



# GAN039-650NTBA

650 V, 33 mOhm Gallium Nitride (GaN) FET in a CCPAK1212i package

19 April 2021

Objective data sheet

## 1. General description

The GAN039-650NTBA is an Automotive qualified 650 V, 33 mΩ Gallium Nitride (GaN) FET in a CCPAK1212i inverted 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.

This product has been fully designed and qualified to meet AEC-Q101 requirements.

## 2. Features and benefits

- Fully automotive qualified to AEC-Q101:
  - 175 °C rating suitable for thermally demanding environments
- 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

- Automotive On-Board-Charger systems
- Automotive DC-DC
- 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

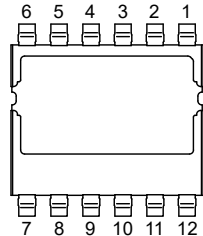
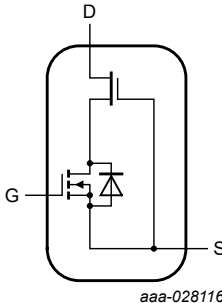
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{DS}$	drain-source voltage	$-55\text{ °C} \leq T_j \leq 175\text{ °C}$	-	-	650	V
$I_D$	drain current	$V_{GS} = 10\text{ V}; T_{mb} = 25\text{ °C}$	-	-	60	A
$P_{tot}$	total power dissipation	$T_{mb} = 25\text{ °C};$ <a href="#">Fig. 1</a>	-	-	300	W

650 V, 33 mOhm Gallium Nitride (GaN) FET in a CCPAK1212i package

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$T_j$	junction temperature		-55	-	175	°C
<b>Static characteristics</b>						
$R_{DS(on)}$	drain-source on-state resistance	$V_{GS} = 10\text{ V}$ ; $I_D = 32\text{ A}$ ; $T_j = 25\text{ °C}$	-	33	39	mΩ
<b>Dynamic characteristics</b>						
$Q_{GD}$	gate-drain charge	$I_D = 32\text{ A}$ ; $V_{DS} = 400\text{ V}$ ; $V_{GS} = 10\text{ V}$ ; $T_j = 25\text{ °C}$	-	5	-	nC
$Q_{G(tot)}$	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 (SOT8005)</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	
GAN039-650NTBA	CCPAK	Plastic, surface mounted copper clip package inverted (CCPAK1212i); 13 terminals; 2.0 mm pitch, 12 mm x 12 mm x 2.5 mm body	SOT8005

## 7. Marking

Table 4. Marking codes

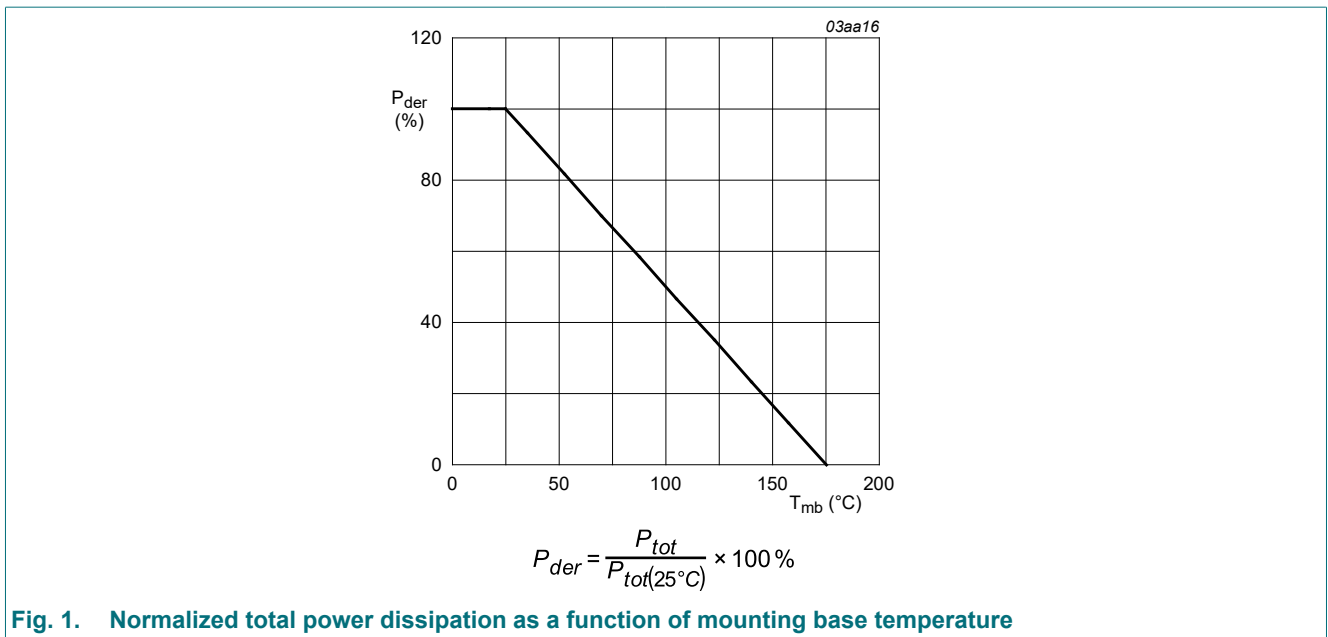
Type number	Marking code
GAN039-650NTBA	039INTBA

