PUSB3BB2DF

Extremely low clamping low capacitance ESD protection

3 November 2020 Product data sheet

1. General description

Symmetrical bidirectional ElectroStatic Discharge (ESD) protection diode array, part of the TrEOS protection family. This device is housed in a DFN0603-3 (SOT8013) leadless ultra small Surface-Mounted Device (SMD) package designed to protect two signal lines from the damage caused by ESD and other transients.

2. Features and benefits

- Bidirectional ESD protection of two lines
- Very low diode capacitance C_d = 0.26 pF
- Extremely low clamping to protect sensitive I/Os
- Extremely low-inductance protection path to ground
- Extremely symmetrical layout
- ESD protection up to ±20 kV according to IEC 61000-4-2
- Ultra small SMD package
- Placed on one differential line pair, almost no extra PCB space demand for protection

3. Applications

- Thunderbolt, USB 3.2 and HDMI 2.1 data lines
- Cellular handsets and accessories
- Portable electronics
- Communication systems
- Computers and peripherals

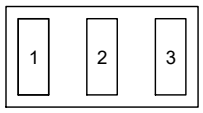
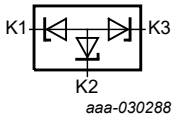
4. Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{RWM}	reverse standoff voltage			-4	-	4	V
C_d	diode capacitance	f = 1 MHz; V_R = 0 V; T_{amb} = 25 °C		-	0.26	-	pF
		f = 1 MHz; V_R = 1.5 V; T_{amb} = 25 °C		-	0.24	-	pF

5. Pinning information

Table 2. Pinning information

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	K1	cathode (diode 1)	 Transparent top view **DFN0603-3 (SOT8013)**	
2	K2	cathode (diode 2)[1]		
3	K3	cathode (diode 3)		

[1] recommended for GND connection.

6. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
PUSB3BB2DF	DFN0603-3	DFN0603-3; plastic, ultra small and leadless full encapsulated package; 3 terminals; 0.225 mm pitch; 0.63 mm x 0.33 mm x 0.25 mm body	SOT8013

7. Marking

Table 4. Marking codes

Type number	Marking code
PUSB3BB2DF	B

8. Limiting values

Table 5. Limiting values

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

Symbol	Parameter	Conditions		Min	Max	Unit
V_{RWM}	reverse standoff voltage			-4	4	V
I_{PPM}	rated peak pulse current	t_p = 8/20 µs	[1]	-8	8	A
T_{amb}	ambient temperature			-40	125	°C
T_{stg}	storage temperature			-65	150	°C
ESD maximum ratings						
V_{ESD}	electrostatic discharge voltage	IEC 61000-4-2; contact discharge	[2]	-20	20	kV
		IEC 61000-4-2; air discharge	[2]	-20	20	kV

[1] Device stressed with 8/20 µs exponential decay waveform according to IEC 61000-4-5.
[2] Device stressed with ten non-repetitive ESD pulses.

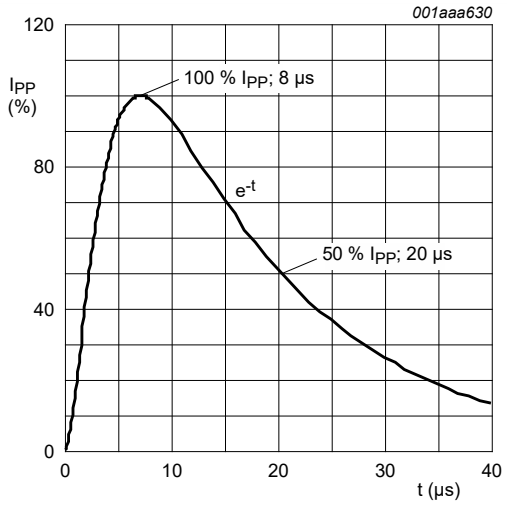


Fig. 1. 8/20 µs pulse waveform according to IEC 61000-4-5 and IEC 61643-321

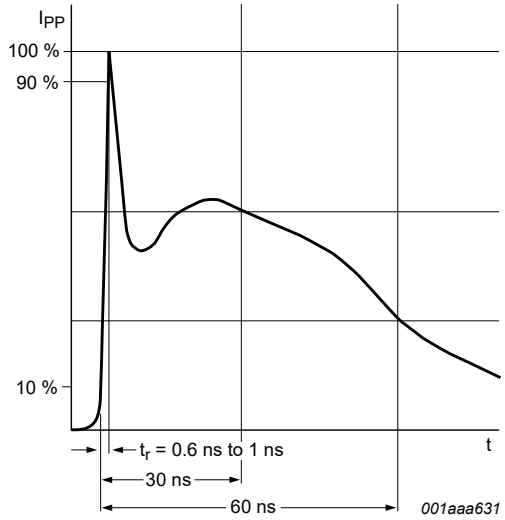


Fig. 2. ESD pulse waveform according to IEC 61000-4-2

9. Characteristics

Table 6. Characteristics

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
V_{BR}	breakdown voltage	I_R = 1 mA; T_{amb} = 25 °C		-	7.4	-	V
I_{RM}	reverse leakage current	V_{RWM} = 4 V; T_{amb} = 25 °C		-	1	50	nA
C_d	diode capacitance	f = 1 MHz; V_R = 0 V; T_{amb} = 25 °C		-	0.26	-	pF
		f = 1 MHz; V_R = 1.5 V; T_{amb} = 25 °C		-	0.24	-	pF
V_{CL}	clamping voltage	I_{PPM} = 8 A; 8/20 µs; T_{amb} = 25 °C	[1]	-	5.3	-	V
		I_{PPM} = 8 A; TLP; t_p = 100 ns	[2]	-	4.5	-	V
		I_{PPM} = 16 A; TLP; t_p = 100 ns; T_{amb} = 25 °C	[2]	-	6.2	-	V
R_{dyn}	dynamic resistance	I_R = 5 A; T_{amb} = 25 °C	[2]	-	0.25	-	Ω
		I_R = -5 A; T_{amb} = 25 °C	[2]	-	0.25	-	Ω
f_{-3dB}	-3 dB cut-off frequency	T_{amb} = 25 °C; normalized to attenuation at 1 MHz		-	> 18	-	GHz

