



# PUSB3FR6

## ESD protection for ultra high-speed interfaces

28 May 2024

Product data sheet

## 1. General description

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The device is designed to protect high-speed interfaces such as SuperSpeed and Hi-Speed USB combination, SD-memory card 3.0 and thunderbolt interfaces against ElectroStatic Discharge (ESD).

The device includes six high-level ESD protection diode structures for ultra high-speed signal lines. The device is encapsulated in a leadless ultra small DFN2111-7 (SOT1358-1) Surface-Mounted Device (SMD) plastic package.

All signal lines are protected by a special diode structure offering ultra low line capacitance of only 0.35 pF. These diodes utilize a snap-back structure in order to provide protection to downstream components from ESD voltages up to  $\pm 15$  kV contact exceeding IEC 61000-4-2, level 4.

## 2. Features and benefits

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- System-level ESD protection for USB 2.0 and USB 3.2 combination, SD-memory card and thunderbolt interfaces
- Supports SuperSpeed USB 3.2 at 10 Gbps
- All signal lines with integrated rail-to-rail clamping diodes for downstream ESD protection of  $\pm 15$  kV exceeding IEC 61000-4-2, level 4
- Matched 0.5 mm trace spacing
- Line capacitance of only 0.35 pF for each channel
- Design-friendly 'pass-through' signal routing

## 3. Applications

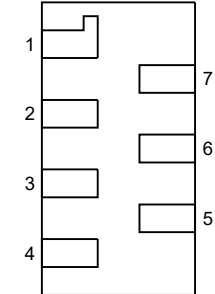
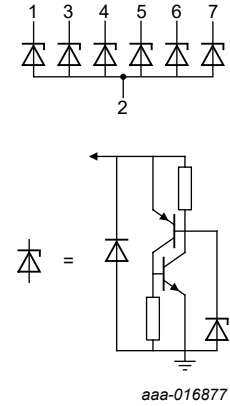
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The device is designed for high-speed receiver and transmitter port protection:

- Portable and wearable devices
- Smartphones and tablet PCs
- TVs and monitors
- DVD recorders and players
- Notebooks, main board graphic cards and ports
- Set-top boxes and game consoles

## 4. Pinning information

Table 1. Pinning information

Pin	Symbol	Description	Simplified outline	Graphic symbol
1	CH1	channel 1 ESD protection	 <p>Transparent top view <b>XSON7 (SOT1358-1)</b></p>	 <p>aaa-016877</p>
2	GND	ground		
3	CH2	channel 2 ESD protection		
4	CH3	channel 3 ESD protection		
5	CH4	channel 4 ESD protection		
6	CH5	channel 5 ESD protection		
7	CH6	channel 6 ESD protection		

## 5. Ordering information

Table 2. Ordering information

Type number	Package		
	Name	Description	Version
PUSB3FR6	XSON7	plastic, leadless extremely thin small outline package; 7 terminals; 0.5 mm pitch; 1.1 mm x 2.1 mm x 0.5 mm body	SOT1358-1

## 6. Marking

Table 3. Marking codes

Type number	Marking code
PUSB3FR6	FR

## 7. Limiting values

**Table 4. Limiting values**

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

Symbol	Parameter	Conditions	Min	Max	Unit
$V_I$	input voltage		-0.5	3.3	V
$I_{PPM}$	rated peak pulse current	$t_p = 8/20 \mu s$	-	7	A
$V_{ESD}$	electrostatic discharge voltage	IEC 61000-4-2, level 4; contact discharge [1]	-15	15	kV
		IEC 61000-4-2, level 4; air discharge [1]	-15	15	kV
$T_{stg}$	storage temperature		-55	125	°C
$T_{amb}$	ambient temperature		-40	85	°C

[1] All pins to ground.

