1. General description

Fully OPEN Alliance 100BASE-T1 and 1000BASE-T1 compliant Electrostatic discharge (ESD) protection device in a small SOT23 surface-mounted plastic package designed to protect two automotive in-vehicle network bus lines from the damage caused by ESD and other transients.

2. Features and benefits

- Fully OPEN Alliance 100BASE-T1 and 1000BASE-T1 compliant
- High trigger voltage: $V_{t1} = 100 \text{ V min.}$
- Low capacitance: $C_d < 2 \text{ pF}$
- ESD protection up to 30 kV (IEC 61000-4-2)
- 1000 contact discharges (OPEN Alliance specification) with 15 kV (IEC 61000-4-2)
- AEC-Q101 qualified / automotive grade

3. Applications

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

- OPEN Alliance 100/1000BASE-T1 Ethernet
- Low-Voltage Differential Signaling (LVDS) automotive

4. Quick reference data

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{RWM}$</td>
<td>reverse standoff voltage</td>
<td>$T_{amb} = 25 \degree \text{C}$</td>
<td>-</td>
<td>-</td>
<td>24</td>
<td>V</td>
</tr>
<tr>
<td>$C_d$</td>
<td>diode capacitance</td>
<td>$f = 1 \text{ MHz}; V_R = 0 \text{ V}; T_{amb} = 25 \degree \text{C}$</td>
<td>-</td>
<td>1.8</td>
<td>2</td>
<td>pF</td>
</tr>
<tr>
<td>$V_{t1}$</td>
<td>trigger voltage</td>
<td>$t_p = 100 \text{ ns}; T_{amb} = 25 \degree \text{C}$</td>
<td>[1] 100</td>
<td>130</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>$V_{ESD}$</td>
<td>electrostatic discharge voltage</td>
<td>IEC 61000-4-2; contact discharge</td>
<td>[2] [3] 30</td>
<td>-</td>
<td>-</td>
<td>kV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1000 contact discharges (IEC 61000-4-2); OPEN Alliance specification</td>
<td>[3] 15</td>
<td>-</td>
<td>-</td>
<td>kV</td>
</tr>
</tbody>
</table>

[1] Non-repetitive current pulse, Transmission Line Pulse (TLP); square pulse; ANSI / ESD STM5.5.1-2008
[3] Measured from pin 1 or 2 to pin 3.
5. Pinning information

Table 2. Pinning information

<table>
<thead>
<tr>
<th>Pin</th>
<th>Symbol</th>
<th>Description</th>
<th>Simplified outline</th>
<th>Graphic symbol</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>K</td>
<td>cathode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>K</td>
<td>cathode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CC</td>
<td>common cathode</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Ordering information

Table 3. Ordering information

<table>
<thead>
<tr>
<th>Type number</th>
<th>Package Name</th>
<th>Description</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>PESD2ETH1G-T</td>
<td>SOT23</td>
<td>plastic, surface-mounted package; 3 terminals; 1.9 mm pitch; 2.9 mm x 1.3 mm x 1 mm body</td>
<td>SOT23</td>
</tr>
</tbody>
</table>

7. Marking

Table 4. Marking codes

<table>
<thead>
<tr>
<th>Type number</th>
<th>Marking code[1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>PESD2ETH1G-T</td>
<td>%HK</td>
</tr>
</tbody>
</table>

