

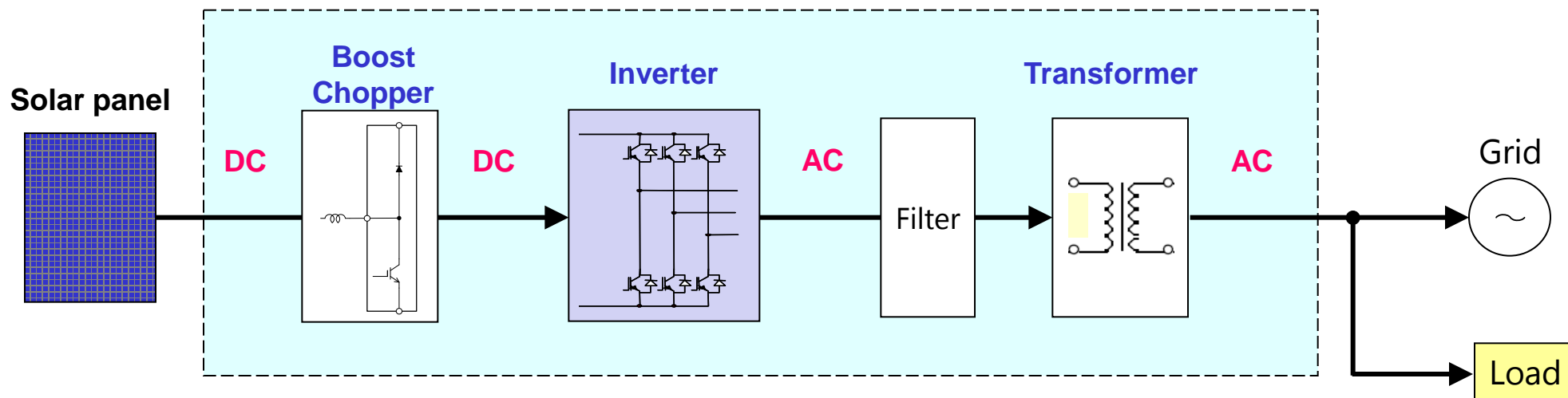
Fuji IGBT Modules for Solar Inverter



Device Application Technology Dept.
Sales Div.
Electronic Devices Business Group

- Topology in solar inverter
- Fuji IGBT modules for solar inverter
- Fuji solution in Gate Driver Unit (GDU)
- Fuji 2-level topology solution
- Fuji 3-level topology solution – Stack
- Snubber capacitor

Example of Solar Inverter Schematic



■ Feature of solar inverter: High efficiency, High reliability.

	General inverter	Solar inverter
Input voltage	AC (Ex. 400V \pm 10%)	DC 400~1000V
Output frequency	Ex. 0.5~120Hz	50 / 60Hz
Efficiency	90~95%	> 95%
Overload	150~200%	100~120%
Device (ex. 30kW)	1200V / 150A	1200V / 200A

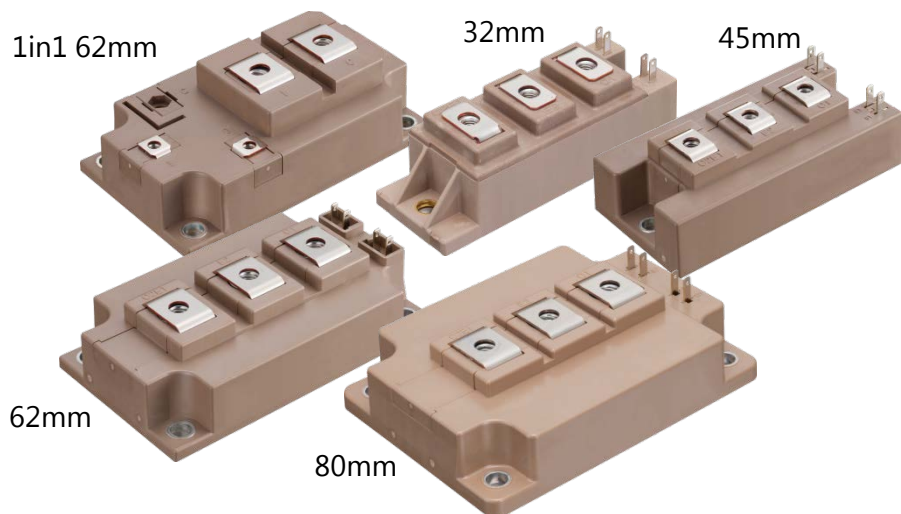
Topology in Solar Inverter

Type	Single-phase inverter	2-level inverter	NPC 3-level inverter	A-NPC 3-level with RB-IGBT
Circuit				
Device	IGBT:600V	IGBT:1200V	IGBT:600V	IGBT:1200V +600V(RB-IGBT)
Output Voltage				
Capacity	< 10kW	> 10kW	> 10kW	> 10kW

- Topology in solar inverter
- **Fuji IGBT modules for solar inverter**
 - 2-Level**
 - 3-Level
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Fuji IGBT Module for Solar Inverter (2-level)

Standard 1in1/2in1



Dual XT (2in1)

M254
62 x 150 x 17mm



PrimePACK™ (2in1)



EconoPACK™+ (6in1)

M629
150 x 162 x 17mm



Note: EconoPACK™+ and PrimePACK™ are registered trademarks of Infineon Technology AG, Germany.


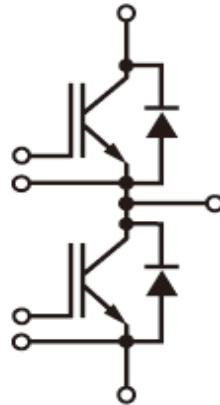




2-level Topology (Condition: $V_{DC(\text{rating})} = 450\text{V}$, $V_{DC(\text{max})} = 850\text{V}$)

Output Power	IGBT P/N	Configuration	V_{CES}	I_C	Number of parallel
10 kW	2MBI75VA-120-50	2-Pack	1200V	75A	1
15 kW	2MBI100VA-120-50	2-Pack	1200V	100A	1
20 kW	2MBI150VA-120-50	2-Pack	1200V	150A	1
	2MBI150VB-120-50				
30 kW	2MBI200VB-120-50	2-Pack	1200V	200A	1
	2MBI200VH-120-50				
	6MBI225V-120-50	6-Pack	1200V	225A	1
50 kW	2MBI300VD-120-50	2-Pack	1200V	300A	1
	2MBI300VH-120-50				
	2MBI300VE-120-50				
	2MBI300VN-120-50				
	2MBI300VJ-120-50	6-Pack	1200V	300A	1
6MBI300V-120-50					
100 kW	2MBI450VH-120-50	2-Pack	1200V	450A	1
	2MBI450VE-120-50				
	2MBI450VN-120-50				
	2MBI450VJ-120-50	6-Pack	1200V	450A	1
6MBI450V-120-50					
125 kW	2MBI600VE-120-50	2-Pack	1200V	600A	1
	2MBI600VN-120-50				
	2MBI600VJ-120-50				
	2MBI600VG-120-50				
	2MBI600VXA-120E-50				
250 kW	2MBI1400VXB-120E-50	2-Pack	1200V	1400A	1
	2MBI1400VXB-120P-50				
500 kW	2MBI1400VXB-120E-50	2-Pack	1200V	1400A	2
	2MBI1400VXB-120P-50				
1000 kW	2MBI1400VXB-120E-50	2-Pack	1200V	1400A	4
	2MBI1400VXB-120P-50				

Fuji IGBT Module for Solar Inverter (2in1)

Feature

- ✓ Low power dissipation with V-silicon chipset
- ✓ Extra thermal design ($T_{jmax} = 175^{\circ}\text{C}$ repetitive guarantee)


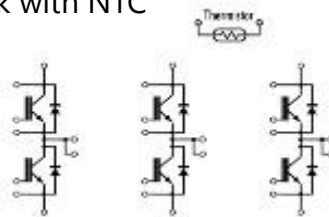

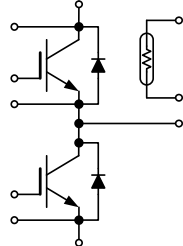

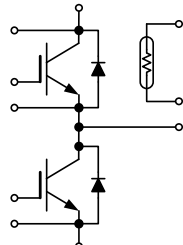
IGBT P/N	V_{CES}	I_C	Std. Package (mm)	Equivalent circuit
2MBI□VA-120-50 □: Current	1200V	75A, 100A, 150A	 M263 34 x 94	
2MBI□VB-120-50	1200V	150A, 200A	 M274 45 x 92	
2MBI□VD-120-50	1200V	300A, 400A	 M275 62 x 108	
2MBI□VH-120-50	1200V	200A 300A, 450A	 M276 62 x 108	
2MBI□VE-120-50	1200V	300A, 450A, 600A	 M277 80 x 110	

Fuji IGBT Module for Solar Inverter EconoPACK™+, Dual XT

Note: EconoPACK™+ are registered trademarks of Infineon Technology AG, Germany


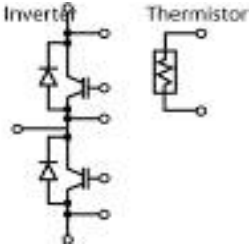

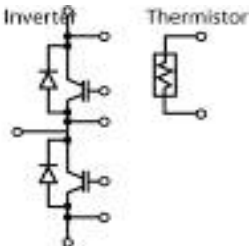
Feature

- ✓ Low power dissipation with V-silicon chipset
- ✓ Extra thermal design ($T_{jmax} = 175^{\circ}\text{C}$ repetitive guarantee)
- ✓ 2 kinds of pin connection for Dual XT (Solder/Press fit pins)

