



TUTORIAL

IGBT and MOSFET Loss Calculation in Thermal Module

July, 2019





The Thermal Module is an add-on option to PSIM. Its purpose is to simulate the losses of semiconductor devices and inductors quickly from manufacturer device datasheets.

In this tutorial, the process of how to use the Thermal Module for power loss calculation of IGBT and MOSFET is described. The loss calculation of SiC and GaN devices is covered in the tutorial "Tutorial – SiC and GaN loss calculation and transient analysis.pdf", and the loss calculation of inductors is covered in another tutorial "Tutorial – Inductor loss calculation in the Thermal Module.pdf".

1. IGBT Loss Calculation

To illustrate how IGBT losses and junction temperature are calculated in PSIM's Thermal Module, the datasheet of Semikron's IGBT Module SEMiX151GD066HDs (600V, 150A) is used in a 3-phase voltage source inverter example, as shown below:



In this example, the inverter operating conditions are:

DC Bus Voltage:450 VdcAC Output:230 V (line-line, rms), 60 Hz, 20 kW, 0.8 power factor (lagging)Switching Frequency:8 kHz

From the values above, the ac output current is calculated as: Io = 62.75 A.

1.1 Simulation of IGBT Losses in PSIM

Assuming the IGBT device is already available in PSIM's device database, it can be placed in a PSIM schematic for the calculation of losses. To choose this device, in PSIM, select **Elements** >> **Power** >> **Thermal Module** >> **IGBT (database)** as shown below:





IGBT and MOSFET Loss Calculation in the Thermal Module



Place the discrete IGBT element on the schematic. Double click on the IGBT element to open the parameter dialog window. Click on the Browser button next to the "Device" input field, and choose the device "Semikron SEMiX151GD066HDs".

rameters Color			1.1	Select De	vice type: IGBT	*			
BT (database)		Help		Select Field	•	<u></u>			
	20	Display							
Name	Q1					Demous Orliering	1 And College	1	
Device	SEMiX151GD066HDs		2110-		<u>.</u>	Remove criterion	Aud Criteri	Un	
Number of Parallel Devices	1		PHUS	Field name			Operation		
	60	— <u> </u>		·					
Frequency	00		ţ						
Rg_on (turn-on)	4.5		1.1						
Rg_off (turn-off)	4.5		0.5						
Pcond_Q Calibration Factor	1			Match all (AND)	•		Search		
Psw_Q Calibration Factor	1		10.5						_
People D Calibration Factor	1	I		Search Result					
FCOILU_D Calibration Factor	1		_	Manufacturer	Part Number	Package	Vce,max	Ic.max	^
Psw_D Calibration Factor	1		1.1	IXYS	IXGH40N60C2	Discrete	600	40	_
Initial Ti	25			Powerex	PS21A79	6-Pack	600	50	
				Infineon	FS50R07N2E4	6-Pack	650	70	
Tj_Q Flag	1		1.1	Fuji Electric	6MBP300RA060	6-Pack	600	300	
Ti D Elad	1		10.00	Infineon	FS800R07A2E3	6-Pack	650	800	
1j_0 ndg	-			Infineon	FF450R12KE4_E	Discrete	1200	450	
Pcond_Q Flag	1			Infineon	F3L400R12PT4P_B26	Dual	1200	400	
			1.1	Infineon	F3L400R12PT4P_B26	Discrete	650	280	
PSW_Q Flag	11			Semikron	SEMiX151GD066HDs	6-Pack	600	150	
	1		10.10	MagnaChip	MBQ40T120FES	Discrete	1200	40	~
<pre>Pcond_D Flag</pre>			1.15	<	14				>
Pcond_D Flag Psw_D Flag	1		1.11	January 11					

The IGBT image will change to a 6-pack inverter bridge. Continue to build the rest of the circuit.

The circuit below shows the completed inverter circuit using the IGBT Module SEMIX151GD066HDs. The load resistances and inductances and the modulation index are selected such that the circuit operates under the specified conditions (output of 230 Vac, 20-kW, 0.8 power factor (lagging)).







