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COLOR TFT-LCD MODULES FOR INDUSTRIAL USE



TFT LCD Modules

C

True-to-life Color Reproduction & Variety of Sizes Highly Advanced TFT-LCD Modules by Mitsubishi Electric



LINEUP A line-up rich in variety to match diversified customer requirements

Standard

	5.7″	6.5″	8.4″	10.4″	12.1″	15.0″	17.0″	19.0″
QVGA 320x240	Standard Type							
VGA 640x480	Super High Brightness	Super High Brightness	Standard Type Super High Brightness Transflective	Standard Type				
SVGA 800x600	CMOS-IF Comp	patible	Standard Type Super High Brightness Super Wide Viewing Angle	Standard Type Super High Brightness Super Wide Viewing Angle Tough TFT-LCD	Standard Type Super High Brightness Super Wide Viewing Angle			
XGA 1024x768			Standard Type	Standard Type Super High Brightness Super Wide Wid	Standard Type Super High Brightness Super Wide Viewing Angle	Standard Type*		
SXGA 1280x1024				LVDS-IF C	ompatible		Standard Type	Standard Type Standard Type Super High Brightness
SXGA+ 1400x1050	Mour Com	nting patible				Super High Brightness Super Wide Viewing Angle	2ch LVDS-IF	Compatible

*The pin assignment is compatible, but the connector model name is different.

Mitsubishi Electric color thin-film transistor liquid-crystal display (TFT-LCD) modules are produced utilizing advanced imaging and color reproduction technologies and come in a variety of sizes to match diversified needs. With applications including point of sale (POS) terminals, vending and ticketing machines, bank automatic teller machines (ATMs) and monitors in vehicles and boats, our TFT-LCD modules have become an essential part of society and people's lives today. Features include excellent visibility, stylish design, simplicity of use and customer-focused product development.



For GAS POS

For Camera Monitor

For Boat Monitor

For Drive-through

Wide

	4.3″	5.0″	7.0″	8.0″	9.0″	10.6″	12.1″	14.1″	17.5″
Wide-VGA 800x480	Standard Type	Super Wide Viewing Angle	Super High Brightness Super Wide Viewing Angle	Super High Brightness Super Wide Viewing Angle	Standard Type Super High Brightness Super Wide Viewing Angle		LVDS-IF C	ompatible	
Wide-XGA 1280x768					Super Wide Viewing Angle	Super High Brightness Super Wide Viewing Angle			Standard Type *
Wide-XGA 1280x800	Mour Com	nting patible					Standard Type Super High Brightness Super Wide Viewing Angle	Standard Type	

*The pin assignment is compatible, but the connector model name is different.

Special

	3.5″	7.8″	19.2″
800x300		Super Wide Viewing Angle	
QHD 960x540	Super Wide Viewing Angle		
1/3HD 1920x360			Standard Type ***

*The pin assignment is compatible, but the connector model name is different. **There are Landscape(AA192AA01) and Portrait(AA192AA51).

Color TFT-LCD Modules for Industrial Use with Touch Panel

TFT-LCD Modules with PCAP*1 Touch Panel

There is a growing demand in the industrial equipment market for intuitive touch interfaces like those on smartphones and tablet PCs. Mitsubishi Electric has responded to that demand with new LCD modules employing PCAP touch panel technology for superior visibility and durability. Our unique TFT array processing technology coupled with low-resistance material has paved the way to a breakthrough development in microfine sensing wires for touch panels. You can now say goodbye to color shift and hello to superior visibility without the need for any transparent conductive film like ITO^{*2}. Mitsubishi Electric's original detection control treatment technology enables use with protective glass thicknesses up to 2.8mm, realizing enhanced durability. Operation while wearing gloves and detection with water drops on the screen are now possible. Additionally, the new 3rd-generation PCAP product lineup, with units smaller than the 8.4-inch model^{*3}, is equipped with enhanced detection sensitivity including multi-touch^{*4} compatibility up to a maximum of 10 points, and can be used with a protective glass over 5.0mm-thick and when wearing thick heart-resistant gloves. Everything, including the LCD module's touch panel, control board, and driver software has been integrated during manufacturing to deliver all its outstanding features in one neat package. This integrated assembly process ensures a highly reliable user interface environment that delivers steady performance in the toughest industrial or outdoor environments.

*1 PCAP: Projected Capacitive *2 ITO: Indium-tin-oxide *3 Excluding models from 3.5-5.7 inches





Glass bonding and touch panel options are also available. Please contact our sales office.

Intelligent GUI Equipped TFT-LCD Modules

In addition to the DIAFINE industrial TFT liquid-crystal module, we also provide a graphics board easily realizes intuitive operation thanks for a projected capacitive touch panel and high-quality graphics of 60 frames/sec. Utilizing Mitsubishi proprietary GUI designer to combine design images together with input information from industrial devices, burdensome software development is not required anymore, and customer device development costs can be saved drastically.



Tough TFT-LCD Modules

Recently, there is an increasing demand for thinner, lighter industrial-use color TFT-LCD modules. However, the work environment where they are used is often harsh, requiring robust operating characteristics that are contradictory to the features demanded.

Mitsubishi Electric has developed a new product lineup of color TFT-LCD modules for use in harsh work environments. Features include higher vibration resistance capable of withstanding acceleration of up to 6.8G, and a wider operating and storage temperature range, -40 to 85°C.



Glass Bonding Technology

Outdoor-use equipment incorporating LCDs often comes equipped with a glass panel to protect the LCD surface. However, the reflection of sunlight off the surface of the LCD can adversely affect visibility. As a solution, Mitsubishi Electric has introduced bonding of the LCD and protective glass with resin. This minimizes the reflection of sunlight and realizes superior visibility for products with protective glass.



Transflective TFT-LCD Modules

Transflective TFT-LCD modules have both "transmissive" and "reflective" modes, which utilize a backlight or ambient light as a light source respectively. Transmissive mode provides high visibility in dark environment, and reflective mode helps to maintain high visibility under strong sunlight without booting up the backlight brightness. Thus, transflective TFT-LCD modules can save power consumption and are suitable for mobile devices. Mitsubishi Electric currently mass-produces the 5.7-inch and 8.4-inch models, and continues to expand its product lineup.



Wide Product Line-up

Mitsubishi Electric offers a variety of original industrial-use color TFT-LCD modules in addition to its standard and wide format standard models. For example, a ultra-wide 19.2-inch which resolution is one-third the height of full high-definition, 7.8-inch which resolution is half the height of SVGA.



Specification

					Fe	ature	S*1											
Screen Size (inch)	Resolution (pixel)	Model Name	LED Driver	Natural Color Matrix	Second Sector 72%	Transflective	🐝 Super High Brightness	🚺 Super Wide Viewing Angle	Tough TFT-LCD	Surface 🐰	Touch panel $_{s}$	PCAP touch points (Max.)	LCD interface [PCAP interface]	Brightness (cd/m) $_{\&}$	Contrast Ratio	Viewing Angle (°) <u d=""><l r=""></l></u>	Number of Colors	Outline Dimensions (mm) <w><h><d></d></h></w>
3.5	QHD(960x540)	AA035AE01			$\overline{\mathbf{v}}$			$\overline{\mathbf{v}}$		Clear			LVDS	400	800:1	85/85,85/85	262k	90.0x57.0x4.0*4
4.3	Wide-VGA(800x480)	AA043MA01		\checkmark	•			•		Clear			CMOS	200	400:1	45/65,65/65	262k/16.7M	103.0x67.5x5.3
		AA050MG03						$\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{$		Clear			CMOS	900	1000:1	85/85,85/85	16.7M	118.5x84.7x3.9*4
		AA050MG03T1						$\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{\mathbf{$		Clear	RES		CMOS	720	1000:1	85/85,85/85	16.7M	118.5x84.7x5.1*4
50	Wide-VGA	AA050MG03-DA1						\checkmark		Clear	PCAP	Two points	CMOS [UART,USB]	720	1000:1	85/85,85/85	16.7M	129.1x95.3x10.0*4
	(800x480)	AA050MH01						\checkmark		Clear			CMOS	500	1000:1	85/85,85/85	16.7M	118.5x77.8x3.9*4
		AA050MH01T1						V		Clear	RES		CMOS	400	950:1	85/85,85/85	16.7M	118.5x77.8x5.1*4
		AA050MH01-DA1	. /					$\mathbf{\vee}$		Clear	PCAP	Two points	CMOS[UART,USB]	400	1000:1	85/85,85/85	16.7M	129.1x95.3x10.0*4
	QVGA (320x240)	AA057QD01 T1	×							Clear	DEC		CMOS	450	800:1	80/60,80/80	262K	144.0x104.6x8.8
57	(520/(210)	AA057UE12	$\mathbf{\dot{\mathbf{v}}}$	\mathbf{V}			$\mathbf{\nabla}$			Clear	RED		CMOS	1100	600.1	80/60,80/80	202k	135 0x104.0x10.4
5	VGA	AA057VF12T1	V	V			•			AG	RES		CMOS	880	570:1	80/60.80/80	262k	135.0x104.6x10.4
	(640x480)	AA057VG12	V	V		$\overline{\mathbf{v}}$				AR			CMOS	500*3	185:1*3	50/65,80/80*3	262k	135.0x104.6x8.85
	VGA	AA065VE11	•	V		•	$\mathbf{\vee}$			AG			LVDS	1300	600:1	80/60,80/80	262k/16.7M	154.0x121.0x11.0
6.5	(640x480)	AA065VE11ADA11 (NEW		\mathbf{V}			\mathbf{V}			Clear	PCAP	Ten points	LVDS [USB]	1000	600:1	80/60,80/80	262k/16.7M	170.2x132.6x14.5
		AA070MC01	\checkmark	\checkmark			$\mathbf{\mathbf{\vee}}$	$\mathbf{>}$		Clear			LVDS	1000	1000:1	85/85,85/85	262k/16.7M	169.8x109.7x8.9
		AA070MC01ADA11 (NEW	\checkmark	\checkmark				>		Clear	PCAP	Ten points	LVDS [USB]	800	1000:1	85/85,85/85	262k/16.7M	189.8x129.7x13.8
		AA070MC11		\checkmark			$\mathbf{\vee}$	\checkmark		Clear			LVDS	1300	1000:1	85/85,85/85	262k/16.7M	169.8x109.7x8.9
		AA070MC11ADA11		\checkmark			\checkmark	\checkmark		Clear	PCAP	Ten points	LVDS [USB]	1040	1000:1	85/85,85/85	262k/16.7M	189.8x129.7x13.8
		AA070ME01		$\mathbf{\vee}$			$\mathbf{\vee}$			AG	056		LVDS	1000	600:1	60/80,80/80	262k/16.7M	169.8x109.7x8.9
		AA0/0ME0111	$\mathbf{\nabla}$							Clear	RES	Tan naintr		800	5/0:1	60/80,80/80	262k/16./M	169.8x109./x10.5
7.0	Wide-VGA (800x480)		~				\mathbf{N}			AG	PCAP	Temporitis		1500	600:1	60/80 80/80	202K/10.7W	169.00129.7013.0
	(0000 100)	AA070ME11T1		\mathbf{v}			$\mathbf{\tilde{\mathbf{v}}}$			Clear	RES		LVDS	1200	570.1	60/80,80/80	262k/16.7M	169.8x109.7x10.5
		AA070ME11ADA11		V			Ň			Clear	PCAP	Ten points	LVDS[USB]	1200	600:1	60/80.80/80	262k/16.7M	189.8x129.7x13.8
		AT070MJ01	$\overline{\mathbf{v}}$	V			V		$\mathbf{\vee}$	AG			LVDS	1000	800:1	60/80,80/80	262k/16.7M	169.8x109.7x8.9
		AT070MJ11		Ý			V		V	AG			LVDS	1500	800:1	60/80,80/80	262k/16.7M	169.8x109.7x8.9
		AT070MP01 (NEW	\checkmark	\checkmark			<	>	\checkmark	AG			LVDS	1100	1000:1	85/85,85/85	262k/16.7M	169.8x109.7x8.9
		AT070MP11 (NEW		\checkmark			$\mathbf{\vee}$	$\mathbf{>}$	\checkmark	AG			LVDS	1400	1000:1	85/85,85/85	262k/16.7M	169.8x109.7x8.9
7.8	800x300	AA078AA01	\checkmark	\checkmark	\checkmark			\checkmark		AG			LVDS	500	1000:1	85/85,85/85	262k/16.7M	207.0x86.0x10.0
		AA080MB01	\checkmark	V			\checkmark			AG			LVDS	1200	700:1	80/80,80/80	262k/16.7M	192.0x122.0x8.9
8.0	Wide-VGA (800x480)	AA080MB11	. /	\checkmark			\mathbf{V}	. (AG			LVDS	1500	/00:1	80/80,80/80	262k/16./M	192.0x122.0x8.9
	(000/(100)		$\mathbf{\nabla}$				$\mathbf{\mathbf{v}}$	Y	V	AG				1000	1000:1	85/85 85/85	262k/16.7M	192.0x122.0x11.2
		A1080WD11	$\overline{\mathbf{v}}$	\mathbf{v}			V	V	V	AG			LVDS	800	800:1	80/60.80/80	262k/16.7M	199.5x149.0x9.7
	VGA	AA084VJ11	•	Ň			V			AG			LVDS	1500	800:1	80/60,80/80	262k/16.7M	199.5x149.0x9.7
	(640x480)	AA084VM01 (NEW	\checkmark	Ň		\checkmark	•			Clear			LVDS	400*3	150:1*3	25/50,50/35*3	262k/16.7M	199.5x149.0x9.7
		AA084VM11 (NEW		V		\checkmark				Clear			LVDS	750*3	150:1*3	25/50,50/35*3	262k/16.7M	199.5x149.0x9.7
		AA084SC01	\checkmark	\checkmark	\checkmark			>		AG			LVDS	600	1000:1	85/85,85/85	262k/16.7M	199.5x149.0x9.7
		AA084SC01T2	\checkmark	\checkmark	$\mathbf{\vee}$			\checkmark		AG	RES		LVDS	480	950:1	85/85,85/85	262k/16.7M	199.5x149.0x12.0
		AA084SC01ADA11 (NEW	$\mathbf{\vee}$	\checkmark	\checkmark			\checkmark		Clear	PCAP	Ten points	LVDS [USB]	480	1000:1	85/85,85/85	262k/16.7M	209.5x159.0x14.4
	SVGA	AA084SD01	V	V						AG	DEC		LVDS	600	600:1	80/60,80/80	262k/16./M	199.5x149.0x9./
	(0000000)		\mathbf{Y}							AG	RES	Ton pointr		480	5/0:1	80/60,80/80	262K/16./M	199.5X149.0X12.0
8.4		AA084SD11		\mathbf{V}			\mathbf{N}			AG	T CAI	Tempolito		1200	600.1	80/60 80/80	262k/16.7M	199 5x149 0x9 7
		AA084SD11ADA11 (NEW		V			Y			Clear	PCAP	Ten points	LVDS [USB]	960	600:1	80/60,80/80	262k/16.7M	209.5x159.0x14.4
		AA084XD01	\checkmark	Ň				\checkmark		AG			LVDS	700	1000:1	85/85,85/85	262k/16.7M	199.5x149.0x9.7
		AA084XD01ADA11 (NEW	V	V				V		Clear	PCAP	Ten points	LVDS [USB]	560	1000:1	85/85,85/85	262k/16.7M	209.5x159.0x14.4
		AA084XD11		\checkmark			$\mathbf{\mathbf{\vee}}$	$\mathbf{>}$		AG			LVDS	1000	1000:1	85/85,85/85	262k/16.7M	199.5x149.0x9.7
	XGA	AA084XD11ADA11		\checkmark				\checkmark		Clear	PCAP	Ten points	LVDS [USB]	800	1000:1	85/85,85/85	262k/16.7M	209.5x159.0x14.4
	(1024x768)	AA084XE01	$\mathbf{\vee}$	V						AG			LVDS	500	800:1	80/60,80/80	262k/16.7M	199.5x149.0x9.7
		AA084XE01ADA11	$\mathbf{\vee}$	V			. (Clear	PCAP	len points	LVDS[USB]	400	800:1	80/60,80/80	262k/16./M	209.5x159.0x14.4
				V			$\mathbf{\nabla}$			AG	DCAD	Tan naintr		1000	800:1	80/60,80/80	262K/16./M	199.5x149.0x9./
				\mathbf{X}	~			./		AG	PCAP	Temporitis		400	000:1	85/85 85/85	262k/16.7M	209.5X159.0X14.4
	Wide VCA	AA090ME01T1		\mathbf{v}	\mathbf{V}			$\mathbf{\tilde{\mathbf{v}}}$		AG	RES		LVDS	320	850.1	85/85 85/85	262k/16.7M	219.0x136.2x11.1
	(800x480)	AA090MH01	$\overline{\mathbf{v}}$	V	•			•		AG			LVDS	800	800:1	80/60,80/80	262k/16.7M	219.0x136.2x9.5
9.0		AA090MH11	•	V			$\mathbf{\vee}$			AG			LVDS	1500	800:1	80/60,80/80	262k/16.7M	219.0x136.2x9.5
	Wide-XGA	AA090TB01	\checkmark	\checkmark				\checkmark		AG			LVDS	800	1000:1	85/85,85/85	262k/16.7M	219.0x136.2x9.5
	(1280x768)	AA090TB01-DA2	\checkmark	\checkmark				\checkmark		Clear	PCAP	Two points	LVDS[UART,USB]	640	1000:1	85/85,85/85	262k/16.7M	229.0x146.2x14.3
		AA104VJ02	V	$\mathbf{\vee}$						AG			LVDS	900	800:1	80/60,80/80	262k/16.7M	230.0x180.2x9.5
	VGA (640x480)	AA104VJ02T1	$\mathbf{\vee}$							AG	RES		LVDS	720	760:1	80/60,80/80	262k/16.7M	230.0x180.2x11.1
		AA104VJ12	. /	V	. /		$\mathbf{\vee}$. /		AG				600	000:1 1000-1	0U/0U,8U/8U 85/85 85/05	202K/10./M	230.0x180.2X9.5
10.4		AA1045J02-DF1		×.	V			\mathbf{V}		Clear	РСАР	Two noints		480	1000.1	85/85 85/85	262k/16.7M	240.6x190.8x15.0
10.4	SVGA	AA104SL02	\mathbf{v}	\mathbf{v}	V			V		AG	11		LVDS	700	700:1	80/60,80/80	262k/16.7M	230.0x180.2x9.5
	(800x600)	AA104SL02T1	V	V						AG	RES		LVDS	560	670:1	80/60,80/80	262k/16.7M	230.0x180.2x11.1
		AA104SL02-DE1	V	V						Clear	PCAP	Two points	LVDS[UART,USB]	560	700:1	80/60,80/80	262k/16.7M	240.6x190.8x15.0
		AA104SL12		V			$\mathbf{\vee}$			AG			LVDS	1200	700:1	80/60,80/80	262k/16.7M	230.0x180.2x9.5

