INSTRUCTION MANUAL

MODEL ESD-255 ELECTROSTATIC DISCHARGE GENERATOR

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MODEL ESD-255

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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: $\pm$ 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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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.

THEORY OF OPERATION

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.

2.1 THEORY OF CIRCUIT OPERATION

The theory of operation of the charging source is described with reference to the Block Diagram illustrated in Figure 1.

The Power Circuits provide plus and minus 9 volts from the applied AC input power. The minus 9 volt DC provides the energy necessary to generate the output potential. The plus 9 volt DC is used to power the control and metering circuits. Therefore, these circuits are isolated from any loading effect of the variable energy required by the variable output potential. A synchronization signal is also developed within the power circuits for use by the Variable Pulse Generator.

THEORY OF OPERATION

The Synchronous Variable Pulse Generator circuit consists of a micro-electronic "timer" circuit and two timing components. The timer is triggered "on" by the 60 Hertz sync signal provided by the power circuits and "off" when the timing waveform falls below the internal timer threshold. The "on" time is determined by the timing components, one of which is a potentiometer which is varied by the output control knob. With the control set to minimum, the "on" time is essentially zero and the generator output potential is zero. As the control is rotated clockwise from zero, the "on" time increases proportionately to the potentiometer resistance thereby generating an increasing output potential.

The Pulse Power Amplifier serves a dual purpose. First, the timer output pulses which switch between +9 volts and ground are translated to switch between ground and negative voltage. Secondly, the current drive capability of the pulses is amplified to approximately 8 amperes which is needed to drive the primary of the High-Voltage Step-Up Transformer (SUT). The pulse amplifier also includes protective devices to prevent transients which may develop within the transformer from damaging the amplifier circuits.

The High Voltage Module and output power of the High-Voltage SUT are integrally encapsulated to eliminate any possibility of corona. As the width of the drive pulses is increased by the Output Control, peak current in the primary of the SUT increases, as does the stored energy. When the current flow is terminated, the inductive reaction causes a high voltage pulse in the SUT secondary and the stored energy is transferred into the High Voltage Module. Storage Capacitors within the Module serve to filter the pulses and store the energy as a DC voltage equal to the desired output potential. The module also contains a precision voltage divider to provide a low voltage output which is proportional to the output potential.

The Metering Circuits consist of a current amplifier and universal shunt which provide a dual scale precision indication of the output potential. When the "low" meter range is selected, the current amplifier develops the full scale current required by the meter with only a low-input current from the High Voltage Module. For the "high" meter range, the amplifier output current is shunted by the required scale factor.

After each discharge of the output network, the Discharge Sensor provides a delay before the potential is allowed to again build up. This prevents undesirable D.C. "relaxation oscillator" discharge effects from the probe. The instant of output discharge is sensed via a capacitor divider and used to trigger a microelectronic "timer" circuit. This circuit, in turn, disables the timer circuit in the Variable Pulse Generator preventing recharge of the output network. The disable period is determined by the timing components and is switchable using the Pulse Rate Selector between 1/2, 1, and 2 seconds. These disable periods provide respective pulse rates of 2, 1, and 1/2 pulses per second. After the disable period the discharge timer resets allowing build up of the output potential to provide a subsequent static discharge. During the disable interval, the probe will provide multiple ESD impulses in the same approximate periodicity as would be anticipated during the "actual" ESD events that the particular probe is intended to simulate. The rate and periodicity of such multiple events are dependent on the probe characteristics and the velocity of approach to the surface being subjected to the discharge. (See Section 3.1).

2.2 DETAILED CIRCUIT DESCRIPTION

Refer to Schematic Diagram, Figure 2 for purposes of this description. Power Circuits- The AC power input is filtered for RFI by LF1 and then applied to the primary of transformer T1 via fuse F1 and switch S1. DS1 is the power "on" indicator. The 12.6 VAC center-tapped output of T1 is full wave rectified by CR1 and CR2 to provide plus 9 volts DC. Capacitors C1 and C2 provide ripple filtering and high frequency filtering respectively of the DC voltage. Similarly, CR3 and CR4 provide minus 9 volts DC with filter capacitors C3 and C4. A ground reference sync signal of approximately 10 volts amplitude is developed by capacitor divider C5 and C6 in conjunction with diode CR5.

