

## Reverse Conduction Series

Reverse conducting IGBT with monolithic body diode

**IKW40N65WR5**

Data sheet

Industrial Power Control

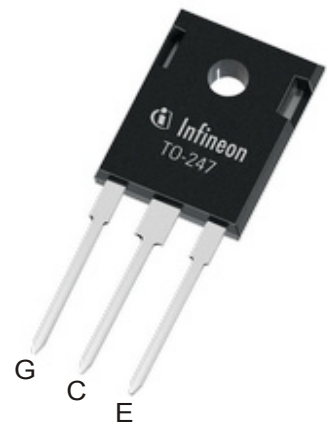
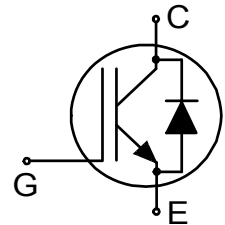
Reverse conducting IGBT with monolithic body diode

**Features:**

- Powerful monolithic diode optimized for ZCS applications
- TRENCHSTOP™ 5 technology applications offers:
  - high ruggedness, temperature stable behavior
  - very low  $V_{CEsat}$  and low  $E_{off}$
  - easy parallel switching capability due to positive temperature coefficient in  $V_{CEsat}$
- Low EMI
- Low electrical parameters depending (dependence) on temperature
- Qualified according to JESD-022 for target applications
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models:  
<http://www.infineon.com/igbt/>

**Applications:**

- Welding
- PFC
- ZCS - converters



**Key Performance and Package Parameters**

Type	$V_{CE}$	$I_C$	$V_{CEsat}, T_{vj}=25^{\circ}C$	$T_{vjmax}$	Marking	Package
IKW40N65WR5	650V	40A	1.4V	175°C	K40EWR5	PG-TO247-3



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**Maximum Ratings**

For optimum lifetime and reliability, Infineon recommends operating conditions that do not exceed 80% of the maximum ratings stated in this datasheet.

Parameter	Symbol	Value	Unit
Collector-emitter voltage, $T_{vj} \geq 25^{\circ}\text{C}$	$V_{CE}$	650	V
DC collector current, limited by $T_{vjmax}$ $T_C = 25^{\circ}\text{C}$ value limited by bondwire $T_C = 130^{\circ}\text{C}$	$I_C$	80.0 40.0	A
Pulsed collector current, $t_p$ limited by $T_{vjmax}$	$I_{Cpuls}$	120.0	A
Turn off safe operating area $V_{CE} \leq 650\text{V}$ , $T_{vj} \leq 175^{\circ}\text{C}$ , $t_p = 1\mu\text{s}$	-	120.0	A
Diode forward current, limited by $T_{vjmax}$ $T_C = 25^{\circ}\text{C}$ value limited by bondwire $T_C = 100^{\circ}\text{C}$	$I_F$	32.0 19.0	A
Diode pulsed current, $t_p$ limited by $T_{vjmax}$	$I_{Fpuls}$	120.0	A
Gate-emitter voltage	$V_{GE}$	$\pm 20$	V
Power dissipation $T_C = 25^{\circ}\text{C}$ Power dissipation $T_C = 130^{\circ}\text{C}$	$P_{tot}$	230.0 115.0	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	Max. Value	Unit
<b>Characteristic</b>				
IGBT thermal resistance, junction - case	$R_{th(j-c)}$		0.65	K/W
Diode thermal resistance, junction - case	$R_{th(j-c)}$		2.85	K/W
Thermal resistance junction - ambient	$R_{th(j-a)}$		40	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	$V_{(BR)CES}$	$V_{GE} = 0\text{V}, I_C = 0.20\text{mA}$	650	-	-	V
Collector-emitter saturation voltage	$V_{CESat}$	$V_{GE} = 15.0\text{V}, I_C = 40.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	1.40 1.65	1.80 -	V
Diode forward voltage	$V_F$	$V_{GE} = 0\text{V}, I_F = 20.0\text{A}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	1.40 1.50	1.90 -	V
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C = 0.40\text{mA}, V_{CE} = V_{GE}$	3.2	4.0	4.8	V
Zero gate voltage collector current	$I_{CES}$	$V_{CE} = 650\text{V}, V_{GE} = 0\text{V}$ $T_{vj} = 25^{\circ}\text{C}$ $T_{vj} = 175^{\circ}\text{C}$	- -	- -	40 -	$\mu\text{A}$
Gate-emitter leakage current	$I_{GES}$	$V_{CE} = 0\text{V}, V_{GE} = 20\text{V}$	-	-	100	nA
Transconductance	$g_{fs}$	$V_{CE} = 20\text{V}, I_C = 40.0\text{A}$	-	55.0	-	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	$C_{ies}$	$V_{CE} = 25\text{V}, V_{GE} = 0\text{V}, f = 1\text{MHz}$	-	4755	-	pF
Output capacitance	$C_{oes}$		-	45	-	
Reverse transfer capacitance	$C_{res}$		-	20	-	
Gate charge	$Q_G$	$V_{CC} = 520\text{V}, I_C = 40.0\text{A},$ $V_{GE} = 15\text{V}$	-	193.0	-	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	$t_{d(on)}$	$T_{vj} = 25^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 20.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $R_{G(on)} = 20.0\Omega, R_{G(off)} = 20.0\Omega,$ $L_{\sigma} = 70\text{nH}, C_{\sigma} = 30\text{pF}$ $L_{\sigma}, C_{\sigma}$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	42	-	ns
Rise time	$t_r$		-	18	-	ns
Turn-off delay time	$t_{d(off)}$		-	432	-	ns
Fall time	$t_f$		-	16	-	ns
Turn-on energy	$E_{on}$		-	0.77	-	mJ
Turn-off energy	$E_{off}$		-	0.16	-	mJ
Total switching energy	$E_{ts}$		-	0.93	-	mJ

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

Diode reverse recovery time	$t_{rr}$	$T_{vj} = 25^{\circ}\text{C},$ $V_R = 400\text{V},$ $I_F = 20.0\text{A},$ $di_F/dt = 900\text{A}/\mu\text{s}$	-	112	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	1.65	-	$\mu\text{C}$
Diode peak reverse recovery current	$I_{rrm}$		-	27.0	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	-585	-	$\text{A}/\mu\text{s}$

