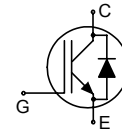# HighSpeed 2-Technology with soft, fast recovery anti-parallel EmCon HE diode

- **Designed for:**
  - SMPS
  - Lamp Ballast
  - ZVS-Converter
  - optimised for soft-switching / resonant topologies

- **2nd generation HighSpeed-Technology for 1200V applications offers:**
  - loss reduction in resonant circuits
  - temperature stable behavior
  - parallel switching capability
  - tight parameter distribution
  - E_{off} optimized for I_C =1A
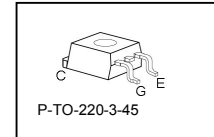
- Qualified according to JEDEC[2] for target applications
- Pb-free lead plating; RoHS compliant
- Complete product spectrum and PSpice Models : http://www.infineon.com/igbt/

P-TO-220-3-45

Type	V_{CE}	I_C	E_{off}	T_j	Marking	Package
IKB01N120H2	1200V	1A	0.09mJ	150°C	K01H1202	P-TO-220-3-45

Maximum Ratings

Parameter	Symbol	Value	Unit
Collector-emitter voltage	V_{CE}	1200	V
Triangular collector current	I_C		A
T_C = 25°C, f = 140kHz		3.2	
T_C = 100°C, f = 140kHz		1.3	
Pulsed collector current, t_p limited by T_{jmax}	I_{Cpuls}	3.5	
Turn off safe operating area $V_{CE} \leq$ 1200V, $T_j \leq$ 150°C	-	3.5	
Diode forward current	I_F		
T_C = 25°C		3.2	
T_C = 100°C		1.3	
Gate-emitter voltage	V_{GE}	±20	V
Power dissipation T_C = 25°C	P_{tot}	28	W
Operating junction and storage temperature	T_j , T_{stg}	-40...+150	°C
Soldering temperature (reflow soldering, MSL1)	-	220	

[2] J-STD-020 and JESD-022

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Thermal Resistance

Parameter	Symbol	Conditions	Max. Value	Unit
Characteristic				
IGBT thermal resistance, junction – case	R_{thJC}		4.5	K/W
Diode thermal resistance, Junction - case	R_{thJCD}		11	
Thermal resistance, junction – ambient[1]	R_{thJA}		40	

Electrical Characteristic, at T_j = 25 °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=300µA	1200	-	-	V
Collector-emitter saturation voltage	$V_{CE(sat)}$	V_{GE} = 15V, I_C=1A				
		T_j=25°C	-	2.2	2.8	
		T_j=150°C	-	2.5	-	
		V_{GE} = 10V, I_C=1A, T_j=25°C	-	2.4	-	
Gate-emitter threshold voltage	$V_{GE(th)}$	I_C=30µA, V_{CE}=V_{GE}	2.1	3	3.9	
Zero gate voltage collector current	I_{CES}	V_{CE}=1200V, V_{GE}=0V				µA
		T_j=25°C	-	-	20	
		T_j=150°C	-	-	80	
Diode forward voltage	V_F	V_{GE} = 0, I_F=0.5A				V
		T_j=25°C	-	2.0	2.5	
		T_j=150°C	-	1.75	-	
Gate-emitter leakage current	I_{GES}	V_{CE}=0V, V_{GE}=20V	-	-	40	nA
Transconductance	g_{fs}	V_{CE}=20V, I_C=1A	-	0.75	-	S
Dynamic Characteristic						
Input capacitance	C_{iss}	V_{CE}=25V,	-	91.6	-	pF
Output capacitance	C_{oss}	V_{GE}=0V,	-	9.8	-	
Reverse transfer capacitance	C_{rss}	f=1MHz	-	3.4	-	
Gate charge	Q_{Gate}	V_{CC}=960V, I_C=1A V_{GE}=15V	-	8.6	-	nC
Internal emitter inductance measured 5mm (0.197 in.) from case	L_E		-	7	-	nH

[1] Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6cm^2 (one layer, 70µm thick) copper area for collector connection. PCB is vertical without blown air.

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Switching Characteristic, Inductive Load, at T_j=25 °C

Parameter	Symbol	Conditions	Value min.	Typ.	max.	Unit
IGBT Characteristic						
Turn-on delay time	$t_{d(on)}$	T_j=25°C,	-	13	-	ns
Rise time	t_r	V_{CC}=800V,	-	6.3	-	
Turn-off delay time	$t_{d(off)}$	I_C=1A,	-	370	-	
Fall time	t_f	V_{GE}=15V/0V,	-	28	-	
Turn-on energy	E_{on}	R_G=241Ω,	-	0.08	-	mJ
Turn-off energy	E_{off}	$L_\sigma^{2)}$=180nH,	-	0.06	-	
Total switching energy	E_{ts}	$C_\sigma^{2)}$=40pF Energy losses include "tail" and diode [3] reverse recovery.	-	0.14	-	
Anti-Parallel Diode Characteristic						
Diode reverse recovery time	t_{rr}	T_j=25°C,	-	83	-	ns
Diode reverse recovery charge	Q_{rr}	V_R=800V, I_F=1A,	-	89	-	µC
Diode peak reverse recovery current	I_{rrm}	R_G=241Ω	-	2.5	-	A
Diode current slope	di_F/dt		-	289	-	A/µs
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	178	-	

Switching Characteristic, Inductive Load, at T_j=150 °C

Parameter	Symbol	Conditions	Value min.	Typ.	max.	Unit
IGBT Characteristic						
Turn-on delay time	$t_{d(on)}$	T_j=150°C	-	12	-	ns
Rise time	t_r	V_{CC}=800V,	-	8.9	-	
Turn-off delay time	$t_{d(off)}$	I_C=1A,	-	450	-	
Fall time	t_f	V_{GE}=15V/0V,	-	43	-	
Turn-on energy	E_{on}	R_G=241Ω,	-	0.11	-	mJ
Turn-off energy	E_{off}	$L_\sigma^{2)}$=180nH,	-	0.09	-	
Total switching energy	E_{ts}	$C_\sigma^{2)}$=40pF Energy losses include "tail" and diode [4] reverse recovery.	-	0.2	-	
Anti-Parallel Diode Characteristic						
Diode reverse recovery time	t_{rr}	T_j=150°C,	-	213	-	ns
Diode reverse recovery charge	Q_{rr}	V_R=800V, I_F=1A,	-	180	-	µC
Diode peak reverse recovery current	I_{rrm}	R_G=241Ω	-	2.7	-	A
Diode current slope	di_F/dt		-	240	-	A/µs
Diode peak rate of fall of reverse recovery current during t_b	di_{rr}/dt		-	135	-	

