

Electrostatic Discharge Simulator

ETS PinPulse™ Model 9910

Operating Manual

Table of Contents

I. IMPORTANT SAFETY INFORMATION AND INSTRUCTIONS	3
II. Description of Components.....	5
III. Set-Up Guide.....	7
IV. Quick Start Guide	8
V. Operating Instructions	10
A. Waveform Verification Procedures	10
B. Device Testing	10
C. Testing Hints.....	15
VI. Calibration, Maintenance, Troubleshooting	16
VII. Warranty.....	16
Appendix A - ESD Testing Background	17
Appendix B - Model 9910 components - Detailed description	21
Appendix C - Waveform Verification – Detailed Procedures	27

I. IMPORTANT SAFETY INFORMATION AND INSTRUCTIONS

The equipment described in this Manual is designed and manufactured to operate according to defined procedures and within defined design limits. Any misuse may result in electric shock, fire, injury, or damage. For safe operation, the following rules must be observed for installation, use, and maintenance. **Read the following safety instructions before operating the instrument.**

POWER

POWER CORD: Use only the power cord specified for this equipment and certified for the country of use. If the power (mains) plug is replaced, follow the wiring connections specified for the country of use. When installing or removing the power plug **hold the plug, not the cord.**

The power cord provided is equipped with a **3-prong grounded plug (a plug with a third grounding pin)**. This is both a safety feature to avoid electrical shock and a requirement for correct equipment operation. If the outlet to be used does not accommodate the 3-prong plug, either change the outlet or use a grounding adapter.

FUSES: The Model 9910 utilizes switching power supplies that operate over the voltage range of 90-260VAC, 50/60Hz. This unit incorporates resettable fuses. To reset, the instrument must be powered down for 10 seconds before turning the power back on.

POWER LINE VOLTAGE (MAINS): If the line (mains) voltage is changed or isolated by an autotransformer the common terminal **must** be connected to the ground (earth) terminal of the power source.

OPERATION **CAUTION!**

THE MODEL 9910 DISCHARGE SIMULATOR IS CAPABLE OF PRODUCING HIGH VOLTAGE OUTPUT PULSES UP TO 8,250 VOLTS AT A STORED ENERGY LEVEL OF ABOUT 75×10^{-4} JOULES. WHEN IT IS NECESSARY TO HANDLE THE DUT OR ANY OF THE OUTPUT INTERCONNECT TEST LEADS, IT IS RECOMMENDED THAT THE HIGH VOLTAGE ON/OFF SWITCH BE PLACED IN THE OFF POSITION. THIS IS INDICATED BY "VOLTAGE OFF" BEING DISPLAYED AND THE RED LED ABOVE THE HV ON/OFF BUTTON TURNED OFF.

DO NOT TOUCH OR COME IN CONTACT WITH THE EQUIPMENT WHILE IN USE. Voltages used in the equipment may cause serious discomfort, injury, or death. ESD testing, by definition, involves hazardous voltage and unenclosed wiring. Power down and discharge all circuitry before contact.

DO NOT OPERATE WITH COVERS OR PANELS REMOVED. Voltages inside the equipment may pose a further threat of serious discomfort, injury, or death.

DO NOT OPERATE IN THE PRESENCE OF A PACEMAKER OR OTHER MEDICAL OR LIFE-SUSTAINING ELECTRONICS. The equipment produces high-voltage discharges which may cause malfunction of nearby electronic circuits.

DO NOT OPERATE WITH SUSPECTED EQUIPMENT FAILURES. If any odor or smoke becomes apparent turn off the equipment and unplug it immediately. Failure to do so may result in electrical shock, fire, explosion, or permanent damage to the equipment. Contact the factory for maintenance instructions.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE: Operating the equipment in the presence of flammable gases or fumes **constitutes a definite safety hazard** and may cause explosion or fire. For equipment designed to operate in such environments the proper safety devices must be used such as dry air or inert gas purge, intrinsically safe barriers and/or explosion-proof enclosures.

DO NOT USE IN ANY MANNER NOT SPECIFIED OR APPROVED BY THE MANUFACTURER: Unapproved use may result in damage to the equipment or present an electrical shock or fire hazard.

II. Description of Components

For a detailed description of all components, see Appendix B.

Included in the standard Model 9910 package are the following:

Item	Qty.	Description
Model 9910 PinPulse system	1	Main control unit. See Figure 2.1
9910 DUT board holder	1	DUT board holder, 30 degree. See Figure 2.1
9910 40-pin DIP DUT adapter	1	PC board with 40-pin ZIF socket. See Figure 2.1
9910 Universal DUT holder	1	PC board with clamp to secure DUT. See Figure 2.2
Programming Pins	50	Gold plated, Red insulated, .025 x 0.30". See Figure 2.3.
9910 Output Cable Set	1	Set of 6 "e-z hook" cables with ferrite cores. See Figures 2.1 and 2.3.
Cable, RS232	1	DB9F-DB9F, 6 ft. length
Cable, AC line	1	USA standard, 6 ft. length, 18 AWG, black

The Model 9910 Electrostatic Discharge Simulator, shown in Figure 2.1, is designed to produce discharge pulses that meet the requirements of the respective HBM, MM and HMM standards to perform required ESD sensitivity testing.

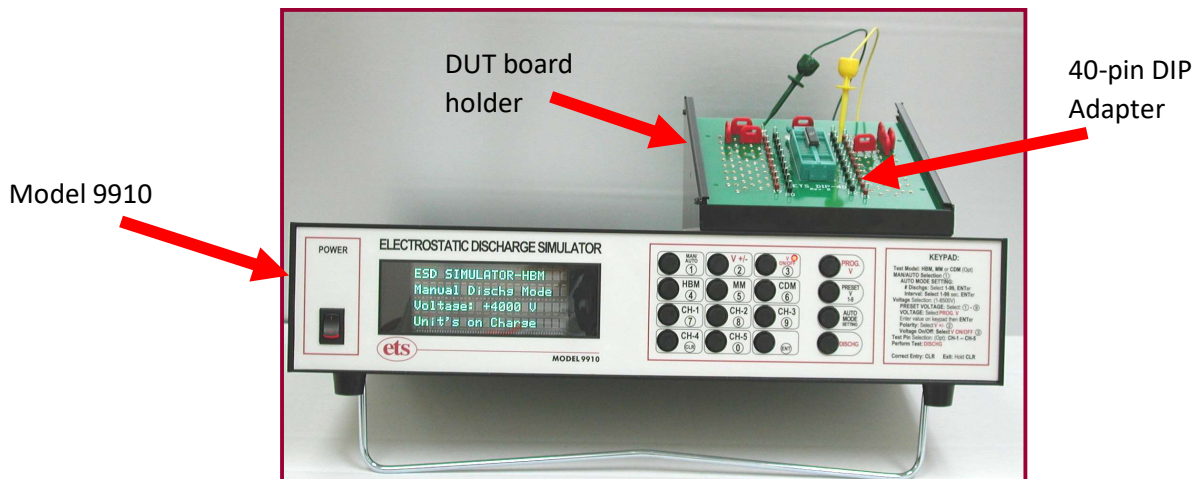


Figure 2.1. Model 9910 PinPulse ESD Simulator

Atop the 9910 enclosure is the ergonomically-designed 30° DUT board holder. This fixture accommodates the 40-pin DIP adapter or the Universal DUT holder.

The Universal DUT Holder secures the device under test so test leads can be connected directly to the appropriate pin pair.



Figure 2.2. Universal DUT Holder

A set of 50 programming pins is provided for the DUT mounting boards.



Figure 2.3. Programming Pins.

A set of dedicated color-coded cables, is included to provide waveforms that meet the specified HBM, HMM and MM requirements.



HBM



HMM



MM

Figure 2.3. Output cables

III. Set-Up Guide



Step 1 – Connect the HV cables to 9910

For HBM testing, select the Red/Black HV cable pair and plug the color-coded banana plugs into the 9910 output panel jacks marked “HBM” and “GND”.



Step 2 – Connect the power cable to 9910

With the front panel power switch OFF, Connect the 3-pin power plug into the connector located on the rear panel.

