

Investigating R&D Committee on Measurement and Evaluation Technologies to Clarify ESD Phenomena from EMC Perspectives

Technical Committee on Electromagnetic Compatibility

1. Objective

Electrostatic discharge (ESD) generates fast transient currents with sub-nanosecond rise depending on conditions. Moreover, the transient electromagnetic field produced by ESD may generate broadband electromagnetic waves up to the GHz band, which may cause electrical breakdown or malfunctioning of electronic devices that constitute the foundation of an enhanced IT society, as well as interference with radio communications. ESD is a phenomenon in which several parameters—such as the temperature and humidity of the environments in which discharge is generated, the electrode shape, the surface conditions, and the movement speed—affect discharge characteristics in a complex manner, and several aspects of these characteristics and ESD-generating mechanisms remain unknown. Analysis of the generation mechanism and characteristics of ESD is integral to the development of measurement techniques; hence, determining the performance of measuring instruments is crucial. However, several problems also remain in this regard. Furthermore, while international standards for techniques to evaluate ESD immunity have been implemented worldwide for electronic equipment since the 1980s, there are several uncertain elements, e.g., test reproducibility and effects on electronic circuits; additionally, several problems are raised in deliberations to revise standards. Moreover, electronic device failure involves the threat of deliberate attacks on electronics and communications.

However, with the rapid proliferation of automated driving automobiles and robots for caregiving and life support coexistence with human in near future, ensuring the noise immunity of electronic devices against ESD is essential for the safety of people and property.

Therefore, the objective of this committee is to promote the enhancement of ESD countermeasures and systematization of knowledge by advancing research into integrating issues faced by the industrial world, results of practical application of ESD countermeasures, and academic findings cultivated through basic research by universities. Focusing mainly on investigative research by past committees that yielded significant results and committee members who succeeded in cooperation and achieving mutual understanding, this committee will add specialists in areas of weakness as new members, set more in-depth investigative targets, and then conduct an investigation from the position of rapidly advancing progress toward identifying ESD phenomena.

2. Background and internal and external research activities

The objective of our previous Investigating R&D committees was to research and investigate electromagnetic compatibility (EMC) due to discharge because of importance of the serious problems related to electromagnetic noise caused by discharge. We proceeded with our research and investigation by establishing the “Investigating R&D Committee on EMC technology of Electrostatic Discharge” (Chairperson Shigeki Minegishi (Tohoku Gakuin University) in April 2008, the “Investigating R&D Committee on the Characteristics of Electromagnetic Noise Caused by Discharges” (Chairperson Ken Kawamata (Hachinohe Institute of Technology, presently Tohoku Gakuin University) in April 2011, the “Investigating R&D Committee on Electronic Equipment and Communication Damage Caused by Transient Electromagnetic Field” (Chairperson Shinobu

Ishigami (National Institute of Information and Communications Technology, presently Tohoku Gakuin University) in April 2014, and the “Investigating R&D Committee on Evaluation of Impact of ESD Transient Electromagnetic Field to Electronic Device” (Chairperson Takeshi Ishida (Noise Laboratory Co., Ltd.) in August 2017 in the Technical Committee on Electromagnetic Compatibility.

The following were the main results: (1) Unstable characteristics of aerial discharge from an ESD tester were identified. Different phenomena could be identified in relation to environmental temperature and humidity, as well as moving speed, and these were explained on the basis of spark resistance formulae. (2) Detailed analysis of ESD between spherical electrodes revealed a high-speed rise at a microgap under low voltage, generation of broadband electromagnetic waves, and the existence of peculiar characteristics depending on the charging voltage. (3) An attempt was made to improve the properties of an optical electric field sensor that measures electric field generation corresponding to wide bands and high frequencies exceeding 1 GHz through ESD between spherical electrodes. Moreover, the separation of the radiation field and induction field, which depends on the distance, was clarified experimentally. (4) Experimental data on the effects of gradual, microsecond-scale electric field changes generated by changes in the human body potential through discharge from the human body to electronic equipment was obtained, and a test method was developed accordingly. (5) Problems and countermeasures for the security of electronic equipment based on intentional electromagnetic interference were examined. (6) Characteristics and failure modes of ESD protection devices that prevent semiconductors in electronic circuits from destroying by bypassing discharge currents by ESD testers were analyzed. In addition, an optimum design for ESD protection and a technique for characterization of ESD protection devices were explored. (7) Electrostatic induction phenomena caused by a charged body on a discharge object were studied experimentally with and without grounding, and the specific characteristics of the ESD generated there were confirmed. (8) Problems pertaining to the IEC 61000-4-2 international standard for ESD tests were clarified based on the demonstration experiment.

