

# PMCM4401UPE

20 V, P-channel Trench MOSFET

7 October 2016

Product data sheet

## 1. General description

P-channel enhancement mode Field-Effect Transistor (FET) in a 4 bumps Wafer Level Chip-Size Package (WLCSP) using Trench MOSFET technology.

## 2. Features and benefits

- Low threshold voltage
- Ultra small package:  $0.78 \times 0.78 \times 0.35$  mm
- Trench MOSFET technology
- ElectroStatic Discharge (ESD) protection  $> 2$  kV HBM

## 3. Applications

- Battery switch
- High-speed line driver
- Low-side loadswitch
- Switching circuits

## 4. Quick reference data

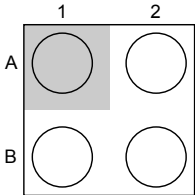
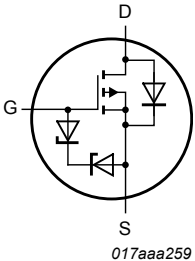
Table 1. Quick reference data

| Symbol                        | Parameter                        | Conditions                                                                        |     | Min | Typ | Max | Unit       |
|-------------------------------|----------------------------------|-----------------------------------------------------------------------------------|-----|-----|-----|-----|------------|
| $V_{DS}$                      | drain-source voltage             | $T_j = 25\text{ }^{\circ}\text{C}$                                                |     | -   | -   | -20 | V          |
| $V_{GS}$                      | gate-source voltage              |                                                                                   |     | -8  | -   | 8   | V          |
| $I_D$                         | drain current                    | $V_{GS} = -4.5\text{ V}; T_{amb} = 25\text{ }^{\circ}\text{C}; t \leq 5\text{ s}$ | [1] | -   | -   | -4  | A          |
| <b>Static characteristics</b> |                                  |                                                                                   |     |     |     |     |            |
| $R_{DSon}$                    | drain-source on-state resistance | $V_{GS} = -4.5\text{ V}; I_D = -3\text{ A}; T_j = 25\text{ }^{\circ}\text{C}$     |     | -   | 75  | 95  | m $\Omega$ |

[1] Device mounted on an FR4 Printed-Circuit Board (PCB), single-sided copper, tin-plated, mounting pad for drain  $6\text{ cm}^2$ .

5. Pinning information

Table 2. Pinning information

| Pin | Symbol | Description | Simplified outline                                                                                                                               | Graphic symbol                                                                      |
|-----|--------|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| A1  | G      | gate        |  <p>Transparent top view<br/><b>WLCSP4 (OL-PMCM4401UPE)</b></p> |  |
| A2  | S      | source      |                                                                                                                                                  |                                                                                     |
| B1  | D      | drain       |                                                                                                                                                  |                                                                                     |
| B2  | S      | source      |                                                                                                                                                  |                                                                                     |

6. Ordering information

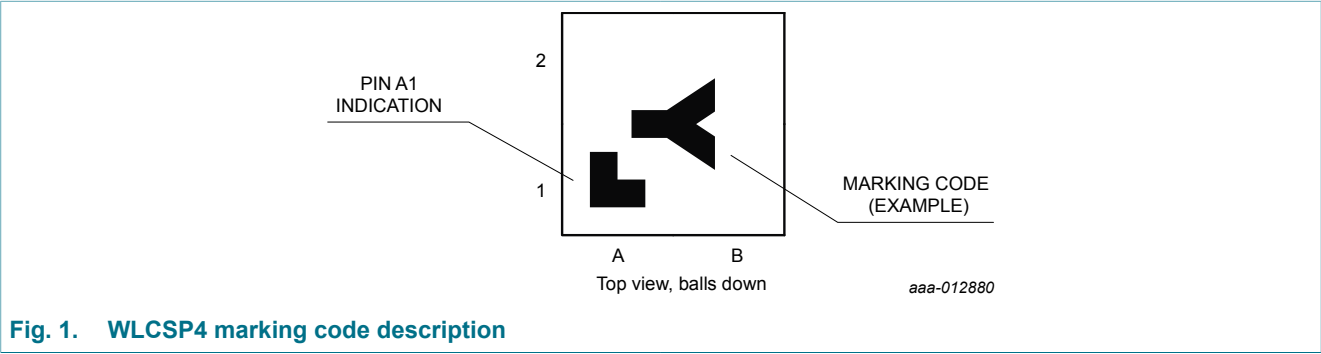
Table 3. Ordering information

| Type number | Package |                                                        |                |
|-------------|---------|--------------------------------------------------------|----------------|
|             | Name    | Description                                            | Version        |
| PMCM4401UPE | WLCSP4  | WLCSP4: wafer level chip-size package; 4 bumps (2 x 2) | OL-PMCM4401UPE |

7. Marking

Table 4. Marking codes

| Type number | Marking code |
|-------------|--------------|
| PMCM4401UPE | S            |



