

## TRENCHSTOP™ RC-Series for hard switching applications

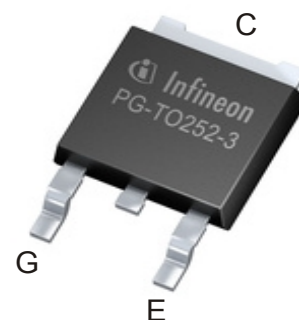
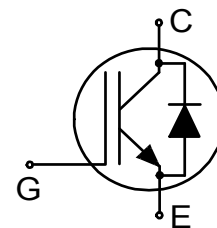
IGBT with integrated diode in packages offering space saving advantage

### Features:

TRENCHSTOP™ Reverse Conducting (RC) technology for 600V applications offering

- Optimised  $V_{CEsat}$  and  $V_F$  for low conduction losses
- Smooth switching performance leading to low EMI levels
- Very tight parameter distribution
- Operating range of 1 to 20kHz
- Maximum junction temperature 175°C
- Dynamically stress tested
- Short circuit capability of 5µs
- Best in class current versus package size performance
- Qualified according to AECQ101
- Pb-free lead plating; RoHS compliant (for PG-TO252: solder temperature 260°C, MSL1)

Complete product spectrum and PSpice Models:  
<http://www.infineon.com/igbt/>



### Applications:

- HID lighting
- Piezo injection



### Key Performance and Package Parameters

Type	$V_{CE}$	$I_C$	$V_{CEsat}, T_{vj}=25^\circ\text{C}$	$T_{vjmax}$	Marking	Package
AIHD04N60R	600V	4A	1.65V	175°C	AH04DR	PG-TO252-3

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## TRENCHSTOP™ RC-Series for hard switching applications

## Maximum Ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage	$V_{CE}$	600	V
DC collector current, limited by $T_{vjmax}$ $T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$	$I_C$	8.0 4.0	A
Pulsed collector current, $t_p$ limited by $T_{vjmax}$	$I_{Cpuls}$	12.0	A
Turn off safe operating area $V_{CE} \leq 600\text{V}$ , $T_{vj} \leq 175^\circ\text{C}$	-	12.0	A
Diode forward current, limited by $T_{vjmax}$ $T_C = 25^\circ\text{C}$ $T_C = 100^\circ\text{C}$	$I_F$	8.0 4.0	A
Diode pulsed current, $t_p$ limited by $T_{vjmax}$	$I_{Fpuls}$	12.0	A
Gate-emitter voltage	$V_{GE}$	$\pm 20$	V
Short circuit withstand time $V_{GE} = 15.0\text{V}$ , $V_{CC} \leq 400\text{V}$ Allowed number of short circuits < 1000 Time between short circuits: $\geq 1.0\text{s}$ $T_{vj} = 150^\circ\text{C}$	$t_{SC}$	5	$\mu\text{s}$
Power dissipation $T_C = 25^\circ\text{C}$	$P_{tot}$	75.0	W
Operating junction temperature	$T_{vj}$	-40...+175	$^\circ\text{C}$
Storage temperature	$T_{stg}$	-55...+175	$^\circ\text{C}$
Soldering temperature, reflow soldering (MSL1 according to JEDEC J-STA-020)		260	$^\circ\text{C}$

## Thermal Resistance

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b><math>R_{th}</math> Characteristics</b>						
IGBT thermal resistance, junction - case	$R_{th(j-c)}$		-	-	2.00	K/W
Diode thermal resistance, junction - case	$R_{th(j-c)}$		-	-	4.50	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

## TRENCHSTOP™ RC-Series for hard switching applications

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	$V_{CEsat}$	$V_{GE} = 15.0\text{V}, I_C = 4.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	1.65 1.85	2.10 -	V
Diode forward voltage	$V_F$	$V_{GE} = 0\text{V}, I_F = 4.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	1.70 1.70	2.10 -	V
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C = 0.07\text{mA}, V_{CE} = V_{GE}$	4.3	5.0	5.7	V
Zero gate voltage collector current	$I_{CES}$	$V_{CE} = 600\text{V}, V_{GE} = 0\text{V}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	- 180	40 -	$\mu\text{A}$
Gate-emitter leakage current	$I_{GES}$	$V_{CE} = 0\text{V}, V_{GE} = 20\text{V}$	-	-	100	nA
Transconductance	$g_{fs}$	$V_{CE} = 20\text{V}, I_C = 4.0\text{A}$	-	2.2	-	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	$C_{ies}$	$V_{CE} = 25\text{V}, V_{GE} = 0\text{V}, f = 1\text{MHz}$	-	305	-	pF
Output capacitance	$C_{oes}$		-	18	-	
Reverse transfer capacitance	$C_{res}$		-	9	-	
Gate charge	$Q_G$	$V_{CC} = 480\text{V}, I_C = 4.0\text{A},$ $V_{GE} = 15\text{V}$	-	27.0	-	nC
Short circuit collector current Max. 1000 short circuits Time between short circuits: $\geq 1.0\text{s}$	$I_{C(SC)}$	$V_{GE} = 15.0\text{V}, V_{CC} \leq 400\text{V},$ $t_{SC} \leq 5\mu\text{s}$ $T_{vj} = 25^{\circ}\text{C}$	-	31	-	A

## Switching Characteristic, Inductive Load

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b>IGBT Characteristic, at <math>T_{vj} = 25^{\circ}\text{C}</math></b>						
Turn-on delay time	$t_{d(on)}$	$T_{vj} = 25^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 4.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $R_{G(on)} = 43.0\Omega, R_{G(off)} = 43.0\Omega,$ $L_{\sigma} = 60\text{nH}, C_{\sigma} = 40\text{pF}$ $L_{\sigma}, C_{\sigma}$ from Fig. E	-	14	-	ns
Rise time	$t_r$		-	8	-	ns
Turn-off delay time	$t_{d(off)}$		-	146	-	ns
Fall time	$t_f$		-	171	-	ns
Turn-on energy	$E_{on}$		-	0.09	-	mJ
Turn-off energy	$E_{off}$		-	0.15	-	mJ
Total switching energy	$E_{ts}$		-	0.24	-	mJ

## TRENCHSTOP™ RC-Series for hard switching applications

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

Diode reverse recovery time	$t_{rr}$	$T_{vj} = 25^{\circ}\text{C},$ $V_R = 400\text{V},$ $I_F = 4.0\text{A},$ $di_F/dt = 600\text{A}/\mu\text{s}$	-	43	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	0.22	-	$\mu\text{C}$
Diode peak reverse recovery current	$I_{rrm}$		-	7.6	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	-330	-	$\text{A}/\mu\text{s}$

## Switching Characteristic, Inductive Load

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	

IGBT Characteristic, at  $T_{vj} = 175^{\circ}\text{C}$ 

Turn-on delay time	$t_{d(on)}$	$T_{vj} = 175^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 4.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $R_{G(on)} = 43.0\Omega, R_{G(off)} = 43.0\Omega,$ $L\sigma = 60\text{nH}, C\sigma = 40\text{pF}$ $L\sigma, C\sigma$ from Fig. E	-	12	-	ns
Rise time	$t_r$		-	8	-	ns
Turn-off delay time	$t_{d(off)}$		-	177	-	ns
Fall time	$t_f$		-	165	-	ns
Turn-on energy	$E_{on}$		-	0.16	-	mJ
Turn-off energy	$E_{off}$		-	0.24	-	mJ
Total switching energy	$E_{ts}$		-	0.40	-	mJ