## 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

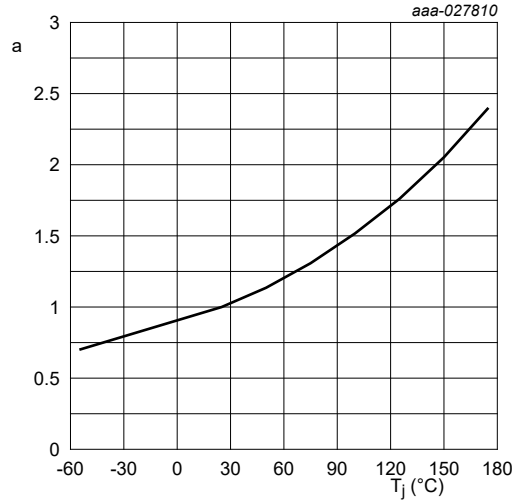
**Table 6. Thermal characteristics**

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	$V_{DS} = 650 \text{ V}$ ; $V_{GS} = 0 \text{ V}$ ; $T_j = 25 \text{ }^\circ\text{C}$	-	[tbd]	[tbd]	$\mu\text{A}$
		$V_{DS} = 650 \text{ V}$ ; $V_{GS} = 0 \text{ V}$ ; $T_j = 175 \text{ }^\circ\text{C}$	-	[tbd]	-	$\mu\text{A}$
$I_{GSS}$	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	$f = 1 \text{ MHz}$	-	1.88	-	$\Omega$
<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	-	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

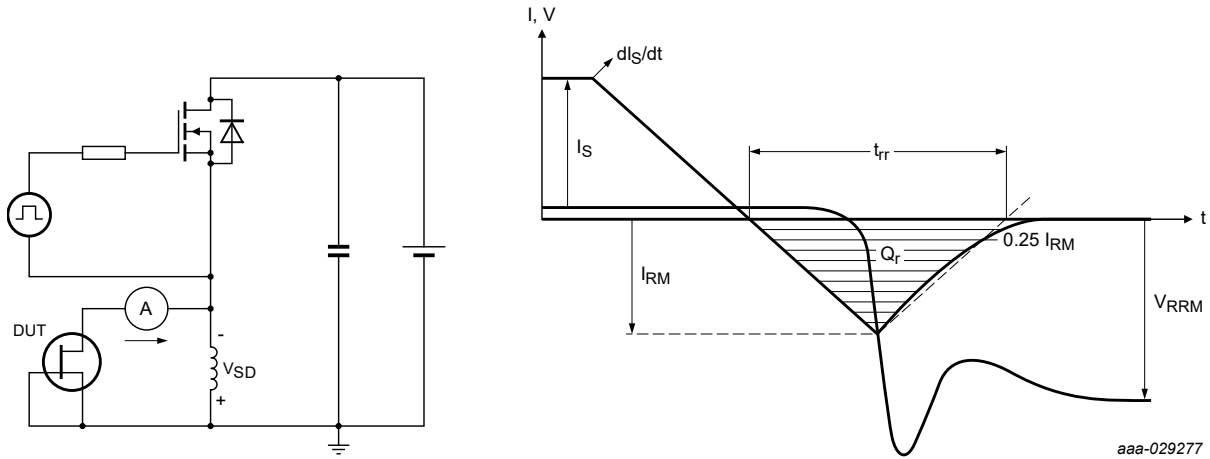
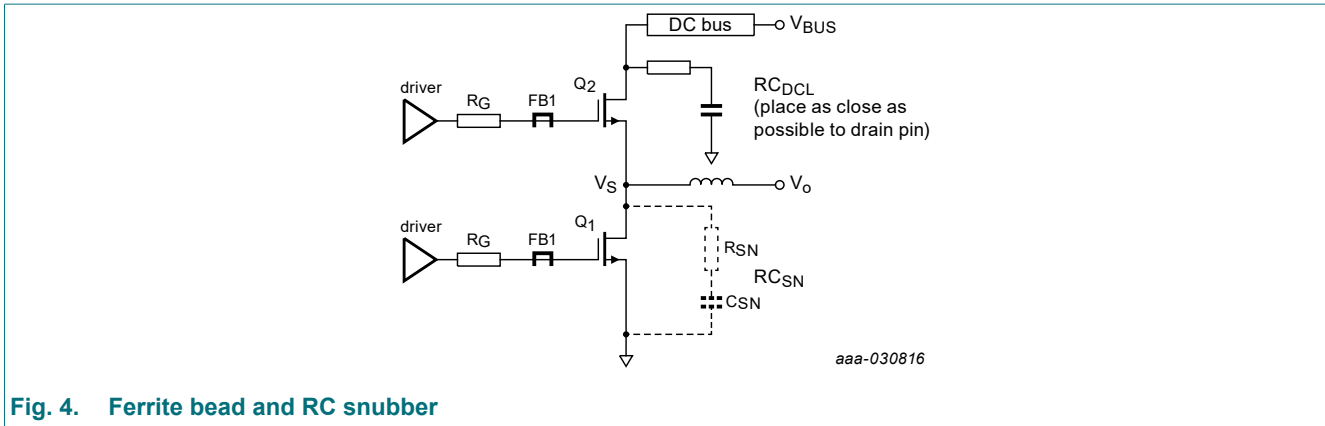