[1] Device stressed with 8/20 µs exponential decay waveform according to IEC 61000-4-5.
[2] Non-repetitive current pulse, Transmission Line Pulse (TLP); square pulse; ANSI / ESD STM5.5.1-2008.

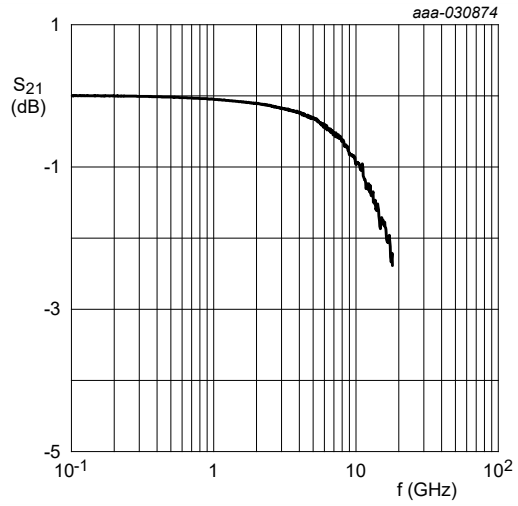


Fig. 3. Insertion loss; typical values

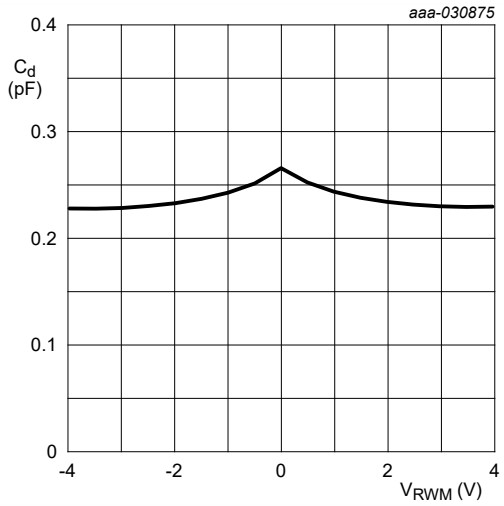
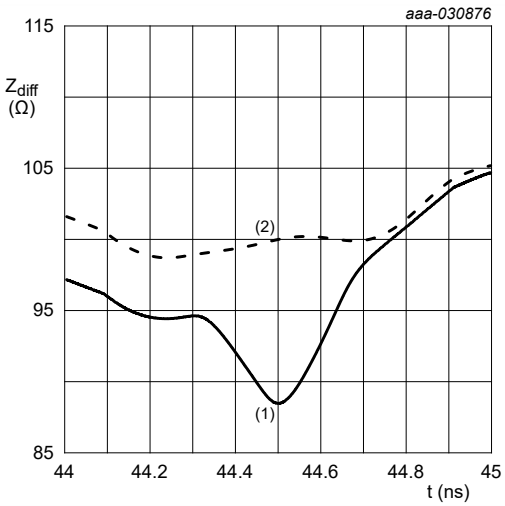
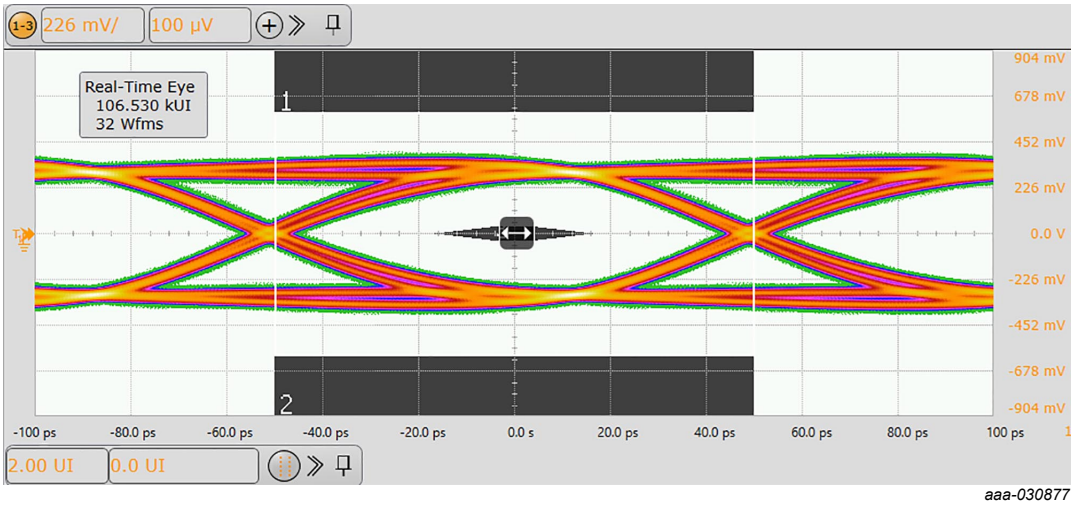


