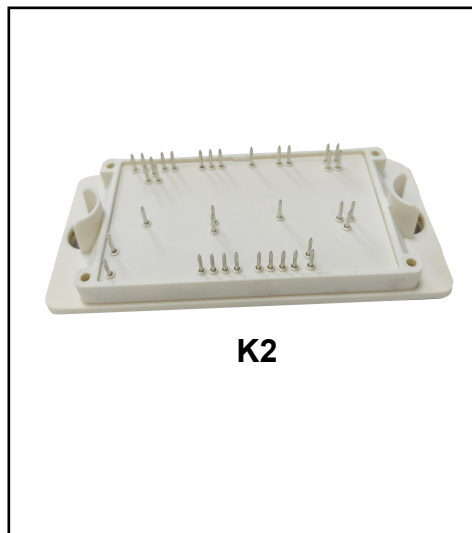


3-Level NPC Inverter Module with 650V Trench Stop IGBTs

Features

- Electrical features
 - Neutral Point Clamped Three-Level Inverter Module
 - 650V Trench Stop IGBTs
 - $T_{vj\ op}=150^{\circ}\text{C}$
 - Low Inductive Layout
 - Thermistor
- Mechanical features
 - Package with CTI >500
 - Solderable Pins



K2

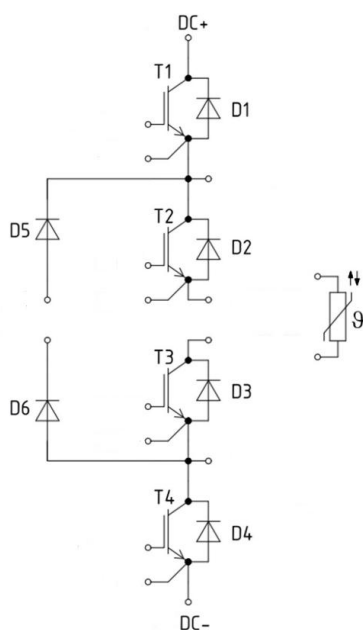
Typical Applications

- Solar Inverters
- UPS Systems

Product validation

- Qualified for industrial applications according to the relevant tests of IEC 60747, 60749 and 60068

Description



Package Insulation coordination

Parameter	Symbol	Note or test condition	Values	Unit
Isolation test voltage	V_{ISOL}	RMS, f=50Hz, t=60s	4.0	kV
Material of module baseplate			Cu	
Internal isolation		basic insulation(class 1, IEC 61140)	Al_2O_3	
Creepage distance	d_{creep}	terminal to heatsink	12.90	mm
Creepage distance	d_{creep}	terminal to terminal	7.7	mm
Clearance	d_{clear}	terminal to heatsink	12.70	mm
Clearance	d_{clear}	terminal to terminal	7.5	mm
Comparative tracking index (electrical)	CTI		>500	

Package Characteristic values

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Mounting torque for module mounting	M	-Mounting according to valid application note	M5, Screw	3		5	Nm
Weight	G				179.7		g

MAXIMUM RATINGS (Note 1)

Symbol	Rating	Value	Unit
--------	--------	-------	------

OUTER IGBT (T1-1, T1-2,T4-1,T4-2)

V _{CES}	Collector–Emitter Voltage	650	V
V _{GE}	Gate– Emitter Voltage	±20	V
	Positive Transient Gate–Emitter Voltage (tpulse = 5 s, D < 0.10)	30	
I _{CN}	Implemented collector current	225	A
I _{CDC}	Continuous Collector Current @ T _c = 80°C (T _{JMAX} = 175°C)	178	A
I _{CRM}	Repetitive peak collector current (tp = 1ms)	450	A
P _{tot}	Maximum Power Dissipation @ T _c = 80°C (T _{JMAX} = 175°C)	431	W
T _{JMAX}	Maximum Operating Junction Temperature	175	°C

INNER IGBT (T2, T3)

V _{CES}	Collector–Emitter Voltage	650	V
V _{GE}	Gate– Emitter Voltage	±20	V
	Positive Transient Gate–Emitter Voltage (tpulse = 5 s, D < 0.10)	30	
I _{CN}	Implemented collector current	375	A
I _{CDC}	Continuous Collector Current @ T _c = 80°C (T _{JMAX} = 175°C)	298	A
I _{CRM}	Repetitive peak collector current (tp = 1ms)	750	A
P _{tot}	Maximum Power Dissipation @ T _c = 80°C (T _{JMAX} = 175°C)	678	W
T _{JMAX}	Maximum Operating Junction Temperature	175	°C

NEUTRAL POINT DIODE (D5, D6)

V _{RRM}	Peak Repetitive Reverse Voltage	650	V
I _F	Continuous Forward Current @ T _c = 80°C (T _{JMAX} = 175°C)	289	A
I _{FRM}	Repetitive Peak Forward Current (T _{JMAX} = 175°C)	867	A
P _{tot}	Maximum Power Dissipation @ T _c = 80°C (T _{JMAX} = 175°C)	633	W
T _{JMAX}	Maximum Operating Junction Temperature	175	°C

INVERSE DIODES (D1, D2, D3, D4)

V _{RRM}	Peak Repetitive Reverse Voltage	650	V
I _F	Continuous Forward Current @ T _c = 80°C (T _J = 175°C)	150	A
I _{FRM}	Repetitive Peak Forward Current (tp = 1 ms)	450	A
P _{tot}	Maximum Power Dissipation @ T _c = 80°C (T _{JMAX} = 175°C)	327	W
T _{JMAX}	Maximum Operating Junction Temperature	175	°C

THERMAL PROPERTIES

T _{stg}	Storage Temperature Range	-40 to 125	°C
T _{vj op}	Temperature under switching condition	-40 to (T _{jmax} -25)	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Refer to ELECTRICAL CHARACTERISTICS, RECOMMENDED OPERATING RANGES and/or APPLICATION INFORMATION for Safe Operating parameters.

RECOMMENDED OPERATING RANGES

Symbol	Rating	Min	Max	Unit
T _J	Module Operating Junction Temperature	-40	T _{JMAX}	°C

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise noted)(AC test is three-level test mode)

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
OUTER IGBT (T1-1, T1-2,T4-1,T4-2)						
ICES	Collector-Emitter Cutoff Current	V _{GE} = 0 V, V _{CE} = 650 V	--	--	300	μA
V _{CE(sat)}	Collector-Emitter Saturation Voltage	V _{GE} = 15 V, I _C = 225 A, T _J = 25°C	--	1.58	2.2	V
		V _{GE} = 15 V, I _C = 225 A, T _J = 150°C	--	1.98	--	
V _{GE(TH)}	Gate-Emitter Threshold Voltage	V _{GE} = V _{CE} , I _C = 3 mA	4.0	4.75	5.5	V
I _{GES}	Gate Leakage Current	V _{GE} = 30 V, V _{CE} = 0 V	--	--	300	nA
t _{d(on)}	Turn-On Delay Time	T _J = 25°C V _{CE} = 400 V, I _C = 100 A V _{GE} = -5 V to +15 V, R _G = 25Ω	--	234	--	ns
t _r	Rise Time		--	65	--	
t _{d(off)}	Turn-off Delay Time		--	1166	--	
t _f	Fall Time		--	212	--	
E _{on}	Turn-On Switching Loss per Pulse		--	4.36	--	mJ
E _{off}	Turn Off Switching Loss per Pulse		--	3.95	--	
t _{d(on)}	Turn-On Delay Time	T _J = 125°C V _{CE} = 400 V, I _C = 100 A V _{GE} = -5 V to +15 V, R _G = 25Ω	--	195	--	ns
t _r	Rise Time		--	82	--	
t _{d(off)}	Turn-off Delay Time		--	1238	--	
t _f	Fall Time		--	262	--	
E _{on}	Turn-on Switching Loss per Pulse		--	6.01	--	mJ
E _{off}	Turn Off Switching Loss per Pulse		--	5.79	--	
C _{ies}	Input Capacitance	V _{CE} = 50 V, V _{GE} = 0 V, f = 100 kHz	--	23.31	--	nF
C _{oes}	Output Capacitance		--	0.48	--	
C _{res}	Reverse Transfer Capacitance		--	0.30	--	
Q _g	Total Gate Charge	V _{CE} = 480 V, I _C = 225 A, V _{GE} = ± 15 V	--	0.86	--	μC
R _{thJH}	Thermal Resistance - Chip-to-Heatsink	Thermal grease, Thickness = 2 Mil ±2%, A = 2.9 W/mK	--	0.43	--	°C/W
R _{thJC}	Thermal Resistance - Chip-to-Case		--	0.22	--	°C/W

NEUTRAL POINT DIODE (D5, D6)

V _F	Diode Forward Voltage	I _F = 375 A, T _J = 25°C	--	1.19	1.80	V
		I _F = 375 A, T _J = 150°C	--	1.10	--	
t _{rr}	Reverse Recovery Time	T _J = 25°C V _{CE} = 400 V, I _C = 100 A V _{GE} = -5 V to +15 V, R _G = 25Ω	--	73	--	ns
Q _{rr}	Reverse Recovery Charge		--	2.25	--	μC
I _{RRM}	Peak Reverse Recovery Current		--	42	--	A
di/dt	Peak Rate of Fall of Recovery Current		--	619	--	A/μs
E _{rr}	Reverse Recovery Energy		--	0.41	--	mJ
t _{rr}	Reverse Recovery Time	T _J = 125°C V _{CE} = 400 V, I _C = 100 A V _{GE} = -5 V to +15 V, R _G = 25Ω	--	132	--	ns
Q _{rr}	Reverse Recovery Charge		--	6.39	--	μC
I _{RRM}	Peak Reverse Recovery Current		--	62	--	A
di/dt	Peak Rate of Fall of Recovery Current		--	517	--	A/μs
E _{rr}	Reverse Recovery Energy		--	1.23	--	mJ
R _{thJH}	Thermal Resistance - Chip-to-Heatsink	Thermal grease, Thickness = 2 Mil ±2%, A = 2.9 W/mK	--	0.35	--	°C/W
R _{thJC}	Thermal Resistance - Chip-to-Case		--	0.15	--	°C/W

INNER IGBT (T2, T3)

