



# PMCM4401VPE

12 V, P-channel Trench MOSFET

29 July 2015

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 × 0.78 × 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

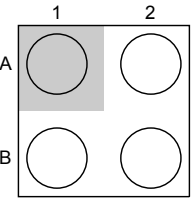
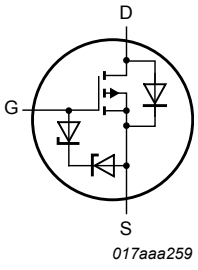
Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{DS}$	drain-source voltage	$T_j = 25\text{ °C}$	-	-	-12	V
$V_{GS}$	gate-source voltage		-8	-	8	V
$I_D$	drain current	$V_{GS} = -4.5\text{ V}; T_{amb} = 25\text{ °C}; t \leq 5\text{ s}$	[1]	-	-4.9	A
<b>Static characteristics</b>						
$R_{DSon}$	drain-source on-state resistance	$V_{GS} = -4.5\text{ V}; I_D = -3\text{ A}; T_j = 25\text{ °C}$	-	55	65	mΩ

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

### 5. Pinning information

Table 2. Pinning information

Pin	Symbol	Description	Simplified outline	Graphic symbol
A1	G	gate	 <p>Transparent top view <b>WLCSP4 (OL-PMCM4401VPE)</b></p>	 <p>017aaa259</p>
A2	S	source		
B1	D	drain		
B2	S	source		

### 6. Ordering information

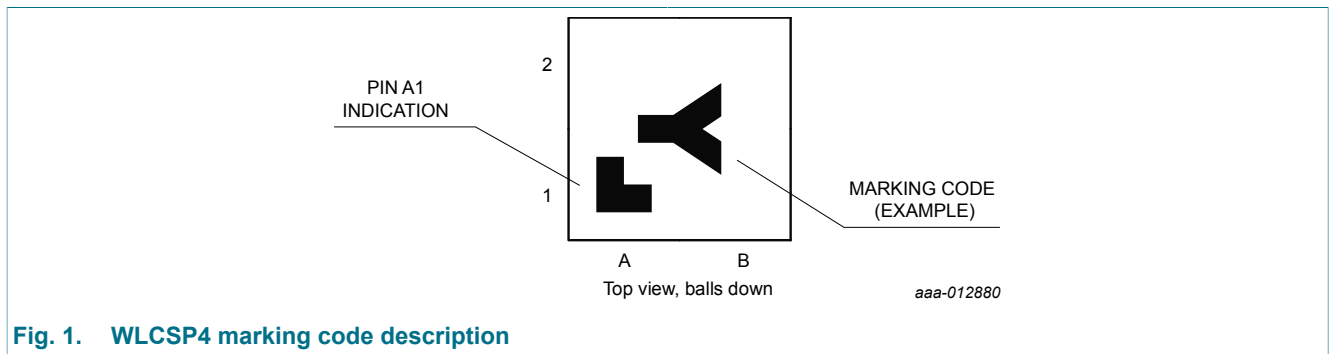
Table 3. Ordering information

Type number	Package		
	Name	Description	Version
PMCM4401VPE	WLCSP4	WLCSP4: wafer level chip-size package; 4 bumps (2 x 2)	OL-PMCM4401VPE

### 7. Marking

Table 4. Marking codes

Type number	Marking code
PMCM4401VPE	Q



## 8. Limiting values

**Table 5. Limiting values**

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

Symbol	Parameter	Conditions		Min	Max	Unit
$V_{DS}$	drain-source voltage	$T_j = 25\text{ °C}$		-	-12	V
$V_{GS}$	gate-source voltage			-8	8	V
$I_D$	drain current	$V_{GS} = -4.5\text{ V}; T_{amb} = 25\text{ °C}; t \leq 5\text{ s}$	[1]	-	-4.9	A
		$V_{GS} = -4.5\text{ V}; T_{amb} = 25\text{ °C}$	[1]	-	-3.9	A
		$V_{GS} = -4.5\text{ V}; T_{amb} = 100\text{ °C}$	[1]	-	-2.5	A
$I_{DM}$	peak drain current	$T_{amb} = 25\text{ °C}; \text{single pulse}; t_p \leq 10\text{ }\mu\text{s}$		-	-16	A
$P_{tot}$	total power dissipation	$T_{amb} = 25\text{ °C}$	[2]	-	400	mW
			[1]	-	1300	mW
		$T_{sp} = 25\text{ °C}$		-	12500	mW
$T_j$	junction temperature			-55	150	°C
$T_{amb}$	ambient temperature			-55	150	°C
$T_{stg}$	storage temperature			-65	150	°C
<b>Source-drain diode</b>						
$I_S$	source current	$T_{amb} = 25\text{ °C}$	[1]	-	-1.2	A