*1 White LED backlights are used in all models. *2 AG = antiglare treatment, AR = anti-reflection treatment *3 Transmissive mode *4 W/O FPC *5 RES = Resistive Touch Panel

					Fe	ature	s *1											
Screen Size (inch)	Resolution (pixel)	Model Name	LED Driver	Natural Color Matrix	Golor Saturation 72%	Transflective	🐝 Super High Brightness	G Super Wide Viewing Angle	Tough TFT-LCD	Surface _*	Touch panel $_{s}$	PCAP touch points (Max.)	LCD interface [PCAP interface]	Brightness (cd/mi) $_{\&}$	Contrast Ratio	Viewing Angle (°) <u d=""><l r=""></l></u>	Number of Colors	Outline Dimensions (mm) <w><h><d></d></h></w>
	01/04	AA104SL12-DE1		\checkmark						Clear	PCAP	Two points	LVDS [UART,USB]	960	700:1	80/60,80/80	262k/16.7M	240.6x190.8x15.0
	SVGA (800x600)	AT104SN01	$\mathbf{\vee}$	$\mathbf{\vee}$					$\mathbf{\vee}$	AG			LVDS	700	700:1	80/80,80/80	262k/16.7M	230.0x180.2x11.0
	(000000)	AT104SN11		\checkmark			\checkmark		\checkmark	AG			LVDS	1500	700:1	80/80,80/80	262k/16.7M	230.0x180.2x11.0
		AA104XF02	\checkmark	V						AG			LVDS	600	700:1	80/80,80/80	262k/16.7M	230.0x180.2x9.5
		AA104XF02T1	V	V						AG	RES		LVDS	480	670:1	80/80.80/80	262k/16.7M	230.0x180.2x11.1
		AA104XF02-DE2	Ň	V.						Clear	PCAP	Two points	LVDS[UART,USB]	480	700:1	80/80.80/80	262k/16 7M	240 6x190 8x15 0
		AA104XF12	•	V			\mathbf{V}			AG			LVDS	1000	700:1	80/80.80/80	262k/16.7M	230.0x180.2x9.5
10.4		AA104XF12-DE2		V			•			Clear	PCAP	Two points	LVDS[UART,USB]	800	700:1	80/80.80/80	262k/16.7M	240.6x190.8x15.0
	XGA	AA104XG02	\checkmark	V				$\overline{\mathbf{v}}$		AG			LVDS	500	1000:1	85/85.85/85	262k/16.7M	230.0x180.2x9.5
	(1024x768)	AA104XG02-DE1	V	V				V		Clear	PCAP	Two points	LVDS[UART,USB]	400	1000:1	85/85.85/85	262k/16.7M	240.6x190.8x15.0
		AA104XG12		V				V		AG			LVDS	900	1000:1	85/85.85/85	262k/16.7M	230.0x180.2x9.5
		AA104XL02 (NEW	\checkmark	V		\checkmark				Clear			LVDS	250*3	120:1*3	25/50.50/35*3	262k/16.7M	230.0x180.2x9.5
		AA104XL12 (NEW	•	V		V				Clear			LVDS	350*3	120:1*3	25/50.50/35*3	262k/16.7M	230.0x180.2x9.5
		AT104XH01	\checkmark	V					$\overline{\mathbf{v}}$	AG			LVDS	600	700:1	80/80.80/80	262k/16.7M	230.0x180.2x11.0
		AT104XH11		V			\checkmark		Ň	AG			LVDS	1300	700:1	80/80.80/80	262k/16.7M	230.0x180.2x11.0
		AA106TA01	$\overline{\mathbf{v}}$	V			V	$\mathbf{\nabla}$		Clear			LVDS	1000	1000:1	85/85.85/85	262k/16.7M	250.0x157.0x8.9
	Wide-XGA	AA106TA01DDA11	Ň	Ň			•	V		Clear	PCAP	Ten points	LVDS [USB]	800	1000:1	85/85.85/85	262k/16.7M	260.0x167.0x13.8
10.6	(1280x768)	AA106TA11	Ť	Ň			$\mathbf{\nabla}$	V		Clear			LVDS	1000	1000:1	85/85.85/85	262k/16.7M	250.0x157.0x8.9
		AA106TA11DDA11		V			•	V		Clear	PCAP	Ten points	LVDS [USB]	800	1000:1	85/85.85/85	262k/16.7M	260.0x167.0x13.8
		AA121ST01	\checkmark	V	\checkmark			V		AG			LVDS	600	1000:1	85/85.85/85	262k/16.7M	260.5x203.0x9.5
	SVGA	AA121SU01	V	V	•					AG			LVDS	800	800:1	80/80.80/80	262k/16.7M	260.5x203.0x9.5
	(800x600)	AA121SU11	•	V			\checkmark			AG			LVDS	1500	800:1	80/80.80/80	262k/16.7M	260.5x203.0x9.5
		AA121XN01	\checkmark	Ň			·			AG			LVDS	700	800:1	80/80.80/80	262k/16.7M	260.5x203.0x9.5
		AA121XN01-DE2	Ň	V						Clear	PCAP	Two points	LVDS[UART,USB]	600	800:1	80/80.80/80	262k/16.7M	281.8x220.8x15.3
		AA121XN11		V			\checkmark			AG			LVDS	1300	800:1	80/80,80/80	262k/16.7M	260.5x203.0x9.5
	XGA (1024/768)	AA121XN11T1		V			Ň			AG	RES		LVDS	1000	760:1	80/80.80/80	262k/16.7M	260.5x203.0x11.8
	(1024x/00)	AA121XN11-DE1		V			V			Clear	PCAP	Two points	LVDS[UART,USB]	1000	800:1	80/80,80/80	262k/16.7M	281.8x220.8x15.3
		AA121XP01	\checkmark	V	\checkmark		•	$\overline{\mathbf{v}}$		AG			LVDS	500	1000:1	85/85,85/85	262k/16.7M	260.5x203.0x9.5
12.1		AA121XP13	•	V	·		$\mathbf{\vee}$	V		AG			LVDS	1000	1000:1	85/85.85/85	262k/16.7M	260.5x203.0x9.5
		AA121TD01	\checkmark	V						AG			LVDS	800	700:1	80/60,80/80	262k/16.7M	283.0x185.1x9.7
		AA121TD01T1	V	V						AG	RES		LVDS	640	670:1	80/60,80/80	262k/16.7M	283.0x185.1x11.3
		AA121TD01-DE3	V	V						Clear	PCAP	Two points	LVDS[UART,USB]	640	700:1	80/60,80/80	262k/16.7M	303.0x205.1x15.5
		AA121TD11		\checkmark			\checkmark			AG			LVDS	1500	700:1	80/60,80/80	262k/16.7M	283.0x185.1x9.7
	Wide-XGA (1280x800)	AA121TD11-DE1		\checkmark			\checkmark			Clear	PCAP	Two points	LVDS[UART,USB]	1200	700:1	80/60,80/80	262k/16.7M	303.0x205.1x15.5
	(1200)(000)	AA121TH01	\checkmark	$\mathbf{\vee}$				\checkmark		AG			LVDS	500	1000:1	85/85,85/85	262k/16.7M	283.0x185.1x9.7
		AA121TH01-DE1	$\mathbf{\vee}$	$\mathbf{\vee}$				$\mathbf{\vee}$		Clear	PCAP	Two points	LVDS[UART,USB]	400	1000:1	85/85,85/85	262k/16.7M	303.0x205.1x15.3
		AA121TH11		$\mathbf{\vee}$			\checkmark	\checkmark		AG			LVDS	1000	1000:1	85/85,85/85	262k/16.7M	283.0x185.1x9.7
		AA121TH11-DE1		$\mathbf{\vee}$				$\mathbf{\vee}$		Clear	PCAP	Two points	LVDS[UART,USB]	800	1000:1	85/85,85/85	262k/16.7M	303.0x205.1x15.3
14.1	Wide-XGA(1280x800)	AA141TC01		$\mathbf{\vee}$						AG			LVDS	800	700:1	80/60,80/80	262k/16.7M	326.0x216.5x16.0
		AA150XT01		$\mathbf{\vee}$						AG			LVDS	800	800:1	60/80,80/80	262k/16.7M	326.0x255.0x16.6
		AA150XT01T1		$\mathbf{\vee}$						AG	RES		LVDS	640	760:1	60/80,80/80	262k/16.7M	326.0x255.0x18.2
	XGA	AA150XT11		$\mathbf{\vee}$			\checkmark			AG			LVDS	1500	800:1	60/80,80/80	262k/16.7M	326.0x255.0x16.6
15.0	(1024x/68)	AA150XT12-DE1		$\mathbf{\vee}$			\checkmark			Clear	PCAP	Two points	LVDS[UART,USB]	1200	800:1	60/80,80/80	262k/16.7M	346.5x275.0x20.6
. 5.0		AA150XW01	\checkmark	$\mathbf{\vee}$	$\mathbf{\vee}$			$\mathbf{\vee}$		AG			LVDS	500	1000:1	85/85,85/85	262k/16.7M	326.0x255.0x10.5
		AA150XW14					\checkmark	$\mathbf{\vee}$		Clear			LVDS	1000	1000:1	85/85,85/85	262k/16.7M	326.0x255.0x10.5
	SXGA+	AA150PD03	\checkmark	$\mathbf{\vee}$				$\mathbf{\vee}$		AG			LVDS	500	1000:1	85/85,85/85	262k/16.7M	326.0x255.0x10.5
	(1400x1050)	AA150PD13		$\mathbf{\vee}$			\checkmark	$\mathbf{\vee}$		AG			LVDS	1000	1000:1	85/85,85/85	262k/16.7M	326.0x255.0x10.5
17.0	SXGA(1280x1024)	AA170EC01			$\mathbf{\vee}$					AG			LVDS	600	800:1	80/60,80/80	262k/16.7M	358.5x296.5x16.9
17.5	Wide-XGA	AA175TD01		$\mathbf{\vee}$						AG			LVDS	700	700:1	80/60,80/80	262k/16.7M	404.0x258.0x16.2
	(1280x768)	AA175TE03						$\mathbf{\vee}$		AG			LVDS	450	1000:1	85/85,85/85	262k/16.7M	404.0x258.0x16.2
		AA190EA01					V			AG			LVDS	1500	800:1	80/80,80/80	262k/16.7M	404.2x330.0x14.9
19.0	SXGA	AA190EA01-DE1					$\mathbf{\vee}$			Clear	PCAP	Two points	LVDS[UART,USB]	1200	800:1	80/80,80/80	262k/16.7M	434.0x359.0x18.9
	(1200X1024)	AA190EB02	V	V.						AG	DCIT		LVDS	500	800:1	80/80,80/80	262k/16.7M	404.2x330.0x14.9
		AA190EB02-DE1	\mathbf{V}							Clear	PCAP	Iwo points	LVDS[UART,USB]	400	800:1	80/80,80/80	262k/16.7M	434.0x359.0x18.9
19.2	1/3HD	AA192AA01	V							AG			LVDS	500	700:1	80/60,80/80	262k/16.7M	496.0x109.2x13.9
	(1920X300)	AA 192AA 51								AG			LVDS	650	/00:1	80/80,60/80	262k/16.7M	496.0x109.2x13.9

Thinner and lighter

Others

25	QVGA	AC035QG01				\checkmark	AG		SPI+RGB	520	1000:1	85/85,85/85	262k	63.5x85.0x4.5*4
5.5	(240x320)	AC035QG01T1				\checkmark	AG	RES	SPI+RGB	410	950:1	85/85,85/85	262k	63.5x85.0x6.17*4
4.3	Wide-QVGA(480x272)	AC043NA11			\checkmark	\checkmark	AG		CMOS	1000	1000:1	85/85,85/85	16.7M	105.5x67.2x4.5*4
	QVGA(320x240)	AC057QE02					AG		CMOS	600	1000:1	60/80,80/80	262k	127.0x100.0x7.3
5.7	VGA	AC057VK04					AG		CMOS	520	600:1	80/60,80/80	262k	127.0x100.0x7.3
	(640x480)	AC057VK04T4					AG	RES	CMOS	410	570:1	80/60,80/80	262k	127.0x100.0x9.02

15.6 HD(1366x768) AC156GA01 🗸 AG AG LVDS 450 600:1 150,160 16.7M 363.8x215.9x11.1

Regarding the sales of our thinner, lighter models as well as other model availability, please contact a Mitsubishi Electric sales office.

COLOR TFT-LCD MODULES FOR INDUSTRIAL USE

Please visit our website for further details.

www.MitsubishiElectric.com

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IGBT Modules Application Note

The 5th Generation [**CSTBT**[™]] IGBT Chip use

12NF/24NF/24A series

Mar. 2014

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NF/A series IGBT Module Features

- 1. The 5th generation IGBT chip
 - A newly developed IGBT chip, the novel Carrier Stored Trench Gate Bipolar Transistor (CSTBTTM), meets all requirements for low on-state voltage V_{CE(sat)} and low on-state losses.

CSTBT[™]: Carrier Stored Trench Gate Bipolar Transistor



A significant performance with an excellent natural short circuit capability (SCSOA) and reduced gate capacitance was obtained by employing the novel Plugged Cell Merged (PCM) surface pattern.



■ 1200V chips are using Light Punch Through (LPT) structure, and 600V chips are using Punch Through (PT) structure.





- 2. Low inductance package
 - Full package compatibility with Mitsubishi Electric's 3rd generation H series IGBTs allows easy drop-in replacement without needing changes to either the bus bar or the heat sink. In addition, the same low inductance as F series has been achieved by the low inductance package.



Product Line-up

■IGBT Modules

Dual	MPD	CM150TL-24NF	
<u>600V</u>	<u>1200V</u>	CM200TL-24NF	Dual (A series)
CM150DY-12NF	CM900DU-24NF		<u>1200V</u>
CM200DY-12NF	CM1400DU-24NF	7pack	CM100DY-24A
CM300DY-12NF		<u>600V</u>	CM150DY-24A
CM400DY-12NF	6pack	CM 75RL-12NF	CM200DY-24A
CM600DY-12NF	<u>600V</u>	CM100RL-12NF	CM300DY-24A
	CM 75TL-12NF	CM150RL-12NF	CM400DY-24A
<u>1200V</u>	CM100TL-12NF	CM200RL-12NF	CM600DY-24A
CM100DY-24NF	CM150TL-12NF		
CM150DY-24NF	CM200TL-12NF	<u>1200V</u>	Single (A series)
CM200DY-24NF		CM 50RL-24NF	<u>1200V</u>
CM300DY-24NF	<u>1200V</u>	CM 75RL-24NF	CM400HA-24A
CM400DY-24NF	CM 50TL-24NF	CM100RL-24NF	CM600HA-24A
CM600DU-24NF	CM 75TL-24NF	CM150RL-24NF	CM600HB-24A
	CM100TL-24NF	CM200RL-24NF	

%MPD (Mega Power Dual) : "Mega Power Dual" IGBT module sizes available are 900A and 1400A at 1200V.

Related Products

Rectifier Diode Modules

RM20TPM-H	RM20TPM-2H
RM30TPM-H	RM75TPM-M, H, 24,2H

■ Fast Recovery Diode Modules (for CRDi snubber circuit)

RM50HG-12S RM25HG-24S

Hybrid ICs (ISAHAYA Electronics Corporation : for more information please refer to : http://www.idc-com.co.jp/)

VLA500-01	M57959AL-01
VLA502-01	M57962AL-01
M57159L-01	M57962CL-01



Term Explanation

Term Explanation

General 1		
Symbol		Definition
IGBT	Insulated Gate Bipolar Transistor	
FWDi	Free Wheeling Diode	anti-parallel to the IGBT
IPM	Intelligent Power Module	
tdead	Dead Time	Low side turn-off to high Side turn-on & High Side turn-off to low side turn-on
IPM Motor	Interior Permanent Magnet Motor	
(PC)	Opto-coupler	
PC	Programmable Controller	
CMR	Common Mode Noise Reduction	The maximum rise ratio of common mode voltage
CM _H		The maximum rise ratio of common mode voltage at the specific high level
CML		The maximum rise ratio of common mode voltage at the specific low level
CTR	Current Transfer Ratio	the ratio of the output current to the input current

General 2

Symbol	Parameter	Definition
Ta	Ambient Temperature	Atmosphere temperature without being subject to thermal source
Tc	Case Temperature	Case temperature measured at specified point
T _c '	Case Temperature	Case temperature measured at specified point different from the Tc measured point

Absolute maximum Ratings

		· · · · · · · · · · · · · · · · · · ·
Symbol	Parameter	Definition
V _{CES}	Collector-Emitter Blocking Voltage	Maximum Off-state collector-emitter voltage with gate-emitter shorted
V _{GES}	Gate-Emitter Voltage	Maximum gate-emitter voltage with collector-emitter shorted
lc	Continuous Collector Current	Maximum collector current – DC
I _{CM}	Peak Collector Current Repetitive	Peak collector current, Tj≤150°C
Ι _Ε	Continuous FWDi Current	Maximum diode current – DC
I _{EM}	Peak FWDi Current Repetitive	Diode peak current, Tj≤150°C
Pc	Power Dissipation	Maximum power dissipation, per device, T _C =25°C
Tj	Junction Temperature	Allowable range of IGBT junction temperature during operation
т.	Storage Temperature	Allowable range of temperature within which the module may be stored or
I stg	Storage remperature	transported without being subject to electrical load.
V.	Isolation Voltage	Minimum RMS isolation voltage capability applied all shorted electric terminal
V ISO	Isolation voltage	to base plate, 1 minute duration
-	Mounting Torque	Allowable tightening torque for terminal and mounting screws

I E and I F are using by the difference of the connection and so on like the following figure.