IV. Quick Start Guide



Step 1 – Verify Setup

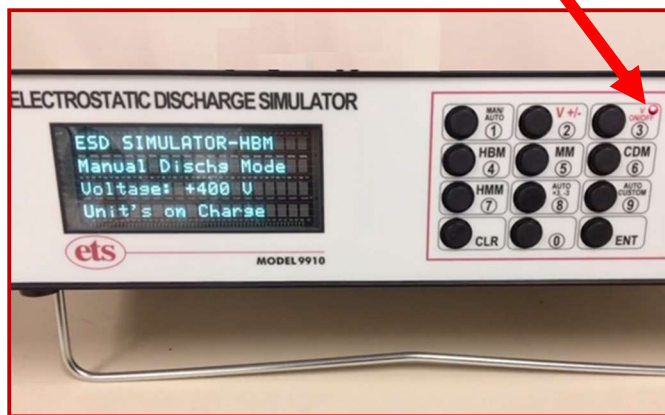
Ensure the AC cable is connected, the HV test cables are plugged in, and the front panel power switch is OFF. Place the “Computer/Keypad” switch in the Keypad position. This switch selection is applied when power is switched ON, and has no effect at other times



Step 2 - Turn On Power

Switch the unit ON using the front panel switch. When the system is initially turned on, it reads the “Computer / Keypad” switch and defaults to the HBM **MAN**ual mode with Voltage **OFF** and the system in the Charge mode.

HV LED



Step 3 – Select Voltage

Depress the **V PROG** or Program Voltage button and key in the desired voltage.

Press the **ENT**er key.

The selected voltage will be displayed and the red LED next to the **V ON/OFF** button will turn on.

To turn the voltage **OFF**, depress the **V ON/OFF** (3) button. Press the key again to turn the voltage back **ON**.

To change polarity, depress the **V +/-** (2) button.



Step 4 - Initiate a Discharge

When the voltage is turned on, the storage capacitor becomes charged.

To initiate a discharge, depress the **DISCHG** key. In the **MAN**ual mode a single discharge will occur with each keystroke. (In the **AUTO** mode, depressing the **DISCHG** key will initiate the discharge/interval sequence programmed.) Each discharge will be counted on the display.

V. Operating Instructions

A. Waveform Verification Procedures

See Appendix C for the detailed procedures for Waveform Verification.

Human Body Model (HBM) – Mil-Std 883E, Method 3015.8, ANSI/ESD/JEDEC JS-001-2010 (formerly ANSI/ESD-STM5.1 & JESD A114B). **SEE SECTION C.1**

These test methods require system calibration utilizing the discharge pulse current waveform. The Human Body Model is $C=100\text{pF}$ and $R=1500\text{ Ohms}$.

Machine Model (MM) – ANSI/ESD-STM5.2, JEDEC 22-A11C. **SEE SECTION C.2**

These standards require system calibration utilizing the discharge pulse waveform obtained from a 200pF capacitor discharged through 0 Ohms to ground. The same oscilloscope and current transducer setup used for HBM verification are used for the MM verification waveforms.

Human Metal Model (HMM) - IEC 61000-4-2. **SEE SECTION C.3**

This international standard is primarily used for evaluating the ESD susceptibility of electronic equipment, and more recently to evaluate the electronic devices themselves. The $150\text{pF}/330\Omega$ contact model simulates a charged person holding a tool such as a screwdriver discharging to an electronic component or system. The discharge waveform shown in Figure 5.0-10 are the requirements specified for contact discharge.

B. Device Testing

Place the system in Keypad Mode:

In keypad mode, the ESD Simulator is controlled by the 16-button keypad shown in Figure 5.1 keypad. (To enter keypad mode, switch the front panel power switch OFF, set the rear panel toggle switch to keypad, and switch power ON.)

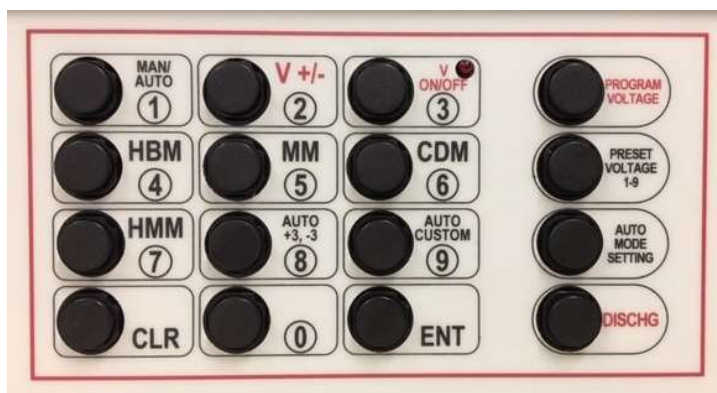


Figure 5.1: Keypad

Turn On the Power

When the system is initially turned on, it defaults to the HBM **MAN**ual discharge mode with **V**oltage **OFF** and the system in the Charge mode.



Figure 5.2. Power up display.

Select the Testing Model

To select **HBM** testing, depress the **HBM** (4) key, then **ENTER**. Make sure that the HBM cable set (**RED & BLACK**) is used and are plugged into the HBM output jack on the Output panel. Otherwise, incorrect waveforms will be obtained. This test is limited to $\pm 8250V$.

To select **MM** testing, depress the **MM** (5) key, then **ENTER**. Make sure that the MM cable set (**YELLOW & GREEN**) is used and are plugged into the MM output jack on the Output panel. Otherwise, a incorrect waveforms will be obtained. This test is limited to $\pm 1000V$.

To select **HMM** testing, depress the **HMM** (6) key, then **ENTER**. Make sure that the HMM cable set (**BLUE & ORANGE**) is used and are plugged into the HMM output jack on the Output panel. Otherwise, a incorrect waveforms will be obtained. This test is limited to $\pm 4250V$.

(CDM Testing is an Optional mode, used with the ETS Model 9903 CDM Test Fixture).

To select **CDM** testing the Model 9903 Charge Device Model Test Fixture must be used and the 9910 configured for this test. Depress the **CDM** (6) key then **ENTER**. This test is limited to $\pm 1000V$.

Select the Voltage

- Depress the **PROG V** button and key in the desired voltage. The maximum voltage will be determined by the discharge Model selected.
- Press the **ENTER** key.
- The selected voltage will be displayed and the red LED next to the **V ON/OFF** button will turn on.

- To turn the voltage **OFF**, depress the **V ON/OFF** (3) key. Press the key again to turn the voltage back **ON**.
- To change polarity, depress the **V +/-** (2) button.

Preset Voltages

The voltage automatically turns on when the **PRESET V** and a preset key from 1-9 is selected. To turn off the voltage depress the **V ON/OFF** (3) key. Press the key again to turn the voltage back on.

The preset voltages are initially set at the factory as follows:

Key	Preset Voltage	Verification V Model
1	100	MM
2	200	MM
3	400	MM
4	800	MM
5	500	HBM, HMM
6	1000	HBM, HMM
7	2000	HBM, HMM
8	4000	HBM, HMM
9	8000	HBM

To change the preset voltage, proceed as follows:

- Depress the **PROG V** button and key in the desired voltage.
- Depress the **PRESET V** then press and hold the desired preset location (key 1-9) for approximately 5 sec.
- Release the key to save the selected voltage.
- To select a preset voltage, depress the **PRESET V (1-9)** key to select the desired preset voltage (keys 1-9).

Initiating a Discharge – Manual Mode

When the voltage is turned on the storage capacitor becomes charged.

To initiate a discharge depress the **DISCHG** key. In the **MAN**ual mode a single discharge will occur with each keystroke. Each discharge will be counted on the display.

Auto Mode

To select the **AUTO** mode, depress the **AUTO/MAN** (1) key. The display will show that the AUTO mode has been selected and defaults to 3 discharges at 1 second interval.

If another sequence is desired, depress the **AUTO MODE SETTING** key. The display will ask “**Number of discharges**”. Key in any number from **1-9** then press **ENTER**.

The display will then ask for “**Interval**”. This is the time in seconds between discharges. Key in the desired number from **1-99** seconds then press **ENTER**.

The display will look similar to the example shown in Figure 3.0-2.

At the end of a discharge sequence, the last discharge will be displayed that corresponds to the number of discharges selected.

