ANDY HISH ASSOCIATES

INSTRUCTION MANUAL

MODEL ESD-255 ELECTROSTATIC DISCHARGE GENERATOR

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No. 057255-2

8701

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ESD-255 ELECTROSTATIC DISCHARGE GENERATOR

SPECIFICATIONS

INPUT	115 volt AC, 50 to 60 Hz single phase, three conductor grounding line cord.
OUTPUT	Continuously adjustable from zero to 25 KV DC.
VOLTMETER	Wide View, 3 1/2", 90 degree extended range. Two ranges: 0 - 5,000; 0 - 25,000 volts. Output voltage accuracy: ± 5%.
PROBES	Two probes are available using distributed line techniques to replicate the wave forms of static discharge from personnel with a metal intervening object such as a key, ring (Probe P255-1) deck chairs or push cart (Probe P255-2). The networks of these probes replicate these complex networks.
SIZE	8 1/2" deep X 16 1/2" wide X 11" high.
WEIGHT	15 lbs.

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SAFETY PRECAUTIONS

THE ELECTROSTATIC TEST DISCHARGES AS OTHER HIGH VOLTAGE DISCHARGES MAY BE HAZARDOUS TO PACE-MAKER WEARERS.

THE ELECTROSTATIC DISCHARGE SIMULATOR IS A HIGH VOLTAGE INSTRUMENT PRODUCING VOLTAGE LEVELS UP TO 25 KILOVOLTS. THE ENERGY LEVEL OF THIS VOLTAGE IS BELOW THAT WHICH IS CONSIDERED LETHAL FOR A NORMAL HEALTHY PERSON, BUT EVEN THIS ENERGY LEVEL CAN GIVE AN UNPLEASANT SHOCK TO THE USER. OPERATING AND WORKING AROUND ANY HIGH VOLTAGE INSTRUMENT OR DEVICE REQUIRES A HIGH DEGREE OF RESPONSIBILITY, CARE, AND COMMON SENSE.

INTRODUCTION

1.0 GENERAL

The Andy Hish Electrostatic Test Generator, Model ESD-255, provides a comprehensive simulation of the broad spectrum of electrostatic discharge events that occur under actual-use conditions.

Comparative data taken between actual ESD events and those produced by the ESD-255 illustrate that: (A) the spectral distribution of the dynamic impulses is virtually identical; (B) the correlation of waveform-to-amplitude is virtually identical; and, (C) the time interval between impulses in the multiple-pulse ESD event series is comparable. (See Appendix A)

1.1 SPECIFICATIONS

INPUT	115 volt AC, 50 to 60 Hz single phase, three conductor grounding line cord.
OUTPUT LEVEL	Continuously adjustable from zero to 25 KV DC.
IMPULSE WAVEFORM CHARACTERISTICS	See Appendix A (Bulletin 057255-1)
PROBES	Two probes are currently available using distributed line techniques to replicate the wave forms of static discharge from personnel with a metal intervening object such as a key, or ring, (Probe 255-1) desk chair or push cart (Probe 255-2). It should be noted that the ESD circuit is significantly more complex than a simple R-C network description. The networks of these probes replicate these more complex networks. (Other probes on custom order basis are described herein)
SIZE	8 1/2" Deep X 16 1/2" Wide X 11" High.
WEIGHT	15 LBS.

2.0 GENERAL DESCRIPTION OF OPERATION

The basic system is comprised of an AC powered charging source with a control allowing the operator to vary the output potential continuously between 0 and 25,000 volts. The selected output potential is monitored by a metering network and accurately displayed on a dual-scale analog meter. The operator may apply a single static discharge pulse into the item under test and may select an inhibit rate equal to 1 discharge per 2 second, 1 discharge per second or 2 discharges per second.

Various discharge probes may be connected to the output cable of the ESD-255. Each highly-insulated probe is designed with specific networks to simulate the discharge characteristics of various sources of electrostatic energy. Examples: The human body with a small intervening metal object such as a ring, key or a coin; an impact of a charged furnishing, such as an office chair or push cart.

All circuits and components of the ESD-255 generator have been professionally engineered and reliably designed to provide consistent performance over an extended period of usage. All parts are highest quality industrial grade and are conservatively derated to assure failure-free performance.