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



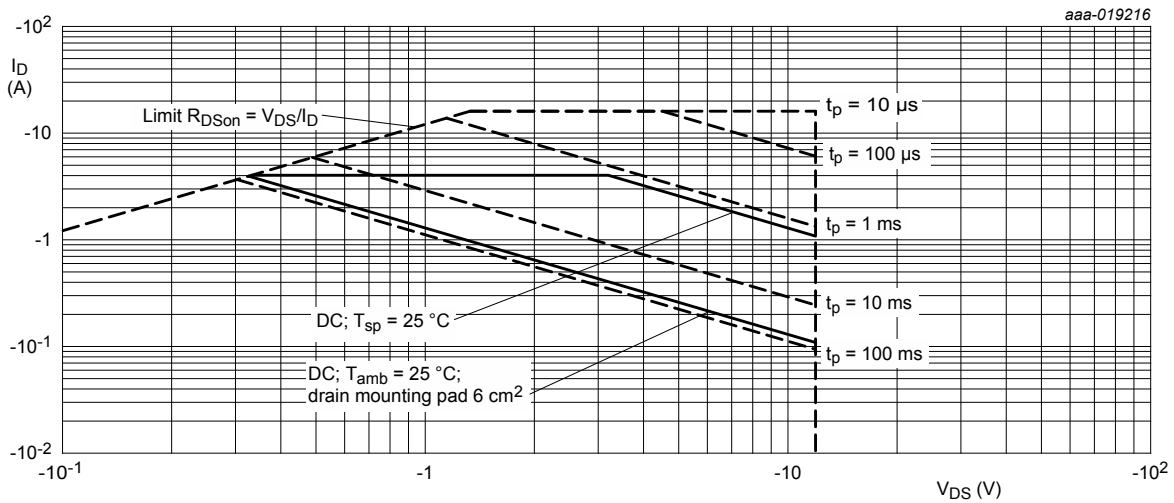
Fig. 2. MOSFET transistor: Normalized total power dissipation as a function of junction temperature

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



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

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



I<sub>DM</sub> = single pulse

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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
		in free air; $t \leq 5$ s	[3]	-	50	60	K/W
$R_{th(j-sp)}$	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>.

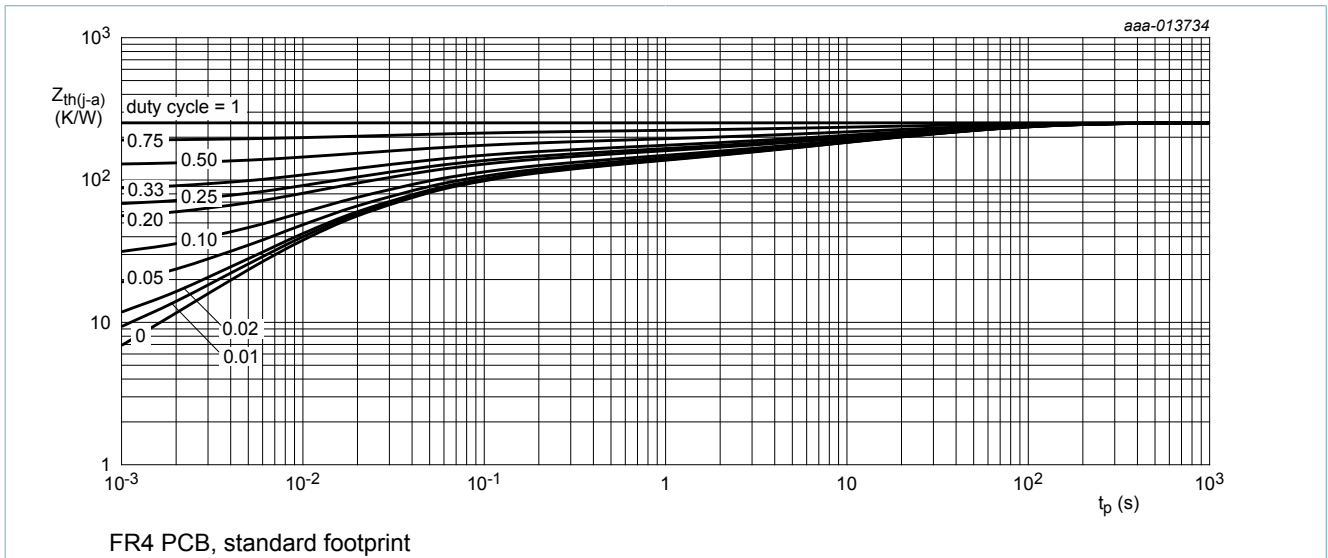


Fig. 5. Transient thermal impedance from junction to ambient as a function of pulse duration; typical values

