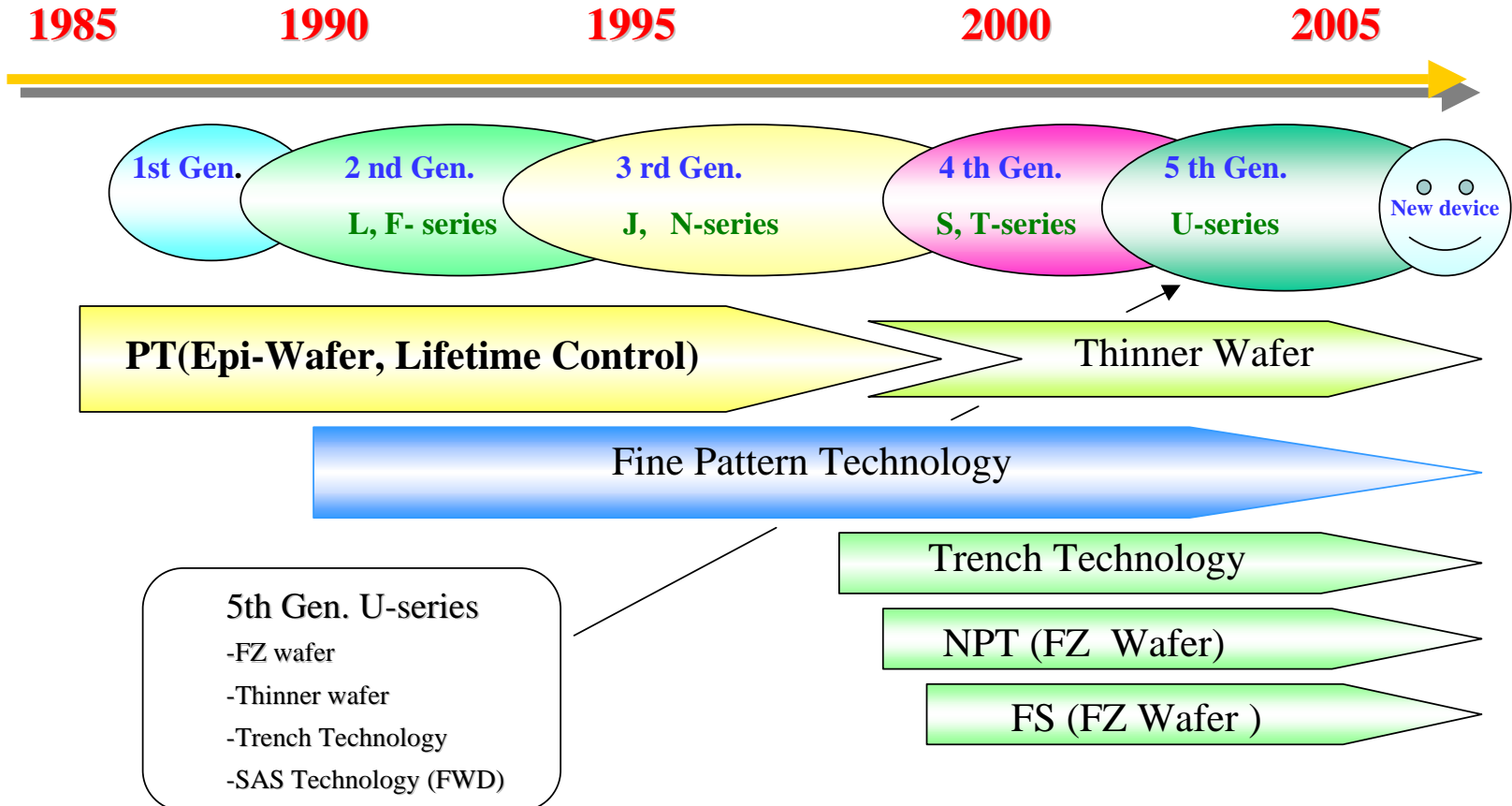


5th Gen. IGBT Module

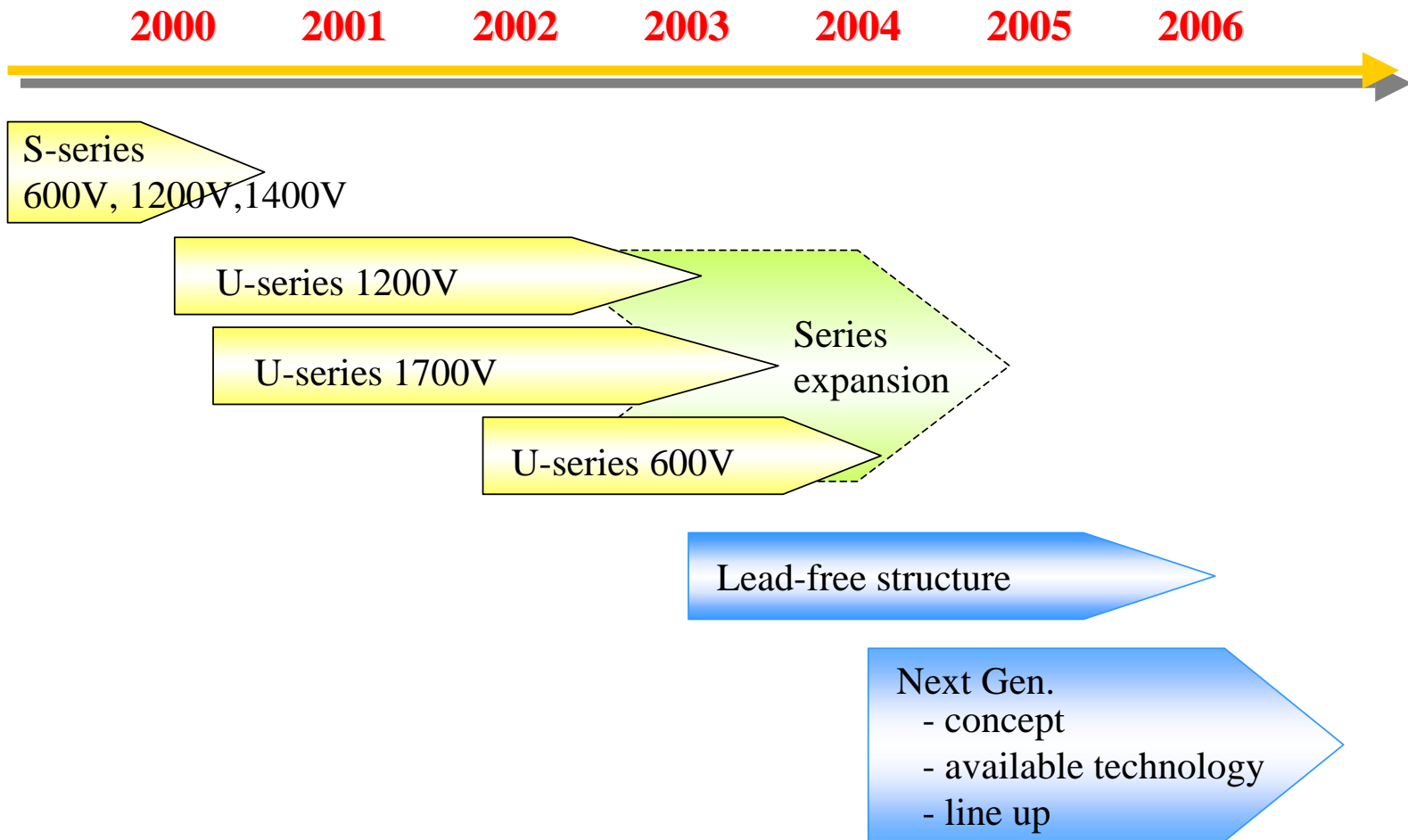
Quality is our message

Trend of Fuji's IGBT chips



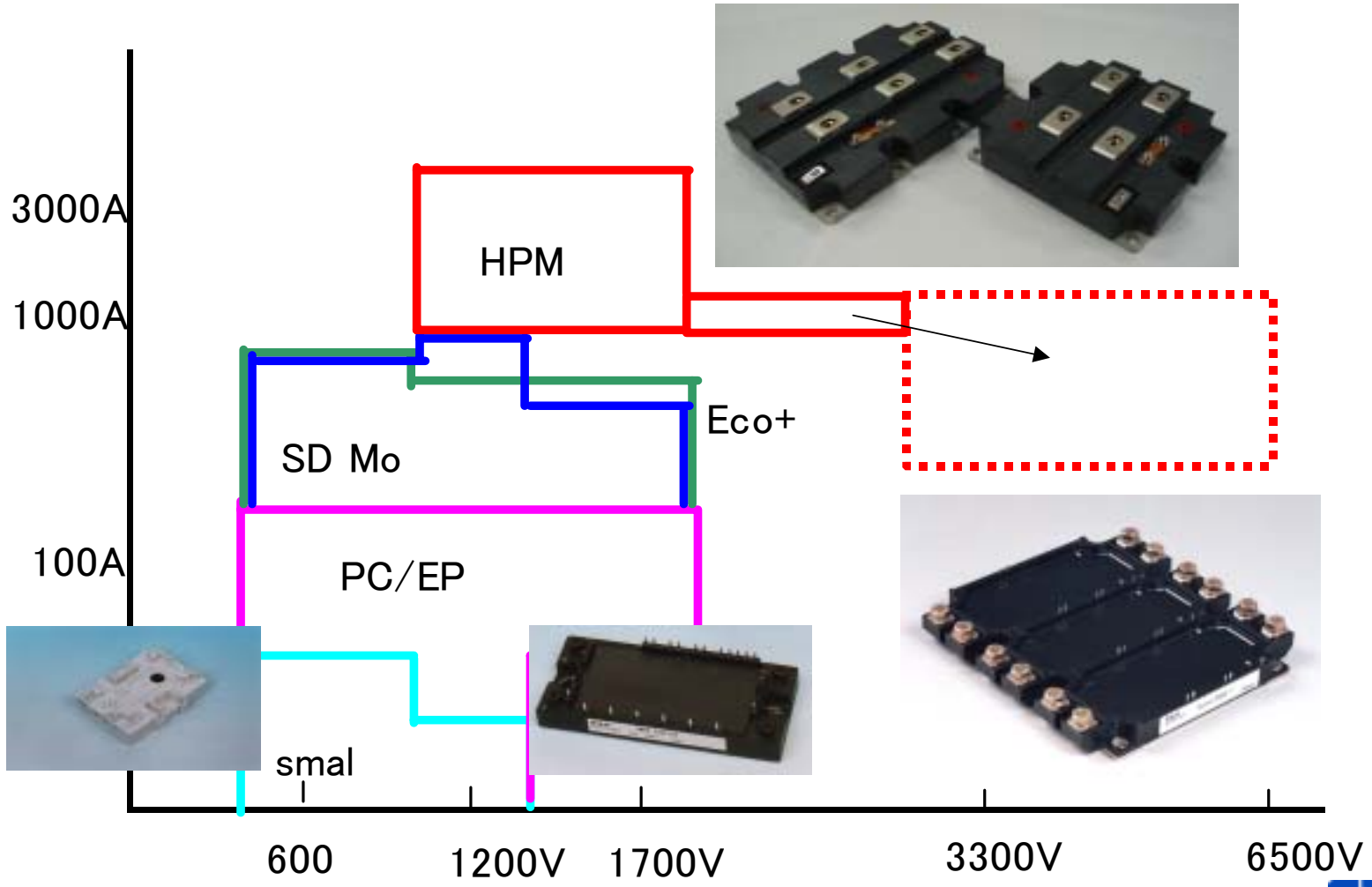
Quality is our message

IGBT module development Road-map



Quality is our message

Fuji IGBT Spectrum



Quality is our message



5th Gen. IGBT Module U-series

Concept

Development of the IGBT Module for 'Ecology Electronics'

- 1) Lower power dissipation loss
- 2) Smaller package and easy to use
- 3) Higher reliability

