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APPLICATION NOTE

Requirements for Successful ESD Monitoring in Semiconductor ASAT Facilities

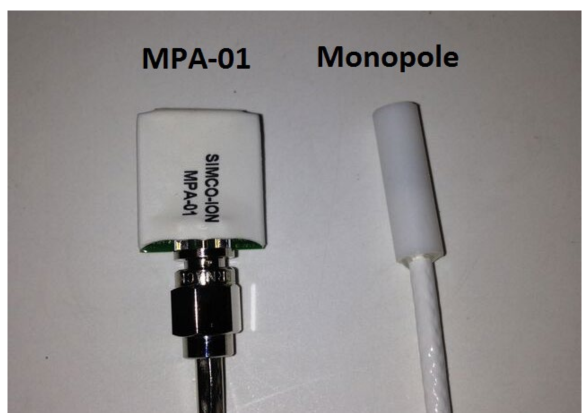
The goal in monitoring a semiconductor assembly and test area for ESD events is to be able to distinguish ESD events of concern from spurious tool or other process electromagnetic noise. To successfully characterize ESD events requires a combination of careful selection of antenna based on its characteristics, using an instrument with appropriately discriminatory algorithms to filter out irrelevant signals, and calibrating the instrument/antenna system to ignore events below the device's threshold for damage. Earlier efforts to monitor for ESD events have failed in one or more of these three areas.

This Application Note is meant to help explain the significance of these factors and provide some guidance in setting up an application. This Note relates to setups using directional and non-directional antennas, the stand-alone MiniPulse or the Novx 7000 Monitor with MiniPulse capability, and the CDMES calibration tool.

ESD Antenna Basics

ESD antennas are transducers which take the radiated electromagnetic field produced by an electrostatic discharge event (ESD) and turn it into an electrical signal which can be captured by an ESD detector or oscilloscope. Antennas typically have the following features:

- *Antenna Gain*. This refers to an antennas ability to convert the radiated ESD pulse signal into an electrical signal. As a rule, the larger the antenna surface, the more sensitivity to ESD events. This means that smaller ESD events can be detected and ESD events can be detected from a greater distance from the source.
- *Directivity*. This refers to the antenna ability to receive ESD event signals from a desired source, while rejecting unwanted signals from other sources. Some applications will benefit from low directivity, detecting ESD events in a wide surrounding area. Other applications will require a much more restricted solution focusing on a very specific location.



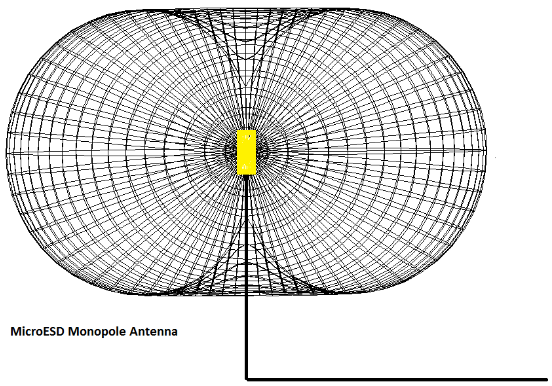
MPA-01 and Monopole Antenna Types

ESD Antenna Types

Monopole Micro ESD Antenna

This general use antenna was developed to provide non-directional ESD detection capabilities. This antenna version is most often use when multiple ESD sources in a small area need to be monitored.

This antenna is sensitive to 1V ESD events at 3 mm distance from any side of the antenna.

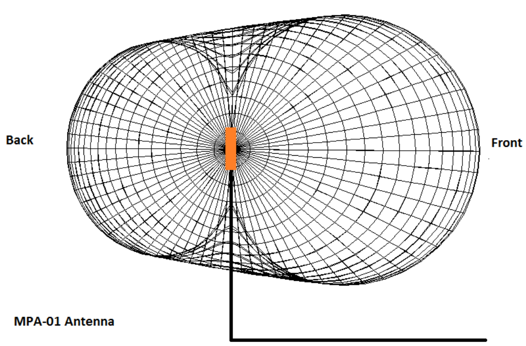


Monopole Micro ESD Gain Pattern

MPA-01 Directional Antenna

This antenna was developed for single ESD source monitoring, typically inside semiconductor device handling tools. The directionality factor helps to eliminate tool and environmental electromagnetic pulse noise which is not of interest. The focal plane (labeled front side) of the antenna receives the ESD pulse signal, and the backplane of the antenna rejects signals originating from other sources.

This antenna is also sensitive to 1V ESD events at 3mm distance on the front side of the antenna.



