

# EMI4184

## Common Mode Filter with ESD Protection

### Functional Description

The EMI4184 is an integrated common mode filter providing both ESD protection and EMI filtering for high speed digital serial interfaces such as HDMI or MIPI D-PHY.

The EMI4184 provides protection for two differential data line pairs in a small RoHS-compliant UDFN20 package.

### Features

- Highly Integrated Common Mode Filter (CMF) with ESD Protection provides protection and EMI reduction for systems using High Speed Serial Data Lines with cost and space savings over discrete solutions
- Large Differential Mode Bandwidth with Cutoff Frequency > 2 GHz
- High Common Mode Stop Band Attenuation: >25 dB at 700 MHz, >30 dB at 800 MHz
- Provides ESD Protection to IEC61000-4-2 Level 4,  $\pm 15$  kV Contact Discharge
- Low Channel Input Capacitance Provides Superior Impedance Matching Performance
- Low Profile Package with Small Footprint in UDFN20 2 x 5 mm Pb-Free Package
- These Devices are Pb-Free, Halogen Free/BFR Free and are RoHS Compliant

### Applications

- HDMI/DVI Display in Mobile Phones
- MIPI D-PHY (CSI-2, DSI, etc) in Mobile Phones and Digital Still Cameras

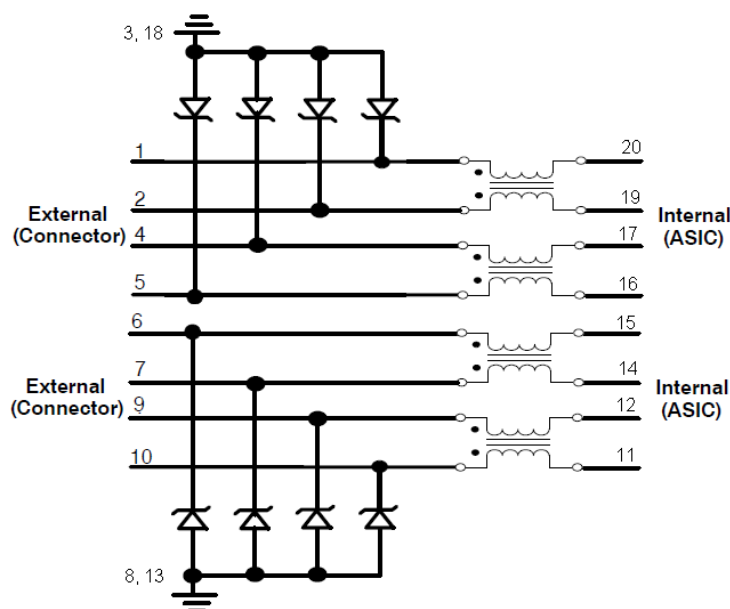
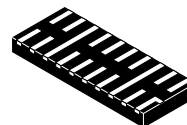


Figure 1. EMI4184 Electrical Schematic



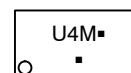
ON Semiconductor®

<http://onsemi.com>



UDFN20  
CASE 517CL

### MARKING DIAGRAMS



U4 = Specific Device Code  
M = Date Code  
▪ = Pb-Free Package

(\*Note: Microdot may be in either location)

### PIN CONNECTIONS

In_1+	1	20	Out_1+
In_1-	2	19	Out_1-
GND	3	18	GND
In_2+	4	17	Out_2+
In_2-	5	16	Out_2-
In_3+	6	15	Out_3+
In_3-	7	14	Out_3-
GND	8	13	GND
In_4+	9	12	Out_4+
In_4-	10	11	Out_4-

### ORDERING INFORMATION

Device	Package	Shipping†
EMI4184MUTAG	UDFN20 (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 Specifications Brochure, BRD8011/D.

