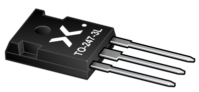


NGW40T65M3DFP

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 µs. 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 µs short circuit withstand time
- RoHS compliant, lead-free plating

3. Applications

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

4. Quick reference data

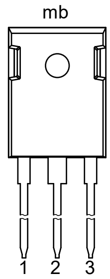
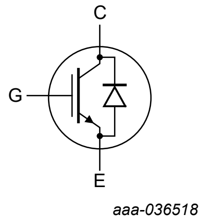
Table 1. Quick reference data

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

nexperia

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
NGW40T65M3DFP	TO-247-3L	Plastic single-ended through-hole package; heatsink mounted; 1 mounting hole; 3-lead TO-247-3L	SOT429-2

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_{CE}	collector-emitter voltage	T_j = 25 °C	-	650	V
I_C	collector current	T_{case} = 25 °C [1]	-	72	A
		T_{case} = 100 °C [1]	-	48	A
I_{Cpuls}	peak pulse collector current [2]		-	120	A
t_{sc}	short circuit withstand time	V_{GE} = 15 V; V_{CC} = 400 V; T_j ≤ 150 °C	-	5.0	µs
V_{GS}	gate-source voltage		-20	+20	V
P_{tot}	total power dissipation	T_{case} = 25 °C	-	283	W
		T_{case} = 100 °C	-	142	W
T_j	operating junction temperature		-40	+175	°C
T_{stg}	storage temperature		-55	+150	°C
T_{solder}	soldering temperature		-	260	°C
M	mounting torque, M3 screw		-	0.6	Nm
Diode					
I_F	diode forward current	T_{case} = 25 °C [1]	-	80	A
		T_{case} = 100 °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 °C, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Static characteristics						
$V_{(BR)CE}$	collector-emitter breakdown voltage	V_{GE} = 0 V; I_C = 0.2 mA	650	-	-	V
V_{CEsat}	collector-emitter saturation voltage	V_{GE} = 15 V; I_C = 40 A; T_j = 25 °C	-	1.5	1.9	V
		V_{GE} = 15 V; I_C = 40 A; T_j = 175 °C	-	1.9	-	V
V_F	diode forward voltage	V_{GE} = 0 V; I_F = 40 A; T_j = 25 °C	-	1.62	2.1	V
		V_{GE} = 0 V; I_F = 40 A; T_j = 175 °C	-	1.33	-	V
$V_{GE(th)}$	gate-emitter threshold voltage	I_C = 0.4 mA; V_{CE} = V_{GE}; T_j = 25 °C	4.3	5	5.7	V
I_{CES}	zero gate voltage collector current	V_{CE} = 650 V; V_{GE} = 0 V; T_j = 25 °C	-	10	-	nA
		V_{CE} = 650 V; V_{GE} = 0 V; T_j = 175 °C	-	0.5	-	mA
I_{GES}	gate-emitter leakage current	V_{CE} = 0 V; V_{GE} = 20 V	-	-	100	nA
g_{fs}	transconductance	V_{CE} = 20 V; I_C = 40 A; T_j = 25 °C	-	20	-	S
r_G	integrated gate resistor		-	1.3	-	Ω
Dynamic characteristics						
C_{ies}	input capacitance	V_{CE} = 25 V; V_{GE} = 0 V; f = 1 MHz	-	2040	-	pF
C_{oes}	output capacitance		-	136	-	pF
C_{res}	reverse transfer capacitance		-	31	-	pF
Q_G	gate charge	V_{CC} = 520 V; V_{GE} = 15 V; I_C = 40 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 V; V_{CC} = 400 V; t_{sc} ≤ 5 µs; T_j ≤ 150 ° C	-	130	-	A

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
IGBT switching characteristics, inductive load							
$t_{d(on)}$	turn-on delay time	V_{GE} = 15/0 V; V_{CC} = 400 V; I_C = 40 A; $r_{G(on)}$ = 10 Ω; $r_{G(off)}$ = 10 Ω; see Fig. 27 and Fig. 28	T_j = 25 °C	-	22	-	ns
			T_j = 175 °C	-	20	-	ns
t_r	rise time		T_j = 25 °C	-	22	-	ns
			T_j = 175 °C	-	23	-	ns
$t_{d(off)}$	turn-off delay time		T_j = 25 °C	-	185	-	ns
			T_j = 175 °C	-	220	-	ns
t_f	fall time		T_j = 25 °C	-	13	-	ns
			T_j = 175 °C	-	50	-	ns
E_{on}	turn-on switching loss		T_j = 25 °C	-	1.05	-	mJ
			T_j = 175 °C	-	2.15	-	mJ
E_{off}	turn-off switching loss		T_j = 25 °C	-	0.52	-	mJ
			T_j = 175 °C	-	0.9	-	mJ
E_{ts}	total switching loss		T_j = 25 °C	-	1.57	-	mJ
			T_j = 175 °C	-	3.05	-	mJ
Diode switching characteristics, inductive load							
t_{rr}	diode reverse recovery time	V_R = 400 V; I_F = 40 A; $\Delta I_F/\Delta t$ = 1000 A/µs; see Fig. 26	T_j = 25 °C	-	55	-	ns
			T_j = 175 °C	-	215	-	ns
Q_{rr}	diode reverse recovery charge		T_j = 25 °C	-	700	-	nC
			T_j = 175 °C	-	3830	-	nC
I_{rrm}	diode peak reverse recovery current		T_j = 25 °C	-	22	-	A
			T_j = 175 °C	-	37	-	A
E_{rr}	reverse recovery energy		T_j = 25 °C	-	0.12	-	mJ
			T_j = 175 °C	-	0.36	-	mJ
di_{rr}/dt	diode peak rate or fall of reverse recovery current		T_j = 25 °C	-	650	-	A/µs
			T_j = 175 °C	-	760	-	A/µs

