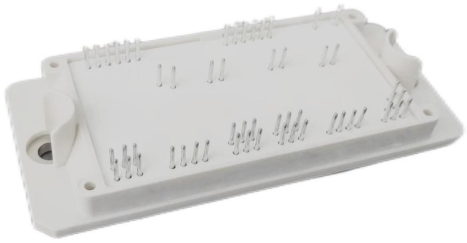
3-Level NPC Inverter Module with 650V Trench Stop IGBTs

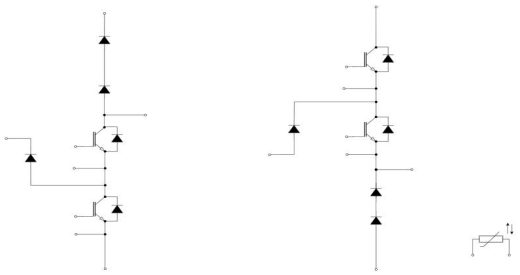
Features

- Electrical features

Neutral Point Clamped Three−level Inverter Module
650V Field Stop IGBTs
Low Inductive layout
Solderable Pins/Press−fit Pins
Thermistor
Pb−Free, Halogen Free/BFR Free and RoHS Compliant



K1



Equivalent Circuit

Applications

Uninterruptable Power Supplies Systems
Energy Storage System

Package Insulation coordination

Parameter	Symbol	Note or test condition	Values	Unit
Isolation test voltage	V_{ISOL}	DC Test Voltage (t_p=2s）	6.0	kV
		AC Test Voltage (t_p=60s）	2.5	
Creepage distance	d_{creep}		＞12.7	mm
Clearance	d_{clear}		＞12.7	mm
Comparative tracking index (electrical)	*CTI*		≥200	

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
BUCK Swich			
V_{CES}	Collector−Emitter Voltage	650	V
V_{GE}	Gate− Emitter Voltage	±20V	V
I_C	Continuous Collector Current @ T_c = 80°C (T_{JMAX} = 175°C)	300	A
I_{CRM}	Repetitive peak collector current (tp limited by Tjmax)	900	A
P_{tot}	Maximum Power Dissipation @ T_c = 80°C (T_{JMAX} = 175°C)	401	W
T_{JMAX}	Maximum Operating Junction Temperature	175	°C
BUCK Diode			
V_{RRM}	Peak Repetitive Reverse Voltage	650	V
I_F	Continuous Forward Current @ T_c = 80°C (T_{JMAX} = 175°C)	300	A
I_{FRM}	Repetitive Peak Forward Current (tp limited by Tjmax)	600	A
P_{tot}	Maximum Power Dissipation @ T_c = 80°C (T_{JMAX} = 175°C)	539	W
T_{JMAX}	Maximum Operating Junction Temperature	175	°C
BUCK Sw.Protection Diode			
V_{RRM}	Peak Repetitive Reverse Voltage	650	V
I_F	Continuous Forward Current @ T_c = 80°C (T_J = 175°C)	30	A
I_{FRM}	Repetitive Peak Forward Current (tp limited by Tjmax)	60	A
P_{tot}	Maximum Power Dissipation @ T_c = 80°C (T_{JMAX} = 175°C)	102	W
T_{JMAX}	Maximum Operating Junction Temperature	175	°C

Symbol	Rating	Value	Unit
Boost Swich			
V_{CES}	Collector−Emitter Voltage	650	V
V_{GE}	Gate− Emitter Voltage	±20	V
I_C	Continuous Collector Current @ T_c = 80°C (T_{JMAX} = 175°C)	300	A
I_{CRM}	Repetitive peak collector current (tp limited by Tjmax)	900	A
P_{tot}	Maximum Power Dissipation @ T_c = 80°C (T_{JMAX} = 175°C)	409	W
T_{JMAX}	Maximum Operating Junction Temperature	175	°C
Boost Diode			
V_{RRM}	Peak Repetitive Reverse Voltage	650	V
I_F	Continuous Forward Current @ T_c = 80°C (T_{JMAX} = 175°C)	220	A
I_{FRM}	Repetitive Peak Forward Current (tp limited by Tjmax)	600	A
P_{tot}	Maximum Power Dissipation @ T_c = 80°C (T_{JMAX} = 175°C)	448	W
T_{JMAX}	Maximum Operating Junction Temperature	175	°C
Boost Sw.Protection Diode			
V_{RRM}	Peak Repetitive Reverse Voltage	650	V
I_F	Continuous Forward Current @ T_c = 80°C (T_J = 175°C)	30	A
I_{FRM}	Repetitive Peak Forward Current (tp limited by Tjmax)	60	A
P_{tot}	Maximum Power Dissipation @ T_c = 80°C (T_{JMAX} = 175°C)	103	W
T_{JMAX}	Maximum Operating Junction Temperature	175	°C

THERMAL PROPERTIES

T_{stg}	Storage Temperature Range	−40 to 125	℃
$T_{vj\,op}$	Temperature under switching condition	−40 to 150	℃

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	175	℃

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
BUCK Switch						
I_{CES}	Collector−Emitter Cutoff Current	V_{GE} = 0 V, V_{CE} = 650 V	--	--	200	μA
$V_{CE(sat)}$	Collector−Emitter Saturation Voltage	V_{GE} = 15 V, I_C =300 A, T_J = 25°C	--	1.50	1.85	V
		V_{GE} = 15 V, I_C = 300 A, T_J = 150°C	--	1.75	--	
$V_{GE(TH)}$	Gate−Emitter Threshold Voltage	V_{GE} = V_{CE} , I_C = 3 mA	4.2	4.8	5.4	V
I_{GES}	Gate Leakage Current	V_{GE} = 20 V, V_{CE} = 0 V	--	--	300	nA
$t_{d(on)}$	Turn−On Delay Time	T_J = 25°C V_{CE} =350 V,I_C =200A V_{GE} =15V/-5V,R_G = 10Ω	--	180	--	ns
t_r	Rise Time		--	40	--	
$t_{d(off)}$	Turn−off Delay Time		--	500	--	
t_f	Fall Time		--	30	--	
E_{on}	Turn−On Switching Loss per Pulse		--	2.37	--	mJ
E_{off}	Turn Off Switching Loss per Pulse		--	6.99	--	
$t_{d(on)}$	Turn−On Delay Time	T_J =150°C V_{CE} =350 V, I_C =200A V_{GE} = 15V/-5V, R_G = 10Ω	--	170	--	ns
t_r	Rise Time		--	41	--	
$t_{d(off)}$	Turn−off Delay Time		--	550	--	
t_f	Fall Time		--	40	--	
E_{on}	Turn−on Switching Loss per Pulse		--	4.25	--	mJ
E_{off}	Turn Off Switching Loss per Pulse		--	7.45	--	
C_{ies}	Input Capacitance	V_{CE} = 25 V, V_{GE} = 0 V, f = 1 Mhz	--	19300	--	nF
C_{oes}	Output Capacitance		--	616	--	
C_{res}	Reverse Transfer Capacitance		--	120	--	
Q_g	Total Gate Charge	V_{CC} = 600 V, I_C =300 A, V_{GE} = ± 15 V	--	588	--	nC
R_{thJC}	Thermal Resistance − Chip−to−Case	Thermal grease, Thickness = 2 Mil ±2%, λ_{paste}=3.4 W/mK	--	0.237	--	°C/W
BUCK Diode						
V_F	Diode Forward Voltage	I_F = 300 A, T_J = 25°C	--	1.30	1.80	V
		I_F = 300 A, T_J = 150°C	--	1.20	--	
I_R	Reverse leakage current	V_r=650V	--	--	15	μA
t_{rr}	Reverse Recovery Time	T_J = 25°C V_{CE} =350 V, I_C =200A R_G = 10Ω	--	37	--	ns
Q_r	Reverse Recovery Charge		--	4.45	--	μC
I_{RM}	Peak Reverse Recovery Current		--	179	--	A
Erec	Reverse recovered energy		--	2.55	--	mJ
t_{rr}	Reverse Recovery Time	T_J = 150°C V_{CE} =350 V, I_C =200A R_G = 10Ω	--	63.1	--	ns
Q_r	Reverse Recovery Charge		--	10.53	--	μC
I_{RM}	Peak Reverse Recovery Current		--	252	--	A
Erec	Reverse recovered energy		--	5.85	--	mJ
R_{thJC}	Thermal Resistance − Chip−to−Case	Thermal grease, Thickness = 2 Mil ±2%, λ_{paste}=3.4 W/mK	--	0.175	--	°C/W

BUCK Sw.Protection Diode

V_F	Diode Forward Voltage	I_F = 30 A, T_J = 25°C	--	1.20	1.6	V
		I_F =30 A, T_J =150°C	--	1.05	--	
I_R	Reverse leakage current	V_r=650V	--	--	0.5	μA
R_{thJC}	Thermal Resistance − Chip−to−Case	Thermal grease, Thickness = 2 Mil ±2%, λ_{paste}=3.4 W/mK	--	0.935	--	°C/W

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

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
Boost Switch						
I_{CES}	Collector−Emitter Cutoff Current	V_{GE} = 0 V, V_{CE} = 650 V	--	--	200	μA
$V_{CE(sat)}$	Collector−Emitter Saturation Voltage	V_{GE} = 15 V, I_C =300 A, T_J = 25°C	--	1.45	1.80	V
		V_{GE} = 15 V, I_C = 300 A, T_J = 150°C	--	1.70	--	
$V_{GE(TH)}$	Gate−Emitter Threshold Voltage	V_{GE} = V_{CE} , I_C = 3 mA	4.2	4.8	5.4	V
I_{GES}	Gate Leakage Current	V_{GE} = 20 V, V_{CE} = 0 V	--	--	300	nA
$t_{d(on)}$	Turn−On Delay Time	T_J = 25°C V_{CE} =350 V,I_C =200A V_{GE} = 15V/-5V, R_G = 10Ω	--	190	--	ns
t_r	Rise Time		--	40	--	
$t_{d(off)}$	Turn−off Delay Time		--	510	--	
t_f	Fall Time		--	40	--	
E_{on}	Turn−On Switching Loss per Pulse		--	2.02	--	mJ
E_{off}	Turn Off Switching Loss per Pulse		--	8.62	--	
$t_{d(on)}$	Turn−On Delay Time	T_J = 150°C V_{CE} =350 V,I_C =200A V_{GE} = 15V/-5V, R_G = 10Ω	--	180	--	ns
t_r	Rise Time		--	50	--	
$t_{d(off)}$	Turn−off Delay Time		--	560	--	
t_f	Fall Time		--	40	--	
E_{on}	Turn−on Switching Loss per Pulse		--	2.94	--	mJ
E_{off}	Turn Off Switching Loss per Pulse		--	8.99	--	
C_{ies}	Input Capacitance	V_{CE} = 25 V, V_{GE} = 0 V, f = 1 Mhz	--	19300	--	nF
C_{oes}	Output Capacitance		--	616	--	
C_{res}	Reverse Transfer Capacitance		--	120	--	
Q_g	Total Gate Charge	V_{CC} = 600 V, I_C =300 A, V_{GE} = ± 15 V	--	588	--	nC
R_{thJC}	Thermal Resistance − Chip−to−Case	Thermal grease, Thickness = 2 Mil ±2%, λ_{paste}=3.4 W/mK	--	0.231	--	°C/W
Boost Diode						
V_F	Diode Forward Voltage	I_F = 300 A, T_J = 25°C	--	2.70	3.20	V
		I_F = 300 A, T_J = 150°C	--	2.50	--	
I_R	Reverse leakage current	V_r=1300V	--	--	15	μA
t_{rr}	Reverse Recovery Time	T_J = 25°C V_{CE} =350 V, I_C =200A R_G = 10Ω	--	47	--	ns
Q_r	Reverse Recovery Charge		--	3.8	--	μC
I_{RM}	Peak Reverse Recovery Current		--	127	--	A
Erec	Reverse recovered energy		--	2.45	--	mJ
t_{rr}	Reverse Recovery Time	T_J = 150°C V_{CE} =350 V, I_C =200A R_G = 10Ω	--	71	--	ns
Q_r	Reverse Recovery Charge		--	8.56	--	μC
I_{RM}	Peak Reverse Recovery Current		--	178	--	A
Erec	Reverse recovered energy		--	5.85	--	mJ
R_{thJC}	Thermal Resistance − Chip−to−Case	Thermal grease, Thickness = 2 Mil ±2%, λ_{paste}=3.4 W/mK	--	0.212	--	°C/W

Boost Sw.Protection Diode

V_F	Diode Forward Voltage	I_F = 30 A, T_J = 25°C	--	1.20	1.60	V
		I_F =30 A, T_J =150°C	--	1.05	--	
I_R	Reverse leakage current	V_r=650V	--	--	0.5	μA
R_{thJC}	Thermal Resistance − Chip−to−Case	Thermal grease, Thickness = 2 Mil ±2%, λ_{paste}=3.4 W/mK	--	0.915	--	°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	%
PD	Power Dissipation		--	200	--	mW
	Power Dissipation Constant		--	2	--	mW/K
	B−value	B $_{(25/50)}$, tolerance ±1%	--	3950	--	K
	B−value	B $_{(25/100)}$, tolerance ±1%	--	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.