[2] Leakage inductance L_σ and stray capacity C_σ due to dynamic test circuit in figure E
[4] Commutation diode from device IKP01N120H2

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Switching Energy ZVT, Inductive Load

Parameter	Symbol	Conditions	Value			Unit
			min.	typ.	max.	
IGBT Characteristic						
Turn-off energy	E_{off}	V_{CC}=800V, I_C=1A, V_{GE}=15V/0V, R_G=241Ω, $C_r{}^{2)}$=1nF				mJ
		T_j=25°C	-	0.02	-	
		T_j=150°C	-	0.044	-	

f, SWITCHING FREQUENCY
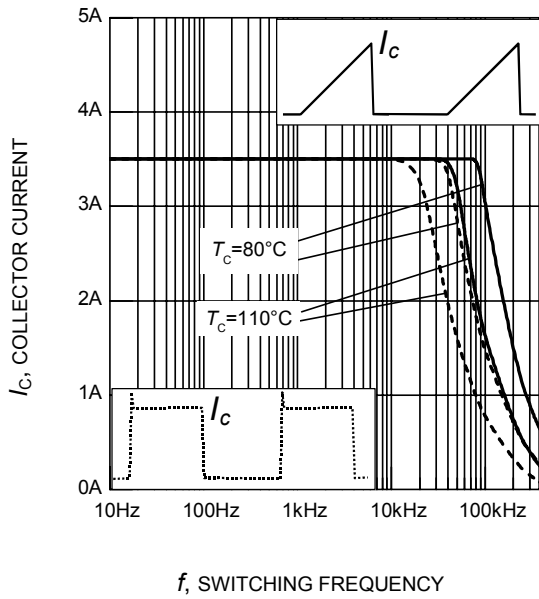
Figure 1. Collector current as a function of switching frequency

($T_j \leq 150°C$, $D = 0.5$, $V_{CE} = 800V$,
$V_{GE} = +15V/0V$, $R_G = 241\Omega$)

V_{CE}, COLLECTOR-EMITTER VOLTAGE
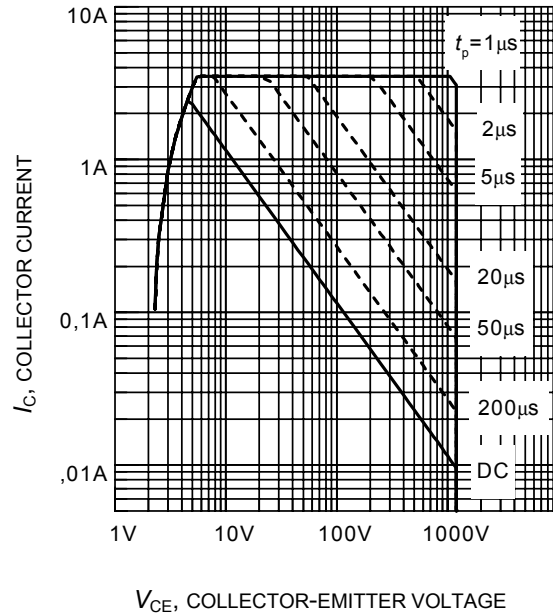
Figure 2. Safe operating area
($D = 0$, $T_C = 25°C$, $T_j \leq 150°C$)

T_C, CASE TEMPERATURE
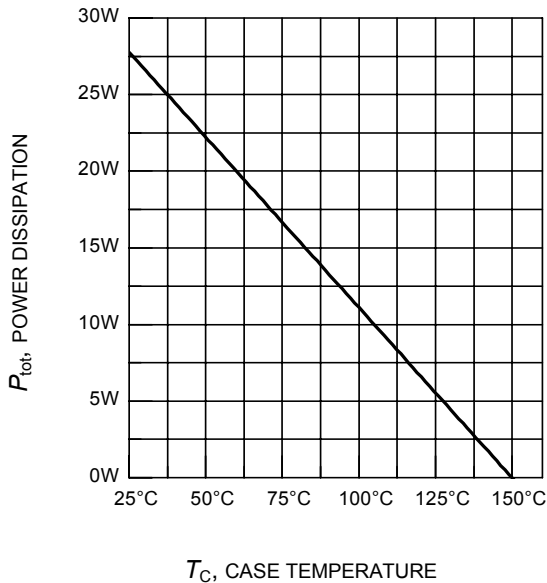
Figure 3. Power dissipation as a function of case temperature
($T_j \leq 150°C$)

T_C, CASE TEMPERATURE
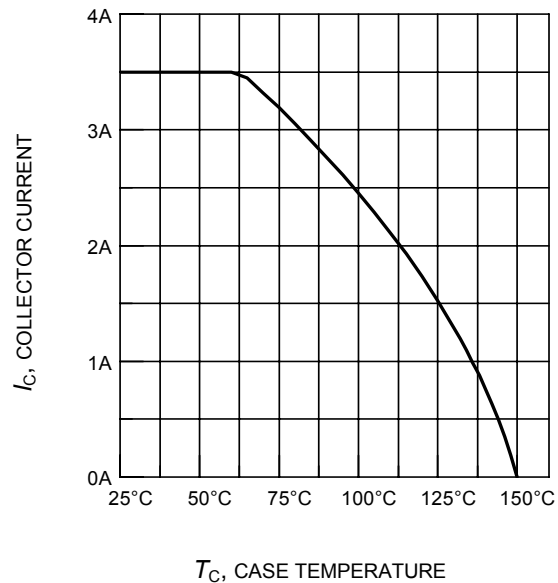
Figure 4. Collector current as a function of case temperature
($V_{GE} \leq 15V$, $T_j \leq 150°C$)

