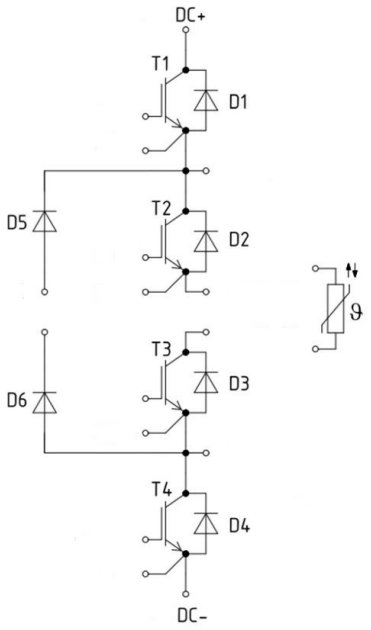
3-Level NPC Inverter Module with 650V Trench Stop IGBTs

K2



Features

- Electrical features

  Neutral Point Clamped Three−Level Inverter Module

  650V Trench Stop IGBTs

  $T_{vj\ op}$=150℃

  Low Inductive Layout

  Thermistor

- Mechanical features

  Package with CTI >500

  Solderable Pins

Typical Applications

- Solar Inverters
- UPS Systems

Product validation

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

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 (t_p = 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 (t_p = 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 (t_p = 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 to125	°C
Tvj op	Temperature under switching condition	-40 to (Tjmax-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)						
I_{CES}	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)						
I_{CES}	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	--	kQ
R_{100}	Nominal Resistance	T = 100°C	--	1486	--	Q
R/R	Deviation of R25		-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

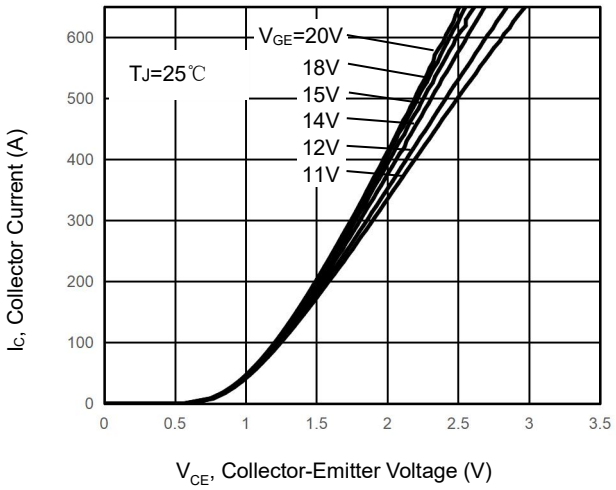


Figure 2.Typical Output Characteristics

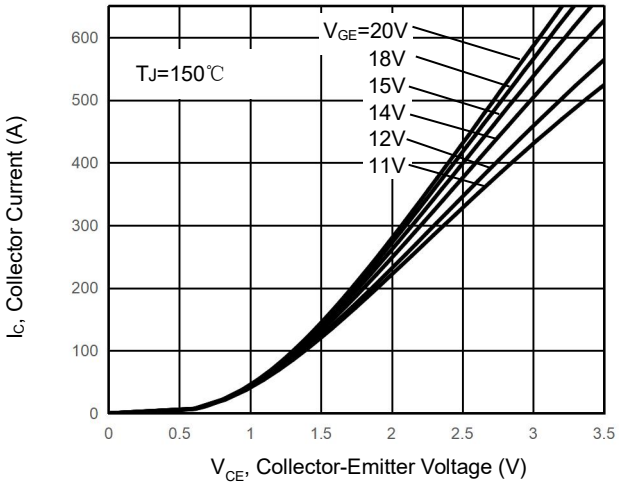


Figure 3.Typical Transfer Characteristics

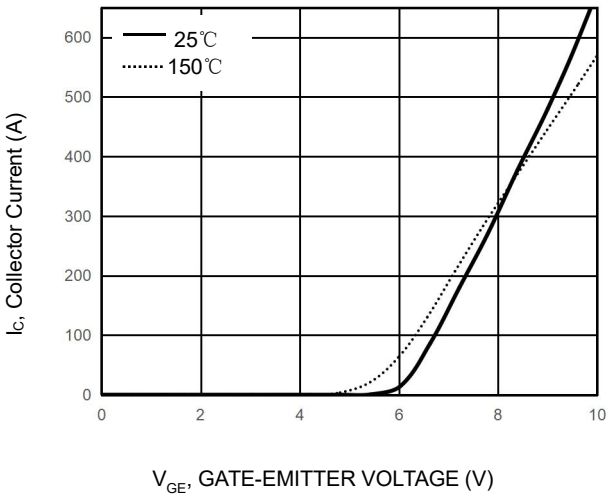
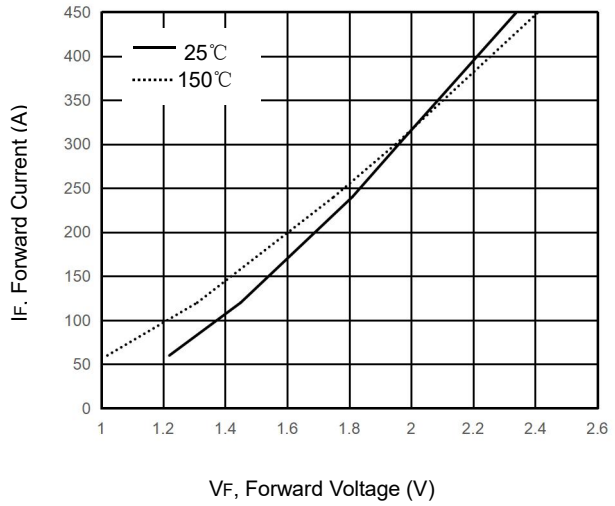


Figure 4.Typical Transfer Characteristics



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)

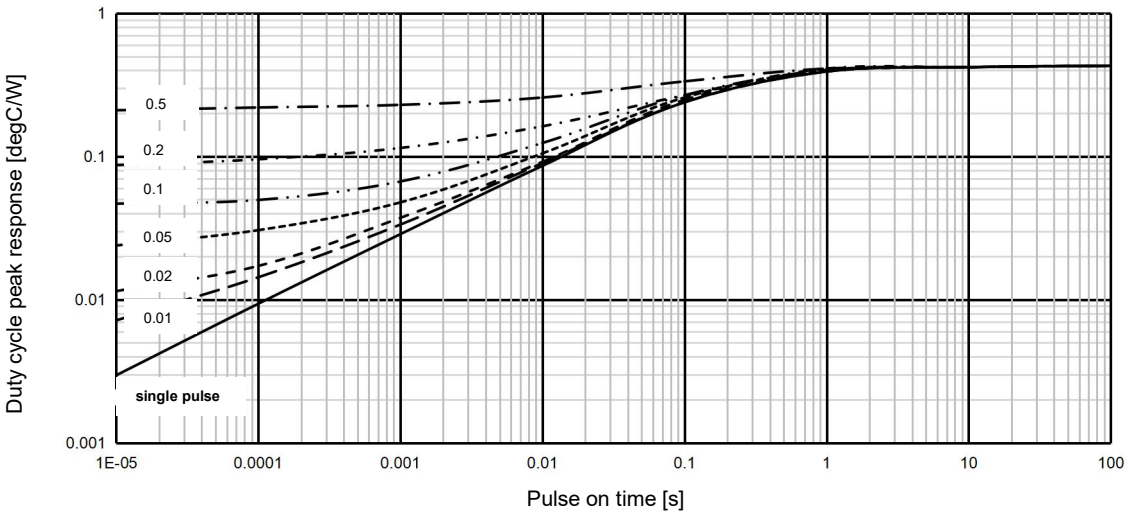
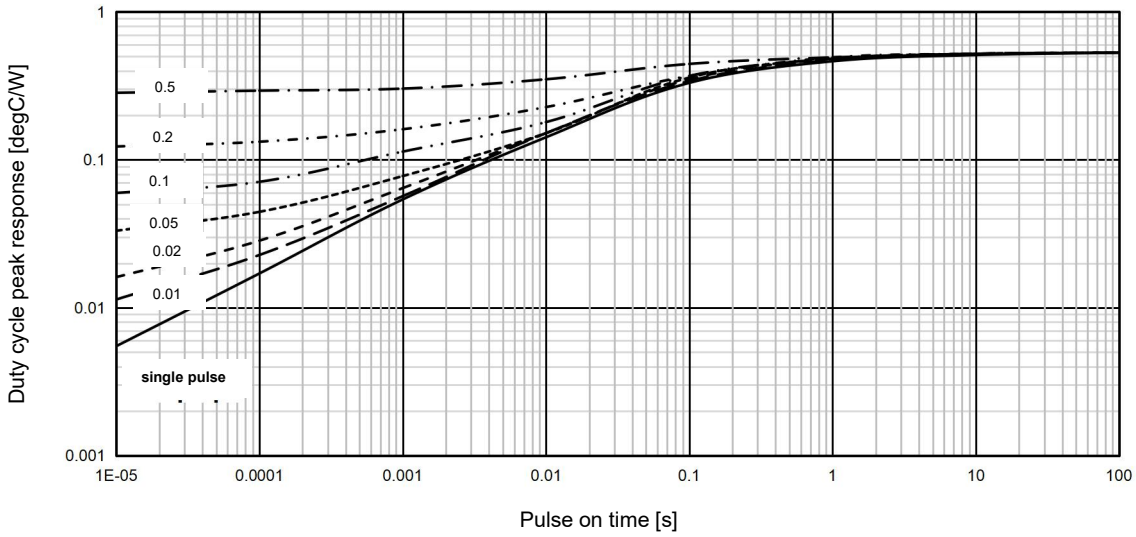


