



# 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
  - Serve 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

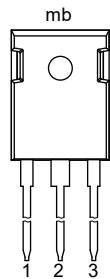
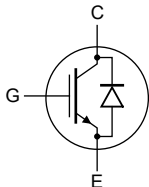
## 4. Quick reference data

Table 1. Quick reference data

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

5. Pinning information

Table 2. Pinning information

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

6. Ordering information

Table 3. Ordering information

Type number	Package		
	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	$T_j = 25\text{ °C}$	-	650	V
$I_C$	collector current	$T_{case} = 25\text{ °C}$ [1]	-	72	A
		$T_{case} = 100\text{ °C}$ [1]	-	48	A
$I_{Cpuls}$	peak pulse collector current [2]		-	120	A
$t_{sc}$	short circuit withstand time	$V_{GE} = 15\text{ V}; V_{CC} = 400\text{ V}; T_j \leq 150\text{ °C}$	-	5.0	$\mu s$
$V_{GS}$	gate-source voltage		-20	+20	V
$P_{tot}$	total power dissipation	$T_{case} = 25\text{ °C}$	-	283	W
		$T_{case} = 100\text{ °C}$	-	142	W
$T_j$	operating junction temperature		-40	+175	$^{\circ}C$
$T_{stg}$	storage temperature		-55	+150	$^{\circ}C$
$T_{solder}$	soldering temperature		-	260	$^{\circ}C$
M	mounting torque, M3 screw		-	0.6	Nm
<b>Diode</b>					
$I_F$	diode forward current	$T_{case} = 25\text{ °C}$ [1]	-	80	A
		$T_{case} = 100\text{ °C}$ [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 <sub>th(j-c)</sub>	thermal resistance from junction to case	IGBT	-	0.45	0.53	K/W
		diode	-	0.71	0.84	K/W
R <sub>th(j-a)</sub>	thermal resistance from junction to ambient	in free air	-	-	40	K/W

9. Characteristics

Table 6. Characteristics

All values at T<sub>j</sub> = 25 °C, unless otherwise specified.

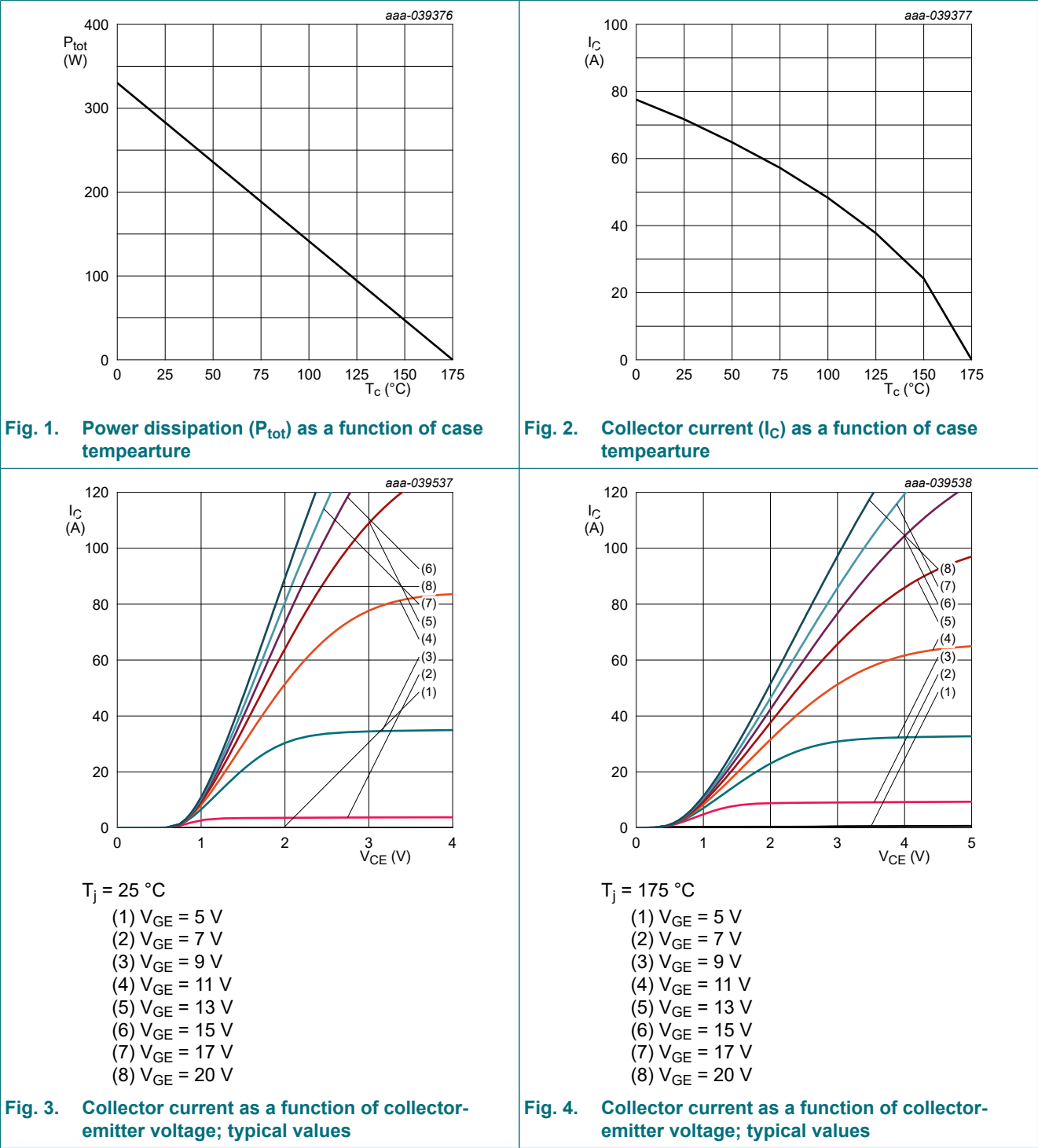
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Static characteristics						
V <sub>(BR)CE</sub>	collector-emitter breakdown voltage	V <sub>GE</sub> = 0 V; I <sub>C</sub> = 0.2 mA	650	-	-	V
V <sub>CEsat</sub>	collector-emitter saturation voltage	V <sub>GE</sub> = 15 V; I <sub>C</sub> = 40 A; T <sub>j</sub> = 25 °C	-	1.5	1.9	V
		V <sub>GE</sub> = 15 V; I <sub>C</sub> = 40 A; T <sub>j</sub> = 175 °C	-	1.9	-	V
V <sub>F</sub>	diode forward voltage	V <sub>GE</sub> = 0 V; I <sub>F</sub> = 40 A; T <sub>j</sub> = 25 °C	-	1.62	2.1	V
		V <sub>GE</sub> = 0 V; I <sub>F</sub> = 40 A; T <sub>j</sub> = 175 °C	-	1.33	-	V
V <sub>GE(th)</sub>	gate-emitter threshold voltage	I <sub>C</sub> = 0.4 mA; V <sub>CE</sub> = V <sub>GE</sub> ; T <sub>j</sub> = 25 °C	4.3	5	5.7	V
I <sub>CES</sub>	zero gate voltage collector current	V <sub>CE</sub> = 650 V; V <sub>GE</sub> = 0 V; T <sub>j</sub> = 25 °C	-	10	-	nA
		V <sub>CE</sub> = 650 V; V <sub>GE</sub> = 0 V; T <sub>j</sub> = 175 °C	-	0.5	-	mA
I <sub>GES</sub>	gate-emitter leakage current	V <sub>CE</sub> = 0 V; V <sub>GE</sub> = 20 V	-	-	100	nA
g <sub>fs</sub>	transconductance	V <sub>CE</sub> = 20 V; I <sub>C</sub> = 40 A; T <sub>j</sub> = 25 °C	-	20	-	S
r <sub>G</sub>	integrated gate resistor		-	1.3	-	Ω
Dynamic characteristics						
C <sub>ies</sub>	input capacitance	V <sub>CE</sub> = 25 V; V <sub>GE</sub> = 0 V; f = 1 MHz	-	2040	-	pF
C <sub>oes</sub>	output capacitance		-	136	-	pF
C <sub>res</sub>	reverse transfer capacitance		-	31	-	pF
Q <sub>G</sub>	gate charge	V <sub>CC</sub> = 520 V; V <sub>GE</sub> = 15 V; I <sub>C</sub> = 40 A	-	130	-	nC
L <sub>sCE</sub>	internal stray inductance	measured 5 mm from case	-	7.9	-	nH
I <sub>C(sc)</sub>	short circuit collector current	V <sub>GE</sub> = 15 V; V <sub>CC</sub> = 400 V; t <sub>sc</sub> ≤ 5 μs; T <sub>j</sub> ≤ 150 °C	-	130	-	A

