FUJI WEB SIMULATION TOOL:
PLECS BASED POWER ELECTRONIC
APPLICATION SIMULATOR

USER MANUAL
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How to Start

Choose between two different models:

3 Phases 2 Level Inverter

http://simu.fujielectric-europe.com/2_level_inverter.html

3 Level T type Inverter

http://simu.fujielectric-europe.com/3_level_inverter_t_type.html
3 Phases 2 Level Inverter
3 Phases 2 Level Inverter

Variable Parameters for Simulation

- Modulation rate: 1
- Modulation strategy: Sinusoidal
- Inverter output current: 100 A
- Inverter output frequency: 50 Hz
- Switching frequency: 5000 Hz
- Power factor: 0.9

Module Selection

- Module type: Single IGBT
- Blocking voltage: 1200 V
- Package: High Power Module

IGBT Module:
- 1MBI1200VC-120P V Series, 1200 A
- 1MBI1600VC-120P V Series, 1600 A
- 1MBI2400VC-120P V Series, 2400 A
- 1MBI2400VD-120P V Series, 2400 A
- 1MBI3600VD-120P V Series, 3600 A

Scope

Numerical results from Scope

- Temperatures
- Losses
Variables Parameters in the Circuit

Components highlighted in grey contain adjustable parameters

Thermal Settings
- $R_{th(c-f)}$ case to heat sink
- $R_{th(f-a)}$ heat sink to ambient
- Ambient temperature $T_a$

Electrical Settings
- $R_{g,on}$ and $R_{g,off}$
- $V_{dc}$

$V_{DC}$

$R_{th(f-a)}$

$T_a$

$R_{g,on}$, $R_{g,off}$, $R_{th(c-f)}$
Thermal Conditions: Overview

Different scenarios in the thermal calculation can be considered:

1) Calculate case temperature
   - Input $R_{th(c-f)}$
   - Input $R_{th(f-a)}$
   - Set ambient temperature

2) Fixed case temperature
   - $R_{th(c-f)} = R_{th(f-a)} = 0$
   - Set ambient temperature

3) Fixed heat sink temperature
   - Set $R_{th(f-a)} = 0$
   - Set heat sink temperature = ambient temperature
   - Provide $R_{th_c-h}$

Refer to next page how to input the values!
Thermal Conditions: Settings

$R_{th(c-f)}$
Click on the grey box in the inverter model.
A drop down menu will open.

$R_{th(h-a)}$
Click on the resistor "Rth_HA”

$T_a$
Click on the constant temperature symbol "Ambient temperature”

Input $R_{th(c-f)}$ here.
Please check the datasheet for the value.

Input $R_{th(h-a)}$ here.

Input ambient temperature.
**Electrical Conditions**

**$R_{g,\text{on}}$ and $R_{g,\text{off}}$**

Click on the grey inverter part and the menu will open.

Input $R_{g,\text{on}}$ and $R_{g,\text{off}}$. Set them to 0 if you want to use the datasheet values.

**$V_{\text{DC}}$**

Drop Down Menu when clicking on the voltage source "$V_{\text{dc}}$".

**$m$, PWM, $I_{\text{out}}$, $f_{\text{out}}$, $f_{\text{sw}}$, $\text{pf}$**

Input the simulation parameters.
3 Level T Type Inverter
Variables Parameters in the Circuit

Components highlighted in **grey** contain adjustables parameters

**Thermal Settings**
- $R_{th(c-f)}$ case to heat sink
- $R_{th(f-a)}$ heat sink to ambient
- Ambient temperature $T_a$

**Electrical Settings**
- IGBT1 $R_{g,on}$ and $R_{g,off}$
- RB IGBT $R_{g,on}$ and $R_{g,off}$
- $V_{DC}$

**Diagram**
- $R_{th(c-f)}$
- $R_{th(f-a)}$
- $V_{DC}$
- IGBT1
- RB IGBT
- Ambient temperature $T_a$

**Click**
- $R_{g,on}$, $R_{g,off}$, $R_{th(c-f)}$
Electrical Conditions

Click on the grey inverter part and the menu will open.
Input $R_{g,on}$ and $R_{g,off}$ for IGBT and RB IGBT. Set them to 0 if you want to use the datasheet values.

Drop Down Menu when clicking on the voltage source "V_DC/2".

Input the simulation parameters.

