

Fuji IGBT Simulator Ver 6.3.2

Language Help

Module Selection Thermal Condition Single Mode Cycle Mode

**Select Module Type**

Series: X series Clear VCES[V]: 1200 Clear

Circuit: Clear IC[A]: 600 Clear

Module: 2MBI600XNG120-50

**Product Information**

Type: 2MBI600XNG120-50  
Series: X series  
Circuit: 2-Pack  
VCES[V]: 1200  
IC[A]: 600  
Package: M254

M285

Fuji IGBT Simulator Ver 6.3.2 Result002

2MBI600XNG120-50

**Loss(W)**

Total per arm	350.9	Total per system	2105.4
Total per arm per parallel	175.5	Total per system per parallel	1052.7

**Temperature(°C)**

	T1	D1	T2	D2	T5	D5
Tvj (peak)	100.8	97.2				
Tvj (ave)	98.7	96.1				
Tvj-c (ave)	5.8	3.1				
ΔTvj	3.8	2.0				
Tc(T1/D1)						
Tc (peak)	93.0					
Tc (ave)	92.9					

**Condition**

3-Phase 2-Level Inverter

Number of Parallel Devices: 2

Fo(Hz): 50

Io(Arms): 300

Fc(kHz): 5

pf: 0.8

Mod: 0.9

Duty: 0.9

Vdc(V): 600

T1 RG(on): 0.56

T1 RG(off): 0.56

T2 RG(on):

T2 RG(off):

**Loss Calibration Factor**

**Temperature(°C)**

Tf (peak): 90.0

Tf (ave): 90.0

Ta:

Save Image Data Export Close

## Fuji IGBT Simulator Ver.6.3

# User Manual

(Caution)

Before downloading and using the software, please read the following “End-user Software Agreement”. By downloading the software, you agree to be bound by the terms of the following agreement. If you don’t agree the agreement, remove the software and erase all copies of the software and the related documents.

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5. (Program update) The program specification of this software is subject to change without any notice.

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## 1. Software Setup

This software is suitable for Microsoft® Windows® Windows7, Windows & Windows10.  
In order to operate, Microsoft .NET Framework 3.5 or later is required .

### (1) Download site

<https://www.fujielectric.com/products/semiconductor/model/igbt/simulation/list.html>

The screenshot shows the Fuji Electric website interface. The top navigation bar includes 'About Us', 'Products & Solutions', 'Investor Relations', and 'Contact Us'. The breadcrumb trail is 'Home > Product Information > Power Semiconductors > Design Support > IGBT Modules > Loss Simulation'. The main content area is titled 'Loss Simulation' and features a red dashed box around the 'Fuji IGBT Simulator TOP' link. Below this, there is a 'Contact' button and a help icon. The right-hand side of the image shows a zoomed-in view of the 'Fuji IGBT Simulator' page, which includes a section for 'Using (downloading) the software' and a table of download links.

Fuji IGBT Simulator	Document No.	Size	Date
Software (Ver 6.3.2) <b>TOP</b>	-	13.0MB	Nov. 2021
User Manual (Ver 6.2)	MT5F31341	5.6MB	Dec. 2020

### (2) install

Unzip the downloaded file and copy to a custom folder.

Please double-click the file "IGBTSim.exe" to start the simulator.

Windows is a registered trademark of Microsoft Corporation in the United States and other countries.


## 2. Startup screen

### (1) End-User Software License Agreement

The software license agreement is displayed at startup.

Please confirm the contents and click the "ACCEPT" button.

End-User Software License Agreement

 **Fuji Electric**  
Innovating Energy Technology

This is a software license agreement (the "Agreement") between you ("Customer") and Fuji Electric Co. Ltd. ("Fuji") with regard to the use of Fuji IGBT Simulator ("Software").

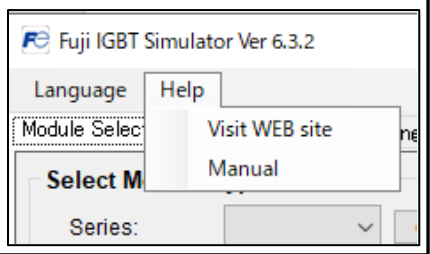
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5. (Program update) The program specification of this software is subject to change without any notice.

## (2) IGBT simulator menu

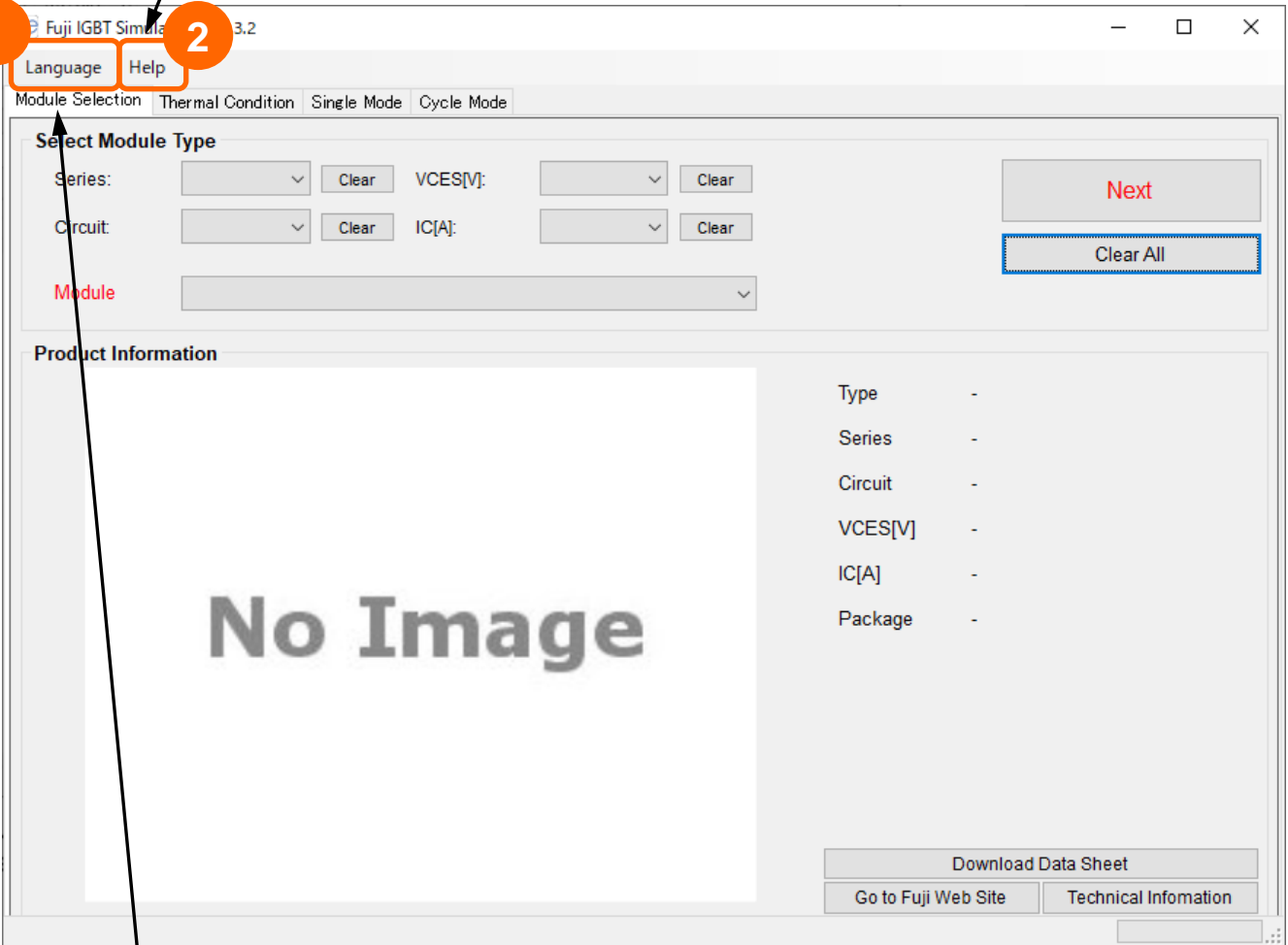
You can select the language from the menu. Help is available.

**2 Help menu**

The latest version of this software can be downloaded from web site by clicking "Visit WEB site".



**1**



**2**

Language Help

Module Selection Thermal Condition Single Mode Cycle Mode

**Select Module Type**

Series: [ ] Clear VCES[V]: [ ] Clear

Circuit: [ ] Clear IC[A]: [ ] Clear

Module [ ]

Next

Clear All

**Product Information**

No Image

Type -

Series -

Circuit -

VCES[V] -

IC[A] -

Package -

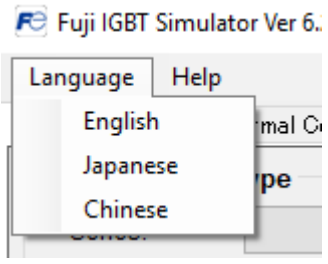
Download Data Sheet

Go to Fuji Web Site Technical Information

**1 Select language**

You can select the language by clicking "Language"

- English
- Japanese
- Chinese



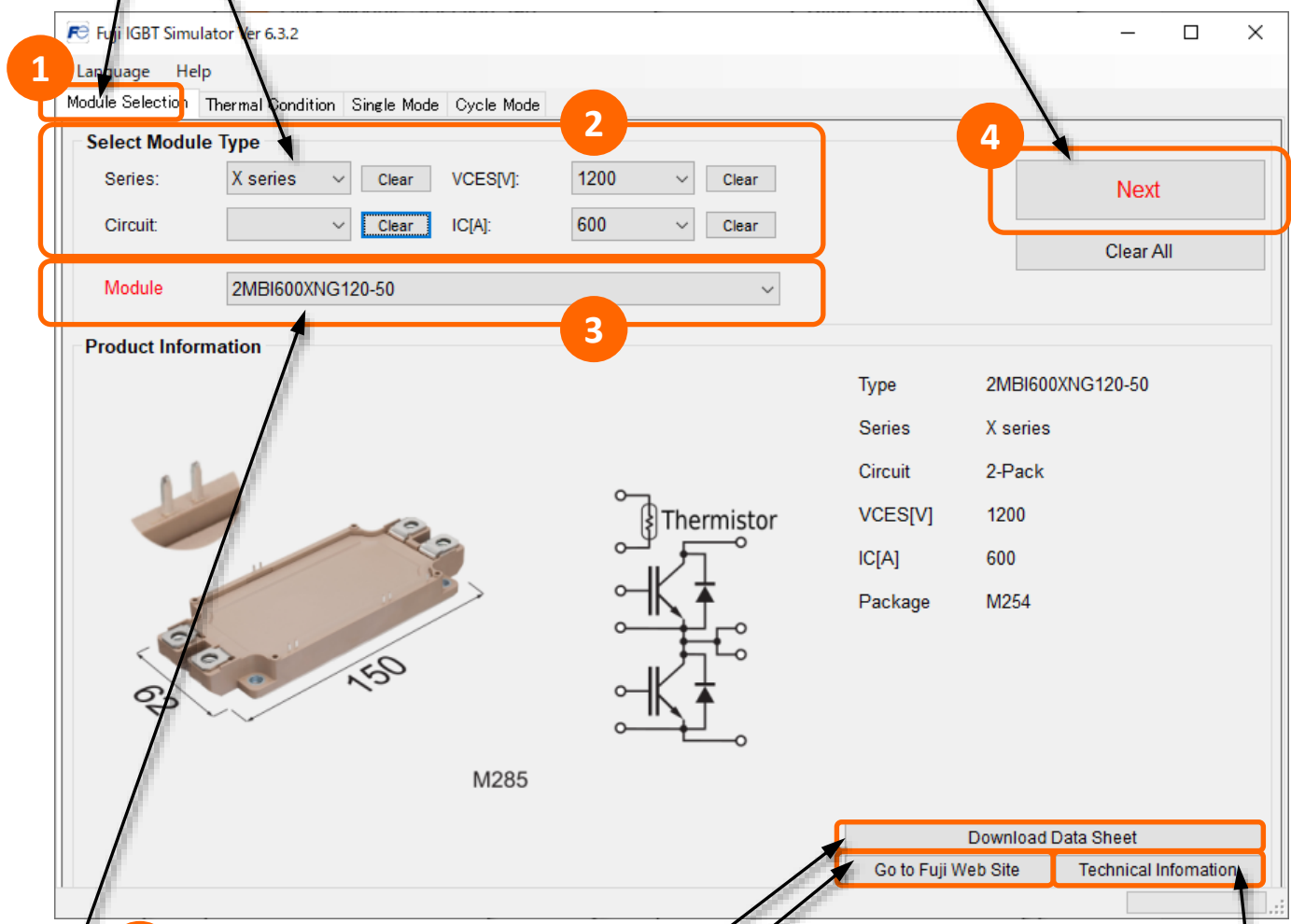
### 3. Module Selection

Select the IGBT to simulation.

