



# NGW50T65H3DFP

650 V, 50 A high speed trench field-stop IGBT with full rated silicon diode

Rev. 1 — 28 June 2024

Product data sheet

## 1. General description

The NGW50T65H3DFP is a robust Insulated-Gate Bipolar Transistor (IGBT) featuring third-generation technology. It combines carrier stored trench-gate and field-stop (FS) structures. The NGW50T65H3DFP is rated to 175 °C with optimized IGBT turn-off losses. This hard-switching 650 V, 50 A IGBT is optimized for high-voltage, high-frequency industrial power inverter applications.

## 2. Features and benefits

- Collector current ( $I_C$ ) rated at 50 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
- RoHS compliant, lead-free plating

## 3. Applications

- Power inverters
  - Uninterruptible Power Supply (UPS) inverter
  - Photovoltaic (PV) strings
  - EV charging
- Induction heating
- Welding

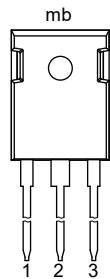
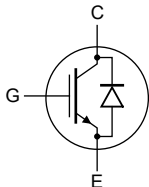
## 4. Quick reference data

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

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		

6. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
<a href="#">NGW50T65H3DFP</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
IGBT					
V <sub>CE</sub>	collector-emitter voltage	T <sub>j</sub> = 25 °C	-	650	V
I <sub>C</sub>	collector current	T <sub>case</sub> = 25 °C [1]	-	80	A
		T <sub>case</sub> = 100 °C [2]	-	54	A
I <sub>Cpuls</sub>	peak pulse collector current [3]		-	200	A
V <sub>GS</sub>	gate-source voltage		-20	+20	V
P <sub>tot</sub>	total power dissipation	T <sub>case</sub> = 25 °C	-	340	W
		T <sub>case</sub> = 100 °C	-	170	W
T <sub>j</sub>	operating junction temperature		-40	+175	°C
T <sub>stg</sub>	storage temperature		-55	+150	°C
T <sub>solder</sub>	soldering temperature		-	260	°C
M	mounting torque, M3 screw		-	0.5	Nm
Diode					
I <sub>F</sub>	diode forward current	T <sub>case</sub> = 25 °C [1]	-	80	A
		T <sub>case</sub> = 100 °C [1]	-	68	A
I <sub>Fpuls</sub>	peak pulse diode current [3]	T <sub>case</sub> = 25 °C		200	A

[1] Value limited by bondwire and T<sub>j(max)</sub>.

[2] t<sub>p</sub> limited by T<sub>j(max)</sub>

[3] t<sub>p</sub> limited by T<sub>j(max)</sub>.

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	-	0.37	0.44	K/W
		diode	-	0.52	0.64	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.

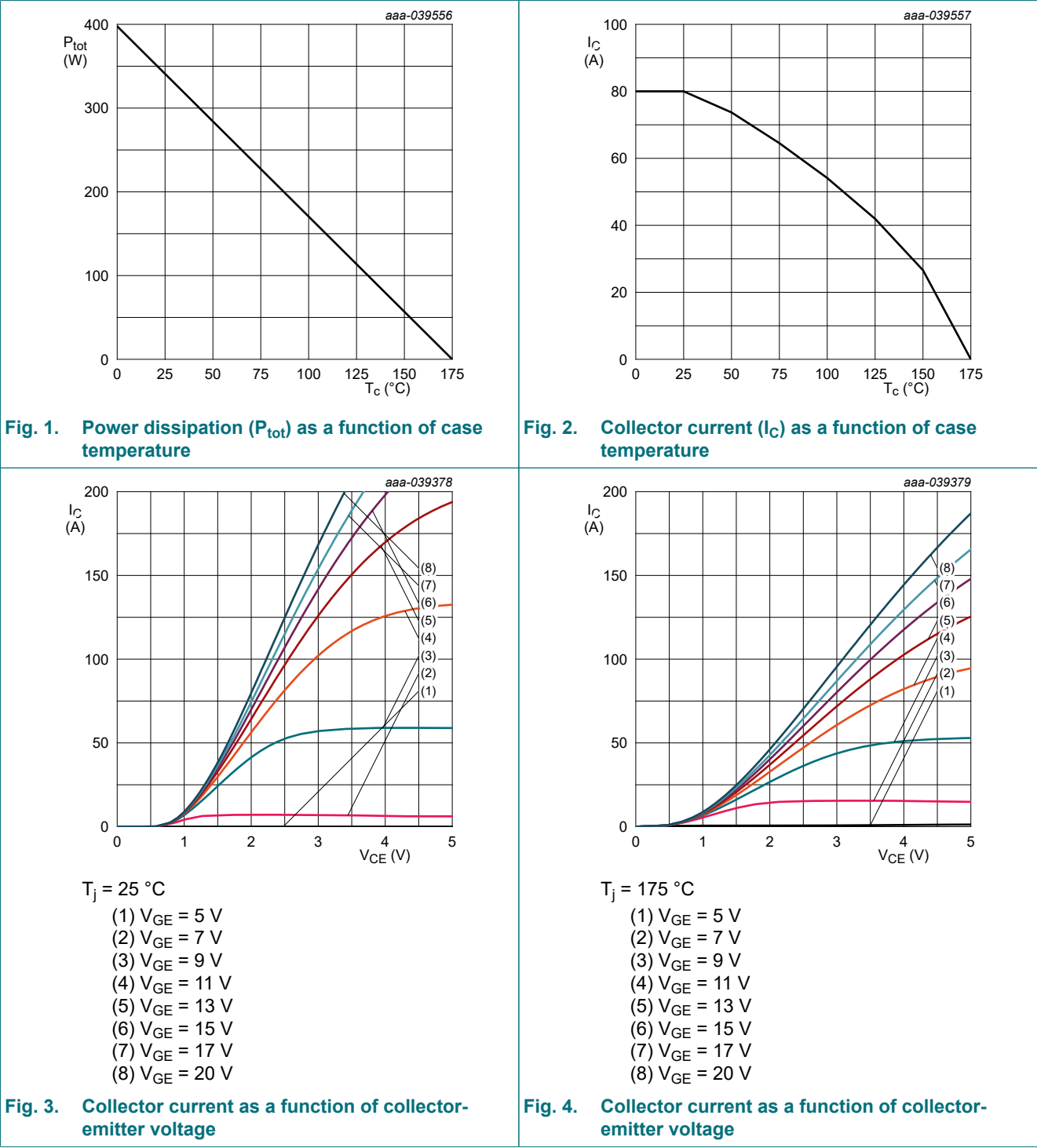
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Static characteristics						
V <sub>(BR)CE</sub>	collector-emitter stop voltage	V <sub>GE</sub> = 0 V; I <sub>C</sub> = 0.2 mA	650	-	-	V
V <sub>CEsat</sub>	collector-emitter saturation voltage	V <sub>GE</sub> = 15 V; I <sub>C</sub> = 50 A; T <sub>j</sub> = 25 °C	-	1.72	2.2	V
		V <sub>GE</sub> = 15 V; I <sub>C</sub> = 50 A; T <sub>j</sub> = 175 °C	-	2.25	-	V
V <sub>F</sub>	diode forward voltage	V <sub>GE</sub> = 0 V; I <sub>F</sub> = 50 A; T <sub>j</sub> = 25 °C	-	1.45	2.1	V
		V <sub>GE</sub> = 0 V; I <sub>F</sub> = 50 A; T <sub>j</sub> = 175 °C	-	1.2	-	V
V <sub>GE(th)</sub>	gate-emitter threshold voltage	I <sub>C</sub> = 0.5 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	-	0.6	-	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> = 50 A; T <sub>j</sub> = 25 °C	-	28	-	S
r <sub>G</sub>	integrated gate resistor		-	1.6	-	Ω
Dynamic characteristics						
C <sub>ies</sub>	input capacitance	V <sub>CE</sub> = 25 V; V <sub>GE</sub> = 0 V; f = 1 MHz	-	2210	-	pF
C <sub>oes</sub>	output capacitance		-	180	-	pF
C <sub>res</sub>	reverse transfer capacitance		-	16.5	-	pF
Q <sub>G</sub>	gate charge	V <sub>CC</sub> = 520 V; V <sub>GE</sub> = 15 V; I <sub>C</sub> = 50 A	-	85	-	nC
L <sub>sCE</sub>	internal stray inductance	measured 5 mm from case	-	7.9	-	nH