ICES	Collector-Emitter Cutoff Current	V _{GE} = 0 V, V _{CE} = 650 V	--	--	300	μA
V _{CE(sat)}	Collector-Emitter Saturation Voltage	V _{GE} = 15 V, I _C = 375 A, T _J = 25°C	--	1.58	2.2	V
		V _{GE} = 15 V, I _C = 375 A, T _J = 150°C	--	1.98	--	
V _{GE(TH)}	Gate-Emitter Threshold Voltage	V _{GE} = V _{CE} , I _C = 5 mA	4.0	4.75	5.5	V
I _{GES}	Gate Leakage Current	V _{GE} = 30 V, V _{CE} = 0 V	--	--	300	nA

ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise noted) (AC test is three-level test mode)

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
INNER IGBT (T₂, T₃)						
t _{d(on)}	Turn-On Delay Time	T _J = 25°C V _{CE} = 400 V, I _C = 100 A V _{GE} = -5 V to +15 V, R _G = 25Ω	--	242	--	ns
t _r	Rise Time		--	59	--	
t _{d(off)}	Turn-Off Delay Time		--	843	--	
t _f	Fall Time		--	236	--	
E _{on}	Turn-On Switching Loss per Pulse		--	3.85	--	mJ
E _{off}	Turn Off Switching Loss per Pulse		--	3.96	--	
t _{d(on)}	Turn-On Delay Time	T _J = 125°C V _{CE} = 400 V, I _C = 100 A V _{GE} = -5 V to +15 V, R _G = 25Ω	--	203	--	ns
t _r	Rise Time		--	68	--	
t _{d(off)}	Turn-Off Delay Time		--	976	--	
t _f	Fall Time		--	268	--	
E _{on}	Turn-On Switching Loss per Pulse		--	4.97	--	mJ
E _{off}	Turn Off Switching Loss per Pulse		--	4.36	--	
C _{ies}	Input Capacitance	V _{CE} = 50 V, V _{GE} = 0 V, f = 10 kHz	--	38.85	--	nF
C _{oes}	Output Capacitance		--	0.80	--	
C _{res}	Reverse Transfer Capacitance		--	0.50	--	
Q _g	Total Gate Charge	V _{CE} = 480 V, I _C = 375 A, V _{GE} = ± 15 V	--	1.45	--	μC
R _{thJH}	Thermal Resistance – Chip-to-Heatsink	Thermal grease, Thickness = 2 Mil ±2%, A = 2.9 W/mK	--	0.29	--	°C/W
R _{thJC}	Thermal Resistance – Chip-to-Case		--	0.14	--	°C/W

INVERSE DIODES (D₁, D₂, D₃, D₄)

V _F	Diode Forward Voltage	I _F = 150 A, T _J = 25°C	--	1.37	1.80	V
		I _F = 150 A, T _J = 150°C	--	1.33	--	
t _{rr}	Reverse Recovery Time	T _J = 25°C V _{CE} = 400 V, I _C = 100 A V _{GE} = -5 V to +15 V, R _G = 25Ω	--	76	--	ns
Q _{rr}	Reverse Recovery Charge		--	1.99	--	μC
I _{RRM}	Peak Reverse Recovery Current		--	35	--	A
di/dt	Peak Rate of Fall of Recovery Current		--	568	--	A/μs
E _{rr}	Reverse Recovery Energy		--	0.62	--	mJ
t _{rr}	Reverse Recovery Time	T _J = 125°C V _{CE} = 400 V, I _C = 100 A V _{GE} = -5 V to +15 V, R _G = 25Ω	--	116	--	ns
Q _{rr}	Reverse Recovery Charge		--	4.51	--	μC
I _{RRM}	Peak Reverse Recovery Current		--	55	--	A
di/dt	Peak Rate of Fall of Recovery Current		--	547	--	A/μs
E _{rr}	Reverse Recovery Energy		--	1.47	--	mJ
R _{thJH}	Thermal Resistance – Chip-to-Heatsink	Thermal grease, Thickness = 2 Mil ±2%, A = 2.9 W/mK	--	0.53	--	°C/W
R _{thJC}	Thermal Resistance – Chip-to-Case		--	0.29	--	°C/W

THERMISTOR PROPERTIES

R ₂₅	Nominal Resistance	T = 25°C	--	22	--	kΩ
R ₁₀₀	Nominal Resistance	T = 100°C	--	1486	--	Ω
R/R	Deviation of R ₂₅		-5	--	-5	%
P _D	Power Dissipation		--	200	--	mW
	Power Dissipation Constant		--	2	--	mW/K
	B-value	B (25/50), tolerance ±3%	--	3950	--	K
	B-value	B (25/100), tolerance ±3%	--	3998	--	K

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted.
Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

TYPICAL CHARACTERISTICS - IGBT T1-1,T1-2,T4-1,T4-2 AND DIODE D1,D4

Figure 1. Typical Output Characteristics

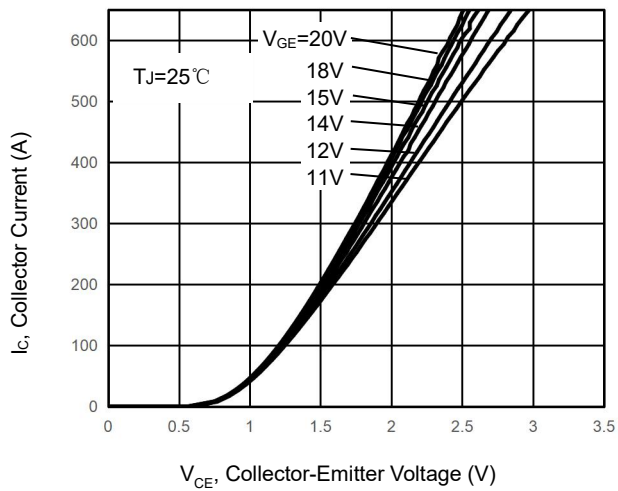


Figure 2. Typical Output Characteristics

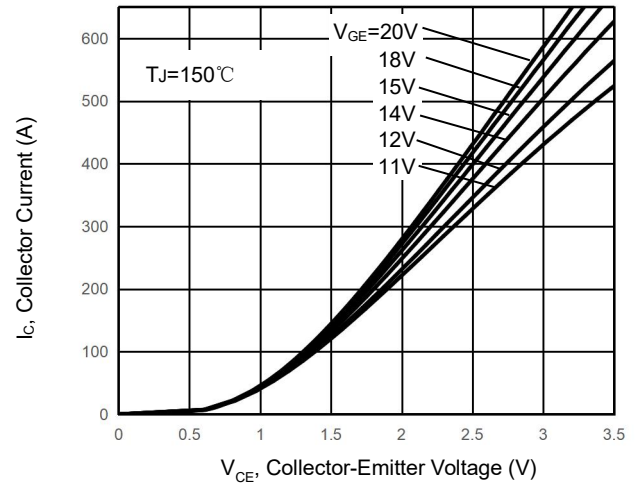


Figure 3. Typical Transfer Characteristics

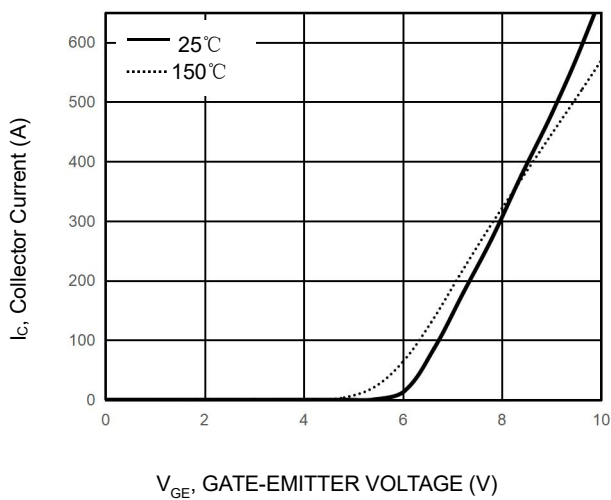
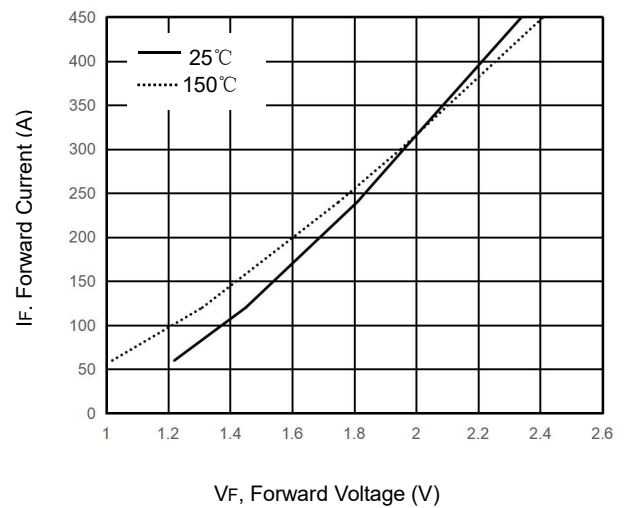


Figure 4. Typical Transfer Characteristics



TYPICAL CHARACTERISTICS - IGBT T1-1,T1-2,T4-1,T4-2 AND DIODE D1,D4

Figure 5. Transient Thermal Impedance(T1-1,T1-2,T4-1,T4-2)