## 8. Characteristics

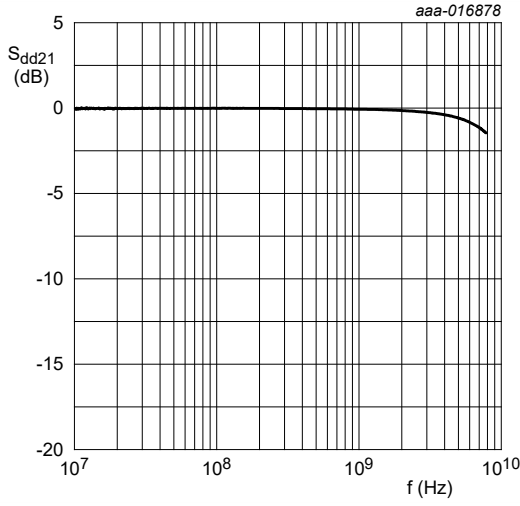
**Table 5. Characteristics**

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$V_{BR}$	breakdown voltage	$I_I = 1 \text{ mA}$ ; $T_{amb} = 25 \text{ °C}$	6	-	-	V
$I_{LR}$	reverse leakage current	per channel; $V_I = 3 \text{ V}$ ; $T_{amb} = 25 \text{ °C}$	-	1	100	nA
$V_F$	forward voltage	$I_I = 1 \text{ mA}$ ; $T_{amb} = 25 \text{ °C}$	-	0.7	-	V
$C_{line}$	line capacitance	$f = 1 \text{ MHz}$ ; $V_I = 1.5 \text{ V}$ ; $T_{amb} = 25 \text{ °C}$ [1]	-	0.35	0.4	pF
$R_{dyn}$	dynamic resistance	TLP; positive transient; $T_{amb} = 25 \text{ °C}$ [2]	-	0.29	-	$\Omega$
		TLP; negative transient; $T_{amb} = 25 \text{ °C}$ [2]	-	0.29	-	$\Omega$
$V_{sbck}$	snapback voltage	$I_I = 1 \text{ A}$ ; TLP 100/10 ns; $T_{amb} = 25 \text{ °C}$	-	1.6	-	V
$V_{CL}$	clamping voltage	$I_{PP} = 5 \text{ A}$ ; positive transient; $T_{amb} = 25 \text{ °C}$ [3]	-	3	-	V
		$I_{PP} = -5 \text{ A}$ ; negative transient; $T_{amb} = 25 \text{ °C}$ [3]	-	-3	-	V

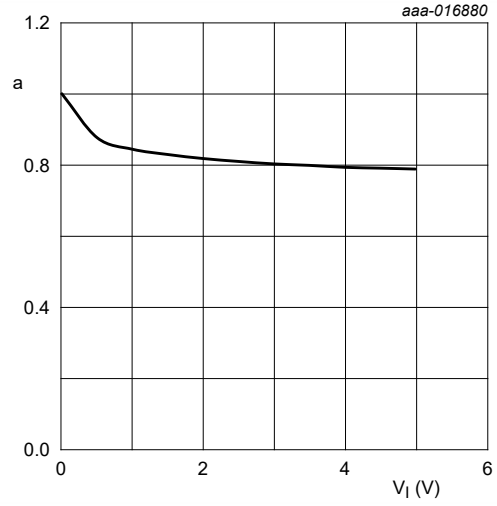
[1] The parameter is guaranteed by design.

[2] 100 ns Transmission Line Pulse (TLP), 50  $\Omega$ , pulser at 80 ns.

[3] According to IEC 61000-4-5 (8/20  $\mu s$  current waveform).

