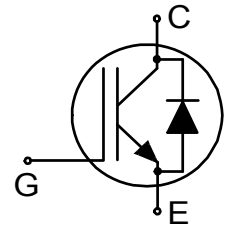


## CoolSiC™ Hybrid Discrete for Automotive

## Discrete 650V Hybrid with TRENCHSTOP™ 5 Fast-Switching IGBT and CoolSiC™ Schottky Diode G5 for Automotive

## Features and Benefits:

- Best-in-Class efficiency in hard switching and resonant topologies
- 650V break-down voltage
- Trenchstop™ 5 fast-switching IGBT
- CoolSiC™ Schottky Diode G5
- Low gate charge  $Q_g$
- Maximum junction temperature 175°C
- Qualified according to AEC-Q101/100
- Pb-free lead plating; RoHS compliant

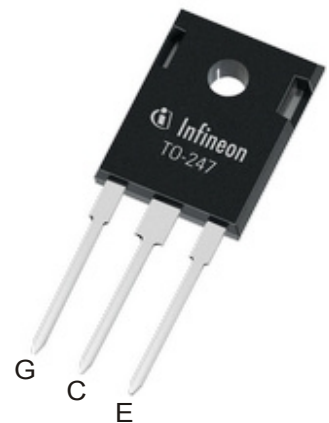


## Applications:

- On-board charger
- DC/DC converter

## Package pin definition:

- Pin 1 - gate
- Pin 2 & backside - collector
- Pin 3 - emitter



## Key Performance and Package Parameters

Type	$V_{CE}$	$I_C$	$V_{CEsat}, T_{vj}=25^\circ\text{C}$	$T_{vjmax}$	Marking	Package
AIKW50N65RF5	650V	50A	1.6V	175°C	AK50ERF5	PG-TO247-3



**Table of Contents**

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## CoolSiC™ Hybrid Discrete for Automotive

## Maximum Ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage	$V_{CE}$	650	V
DC collector current, limited by $T_{vjmax}^{1)}$ $T_c = 25^\circ\text{C}$ value limited by bondwire $T_c = 100^\circ\text{C}$	$I_C$	80.0 46.0	A
Pulsed collector current, $t_p$ limited by $T_{vjmax}^{1)}$	$I_{Cpuls}$	150.0	A
Turn off safe operating area $V_{CE} \leq 650\text{V}$ , $T_{vj} \leq 175^\circ\text{C}^{1)}$	-	150.0	A
Diode forward current, limited by $T_{vjmax}^{1)}$ $T_c = 25^\circ\text{C}$ value limited by bondwire $T_c = 100^\circ\text{C}$	$I_F$	40.0 27.0	A
Diode pulsed current, $t_p$ limited by $T_{vjmax}^{1)}$	$I_{Fpuls}$	100.0	A
Gate-emitter voltage <sup>1)</sup> Transient Gate-emitter voltage ( $t_p \leq 10\mu\text{s}$ , $D < 0.010$ )	$V_{GE}$	$\pm 20$ $\pm 30$	V
Power dissipation $T_c = 25^\circ\text{C}^{1)}$ Power dissipation $T_c = 100^\circ\text{C}$	$P_{tot}$	250.0 125.0	W
Operating junction temperature	$T_{vj}$	-40...+175	$^\circ\text{C}$
Storage temperature	$T_{stg}$	-55...+150	$^\circ\text{C}$
Soldering temperature, wave soldering 1.6mm (0.063in.) from case for 10s		260	$^\circ\text{C}$
Mounting torque, M3 screw Maximum of mounting processes: 3	$M$	0.6	Nm

## Thermal Resistance

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
<b><math>R_{th}</math> Characteristics</b>						
IGBT thermal resistance, <sup>1)</sup> junction - case	$R_{th(j-c)}$		-	0.45	0.60	K/W
Diode thermal resistance, <sup>1)</sup> junction - case	$R_{th(j-c)}$		-	1.00	1.40	K/W
Thermal resistance <sup>1)</sup> junction - ambient	$R_{th(j-a)}$		-	-	40	K/W

<sup>1)</sup> Not subject to production test. Verified by design/characterization

## CoolSiC™ Hybrid Discrete for Automotive

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	$V_{(BR)CES}$	$V_{GE} = 0\text{V}, I_C = 0.20\text{mA}$	650	-	-	V
Collector-emitter saturation voltage	$V_{CESat}$	$V_{GE} = 15.0\text{V}, I_C = 50.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	-	1.60	2.10	V
			-	1.80	-	
			-	1.90	-	
Diode forward voltage	$V_F$	$V_{GE} = 0\text{V}, I_F = 20.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 125^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	-	1.45	1.70	V
			-	1.60	-	
			-	1.80	-	
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C = 0.50\text{mA}, V_{CE} = V_{GE}$	3.2	4.0	4.8	V
Zero gate voltage collector current	$I_{CES}$	$V_{CE} = 650\text{V}, V_{GE} = 0\text{V}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	-	-	120	$\mu\text{A}$
			-	1500	-	
Gate-emitter leakage current	$I_{GES}$	$V_{CE} = 0\text{V}, V_{GE} = 20\text{V}$	-	-	100	nA
Transconductance	$g_{fs}$	$V_{CE} = 20\text{V}, I_C = 50.0\text{A}$	-	61.0	-	S

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	$C_{ies}$	$V_{CE} = 25\text{V}, V_{GE} = 0\text{V}$ $f = 1000\text{kHz}$	-	2850	-	pF
Output capacitance	$C_{oes}$		-	240	-	
Reverse transfer capacitance	$C_{res}$		-	8	-	
Gate charge	$Q_G$	$V_{CC} = 520\text{V}, I_C = 50.0\text{A},$ $V_{GE} = 15\text{V}$	-	109.0	-	nC
Internal emitter inductance measured 5mm (0.197 in.) from case	$L_E$		-	13.0	-	nH

## 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	$t_{d(on)}$	$T_{vj} = 25^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 25.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $R_{G(on)} = 12.0\Omega, R_{G(off)} = 12.0\Omega,$ $L_{\sigma} = 30\text{nH}, C_{\sigma} = 30\text{pF}$ $L_{\sigma}, C_{\sigma}$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	20	-	ns
Rise time	$t_r$		-	12	-	ns
Turn-off delay time	$t_{d(off)}$		-	156	-	ns
Fall time	$t_f$		-	13	-	ns
Turn-on energy	$E_{on}$		-	0.31	-	mJ
Turn-off energy	$E_{off}$		-	0.12	-	mJ
Total switching energy	$E_{ts}$	-	0.43	-	mJ	

