Common-mode EMI filter for differential channels with integrated ESD protection

Rev. 3 — 7 March 2019

1. General description

Common-mode ElectroMagnetic Interference (EMI) filters with integrated ElectroStatic Discharge (ESD) protection for one, two and three differential channels. The devices are designed to provide low insertion loss for differential high-speed signals on each channel while unwanted common-mode signals are attenuated.

Each differential channel incorporates two signal lines that are coupled by integrated coils. Diodes provide protection to downstream components from ESD voltages up to ±15 kV on each signal line.

Table 1. Product overview

Type number	Number of channels	Package Name
PCMF1USB3S	1	WLCSP5
PCMF2USB3S	2	WLCSP10
PCMF3USB3S	3	WLCSP15

2. Features and benefits

- One, two and three differential channels common-mode EMI filters with integrated ESD protection
- ESD protection up to ±15 kV contact discharge according to IEC 61000-4-2
- Superior common-mode suppression over a wide frequency range
- Superior RF performance compared to other integrated filters or discrete filters with external ESD protection
- Extremely high symmetry between line pairs
- Industry-standard Wafer-Level Chip-Scale Packages: WLCSP5, 10 and 15 for smaller footprint

3. Applications

- Smartphone, cellular and cordless phone
- Tablet PC and Mobile Internet Device (MID)
- USB 3.2, USB 2.0, HDMI 2.0, HDMI 1.4
- MIPI M-PHY and D-PHY as used in Camera Serial Interface (CSI) and Display Serial Interface (DSI)
- General-purpose EMI and Radio-Frequency Interference (RFI) filter and downstream ESD protection

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4. Pinning information

	2. Pinning	-		
Pin	Symbol	Description	Simplified outline	Graphic symbol
PCMF	1USB3S (WLCS		1	
A1	CH1_IN+	channel 1+, external	2	A1C1
A2	CH1_IN-	channel 1-, external	(B1)	A2C2
B1	GND_CH1	ground channel 1		
C1	CH1_OUT+	channel 1+, internal	A B C	
C2	CH1_OUT-	channel 1-, internal	Transparent top view	
			WLCSP5_2-1-2	- <u>+</u> B1
				aaa-019784
PCMF	2USB3S (WLCS	P10_4-2-4)		
A1	CH1_IN+	channel 1+, external		A1, 3 C1, 3
A2	CH1_IN-	channel 1-, external		A2, 4 C2, 4
A3	CH2_IN+	channel 2+, external	3	
A4	CH2_IN-	channel 2-, external		本 本
B1	GND_CH1	ground channel 1		
B2	GND_CH2	ground channel 2		
C1	CH1_OUT+	channel 1+, internal		B1, B2 - no internal connection aaa-019785
C2	CH1_OUT-	channel 1-, internal	A B C Transparent top view	
C3	CH2_OUT+	channel 2+, internal	WLCSP10_4-2-4	
C4	CH2_OUT-	channel 2-, internal		
PCMF	3USB3S (WLCS	P15_6-3-6)		
A1	CH1_IN+	channel 1+, external	6	A1, 3, 5C1, 3, 5
A2	CH1_IN-	channel 1-, external	B3 B3	A2, 4, 6C2, 4, 6
A3	CH2_IN+	channel 2+, external	5	
A4	CH2_IN-	channel 2-, external		本 本
A5	CH3_IN+	channel 3+, external		
A6	CH3_IN-	channel 3-, external		
B1	GND_CH1	ground channel 1		B1, B2, B3 - no internal connection aaa-019786
B2	GND_CH2	ground channel 2		
B3	GND_CH3	ground channel 3		
C1	CH1_OUT+	channel 1+, internal		
C2	CH1_OUT-	channel 1-, internal	A B C	
C3	CH2_OUT+	channel 2+, internal	Transparent top view WLCSP15_6-3-6	
C4	CH2_OUT-	channel 2-, internal	WEOGP 15_0-3-0	
C5	CH3_OUT+	channel 3+, internal		
C6	CH3_OUT-	channel 3-, internal		

