

Reverse-Conducting IGBT with monolithic body diode

Features

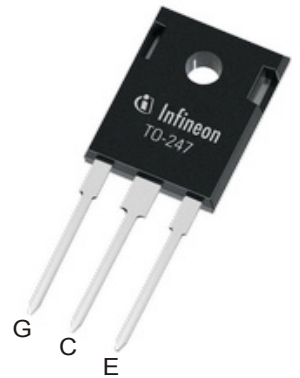
- Complete product spectrum and PSpice Models: <http://www.infineon.com/igbt/>
- Easy parallel switching capability due to positive temperature coefficient in V_{CEsat}
- High ruggedness and stable temperature behavior
- Low EMI
- Pb-free lead plating; RoHS compliant
- Powerful monolithic reverse-conducting diode with low forward voltage
- Very low V_{CEsat} and low E_{off}
- Very tight parameter distribution

Potential applications

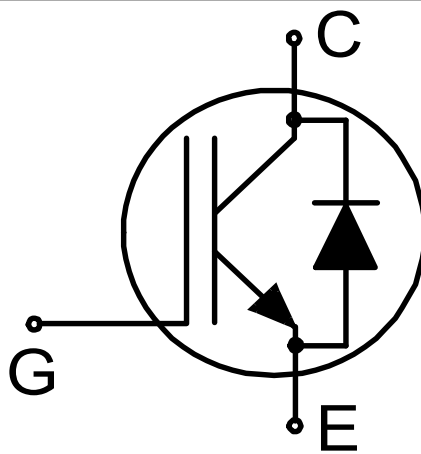
- Induction Cooking
- Microwave Ovens

Product validation

- Product Validation: Qualified for industrial applications according to the relevant tests of JEDEC47/20/22



Description



Type	Package	Marking
IHW40N65R6	PG-TO247-3	H40ER6

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1 Package

1 Package

Table 1 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Internal emitter inductance measured 5mm. (0.197in) from case	L_E			13.0		nH
Storage temperature	T_{stg}		-55		150	°C
Soldering temperature		wave soldering 1.6mm (0.063in.) from case for 10s			260	°C
Mounting torque , M3 screw Maximum of mounting process: 3	M				0.6	Nm
Thermal resistance, junction-ambient	$R_{th(j-a)}$				40	K/W

2 IGBT

Table 2 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit	
Collector-emitter voltage	V_{CE}	$T_{vj} \geq 25\text{ °C}$	650	V	
DC collector current, limited by T_{vjmax}	I_C		$T_C = 25\text{ °C}$	83	A
			$T_C = 100\text{ °C}$	54	
Pulsed collector current, t_p limited by T_{vjmax}	I_{Cpuls}		120	A	
Turn-off safe operating area		$V_{CE} \leq 650\text{ V}, t_p \leq 1\text{ }\mu\text{s}, T_{vj} \leq 175\text{ °C}$	120	A	
Gate-emitter voltage	V_{GE}		± 20	V	
Transient gate-emitter voltage	V_{GE}	$t_p = 10\text{ }\mu\text{s}, D < 0.010$	± 30	V	
Power dissipation	P_{tot}		$T_C = 25\text{ °C}$	210	W
			$T_C = 100\text{ °C}$	105	

Table 3 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Collector-emitter breakdown voltage	V_{BRCES}	$I_C = 0.2\text{ mA}, V_{GE} = 0\text{ V}$	650			V
Collector-emitter saturation voltage	$V_{CE\text{ sat}}$	$I_C = 40.0\text{ A}, V_{GE} = 15\text{ V}$	$T_{vj} = 25\text{ °C}$	1.29	1.60	V
			$T_{vj} = 175\text{ °C}$	1.50		

Table 3 Characteristic values (continued)

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Gate-emitter threshold voltage	V_{GEth}	$I_C = 0.40 \text{ mA}, V_{CE} = V_{GE}$	3.20	4.00	4.80	V
Zero gate voltage collector current	I_{CES}	$V_{CE} = 650 \text{ V}, V_{GE} = 0 \text{ V}$	$T_{vj} = 25 \text{ }^\circ\text{C}$		40	μA
			$T_{vj} = 175 \text{ }^\circ\text{C}$		1000	
Gate-emitter leakage current	I_{GES}	$V_{CE} = 0 \text{ V}, V_{GE} = 20 \text{ V}$			100	nA
Transconductance	g_{fs}	$I_C = 40.0 \text{ A}, V_{CE} = 20 \text{ V}$		97.0		S
Input capacitance	C_{ies}	$V_{CE} = 25 \text{ V}, V_{GE} = 0 \text{ V}, f = 100 \text{ kHz}$		4029		pF
Output capacitance	C_{oes}	$V_{CE} = 25 \text{ V}, V_{GE} = 0 \text{ V}, f = 100 \text{ kHz}$		42		pF
Reverse transfer capacitance	C_{res}	$V_{CE} = 25 \text{ V}, V_{GE} = 0 \text{ V}, f = 100 \text{ kHz}$		16		pF
Gate charge	Q_G	$I_C = 40.0 \text{ A}, V_{GE} = 15 \text{ V}, V_{CE} = 520 \text{ V}$		159		nC
Turn-on delay time	t_{don}	$V_{CE} = 400 \text{ V}, V_{GE} = 15 \text{ V},$ $R_{Gon} = 10.0 \text{ } \Omega,$ $R_{Goff} = 10.0 \text{ } \Omega,$ $L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C},$ $I_C = 40.0 \text{ A}$		17	ns
			$T_{vj} = 175 \text{ }^\circ\text{C},$ $I_C = 40.0 \text{ A}$		17	
Rise time (inductive load)	t_r	$V_{CE} = 400 \text{ V}, V_{GE} = 15 \text{ V},$ $R_{Gon} = 10.0 \text{ } \Omega,$ $R_{Goff} = 10.0 \text{ } \Omega,$ $L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C},$ $I_C = 40.0 \text{ A}$		19	ns
			$T_{vj} = 175 \text{ }^\circ\text{C},$ $I_C = 40.0 \text{ A}$		19	
Turn-off delay time	t_{doff}	$V_{CE} = 400 \text{ V}, V_{GE} = 15 \text{ V},$ $R_{Gon} = 10.0 \text{ } \Omega,$ $R_{Goff} = 10.0 \text{ } \Omega,$ $L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C},$ $I_C = 40.0 \text{ A}$		211	ns
			$T_{vj} = 175 \text{ }^\circ\text{C},$ $I_C = 40.0 \text{ A}$		236	
Fall time (inductive load)	t_f	$V_{CE} = 400 \text{ V}, V_{GE} = 15 \text{ V},$ $R_{Gon} = 10.0 \text{ } \Omega,$ $R_{Goff} = 10.0 \text{ } \Omega,$ $L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C},$ $I_C = 40.0 \text{ A}$		15	ns
			$T_{vj} = 175 \text{ }^\circ\text{C},$ $I_C = 40.0 \text{ A}$		20	
Turn-on energy	E_{on}	$V_{CE} = 400 \text{ V}, V_{GE} = 15 \text{ V},$ $R_{Gon} = 10.0 \text{ } \Omega,$ $R_{Goff} = 10.0 \text{ } \Omega,$ $L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C},$ $I_C = 40.0 \text{ A}$		1.10	mJ
			$T_{vj} = 175 \text{ }^\circ\text{C},$ $I_C = 40.0 \text{ A}$		1.27	
Turn-off energy	E_{off}	$V_{CE} = 400 \text{ V}, V_{GE} = 15 \text{ V},$ $R_{Gon} = 10.0 \text{ } \Omega,$ $R_{Goff} = 10.0 \text{ } \Omega,$ $L_\sigma = 70 \text{ nH}, C_\sigma = 30 \text{ pF}$	$T_{vj} = 25 \text{ }^\circ\text{C},$ $I_C = 40.0 \text{ A}$		0.42	mJ
			$T_{vj} = 175 \text{ }^\circ\text{C},$ $I_C = 40.0 \text{ A}$		0.61	