Fig. 4. Capacitance as a function of reverse standoff voltage; typical values



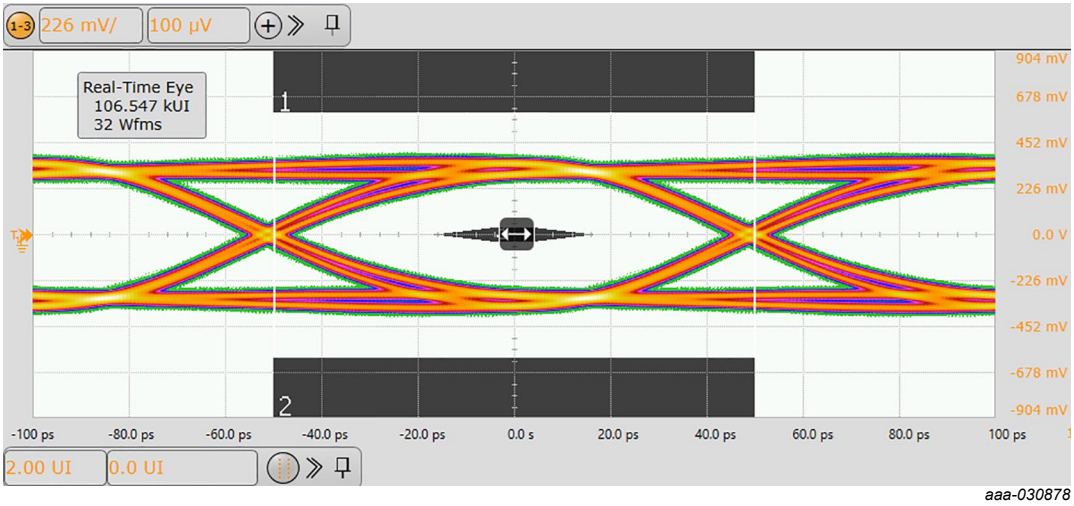
t_r = 200 ps
(1) Device on reference board
(2) Reference board without Device Under Test (DUT)

