

Table of Contents

# VincotechISE User Manual

# Integrated Simulation Environment for Vincotech Power Modules





# Table of Contents

1	Abstract	4	1
2	Introduction		1
3	Installing Vincotech ISE2		1
4	Launching Vincotech ISE2		1
4.1	Updating	(	5
4.2	Version Information	(	5
4.3	Support		7
5	Working with Vincotech ISE	8	3
6	Simulation Tools	1(	C
6.1	flowSOL	1(	C
6.2	flowSIM	19	Э
6.3	flowSEL	27	7



Date	Revision Level	Description	Page Number(s)
Aug. 2008	1	VincotechISE - first release	17
Apr. 2014	2	VincotechISE2, - second release	31
May 2015	3	VicotechISE – adjusted for ISE versions beginning with 3.xx	30



# 1 Abstract

Vincotech ISE is a set of integrated simulation tools designed to help you select power modules for various applications. All power loss and temperature calculations are based on actual measurements taken of each module.

## 2 Introduction

Vincotech ISE features the tools for *flow*SOL, *flow*SIM and *flow*SEL. Besides two other tools, *flow*MIS and the new thermal simulator *flow*THERM, are available; calculations can be provided on special request. These software components are here to support your efforts to develop electronic applications and find the power module best suited for the task at hand.

# 3 Installing Vincotech ISE2

Vincotech ISE is based on the labVIEW runtime engine, so you'll need it to launch our simulation tool.

Go to <u>www.vincotech.com</u> to get the right version. Once it is installed, download Vincotech ISE2 from our website at <u>http://www.vincotech.com/en/support/simulation-software.html</u>. Save it to the simulation directory of your choice.

# 4 Launching Vincotech ISE2

Only the executable file is downloaded, so when you first launch the tool a Download/Update window appears showing the latest data files. They contain the modules' parametrical data and other information needed to run the software. Click the download button to retrieve these data.



			download re	commended files
file	local version	server version	status	size
ossTable3.dat		Mar.26.2015.	missing	18301
flowSIM.dat		Mar.25.2015.	missing	15127976
flowSOL.dat		Mar.18.2015.	missing	4323664
flowSEL.dat		Apr.14.2015.	missing	97687
SIM-report.xltx		Apr.24.2015.	missing	25602
SOL-report.xltx		Apr.24.2015.	missing	25460
ample-1.mpr			missing	173
ample-2.mpr			missing	324
ample-3.mpr			missing	477
ample-4.mpr			missing	401
sy-to-start.mpr			missing	173
	file ossTable3.dat flowSIM.dat flowSOL.dat flowSEL.dat SIM-report.xltx SOL-report.xltx cample-1.mpr cample-2.mpr cample-3.mpr cample-4.mpr cample-4.mpr	file         local version           ossTable3.dat	file         local version         server version           ossTable3.dat         Mar.26.2015.         Mar.26.2015.           flowSIM.dat         Mar.25.2015.         Mar.25.2015.           flowSOL.dat         Mar.18.2015.         Mar.18.2015.           flowSEL.dat         Apr.14.2015.         SIM-report.xltx           SOL-report.xltx         Apr.24.2015.         sample-1.mpr           aample-2.mpr         aample-4.mpr         sample-4.mpr           sty-to-start.mpr	file         local version         server version         status           ossTable3.dat         Mar.26.2015.         missing           flowSIM.dat         Mar.25.2015.         missing           flowSOL.dat         Mar.18.2015.         missing           flowSEL.dat         Apr.14.2015.         missing           SIM-report.xltx         Apr.24.2015.         missing           SOL-report.xltx         Apr.24.2015.         missing           cample-1.mpr         missing         missing           cample-2.mpr         missing         missing           cample-4.mpr         missing         missing           cy-to-start.mpr          missing

Once all files are up to date, click the finish button to close the window. All data files are stored in a folder named 'data' generated in the chosen simulation directory. The program stops if the download fails, in which case you'll have to restart it and try again.

<b>••</b>	► ISE ►			•	<del>4</del> 9	Search IS	i 🗆	x P
Organize 🔻	Include in	library 🔻	Share with 🔻	Burn	»	•••		?
data	Vincotech ISE3.exe	Vincotech ISE3.ini						





### 4.1 Updating

The program starts checking the revision history of files on the server at every start of VincotechISE. If more recent versions of files are found, they appear in the Download/Update window. If so, click the download button to load all files to the 'data' folder. There is no need to delete old files manually as the program uses only the latest versions of data files.

If an updated version of Vincotech ISE2 is available, you will have to restart the program after downloading the new files.