**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	$t_{d(\text{on})}$	$T_{vj} = 175^{\circ}\text{C},$ $V_{CC} = 400\text{V}, I_C = 20.0\text{A},$ $V_{GE} = 0.0/15.0\text{V},$ $R_{G(\text{on})} = 20.0\Omega, R_{G(\text{off})} = 20.0\Omega,$ $L\sigma = 70\text{nH}, C\sigma = 30\text{pF}$ $L\sigma, C\sigma$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	42	-	ns
Rise time	$t_r$		-	21	-	ns
Turn-off delay time	$t_{d(\text{off})}$		-	500	-	ns
Fall time	$t_f$		-	10	-	ns
Turn-on energy	$E_{\text{on}}$		-	0.82	-	mJ
Turn-off energy	$E_{\text{off}}$		-	0.24	-	mJ
Total switching energy	$E_{\text{ts}}$		-	1.06	-	mJ

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

Diode reverse recovery time	$t_{rr}$	$T_{vj} = 175^{\circ}\text{C},$ $V_R = 400\text{V},$ $I_F = 20.0\text{A},$ $di_F/dt = 900\text{A}/\mu\text{s}$	-	153	-	ns
Diode reverse recovery charge	$Q_{rr}$		-	2.80	-	$\mu\text{C}$
Diode peak reverse recovery current	$I_{rrm}$		-	32.0	-	A
Diode peak rate of fall of reverse recovery current during $t_b$	$di_{rr}/dt$		-	-1030	-	$\text{A}/\mu\text{s}$

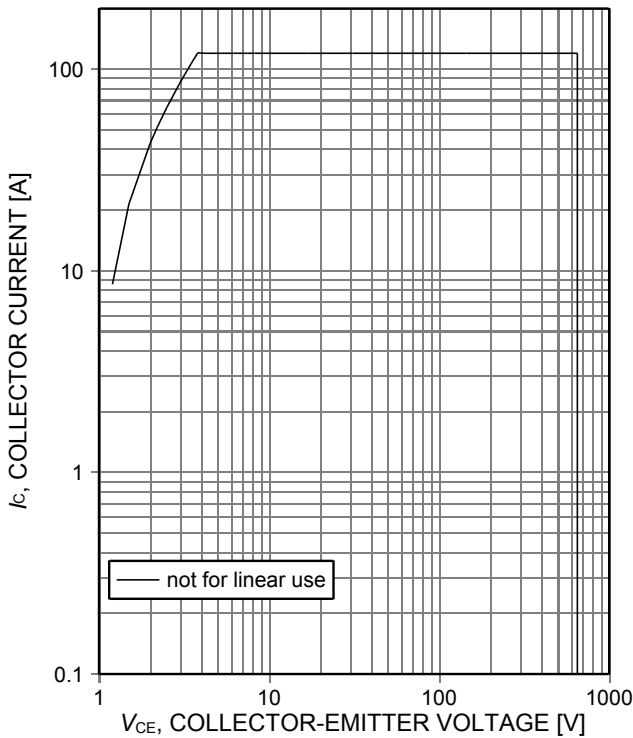


Figure 1. **Forward bias safe operating area**  
( $D=0$ ,  $T_C=25^\circ\text{C}$ ,  $T_{vj}\leq 175^\circ\text{C}$ ;  $V_{GE}=15\text{V}$ )

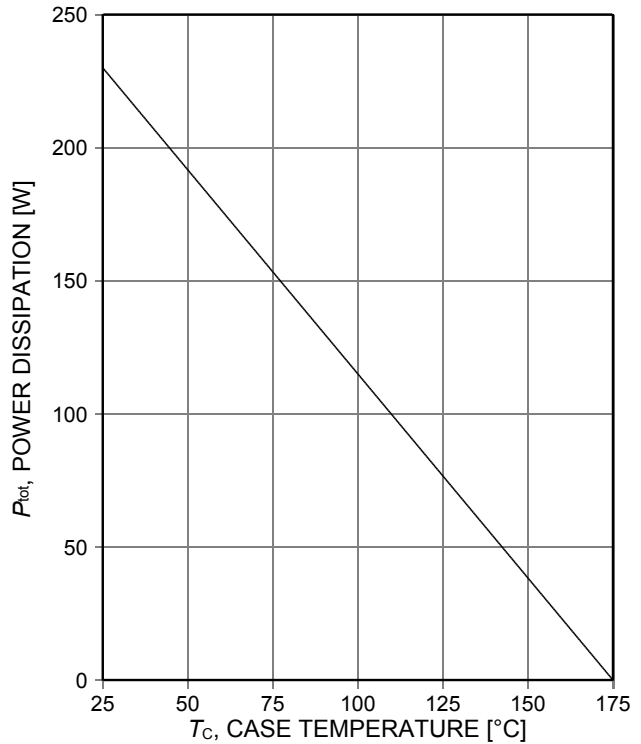


Figure 2. **Power dissipation as a function of case temperature**  
( $T_{vj}\leq 175^\circ\text{C}$ )

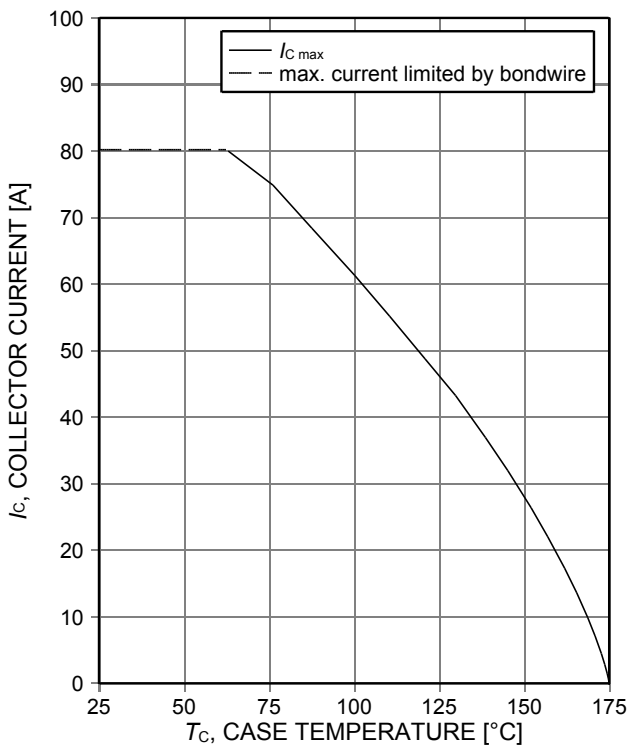


Figure 3. **Collector current as a function of case temperature**  
( $V_{GE}\geq 15\text{V}$ ,  $T_{vj}\leq 175^\circ\text{C}$ )