650 V, 50 A high speed 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 V to 0 V; V <sub>CC</sub> = 400 V; I <sub>C</sub> = 50 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	-	20	-	ns
			T <sub>J</sub> = 175 °C	-	20	-	ns
t <sub>r</sub>	increase time		T <sub>J</sub> = 25 °C	-	36	-	ns
			T <sub>J</sub> = 175 °C	-	36	-	ns
t <sub>d(off)</sub>	turn-off delay time		T <sub>J</sub> = 25 °C	-	98	-	ns
			T <sub>J</sub> = 175 °C	-	125	-	ns
t <sub>f</sub>	decrease time		T <sub>J</sub> = 25 °C	-	32	-	ns
			T <sub>J</sub> = 175 °C	-	36	-	ns
E <sub>on</sub>	turn-on switching loss		T <sub>J</sub> = 25 °C	-	1.70	-	mJ
			T <sub>J</sub> = 175 °C	-	3.52	-	mJ
E <sub>off</sub>	turn-off switching loss		T <sub>J</sub> = 25 °C	-	0.50	-	mJ
			T <sub>J</sub> = 175 °C	-	0.76	-	mJ
E <sub>ts</sub>	total switching loss		T <sub>J</sub> = 25 °C	-	2.20	-	mJ
			T <sub>J</sub> = 175 °C	-	4.28	-	mJ
Diode switching characteristics, inductive load							
t <sub>rr</sub>	diode reverse recovery time	V <sub>R</sub> = 400 V; I <sub>F</sub> = 50 A; ΔI <sub>F</sub> /Δt = 500 A/μs; see <a href="#">Fig. 26</a>	T <sub>J</sub> = 25 °C	-	145	-	ns
			T <sub>J</sub> = 175 °C	-	260	-	ns
Q <sub>rr</sub>	diode reverse recovery charge		T <sub>J</sub> = 25 °C	-	1170	-	nC
			T <sub>J</sub> = 175 °C	-	5370	-	nC
I <sub>rrm</sub>	diode peak reverse recovery current		T <sub>J</sub> = 25 °C	-	20	-	A
			T <sub>J</sub> = 175 °C	-	37	-	A
E <sub>rr</sub>	opposite recovery energy		T <sub>J</sub> = 25 °C	-	0.12	-	mJ
			T <sub>J</sub> = 175 °C	-	0.65	-	mJ
di <sub>rr</sub> /dt	diode peak rate of decrease of reverse recovery current		T <sub>J</sub> = 25 °C	-	160	-	A/μs
			T <sub>J</sub> = 175 °C	-	185	-	A/μs

