

# ESD7004

## Transient Voltage Suppressors

### Low Capacitance ESD Protection Diode for High Speed Data Line

The ESD7004 transient voltage suppressor is designed to protect high speed data lines from ESD. Ultra-low capacitance and low ESD clamping voltage make this device an ideal solution for protecting voltage sensitive high speed data lines. The flow-through style package allows for easy PCB layout and matched trace lengths necessary to maintain consistent impedance between high speed differential lines such as USB 3.0 and HDMI.

#### Features

- Low Capacitance (0.4 pF Typical, I/O to GND)
- Protection for the Following IEC Standards:  
IEC 61000-4-2 (Level 4)
- Low ESD Clamping Voltage
- This is a Pb-Free Device

#### Typical Applications

- USB 3.0
- HDMI
- Display Port
- eSATA

#### MAXIMUM RATINGS ( $T_J = 25^\circ\text{C}$ unless otherwise noted)

Rating	Symbol	Value	Unit
Operating Junction Temperature Range	$T_J$	-55 to +125	$^\circ\text{C}$
Storage Temperature Range	$T_{\text{stg}}$	-55 to +150	$^\circ\text{C}$
Lead Solder Temperature – Maximum (10 Seconds)	$T_L$	260	$^\circ\text{C}$
IEC 61000-4-2 Contact (ESD)	ESD	$\pm 15$	kV
IEC 61000-4-2 Air (ESD)	ESD	$\pm 15$	kV

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

See Application Note AND8308/D for further description of survivability specs.



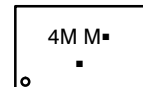
ON Semiconductor®

<http://onsemi.com>

#### MARKING DIAGRAM

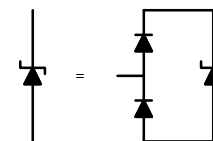
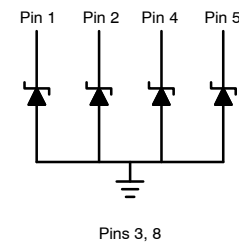
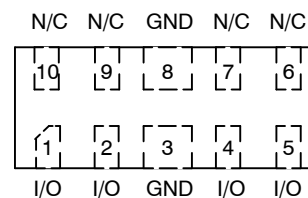


UDFN10  
CASE 517BB



- 4M = Specific Device Code (tbd)
  - M = Date Code
  - = Pb-Free Package
- (\*Note: Microdot may be in either location)

#### PIN CONFIGURATION AND SCHEMATIC



#### ORDERING INFORMATION

Device	Package	Shipping
ESD7004MUTAG	UDFN10 (Pb-Free)	3000 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

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## ELECTRICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ unless otherwise specified)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Reverse Working Voltage	$V_{RWM}$	I/O Pin to GND			5.0	V
Breakdown Voltage	$V_{BR}$	$I_T = 1\text{ mA}$ , I/O Pin to GND	5.5			V
Reverse Leakage Current	$I_R$	$V_{RWM} = 5\text{ V}$ , I/O Pin to GND			1.0	$\mu\text{A}$
Clamping Voltage (Note 1)	$V_C$	$I_{PP} = 1\text{ A}$ , I/O Pin to GND (8 x 20 $\mu\text{s}$ pulse)			10	V
Clamping Voltage (Note 2)	$V_C$	IEC61000-4-2, $\pm 8\text{ KV}$ Contact	See Figures 1 and 2			V
Clamping Voltage TLP (Note 3) See Figures 6 through 9	$V_C$	$I_{PP} = 8\text{ A}$ $I_{PP} = 16\text{ A}$ $I_{PP} = -8\text{ A}$ $I_{PP} = -16\text{ A}$		11.4 15.6 -4.5 -8.1		
Junction Capacitance	$C_J$	$V_R = 0\text{ V}$ , $f = 1\text{ MHz}$ between I/O Pins		0.2	0.3	pF
Junction Capacitance	$C_J$	$V_R = 0\text{ V}$ , $f = 1\text{ MHz}$ between I/O Pins and GND		0.4	0.5	pF

- Surge current waveform per Figure 5.
- For test procedure see Figures 3 and 4 and application note AND8307/D.
- ANSI/ESD STM5.5.1 – Electrostatic Discharge Sensitivity Testing using Transmission Line Pulse (TLP) Model.  
TLP conditions:  $Z_0 = 50\ \Omega$ ,  $t_p = 100\text{ ns}$ ,  $t_r = 4\text{ ns}$ , averaging window;  $t_1 = 30\text{ ns}$  to  $t_2 = 60\text{ ns}$ .

