

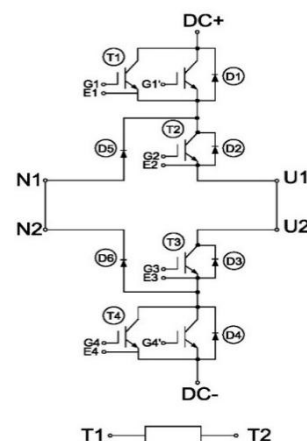
GT400TL65P4H-SE

IGBT Module

Circuit Diagram

Features:

- $V_{CES}=650V$ $I_C=400A$ Trench & Field Stop IGBT Module
- Short Circuit Capability
- Low Switching Loss
- 100% RBSOA Tested($2 \times I_C$)
- Low Stray Inductance
- Lead Free, Compliant with RoHS Requirement



Applications:

- 3-Level-Application
- Energy Storage Application



Type	Package	Marking
GT400TL65P4H-SE	P4	GT400TL65P4H-SE

IGBT, Buck Switch(T1/T4)

Maximum Rated Values ($T_C=25^\circ C$ unless otherwise specified)

Symbol	Description		Value	Units
V _{CES}	Collector-Emitter Blocking Voltage		650	V
V _{GES}	Gate-Emitter Voltage		±20	V
I _C	Continuous Collector Current, limited by T _{Jmax}	T _C =80°C	400	A
		T _C =25°C	800	A
I _{CM}	Peak Collector Current Repetitive	t _p limited by T _{Jmax}	800	A
P _D	Maximum Power Dissipation (IGBT)	T _C =25°C, T _{Jmax} =150°C	2100	W



Electrical Characteristics of IGBT ($T_C=25^\circ\text{C}$ unless otherwise specified)

Static Characteristics

Symbol	Description	Conditions	Min.	Typ.	Max.	Units
$V_{GE(th)}$	Gate-Emitter Threshold Voltage	$I_C=8\text{mA}$, $V_{CE}=V_{GE}$	5.0	6.0	6.5	V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$I_C=400\text{A}$, $V_{GE}=15\text{V}$	$T_J=25^\circ\text{C}$	2.10	2.52	V
			$T_J=125^\circ\text{C}$	2.61		V
			$T_J=150^\circ\text{C}$	2.72		V
I_{CES}	Collector-Emitter Leakage Current	$V_{GE}=0\text{V}$, $V_{CE}=650\text{V}$, $T_J=25^\circ\text{C}$			1	mA
I_{GES}	Gate-Emitter Leakage Current	$V_{GE}=20\text{V}$, $V_{CE}=0\text{V}$, $T_J=25^\circ\text{C}$			400	nA
C_{ies}	Input Capacitance	$V_{CE}=25\text{V}$, $V_{GE}=0\text{V}$, $f=100\text{kHz}$		33		nF
C_{oes}	Output Capacitance			1.71		nF
C_{res}	Reverse Transfer Capacitance			0.45		nF

Switching Characteristics

t _{d(on)}	Turn-on Delay Time	V _{CC} =400V, I _C =300A, R _{Gon} =3.3Ω, R _{Goff} =13.3Ω V _{GE} =±15V, Inductive Load	T _J =25°C		86		ns
			T _J =125°C		80		
			T _J =150°C		85		
t _r	Rise Time		T _J =25°C		43		ns
			T _J =125°C		48		
			T _J =150°C		50		
t _{d(off)}	Turn-off Delay Time	V _{CC} =400V, I _C =300A, R _{Gon} =3.3Ω, R _{Goff} =13.3Ω V _{GE} =±15V, Inductive Load	T _J =25°C		363		ns
			T _J =125°C		384		
			T _J =150°C		378		
t _f	Fall Time		T _J =25°C		38		ns
			T _J =125°C		51		
			T _J =150°C		55		
E _{on}	Turn-on Switching Loss	V _{CC} =400V, I _C =300A, R _{Gon} =3.3Ω, R _{Goff} =13.3Ω V _{GE} =±15V, di/dt=4800A/μs(T _J =150°C) Inductive Load	T _J =25°C		6.7		mJ
			T _J =125°C		9.5		
			T _J =150°C		10.2		

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E _{off}	Turn-off Switching Loss	V _{CC} =400V, I _C =300A, R _{Goff} =3.3Ω, R _{Goff} =13.3Ω V _{GE} =±15V, du/dt=4800V/μs(T _J =150°C) Inductive Load	T _J =25°C		9.0		mJ
			T _J =125°C		11.8		
			T _J =150°C		12.3		
Q _g	Total Gate Charge	V _{GE} =+15V...-15V	T _J =25°C		1.57		μC
R _{G (int)}	Internal Gate Resistance		T _J =25°C		1		Ω
T _{SC}	V _{CC} =400V, V _{GE} =±15V, T _J =150°C ^{note1}					10	μs
R _{θJC}	IGBT Thermal Resistance: Junction-to-Case (per IGBT)					0.059	°C/W
R _{θCS}	IGBT Thermal Resistance: Case-to-Sink (per IGBT) (per IGBT, λ _{grease} = 1 W/(m · K))				0.089		°C/W

note1: Short circuit withstand time cannot exceed 10μs under specified condition

Buck Diode(D5/D6)

Maximum Rated Values of Diode (T_C=25°C unless otherwise specified)

V _{RRM}	Repetitive Peak Reverse Voltage	T _J =25°C	650	V
I _F	Diode Continuous Forward Current		300	A
I _{FM}	Diode Maximum Forward Current	t _p =1ms	600	A

Electrical Characteristics of Diode (T_C=25°C unless otherwise specified)

Symbol	Description	Conditions		Min.	Typ.	Max.	Units
V _{FM}	Forward Voltage	I _F =300A	T _J =25°C		1.63	1.95	V
			T _J =125°C		1.74		
			T _J =150°C		1.71		
t _{rr}	Reverse Recovery Time	I _F =300A, -diF/dt=6080A/μs(T _J =150°C), V _R =400V, V _{GE} =-15V	T _J =25°C		78		ns
			T _J =125°C		132		
			T _J =150°C		150		
I _{rr}	Peak Reverse Recovery Current		T _J =25°C		228		A
			T _J =125°C		248		
			T _J =150°C		252		
Q _{rr}	Reverse Recovery Charge		T _J =25°C		10.5		μC
			T _J =125°C		17.2		
			T _J =150°C		19.1		

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E _{rec}	Reverse Recovery Energy	I _F =300A, -diF/dt=6080A/μs(T _J =150°C), V _R =400V, V _{GE} =-15V	T _J =25°C		2.43		mJ
			T _J =125°C		4.18		
			T _J =150°C		4.72		
R _{θJC}	Diode Thermal Resistance: Junction-to-Case (per Diode)					0.157	°C/W
R _{θCS}	Diode Thermal Resistance: Case-to-Sink (per Diode, λ _{grease} = 1 W/(m • K))				0.238		°C/W

IGBT, Boost Switch(T2/T3)

Maximum Rated Values (T_C=25°C unless otherwise specified)

Symbol	Description		Value	Units
V _{CES}	Collector-Emitter Blocking Voltage		650	V
V _{GES}	Gate-Emitter Voltage		±20	V
I _C	Continuous Collector Current, Limited by T _{Jmax}	T _C =80°C	300	A
		T _C =25°C	600	A
I _{CM}	Peak Collector Current Repetitive	T _p limited by T _{Jmax}	600	A
P _D	Maximum Power Dissipation (IGBT)	T _C =25°C, T _{Jmax} =150°C	1580	W

Electrical Characteristics of IGBT (T_C=25°C unless otherwise specified)

Static Characteristics

Symbol	Description	Conditions	Min.	Typ.	Max.	Units
V _{GE(th)}	Gate-Emitter Threshold Voltage	I _C =8mA, V _{CE} =V _{GE}	5.0	5.7	6.5	V
V _{CE(sat)}	Collector-Emitter Saturation Voltage	I _C =300A, V _{GE} =15V	T _J =25°C	2.10	2.52	V
			T _J =125°C	2.61		V
			T _J =150°C	2.70		V
I _{CES}	Collector-Emitter Leakage Current	V _{GE} =0V, V _{CE} =650V, T _J =25°C			1	mA
I _{GES}	Gate-Emitter Leakage Current	V _{GE} =20V, V _{CE} =0V, T _J =25°C			400	nA
C _{ies}	Input Capacitance	V _{CE} =25V, V _{GE} =0V, f=100kHz		25		nF
C _{oes}	Output Capacitance			1.64		nF
C _{res}	Reverse Transfer Capacitance			0.33		nF