Fig. 5. Differential Time Domain Reflectometer (TDR) plot; typical values



Data rate: 10 Gbit/s

Fig. 6. USB 3.2 eye diagram, PCB with device; typical values



Data rate: 10 Gbit/s

Fig. 7. USB 3.2 eye diagram, PCB without device; typical values

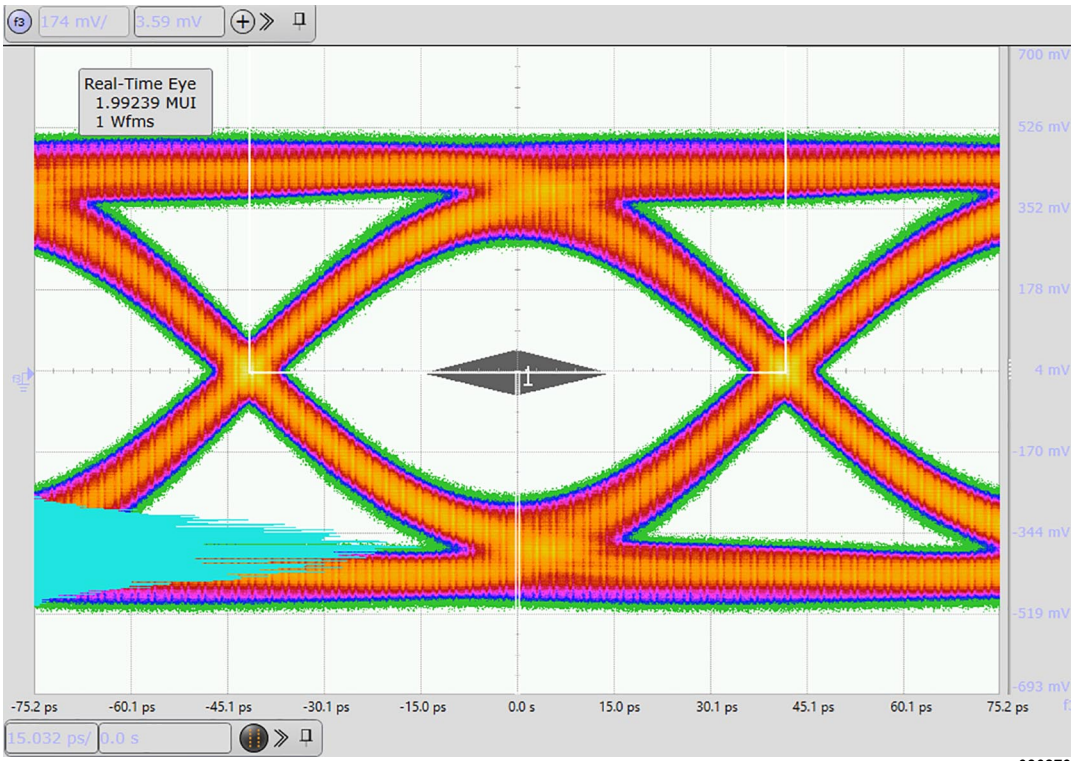


Fig. 8. HDMI 2.1 12G FRL TP1 eye diagram, PCB with device; typical values

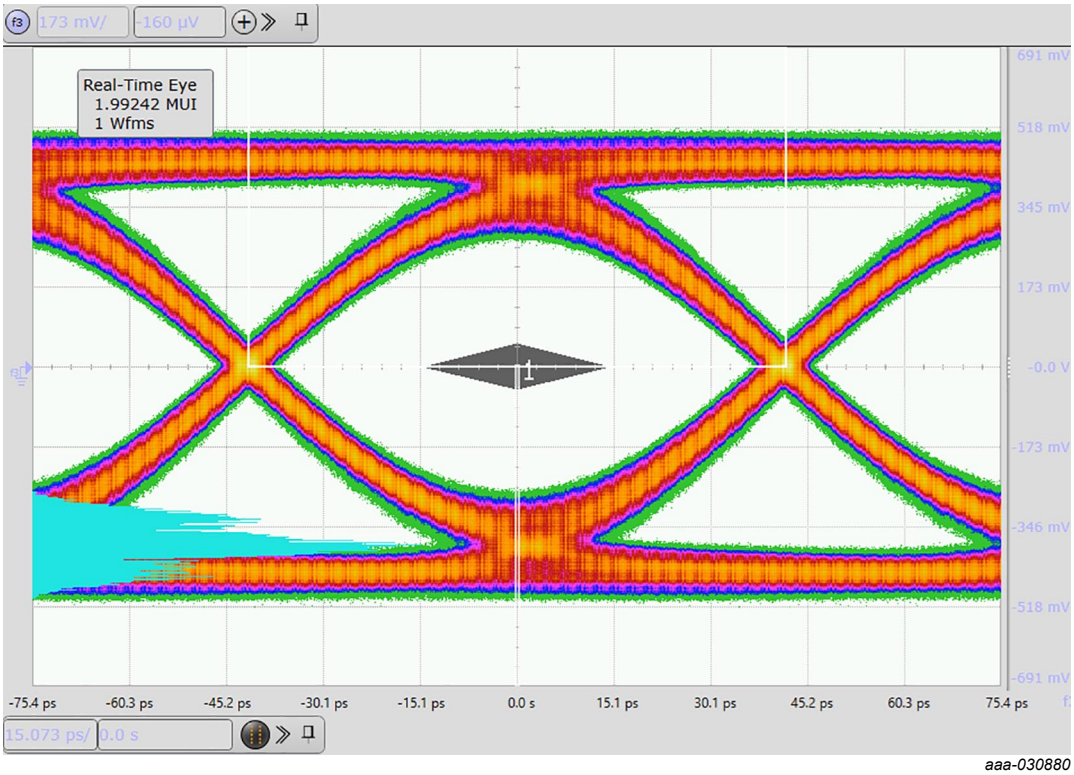


Fig. 9. HDMI 2.1 12G FRL TP1 eye diagram, PCB without device; typical values

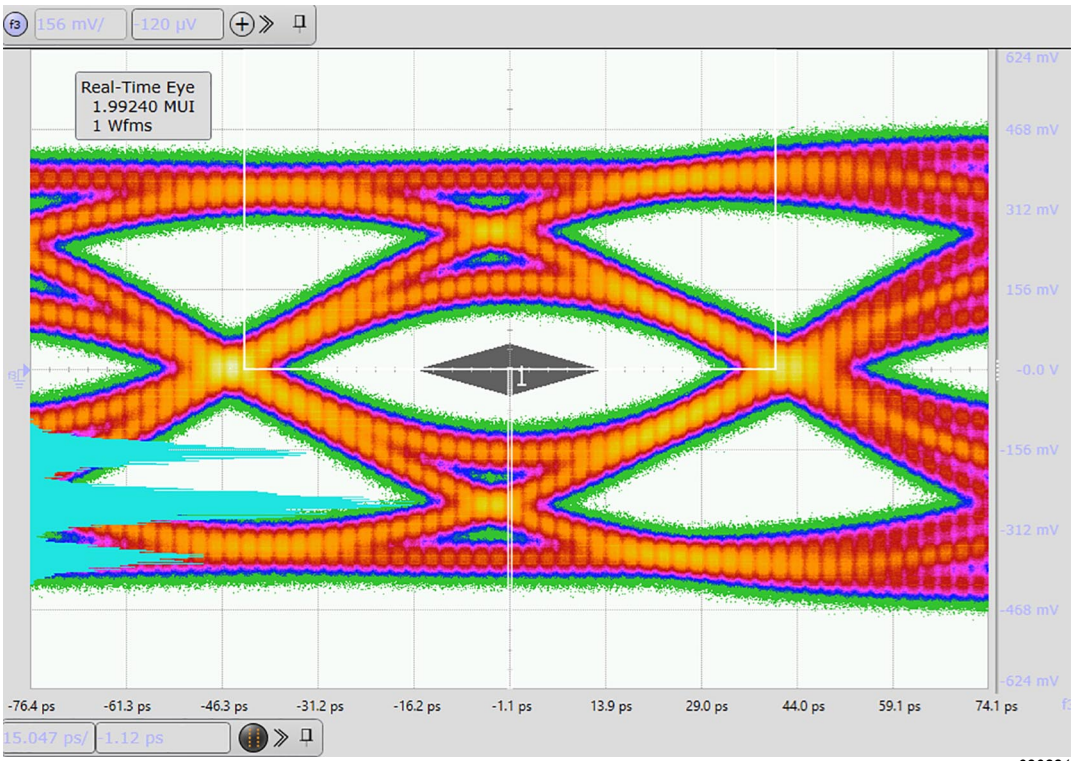


Fig. 10. HDMI 2.1 12G FRL TP2, Worst Case Model, 8 dB eye diagram, PCB with device; typical values

