

## Resonant Switching Series

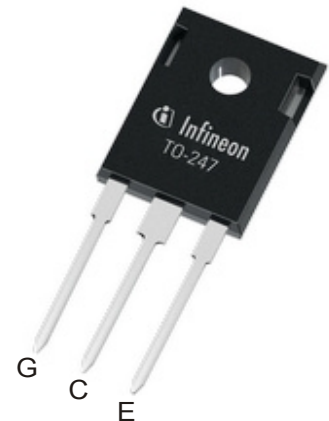
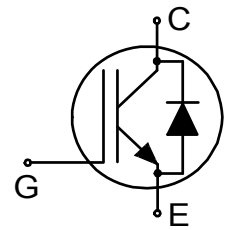
## Reverse Conducting IGBT with monolithic body diode

**Features:**

- Powerful monolithic body diode with low forward voltage designed for soft commutation
- TRENCHSTOP™ technology offering:
  - 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 according to JESD-022 for target applications
- Pb-free lead plating; RoHS compliant
- Halogen free (according to IEC 61249-2-21)
- Complete product spectrum and PSpice Models: <http://www.infineon.com/igbt/>

**Applications:**

- Induction cooking
- Microwave ovens

**Key Performance and Package Parameters**

Type	$V_{CE}$	$I_C$	$V_{CEsat}, T_{vj}=25^{\circ}C$	$T_{vjmax}$	Marking	Package
IHW40N135R5	1350V	40A	1.65V	175°C	H40PR5	PG-TO247-3

### Table of Contents

Description .....	1
Table of Contents .....	2
Maximum Ratings .....	3
Thermal Resistance .....	3
Electrical Characteristics .....	4
Electrical Characteristics Diagrams .....	6
Package Drawing .....	12
Testing Conditions .....	13
Revision History .....	14
Disclaimer .....	15

## Resonant Switching Series

## 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, $T_{vj} \geq 25^{\circ}\text{C}$	$V_{CE}$	1350	V
DC collector current, limited by $T_{vjmax}$ $T_c = 25^{\circ}\text{C}$ $T_c = 100^{\circ}\text{C}$	$I_C$	80.0 40.0	A
Pulsed collector current, $t_p$ limited by $T_{vjmax}$	$I_{Cpuls}$	120.0	A
Non repetitive peak collector current <sup>1)</sup>	$I_{CSM}$	200	A
Turn off safe operating area $V_{CE} \leq 1350\text{V}$ , $T_{vj} \leq 175^{\circ}\text{C}$ , $t_p = 1\mu\text{s}$	-	120.0	A
Diode forward current, limited by $T_{vjmax}$ $T_c = 25^{\circ}\text{C}$ $T_c = 100^{\circ}\text{C}$	$I_F$	80.0 40.0	A
Diode pulsed current, $t_p$ limited by $T_{vjmax}$	$I_{Fpuls}$	120.0	A
Gate-emitter voltage Transient Gate-emitter voltage ( $t_p \leq 10\mu\text{s}$ , $D < 0.010$ )	$V_{GE}$	$\pm 20$ $\pm 25$	V
Power dissipation $T_c = 25^{\circ}\text{C}$ Power dissipation $T_c = 100^{\circ}\text{C}$	$P_{tot}$	394.0 197.0	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>R<sub>th</sub> Characteristics</b>						
IGBT thermal resistance, junction - case	$R_{th(j-c)}$		-	-	0.38	K/W
Diode thermal resistance, junction - case	$R_{th(j-c)}$		-	-	0.38	K/W
Thermal resistance junction - ambient	$R_{th(j-a)}$		-	-	40	K/W

<sup>1)</sup> capacitor charging saturation current limited by  $T_{vjmax} < 175^{\circ}\text{C}$  and  $t_p < 3\mu\text{s}$

## Resonant Switching Series

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	$V_{(BR)CES}$	$V_{GE} = 0\text{V}, I_C = 0.50\text{mA}$	1350	-	-	V
Collector-emitter saturation voltage	$V_{CESat}$	$V_{GE} = 15.0\text{V}, I_C = 40.0\text{A}$	-	1.65	1.95	V
		$T_{vj} = 25^{\circ}\text{C}$	-	1.95	-	
		$T_{vj} = 125^{\circ}\text{C}$	-	2.05	-	
Diode forward voltage	$V_F$	$V_{GE} = 0\text{V}, I_F = 40.0\text{A}$	-	1.95	2.15	V
		$T_{vj} = 25^{\circ}\text{C}$	-	2.30	-	
		$T_{vj} = 175^{\circ}\text{C}$	-	2.40	-	
Gate-emitter threshold voltage	$V_{GE(th)}$	$I_C = 1.00\text{mA}, V_{CE} = V_{GE}$	5.1	5.8	6.4	V
Zero gate voltage collector current	$I_{CES}$	$V_{CE} = 1350\text{V}, V_{GE} = 0\text{V}$	-	-	100	$\mu\text{A}$
		$T_{vj} = 25^{\circ}\text{C}$	-	850	-	
Gate-emitter leakage current	$I_{GES}$	$V_{CE} = 0\text{V}, V_{GE} = 20\text{V}$	-	-	100	nA
		$T_{vj} = 175^{\circ}\text{C}$	-	-	-	
Transconductance	$g_{fs}$	$V_{CE} = 20\text{V}, I_C = 40.0\text{A}$	-	30.0	-	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	$C_{ies}$	$V_{CE} = 25\text{V}, V_{GE} = 0\text{V}, f = 1\text{MHz}$	-	2360	-	pF
Output capacitance	$C_{oes}$		-	70	-	
Reverse transfer capacitance	$C_{res}$		-	60	-	
Gate charge	$Q_G$	$V_{CC} = 1080\text{V}, I_C = 40.0\text{A}, V_{GE} = 15\text{V}$	-	305.0	-	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.	
<b>IGBT Characteristic, at <math>T_{vj} = 25^{\circ}\text{C}</math></b>						
Turn-off delay time	$t_{d(off)}$	$T_{vj} = 25^{\circ}\text{C}, V_{CC} = 600\text{V}, I_C = 40.0\text{A}, V_{GE} = 0.0/15.0\text{V}, R_{G(on)} = 10.0\Omega, R_{G(off)} = 10.0\Omega, L_{\sigma} = 175\text{nH}, C_{\sigma} = 40\text{pF}$ $L_{\sigma}, C_{\sigma}$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	410	-	ns
Fall time	$t_f$		-	90	-	ns
Turn-off energy	$E_{off}$		-	2.00	-	mJ
Turn-off energy, soft switching	$E_{off}$		$dv/dt = 200.0\text{V}/\mu\text{s}$	-	0.30	-