Features

- 1) Low-loss : More than 20% reduction compare with conventional by using 5th Gen. IGBT technologies .
- 2) Soft and fast reverse recovery by SAS-FWD.
- 3) Wide Line-up : 600V/10-600A, 1200V/10-3600A, 1700V/150-3600A, Small, standard, Econo-family, HPM package will be available.
- 4) Package compatibility with conventional.
- 5) Large-current support : New-Package for parallel-using is applied. (EconoPACK-Plus)
- 6) Higher reliability : higher power cycle capability by Sn-Ag solder under the power chip

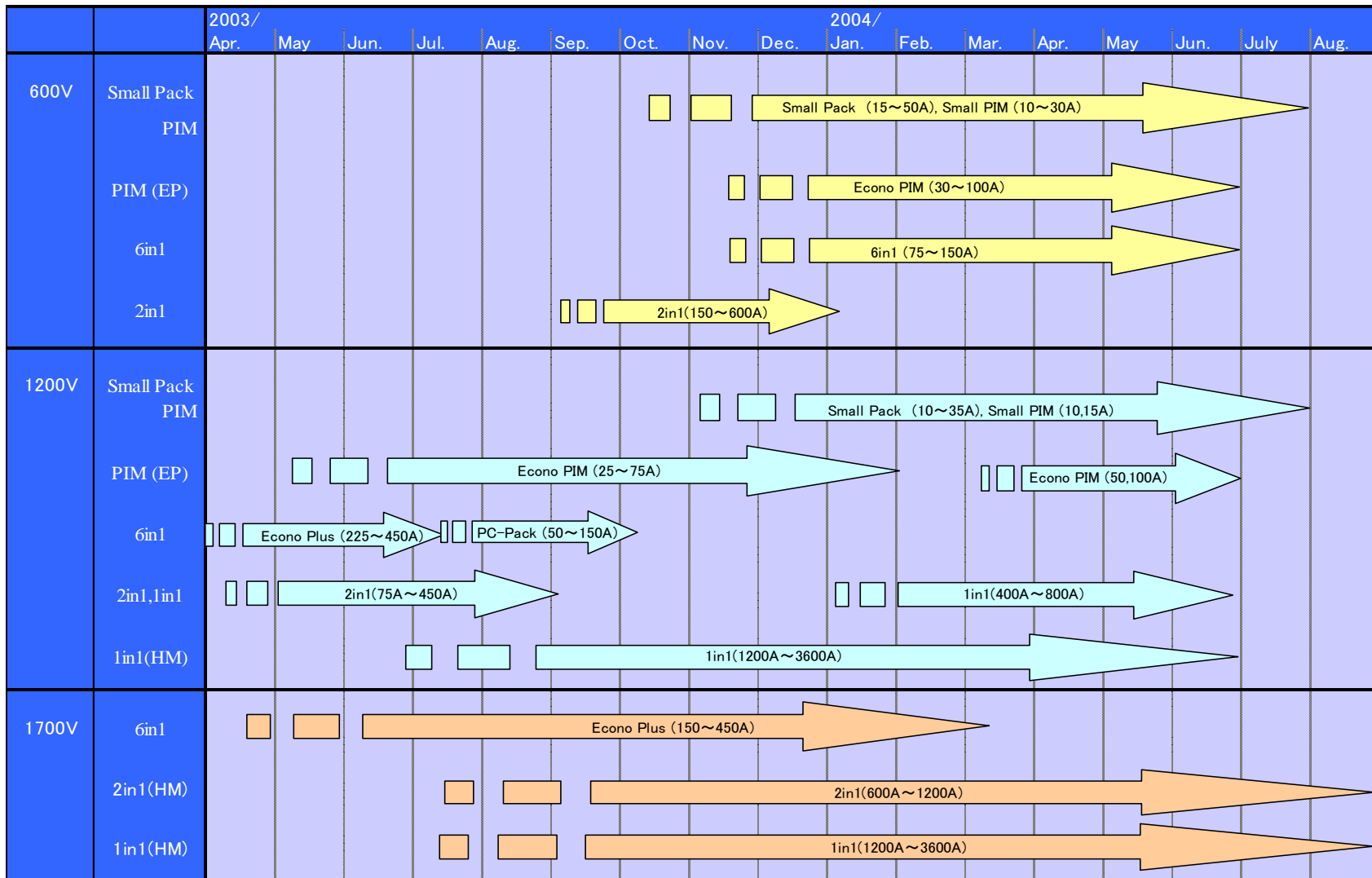


Quality is our message

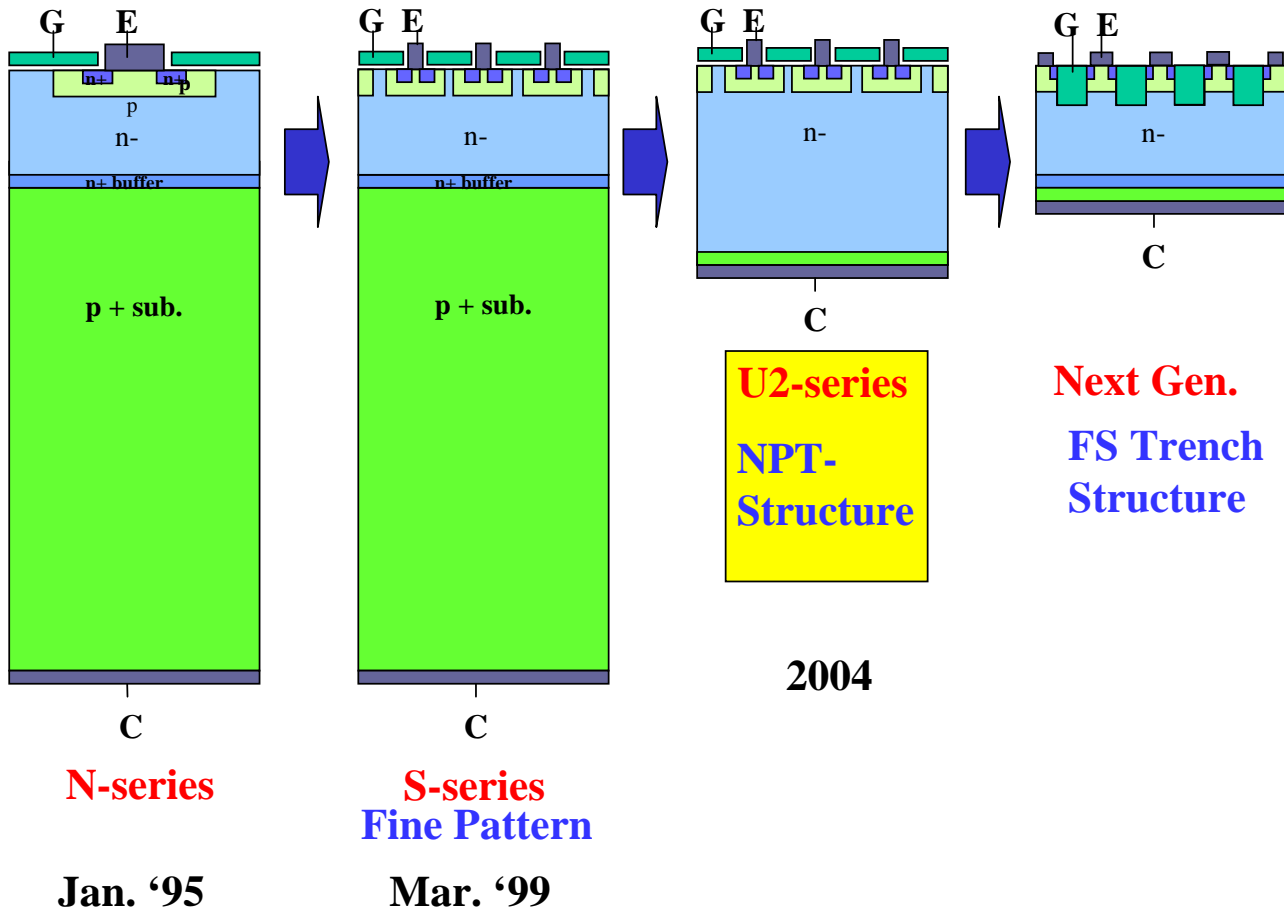
FUJI
ELECTRIC

Development road map of U-series IGBT modules

Road map of U-series IGBT modules



Progress of Fuji's 600V IGBT chip design

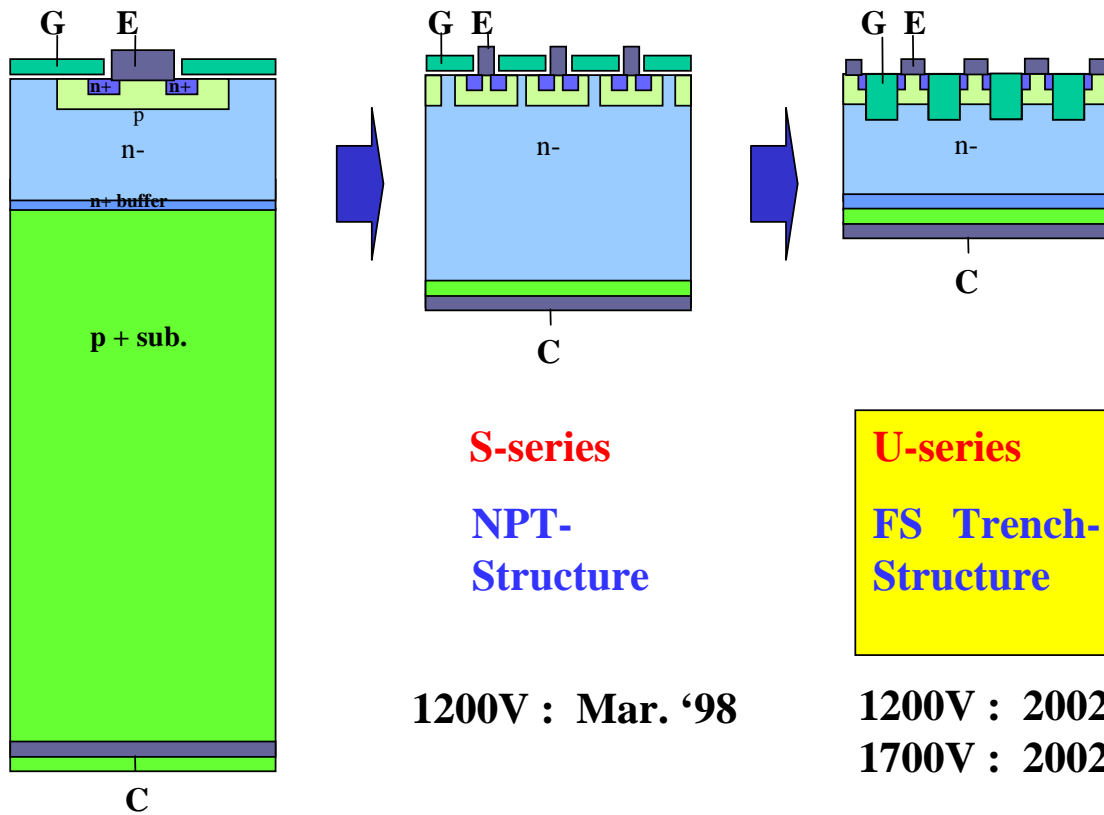


**U2-series
NPT-
Structure**

2004

**Next Gen.
FS Trench
Structure**

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



N-series

