



# GAN190-650FBE

650 V, 190 mOhm Gallium Nitride (GaN) FET in a DFN  
5 mm x 6 mm package

19 April 2023

Product data sheet

## 1. General description

The GAN190-650FBE is a general purpose 650 V, 190 m $\Omega$  Gallium Nitride (GaN) FET in a DFN 5 mm x 6 mm surface mount package. It is a normally-off e-mode device offering superior performance.

## 2. Features and benefits

- Enhancement mode - normally-off power switch
- Ultra high frequency switching capability
- No body diode
- Low gate charge, low output charge
- Qualified for standard applications
- ESD protection
- RoHS, Pb-free, REACH-compliant
- High efficiency and high power density
- Low package inductance and low package resistance

## 3. Applications

- High power density and high efficiency power conversion
- AC-to-DC converters, totem pole PFC
- DC-to-DC converters
- Fast battery charging, mobile phone, laptop, tablet and USB type-C chargers
- Datacom and telecom (AC-to-DC and DC-to-DC) converters
- Motor drives
- Solar (PV) inverters
- Class D audio amplifiers, TV PSU and LED drivers

## 4. Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{DS}$	drain-source voltage	$-55\text{ }^{\circ}\text{C} \leq T_j \leq 150\text{ }^{\circ}\text{C}$	-	-	650	V
$V_{TDS}$	transient drain to source voltage	pulsed; $t_p = 1\text{ }\mu\text{s}$ ; $\delta_{factor} = 0.01$	-	-	800	V
$I_D$	drain current	$V_{GS} = 6\text{ V}$ ; $T_{mb} = 25\text{ }^{\circ}\text{C}$	[1]	-	11.5	A
$P_{tot}$	total power dissipation	$T_{mb} = 25\text{ }^{\circ}\text{C}$ ; <a href="#">Fig. 1</a>	-	-	125	W
$T_j$	junction temperature		-55	-	150	$^{\circ}\text{C}$
<b>Static characteristics</b>						
$R_{DSon}$	drain-source on-state resistance	$V_{GS} = 6\text{ V}$ ; $I_D = 3.9\text{ A}$ ; $T_j = 25\text{ }^{\circ}\text{C}$ ; <a href="#">Fig. 11</a> ; <a href="#">Fig. 12</a> ; <a href="#">Fig. 13</a>	-	138	190	m $\Omega$
		$V_{GS} = 6\text{ V}$ ; $I_D = 3.9\text{ A}$ ; $T_j = 150\text{ }^{\circ}\text{C}$ ; <a href="#">Fig. 11</a> ; <a href="#">Fig. 14</a>	-	300	-	m $\Omega$

650 V, 190 mOhm Gallium Nitride (GaN) FET in a DFN 5 mm x 6 mm package

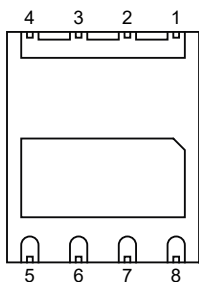
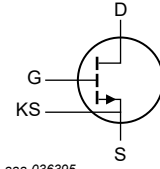
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
R <sub>G</sub>	gate resistance	f = 5 MHz; T <sub>j</sub> = 25 °C; open drain	-	5	-	Ω
<b>Dynamic characteristics</b>						
Q <sub>GD</sub>	gate-drain charge	I <sub>D</sub> = 3.9 A; V <sub>DS</sub> = 400 V; V <sub>GS</sub> = 6 V; T <sub>j</sub> = 25 °C; <a href="#">Fig. 15</a> ; <a href="#">Fig. 16</a>	-	1.1	-	nC
Q <sub>G(tot)</sub>	total gate charge		-	2.8	-	nC
Q <sub>oss</sub>	output charge	V <sub>GS</sub> = 0 V; V <sub>DS</sub> = 400 V; T <sub>j</sub> = 25 °C	[2]	24.5	-	nC

[1] Limited by device saturation

[2] Q<sub>r</sub> is not specified separately from Q<sub>oss</sub> for e-mode GaN FETs, since Q<sub>r</sub> = Q<sub>oss</sub> + Q<sub>D</sub>, and Q<sub>D</sub> = 0. (Q<sub>D</sub> is charge associated with diffusion of minority carriers. Since there is no body diode, no minority carriers in excess of Q<sub>oss</sub> have to be transferred for e-mode GaN FETs.)

## 5. Pinning information

Table 2. Pinning information

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	D	drain	 <p>Transparent top view DFN5060-5 (SOT8075-1)</p>	 <p>aaa-036395</p>
2	D	drain		
3	D	drain		
4	D	drain		
5	S	source		
6	S	source		
7	KS	kelvin source		
8	G	gate		
mb	S	mounting base; connected to source		

## 6. Ordering information

Table 3. Ordering information

Type number	Package		Version
	Name	Description	
GAN190-650FBE	DFN5060-5	plastic thermal enhanced small outline package; no leads; 5 terminals; body: 5 × 6 × 0.9 mm	SOT8075-1

## 7. Marking

Table 4. Marking codes

Type number	Marking code
GAN190-650FBE	190IFBE

## 8. Limiting values

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). T<sub>j</sub> = 25 °C unless otherwise stated.

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>DS</sub>	drain-source voltage	-55 °C ≤ T <sub>j</sub> ≤ 150 °C	-	650	V

650 V, 190 mOhm Gallium Nitride (GaN) FET in a DFN 5 mm x 6 mm package

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>TDS</sub>	transient drain to source voltage	pulsed; t <sub>p</sub> = 1 μs; δ <sub>factor</sub> = 0.01	-	800	V
V <sub>GS</sub>	gate-source voltage		-1.4	7	V
P <sub>tot</sub>	total power dissipation	T <sub>mb</sub> = 25 °C; Fig. 1	-	125	W
I <sub>D</sub>	drain current	V <sub>GS</sub> = 6 V; T <sub>mb</sub> = 25 °C	[1]	11.5	A
I <sub>DM</sub>	peak drain current	pulsed; t <sub>p</sub> ≤ 10 μs; T <sub>mb</sub> = 25 °C; Fig. 2	[1]	20.5	A
T <sub>stg</sub>	storage temperature		-55	150	°C
T <sub>j</sub>	junction temperature		-55	150	°C
T <sub>slid(M)</sub>	peak soldering temperature		-	260	°C

