



**Electrostatic discharge (ESD)  
protection in electronics**

# Protecting Electronic Equipment From Electrostatic Discharge

**Albert Wang**



## **Protecting Electronic Equipment From Electrostatic Discharge:**

**Protecting Electronic Equipment from Electrostatic Discharge** Edward A. Lacy, 1984 Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment (excluding Electrically Initiated Explosive Devices) (metric) United States. Department of Defense, 1991 **Electrostatic Discharge Protection** Juin J. Liou, 2017-12-19 Electrostatic discharge ESD is one of the most prevalent threats to electronic components In an ESD event a finite amount of charge is transferred from one object i e human body to another i e microchip This process can result in a very high current passing through the microchip within a very short period of time Thus more than 35 percent of single event chip damages can be attributed to ESD events and designing ESD structures to protect integrated circuits against the ESD stresses is a high priority in the semiconductor industry **Electrostatic Discharge Protection Advances and Applications** delivers timely coverage of component and system level ESD protection for semiconductor devices and integrated circuits Bringing together contributions from internationally respected researchers and engineers with expertise in ESD design optimization modeling simulation and characterization this book bridges the gap between theory and practice to offer valuable insight into the state of the art of ESD protection Amply illustrated with tables figures and case studies the text Instills a deeper understanding of ESD events and ESD protection design principles Examines vital processes including Si CMOS Si BCD Si SOI and GaN technologies Addresses important aspects pertinent to the modeling and simulation of ESD protection solutions **Electrostatic Discharge Protection Advances and Applications** provides a single source for cutting edge information vital to the research and development of effective robust ESD protection solutions for semiconductor devices and integrated circuits **Electrostatic Discharge Protection for Electronics** Neil Sclater, 1990 Neil Sclater offers practical advice on selecting test and control equipment handling and storing semiconductors and other components building static free workstations creating a protective environment for electronics and much more A complete listing of manufacturers and suppliers is included Prior to founding his own electronics marketing research firm Neil Sclater worked as an engineer for several leading corporations and as editor for *Electronic Design* and *Product Engineering* He is the author of *TPR's Gallium Arsenide IC Technology* No 3089 ESD Steven H. Voldman, 2015-01-05 A comprehensive and in depth review of analog circuit layout schematic architecture device power network and ESD design This book will provide a balanced overview of analog circuit design layout analog circuit schematic development architecture of chips and ESD design It will start at an introductory level and will bring the reader right up to the state of the art Two critical design aspects for analog and power integrated circuits are combined The first design aspect covers analog circuit design techniques to achieve the desired circuit performance The second and main aspect presents the additional challenges associated with the design of adequate and effective ESD protection elements and schemes A comprehensive list of practical application examples is used to demonstrate the successful combination of both techniques and any potential design trade offs Chapter One looks at analog

design discipline including layout and analog matching and analog layout design practices Chapter Two discusses analog design with circuits examining single transistor amplifiers multi transistor amplifiers active loads and more The third chapter covers analog design layout also MOSFET layout before Chapters Four and Five discuss analog design synthesis The next chapters introduce the reader to analog digital mixed signal design synthesis analog signal pin ESD networks and analog ESD power clamps Chapter Nine the last chapter covers ESD design in analog applications Clearly describes analog design fundamentals circuit fundamentals as well as outlining the various ESD implications Covers a large breadth of subjects and technologies such as CMOS LDMOS BCD SOI and thick body SOI Establishes an ESD analog design discipline that distinguishes itself from the alternative ESD digital design focus Focuses on circuit and circuit design applications Assessable with the artwork and tutorial style of the ESD book series PowerPoint slides are available for university faculty members Even in the world of digital circuits analog and power circuits are two very important but under addressed topics especially from the ESD aspect Dr Voldman s new book will serve as an essential and practical guide to the greater IC community With high practical and academic values this book is a bible for professionals graduate students device and circuit designers for investigating the physics of ESD and for product designs and testing **The ESD Handbook** Steven H.