ESD IMPULSE WAVEFORM APPLICABILITY

3.0 GENERAL

Research has demonstrated that dramatic changes occur in the actual ESD waveforms as the ESD amplitude is altered. At lower levels, for example below 4 KV, the predominent ESD waveform exhibits a risetime under 500 picoseconds and a base width of typically under 1 nanosecond with peak impulse amplitudes ranging between a few amperes and many tens of amperes, even approaching 100 amperes.

As the ESD amplitude is increased, the risetime slows, the peak currents develop differently and the base widths extend. At 8 KV, for example, the ESD impulse waveforms exhibit a risetime ranging between approximately 1 nanosecond and 30 nanoseconds, (Typically 2 to 5 nanoseconds) with base widths of 80 to 100 nanoseconds, for human conditions, and 20 to 30 nanoseconds for furnishings discharge conditions. ESD impulses at 15 KV can exhibit risetimes of approximately 10 to 30 nanoseconds, (Typically) with base widths as noted above for the 8 KV event.

The Hish ESD-255 Electrostatic Test Generator is designed to "track" these waveform variations as would be anticipated in "actual" ESD events.

3.1 IMPULSE WAVEFORM TIME INTERVALS

As revealed by research studies, the "ESD Event" can actually consist of a series of individual ESD impulses, spaced apart by a significant time interval between each component impulse.
Multiple impulses within the envelope of an overall "event" usually take the form of a highest amplitude to lowest amplitude series with each specific impulse waveshape dependent on the residual ESD amplitude present after each impulse occurred. Consequently, an initial ESD level of, for example, 12.5 KV would produce waveforms of 12.5 KV on the initial impulse followed by a series of impulses at descending equivalent levels.

The rate, quantity, and periodicity of these multiple "sub-events" is dependent on the probe characteristics, the properties of the surface being subjected to ESD, and the velocity of the approach of the probe to the "load" surface.

ESD IMPULSE WAVEFORM APPLICABILITY

The illustration 3.1 describes typical marker points in time when ESD events occur with the P-255-1 probe. Each marker point, after the initial event, occurred at a descending ESD amplitude.

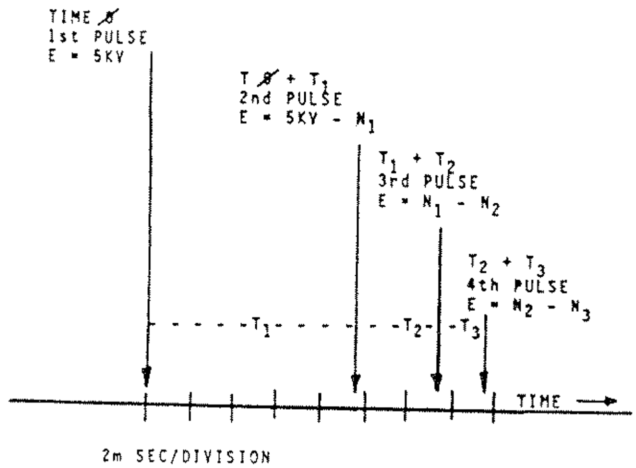


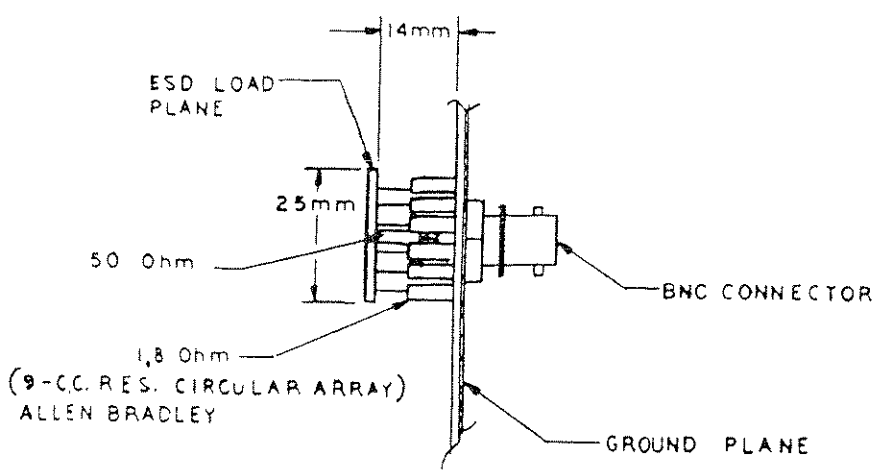
ILLUSTRATION 3-1

CONCEPTUAL DISTRIBUTION OF ESD SUB-EVENT MARKER POINTS FOR P-255-1 PROBE AT 5KV INITIAL LEVEL, VELOCITY DEPENDENT.

