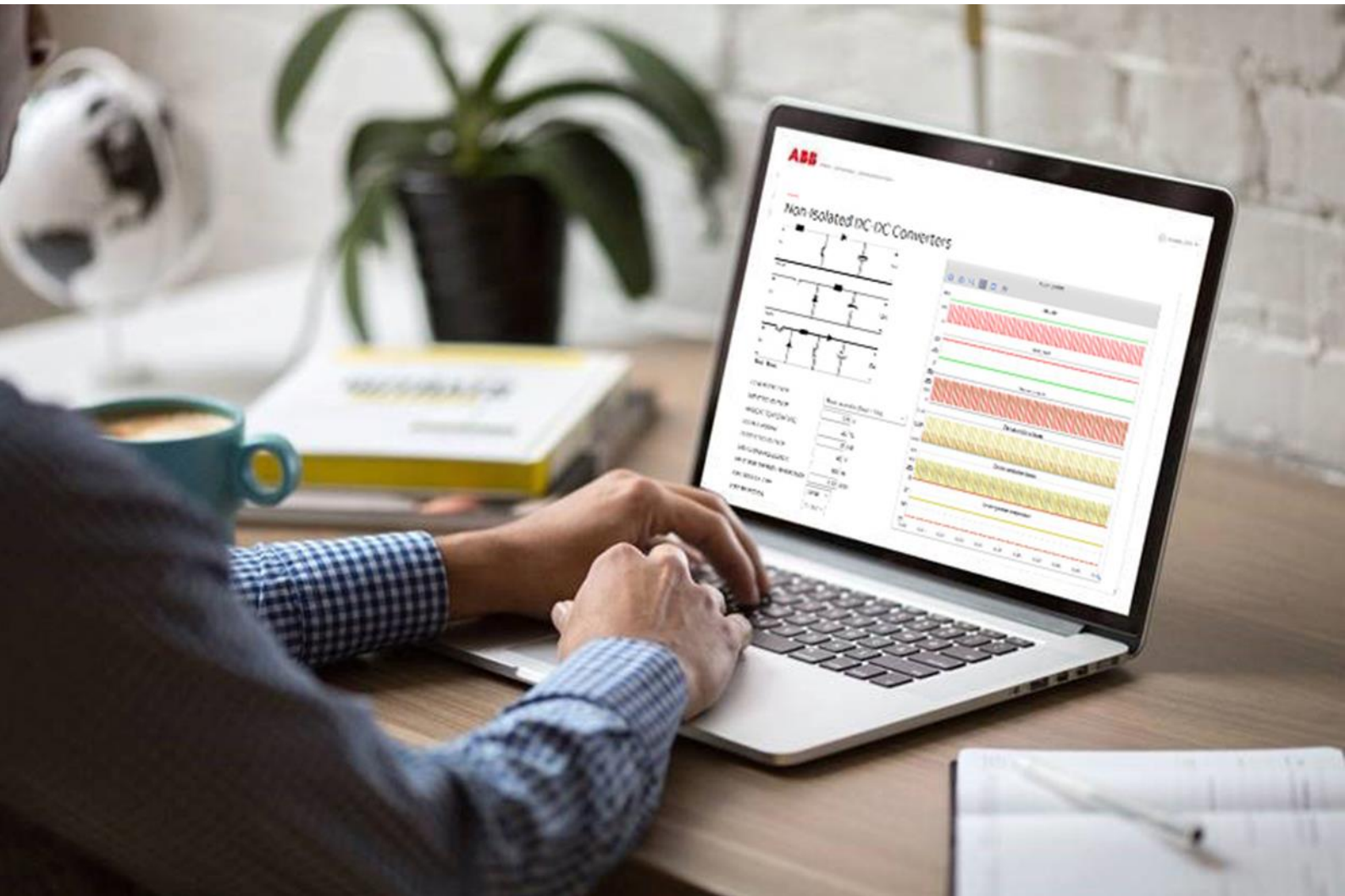
SEMIS Simulation Tool
Non-Isolated DC-DC Converter with IGBT & Diode
User manual



INTRODUCTION

SEMIS is a web-based semiconductor simulation tool providing a thermal calculation of the semiconductor losses for common converter circuits. The simulation simplifies significantly the selection of the switching device and enables the optimal selection of semiconductors for further investigations.

The SEMIS Simulation Tool is a user-friendly online application found on ABB Semiconductors website www.abb.com/semiconductors/semis

SEMIS users select from a substantial selection of topologies. By assigning the circuit parameters and selecting the desired switching device, multiple ABB products can be simulated at the same time. Once a simulation is run, SEMIS returns comprehensive results on semiconductor losses as well as on the electrical parameters in the input and output of the circuit. The results are shown in both graphical (waveforms) and numerical (tables) way.

The SEMIS tool is based on the PLECS simulation software. PLECS users can download our product models in the XML file format from the ABB Semiconductors website and use them for their own simulations. For more specific topologies ABB offers customized converter simulations for non-standard topologies with PLECS simulation software on a project basis.

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1. NON ISOLATED DC-DC CONVERTER MODELS

Non-Isolated DC-DC converters are widely used in battery charging and DC motor drive applications. In general, the output of an AC-DC converter is a fluctuating DC voltage due to the changes in the line voltage magnitude. DC-DC converters are used to convert the unregulated DC input into a controlled DC output at the desired voltage level. These converters can be categorized as Non-Isolated and Isolated types. The difference lies in the fact that isolated converters use high-frequency transformers. This manual discusses only the Non-Isolated type of converters.

