



# NGW40T65M3DFP

650 V, 40 A trench field-stop IGBT with full rated silicon diode

Rev. 1 — 28 June 2024

Product data sheet

## 1. General Description

The NGW40T65M3DFP is a robust Insulated-Gate Bipolar Transistor (IGBT) featuring third-generation technology. It combines carrier stored trench-gate and field-stop (FS) structures. The NGW40T65M3DFP is rated to 175 °C with optimized IGBT turn-off losses, and has a short-circuit withstand time of 5  $\mu$ s. This hard-switching 650 V, 40 A IGBT is optimized for high-voltage, high-frequency industrial power inverter applications and servo motor drive applications.

## 2. Features and benefits

- Collector current ( $I_C$ ) rated at 40 A
- Low conduction and switching losses
- Stable and tight parameters for easy parallel operation
- Maximum junction temperature of 175 °C
- Fully rated as a soft fast reverse recovery diode
- 5  $\mu$ s short circuit withstand time
- RoHS compliant, lead-free plating

## 3. Applications

- Motor drives for industrial and consumer appliances
  - Servo motors operating between 5-20 kW (up to 20 kHz) for robotics, elevators, operating grippers, in-line manufacturing, etc.
- Power inverters
  - Uninterruptible Power Supply (UPS) inverter
  - Photovoltaic (PV) strings
  - EV charging
- Induction heating
- Welding

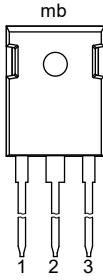
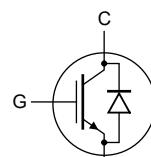
## 4. Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Max	Unit
$V_{CE}$	collector-emitter voltage	$T_j = 25 \text{ }^\circ\text{C}$	-	650	V
$T_j$	operating junction temperature		-40	+175	$^\circ\text{C}$
$t_{sc}$	short circuit withstand time	$V_{GE} = 15 \text{ V} ; V_{CC} = 400 \text{ V} ; T_j \leq 150 \text{ }^\circ\text{C}$	-	5	$\mu\text{s}$

## 5. Pinning information

**Table 2. Pinning information**

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	G	gate		
2	C	collector		
3	E	emitter		
mb	C	mounting base; connected to collector		 <small>aaa-036518</small>

## 6. Ordering information

**Table 3. Ordering information**

Type number	Package			Version
	Name	Description	Version	
<a href="#">NGW40T65M3DFP</a>	TO-247-3L	Plastic single-ended through-hole package; heatsink mounted; 1 mounting hole; 3-lead TO-247-3L	<a href="#">SOT429-2</a>	

## 7. Limiting values

**Table 4. Limiting values**

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit	
<b>IGBT</b>						
$V_{CE}$	collector-emitter voltage	$T_j = 25^\circ\text{C}$	-	650	V	
$I_C$	collector current	$T_{case} = 25^\circ\text{C}$	[1]	-	72	A
		$T_{case} = 100^\circ\text{C}$	[1]	-	48	A
$I_{Cpuls}$	peak pulse collector current	[2]	-	120	A	
$t_{sc}$	short circuit withstand time	$V_{GE} = 15\text{ V}$ ; $V_{CC} = 400\text{ V}$ ; $T_j \leq 150^\circ\text{C}$	-	5.0	$\mu\text{s}$	
$V_{GS}$	gate-source voltage		-20	+20	V	
$P_{tot}$	total power dissipation	$T_{case} = 25^\circ\text{C}$	-	283	W	
		$T_{case} = 100^\circ\text{C}$	-	142	W	
$T_j$	operating junction temperature		-40	+175	$^\circ\text{C}$	
$T_{stg}$	storage temperature		-55	+150	$^\circ\text{C}$	
$T_{solder}$	soldering temperature		-	260	$^\circ\text{C}$	
M	mounting torque, M3 screw		-	0.6	Nm	
<b>Diode</b>						
$I_F$	diode forward current	$T_{case} = 25^\circ\text{C}$	[1]	-	80	A
		$T_{case} = 100^\circ\text{C}$	[1]	-	49	A
$I_{Fpuls}$	peak pulse diode current	[2]	-	120	A	

[1] Value limited by bondwire and  $T_{j(max)}$ .

[2]  $t_p$  limited by  $T_{j(max)}$ .

## 8. Thermal characteristics

**Table 5. Thermal characteristics**

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$R_{th(j-c)}$	thermal resistance from junction to case	IGBT	-	0.45	0.53	K/W
		diode	-	0.71	0.84	K/W
$R_{th(j-a)}$	thermal resistance from junction to ambient in free air	-	-	40	K/W	

