AN6249

Application note

How to protect a high side current sensing against ESD

Introduction

Electronic equipment which uses a shunt based current sensing solution is more and more often exposed to a harsh electromagnetic environment.

In the world of electromagnetic perturbation, one of the most harmful effects is electrostatic discharge (ESD) which can cause product damage. The TSC2020 is a current sensing which can work with a wide range of input common mode voltage, from -4 V up to 100 V. When this voltage is exceeded, the TSC2020 is protected thanks to integrated ESD protections, and it is immune against ESD surges in a controlled environment, such as industrial or laboratory environments. But in an uncontrolled environment, ESD surges can have a much higher energetic level and can cause permanent damage if the device is not well protected.

This application note gives some guidance on protecting the subsystem high-side current sensing TSC2020 and shunt. It is based on the IEC61000-4-2 standard generally used for an industrial environment.

1 What is ESD?

When two materials are placed in contact and separated, some charges can be transferred from one material to the other, thus creating an electrostatic field. This process is also known as triboelectric charging.

An electrostatic discharge happens when two differently charged objects with high electrostatic fields are close together, and it results in an extremely sudden electric current between both objects. ESD can affect a component by changing its electrical characteristics or by destroying it. The charged devices can also attract particles and cause wafer production issues and yield losses.

2 Different standards

The world of ESD is quite broad, but we can divide it into two categories, for a simplified approach.

The first one is related to the component level to ensure manufacturability and it is also called on-chip ESD protection. These types of ESD can appear from wafer production to the assembly of the chips on the PCB in the application. To characterize the robustness of the components, some models have been developed and summarized into a standard. The models used to perform component testing cannot replicate the full spectrum of all possible ESD events, and there is no direct correlation between discharges in the field and in a test system. Nevertheless, these models have been proven to be successful in reproducing almost all ESD field failure signatures.

These standards are based on the two primary models of ESD events:

- Human Body Model (HBM) According to JEDEC standard JESD22-A114F
- Charged Device Model (CDM) According to ANSI/ESD STM 5.3.1.

The TSC2020 high-side current sensing exhibits a good level of immunity to the HBM and CDM models. TSC2020 in MSO8 package is effectively able to sustain 2 kV in HBM and 1 kV in CDM, which means that this circuit can be used without additional protection in a controlled manufacturing environment.

However, these standards have low-level surges as factories are well-controlled environments.

For example, technicians can wear antistatic shoes, and there are de-ionizers to avoid air-charging. Any person or equipment must be connected to the ground to allow for a discharge path.

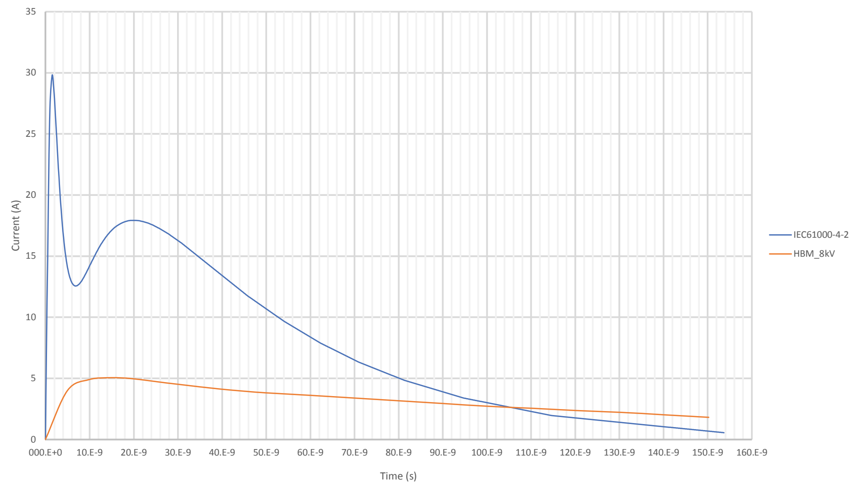
In daily life, on the other hand, the level of surges can be much higher. For example, walking across a carpet could generate, in a dry environment, several tens of kilovolts of electrostatic discharge.

This is the second category of ESD, which is more related to the system level. It describes the system robustness for the end user in an uncontrolled environment.

This second category can be standardized by the IEC61000-4-2 for industrial domains and ISO10605 for automotive domain.

Figure 1 compares the energy carried by the current waveform of these two standards.

Figure 1. HBM vs. IEC61000-4-2 standard 8 kV



It clearly depicts that the IEC61000-4-2 standard carries much more energy than the HBM. The high level of current generated in the IEC61000-4-2 can cause junction failure or burning inside the silicon.

Another difference between the HBM and IEC standards is the number of strikes used during testing. With the HBM standard, only a single positive and negative strike are required, whereas the IEC 61000-4-2 test requires 10 positive strikes and 10 negative strikes. The repetitive strikes are much more stressful, but also more representative of real-life conditions.

And finally, the rise time of the strike of the IEC61000-4-2 is 25 times faster than in the HBM model. This means a device based only on HBM standard may be destroyed before its protection become active.

This is why an integrated circuit exposed to ESD and specified with HBM will still require an external IEC standard ESD protection.

3 Standard IEC61000-4-2

This standard relates to equipment, systems, subsystems, and peripherals which may be involved in static electricity discharges owing to environmental and installation conditions.

This standard defines 4 stress levels and 4 levels of results.

