IEC 61000-4-X STANDARD: EMC TESTING AND MEASUREMENT AS APPLIED TO ALLEGRO INTEGRATED CURRENT SENSORS

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INTRODUCTION

The IEC61000-4-x standard defines testing methodologies to ensure electromagnetic compatibility between electronic systems. These tests cover immunity to electrostatic discharge, electrical fast transient/burst, and surge voltages. Requirements for Allegro integrated current sensors are not identical to these testing standards given that the current sensors are part of a larger system, usually with additional protection. Current sensors are tested under standards IEC 61000-4-2 and 61000-4-5 with alternative voltage levels, while 61000-4-4 is typically reserved for the testing of entire systems and not semiconductors. The scope of testing for current sensors is discussed in more detail in each section.

IEC 61000-4-2 OVERVIEW: ELECTROSTATIC DISCHARGE IMMUNITY TEST

The IEC 61000-4-2 is a testing standard to determine a system's ability to withstand discharging events either in environmental conditions or during installation. This standard is applied to semiconductor components to ensure they are not the weakest component in the system if subjected to an electrostatic discharge (ESD) event. If a device passes the highest levels tested in this standard, it will most likely be able to survive ESD effects without further protective actions needed from the end user. However, system-level protections can also be supplemented to weaker components to ensure maximum survivability. Failure is defined as a temporary loss of function or degradation of performance.

Two testing methodologies are provided in IEC 61000-4-2 with four levels of protection defined in each. The first methodology involves direct contact to conductive surfaces using an ESD gun (Figure 1). In the case of Allegro's integrated current sensors, this means direct contact with the VDD or ground pins. If contact discharge is not achievable in a device under testing, the discharge may be applied through air by adding a small gap between the ESD gun and the device. For the ideal current waveform using contact discharge, see Figure 3.

The second methodology is air discharge, which is performed by slowly bringing the ESD gun toward the conductive surface. While testing a voltage level using contact discharge only requires testing at that voltage, air discharge requires starting from level 1 and testing every voltage level up to the desired testing level. At each level, the device must not fail during 50 discharges in a row. If there is exactly one failure, the test is repeated with 100 consecutive discharges. If there is more than one failure, the device fails that level. The device passes the next lower level if there are no failures.

In the context of device-level ESD testing, current sensors must pass the human body model (HBM) of 2 kV discharge. Other testing standards include the machine model (MM) and charged device model (CDM) which are tested at 200 V and 500 V, respectively.

Table 1: Test Voltage Requirement for Each Level 61000-4-2

Contact Discharge		Air Discharge	
Level	**Test Voltage [kV]**	**Level**	**Test Voltage [kV]**
1	2	1	2
2	4	2	4
3	6	3	8
4	8	4	15