## 8. Limiting values

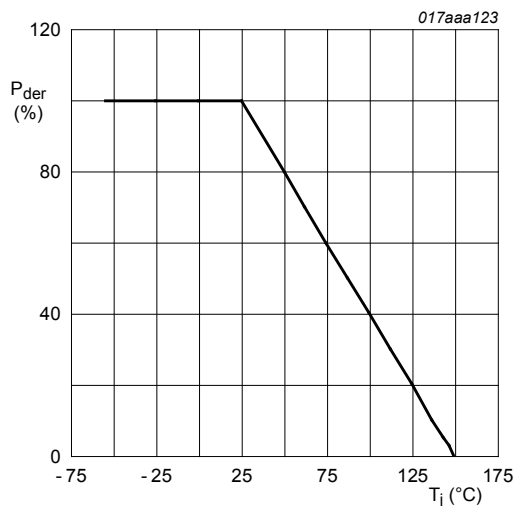
**Table 5. Limiting values**

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

| Symbol                    | Parameter               | Conditions                                                     |     | Min | Max   | Unit |
|---------------------------|-------------------------|----------------------------------------------------------------|-----|-----|-------|------|
| V <sub>DS</sub>           | drain-source voltage    | T <sub>j</sub> = 25 °C                                         |     | -   | -20   | V    |
| V <sub>GS</sub>           | gate-source voltage     |                                                                |     | -8  | 8     | V    |
| I <sub>D</sub>            | drain current           | V <sub>GS</sub> = -4.5 V; T <sub>amb</sub> = 25 °C; t ≤ 5 s    | [1] | -   | -4    | A    |
|                           |                         | V <sub>GS</sub> = -4.5 V; T <sub>amb</sub> = 25 °C             | [1] | -   | -3.2  | A    |
|                           |                         | V <sub>GS</sub> = -4.5 V; T <sub>amb</sub> = 100 °C            | [1] | -   | -2    | A    |
| I <sub>DM</sub>           | peak drain current      | T <sub>amb</sub> = 25 °C; single pulse; t <sub>p</sub> ≤ 10 μs |     | -   | -13   | A    |
| P <sub>tot</sub>          | total power dissipation | T <sub>amb</sub> = 25 °C                                       | [2] | -   | 400   | mW   |
|                           |                         |                                                                | [1] | -   | 1300  | mW   |
|                           |                         | T <sub>sp</sub> = 25 °C                                        |     | -   | 12500 | mW   |
| T <sub>j</sub>            | junction temperature    |                                                                |     | -55 | 150   | °C   |
| T <sub>amb</sub>          | ambient temperature     |                                                                |     | -55 | 150   | °C   |
| T <sub>stg</sub>          | storage temperature     |                                                                |     | -65 | 150   | °C   |
| <b>Source-drain diode</b> |                         |                                                                |     |     |       |      |
| I <sub>S</sub>            | source current          | T <sub>amb</sub> = 25 °C                                       | [1] | -   | -1.2  | A    |

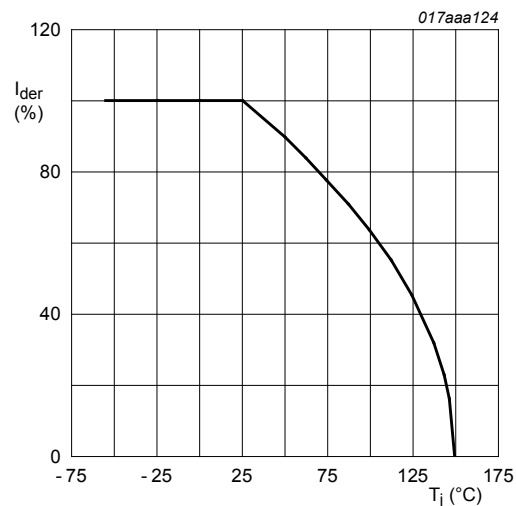
[1] Device mounted on an FR4 Printed-Circuit Board (PCB), single-sided copper, tin-plated, mounting pad for drain 6 cm<sup>2</sup>.

[2] Device mounted on an FR4 Printed-Circuit Board (PCB), single-sided copper, tin-plated and standard footprint.