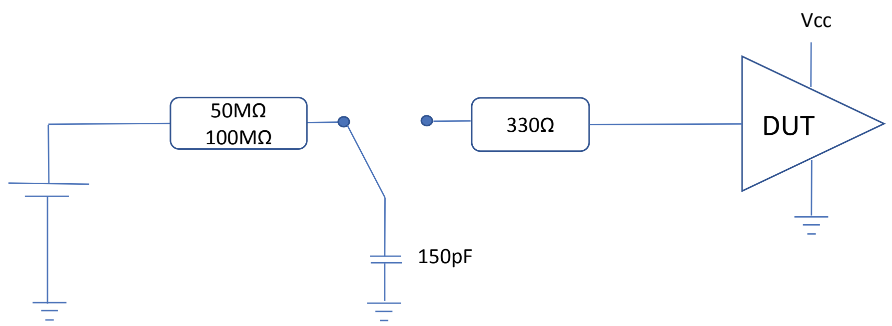
Table 1 summarizes ESD testing level described by the IEC61000-4-2 standard.

Table 1. ESD test level

Level	Contact discharge	Air discharge
	Test voltage (±kV)	Test voltage (±kV)
1	2	2
2	4	4
3	6	8
4	8	15
X	Special	Special

The electrical circuits in Figure 2 model the equivalent ESD discharge linked to the IEC61000-4-2 standard. Firstly, the 150 pF capacitor is charged and then discharged through a 330 Ω resistor. The resulting waveform is represented by the blue curve in Figure 1: HBM vs IEC61000-4-2 standard 8 kV.

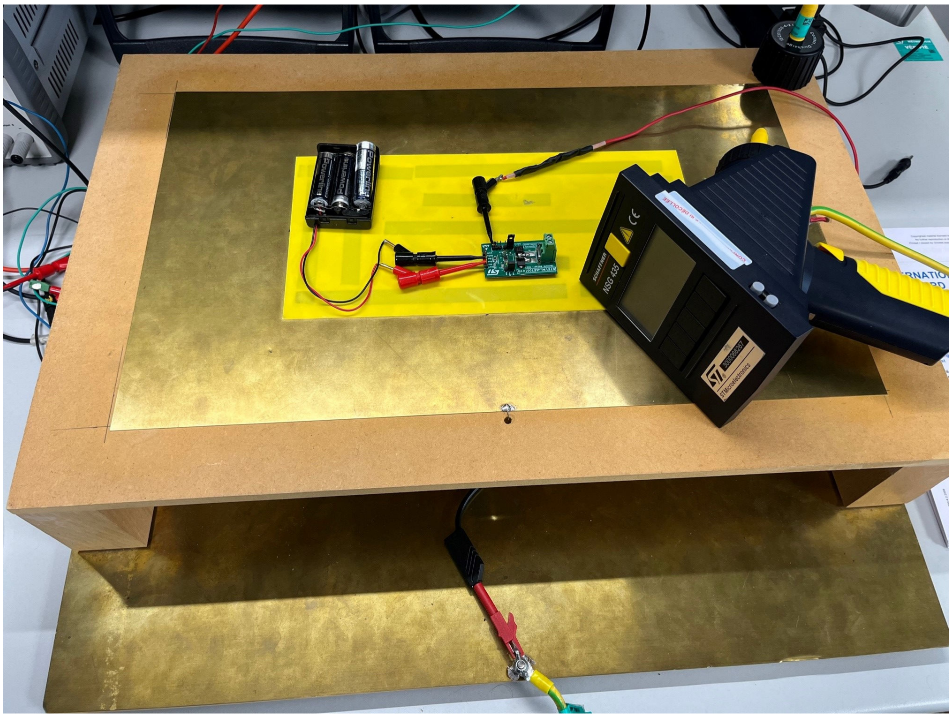
Figure 2. ESD discharge model



Note that for the automotive standard ISO10605, the capacitance used in the ESD discharge model can be 330 pF, resulting in a higher energetic stress than the IEC61000-4-2 standard.

The test bench used is described in Figure 3 and complies with IEC standard. The TSC2020 is placed horizontally on an insulation foil that is fixed on a wooden table. The table is connected to the ground reference plane through two 470 kΩ serial resistances. The ESD gun is grounded to the reference plane.

Figure 3. Test bench



The IEC61000-4-2 ensures that finished products can survive normal operation, where the user does not take specific precautions against ESD stress on the product.

The TSC2020 is a high-side current sensing generally used with a shunt resistance to monitor the current. The large variety of current sensing applications can expose the TSC2020 device to very different conditions from an ESD stress perspective. The bus where the current is monitored can sometimes be accessible to the external environment, so the TSC2020 with its shunt can be considered a subsystem, and its robustness can be tested following the IEC61000-4-2 standard.

However, as seen previously, despite the fact that the TSC2020 is highly immune in a well-controlled manufacturing environment thanks to its high level of HBM and CDM, it clearly does not survive in a non-controlled ESD environment when used standalone. It must be protected by adding specific components which help it survive in a natural environment.

4 Choosing the right component to protect inputs of the TSC2020 against ESD

There are several ways to protect devices against ESD, and the first idea is to think about standard passive components such as resistances which can limit the current but cannot generally support high voltage or repetitive ESD aggression.