## 9. Characteristics

**Table 6. Characteristics**

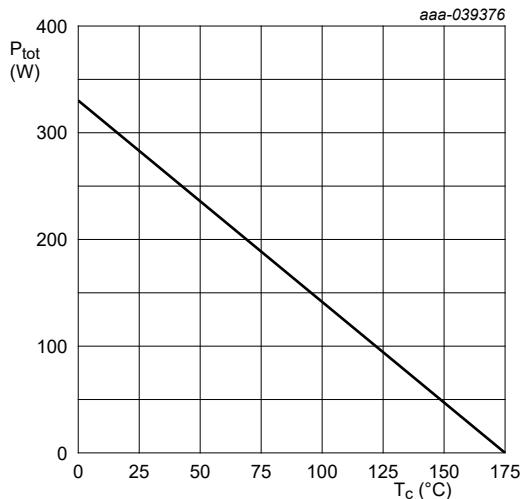
All values at  $T_j = 25^\circ\text{C}$ , unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Static characteristics</b>						
$V_{(BR)CE}$	collector-emitter breakdown voltage	$V_{GE} = 0 \text{ V}$ ; $I_C = 0.2 \text{ mA}$	650	-	-	V
$V_{CEsat}$	collector-emitter saturation voltage	$V_{GE} = 15 \text{ V}$ ; $I_C = 40 \text{ A}$ ; $T_j = 25^\circ\text{C}$	-	1.5	1.9	V
		$V_{GE} = 15 \text{ V}$ ; $I_C = 40 \text{ A}$ ; $T_j = 175^\circ\text{C}$	-	1.9	-	V
$V_F$	diode forward voltage	$V_{GE} = 0 \text{ V}$ ; $I_F = 40 \text{ A}$ ; $T_j = 25^\circ\text{C}$	-	1.62	2.1	V
		$V_{GE} = 0 \text{ V}$ ; $I_F = 40 \text{ A}$ ; $T_j = 175^\circ\text{C}$	-	1.33	-	V
$V_{GE(th)}$	gate-emitter threshold voltage	$I_C = 0.4 \text{ mA}$ ; $V_{CE} = V_{GE}$ ; $T_j = 25^\circ\text{C}$	4.3	5	5.7	V
$I_{CES}$	zero gate voltage collector current	$V_{CE} = 650 \text{ V}$ ; $V_{GE} = 0 \text{ V}$ ; $T_j = 25^\circ\text{C}$	-	10	-	nA
		$V_{CE} = 650 \text{ V}$ ; $V_{GE} = 0 \text{ V}$ ; $T_j = 175^\circ\text{C}$	-	0.5	-	mA
$I_{GES}$	gate-emitter leakage current	$V_{CE} = 0 \text{ V}$ ; $V_{GE} = 20 \text{ V}$	-	-	100	nA
$g_{fs}$	transconductance	$V_{CE} = 20 \text{ V}$ ; $I_C = 40 \text{ A}$ ; $T_j = 25^\circ\text{C}$	-	20	-	S
$r_G$	integrated gate resistor		-	1.3	-	$\Omega$
<b>Dynamic characteristics</b>						
$C_{ies}$	input capacitance	$V_{CE} = 25 \text{ V}$ ; $V_{GE} = 0 \text{ V}$ ; $f = 1 \text{ MHz}$	-	2040	-	pF
$C_{oes}$	output capacitance		-	136	-	pF
$C_{res}$	reverse transfer capacitance		-	31	-	pF
$Q_G$	gate charge	$V_{CC} = 520 \text{ V}$ ; $V_{GE} = 15 \text{ V}$ ; $I_C = 40 \text{ A}$	-	130	-	nC
$L_{sCE}$	internal stray inductance	measured 5 mm from case	-	7.9	-	nH
$I_{C(sc)}$	short circuit collector current	$V_{GE} = 15 \text{ V}$ ; $V_{CC} = 400 \text{ V}$ ; $t_{sc} \leq 5 \mu\text{s}$ ; $T_j \leq 150^\circ\text{C}$	-	130	-	A

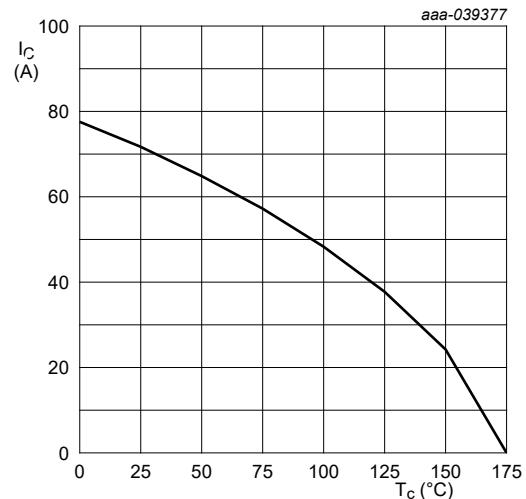
Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
<b>IGBT switching characteristics, inductive load</b>							
$t_{d(on)}$	turn-on delay time	$V_{GE} = 15/0 \text{ V}; V_{CC} = 400 \text{ V}; I_C = 40 \text{ A}; r_{G(on)} = 10 \Omega; r_{G(off)} = 10 \Omega; \text{ see Fig. 27 and Fig. 28}$	$T_j = 25 \text{ }^\circ\text{C}$	-	22	-	ns
	$T_j = 175 \text{ }^\circ\text{C}$		-	20	-	ns	
	$T_j = 25 \text{ }^\circ\text{C}$		-	22	-	ns	
	$T_j = 175 \text{ }^\circ\text{C}$		-	23	-	ns	
	$T_j = 25 \text{ }^\circ\text{C}$		-	185	-	ns	
	$T_j = 175 \text{ }^\circ\text{C}$		-	220	-	ns	
	$T_j = 25 \text{ }^\circ\text{C}$		-	13	-	ns	
	$T_j = 175 \text{ }^\circ\text{C}$		-	50	-	ns	
	$T_j = 25 \text{ }^\circ\text{C}$		-	1.05	-	mJ	
	$T_j = 175 \text{ }^\circ\text{C}$		-	2.15	-	mJ	
$E_{on}$	turn-on switching loss		$T_j = 25 \text{ }^\circ\text{C}$	-	0.52	-	mJ
	$T_j = 175 \text{ }^\circ\text{C}$		-	0.9	-	mJ	
$E_{off}$	turn-off switching loss		$T_j = 25 \text{ }^\circ\text{C}$	-	1.57	-	mJ
	$T_j = 175 \text{ }^\circ\text{C}$		-	3.05	-	mJ	
$E_{ts}$	total switching loss		$T_j = 25 \text{ }^\circ\text{C}$	-	1.57	-	mJ
	$T_j = 175 \text{ }^\circ\text{C}$		-	3.05	-	mJ	
<b>Diode switching characteristics, inductive load</b>							
$t_{rr}$	diode reverse recovery time	$V_R = 400 \text{ V}; I_F = 40 \text{ A}; \Delta I_F/\Delta t = 1000 \text{ A}/\mu\text{s}; \text{ see Fig. 26}$	$T_j = 25 \text{ }^\circ\text{C}$	-	55	-	ns
	$T_j = 175 \text{ }^\circ\text{C}$		-	215	-	ns	
	$T_j = 25 \text{ }^\circ\text{C}$		-	700	-	nC	
	$T_j = 175 \text{ }^\circ\text{C}$		-	3830	-	nC	
	$T_j = 25 \text{ }^\circ\text{C}$		-	22	-	A	
	$T_j = 175 \text{ }^\circ\text{C}$		-	37	-	A	
	$T_j = 25 \text{ }^\circ\text{C}$		-	0.12	-	mJ	
	$T_j = 175 \text{ }^\circ\text{C}$		-	0.36	-	mJ	
	$T_j = 25 \text{ }^\circ\text{C}$		-	650	-	A/ $\mu\text{s}$	
	$T_j = 175 \text{ }^\circ\text{C}$		-	760	-	A/ $\mu\text{s}$	