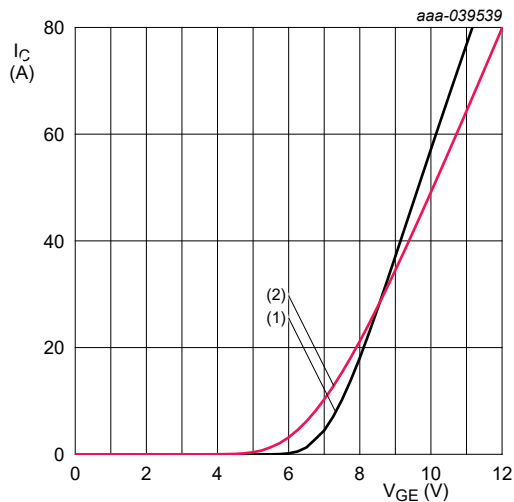
650 V, 40 A trench field-stop IGBT with full rated silicon diode

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
IGBT switching characteristics, inductive load							
t <sub>d(on)</sub>	turn-on delay time	V <sub>GE</sub> = 15/0 V; V <sub>CC</sub> = 400 V; I <sub>C</sub> = 40 A; r <sub>G(on)</sub> = 10 Ω; r <sub>G(off)</sub> = 10 Ω; see <a href="#">Fig. 27</a> and <a href="#">Fig. 28</a>	T <sub>J</sub> = 25 °C	-	22	-	ns
			T <sub>J</sub> = 175 °C	-	20	-	ns
t <sub>r</sub>	rise time		T <sub>J</sub> = 25 °C	-	22	-	ns
			T <sub>J</sub> = 175 °C	-	23	-	ns
t <sub>d(off)</sub>	turn-off delay time		T <sub>J</sub> = 25 °C	-	185	-	ns
			T <sub>J</sub> = 175 °C	-	220	-	ns
t <sub>f</sub>	fall time		T <sub>J</sub> = 25 °C	-	13	-	ns
			T <sub>J</sub> = 175 °C	-	50	-	ns
E <sub>on</sub>	turn-on switching loss		T <sub>J</sub> = 25 °C	-	1.05	-	mJ
			T <sub>J</sub> = 175 °C	-	2.15	-	mJ
E <sub>off</sub>	turn-off switching loss		T <sub>J</sub> = 25 °C	-	0.52	-	mJ
			T <sub>J</sub> = 175 °C	-	0.9	-	mJ
E <sub>ts</sub>	total switching loss		T <sub>J</sub> = 25 °C	-	1.57	-	mJ
			T <sub>J</sub> = 175 °C	-	3.05	-	mJ
Diode switching characteristics, inductive load							
t <sub>rr</sub>	diode reverse recovery time	V <sub>R</sub> = 400 V; I <sub>F</sub> = 40 A; ΔI <sub>F</sub> /Δt = 1000 A/μs; see <a href="#">Fig. 26</a>	T <sub>J</sub> = 25 °C	-	55	-	ns
			T <sub>J</sub> = 175 °C	-	215	-	ns
Q <sub>rr</sub>	diode reverse recovery charge		T <sub>J</sub> = 25 °C	-	700	-	nC
			T <sub>J</sub> = 175 °C	-	3830	-	nC
I <sub>rrm</sub>	diode peak reverse recovery current		T <sub>J</sub> = 25 °C	-	22	-	A
			T <sub>J</sub> = 175 °C	-	37	-	A
E <sub>rr</sub>	reverse recovery energy		T <sub>J</sub> = 25 °C	-	0.12	-	mJ
			T <sub>J</sub> = 175 °C	-	0.36	-	mJ
di <sub>rr</sub> /dt	diode peak rate or fall of reverse recovery current		T <sub>J</sub> = 25 °C	-	650	-	A/μs
			T <sub>J</sub> = 175 °C	-	760	-	A/μs

