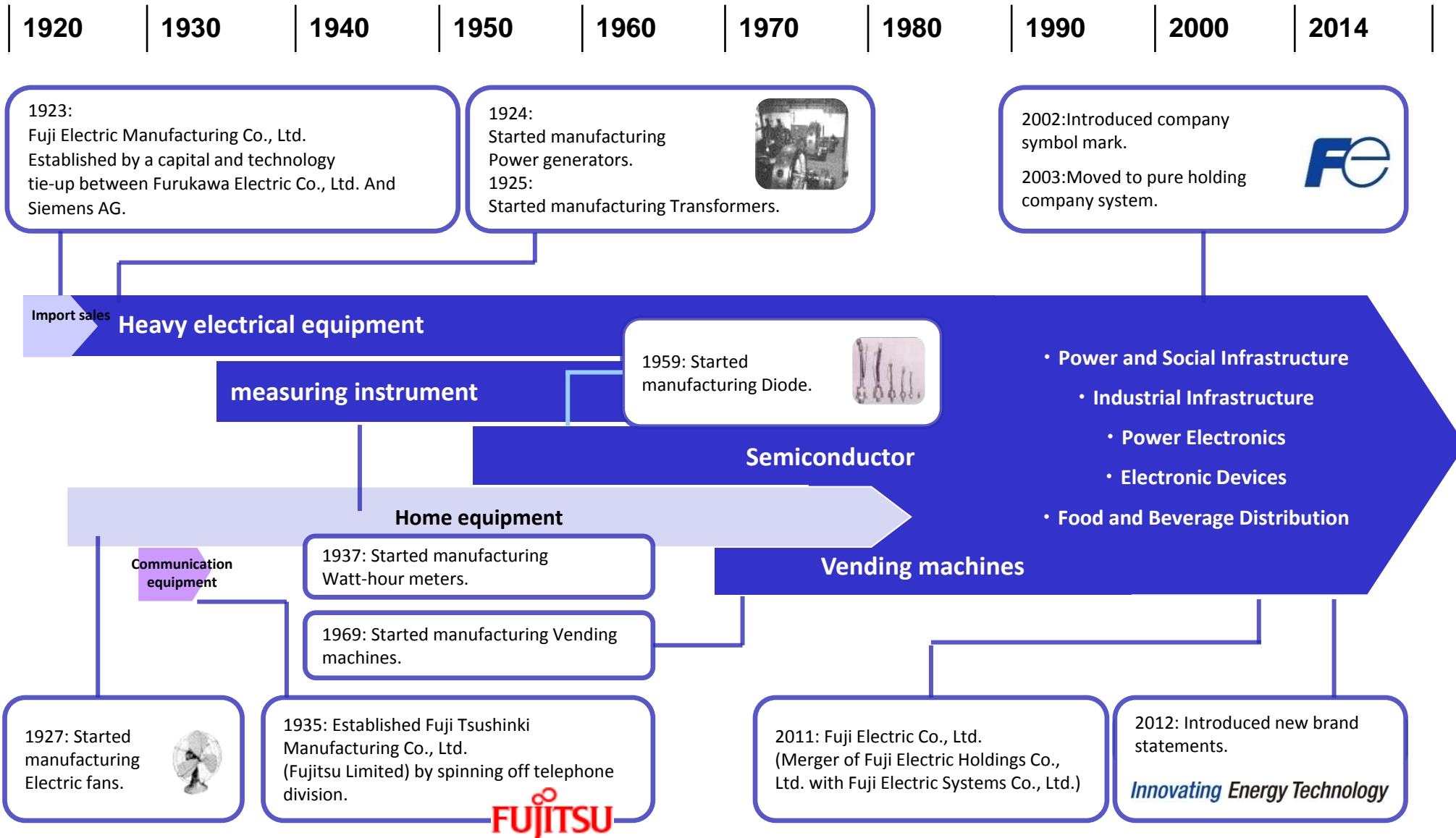


Introduction to Fuji Power Modules

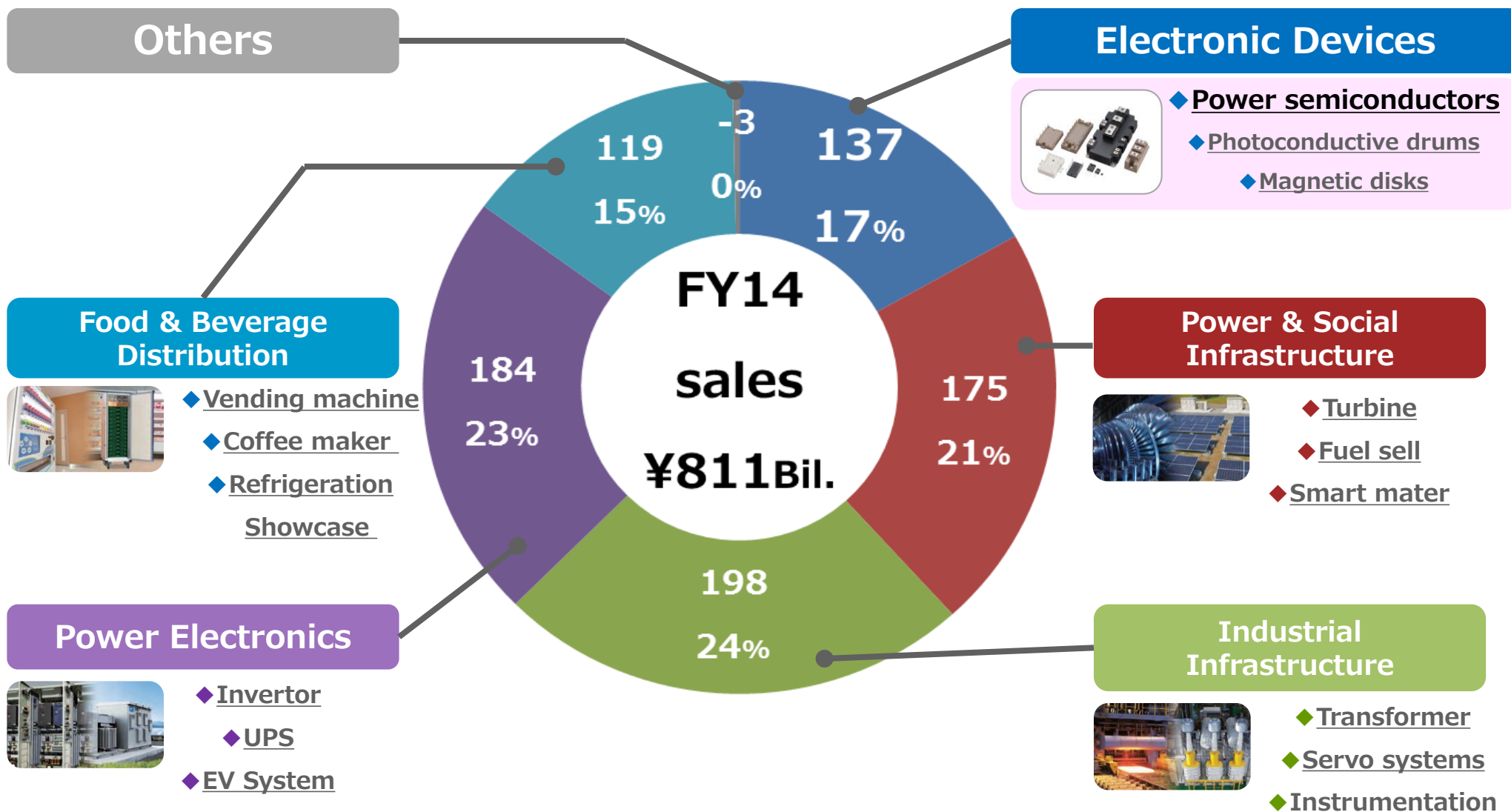
June, 2016
Device Application Technology Dept.
Semiconductors Div, Sales Group
Fuji Electric. Co., Ltd.

What is Fuji Electric?

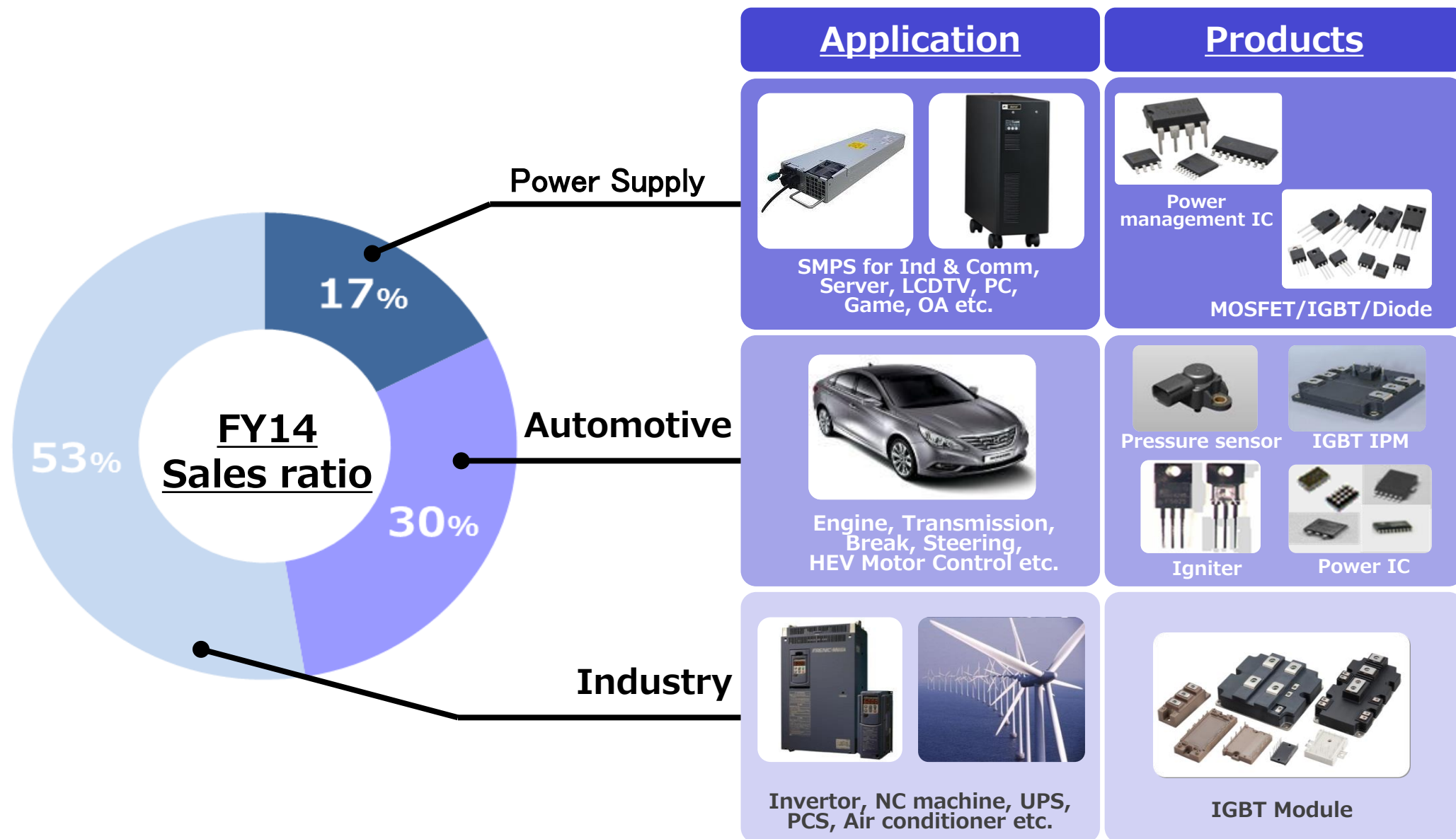
Corporate History



Fuji Electric Sales Result By Segment



Sales and Products of Electronic Devices



Application

Inverters, Industrial Robots, UPS, Automotive, Air Conditioner, PCS(Wind and Solar).....

Inverters

Inverters is used elevators, belt conveyors and fan pumps. The rotational speed of motor are controlled by Inverter.

Industrial Robots

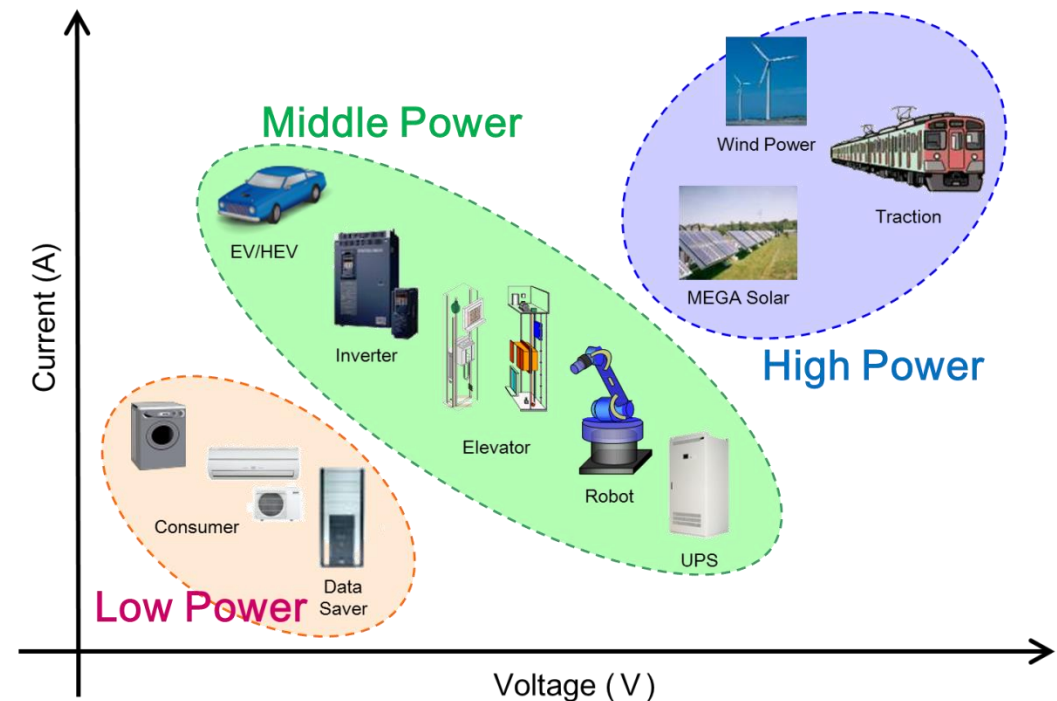
Industrial Robots is used the assembly operation of mass production in manufacture. Hence, the market is expanding.

UPS

UPS is used servers of bank and medical equipment in order to prevent shut down the system. When the power supply is cut off, the power supply from UPS.

Solar PCS

DC voltage charged from the solar panels is converted to AC by Solar PCS. Customer can use these power and can sell them to a power company.



Production Base

Front end

Back end

Hokuriku

Omachi

Iiyama

Shenzhen

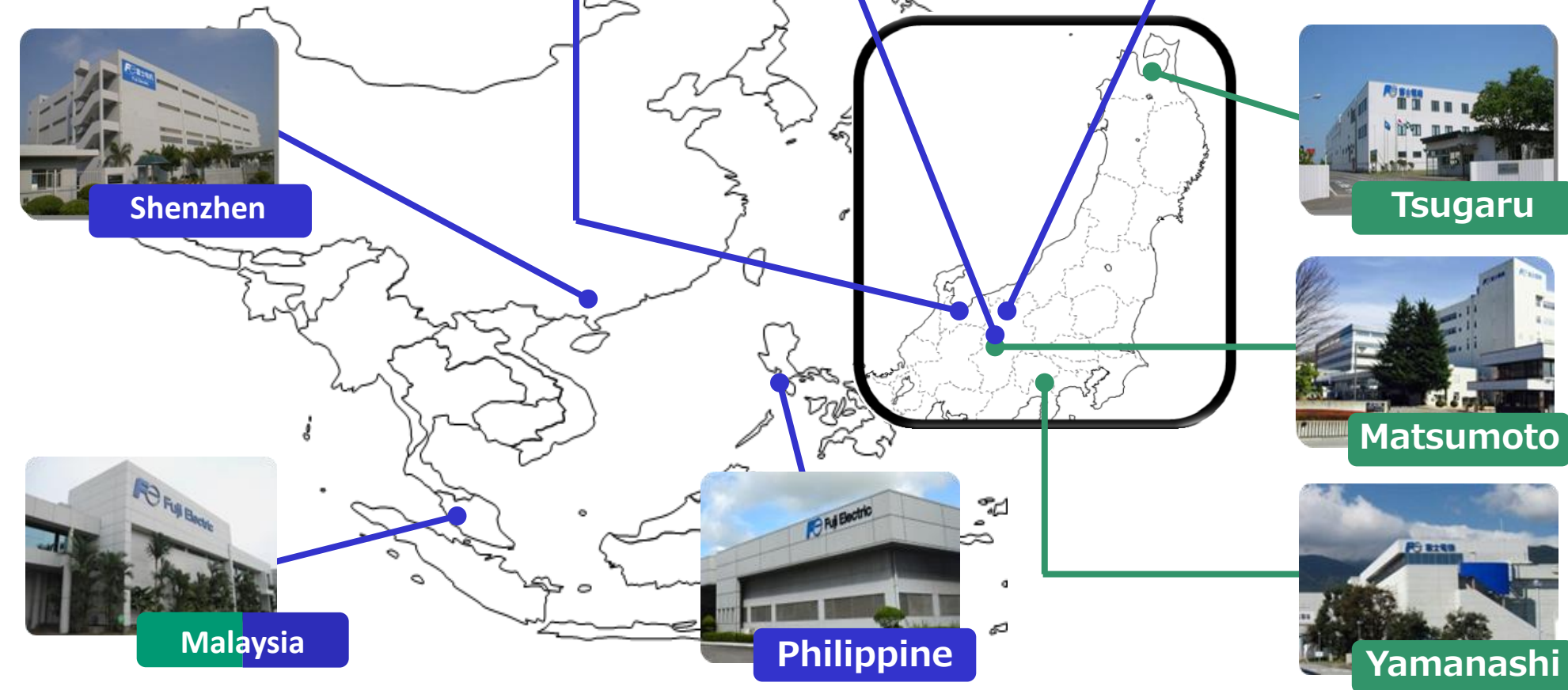
Tsugaru

Matsumoto

Malaysia

Philippine

Yamanashi



Sales office & Design center

Design center

Sales office



FEHK(Hong Kong)