Table 3 Characteristic values (continued)

Parameter	Symbol	Note or test condition	Values			Unit	
			Min.	Typ.	Max.		
Total switching energy	E_{ts}	$V_{CE} = 400\text{ V}$, $V_{GE} = 15\text{ V}$, $R_{Gon} = 10.0\ \Omega$, $R_{Goff} = 10.0\ \Omega$, $L_{\sigma} = 70\text{ nH}$, $C_{\sigma} = 30\text{ pF}$	$T_{vj} = 25\text{ }^{\circ}\text{C}$, $I_C = 40.0\text{ A}$		1.52		mJ
			$T_{vj} = 175\text{ }^{\circ}\text{C}$, $I_C = 40.0\text{ A}$		1.88		
Soft turn-off energy	E_{off}	$V_{CE} = 162\text{ V}$, $V_{GE} = 15\text{ V}$, $R_{Gon} = 10.0\ \Omega$, $R_{Goff} = 10.0\ \Omega$, $C_r = 30\text{ nF}$, $L_{\sigma} = 70\text{ nH}$, $C_{\sigma} = 30\text{ pF}$	$T_{vj} = 25\text{ }^{\circ}\text{C}$, $I_C = 40.0\text{ A}$		0.11		mJ
			$T_{vj} = 175\text{ }^{\circ}\text{C}$, $I_C = 40.0\text{ A}$		0.22		
IGBT thermal resistance, junction-case	R_{thjc}				0.71	K/W	
Operating junction temperature	T_{vj}		-40		175	$^{\circ}\text{C}$	

3 Diode

Table 4 Maximum rated values

Parameter	Symbol	Note or test condition	Values	Unit	
Repetitive peak reverse voltage	V_{RRM}	$T_{vj} \geq 25\text{ }^{\circ}\text{C}$	650	V	
Diode forward current, limited by T_{vjmax}	I_F		$T_C = 25\text{ }^{\circ}\text{C}$	35	A
			$T_C = 100\text{ }^{\circ}\text{C}$	21	
Diode pulsed current, limited by T_{vjmax}	I_{Fpuls}		120	A	
Power dissipation	P_{tot}		$T_C = 25\text{ }^{\circ}\text{C}$	54	W
			$T_C = 100\text{ }^{\circ}\text{C}$	27	

Table 5 Characteristic values

Parameter	Symbol	Note or test condition	Values			Unit
			Min.	Typ.	Max.	
Diode forward voltage	V_F	$I_F = 40.0\text{ A}$	$T_{vj} = 25\text{ }^{\circ}\text{C}$	1.50	1.90	V
			$T_{vj} = 175\text{ }^{\circ}\text{C}$		1.66	
Reverse leakage current	I_R	$V_R = 650\text{ V}$	$T_{vj} = 25\text{ }^{\circ}\text{C}$		40	μA
			$T_{vj} = 175\text{ }^{\circ}\text{C}$		1000	

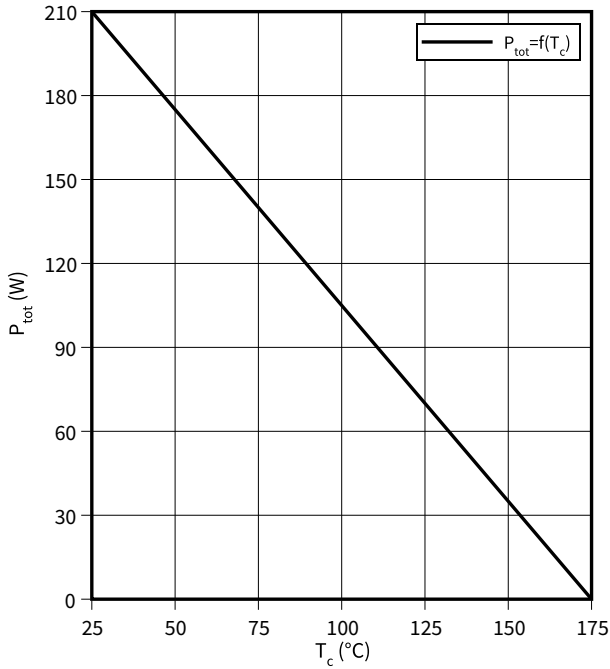
Table 5 Characteristic values (continued)

Parameter	Symbol	Note or test condition		Values			Unit
				Min.	Typ.	Max.	
Diode reverse recovery time	t_{rr}	$V_R = 400\text{ V}$	$T_{vj} = 25\text{ °C}$, $I_F = 40.0\text{ A}$, $-di_F/dt = 1000\text{ A}/\mu\text{s}$		99		ns
			$T_{vj} = 175\text{ °C}$, $I_F = 40.0\text{ A}$, $-di_F/dt = 1000\text{ A}/\mu\text{s}$		133		
Diode reverse recovery charge	Q_{rr}	$V_R = 400\text{ V}$	$T_{vj} = 25\text{ °C}$, $I_F = 40.0\text{ A}$, $-di_F/dt = 1000\text{ A}/\mu\text{s}$		2.16		μC
			$T_{vj} = 175\text{ °C}$, $I_F = 40.0\text{ A}$, $-di_F/dt = 1000\text{ A}/\mu\text{s}$		3.77		
Diode peak reverse recovery current	I_{rrm}	$V_R = 400\text{ V}$	$T_{vj} = 25\text{ °C}$, $I_F = 40.0\text{ A}$, $-di_F/dt = 1000\text{ A}/\mu\text{s}$		35.0		A
			$T_{vj} = 175\text{ °C}$, $I_F = 40.0\text{ A}$, $-di_F/dt = 1000\text{ A}/\mu\text{s}$		46.0		
Diode peak rate off fall of reverse recovery current	di_{rr}/dt	$V_R = 400\text{ V}$	$T_{vj} = 25\text{ °C}$, $I_F = 40.0\text{ A}$, $-di_F/dt = 1000\text{ A}/\mu\text{s}$		-926		$\text{A}/\mu\text{s}$
			$T_{vj} = 175\text{ °C}$, $I_F = 40.0\text{ A}$, $-di_F/dt = 1000\text{ A}/\mu\text{s}$		-901		
Diode thermal resistance, junction-case	R_{thjc}				2.77		K/W
Operating junction temperature	T_{vj}			-40		175	$^{\circ}\text{C}$