1200V : Jan. '95

S-series

**NPT-
Structure**

1200V : Mar. '98

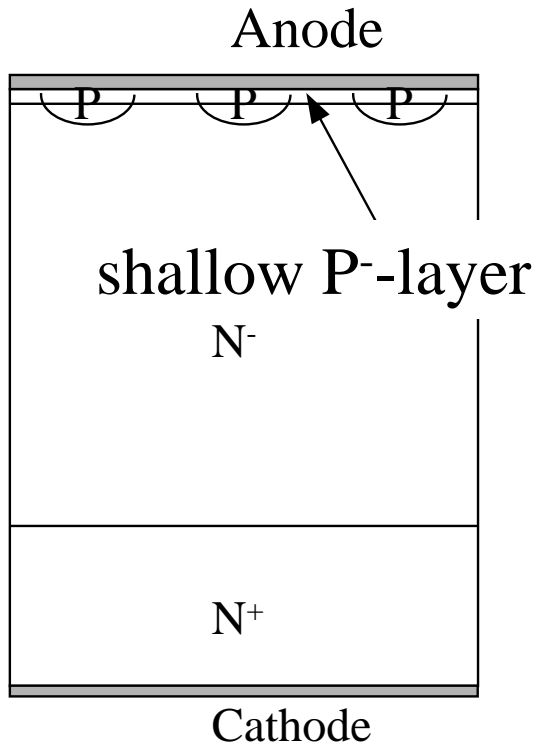
U-series

**FS Trench-
Structure**

1200V : 2002

1700V : 2002

SAS diode structure



Advantages

Lower anode injection
soft and fast recovery

Positive Temperature Coefficient
uniform current distribution

SAS FWD

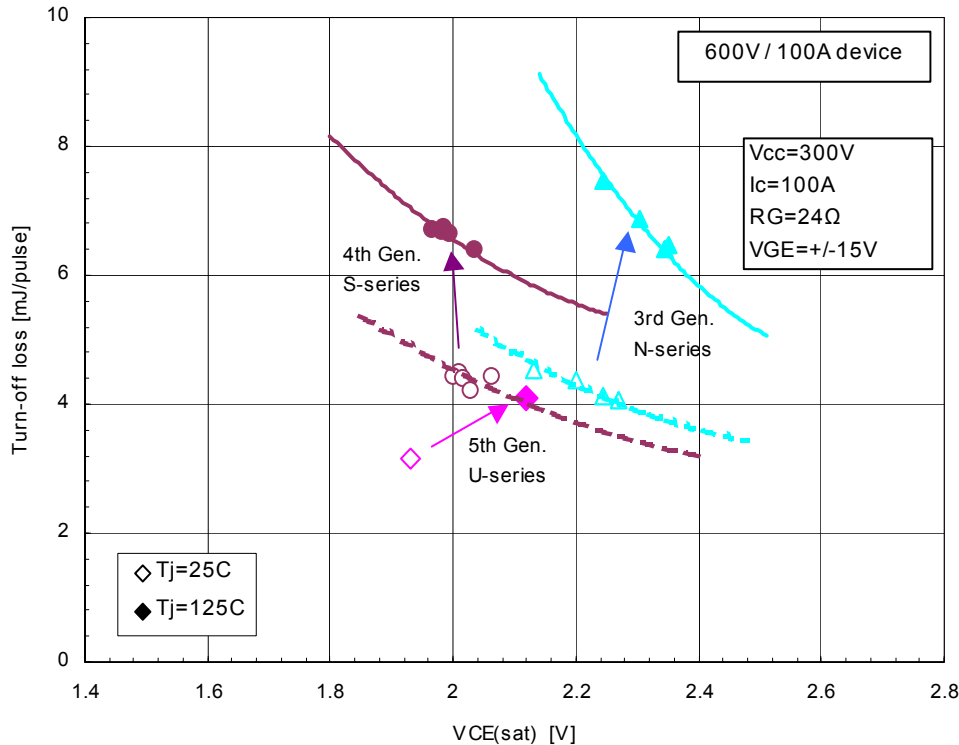
(Shallow-Anode-Structure)

Quality is our message

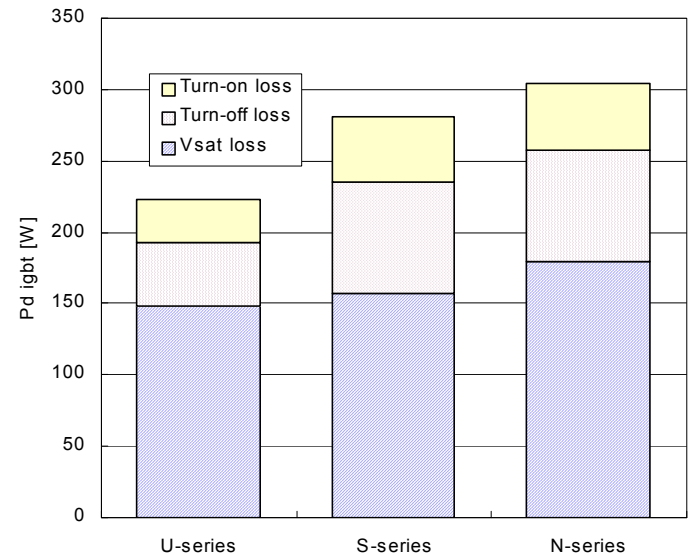
600V 5th Gen.(U2-series) Loss comparison

20% lower losses

600V IGBT Eoff-VCE(sat) Trade-off



Simulated Inverter Power Loss (fc=10kHz, 100% load)



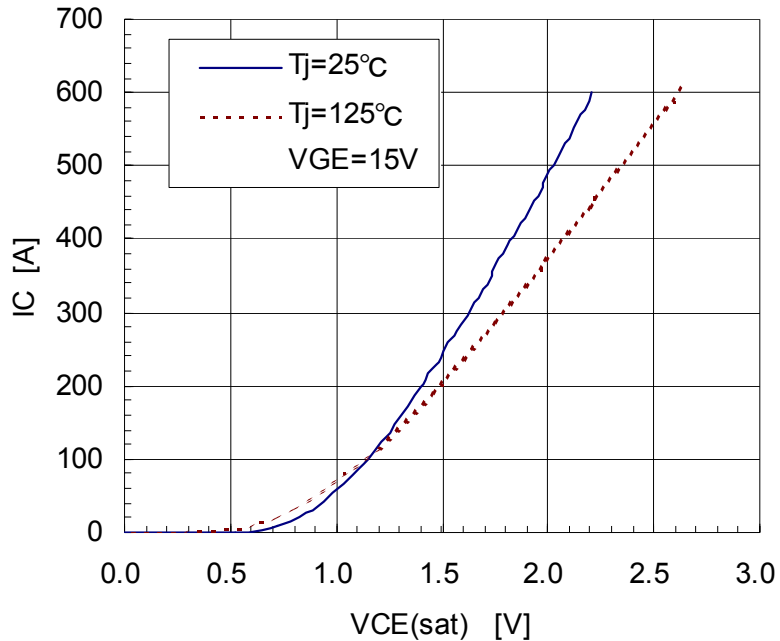
600V / 400A device

3 arm modulation
fc=10kHz
fo=50Hz
Io=225Arms(45kW)
cos φ=0.9
λ=1

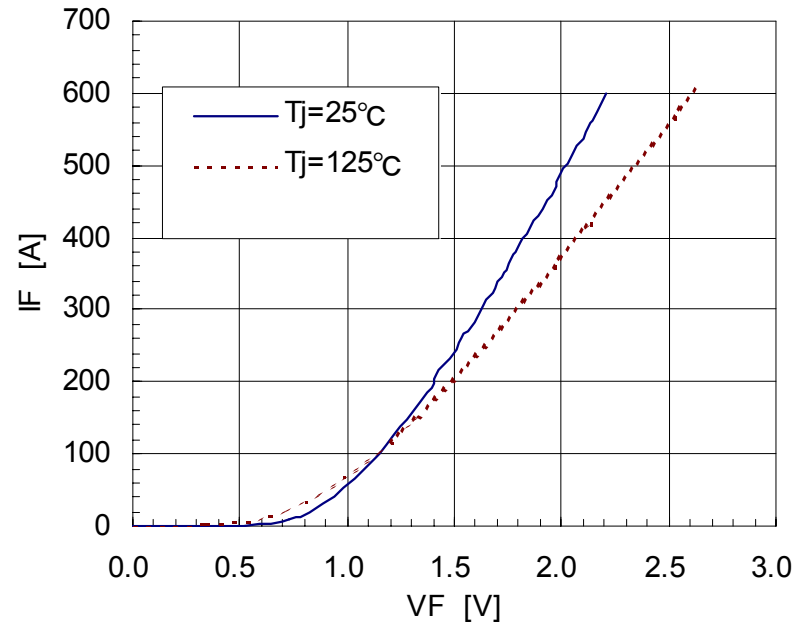
Quality is our message

600V 5th Gen.(U2-series) Static Characteristics

Output characteristic (400A/600V)

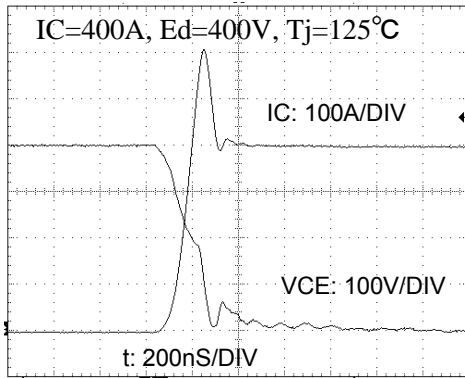


FWD IF-VF characteristic (400A/600V)

