High-speed IGBT Power Transistor

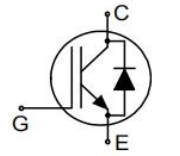
(Integrated FRD)

Preliminary

HKW40N65SHEE

1. Product Features:

- Ultra-low switching losses
- Benchmark efficiency in hard switching topologies
- Internal integrated fast&soft recovery anti-parallel FRD
- Maximum junction temperature 175℃
- Qualified according to JEDEC
- RoHS compliant



Package: TO-247-3

2. Product Applications

- Industrial Power Supplies
- Solar String Inverter
- Energy Storage Inverter
- UPS
- DC Charger for Electric Vehicles
- Welding Machines

3. Typical Performance Parameters

Tab.1. Typical Performance Parameters

Type	V_{CE}	I_C	V_{CEsat} T_{vj} = 25℃	T_{vjmax}	Marking	Package
HKW40N65SHEE	650V	40A	1.55V	175℃	HKW40N65SHEE	TO-247-3

4. Maximum Ratings

Tab.2. Maximum Ratings

Parameters	Symbol	Value	Unit
Collector-emitter voltage, $Tvj \geq 25$℃	V_{CE}	650	V
DC collector current (limited by T_{vjmax})	I_C	75(T_c = 25℃) 50(T_c = 100℃)	A
Pulsed collector current (t_p limited by $T_{vjmax.}$)	I_{Cpuls}	120	A
Diode forward current (limited by T_{vjmax})	I_F	40 (T_c = 100℃)	A
Diode pulse current (t_p limited by $T_{vjmax.}$)	I_{Fpuls}	120(T_c = 25℃)	A
Gate-emitter voltage	V_{GE}	±20	V
Transient Gate-emitter voltage (tp ≤ 10μs, D < 0.0100)		±30	V
Power dissipation	P_{tot}	340(T_c = 25℃) 170(T_c = 100℃)	W
Operating junction temperature	T_{vj}	-40 to +175	℃
Storage temperature	T_{stg}	-55 to +150	℃
Soldering temperature, (wave soldering 1.6mm from case for 10s)		260	℃
Mounting torque (M3 screw) (Maximum of mounting processes: 3)	M	0.6	Nm

5. Thermal Properties

Tab.3. Thermal Properties

Parameters	Symbol	Max. value	Unit
IGBT thermal resistance (junction - case)	$R_{th(j-c)}$	0.44	℃/W
Diode thermal resistance (junction - case)	$R_{th(j-c)}$	0.55	℃/W
Thermal resistance (junction – ambient)	$R_{th(j-a)}$	40	℃/W

6. Electrical Characteristics

Tab.4. Static Characteristic (T_{vj} = 25℃, unless otherwise specified)

Parameters	Symbol	Conditions	Min. value	Typ. value	Max. value	Unit
Collector-emitter breakdown voltage	$V_{(BR)CES}$	V_{GE}= 0V, I_C= 1mA	650	-	-	V
Collector-emitter saturation voltage	V_{CEsat}	V_{GE}= 15V, I_C= 40A T_{vj}= 25℃ T_{vj}= 175℃	 - -	 1.55 2.19	 2.1 -	V
Diode forward voltage	V_F	V_{GE}= 0V, I_F= 40A T_{vj} = 25℃ T_{vj}= 175℃	 - -	 1.45 1.21	 2.2 -	V
Gate-emitter threshold voltage	$V_{GE(th)}$	I_C= 0.4mA, V_{CE}= V_{GE}	4.2	5.12	6.2	V
Zero gate voltage collector current	I_{CES}	V_{CE}= 650V, V_{GE}= 0V T_{vj}= 25℃ T_{vj}= 175℃	 - -	 1 2000	 75 -	μA
Gate-emitter leakage current	I_{GES}	V_{CE}= 0V, V_{GE}= 20V	-	-	100	nA
Transconductance	g_{fs}	V_{CE}= 20V, I_C= 40A	-	33	-	S
Internal Gate Resistance	$R_{G\ (int)}$	f = 1MHz, Vac=10mV	-	8.2	-	Ω

Tab.5. Dynamic Characteristic (T_{vj} = 25℃, unless otherwise specified)

Parameters	Symbol	Conditions	Min. value	Typ. value	Max. value	Unit
Input capacitance	C_{ies}	V_{CE}= 25V, V_{GE}= 0V f = 1MHz	-	1277	-	pF
Output capacitance	C_{oes}		-	175	-	
Reverse transfer capacitance	C_{res}		-	26	-	
Gate-charge	Q_g	V_{CE}= 520V, I_C= 40A, V_{GE}= 15V	-	59	-	nC

Tab.6. Switching Characteristic (Inductive load)