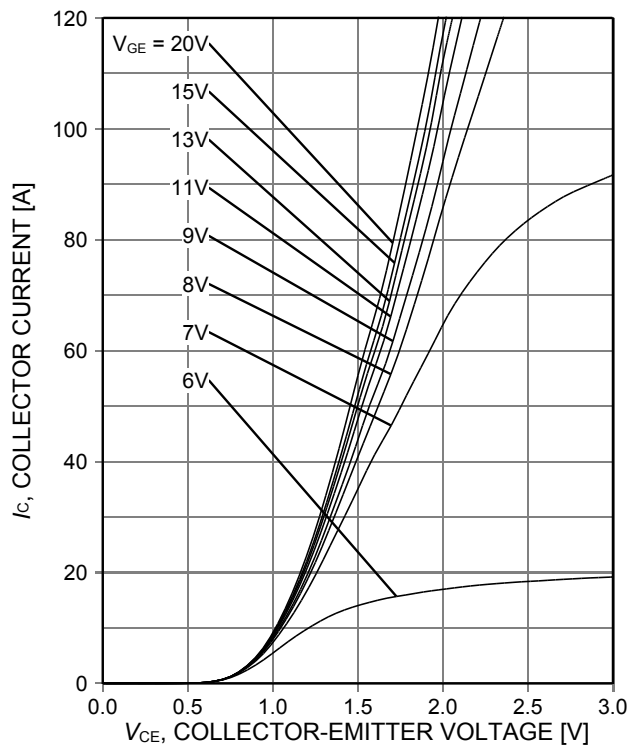


Figure 4. **Typical output characteristic**  
( $T_{vj}=25^\circ\text{C}$ )

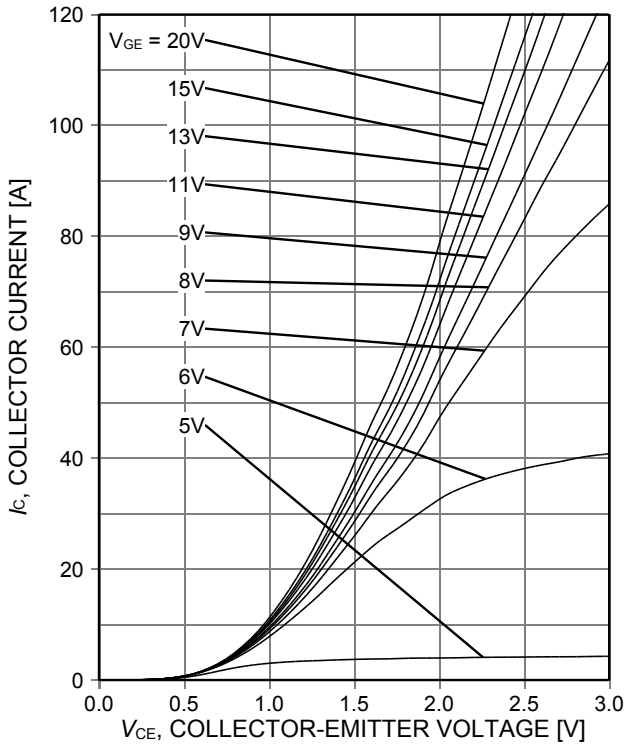


Figure 5. Typical output characteristic ( $T_{vj}=175^{\circ}\text{C}$ )

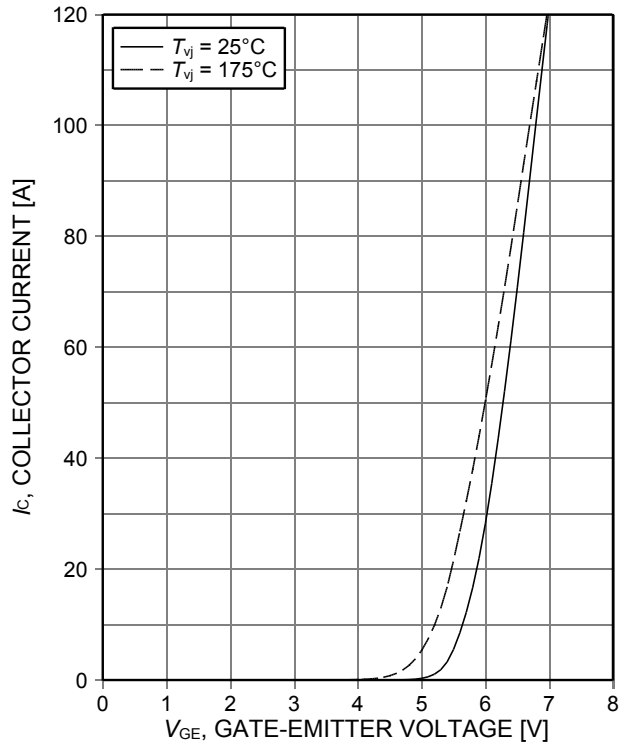


Figure 6. Typical transfer characteristic ( $V_{CE}=20\text{V}$ )

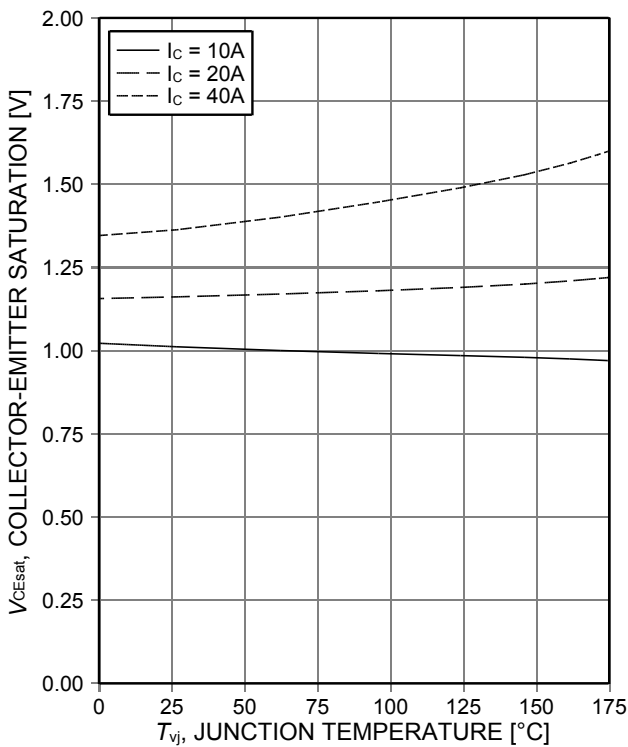


Figure 7. Typical collector-emitter saturation voltage as a function of junction temperature ( $V_{GE}=15\text{V}$ )