To stop the **AUTO** mode sequence, depress the **CLR** button. The display will show “Stop at x”.

Error Correction: To correct an entry, depress the **CLR** button. To clear an entire function, depress and hold the **CLR** button for approximately 5 seconds. The system returns to the default settings.

Initiating a Discharge – Auto Mode

When the voltage is turned on the storage capacitor becomes charged.

To initiate a discharge depress the **DISCHG** key. In the **AUTO** mode, depressing the **DISCHG** key will initiate the discharge/interval sequence programmed. Each discharge will be counted on the display.

Computer Control (User Programming Guide)

The Model 9910 with computer control capability has an embedded microcontroller that is currently capable of RS232 serial communication. In order to fully control ETS equipment using this link, the user **MUST** select the **COMPUTER** mode using the **KEYBOARD/COMPUTER** toggle switch located on the rear panel and then cycle the power. The main **POWER** switch cannot be controlled automatically. The user **MUST** turn the unit on and off manually.

RS232 parameters

Baud rate 9600	1 stop bit
8 data bits	no flow control
even parity	Communication cable: NULL cable (pin 2 to 3; pin 3 to 2)

Character codes:

1. Start code, control-B, ascii STX, hex 02, which is abbreviated below as *****. This character is used to start all messages to ETS devices.
2. **:** (colon). This is the delimiter character used to separate the parts of a command.
3. Command Code, an abbreviation for the function requested, **XXX** (three upper case characters). This denotes a particular command or operation. The 3-character code is created from the description of the command for ease of memorization. For example: **SHB** is the abbreviation for the command **SetHumanBodymodel** to select HBM testing.
4. **,** (comma). A delimiter character used only between a command and its argument.
5. **value** (integer number). This number is the desired numeric value for the entered command.

6. End code, control-I, ascii TAB, hex 09, which is abbreviated below as **HT**. This is the horizontal tab character typed as CTRL-I on a standard computer keyboard. This is a non-printing control character that is used to end all messages to ETS equipment.

Command Structure:

There are two types of commands.

Function Command

***:XXX:HT**

Parameter Command

***:XXX,value:HT**

- Parameter commands must be followed by a comma and an argument.
For example: **SVP** must have a number (such as 10, 2000, etc.), the requested voltage.
- Any valid command received by the 9910 will create the reply "String received. Wait for execution." An invalid command will receive a "?" reply.
- For commands starting with **S** (abbreviation for "Set..."), a valid command will receive a "done" return message after it is executed successfully. An invalid command will receive a "?" return message.
- For a command starting with **G** (abbreviation for "Get..."), the return message will be the value that end user is looking for. An invalid command will receive a "?" return message.
- Replies from the 9910 end with **[CR][LF]**. (Hex [0D][0A], keyboard [CTRL-M][CTRL-J])

List of Commands:

<i>Command name</i>	<i>Syntax</i>	<i>9910 1st Reply</i>	<i>9910 Finished reply</i>
SetVoltageNegative:	*:SVN,value:HT	String received. Wait for execution.	done
SetVoltagePositive:	*:SVP,value:HT	String received. Wait for execution.	done
SetHumanBodymodel:	*:SHB:HT	String received. Wait for execution.	done
SetHumanMetalmodel:	*:SHM:HT	String received. Wait for execution.	done
SetMachineModel:	*:SMM:HT	String received. Wait for execution.	done
SetDisCharge:	*:SDC:HT	String received. Wait for execution.	done
GetVolTage:	*:GVT:HT	String received. Wait for execution.	XXXX
GetModel:	*:GML:HT	String received. Wait for execution.	HBM/HMM/MM

A special command implements the IEEE identification scheme:

Identify Command: ***IDN HT** String received. Wait for execution. **ETS,9910,<software version>**

Examples:

1. To set voltage to +1000V, send string [***:SVP,1000:HT**]
2. To set voltage to -1000V, send string [***:SVN,1000:HT**]
3. To select HBM, send string [***:SHB:HT**]
4. To select HMM, send string [***:SHM:HT**]
5. To select MM, send string [***:SMM:HT**]
6. To discharge, send string [***:SDC:HT**]
7. To get current voltage setting, send string [***:GVT:HT**]
8. To get current model, send string [***:GML:HT**]

Notes:

Any valid command string will receive the reply “String received. Wait for execution.”

An invalid string will receive a “?” almost immediately.

After task is completed, the reply “done” is sent by the 9910.

If using Hyper Terminal, type ^I for the tab character.

It can take up to 5 seconds to switch polarities.

C. Testing Hints

Testing requirements are often specified in terms of levels. The recommended stress levels are slightly different between the JEDEC and ANSI/ESD specifications as listed in the table below.

Level	JESD Level V	ANSI/ESD Level V
1	100	125
2	200	250
3	500	500
4	1000	1000
5	2000	1500
6	-	2000

VI. Calibration, Maintenance, Troubleshooting

The Model 9910 Electrostatic Discharge Simulator, like all precision electronic instruments, should be returned to the factory once a year for calibration.

There is no user maintenance or adjustment required. Always handle the HV output connection cables with care. If the instrument needs to be moved, provide padding and protection to avoid applying any shock to the unit.

If a waveform problem is found, re-check that the HV output cables are securely plugged into the correct receptacles and the clips are clean and making proper contact with the test fixture.

If using the Keypad/Computer switch, remember to power cycle the unit after setting the switch.

If the 9910 reports difficulty in charging to a voltage, contact the factory for assistance.

VII. Warranty

Limited Warranties. Seller warrants that all goods manufactured and delivered hereunder shall (a) conform to any samples, drawings, specifications or other written documents provided to Seller by Buyer, or approved by Buyer to Seller and (b) be free from all defects in workmanship and material. Buyer's sole remedy against Seller for breach of either of the specifically mentioned warranty shall be the repair or replacement, at Seller's sole option, of the defective workmanship or material. Seller expressly disclaims all other warranties, express and/or implied, including but not limited to those of merchantability and fitness for a particular purpose. In no event shall Seller be liable, under either warranty or otherwise, to Buyer in excess of the purchase price of the products paid to Seller by Buyer. In no event shall Seller be liable for any loss or damage arising directly or indirectly from the use of the product or for consequential or incidental damages. Seller's specified warranties will expire and lapse (i) for renewable items (such as gloves, iris ports and desiccants), sixty (60) days from date of shipment and (ii) for all standard equipment and otherwise nonrenewable items, one year from date of shipment.

Appendix A - ESD Testing Background

The rapid advancement in the electronics industry during recent decades has placed increasing importance on the understanding of electrostatics and its effect on electronic devices and systems. Electrostatic discharge (ESD) is a common cause of microelectronic circuit failure. Many devices can be seriously damaged or destroyed by an electrostatic discharge below 20 Volts. The sensitivity to ESD of other components has also become evident through use, testing and failure analysis. The trend in technology towards greater complexity and increased packaging density, hence thinner dielectrics between active elements results in parts becoming ever more sensitive to ESD.

Failure mechanisms of electrical and electronic parts due to ESD typically include thermal breakdown, metallization melt and bulk breakdown that are power dependent; dielectric breakdown, metallization to metallization arc over, surface breakdown and surface inversion that are voltage dependent.

ESD can also induce latent failure mechanisms in both MOS structures and bipolar junctions in both discrete devices and microcircuits. This latent failure mechanism results in performance degradation and eventually a failure.

Personnel are prime sources of ESD for damaging electrical and electronic parts. Electrostatic charges generated by rubbing or separating materials are readily transmitted to a person's conductive sweat layer charging that person. When a person handles or comes in close proximity to an ESD sensitive part, that part can then be damaged from a direct discharge by touching the part or by subjecting the part to an electrostatic field. The ESD from a human body can be reasonably simulated for test purposes from the circuit shown in Figure A.1.

