

CoolSiC™ Hybrid Discrete for Automotive

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

Features and Benefits:

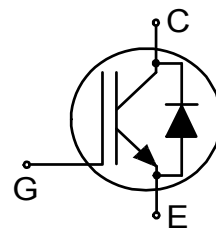
- Best-in-Class efficiency in hard switching and resonant topologies
- 650V break-down voltage
- Trenchstop™ 5 fast-switching IGBT
- CoolSiC™ Schottky Diode G5
- Low gate charge Q_G
- Maximum junction temperature 175°C
- Qualified according to AEC-Q101/100
- Pb-free lead plating; RoHS compliant

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



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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 ¹⁾ Transient Gate-emitter voltage ($t_p \leq 10\mu\text{s}$, $D < 0.010$)	V_{GE}	± 20 ± 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.	
R _{th} Characteristics						
IGBT thermal resistance, ¹⁾ junction - case	R _{th(j-c)}		-	0.45	0.60	K/W
Diode thermal resistance, ¹⁾ junction - case	R _{th(j-c)}		-	1.00	1.40	K/W
Thermal resistance ¹⁾ junction - ambient	R _{th(j-a)}		-	-	40	K/W

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

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

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

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

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
Dynamic Characteristic						
Input capacitance	C _{ies}	V _{CE} = 25V, V _{GE} = 0V f = 1000kHz	-	2850	-	pF
Output capacitance	C _{oes}		-	240	-	
Reverse transfer capacitance	C _{res}		-	8	-	
Gate charge	Q _G	V _{CC} = 520V, I _C = 50.0A, V _{GE} = 15V	-	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	$t_{d(\text{on})}$	$T_{vj} = 25^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 25.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $R_{G(\text{on})} = 12.0\Omega, R_{G(\text{off})} = 12.0\Omega,$ $L\sigma = 30\text{nH}, C\sigma = 30\text{pF}$ $L\sigma, C\sigma$ from Fig. E Energy losses include “tail” and diode reverse recovery.	-	20	-	ns
Rise time	t_r		-	12	-	ns
Turn-off delay time	$t_{d(\text{off})}$		-	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

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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	-	μC
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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 ¹⁾	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	-	μC
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¹⁾ There is no reverse recovery of Schottky barrier diodes. Q_{rr} denotes capacitive charge Q_c .

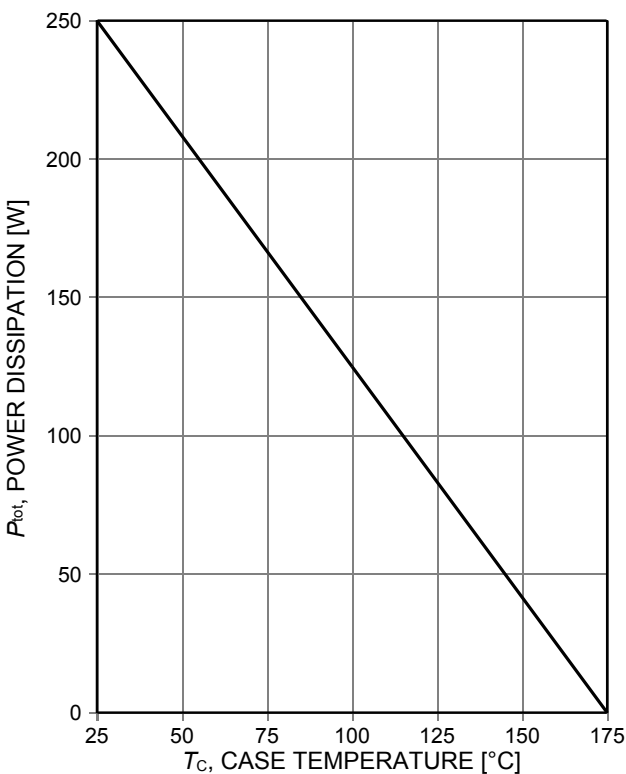


Figure 1. Power dissipation as a function of case temperature ($T_{vj} \leq 175^\circ\text{C}$)

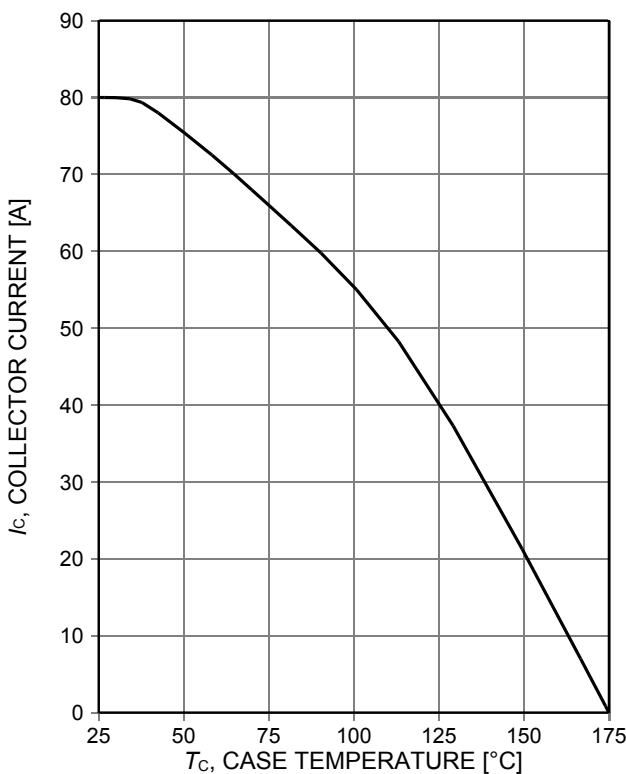


Figure 2. Collector current as a function of case temperature ($V_{GE} \geq 15\text{V}$, $T_{vj} \leq 175^\circ\text{C}$)

