# Automotive Ethernet ESD Protection

Nexperia offers the first true OPEN Alliance compliant ESD Protection with outstanding signal integrity

To take the next step in automotive connectivity and electrification, high-speed and high-bandwidth Automotive Ethernet is required. Industry leaders collaborate within the OPEN Alliance SIG to encourage Ethernet adoption in cars. But with more advanced electrical designs, discrete ESD Protection is becoming ever more essential.

Nexperia is the first in offering a fully compliant 10 Base T1s and 100/1000BASE-T1 OPEN Alliance Ethernet ESD Protection with improved diode capacitance of 0.45 pF (max), ensuring outstanding signal integrity.

#### **Key Features**

- Fully 10 Base T1s and 100/1000BASE-T1 OPEN Alliance compliant
- > Low capacitance down to < 0.45 pF
- > ESD protection up to 30 kV (IEC 61000-4-2, contact)
- > ESD robustness 15 kV at 1000 discharges
- > High trigger voltage: Vt1 = 100 V min
- > Available in various package options
- > AEC-Q101 qualified / automotive grade

#### **Key Applications**

ESD protection for in-vehicle network lines In-automotive environments

> OPEN Alliance 10 Base T1s and 100/1000BASE-T1 Ethernet



www.nexperia.com/ESDprotection/automotive-ethernet

### Available package options:



**DFN1006D-2** 1.0 × 0.6 × 0.37



**DFN1006(BD)-2** 1.0 × 0.6 × 0.48







**SOT143B** 2.9 x 1.3 x 1.0



**SOT457** 2.9 x 1.5 x 1.0



## Automotive Ethernet Product Portfolio

Types in **bold** represent the new products

Main Application	Number of protected lines	V <sub>RWM</sub> (V)	V <sub>trigger</sub> min(V)	ESD rating max (kV) <sup>[1]</sup>	C <sub>line</sub> typ (pF)	C <sub>line</sub> max (pF)	І <sub>РРМ</sub> max (µA)	Configuration	Туре	Package	Size (mm)
100BASE-T1 1000BASE-T1	1	24	100	30	1.5	1.8	2.3	1 2 Sym045	PESD1ETH1GLS-Q	DFN1006BD-2 (SOD882BD)	1.0 × 0.6 × 0.48
					0.9	1.2	2.3		PESD1ETH1GXLS-Q		
					-	-	-		PESD2ETH1G-T	æ	2.9 x 1.3 x 1.0
					1.1	1.3	2.3		PESD2ETH1GXT-Q		
100BASE-T1					-	-	-		PESD2ETH100-T	SOT23	
10/100/1000 Mbit/s ESD Protection at the PHY	2	5	-	8	-	-	-		PESD2ETH-X	AR 29×13×1	20×12×10
			-	12	1.8	-	-		PESD2ETH-AX	SOT143B	2.9 x 1.5 x 1.0
			-	8	1.3	1.5	-		PESD2ETH-D	.9 x SOT457	9 × 1 5 × 1 0
			-	12	2	2.3	-	102 3 4 102	PESD2ETH-AD		
	- 1	5.5	-	10	0.4	0.55	2.5	- 1 <u>F(-1)</u> 2 Sym645	PESD5V0F1BL	DFN1006-2 (SOD882)	1.0 x 0.6 x 0.48
			-	10	0.4	0.55	2.5		PESD5V0F1BLD	DFN1006D-2 (SOD882D)	1.0 x 0.6 x 0.37
10 base T1s * In development, to be released in Q3 2024		24	100	30	0.35	0.45	2		PESD1ETH10L-Q	DFN1006-2 (SOD882)	1.0 x 0.6 x 0.48
									PESD1ETH10LS-Q	DFN1006D-2 (SOD882)	1.0 x 0.6 x 0.37

#### **OPEN Alliance and ESD protection placement**

The OPEN Alliance (One-Pair Ether-Net) Special Interest Group (SIG) is a non-profit alliance of mainly automotive industry and technology providers collaborating to encourage wide scale adoption of Ethernet-based networks as the standard in automotive networking applications. One key goal is to enable the deployment of the existing IEEE 10 BASE T1s/ 100BASE-T1 and1000BASE-T1 physical layer specifications with complementing specifications for conformance and interoperability.



Figure 1: Arrangement of ESD suppression device within the 100/1000BASE-T1 MDI interface, OPEN Alliance SIG (2020) SPDT in Power Amplifier Application, and 10 Base T1s TC14 implemetation specification (2023)

Discrete ESD protection devices play a crucial role when it comes to ensuring high system level robustness and to fulfill specific requirements. In previous automotive Ethernet implementations, PHY vendors recommended to place a discrete ESD protection device between the CMC and the PHY, if required.

When there is either no ESD protection or it is located closer to the PHY, the energy of ESD strikes would pass the CM termination, DC Block and CMC. If the ESD protection device is placed right at the connector, it not only protects the PHY but also the common-mode choke (CMC) and the passives. At this position, the energy of ESD pulses can immediately be directed to ground. The OPEN Alliance recommends placement of ESD protection directly at the connector. This change in topology however requires a completely different kind of ESD protection.

According to the OPEN Alliance specifications, for the direct placement of ESD protection at the connector a high trigger voltage (Vt >100V) is required. The high trigger voltage should account for any additional coupling voltages because of the use of unshielded twisted pairs used in the 10 Base T1s and the 100/1000 Base T1 networks.

