

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 10BASE-T1s and 100/1000BASE-T1 OPEN Alliance Ethernet ESD Protection with improved diode capacitance of 0.4 pF (max), ensuring outstanding signal integrity. And even going beyond this standard with Multi Gigabit Ethernet and high speed optimised FC-LGA packages.

Key Features

- › Fully 10BASE-T1s and 100/1000BASE-T1 OPEN Alliance compliant
- › Low capacitance down to < 0.4 pF
- › ESD protection up to 30 kV (IEC 61000-4-2, contact)
- › ESD robustness 15 kV at 1000 discharges
- › High trigger voltage: $V_{t1} = 100$ 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 10BASE-T1s and 100/1000BASE-T1 Ethernet



More information

[www.nexperia.com/
automotive-ethernet](http://www.nexperia.com/automotive-ethernet)

Available package options:



DFN1006D-2
1.0 x 0.6 x 0.37



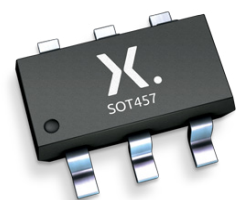
DFN1006(BD)-2
1.0 x 0.6 x 0.48



SOT23
2.9 x 1.3 x 1.0



SOT143B
2.9 x 1.3 x 1.0



SOT457
2.9 x 1.5 x 1.0

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Main Application	Number of protected lines	V_{RWM} (V)	$V_{trigger}$ min(V)	ESD rating max (kV) (1)	C_{line} typ (pF)	C_{line} max (pF)	I_{PPM} max (μA)	Configuration	Type	Package	Size (mm)				
100BASE-T1 1000BASE-T1	1	24	100	30	1.5	1.8	2.3		PESD1ETH1GLS-Q	DFN1006BD-2 (SOD882BD)	1.0 x 0.6 x 0.48				
					0.9	1.2	2.3		PESD1ETH1GXL5-Q						
	100BASE-T1				2	-	-	-	1.1	1.3	2.3		PESD2ETH1G-T	SOT23	2.9 x 1.3 x 1.0
									-	-	-		PESD2ETH100T-Q		
10/100/1000 Mbit/s ESD Protection at the PHY	2	5	-	8	-	-	-		PESD2ETHX-Q	SOT143B	2.9 x 1.3 x 1.0				
				12	1.8	-	-		PESD2ETHAX-Q						
				5	-	-	8	1.3	1.5	-		PESD2ETHD-Q	SOT457	.9 x 1.5 x 1.0	
							12	2	2.3	-		PESD2ETHAD-Q			
10BASE-T1	1	24	100	30	0.35	0.45	2		PESD5V0H1BLG-Q	DFN1006LD-2 (SOD882LD)	1.0 x 0.6 x 0.48				
									PESD5V0C1BLS-Q	DFN1006BD-2 (SOD882BD)	1.0 x 0.6 x 0.37				
									PESD1ETH10L-Q	DFN1006-2 (SOD882)	1.0 x 0.6 x 0.48				
									PESD1ETH10LS-Q	DFN1006BD-2 (SOD882BD)	1.0 x 0.6 x 0.47				

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 10BASE-T1s/100BASE-T1 and 1000BASE-T1 physical layer specifications with complementing specifications for conformance and interoperability.

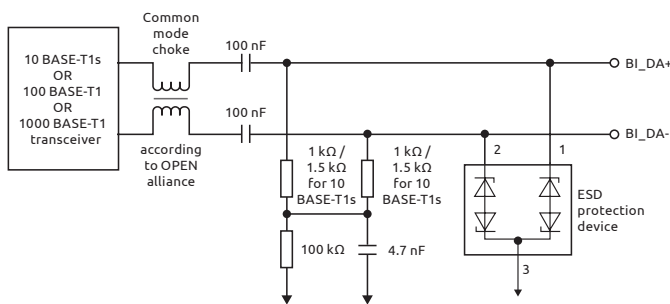


Figure 1: Arrangement of ESD suppression device within the 100/1000BASE-T1 MDI interface, OPEN Alliance SIG (2020) SPDT in Power Amplifier Application, and 10 Base T1s TC14 implementation specification (2023)

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 common-mode choke (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 through 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 CMC and the other passive components. 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 ($V_t > 100$ V) is required. The high trigger voltage should account for any additional coupling voltages because of the use of unshielded twisted pairs used in the 10BASE-T1s and the 100/1000BASE-T1 networks.

