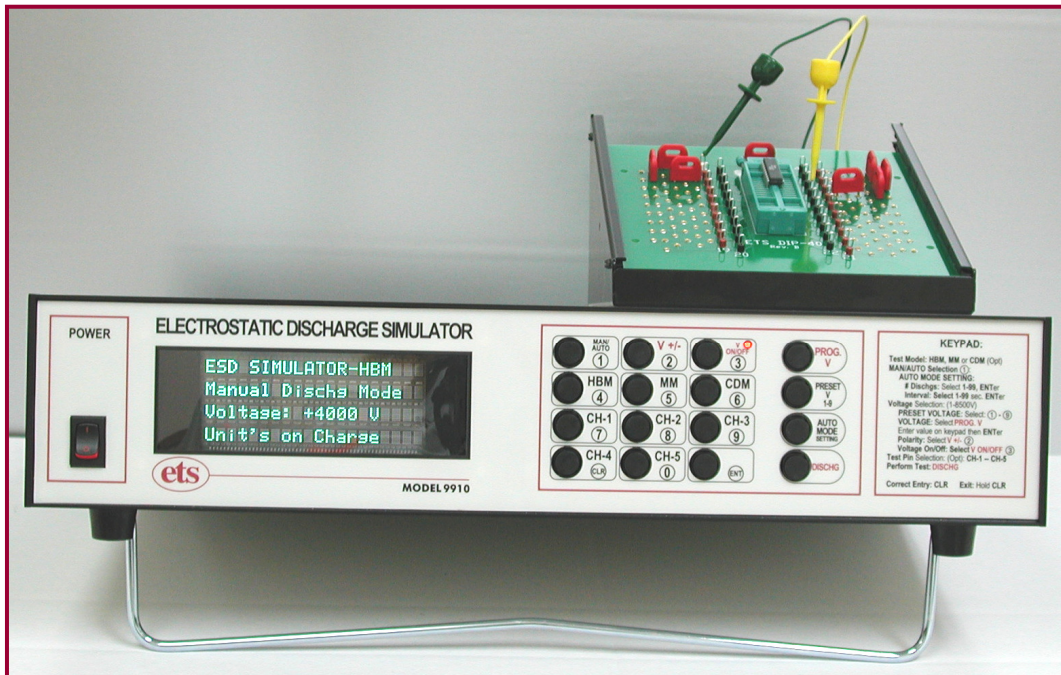


# ELECTROSTATIC DISCHARGE SIMULATOR

## Model 9910



## Operating Manual

6/15



**electro-tech systems, inc.**

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# IMPORTANT SAFETY INSTRUCTIONS

(Equipment containing HV)

The equipment described in this Manual is designed and manufactured to operate within defined design limits. Any misuse may result in electric shock or fire. To prevent the equipment from being damaged, the following rules should be observed for installation, use and maintenance. Read the following safety instructions before operating the instrument. Retain these instructions in a safe place for future reference.

## 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. These units incorporate 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

Equipment designed to simulate a high voltage electrostatic discharge such as the Series 900 ESD Simulators and the Model 4046 Static Decay Meter utilize voltages up to 30kV. The basic nature of an ESD event will result in electromagnetic radiation in addition to the high level, short duration current pulse. **Therefore, personnel with a heart pacemaker must not operate the instrument or be in the vicinity while it is being used.**

**DO NOT OPERATE WITH COVERS OR PANELS REMOVED. Voltages inside the equipment consist of line (mains) that can be anywhere from 100-240VAC, 50/60Hz and in some equipment, voltages as high as 30kV. In addition, equipment may contain capacitors up to 0.035  $\mu$ F charged to 30kV and capacitors up to 0.5  $\mu$ F charged up to 6kV. Capacitors can retain a charge even if the equipment is turned off.**

**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 or permanent damage to the equipment. Contact the factory for further instructions.

**DO NOT OPERATE IN WET/DAMP CONDITIONS:** If water or other liquid penetrates the equipment, unplug the power cord and contact the factory for further instructions. Continuous use in this case may result in electrical shock, fire or permanent damage to the equipment.

**DO NOT OPERATE IN HIGH HUMIDITY:** Operating the equipment in high humidity conditions will cause deterioration in performance, system failure, or present a shock or fire hazard. Contact the factory for further instructions.

**DO NOT OPERATE IN AREAS WITH HEAVY DUST:** Operating the equipment in high dust conditions will cause deterioration in performance, system failure, or present a shock or fire hazard. Contact the factory for further instructions.

**DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE:** Operating the equipment in the presence of flammable gases or fumes **constitutes a definite safety hazard**. For equipment designed to operate in such environments the proper safety devices must be used such as dry air or inert gas purge, intrinsic 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.

## **MAINTENANCE and SERVICE**

**CLEANING:** Keep surfaces clean and free from dust or other contaminants. Such contaminants can have an adverse affect on system performance or result in electrical shock or fire. To clean use a damp cloth. Let dry before use. Do not use detergent, alcohol or antistatic cleaner as these products may have an adverse affect on system performance.

**SERVICE:** Do not attempt to repair or service the instrument yourself unless instructed by the factory to do so. **Opening or removing the covers may expose you to high voltages, charged capacitors, electric shock and other hazards. If service or repair is required, contact the factory.**

## 1.0 INTRODUCTION

The rapid advancement in the electronics industry during the past two 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, metalization melt and bulk breakdown that are power dependent; dielectric breakdown, metalization to metalization 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 1.0-1.

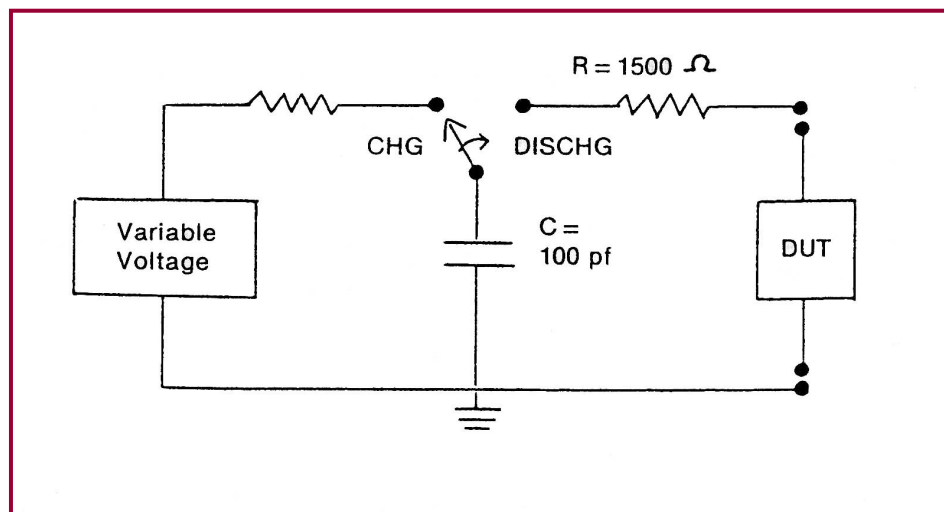


Figure 1.0-1: Basic Human Body Model equivalent circuit

This circuit is specified in Mil-Std-883H, Method 3015.8 and *ANSI/ESDA/JEDEC JS-001-2010* (formerly ANSI/ESD-STM 5.1 and JEDEC TEST METHOD A114.A) to represent a human body discharge for ESD testing. The human body capacitance

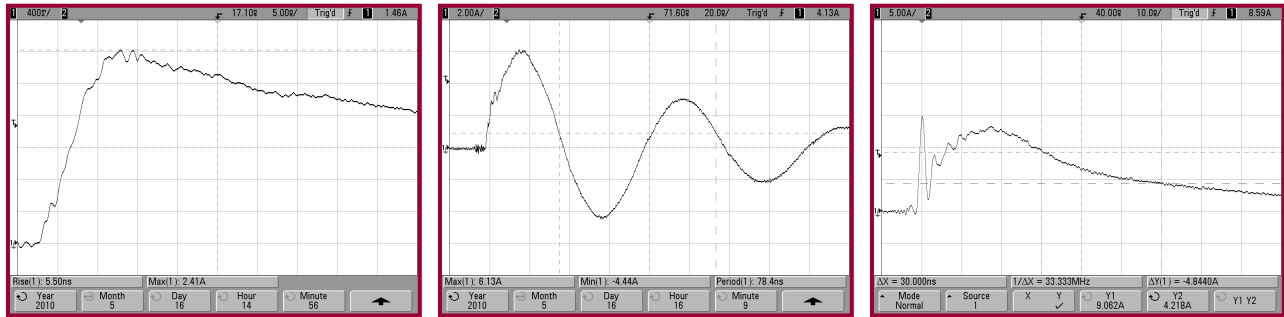
may be as high as several hundred picofarads, but more typically, ranges between 60 to 500pF. Studies have shown that approximately 80% of the population that was tested has a capacitance of 100pF or less. The variation in human capacitance is due to factors such as the amount and type of clothing and 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.