The IGBT Module image shows 2 dc bus terminals on the left, 3 ac output terminals on the right, 6 gating signal nodes at the bottom, and one extra nodes on the top. This node is for the monitoring of the device's thermal effects:

- The voltage at this node is the module's case temperature, can be monitored with a Voltmeter.
- The current flowing out of this node is the total power losses of the whole module (all 6 devices), can be monitored with an Ammeter.

This node should be connected to a voltage source representing the ambient temperature or grounded via a network representing the dynamic thermal impedance between the case of the module and the ambient. In this example, the resistor **Rth_cs_sink** is the sum of the thermal resistances between the case and heat sink, and between the heat sink and the ambient.

The parameters of the IGBT (database) are defined as below:

The parameter **Frequency** defines the interval under which the losses are calculated. For example, if the frequency is 60 Hz, the losses results are the average value for an interval of 16.67 ms. If the frequency is set to be the same as the switching frequency, the losses in each switching cycle are obtained.

The parameters *Rg_on* and *Rg_off* are the gate resistances at turn-on and turn-off. Note that they must be defined correctly to reflect the actual operating conditions.

The *Calibration Factors* are used to scale the calculation results against experimental results. For example, for a specific device, if the datasheet losses are 10 W, but the measured losses from the experiments are 12 W, the calibration factor should be set to 1.2.

If the *flags* are for the monitoring of the device's thermal behaviour. When the flags are set, the following thermal related characteristics can be monitored:

- transistor junction temperature Tj_Q
- diode junction temperature Tj_D
- transistor conduction loss Pcond_Q,





- transistor switching loss Psw_Q,
- diode conduction loss Pcond_D, and
- diode switching loss Psw_D.

The temperatures are in °C. The losses are for the whole IGBT module (all 6 IGBT switches).

The simulation result displayed in SimView is as below:



The following thermal results are obtained from the PSIM simulation of this example:

Diode Junction Temperature (°C):	93.28	
Transistor Junction Temperature (°C):	103.3	
Transistor Conduction Loss (W):	165.8	
Transistor Switching Loss (W):	163.1	
Diode Conduction Loss (W):		45.2
Diode Switching Loss (W):	58.2	
Total Loss per Module (W):		432.2

1.2 Adding an IGBT Device into the Device Database

The above example shows how to run a thermal simulation in PSIM when the device is already available in the database. However, in many cases, a device is no available in the database.





Therefore, it has to be entered into the database before it can be used in a PSIM schematic for thermal simulation.

Here, the IGBT Module SEMiX151GD066HDs is used as the example to illustrate the procedure of entering a device into PSIM's device database. Below is the procedure to add this device as a new IGBT device into the device database file "IGBT.dev".

Step 1. In PSIM, go to **Utilities** >> **Device Database Editor** to launch the **PcdEditor**.

- Step 2. Highlight the device file "IGBT.dev" in the **File Name** list box. Select **Device** >> **New IGBT**, and confirm that you want to save the new device to "IGBT.dev".
- Step 3. Enter basic device information from manufacturer's datasheet into PSIM's Device Database. To avoid destroying the device information in PSIM's original database, the new device is be named as "SEMiX151GD066HDs_6" instead.



Step 4. Use PSIM's Curve Capture Tool to enter the transistor Electrical Characteristics from the graphs provided in manufacturer's datasheet.

The forward conduction characteristic **Vce(sat) vs. Ic** is used as the example.

This characteristic is provided in Fig. 1 of the datasheet. Fig. 1 provides one curve at Tj=25 °C for VGE=15V, but it provides three curves at Tj=150 °C for VGE=10, 15, and 17V. We will select the curves corresponding to VGE=15V since curves of the energy losses Eon and Eoff vs. Ic are for VGE=-8/+15V.

To capture the curve from Fig. 1 of the datasheet, click on the **Edit** button of the "Vce(sat) vs. Ic" characteristics. A window for the Curve Capture Tool will open.

In the dialog window, click on **Add Curve**. We will use the Graph Wizard button at the upper left corner to capture the 25°C curve. Follow the directions as displayed in the text window. The steps are:

- Display the graph of Fig. 1 on the screen. Click on the Print Screen key (PrtSc) to copy the screen to the clipboard.
- Click on the forward green arrow of the Graph Wizard. The image in the clipboard will be copied into the dialog window, as shown below.







