



# GAN039-650NBB

650 V, 33 mOhm Gallium Nitride (GaN) FET in a CCPAK1212 package

19 April 2021

Objective data sheet

## 1. General description

The GAN039-650NBB is a 650 V, 33 m $\Omega$  Gallium Nitride (GaN) FET in a CCPAK1212 package. It is a normally-off device that combines Nexperia's latest high-voltage GaN HEMT H2 technology and low-voltage silicon MOSFET technologies — offering superior reliability and performance.

## 2. Features and benefits

- Simplified driver design as standard level MOSFET gate drivers can be used:
  - 0 V to 12 V drive voltage
  - Gate threshold voltage  $V_{GSth}$  of 4 V
- Robust gate oxide with  $\pm 20$  V  $V_{GS}$  rating
- High gate threshold voltage of 4 V for gate bounce immunity
- Low body diode  $V_f$  for reduced losses and simplified dead-time adjustments
- Transient over-voltage capability for increased robustness
- CCPAK package technology:
  - Improved reliability, with reduced  $R_{th(j-mb)}$  for optimal cooling
  - Lower inductances for lower switching losses and EMI
  - 175 °C maximum junction temperature
  - High Board Level Reliability absorbing mechanical stress during thermal cycling, unlike traditional QFN packages
  - Visual (AOI) soldering inspection, no need for expensive x-ray equipment
  - Easy solder wetting for good mechanical solder joints

## 3. Applications

- Hard and soft switching converters for industrial and datacom power
- Bridgeless totempole PFC
- PV and UPS inverters
- Servo motor drives

## 4. Quick reference data

Table 1. Quick reference data

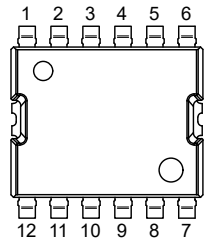
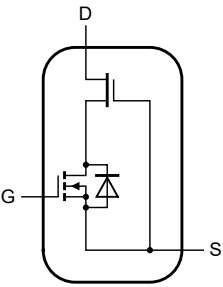
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{DS}$	drain-source voltage	$-55\text{ °C} \leq T_j \leq 175\text{ °C}$	-	-	650	V
$I_D$	drain current	$V_{GS} = 10\text{ V}; T_{mb} = 25\text{ °C}$	-	-	60	A
$P_{tot}$	total power dissipation	$T_{mb} = 25\text{ °C};$ <a href="#">Fig. 1</a>	-	-	300	W
$T_j$	junction temperature		-55	-	175	°C
<b>Static characteristics</b>						
$R_{DSon}$	drain-source on-state resistance	$V_{GS} = 10\text{ V}; I_D = 32\text{ A}; T_j = 25\text{ °C}$	-	33	39	m $\Omega$

650 V, 33 mOhm Gallium Nitride (GaN) FET in a CCPAK1212 package

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Dynamic characteristics</b>						
$Q_{GD}$	gate-drain charge	$I_D = 32\text{ A}$ ; $V_{DS} = 400\text{ V}$ ; $V_{GS} = 10\text{ V}$ ; $T_j = 25\text{ }^\circ\text{C}$	-	5	-	nC
$Q_{G(\text{tot})}$	total gate charge		-	30	-	nC
<b>Source-drain diode</b>						
$Q_r$	recovered charge	$I_S = 32\text{ A}$ ; $di_S/dt = -1000\text{ A}/\mu\text{s}$ ; $V_{GS} = 0\text{ V}$ ; $V_{DS} = 400\text{ V}$ ; <a href="#">Fig. 3</a>	-	150	-	nC

### 5. Pinning information

Table 2. Pinning information

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	G	gate	 <p>CCPAK (SOT8000)</p>	 <p>aaa-028116</p>
2	S	source		
3	S	source		
4	S	source		
5	S	source		
6	S	source		
7	D	drain		
8	D	drain		
9	D	drain		
10	D	drain		
11	D	drain		
12	D	drain		
mb	S	mounting base; connected to source		