Figure 1.0-2 shows typical HBM, MM and HMM waveforms.



Human Body Model (HBM)  
(100pF/1,500Ω)

Machine Model (MM)  
(200pF/0Ω)

Human Metal Model (HMM)  
(150pF/330Ω)

Figure 1.0-2: 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-STM 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.

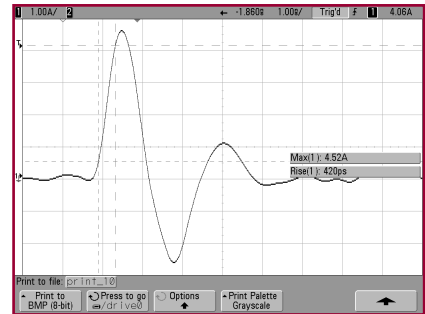
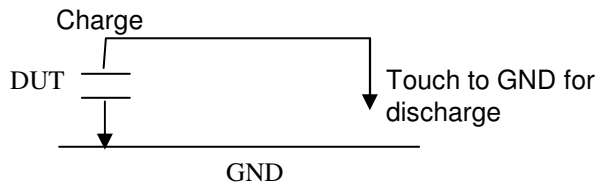


Figure 1.0-1: Basic Charge Device Model equivalent circuit

Available as an optional accessory, the Model 9902 Remote Discharge Probe shown in Figure 1.0-3 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 1.0-3: Model 9902 Remote Discharge Probe

## 2.0 EQUIPMENT DESCRIPTION

### 2.1 General

The Model 9910 Electrostatic Discharge Simulator, shown in Figure 2.0-1, 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  $\pm 5$  to 8250V for HBM,  $\pm 5$  to 4250 for HMM and  $\pm 5$  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.

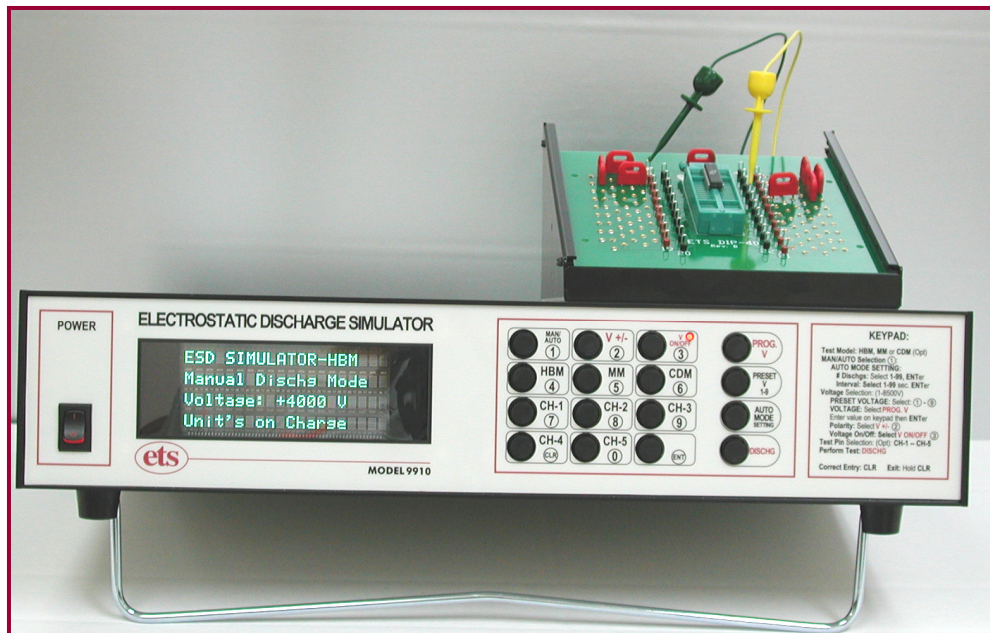


Figure 2.0-1: Model 9910 ESD Simulator

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.

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 minigrabber test leads can be connected directly to the appropriate pin pair as shown in Figure 2.0-2. Standard test fixtures with zero insertion force test sockets for DIP and SOIC type packages, shown in Figure 2.0-3, are also available as accessories along with custom designed fixtures for special applications. These test fixtures feature programming pins for tying groups of like V, signal and ground pins together as required in many specifications.

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 the adapters along with availability of other stock units.

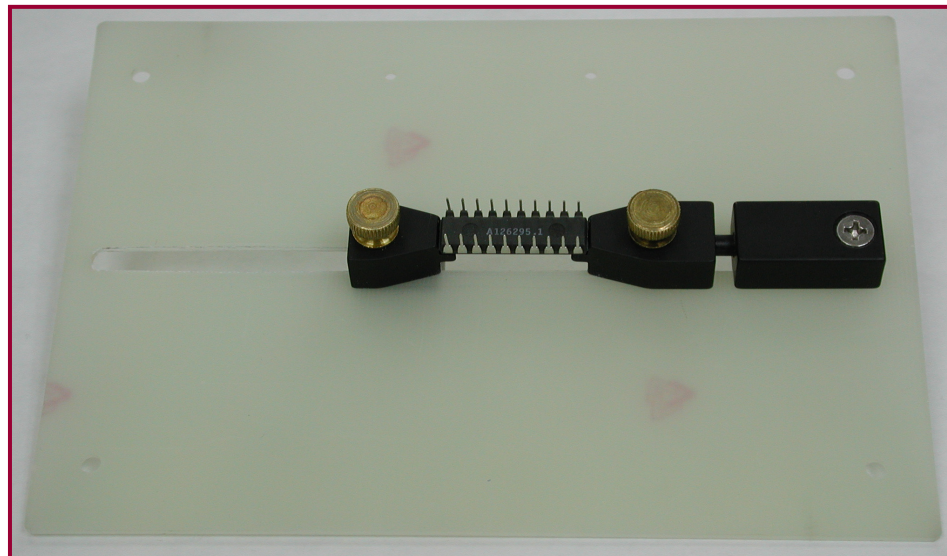
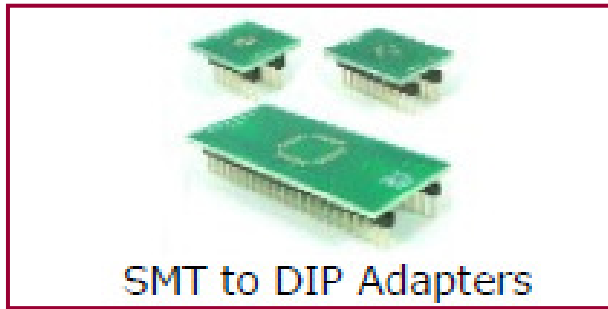


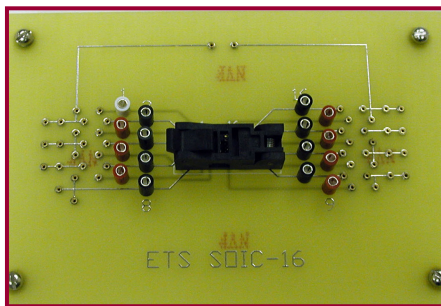
Figure 2.0-2: Standard universal DUT holding fixture