- Position the image properly within the window so that the complete graph is in full view. Click on the forward arrow. Define the border of the graph by left clicking on the graph's origin (lower left corner), and then move the cursor to the opposite corner (upper right corner) and left click. Right click to zoom in for easier cursor placement. After this, a blue frame will be superimposed on top of the original graph frame.
- Click on the forward arrow. Check if the x-axis and y-axis definitions are correct. By default, the x-axis is Ic and the y-axis is Vce(sat). But the x-axis is Vce(sat) and the y-axis is Ic in the datasheet. To match the datasheet, check the box Invert graph. Then define the axis settings X0, Xmax, Y0, Ymax. In this case, enter X0=0, Xmax=4, Y0=0, Ymax=300. Enter the junction temperature Tj as 25 for the 25°C curve. The dialog window will look as follows:







- Click on the forward arrow. Starting from the origin, left click on top of the 25°C curve to capture the data point. Right click to zoom in for easier cursor placement. As you click along the curve, a red curve will be drawn indicating the data points captured. The dialog window is shown below on the left.
- Click on the forward arrow. The capture process will be completed, and the captured curve will be shown below on the right.

You can edit the captured values directly in the input field on the left of the Refresh button. For example, you can round off the first two points from (-0.006135,-0.23292) (0.71472,0.11646) to (0,0) (0.71,0.12). But avoid having sudden jump between two points, for example, (0,0) (0.71,0). PSIM uses interpolation between two points. When there is sudden jump, interpolation may not give desired result.





IGBT and MOSFET Loss Calculation in the Thermal Module



- Repeat the same process to capture the 150 °C curve.
- Enter the transistor switching energy losses characteristics **Eon and Eoff vs. Ic** from the curves in Fig. 3 of the datasheet. Use the Graph Wizard and the same process as described above to capture these curves.
- Enter the transistor switching energy losses characteristics **Eon and Eoff vs. RG** from the curves in Fig. 4 of the datasheet. Use the same process to capture these curves.

When entering these curves, be sure to click on **Other Test Conditions** and enter the test conditions as obtained from Fig. 3 and Fig. 4 of the datasheet. The test condition dialogs are shown as follows:

Ec	on/Eoff vs. Ic		Eor	n/Eoff vs. RG	
Other Test Conditions		×	Other Test Conditions		×
Voltage VCE (V)	300	ОК	Voltage VCE (V)	β <u>οο</u> Ο	Ж
		Cancel		Car	ncel
Gate voltage (V)	VGE_on 15 VGE_off 🔽 -8		Collector current IC (A)	150	
Gate resistance (Ohm)	RG_on 4.5 RG_off 🗆		Gate voltage VGE (V)	15	

While values of the gate voltages are not used in the loss calculation, values of the voltage VCE, collector current Ic, and the gate resistances are used in the calculation. Make sure to enter them correctly.

Step 5. Use PSIM's Curve Capture Tool to enter the diode Electrical Characteristics from the graphs provided in manufacturer's datasheet.





- Enter the diode forward conduction characteristic Vd vs. IF.

The diode forward conduction characteristics are provided in Fig. 11 in the datasheet. Use the Graph Wizard and the same procedure to capture the curves.

- Enter the diode switching characteristics trr/Irr/Qrr/Err vs. IF and Err vs. RG:

The diode reverse recovery characteristics trr, Irr, and Qrr vs. the current IF, and Err vs. RG, are not provided in the datasheet. Only the characteristic of the reverse recovery energy Err vs. the current IF is provided in Fig. 3 of the datasheet.

Use the same procedure to capture the curve. The test condition is the same as in Eon vs. Ic.

Step 6. Enter the thermal characteristics. Two types of the thermal impedance network are available: Cauer and Froster. For this example, the thermal impedance consists of one resister only, therefore the number of stages is 1 and the values of the capacitor is left empty. The "Tamb" in the circuits below is actually the case temperature. Between case and ambient, there might be a heatsink thermal impedance to be added, as shown in the simulation circuit of the example.



Step 7. Enter the information about dimensions and weight. This information is not used in the calculation, and is for reference only. Entering of the information is optional.