	IGBT P/N	V_{CES}	I_C	Package (mm)	Equivalent circuit
EconoPACK™+	6MBI225V-120-50	1200V	225A	 M629 150 x 162	6-Pack with NTC 
	6MBI300V-120-50	1200V	300A		
	6MBI450V-120-50	1200V	450A		
Dual XT	2MBI300VN-120-50	1200V	300A	 Solder pin M254 62 x 150	2-Pack with NTC 
	2MBI450VN-120-50	1200V	450A		
	2MBI600VN-120-50	1200V	600A		
	2MBI300VX-120-50	1200V	300A	 Press fit M282 62 x 150	2-Pack with NTC 
	2MBI450VX-120-50	1200V	450A		
	2MBI600VX-120-50	1200V	600A		

Feature

- ✓ Low power dissipation with V-silicon chipset
- ✓ Extra thermal design (Tjmax=175°C repetitive guarantee)
- ✓ Low inductance and good current balance package
- ✓ Long-term reliability (CTI > 600, High Tc capability)

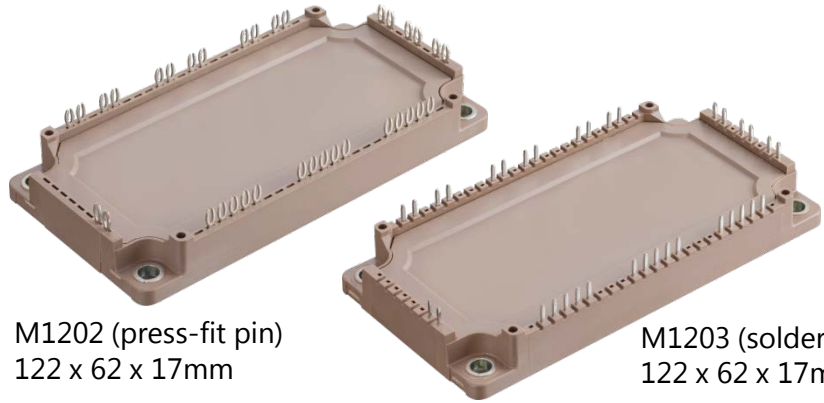
IGBT P/N	V _{CES}	I _C	Package (mm)	Equivalent circuit	Base plate	Isolation
2MBI600VXA-120E-50	1200V	600A	 M271 89 x 172 x 38	2-Pack with NTC 	Copper (Cu)	Al ₃ O ₂ Viso=4.0kV/60s
2MBI900VXA-120E-50 2MBI900VXA-120P-50	1200V	900A				
2MBI1400VXB-120E-50 2MBI1400VXB-120P-50	1200V	1400A	 M272 89 x 250 x 38	2-Pack with NTC 	Copper (Cu)	Al ₃ O ₂ Viso=4.0kV/60s

Note: PrimePACK™ are registered trademarks of Infineon Technology AG, Germany.

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 - 2-Level
 - 3-Level**
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Fuji IGBT Module for Solar Inverter (3-level)

EP3 (12in1)

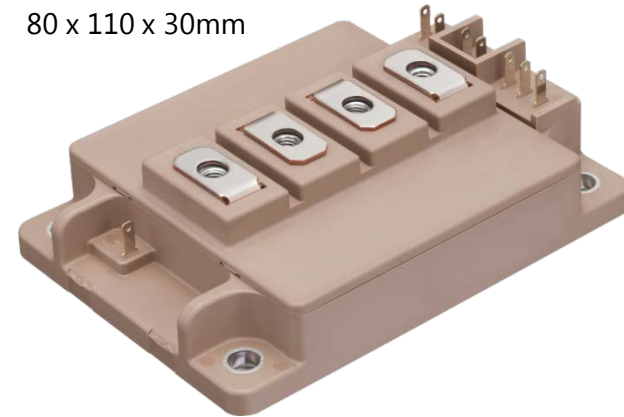


M1202 (press-fit pin)
122 x 62 x 17mm

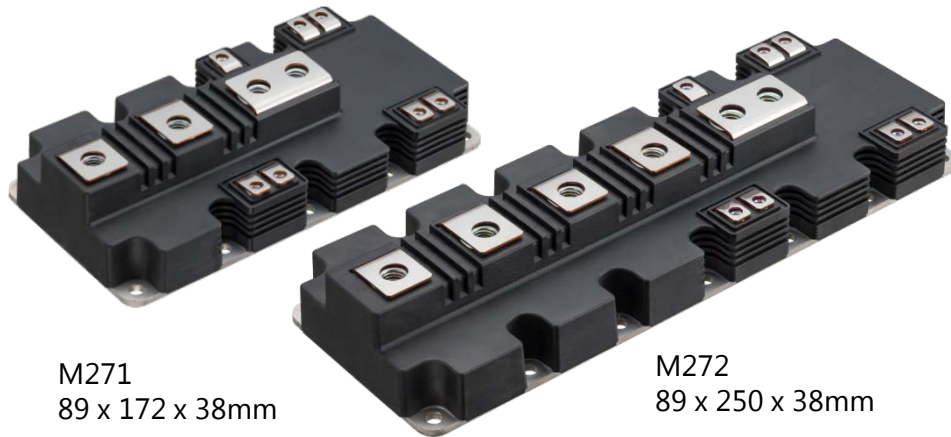
M1203 (solder pin)
122 x 62 x 17mm

M403 (4in1)

80 x 110 x 30mm



PrimePACK™ (2in1+chopper)



M271
89 x 172 x 38mm

M272
89 x 250 x 38mm

T-Prime (4in1)

M404
89 x 250 x 38mm



Note: PrimePACK™ is registered trademarks of Infineon Technology AG, Germany.

Advanced T-type 3-level Module

(Condition: $V_{DC(\text{rating})} = 450\text{V}$, $V_{DC(\text{max})} = 850\text{V}$)

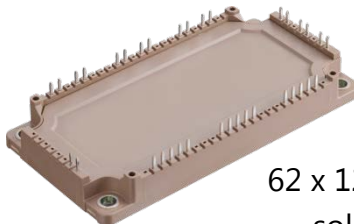
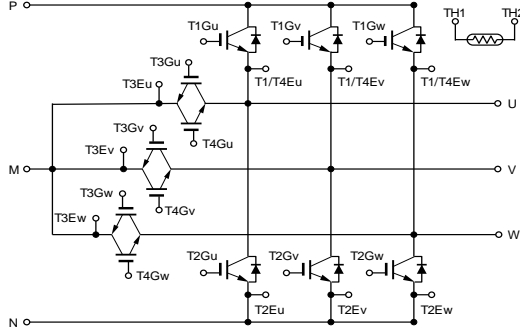

Output Power	IGBT P/N	Configuration	Package	Number of parallel
10 kW	12MBI75VN-120-50 12MBI75VX-120-50	12in1	EP3	1
15 kW	12MBI100VN-120-50 12MBI100VX-120-50	12in1	EP3	1
20 kW	4MBI300VG-120R-50	4in1	standard M403	1
30 kW	4MBI300VG-120R-50	4in1	standard M403	1
50 kW	4MBI300VG-120R-50	4in1	standard M403	1
100 kW	4MBI300VG-120R-50	4in1	standard M403	2
	4MBI650VB-120R1-50	4in1	T-Prime M404	1
125 kW	4MBI300VG-120R-50	4in1	standard M403	2
	4MBI650VB-120R1-50	4in1	T-Prime M404	1
250 kW	4MBI300VG-120R-50	4in1	standard M403	4
	4MBI900VB-120R1-50	4in1	T-Prime M404	1
500 kW	4MBI900VB-120R1-50	4in1	T-Prime M404	2
1000 kW	4MBI900VB-120R1-50	4in1	T-Prime M404	4

Notice : Applicable device might be different by control method, control condition, cooling condition, etc.

Feature

- ✓ A new **RB-IGBT** and an existing IGBT are integrated in one package. (Fuji specific technology!)
- ✓ The stray inductance between each main terminals < 40nH
- ✓ The arrangement of the terminals is optimized for construction of A-NPC power converters.