4 Characteristics diagrams

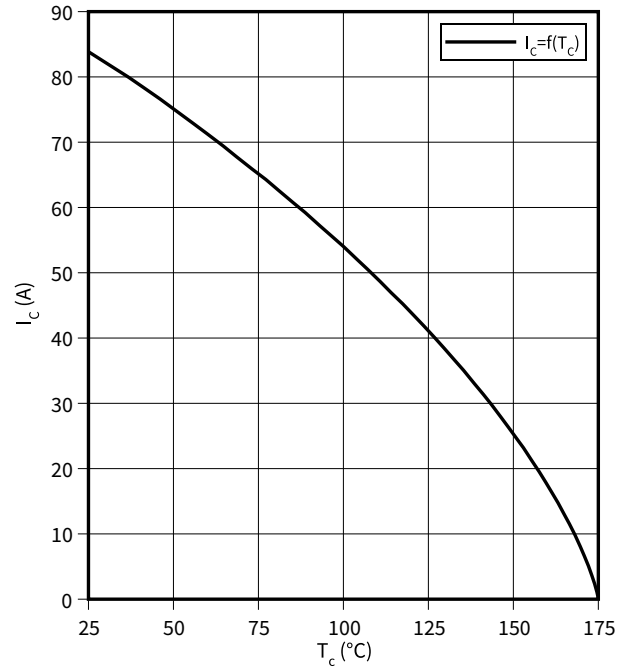
Power dissipation as a function of case temperature, IGBT

$P_{tot} = f(T_c)$
 $T_{vj} \leq 175\text{ °C}$



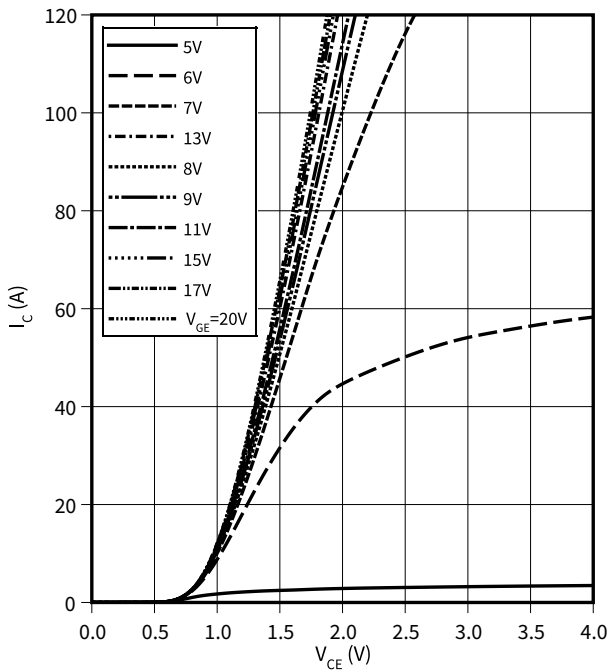
Collector current as a function of case temperature, IGBT

$I_C = f(T_c)$
 $T_{vj} \leq 175\text{ °C}, V_{GE} = 15\text{ V}$



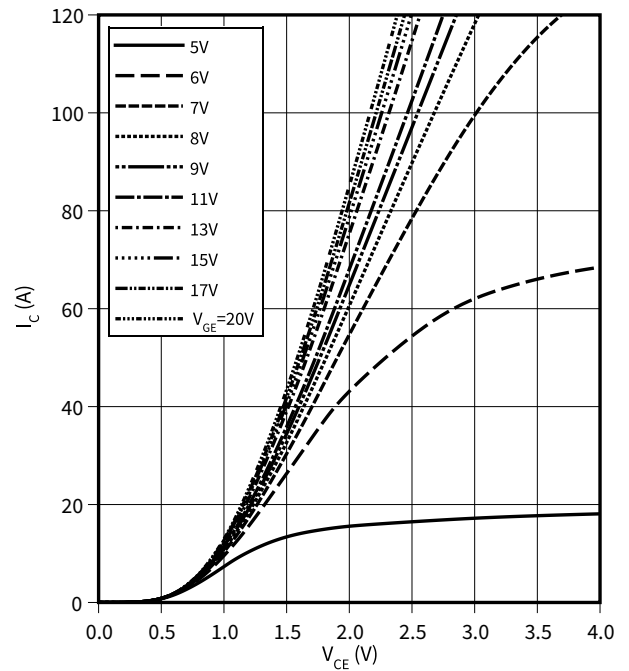
Typical output characteristic, IGBT

$I_C = f(V_{CE})$
 $T_{vj} = 25\text{ °C}$



Typical output characteristic, IGBT

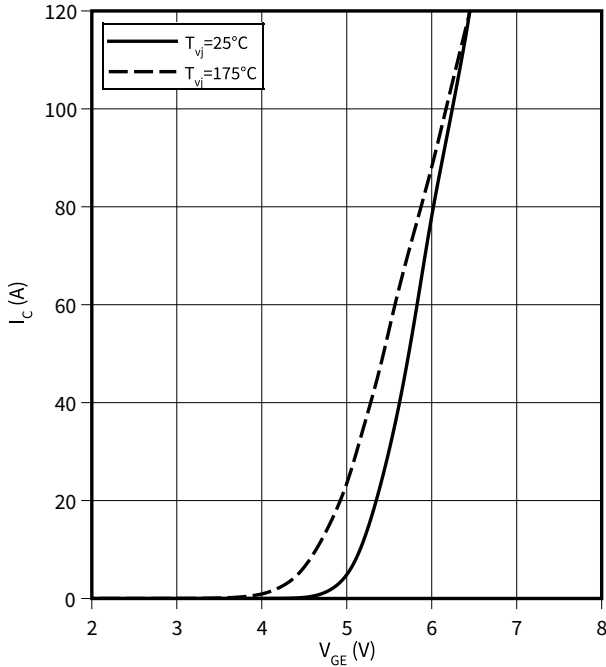
$I_C = f(V_{CE})$
 $T_{vj} = 175\text{ °C}$



4 Characteristics diagrams

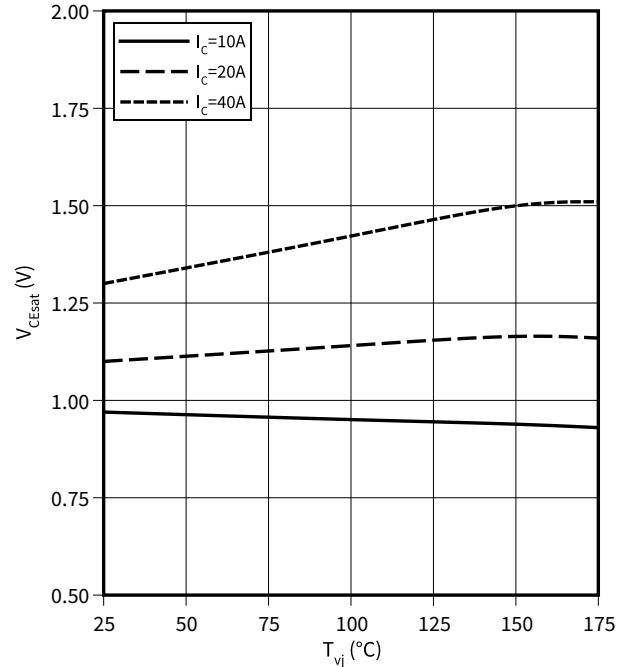
Typical transfer characteristic, IGBT

$I_C = f(V_{GE})$
 $V_{CE} = 20\text{ V}$



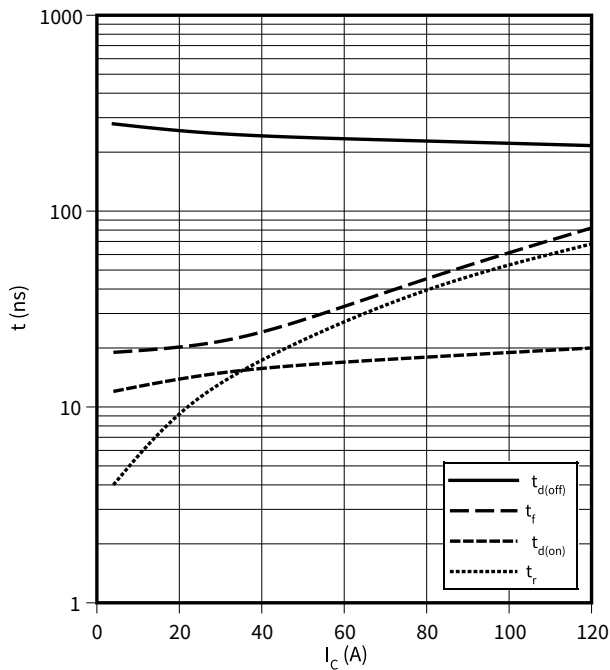
Typical collector-emitter saturation voltage as a function of junction temperature, IGBT