Parameters	Symbol	Conditions	Min. value	Typ. value	Max. value	Unit
IGBT Characteristic， at T_{vj} = 25°C						
Turn-on delay time	$t_{d(on)}$	T_{vj} = 25°C, V_{CC} = 400V, I_C = 40.0A, V_{GE} = 0.0/15.0V, $R_{G(on)}$ =$R_{G(off)}$=15Ω Inductive load Energy losses include “tail” and diode reverse recovery.	-	14	-	ns
Rise time	t_r		-	22	-	
Turn-off delay time	$t_{d(off)}$		-	96	-	
Fall time	t_f		-	28	-	
Turn-on energy	E_{on}		-	1.12	-	mJ
Turn-off energy	E_{off}		-	0.31	-	
Total switching energy	E_{ts}		-	1.43	-	
Turn-on delay time	$t_{d(on)}$	T_{vj} = 25°C, V_{CC} = 400V, I_C = 20.0A, V_{GE} = 0.0/15.0V, $R_{G(on)}$ =$R_{G(off)}$=15Ω Inductive load Energy losses include “tail” and diode reverse recovery.	-	12	-	ns
Rise time	t_r		-	10	-	
Turn-off delay time	$t_{d(off)}$		-	112	-	
Fall time	t_f		-	12	-	
Turn-on energy	E_{on}		-	0.46	-	mJ
Turn-off energy	E_{off}		-	0.09	-	
Total switching energy	E_{ts}		-	0.55	-	
Diode Characteristic， at T_{vj} = 25°C						
Diode reverse recovery time	t_{rr}	T_{vj} = 25°C, V_R =400V, I_F =40.0A, di_F/dt= 1000A/μs	-	59	-	ns
Diode reverse recovery charge	Q_{rr}		-	0.87	-	μC
Diode peak reverse recovery current	I_{rrm}		-	24	-	A
Diode peak rate of fall of reverse Recovery current during t_b	di_{rr}/dt		-	1290	-	A/μs

Diode reverse recovery time	t_{rr}	T_{vj} = 25°C, V_R =400V, I_F =20.0A, di_F/dt= 1000A/μs	-	52	-	ns
Diode reverse recovery charge	Q_{rr}		-	0.57	-	μC
Diode peak reverse recovery current	I_{rrm}		-	17	-	A
Diode peak rate of fall of reverse Recovery current during t_b	di_{rr}/dt		-	1800	-	A/μs

Tab.7. Switching Characteristic (Inductive load)

Parameters	**Symbol**	**Conditions**	**Min. value**	**Typ. value**	**Max. value**	**Unit**
IGBT Characteristic， at T_{vj} = 150°C						
Turn-on delay time	$t_{d(on)}$	T_{vj} = 150°C, V_{CC} = 400V, I_C = 40.0A, V_{GE} = 0.0/15.0V, $R_{G(on)}$ =$R_{G(off)}$=15Ω Inductive load Energy losses include “tail” and diode reverse recovery.	-	14	-	ns
Rise time	t_r		-	26	-	
Turn-off delay time	$t_{d(off)}$		-	115	-	
Fall time	t_f		-	31	-	
Turn-on energy	E_{on}		-	1.34	-	mJ
Turn-off energy	E_{off}		-	0.46	-	
Total switching energy	E_{ts}		-	1.8	-	
Turn-on delay time	$t_{d(on)}$	T_{vj} = 150°C, V_{CC} = 400V, I_C = 20.0A, V_{GE} = 0.0/15.0V, $R_{G(on)}$ =$R_{G(off)}$=15Ω Inductive load Energy losses include “tail” and diode reverse recovery.	-	12	-	ns
Rise time	t_r		-	14	-	
Turn-off delay time	$t_{d(off)}$		-	134	-	
Fall time	t_f		-	34	-	
Turn-on energy	E_{on}		-	0.58	-	mJ
Turn-off energy	E_{off}		-	0.23	-	
Total switching energy	E_{ts}		-	0.81	-	

Diode Characteristic， at T_{vj} = 150°C						
Diode reverse recovery time	t_{rr}	T_{vj} = 150°C, V_R =400V, I_F =40.0A, di_F/dt= 1000A/μs	-	125	-	ns
Diode reverse recovery charge	Q_{rr}		-	3.38	-	μC
Diode peak reverse recovery current	I_{rrm}		-	46	-	A
Diode peak rate of fall of reverse Recovery current during t_b	di_{rr}/dt		-	800	-	A/μs
Diode reverse recovery time	t_{rr}	T_{vj} = 150°C, V_R =400V, I_F =20.0A, di_F/dt= 1000A/μs	-	112	-	ns
Diode reverse recovery charge	Q_{rr}		-	1.85	-	μC
Diode peak reverse recovery current	I_{rrm}		-	35	-	A
Diode peak rate of fall of reverse Recovery current during t_b	di_{rr}/dt		-	1300	-	A/μs