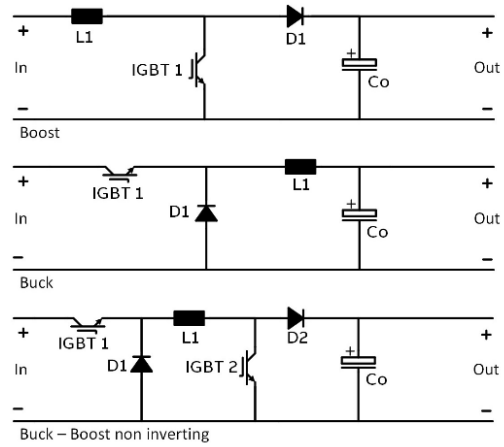
ABB offers the following Non-Isolated DC-DC converters for thermal analysis simulation in non-Isolated DC-DC converters:

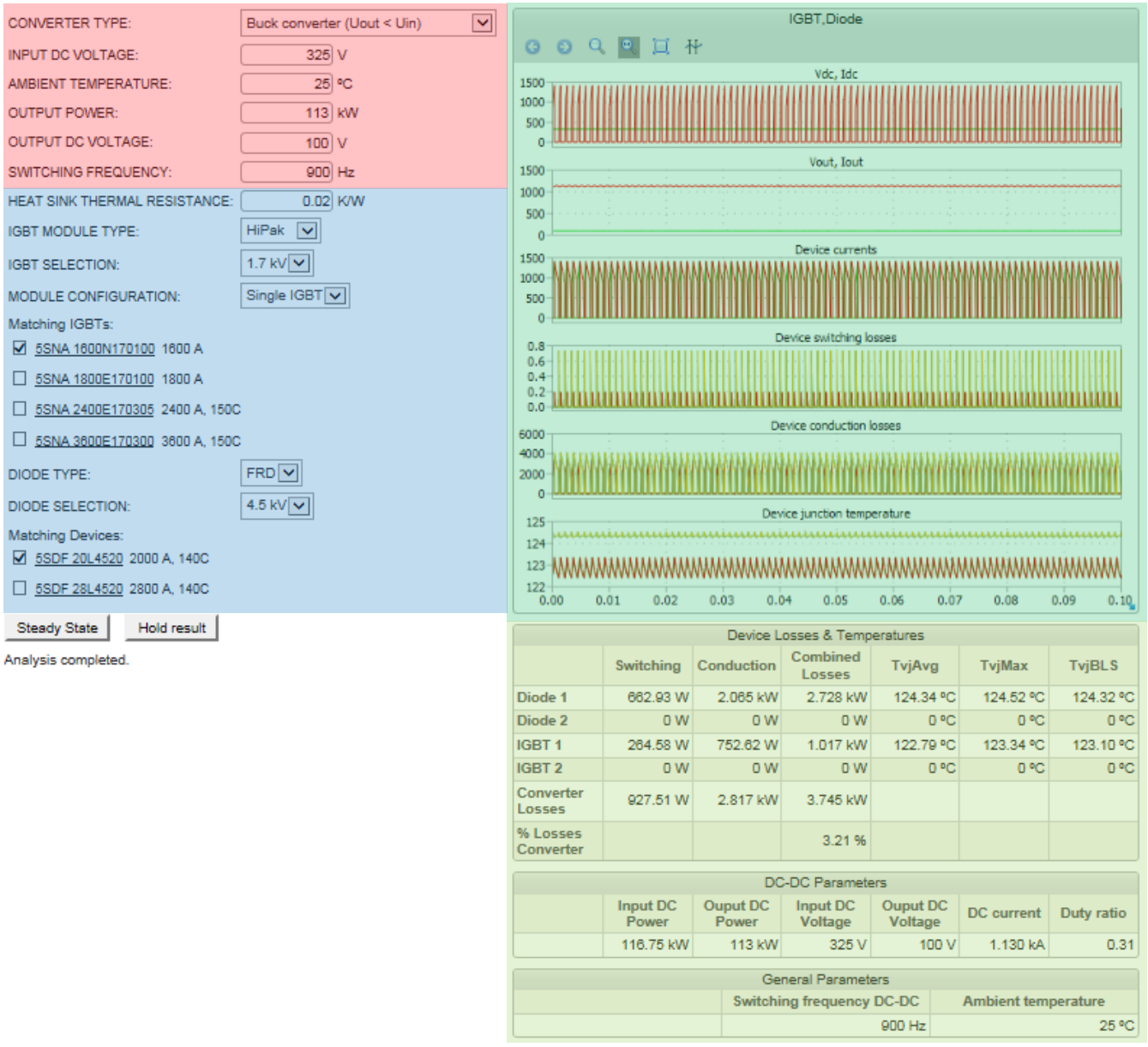
- Non-Isolated Buck converter (Uout < Uin)
- Non-Isolated Boost converter (Uout > Uin)
- Non-Isolated Buck-Boost converter (Uout <> Uin)

Furthermore, ABB offers the following Isolated DC-DC converters for thermal analysis simulation

- Isolated Flyback converter (Derived from Buck-Boost converter)
- Isolated Forward converter (Derived from step-down converter)
- Isolated Push-Pull converter
- Isolated Half-Bridge converter
- Isolated Full-Bridge converter

2. OVERVIEW





Device Losses & Temperatures						
	Switching	Conduction	Combined Losses	TvjAvg	TvjMax	TvjBLS
Diode 1	662.93 W	2.065 kW	2.728 kW	124.34 °C	124.52 °C	124.32 °C
Diode 2	0 W	0 W	0 W	0 °C	0 °C	0 °C
IGBT 1	264.58 W	752.62 W	1.017 kW	122.79 °C	123.34 °C	123.10 °C
IGBT 2	0 W	0 W	0 W	0 °C	0 °C	0 °C
Converter Losses	927.51 W	2.817 kW	3.745 kW			
% Losses Converter			3.21 %			

DC-DC Parameters						
	Input DC Power	Ouput DC Power	Input DC Voltage	Ouput DC Voltage	DC current	Duty ratio
	116.75 kW	113 kW	325 V	100 V	1.130 kA	0.31

General Parameters		
	Switching frequency DC-DC	Ambient temperature
	900 Hz	25 °C

Figure 1: Page layout of Non-Isolated DC-DC Converters in the ABB semiconductors website.