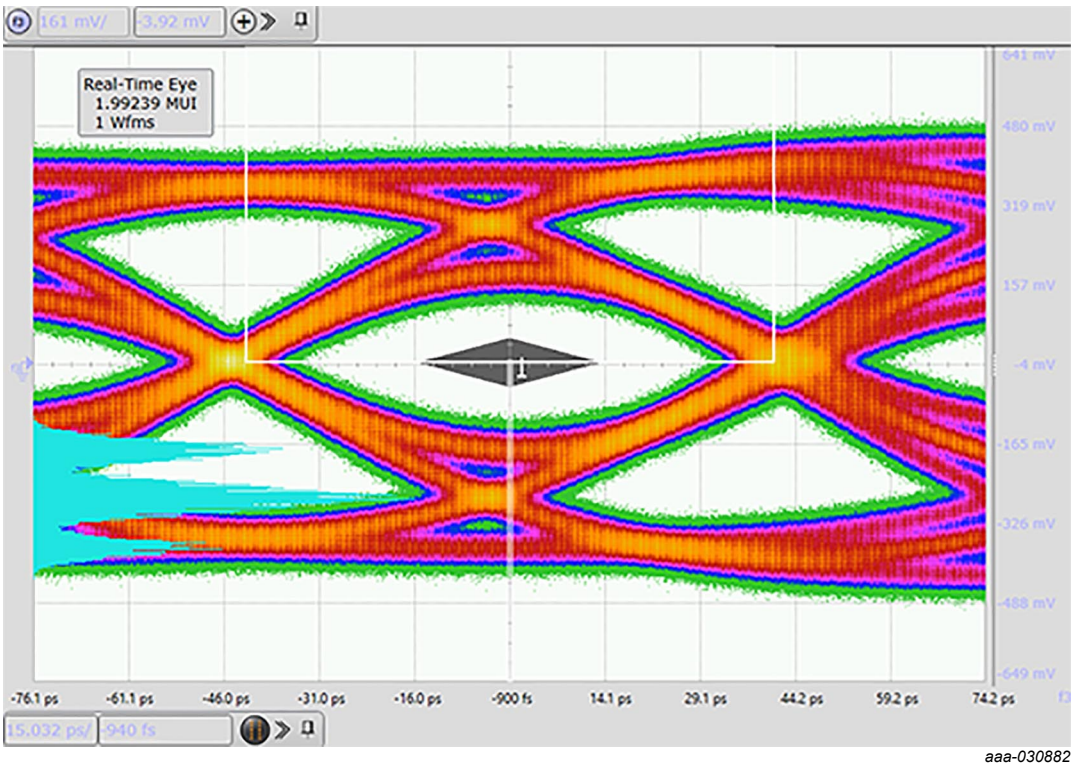
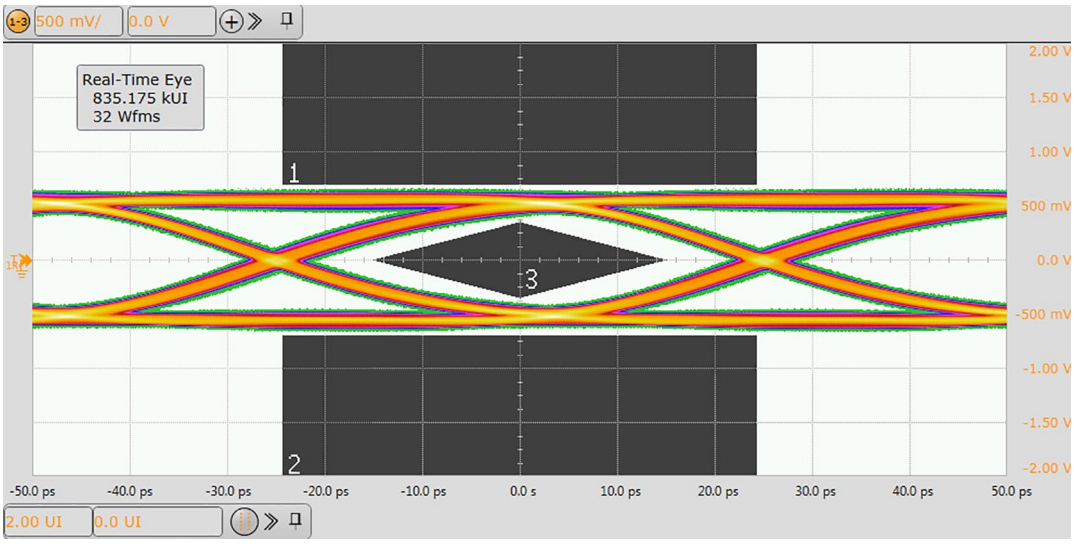
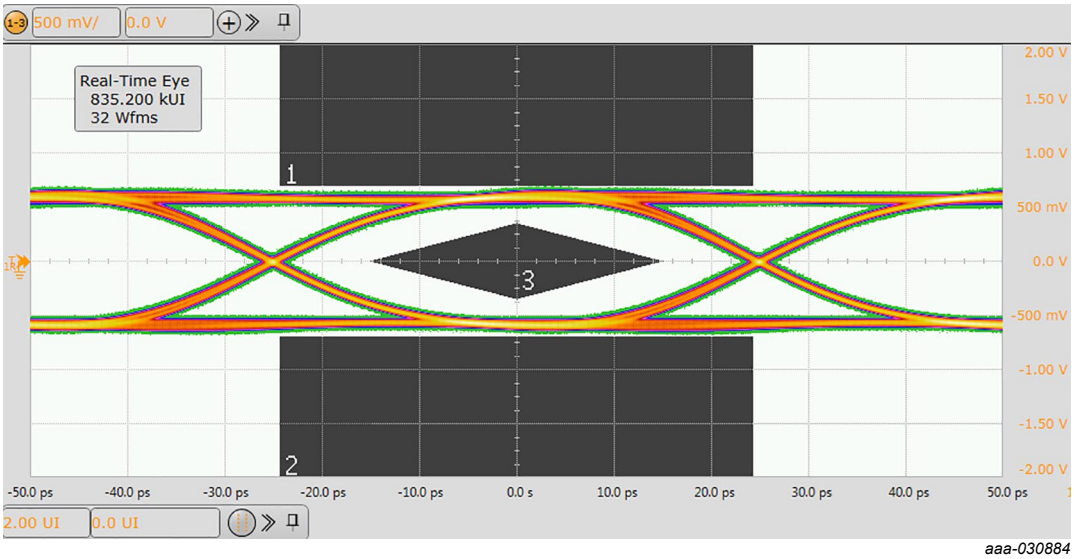