## PIN FUNCTION DESCRIPTION

Pin Name	Pin No.	Type	Description
In_1+	1	I/O	CMF Channel 1+ to Connector
In_1-	2	I/O	CMF Channel 1- to Connector
Out_1+	20	I/O	CMF Channel 1+ to ASIC
Out_1-	19	I/O	CMF Channel 1- to ASIC
In_2+	4	I/O	CMF Channel 2+ to Connector
In_2-	5	I/O	CMF Channel 2- to Connector
Out_2+	17	I/O	CMF Channel 2+ to ASIC
Out_2-	16	I/O	CMF Channel 2- to ASIC
In_3+	6	I/O	CMF Channel 3+ to Connector
In_3-	7	I/O	CMF Channel 3- to Connector
Out_3+	15	I/O	CMF Channel 3+ to ASIC
Out_3-	14	I/O	CMF Channel 3- to ASIC
In_4+	9	I/O	CMF Channel 4+ to Connector
In_4-	10	I/O	CMF Channel 4- to Connector
Out_4+	12	I/O	CMF Channel 4+ to ASIC
Out_4-	11	I/O	CMF Channel 4- to ASIC
GND1	3, 18	GND	Ground
GND2	8, 13	GND	Ground

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

Parameter	Symbol	Value	Unit
Operating Temperature Range	$T_{OP}$	-40 to +85	$^\circ\text{C}$
Storage Temperature Range	$T_{STG}$	-65 to +150	$^\circ\text{C}$
ESD Discharge IEC61000-4-2 Contact Discharge	$V_{PP}$	$\pm 15$	kV
Maximum Lead Temperature for Soldering Purposes (1/8" from Case for 10 seconds)	$T_L$	260	$^\circ\text{C}$
DC Current per Line	$I_{LINE}$	100	mA

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.

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

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$I_{LEAK}$	Channel Leakage Current	$T_A = 25^\circ\text{C}$ , $V_{IN} = 5\text{ V}$ , $GND = 0\text{ V}$			1.0	$\mu\text{A}$
$V_F$	Channel Negative Voltage	$T_A = 25^\circ\text{C}$ , $I_F = 10\text{ mA}$	0.1		1.5	V
$C_{IN}$	Channel Input Capacitance to Ground (Pins 1, 2, 4, 5 to Pins 3, 8 and 6, 7, 9, 10 to Pins 8, 13)	$T_A = 25^\circ\text{C}$ , At 1 MHz, $GND = 0\text{ V}$ , $V_{IN} = 1.65\text{ V}$		0.8	1.3	pF
$R_{CH}$	Channel Resistance (Pins 1–20, 2–19, 4–17, 5–16, 6–15, 7–14, 9–12, 10–11)			8.0		$\Omega$
$f_{3dB}$	Differential Mode Cut-off Frequency	50 $\Omega$ Source and Load Termination		2.0		GHz
$F_{atten}$	Common Mode Stop Band Attenuation	@ 800 MHz		30		dB
$V_{ESD}$	ESD Protection – Peak Discharge Voltage at any channel input, in system: Contact discharge per IEC61000–4–2 standard	$T_A = 25^\circ\text{C}$ (Notes 1 and 2) Pins 1, 2, 4, 5, 6, 7, 9, 10	$\pm 15$			kV
$V_{CL}$	TLP Clamping Voltage (See Figure 12)	Forward $I_{PP} = 8\text{ A}$ Forward $I_{PP} = 16\text{ A}$ Forward $I_{PP} = -8\text{ A}$ Forward $I_{PP} = -16\text{ A}$		12 18 –6 –12		V V V V
$R_{DYN}$	Dynamic Resistance Positive Transients Negative Transients	$T_A = 25^\circ\text{C}$ , $I_{PP} = 1\text{ A}$ , $t_p = 8/20\text{ }\mu\text{s}$ Any I/O pin to Ground; Notes 1 and 3		1.36 0.6		
$V_{RWM}$	Reverse Working Voltage	(Note 3)			5.0	V
$V_{BR}$	Breakdown Voltage	$I_T = 1\text{ mA}$ ; (Note 4)	5.6		9.0	V

1. Standard IEC61000–4–2 with  $C_{Discharge} = 150\text{ pF}$ ,  $R_{Discharge} = 330$ ,  $GND$  grounded.
2. These measurements performed with no external capacitor.
3. TVS devices are normally selected according to the working peak reverse voltage ( $V_{RWM}$ ), which should be equal to or greater than the DC or continuous peak operating voltage level.
4.  $V_{BR}$  is measured at pulse test current  $I_T$ .