Converter settings

IGBT, Diode selection

Results graphs

Results tables

3. SIMULATION SETTINGS

3.1 Circuit parameters

3.1.1 Converter settings

The user can choose between the 3 types of converters here. For the case when the output voltage required is less than the input voltage, the buck converter can be chosen. If the output must be stepped up, the Boost converter can be chosen. To do either step-up or step-down operation, the buck-boost converter can be chosen.

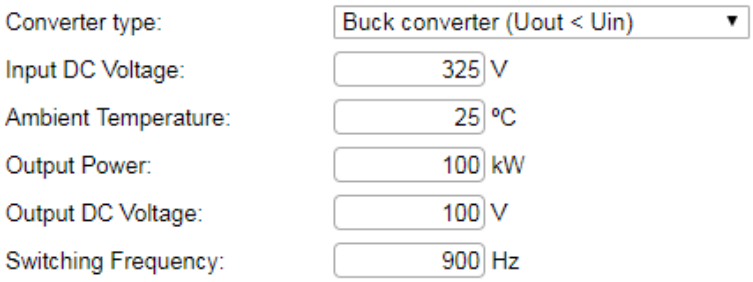


Figure 2 Converter settings input blocks

CONVERTER TYPE	Converter is operated as Buck, Boost or Buck-Boost mode	Selection
INPUT DC VOLTAGE	Input DC Voltage of the converter	Range 10 .. 1500 V
AMBIENT TEMPERATURE	Ambient Temperature	Range -25 .. 90 ºC
OUTPUT POWER	Power demand of load	Range 1 .. 150 kW
OUTPUT DC VOLTAGE	The constant DC output voltage on load	Range 30 .. 1000V
SWITCHING FREQUENCY	Frequency at which the IGBT is turned ON/OFF	Range 200 .. 10000 Hz

3.2 IGBT Settings

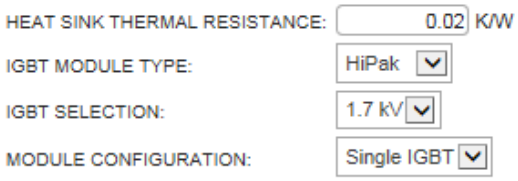


Figure 3 Thermal settings and IGBT selection

Heat Sink Thermal Resistance	Definition of thermal resistance of the cooling system applied.	Range 0.0001 .. 0.5 K/W
Remark:	Include the thermal resistance of case to heatsink to ensure correct simulation results. The value entered is attributed to each individual switch shown in the electrical configuration schematic of the IGBT module datasheet. Therefore, if the user selects a dual switch module, the Rth should be multiplied with a factor of 2 to differentiate from the single switch case, if the same heatsink would be used in both cases. The selected Rth is also accounted for the diode position for which same consideration applies for its electrical configuration.	
IGBT module type	Select housing type of IGBT for filtering	Selection
IGBT selection	Select voltage class of IGBT for filtering	Selection
Module configuration	Select topology of IGBT module for filtering	Selection

3.2.1 Matching IGBTs

Once the previous IGBT properties are selected the matching IGBT options appear. By clicking on the product code name the user may access the datasheet from ABB website.

Figure 4 Matching IGBTs for selection

Users can select the desired IGBTs and Diodes product names for simulation.

Up to 4 elements can be selected simultaneously and simulated. If one or more elements produce results exceeding the safe operating area (SOA) then they will return no results. In this case, the user should run the simulation again with changed parameters and/or product selection to enable results within SOA operating conditions.

3.2.2 Matching Diodes

Once the IGBT's are selected, the user can choose between Chopper diodes or FRDs based on the choice in the MODULE CONFIGURATION of section 3.2.1. Chopper diodes are populated in this dropdown in addition to the FRDs if Chopper is chosen in MODULE CONFIGURATION. After choosing the DIODE TYPE, the matching Diodes can be selected according to the voltage and current ratings. By clicking on the product code name the user may access the datasheet from the ABB website.

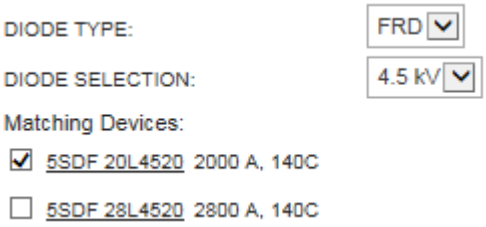


Figure 5 Matching IGBTs and Diodes for selection

3.3 Selection of articles / Start simulation

To simulate one or more articles, select from the list by activating the checkbox

Simulate	Starts the simulation
The progress of the simulation is shown with the number of calculated Jacobian.	
Abort	Stops the simulation; No results generated
Hold results	To compare multiple simulations, results can be held for later viewing. By selecting the button, the result are hold after the simulation has finalized for later comparison with succeeding simulations

Figure 6 Start of simulation

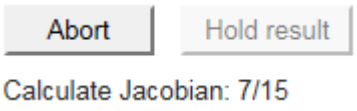


Figure 7 Simulation progress and termination

4. SIMULATION RESULTS

The simulation results are displayed in two different ways for all selected articles simulated.