## CoolSiC™ Hybrid Discrete for Automotive

Turn-on delay time	$t_{d(on)}$	$T_{vj} = 25^{\circ}\text{C}$ , $V_{CC} = 400\text{V}$ , $I_C = 6.0\text{A}$ , $V_{GE} = 0.0/15.0\text{V}$ , $R_{G(on)} = 12.0\Omega$ , $R_{G(off)} = 12.0\Omega$ , $L\sigma = 30\text{nH}$ , $C\sigma = 30\text{pF}$ $L\sigma$ , $C\sigma$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	18	-	ns
Rise time	$t_r$		-	4	-	ns
Turn-off delay time	$t_{d(off)}$		-	173	-	ns
Fall time	$t_f$		-	10	-	ns
Turn-on energy	$E_{on}$		-	0.07	-	mJ
Turn-off energy	$E_{off}$		-	0.04	-	mJ
Total switching energy	$E_{ts}$		-	0.11	-	mJ

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

Diode reverse recovery charge	$Q_{rr}$	$T_{vj} = 25^{\circ}\text{C}$ , $V_R = 400\text{V}$ , $I_F = 25.0\text{A}$ , $di_F/dt = 200\text{A}/\mu\text{s}$	-	0.03	-	$\mu\text{C}$
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## Switching Characteristic, Inductive Load

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	

IGBT Characteristic, at  $T_{vj} = 150^{\circ}\text{C}$ 

Turn-on delay time	$t_{d(on)}$	$T_{vj} = 150^{\circ}\text{C}$ , $V_{CC} = 400\text{V}$ , $I_C = 25.0\text{A}$ , $V_{GE} = 0.0/15.0\text{V}$ , $R_{G(on)} = 12.0\Omega$ , $R_{G(off)} = 12.0\Omega$ , $L\sigma = 30\text{nH}$ , $C\sigma = 30\text{pF}$ $L\sigma$ , $C\sigma$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	20	-	ns
Rise time	$t_r$		-	15	-	ns
Turn-off delay time	$t_{d(off)}$		-	191	-	ns
Fall time	$t_f$		-	6	-	ns
Turn-on energy	$E_{on}$		-	0.33	-	mJ
Turn-off energy	$E_{off}$		-	0.19	-	mJ
Total switching energy	$E_{ts}$		-	0.52	-	mJ

Turn-on delay time	$t_{d(on)}$	$T_{vj} = 150^{\circ}\text{C}$ , $V_{CC} = 400\text{V}$ , $I_C = 6.0\text{A}$ , $V_{GE} = 0.0/15.0\text{V}$ , $R_{G(on)} = 12.0\Omega$ , $R_{G(off)} = 12.0\Omega$ , $L\sigma = 30\text{nH}$ , $C\sigma = 30\text{pF}$ $L\sigma$ , $C\sigma$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	17	-	ns
Rise time	$t_r$		-	6	-	ns
Turn-off delay time	$t_{d(off)}$		-	229	-	ns
Fall time	$t_f$		-	26	-	ns
Turn-on energy	$E_{on}$		-	0.07	-	mJ
Turn-off energy	$E_{off}$		-	0.07	-	mJ
Total switching energy	$E_{ts}$		-	0.14	-	mJ

Diode Characteristic, at  $T_{vj} = 150^{\circ}\text{C}$ 

Diode reverse recovery charge <sup>1)</sup>	$Q_{rr}$	$T_{vj} = 150^{\circ}\text{C}$ , $V_R = 400\text{V}$ , $I_F = 25.0\text{A}$ , $di_F/dt = 200\text{A}/\mu\text{s}$	-	0.03	-	$\mu\text{C}$
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<sup>1)</sup> There is no reverse recovery of Schottky barrier diodes.  $Q_{rr}$  denotes capacitive charge  $Q_c$ .

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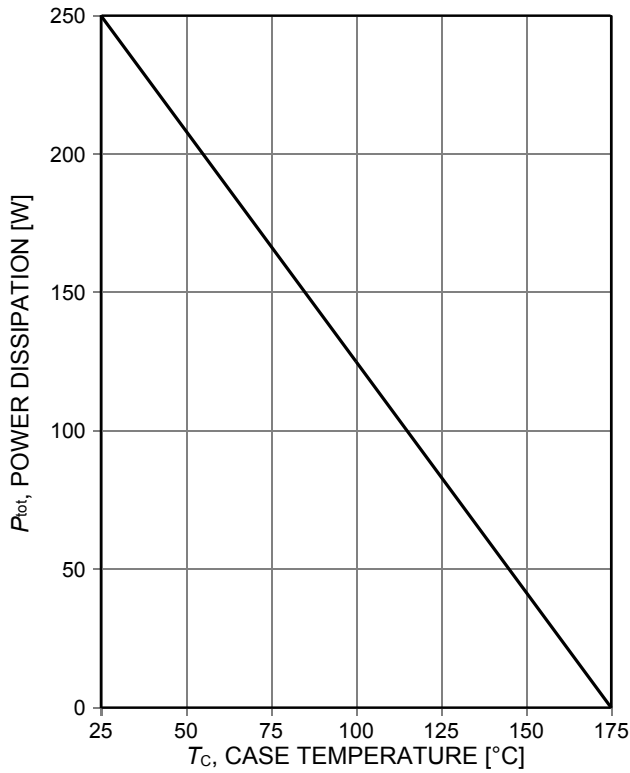


Figure 1. Power dissipation as a function of case temperature ( $T_{vj} \leq 175^\circ\text{C}$ )

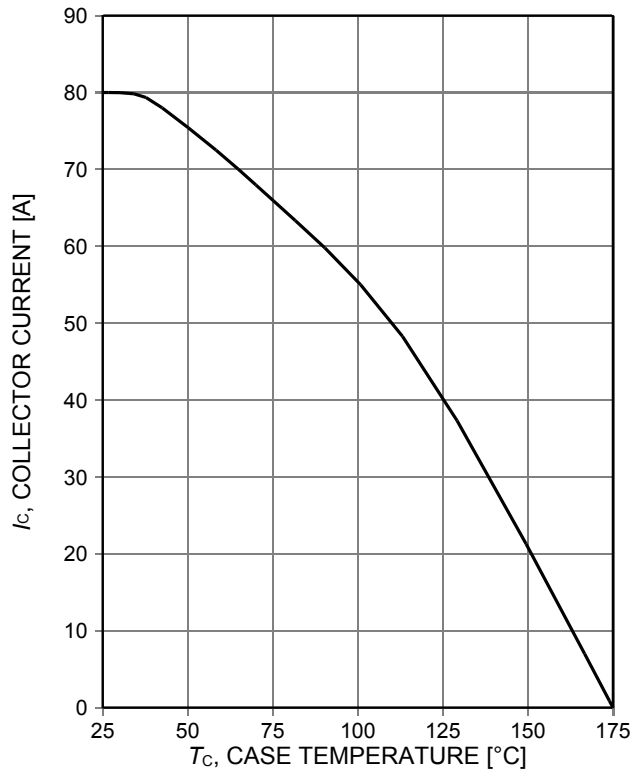


Figure 2. Collector current as a function of case temperature ( $V_{GE} \geq 15\text{V}$ ,  $T_{vj} \leq 175^\circ\text{C}$ )

