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# TVS Diodes

Transient Voltage Suppressor Diodes

## ESD3V3U4ULC

Ultra-low Capacitance ESD / Transient Protection Array

ESD3V3U4ULC

## Data Sheet

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Final

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**Revision History Revision 1.5, 2012-12-05**

Page or Item	Subjects (major changes since previous revision)
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**Rev. 1.6, 2013-02-20**

6	Small updateds in Table 3

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Last Trademarks Update 2010-06-09

# 1 Ultra-low Capacitance ESD / Transient Protection Array

## 1.1 Features

- ESD / transient protection of high speed data lines exceeding:
  - IEC61000-4-2 (ESD):  $\pm 20$  kV (air/contact)
  - IEC61000-4-4 (EFT):  $\pm 2.5$  kV (5/50ns)
  - IEC61000-4-5 (Surge):  $\pm 3$  A (8/20 $\mu$ s)
- Maximum working voltage:  $V_{RWM} = 3.3$  V
- Ultra low capacitance  $C_L = 0.4$  pF I/O to GND (typical)
- Very low clamping voltage:  $V_{CL} = 8$  V (typical) at  $I_{PP} = 16$  A
- Very low dynamic resistance:  $R_{DYN} = 0.19$   $\Omega$  (typical)
- TSLP-9-1 package with pad pitch 0.5 mm, optimized pad design to simplify PCB layout
- Pb-free and halogen free package (RoHS compliant)



## 1.2 Application Examples

- USB 3.0, 10/100/1000 Ethernet, Firewire
- DVI, HDMI, S-ATA, DisplayPort
- Mobile HDMI Link, MDDI, MIPI, etc.

## 1.3 Product Description

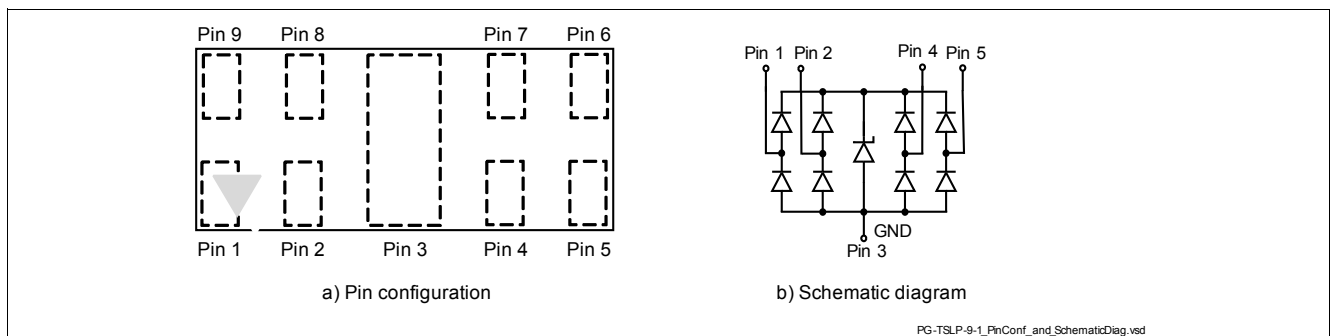


Figure 1 Pin Configuration and Schematic Diagram

Table 1 Ordering Information

Type	Package	Configuration	Marking code
ESD3V3U4ULC	TSLP-9-1	4 lines, uni-directional	Z2

## 2 Characteristics

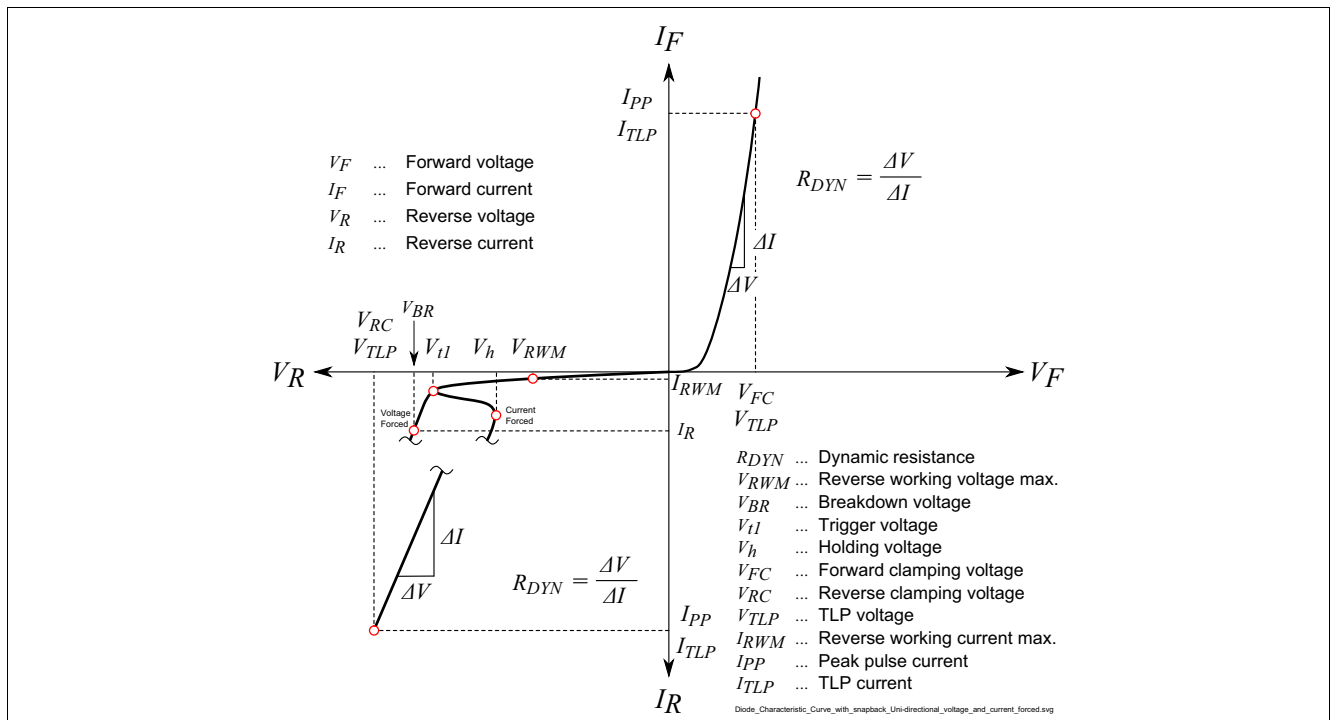
**Table 2** Maximum Rating at  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified

Parameter	Symbol	Values			Unit
		Min.	Typ.	Max.	
ESD contact discharge <sup>1)</sup>	$V_{ESD}$	-20	–	20	kV
Peak pulse current ( $t_p = 8/20\text{ }\mu\text{s}$ ) <sup>2)</sup>	$I_{PP}$	-3	–	3	A
Operating temperature	$T_{OP}$	-40	–	125	$^\circ\text{C}$
Storage temperature	$T_{stg}$	-65	–	150	$^\circ\text{C}$

1)  $V_{ESD}$  according to IEC61000-4-2

2)  $I_{PP}$  according to IEC61000-4-5

### 2.1 Electrical Characteristics at $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified



**Figure 2** Definitions of electrical characteristics[1]

**Table 3 DC Characteristics at  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Reverse working voltage <sup>1)</sup>	$V_{RWM}$	–	–	3.3	V	I/O to GND
Reverse current <sup>1)</sup>	$I_R$	–	1	50	nA	I/O to GND, $V_R = 3.3\text{ V}$
Breakdown voltage <sup>1)</sup>	$V_{BR}$	–	6.2	–	V	I/O to GND,
Reverse trigger voltage <sup>2)</sup>	$V_{t1}$	–	6.2	–	V	I/O to GND,
Reverse holding voltage <sup>2)</sup>	$V_h$	3.35	4	4.4	V	I/O to GND, $I_R = 10\text{ mA}$

1) Voltage forced

2) Current forced

**Table 4 RF Characteristics at  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Line capacitance <sup>1)</sup>	$C_L$	–	0.4	0.65	pF	$V_R = 0\text{ V}$ , $f = 1\text{ MHz}$ , I/O to GND
		–	0.2	0.35	pF	$V_R = 0\text{ V}$ , $f = 1\text{ MHz}$ , I/O to I/O
Channel capacitance matching between I/O to GND	$\Delta C_{i/o-GND}$	–	0.035	–	pF	$V_R = 0\text{ V}$ , $f = 1\text{ MHz}$ , I/O to GND
Channel capacitance matching between I/O to I/O	$\Delta C_{i/o-i/o}$	–	0.017	–	pF	$V_R = 0\text{ V}$ , $f = 1\text{ MHz}$ , I/O to I/O

1) Total capacitance line to ground

**Table 5 ESD Characteristics at  $T_A = 25\text{ °C}$ , unless otherwise specified**

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Clamping volage <sup>1)</sup>	$V_{CL}$	–	4.8	–	V	$I_{PP} = 1\text{ A}$ , $t_p = 8/20\mu\text{s}$ from I/O to GND
		–	6.2	–		$I_{PP} = 3\text{ A}$ , $t_p = 8/20\mu\text{s}$ from I/O to GND
Clamping voltage <sup>2)</sup>	$V_{CL}$	–	8	–		$I_{TLP} = 16\text{ A}$ , from I/O to GND
		–	11	–		$I_{TLP} = 30\text{ A}$ , from I/O to GND
Forward clamping voltage <sup>1)</sup>	$V_{FC}$	–	1.4	–		$I_{PP} = 1\text{ A}$ , $t_p = 8/20\mu\text{s}$ from GND to I/O
		–	2.3	–		$I_{PP} = 3\text{ A}$ , $t_p = 8/20\mu\text{s}$ from GND to I/O
Forward clamping voltage <sup>2)</sup>	$V_{FC}$	–	6	–		$I_{TLP} = 16\text{ A}$ , from GND to I/O
		–	9	–		$I_{TLP} = 30\text{ A}$ , from GND to I/O
Dynamic resistance <sup>2)</sup>	$R_{DYN}$	–	0.19	–	$\Omega$	I/O to GND
		–	0.23	–	$\Omega$	GND to any I/O

1)  $I_{PP}$  according to IEC61000-4-5

2) Please refer to Application Note AN210. TLP parameter:  $Z_0 = 50\ \Omega$ ,  $t_p = 100\text{ ns}$ ,  $t_r = 300\text{ ps}$ , averaging window:  $t_1 = 30\text{ ns}$  to  $t_2 = 60\text{ ns}$ , extraction of dynamic resistance using least squares fit of TLP characteristic between  $I_{PP1} = 10\text{ A}$  and  $I_{PP2} = 40\text{ A}$  [2].



Typical Characteristics at  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified

### 3 Typical Characteristics at $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified

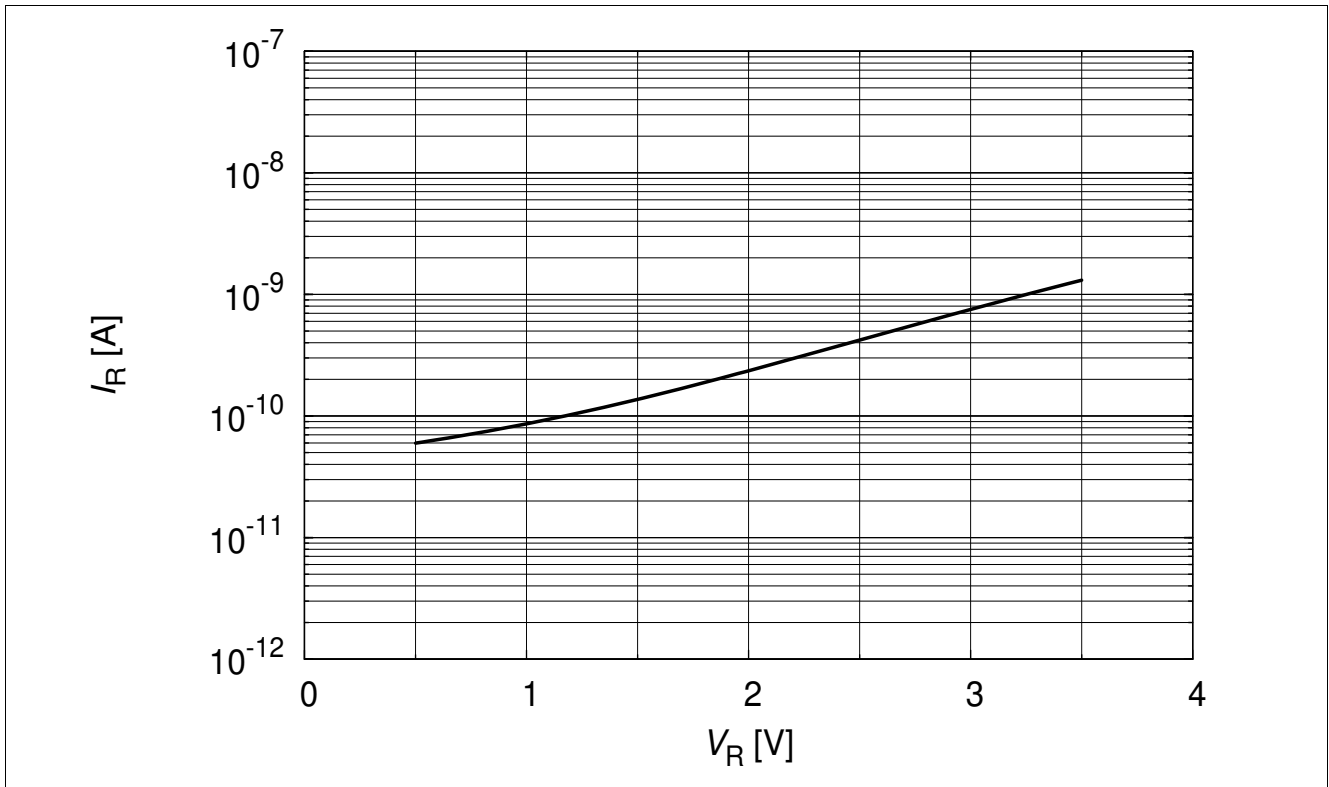


Figure 3 Reverse current,  $I_R = (V_R)$

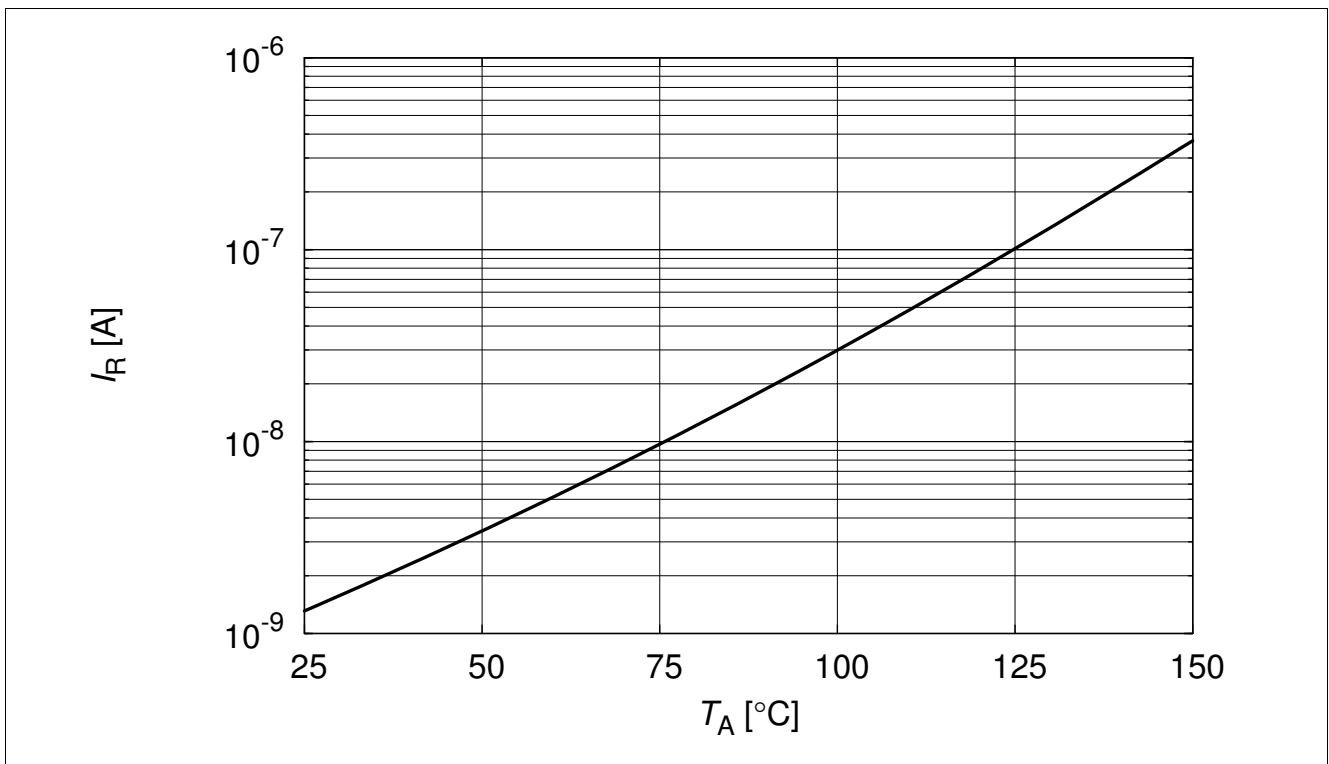


Figure 4 Reverse current:  $I_R = f(T_A)$ ,  $V_R = 3.3\text{ V}$

Typical Characteristics at  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified

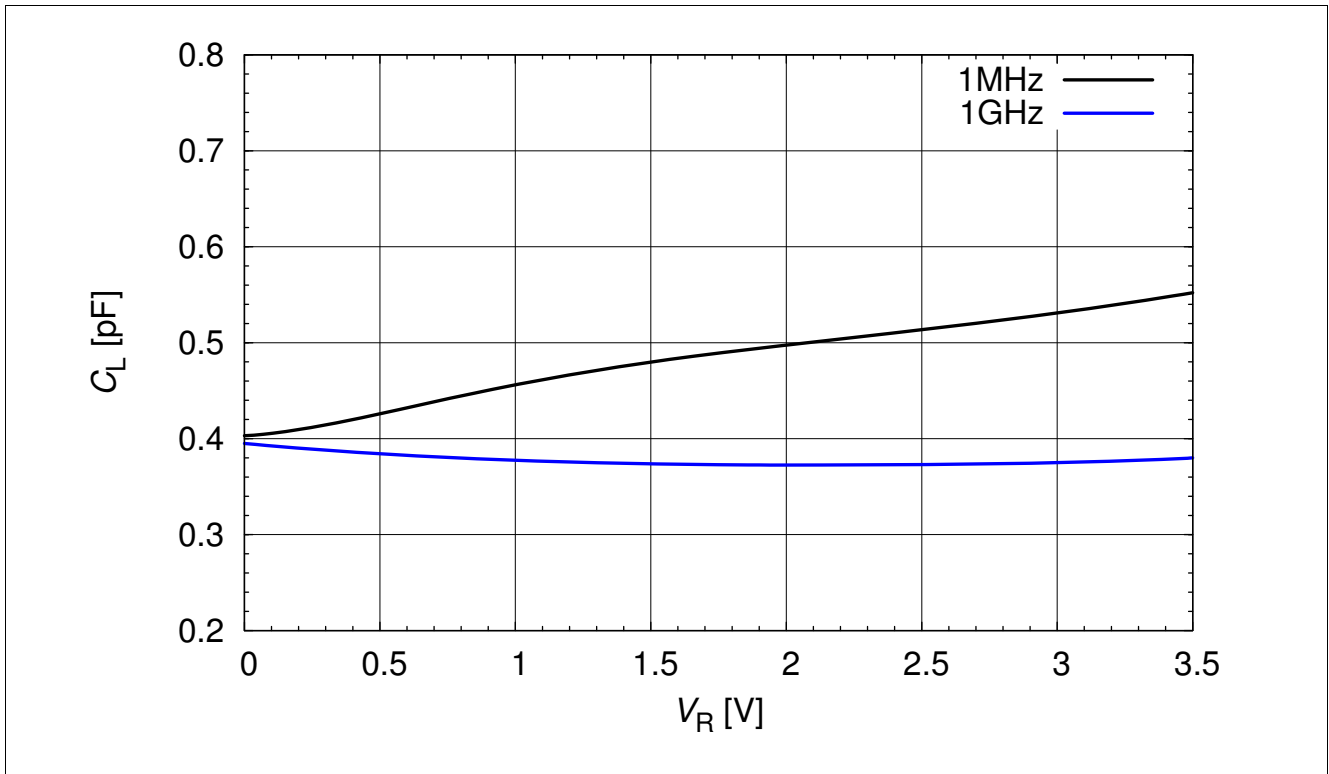
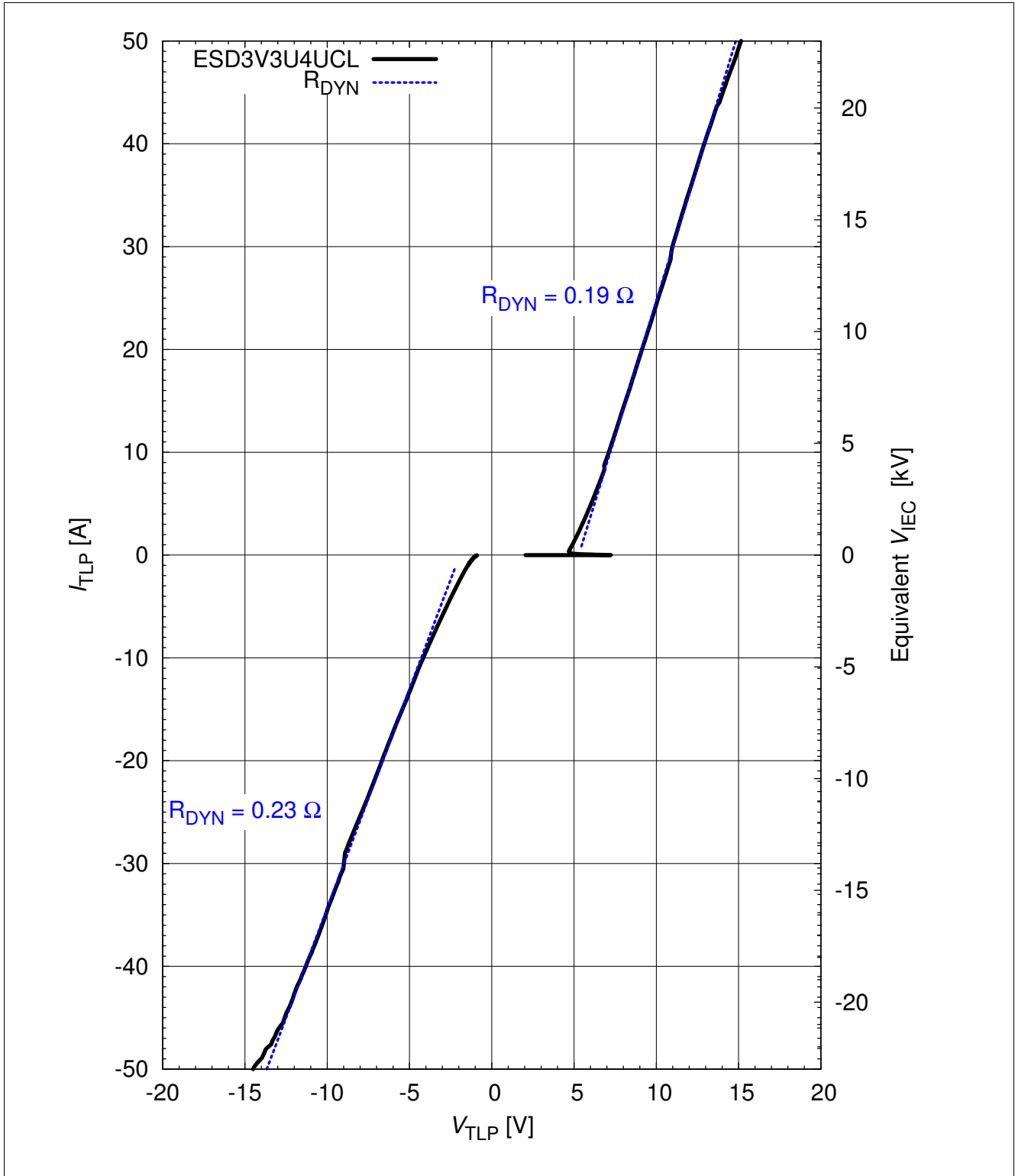


Figure 5 Line capacitance:  $C_L = f(V_R), f = 1\text{MHz}$ , from I/O to GND

Typical Characteristics at  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified



**Figure 6** Clamping voltage (TLP):  $I_{TLP} = f(V_{TLP})$  according ANSI/ESD STM5.5.1- Electrostatic Discharge Sensitivity Testing using Transmission Line Pulse (TLP) Model. TLP conditions:  $Z_0 = 50\ \Omega$ ,  $t_p = 100\text{ ns}$ ,  $t_r = 0.6\text{ ns}$ ,  $I_{TLP}$  and  $V_{TLP}$  averaging window:  $t_1 = 30\text{ ns}$  to  $t_2 = 60\text{ ns}$ , extraction of dynamic resistance using squares fit to TLP characteristics between  $I_{TLP1} = 10\text{ A}$  and  $I_{TLP2} = 40\text{ A}$ . Please refer to Application Note AN210[2]