9.1. Waveforms and output characteristics

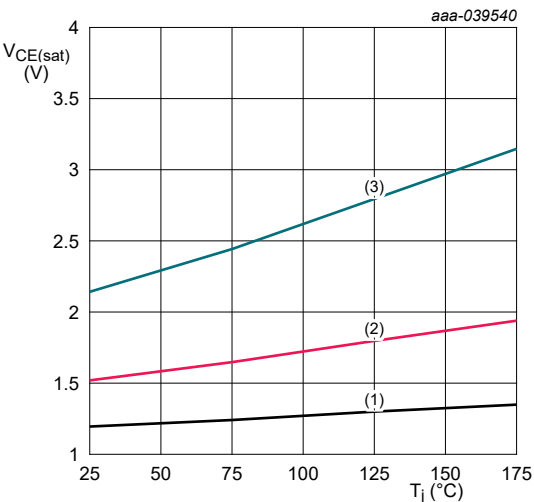
Table 7. Waveforms and output characteristics





$V_{CE} = 20\text{ V}$   
(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 vlaues



$V_{GE} = 15\text{ V}$   
(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

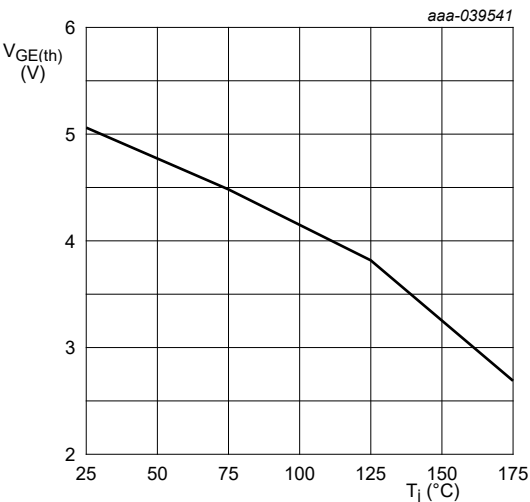
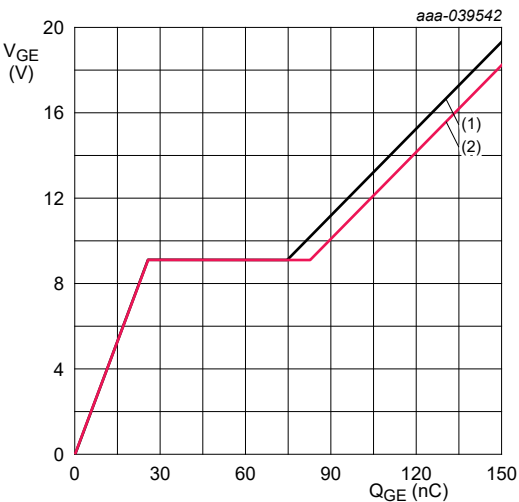
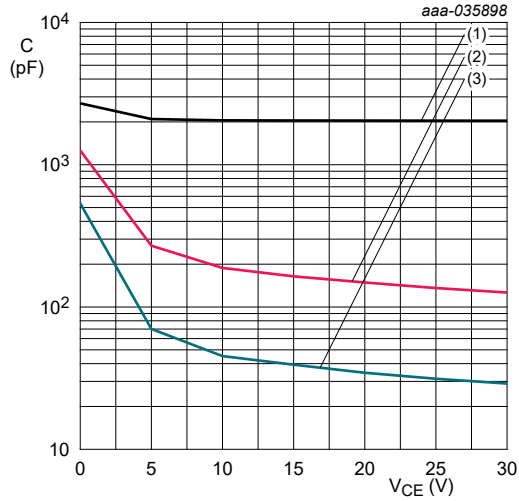


Fig. 7. Gate-emitter threshold voltage as a function of junction temperature



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

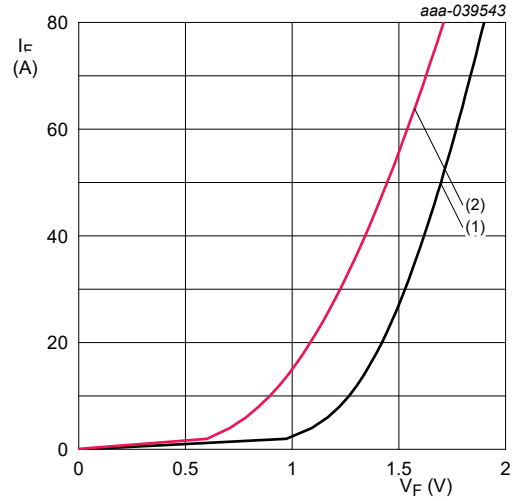
Fig. 8. Gate-emitter voltage as a function of gate charge