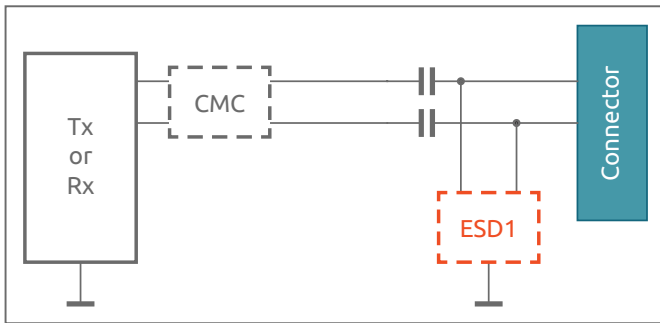
Multi-Gigabit Ethernet

Going beyond the industry standard Open Alliance Ethernet 10, 100, and 1000BASE-T1, 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, including the PHY but also passive components such as common mode chokes, resistors, and capacitors.

Schematic of Multi-Gig Ethernet

Option 1: Before DC caps



Option 2: Behind DC caps

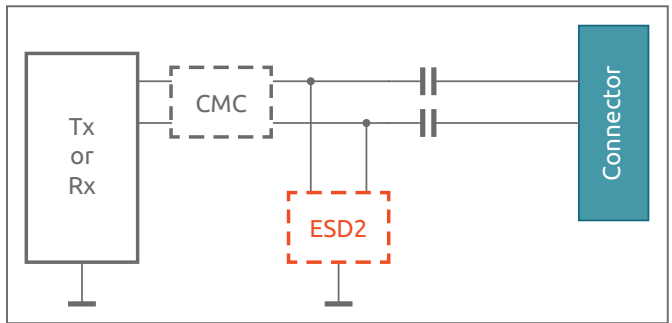


Figure 3: Placement options of ESD protection for Multi-Gigabit Ethernet and high-speed video links

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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 or closer to the PHY behind the DC caps.

If an ESD protection is placed directly at the connector, a higher V_{RWM} 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 V_{RWM} needs to be lower and must be matched to the breakdown behaviour of the PHY internal ESD protection circuitry.

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 ESD1

Device	Package	V_{RWM}	C_D typ	V_{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
PESD18VF1BLG-Q*	DFN1006LD-2	18 V	0.35 pF	10 kV
PESD18VF2BF(G/L)-Q*	DFN1006L(D)-3	18 V	0.35 pF	10 kV
PESD24VF1BLG-Q*	DFN1006LD-2	24 V	0.32 pF	10 kV
PESD24VF2BF(G/L)-Q*	DFN1006L(D)-3	24 V	0.32 pF	10 kV
PESD30VF1BLG-Q*	DFN1006LD-2	30 V	0.28 pF	10 kV
PESD30VF2BF(G/L)-Q*	DFN1006L(D)-3	30 V	0.28 pF	10 kV

Types in **bold** represent new products, types in **bold red** represent products in development.

* In 2 and 3 pin FC-LGA 1.0x0.6mm footprint packages – DFN1006L-2, DFN1006LD-2, DFN1006L-3 and DFN1006LD-3

Nexperia's product selection for ESD2

Device	Package	V_{RWM}	C_D typ	V_{ESD}
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 V	0.3 pF	15 kV
PESD5V0C1BLS-Q	DFN1006BD-2	5 V	0.3 pF	15 kV
PESD5V0H1BLG-Q*	DFN1006LD-2	5 V	0.2 pF	15 kV
PESD5V0H1BLL-Q*	DFN1006L-2	5 V	0.2 pF	15 kV
PESD5V0H2BF(G/L)-Q*	DFN1006L(D)-3	5 V	0.2 pF	15 kV

Types in **bold** represent new products, types in **bold red** represent products in development.

* In 2 and 3 pin FC-LGA 1.0x0.6mm footprint packages – DFN1006L-2, DFN1006LD-2, DFN1006L-3 and DFN1006LD-3

Flip-Chip LGA Packages

To meet the signal integrity needs of high data rates, Nexperia is introducing the Flip-Chip LGA packages. Unlike conventional lead-frame-based packages, Flip-Chip LGA minimizes parasitic components by eliminating bond wires and copper lead frames. This results in high performance and good signal integrity while meeting automotive quality and reliability standards. Including side-wettable flanks options for AOI capability.