$$P_{der} = \frac{P_{tot}}{P_{tot(25^\circ\text{C})}} \times 100 \%$$

**Fig. 2. MOSFET transistor: Normalized total power dissipation as a function of junction temperature**



$$I_{der} = \frac{I_D}{I_{D(25^\circ\text{C})}} \times 100 \%$$

**Fig. 3. MOSFET transistor: Normalized continuous drain current as a function of junction temperature**

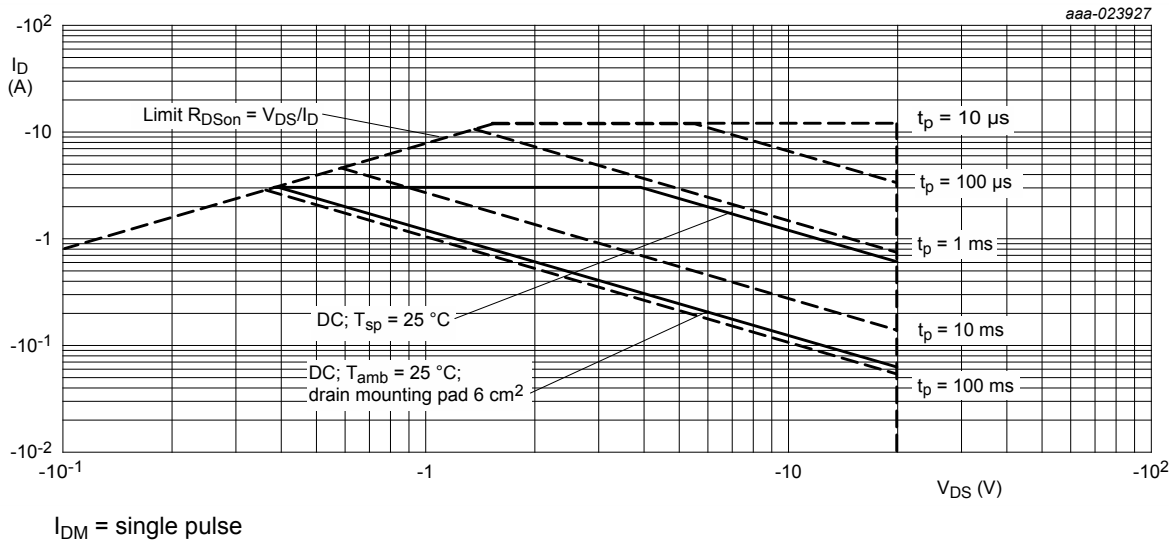


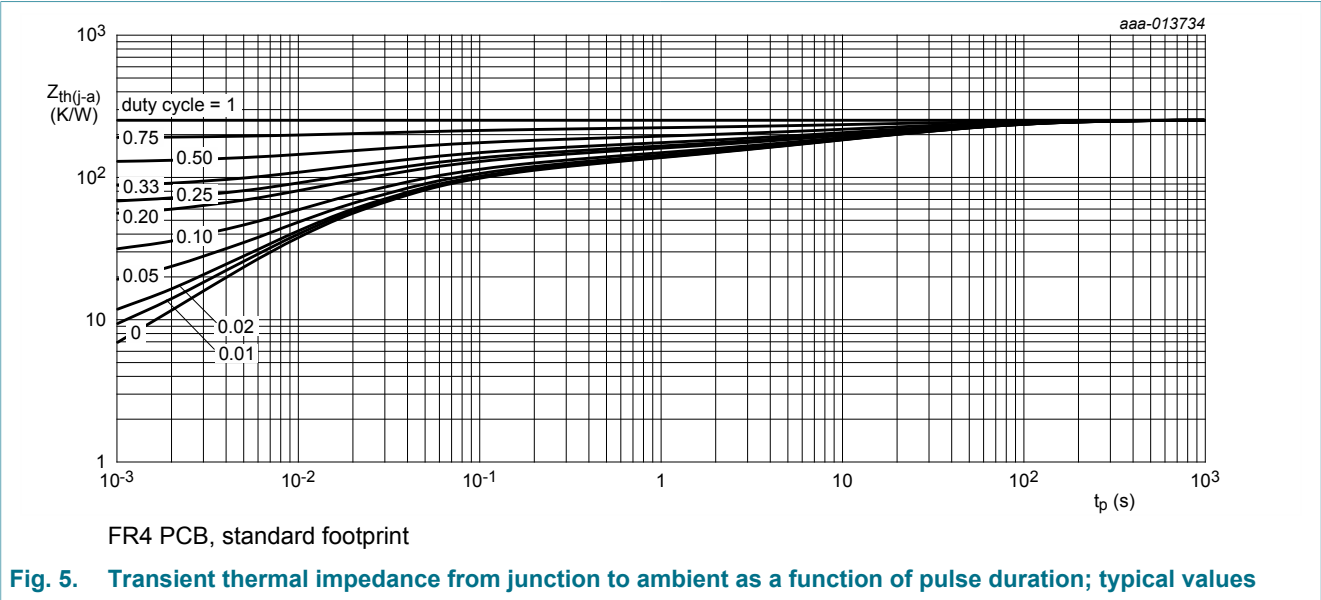
Fig. 4. Safe operating area; junction to ambient; continuous and peak drain currents as a function of drain-source voltage