Synchronous Variable Pulse Generator- One-half of a dual micro-electronic timer, type 556, and associated timing components comprise the Synchronous Variable Pulse Generator. Timing capacitor C7 is initially charged from +9 VDC via re-

sistor R11 and R1, the output control on the front panel. The sync input waveform is applied to Pin 2 of U1A, the threshold input of the timer, which is internally referenced to two-thirds of the supply voltage.
When the trigger threshold is exceeded pin 1 switches low and begins discharging C7 via R1, the output control. The timer remains triggered until the voltage on pin 6, which is connected to C7, falls below the internal reference of one-third the supply voltage. Thus, the trigger period will vary between essentially zero, when R1 is shorted, and a maximum of several milliseconds, when R1 is rotated to maximum. The timer output, pin 5, is switched low during the trigger period and resistor R9 couples this signal to the Pulse Power Amplifier. Resistor R10 provides sink current into pin 5 while the timer output is low. Diode CR6 discharges the sync waveform capacitors to assure that the timer triggers only once during each cycle of the input power. Capacitor C8 provides high frequency filtering from pin 3 to ground for the reference voltage within the timer. The inhibit control for timer U1A, pin 4 is biased by R20.

Pulse Power Amplifier - Transistors Q4, Q5, Q6 and associated components comprise the pulse power amplifier which drives the primary of the High Voltage Step-Up Transformer, T2. When timer U1A is untriggered, its quiescent state, the voltage at the input end of coupling resistor R9 is high. This causes the base of NPN transistor Q4, connected as an emitter follower with grounded collector, to be positive with respect to ground. Therefore, Q4 is saturated and sources all current required by R7 thereby maintaining PNP grounded emitter amplifier Q5 biased off. With no current flow in Q5, Q6 is also biased off by base-emitter resistor R12; thus no voltage is applied to the primary of T2.

When the timer is triggered, its output is low and R6 drives Q4 base negative allowing R7 to drive Q4 emitter negative until the forward bias threshold of Q5 base is reached. At this point, Q6 begins to turn on and apply a positive going voltage to the primary terminal of T2 primary.

It is necessary to stretch the risetime of the primary input voltage to prevent ringing of the primary current and to assure smooth and gradual operation of the output control at low settings. This is accomplished by feedback coupling from Q6 emitter to Q4 base via capacitor C9 and diode CR7. Under this condition, the Power Amplifier is an active linear feedback amplifier controlling the rate of rise of the transformer primary voltage. During this action the value of C9 and R8 determines the voltage rate of rise and C10 provides high frequency roll-off within the feedback loop. For wide pulse widths, Q5 saturates which terminates the feedback action allowing Q4 to become biased full off.

While voltage is applied to T2 primary, current continues to increase as determined by the primary time constant. When the trigger period terminates, Q4 switches on rapidly biasing both Q5 and Q6 off. When this occurs, the inductive reaction in T2 primary couples the stored energy to the high voltage secondary. The negative induced primary voltage is restricted to a safe value for Q5 and Q6 by zener diode CR8. Positive ringing voltages from T2 primary are clamped by CR9 thereby preventing the application of excessive reverse voltage to Q6.

2.3 HIGH VOLTAGE MODULE AND STEP-UP TRANSFORMER

The high voltage output from T2 Secondary is coupled to the network in the High Voltage Module by diode CR1. The diode also isolates the network from being loaded by the secondary during the quiescent time between voltage pulses. Energy storage and filtering of the DC potential is provided by the series equivalent capacitance of capacitors C1, C2, and C3. Resistors R1 through R6 are precision high-voltage resistors which, in conjunction with precision resistors in the Metering Circuit, allow accurate measurement of the DC output potential. R7 limits the voltage that could appear at the metering mode in the event the metering connection develops an open-circuit. Resistors R8 thru R16 limit the current that is available at the output when the High Voltage Probe is disconnected from the high voltage coaxial cable.

Metering Circuits - Transistors Q1, Q2, and Q3 comprise a three(3) transistor current amplifying "mirror". Q3 has very high current gain, therefore virtually all of the current from the high voltage resistor network flows in Q2 emitter and through R4 and R5. The common base connection of Q1 and Q2 causes the voltage at Q2 emitter to be "mirrored" to Q1 emitter. Since R2 and R3 are lower in value than R4 and R5, current amplification results. Q3 provides any necessary base current for Q1 and Q2 plus any leakage current in C11. Capacitor C11 establishes the decay and recovery rate of the meter for each high voltage discharge. C12 filters high frequency transients that could overstress the amplifier transistors.