3.2 MEASUREMENT LOAD

A suitable measurement load was developed for use in conjunction with the Tektronix 7104 Oscilloscope System.

This load may be constructed as noted below.



ESD LOAD, 0.2 Ohm, 1.0AMP PER 0.1 VOLT AT 50 Ohms.

The load consists of a circular array of 1/2 watt carbon composition resistors, manufactured by the Allen-Bradley Company. (These resistors have been chosen due to their low inductive content).

The circular array is to be comprised of nine resistors, measured to be 1.8 ohms each for a total of 0.2 ohms. Solder the resistors to a circular copper plate, drilled for the leads of the resistors, that has an outside diameter of 25 mm. The circular pattern of the resistor leads within the circumference of the plate is 20 mm. Centered in the plate, connect a 50 ohm carbon composition resistor (same manufacturer), 47 ohms selected to be 50 ohms to feed the center of the BNC connector. The separation between the circular plate and the parallel ground plate should be 14 mm.

Drill the ground plate in the same 20 mm circular pattern for the resistors, with the BNC connector mounted in the center. The ground plate is made of copper and is at least 2 X the diameter of the load (circular) plate, but may be square or rectangular in shape.

The load decribed above will yield a response of 1.0 amps/volt when loaded by the 50 ohm input of the Tektronix 7429 amplifier. Other oscilloscopes may be used that provide adequate bandwidth, write speed (200 picoseconds) and input impedance (50 ohms).

3.3 ESD-255 SIMULATION

To the maximum extent practicable, the ESD-255 Test Generator produces simulated ESD impulses that closely follow the characteristics overviewed above for "Actual" ESD events.

Reference:

(1) King, W. & Reynolds, D. "Personnel Electrostatic Discharge; Impulse Waveforms Resulting from ESD of Humans Directly and Through Small Hand-Held Metallic Objects Intervening in the Discharge Path" - 1981 Proceedings, International IEEE EMC Symposium, Pages 577 - 590. (IEEE Ref. 81CH1675-8).

INTERACTION OF ESD SIMULATION WITH ACTIVE SYSTEMS

4.0 GENERAL

In that the ESD-255 Test Generator closely follows the characteristics of "actual" events, the system-product susceptibility characterized responses that may occur as the result of "actual" ESD events will occur in essentially the same manner and magnitude utilizing the ESD-255 as they would to the "actual" event. The technique and accuracy of this simulation has ramifications towards the test approach in active systems, as discussed below.

4.1 SYSTEMS RESPONSE CHARACTERISTICS

The propagation of the ESD event within a product or system may take several forms due to the radio frequency susceptibility characteristics unique to the system-product. At ultra high bandwidths, for example 500 MHz to 2 GHz, apertures local to or in product surfaces may become "slot antennas", propagating an ultra-high frequency signal component efficiently to sensitive circuits. Although the "sensitive circuits" may not be directly rated for such U.H.F. bandwidths, the U.H.F. "effective aperture" can propagate sufficient energy into the "sensitive circuit" causing that circuit to be susceptible to a lower frequency spectral component of the spectral distribution of the impinging signal. At lower radio frequencies, for example 50 to 100 MHz, the "aperture" might be sufficiently mismatched to the impinging signal such that susceptibility would not occur because the energy would be blocked from entering the "sensitive circuit" by the bandwidth-efficiency characteristics of the aperture. This could occur although the 50 to 100 MHz impinging signal is within the bandwidth of the "sensitive circuit" because the aperture excludes it from propagating efficiently in the product.

At lower frequencies, the radio frequency susceptibility characteristics of a product may be due to an entirely different propagational mechanism. Interface cables, for example, may support significant susceptibility effects in the bandwidth areas of 10 to 100 MHz. Large sheet metal panels may be efficent antenna structures within the same bandwidth range. Smaller casework assemblies, internal harnesses and circuit boards may be efficient susceptibility considerations at 50 to 500 MHz. Simply, the system-product may often exhibit various susceptibility responses that are attributable to various mechanisms within the product that may be influenced by propagational efficiencies of susceptibility events at specific ESD amplitudes, and not at other amplitudes.