[1] Limited by device saturation

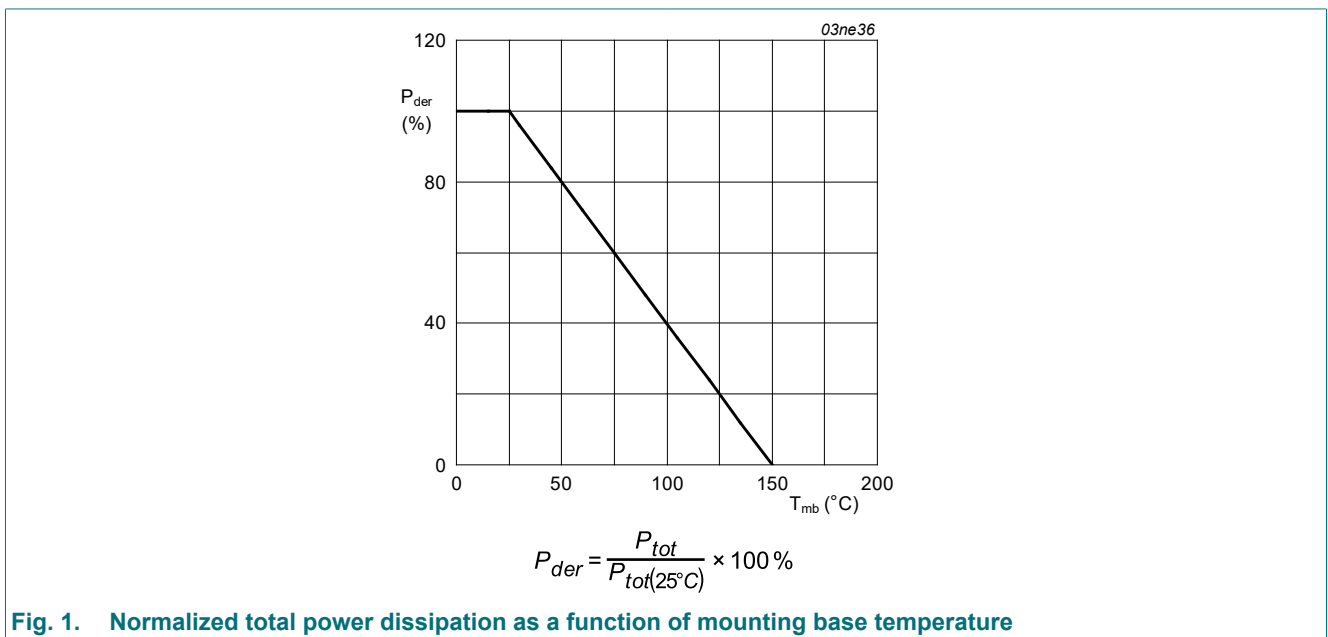


Fig. 1. Normalized total power dissipation as a function of mounting base temperature

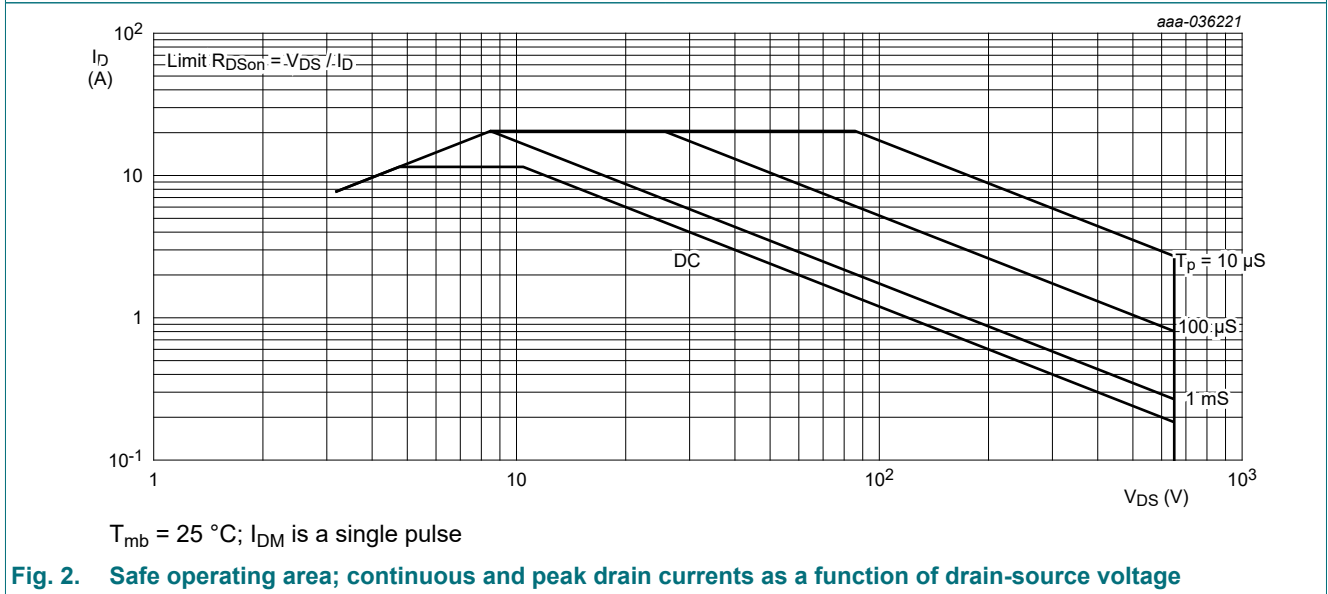


Fig. 2. Safe operating area; continuous and peak drain currents as a function of drain-source voltage

## 9. Thermal characteristics

Table 6. Thermal characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$R_{th(j-c)}$	thermal resistance from junction to case	<a href="#">Fig. 3</a>	-	-	1	K/W
$R_{th(j-a)}$	thermal resistance from junction to ambient		-	-	35.9	K/W