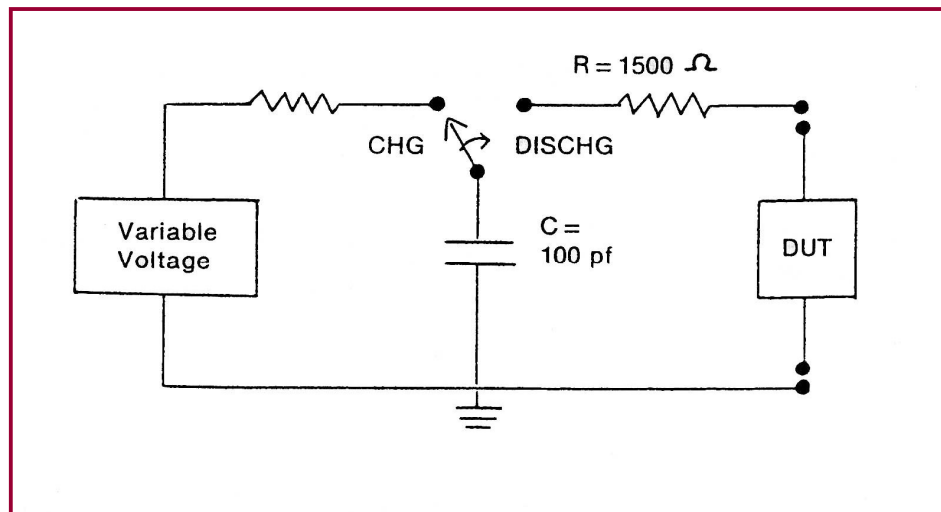


Figure A.1: Basic Human Body Model equivalent circuit

This circuit is specified in Mil-Std-883H, Method 3015.8 and *ANSI/ESDA/JEDEC JS-001-2010* (formally ANSI/ESD-STM 5.1 and JEDEC TEST METHOD A114.A) to represent a human body discharge for ESD testing. The human body capacitance may be as high as several hundred picofarads, but more typically, ranges between 60 to 500pF. Studies have shown that approximately 80% of the population that was tested has a capacitance of 100pF or less. The variation in human capacitance is due to factors such as the amount and type of clothing and footwear worn by personnel and differences in floor materials.

Human body resistances can range from 100 to 100,000 Ohms, but is typically between 500 and 5,000 Ohms for actions that are considered pertinent to holding or touching ESD sensitive parts or containers of ESD sensitive parts. The variation in human body resistance is due to factors such as the amount of moisture, salt and oils at the surface, contact area and pressure of the skin. A value of 1,500 Ohms provides a reasonable lower human body resistance value. In view of the above, Mil-Std-883H specifies a Human Body Model (HBM) using 100pF discharged through 1,500 Ohms.

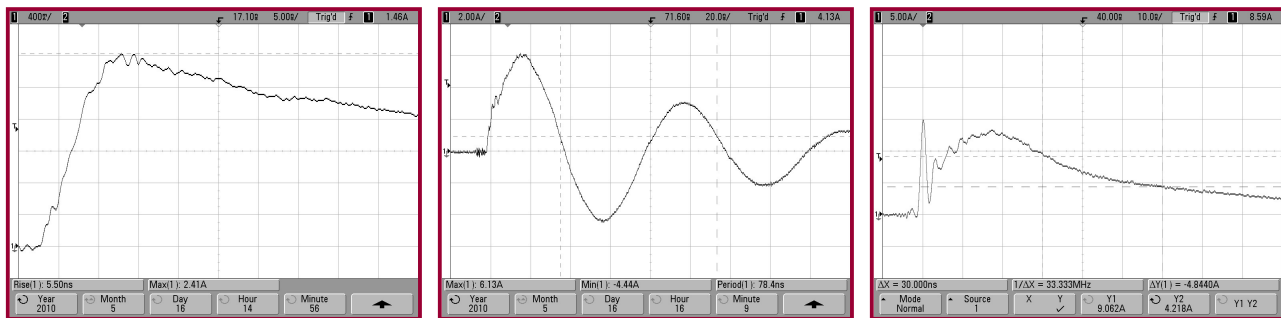
For power sensitive parts, a change to a worst case Human Body Model capacitance (i.e., greater than 100pF) could result in damage to ESD sensitive parts at voltage levels below those shown in Mil-Std-883H, Appendix 1. Therefore, a component that has been classified as non-ESD sensitive could actually become ESD sensitive under more stringent Human Body Model conditions. For voltage sensitive ESD parts, a variation in the capacitance value in the test circuit generally will not affect ESD sensitivity. However, a decrease in Human Body Model resistance will increase the voltage and power delivered to the part that could adversely affect voltage and power sensitive ESD sensitive parts at lower HBM voltage levels. The Human Body Model specified is considered a reasonable test circuit for evaluating the sensitivity of ESD sensitive parts because personnel are generally the most common source of damaging ESD.

The Model 9910 Electrostatic Discharge Simulator is an instrument specifically designed to simulate the electrostatic discharge produced by human handling and meets all of the testing requirements specified in Mil-Std-883H, Method 3015.8, *ANSI/ESDA/JEDEC JS-001-2010*, and other specifications based on the Mil-Std-883H model.

The Machine Model (MM) as defined in ANSI/ESD-STM 5.2 and JEDEC 22-A11C is “An electrostatic discharge simulation test based on a discharge network consisting of a charged 200 picofarad capacitor and (nominally) 0 (zero) Ohms of series resistance. Actual series resistance and inductance are specified in terms of the current waveform through a shorting wire. The simulation test approximates the electrostatic discharge from a machine.” The Machine Model network is standard with the Model 9910.

Another model commonly used is the Hand/Tool model also referred to as the Human Metal Model (HMM) that is specified in IEC 61000-4-2. This model simulates a person holding a tool when discharging to a device. It is typically used for system ESD testing, but is now also being

used to evaluate components and devices. The standard model is 150pF/330Ω, but other models such as 150pF/150 and 150pf/2000Ω are also specified. The Model 9910 incorporates the 150pF/330Ω model as standard. The other models are available as options.



Human Body Model (HBM)
(100pF/1,500Ω)

Machine Model (MM)
(200pF/0Ω)

Human Metal Model (HMM)
(150pF/330Ω)

Figure A.2: Typical HBM, MM and HMM waveforms

However, another type of discharge that is far more severe than the discharge from a person touching a device is the Charge Device Model (CDM). This occurs when the device itself becomes charged then touches ground resulting in a very fast rise time discharge.

The Charged Device Model (CDM) as defined in ANSI/ESD-STN 5.3, JEDS22-C101C and AEC-Q101-005 is when a component is slowly charged to a given voltage and then discharged to ground through one or more leads of the device. The Model 9903 Charge Device Model Test Fixture that connects to the Model 9910 is available as an option.

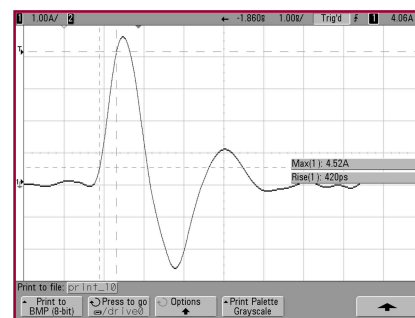
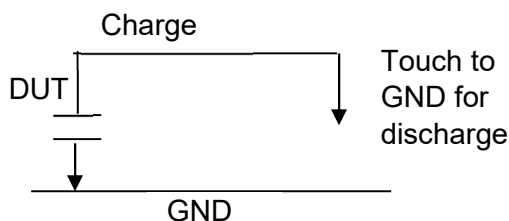


Figure A.3: Basic Charge Device Model equivalent circuit

Available as an optional accessory, the Model 9902 Remote Discharge Probe shown in Figure A.4 can be used as a handheld device or with the addition of remote cables, be attached to an automatic test system. The Probe operates only in the LO Range (up to 1000V) for the HBM and MM models.



Figure A.4: ETS Model 9902 Remote Discharge Probe

Appendix B - Model 9910 components - Detailed description

The Model 9910 Electrostatic Discharge Simulator, shown in Figure B.1, is designed to produce discharge pulses that meet the requirements of the respective HBM, MM and HMM standards to perform required ESD sensitivity testing. It also provides the necessary control and charging voltages to perform the optional CDM testing. The charging voltage may be set to any level from ± 5 to 8250V for HBM, ± 5 to 4250 for HMM and ± 5 to 1,000V for MM and CDM using the front panel keypad or by remote computer control. Resolution is 1 Volt. A 4-line vacuum fluorescent display indicates the charging voltage level and polarity prior to discharge.