This concludes the entry of the device information into the database SEMiX151GD066HDs_6. The figure below shows the device in the **PcdEditor** after it has been added into the device file "IGBT.dev".





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File Name C:\Powersim\PSIM12.0\Device\diode C:\Powersim\PSIM12.0\Device\diode C:\Powersim\PSIM12.0\Device\UGB C:\Powersim\PSIM12.0\Device\UGB C:\Powersim\PSIM12.0\Device\UGB C:\Powersim\PSIM12.0\Device\UGS C:\Powersim\PSIM12.0\Device\UGS C:\Powersim\PSIM12.0\Device\UGS	dev HB.dev RB.dev dev tor.dev FET_dev FET_SIC - Rohm. FET_SIC.dev	dev	Manufacturer Semikron Part Number SEMIX151GD066HDs_6 Package
IGBT	Manufacturer [All Manufacture	u2]	VCE(sat) vs. IC Edit Eon vs. IC Edit Eon vs. IC Edit Eon vs. RG Edit Eon vs. RG Edit
Part Number 12:48150/N-120-50(16BT) 14:48150/N-120-50(16BT) 15:041000HA-24H 15:0410001-24F 15:0410001-24F 15:741000124F 15:741000124F 15:741000124F 15:741000124F 15:755007N224 15:755007N224 15:755007N224 15:755007N224 15:755007N224 15:755007N224 15:755007N224 15:755007N224 15:755007N224 15:755007N224 15:755007N224 15:755007N224 15:755007N224 15:755007N224 15:755007N225 15:755007N225 15:755007N225 15:755007N225 15:755007N225 15:755007N225 15:755007N225 15:755007N225 15:755007N225 15:755007N225 15:755007N225 15:755007N225 15:755007N25 15:75007N25 15:7500	Voltage 1200 600 1200 600 1200 1200 650 650 650 650 600 1200 600 600 1200 600 600 1200 600 600 1200 600 600 600 1200 600 600 600 600 600 600 600	Current 50 300 1000 100 600 400 280 450 70 800 40 50 150 150	Ind Electrical Characteristics · Diode Vd vs. IF Edit Irr vs

The newly created database device will be available for next PSIM session. This means, to use the new device in a PSIM schematic, user must exit and re-launch PSIM.

To verify this new device's thermal characteristics, in the example PSIM circuit, replace the IGBT with the newly added SEMiX151GD066HDs_6. The simulation result should be the same with negligible differences.

2. Managing User's Devices in Database

When users add their own devices, they may add these devices into one of the standard device files that come with PSIM. But it is strongly recommended that users save a copy of these devices in their own separate device files. This is because when a PSIM version is updated or upgraded, all the .dev files will be replaced by the files of the newer PSIM version. These user-added devices will be lost. If they are saved to a separate device files, these files can be easily copied to the "device" folder in the newer PSIM version.

To create a user-defined device file "My_Device.dev", and to transfer a device from the "IGBT.dev" file to it:

- In the PcdEditor, click "File >> New Device File". In the correct location (folder), write the file name "My_Device".
- In the PdcEditor, click on the device SEMiX151GD066HDs_6 to highlight it.
- Click on the file "My_Device.dev" in the File Name list box to highlight it.
- Select Device >> Save Device As, and confirm to save the device to "My_Device.dev".





3. MOSFET Loss Calculation

To illustrate how to calculate MOSFET losses with PSIM's Thermal Module, the datasheet of Infineon's MOSFET IRFP460 (500V, 20A) is used in a buck converter example, as shown below:



The buck converter operating conditions are:

DC Input:250 VdcDC Output:125 Vdc, 20ASwitching Frequency:20 kHz

3.1 Adding the MOSFET device into the Device Database

Assuming the MOSFET device IRFP460 is not available in PSIM's device database, the first step is to add it into the device database.

Below is the procedure to add this device into the device database file "MOSFET.dev".

- Step 1. In PSIM, go to **Utilities** >> **Device Database Editor** to launch the PcdEditor.
- Step 2. Highlight the device file "MOSFET.dev" in the **File Name** list box. Select **Device** >> **New MOSFET**, and confirm that you want to save the new device to "MOSFET.dev".
- Step 3. Enter the required basic information from the datasheet, such as the part number, package, and maximum ratings.
- Step 4. Enter the information for the Electrical Characteristics for the transistor.