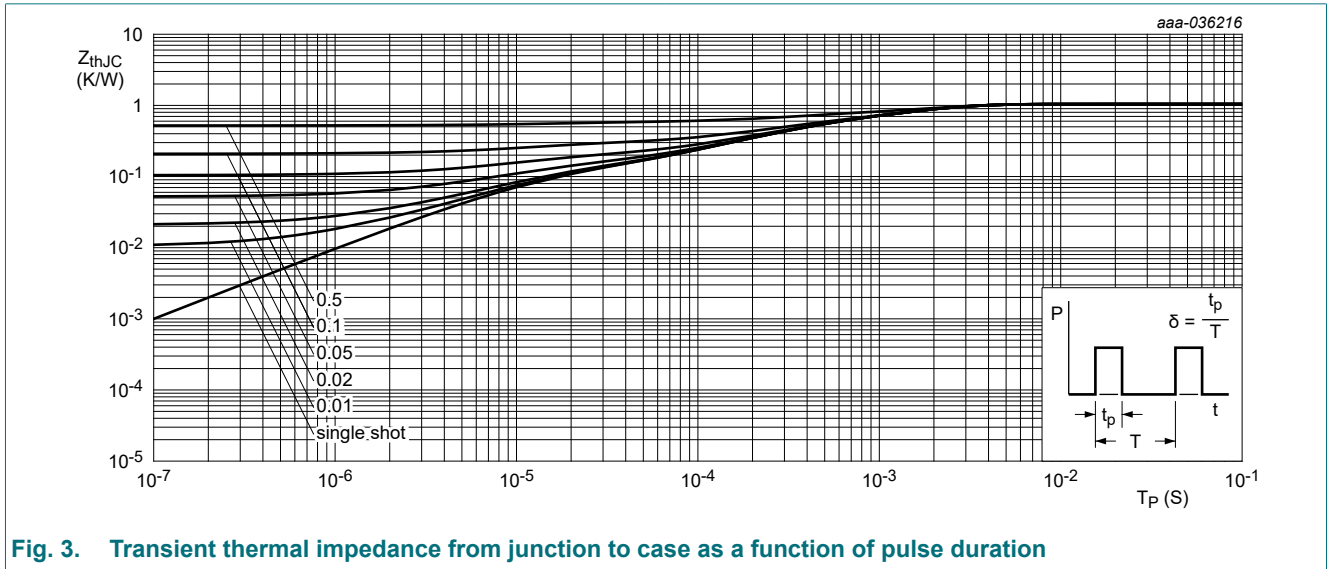


Fig. 3. Transient thermal impedance from junction to case as a function of pulse duration

## 10. Characteristics

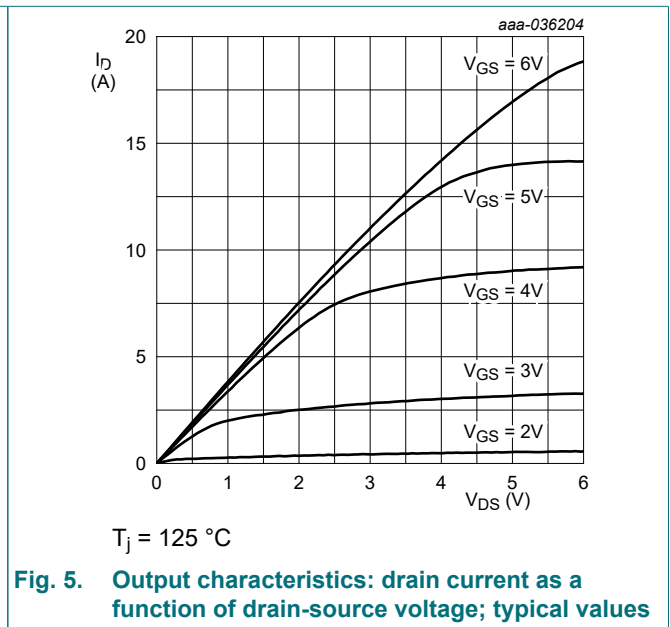
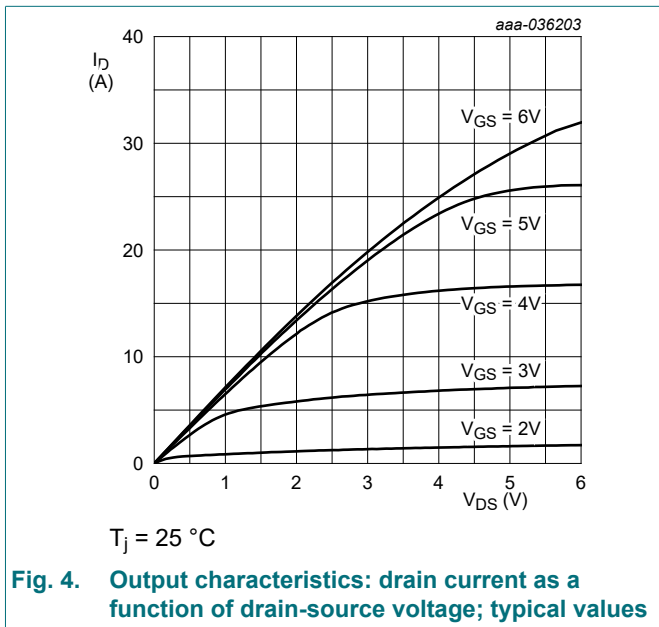
Table 7. Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Static characteristics</b>						
$V_{GS(th)}$	gate-source threshold voltage	$I_D = 12.2 \text{ mA}; V_{DS} = V_{GS}; T_j = 25 \text{ }^\circ\text{C};$ <a href="#">Fig. 8</a>	1.2	1.7	2.5	V
		$I_D = 12.2 \text{ mA}; V_{DS} = V_{GS}; T_j = 150 \text{ }^\circ\text{C};$ <a href="#">Fig. 8</a>	-	1.7	-	V
$I_{DSS}$	drain leakage current	$V_{DS} = 650 \text{ V}; V_{GS} = 0 \text{ V}; T_j = 25 \text{ }^\circ\text{C};$ <a href="#">Fig. 9</a>	-	0.45	20	$\mu\text{A}$
		$V_{DS} = 650 \text{ V}; V_{GS} = 0 \text{ V}; T_j = 150 \text{ }^\circ\text{C};$ <a href="#">Fig. 9</a>	-	6	-	$\mu\text{A}$
$I_{GSS}$	gate leakage current	$V_{GS} = 6 \text{ V}; V_{DS} = 0 \text{ V}; T_j = 25 \text{ }^\circ\text{C};$ <a href="#">Fig. 10</a>	-	60	-	$\mu\text{A}$
$R_{DS(on)}$	drain-source on-state resistance	$V_{GS} = 6 \text{ V}; I_D = 3.9 \text{ A}; T_j = 25 \text{ }^\circ\text{C};$ <a href="#">Fig. 11; Fig. 12; Fig. 13</a>	-	138	190	m $\Omega$
		$V_{GS} = 6 \text{ V}; I_D = 3.9 \text{ A}; T_j = 150 \text{ }^\circ\text{C};$ <a href="#">Fig. 11; Fig. 14</a>	-	300	-	m $\Omega$
$R_G$	gate resistance	$f = 5 \text{ MHz}; T_j = 25 \text{ }^\circ\text{C};$ open drain	-	5	-	$\Omega$
<b>Dynamic characteristics</b>						
$Q_{G(tot)}$	total gate charge	$I_D = 3.9 \text{ A}; V_{DS} = 400 \text{ V}; V_{GS} = 6 \text{ V};$ $T_j = 25 \text{ }^\circ\text{C};$ <a href="#">Fig. 15; Fig. 16</a>	-	2.8	-	nC
$Q_{GS}$	gate-source charge		-	0.25	-	nC
$Q_{GD}$	gate-drain charge		-	1.1	-	nC