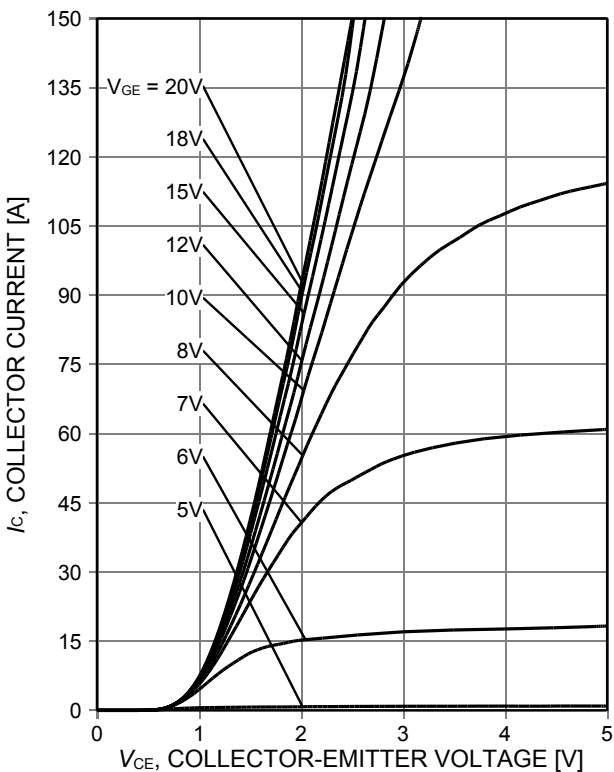


Figure 3. Typical output characteristic ($T_{vj} = 25^\circ\text{C}$)

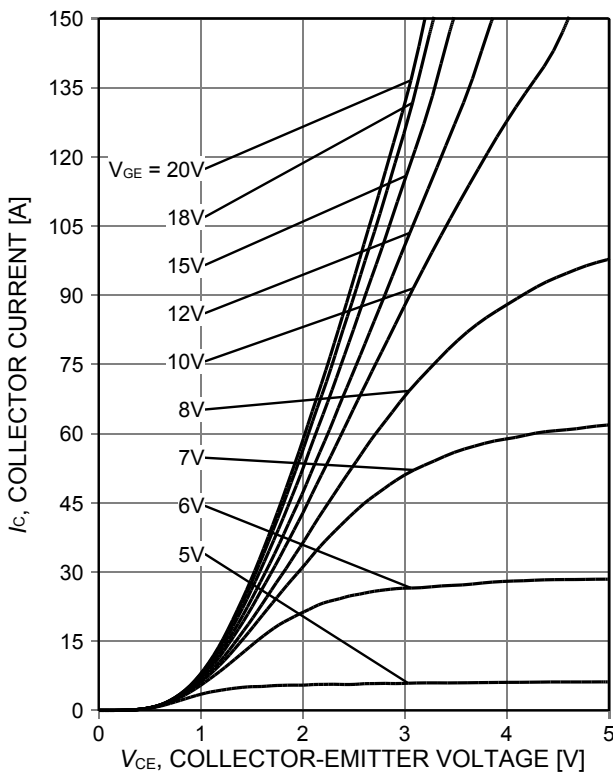


Figure 4. Typical output characteristic ($T_{vj} = 150^\circ\text{C}$)

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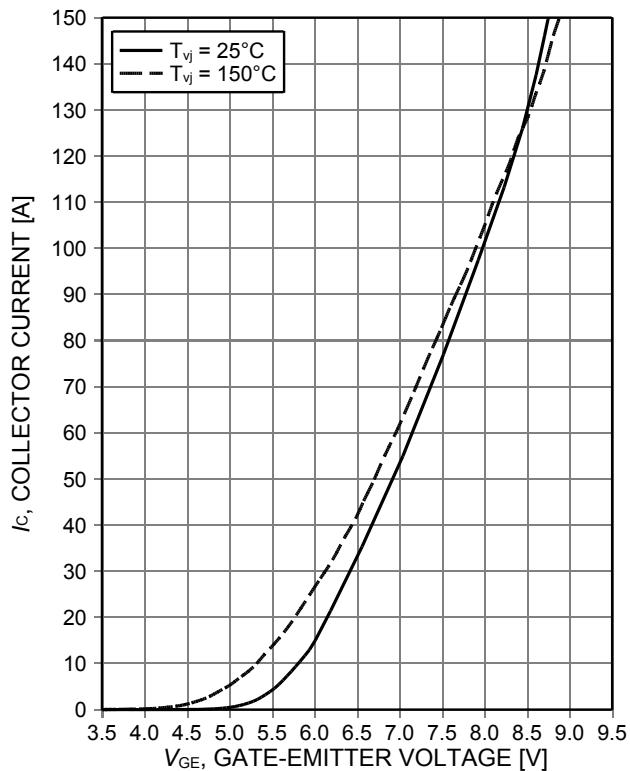


Figure 5. **Typical transfer characteristic**
($V_{CE}=20V$)

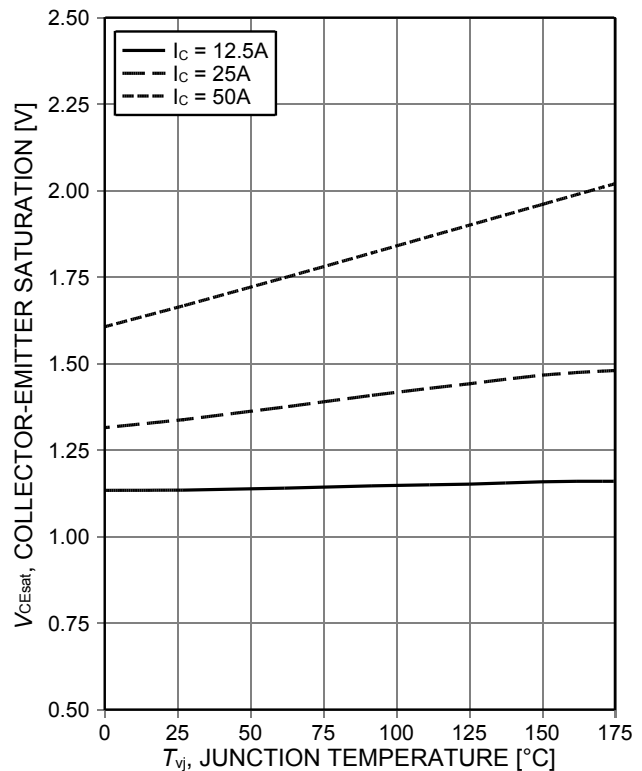


Figure 6. **Typical collector-emitter saturation voltage as a function of junction temperature**
($V_{GE}=15V$)