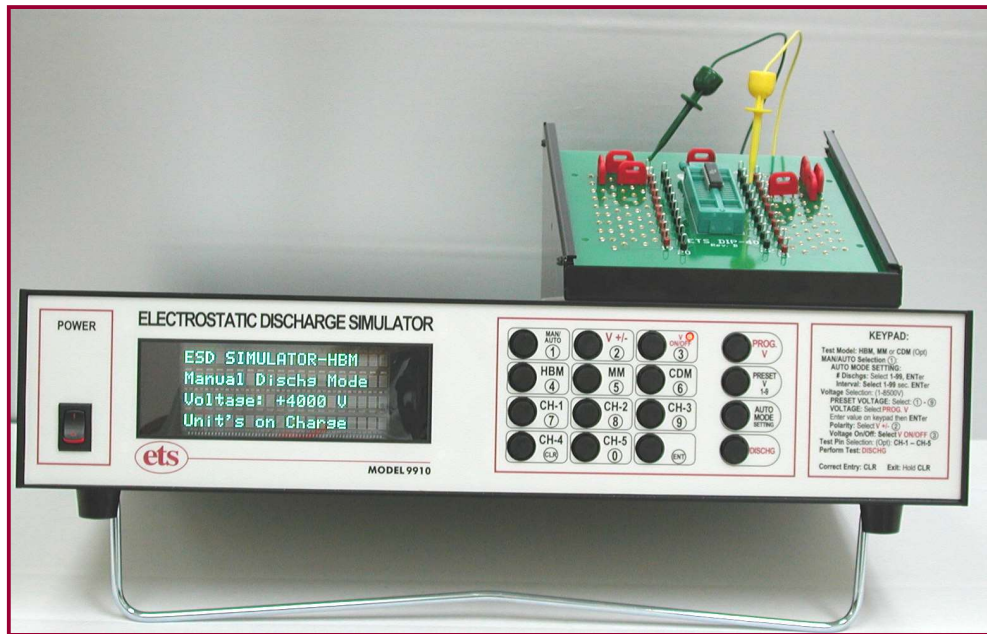


Figure B.1: Model 9910 ESD Simulator

Device testing may be performed either manually or automatically. In the Manual mode, the user initiates each discharge pulse. In the Automatic mode, the user selects the number of discharge pulses desired (1-9) and the time interval between pulses (1-99 sec in 1.0 sec increments). When the DISCHG (Discharge) button is pushed the correct number of discharge pulses is produced and the count displayed. A CLR (clear) button halts the test sequence in the Automatic mode.

The front panel displays the mode selected, the status of the charging voltage, (voltage level and polarity or OFF) of the high voltage power supply, the charge/discharge state of the unit, the number of discharge pulses programmed and the number produced in the Automatic mode and the interval selected.

FRONT PANEL

The Front Panel shown in Figure 2.0-4 consists of a 16-button keyboard with soft touch keys, a 4-line vacuum fluorescent display and a system power ON/OFF switch.



Figure B.2: Front panel

The front panel displays the mode selected, the status of the charging voltage, (voltage level and polarity or OFF) of the high voltage power supply, the charge/discharge state of the unit, the number of discharge pulses programmed, the number produced in the Automatic mode, and the interval selected.

As an example, the display shown in Figure B.2 shows the Model 9910 set for **HBM** testing, the DUT pin connected to Channel 1 (standard connection for the Model 9910.) at a voltage of +2000V in the Auto mode with 3 discharges at 1 second intervals. When a discharge occurs, the “Charge” changes to “Discharge 1 then 2 then 3 etc. At the conclusion of the sequence, the display remains at the last discharge initiated.

The keypad controls all the following Model 9910 operating functions:

1. Select HBM, MM, CDM, or HMM testing.
2. Select Manual or Auto modes;
3. Select # discharges (1-9) and Interval (1-99 sec).
4. Select Program voltage with $\pm 1V$ resolution

NOTE: Voltage levels provided are: ± 5 to 8250V for HBM; ± 5 to 4250V for HMM; ± 5 to $\pm 1,000V$ for MM and CDM (opt).

5. Select up to 9 user programmed voltage settings
6. Initiate discharge sequence.

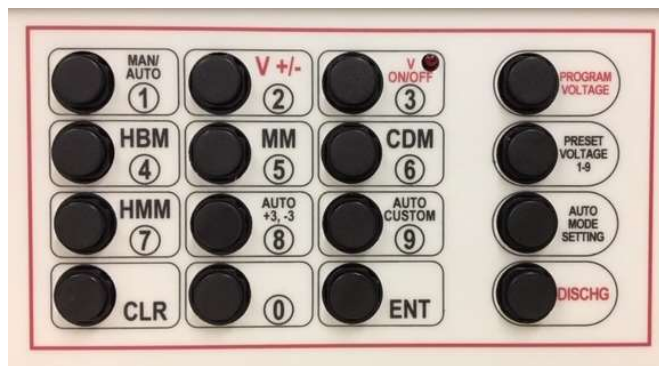


Figure B.3. Keypad

REAR PANEL

The Rear Panel shown in Figure 2.0-5 consists of the following: IEC Power connector (Unit utilizes universal power supplies that operate from 90-260VAC, 50/60Hz with internal fuse that can be reset by powering down the system for 20 seconds. The **SYSTEM CONTROL** consists of the **KEYPAD/COMPUTER** selector switch for selecting keypad or computer control and 9-Pin Sub-D, RS232 serial communications port for connection to a computer. A 3-Pin DIN connector provides the 5V required for operating the CDM Test Fixture and the Model 9902 Remote Probe. Also included is a 0.080" jack to access the 5-1,000V for the CDM and Remote Probe options when either of these options is ordered.



Figure 2.0-5: Rear Panel (standard configuration)

OUTPUT PANEL

The output panel shown in Figure 2.0-6 is located at the right rear corner of the top cover and contains the HBM, HMM, GND and Curve Tracer outputs.



Figure 2.0-6: Output panel

OUTPUT CABLES

The HBM, HMM and MM networks each have a dedicated output and require dedicated color-coded cables, shown in Figure 2.0-7 to provide waveforms that meet the specified HBM, HMM and MM requirements.



HBM



HMM



MM

Figure 2.0-7: Output cables

DUT HOLDING FIXTURE

Adapter modules are available for holding a wide variety of devices and providing for their connection to the OUTPUT terminals of the ESD Simulator. Standard with the Model 9910 is a universal holding fixture that retains the device under test (DUT) so the test leads can be connected directly to the appropriate pin pair as shown in Figure 2.0-2..

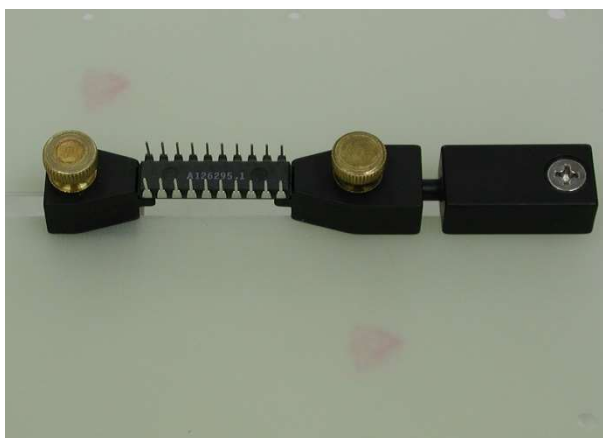


Figure 2.0-2: Standard universal DUT holding fixture

DIP DUT TEST FIXTURE

Standard test fixtures with zero insertion force test sockets for DIP and SOIC type packages, shown in Figure 2.0-3, are also available from ETS as accessories. Connected to each pin on the PC board is a loop connector for easy attachment of minigrabber test leads. The board slides into the frame as shown in Figure 2.0-8. Pin 1 is white. All other pins are alternating red and black.

