ABSTRACT

The IEC 61000-4-X set of standards are used to test system-level transient immunity. Many system designs used in an industrial environment specify one or more of the tests listed within the IEC 61000-4-X specification to comply with reliability standards for end customers. This document covers the TI high side switch TPS27S100 device immunity tests under the three most common industrial market requirements: System ESD Immunity (IEC 61000-4-2), Electrical Fast Transient Immunity (EFT) (IEC 61000-4-4), Lightning and Surge Immunity (IEC 61000-4-5). This document provides the test setup and results for each of these tests. Refer to IEC 61000-4-x Tests for TI’s Protection Devices (SLVA711) for more details on test setup and procedures.

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1 Application Description

These tests are based on TPS27S100 standard evaluation board TPS27S100x EVM.

Figure 1 shows the schematic of the TPS27S100x EVM. The following will list some modifications of the board to survive the EMC tests and indicate the working status of the board:

- Add a 47 µF capacitor between supply voltage IN to GND
- Add a 0.1 µF at C7 position
- Add a TVS diode (SM15T30A) at C6 position
- Add a 22 nF ceramic capacitor at C9 position
- Connect a LED with limiting resistor output to GND

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Figure 1. TPS27S100x EVM Schematic
2 TPS27S100x EVM Board

Figure 2 is the top view of the standard EVM board.

![Figure 2. TPS27S100x EVM Board (Standard) Top View](image)

3 List of Equipment

Table 1 shows the list of required equipment.

Table 1. List of Equipment

<table>
<thead>
<tr>
<th>Qty</th>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Transient 2000</td>
<td>EFT and Surge generator, up to 4.4 kV</td>
</tr>
<tr>
<td>2</td>
<td>CN-EFT1000</td>
<td>Capacitive coupling clamp used for EFT test</td>
</tr>
<tr>
<td>3</td>
<td>40 Ω, 0.5 µF</td>
<td>Coupling module used for Surge test</td>
</tr>
<tr>
<td>4</td>
<td>YOKOGAWA</td>
<td>Power Supply</td>
</tr>
<tr>
<td>5</td>
<td>ESS-2000</td>
<td>ESD generator</td>
</tr>
<tr>
<td>6</td>
<td>Fluke 189</td>
<td>Multimeter</td>
</tr>
<tr>
<td>7</td>
<td>TPS27S100x EVM</td>
<td>Standard EVM board with modifications</td>
</tr>
</tbody>
</table>
4 IEC 61000-4-2 System ESD Immunity

4.1 IEC61000-4-2 (ESD) Stress Levels

See Table 2 for levels specified by the IEC 61000-4-2 standard.

<table>
<thead>
<tr>
<th>Level</th>
<th>Contact Discharge Test Voltage (± kV)</th>
<th>Air Discharge Test Voltage (± kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>X</td>
<td>Custom</td>
<td>Custom</td>
</tr>
</tbody>
</table>

4.2 Test Conditions

The following test conditions exist for IEC61000-4-2 system ESD immunity:

- Supply voltage: 24 V DC, always ON
- Inputs High → Outputs High (ON)
- Outputs not loaded (floating)

4.3 Test Signals

According to the IEC 61000-4-2:

- Contact discharge and air discharge
- Polarity: positive and negative
- Discharge unit: 150 pF, 330 Ω
- Applied to: TPS27S100x EVM output port

4.4 Test Setup

The TI ESD test bench setup complies with the IEC standard and is shown in Figure 3. The TPS27S100x EVM is placed on a horizontal coupling plane (HCP) with insulation in between. Any power connections are made on the non-conductive table and two 470-kΩ resistors are used to connect the HCP to the ground reference plane (GRP).

The ESD contact and air discharge pulses have been applied to the board output port. The EVM board is always supplied during the test. Input of the board has connected to 5 V output of the board, and output is ON as indicated by the added LED.