### 6. Ordering information

Table 3. Ordering information

Type number	Package		Version
	Name	Description	
GAN039-650NBB	CCPAK	Plastic, surface mounted copper clip package (CCPAK1212); 13 terminals; 2.0 mm pitch, 12 mm x 12 mm x 2.5 mm body	SOT8000

### 7. Marking

Table 4. Marking codes

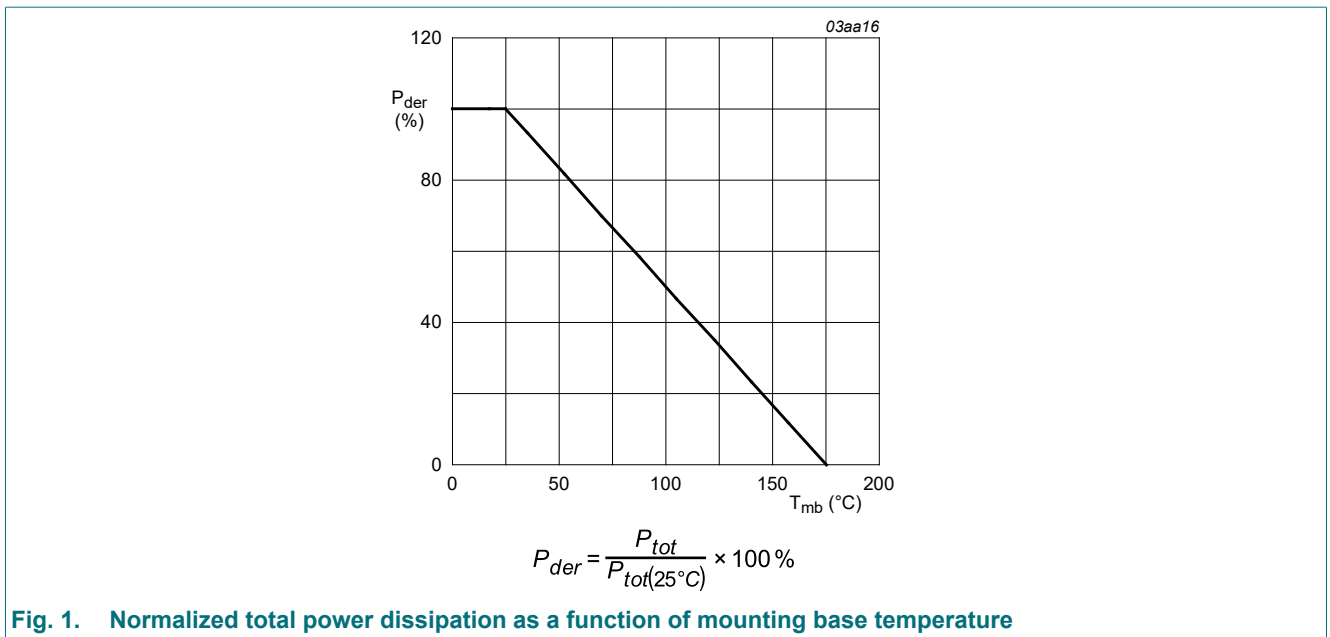
Type number	Marking code
GAN039-650NBB	039INBBX

## 8. Limiting values

**Table 5. Limiting values**

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

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>DS</sub>	drain-source voltage	-55 °C ≤ T <sub>J</sub> ≤ 175 °C	-	650	V
V <sub>TDS</sub>	transient drain to source voltage	pulsed; t <sub>p</sub> = 1 μs; δ <sub>factor</sub> = 0.01	-	[tbd]	V
V <sub>GS</sub>	gate-source voltage		-20	20	V
P <sub>tot</sub>	total power dissipation	T <sub>mb</sub> = 25 °C; <a href="#">Fig. 1</a>	-	300	W
I <sub>D</sub>	drain current	V <sub>GS</sub> = 10 V; T <sub>mb</sub> = 25 °C	-	60	A
		V <sub>GS</sub> = 10 V; T <sub>mb</sub> = 100 °C	-	42	A
I <sub>DM</sub>	peak drain current	pulsed; t <sub>p</sub> ≤ 10 μs; T <sub>mb</sub> = 25 °C	-	240	A
T <sub>stg</sub>	storage temperature		-55	175	°C
T <sub>J</sub>	junction temperature		-55	175	°C
T <sub>slid(M)</sub>	peak soldering temperature		-	260	°C
<b>Source-drain diode</b>					
I <sub>S</sub>	source current	T <sub>mb</sub> = 25 °C; V <sub>GS</sub> = 0 V	-	55	A
I <sub>SM</sub>	peak source current	pulsed; t <sub>p</sub> ≤ 10 μs; T <sub>mb</sub> = 25 °C	-	240	A