4.2 ESD SPECTRUM-AMPLITUDE DEPENDENCY

From the overview in Section 3.0, it should be recognized that the spectral product-response distribution across the frequency range of the ESD impulse varies significantly as an inter-dependency on the ESD amplitude established ("actual" or simulated with the ESD-255). For example, the ESD amplitudes: A) below approximately 4 KV have spectra in the UHF-SHF range, B) between approximately 4 KV and 10 KV have spectra in the general VHF-UHF range; and C) between 10 KV and 25 KV have spectra in the HF-VHF range. When these ESD characteristics are considered in conjunction with the "systems-bandwidth" susceptibility dependency noted in 4.1, a major conclusion becomes evident: System-Products may exhibit an ESD Amplitude dependency for susceptibility effect. In addition, the amplitude-spectrum dependency could vary between various ESD conditons, such as the ESD of humans compared to the ESD of humans through furnishings (such as carts and chairs).

5.0 APPLYING POWER - INITIAL ADJUSTMENTS

With the amplitude output control of the ESD-255 turned fully counter-clockwise and the power switch set to the "Off" position, connect the power to the AC input connector of the ESD-255 using the power cable supplied. Ground the grounding braid of the ESD-255 to the ground plane required (See Section 5.2, 5.3, 5.4 herein). Connect the probe desired (See Section 5.8) to the output of the ESD-255 and execute any probe ground connections required as indicated in the instructions for each probe. (Note: The P-255-0 and P-255-1 probes do not require additional grounds). Select the output range of the amplitude meter desired by the "range" switch on the front panel (0-5 kV or 0 - 25 kV). Position the AC power switch to the "on" position and slowly rotate the output amplitude control knob clockwise to establish the initialization (output) level desired. See Section 5.3 for use of the pulse repetition switch).

5.1 SHOCK HAZARD

CAUTION: SHOCK HAZARD! THIS INSTRUMENT DEVELOPS VERY HIGH VOLTAGES. Personnel using or handling this instrument are cautioned never to come in contact with the probe tips or in contact with the center pin of the output connector prior to connecting the probes.

Although every reasonable effort has been taken in the design of the ESD-255 to preclude lethal currents from resulting due to the high voltages, Andy Hish Associates assumes no liability for the improper handling or use of this equipment.

5.2 GROUNDING

"Actual" ESD sources (Humans and Humans holding furnishings) are "grounded" dynamically throught a distributive transfer impedance that acts, effectively, as a reference plane. Accordingly, the ESD-255 requires a minimum distributive ground to assure accurate impulse waveform development. For safety purposes, however, it is important to assure that the ground wire in the power cord is connected to a correct building ground, usually found within a receptacle meeting electrical code requirements. Note: Other than sharing a common electrical outlet ground, the ESD-255 is not grounded directly to the frame of the unit-under-test since such a ground is not representative of "actual" events.

5.3 ESD-255 WITH HUMAN SIMULATION PROBES

Ground the crocodile clip at the end of the braid ground strap supplied in the ESD-255 to ground plate with a minimum surface area of 0.5 meter. Locate the plate adjacent to the unit-under-test, or below the unit-under-test, but do not allow the plate to contact the unit-under-test. Be certain, for safety purposes, that the ground wire of the electrical power to the ESD-255 is properly connected in the receptacle.

5.4 ESD-255 WITH FURNISHINGS SIMULATION PROBES

The furnishings simulation probes require a separate ground strap directly to the probe itself through the grounding fixture supplied with those probes. It is recommended that ground planes for these probes have a mimimum surface area of 1.5 square meter. Follow the grounding directions supplied with the probe. Connect the safety electrical ground as described in 5.2 and 5.3 and locate the ground plate as described above. The braid-strap ground with the crocodile clip in the ESD-255 is not required for these probes, and its use is only redundant provided that the appropriate ground is connected to the probes.

The furnishings probes are supplied with the following specific instructions:

A. Mount the three inch disc on the discharge end of the probe and secure with the discharge ball.

B. When discharging to a unit under test, the discharge should be through the ball and not the disc.

C. The four grounding clamp screws at the back of the grounding fixture GF255-2 should be unscrewed to permit the insertion of grounding foil (not furnished). The ground foil may be copper or aluminum and should be one foot wide and three feet long. (longer length may be used as long as a maximum aspect ratio of 3 to 1 is maintained).

D. One end of the foil should be clamped in GF255-2 and the other end grounded to the ground plane of the test arrangement. The ground plane of the test arrangement for the P255-2 or P255-3 probe should have a minimum surface area of 1.5 square meters.