650 V, 190 mOhm Gallium Nitride (GaN) FET in a DFN 5 mm x 6 mm package

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{GS(pl)}$	gate-source plateau voltage	$I_D = 3.9\text{ A}$ ; $V_{DS} = 400\text{ V}$ ; $T_j = 25\text{ }^\circ\text{C}$ ; <a href="#">Fig. 15</a>	-	2.2	-	V
$C_{iss}$	input capacitance	$V_{DS} = 400\text{ V}$ ; $V_{GS} = 0\text{ V}$ ; $f = 100\text{ kHz}$ ; $T_j = 25\text{ }^\circ\text{C}$ ; <a href="#">Fig. 17</a>	-	96	-	pF
$C_{oss}$	output capacitance		-	30	-	pF
$C_{rss}$	reverse transfer capacitance		-	0.5	-	pF
$C_{o(er)}$	effective output capacitance, energy related	$0\text{ V} \leq V_{DS} \leq 400\text{ V}$ ; $V_{GS} = 0\text{ V}$ ; $T_j = 25\text{ }^\circ\text{C}$ ; <a href="#">Fig. 18</a>	[1]	43	-	pF
$C_{o(tr)}$	effective output capacitance, time related	$0\text{ V} \leq V_{DS} \leq 400\text{ V}$ ; $V_{GS} = 0\text{ V}$ ; $T_j = 25\text{ }^\circ\text{C}$	[2]	60	-	pF
$t_{d(on)}$	turn-on delay time	$V_{DS} = 400\text{ V}$ ; $V_{GS} = 6\text{ V}$ ; $T_j = 25\text{ }^\circ\text{C}$ ; $I_D = 8\text{ A}$ ; $L = 318\text{ }\mu\text{H}$ ; $R_{on} = 10\text{ }\Omega$ ; $R_{off} = 2\text{ }\Omega$ ; <a href="#">Fig. 19</a> ; <a href="#">Fig. 20</a>	-	1.4	-	ns
$t_r$	rise time		-	4	-	ns
$t_{d(off)}$	turn-off delay time		-	1.7	-	ns
$t_f$	fall time		-	4	-	ns
$Q_{oss}$	output charge	$V_{GS} = 0\text{ V}$ ; $V_{DS} = 400\text{ V}$ ; $T_j = 25\text{ }^\circ\text{C}$	[3]	24.5	-	nC
<b>Source-drain characteristics</b>						
$V_{SD}$	source-drain voltage	$I_S = 3.9\text{ A}$ ; $V_{GS} = 0\text{ V}$ ; $T_j = 25\text{ }^\circ\text{C}$ ; <a href="#">Fig. 21</a> ; <a href="#">Fig. 22</a> ; <a href="#">Fig. 23</a> ; <a href="#">Fig. 24</a>	-	2.6	-	V

- [1]  $C_{O(er)}$  is the fixed capacitance that gives the same stored energy as  $C_{OSS}$  while  $V_{DS}$  is rising from 0 to 400 V
- [2]  $C_{O(tr)}$  is the fixed capacitance that gives the same charging time as  $C_{OSS}$  while  $V_{DS}$  is rising from 0 to 400 V
- [3]  $Q_r$  is not specified separately from  $Q_{oss}$  for e-mode GaN FETs, since  $Q_r = Q_{oss} + Q_D$ , and  $Q_D = 0$ . ( $Q_D$  is charge associated with diffusion of minority carriers. Since there is no body diode, no minority carriers in excess of  $Q_{oss}$  have to be transferred for e-mode GaN FETs.)



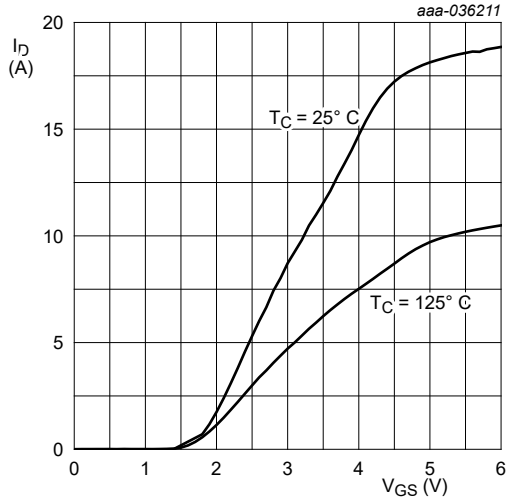


Fig. 6. Transfer characteristics; drain current as a function of gate-source voltage; typical values