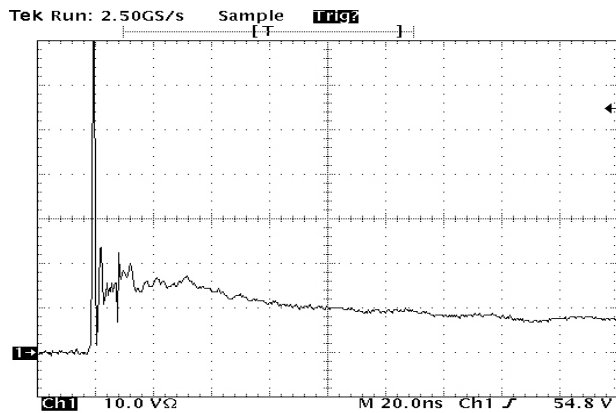


Figure 1. IEC61000-4-2 +8 KV Contact ESD Clamping Voltage

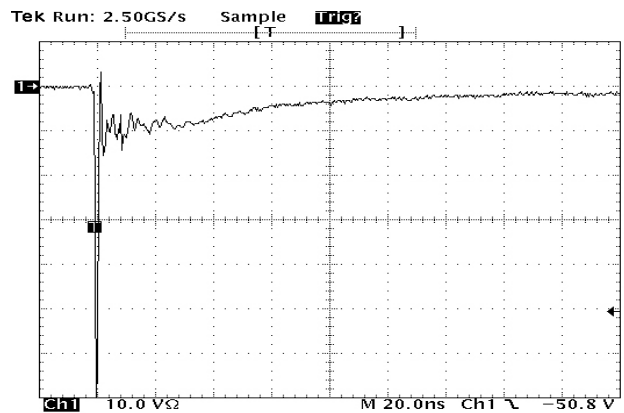


Figure 2. IEC61000-4-2 -8 KV Contact Clamping Voltage

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## IEC 61000-4-2 Spec.

Level	Test Voltage (kV)	First Peak Current (A)	Current at 30 ns (A)	Current at 60 ns (A)
1	2	7.5	4	2
2	4	15	8	4
3	6	22.5	12	6
4	8	30	16	8

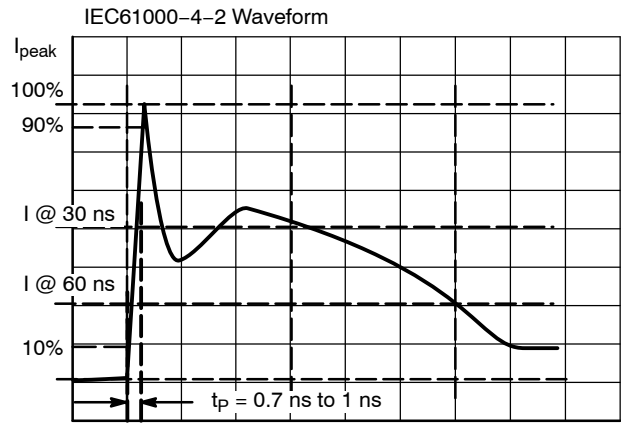


Figure 3. IEC61000-4-2 Spec

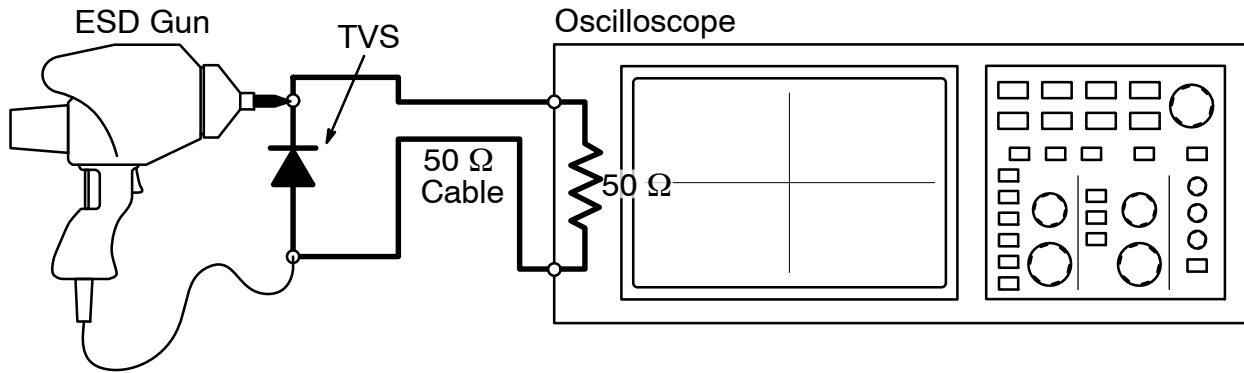


Figure 4. Diagram of ESD Clamping Voltage Test Setup

The following is taken from Application Note AND8308/D – Interpretation of Datasheet Parameters for ESD Devices.

### ESD Voltage Clamping

For sensitive circuit elements it is important to limit the voltage that an IC will be exposed to during an ESD event to as low a voltage as possible. The ESD clamping voltage is the voltage drop across the ESD protection diode during an ESD event per the IEC61000-4-2 waveform. Since the IEC61000-4-2 was written as a pass/fail spec for larger

systems such as cell phones or laptop computers it is not clearly defined in the spec how to specify a clamping voltage at the device level. ON Semiconductor has developed a way to examine the entire voltage waveform across the ESD protection diode over the time domain of an ESD pulse in the form of an oscilloscope screenshot, which can be found on the datasheets for all ESD protection diodes. For more information on how ON Semiconductor creates these screenshots and how to interpret them please refer to AND8307/D.