Figure 6.Transient Thermal Impedance(D1,D4)



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)

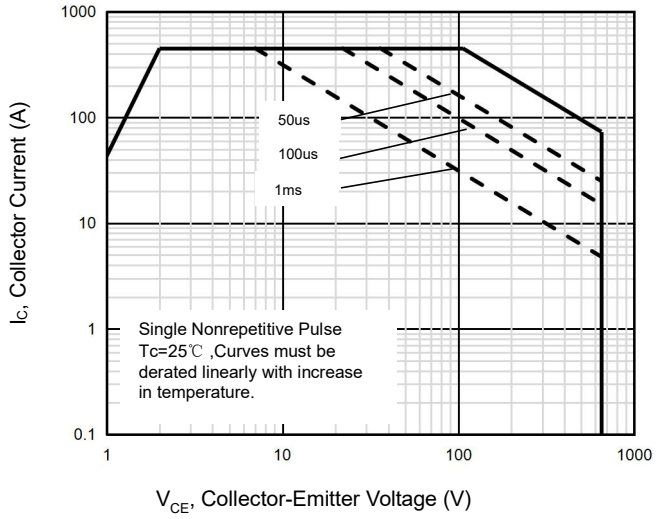


Figure 8.RBSOA(T1-1,T1-2,T4-1,T4-2)

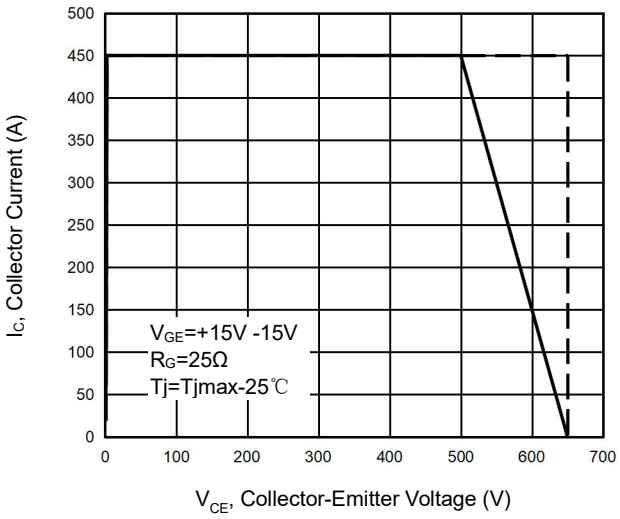
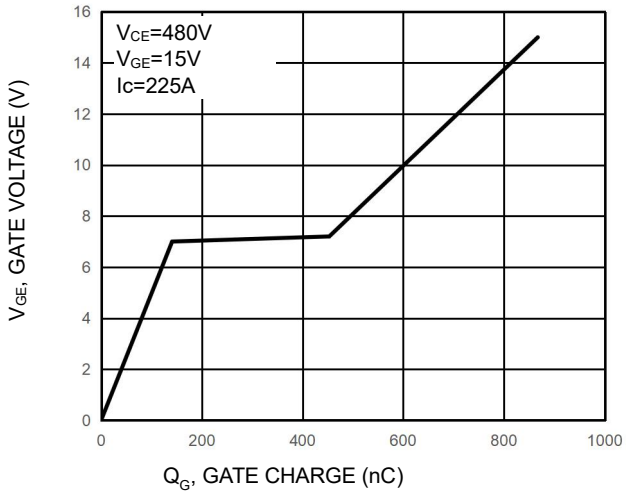