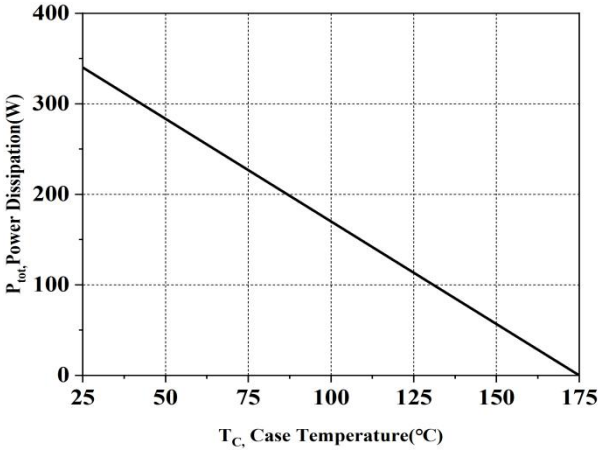


Fig.1. Power dissipation as a function of case temperature ($T_j \leq$ 175°C)

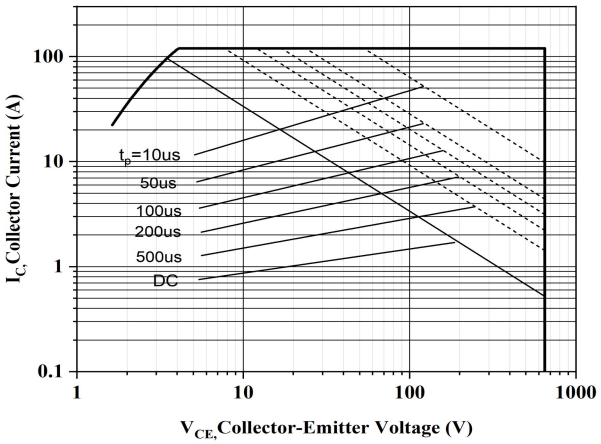


Fig.2. Forward bias safe operating area
(D = 0, T_C= 25°C, $T_j \leq$ 175°C, V_{GE}= 15V)

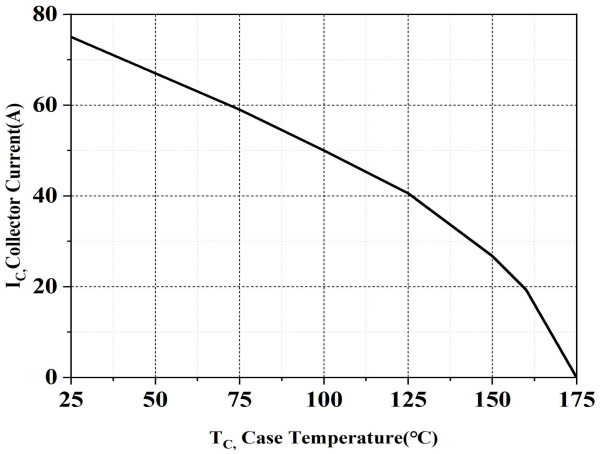


Fig.3. Collector current as a function of case temperature ($V_{GE} \geq$ 15V,$T_j \leq$ 175°C)

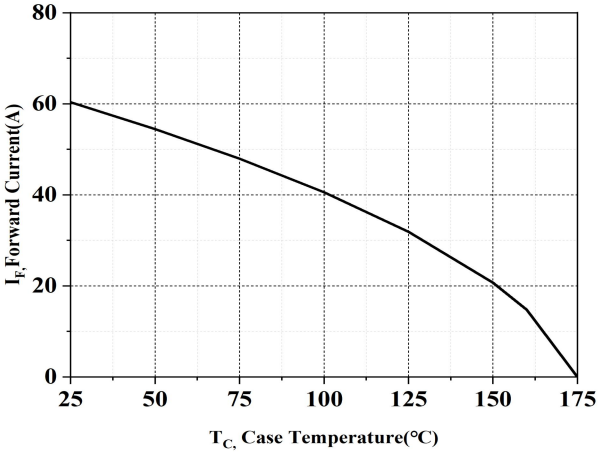


Fig.4. Diode Forward current as a function of case temperature ($T_j \leq$ 175°C)