SZF(Shenzhen)



FEC(Shanghai)



FE (Japan)



FEE(Frankfurt)



FEA (New Jersey)



FEI(Chennai)



FAP(Singapore)

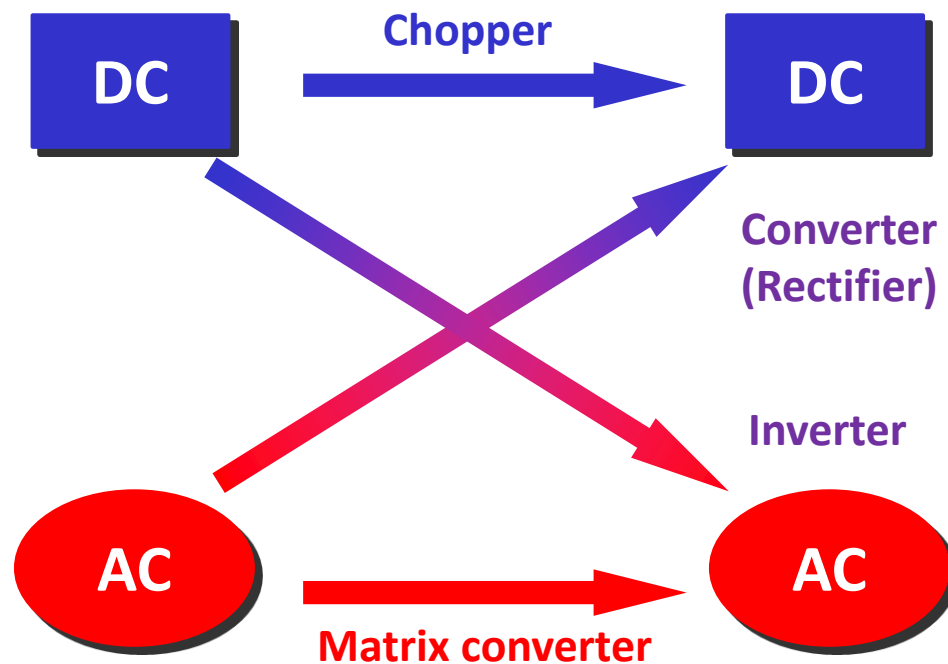


FETW(Taipei)

Basic of power semiconductors

Power conversion

Change current, voltage, frequency, phase, amplitude by using **switching valve devices**.



Switching Valve Device:

- Diode
- Thyristor
- GTO
- Transistor
- MOSFET
- IGBT

What is Inverter?

$V_{in}=400V$



f_{IN}
50Hz

Fixed speed

Motor



f_{OUT}
50Hz

Rotational Speed 1500(/min)



f_{IN}
50Hz



Variable
speed

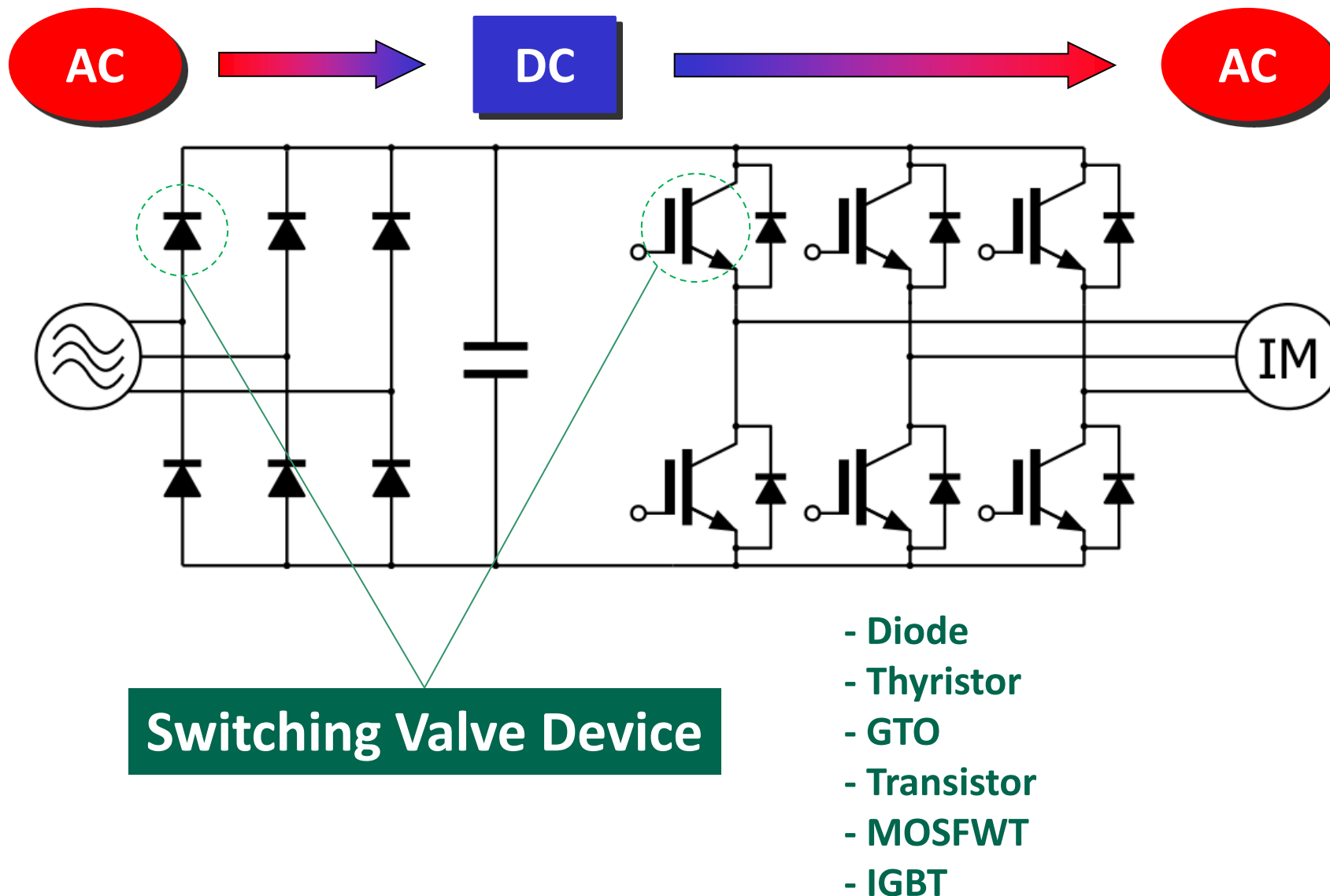


f_{OUT}
0.5~200Hz

Rotational Speed 15~6000(/min)

Inverter controls motor rotation speed with high efficiency.

Inverter Circuit



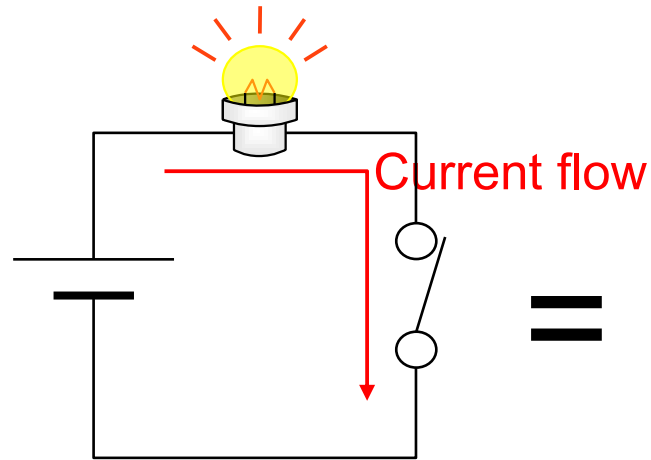
Power Semiconductor = Switch

Mechanical switch

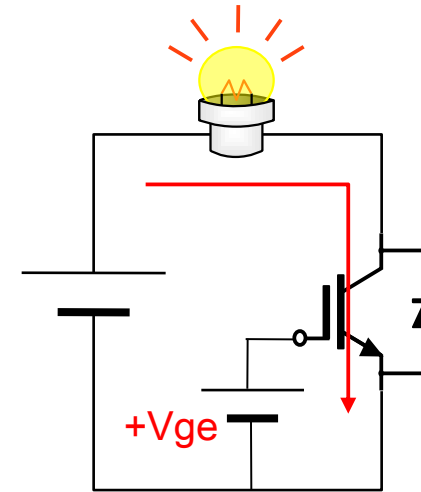
Electrical switch

ON

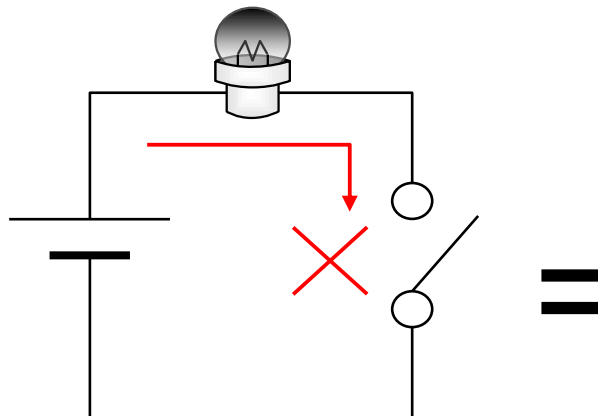
(Apply voltage
to gate terminal)



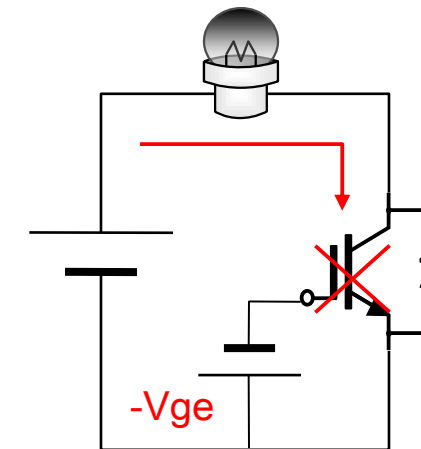
=



OFF

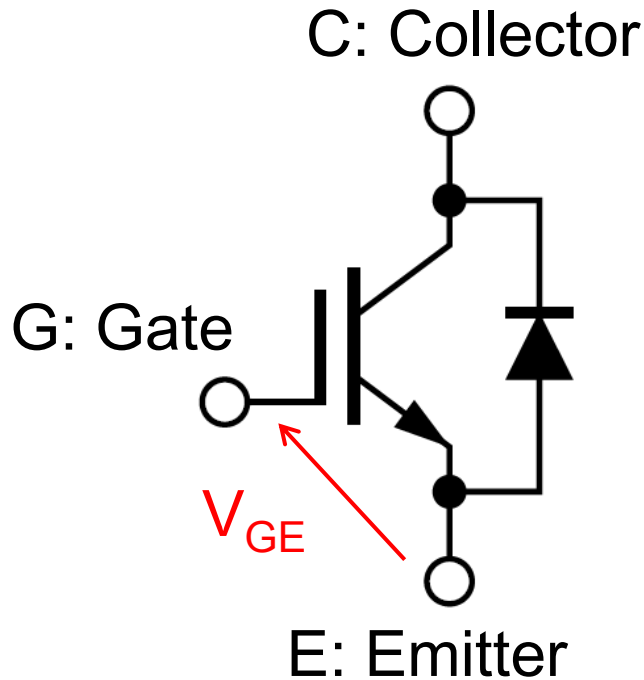


=

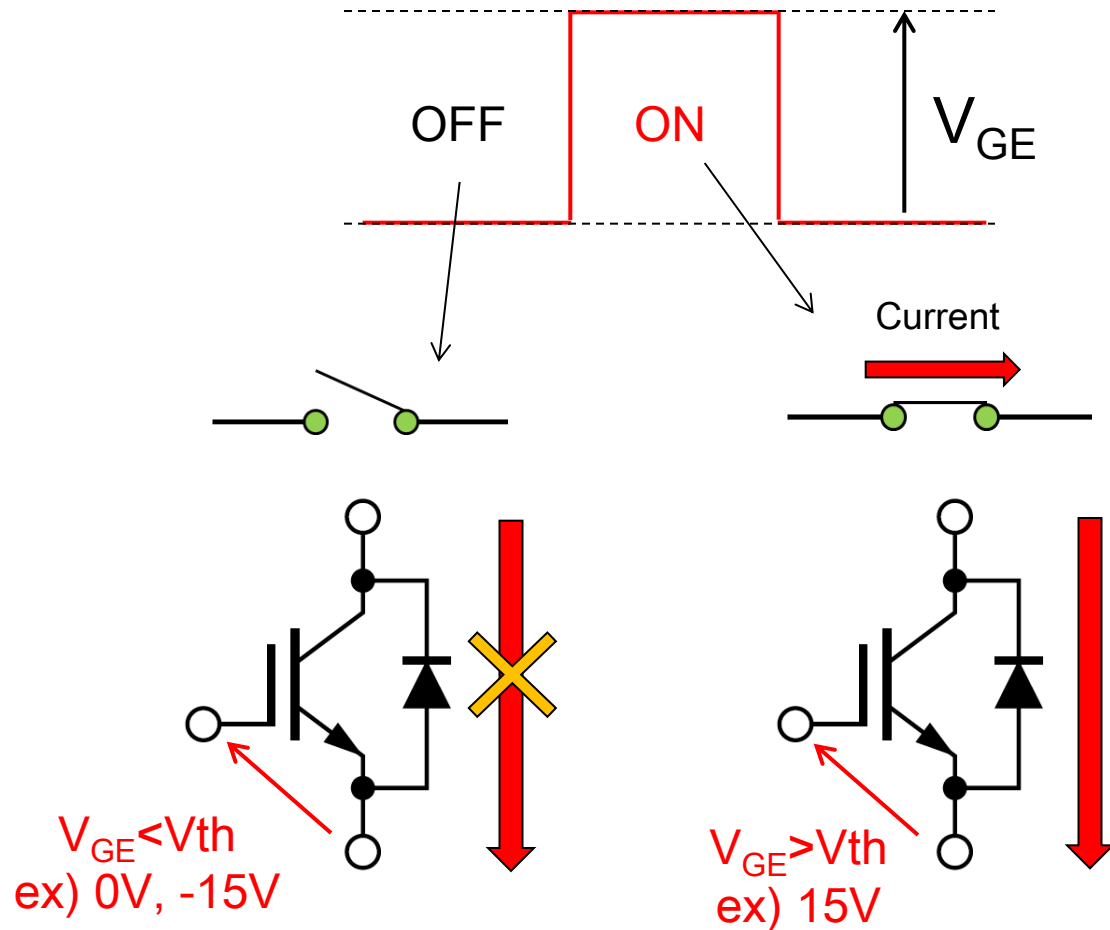


How to work IGBT?

The current flowing along IGBT is controlled by V_{GE} .



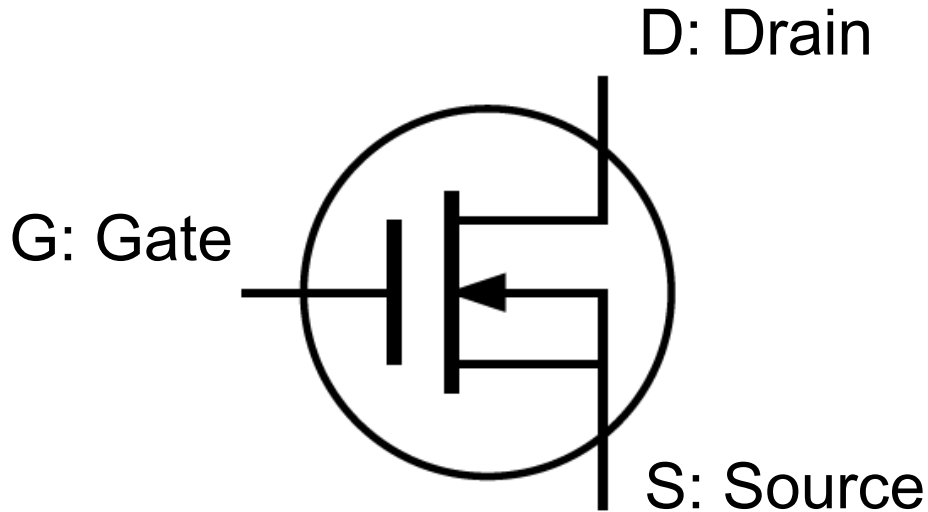
V_{GE} : Gate-Emitter Voltage



Type of the power semiconductor

MOSFET

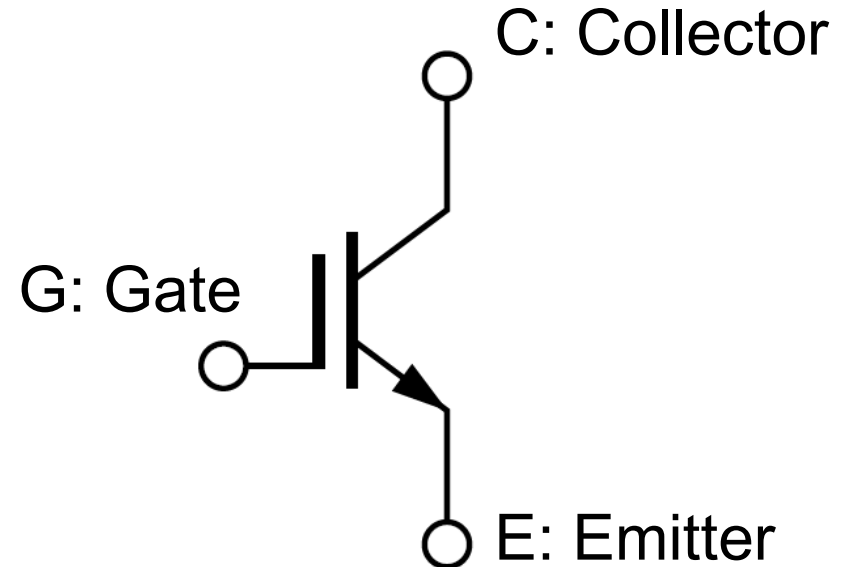
(Metal Oxide Semiconductor Field-Effect Transistor)