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Switching Characteristics

t _{d(on)}	Turn-on Delay Time	V _{CC} =400V, I _C =300A, R _{Gon} =3.3Ω, R _{Goff} =18.3Ω V _{GE} =±15V, Inductive Load	T _J =25°C		73		ns
			T _J =125°C		75		
			T _J =150°C		84		
t _r	Rise Time		T _J =25°C		45		ns
			T _J =125°C		50		
			T _J =150°C		54		
t _{d(off)}	Turn-off Delay Time		T _J =25°C		365		ns
			T _J =125°C		376		
			T _J =150°C		401		
t _f	Fall Time	T _J =25°C		43		ns	
		T _J =125°C		53			
		T _J =150°C		59			
E _{on}	Turn-on Switching Loss	V _{CC} =400V, I _C =300A, R _{Gon} =3.3Ω, R _{Goff} =18.3Ω V _{GE} =±15V, di/dt=4444A/μs(T _J =150°C) Inductive Load	T _J =25°C		8.0		mJ
		T _J =125°C		11.4			
		T _J =150°C		12.4			
E _{off}	Turn-off Switching Loss	V _{CC} =400V, I _C =300A, R _{Goff} =3.3Ω, R _{Goff} =18.3Ω V _{GE} =±15V, du/dt=4270V/μs(T _J =150°C) Inductive Load	T _J =25°C		9.8		mJ
		T _J =125°C		13.0			
		T _J =150°C		13.6			
Q _g	Total Gate Charge	V _{GE} =+15V...-15V	T _J =25°C		1.17		uC
R _{G (int)}	Internal Gate Resistance		T _J =25°C		1.3		Ω
T _{SC}	V _{CC} =400V, V _{GE} =±15V, T _J =150°C ^{note2}					10	us
R _{θJC}	IGBT Thermal Resistance: Junction-to-Case (per IGBT)					0.079	°C/W
R _{θCS}	IGBT Thermal Resistance: Case-to-Sink (per IGBT) (per IGBT, λ _{grease} = 1 W/(m • K))				0.120		°C/W

note2: Short circuit withstand time cannot exceed 10 μs under specified condition

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Boost Diode(D1/D4)

Maximum Rated Values of Diode ($T_C=25^{\circ}\text{C}$ unless otherwise specified)

V_{RRM}	Repetitive Peak Reverse Voltage	$T_J=25^{\circ}\text{C}$	650	V
I_F	Diode Continuous Forward Current		300	A
I_{FM}	Diode Maximum Forward Current	$t_p=1\text{ms}$	600	A

Electrical Characteristics of Diode ($T_C=25^{\circ}\text{C}$ unless otherwise specified)

Symbol	Description	Conditions		Min.	Typ.	Max.	Units
V _{FM}	Forward Voltage	I _F =300A	T _J =25°C		1.63	1.95	V
			T _J =125°C		1.74		
			T _J =150°C		1.71		
t _{rr}	Reverse Recovery Time	I _F =300A, -diF/dt=5000A/μs(T _J =150°C), V _R =400V, V _{GE} =-15V	T _J =25°C		93		ns
			T _J =125°C		165		
			T _J =150°C		185		
I _{rr}	Peak Reverse Recovery Current		T _J =25°C		180		A
			T _J =125°C		188		
			T _J =150°C		196		
Q _{rr}	Reverse Recovery Charge		T _J =25°C		9.6		μC
			T _J =125°C		16.5		
			T _J =150°C		19.8		
E _{rec}	Reverse Recovery Energy	I _F =300A, -diF/dt=4270A/μs(T _J =150°C), V _R =400V, V _{GE} =-15V	T _J =25°C		2.10		mJ
		T _J =125°C		3.93			
		T _J =150°C		4.70			
R _{θJC}	Diode Thermal Resistance: Junction-to-Case (per Diode)					0.157	°C/W
R _{θCS}	Diode Thermal Resistance: Case-to-Sink (per Diode, λ _{grease} = 1 W/(m • K))				0.238		°C/W

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Boost Switch Inverter Diode(D2/D3)

Maximum Rated Values of Diode ($T_C=25^{\circ}\text{C}$ unless otherwise specified)

V_{RRM}	Repetitive Peak Reverse Voltage	$T_J=25^{\circ}\text{C}$	650	V
I_F	Diode Continuous Forward Current		300	A
I_{FM}	Diode Maximum Forward Current	$t_p=1\text{ms}$	600	A

Electrical Characteristics of Diode ($T_C=25^{\circ}\text{C}$ unless otherwise specified)

Symbol	Description	Conditions		Min.	Typ.	Max.	Units
V _{FM}	Forward Voltage	I _F =300A	T _J =25°C		1.63	1.95	V
			T _J =125°C		1.74		
			T _J =150°C		1.71		
R _{θJC}	Diode Thermal Resistance: Junction-to-Case (per Diode)					0.157	°C/W
R _{θCS}	Diode Thermal Resistance: Case-to-Sink (per Diode, λ _{grease} = 1 W/(m • K))				0.238		°C/W

Internal NTC-Thermistor Characteristics

Symbol	Conditions	Min.	Typ.	Max.	Units
R_{25}	$T_C=25^{\circ}\text{C}$		5		$\text{k}\Omega$
$\Delta R/R$	$T_C=100^{\circ}\text{C}$, $R_{100}=465\Omega$	-5		+5	%
P_{25}	$T_C=25^{\circ}\text{C}$			10	mW
$B_{25/50}$	$R_2=R_{25} \exp[B_{25/50}(1/T_2-1/(298.15\text{K}))]$		3380		K
$B_{25/80}$	$R_2=R_{25} \exp[B_{25/80}(1/T_2-1/(298.15\text{K}))]$		3440		K
$B_{25/100}$	$R_2=R_{25} \exp[B_{25/100}(1/T_2-1/(298.15\text{K}))]$		3545		K

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Module

Symbol	Description		Min.	Typ.	Max.	Units
V _{IOS}	Isolation Voltage (All Terminals Shorted)	RMS, f=50Hz, 60s	3400			V
Internal Isolation			IMS with Copper Baseplate			
d _{creep}	Creepage Distance: Terminal to Heatsink		11.2			mm
	Creepage Distance: Terminal to Terminal		6.8			
d _{clear}	Clearance: Terminal to Heatsink		9.4			mm
	Clearance: Terminal to Terminal		5.5			
L _{SCE}	Stray Inductance Module			12		nH
T _J	Maximum Junction Temperature		-40		+150	°C
T _{JOP}	Maximum Operating Junction Temperature Range		-40		+150	°C
T _{stg}	Storage Temperature		-40		+125	°C
CTI	Comparative Tracking Index		400			
T	Mounting Screw:M5		2.5		4	N·m
G	Weight			162		g

Ordering Information Table

Device code	G	T	400	TL	65	P4	H	-	SE
	①	②	③	④	⑤	⑥	⑦		⑧

- ① - IGBT Module
- ② - Trench, Low Switching Losses IGBT
- ③ - Rated Current (400=400A)
- ④ - Circuit Configuration (Three Level, I Type)
- ⑤ - Rated Voltage (65=650V)
- ⑥ - Package Type
- ⑦ - Test Level (Pass the Important Reliability Test-Industrial Grade)
- ⑧ - Stored Energy System