**1** Click "Module Selection" tab.

**2** Select "Series, Circuit, VCES, IC" from each dropdown list.

**4** Click "Next" button.



**1**

**2**

**3**

**4**

**3**

Select module from the dropdown list.

Download product datasheet.

Visit Fuji Semiconductor web site.

Visit technical information page.

## 4. Set temperature condition

Set the temperature conditions for the simulation.

### (1) When calculating with fixed Case Temperature

1

Select fixed Case Temperature.  
Calculate  $T_c$  as constant.

1

2

Single Mode >>

Cycle Mode >>

<< Back

Thermal Resistance Model

Thermal impedance model (Foster equivalent network)

$$Z_{th}(t) = \sum_{n=1}^4 r_n \left\{ 1 - \exp\left(-\frac{t}{\tau_n}\right) \right\}$$

$$\tau_n = r_n \cdot c_n$$

2

Click "Single Mode" or "Cycle Mode" to proceed to the next step.

For details of the thermal circuit model, refer to pages 9 to 10.



## (2) When calculating without fixed Case Temperature

When calculating the case temperature, you can choose between fixed heatsink and heatsink temperature calculation.

**1** Select Calculate Case Temperature. Calculate  $T_c$  using thermal resistance  $R_{th(c-f)}$  case to heat sink.

**3** Click "Single Mode" or "Cycle Mode" to proceed to the next step.

**2** Input heat sink condition

**a** Fixed heat sink condition  
Calculate with constant  $T_f$

**b** Calculate heat sink temperature  
 $T_f$  is calculated using thermal impedance  $Z_{th(f-a)}$  between heat sink and ambient temperature

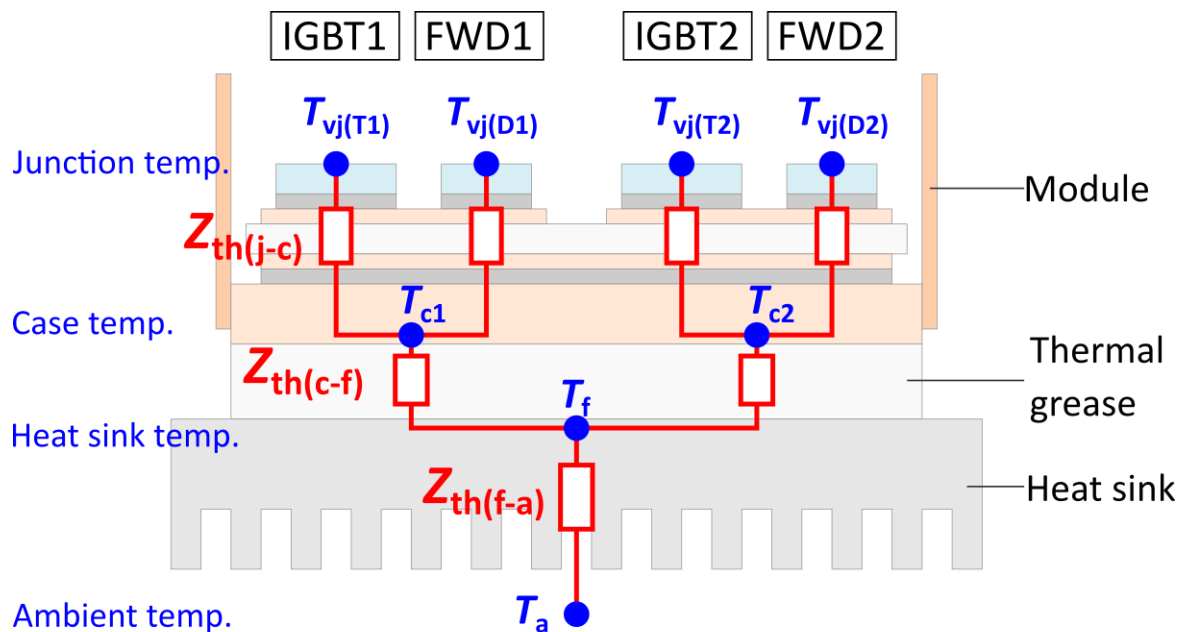
**c** Input  $Z_{th(f-a)}$  as constant without any time constants.

**d** If  $Z_{th(f-a)}$  is represented by a 4th order Foster network model, input  $r_1$  to  $r_4$  and  $\tau_1$  to  $\tau_4$ .

## 5. Thermal Circuit Model

### (1) Thermal Circuit Model

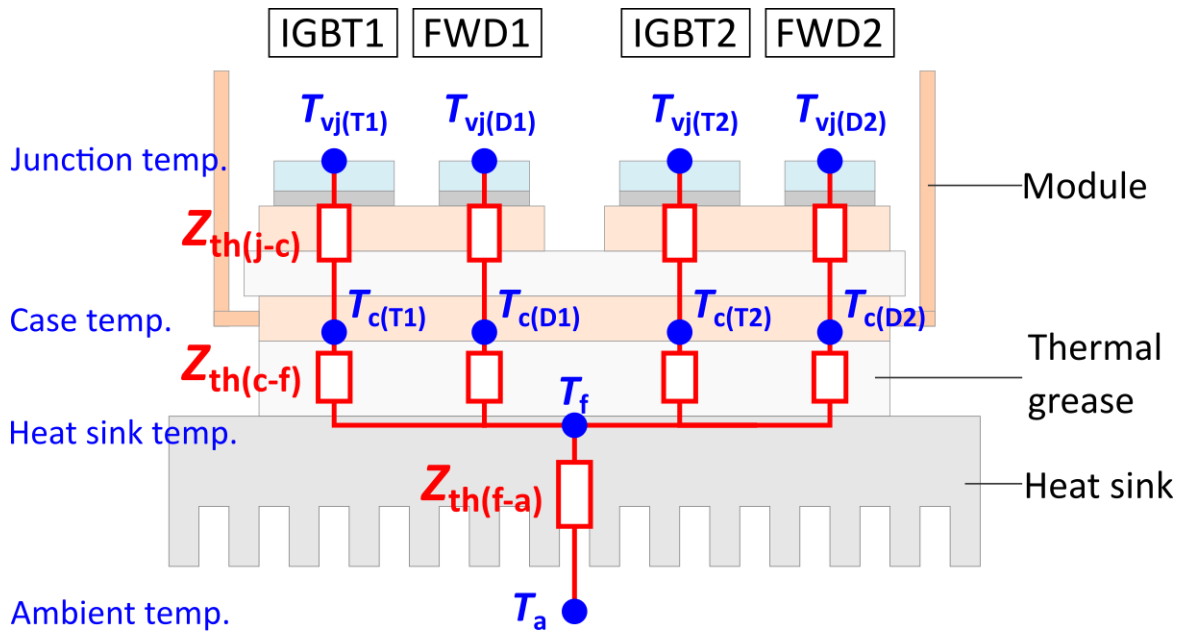
In the simulator, calculations are performed based on the following thermal circuit model.



The heat sink temperature  $T_f$  is calculated based on the assumption that the surface temperature distribution of the heat sink's area, which is in contact with the module, is uniform. If there is a deviation in the real temperature distribution, the calculated value might be different to the real one.

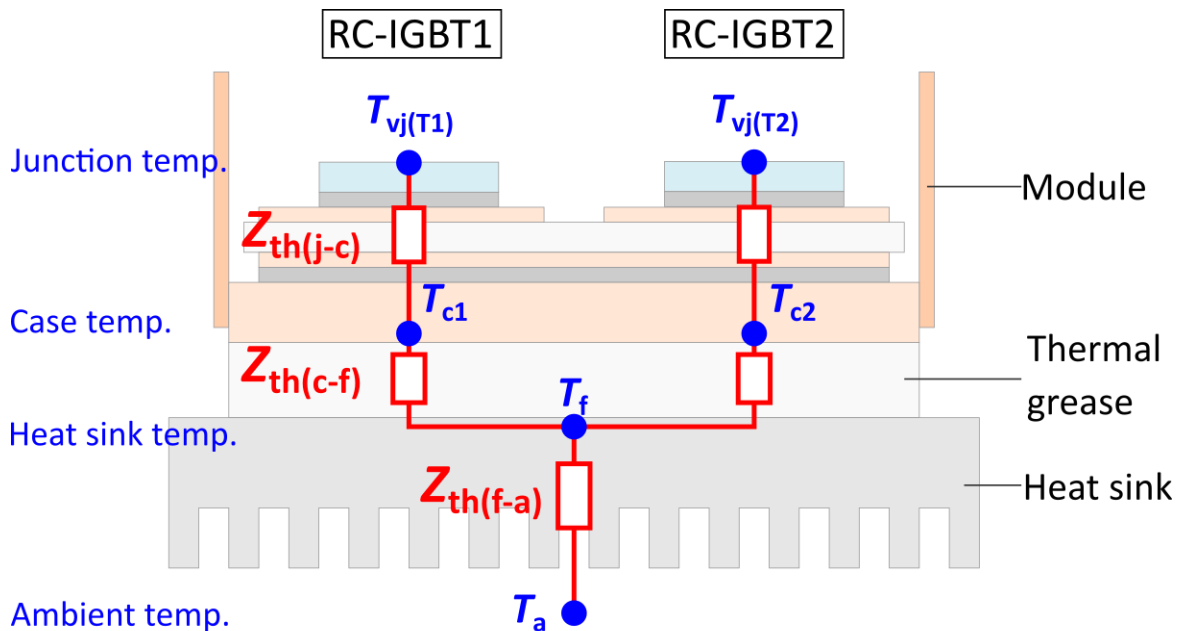
**(2) Thermal Circuit Model - without copper baseplate -**

The following thermal circuit model is applied for modules without copper baseplate.



**(3) Thermal Circuit Model -RC-IGBT-**

The following thermal circuit model is applied for RC-IGBT modules.



The heat sink temperature  $T_f$  is calculated based on the assumption that the surface temperature distribution of the heat sink's area, which is in contact with the module, is uniform. If there is a deviation in the real temperature distribution, the calculated value might be different to the real one.

# Single Mode Calculation

## 6. Single Mode Calculation

### (1) Input simulation condition

Single mode calculation allows simulation for one cycle.