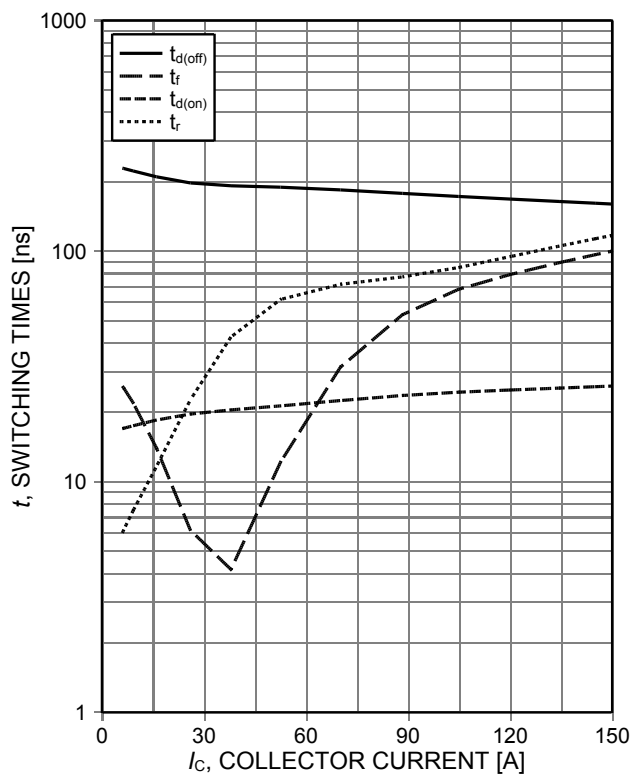


Figure 7. **Typical switching times as a function of collector current**
(inductive load, $T_{vj}=150^{\circ}C$, $V_{CE}=400V$, $V_{GE}=15/0V$, $r_G=12\Omega$, Dynamic test circuit in Figure E)

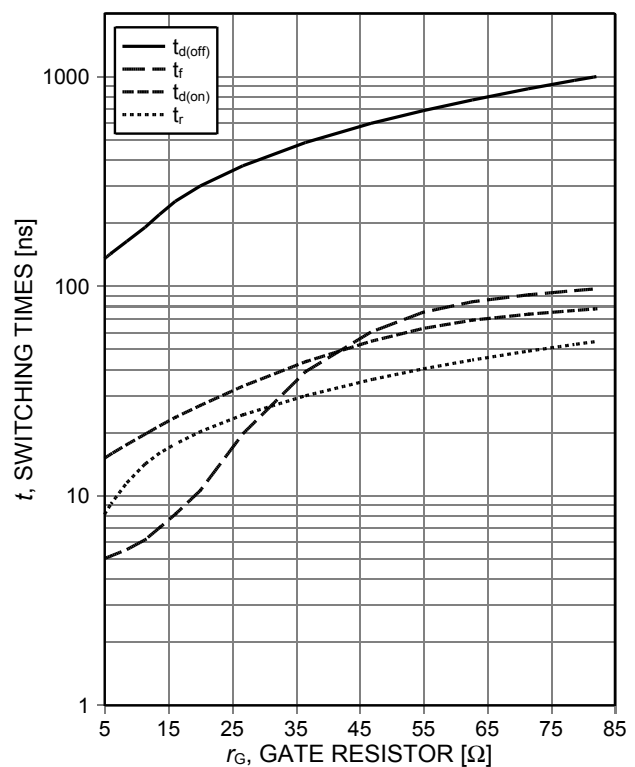


Figure 8. **Typical switching times as a function of gate resistor**
(inductive load, $T_{vj}=150^{\circ}C$, $V_{CE}=400V$, $V_{GE}=15/0V$, $I_C=25A$, Dynamic test circuit in Figure E)

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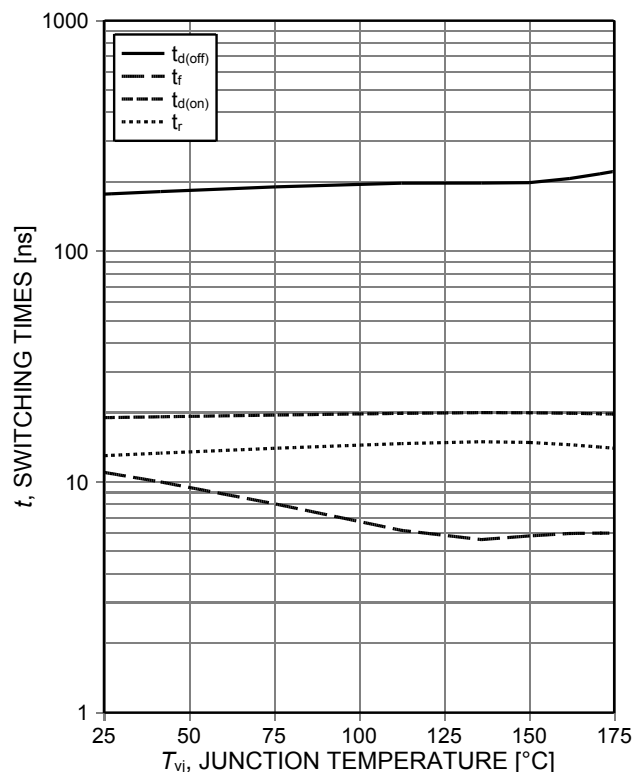