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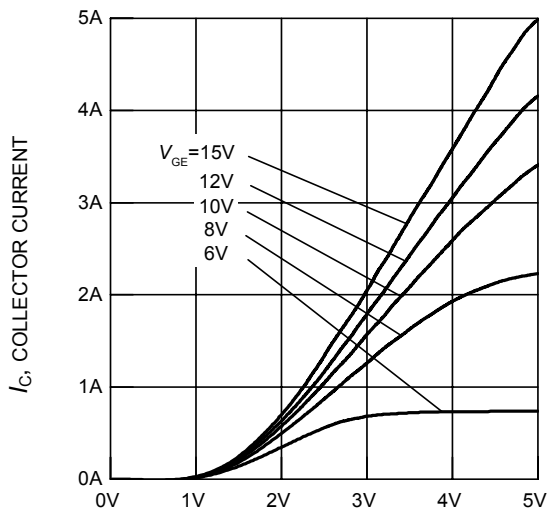
V_{CE}, COLLECTOR-EMITTER VOLTAGE
Figure 5. Typical output characteristics
(T_j = 25°C)
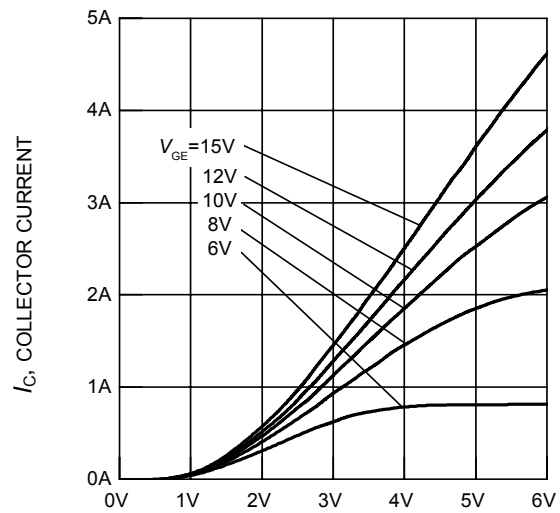
V_{CE}, COLLECTOR-EMITTER VOLTAGE
Figure 6. Typical output characteristics
(T_j = 150°C)
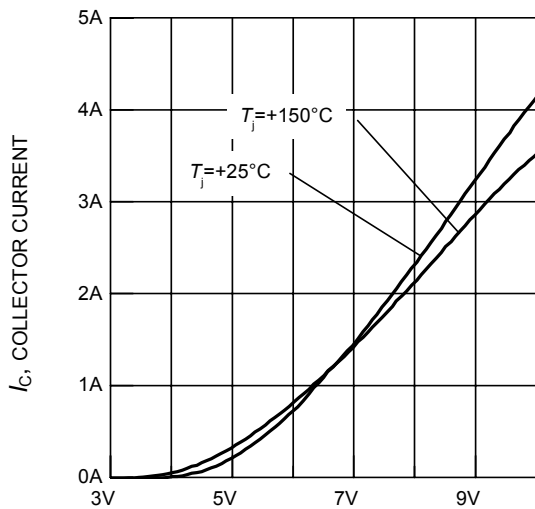
V_{GE}, GATE-EMITTER VOLTAGE
Figure 7. Typical transfer characteristics
(V_{CE} = 20V)
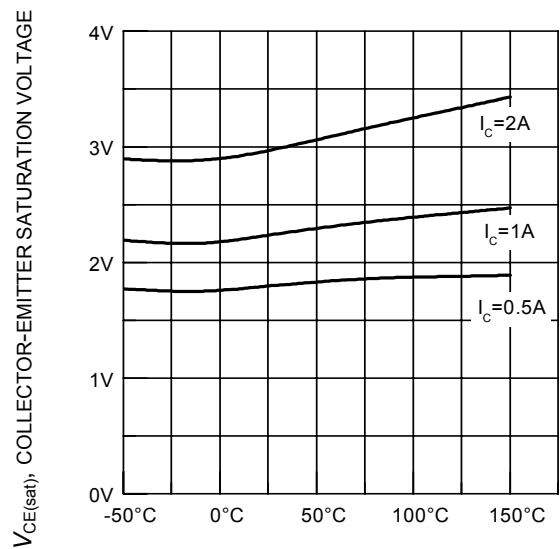
T_j, JUNCTION TEMPERATURE
Figure 8. Typical collector-emitter saturation voltage as a function of junction temperature
(V_{GE} = 15V)
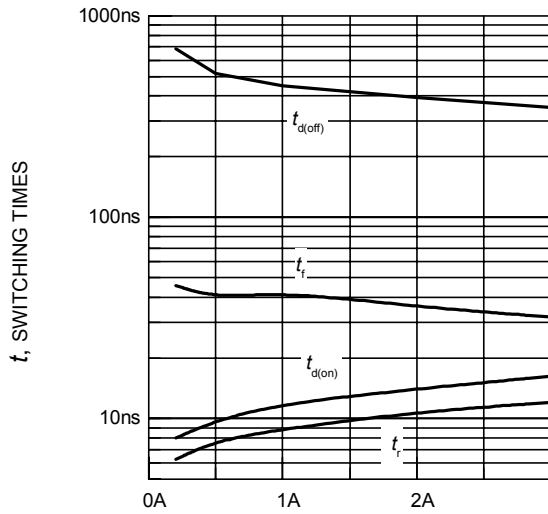
Figure 9. Typical switching times as a function of collector current
(inductive load, T_j = 150°C,
V_{CE} = 800V, V_{GE} = +15V/0V, R_G = 241Ω,
dynamic test circuit in Fig.E)
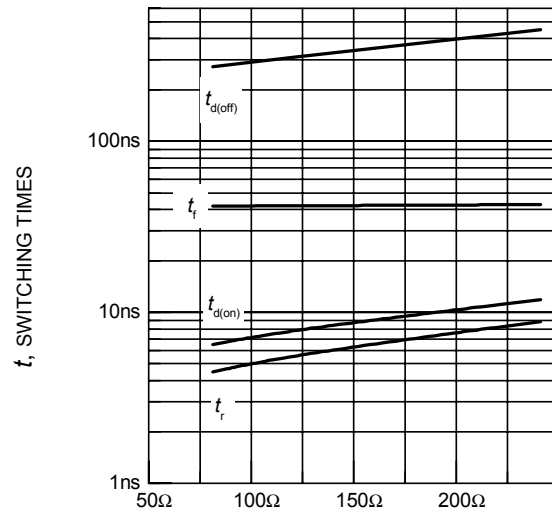
Figure 10. Typical switching times as a function of gate resistor
(inductive load, T_j = 150°C,
V_{CE} = 800V, V_{GE} = +15V/0V, I_C = 1A,
dynamic test circuit in Fig.E)
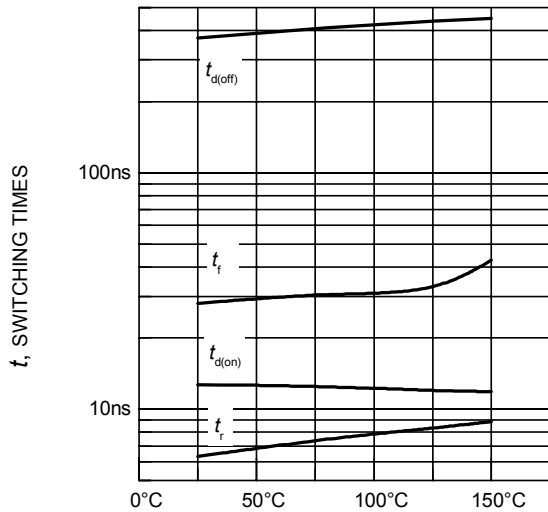
Figure 11. Typical switching times as a function of junction temperature
(inductive load, V_{CE} = 800V,
V_{GE} = +15V/0V, I_C = 1A, R_G = 241Ω,
dynamic test circuit in Fig.E)
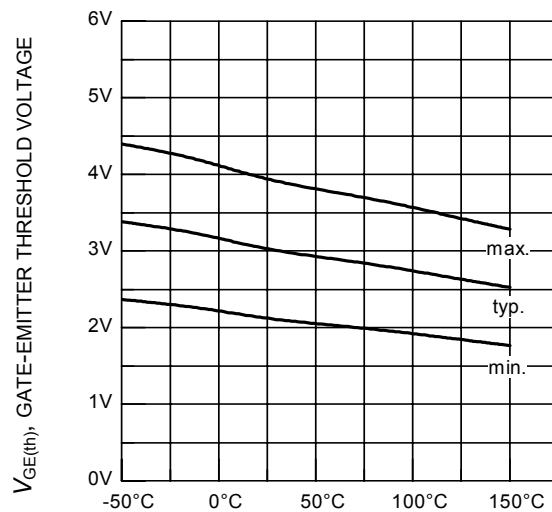
Figure 12. Gate-emitter threshold voltage as a function of junction temperature
(I_C = 0.03mA)
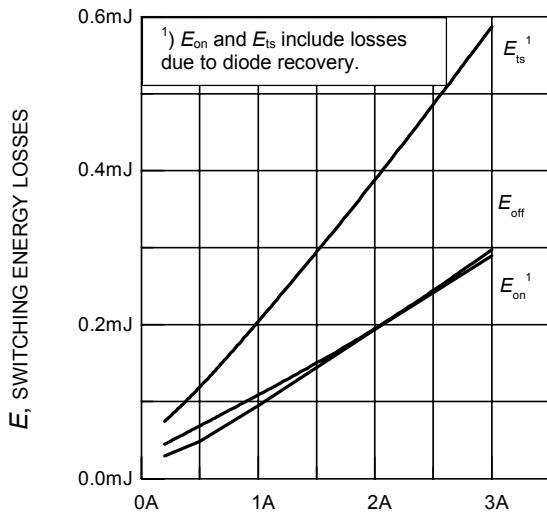
Figure 13. Typical switching energy losses
as a function of collector current
(inductive load, T_j = 150°C,
V_{CE} = 800V, V_{GE} = +15V/0V, R_G = 241Ω,
dynamic test circuit in Fig.E)
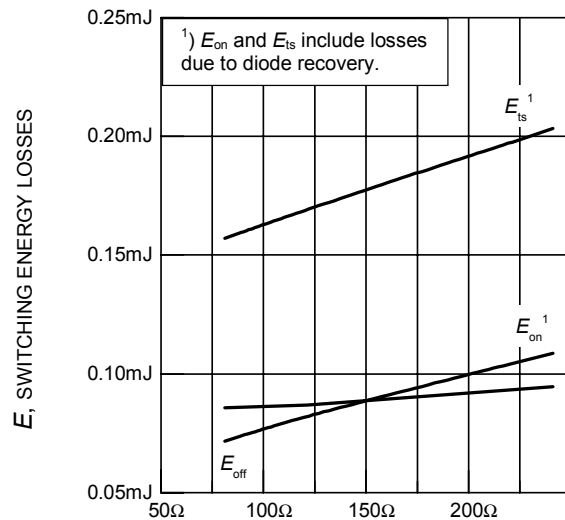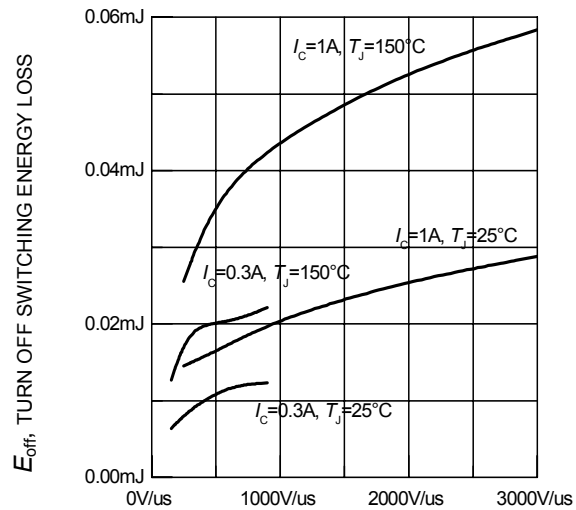