Fig. 11. HDMI 2.1 12G FRL TP2, Worst Case Model eye diagram, PCB without device; typical values



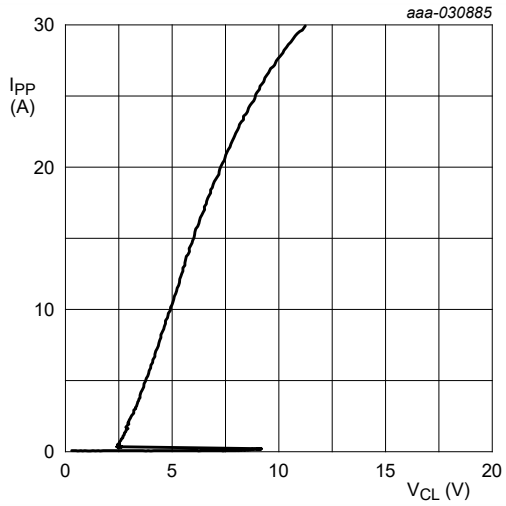
Data rate: 20 Gbit/s, GND on pin 2

Fig. 12. Thunderbolt eye diagram, PCB with device; typical values



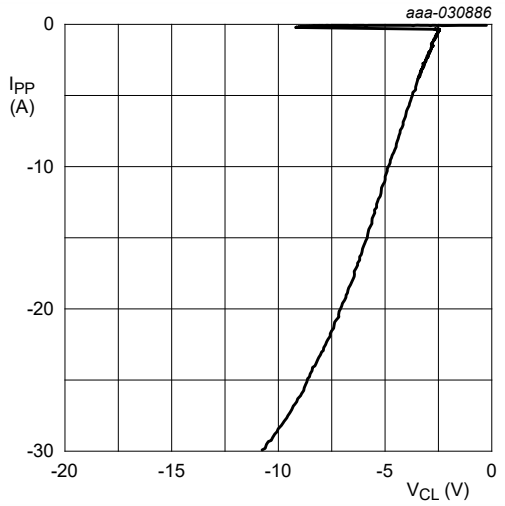
Data rate: 20 Gbit/s

Fig. 13. Thunderbolt eye diagram, PCB without device; typical values



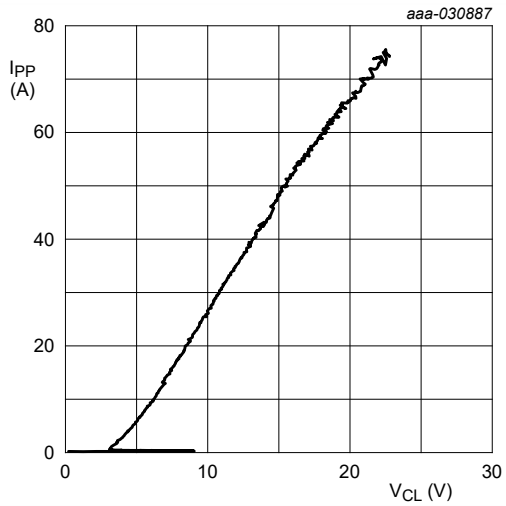
t_r = 1 ns
t_p = 100 ns; Transmission Line Pulse (TLP)

Fig. 14. Dynamic resistance with positive clamping; typical values



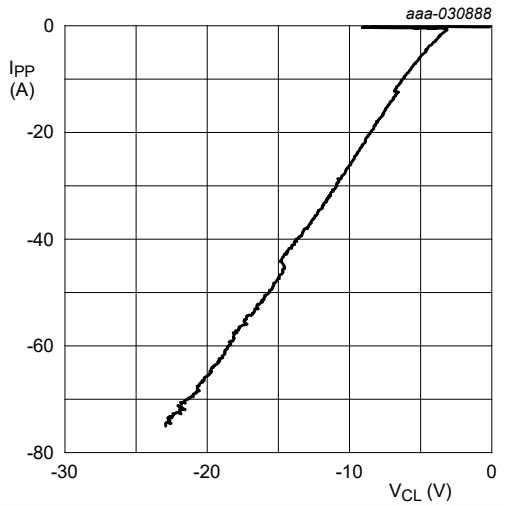
t_r = 1 ns
t_p = 100 ns; Transmission Line Pulse (TLP)

Fig. 15. Dynamic resistance with negative clamping; typical values



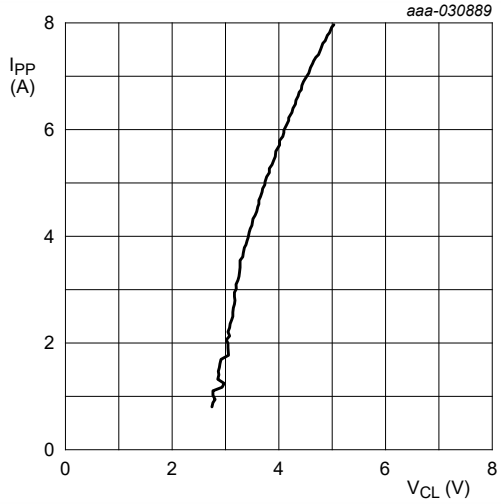
t_r = 600 ps
t_p = 5 ns; Very-Fast Transmission Line Pulse (VF-TLP)