Characteristic diagram

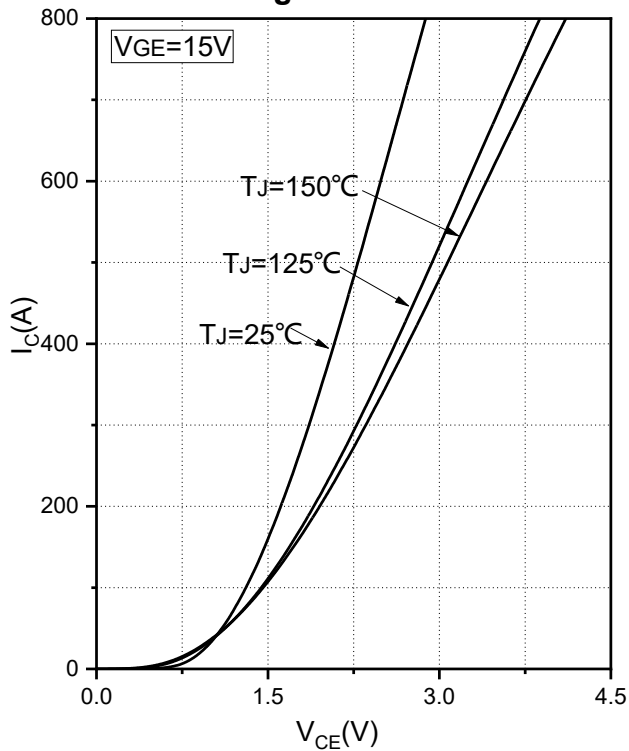


Fig.1 Typical Saturation Voltage Characteristics(T1,T4)

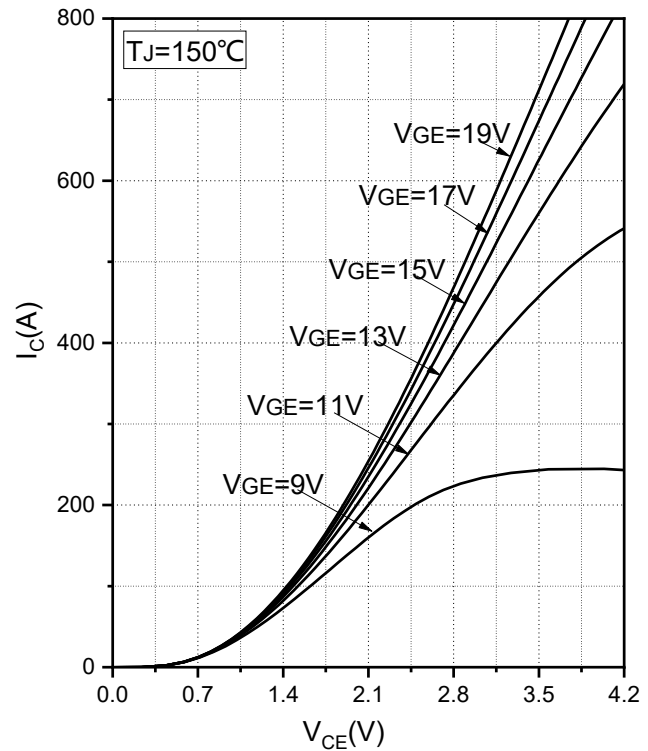


Fig.2 Typical Output Characteristics(T1,T4)

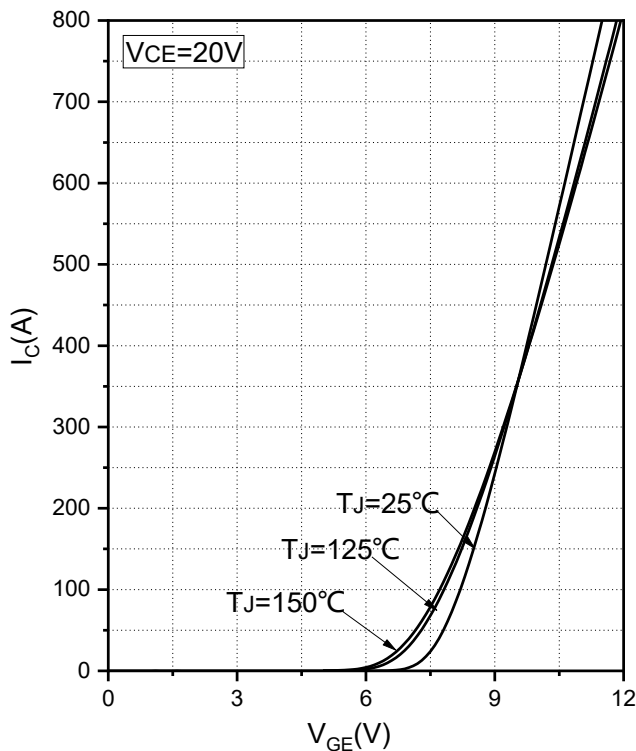


Fig.3 Transfer Characteristic(T1,T4)

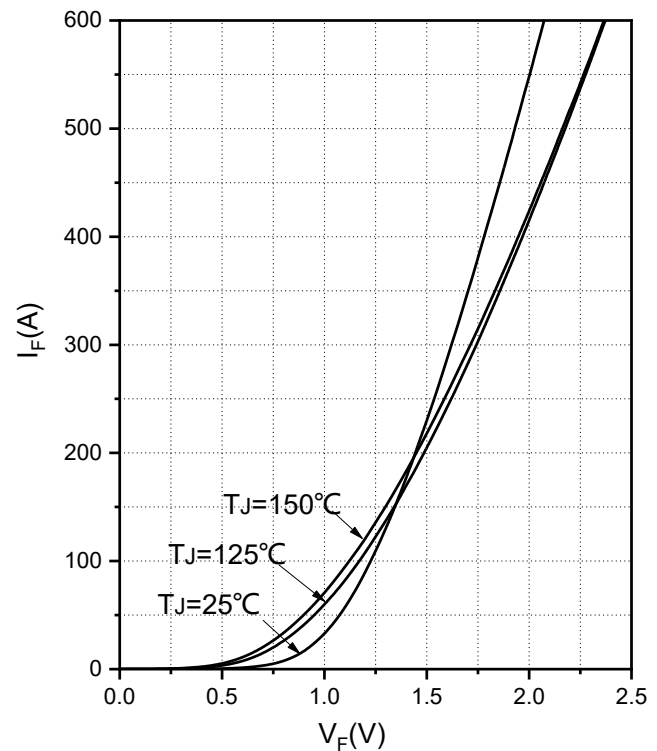


Fig.4 Forward Characteristics of Diode(D1,D4)

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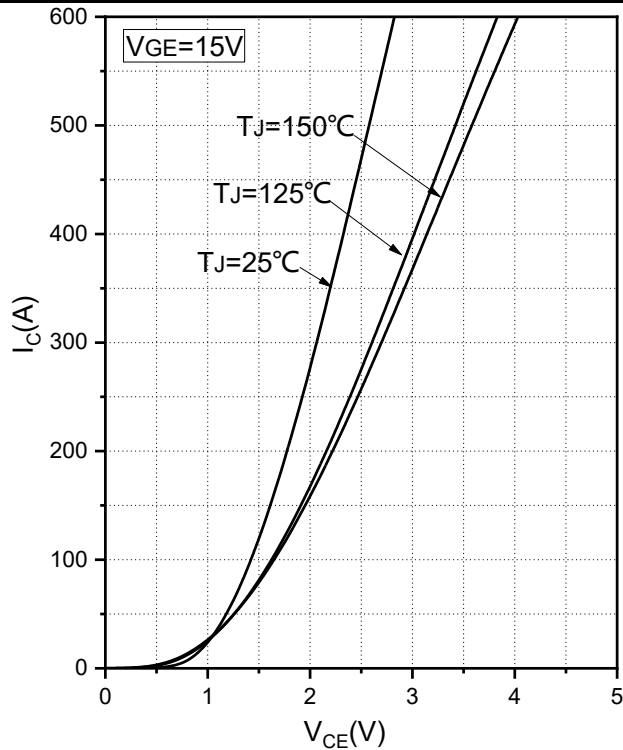


Fig.5 Typical Saturation Voltage Characteristics(T2,T3)