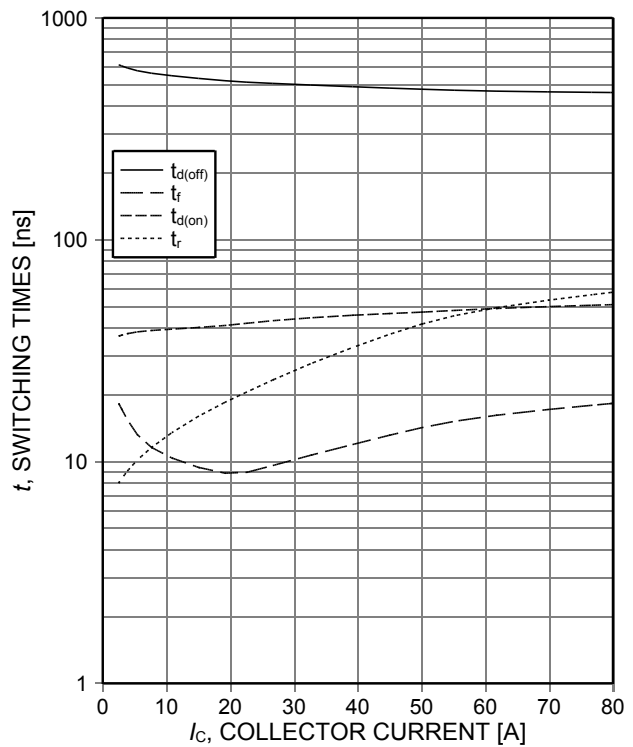


Figure 8. Typical switching times as a function of collector current (inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $R_{G(on)}=20\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)



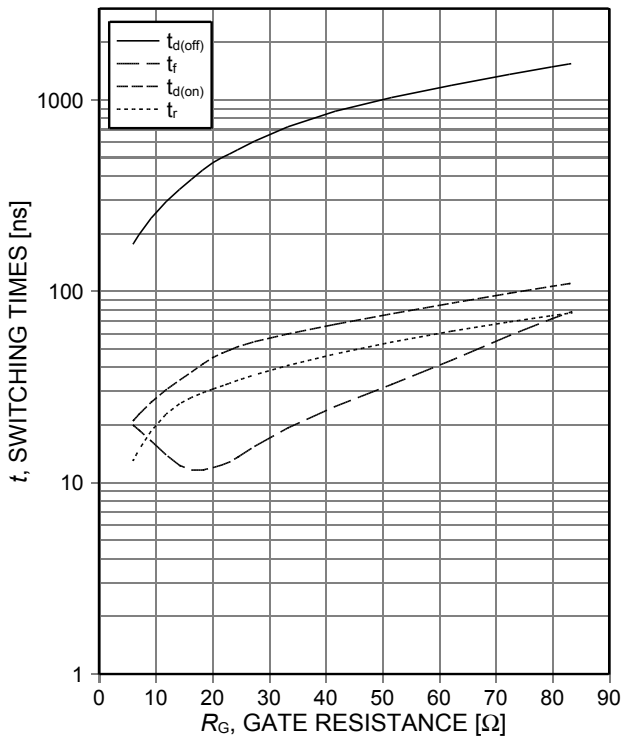


Figure 9. **Typical switching times as a function of gate resistance**  
 (inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=40\text{A}$ , dynamic test circuit in Figure E)

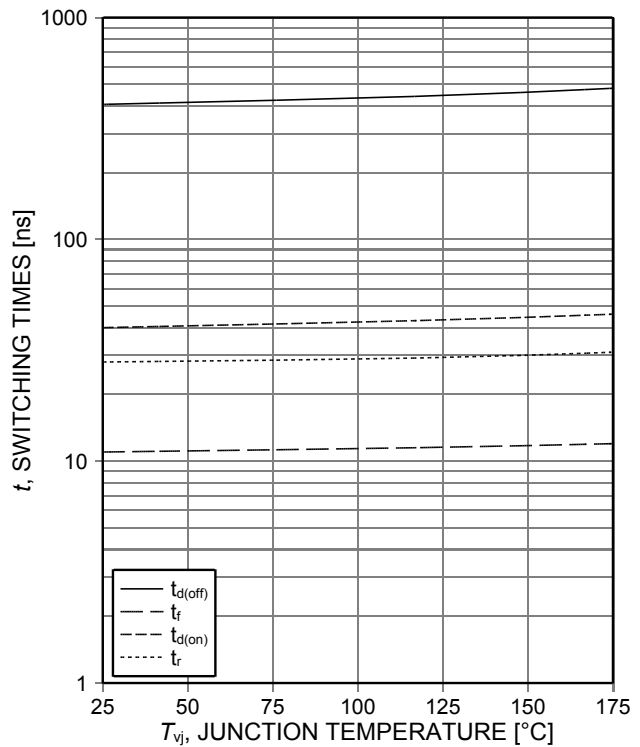


Figure 10. **Typical switching times as a function of junction temperature**  
 (inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=40\text{A}$ ,  $R_{G(on)}=20\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)

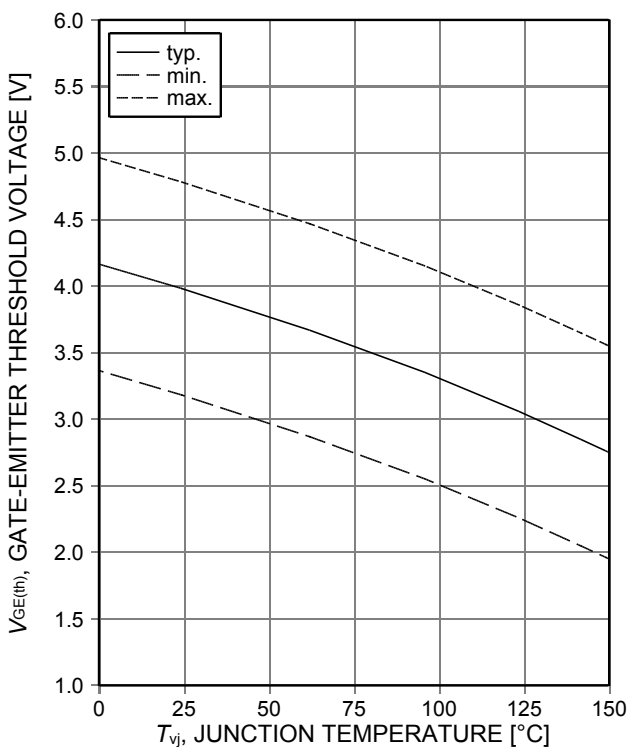


Figure 11. **Gate-emitter threshold voltage as a function of junction temperature**  
 ( $I_C=0,4\text{mA}$ )