$V_{CEsat} = f(T_{vj})$
 $V_{GE} = 15\text{ V}$



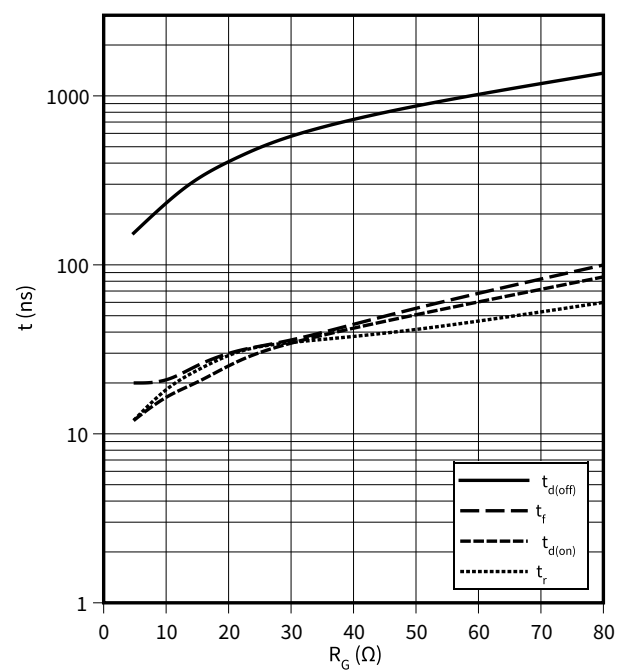
Typical switching times as a function of collector current, IGBT

$t = f(I_C)$
 $R_{Goff} = 10.0\ \Omega$, $V_{CE} = 400\text{ V}$, $T_{vj} = 175^\circ\text{C}$, $V_{GE} = 0/15\text{ V}$, $R_{Gon} = 10.0\ \Omega$



Typical switching times as a function of gate resistor, IGBT

$t = f(R_G)$
 $I_C = 40.0\text{ A}$, $V_{CE} = 400\text{ V}$, $T_{vj} = 175^\circ\text{C}$, $V_{GE} = 0/15\text{ V}$

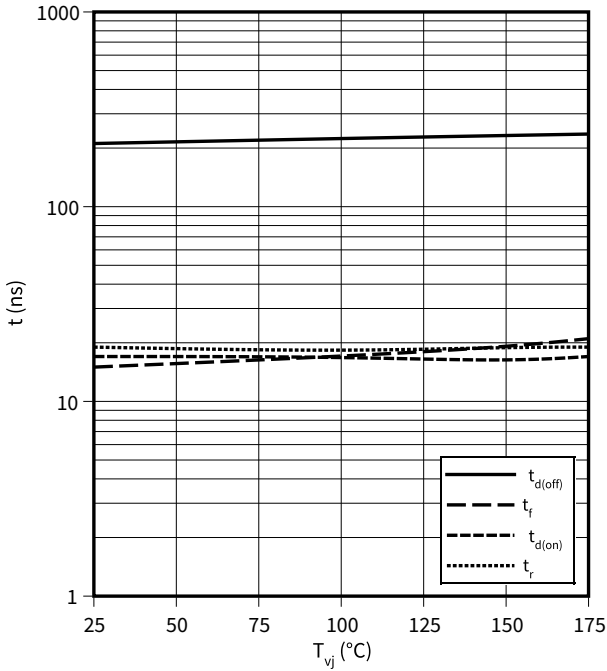


4 Characteristics diagrams

Typical switching times as a function of junction temperature, IGBT

$t = f(T_{vj})$

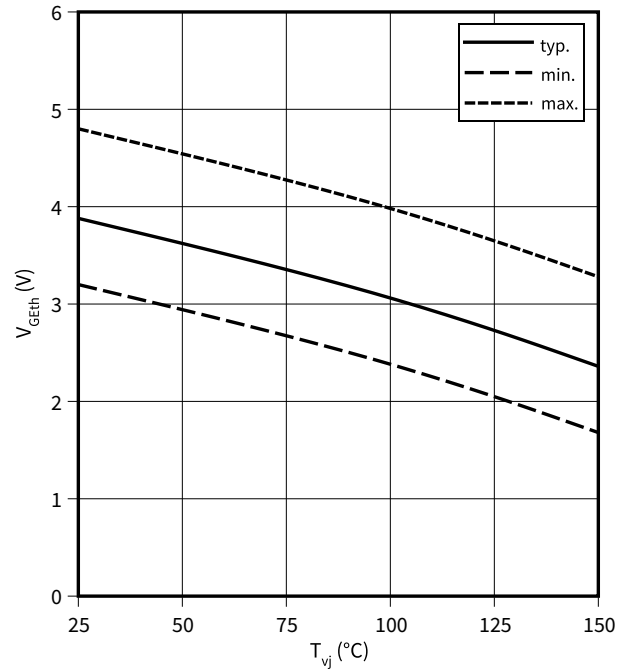
$I_C = 40.0 \text{ A}$, $R_{Goff} = 10.0 \text{ } \Omega$, $V_{CE} = 400 \text{ V}$, $V_{GE} = 0/15 \text{ V}$, $R_{Gon} = 10.0 \text{ } \Omega$