#### 4.2 Version Information

Click 'Version information' in the help menu to learn more about every software component and data file.



Version information	mation		<b>X</b>
program versions:		data file versions:	
Vincotech ISE:	build nr: 5.11.15.1		
ISE main frame:	3.00		
Cross table:	3.00	Cross table data:	Mar.26.2015.
flowSOL:	4.00	flowSOL data:	Mar.18.2015.
flowSIM:	6.00	flowSIM data:	Mar.25.2015.
flowSEL:	3.00	flowSEL data:	Apr.14.2015.
flowMIS:	3.00		
			BACK

#### 4.3 Support

If you need any help, go to the contact menu and click the support button to see a list of Vincotech's regional field application engineers and developers. Links to Vincotech's latest application notes, reference designs and technical papers are also posted here.

echnical Support		Contact Us
Field Application Engineering       R&D -         Patrick Baginski       EMEA Regional Field Application Engineer         E-Mail: Patrick.Baginski@vincotech.com       EMEA Regional Field Application Engineer - Europe Central         E-Mail: Mirko.Haardt@vincotech.com       Ereq Mouldlos         Regional Field Application Engineer - North America       E-Mail: Mirko.Haardt@vincotech.com         Herko The Application Manager - Asia Pacific       E-Mail: Chen.Roger@vincotech.com	Application and Test  Ernö Temesi Sr. Development Engineer - Application & Test E-Mail: Erno.Temesi@vincotech.com  Zoltň Ureczki Development Engineer - Application & Test E-Mail: Zoltn.Ureczki@vincotech.com  Vince Zsolt Szabó Sr. Development Engineer - Application & Test E-Mail: Zolts.Zsabó@vincotech.com	Headquarters         Vincotech GmbH         Biberger Strasse 93         82008 Unterhaching / Germany         Tel: +49 (0) 89 8780 67 - 030         Fax: +49 (0) 89 8780 67 - 030         E-Mail:         info@vincotech.com         Regional Contacts         Mr. Alan Zhao         Europe/Middle East Africa:         Mr. Eksart Seitter         Americas:         Mr. Mike Thompson
Jacky Wu         Regional Field Application Engineer - China           E-Mail: Dina.Wu@vincotech.com         Nosung Park           Regional Field Application Engineer - South Korea         E-Mail: Nosung.Park@vincotech.com	Technical documentation Vincotech - Application Notes Vincotech - Reference Design Vincotech - Technical Papers	Васк



# 5 Working with Vincotech ISE

Once all files are up to date, Vincotech ISE is ready to simulate modules. There are two ways to get the simulation of the power module of choice started; choose the preferred product family via a cross-reference table or select a concrete power module by typing the name in the module search.

If only a preferred topology is specified at the start of the simulation tool, the table crossreferencing *flow* and MiniSKiiP power module housings with topologies helps you to find the right product family. This table appears directly after launching Vincotech ISE. Select either 'solar inverter' or 'industrial drive' at the top of the table to change the application field. The selection of topologies will change accordingly.

				Applic	ation	field s	select	ion										
Restance 126         Note 126	cotech ISE - Integrated Simulat Tools View Help	tion Environment		/												- 6 <u>×</u>		
NUMBER VALUE 1000       Index value 10000       Index value 10000	cotechISE - Inte	egrated Si	imulation	Enviroment											💙 Vi	ncotech		
MODEL       Row T       Row T <th< th=""><th>HOME</th><th>solar ir</th><th>nverter</th><th>industrial dr</th><th>ve</th><th></th><th></th><th>_</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th colspan="3"></th></th<>	HOME	solar ir	nverter	industrial dr	ve			_										
RowSEL         H         RedG (S B (T))         Red (S B (T))         Red(S (S B (T)))         Red(S (S (S (T)))         Red(S (S (S (T))))	MODULE SEARCH flowSOL flowSIM	SOLAR		N. S.Y	Harris	flow 1	flow90 1	flow 1B	flow 2	flowSCREW 2	flowSCREW 3	flowSCREW 4w	2xflowSCREW 4v	a 3xflowSCREW 4w	MiniSKiiP® 0	MiniSKiiP®		
Now THERM         Boolter         ReadCOUT 0 th ReadCOUT 0	flowSEL flowMIS	BH BI RI		flowSOL 0 BI (TL) flowSOL 0 RI (T) flow3xPHASE 0 SIC		RewSOL 1 BI (T) RewSOL1 RI (T) RewPACK 1 H												
NEC / NEC 8         Runne C 0         Runne C 1         Runne C 1         Runne C 2         Runne C 4         Dafaunte C 4 <th< td=""><td>flowTHERM</td><td>Booster</td><td></td><td>flowBOOST 0 s+b flowBOOST 0 sym. flowBOOST 0 dual flowBOOST 0 SIC flow3xBOOST 0 SIC</td><td></td><td>flowBOOST 1 sym.</td><td></td><td></td><td>flowBOOST 2 sym.</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></th<>	flowTHERM	Booster		flowBOOST 0 s+b flowBOOST 0 sym. flowBOOST 0 dual flowBOOST 0 SIC flow3xBOOST 0 SIC		flowBOOST 1 sym.			flowBOOST 2 sym.									
NBCC / BUINDE 0 SIC         BUINDE		NPC / NPC-R		flowNPC 0		flowNPC 1 flowNPC 1 MOS			flowNPC 2					3xflowNPC 4w				
anna sin set		MNPC / MNPC-R		flowMNPC 0 flowMNPC 0 SIC		flowMNPC 1 flow3xMNPC 1			flowMNPC 2			flowMNPC 4w		3xflowMNPC 4w				
ans sin.set r		select a	11															
mg Set g																		
ms Set z																		
me set z																		
ams śm. set /																		
	ams sim. set	1																