To hide curves of selected articles, unselect in the table “Results History”

Graphical results - Waveforms

Visual analysis of waveforms for fast and efficient detection of most significant sources

Numerical / Tabular results

Numeric indication of all simulations values for direct comparison

4.1 Graphical Output – Waveforms

When the simulation finishes the semiconductor and DC side waveforms are shown as follows:

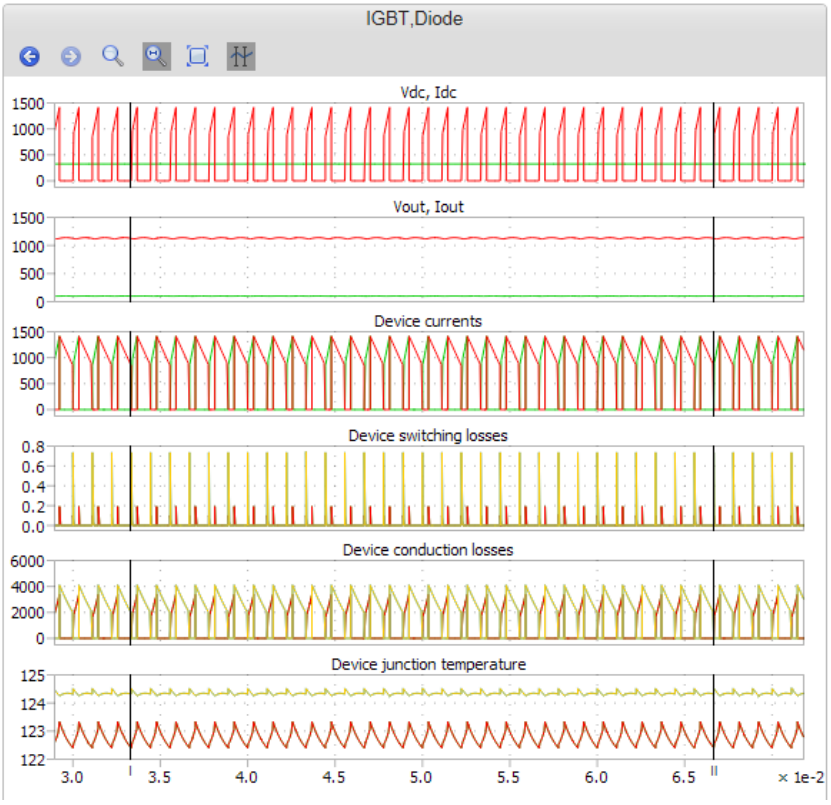
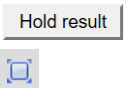


Figure 8 Graphical results of Buck converter

4.1.1 Control

For an indication of values within the graph, a cursor can be activated to show curve values in a table.

Sections of graphs can be zoomed in by click, move and release mouse button for more details



Hide selectively waveforms of products

Rest zoom to full view

Activate cursors and to show parameter values table according to the cursor position

Zoom selectable rectangle

Zoom horizontal or vertical band

4.1.2 Parameters values indication

Tabular indication of graphical waveforms values according to the cursor position selected. Values are indicated for each parameter Color of the waveform is indicated. The third column shows the difference between the two cursors per parameter.

Name	Cursor 1	Cursor 2	Delta
Time	0.033333	0.066667	0.033333
Vdc, Idc			
Source voltage	325.0	325.0	0.000
Source current	846.4	846.4	1.705e-11
Vout, Iout			
Resistor voltage	99.44	99.44	3.411e-13
Resistor current	1124	1124	3.865e-12
Device currents			
IGBT currents	846.4	846.4	1.705e-11
Diode currents	0.000	0.000	0.000
Device switching losses			
IGBT switching losses:1	0.1021	0.1021	3.458e-12
IGBT switching losses:2	0.1021	0.1021	3.458e-12
Diode switching losses:1	0.7366	0.7366	-5.307e-14
Diode switching losses:2	0.7366	0.7366	-5.307e-14
Device conduction losses			
IGBT conduction losses:1	1586	1586	1.330e-8
IGBT conduction losses:2	1586	1586	1.330e-8
Diode conduction losses:1	0.000	0.000	0.000
Diode conduction losses:2	0.000	0.000	0.000
Device junction temperature			
IGBT junction temperature:1	122.5	122.5	1.106e-8
IGBT junction temperature:2	122.5	122.5	1.106e-8
Diode junction temperature:1	124.5	124.5	4.029e-11
Diode junction temperature:2	124.5	124.5	4.029e-11

Figure 9 Tabular indication of cursor position graph values

Remark:
The numerical values of Voltage/Current at the position of respective cursors are shown in the Table. The numerical values of IGBT current/Diode Current along with their Switching loss, Conduction loss and Junction temperatures at the position of respective cursors are shown in the Table.

4.2 Numerical / Tabular results

The following parameters are given in a tabular format in multiple sections. All calculations and simulation results are based on datasheet typical values.

All types of semiconductor losses are calculated according to the PLEXIM PLECS software principle through the reference to the lookup table and linear interpolation of the actual device current, voltage and junction temperature.

The indicated elements (numbered) in the table correspond to the different semiconductor devices in the DC-DC converters as shown in 2.

As converter losses, the aggregated losses in all devices are accounted for. The buck and boost converters have 2 devices each (an IGBT and a diode), so the losses and other parameters for IGBT2 and Diode2 are shown as zero. These values will be non-zero in the case of the Buck-Boost converter as it has 2 IGBTS and 2 Diodes.