## Resonant Switching Series

## 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-off delay time	$t_{d(off)}$	$T_{vj} = 175^{\circ}\text{C}$ , $V_{CC} = 600\text{V}$ , $I_C = 40.0\text{A}$ , $V_{GE} = 0.0/15.0\text{V}$ , $R_{G(on)} = 10.0\Omega$ , $R_{G(off)} = 10.0\Omega$ , $L_{\sigma} = 175\text{nH}$ , $C_{\sigma} = 40\text{pF}$ $L_{\sigma}$ , $C_{\sigma}$ from Fig. E Energy losses include "tail" and diode reverse recovery.	-	480	-	ns
Fall time	$t_f$		-	220	-	ns
Turn-off energy	$E_{off}$		-	3.70	-	mJ
Turn-off energy, soft switching	$E_{off}$	$dv/dt = 200.0\text{V}/\mu\text{s}$	-	0.85	-	mJ

Resonant Switching Series

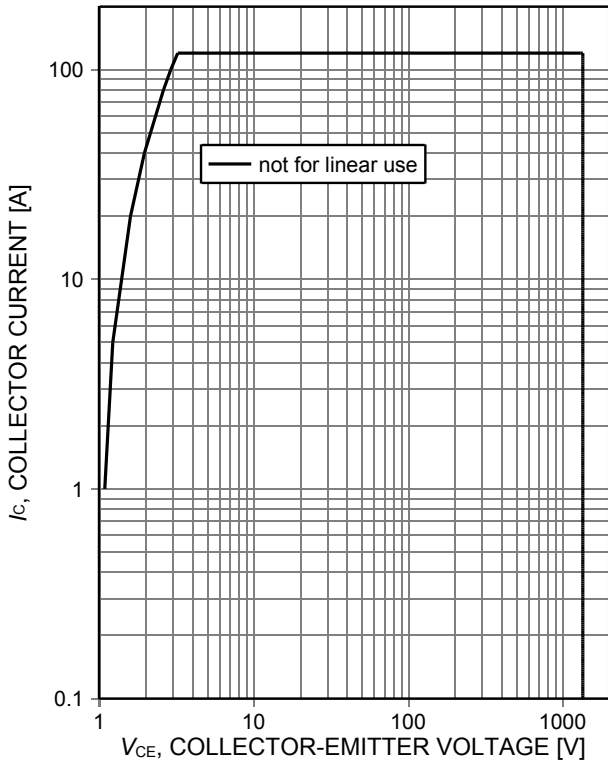


Figure 1. **Forward bias safe operating area**  
 ( $D=0$ ,  $T_C=25^\circ\text{C}$ ,  $T_{vj}\leq 175^\circ\text{C}$ ;  $V_{GE}=15\text{V}$ ;  $t_p=1\mu\text{s}$ )

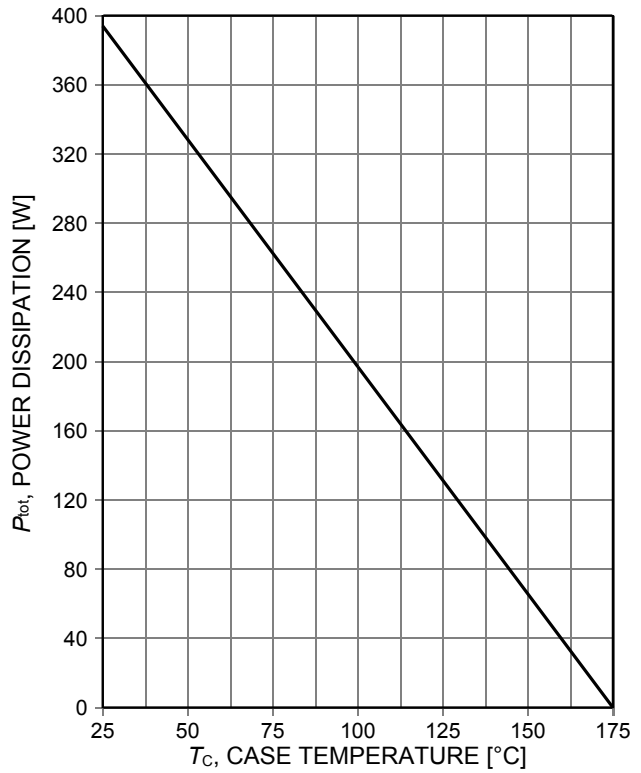


Figure 2. **Power dissipation as a function of case temperature**  
 ( $T_{vj}\leq 175^\circ\text{C}$ )

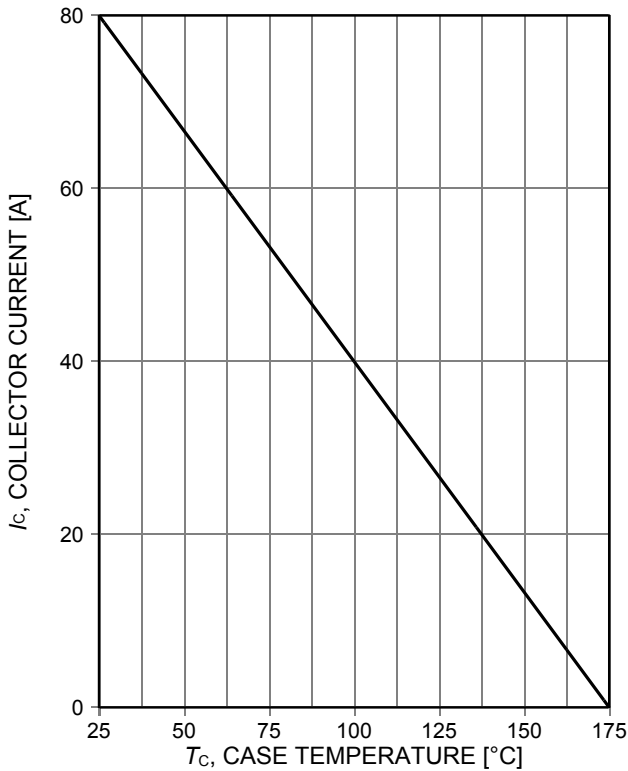


Figure 3. **Collector current as a function of case temperature**  
 ( $V_{GE}\geq 15\text{V}$ ,  $T_{vj}\leq 175^\circ\text{C}$ )