Figure 9.Gate Voltage vs. Gate Charge



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

Figure 10.Typical Output Characteristics

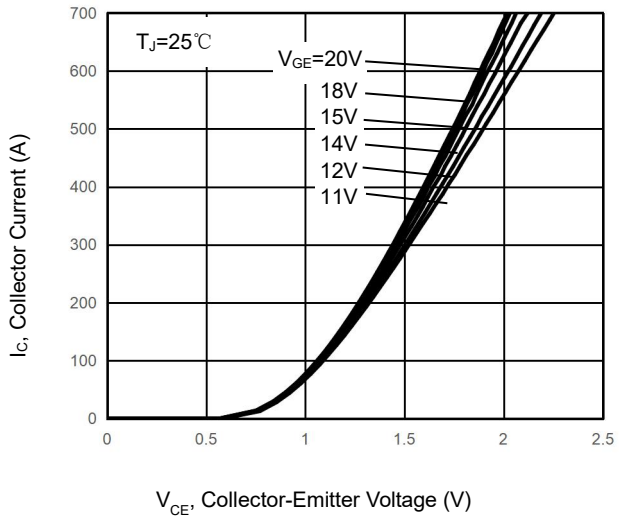


Figure 11.Typical Output Characteristics

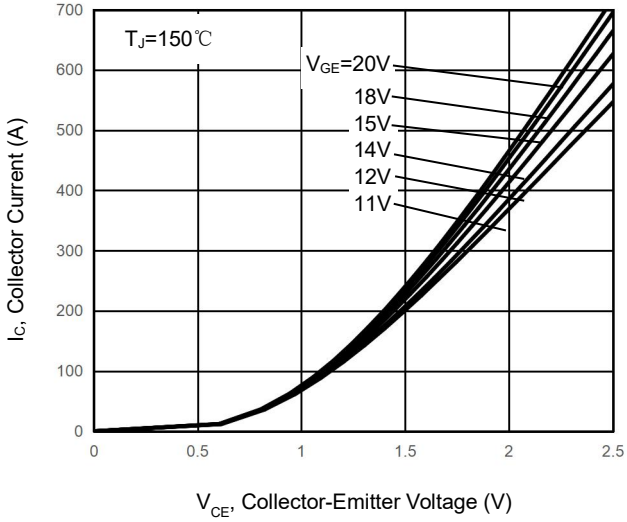


Figure 12.Typical Transfer Characteristics

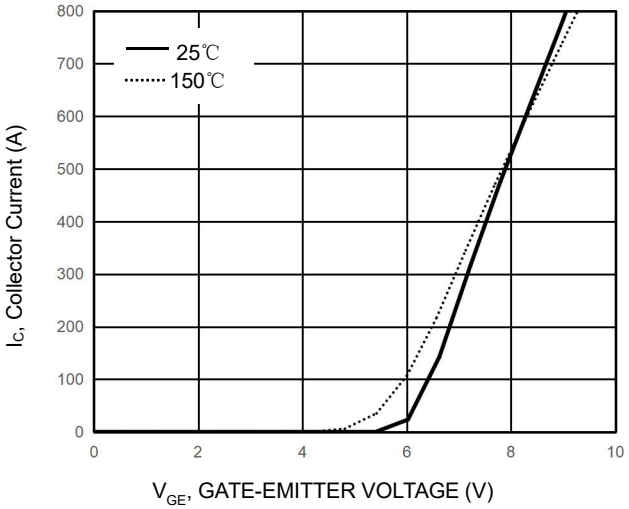
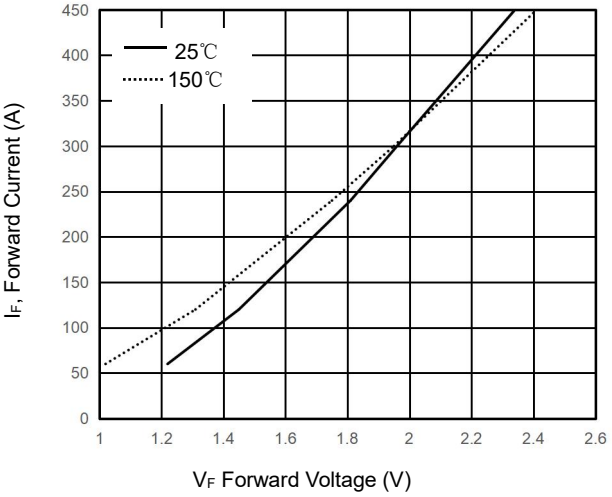


Figure 13.Typical Transfer Characteristics



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

Figure 14.Transient Thermal Impedance(T2,T3)

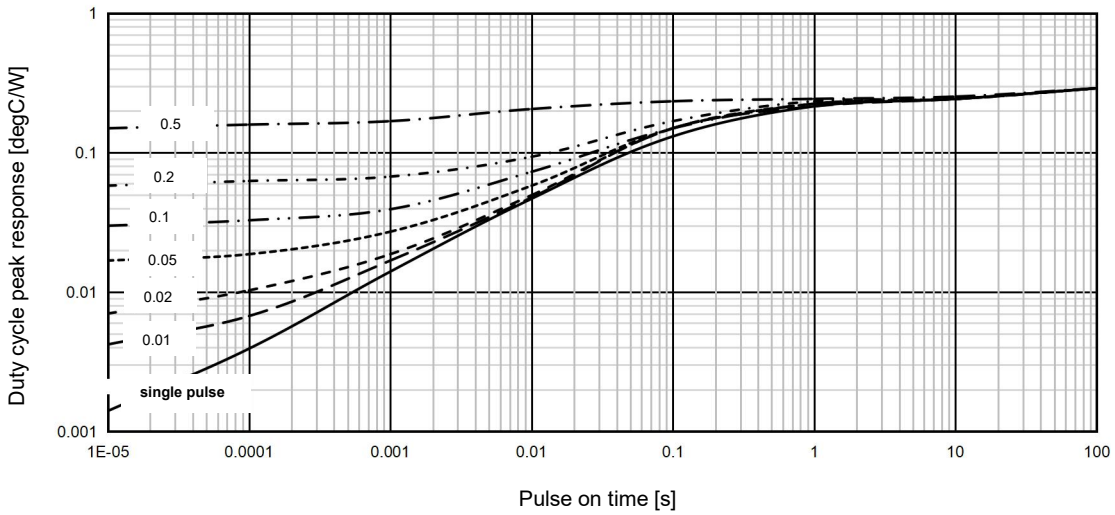
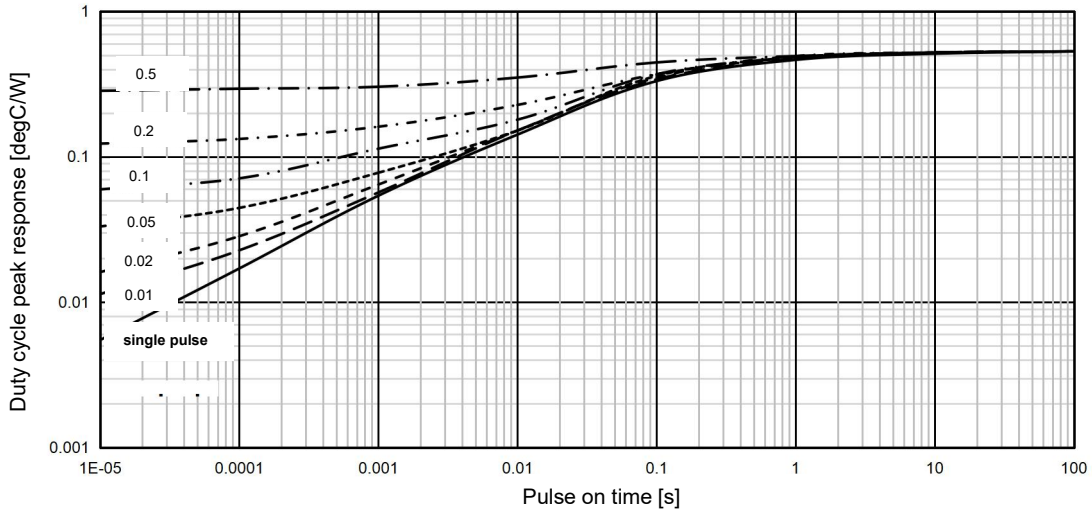


Figure 15.Transient Thermal Impedance(D2,D3)



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

Figure 16.FBSOA (T2,T3)

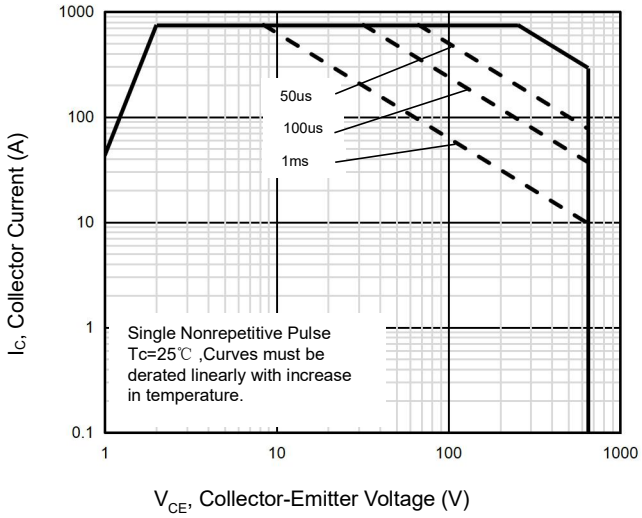


Figure 17.RBSOA (T2,T3)

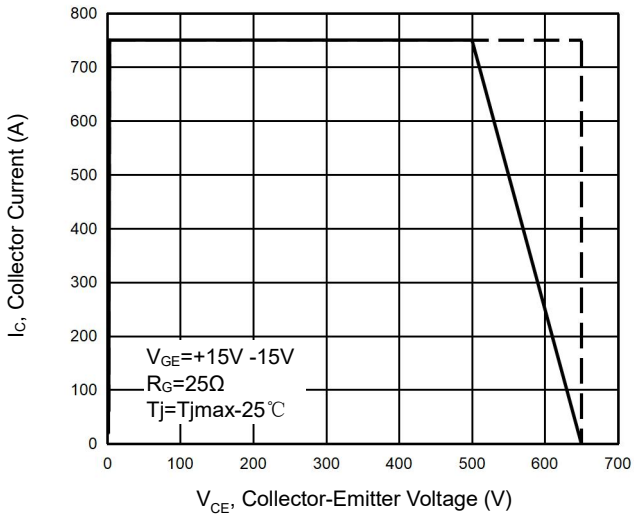
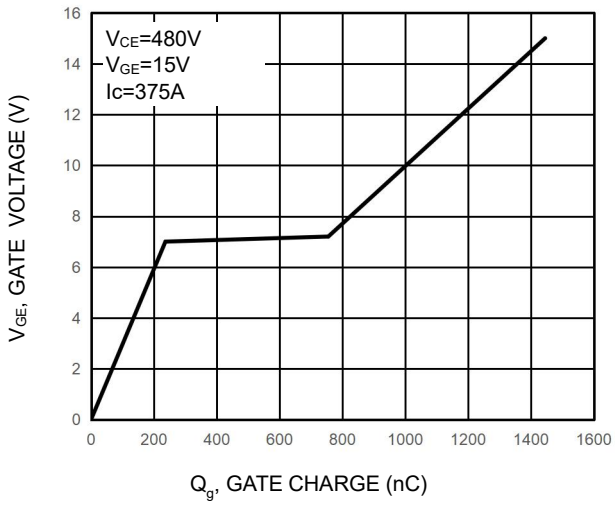