9.1. Output characteristics

Table 7. Waveforms and output characteristics



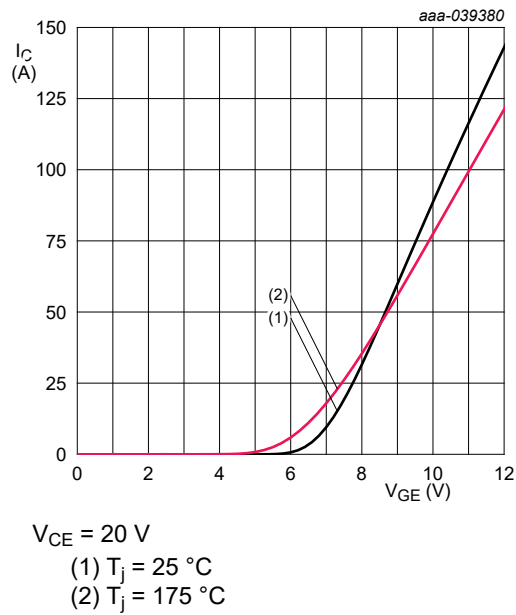


Fig. 5. Collector current as a function of gate-emitter voltage; typical values

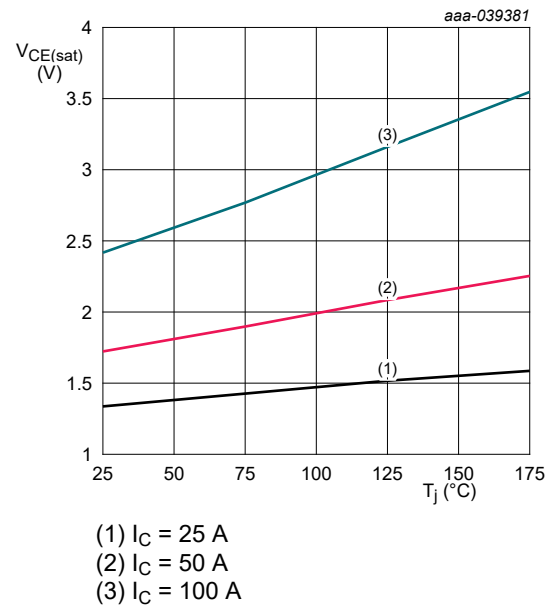


Fig. 6. Collector-emitter saturation voltage as a function of junction temperature; typical values

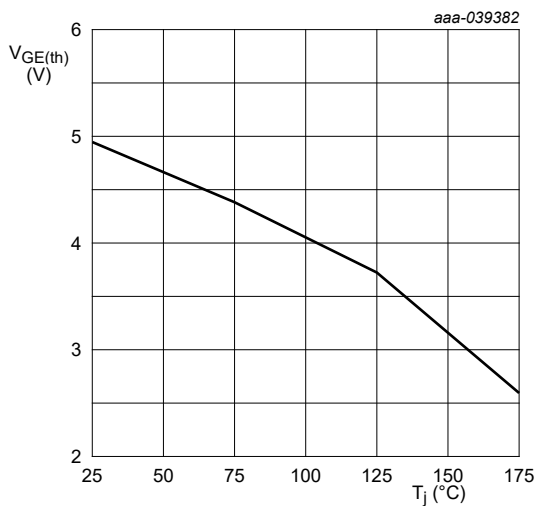


Fig. 7. Gate-emitter threshold voltage as a function of junction temperature

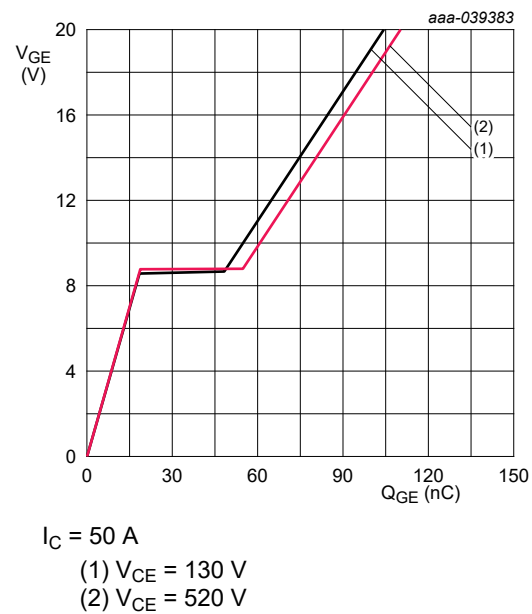
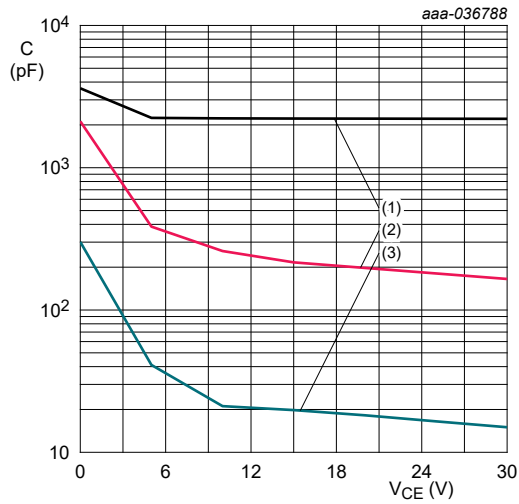


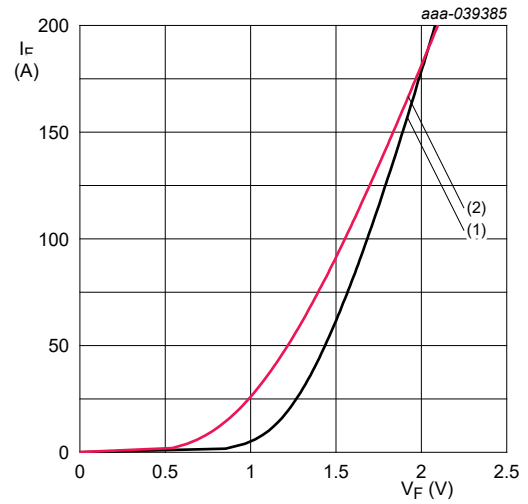
Fig. 8. Gate-emitter voltage as a function of gate charge; typical values