5.5 GROUND PLANE MATERIAL

The ground planes noted in 5.3 and 5.4 may be made of any reasonably conductive material such as aluminum, copper, or brass. If steel is used, it should be plated conductively.

5.6 IMPULSE RATE

The impulse rate switch is provided only to inhibit the reinitializing of the ESD probe to a specific figure as determined by the switch position. This switch does not influence the ESD waveshape development or the development of the multiple pulses discussed in Paragraph 3.1 .

5.7 AMPLITUDE ESTABLISHMENT

Considering the discussion of Section 3.0 through 4.2, it should be recognized that a thorough ESD Test must be performed utilizing incrementally ascending amplitudes, as a test series. It is recommended that each test location be subjected to test at 2.5 kV increments in the series 2.5, 5.0, 7.5, 10.0, 12.5, et cetera, to assure that each test location will receive the variety of spectrum shapes possible.

5.8 PROBE TIPS

The probes have been designed to utilize specific tips that are required in order for the appropriate waveform to be developed. These are listed below.

Probe Type	Tip Required	Simulation
P255-1	Conical	Human with small intervening object (keys, pens, coins)
P255-2	Sphere W/Disc	Humans/furnishings (Desk Chair)

P255-X Other condition probes per request.

Use of other tips will distort the intended ESD simulations. It should be noted, however, that use of a sphere on the P255-1.

probe at levels equal to or greater than 15 kV may be required to minimize corona loading when used in high relative humidity test environments.

5.9 RELATIVE HUMIDITY

The moisture content in the test environment can impact the propagated ESD waveform within a product. Some products tend to exhibit greatest sensitivity when the relative humidity levels are lowest. Allowing the relative humidity to greatly vary in the test environment may significantly influence the test results causing measurement instability. Testing ESD levels at high relative humidities may artifically improve the test results. It is recommended that the ESD tests be performed under a reasonably stabilized relative humidity environment between approximately 30 % to 45 %, with a temperature between 65 F. and 75 F. ESD tests above 7.5 KV should be avoided at relative humidities of 60 % or greater.

5.10 IMPULSE QUANTITIES

At any established ESD amplitude, a variety of impulse waveshapes are possible due to random changes in the velocity of probe approach and specific arc-path changes due to the characteristics of the surface of each location. In order to assure that a reasonable distribution of these amplitude-specific variations is experienced during tests, it is recommended that each test location at each test amplitude be subjected to 50 pulses. This requires about 30 seconds test time at each test location at each amplitude using the "2 PPS" inhibit rate on the ESD-255. Always allow the ESD-255 to recover to the desired level by monitoring the front panel meter.

5.11 PROBE MOTION-DISCHARGE

With the ESD255 at the desired amplitude, simply move the probe toward the test location until discharge or contact occurs. Random probe motion will develop randomly normal pulses. Remember that multiple pulses will develop with the ESD255 in a manner similar to the development of multiple pulses in the "Actual" event. This means that a 10 kV initial impulse, for example, will produce pulses at lower voltages, assuming that probe motion is continued toward the test location until contact is made. Accordingly, if the unit-in-test had been found susceptible to 1 kV or 2 kV levels, for example, then a full-probe-motion based 10 kV event could cause susceptibility as 1 kV or 2 kV pulses are randomly struck. To develop only the initial pulse, simply move the probe forward until the first

pulse occurs, then stop and reverse the probe motion. A product found not to be susceptible to incrementally ascending levels below a higher test amplitude should not be susceptible to the decending amplitude multiple-pulse developments, but may be susceptible to the higher initial level.

5.12 PROBE SELECTION

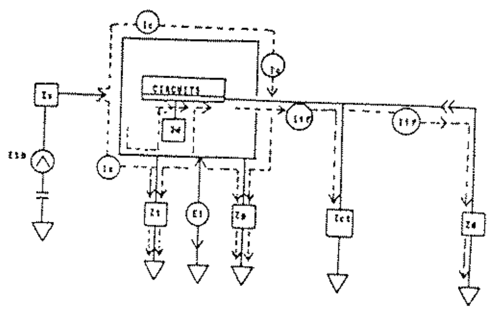
The ESD255 makes it possible to expose various product surfaces to various characteristic waveform simulations as would be appropriate in "Actual" circumstances. Waveforms from Human Simulation Probes should be applied to those product areas where human contact is probable, and to plane surfaces that simulate radiated fields form adjacent conductive structures. Waveforms from human/furnishing simulation probes should be applied to those product areas that may be impacted by desk chairs, mobile files, push or grocery carts, and to plane surfaces simulating radiated fields from adjacent fixtures.

