

# Fuji

## High Power IGBT Module

Industrial Application Div.  
Semiconductors Group  
Fuji Electric Device Technology Co., Ltd.

# Fuji High Power IGBT Modules

*Quality is our message*

6in1 PKG type: EconoPack-Plus



2in1 PKG type: M248



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# *Features*

- 1. High voltage and high current line-up*
- 2. Low on-state voltage*
- 3. Fast switching and low loss characteristics*
- 4. Low inductance package design*
- 5. Easy Parallel connection*

**1. High voltage and high current line-up**

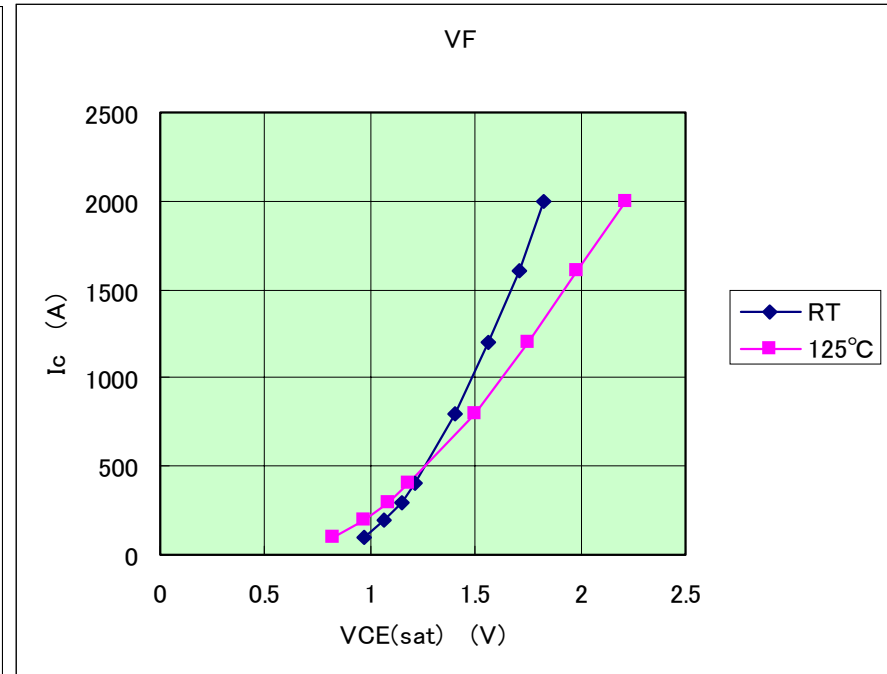
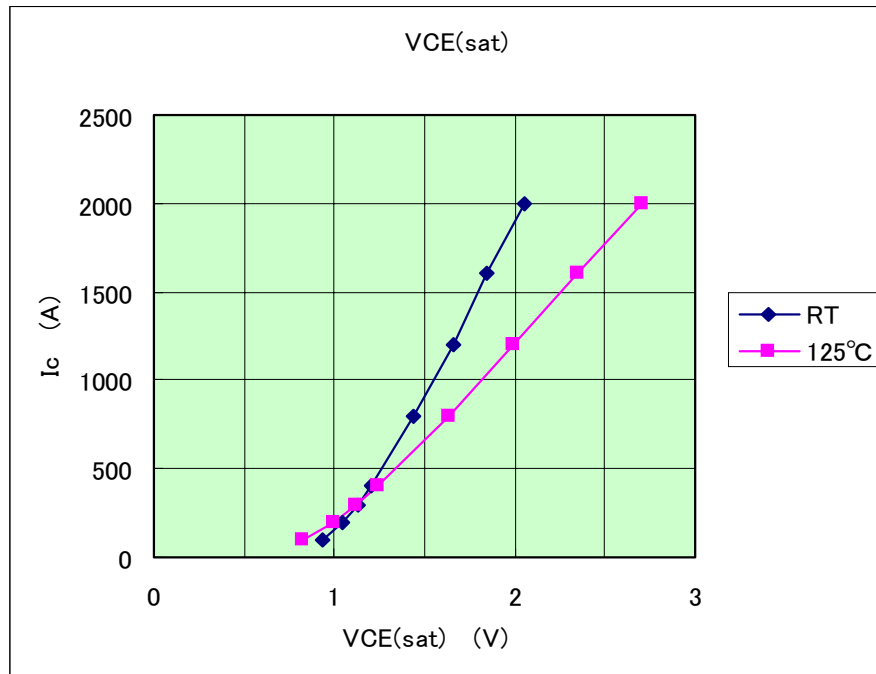
***1in1 : 1200V,1700V / 1200A,1600A,2400A,3600A***

***2in1 : 1700V / 600A,800A,1200A***

***6in1: 1200V,1700V/ (150A),225A,300A,450A***

**2. Low on-state voltage  $V_{CE(sat)}=2.0V$ ,  $V_F=1.65V$  @1in1, 2in1**

(1in1 1200V-1200A device, rating current, 125°C, typical value)