Symbol	Parameter	Definition
	Collector-Emitter Leakage	I_C at $V_{CE} = V_{CES}$, $V_{GE} = 0V$
ICES	Current	
V _{GE(th)}	Gate-Emitter Threshold Voltage	V_{GE} at I _C = specified mA, V_{CE} = 10V
I _{GES}	Gate-Emitter Leakage Current	I_G at V_{GE} = V_{GES} , V_{CE} = 0V
V	Collector-Emitter Saturation	V_{CE} at I_C = rated I_C and V_{GE} = 15V
V CE(sat)	Voltage	
Cies	Input Capacitance	Gate-Emitter capacitance with V _{CE} =10V
Coes	Output Capacitance	Collector-Emitter capacitance with the gate shorted to the emitter
C	Reverse Transfer Capacitance	Gate-Collector capacitance with the emitter connected to the guard terminal
Ores		of the impedance analyzer
t _{d(on)}	Turn-on Delay Time	Time from $V_{GE}=0V$ to $I_{C}=10\%$ of final value
t _r	Rise Time	Time from $I_C=10\%$ of final value to $I_C=90\%$ of final value
t _{d(off)}	Turn-off Delay Time	Time from V_{GE} =90% of initial value to I_C =90% of initial value
t _f	Fall Time	Time from $I_C = 90\%$ of initial value to $I_C = 10\%$ of initial value
		Energy dissipated inside the IGBT during the turn-on of a single collector
Eon	Turn-on Switching loss	current pulse. Integral time starts from the 10% rise point of the collector
		current and ends at the 10% of the collector-emitter voltage point.
		Energy dissipated inside the IGBT during the turn-off of a single collector
		current pulse. Integral time starts from the 10% rise point of the
E _{off}	Turn-off Switching loss	collector-emitter voltage and ends at the specified low collector current point,
		x% of Ic.
		x%:2% (NF/A series) , 10% (F series)
Err	Recovery loss	
	Diada Davaraa Daaayar / Tima	Time from I _C =0A to projection of zero I _C from Irr and $0.5 \times$ Irr points with I _E =
Lrr	Didde Reverse Recovery Time	rated I _C .
0	Diada Davaraa Daaayar (Charga	Area under Irr curve from I _c =0A to projection of zero I _c from Irr and $0.5 \times$ Irr
Qrr	Diode Reverse Recovery Charge	points with I_E =rated I_C and at specified di/dt.
V _{EC}	Forward Voltage Drop of Diode	V_{EC} at $-I_{C}$ = rated Ic
D	Thermal Desistance	The rise of junction temperature per unit of power applied for a given time
Rth	Thermal Resistance	period
Р	Thermal Resistance, Junction to	L conducting to establish thermal equilibrium
r∿th(j-c)	Case	
R _{th(c-f)}	Thermal Resistance, Case to Fin	I _C conducting to establish thermal equilibrium lubricated
R _G	Gate Resistance	Allowable range of gate resistance

Electrical and Thermal Characteristics

Parts name (example : MPD)

Case

Cover

-Main terminals

Collector sense terminals

Gate/Emitter auxiliary (signal) terminals

Label

· · · · ·

Base plate



Numbering System

Numbering System



Table A. Voltage Class

	IGBT n	nodules	Rectifier Diode modules		
AC Input Voltage (V)	Voltage Class	V _{CES} (V)	Voltage Class	V _{RRM} (V)	
220 ~ 240	12	600	Н	800	
440 ~ 480	24	1200	2H	1600	
575 ~ 600	34	1700	40	2000	
~ 690	- 34	1700	-	-	

Table B. Connection Diagram : without mark on nameplate

H: Single	D: Dual	T: 6pack	R: 7pack
(F) + <u>H</u> + (¢) ⊊			

Lot number

	~ • • •						
<u>S</u>	5	1	<u>A A 1</u>	<u>G</u>	<u> </u>	$\frac{-0}{ }$ 0 1	
		İ	i	İ		I 	-Serial number (not included during mass-production)
					L		 Symbol of V_{CE(sat)} rank for parallel use
				L			 – RoHS Directive compliance symbol
			L				 Manufacturing lot management number
 L	 						 Manufacturing month (Jan~Sept:1~9, Oct:O, Nov:N, Dec:D) Manufacturing year (the last digit of A.D., 5=2005) UL ID code (UL recognized products only) ex.) N:IT semicon ichijima factory



Example Applications of IGBT Modules to AC Motor Controls(General purpose Inverter)

■AC220V Line

Motor Ratings		For Converter		
(kW)	NF Series	F Series	U Series	Diode
5 5			CM75TU-12H	
5.5	CIMP STE/RE-12INI	CIM7 51 0-121	CM75DU-12H × 3	
7.5	CM75TL/RL-12NF	CM75TU-12F	CM100TU-12H	
7.5		CM/ 310-121	CM100DU-12H × 3	
11	CM100TL/PL 12NE	CM100TU 12E	CM100TU-12H	RM50TC-H
11	CIVITOUTE/RE-T2INF	CM10010-12F	CM100DU-12H × 3	RM60DZ-H × 3
15	CM150DY-12NF × 3	CM150TU 12E	CM150TU-12H	RM75TC-H
15	CM150TL/RL-12NF	CIM15010-121	CM150DU-12H × 3	RM60DZ-H × 3
19.5	CM200DY-12NF × 3	CM200TU 12E	CM200TU-12H	
10.5	CM200TL/RL-12NF	CM20010-12F	CM200DU-12H × 3	RIVIOUDZ-H × 3
22	CM200DY-12NF × 3			RM100DZ-H × 3
22	CM200TL/RL-12NF	CINS00D0-121 ~ 3		
30	CM300DY-12NF × 3	CM300DU-12F × 3	CM300DU-12H × 3	RM100DZ-H × 3
37	CM400DY-12NF × 3	CM400DU-12F × 3	CM400DU-12H × 3	RM150DZ-H × 3
45	CM400DY-12NF × 3	CM400DU-12F × 3	CM600HU-12H × 6	RM150DZ-H × 3
55		CM600DU-12F × 3		
55	CIVIOUUDIT-IZINE × 3	CM600HU-12F × 6		RM150DZ-H \times 3

■AC440V Line

Motor Ratings		For Converter		
(kW)	NF Series	F Series	U Series	Diode
5.5	CM50TL/RL-24NF	CM50TU-24F	CM50TU-24H	RM15TA-2H
			CM50DU-24H × 3	
7.5	CM50TL/RL-24NF	CM50TU-24F	CM50TU-24H	RM20TA-2H
			CM50DU-24H × 3	
11	CM75TL/RL-24NF	CM75TU-24F	CM75TU-24H	RM50TC-2H
			CM75DU-24H × 3	
15	CM75TL/RL-24NF	CM100TU-24F	CM100TU-24H	RM30DZ-2H × 3
			CM100DU-24H × 3	
18.5	CM100DY-24NF × 3	CM150DU-24F × 3	CM150DU-24H × 3	RM60DZ-2H × 3
	CM100DY-24A × 3			
	CM100TL/RL-24NF			
22	CM100DY-24NF × 3	CM150DU-24F × 3	CM150DU-24H × 3	RM60DZ-2H × 3
	CM100DY-24A × 3			RM50TC-2H
	CM100TL/RL-24NF			
30	CM150DY-24NF × 3	CM200DU-24F × 3	CM200DU-24H × 3	RM60DZ-2H × 3
	CM150DY-24A × 3			
07	CM150TL/RL-24NF		01/000001100/11	
37	CM200DY-24NF × 3	CM200DU-24F × 3	CM200DU-24H × 3	RM60DZ-2H × 3
	$CM200DY-24A \times 3$			
45				
45	$CM200DY 24A \times 3$	CIVI300D0-24F × 3	CIVI300D0-24H × 3	RIVITUUDZ-2H × 3
	CM200D1-24A ~ 3			
55	$CM300DY-24NF \times 3$	CM300DU-24F x 3	CM300DU-24H × 3	RM150D7-2H × 3
	$CM300DY-24A \times 3$		0	
75-90	CM400DY-24NF × 3	CM400HU-24F × 6	CM400HU-24H × 6	RM150DZ-2H × 3
	CM400DY-24A × 3			
	CM400HA-24A × 6			
110	CM600DY-24NF × 3	CM600DU-24F × 3	CM600HU-24H × 6	RM250DZ-2H × 3
	CM600DY-24A × 3	CM600HU-24F × 6		
	CM600HA-24A × 6			
	CM600HB-24A × 6			



Mitsubishi IGBT Modules <NF/A> series Application Note

Structure (Dual)



MPD (an image figure for the ~600A comparison. The actual structure is different.)



About the flammable

The epoxy to be using for IGBT module has the fireproof of the UL 94V-0 fitness, but the silicone gel is combustible and does not base plate in with UL 94V-0.

The breakdown strength after the hardening is using the product of the characteristic above 10kV/mm at the 340°C flash point, the 450°C ignition point.

Because there is not self extinguish-ability, too, in case of the fire, a fire must be extinguished using the dry chemicals, the carbon dioxide extinguishing agent and the bubble extinguishing agent and so on.

Because epoxy has self extinguish-ability, if a burning source is cut off, there is not live danger.

There is not a fireproof standard of UL which corresponds to the other silicon chip, the copper base board and so on.



Safety Standard (UL)

Safety Standard (UL)

Compliance with international standard UL1557 has already been certified (File No. E80271). Please refer the certified modules to UL homepage.

1. Certified modules can be searched through the following website (2007/12), click the Certifications button, and input the card number E80276 in frame of UL File No, then hit the SEARCH button.

http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/index.htm

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2. In the search results page as in the below figure, click QQQX2.E80276 shown in cell of Link to File, then the certified module table will be displayed (refer to the next page).

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Safety Standard (UL)

Certified Modules Power Switching Semiconductors - Component **Guide Information** MITSUBISHI ELECTRIC CORP. 280276 SEMICONDUCTOR DIV MITSUEISEI DENKUBLDG MARUNOUCH TOKYO 100-8310, JAPAN Diades, Type RM as 58 tollowed by 10, 15, 20, 10, 40, 50, 40, 15, 100, 150, 200, 200, 100, 400 as 500, referred by C, CLA, CLA, CLZ, CLZ, CA, CF, CZ, DZF, DA, DF, DZ, HA, HO, TA, TB, TO, TPM as UZ, followed by 1H, 5H, 65, 10F, 12, 120, 125, 16, 160, 20, 200, 205, 20, 200, 205, 40, 11 or M KARTER B., THAM, RATETICH, TRAM, TEM 21, KARTEM 20, TEM 24, TEM 11, TEM 14, KARTER H. TB-M. TPM-H. TPM-M. Power switching semi-conductors, Cut. Nov. ECR30004, Types A, B, C. Type EM toleward by 15, 20, 25, 10, 50, 75, 100, 150, 200, 100, 400,401, 401, or 1000, 1200, tolewardby EX, 127, 1371, ESY, HA, HAL, HE, HK, TF or TX, followed by -10, -11E, -126, -11H, -12HE, -20, -24, -24E, -34G, -24H, -34J, -28 or -2511 4. Naming Approach CM150DY-12NF as an example, from the line 7th to the 10th of Power Switching Semi-conductors table(In square frame) Type CM followed by -10,15,20....or 24H, the module is named by combination of CM, 150, DY, -12NF. Power switching semi-conductors, Cat. Nos. BCR30GM; Types A, B, C. Type CM followed by 10, 15, 20, 25, 30, 50, 75, 100, 150, 200, 300, 400, 600, 800, or 1000, followed by AD00 thru AD63, DY, E3Y, HA, LD, LDL, MD, MDL, MD1, MD1L, MD3 or MDC, followed by -12H, -24H, -28H or -28K. Type CM followed by 15, 20, 25, 30, 50, 75, 100, 150, 200, 300, 400 600, 800, or 1000, 1200, followed by DK, DY, DY1, E3Y, HA, HA1, HB, HK, TF or TX, followed by -12, -12E, -12G, -12H, -12HE, -20, -24, -24E, -24G, -24H, -24J, -28 or -28H. Type CM followed by -10, 15, 25, 40, 50, 75, 100, 110, 150, 165, 200, 300, 400, 450, 600, 800, 900 or 1400, followed by BU, BU1, DU, DUM, DUR, DUS, DY, E2U, EU2A, EC2U, E3U, E3UA, EC3U, HU, HUA, HUE, HUS, RU, TJ, TJA, TU, YE4, YE2N, YE2P, YE4 or YE13, followed by -5F, -12, -12F, -12H, -12NF, -12NFA, -12NFH, -24, -24A, -24F, -24NF, -24NFH or -24H. Type FM followed by 15, 20 or 30, followed by BF or TF, followed by -5, -6, -9, -98, -10 or -108. Type FM followed by 30, 50, 75 or 100, followed by DW, DY, E2Y, E3Y, HA or HY, followed by -1, -9, -98, -10 or -108. Type CM followed by 40, 50, 75, 100, 150 or 200, followed by RL, TL or YE13, followed by -12F, -12H, -12NF, -12NFB or -24NF. Type PM followed by 10, 15, 20, 25, 30, 50, 75, 100, 150, 200, 300, 400, 600 or 800, followed by B, C, D, E, H, R or V, followed by AN, B\$, EA, FE, HA, HB, HC, H\$, KA, KF, KK, LA, LB, LG, MA, MC, NA, NC, NE, NJ, RA, RB, R\$, \$A, SB, SC, SD, SE, SEA, SF, SH, SJ, SK, TJ, TK, TM, VA, VD or ZF, followed by 060, 060-1, 060-3, 060-4, 060-5, 060-8, 060-9, 060-10, 060-12, 060-13, 060-16, 060-17, 060-21, 060-22, 060-39, 120, 120-1 or 120-2 or 120-18.



^{*} Not the product that the form name which derives in the combination has authorized (and, are producibility) all UL.

^{*} There is a case of the omission of the update delay and the authorization article according to the convenience of the update of HomePage.

^{*} When a corresponding article isn't found out, please contact us...

^{*} At present, we don't publish yellow card "E80276".

Correct and Safety Use of Power Module

Unsuitable operation (such as electrical, mechanical stress and so on) may lead to damage of power modules. Please pay attention to the following descriptions and use Mitsubishi Electric's IGBT modules according to the guidance.

	I Cautions
During Transit	 Keep sipping cartons right side up. If stress is applied by either placing a carton upside down or by leaning a box against something, terminals can be bent and/or resin packages can be damaged. Tossing or dropping of a carton may damage devices inside. If a device gets wet with water, malfunctioning and failure may result. Special care should be taken during rain or spow to prevent the devices from getting wet
Storage	 The temperature and humidity of the storage place should be 5~35°C and 45~75% respectively. The performance and reliability of devices may be jeopardized if devices are stored in an environment far above or below the range indicated above.
Prolonged Storage	• When storing devices more than one year, dehumidifying measures should be provided for the storage place. When using devices after a long period of storage, make sure to check the exterior of the devices is free from scratches, dirt, rust, and so on.
Operating Environment Flame Resistance	 Devices should not be exposed to water, organic solvents, corrosive gases, explosive gases, fine particles, or corrosive agents, since any of those can lead to a serious accident. Although the epoxy resin and case materials are in conformity with UL 94-V0 standards, it should be
Anti-electrostatic Measures	 noted that those are not non-flammable. Following precautions should be taken for MOS-gated devices such as IGBT modules (CM***Series), to prevent static build up which could damage the devices.
	 (1) Precautions against the device rupture caused by static electricity Static electricity of human bodies and cartons and/or excessive voltage applied across the gate to emitter may damage and rupture devices. The basis of anti-electro static build-up and quick dissipation of the charged electricity. * Containers that are susceptible to static electricity should not be used for transit nor for storage. * Gate to emitter should be always shorted with a carbon cloth or the like until right before a module is used. Never touch the gate terminals with bare hands.
Anti-electrostatic Measures	 * Always ground the equipment and your body during installation (after removing a carbon cloth or the like. It is advisable to cover the workstation and it's surrounding floor with conductive mats and ground them. * It should be noted that devices may get damaged by the static electricity charged to a printed circuit board if the gate to emitter of the circuit board is open. * Use soldering irons with grounded tips.
	 (2) Precautions when the gate to emitter is open * Voltage should not be applied across the collector to emitter when the gate to emitter is open. * The gate to emitter should be shorted before removing a device from a unit.



Correct and Safety Use of Power Module





1. Installing Capacitor

During switching, voltage is induced in power circuit stray inductance by the high di/dt of the main current. This voltage can appear on the IGBT module and cause damage. In order to avoid this problem, guidelines that should be followed in designing the circuit layout are:

- ① Located the smoothing capacitor as close as possible to the IGBT module
- ② Use ceramic capacitor near the IGBT module to bypass high frequency current
- ③ Adopt low impedance electrolytic capacitor as smoothing capacitor
- ④ Use snubber circuit to absorb surge voltage
- ⑤ Decrease switching speed in order to lower di/dt.

@ and @ are the most effective to reduce surge voltage. The stray inductance of snubber circuit generally is not considered to avoid complicating the circuit. In addition, combination of @, @, @ is needed since there is a limit on the length of wiring. The bypass capacitor of approach @ act as a snubber when oscillation is occurring.



- L1 : Stray inductance between the smoothing (electrolytic) capacitor and the IGBT module.
- L2 : Stray inductance between the snubber (filter) capacitor and the IGBT module.
- L3 : Stray inductance between the load and the power circuit's output stage

2. Installation Hints

When mounting IGBT modules on a heat sink, uneven mounting can cause the modules ceramic isolation to crack. To achieve the best thermal radiation effect, the bigger the contact area is, the smaller the thermal resistance is. Heat sink should have a surface finish in range of Rz6 ~ Rz12, curvature within 100µm (for 24A series products, heat sink should have a surface roughness within 10µm, curvature within 20µm corresponding to 100mm length).

Uniform coating of thermal grease between the module and heat sink can prevent corrosion of contact parts. Select a compound, which has stable characteristics over the whole operating temperature range and does not change its properties over the life of the equipment. (See Table1 for suggested type).

Use a uniform coating of thermal interface compound.

The thickness of thermal grease should be ranked in 100~200µm (24A series 50~100µm) according to the surface finish. Mounting screws should be tightened by using a torque wrench to the prescribed torque in progressive stages in a cross pattern. As mentioned before, over torque terminal or mounting screws may result in damage of IGBT modules. When an electric driver is used, thermal grease with low viscosity is recommended and extra grease must be extruded before final tightening screws.

* For the recommended torque order for mounting screws referring to "Inistallation Method" in the section of "Correct and Safety Use of Power Module"

Note) Maximum torque specifications are provided in device data sheets. The type and quantity of thermal compounds having an effect on the thermal resistance are determined by consideration of both thermal grease and heat sink. Typical value given in datasheet is measured by using thermal grease producted by Shin-Etsu Chemical Co.,Ltd. (G-746, which has not issued in Shin-Etsu's publications, is almost the same as G-747.)



Note : Usually the mounting screws are prepared for users as accessories with module. But for some reasons, this service is stopped for NF series products.