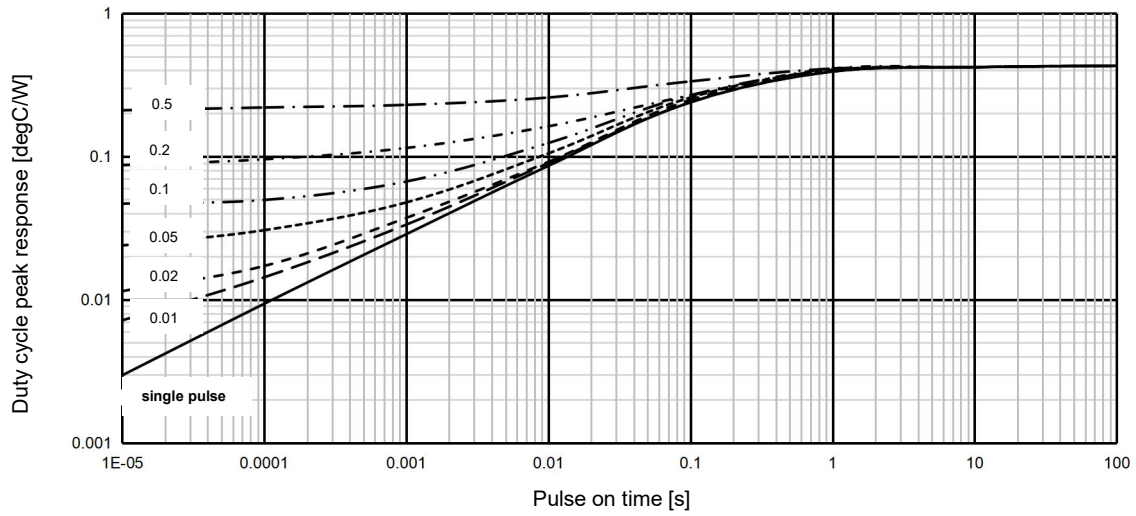
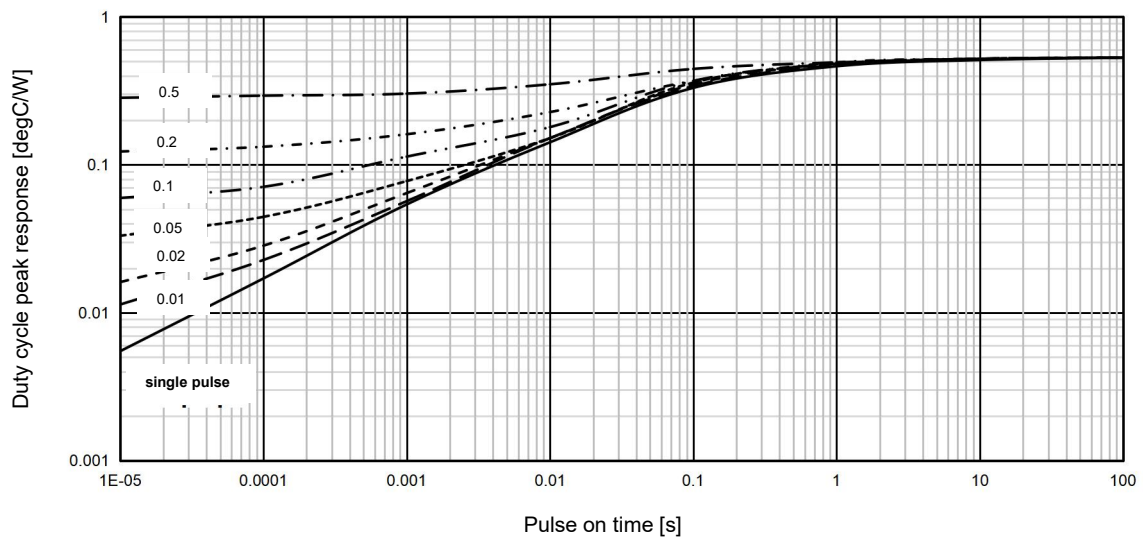


Figure 6. Transient Thermal Impedance(D1,D4)



TYPICAL CHARACTERISTICS - IGBT T1-1,T1-2,T4-1,T4-2 AND DIODE D1,D4

Figure 7.FBSOA(T1-1,T1-2,T4-1,T4-2)

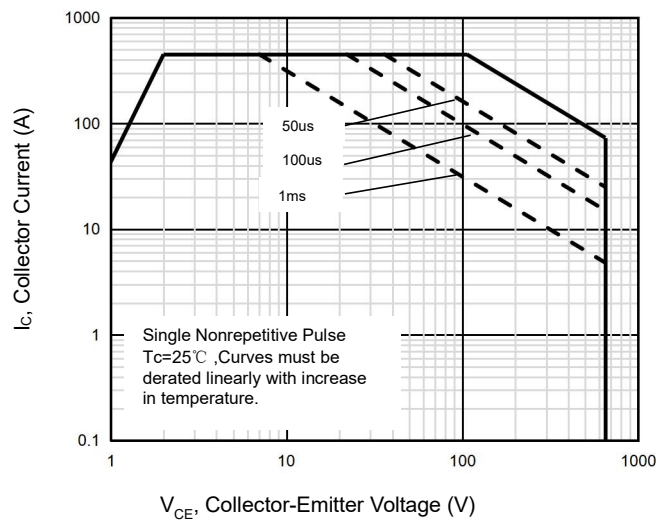


Figure 8.RBSOA(T1-1,T1-2,T4-1,T4-2)

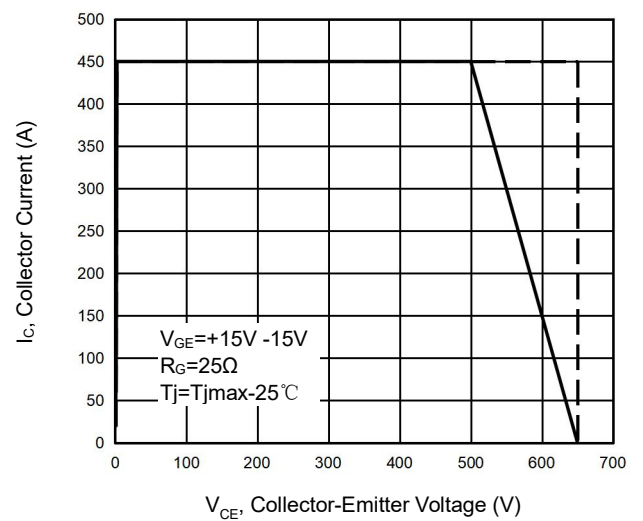
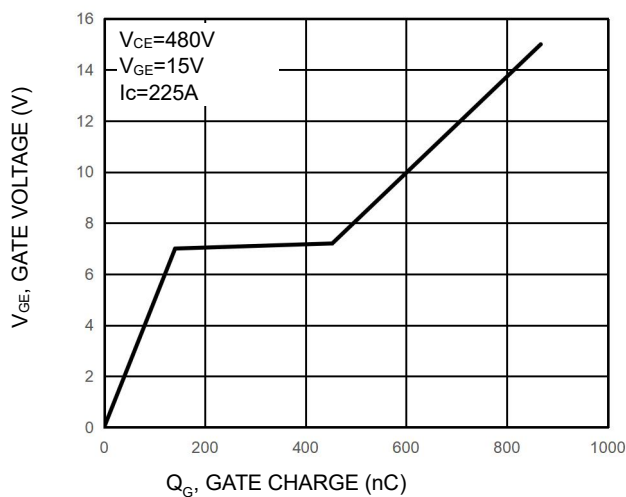


Figure 9.Gate Voltage vs. Gate Charge



TYPICAL CHARACTERISTICS - IGBT T2,T3 AND DIODE D2,D3

Figure 10. Typical Output Characteristics

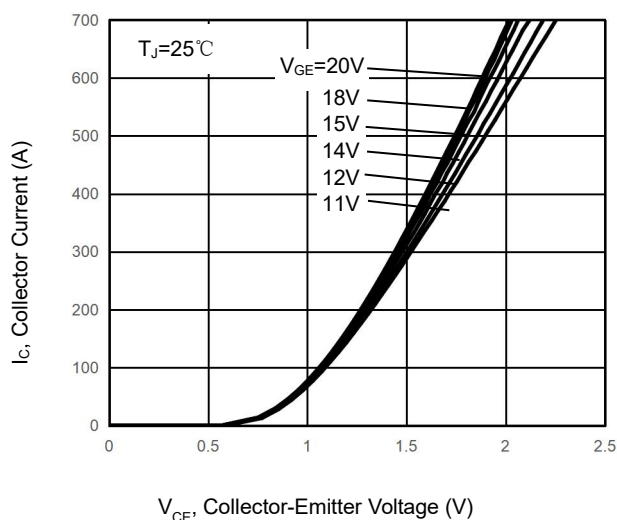


Figure 11. Typical Output Characteristics

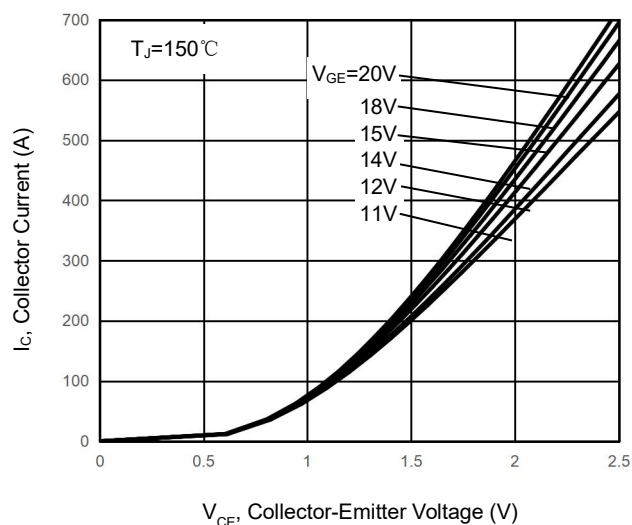


Figure 12. Typical Transfer Characteristics

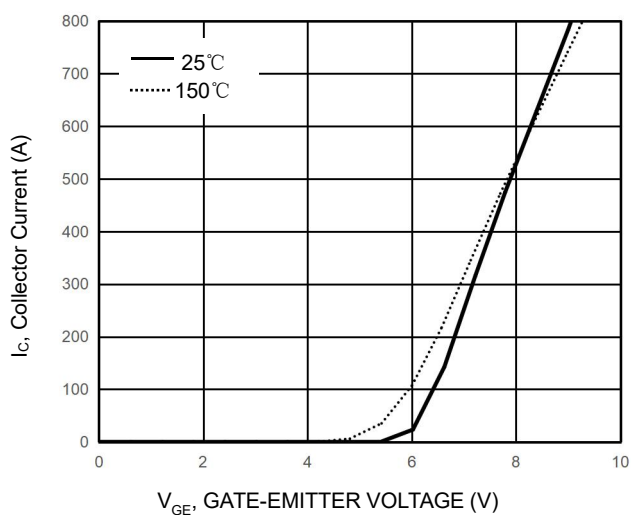
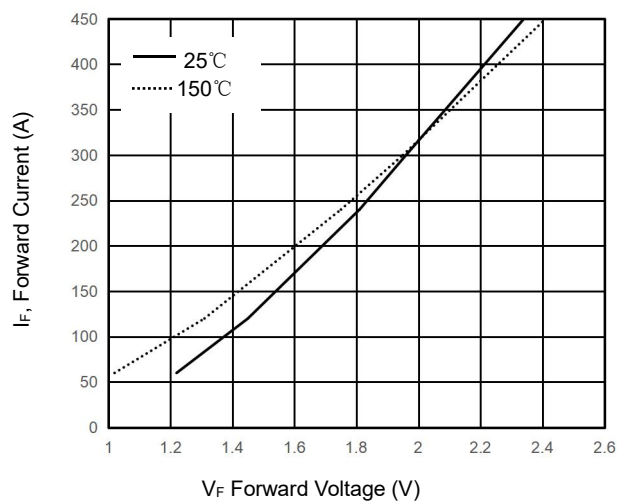