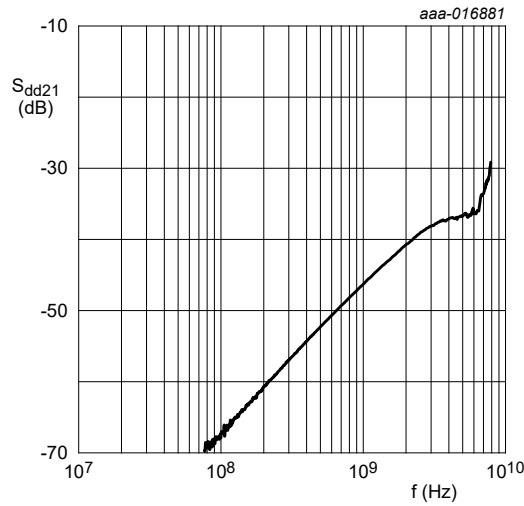


differential mode  
**Fig. 1. Insertion loss; typical values**



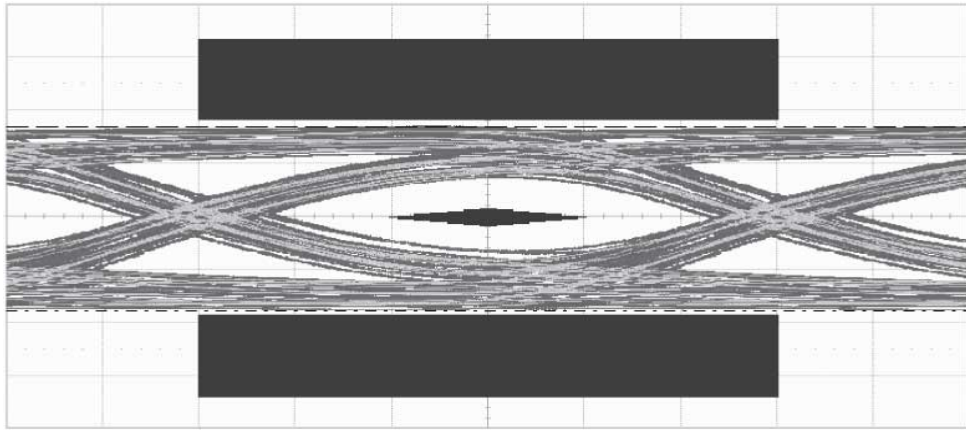
$$a = \frac{C_{line}}{C_{line}(V_I = 0 V)}$$

**Fig. 2. Relative capacitance as a function of input voltage; typical values**



normalized to 100 #Ω

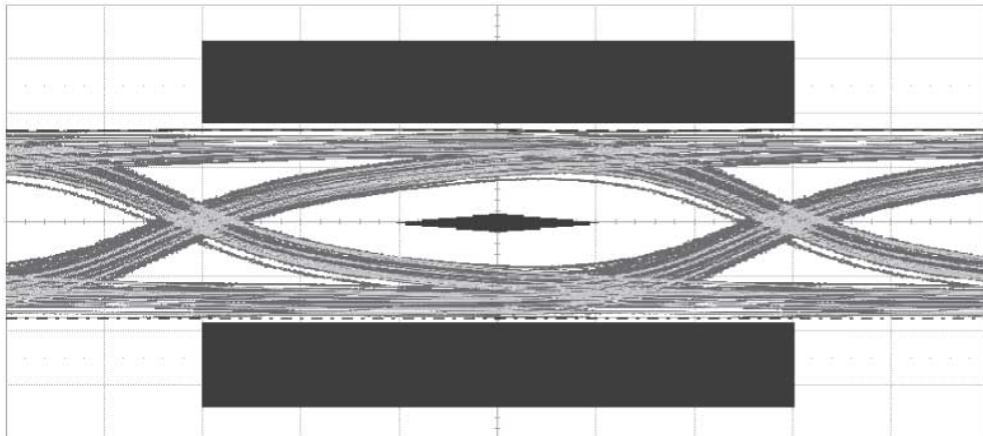
**Fig. 3. Crosstalk; typical values**



aaa-016882

Data rate: 10 Gbit/s  
Vertical scale: 325 mV/div  
Horizontal scale: 16.7 ps/div