BUCK Switch Characteristics

Figure 1.Typical Output Characteristics
V_G =15V

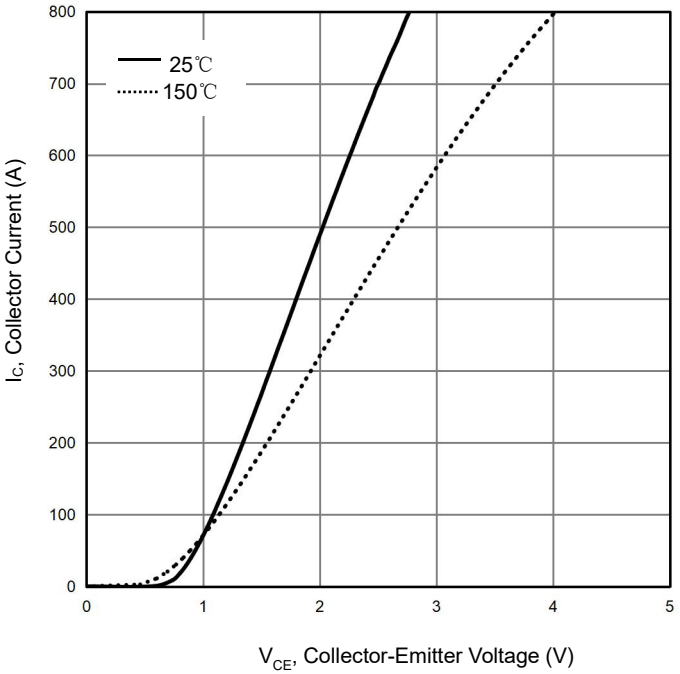


Figure 2.Typical Output Characteristics
T_j =150℃

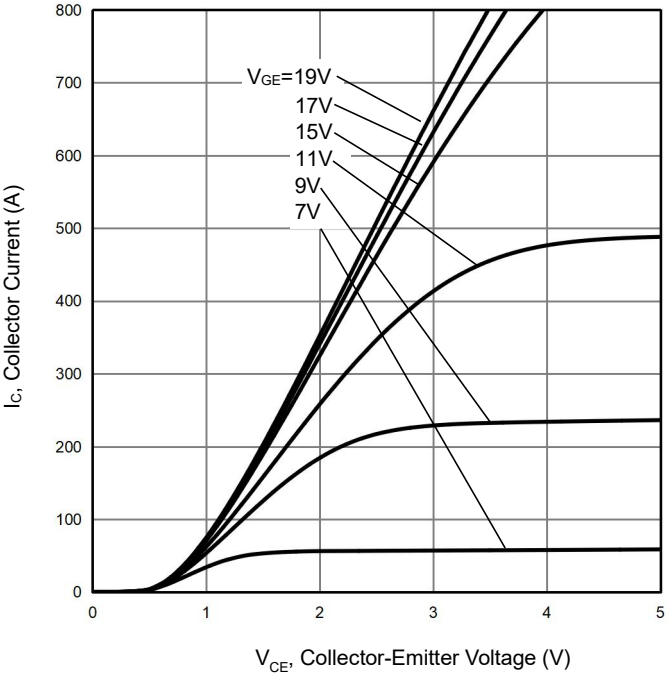


Figure 3.Typical Transfer Characteristics
V_{CE} =20V

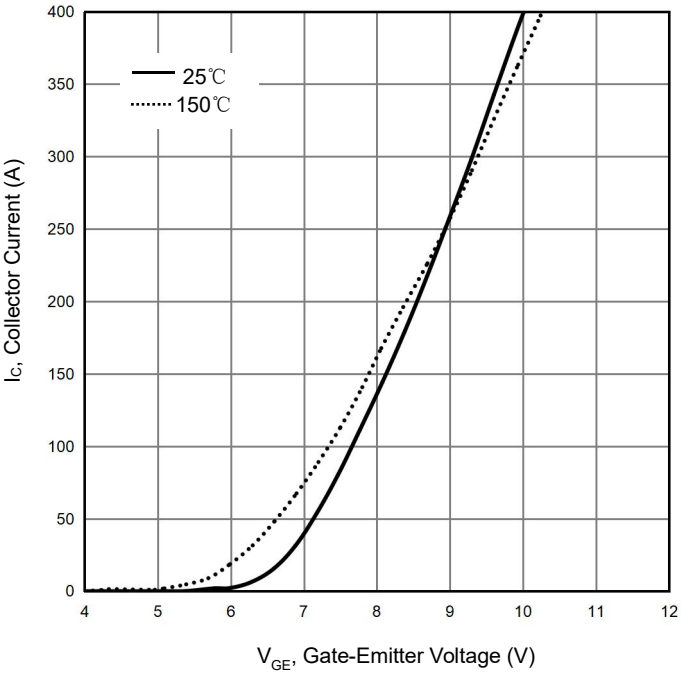
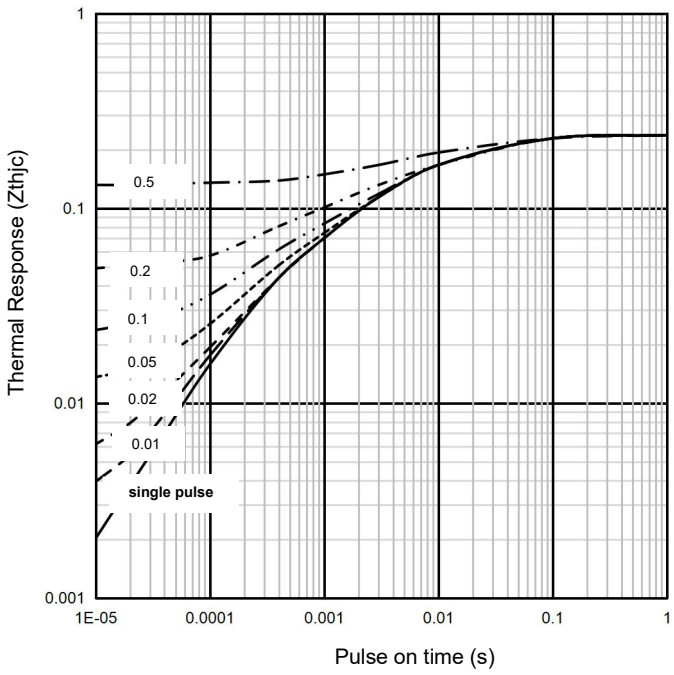


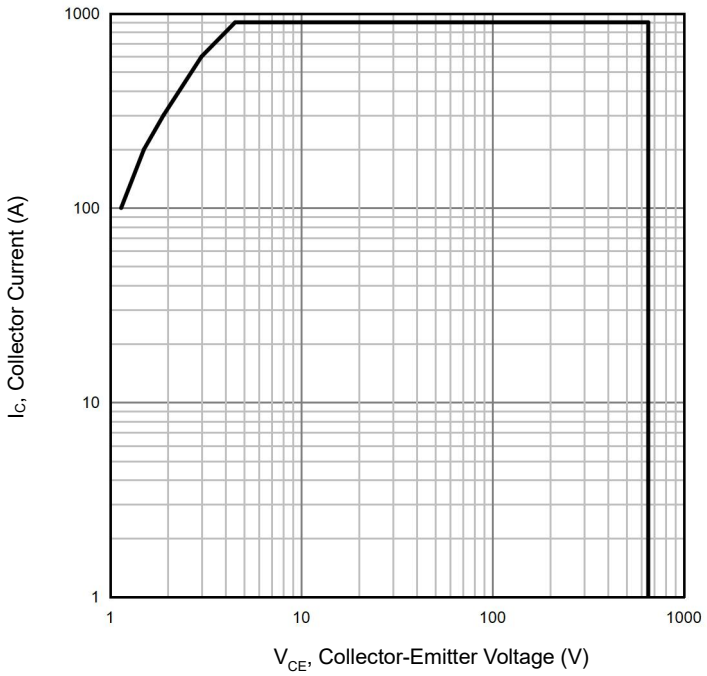
Figure 4.Transient thermal impedance as a function of pulse width



BUCK Switch Characteristics

Figure 5.Forward Bias Safe Operating Area

T_C =80℃, T_j ≤T_j max ,V_G =15V



BUCK Diode Characteristics

Figure 6.Typical forward characteristics

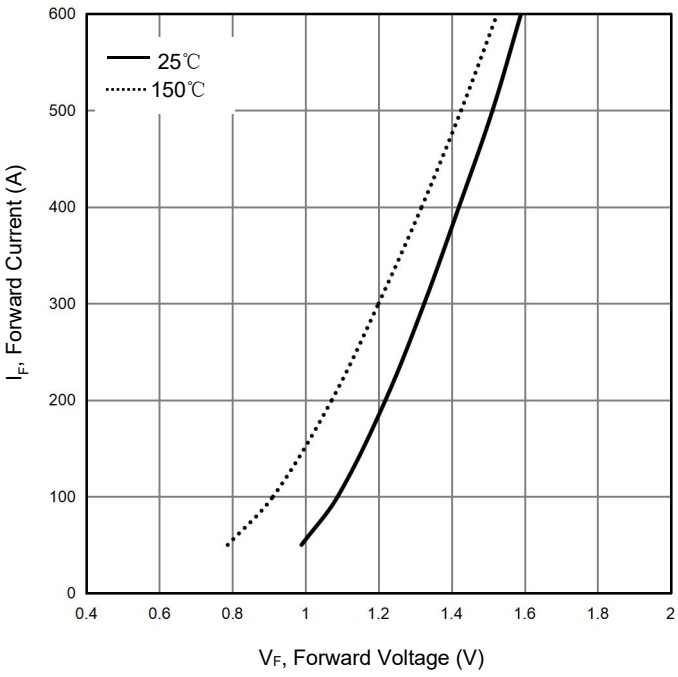
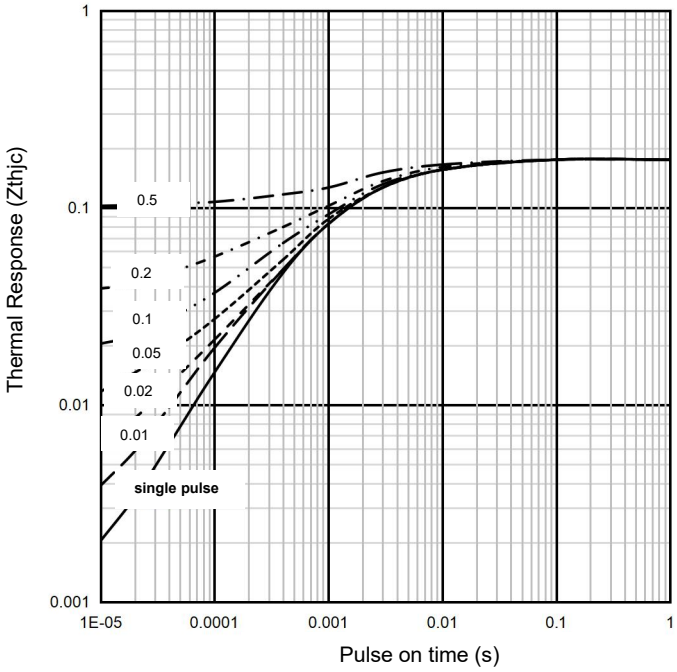