[1] % = placeholder for manufacturing site code
8. Limiting values

Table 5. Limiting values

*In accordance with the Absolute Maximum Rating System (IEC60134)*

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( I_{\text{PPM}} )</td>
<td>rated peak pulse current ( I_p = 8/20 \mu s )</td>
<td>[1] [2]</td>
<td>-</td>
<td>2.3</td>
<td>A</td>
</tr>
<tr>
<td>( T_j )</td>
<td>junction temperature</td>
<td></td>
<td>-</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>( T_{\text{amb}} )</td>
<td>ambient temperature</td>
<td></td>
<td>-55</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>( T_{\text{stg}} )</td>
<td>storage temperature</td>
<td></td>
<td>-65</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>( V_{\text{ESD}} )</td>
<td>electrostatic discharge voltage</td>
<td>IEC 61000-4-2; contact discharge</td>
<td>[3] [2]</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>ISO 10605; contact discharge; C = 150 pF; R = 330 Ω</td>
<td></td>
<td>[3] [2]</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>ISO 10605; contact discharge; C = 330 pF; R = 330 Ω</td>
<td></td>
<td>[3] [2]</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1000 contact discharges (IEC 61000-4-2); OPEN Alliance specification</td>
<td></td>
<td>[2]</td>
<td>15</td>
<td>-</td>
</tr>
</tbody>
</table>

[1] Device stressed with 8/20 µs exponential decay waveform according to IEC 61000-4-5.
[2] Measured from pin 1 or 2 to pin 3.

Fig. 1. 8/20 µs pulse waveform according to IEC 61000-4-5

Fig. 2. ESD pulse waveform according to IEC 61000-4-2
Table 6. Characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{RWM}$</td>
<td>reverse standoff voltage</td>
<td>$T_{amb} = 25 ^\circ C$</td>
<td>-</td>
<td>-</td>
<td>24</td>
<td>V</td>
</tr>
<tr>
<td>$V_h$</td>
<td>holding voltage</td>
<td>$I_p = 100 , ns$; $T_{amb} = 25 ^\circ C$</td>
<td>[1] 28</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>$V_{t1}$</td>
<td>trigger voltage</td>
<td></td>
<td>[1] 100</td>
<td>130</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>$I_{RM}$</td>
<td>reverse leakage current</td>
<td>$V_{RWM} = 24 , V$; $V_R = 0 , V$; $T_{amb} = 25 ^\circ C$</td>
<td>-</td>
<td>1</td>
<td>100</td>
<td>nA</td>
</tr>
<tr>
<td>$C_d$</td>
<td>diode capacitance</td>
<td>$f = 1 , MHz$; $V_R = 0 , V$; $T_{amb} = 25 ^\circ C$</td>
<td>-</td>
<td>1.8</td>
<td>2</td>
<td>pF</td>
</tr>
<tr>
<td>$\Delta C_d/C_d$</td>
<td>diode capacitance matching</td>
<td>$f = 1 , MHz$; $V_R = 2.5 , V$; $T_{amb} = 25 ^\circ C$</td>
<td>[2] -</td>
<td>0.5</td>
<td>-</td>
<td>%</td>
</tr>
<tr>
<td>$R_{dyn}$</td>
<td>dynamic resistance</td>
<td>$I_R = 40 , A$; $t_p = 100 , ns$; $T_{amb} = 25 ^\circ C$</td>
<td>[1] -</td>
<td>0.6</td>
<td>-</td>
<td>Ω</td>
</tr>
</tbody>
</table>

[1] Non-repetitive current pulse, Transmission Line Pulse (TLP); square pulse; ANSI / ESD STM5.5.1-2008
[2] $\Delta C_d$ is the difference of the capacitance measured between pin 1 and pin 3 and the capacitance measured between pin 2 and pin 3.

Fig. 3. V-I characteristics for a bidirectional ESD protection diode

Fig. 4. Relative variation of peak pulse power as a function of junction temperature; typical values
Transmission Line Pulse (TLP); 
$t_p = 100$ ns; $t_r = 1$ ns

**Fig. 5. Dynamic resistance with positive clamping; typical values**

Transmission Line Pulse (TLP); 
$t_p = 100$ ns; $t_r = 1$ ns

**Fig. 6. Dynamic resistance with negative clamping; typical values**
10. Application information

In the "IEEE 100BASE-T1 EMC Test Specification for ESD suppression devices" document (further referred as OPEN Alliance 100BASE-T1 specification), the OPEN Alliance describes four different tests to ensure compliance of ESD suppressor devices and PHYs which are compliant according to the document "Transceiver EMC Test Specification". The PESD2ETH1G-T passes all tests as shown on figures 6 to 16. Furthermore, it complies with the requirements mentioned in Section 2.2. of "IEEE 100BASE-T1 EMC Test Specification for ESD suppression devices".