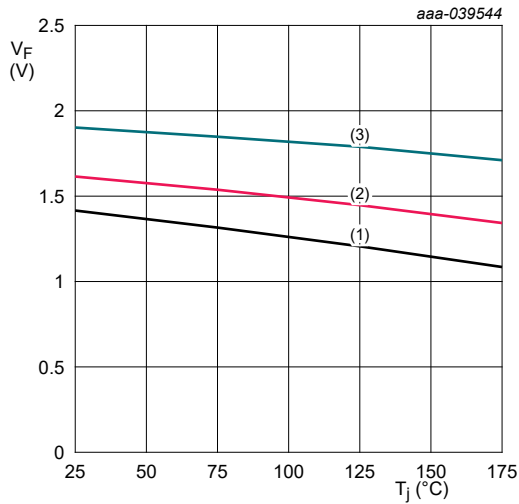
$V_{GE} = 0 \text{ V}$ ,  $f = 1 \text{ MHz}$

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

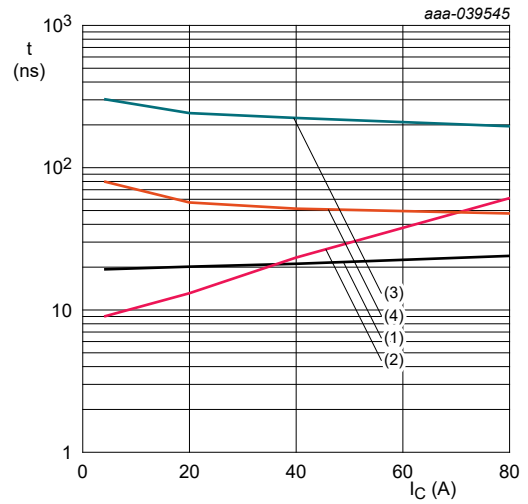
**Fig. 9. Typical capacitance as a function of collector-emitter voltage**



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



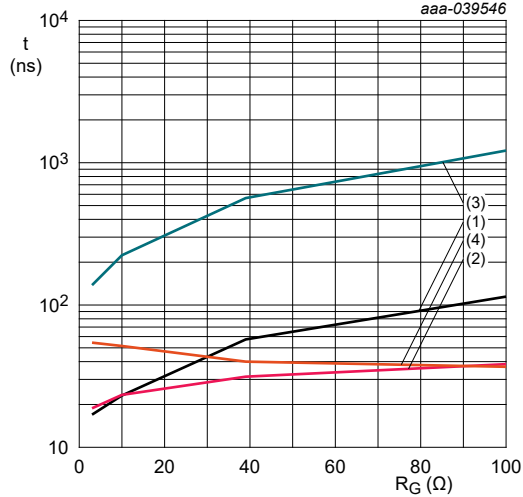
**Fig. 11. Typical diode forward voltage as a function of junction temperature**



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

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

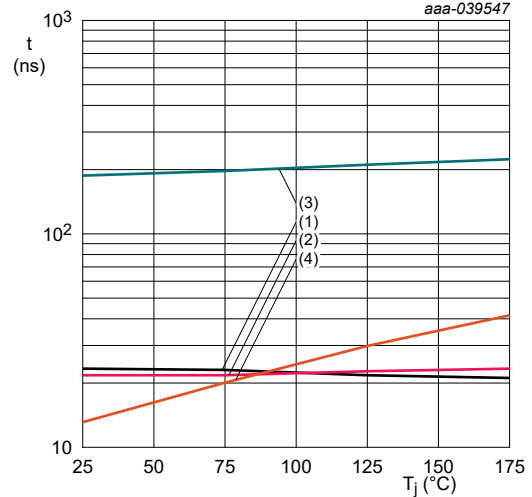
**Fig. 12. Typical switching times as a function of collector current**



$V_{GE} = 15 \text{ V to } 0 \text{ V}$ ;  $V_{CC} = 400 \text{ V}$ ;  $I_C = 40 \text{ A}$ ;  
 $T_j = 175 \text{ }^\circ\text{C}$

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

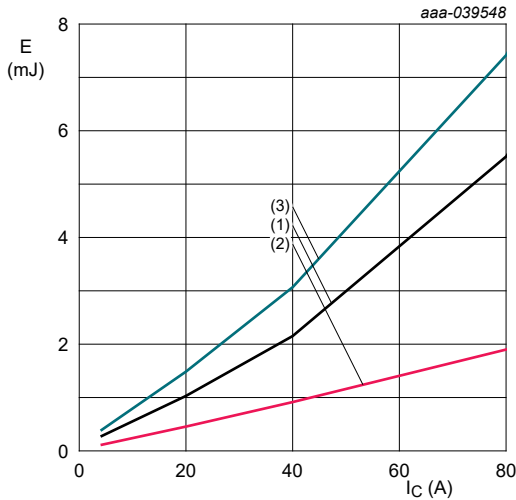
Fig. 13. Typical switching times as a function of gate resistor



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

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

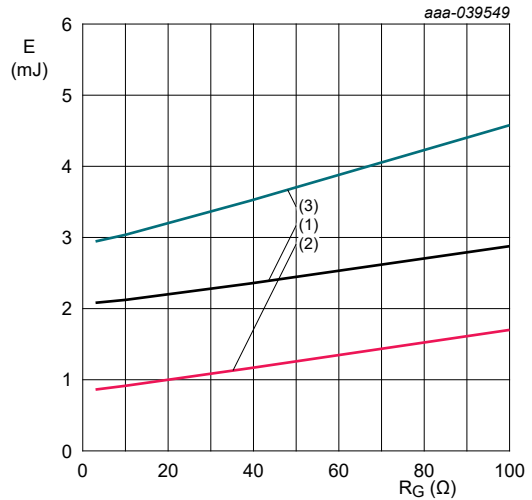
Fig. 14. Typical switching times as a function of junction temperature