Figure 7.Transient thermal impedance as a function of pulse width



Buck Sw. Protection Diode Characteristics

Figure 8.Typical forward characteristics

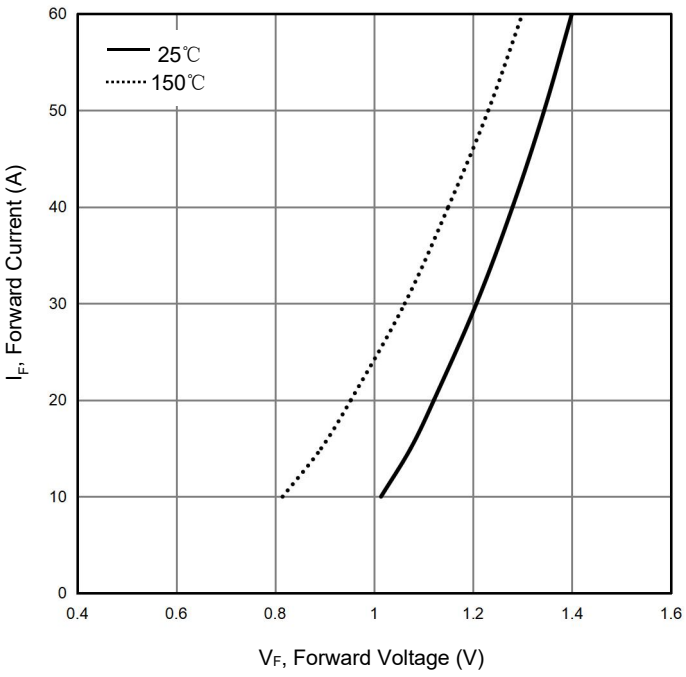
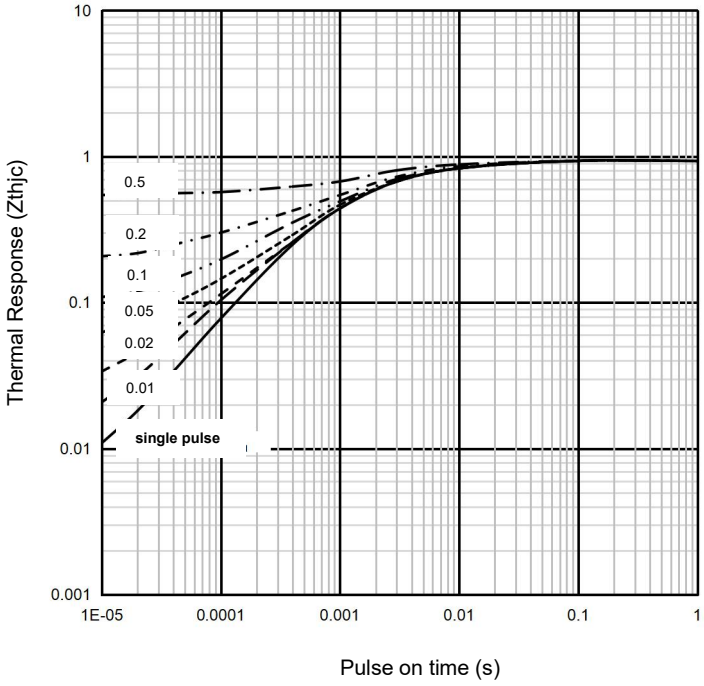


Figure 9.Transient thermal impedance as a function of pulse width



Boost Switch Characteristics

Figure 10.Typical Output Characteristics
V_G =15V

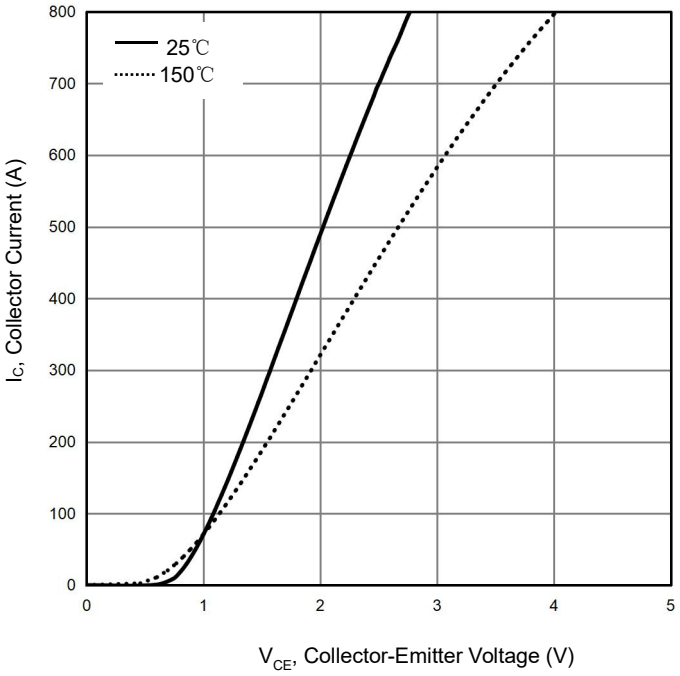


Figure 11.Typical Output Characteristics
T_j =150℃

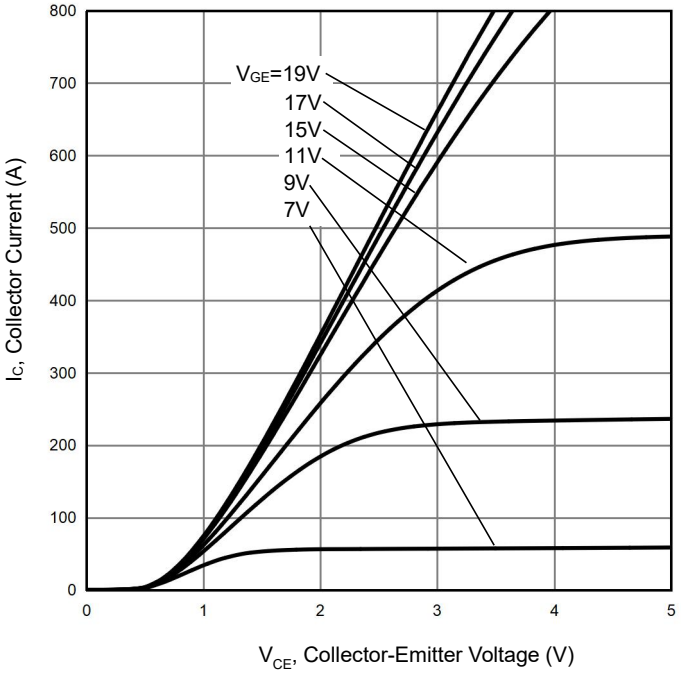


Figure 12.Typical Transfer Characteristics

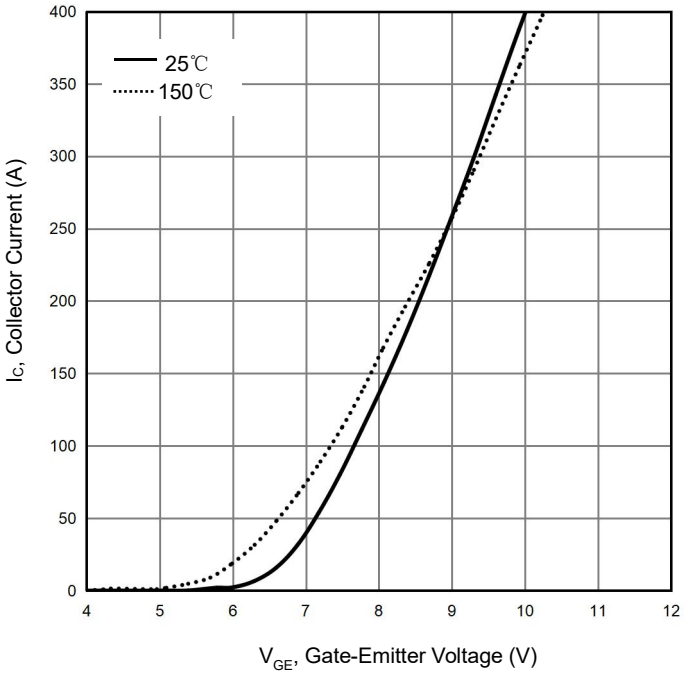
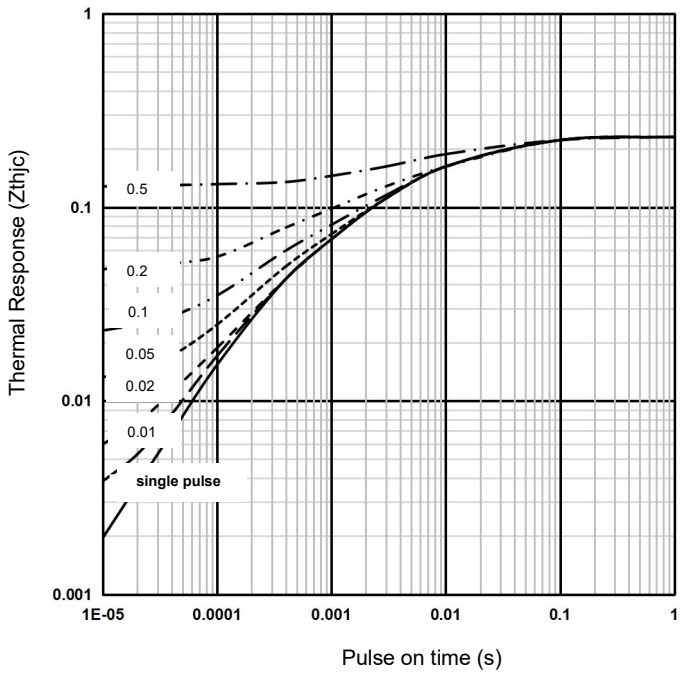
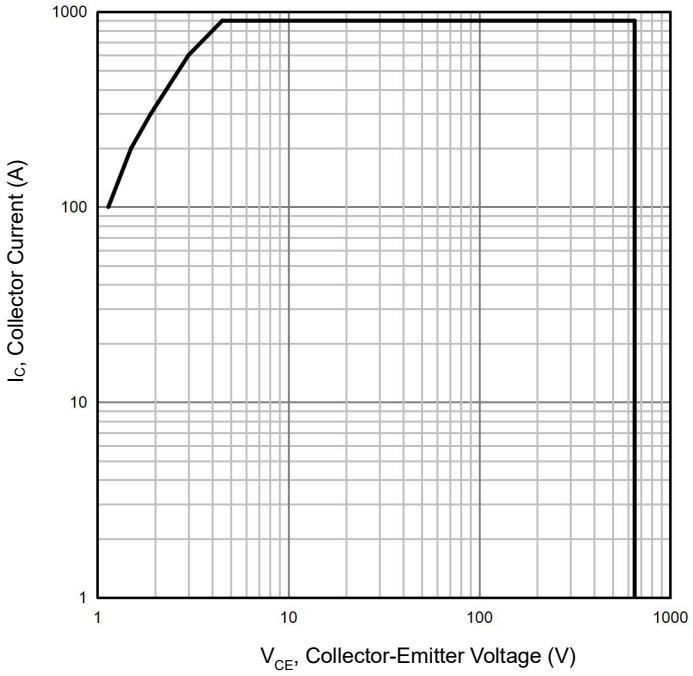