Now select your preferred topology by clicking it in the column of your chosen housing. Then click the *flow*SOL button for solar inverters or the *flow*SIM button for industrial drives to start the simulation. Use the control key if you wish to select multiple modules with the same



topology. If you don't select a topology now, you will be asked to do so when the selected simulation tool launches.

In case of an already preselected Vincotech power module, you can easily find this module by typing the product name in the search engine. Just click on the button module search to open the search function.

V Search module												
Search mo	dule				BACK							
		$\sim$										
product family	part number	nom. voltage	nom. current	simulation toc								
3xflowMNPC 4w	70-W612M3A300SC-M208E	1200	300	flowSOL	E							
3xflowMNPC 4w	70-W612M3A400SC-M209E	1200	400	flowSOL								
3xflowMNPC 4w	70-W612M3A600SC-M200E	1200	600	flowSOL								
3xflowNPC 4w	70-W624N3A320SH-M400F	2400	400	flowSOL								
MiniSKiiP PACK 1	V23990-K218-F-PM	1200	10	flowSIM								
MiniSKiiP PACK 1	V23990-K219-F-PM	1200	15	flowSIM								
MiniSKiiP PACK 1	V23990-K210-F-PM	1200	25	flowSIM								
MiniSKiiP PACK 1	V23990-K218-F40-PM	1200	8	flowSIM								
MiniSKiiP PACK 1	V23990-K219-F40-PM	1200	15	flowSIM								
MiniSKiiP PACK 1	V23990-K210-F40-PM	1200	25	flowSIM								
MiniSKiiP PACK 2	V23990-K232-F-PM	600	50	flowSIM								
MiniSKiiP PACK 2	V23990-K233-F-PM	600	75	flowSIM								
MiniSKiiP PACK 2	V23990-K238-F-PM	1200	35	flowSIM								
MiniSKiiP PACK 2	V23990-K239-F-PM	1200	50	flowSIM	<b>T</b>							
•												
Figure 7: The IS	E module search											

Type the name (or only a part of it) of the selected power module in the search bar and click on the magnifier button. Afterwards, all suitable power modules will be listed here. Just double click on the preferred one and the simulation starts at once. In some cases, topologies respectively power modules can be simulated in *flow*SOL and *flow*SIM, then please check in column "simulation tool" which tool fits best to your application and select the module accordingly.

If you wish to open and continue a stored simulation, the 'custom simulations' window can be opened by clicking on 'sim. set' at the lower left corner of the screen. It serves to open former simulations and to save the currently configured simulation. Click the plus button and name the current simulation. It is stored automatically in the given simulation tool folder.



# 6 Simulation Tools

All other Vincotech ISE2 components are launched by clicking the appropriate buttons in the top row of the start screen:

	flowSOL	Simulation program for solar inverter modules
	flowSIM	Simulation program for industrial drive modules
<b>1</b>	flowSEL	Selector tool for drive modules
2	MODULE SEARCH	Opens the search function
V	HOME	Takes you back to the start screen

#### 6.1 *flow*SOL

This tool simulates Vincotech power modules designed for solar applications. The user interface provides several windows and entry masks where you can adjust all the key parameters. The window consists of two panels. The top panel contains all modules' parameters and the simulation section; the bottom panel shows graphs with information on voltage, current, temperature and losses.