Figure 18.Gate Voltage vs. Gate Charge



TYPICAL CHARACTERISTICS - DIODE D5,D6

Figure 19.Diode Forward Characteristics

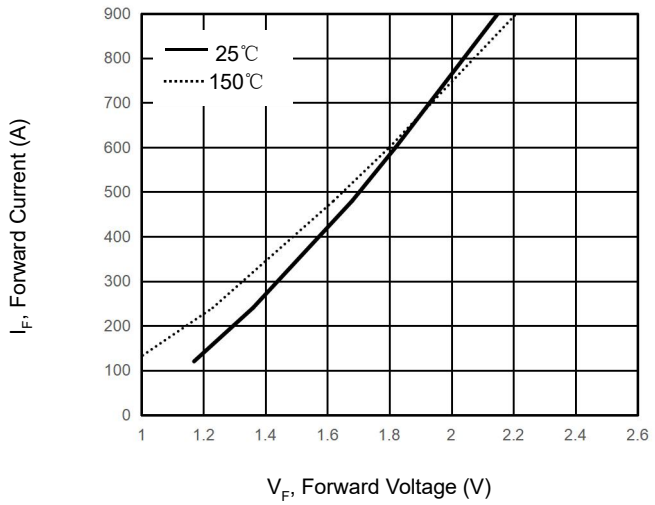
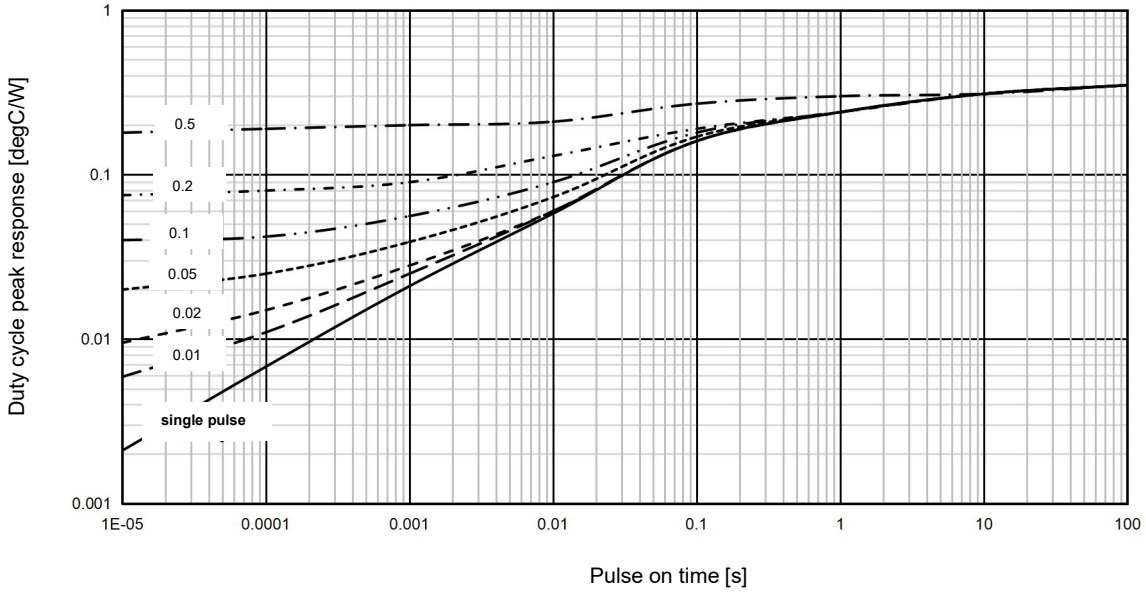


Figure 20.Transient Thermal Impedance(D5,D6)