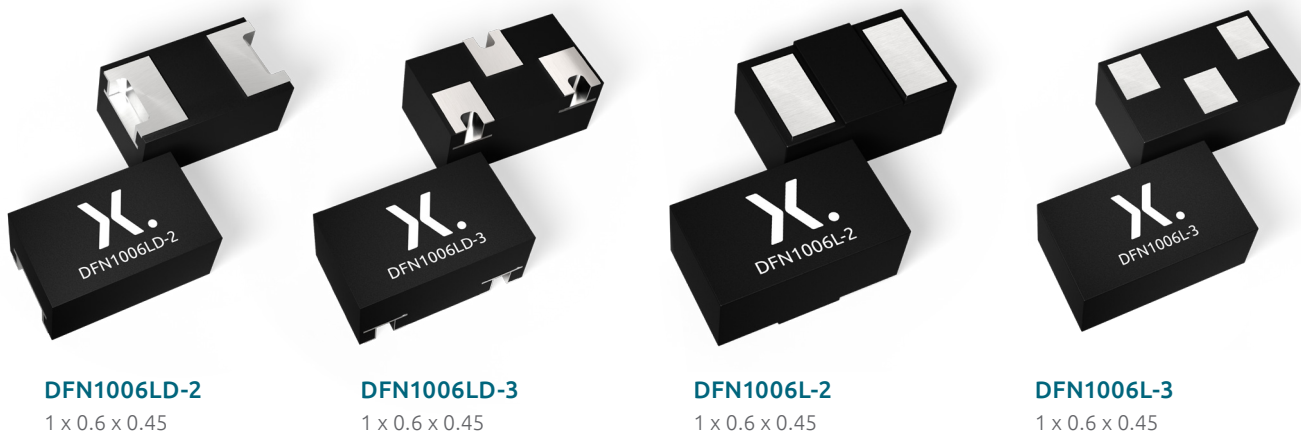
The advantages of this design include significant performance improvements. For example, the 2-pin DFN1006LD-2 FC-LGA package provides a bandwidth improvement of approximately 5 GHz, and the 3-pin DFN1006LD-3 package offers up to a 6 GHz boost compared to the conventional 2-pin DFN1006BD-2 package. These enhancements are a direct result of the minimized parasitic components in Flip-Chip LGA packages.

Key Features and benefits

- › Ultra-low capacitance: $C_d < 0.25$ pF
- › Deep snap-back combined with dynamic resistance down to 0.35Ω
- › ESD protection robustness up to 15 kV (IEC61000-4-2)
- › Very good RF, signal integrity and clamping performance optimized for high-speed networks
- › Qualified according to AEC-Q101 / automotive grade

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.



Flip-chip LGA package comparison

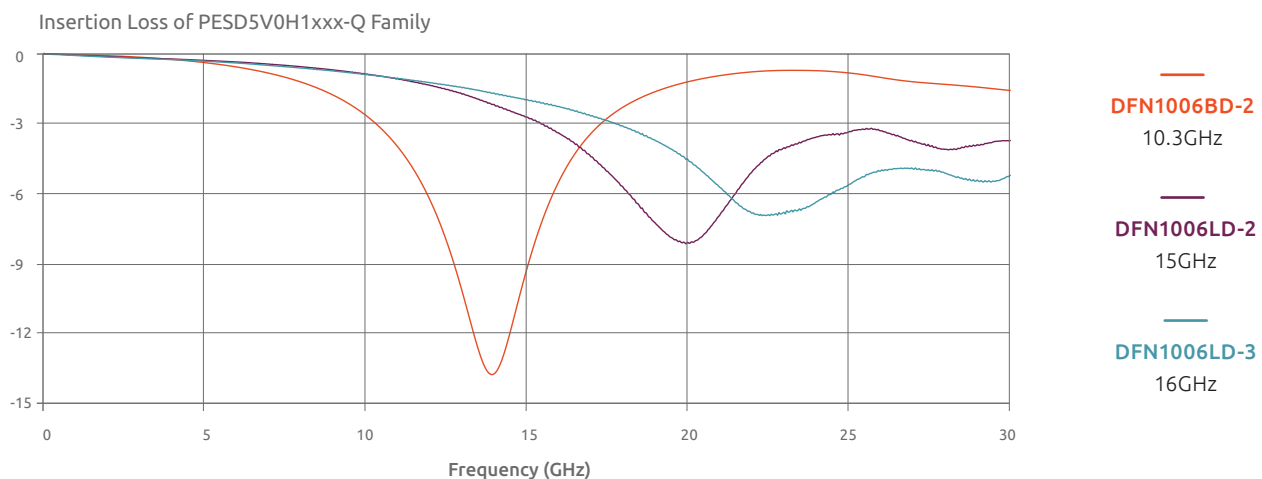


Figure 2: Package performance comparison: Flip-Chip LGA versus a conventional lead-frame package with the same size.

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