

## IGBT

Reverse conducting IGBT with monolithic body diode

## IHD06N60RA

600V Soft Switching Series

Qualified to automotive standard AECQ101

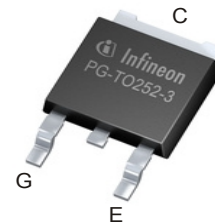
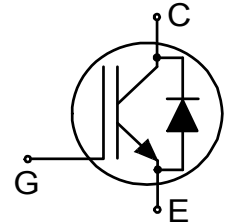
Data sheet

Industrial Power Control

Reverse conducting IGBT with monolithic body diode

Features:

- Powerful monolithic body diode with low forward voltage designed for soft commutation only
- TRENCHSTOP™ technology applications offers:
  - very tight parameter distribution
  - high ruggedness, temperature stable behavior
  - low  $V_{CEsat}$
  - easy parallel switching capability due to positive temperature coefficient in  $V_{CEsat}$
- Low EMI
- Qualified to automotive standard AECQ101
- Pb-free lead plating; RoHS compliant; solder temperature 260°C, MSL1
- Complete product spectrum and PSpice Models: <http://www.infineon.com/igbt/>



Key Performance and Package Parameters

Type	$V_{CE}$	$I_C$	$V_{CEsat}, T_{vj}=25^{\circ}C$	$T_{vjmax}$	Marking	Package
IHD06N60RA	600V	6A	1.45V	175°C	H06R60A	PG-TO252-3



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**Maximum ratings**

Parameter	Symbol	Value	Unit
Collector-emitter voltage, $T_{vj} \geq 25^{\circ}\text{C}$	$V_{CE}$	600	V
DC collector current, limited by $T_{vjmax}$ $T_C = 25^{\circ}\text{C}$ $T_C = 100^{\circ}\text{C}$	$I_C$	12.0 6.0	A
Pulsed collector current, $t_p$ limited by $T_{vjmax}$	$I_{Cpuls}$	18.0	A
Turn off safe operating area $V_{CE} \leq 600\text{V}$ , $T_{vj} \leq 175^{\circ}\text{C}$	-	18.0	A
Diode forward current, limited by $T_{vjmax}$ $T_C = 25^{\circ}\text{C}$ $T_C = 100^{\circ}\text{C}$	$I_F$	12.0 6.0	A
Diode pulsed current, $t_p$ limited by $T_{vjmax}$	$I_{Fpuls}$	18.0	A
Gate-emitter voltage	$V_{GE}$	$\pm 20$	V
Short circuit withstand time $V_{GE} = 15.0\text{V}$ , $V_{CC} \leq 250\text{V}$ Allowed number of short circuits < 1000 Time between short circuits: $\geq 1.0\text{s}$ $T_{vj} = 150^{\circ}\text{C}$	$t_{SC}$	10	$\mu\text{s}$
Power dissipation $T_C = 25^{\circ}\text{C}$	$P_{tot}$	88.0	W
Operating junction temperature	$T_{vj}$	-40...+175	$^{\circ}\text{C}$
Storage temperature	$T_{stg}$	-40...+175	$^{\circ}\text{C}$
Soldering temperature, reflow soldering (MSL1 according to JEDEC J-STA-020)		260	$^{\circ}\text{C}$

**Thermal Resistance**

Parameter	Symbol	Conditions	Max. Value	Unit
<b>Characteristic</b>				
IGBT thermal resistance, junction - case	$R_{th(j-c)}$		1.70	K/W
Diode thermal resistance, junction - case	$R_{th(j-c)}$		1.70	K/W
Thermal resistance, min. footprint junction - ambient	$R_{th(j-a)}$		75	K/W
Thermal resistance, 6cm <sup>2</sup> Cu on PCB junction - ambient	$R_{th(j-a)}$		50	K/W

**Electrical Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$ , unless otherwise specified**

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>Static Characteristic</b>						
Collector-emitter breakdown voltage	$V_{(BR)CES}$	$V_{GE} = 0\text{V}, I_C = 0.20\text{mA}$	600	-	-	V
Collector-emitter saturation voltage	$V_{CEsat}$	$V_{GE} = 15.0\text{V}, I_C = 6.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- - -	1.45 1.70 1.75	1.90 - -	V
Diode forward voltage	$V_F$	$V_{GE} = 0\text{V}, I_F = 6.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 150^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- - -	1.55 1.65 1.65	1.90 - -	V
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C = 0.18\text{mA}, V_{CE} = V_{GE}$	4.1	4.9	5.7	V
Zero gate voltage collector current	$I_{CES}$	$V_{CE} = 600\text{V}, V_{GE} = 0\text{V}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	- -	40.0 600.0	$\mu\text{A}$
Gate-emitter leakage current	$I_{GES}$	$V_{CE} = 0\text{V}, V_{GE} = 20\text{V}$	-	-	100	nA
Transconductance	$g_{fs}$	$V_{CE} = 20\text{V}, I_C = 6.0\text{A}$	-	3.7	-	S
Integrated gate resistor	$r_G$			none		$\Omega$

**Electrical Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$ , unless otherwise specified**

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>Dynamic Characteristic</b>						
Input capacitance	$C_{ies}$	$V_{CE} = 25\text{V}, V_{GE} = 0\text{V}, f = 1\text{MHz}$	-	370	-	pF
Output capacitance	$C_{oes}$		-	28	-	
Reverse transfer capacitance	$C_{res}$		-	11	-	
Gate charge	$Q_G$	$V_{CC} = 480\text{V}, I_C = 6.0\text{A},$ $V_{GE} = 15\text{V}$	-	42.0	-	nC
Short circuit collector current Max. 1000 short circuits Time between short circuits: $\geq 1.0\text{s}$	$I_{C(SC)}$	$V_{GE} = 15.0\text{V}, V_{CC} \leq 250\text{V},$ $t_{SC} \leq 10\mu\text{s}$ $T_{vj} = 150^{\circ}\text{C}$	-	39	-	A

**Switching Characteristic, Inductive Load**

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	

**IGBT Characteristic, at  $T_{vj} = 25^{\circ}\text{C}$** 

Turn-on delay time	$t_{d(on)}$	$T_{vj} = 25^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 6.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $r_G = 14.7\Omega, L\sigma = 60\text{nH},$ $C\sigma = 40\text{pF}$ $L\sigma, C\sigma$ from Fig. E Diode used for turn on results: SDP04S60	-	25	-	ns
Rise time	$t_r$		-	20	-	ns
Turn-off delay time	$t_{d(off)}$		-	125	-	ns
Fall time	$t_f$		-	145	-	ns
Turn-on energy	$E_{on}$		-	0.05	-	mJ
Turn-off energy	$E_{off}$		-	0.15	-	mJ
Total switching energy	$E_{ts}$	-	0.20	-	mJ	