Gate-emitter threshold voltage as a function of junction temperature, IGBT

$V_{GEth} = f(T_{vj})$

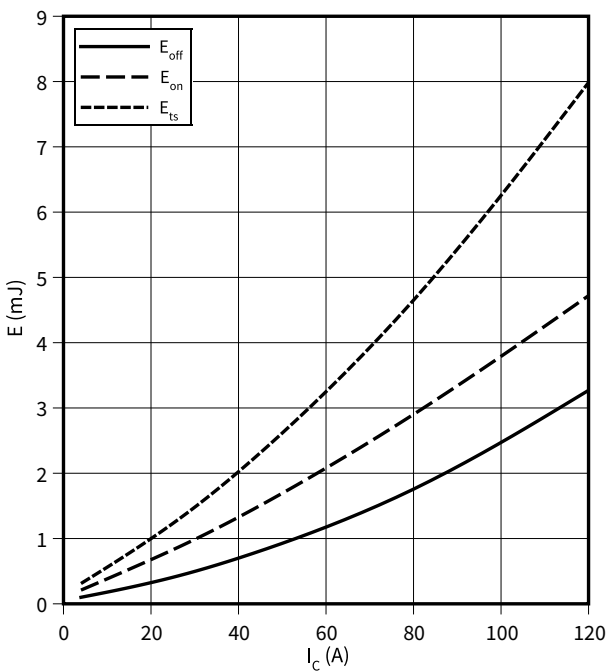
$I_C = 0.40 \text{ mA}$



Typical switching energy losses as a function of collector current, IGBT

$E = f(I_C)$

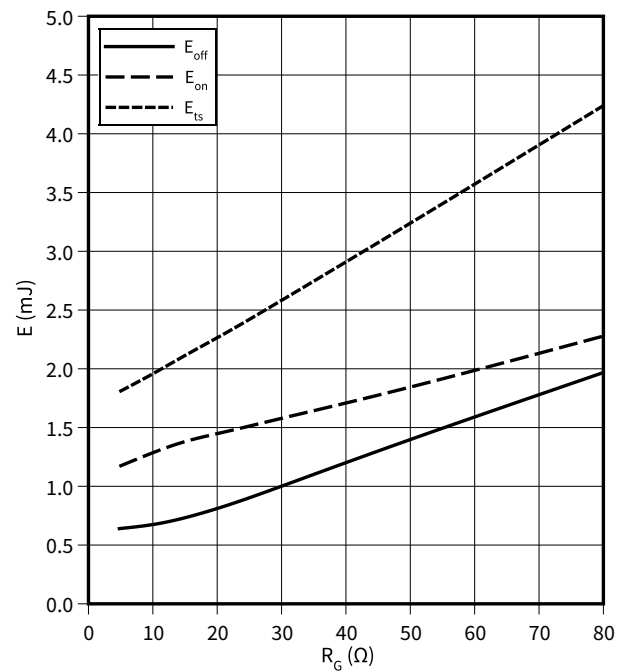
$R_{Goff} = 10.0 \text{ } \Omega$, $V_{CE} = 400 \text{ V}$, $T_{vj} = 175 \text{ } ^\circ\text{C}$, $V_{GE} = 0/15 \text{ V}$, $R_{Gon} = 10.0 \text{ } \Omega$



Typical switching energy losses as a function of gate resistor, IGBT

$E = f(R_G)$

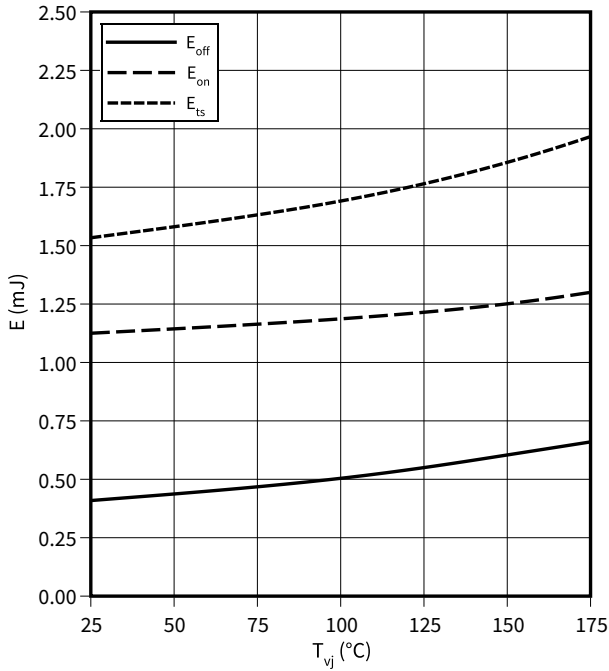
$I_C = 40.0 \text{ A}$, $V_{CE} = 400 \text{ V}$, $T_{vj} = 175 \text{ } ^\circ\text{C}$, $V_{GE} = 0/15 \text{ V}$



4 Characteristics diagrams

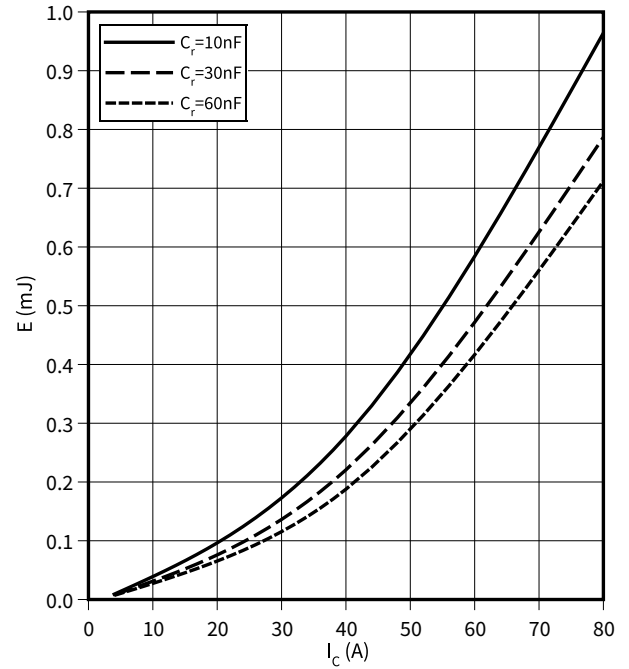
Typical switching energy losses as a function of junction temperature, IGBT

$E = f(T_{vj})$
 $I_C = 40.0 \text{ A}$, $R_{Goff} = 10.0 \text{ } \Omega$, $V_{CE} = 400 \text{ V}$, $V_{GE} = 0/15 \text{ V}$, $R_{Gon} = 10.0 \text{ } \Omega$



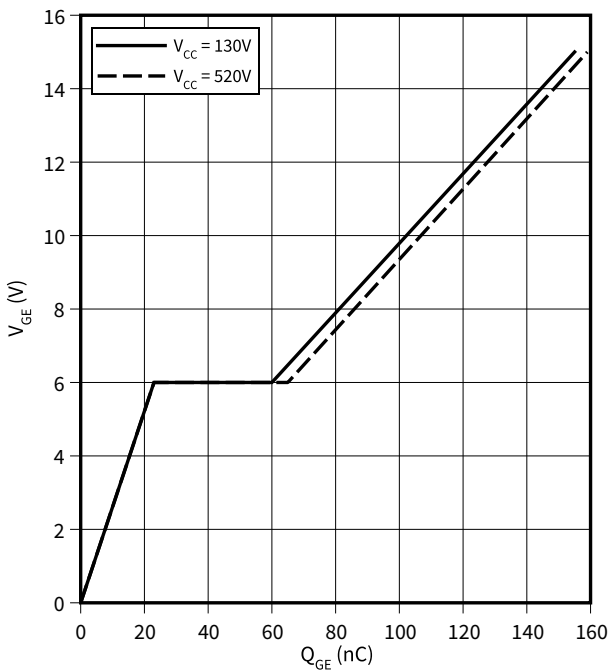
Typical soft-switching turn-off energy loss as a function of collector current, IGBT

$E = f(I_C)$
 $R_{Goff} = 10.0 \text{ } \Omega$, $T_{vj} = 175 \text{ } ^\circ\text{C}$, $V_{GE} = 0/15 \text{ V}$