Figure 13.Transient thermal impedance as a function of pulse width



Boost Switch Characteristics

Figure 14.Forward Bias Safe Operating Area
T_C =80℃, $T_j \leq T_j$ max ,V_G =15V



Boost Diode Characteristics

Figure 15.Typical forward characteristics

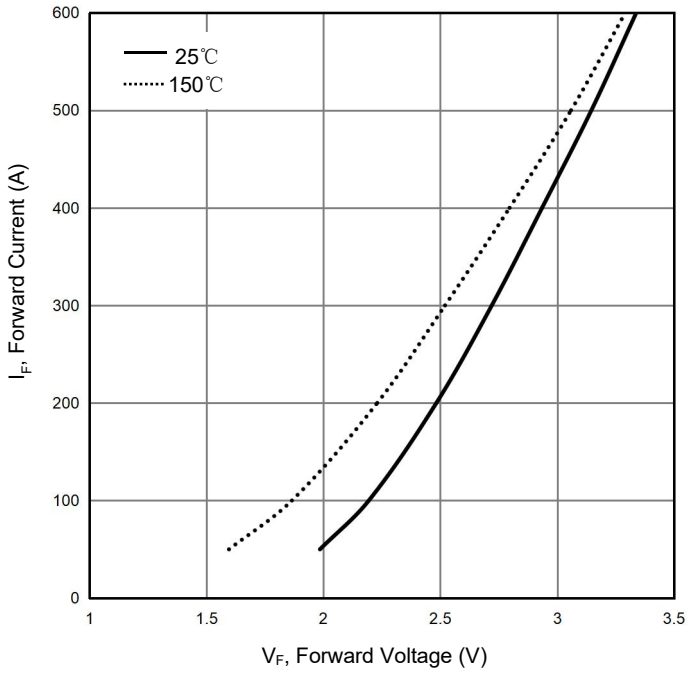
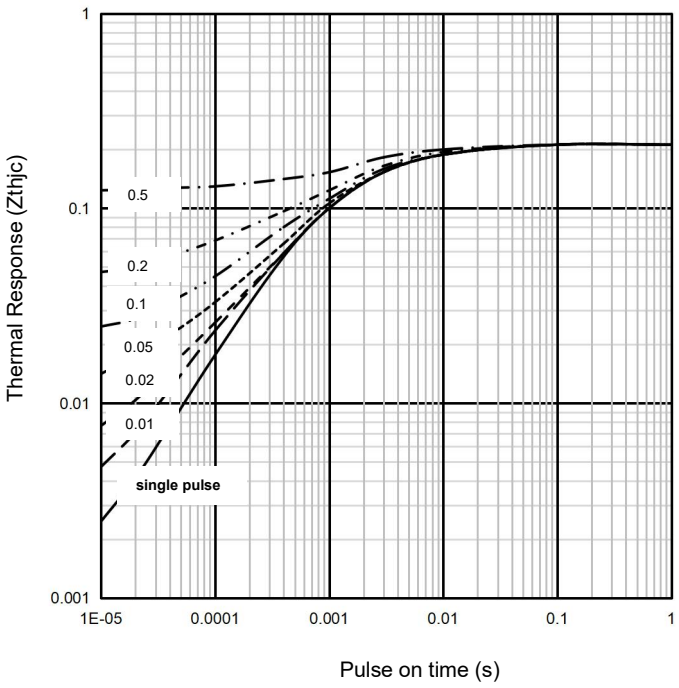


Figure 16.Transient thermal impedance as a function of pulse width



Boost Sw. Protection Diode Characteristics

Figure 17.Typical forward characteristics

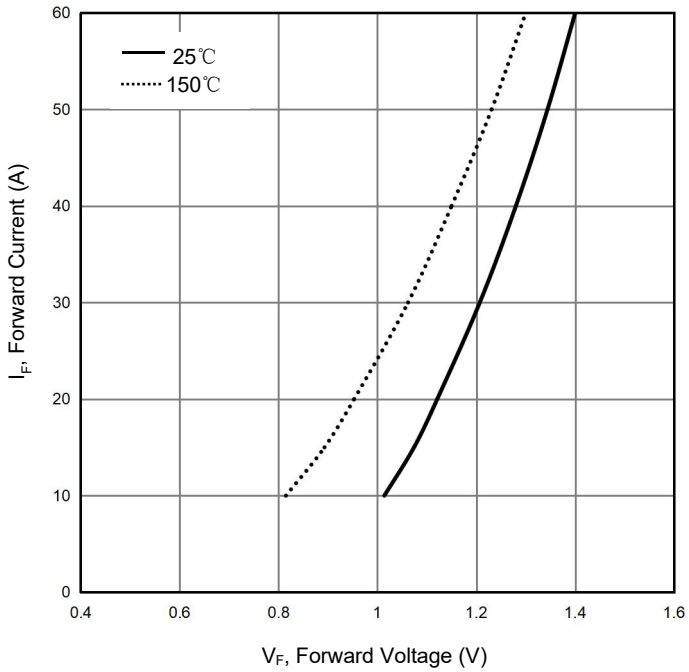
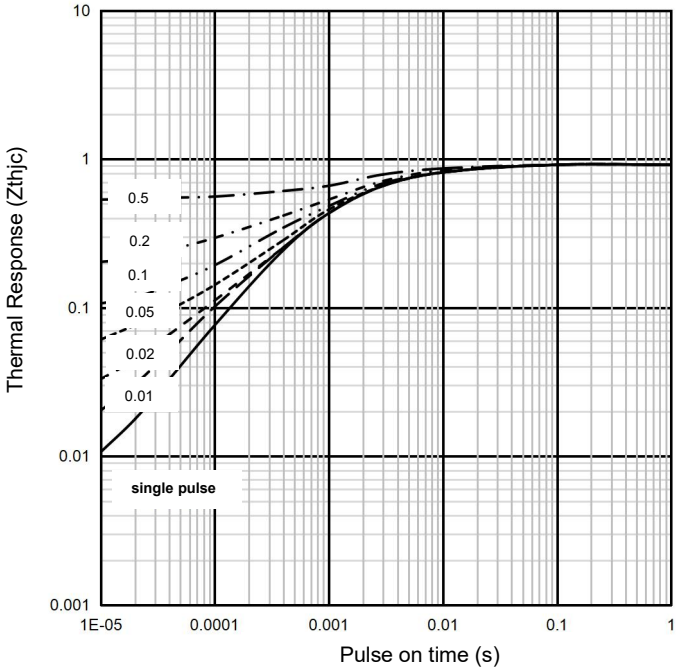
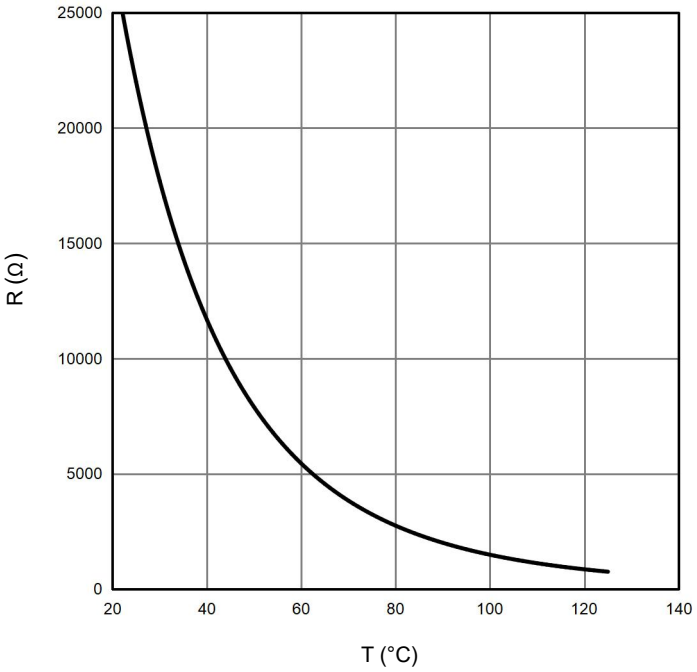


Figure 18.Transient thermal impedance as a function of pulse width



Thermistor Characteristics

Figure 19.Typical NTC characteristic as function of temperature



Buck Switching Characteristics

Figure 20.Typical switching energy losses as a function of collector current Characteristics
V_{CE} =350V,R_G =15Ω,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

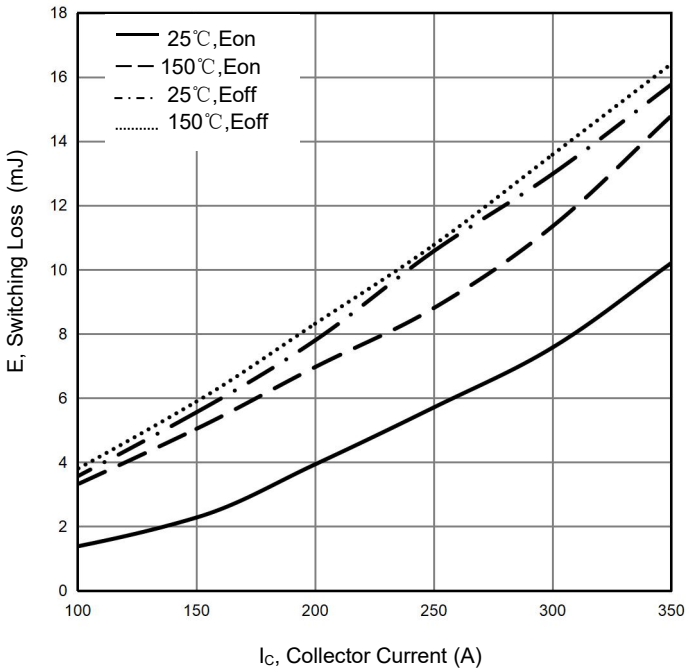


Figure21.Typical switching energy losses as a function of IGBT turn on gate resistor
V_{CE} =350V,I_C =200A,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

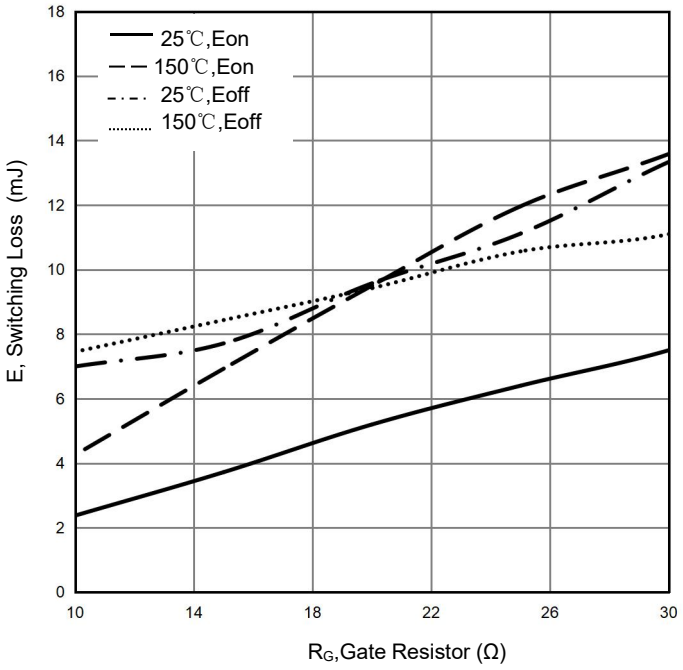


Figure 22.Typical reverse recovered energy loss as a function of collector current
V_{CE} =350V,R_G =15Ω,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