**Switching Characteristic, Inductive Load**

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>IGBT Characteristic, at <math>T_{vj} = 175^{\circ}\text{C}</math></b>						
Turn-on delay time	$t_{d(on)}$	$T_{vj} = 175^{\circ}\text{C}$ , $V_{CC} = 400\text{V}$ , $I_C = 6.0\text{A}$ , $V_{GE} = 0.0/15.0\text{V}$ , $r_G = 14.7\Omega$ , $L\sigma = 60\text{nH}$ , $C\sigma = 40\text{pF}$ $L\sigma$ , $C\sigma$ from Fig. E Diode used for turn on results: SDP04S60	-	28	-	ns
Rise time	$t_r$		-	22	-	ns
Turn-off delay time	$t_{d(off)}$		-	165	-	ns
Fall time	$t_f$		-	160	-	ns
Turn-on energy	$E_{on}$		-	0.06	-	mJ
Turn-off energy	$E_{off}$		-	0.25	-	mJ
Total switching energy	$E_{ts}$		-	0.31	-	mJ

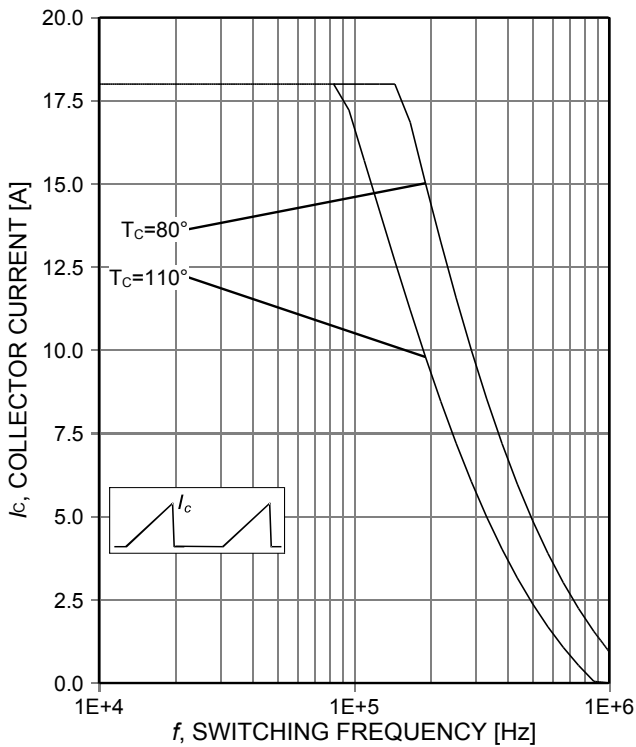


Figure 1. **Collector current as a function of switching frequency**  
 ( $T_{vj} \leq 175^\circ\text{C}$ ,  $D=0.5$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=14.7\Omega$ )

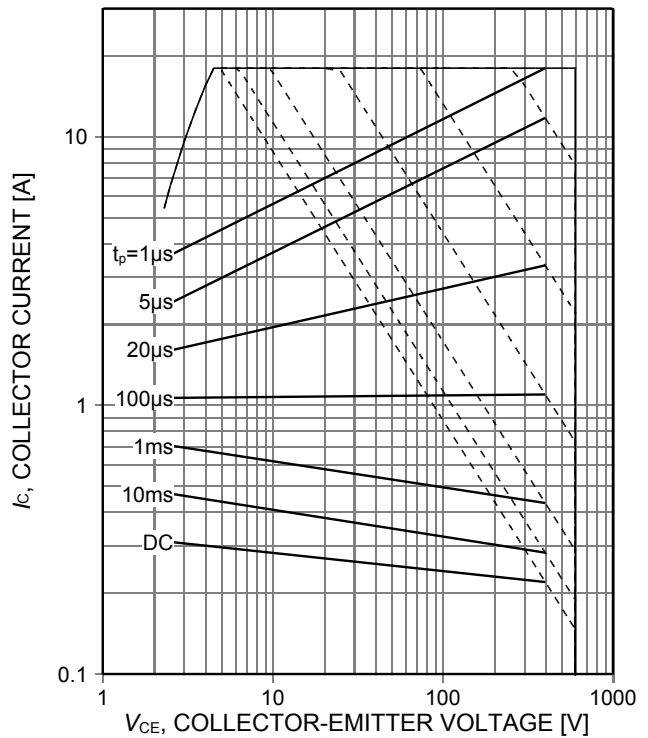


Figure 2. **Forward bias safe operating area**  
 ( $D=0$ ,  $T_C=25^\circ\text{C}$ ,  $T_{vj} \leq 175^\circ\text{C}$ ;  $V_{GE}=15\text{V}$ )

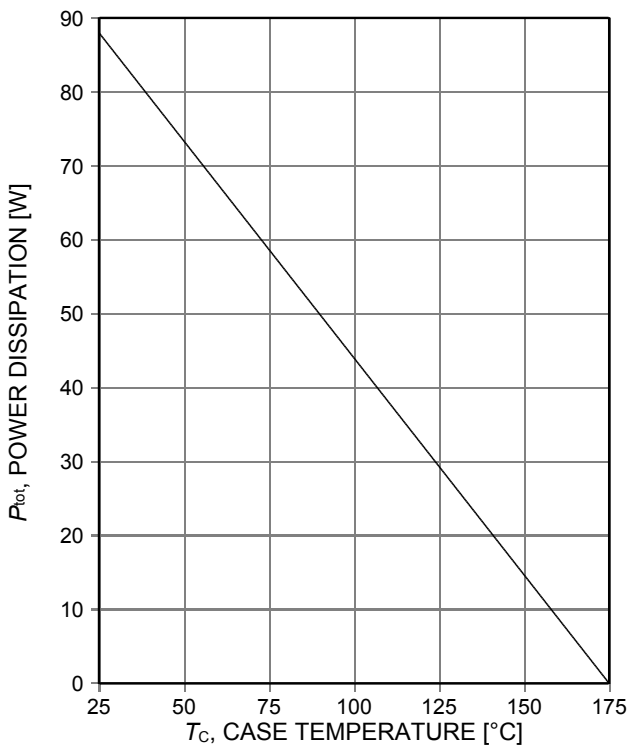


Figure 3. **Power dissipation as a function of case temperature**  
 ( $T_{vj} \leq 175^\circ\text{C}$ )

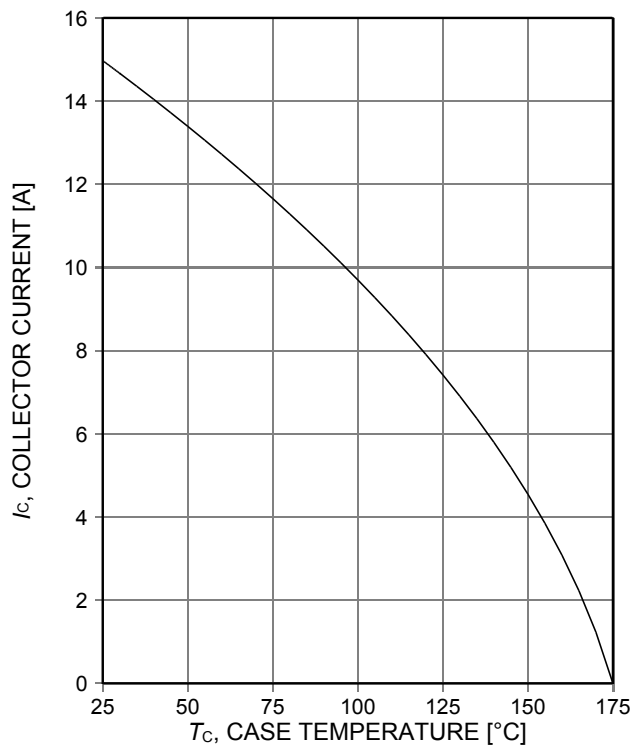


Figure 4. **Collector current as a function of case temperature**  
 ( $V_{GE} \geq 15\text{V}$ ,  $T_{vj} \leq 175^\circ\text{C}$ )