## TYPICAL CHARACTERISTICS

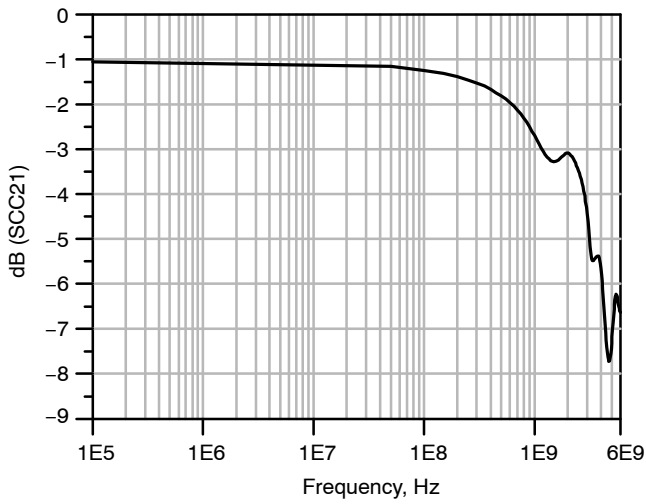


Figure 2. Differential Mode Attenuation vs. Frequency ( $Z_{diff} = 100 \Omega$ )

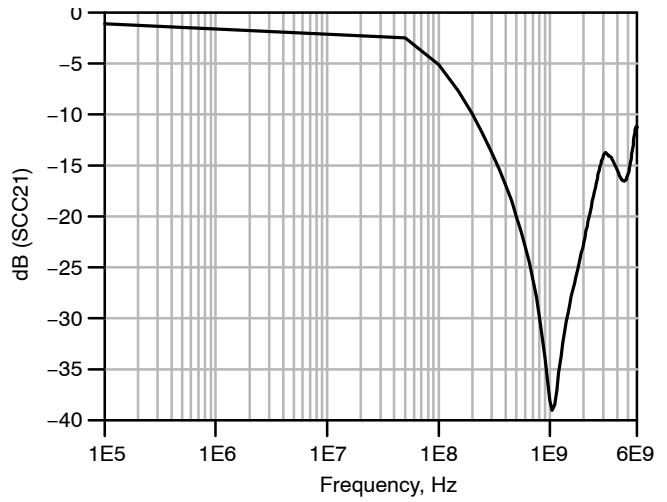


Figure 3. Common Mode Attenuation vs. Frequency ( $Z_{comm} = 50 \Omega$ )

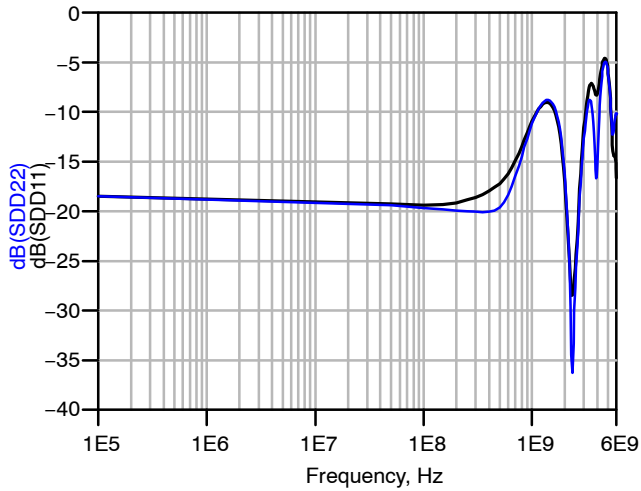


Figure 4. Differential Return Loss vs. Frequency ( $Z_{diff}=100 \Omega$ )