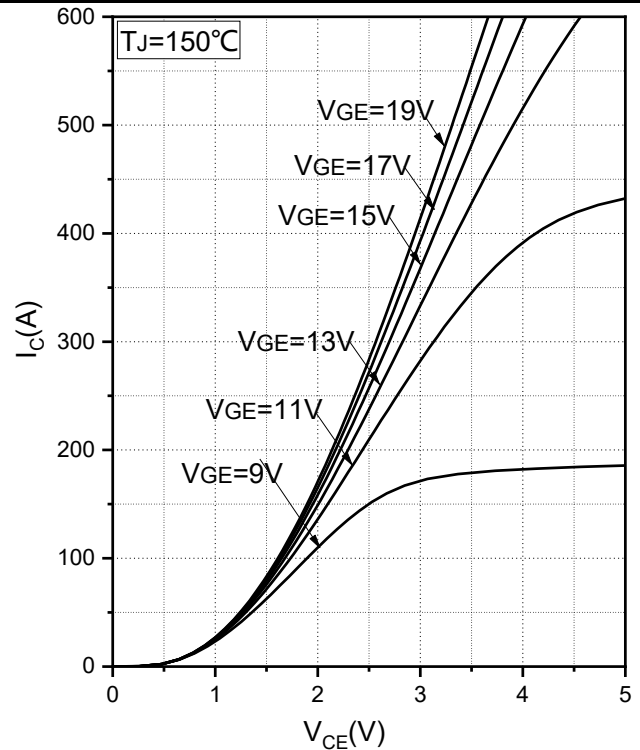


Fig.6 Typical Output Characteristics(T2,T3)

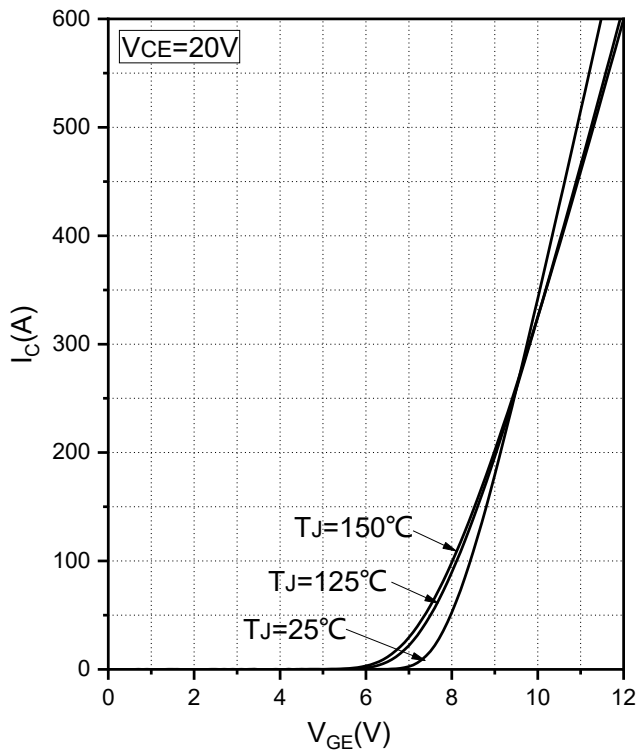


Fig.7 Transfer Characteristic(T2,T3)

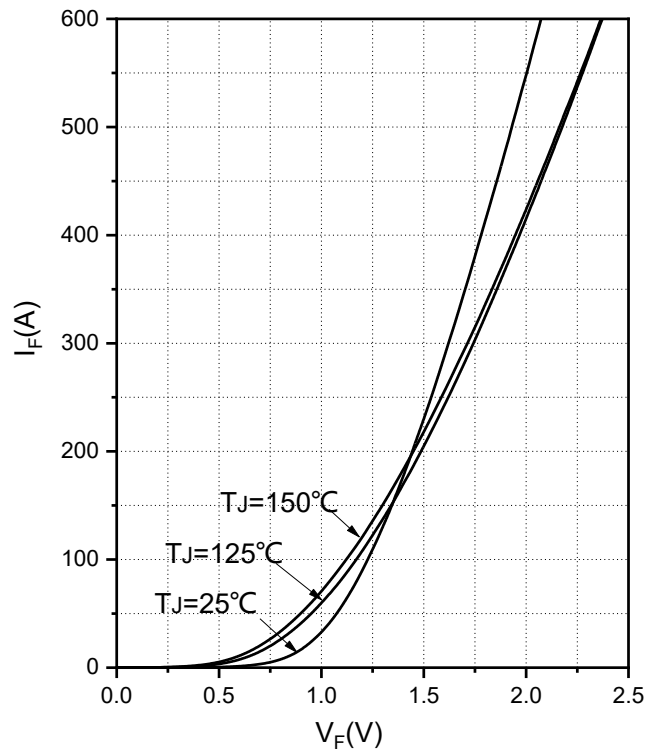


Fig.8 Forward Characteristics of Diode(D2,D3)

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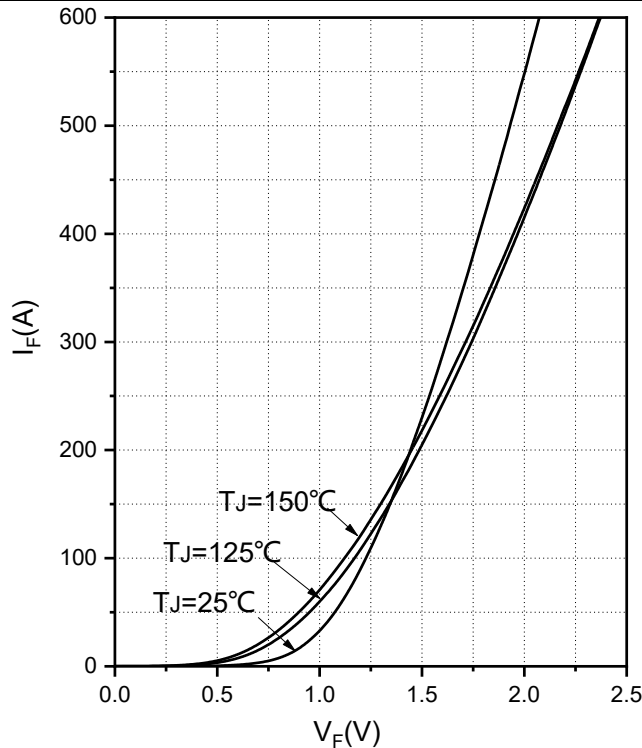


Fig.9 Forward Characteristics of Diode(D5,D6)

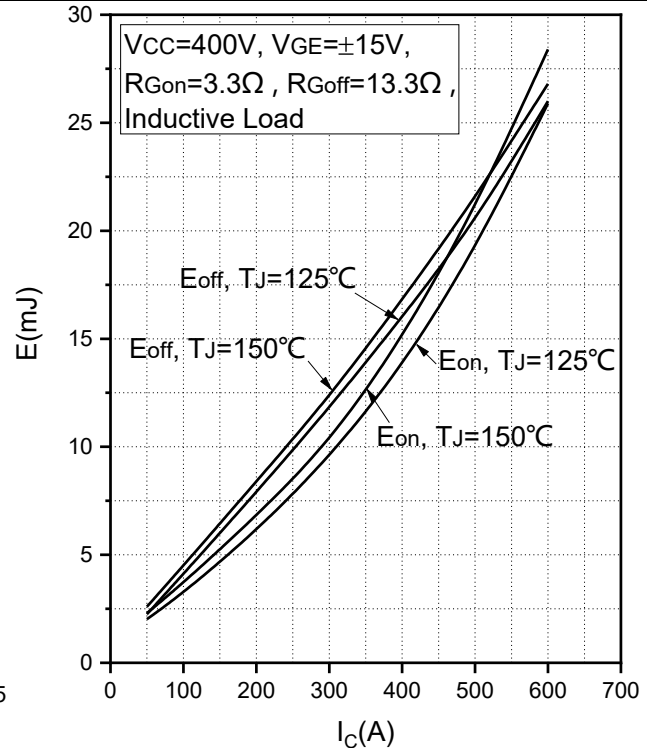


Fig.10 Typical Switching Loss vs. Collector Current(T1,T4)