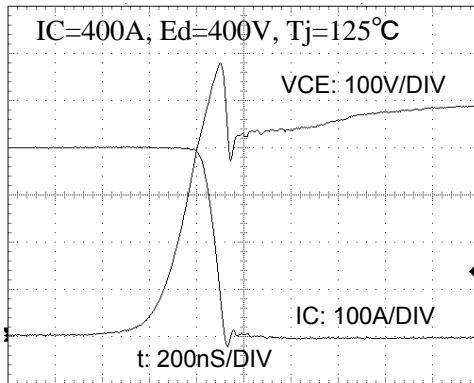


600V 5th Gen.(U2-series) Switching Waveforms

Turn-on



Turn-off

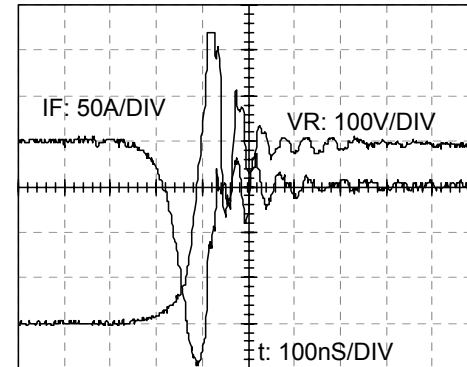


FWD reverse recovery

Conventional FWD

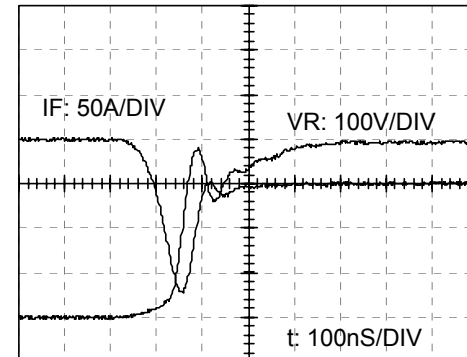


IF=50A
Ed=400V
Tj=125°C

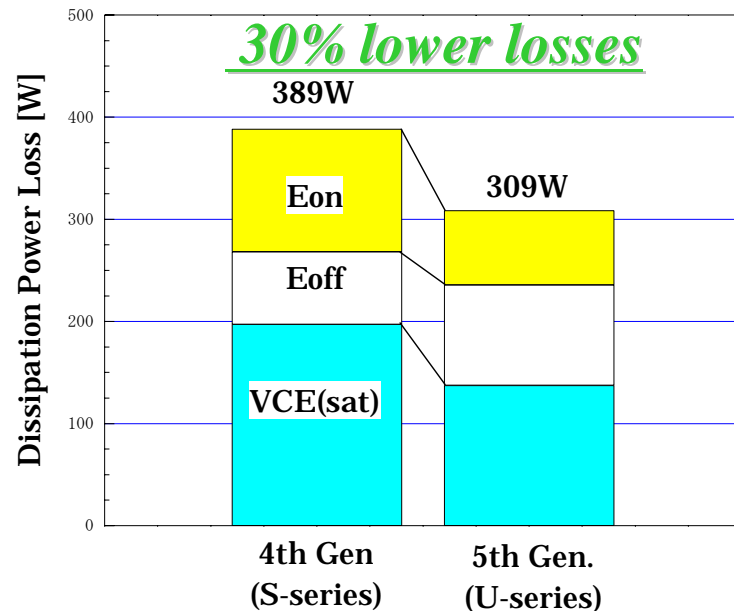
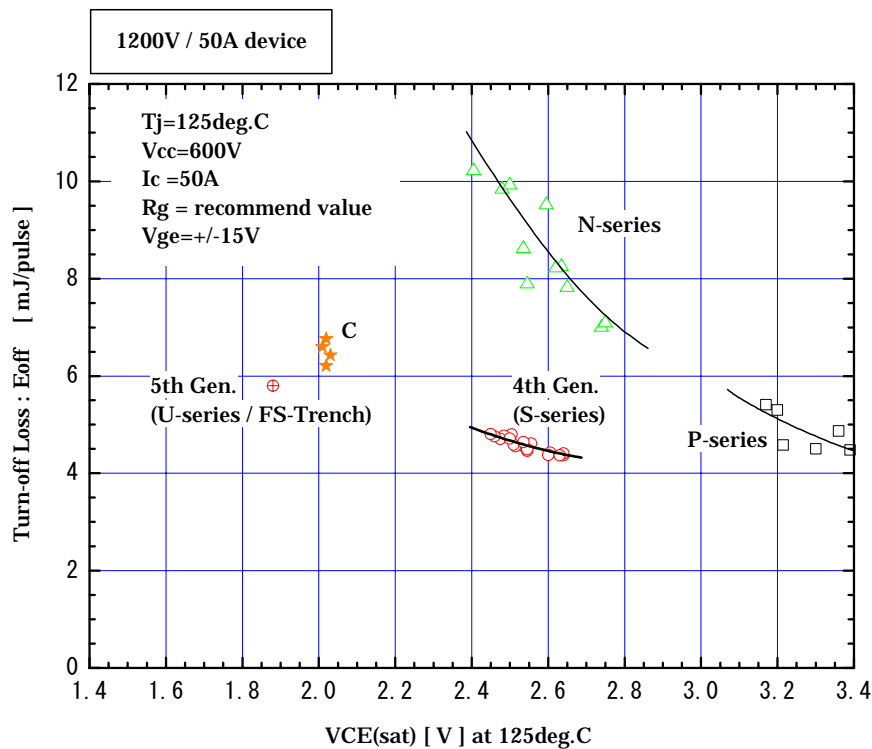


New FWD

IF=50A
Ed=400V
Tj=125°C



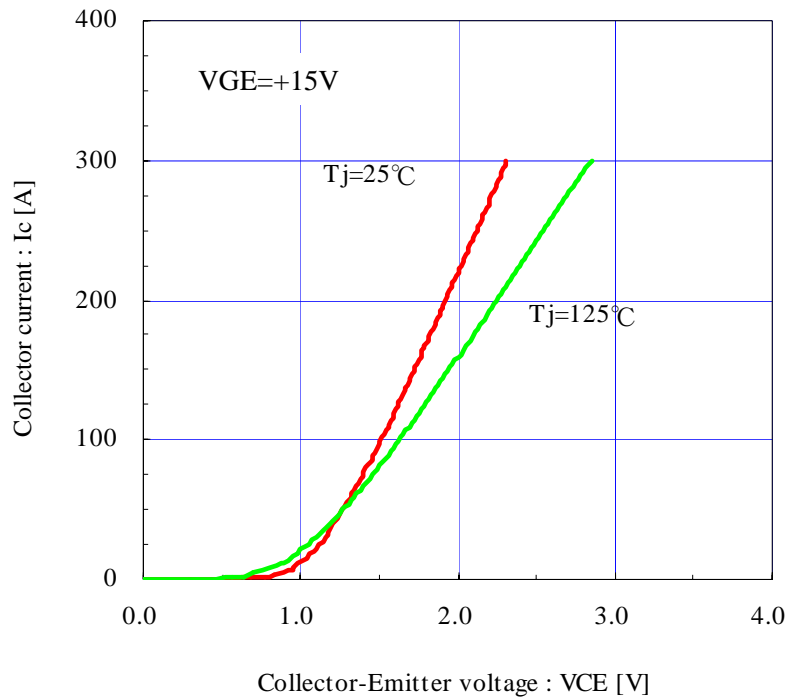
1200V 5th Gen.(U-series) Loss comparison



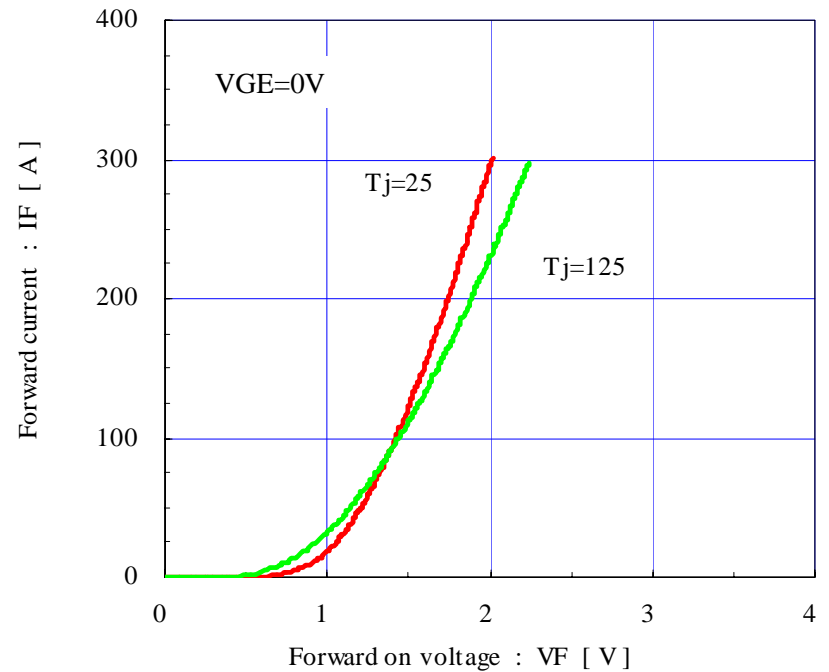
Parameters :
 1200V/200A-devices
 40kW-inverter
 $T_j=125^\circ\text{C}$ / $V_{in}=400\text{VAC}$
 $I_o=180\text{Arms}$ (180% load)
 $f_c=10\text{kHz}$ / $f_o=50\text{Hz}$ / $\cos\phi=0.9$ / $\lambda=1$

1200V 5th Gen.(U-series) Output characteristics

IGBT-Part



FWD-Part



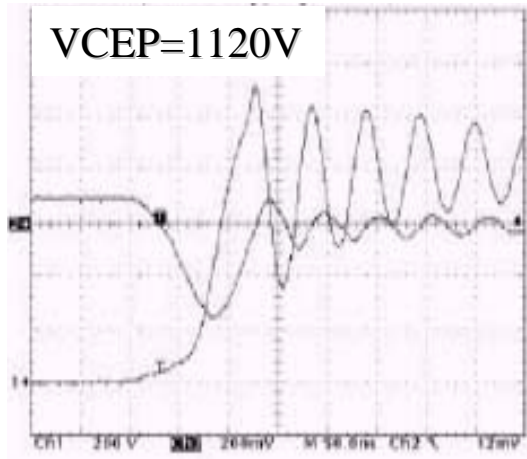
150A/1200V-device / $V_{CE(sat)}=1.95V$, $V_F=2.0V$ at 125deg.C

Quality is our message

Reverse Recovery characteristics at low-current & high voltage

Conventional

$V_{CC} = 840V$



5th Gen. (U-series)

$V_{CC} = 1000V$

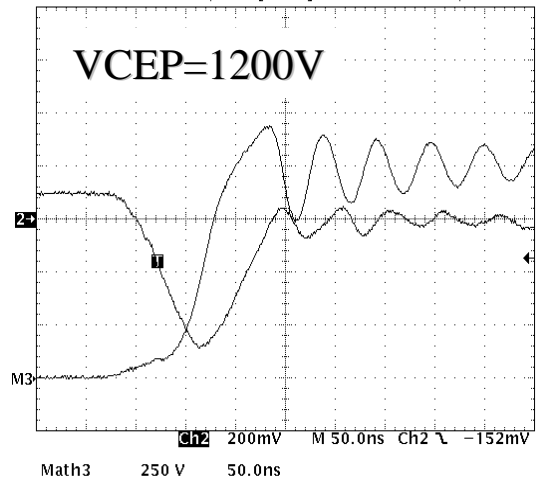
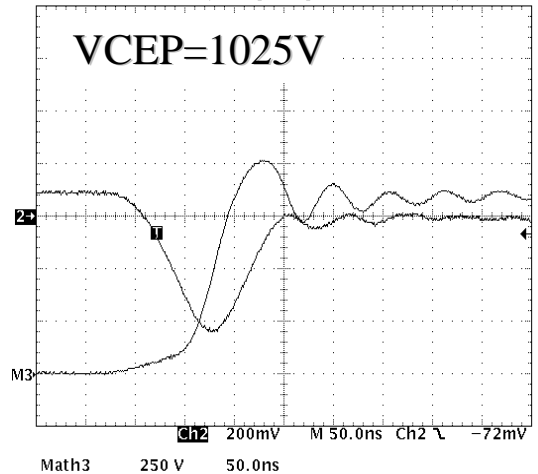
Conditions:

1200V/450A Devices

$T_j = RT / IF = 45A(\text{rating}/10)$

$V_{GE} = +, -15V / R_G = 1.1\text{ohm}$

$L_s = 65nH$



**Soft-switching
is our design
concept.**

Ch1 or Math3: Vak

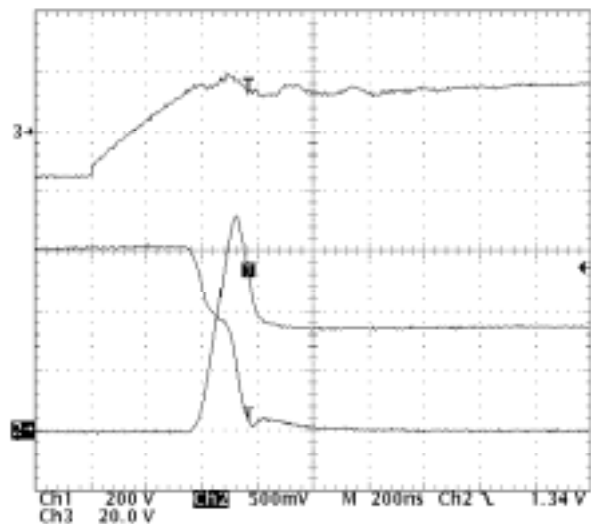
Ch2 : IF

(100mA/div=100A/div)

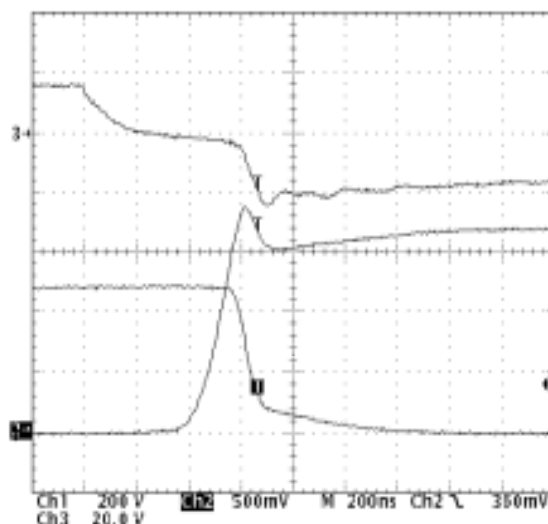
Quality is our message

1200V 5th Gen.(U-series) Switching waveforms

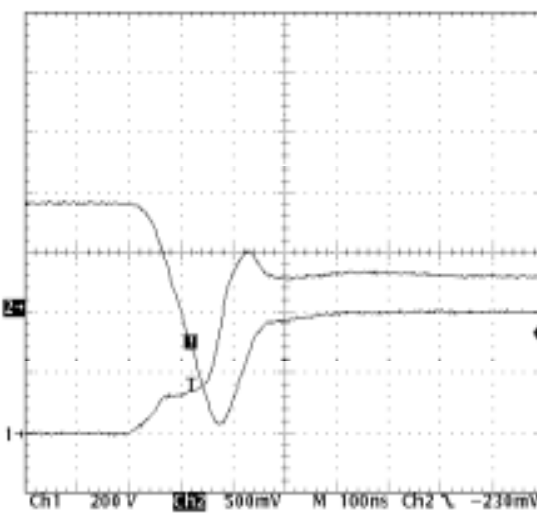
Turn-on



Turn-off



Reverse Recovery



450A/1200V-device

$T_j=125\text{deg.C}$ / $V_{cc}=600\text{V}$ / $I_c=450\text{A}(\text{rating})$ / $V_{GE}=+,-15\text{V}$ / $R_G=1.1\text{ohm}$ / $L_s=80\text{nH}$