MPA-01 Micro ESD gain pattern

ESD Antenna Accuracy

Due to the properties of electromagnetic waves, in this case produced by an ESD event, great accuracy can be obtained with proper antenna calibration by distance from source. As shown in the chart below, a difference of 1.25 cm (0.5") in antenna position can make a difference in ESD event detection for a given event amplitude. In addition, as can be seen in Table 1, MiniPulse sensitivity is indicated by a 140V event being rejected for a 150V alarm setting.

Table 1. Antenna Sensitivity Example

CDMES Voltage	Distance (inches)	MP Detects	MP Non-detects
150	1.0	30	0
150	1.5	0	30
125	1.0	0	30
135	1.0	0	30
140	1.0	1	29
140	1.0	2	28

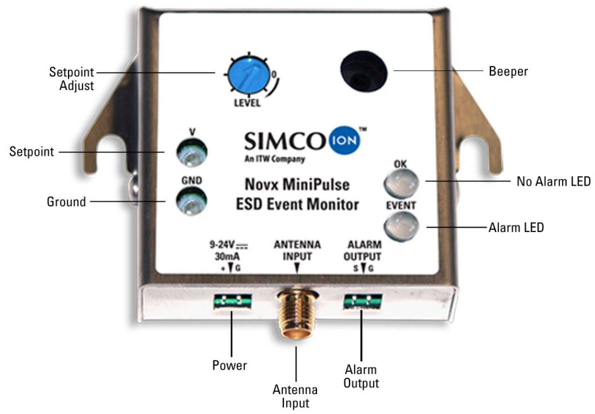
The table below shows how the directionality of the MPA-01 antenna rejects unwanted ESD events coming from the back side of the antenna (example: 75V calibrated ESD event rejects up to 175V ESD event from back side). By contrast, the omnidirectional Monopole antenna has the same sensitivity for all directions (i.e., no rejection).

Table 2. Comparison of antenna rejection ratios

CDMES V @1" Distance	MPA01 Backside Reject (V)	Antenna Rejection (%)	Monopole Reject V	Antenna Rejection (%)
75	175	233%	75	0
100	200	200%	100	0
125	200	160%	125	0
150	225	150%	150	0
175	250	143%	175	0
200	350	175%	200	0
250	400	160%	250	0
300	525	175%	300	0
350	575	164%	350	0
400	775	194%	400	0
500	800	160%	500	0
600	1100	183%	600	0
700	1400	200%	700	0
800	1500	188%	800	0
900	2000	222%	900	0
1000	2000	200%		

ESD Signal Processing

The other part of ESD event detection is a monitoring unit capable of disambiguating radiated electromagnetic pulse events from background events not of interest. The MiniPulse technology uses proprietary time and amplitude domain discrimination to qualify and quantify ESD events and was designed to work with specific types of antennas.



The MiniPulse uses specific antenna gain factors together with digital threshold settings to adapt event detection to specific applications. This gives great flexibility in adjusting to different processing environments and requirements. The historic difficulty associated with many approaches to ESD detection has been focused on separating ESD events of interest from other competing events in the environment. General antennas and monitoring units have often failed to provide the qualified alerts required. The MiniPulse technology, both as a standalone process-embeddable unit and as a modular option in the Series 7000 process monitor, addresses this.

Application Rules

Implementing ESD event monitoring in tools and processes which have some level of background noise requires some careful planning and qualification. Modern tools are getting quieter by, for instance, adopting brushless DC motors to run actuators and tool operations. However, depending upon the tool type and surrounding environment, electromagnetic noise with narrow pulse widths can mimic ESD event pulse events. Below is a brief summary of elements to take into consideration.

- ESD detector calibration should be performed with an accurate and repeatable CDM event source. The Simco-Ion CDMES (Charged Device Model Event Simulator) system is highly recommended. Some organizations require a statistical validation test to be performed to demonstrate monitoring effectiveness. This necessitates having a repeatable CDM event calibration source.
- Careful attention should be placed on identifying the probable device ESD location (e.g., test socket, device/board placement, etc.). ESD antenna type and placement needs to be determined based upon application requirements. For instance, if noise rejection is necessary, then the MPA-01 antenna should be chosen to minimize unwanted signal acquisition. The antenna should be placed as close to the ESD event source location as possible. The farther the antenna is placed from this location, the more problematic it will be to separate real ESD signals from ambient noise events.
- Once an antenna position has been chosen, a rejection test should be performed with the CDM event source to determine the ESD event detection sensitivity and rejection characteristics. If the event detector is picking up conducted events from other locations, it may be necessary to place the antenna in a different position. This rejection test should answer questions like, “The MiniPulse at this threshold setting is able to reject a 500V ESD event at 1 meter.”

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