Fig. 3. Diode reverse recovery test circuit and waveform

## 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 ( $R_G$ ) of 10 - 15 Ω is also recommended.



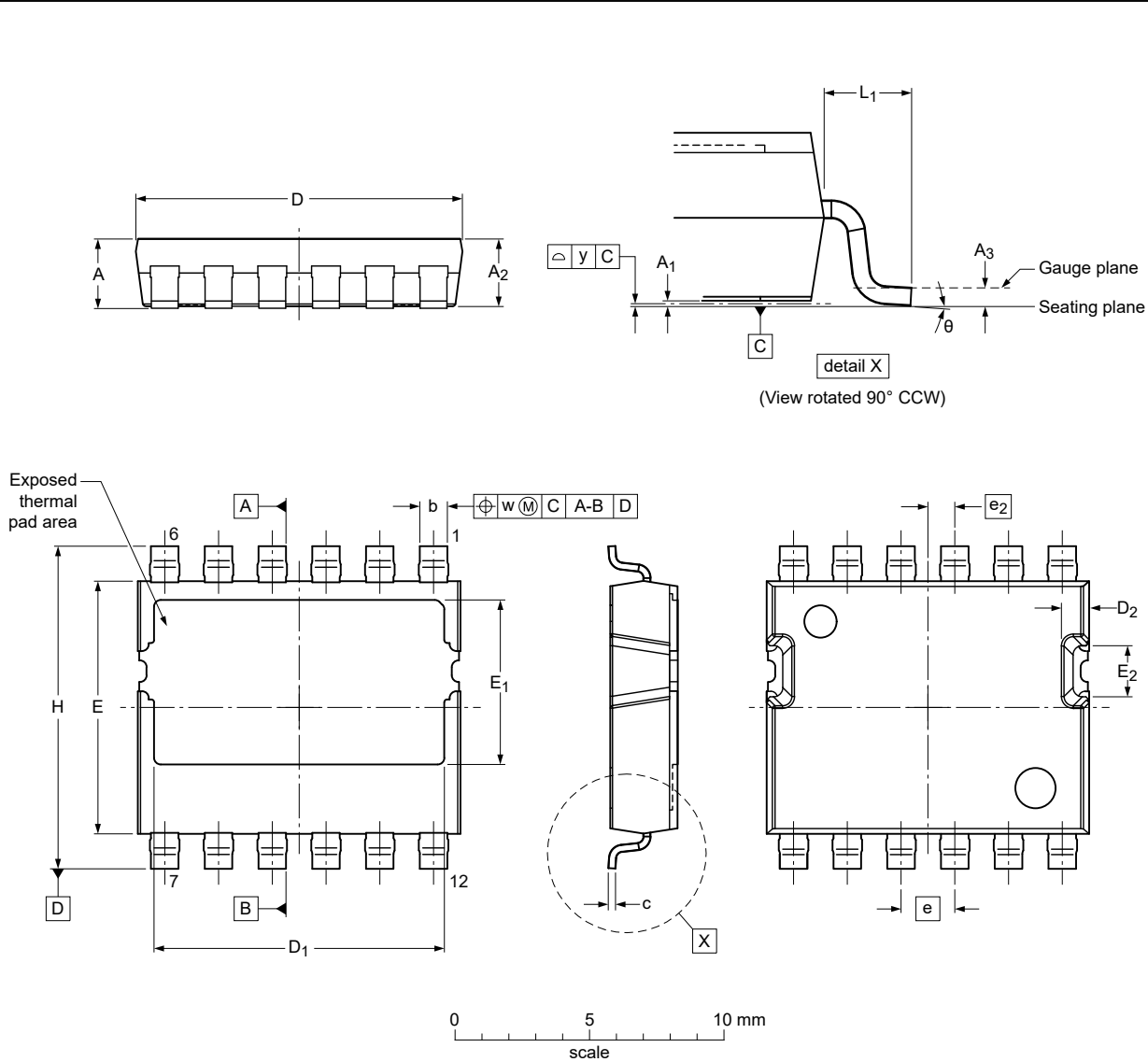
**Fig. 4. Ferrite bead and RC snubber**

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 inverted (CCPAK1212i);  
13 terminals; 2.0 mm pitch, 12 mm x 12 mm x 2.5 mm body

SOT8005



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>	D <sub>2</sub>	E	E <sub>1</sub>	E <sub>2</sub>	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	1.5	9.6	5.72	2.2		12.3	1.0					8°
nom				0.25									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	5.12	1.6		11.7	0.6					0°

Note

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

sot8005\_po

Outline version	References			European projection	Issue date
	IEC	JEDEC	JEITA		
SOT8005					20-03-11- 20-03-16

Fig. 5. Package outline CCPAK (SOT8005)