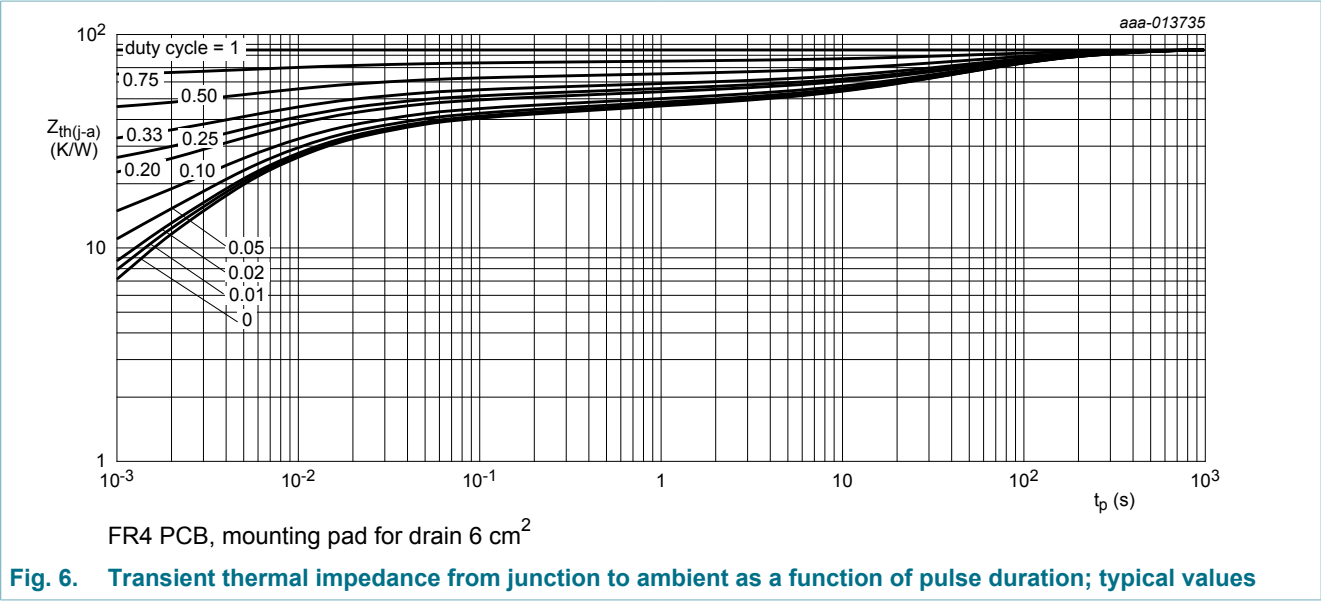
9. Thermal characteristics

Table 6. Thermal characteristics

| Symbol                | Parameter                                        | Conditions           |     | Min | Typ | Max | Unit |
|-----------------------|--------------------------------------------------|----------------------|-----|-----|-----|-----|------|
| R <sub>th(j-a)</sub>  | thermal resistance from junction to ambient      | in free air          | [1] | -   | 250 | 300 | K/W  |
|                       |                                                  |                      | [2] | -   | 70  | 85  | K/W  |
|                       |                                                  |                      | [3] | -   | 85  | 100 | K/W  |
|                       |                                                  | in free air; t ≤ 5 s | [3] | -   | 50  | 60  | K/W  |
| R <sub>th(j-sp)</sub> | thermal resistance from junction to solder point |                      |     | -   | 5   | 10  | K/W  |

- [1] Device mounted on an FR4 PCB, single-sided copper, tin-plated and standard footprint.  
[2] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for drain, 4-layer, 1 cm<sup>2</sup>.  
[3] Device mounted on an FR4 PCB, single-sided copper, tin-plated, mounting pad for drain 6 cm<sup>2</sup>.





## 10. Characteristics

Table 7. Characteristics

| Symbol                  | Parameter                        | Conditions                                                                                                                    |  | Min  | Typ  | Max  | Unit |
|-------------------------|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------|--|------|------|------|------|
| Static characteristics  |                                  |                                                                                                                               |  |      |      |      |      |
| V <sub>(BR)DSS</sub>    | drain-source breakdown voltage   | I <sub>D</sub> = -250 μA; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                       |  | -20  | -    | -    | V    |
| V <sub>GSth</sub>       | gate-source threshold voltage    | I <sub>D</sub> = -250 μA; V <sub>DS</sub> =V <sub>GS</sub> ; T <sub>j</sub> = 25 °C                                           |  | -0.4 | -0.6 | -0.9 | V    |
| I <sub>DSS</sub>        | drain leakage current            | V <sub>DS</sub> = -20 V; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                        |  | -    | -    | -1   | μA   |
| I <sub>GSS</sub>        | gate leakage current             | V <sub>GS</sub> = -8 V; V <sub>DS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                         |  | -    | -    | -10  | μA   |
|                         |                                  | V <sub>GS</sub> = 8 V; V <sub>DS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                          |  | -    | -    | 10   | μA   |
|                         |                                  | V <sub>GS</sub> = -4.5 V; V <sub>DS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                       |  | -    | -    | -1   | μA   |
|                         |                                  | V <sub>GS</sub> = 4.5 V; V <sub>DS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                        |  | -    | -    | 1    | μA   |
|                         |                                  | V <sub>GS</sub> = -2.5 V; V <sub>DS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                       |  | -    | -    | -200 | nA   |
|                         |                                  | V <sub>GS</sub> = 2.5 V; V <sub>DS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                        |  | -    | -    | 200  | nA   |
| R <sub>DSon</sub>       | drain-source on-state resistance | V <sub>GS</sub> = -4.5 V; I <sub>D</sub> = -3 A; T <sub>j</sub> = 25 °C                                                       |  | -    | 75   | 95   | mΩ   |
|                         |                                  | V <sub>GS</sub> = -4.5 V; I <sub>D</sub> = -3 A; T <sub>j</sub> = 150 °C                                                      |  | -    | 100  | 120  | mΩ   |
|                         |                                  | V <sub>GS</sub> = -2.5 V; I <sub>D</sub> = -2 A; T <sub>j</sub> = 25 °C                                                       |  | -    | 95   | 130  | mΩ   |
|                         |                                  | V <sub>GS</sub> = -1.8 V; I <sub>D</sub> = -0.1 A; T <sub>j</sub> = 25 °C                                                     |  | -    | 130  | 190  | mΩ   |
| g <sub>fs</sub>         | forward transconductance         | V <sub>DS</sub> = -6 V; I <sub>D</sub> = -3 A; T <sub>j</sub> = 25 °C                                                         |  | -    | 10.8 | -    | S    |
| R <sub>G</sub>          | gate resistance                  | f = 1 MHz                                                                                                                     |  | -    | 7    | -    | Ω    |
| Dynamic characteristics |                                  |                                                                                                                               |  |      |      |      |      |
| Q <sub>G(tot)</sub>     | total gate charge                | V <sub>DS</sub> = -10 V; I <sub>D</sub> = -3 A; V <sub>GS</sub> = -4.5 V; T <sub>j</sub> = 25 °C                              |  | -    | 5.9  | 10   | nC   |
| Q <sub>GS</sub>         | gate-source charge               |                                                                                                                               |  | -    | 0.6  | -    | nC   |
| Q <sub>GD</sub>         | gate-drain charge                |                                                                                                                               |  | -    | 1.7  | -    | nC   |
| C <sub>iss</sub>        | input capacitance                | V <sub>DS</sub> = -10 V; f = 1 MHz; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 25 °C                                             |  | -    | 420  | -    | pF   |
| C <sub>oss</sub>        | output capacitance               |                                                                                                                               |  | -    | 64   | -    | pF   |
| C <sub>rss</sub>        | reverse transfer capacitance     |                                                                                                                               |  | -    | 58   | -    | pF   |
| t <sub>d(on)</sub>      | turn-on delay time               | V <sub>DS</sub> = -10 V; I <sub>D</sub> = -3.3 A; V <sub>GS</sub> = -4.5 V; R <sub>G(ext)</sub> = 6 Ω; T <sub>j</sub> = 25 °C |  | -    | 4    | -    | ns   |
| t <sub>r</sub>          | rise time                        |                                                                                                                               |  | -    | 18   | -    | ns   |
| t <sub>d(off)</sub>     | turn-off delay time              |                                                                                                                               |  | -    | 31   | -    | ns   |
| t <sub>f</sub>          | fall time                        |                                                                                                                               |  | -    | 13   | -    | ns   |
| Source-drain diode      |                                  |                                                                                                                               |  |      |      |      |      |
| V <sub>SD</sub>         | source-drain voltage             | I <sub>S</sub> = -1.2 A; V <sub>GS</sub> = 0 V; T <sub>j</sub> = 25 °C                                                        |  | -    | -0.8 | -1.2 | V    |