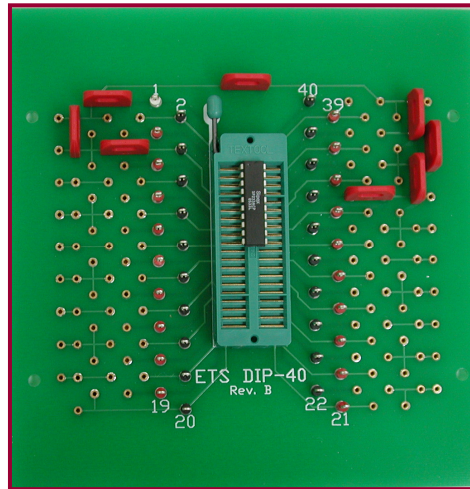


<b>SMT to DIP</b>	<b>Mini SOIC</b>	<b>QSOP</b>	<b>TSOP</b>
BGA	MLF	SC	TSOT
CSP	MLP	SOIC	TSSOP
DFN	MQFP	SOP	TVSOP
HSOP	MSOP	SOT	uCSP
JLCC	PLCC	SSOP	uMAX
LCC	POS	TCSP	uSOP
LGA	PowerSOIC	TO	VQFP
LLP	PQFP	TQFP	VSOP
LQFP	PSOP	TSOC	VSSOP
Micro SMD	QFN	TSOP	

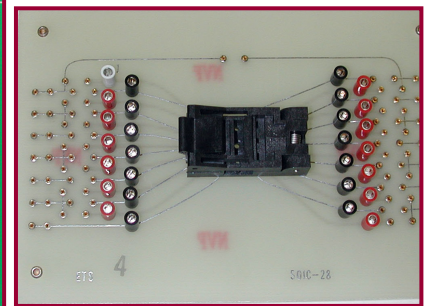
Figure 2.0-3: SMT-DIP adapters



16-Pin SOIC  
(with programming pins)



40-Pin DIP - 0.3" to .6" (7.6-15.2mm)  
(with programming pins)



28-Pin SOIC  
(with programming pins)

Figure 2.0-4: Socketed DUT test fixtures

## 2.2 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. The front panel overlay also incorporates basic instructions for operating the keyboard.

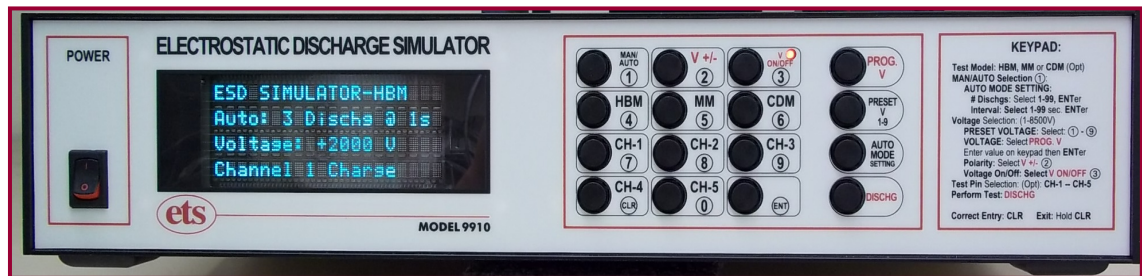


Figure 2.0-4: Front panel

The keypad controls all the following Model 9910 operating functions:

1. Select HBM, MM and CDM (also used to select HMM) testing.
2. Select Manual or Auto modes; # discharges (1-9) and Interval (1-99 sec).
3. Program voltage with  $\pm 1V$  resolution up to the following **maximum voltage levels**:  $\pm 5$  to 8250V for HBM,  $\pm 5$  to 4250V for HMM and  $\pm 5$  to  $\pm 1,000V$  for MM and CDM (opt).
4. Select up to 9 user programmed voltage settings
5. Initiate discharge sequence.

## 2.3 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.

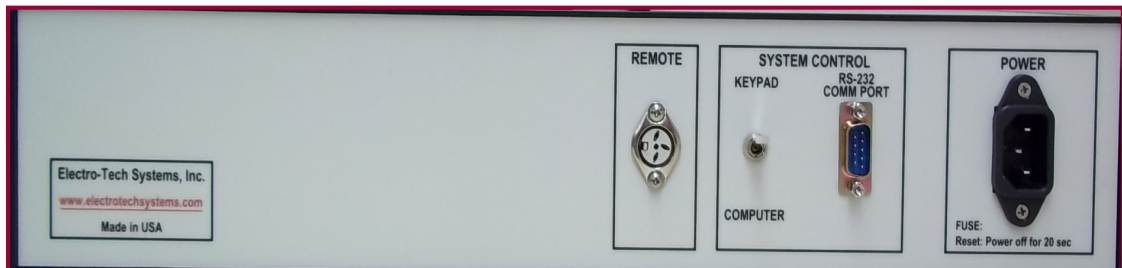


Figure 2.0-5: Rear Panel (standard configuration)

## 2.4 Output Panel

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



Figure 2.0-6: Output panel

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.

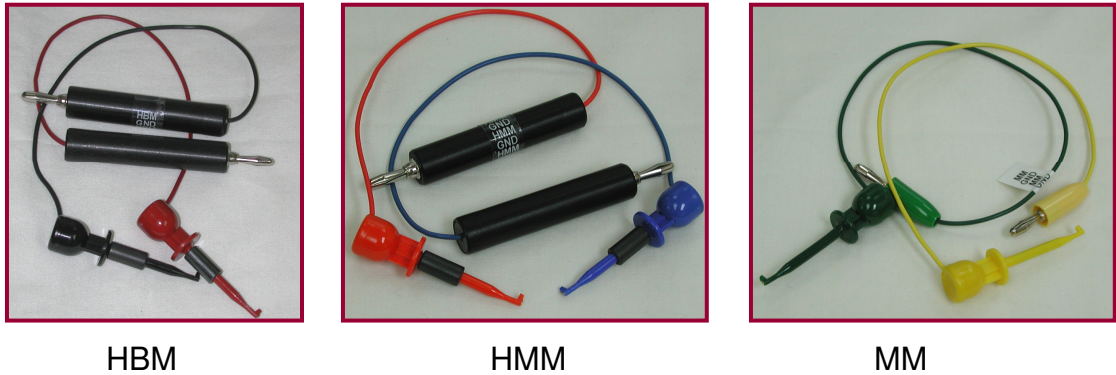


Figure 2.0-7: Output cables

The CURVE TRACER output is a 0.080" pin jack that is connected to the discharge output. During the discharge cycle, the HV relay connecting this output opens to isolate the DUT from the discharge. After the discharge has occurred, the relay is reconnected to the selected DUT pin. Typically, this feature allows the DUT to be connected to an ohmmeter or other type of device check instrument to monitor the change in characteristics after being exposed to an ESD pulse.

## 2.5 DUT Test Fixtures

The DUT test fixtures shown in Figure 2.0-3 above contain zero-insertion force sockets. Connected to each pin on the PC board is a loop connector to which the supplied minigrabber test leads are attached. 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.

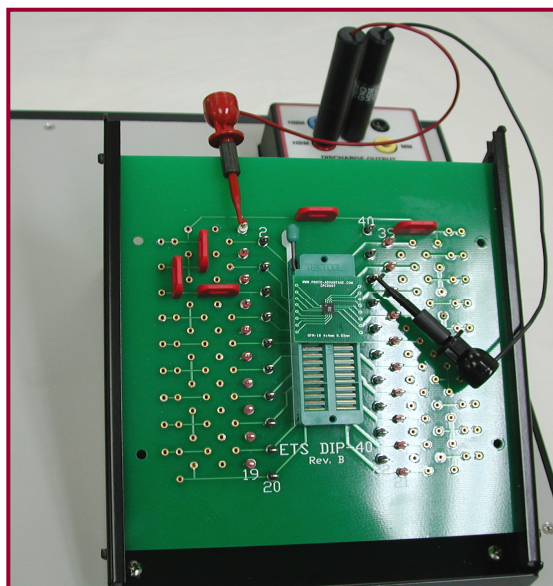
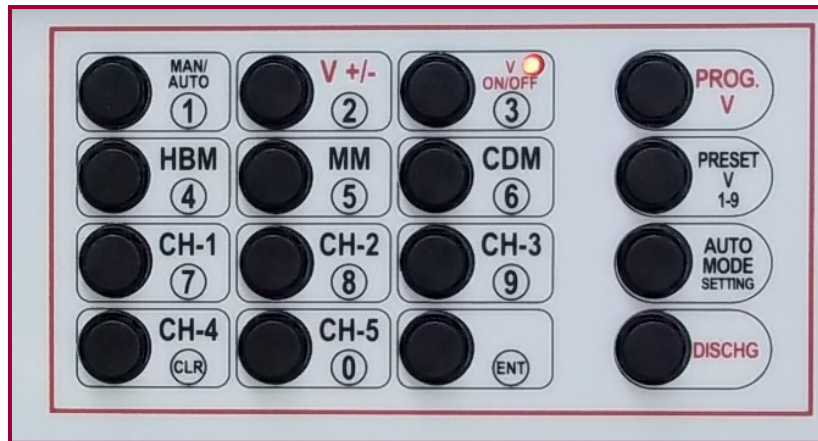


Figure 2.0-8: 40-Pin DIP DUT Board with programming pins

## 3.0 OPERATION

### 3.1 Keypad Mode

In this mode, the ESD Simulator is controlled by the 16-button keypad shown in Figure 3.0-1 keypad. The toggle switch on the rear panel **must be in the UP position**. To change the mode to **Computer Control** (down position) the unit **must first be turned off, switched** then turned back on to set the mode.