**1** Click "Single Mode" Tab.

**2** Select circuit topology. For details, please refer to page 34 to 36.

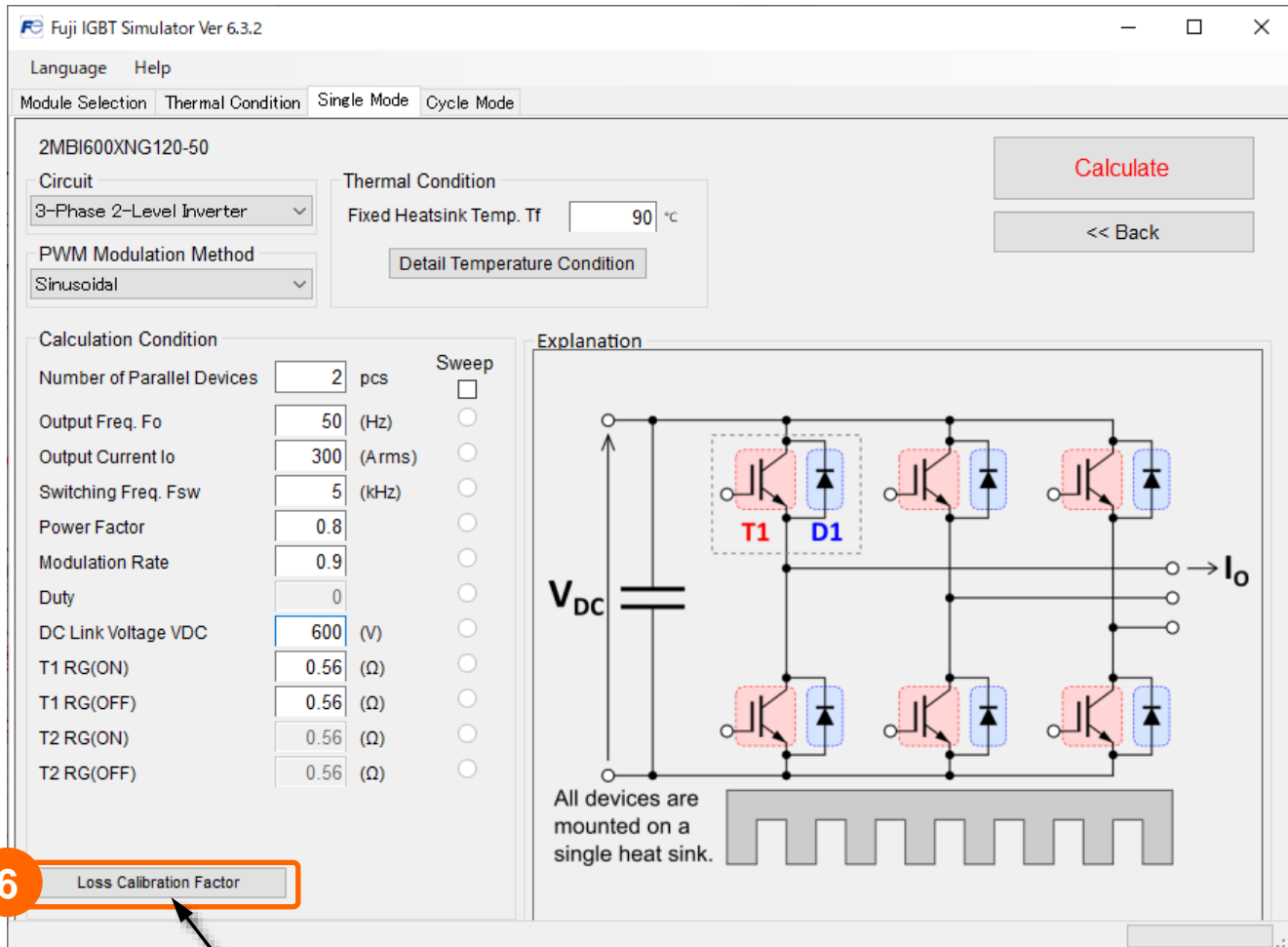
**3** Select PWM modulation method. For details, please refer to page 37 to 40.

**4** Input the number of parallel connected modules. The calculation is based on the assumption that all modules are mounted on the same heat sink.

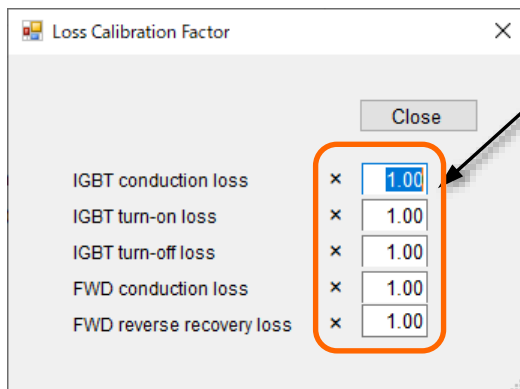
**5** Input operation condition. For paralleled modules, the current through the individual module is obtained by dividing given  $I_o$  by number of parallel modules.

## (2) Loss Calibration Factor

The calibration factor of each parameter can be set from "Loss calibration Factor".



6 Click "Loss Calibration Factor" tab.  
The dialog box to input coefficients for calibrating the loss calculation value will open.



Every generated loss by IGBT / FWD is multiplied with the provided calibration factor.

### (3) Run Calculation

Entering “Calculation Condition” will allow you to perform the calculation.

Calculation will start when you click the “Calculation” Button.

The screenshot displays the Fuji IGBT Simulator Ver 6.3.2 interface. The main window is titled "2MBI600XNG120-50". It features several tabs: "Language", "Help", "Module Selection", "Thermal Condition", "Single Mode", and "Cycle Mode".

**Thermal Condition:** Fixed Heatsink Temp. Tf is set to 90 °C. A "Detail Temperature Condition" button is visible.

**Calculation Condition:**

Number of Parallel Devices	2	pcs	Sweep	<input type="checkbox"/>
Output Freq. Fo	50	(Hz)		<input type="radio"/>
Output Current Io	300	(Arms)		<input type="radio"/>
Switching Freq. Fsw	5	(kHz)		<input type="radio"/>
Power Factor	0.8			<input type="radio"/>
Modulation Rate	0.9			<input type="radio"/>
Duty	0			<input type="radio"/>
DC Link Voltage VDC	600	(V)		<input type="radio"/>
T1 RG(ON)	0.56	(Ω)		<input type="radio"/>
T1 RG(OFF)	0.56	(Ω)		<input type="radio"/>
T2 RG(ON)	0.56	(Ω)		<input type="radio"/>
T2 RG(OFF)	0.56	(Ω)		<input type="radio"/>

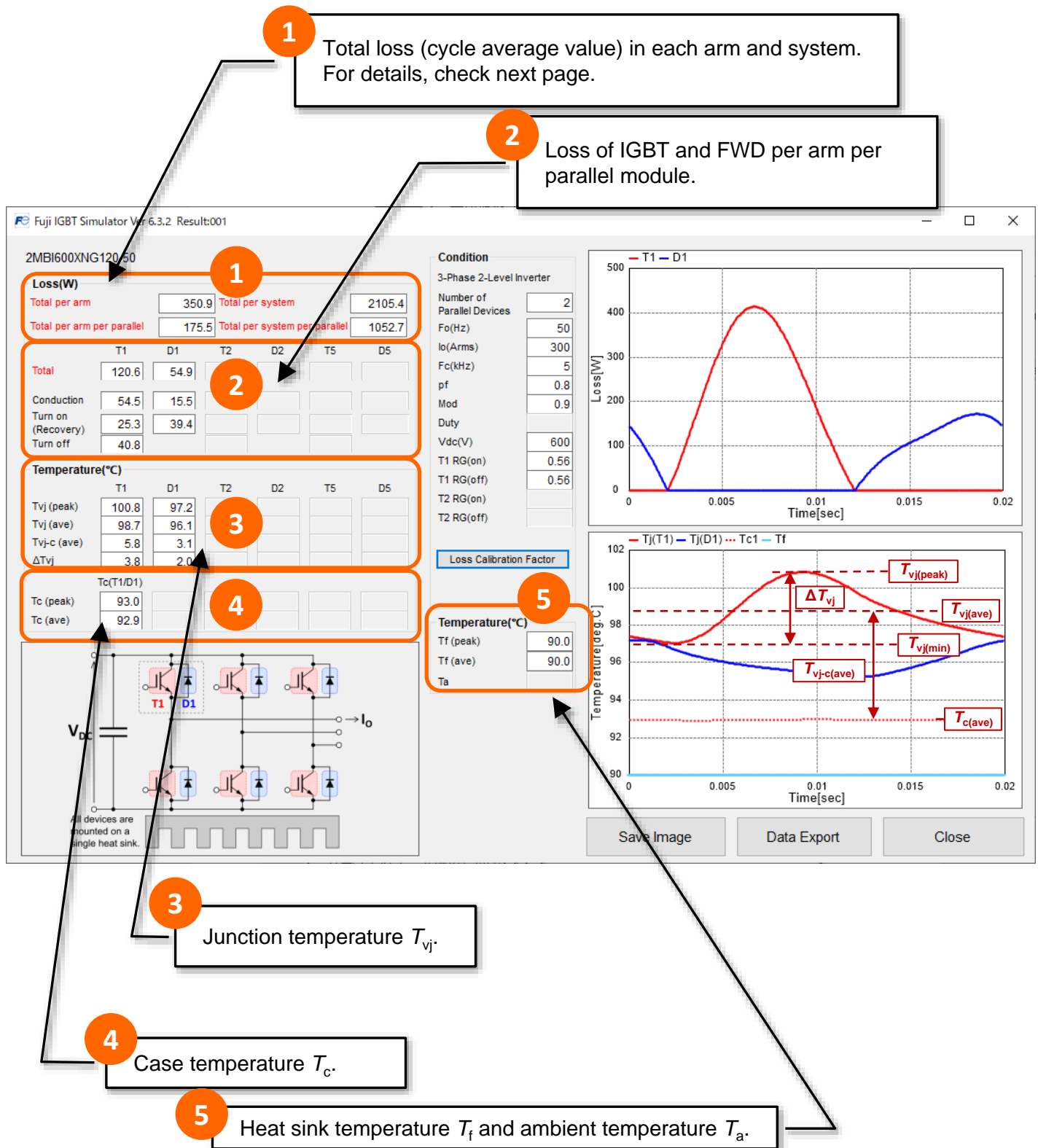
A "Loss Calibration Factor" button is located at the bottom left of the settings panel.

**Explanation:** A circuit diagram of a 3-phase 2-level inverter is shown. It includes a DC link with voltage  $V_{DC}$  and an output current  $I_o$ . The diagram highlights a specific transistor and diode pair labeled T1 and D1. Below the circuit, a heat sink is depicted with the text: "All devices are mounted on a single heat sink."

An orange box highlights the "Calculate" button in the top right corner, with a red circle containing the number "1" and an arrow pointing to it.

#### (4) Simulation Results

When the calculation is executed, the calculation result will be output in a separate window.





#### (4)-1 Simulation Results (Total Loss)

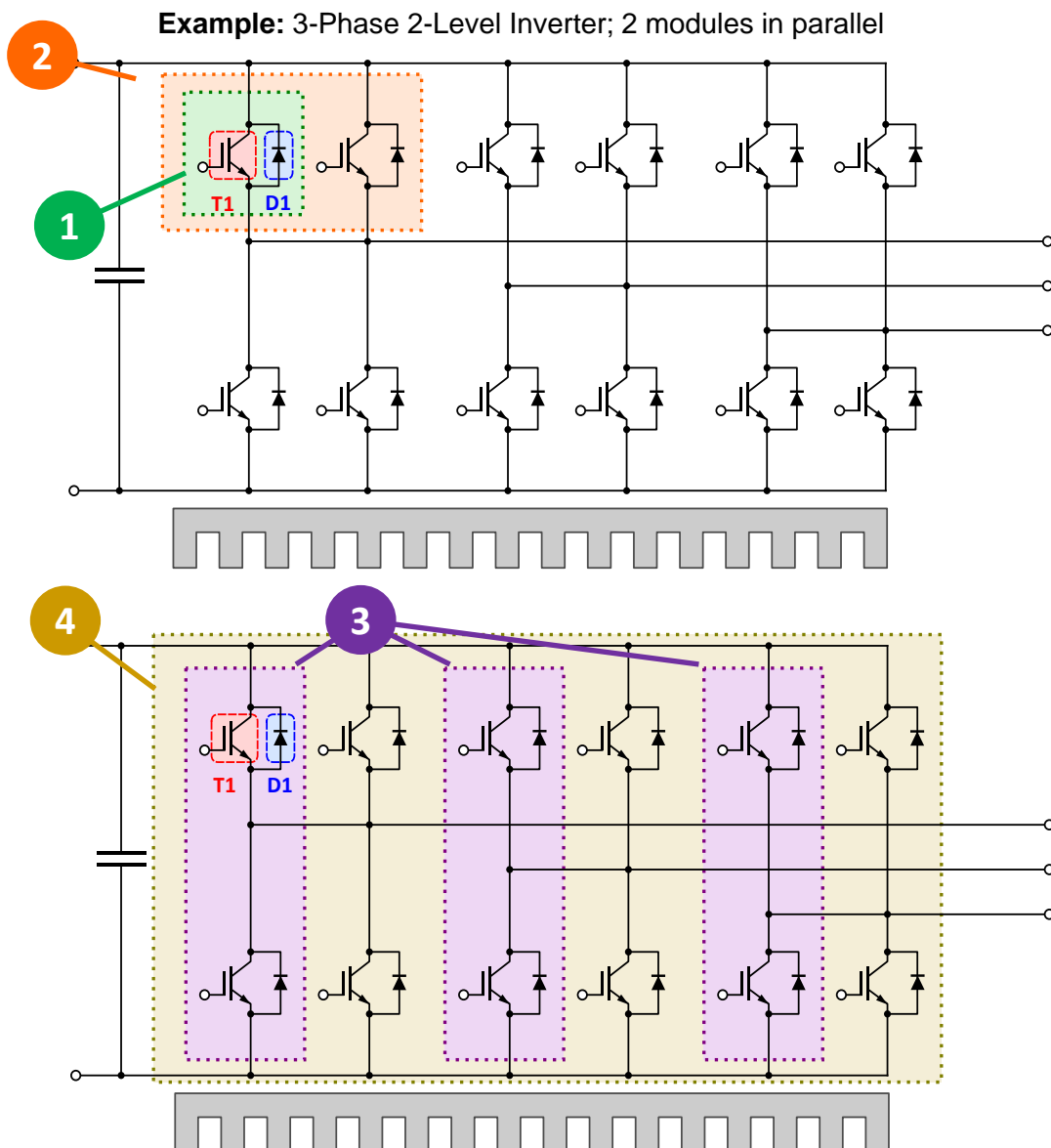
The detail of total loss (cycle average) for each arm and each system is shown below.