Figure 9. **Typical switching times as a function of junction temperature**
(inductive load, $V_{CE}=400V$, $V_{GE}=15/0V$, $I_C=25A$, $r_G=12\Omega$, Dynamic test circuit in Figure E)

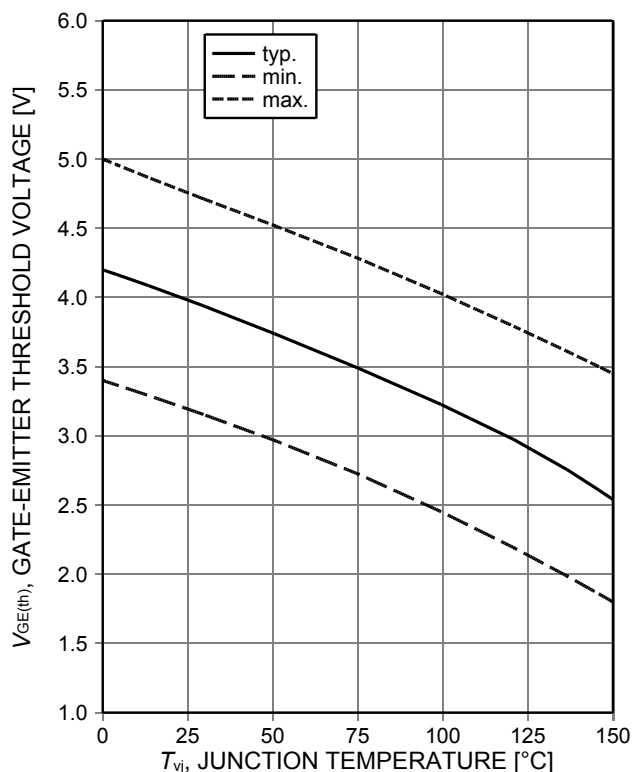


Figure 10. **Gate-emitter threshold voltage as a function of junction temperature**
($I_C=0.5mA$. Only values at 25°C subject to production test. All other values are verified by design/characterization)

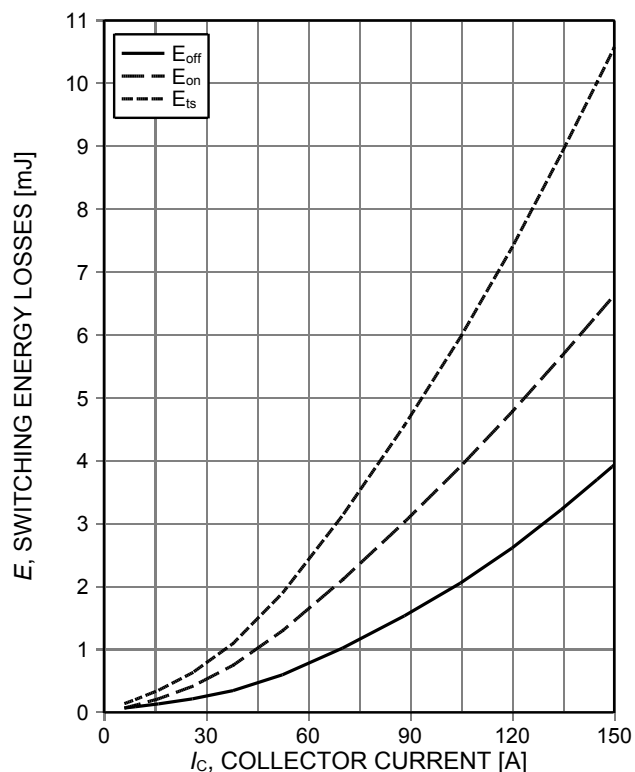


Figure 11. **Typical switching energy losses as a function of collector current**
(inductive load, $T_{vj}=150^{\circ}C$, $V_{CE}=400V$, $V_{GE}=15/0V$, $r_G=12\Omega$, Dynamic test circuit in Figure E)

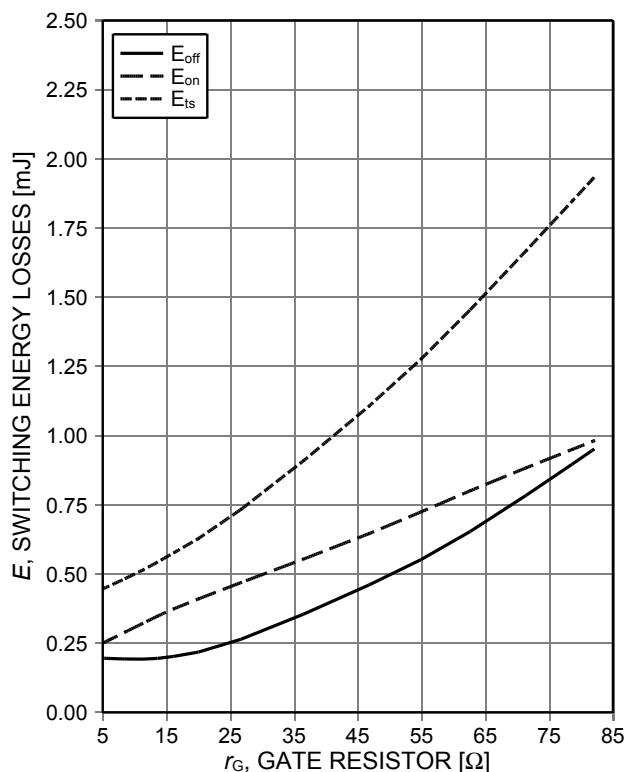


Figure 12. **Typical switching energy losses as a function of gate resistor**
(inductive load, $T_{vj}=150^{\circ}C$, $V_{CE}=400V$, $V_{GE}=15/0V$, $I_C=25A$, Dynamic test circuit in Figure E)