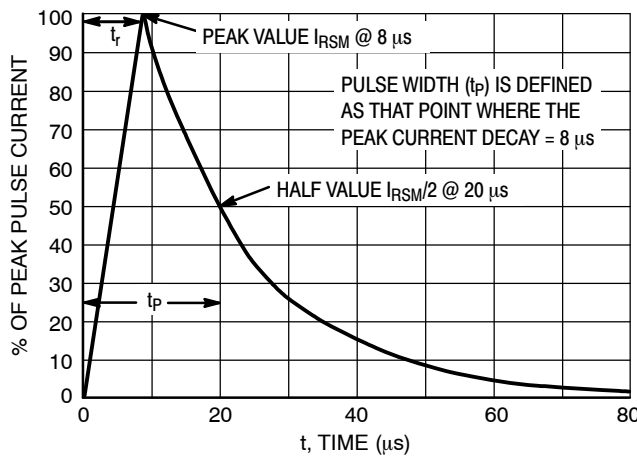


Figure 5. 8 X 20 μs Pulse Waveform

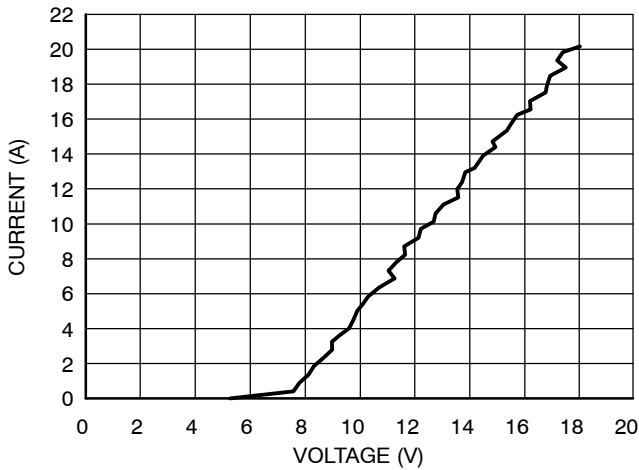


Figure 6. Positive TLP I-V Curve

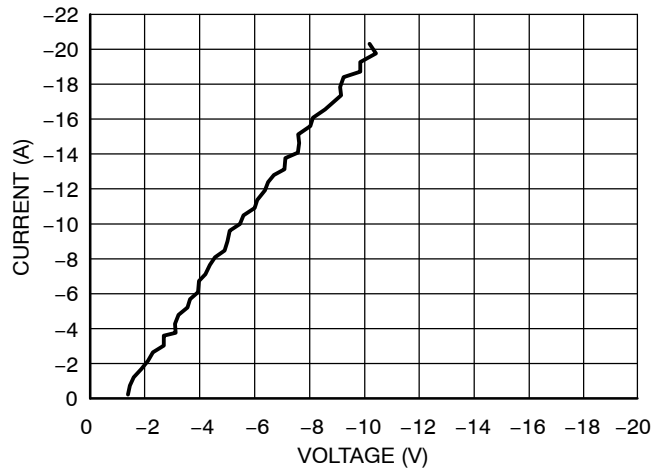


Figure 7. Negative TLP I-V Curve

**Transmission Line Pulse (TLP) Measurement**

Transmission Line Pulse (TLP) provides current versus voltage (I-V) curves in which each data point is obtained from a 100 ns long rectangular pulse from a charged transmission line. A simplified schematic of a typical TLP system is shown in Figure 8. TLP I-V curves of ESD protection devices accurately demonstrate the product’s ESD capability because the 10s of amps current levels and under 100 ns time scale match those of an ESD event. This is illustrated in Figure 9 where an 8 kV IEC 61000-4-2 current waveform is compared with TLP current pulses at 8 A and 16 A. A TLP I-V curve shows the voltage at which the device turns on as well as how well the device clamps voltage over a range of current levels. A typical TLP I-V curve for the ESD7004 is shown in Figures 6 and 7.