Fuji IGBT Simulator Ver 6.3.2 Result:001

2MBI600XNG120-50

Loss(W)			
Total per arm	350.4	Total per system	2105.4
Total per arm per parallel	175.2	Total per system per parallel	1052.7
	D1	T2	D2
Total	120.8	54.9	
Conduction	54.5	15.5	
Turn on (Recovery)	25.3	39.4	
Turn off	40.8		

- 1** Total loss per arm per parallel module  
(= T1 + D1 + T2 + D2 + D5)
- 2** Total loss per arm  
(= **1** × number of parallel modules)
- 3** Total loss of system per parallel module  
(3-Phase 2-Level Inverter: **1** × 6)
- 4** Total loss of the system  
(= **3** × number of parallel modules)



#### (4)-2 Simulation Results (Graph / Data output)

The loss transition and temperature transition waveforms of the simulation results for one cycle are displayed.

The data can be saved in image data and csv format.

**1** Loss waveforms (1 cycle)

**2** Temperature waveforms (1 cycle)

**3** Save the window as image file  
filename: \*.bmp

**4** Export the results to text file  
filename: \*.csv

**5** Close the window and return to the previous window

Loss(W)	
Total per arm	350.9
Total per system	2105.4
Total per arm per parallel	175.5
Total per system per parallel	1052.7

	T1	D1	T2	D2	T5	D5
Total	120.6	54.9				
Conduction	54.5	15.5				
Turn on (Recovery)	25.3	39.4				
Turn off	40.8					

Temperature(°C)	
Tvj (peak)	100.8
Tvj (ave)	98.7
Tvj-c (ave)	5.8
ΔTvj	3.8

	T1	D1	T2	D2	T5	D5
Tvj (peak)	100.8	97.2				
Tvj (ave)	98.7	96.1				
Tvj-c (ave)	5.8	3.1				
ΔTvj	3.8	2.0				

Temperature(°C)	
Tf (peak)	90.0
Tf (ave)	90.0
Ta	

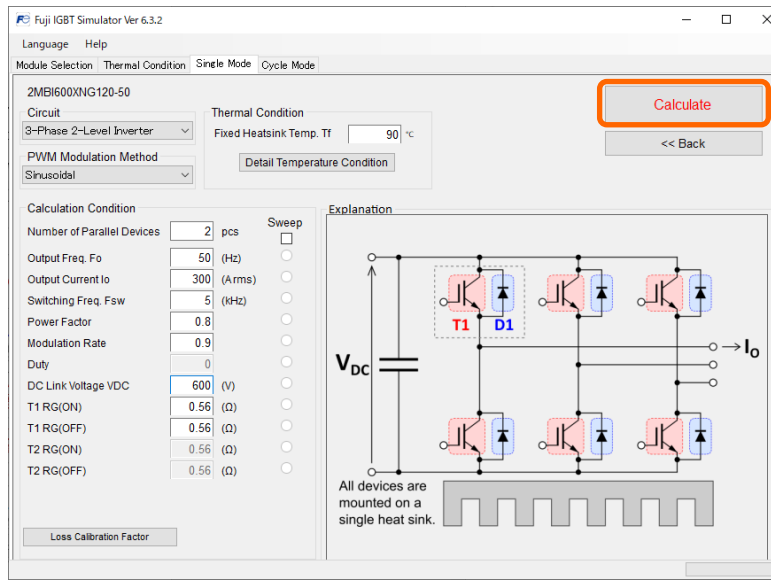
## (5) Display Multiple Results

Multiple windows of calculation result can be displayed at the same time (max. 40).

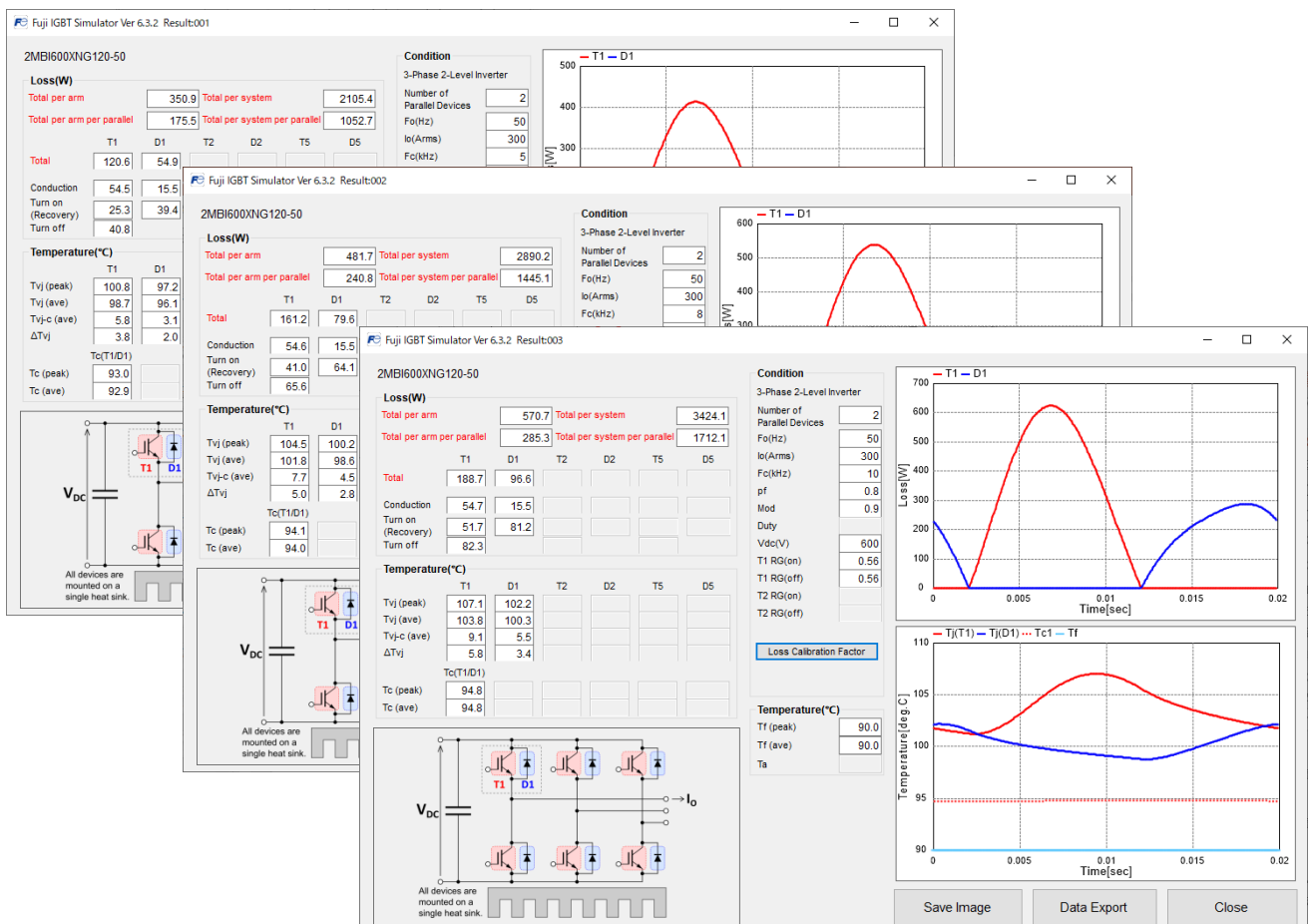
Each time you press the Execute Calculation button, a new Calculation Results window will be displayed.

The windows will be displayed in the order of Result001, Result002, ... continuous numbering.

Please use this function for comparison when changing the calculation conditions.



## Calculation result window



# Parameter Sweep Calculation

## 6. Parameter Sweep Calculation

### (1) Input simulation condition(Parameter Sweep Calculation)

In the parameter sweep calculation, it is possible to calculate the losses and temperature for a change in that parameter by setting one of the parameter in the calculation conditions as a sweep.

The screenshot shows the 'Fuji IGBT Simulator Ver 6.3.2' interface. The 'Single Mode' tab is selected. The 'Calculate' button is highlighted. The 'Calculation Condition' section lists various parameters, with the 'Sweep' checkbox checked. The 'Explanation' section shows a circuit diagram of a 3-phase inverter with a DC link and a heat sink.

**1** Click „Single Mode“ Tab.

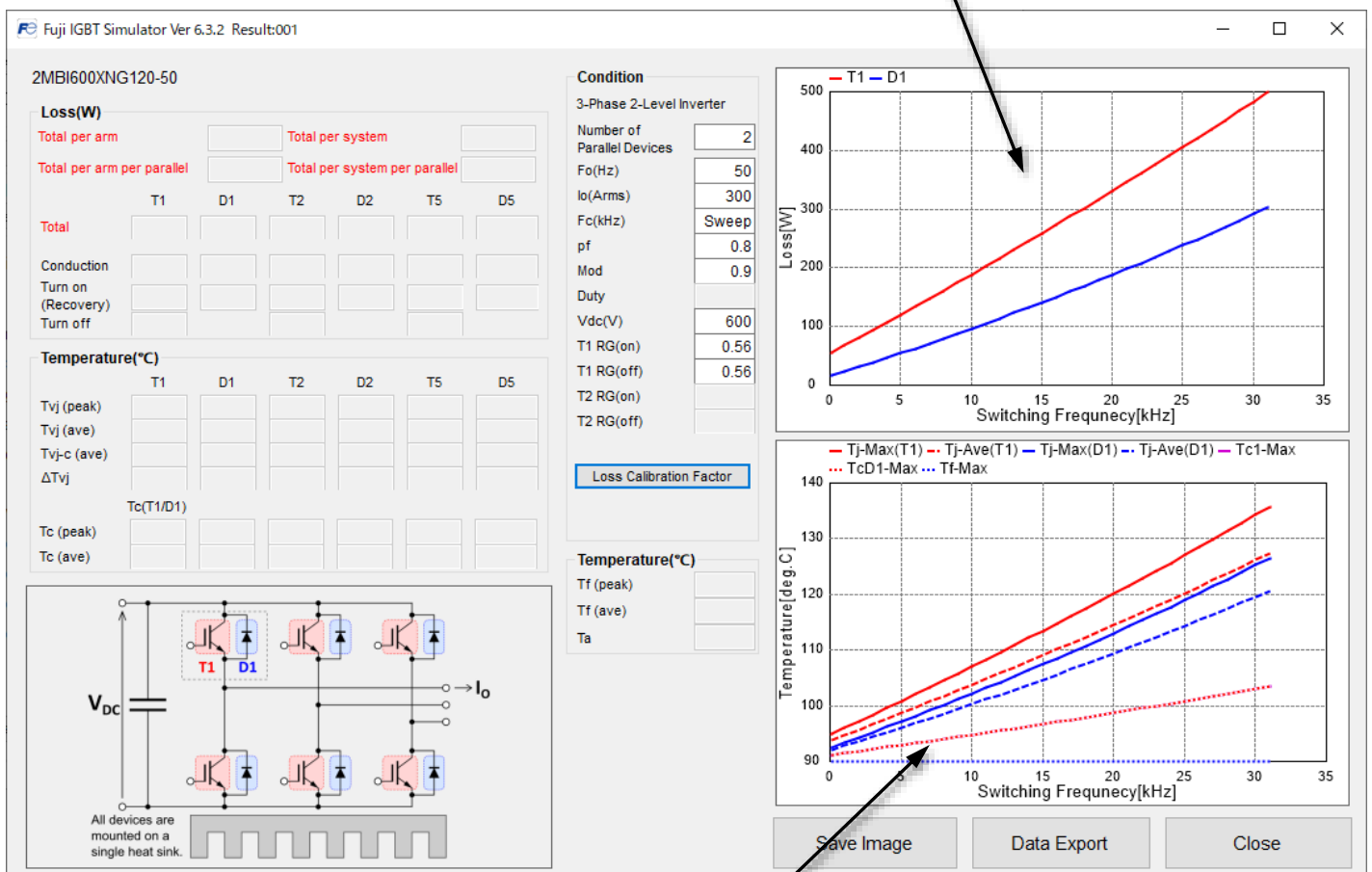
**2** Click „Sweep“ check box.