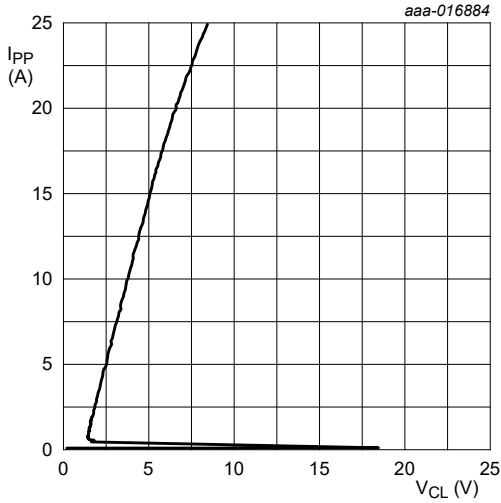
**Fig. 4. USB 3.2 eye diagram, PCB with device**



aaa-016883

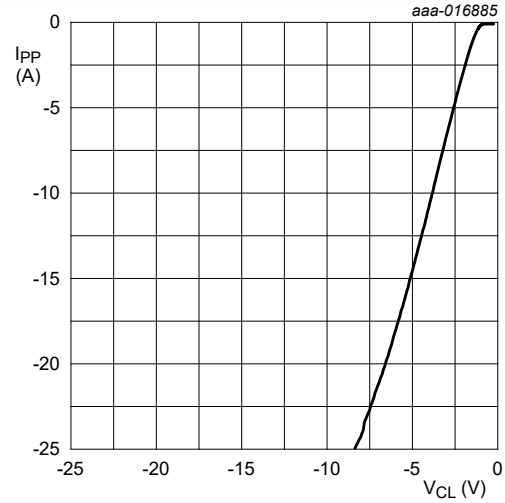
Data rate: 10 Gbit/s  
Vertical scale: 325 mV/div  
Horizontal scale: 16.7 ps/div

**Fig. 5. USB 3.2 eye diagram, PCB without device**



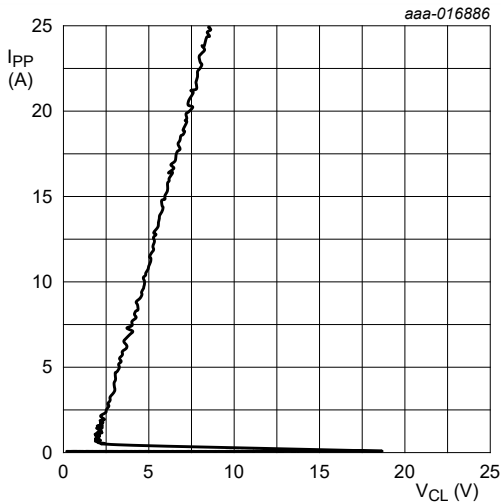
$t_p = 100 \text{ ns}$ ; Transmission Line Pulse (TLP);  $t_r = 1 \text{ ns}$

**Fig. 6. Dynamic resistance with positive clamping; typical values**



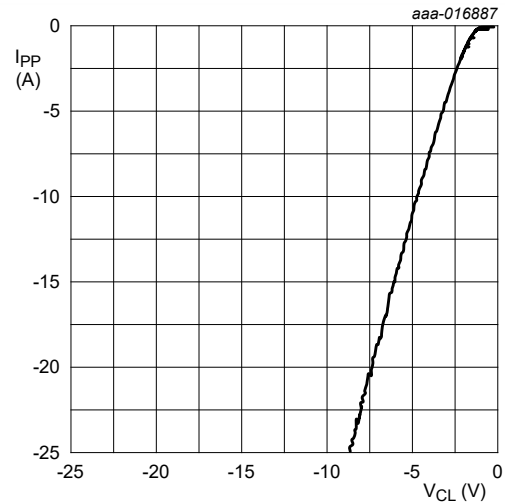
$t_p = 100 \text{ ns}$ ; Transmission Line Pulse (TLP);  $t_r = 1 \text{ ns}$