※RB-IGBT: Reverse Blocking-Insulated Gate-Bipolar Transistor

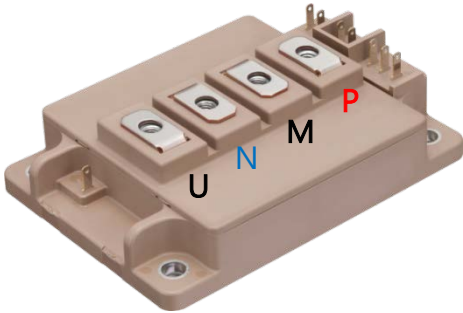
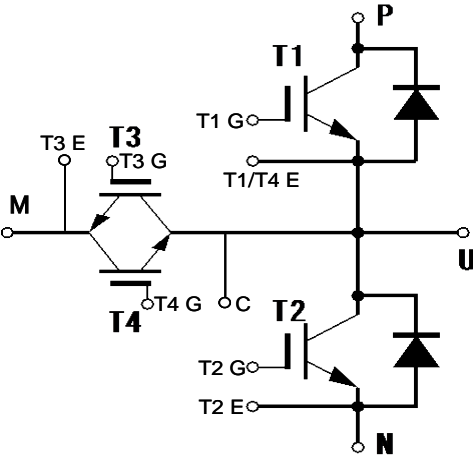
IGBT P/N	Main		AC switch		Package (mm)	Equivalent circuit
	V_{CES}	I_C	V_{CES}	I_C		
12MBI50VN-120-50	1200V	50A	+/-600V	50A	 <p>M1203 62 x 122 x 17 solder pin</p>	<p>3-phase T-type 3-Level Inverter with NTC</p> 
12MBI75VN-120-50	1200V	75A	+/-600V	75A		
12MBI100VN-120-50	1200V	100A	+/-600V	100A		
12MBI50VX-120-50	1200V	50A	+/-600V	50A	 <p>M1202 62 x 122 x 17 press fit pin</p>	
12MBI75VX-120-50	1200V	75A	+/-600V	75A		
12MBI100VX-120-50	1200V	100A	+/-600V	100A		

Fuji IGBT Module for Solar Inverter – M403(4in1)

Feature

- ✓ A new **RB-IGBT** and an existing IGBT are integrated in one package. (Fuji specific technology!)
- ✓ The stray inductance between each main terminals < 40nH
- ✓ The arrangement of the terminals is optimized for construction of A-NPC power converters.

※RB-IGBT: Reverse Blocking Insulated Gate Bipolar Transistor

IGBT P/N	V _{dc} max.	Main (T1,T2)		AC switch (T3,T4)		Package (mm)	Equivalent circuit
		V _{CES}	I _C	V _{CES}	I _C		
4MBI400VG-060R-50	400V	600V	400A	+/-600V	400A	 <p>M403 80 x 110 x 30</p>	<p>Single-phase T-type 3-Level Inverter</p> 
4MBI300VG-120R-50	850V	1200V	300A	+/-600V	300A		
4MBI300VG-120R1-50	850V	1200V	300A	+/-900V	300A		
4MBI340VF-120R-50	850V	1200V	340A	+/-600V	340A		
4MBI400VF-120R-50	850V	1200V	400A	+/-600V	450A		
4MBI220VF-170R2-50	1300V	1700V	220A	+/-1200V	220A		

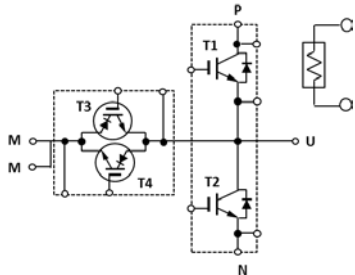
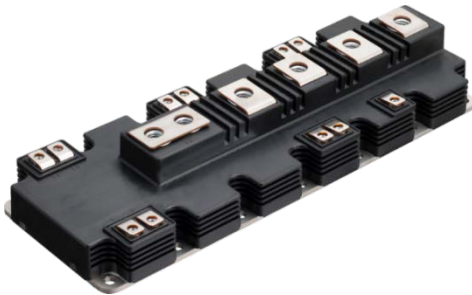
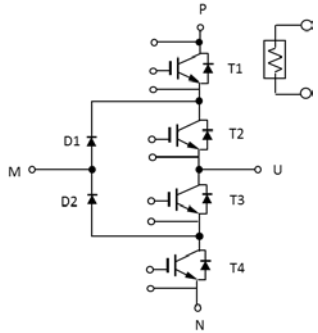
“VF” type: Low thermal resistance isolation substrate

Fuji IGBT Module for Solar Inverter – M404(4in1)

Feature

- ✓ A new **RB-IGBT** and an existing IGBT are integrated in one package. (Fuji specific technology!)
- ✓ Common terminal layout for both T-Type and I-Type 3-Level Inverter circuit

※RB-IGBT: Reverse Blocking Insulated Gate Bipolar Transistor

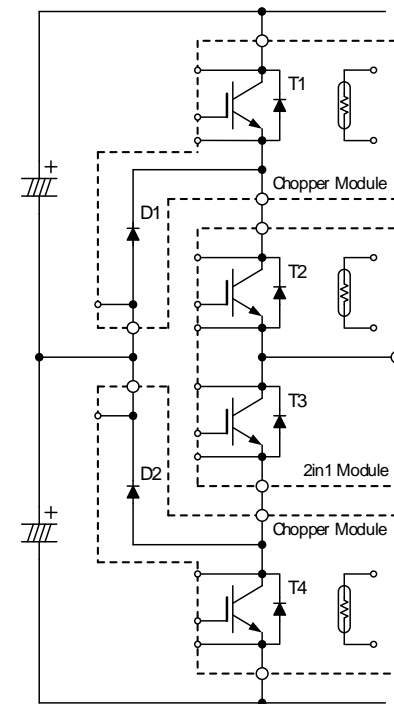
IGBT P/N	Vdc max.	Main (T1,T2)		AC switch (T3,T4)		Equivalent circuit	Package (mm)
		V_{CES}	I_C	V_{CES}	I_C		
4MBI450VB-120R1-50	850V	1200V	450A	+/-900V	450A	 <p>T-type Single-phase with NTC</p>	
4MBI650VB-120R1-50	850V	1200V	650A	+/-900V	650A		
4MBI900VB-120R1-50	850V	1200V	900A	+/-900V	900A		
4MBI450VB-170R2-50	1300V	1700V	450A	+/-1200V	450A		
4MBI600VB-170R2-50	1300V	1700V	600A	+/-1200V	600A		
IGBT P/N	Vdc max.	Main (T1-T4)		Clamp Diode		Equivalent circuit	Package (mm)
		V_{CES}	I_C	V_R	I_F		
4MBI600VC-120-50	1500V	1200V	600A	1200V	600A	 <p>I-type Single-phase with NTC</p>	<p>M404 89 x 250 x 38</p>

Fuji IGBT Module for I-type 3-Level Solar Inverter

Feature

- ✓ By combining 2in1 Module and Chopper Module of the same shape, a large capacity 3-Level inverter can be constructed.
- ✓ I-type is suitable for high DC voltage applications.

PrimePACK™ (2in1 + chopper)

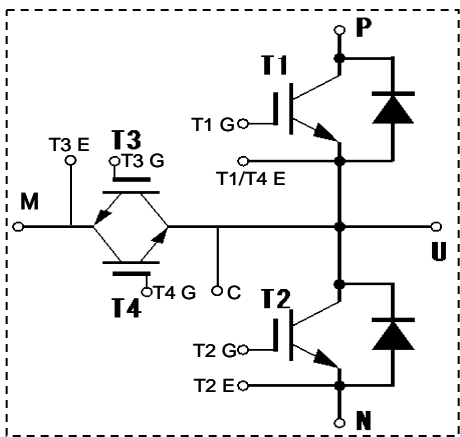


Vdc max.	2in1 Module (T2,T3)			High-side switch Chopper (T1,D1)			Low-side switch Chopper (T4,D2)			Package
	IGBT P/N	V _{CES}	I _C	IGBT P/N	V _{CES}	I _C	IGBT P/N	V _{CES}	I _C	
1500V	2MBI1400VXB-120P-54	1200V	1400A	1MBI1400VXB-120PH-54	1200V	1400A	1MBI1400VXB-120PL-54	1400V	1400A	M272
High	2MBI650VXA-170E-54	1700V	650A	1MBI650VXA-170EH-54	1700V	650A	1MBI650VXA-170EL-54	1700V	650A	M271
High	2MBI1000VXB-170E-54	1700V	1000A	1MBI1000VXB-170EH-54	1700V	1000A	1MBI1000VXB-170EL-54	1700V	1000A	M272
High	2MBI1400VXB-170P-54	1700V	1400A	1MBI1400VXB-170PH-54	1700V	1400A	1MBI1400VXB-170PL-54	1700V	1400A	M272

Note: PrimePACK™ is registered trademarks of Infineon Technology AG, Germany.