$V_{GE} = 15 \text{ V to } 0 \text{ V}$ ;  $V_{CC} = 400 \text{ V}$ ;  $r_{G(on)} = 10 \text{ } \Omega$ ;  
 $r_{G(off)} = 10 \text{ } \Omega$ ;  $T_j = 175 \text{ }^\circ\text{C}$

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

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

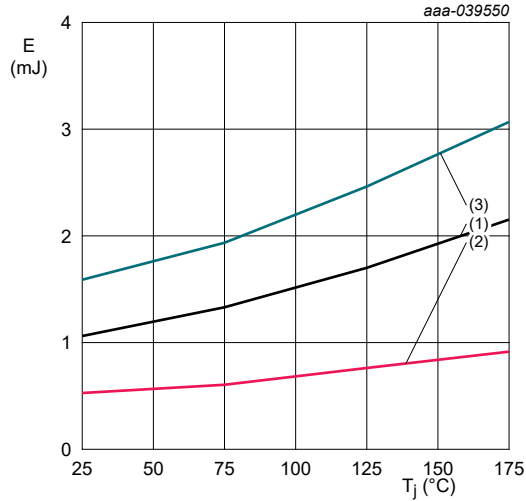


$V_{GE} = 15 \text{ V to } 0 \text{ V}$ ;  $V_{CC} = 400 \text{ V}$ ;  $I_C = 40 \text{ A}$ ;  
 $T_j = 175 \text{ }^\circ\text{C}$

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

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

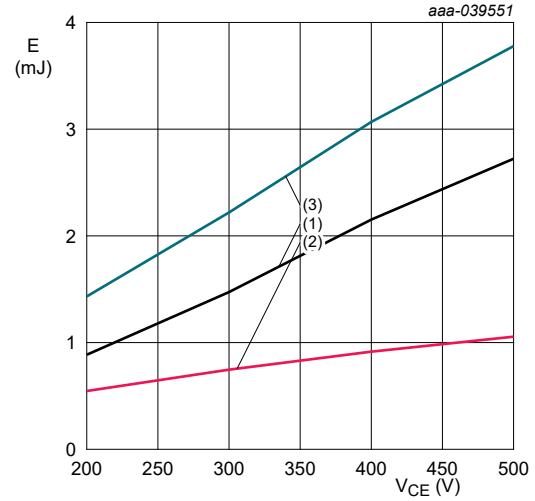




$V_{GE} = 15 \text{ V to } 0 \text{ V}$ ;  $I_C = 40 \text{ A}$ ;  $V_{CC} = 400 \text{ V}$ ;  
 $r_{G(on)} = 10 \text{ } \Omega$ ;  $r_{G(off)} = 10 \text{ } \Omega$

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

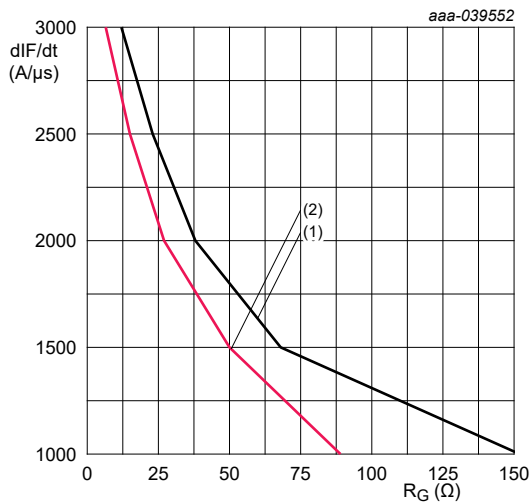
Fig. 17. Typical switching energy losses as a function of junction temperature



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

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

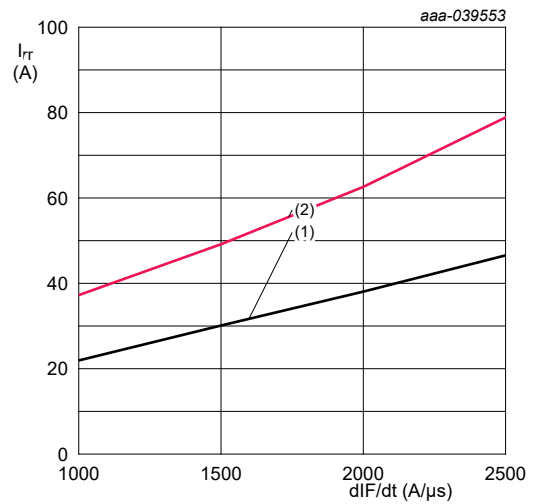
Fig. 18. Typical switching energy losses as a function of collector-emitter voltage