Figure 14. Typical switching energy losses
as a function of gate resistor
(inductive load, T_j = 150°C,
V_{CE} = 800V, V_{GE} = +15V/0V, I_C = 1A,
dynamic test circuit in Fig.E)
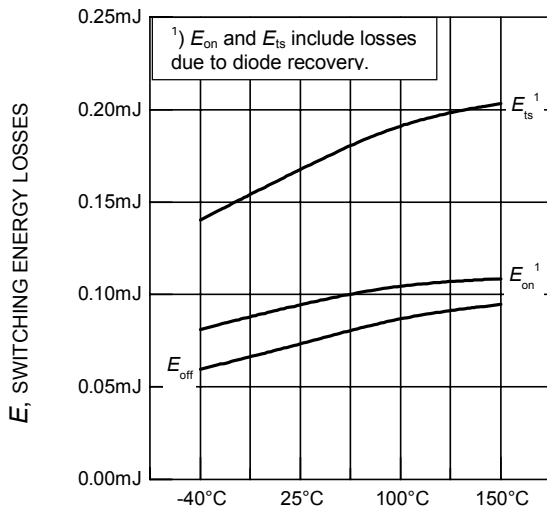
Figure 15. Typical switching energy losses
as a function of junction temperature
(inductive load, V_{CE} = 800V,
V_{GE} = +15V/0V, I_C = 1A, R_G = 241Ω,
dynamic test circuit in Fig.E)