Below is a screenshot of the datasheet, with required parameters highlighted in red.



	Parameter	Min.	Тур.	Max.	Units	Test Conditions		
V(BR)DSS	Drain-to-Source Breakdown Voltage	500	_		V	V _{GS} =0V, I _D = 250μA		
$\Delta V_{(BR)DSS}/\Delta T_J$	J Breakdown Voltage Temp. Coefficient		0.63	_	V/°C	Reference to 25°C, Ip= 1mA		
RDS(on)	Static Drain-to-Source On-Resistance	_	_	0.27	Ω	V _{GS} =10V, I _D =12A @		
V _{GS(th)}	Gate Threshold Voltage	2.0	—	4.0	V	V _{DS} =V _{GS} , I _D = 250µA		
Gfs	Forward Transconductance	13	—		S	V _{DS} =50V, I _D =12A ④		
Ince	Drain-to-Source Leakage Current		-	25		V _{DS} =500V, V _{GS} =0V		
1055	Diam-to-Ooulce Leakage ourient	_	_	250] μΑ	V _{DS} =400V, V _{GS} =0V, T _J =125°C		
loso	Gate-to-Source Forward Leakage	—	—	100	n A	V _{GS} =20V		
1035	Gate-to-Source Reverse Leakage		—	-100		V _{GS} =-20V		
Qg	Total Gate Charge		_	210		I _D =20A		
Q _{gs}	Gate-to-Source Charge	-	_	29	nC	V _{DS} =400V		
Q _{gd}	Gate-to-Drain ("Miller") Charge		—	110		V _{GS} =10V See Fig. 6 and 13 ④		
td(on)	Turn-On Delay Time		18	—		V _{DD} =250V		
tr	Rise Time	_	59		ne	I _D =20A		
td(off)	Turn-Off Delay Time	_	110	_	115	R _G =4.3Ω		
tı	Fall Time		58		1	R ₀ =13Ω See Figure 10 [®]		
LD	Internal Drain Inductance	-	5.0	_		Between lead, 6 mm (0.25in.)		
Ls	Internal Source Inductance	_	13	_		and center of die contact		
Ciss	Input Capacitance	—	4200			V _{GS} =0V		
Coss	Output Capacitance	_	870	-	pF	V _{DS} = 25V		
Crss	Reverse Transfer Capacitance	_	350			f=1.0MHz See Figure 5		

Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

Source-Drain Ratings and Characteristics

	Parameter	Min.	Тур.	Max.	Units	Test Conditions
ls	Continuous Source Current (Body Diode)	_	-	20		MOSFET symbol showing the
Ism	Pulsed Source Current (Body Diodè) ①	_	-	80		p-n junction diode.
Vsd	Diode Forward Voltage	_	-	1.8	٧	TJ=25°C, IS=20A, VGS=0V ④
t _{rr}	Reverse Recovery Time	-	570	860	ns	TJ=25°C, I⊧=20A
Qrr	Reverse Recovery Charge	_	5.7	8.6	μC	di/dt=100A/μs ④
ton	Forward Turn-On Time	Intrinsio	Intrinsic turn-on time is neglegible (turn-on is dominated by Ls+L			

For the parameter VGS(th), an average value of 3V is selected out of the minimum and maximum values.

Note that the parameter "Temperature Coefficient" of RDS(on) is typically not provided in a datasheet, such as in this case. It needs to be calculated from the graph "Normalized on-resistance vs. temperature" (Fig. 4 for this device), as shown below:



The temperature coefficient K_T can be calculated using the expression below:





$$K_T = \frac{R_{DS(on)_normalized} - 1}{T_i - 25}$$

From Fig. 4 of the datasheet, at Tj = 100, we obtain $R_{DS(on)_normalized} = 1.8$. We can then calculate K_T as: $K_T = 0.01$.

The on-resistance RDS(on) is calculated from K_T in the following way:

$$R_{DS(on)} = R_{DS(on)_{25} \deg} \cdot (1 + K_T \cdot (T_j - 25))$$

where $R_{DS(on)_{25deg}}$ is the on-resistance at 25 °C. In this example, $R_{DS(on)_{25deg}} = 0.27$ Ohm.