Typical Characteristics at  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified

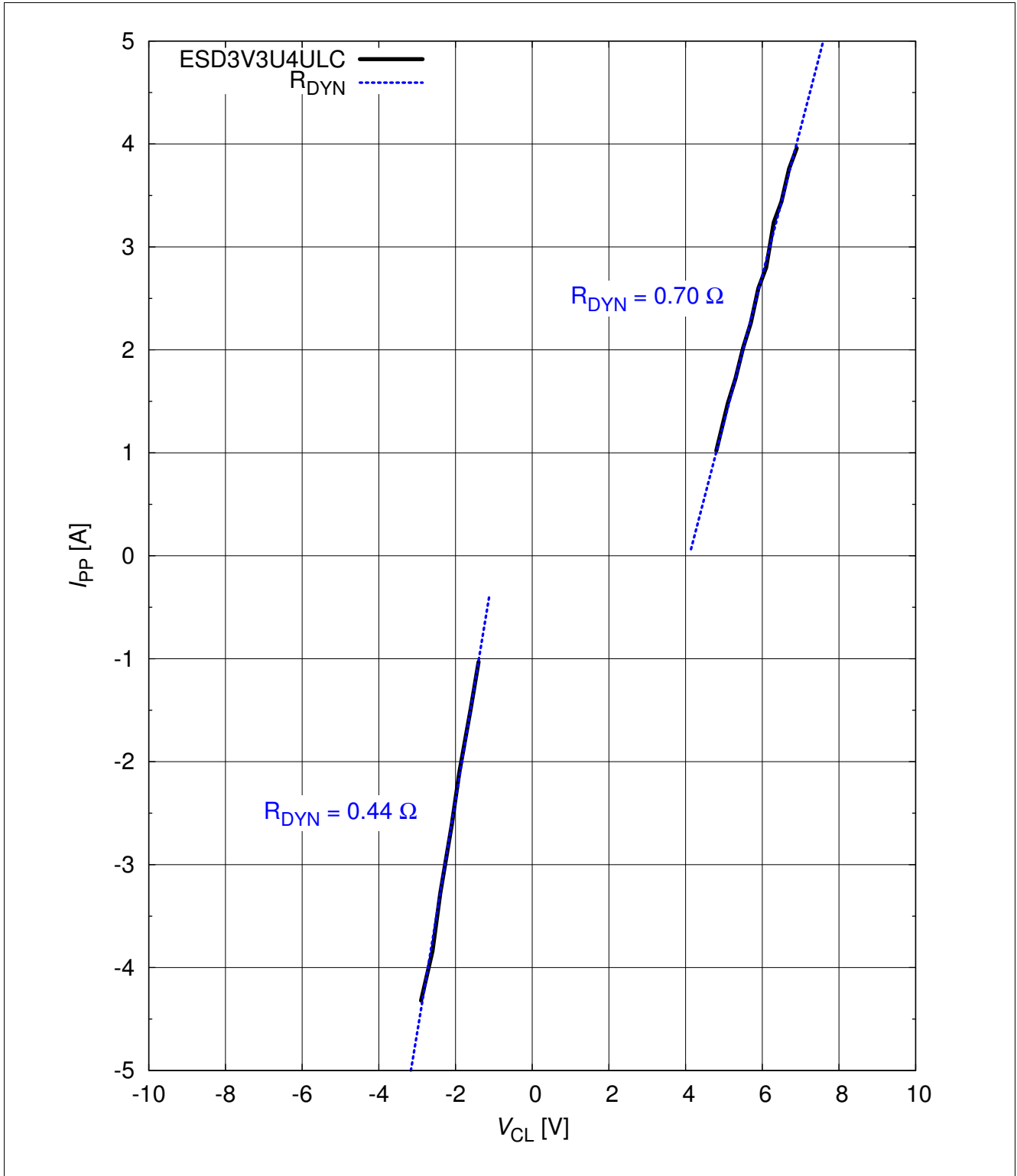


Figure 7 Pulse current (IEC61000-4-5) versus clamping voltage:  $I_{PP} = f(V_{CL})$

Typical Characteristics at  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified

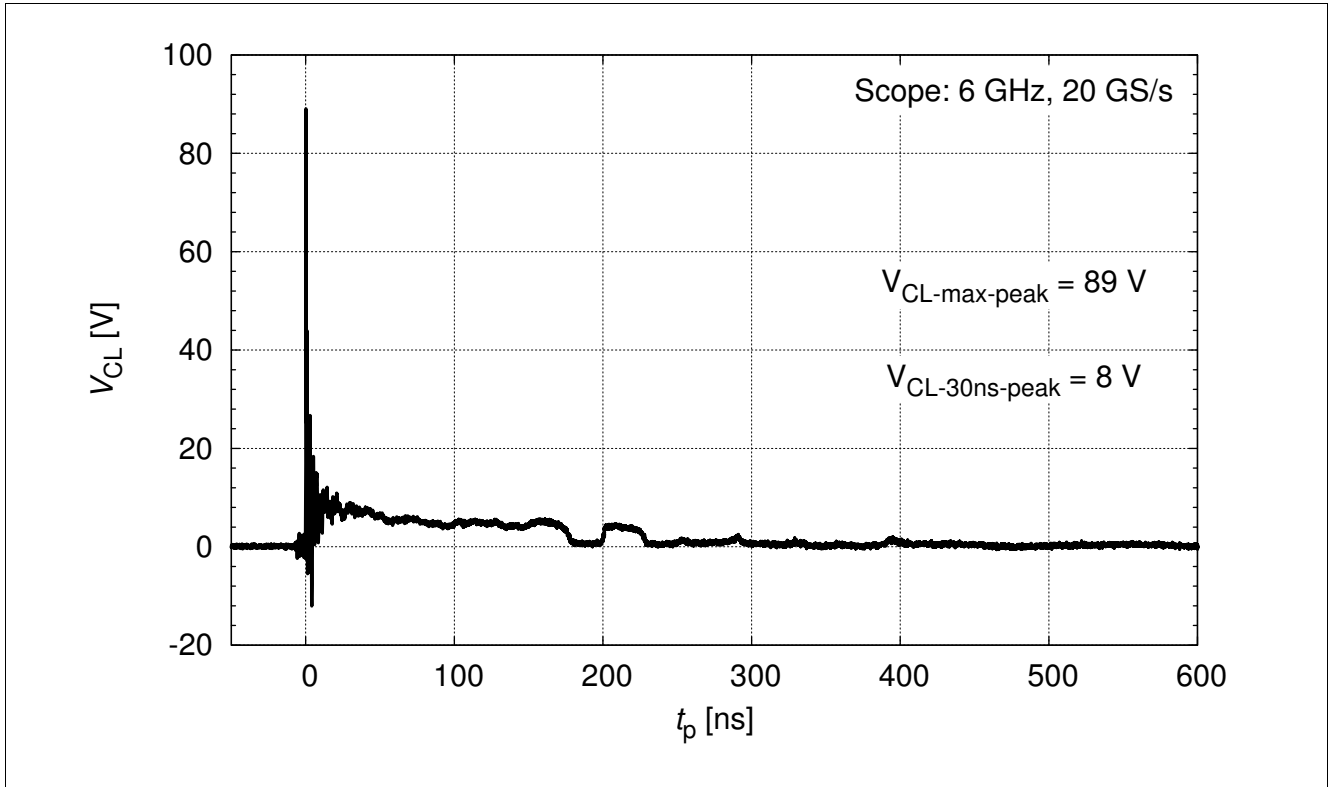


Figure 8 Clamping voltage at +8 kV discharge according IEC61000-4-2 ( $R = 330\ \Omega$ ,  $C = 150\ \text{pF}$ )

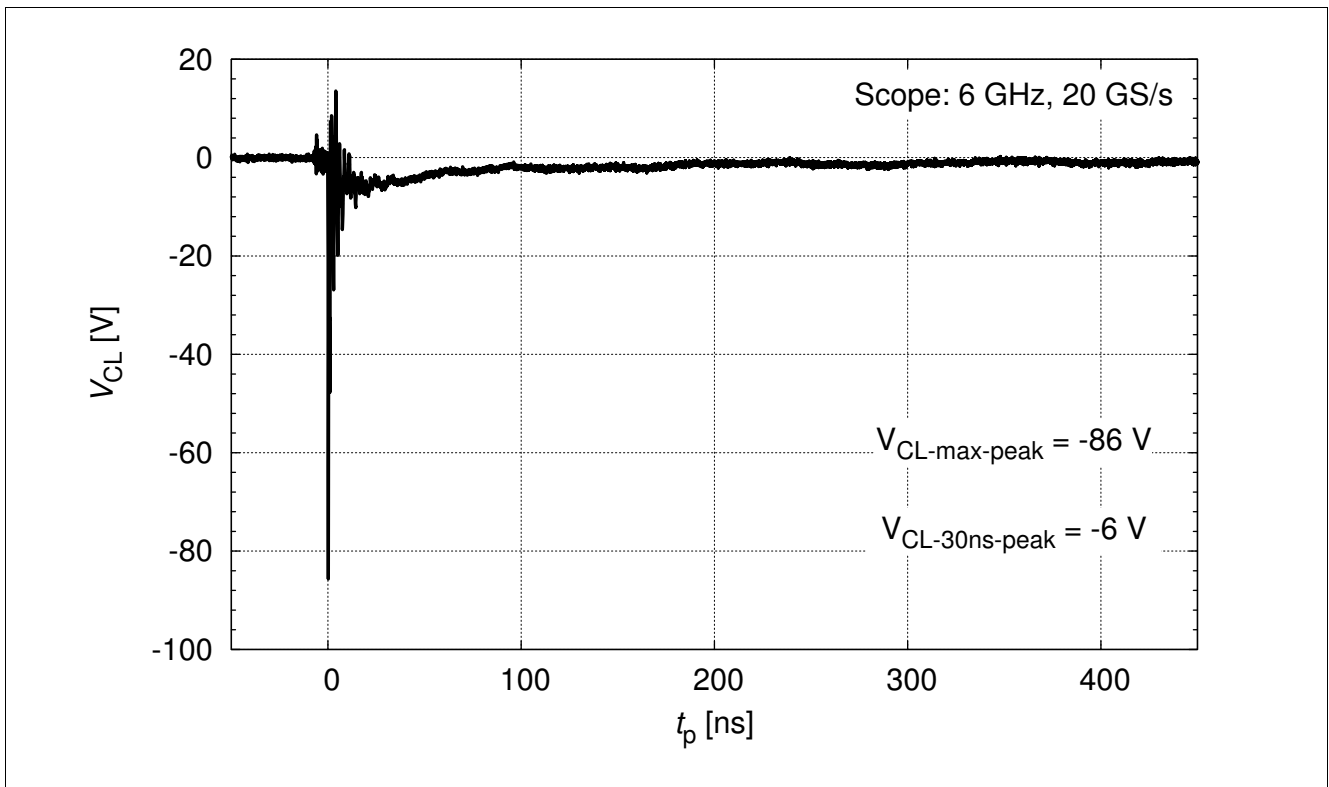


Figure 9 Clamping voltage at -8 kV discharge according IEC61000-4-2 ( $R = 330\ \Omega$ ,  $C = 150\ \text{pF}$ )

Typical Characteristics at  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified