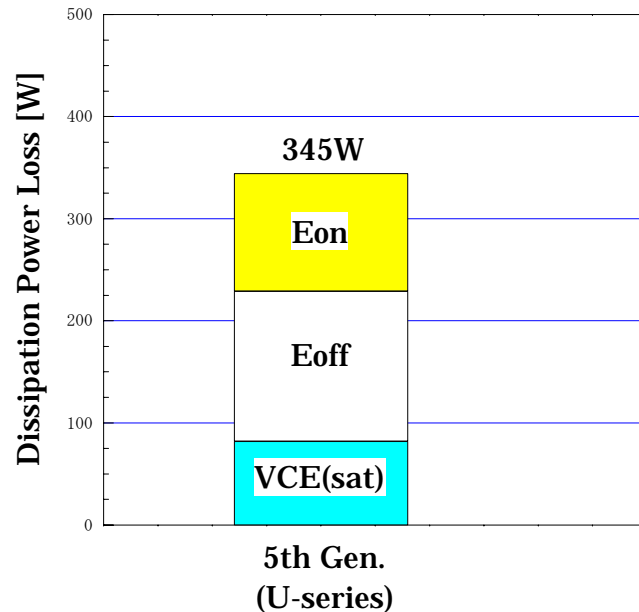
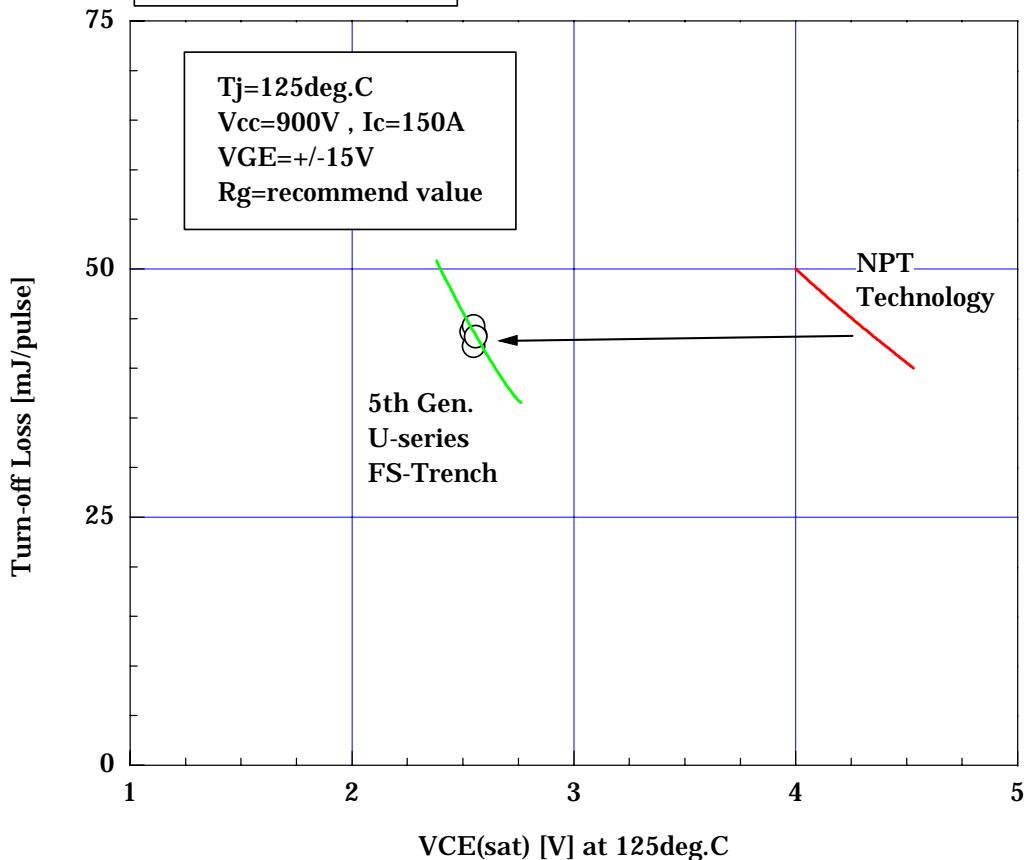
Ch1:VCE / Ch2:Ic(250A/div) / Ch3:VGE

Quality is our message

1700V 5th Gen.(U-series) Loss comparison

1700V/150A-Device

T_j=125deg.C
 V_{cc}=900V, I_c=150A
 V_{GE}=+/-15V
 R_g=recommend value



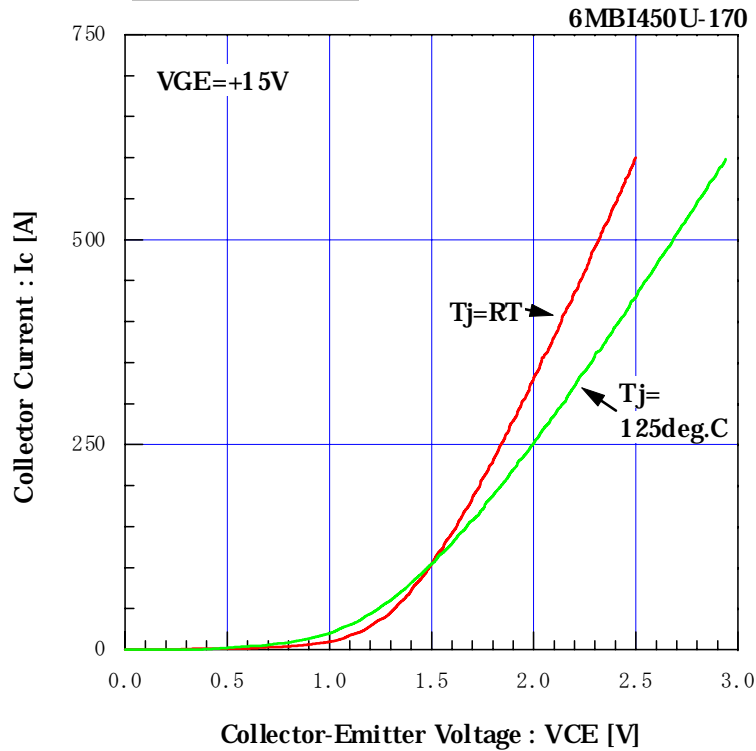
Parameters :
 1700V/200A-devices
 40kW-inverter
 T_j=125°C / V_{in}=690VAC
 I_o=104Arms(180% load)
 f_c=10kHz / f_o=50Hz / cosφ=0.9 / λ=1

Quality is our message

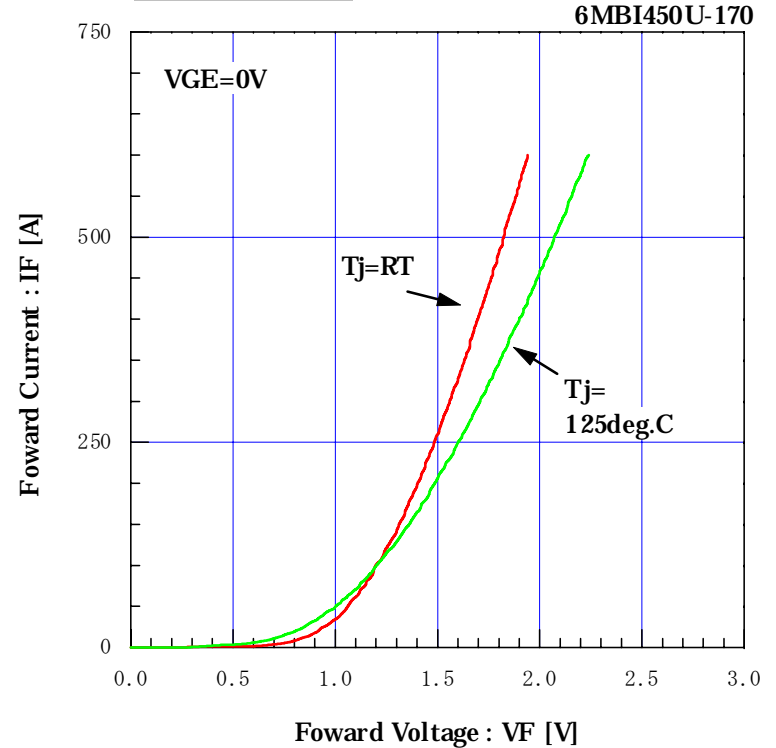


1700V 5th Gen.(U-series) Output characteristics

IGBT-Part



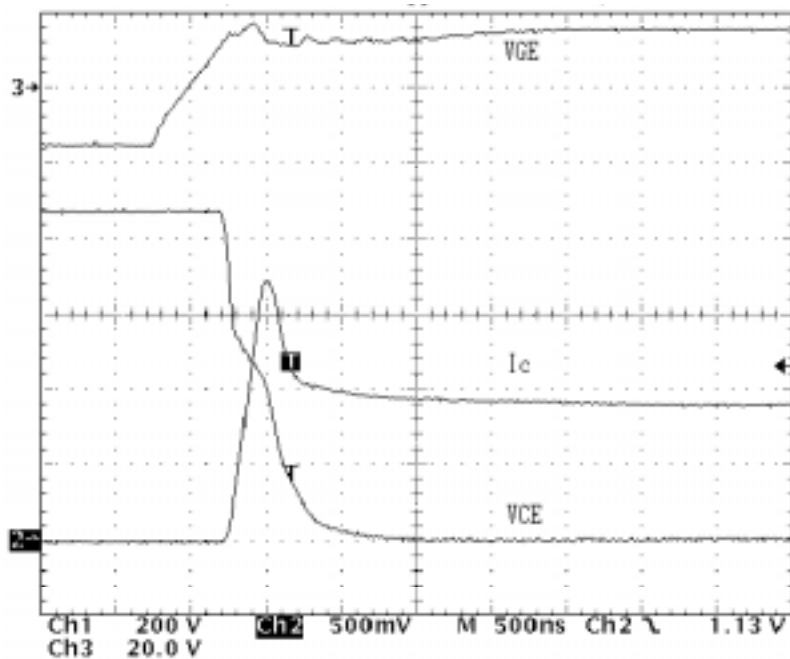
FWD-Part



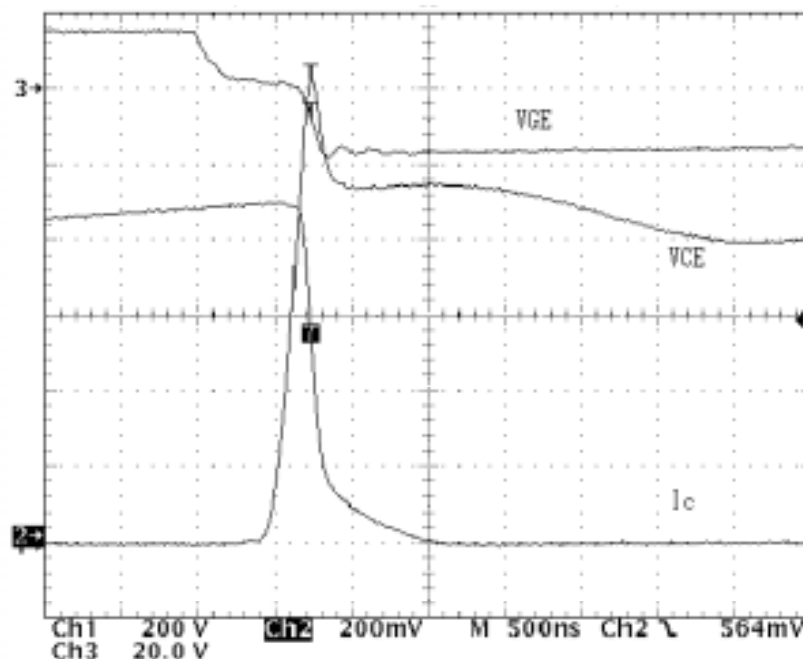
450A/1700V-device / VCE(sat)=2.55V , VF=2.0V at 125deg.C