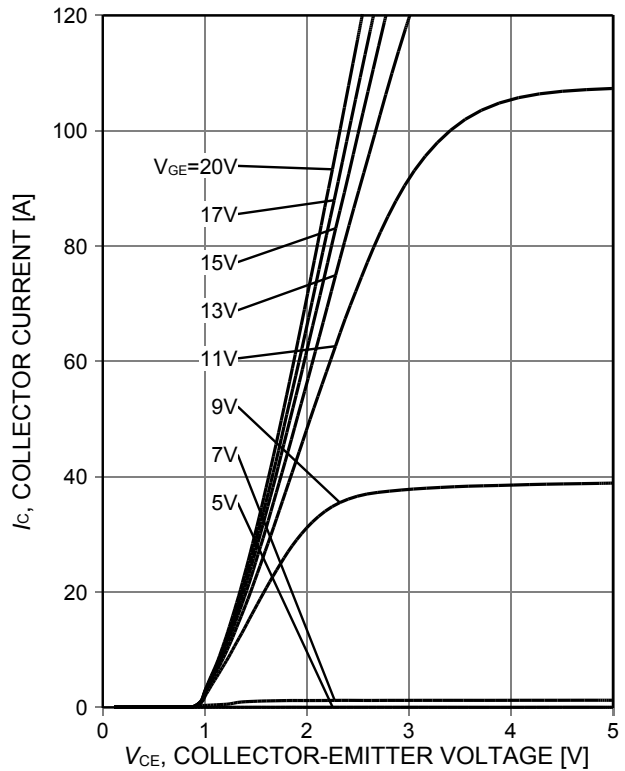


Figure 4. **Typical output characteristic**  
 ( $T_{vj}=25^\circ\text{C}$ )

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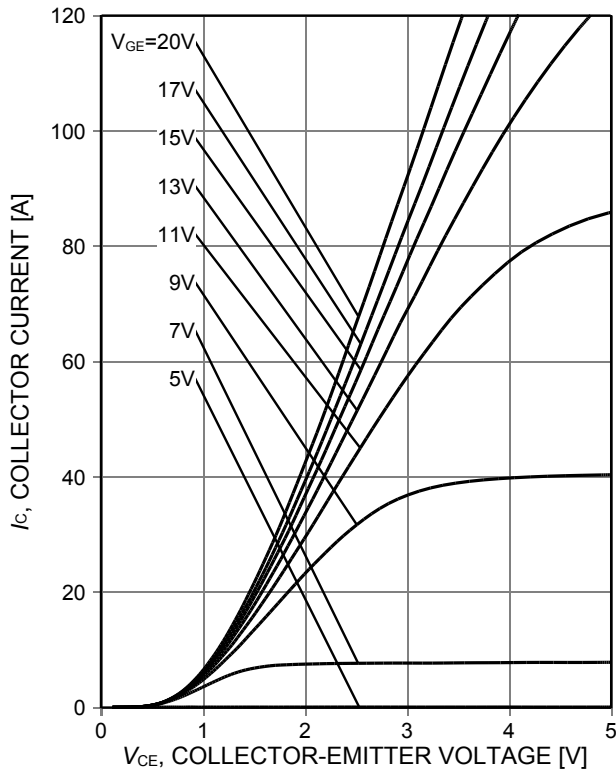


Figure 5. Typical output characteristic ( $T_{vj}=175^\circ\text{C}$ )

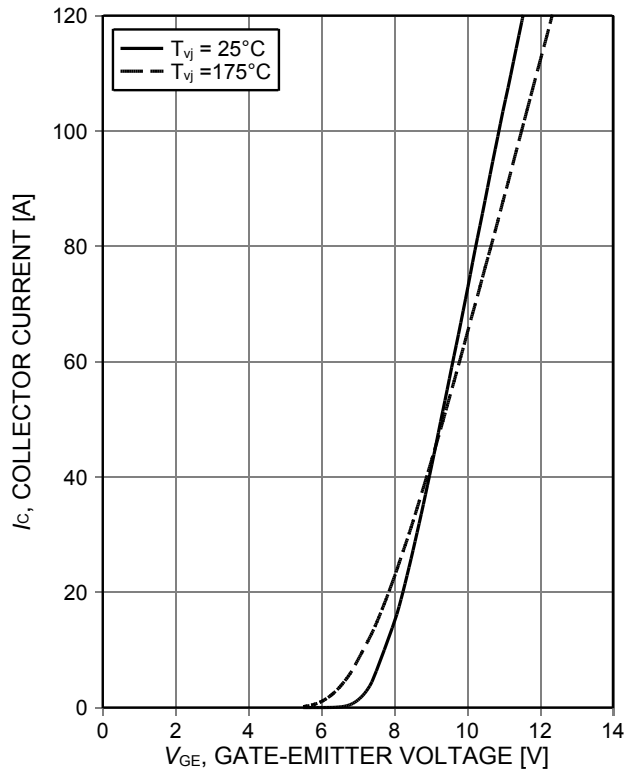


Figure 6. Typical transfer characteristic ( $V_{CE}=20\text{V}$ )

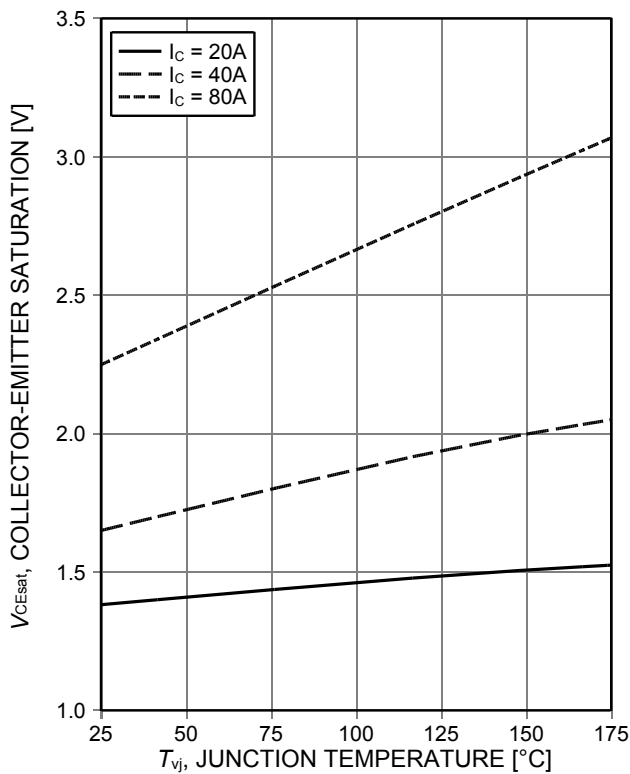


Figure 7. Typical collector-emitter saturation voltage as a function of junction temperature ( $V_{GE}=15\text{V}$ )