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

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

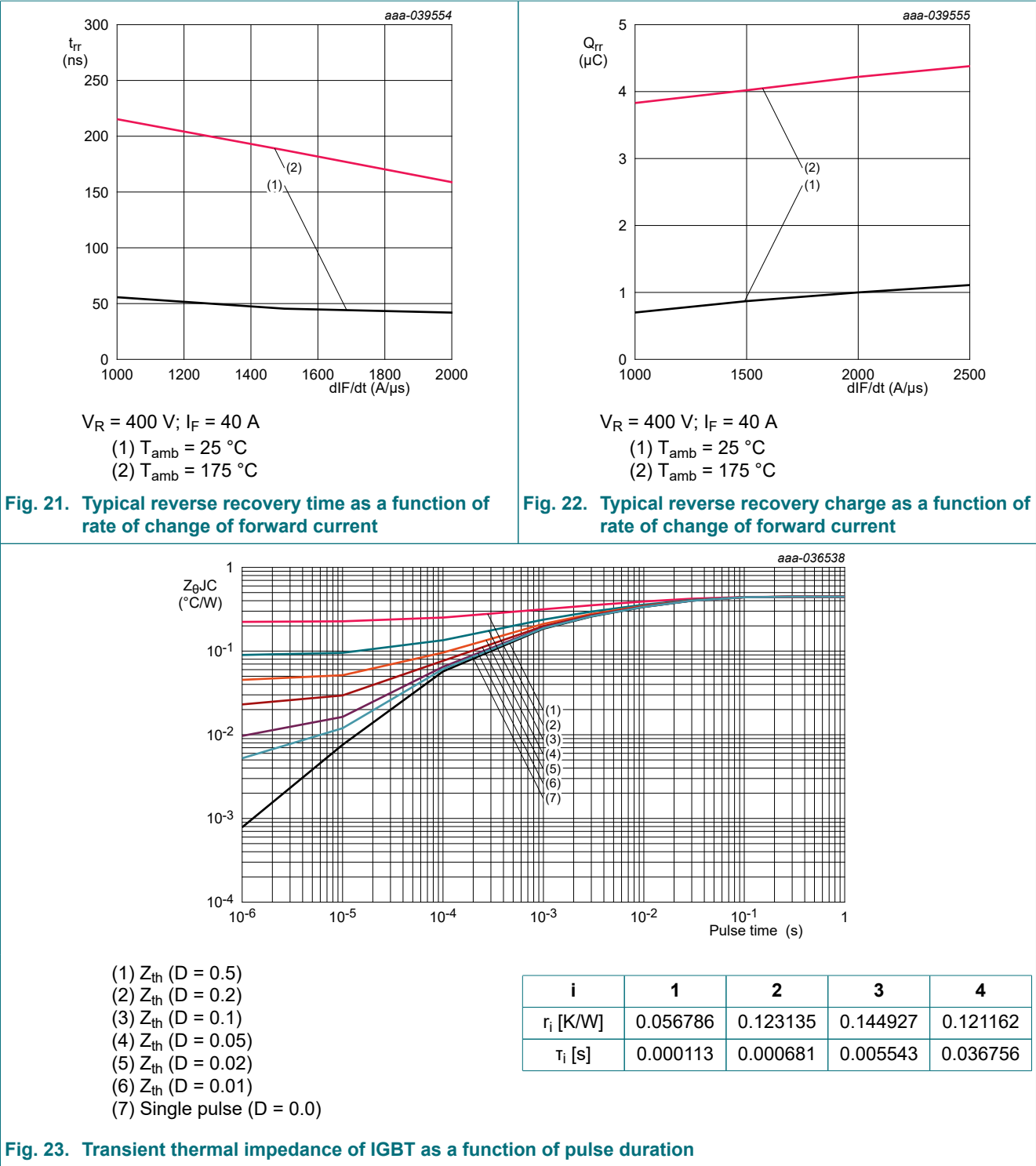
Fig. 19. Typical reverse recovery current as a function of change of gate resistance