**Note:** CH-1 has been relabeled **HMM**

Figure 3.0-1: Keypad

As an example, the display shown in Figure 3.0-2 shows the Model 9910 set for **HBM** testing, the DUT pin connected to Channel 1 (connection with standard 1-channel Model 9910. The 5-CH option is a custom modification to 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.

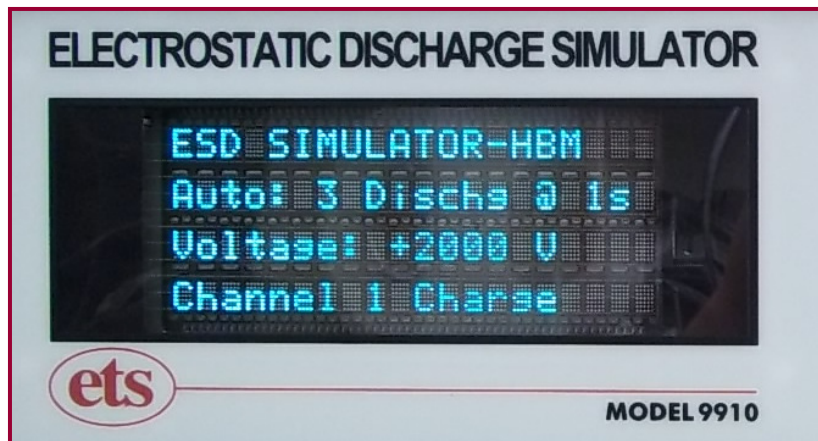


Figure 3.0-2: HBM testing in Auto mode at +2000V

Basic keyboard instructions as shown in Figure 3.0-3 are provided on the front panel overlay. They enable an operator with some degree of knowledge about the Model 9910 to perform basic testing.

**Note: #Dischgs has been changed to 1-9**

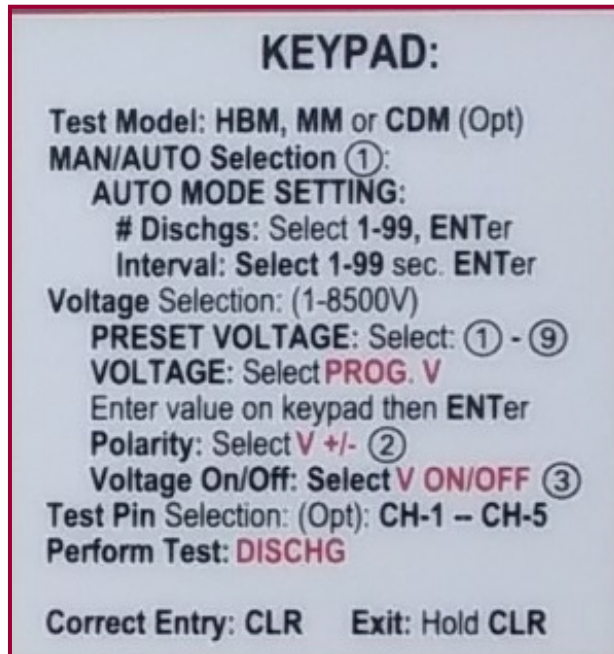


Figure 12: Basic Keypad instructions

### 3.1.1 Initial Turn On

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

### 3.1.2 HBM Testing

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  $\pm 8250V$ .**

### 3.1.3 MM Testing

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  $\pm 1000V$ .**

### 3.1.4 HMM Testing

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  $\pm 4250V$ .**

### 3.1.5 CDM Testing (Optional).

To select **CDM** testing (optional) 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  $\pm 1000V$ .**

### 3.1.6 Voltage Selection

To set the voltage proceed as follows:

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.

### 3.1.7 Preset Voltage

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).

### 3.1.9 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.

### 3.1.10 Initiating 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.

## 4.0 Computer Control (User Programming Guide)

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

### 4.1 RS232 parameters

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

### 4.1.1 Syntax and Commands

This section describes the structure of the messages the program sends to the Model 9910 microcontroller. Messages start and stop with non-printing Control Characters.

#### Command String Syntax:

1. Start of text, which is **STX** and equivalent to decimal number A non-printing control character that is used to start a message.
2. **:** (colon). This printing character is used to separate non-printing and printing characters (see Command Structure).
3. **XXX** (three upper case characters). These printing characters are used to determine a particular command function (see Command Structure).
4. **,** (comma). This printing character is used to start an argument (see Command Structure).
5. **value** (integer number) if necessarily. This number is the desire value of end user depends on the entered command (see Command Structure).
6. **:** (colon). This printing character is used to separate non-printing and printing characters (see Command Structure).
7. End of text, which is **ETX** and equivalent to decimal number A non-printing control character that is used to end a message.

### 4.1.2 Command Structures:

There are two types of commands. One is the stand-alone and the other is followed by an integer.

1. A particular command is represented by three upper case characters. The description of a command is a complete meaningful string. However, only three capital letters are extracted that string to indicate its function.

For example: **SRL** can be extracted from the command SetReLay to turn on a specific test relay.

2. Some commands must be followed by an argument (see List of Commands).

For example: **SRL** must have an ID number (such as 1,2,3...) of the selected test relay.

3. For a command starts with the word "Set...", a valid command string will receive a "done" return message after it was executed successfully. An invalid command will receive a "?" return message.

4. For a command starts with the word "Get...", the return will simple be the value that end user is looking for.

For example: The GetVolTage command will return the actual voltage that is currently display on front panel.



### 4.1.3 List of Commands:

SetVoltageNegative:	“STX”:SVN,“value”:"ETX”
SetVoltagePositive:	“STX”:SVP,“value”:"ETX”
SetHumanBodymodel:	“STX”:SHB:"ETX”
SetHumanMetalmodel:	“STX”:SHM:"ETX”
SetMachineModel:	“STX”:SMM:"ETX”
SetDisCharge:	“STX”:SDC:"ETX”
GetVolTage:	“STX”:GVT:"ETX”
GetModel:	“STX”:GML:"ETX”

#### Samples:

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

#### **Note:**

It can take up to 5 seconds to switch polarities.

A valid string will receive “String received. Wait for execution.” and a “done” message after task is done.

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

Look up Control Characters table for STX and ETX formats. To test using Hyper Terminal, type ^B for STX and ^C for ETX.