Testing is performed by charging the 150 pF discharge capacitor and discharging it through a 330-Ω resistor into the strike tip. Contact discharge is performed by touching the discharge tip directly to the pin under test then triggering the strike. Conversely, air discharge is performed by triggering the gun then moving the discharge tip towards the pin under test until arcing occurs.
4.5 Classification of The Test

(A) Normal performance within the limits specified by the manufacturer, requester or purchaser.
(B) Temporary loss of function or temporary degradation of performance not requiring an operator.
(C) Temporary loss of function or degradation of performance, the correction of which requires operator intervention.
(D) Loss of function or degradation of performance which is not recoverable, owing to damage of the hardware or software, or loss of data.

4.6 Test Results

Test results are listed in Table 3 and Table 4:

Table 3. ESD Testing Contact Discharge Results

<table>
<thead>
<tr>
<th>ESD Test Signal Amplitude, Test Result At Polarity (±)</th>
<th>Applied To</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 kV</td>
</tr>
<tr>
<td>Output (Floating)</td>
<td>A/A</td>
</tr>
</tbody>
</table>

Table 4. ESD Testing Air Discharge Results

<table>
<thead>
<tr>
<th>ESD Test Signal Amplitude, Test Result At Polarity (±)</th>
<th>Applied To</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 kV</td>
</tr>
<tr>
<td>Output (Floating)</td>
<td>A/A</td>
</tr>
</tbody>
</table>
4.7 Conclusion

The tested TPS27S100x EVM passed all of the ESD immunity tests against ESD applied to output in contact and air discharge mode. According to Section 4.1, it passed all specified levels of IEC standard. From Section 4.6, ESD applied to output had no influence on the performance of the board up to 20 kV (contact discharge) and 25 kV (air discharge).

5 EMC IEC 61000-4-4 BURST Immunity Test

5.1 IEC61000-4-4 (EFT) Stress Levels

See Table 5 for levels specified by the IEC 61000-4-4 standard.

### Table 5. EFT Stress Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Peak Amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Power Supply Port</td>
</tr>
<tr>
<td></td>
<td>$V_{\text{peak}}$ (kV)</td>
</tr>
<tr>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

5.2 Test Conditions

The following test conditions exist for IEC61000-4-4 BURST immunity:

- Supply voltage: 24 V DC, always ON
- Inputs High $\rightarrow$ Outputs High (ON)
- Outputs floating and loaded with 1 kΩ resistor

5.3 Test Signals

According to the IEC 61000-4-4:

- Polarity: positive and negative
- Burst duration: 15 ms ± 20 % at 5 kHz
- Burst period: 300 ms ± 20 %
- Duration time: 1 minute
- Applied to: Supply voltage line ($V_{\text{CC}}$), output line

5.4 Test Setup

The IEC 61000-4-4 standard defines the EFT immunity tests, set-up procedures, and test levels. The EFT immunity test setup for I/O ports is shown in Figure 4. A burst signal from a burst generator is sent through the test cable (inside a capacitive trench) and is measured through a coupled data cable (inside the same trench) which is connected to the test board. Power port tests are intrinsically coupled with a tester and applied to the power port of TPS27S100x EVM board.
5.5 Classification of the Test

(A) Normal performance within the limits specified by the manufacturer, requester or purchaser.
(B) Temporary loss of function or temporary degradation of performance not requiring an operator.
(C) Temporary loss of function or degradation of performance, the correction of which requires operator intervention.
(D) Loss of function or degradation of performance which is not recoverable, owing to damage of the hardware or software, or loss of data.