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

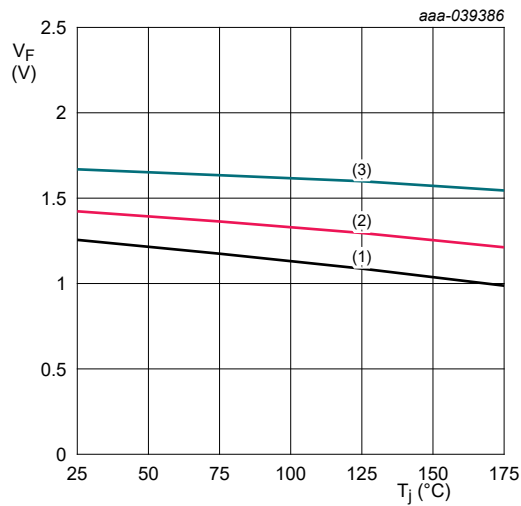
- (1)  $C_{ies}$
- (2)  $C_{oes}$
- (3)  $C_{res}$

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



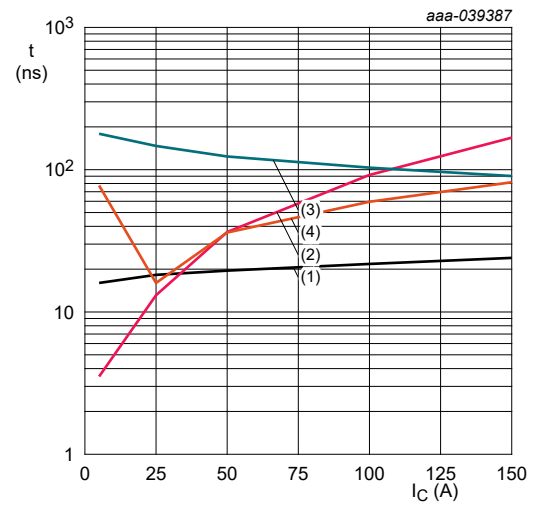
- (1)  $T_{amb} = 25 \text{ °C}$
- (2)  $T_{amb} = 175 \text{ °C}$

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



- (1)  $I_F = 25 \text{ A}$
- (2)  $I_F = 50 \text{ A}$
- (3)  $I_F = 100 \text{ A}$

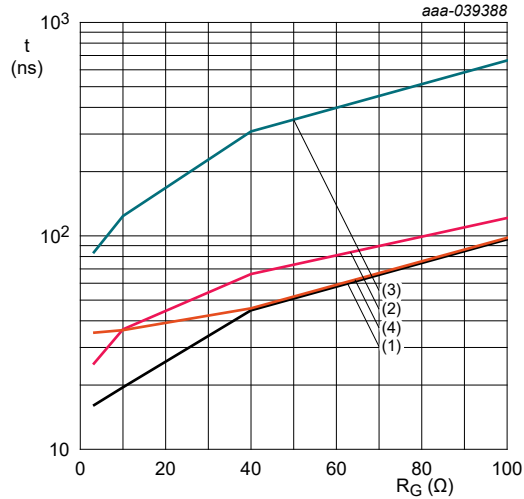
**Fig. 11.** Typical diode forward voltage as a function of junction temperature



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

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

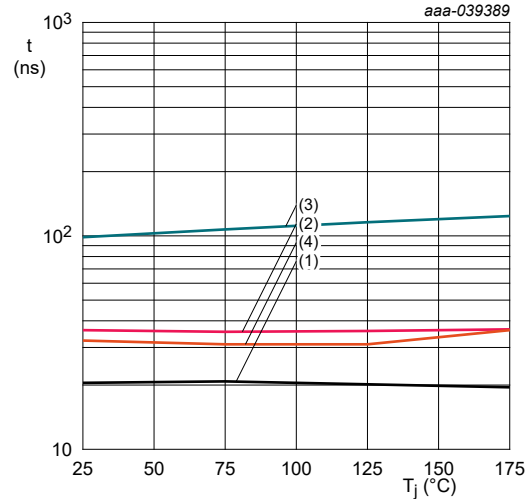
**Fig. 12.** Typical switching times as a function of collector current



$V_{GE} = 15 \text{ V to } 0 \text{ V}$ ;  $V_{CC} = 400 \text{ V}$ ;  $I_C = 50 \text{ A}$ ;  $T_j = 175^\circ\text{C}$

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

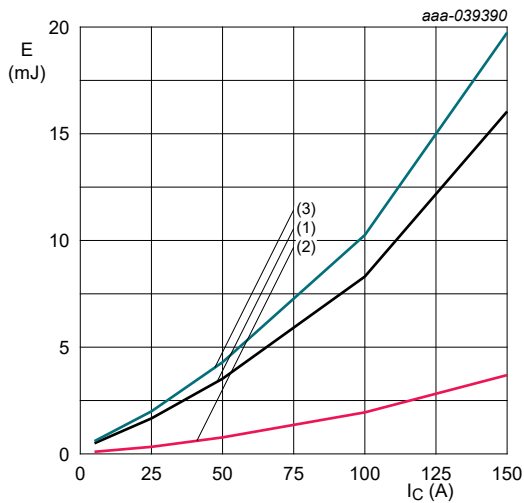
**Fig. 13. Typical switching times as a function of gate resistor**



$V_{GE} = 15 \text{ V to } 0 \text{ V}$ ;  $I_C = 50 \text{ A}$ ;  $V_{CC} = 400 \text{ V}$ ;  $r_{G(on)} = 10 \Omega$ ;  $r_{G(off)} = 10 \Omega$

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

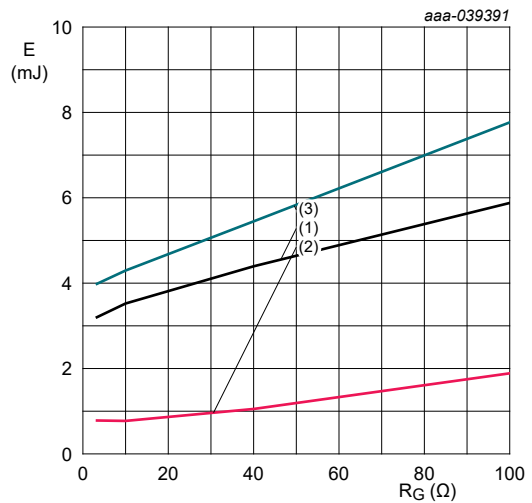
**Fig. 14. Typical switching times as a function of junction temperature**