Figure 16. Typical turn off switching energy
loss for soft switching
(*dynamic test circuit in Fig. E*)

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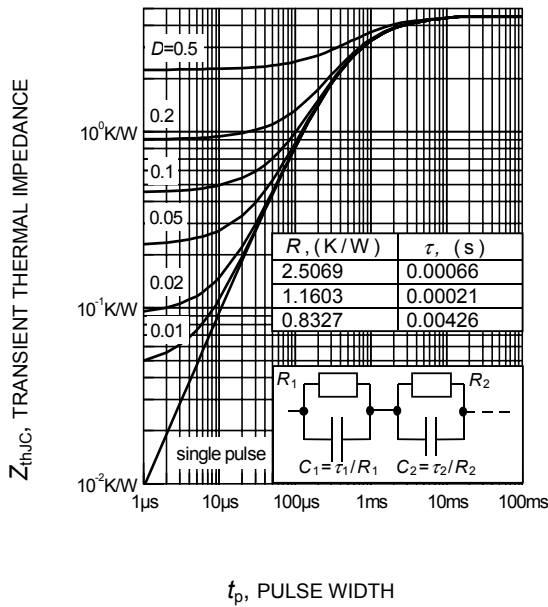
t_p, PULSE WIDTH

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

R, (K/W)	τ, (s)
2.5069	0.00066
1.1603	0.00021
0.8327	0.00426
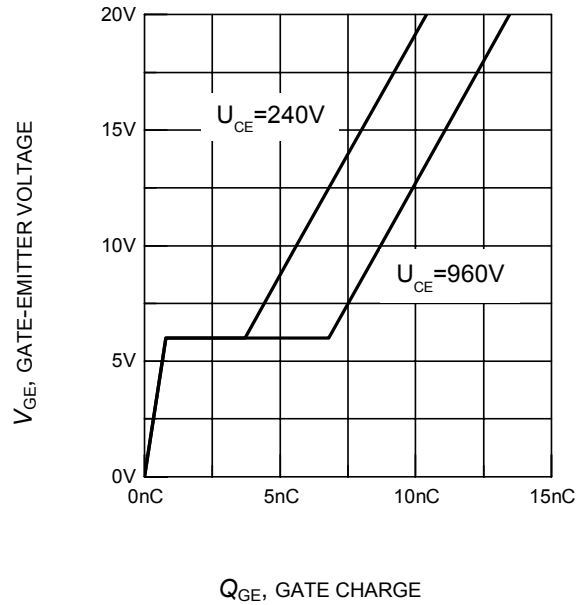
Q_{GE}, GATE CHARGE

Figure 18. Typical gate charge
(I_C = 1A)
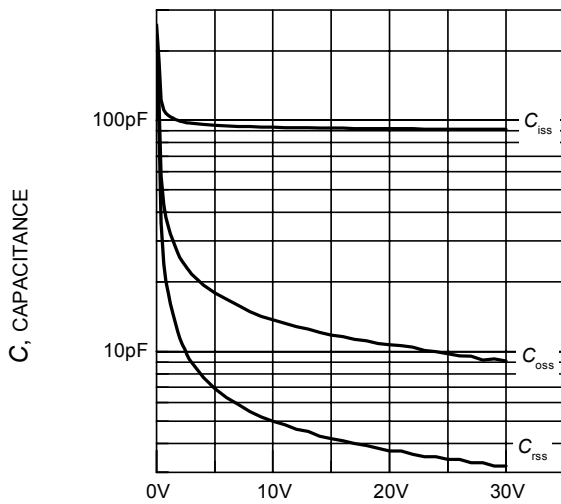

V_{CE}, COLLECTOR-EMITTER VOLTAGE

Figure 19. Typical capacitance as a function of collector-emitter voltage
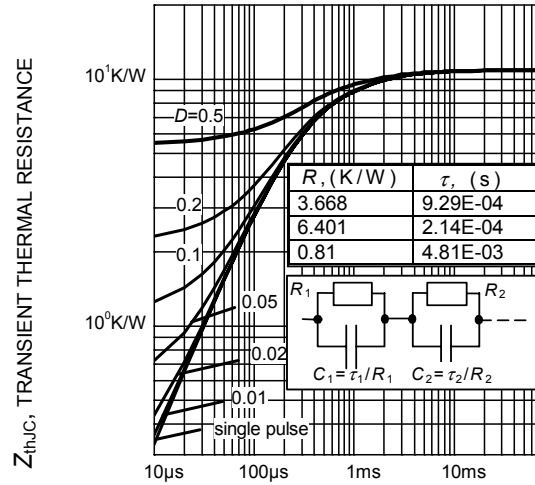(V_{GE} = 0V, f = 1MHz)
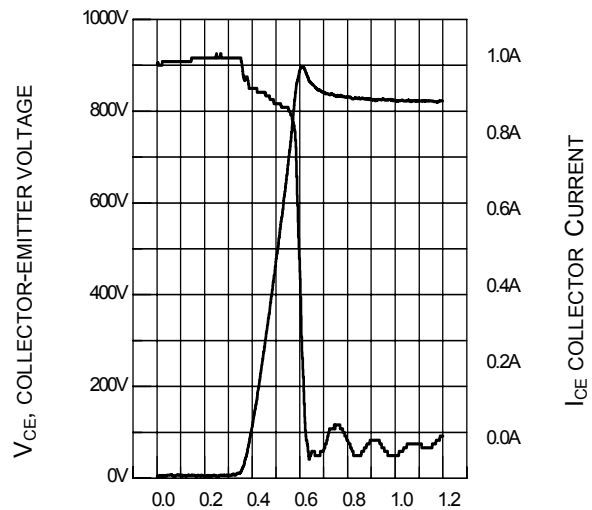
t_p, PULSE WIDTH