5. Ordering information

Table 3. Ordering information Type number Package					
	Name	Description			
PCMF1USB3S	WLCSP5	wafer level chip-size package; 5 bumps (2-1-2)			
PCMF2USB3S	WLCSP10	wafer level chip-size package; 10 bumps (4-2-4)			
PCMF3USB3S	WLCSP15	wafer level chip-size package; 15 bumps (6-3-6)			

6. Marking

Table 4. Marking codesType numberMarking codePCMF1USB3SPF1SPCMF2USB3SPF2SPCMF3USB3SPF3S

7. Limiting values

Table 5. Limiting values

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

Symbol	Parameter	Conditions	Min	Max	Unit
VI	input voltage		-0.5	5	V
V _{ESD}	electrostatic discharge voltage	IEC 61000-4-2, level 4; all input pins to ground			
		contact discharge	-15	15	kV
		air discharge	-15	15	kV
		IEC 61000-4-2, level 4; all output pins to ground			
		contact discharge	-2	2	kV
		air discharge	-2	2	kV
I _{PPM}	rated peak-pulse current	t _p = 8/20 μs	-7	7	А
T _{stg}	storage temperature		-40	125	°C
T _{amb}	ambient temperature		-40	125	°C

8. Characteristics

8.1. Channel characteristics

Table 6. Channel characteristics

 T_{amb} = 25 °C unless otherwise specified.

Symbol	Parameter	Conditions		Min	Тур	Max	Unit
R _{s(ch)}	channel series resistance	single line; input to output		-	3	-	Ω
C _d	diode capacitance	f = 1 MHz; V _I = 2.5 V	[1]	-	0.25	-	pF
I _{RM}	reverse leakage current	per line; V _I = 5 V		-	-	100	nA
V _{BR}	breakdown voltage	I _R = 1 mA		6	9	-	V
V _F	forward voltage	I _F = 10 mA		-	0.8	-	V
R _{dyn}	dynamic resistance	TLP; positive transient	[2]	-	0.14	-	Ω
		TLP; negative transient	[2]	-	0.14	-	Ω
		surge; positive transient	[3]	-	0.22	-	Ω
		surge; negative transient	[3]	-	0.22	-	Ω

[1] This parameter is guaranteed by design.

[2] 100 ns Transmission Line Pulse (TLP); 50 Ω ; pulser at 70 ns to 90 ns.

[3] According to IEC 61000-4-5 (8/20 µs).

8.2. Frequency characteristics

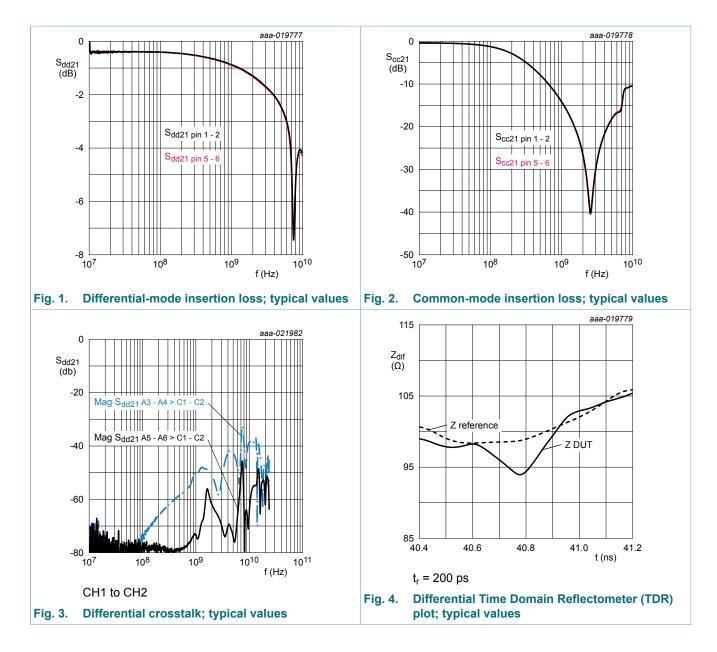
Table 7. Frequency characteristics

 T_{amb} = 25 °C unless otherwise specified.