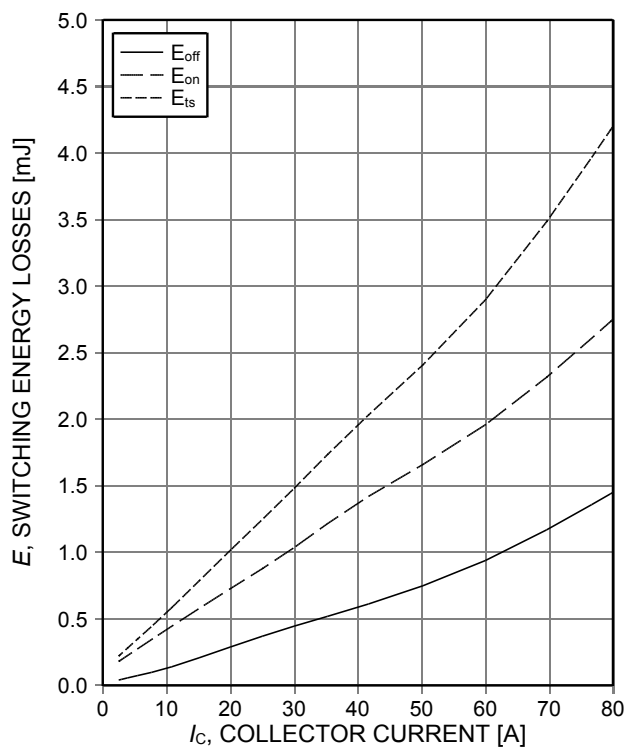


Figure 12. **Typical switching energy losses as a function of collector current**  
 (inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $R_{G(on)}=20\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)

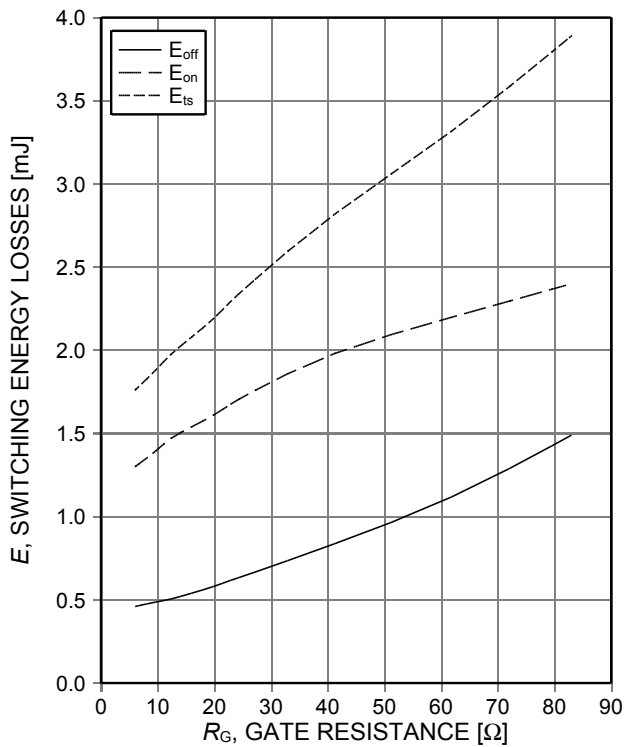


Figure 13. **Typical switching energy losses as a function of gate resistance**  
 (inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=400\text{V}$ ,  $V_{GE}=150\text{V}$ ,  $I_C=40\text{A}$ , dynamic test circuit in Figure E)

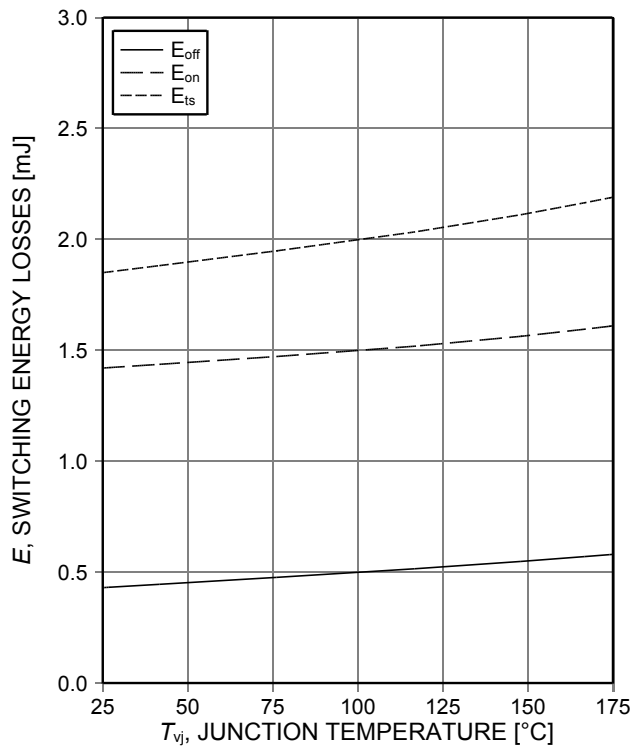


Figure 14. **Typical switching energy losses as a function of junction temperature**  
 (inductive load,  $V_{CE}=400\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=40\text{A}$ ,  $R_{G(on)}=20\Omega$ ,  $R_{G(off)}=20\Omega$ , dynamic test circuit in Figure E)

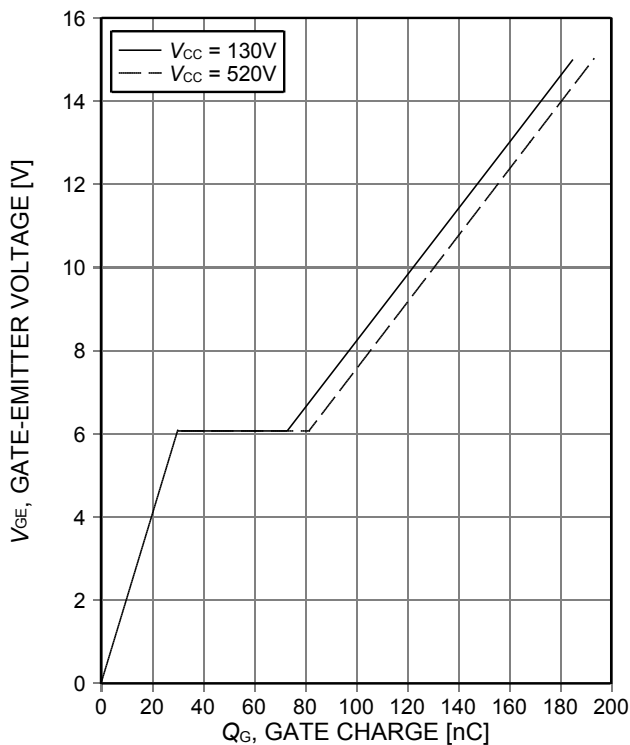


Figure 15. **Typical gate charge**  
 ( $I_C=40\text{A}$ )