## 9. Thermal characteristics

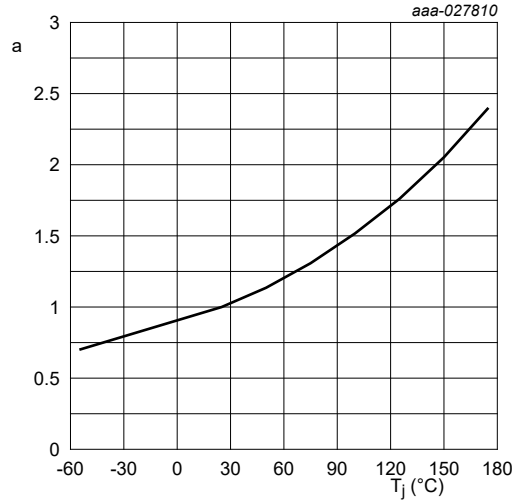
**Table 6. Thermal characteristics**

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
R <sub>th(j-mb)</sub>	thermal resistance from junction to mounting base		-	-	0.5	K/W

## 10. Characteristics

Table 7. Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Static characteristics</b>						
$V_{GS(th)}$	gate-source threshold voltage	$I_D = 1 \text{ mA}$ ; $V_{DS} = V_{GS}$ ; $T_j = 25 \text{ }^\circ\text{C}$	3.3	4	4.8	V
$I_{DSS}$	drain leakage current	$V_{DS} = 650 \text{ V}$ ; $V_{GS} = 0 \text{ V}$ ; $T_j = 25 \text{ }^\circ\text{C}$	-	3	30	$\mu\text{A}$
		$V_{DS} = 650 \text{ V}$ ; $V_{GS} = 0 \text{ V}$ ; $T_j = 150 \text{ }^\circ\text{C}$	-	20	-	$\mu\text{A}$
$I_{GSS}$	gate leakage current	$V_{GS} = -20 \text{ V}$ ; $V_{DS} = 0 \text{ V}$ ; $T_j = 25 \text{ }^\circ\text{C}$	-	10	400	nA
		$V_{GS} = 20 \text{ V}$ ; $V_{DS} = 0 \text{ V}$ ; $T_j = 25 \text{ }^\circ\text{C}$	-	10	400	nA
$R_{DS(on)}$	drain-source on-state resistance	$V_{GS} = 10 \text{ V}$ ; $I_D = 32 \text{ A}$ ; $T_j = 25 \text{ }^\circ\text{C}$	-	33	39	m $\Omega$
		$V_{GS} = 10 \text{ V}$ ; $I_D = 32 \text{ A}$ ; $T_j = 175 \text{ }^\circ\text{C}$ ; <a href="#">Fig. 2</a>	-	80	-	m $\Omega$
$R_G$	gate resistance	$f = 1 \text{ MHz}$ ; Fig 4	0.2	0.5	1.25	$\Omega$
<b>Dynamic characteristics</b>						
$Q_{G(tot)}$	total gate charge	$I_D = 32 \text{ A}$ ; $V_{DS} = 400 \text{ V}$ ; $V_{GS} = 10 \text{ V}$ ; $T_j = 25 \text{ }^\circ\text{C}$	-	30	-	nC