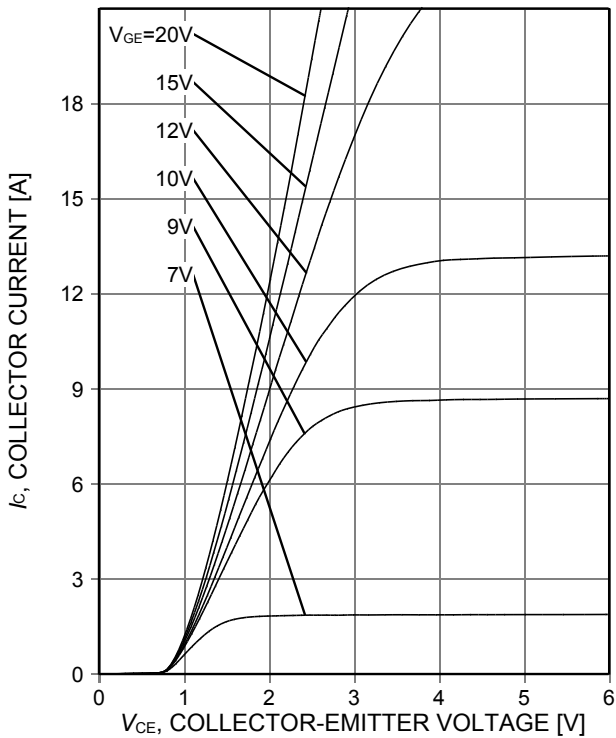


Figure 5. Typical output characteristic ( $T_{vj}=25^{\circ}\text{C}$ )

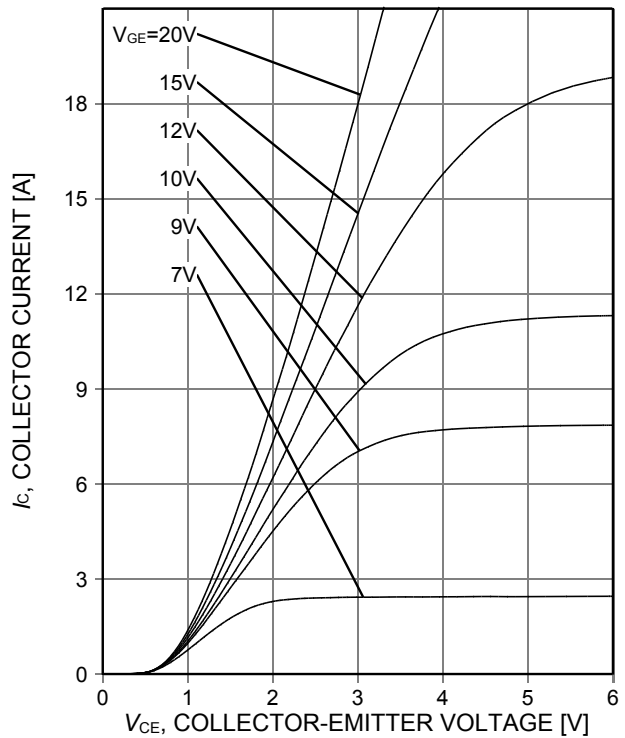


Figure 6. Typical output characteristic ( $T_{vj}=175^{\circ}\text{C}$ )

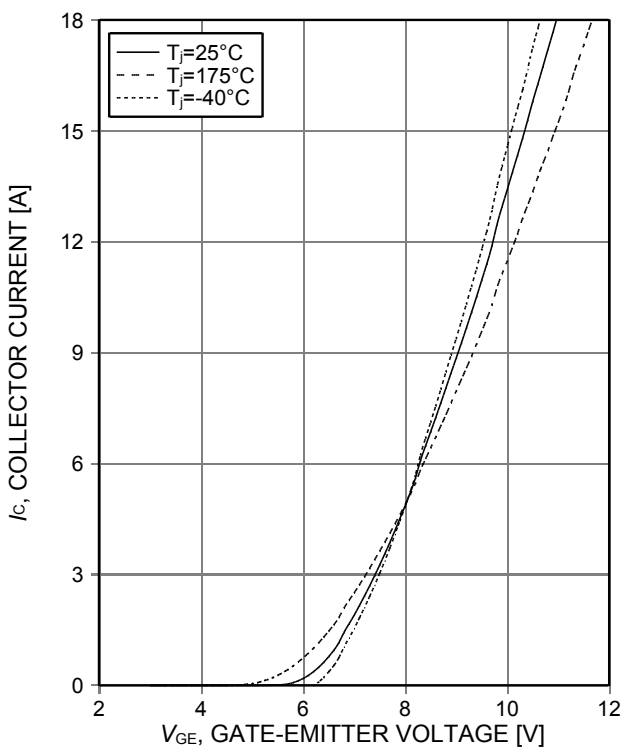


Figure 7. Typical transfer characteristic ( $V_{CE}=20\text{V}$ )

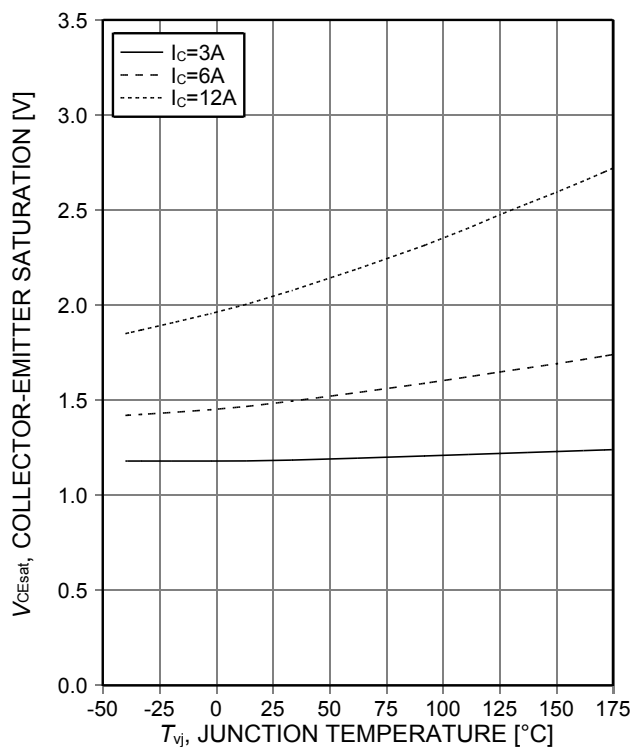


Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature ( $V_{GE}=15\text{V}$ )