Symbol	Parameter	Conditions	N	Min	Тур	Max	Unit
Commo	n mode: S _{21cc}				_		
α _{il}	insertion loss	f = 800 MHz	[1] -		-12	-	dB
		f = 2.6 GHz	[1] -		-38	-	dB
		f = 5 GHz	[1] -		-18	-	dB
Different	tial mode: S _{21dd}						
α _{il}	insertion loss	f = 1 MHz	[1] -		0.3	-	dB
f _{-3dB}	cut-off frequency		[1] -		6	-	GHz

[1] Normalized to attenuation at 1 MHz.

Common-mode EMI filter for differential channels with integrated ESD protection



Product data sheet

Common-mode EMI filter for differential channels with integrated ESD protection

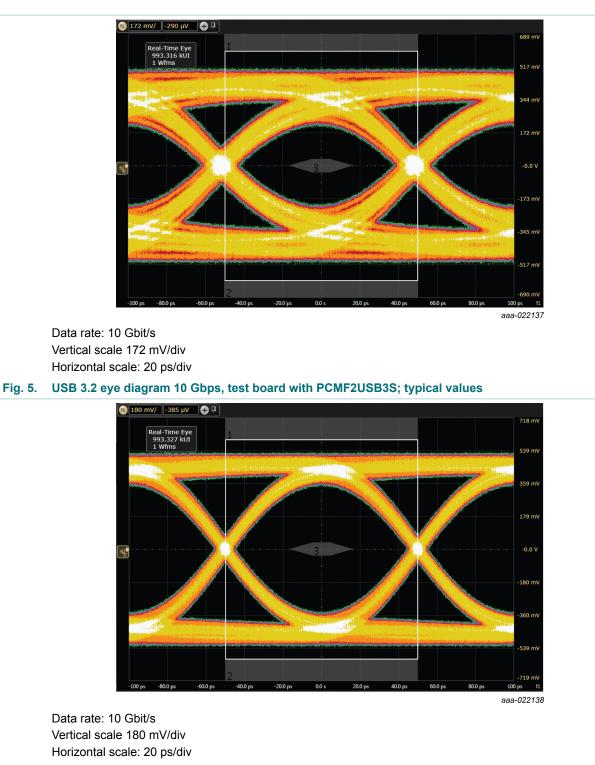
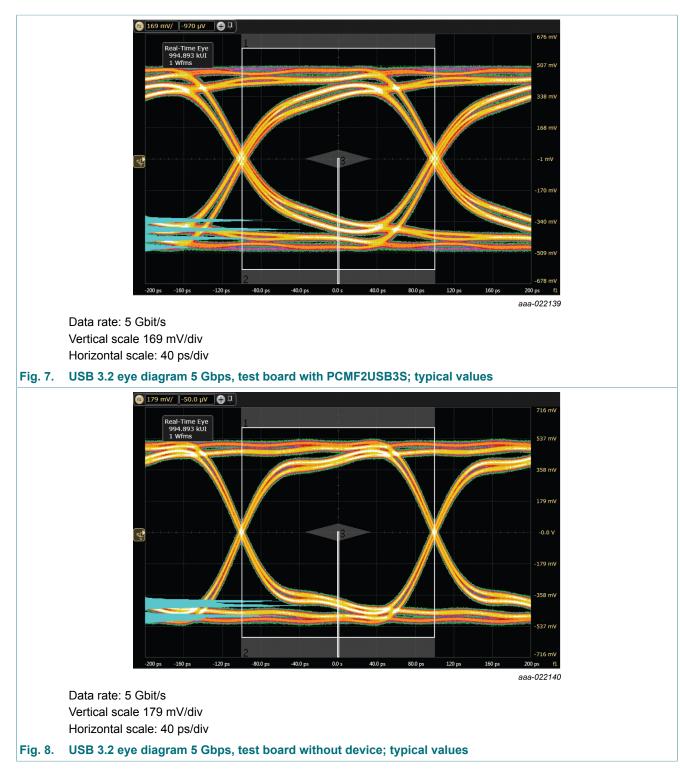
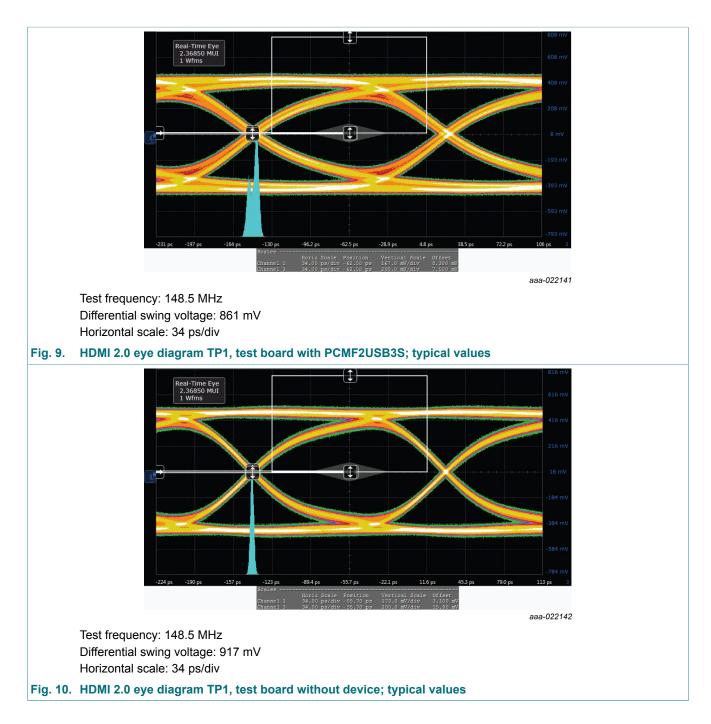