Table. T					
Size	Туре	Manufacturer	(2004/09/30 to present)		
M4 × 8/10	Cross recess nuts and screws	Toyo Bussan Co. Ltd.	http://www.tobutsu.co.jp/		
M5×12	Cross recess nuts and Hexagon head bolts				
M6×12	Cross recess nuts and Hexagon head bolts	FC tech Company	+81-52-991-7311		
M8×16	Cross recess nuts and Hexagon head bolts				
M5~N	M5~M8 Hexagon head bolt : JIS B 1187				

The mounting screws for 《H Series》 modules can be referred according to Table 1.

Table.2 The terminal screw attached products

Module type	Size	Screw type
CM150DY-12NF, CM200DY-12NF, CM300DY-12NF CM100DY-24NF, CM150DY-24NF CM100DY-24A, CM150DY-24A, CM200DY-24A	M5 × 12 (main)	Cross-recessed hexagon screws with washer
CM400DY-12NF, CM600DY-12NF CM200DY-24NF, CM300DY-24NF, CM400DY-24NF CM300DY-24A, CM400DY-24A, CM600DY-24A	M6 × 12 (main)	Cross-recessed hexagon screws with washer
	M6 × 12 (main)	Cross-recessed hexagon screws with washer
	M4 × 10 (auxiliary)	Cross-recessed pan head screws with washer
	M8×16 (main)	Cross-recessed hexagon screws with washer
	M4 × 10 (auxiliary)	Cross-recessed pan head screws with washer
	M8 × 16 (main)	Cross-recessed hexagon screws with washer
	M4 × 8 (auxiliary)	Cross-recessed pan head screws with washer



Note: when used the screw except the attached screw, be careful of the screw length. If use the screw which is long more than necessary, the bursting screw head reaches gel and an aluminum wire in the module and causes the device destruction in the resin of the terminal area. Use a screw with the length which is the optimal for the top to refer to the thickness and the following size of the terminal for the connection.



Terminal screwing hole depth and thickness(Unit in mm tolerance: ± 0.3 mm)

V _{CES} (V)	Part number	Screw size		А	В	С	depth
600	CM150DY-12NF, CM200DY-12NF, CM300DY-12NF	main	M5	12.5	4.2	1	13.2
1200	CM100DY-24NF, CM150DY-24NF CM100DY-24A, CM150DY-24A, CM200DY-24A			12.5	7.2		10.2
600	CM400DY-12NF	main	M6	13.7	5.2	1	14.4
600	CM600DY-12NF						
1200	CM300DY-24NF,CM400DY-24NF, CM400DY-24A	main	M6	12	5.3	1	12.7
1200	CM600DU-24NF	main	M8	11	7.3	1.6	12.3
		auxiliary	M4	6.2	3.2	0.5	6.4
600	CM75TL/RL-12NF, CM100TL/RL-12NF, CM150TL/RL-12NF	main	ME	10	4.2	1	10.7
1200	CM50TL/RL-24NF, CM75TL/RL-24NF, CM100TL/RL-24NF	main ivio		12	4.2		12.7
600	CM200TL/RL-12NF	main M5		15	4.2	1	15.7
1200	CM150TL/RL-24NF, CM200TL/RL-24NF						
1200	CM400HA-24A, CM600HA-24A	main	M6	11.5	5	1	12.2
		auxiliary	M4	8.2	3.2	0.8	8.7
1200		main	M8	12.4	7	1	13.1
		auxiliary	M4	8.2	3.5	0.8	8.7
1200	CM900DU-24NF, CM1400DU-24NF	main	M6	15	5.2	1.2	16.3

X Not include the float of the terminal in size C.

The expression with minimum valid depth

The formula with minimum valid depth in CM600DU-24NF is as the following.

The main terminal The auxiliary terminal A - tolerance + C=11-0.3+1.6=12.3 mm

A - tolerance + C=6.2-0.3+0.5=6.4 mm



3. Thermal Impedance Considerations

The junction to case thermal resistance $R_{th(j-c)}$ and the case to heat sink thermal resistance $R_{th(c-f)}$ are given in datasheet. The case temperature has been measured at the side of base. However, the European standards indicate that the temperature measurement point is just under the chip.

The case temperature measurement point of various products is shown in Table 3-1, 3-2, 3-3, 3-4, 3-5 and Table 3-6. It is measured by uniform $100\mu m \sim 200\mu m$ (50~100 μm for 24A single series) coating of thermal grease with thermal conductivity of 0.92W/m $^{\circ}$ C between the module and heat sink. A Thermo-couple is used to measure the temperature of case and heat sink at the same point shown in the following tables. (0.8 ϕ 3mm depth, 0.3 ϕ thermo-couple)

Note

*The thermal impedance depends on the material, area and thickness of heat sink. The smaller the area and the thinner the heat sink is, the lower the impedance is for the same material.

%The type and quantity of thermal compounds can affect the thermal resistance.

The thermal impedance just under the chips for Dual types (unit 1 C/W)											
Part number	R _{th(j-c)} maximum		Contact	Part number	R _{th(j-c)} m	Contact					
Fait number	IGBT	FWDi	(typical)	Fait number	IGBT	FWDi	(typical)				
CM150DY-12NF	0.16	0.29	0.022	CM100DY-24NF	0.13	0.23	0.022				
CM200DY-12NF	0.13	0.22	0.022	CM150DY-24NF	0.093	0.17	0.022				
CM300DY-12NF	0.093	0.16	0.022	CM200DY-24NF	0.066	0.12	0.02				
CM400DY-12NF	0.066	0.11	0.020	CM300DY-24NF	0.046	0.085	0.02				
CM600DY-12NF	0.046	0.078	0.018	CM400DY-24NF	0.034	0.062	0.018				
—	_	—	—	CM600DU-24NF	0.023	0.042	0.015				

The thermal impedance just under the chips for Dual types (unit : $^\circ$ C/W)

* With the thickness of the heat sink to use, the thermal resistance R_{th(f-a)} of the heat sink sometimes changes with the area of it with the material of it.

The smaller the area is in the heat sink with the identical material, the thinner the thickness becomes, the bigger the thermal resistance becomes.

* With the amount of coating of grease, contact thermal resistance R_{th(c-f)} sometimes changes with the kind of it.

* As for water-cooled, the: general industrial power module presupposes use by the cooling system, which used an auto cooling, and an air-cooled heat sink.

When using a water-cooled heat sink, the qualitatively of the expanse of the heat, thermal resistance $R_{th(j-c)}$ sometimes change substantially.

* Because the package of the: general industrial power module is not secret structure in the basic of it about the liquid cooling, it is possible for liquid to invade easily inside the module.

We assume and we aren't designing long-range contact with the one except the package material, the semiconductor chips, the silicone gel to be using.

Therefore, when making IGBT module silicone oil and so on in the immersion as for oil cooling, therefore, the characteristic and the reliability cannot be guaranteed.















Table 3-2 Chip location - 600V class 7pack CM75RL-12NF (Tr : IGBT, Di : FWDi) (Unit : mm) 27.6 37.6 75.0 47.2 57.4 -84.4 -90.4 0 ٠Û Та M ٦, ln. 26.0 œ 32.0 2 34.2 20,9 **F** 26.4 22 ŧ Ð 34.8 Br 57.6-37.4ò ف Ó, à 94. 2. 4. 74. \$. (106)LABEL SIDE (120) (11) CM100RL-12NF (Tr : IGBT, Di : FWDi) 59.0 73.8 84,8 .94.0 2 æ 5 26 4 0 O ۱n 63 22. o, 32 o 34. ž Τı 22.5 ÷ θ (55)Æ 교 Ir Br 38.0 58.8 73.8-84.8-26.2-37.4. 48.0ò 95. (106)LABEL SIDE (120) (11)










































Mitsubishi IGBT Modules <NF/A> series Application Note Installation of Power Module







Mitsubishi IGBT Modules <NF/A> series Application Note

Reliabilitiy

Reliability

1. Introduction

It has only been somewhat over 30 years since semiconductor devices such as rectifier diodes, thyristors, and transistors gained widespread acceptance for use in industrial machinery and consumer appliances, but during that period the reliability standards for these devices have made rapid advances.

In equipment where high reliability is a must, failure rate of the semiconductor devices must range from 10 to 100 FIT (1 FIT=10⁻⁹/hours). Of course, to achieve such reliability in the equipment itself, not only must each individual device be reliable, but also it is also extremely important to match the specific characteristics of the device with its application within the piece of equipment. In fact, information obtained in field studies show that for semiconductor devices manufactured using identical procedures, failure rates in the field could vary by a factor of 10 depending simply on how the device was used.

The following information covers device reliability with regards to how a device is used. An introductory discussion is also presented on quality-control procedures, and some examples of reliability testing data are given.

2. Basic Concepts of Semiconductor Device Reliability

2.1 Semiconductor Device Failure Rate Varied with The Lapse of Time







Fig.2 Semiconductor Device Failure Rate Versus Time

The failure rate of devices used in an average piece of equipment can be expressed by using the bathtub curve shown in Fig.1, line (a). Taken from the standpoint of time, device failures can be classified as an early failure, random failure and wear out failure period.

Three points must be considered regarding the service life of a device; early and random failures rate, and lifetime before wear out.

But the failure rate of semiconductors is illustrated by line (b) in the graph, where failure rate is shown to gradually diminish as a factor of time. In other words, a notable feature of semiconductor devices is that the longer a particular device has been used, the more stable it will be. Viewed from a different perspective, even though random failure rate has been reduced to virtual stability, the failure distribution pattern shows early failures to still be prevalent. As shown by Fig.2 where failure rate versus time is given for an actual device, the highest failure rate occurs immediately after manufacture, but the process of ageing and debugging gradually lowers this failure rate.

The next step is with the user, who assembles, adjusts, and takes the device aging. Failure rates continue to decline during this period also. Generally, the rate for major defect during this period drops to less than 0.1%, and if this rate is exceeded by a substantial margin, one must look for a fault in the circuit design, assembly procedure, or the device itself. Unless the problem is found and corrected, frequent field failures will be the likely result. In most cases, the field failure rate can be correlated to major defect during this period, so this is an important aspect of device reliability.

Upon transferring the equipment to field service, the stress level is reduced further, with a corresponding drop in failure rates. Failure rates normally range from several FIT to several hundred FIT during this period.

On the other hand, the user must design greater margins. For example, diodes and thyristors should be operated at $50 \sim 60\%$ of their maximum voltage ratings or lesser, and junction temperatures should not exceed $70 \sim 80\%$ of maximum rating. It is also important to remember that a device must be in working harmony with other components in the circuit for maximum reliability standards can be assured.

When designing a piece of equipment for reliable service, device selection must be considered from a standpoint of performance, reliability, and economy. Since it is not easy to achieve high performance/reliability and economy at the same time, a balance must be struck on the side of practical value. In other words, device selection should be based on the user's expectations for the machine he is designing.



2.2 Power Module Failure Reason

After a piece of equipment has been assembled and adjusted, or has been placed in field service, failed devices that are returned to the factory are analyzed to determine the cause of failure. This procedure is intended to determine whether the problem lays with the device itself, or the manner in which it was used. This section will list potential reasons of failure.

• Good	Device Unmatch for Circuit or Usage Condition
Usage Condition	Over voltage
	└── V _{CE} Over voltage (Collector-Emitter)
	│ │ │ │ │ Switching Surge
	│
	Abnormal Control Signal
	│
	│
	└── V _{GE} Over voltage (Gate-Emitter)
	│
	Abnormal Gate Drive Circuit
	⊢ Gate Oscillation
	│
	└ Interfered Surge
	Over Temperature (Over Current, Over Load)
	Inappropriate Thermal Design
	Short Arms (Not Enough Dead-Time, False Turn-on)
	Over Current
	Under Gate Drive Voltage
	Gate Circuit Open
	Abnormal Switching Frequency Increase
	Abnormal Switching Frequency Decrease
	Inappropriate Thermal System
	Bonding Surface Fatigue
	Insulation Failure (Ceramic Crack, Internal Solder Melting)
	Heat Sink Mounting Failure (Over Stress)
	└── Over Voltage
Power Device Defect -	IGBT Chip Manufacture Defect
	Pattern Defect
	└── Surface Fault (Impurity ion)
	└── Module Manufacture Defect
	├── Wire Bonding Fault
	Connection Fault Between Insulation Base Plate and Module Base Plate (Solder, etc.)
	Internal Electrode Solder Fault
	└── Metalization Fault

Operation life is dependent on the internal wire bonding, thermal fatigue between insulation base plate and module base plate. The thermal fatigue will be described in the next page.

2.3 Thermal Fatigue of Power Module

2.3.1 Operating Temperature Pattern

The operating temperature pattern of power module is displayed in Fig.3. It is important to consider two patterns that are independent each other in thermal fatigue life of power module.

■Operation Mode 1

Power cycle life is called when change of case temperature is small, but frequent change of junction temperature occurs. Operation Mode 2

The other one is thermal cycle life when comparatively slow change of temperature occurs by start and stop of the system.



Fig.3 Operating Temperature Pattern



2.3.2 Power Cycle Failure Mechanism

Fig.4 shows the typical construction of power module. When junction temperature of power module is changed, stress strain between aluminum wire and silicon chip, and between silicon chip and insulation substrate occurs due to the difference of coefficient of linear expansion. If this stress is supplied repetitively, thermal fatigue for the junction becomes failure.

For inverter use, power cycle life is a necessary concern, which should be given during designing system. An example is given in Fig.5. The failure mode is that the crack of bonding surface makes progress by stress due to the difference of linear expansion between aluminum wire and silicon chip and finally lead to the peel failure mode.

A power cycle testing result of Mitsubishi Electric's module is shown in Fig.6.





2.3.3 Thermal Cycle Failure Mechanism

In case of operation pattern at which case temperature (Tc) of power module become comparatively slowly and big change, the stress strain in the solder layer between insulation substrate and cupper base plate occur due to the different coefficient of expansion between the insulation substrate and the cupper base plate.

The crack in the solder occurs due to the accumulation of these stress cycles. And if this crack reaches to the part of the solder under the chip, thermal resistance increases and leads to the thermal runaway. Or ∆Tj become increased by rise of thermal resistance and power cycling capability become decreased and finally lead to the wire peeling failure as shown in Fig.7. A thermal cycle testing result of Mitsubishi Electric's module is shown in Fig.8.



Fig.8 Thermal Cycle Curve



3. Mitsubishi's Quality-Assurance Program

One of the basic goals of Mitsubishi Electric is to offer our customers quality products. As a consequence, product quality, price, timely delivery, and service are equally important aspects deserving an equal amount of attention. Still, product quality must stand above all others from a standpoint of customer confidence.

Quality standards in the semiconductor industry are extremely high; production of wafers is a carefully controlled, precision process, and assembly processes are done under microscopes to assure that there are no sacrifices made in technology, or in quality.

The following subsections outline the quality-assurance programs Mitsubishi Electric uses in its mass-production.

3.1 The Path to a Mass-Production Device

From research prototype, through mass-production, a serial type tests are run at each stage to assure performance and reliability of the ultimate product. At the same time, the design drawings are also closely checked. The path from the research stage to mass-production is shown in the flow chart of Fig.3. The subsections that follow briefly describe the reliability tests used to check for device reliability.

3.2 Environmental Controls

The semiconductor industry as a whole recognizes the affect environmental factors have on product quality, and rigorous standards have been established regarding the control of dust, humidity, and temperature in manufacturing facilities. The same level of standards is also used for the various gases, and the water used in the manufacturing process.

3.3 Periodic Inspection and Maintenance of Manufacturing Equipment and Instrumentation

The various equipment and measuring instruments used in semiconductor production are an extremely important element of the total process. It is therefore imperative that a periodic program be implemented to inspect and adjust these components so that optimum precision standards are maintained, and to forestall any interruptions in the production process.

3.4 Quality-Control of Materials Purchases

Materials are subjected to rigorous acceptance tests using equipment such as spectrometers, helium leak detectors, etc. Before placing full orders, thorough sample testing is done, and all problem areas are worked out before making an official decision. Quality-control procedures at the supplier's plant are also considered in any procurement decision.

3.5 Control of the Manufacturing Process

Various measures have been taken to control the elements that have a decisive influence on the quality of the product. Measuring instruments are used to monitor water purity, atmospheric conditions, furnace temperatures, gas flow, and other factors. Check-sheet inspections are made, and recorders keep automatic records. These records are carefully correlated with the records kept on matters such as diffusion depth and surface density to establish proper working conditions.

3.6 In-Process and Final Inspections

The goals of the in-process and final inspections are twofold: the first is to assure product quality from the standpoint of outer appearance, dimensions, structural integrity, and mechanical and electrical characteristics. The second is to feed this information back upline to improve quality, and to reduce variations in future batches.

In-process inspections are intended to check the wafer and assembly processes, and serve two purposes; one being self-imposed checks on the production process, the other for use as a quality-control tool. As its name implies, production personnel to correct deficiencies they clearly recognize use the self-imposed check, and emphasis is placed on points that are difficult to detect in completed devices. After the device is completed, it is subjected to the final inspection and the quality-assurance inspection. The final inspection is run on all devices, and consists of testing electrical characteristics and outer appearance. Quality-assurance personnel assume the role of the end user, and inspect samples for correct electrical characteristics, outer appearance, and reliability before devices are packed in storage.

The flow chart for the quality-assurance program covered in the above is noted in Fig.9.

3.7 Quality Information

Mainly the quality assurance division compiles various kinds of quality information such as inspection results and customer-supplied information. They are quickly fed back to related divisions including the production division for maintenance and improvement of quality.

In addition, we employ computer-based, streamlined, and effective quality control systems in order to modernize the information management.









4. Reliability Testing

4.1 Reliability Testing Procedures

High reliability standards are assured with Mitsubishi semiconductor devices through the rigorous quality-control inspections, which the devices are subjected to in the design and manufacturing stages, and through the quality-assurance inspections run on each production lot. Numerous reliability tests have been implemented in order to maintain this standard of reliability.

This section provides an overview of the reliability testing of thyristor devices. Test parameters are shown in Table 1, and as noted, conform to the procedures specified by the Japan Electronics and Information Technology Association (JEITA) handbook. (Related standards: International Electrotechnical Commission (IEC))

4.2 Results of Reliability Test of IGBT Module

Table 2 lists the results of the reliability tests performed on IGBT module CM300DY-24NF, a resin sealed type with current rating up to 300A to date. Failure criterion information is noted in Table 3.