Diode Characteristic, at  $T_{vj} = 175^{\circ}\text{C}$ 

Diode reverse recovery time	$t_{rr}$	$T_{vj} = 175^{\circ}\text{C},$ $V_R = 400\text{V},$ $I_F = 4.0\text{A},$ $di_F/dt = 600\text{A}/\mu\text{s}$	-	98	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	0.52	-	$\mu\text{C}$
Diode peak reverse recovery current	$I_{rrm}$		-	11.0	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	-200	-	$\text{A}/\mu\text{s}$

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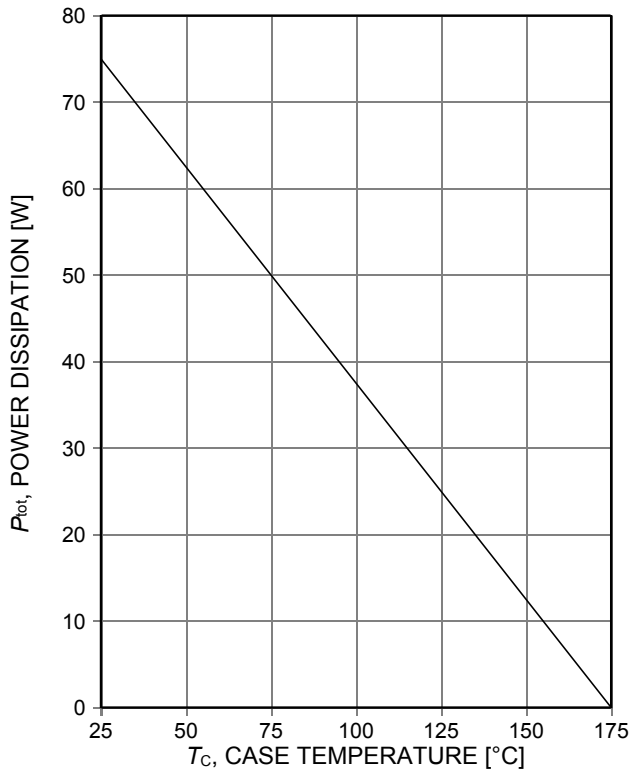


Figure 1. Power dissipation as a function of case temperature ( $T_{vj} \leq 175^\circ\text{C}$ )

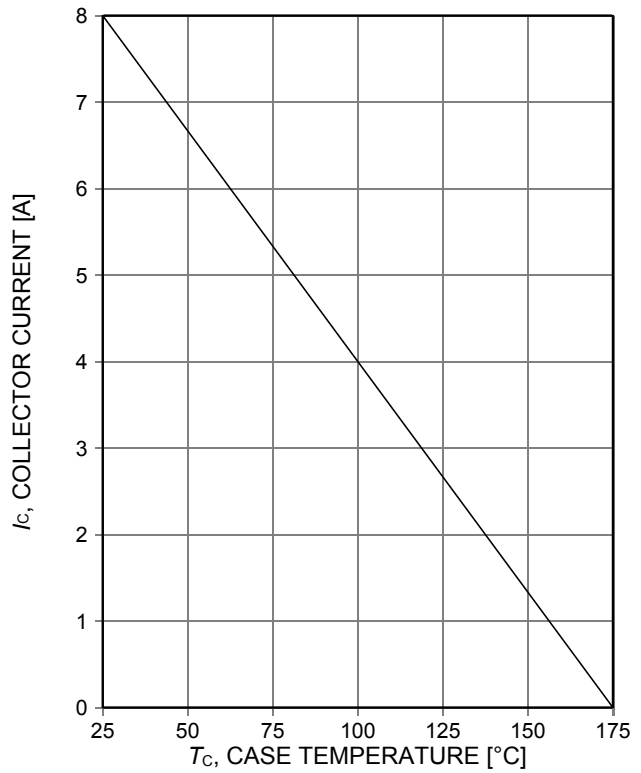


Figure 2. Collector current as a function of case temperature ( $V_{GE} \geq 15\text{V}$ ,  $T_{vj} \leq 175^\circ\text{C}$ )

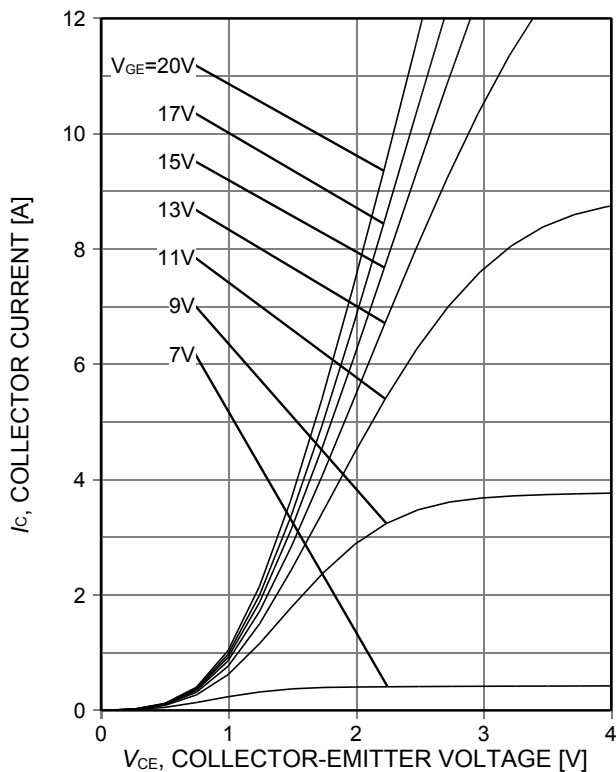


Figure 3. Typical output characteristic ( $T_{vj} = 25^\circ\text{C}$ )

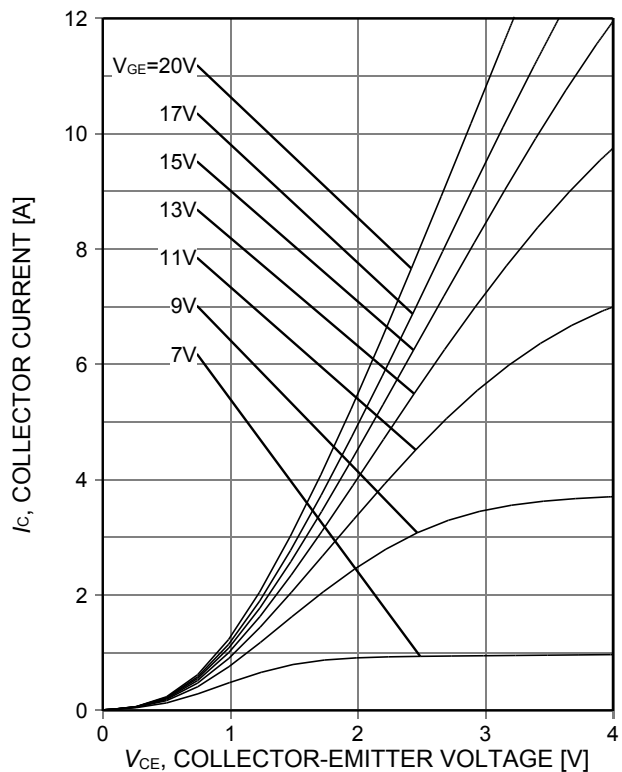


Figure 4. Typical output characteristic ( $T_{vj} = 175^\circ\text{C}$ )