## 9.1. Waveforms and output characteristics

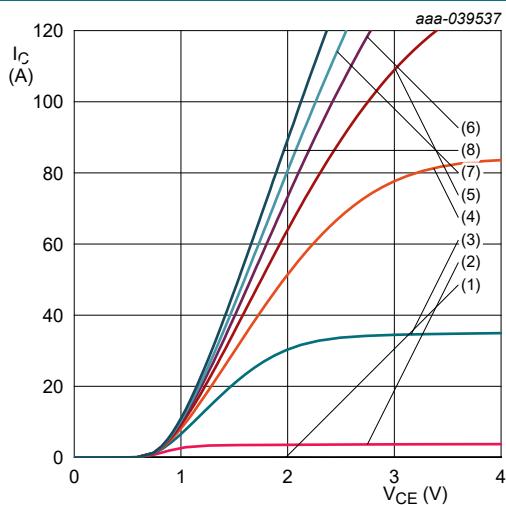
**Table 7. Waveforms and output characteristics**



**Fig. 1. Power dissipation ( $P_{tot}$ ) as a function of case temperature**



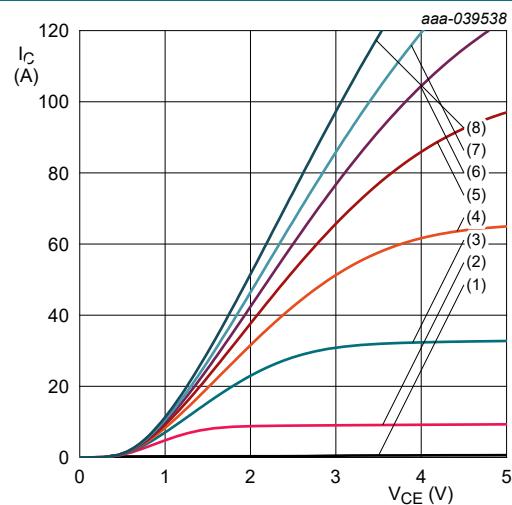
**Fig. 2. Collector current ( $I_C$ ) as a function of case temperature**



$T_j = 25$  °C

- (1)  $V_{GE} = 5$  V
- (2)  $V_{GE} = 7$  V
- (3)  $V_{GE} = 9$  V
- (4)  $V_{GE} = 11$  V
- (5)  $V_{GE} = 13$  V
- (6)  $V_{GE} = 15$  V
- (7)  $V_{GE} = 17$  V
- (8)  $V_{GE} = 20$  V

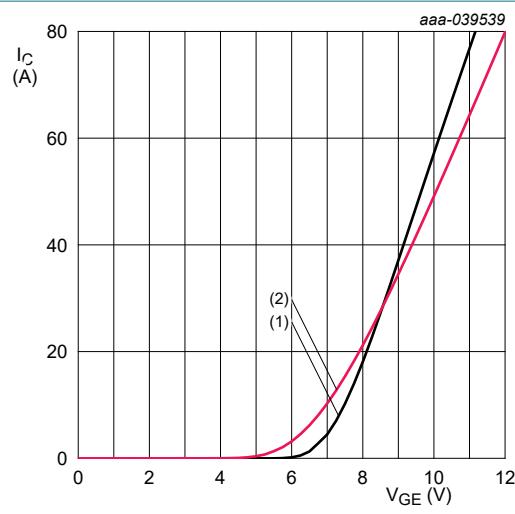
**Fig. 3. Collector current as a function of collector-emitter voltage; typical values**



$T_j = 175$  °C

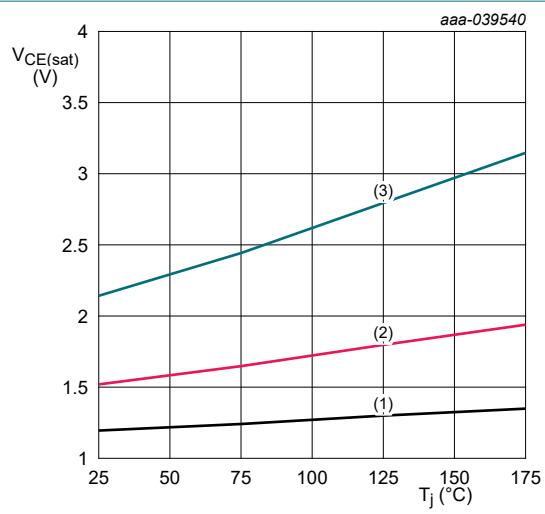
- (1)  $V_{GE} = 5$  V
- (2)  $V_{GE} = 7$  V
- (3)  $V_{GE} = 9$  V
- (4)  $V_{GE} = 11$  V
- (5)  $V_{GE} = 13$  V
- (6)  $V_{GE} = 15$  V
- (7)  $V_{GE} = 17$  V
- (8)  $V_{GE} = 20$  V

**Fig. 4. Collector current as a function of collector-emitter voltage; typical values**



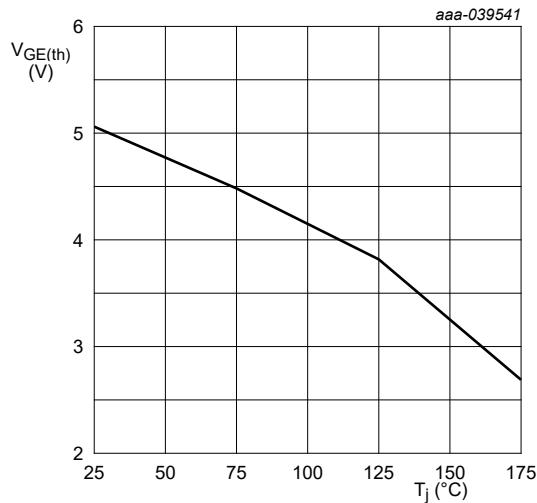
$V_{CE} = 20\text{ V}$   
(1)  $T_j = 25\text{ }^\circ\text{C}$   
(2)  $T_j = 175\text{ }^\circ\text{C}$

**Fig. 5. Collector current as a function of gate-emitter voltage; typical values**

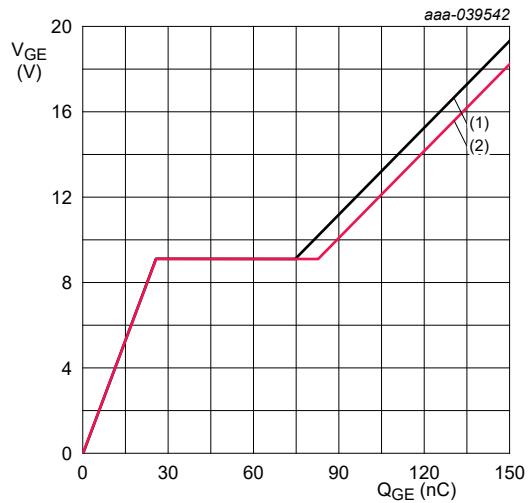


$V_{GE} = 15\text{ V}$   
(1)  $I_C = 20\text{ A}$   
(2)  $I_C = 40\text{ A}$   
(3)  $I_C = 80\text{ A}$