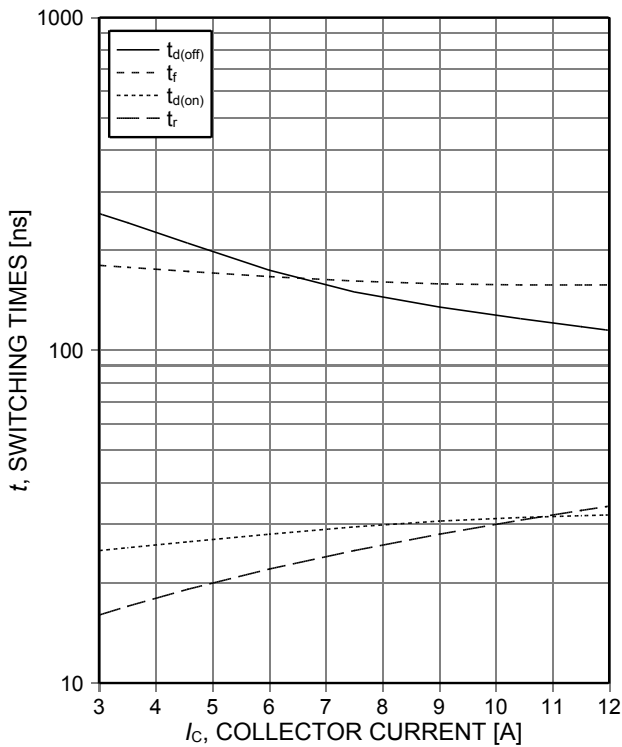


Figure 9. **Typical switching times as a function of collector current**  
 (inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=14.7\Omega$ , Dynamic test circuit in Figure E. Used diode: SDP04S60)

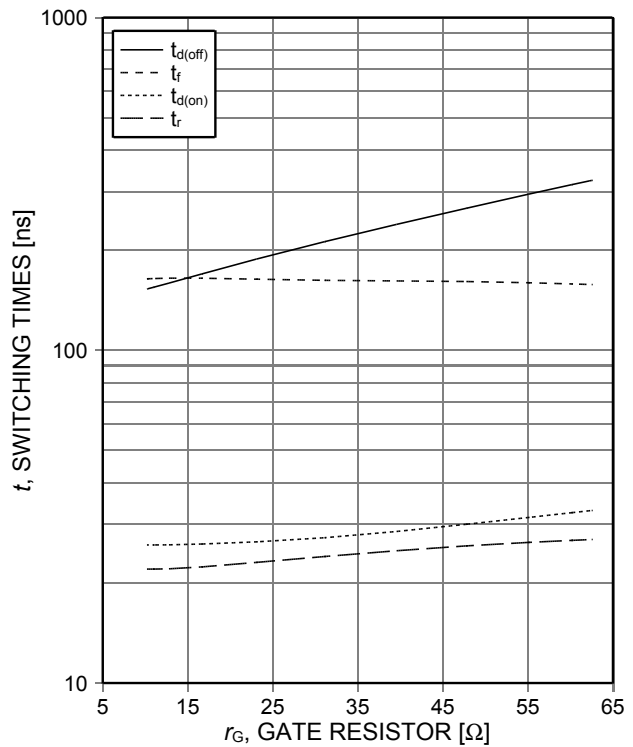


Figure 10. **Typical switching times as a function of gate resistor**  
 (inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=6\text{A}$ , Dynamic test circuit in Figure E. Used diode: SDP04S60)

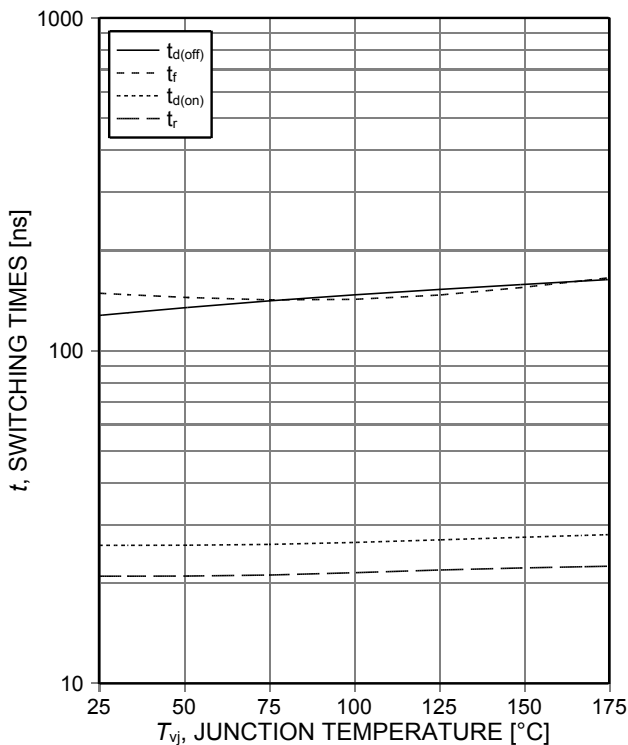


Figure 11. **Typical switching times as a function of junction temperature**  
 (inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=6\text{A}$ ,  $r_G=14.7\Omega$ , Dynamic test circuit in Figure E. Used diode: SDP04S60)

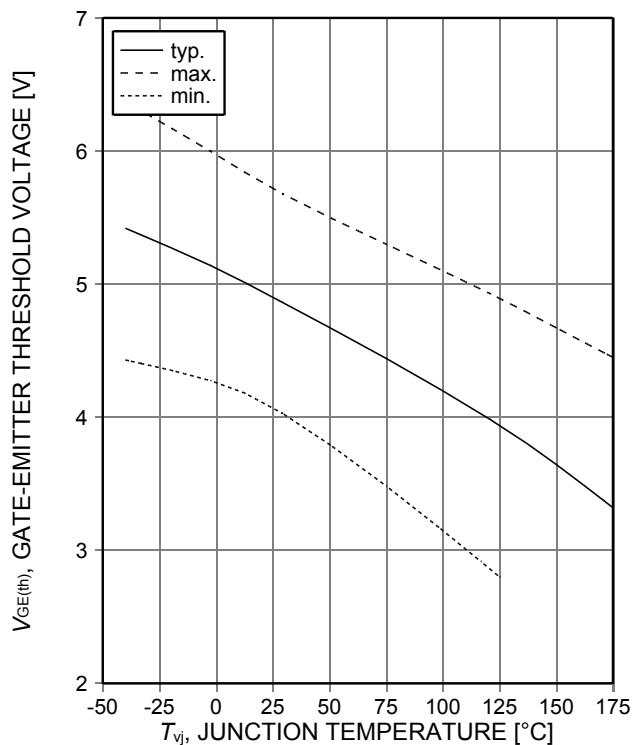


Figure 12. **Gate-emitter threshold voltage as a function of junction temperature**  
 ( $I_C=0.18\text{mA}$ )