1700V 5th Gen.(U-series) Switching waveforms

Turn-on waveforms



Turn-off waveforms



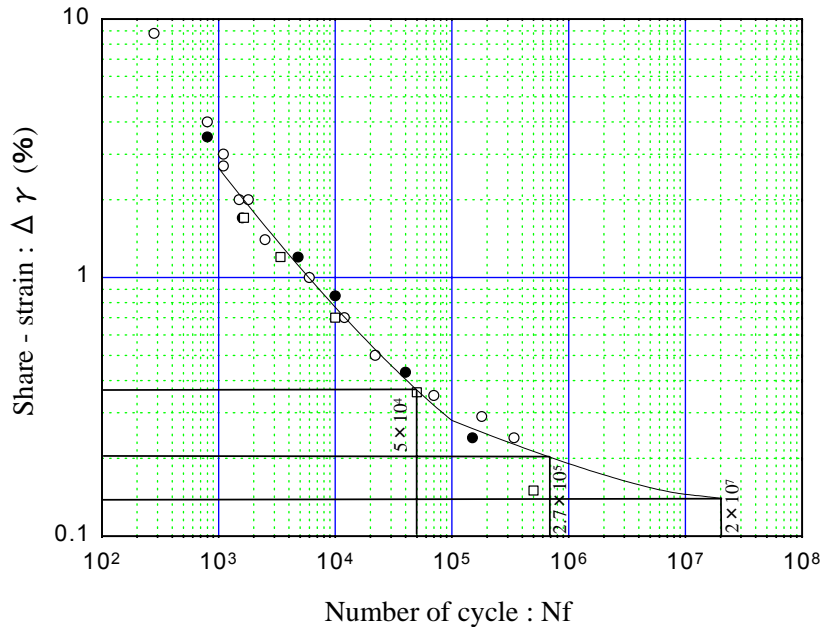
450A/1700V-device

$T_j=125\text{deg.C}$ / $V_{cc}=900\text{V}$ / $I_c=450\text{A}(\text{rating})$ / $V_{GE}=+,-15\text{V}$ / $R_G=1.1\text{ohm}$ / $L_s=80\text{nH}$

Ch1:VCE / Ch2:Ic(200mA=100A) / Ch3:VGE

Quality is our message

Characteristics of solders



○ : Sn-Pb solder

(Ref. Fatigue of solder

Morris E, Fine Symp. Detroit Mid)

● : Sn-Pb solder (experimental)

□ : Sn-Ag solder (experimental)

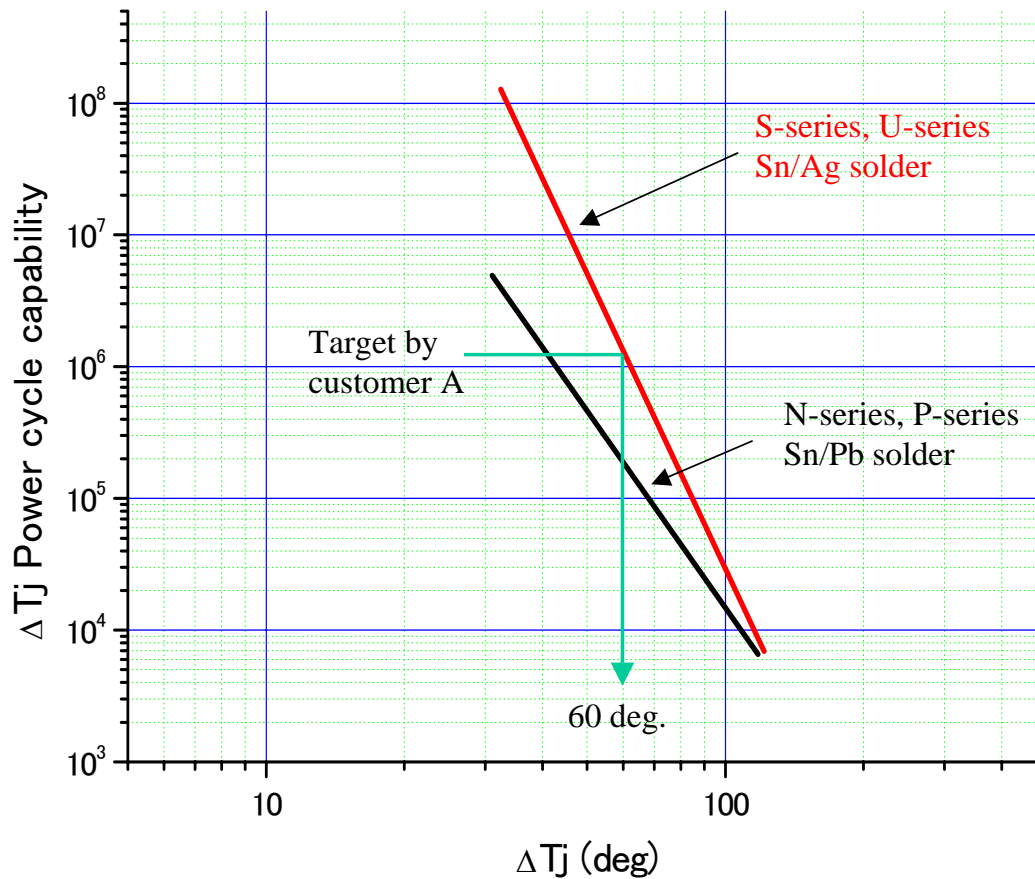
Mechanical property of the newly development solder alloys

	Sn-Ag (developed)	Sn 3.5 Ag	Pb-based (conventional)
Yield strength (MPa)	53	38	22
Elongation (%)	19	18	25
Creep rate (%/h)	0.09	0.20	1.30

High Yield strength and Cow Elongation
decrease the sharing stress of solder joint.

Quality is our message

Power cycle curve



5th Gen. IGBT Module (U-series) Line-up Plan

 Standard (General purpose)
 High performance
 Optional

VCES	PKG	Ic rating																									
		10A	15A	20A	30A	50A (5.5kW)	75A	100A (11kW)	150A	200A (22kW)	300A	400A (40kW)	600A	800A	1200A	1600A	2400A	3600A									
600V	Small	Small-PIM, -Pack				SmallPack																					
	PIM				EP2		EP3																				
	6in1				NewPC2		NewPC3																				
	2in1							M232		M233		M247															
		Ic rating																									
		10A	15A	25A (5.5kW)	35A	50A (11kW)	75A	100A (22kW)	150A	200A (40kW)	300A	400A (75kW)	600A	800A	1200A	1600A	2400A	3600A									
1200V	Small	Small-PIM, -Pack		Small-Pack																							
	PIM	Optional		EP2		EP3																					
	6in1				NewPC2 with NTC		NewPC3 with NTC		EconoPack-Plus (6in1)																		
	2in1/1in1				M232		M233		M247		M138		M142		M143												
					M234		M249		M235		M127																
					M234		M249		M235		M127																
	PIM/6in1	For Vector Control			NewPC3 (with Shunt R)																						
1700V	6in1				NewPC3 with NTC		EconoPack-Plus (6in1)			M234(M249)		M248		M142		M143											
	2in1																										

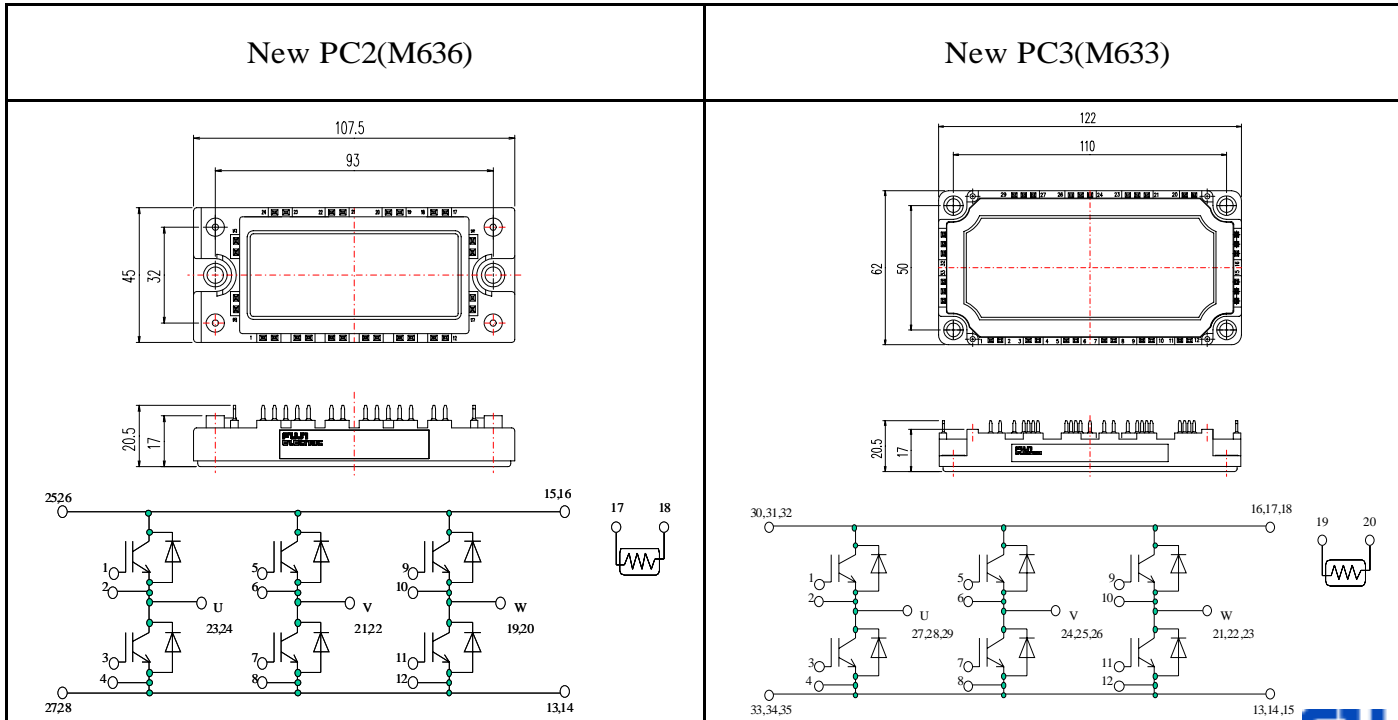
Quality is our message

U-series (PC-Pack)

Line-up

Type Name	VCES	IC(DC)	Type Name	VCES	IC(DC)	Package
			6MBI50UA-120	1200V	50A	NewPC2(M636)
6MBI75U2A-060	600V	75A	6MBI75UA-120	1200V	75A	NewPC2(M636)
			6MBI75UB-120	1200V	75A	NewPC3(M633)
6MBI100U2B-060	600V	100A	6MBI100UB-120	1200V	100A	NewPC3(M633)
6MBI150U2B-060	600V	150A	6MBI150UB-120	1200V	150A	NewPC3(M633)