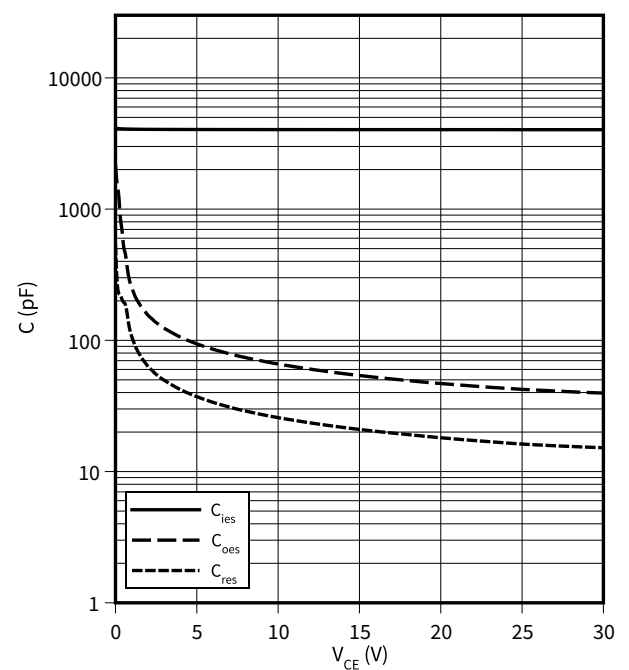
Typical gate charge, IGBT

$V_{GE} = f(Q_{GE})$
 $I_C = 40.0 \text{ A}$



Typical capacitance as a function of collector-emitter voltage, IGBT

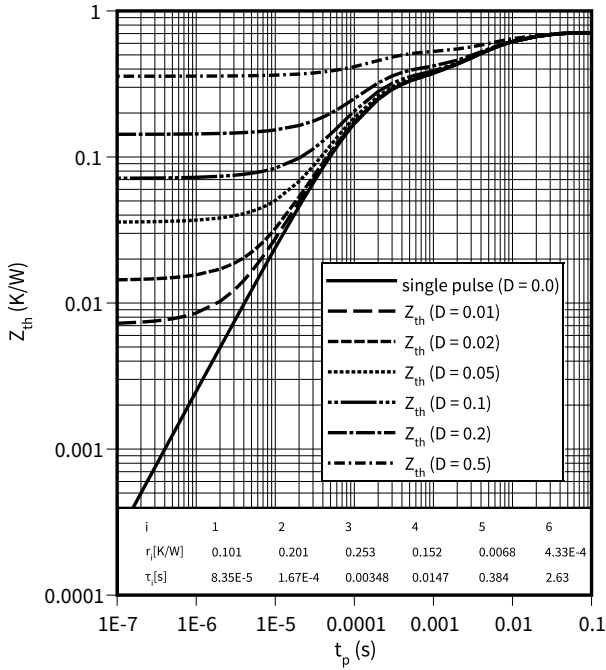
$C = f(V_{CE})$
 $f = 100 \text{ kHz}$, $V_{GE} = 0 \text{ V}$



4 Characteristics diagrams

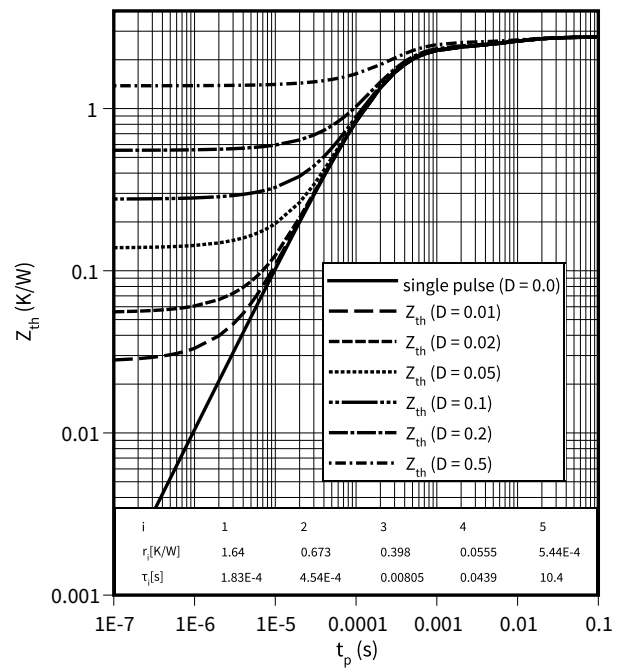
IGBT transient thermal resistance, IGBT

$Z_{th} = f(t_p)$
 $D = t_p/T$



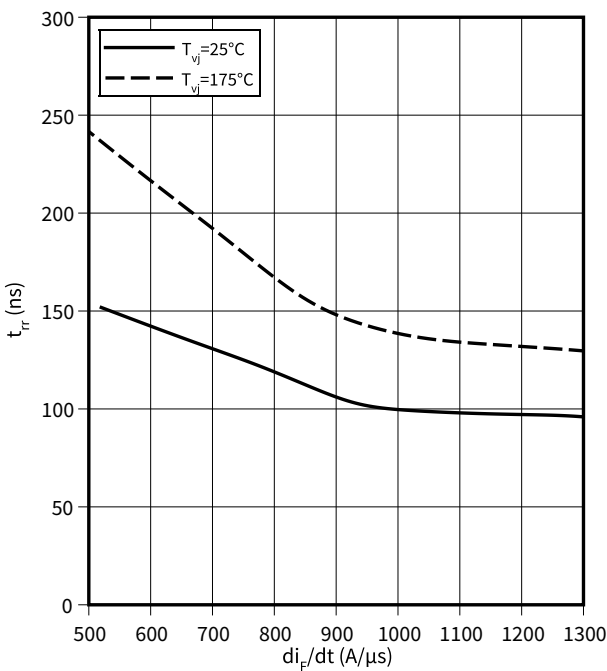
Diode transient thermal impedance as a function of pulse width, Diode

$Z_{th} = f(t_p)$
 $D = t_p/T$



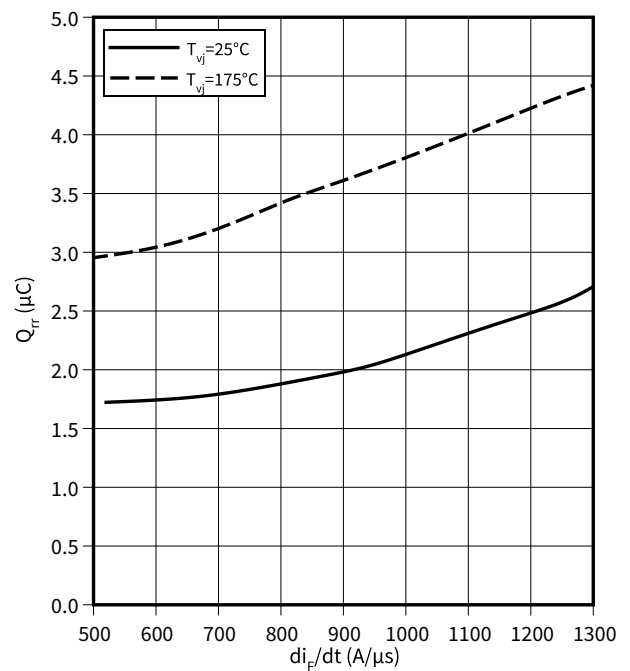
Typical reverse recovery time as a function of diode current slope, Diode