**3** Select parameter which you want to sweep by clicking radio button.

**4** Click “Calculate” button to start the calculation.

## (2) Parameter Sweep Calculation Result

Calculated losses with variable parameter on horizontal axis.



Calculated temperature with variable parameter on horizontal axis.

# Cycle Mode Calculation

## 7. Cycle Mode Calculation

### (1) Input simulation condition(Cycle Mode Calculation)

Cycle mode calculation enables simulation under intended operating conditions.

Click the „Cycle Mode“ tab.

Input gate resistance value.

Heat sink temperature  $T_f$ ; if  $T_f$  is fixed, enter value. For changing detailed temperature condition, please click this button and back to thermal condition tab.

Select boundary conditions For details, please refer to page 28.

#	t [sec]	Fo [Hz]	Fsw [kHz]	Io [A]*	PF	Mod. Rate	Duty	VDC [V]	Circuit
1	0	50	5	0	0.9	1	1	600	3-phase Sinusoi...
2	1	50	5	450	0.9	1	1	600	3-phase Sinusoi...
3	2	50	5	450	0.9	1	1	600	3-phase Sinusoi...
4	2	50	5	300	-0.9	1	1	600	3-phase Sinusoi...
5	3	50	5	300	-0.9	1	1	600	3-phase Sinusoi...
6	4	50	5	0	-0.9	1	1	600	3-phase Sinusoi...
**	7								3-phase Sinusoi...



**5** Number of parallel connected modules.  
Note: All modules are considered to be mounted on the same heat sink.

The screenshot shows the Fuji IGBT Simulator interface. Callout 5 points to the 'Number of Parallel Devices' field in the 'Cycle Data' section, which is set to 1 pcs. Callout 6 points to the 'Loss Calibration Factor' button. Callout 7 points to the 'Input operation pattern' table.

#	t [sec]	Fo [Hz]	Fsw [kHz]	Io [A]*	PF	Mod. Rate	Duty	VDC [V]	Circuit
1	0	50	5	0	0.9	1	1	600	3-phase Sinusoi...
2	1	50	5	450	0.9	1	1	600	3-phase Sinusoi...
3	2	50	5	450	0.9	1	1	600	3-phase Sinusoi...
4	2	50	5	300	-0.9	1	1	600	3-phase Sinusoi...
5	3	50	5	300	-0.9	1	1	600	3-phase Sinusoi...
6	4	50	5	0	-0.9	1	1	600	3-phase Sinusoi...
**	7								3-phase Sinusoi...

**6** Click „Loss Calibration Coefficient“ button to enter calibration coefficients for each loss calculation.

**7** Input operation pattern.  
For details, please refer to page 29 et seq.

8

Click "Calculate" button to start the calculation.

9

If the cycle data have more than 2048 lines, it is possible to divide the pattern and calculate them separately.

2MBI600XNG120-50

Thermal Condition  
Fixed Heatsink Temp. Tf  °C

Gate Resistance  
T1 RG(ON)  Ω  
T1 RG(OFF)  Ω  
T2 RG(ON)  Ω  
T2 RG(OFF)  Ω

Boundary Condition  
 Cyclic  1 shot  
Sampling Number

Cycle Data  
Number of Parallel Devices  pcs  
    
\* Input [A peak] in case of DC Lock or Chopper circuit  
\* Input [A rms] in other circuits

#	t [sec]	Fo [Hz]	Fsw [kHz]	Io [A]*	PF	Mod. Rate	Duty	VDC [V]	Circuit
1	0	50	5	0	0.9	1	1	600	3-phase Sinusoi...
2	1	50	5	450	0.9	1	1	600	3-phase Sinusoi...
3	2	50	5	450	0.9	1	1	600	3-phase Sinusoi...
4	2	50	5	300	-0.9	1	1	600	3-phase Sinusoi...
5	3	50	5	300	-0.9	1	1	600	3-phase Sinusoi...
6	4	50	5	0	-0.9	1	1	600	3-phase Sinusoi...
**	7								3-phase Sinusoi...

Drive Condition  
Fo[Hz] 53, 47, 5.3  
Fsw[kHz] 4.7, 500  
Io[A] 0, 1, 1.06  
P. F. -1, 1.06  
Mod. Rate 0.94, 1.06  
Duty 0.94, 1.06  
VDC[V] 630, 570, 1.06  
Mode 0.94

10

Save operation pattern  
Filename: \*.xml

11

Load operation pattern  
Filename: \*.xml

## (2) Partial Calculation

Number of cycle data points: 3000

Division number: 3

Number of overlaps: 100

Number of sampling data points: 1000

Buttons: Set default, Calculate, Data Export, Close

Pattern Folder: Folder select

#	Select	Start	End	Number of sampling data points	CSV
1	<input checked="" type="checkbox"/>	1	1000	1000	x
2	<input checked="" type="checkbox"/>	901	2000	1100	x
3	<input checked="" type="checkbox"/>	1901	3000	1100	x

Buttons: Save, Load

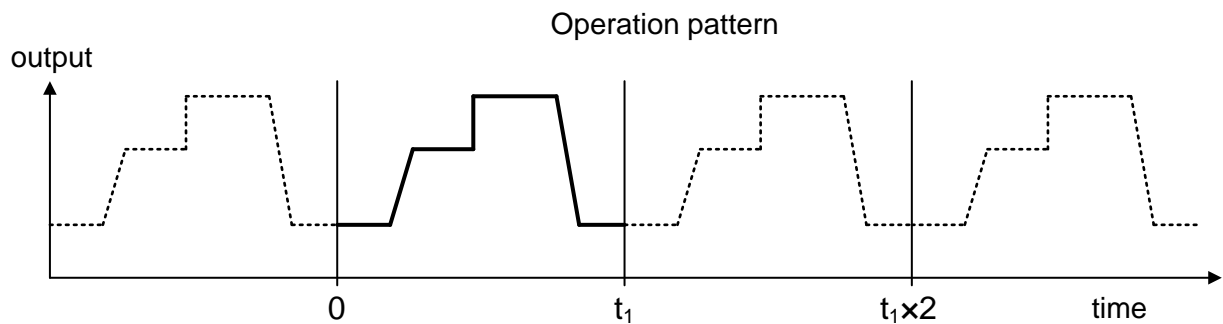
Callout boxes:

- Number of splits of cycle data.
- When dividing cycle data, enter the number of lines to be overlapped before and after.
- Reset partial calculation table.
- Calculate the split data.
- Enter the number of sampling date points for the calculation of the divided cycle data.
- Select a specific folder to save the pattern file.
- „o“: calculation result exists in the pattern folder  
„x“: result does not exist there.
- The information in the partial calculation table are based on the entered division number, number of overlaps and number of sampling data points. It is also possible to enter values directly in the table.
- Select the parts which have to be calculated.
- Load the saved partial calculation table.
- Save partial calculation table.

### (3) Cycle Mode Calculation : Boundary Condition

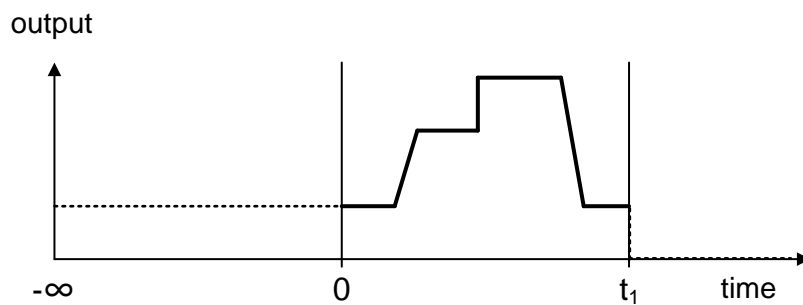
Boundary Condition  
 Cyclic    1 shot

**Cyclic mode:** The load cycle pattern is repeated continuously.



Boundary Condition  
 Cyclic    1 shot

**1 shot mode:** The load cycle pattern is not repeated



#	t [sec]	Fo [Hz]	Fsw [kHz]	Io [A]*	PF	Mod. Rate	Duty	VDC [V]	Circuit
1	-∞ ≤ ...	50	5	0	0.9	1	1	600	3-phase Sinusoi...
2	1	50	5	450	0.9	1	1	600	3-phase Sinusoi...
3	2	50	5	450	0.9	1	1	600	3-phase Sinusoi...

Enter the initial conditions in first line.

(4) Enter cycle mode operating conditions

**1 Time**  
For details, please refer to page 29

Input default value into selected row.

**2 Output Current**  
[A peak] in case of DC Lock or Chopper circuit.  
[A rms] in case of other circuits.

**3 Duty**  
For DC Lock or Chopper: please enter the duty value in this column.  
All other cases: column will be ignored.

**4 Circuit**  
Select circuit and PWM method from the dropdown list.

	1	t [sec]	Fo [Hz]	Fc [kHz]	2 Io [A]*	PF	M Rate	3 Duty	VD [V]	4 Circuit
	1	0	50	5	0	0.9	1	1	600	3-phase Sinusoi...
	2	1	50	5	150	0.9	1	1	600	3-phase Sinusoi...
	3	2	50	5	150	0.9	1	1	600	3-phase Sinusoi...
	4	2	50	5	50	0.9	1	1	600	3-phase Sinusoi...
	5	3	50	5	50	0.9	1	1	600	3-phase Sinusoi...
	6	4	50	5	0	0.9	1	1	600	3-phase Sinusoi...
▶*	7									3-phase Sinusoi...

**A**

**Parameter values linearly change between two operation points.**

Example: #1 → #2 [ $I_o$ ]

If you enter [ $t=0\text{sec}$ ,  $I_o=0\text{A}$ ] in #1 and [ $t=1\text{sec}$ ,  $I_o=150\text{A}$ ] in #2,  $I_o$  changes linearly from #1 to #2.

**B**

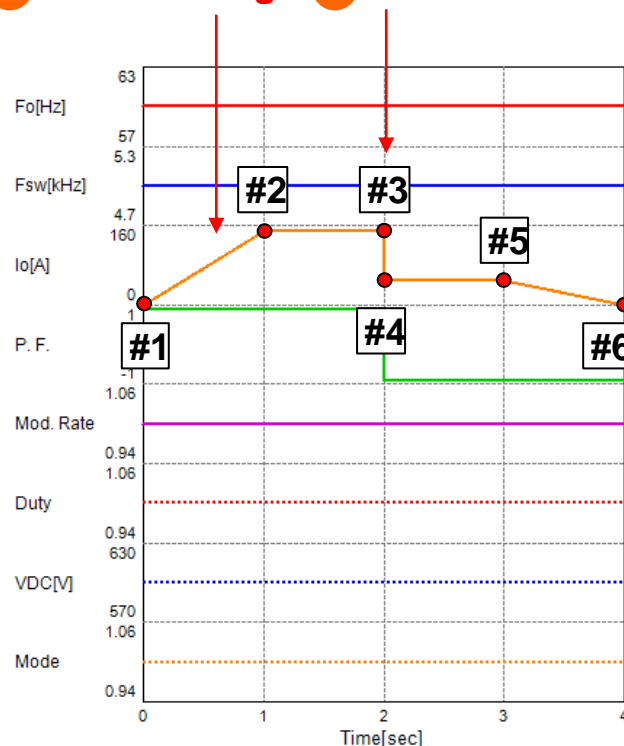
**Parameter values change instantaneously if two operation points have same time t.**

Example: #3 → #4 [ $I_o$ , PF]

If you enter [ $t=2\text{sec}$ ,  $I_o=150\text{A}$ ] in #3 and [ $t=2\text{sec}$ ,  $I_o=50\text{A}$ ] in #4,  $I_o$  changes instantaneously from #3 to #4.

#	t [sec]	Fo [Hz]	Fsw [kHz]	Io [A]*	PF	Mod. Rate	Duty	VDC [V]	Circuit
1	0	60	5	0	0.9	1	1	600	3-phase Sinusoi...
2	1	60	5	150	0.9	1	1	600	3-phase Sinusoi...
3	2	60	5	150	0.9	1	1	600	3-phase Sinusoi...
4	2	60	5	50	-0.9	1	1	600	3-phase Sinusoi...
5	3	60	5	50	-0.9	1	1	600	3-phase Sinusoi...
6	4	60	5	0	-0.9	1	1	600	3-phase Sinusoi...
**	7								3-phase Sinusoi...