The amplified current flows in Q1 collector and is coupled by R17 to the meter range switch and meter shunt circuit. R1 sources the meter current from +9 volts and also limits available current to a safe value in the event of an accidental short circuit. R17 and C13 filter high frequency transients that could overstress the amplifier transistors.

Resistors R2 and R3 on the control panel comprise a universal Aytron shunt for the meter. This arrangement provides a 5 to 1 ratio of high to low meter current which is independent of meter resistance.

In order to establish a reference standard within the metering circuit, R5 is factory selected so that a calibrated 4.00 volts appears at TP1 when the output potential is set at 20.0 KV. Secondly, R3 is factory selected for a meter reading of 20.0 KV when the TP1 calibrated voltage is 4.00 volts. In this manner, any inaccuracy that could result from initial tolerance of metering components is eliminated.

<u>Discharge Sensor and Pulse Rate Selector</u> Transistor Q7, timer U1B and associated components comprise a discharge sensor and delay inhibit circuit. Under quiescent conditions, Q7 is biased on by R15 and holds Pin 12 of U1B low, therefore the timer remains in the untriggered state. When a discharge occurs, the negative transition is capacitively divided by the coupling wire and C14, then coupled to the base of Q7 by R16. Diode CR10 limits the transition at Q7 base to a safe value. The transition biases Q7 off, causing a positive transition at Pin 12 of U1B which triggers the timer. Pi~ 13, the discharge output of U1B, switches low and discharges the timing capacitor of U1A, thereby inhibiting operation of the Synchronous Pulse Generator Circuit.

The timer output, Pin 9 also switches low and begins discharging timing capacitor C15 via R13 and resistors R4 and R5 on the control panel. The timer remains triggered until the voltage on Pin 8, which is connected to C15, falls below the internal reference of one-third the supply voltage. Thus, the trigger period will vary between 0.5 and 2 seconds depending on the selected position of the Pulse Rate Selector Switch. When timer U1B resets, timer U1A is no longer inhibited and the output potential is allowed to be re-established at the selected level. Diode CR11 allows timing capacitor C15 to be recharged rapidly in preparation for subsequent output discharges. The inhibit control for timer U1B Pin 10, is biased inactive by R20.

2.4 PROBES

The dynamic impulse waveform characteristics are developed entirely within the probes connected to the output of the ESD-255. To prevent interaction of the inductive and capacitive properties of the output high voltage coaxial cable with the "ESD Network" within the probes, each probe contains a 5,600 ohm (non-inductive) resistor between the high voltage coaxial connector (on the probe) and the internal probe network. The "ESD Network" within the probe is the proprietary design of Andy Hish Associates, but consists of the multiple circuit parameters required to develop the applicable simulations desired.