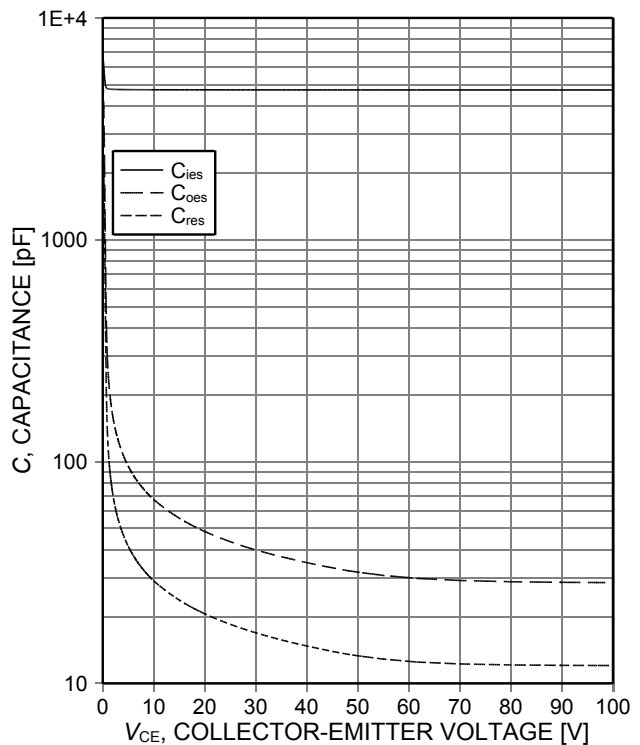


Figure 16. **Typical capacitance as a function of collector-emitter voltage**  
 ( $V_{GE}=0\text{V}$ ,  $f=1\text{MHz}$ )

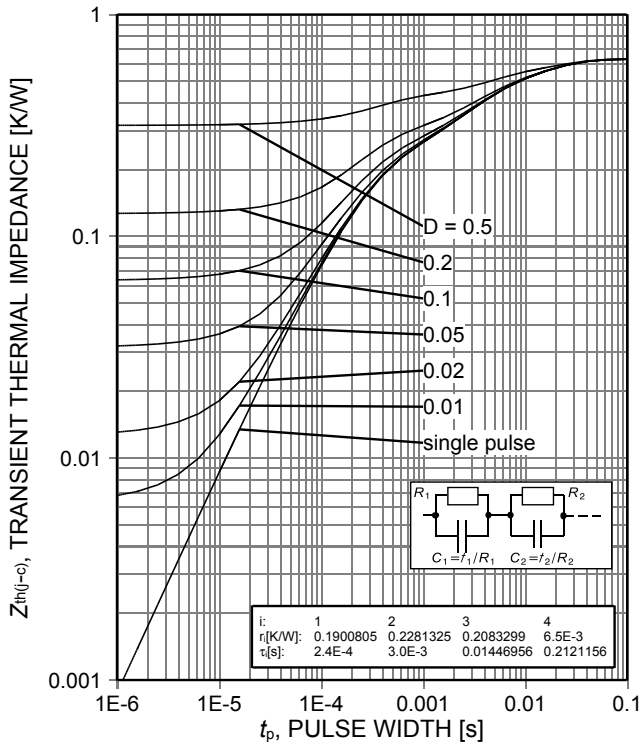


Figure 17. IGBT transient thermal impedance as a function of pulse width ( $D=t_p/T$ )

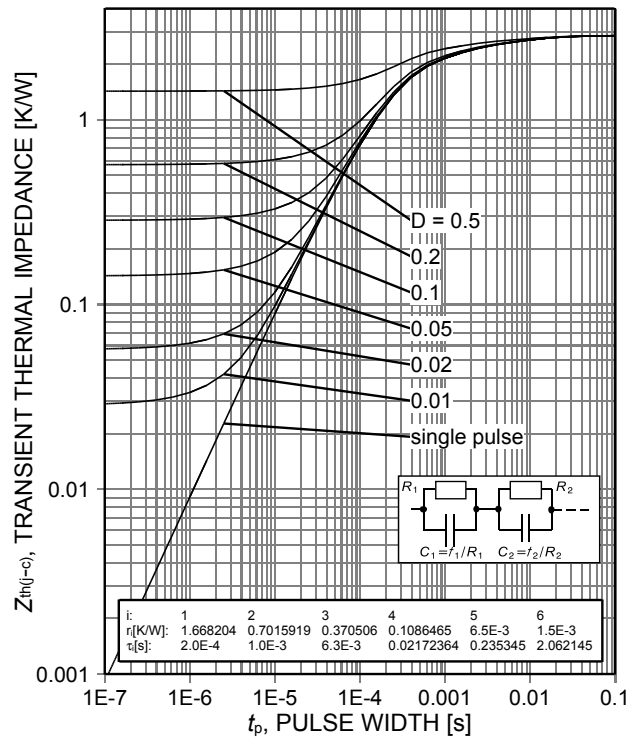


Figure 18. Diode transient thermal impedance as a function of pulse width ( $D=t_p/T$ )

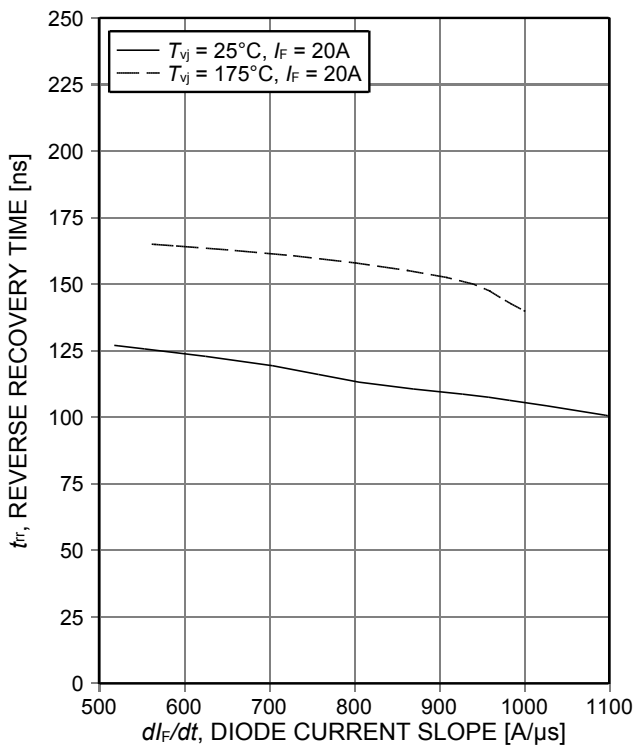


Figure 19. Typical reverse recovery time as a function of diode current slope ( $V_R=400V$ )