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

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

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

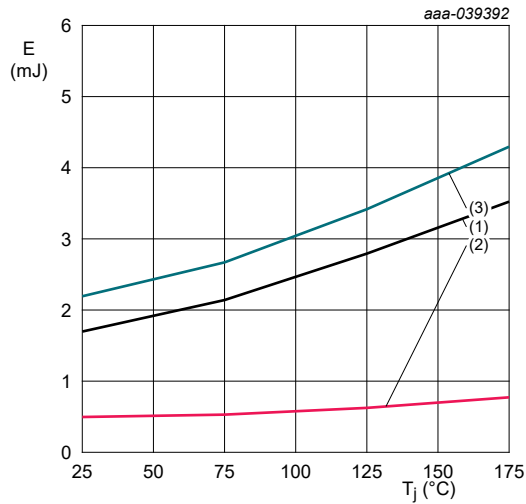


$V_{GE} = 15 \text{ V to } 0 \text{ V}$ ;  $V_{CC} = 400 \text{ V}$ ;  $I_C = 50 \text{ A}$ ;  $T_j = 175^\circ\text{C}$

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

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

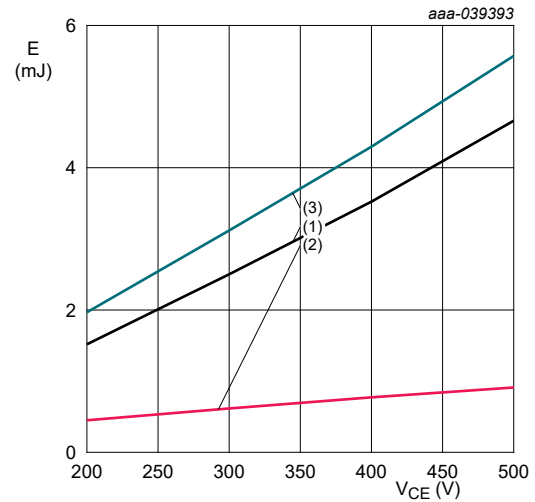




$V_{GE} = 15 \text{ V to } 0 \text{ V}$ ;  $I_C = 50 \text{ A}$ ;  $V_{CC} = 400 \text{ V}$ ;  $r_{G(on)} = 10 \text{ } \Omega$ ;  $r_{G(off)} = 10 \text{ } \Omega$

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

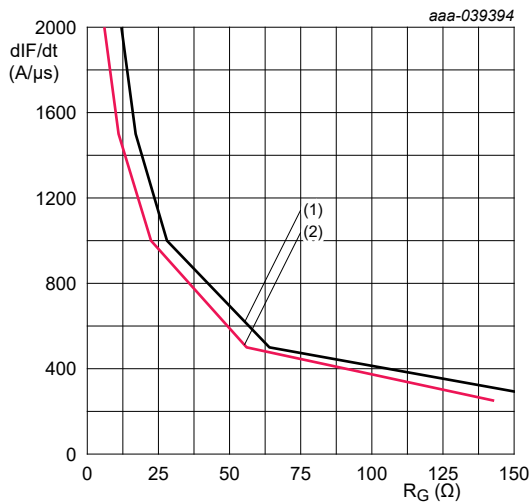
**Fig. 17. Typical switching energy losses as a function of junction temperature**



$V_{GE} = 15 \text{ V to } 0 \text{ V}$ ;  $I_C = 50 \text{ A}$ ;  $r_{G(on)} = 10 \text{ } \Omega$ ;  $r_{G(off)} = 10 \text{ } \Omega$ ;  $T_j = 175 \text{ } ^\circ\text{C}$

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

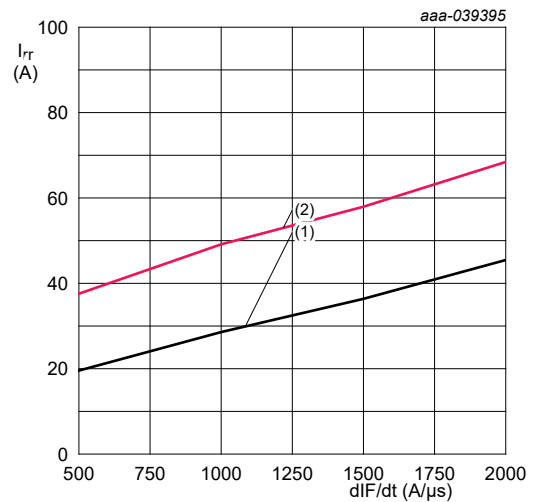
**Fig. 18. Typical switching energy losses as a function of collector-emitter voltage**



$V_R = 400 \text{ V}$ ;  $I_F = 50 \text{ A}$

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

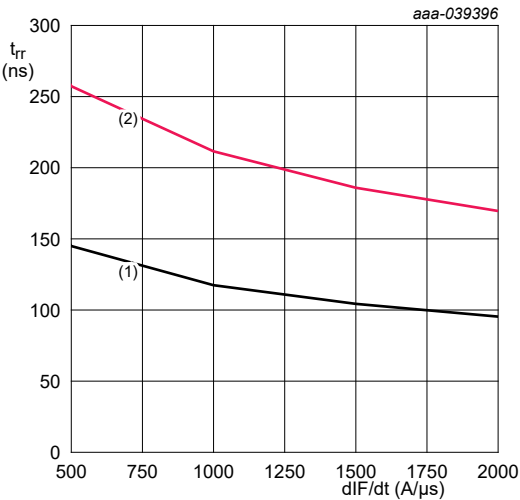
**Fig. 19. Typical rate of change of forward current as a function of gate resistance**