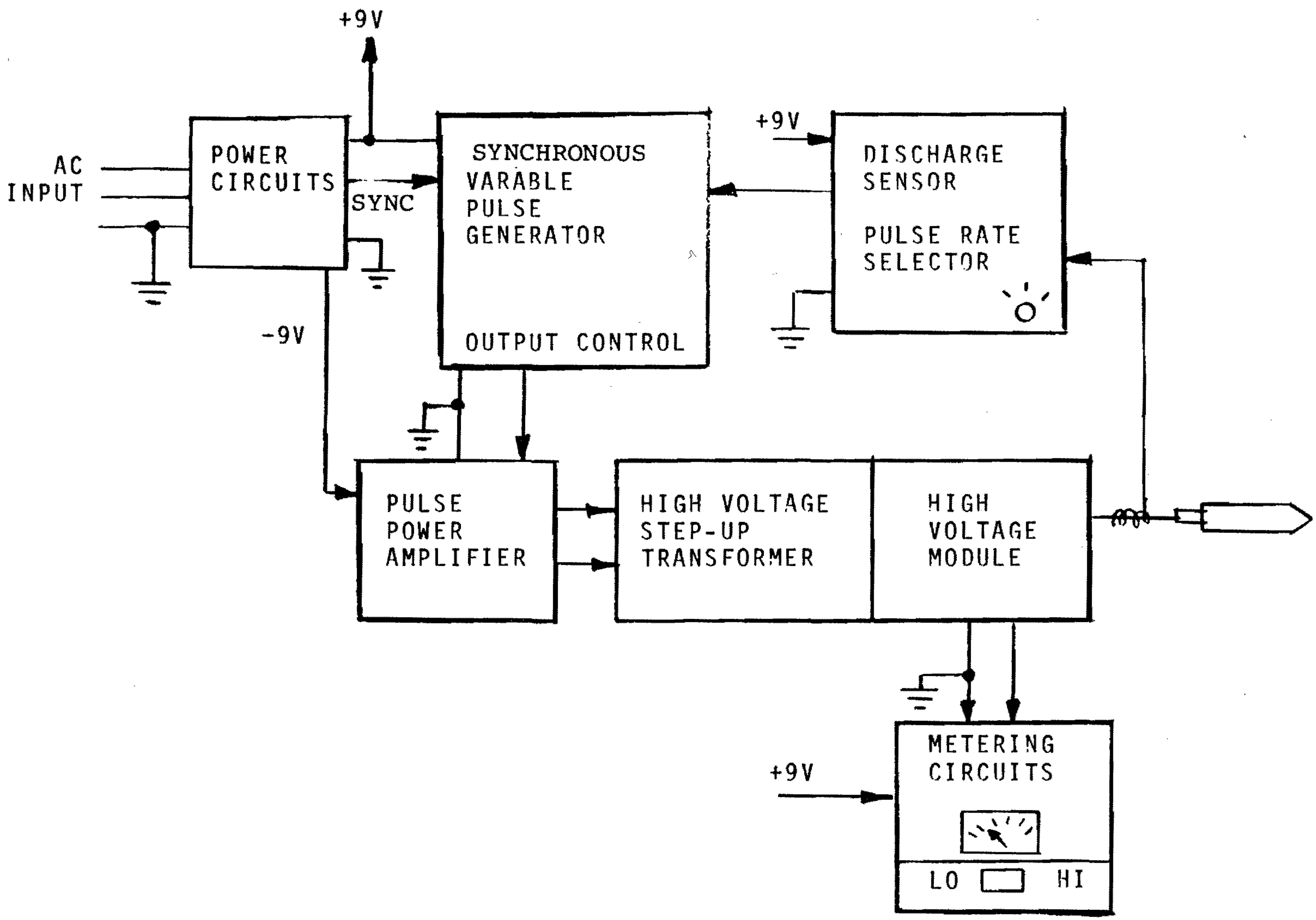
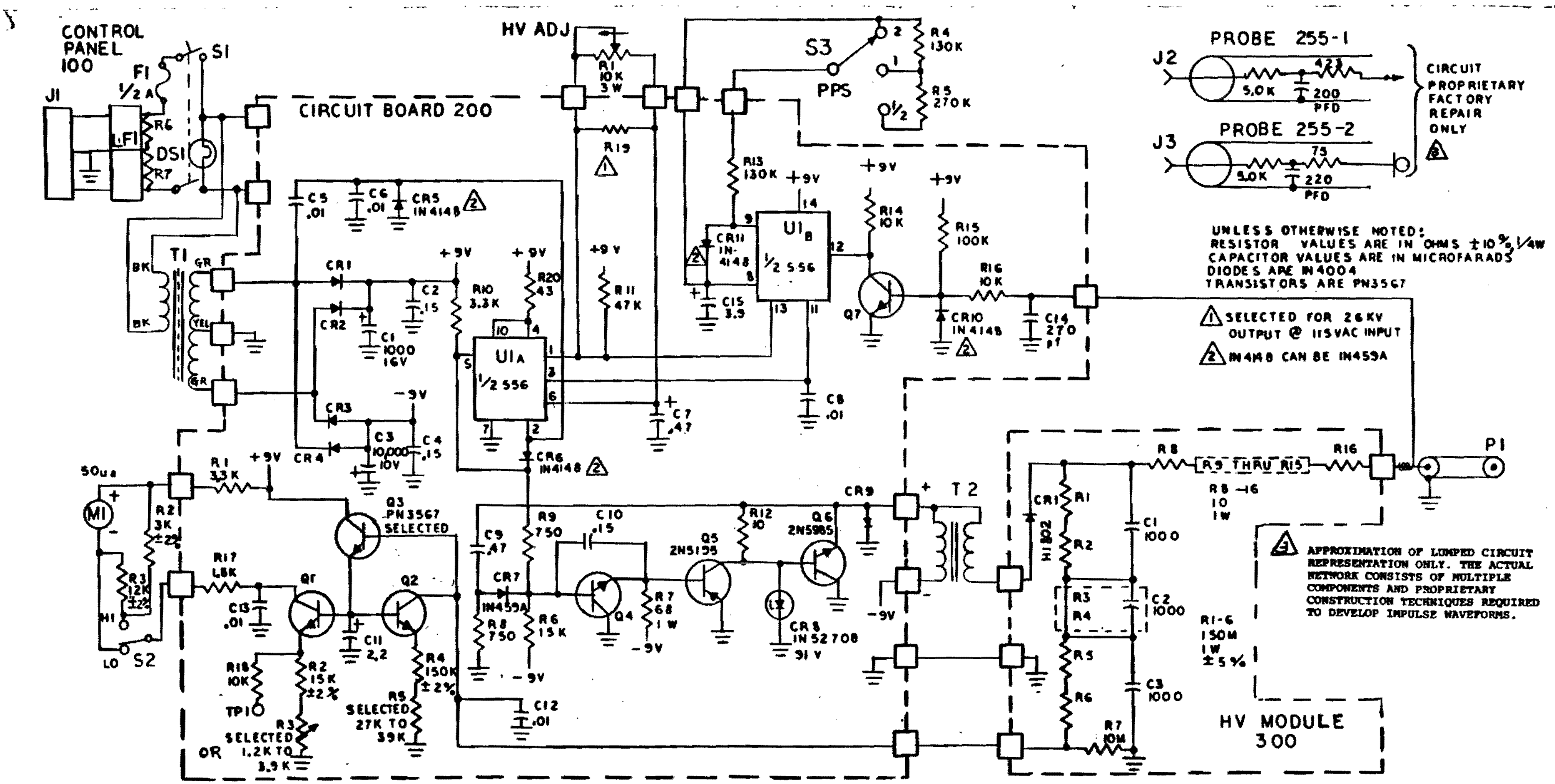