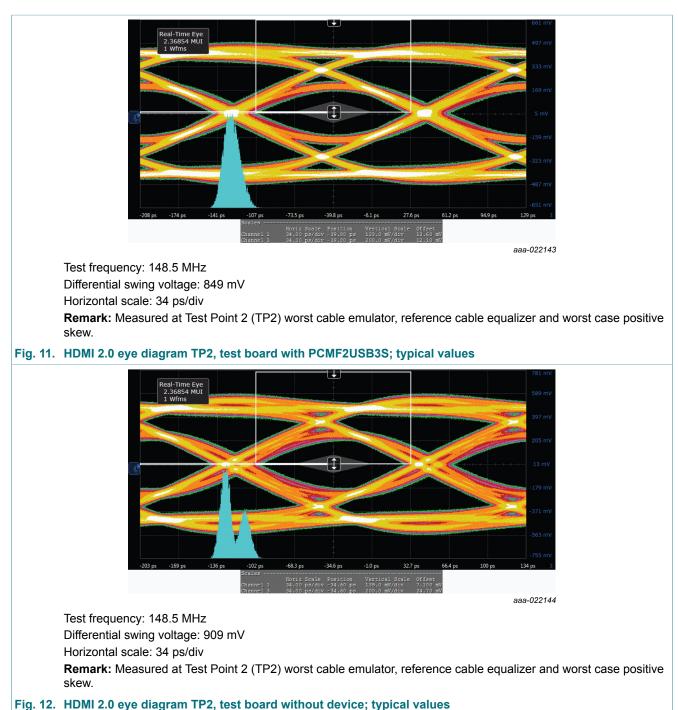
Fig. 6. USB 3.2 eye diagram 10 Gbps, test board without device; typical values