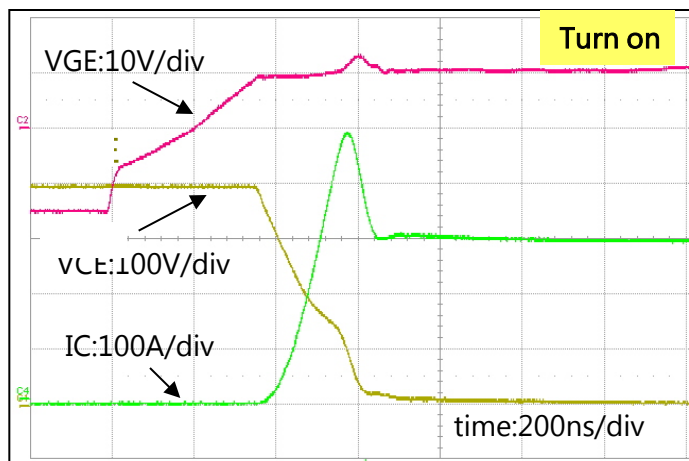
Switching Waveform of RB-IGBT

Equivalent circuit



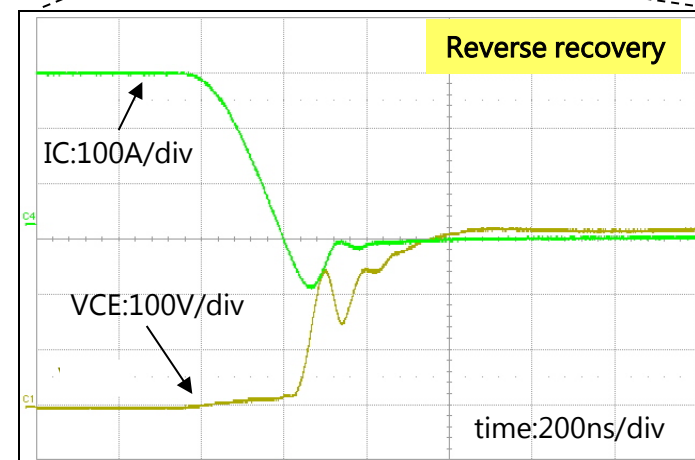
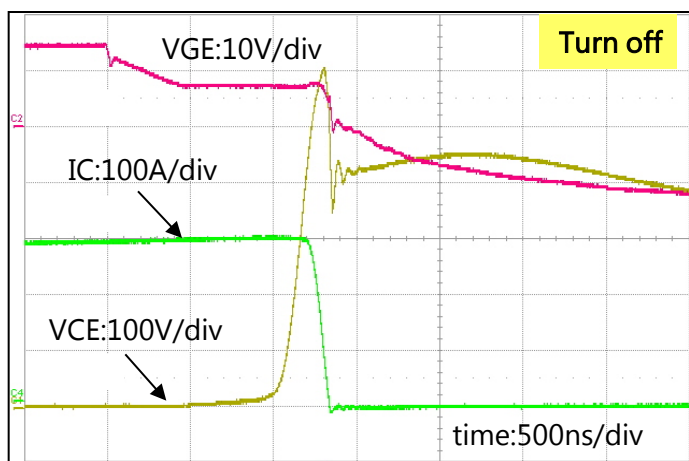
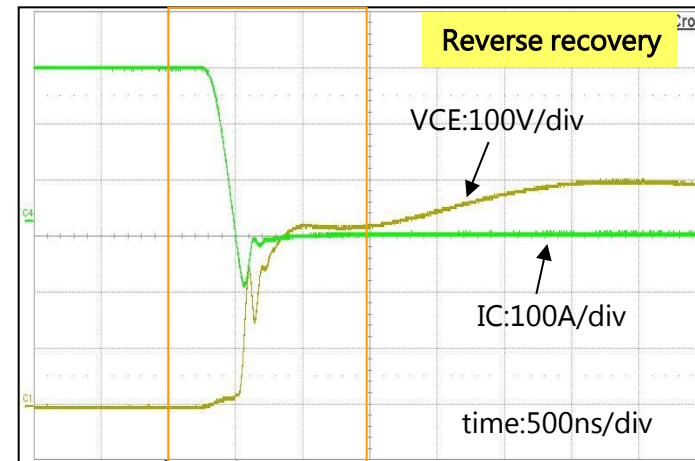
T3 switching T1-FWD recovery mode

$T_j = RT$, $V_{cc2} = 400V$, $I_c = 300A$, $R_G = +8.2/-39\Omega$
 $V_{GE}(T3) = +/-15V$, $V_{GE}(T4) = +15V$,
 snubber = $1.84\mu F$, $L_s = 34nH$



T1 switching T4 RB-IGBT recovery mode

$T_j = RT$, $V_{cc2} = 400V$, $I_c = 300A$, $R_G = +10\Omega$
 $V_{GE}(T1) = +/-15V$, $V_{GE}(T4) = +15V$,
 snubber = $1.84\mu F$, $L_s = 34nH$



Fuji RB-IGBT can be realized of fast switching operation same as normal IGBT and FWD.

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- Fuji IGBT modules for solar inverter
- **Fuji solution in Gate Driver Unit (GDU)**
- Fuji 2-level topology solution
- Fuji 3-level topology solution – Stack
- Snubber capacitor

Fuji Solution in GDU for 2-level Topology

CONCEPT
A Power Integrations Company

<http://igbt-driver.com/>



Package	IGBT part No.	V_{CES}	I_C	Plug-and-Play driver part No.
Dual XT	2MBI225VN-120-50	1200V	225A	2SP0115T2Ax-2MBI225VN-120-50
	2MBI300VN-120-50	1200V	300A	2SP0115T2Ax-2MBI300VN-120-50
	2MBI450VN-120-50	1200V	450A	2SP0115T2Ax-2MBI450VN-120-50
	2MBI600VN-120-50	1200V	600A	2SP0115T2Ax-2MBI600VN-120-50
PrimePACK™	2MBI600VXA-120E-50	1200V	600A	2SP0320x2Ax-2MBI600VXA-120E-50
	2MBI900VXA-120E-50	1200V	900A	2SP0320x2Ax-2MBI900VXA-120E-50
	2MBI900VXA-120P-50	1200V	900A	2SP0320x2Ax-2MBI900VXA-120P-50
	2MBI1400VXB-120E-50	1200V	1400A	2SP0320x2Ax-2MBI1400VXB-120E-50
	2MBI1400VXB-120P-50	1200V	1400A	2SP0320x2Ax-2MBI1400VXB-120P-50

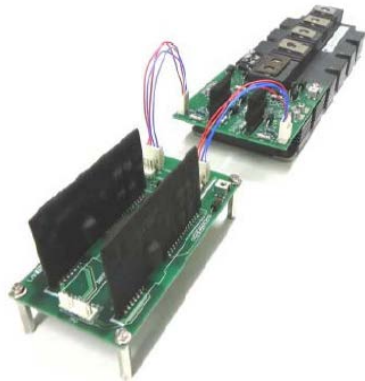
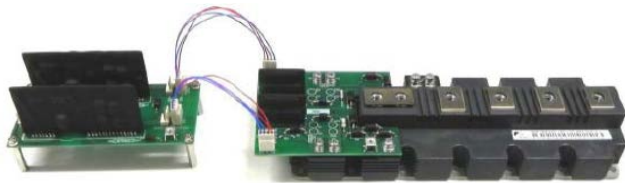
Package	IGBT part No.	V_{CES}	I_C	Plug-and-Play driver part No.
Dual XT	2MBI300VN-170-50	1700V	300A	2SP0115T2Ax-17
	2MBI450VN-170-50	1700V	450A	2SP0115T2Ax-2MBI450VN-170-50
	2MBI550VN-170-50	1700V	550A	2SP0115T2Ax-2MBI550VN-170-50
PrimePACK™	2MBI650VXA-170E-50	1700V	650A	2SP0320x2Ax-2MBI650VXA-170E-50
	2MBI1000VXA-170E-50	1700V	1000A	2SP0320x2Ax-2MBI1000VXA-170E-50
	2MBI1400VXB-170E-50	1700V	1400A	2SP0320x2Ax-2MBI1400VXB-170E-50
	2MBI1400VXB-170P-50	1700V	1400A	2SP0320x2Ax-2MBI1400VXB-170P-50

Note: PrimePACK™ are registered trademarks of Infineon Technology AG, Germany.

Fuji Solution in GDU for 2-level Topology

IDC
イザルヤ電子株式会社

<http://www.idc-com.co.jp/>



Ic rating (A)	600V	1200V	1700V
50	M57159L/VLA517	M5719L/VLA517	-
75	M57159L/VLA517	VLA541/VLA517	-
100	VLA541/VLA517	VLA541/VLA517	-
150	VLA541/VLA517	VLA541/VLA517	-
200	VLA541/VLA517	VLA542/VLA517	-
225	-	VLA542/VLA517	-
300	VLA542/VLA517	VLA542/VLA517	VLA546**
400	VLA542/VLA517	VLA500	-
450	-	VLA500	VLA500K
550	-	VLA500	VLA500K
600	VLA500	VLA500	VLA500K
650	-	-	VLA500K
800	-	VLA500	VLA500K
900	-	VLA500	-
1000	-	-	VLA539
1200	-	VLA539	VLA539
1400	-	VLA539	VLA539
1600	-	VLA539	VLA539
2400	-	Under investigation	Under investigation
3600	-	Under investigation	Under investigation

Evaluation Board for 3-Level Module (12in1)

✓ **Target module**

Package: M1203 solder pin
12MBI50VN-120-50
12MBI75VN-120-50
12MBI100VN-120-50

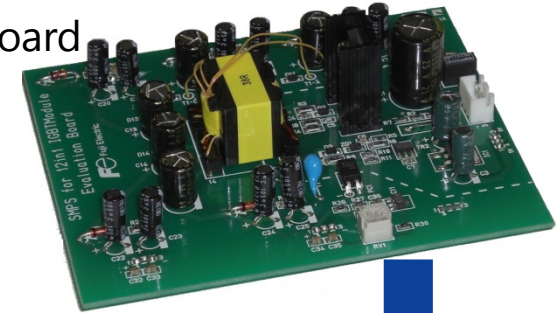
✓ **Features**

Built in DC/DC Converter for Control Power Supply
5V TTL Logic input
Adopted Avago's ACPL-333J IGBT gate drive optocoupler
Built-in OC protection by DESAT detection
Active Miller Clamp circuit
Under Voltage Lockout