**A Linear change** **B Instantaneous change**



## Copy & Paste cell(s) value

Select a cell or range of cell(s) → Right click  
→ Copy

#	t [sec]	Fo [Hz]	Fsw [kHz]	Io [A]*	PF	Mod. Rate	Duty	VDC [V]	Circuit
▶ 1	0	60	5	0	0.9			600	3-phase Sinusoidal
2	1	60	5	150	0.9			600	3-phase Sinusoidal
3	2	60	5	150	0.9			600	3-phase Sinusoidal
4	2	60	5	50	-0.9			600	3-phase Sinusoidal
5	3	60	5	50	-0.9			600	3-phase Sinusoidal
6	4	60	5	0	-0.9			600	3-phase Sinusoidal
* 7									3-phase Sinusoidal

Select cell(s) → Right click → Paste

#	t [sec]	Fo [Hz]	Fsw [kHz]	Io [A]*	PF	Mod. Rate	Duty	VDC [V]	Circuit
1	0	60	5	0	0.9	1	1	600	3-phase Sinusoidal
2	1	60	5	150	0.9	1	1	600	3-phase Sinusoidal
3	2	60	5	150	0.9	1	1	600	3-phase Sinusoidal
▶ 4	2	60	5	50	-0.9	1	1	600	3-phase Sinusoidal
5	3	60	5	50	-0.9	1	1	600	3-phase Sinusoidal
6	4	60	5	0	-0.9	1	1	600	3-phase Sinusoidal
* 7									3-phase Sinusoidal

## Copy & Paste line

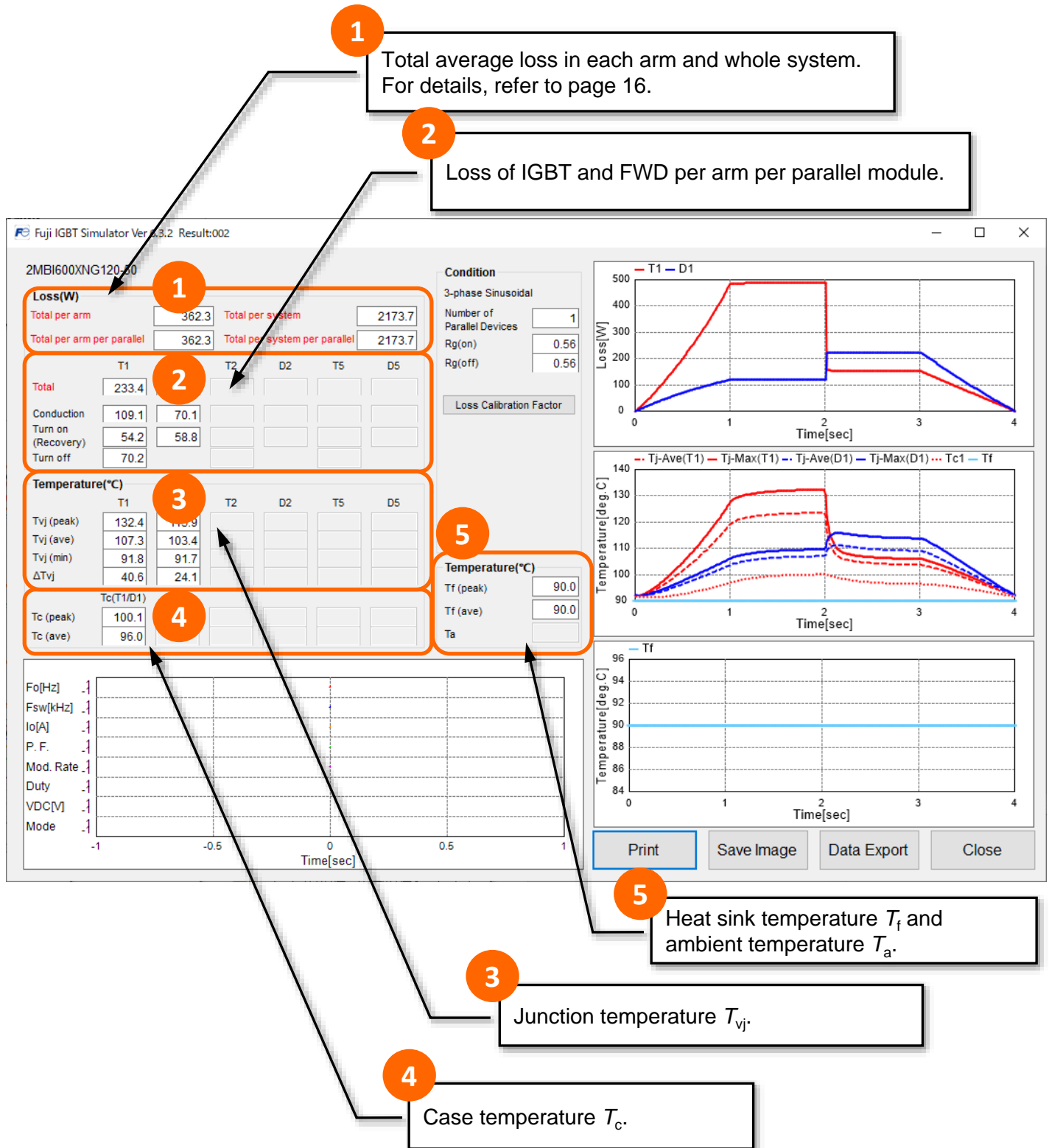
Select a line (click 1<sup>st</sup> column) → Right click  
→ Copy

#	t [sec]	Fo [Hz]	Fsw [kHz]	Io [A]*	PF	Mod. Rate	Duty	VDC [V]	Circuit
▶ 1	0	60	5	0	0.9	1	1	600	3-phase Sinusoidal
2	1	60	5	150	0.9	1	1	600	3-phase Sinusoidal
3	2	60	5	150	0.9	1	1	600	3-phase Sinusoidal
4	2	60	5	50	-0.9	1	1	600	3-phase Sinusoidal
5	3	60	5	50	-0.9	1	1	600	3-phase Sinusoidal
6	4	60	5	0	-0.9	1	1	600	3-phase Sinusoidal
* 7									3-phase Sinusoidal

Select a line → Right click → Paste

#	t [sec]	Fo [Hz]	Fsw [kHz]	Io [A]*	PF	Mod. Rate	Duty	VDC [V]	Circuit
1	0	60	5	0	0.9	1	1	600	3-phase Sinusoidal
2	1	60	5	150	0.9	1	1	600	3-phase Sinusoidal
3	2	60	5	150	0.9	1	1	600	3-phase Sinusoidal
4	2	60	5	50	-0.9	1	1	600	3-phase Sinusoidal
5	3	60	5	50	-0.9	1	1	600	3-phase Sinusoidal
6	4	60	5	0	-0.9	1	1	600	3-phase Sinusoidal
▶ 7									3-phase Sinusoidal

**(5) Simulation Results(Cycle Mode Calculation)**





**1** Loss waveforms

**2** Temperature waveforms

**3** Temperature waveforms

2MBI600XNG120-50

**Loss(W)**

Total per arm	362.3	Total per system	2173.7
Total per arm per parallel	362.3	Total per system per parallel	2173.7
<b>Total</b>	T1: 233.4, D1: 128.8	T2: , D2: , T5: , D5:	
Conduction	109.1, 70.1		
Turn on (Recovery)	54.2, 58.8		
Turn off	70.2		

**Temperature(°C)**

	T1	D1	T2	D2	T5	D5
Tvj (peak)	132.4	115.9				
Tvj (ave)	107.3	103.4				
Tvj (min)	91.8	91.7				
ΔTvj	40.6	24.1				
Tc(T1/D1)						
Tc (peak)	100.1					
Tc (ave)	96.0					

**Condition**

3-phase Sinusoidal

Number of Parallel Devices: 1

Rg(on): 0.56

Rg(off): 0.56

Loss Calibration Factor: [ ]

**Temperature(°C)**

Tf (peak): 90.0

Tf (ave): 90.0

Ta: [ ]

Buttons: **4** Print, **5** Save Image, **6** Data Export, **7** Close

**4** Print the window

**5** Save the window  
Filename: \*\*\*\*.bmp

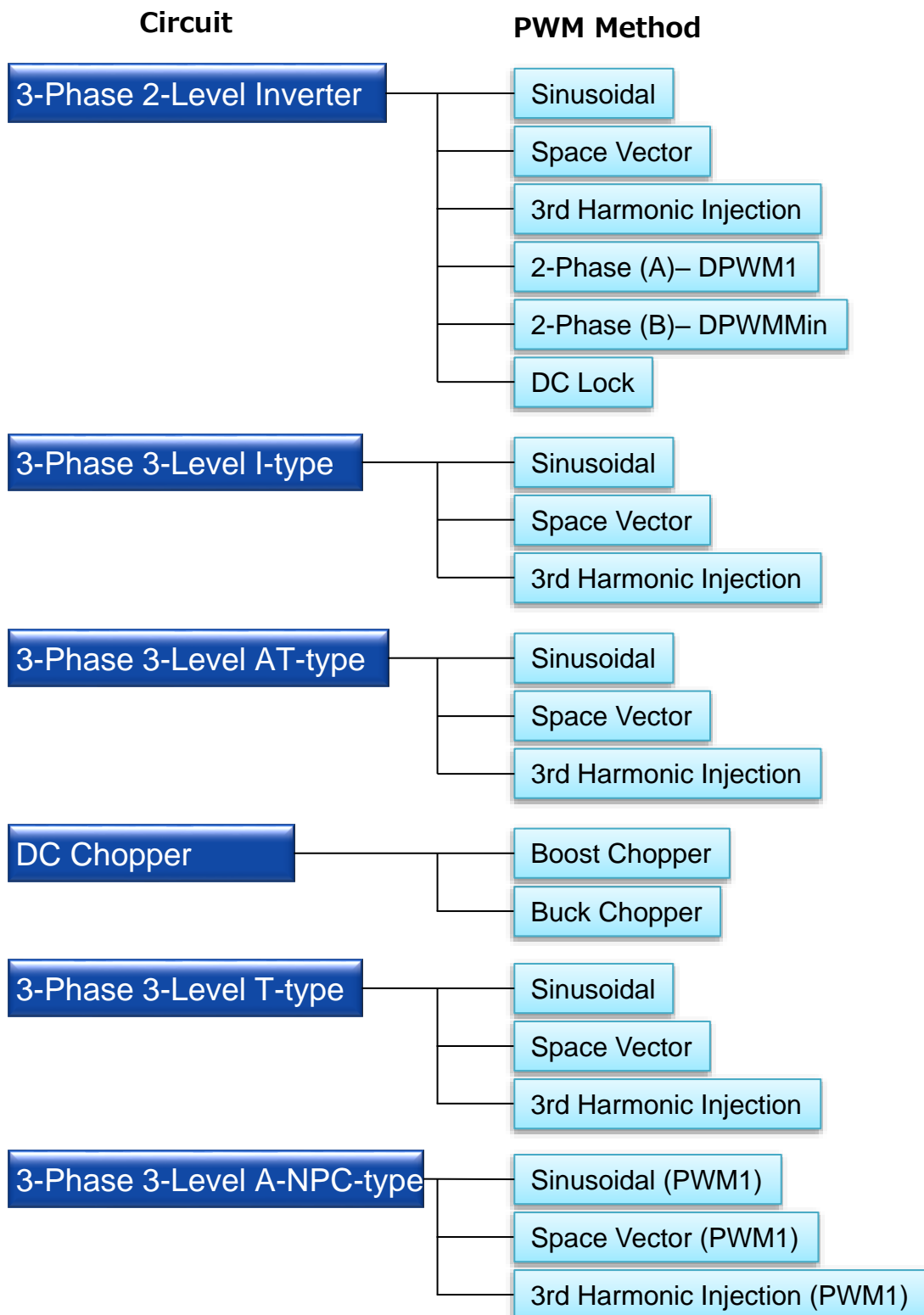
**6** Export the results  
Filename: \*.csv

**7** Close the window

## Application circuit and PWM control

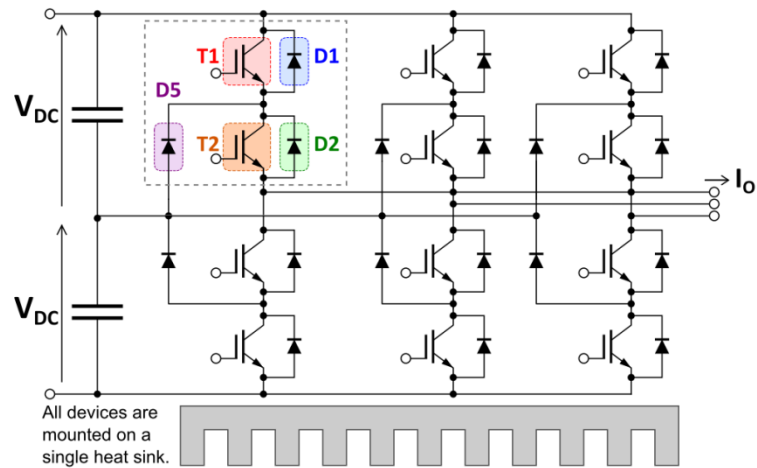
## 8. Application circuit and PWM control

This page shows a list of applicable circuits and PWM methods that are supported by the simulator.