- Step 5. Enter the Electrical Characteristics for the diode. The Vd vs IF curve can be captured as explained in the IGBT section. The test conditions must be entered, too.
- Step 6. Enter the Thermal Characteristics, the same way as in the IGBT section.
- Step 7. Enter the dimensions and weight, optional.

This concludes the entry of the device information into the database IRFP460. The figure below shows the device in the PcdEditor after it has been added into the device file "MOSFET.dev".

				1							
ile Name				Manufacturer	Infinan			Part Number			IDEDAC
:\Powersim\PSIM12.0\	Device\diode	.dev	^	Manufacturer	Inneon		<u> </u>	archidaniber			Inrr40
NPowersim\PSIM12.0\ \Powersim\PSIM12.0\	Device\Gan.	BB dev		Package							
VPowersim\PSIM12.0	Device\IGBT	dev		RA D	iscrete (n.c	hannell		Stule			
Powersim\PSIM12.0	Device\Induc	tor.dev				, nan inon,	<u></u>] -91			
Powersim\PSIM12.0	Device\MOSI	ET.dev		Absolute Maxim	ium Rating	s					
VPowersim/PSIM12.0	Device\MOSI	ET_SiC · Rohr	m.dev	VDS,max (V):	Ę	500	ID, max (A):	20	Ti,max (c	C):	150
VPowersim/PSIM12.0	Device\MOSI	ET_SiC.dev	~	[-/ 1	
wice Tune		Manufacturer		Electrical Chara	cteristics -	Transis	tor				
		Manufacturer	-			Test	Conditions:			Test Co	nditions:
USPET	<u> </u>	[All Manuractu		RDS(on):	0.27	TJ:	25	Qg (nC):	210	VDS:	400
Part Number	Voltage	Current	Inductance	Temperature	0.01	VGS:	10	Qgs (nC):	29	VGS:	10
* FCD7N60	600	7		Coefficient:	0.01	ID:	12	Qad (nC):	110	ID:	20
IPB60B190C6	650	12.8					-	-2-(/)			
IRF1010EZ	60	75		VGS(th):	3	ID:	0.00025	Ciss (pF):	4200	VDS:	25
IRF3805S	55	75		gfs (S):	13	VDS:	50	Coss (pF):	870	VGS:	0
IRF7380	80	3.6		- · · ·		ID:	12	Crss (pF);	350	Freq.	1
FIRF744	450	8.8						,		(MHz): "	
FIRFP460	500	20		tr (ns):	59	VDS:	250	Mater Aller			
FIRFS4321PbF	150	60		tf (ns):	58	ID:	20	and resista	nces in Ohr	n v, cuneni n.	sina,
*NTF3055L175	60	2				RG:	4.3				
SPA21N50C3	560	21									
STW45NM50	550	45		Electrical Chara	cteristics -	Diode-				Test Co	anditions:
TPH3202L	600	9			Vd v	s. IF	Edit	1	570	IF (A)	20
								trr (ns):	570	di/dt	20
						-		Qirr (uC):	5.7	(A/us):	100
					-					TJ (oC):	25
				- Thermal Charao	teristics				-	Dimensions	and Weid
						Type	Cauer - No	o. of Stages	ī÷.	1	
							Tranc	irtor		Length (mm	ι – ι —
							Trans	istor		Height (mm) (
						R1		0.45		Width (mm)	: 0
						C1					Í

The newly created database device will be available for next PSIM session. This means, to use the new device in a PSIM schematic, user must exit and re-launch PSIM.





3.2 Simulation of MOSFET Losses in PSIM

Once the device is added to the device database, it can be used in PSIM for the loss calculation. The newly added device in database should be verified with a simple example circuit before applied to a complex power system.

In PSIM, select Elements >> Power >> Thermal Module >> MOSFET (database).

Place the discrete MOSFET element on the schematic. Double click on the MOSFET element to open the property dialog window. Click on the Browser button next to the "Device" input field, and choose the device "IRFP460". Continue to build the rest of the circuit.