Device Losses & Temperatures						
	Switching	Conduction	Combined Losses	TvjAvg	TvjMax	TvjBLS
Diode 1	662.93 W	2.065 kW	2.728 kW	124.34 °C	124.52 °C	124.32 °C
Diode 2	0 W	0 W	0 W	0 °C	0 °C	0 °C
IGBT 1	264.58 W	752.62 W	1.017 kW	122.79 °C	123.34 °C	123.10 °C
IGBT 2	0 W	0 W	0 W	0 °C	0 °C	0 °C
Converter Losses	927.51 W	2.817 kW	3.745 kW			
% Losses Converter			3.21 %			

Figure 10 Device Losses & Temperatures

Switching Loss	Single IGBT or Diode Losses during turn on and turn off events (dynamic)
Conduction loss	Single IGBT or Diode Losses during on state (static)
Combined losses	Sum of single IGBT or Diode switching and conduction loss.
Converter losses	Sum of all IGBT and Diode losses
% Losses	Defined as the (%) ratio of calculated combined converter losses with respect to the total output power and losses i.e., total apparent power flow.
Junction Temperature Avg	Junction temperature average during the simulation period
Junction Temperature Max	Maximum junction temperature during the simulation period
Junction Temperature BLS	Junction temperature at the time point just before the switching, after which the maximum junction temperature is achieved

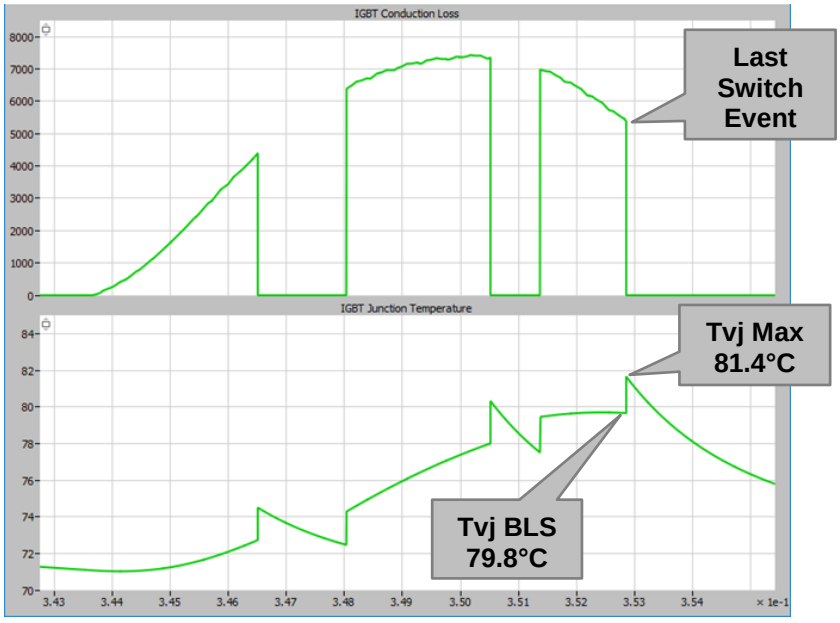


Figure 11 Definition of Tvj before the last switch

DC-DC parameters

DC-DC Parameters						
	Input DC Power	Ouput DC Power	Input DC Voltage	Ouput DC Voltage	DC current	Duty ratio
	103.21 kW	100 kW	325 V	100 V	1000 A	0.31

Figure 12 Converter DC-DC Parameters

Input DC power	Active power supplied by the source including the thermal losses
Output DC power	Load power set by the user as explained in section 3.1.1.
Input DC voltage	DC voltage supplied at the input of the converter (Usually the output of a rectifier)
Output DC voltage	DC voltage output set by the user as explained in section 3.1.1.
DC Current	DC current is drawn by the load at the power set by the user.
Duty ratio	Duty ratio is calculated and displayed as per section 6.

General parameters

General Parameters		
	Switching frequency DC-DC	**Ambient temperature**
	900 Hz	25 °C

Figure 13 General Parameters

Switching Freq.	According to the definition
Ambient Temp.	According to the definition

5. ALERTS & FEATURES

The system verifies results and generated warning messages in case of limits are violated.

Parameter	Junction temperature
Verification	If the maximum junction temperature of IGBT and/or diode is above its maximum junction temperature limit, the alert message is displayed
Warning message	IGBT temperature out of the safe operating area

Parameter	DC Blocking voltage
Verification	If the voltage rating of the IGBT and/or diode is less than the DC blocking voltage, the alert message is displayed
Warning message	For the selected device voltage rating, the operating range of the device is displayed

Parameter	Duty ratio
Verification	Range of Duty ratio is 0 to 1. If the duty ratio is out of these limits and an alert message is displayed
Warning message(s)	Output voltage should be less than the input voltage for Buck operation Output voltage should be greater than the input voltage for Boost operation

6. APPLIED CALCULATIONS

6.1 Input Parameter Definitions

V_{DC}	Input DC voltage
V_{OUT}	Output DC voltage

6.2 Duty ratio of the converter

The following calculations have been used in the model to calculate the duty ratio:

For Buck converter: $D = \frac{V_{OUT}}{V_{DC}}$

For Boost converter: $D = 1 - \frac{V_{DC}}{V_{OUT}}$

For Buck-Boost converter $D = \frac{V_{OUT}}{V_{DC}+V_{OUT}}$

6.3 Load side

The resistive load is formulated based on the following equations for each of the converters:

P_{OUT}	DC power / real power at the load
D	Duty cycle as per section 6.2
Rout	Resistive load of the converter

For Buck converter: $R_{OUT} = \frac{D^2 * V_{DC}^2}{P_{OUT}}$

For Boost converter: $R_{OUT} = \frac{1}{(1-D)^2} * \frac{V_{DC}^2}{P_{OUT}}$

For Buck-Boost converter: $R_{OUT} = \frac{D^2}{(1-D)^2} * \frac{V_{DC}^2}{P_{OUT}}$

7. VALIDATION OF PLECS RESULTS WITH PSCAD

To ensure supplied simulation results are reliable, each of the Non-Isolated DC-DC converter model is validated with another simulation platform or compared to real measurement data.