Figure 20. Typical turn off behavior, hard switching
(V_{GE}=15/0V, R_G=220Ω, T_j = 150°C, Dynamic test circuit in Figure E)

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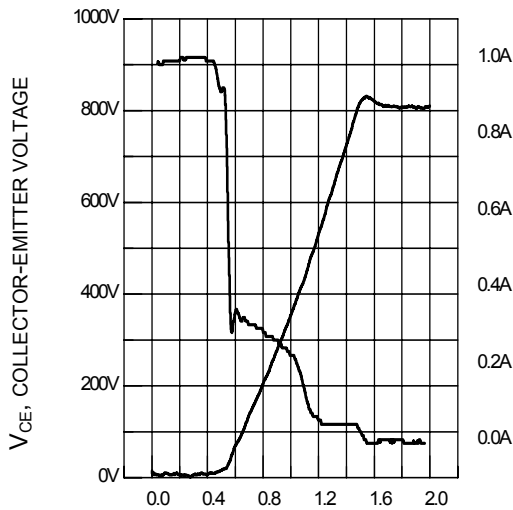
t_p, PULSE WIDTH
Figure 21. Typical turn off behavior, soft switching
(V_{GE}=15/0V, R_G=220Ω, T_j = 150°C, Dynamic test circuit in Figure E)

R, (K/W)	τ, (s)
3.668	9.29E-04
6.401	2.14E-04
0.81	4.81E-03

$C_1 = \tau_1/R_1$ $C_2 = \tau_2/R_2$

t_P, PULSE WIDTH
Figure 22. Diode transient thermal impedance as a function of pulse width
($D=t_P/T$)
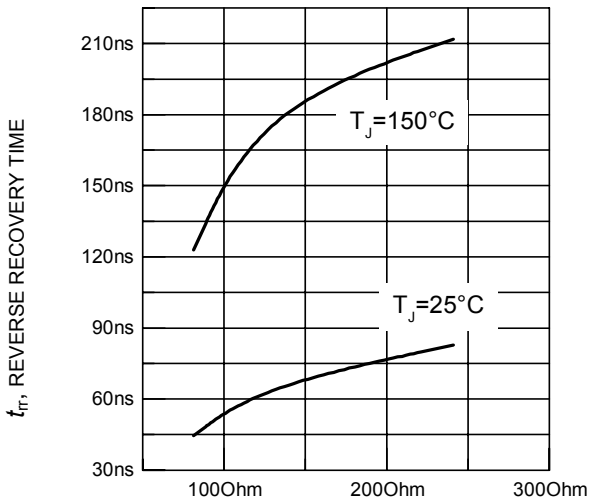
R_G, GATE RESISTANCE
Figure 23. Typical reverse recovery time as a function of diode current slope
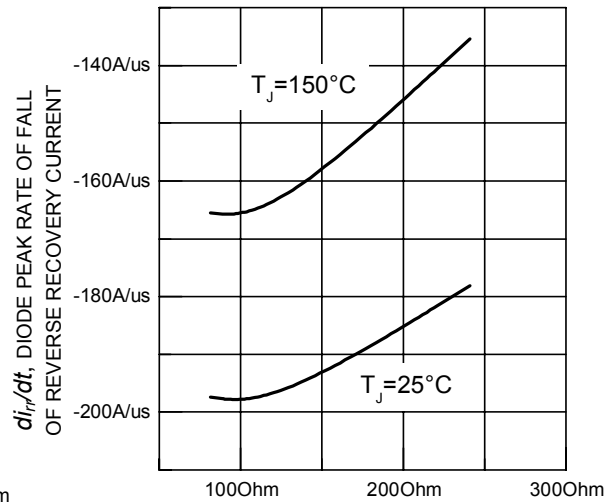V_R=800V, I_F=3A, Dynamic test circuit in Figure E)
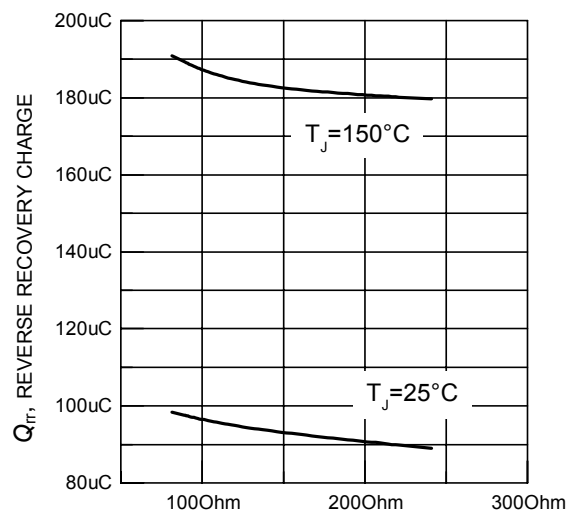
R_G, GATE RESISTANCE
Figure 24. Typical reverse recovery charge as a function of diode current slope
(V_R=800V, I_F=3A, Dynamic test circuit in Figure E)