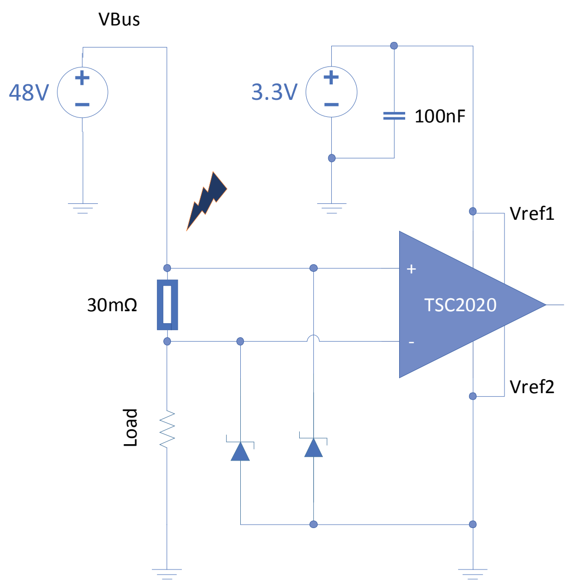
Capacitance might absorb a transient, but generally their internal inductance may generate high voltage peaks.

Diodes might also be used to protect device only against HBM surge, but they are not fast enough to support the IEC61000-4-2 standard.

One of the best solutions to protect the TSC2020 high-side current sensing against ESD is to use a transient voltage suppressor (TVS). The main advantage of the TVS is that it presents high impedance until its breakdown voltage is reached. When the breakdown voltage is reached, the TVS provides a low impedance path to redirect the current, generally to the ground. It is an avalanche diode specially designed to clamp overvoltage and dissipate high transient power surges. TVS protection devices can absorb a high current surge for a short duration with a very fast response time.

In a typical application as described in Figure 4, the common-mode or Vbus may be accessible for maintenance and thus susceptible to being struck by ESD.

Figure 4. Typical 48 V application



To choose the right TVS, it is first of all important to know the application. Except for special requirements in the application, we can choose a TVS diode which matches the working input voltage of the TSC2020.

The first point to check is the clamping voltage generally called V_{CL}. The TVS's clamping voltage must not exceed the absolute maximum rating (AMR) of the TCS2020, which is 105 V on the input common-mode voltage. So, ideally the TVS diode should be chosen with a V_{CL} < 105 V. However, it is important to note that the AMR of the TSC2020 is given for a DC voltage, and in the case of ESD protection we are dealing with spikes. It is therefore completely different; proof is that the TSC2020 can sustain 2 kV in HBM. So, we can consider that the voltage limit V_{CL} can be pushed back in relation to the TSC2020 AMR. In this case, it is mandatory to conduct through testing and pay special attention to the PCB layout and the connectors used.

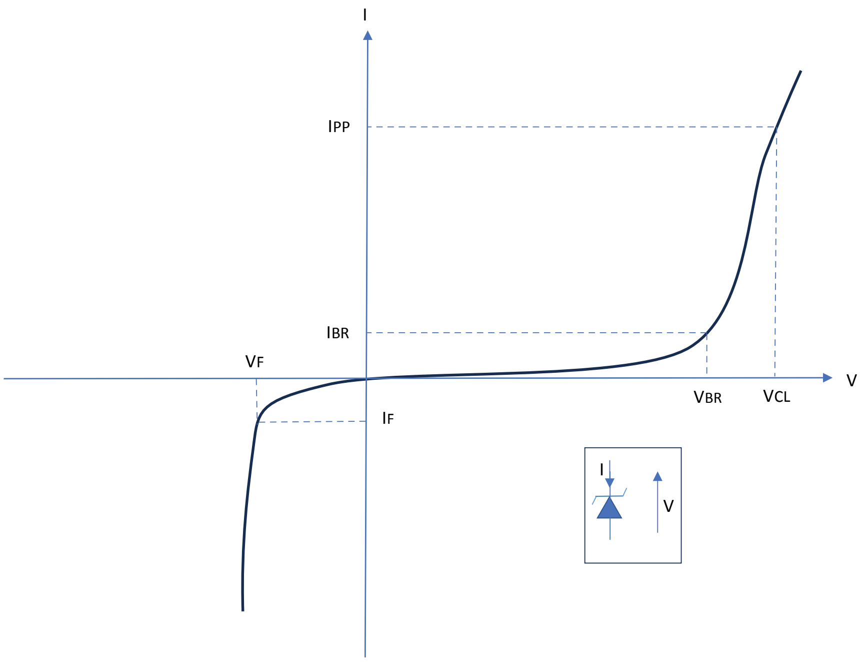
Secondly, it is important to consider when the ESD protection starts to conduct at breakdown voltage, generally called V_{BR}. In some applications using a 48 V battery, to choose the TVS diode correctly, its breakdown voltage should be higher than 48 V, to ensure that the diode will not be activated during normal operation.

And a non-negligible third point is that it is important to consider the power that the TVS can support. The V_{CL} voltage, the I_{PP} peak pulse current combined with the duration of the ESD strike allow you to choose the right protection. Once the diode characteristics are defined depending on the application, it is important to choose if the ESD protection must be done with a unidirectional TVS diode or a bidirectional one.

5 Unidirectional TVS

The unidirectional TVS is an asymmetrical voltage vs current device as depicted in Figure 5.

Figure 5. Unidirectional TVS voltage-current characteristic



On a positive pulse such as the one described in the IEC61000-4-2 (+8 kV), the TVS diode starts to protect the TSC2020 from the V_{BR} voltage. For the negative pulse (-8 kV) the TVS protects the TSC2020 from the V_F voltage, generally close to -0.7 V.

In a way, unidirectional TVS diodes can offer better protection for negative pulses due to the lower negative breakdown.