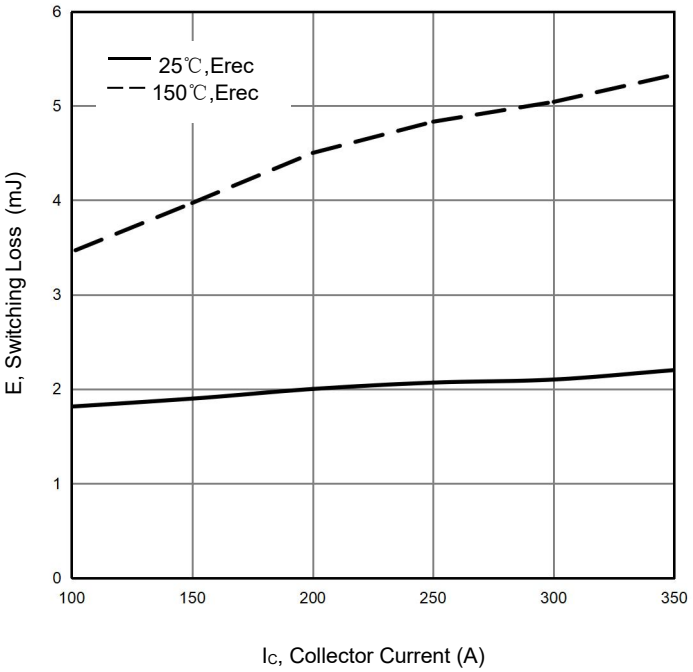
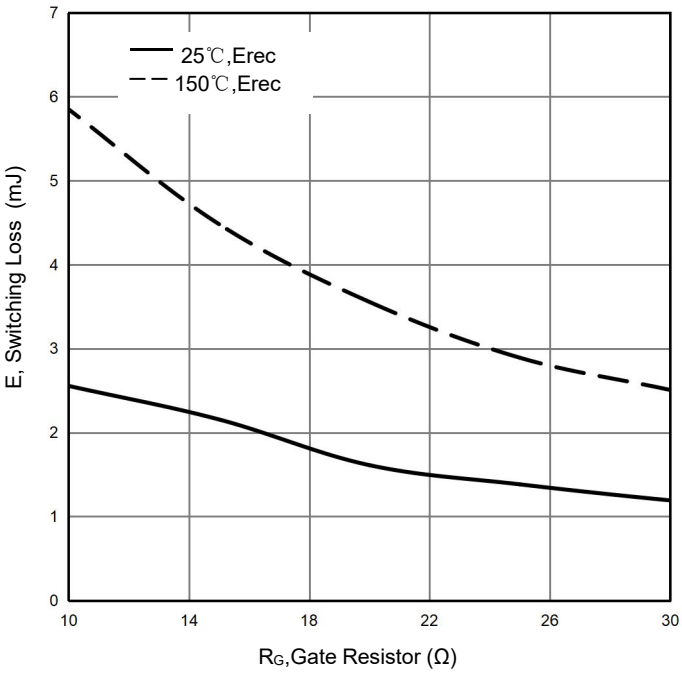


Figure 23.Typical reverse recovered energy loss as a function of IGBT turn on gate
V_{CE} =350V,I_C =200A,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V



Buck Switching Characteristics

Figure 24.Typical switching times as a function of collector current

V_{CE} =350V,R_G =15Ω,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V,T_j =150℃

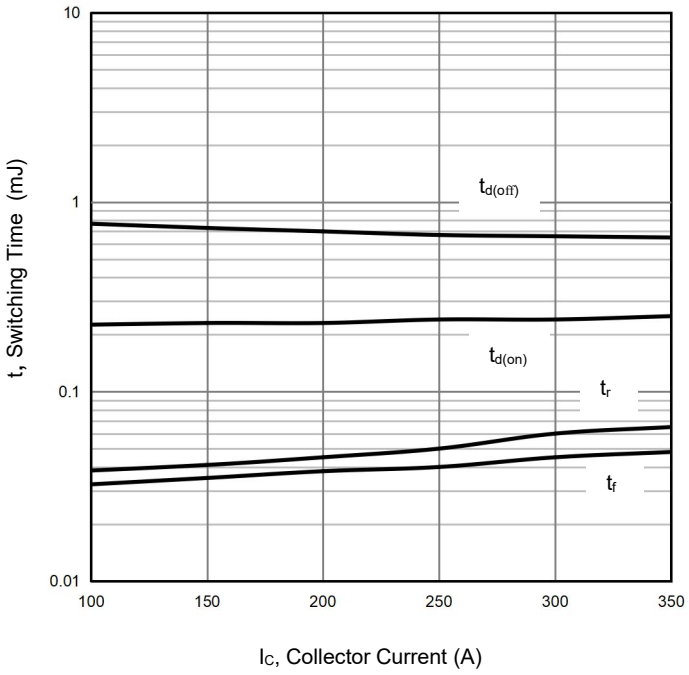


Figure 25.Typical switching times as a function of IGBT turn on gate resistor

V_{CE} =350V,I_C =200A,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V,T_j =150℃

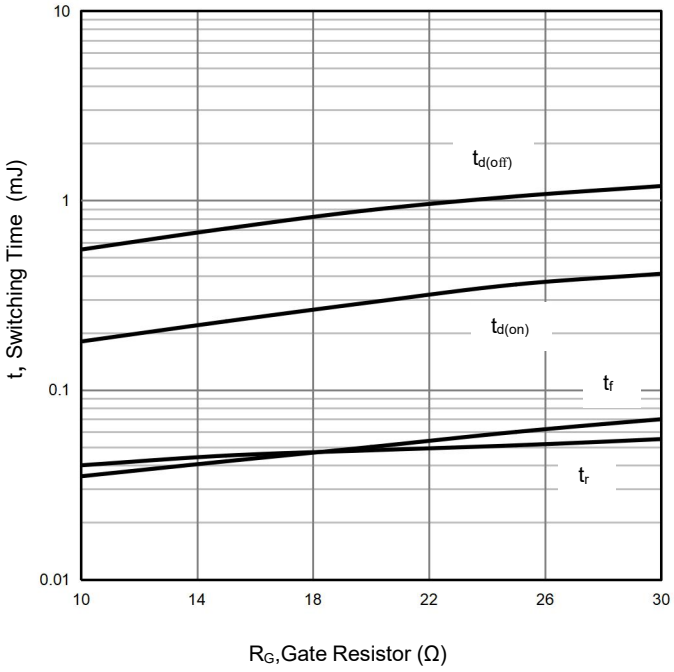


Figure 26.Typical reverse recovery time as a function of collector current

V_{CE} =350V,R_G =15Ω,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

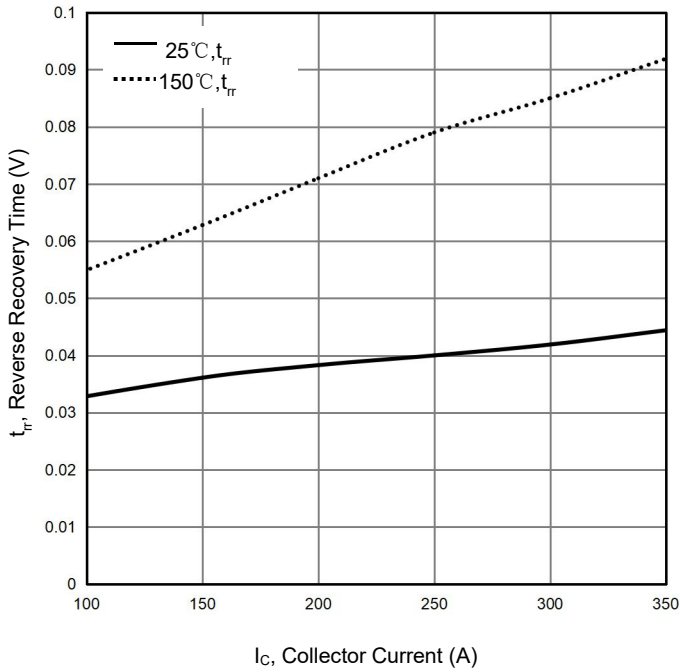
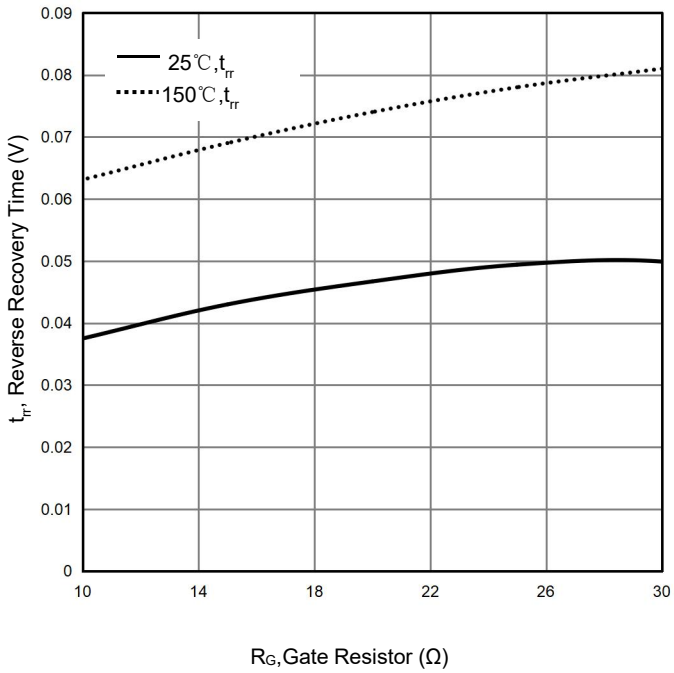


Figure27.Typical reverse recovery time as a function of IGBT turn on gate resistor

V_{CE} =350V,I_C =200A,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V



Buck Switching Characteristics

Figure 28.Typical recovered charge as a function of collector current
V_{CE} =350V,R_G =15Ω,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

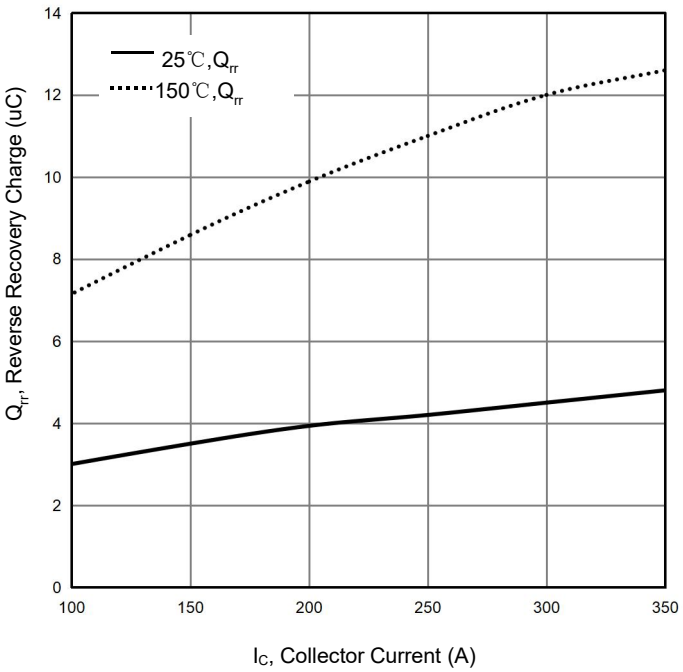


Figure 29.Typical recovered charge as a function of IGBT turn on gate resistor
V_{CE} =350V,I_C =200A,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