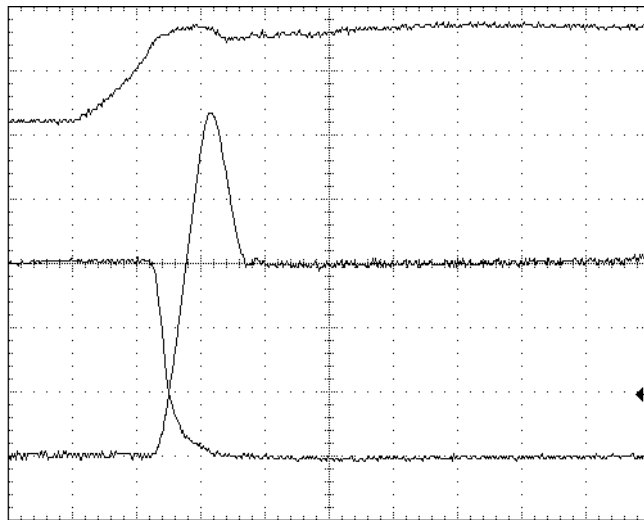


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### 3. *Fast switching and low loss characteristics*

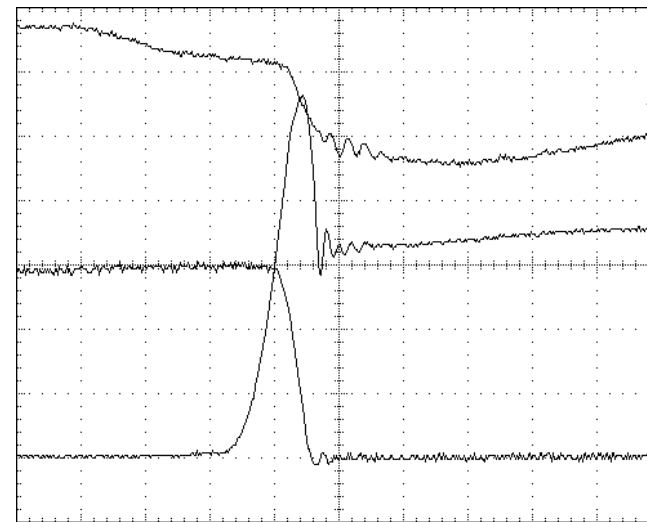
*Test conditions :  $T_j=125^\circ\text{C}$ ,  $V_{cc}=600\text{V}$ ,  $R_G=0.8\text{ohm}$ ,  $V_{GE}=\pm 15\text{V}$ ,  $L_s \doteq 65\text{nH}$*

***Turn-on wave form*** (1in1 1200V-1200A device)



(time:500ns/div, VGE:20V/div, VCE:200V/div, Ic:400A/div)

***Turn-off wave form*** (1in1 1200V-1200A device)



(time:500ns/div, VGE:20V/div, VCE:200V/div, Ic:400A/div)