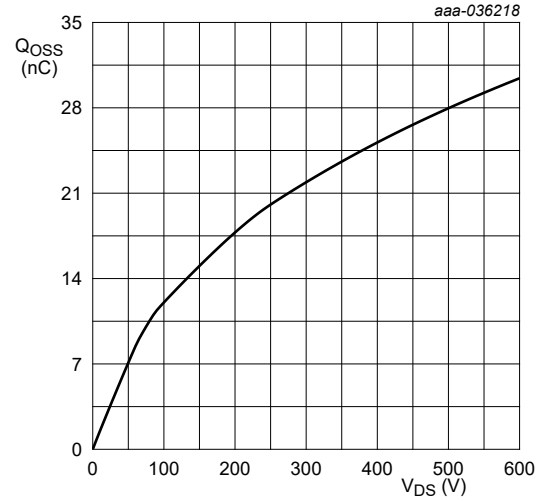


Fig. 7. Output charge as a function of drain-source voltage; typical values

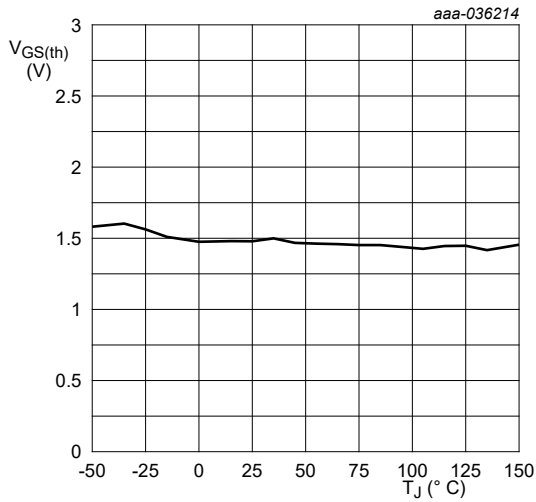


Fig. 8. Gate-source threshold voltage as a function of junction temperature

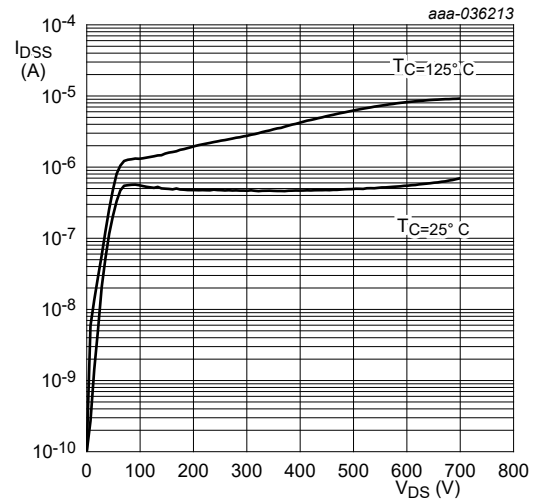
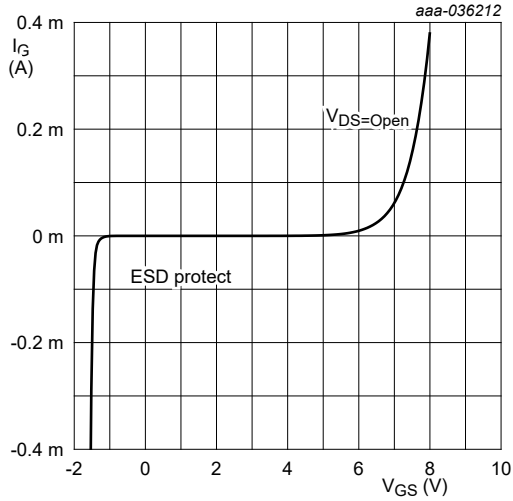
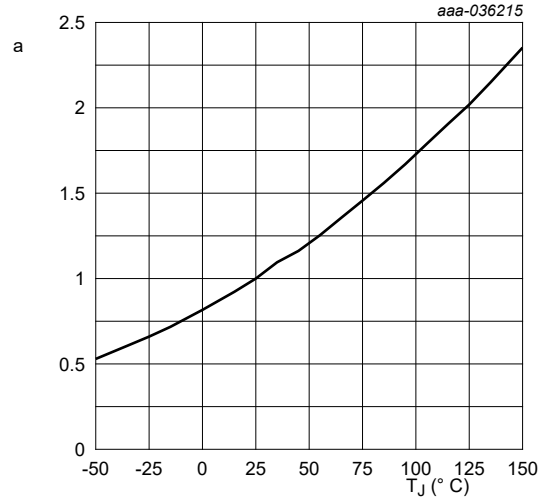


Fig. 9. Drain-source current as a function of drain-source voltage; typical values



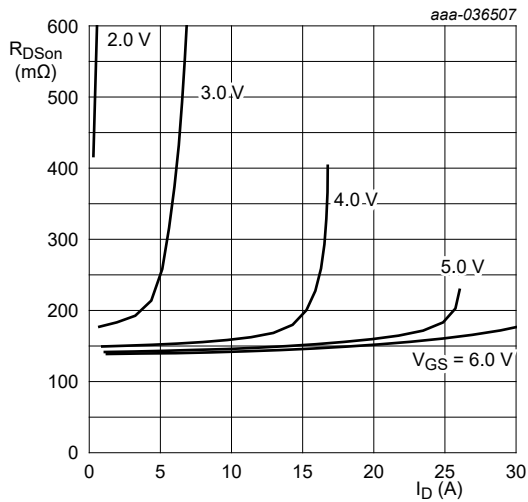
$I_g$  reverse turn on by ESD unit

Fig. 10. Gate-source current as a function of gate-source voltage; typical values



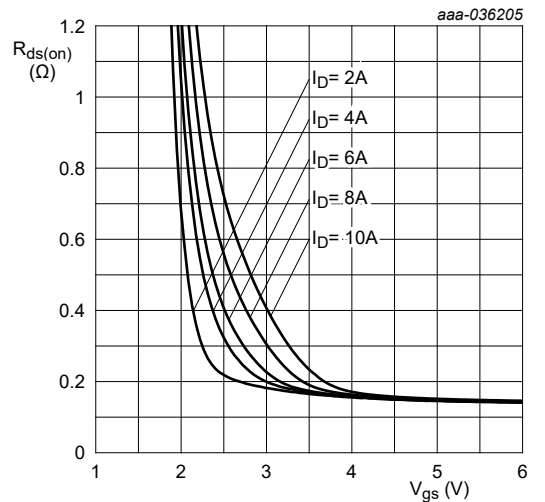
$$a = \frac{R_{DSon}}{R_{DSon}(25^\circ C)}$$

Fig. 11. Normalized drain-source on-state resistance factor as a function of junction temperature



$T_j = 25^\circ C$

Fig. 12. Drain-source on-state resistance as a function of drain current ; typical values