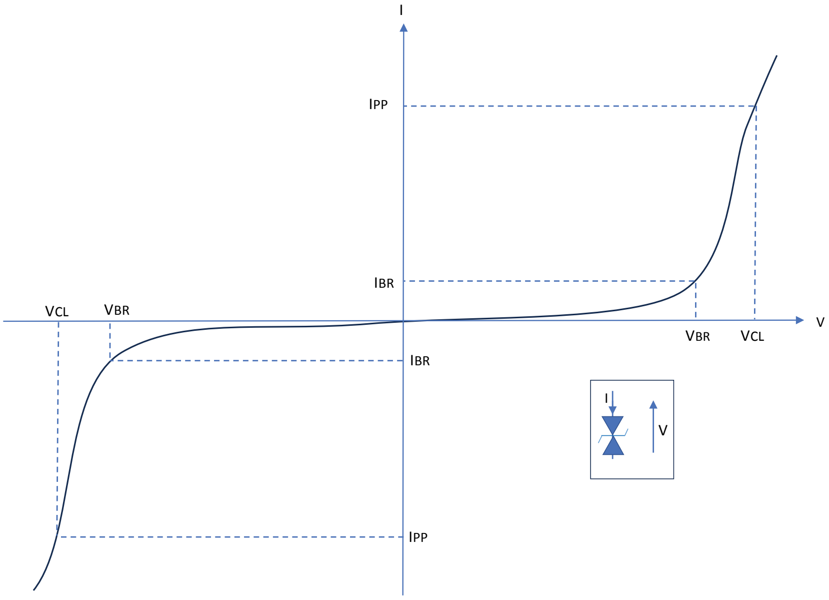
By choosing a TVS diode such as, for example, the SMAJ70A, no significant leakage is introduced, and the protection is activated not far from the AMR of the TSC2020 (see first point of Section 4.) (V_{BR} being 82 V, V_{CL} = 113 V).

6 Bidirectional TVS

In most 48 V applications, the input common-mode voltage remains within a positive range voltage and, in this case, a unidirectional TVS is enough to protect the TSC2020. But in some applications where the input common-mode voltage is susceptible to dropping 4 V below ground, the use of a unidirectional TVS may prove limited because it is at risk of frequently being activated. It is then preferable to choose a bidirectional TVS.

It may happen in applications where the TSC2020 is used in low-side and when a rapid current change in the shunt occurs, or in applications where the common-mode is switched from negative voltage to positive voltage. If you consider a SMAJ70CA, the breakdown voltage is well below -4 V and will not be activated during normal operation of the TSC2020 (with negative Vicm). Nevertheless, it may be enough to protect the current sensing due to the margin on the AMR.

Figure 6. Bidirectional TVS voltage-current characteristic



In the case of a bidirectional TVS, for a negative strike (for example -8 kV) both ESD protections (the TVS and the integrated ESD protection of the TSC2020) will work together to absorb it. In this case, it is extremely important to experiment. This application note aims to demonstrate that.

7 Test board

If the protection device is too far from the discharge point, the discharge current may induce an excessive electric field. It is recommended to keep the TVS diode as close as possible to the expected point of electrostatic discharge. Figure 7. Schematic board and Figure 8. PCB board show an example of PCB layout.

Figure 7. Schematic board

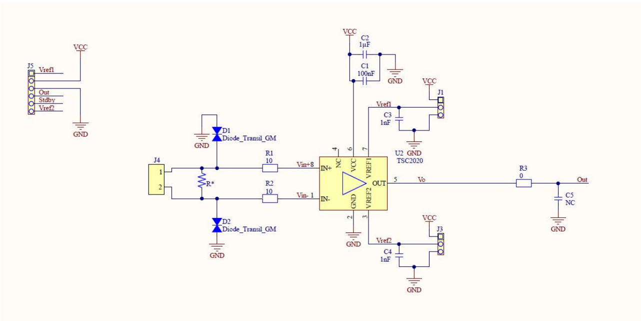
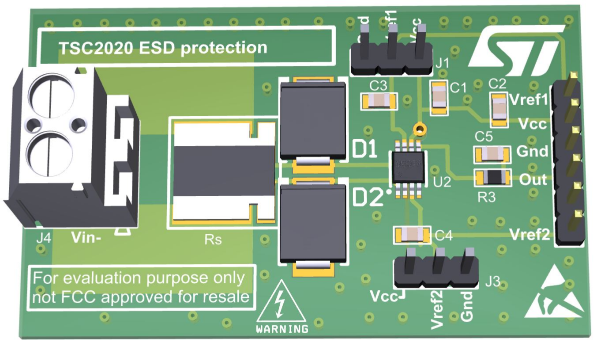


Figure 8. PCB board



PCB tracks must be controlled and as short as possible. If the TVS protection is placed far from the line to protect, the parasitic inductance can cause a much higher voltage than expected and limit the protection diode efficiency.

It is advised to use a ground plane on both layers to allow for the shortest possible connection and limit the parasitic inductance.

8 Test and results following IEC61000-4-2

Tests have been done with a standardized table as described in Figure 3. Test bench, using the ESD gun SCHAFFNER NSG 435.

Four different setups have been used to test the robustness of the TSC2020 current sensing and TVS diodes to electrostatic discharge following the IEC61000-4-2.

- Setup 1: TSC2020 is powered and used in a low-side configuration.
- Setup 2: TSC2020 is not powered and used in a low-side configuration.
- Setup 3: TSC2020 is powered and in a high-side configuration.
- Setup 4: TSC2020 is not powered supply and in a high-side configuration.

For each of the following setups, ESD strikes are applied:

- Contact discharge ±8 kV (x10 discharges applied on each input pin, with 1 s delay between each discharge).
- Air discharge ±2 kV, ±4 kV, ±8 kV ±15 kV (x10 discharges applied directly on shunt with 1 s delay between each discharge).