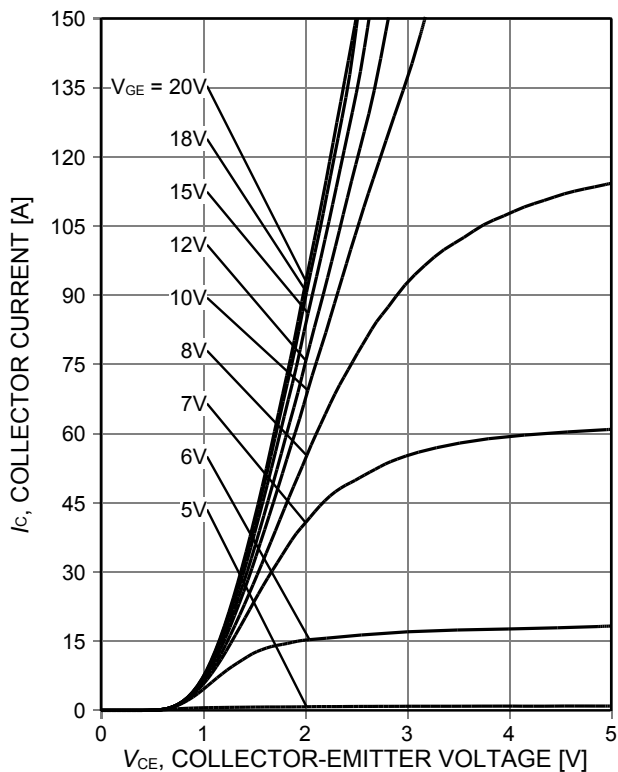


Figure 3. Typical output characteristic ( $T_{vj} = 25^\circ\text{C}$ )

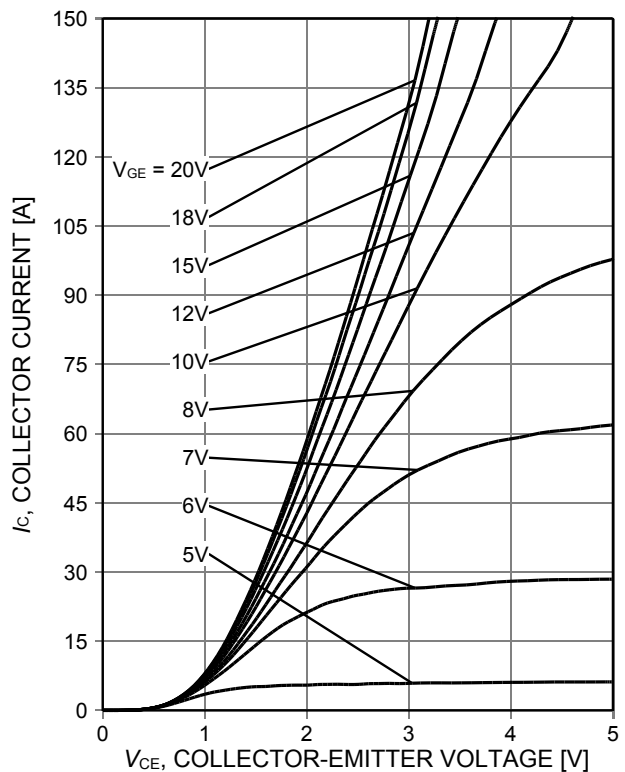


Figure 4. Typical output characteristic ( $T_{vj} = 150^\circ\text{C}$ )

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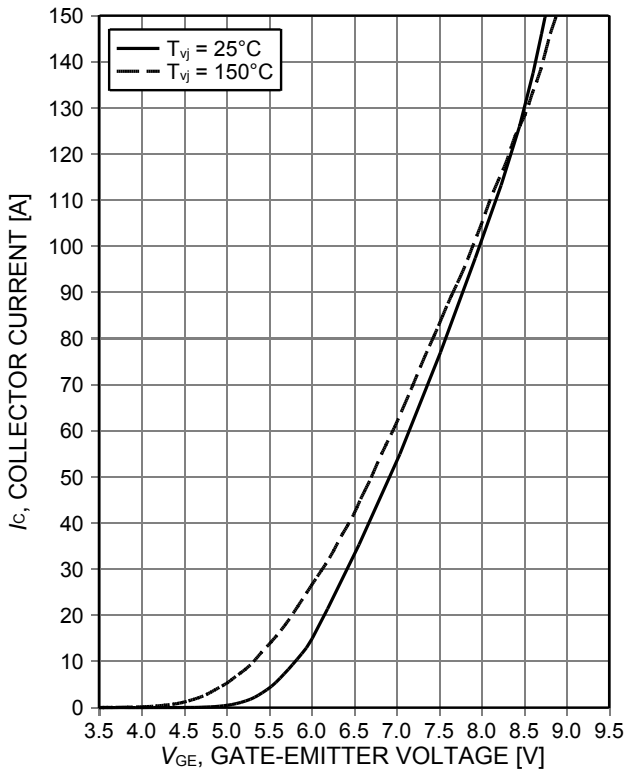


Figure 5. Typical transfer characteristic (V<sub>CE</sub>=20V)

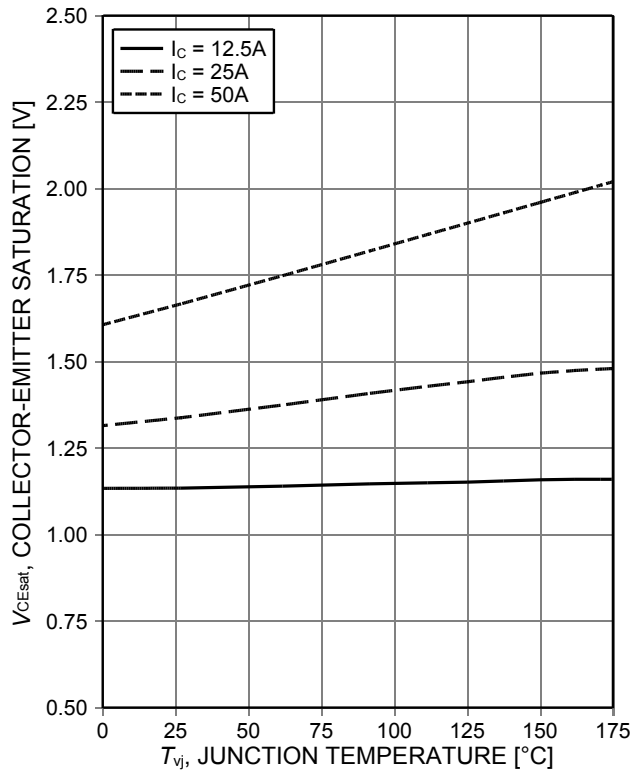


Figure 6. Typical collector-emitter saturation voltage as a function of junction temperature (V<sub>GE</sub>=15V)