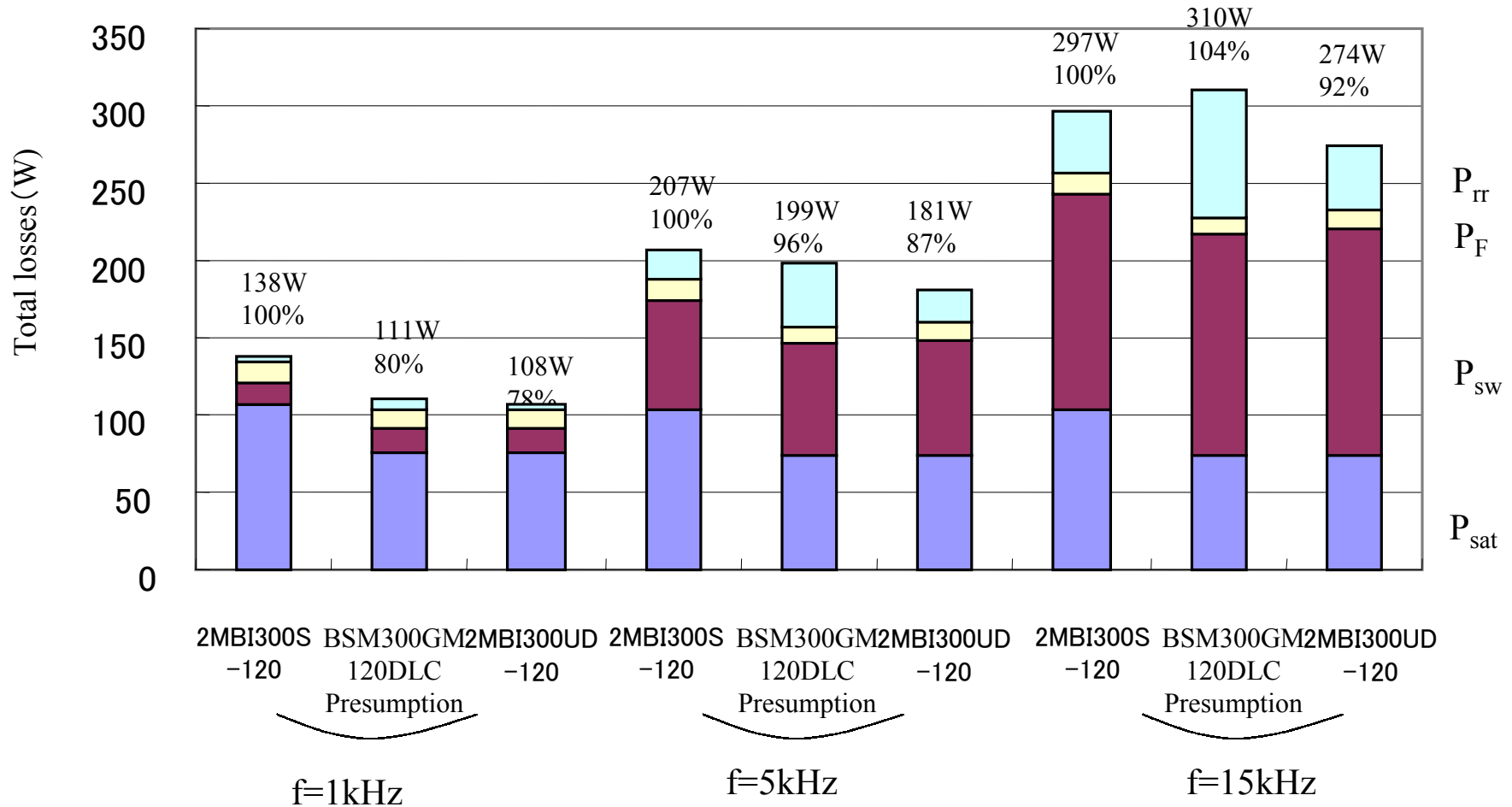
### 4. *Low inductance package design*

*Main terminal inductance(between collector and emitter) : 12nH 1in1 M142 PKG.*

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# 1200V 5<sup>th</sup> Gen.(U-series) Losses comparison

Ed=600V, Iout=135Arms  
 cos θ=0.85, λ=1, Tj=125°C



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## Features of FS-IGBT chip technology

- (1) Narrower distribution of characteristics
- (2) Positive temperature coefficient of on-voltage
- (3) Less temperature dependence of switching loss

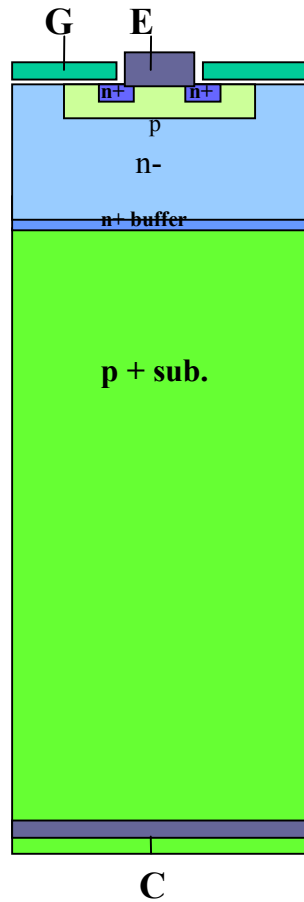


Easy to connect in parallel

### Comparison of 1200V IGBT chips

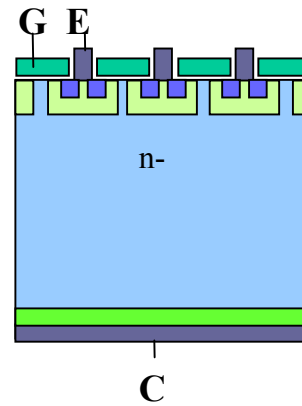
	N-IGBT	U-IGBT
Type of IGBT	Punch Through Type	Field-Stop Type
Gate Structure	Planner Gate	Trench Gate
Wafer	Epitaxial Wafer	Floating Zone(FZ) Wafer
Thickness	350 micrometers	130 micrometers
Lifetime Control	Electron Irradiation	<i>not needed</i>