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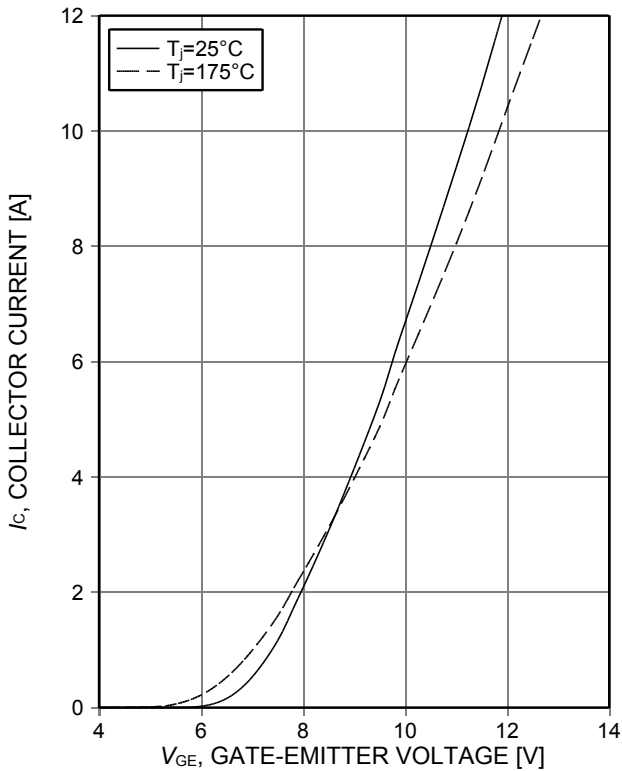


Figure 5. Typical transfer characteristic (V<sub>CE</sub>=10V)

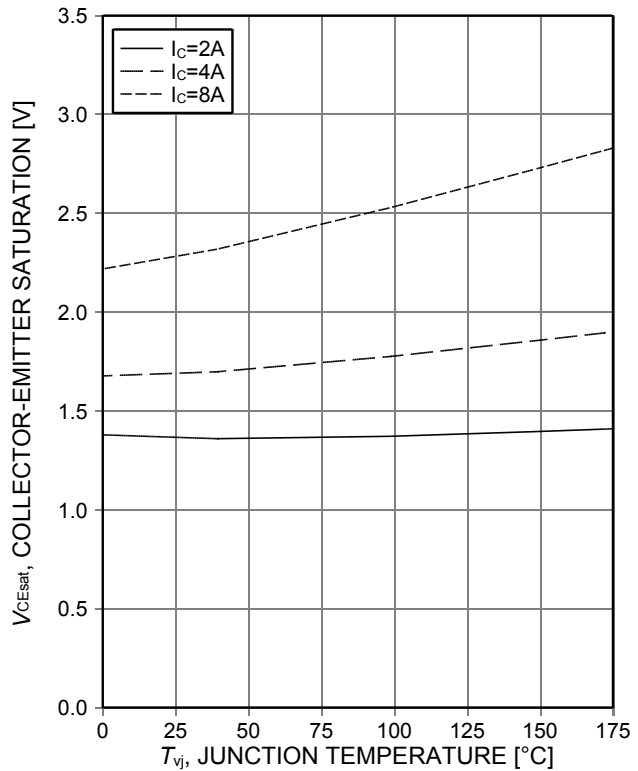


Figure 6. Typical collector-emitter saturation voltage as a function of junction temperature (V<sub>GE</sub>=15V)

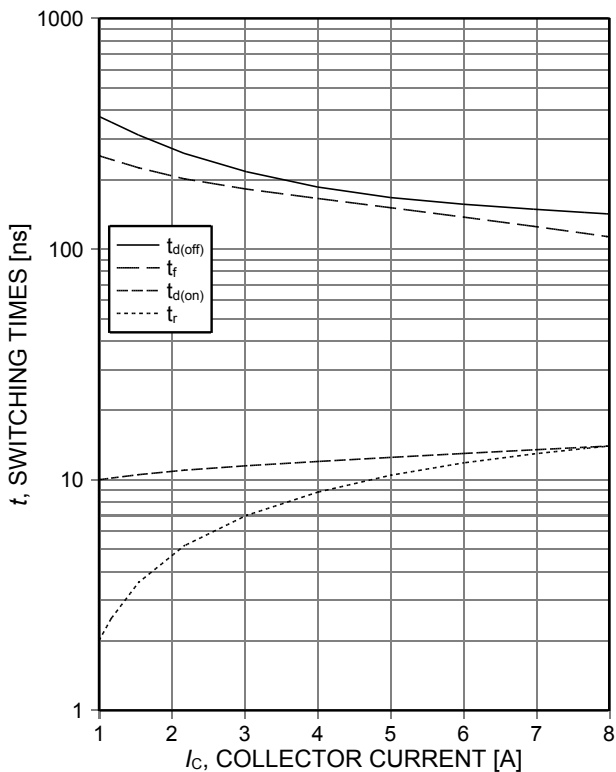


Figure 7. Typical switching times as a function of collector current (inductive load, T<sub>vj</sub>=175°C, V<sub>CE</sub>=400V, V<sub>GE</sub>=15/0V, r<sub>G</sub>=43Ω, Dynamic test circuit in Figure E)

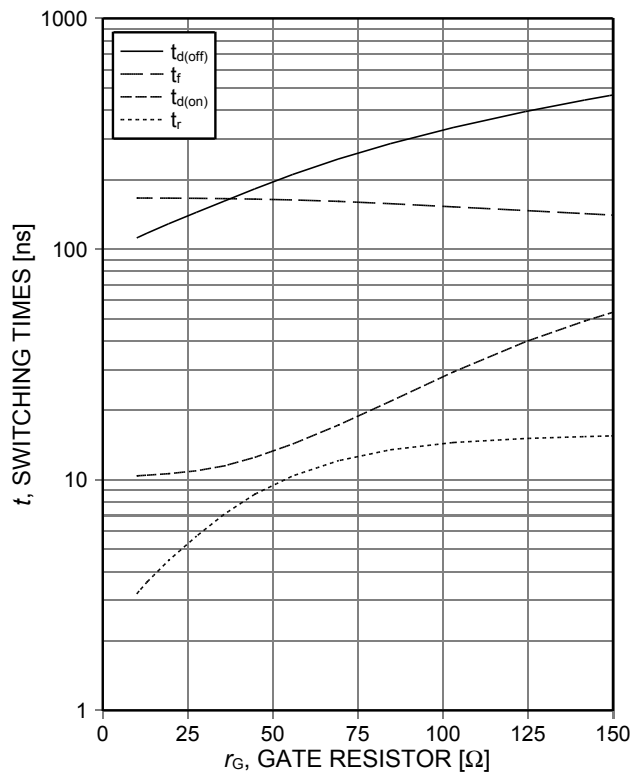


Figure 8. Typical switching times as a function of gate resistor (inductive load, T<sub>vj</sub>=175°C, V<sub>CE</sub>=400V, V<sub>GE</sub>=15/0V, I<sub>C</sub>=4A, Dynamic test circuit in Figure E)

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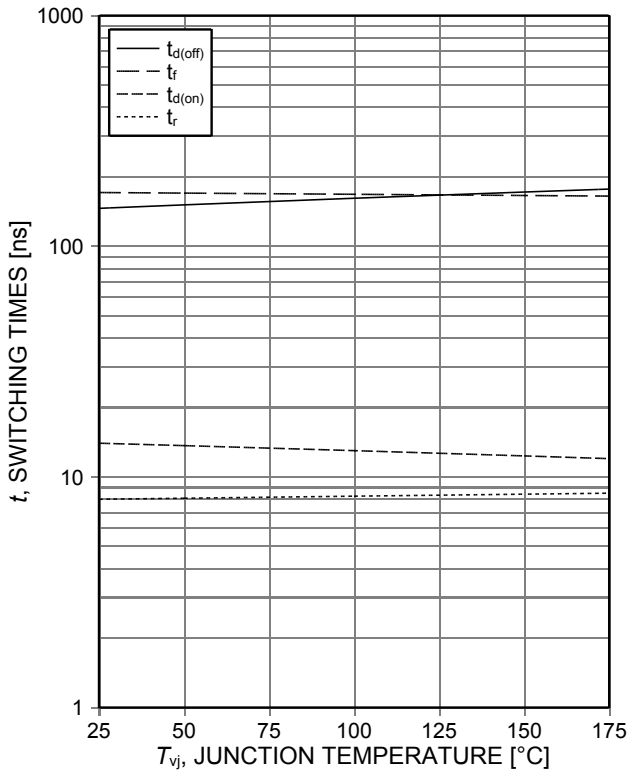