	Test Parameter	Test Method		Test Conditions	
	Thermal Shock	ED-4701	B-141	[Condition A] 100°C : 5 minutes, 0°C: 5 minutes, 10 cycles	
	Temperature Cycling	"	B-131	Tstg min 60 minutes ~ Tstg max 60 minutes, 10 cycles	
	Vibration	"	A-121	[Condition B] 10~500Hz/15 minutes, 98.1m/s ² , 6h	
	Robustness of Termination	"	A-111- I	9.8~40N, 10±1s	
Environmentel	Solder Heat Resistance	"	A-132	[Condition A] 260±5°C, 10±1s, Rosin flux used	
	Solderability	"	A-131	[Condition A] 235±5°C, 5±0.5s, Rosin flux used	
1031				M8:8.83~10.8N·m, 10±1s	
			A-112- II	M6:2.94~4.5N·m, 10±1s	
	Mounting Torque	"		M5:1.96~3.5N·m, 10±1s	
				M4:1.47~1.7N·m, 10±1s	
				M3:0.98N·m, 10±1s	
	High Temperature Storage	"	B-111	Ta=Tstg max, 1000 h	
	Low Temperature Storage	"	B-112	Ta=Tstg min, 1000 h	
	Wetproof	"	B-121	[Condition B] Ta=60°C, RH=90%, 1000h	
Endurance	Intermittent Current Flow	"	-	ΔTc=50°C(ΔTc=100°C), 5000 cycles	
Test	High Temperature Reverse		-	Ta=Tstg max, VCE=85%VCES, VGE=0V, 1000h	
	High Temperature Gate Bias	"	_	Ta=Tstg max, VCE=20V, VGE=0V, 1000h	

Table1. Mitsubishi Power Module Reliability Testing

*: Environmental and resistance testing conforms to standards specified in EIAJ E4-4701 for discrete semiconductor devices.

Table2. CM300DY-24NF Reliability Test Results

	Test Parameter	Test M	/lethod	Test Conditions		No of
		10001	lotiloa		Samples	Failures
	Thermal Shock	ED-4701	B-141	[Condition A] 100°C(5 minutes), 0°C(5 minutes), 10 cycles	5	0
	Temperature Cycling		B-131	-40°C(60 minutes)~125°C(60 minutes), 10 cycles	5	0
	Vibration		A-121	[Condition B] 10~500Hz / 15 minutes, 98.1m/s ² , 6h	5	0
Environmental Test	Robustness of Termination		A-111- I	40N, 10±1 s	5	0
	Solder Heat Resistance		A-132	[Condition A] 260°C±5°C, 10±1 s, Rosin flux used	5	0
	Mounting Torque		A-112- II	Mounting Screws:M6, 4.5N ⋅ m, 10±1 s Main Terminal Screws:M6, 4.5N ⋅ m, 10±1 s	5	0
	High Temperature Storage		B-111	Ta=125°C, 1000h	5	0
	Low Temperature Storage		B-112	Ta=-40°C, 1000h	5	0
	Wetproof		B-121	Ta=60°C, RH=90%, 1000 h	5	0
Endurance	Intermittent Current Flow	-		Ta=125°C, VCES=1020V, VGE=0V, 1000h	5	0
Test	High Temperature Reverse Bias	-		Ta=125°C, VCE=20V, VGE=0V, 1000h	5	0
	High Temperature Gate Bias	-		Tc=50°C~100°C, 5000cycles	5	0

Talbe3. CM300DY-24NF Failure Criterion

Test Parameter	Test Conditions	Failure	Nota	
	Test Conditions	Lower Limit	Upper Limit	Note
ICES	VCE=1200V, VGE=0V	-	U.S.L × 2.0	
IGES	VGE=±20V, VCE=0V	-	U.S.L×2.0	
VGE(th)	IC=30mA, VCE=10V	L.S.L. × 0.8	U.S.L × 1.2	
VCE(sat)	IC=300A, VGE=15V	-	U.S.L × 1.2	
VEC	IE=300A, VGE=0V	-	U.S.L × 1.2	
Electrical Stress	AC2500Vrms 1 minute	Insulation breakdown		

Note. U.S.L: Upper Specification Limit / L.S.L: Lower Specification Limit



5. Failure Analysis

Failure analysis is one of the sources of information used in maintaining, and making improvements in standards of quality and reliability. Failure analysis procedures are performed on failed devices at all stages of their life cycle, ranging from the development state to failure while in use.

Failure analysis procedures are generally divided into area of external inspections, electrical testing, internal inspections, and chip analysis. The flow chart for these procedures is shown in Fig.10, while Table 4 lists the nature of the tests.

The results of the various reliability and failure analysis tests reveal the failure mode and mechanism, and this information is fed back to the process technology and manufacturing personnel so that they can take the appropriate measures to improve the final product.

6. Derating and Reliability Projections

The degree of reliability for a semiconductor device varies considerably depending on usage and environmental conditions. Design standards, the method of manufacture, and quality-control procedures also play a role in establishing the intrinsic reliability for semiconductors. Correlating device derating with reliability is also not an easy task.



Fig.10 Failure Analysis Procedure

Table4. Failure analysis inspections and equipment used

Category	Inspection Items	Equipment
External Inspection	 O Condition of leads, plating, soldering, and welds O Packaging defect O Solderability 	Stereoscopic microscope Metallurgy microscope
Electrical Characteristics Testing	 O Static electrical characteristics, voltage and temperature margins, checking for broken bond wire, wire O Internal wiring 	Oscilloscope Curve tracer Characteristics tester X-ray equipment
Internal Inspection	 O Device removed from package and chip surface observed for defects O Electrical characteristic check using microprobe O Check for hot spots and other abnormalities 	Metallurgy microscope microprobe Scanning electron microscope
Chip Analysis	 O Analysis techniques used to supplement chip surface observation in internal inspection O Cross-section of chip observed for analyzing oxide film, diffusion and metallizing 	X-ray micro-analyzer Infrared micro-scanner Spectrum analyzer

7. Conclusion

The above is a simple introduction to general ideas about reliability, reliability tests, and derating and forcasting of reliability of high power semiconductor, which are semiconductor devices for electric power. As explained above, it is vital for higher reliability in practical use of semiconductor devices to understand their features and select those, which are suitable for equipment and sets. It is also important to design semiconductor devices with some allowance to improve reliability, fully taking their derating into consideration in relation to operating and environmental conditions.

Other essential things to do are to "debug" equipment and sets, and to analyze data obtained in fabrication process and actual operation to feed them back to design and fabrication stages. To improve the reliability by design of high power semiconductor requires considerations on many issues as described above. Utilize the semiconductor devices successfully with the utmost care with comprehensive understanding of their quality, reliability, and economy.



1. IGBT Module Characteristics

It is necessary to comprehend IGBT module characteristics before using it. The main characteristic is described in this section.

(1) Voltage Drive Device

As IGBTs are derived by voltage applied to the gate terminal, it has three characteristic capacitances Cies, Coes, and Cres, shown in Fig.1. The input capacitor (Cies) is charged at turn-on switching and discharged at turn-off switching.



(2) High Speed Device

The IGBT is a high speed switching used under high voltage and high current. High di/dt during switching operation may cause surge voltage.



(3) Insulated Gate

Since IGBT gates are insulated from any other conducting region, care should be taken to prevent static build up which could possible damage gate oxides. In no case should a gate drive outside of the range of $\pm 20V$. Moreover, no voltage should be applied between collector and emitter while the gate is open. The mechanism to the destruction is the following of the outline.

2. Static Electricity Precaution

(1) IGBT modules are shipped from the factory with conductive foam contacting the gate and emitter control terminals. Never touch the gate terminals during assembly and keep the conducting foam in place until permanent connections are made to the gate and emitter control terminals.

(2) Use grounded work station with grounded floors and grounded wrist straps when handling devices.

3. Derating Consideration

(1) Voltage Rating

The relationship of voltage rating of power device for inverter use and ac line voltage of power supply is

Device Voltage Rating=Input AC Voltage × √2

+Brake Voltage Increase+Surge Voltage+Allowance

Table1 shows the relationship of AC line voltage and rating voltage of the power device.

Therefore, the busbar line voltage is recommend to be lesser than 50~60% of the device rating voltage. The free-wheeling diode has the same rating as the IGBT device.

Table I.						
	_	Input AC Voltage (V)				
	180~220	380~440	480~575			
Rating Voltage (V)	600	1000~1200	1400~1700			
Busbar Line Voltage (V)	300~400	600~800	750~900			

(2) Collector Current Rating

Proper selection of an IGBT involves two key points. One is that the peak collector current during operation including any required overload current must be within the maximum rating current value. The other one is that the IGBT operating junction temperature must always be kept below maximum rating temperature in all normal operation including expected motor overload.

Usually, the suggested overload rate of an inverter ranges from 150% to 200%. The Stationary current should be about 50~60% of the maximum rating current.

In addition, the peak collector current given in datasheet is including the reverse recovery current (shorter than 1μ s) of free-wheeling diode shown in Fig.3.

The free-wheeling diode is designed to flow short pulse. In order to achieve a high efficiency inverter, the duty of free wheeling diode should be designed less than that of IGBT. Therefore, the junction temperature rise due to on-state voltage of the free-wheeling diode can be negligent. However, the on-state power loss of the diode can obviously increase when the diode has almost the same on duty as the IGBT, e.g. converter. In this case, rating values should be derated to half ratings given in the datasheet.





Current rating of device for inverter use is decided according to the following method.

(Inverter = AC 3-phase inductive motor control)

- Current rating is dependent on the capacity of inverter.
 - Inverter Capacity = Motor Capacity ÷ Efficiency (0.75)
 Current rating is,
 - Peak Current=Inverter Capacity × Overload Rate \div AC Voltage(rmsV) $\div \sqrt{3} \times \sqrt{2} \times$ Ripple Rate

<Example>

The current rating of IGBT used in an inverter, which is applied with AC200V to control a 3.7kW motor, is:

• Voltage rating can be chosen from 600V class indicated in Table 1.

Current rating is

3.7(kW)÷0.75=5(kVA)

 $5(kVA) \times 2 \div 200 \div \sqrt{3} \times \sqrt{2} \times 1.2 = 49 (A)$

Therefore the appropriate IGBT module is 600V, 50A.

(3) Junction Temperature

Good design practice with considerations of reliability and the worst-case maximum junction temperature is to limit the steadystate junction temperature to 70% to 80% of the maximum junction temperature or less.

4. Precautions in Using IGBT Modules

(1) Environmental Temperature

In order to avoid disconnection between IGBT chip and bonding wire due to stiffness or crystallization of internal silicon gel, environmental temperature of IGBT modules should be kept in the range from -40°C to 55°C. Never use IGBT modules below -40°C. In addition, rapid temperature change may cause damage of modules.

Keep modules far from dewy environment since water seepage may result in operation fault.

(2) In order to lower surge voltage, the wire length of drive circuit should be as short as possible and snubber capacitor is adopted. The layout must minimize the stray inductance between the driver's output stage and the IGBT. This corresponds to keeping the loop area as small as possible in the indicated section of Fig.4-1.



Care should be taken to design the layout of drive circuit especially for high speed switching use. An example is shown in Fig.4-2.



(3) Never apply voltage between collector and emitter while the gate is open.

4) Snubber Circuit Example

The snubber circuit adopted in IGBT module application is shown in Fig.4-3. The recommended stray inductance of main power circuit is indicated in the next page.









Insulation distances of Mitsubishi Electric's modules are in accordance with UL standards. In general, the electric strength to the same space distance falls due to the decrease of atmospheric pressure at high altitude. Moreover, the amount of cosmic rays increases rapidly when the altitude goes up. It has been known that cosmic rays can raise the possibility of faults in semiconductors. There is no data concerning the probability. Practically, it will not become a problem for general industrial use because its voltage is a comparatively low level.





Fig.4.5

Snubber Recommenda	ations	C C	
Collector Current	Snubber Capacitor	Main Bus inductance	Snubber Loop inductance
Rating	"C"	"L1"	"L2"
15A~75A	0.2µF ≦	<200nH	<70nH
100A~200A	0.8µF ≦	<100nH	<20n
300A~400A	1.6µF ≦	<50nH	<10nH
600A~	3.6µF ≦	<50nH	<7nH

4.1 Snubber Design

(1) Snubber Circuit Constant

The voltage spike $\Delta V'$ is caused by a combination of the stray inductance in the snubber circuit and the forward recovery of the snubber diode. The snubber circuit itself cannot absorb it. If a fast IGBT snubber diode is used the majority of this spike will be due to the inductance of the snubber. In this case, the magnitude of $\Delta V'$ can be calculated by using di/dt × L2.

Snubber capacitance can be computed as the following.

$$\frac{1}{2} \bullet L1 \bullet (I_{OFF})^2 = \frac{1}{2} \bullet C_{\underline{S}} \bullet (\Delta V)^2$$
$$C_{\underline{S}} = \frac{L_1 \bullet (I_{OFF})^2}{(\Delta V)^2}$$

From the computations above, it is clear that high power IGBT circuits will require very low inductance snubbers. Snubbers must be connected as close as possible to the IGBT module and the loop area must be kept as small as possible. It is recommended to use snubbers for each module individually when parallel operation is connected for high current requirement.

In applications using 6pack or 7pack type modules, it is usually possible to use a single low inductance capacitor connected across the P and N terminals as the snubber. In high power designs this single bus decoupling capacitor alone is usually insufficient for control of transient voltages. In these applications a clamp type RCDi circuit like the one shown in Fig.5 is usually used.



(2) Surge Reduction

- Low stray inductance (L1, L2)
- ●10~200A (6pack module) : printed circuit boards
- ●100A~600A (Dual module) : bus bar or laminated bus plates
- ② Snubber Circuit
- ●10~150A (6pack module) : snubber circuit a or b
- ●200~600A (Dual module) : snubber circuit c
- ●400A or more (Single module) : snubber circuit a and c (each phase)

Common IGBT Snubber Circuits



(3) Example Layout with Low Inductance (Single Module) Laminated busses consisting of alternate copper plates and insulating layers can be designed with very low inductance. The connection sequence has no influence on inductance. The following considerations should be given in laminated bus designs.

① Use copper pipe as a spacer <more than 2 layers>



<one unit layout of 3-phase full bridge>





Fig.9

The empirical width of overlapping of conductor is from 40mm to 300mm.

The output leads are connected with module terminals or projections designed on the side of conductors. (Inductance of the output leads can be negligent.)

The Ministry wiring and low inductance wiring (the bus bar) manufacturer example.

Furukawa Electric Works : " The power board "

http://www.furukawa.co.jp/index.htm

ELDRE Inc. : "Bus Bars" http://www.busbar.com/



snubber lead

② L shape used to reduce thickness of the conductor. <two layers as an example>



Fig.10

③ Crank shape used to reduce thickness of the conductor <two layers as an example>



example of horizontal connection snubber lead





Fig.14

Refer to $\cdots \cdots$ snubber circuit layout between collector and emitter <N side as an example>



to positive DC bus

4.2 Gate Drive Recommendation

(1) Gate Drive Design

For turn-on a positive gate voltage of 15V±10% is recommended, and for turn-off a negative gate voltage from

-5V to maximum minus voltage is suggested. In order to ensure that the IGBT stays in its off state when dv/dt noise is present in the collector-emitter voltage a reverse bias must be used. A series gate resistor is used to limit current flowing through the gate. The minimum series gate resistance is given in datasheet. In theory, there is no maximum requirement for gate resistance. However, big gate resistor may lead to ·switching loss (time) increase

·oscillation in conjunction with the gate-emitter capacitance and any stray inductance in the gate drive wiring.

Therefore, the recommended maximum gate resistance is 10 times of the minimum value.

Standard resistance given in datasheet is

600V class · · · · · · · · · · · · 625 (Ω · A)/current rating (A) 1200V class $\cdots 313 (\Omega \cdot A)$ /current rating (A)

(a part of products excluded)

Key points of IGBT gate drive design are gate drive voltage, series gate resistor and circuit layout. The layout of gate drive circuit is shown in Fig.16.



Fig.16

Guidelines that should be followed in designing the gate drive layout are:

(Cies>10nF, V_{CES} = 600V IGBT Drive)



Block Diagram (M57958L)



Fig.17-2

M57962AL as an example For parallel operation of IGBT modules, the snubber circuit shown in Fig.18 must be adopted.

Notes in Application

- a. C1 and C2 are low inductance (for switching power supply use) aluminum electrolytic capacitors with value of 220µF or more.
- b. Buffer transistor is recommended to use TO-220 series with 5A peak value or more. (Peak value can be measured or calculated.)

R_G : gate resistor, R_G':oscillation prevention resistance c. Over current detection terminal ① is connected with the collector of IGBTs in parallel.

current detection point is in the middle of parallel connection



Fig.18

<key points for drive design>

- ① With consideration of IGBT short circuit capability and power loss, the recommended gate voltage is . +V_{GE}=15V±10%, -V_{GE}=5~10V
- ② The drive capacity is proportional to current rating of the IGBT and the peak charge/discharge current of high power IGBT may be up to several amperes.
- ③ Consideration should be given to all of the effects, such as surge voltage (∝di/dt) at FWDi recovery and switching losses, in order to use appropriate gate resistor. Gate resistance value has no effect on V_{CE(sat)}.
- ④ Power supply transformer inter-winding capacitance can be another source of coupled noise. Appropriate measures to reduce these stray capacitances have to be implemented. If opto-couplers are used for isolation of the high side gate drive signals they should have a high common mode transient immunity.
- ⑤ Keep the loop area of drive circuit as small as possible in the indicated section of Fig.17-1.



(2) Gate Drive Voltage

For turn-on a positive gate voltage of 15V±10% is recommended. In no case should a gate drive beyond the range of 12 to 20V be used for turn-on. In order to limit short circuit current, the gate drive voltage is sufficiently low less than 6.5V. While the gate drive voltage is sufficiently high more than 13.5V to minimize on-state losses. It must be in action to stop IGBT switching when under drive voltage is occurring. In order to ensure that the IGBT stays in its off state when dv/dt noise is present in the collector-emitter voltage a reverse bias must be used. However, the gate voltage increase of trench IGBT during switching off is not that easy because it has smaller reverse transfer capacitance than planar IGBT. The reverse off bias of trench IGBT can be lowered. For F series IGBTs the reverse bias can be as low as -2V. But the NF/A series use plugging cell structure, so reverse bias voltage minimum -5V. Low reverse bias voltage can not only reduce drive circuit power, but also improve switching drive response characteristics. In addition, low reverse bias voltage can speed up switching on time and delay switching off time. Care should be given to dead time design.

Positive Gate Drive Voltage (+V_{GE})

Fig.19-1 shows the relationship between positive gate drive voltage and on-state voltage. The higher the positive gate drive voltage V_{GE} is, the higher on-state voltage $V_{CE(sat)}$ is and the lower switching power loss during turn on operation. To simplify short circuit protection, the recommended turn-on positive gate drive is +15V±10%.