# Progress of Fuji's 1200/1700V IGBT chip design structure



**N-series**

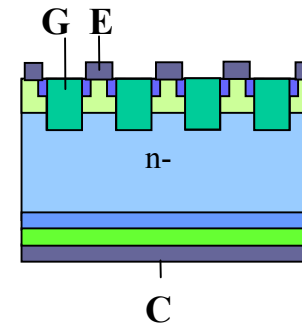
1200V : Jan. '95



**S-series**

**NPT-  
Structure**

1200V : Mar. '98



**U-series**

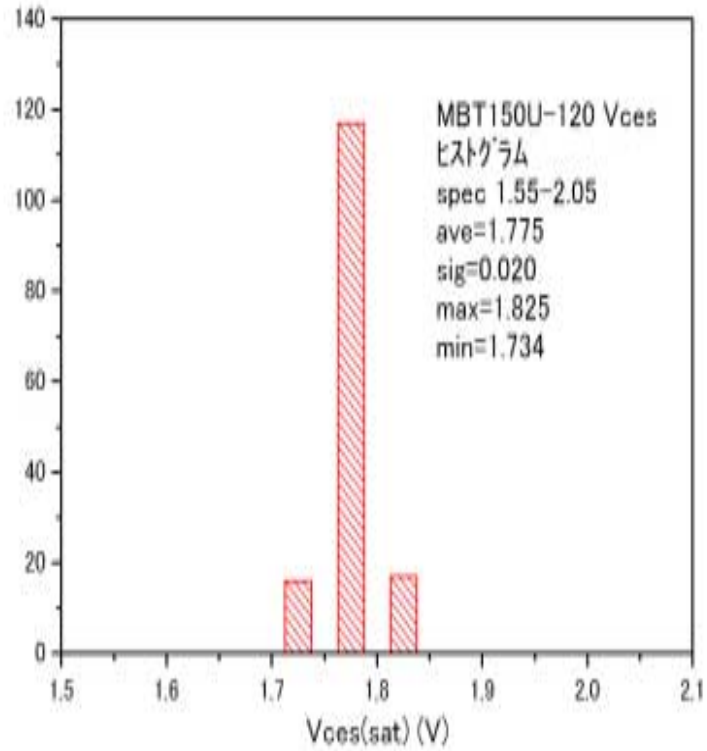
**FS Trench-  
Structure**

1200V : 2002

1700V : 2002

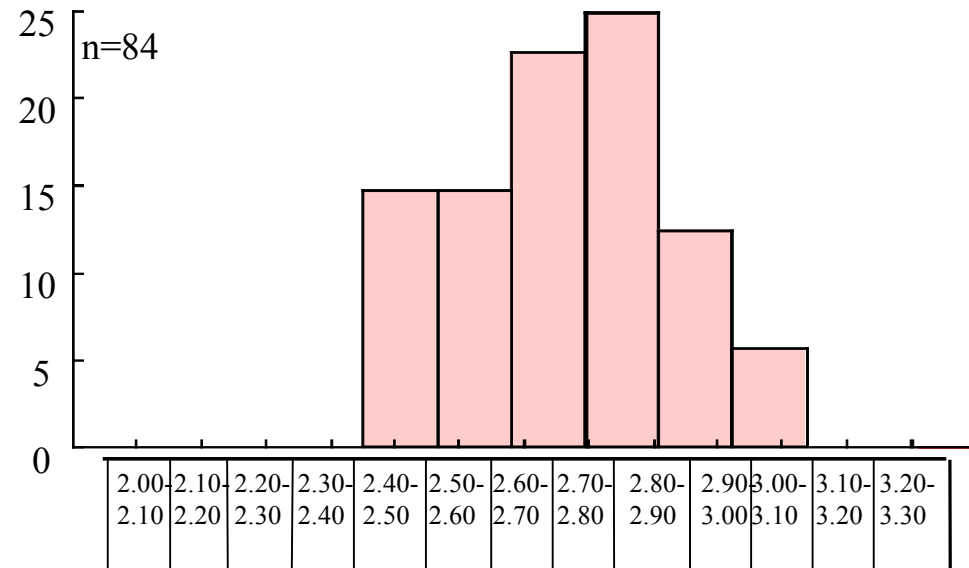
## Comparison of $V_{ce(sat)}$ distribution