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

Figure 21.Typical Switching Loss Eon vs. IC

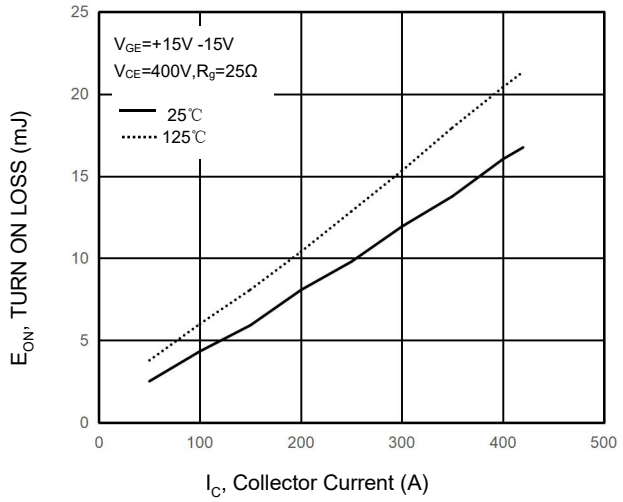


Figure22.Typical Switching Loss Eoff vs. IC

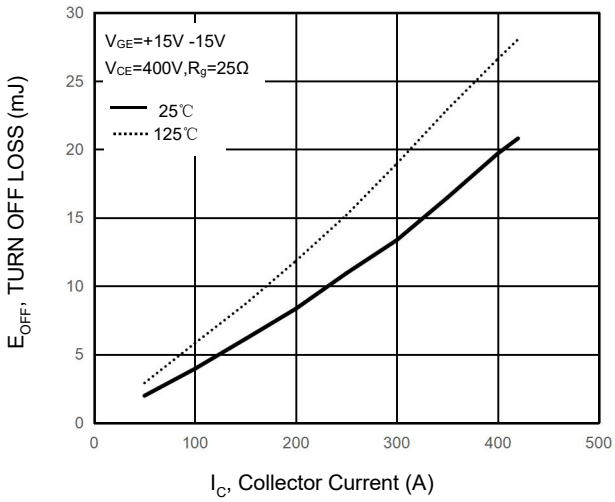


Figure 23.Typical Switching Loss Eon vs. R_G

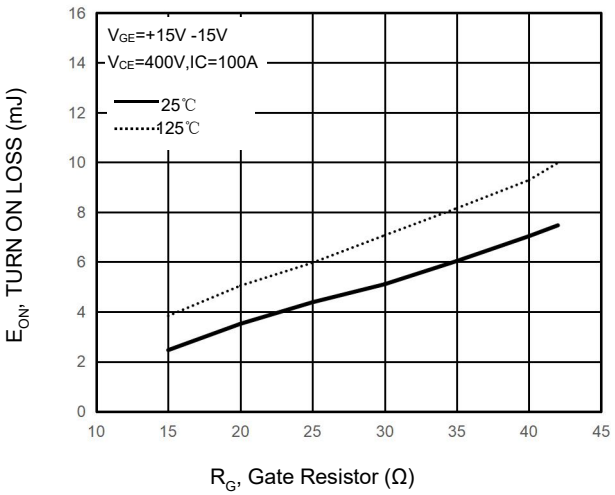


Figure 24.Typical Switching Loss Eoff vs. R_G

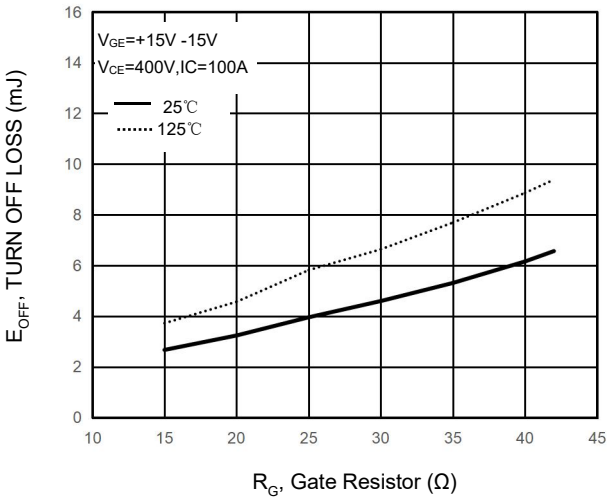


Figure 25.Typical Switching Time Tdon vs. IC

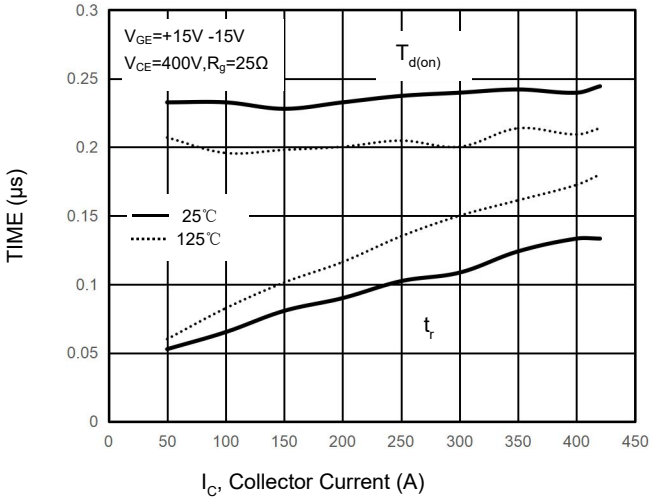
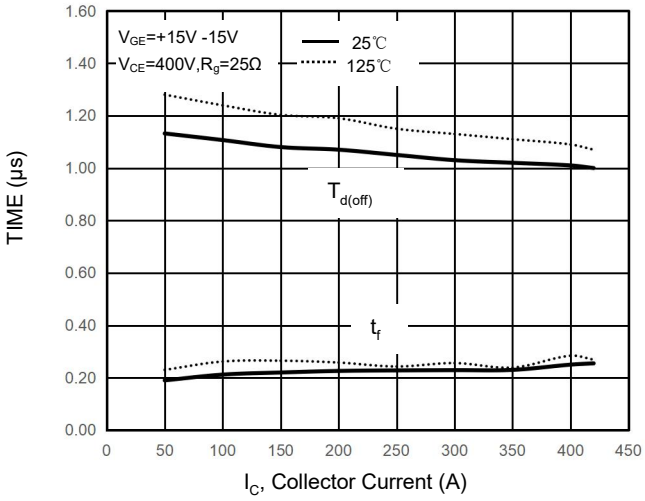


Figure 26.Typical Switching Time Tdoff vs. IC



TYPICAL CHARACTERISTICS - Q1/Q4 COMUTATES D5,D6 DIODE

Figure 27.Typical Switching Time Tdon vs. R_G

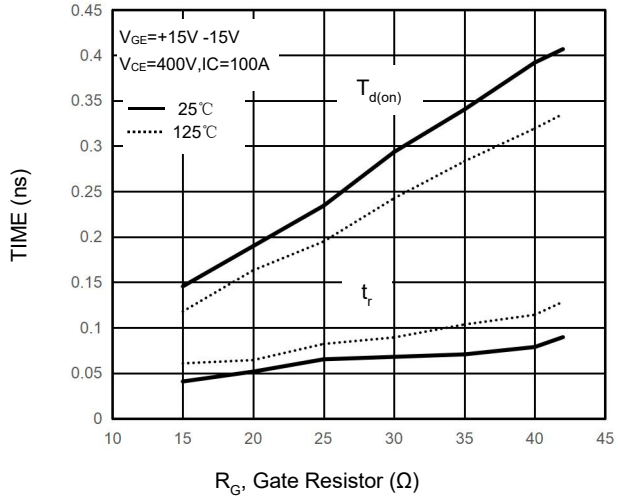


Figure28.Typical Switching Time Tdoff vs. R_G

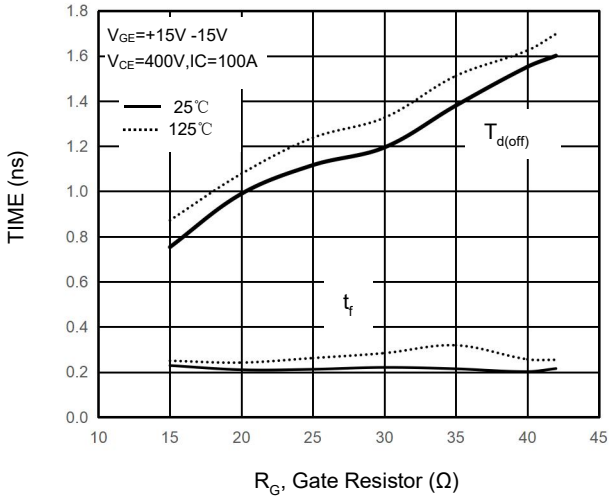


Figure 29.Typical Reverse Recovery Energy vs. IC

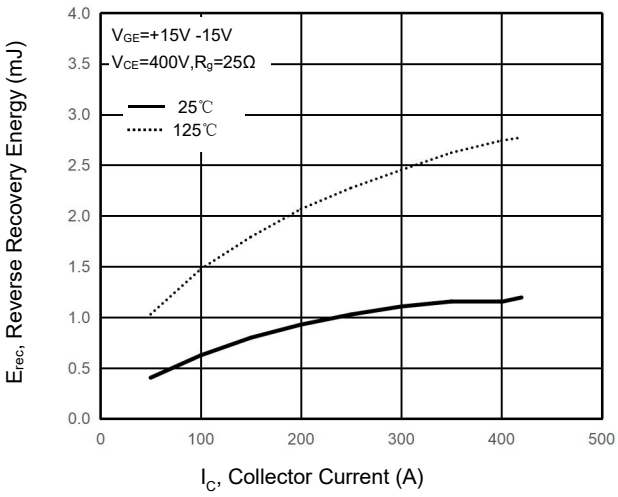


Figure 30.Typical Reverse Recovery Energy vs. R_G

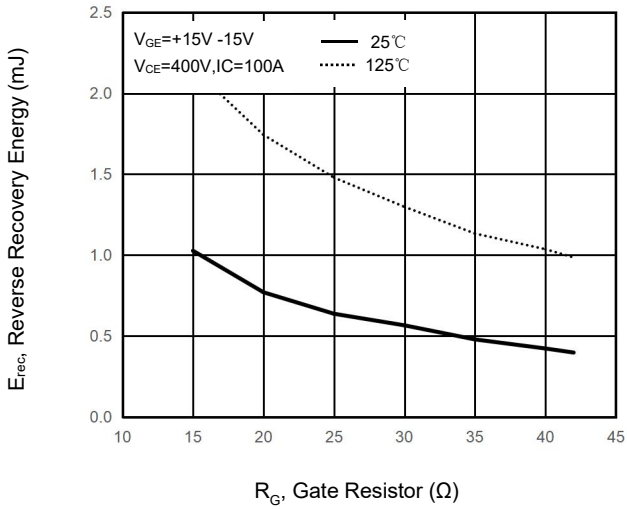


Figure 31.Typical Reverse Recovery Time vs. IC

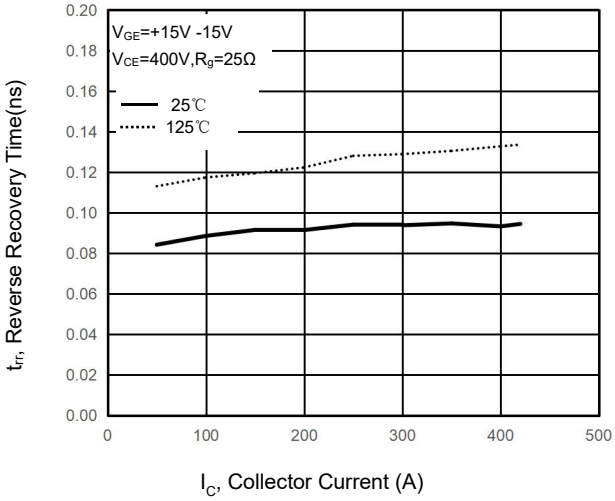
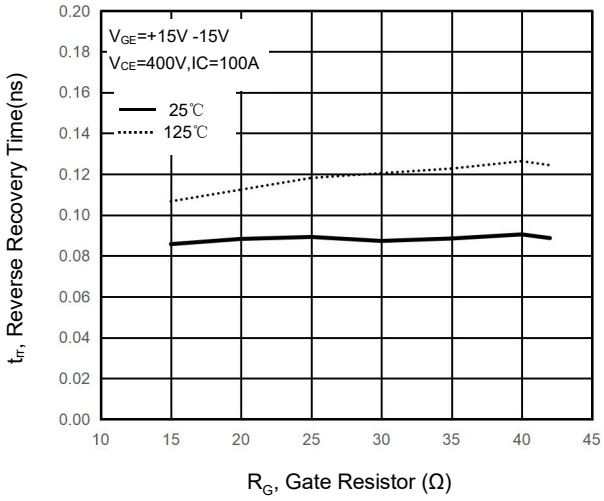