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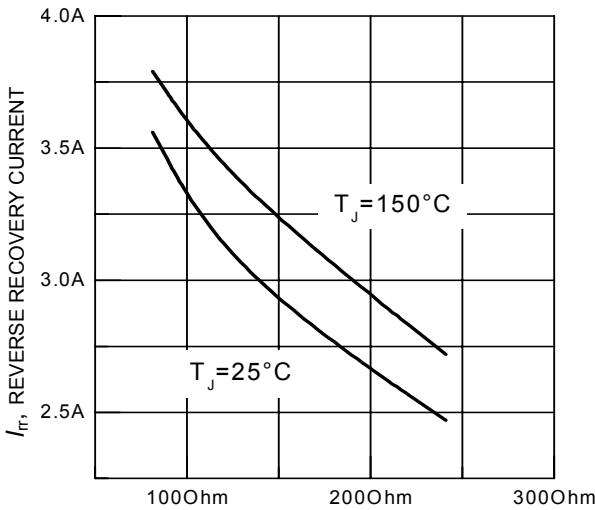
R_G, GATE RESISTANCE

Figure 25. Typical reverse recovery current as a function of diode current slope
(V_R=800V, I_F=3A,
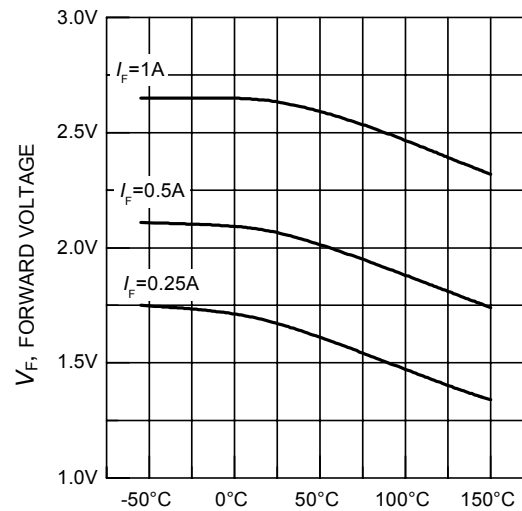Dynamic test circuit in Figure E)

R_G, GATE RESISTANCE

Figure 26. Typical diode peak rate of fall of reverse recovery current as a function of diode current slope
(V_R=800V, I_F=3A,
Dynamic test circuit in Figure E)
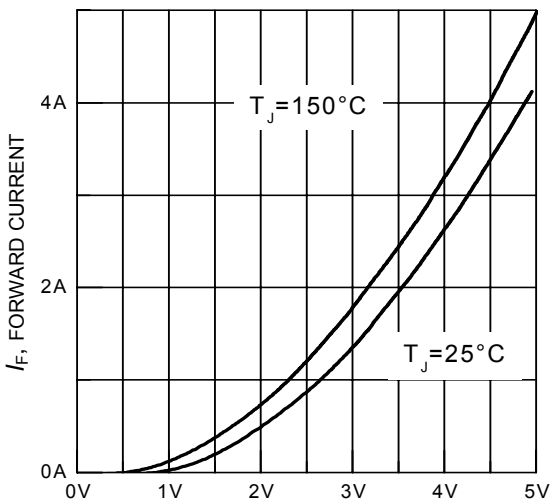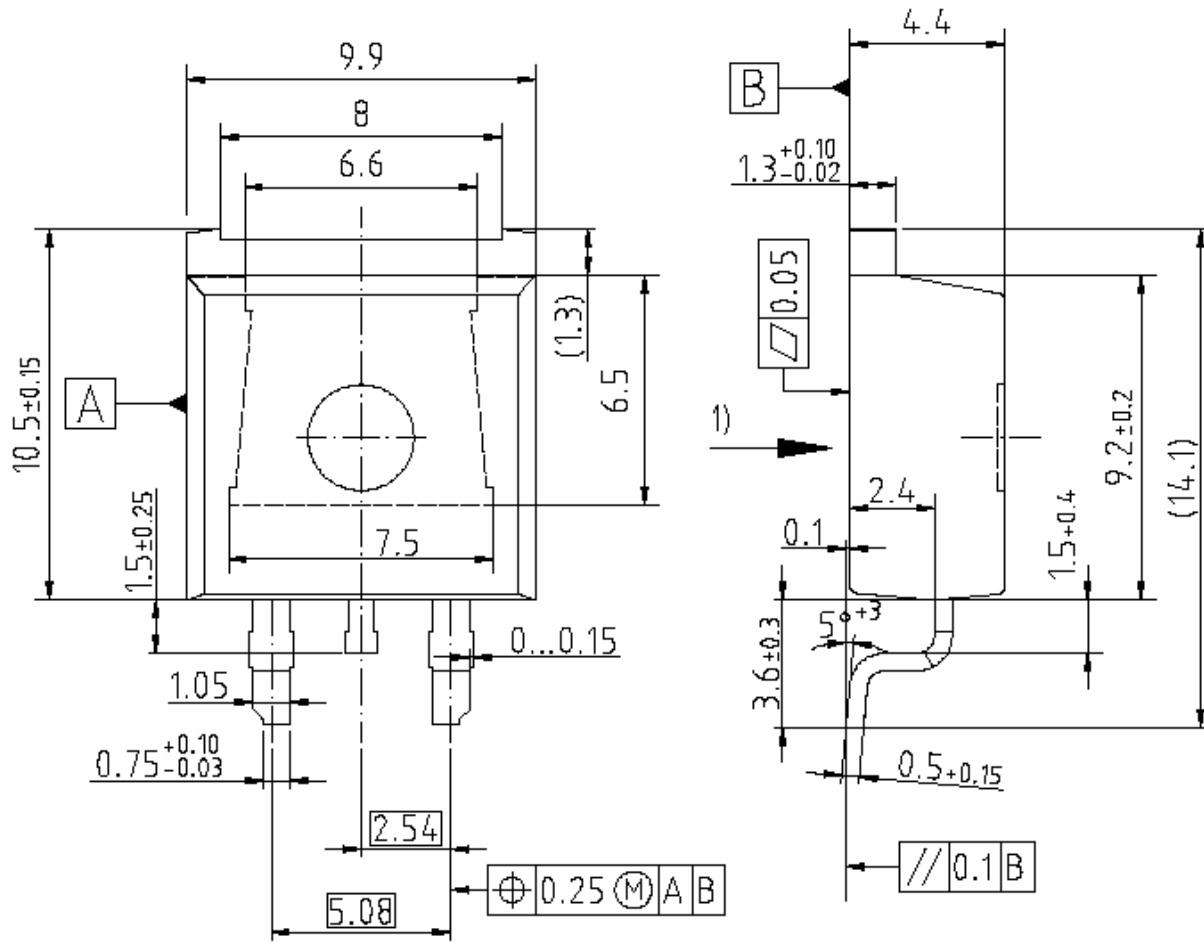