Voldman,2021-03-25 A practical and comprehensive reference that explores Electrostatic Discharge ESD in semiconductor components and electronic systems The ESD Handbook offers a comprehensive reference that explores topics relevant to ESD design in semiconductor components and explores ESD in various systems Electrostatic discharge is a common problem in the semiconductor environment and this reference fills a gap in the literature by discussing ESD protection Written by a noted expert on the topic the text offers a topic by topic reference that includes illustrative figures discussions and drawings The handbook covers a wide range of topics including ESD in manufacturing garments wrist straps and shoes ESD Testing ESD device physics ESD semiconductor process effects ESD failure mechanisms ESD circuits in different technologies CMOS Bipolar etc ESD circuit types Pin Power Pin to Pin etc and much more In addition the text includes a glossary index tables illustrations and a variety of case studies Contains a well organized reference that provides a quick review on a range of ESD topics Fills the gap in the current literature by providing information from purely scientific and physical aspects to practical applications Offers information in clear and accessible terms Written by the accomplished author of the popular ESD book series Written for technicians operators engineers circuit designers and failure analysis engineers The ESD Handbook contains an accessible reference to ESD design and ESD systems Electronic Equipment Packaging Technology Gerald L. Ginsberg,2013-11-27 The last twenty years have seen major advances in the electronics industry Perhaps the most significant aspect of these advances has been the significant role that electronic equipment plays in almost all product markets Even though electronic equipment is used in a broad base of applications many future applications have yet to be conceived This versatility of electron ics has been brought about primarily by the significant advances that have been made in integrated

circuit technology The electronic product user is rarely aware of the integrated circuits within the equipment However the user is often very aware of the size weight mod ularity maintainability aesthetics and human interface features of the product In fact these are aspects of the products that often are instrumental in deter mining its success or failure in the marketplace Optimizing these and other product features is the primary role of Electronic Equipment Packaging Technology As the electronics industry continues to pro vide products that operate faster than their predecessors in a smaller space with a reduced cost per function the role of electronic packaging technology will assume an even greater role in the development of cost effective products

EMI Protection for Communication Systems Kresimir Malaric, 2010 In recent years the protection of communication services operating in the same of adjacent channels has become more and more challenging Communication systems need to be protected from natural and man made interference This practical reference provides a thorough understanding of how to protect communication systems from intentional and unintentional electromagnetic interference Engineers learn how to overcome critical problems in both digital and analog communications This unique resource shows how to shield equipment from electrical and magnetic fields design TEM and GTEM Cell build capacitive coupling clamps for susceptibility tests protect electronic equipment with filters and calculate the measurement uncertainty Professionals find numerous well illustrated examples that make challenging electromagnetics issues far easier to comprehend CD ROM Included Contains time saving software that helps engineers perform important calculations including characteristic impedance of TEM Cell cut off frequencies for higher order modes and cut off and resonant frequencies for GTEM cell

ESD Testing Steven H. Voldman, 2016-12-19 With the evolution of semiconductor technology and global diversification of the semiconductor business testing of semiconductor devices to systems for electrostatic discharge ESD and electrical overstress EOS has increased in importance ESD Testing From Components to Systems updates the reader in the new tests test models and techniques in the characterization of semiconductor components for ESD EOS and latchup Key features Provides understanding and knowledge of ESD models and specifications including human body model HBM machine model MM charged device model CDM charged board model CBM cable discharge events CDE human metal model HMM IEC 61000 4 2 and IEC 61000 4 5 Discusses new testing methodologies such as transmission line pulse TLP to very fast transmission line pulse VF TLP and future methods of long pulse TLP to ultra fast TLP UF TLP Describes both conventional testing and new testing techniques for both chip and system level evaluation Addresses EOS testing electromagnetic compatibility EMC scanning to current reconstruction methods Discusses latchup characterization and testing methodologies for evaluation of semiconductor technology to product testing ESD Testing From Components to Systems is part of the authors series of books on electrostatic discharge ESD protection this book will be an invaluable reference for the professional semiconductor chip and system level ESD and EOS test engineer Semiconductor device and process development circuit designers quality reliability and failure analysis engineers will also find it an essential reference In

addition its academic treatment will appeal to both senior and graduate students with interests in semiconductor process device physics semiconductor testing and experimental work