CONFICTOR ENTIRE VOLTAGE MARKS Fig.19-1 Output Characteristics

② Negative Gate Drive Voltage (-V_{GE})

The negative gate drive voltage has small influence on IGBT characteristics. The relationship between switching loss and reverse bias is shown in Fig.19-2. From the Fig.19-2 it can be seen that switching loss E_{Off} is barely influenced by the reverse bias while $-V_{GE}$ is up to 5V or more. Therefore, the recommended minimum negative gate drive voltage is -5V. In addition, to avoid the gate drive voltage at occurrence of surge exceeding withstand voltage of IGBT gate, optimal reverse bias value is in the range of 5~10V.



Fig.19-2 Switching Loss vs. Reverse Bias

When a dual module is used for a brake, the gate-emitter short of 600V class module can generally prevent the module from false turn-on. Practically, the voltage between the gate and emitter of the unused IGBT in the brake is monitored to make sure there is no malfunction. For the 1200V class module, because the voltage between the gate and emitter is relatively high and may exceed the threshold voltage, it is necessary to apply reverse bias voltage.



Fig.19-3 and Fig.19-4 show that the value of the gate resistance has a significant impact on the dynamic performance of the IGBT. A smaller gate resistor will reduce the switching times and switching losses. On the other hand, smaller gate resistors allow faster turn-on di/dt of the IGBT. This may cause high surge voltage. Giving consideration to both switching loss and surge voltage, an optimal gate resistance is decided depending on usage conditions. The drive circuit for NF series IGBTs is same as planar IGBTs. It is recommended to choose R_G in the range of standard value given in datasheet to 10 times of standard value.



COLLECTOR CONNEX IN DR Fig.19-3 Switching Time vs. Gate Resistance

Switching Loss Characteristics (Eon, Eoff-RG (Typical))



Fig.19-4 Switching Loss vs. Gate Resistance



(3) Example Gate Drive Circuit Design

IGBT switching consumes power from the gate drive power supply as a function of $\pm V_{GE}$, the total gate charge QG and the switching frequency fc. It can be calculated as the followings.

① The average current is (not including drive circuit power consumption)

average current (typ.)=Q_G(-10V→+15V)×fc≒1.3×Q_G×fc Q_G:total gate charge(V_{GE}=0→15V) fc:switching frequency Note) Q_G is about 15% increase while V_{CE}=0V.

② The peak current of the supply is

$$I_{Gpeak} = \frac{(+V_{GE}) + (+V_{GE})}{(external R_G) + (inner module R_G)}$$

Note) In practical applications, the peak current of the supply is 60 to 80% of calculation value due to delay of I_G caused by drive circuit delay or stray inductance.

The value of the gate resistor has a significant impact on the turn-on speed of IGBTs, while it barely affects the turn-off speed. For some usage with low radiation noise requirement, slowing only the turn-on switching speed is an effective approach. In this case, different gate resistors at turn-on and turn-off are used to adjust switching on/off time. Fig.19-5 shows the connection of gate resistors. Table 1 displays the gate resistance range of the NF series. (For those modules not shown in Table1, please refer to the electrical characteristics) The value given for the minimum series gate resistor is the standard resistor that is used for determining all data sheet parameters and characteristics.



Fig.19-5 Connection of different gate resistors at turn-on and turn-off of IGBT

Linear Operation

Mitsubishi Electric's IGBT modules are not suitable for linear operation. NF series is easy to oscillate when it is operated in linear area for a long time due to the rise of the amplification rate of NF series in linear operation. Gate voltages in the 3 to 11V range should only be applied on the IGBT's gate during rapid switching transitions. If this long time application of gate voltage is unavoidable, inductance should be carefully chosen to prevent from oscillation. Moreover, the surge voltage appears on the IGBT's gate due to reverse transfer capacitor of IGBT may result in linear operation and destruction of the module. An abnormal emitter loop can raise feedback voltage between gate and emitter and may cause linear operation. It might lead to linear operation when the drive circuit is not connected to the drive emitter but the main terminal.





Fig.20. Total Gate Charge in IGBT Switching

The average power is

$$= \frac{1}{T} \int V \bullet idt$$

= (+VGE) $\frac{1}{T_1} \int idt + (-VGE) \frac{1}{T_2} \int idt$
= (+VGE) \bullet QG \bullet fc + (-VGE) \bullet QG \bullet fc
= ((+VGE) + (-VGE)) \bullet QG \bullet fc

④ Bridge Circuit



- (a) For the noise malfunction prevention, reverse bias voltage is applied in the off state.
- (b) IGBTs used in bridge drive circuit and their insulation parts must not malfunction in the switching range of main circuit. (dV_{CE}/dt=DC~10V/ns).
 - Care must be taken to avoid coupling of noise between the power circuit and the control circuit. This can be accomplished by proper placement of the gate drive board and/or shielding the gate drive circuit.
 - If opto-couplers are used for isolation of the high side gate drive signals they should have a high common mode transient immunity. (up to 15kV/µs or more)
 - •Use a bypass capacitor near the control IC to filter out induced noises in order to avoid voltage disturb.



<Example>

gate drive circuit layout in order to prevent turn-on malfunction



Problem in gate drive circuit layout

- Cause of gate oscillation
- Measures to induced noise
- •Wiring as short as possible
- Use twisted pair
- Wireless(direct connection of the drive PCB to the IGBT control terminals)
- ●Use the auxiliary emitter terminal
- (c) For an arm shoot through prevention, appropriate deadtime (about 5µs) must be considered in designing control signal.
- (d) Overcurrent protection cannot react to the recovery current of normal operation. A delay circuit with delay time of 5µs is recommended.
- (e) In applications using large IGBT modules (up to 100A or more) high di/dts make it increasingly difficult to avoid ground loop problems. Ground loops are caused when gate drive or control signals share a return current path with the main current. It may cause devices that are supposed to be biased off to turn on. In order to avoid this problem, connection of low side drivers using a single gate drive power supply is recommended.



Fig.22. Ground loop

During turning on of IGBT^①, voltage is induced in power circuit leakage inductance L by the high di/dt of the main current. (-L·di/dt) When this happens, points in the circuit that should be at "ground" potential may in fact be several volts above ground. Voltages at point A, B and C have the relationship of \otimes >[®]>[©].

Because the gate drive voltage is based on B

@>®, turn-on of IGBT① is become slowly

 \mathbb{C} < \mathbb{B} , gate drive voltage of IGBT \mathbb{O} is increased



 \otimes > \otimes , current iloop flowing through emitter terminals can cause that bus current increase depends on power circuit leakage inductance L.

(5) Main Circuit (Power Circuit) Layout

It is recommended to use the auxiliary emitter terminal for connecting the gate drive.

Power circuit and gate drive circuit must be located as close as possible to the gate-emitter control terminals of the IGBT module.



5. Switching Loss

Temperature of inductive load at half-bridge operation is raised with current increase. Measured switching losses are shown in Fig.23, 24, 25, 26, 27, 28 and 29 (from next page).

Conditions:

Half-bridge switching mode Tj=125°C, Vcc=300(12NF)/600(24NF,24A)V, V_{GE}= \pm 15V R_G:see Table1 SWLOSS



Fig.23 Inductive load half-bridge switching loss "12NF-Dual"



図24 Inductive load half-bridge switching loss "24NF-Dual"



Fig.25 Inductive load half-bridge switching loss "24A-Dual"



Fig.26-2 Turn-off switching Loss

Fig.26 Inductive load half-bridge switching loss "24A-Single"





Fig.27 Inductive load half-bridge switching loss "12NF-6pack/7pack Inverter part"



Fig.28-2 Turn-off switching Loss

Fig.28 Inductive load half-bridge switching loss "24NF-6pack/7pack Inverter part"





Fig.29-2 Turn-off switching Loss

Fig.29 Inductive load half-bridge switching loss "MPD"



able 1. Recommended Gate Resistance and RG value used for power loss measurement (LOGG)								
Module	R _G	LOSS	Module	Module R _G		Module	R _G	LOSS
	(Ω)	(Ω)		(Ω)	(Ω)	modulo	(Ω)	(Ω)
CM150DY-12NF	4.2~42	4.2	CM600DU-24NF	1.0~10	1.0	CM 75TL/RL-12NF	8.3~83	8.3
CM200DY-12NF	3.1~31	3.1	CM900DU-24NF	0.35~2.2	0.35	CM100TL/RL-12NF	6.3~63	6.3
CM300DY-12NF	2.1~21	2.1	CM1400DU-24NF	0.22~2.2	0.22	CM150TL/RL-12NF	4.2~42	4.2
CM400DY-12NF	1.6~16	1.6	CM100DY-24A	3.1~42	3.1	CM200TL/RL-12NF	3.1~31	3.1
CM600DY-12NF	1.0~10	4.2	CM150DY-24A	2.1~31	2.1	CM 50TL/RL-24NF	6.3~96	6.3
CM100DY-24NF	3.1~31	3.1	CM200DY-24A	1.6~21	1.6	CM 75TL/RL-24NF	4.2~63	4.2
CM150DY-24NF	2.1~21	2.1	CM300DY-24A	1.0~16	1.0	CM100TL/RL-24NF	3.1~42	3.1
CM200DY-24NF	1.6~16	1.6	CM400DY/HA-24A	0.78~10	0.78	CM150TL/RL-24NF	2.1~31	2.1
CM300DY-24NF	1.0~10	1.0	CM600DY/HA-24A	0.52~7.8	0.52	CM200TL/RL-24NF	1.6~21	1.6
CM400DY-24NF	0.78~7.8	0.73	CM600HB-24A	0.02.07.0	0.52			

Table 1. Recommended Gate Resistance and Revalue used for power loss measurement (LOSS)

*: In case of type CM**RL, LOSS refer for inverter part only

Table2. Internal gate resistance

Part number	Int. R _G (Ω)	Part number	Int. R _G (Ω)	Part number	Int. R _G (Ω)	Part number	Int. R _G (Ω)
CM400DY-12NF	0.8	CM200DY-24NF	3	CM900DU-24NF	1	CM600DY-24A	2
CM600DY-12NF	0.8	CM300DY-24NF	2	CM1400DU-24NF	0.67	CM400HA-24A	1.5
		CM400DY-24NF	2	CM300DY-24A	3	CM600HA-24A	1
		CM600DU-24NF	1.5	CM400DY-24A	2	CM600HB-24A	1

Example of connectors used in 6pack and 7pack modules (for gate drive circuit) 2 pins (upper side):B2P-VH-FB-B 8 pins (lower side):B8P-VH-FB-B

manufactured by J.S.T connector company

Homepage : http://www.jst-mfg.com/index.html


Test Circuit and Waveform

Half-Bridge Switching Test Circuit





100 % to fix each 10 % and 2 % don't include the electric current, which is caused by the recovery current and the stray-capacitance of load of FWDi, a surge voltage and a voltage drop by the floating inductance. 100 % of VCE is Vcc.

An influence over the switching loss by the corrugated change, which is caused by these, is reflected in the switching loss just as it is.

Also, for the reactive-power, we are included in the integration value because it is impossible to separate.

Strictly, 0 % of the I_C is not I_C=0A and it is Ices. 0 % of V_{CE} is not V_{CE} =0V and it is $V_{CE(sat)}$.

When it isn't possible to sufficiently remove the vibration, which is caused by the wiring inductance, a range is fixed based on the line, which estimated the center of the vibration.

But, when the same estimation is difficult, we sometimes suppose that it does the time to have intersected with 10 % most on the inside in the range.



Using IGBT Module

6. Parallel Operation

(1) Parallel Specification

The following sub-sections outline the basic requirements and considerations for parallel operation of single IGBT modules with ratings of 200A or more.

With proper attention to circuit design and device selection several modules can be reliably operated in parallel.
 A parallel number is specified when ordering and parallel connected devices should be selected with matched saturation voltages.

• The saturation voltage rank (G, H, J and so on) will be indicated on the label.

Table 3 NF/A series saturation voltage ranks for parallel applications (I_C=rated current, V_{GE}=15V, Tj=25°C)

12NF				24NF		24A		
Rank	V _{CE(sat)} (V)			Rank	V _{CE(sat)} (V)	Rank	V _{CE(sat)} (V)	
E	1.50 ~ 1.60	К	1.75 ~ 1.85	С	1.62 ~ 1.81	D	1.76 ~ 1.96	
F	1.55 ~ 1.65	L	1.80 ~ 1.95	D	1.76 ~ 2.00	E	1.92 ~ 2.16	
G	1.60 ~ 1.70	Μ	1.90 ~ 2.05	E	1.95 ~ 2.26	F	2.12 ~ 2.41	
Н	1.65 ~ 1.75	Ν	2.00 ~ 2.20	-	-	G	2.37 ~ 2.69	
J	1.70 ~ 1.80	-	-	-	-	Н	2.65 ~ 3.00	

(2) Parallel Operation Notes

All devices to be operated in parallel should have the same saturation voltage rank.

Modules of different saturation voltage ranks may be used in the same inverter provided that devices connected in parallel are of the same rank.

When modules of the same saturation voltage rank are paralleled the static current imbalance will be minimized so that the following recommended deratings can be applied: For 600V class derate I_C by 10%, For 1200V class derate I_C by 15%.

The imbalance rate is defined when more than two modules are paralleled. The collector current easily concentrates on one element with the parallel number increasing. Therefore, Derating is important for parallel operation.

(reference Fig.35)

When more than two modules are paralleled the derating can be computed using the following formula:

 $(1-((n-1)\times(1-x)/(1+x)+1)/n)\times 100\%$

For example, in case of four IGBT modules of 600V class connected in parallel, the current derating is

 $(1-((4-1)\times(1-0.1)/(1+0.1)+1)/4)\times 100\%=13.6\%$

, so the derated current with 4 parallel 300A modules is $300 \times (1 - 0.136) \times 4 = 1036A$

Parallel No.	derating (%)					
n	600V class	1200V class				
2	10.0	15.0				
3	12.1	17.4				
4	13.6	19.6				

Matching $V_{CE(sat)}$ is effective for maintaining good static steady state current balance. This matching also helps some with turn off current balance because of the fundamental inverse relationship of fall time and saturation voltage. However, gate drive conditions and power circuit layout have by far the greatest impact on dynamic current balance between paralleled devices. The application circuit of IGBT modules should be connected with a short, low impedance symmetric connection in order to minimize the current imbalance.

(3) Current Imbalance Factors and Notes

① Device Characteristics

a) On-state Voltage Difference

Under static on state (di/dt=0) the collector to emitter saturation voltage $V_{CE(sat)}$ has influence on current sharing. (reference Fig.32, Fig.34)

b) Temperature Difference

Under static on state (di/dt=0) the junction temperature has



Fig.31 Current imbalance rate of IGBT modules in parallel

Temperature differences between paralleled modules are also a factor because of the resulting effect on delay time. (reference Fig.32, Fig.34)

Note) Power loss imbalance due to instantaneous transient current imbalance is very small.

- •Use modules of the same saturation voltage rank in parallel.
- Devices should be mounted on the heat sink near to each other with cooling arranged to maintain uniform base plate temperatures between paralleled modules.

② Circuit Layout

a) Main Circuit Layout

a-1) Difference of the inductance between power supply elements

Difference of the inductance in the power circuit between the main supply capacitors and devices may result in current imbalance at the moment of turn-on or turn-off switching. (reference Fig.33, Fig.35)

a-2) Difference of the total loop including a load

The difference of the total loop including a load causes current imbalance at turn-on (di/dt \neq 0).

(reference Fig.36, Fig.38)



Using IGBT Module

- An asymmetric connection can result in current imbalance at the moment of turn-on or turn-off switching. In order to minimize the current imbalance, circuit connection should be low inductance symmetric.
- b) Gate Drive Wiring
- b-1) Difference between gate drive wirings may result in nonuniform switching and current imbalance. (reference Fig.33, 35 and Fig.37)
- b-2) The output impedance of gate drive circuit has influence on current balance. High impedance consisting of gate resistance and stray inductance of drive circuit may raise switching speed difference at turn-on or turn-off and increase current imbalance. (reference Fig.33, 35 and Fig.37)
- •Use short tightly twisted wires of equal length.
- Recommend to use relatively small values of series gate resistance.

 $(R_G{\leq}recommended \text{ on the datasheet }R_G{\,\times\,}10)$

• Avoid running a drive circuit parallel to the main circuit.



Fig.32 Example of R Load Switching Circuit



Fig.33 Example of L Load Switching Circuit







Fig.36 Typical Turn-on Waveform with Current Imbalance Caused by Asymmetric Main Circuit Inductance



Fig.37 Typical Current Waveform Showing Imbalance at Turn-off Due to Improper Gate Drive



Because the possibility of catching fire is large if only the fault module is replaced by new one. It is suggested to exchange all parts connected in parallel when fault occurs. Moreover, modules with same lot number are recommended to use in parallel operation for the purpose of current balance improvement.



7. Safe Operation Area

7.1 Turn-off Switching SOA (RBSOA) Unlike MOSFETs, the turn-off switching SOA of IGBTs is the locus of points defining the maximum allowable simultaneous occurrence of collector current and collector to emitter voltage during turn-off, shown in Fig.39.



7.2 Short Circuit Capability

Most power conversion applications require that the applied switch should survive a short circuit on the system output without any damage. However, there is a limit on the amount of short circuit capability of IGBT modules.

(1) Limit Value Probability

There is a limit value probability depending on the period within which the short circuit current has to be cut off as shown in Fig.40.

probability Rn(t) (%)	
limit value probab	

Pulse width (µs) Fig.40 Short Circuit Limit Value Probability

7.3 Short Circuit SOA (SCSOA)





Fig.41-1 Short-Circuit SOA for Modules 600V Class



(1) Gate-Emitter Voltage (V_{GE})

Due to the limit of short circuit time, the gate-emitter voltage may be beyond 16.5V. However, under the case of vibration with duty of 0.1µs or less, gate voltage should never exceed 16.5V.

(2) Short Circuit Times

The non-repetitive short circuit is limited to 100 times and short-circuited elements should be replaced as soon as possible.

(3) Short Circuit Protection

Once a short circuit is detected, several techniques can be employed to protect the IGBT from destruction. The most elementary technique is to simply turn off the IGBT. (See Fig.42)

The peak of the short circuit current depends on VGE, which is augmented by the feedback of dv/dt through the gate-collector capacitance. The effect can be overcome by using VGE clamping circuit shown in Fig.43. The short circuit current waveforms are displayed in Fig.44.

Short Circuit Detection

The method of measuring Vce(sat) instead of the collector current at turn-on moment is used to detect short circuit. This method can effectively detect the IGBT short circuit, but it is not working on overcurrent detection, e.g. the load short circuit, which the current is limited by the wiring impedance. (It is a difficult technique to adjust each device for Vce of IGBT measurement in respect of the reproducibility of noise.) It is necessary to measure the collector current directly in case of the overcurrent. In order to lower Vce and avoid rapid thermal rising due to overcurrent, usually there is enough time allowance in thermal design so that a relatively low speed current detector could be used. Especially for high current usage, a high-speed measurement of the collector current is needed to decrease the capacity of the snubber circuit used to lower the overcurrent level.