The circuit topology is reconstructed in PSCAD to validate the results obtained from the SEMIS web simulation tool. The objective of the work is to develop an open-loop, Buck, Boost and Buck-Boost converter models with loss and temperature estimation in PSCAD and to validate the steady-state results obtained through SEMIS-22 web simulation model using pulse-width modulation.

The IGBT and Diode XML data which was created from the device datasheets for SEMIS simulations is modified to individual .txt files for switch turn-on energy (Eon), switch turn-off energy (Eoff), diode reverse recovery energy (Erec), on-state voltage drop of IGBT (Vt), and on state voltage drop of diode (Vd) at different temperatures, to make the data readable in PSCAD.

The PSCAD and SEMIS circuit models are made as identical as possible to prevent any errors in validation due to the dissimilarities. Junction to Case and Case to Heat sink thermal resistances for the IGBT and Diode have been captured from the device datasheet while the Heat sink to ambient thermal resistance Rth(h-a) is assumed as 2K/kW with different ambient temperatures.

Five cases are simulated in PSCAD and SEMIS by varying different parameters like DC Voltage, Switching Frequency, Load Power, Heat Sink, etc. with the electrical parameters presented in the tables below for comparison.

Results analysis according settings

Topology	SEMIS 22 Buck Non Isolated DC-DC converters
Tester:	Tirthasarathi Lodh, Harshavardhan Marabathina
Date	February 28, 2019
Device used (.xml)	5SNE 0800M170100
Limit acceptance level Green / Orange / Red	0% / 2% / 5%

Instructions

1. Enter all values according the final results table in the column SEMIS
2. Enter all values according the final results from the PSCAD in the column PSCad
3. Verify the relative difference; Results must not vary more than 2 %

Description of Settings Set	**Set 1**			**Set 2**			**Set 3**			**Set 4**			**Set 5**		
Parameter	**SEMIS**	**PSCad**	**Difference**	**SEMIS**	**PSCad**	**Difference**	**SEMIS**	**PSCad**	**Difference**	**SEMIS**	**PSCad**	**Difference**	**SEMIS**	**PSCad**	**Difference**
Absolute average difference [%]			0.04%			0.01%			0.03%			0.12%			0.02%
Max difference [%]			0.34%			0.23%			0.47%			1.67%			0.33%
Device Losses & Temperatures															
Switching Losses IGBT (W)	296	297	- 0.34%	152	152	+ 0.00%	267	267	+ 0.00%	451	451	+ 0.00%	196	196	+ 0.00%
Switching Losses Diode (W)	138	138	+ 0.00%	58	58	+ 0.00%	102	102	+ 0.00%	221	221	+ 0.00%	82	82	+ 0.00%
Conduction Losses IGBT (W)	240	240	+ 0.00%	133	133	+ 0.00%	133	133	+ 0.00%	284	284	+ 0.00%	360	360	+ 0.00%
Conduction Losses Diode (W)	181	181	+ 0.00%	43.5	43.4	+ 0.23%	43	42.8	+ 0.47%	405	405	+ 0.00%	91.9	91.6	+ 0.33%
Combined Losses IGBT (W)	537	537	+ 0.00%	285	285	+ 0.00%	400	400	+ 0.00%	735	736	- 0.14%	557	557	+ 0.00%
Combined Losses Diode (W)	319	318	+ 0.31%	101	101	+ 0.00%	145	145	+ 0.00%	626	625	+ 0.16%	174	174	+ 0.00%
Junction Temperature Before Last Switch IGBT															
Junction Temperature Before Last Switch Diode															
Junction Temperature Avg IGBT (°C)	81	81	+ 0.00%	61	61	+ 0.00%	69	69	+ 0.00%	100	100	+ 0.00%	80	80	+ 0.00%
Junction Temperature Avg Diode (°C)	84	84	+ 0.00%	56	56	+ 0.00%	63	63	+ 0.00%	120	120	+ 0.00%	69	69	+ 0.00%
Converter Losses (W)	855	855	+ 0.00%	387	387	+ 0.00%	545	545	+ 0.00%	1361	1361	+ 0.00%	731	731	+ 0.00%
Losses Efficiency	0.38	0.38	+ 0.00%	0.26	0.26	+ 0.00%	0.36	0.36	+ 0.00%	0.6	0.59	+ 1.67%	0.32	0.32	+ 0.00%
DC Parameters & Control Parameters															
Ouput DC Power (kW)	225	225	+ 0.00%	150	150	+ 0.00%	150	150	+ 0.00%	225	225	+ 0.00%	225	225	+ 0.00%
Input DC Power (kW)	225.85	225.85	+ 0.00%	150.38	150.38	+ 0.00%	150.54	150.54	+ 0.00%	226.36	226.36	+ 0.00%	225.73	225.73	+ 0.00%
Output DC Voltage (V)	750	750	+ 0.00%	1000	1000	+ 0.00%	1000	1000	+ 0.00%	500	500	+ 0.00%	750	750	+ 0.00%
Input DC Voltage (V)	1500	1500	+ 0.00%	1500	1500	+ 0.00%	1500	1500	+ 0.00%	1500	1500	+ 0.00%	1000	1000	+ 0.00%
Output DC Current (A)	300	300	+ 0.00%	150	150	+ 0.00%	150	150	+ 0.00%	450	450	+ 0.00%	300	300	+ 0.00%
Switching Frequency (Hz)	900	900	+ 0.00%	900	900	+ 0.00%	1500	1500	+ 0.00%	900	900	+ 0.00%	900	900	+ 0.00%
Duty Cycle	0.5	0.5	+ 0.00%	0.66	0.66	+ 0.00%	0.66	0.66	+ 0.00%	0.33	0.33	+ 0.00%	0.75	0.75	+ 0.00%