MBT150U-120

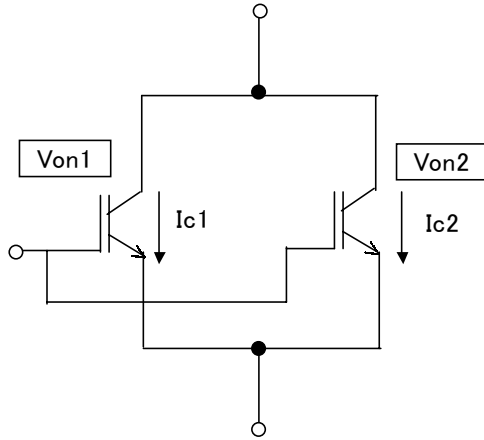


MBT100N-120

Ave. 2.774V  
 $\sigma = 0.141$



## Comparison of current imbalance between U-series and N-series

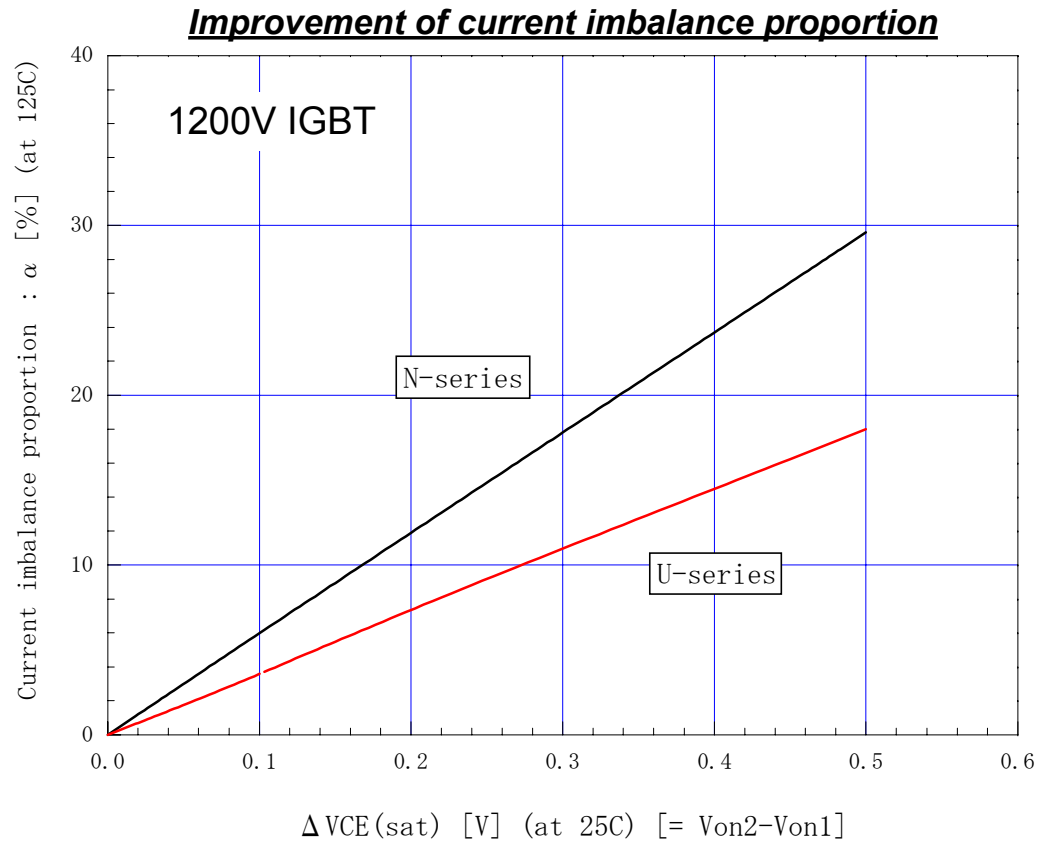


$$V_{on1} < V_{on2}$$

$$\Delta V_{on} = V_{on2} - V_{on1}$$

$$I_{c(ave.)} = (I_{c1} + I_{c2}) / 2$$

$$\alpha = (I_{c1} / I_{c(ave.)} - 1) \times 100$$



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## *Maximum current in parallel connection IGBTs*

The worst case conditions where the entire current is concentrated into one module.

$$\sum I_C = I_{C(\max)} \left[ 1 + (n-1) \frac{\left(1 - \frac{\alpha}{100}\right)}{\left(1 + \frac{\alpha}{100}\right)} \right]$$

$$\alpha = \left( \frac{I_{C1}}{I_{C(\text{ave})}} - 1 \right) \times 100$$

For example

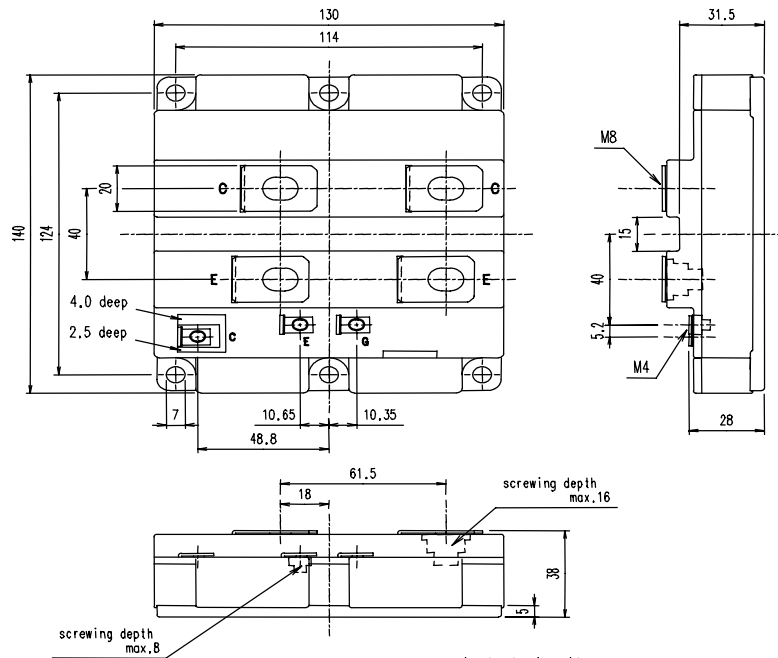
$$n=4, \alpha=10\%, I_{C(\max)}=600\text{A}$$