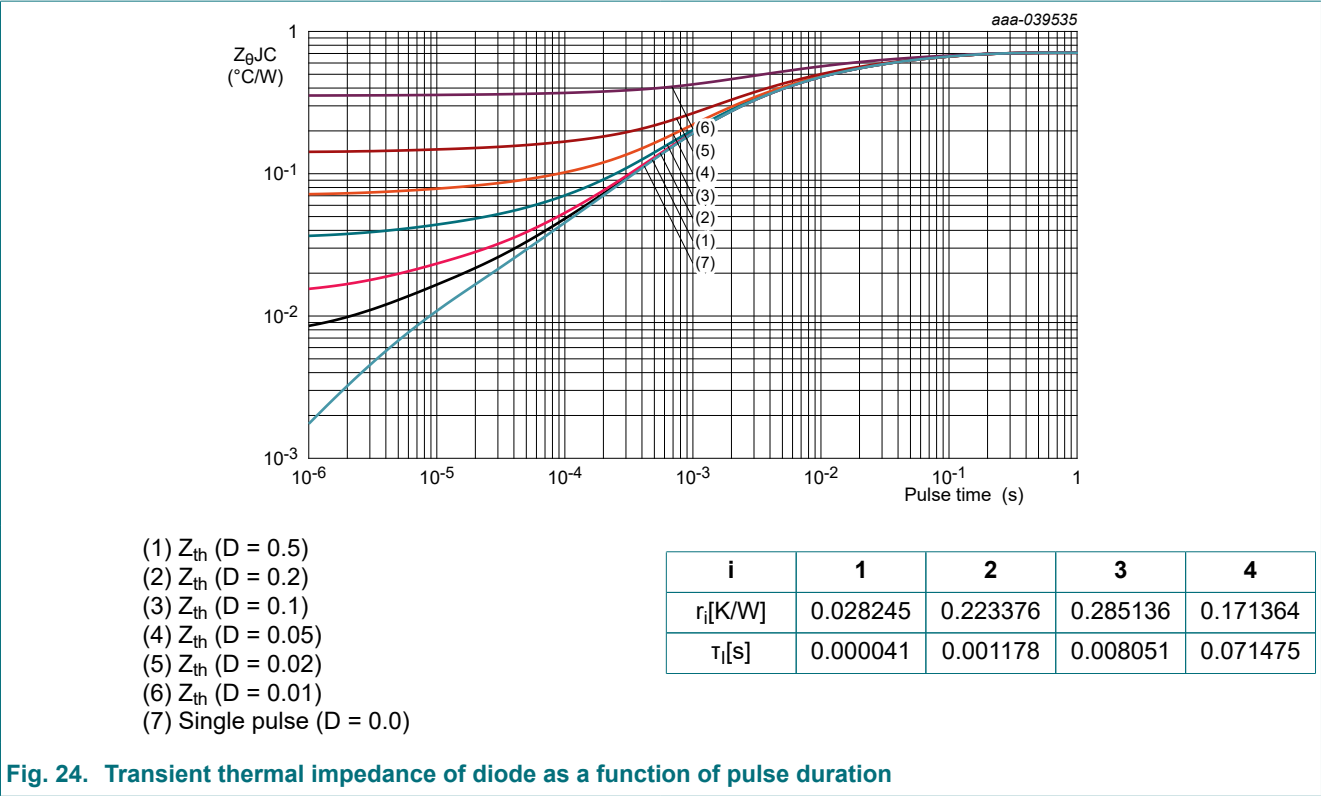


$V_R = 400 \text{ V}$ ;  $I_F = 40 \text{ A}$

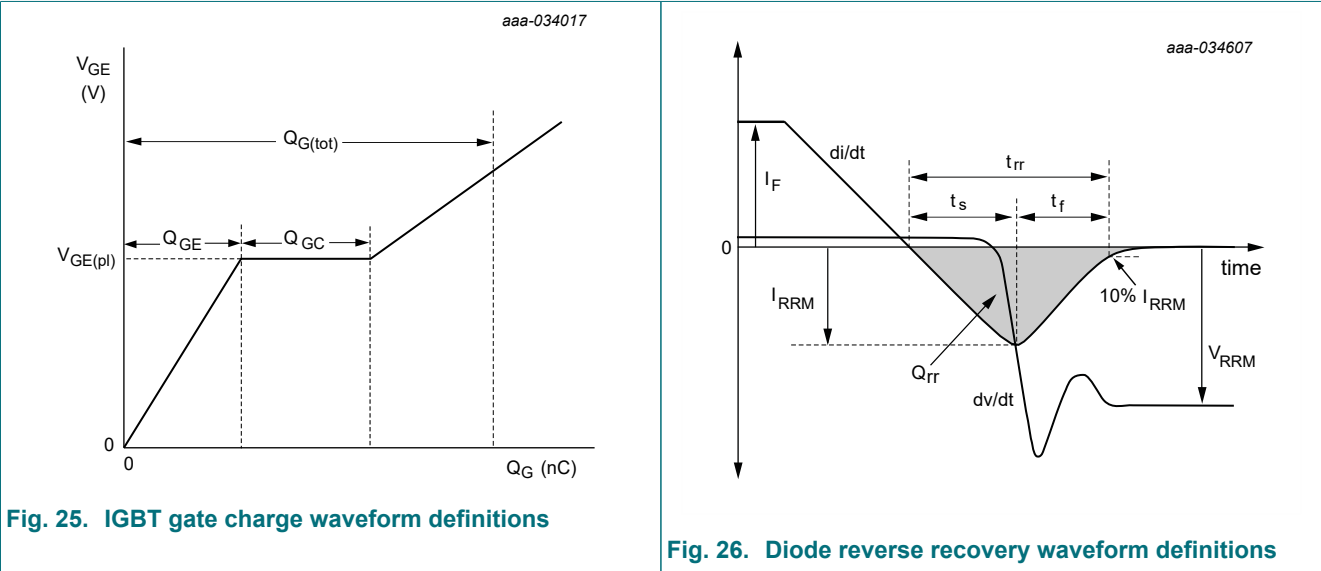
- (1)  $T_{amb} = 25 \text{ } ^\circ\text{C}$
- (2)  $T_{amb} = 175 \text{ } ^\circ\text{C}$

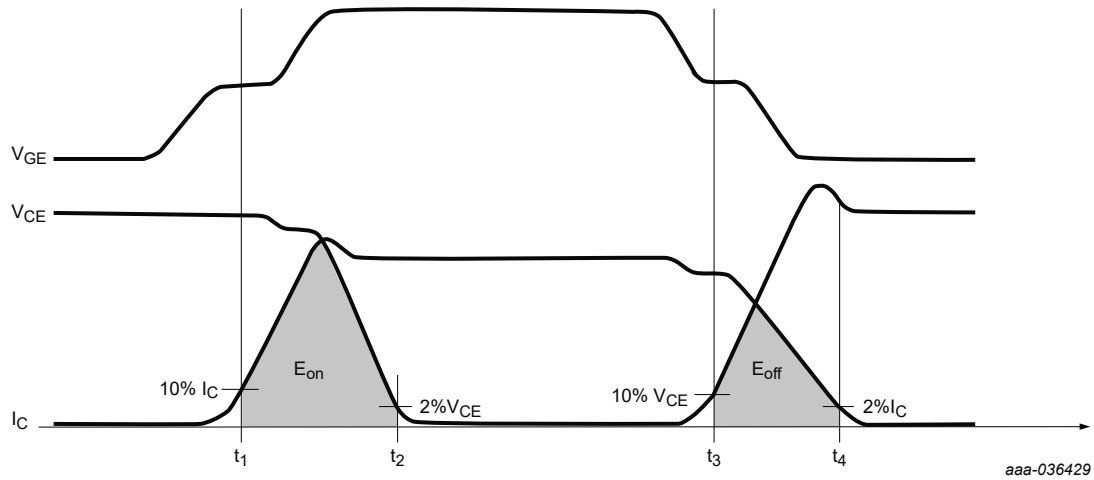
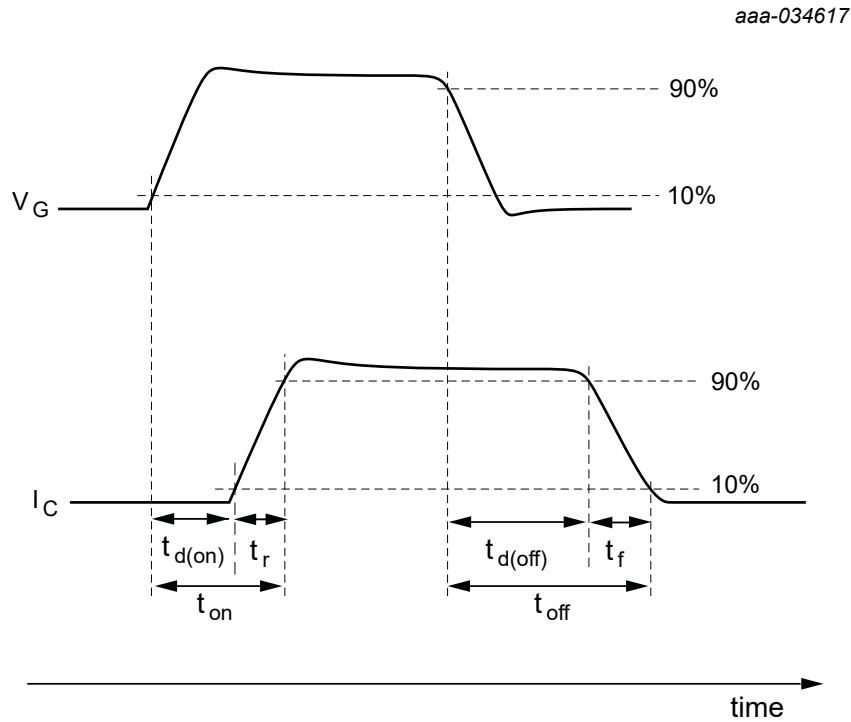
Fig. 20. Typical reverse recovery current as a function of change of forward current