Figure 14 Validation results from comparison Buck Converter

Validation of PLECS Results with PSCAD

Results analysis according settings

Topology	SEMIS 22 Boost Non Isolated DC-DC converters
Tester:	Tirthasarathi Lodh, Harshavardhan Marabathina
Date	February 28, 2019
Device used (.xml)	5SNE 0800M170100
Limit acceptance level Green / Orange / Red	0% / 2% / 5%

Instructions

1. Enter all values according the final results table in the column SEMIS
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3. Verify the relative difference; Results must not vary more than 2 %

Description of Settings Set	Set 1			Set 2			Set 3			Set 4			Set 5		
Parameter	**SEMIS**	**PSCad**	**Difference**	**SEMIS**	**PSCad**	**Difference**	**SEMIS**	**PSCad**	**Difference**	**SEMIS**	**PSCad**	**Difference**	**SEMIS**	**PSCad**	**Difference**
Absolute average difference [%]			0.03%			0.02%			0.05%			0.04%			0.03%
Max difference [%]			0.22%			0.23%			0.30%			0.29%			0.12%
Device Losses & Temperatures															
Switching Losses IGBT (W)	293.8	294	- 0.07%	147	147	+ 0.00%	257.67	257.8	- 0.05%	478.6	478.9	- 0.06%	182.5	182.6	- 0.05%
Switching Losses Diode (W)	138.6	138.6	+ 0.00%	59.8	59.8	+ 0.00%	105.49	105.48	+ 0.01%	204.4	204.4	+ 0.00%	92.1	92	+ 0.11%
Conduction Losses IGBT (W)	239.5	239.5	+ 0.00%	66.4	66.4	+ 0.00%	66.3	66.25	+ 0.08%	572	571.9	+ 0.02%	119	119	+ 0.00%
Conduction Losses Diode (W)	181.1	180.7	+ 0.22%	86.5	86.3	+ 0.23%	85.58	85.32	+ 0.30%	203.8	203.2	+ 0.29%	271.6	271.3	+ 0.11%
Combined Losses IGBT (W)	533.3	533.5	- 0.04%	213.4	213.4	+ 0.00%	323.97	324.05	- 0.02%	1050.6	1050.8	- 0.02%	301.6	301.6	+ 0.00%
Combined Losses Diode (W)	319.6	319.3	+ 0.09%	59.5	59.5	+ 0.00%	191.07	190.8	+ 0.14%	408.2	407.6	+ 0.15%	363.7	363.3	+ 0.11%
Junction Temperature Avg IGBT (°C)	81.1	81.1	+ 0.00%	56.8	56.8	+ 0.00%	64.89	64.88	+ 0.02%	116.5	116.5	+ 0.00%	66.9	66.9	+ 0.00%
Junction Temperature Avg Diode (°C)	84	83.9	+ 0.12%	59.5	59.5	+ 0.00%	66.39	66.32	+ 0.11%	103.6	103.4	+ 0.19%	83.9	83.8	+ 0.12%
Converter Losses (W)	853	852.8	+ 0.02%	359.7	359.6	+ 0.03%	515.05	514.85	+ 0.04%	1458.8	1458.4	+ 0.03%	665.2	665	+ 0.03%
Losses Efficiency	0.38	0.38	+ 0.00%	0.24	0.24	+ 0.00%	0.34	0.34	+ 0.00%	0.64	0.64	+ 0.00%	0.29	0.29	+ 0.00%
DC Parameters & Control Parameters															
Ouput DC Power (kW)	225	225	+ 0.00%	150	150	+ 0.00%	150	150	+ 0.00%	225	225	+ 0.00%	225	225	+ 0.00%
Input DC Power (kW)	225.9	225.9	+ 0.00%	150.4	150.4	+ 0.00%	150.52	150.51	+ 0.01%	226.5	226.5	+ 0.00%	225.7	225.7	+ 0.00%
Output DC Voltage (V)	1500	1500	+ 0.00%	1500	1500	+ 0.00%	1500	1500	+ 0.00%	1500	1500	+ 0.00%	1000	1000	+ 0.00%
Input DC Voltage (V)	750	750	+ 0.00%	1000	1000	+ 0.00%	1000	1000	+ 0.00%	500	500	+ 0.00%	750	750	+ 0.00%
Output DC Current (A)	150	150	+ 0.00%	100	100	+ 0.00%	100	100	+ 0.00%	150	150	+ 0.00%	225	225	+ 0.00%
Switching Frequency (Hz)	900	900	+ 0.00%	900	900	+ 0.00%	1500	1500	+ 0.00%	900	900	+ 0.00%	900	900	+ 0.00%
Duty Cycle	0.5	0.5	+ 0.00%	0.33	0.33	+ 0.00%	0.33	0.33	+ 0.00%	0.67	0.67	+ 0.00%	0.25	0.25	+ 0.00%

Figure 15 Validation results comparison Boost Converter

Results analysis according settings

Topology	SEMIS 22 Buck-Boost Non Isolated DC-DC converters
Tester:	Tirthasarathi Lodh, Harshavardhan Marabathina
Date	February 28, 2019
Device used (.xml)	5SNE 0800M170100
Limit acceptance level Green / Orange / Red	0% / 2% / 5%

Instructions

1. Enter all values according the final results table in the column SEMIS
2. Enter all values according the final results from the PSCAD in the column PSCad
3. Verify the relative difference; Results must not vary more than 2 %