#### 4.1.4 Control Characters

Char	Oct	Dec	Hex	Control-Key	Control Action
NUL	0	0	0	^@	Null character
SOH	1	1	1	^A	Start of heading, = console interrupt
STX	2	2	2	^B	Start of text, maintenance mode on HP console
ETX	3	3	3	^C	End of text
EOT	4	4	4	^D	End of transmission, not the same as ETB
ENQ	5	5	5	^E	Enquiry, goes with ACK; old HP flow control
ACK	6	6	6	^F	Acknowledge, clears ENQ logon hand
BEL	7	7	7	^G	Bell, rings the bell...
BS	10	8	8	^H	Backspace, works on HP terminals/computers
HT	11	9	9	^I	Horizontal tab, move to next tab stop
LF	12	10	a	^J	Line Feed
VT	13	11	b	^K	Vertical tab
FF	14	12	c	^L	Form Feed, page eject
CR	15	13	d	^M	Carriage Return
SO	16	14	e	^N	Shift Out, alternate character set
SI	17	15	f	^O	Shift In, resume default n character set
DLE	20	16	10	^P	Data link escape
DC1	21	17	11	^Q	XON, with XOFF to pause listings; ":okay to send".
DC2	22	18	12	^R	Device control 2, block-mode flow control
DC3	23	19	13	^S	XOFF, with XON is TERM=18 flow control
DC4	24	20	14	^T	Device control 4
NAK	25	21	15	^U	Negative acknowledge
SYN	26	22	16	^V	Synchronous idle
ETB	27	23	17	^W	End transmission block, not the same as EOT
CAN	30	24	17	^X	Cancel line, MPE echoes !!!
EM	31	25	19	^Y	End of medium, Control-Y interrupt
SUB	32	26	1a	^Z	Substitute
ESC	33	27	1b	^[	Escape, next character is not echoed
FS	34	28	1c	^\	File separator
GS	35	29	1d	^]	Group separator
RS	36	30	1e	^^	Record separator, block-mode terminator
US	37	31	1f	^_	Unit separator

### 4.1.5 Printing Characters

Char	Octal	Dec	Hex	Description
SP	40	32	20	Space
!	41	33	21	Exclamation mark
"	42	34	22	Quotation mark (&quot; in HTML)
#	43	35	23	Cross hatch (number sign)
\$	44	36	24	Dollar sign
%	45	37	25	Percent sign
&	46	38	26	Ampersand
`	47	39	27	Closing single quote (apostrophe)
(	50	40	28	Opening parentheses
)	51	41	29	Closing parentheses
*	52	42	2a	Asterisk (star, multiply)
+	53	43	2b	Plus
,	54	44	2c	Comma
-	55	45	2d	Hyphen, dash, minus
.	56	46	2e	Period
/	57	47	2f	Slant (forward slash, divide)
0	60	48	30	Zero
1	61	49	31	One
2	62	50	32	Two
3	63	51	33	Three
4	64	52	34	Four
5	65	53	35	Five
6	66	54	36	Six
7	67	55	37	Seven
8	70	56	38	Eight
9	71	57	39	Nine
:	72	58	3a	Colon
;	73	59	3b	Semicolon
<	74	60	3c	Less than sign (&lt; in HTML)
=	75	61	3d	Equals sign
>	76	62	3e	Greater than sign (&gt; in HTML)
?	77	63	3f	Question mark
@	100	64	40	At-sign
A	101	65	41	Uppercase A
B	102	66	42	Uppercase B
C	103	67	43	Uppercase C
D	104	68	44	Uppercase D
E	105	69	45	Uppercase E

F	106	70	46	Uppercase F
G	107	71	47	Uppercase G
H	110	72	48	Uppercase H
I	111	73	49	Uppercase I
J	112	74	4a	Uppercase J
K	113	75	4b	Uppercase K
L	114	76	4c	Uppercase L
M	115	77	4d	Uppercase M
N	116	78	4e	Uppercase N
O	117	79	4f	Uppercase O
P	120	80	50	Uppercase P
Q	121	81	51	Uppercase Q
R	122	82	52	Uppercase R
S	123	83	53	Uppercase S
T	124	84	54	Uppercase T
U	125	85	55	Uppercase U
V	126	86	56	Uppercase V
W	127	87	57	Uppercase W
X	130	88	58	Uppercase X
Y	131	89	59	Uppercase Y
Z	132	90	5a	Uppercase Z
[	133	91	5b	Opening square bracket
\	134	92	5c	Reverse slant (Backslash)
]	135	93	5d	Closing square bracket
^	136	94	5e	Caret (Circumflex)
_	137	95	5f	Underscore
`	140	96	60	Opening single quote
A	141	97	61	Lowercase a
B	142	98	62	Lowercase b
C	143	99	63	Lowercase c
D	144	100	64	Lowercase d
E	145	101	65	Lowercase e
f	146	102	66	Lowercase f
G	147	103	67	Lowercase g
H	150	104	68	Lowercase h
i	151	105	69	Lowercase i
j	152	106	6a	Lowercase j
K	153	107	6b	Lowercase k
l	154	108	6c	Lowercase l
M	155	109	6d	Lowercase m
N	156	110	6e	Lowercase n

O	157	111	6f	Lowercase o
P	160	112	70	Lowercase p
Q	161	113	71	Lowercase q
r	162	114	72	Lowercase r
S	163	115	73	Lowercase s
t	164	116	74	Lowercase t
U	165	117	75	Lowercase u
V	166	118	76	Lowercase v
W	167	119	77	Lowercase w
X	170	120	78	Lowercase x
Y	171	121	79	Lowercase y
Z	172	122	7a	Lowercase z
{	173	123	7b	Opening curly brace
	174	124	7c	Vertical line
}	175	125	7d	Closing curly brace
~	176	126	7e	Tilde (approximate)
DEL	177	127	7f	Delete (rubout), cross-hatch box

### 3.2 Computer Control (User developed program)

If the user controls the Model 9910 using their own program, it is recommended that the operation duplicate the procedure described in Section 3.1 Keypad Mode.

**NOTE:**

**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  $75 \times 10^{-4}$  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.**

## 5.0 WAVEFORM VERIFICATION PROCEDURES

### 5.1 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=100pF and R=1500 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.**

### 5.1.1 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.

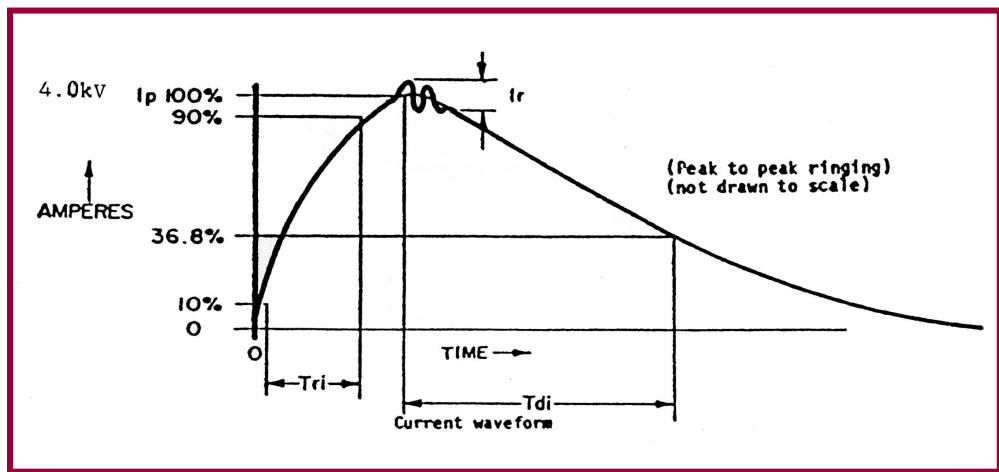


Figure 5.0-1: Current Waveform per Method 3015.8

The current pulse shall have the following characteristics:

$T_r$ (rise time)	2-10 nanoseconds
$T_d$ (decay time)	150 $\pm$ 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 $\Omega$  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.

### 5.1.2 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.

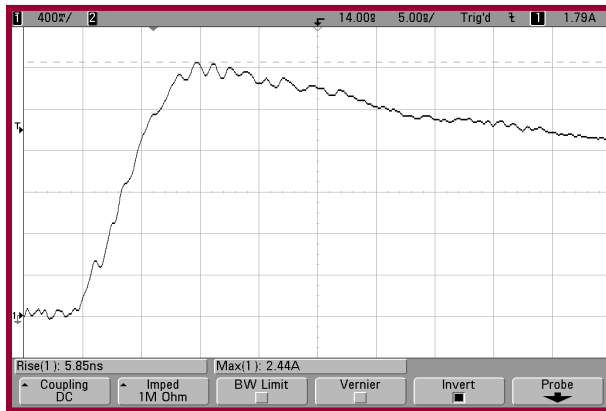


Figure 5.0-4: Model 9910 Rise Time and Ringing Waveform at 4kV

### 5.1.3 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  $150 \pm 20$  nsec from the 100% point to the 37% point.