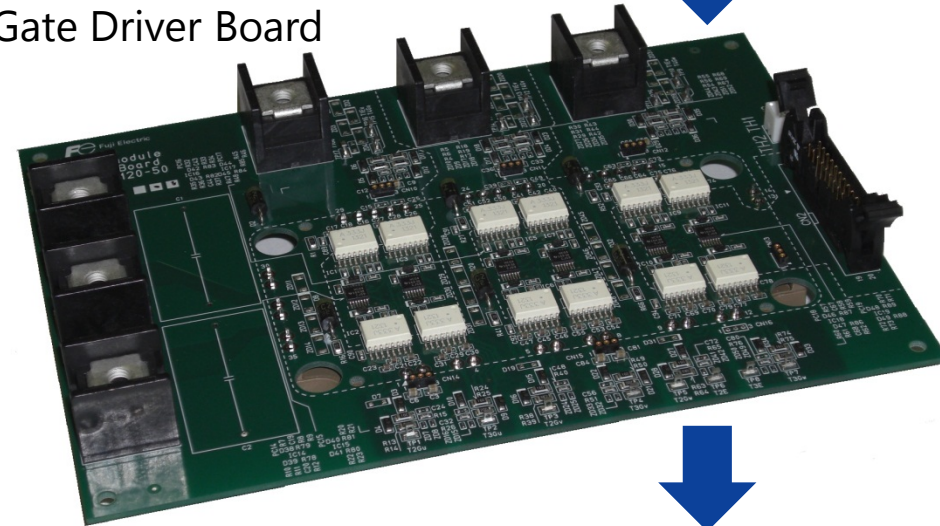
✓ **Board outline**

190 x 135 mm

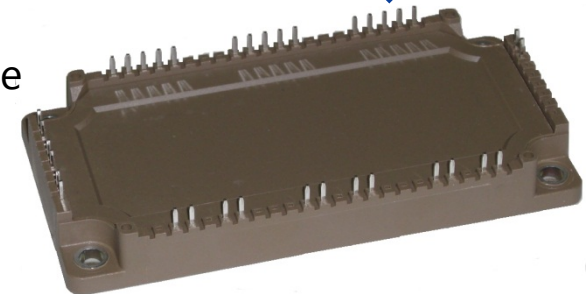
DC/DC Converter Board



Gate Driver Board

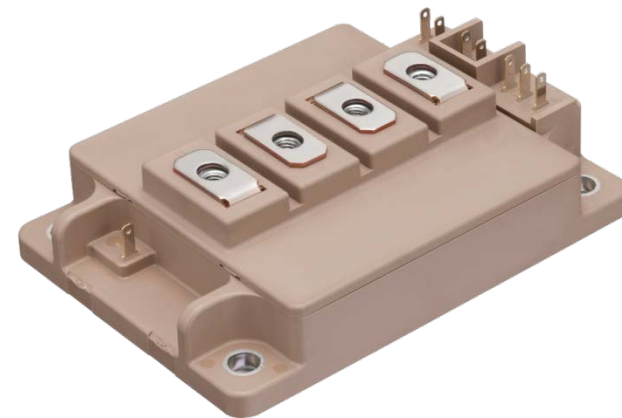
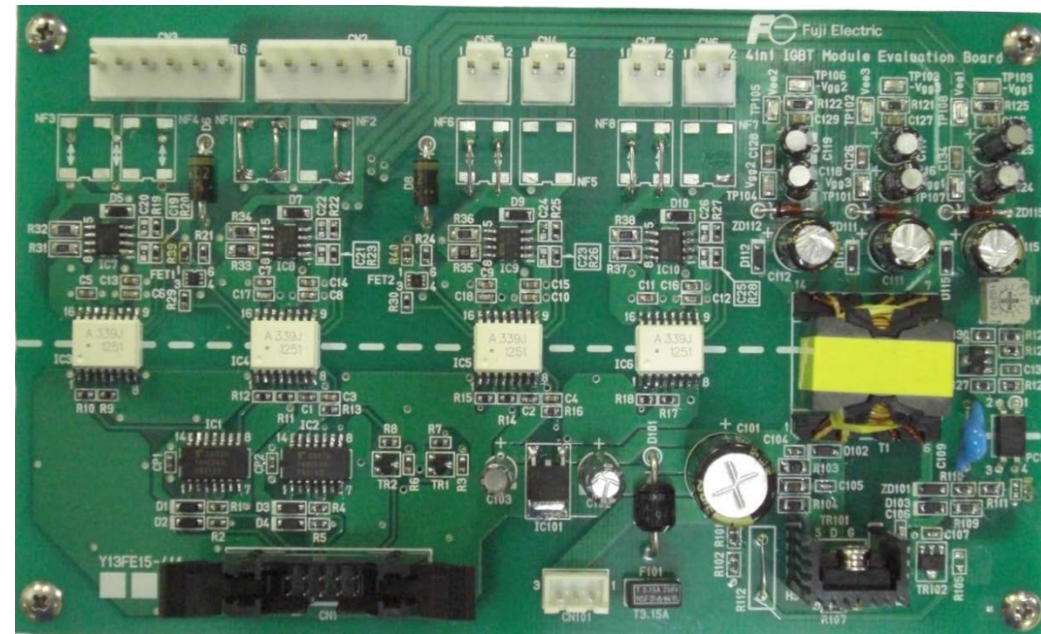


3-Level Module



Evaluation Board for 3-Level Module (4in1)

- ✓ **Target module**
Package: M403
4MBI400VG-060R-50
4MBI300VG-120R-50
4MBI400VF-120R-50
- ✓ **Features**
Built in DC/DC Converter for Control Power Supply
5V TTL Logic input
Adopted Avago's ACPL-339J IGBT gate drive optocoupler
Built-in OC protection by DESAT detection
Active Miller Clamp circuit
Under Voltage Lockout
- ✓ **Board outline**
165 x 100 mm



This driver board for I-type 3-level IGBT module (M404)

ANVILEX

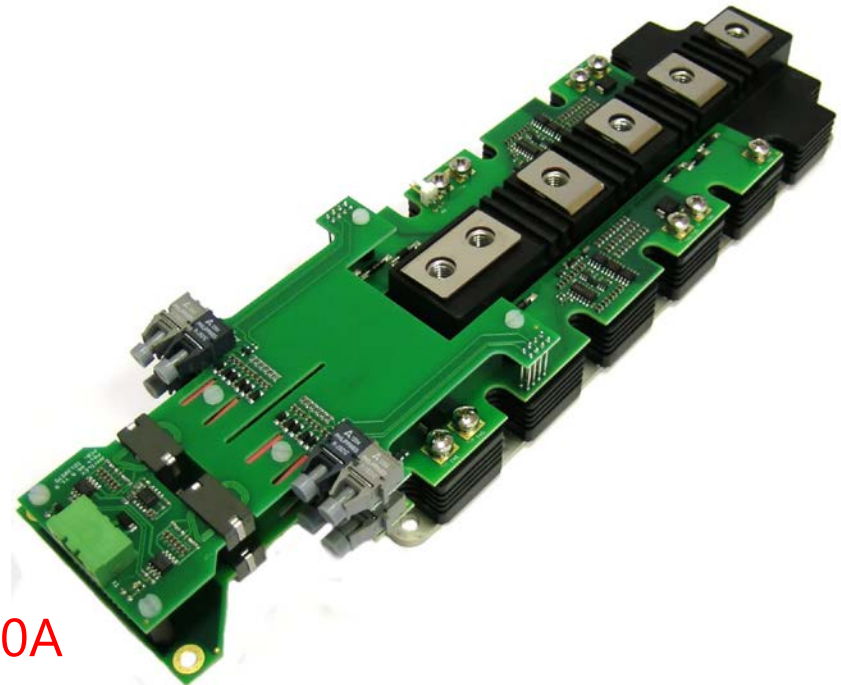
<http://www.anvilex.de/>

Contact: information@anvilex.de

Target module : 4MBI600VC-120-50

Delivery: Starting from **December 2015**

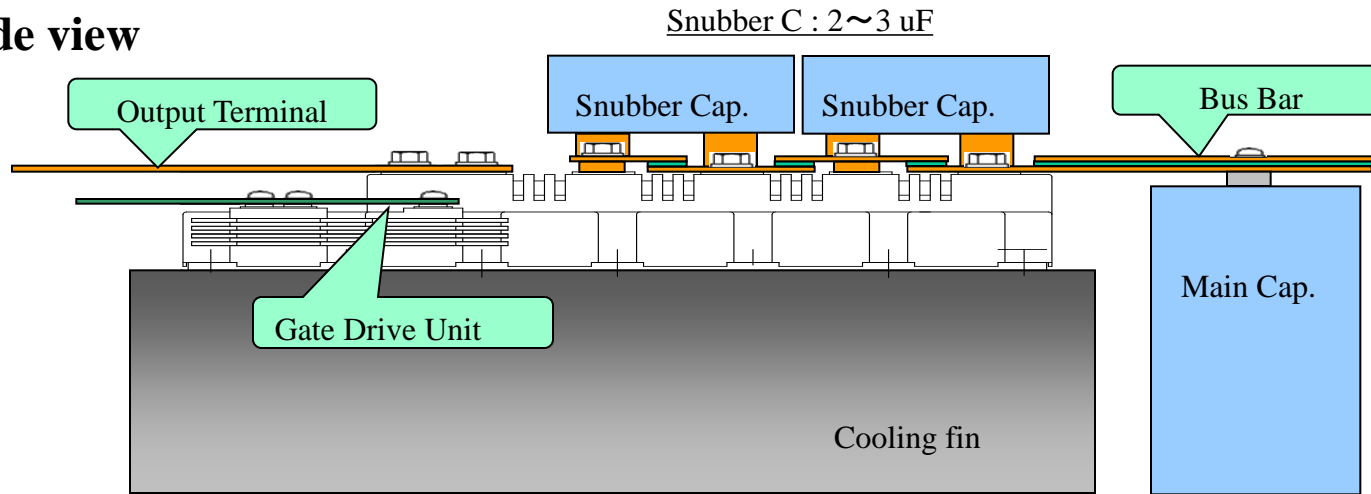
Rated voltage/current of the Driver : **1700V/ 900A**