flowsol	Input Booster		H-Bridge	HF-R	tectifier	Inverter			component selector:					
NUWSUL		+		_			_					In. Boost Sw	itch	
software version: 4.00 data file version: Mar 18 2015		l												
module selector		T												
3xflowMNPC 4w		+		_			_							
3xflowNPC 4w	Notincl	uded	Not inclu	uded		Not incl		lot included						
flow3xBOOST 0 SIC	Comment	Dhat Tiana	Commente	Dhat Tiana	0.000		Dhat	Time	Comment	Dist				
flow3xPHASE 0 SIC	Component	[W] [oC]	Component	[W] [oC]	Com	iponent	[W]	[oC]	Component	[W]	[oC]	module power:		
B flowBOOST 0 SIC ■												Sum DC Power :	0.0	0 kW
flowBOOST 0 dual					_						_	Sum losses:	0.0	00 W OC
flowBOOST 0 s+b												Sum efficiency:	0.00	0 %
flowBOOST 1 sym.														
flowBOOST 2 sym.	Stage losses:	0.00 W	Stage losses:	0.00 V	/ Stage	e losses:		0.00 W	Stage losses:		0.00 W			
flowMNPC 0	Efficiency:	0.000 %	Efficiency:	0.000 %	6 Efficie	ency:		0.000 %	Efficiency:		0.000 %			
flowMNPC 1	١	/in: 240 V				Vout:	240 V	cos phi	: 1.00	Rgon:	0.0 Ohm	Rth modifier:		
flowMNPC 2	Vd	c1: 350 V				Iout: 🔹	0.0 A	fsw	: 20.0 kHz	Rgoff:	0.0 Ohm	4		* 0%
flowMNPC 4w		fb: 50.0 kHz				C:	1500 uF	fout	: 50 Hz	Vgon:	0.0 V	-40%	409	/6
flowNPC 0     ▼	exciting:			()				mod.	: normal	Vgoff:	0.0 V	Auto scale: 🔽	Tsink =	80.0 °C
Input Voltage (V) and Cun 805.0 m	rent (A)	1.0	H-Bridge Current	(A)		1.6 ml	evice Vol	ltage (V)	and Current (/	A)		Total Power dissipation	h (W)	
0.0V lin rms = 0.0V lin rm	is = 0.0A	0.9		Irms =	0.0A	4.0 Vd rms	= 0.	ov	Id rms =	0.0A 131.1 120.0	522.6		P total =	0.00
790.0	40.0	0.8				4.0					555.0			
780.0		0.7				3.5				100.0	400.0			
760.0	30.0	0.6				3.0				80.0	400.0			
750.0	20.0	0.5				2.5				60.0	300.0			
740.0		0.4				2.0				00.0				
730.0	10.0	0.3				1.5				40.0	200.0			
720.0	0.0	0.2				1.0				20.0	100.0			
710.0		0.0				0.5								
200.0 0 10m	-10.0 20m	6	10m		20m	0.0		10m		0.0 <sub>1</sub> 20m	0.0	10m		20m
DC link voltage (V) and avg.	Current (A)	Ir	verter Switched Curr	rents (A)			D	evice dut	y cycle	201	1	Junction temperature	(oC)	
805.0 Vdc avg = 0.0V Idc rm	ns = 0.0A <sup>52.9</sup>	131.1 IGBT				1.1					165.2		Tj avg =	0.0 °C
700.0		120.0 FWD				1.0					164.0			
600.0	40.0	100.0									162.0			
500.0	30.0	80.0				0.8					160.0			
100.0						0.6					158.0			
400.0	20.0	60.0				0.0					156.0			
300.0	10.0	40.0				0.4					154.0			
200.0		20.0									152.0			
100.0	0.0					0.2					150.0			
0.0	- 10.0 <sub>1</sub>	10.0 10.0	10m		20m	0.0		10m		200	148.0	10m		20m
	20m	~	1010		200	1 *		10m		201		100		2011
Figure 8: A look	at the fl	owSOL	tool											

You must choose a specific module in the module selector window. It shows all available modules for the topologies selected on the Vincotech ISE2 start screen.





The simulation starts as soon as you choose a module, using the preset parameters as the basis. The top row of the upper panel is divided by function into four boxes called Input Booster, H-Bridge, HF-Rectifier and Inverter. These boxes are disabled (empty and framed in dark blue) or enabled (filled with a circuit diagram and framed in polar blue) in accordance with your chosen topology. The selected power module's full name is also indicated. Below these boxes you'll see listed the circuit's components and information about their losses and average temperature.

A right-click on an enabled box opens the module selector. It lists all power modules that you can substitute to perform this function. This way of choosing a replacement has the benefit that your parameters are retained. If instead you select a new module in the module selector on the left, all parameters are reset to their defaults.