Figure 13. Typical Transfer Characteristics



TYPICAL CHARACTERISTICS - IGBT T2,T3 AND DIODE D2,D3

Figure 14. Transient Thermal Impedance(T2,T3)

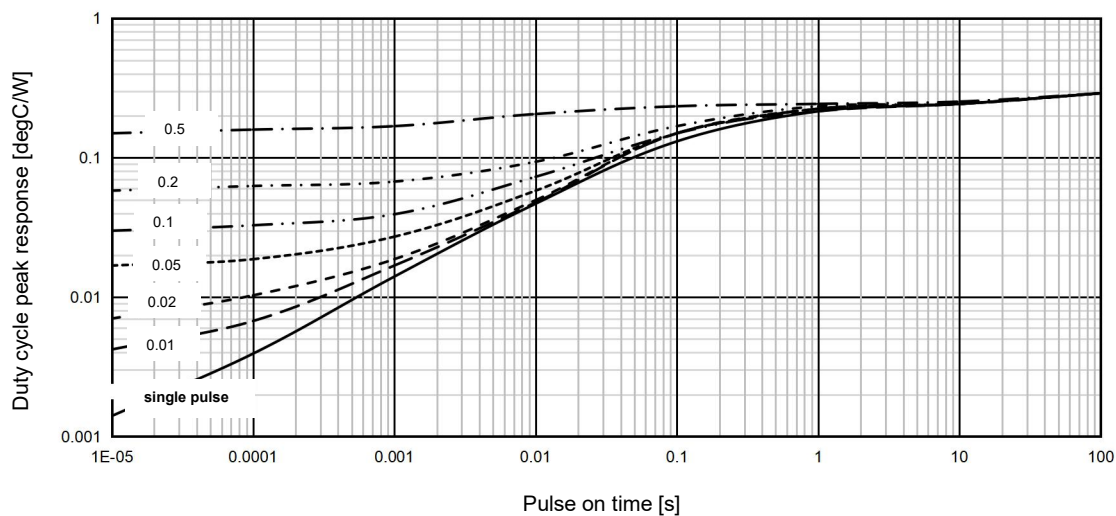
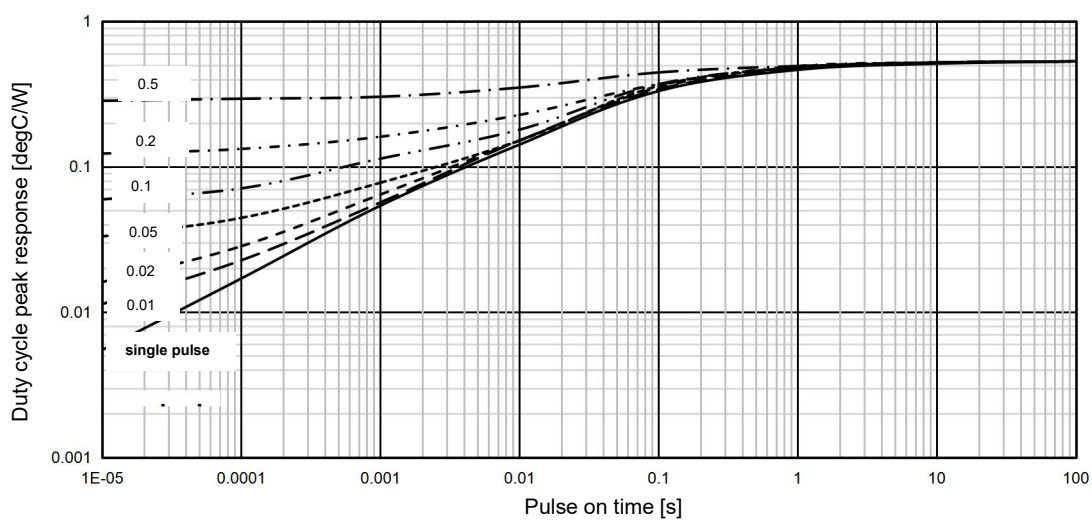


Figure 15. Transient Thermal Impedance(D2,D3)



TYPICAL CHARACTERISTICS - IGBT T2,T3 AND DIODE D2,D3

Figure 16.FBSOA (T2,T3)

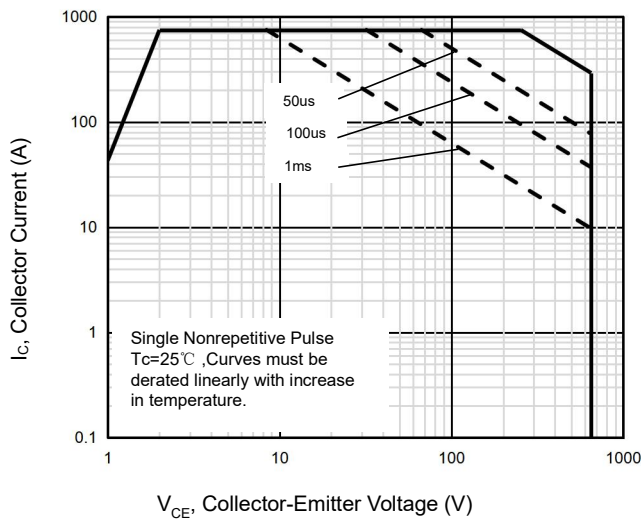


Figure 17.RBSOA (T2,T3)

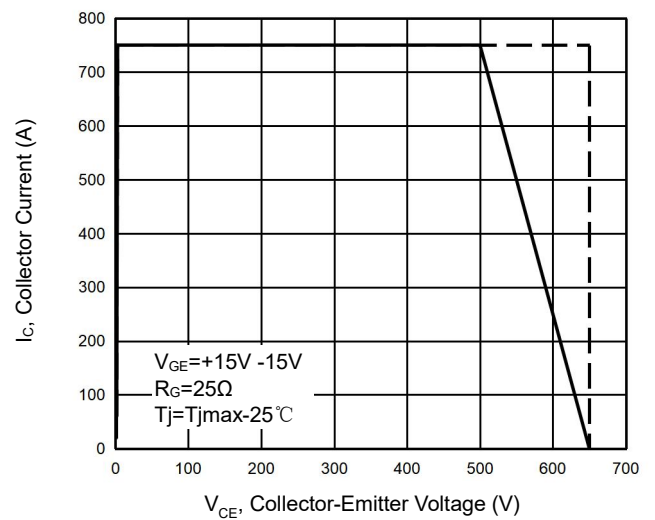
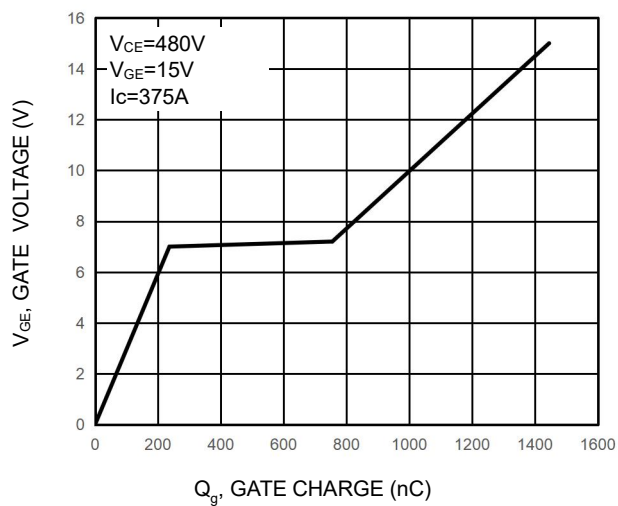