6.0 TEST APPLICATIONS

It may be recognized that the complexity of the ESD phenomena can combine with other complexities that are attributable to systems installation conditions. Considering this conditional-dependency the following is offered to assist in understanding a thorough test approach.

ESD PROPAGATIONAL FLOW

Consider the following simplified diagram:



Where:

Zs	=	Source impedance of ESD events
Zt	=	Distributive transfer impedance of case-to-ground, a variable
Zp	=	Impedance of external power to ground (including ground wire)
Zct	=	Distributive cable transfers
Zd	=	Direct transfer impedance within interconnected product
Ic	=	Case-injected impulse current
Iif	=	Interface cable exit current
Ei	=	Impulse field gradient

In the above diagrammatic model an impulse is applied to the case/chassis of a product through an impedance of the impulse ESD source, Zs. Immediately upon application, an impulse case-current, Ic, is developed. The Ic case current, apart from developing fields within the case (not diagrammed), initially form a branch current at higher frequencies through the variable Zt distributive transfer impedance of the unit-in-test to ground. This transfer is paralleled at lower frequency components by Zp,(the coupling of power and power ground wires to ground). These components of the loop flow model result in the formation of a field gradient, Ei, from the case/chassis to ground.

TEST APPLICATIONS

The formation of Ei permits the excitation of an interface "exit" current Iif, in the external interface cables to the product, sourced through the distributive transfer direct impedances, Zd, between the logic circuits and the case/chassis.

The interface exit current, Iif, is loaded by a combination of distributive transfers from the cable to ground, Zct, at higher frequencies that are paralleled by directly conducted impedances, Zd, in connected products.

From the simplified model, it may be recognized that a significant interdependency exists during ESD tests between the variable values of: Zt, and Zp; Zct and Zd; all are driven from the source, Zs. These alter the relative magnitudes of Ei, Ic and Iif.

Considering this interdependency, the ESD susceptibility response from a unit under test may vary as a function of the test arrangement and condition. Accordingly, it is suggested that the user of the ESD255 standardize on a stable set of test arrangement conditions in order to:

a. Simulate various conditions of product installation in end-use circumstances; and,

b. Stabilize the ESD test results under each of these conditions. Usually such stabilization requires (and are not limited to) standards for relative humidity, temperature, interface cable conditions and distance of the product under test from the ground plane, and other adjacent grounded structures.

<u>EXAMPLES</u> of 'a.' above:

1. Place a table-top product above a conductive table plane, isolated by an insulator, to test for effects of worst-case currents in the product case when subjected to direct events. (Effect of Zt and Ic maximized).

2. Place the table-top product above a non-conductive plane/table. When case-direct ESD is applied the worst-case interface cable currents will be developed. (Effect of Zct and Iif maximized, Zt and Ic minimized).

3. Evlauate for radiated field effects by discharging to structures, or standard simulations of structures, that may be immediately adjacent to the product in actual-use installations. Examples of such structures are metal mail trays and card files on desk-tops, file cabinets and furnishings on floors.

4. Use the correct probe-simulation on the appropriate product or radiated structure location as would be anticipated under actual-use conditions. For Example use a P-255-1 Probe on product areas that are likely to be contacted by hands. Use the P-255-2 Probe on product areas or radiated structures that may be impacted by furnishings.

ESD-255 ELECTROSTATIC DISCHARGE GENERATOR

OPTION "A"

DESCRIPTION

OPTION "A" consists of a 4 digital counter installed in the ESD-255. It counts and displays the discharge events from the probes of the ESD-255. The counter operates over an initialization voltage level from 500 to 25,000 volts. It permits the operator to count discharges while scanning an equipment to determine it's immunity level.

The discharge pulse is coupled from pin 9 to U1B via R401 and CR401 to input pin "F" of the counter. The + 9 volts of the ESD-255 is regulated to 5V via U401 through S401 to pin K of the counter. S402 is the reset switch for the counter. Refer to ESD-255 schematic and Figure 1 below.

OPERATION

1) Energize the ESD-255 with it's panel "ON" switch.
2) Energize the counter with it's "ON" switch.
3) An "E" will appear on the counter. Press the "RESET" switch and zeros will appear.
4) Set the output of the ESD-255 for the desired voltage level from 500 to 25,000 volts.
5) When the operator discharges the probe to the unit under test the counter will count every discharge.
6) To reset the counter and reinitiate the count, press the "RESET" switch.