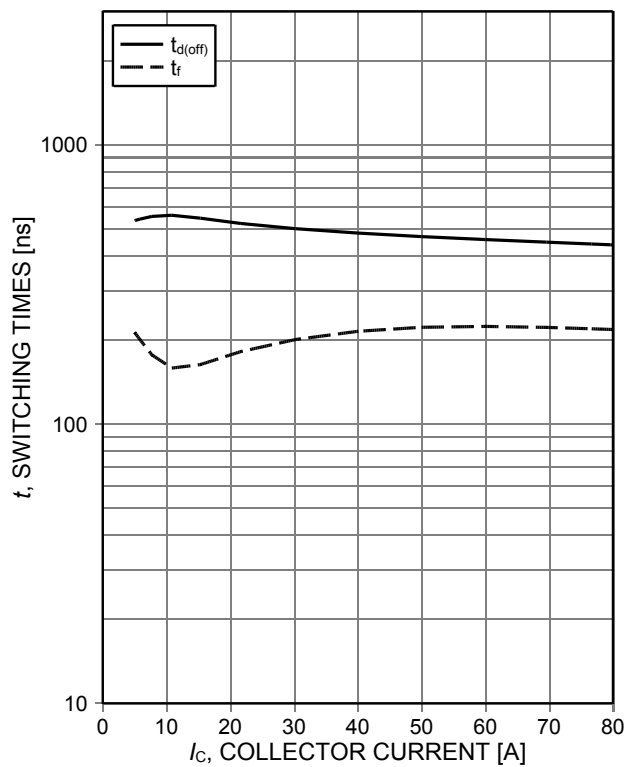


Figure 8. Typical switching times as a function of collector current (inductive load,  $T_{vj}=175^\circ\text{C}$ ,  $V_{CE}=600\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $r_G=10\Omega$ , Dynamic test circuit in Figure E)

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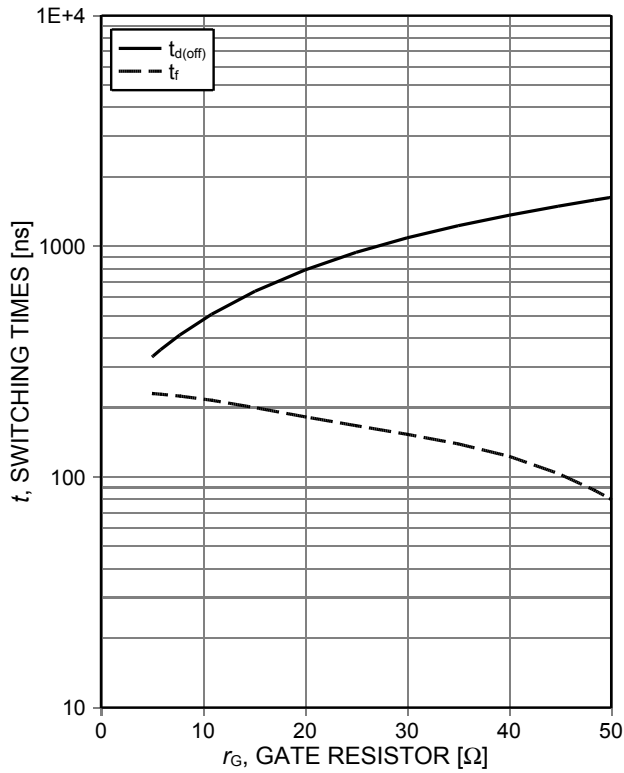


Figure 9. **Typical switching times as a function of gate resistor**  
 (inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=600\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=40\text{A}$ , Dynamic test circuit in Figure E)

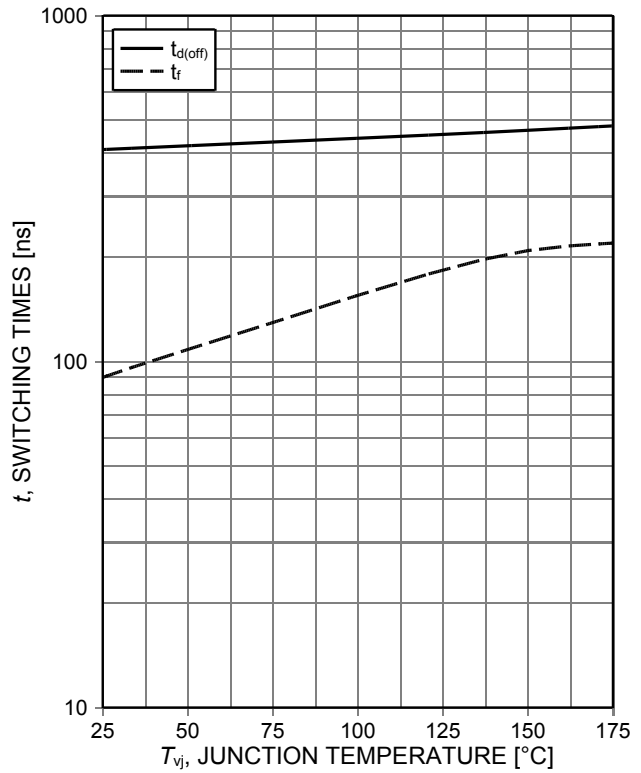


Figure 10. **Typical switching times as a function of junction temperature**  
 (inductive load,  $V_{CE}=600\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=40\text{A}$ ,  $r_G=10\Omega$ , Dynamic test circuit in Figure E)

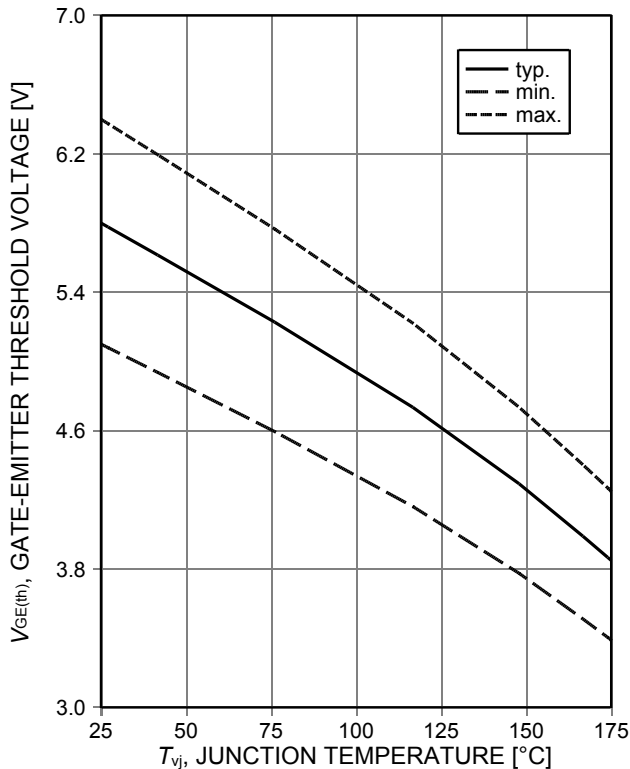


Figure 11. **Gate-emitter threshold voltage as a function of junction temperature**  
 ( $I_C=1\text{mA}$ )