Right-clicking a disabled function box also opens the module selector. In this case, a combination of different power modules, say a booster and an inverter, can be simulated.

Input Booster			H-Bridge			HF-Rectifier			Inverter				component selector:	
	Ţ									l. Læ-k			Out. Buck Sv	vitch 💌
Not included Not included						Not incl	uded		flow 10-PZ12NM 1200V;1	MNPC A0271 D0A (N	0 SiC ME-M340 1340-F63	F63Y 3Y)		
Component	Ptot [W]	Tjavg [oC]	Component	Tjavg [oC]	Component	Ptot [W]	Tjavg [oC]	Component		Ptot [W]	Tjavg [oC]	module power:		
							Out.Buck Sw. (2x) 4		42.84	110.59	Sum DC Power :	12.00 kW		
	_						Out.Buck D. (2x) 13.34 101.86			101.86	Sum losses:	127.38 W		
	_			_			Out.Boost Sw. (2x) 7.51 87.20			87.20	Sum efficiency:	98,950 %		
	_			_				Out.Boost D. (2x) 0.00 80.00			80.00	,-		
Stage Josses:		0.00 W	Stage losses:		0.00 W	Stage losses:		0.00 W	Stage Josses: 127.38 W					
Efficiency:	10	0.000 %	Efficiency:	10	0.000 %	Efficiency:	10	0.000 %	Efficiency:		9	3.950 %		
	Vin:	700 V				Vout:	240 V	cos ph	1.00	Raon	1: 4	1.0 Ohm	Rth modifier:	
N N	Vdc1: 700 V						50.0 A	fsw	20.0 kHz	Raof	f: 4	1.0 Ohm	4]]	▶ 0%
	fb: 50.0 kHz						C: 1500 uF fout				1:	16.0 V	-40%	40%
exciting:	exciting:						m				f:	-50.0 V	Auto scale: 🔽	Tsink = 80.0 °C
		~												

The far right column indicates DC power, overall losses and the module's efficiency. The stated values always refer to both power modules when simulating a combination of modules.

Figure 10: The flowSOL tool's function boxes and entry mask

Now you can fine-tune input/output voltage, output current, switching frequency and all other parameters for the selected topology. Depending on the enabled function box and power module, you can adjust:



- Vin input voltage in [V]
- Vdc1 booster output voltage in [V]
- fb booster switching frequency in [Hz]
- Vout phase voltage in [V]
   Line-to-ground RMS value
- Iout RMS output current in [A]
   A green light indicates that negative currents may also be simulated.
- C DC link capacitance in [µF]
- cos phi efficiency factor cos  $\phi$ , range 0 to 1
- fsw switching frequency in [Hz]
   Configuration-dependent: H-bridge or inverter
- fout output/grid frequency in [Hz] Available presets: 50 Hz and 60 Hz
- Rgon switch-on gate resistor in  $[\Omega]$
- Rgoff switch-off gate resistor in [Ω]
   Value must be equal to or lower than switch-on gate resistor Rgon.
- Tsink heat sink temperature in [°C]
- Inverter modulation

Configuration-dependent presets: normal, unipolar, bipolar, 3rd harmonic

- Rth mod.
   This slider allows to adjust the preset Rth, if in the application a better or worse thermal resistance than in the datasheet stated is expected
- Vgon positive gate driver voltage in [V]. This preset is nonadjustable.
- Vgoff negative gate driver voltage in [V]. This preset is nonadjustable.

The graphs in the *flow*SOL screen's lower panel are updated after every parameter change. These graphs are windows into the simulation affording you views of input voltage curves, input current, DC link values and the like to show how individual components respond to the given parameters. Select the component you wish to analyze in the component selector box at the right of the top panel.





To gain deeper insight into the chosen component's input and output waveforms, left-click the three buttons in the simulation section to see detailed graphs indicating:



Input and output waveforms



Static and dynamic losses and temperature graphs



Static and switching characteristics



Generates an Excel report file









The 'Detailed parts diagrams' window serves to analyze static and dynamic switching characteristics and thermal impedance. Informative graphs are shown on various pages depending on the selected module's configuration as an input booster, H-bridge, HF rectifier or inverter.

You can also select a second power module to compare two options directly. To do this, open the module selector by clicking the 'select module to compare' button on the right. A second module is then simulated using the same set of parameters as for the first.





Each device's static loss is calculated on the basis of output characteristics V = f(I) measured at 25 °C and 125 °C. The device's voltage drop at any other temperature is calculated using the linear interpolation method.





Switching losses are calculated by measuring  $E_{on}$ ,  $E_{off}$  and  $E_{rec}$ . Measurements were taken at 25 °C and 125 °C with discrete values of  $I_c$  and  $R_g$ .