FIGURE 1. BLOCK DIAGRAM



SCHEMATIC, ELECTROSTATIC DISCHARGE GENERATOR. MODEL ESD 255

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.

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.

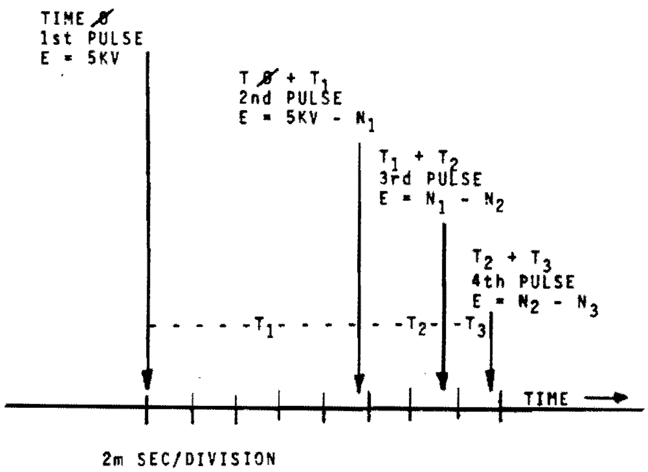


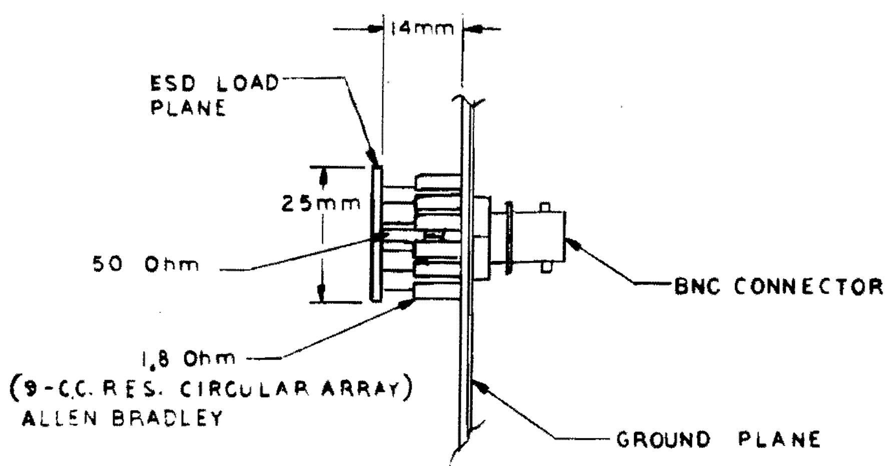
ILLUSTRATION 3-1

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, 1.0 AMP 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).