						PADD	🐨 🙂 📑	🗢 Lt 🤅	
IOSFET (database)		Help							
		Display			Display				
Name	MSF2		P_total Flag	1					
Device	IRFP460	🔽		Canada dan Danian					
Number of Parallel Devices	1			Search for Device					
Frequency	20k	Γ		Select Device t	pe: MOSFET	*			
VGG+ (upper level)	10			Select Field	1				
VGG- (lower level)	0	Г							
Rg_on (turn-on)	4.3								
Rg_off (turn-off)	4.3					Remove Criteri	on Add C	riterion	
RDS(on) Calibration Factor	1			Field name		-	Operation		
ofs Calibration Factor	1								
Pcond O Calibration Factor	1								
Psw. O. Calibration Factor	1								
Prond D Calibration Eactor	1								
Pow D Calibration Factor	1			Match all (AND)		<u> </u>	Search		
Taitial Ti	25			-					
uniudi i j	25	[Search Kesult	1				
	11			Manufacturer	Part Number	Package	Vds,max	Id,max	тј, ^
rj Flag				Infineon	TREP460	Discrote (n ch	500	20	
'j Flag ?cond_Q Flag	1			Infineon Infineon	IRFP460 IRF7380	Discrete (n ch Dual	500 80	3.6	
⊺j Flag Pcond_Q Flag Psw_Q Flag	1			Infineon Infineon Infineon	IRFP460 IRF7380 IRF3805S	Discrete (n ch Dual Discrete (n ch	500 80 55	3.6 75	
Fj Flag Pcond_Q Flag Psw_Q Flag Pcond_D Flag	1			Infineon Infineon On Semiconductor ST Microelectronics	IRFP460 IRF7380 IRF3805S NTF3055L175 STW45NM50	Discrete (n ch Dual Discrete (n ch Discrete (n ch Discrete (n ch	500 80 55 60 550	3.6 75 2 45	
rj Flag 'cond_Q Flag 'sw_Q Flag 'cond_D Flag	1 1 1 1 1			Infineon Infineon Infineon On Semiconductor ST Microelectronics Infineon	IRFP460 IRF7380 IRF3805S NTF3055L175 STW45NM50 SPA21N50C3	Discrete (n ch Dual Discrete (n ch Discrete (n ch Discrete (n ch Discrete (n ch	500 80 55 60 550 560	3.6 75 2 45 21	
rj Flag Pcond_Q Flag Psw_Q Flag Pcond_D Flag Psw_D Flag	1 1 1 1			Infineon Infineon Infineon On Semiconductor ST Microelectronics Infineon Infineon	IRFP460 IRF7380 IRF3805S NTF3055L175 STW45NM50 SPA21N50C3 IRF744	Discrete (n ch Dual Discrete (n ch Discrete (n ch Discrete (n ch Discrete (n ch Discrete (n ch	500 80 55 60 550 560 450	3.6 75 2 45 21 8.8	
'j Flag ?cond_Q Flag ?sw_Q Flag ?cond_D Flag ?sw_D Flag	1 1 1 1			Infineon Infineon Infineon On Semiconductor ST Microelectronics Infineon Infineon	IRFP460 IRF7380 IRF38055 NTF3055L175 STW45NM50 SPA21N50C3 IRF744 IRF1010EZ	Discrete (n ch Dual Discrete (n ch Discrete (n ch Discrete (n ch Discrete (n ch Discrete (n ch	500 80 55 60 550 560 450 60	3.6 75 2 45 21 8.8 75	
'j Flag Pcond_Q Flag Psw_Q Flag Pcond_D Flag Psw_D Flag	1 1 1 1			Infineon Infineon On Semiconductor ST Microelectronics Infineon Infineon Fairchild Semiconductor	IRFP460 IRF7380 IRF38055 NTF3055L175 STW45NM50 SPA21N50C3 IRF744 IRF1010EZ FCD7N60	Discrete (n ch Dual Discrete (n ch Discrete (n ch Discrete (n ch Discrete (n ch Discrete (n ch Discrete (n ch Discrete (n ch	80 80 55 60 550 560 450 60 60 600	3.6 75 2 45 21 8.8 75 7	
'j Flag Pcond_Q Flag 2sw_Q Flag 2cond_D Flag 2sw_D Flag	1 1 1 1			Infineon Fairchild Semiconductor Transphorn Infineon	IRFP460 IRF7380 IRF38055 INFF3055L175 STW45NM50 SPA21N50C3 IRF744 IRF1010EZ FCD7N60 TPH3202L IPE5A231PbE	Discrete (n ch Dual Discrete (n ch Discrete (n ch	500 80 55 60 550 560 450 60 60 600 600 150	3.6 75 2 45 21 8.8 75 7 9 60	
'j Flag 'cond_Q Flag 'sw_Q Flag 'cond_D Flag 'sw_D Flag	1 1 1 1			Infineon Infineon On Semiconductor ST Microelectronics Infineon Infineon Fairchild Semiconductor Transphorn Infineon	IRFP460 IRF7380 IRF38055 NTF3055L175 STW45NM50 SPA21N50C3 IRF744 IRF1010EZ FCD7N60 TPH3202L IRF54321PbE	Discrete (n ch Dual Discrete (n ch Discrete (n ch	500 80 555 60 550 560 450 60 600 600 150	3.6 75 2 45 21 8.8 75 7 9 60	>
T) Flag Pcond_Q Flag 2sw_Q Flag 2cond_D Flag 2sw_D Flag	1 1 1 1			Infineon Infineon On Semiconductor ST Microelectronics Infineon Infineon Farchild Semiconductor Transphorn Infineon	IRFP460 IRF380 IRF38055 NTF3055L175 STW45NM50 SPA21N50C3 IRF744 IRF1010EZ FCD7N60 TPH3202L IRF54321PhE	Discrete (n ch Dual Discrete (n ch Discrete (n ch	500 80 55 60 550 560 450 60 600 600 150	3.6 75 2 45 21 8.8 75 7 9 60	>