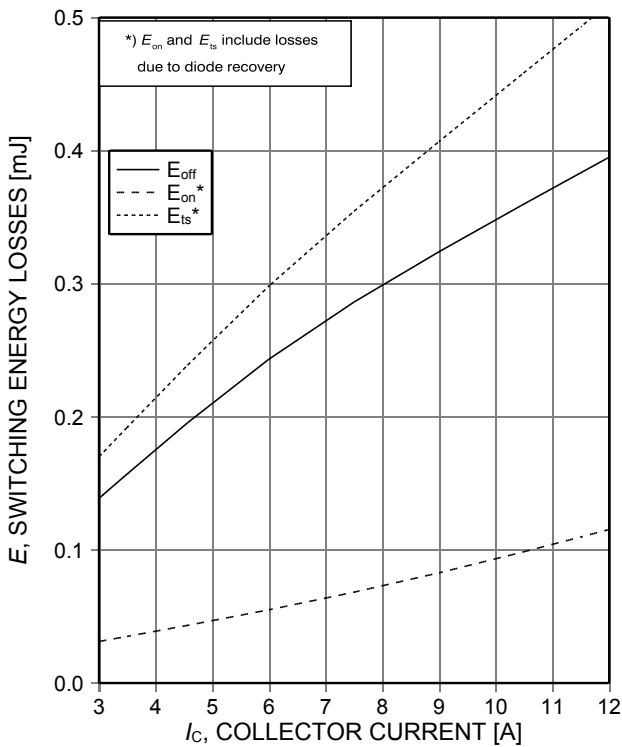


Figure 13. Typical switching energy losses as a function of collector current (inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $r_G=14.7\Omega$ , Dynamic test circuit in Figure E. Used diode: SDP04S60)

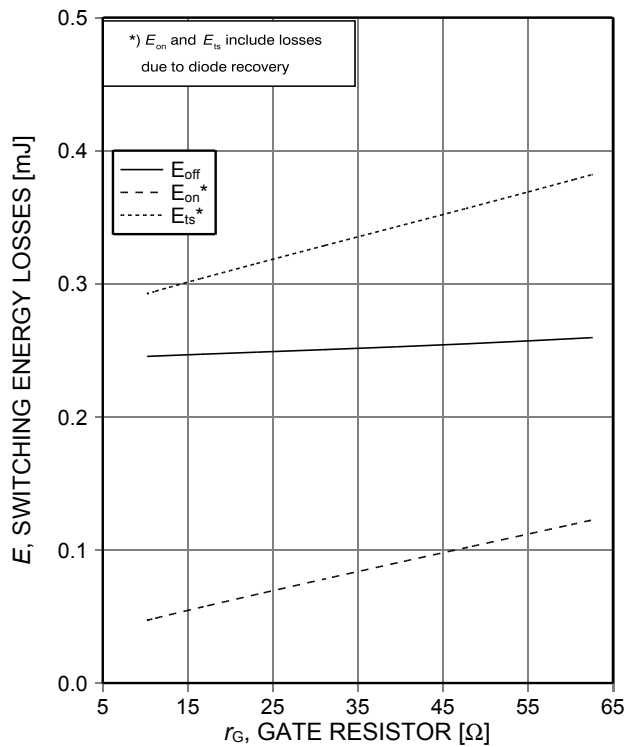


Figure 14. Typical switching energy losses as a function of gate resistor (inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=6\text{A}$ , Dynamic test circuit in Figure E. Used diode: SDP04S60)

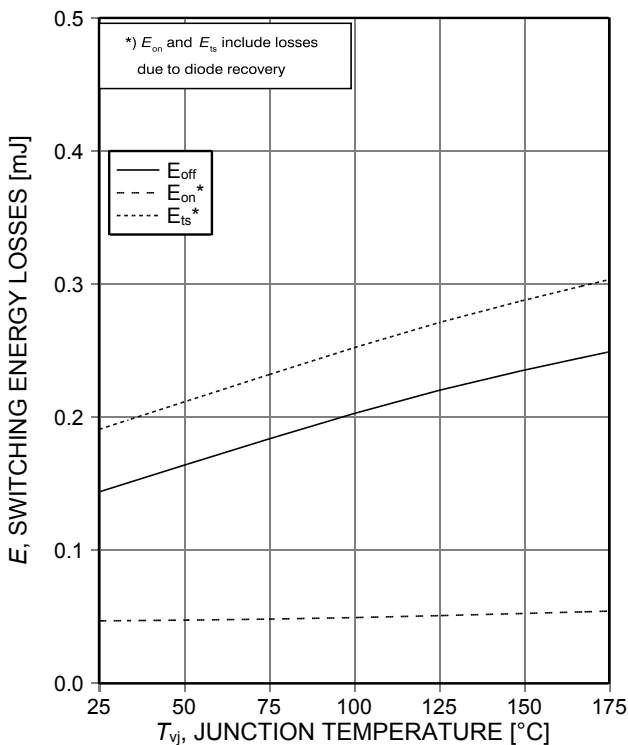


Figure 15. Typical switching energy losses as a function of junction temperature (inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=6\text{A}$ ,  $r_G=14.7\Omega$ , Dynamic test circuit in Figure E. Used diode: SDP04S60)

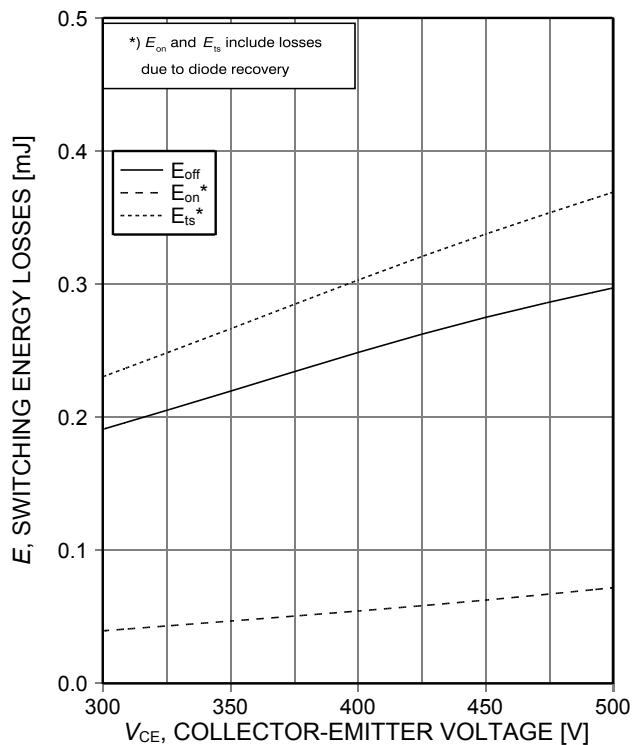


Figure 16. Typical switching energy losses as a function of collector emitter voltage (inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{GE}=15/0\text{V}$ ,  $I_C=6\text{A}$ ,  $r_G=14.7\Omega$ , Dynamic test circuit in Figure E. Used diode: SDP04S60)

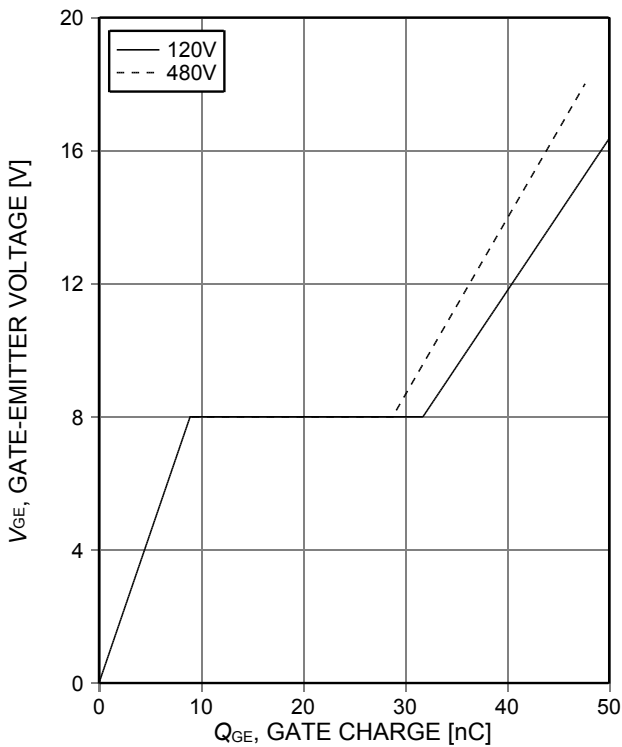


Figure 17. **Typical gate charge**  
( $I_C=6A$ )