Between each set of discharges, the functionality of TSC2020 is tested. And the test is considered a PASS if the current consumption and the Vout voltage remain in a range of ±3%

These four setups are tested with unidirectional TVS and bidirectional TVS.

9 Test with unidirectional TVS

To protect the TSC2020, a unidirectional TVS diode that can sustain the maximum range of TSC2020 parameters can be chosen.

For an industrial application, the SMAJ70A has been selected, a 400 W TVS which offers a typical V_{BR} at 81.9 V.

For the automotive domain, the unidirectional automotive grade TVS SM4T82AY can be chosen.

This diode can support the ISO10605 standard. While the ISO 10605 standard is similar to the IEC 61000-4-2 standard, it nevertheless imposes higher stress levels.

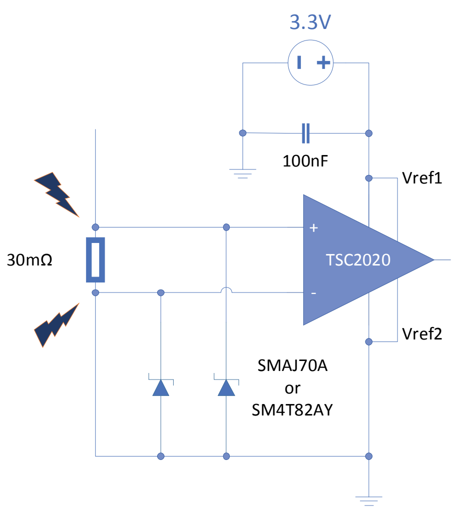
Tests in this application note focus only on the IEC61000-4-2.

The main goal is to sustain the level 4 mentioned in the IEC61000-4-2, which is ± 8 kV in contact discharge and ± 15 kV in air discharge described in Table 1: ESD test level.

9.1 SETUP 1 with unidirectional TVS SMAJ70A

TSC2020 is powered by a 3.3 V battery and the shunt is connected to the TSC2020 reference as described in Figure 9. Setup 1 with SMAJ70A.

Figure 9. Setup 1 with SMAJ70A



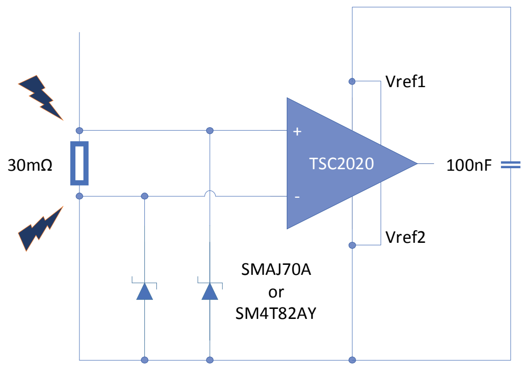
CONTACT DISCHARGE	Setup 1 TSC2020 Power On and shunt connected to GND
+8 kV	PASS
-8 kV	PASS

AIR DISCHARGE	Setup 1 TSC2020 Power On and shunt connected to GND
+2 kV	PASS
-2 kV	PASS
+4 kV	PASS
-4 kV	PASS
+8 kV	PASS
-8 kV	PASS
+15 kV	PASS
-15 kV	PASS

9.2 SETUP 2 with unidirectional TVS SMAJ70A

TSC2020 is not powered, and the shunt is connected to the TSC2020 reference as described in Figure 10. Setup 2 with SMAJ70A.

Figure 10. Setup 2 with SMAJ70A



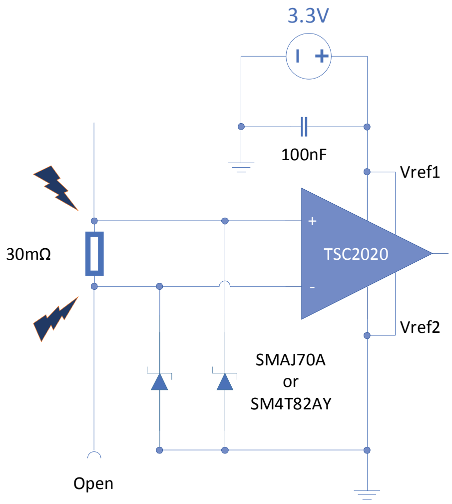
CONTACT DISCHARGE	Setup 2 TSC2020 Power OFF and shunt connected to reference
+8 kV	PASS
-8 kV	PASS

AIR DISCHARGE	Setup 2 TSC2020 Power OFF and shunt connected to reference
+2 kV	PASS
-2 kV	PASS
+4 kV	PASS
-4 kV	PASS
+8 kV	PASS
-8 kV	PASS
+15 kV	PASS
-15 kV	PASS

9.3 SETUP 3 with unidirectional TVS SMAJ70A

TSC2020 is powered by a 3.3 V battery and the shunt is left floating as described in Figure 11. Setup 3 with SMAJ70A. This test is more restrictive in terms of ESD resistance.