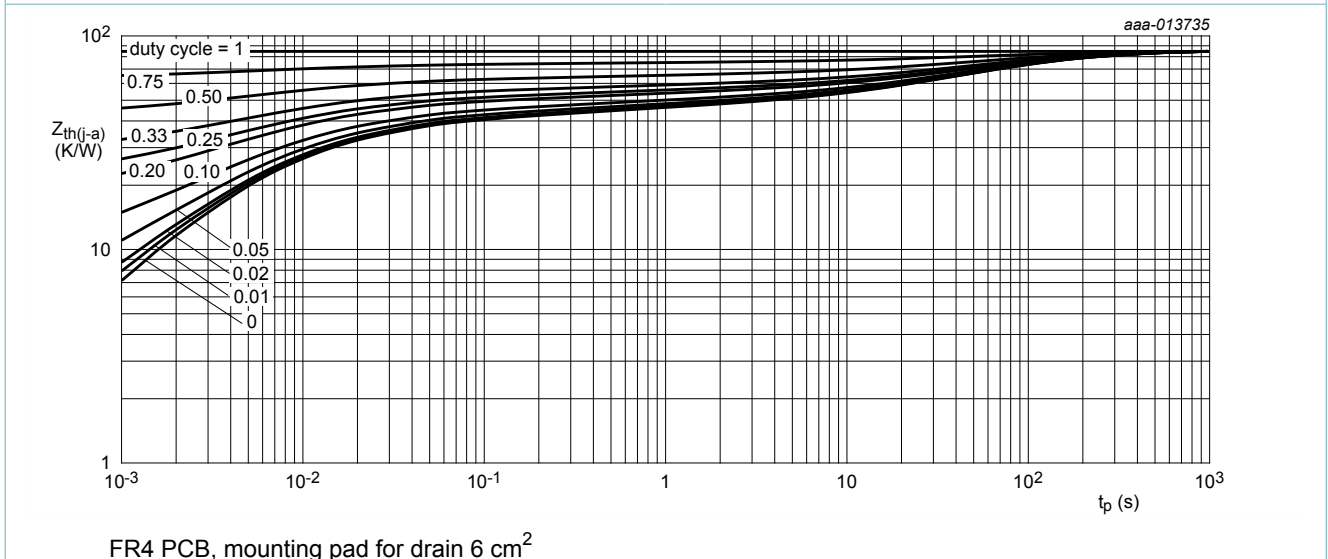
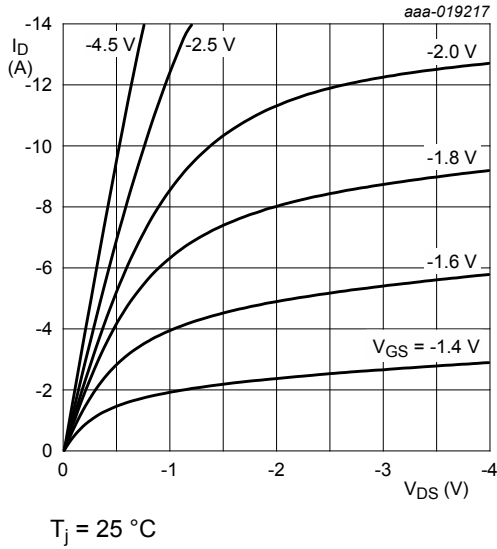


Fig. 6. Transient thermal impedance from junction to ambient as a function of pulse duration; typical values