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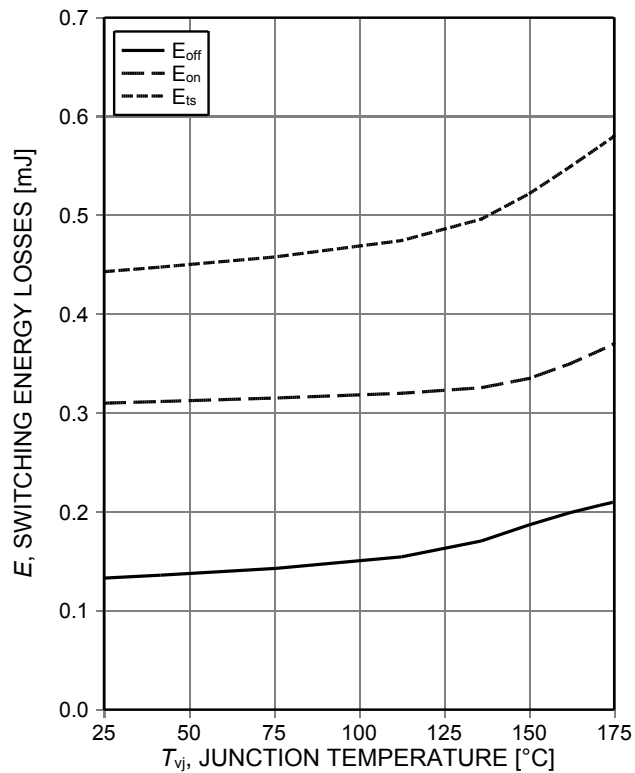


Figure 13. **Typical switching energy losses as a function of junction temperature**
(inductive load, $V_{CE}=400V$, $V_{GE}=15/0V$, $I_C=25A$, $r_G=12\Omega$, Dynamic test circuit in Figure E)

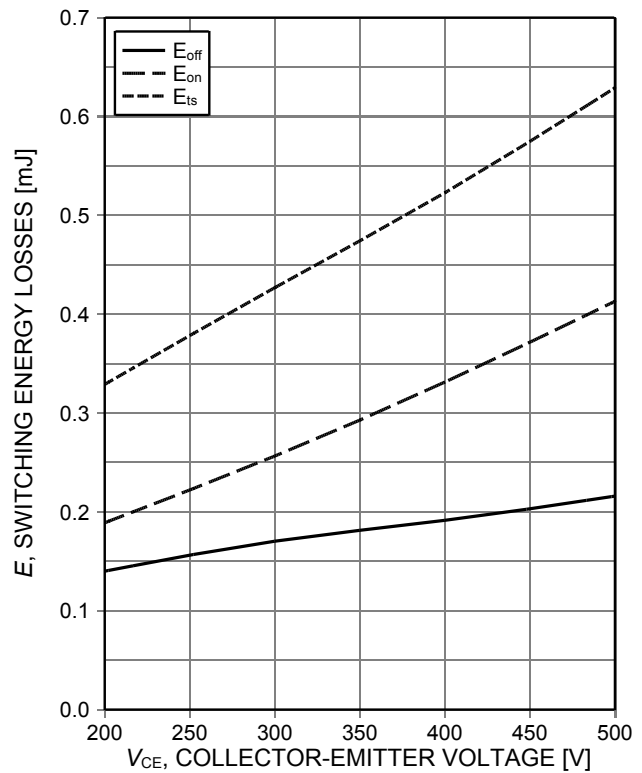


Figure 14. **Typical switching energy losses as a function of collector emitter voltage**
(inductive load, $T_{vj}=150^\circ C$, $V_{GE}=15/0V$, $I_C=25A$, $r_G=12\Omega$, Dynamic test circuit in Figure E)

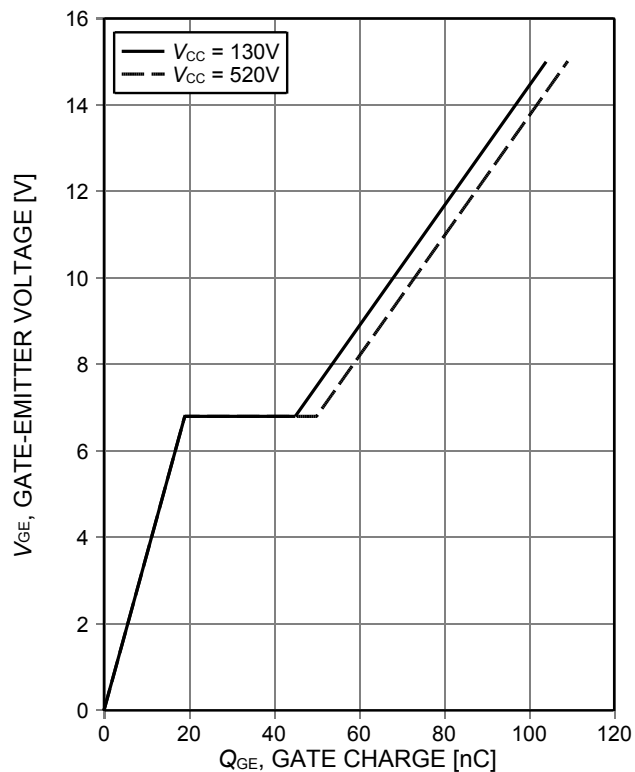


Figure 15. **Typical gate charge**
($I_C=50A$)