5.6 Test Results

Test results are listed in Table 6 and Table 7:

<table>
<thead>
<tr>
<th>EFT Test Signal Amplitude, Test Result At Polarity (±)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied to</td>
</tr>
<tr>
<td>V_{CC}</td>
</tr>
<tr>
<td>1 kV</td>
</tr>
<tr>
<td>A/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EFT Test Signal Amplitude, Test Result At Polarity (±)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied to</td>
</tr>
<tr>
<td>V_{CC}</td>
</tr>
<tr>
<td>1 kV</td>
</tr>
<tr>
<td>A/A</td>
</tr>
</tbody>
</table>

5.7 Conclusion

The tested TPS27S100x EVM system survived all the burst tests without silicon degradation. Bursts applied to V_{CC} and OUT have no influence on performance of the application in the TPS27S100x EVM up to ±4.4 kV amplitude. According to Section 5.1, the test board passes all the specific levels.

6 EMC IEC 61000-4-5 Surge Immunity Test

6.1 IEC61000-4-5 (Surge) Stress Levels

TI's surge tests are compliant with the IEC 61000-4-5 standard. Depending on what environment a system is designed for, the IEC 61000-4-5 specifies several levels of tests in association with an environment.
### Table 8. Surge Stress Levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Open-Circuit Test Voltage ±10% kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>X</td>
<td>Custom</td>
</tr>
</tbody>
</table>

- Class 1: Partly protected electrical environment.
- Class 2: Electrical environment where the cables are well-separated, even at short runs.
- Class 3: Electrical environment where cables run in parallel.
- Class 4: Electrical environment where the interconnections are run as outdoor cables along with power cables used for both electronic and electric circuits.
- Class X: Special conditions specified in the product specification.

### 6.2 Test Conditions
- Supply voltage: 24 V DC, always ON
- Inputs High → Outputs High (ON)
- Outputs floating

### 6.3 Test Signals
According to the IEC 61000-4-4:
- 5 positive and 5 negative surges
- Repetition rate: 1 minute
- Coupling: 42 Ω, 0.5 µF
- Applied to: Supply voltage line (V\(_{CC}\)), output line

### 6.4 Test Setup
For the surge imposed between all other kinds of lines and ground (unshielded unsymmetrical interconnection lines; line-to-line and line-to-ground coupling), a 40 Ω resistance and a 0.5 µF capacitor are used in the coupling network. Together with the 2 Ω from the combinational waveform generator (CWG), the total source impedance of the surge pulse is 42 Ω.
6.5 **Classification of the Test**

(A) Normal performance within the limits specified by the manufacturer, requester or purchaser.

(B) Temporary loss of function or temporary degradation of performance not requiring an operator.

(C) Temporary loss of function or degradation of performance, the correction of which requires operator intervention.

(D) Loss of function or degradation of performance which is not recoverable, owing to damage of the hardware or software, or loss of data.

6.6 **Test Results**

Test results are listed in Table 9 and Table 10:

### Table 9. Surge Testing Results of Supply Voltage Lines

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Applied To</th>
<th>REQ</th>
<th>Surge Test Signal Amplitude, Test Result At Polarity (±)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Class 1</td>
</tr>
<tr>
<td>Standard EVM board</td>
<td></td>
<td></td>
<td>500 V</td>
</tr>
<tr>
<td>Input clamped with SM15T30A</td>
<td>$V_{CC}$</td>
<td>42 Ω</td>
<td>A/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A/A</td>
</tr>
</tbody>
</table>
6.7 Conclusion

Without protection of TVS diode, the standard TPS27S100x EVM could survive 500 V stress at $V_{CC}$ and 1 kV stress at output port. After using SM15T30A to clamp the input voltage, the test board can survive as high as 2 kV stress on $V_{CC}$ while performing normally. Additional external protection circuits need to be added if the system is required to pass class 4 level for both $V_{CC}$ and output ports.

7 References

- Texas Instruments, TPS27S100, 40-V, 100 mΩ Single-Channel Smart High-Side Power Switch
- Texas Instruments, TPS27S100A 40-V, 100 mΩ Single-Channel High-Side Switch Evaluation Module
- Texas Instruments, TPS27S100B 40-V, 100 mΩ Single-Channel High-Side Switch Evaluation Module
- Texas Instruments, IEC 61000-4-x Tests for TI's Protection Devices Application Report
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