$t_{rr} = f(di_F/dt)$
 $V_R = 400 \text{ V}, I_F = 40.0 \text{ A}$



Typical reverse recovery charge as a function of diode current slope, Diode

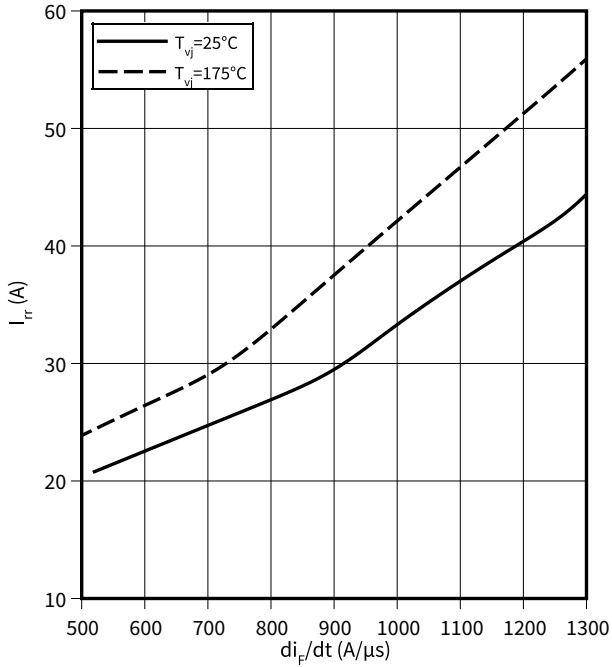
$Q_{rr} = f(di_F/dt)$
 $V_R = 400 \text{ V}, I_F = 40.0 \text{ A}$



4 Characteristics diagrams

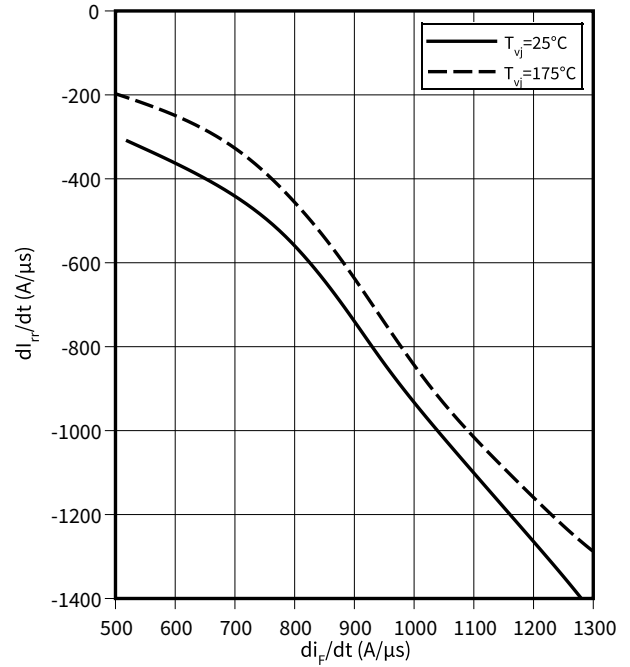
Typical reverse recovery current as a function of diode current slope, Diode

$I_{rr} = f(di_F/dt)$
 $V_R = 400\text{ V}, I_F = 40.0\text{ A}$



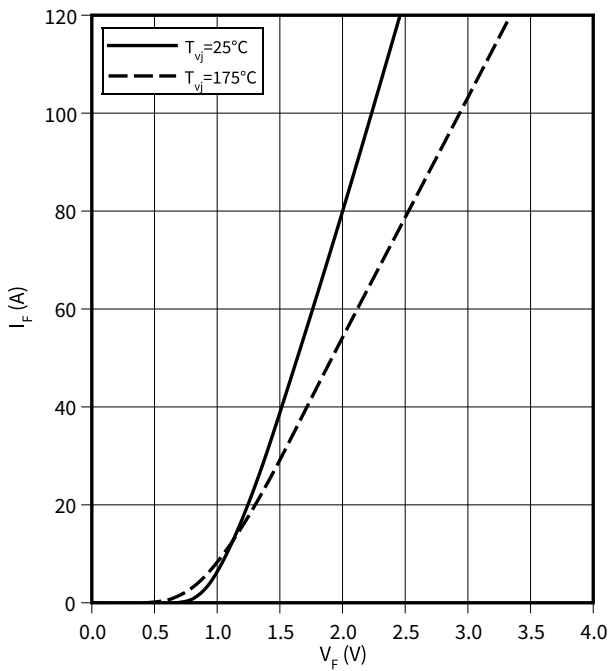
Typical diode peak rate of fall of reverse recovery current as a function of diode current slope, Diode

$dI_{rr}/dt = f(di_F/dt)$
 $I_F = 40.0\text{ A}, V_R = 400\text{ V}$



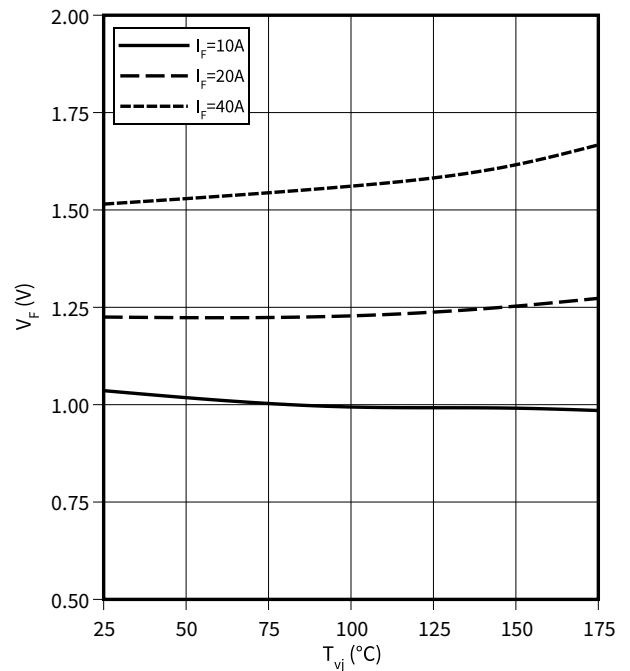
Typical diode forward current as a function of forward voltage, Diode