- Topology in solar inverter
- Fuji IGBT modules for solar inverter
- Fuji solution in Gate Driver Unit (GDU)
- **Fuji 2-level topology solution**
- Fuji 3-level topology solution – Stack
- Snubber capacitor

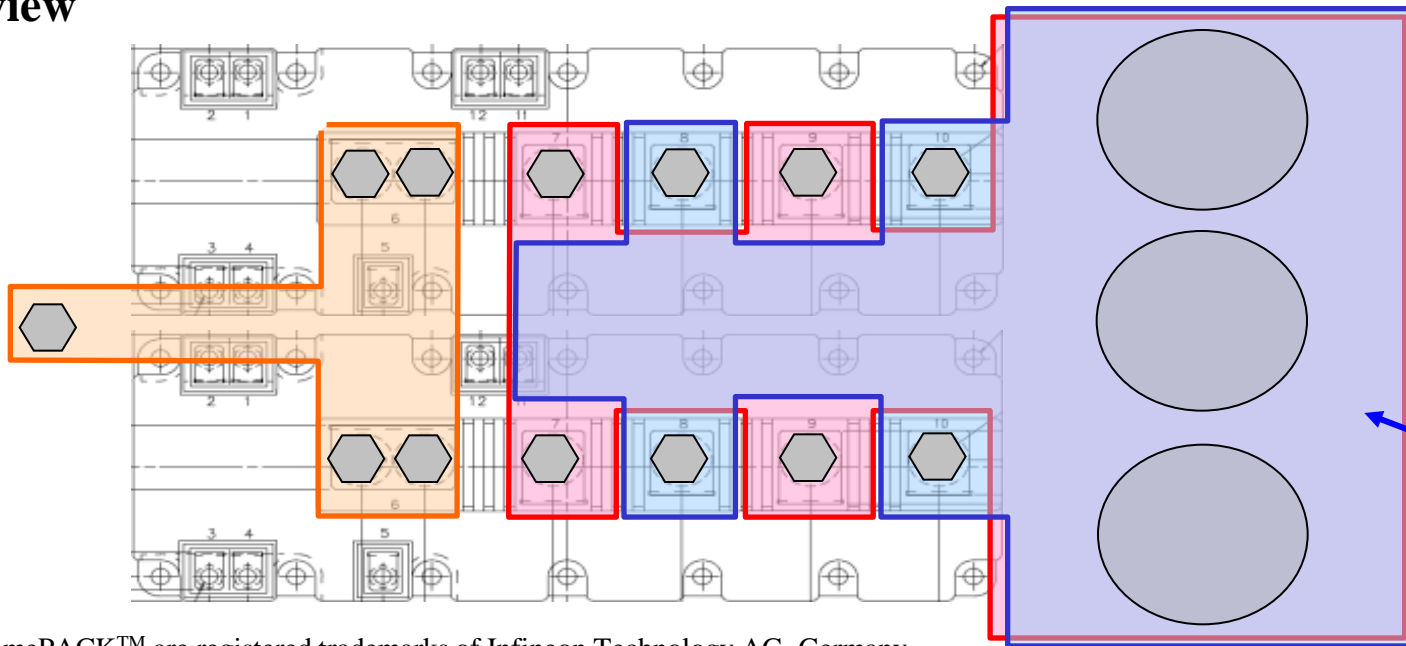
Parallel Connection of PrimePACK™

Side view



PrimePACK™ can easily construct inverter circuit . This figure shows the example.

Top view

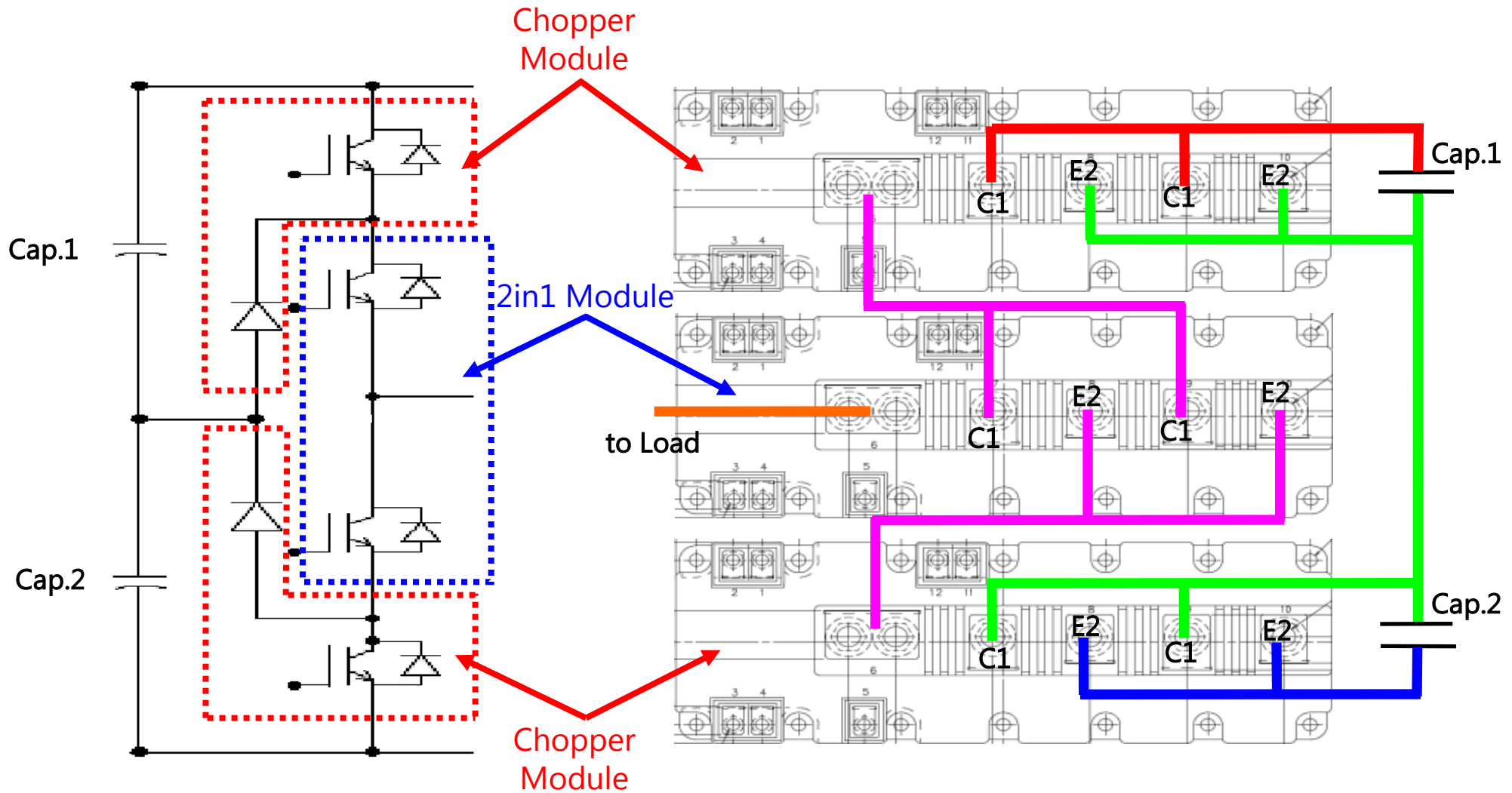


Laminate bus bar to realize low leakage inductance.

Note: PrimePACK™ are registered trademarks of Infineon Technology AG, Germany.

- Topology in solar inverter
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- Snubber capacitor