**Fig. 6. Collector-emitter saturation voltage as a function of junction temperature; typical values**

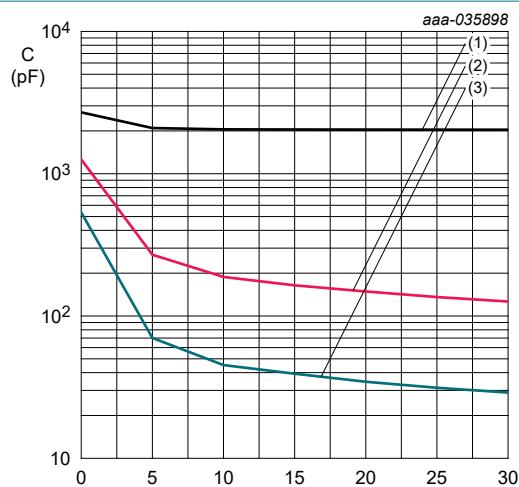


**Fig. 7. Gate-emitter threshold voltage as a function of junction temperature**



$I_C = 40\text{ A}$   
(1)  $V_{CE} = 130\text{ V}$   
(2)  $V_{CE} = 520\text{ V}$

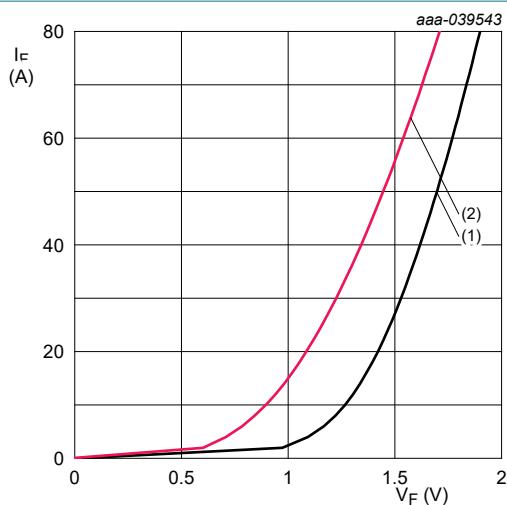
**Fig. 8. Gate-emitter voltage as a function of gate charge**



$V_{GE} = 0 \text{ V}$ ,  $f = 1 \text{ MHz}$

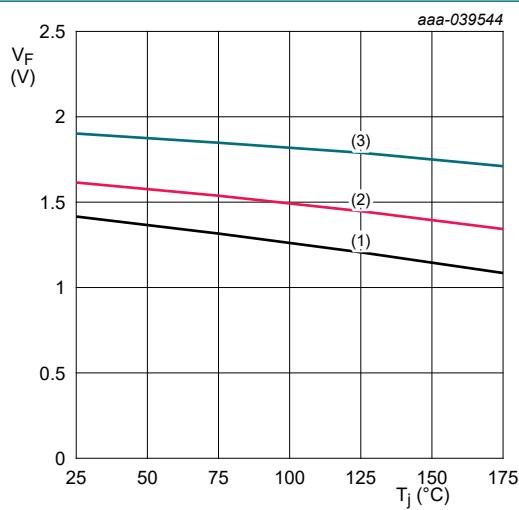
- (1)  $C_{ies}$
- (2)  $C_{oes}$
- (3)  $C_{res}$

**Fig. 9. Typical capacitance as a function of collector-emitter voltage**



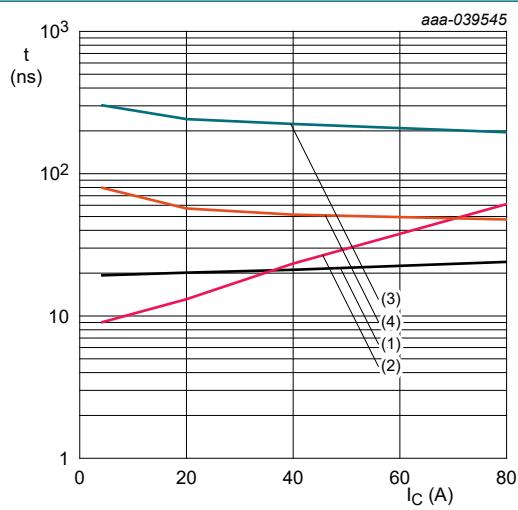
- (1)  $T_{amb} = 25 \text{ }^{\circ}\text{C}$
- (2)  $T_{amb} = 175 \text{ }^{\circ}\text{C}$

**Fig. 10. Typical diode forward current as function of forward voltage**



- (1)  $I_F = 20 \text{ A}$
- (2)  $I_F = 40 \text{ A}$
- (3)  $I_F = 80 \text{ A}$

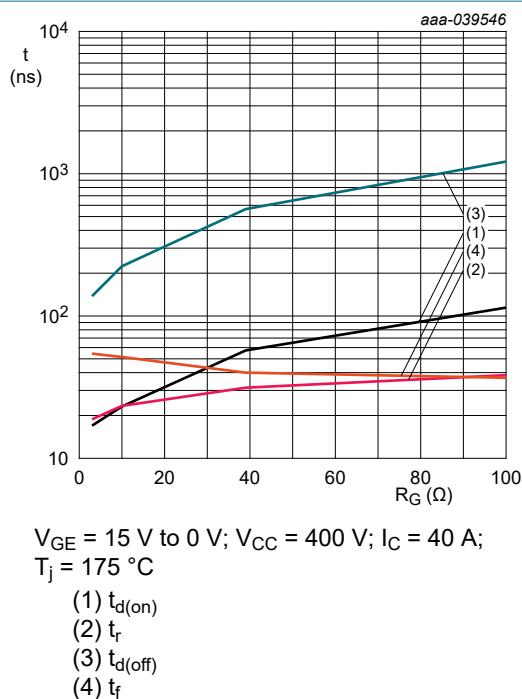
**Fig. 11. Typical diode forward voltage as function of junction temperature**