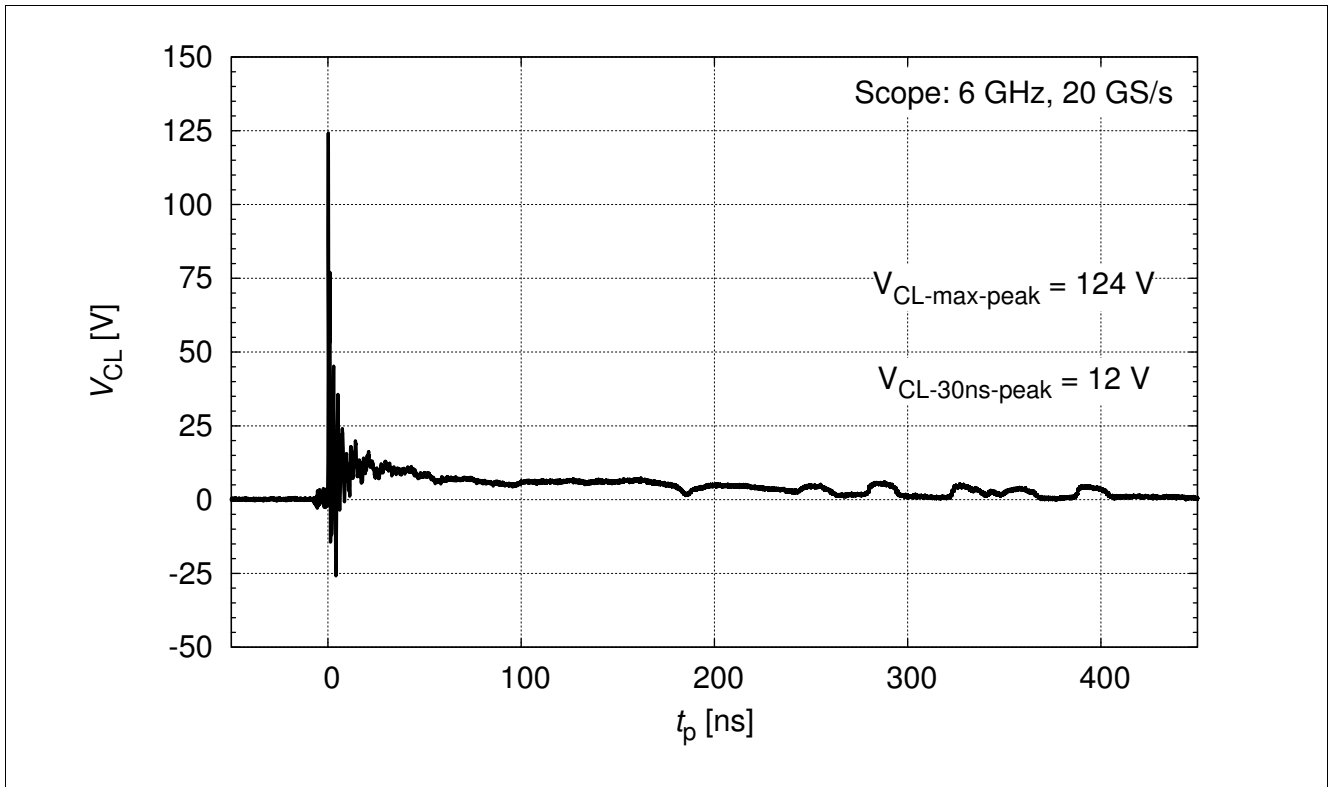


Figure 10 Clamping voltage at +15 kV discharge according IEC61000-4-2 ( $R = 330\text{ Ohm}$ ,  $C = 150\text{ pF}$ )

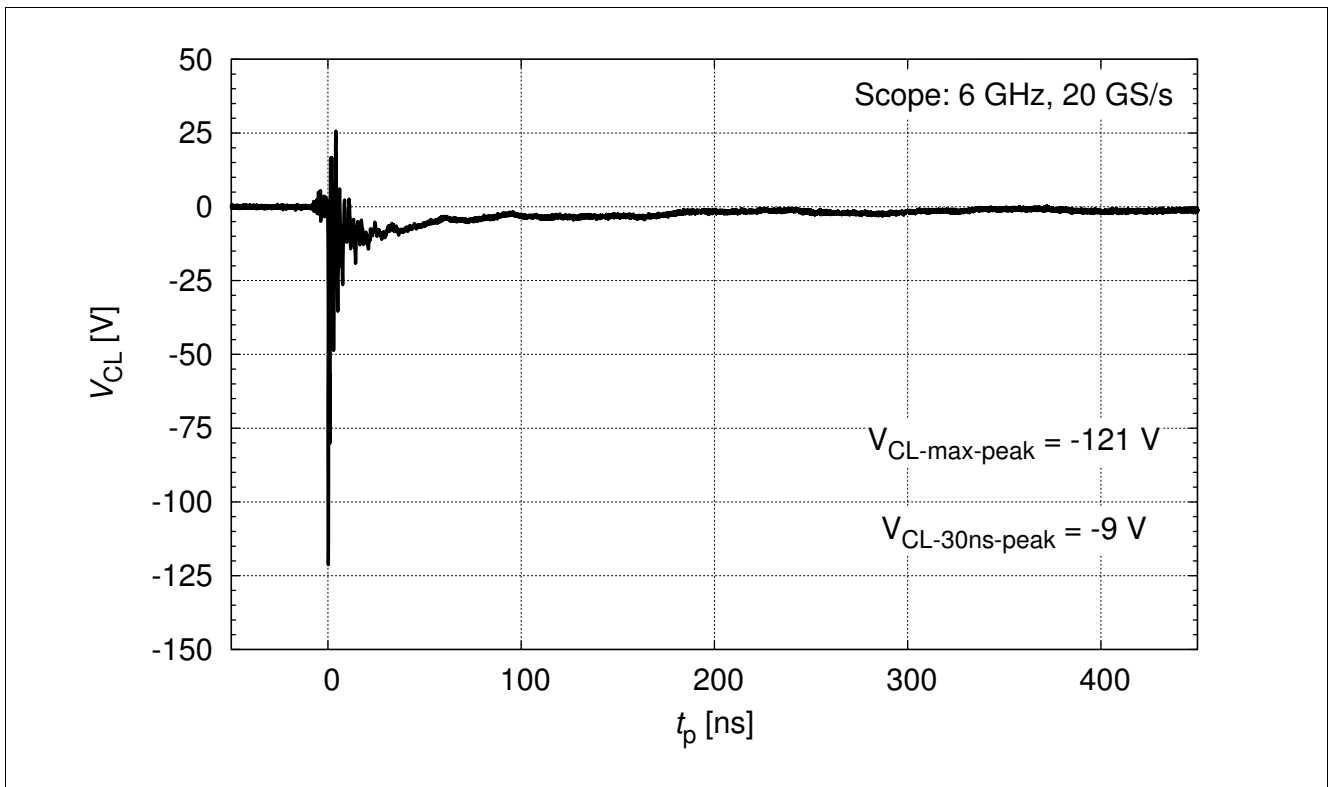


Figure 11 Clamping voltage at -15 kV discharge according IEC61000-4-2 ( $R = 330\text{ }\Omega$ ,  $C = 150\text{ pF}$ )

## 4 Application Information

To design USB3.0 link for best system level ESD performance and error free Signal Integrity is mandatory.

To bring both requirements together, the ESD protection devices has to provide excellent ESD and a very low device capacitance. The Infineon ESD3V3U4ULC in “array” configuration, combined with a clear and straight forward “full through” layout fulfills these requirements in the best way.