9.1. Waveforms and output characteristics

Table 7. Waveforms and output characteristics

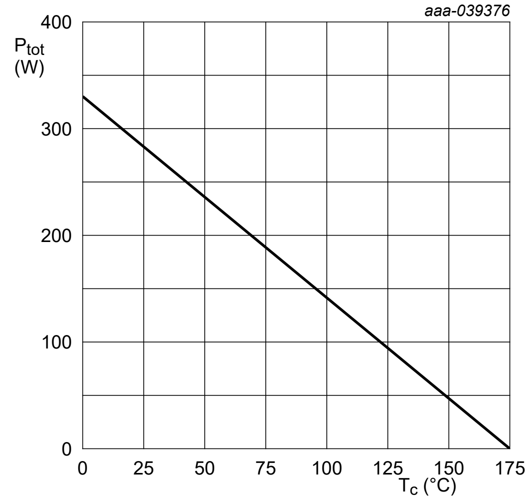


Fig. 1. Power dissipation (P_{tot}) as a function of case tempearture

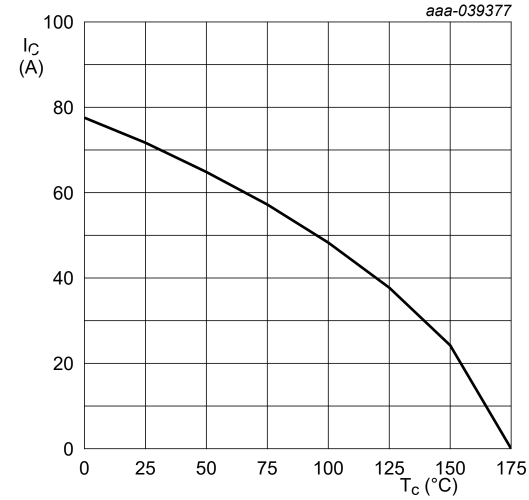
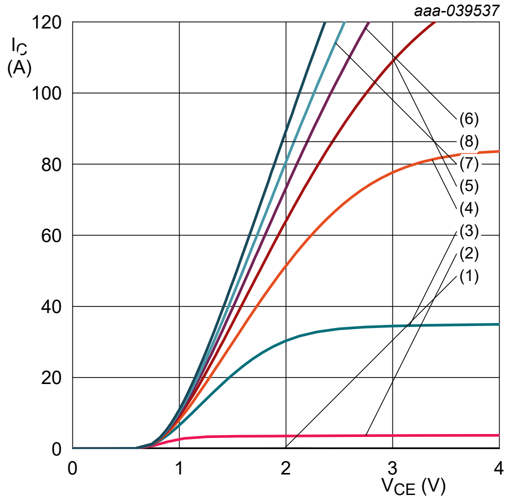


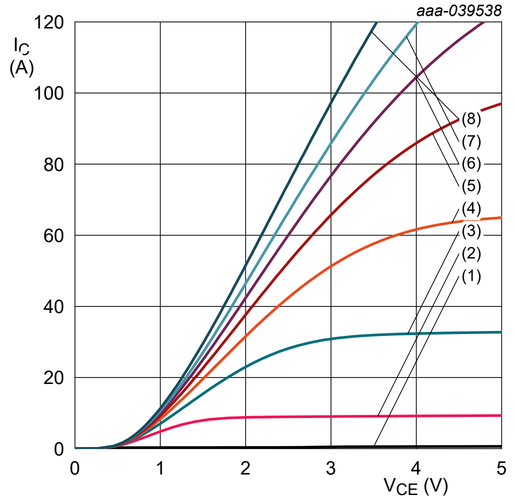
Fig. 2. Collector current (I_C) as a function of case tempearture



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

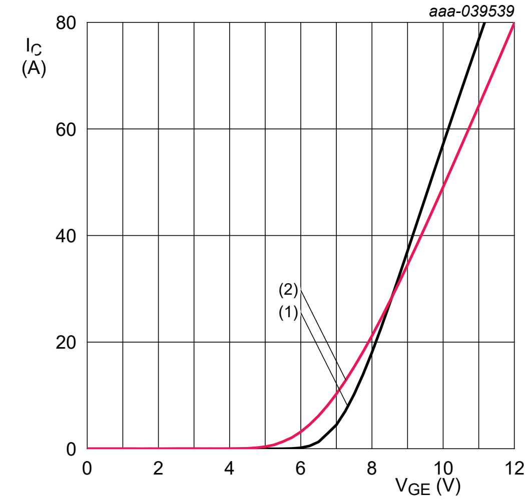
Fig. 3. Collector current as a function of collector-emitter voltage; typical values