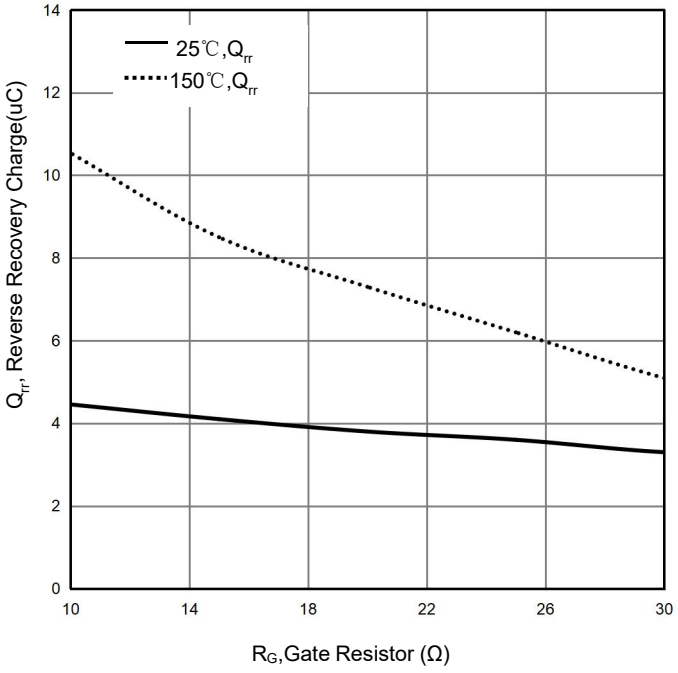


Figure 30.Typical peak reverse recovery current as a function of collector current
V_{CE} =350V,R_G =15Ω,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

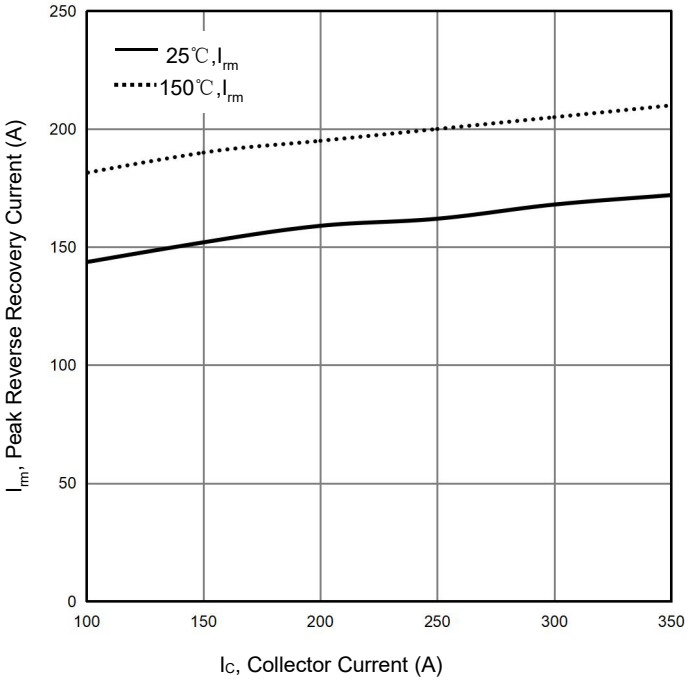
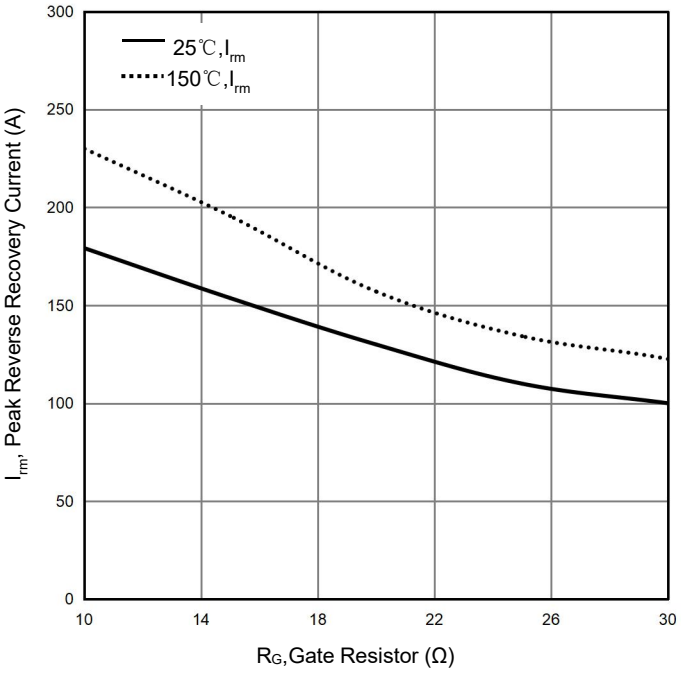


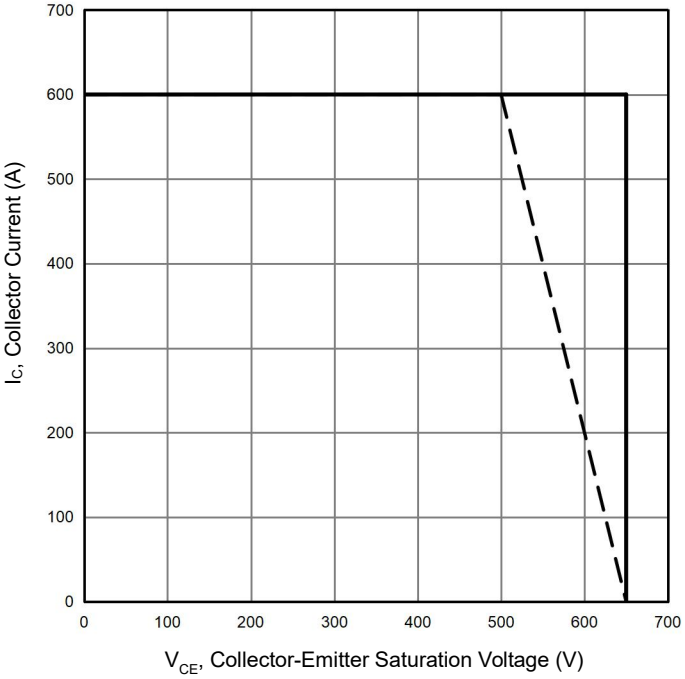
Figure 31.Typical peak reverse recovery current as a function of IGBT turn on gate resistor
V_{CE} =350V,I_C =200A,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V



Buck Switching Characteristics

Figure 32.Reverse bias safe operating area

$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V,T_j =150℃,R_G =25Ω



Boost Switching Characteristics

Figure 33.Typical switching energy losses as a function of collector current
V_{CE} =350V,R_G =15Ω,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

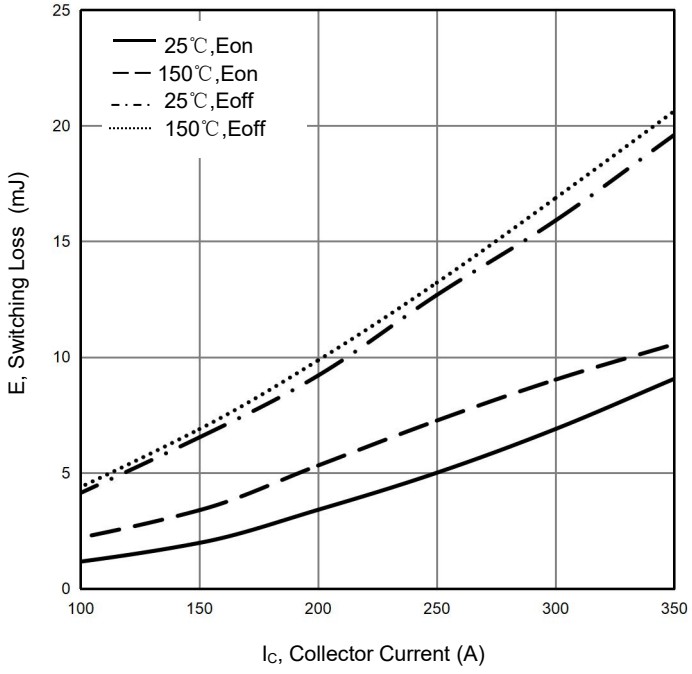


Figure 34.Typical switching energy losses as a function of IGBT turn on gate resistor
V_{CE} =350V,I_C =200A,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

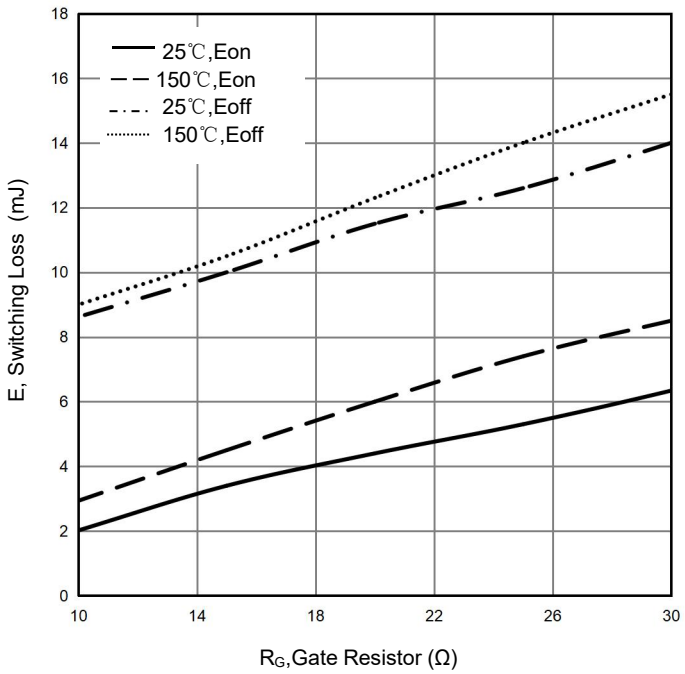


Figure 35.Typical reverse recovered energy loss as a function of collector current
V_{CE} =350V,R_G =15Ω,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