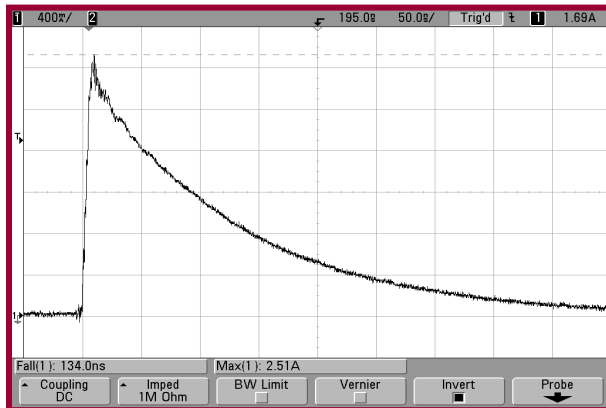


Figure 5.0-5: Model 9910 Discharge Pulse Fall Time Measurement at 4kV

### 5.1.4 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  $500\Omega$  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.



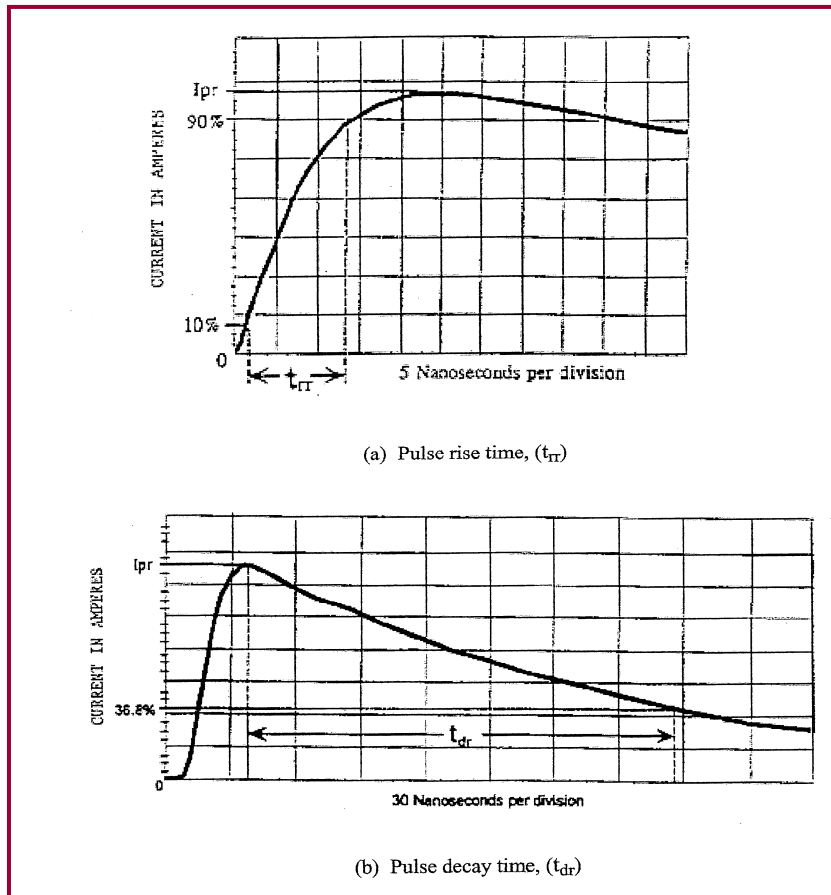


Figure 5.0-6: Current waveform through a 500 Ohm resistor

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.

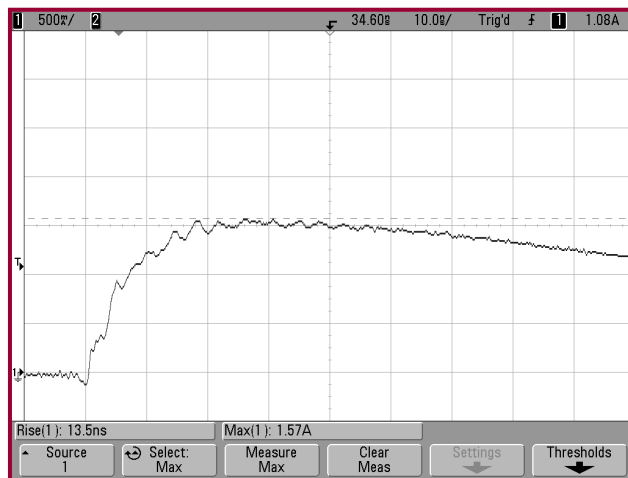


Figure 5.0-7: Current waveform through a 500 Ohm resistor at 4000V

### 5.1.5 Waveform Parameters\*

Voltage Level (V)	I <sub>peak</sub> for Short, I/Ips (A)	I <sub>peak</sub> for 500 Ohm* I <sub>pr</sub> (A)	Rise Time for Short, t <sub>r</sub> (ns)	Rise Time for 500 Ohm* t <sub>rr</sub> (ns)	Decay Time for Short, t <sub>d</sub> (ns)	Ringing Current I <sub>R</sub> (A)
250	0.15-0.19	N/A	2.0-10	N/A	130-170	15% of I <sub>ps</sub>
500	0.30-0.37	N/A	2.0-10	N/A	130-170	15% of I <sub>ps</sub>
1000	0.60-0.74	0.37-0.55	2.0-10	5.0-25	130-170	15% of I <sub>ps</sub>
2000	1.20-1.48	N/A	2.0-10	N/A	130-170	15% of I <sub>ps</sub>
4000	2.40-2.96	1.5-2.2	2.0-10	5.0-25	130-170	15% of I <sub>ps</sub> and I <sub>pr</sub>
8000 (optional)	4.80-5.86	N/A	2.0-10	N/A	130-170	15% of I <sub>ps</sub>

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

### 5.1.6 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 1500Ω, 3000Ω (1500 from the low and high voltage relays) for the HBM, HMM and MM are connected in series with the **Curve Tracer** output.