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

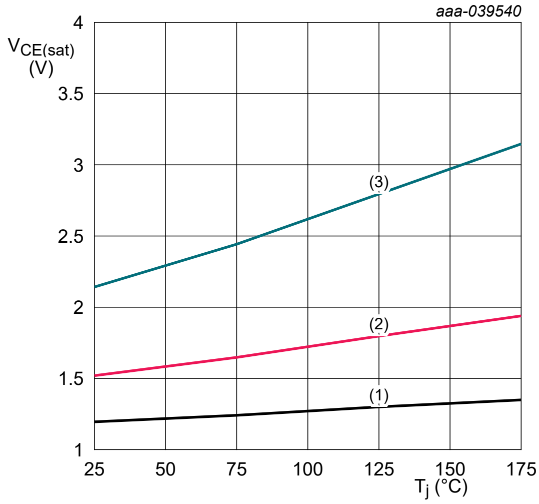


V_{CE} = 20 V

(1) T_j = 25 °C

(2) T_j = 175 °C

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



V_{GE} = 15 V

(1) I_C = 20 A

(2) I_C = 40 A

(3) I_C = 80 A

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

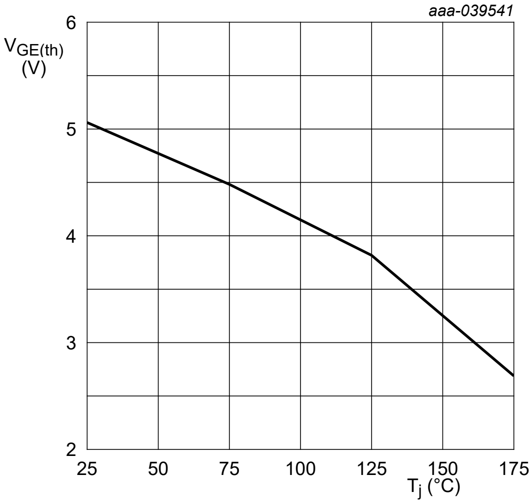
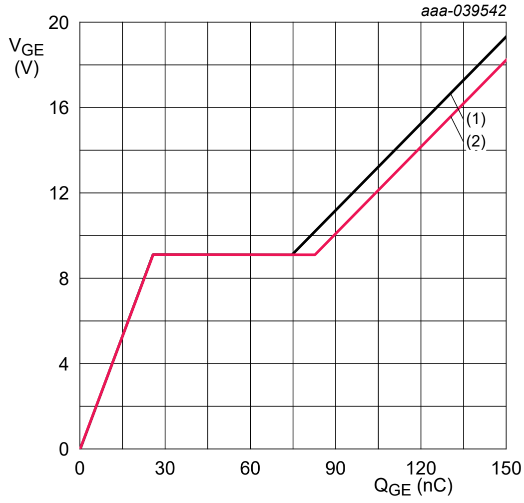


Fig. 7. Gate-emitter threshold voltage as a function of junction temperature

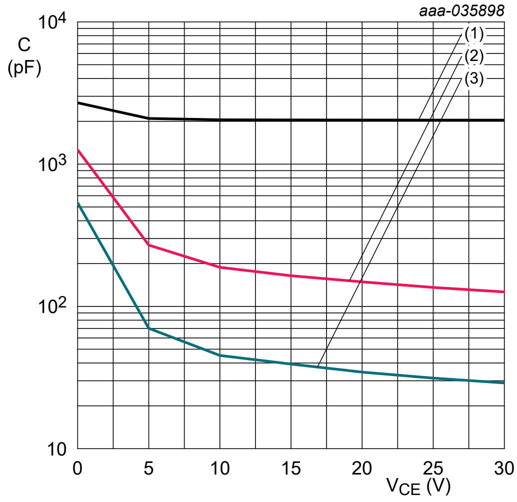


I_C = 40 A

(1) V_{CE} = 130 V

(1) V_{CE} = 520 V

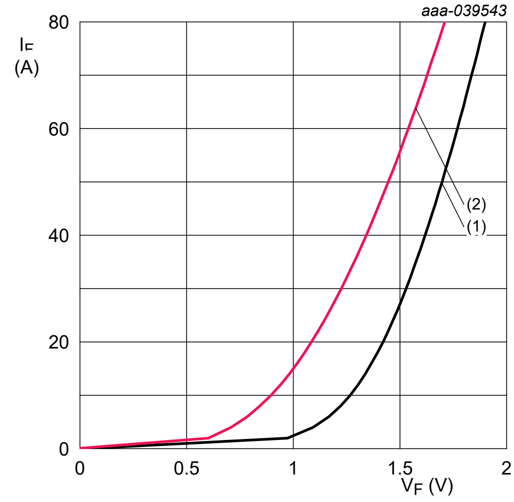
Fig. 8. Gate-emitter voltage as a function of gate charge