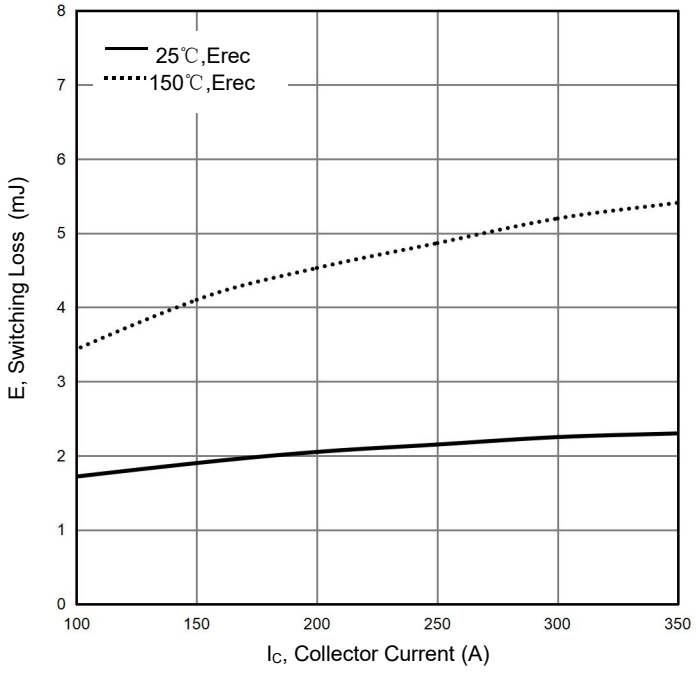
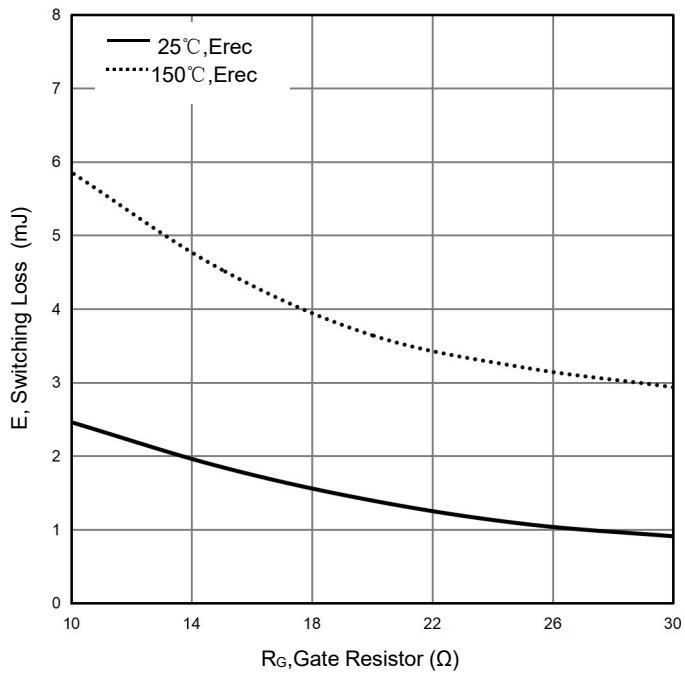


Figure 36.Typical reverse recovered energy loss as a function of IGBT turn on gate
V_{CE} =350V,I_C =200A,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V



Boost Switching Characteristics

Figure 37.Typical reverse recovery time as a function of collector current

V_{CE} =350V,R_G =15Ω,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V,T_j =150℃

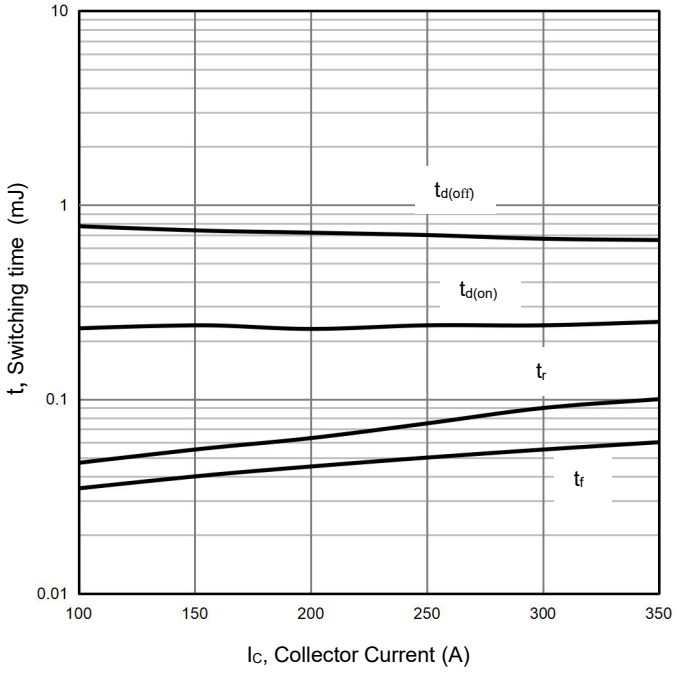


Figure 38.Typical reverse recovery time as a function of collector current

V_{CE} =350V,I_C =200A,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V,T_j =150℃

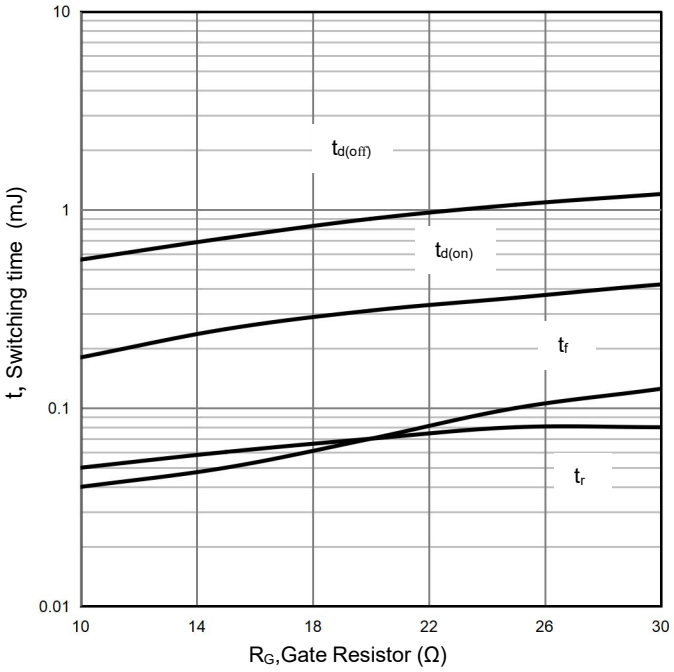


Figure 39.Typical reverse recovery time as a function of collector current

V_{CE} =350V,R_G =15Ω,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

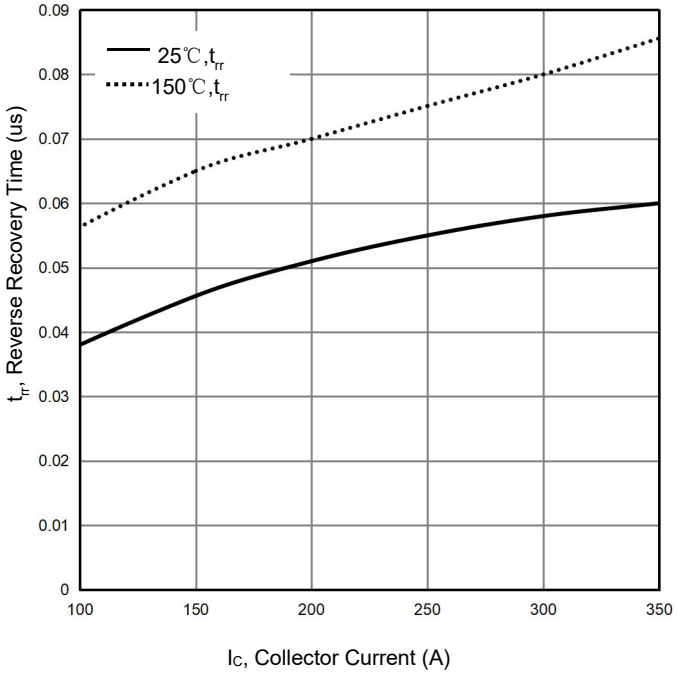
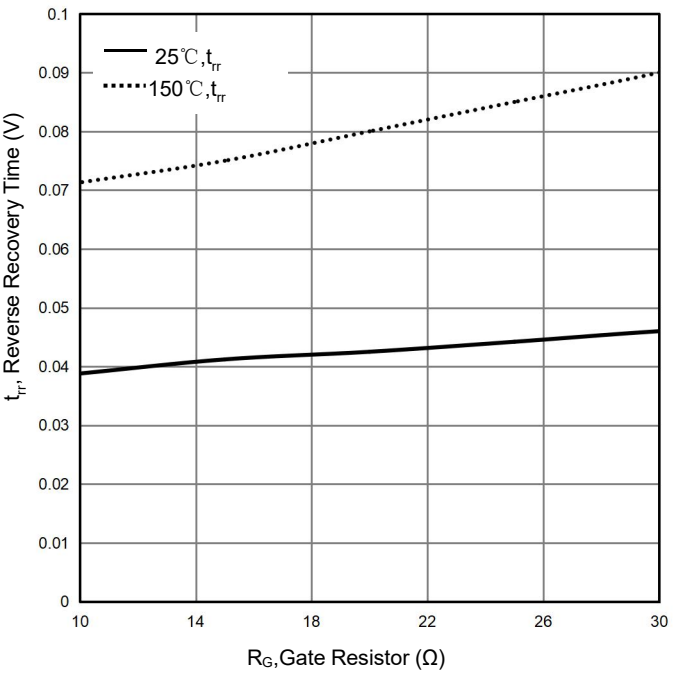


Figure 40.Typical reverse recovery time as a function of IGBT turn on gate resistor

V_{CE} =350V,I_C =200A,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V



Boost Switching Characteristics

Figure 41.Typical recovered charge as a function of collector current
V_{CE} =350V,R_G =15Ω,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

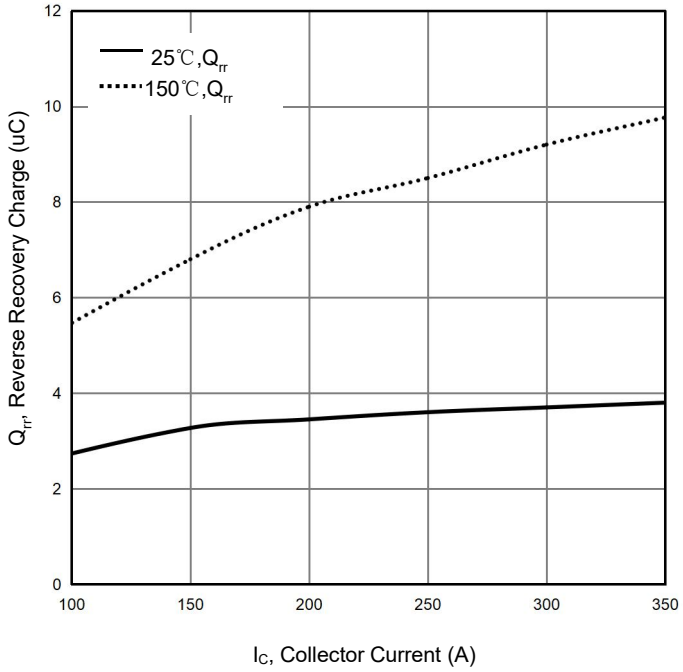


Figure 42.Typical recovered charge as a function of IGBT turn on gate resistor
V_{CE} =350V,I_C =200A,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

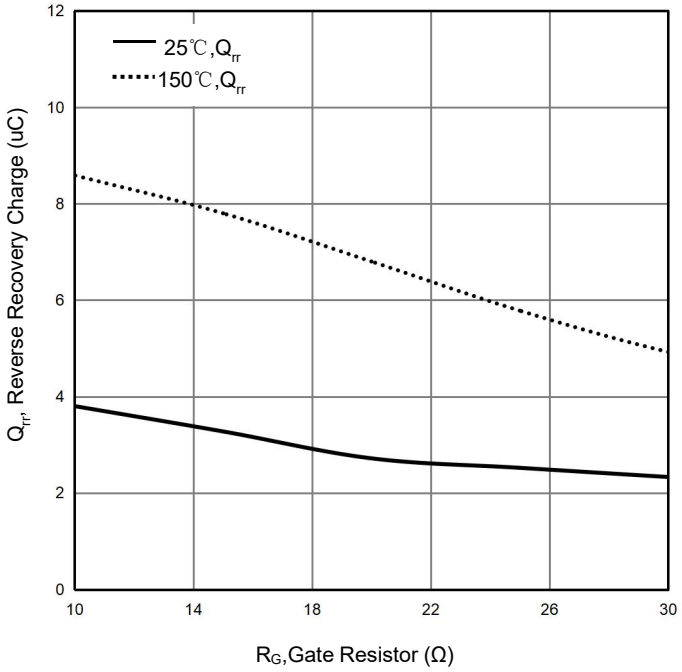


Figure 43.Typical peak reverse recovery current as a function of collector current
V_{CE} =350V,R_G =15Ω,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V