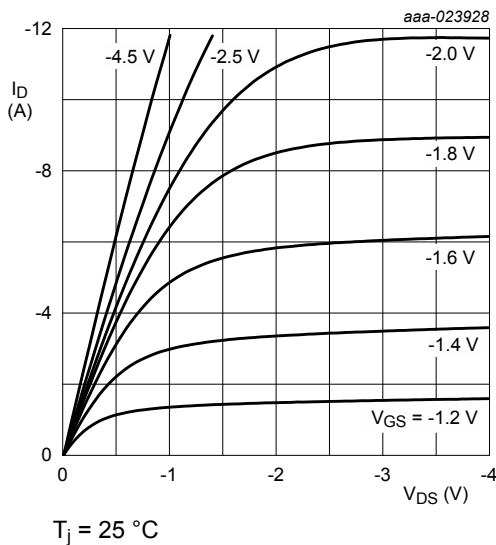


Fig. 7. Output characteristics: drain current as a function of drain-source voltage; typical values

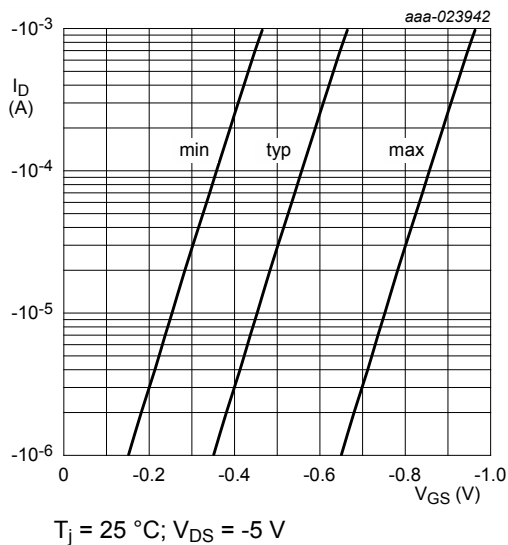


Fig. 8. Sub-threshold drain current as a function of gate-source voltage

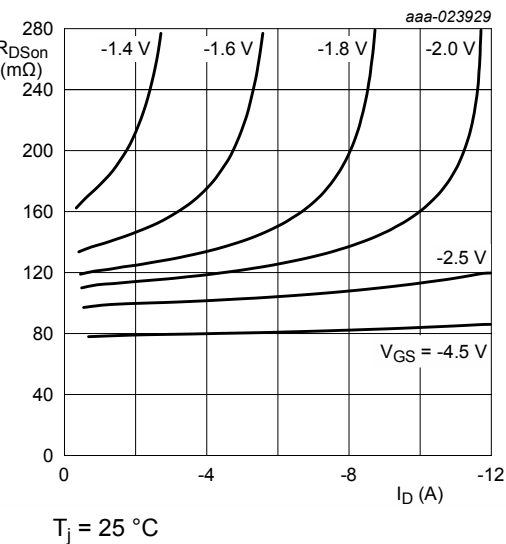


Fig. 9. Drain-source on-state resistance as a function of drain current; typical values

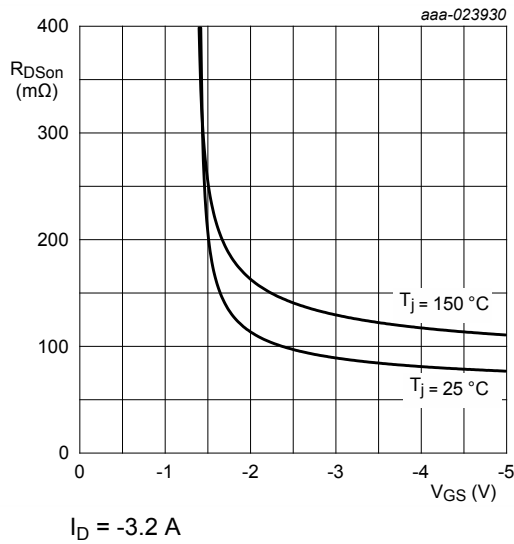


Fig. 10. Drain-source on-state resistance as a function of gate-source voltage; typical values