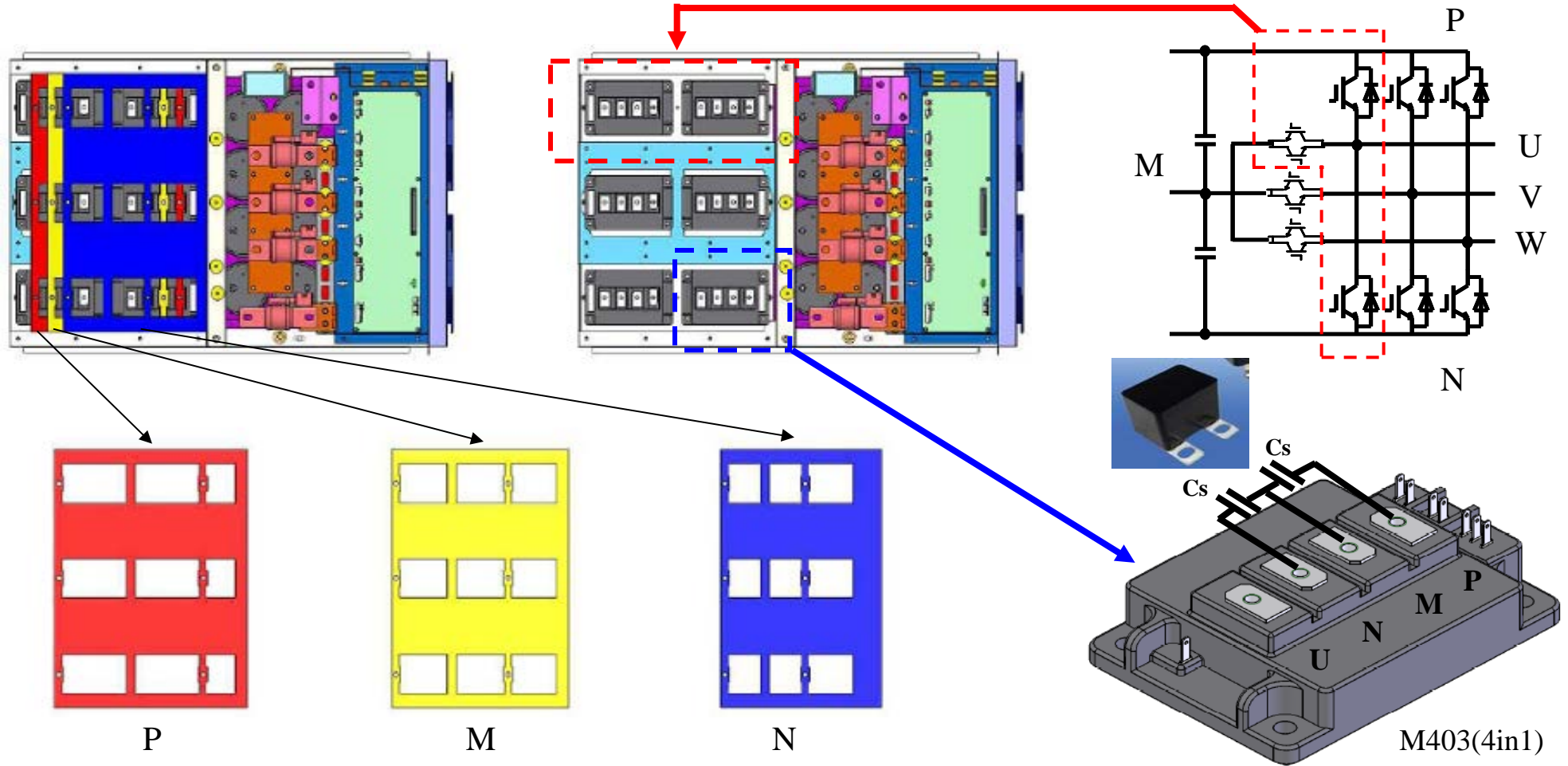
3-level Circuit Configuration (PrimePACK™)



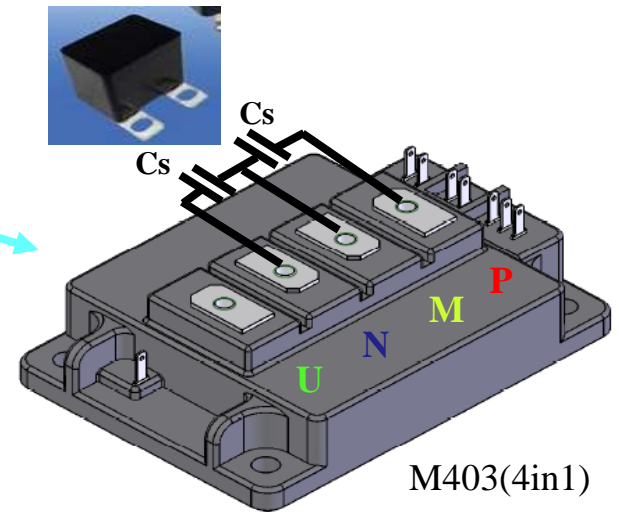
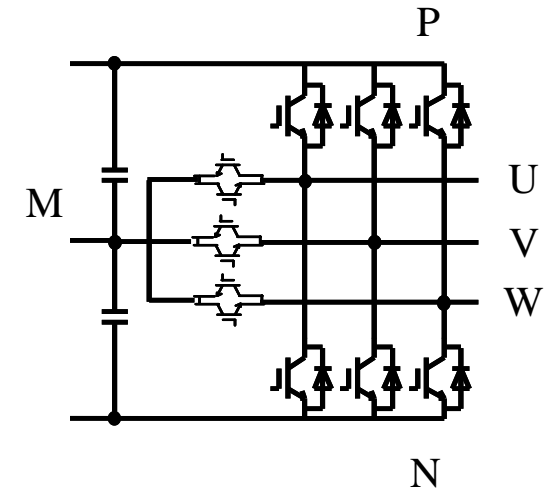
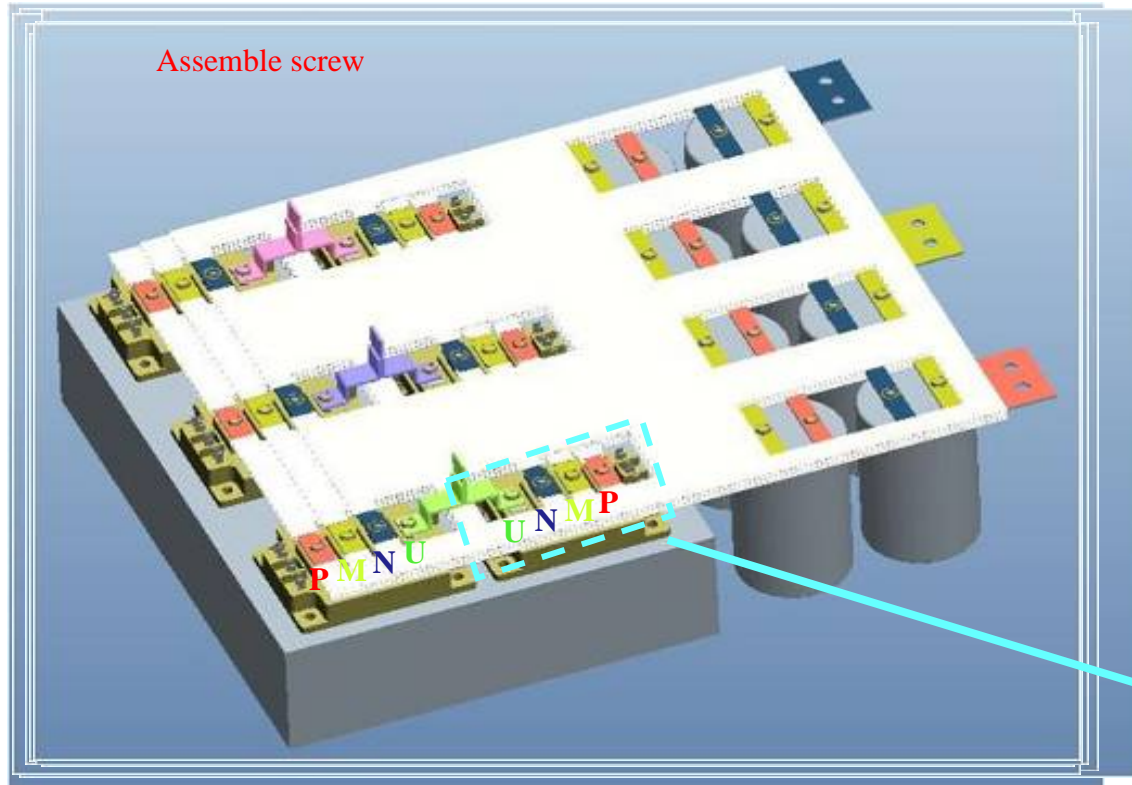
Easy connected "3 level inverter" by 2in1 module and chopper module

Parallel Connection of M403 (4in1)

A-NPC 3 level module * 2 parallel image



Parallel Connection of M403 (4in1)

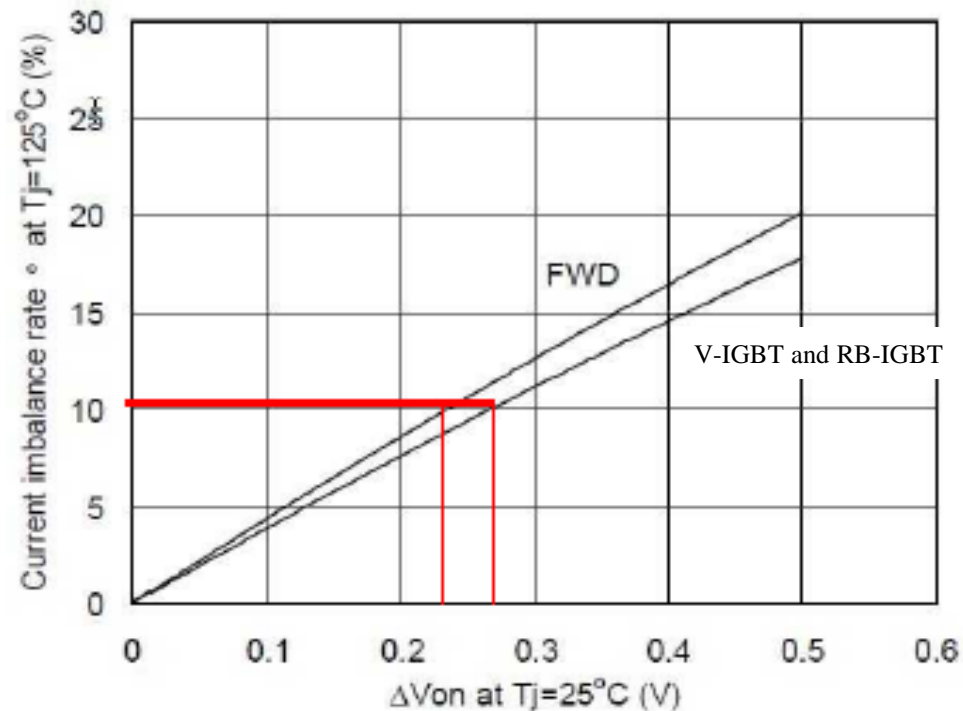
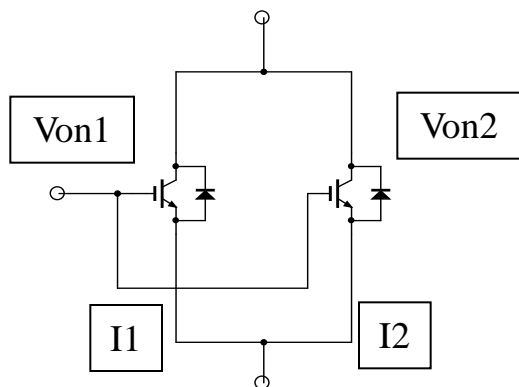