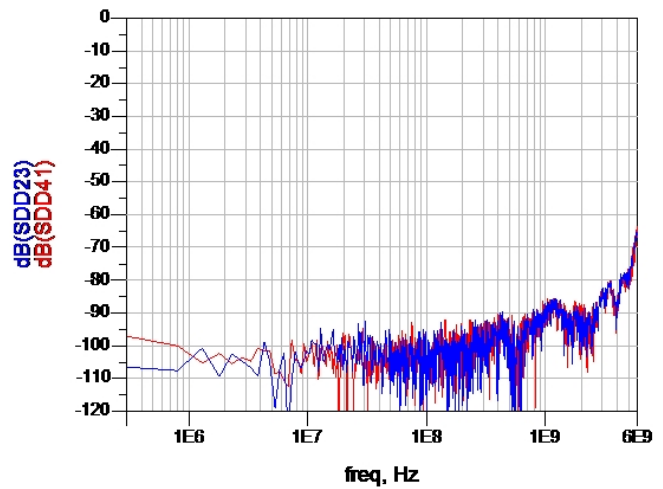


Figure 5. Differential Inter-Lane Cross-Coupling

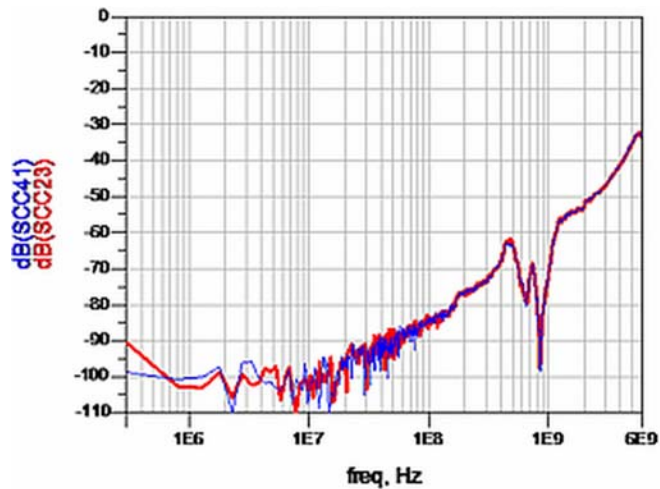


Figure 6. Common Mode Inter-Lane Cross-Coupling

## EMI4184

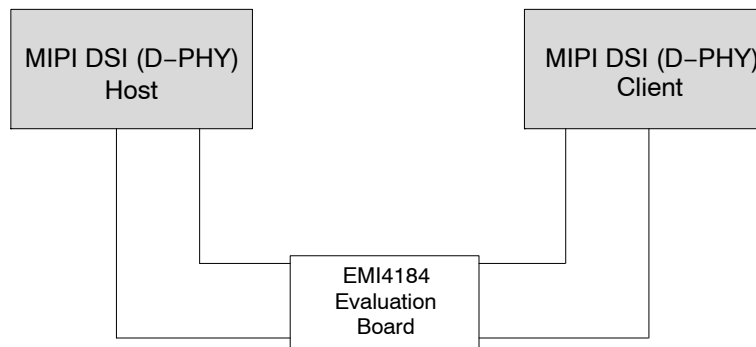


Figure 7. MIPI D-PHY LP Mode Test Setup



Figure 8. EMI4184 MIPI D-PHY LP Mode Measured Results

## EMI4184

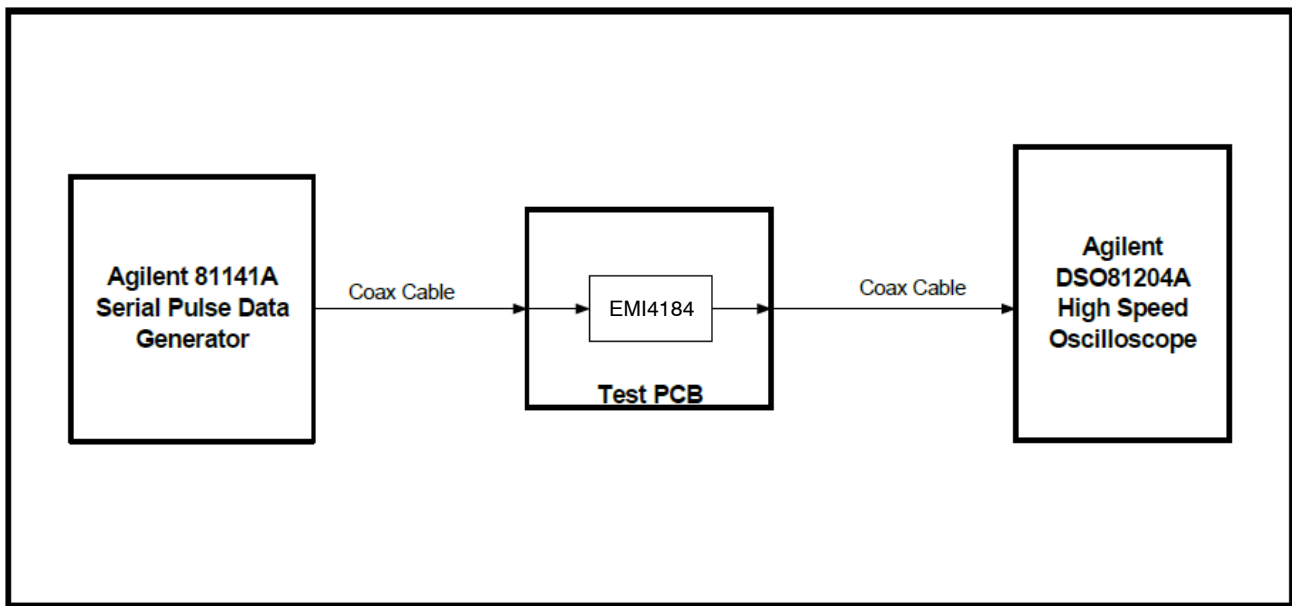


Figure 9. EMI4184 Eye Diagram Test Setup



Figure 10. EMI4184 Measured Eye Diagram @ 3.4Gbps (EVB through on left, EVB with EMI4184 on right)

## TRANSMISSION LINE PULSE (TLP) MEASUREMENTS

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 11. TLP I-V curves of ESD protection devices accurately demonstrate the product's ESD capability because the 10 s of amps current levels and under 100 ns time scale match those of an ESD event. This is illustrated in Figure 12 where an 8 kV IEC61000-4-2 current waveform is compared with TLP current pulses at 8 and 16 A. A TLP 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. Typical TLP I-V curves for the EMI4184 are shown in Figure 13.