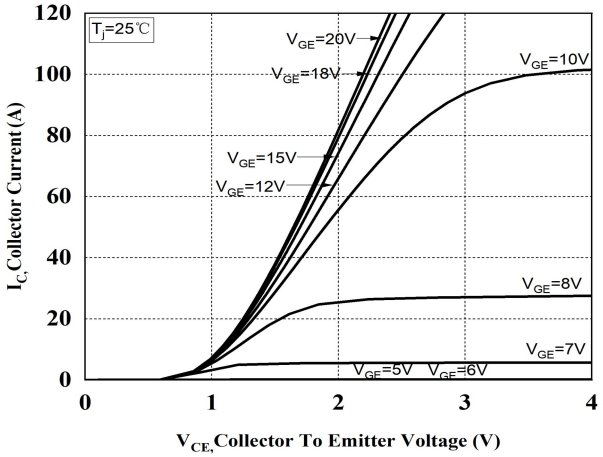


Fig.5. Typical output characteristics
(T_j= 25°C）

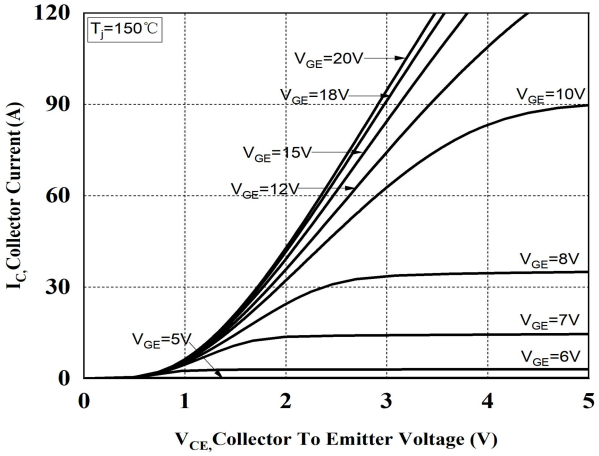


Fig.6. Typical output characteristics
(T_j= 150°C）

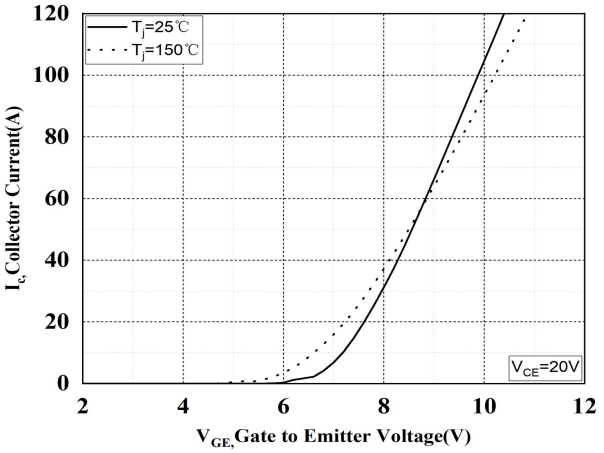


Fig.7. Typical transfer characteristic

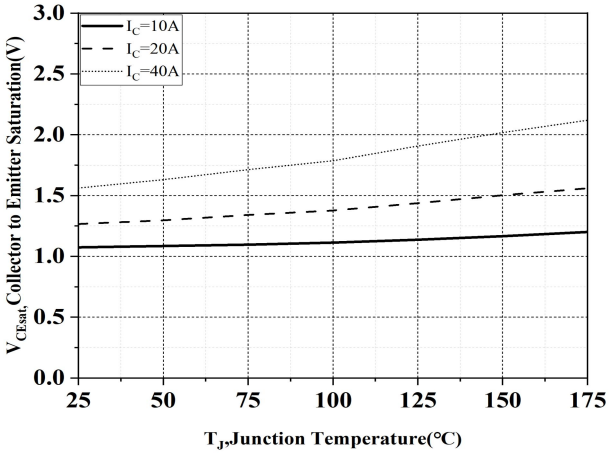


Fig.8. Typical collector-emitter saturation voltage vs. junction temperature (V_{GE}=15V)

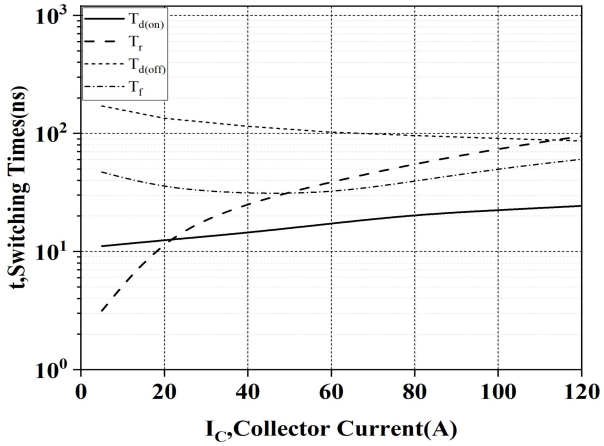


Fig.9. Typical switching times vs. collector current

(T_j= 150°C, V_{CE}= 400V, V_{GE}= 15/0V)

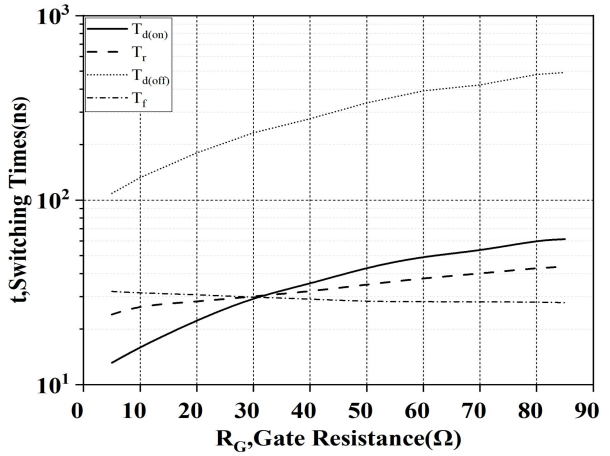


Fig.10. Typical switching times vs. gate Resistor

(Tj= 150°C, VCE=400V, VGE= 15/0V, IC = 40A)