Figure 18.Gate Voltage vs. Gate Charge



TYPICAL CHARACTERISTICS - DIODE D5,D6

Figure 19. Diode Forward Characteristics

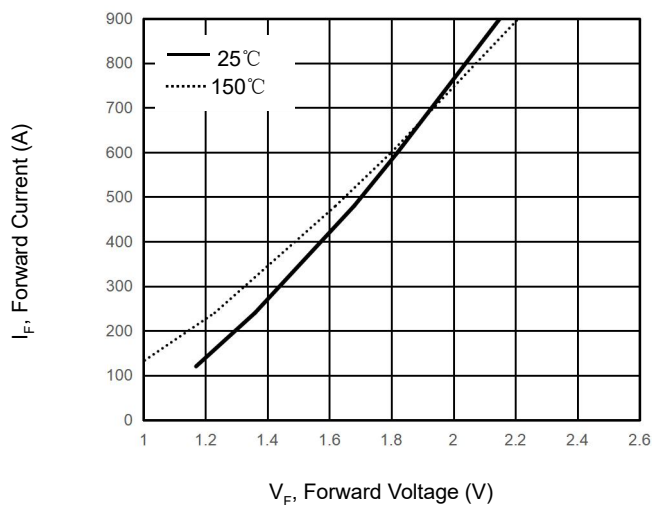
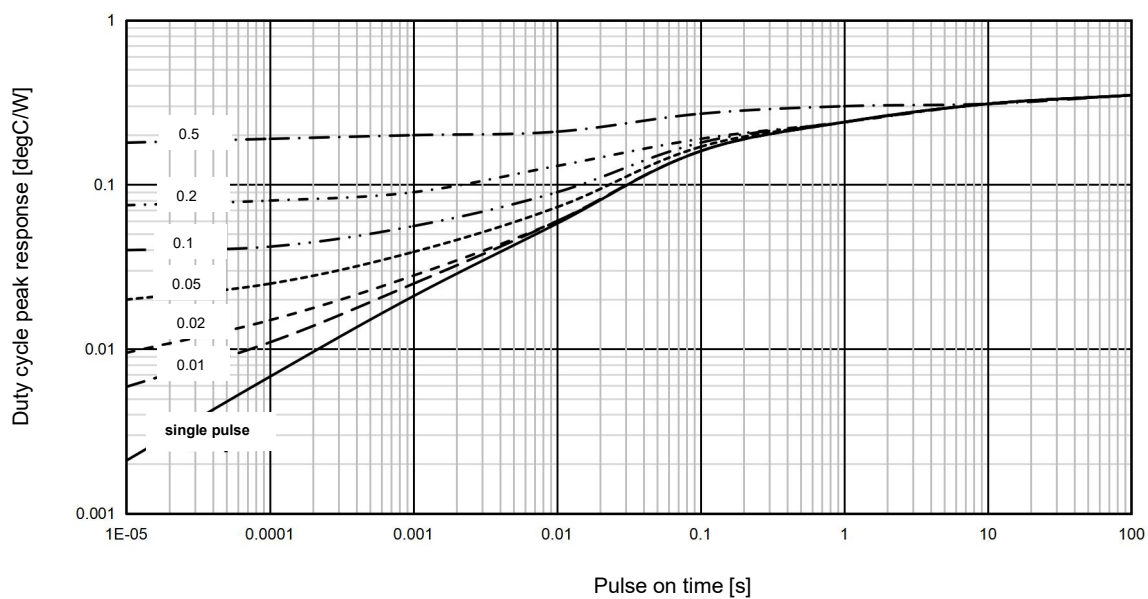


Figure 20. Transient Thermal Impedance(D5,D6)



TYPICAL CHARACTERISTICS - Q1/Q4 IGBT COMUTATES D5,D6 DIODE

Figure 21. Typical Switching Loss E_{on} vs. I_C

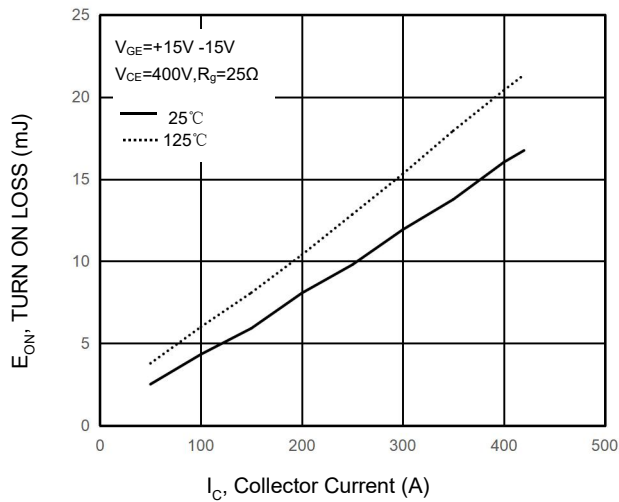


Figure 22. Typical Switching Loss E_{off} vs. I_C

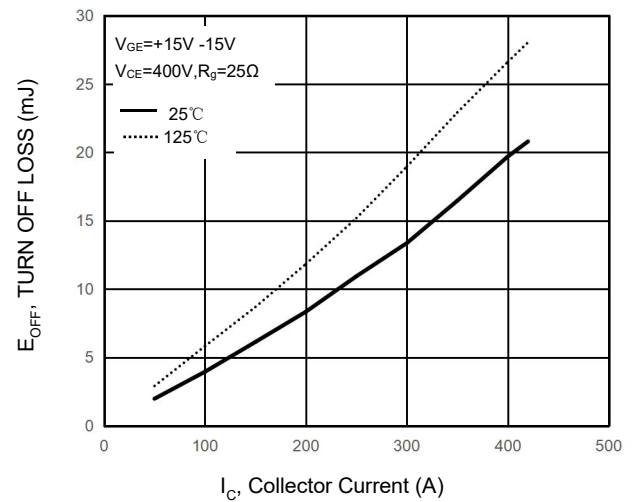


Figure 23. Typical Switching Loss E_{on} vs. R_g

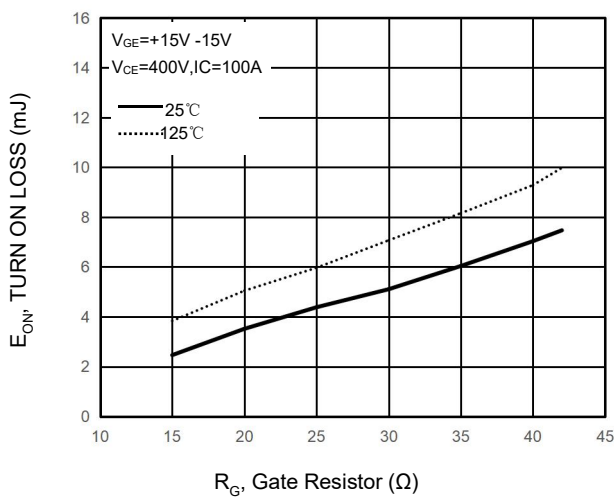


Figure 24. Typical Switching Loss E_{off} vs. R_g

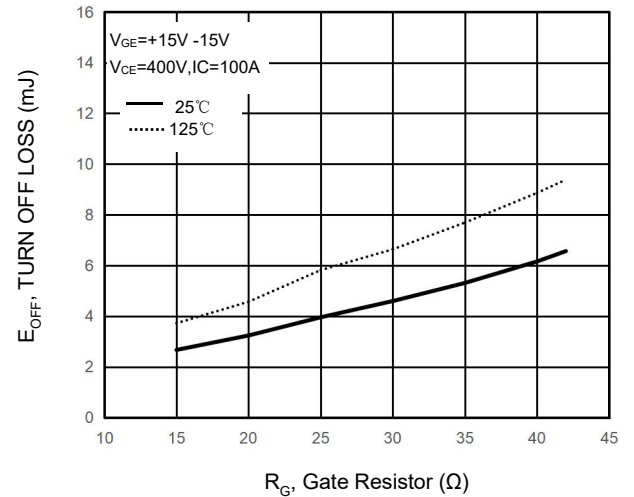


Figure 25. Typical Switching Time T_{don} vs. I_C

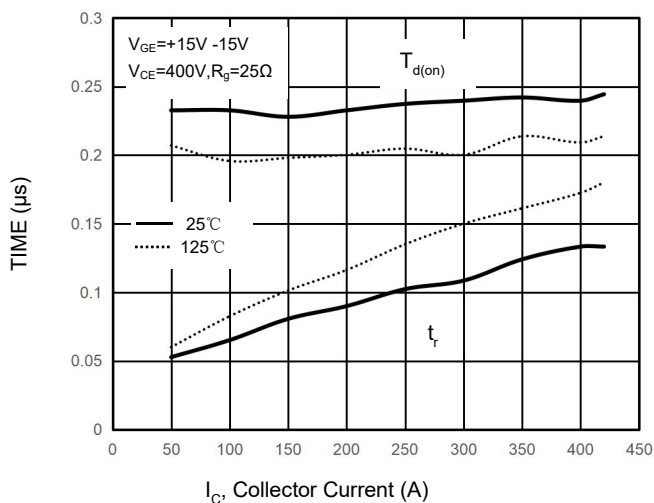
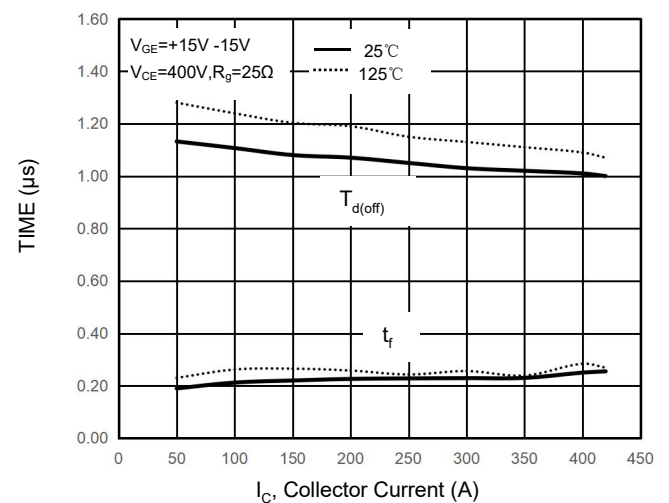