V_{GE} = 0 V, f = 1 MHz

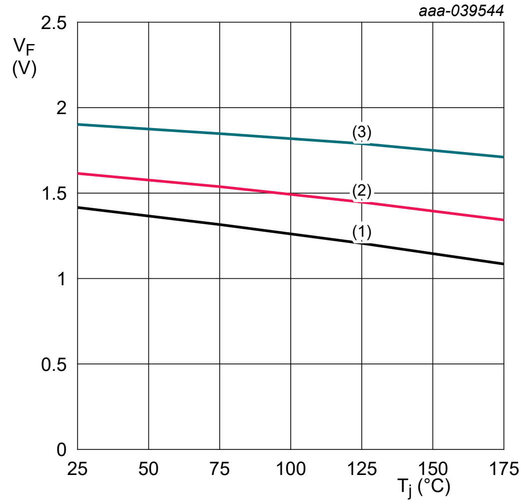
(1) C_{ies}
(2) C_{oes}
(3) C_{res}

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



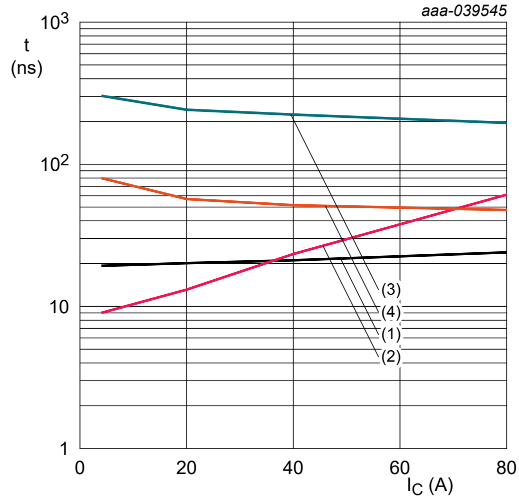
(1) T_{amb} = 25 °C
(2) T_{amb} = 175 °C

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



(1) I_F = 20 A
(2) I_F = 40 A
(3) I_F = 80 A

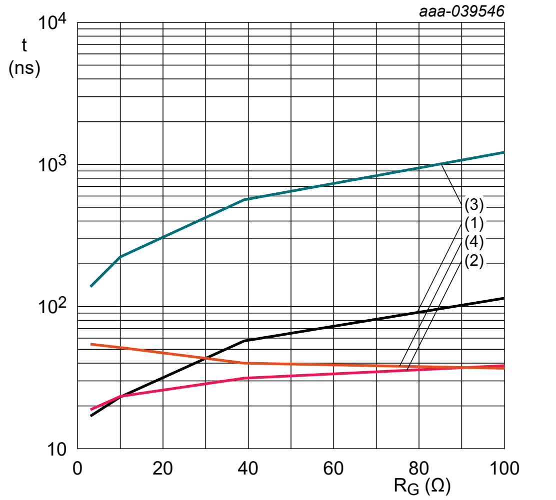
Fig. 11. Typical diode forward voltage as a function of junction temperature



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

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

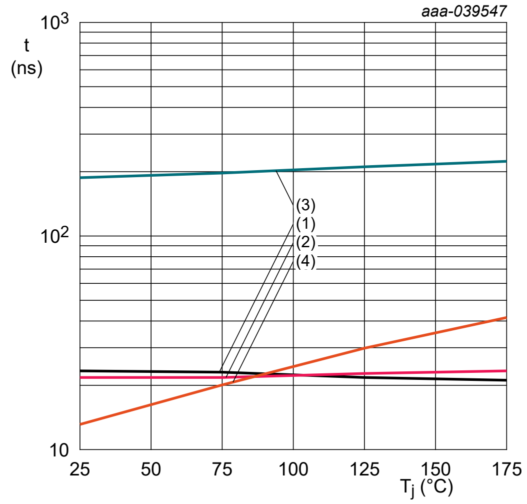
Fig. 12. Typical switching times as a function of collector current



V_{GE} = 15 V to 0 V; V_{CC} = 400 V; I_C = 40 A;
T_j = 175 °C

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

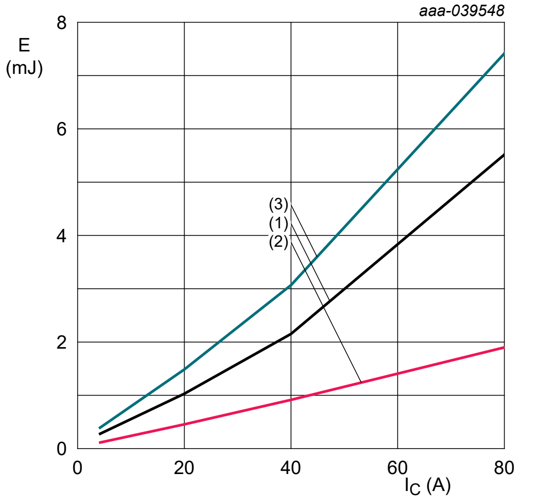
Fig. 13. Typical switching times as a function of gate resistor



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

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

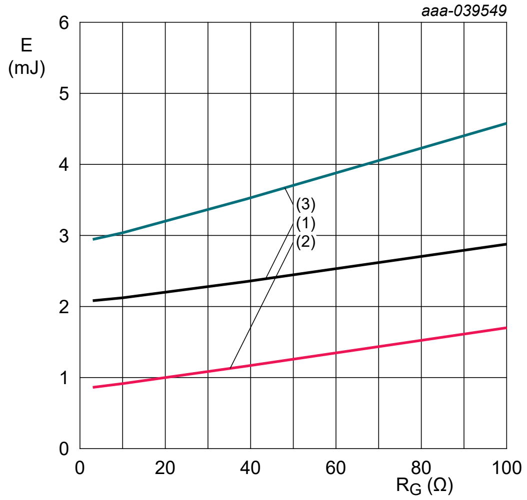
Fig. 14. Typical switching times as a function of junction temperature