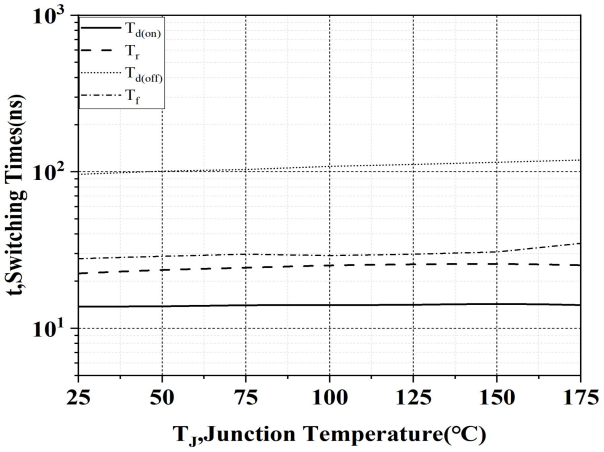


Fig.11. Typical switching times vs. junction temperature

(V_{CE}= 400V, V_{GE}= 15/0V, I_C = 40A）

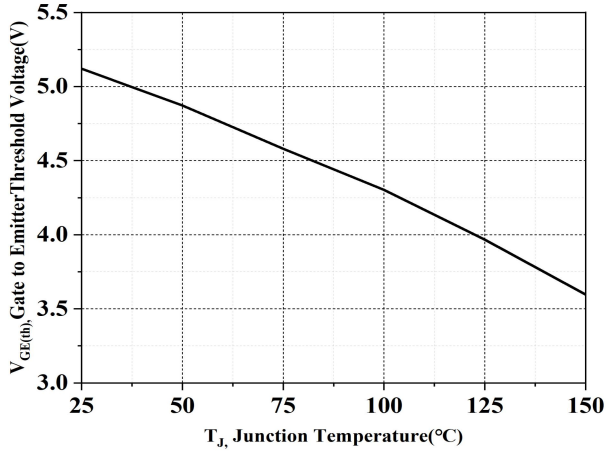


Fig.12. Gate-emitter threshold voltage vs. junction temperature

(I_C=0.4mA)