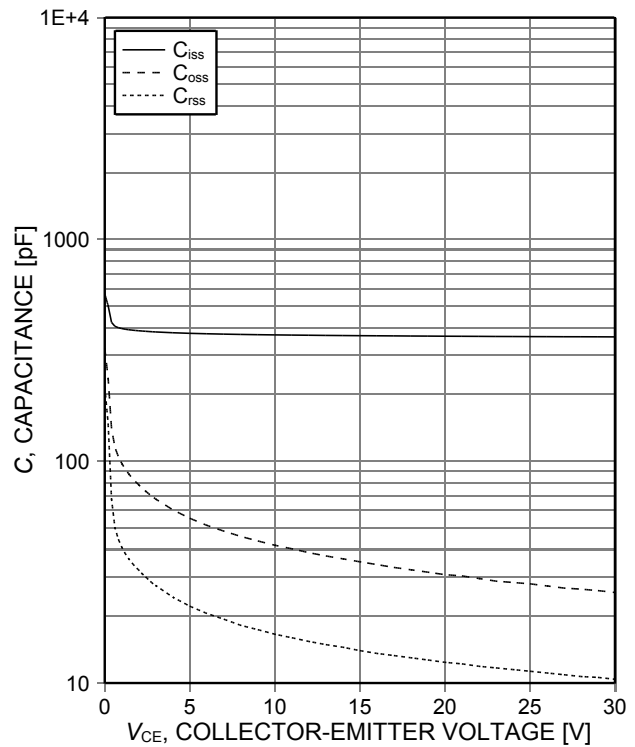


Figure 18. **Typical capacitance as a function of collector-emitter voltage**  
( $V_{GE}=0V$ ,  $f=1MHz$ )

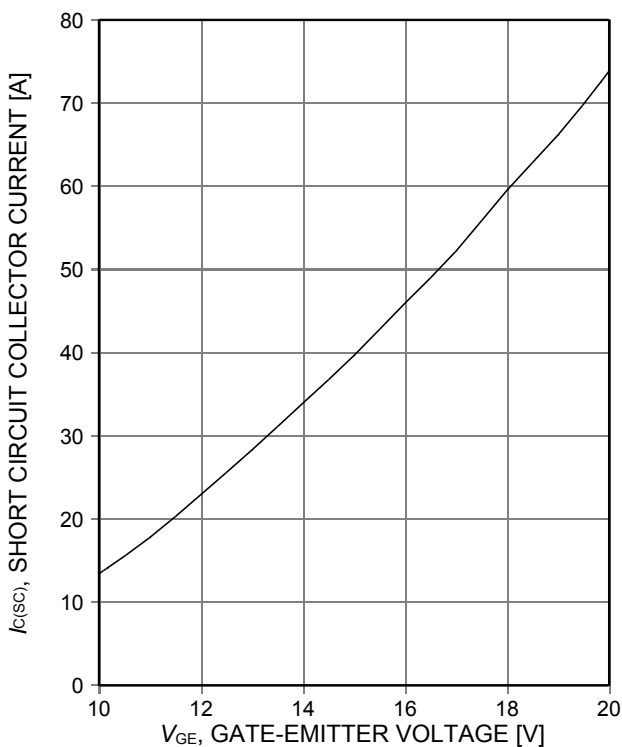


Figure 19. **Typical short circuit collector current as a function of gate-emitter voltage**  
( $V_{CE}=250V$ ,  $T_{vj}=150^{\circ}C$ )

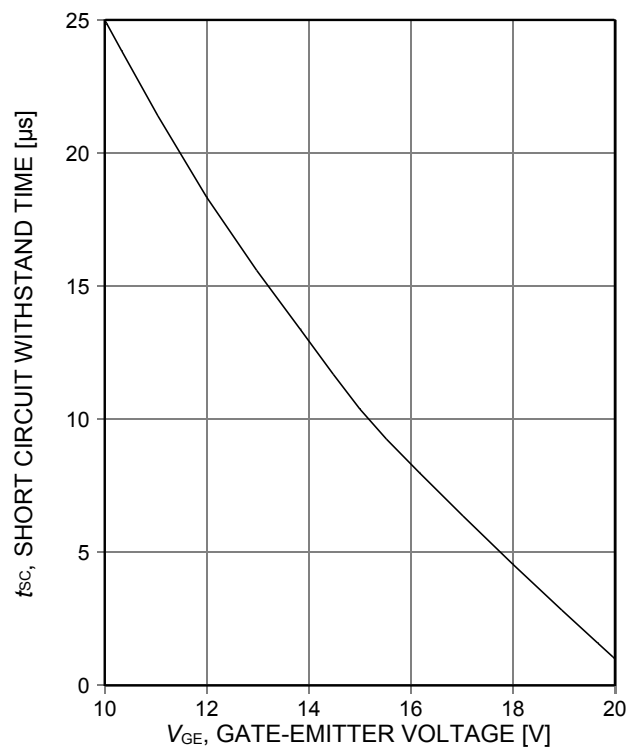


Figure 20. **Short circuit withstand time as a function of gate-emitter voltage**  
( $V_{CE}\leq 250V$ , start at  $T_{vj}\leq 150^{\circ}C$ )

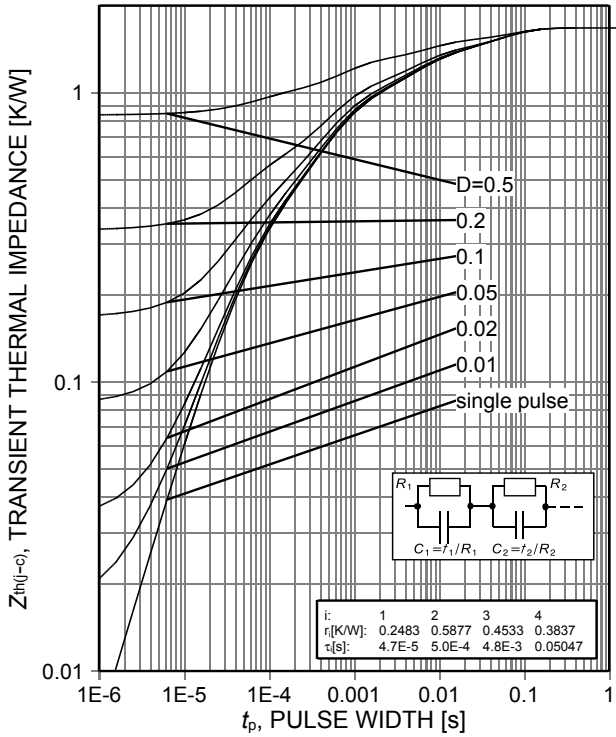


Figure 21. IGBT transient thermal impedance (D=t<sub>p</sub>/T)