$$\sum I_C = 2072\text{A}, I_{C(\text{ave})}=518\text{A}$$

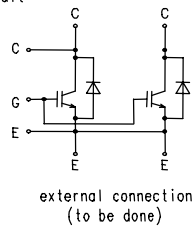
# *in1 Package out line*

**Tentative**

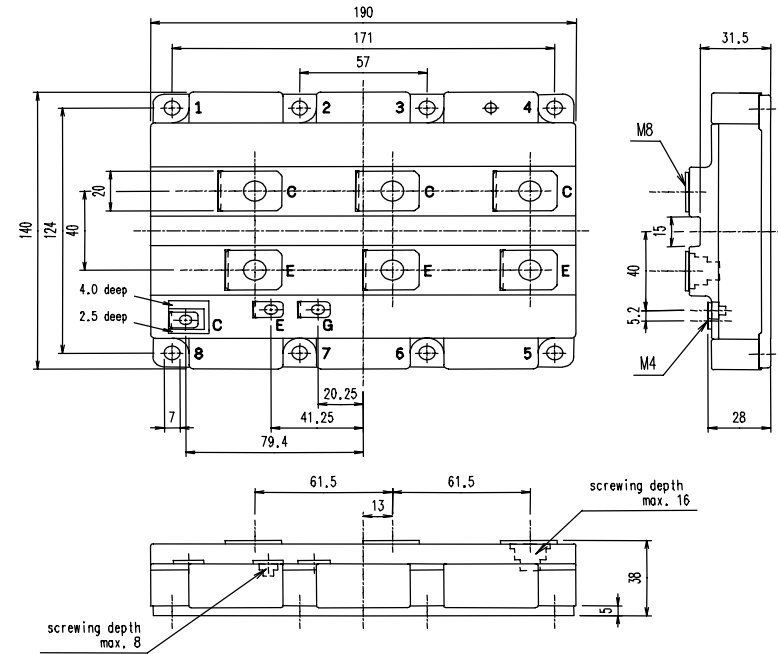
130x140 M142



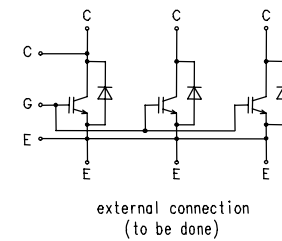
equivalent circuit



140x190 M143



equivalent circuit



# 1in1 Electrical and thermal characteristics

Tentative

## Electrical properties

Collector emitter voltage		1200V				1700V			
Collector current	TC= 80°C	1200A	1600A	2400A	3600A	1200A	1600A	2400A	3600A
housing		140* 130 M142	140* 130 M142	140* 190 M143	140*190 M143	140* 130 M142	140* 130 M142	140* 190 M143	140*190 M143
Peak collector current		2400A	3200A	4800A	7200A	2400A	3200A	4800A	7200A
Vcesat	VGE= 15V Tj= 25°C VGE= 15V Tj= 125°C	1.7V typ 2V typ	1.7V typ 2V typ	1.7V typ 2V typ	1.7V typ 2V typ	2.0V typ 2.4V typ	2.0V typ 2.4V typ	2.0V typ 2.4V typ	2.0V typ 2.4V typ
VF- diode (chip)	Tj= 125°C	2.2V typ	2.2V typ	2.2V typ	2.2V typ	2.0V typ	2.0V typ	2.0V typ	2.0V typ
Gate threshold voltage	Tj= 25°C	6.2V typ	6.2V typ	6.2V typ	6.2V typ	7.5V typ	7.5V typ	7.5V typ	7.5V typ
Stray inductance module		12nH	12nH	10nH	10nH	12nH	12nH	10nH	10nH
Stray inductance between Sense and main emitter		3- 3.5nH	3- 3.5nH	2.5- 3nH	2.5- 3nH	3- 3.5nH	3- 3.5nH	2.5- 3nH	2.5- 3nH