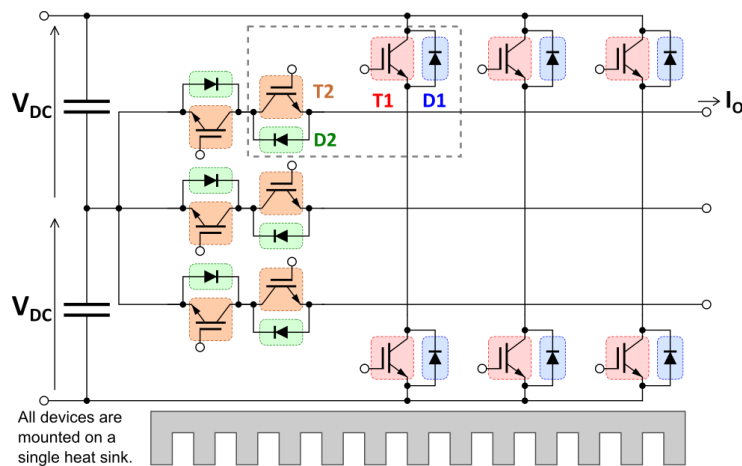


(1) Type of Circuit Topology

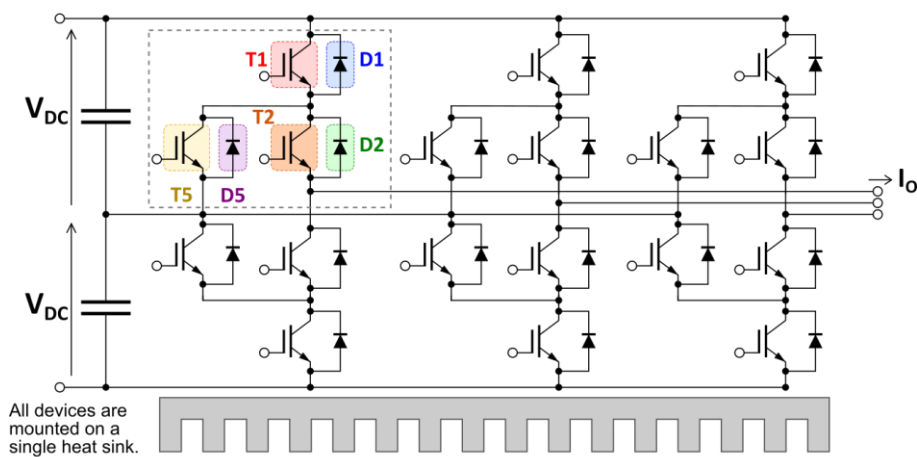
**3-Phase 3-Level I-type**



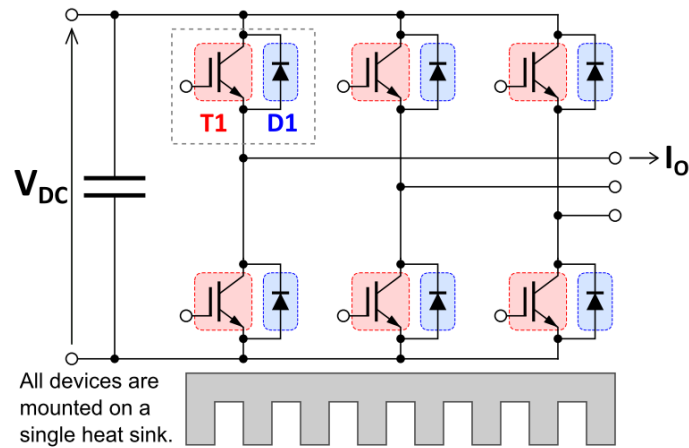
**3-Phase 3-Level T-type**



**3-Phase 3-Level A-NPC-type**

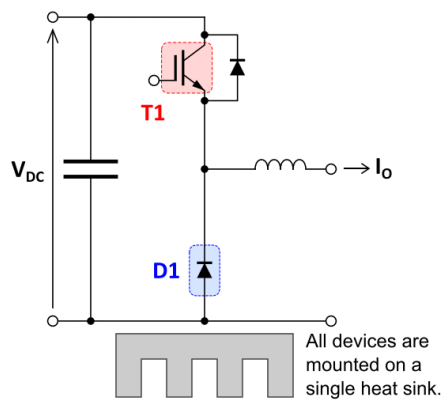


### 3-Phase 2-Level

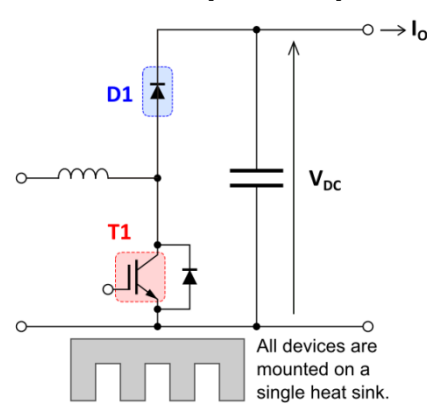


### DC Chopper

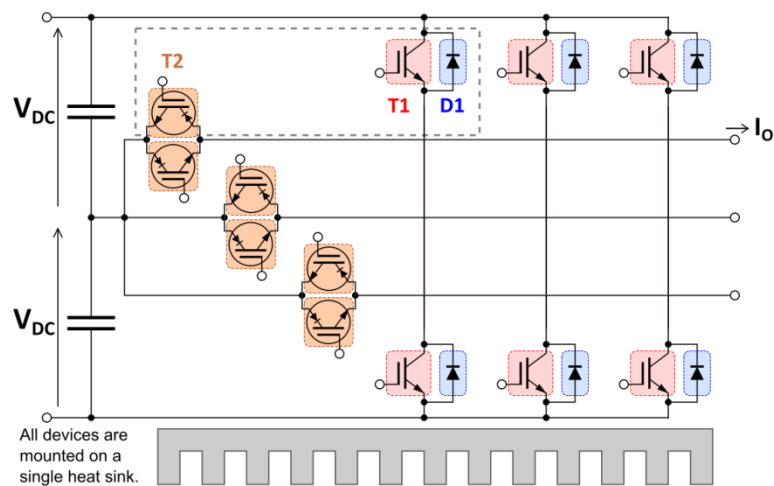
#### (Buck)



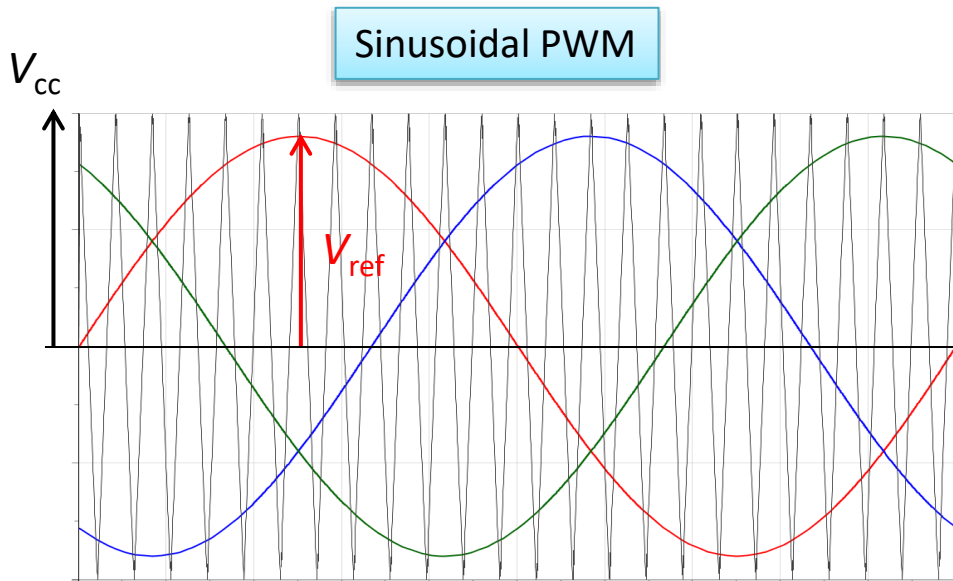
#### (Boost)



### 3-Phase 3-Level AT-type



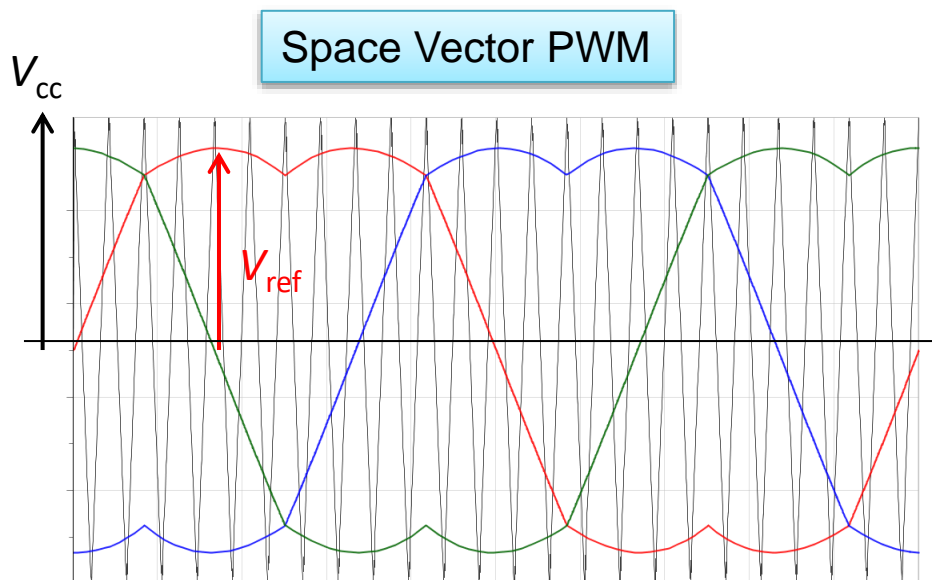
(2) PWM Method (SPWM, SVPWM)



The reference voltage is a sinusoidal waveform.  
The amplitude  $V_{ref}$  of the reference voltage for Sinusoidal PWM is defined by the following equation using modulation ratio  $m$ .

$$V_{ref} = mV_{dc}$$

The maximum value of  $m$  is 1.