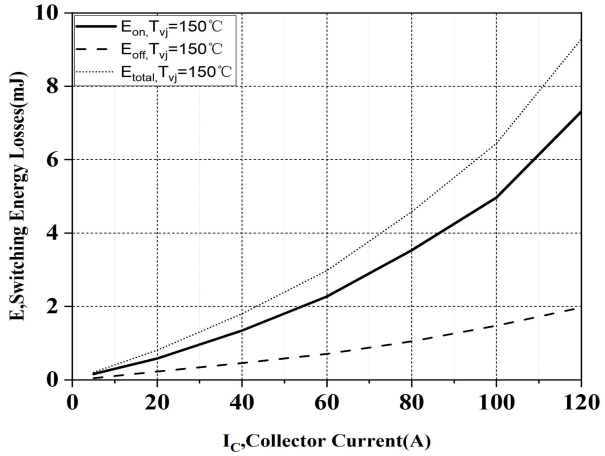


Fig.13. Typical switching energy losses as a function of collector current

(T_j= 150°C, V_{CE}= 400V, V_{GE}= 15/0V）

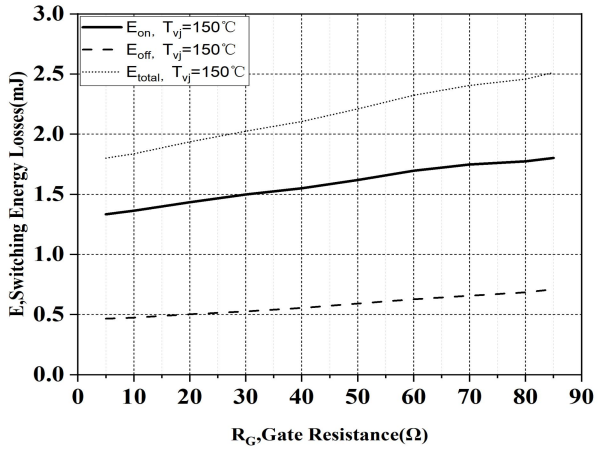


Fig.14. Typical switching energy losses as a function of gate resistor

(T_j= 150°C, V_{CE}= 400V, V_{GE}= 15/0V, I_C = 40A）

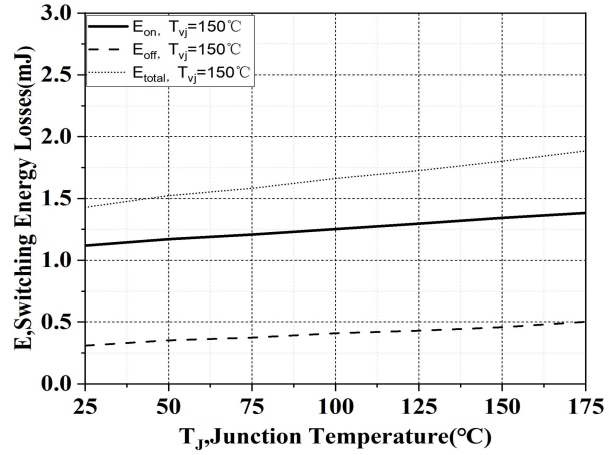


Fig.15. Typical switching energy losses as a function of junction temperature

(Inductive load, V_{CE}= 400V, V_{GE}= 15/0V, I_C = 40A）

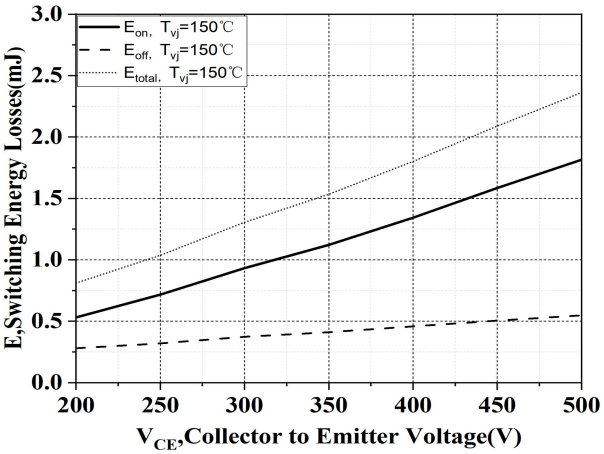


Fig.16. Typical switching energy losses as a function of collector emitter voltage

(Inductive load, T_j= 150°C, V_{GE}= 15/0V, I_C = 40A）

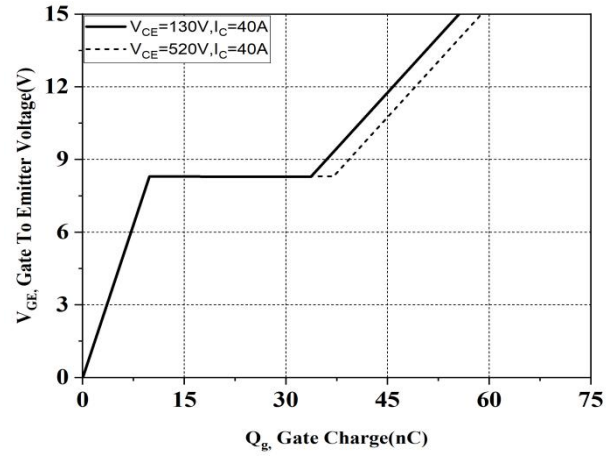


Fig.17. Typical gate charge

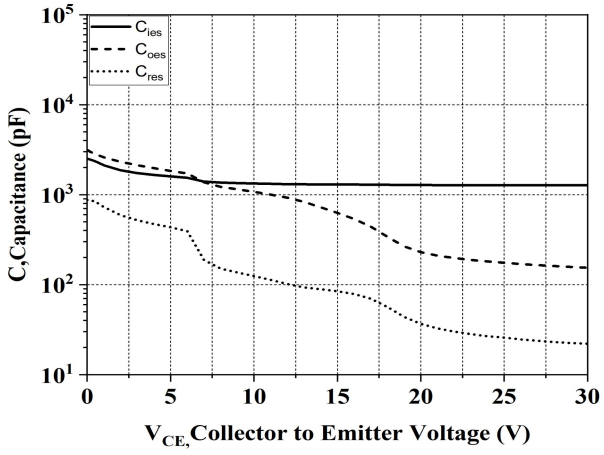


Fig.18. Typical capacitance as a function of collector-emitter voltage

(V_{GE} = 0V,f = 1MHz)

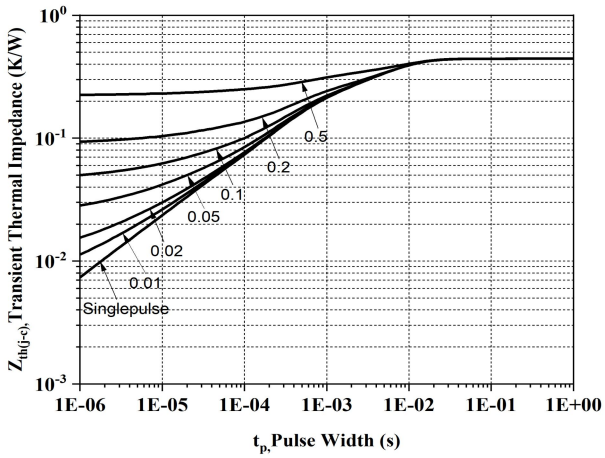


Fig.19. IGBT transient thermal impedance
(D = t_p/T)

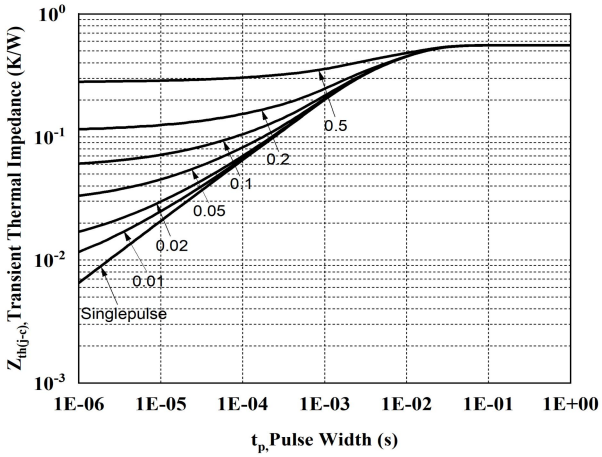


Fig.20. Transient thermal impedance of diode
(D = t_p/T)