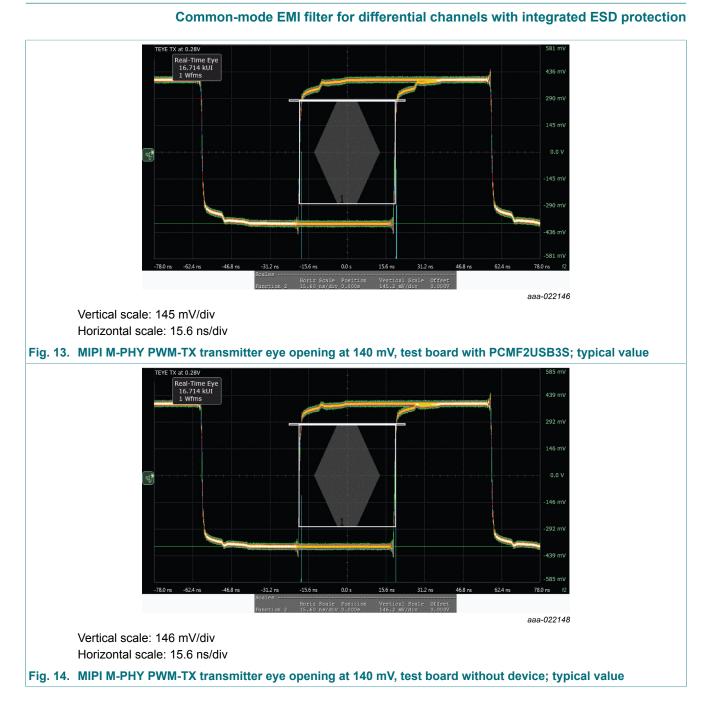
Common-mode EMI filter for differential channels with integrated ESD protection