Figure 32.Typical Reverse Recovery Time vs. R_G



TYPICAL CHARACTERISTICS - Q1/Q4 COMUTATES D5,D6 DIODE

Figure 33.Typical Reverse Recovery Charge vs. IC

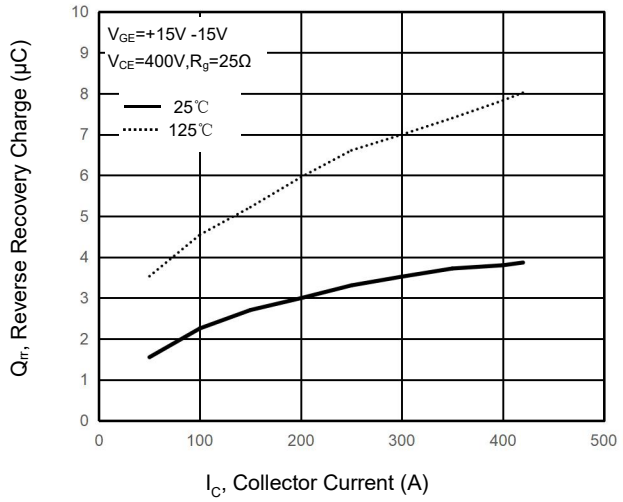


Figure 34.Typical Reverse Recovery Charge vs. R_G

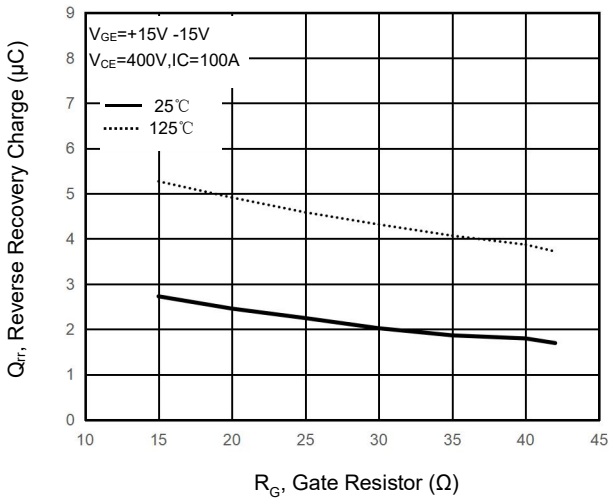


Figure 35.Typical Reverse Recovery Current vs. IC

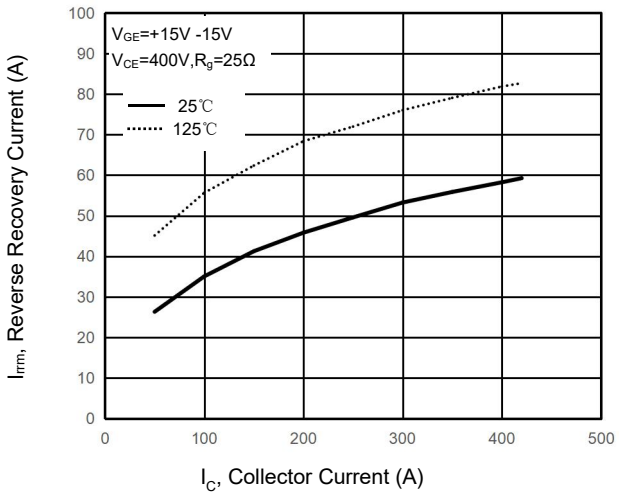
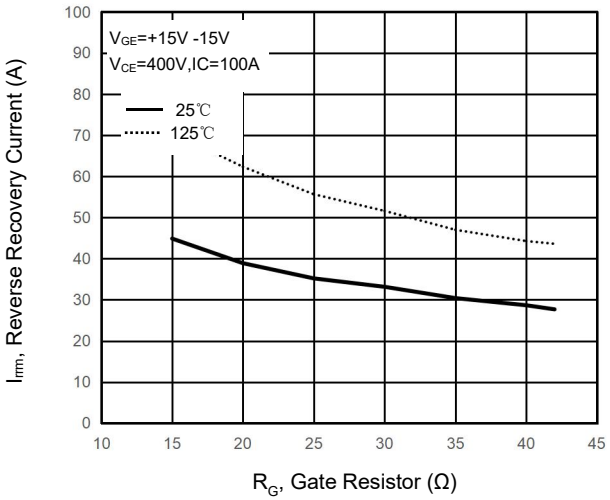