Choose load type.
General Settings
Module Selection

1. **Module type**
   - **Dual IGBT**
   - **Single IGBT**

2. **Blocking voltage**
   - **1200 V**
   - **600 V**
   - **650 V**
   - **1700 V**

3. **Package**
   - **2MBI225VJ-120-50**
   - **2MBI225VN-120-50**
   - **2MBI225VX-120-50**
   - **2MBI225XNA120-50**
   - **2MBI225XNE120-50**
   - **2MBI300VN-120-50**
   - **2MBI300VX-120-50**
   - **2MBI300XNA120-50**
   - **2MBI300XNE120-50**
   - **2MBI450VN-120-50**
   - **2MBI450VX-120-50**
   - **2MBI450XNA120-50**
   - **2MBI450XNE120-50**
   - **2MBI600VJ-120-50**
   - **2MBI600VN-120-50**
   - **2MBI600VX-120-50**
   - **2MBI600XNE120-50**
   - **2MBI600XNF120-50**

4. **Modules**
   - **2MBI225VJ-120-50** V Series, 225 A
   - **2MBI225VN-120-50** V Series, 225 A
   - **2MBI225VX-120-50** V Series, 225 A
   - **2MBI225XNA120-50** X Series, 225 A
   - **2MBI225XNE120-50** X Series, 225 A
   - **2MBI300VN-120-50** V Series, 300 A
   - **2MBI300VX-120-50** V Series, 300 A
   - **2MBI300XNA120-50** X Series, 300 A
   - **2MBI300XNE120-50** X Series, 300 A
   - **2MBI450VN-120-50** V Series, 450 A
   - **2MBI450VX-120-50** V Series, 450 A
   - **2MBI450XNA120-50** X Series, 450 A
   - **2MBI450XNE120-50** X Series, 450 A
   - **2MBI600VJ-120-50** V Series, 600 A
   - **2MBI600VN-120-50** V Series, 600 A
   - **2MBI600VX-120-50** V Series, 600 A
   - **2MBI600XNE120-50** X Series, 600 A
   - **2MBI600XNF120-50** X Series, 600 A

**Link to data sheet on www.fujielectric.com**

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Currently the following modulation methods are available:
- Sinusoidal
- Sawtooth
- Space Vector
- 3rd harmonic injection

Open the drop down menu by clicking here.
Run Simulation

The resulting waveforms will be displayed in the screen of the scope.

Corresponding numerical values are shown in the Temperatures / Losses windows.

Simulation will start when you click the “Steady-State Analysis” button.
Simulation Results

Using Cursors

Cursors will firstly appear at the edges. Use mouse cursor to move them to the right position.

New window will open

Analysis window:

Characteristics

IGBT & Diode:
- Tj, losses, current

Module:
- Tc

Inverter:
- Iout, Vout

Values
- Delta, min, max, mean, rms
Simulation Results: Comparison

Use “hold result” to easily compare different simulations:
The first result will be kept automatically. For more please use + when the simulation is finished.
To remove a result from the history, please click −

3 different simulation results

Scope IGBT + Diode

IGBT 1, Diode 1, Baseplate Temperature (°C)

IGBT 1, Diode 1 losses (W)

Line, IGBT and Diode current

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Comparison: Multiple results

Results of all 3 traces are displayed.

Scope values

<table>
<thead>
<tr>
<th>Temperatures</th>
<th>Max temperature</th>
<th>Min temperature</th>
<th>Avg temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGBT</td>
<td>47.8 °C</td>
<td>37.0 °C</td>
<td>41.8 °C</td>
</tr>
<tr>
<td></td>
<td>34.9 °C</td>
<td>29.9 °C</td>
<td>31.5 °C</td>
</tr>
<tr>
<td></td>
<td>40.6 °C</td>
<td>33.1 °C</td>
<td>36.4 °C</td>
</tr>
<tr>
<td>Diode</td>
<td>33.6 °C</td>
<td>29.2 °C</td>
<td>31.0 °C</td>
</tr>
<tr>
<td></td>
<td>28.5 °C</td>
<td>26.5 °C</td>
<td>27.1 °C</td>
</tr>
<tr>
<td></td>
<td>30.9 °C</td>
<td>27.8 °C</td>
<td>29.0 °C</td>
</tr>
<tr>
<td>Case</td>
<td>25.0 °C</td>
<td>25.0 °C</td>
<td>25.0 °C</td>
</tr>
<tr>
<td>Heat sink</td>
<td>25.0 °C</td>
<td>25.0 °C</td>
<td>25.0 °C</td>
</tr>
</tbody>
</table>