Left-click and hold the 3D graph to turn the model in any direction. Zoom in and out using the mouse wheel.



The heat-sink temperature has to be fixed first for thermal modeling. The default value is  $T_{\text{sink}}$ =80 °C. The calculated total power loss is applied to a serial R-C thermal model to determine chip temperature.

The graph represents Tau over  $R_{\rm th}$ .





All axes can be adjusted by double clicking on a value and retyping it. A change of the highest axis value performs a zoom in or out, a change of another values changes the step range.

#### 6.2 *flow*SIM

The *flow*SIM tool calculates Vincotech's power modules for industrial drive applications. Its user interface looks much like that of the flowSOL tool. The top panel consists of the module selector, function boxes, entry mask and simulation section; the bottom panel presents the output graphs.

<i>a</i>	1	Rectifier			PFC Shunt PFC					Brake Inv. Shunt				Inverte	r		component selector:					
software version: 6.00 data file version: Mar.25.2015. module selector B- MiniSkiiP PACK 1 B- MiniSkiiP PACK 2	1			:			_													Rect	ifier	
MiniSKiiP PACK 3 MiniSKiiP PIM 1 MiniSKiiP PIM 2	=	Not ii	ncludeo		Not included			Not included			Not included			Not included			Not included		uded			
MiniSKiiP PIM 3		Component	Ptot [w]	Tjavg	Component	Ptot [w]	Tjavg [oC]	Component	Ptot [w]	Tjavg	Component	Ptot [w]	Tjavg	Component	Ptot [w]	Tjavg	Componer	nt Pi	tot Tjavg	module power:		
fastPACK 0 H	-15		1.11	[00]			[00]		1.43	1001		1.11	[00]		1.1.1	[00]				Sum DC Power:		0.00 kW
ii fastPIM 1 H																		_		Sum losses:		0.00 W
I flow3xPHASE 0 SIC																				Sum efficiency:		0.000 %
B flow90CON 1		Stage losses	: 0.	00 W	Stage losses	: 0.	00 W	Stage losses	s: 0.0	00 W	Stage losses	: 0.0	00 W	Stage losse	s: 0.(	W 00	Stage los:	ses:	0.00 W			
B flow90PACK 1		Efficiency:	0.0	00 %	Efficiency:	0.0	00 %	Efficiency:	0.0	00 %	Efficiency:	0.0	00 %	Efficiency:	0.0	00 %	Efficiency		0.000 %			
I flow90PIM 1		Vin	-	0 V				Vdo	-	0 V		Vout:		0 V co:	s phi:	0.	80 Rgor	<u>"</u>	0.0 Ohm	Rth modifier:		► 0%
flowBOOST 4w sym.		Kiine: fin:	. 0.0	50 Hz				6.6		1500 uF		Iout:		1.0 A	fourte	4.0 k	Hz Rgof		0.0 Ohm	-40%		40%
B flowCON 0	- I.	excitina:		00112				ipic	. 10	0.0 KH2		Vbr:	-	0 V	rout.	50.0	Vqof	'' f:	0.0 V	Auto scale: 🗸	Tsink =	80.0 °C
Input Voltage (V) and C	Curr	ent (A)				H-Br	idge Cu	rrent (A)				Devic	e Volta	ge (V) and C	Current	(A)			To	otal Power dissipation	1 (W)	
391.0 Vin rms = 0.0V Iin	n rms	s = 0.0A	31.0	1	.0				Irms =	0.0A	3.4 Vd r	ms =	0.0\	/ Idr	ms =	0.0A	49.4				P total	= 0.0W
385.0 TH	ID =	0.00 %	30.5	0	.9						3.0						45.0	109.2				
380.0			30.0	0	.8						2.5						40.0	100.0				
375.0			29.0	0	.6												30.0	80.0				
365.0			28.5	0	.5						2.0						25.0	60.0				
360.0			28.0	0	.4						1.5						20.0					
355.0			27.5	0	.3						1.0						15.0	40.0				
350.0			27.0	0	.2						0.5						10.0	20.0				
345.0			26.5	0	.0						0.0						5.0					
339.0 0 10m			26.0	m 0			100	1		20m	0.0			10m			0.0, 20m (	0.0		10m		20m
DC link voltage (V) and av	/g. C	Current (A)			Inv	erter S	witched	Currents (	4)				Dev	ice duty cyc	le				J	unction temperature	(oC)	
391.0 Vdc avg = 0.0V Id	lc rm	s = 0.0A	31.0	49	.4 IGBT						1.1							149.1			Tj avg =	0.0 °C
350.0			30.5	40	DC link						1.0							145.0				
300.0			29.5	35	.0																	
250.0			29.0	30	.0						0.0							140.0				
200.0			28.5	25	.0						0.6							135.0				
150.0			28.0	20	.0						0.4							130.0				
100.0			27.5	15	.0						0.4											
50.0			27.0	10	.0						0.2							125.0				
0.0			26.0	0	.0						0.0							118.0				
0 10m			20	m			10m			201	1 0			10m			20m	0		10m		20m
Figure 18: The	e f	lowS	IM	too																		

The module selector lists all power modules designed for industrial drives. If you preselected modules earlier on the start screen, only those modules will be listed.