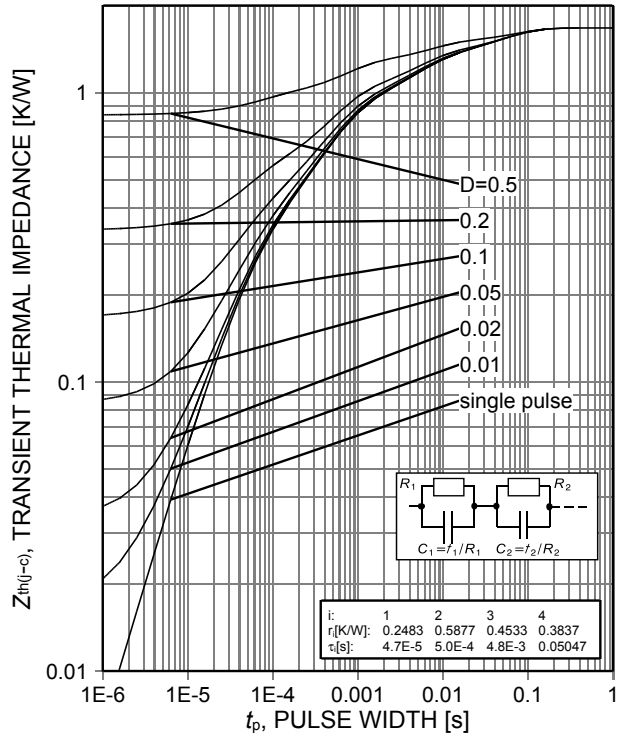


Figure 22. Diode transient thermal impedance as a function of pulse width (D=t<sub>p</sub>/T)

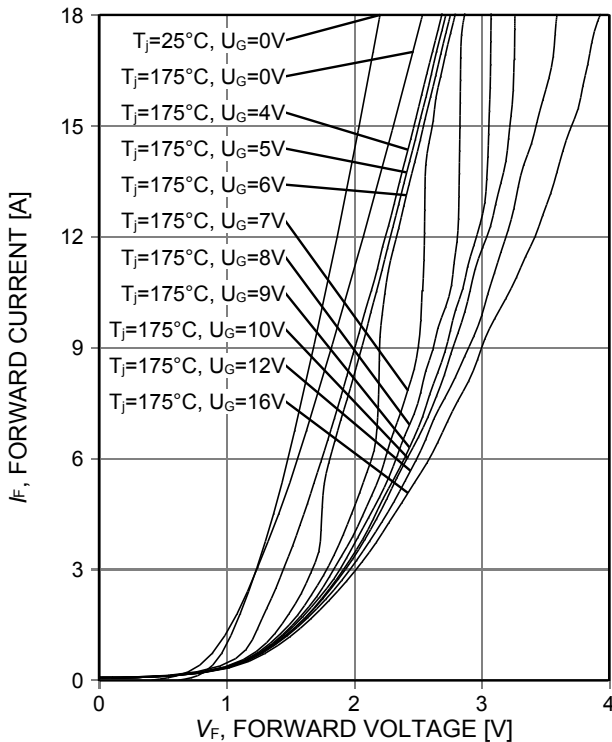


Figure 23. Typical diode forward current as a function of forward voltage

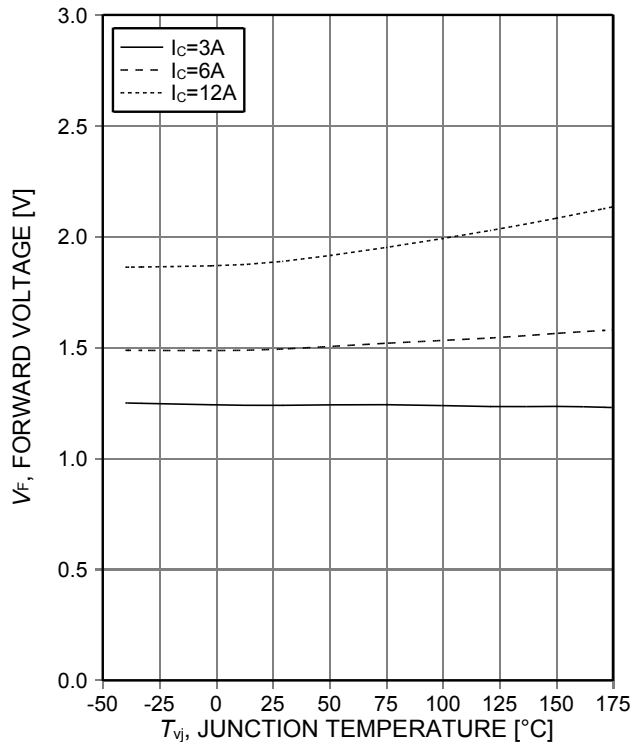
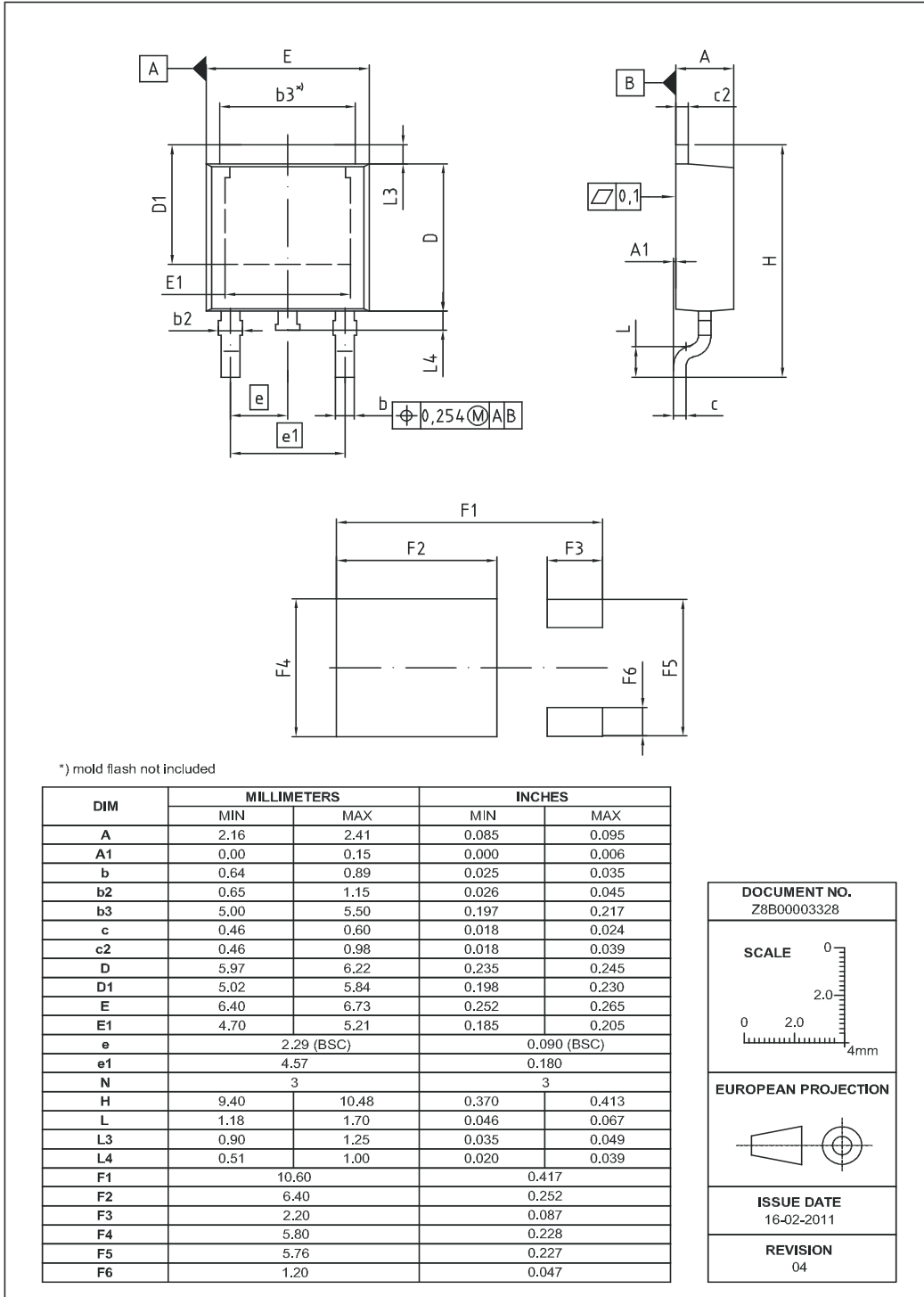