Losses

<table>
<thead>
<tr>
<th>Losses</th>
<th>Cond. losses</th>
<th>Turn-on losses</th>
<th>Turn-off losses</th>
<th>Reverse recovery losses</th>
<th>Total losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGBT</td>
<td>130.5 W</td>
<td>82.1 W</td>
<td>137.4 W</td>
<td>350.0 W</td>
<td></td>
</tr>
<tr>
<td></td>
<td>133.6 W</td>
<td>3.6 W</td>
<td>7.1 W</td>
<td>144.3 W</td>
<td></td>
</tr>
<tr>
<td></td>
<td>129.7 W</td>
<td>39.5 W</td>
<td>68.2 W</td>
<td>237.5 W</td>
<td></td>
</tr>
<tr>
<td>Diode</td>
<td>37.8 W</td>
<td>3.1 W</td>
<td>105.7 W</td>
<td>33.0 W</td>
<td></td>
</tr>
</tbody>
</table>

Analysis result between the Cursors

<table>
<thead>
<tr>
<th>Name</th>
<th>Cursor 1</th>
<th>Cursor 2</th>
<th>Delta</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGBT 1, Diode 1, Baseplate Temperature (°C)</td>
<td>41.87</td>
<td>42.40</td>
<td>-0.5326</td>
<td>37.01</td>
<td>47.84</td>
<td>41.80</td>
</tr>
<tr>
<td>IGBT 1 junction temperature</td>
<td>51.90</td>
<td>32.20</td>
<td>-19.70</td>
<td>29.02</td>
<td>24.91</td>
<td>31.93</td>
</tr>
<tr>
<td>Diode 1 junction temperature</td>
<td>30.35</td>
<td>30.76</td>
<td>0.0051</td>
<td>29.23</td>
<td>33.62</td>
<td>31.02</td>
</tr>
<tr>
<td>Case temperature</td>
<td>25.00</td>
<td>25.00</td>
<td>0.00</td>
<td>25.00</td>
<td>25.00</td>
<td>25.00</td>
</tr>
<tr>
<td>IGBT 1, Diode 1 losses (W)</td>
<td>1019</td>
<td>1076</td>
<td>-57.23</td>
<td>0.00</td>
<td>1175</td>
<td>359.1</td>
</tr>
<tr>
<td>IGBT losses</td>
<td>114.7</td>
<td>114.7</td>
<td>3.965E-10</td>
<td>0.00</td>
<td>519.8</td>
<td>143.9</td>
</tr>
<tr>
<td>Diode losses</td>
<td>712.4</td>
<td>741.9</td>
<td>-29.49</td>
<td>0.00</td>
<td>825.3</td>
<td>243.8</td>
</tr>
<tr>
<td>Linc, IGBT and Diode current</td>
<td>372.6</td>
<td>388.2</td>
<td>-15.54</td>
<td>0.00</td>
<td>424.3</td>
<td>109.2</td>
</tr>
<tr>
<td>IGBT 1 current</td>
<td>372.6</td>
<td>388.2</td>
<td>-15.54</td>
<td>0.00</td>
<td>424.3</td>
<td>113.6</td>
</tr>
<tr>
<td>Diode 1 current</td>
<td>372.6</td>
<td>388.2</td>
<td>-15.54</td>
<td>0.00</td>
<td>424.3</td>
<td>109.5</td>
</tr>
<tr>
<td>Output voltage</td>
<td>200.0</td>
<td>400.0</td>
<td>-200.0</td>
<td>-400.0</td>
<td>400.0</td>
<td>3.728</td>
</tr>
<tr>
<td>Output current</td>
<td>372.6</td>
<td>388.2</td>
<td>-15.54</td>
<td>-424.3</td>
<td>424.3</td>
<td>4.965</td>
</tr>
</tbody>
</table>
More Scope Functions

You can use different kind of zoom functions. Please note that (according to your hardware / internet connections etc.) the responding time might be slow.

Free zoom:
Zoom in x and y direction possible

Constrained zoom:
the whole y-axis range is fixed.
Zoom in x direction

Zoom to fit:
resets all zoom operations
Thank you!

If you have any questions, please contact us.
http://www.fujielectric.com/products/semiconductor/contact/index.html