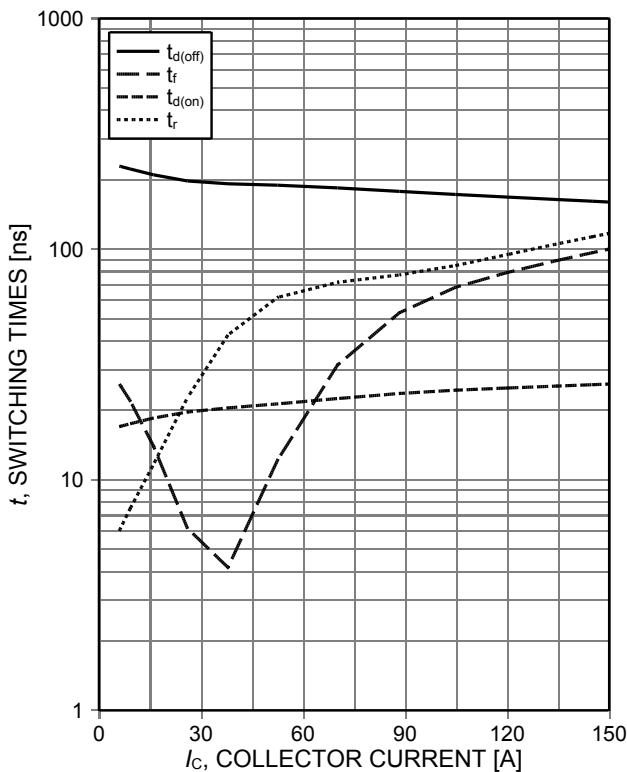


Figure 7. Typical switching times as a function of collector current (inductive load, T<sub>vj</sub>=150°C, V<sub>CE</sub>=400V, V<sub>GE</sub>=15/0V, r<sub>G</sub>=12Ω, Dynamic test circuit in Figure E)

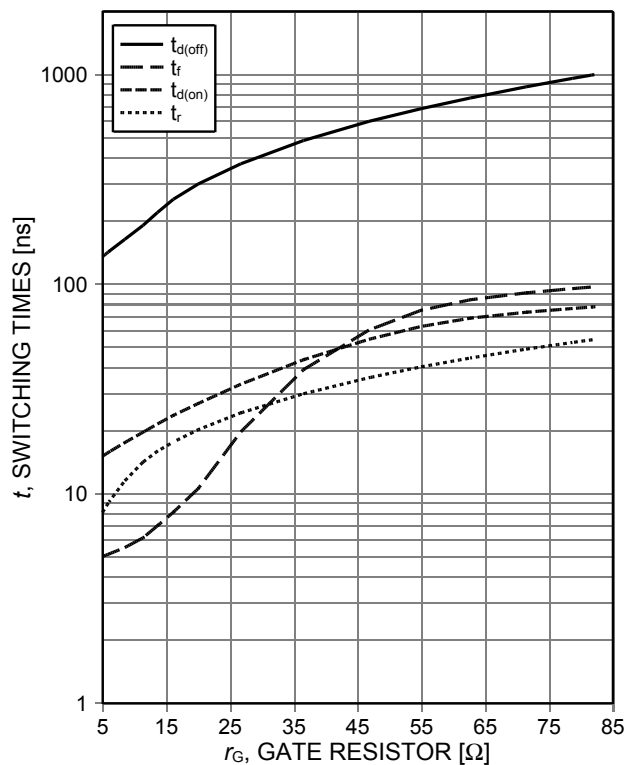


Figure 8. Typical switching times as a function of gate resistor (inductive load, T<sub>vj</sub>=150°C, V<sub>CE</sub>=400V, V<sub>GE</sub>=15/0V, I<sub>C</sub>=25A, Dynamic test circuit in Figure E)

CoolSiC™ Hybrid Discrete for Automotive

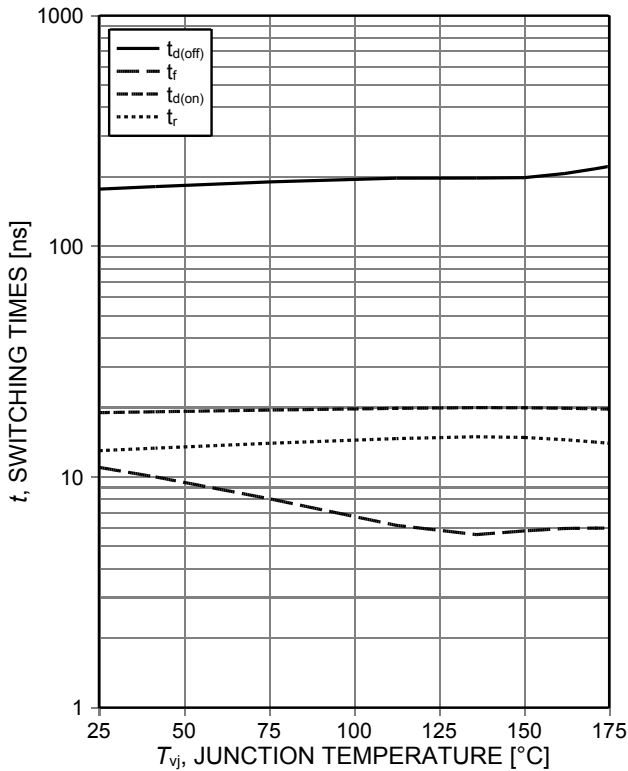


Figure 9. **Typical switching times as a function of junction temperature**  
 (inductive load,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=25A$ ,  $r_G=12\Omega$ , Dynamic test circuit in Figure E)

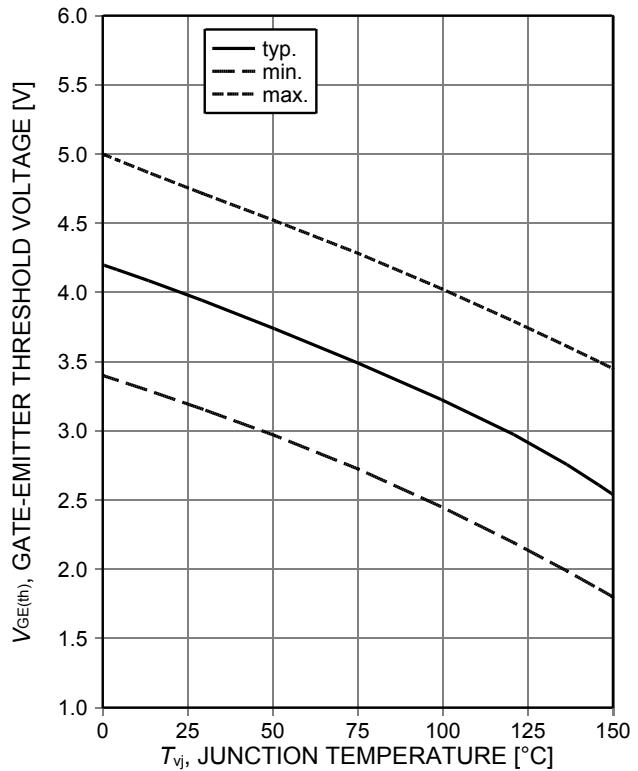


Figure 10. **Gate-emitter threshold voltage as a function of junction temperature**  
 ( $I_C=0.5mA$ . Only values at 25°C subject to production test. All other values are verified by design/characterization)