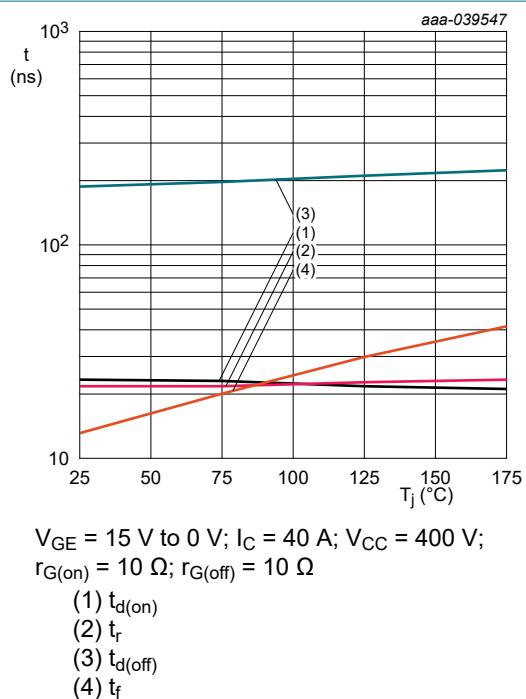
$V_{GE} = 15 \text{ V to } 0 \text{ V}$ ;  $V_{CC} = 400 \text{ V}$ ;  $r_{G(on)} = 10 \Omega$ ;  
 $r_{G(off)} = 10 \Omega$

- (1)  $t_{d(on)}$
- (2)  $t_r$
- (3)  $t_{d(off)}$
- (4)  $t_f$

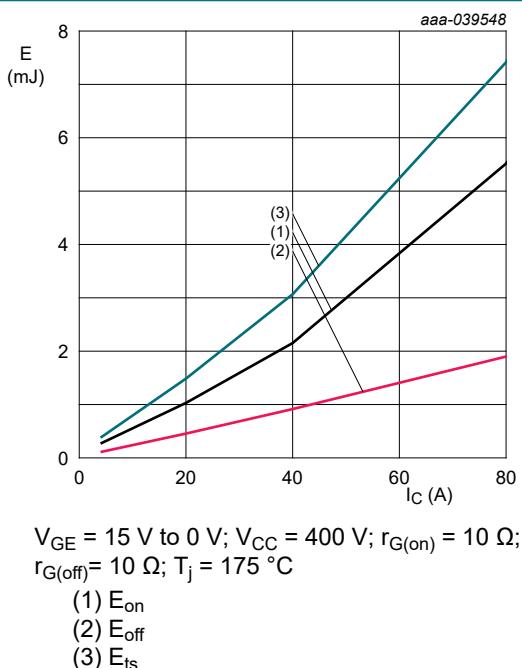
**Fig. 12. Typical switching times as a function of collector current**



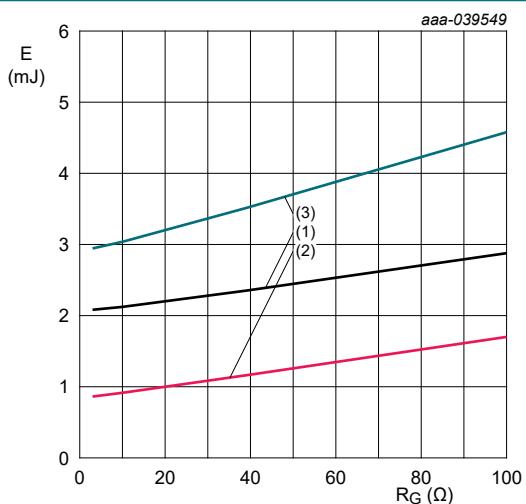
**Fig. 13. Typical switching times as a function of gate resistor**



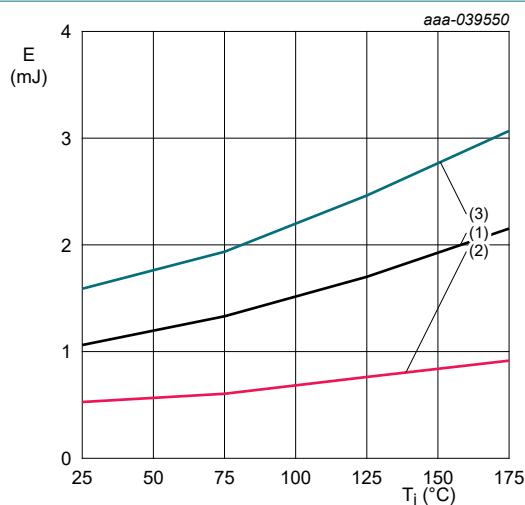
**Fig. 14. Typical switching times as a function of junction temperature**



**Fig. 15. Typical switching energy losses as a function of collector current**



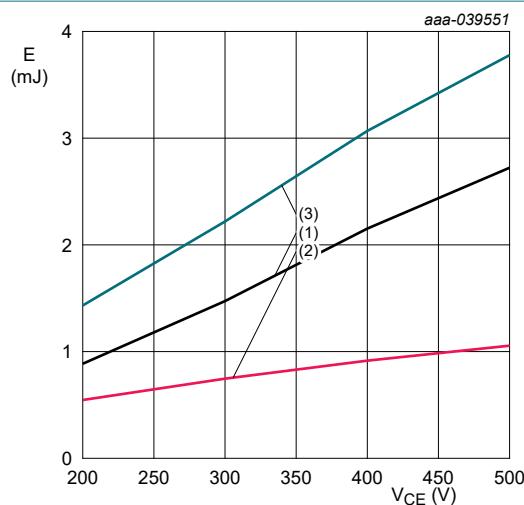
**Fig. 16. Typical switching energy losses as a function of gate resistance**



$V_{GE} = 15 \text{ V to } 0 \text{ V}$ ;  $I_C = 40 \text{ A}$ ;  $V_{CC} = 400 \text{ V}$ ;  
 $r_{G(on)} = 10 \Omega$ ;  $r_{G(off)} = 10 \Omega$

- (1)  $E_{on}$
- (2)  $E_{off}$
- (3)  $E_{ts}$

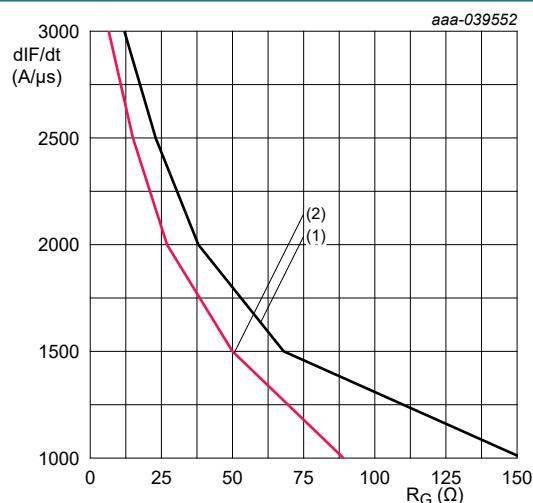
Fig. 17. Typical switching energy losses as a function of junction temperature