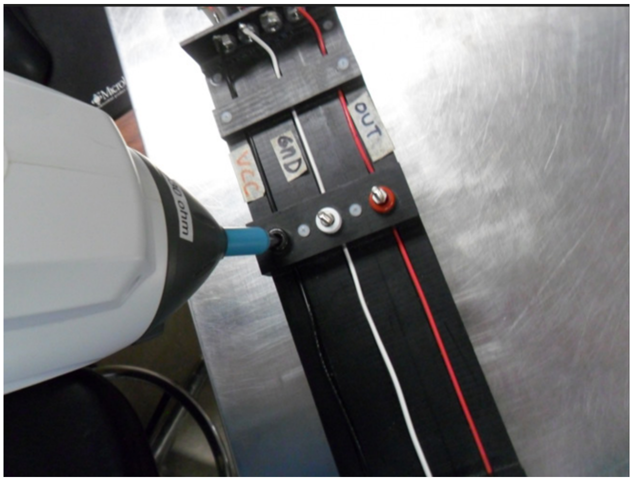

Figure 1: ESD Gun Injecting Contact Discharge Voltage onto VCC

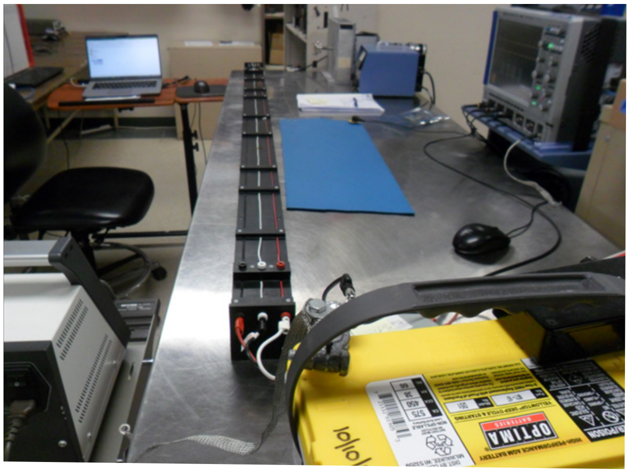

Figure 2: ESD Test Setup

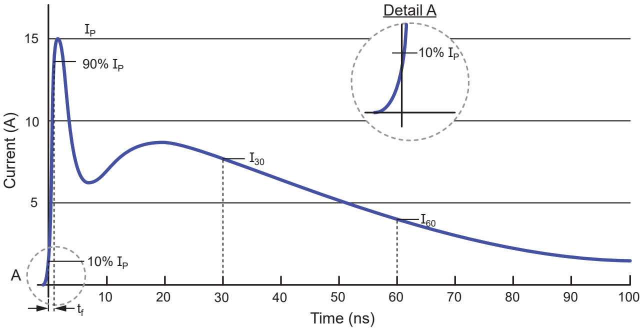

Figure 3: IEC 61000-4-2 Ideal Contact Discharge Waveform

IEC 61000-4-4 OVERVIEW: ELECTRICAL FAST TRANSIENT/BURST IMMUNITY TEST

The IEC 61000-4-4 standard provides methods for determining immunity to transient spikes along power or data lines. This standard determines immunity of equipment and components to electrical fast transients (EFT), such as those created due to switching transients. Voltage spikes can be injected into power lines as well as inputs/outputs (I/Os), and the pulse voltage amplitudes vary for each (see Table 2). Applied spikes are triangular pulses with 5 ns rise time and 50 ns fall time, repeated for 15 ms if the repetition frequency is 5 kHz, or 0.75 ms if it is 100 kH (Figure 4). Failure is defined as a temporary loss of function or degradation of performance. These tests are larger-scale system-level requirements that are not used on Allegro current sensors due to PCBs having protection at the wiring inputs. These tests are more applicable to parts on a wire harness.

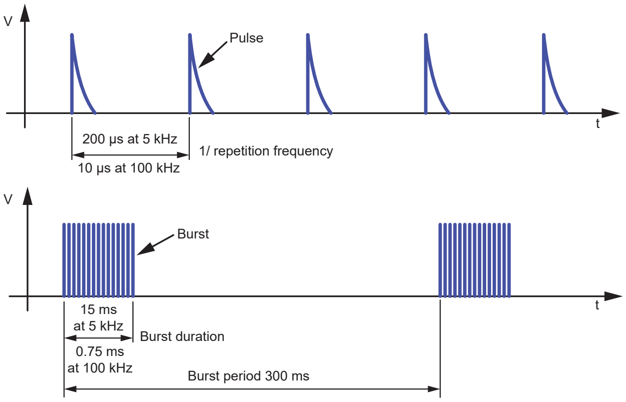

Figure 4: IEC 61000-4-4 Ideal Contact Discharge Waveform

Table 2: Test Voltage Requirements for Each Level 61000-4-5

Class	Test Levels [kV]							
	AC Power Supply and AC I/O External		AC Power Supply and AC I/O Internal		DC Power Supply and DC I/O External		DC Power Supply and DC I/O Internal	
	Line-to-Line	Line-to-Ground	Line-to-Line	Line-to-Ground	Line-to-Line	Line-to-Ground	Line-to-Line	Line-to-Ground
0	–	–	–	–	–	–	–	–
1	–	0.5	–	–	–	–	–	–
2	0.5	1	–	–	–	–	–	–
3	1	2	1	2	–	–	–	–
4	2	4	2	4	2	4	2	4
5	Dependent	Dependent	2	4	2	4	2	4

IEC 61000-4-5 OVERVIEW: SURGE IMMUNITY TEST

IEC 61000-4-5 defines surge immunity for an electronic device or equipment to a high-power event that occurs during lightning strikes and high voltages caused by switching events. The levels of IEC 61000-4-5 determine the events that the device is capable of surviving, which is defined as a temporary loss of function or degradation of performance. Tests shall be performed at each level up to the desired testing voltage. Generated surges replicate open-circuit voltages with a rise time of 1.2 µs and duration of 50 µs. Tests shall have five positive pulses followed by five negative pulses, with a maximum of one minute between each. Allegro integrated current sensors are tested with voltage applied from the current pins to the I/O pins to test shielding capabilities from the current-carrying leadframe to the signal pins.

The classification of environments (as defined by IEC 61000-4-5 standard) are:

- Class 0: Well-protected electrical environment, often within a special room
- 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 run as outdoor cables along with power cables, and cables are used for both electronic and electric circuits
- Class 5: Electrical environment for electronic equipment connected to communication cables and overhead power lines in a nondensely populated area.

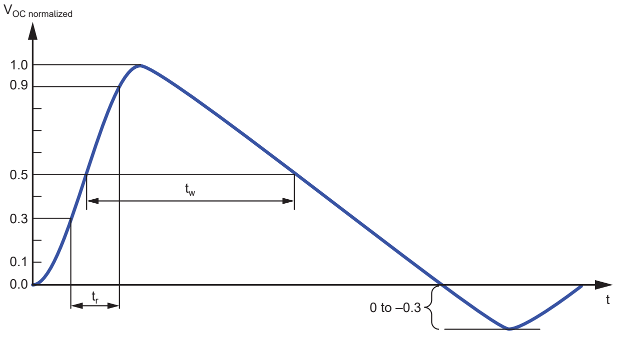

Figure 5: Ideal Surge Waveform Normalized to Peak Voltage

Surge voltages for Allegro integrated current senors vary depending on package. Each device exceeds the level 4 requirement for the IEC 61000-4-5 standard, demonstrating that, in regard to a surge event in a larger system, these devices will not be a cause of failure. Surge voltages must be at least 1.6 times the impulse voltage for reinforced insulation, and 1.3 times the impulse voltage for basic insulation, which is determined by each package. More information regarding insulation is provided in the product datasheets.

Table 3: Surge Voltage Immunities for Different Allegro Integrated Current Sensor Projects

Package Type	Package Designator	Surge Voltage Immunity [kV]
SOIC-8	LC	5
SOICW-16	LA	10
	MA	10
	MC	8
Fused SOIC-6	LZ	13
XtremeSense™ SOIC-8	SOIC-8	10
XtremeSense™ SOIC-16	SOIC-16	13

Revision History

Number	Date	Description
–	June 14, 2024	Initial release