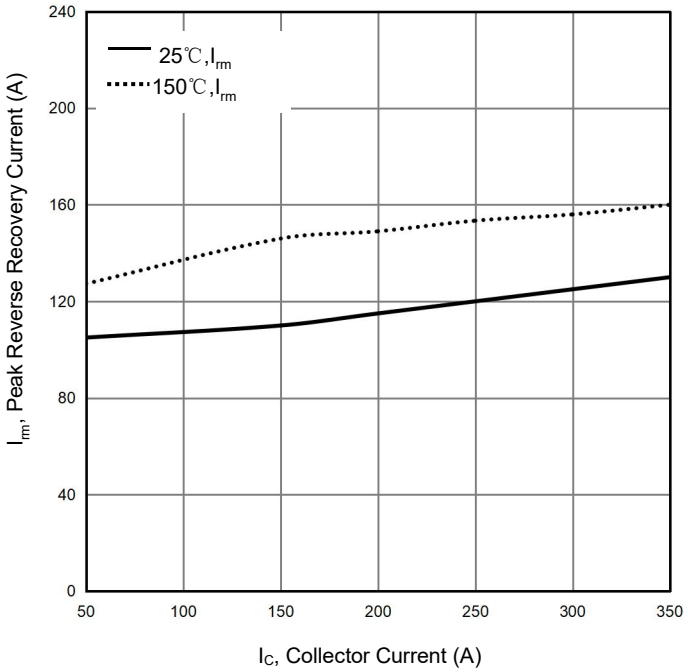
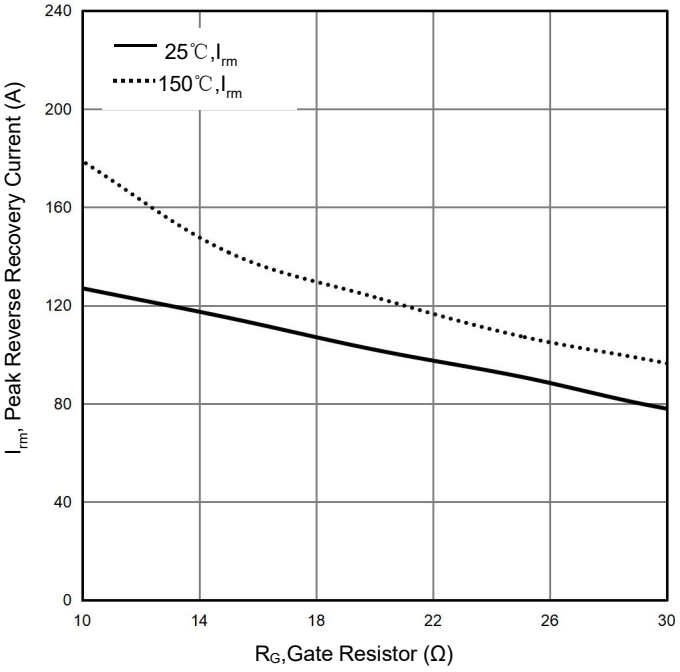


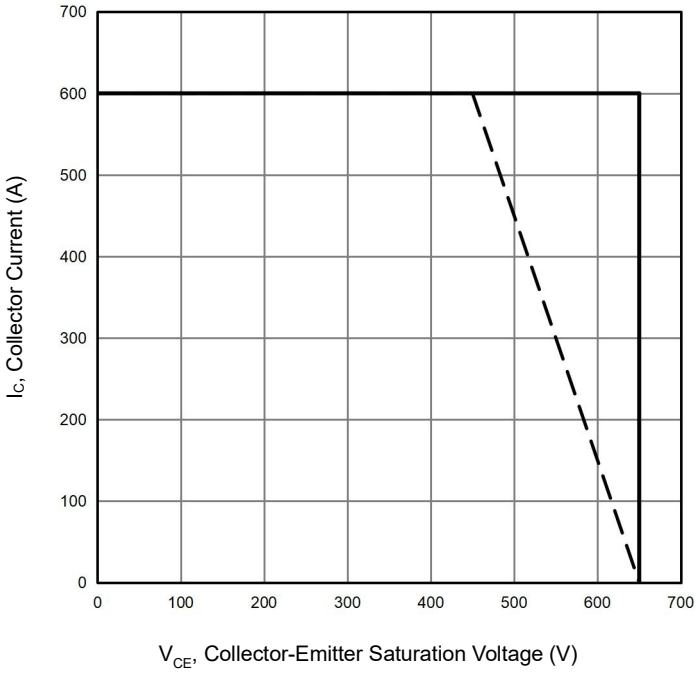
Figure 44.Typical peak reverse recovery current as a function of IGBT turn on gate resistor
V_{CE} =350V,I_C =200A,$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V



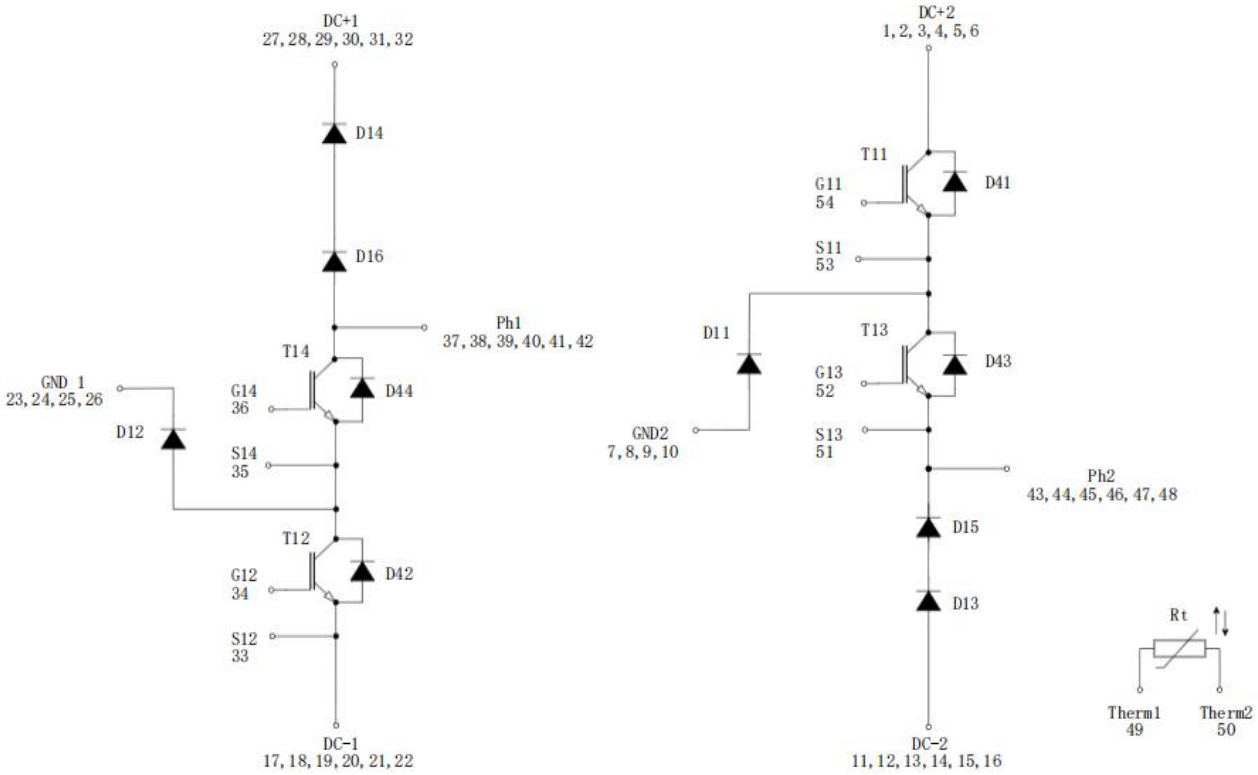
Boost Switching Characteristics

Figure 45.Reverse bias safe operating area

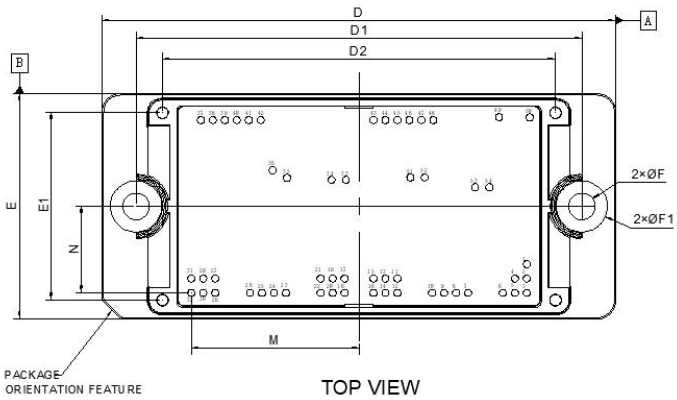
$V_{G(on)}$ =15V,$V_{G(off)}$ =-5V,T_j =150℃,R_G =25Ω



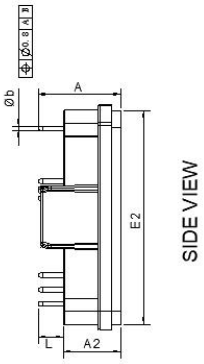
CIRCUIT DIAGRAM



PACKAGE DIMENSIONS

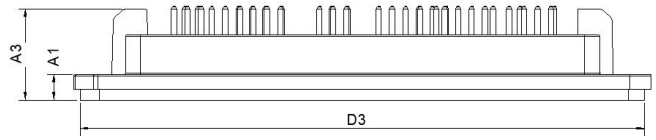


TOP VIEW

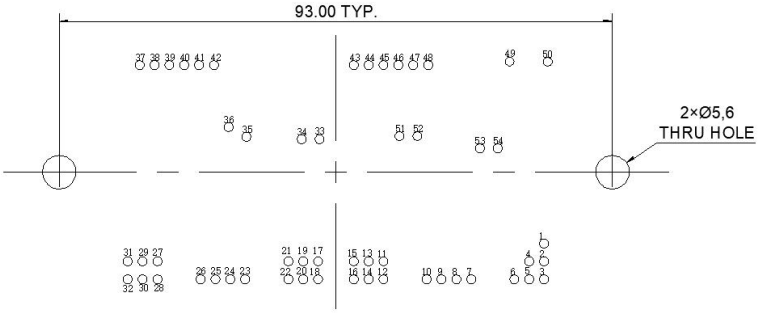


SIDE VIEW

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
M	35 REF		
D2	81.80	82.00	82.20
D3	104.35	104.75	105.15
E	46.60	47.00	47.40
E1	38.80	39.00	39.20
N	18 REF		
E2	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	70	6
2	70	3
3	70	0
4	67.5	3
5	67.5	0
6	65	0
7	57.75	0
8	55.25	0
9	52.75	0
10	50.25	0
11	43	3
12	43	0
13	40.5	3
14	40.5	0
15	38	3
16	38	0
17	32	3
18	32	0
19	29.5	3
20	29.5	0
21	27	3
22	27	0
23	19.75	0
24	17.25	0

PIN	PIN POSITION	
	X	Y
25	14.75	0
26	12.25	0
27	5	3
28	5	0
29	2.5	3
30	2.5	0
31	0	3
32	0	0
33	32.25	23.55
34	29.25	23.55
35	19.95	23.95
36	16.95	25.55
37	2	36
38	4.5	36
39	7	36
40	9.5	36
41	12	36
42	14.5	36
43	38	36
44	40.5	36
45	43	36
46	45.5	36
47	48	36
48	50.5	36

PIN	PIN POSITION	
	X	Y
49	64.2	36.6
50	70.6	36.55
51	45.7	24.05
52	48.7	24.05
53	59.2	22
54	62.2	22