Figure 36.Typical Reverse Recovery Current vs. R_G



TYPICAL CHARACTERISTICS - Q2/Q3 COMUTATES D1,D4 DIODE

Figure 37.Typical Switching Loss Eon vs. IC

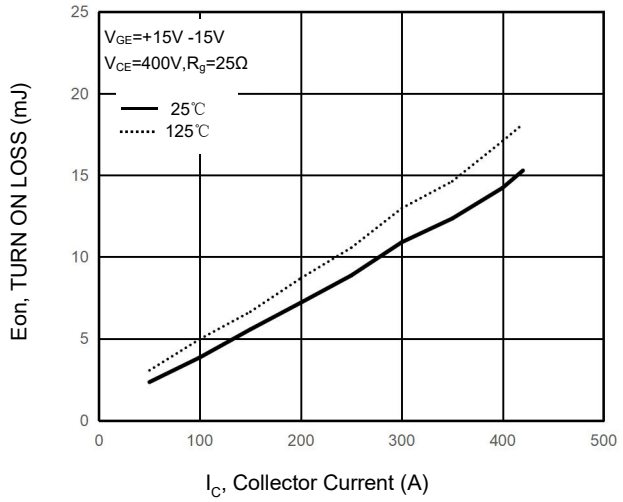


Figure 38.Typical Switching Loss Eoff vs. IC

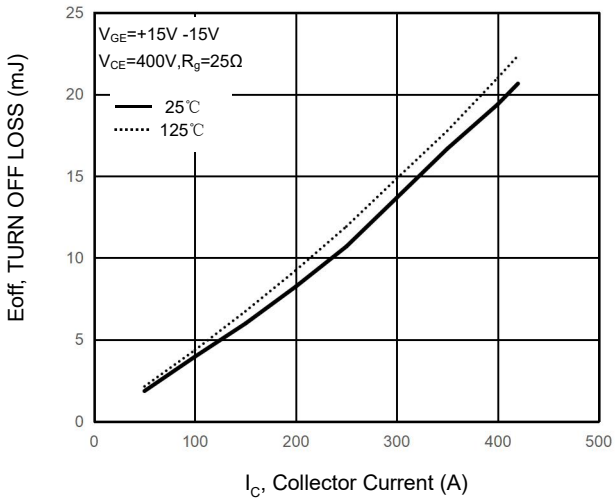


Figure 39.Typical Switching Loss Eon vs. R_G

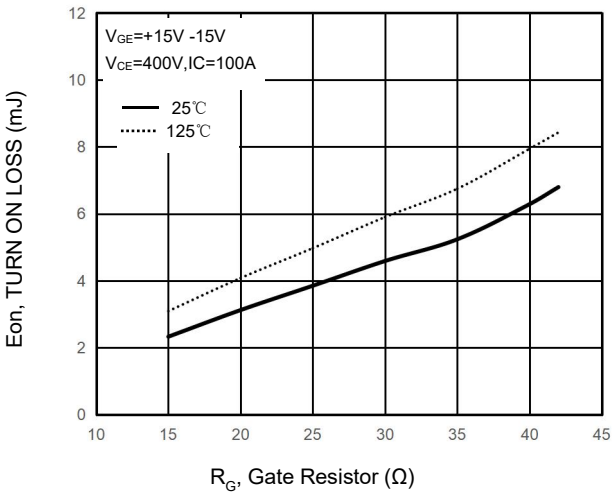


Figure 40.Typical Switching Loss Eoff vs. R_G

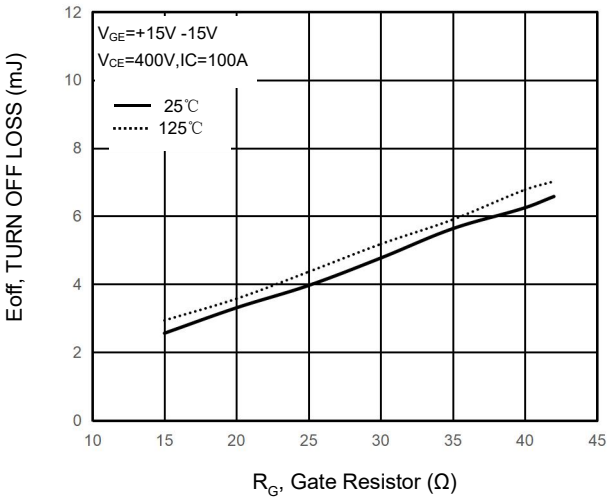


Figure 41.Typical Switching Time Tdon vs. IC

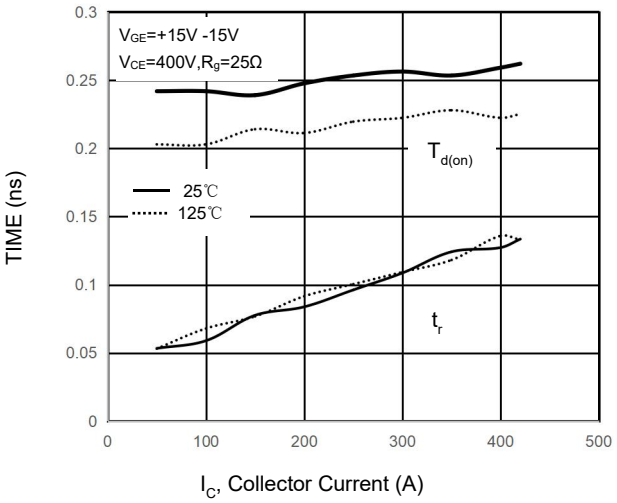
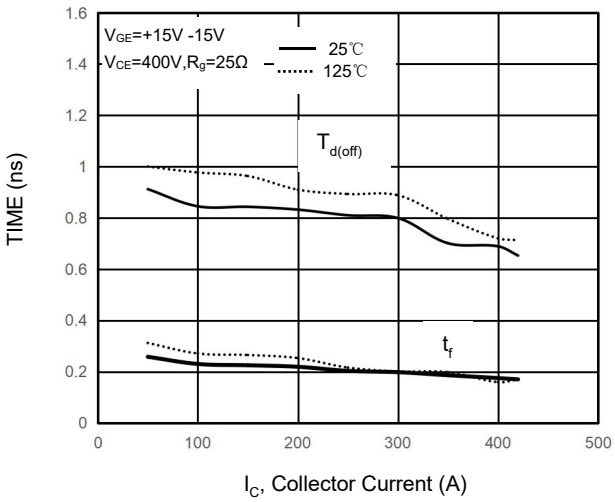