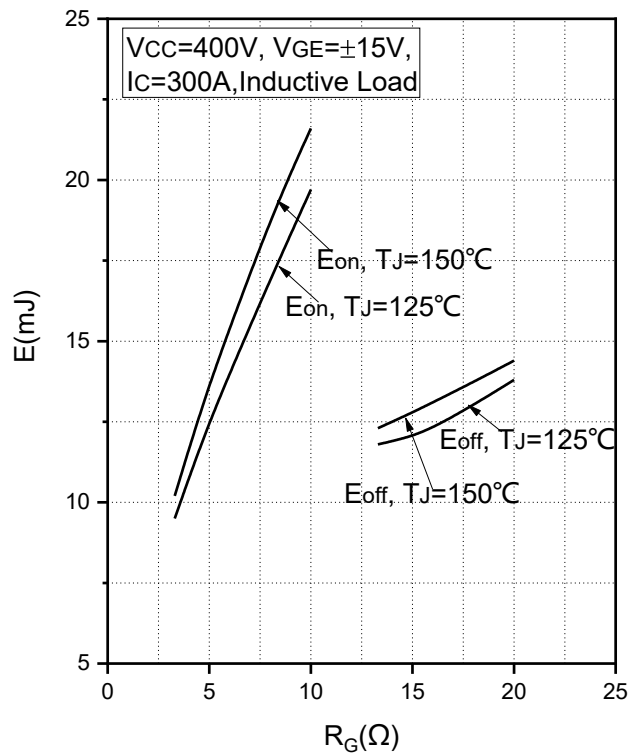


Fig.11 Typical Switching Loss vs. Gate Resistance(T1,T4)

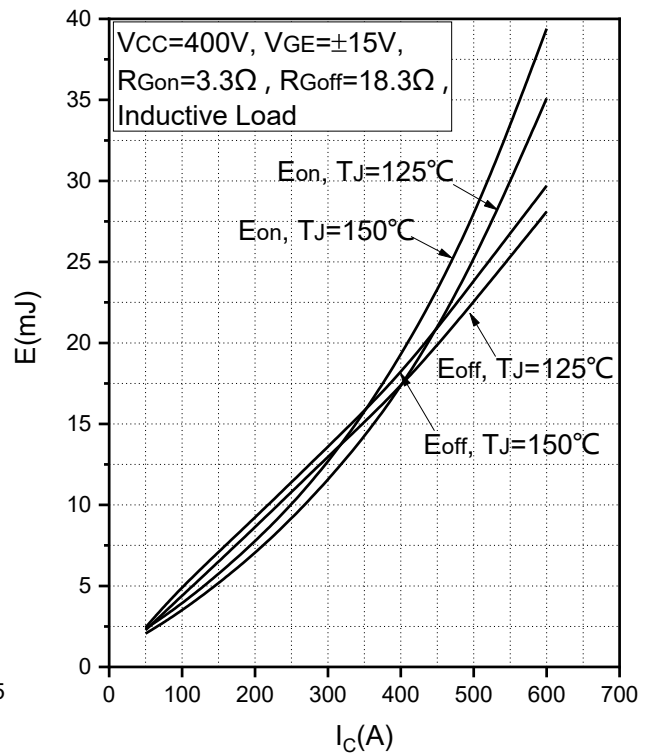


Fig.12 Typical Switching Loss vs. Collector Current(T2,T3)

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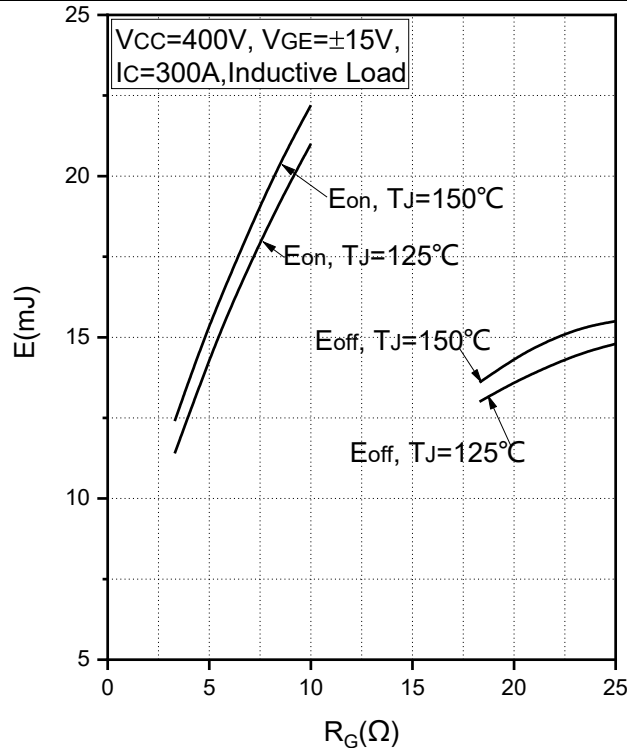


Fig.13 Typical Switching Loss vs. Gate Resistance(T2,T3)

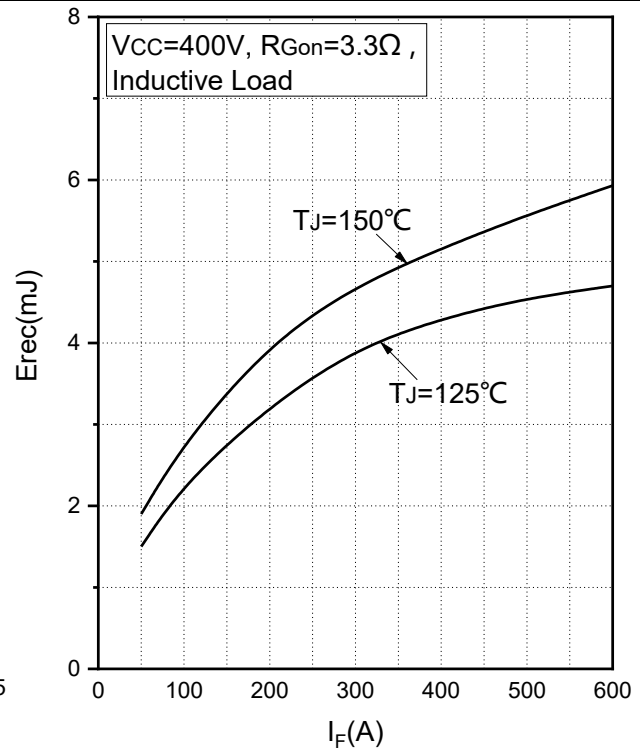


Fig.14 Typical Switching Loss vs. Forward Current(D1,D4)

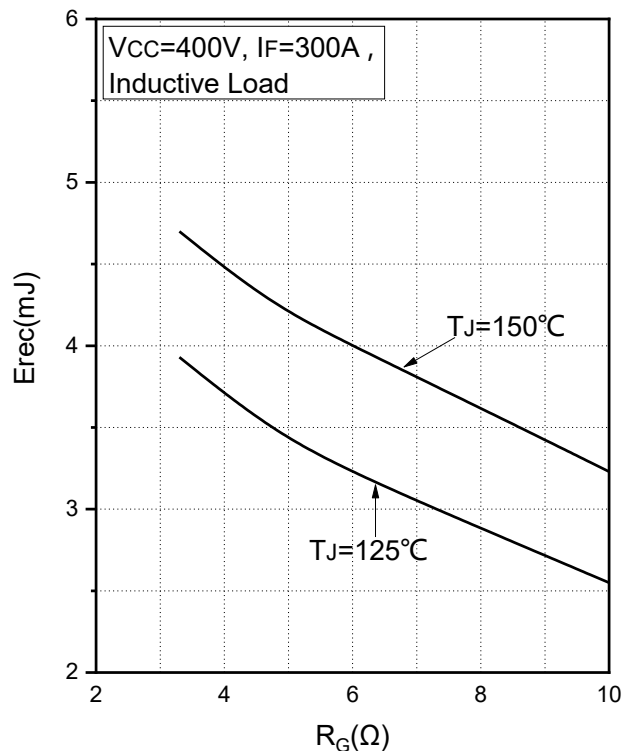


Fig.15 Typical Switching Loss vs. Gate Resistance(D1,D4)