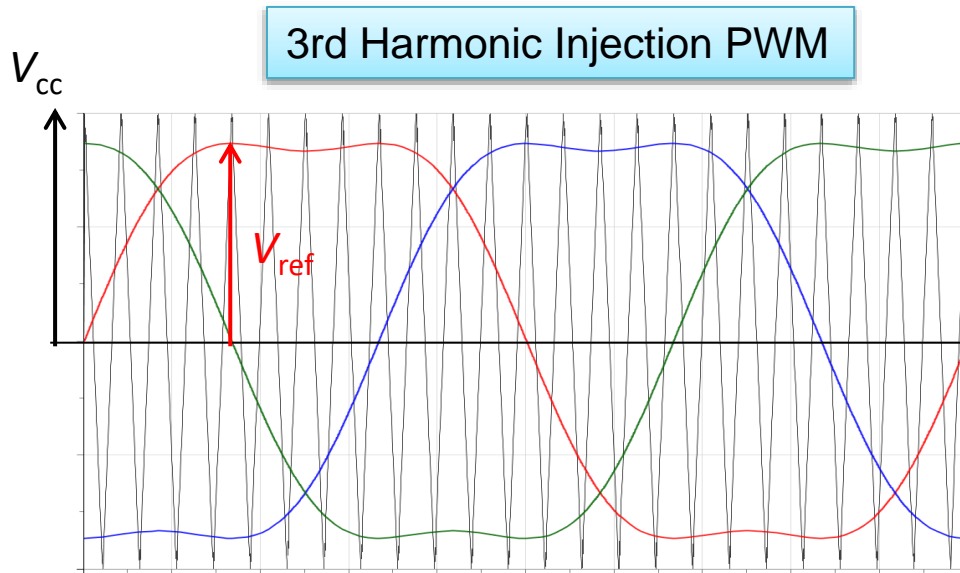


The amplitude  $V_{ref}$  of the reference voltage for Space Vector PWM is defined by the following equation using modulation ratio  $m$

$$V_{ref} = \frac{\sqrt{3}}{2} mV_{dc}$$

$m$  is defined to be the same output voltage to the sinusoidal PWM.  
The maximum value of  $m$  is  $2/\sqrt{3} = 1.1547$

(3) PWM Method (3rd harmonic injection)



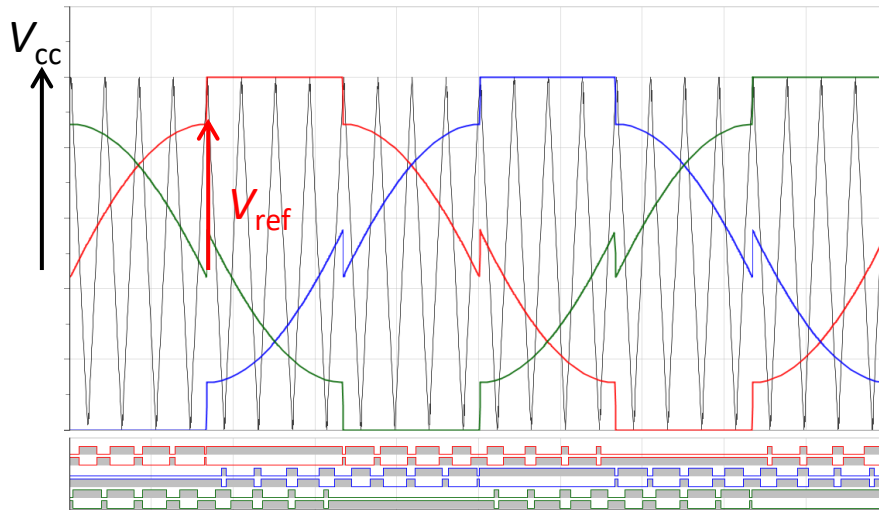
The amplitude  $V_{ref}$  of the reference voltage for 3rd Harmonic Injection PWM is defined by the following equation using modulation ratio  $m$

$$V_{ref} = \frac{\sqrt{3}}{2} m V_{dc}$$

$m$  is defined to be the same output voltage to the sinusoidal PWM.  
The maximum value of  $m$  is  $2/\sqrt{3} = 1.1547$

(4) 2-Phase Modulation (Discontinuous PWM: DPWM)

2-Phase (A) – DPWM1

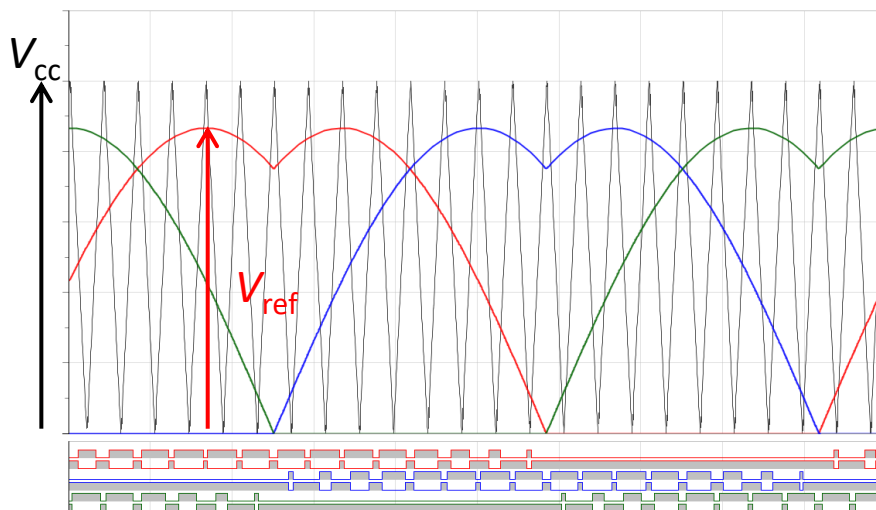


The amplitude  $V_{ref}$  of the reference voltage for 2-Phase (A) – DPWM1 is defined by the following equation using modulation ratio  $m$ .

$$V_{ref} = \frac{\sqrt{3}}{2} m V_{dc}$$

$m$  is defined to be the same output voltage to the sinusoidal PWM.  
The maximum value of  $m$  is  $2/\sqrt{3} = 1.1547$

2-Phase (B) – DPWMMin



The amplitude  $V_{ref}$  of the reference voltage for 2-Phase (B) – DPWMMin is defined by the following equation using modulation ratio  $m$ .

$$V_{ref} = \frac{\sqrt{3}}{2} m V_{dc}$$

$m$  is defined to be the same output voltage to the sinusoidal PWM.  
The maximum value of  $m$  is  $2/\sqrt{3} = 1.1547$

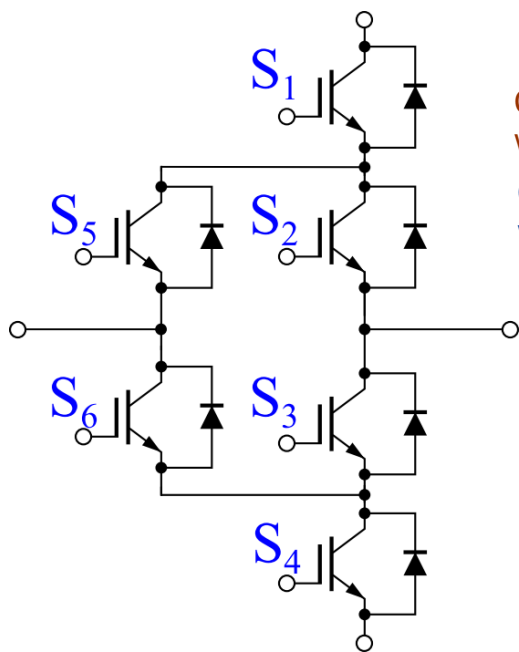


**(5) PWM Method (A-NPC circuit)**

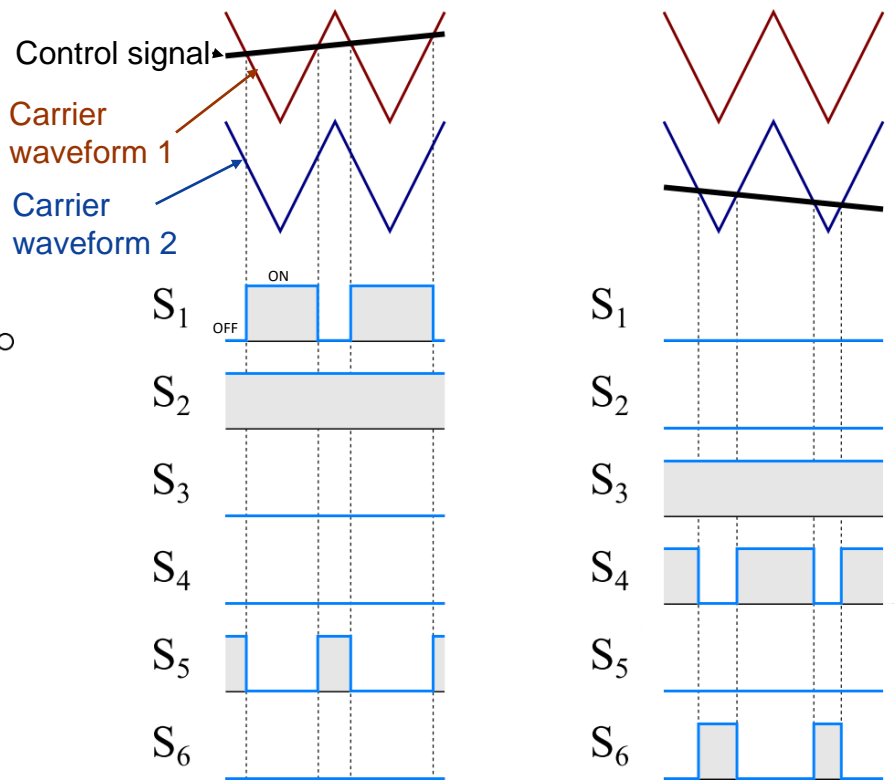
Several methods have been proposed for the PWM method of the A-NPC circuit.

This simulator performs simulation with the PWM method (PWM 1) shown below.

**A-NPC circuit diagram**



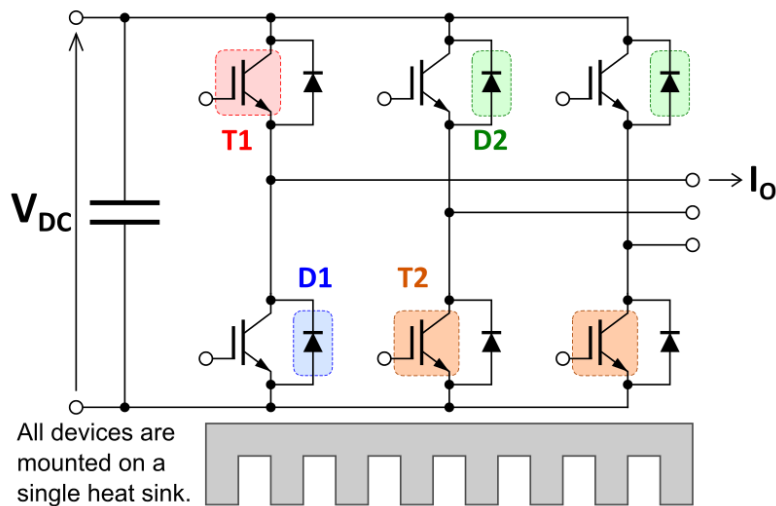
**Switching pattern (PWM1)**



### (6) Motor DC Lock Operation

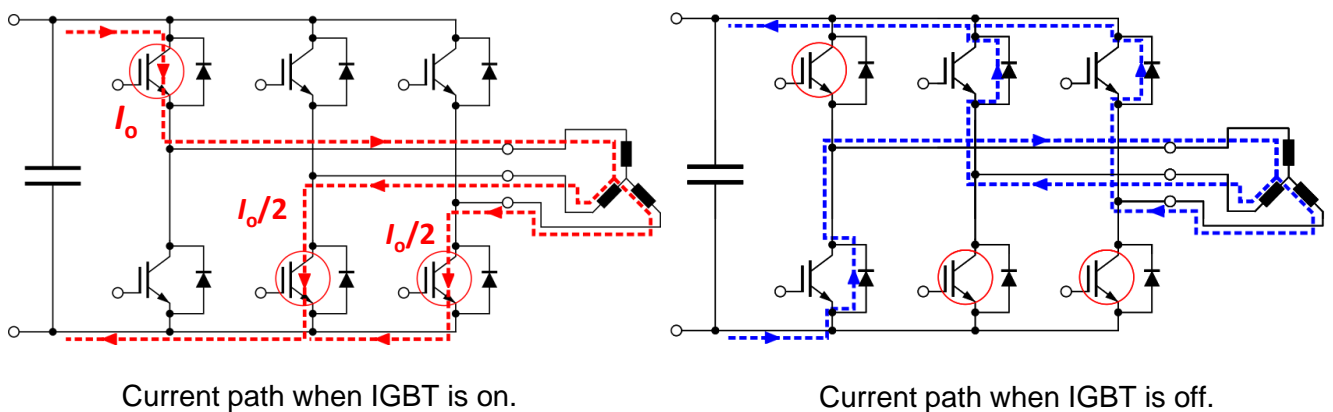
Calculate the IGBT / FWD loss when locking the motor rotation with a servo drive or the like.

As shown in the figure below, one IGBT of the upper arm (or the lower arm) of one phase and the IGBT of the other arm of the other two phases are switching controlled.



Note : The heat sink temperature  $T_f$  is calculated based on the assumption that the surface temperature distribution of the heat sink's area, which is in contact with the module, is uniform.

In the motor lock operation, only specific elements generate heat. Thus the heat does not spread optimally on the heat sink's surface and the heat sink's thermal resistance increases. As a result,  $T_f$  and  $T_c$  might become high.



If you have any questions, please contact us.

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