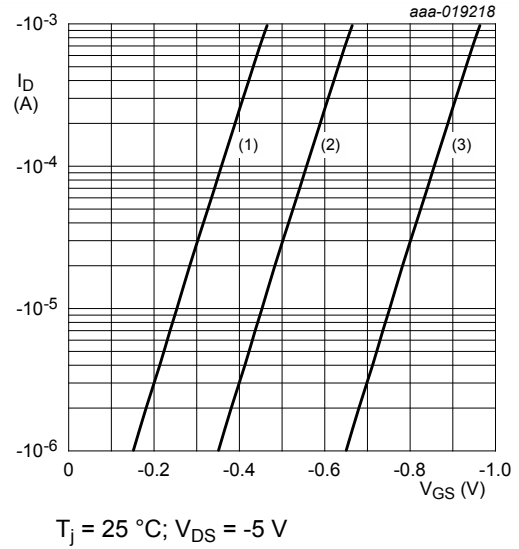
## 10. Characteristics

Table 7. Characteristics

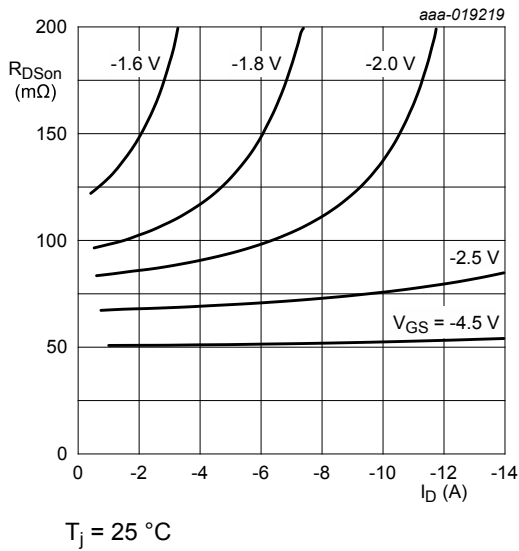
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Static characteristics</b>						
$V_{(BR)DSS}$	drain-source breakdown voltage	$I_D = -250 \mu A$ ; $V_{GS} = 0 V$ ; $T_j = 25 \text{ }^\circ C$	-12	-	-	V
$V_{GSth}$	gate-source threshold voltage	$I_D = -250 \mu A$ ; $V_{DS} = V_{GS}$ ; $T_j = 25 \text{ }^\circ C$	-0.4	-0.6	-0.9	V
$I_{DSS}$	drain leakage current	$V_{DS} = -12 V$ ; $V_{GS} = 0 V$ ; $T_j = 25 \text{ }^\circ C$	-	-	-1	$\mu A$
$I_{GSS}$	gate leakage current	$V_{GS} = -8 V$ ; $V_{DS} = 0 V$ ; $T_j = 25 \text{ }^\circ C$	-	-	-10	$\mu A$
		$V_{GS} = 8 V$ ; $V_{DS} = 0 V$ ; $T_j = 25 \text{ }^\circ C$	-	-	10	$\mu A$
		$V_{GS} = -4.5 V$ ; $V_{DS} = 0 V$ ; $T_j = 25 \text{ }^\circ C$	-	-	-1	$\mu A$
		$V_{GS} = 4.5 V$ ; $V_{DS} = 0 V$ ; $T_j = 25 \text{ }^\circ C$	-	-	1	$\mu A$
		$V_{GS} = -2.5 V$ ; $V_{DS} = 0 V$ ; $T_j = 25 \text{ }^\circ C$	-	-	-200	nA
		$V_{GS} = 2.5 V$ ; $V_{DS} = 0 V$ ; $T_j = 25 \text{ }^\circ C$	-	-	200	nA
$R_{DSon}$	drain-source on-state resistance	$V_{GS} = -4.5 V$ ; $I_D = -3 A$ ; $T_j = 25 \text{ }^\circ C$	-	55	65	m $\Omega$
		$V_{GS} = -4.5 V$ ; $I_D = -3 A$ ; $T_j = 150 \text{ }^\circ C$	-	73	86	m $\Omega$
		$V_{GS} = -2.5 V$ ; $I_D = -2 A$ ; $T_j = 25 \text{ }^\circ C$	-	77	96	m $\Omega$
		$V_{GS} = -1.8 V$ ; $I_D = -0.1 A$ ; $T_j = 25 \text{ }^\circ C$	-	110	160	m $\Omega$
$g_{fs}$	forward transconductance	$V_{DS} = -6 V$ ; $I_D = -3 A$ ; $T_j = 25 \text{ }^\circ C$	-	13.6	-	S
$R_G$	gate resistance	$f = 1 \text{ MHz}$	-	5.5	-	$\Omega$
<b>Dynamic characteristics</b>						
$Q_{G(tot)}$	total gate charge	$V_{DS} = -6 V$ ; $I_D = -3 A$ ; $V_{GS} = -4.5 V$ ; $T_j = 25 \text{ }^\circ C$	-	6.8	10	nC
$Q_{GS}$	gate-source charge		-	0.8	-	nC
$Q_{GD}$	gate-drain charge		-	2.2	-	nC
$C_{iss}$	input capacitance	$V_{DS} = -6 V$ ; $f = 1 \text{ MHz}$ ; $V_{GS} = 0 V$ ; $T_j = 25 \text{ }^\circ C$	-	415	-	pF
$C_{oss}$	output capacitance		-	195	-	pF
$C_{rss}$	reverse transfer capacitance		-	165	-	pF
$t_{d(on)}$	turn-on delay time	$V_{DS} = -6 V$ ; $I_D = -3.5 A$ ; $V_{GS} = -4.5 V$ ; $R_{G(ext)} = 6 \Omega$ ; $T_j = 25 \text{ }^\circ C$	-	4.8	-	ns
$t_r$	rise time		-	24.7	-	ns
$t_{d(off)}$	turn-off delay time		-	25.1	-	ns
$t_f$	fall time		-	16.5	-	ns
<b>Source-drain diode</b>						
$V_{SD}$	source-drain voltage	$I_S = -1.2 A$ ; $V_{GS} = 0 V$ ; $T_j = 25 \text{ }^\circ C$	-	-0.8	-1.2	V