$Q_{GS}$	gate-source charge		-	9	-	nC
$Q_{GD}$	gate-drain charge		-	5	-	nC
$C_{iss}$	input capacitance	$V_{DS} = 400 \text{ V}$ ; $V_{GS} = 0 \text{ V}$ ; $f = 1 \text{ MHz}$ ; $T_j = 25 \text{ }^\circ\text{C}$	-	1500	-	pF
$C_{oss}$	output capacitance		-	147	-	pF
$C_{rss}$	reverse transfer capacitance		-	5	-	pF
$C_{o(er)}$	effective output capacitance, energy related		$0 \text{ V} \leq V_{DS} \leq 400 \text{ V}$ ; $V_{GS} = 0 \text{ V}$ ; $f = 1 \text{ MHz}$ ; $T_j = 25 \text{ }^\circ\text{C}$	-	220	-
$C_{o(tr)}$	effective output capacitance, time related		-	380	-	pF
$t_{d(on)}$	turn-on delay time	$V_{DS} = 400 \text{ V}$ ; $R_L = 12.5 \text{ } \Omega$ ; $V_{GS} = 12 \text{ V}$ ; $R_{G(ext)} = 30 \text{ } \Omega$	-	[tbd]	-	ns
$t_r$	rise time		-	[tbd]	-	ns
$t_{d(off)}$	turn-off delay time		-	[tbd]	-	ns
$t_f$	fall time		-	[tbd]	-	ns
$Q_{oss}$	output charge		$V_{GS} = 0 \text{ V}$ ; $V_{DS} = 400 \text{ V}$	-	150	-
<b>Source-drain diode</b>						
$V_{SD}$	source-drain voltage	$I_S = 32 \text{ A}$ ; $V_{GS} = 0 \text{ V}$ ; $T_j = 25 \text{ }^\circ\text{C}$	-	1.8	2.5	V
		$I_S = 16 \text{ A}$ ; $V_{GS} = 0 \text{ V}$ ; $T_j = 25 \text{ }^\circ\text{C}$	-	1.3	-	V
$t_{rr}$	reverse recovery time	$I_S = 32 \text{ A}$ ; $di_S/dt = -1000 \text{ A}/\mu\text{s}$ ; $V_{GS} = 0 \text{ V}$ ; $V_{DS} = 400 \text{ V}$ ; <a href="#">Fig. 3</a>	-	[tbd]	-	ns
$Q_r$	recovered charge		-	150	-	nC