## 5.2 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.**

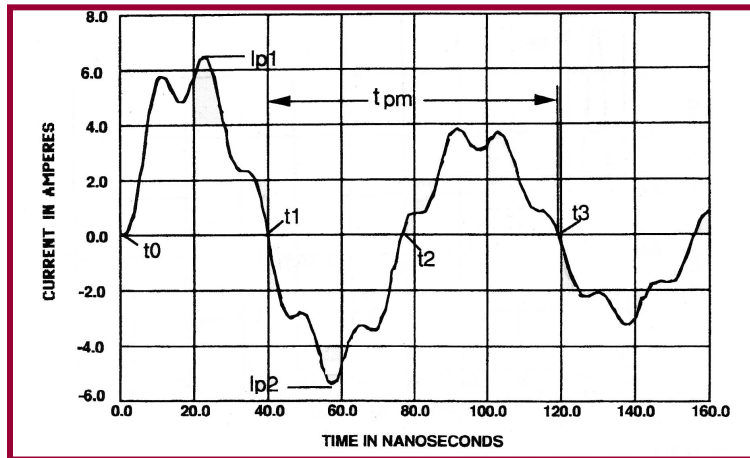


Figure 5.0-7: Current waveform through a short to ground

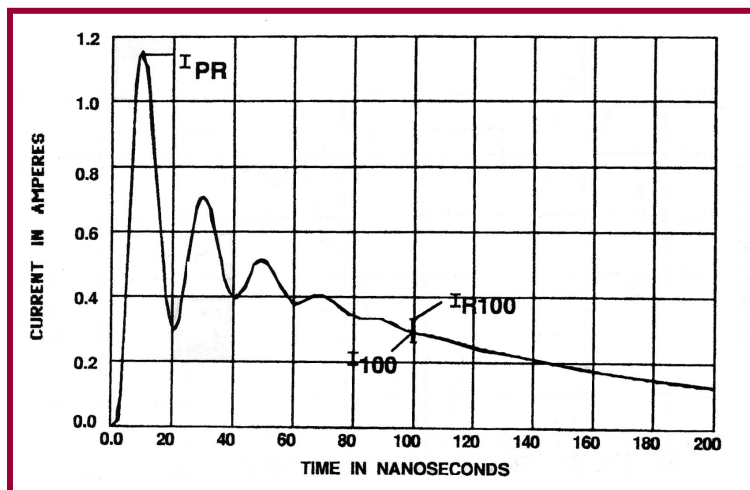
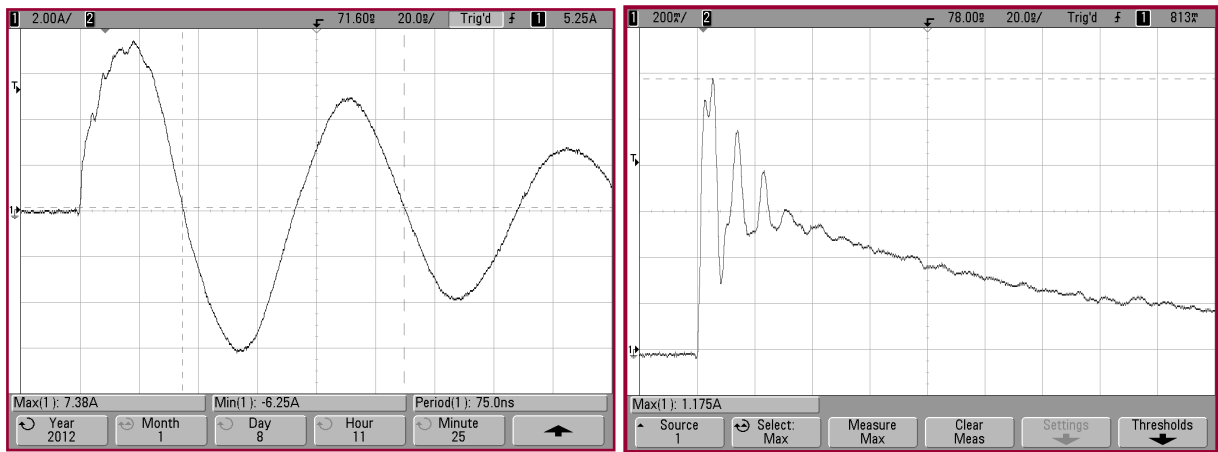


Figure 5.0-8: Current waveform through a 500 Ohm resistor to ground

Figure 5.0-9 shows actual Model 9910 MM waveforms at 400V.



a. Short to Ground

b. Through 500 Ohm Resistor

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

### 5.3 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/330Ω 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.

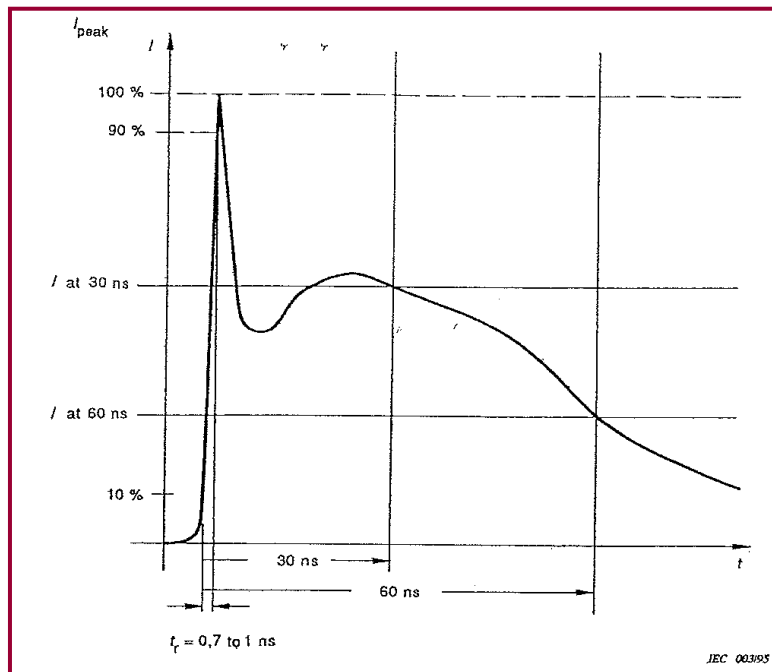


Figure 5.0-10: IEC 61000-4-2 waveform parameters

Figure 5.0-11 shows an actual Model 9910 HMM waveform at 4000V.

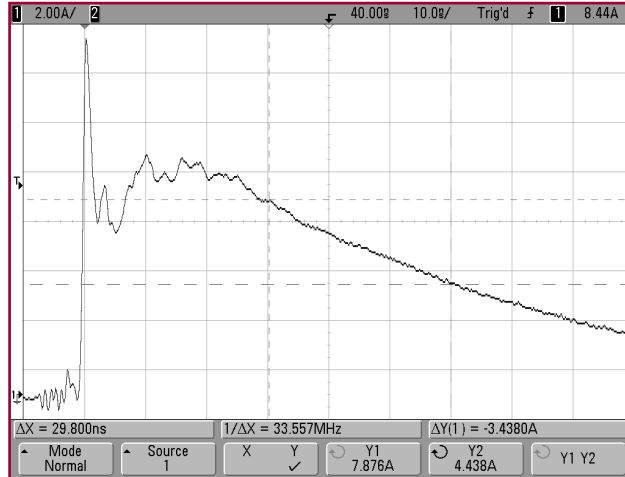


Figure 5.0-11: Actual Model 9910 HMM waveform at 4000V.

Level	Indicated Voltage kV	First peak current of discharge $\pm 10\%$	Rise Time $t_r$ with discharge switch nsec	Current ( $\pm 30\%$ ) at 30 nsec	Current ( $\pm 30\%$ ) 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.**

## 6.0 DUT TESTING PROCEDURE

### 6.1 Set-Up

Insert the DUT into either the clamping fixture or the appropriate optional zero insertion force Socket Test Fixture. Connect the minigrabber to the desired pin pairs when the clamping fixture is used.

Turn the HIGH VOLTAGE ON and select or adjust the desired voltage and polarity.

Select either Manual or Auto mode operation. If the **AUTO** mode is selected, the number of discharge pulses (1-9) and cool down interval period (1-99 sec) programmed will control the test sequence when the **DISCHG** key is depressed. The default settings are 3 discharges at 1 second intervals. Each discharge will register on the display until the total number of cycles selected has been completed.

If a programmable Socket Test Fixture is used, follow the procedure shown in Figure 6.0-1 on how to program the module for the desired pin group configurations. Use the same minigrabber cables to connect the socket module to the Simulator output jacks.

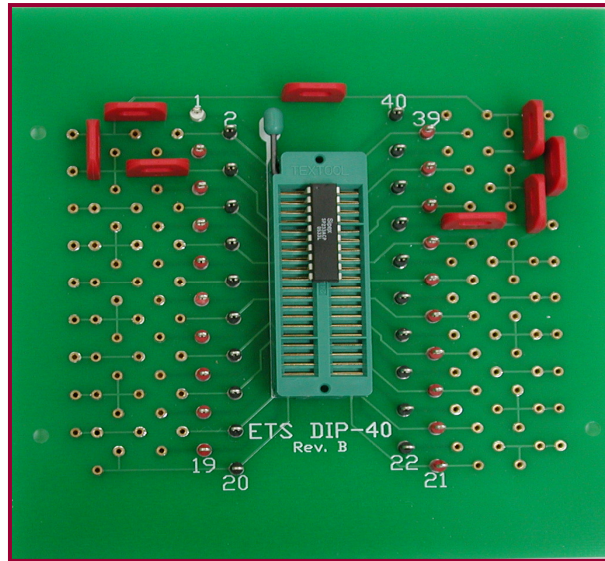


Figure 6.0-1: Programming IC Adapter Modules

## 6.2 Test Procedure

For manual testing, depress the **DISCHG** button to initiate a discharge. Each time the **DISCHG** button is depressed, a discharge will occur and the event will be indicated on the display.

To reverse polarity, depress the **V +/-** key.

For Auto mode testing, select the **AUTO** function (1). Then depress the **DISCHG** key. The programmed auto sequence will start.

To interrupt the test cycle, depress the **CLR** key. To resume the test, depress the **DISCHG** key. To start a new cycle after interruption, depress and hold the **CLR** key for 5 seconds. This clears the sequence.