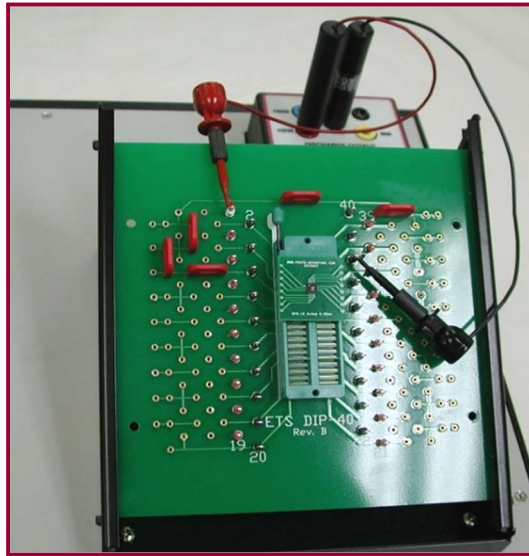


Figure 2.0-8: 40-Pin DIP DUT Board with programming pins

The ETS test fixtures feature specially designed insulated gold plated programming pins for tying groups of pins together as required in many specifications.



Figure Programming pins

Adapter modules and fixtures are available for holding a wide variety of devices and providing for their connection to the OUTPUT terminals of the ESD Simulator. Custom fixtures may be designed by ETS or the user for special applications, including test fixtures with solder areas or zero insertion force test sockets for DIP and SOIC type packages.

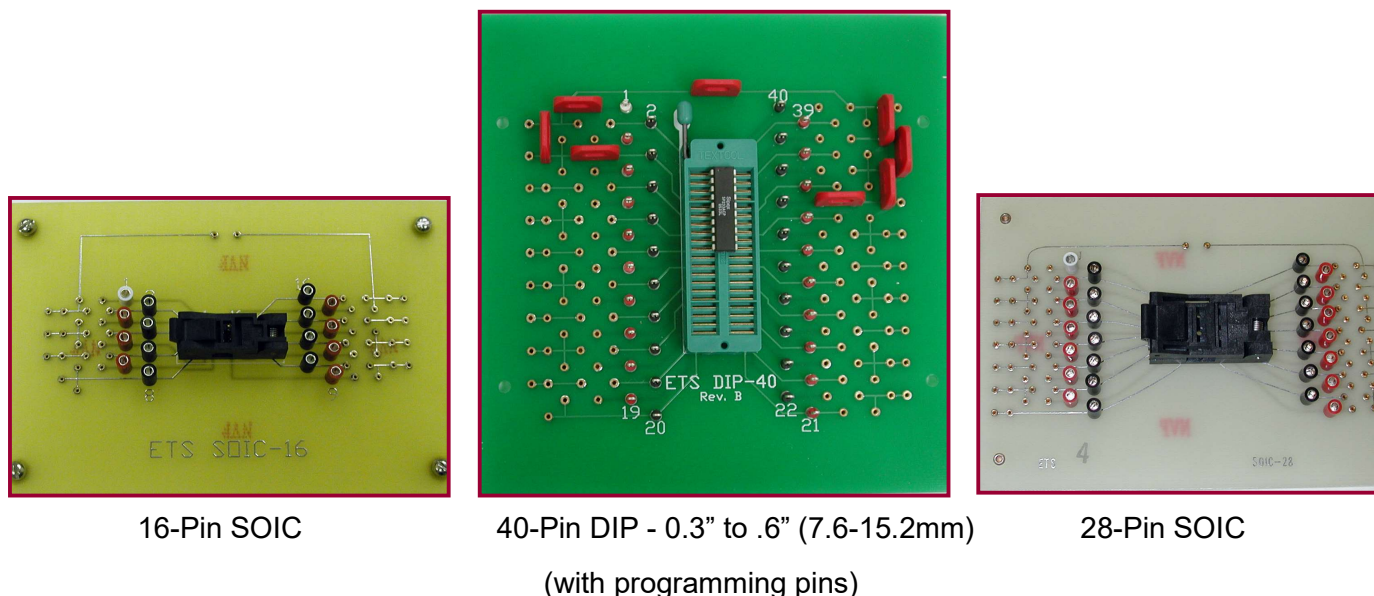


Figure 2.0-4: Socketed DUT test fixtures

There are many surface mount devices that are either too small or are unique in their configuration making them incompatible with available sockets. Adapter boards are commercially available that convert SMT packages to DIP devices. (One such source is Proto-Advantage (<http://www.proto-advantage.com>)). Figure 2.0-3 illustrates such adapters along with availability of other stock units.

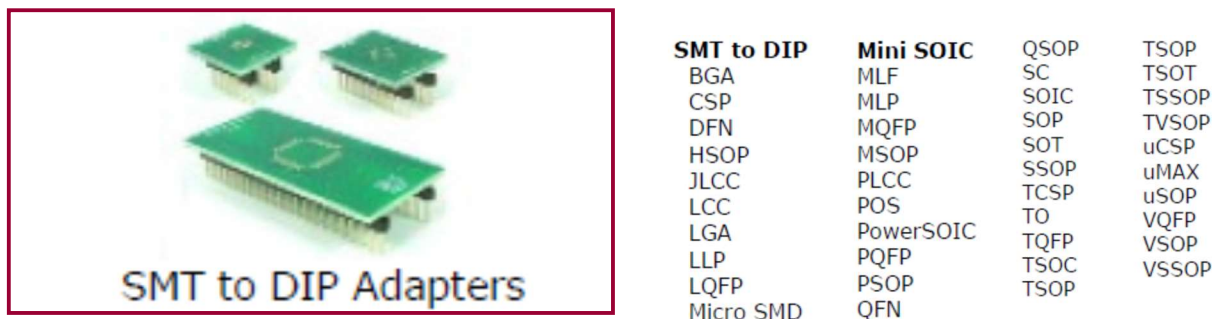


Figure 2.0-3: Example SMT-DIP adapters

Appendix C - Waveform Verification – Detailed Procedures

C.1 Human Body Model (HBM) – Mil-Std 883E, Method 3015.8, ANSI/ESD/JEDEC JS-001-2010 (formerly ANSI/ESD-STM5.1 & JESD A114B).

These test methods require system calibration utilizing the discharge pulse current waveform. The Human Body Model is $C=100\text{pF}$ and $R=1500\text{ Ohms}$.

The waveform must be verified using both + and –4kV charging voltages. Other voltage levels such as 500, 1000 & 2000V may also be required. Refer to the specific standard being referenced. The discharge current must be within $\pm 10\%$ of the specified I_p value (2.67 Amps).

Photographs of the rise time, fall time, and peak current calibration are required. Figure 4.0-1 shows the waveform requirements specified in Method 3015.7 and ANSI/ESD/JEDEC JS-001-2010.

HBM TEST LEADS (RED & BLACK) MUST BE USED TO OBTAIN THE CORRECT WAVEFORM.

Set-Up

A high speed oscilloscope and current probe with a bandwidth of at least 350 MHz and a visual writing speed 4 cm/nsec minimum are required. Scopes satisfactory for this measurement are the Tektronix Model 2467 high-speed analog oscilloscope, or digital storage oscilloscopes (DSO) having a minimum frequency response of 350 MHz and a sampling rate at least 1 Gs/sec or better. Tektronix TDS 300 and 3000 series, Agilent Technologies Model DSO6102A or any other oscilloscope that meet these criteria are satisfactory. If CDM testing is also to be performed then a 1GHz scope with at least 4Gs/sec sampling rate must be used to perform all three tests. Tektronix Models CT-1 or CT-2 current transducers are satisfactory for detecting the current pulse.

The 50 Ohm impedance of the current probe must be matched to the input impedance of the oscilloscope. For oscilloscopes with only a 1 MegOhm input impedance, a terminator is available to match the 50 Ohm impedance of the probe to the 1 MegOhm impedance of the scope. Because of the very high frequencies being measured, it may be necessary to double shield the current probe.

Figure 5.0-1 is the short-to-ground current waveform requirement.