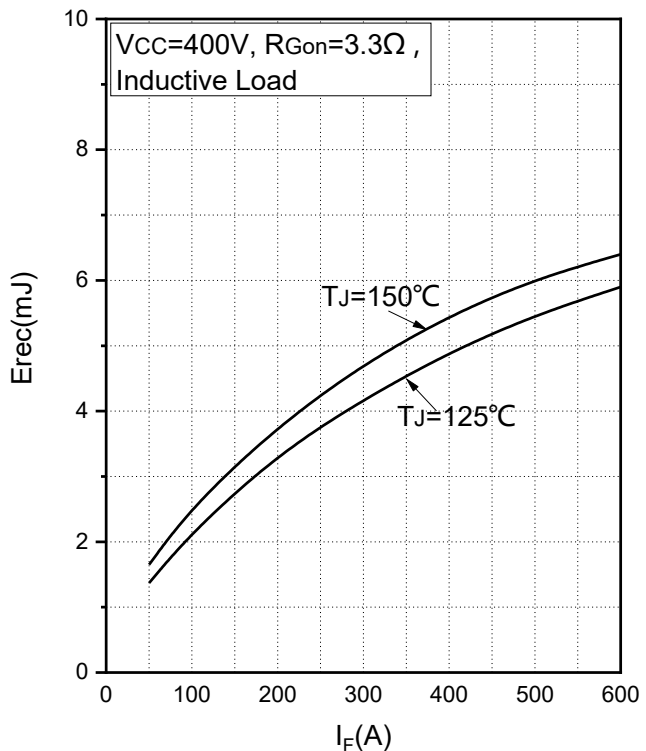


Fig.16 Typical Switching Loss vs. Forward Current(D5,D6)

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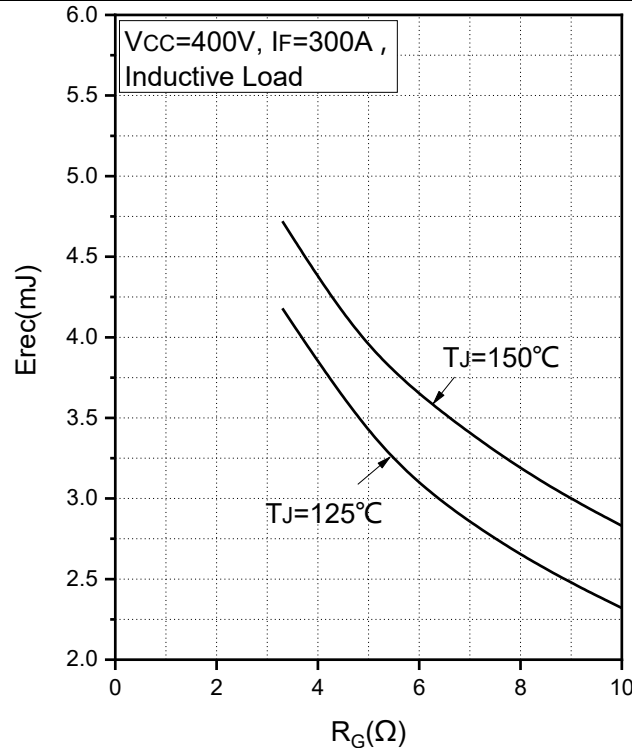


Fig.17 Typical Switching Loss vs. Gate Resistance(D5,D6)

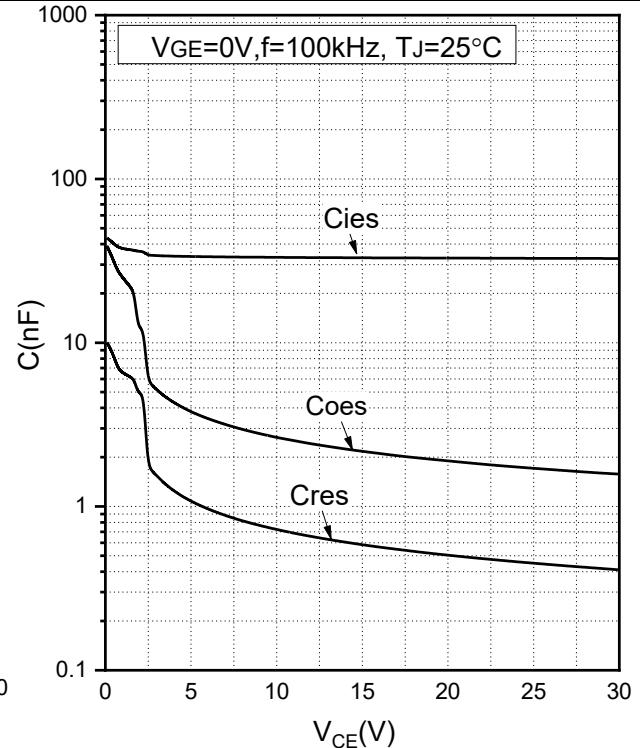


Fig.18 Capacitance Characteristics(T1,T4)

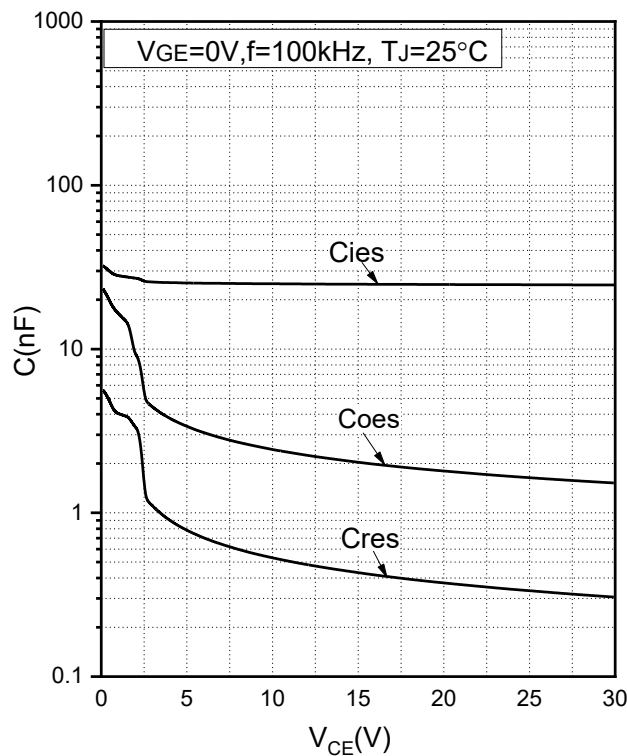


Fig.19 Capacitance Characteristics(T2,T3)

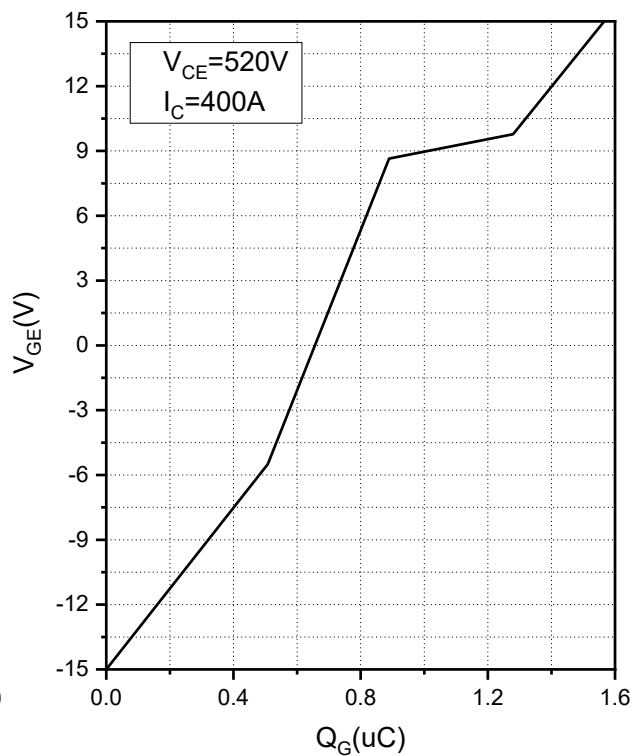


Fig.20 Gate Charge Characteristics(T1,T4)