Figure 9. **Typical switching times as a function of junction temperature**  
(inductive load,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=4A$ ,  $r_G=43\Omega$ , Dynamic test circuit in Figure E)

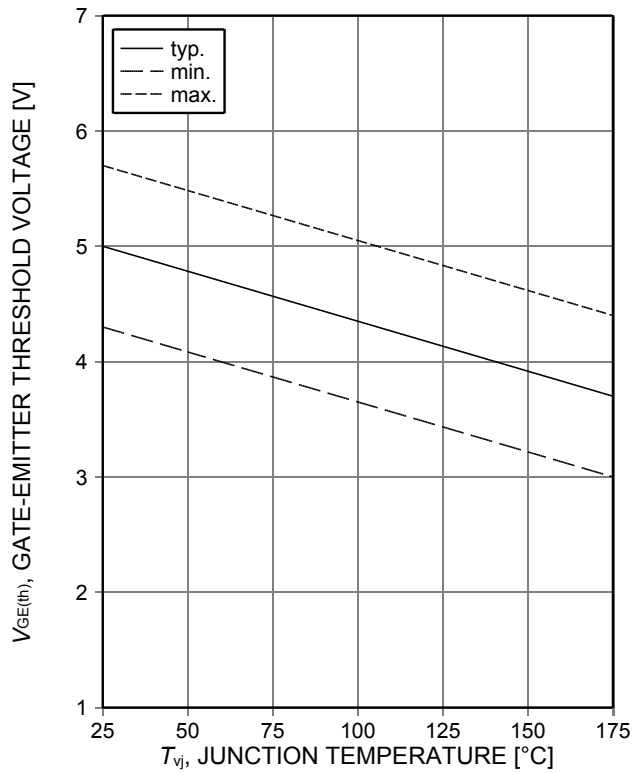


Figure 10. **Gate-emitter threshold voltage as a function of junction temperature**  
( $I_C=0,07mA$ )

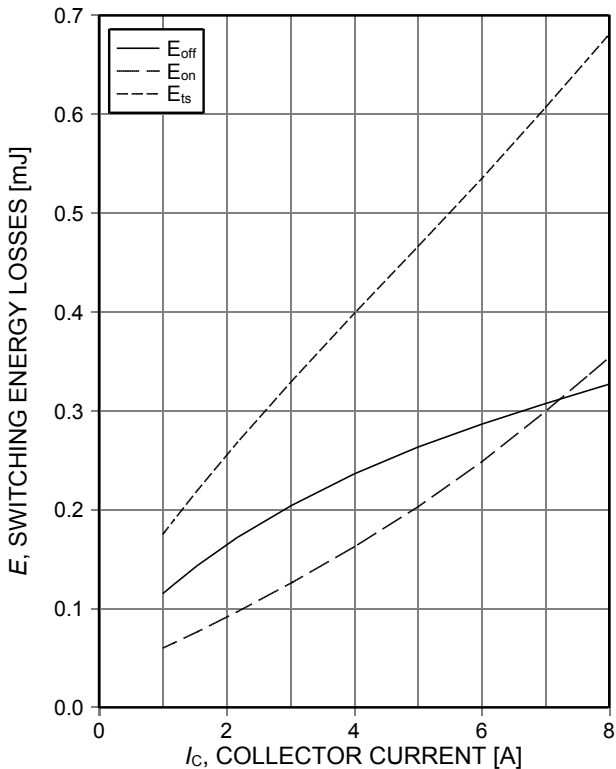


Figure 11. **Typical switching energy losses as a function of collector current**  
(inductive load,  $T_{vj}=175^\circ C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $r_G=43\Omega$ , Dynamic test circuit in Figure E)

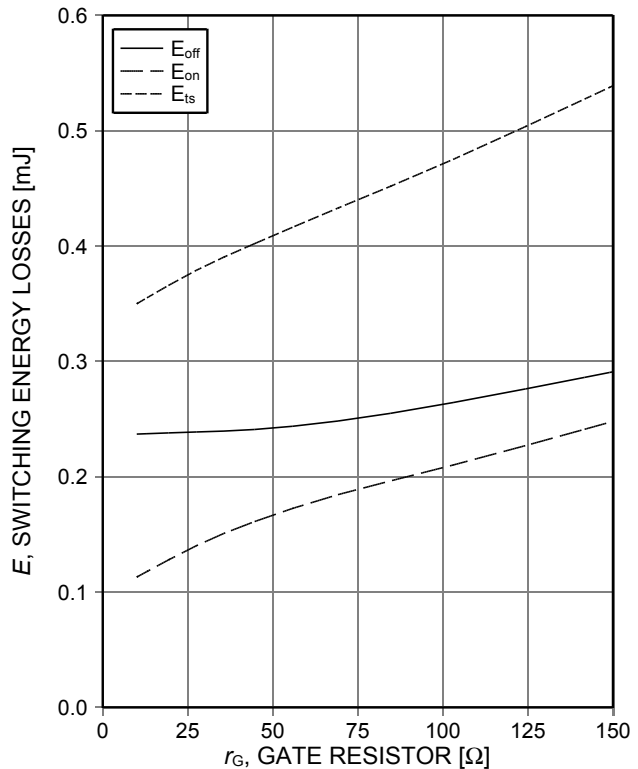


Figure 12. **Typical switching energy losses as a function of gate resistor**  
(inductive load,  $T_{vj}=175^\circ C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=4A$ , Dynamic test circuit in Figure E)

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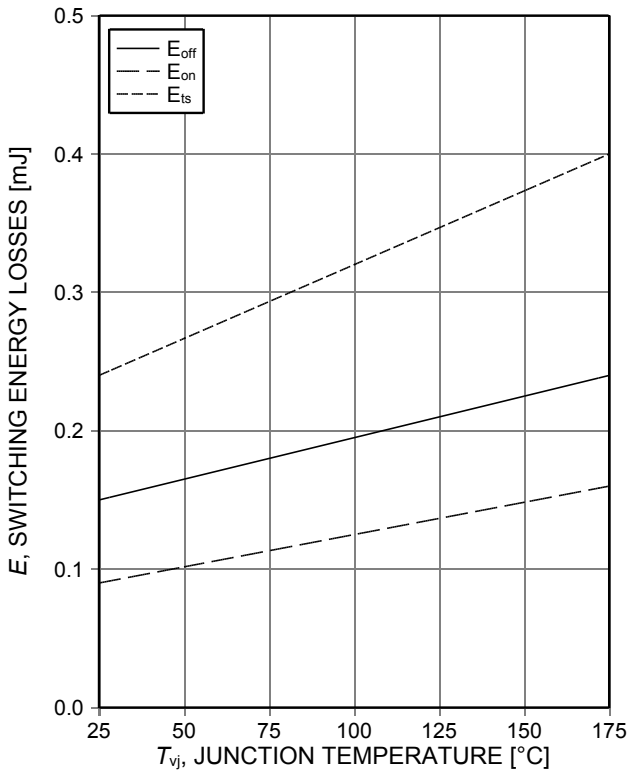


Figure 13. **Typical switching energy losses as a function of junction temperature** (inductive load,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=4A$ ,  $r_G=43\Omega$ , Dynamic test circuit in Figure E)