$T_j = 25^\circ C$

Fig. 13. Drain-source on-state resistance as a function of gate-source voltage; typical values

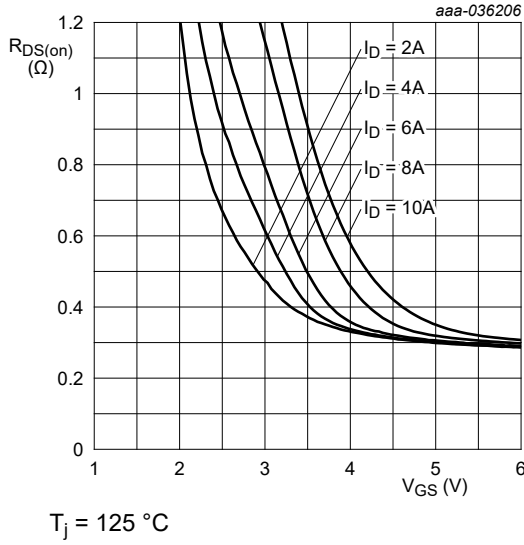


Fig. 14. Drain-source on-state resistance as a function of gate-source voltage; typical values

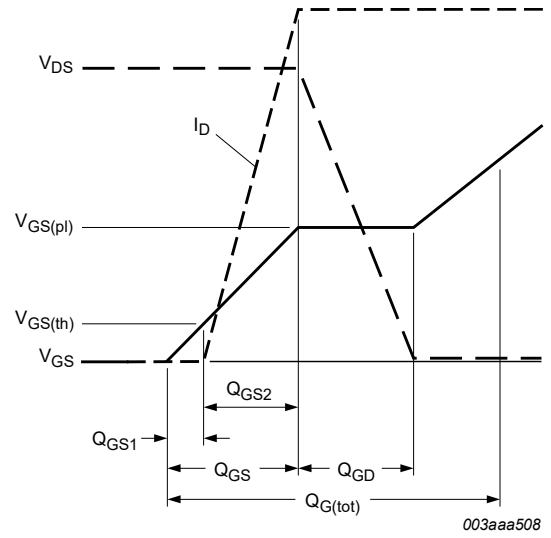


Fig. 15. Gate charge waveform definitions

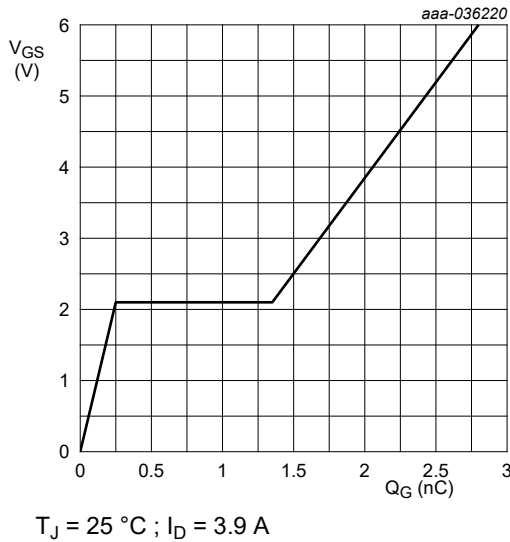


Fig. 16. Gate-source voltage as a function of gate charge; typical values

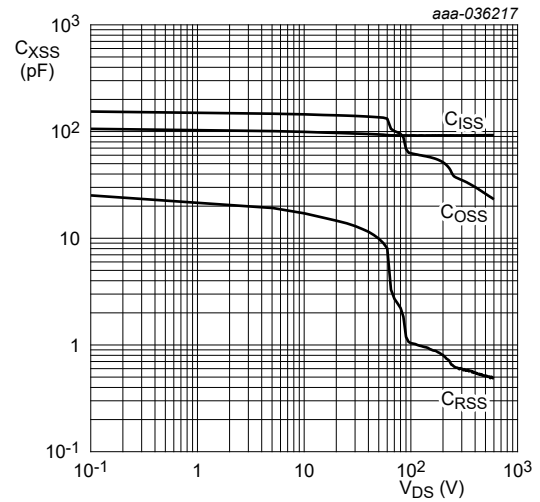
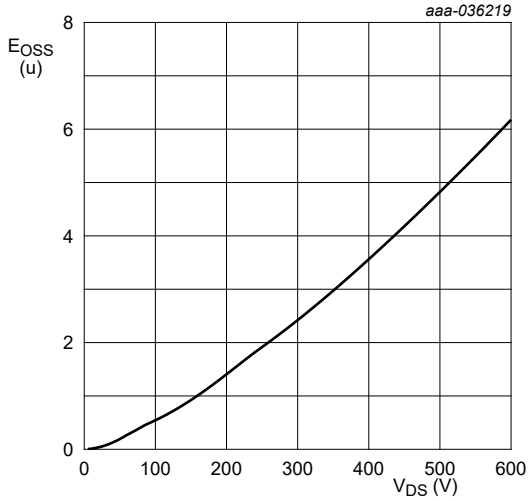


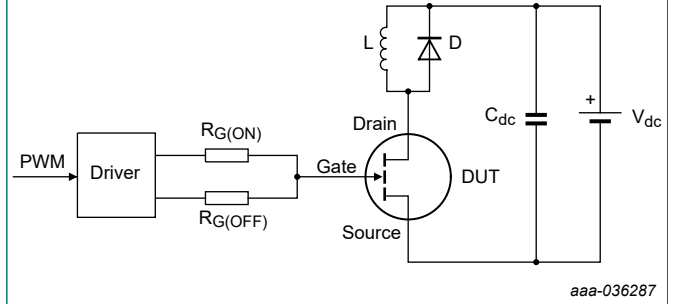
Fig. 17. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values





Freq. = 100 kHz

Fig. 18. COSS stored energy as a function of drain-source voltage; typical values



V<sub>DS</sub> = 400 V; I<sub>D</sub> = 10 A; L = 318 μH; V<sub>GS</sub> = 6 V;  
R<sub>on</sub> = 10 Ω; R<sub>off</sub> = 2 Ω