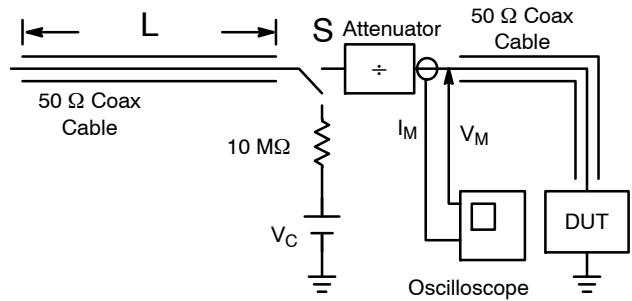


Figure 8. Simplified Schematic of a Typical TLP System

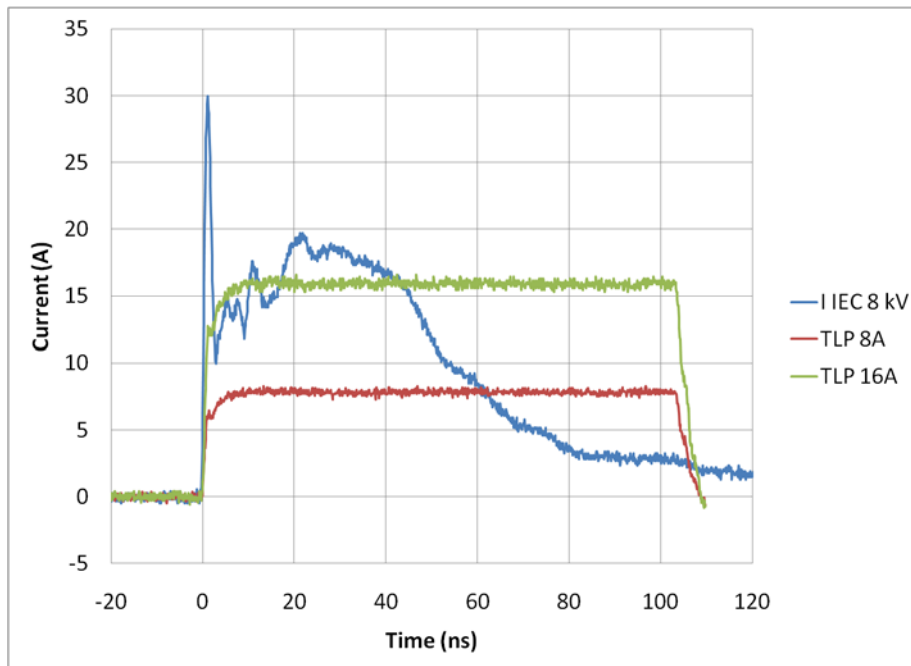
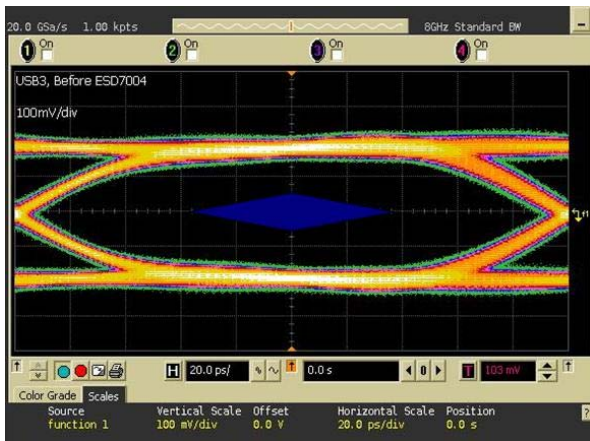
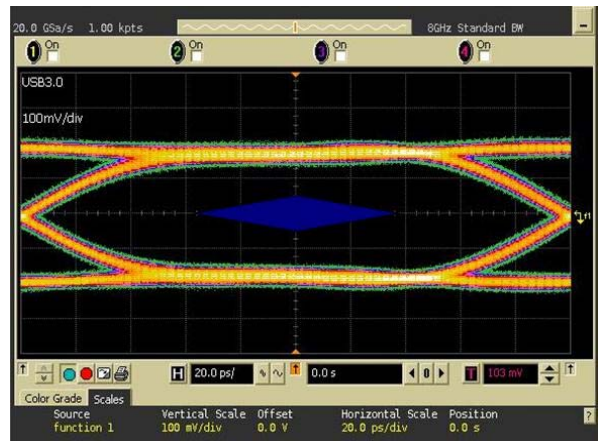


Figure 9. Comparison Between 8 kV IEC 61000-4-2 and 8 A and 16 A TLP Waveforms

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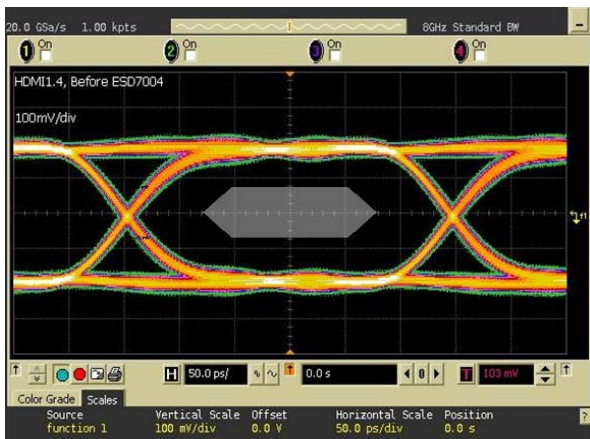


Without ESD

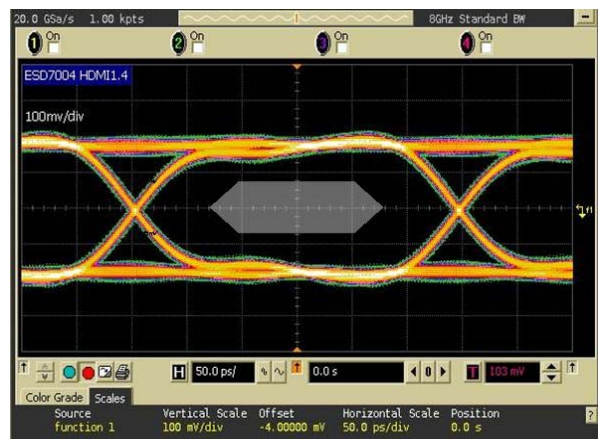


With ESD7004

Figure 10. USB3.0 Eye Diagram with and without ESD7004. 5.0 Gb/s, 400 mV<sub>pp</sub>