$V_{GE} = 15 \text{ V to } 0 \text{ V}$ ;  $I_C = 40 \text{ A}$ ;  $r_{G(on)} = 10 \Omega$ ;  
 $r_{G(off)} = 10 \Omega$ ;  $T_j = 175 \text{ }^\circ\text{C}$

- (1)  $E_{on}$
- (2)  $E_{off}$
- (3)  $E_{ts}$

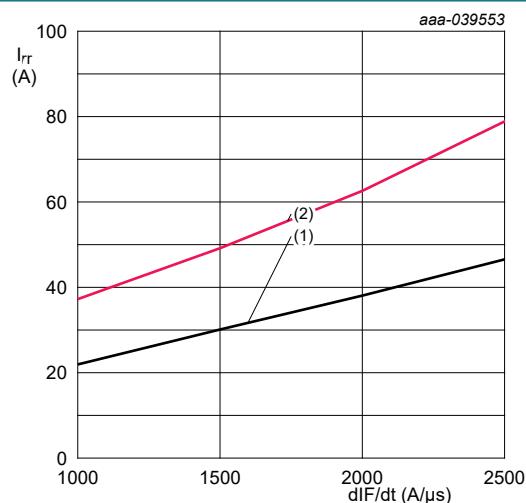
Fig. 18. Typical switching energy losses as a function of collector-emitter voltage



$V_R = 400 \text{ V}$ ;  $I_F = 40 \text{ A}$

- (1)  $T_{amb} = 25 \text{ }^\circ\text{C}$
- (2)  $T_{amb} = 175 \text{ }^\circ\text{C}$

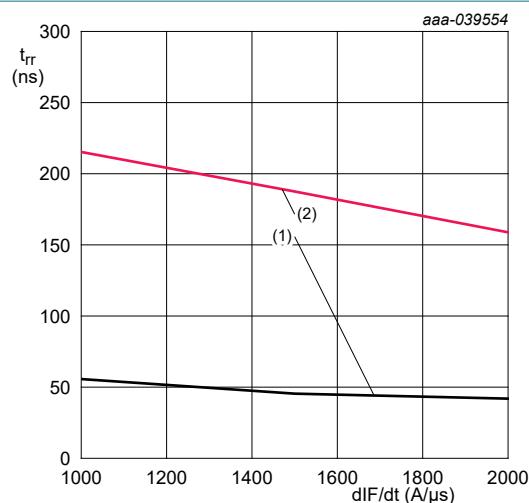
Fig. 19. Typical reverse recovery current as a function of change of gate resistance



$V_R = 400 \text{ V}$ ;  $I_F = 40 \text{ A}$

- (1)  $T_{amb} = 25 \text{ }^\circ\text{C}$
- (2)  $T_{amb} = 175 \text{ }^\circ\text{C}$

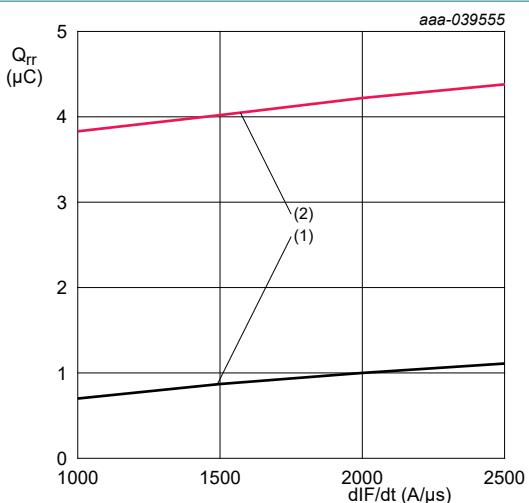
Fig. 20. Typical reverse recovery current as a function of change of forward current



$V_R = 400 \text{ V}; I_F = 40 \text{ A}$

- (1)  $T_{\text{amb}} = 25 \text{ }^{\circ}\text{C}$
- (2)  $T_{\text{amb}} = 175 \text{ }^{\circ}\text{C}$

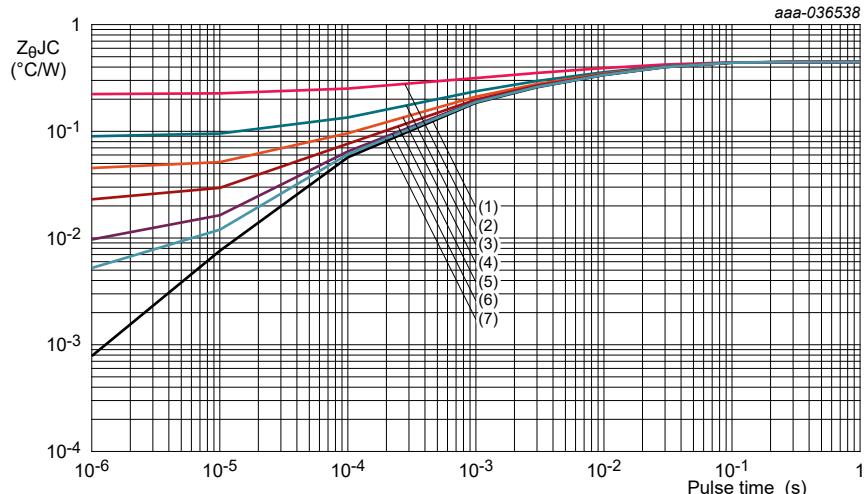
**Fig. 21. Typical reverse recovery time as a function of rate of change of forward current**



$V_R = 400 \text{ V}; I_F = 40 \text{ A}$

- (1)  $T_{\text{amb}} = 25 \text{ }^{\circ}\text{C}$
- (2)  $T_{\text{amb}} = 175 \text{ }^{\circ}\text{C}$