V_{GE} = 15 V to 0 V; V_{CC} = 400 V; $r_{G(on)}$ = 10 Ω;
$r_{G(off)}$= 10 Ω; T_j = 175 °C

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

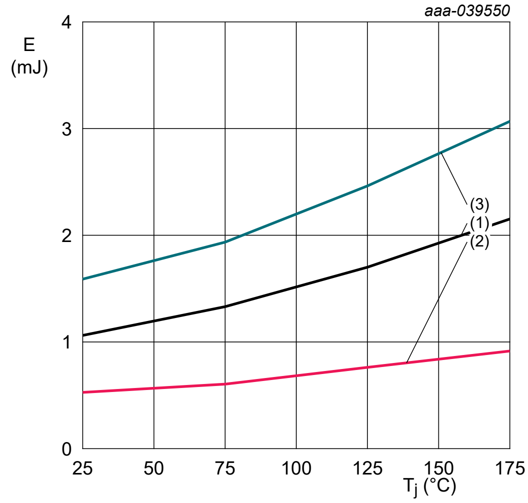
Fig. 15. Typical switching energy losses as a function of collecor current



V_{GE} = 15 V to 0 V; V_{CC} = 400 V; I_C = 40 A;
T_j = 175 °C

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

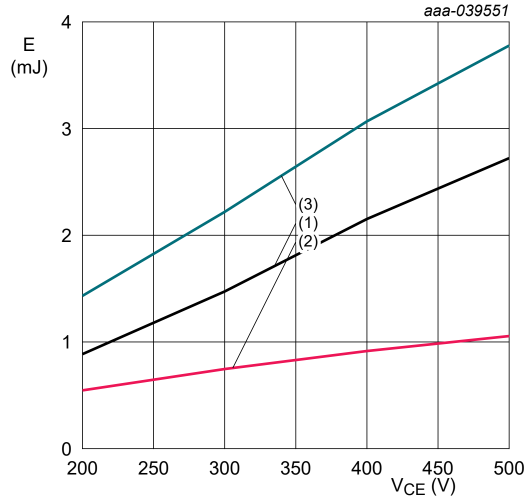
Fig. 16. Typical switching energy losses as a function of gate resistance



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

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

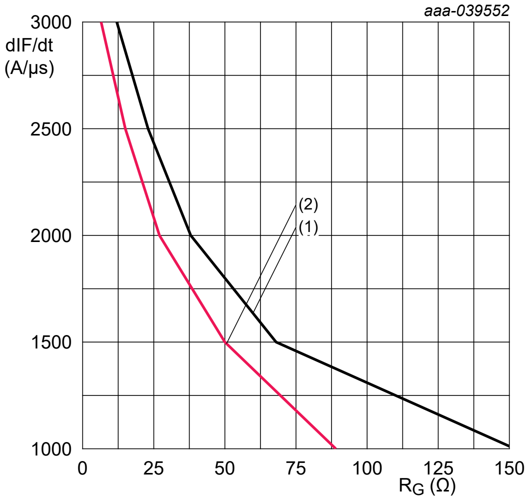
Fig. 17. Typical switching energy losses as a function of junction temperature



V_{GE} = 15 V to 0 V; I_C = 40 A; $r_{G(on)}$ = 10 Ω;
$r_{G(off)}$ = 10 Ω; T_j = 175 °C

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

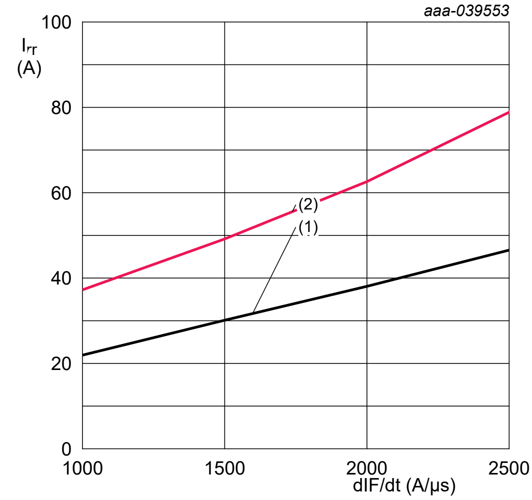
Fig. 18. Typical switching energy losses as a function of collector-emitter voltage



V_R = 400 V; I_F = 40 A

(1) T_{amb} = 25 °C
(2) T_{amb} = 175 °C

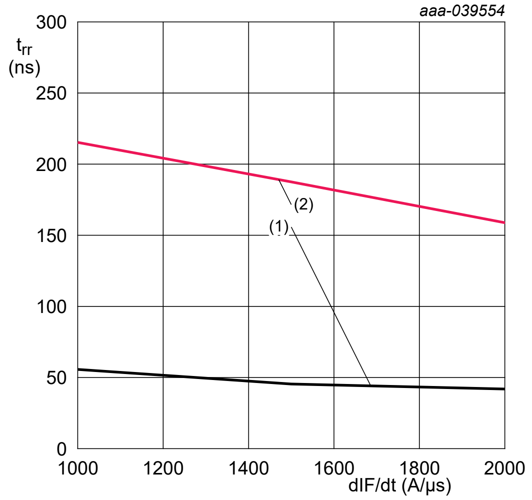
Fig. 19. Typical reverse recovery current as a function of change of gate resistance