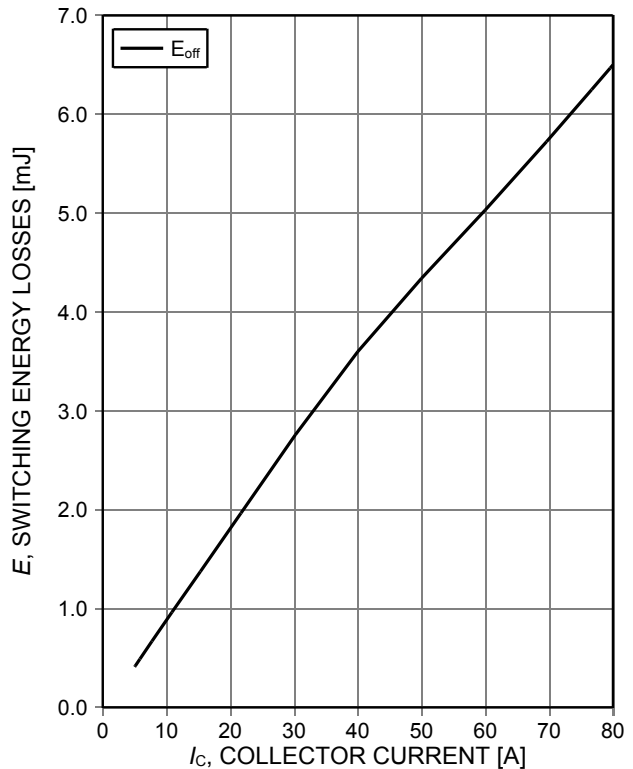


Figure 12. **Typical switching energy losses as a function of collector current**  
 (inductive load,  $T_j=175^{\circ}\text{C}$ ,  $V_{CE}=600\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $R_G=10\Omega$ , Dynamic test circuit in Figure E)



Resonant Switching Series

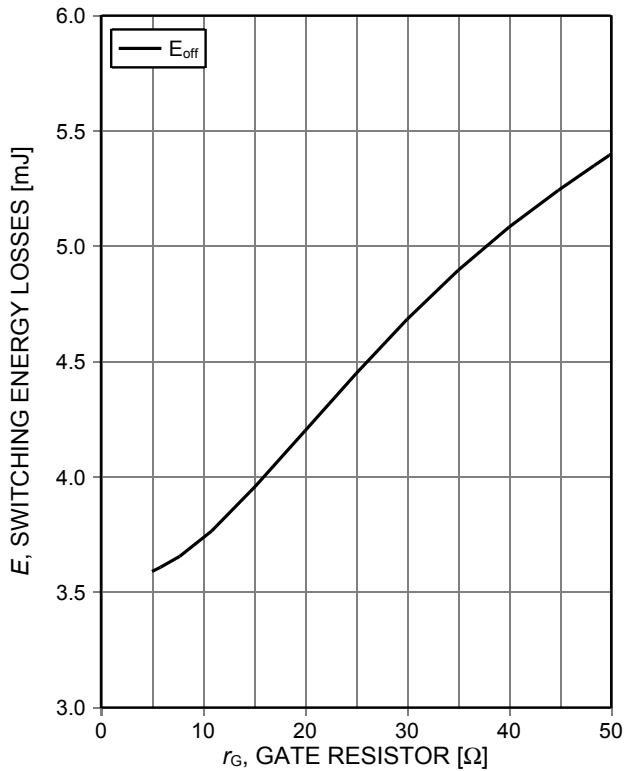


Figure 13. **Typical switching energy losses as a function of gate resistor**  
 (inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{CE}=600\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=40\text{A}$ , Dynamic test circuit in Figure E)

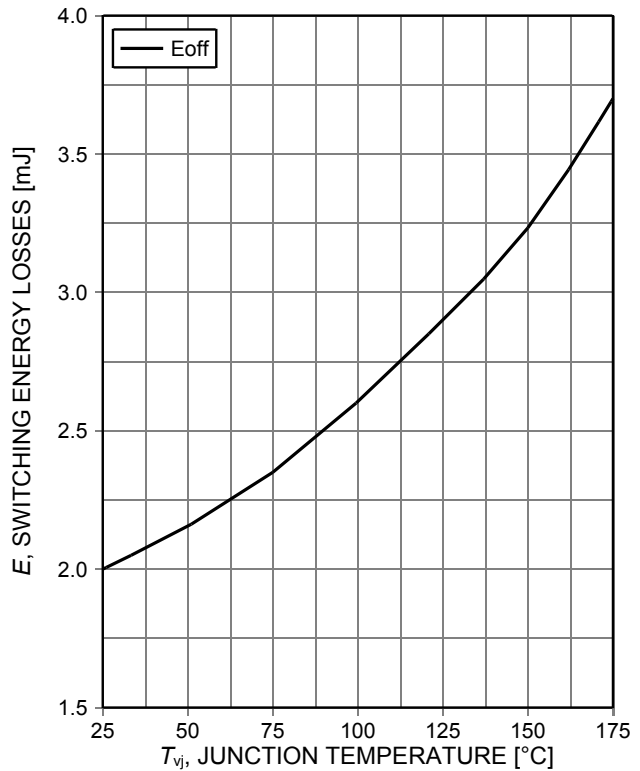


Figure 14. **Typical switching energy losses as a function of junction temperature**  
 (inductive load,  $V_{CE}=600\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=40\text{A}$ ,  $r_G=10\Omega$ , Dynamic test circuit in Figure E)