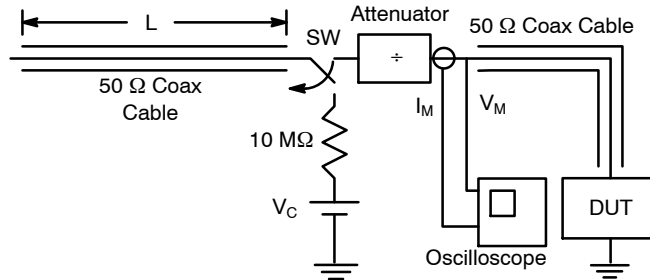


Figure 11. Simplified Schematic of a Typical TLP System

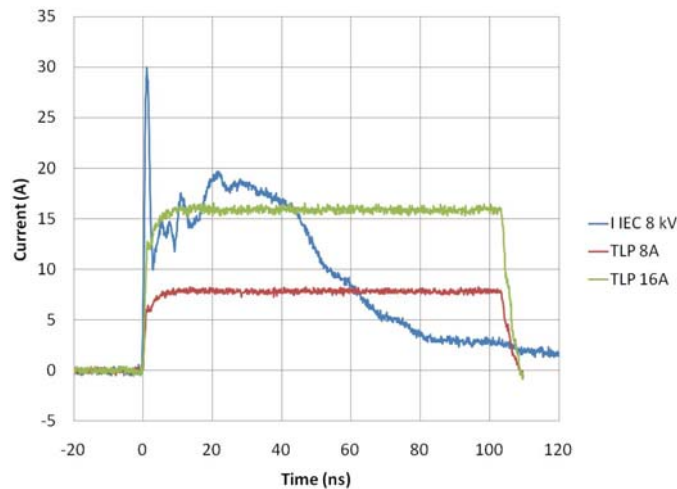


Figure 12. Comparison Between 8 kV IEC61000-4-2 and 8 A and 16 A TLP Waveforms

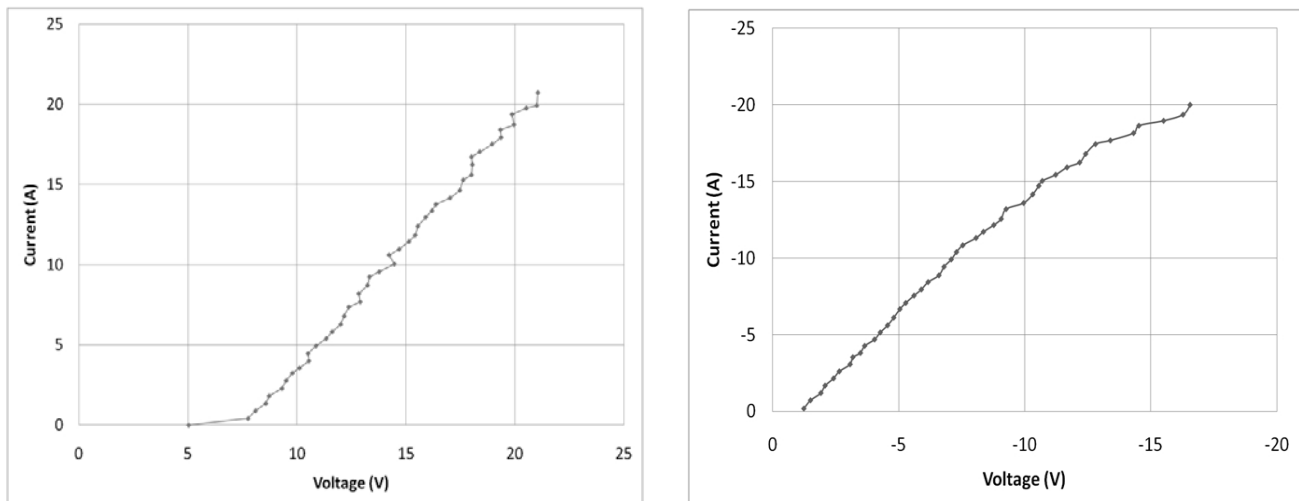


Figure 13. Positive and Negative TLP Waveforms