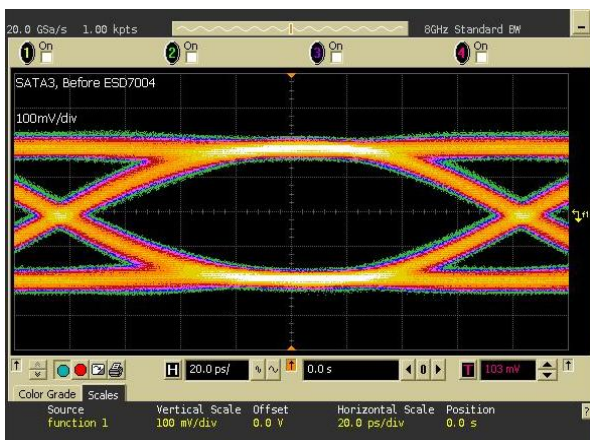


Without ESD

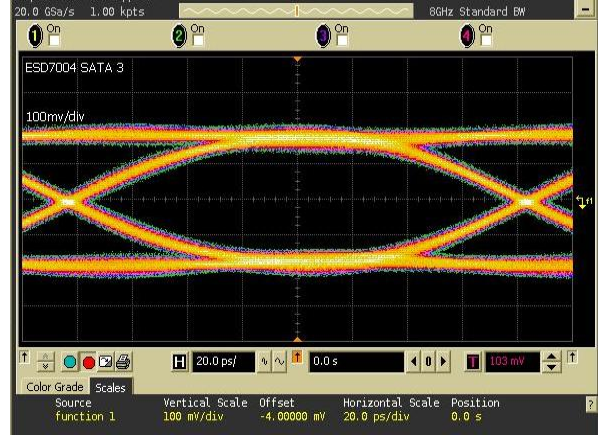


With ESD7004

Figure 11. HDMI1.4 Eye Diagram with and without ESD7004. 3.4 Gb/s, 400 mV<sub>pp</sub>