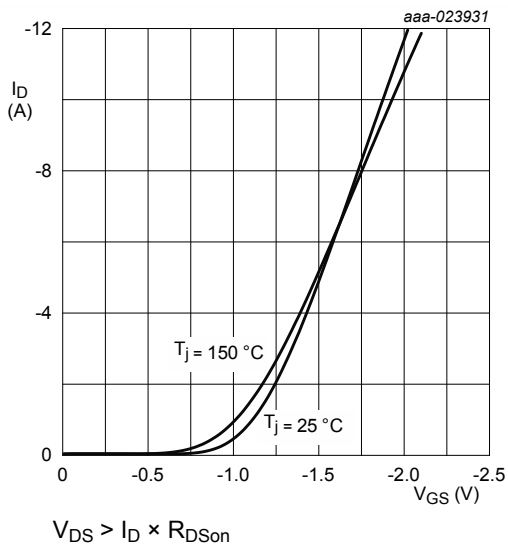


Fig. 11. Transfer characteristics: drain current as a function of gate-source voltage; typical values

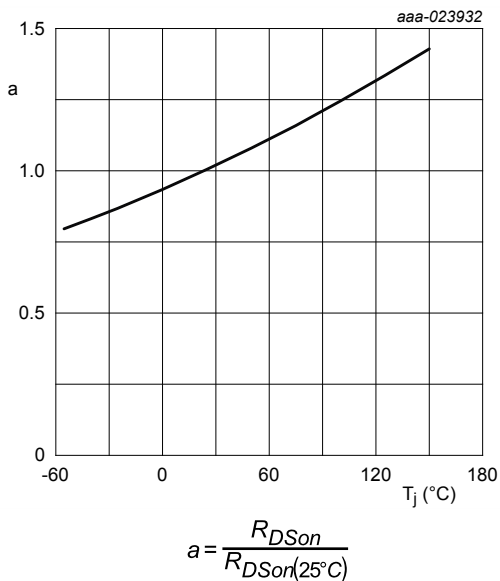


Fig. 12. Normalized drain-source on-state resistance as a function of junction temperature; typical values

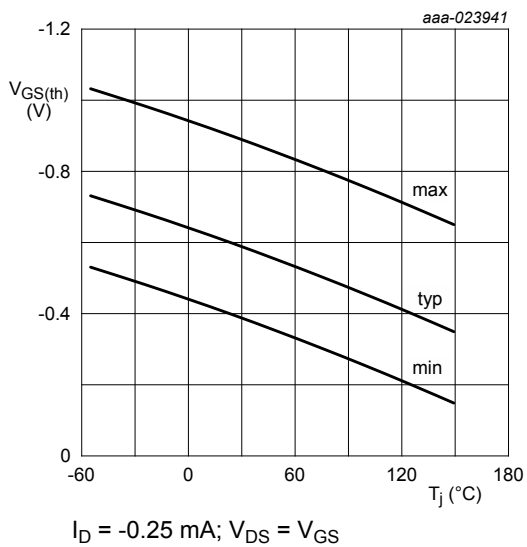


Fig. 13. Gate-source threshold voltage as a function of junction temperature

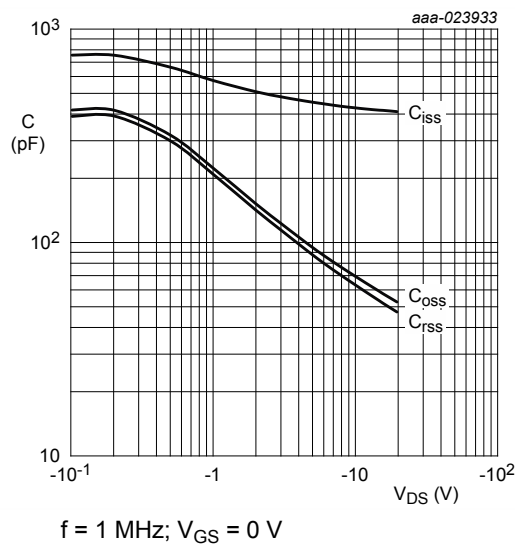


Fig. 14. Input, output and reverse transfer capacitances as a function of drain-source voltage; typical values