## Multi-Gigabit Ethernet and Flip-Chip LGA Packages

Going beyond the industry standard Open Alliance Ethernet 10, 100, and 1000 BaseT-1, there have been further efforts to provide higher connectivity with higher data bandwidths for automotive applications. Multi-Gigabit Ethernet refers to solutions aimed at supporting higher data rates of 2.5, 5, and 10 Gbps. It is widely adopted in automobile applications to accommodate data-intensive requirements. To enable the reliability and performance of the Ethernet PHY, it is recommended to use an ESD protection device to prevent any damage to the electrical components used,

#### Key Features and benefits

- > Ultra-low capacitance: Cd <0.25 pF
- > Deep snap-back combined with dynamic resistance down to 0.35  $\Omega$
- > ESD protection robustness up to 15 kV (IEC61000-4-2)
- Available in Flip Chip Land Grid Array (FC-LGA) packages DFN1006L-2, DFN1006LD-2 and DFN1006LD-2: DFN1006LD-2, DFN1006LD-3 with side wettable flanks for AOI
- Very good RF, a signal integrity and clamping performance optimized for high-speed networks
- > Part of the Nexperia TrEOS Protection family
- > Qualified according to AEC-Q101 / automotive grade

#### Flip-chip LGA package comparison

including the PHY but also passive components such as common mode chokes, resistors, and capacitors.

To meet the signal integrity needs of such high datarates, Nexperia is introducing the Flip Chip LGA packages. These Flip-Chip LGA packages have minimal parasitic components such as no bond wires or copper lead frames, therefore resulting in high performance and good signal integrity while fulfilling all automotive quality and reliability requirements.

#### Applications

- > Automotive Multi-Gigabit Ethernet
- > Automotive Infotainment: A/V monitors, display, cameras
- > High-Speed networks: USB 3.2, HDMI 2.0
- > Low-Voltage Differential Signaling (LVDS) automotive.



Figure 2: Package performance comparison: Flip-Chip LGA versus a conventional lead-frame package with the same size.

The conventional lead-frame based packages with bond wires have additional parasitic inductances and capacitances which add an overhead to the signal integrity performance of an ESD protection device. The Flip-Chip LGA packages on the other hand have been specifically designed to remove most of these additional parasitic elements while still enabling automotive level quality with side wettable flanks for AOI capability. The performance improvement can be seen in the figure above. The 2-pin SOD882LD FC-LGA package offers around 5 GHz bandwidth improvement while the 3 pin SOT8079LD package offers a performance boost of up to 6 GHz in comparison to the conventional 2-pin SOD882BD package. This performance improvement is, as mentioned before, because of the minimal parasitic components in the Flip-Chip LGA packages.

Insertion Loss of PESD5V0H1xxx-Q Family

#### Flip-Chip LGA package overview

The flip-chip LGA package is designed for automotive applications and offers superior RF performance compared to conventional DFN packages of the same size. Minimizing the metal features in the package design result in an ultra-low packet impedance.







**DFN1006LD-:** 1 x 0.6 x 0.45

## **DFN1006LD-2** 1 x 0.6 x 0.45

**DFN1006L-2** 1 x 0.6 x 0.45

#### Schematic of Multi-Gig Ethernet Option 1: Before DC caps



**Option 2: Behind DC caps** 

Figure 3: Placement options of ESD protection for Multi-Gigabit Ethernet and high-speed video links

In the figure above, a typical block diagram of a Multi-gigabit ethernet and highspeed video-links can be seen. There are two possible options for the placement of an ESD protection device i.e. either directly at the connector side or at the PHY side behind the DC caps.

If an ESD protection is placed directly at the connector, a higher VRWM is required to be able to withstand a short to battery condition. However, if the ESD protection is placed closer to the PHY behind the DC caps, the VRWM needs to be lower and must be matched to the breakdown behaviour of the PHY internal ESD protection circuitry.

Nexperia's product selection for ESD1

Device	Package	V <sub>RWM</sub>	C <sub>D typ</sub>	$V_{\scriptscriptstyle ESD}$
PESDxVF1BL-Q	DFN1006-2	18-32 V	0.3 pF	10 kV
PESDxVF1BLS-Q	DFN1006BD-2	18-32 V	0.3 pF	10 kV
PESDxVF2BLG-Q	FC-LGA DFN1006LDx*	18-32 V	0.3 pF	10 kV

\* In 2 and 3 pin FC-LGA 1.0x0.6mm footprint packages –

DFN1006L-2, DFN1006LD-2 and DFN1006LD-3

Matching the ESD protection to PHY internal ESD protection allows for a timely triggering of the external ESD protection device therefore taking in the energy of an ESD pulse and blocking it from going to the PHY and causing damage.

Nexperia offers a broad portfolio to protect either configuration. All devices have a very low capacitance, an outstanding signal integrity performance and a high ESD robustness to ensure a smooth operation of the protected circuit while enabling a robust ESD protection.

#### Nexperia's product selection for ESD2

Device	Package	V <sub>RWM</sub>	C <sub>D typ</sub>	V <sub>esd</sub>
PESD5V0F1BL-Q	DFN1006-2	5 V	0.4 pF	10 kV
PESD5V0F1BLD-Q	DFN1006D-2	5 V	0.4 pF	10 kV
PESD4USBxTx-Q	DFN2510x	3.3/5	0.3 pF	15 kV
PESD5V0C1BLS-Q	DFN1006BD-2	5 V	0.3 pF	15 kV
PESD5V0HxBLG-Q	FC-LGA DFN1006LDx*	5 V	0.3 pF	15 kV

\* In 2 and 3 pin FC-LGA 1.0x0.6mm footprint packages –

DFN1006L-2, DFN1006LD-2 and DFN1006LD-3

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