**Fig. 7. Dynamic resistance with negative clamping; typical values**



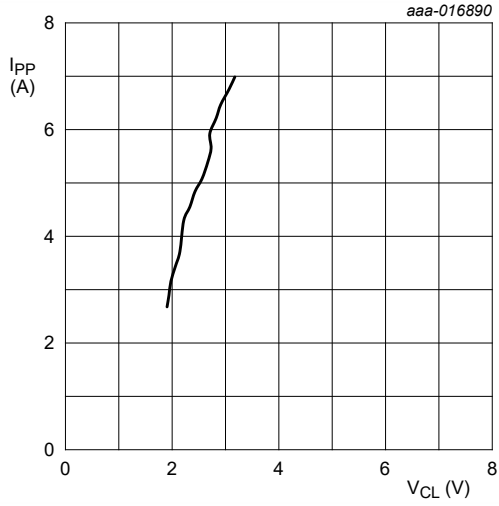
$t_p = 5 \text{ ns}$ ; Very-Fast TLP (VF-TLP)

**Fig. 8. Dynamic resistance with positive clamping; typical values**



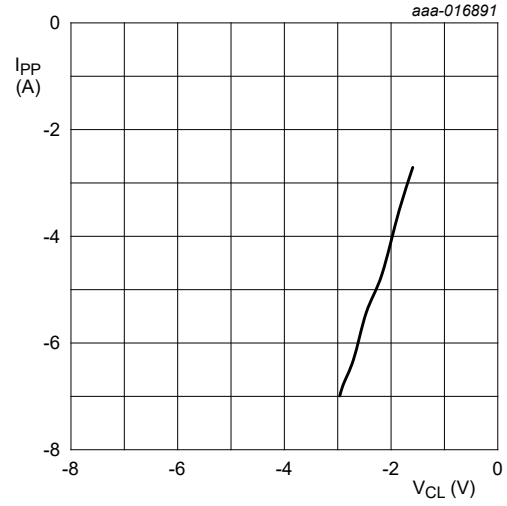
$t_p = 5 \text{ ns}$ ; Very-Fast TLP (VF-TLP)