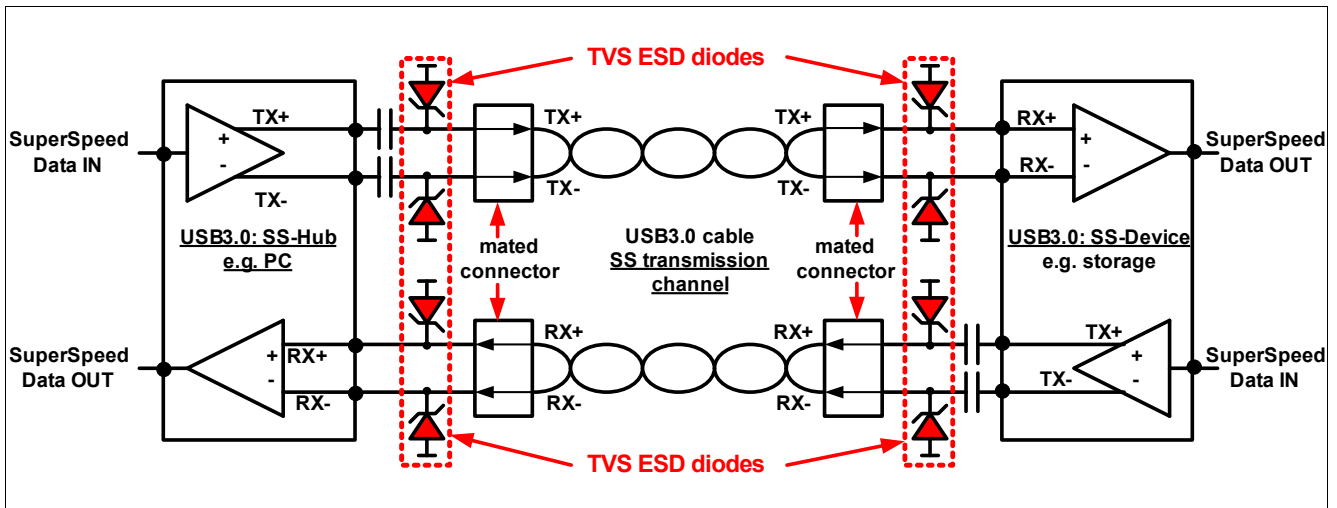


Figure 12 USB3.0 structure with ESD protection devices [3]

## 5 Ordering Information Scheme

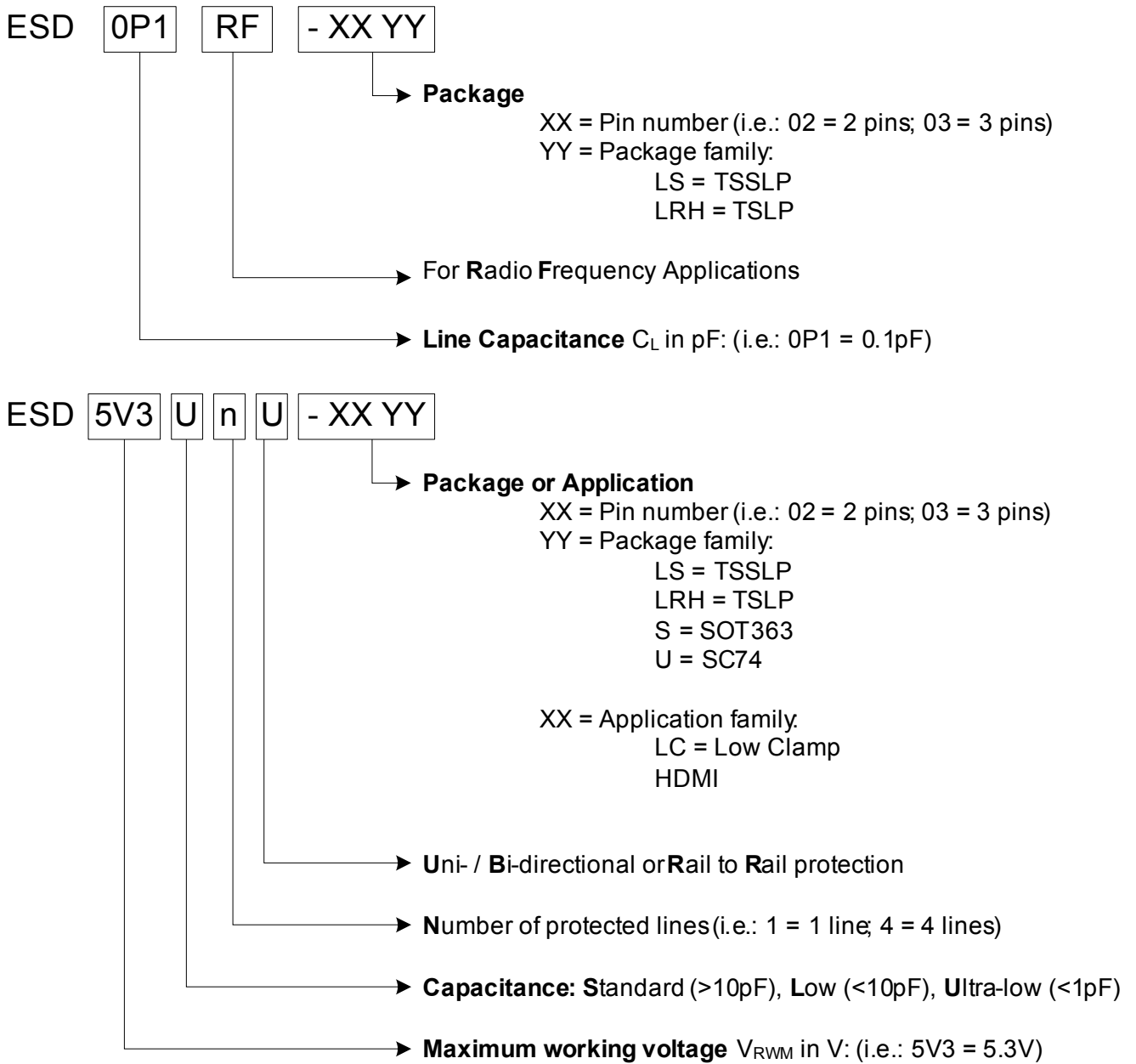


Figure 13 Ordering information scheme





**References**

- [1] **On-chip ESD protection for integrated circuits**, Albert Z. H. Wang, ISBN:0-7923-7647-1
- [2] Infineon Technologie AG - **Application Note AN210**: Effective ESD Protection Design at System Level Using VF-TLP Characterization Methodology
- [3] Infineon Technologie AG - **Application Note AN240**: Effective ESD Protection for USB3.0, combined with perfect Signal Integrity.

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