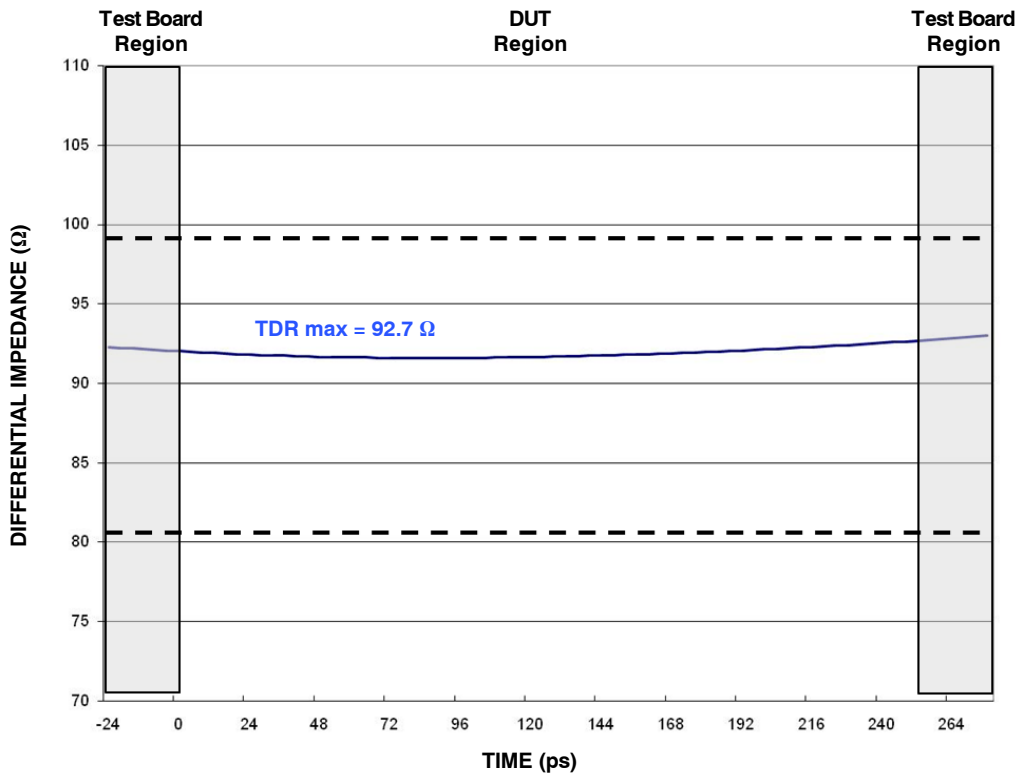
Without ESD



With ESD7004

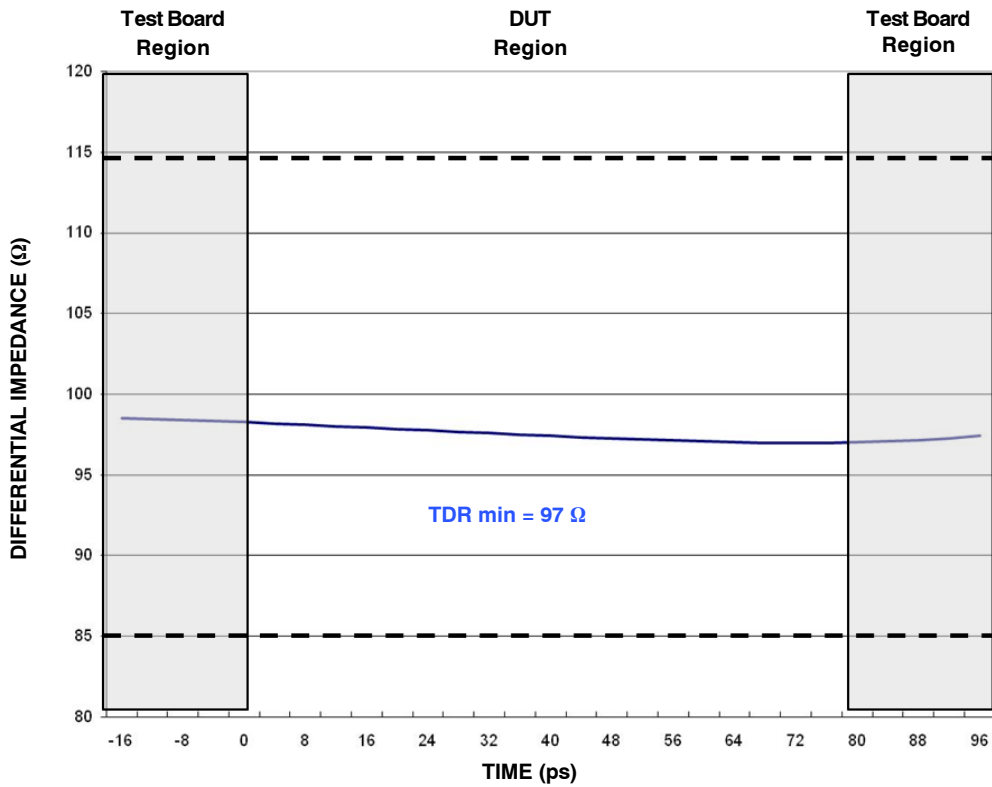
Figure 12. ESATA3.0 Eye Diagram with and without ESD7004. 6 Gb/s, 400 mV<sub>pp</sub>

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\*\* USB spec requirement is  $90 \Omega \pm 10\%$  — — — — —

Figure 13. USB TDR Measurement. 90  $\Omega$  Differential Impedance Target, 200 ps Rise Time



\*\* HDMI spec requirement is  $100 \Omega \pm 15\%$  — — — — —

Figure 14. HDMI TDR Measurement. 100  $\Omega$  Differential Impedance Target, 200 ps Rise Time

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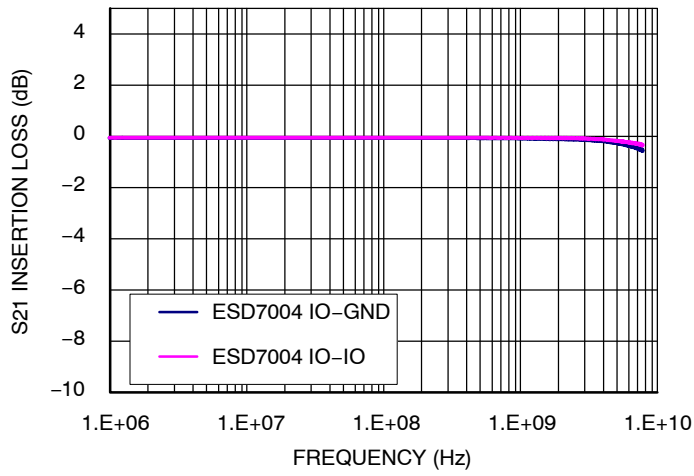