The *flow*SIM tool provides six function boxes labeled Rectifier, PFC Shunt, PFC, Brake, Inverter Shunt and Inverter. If the module is configured to perform one of these functions, the corresponding box will present the applicable circuit diagram framed in polar blue. If not, the box will be empty and framed in dark blue. The selected power module's full name is indicated below the enabled boxes.



A right-click on an enabled box opens the module selector. It lists all power modules that you can substitute to perform this function. In this case, all parameter changes are retained as described for the *flow*SOL tool.

Right-clicking a disabled function box also opens the module selector. In this case, a combination of different power modules, say a rectifier and an inverter, can be simulated.

Left-clicking any function box, enabled or disabled, changes the configuration of that part of the circuit.

Here's an example of what you can do with a disabled block:

Say you want to simulate a six-pack inverter and need to define the type of input voltage to this end. You can choose DC voltage, one phase rectified or three phases rectified, and then adjust the voltage value, line resistance and – depending on your selection – the frequency.

Here's an example for an enabled block:

If you're simulating a six-pack, you could change the type of application from three-phase to one-phase.

Adjust the parameters after you have configured the module. Several are available depending on the enabled function box and selected power module.

Rectifier			PFC Shunt			PFC			Brake			Inv. Shunt			Inverter			component selector:	
																		Rectifi	er 💌
Not included			Not included			Not included			Not included			Not included			Not included				
Component	Ptot [W]	Tjavg [oC]	Component	Ptot [W]	Tjavg [oC]	Component	Ptot [W]	Tjavg [oC]	Component	Ptot [W]	Tjavg [oC]	Component	Ptot [W]	Tjavg [oC]	Component	Ptot [W]	Tjavg [oC]	module power:	
																		Sum DC Power:	0.00 kW
																		Sum losses:	0.00 W
																		Sum efficiency:	0.000 %
Stage losses: 0.00 W		Stage losses: 0.00 W		Stage losses: 0.00 W		Stage losses: 0.00 W		Stage losses: 0.00 W		Stage losses: 0.00 W		00 W 00	1						
Efficiency:	0.0	00 %	Efficiency:	0.0	00 %	Efficiency:	0.0	00 %	Efficiency:	0.0	00 %	Efficiency:	0.0	00 %	Efficiency:	0.0	00 %		
Vin:	Vin: 0 V					Vdc: 0 V			Vout:			0 V cos phi: 0.			.80 Rgon:	0.	0 Ohm	Rth modifier:	
Rline	Rline: 0.01 Ohm					C: 1500 uF			Iout:			1.0 A fsw: 4.0 k			Hz Rgoff: 0.0 Ohm		<b> </b>	▶ 0%	
fin: 50 Hz						fpfc: 100.0 kHz			mod: n			ormal fout: 50.0		000 Vgon:	Vgon: 0.0 V		40%		
exciting:										Vbr		0 V			Vgoff:		0.0 V	Auto scale:	Tsink = 80.0 °C

Figure 19: The flowSIM tool's function boxes and parameter entry mask



#### Rectifier

- Vin - input voltage in [V]

Input voltage is specified as a line-to-line RMS value for three-phase devices and as a line-to-ground RMS value for single-phase or DC applications. The default is DC if the module lacks a rectifier, but this can be changed to single-phase or three-phase.

- Rline line resistance in  $[\Omega]$
- fin frequency of the input voltage in [Hz]
- PFC
  - V<sub>dc</sub> output voltage of the PFC stage in [V]
     For a PFC simulation, Vdc must be higher than Vin\_peak:

 $V_{in\_peak} = V_{in} \cdot \sqrt{2}$ 

- C DC link capacitance in [μF]
   AC ripple on the DC link voltage is determined by DC link capacitance.
- fpfc switching frequency of the PFC stage in [Hz]
   A virtual six-pack is added to the configuration if only a PFC stage is to be simulated. It serves as a load for the PFC even if the selected module does not include a six-pack. (The output parameters field is enabled even for a virtual six-pack.)
- Brake
  - V<sub>br</sub> brake voltage in [V]

Brake voltage must be equal to or higher than the rectified input voltage  $V_{in}$ .