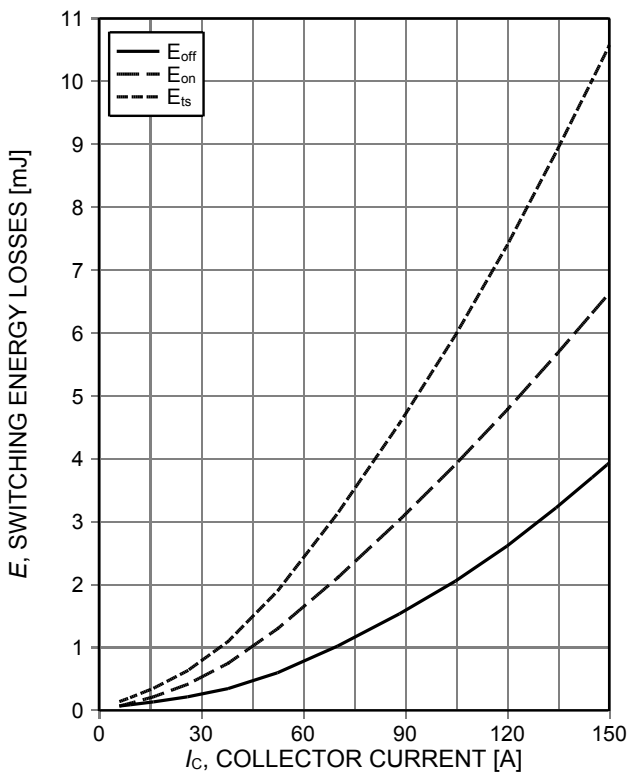


Figure 11. **Typical switching energy losses as a function of collector current**  
 (inductive load,  $T_{vj}=150^\circ C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $r_G=12\Omega$ , Dynamic test circuit in Figure E)

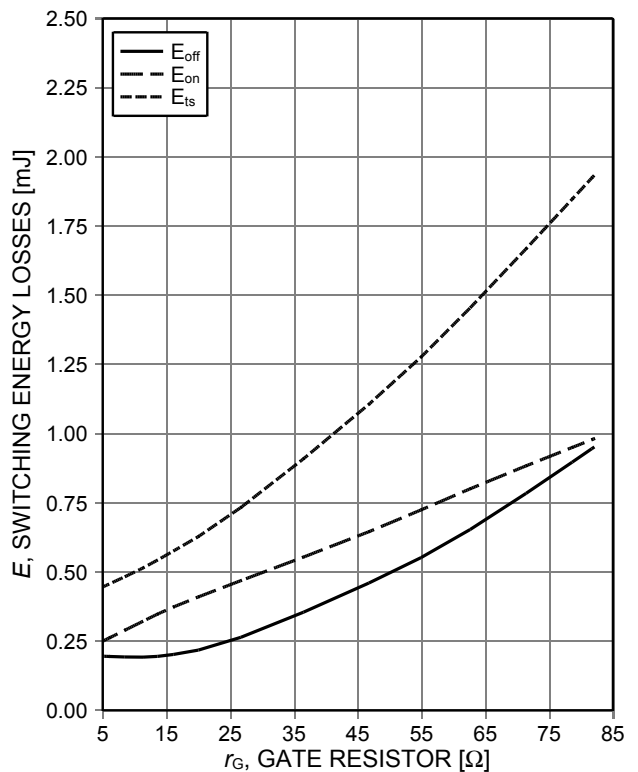


Figure 12. **Typical switching energy losses as a function of gate resistor**  
 (inductive load,  $T_{vj}=150^\circ C$ ,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=25A$ , Dynamic test circuit in Figure E)



CoolSiC™ Hybrid Discrete for Automotive

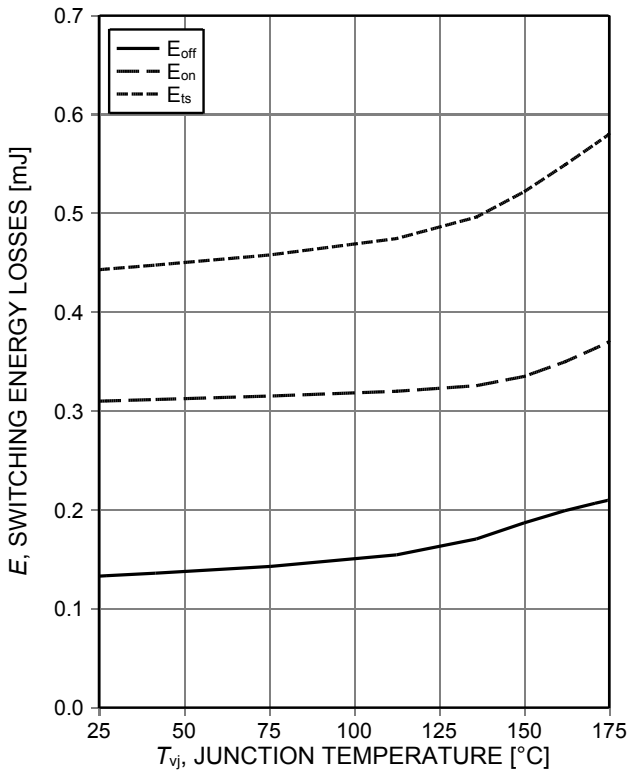


Figure 13. **Typical switching energy losses as a function of junction temperature** (inductive load,  $V_{CE}=400V$ ,  $V_{GE}=15/0V$ ,  $I_C=25A$ ,  $r_G=12\Omega$ , Dynamic test circuit in Figure E)

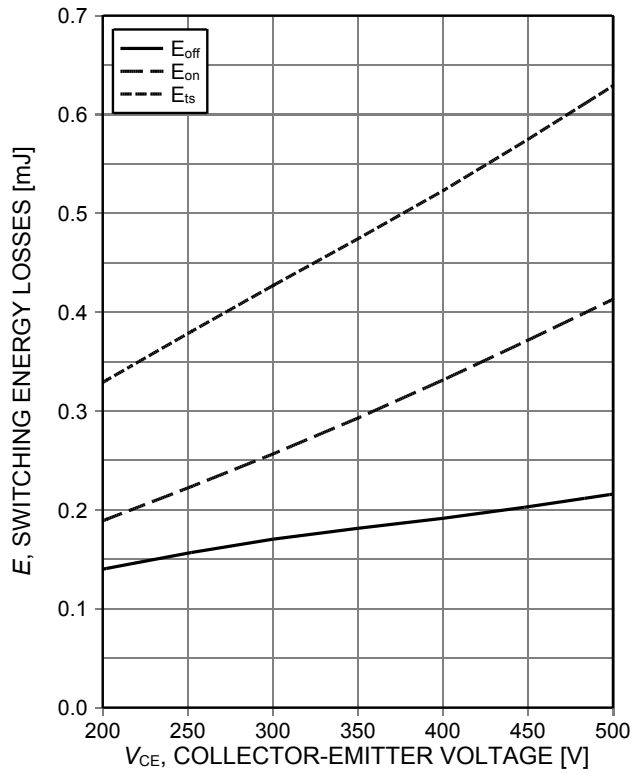


Figure 14. **Typical switching energy losses as a function of collector emitter voltage** (inductive load,  $T_{vj}=150^\circ C$ ,  $V_{GE}=15/0V$ ,  $I_C=25A$ ,  $r_G=12\Omega$ , Dynamic test circuit in Figure E)