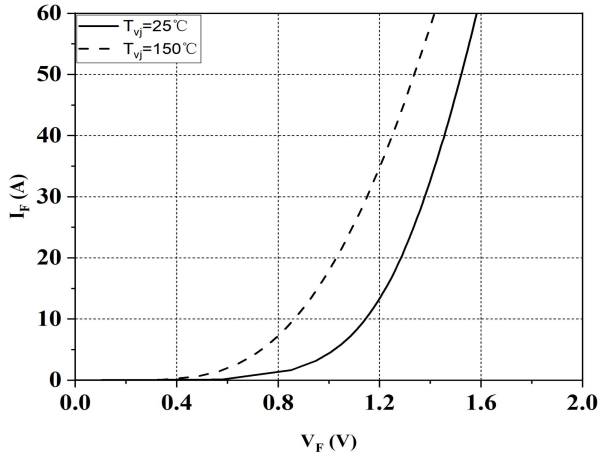


Fig.21. Typical diode forward current as a function of forward voltage

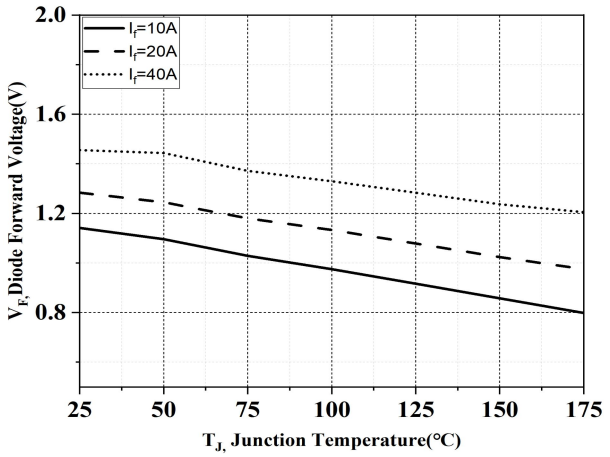


Fig.22. Typical diode forward voltage as a function of junction temperature

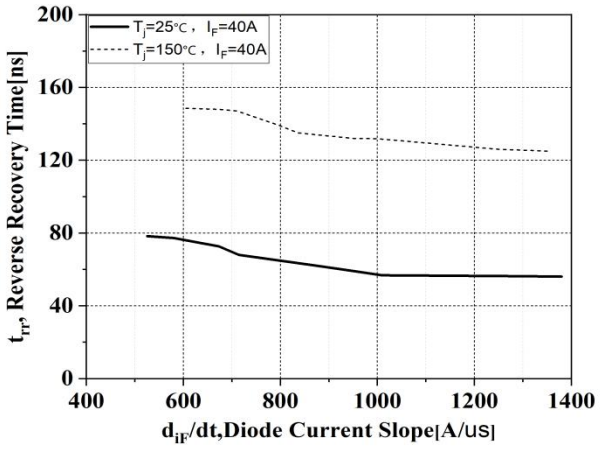


Fig.23.Typical reverse recovery time as a function of diode current slope
(VR=400V)

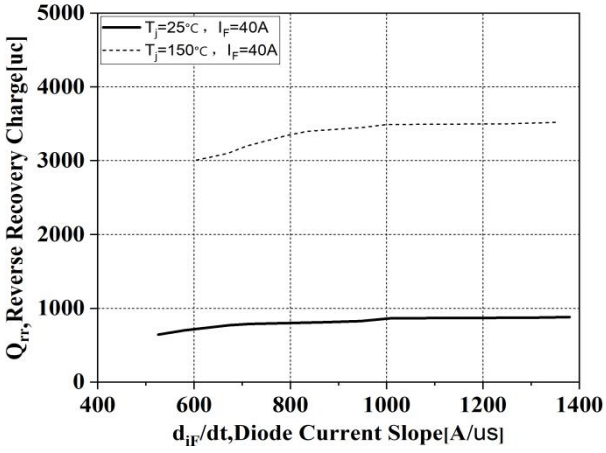


Fig.24. Typical reverse recovery charge as a function of diode current slope
(VR=400V)

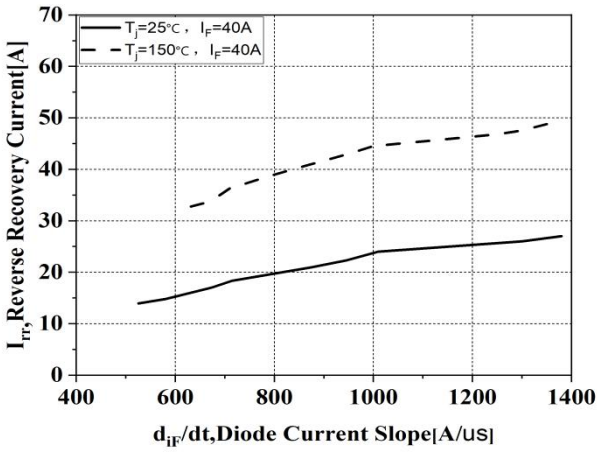


Fig.25.Typical reverse recovery current as a function of diode current slope
(VR=400V)