- Low power range(~5kW)
Consumer, Power supply,
low power UPS, and so on

IGBT

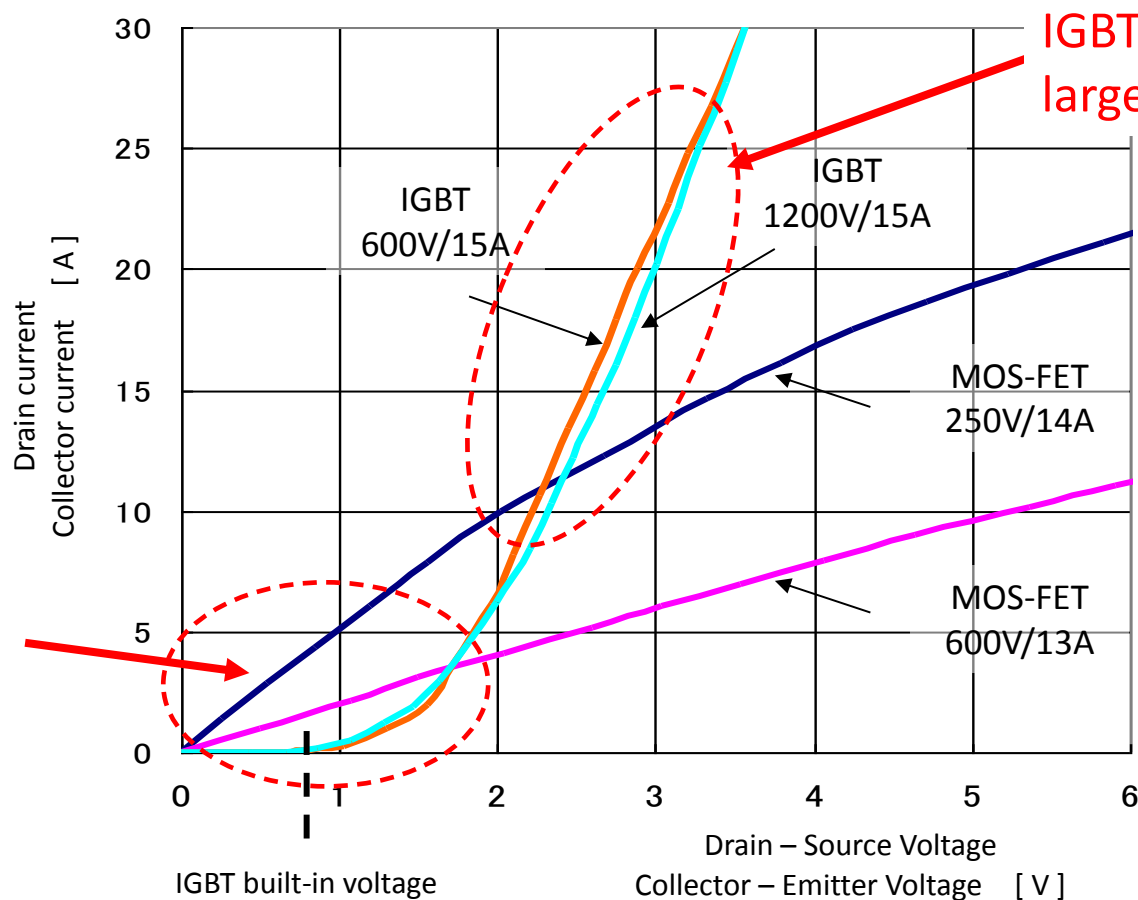
(Insulated Gate Bipolar Transistor)



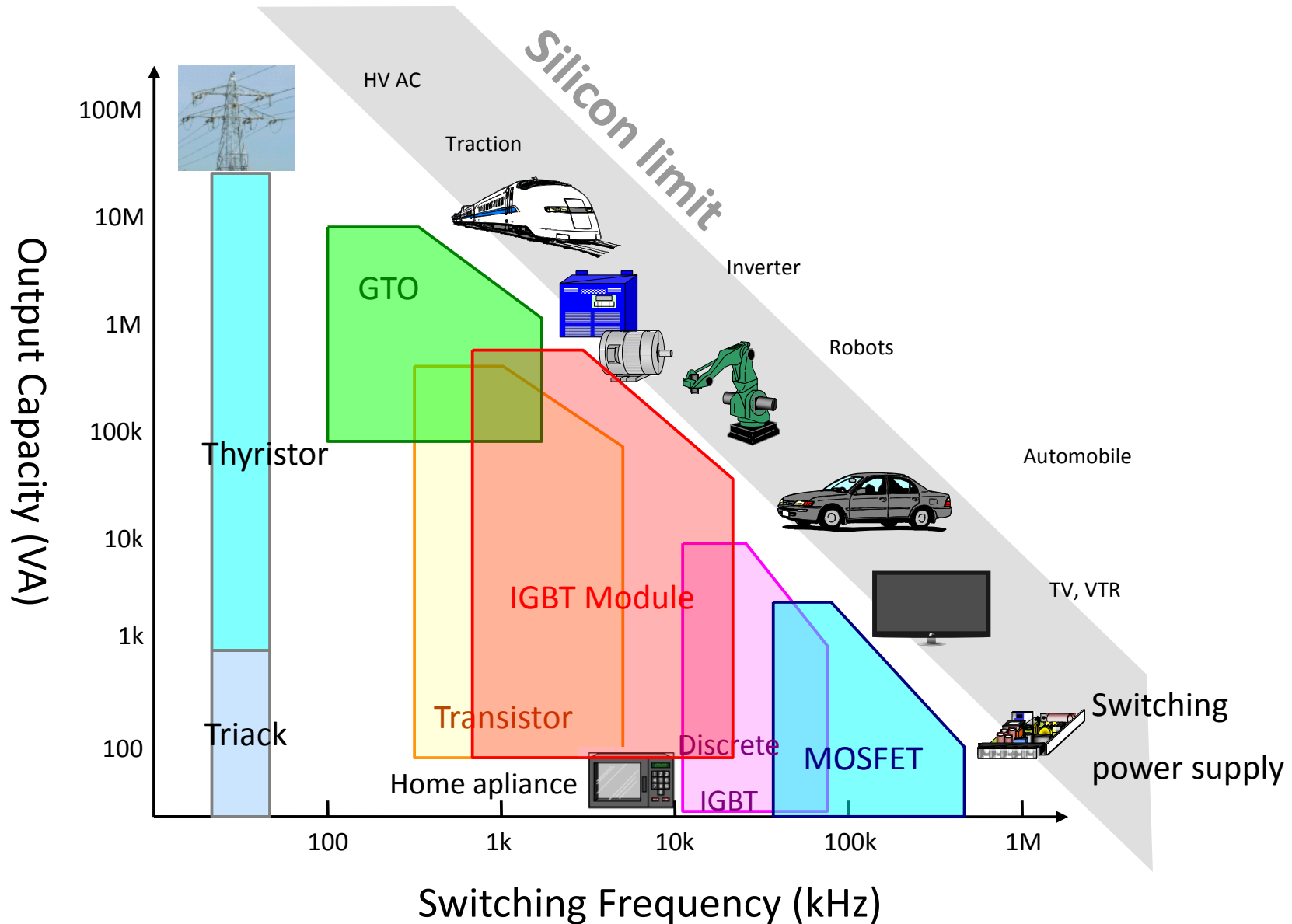
- Low, Middle, High power range(2kW~)
Inverter, Robot, PCS, UPS,
Elevator, Traction, and so on

Output Characteristics MOSFET vs IGBT

Output characteristics of 15A class module



Application Field



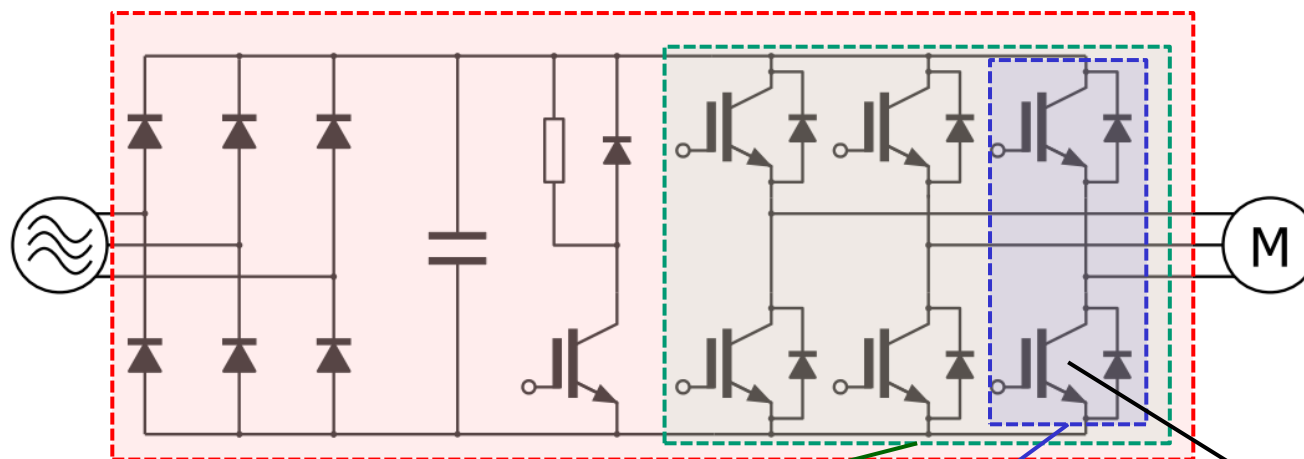
FUJI's IGBT Module

What is “Module”?

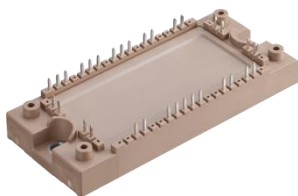
IGBT Module: packaging products with IGBT+FWD(diode)

High current
High reliability

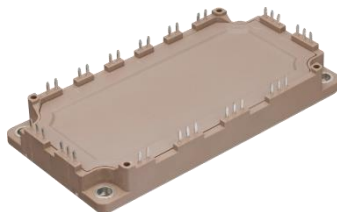
Easy assembling
Compact



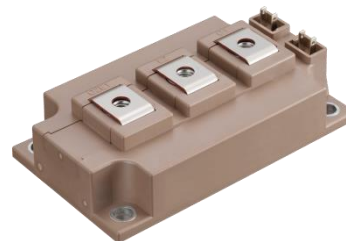
PIM x1
(Power Integrated Module)



6in1 x1



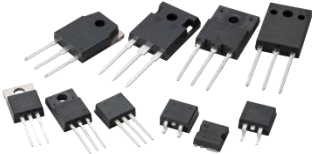
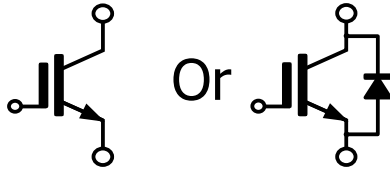

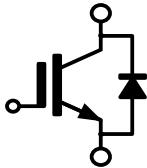

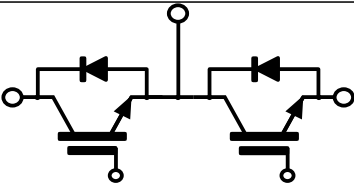
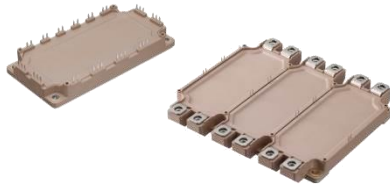
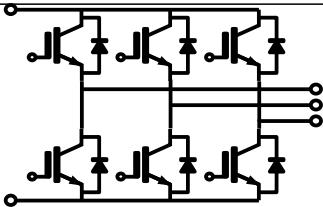
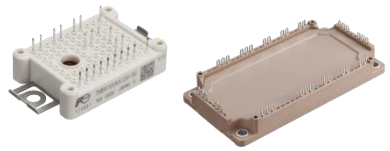
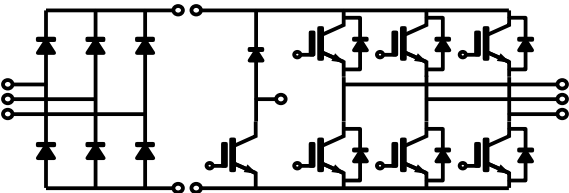
2in1 x3



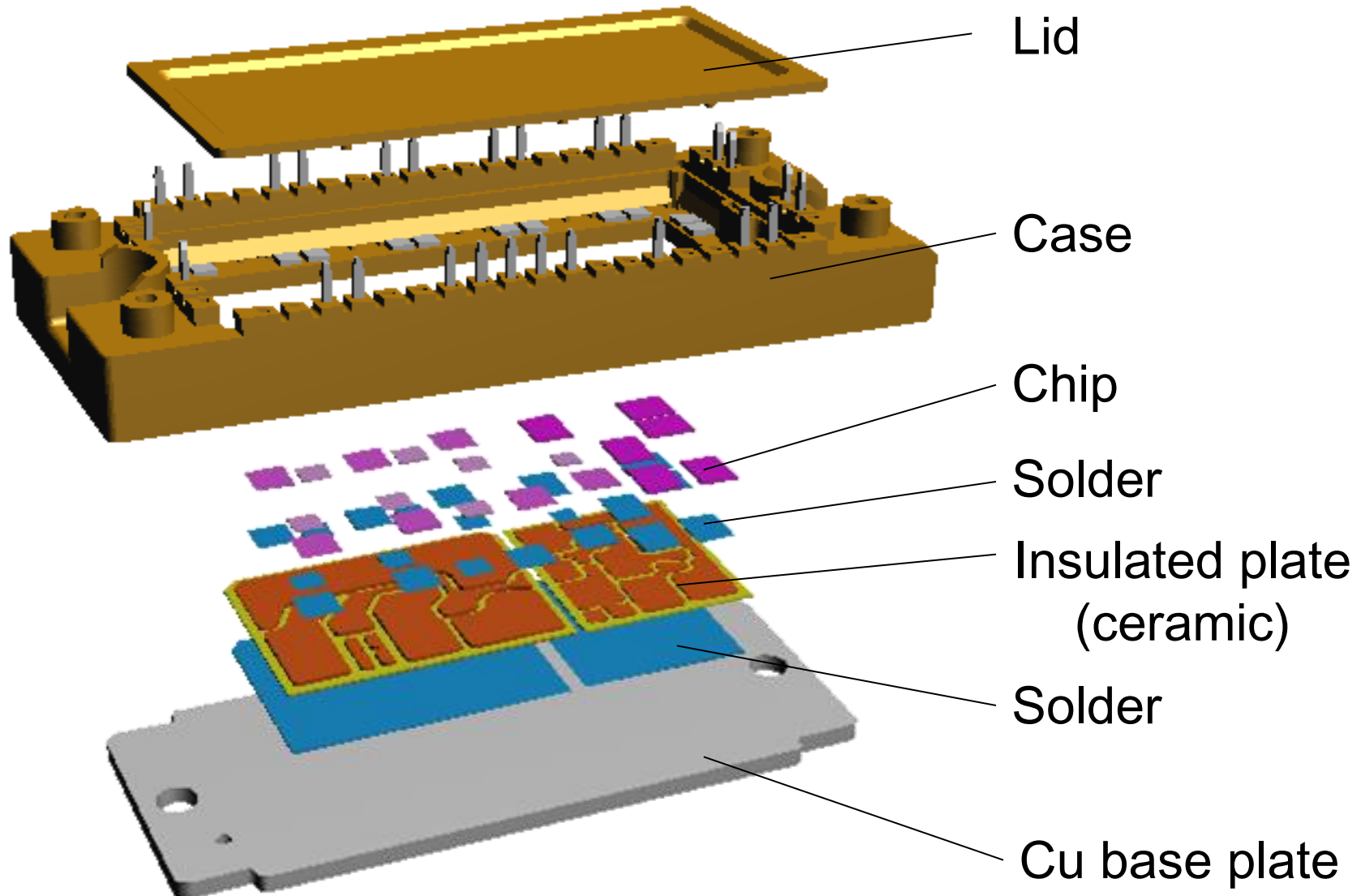
1in1 x6



Circuit Configuration of IGBT Modules

	package	Circuit	
Discreate			Discrete type package. This product is widely used for small capacity applications, such as home appliance, switching power supply, and UPS.
1in1			Each product contains one IGBT and one FWD. Products having a high current rating are after connected in parallel in large capacity applications.
2in1			Three units are generally used in a set to make up a PWM inverter. Otherwise, products having a high current rating are often connected in parallel.
6in1			Each product contains six IGBTs and six FWDs in the inverter. Some products having a brake section (one IGBT and one FWD).
PIM (7in1)			PIM includes a converter section in addition to 7 in1. Some variations contain a NTC or a thyristor used for a capacitor charging circuit.