Figure 42.Typical Switching Time Tdoff vs. IC



TYPICAL CHARACTERISTICS - Q2/Q3 COMUTATES D1,D4 DIODE

Figure 43.Typical Switching Time Tdon vs. R_G

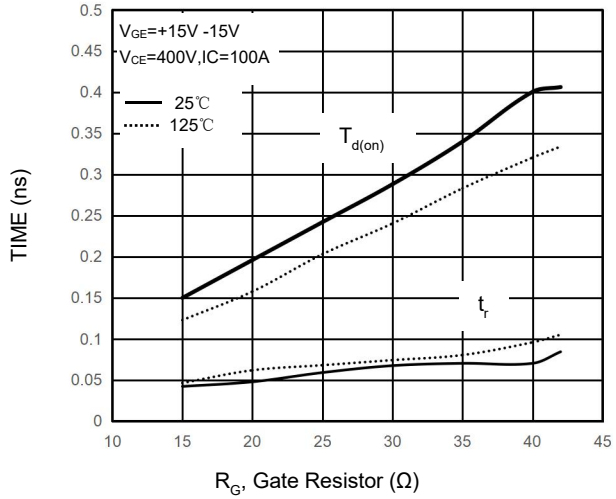


Figure 44.Typical Switching Time Tdoff vs. R_G

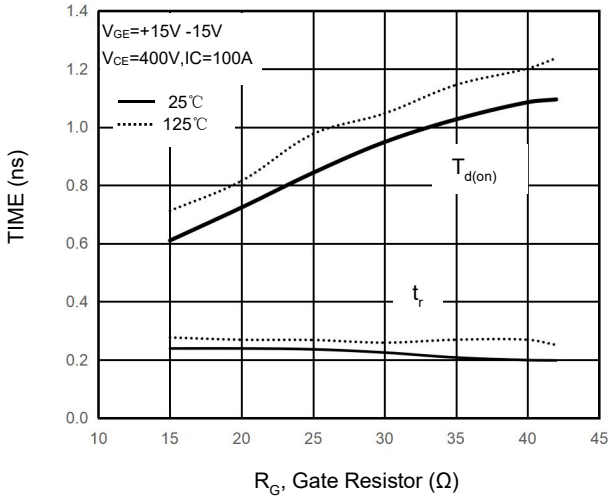


Figure 45.Typical Reverse Recovery Energy Loss vs. IC

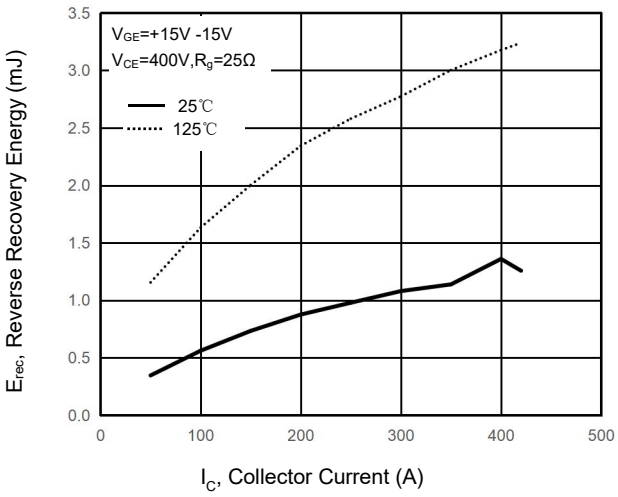


Figure 46.Typical Reverse Recovery Energy Loss vs. R_G

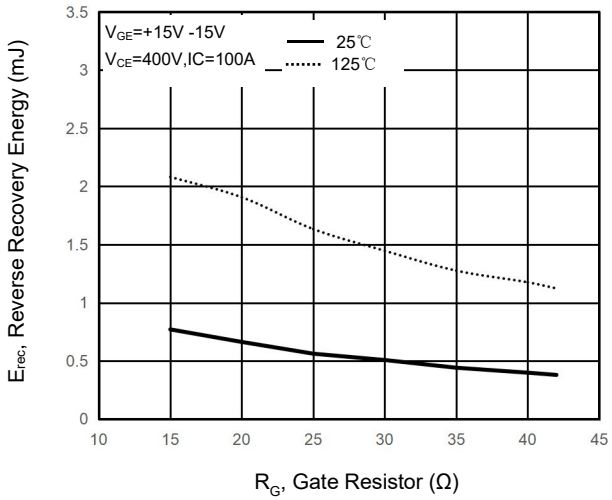


Figure 47.Typical Reverse Recovery Time vs. IC

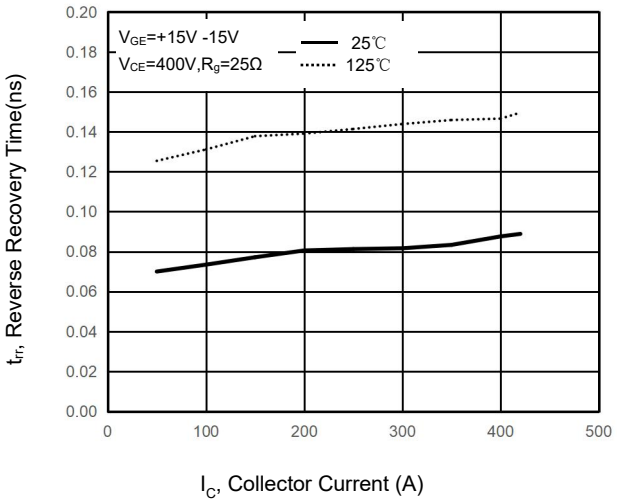
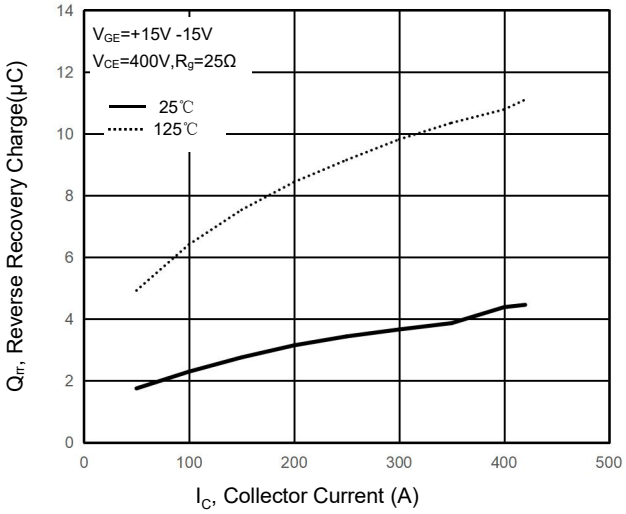
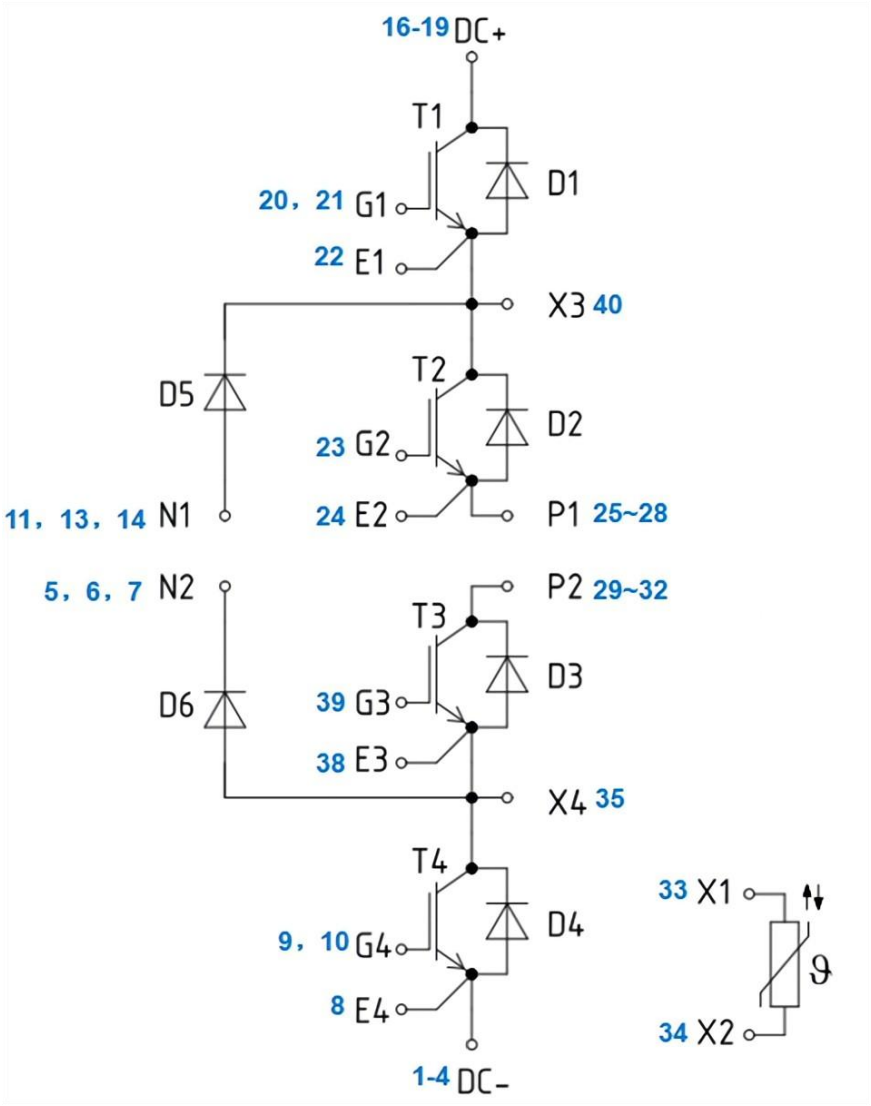


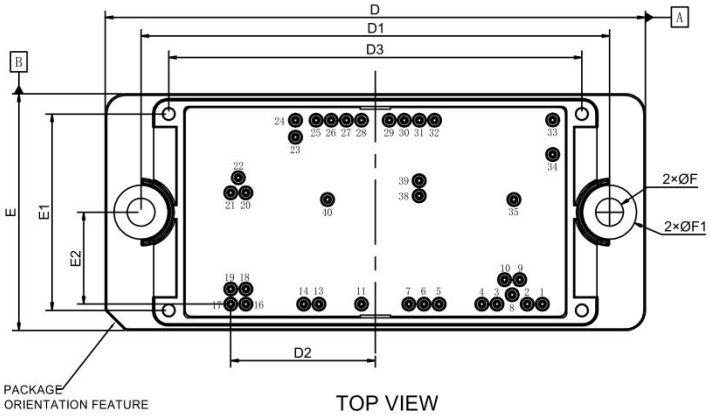
Figure 48.Typical Reverse Recovery Charge vs. IC



CIRCUIT DIAGRAM



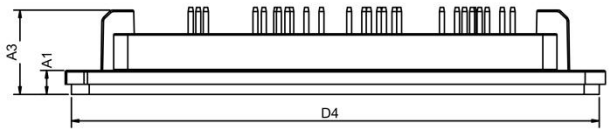
PACKAGE DIMENSIONS



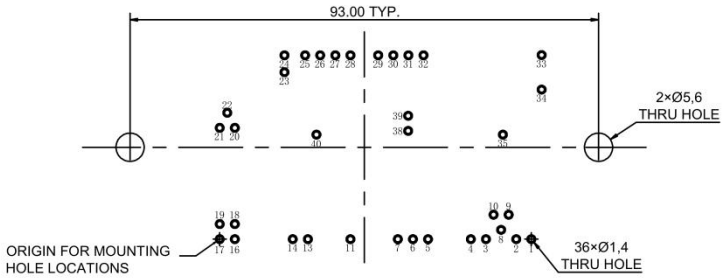
TOP VIEW

SIDE VIEW

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



SIDE VIEW



RECOMMENDED MOUNTING PATTERN

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

NOTES：
1. DIMENSIONING AND TOLERANCING PER ASME 7 14.5M,2009.
2. CONTROLLING DIMENSION:MILLIMETERS
3. DIMESSION b APPLY TO THE PLATED TERMINALS AND ARE MEASURED WHRER 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.