Fig. 19. Typical switching times with inductive load

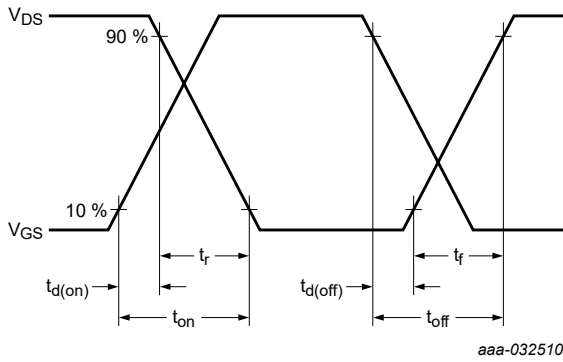
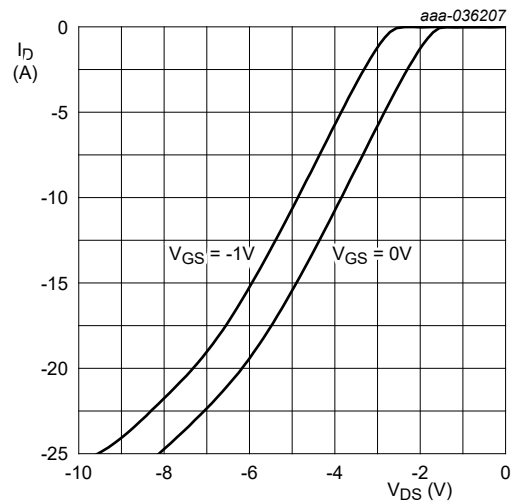


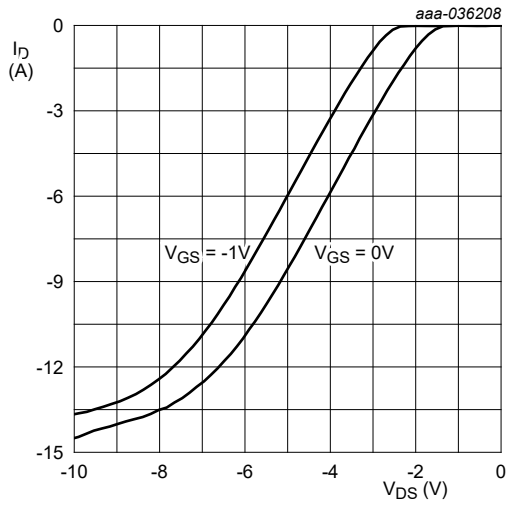
Fig. 20. Switching time waveform



T<sub>j</sub> = 25 °C

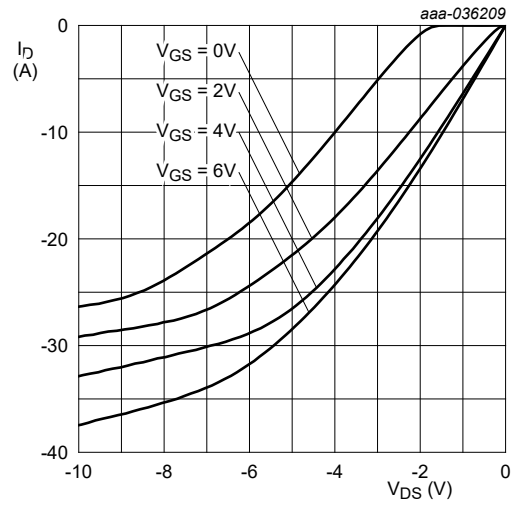
Fig. 21. Source current as a function of source-drain voltage; typical values