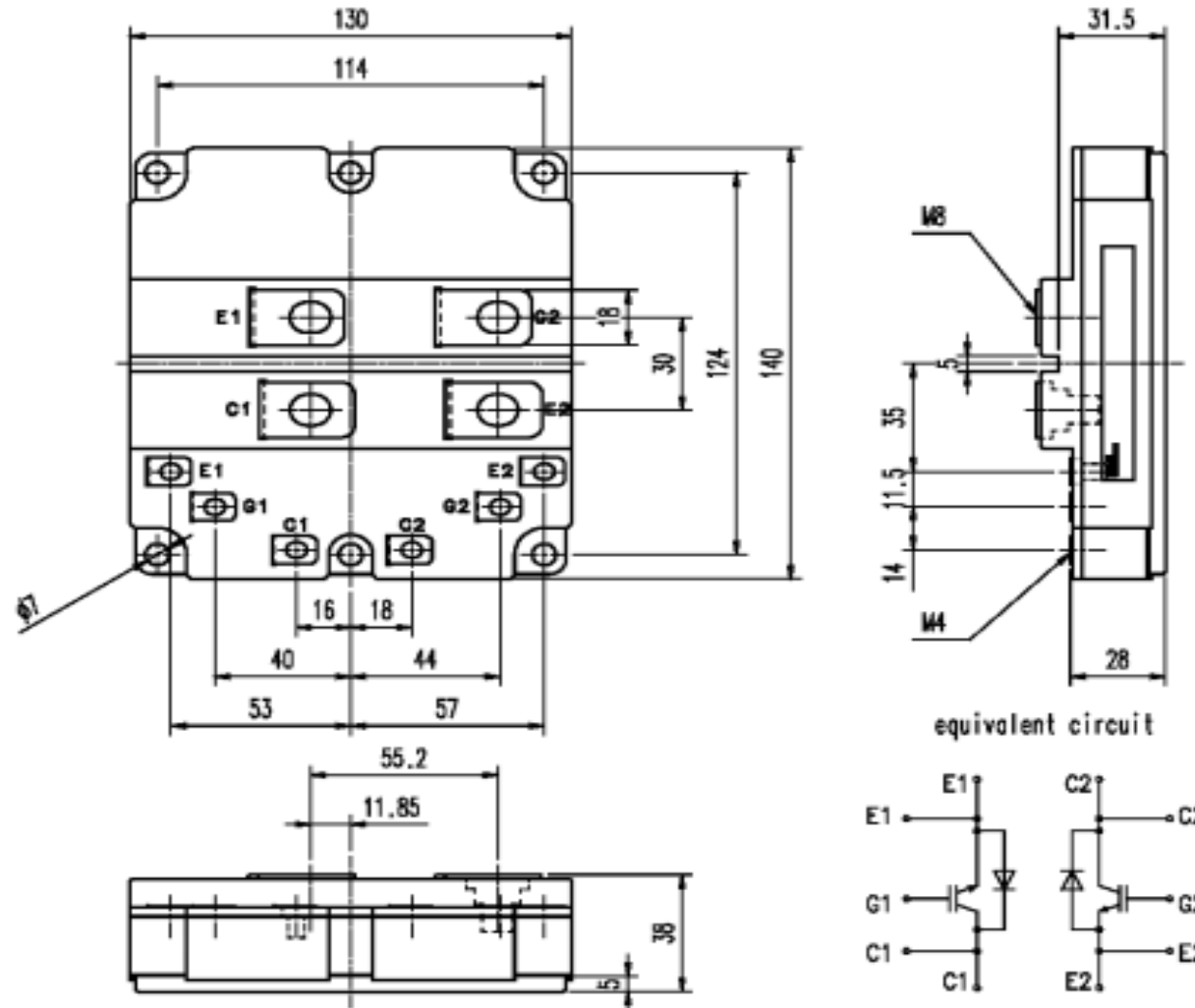
## Thermal properties

Transistor RthJC	Max. values	0.022K/W	0.016	0.0125	0.0084	≒0.022	≒0.016	≒0.0125	≒0.0084
Diode RthJC	Max. values	0.04K/W	0.032	0.021	0.014	≒0.04	≒0.032	≒0.021	≒0.014
Max junction temperature	Max. values	150°C	150°C	150°C	150°C	150°C	150°C	150°C	150°C
Operation temperature	Max. values	125°C	125°C	125°C	125°C	125°C	125°C	125°C	125°C

# 2in1 Package out line

Tentative

M248



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## 2in1 Electrical and thermal characteristics