Figure 26. Typical Switching Time T_{doff} vs. I_C



TYPICAL CHARACTERISTICS - Q1/Q4 COMUTATES D5,D6 DIODE

Figure 27. Typical Switching Time T_{don} vs. R_G

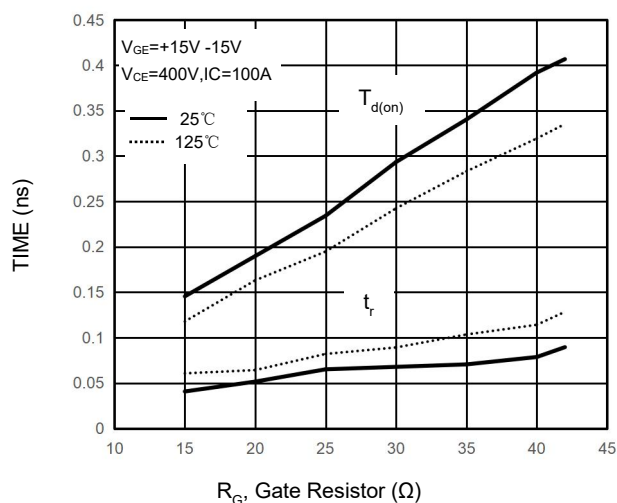


Figure 28. Typical Switching Time T_{doff} vs. R_G

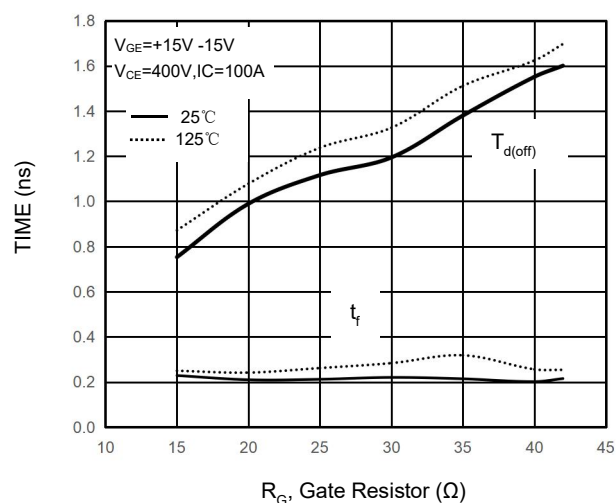


Figure 29. Typical Reverse Recovery Energy vs. I_C

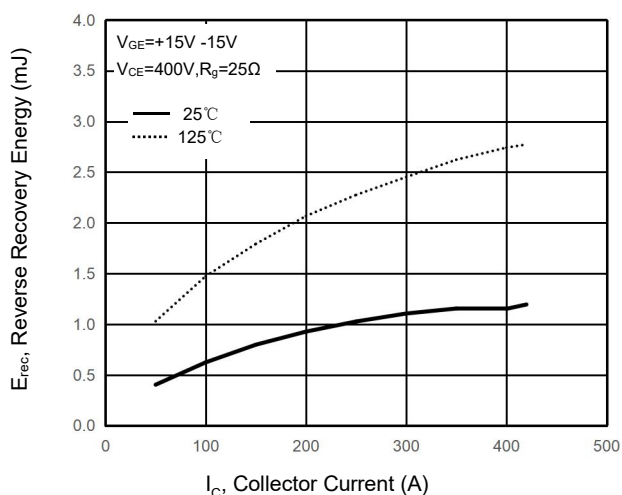


Figure 30. Typical Reverse Recovery Energy vs. R_G

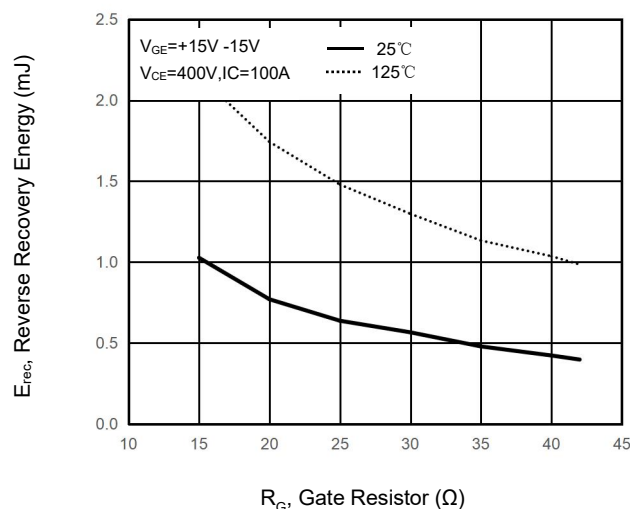


Figure 31. Typical Reverse Recovery Time vs. I_C

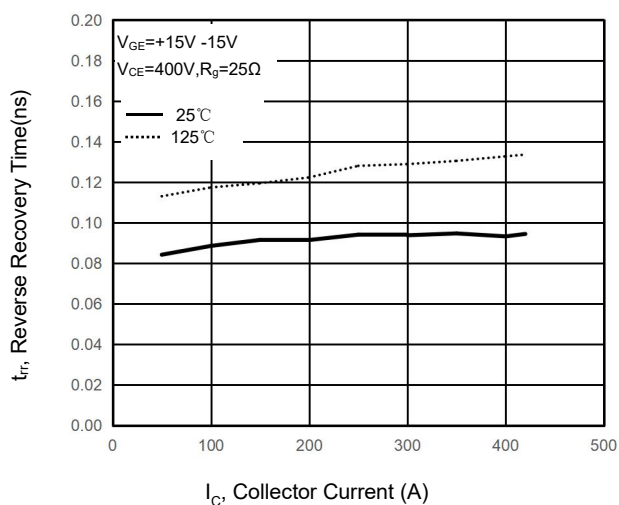
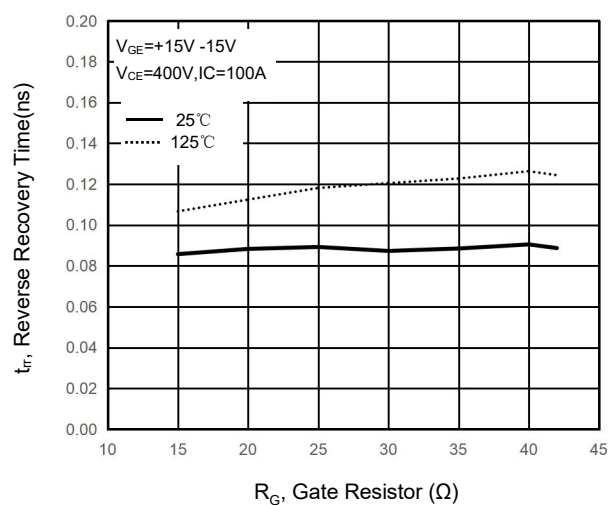


Figure 32. Typical Reverse Recovery Time vs. R_G



TYPICAL CHARACTERISTICS - Q1/Q4 COMUTATES D5,D6 DIODE

Figure 33. Typical Reverse Recovery Charge vs. I_C

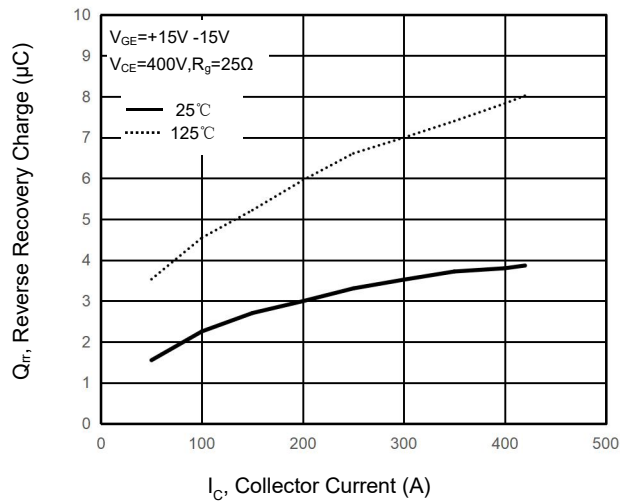


Figure 34. Typical Reverse Recovery Charge vs. R_G

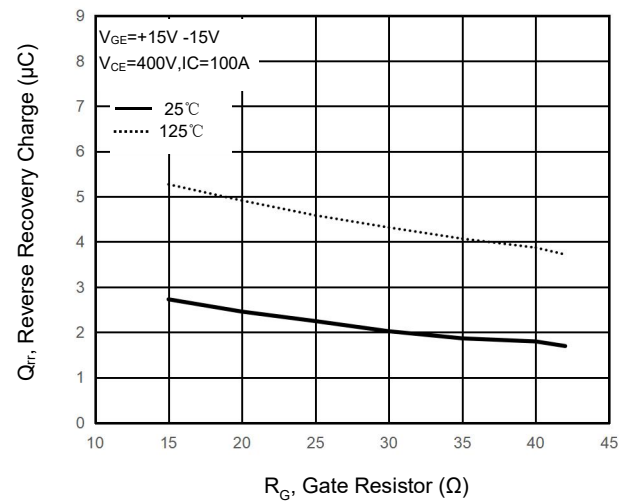


Figure 35. Typical Reverse Recovery Current vs. I_C

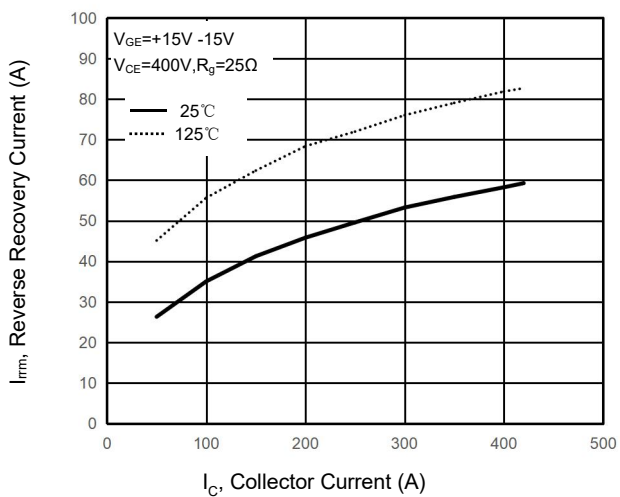
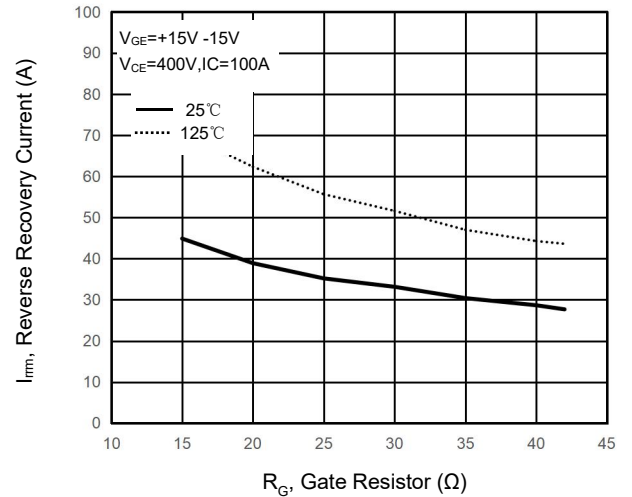