Figure 24. Typical diode forward voltage as a function of junction temperature

PG-TO252-3



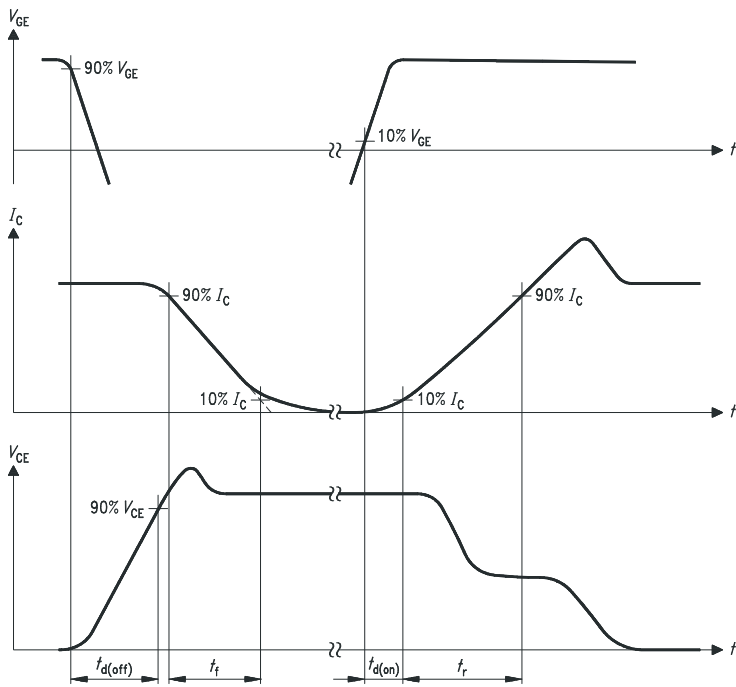


Figure A. Definition of switching times

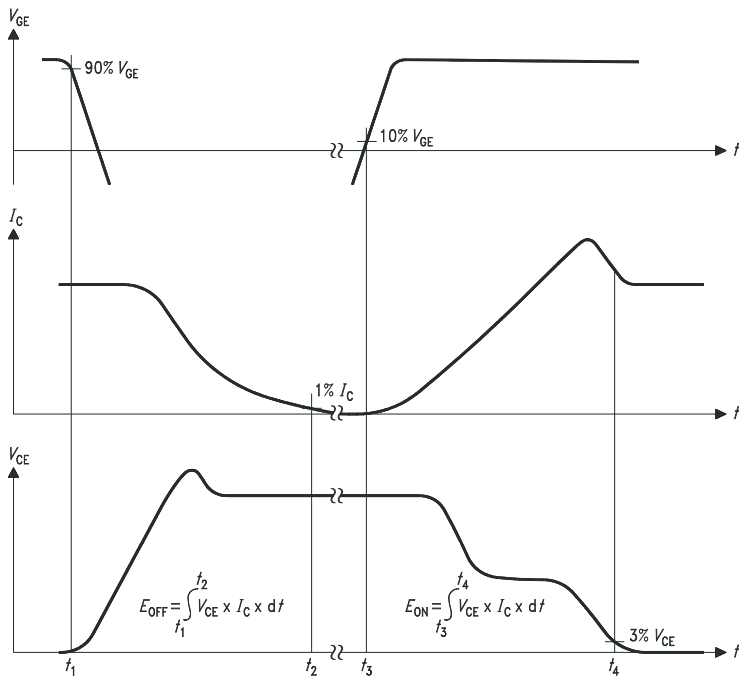


Figure B. Definition of switching losses

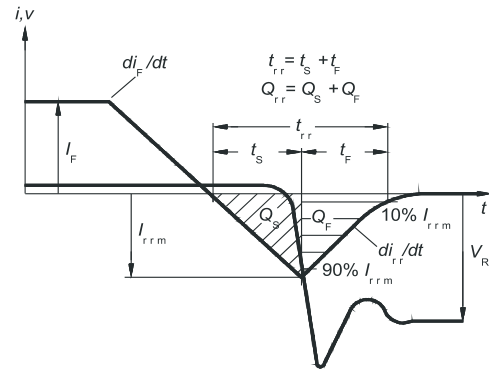


Figure C. Definition of diodes switching characteristics

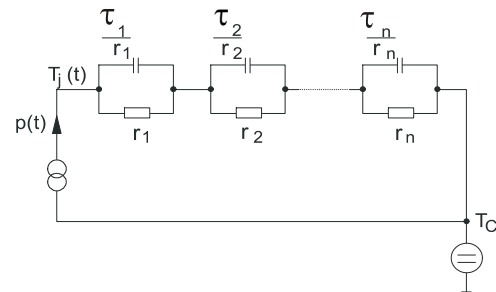


Figure D. Thermal equivalent circuit

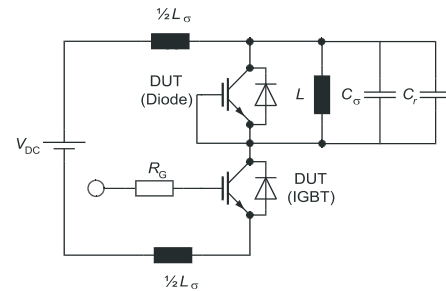


Figure E. Dynamic test circuit  
Parasitic inductance  $L_\sigma$ ,  
Parasitic capacitor  $C_\sigma$ ,  
Relief capacitor  $C_r$   
(only for ZVT switching)

**Revision History**

IHD06N60RA

**Revision: 2013-02-19, Rev. 2.1**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
0.1	2008-03-17	-
1.2	2008-07-22	-
1.3	2008-07-29	-
1.4	2009-07-14	-
2.1	2013-02-19	Final data sheet

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