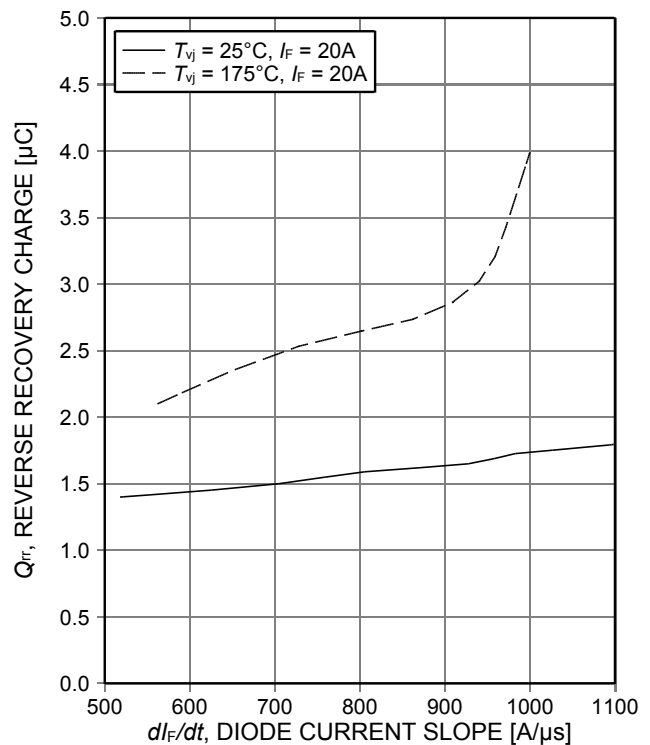


Figure 20. Typical reverse recovery charge as a function of diode current slope ( $V_R=400V$ )

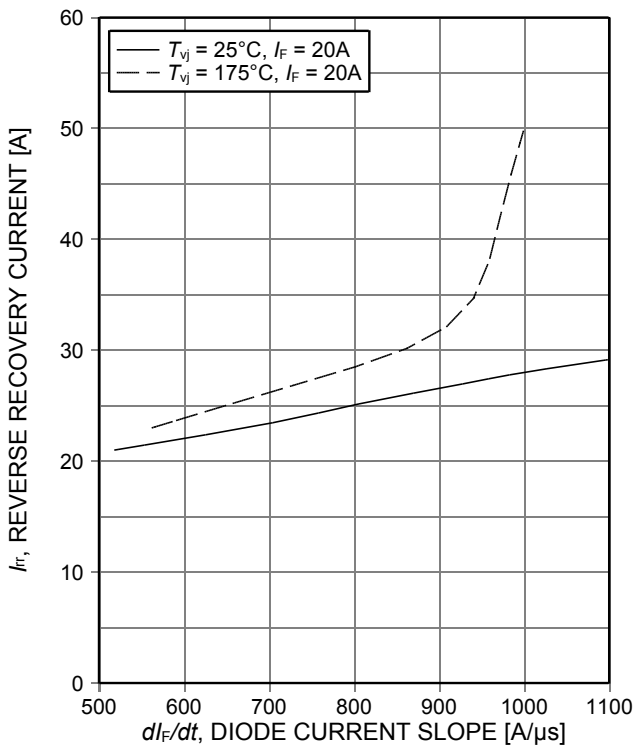


Figure 21. Typical reverse recovery current as a function of diode current slope (VR=400V)

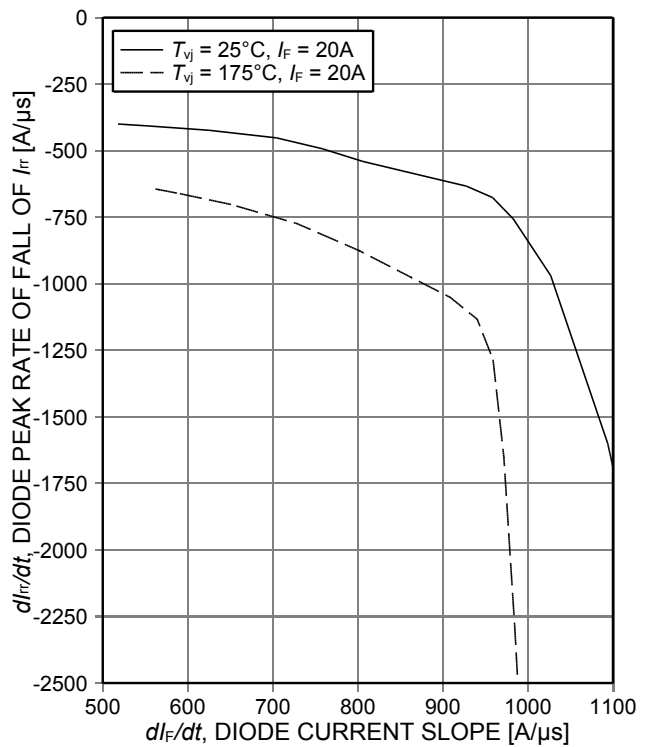


Figure 22. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope (VR=400V)