**The ESD Control Program Handbook** Jeremy M. Smallwood, 2020-11-09 Provides the understanding and practical skills needed to develop and maintain an effective ESD control program for manufacturing storage and handling of ESD sensitive components This essential guide to ESD control programs explains the principles and practice of ESD control in an easily accessible way whilst also providing more depth and a wealth of references for those who want to gain a deeper knowledge of the subject It describes static electricity and ESD principles such as triboelectrification electrostatic fields and induced voltages with the minimum of theory or mathematics It is designed for the reader to dip into as required rather than need to read cover to cover The ESD Control Program Handbook begins with definitions and commonly used terminology followed by the principles of static electricity and ESD control Chapter 3 discusses ESD susceptible electronic devices and how ESD susceptibility of a component is measured This is followed by the Seven habits of a highly effective ESD program explaining the essential activities of an effective ESD control program While most texts mainly address manual handling of ESD susceptible devices Chapter 5 extends the discussion to ESD control in automated systems processes and handling which form a major part of modern electronic manufacture Chapter 6 deals with requirements for compliance given by the IEC 61340 5 1 and ANSI ESD S20 20 ESD control standards Chapter 7 gives an overview of the selection use care and maintenance of equipment and furniture commonly used to control ESD risks The chapter explains how these often work together as part of a system and must be specified with that in mind ESD protective packaging is available in an extraordinary range of forms from bags boxes and bubble wrap to tape and reel packaging for automated processes The principles and practice of this widely misunderstood area of ESD control are introduced in Chapter 8 The thorny question of how to evaluate an ESD control program is addressed in Chapter 9 with a goal of compliance with a standard as well as effective control of ESD risks and possible customer perceptions Whilst evaluating an existing ESD control program provides challenges developing an ESD control program from scratch provides others Chapter 10 gives an approach to this Standard test methods used in compliance with ESD control standards are explained and simple test procedures given in Chapter 11 ESD Training has long been recognised as essential in maintaining effective ESD control Chapter 12 discusses ways of covering essential topics and how to demonstrate static electricity in action The book ends with a look at where ESD control may go in the near future The ESD Control Program Handbook Gives readers a sound understanding of the subject to analyze the ESD control requirements of manufacturing processes and develop an effective ESD control program Provides practical knowledge as well as sufficient theory and background to understand the principles of ESD control Teaches how to track and identify how ESD risks arise and how to identify fitting means for minimizing or eliminating them Emphasizes working with modern ESD control program standards IEC 61340 5 1 and ESD S20 20 The ESD Control Program Handbook is an invaluable reference for anyone tasked with

setting up evaluating or maintaining an effective ESD control program training personnel or making ESD control related measurements It would form an excellent basis for a University course on the subject as well as a guide and resource for industry professionals

**Practical ESD Protection Design** Albert Wang,2022-01-06 An authoritative single volume reference on the design and analysis of ESD protection for ICs Electrostatic discharge ESD is a major reliability challenge to semiconductors integrated circuits ICs and microelectronic systems On chip ESD protection is a vital to any electronic products such as smartphones laptops tablets and other electronic devices Practical ESD Protection Design provides comprehensive and systematic guidance on all major aspects of designs of on chip ESD protection for integrated circuits ICs Written for students and practicing engineers alike this one stop resource covers essential theories hands on design skills computer aided design CAD methods characterization and analysis techniques and more on ESD protection designs Detailed chapters examine an array of topics ranging from fundamental to advanced including ESD phenomena ESD failure analysis ESD testing models ESD protection devices and circuits ESD design layout and technology effects ESD design flows and co design methods ESD modelling and CAD techniques and future ESD protection concepts Based on the author s decades of design research and teaching experiences Practical ESD Protection Design Features numerous real world ESD protection design examples Emphasizes on ESD protection design techniques and procedures Describes ESD IC co design methodology for high performance mixed signal ICs and broadband radio frequency RF ICs Discusses CAD based ESD protection design optimization and prediction using both Technology and Electrical Computer Aided Design TCAD ECAD simulation Addresses new ESD CAD algorithms and tools for full chip ESD physical design verification Explores the disruptive future outlook of ESD protection Practical ESD Protection Design is a valuable reference for industrial engineers and academic researchers in the field and an excellent textbook for electronic engineering courses in semiconductor microelectronics and integrated circuit designs

**Electronic cryptographic communications equipment specialist (AFSC 30650).** John M. Hardy,Douglas R. Long,1985

Wireless Sensor Networks Jr., Edgar H. Callaway,2003-08-26 Because they provide practical machine to machine communication at a very low cost the popularity of wireless sensor networks is expected to skyrocket in the next few years duplicating the recent explosion of wireless LANs Wireless Sensor Networks Architectures and Protocols describes how to build these networks from the layers of the