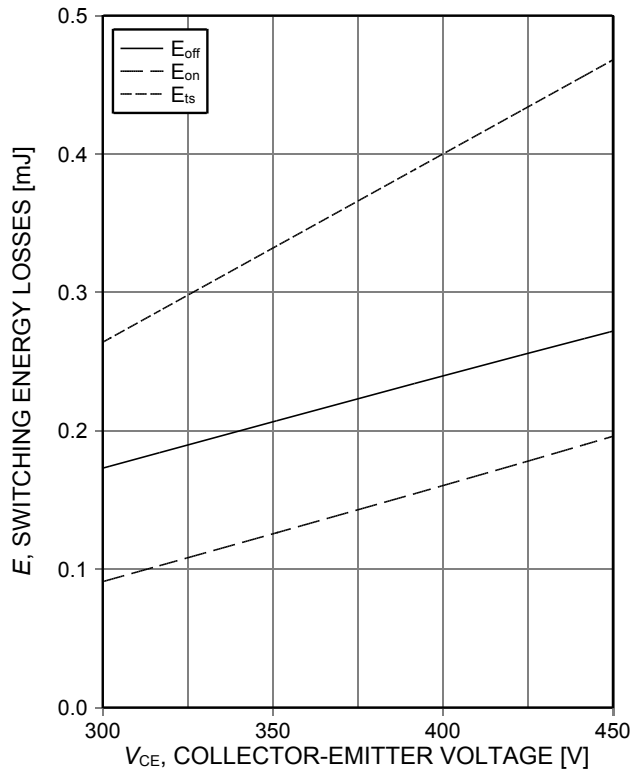


Figure 14. **Typical switching energy losses as a function of collector-emitter voltage** (inductive load,  $T_{vj}=175^\circ C$ ,  $V_{GE}=15/0V$ ,  $I_C=4A$ ,  $r_G=43\Omega$ , Dynamic test circuit in Figure E)

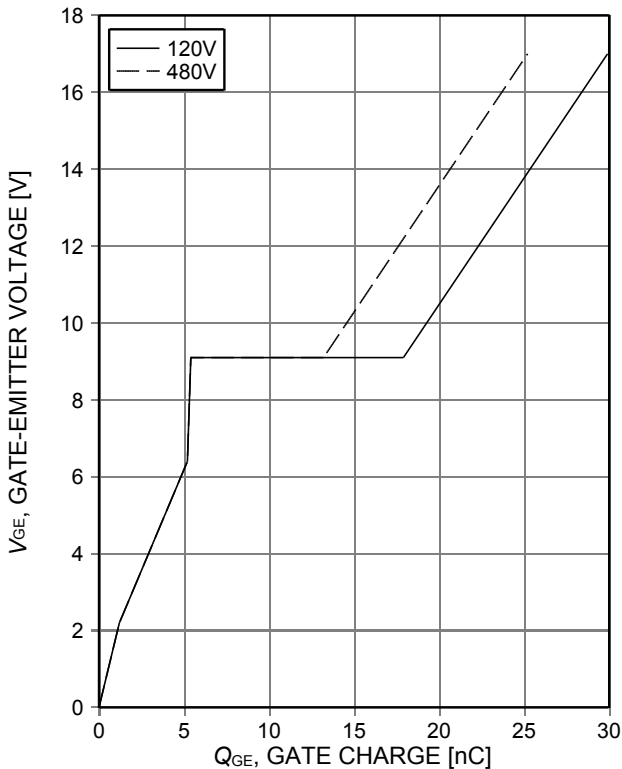


Figure 15. **Typical gate charge** ( $I_C=4A$ )

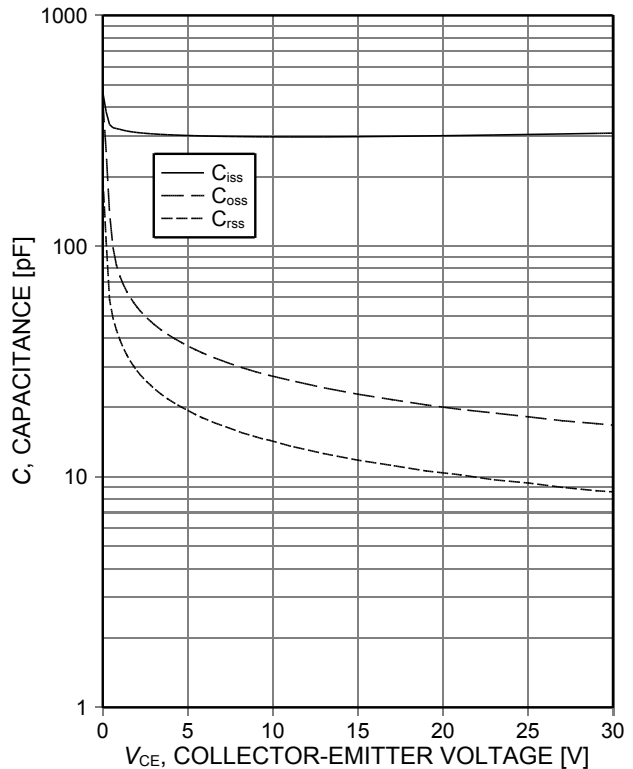


Figure 16. **Typical capacitance as a function of collector-emitter voltage** ( $V_{GE}=0V$ ,  $f=1MHz$ )

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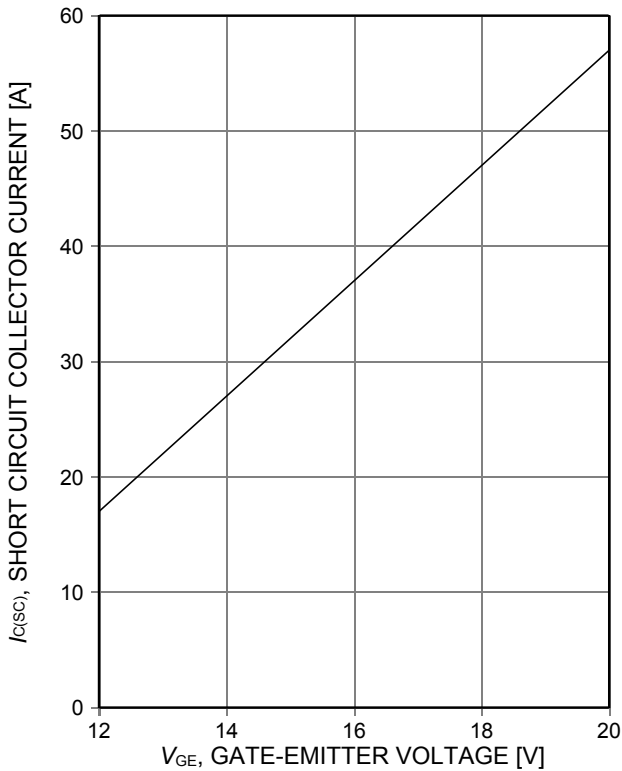


Figure 17. Typical short circuit collector current as a function of gate-emitter voltage (V<sub>CE</sub>≤400V, start at T<sub>vj</sub>=25°C)