Definition of Pulse width at Short Circuit SOA of IGBT Module

Definition of pulse width (tw) at Short Circuit SOA (SCSOA) is shown following figures.

The system design for the time (tw), that is shown in each short circuit mode, should be equal to or less than 10µs of SCSOA. ** This application note dose not define the SCSOA. Please refer each specification sheet and SCSOA.

Condition example:

- V_{CC}: 200~400V (600V class IGBT), 400~800V (1200V class IGBT)
- $\begin{array}{l} \mathsf{V}_{\mathsf{GE1}} = +15\mathsf{V}, \ \mathsf{I}_{\mathsf{SC}(\mathsf{peak})\mathsf{max}} = \mathsf{I}_{\mathsf{C}(\mathsf{rating})} \times 10[\mathsf{A}], \ \mathsf{T} = 125\,^\circ\mathsf{C} \ \mathsf{start}, \\ \mathsf{R}_{\mathsf{G}}: 6250/\mathsf{I}_{\mathsf{C}(\mathsf{rating})} \sim 625/\mathsf{I}_{\mathsf{C}(\mathsf{rating})} \ (600\mathsf{V} \ \mathsf{class} \ \mathsf{IGBT}), \ 3130/\mathsf{I}_{\mathsf{C}(\mathsf{rating})} \sim 313/\mathsf{I}_{\mathsf{C}(\mathsf{rating})} \ (1200\mathsf{V} \ \mathsf{class} \ \mathsf{IGBT}) \\ \times 1. \ \mathsf{In} \ \mathsf{case} \ \mathsf{of} \ \mathsf{above} \ \mathsf{condition}, \ \mathsf{generally} \ \mathsf{I}_{\mathsf{SC}(\mathsf{peak})} \ \mathsf{is} \ \mathsf{less} \ \mathsf{than} \ \mathsf{5} \ \mathsf{to} \ \mathsf{6} \ \mathsf{times} \ \mathsf{of} \ \mathsf{the} \ \mathsf{current} \ \mathsf{rating}. \end{array}$

 - *2: V_{CEp} should be equal to or less than V_{CES} .
 - *3: R_G limitation may be defined individually for some part number.
- 1. Load short circuit









I²t value for 12NF/24NF/24A series

6/7pack

Part number	l ² t (kA ² s)	Part number	l ² t (kA ² s)
	—	CM50TL(RL)-24NF	1.5
CM75TL(RL)-12NF	1.5	CM75TL(RL)-24NF	2.5
CM100TL(RL)-12NF	2.5	CM100TL(RL)-24NF	2.5
CM150TL(RL)-12NF	3.0	CM150TL(RL)-24NF	4.0
CM200TL(RL)-12NF	4.0	CM200TL(RL)-24NF	4.0

*: In case of RL, apply to only the Inverter part.

Dual			
Part number	l ² t (kA ² s)	Part number	l ² t (kA ² s)
CM150DY-12NF	2.5	CM100DY-24NF	1.8
CM200DY-12NF	3.5	CM150DY-24NF	2.5
CM300DY-12NF	5.0	CM200DY-24NF	3.5
CM400DY-12NF	7.0	CM300DY-24NF	5.0
CM600DY-12NF	10.0	CM400DY-24NF	6.8
—	_	CM600DU-24NF	18.0

MPD

Part number	l ² t (kA ² s) Part number		l ² t (kA ² s)
CM900DU-24NF	27.0	CM1400DU-24NF	40.5

A series

Part number	l ² t (kA ² s)	Part number	l ² t (kA ² s)
CM100DY-24A	1.8	CM400HA-24A	13.0
CM150DY-24A	3.0	CM600HA-24A	19.5
CM200DY-24A	3.5	CM600HB-24A	19.5
CM300DY-24A	6.0		—
CM400DY-24A	7.5	—	—
CM600DY-24A	10.0	_	—

Note) The above value is a value with the wire which blows out after the chip destroys.

When using a fuse, use the one of the rating which is smaller than of above value.

When using as the converter, the FWDi part doesn't become the design to have supported an inrush current, I2t of the non destruction like the general rectifier diode can not be guaranteed.

The peak of the inrush current use by equal to or less than twice of the rated emitter current and moreover the within the limits which is no problem in case of thermal design.





Logic Diagram for Over Current Protection



Fig.42 Short-Circuit Protection Scheme (Example)

VGE Clamping







Fig.43 VGE Clamping Circuit





8. Power Loss and Junction Temperature

Junction temperature can be used as an indication of IGBT module situation. This section will discuss how to calculate junction temperature and give an example based on waveform shown in Fig.45. Here, only power loss of IGBT part is given. The power loss of Diode can be obtained by using the same method as IGBT part. Moreover, junction temperature must never be outside of the maximum allowable value. It also has impact on the power cycle life.



a. Power Loss

In order to estimate junction temperature for thermal design, it is necessary to compute total power loss. The first step is the calculation of power loss per pulse.

Two most important sources of power dissipation that must be considered are conduction losses and switching losses. (Fig.46)

(1) Conduction Losses

The total power dissipation during conduction is computed by multiplying the on-state saturation voltage by the on-state current.

$$\mathsf{E}(\mathsf{sat}) = \frac{\mathsf{IC1} \times \mathsf{VCE}(\mathsf{sat})^1 + \mathsf{IC2} \times \mathsf{VCE}(\mathsf{sat})^2}{2} \times \mathsf{t_{w1}} \quad (\mathsf{J})$$

Note)The above equation is a simplification of the below one

$$\mathsf{E}_{(\mathsf{sat})} = \int_{0}^{\mathsf{tw'}} \mathsf{Ic}(t) \bullet \mathsf{Vce}(t) \mathsf{d}t$$

 $\mathsf{VCE}(\mathsf{sat})\,\mathsf{VS}.\;\;\mathsf{Ic}\;\mathsf{characteristics}\;\mathsf{at}\;\mathsf{Tj}\text{=}125^\circ\mathsf{C}\;\mathsf{is}\;\mathsf{used}\;\mathsf{in}\;\mathsf{power}\;\mathsf{loss}\;\mathsf{calculation}.$



(3) Average Power Loss

The average power loss per pulse is

$$P_1 = \frac{E_1}{t_{w1}} \quad (W_1)$$

Fig.48 is approximation of Fig.45 by using rectangle wave.



(2) Switching Losses

The most accurate method of determining switching losses is to plot the Ic and VCE waveforms during the switching transition. Multiply the waveforms point by point to get an instantaneous power waveform. The area under the power waveform is the switching energy expressed in watt-seconds/pulse or J/pulse.

$$\mathsf{Eon} = \int_{\mathsf{ta}}^{\mathsf{tb}} \mathsf{Ic}(\mathsf{t}) \bullet \mathsf{Vce}(\mathsf{t}) \mathsf{d}\mathsf{t} = \frac{1}{n} \sum_{n=1}^{n} \mathsf{P}_n \times (\mathsf{tb} - \mathsf{ta})$$

n:number of partitions

(divide interval between ta and tb equally into n parts, compute average power loss for each interval.) Calculation of Eoff has the same method.

The total power loss of one pulse is the sum of (1) and (2). $E_1 = E(sat) + Eon + Eoff$





b. Junction Temperature Calculation

Junction temperature can be calculated by using P1, Pav, and PAV that has been obtained so far. Three cases should be considered according to pulse width.

(1) tw1 is short (tw1<<1ms)
(2) Both of tw1 and tw2 are long(1ms<tw1<tw2<1s)
(3) tw2 is longer than 1s.(tw2>1s)



Using IGBT Module

(1) tw1<<1ms

In case of short on interval or low duty as in Fig.49, Junction temperatures rise to the highest value at the turn-off moment of tw2 while the case temperature is stationary. (See Fig.51)



Temperature difference between junction and case can be calculated by using the following formula.

 $\Delta T(j-c) = R_{th(j-c)} \times P_{AV} - Z_{th(j-c)(tw2)} \times P_{AV} + Z_{th(j-c)(tw2)} \times Pav = R_{th(j-c)} \times P_{AV} + (Pav - P_{AV}) \times Z_{th(j-c)(tw2)}$

R_{th(j-c)}thermal resistance between junction and case

 $Z_{th(j-c)(tw2)}$ thermal impedance between junction and case at tw2 moment

 \therefore Tj=Tc+ Δ T(j-c) (Tc is measured by thermo-couple.)

Tj(max)=150°C, therefore the allowable case temperature Tc(max) is, Tc(max)=150-△T(j-c).

In this case, ripple should be considered in calculation of average power loss P1. Using approximation similar to (1) Fig.53 is obtained for calculation.



$$\begin{split} \Delta \mathsf{T}(j\text{-}c) &= \mathsf{R}_{th(j\text{-}c)} \times \mathsf{P}_{AV} - \mathsf{Z}_{th(j\text{-}c)(tw2)} \times \mathsf{P} AV + \mathsf{Z}_{th(j\text{-}c)(tw2)} \times \mathsf{P} av - \mathsf{Z}_{th(j\text{-}c)(tw1)} \times \mathsf{P} av + \mathsf{Z}_{th(j\text{-}c)(tw1)} \times \mathsf{P} 1 \\ &= \mathsf{R}_{th(j\text{-}c)} \times \mathsf{P}_{AV} + (\mathsf{P} av - \mathsf{P}_{AV}) \times \mathsf{Z}_{th(j\text{-}c)(tW2)} + (\mathsf{P} 1 - \mathsf{P} av) \times \mathsf{Z}_{th(j\text{-}c)(tw1)} \\ \mathsf{R}_{th(j\text{-}c)} & \cdots & \text{thermal resistance between junction and case} \\ \mathsf{Z}_{th(j\text{-}c)(tw2)} & \cdots & \text{thermal impedance between junction and case at tw2 moment} \\ \mathsf{Z}_{th(j\text{-}c)(tw1)} & \cdots & \text{thermal impedance between junction and case at tw1 moment} \\ \therefore \mathsf{T}j = \mathsf{T} c + \Delta \mathsf{T}(j\text{-}c) & (\mathsf{T} c \text{ is measured by thermo-couple.}) \\ \mathsf{T} c(max) = 150 - \Delta \mathsf{T}(j\text{-}c) \end{split}$$



^{(2) 1}ms<tw1<tw2<1s

(3) tw2>1s

In a similar way to (2), temperature change of heat sink should be taken into consideration as well. It is necessary to know the transient heat impedance of the heat sink. (Fig.54)



Similarly, the temperature difference between junction and ambient can be calculated by using the following formula.

$$\begin{split} & \Delta T(j\text{-}a) = R_{th(j\text{-}a)} \times P_{AV} - Z_{th(j\text{-}a)(tw2)} \times P_{AV} + Z_{th(j\text{-}a)(tw2)} \times Pav - Z_{th(j\text{-}a)(tw1)} \times Pav + Z_{th(j\text{-}a)(tw1)} \times P1 \\ & = R_{th(j\text{-}a)} \times P_{AV} + (P_{av} - P_{AV}) \times Z_{th(j\text{-}c)(tw2)} + (P1 - Pav) \times Z_{th(j\text{-}c)(tw1)} \\ & \therefore Tj = Ta + \Delta T(j\text{-}a) \quad (Ta \text{ is measured by a thermometer.}) \end{split}$$

c. Heat Sink Selection

Fig.55 shows the thermal equivalent circuit when two or more modules are mounted on one heat sink. According to this equivalent circuit, the temperature of í the heat sink is $Tf = Ta + (P_{T(AV)} + P_{D(AV)}) \times N \times R_{th(f-a)}$ Ta : Ambient temperature P_{T(AV)}:Average power loss of IGBT P_{D(AV)}:Average power loss of FWDi N:Arm number R_{th(f-a)}:The heat sink to ambient thermal resistance 2 The case temperature Tc is, $Tc = Tf + (P_{T(AV)} + P_{D(AV)}) \times R_{th(c-f)}$ Rth(c-f) : The case to heat sink thermal resistance Tc(max) can be calculated by using the below formula. $::T_{c(max)} = Ta + (P_{T(AV)} + P_{D(AV)}) \times N \times R_{th(f-a)} + (P_{T(AV)} + P_{T(AV)}) \times N \times R_{th(f-a)} +$ $P_{D(AV)}) \times R_{th(c-f)}$ Therefore, the heat sink to ambient thermal resistance can be computed as $TC(max) - Ta - (PT(AV) + PD(AV)) \times Rth(c - f)$ Ŀ. Rth(f - a) = $(PT(AV) + PD(AV)) \times N$ Moreover, power loss of FWDi should be considered

Moreover, power loss of FWDi should be considered as well. In thermal design, the allowable case temperature Tc(max) is up to the smaller one of IGBT power loss and FWDi part.



Fig.55 Thermal Calculation Model



For Mitsubishi Electric's modules in a variable voltage variable frequency (VVVF) inverter, power loss of IGBT or average power loss of IPM can be computed by using the software recommended in the following link.

http://www.MitsubishiElectric.co.jp/semiconductors/

Link to the above URL and click the button of Simulation Soft : Or, directly access the download page through the following URL.

https://www.semicon.melco.co.jp/dm/bin/u_als_form.pl

After input necessary information, the software can be downloaded. The requirement for operation system (OS) is at least Windows®98SE.

Average Power Loss Simplified Calculation

(1) VVVF Inverter

Applicability Range

It is applicable to total power loss calculation for selection of IGBTs used in VVVF inverters. It is not applicable in the thermal design of the device (limit design).

Assumption Condition

① PWM modulation used to synthesize sinusoidal output currents in VVVF inverters

- ② PWM signal generated by comparing sinusoidal wave to triangular wave
- ③ Duty cycle of PWM among the rank of $\frac{1-D}{2} \sim \frac{1+D}{2} (\%/100)$ D : modulation rate
- ④ Output current of I_{CP} ·sin x without ripple
- **(5)** With inductive load rate of $\cos \theta$

Calculation Equation

Duty cycle of PWM is constantly changing and its value equal to time x $\frac{1+D \times \sin x}{2}$ at the corresponding moment.

The output current corresponds to the output voltage change and this relationship is represented by power factor $\cos \theta$. Therefore, the duty cycle of PWM corresponding to output current at arbitrary phase x is

Output current =
$$Ip \times sin x$$

PWM Duty = $\frac{1 + D \times sin(x + \theta)}{2}$

 $V_{CE(sat)}$ and V_{EC} at this moment are

 $Vce(sat) = Vce(sat)(@lp \times sin x)$

$$Vec = Vec(@(-1) \times Ip \times sin x)$$

Static power loss of IGBT is

$$\frac{1}{2\pi}\int_0^{\pi} (p \times \sin x) \times Vce(sat)(@lp \times \sin x) \times \frac{1 + Dsin(x - 0)}{2} \bullet dx$$

Similarly, static power loss of FWDi is

$$\frac{1}{2\pi}\int_{0}^{2\pi}((-1)\times |\mathbf{p}\times\sin\mathbf{x}|)\times (\operatorname{Vec}(@(-1)\times |\mathbf{p}\times\sin\mathbf{x}|)\times \frac{1+\operatorname{Dsin}(\mathbf{x}+0)}{2}\bullet\operatorname{ds}$$

On the other hand, dynamic power loss of IGBT is not dependent on the PWM duty and can be expressed as the following formula.

$$\frac{1}{2\pi}\int_{0}^{\pi} (\operatorname{Eon}(\operatorname{@lp}\times\sin x) - \operatorname{Eoff}(\operatorname{@lp}\times\sin x)) \times f_{0} \bullet dx$$



As for dynamic power loss of free-wheeling diode, calculation is given by an example of ideal diode shown in Fig.52.



Fig.56. Dynamic Power Loss of FWDi

$$\mathsf{Err} = \frac{\mathsf{Irr} \times \mathsf{Vcc} \ \mathsf{trr}}{4}$$

Because reverse recovery of free-wheeling diodes occurs in half cycle of the output current, the dynamic power loss of FWDi is

$$\frac{1}{2} \int_{0}^{2\pi} \frac{\operatorname{Irr}(@\operatorname{Ip} \times \sin x) \times \operatorname{Vec} \times \operatorname{Irr}(@\operatorname{Ip} \times \sin x)}{4} \times \operatorname{Ic} \bullet dx$$
$$= \frac{1}{6} \int_{0}^{2\pi} \operatorname{Irr}(@\operatorname{Ip} \times \sin x) \times \operatorname{Vec} \times \operatorname{trr}(@\operatorname{Ip} \times \sin x) \times \operatorname{Ic} \bullet dx$$

■Inverter Loss Calculation Notes

- Divide one cycle of output current into many equal intervals, then calculate actual "PWM duty", "Output current", and "V_{CE(sat)}, V_{EC}, Eon, Eoff and Err responding to the current" in each interval. The power loss during one cycle is the sum of each interval.
- The PWM duty depends on the method of generating the signal.
- The output current waveform and the relationship between output current and PWM duty cycle are dependent on signal generator, load and other factors. Therefore, calculation should always be done with actual waveforms.
- V_{CE(sat)} uses the value of Tj=125°C.
- Eon, Eoff and Err uses the value under half bridge operating case at Tj=125°C.
- Thermal Design Notes

① It is necessary to examine the worst switching condition.

- ② Consideration of temperature variation due to current cycle should be given in thermal design. (Temperature variation rate is 30% to 35% for 60Hz case. When the output current of several Hz switches for a few seconds, it almost has equal temperature to a direct current with the same peak value continuously flowing.)
- ③ Temperature ripple caused by switching operation should be considered especially when switching frequency is much lower than 10kHz.





Innovating Energy Technology



For explanation of IGBT-series & type names go to page (4-5)



Industrialized process for Pre-applied Thermal Interface Material (TIM)



Fuji Electric's printing process of pre-applied TIM is automated and carried out by a computer controlled printing line under clean environment.

Precise printing equipment and optimized module specific printing patterns guaranty a uniform print and maximum thermal conductivity.

3D-imaging tests ensure the compliance of our specified TIM thickness.

The whole process is controlled by our qualified staff to ensure our high quality standards.

Features

- + Optimized for Fuji modules
- + Increase lifetime of IGBT
- + Advanced IGBT power density

Process - Benefits

- + Outsourcing of a dirty process
- + Stable quality level
- + Increased system reliability

Thermal - Benefits

- + Higher thermal conductivity
- + Uniform thermal resistance
- + Higher reliability and life time.