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

Fig. 2. Normalized drain-source on-state resistance factor as a function of junction temperature

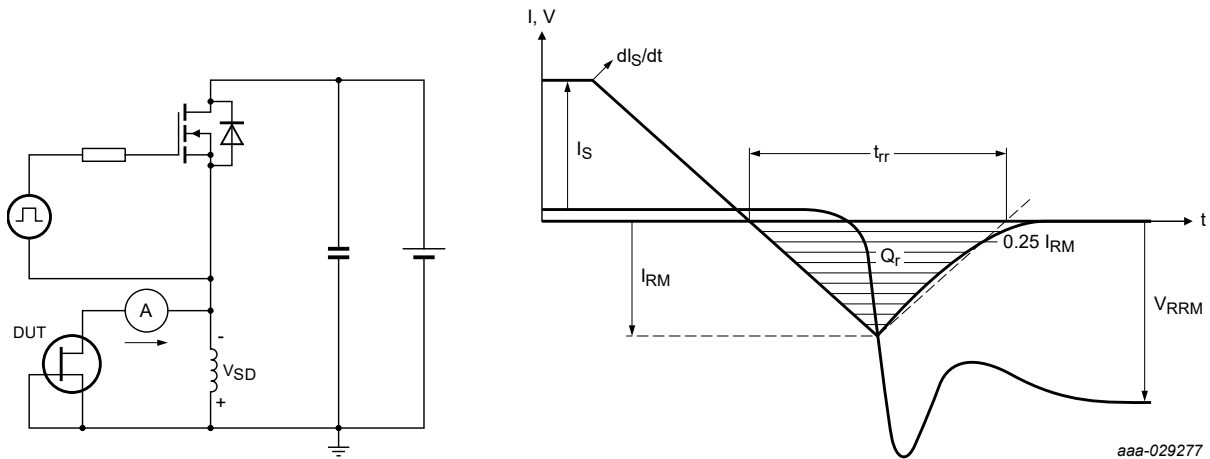
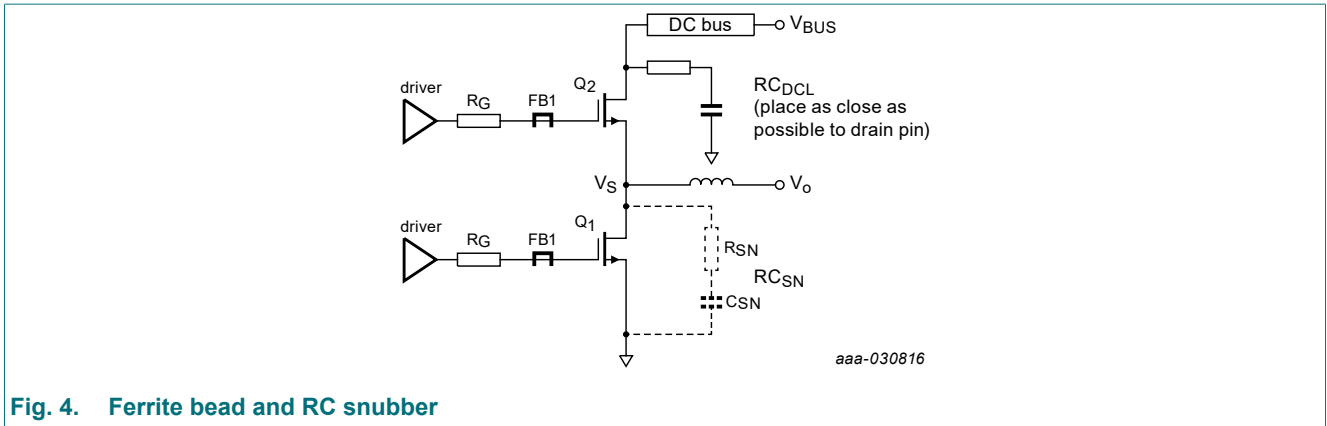


Fig. 3. Diode reverse recovery test circuit and waveform

## 11. Application information

A Ferrite bead must be fitted in series with the gate of the GaN FET and should be located as close as possible to the gate pin, (see figure below). Keeping the gate-source loop as compact as possible minimizes the gate loop inductance. The Ferrite bead damps the resonant circuit made up of the gate source loop inductance and the GaN FET input capacitance, thus providing fast switching stability. It is recommended that the impedance of the ferrite bead should be 30 Ω @ 100 MHz, (recommended p/n BLM18PG300SN1D). A series resistance (R<sub>G</sub>) of 10 - 15 Ω is also recommended.