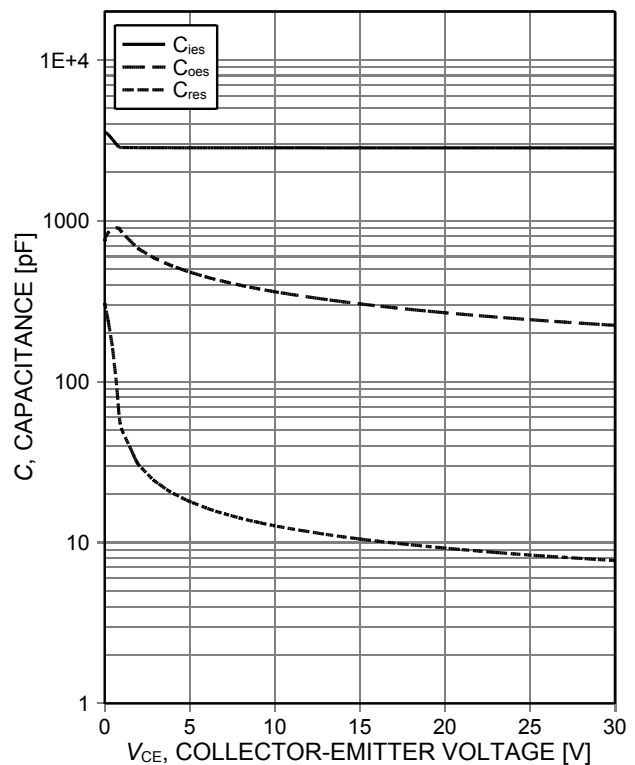


Figure 16. **Typical capacitance as a function of collector-emitter voltage**
($V_{GE}=0V$, $f=1MHz$)

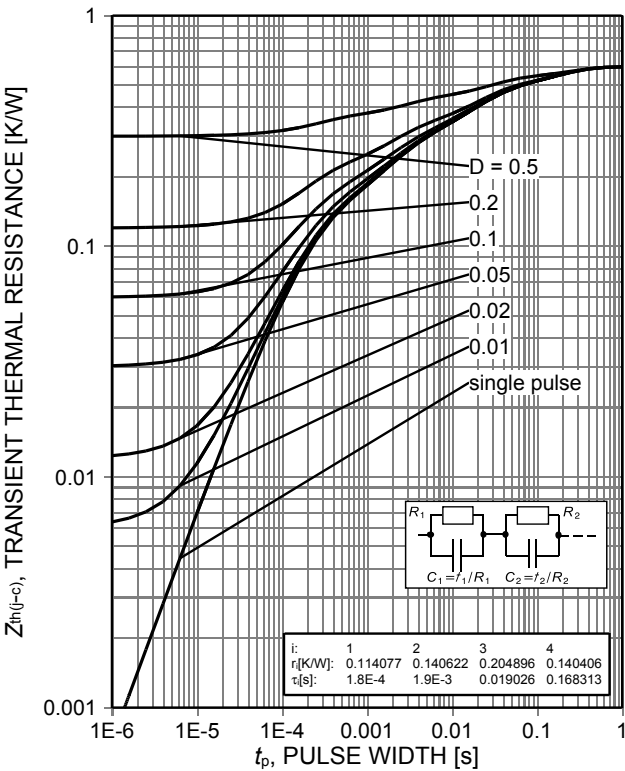


Figure 17. IGBT transient thermal resistance ($D=t_p/T$)

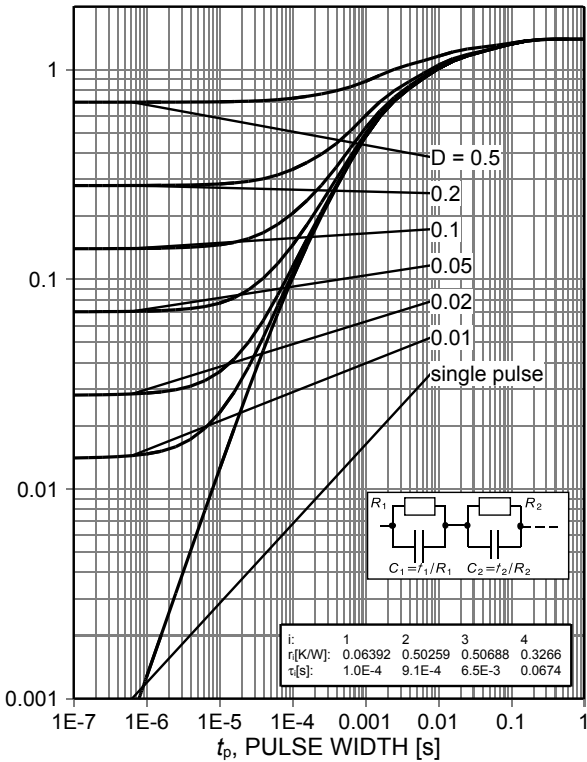


Figure 18. Diode transient thermal impedance as a function of pulse width ($D=t_p/T$)