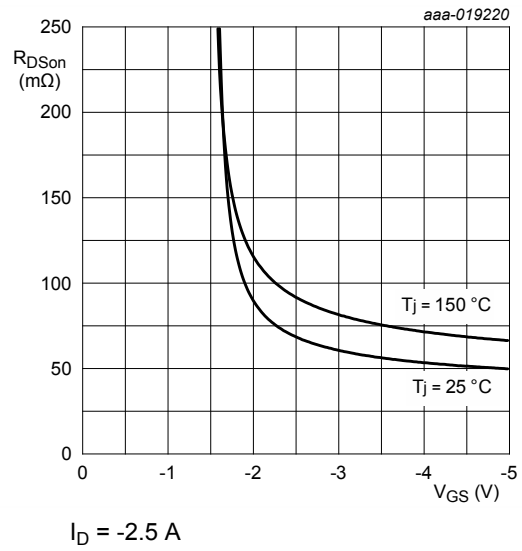
**Fig. 7. Output characteristics: drain current as a function of drain-source voltage; typical values**



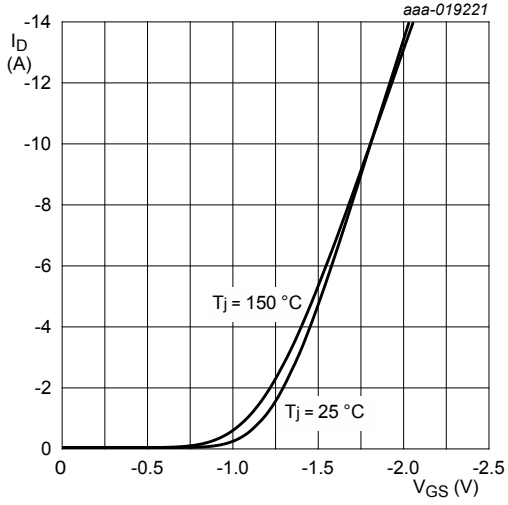
**Fig. 8. Sub-threshold drain current as a function of gate-source voltage**