9.2. Waveforms

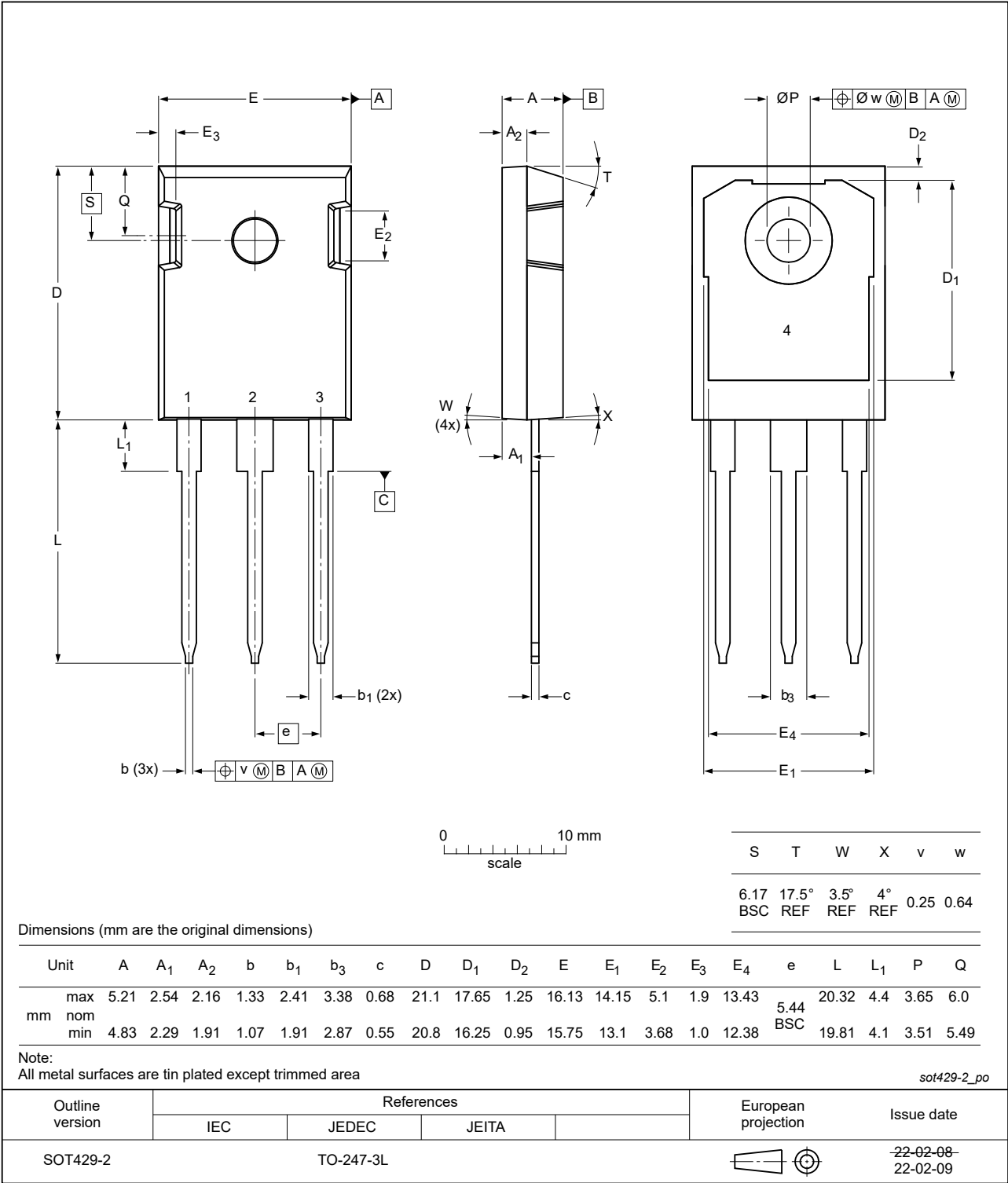




10. Package outline

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.
- [2] The term 'short data sheet' is explained in section "Definitions".
- [3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the internet at <https://www.nexperia.com>.

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