Module Configuration



FUJI Package Type

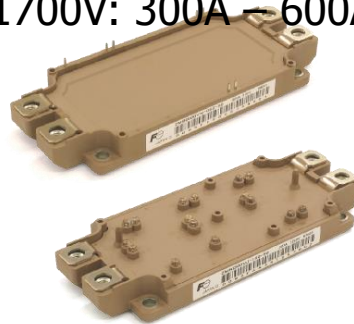
Standard 2in1/1in1

600V: 100A – 600A
1200V: 75A – 600A



DualXT

1200V: 225A – 600A
1700V: 300A – 600A



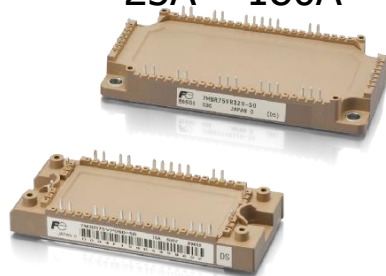
PrimePACK™

2in1 / chopper
1200V: 600A – 1400A
1700V: 650A – 1400A



6-pack / PIM

600V / 1200V
25A – 180A



Small PIM

600V / 1200V



3-level / RB-IGBT



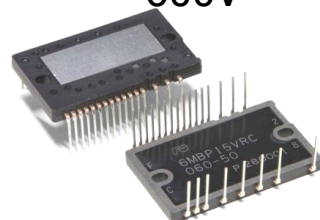
HPM

2in1 / 1in1
1200V / 1700V / 3300V

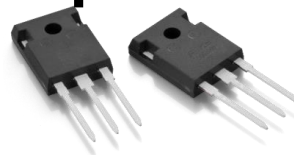


Small IPM

600V

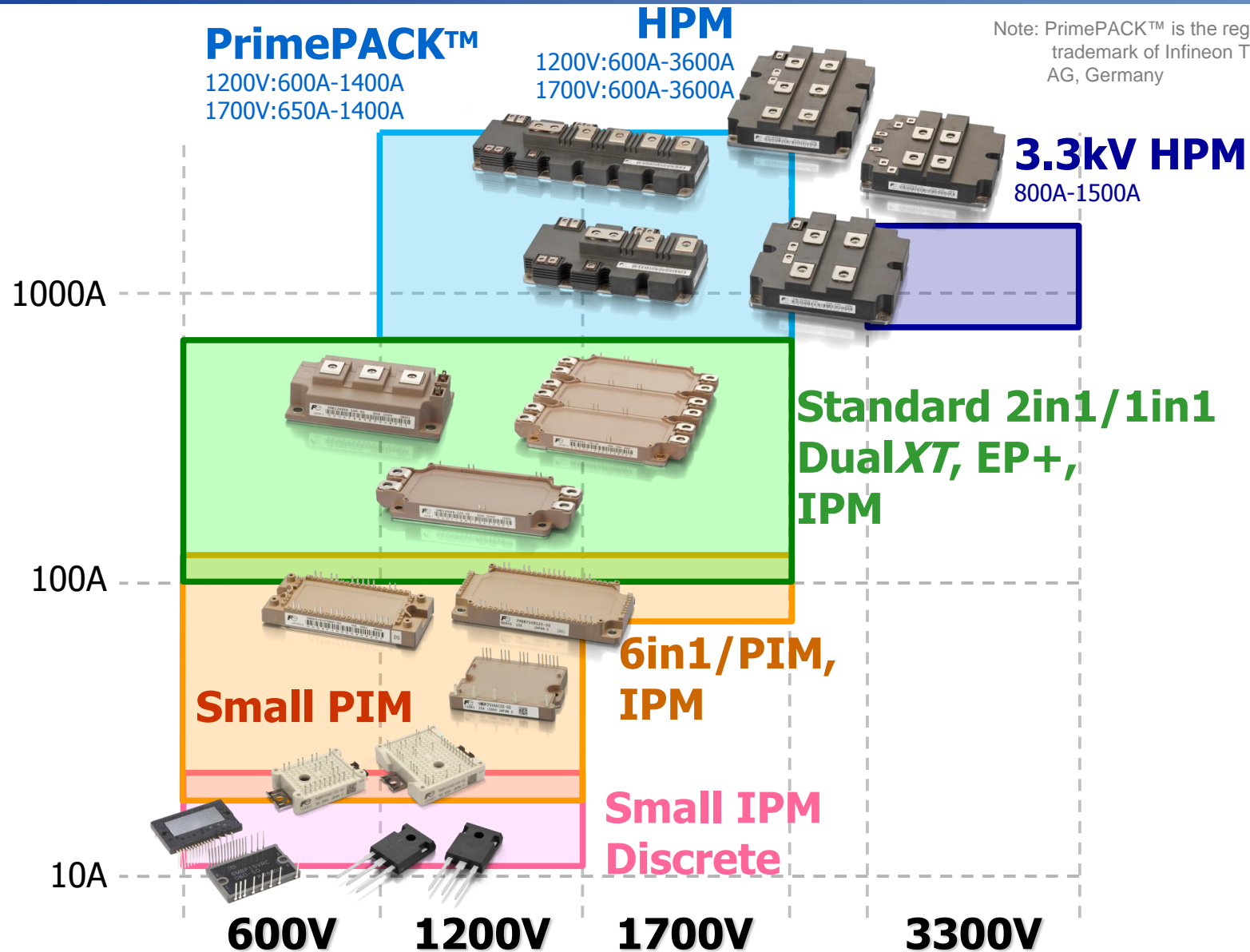


Discrete IGBT / Super J-MOS

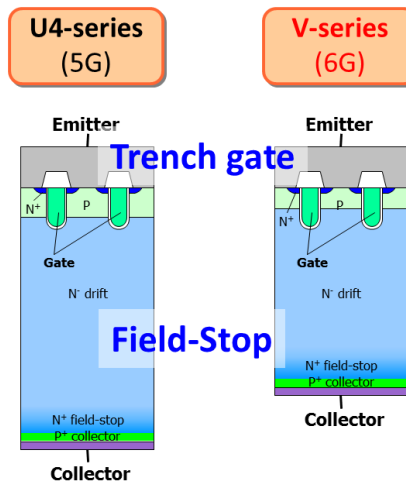
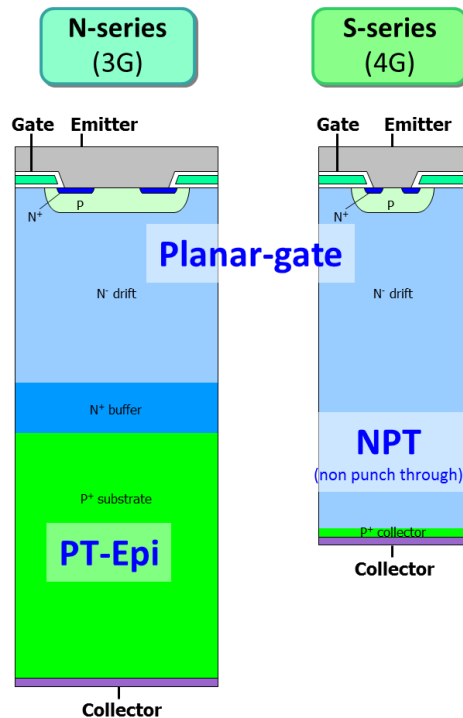
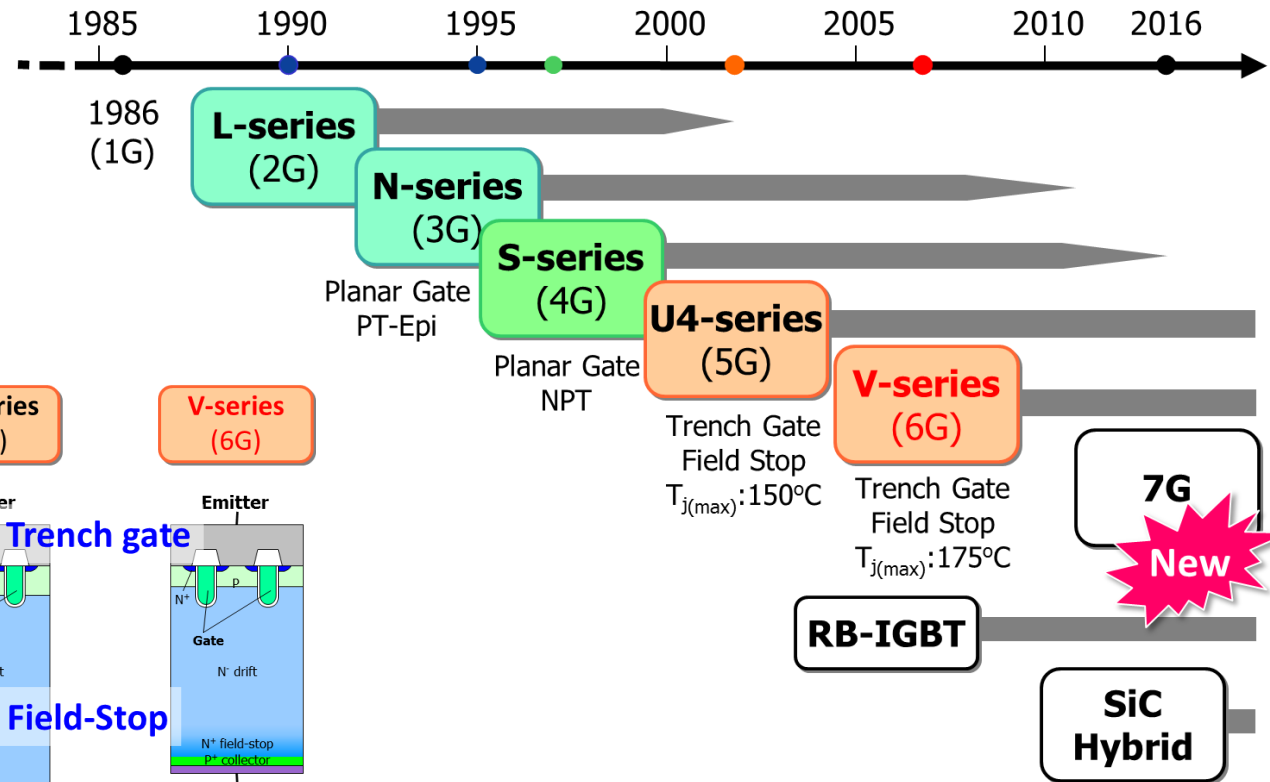


Note: PrimePACK™ is registered trademark of Infineon Technology AG, Germany.

FUJI Product lineup



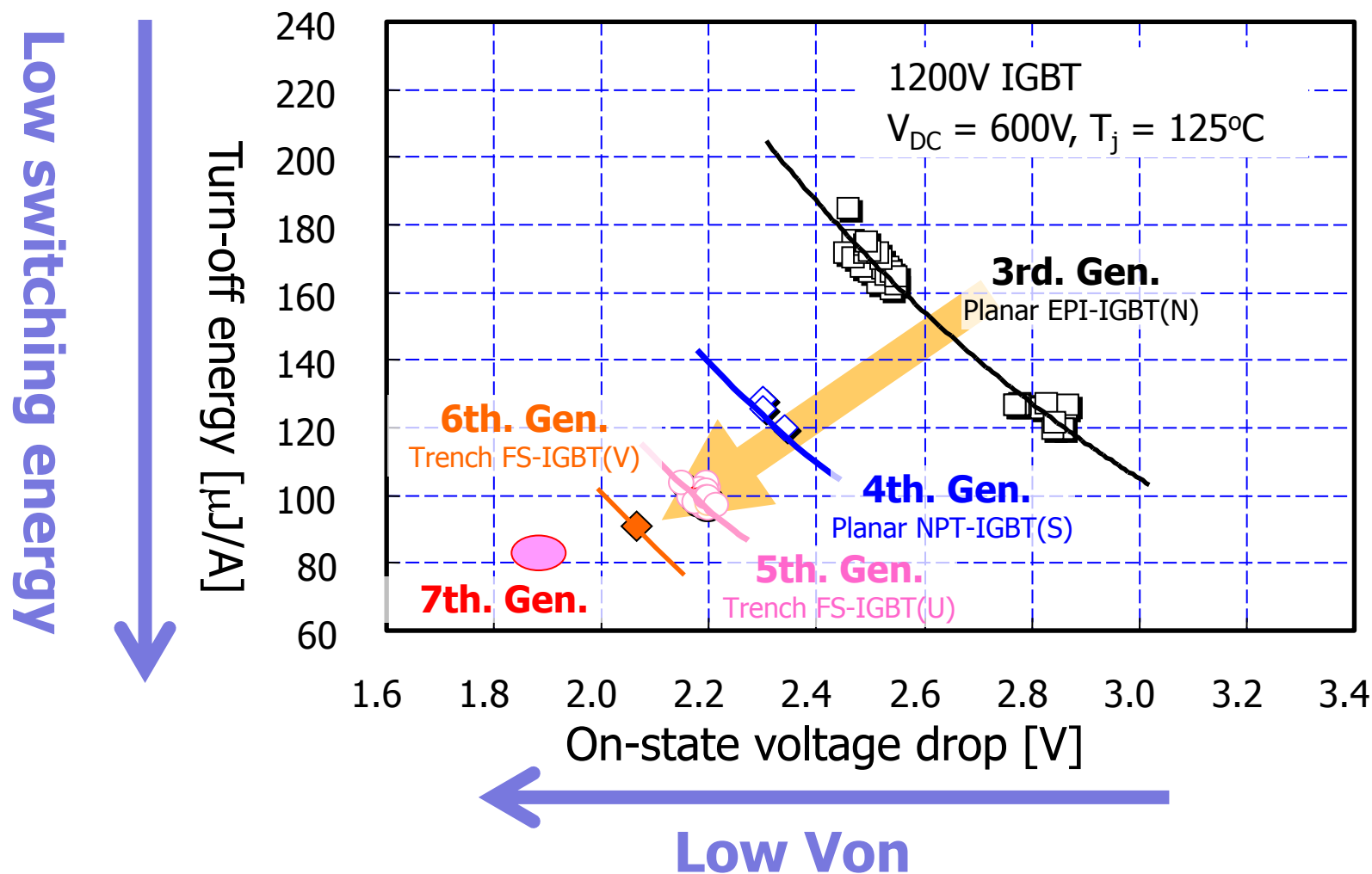
Chip Generation



The performance of IGBT are grown by thin chip with next generation.