To run another sequence after the prior one has been completed, depress the **DISCHG** key.

## 6.3 HBM (Method 3015.8, ANSI/ESD-STM5.1 & JESD22-A114-B)

A sample of devices shall be characterized for device ESD failure threshold using voltage steps of 250, 500, 1000, 2000 and 4000 Volts as a minimum. Other voltage steps may be used to obtain a more accurate measure of the failure voltage. Testing may begin at any voltage step, except for devices which have demonstrated healing effects, including those with spark gap protection, which shall be started at the lowest step. Cumulative damage effects may be eliminated by retesting at the failure voltage step using a new

sample of devices starting at one or two voltage steps lower than the failure threshold.

### 6.3.1 Control Settings

Select the HBM by depressing the **HBM** (4) then **ENTR** keys. Initially select + Polarity and set the voltage level to the desired start voltage. If the voltage steps are known then up to 9 preset voltages can be programmed. Select either the **MAN**ual mode or the **AUTO** mode and using the default setting of the number of DISCHARGES to 3 and the INTERVAL (cool down period) to 1 second. Depress the **DISCHG** key to initiate either a single discharge or the discharge sequence programmed.

### 6.3.2 Testing Procedure

Refer to the appropriate test standard being used to establish the correct testing protocol (starting voltage, number of discharges, pin combinations, etc).

## 6.4 MM (ANSI/ESD-STM5.2)

Machine Model testing is described in ANSI/ESD-STM5.2. This Standard defines five component classification levels and four stress levels as shown in Figure 6.0-2. Testing protocol and pin combinations are also defined.

Level	First peak current into a shorting wire Ip1(Amps)	Peak current into 500 ohms IPR (Amps)	Current into 500 ohms at 100ns (Amps)	Equivalent Charging voltage Vp (volts)
1	1.75			100
2	3.5			200
3	7.0	0.85 - 1.2	0.29	400
4	14.0			800

Figure 6.0-2: MM classification and stress levels

## 6.5 HMM (IEC 61000-4-2)

A sample of devices shall be characterized for device ESD failure threshold using voltage steps of 2,000 and 4,000. (6,000 and 8,000 Volts are not available with the Model 9910). Other voltage steps may be used to obtain a more accurate measure of the failure voltage. Testing may begin at any voltage step, except for devices that have demonstrated healing effects, including those with spark gap protection, which shall be started at the lowest step. Cumulative damage effects may be eliminated by retesting at the failure voltage step using a new sample of devices starting at one or two voltage steps lower than the failure threshold.

### 6.5.1 Control Settings

Select the **HMM** by depressing the **HMM** (7) then **ENTR** keys. Initially select + Polarity and set the voltage level to the desired start voltage. If the voltage steps are known then up to 9 preset voltages can be programmed. Select either **MAN**ual or **AUTO** mode, the number of **DISCHARGES** to 3 (some specs require only a single discharge) and the **INTERVAL** (cool down period) to 1 second. Depress the **DISCHG** key to initiate either a single discharge or the discharge sequence programmed.

### 6.5.2 Testing Procedure

Refer to the appropriate test standard being used to establish the correct testing protocol (starting voltage, number of discharges, pin combinations, etc).

## 6.6 Charged Device Model (CDM ) Option

The standard Model 9910 can be configured to perform Charged Device Model testing directly with the Model 9903 Charge Device Model Test Fixture. The charging system of the Model 9910 incorporates a 400 MegOhm resistor in the charging circuit that allows an isolated device to be charged slowly enough as not to cause a discharge as specified in current CDM standards. In addition, the **REMOTE** output of the Model 9910 provides the 5V necessary to operate the Model 9903 CDM Test Fixture. The Fixture can perform both field-induced and direct charging tests up to 1000V.

The Charge Device Model (CDM) is a more severe test than the standard HBM model since this event occurs when the device itself becomes charged then when touched to ground or a lower potential causes a very fast rise time discharge to occur as shown in Figure 6.0-3.

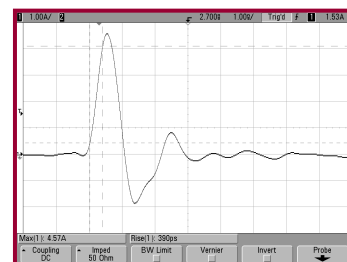
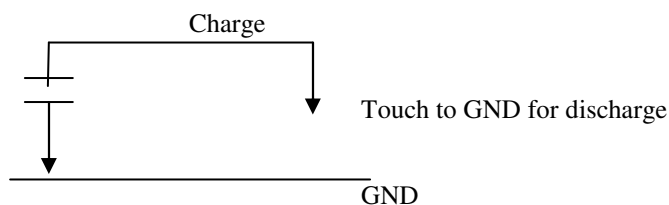


Figure 6.0-3: Basic Charge Device Model equivalent circuit

The CDM discharge is a function of the device capacitance that may be as low as a few picofarads (the example is a 6.8pF disc) or can be as high as several hundred picofarads (a complete assembly). This variation has a significant affect on the severity of the discharge. Small component packages may not be able to hold sufficient charge to meet specified discharge levels.



The Charged Device Model (CDM) test, as defined in standards JEDS22-C101C, ANSI/ESD-STM 5.3 and AEC-Q101-005 describe a test procedure where a component is slowly charged to a given voltage and then discharged to ground through one of the device leads. The CDM test permits either field induced or direct charge/discharge.

The optional Model 9903 Charge Device Test Fixture shown in Figure 5.0-4 is a completely integrated unit that provides the means of performing both direct charge and field induced CDM tests.

**IMPORTANT NOTE**

**The Model 9903 only provides the means to perform CDM testing. It may not produce verification waveforms that meet all the requirements specified in the test standards referenced above.**



Figure 6.0-4: Model 9903 Charge Device Model Test Fixture

## 6.0 WARRANTY

Electro-Tech Systems, Inc. warrants its equipment, accessories and parts of its manufacture to be and remain free from defects in material and workmanship for a period of one (1) year from date of invoice. It will, at its discretion, either replace or repair without charge, F.O.B. Glenside, similar equipment or a similar part to replace any equipment or part of its manufacture which, within the above stated time, is proved to have been defective at the time it was sold. All equipment claimed defective must be returned properly identified to the Seller (or presented to one of its agents for inspection). This warranty only applies to equipment operated in accordance with Seller's operating instructions.

Seller's warranty with respect to those parts of the equipment that are purchased from other manufacturers shall be subject only to that manufacturer's warranty.

The Seller's liability hereunder is expressly limited to repairing or replacing any parts of the equipment manufactured by the manufacturer and found to have been defective. The Seller shall not be liable for damage resulting or claimed to result from any cause whatsoever.

This warranty becomes null and void should the equipment, or any part thereof, be abused or modified by the customer or if used in any application other than that for which it was intended. This warranty to replace or repair is the only warranty, either expressed or implied or provided by law, and is in lieu of all other warranties. Seller denies any other promise, guarantee, or warranty with respect to the equipment or accessories and, in particular, as to its or their suitability for the purposes of the buyer or its or their performance, either quantitatively or qualitatively or as to the products that it may produce. The buyer is expected to expressly waive rights to any warranty other than that stated herein.

ETS must be notified before any equipment is returned for repair. ETS will issue an RMA (Return Material Authorization) number for return of equipment.

Equipment should be shipped prepaid and insured in the original packaging. If the original packaging is not available, the equipment must be packed in a sufficiently large box (or boxes if applicable) of double wall construction with substantial packing around all sides. The RMA number, description of the problem along with the contact name and telephone number must be included in formal paperwork and enclosed with the instrument. Round trip freight and related charges are the owner's responsibility.

### **WARNING:**

**WOODEN CRATES MUST NOT BE USED TO PACKAGE THE ELECTRONIC UNITS. PACKAGING OF DELICATE INSTRUMENTS IN WOODEN CRATES SUBSTANTIALLY INCREASES THE CONTENT'S SUSCEPTIBILITY TO SHOCK DAMAGE. ELECTRO-TECH SYSTEMS, INC. WILL NOT ASSUME RESPONSIBILITY FOR ADDITIONAL COST OF REPAIR DUE TO DAMAGE INCURRED DURING SHIPMENT DUE TO POOR PACKAGING.**