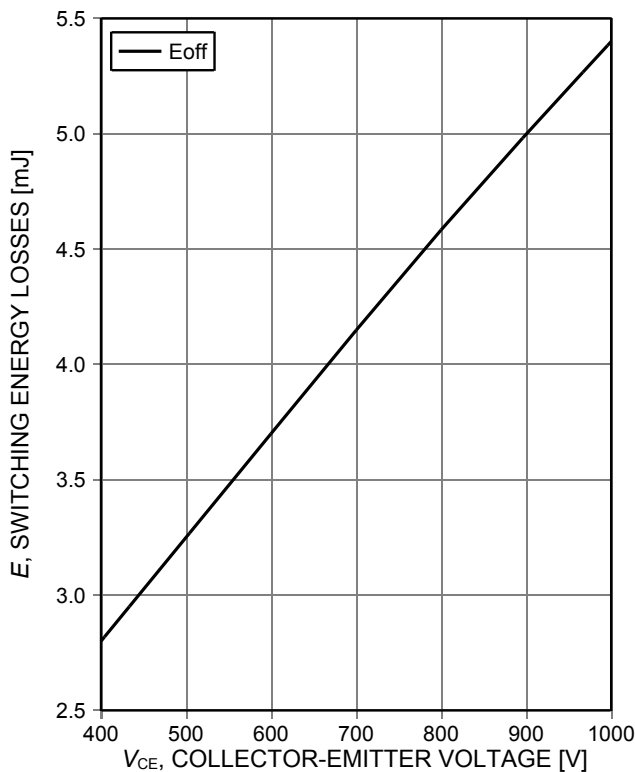


Figure 15. **Typical switching energy losses as a function of collector emitter voltage**  
 (inductive load,  $T_{vj}=175^{\circ}\text{C}$ ,  $V_{GE}=0/15\text{V}$ ,  $I_C=40\text{A}$ ,  $r_G=10\Omega$ , Dynamic test circuit in Figure E)

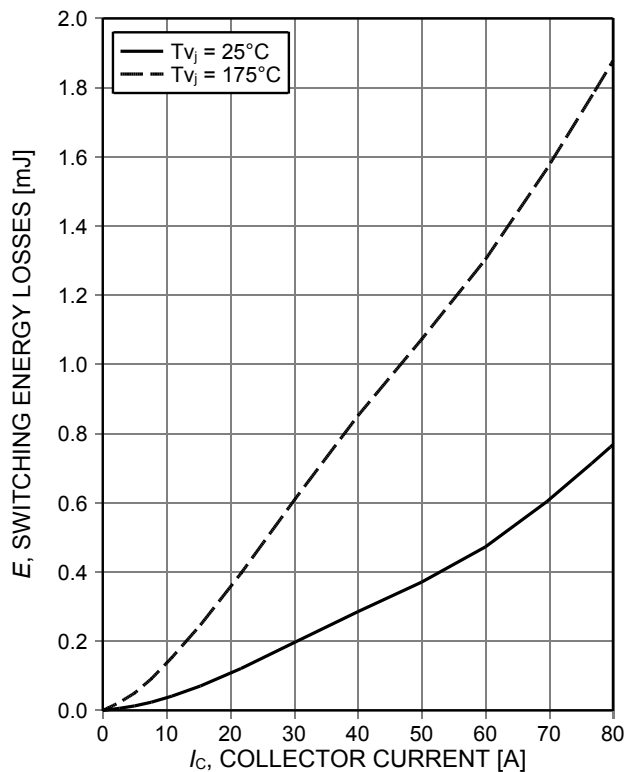


Figure 16. **Typical turn off switching energy loss for soft switching**  
 (inductive load,  $V_{CE}=600\text{V}$ ,  $V_{GE}=0/15\text{V}$ ,  $R_G=10\Omega$ , Dynamic test circuit in Figure E)

Resonant Switching Series

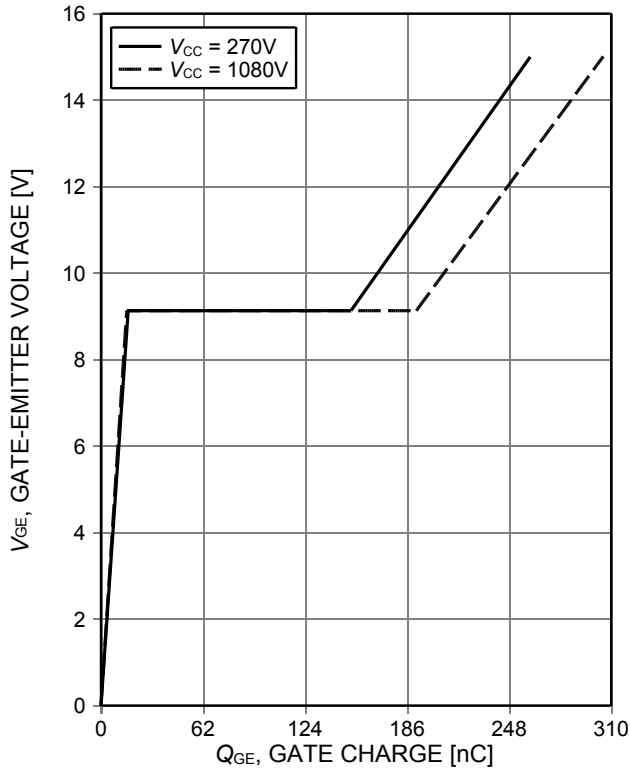


Figure 17. Typical gate charge ( $I_C=40A$ )

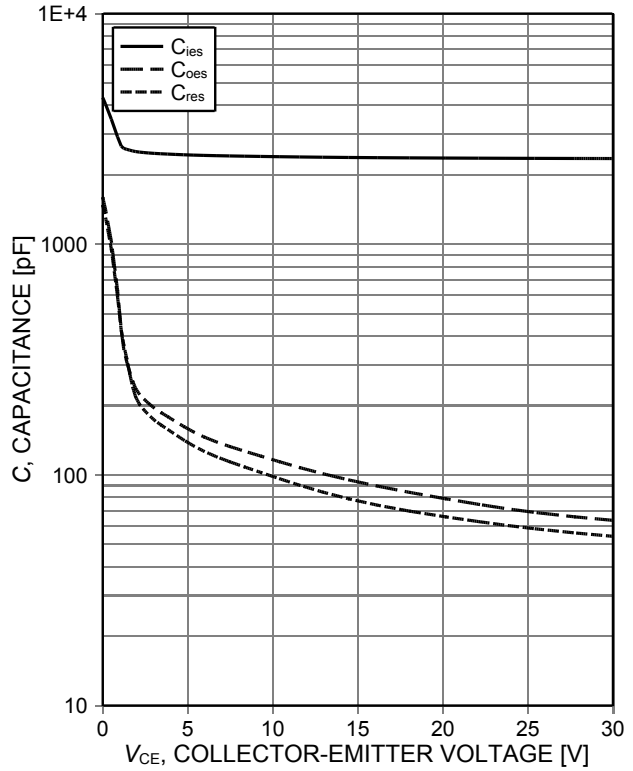


Figure 18. Typical capacitance as a function of collector-emitter voltage ( $V_{GE}=0V, f=1MHz$ )