- Inverter
  - V<sub>out</sub> output voltage in [V]
    - (first harmonic of the output voltage under nominal operating conditions) Output voltage is specified as a line-to-line RMS value for three-phase devices and as a line-to-ground RMS value for single-phase or DC applications.
  - Iout RMS output current in [A]
     The output current can be specified in positive values for motor applications and negative values for generator mode. In generator mode, calculations are made on the basis of a DC link voltage Vdc equal to the brake voltage. Vbr must be equal to or higher than the rectified input voltage Vin.
  - cos phi efficiency factor cos  $\phi$ , range 0 to 1
  - fsw switching frequency in [Hz]
  - mod modulation index
    - the 3rd harmonic can be added to the modulator signal



- fout first harmonic output voltage frequency in [Hz] only preset values can be selected
- Rgon switch-on gate resistor in  $[\Omega]$
- Rgoff switch-off gate resistor in  $[\Omega]$
- The value must be equal to or lower than switch on-gate resistor Rgon.
- Vgon positive gate driver voltage in [V] (This preset is nonadjustable)
- Vgoff negative gate driver voltage in [V] (This preset is nonadjustable)
- T<sub>sink</sub> heat sink temperature in [°C]

DC power is indicated below the simulation section and calculated as follows:

 $P_{\rm DC} = \sqrt{3} \cdot V_{line} \cdot I_{\rm out} \cdot cos \varphi$  Three-phase applications

 $P_{\rm DC} = V_{\rm line} \cdot I_{\rm out} \cdot cos \varphi$  One-phase applications

The graphs in the lower *flow*SIM panel are updated after every parameter change. These graphs are windows into the simulation affording you views of input voltage curves, input current, DC link values and the like to show how individual components respond to the given parameters. Select the component you wish to analyze in the component selector box at the right of the top panel.



Figure 20: flowSIM component selector and simulation section

Click these three buttons to get full views of the selected component's input and output waveforms, losses and switching characteristics, respectively.









The 'Detailed parts diagrams' window serves to analyze static and dynamic switching characteristics and thermal impedance. Informative graphs will be shown on various pages depending on the selected module's configuration as a rectifier, PFC or inverter.

You can also select a second power module to compare two options directly. To do this, open the module selector by clicking the 'select module to compare' button on the left. A second module is then simulated using the same set of parameters as for the first.





Each device's static loss is calculated on the basis of output characteristics U = f(I) measured at 25 °C and 125 °C. The device's voltage drop at any other temperature is calculated using the linear interpolation method.





Switching losses are calculated by measuring  $E_{on}$ ,  $E_{off}$  and  $E_{rec}$ . Measurements were taken at 25 °C and 125 °C with discrete values of  $I_c$  and  $R_g$ .

Left-click and hold the 3D graph to turn the model in any direction. Zoom in and out using the mouse wheel.



The heat-sink temperature has to be fixed first for thermal modeling. The default value is  $T_{\text{sink}}$ =80 °C. The calculated total power loss is applied to a serial R-C thermal model to determine chip temperature.



All axes can be adjusted by double clicking on a value and retyping it. A change of the highest axis value performs a zoom in or out, a change of another values changes the step range.



#### 6.3 flowSEL

If you need to find the right power module for an industrial drive application, *flow*SEL is the tool to use. All graphs are based on actual measurements, which is why *flow*SEL provides accurate data on current, power and temperature conditions that will help you identify the best solution.

The *flow*SEL screen is divided into three sections, the entry mask on the top left, the module repertory below it, and the graphs on the right.



First open the drop-down menu under "Group modules by customer name" to select a module group and narrow down the list of available power modules. You can reduce this list further by choosing among the available housings and topologies. Then adjust the set of parameters to suit the application you have in mind. The list of suitable modules is refreshed automatically with every parameter change.



The adjustable parameters are:

- DC voltage in [V]
- Switching frequency in [Hz]
- Heat sink temperature in [°C]
- Output/grid frequency in [Hz]
- Efficiency factor  $\cos \phi$
- RMS output current in [A]
- RMS output voltage in [V]
- The switch on the right of the application diagram toggles between motor and generator operating modes.

The program calculates the average junction temperature of the switching element, the freewheeling diodes and the coefficient of efficiency. These values are displayed in the module table's right columns.

The lower limit for the average junction temperature may also be adjusted. Modules with less than  $T_{j avg min}$  are not displayed in the table. The default value is 110 °C.

The simulation starts automatically once a power module is selected.