Outline and Equivalent Circuit

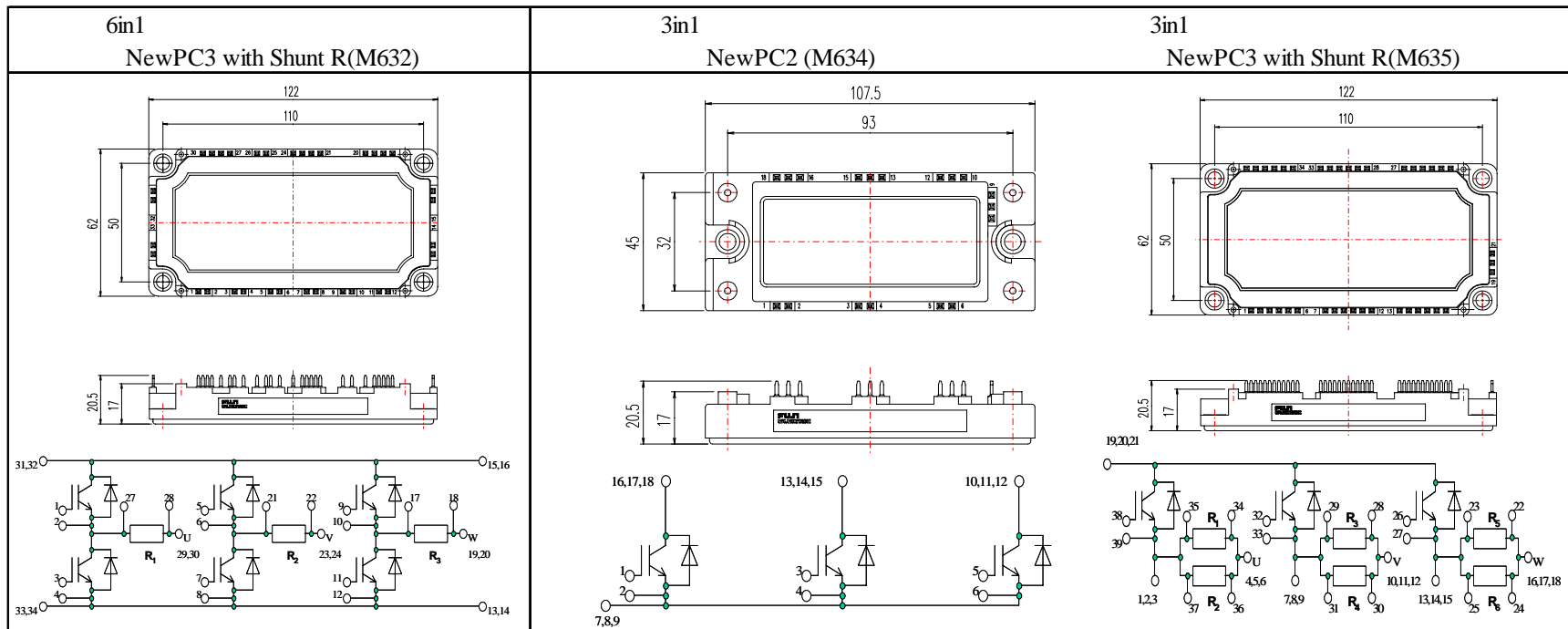


Quality is our message

Line-up

Type Name	VCES	IC(DC)	Shunt-R	Package
6MBI75UC-120	1200V	75A	2.4mΩ	NewPC3 with Shunt R (M632)
6MBI100UC-120	1200V	100A	1.5mΩ	NewPC3 with Shunt R (M632)
3MBI150U-120	1200V	150A	-	NewPC2(M634)
3MBI150UC-120	1200V	150A	2.4mΩ	NewPC3 with Shunt R (M635)

Outline and Equivalent Circuit



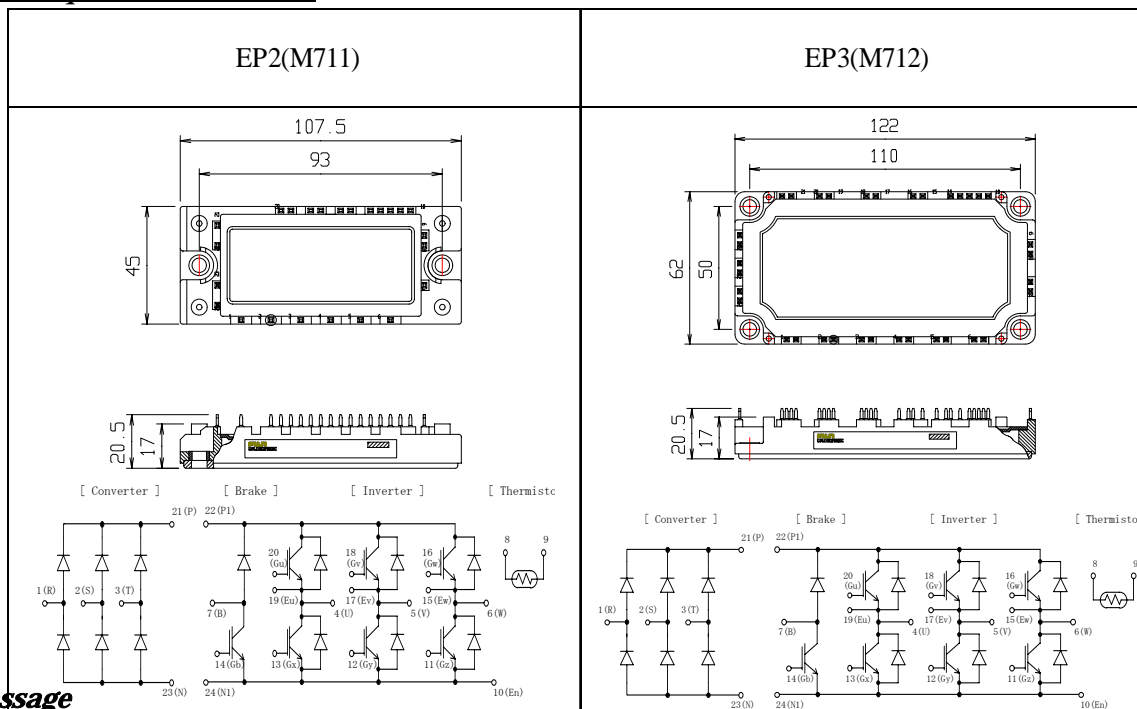
Quality is our message

U-series (EP2/EP3)

Line-up

Type Name	VCES	IC(DC)	Package
7MBR50U2A060	600V	50A	EP2(M711)
7MBR75U2B060	600V	75A	EP3(M712)
7MBR100U2B060	600V	100A	EP3(M712)
7MBR25UA120	1200V	25A	EP2(M711)
7MBR35UA120	1200V	35A	EP2(M711)
7MBR35UB120	1200V	35A	EP3(M712)
7MBR50UB120	1200V	50A	EP3(M712)
7MBR75UB120	1200V	75A	EP3(M712)

Outline and Equivalent Circuit



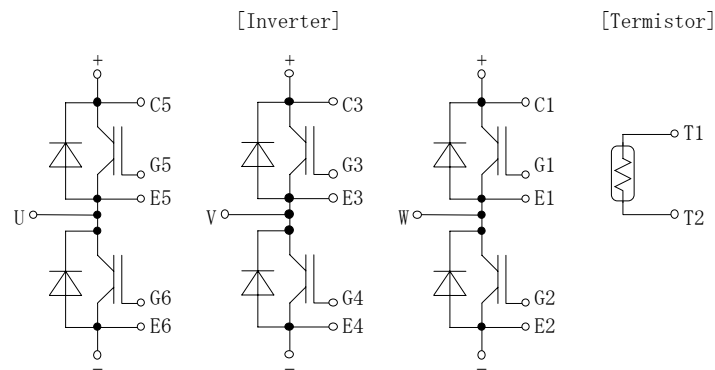
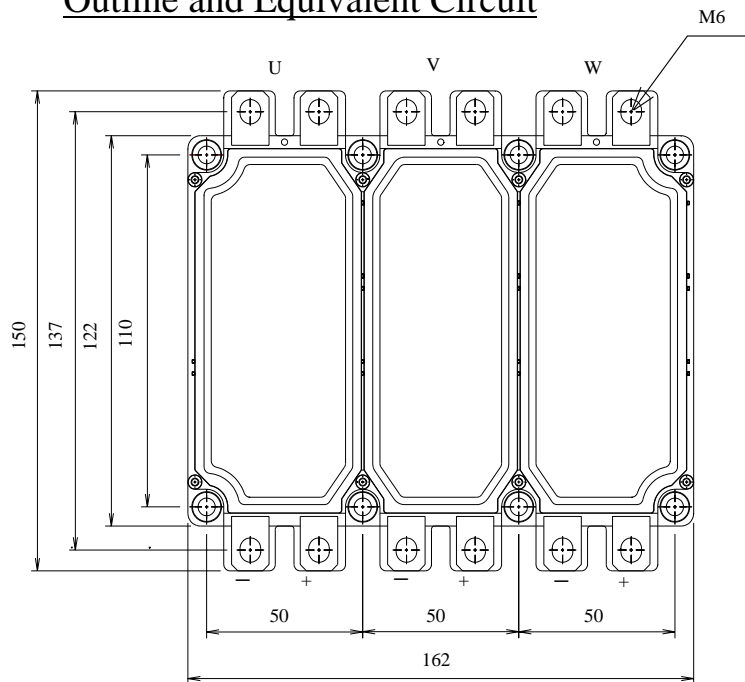
Quality is our message

EconoPACK+™ is a trademark of eupec GmbH,Warstein

Line-up

Type Name	VCES	IC(DC)	Package
6MBI225U-120	1200V	225A	Econo PACK-Plus (M629)
6MBI300U-120	1200V	300A	
6MBI450U-120	1200V	450A	
6MBI150U-170	1700V	150A	
6MBI225U-170	1700V	225A	
6MBI300U-170	1700V	300A	
6MBI450U-170	1700V	450A	

Outline and Equivalent Circuit

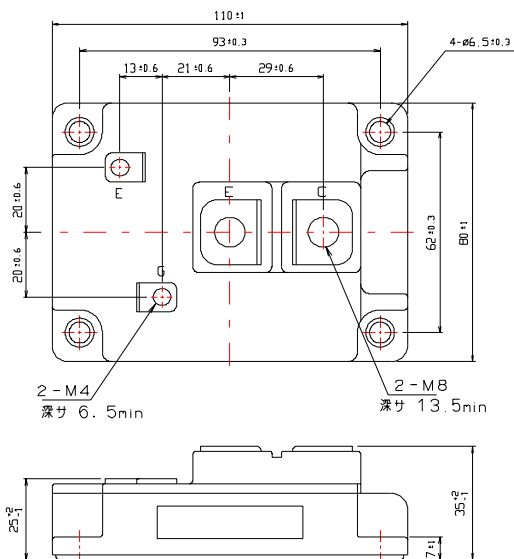
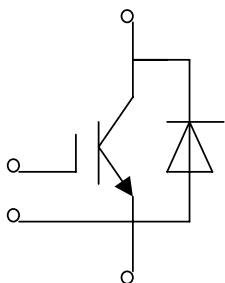


Quality is our message

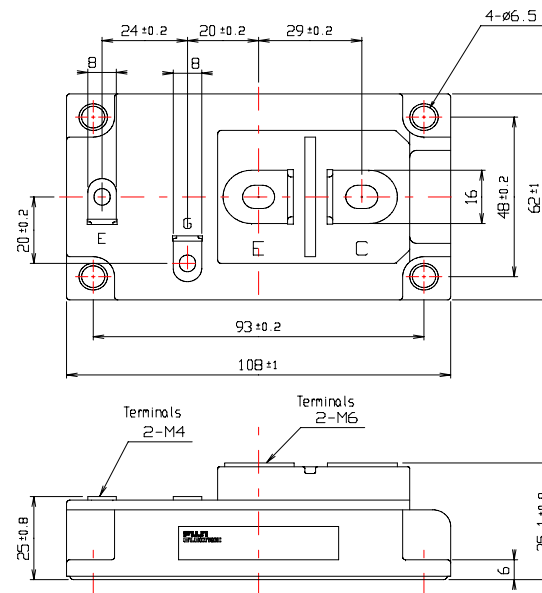
Line-up

Type Name	VCES	IC(DC)	Package
1MBI600UB-120	1200V	600A	M138
1MBI800UB-120	1200V	800A	
1MBI400U-120	1200V	400A	M127
1MBI600U-120	1200V	600A	