## 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 On Semiconductor Application Notes AND8307/D and AND8308/D.

## IEC61000-4-2 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

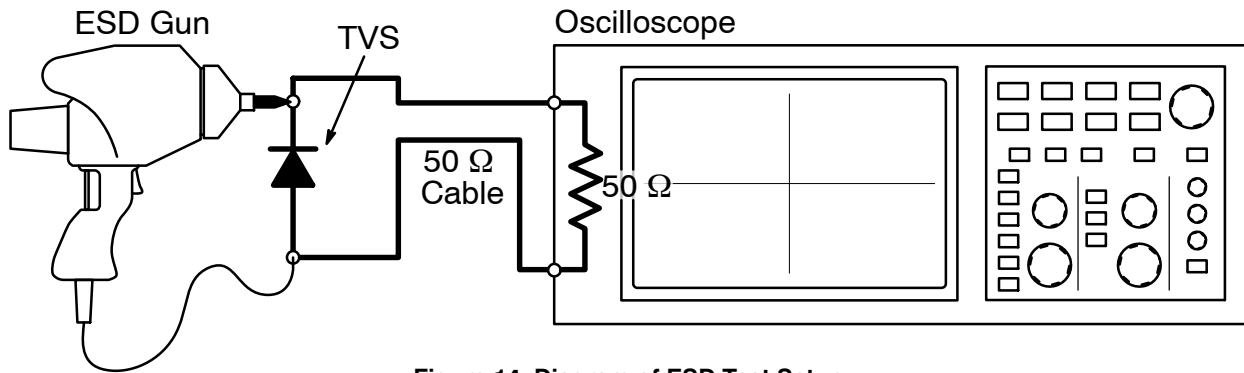
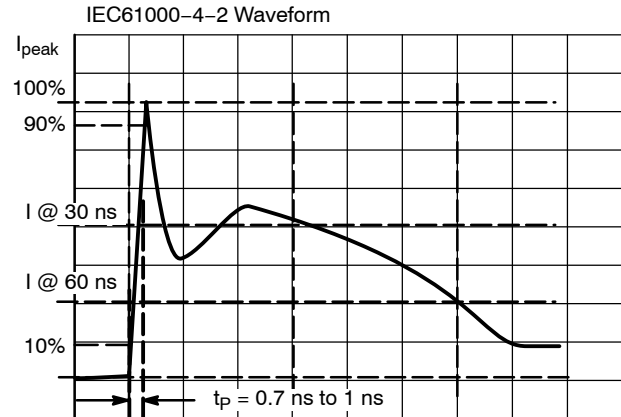
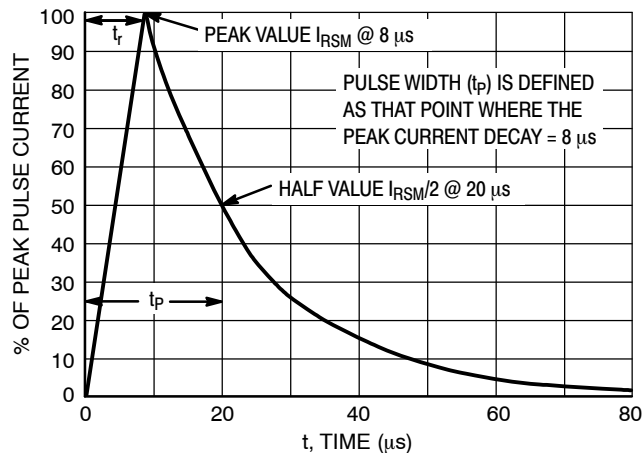