$V_R = 400 \text{ V}$ ;  $I_F = 50 \text{ A}$

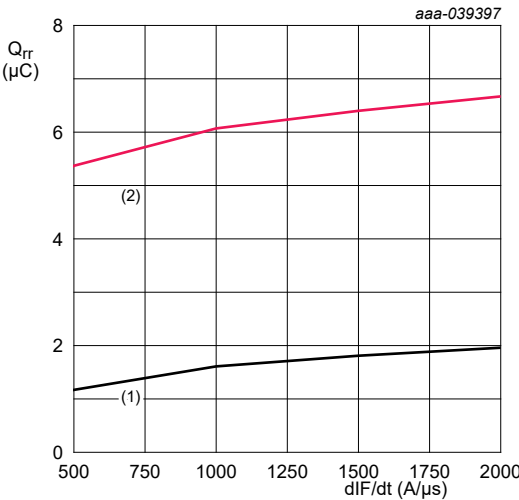
- (1)  $T_{amb} = 25 \text{ } ^\circ\text{C}$
- (2)  $T_{amb} = 175 \text{ } ^\circ\text{C}$

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



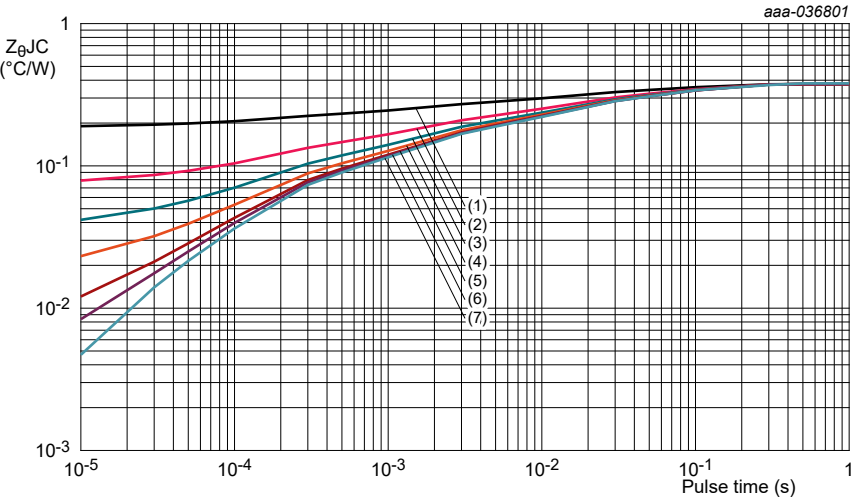
$V_R = 400\text{ V}$ ;  $I_F = 50\text{ A}$   
(1)  $T_{\text{amb}} = 25\text{ °C}$   
(2)  $T_{\text{amb}} = 175\text{ °C}$

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



$V_R = 400\text{ V}$ ;  $I_F = 50\text{ A}$   
(1)  $T_{\text{amb}} = 25\text{ °C}$   
(2)  $T_{\text{amb}} = 175\text{ °C}$

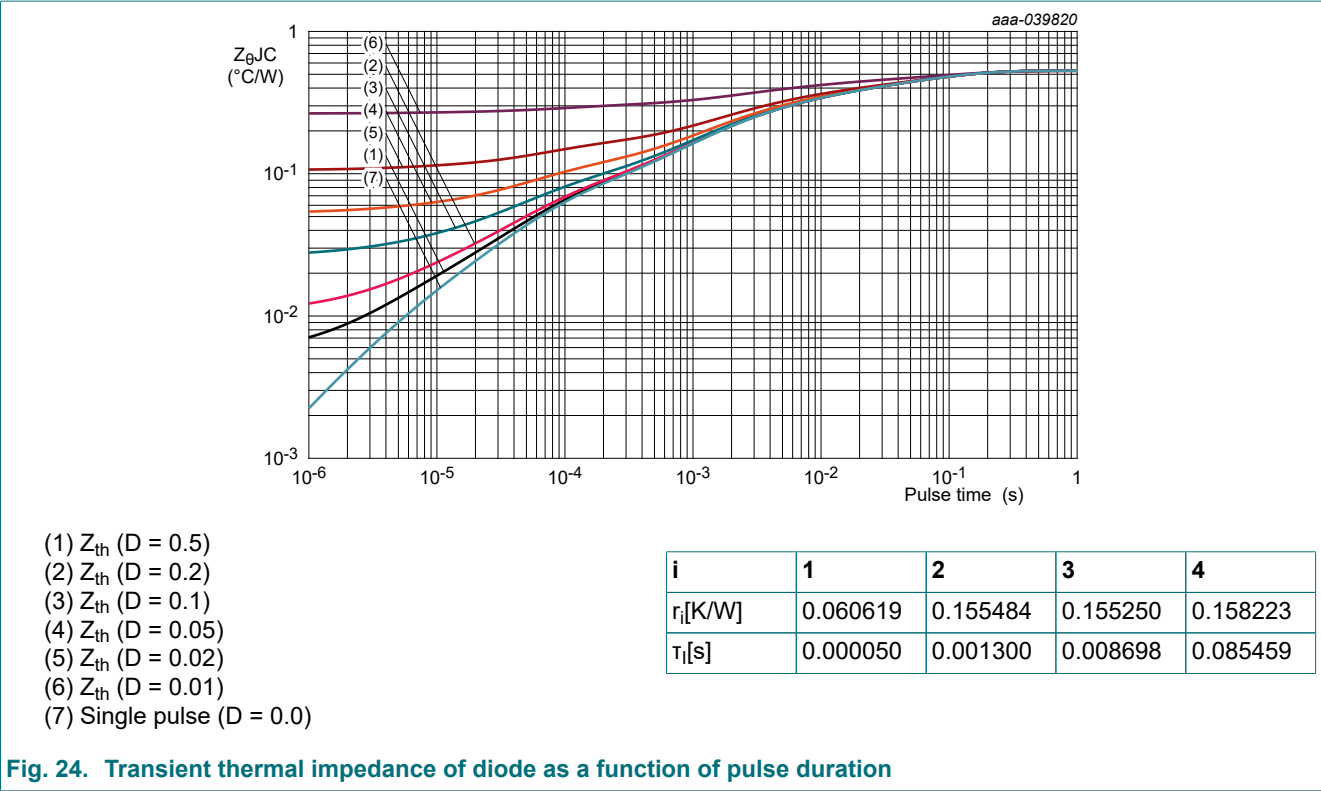
Fig. 22. Typical reverse recovery charge as a function of rate of change of forward current