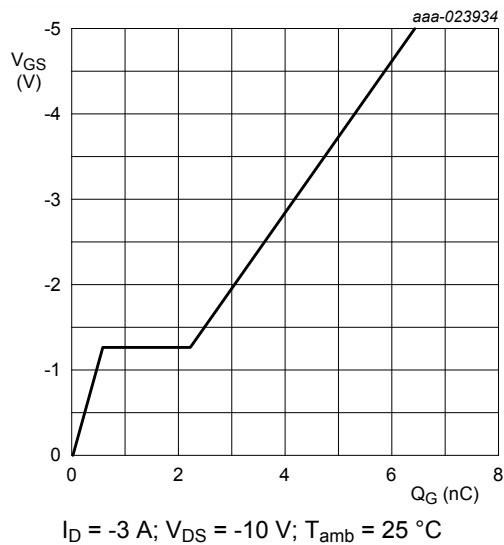


Fig. 15. Gate-source voltage as a function of gate charge; typical values

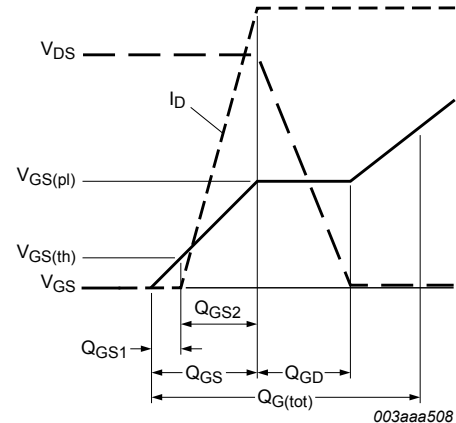


Fig. 16. MOSFET transistor: Gate charge waveform definitions

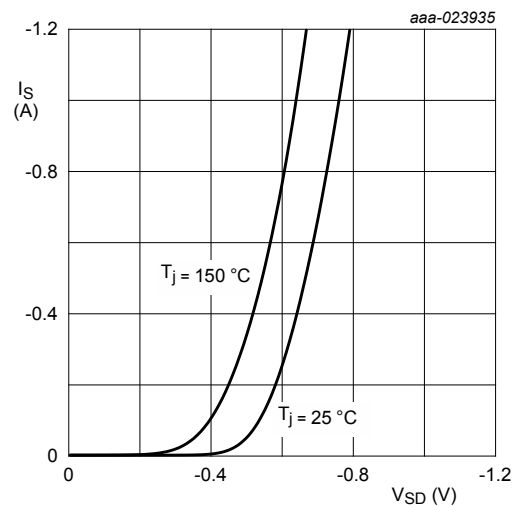


Fig. 17. Source current as a function of source-drain voltage; typical values

11. Test information

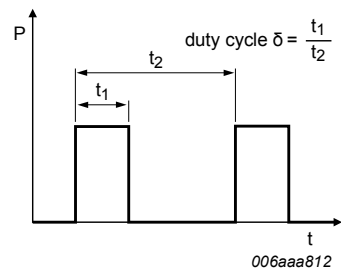


Fig. 18. Duty cycle definition

12. Package outline

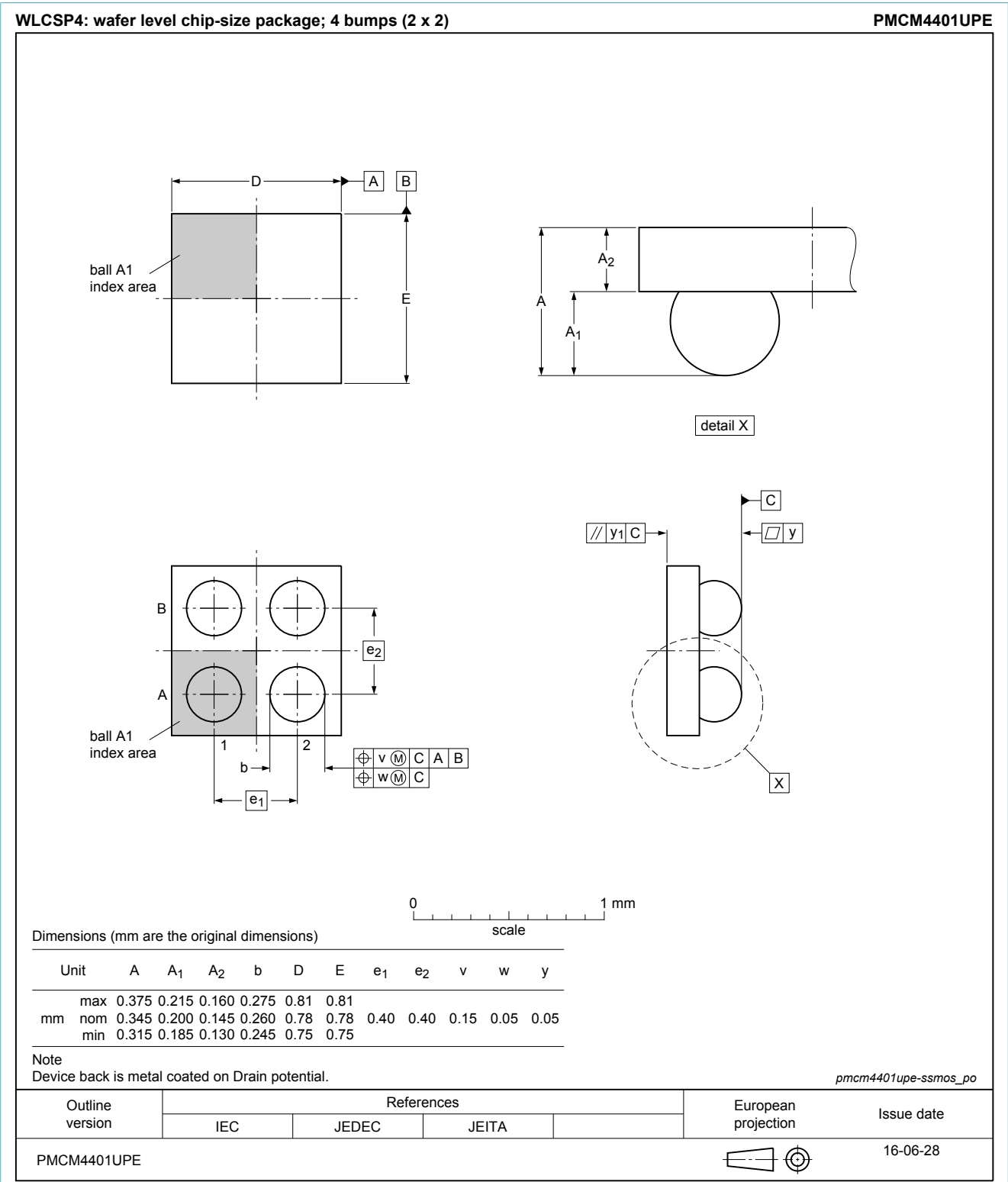
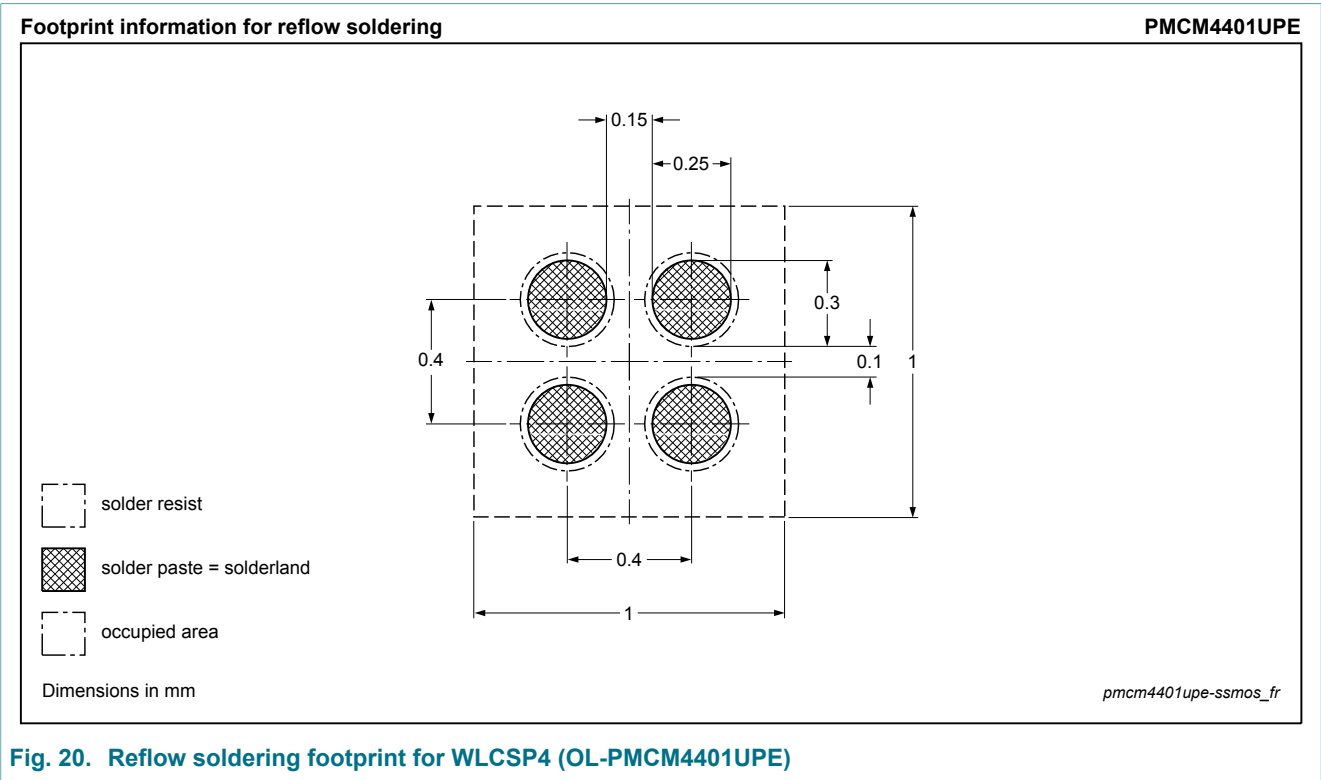


Fig. 19. Package outline WLCSP4 (OL-PMCM4401UPE)

13. Soldering



14. Revision history

Table 8. Revision history

| Data sheet ID   | Release date                                                                                                                                                                                                                                                                 | Data sheet status  | Change notice | Supersedes      |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|---------------|-----------------|
| PMCM4401UPE v.2 | 20161007                                                                                                                                                                                                                                                                     | Product data sheet | -             | PMCM4401UPE v.1 |
| Modification:   | <ul style="list-style-type: none"><li><math>R_{\text{dson}}</math> at <math>V_{\text{GS}} = -4.5 \text{ V}</math>; <math>I_{\text{D}} = -3 \text{ A}</math>; <math>T_{\text{j}} = 25 \text{ }^{\circ}\text{C}</math> corrected to <math>95 \text{ m}\Omega</math>.</li></ul> |                    |               |                 |
| PMCM4401UPE v.1 | 20160704                                                                                                                                                                                                                                                                     | Product data sheet | -             | -               |

## 15. 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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16. 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..... 5

10. Characteristics.....7

11. Test information..... 10

12. Package outline..... 11

13. Soldering..... 12

14. Revision history.....13

15. Legal information..... 14

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