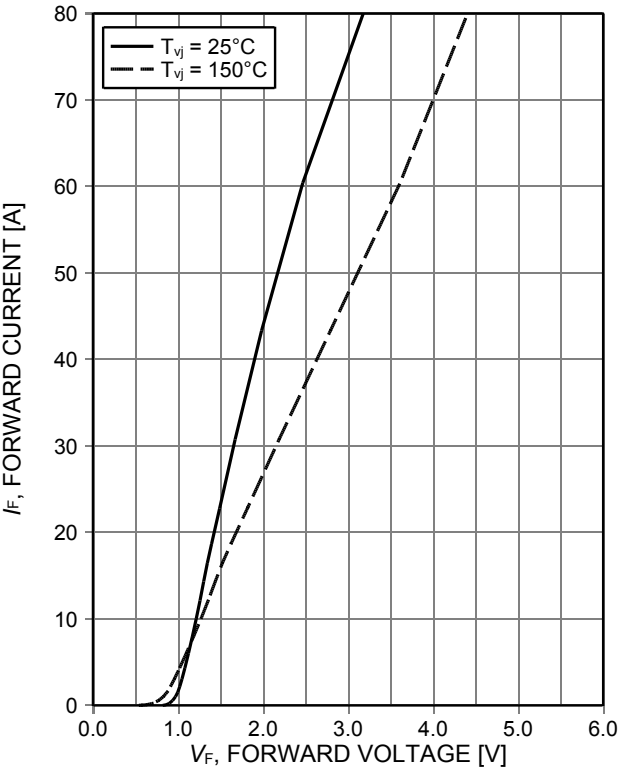


Figure 19. Typical diode forward current as a function of forward voltage

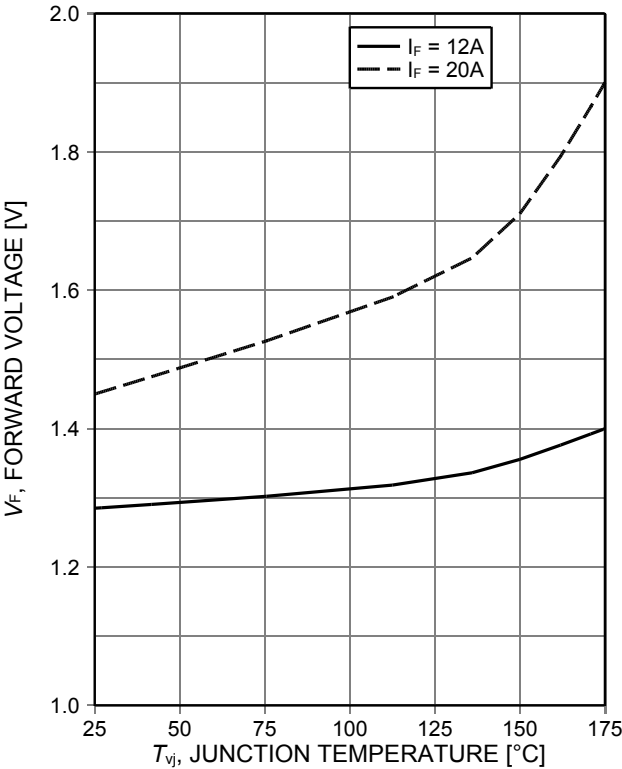
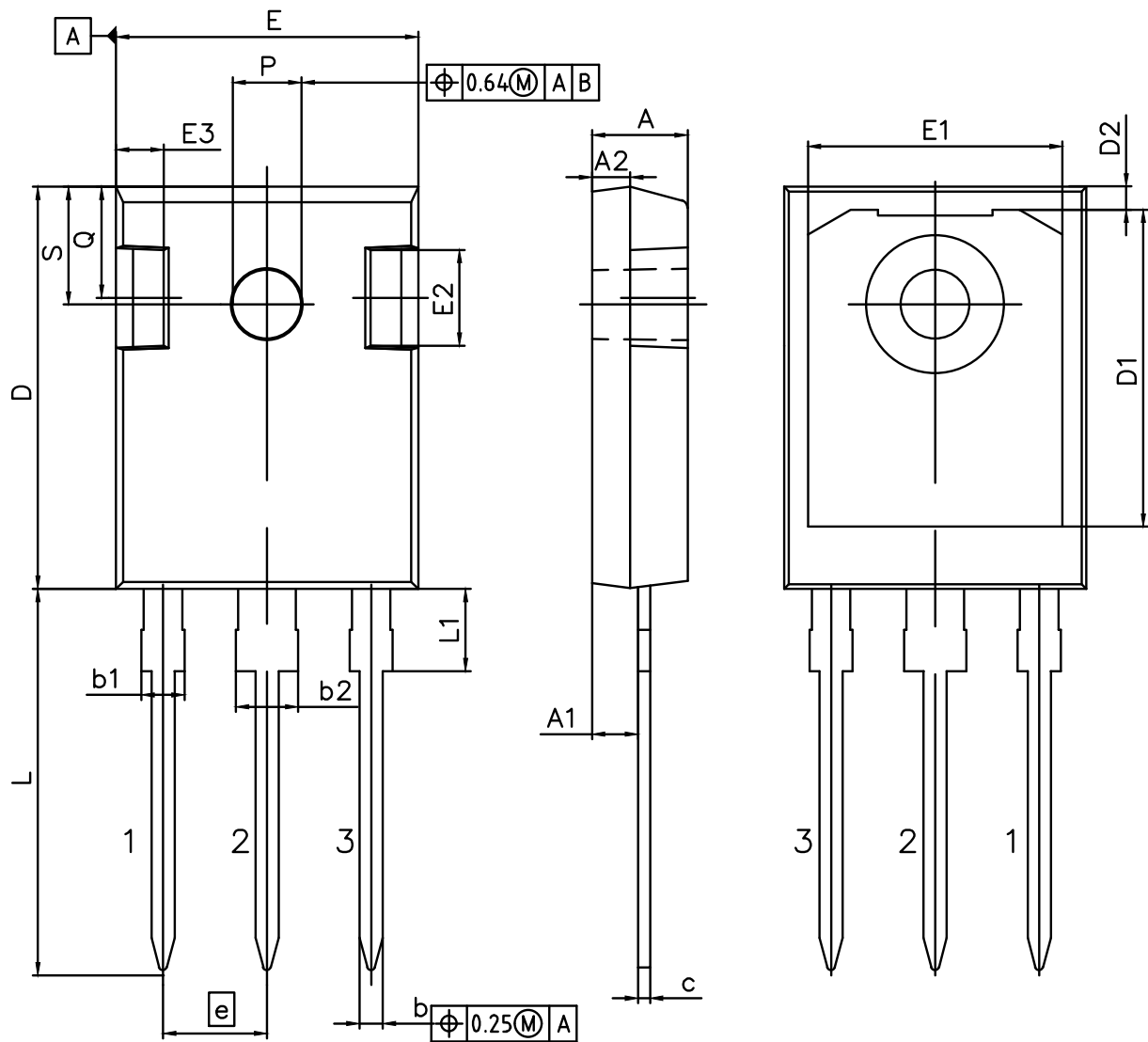