**Fig. 9. Dynamic resistance with negative clamping; typical values**



IEC 61000-4-5;  $t_p = 8/20 \mu s$ ; positive pulse

**Fig. 10. Dynamic resistance with positive clamping; typical values**



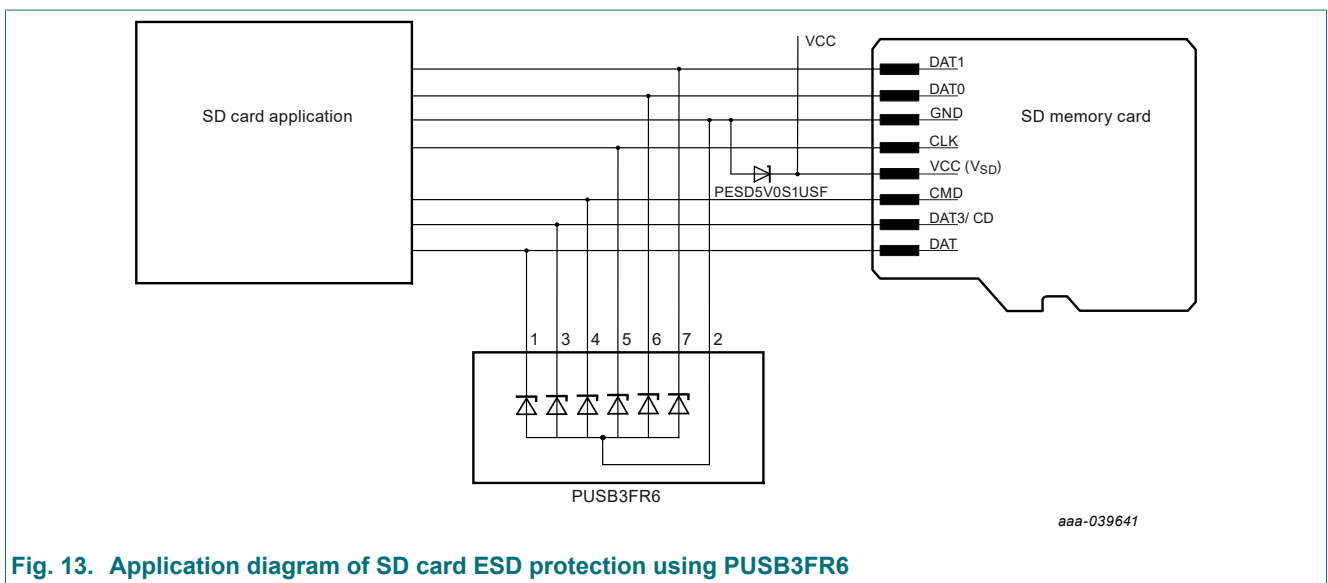
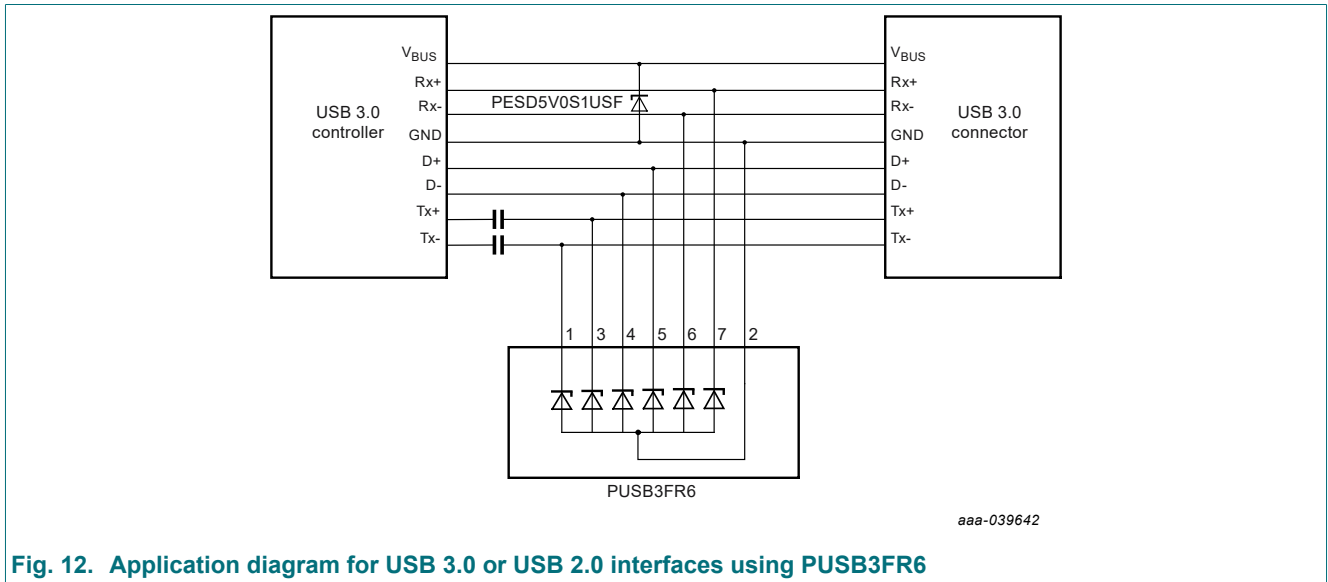
IEC 61000-4-5;  $t_p = 8/20 \mu s$ ; negative pulse

**Fig. 11. Dynamic resistance with negative clamping; typical values**

## 9. Application information

The device is designed to provide high-level ESD protection for high-speed serial data buses such as HDMI, DisplayPort, eSATA and LVDS data lines.

**Note:** When designing the PCB, give careful consideration to impedance matching and signal coupling. Do not connect the signal lines to unlimited current sources like, for example, a battery.