V_R = 400 V; I_F = 40 A

(1) T_{amb} = 25 °C
(2) T_{amb} = 175 °C

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

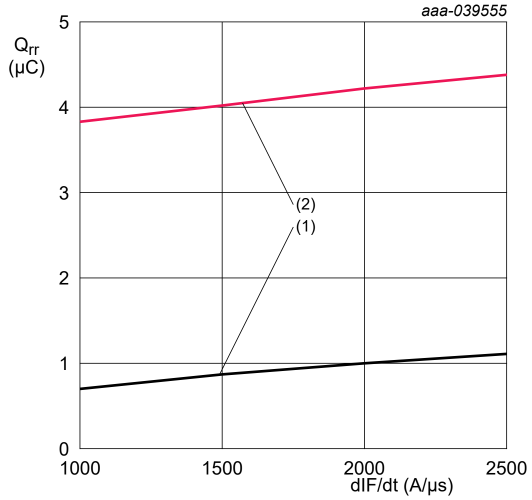


V_R = 400 V; I_F = 40 A

(1) T_{amb} = 25 °C

(2) T_{amb} = 175 °C

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

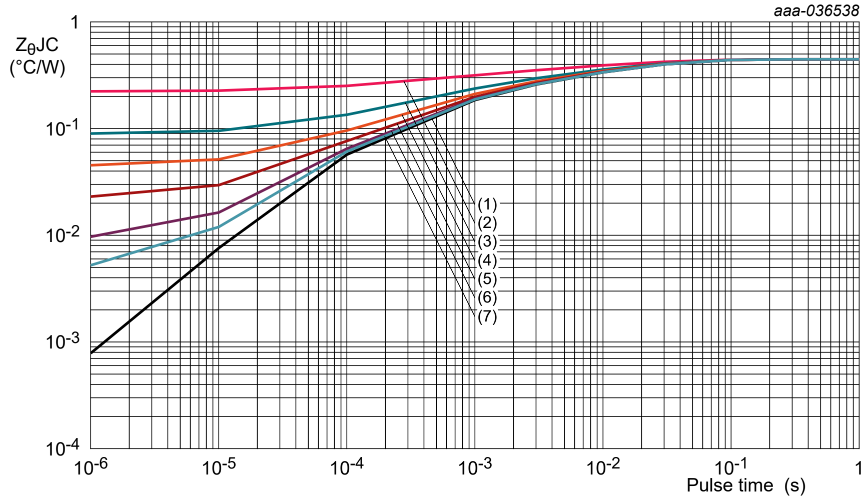


V_R = 400 V; I_F = 40 A

(1) T_{amb} = 25 °C

(2) T_{amb} = 175 °C

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



(1) Z_{th} (D = 0.5)

(2) Z_{th} (D = 0.2)

(3) Z_{th} (D = 0.1)

(4) Z_{th} (D = 0.05)

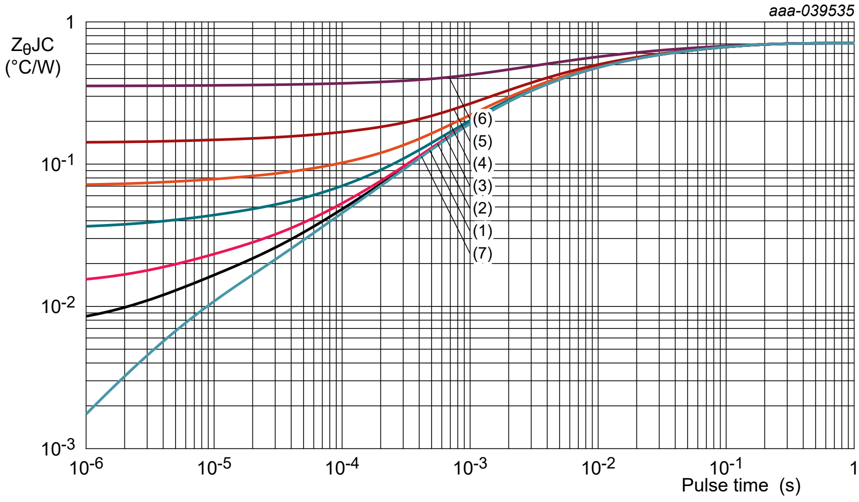
(5) Z_{th} (D = 0.02)

(6) Z_{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
$τ_i$ [s]	0.000113	0.000681	0.005543	0.036756

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



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

i	1	2	3	4
r_i[K/W]	0.028245	0.223376	0.285136	0.171364
τ_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