Figure 11. Setup 3 with SMAJ70A



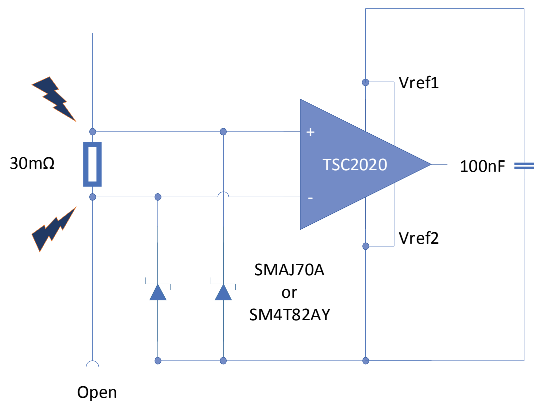
CONTACT DISCHARGE	Setup 3 TSC2020 Power On and shunt left floating
+8 kV	PASS
-8 kV	PASS

AIR DISCHARGE	Setup 3 TSC2020 Power On and shunt left floating
+2 kV	PASS
-2 kV	PASS
+4 kV	PASS
-4 kV	PASS
+8 kV	PASS
-8 kV	PASS
+15 kV	PASS
-15 kV	PASS

9.4 SETUP 4 with unidirectional TVS SMAJ70A

TSC2020 is not powered, and the shunt is left floating as described in Figure 12. Setup 4 with SMAJ70A. This test is more restrictive in terms of ESD resistance.

Figure 12. **Setup 4 with SMAJ70A**



CONTACT DISCHARGE	Setup 4 TSC2020 Power OFF and shunt left floating
+8 kV	PASS
-8 kV	PASS

AIR DISCHARGE	Setup 4 TSC2020 Power OFF and shunt left floating
+2 kV	PASS
-2 kV	PASS
+4 kV	PASS
-4 kV	PASS
+8 kV	PASS
-8 kV	PASS
+15 kV	PASS
-15 kV	PASS

9.5 Summary test with unidirectional TVS SMAJ70A

The unidirectional TVS SMAJ70A is able to protect the high-side current sensing against ESD surge following the IEC61000-4-2 standard at the highest level (4).

10 Test with bidirectional TVS

For an application where the TSC2020 needs to be used with a negative common-mode voltage, a bidirectional TVS must be used.

For an industrial application, the SMAJ70CA has been selected, a 400 W TVS which offers a typical V_{BR} at 81.9 V, as well as a SMAJ58CA, a 400 W TVS which offers a typical V_{BR} at 67.8 V.

For automotive applications, we may consider SM4T82CAY or SM4T68CAY.

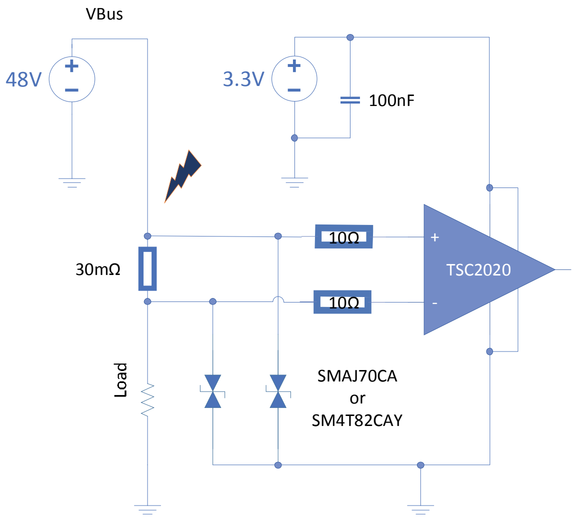
The SM4T82AY and SM4T68CAY are automotive grade TVS diodes, which means that these diodes are able to support the ISO10605 standard. As for tests realized with unidirectional TVS, this application note only focuses on the IEC61000-4-2.

The main goal is to sustain the level 4 mentioned in the IEC61000-4-2, which is ± 8 kV in contact discharge and ± 15 kV in air discharge described in Table 1. ESD test level.

The same four setups as the ones for the unidirectional TVS (described in Figure 9. Setup 1 with SMAJ70A, Figure 10. Setup 2 with SMAJ70A, Figure 11. Setup 3 with SMAJ70A, Figure 12. Setup 4 with SMAJ70A) are used for the bidirectional TVS diode.

During laboratory tests, it was noted that to obtain level 4 ESD immunity by using the SMAJ70CA TVS diode, it was necessary to add a 10 Ω serial resistance on the TSC2020 inputs as described in Figure 13. Serial resistance with bidirectional TVS SMAJ70CA.

Figure 13. Serial resistance with bidirectional TVS SMAJ70CA



The serial resistance offers the advantage of limiting the current generated by the ESD strike by lowering the voltage and limiting the activation of the internal TSC2020 ESD protection diode. In other words, it simply limits the power that the diode must support.

On the other hand, the main drawback to adding serial resistances in the input path of the TSC2020 is that it affects the DC performance slightly.

Adding resistances on the input pins will create an impedance mismatch with the internal input bias block of the TCS2020.

This mismatch will have a direct impact on the gain accuracy, as described by equation (1):

$$Gain\ error = 1 - \frac{700}{Rs + 700} \quad (1)$$

Additionally, due to the mismatch of the external serial resistance it may also add an input-offset voltage as depicted by equation (2):

$$\text{Input Offset voltage} = Rs \,.\, \varepsilon\alpha \,.\, (Iibp + Iibn) \quad (2)$$

Where εα is the resistance precision.

Using a serial resistance of 10 Ω on the input pins of the TSC2020 may introduce a gain error of 1.4% and an added input offset of 40 µV for a V_{icm} = 48 V, using 1% resistors.

To avoid adding resistances on the input, it may be preferable if the application allows it to choose a diode with a lower breakdown voltage V_{BR}, as for example the TVS SMAJ58CA, a 400 W TVS with typical V_{BR} at 67.8 V.

10.1 SETUP 1 with bidirectional TVS SMAJ70CA and SMAJ58CA

TSC2020 is powered by a 3.3V battery and the shunt is connected to the TSC2020 reference.