Past committees obtained significant research and investigation results through proactive steps taken as a group and by individual committee members. This includes presenting numerous papers, planning special sessions at international conferences, and publishing special issues of papers and journals.

However, unraveling the mechanism of ESD phenomena and electromagnetic noise characteristics due to ESD from physical perspectives, developing methods to experimentally reproduce effects on electronic equipment and communication as well as evaluating at the system and device level, and modeling and simulation of discharge EMC are rather difficult. Furthermore, due to the varied nature of ESD phenomena, subjects, and parameters, we are only halfway to finding viable solutions to discharge and EMC problems. Therefore, there is a strong need for further research and investigation, although the committee has disbanded at that time.

To further clarify the EMC problems associated with ESD and transient electromagnetic field phenomena, the results of research and investigation by past committees should be carried over, more in-depth investigative targets should be set, and investigation should then be conducted from the position of rapidly advancing progress towards identifying phenomenon

3. Investigative matters

In consideration of the aforementioned objective and background, this Investigation Committee shall investigate the following items in greater depth based on the results of investigation and research conducted by past committees.

- (1) Identify the basics and generation mechanisms of discharge and ESD phenomena from the physical perspectives
- (2) Identify transient electromagnetic field and radiated electromagnetic field characteristics due to discharge and investigate their measuring techniques
- (3) Investigate techniques for improving the actual environmental adaptability of ESD immunity test methods, mainly for IEC 61000-4-2
- (4) Investigate modeling of EMC against ESD and its simulation techniques
- (5) Assess the impact of transient electromagnetic fields on electronic equipment and communications at the system and device levels
- (6) Investigate the threat of intentional attacks on electronic equipment and communications and their assessment techniques
- (7) Investigate failures in new electronic device fields, such as wearable devices and IoT devices

4. Expected effects

This research and investigation should advance knowledge of transient phenomenon such as discharge and ESD, generation of broadband electromagnetic interference sources, and interference mechanisms; contribute to the physical understanding of discharge; and provide a basis for establishing industrial ESD countermeasures. In addition, it is also expected to improve EMC technology for advancing countermeasures against electromagnetic noise due to discharge.

5. Term of investigation

October 2020 to September 2023

6. Committee members

Position	Name	Affiliation	Member/Non-member category of IEEJ
Chairperson	Takahiro Yoshida	Tokyo University of Science	Member
Member	Fujio Amemiya	The University of Electro-Communications	Non-member
"	Shinobu Ishigami	Tohoku Gakuin University	Member
"	Takeshi Ishida	Noise Laboratory Co., Ltd.	Member
"	Ifong Wu	National Institute of Information and Communications Technology	Non-member
"	Toru Uno	University of Agriculture and Technology	Member
"	Kuniko Urashima	National Institute of Science and Technology Policy	Non-member
"	Ryuji Osawa	Seikoh Giken Co., Ltd.	Member
"	Takayoshi Otsu	National Institute of Technology(KOSEN), Numazu College	Member

Position	Name	Affiliation	Member/Non-member category of IEEJ
Member	Ken Kawamata	Tohoku Gakuin University	Member
"	Masanori Sawada	Hanwa Electronic Ind. Co., Ltd.	Member
"	Hideaki Tokunaga	Panasonic Corporation	Member
"	Yuichi Hayashi	Nara Institute of Science and Technology	Member
"	Osamu Fujiwara	The University of Electro-Communications	Member
"	Masamitsu Honda	Impulse Physics Laboratory, Inc.	Non-member
"	Kazuo Murakawa	Osaka Institute of Technology	Member
Secretary	Yukihiro Tozawa	Noise Laboratory Co., Ltd.	Member

7. Activity schedule

Committee meetings: 3 times/year; Secretariat: 3 times/year; Technical meeting: 1 time/year

8. Reporting format

A technical report shall be prepared to present the results.