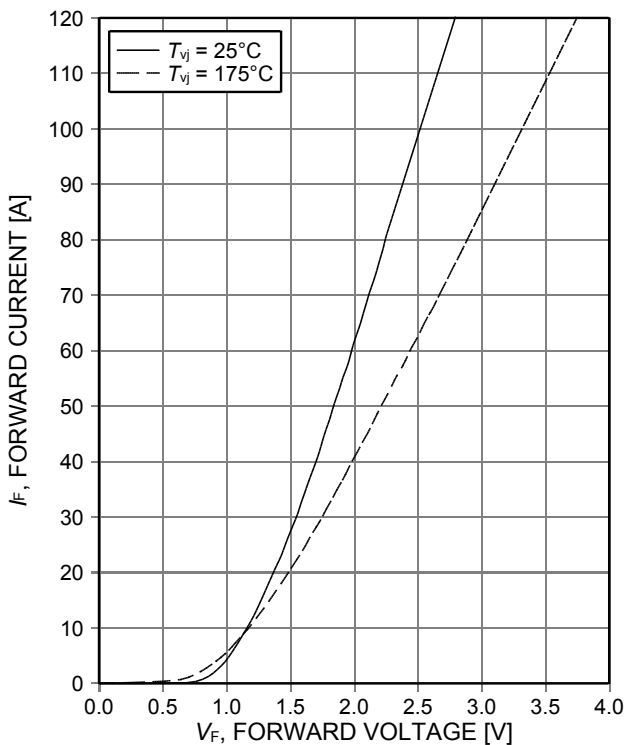


Figure 23. Typical diode forward current as a function of forward voltage

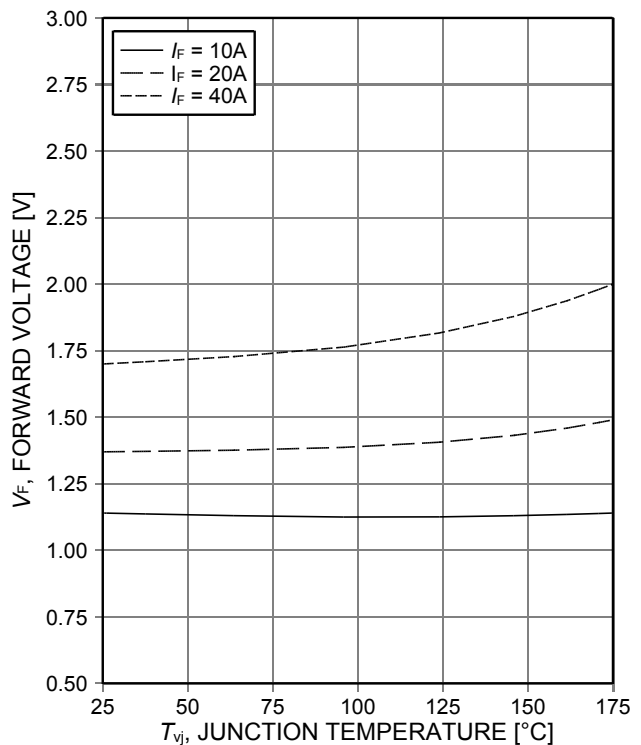


Figure 24. Typical diode forward voltage as a function of junction temperature

Package Drawing PG-TO247-3



DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.83	5.21	0.190	0.205
A1	2.27	2.54	0.089	0.100
A2	1.85	2.16	0.073	0.085
b	1.07	1.33	0.042	0.052
b1	1.90	2.41	0.075	0.095
b2	1.90	2.16	0.075	0.085
b3	2.87	3.38	0.113	0.133
b4	2.87	3.13	0.113	0.123
c	0.55	0.68	0.022	0.027
D	20.80	21.10	0.819	0.831
D1	16.25	17.65	0.640	0.695
D2	0.95	1.35	0.037	0.053
E	15.70	16.13	0.618	0.635
E1	13.10	14.15	0.516	0.557
E2	3.68	5.10	0.145	0.201
E3	1.00	2.60	0.039	0.102
e	5.44 (BSC)		0.214 (BSC)	
N	3		3	
L	19.80	20.32	0.780	0.800
L1	4.10	4.47	0.161	0.176
ØP	3.50	3.70	0.138	0.146
Q	5.49	6.00	0.216	0.236
S	6.04	6.30	0.238	0.248

DOCUMENT NO.  
Z8B00003327

SCALE  
0 5 5 7.5mm

EUROPEAN PROJECTION

ISSUE DATE  
09-07-2010

REVISION  
05

Testing Conditions



Figure A. Definition of switching times

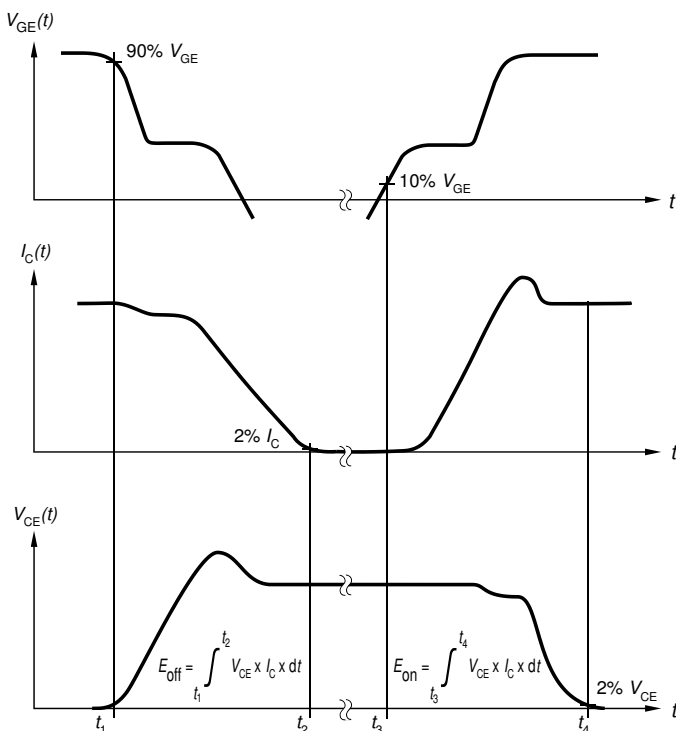


Figure B. Definition of switching losses

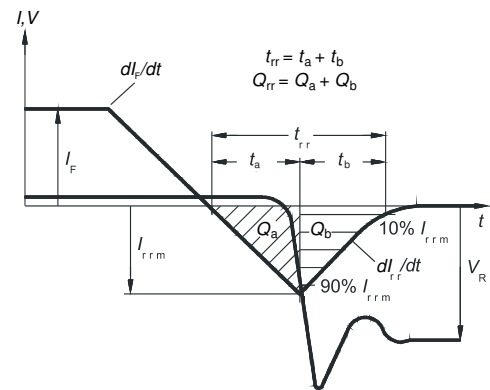


Figure C. Definition of diode switching characteristics

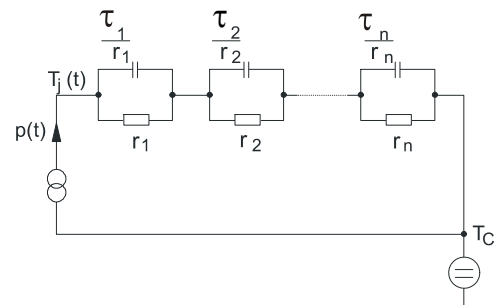


Figure D. Thermal equivalent circuit



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

**Revision History**

IKW40N65WR5

**Revision: 2015-12-10, Rev. 2.1**

Previous Revision

Revision	Date	Subjects (major changes since last revision)
1.1	2014-12-05	Preliminary data sheet
1.2	2015-03-27	New dynamic parameters and graphs
1.3	2015-05-12	New dynamic parameters
2.1	2015-12-10	Final data sheet

**Published by**  
**Infineon Technologies AG**  
**81726 München, Germany**  
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