Figure 14: Setup 1 with SMAJ70CA describes the setup bench with TVS SMAJ70CA and Figure 15: Setup 1 with SMAJ58CA describes the setup bench with TVS SMAJ58CA.

Figure 14. Setup 1 with SMAJ70CA

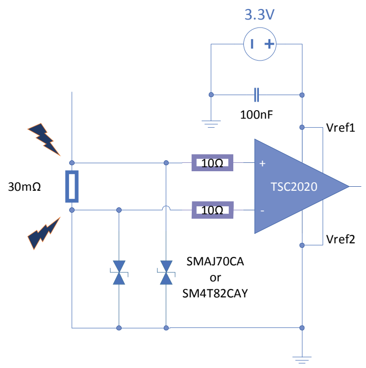
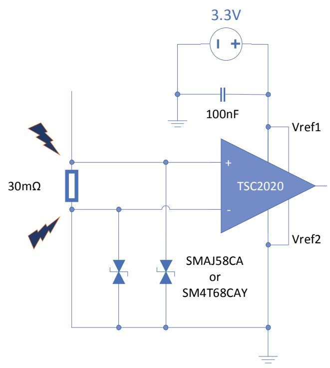


Figure 15. Setup 1 with SMAJ58CA



CONTACT DISCHARGE	Setup 1 with SMAJ70CA+10 Ω TSC2020 Power On and shunt connected to GND	Setup 1 with SMAJ58CA TSC2020 Power On and shunt connected to GND
+8 kV	PASS	PASS
-8 kV	PASS	PASS

AIR DISCHARGE	Setup 1 with SMAJ70CA+10 Ω TSC2020 Power On and shunt connected to GND	Setup 1 with SMAJ58CA TSC2020 Power On and shunt connected to GND
+2 kV	PASS	PASS
-2 kV	PASS	PASS
+4 kV	PASS	PASS
-4 kV	PASS	PASS
+8 kV	PASS	PASS
-8 kV	PASS	PASS
+15 kV	PASS	PASS
-15 kV	PASS	PASS

10.2 SETUP 2 with bidirectional TVS SMAJ70CA and SMAJ58CA

TSC2020 is not powered, and the shunt is connected to the TSC2020 reference. Figure 16: describes the setup bench with TVS SMAJ70CA and Figure 17: Setup 2 with SMAJ58CA describes the setup bench with TVS SMAJ58CA.

Figure 16. Setup 2 with SMAJ70CA

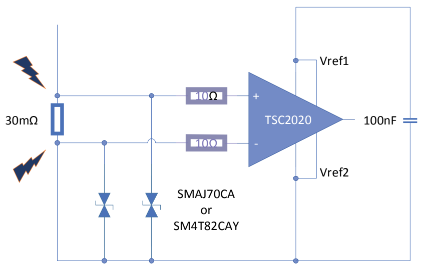
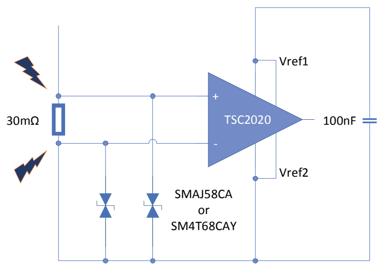


Figure 17. Setup 2 with SMAJ58CA



CONTACT DISCHARGE	Setup 2 with SMAJ70CA+10 Ω TSC2020 Power OFF and shunt connected to reference	Setup 2 with SMAJ58CA TSC2020 Power OFF and shunt connected to reference
+8 kV	PASS	PASS
-8 kV	PASS	PASS

AIR DISCHARGE	Setup 2 with SMAJ70CA+10 Ω TSC2020 Power OFF and shunt connected to reference	Setup 2 with SMAJ58CA TSC2020 Power OFF and shunt connected to reference
+2 kV	PASS	PASS
-2 kV	PASS	PASS
+4 kV	PASS	PASS
-4 kV	PASS	PASS
+8 kV	PASS	PASS
-8 kV	PASS	PASS
+15 kV	PASS	PASS
-15 kV	PASS	PASS

10.3 SETUP 3 with bidirectional TVS SMAJ70CA and SMAJ58CA

TSC2020 is powered by a 3.3 V battery and the shunt is left floating. Figure 18: Setup 3 with SMAJ70CA describes the setup bench with TVS SMAJ70CA and Figure 19: Setup 3 with SMAJ58CA describes the setup bench with TVS SMAJ58CA.

Figure 18. **Setup 3 with SMAJ70CA**

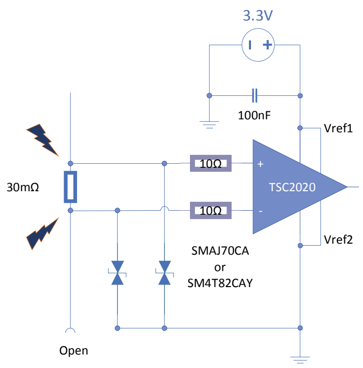
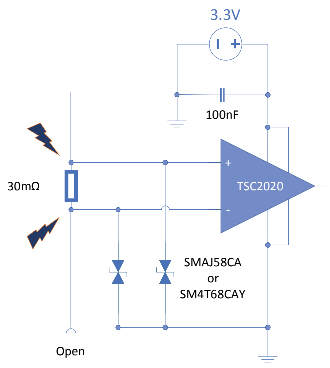