Outline and Equivalent Circuit



M138
(110*80*35mm)



M127
(108*62*35mm)

Quality is our message

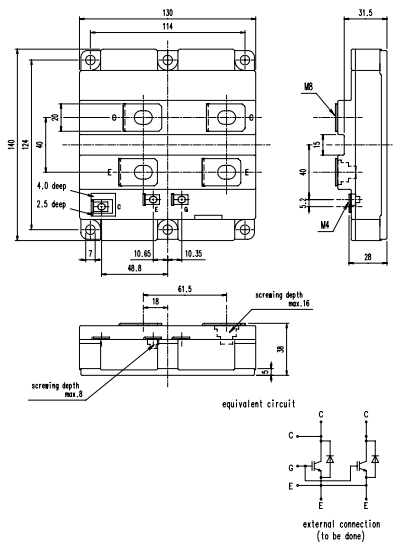
U-series (1 in 1 High Power Module)

Line-up

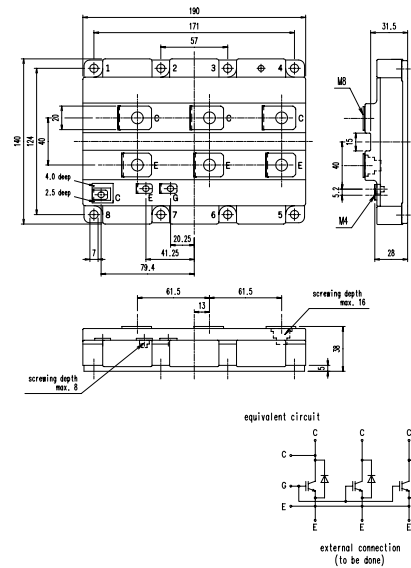
Type name	vces	Ic (DC)	VCE(sat)	VF	PKG
			125 c typ.		
1MB1200UC-120	1200V	1200A	2.0V	1.8V	M142
1MB1600UC-120	1200V	1600A	2.0V	1.8V	M142
1MB12400UD-120	1200V	2400A	2.0V	1.8V	M143
1MB13600UD-120	1200V	3600A	2.0V	1.8V	M143
1MB1200UC-170	1700V	1200A	2.4V	2.0V	M142
1MB1600UC-170	1700V	1600A	2.4V	2.0V	M142
1MB12400UD-170	1700V	2400A	2.4V	2.0V	M143
1MB13600UD-170	1700V	3600A	2.4V	2.0V	M143

Outline and Equivalent Circuit

130x140



140x190

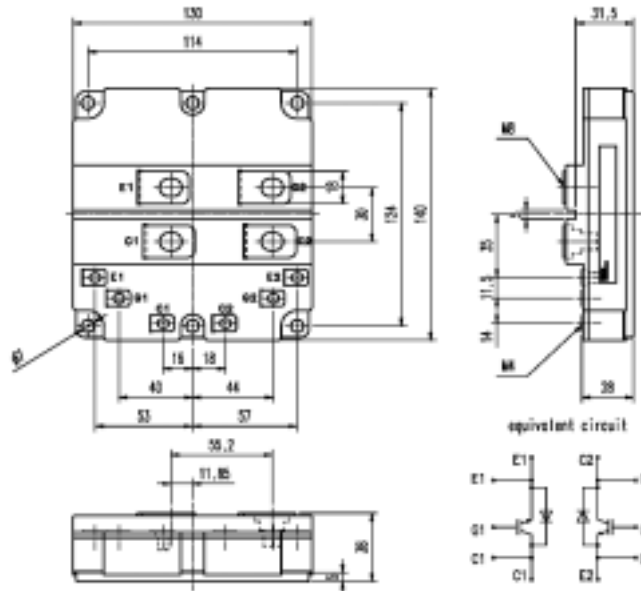


Quality is our message

Line-up

Type name	vces	Ic (DC)	VCE(sat)	VF	PKG
			125 c typ.		
2MBI 600UG-170	1700V	600A	2.4V	2.0V	M248
2MBI 800UG-170	1700V	800A	2.4V	2.0V	M248
2MBI1200UG-170	1700V	1200A	2.4V	2.0V	M248

Outline and Equivalent Circuit



140 x 130 mm

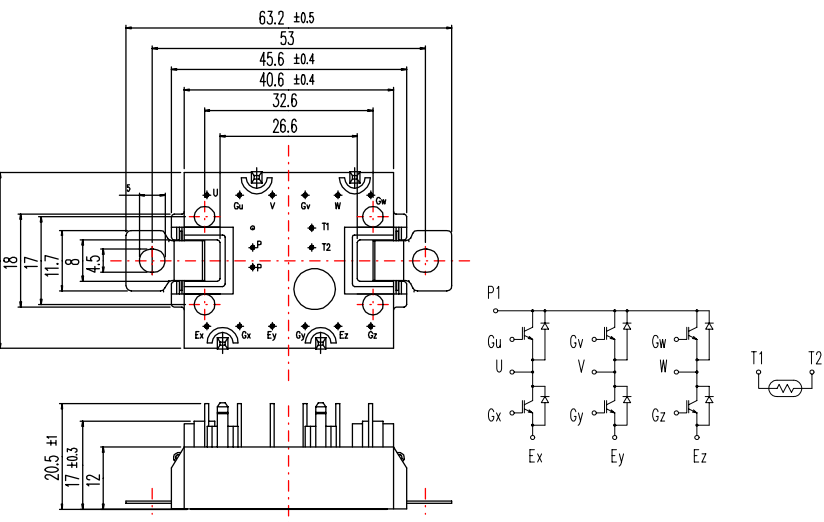
Quality is our message

Line-up

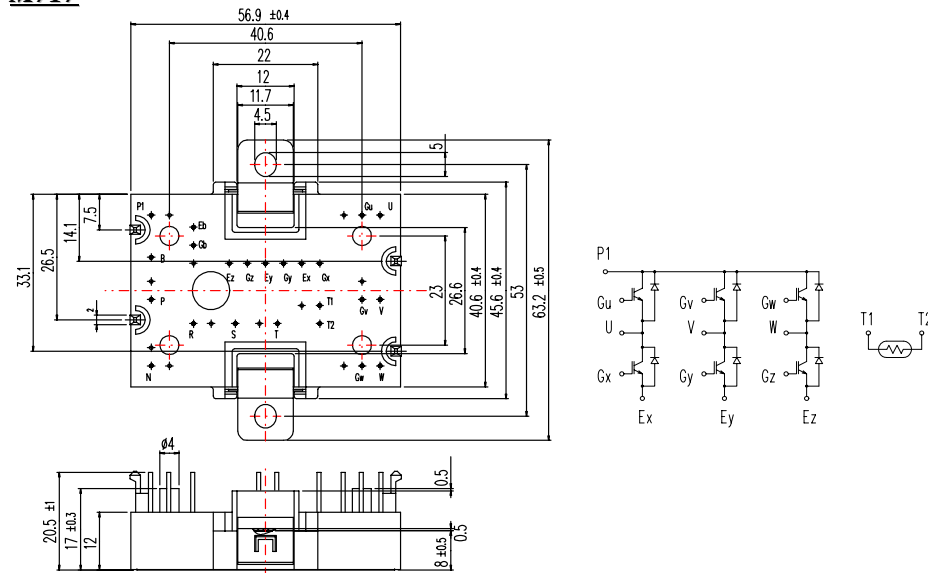
Type name	vces	Ic (DC)	PKG	Type name	vces	Ic (DC)	PKG
6MBI10UE-060	600V	10A	M716	6MBI10UF-120	1200V	10A	M716
6MBI15UE-060		15A	M716	6MBI15UF-120		15A	M716
6MBI20UE-060		20A	M716	6MBI25UF-120		25A	M717
6MBI30UE-060		30A	M716	6MBI35UF-120		30A	M717
6MBI50UF-060		50A	M717				

Outline and Equivalent Circuit

M716



M717



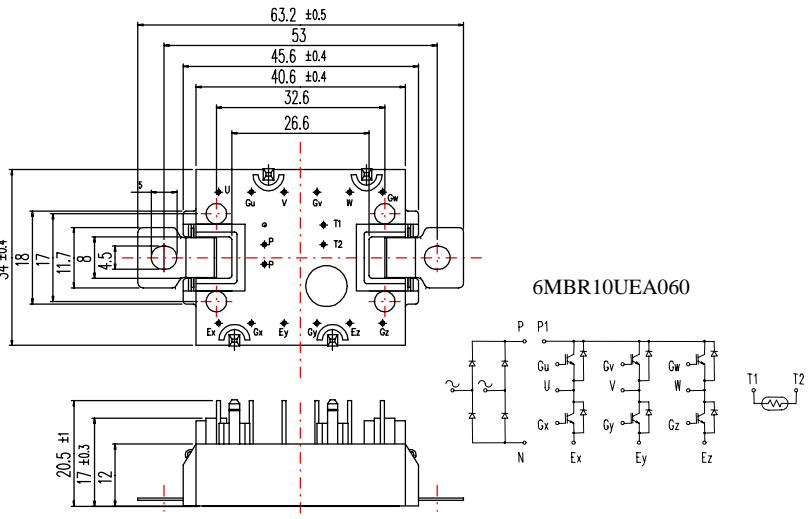
Quality is our message

Line-up

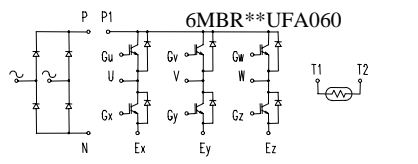
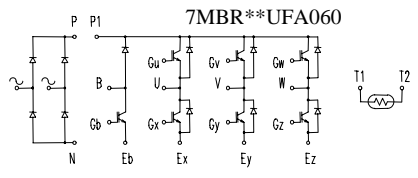
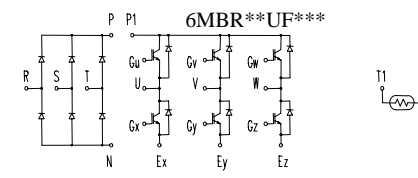
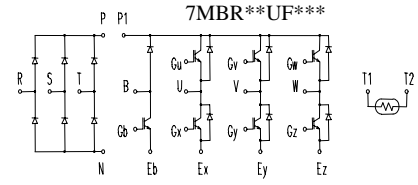
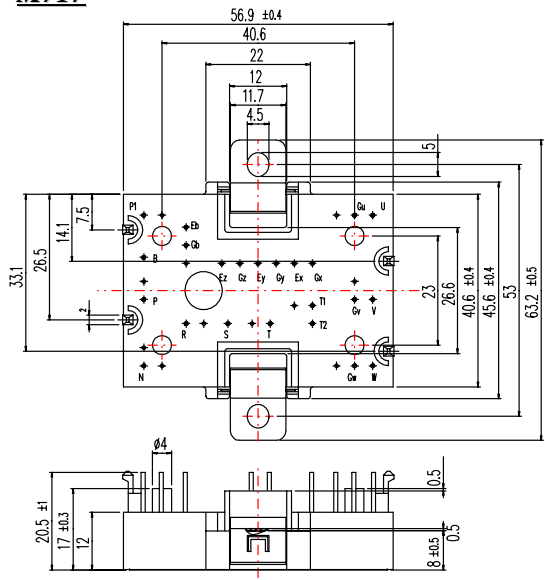
Type name	vces	Ic (DC)	PKG	Type name	vces	Ic (DC)	PKG
6MBR10UEA060	600V	10A	M716	6/7MBR10UF120	1200V	10A	M717
6/7MBR15UF060		15A	M717	6/7MBR15UF-120		15A	M717
6/7MBR15UFA060		15A	M717				
6/7MBR20UF060		20A	M717				
6/7MBR20UFA060		20A	M717				
6/7MBR30UF060		30A	M717				

Outline and Equivalent Circuit

M716



M717



Quality is our message