### 13. Soldering

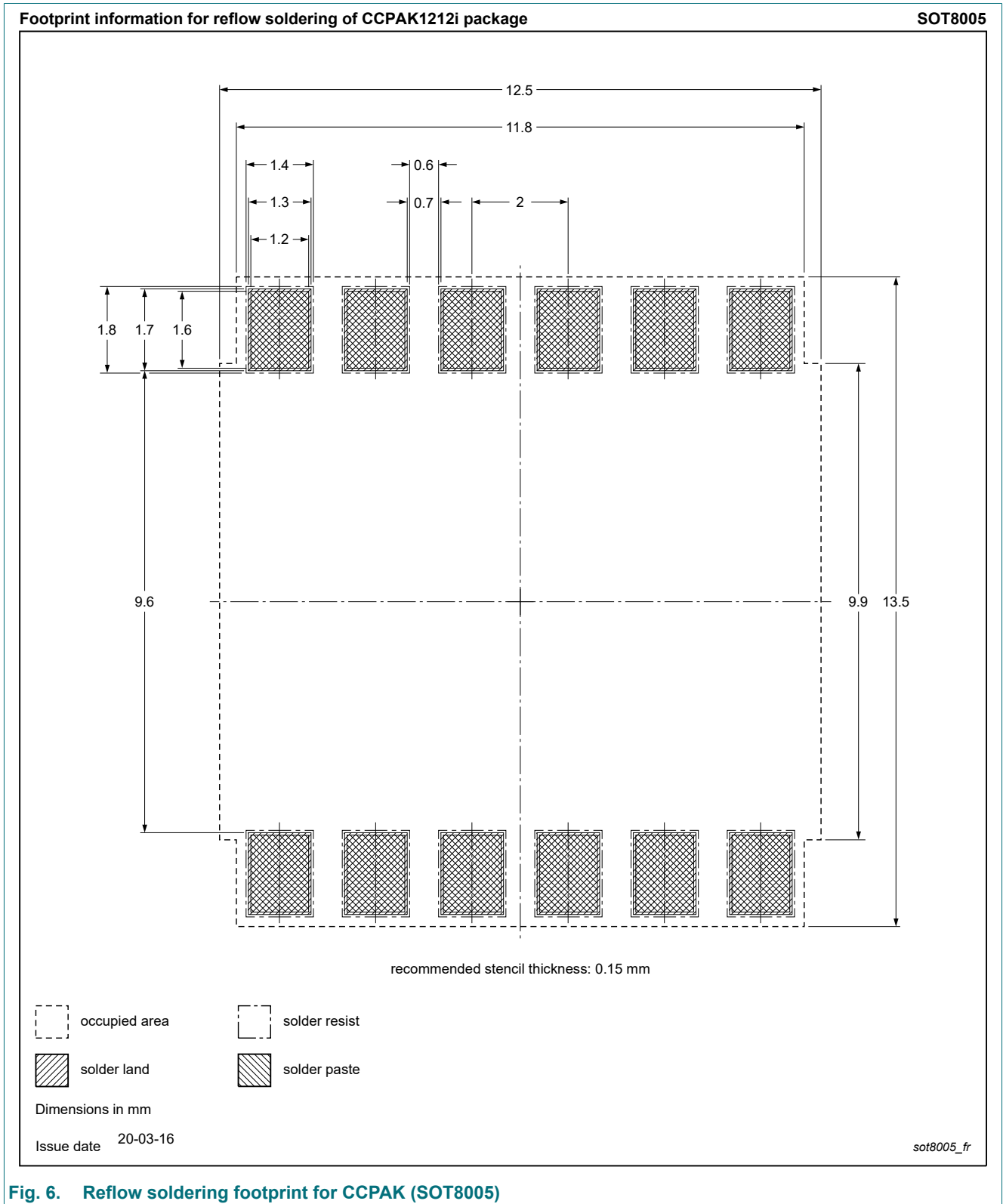


Fig. 6. Reflow soldering footprint for CCPAK (SOT8005)



## 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.
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>.

### Definitions

**Draft** — The document is a draft version only. The content is still under internal review and subject to formal approval, which may result in modifications or additions. Nexperia does not give any representations or warranties as to the accuracy or completeness of information included herein and shall have no liability for the consequences of use of such information.

**Short data sheet** — A short data sheet is an extract from a full data sheet with the same product type number(s) and title. A short data sheet is intended for quick reference only and should not be relied upon to contain detailed and full information. For detailed and full information see the relevant full data sheet, which is available on request via the local Nexperia sales office. In case of any inconsistency or conflict with the short data sheet, the full data sheet shall prevail.

**Product specification** — The information and data provided in a Product data sheet shall define the specification of the product as agreed between Nexperia and its customer, unless Nexperia and customer have explicitly agreed otherwise in writing. In no event however, shall an agreement be valid in which the Nexperia product is deemed to offer functions and qualities beyond those described in the Product data sheet.

### Disclaimers

**Limited warranty and liability** — Information in this document is believed to be accurate and reliable. However, Nexperia does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. Nexperia takes no responsibility for the content in this document if provided by an information source outside of Nexperia.

In no event shall Nexperia be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, Nexperia's aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of Nexperia.

**Right to make changes** — Nexperia reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

**Suitability for use in automotive applications** — This Nexperia product has been qualified for use in automotive applications. Unless otherwise agreed in writing, the product is not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or

equipment, nor in applications where failure or malfunction of an Nexperia product can reasonably be expected to result in personal injury, death or severe property or environmental damage. Nexperia and its suppliers accept no liability for inclusion and/or use of Nexperia products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