Figure 19. **Setup 3 with SMAJ58CA**



CONTACT DISCHARGE	Setup 3 with SMAJ70CA+10 Ω TSC2020 Power On and shunt left floating	Setup 3 with SMAJ58CA TSC2020 Power On and shunt left floating
+8 kV	PASS	PASS
-8 kV	PASS	PASS

AIR DISCHARGE	Setup 3 with SMAJ70CA+10 Ω TSC2020 Power On and shunt left floating	Setup 3 with SMAJ58CA TSC2020 Power On and shunt left floating
+2 kV	PASS	PASS
-2 kV	PASS	PASS
+4 kV	PASS	PASS
-4 kV	PASS	PASS
+8 kV	PASS	PASS
-8 kV	PASS	PASS
+15 kV	PASS	PASS
-15 kV	PASS	PASS

10.4 SETUP 4 with bidirectional TVS SMAJ70CA and SMAJ58CA

TSC2020 is not powered, and the shunt is left floating. Figure 20: Setup 4 with SMAJ70CA describes the setup bench with TVS SMAJ70CA and Figure 21: Setup 4 with SMAJ58CA describes the setup bench with TVS SMAJ58CA.

This test is more restrictive in terms of ESD resistance.

Figure 20. Setup 4 with SMAJ70CA

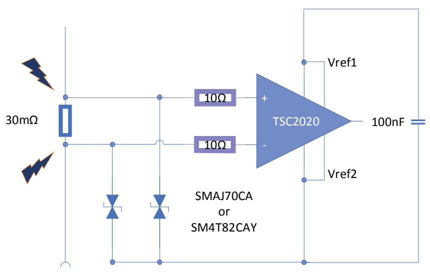
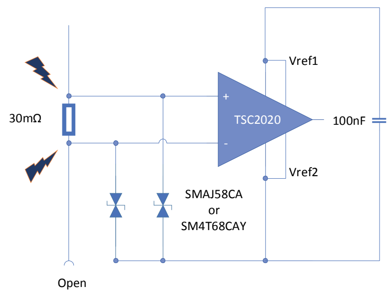


Figure 21. Setup 4 with SMAJ58CA



CONTACT DISCHARGE	Setup 4 with SMAJ70CA+10 Ω TSC2020 Power OFF and shunt left floating	Setup 4 with SMAJ58CA TSC2020 Power OFF and shunt left floating
+8 kV	PASS	PASS
-8 kV	PASS	PASS

AIR DISCHARGE	Setup 4 with SMAJ70CA+10 Ω TSC2020 Power OFF and shunt left floating	Setup 4 with SMAJ58CA TSC2020 Power OFF and shunt left floating
+2 kV	PASS	PASS
-2 kV	PASS	PASS
+4 kV	PASS	PASS
-4 kV	PASS	PASS
+8 kV	PASS	PASS
-8 kV	PASS	PASS
+15 kV	PASS	PASS
-15 kV	PASS	PASS

10.5 Summary test with bidirectional TVS SMAJ70CA and SMAJ58CA

The bidirectional TVS SMAJ70CA can protect the high-side current sensing against ESD surges following the IEC61000-4-2 standard with the highest level (4), thanks to the addition of serial 10 Ω resistance on the input. To be able to protect the TCS2020 devices with the highest immunity level without adding serial resistance, a lower V_{BR} TVS diode can be used such as SMAJ58CA.

11 Conclusion

While the high-ide current sensing TSC2020 is naturally well protected against ESD in a controlled environment such as a laboratory or production site, thanks to its good CDM and HBM immunity levels, it must be protected when it is used in an uncontrolled environment. To ensure the best ESD immunity, it is advisable to use fast transient TVS diodes in unidirectional or bidirectional mode, depending on the application where the TSC2020 is used. Different setup tests have been used to evaluate the TSC2020 ESD protection in different application configurations. Using the unidirectional TVS SMAJ70A has shown good results in protecting the TSC2020 against ESD surge following the IEC61000-4-2 standard, and allows it to sustain the maximum immunity level (level 4). The SMAJ70A allows the use of the TSC2020 practically across its full input common-mode range, with a V_{icm} from - 0.7 V up to 82 V. If an application works with a lower input common-mode voltage (less than 82 V), it is certainly more beneficial to use a lower V_{BR} TVS diode.

By using the SMAJ70CA bidirectional TVS, it has been demonstrated that adding a 10 Ω resistance in series on the input helps to reach the maximum ESD immunity level. However, this resistance can slightly affect the DC performance of the TSC2020. To avoid using serial resistance on the TSC2020 input pins, a lower VBR bidirectional TVS such as the SMAJ58CA can be used.

Although all the tests have been carried out in a laboratory following the IEC61000-4-2 standard, the results cannot be considered certification, but rather a good indicator of the robustness of the TCS2020 and TVS SMAJ70A, SMAJ70CA or SMAJ58CA against ESD in various environments.

This application focuses on the IEC61000-4-2 standard but other standards such as ISO21780 which requires a hold of 60 V for 60 minutes and 70 V for 40 ms, or even ISO7637-2 standard (for 12 V, 24 V application) also require the use of TVS.

12 Bibliography

- Datasheet SMAJxxA “400 W TVS in SMA”
- Datasheet SM4TxxAY “Automotive 400 W TVS in SMA”
- Datasheet TSC2020 “100 V, precision, bidirectional current sense amplifier”
- AN5612: application note: “ESD protection of STM32 MCUs and MPUs”
- IEC61000-4-2 Standard “Electromagnetic compatibility (EMC) –Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test”

Revision history

Table 2. **Document revision history**

Date	Version	Changes
14-Apr-2025	1	Initial release.

Contents

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