Silicon IGBT Trade-off Improvement

Optimized Trench / Field-stop structure

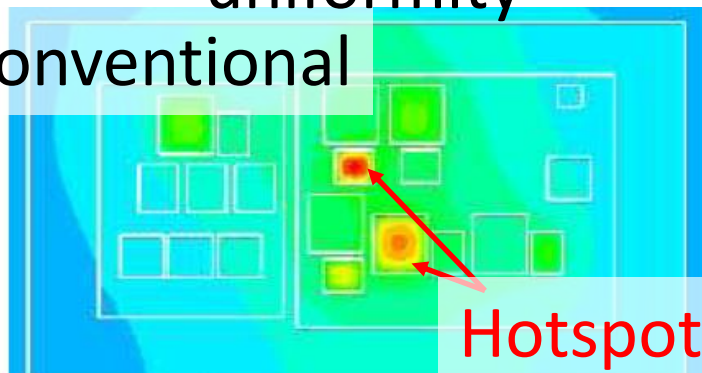


Package Improvement

New layout

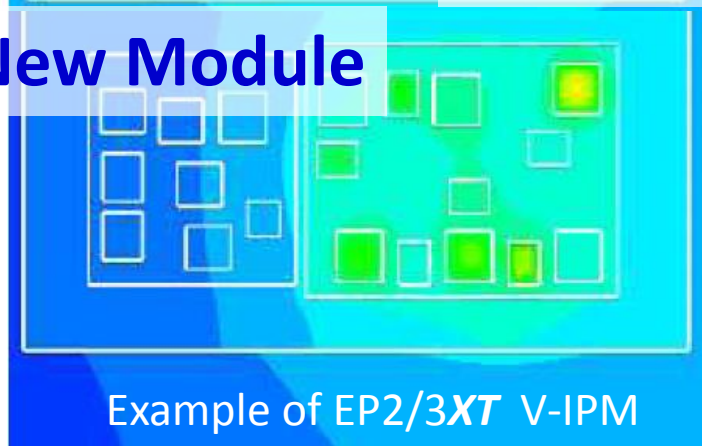
Better temperature
uniformity

Conventional



Hotspots

New Module

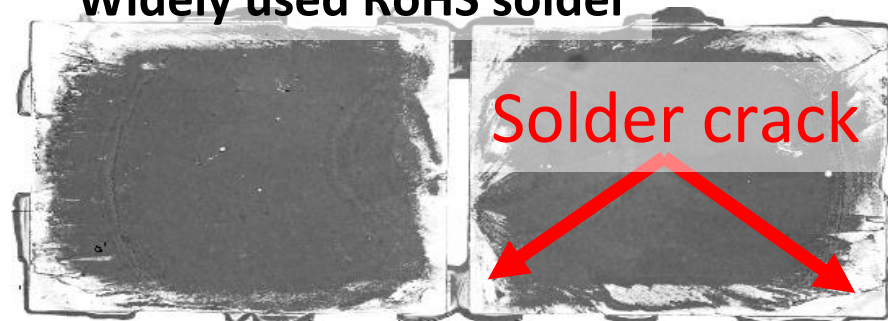


Example of EP2/3XT V-IPM

New solder

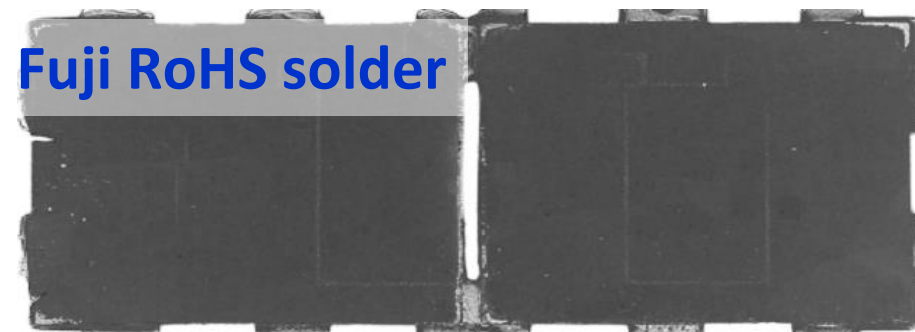
Longer life time

Widely used RoHS solder



Solder crack

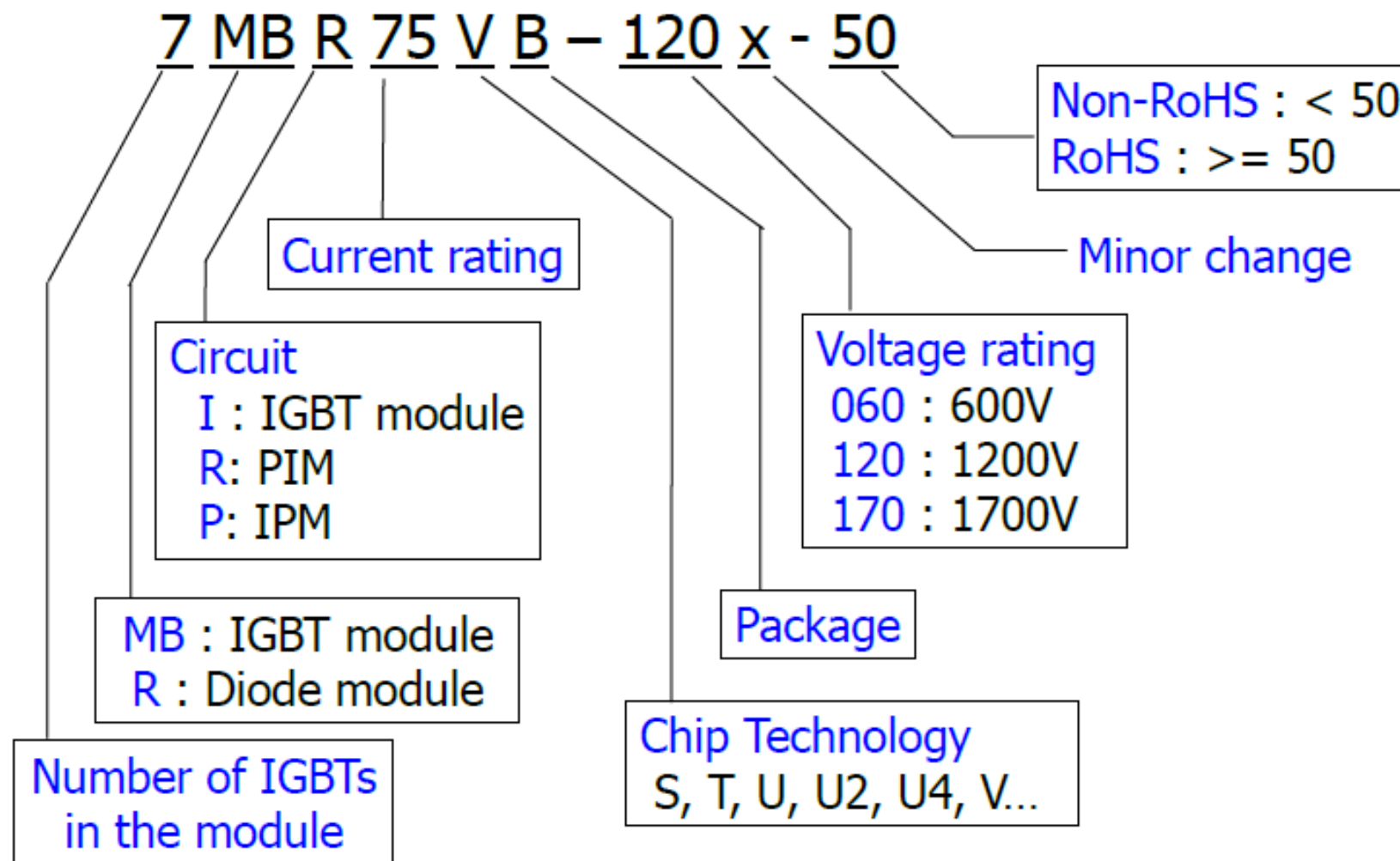
Fuji RoHS solder



Test conditions: 300cycles

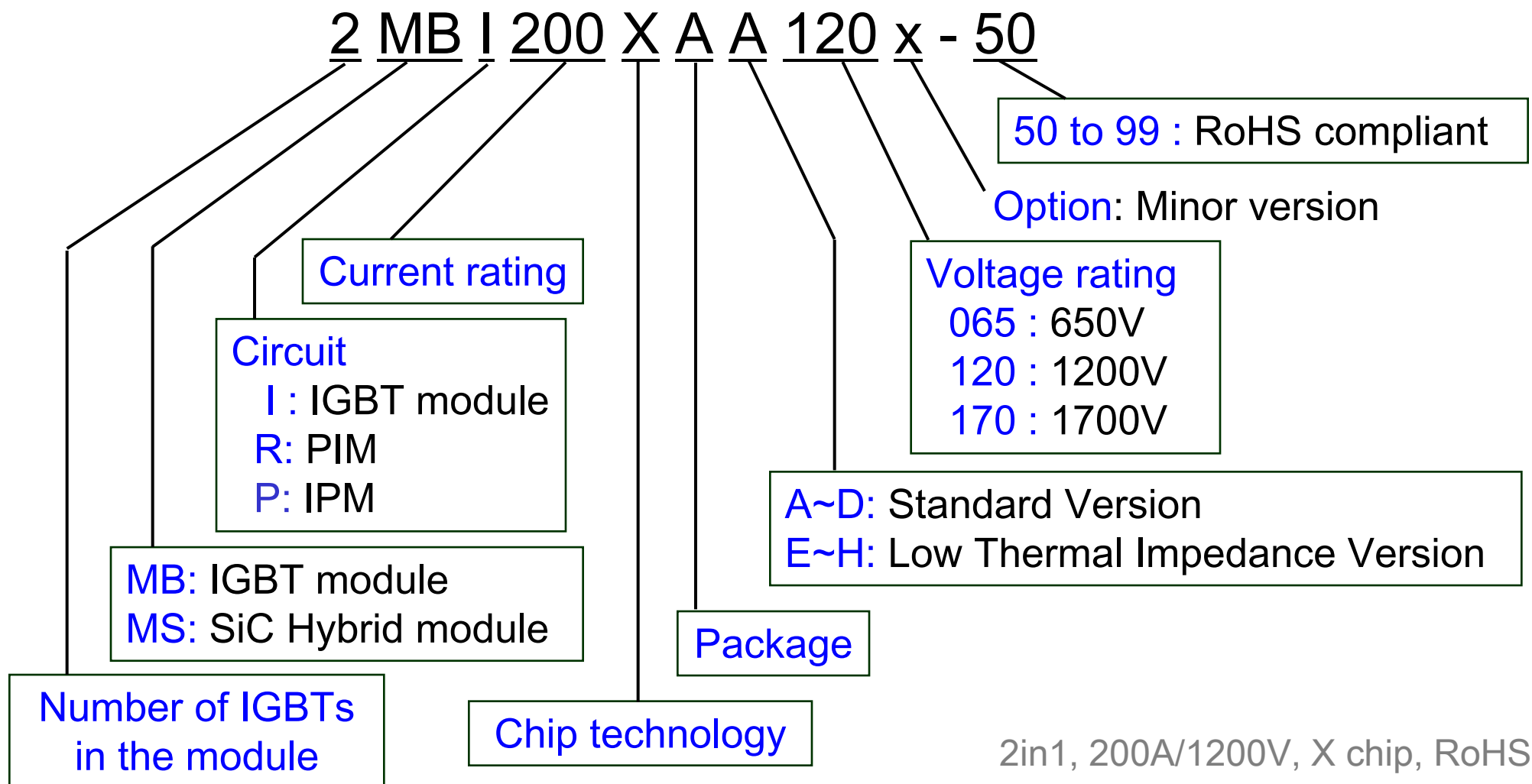
-40°C(1HR)~RT(0.5H)~125°C(1H)

Definition of Type Name (V series)



7in1, 75A/1200V, V chip, EP3, RoHS

Definition of Type Name (X series)



“ – “ in front of the rated voltage is eliminated for X-series IGBT.

Features of FUJI's products

Standard 2in1, Dual XT

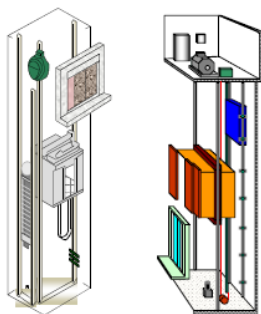
- Low losses by 6th Generation chip (V-series)
- Standard Package in the market

Application field

Inverter, Industrial Robot, PCS, UPS, etc.....

Features

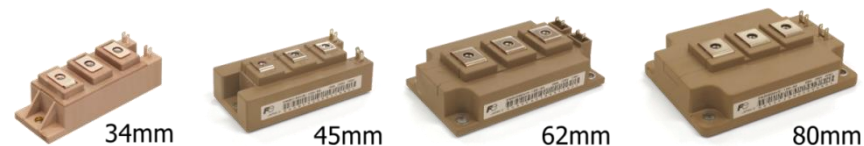
- Standard Package in the market
- We have a lot of experience
- Compatible Package(Infineon, Mitsubishi, etc..)
- Low Cost



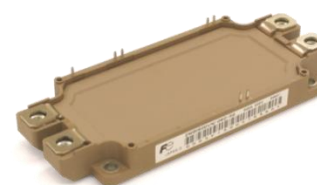
Elevator



Industrial Robot



	75A	100A	150A	200A	300A	400A	450A	600A
600V		34mm			45mm			80mm
1200V		34mm			62mm			
			45mm		80mm			80mm
1700V		34mm		62mm				



DualXT w/ solder pin



DualXT w/ spring contacts

	225A	300A	450A	550A	600A
1200V	solder pin				
	spring				
1700V		solder pin			
				spring	

6-Pack, PIM

- Low losses by 6th Generation chip (V-series)
- Standard Package in the market

Application field

Inverter, Industrial Robot, Servo, etc.....

Features

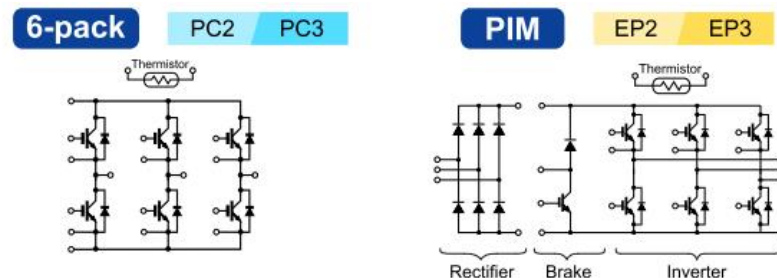
- Standard Package in the market
- Compatible Package
- Low profile
- Easy to assemble (Solder pin/Press-fit pin)



Inverter



Industrial Robot



Solder pin



Pressfit



	25A	35A	50A	75A	100A	150A	180A
600V			6-pack	PC2		PC3	
			PIM	EP2		EP3	
1200V			6-pack	PC2		PC3	
		PIM	EP2		EP3		

Small PIM

- Low losses by 6th Generation chip (V-series)
- Compactness & Light weight
- Baseless Modules

Application field

Air conditioner, Inverter, etc.....

Features

- Easy to assemble (Solder pin/Press-fit pin)
- Compatible Package(Infineon)
- Low Cost

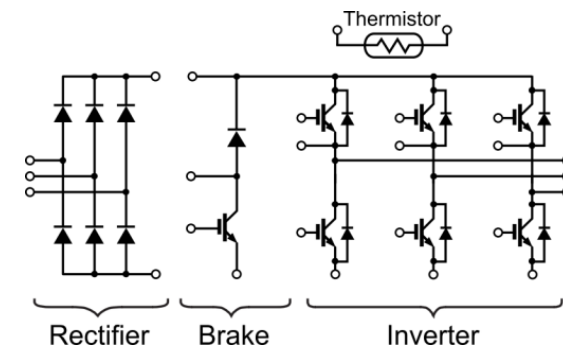


Air Conditioner



FVR E11

Inverter



Rectifier

Brake

Inverter



Small PIM1



Small PIM2



Solder Pin



Press-fit Pin

	10A	15A	20A	25A	30A	35A	50A
600V	Small PIM 1B				1B		2B
1200V	Small PIM 1B	2B		2B		2B	

High Speed IGBT

- High speed IGBT chip (H-series)
- Standard Package in the market

Application field

Induction Heating, X-ray, Welding machine, etc.....

Features

- This products are applied over $f_c=20\text{kHz}$
- Compatible Package(Infineon, Mitsubishi)



Plasma cutter



MRI



45mm



62mm

	1200V						
Series	100A	150A	200A	300A	400A	600A	
HH/HB (Small FWD)	2in1 (45mm)	2in1 (62mm)					Vs. Mitsubishi
HH chopper (High Speed FWD)			Chopper (62mm)				
HJ (Standard FWD)	2in1 (62mm)						Vs. Infineon

- Low losses by 6th Generation chip (V-series)
- Low Inductance

Application field

PCS (PV, Wind), Medium Voltage Inverter, etc..

Features

- Easy to assemble
- Compatible Package (Infineon)
- Low Inductance
- Easy to parallel



Wind Power



Solar Power

Circuit	Pkg	1200V		1700V	
2in1 	M271	600A	2MBI600VXA-120E-50(-54)	650A	2MBI650VXA-170E-50(-54) 2MBI650VXA-170EA-50(-54)
		900A	2MBI900VXA-120E-50(-54) 2MBI900VXA-120P-50(-54)		
	M272			1000A	2MBI1000VXB-170E-50(-54) 2MBI1000VXB-170EA-50(-54)
		1400A	2MBI1400VXB-120E-50(-54) 2MBI1400VXB-120P-50(-54)	1400A	2MBI1400VXB-170E-50(-54) 2MBI1400VXB-170P-50(-54)
Chopper L / D H / C	M271	900A	1MBI900VXA-120PD-50(-54) 1MBI900VXA-120PC-50(-54)	650A	1MBI650VXA-170EL-50(-54) 1MBI650VXA-170EH-50(-54)
	M272	1400A	1MBI1400VXB-120PL-54 1MBI1400VXB-120PH-54	1000A	1MBI1000VXB-170EL-50(-54) 1MBI1000VXB-170EH-50(-54)

3-Level Module

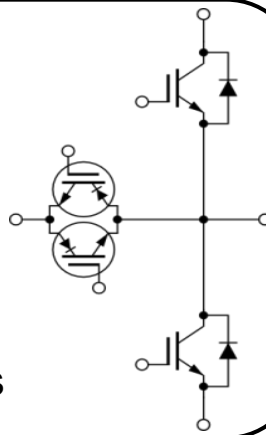
- 3-level circuit in single package
- AC switching devices are used RB-IGBT
(Reverse Blocking IGBT)

Application field

Solar PCS, UPS, etc.....

Features

- Easy Assembly
- Low Inductance
- High Efficiency of PCS
- Lower Losses than 2-level modules



Solar PCS



UPS

T-Prime



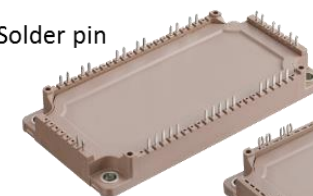
M403



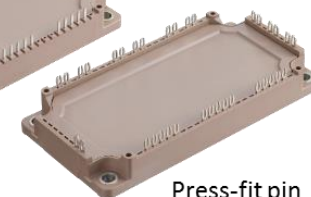
EP3

3-phase
1200V / 50A~100A

Solder pin



Press-fit pin



VCES	50A	75A	100A	200A	300A	400A	600A	900A
600V						M403		
1200V	EP3(12in1)				M403(4in1)			
					T-Prime (4in1)			

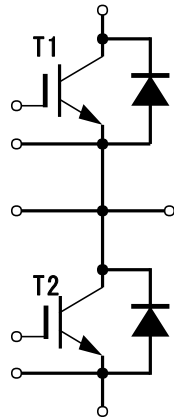
Features of 3-level Topology

□ Advantage: High Efficiency, Down sizing of Inverter

□ Application: Solar PCS, UPS

These market will be expand from 2-level topology to 3-level topology.

■2-level Inverter

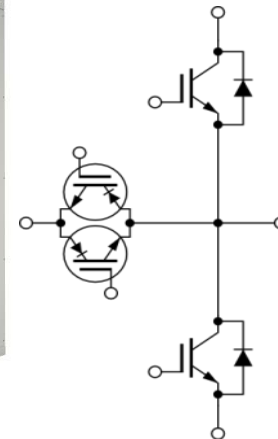


2-level topology

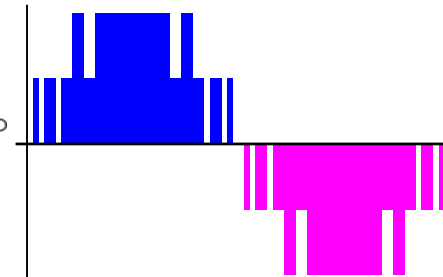


Output Voltage waveform

■3-level Inverter



3-level topology



Output Voltage waveform

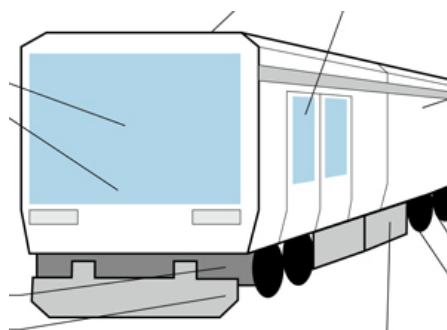
High Power Module

Application

Traction
Medium Voltage inverter

Features

- High reliability
- Compatible Package



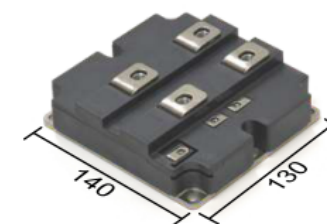
Traction

Voltage	Circuit	Current	Type Name	Package
1200V (6 th gen.)	1in1	1200A	1MBI1200VC-120P	M151
		1600A	1MBI1600VC-120P	
		2400A	1MBI2400VC-120P	
		2400A	1MBI2400VD-120P	
	2in1	3600A	1MBI3600VD-120P	M152
		600A	2MBI600VG-120P	
		800A	2MBI800VG-120P	
		1200A	2MBI1200VG-120P	

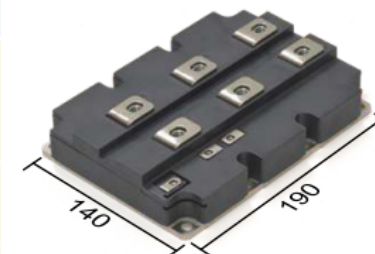
Voltage	Circuit	Current	Type Name	Package
1700V (6 th gen.)	1in1	1200A	1MBI1200VC-170E	M151
		1600A	1MBI1600VC-170E	
		2400A	1MBI2400VC-170E	
		2400A	1MBI2400VD-170E	
	2in1	3600A	1MBI3600VD-170E	M152
		600A	2MBI600VG-170E	
		800A	2MBI800VG-170E	
		1200A	2MBI1200VG-170E	

Voltage	Circuit	Current	Type Name	Package
3300V (5 th gen.)	1in1	800A	1MBI800UG-330	M151
		1000A	1MBI1000UG-330	
		1200A	1MBI1200UE-330	
		1500A	1MBI1500UE-330	

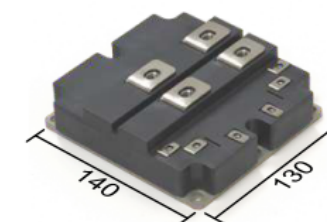
M151 (Single)



M152 (Single)



M256 (Dual)



What is IPM?