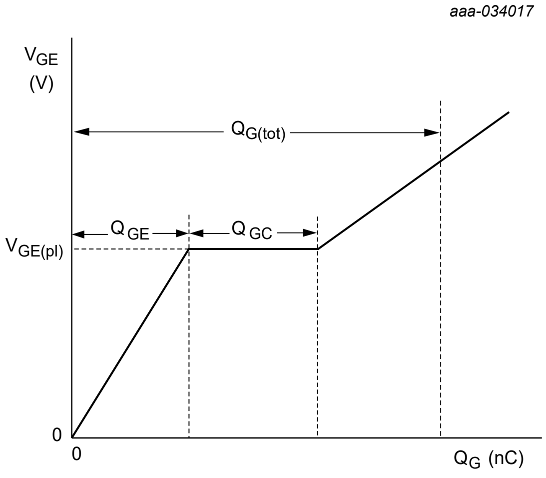


Fig. 25. IGBT gate charge waveform definitions

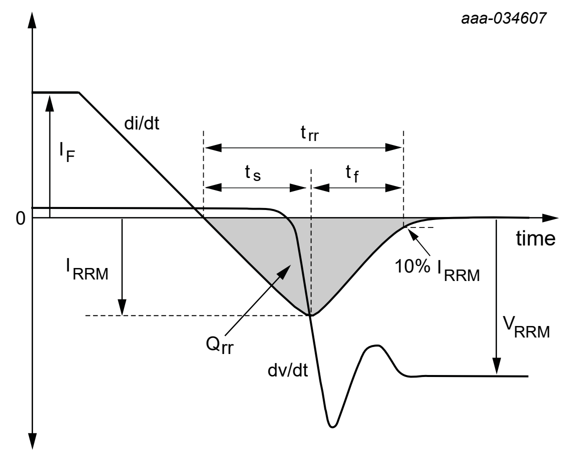


Fig. 26. Diode reverse recovery waveform definitions

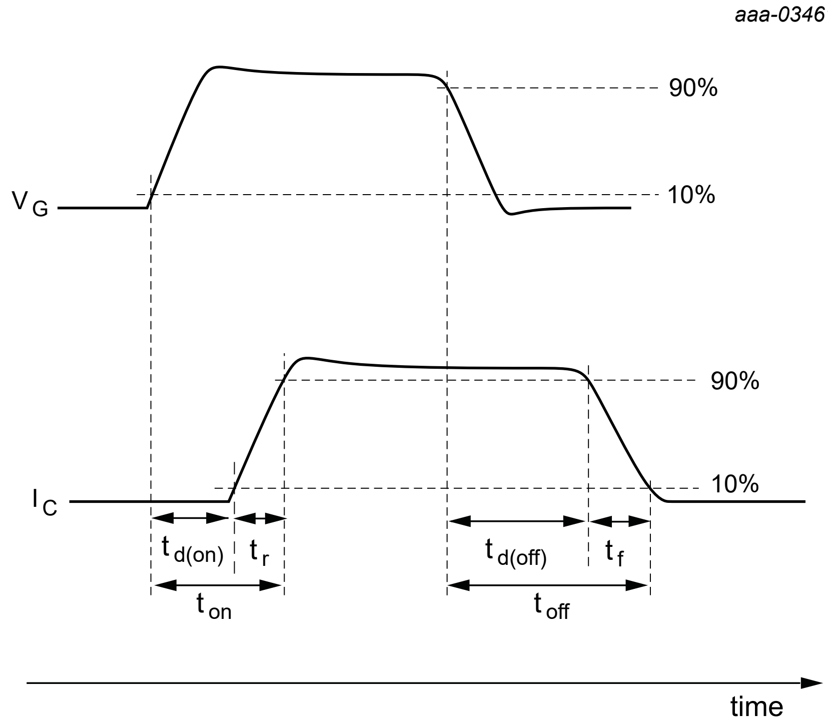
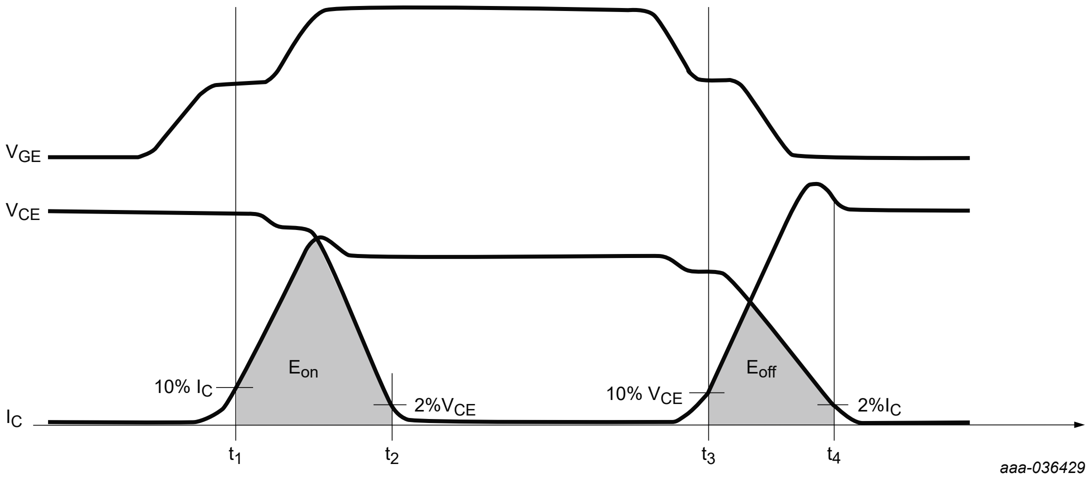