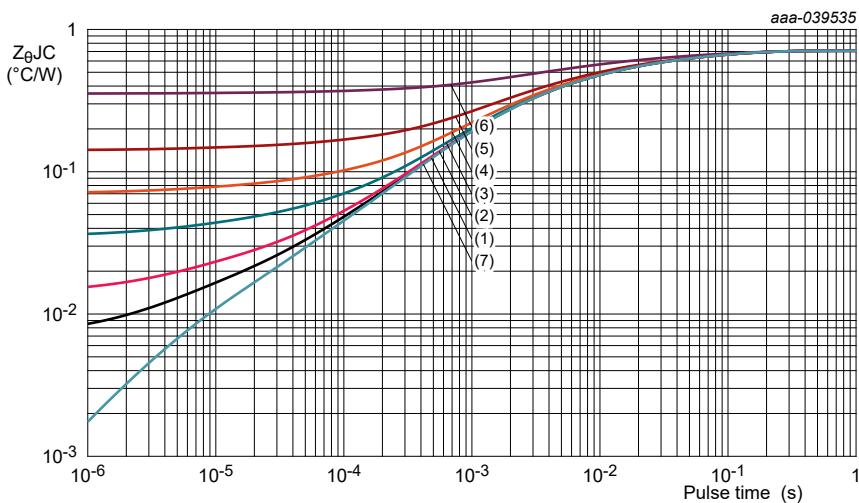
**Fig. 22. Typical reverse recovery charge as a function of rate of change of forward current**



- (1)  $Z_{\text{th}}$  ( $D = 0.5$ )
- (2)  $Z_{\text{th}}$  ( $D = 0.2$ )
- (3)  $Z_{\text{th}}$  ( $D = 0.1$ )
- (4)  $Z_{\text{th}}$  ( $D = 0.05$ )
- (5)  $Z_{\text{th}}$  ( $D = 0.02$ )
- (6)  $Z_{\text{th}}$  ( $D = 0.01$ )
- (7) Single pulse ( $D = 0.0$ )

i	1	2	3	4
$r_i$ [K/W]	0.056786	0.123135	0.144927	0.121162
$\tau_i$ [s]	0.000113	0.000681	0.005543	0.036756

**Fig. 23. Transient thermal impedance of IGBT as a function of pulse duration**



i	1	2	3	4
$r_i$ [K/W]	0.028245	0.223376	0.285136	0.171364
$\tau_i$ [s]	0.000041	0.001178	0.008051	0.071475

Fig. 24. Transient thermal impedance of diode as a function of pulse duration

## 9.2. Waveforms

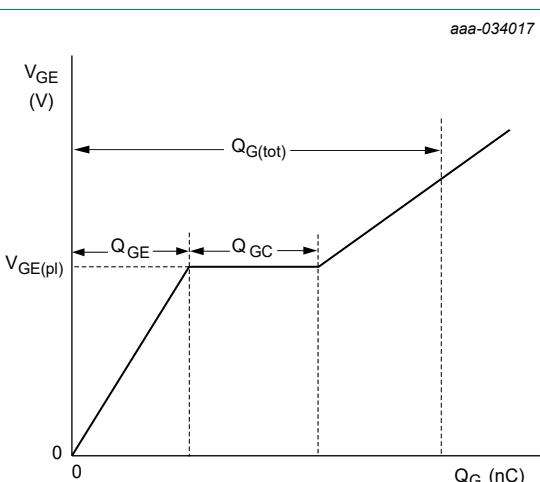


Fig. 25. IGBT gate charge waveform definitions

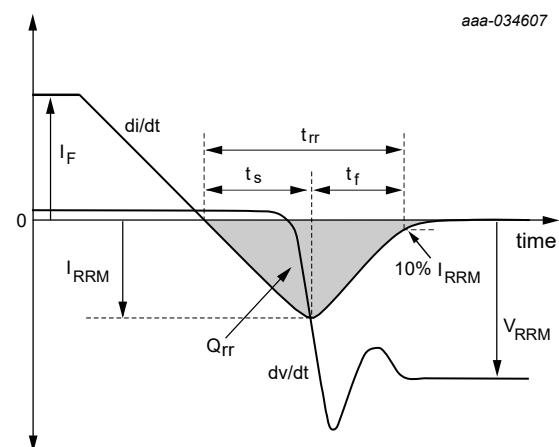


Fig. 26. Diode reverse recovery waveform definitions

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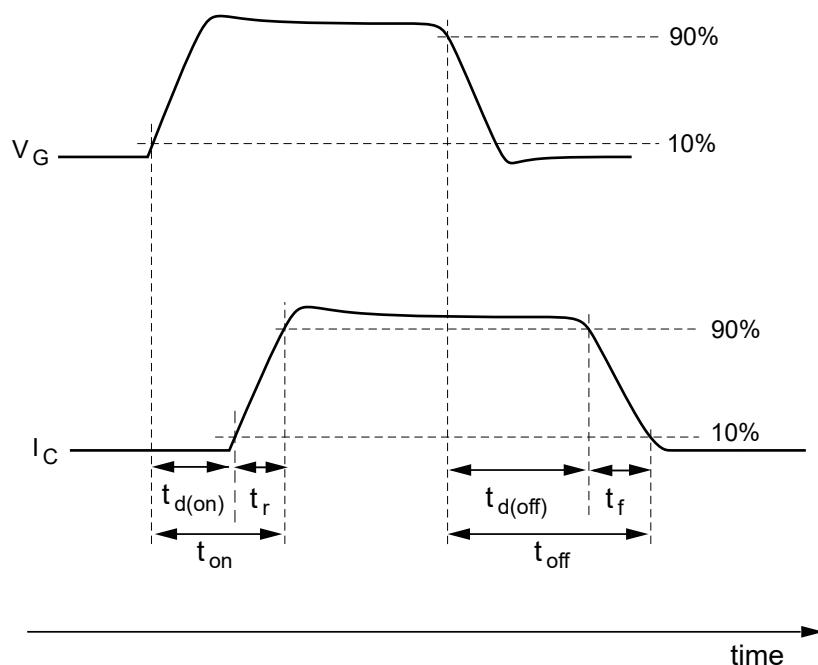
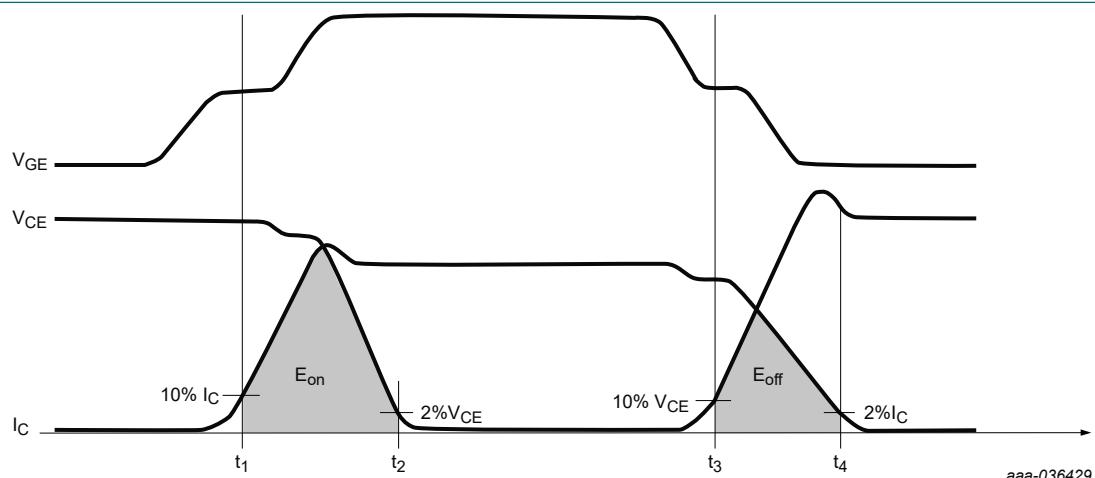