Our range of modules with pre-applied TIM is being continually expanded

For latest availablity status please contact us

info.semi@fujielectric-europe.com



About Type Name

The Type Name is not exactly the item code for the ordering process





About Type Name

The Type Name is not exactly the item code for the ordering process





			600V		1200V		1700V		
	IGE	BT-Modules for 3-Level-inverters	I _c	V-Series 6th Generation	AC-switch	V-Series 6th Generation	AC-switch	V-Series 6th Generation	AC-switch
		Solder pins RB-IGBT = Reverse Blocking IGBT AC-switch Inverter				12MBi 50VN-120-50	600V		
			75A			12MBi 75VN-120-50	600V		
	Jase					12MBi 100VN-120-50	600V		
	3 Pł	PressFit contacts RB-IGBT=Reverse Blocking IGBT AC-switch Inverter	50A			12MBi 50VX-120-50	600V		
			75A			12MBi 75VX-120-50	600V		
			100A			12MBi 100VX-120-50	600V		
		AC-switch Inverter	220A					4MBi 220VF-170R2-50	1200V
			300A			4MBi 300VG-120R-50 4MBi 300VG-120R1-50	600V 900V		
			340A			4MBi 340VF-120R-50	600V		
	ase	RB-IGBT = Reverse Blocking IGBT	400A	4MBi 400VG-060R-50	600V	4MBi 400VF-120R-50	600V		
	1 Ph	4 PressFit contacts	300A			4MBi 300VX-120S -50*	600V		
			400A			4MBi 400VX-120S -50*	600V		



			I	1200V		1700V	
	IGE	3T-Modules for 3-Level-inverters	I _C	V-Series 6th Generation	AC-switch	V-Series 6th Generation	AC-switch
		5 I-Type	600A	4MBi 600VM-120-50*			
 	1 Phase	6 I-Type	600A	4MBi 600VC-120-50 *			
		T-Type <u>AC-switch</u> Inverter	450A	4MBi 450VB-120R1-50	900V	4MBi 450VB-170R2-50*	1200V
			٥00A گ			4MBi 600VB-170R2-50*	1200V
			650A	4MBi 650VB-120R1-50	900V		
		RB-IGBT=Reverse Blocking IGBT	900A	4MBi 900VB-120R1-50	900V		







Suffix -53 = With $V_{CE,sat} \& V_F$ rank label



				600V	1200V
	Hyb	orid IGBT-Modules with SiC-SBD 🔶	⊦ I _c	V-Series 6th Generation	V-Series 6th Generation
			ندر چ		7MSR 35VB-120-50
	PIM		ب لاً • • K • 50A	7MSR 50VB-060-50	7MSR 50VB-120-50
		Ro So To Bo ol	ע ל⊷יע אג≱ אג≱ 75 4	7MSR 75VB-060-50	
			<u>יי</u> יי <u>י</u> 100A	7MSR 100VB-060-50	
	6-Pack				6MSi 100VB-120-50



			600V	650V	120	V0(
Si	nall PIM IGBTs (Power Integrated Modules)	۱ _c	V-Series 6th Generation	X-Series 7th Generation	V-Series 6th Generation	X-Series 7th Generation
	15 Thermistor	10A	7MBR 10VKA-060-50	7MBR 10XKA-065-50	7MBR 10VKA-120-50	7MBR 10XKA-120-50
2		15A	7MBR 15VKA-060-50	7MBR 15XKA-065-50	7MBR 15VKA-120-50	7MBR 15XKA-120-50
		20A	7MBR 20VKA-060-50	7MBR 20XKA-065-50		
2		25A				7MBR 25XKA-120-50
1		30A	7MBR 30VKA-060-50	7MBR 30XKA-065-50		
	16 Thermistor K oktocktocktocktocktocktocktocktocktockto	15A			7MBR 15VKB-120-50	7MBR 15XKB-120-50
		25A			7MBR 25VKB-120-50	7MBR 25XKB-120-50
		35A			7MBR 35VKB-120-50	7MBR 35XKB-120-50
			7MBR 50VKB-060-50	7MBR 50XKB-065-50		
	17	10A	7MBR 10VKC-060-50	7MBR 10XKC-065-50	7MBR 10VKC-120-50	7MBR 10XKC-120-50
		15A	7MBR 15VKC-060-50	7MBR 15XKC-065-50	7MBR 15VKC-120-50	7MBR 15XKC-120-50
		20A	7MBR 20VKC-060-50	7MBR 20XKC-065-50		
		25A				7MBR 25XKC-120-50
		30A	7MBR 30VKC-060-50	7MBR 30XKC-065-50		
	18 Thermistor	15A			7MBR 15VKD-120-50	7MBR 15XKD-120-50
14:747		25A			7MBR 25VKD-120-50	7MBR 25XKD-120-50
		35A			7MBR 35VKD-120-50	7MBR 35XKD-120-50
		50A	7MBR 50VKD-060-50	7MBR 50XKD-065-50		



		1200V			
PIN	A and 6-PACK IGBTs with V-Series IGBT (MiniSKiiP [®]	con	npatible)	Ι _c	V-Series 6th Generation
KiiP [®] 1	19 Standard lid \rightarrow Suffix = -50 Slim lid \rightarrow Suffix = -53 16.5 2.8	IGBT		8A	7MBR 8VJA-120-50 7MBR 8VJA-120-53
MiniS		-MIA		15A	7MBR 15VJA-120-50 7MBR 15VJA-120-53
iP [®] 2	20 Standard lid \rightarrow Suffix = -50 Slim lid \rightarrow Suffix = -53 16.5 12.8	F		25A	7MBR 25VJB-120-50 7MBR 25VJB-120-53
MiniSKii	15.8 59	PIM-IGB		35A	7MBR 35VJB-120-50 7MBR 35VJB-120-53 7MBR 35VJB-120A-50 With larger rectifier diodes 7MBR 35VJB-120A-53 With larger rectifier diodes
	21 Standard lid→Suffix= -50 Slim lid→Suffix= -53	BT		50A	7MBR 50VJC-120-50 7MBR 50VJC-120-53
3		IM-IGE		75A	7MBR 75VJC-120-50 7MBR 75VJC-120-53
li P®	6.5	₽.		100A	7MBR 100VJC-120-50 7MBR 100VJC-120-53
NISK	Law Hora a a a a a a a	BT		100A	6MBi 100VJC-120-50* 6MBi 100VJC-120-53*
Mir		ACK-IG		150A	6MBi 150VJC-120-50* 6MBi 150VJC-120-53*
	82	6-P		1007	6MBi 150VJC-120-55* With SiN-DCB

MiniSKiiP® is a trademark of SEMIKRON Elektronik GmbH & Co. KG - Germany

*) Under development

11



				600V	650V	1200V	
PI۸	A IGBTs (Power Integrate	ed Module) with solder pins	I _C	V-Series 6th Generation	X-Series 7th Generation	V-Series 6th Generation	X-Series 7th Generation
	22		25A			7MBR 25VA-120-50	
	- BUILDER		35A			7MBR 35VA-120-50	
	5-1-101.5		50A	7MBR 50VA-060-50			
	23		35A			7MBR 35VB-120-50	
	A A A A A A A A A A A A A A A A A A A		50A			7MBR 50VB-120-50	
	A A A A A A A A A A A A A A A A A A A		75A	7MBR 75VB-060-50		7MBR 75VB-120-50	
			100A	7MBR 100VB-060-50			
	24		25A			7MBR 25VM-120-50	
ns			35A			7MBR 35VM-120-50	7MBR 35XMA-120-50
Di			50A		7MBR 50XMA-065-50	7MBR 50VM-120-50	7MBR 50XMA-120-50
ler			75A		7MBR 75XMA-065-50		7MBR 75XME-120-50
00	25		25A			7MBR 25VP-120-50	
ר S			35A			7MBR 35VP-120-50	7MBR 35XPA-120-50
t.			50A	7MBR 50VP-060-50	7MBR 50XPA-065-50	7MBR 50VP-120-50	7MBR 50XPA-120-50
≥			75A	7MBR 75VP-060-50	7MBR 75XPA-065-50		7MBR 75XPE-120-50
			100A	7MBR 100VP-060-50	7MBR 100XPE-065-50		
	26		50A			7MBR 50VN-120-50	
	Manufacture D	★ ★ ★ ★ ★ HK} HK} HK	75A		7MBR 75XNA-065-50	7MBR 75VN-120-50	7MBR 75XNA-120-50
			100A		7MBR 100XNA-065-50	7MBR 100VN-120-50	7MBR 100XNA-120-50
			150A		7MBR 150XNA-065-50	7MBR 150VN-120-50	7MBR 150XNE-120-50
	27		50A			7MBR 50VR-120-50	
	and the second s		75A			7MBR 75VR-120-50	7MBR 75XRA-120-50
	A State of the sta		100A	7MBR 100VR-060-50	7MBR 100XRA-065-50	7MBR 100VR-120-50	7MBR 100XRA-120-50
	2 124		150A	7MBR 150VR-060-50	7MBR 150XRA-065-50	7MBR 150VR-120-50	7MBR 150XRE-120-50



				600V	650V	120	VOV
	PIN	A IGBTs (Power Integrated Modules) with PressFit contacts	I _c	V-Series 6th Generation	X-Series 7th Generation	V-Series 6th Generation	X-Series 7th Generation
		28	25A		7MBR 50XWA-065-50	7MBR 25VW-120-50	
			35A			7MBR 35VW-120-50	7MBR 35XWA-120-50
			50A			7MBR 50VW-120-50	7MBR 50XWA-120-50
			75A		7MBR 75XWA-065-50		7MBR 75XWE-120-50
	ts	29	50A			7MBR 50VX-120-50	
	Itac		75A		7MBR 75XXA-065-50	7MBR 75VX-120-50	7MBR 75XXA-120-50
	Fit cor		100A		7MBR 100XXA-065-50	7MBR 100VX-120-50	7MBR 100XXA-120-50
					7MBR 150XXA-065-50	7MBR 150VX-120-50	7MBR 150XXE-120-50
	ess		25A			7MBR 25VY-120-50	
	Pre		35A			7MBR 35VY-120-50	7MBR 35XYA-120-50
	it H		50A	7MBR 50VY-060-50	7MBR 50XYA-065-50	7MBR 50VY-120-50	7MBR 50XYA-120-50
	$ \mathbf{\bar{s}} $		75A	7MBR 75VY-060-50	7MBR 75XYA-065-50		7MBR 75XYE-120-50
			100A	7MBR 100VY-060-50	7MBR 100XYE-065-50		
			50A			7MBR 50VZ-120-50	
			75A			7MBR 75VZ-120-50	7MBR 75XZA-120-50
			100A	7MBR 100VZ-060-50	7MBR 100XZA-065-50	7MBR 100VZ-120-50	7MBR 100XZA-120-50
			150A	7MBR 150VZ-060-50	7MBR 150XZA-065-50	7MBR 150VZ-120-50	7MBR 150XZE-120-50

		Fuji	Electric
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			600V	1200V		1700V	
	<u>6-</u> F	ack IGBTs	I _c	V-Series 6th Generation	V-Series 6th Generation	X-Series 7th Generation	V-Series 6th Generation
			50A	6MBi 50VA-060-50	6MBi 50VA-120-50		
	pins		75A	6MBi 75VA-060-50	6MBi 75VA-120-50		
	der	Et 102	100A	6MBi 100VA-060-50	6MBi 100VA-120-50		
	00	33 C Demisir	100A		6MBi 100VB-120-50	6MBi 100XBA-120-50	
	S		150A	6MBi 150VB-060-50	6MBi 150VB-120-50	6MBi 150XBA-120-50	
	/it/		180A		6MBi 180VB-120-50		
	5		2004		6MBi 180VB-120-55	6MBi 200XBA-120-50	
			2004		Equivalent to 200A by lower R _{th(j-c)}	6MBi 200XBE-120-50	
	cts		50A	6MBi 50VW-060-50	6MBi 50VW-120-50		
	h PressFit conta		75A	6MBi 75VW-060-50	6MBi 75VW-120-50		
		5-1 101.2 No. 101.2	100A	6MBi 100VW-060-50	6MBi 100VW-120-50		
			100A		6MBi 100VX-120-50	6MBi 100XXA-120-50	6MBi 100VX-170-50
			150A	6MBi 150VX-060-50	6MBi 150VX-120-50	6MBi 150XXA-120-50	
			180A		6MBi 180VX-120-50		
	<i>≤it</i>		2004		6MBi 180VX-120-55	6MBi 200XXA-120-50	
			200A		Equivalent to 200A by lower R _{th(j-c)}	6MBi 200XXE-120-50	
		36 With solder pins or with PressFit contacts	225A		6MBi 225V-120-50		
			300A		6MBi 300V-120-50		6MBi 300V-170-50
	×		450A		6MBi 450V-120-50		6MBi 450V-170-50
	bo		550A		6MBi 550V-120-50		
	<u> </u>		225A		6MBi 225VY-120-50*		6MBi 225VY-170-50*
	1ig		300A		6MBi 300VY-120-50*		6MBi 300VY-170-50*
	–		450A		6MBi 450VY-120-50*		6MBi 450VY-170-50*
		Mit Alexandre	550A		6MBi 550VY-120-50*		6MBi 550VY-170-50*



					1200V			1700	
	2-F with	Pack IGBT-Modules Spring-, Pin- & PressFit con	ntacts I _C	V-Series 6th Generation	V-Series 6th Generation With SiN-substrate 20% Lower thermal impedance	X-Series 7th Generation	V-Series 6th Generation	X-Series 7th Generation	
		37	، 225 <i>A</i>	2MBi 225VJ-120-50					
	ntacts		↓ [¶] 3004	2MBi 300VJ-120-50					
	g cor		<u>ل</u> ے ل	2MBi 450VJ-120-50					
	Sprin	63 VI VI	5504	<u> </u>			2MBi 550VJ-170-50		
			° 6004	x	2MBi 600VJ-120-50				
		38	2254	2MBi 225VN-120-50	2MBi 225VN-120S -50	2MBi 225XNA-120-50 *		2MBi 225XNA-170-50 *	
	S		<u>ர</u> ி 🕤 3004	2MBi 300VN-120-50	2MBi 300VN-120S -50	2MBi 300XNA-120-50 *	2MBi 300VN-170-50	2MBi 300XNA-170-50 *	
	er pin		4504	2MBi 450VN-120-50	2MBi 450VN-120S -50	2MBi 450XNA-120-50 *	2MBi 450VN-170-50	2MBi 450XNA-170-50 *	
	olde		5504	x			2MBi 550VN-170-50		
			6004	x	2MBi 600VN-120-50	2MBi 600XNE-120-50 *		2MBi 600XNE-170-50 *	
			8004			2MBi 800XNE-120-50 *			
		39	2254	2MBi 225VX-120-50		2MBi 225XNB-120-50*	2MBi 225VX-170-50	2MBi 225XNB-170-50*	
	acts		<u>ட</u> ் 🕤 3004	2MBi 300VX-120-50		2MBi 300XNB-120-50*	2MBi 300VX-170-50	2MBi 300XNB-170-50*	
	cont		4504	2MBi 450VX-120-50		2MBi 450XNB-120-50*	2MBi 450VX-170-50	2MBi 450XNB-170-50*	
	ssFit	Constant in the office	5504				2MBi 550VX-170-50		
	Pre	(q2) · · · · · · · · · · · · · · · · · ·	6004		2MBi 600VX-120-50	2MBi 600XNF-120-50 *		2MBi 600XNF-170-50 *	
			800A			2MBi 800XNF-120-50 *			

	FƏ	Fuji	Electric
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				600V	650V	1200V		1700V	
Sta	ndard1- & 2-	Pack	۱ _C	V-Series 6th Generation	X-Series 7th Generation	V-Series 6th Generation	X-Series 7th Generation	V-Series 6th Generation	X-Series 7th Generation
	40 23, 23	Ļ	75A			2MBi 75VA-120-50		2MBi 75VA-170-50	2MBi 75XAA-170-50*
		<u>_K</u> t	100A	2MBi 100VA-060-50		2MBi 100VA-120-50	2MBi 100XAA-120-50 *	2MBi 100VA-170-50	2MBi 100XAA-170-50 *
		"IK]ŧ	15 0 A	2MBi 150VA-060-50	2MBi 150XAA-065-50 *	2MBi 150VA-120-50	2MBi 150XAA-120-50 *		2MBi 150XAA-170-50 *
		<u> </u>	200A	2MBi 200VA-060-50	2MBi 200XAA-065-50 *		2MBi 200XAA-120-50 *		
	41 23 ²³	Ļ	150A			2MBi 150VB-120-50			
	FIE PENE	<u> </u>	200A			2MBi 200VB-120-50	2MBi 200XBE-120-50 *		
	5	_K_	300A	2MBi 300VB-060-50	2MBi 300XBE-065-50 *		2MBi 300XBE-120-50 *		
	91	, ľ	400A	2MBi 400VB-060-50	2MBi 400XBE-065-50 *				
	42 25 25		300A			2MBi 300VD-120-50			
<u>c</u>			400A	2MBi 400VD-060-50	2MBi 400XDE-065-50 *	2MBi 400VD-120-50			
-Po	108		600A	2MBi 600VD-060-50	2MBi 600XDE-065-50 *				
2	43		15 0 A					2MBi 150VH-170-50	2MBi 150XHA-170-50 *
	28 28		200A			2MBi 200VH-120-50		2MBi 200VH-170-50	2MBi 200XHA-170-50 *
	TE TE TE		300A			2MBi 300VH-120-50	2MBi 300XHA-120-50 *	2MBi 300VH-170-50	2MBi 300XHA-170-50 *
	5		400A						2MBi 400XHA-170-50 *
	108		450A			2MBi 450VH-120-50	2MBi 450XHA-120-50 *		
			600A				2MBi 600XHA-120-50 *		
	44 25 25	. Ļ	300A			2MBi 300VE-120-50		2MBi 300VE-170-50	2MBi 300XEE-170-50 *
		<u>_K</u> t	400A					2MBi 400VE-170-50	2MBi 400XEE-170-50*
		_K ₹	450A			2MBi 450VE-120-50	2MBi 450XEE-120-50 *		
	5 10 110	, in the second	600A	2MBi 600VE-060-50	2MBi 600XEE-065-50 *	2MBi 600VE-120-50	2MBi 600XEE-120-50*		
	45		300A					1MBi 300V-170-50	
1-Pack	THE THE		400A			1MBi 400V-120-50 1MBi 400VF-120-50		1MBi 400V-170-50	
	23 (a) 108		600A			1MBi 600V-120-50 1MBi 600VF-120-50		1MBi 600V-170-50	
			900A			1MBi 900V-120-50			

модуль, igbt, мост диодный Минск +375447584780

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