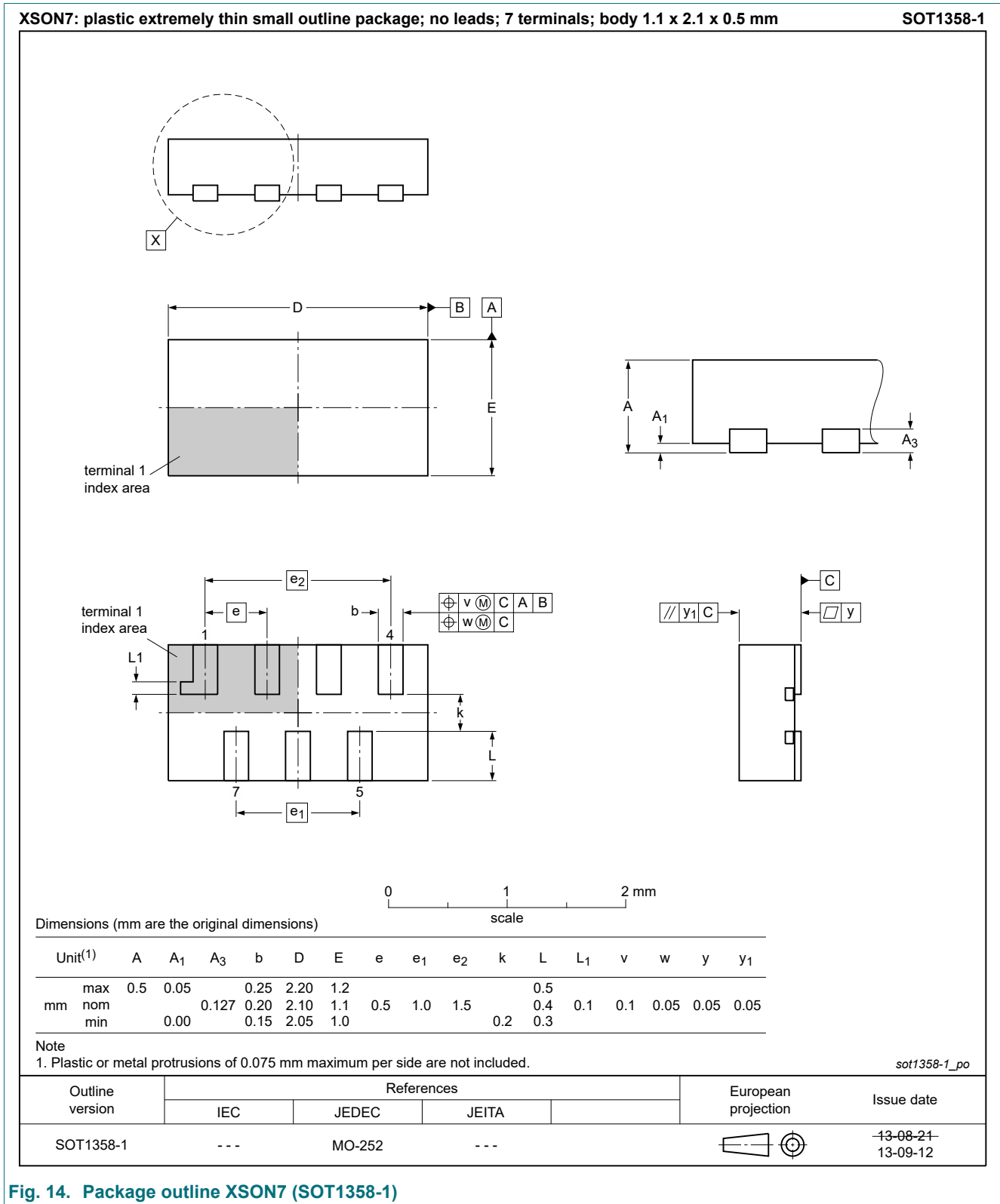
### Dynamic resistance

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).



### 10. Package outline



**Fig. 14. Package outline XSON7 (SOT1358-1)**



## 12. Revision history

Table 6. Revision history

Data sheet ID	Release date	Data sheet status	Change notice	Supersedes
PUSB3FR6 v.3	20240528	Product data sheet	-	PUSB3FR6 v.2
Modifications:	• Chapter application information: rework with focus on Fig. 12 and Fig. 13			
PUSB3FR6 v.2	20181011	Product data sheet	-	PUSB3FR6 v.1
PUSB3FR6 v.1	20150225	Product 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.

- [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>.

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