![Application diagram](image_url)

The return loss and insertion loss are evaluated using the differential S-parameters $S_{dd11}$ and $S_{dd21}$. These measurements replace the requirement for a certain capacitance value. To ensure symmetry, the differential to common mode rejection is evaluated using the S-parameter $S_{sd21}$. This measurement replaces the requirement for a matching of the capacitances per line. To ensure that the device does not degrade and changes behavior after repetitive ESD events, the S-parameter measurements are repeated after discharging 20 times ±8 kV ESD on signal lines 1 and 2, with $C = 150 \, \text{pF}$, $R = 330 \, \Omega$ according to ISO 10605. Subsequently, the S-parameters are measured again and compared to the original data.

![Return loss](image_url)

---

1 OPEN Alliance: "IEEE 100BASE-T1 EMC Test Specification for ESD suppression devices", version 1.0 rev. draft, December 10, 2018
**ESD protection for In-vehicle networks**

---

**Fig. 10. Insertion loss**

1. Limit according to OPEN Alliance 100BASE-T1 specification
2. PESD2ETH1G-T

---

**Fig. 11. Insertion loss**

1. PESD2ETH1G-T
   1. Before repetitive ESD event
   2. After 20 times ±8 kV ESD

---

**Fig. 12. Differential to common mode rejection**

1. Limit according to OPEN Alliance 100BASE-T1 specification
2. PESD2ETH1G-T

---

**Fig. 13. Differential to common mode rejection**

1. PESD2ETH1G-T
   1. Before repetitive ESD event
   2. After 20 times ±8 kV ESD
To predict if the ESD suppressor device would protect a PHY of a certain robustness class (Class I (JEDEC-HBM 4 kV) and Class II (JEDEC-HBM 2 kV)), the ESD discharge current is measured in a reference circuit according to OPEN Alliance 100BASE-T1 specification for ±4 kV and ±6 kV according to IEC 61000-4-2 with C = 150 pF and R = 330 Ω. Unlike in the OPEN Alliance 100BASE-T1 specification of October 29 2017, the „Transceiver Simulation network“ is implemented with 2 Ω and 50 Ω resistors.

Fig. 14. ESD discharge current at +4 kV

Fig. 15. ESD discharge current at -4 kV

Fig. 16. ESD discharge current at +6 kV

Fig. 17. ESD discharge current at -6 kV
To ensure that the ESD suppressor device is not impacting the EMC performance of the complete module, the RF clamping test as defined in the OPEN Alliance specification is applied. First a measurement at a reference power level of 25 dBm is conducted in an environment defined by the OPEN Alliance 100BASE-T1 specification. Next, the power is increased to 33 dBm (Class I), 36 dBm (Class II), and 39 dBm (Class III). No change in the measured common mode rejection indicates that the ESD suppressor device is not impacting the module's EMC performance.

According to OPEN Alliance 100BASE-T1 specification
Common mode rejection for:
(1) reference
(2) Class I
(3) Class II
(4) Class III

Fig. 18. RF Clamping Test
For 1000BASE-T1, there is no published document on the requirements for external ESD suppressor devices. However, a similar requirement specification is in preparation at the time the present document is created. To support the conformity of PESD2ETH1G-T with the to-be-published requirement specification of OPEN Alliance for 1000BASE-T1, results of tests adapted from OPEN Alliance specification for 100BASE-T1 are shown. In these tests, limits are adapted to the current state of the art and the common-mode choke is selected in compliance with the published OPEN Alliance document “IEEE 1000BASE-T1 EMC Test Specification for Common Mode Chokes Version 1.0” as of January 16, 2018.

The following graphs show the S-parameters with adapted limit lines. ESD damage test results of 100BASE-T1 are also valid for 1000BASE-T1.