Figure 15. ESD7004 Insertion Loss



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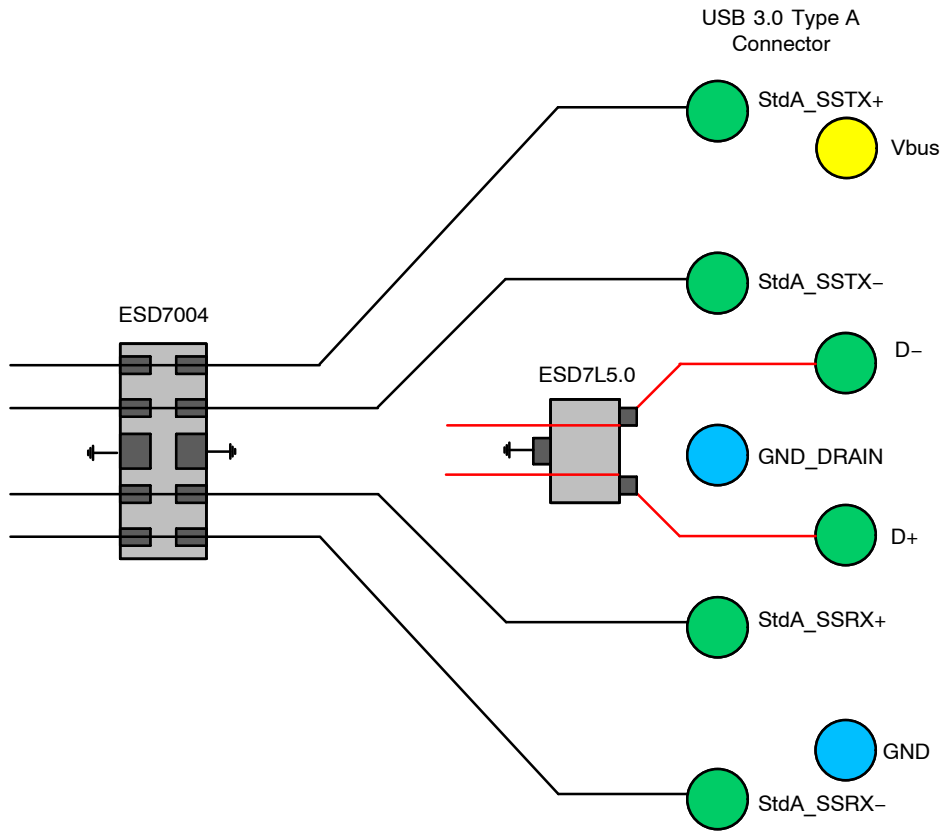


Figure 16. USB3.0 Standard A Connector Layout Diagram

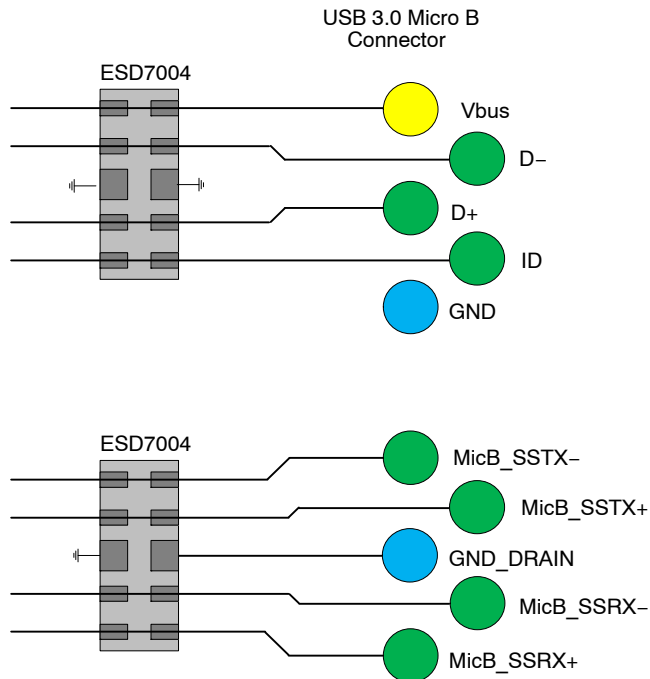


Figure 17. USB3.0 Micro B Connector Layout Diagram



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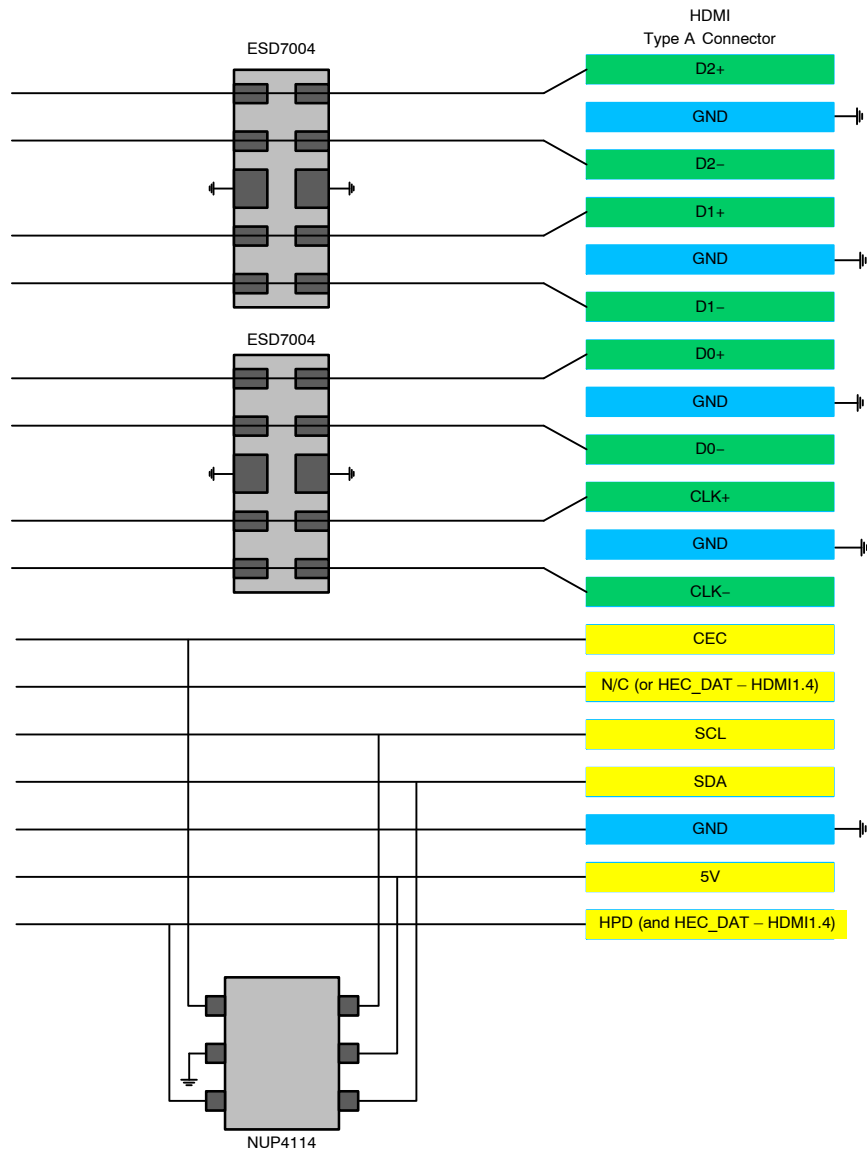