650 V, 190 mOhm Gallium Nitride (GaN) FET in a DFN 5 mm x 6 mm package



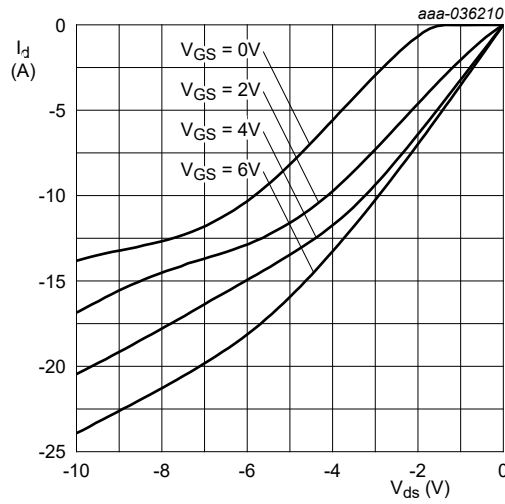
$T_j = 125\text{ °C}$

Fig. 22. Source current as a function of source-drain voltage; typical values



$T_j = 25\text{ °C}$

Fig. 23. Source current as a function of source-drain voltage; typical values



$T_j = 125\text{ °C}$

Fig. 24. Source current as a function of source-drain voltage; typical values

11. Package outline

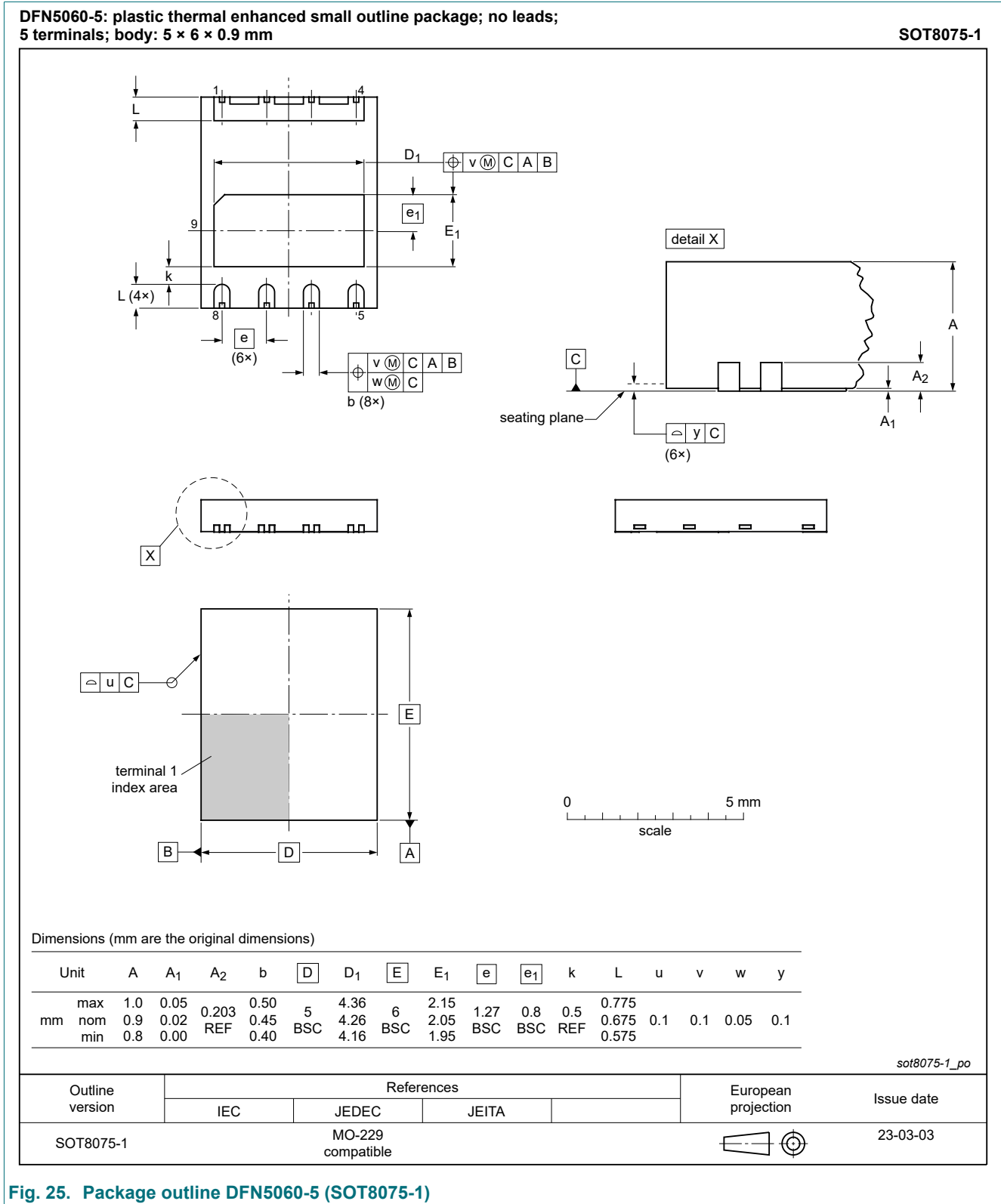


Fig. 25. Package outline DFN5060-5 (SOT8075-1)

## 12. Soldering

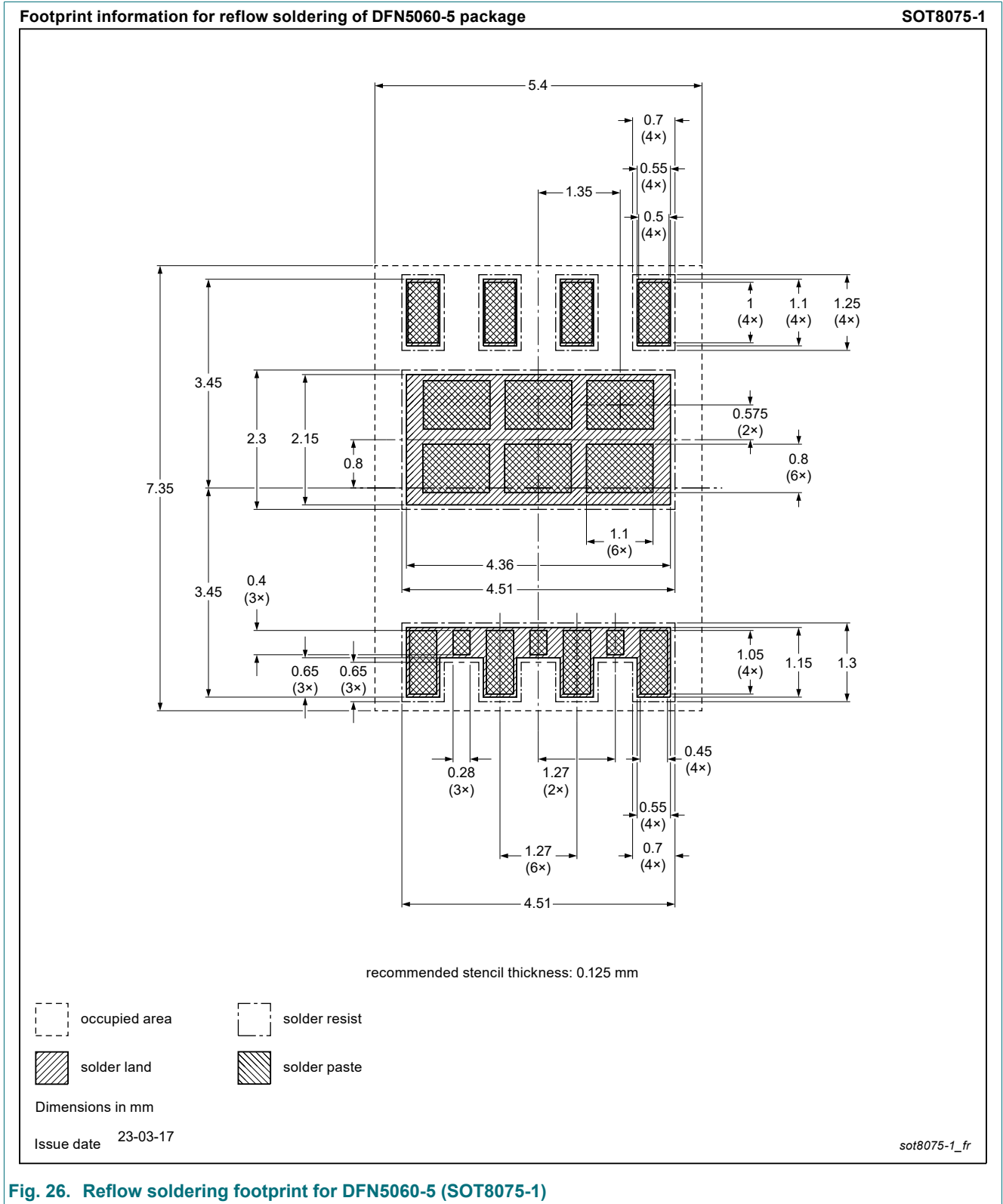


Fig. 26. Reflow soldering footprint for DFN5060-5 (SOT8075-1)

## 13. 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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