Fig. 16. Dynamic resistance with positive clamping; typical values



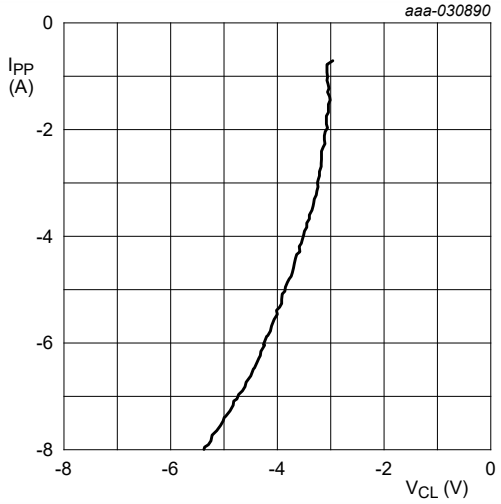
t_r = 600 ps
t_p = 5 ns; Very-Fast Transmission Line Pulse (VF-TLP)

Fig. 17. Dynamic resistance with negative clamping; typical values



IEC 61000-4-5; t_p = 8/20 µs; positive pulse

Fig. 18. Dynamic resistance with positive clamping; typical values



IEC 61000-4-5; t_p = 8/20 µs; negative pulse

Fig. 19. Dynamic resistance with negative clamping; typical values

10. Application information

The device is designed for the protection of two signal lines from surge pulses and ESD damage. The device is suitable on lines where the signal polarities are both, positive and negative with respect to ground.

The device uses an advanced clamping structure showing a negative dynamic resistance. This snap-back behavior strongly reduces the clamping voltage 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 snap-back state after exceeding breakdown voltage (due to an ESD pulse for instance).

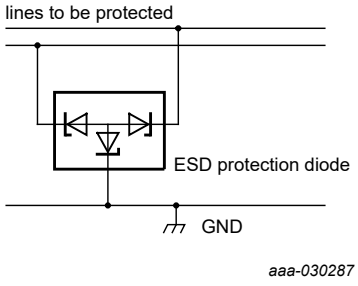


Fig. 20. Application diagram

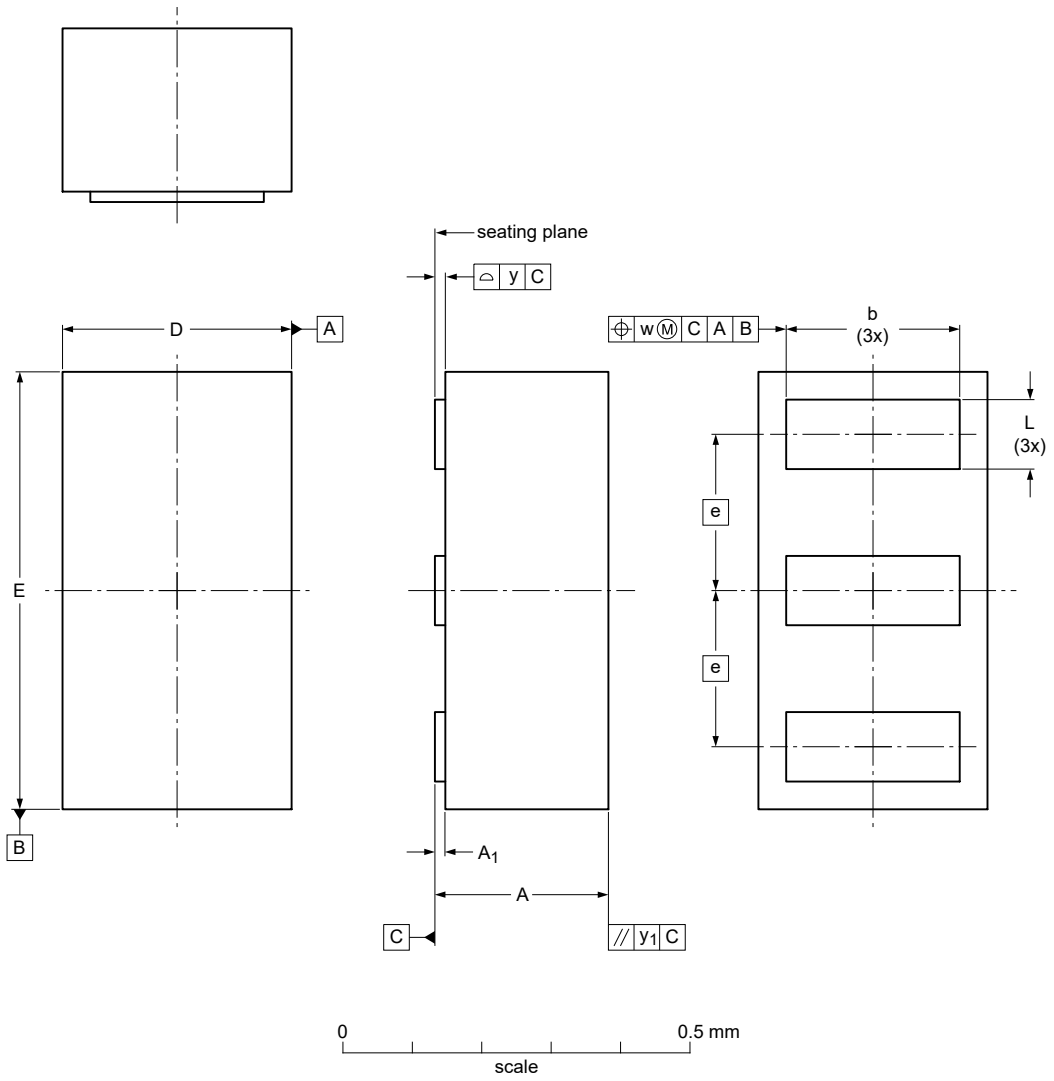
Circuit board layout and protection device placement