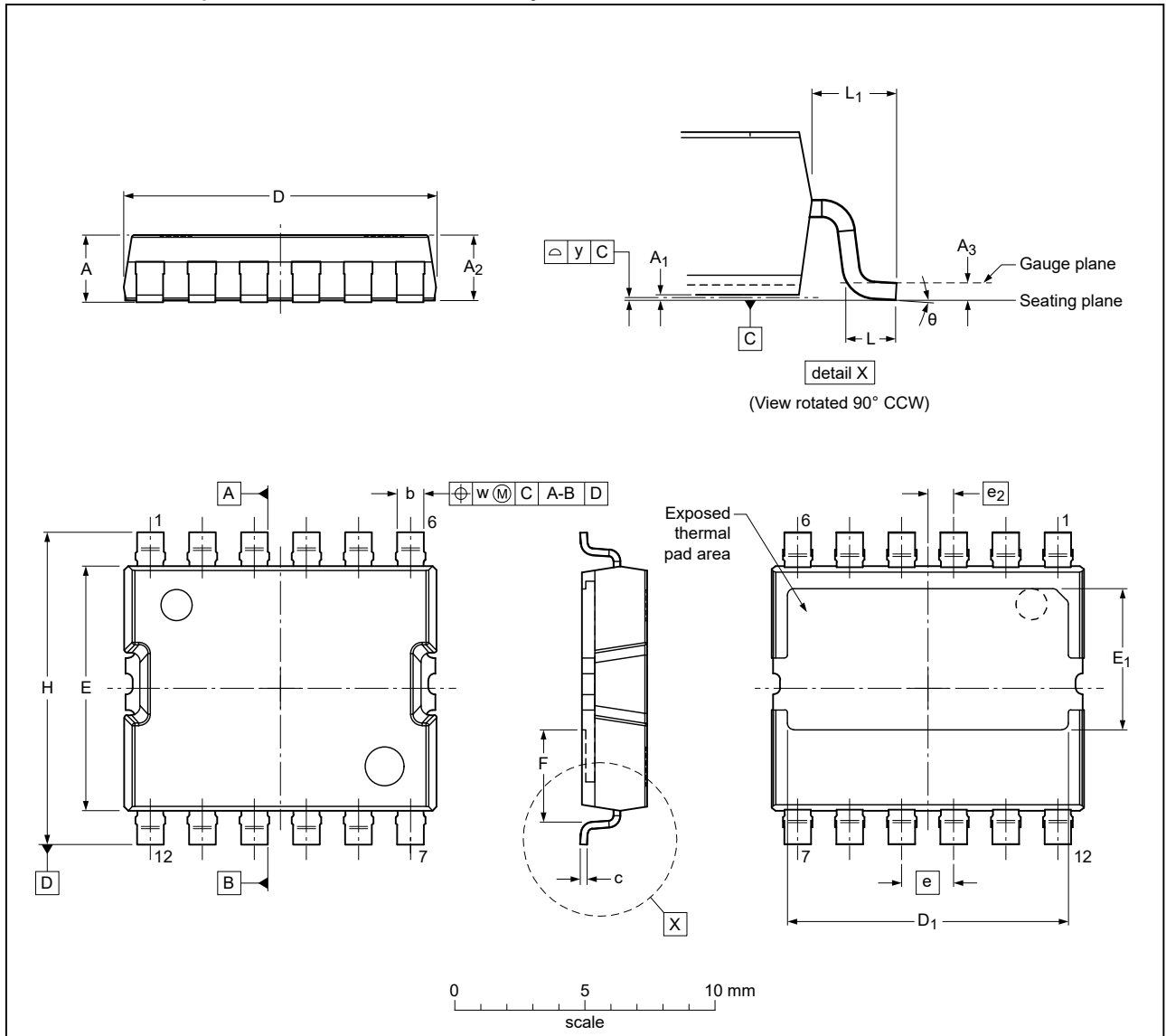
**Fig. 4. Ferrite bead and RC snubber**

A DC-link snubber is recommended in all cases. Optimal is 20 nF in series with 4  $\Omega$ , most easily achieved with parallel combination 10 nF and 8  $\Omega$ . This snubber lowers the Q factor of any resonance in the bus. That resonance will act as a load on the high gain amplifier that is the GaN FET and can lead to instability.

## 12. Package outline

Plastic, surface mounted copper clip package (CCPAK1212);  
13 terminals; 2.0 mm pitch, 12 mm x 12 mm x 2.5 mm body

SOT8000



Dimensions (mm are the original dimensions)

Unit	A	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b	c	D	D <sub>1</sub>	E	E <sub>1</sub>	F	e	H	L	L <sub>1</sub>	w	y	θ
max	2.8	0.15	2.65		1.15	0.30	12.2	11.1	9.6	5.7			12.3	1.0				8°
nom				0.25							(3.6)	2.0	12.0		1.3	0.25	0.1	
min	2.4	0	2.35		0.9	0.24	11.8	10.5	9.2	5.15			11.7	0.6				0°