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

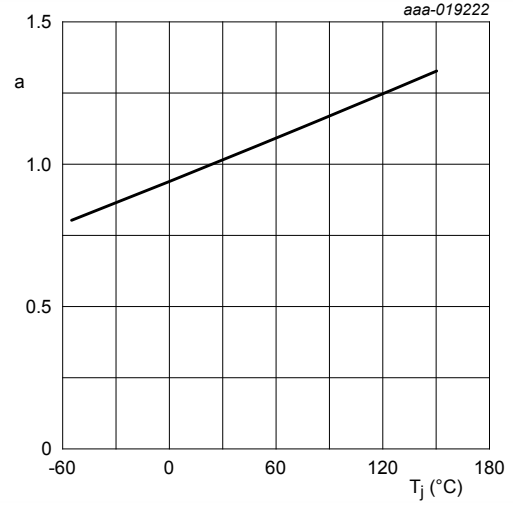


**Fig. 10. Drain-source on-state resistance as a function of gate-source voltage; typical values**



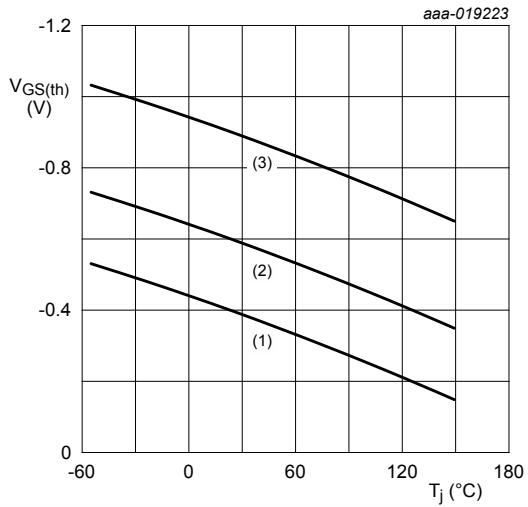
$$V_{DS} > I_D \times R_{DSon}$$

**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**

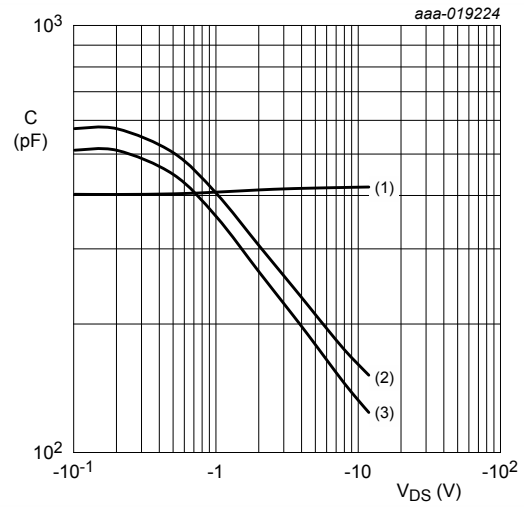
$$a = \frac{R_{DSon}}{R_{DSon(25^\circ C)}}$$



$$I_D = -0.25 \text{ mA}; V_{DS} = V_{GS}$$

- (1) minimum values
- (2) typical values
- (3) maximum values

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

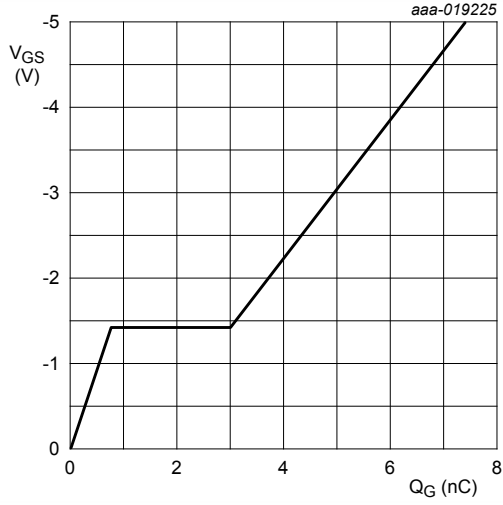


$$f = 1 \text{ MHz}; V_{GS} = 0 \text{ V}$$

- (1)  $C_{iss}$
- (2)  $C_{oss}$
- (3)  $C_{rss}$

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





$I_D = -3$  A;  $V_{DS} = -6$  V;  $T_{amb} = 25$  °C

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

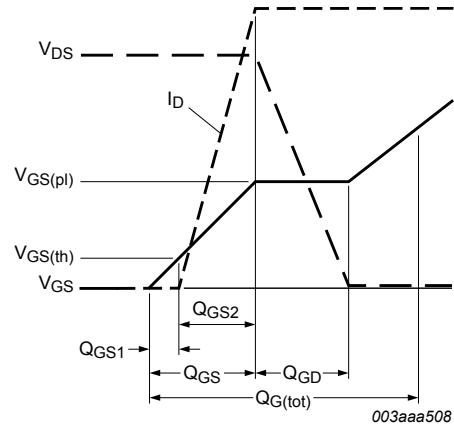
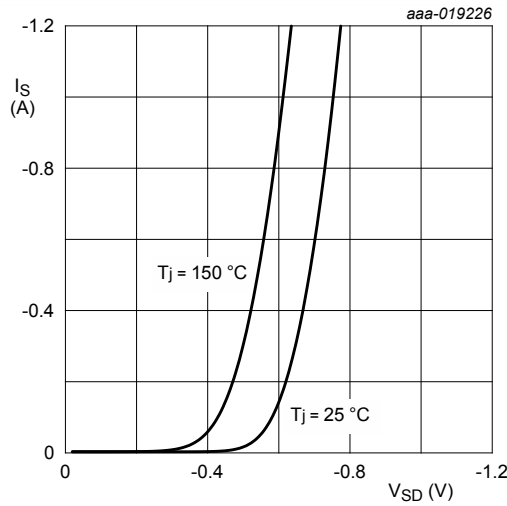