Current Imbalance of Paralleled Modules

V series 1200V IGBT/FWD and 600V RB-IGBT device for parallel standard module

A difference in the V_{on} of two IGBT modules
Connected in parallel can cause a current imbalance.

$$\alpha = \left(\frac{I_1}{I_{c(ave)}} - 1 \right) \times 100\% \quad I_{c(ave)} = (I_1 + I_2) / 2$$

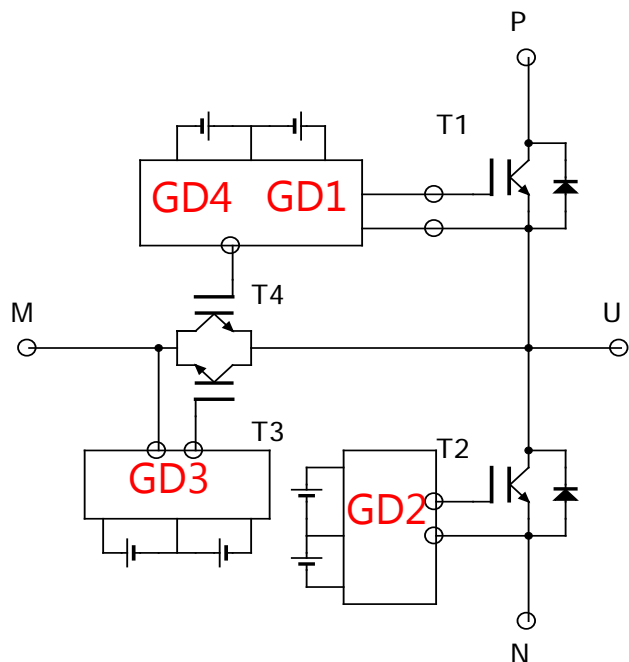


Deviation of $V_{CE(sat)}$ and current imbalance rate

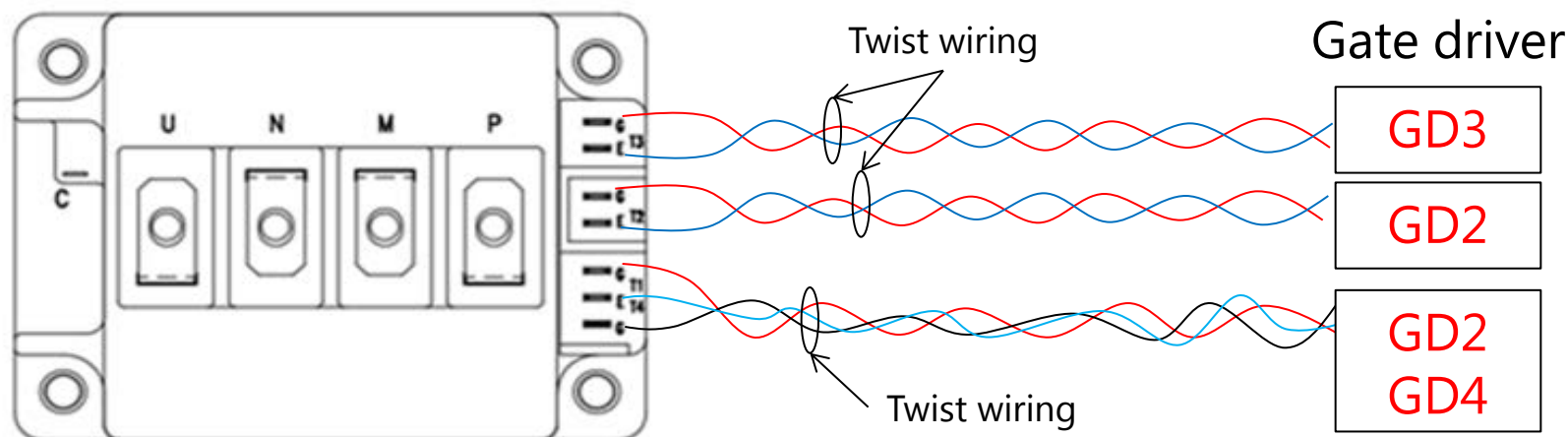
- The condition of current imbalance rate within 10% for V_{on}
- (1) V_{on} of V-IGBT and RB-IGBT must be less than $\Delta 0.27V$.
 - (2) V_F of FWD must be less than $\Delta 0.23V$.

If the modules are the same Lot. , it should be designed with $\alpha= 10\%$.
If the modules are not the same Lot., it should also be designed with $\alpha= 20\%$.

Connection method for auxiliary terminals



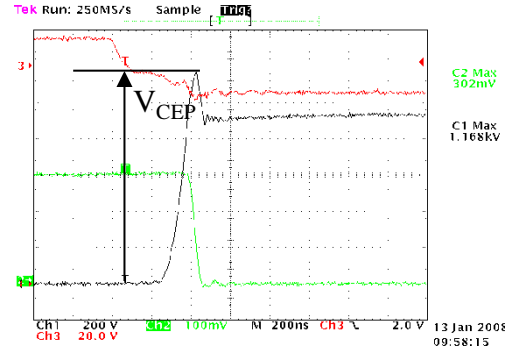
The emitter terminal of T1 and T4 is the same so that gate driver GD1 and GD4 can be used with the same gate driver power supply. Three gate driver power supplies are enough for M403.



- Topology in solar inverter
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$$C_s = \frac{L * I_o^2}{(V_{CEP} - E_d)^2}$$

L: Main circuit wiring parasitic inductance
 I_o: Collector current at IGBT turn-off
 V_{CEP}: Snubber capacitor peak voltage
 E_d: DC supply voltage



Module rating		DC line inductance	snubber capacitance
V _{ces}	I _c		
1200V/1700V	100A	0.2 μH	0.47 μF
	300A	0.1 μH	3.3 μF
	450A	0.08 μH	4.7 μF
	1000A	0.07 μH	6.8 μF
	1400A	0.06 μH	12 μF

Snubber Capacitor for M403

M403 (4in1)



Capacitor for Snubber circuit

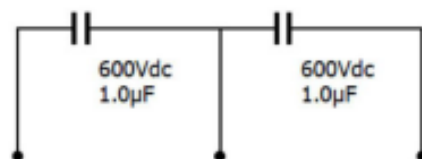
➤ 4-in-1 package for T-type 3-level circuits

Specifications

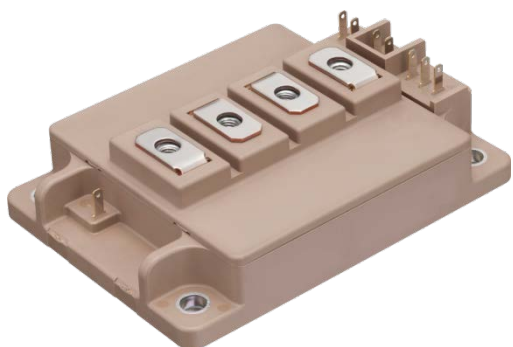
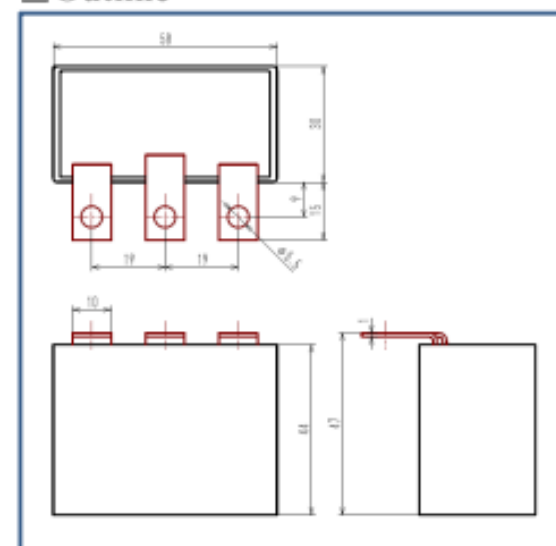
	600YC	
Category Temperature Range	-40 ~ +105°C	
Rated Voltage	600Vdc	
Capacitance	1.0μF * 2	
Capacitance Tolerance	±10% (K)	
Permissible Current	8.0Arms (at 10kHz)	
ESL	≤ 20 nH (at 10MHz)	
Voltage Proof	Between the terminals	900Vdc
	Between the terminal and case	2000Vdc
Insulation Resistance	Between the terminals	≥ 1500MΩ
Case	PPS	
Filling Resin	Epoxy Resin	

*Different capacitance and rated voltage item is available.

Circuit



Outline



For more information:

Please visit : <http://www.rubycon.co.jp/en/profile/oversea.html>