Figure 14. Diagram of ESD Test Setup

Figure 15. 8 x 20  $\mu$ s Pulse Waveform



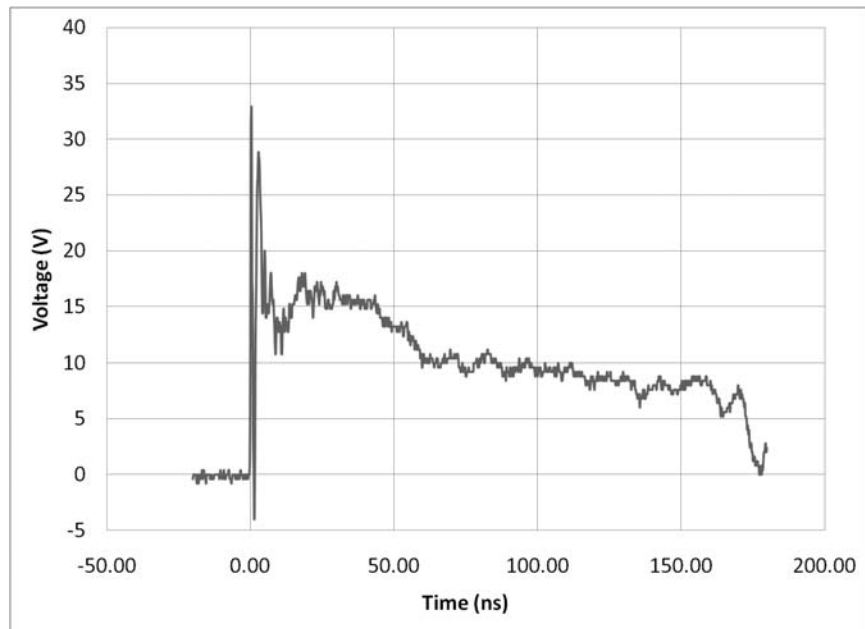


Figure 16. ESD Clamping Voltage +8 kV per IEC6100-4-2 (external to internal pin)