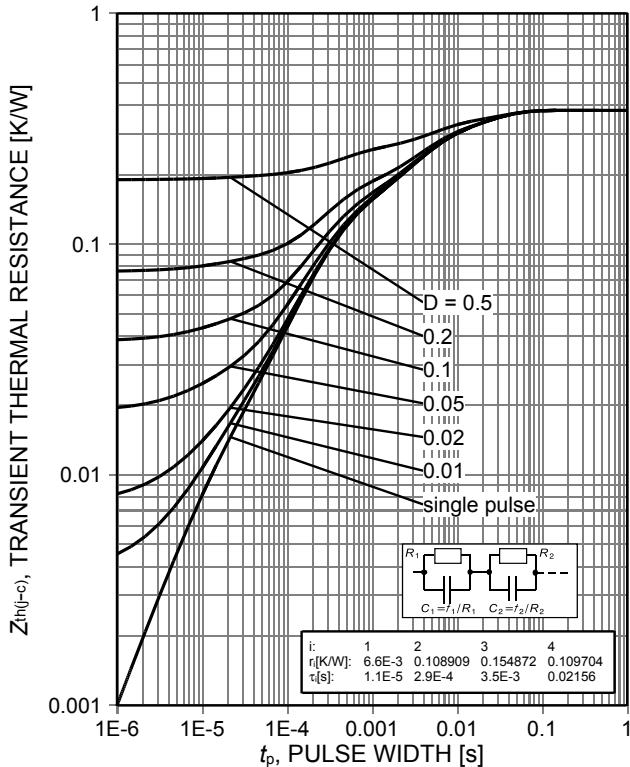


Figure 19. IGBT transient thermal resistance ( $D=t_p/T$ )

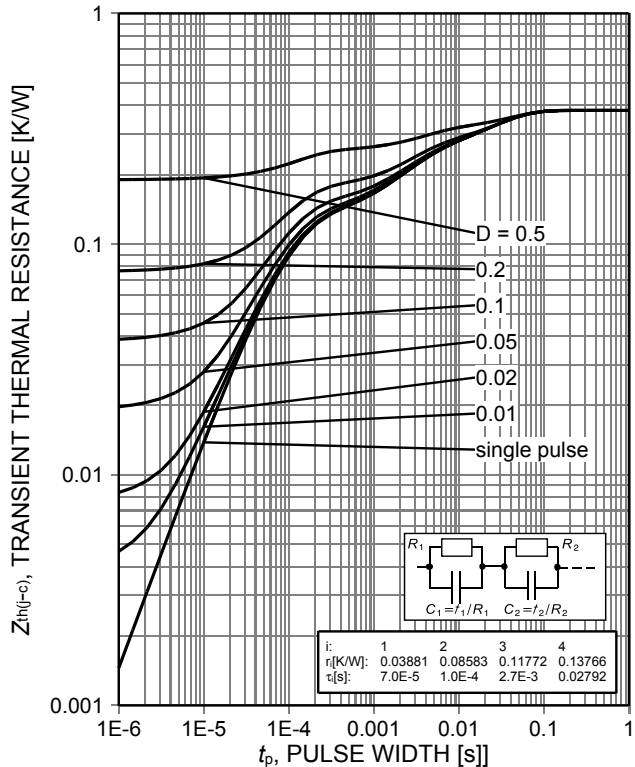


Figure 20. Diode transient thermal impedance as a function of pulse width ( $D=t_p/T$ )