Fig. 16. MOSFET transistor: Gate charge waveform definitions



$V_{GS} = 0$  V

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

## 11. Test information

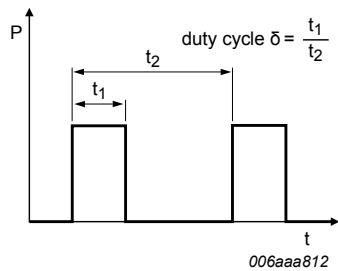


Fig. 18. Duty cycle definition

## 12. Package outline

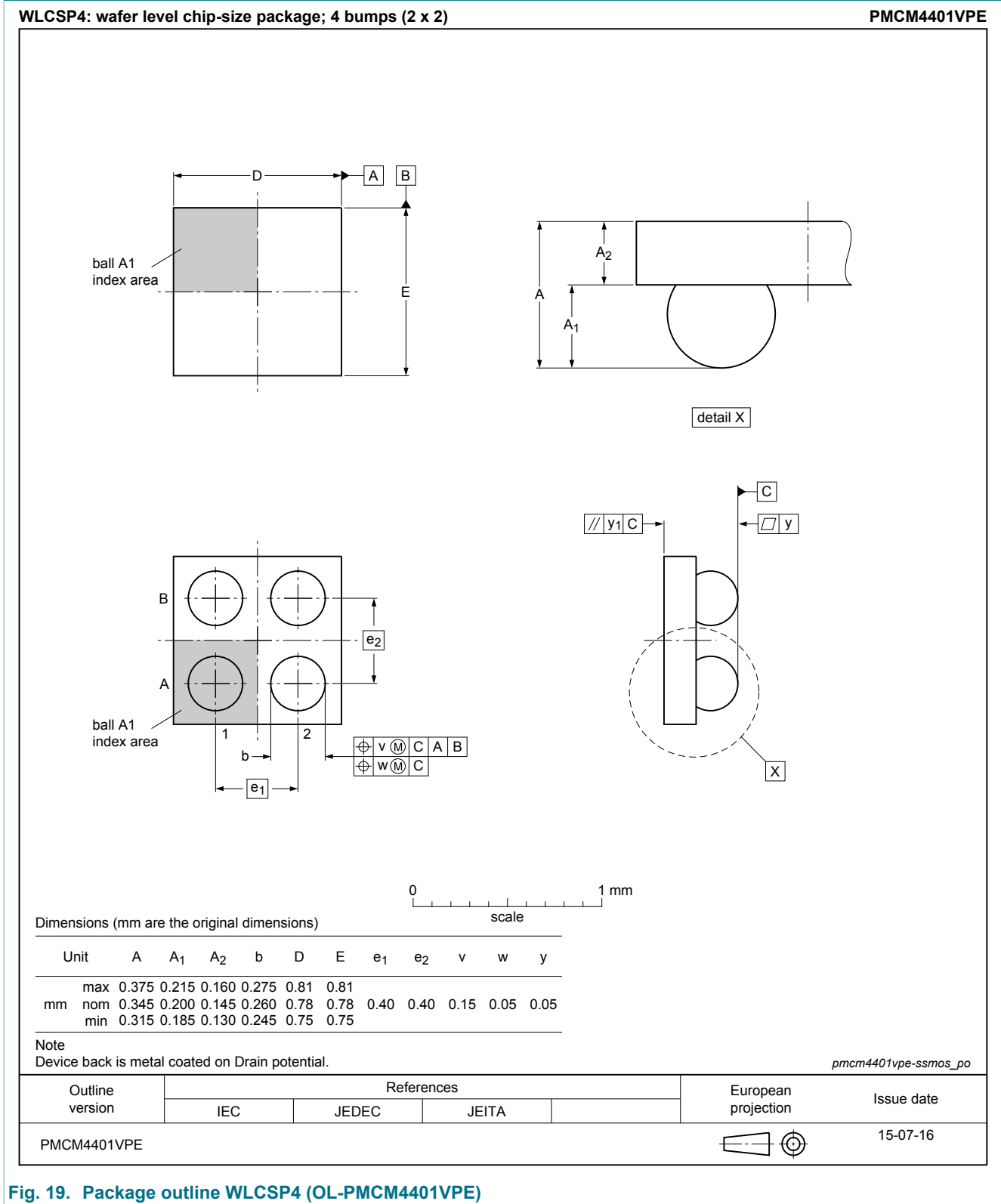


Fig. 19. Package outline WLCSP4 (OL-PMCM4401VPE)

### 13. Soldering

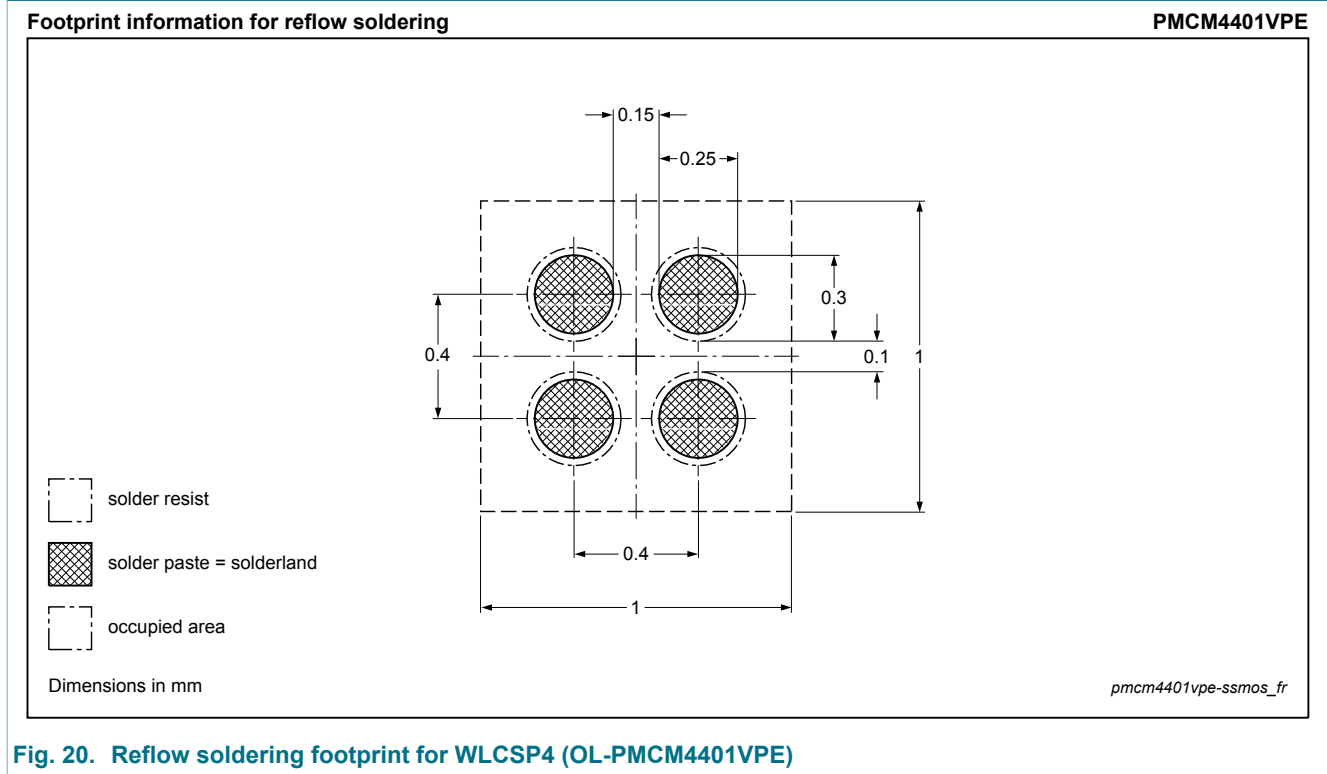


Fig. 20. Reflow soldering footprint for WLCSP4 (OL-PMCM4401VPE)

## 14. Revision history

Table 8. Revision history

Data sheet ID	Release date	Data sheet status	Change notice	Supersedes
PMCM4401VPE v.1	20150729	Product data sheet	-	-

## 15. Legal information

### 15.1 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.

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