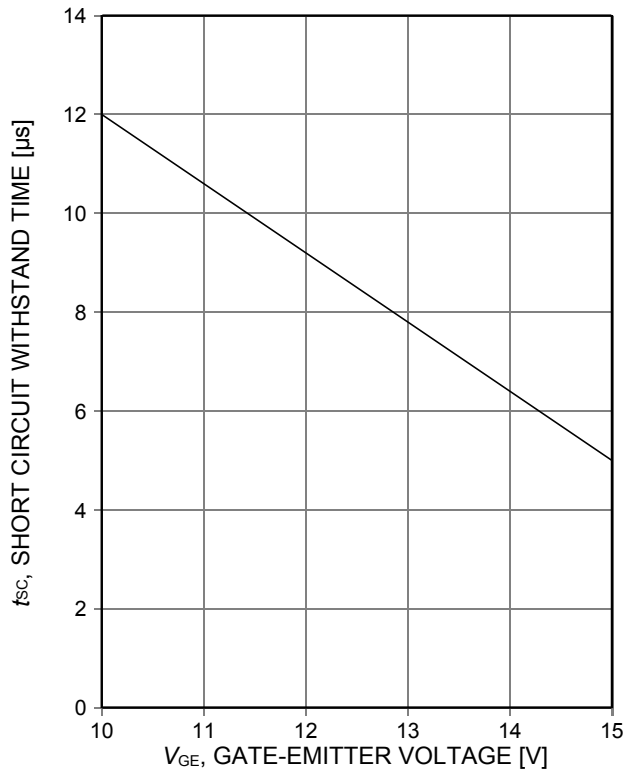


Figure 18. Short circuit withstand time as a function of gate-emitter voltage (V<sub>CE</sub>≤400V, start at T<sub>vj</sub>=150°C)

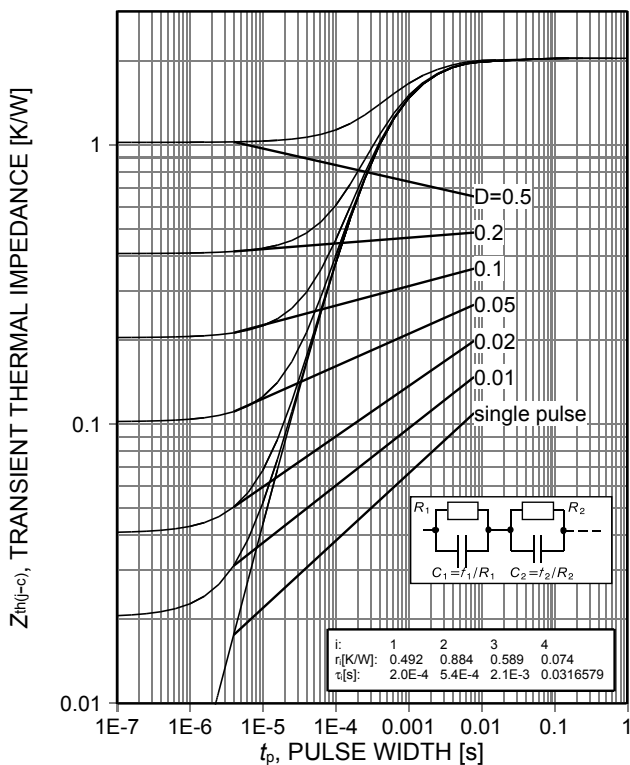


Figure 19. IGBT transient thermal impedance <sup>1)</sup> (D=t<sub>p</sub>/T)

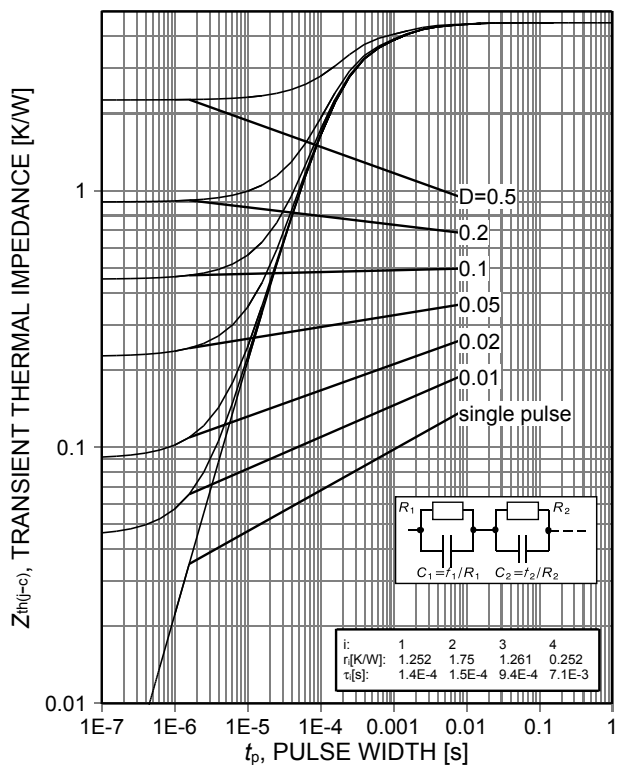


Figure 20. Diode transient thermal impedance as a function of pulse width <sup>1)</sup> (D=t<sub>p</sub>/T)

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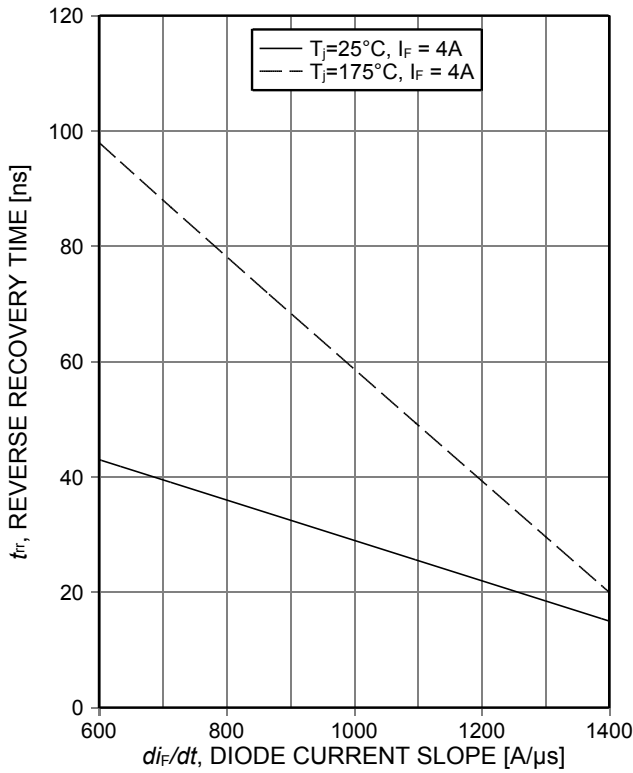


Figure 21. Typical reverse recovery time as a function of diode current slope (V<sub>R</sub>=400V)

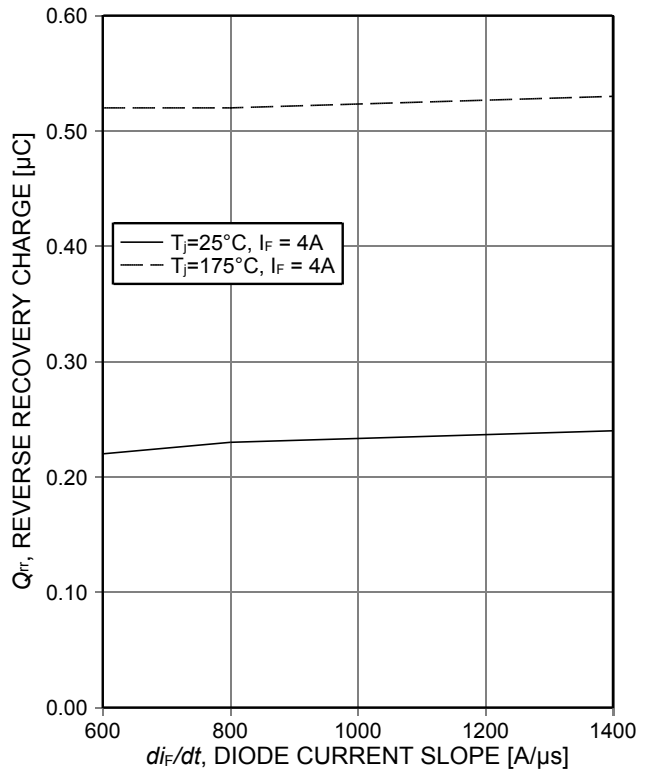


Figure 22. Typical reverse recovery charge as a function of diode current slope (V<sub>R</sub>=400V)