Figure 18. HDMI Layout Diagram

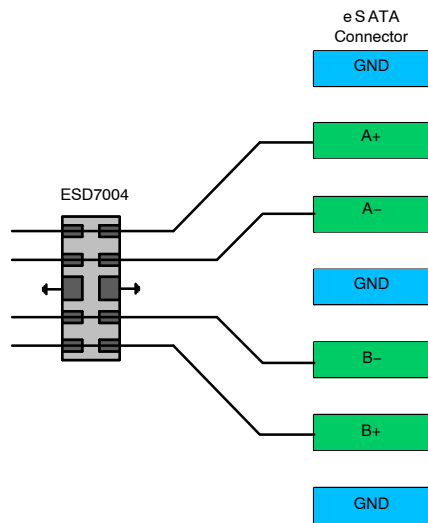
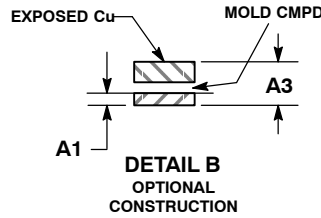
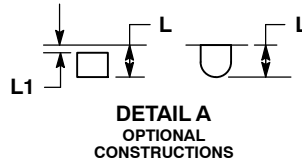
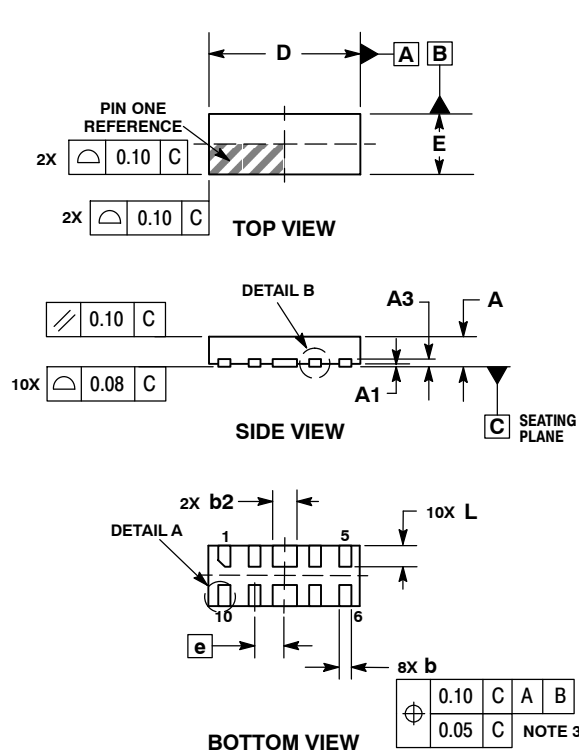


Figure 19. eSATA Layout Diagram

# ESD7004

## PACKAGE DIMENSIONS

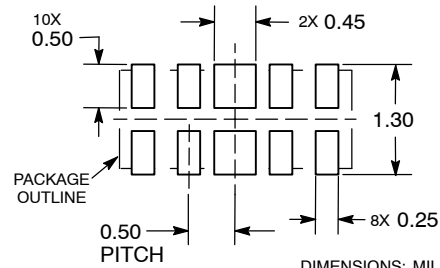
### UDFN10 2.5x1, 0.5P CASE 517BB ISSUE O



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
  2. CONTROLLING DIMENSION: MILLIMETERS.
  3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30mm FROM TERMINAL.

DIM	MILLIMETERS	
	MIN	MAX
A	0.45	0.55
A1	0.00	0.05
A3	0.13 REF	
b	0.15	0.25
b2	0.35	0.45
D	2.50 BSC	
E	1.00 BSC	
e	0.50 BSC	
L	0.30	0.40
L1	---	0.05

### RECOMMENDED SOLDERING FOOTPRINT\*



\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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