![Graph 19: Return loss](image1)

(1) limit according to state of the art for 1000BASE-T1
(2) PESD2ETH1G-T

*Fig. 19. Return loss*

![Graph 20: Insertion loss](image2)

(1) limit according to state of the art for 1000BASE-T1
(2) PESD2ETH1G-T

*Fig. 20. Insertion loss*

![Graph 21: Differential to common mode rejection](image3)

(1) limit according to state of the art for 1000BASE-T1
(2) PESD2ETH1G-T

*Fig. 21. Differential to common mode rejection*
The following graphs show the discharge current measurements, with a 1000BASE-T1 compliant common-mode choke.

Fig. 22. ESD discharge current at +4 kV

Fig. 23. ESD discharge current at -4 kV

Fig. 24. ESD discharge current at +6 kV

Fig. 25. ESD discharge current at -6 kV
Fig. 26. ESD discharge current at +8 kV

(1) PESD2ETH1G-T
(2) limit Class II
(3) limit Class I

Fig. 27. ESD discharge current at -8 kV

(1) PESD2ETH1G-T
(2) limit Class II
(3) limit Class I

Fig. 28. ESD discharge current at +15 kV

(1) PESD2ETH1G-T
(2) limit Class II
(3) limit Class I

Fig. 29. ESD discharge current at -15 kV

(1) PESD2ETH1G-T
(2) limit Class II
(3) limit Class I
The following graph shows the RF clamping test with a 1000BASE-T1 compliant common-mode choke.

According to state of the art for 1000BASE-T1
Common mode rejection for:
(1) reference
(2) Class I
(3) Class II
(4) Class III

Fig. 30. RF Clamping Test
11. Package outline

Plastic surface-mounted package; 3 leads

Dimensions (mm are the original dimensions)

<table>
<thead>
<tr>
<th>Unit</th>
<th>A</th>
<th>A1</th>
<th>b</th>
<th>c</th>
<th>D</th>
<th>E</th>
<th>e1</th>
<th>H_E</th>
<th>L_P</th>
<th>Q</th>
<th>v</th>
<th>w</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>1.1</td>
<td>0.1</td>
<td>0.48</td>
<td>0.15</td>
<td>3.0</td>
<td>1.4</td>
<td>1.9</td>
<td>0.95</td>
<td>2.5</td>
<td>0.45</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>nom</td>
<td>0.9</td>
<td>0.38</td>
<td>0.09</td>
<td>2.8</td>
<td>1.2</td>
<td>1.9</td>
<td>0.95</td>
<td>2.1</td>
<td>0.15</td>
<td>0.45</td>
<td>0.2</td>
<td>0.1</td>
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</table>

Fig. 31. Package outline SOT23

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12. Soldering

Fig. 32. Reflow soldering footprint for SOT23

Fig. 33. Wave soldering footprint for SOT23
## 13. Revision history

### Table 7. Revision history

<table>
<thead>
<tr>
<th>Data sheet ID</th>
<th>Release date</th>
<th>Data sheet status</th>
<th>Change notice</th>
<th>Supersedes</th>
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<td>20221006</td>
<td>Product data sheet</td>
<td>-</td>
<td>PESD2ETH1G-T v.2</td>
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<td>Modifications:</td>
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<td></td>
<td>Parameter $V_{t1}$ (trigger voltage): typical value changed</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Figures 5 and 6 (dynamic resistance): update with latest test results</td>
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<tr>
<td>PESD2ETH1G-T v.2</td>
<td>20200207</td>
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<td>Objective data sheet</td>
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14. Legal information

Data sheet status

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<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Objective [short] data sheet</td>
<td>Development</td>
<td>This document contains data from the objective specification for product development.</td>
</tr>
<tr>
<td>Preliminary [short] data sheet</td>
<td>Qualification</td>
<td>This document contains data from the preliminary specification.</td>
</tr>
<tr>
<td>Product [short] data sheet</td>
<td>Production</td>
<td>This document contains the product specification.</td>
</tr>
</tbody>
</table>

1. Please consult the most recently issued document before initiating or completing a design.
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