Tentative

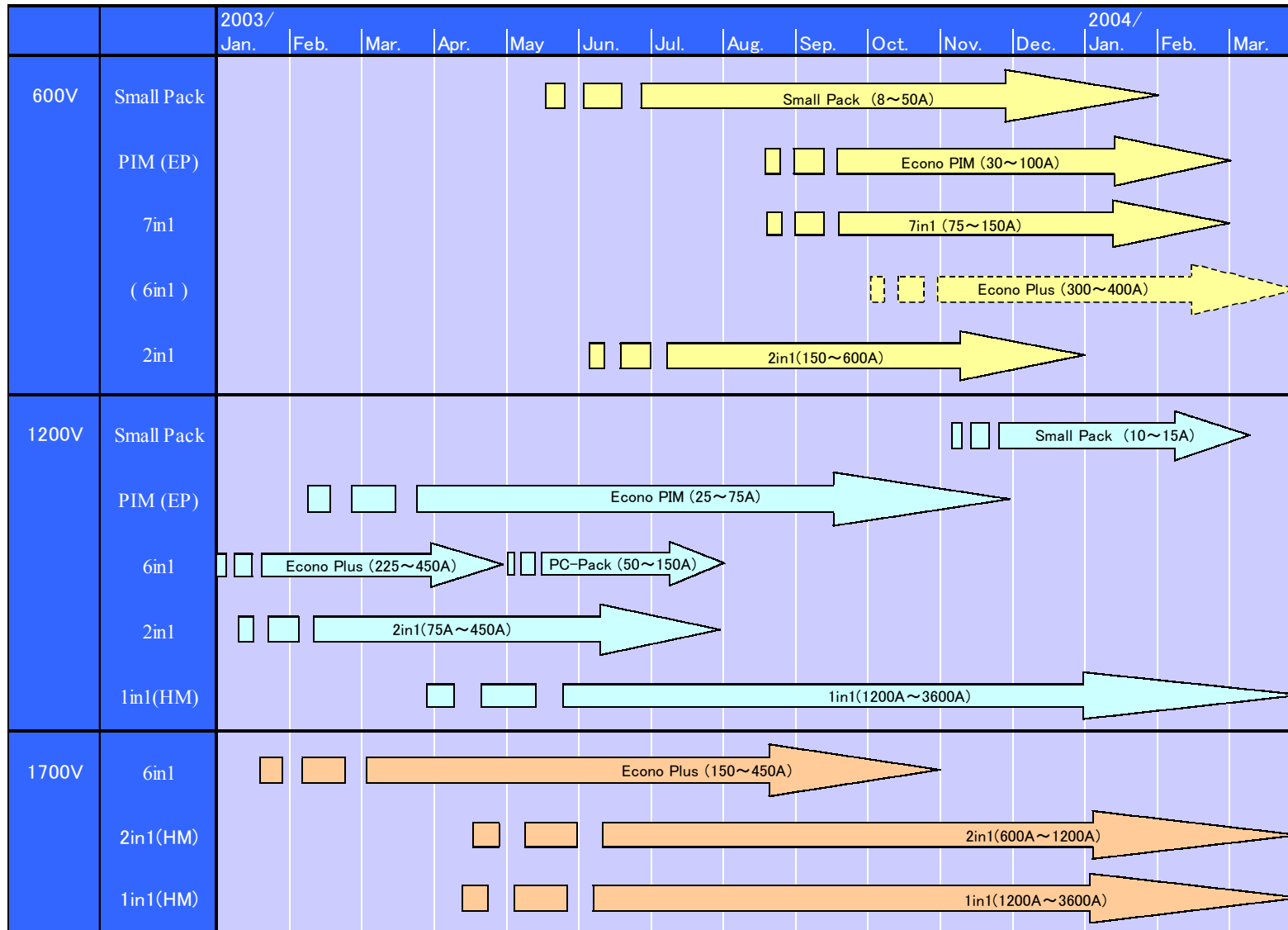
### Electrical properties

Collector emitter voltage		1700V		
Collector current	TC= 80°C	600A	800A	1200A
Peak collector current		1200A	1600A	2400A
Vcesat	VGE= 15V Tj= 25°C	2.0V typ	2.0V typ	2.0V typ
	VGE= 15V Tj= 125°C	2.4V typ	2.4V typ	2.4V typ
VF- diode	Tj= 125°C	2.0V typ	2.0V typ	2.0V typ
Gate threshold voltage	Tj= 25°C	7.5V typ	7.5V typ	7.5V typ
Stray inductance module		12nH	12nH	12nH
Stray inductance between Sense and main emitter		3- 3.5nH	3- 3.5nH	3- 3.5nH

### Thermal properties

Transistor RthJC / arm	Max. values	0.044K/W	0.032K/W	0.025K/W
Diode RthJC / arm	Max. values	0.08K/W	0.064K/W	0.042K/W
Max junction temperature	Max. values	150°C	150°C	150°C
Operation temperature	Max. values	125°C	125°C	125°C

Road map of U-series IGBT modules



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## 1in1 2in1 Engineering sample shipment schedule

Sample	2003				2004							
	9	10	11	12	1	2	3	4	5	6	7	8
<b>ES</b> (Engineering Sample)  <b>1in1</b>					<div style="display: flex; flex-direction: column; align-items: center; justify-content: center;"> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">             ●1200A/1200V PKG.type:M142              ●1600A/1200V PKG.type:M142           </div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">             ●2400A/1200V PKG.type:M143              ●3600A/1200V PKG.type:M143           </div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">             ●1200A/1700V PKG.type:M142              ●1600A/1700V PKG.type:M142           </div> <div style="border: 1px solid black; padding: 2px;">             ●2400A/1700V PKG.type:M143              ●3600A/1700V PKG.type:M143           </div> </div>							
<b>ES</b> (Engineering Sample)  <b>2in1</b>					<div style="display: flex; flex-direction: column; align-items: center; justify-content: center;"> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">             ●1200A/1700V PKG.type:M248           </div> <div style="border: 1px solid black; padding: 2px; margin-bottom: 5px;">             ●600A/1700V PKG.type:M248           </div> <div style="border: 1px solid black; padding: 2px;">             ●800A/1700V PKG.type:M248           </div> </div>							