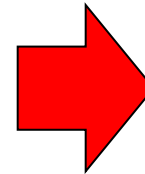
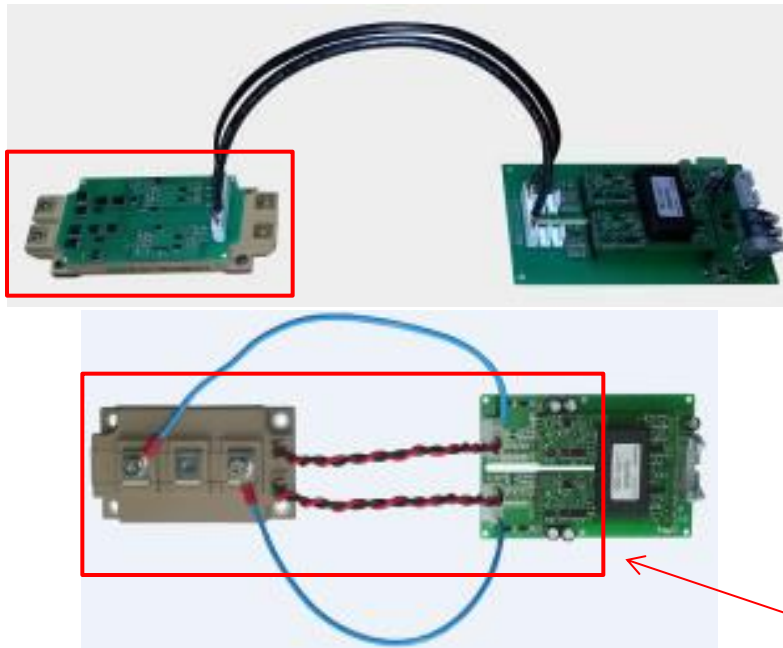
IPM = IGBT module + Gate Driver (drive circuit, protection circuit)

IPM: Intelligent Power Module

Advantage

Customers can design drive circuit easily!!

Standard Module



IPM



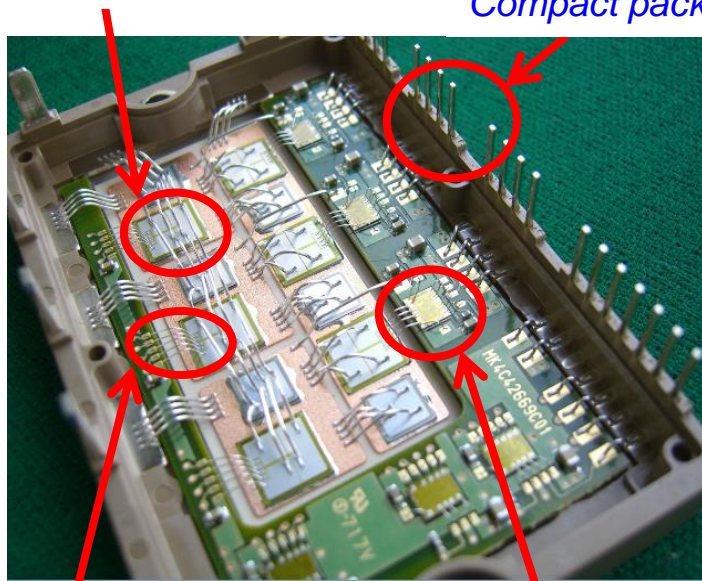
Generally, customers need to design gate drive circuit and protection circuit for using IGBT.

Features of IPM

Application

Inverter, Industrial Robot, Servo Motor, etc..

VR-silicon designed for IPM *Low profile & Compact package*



On-chip sensor

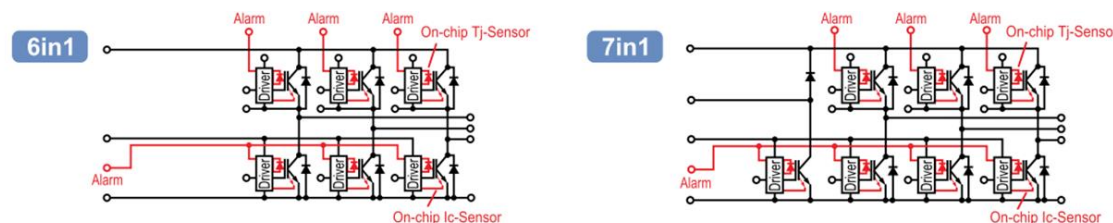
- Current sensor
- Temperature sensor

Driver-IC

IGBT Driver
Protection / Alarm
Fuji own special design

Features

- Integrated Drive/Protection circuit in the package
- High performance and fast protection
- Compact package



	600V	20A	30A	50A	75A	100A	150A	200A	300A	400A
	1200V	10A	15A	25A	35A	50A	75A	100A	150A	200A
	<div> P629 49.5 x 70 x 12mm 6in1 </div>									
	<div> P626 50.2 x 87 x 12mm 6in1 50A/1200V </div>									
	<div> P630 84 x 128.5 x 14mm 6in1 7in1 </div>									
	<div> P636 55 x 90 x 17mm 6in1 7in1 </div>									
	<div> P631 110 x 142 x 22mm 6in1 7in1 </div>									

Small IPM (2nd Gen.)

- IPM can be driven by single power supply (Build in drive ICs & Boot Strap Diodes)
- Standard package in the market

Application field

Air conditioner, Inverter, Servo, etc..

Features

- Protection circuit included in the package
- Compatible Package (Mitsubishi)
- Low price



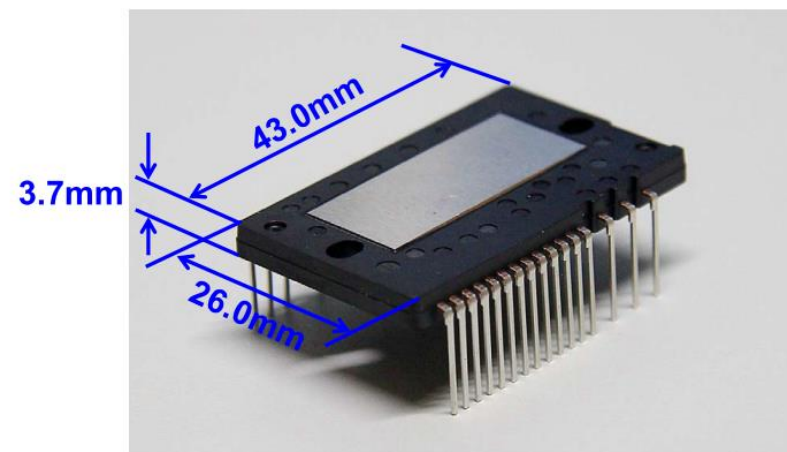
Air Conditioner



FVR E11

Inverter

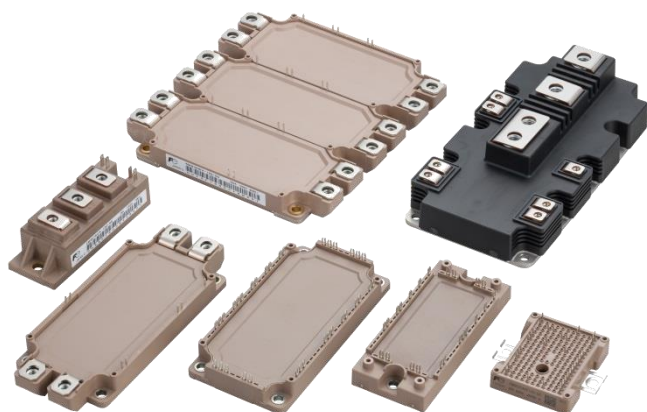
Parts Number *2	IC	VCE(sat) typ.@25°C	VF typ.@25°C	Overheating function	PKG	Cross reference of Company M
6MBP15XSD060-50	15A	1.60V	1.60V	V(temp) OUT	P633A	PSS15S92F6-AG
6MBP15XSF060-50				V(temp) OUT & TOH		PSS15S92E6-AG *1
6MBP20XSD060-50	20A	1.60V	1.70V	V(temp) OUT		PSS20S92F6-AG
6MBP20XSF060-50				V(temp) OUT & TOH		PSS20S92E6-AG *1
6MBP30XSD060-50	30A	1.60V	1.70V	V(temp) OUT		PSS30S92F6-AG
6MBP30XSF060-50				V(temp) OUT & TOH		PSS30S92E6-AG *1
6MBP35XSD060-50	35A	1.40V	1.70V	V(temp) OUT		PSS35S92F6-AG
6MBP35XSF060-50				V(temp) OUT & TOH		PSS35S92E6-AG *1



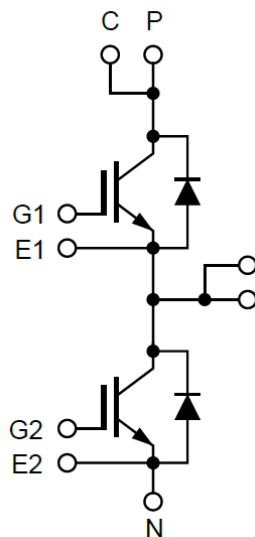
Si-IGBT/SiC-SBD Hybrid Module

FUJI announce two type modules in the Catalog(2016/2017).

All Si Modules



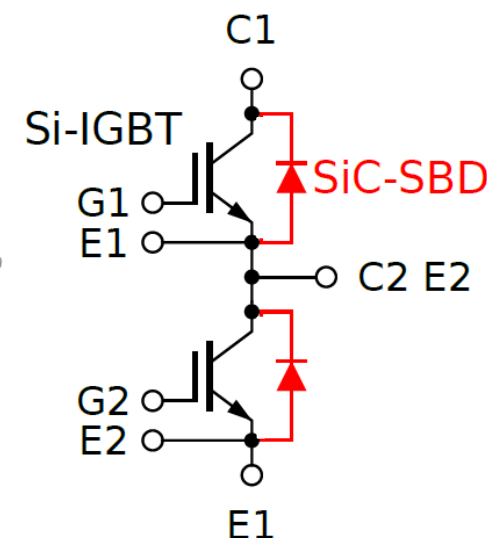
FUJI X-series IGBT modules



Si-IGBT + SiC-SBD



Hybrid modules with SiC-SBD



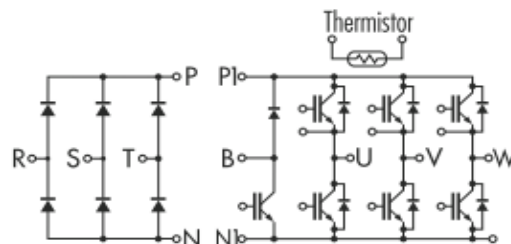
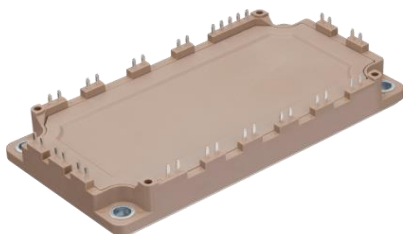
Lower price
Many line-up



Lower Loss
High Efficiency

Line-up of SiC-SBD Hybrid Modules

PIM



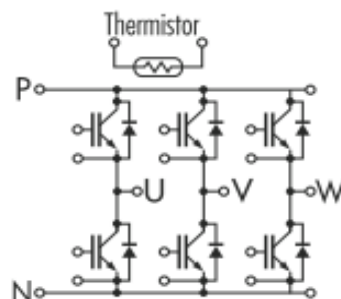
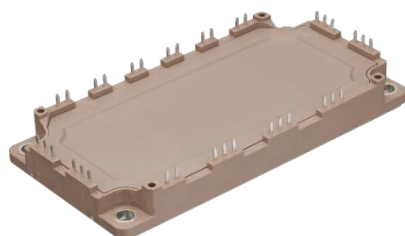
600V

7MSR50VB060-50 (50A)
7MSR75VB060-50 (75A)
7MSR100VB060-50 (100A)

1200V

7MSR35VB120-50 (35A)
7MSR50VB120-50 (50A)

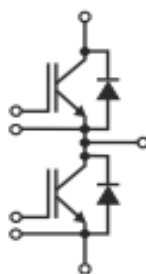
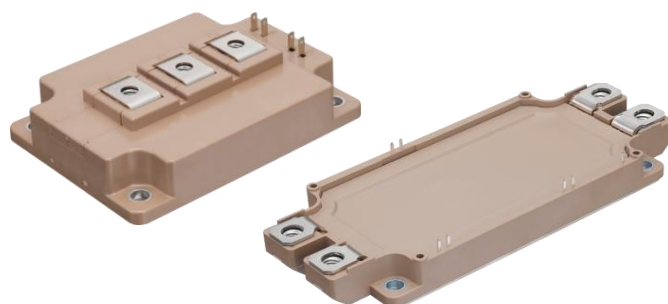
6in1 Package



1200V

6MSI100VB-120-50 (100A)
2MSI600VAN-120-53 (550A)

2in1 Package



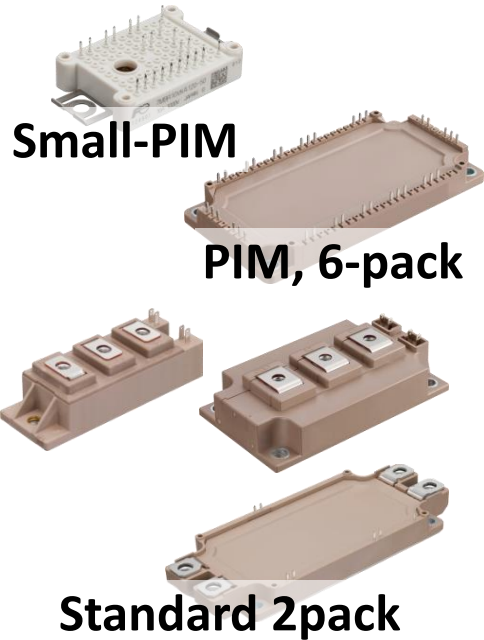
1700V

2MSI400VE-170-53 (400A)
2MSI550VAN-170-53 (600A)
2MSI1200VAT-170 (1200A)

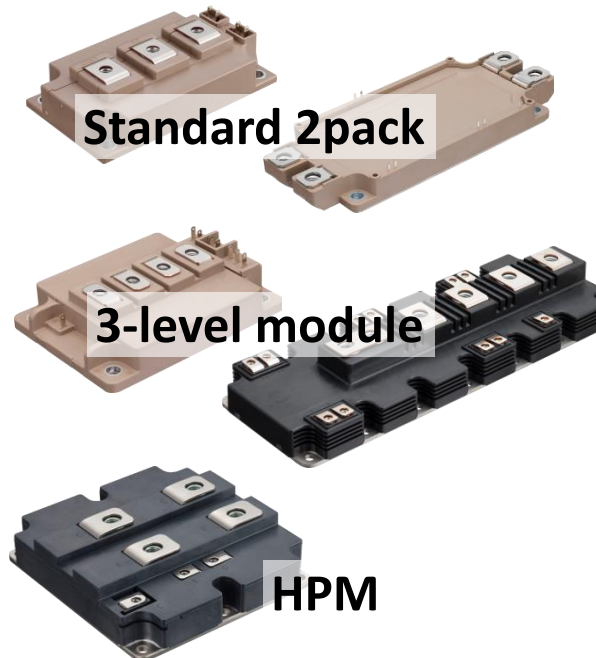
Example of Applications and applied products