V_F, FORWARD VOLTAGE

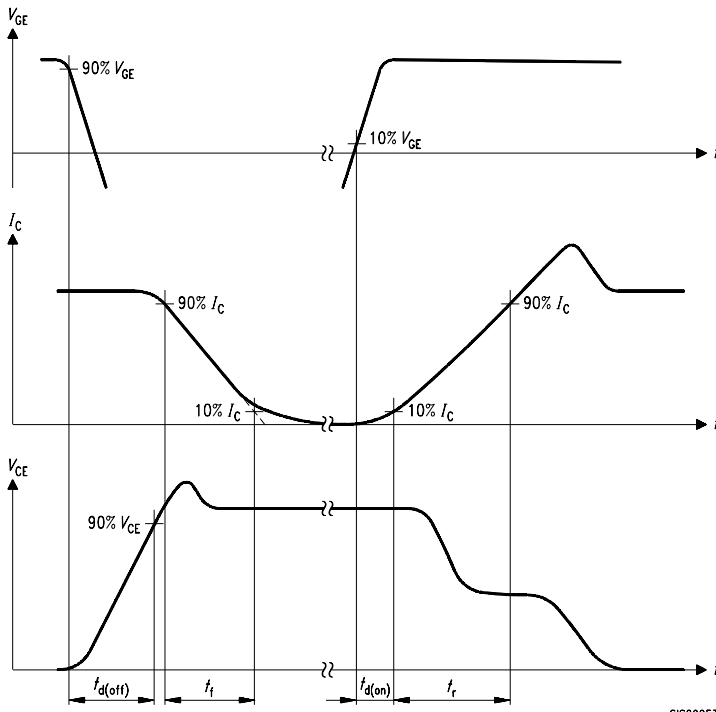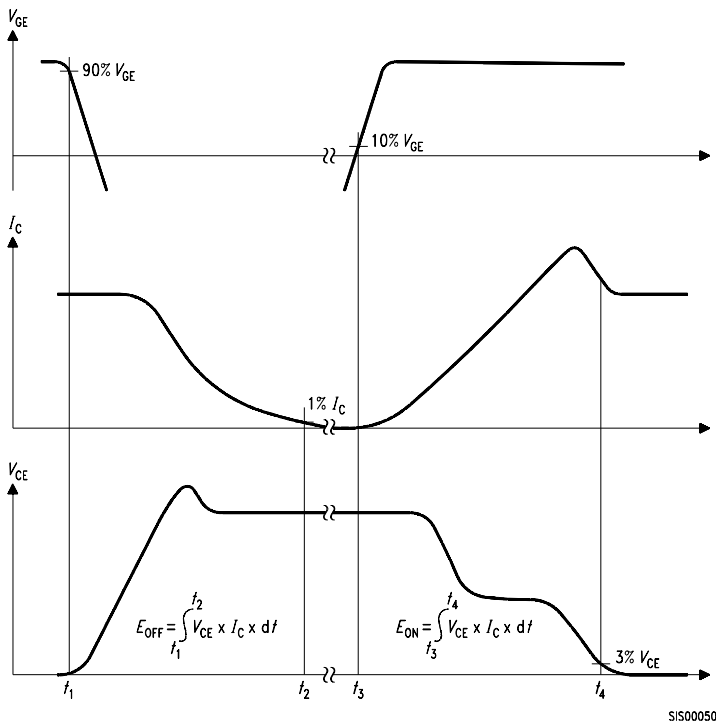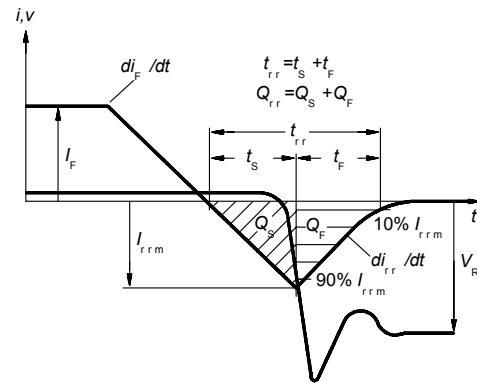**Figure 27. Typical diode forward current as a function of forward voltage**

T_J, JUNCTION TEMPERATURE

Figure 28. Typical diode forward voltage as a function of junction temperature

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Figure A. Definition of switching times

Figure B. Definition of switching losses

$$E_{OFF} = \int_{t_1}^{t_2} V_{CE} \times I_C \times dt$$

$$E_{ON} = \int_{t_3}^{t_4} V_{CE} \times I_C \times dt$$

Figure C. Definition of diodes switching characteristics

$t_{rr} = t_S + t_F$

$Q_{rr} = Q_S + Q_F$
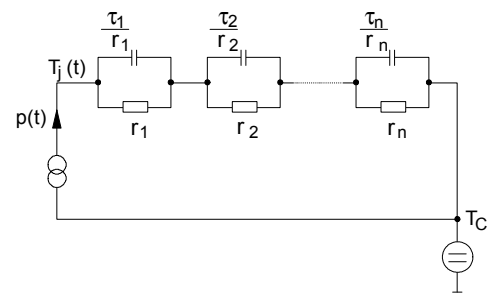
Figure D. Thermal equivalent circuit
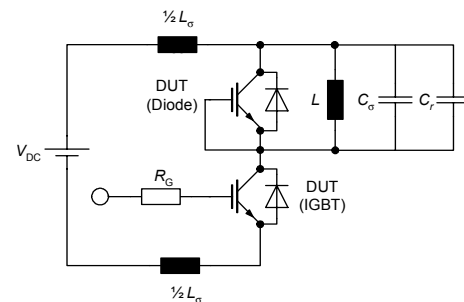
Figure E. Dynamic test circuit
Leakage inductance L_σ= 180nH,
Stray capacitor C_σ = 40pF,
Relief capacitor C_r = 1nF (only for ZVT switching)

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