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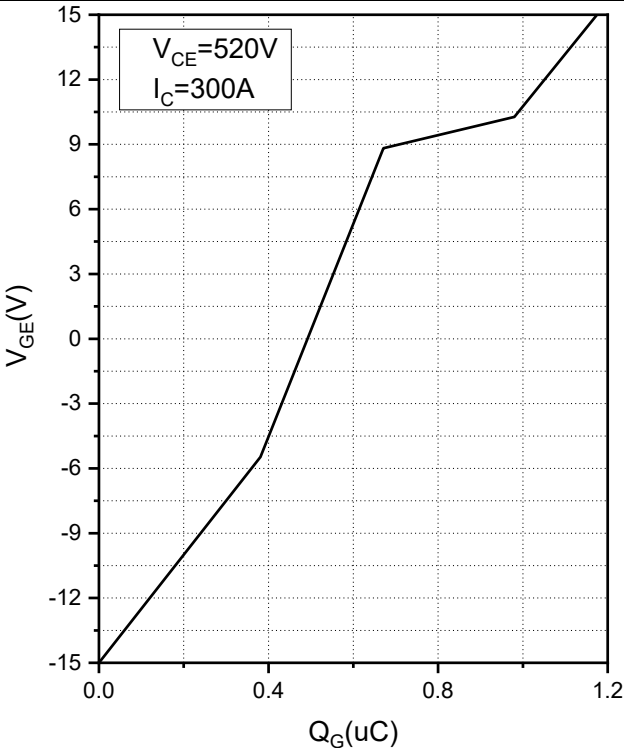


Fig.21 Gate Charge Characteristics(T2,T3)

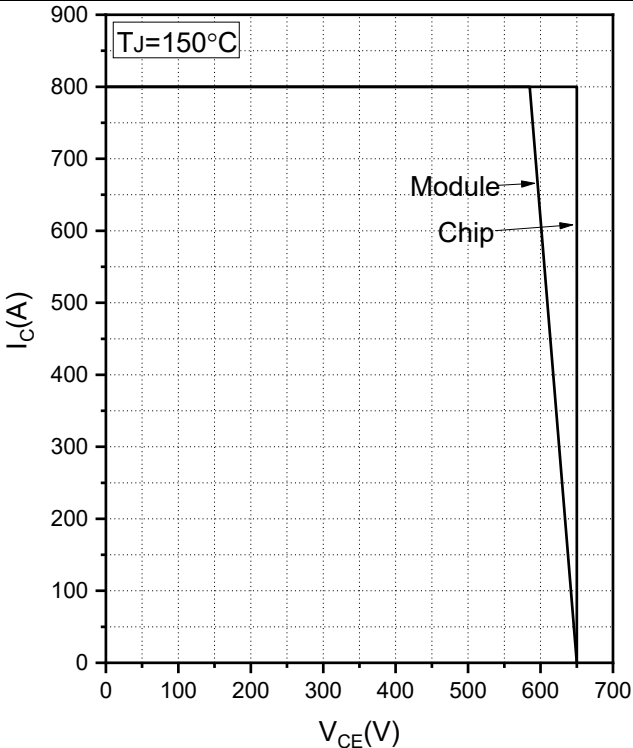


Fig.22 Reverse Bias Safe Operation Area (RBSOA)(T1,T4)

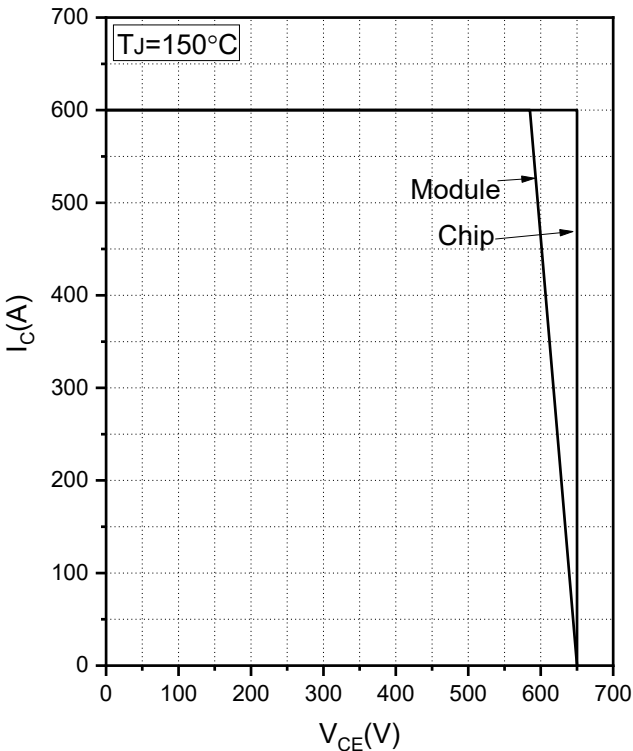


Fig.23 Reverse Bias Safe Operation Area (RBSOA)(T2,T3)

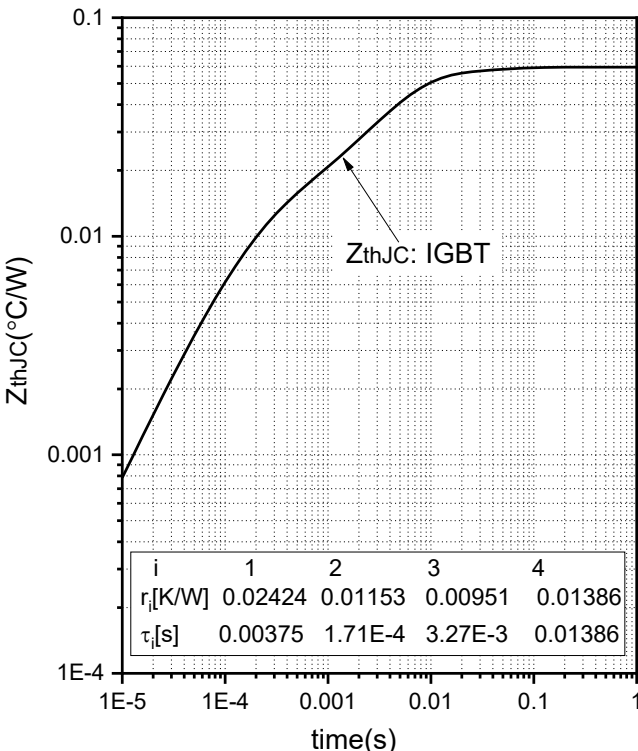


Fig.24 Transient Thermal Impedance (T1,T4)

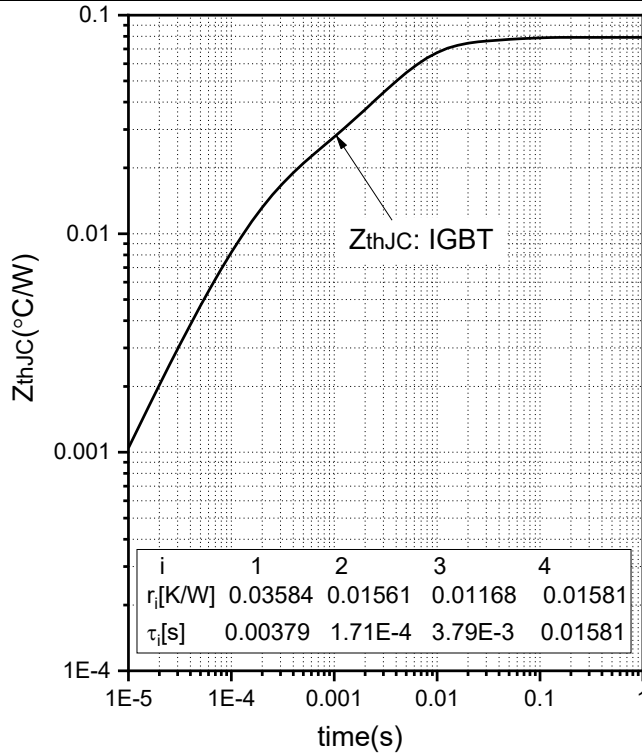


Fig.25 Transient Thermal Impedance (T2,T3)