Applications for Fuji IGBT Modules

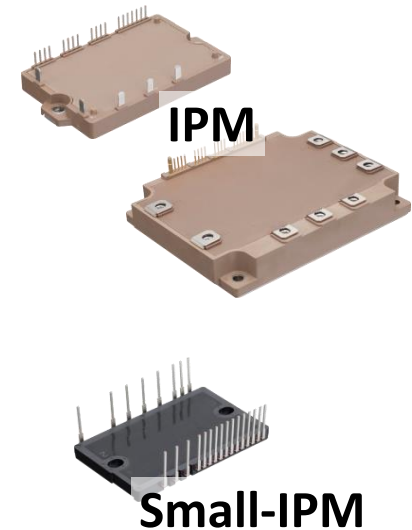
Motor Drive



PV, UPS, Wind

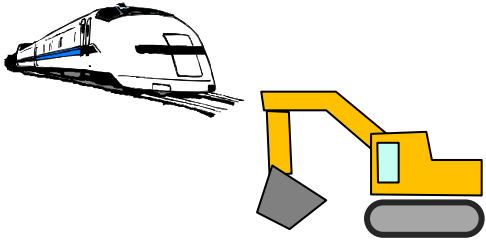


NC, Servo



Applications for Fuji IGBT Modules

Traction



Automotive



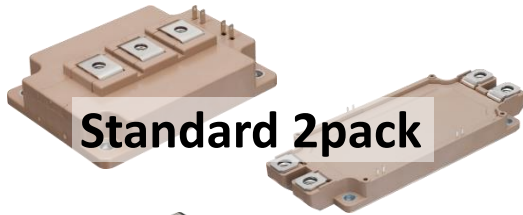
Air conditioner



Welding, IH, Medical



Standard 2pack



Automotive module



Small-IPM



High speed



PrimePACK™

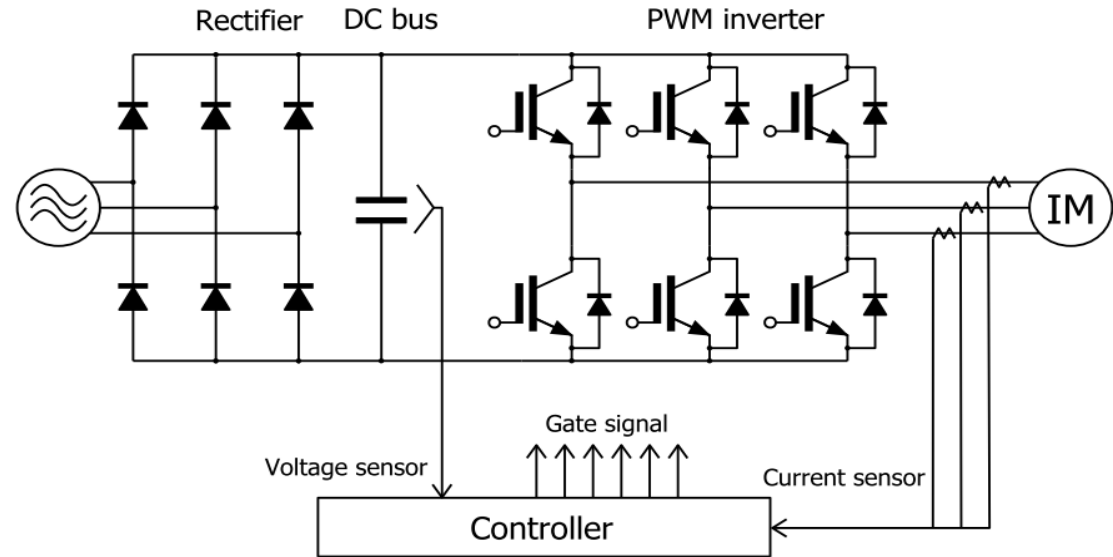


HPM

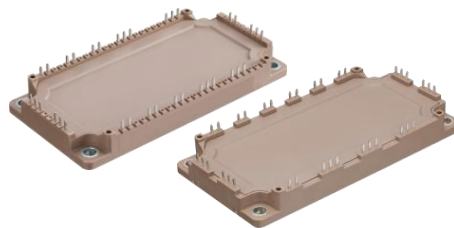


Applications for Fuji IGBT Modules

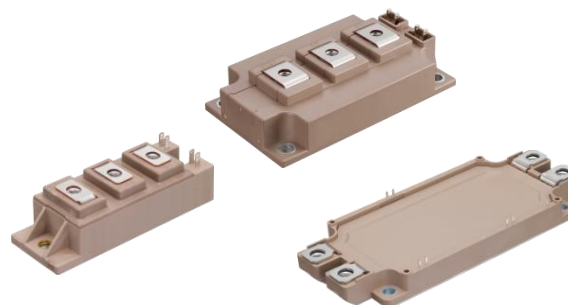
Motor Drive (General Purpose Inverter)



Small-PIM



PIM, 6-pack



Standard 2pack

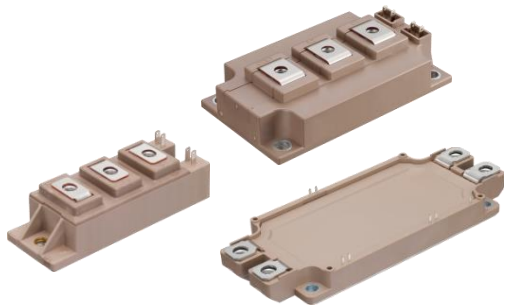
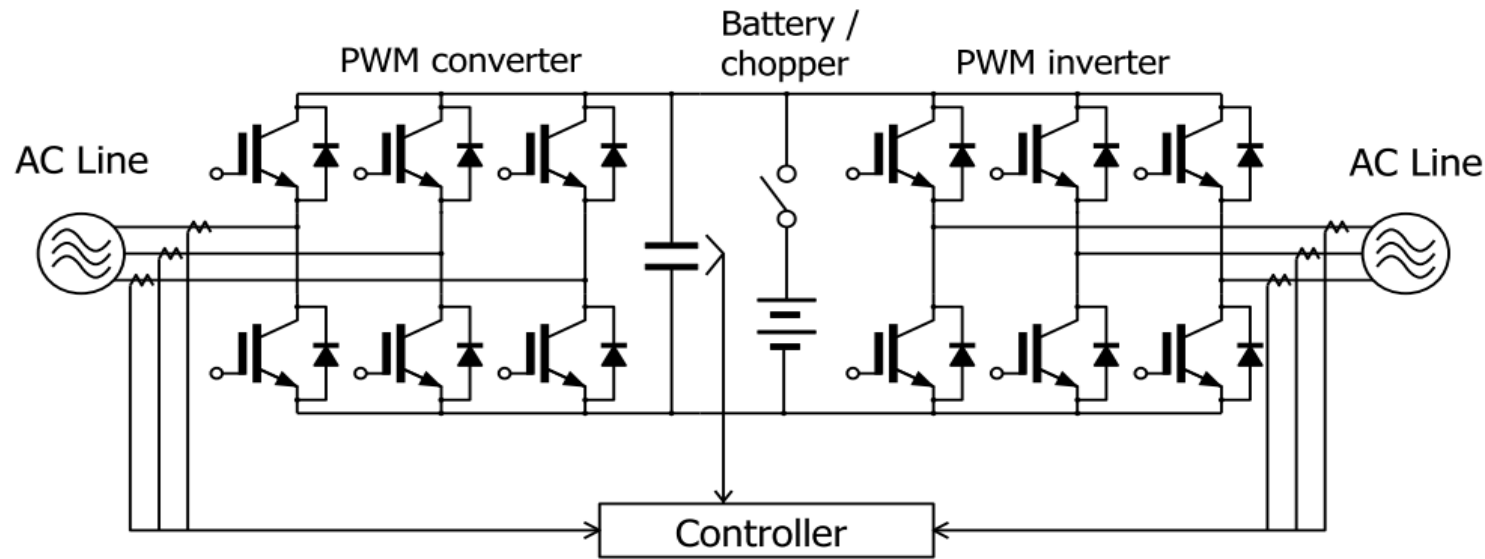


PrimePACK™

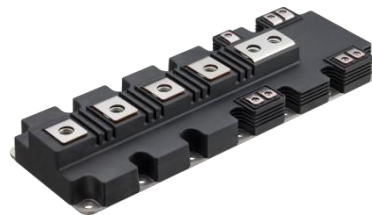
HPM

Applications for Fuji IGBT Modules

UPS



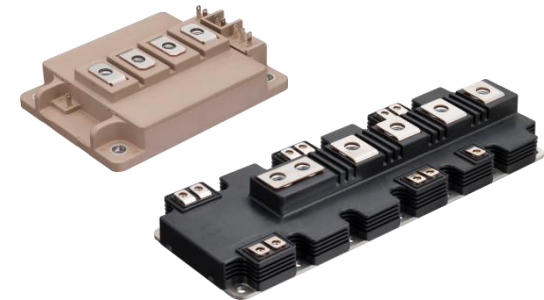
Standard 2pack



PrimePACK™



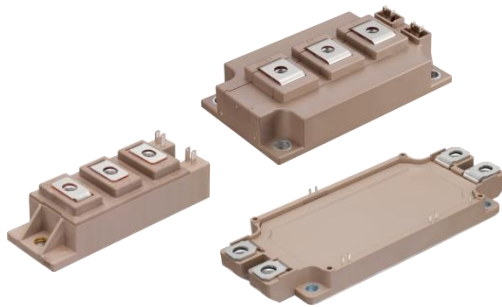
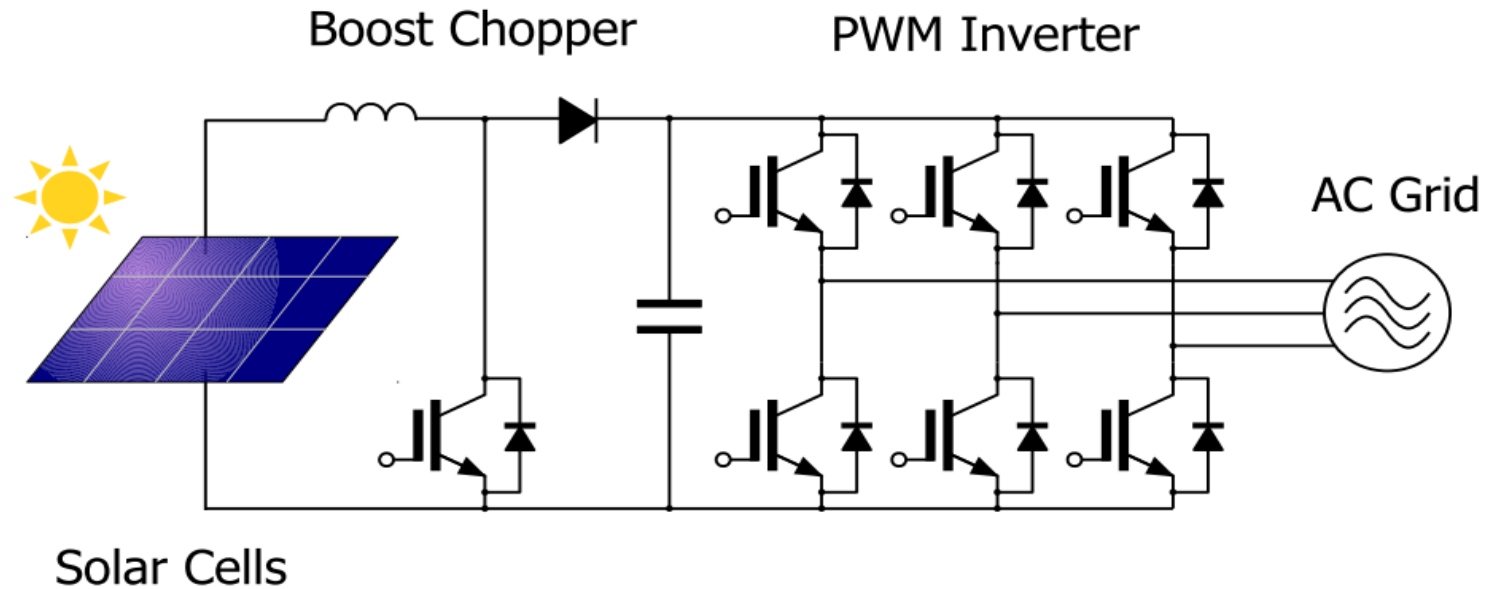
HPM



3-level module

Applications for Fuji IGBT Modules

PV (Mega Solar)



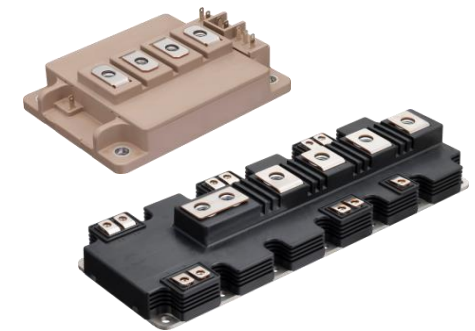
Standard 2pack



Chopper module



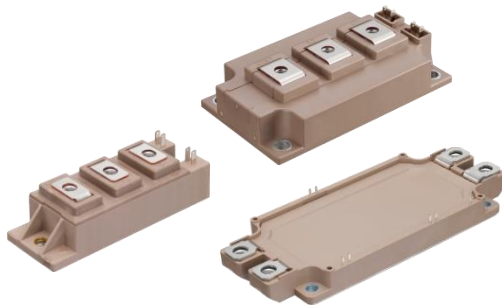
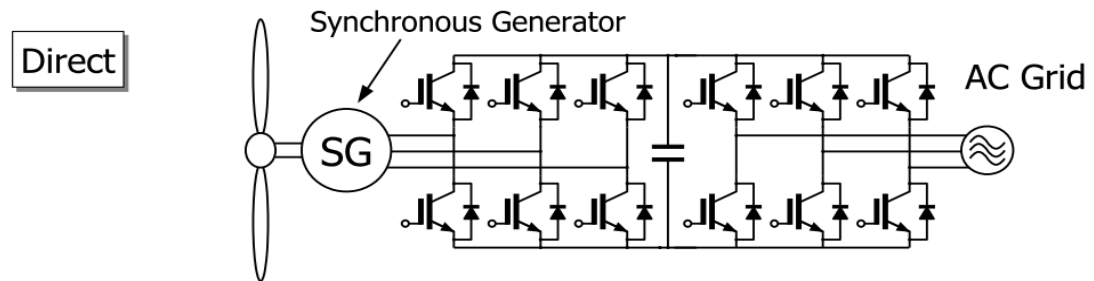
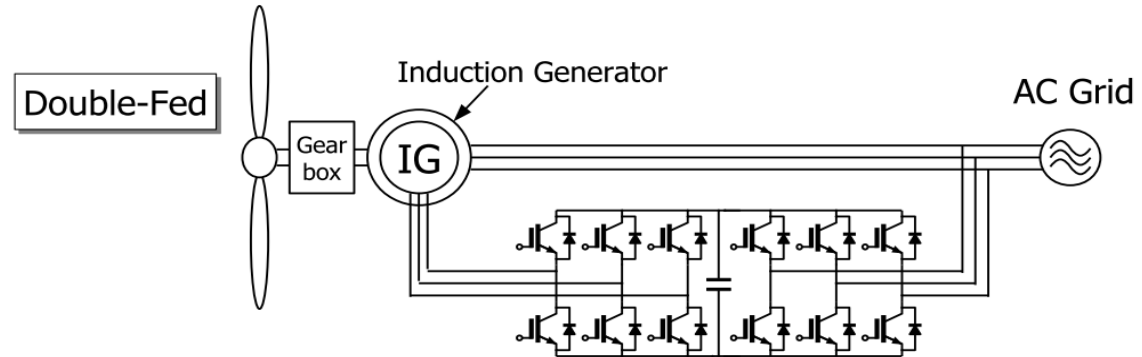
HPM