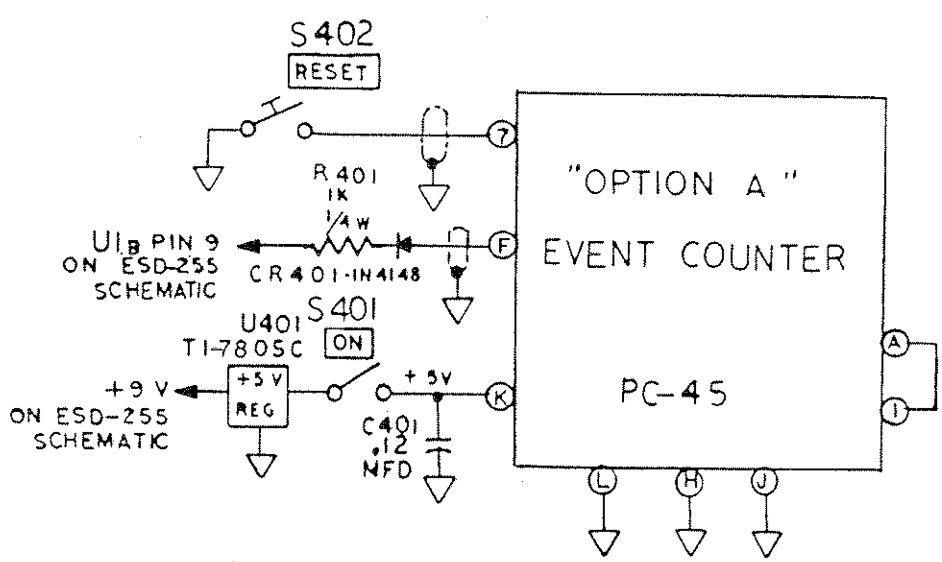


FIGURE 1

ADDENDUM NO. 1

The following modifications have been added to this ESD-255 Electrostatic Discharge Generator:

DESCRIPTION: (See Figure 1)

1). Discharge Control Circuitry.
2). Pistol Grip Handle, Cable and Plug.
3). Pulse Rate Switch.

a). 1 pulse per 2 seconds
b). 1 one pulse per second
c). 2 two pulses per second
d) Fast (Allows pulses at a fast rate to permit operator to search his unit under test to ferret the vulnerability areas of his product).

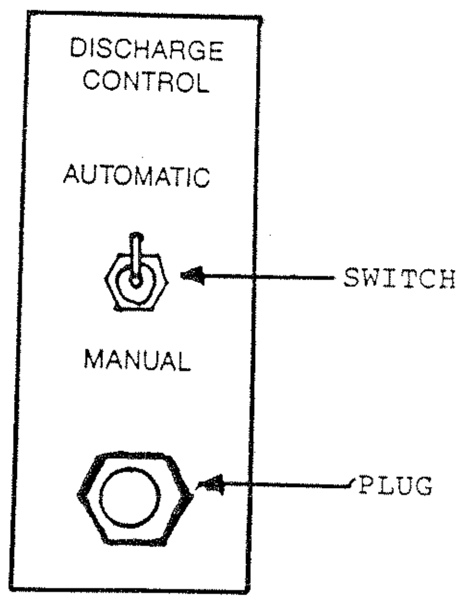


FIGURE 1

OPERATION

AUTOMATIC OPERATION:

1). Switch the Discharge Control Switch to the Automatic position.

2). Adjust the Output Control to the desired level as indicated on the Panel Meter.

3). Select the desired pulse rate position.

CAUTION: In the Automatic Position the Probe Tip is always at the potential as indicated on the Panel Meter.

MANUAL OPERATION:

1). Switch the Discharge Control Switch to the Manual Position.

2). Attach the Pistol Grip Handle to the Probe Mounting Bracket.

3). Snap the Probe Mounting Bracket to the Probe.

4). Insert the Plug on the Pistol Grip Handle Cable into the Panel Jack.

5). Depress the Trigger Switch on the Pistol Grip and adjust the Output Control to the desired level as indicated on the Panel Meter.

6). Select the desired Pulse Rate by the Pulse Rate Switch.

The voltage level is at the Probe Tip only when the Trigger on the Pistol Grip is depressed in the Manual Position.