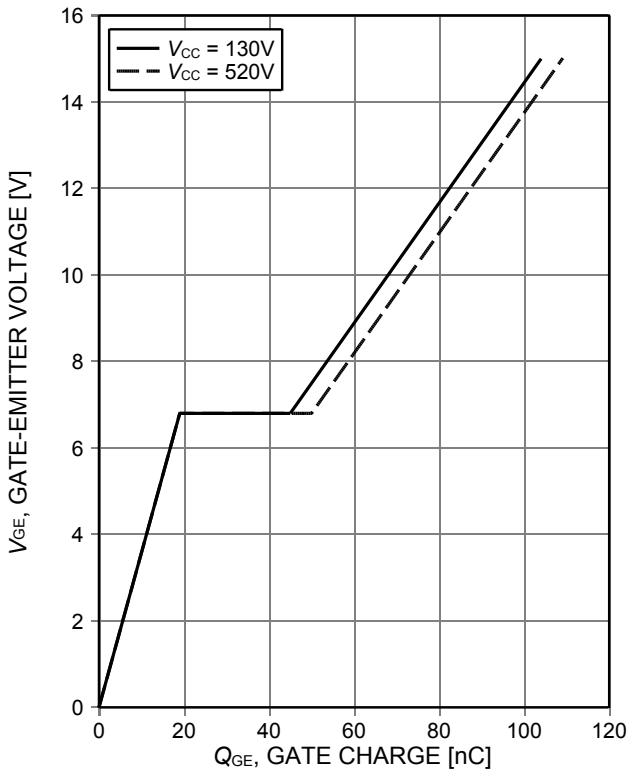


Figure 15. **Typical gate charge** ( $I_C=50A$ )

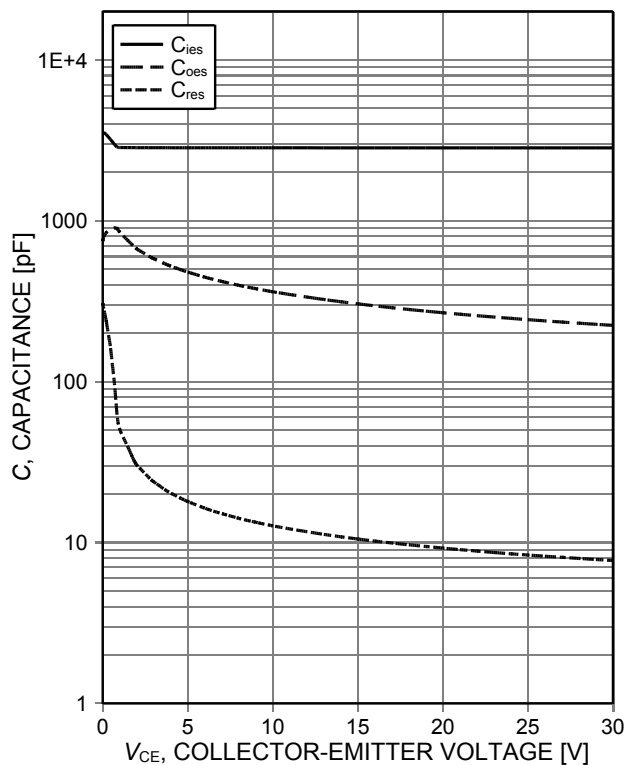


Figure 16. **Typical capacitance as a function of collector-emitter voltage** ( $V_{GE}=0V$ ,  $f=1MHz$ )

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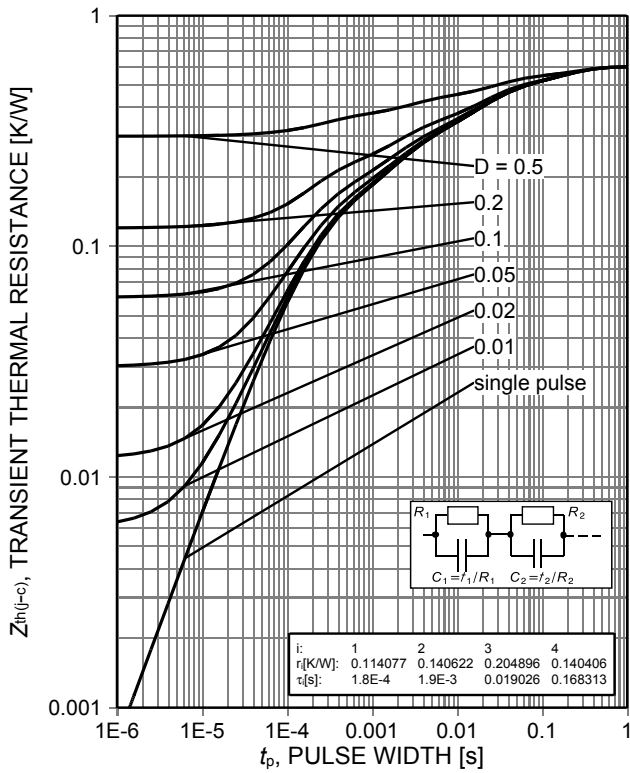


Figure 17. IGBT transient thermal resistance ( $D=t_p/T$ )

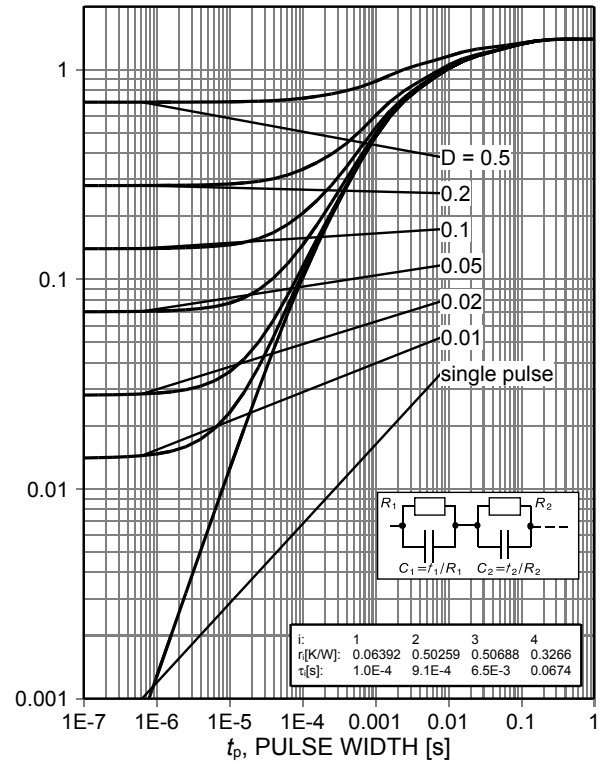


Figure 18. Diode transient thermal impedance as a function of pulse width ( $D=t_p/T$ )