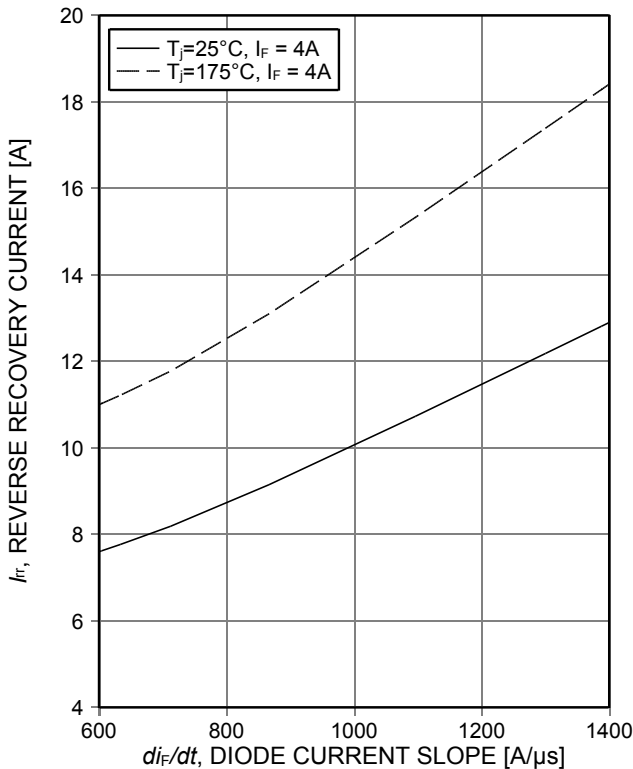


Figure 23. Typical reverse recovery current as a function of diode current slope (V<sub>R</sub>=400V)

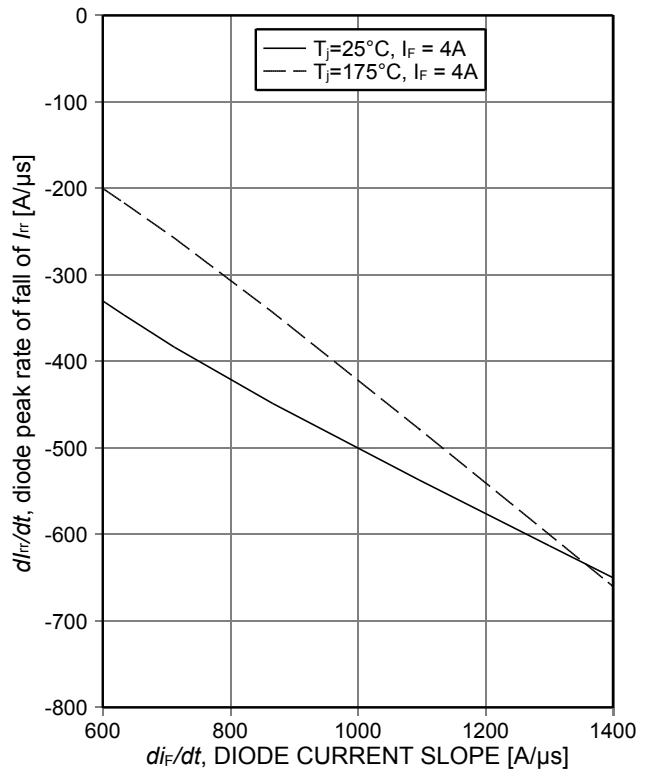


Figure 24. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope (V<sub>R</sub>=400V)

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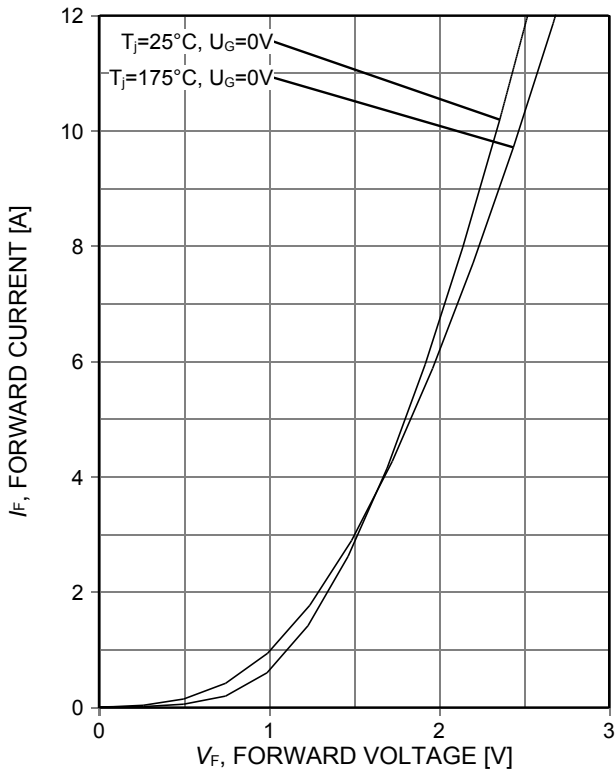