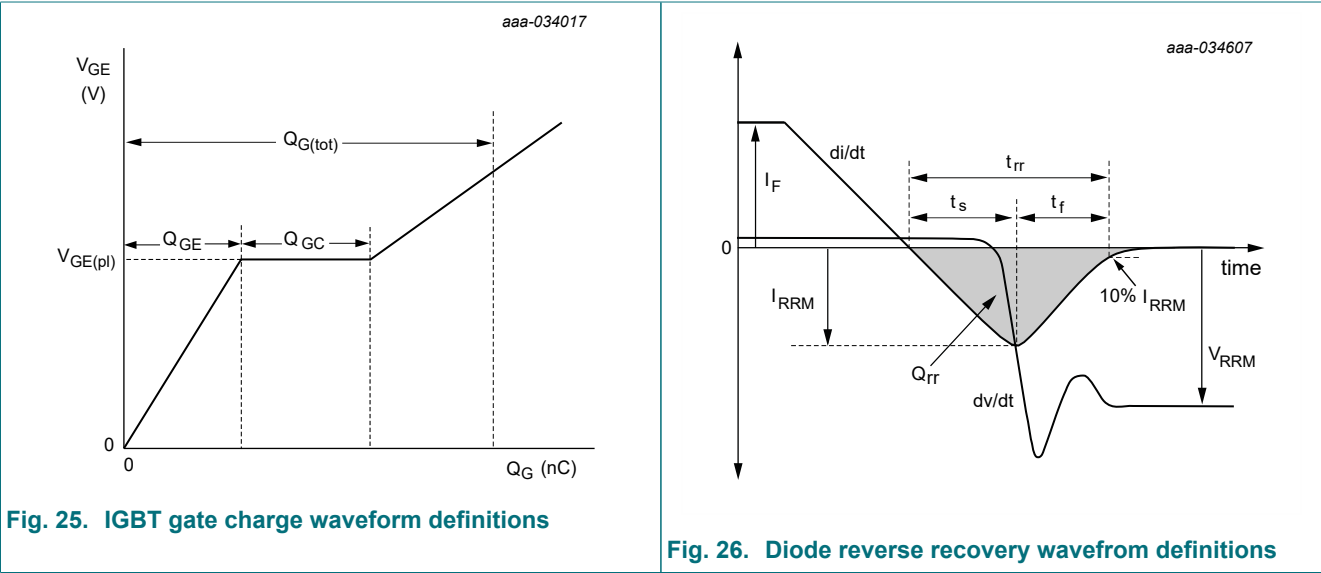
- (1)  $Z_{\text{th}}$  ( $D = 0.5$ )
- (2)  $Z_{\text{th}}$  ( $D = 0.2$ )
- (3)  $Z_{\text{th}}$  ( $D = 0.1$ )
- (4)  $Z_{\text{th}}$  ( $D = 0.05$ )
- (5)  $Z_{\text{th}}$  ( $D = 0.02$ )
- (6)  $Z_{\text{th}}$  ( $D = 0.01$ )
- (7) Single pulse ( $D = 0.0$ )

i	1	2	3	4
$r_i[\text{K/W}]$	0.055995	0.084465	0.107529	0.127726
$\tau_i[\text{s}]$	0.000141	0.001220	0.010526	0.080745

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



9.2. Waveforms



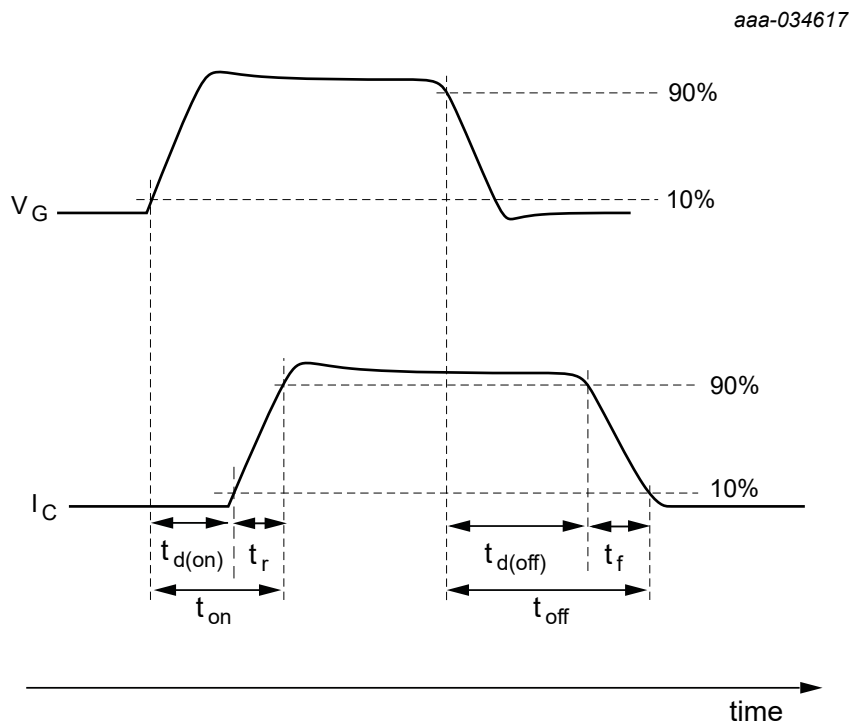
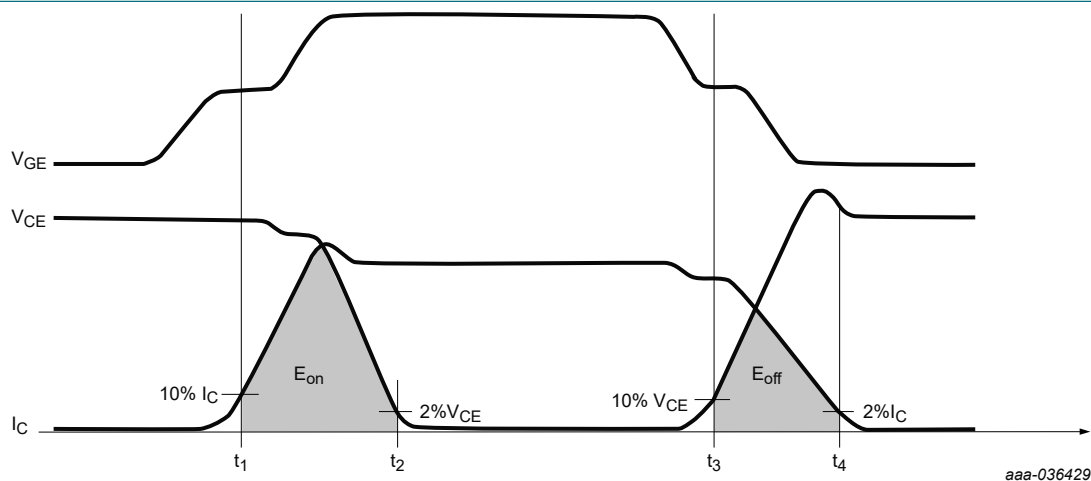