Resonant Switching Series

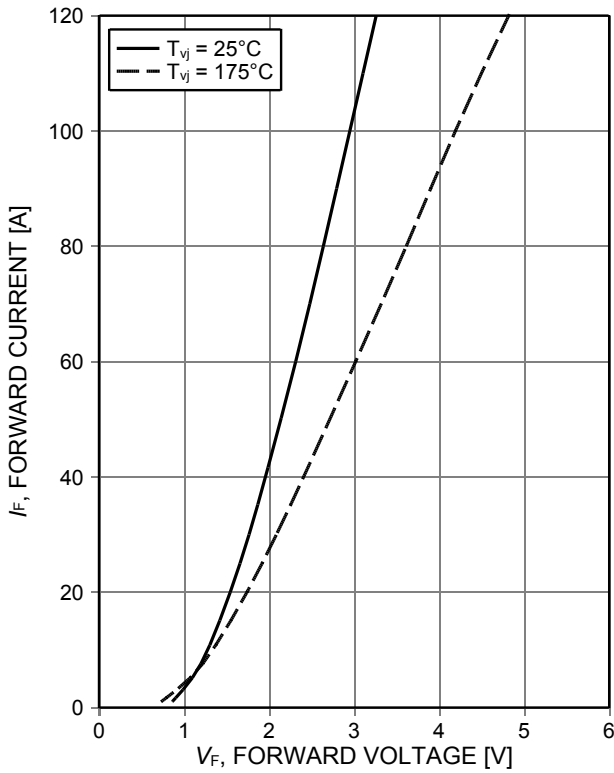


Figure 21. Typical diode forward current as a function of forward voltage

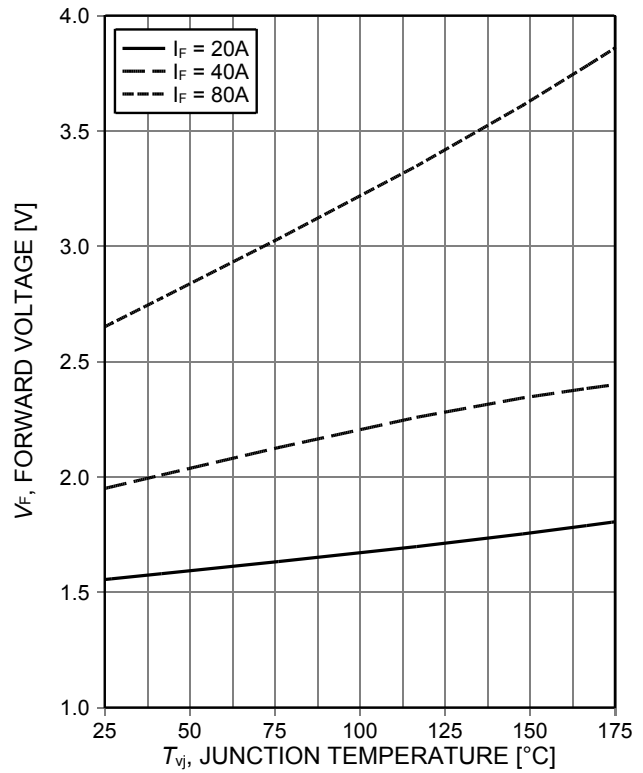
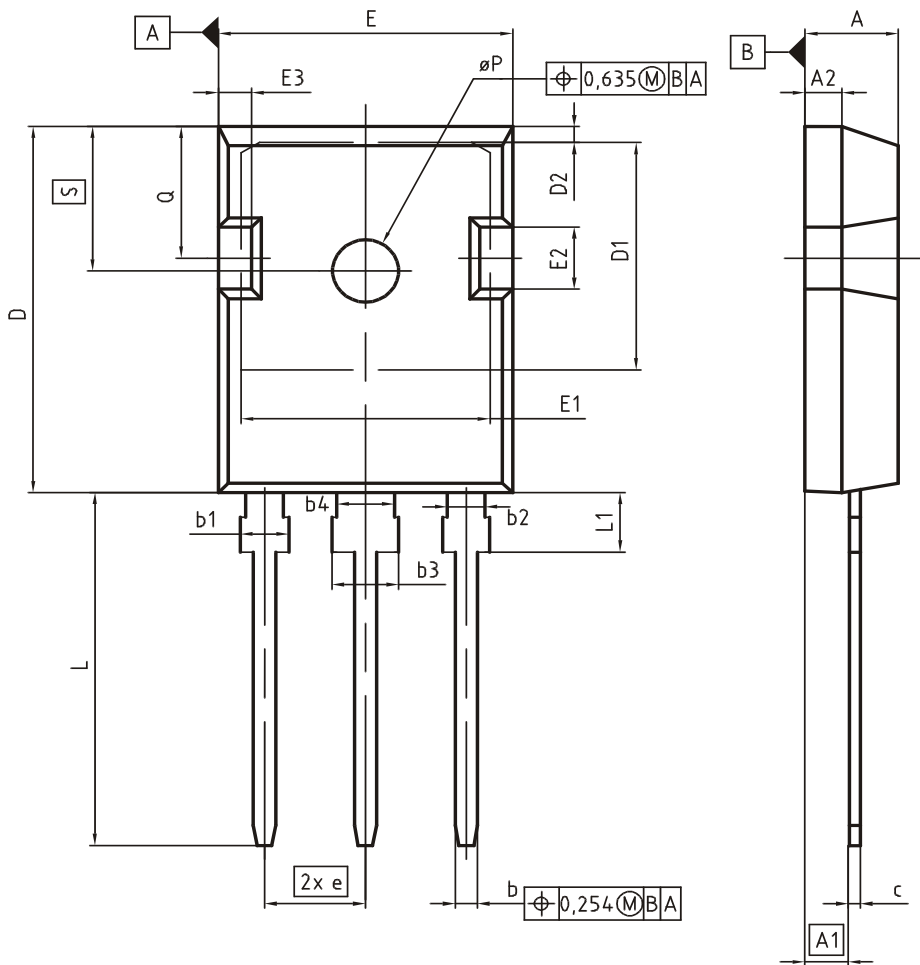


Figure 22. Typical diode forward voltage as a function of junction temperature

### 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**

**EUROPEAN PROJECTION**

**ISSUE DATE**  
09-07-2010

**REVISION**  
05

Resonant Switching Series

Testing Conditions



Figure A. Definition of switching times

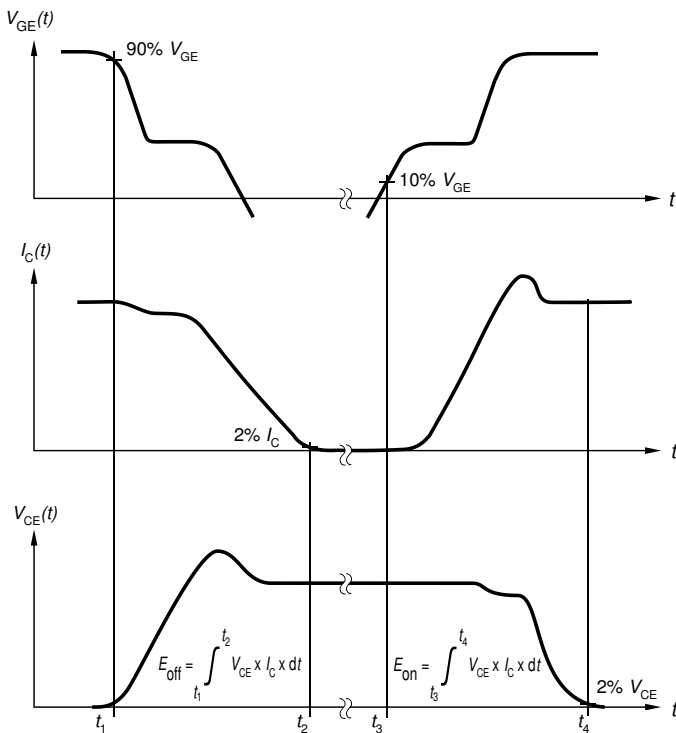


Figure B. Definition of switching losses



Figure C. Definition of diode switching characteristics



Figure D. Thermal equivalent circuit

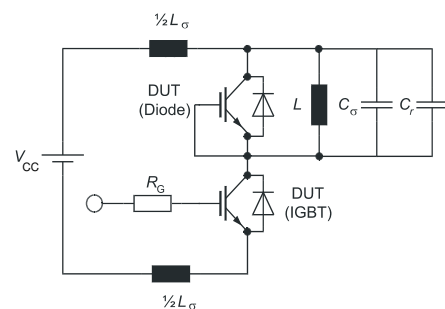


Figure E. Dynamic test circuit  
Parasitic inductance  $L_{\sigma}$ ,  
parasitic capacitor  $C_{\sigma}$ ,  
relief capacitor  $C_r$ ,  
(only for ZVT switching)

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## Resonant Switching Series

### Revision History

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IHW40N135R5

**Revision: 2019-09-20, Rev. 2.3**

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Previous Revision

Revision	Date	Subjects (major changes since last revision)
2.1	2018-04-17	FINAL DATASHEET
2.2	2018-09-17	Added thermal network on Fig.19 & 20
2.3	2019-09-20	additional parameter in maximum ratings table: non repetitive peak collector current