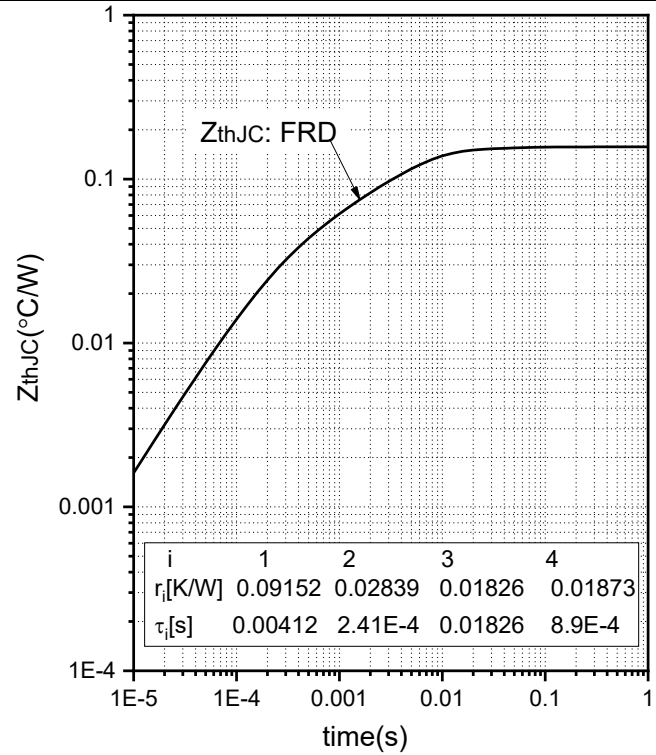


Fig.26 Transient Thermal Impedance (D1-D6)

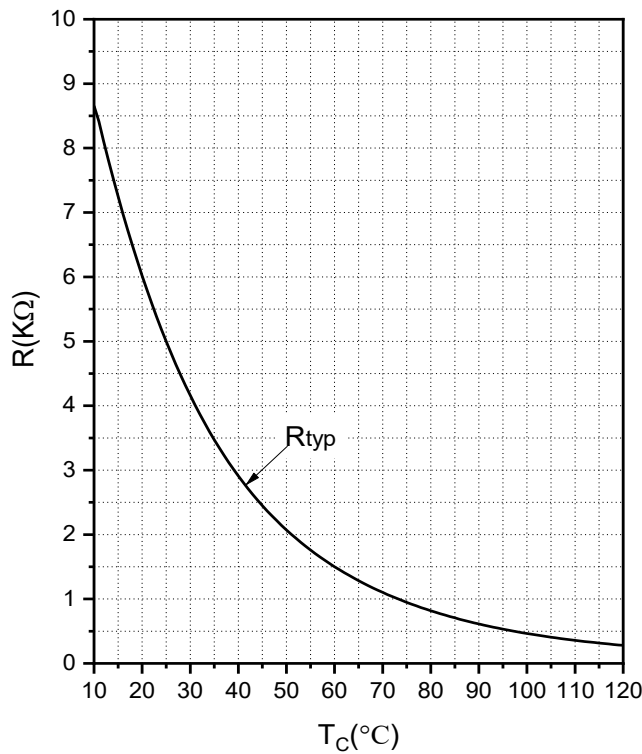


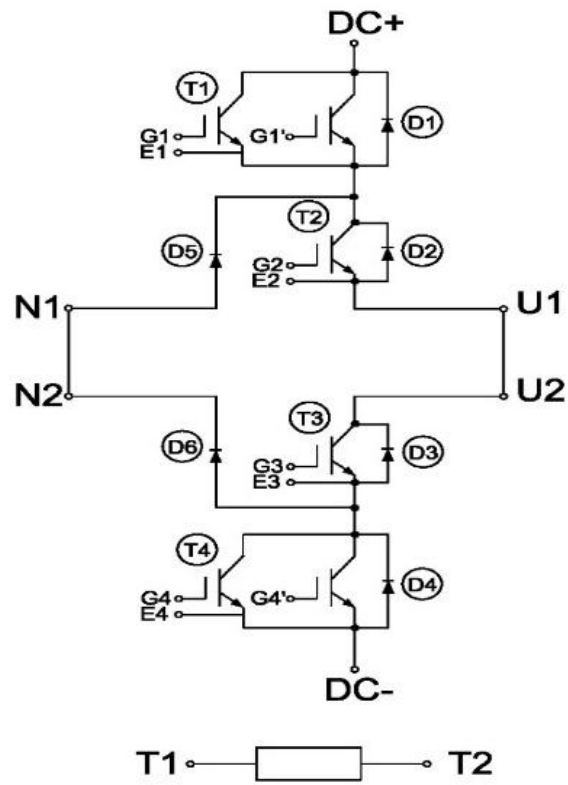
Fig.27 NTC Temperature Characteristics

GT400TL65P4H-SE

IGBT Module Datasheet



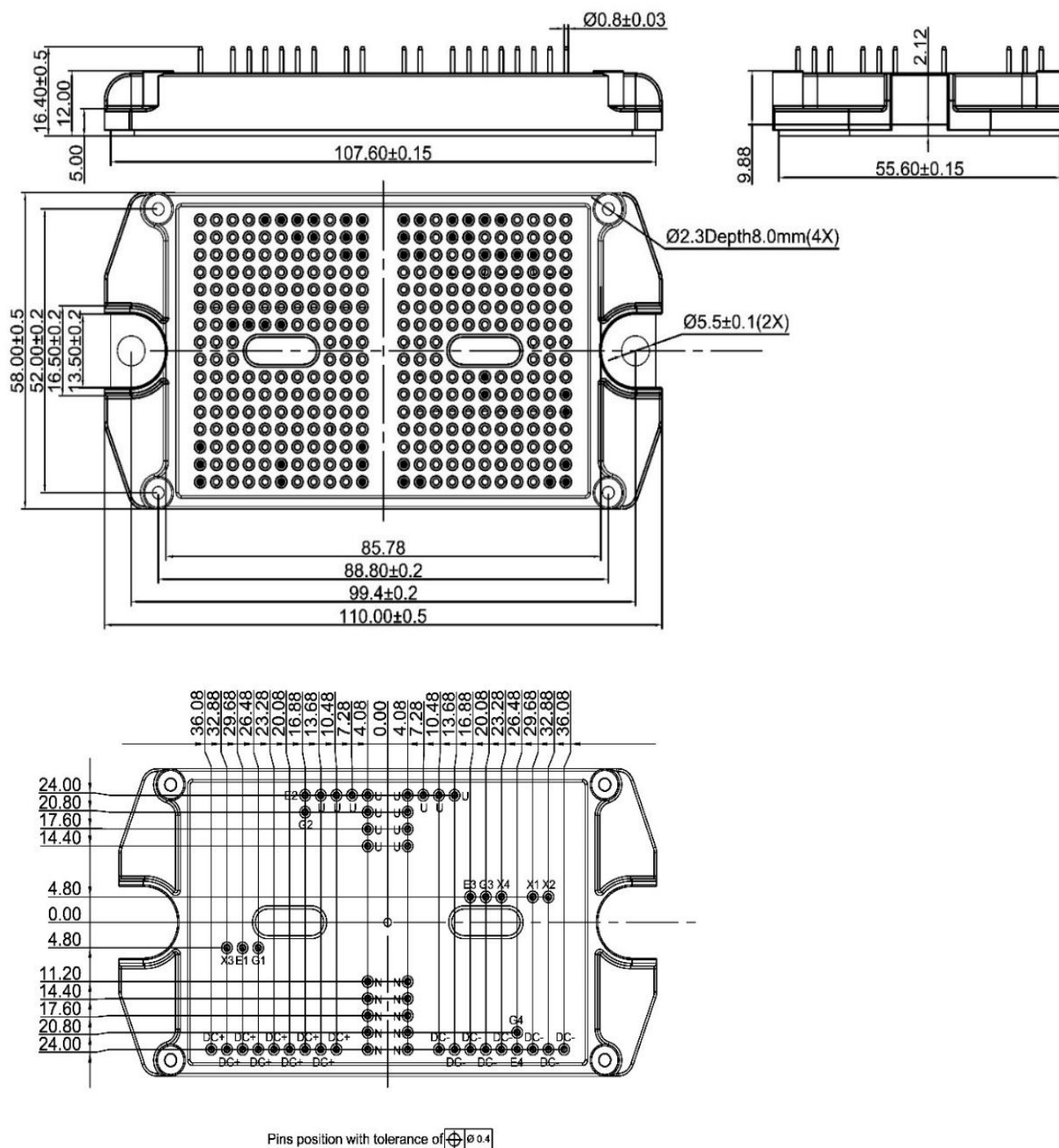
Internal Circuit:



GT400TL65P4H-SE

IGBT Module Datasheet

Package Outline (Unit: mm):



GT400TL65P4H-SE

IGBT Module Datasheet



Revision	Notes
A	Final Datasheet Initial Release

Announcement

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The released datasheet would be issued with “REV.” + “alphabet characters”.