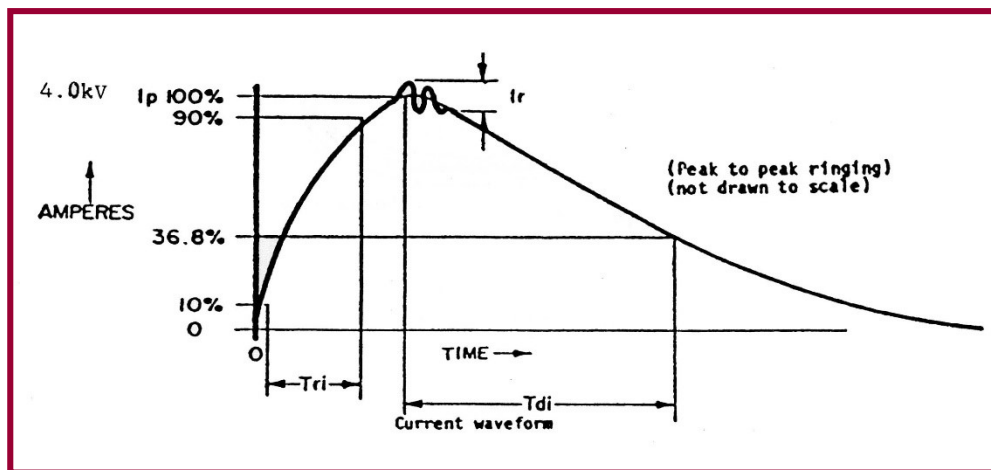


Figure 5.0-1: Current Waveform per Method 3015.8

The current pulse shall have the following characteristics:

T_r (rise time)	2-10 nanoseconds
T_d (decay time)	150 ± 20 nanoseconds
I_p (peak current)	within $\pm 10\%$
I_r (ringing)	The decay shall be smooth, with ringing, break points, double time constants or discontinuities less than 15%, of I_p maximum, but not observable 100 nanoseconds after the start of the pulse

To obtain this waveform place a 1.25" (31mm), 18 gauge wire through the CT-1 sensor then connect the minigrabber leads to the wire. The current probe (Tektronix CT-1) is polarized and is marked with a + on one side. When verifying a positive discharge pulse, the OUTPUT signal from the 1.5k Ω resistor should be connected to this side (+). When verifying a negative discharge pulse, the GND connection should be connected to this side (+). No changes in scope setting are necessary.

Verification Measurement Procedure

Peak Current, Rise Time and Ringing at 4kV through a short: Set the scope vertical amplifier sensitivity to 2 Volts/Div and the time base to 5 nsec/Div. If the CT-1 probe is used then the total current measurement range is 3.2 Amps (CT-1 Probe calibration is 5 Volts/Amp). Probes with different calibration will necessitate using different scope vertical amplifier settings. At a charging voltage of 4kV, the peak current, I_p , must be 2.67 amps $\pm 10\%$ (2.40-2.93 Amps). If using the Tektronix Model 2067 analog scope, switch the vertical amplifier out of the CAL position and adjust the vernier such that a discharge pulse will go from the "0" graticule marking to the "100" graticule marking as shown in Figure 4.04. The rise time is defined as the time for the leading edge to rise from the 10% point to the 90% point. The specification calls for

a rise time between 2 and 10 nsec. For the Model 9910 ESD Simulator the rise time will normally fall between 2.5 and 8 nsec. The peak-to-peak ringing must be less than 15% of I_p .

If using a digital scope all the calculations are performed by the scope and displayed on the screen and printout as shown in Figure 5.0-4.

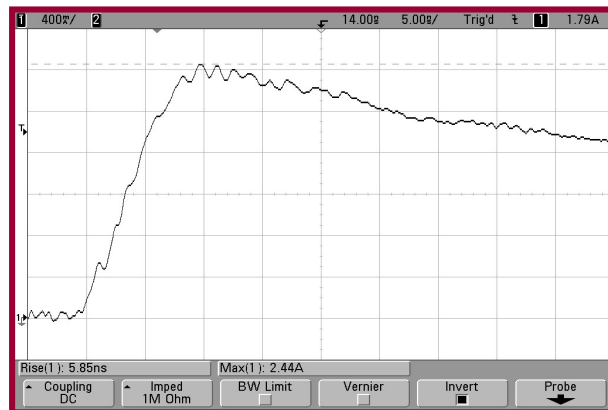


Figure 5.0-4: Model 9910 Rise Time and Ringing Waveform at 4kV

Fall Time at 4kV

Set the scope vertical amplifier sensitivity 2 Volts/Div, the same setting as was done for the rise time measurement. Change the time base to 50 nsec/Div. The discharge pulse should resemble that shown in Figure 5.0-5. The fall time (decay time) must be 150 ± 20 nsec from the 100% point to the 37% point.

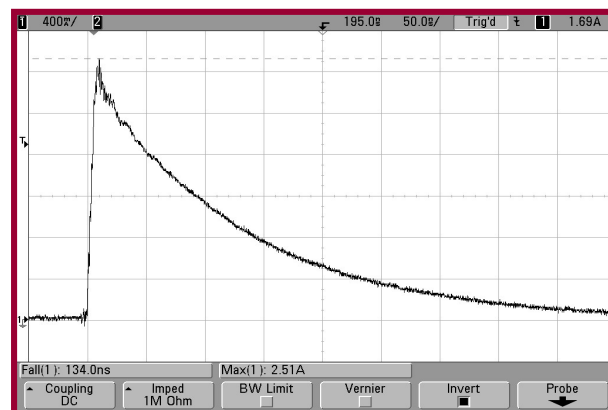


Figure 5.0-5: Model 9910 Discharge Pulse Fall Time Measurement at 4kV

Peak Current, Rise Time and Ringing at 4kV through a 500 Ohm resistor:

ANSI/ESD/JEDEC JS-001-2010 also requires an additional calibration waveform using a 500Ω resistor to ground only during instrument qualification. The waveform parameters are shown in Figure 5.0-6 and the actual waveform from the Model 9910 is shown in Figure 5.0-7.

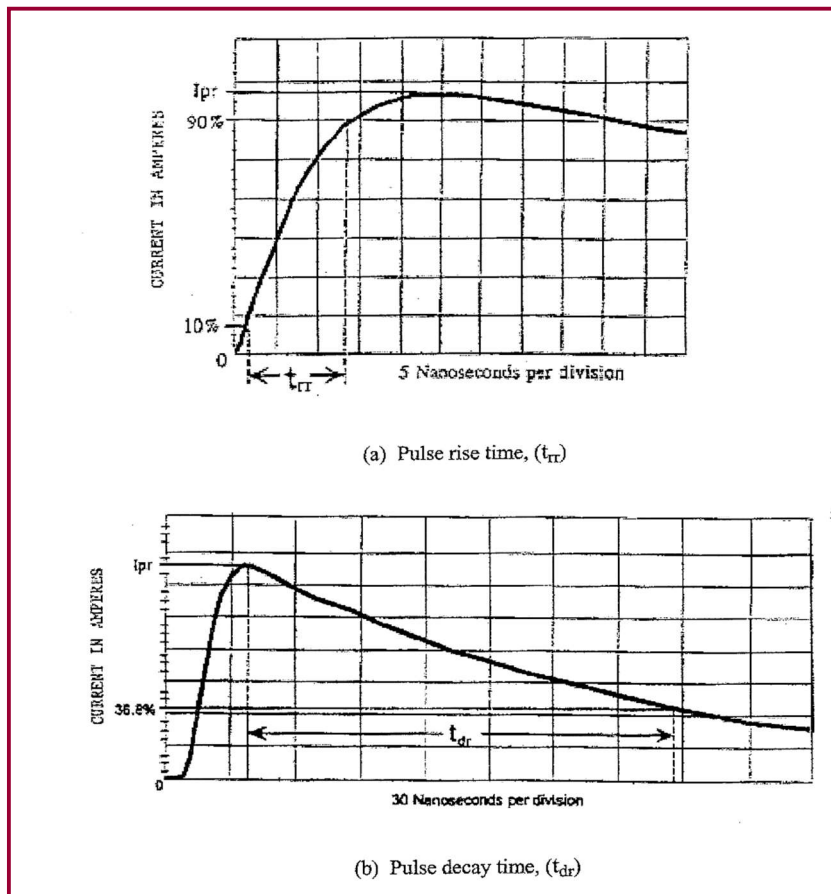


Figure 5.0-6: Current waveform through a 500 Ohm resistor

Other standards also reference Method 3015.8 and/or ANSI/ESD-STM5.1. The specific standard to which testing will be performed should be referred to for the correct calibration of the Model 9910 ESD Simulator.