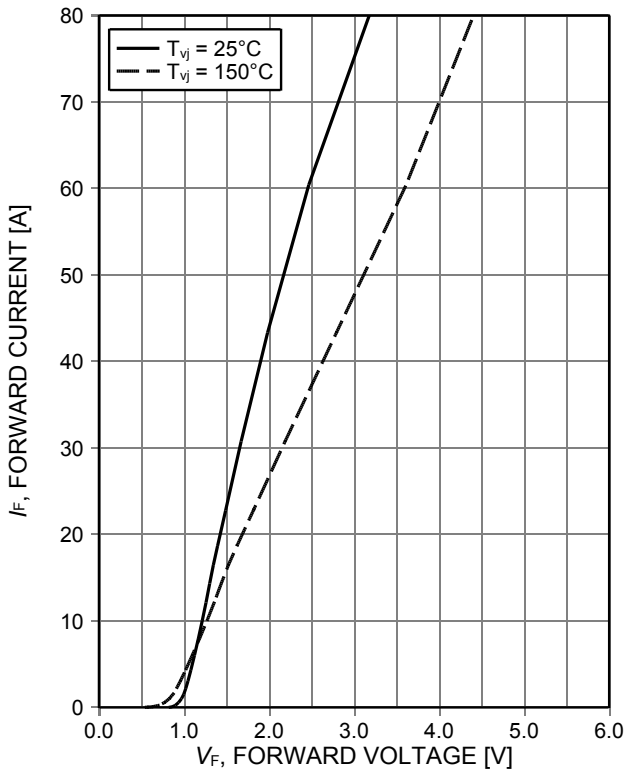


Figure 19. Typical diode forward current as a function of forward voltage

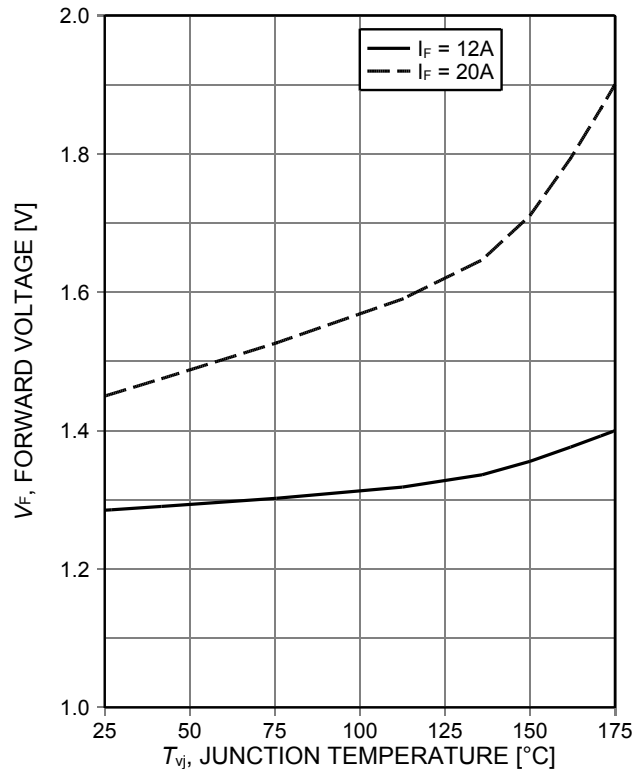
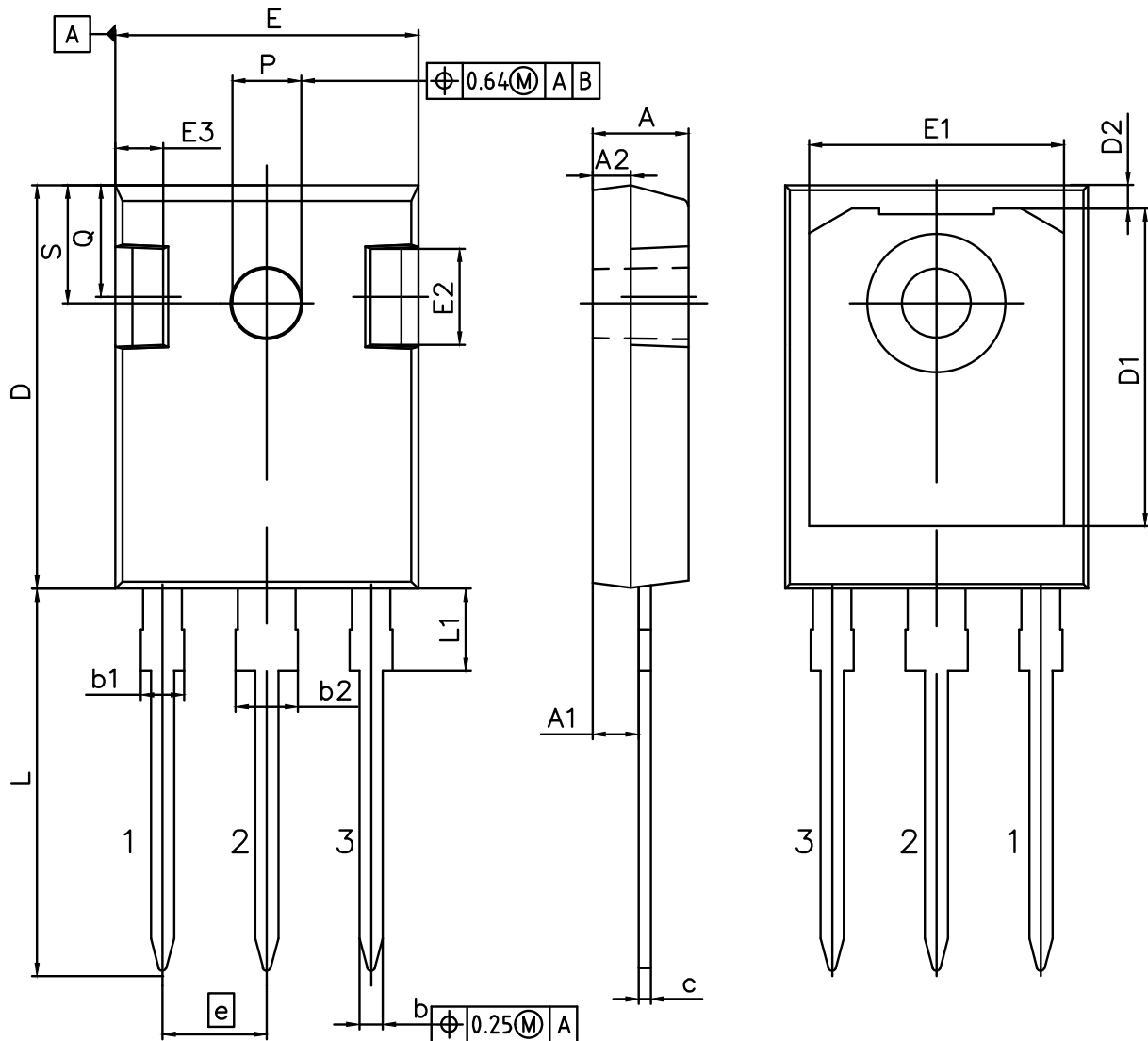