**ESD Basics** Steven H. Voldman,2012-08-22 Electrostatic discharge ESD continues to impact semiconductor manufacturing semiconductor components and systems as technologies scale from micro to nano electronics This book introduces the fundamentals of ESD electrical overstress EOS electromagnetic interference EMI electromagnetic compatibility EMC and latchup as well as provides a coherent overview of the semiconductor manufacturing environment and the final system assembly It provides an illuminating look into the integration of ESD protection networks followed by examples in specific technologies circuits and chips The text is unique in covering semiconductor chip manufacturing issues ESD semiconductor chip design and system problems confronted today as

well as the future of ESD phenomena and nano technology Look inside for extensive coverage on The fundamentals of electrostatics triboelectric charging and how they relate to present day manufacturing environments of micro electronics to nano technology Semiconductor manufacturing handling and auditing processing to avoid ESD failures ESD EOS EMI EMC and latchup semiconductor component and system level testing to demonstrate product resilience from human body model HBM transmission line pulse TLP charged device model CDM human metal model HMM cable discharge events CDE to system level IEC 61000 4 2 tests ESD on chip design and process manufacturing practices and solutions to improve ESD semiconductor chip solutions also practical off chip ESD protection and system level solutions to provide more robust systems System level concerns in servers laptops disk drives cell phones digital cameras hand held devices automobiles and space applications Examples of ESD design for state of the art technologies including CMOS BiCMOS SOI bipolar technology high voltage CMOS HVCMOS RF CMOS smart power magnetic recording technology micro machines MEMs to nano structures ESD Basics From Semiconductor Manufacturing to Product Use complements the author s series of books on ESD protection For those new to the field it is an essential reference and a useful insight into the issues that confront modern technology as we enter the Nano electronic Era

*Electronics Components and Testing: Concepts, Methods, and Applications* Dr. K. Jayakumar, Dr. P. Balakrishnan, 2025-02-24 Electronics Components and Testing Concepts Methods and Applications delves into the critical aspects of electronics that every engineer and technician must understand The book begins with a detailed overview of electronic components such as resistors capacitors diodes and transistors covering their structure function and role in circuits It then moves on to explore various testing techniques used to ensure the performance and integrity of these components including multimeter testing oscilloscope measurements equipment and specialized test The book focuses on the practical application of these concepts showcasing how components interact within larger systems Through a series of case studies and hands on examples the reader gains valuable insight into troubleshooting designing and optimizing electronic devices The book also addresses the latest trends in testing technologies including automated testing and the rise of smart diagnostics Whether you re just starting out in electronics or are looking to update your skills this book is a vital resource for understanding how to effectively select test and apply electronic components in today s fast paced technological landscape

**Spacecraft Electromagnetic Compatibility Technologies** Hua Zhang, Yuting Zhang, Chengbo Huang, Yanxing Yuan, Lili Cheng, 2020-07-27 This book explores key techniques and methods in electromagnetic compatibility management analysis design improvement and test verification for spacecraft The first part introduces the general EMC technology of spacecraft the electromagnetic interference control method and management of electromagnetic compatibility The second part discusses the EMC prediction analysis technique and its application in spacecraft while the third presents the EMC design of spacecraft modules and typical equipment The final two parts address spacecraft magnetic design testing technologies and spacecraft testing technologies The book also covers the program control test process the special power