$I_F = f(V_F)$



Typical diode forward voltage as a function of junction temperature, Diode

$V_F = f(T_{vj})$



5 Package outlines

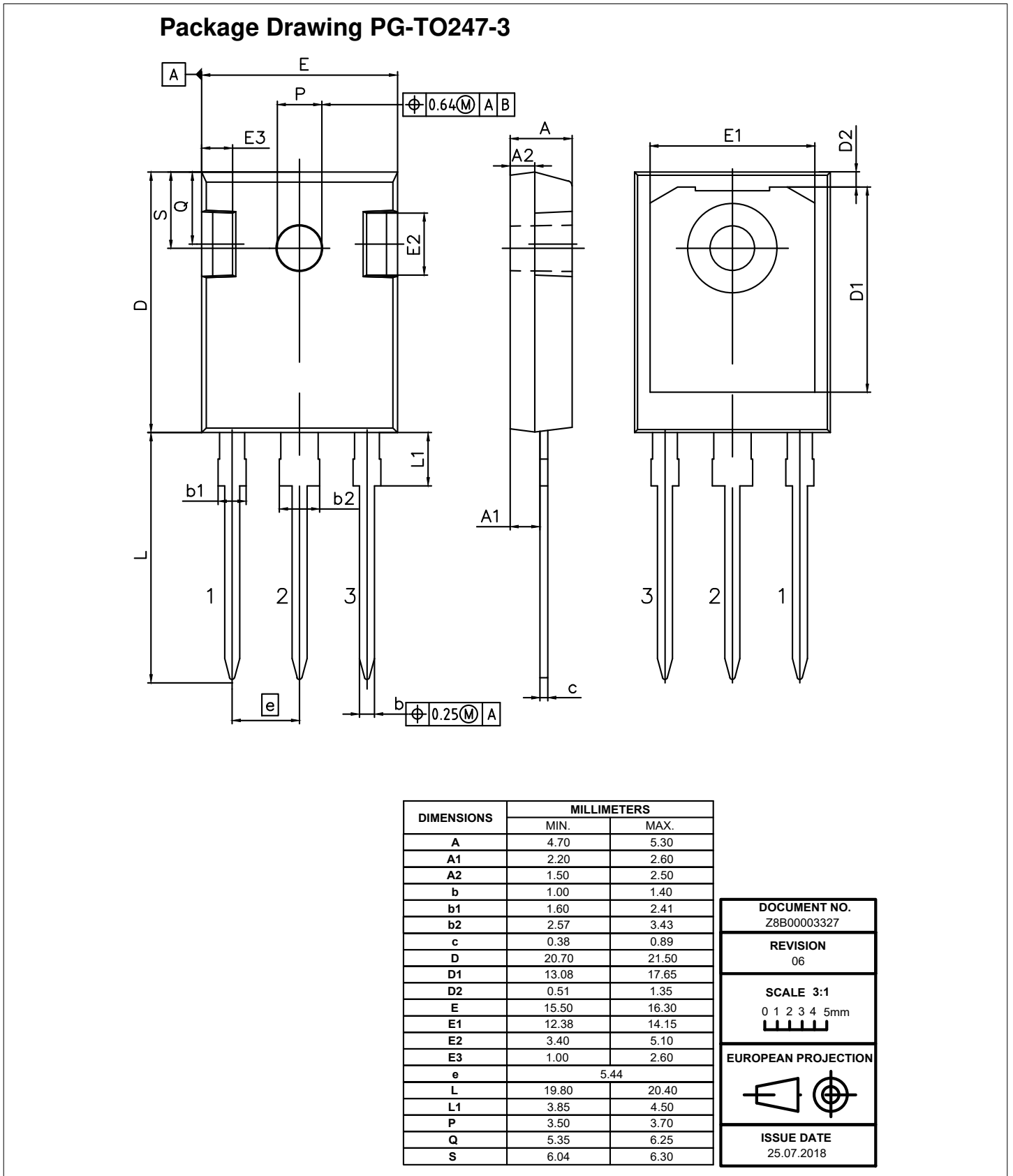


Figure 6

6 Testing conditions

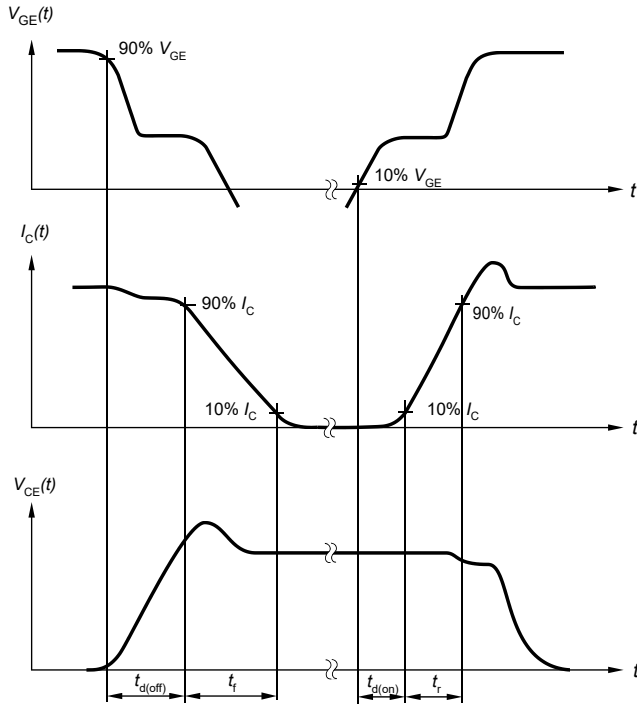


Figure A. Definition of switching times

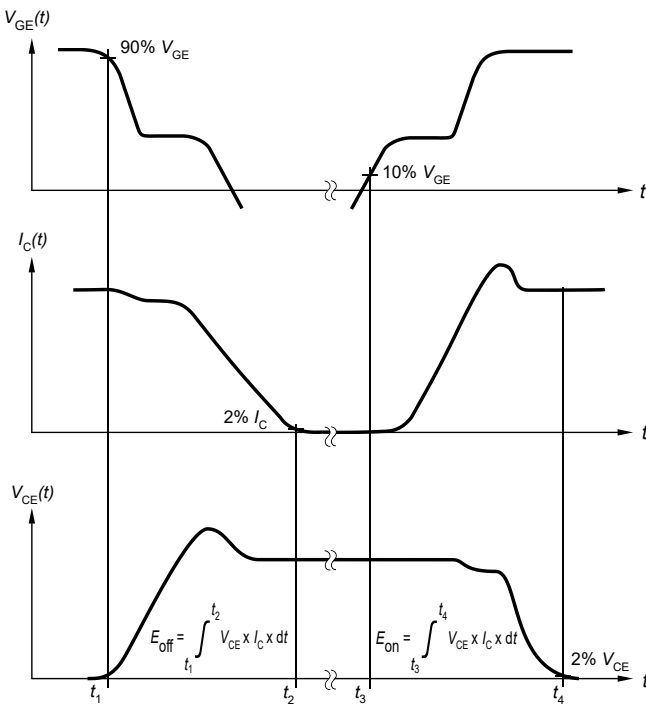


Figure B. Definition of switching losses

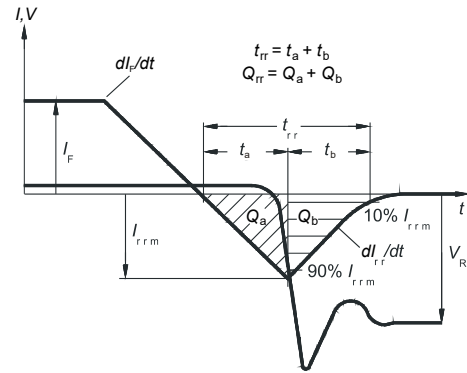


Figure C. Definition of diode switching characteristics

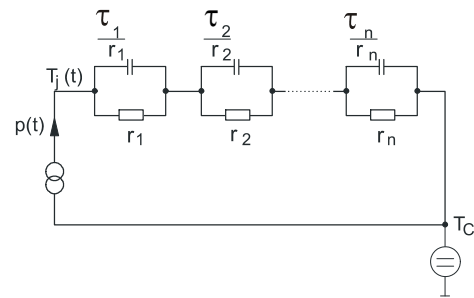


Figure D. Thermal equivalent circuit

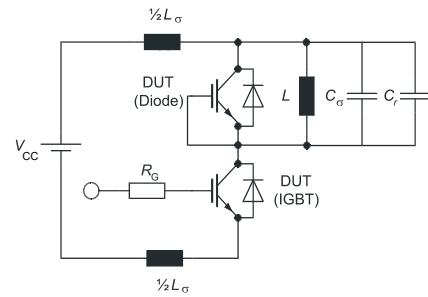


Figure E. Dynamic test circuit
Parasitic inductance L_σ ,
parasitic capacitor C_σ ,
relief capacitor C_r ,
(only for ZVT switching)

Figure 7

Revision history

Revision history

Revision	Date of release	Description of changes
1.00	2020.12.21	Final datasheet
1.10	2021.02.22	Soft turn-off energy data changed. Editorial changes in graph.
1.20	2021.03.21	Dynamic characteristic change from 1000 kHz to 100 kHz

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