Figure 36. Typical Reverse Recovery Current vs. R_G



TYPICAL CHARACTERISTICS - Q2/Q3 COMUTATES D1,D4 DIODE

Figure 37. Typical Switching Loss Eon vs. IC

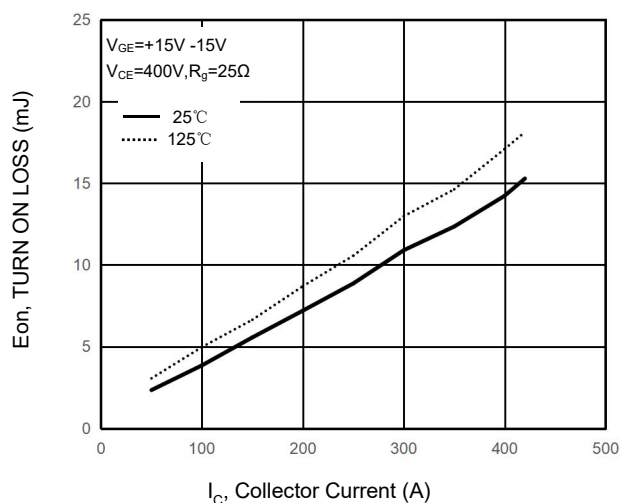


Figure 38. Typical Switching Loss Eoff vs. IC

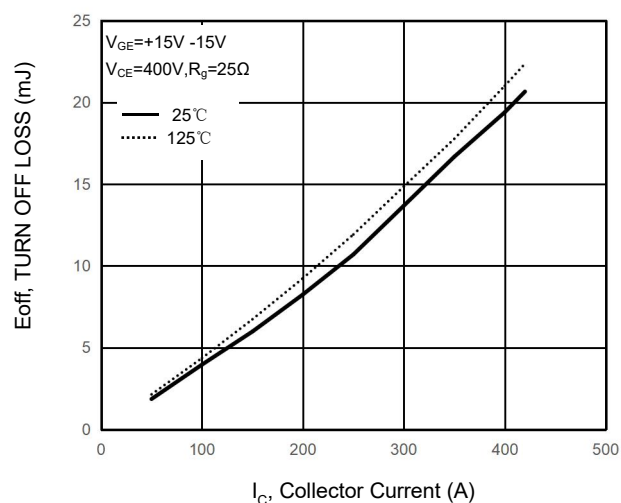


Figure 39. Typical Switching Loss Eon vs. RG

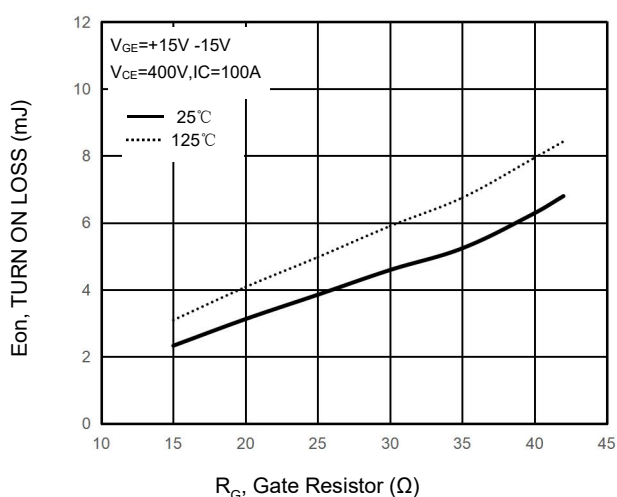


Figure 40. Typical Switching Loss Eoff vs. RG

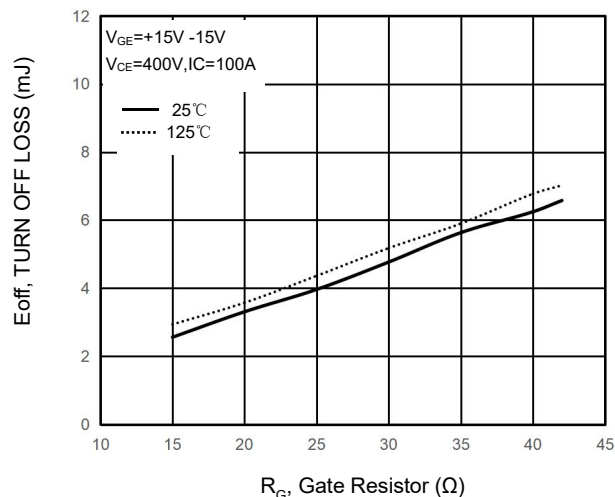


Figure 41. Typical Switching Time Tdon vs. IC

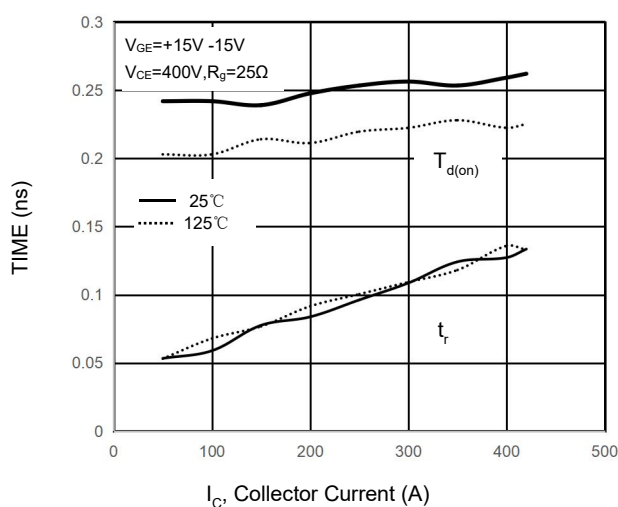
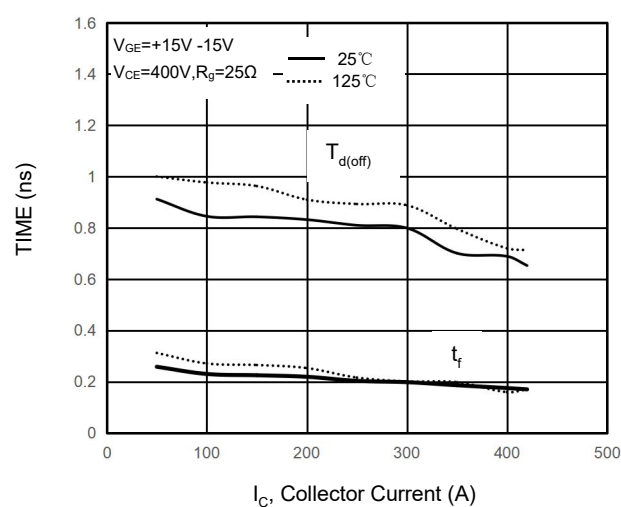