Fig. 27. IGBT switching times definitions



Where

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

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

Fig. 28. IGBT switching loss definitions

10. Package outline

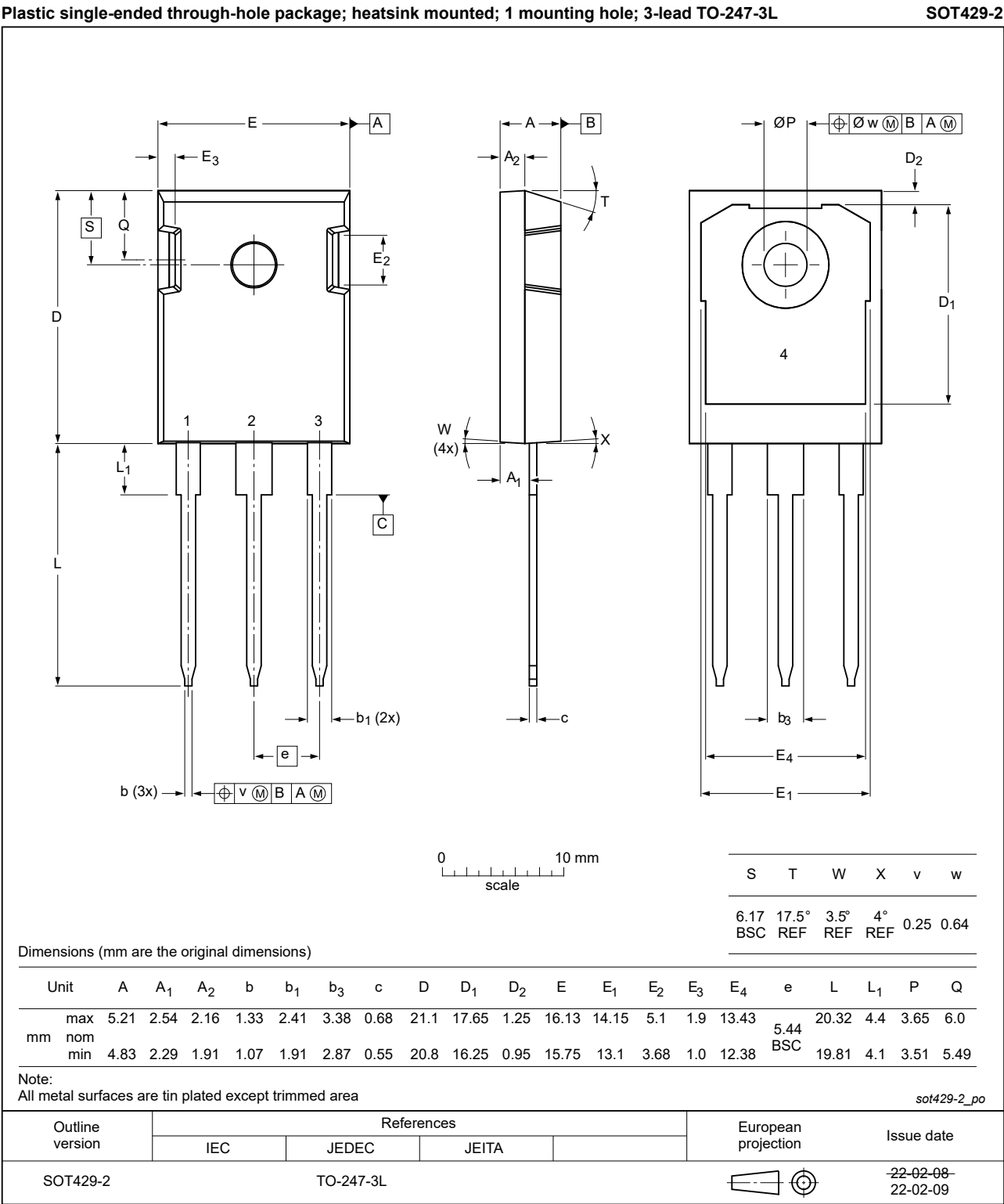


Fig. 29. Package outline TO-247-3L (SOT429-2)

11. Revision history

Table 8. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
NGW50T65H3DFP 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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