Fig. 27. IGBT switching times definitions



Where

$$E_{on} = \frac{t_2 - t_1}{t_2} V_{CE} I_C dt$$

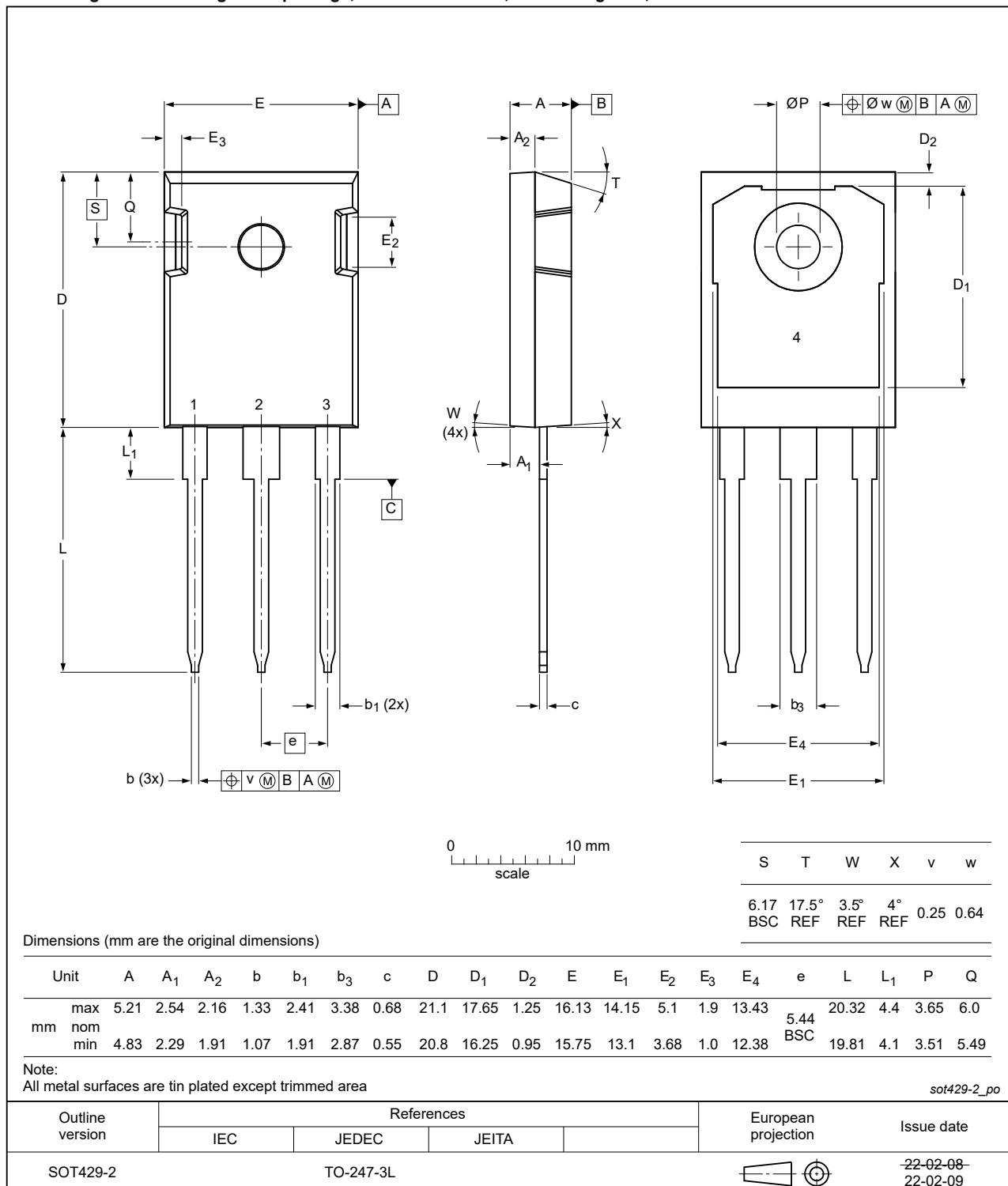
$$E_{off} = \frac{t_4 - t_3}{t_4} V_{CE} I_C dt$$

Fig. 28. IGBT switching loss definitions

## 10. Package outline

Plastic single-ended through-hole package; heatsink mounted; 1 mounting hole; 3-lead TO-247-3L

SOT429-2



## 11. Revision history

**Table 8. Revision history**

Document ID	Release date	Data sheet status	Change notice	Supersedes
NGW40T65M3DFP v. 1	20240628	Product data sheet	-	-

## 12. Legal information

### Data sheet status

Document status [1][2]	Product status [3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

- [1] Please consult the most recently issued document before initiating or completing a design.
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## Contents

1. General Description.....	1
2. Features and benefits.....	1
3. Applications.....	1
4. Quick reference data.....	1
5. Pinning information.....	2
6. Ordering information.....	2
7. Limiting values.....	2
8. Thermal characteristics.....	3
9. Characteristics.....	3
9.1. Waveforms and output characteristics.....	5
9.2. Waveforms.....	11
10. Package outline.....	13
11. Revision history.....	14
12. Legal information.....	15

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