Figure 42. Typical Switching Time Tdoff vs. IC



TYPICAL CHARACTERISTICS - Q2/Q3 COMUTATES D1,D4 DIODE

Figure 43. Typical Switching Time T_{don} vs. R_G

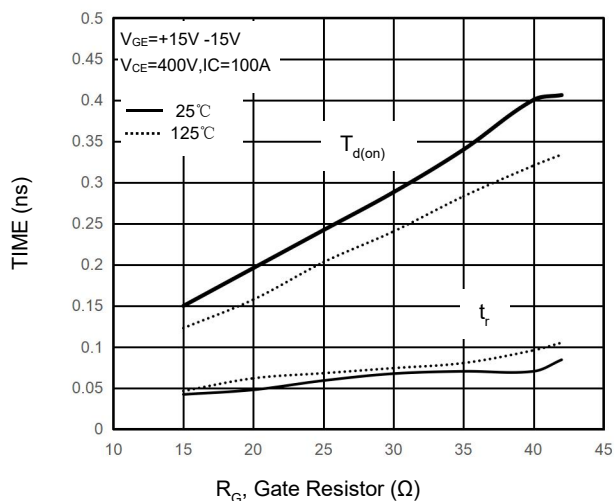


Figure 44. Typical Switching Time T_{doff} vs. R_G

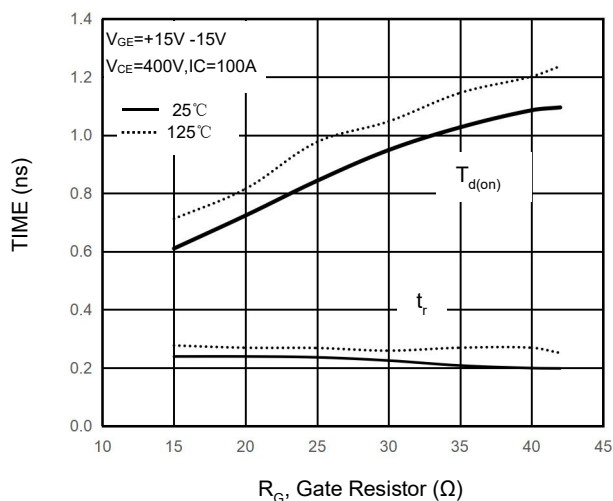


Figure 45. Typical Reverse Recovery Energy Loss vs. I_C

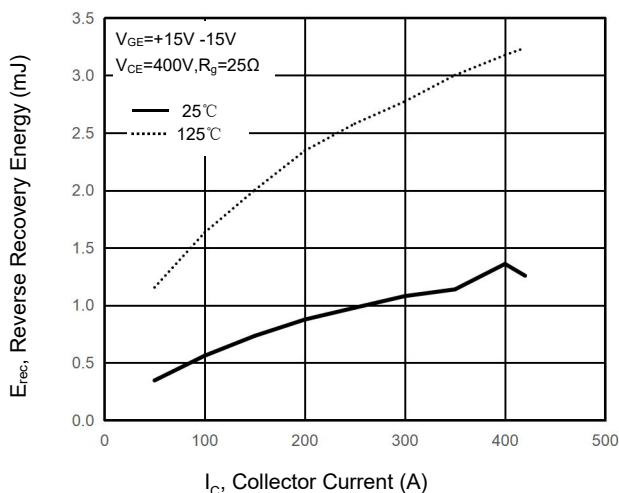


Figure 46. Typical Reverse Recovery Energy Loss vs. R_G

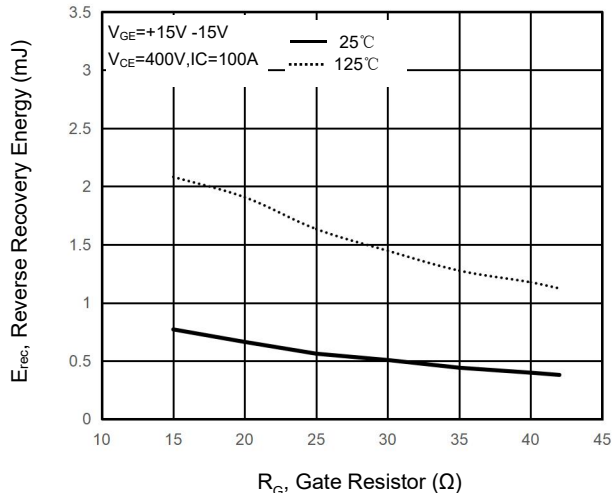


Figure 47. Typical Reverse Recovery Time vs. I_C

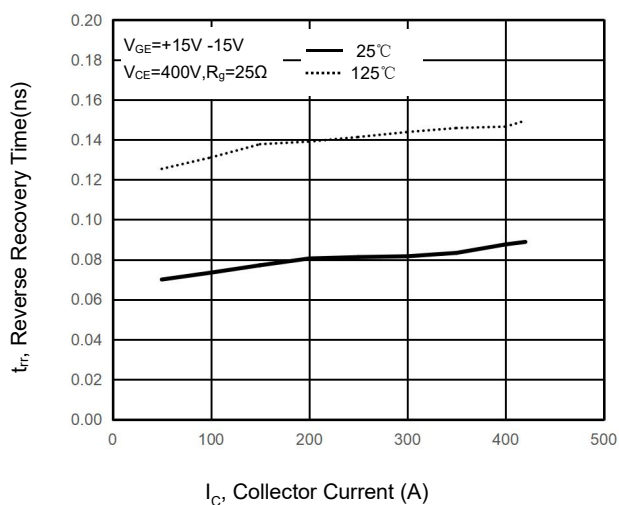
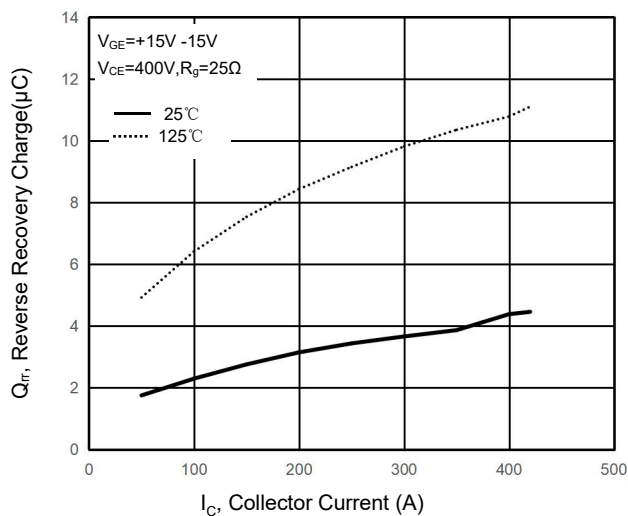
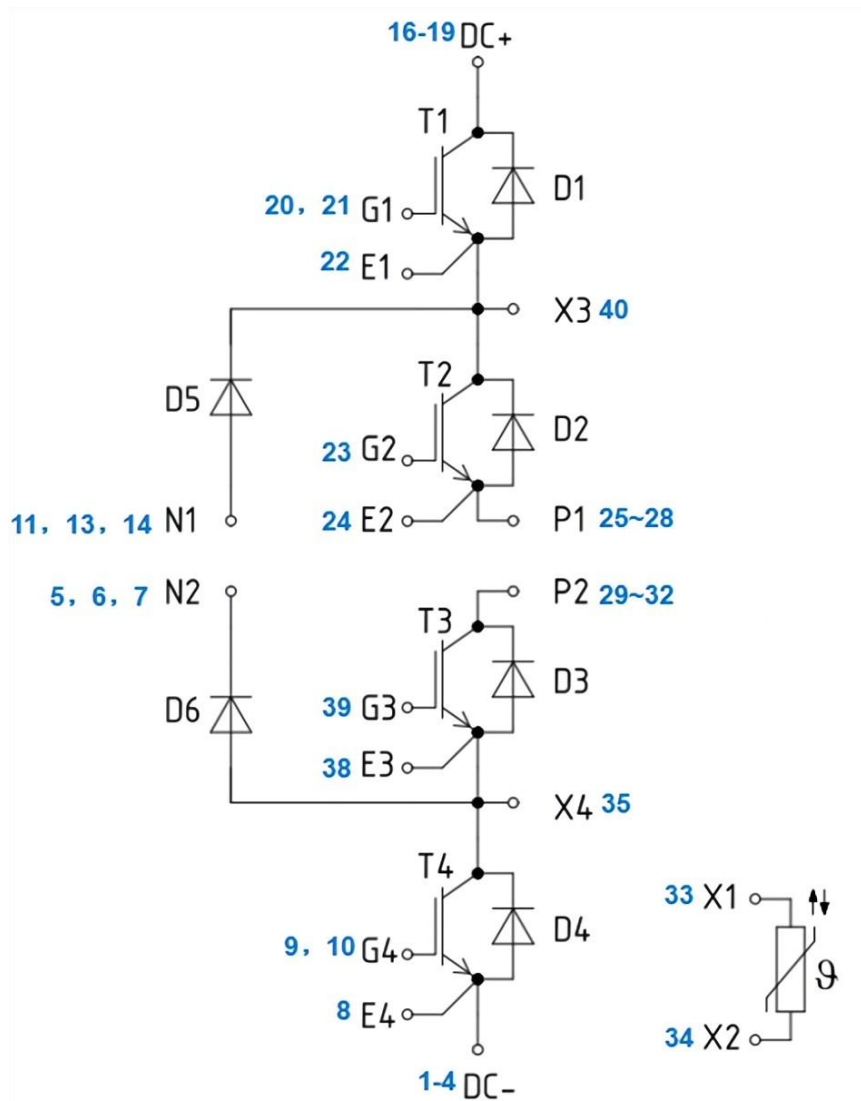


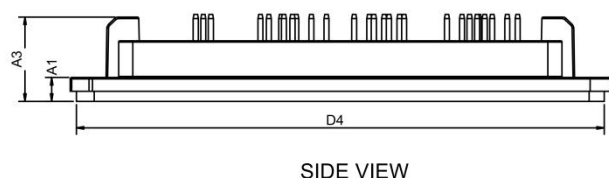
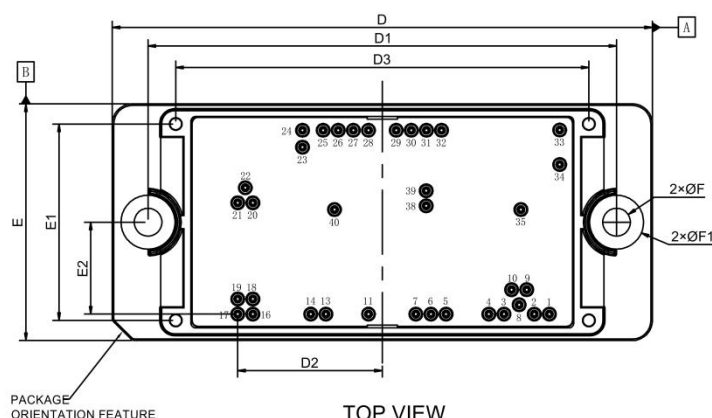
Figure 48. Typical Reverse Recovery Charge vs. I_C



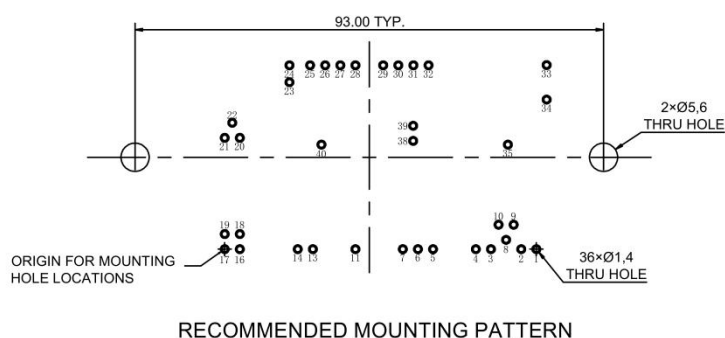
CIRCUIT DIAGRAM



PACKAGE DIMENSIONS



DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	16.63	17.23	17.83
A1	4.50	4.70	4.90
A2	11.60	12.00	12.40
A3	16.40	16.70	17.00
b	0.95	1.00	1.05
D	106.80	107.20	107.60
D1	92.90	93.00	93.10
D2	28.40	28.70	29.00
D3	81.80	82.00	82.20
D4	104.35	104.75	105.15
E	46.60	47.00	47.40
E1	38.80	39.00	39.20
E2	17.95	18.25	18.55
E3	44.30	44.60	44.90
F	5.40	5.50	5.60
F1	10.70 REF		
L	5.03	5.23	5.43



NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME 7 14.5M,2009.
2. CONTROLLING DIMENSION:MILLIMETERS
3. DIMENSION b APPLY TO THE PLATED TERMINALS AND ARE MEASURED WHERE THE PIN EXITS THE PACKAGE BODY.
4. POSITION OF THE CENTER OF THE TERMINALS IS DETERMINED FROM PIN 17.POSITIONAL TOLERANCE ,AS NOTED IN THE DRAWING, APPLIES TO EACH TERMINAL.

PIN	PIN POSITION	
	X	Y
1	61.85	0.0
2	58.85	0.0
3	52.85	0.0
4	49.85	0.0
5	41.35	0.0
6	38.35	0.0
7	35.35	0.0
8	55.85	1.85
9	57.35	4.85
10	54.35	4.85
11	25.95	0.0
13	17.5	0.0
14	14.5	0.0
16	3.0	0.0
17	0.0	0.0
18	3.0	3.0
19	0.0	3.0
20	3	22.1

PIN	PIN POSITION	
	X	Y
21	0.0	22.1
22	1.5	25.1
23	12.85	33.15
24	12.85	36.5
25	16.95	36.5
26	19.95	36.5
27	22.95	36.5
28	25.95	36.5
29	31.45	36.5
30	34.45	36.5
31	37.45	36.5
32	40.45	36.5
33	63.9	36.55
34	63.9	29.7
35	56.2	20.75
38	37.4	21.5
39	37.4	24.5
40	19.2	20.75