Figure 20. Typical diode forward voltage as a function of junction temperature

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

DOCUMENT NO.
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REVISION
06

SCALE 3:1
0 1 2 3 4 5mm

EUROPEAN PROJECTION

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Testing Conditions

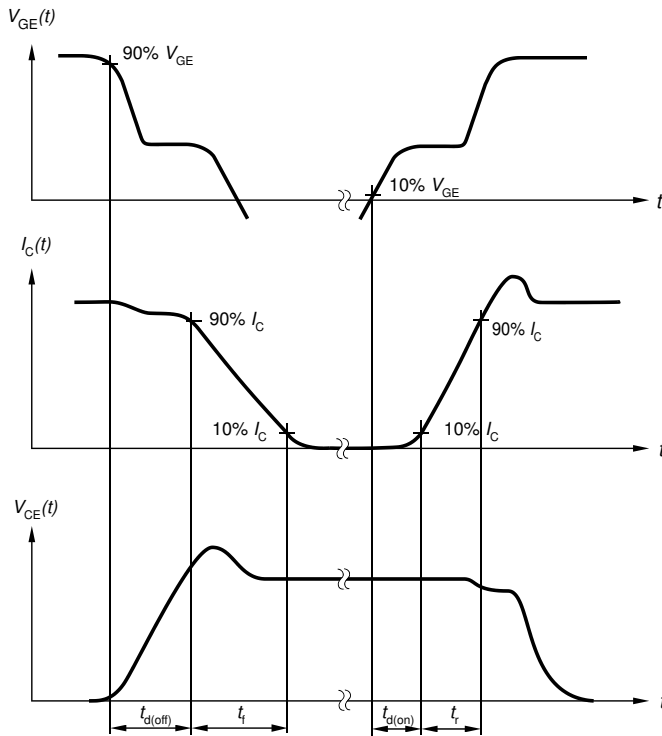


Figure A. Definition of switching times

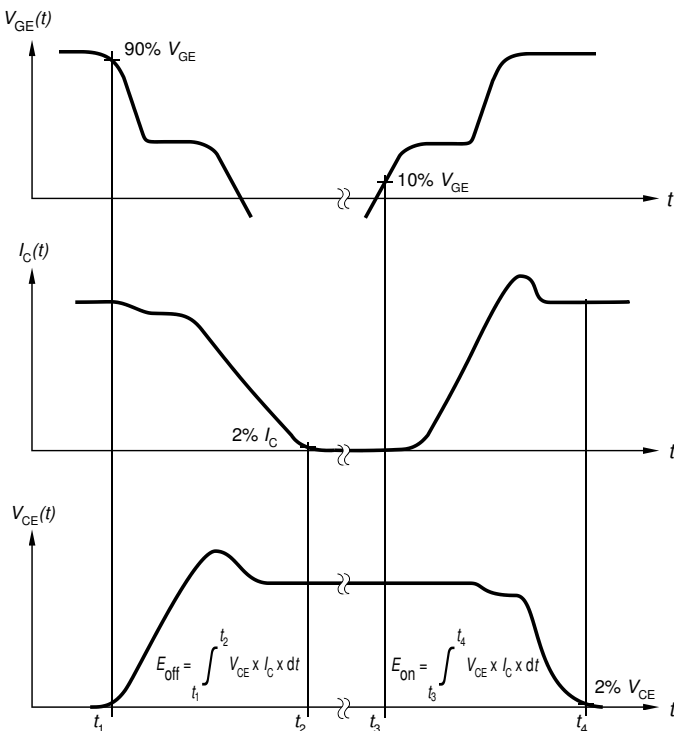


Figure B. Definition of switching losses

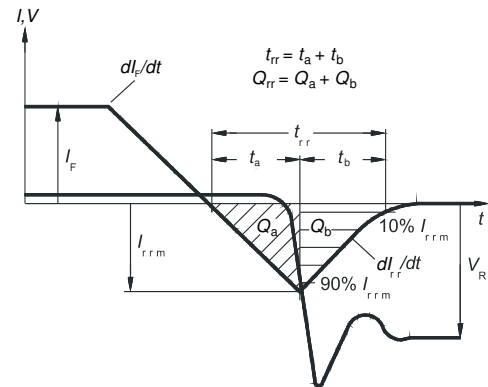


Figure C. Definition of diode switching characteristics

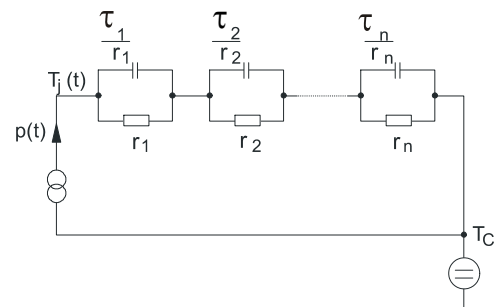


Figure D. Thermal equivalent circuit

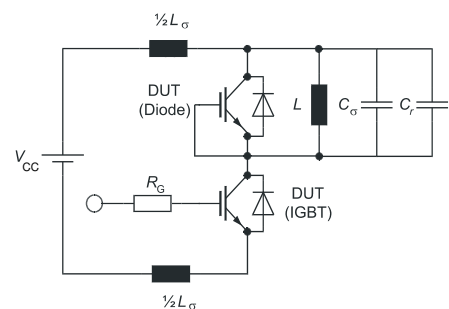


Figure E. **Dynamic test circuit**
 Parasitic inductance L_σ ,
 parasitic capacitor C_σ ,
 relief capacitor C_r ,
 (only for ZVT switching)

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

AIKW50N65RF5**Revision: 2021-02-09, Rev. 2.5**

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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