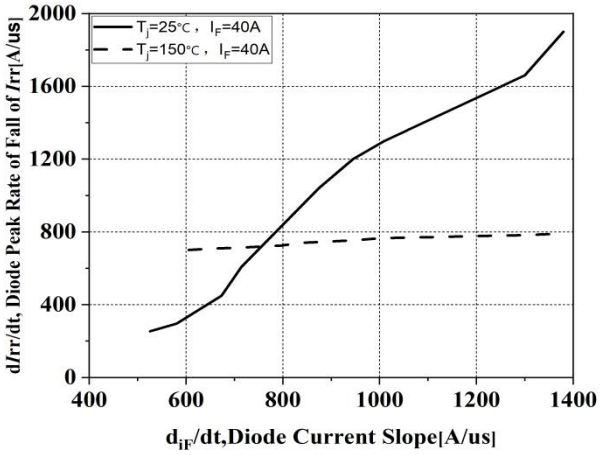
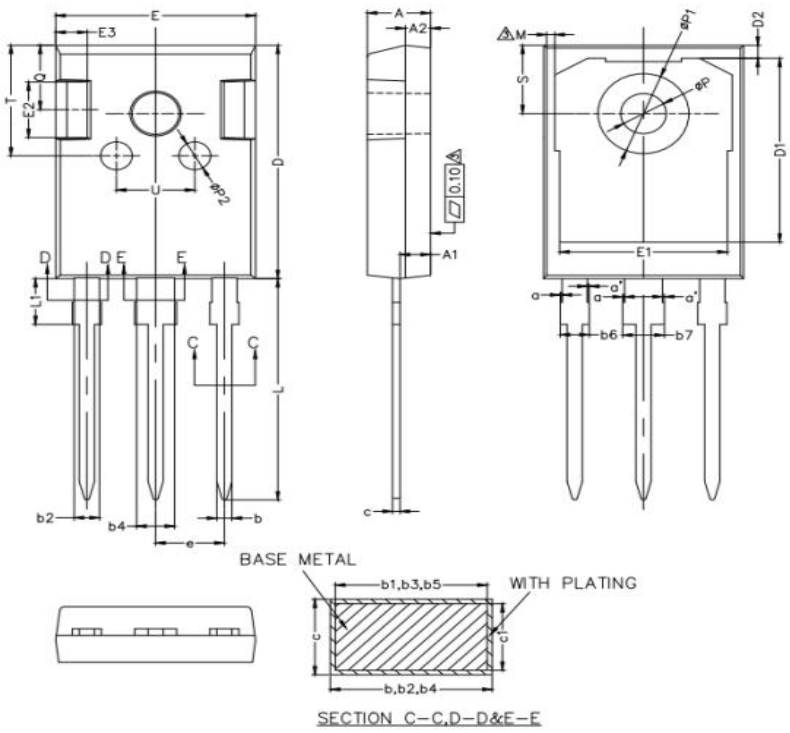


Fig.26.Typical diode peak rate of fall of reverse recovery current as a function of diode current slope
(VR=400V)

7. Package Dimensions



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	4.90	5.00	5.10
A1	2.31	2.41	2.51
A2	1.90	2.00	2.10
⚠ a	0	–	0.15
⚠ a'	0	–	0.15
b	1.16	–	1.26
b1	1.15	1.2	1.22
b2	1.96	–	2.06
b3	1.95	2.00	2.02
b4	2.96	–	3.06
b5	2.95	3.00	3.02
⚠ b6	–	–	2.25
⚠ b7	–	–	3.25
c	0.59	–	0.66
c1	0.58	0.60	0.62
D	20.90	21.00	21.10
D1	16.25	16.55	16.85
D2	1.05	1.20	1.35
E	15.70	15.80	15.90
E1	13.10	13.30	13.50
E2	4.90	5.00	5.10
E3	2.40	2.50	2.60
⚠ e	5.34	5.44	5.54
L	19.80	19.92	20.10
⚠ L1	3.95	4.13	4.30
⚠ M	0.35	–	0.95
P	3.50	3.60	3.70
⚠ P1	7.00	–	7.40
P2	2.40	2.50	2.60
Q	5.60	–	6.00
⚠ S	6.05	6.15	6.25
T	9.80	–	10.20
U	6.00	–	6.40

NOTES:
1. ALL DIMENSIONS REFER TO JEDEC STANDARD TO-247 AD DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
2. EJECTION MARK DEPTH $0.10^{+0.15}_{-0.05}$.

8. Version Information

Version No.	Status	Date changed	Version revision record
V1.0	Preliminary version	2024/03	