control unit PCU electric propulsion PIM test and multipaction testing for spacecraft making it a valuable resource for researchers and engineers alike      *Electronics Projects For Dummies* Earl Boysen, Nancy C. Muir, 2011-02-23 These projects are fun to build and fun to use Make lights dance to music play with radio remote control or build your own metal detector Who says the Science Fair has to end If you love building gadgets this book belongs on your radar Here are complete directions for building ten cool creations that involve light sound or vibrations a weird microphone remote control gizmos talking toys and more with full parts and tools lists safety guidelines and wiring schematics Check out ten cool electronics projects including Chapter 8 Surfing the Radio Waves how to make your own radio Chapter 9 Scary Pumpkins crazy Halloween decorations that have sound light and movement Chapter 12 Hitting Paydirt with an Electronic Metal Detector a project that can pay for itself Discover how to Handle electronic components safely Read a circuit diagram Troubleshoot circuits with a multimeter Build light activated gadgets Set up a motion detector Transform electromagnetic waves into sound Companion Web site Go to [www.dummies.com/go/electronicsprojectsfd](http://www.dummies.com/go/electronicsprojectsfd) Explore new projects with other electronics hobbyists Find additional information and project opportunities      **Safety Design for Space Systems** Gary Eugene Musgrave, Axel Larsen, Tommaso Sgobba, 2009-03-27 Progress in space safety lies in the acceptance of safety design and engineering as an integral part of the design and implementation process for new space systems Safety must be seen as the principle design driver of utmost importance from the outset of the design process which is only achieved through a culture change that moves all stakeholders toward front end loaded safety concepts This approach entails a common understanding and mastering of basic principles of safety design for space systems at all levels of the program organisation Fully supported by the International Association for the Advancement of Space Safety IAASS written by the leading figures in the industry with frontline experience from projects ranging from the Apollo missions Skylab the Space Shuttle and the International Space Station this book provides a comprehensive reference for aerospace engineers in industry It addresses each of the key elements that impact on space systems safety including the space environment natural and induced human physiology in space human rating factors emergency capabilities launch propellants and oxidizer systems life support systems battery and fuel cell safety nuclear power generators NPG safety habitat activities fire protection safety critical software development collision avoidance systems design operations and on orbit maintenance The only comprehensive space systems safety reference its must have status within space agencies and suppliers technical and aerospace libraries is practically guaranteed Written by the leading figures in the industry from NASA ESA JAXA et cetera with frontline experience from projects ranging from the Apollo missions Skylab the Space Shuttle small and large satellite systems and the International Space Station Superb quality information for engineers programme managers suppliers and aerospace technologists fully supported by the IAASS International Association for the Advancement of Space Safety      *Electrostatics - Fundamentals and Modern Applications* Dengming Xiao, Su Zhao, 2025-04-30 *Electrostatics Fundamentals and Modern Applications* is a

comprehensive and in depth academic work designed to provide readers with both the theoretical foundations and cutting edge applications of electrostatics This book places a strong emphasis on the modern applications of electrostatics covering cutting edge fields such as nanotechnology micro electro mechanical systems MEMS energy harvesting and biomedical engineering Through rich case studies and practical examples it demonstrates the critical role of electrostatics in driving technological innovation Authored by a team of renowned experts in the field this book combines academic rigor with practical relevance making it an essential resource for undergraduates graduate students researchers and professionals in related disciplines Whether readers aim to solidify their theoretical understanding or explore the latest applications of electrostatics in engineering and technology this book serves as an indispensable reference Published through IntechOpen s open access model Electrostatics Fundamentals and Modern Applications shares the knowledge of electrostatics with a global audience fostering the dissemination of scientific knowledge and innovation Step into the world of electrostatics and uncover the mysteries and limitless possibilities of electric charges

*Manuals Combined: U.S. Navy FIRE CONTROLMAN Volumes 01 - 06 & FIREMAN* , Over 1 600 total pages 14097 FIRE CONTROLMAN SUPERVISOR Covers Fire Controlman supervisor responsibilities organization administration inspections and maintenance supervision and training combat systems subsystems and their maintenance and weapons exercises 14098 FIRE CONTROLMAN VOLUME 01 ADMINISTRATION AND SAFETY Covers general administration technical administration electronics safety and hazardous materials as they pertain to the FC rating 14099A FIRE CONTROLMAN VOLUME 02 FIRE CONTROL SYSTEMS AND RADAR FUNDAMENTALS Covers basic radar systems fire control systems and radar safety as they relate to the Fire Controlman rating 14100 FIRE CONTROLMAN VOLUME 03 DIGITAL DATA SYSTEMS Covers computer and peripheral fundamentals and operations configurations and hardware operator controls and controlling units components and circuits central processing units and buses memories input output and interfacing instructions and man machine interfaces magnetic tape storage magnetic disk storage CD ROM storage printers data conversion devices and switchboards 14101 FIRE CONTROLMAN VOLUME 04 FIRE CONTROL MAINTENANCE CONCEPTS Introduces the Planned Maintenance System and discusses methods for identifying and isolating system faults liquid cooling systems used by Fire Controlmen battery alignment purpose equipment and alignment considerations and radar collimation 14102 FIRE CONTROLMAN VOLUME 05 DISPLAY SYSTEMS AND DEVICES Covers basic display devices and input devices associated with Navy tactical data systems as used by the FC rating 14103 FIRE CONTROLMAN VOLUME 06 DIGITAL COMMUNICATIONS Covers the fundamentals of data communications the Link 11 and Link 4A systems and local area networks 14104A FIREMAN Provides information on the following subject areas engineering administration engineering fundamentals the basic steam cycle gas turbines internal combustion engines ship propulsion pumps valves and piping auxiliary machinery and equipment instruments shipboard electrical equipment and environmental controls

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