Figure 20. Typical diode forward voltage as a function of junction temperature

Package Drawing PG-TO247-3



DIMENSIONS	MILLIMETERS	
	MIN.	MAX.
A	4.70	5.30
A1	2.20	2.60
A2	1.50	2.50
b	1.00	1.40
b1	1.60	2.41
b2	2.57	3.43
c	0.38	0.89
D	20.70	21.50
D1	13.08	17.65
D2	0.51	1.35
E	15.50	16.30
E1	12.38	14.15
E2	3.40	5.10
E3	1.00	2.60
e	5.44	
L	19.80	20.40
L1	3.85	4.50
P	3.50	3.70
Q	5.35	6.25
S	6.04	6.30

<b>DOCUMENT NO.</b> Z8B00003327
<b>REVISION</b> 06
<b>SCALE 3:1</b> 0 1 2 3 4 5mm 
<b>EUROPEAN PROJECTION</b> 
<b>ISSUE DATE</b> 25.07.2018

Testing Conditions

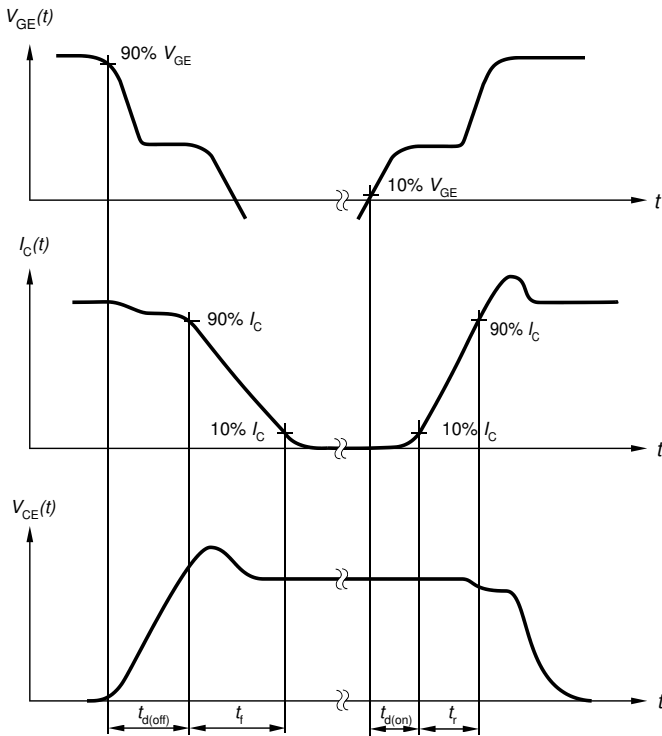


Figure A. Definition of switching times

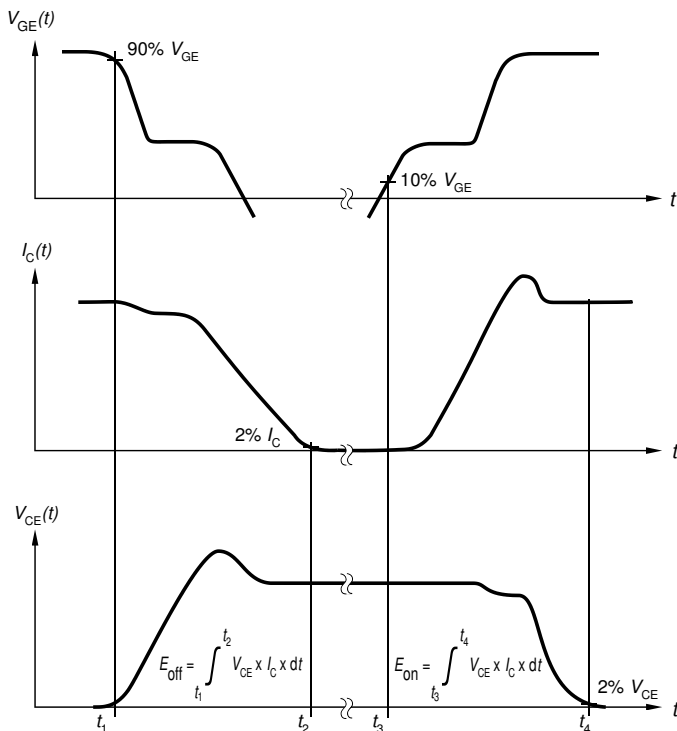


Figure B. Definition of switching losses

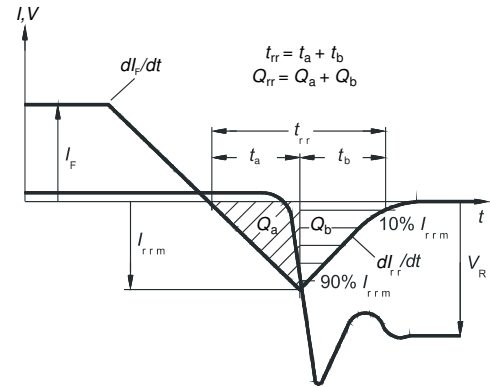


Figure C. Definition of diode switching characteristics

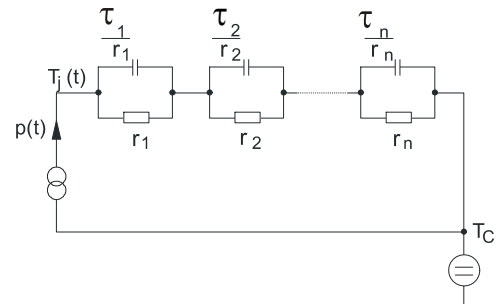


Figure D. Thermal equivalent circuit

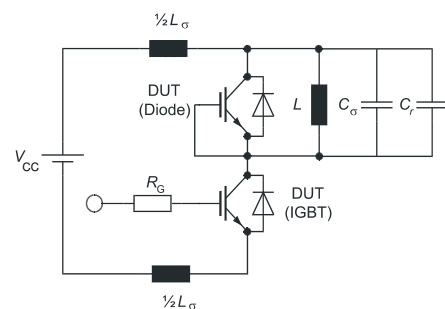


Figure E. Dynamic test circuit  
Parasitic inductance  $L_{\sigma}$ ,  
parasitic capacitor  $C_{\sigma}$ ,  
relief capacitor  $C_r$ ,  
(only for ZVT switching)

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**CoolSiC™ Hybrid Discrete for Automotive****Revision History**

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AIKW50N65RF5

**Revision: 2021-02-09, Rev. 2.5**

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Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.1	2020-02-27	Final Data Sheet
2.2	2020-03-03	Disclaimer changed to Automotive.
2.3	2020-09-17	Update figure 15 typical gate charge
2.4	2020-12-03	Open market branding
2.5	2021-02-09	Update product family name to CoolSiC™ Hybrid Discrete

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