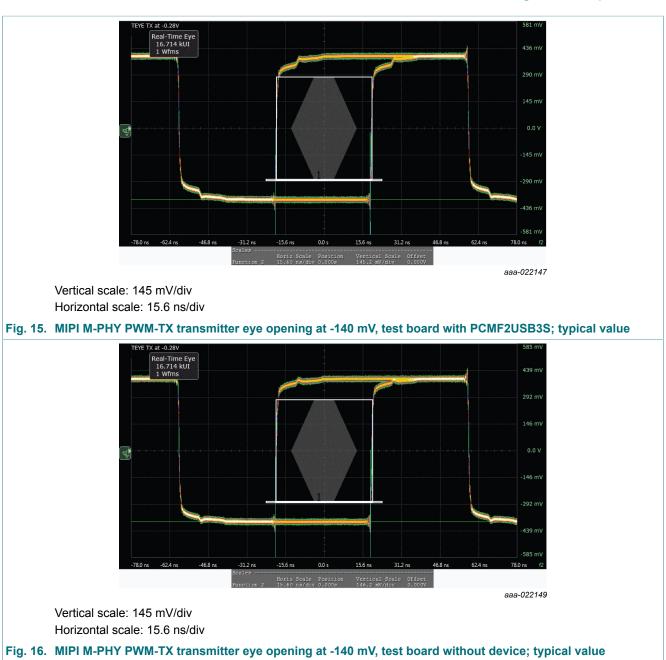


Common-mode EMI filter for differential channels with integrated ESD protection



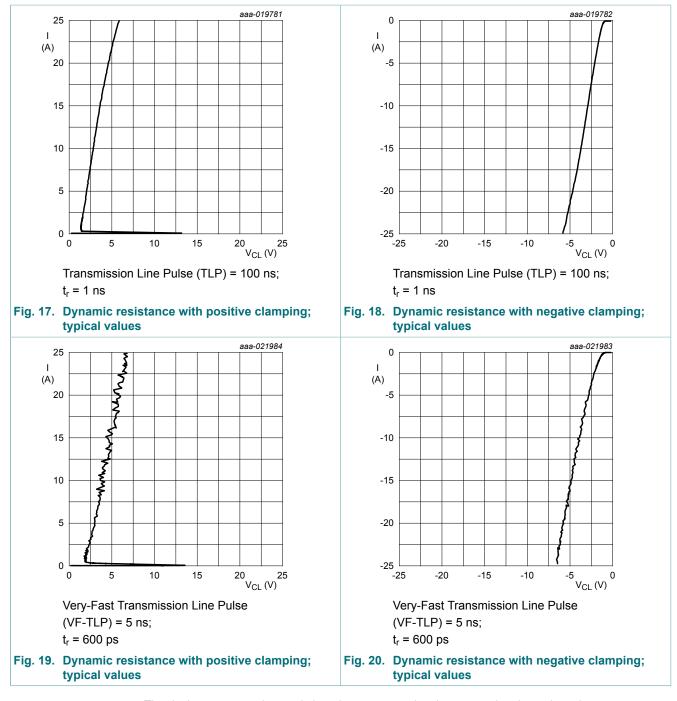






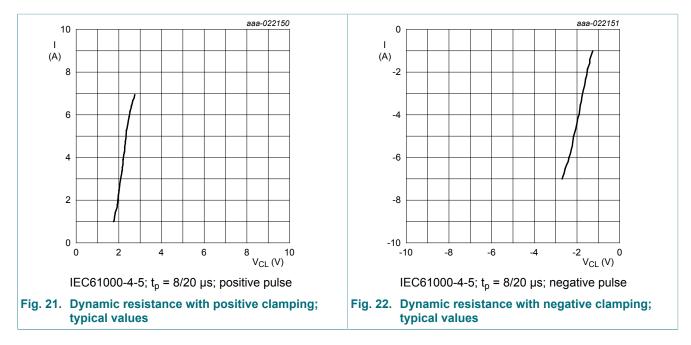
Common-mode EMI filter for differential channels with integrated ESD protection

Common-mode EMI filter for differential channels with integrated ESD protection



The device uses an advanced clamping structure showing a negative dynamic resistance. This snap-back behavior strongly reduces the clamping voltage to the system behind the ESD protection during an ESD event. Do not connect unlimited DC current sources to the data lines to avoid keeping the ESD protection device in snap-back state after exceeding breakdown voltage (due to an ESD pulse for instance).

Common-mode EMI filter for differential channels with integrated ESD protection

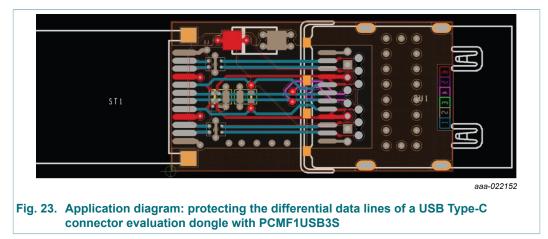


9. Application information

The device is designed to provide high-level ESD protection for differential high-speed data line pairs such as:

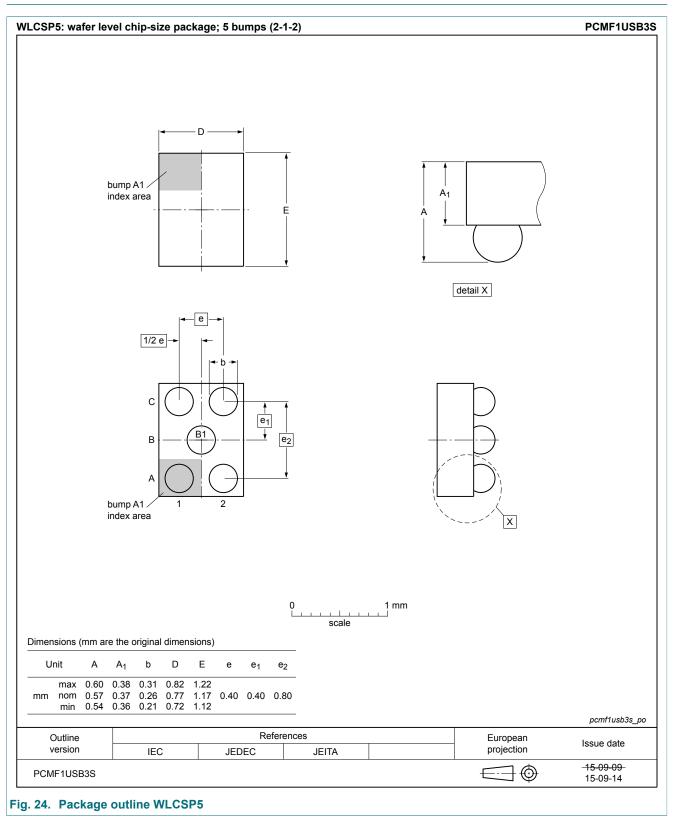
- USB 3.2
- HDMI 2.0
- Transition-Minimized Differential Signaling (TMDS)
- DisplayPort
- external Serial Advanced Technology Attachment (eSATA)
- Low Voltage Differential Signaling (LVDS)

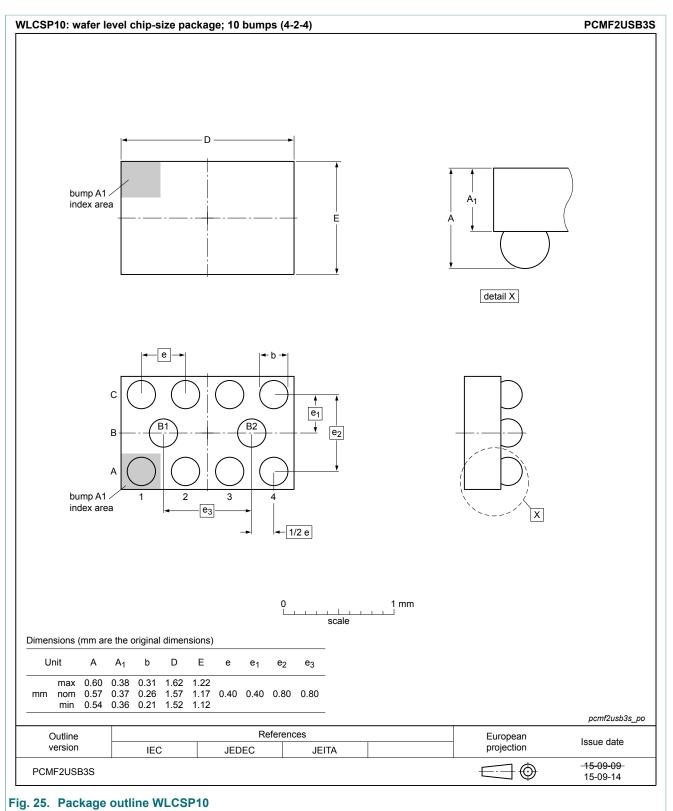
When designing the Printed-Circuit Board (PCB), give careful consideration to impedance matching and signal coupling. Do not connect the protected signal lines to unlimited current sources like, for example, a battery.



Since the SuperSpeed TX/RX lines are separated by GND or VBUS from the Hi-Speed lines, PCMF1USB3S makes it easy to achieve same signal lengths, straight routing, and optimal positioning for ESD protection directly at the connector.