Description of Settings Set	Set 1			Set 2			Set 3			Set 4			Set 5		
Parameter	**SEMIS**	**PSCad**	**Difference**	**SEMIS**	**PSCad**	**Difference**	**SEMIS**	**PSCad**	**Difference**	**SEMIS**	**PSCad**	**Difference**	**SEMIS**	**PSCad**	**Difference**
Absolute average difference [%]			0.03%			0.03%			0.11%			0.04%			0.04%
Max difference [%]			0.31%			0.41%			1.09%			0.52%			0.35%
Device Losses & Temperatures															
Switching Losses IGBT 1 (W)	296	296	+ 0.00%	246	247	- 0.41%	441	442	- 0.23%	242	242	+ 0.00%	368	369	- 0.27%
Switching Losses IGBT 2 (W)	294	294	+ 0.00%	158	158	+ 0.00%	275	276	- 0.36%	378	378	+ 0.00%	233	233	+ 0.00%
Switching Losses Diode 1 (W)	137	137	+ 0.00%	115	115	+ 0.00%	210	210	+ 0.00%	106	106	+ 0.00%	177	177	+ 0.00%
Switching Losses Diode 2 (W)	139	139	+ 0.00%	74	74	+ 0.00%	131	131	+ 0.00%	170	170	+ 0.00%	112	112	+ 0.00%
Conduction Losses IGBT 1 (W)	240	240	+ 0.00%	151	151	+ 0.00%	151	151	+ 0.00%	391	391	+ 0.00%	261	261	+ 0.00%
Conduction Losses IGBT 2 (W)	240	240	+ 0.00%	150	150	+ 0.00%	151	151	+ 0.00%	393	393	+ 0.00%	260	260	+ 0.00%
Conduction Losses Diode 1 (W)	181	181	+ 0.00%	173	173	+ 0.00%	171	170	+ 0.58%	194	193	+ 0.52%	287	287	+ 0.00%
Conduction Losses Diode 2 (W)	181	181	+ 0.00%	175	175	+ 0.00%	173	173	+ 0.00%	192	192	+ 0.00%	289	288	+ 0.35%
Combined Losses IGBT 1 (W)	536	536	+ 0.00%	397	397	+ 0.00%	592	592	+ 0.00%	634	634	+ 0.00%	630	630	+ 0.00%
Combined Losses IGBT 2 (W)	534	534	+ 0.00%	308	308	+ 0.00%	426	426	+ 0.00%	771	771	+ 0.00%	493	493	+ 0.00%
Combined Losses Diode 1 (W)	319	318	+ 0.31%	288	288	+ 0.00%	381	380	+ 0.26%	300	299	+ 0.33%	464	463	+ 0.22%
Combined Losses Diode 2 (W)	320	319	+ 0.31%	249	248	+ 0.40%	304	303	+ 0.33%	363	362	+ 0.28%	401	401	+ 0.00%
Junction Temperature Avg IGBT 1 (°C)	81	81	+ 0.00%	72	72	+ 0.00%	86	86	+ 0.00%	87	87	+ 0.00%	90	90	+ 0.00%
Junction Temperature Avg IGBT 2 (°C)	81	81	+ 0.00%	65	65	+ 0.00%	74	74	+ 0.00%	97	97	+ 0.00%	80	80	+ 0.00%
Junction Temperature Avg Diode 1(°C)	84	84	+ 0.00%	78	78	+ 0.00%	92	91	+ 1.09%	84	84	+ 0.00%	101	101	+ 0.00%
Junction Temperature Avg Diode 2 (°C)	84	84	+ 0.00%	72	72	+ 0.00%	80	80	+ 0.00%	93	93	+ 0.00%	92	92	+ 0.00%
Converter Losses (W)	1708	1707	+ 0.06%	1242	1242	+ 0.00%	1702	1702	+ 0.00%	2067	2067	+ 0.00%	1988	1987	+ 0.05%
Losses Efficiency	0.75	0.75	+ 0.00%	0.82	0.82	+ 0.00%	1.12	1.12	+ 0.00%	0.91	0.91	+ 0.00%	0.88	0.88	+ 0.00%
DC Parameters & Control Parameters															
Ouput DC Power (kW)	225	225	+ 0.00%	150	150	+ 0.00%	150	150	+ 0.00%	225	225	+ 0.00%	225	225	+ 0.00%
Input DC Power (kW)	226.7	226.7	+ 0.00%	151.24	151.24	+ 0.00%	151.7	151.7	+ 0.00%	227.06	227.06	+ 0.00%	226.98	226.98	+ 0.00%
Output DC Voltage (V)	1500	1500	+ 0.00%	1000	1000	+ 0.00%	1000	1000	+ 0.00%	1500	1500	+ 0.00%	1000	1000	+ 0.00%
Input DC Voltage (V)	1500	1500	+ 0.00%	1500	1500	+ 0.00%	1500	1500	+ 0.00%	1000	1000	+ 0.00%	1500	1500	+ 0.00%
Output DC Current (A)	150	150	+ 0.00%	150	150	+ 0.00%	150	150	+ 0.00%	150	150	+ 0.00%	225	225	+ 0.00%
Switching Frequency (Hz)	900	900	+ 0.00%	900	900	+ 0.00%	1500	1500	+ 0.00%	900	900	+ 0.00%	900	900	+ 0.00%
Duty Cycle	0.5	0.5	+ 0.00%	0.4	0.4	+ 0.00%	0.4	0.4	+ 0.00%	0.6	0.6	+ 0.00%	0.4	0.4	+ 0.00%

Figure 16 Validation results from comparison Buck-Boost Converter

REVISION HISTORY

Rev.	Page	Change Description	Date / Initial
1.0	all	Initial version	2019-12-12 PGGI/SD

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