Fig. 27. IGBT switching times definitions



Where

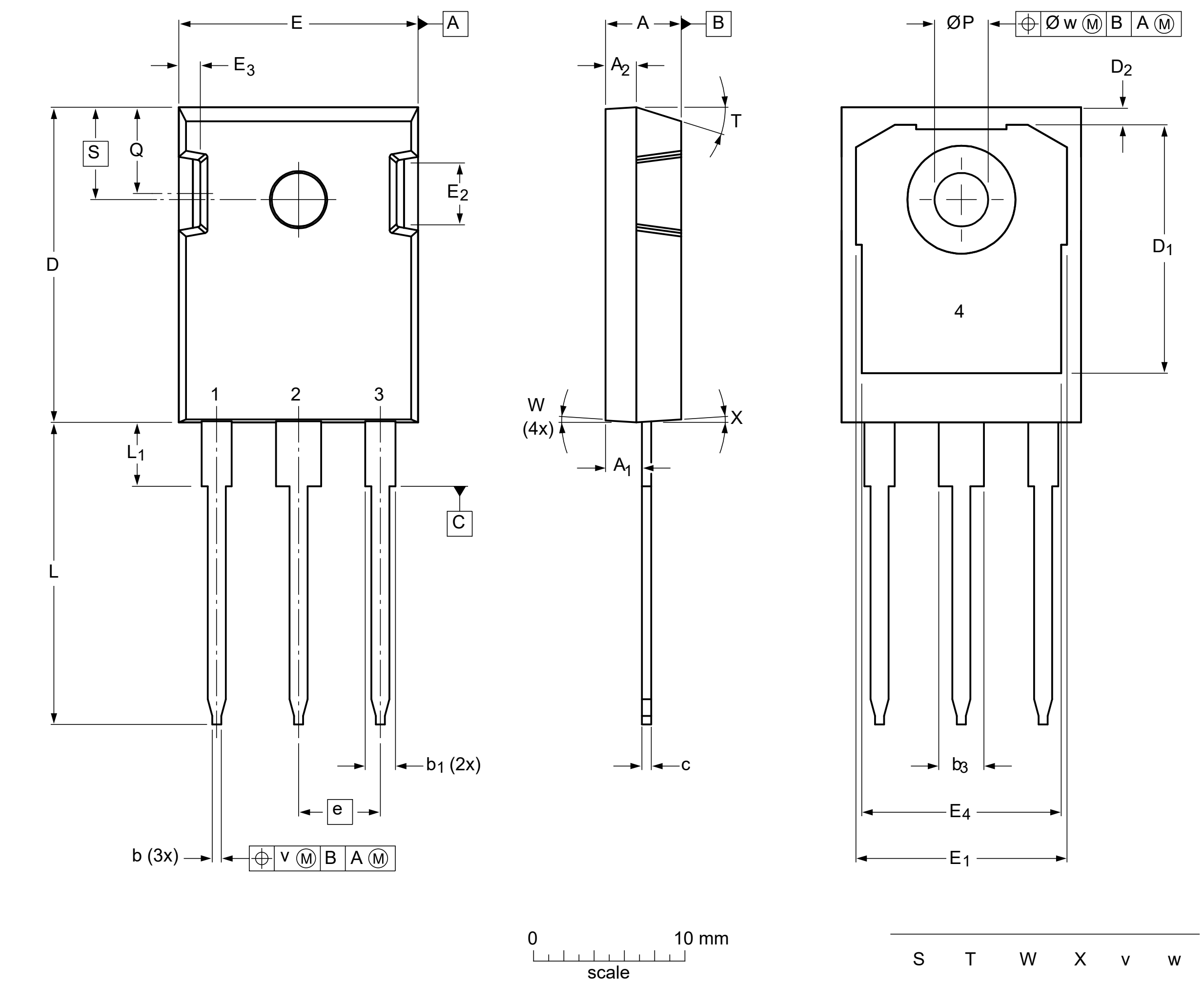
$$E_{on} = \int_{t_1}^{t_2} V_{CE} \, I_C \, dt$$

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

Fig. 28. IGBT switching loss definitions

10. Package outline

Plastic single-ended through-hole package; heatsink mounted; 1 mounting hole; 3-lead TO-247-3L **SOT429-2**



S	T	W	X	v	w
6.17 BSC	17.5° REF	3.5° REF	4° REF	0.25	0.64

Dimensions (mm are the original dimensions)

Unit		A	A_1	A_2	b	b_1	b_3	c	D	D_1	D_2	E	E_1	E_2	E_3	E_4	e	L	L_1	P	Q
mm	max	5.21	2.54	2.16	1.33	2.41	3.38	0.68	21.1	17.65	1.25	16.13	14.15	5.1	1.9	13.43	5.44 BSC	20.32	4.4	3.65	6.0
	nom																				
	min	4.83	2.29	1.91	1.07	1.91	2.87	0.55	20.8	16.25	0.95	15.75	13.1	3.68	1.0	12.38		19.81	4.1	3.51	5.49

Note:
All metal surfaces are tin plated except trimmed area

sot429-2_po

Outline version	References: IEC	References: JEDEC	References: JEITA		European projection	Issue date
SOT429-2		TO-247-3L				~~22-02-08~~ 22-02-09

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".
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