Circuit board layout is critical for the suppression of ESD, Electrical Fast Transient (EFT) and surge transients. The following guidelines are recommended:

1. Place the device as close to the input terminal or connector as possible.
2. Minimize the path length between the device and the protected line.
3. Keep parallel signal paths to a minimum.
4. Avoid running protected conductors in parallel with unprotected conductors.
5. Minimize all Printed-Circuit Board (PCB) conductive loops including power and ground loops.
6. Minimize the length of the transient return path to ground.
7. Avoid using shared transient return paths to a common ground point.
8. Use ground planes whenever possible. For multilayer PCBs, use ground vias.

11. Package outline

DFN0603-3; plastic, ultra small and leadless full encapsulated package; 3 terminals; 0.225 mm pitch; 0.63 mm x 0.33 mm x 0.25 mm body **SOT8013**



Dimensions (mm are the original dimensions)

Unit[1]		A	A_1	b	D	E	e	L	w	y	y_1
mm	max	0.275	0.03	0.27	0.350	0.650		0.12			
	nom						0.225		0.04	0.03	0.05
	min	0.225		0.23	0.305	0.605		0.08			

Note
1. Device is electrically symmetrical

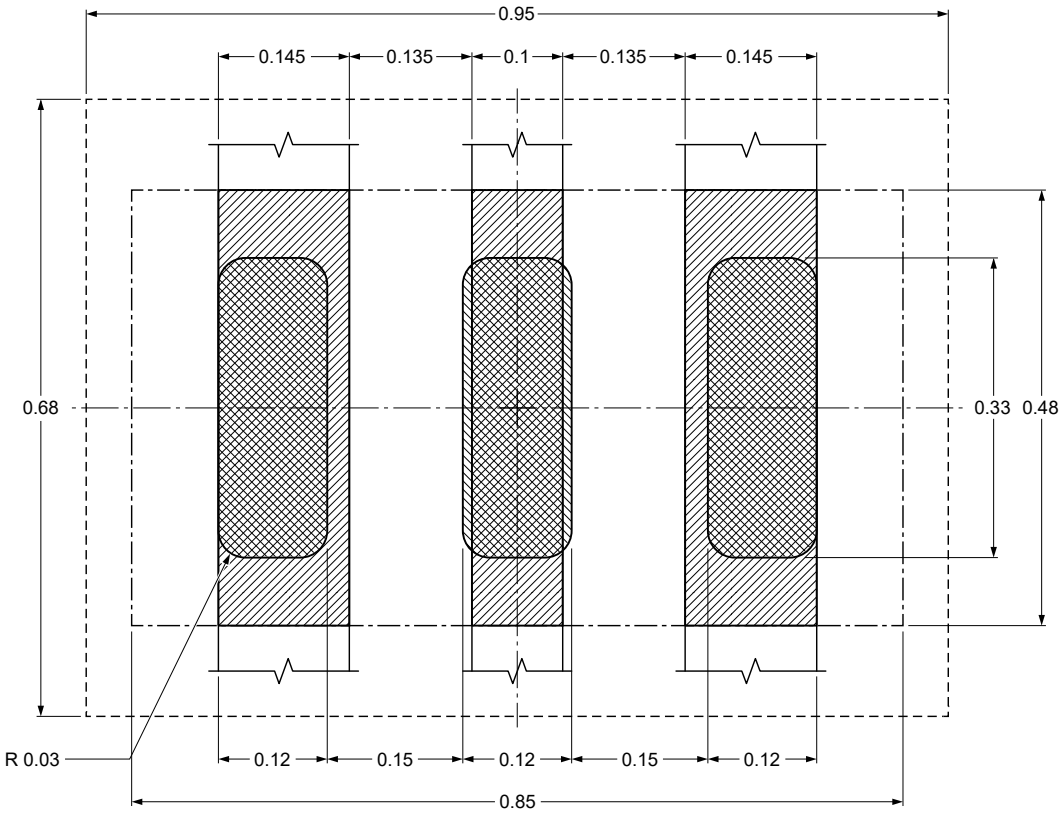
sot8013_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT8013		---				~~19-08-06~~ 19-08-29

Fig. 21. Package outline DFN0603-3 (SOT8013)

12. Soldering

Footprint information for reflow soldering of ultra small and leadless encapsulated package; 3 terminals **SOT8013**



recommended stencil thickness: 0.08 mm

occupied area

solder resist

solder land
(Cu extends under
solder resist)

stencil opening

Dimensions in mm

Issue date ~~19-10-29~~ 20-02-26

sot8013_fr

Fig. 22. Reflow soldering footprint for DFN0603-3 (SOT8013)

13. Revision history

Table 7. Revision history

Data sheet ID	Release date	Data sheet status	Change notice	Supersedes
PUSB3BB2DF v.2	20201103	Product data sheet	-	PUSB3BB2DF v.1
Modifications:	• Correction of the horizontal scale for "Fig. 3. Insertion loss"			
PUSB3BB2DF v.1	20200327	Product data sheet	-	-

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".
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Date of release: 3 November 2020