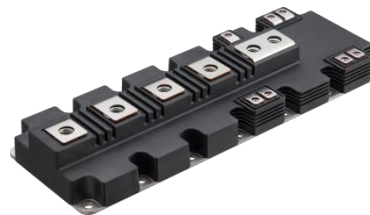
3-level module

Applications for Fuji IGBT Modules

Wind Turbine



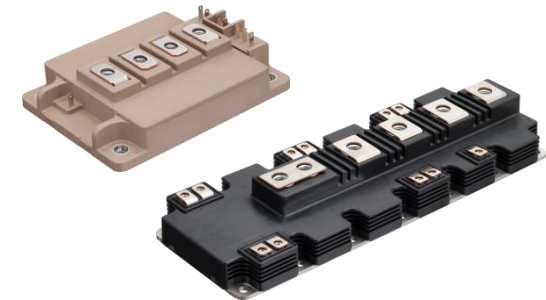
Standard 2pack



PrimePACK™



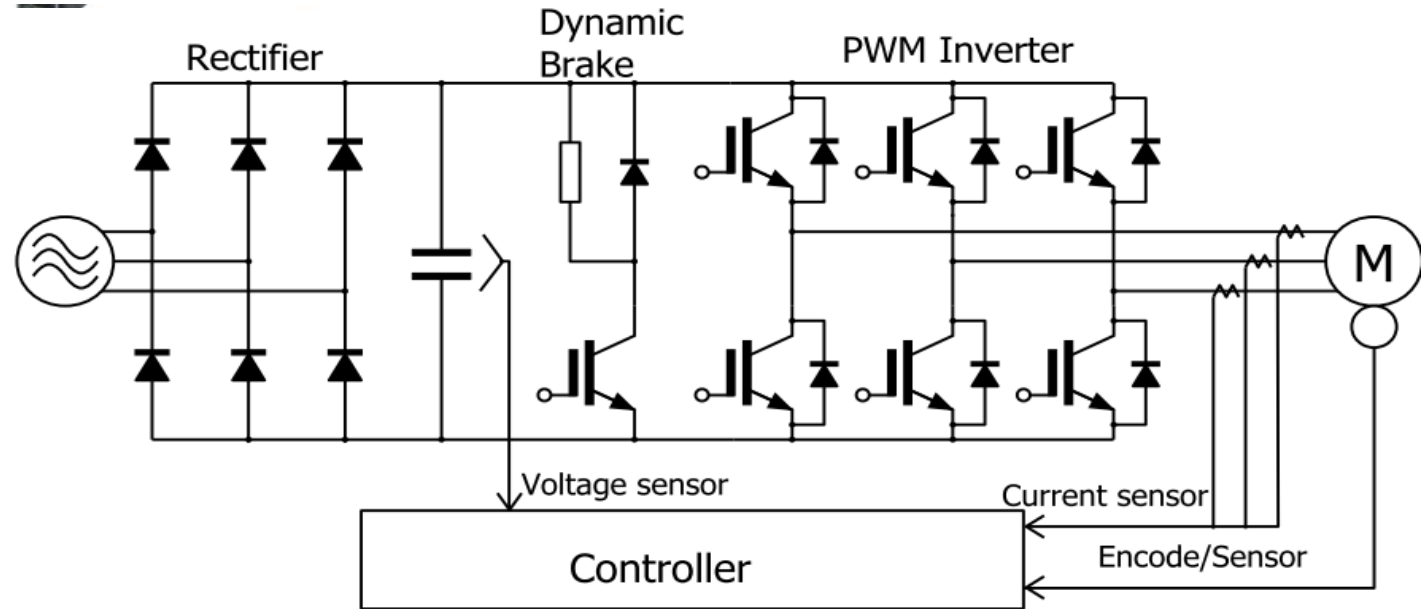
HPM



3-level module

Applications for Fuji IGBT Modules

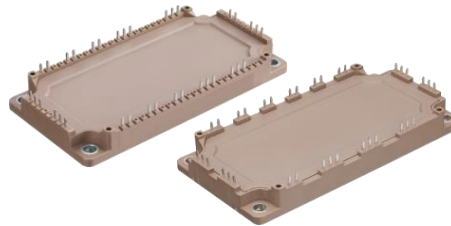
Servo Drive



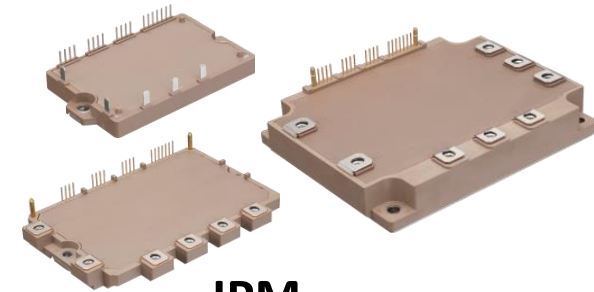
Small-IPM



Small-PIM



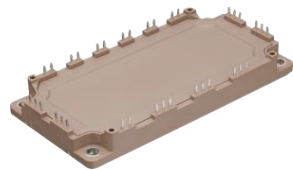
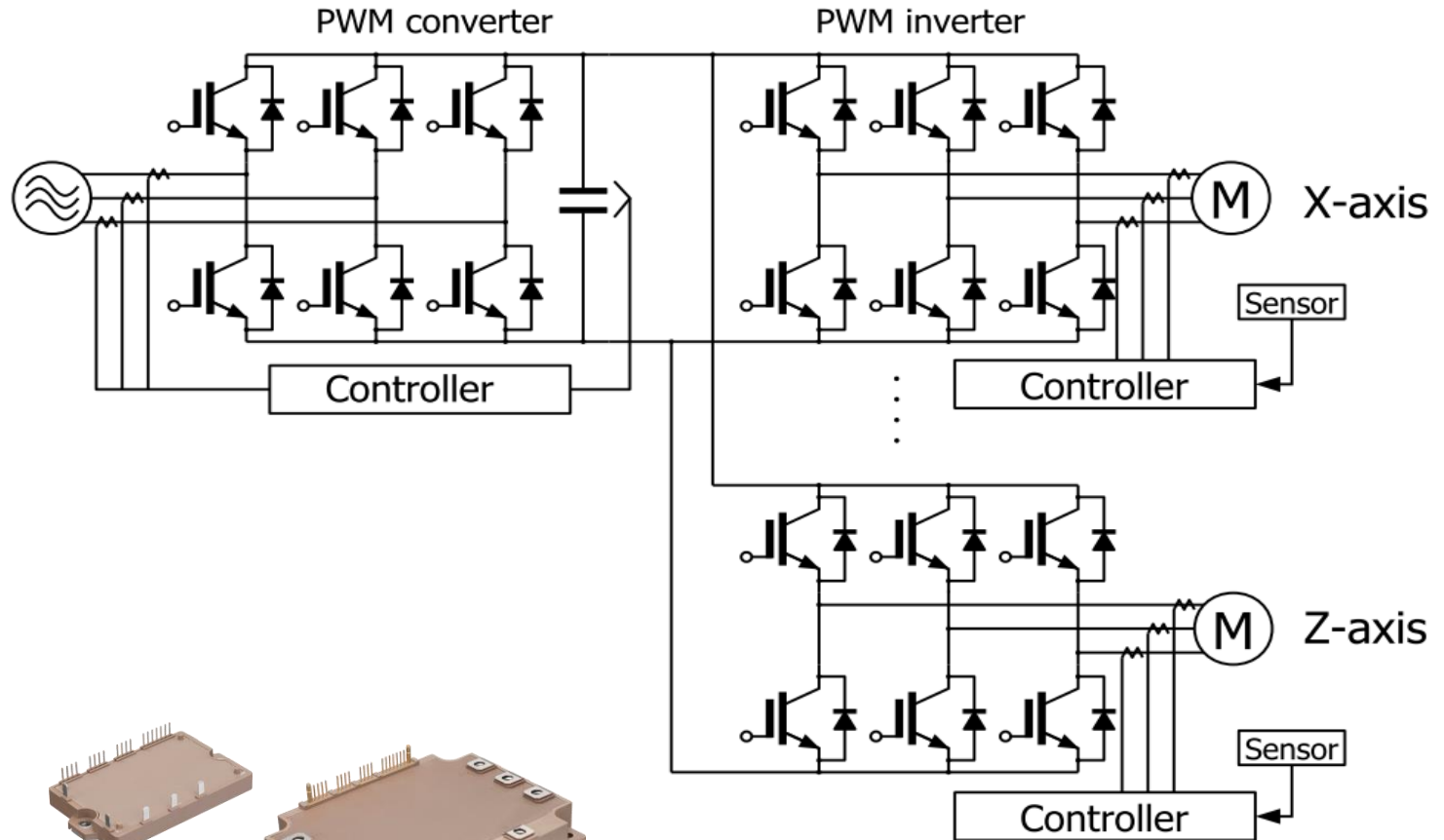
PIM, 6-pack



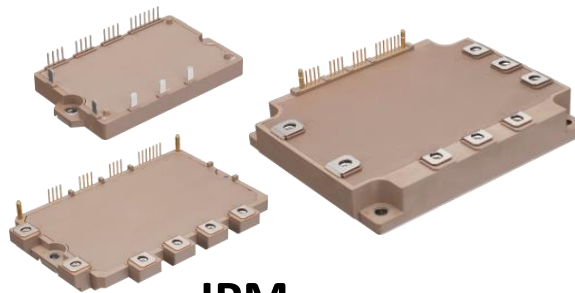
IPM

Applications for Fuji IGBT Modules

NC, Robot



6-pack



IPM

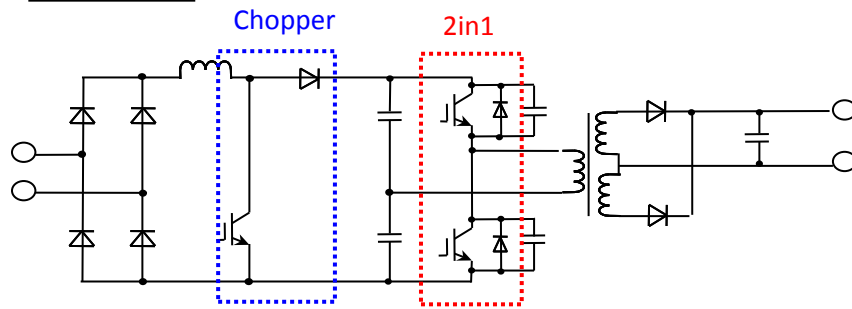
Applications for Fuji IGBT Modules

Welding, IH, Medical (MRI, X-ray)

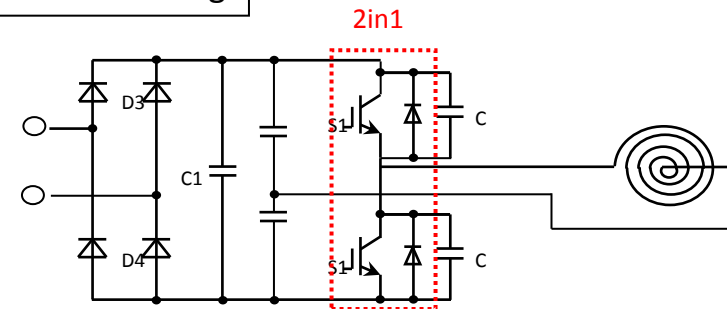


High speed (2in1 / Chopper)

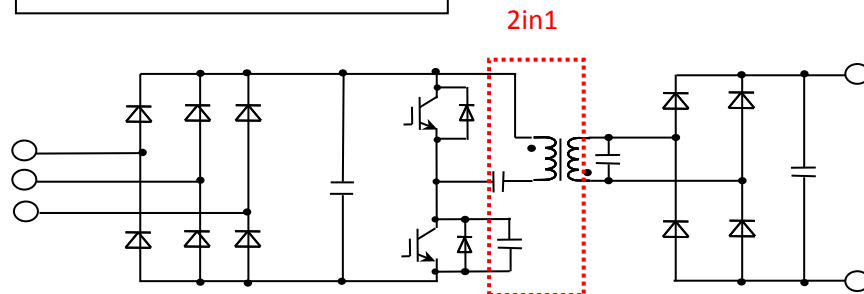
Welding



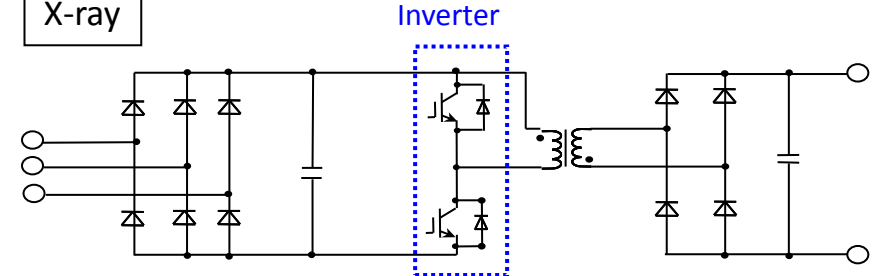
Induction heating



X-ray (soft switching)

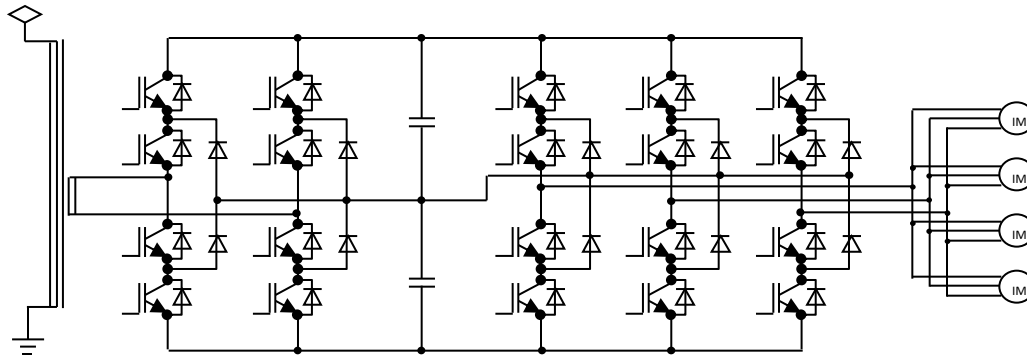
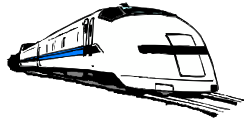


X-ray

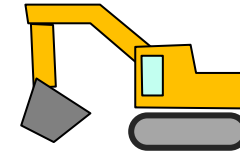


Applications for Fuji IGBT Modules

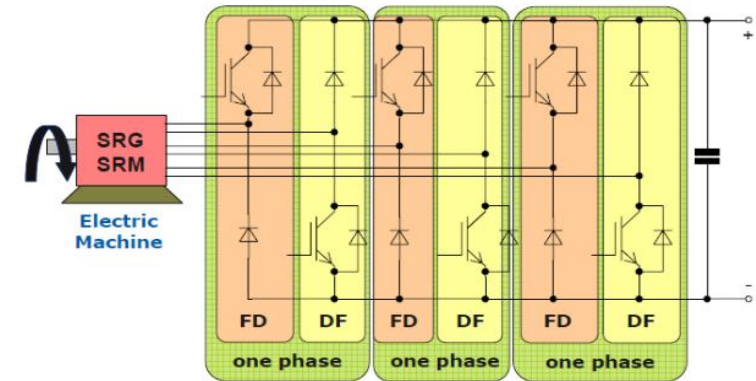
Traction (Locomotive, Constriction Vehicle)



Shinkansen (series 700)



SR motor drive



Motor, Drive and Automation Systems



Standard 2pack



PrimePACK™



HPM



Chopper module

How to Select Voltage and Current Ratings

How to Select Voltage Rating

Region	IGBT ratings voltage (V_{CES})			
	600V	1200V	1400V	1700V
Japan	200V 220V	400V 440V		
America	208V 230V 240V 246V	460V 480V		
Europe	200V 220V 230V 240V	346V 350V 380V 400V 415V 440V		690V
DC voltage	300~400V	600~800V	700~900V	800~1000V

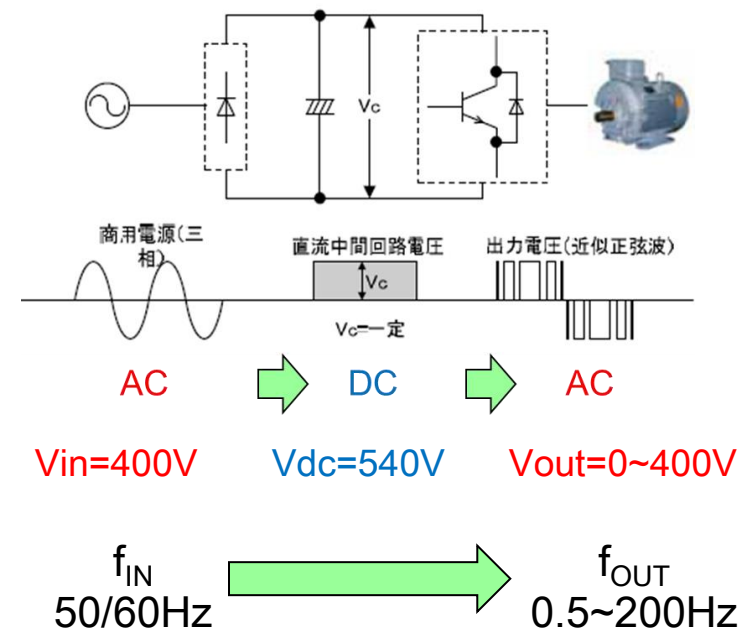
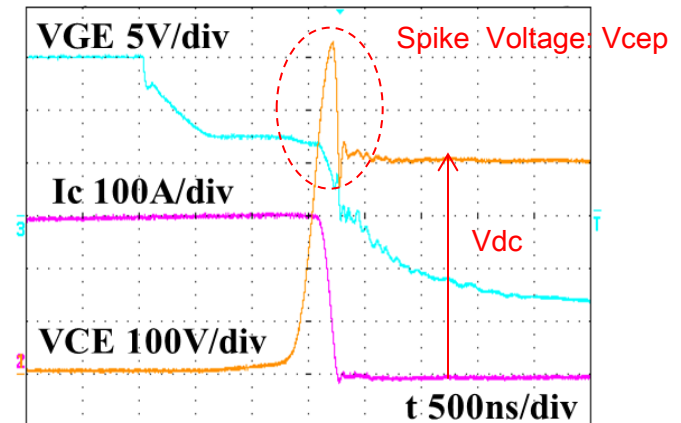
ex) When $V_{dc}=600V$

$600V \times 1.5 = \text{Spike Voltage } 900V$

Spike Voltage $900V + \text{margin } 300V = 1200V$

IGBT rated voltage \rightarrow

Turn-off waveform example



How to Select Current Rating

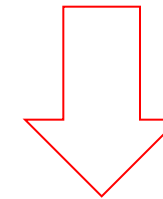
Input	Motor ratings [kW]	Inverter ratings [kVA]	Output current (repetitive) [Arms]	Example of IGBT ratings selection
(1) 220V AC	1.5	3	8	600V/30A
	2.2	4	11	600V/30A
	3.7	6	17	600V/50A
	5.5	9	25	600V/75A
	7.5	13	33	600V/100A
	11	17	49	600V/150A
	15	22	64	
	18.5	28	80	600V/200A
	22	33	96	
	30	44	130	600V/300A
(2) 440V AC	37	55	160	600V/400A
	45	67	183	
	0.75	2	2.5	1200V/10A
	1.5	3	3.5	1200V/15A
	2.2	4	5.5	
	3.7	6	9	1200V/25A
	5.5	9	13	1200V/50A
	7.5	13	18	
	11	17	24	1200V/75A
	15	22	30	
(3)	18.5	28	39	1200V/100A
	22	33	48	
	30	44	65	1200V/150A
	37	55	80	1200V/200A
	45	67	96	
	55	84	128	1200V/300A

Ex) 7.5kW Inverter for 440V_{AC} and pf=0.58

$$x(VA) = 75000(W) \div pf(\text{power factor}) \\ \approx 13000(VA)$$


$$y(Arms) = 13000(VA) \div 440(Vac) \div \sqrt{3} \\ \approx 17(Arms)$$


× 2~3 times



You will suggest **50A/1200V module**

<http://www.fujielectric.com/products/semiconductor/>



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▶ New Products

▶ Product Information 

▶ Application-specific Information

▶ Design support


▶ Catalog 

▶ Fuji Electric Journal

▶ Revised and discontinued product information

▶ Quality and Environmental

Fuji Electric Power Semiconductors
Fuji Electric power semiconductors are bolstering new technologies



News

Apr. 15, 2016 "On-line Catalog(25A2-W-0004)" revised.

Apr. 11, 2016 Fuji IGBT Simulator Ver. 6.0.2 is released



Mar. 29, 2016 Added the datasheets for Power MOSFET's new products (Super J MOS® S2 Series, 600V to 700V).

Japanese | Chinese

▶ Model type Search

☐ Include maintenance models
☐ Include discontinued models

▶ Catalog

 [General Catalog]
Fuji Electric Semiconductors 

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