**Quick reference data** — The Quick reference data is an extract of the product data given in the Limiting values and Characteristics sections of this document, and as such is not complete, exhaustive or legally binding.

**Applications** — Applications that are described herein for any of these products are for illustrative purposes only. Nexperia makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using Nexperia products, and Nexperia accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the Nexperia product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

Nexperia does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using Nexperia products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). Nexperia does not accept any liability in this respect.

**Limiting values** — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

**Terms and conditions of commercial sale** — Nexperia products are sold subject to the general terms and conditions of commercial sale, as published at <http://www.nexperia.com/profile/terms>, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. Nexperia hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of Nexperia products by customer.

**No offer to sell or license** — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

**Export control** — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

**Translations** — A non-English (translated) version of a document is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

### Trademarks

Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

## Contents

---

1. General description.....	1
2. Features and benefits.....	1
3. Applications.....	1
4. Quick reference data.....	1
5. Pinning information.....	2
6. Ordering information.....	2
7. Marking.....	2
8. Limiting values.....	3
9. Thermal characteristics.....	3
10. Characteristics.....	4
11. Application information.....	5
12. Package outline.....	7
13. Soldering.....	8
14. Legal information.....	9

---

© Nexperia B.V. 2021. All rights reserved

For more information, please visit: <http://www.nexperia.com>

For sales office addresses, please send an email to: [salesaddresses@nexperia.com](mailto:salesaddresses@nexperia.com)

Date of release: 19 April 2021

---