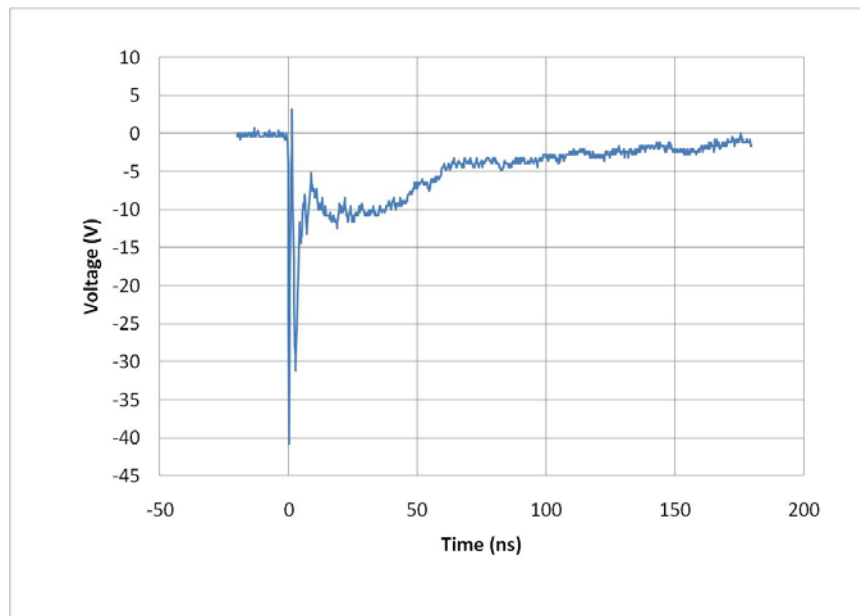
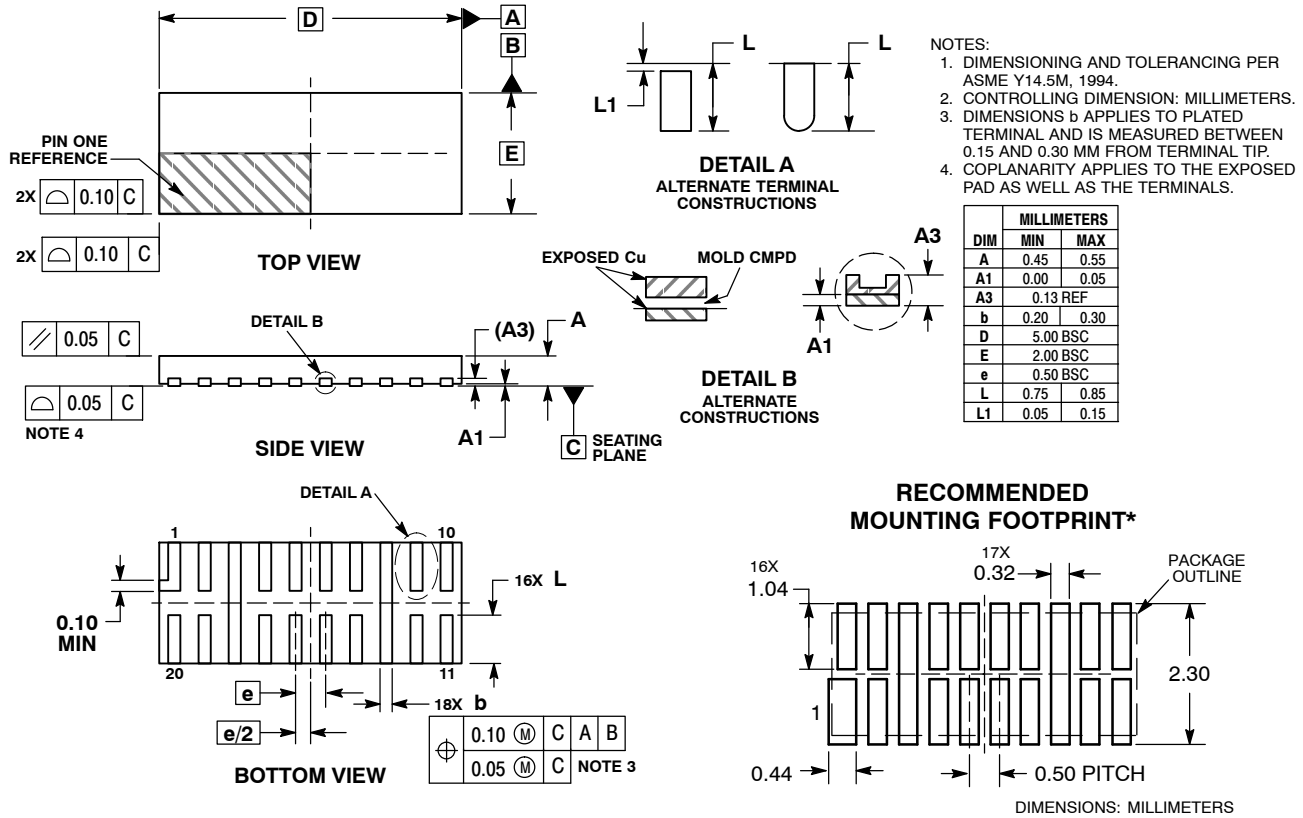


Figure 17. ESD Clamping Voltage -8 kV per IEC6100-4-2 (external to internal pin)

## PACKAGE DIMENSIONS

UDFN20 5x2, 0.5P  
CASE 517CL  
ISSUE O



\*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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