10. Package outline





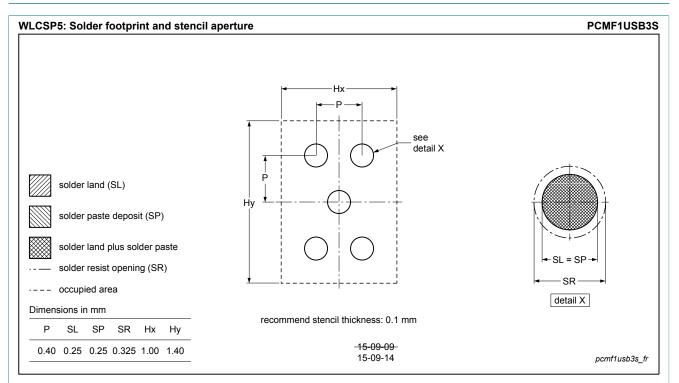
Common-mode EMI filter for differential channels with integrated ESD protection

WLCSP15: wafer level chip-size package; 15 bumps (6-3-6) PCMF3USB3S D bump A1 / A₁ index area E Α detail X е -1/2 e b С e₁ B B3 B2 ł e₂ В A bump A1 2 3 Δ 5 6 index area e₃ Х 1 mm scale Dimensions (mm are the original dimensions) Unit А A_1 b D Е е e₁ e₂ e₃ 0.60 0.38 0.31 2.42 1.22 max 0.26 2.37 0.21 2.32 0.57 0.37 1.17 0.40 0.40 0.80 0.80 mm nom 0.54 0.36 1.12 min pcmf3usb3s_po References Outline European Issue date projection version IEC JEDEC JEITA 15-09-09 \bigcirc PCMF3USB3S 15-09-14

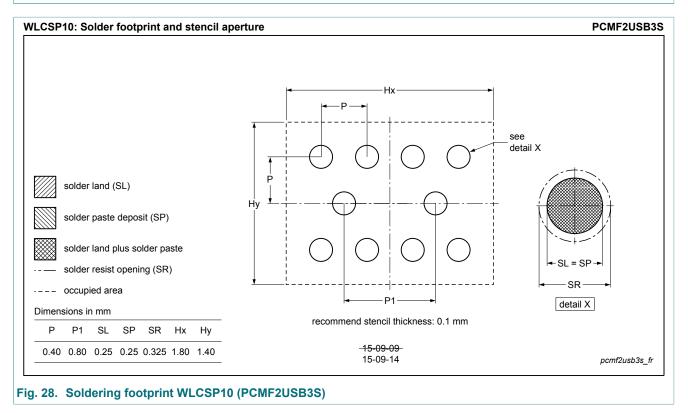
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Fig. 26. Package outline WLCSP15

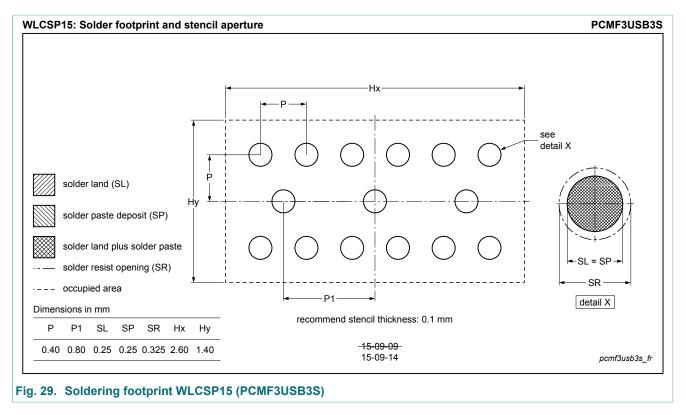
11. Soldering







Common-mode EMI filter for differential channels with integrated ESD protection



12. Revision history

Data sheet ID	Release date	Data sheet status	Change notice	Supersedes
PCMFXUSB3S_SER v.3	20190307	Product data sheet	-	PCMFXUSB3S_SER v.2
Modifications:	•	s: T _{amb} maximum values u aracteristics: corrected typ		, 3 and 5.
PCMFXUSB3S_SER v.2	20160307	Product data sheet	-	PCMFXUSB3S_SER v.1
PCMFXUSB3S_SER v.1	20151007	Preliminary data sheet	-	-

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.

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- [2] The term 'short data sheet' is explained in section "Definitions".
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