The circuit below shows the completed buck converter circuit using the MOSFET IRFP460.







The MOSFET device (database has an one extra nodes on the top. This node is for the monitoring of the device's thermal effects:

- The voltage at this node is the module's case temperature, can be monitored with a Voltmeter.
- The current flowing out of this node is the total power losses of the whole module (all 6 devices), can be monitored with an Ammeter.

This node should be connected to a voltage source representing the ambient temperature or grounded via a network representing the dynamic thermal impedance between the case of the module and the ambient. In this example, the resistor Rth_cs is the thermal resistances between the case and heat sink, and R_heatsing is the thermal resistance of the heatsink.

The parameters of the MOSFET (database) are defined as below:

The parameter **Frequency** defines the interval under which the losses are calculated. In this example, it is set to be the same as the switching frequency, and the losses in each switching cycle are obtained.

The values VGG+ and VGG- are the upper level and lower level of the gate voltage source.

The values **Rg_on** and **Rg_off** are the gate resistances at turn-on and turn-off. They must be defined correctly to reflect the actual operating conditions. If they are not defined correctly (for example, if the gate voltage source is too low, or the load current or the gate resistance is too high), the MOSFET device may not work correctly.

The Calibration Factors are used to scale the calculation results against experimental results.

If the *Flags* are for the monitoring of the device's thermal behaviour. When the flags are set, the following thermal related characteristics can be monitored:

- transistor junction temperature Tj, in °C.
- transistor conduction loss Pcond_Q,
- transistor switching loss Psw_Q,
- diode conduction loss Pcond_D, and
- diode switching loss Psw_D.

The simulation result displayed in SimView is as below:







The following losses results are obtained from the PSIM simulation:

MOSFET Junction Temperature (°C):	134.5
Transistor Conduction Loss (W):	113.1
Transistor Switching Loss (W):	6.5
Transistor Total Loss (W):	119.6

The losses of the diode is zero because there is no reverse conduction in this example circuit.

4. Conclusion

PSIM's Thermal Module provides a quick and convenient way of estimating device conduction and switching losses. One can use the Thermal Module to study device losses under different operating conditions, and compare devices from different manufacturers.

In addition, the Device Database Editor (PcdEditor) provides an easy way to add new devices and manage devices. It also provides an easy-to-use curve capture tool that allow multiple datasheet curves to be entered into the database in minutes.