Figure 5.0-7: Current waveform through a 500 Ohm resistor at 4000V

Waveform Parameters*

Voltage Level (V)	I _{peak} for Short, 1/I _{ps} (A)	I _{peak} for 500 Ohm* I _{pr} (A)	Rise Time for Short, t _r (ns)	Rise Time for 500 Ohm* t _{rr} (ns)	Decay Time for Short, t _d (ns)	Ringling Current I _r (A)
250	0.15-0.19	N/A	2.0-10	N/A	130-170	15% of I _{ps}
500	0.30-0.37	N/A	2.0-10	N/A	130-170	15% of I _{ps}
1000	0.60-0.74	0.37-0.55	2.0-10	5.0-25	130-170	15% of I _{ps}
2000	1.20-1.48	N/A	2.0-10	N/A	130-170	15% of I _{ps}
4000	2.40-2.96	1.5-2.2	2.0-10	5.0-25	130-170	15% of I _{ps} and I _{pr}
8000 (optional)	4.80-5.86	N/A	2.0-10	N/A	130-170	15% of I _{ps}

*From ANSI/ESD/JEDEC JS-001-2010

Additional Information

The measurement of the current waveform can be significantly affected by the test instrument used. Excessive ringing and poor waveform characteristics could be a result of an incorrect test set-up or an oscilloscope that is not adequately shielded.

The Model 9910 incorporates a curve tracer output. The **CURVE TRACER** output connector is connected to the output side of the discharge relay when in the **CHARGE** mode and is disconnected from this point during the **DISCHARGE** cycle. This switching function is accomplished by a high voltage relay. This relay is connected to the discharge relay output. Between this point and the DUT 1500 Ω , 3000 Ω (1500 from the low and high voltage relays) for the HBM, HMM and MM are connected in series with the **Curve Tracer** output.

C.2 Machine Model (MM) – ANSI/ESD-STM5.2, JEDEC 22-A11C

These standards require system calibration utilizing the discharge pulse waveform obtained from a 200pF capacitor discharged through 0 Ohms to ground. The same oscilloscope and current transducer setup used for HBM verification are used for the MM verification waveforms.

The waveform must be verified using both + and -400 Volts through both a short circuit to ground and through a 500 Ohm resistor. Other stress levels of 100, 200 and 800 Volts may be performed using only the discharge through a short to ground.

Figure 5.0-7 shows the waveform requirements for the discharge through a short to ground at 400 Volts and Figure 5.0-8 shows the waveform requirements through the 500 Ohm resistor to ground.

The MM testing can be performed over the range of 5-1,000V.

MM LEADS (YELLOW & GREEN) MUST BE USED TO OBTAIN THE CORRECT MM WAVEFORM.

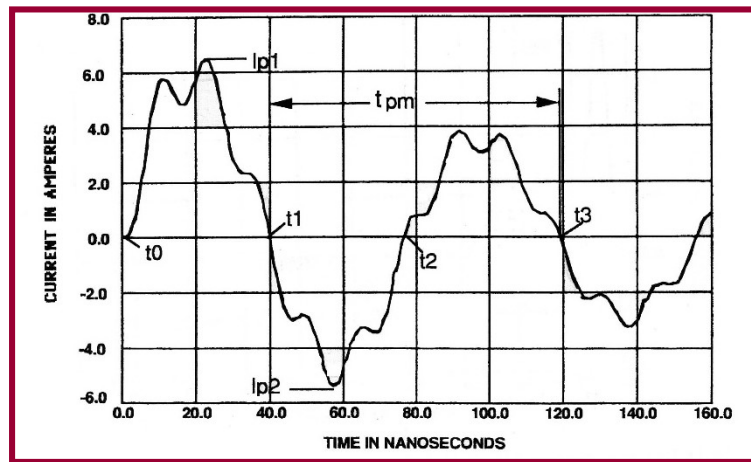


Figure 5.0-7: Current waveform through a short to ground

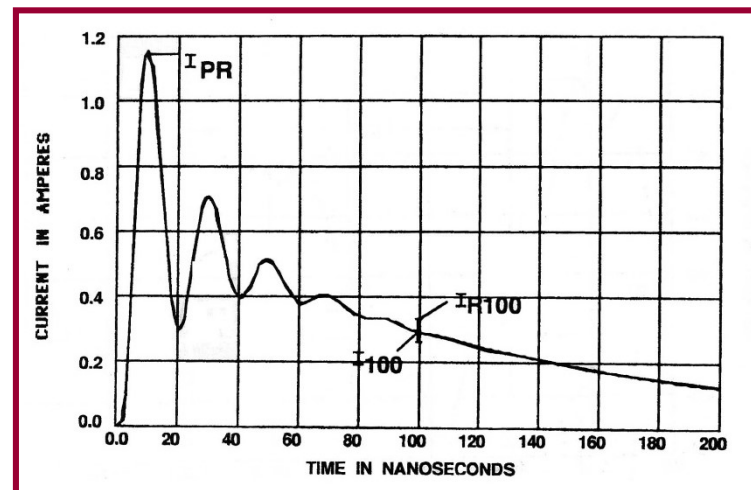


Figure 5.0-8: Current waveform through a 500 Ohm resistor to ground



a. Short to Ground

b. Through 500 Ohm Resistor

Figure 5.0-9: Actual Model 9910 MM waveforms at 400V

C.3 Human Metal Model (HMM), IEC 61000-4-2

This international standard is primarily used for evaluating the ESD susceptibility of electronic equipment. However, it is now being used to evaluate the electronic devices themselves. The 150pF/330 Ω contact model simulates a charged person holding a tool such as a screwdriver discharging to an electronic component or system. The discharge waveform shown in Figure 5.0-10 are the requirements specified for contact discharge.

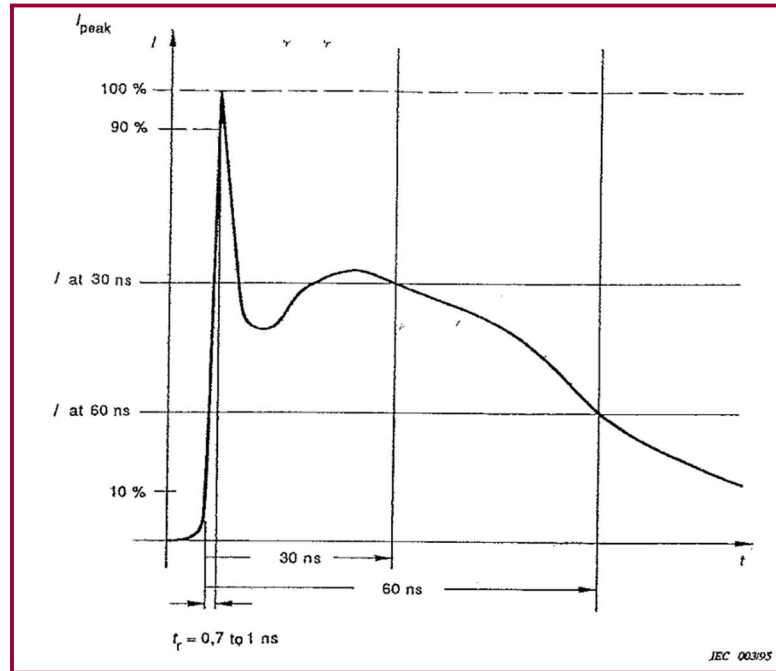


Figure 5.0-10: IEC 61000-4-2 waveform parameters



Figure 5.0-11: Actual Model 9910 HMM waveform at 4000V.

	Indicated Voltage kV	First peak current of discharge $\pm 10\%$	Rise Time t_r with discharge switch nsec	Current at 30 nsec	Current at 60 nsec
1	2	7.5	0.7-1	4	2
2	4	15	0.7-1	8	4
3	6	22.5	0.7-1	12	6
4	8	30	0.7-1	16	8

HMM testing can be performed up to 4250V.

HMM LEADS (BLUE & ORANGE) MUST BE USED TO OBTAIN THE CORRECT HMM WAVEFORM.