Note

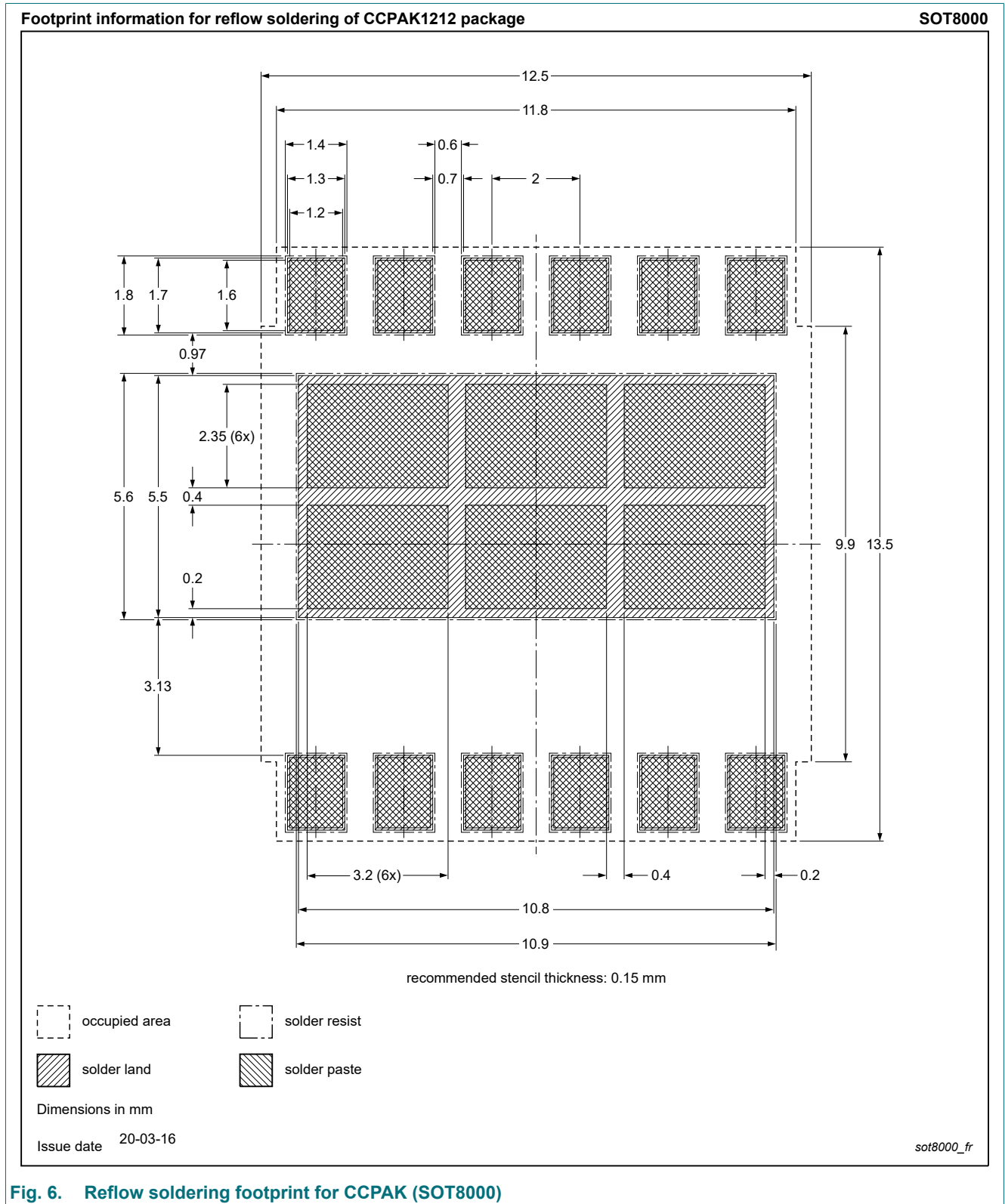
1. Plastic or metal protrusions of 0.2 mm max per side are not included.

sot8000\_po

Outline version	References			European projection	Issue date
	IEC	JEDEC	JEITA		
SOT8000					20-09-16 20-09-30

Fig. 5. Package outline CCPAK (SOT8000)

### 13. Soldering



**Fig. 6. Reflow soldering footprint for CCPAK (SOT8000)**



## 14. 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.
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