Figure 25. Typical diode forward current as a function of forward voltage

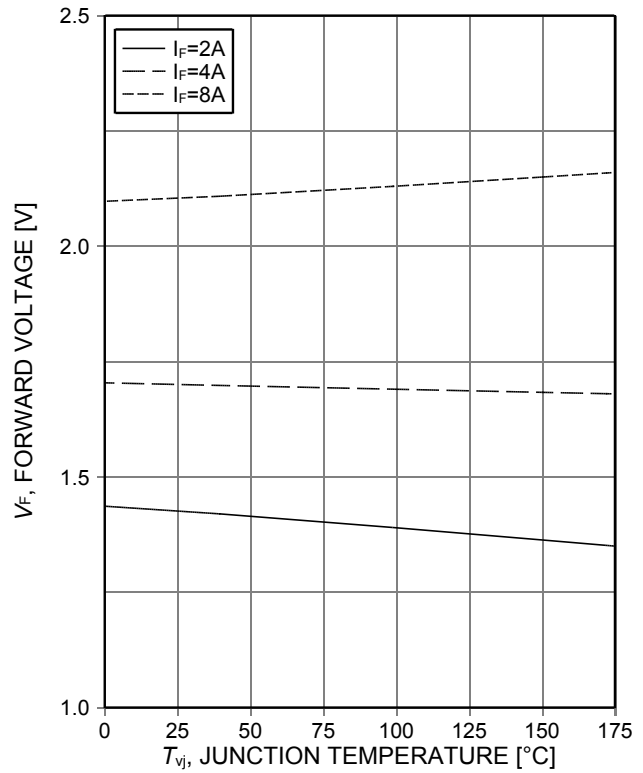
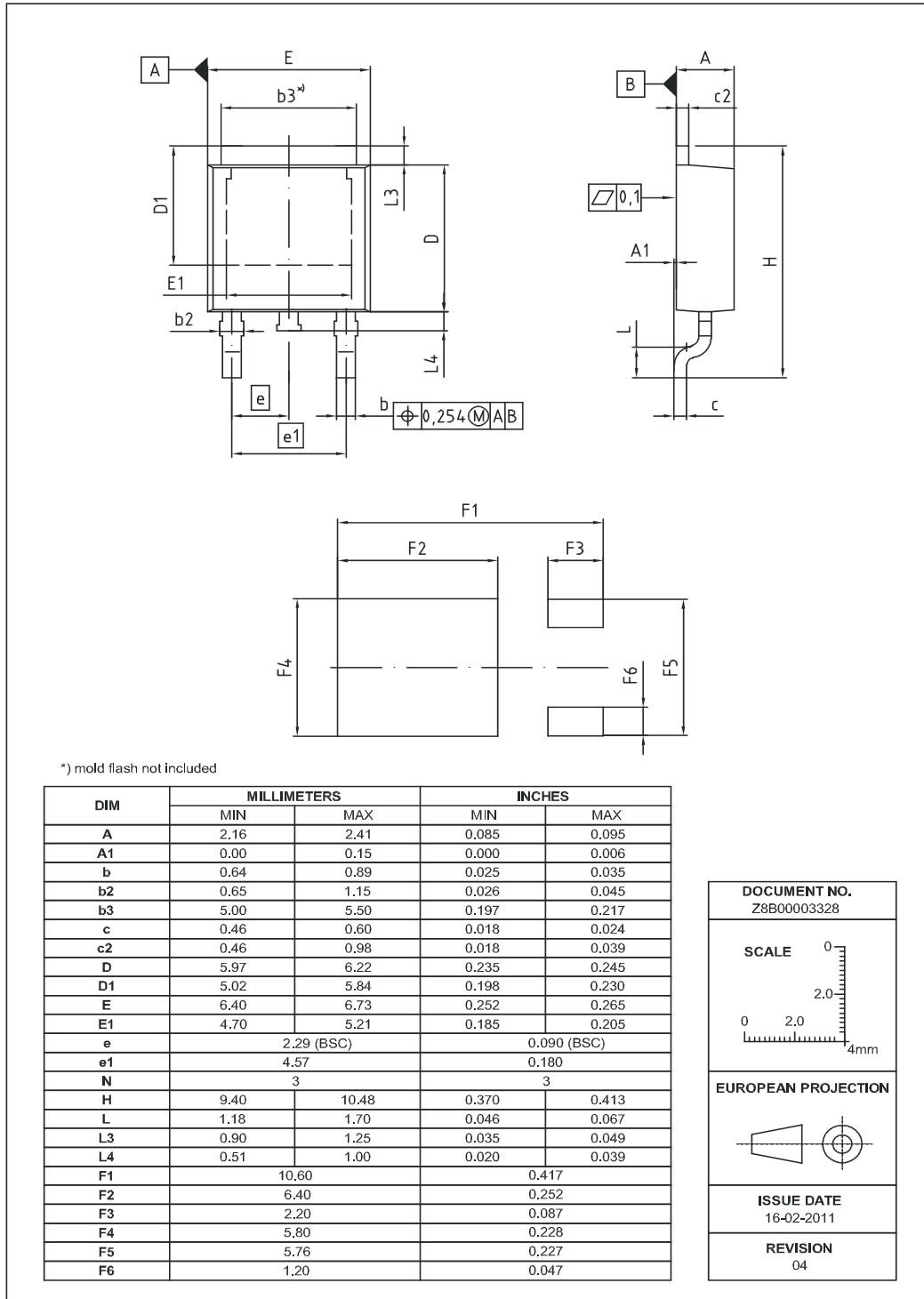


Figure 26. Typical diode forward voltage as a function of junction temperature

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Package Drawing PG-TO252-3



Testing Conditions

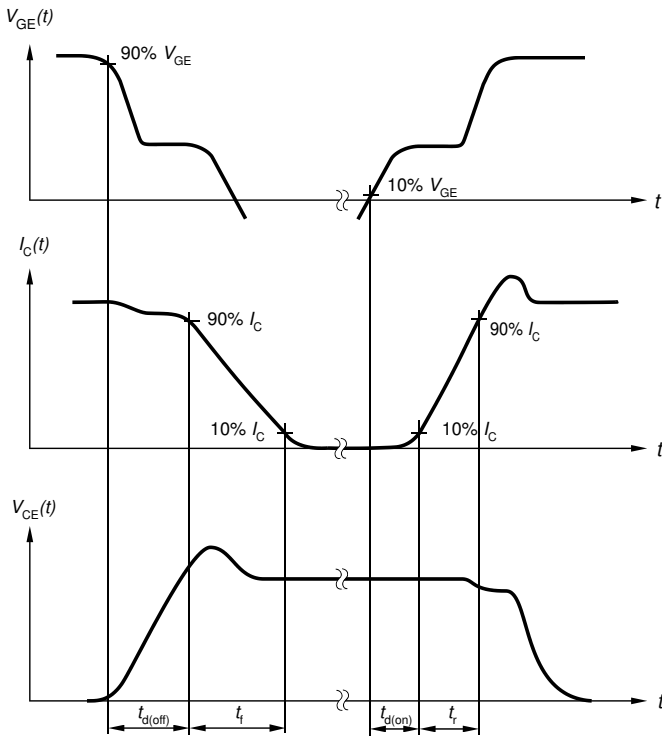


Figure A. Definition of switching times

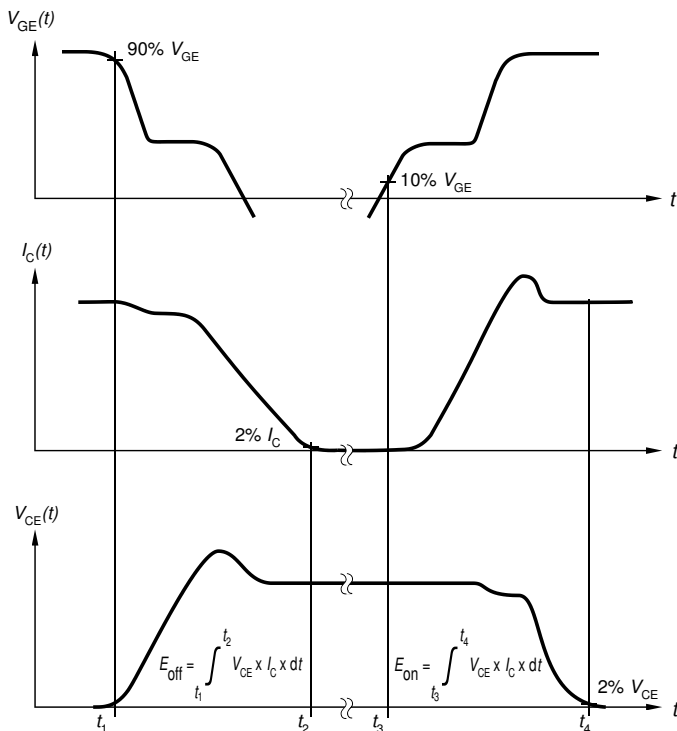


Figure B. Definition of switching losses



Figure C. Definition of diode switching characteristics

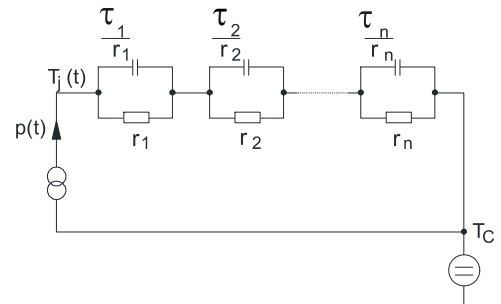


Figure D. Thermal equivalent circuit



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

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**TRENCHSTOP™ RC-Series for hard switching applications****Revision History**

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AIHD04N60R

**Revision: 2017-02-09, Rev. 2.1**

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Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.1	2017-02-09	Data sheet created

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