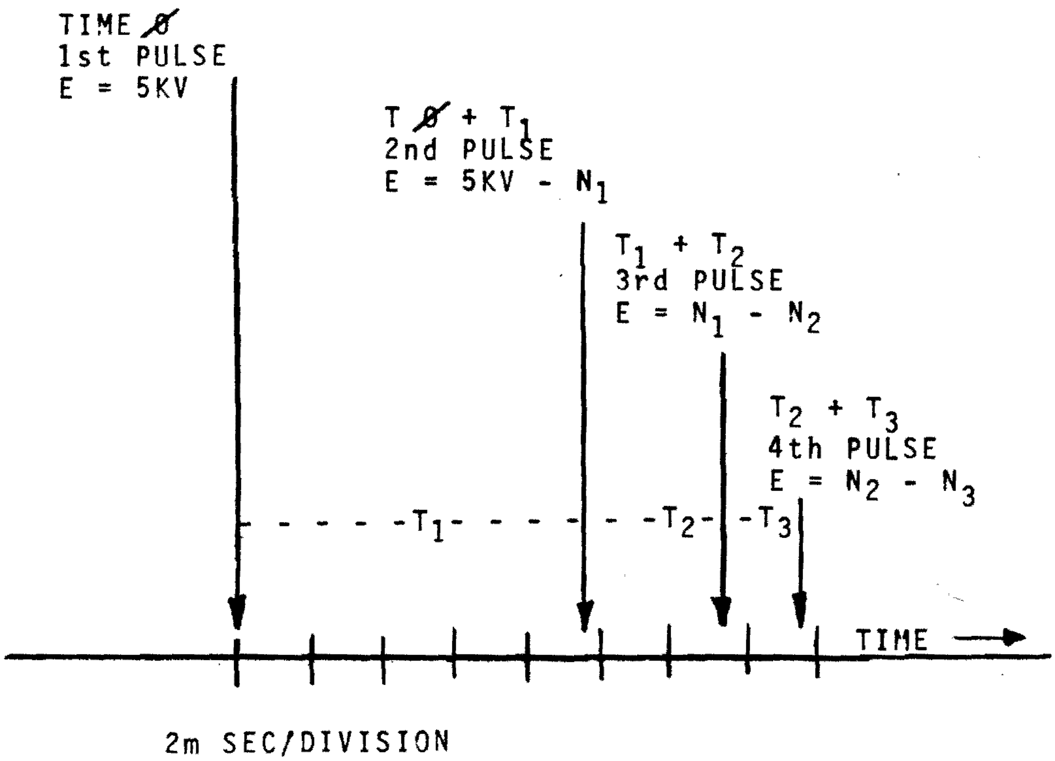


ILLUSTRATION 3-1

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

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).

OPERATING INSTRUCTIONS

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

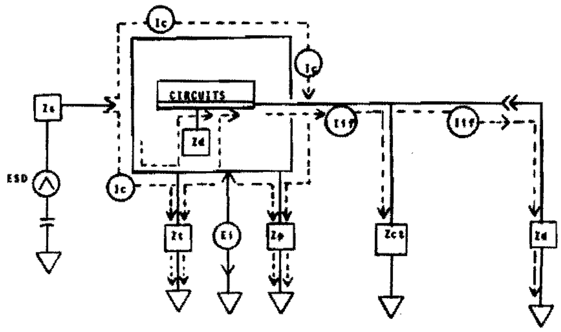
The ESD255 makes it possible to expose various product surfaces to various characteristic waveform simulations as would be appropriate in "Actual" circumstances. Waveforms from Human Simulation Probes should be applied to those product areas where human contact is probable, and to plane surfaces that 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 PARTS LIST

CHASSIS/PANEL PARTS (100)

SYMBOL	DESCRIPTION	MFGR
DS1	LAMP	SOCAL
F1	FUSE,3AG-1/2A	LITTLEFUSE
LF1	FILTER,LINE,EMI	CD,POTTER,CORCOM
J1	JACK,AC POWER,(P/O LFI)	
M1	METER,PANEL.50uA	AHA
P1	CONNECTOR,HV.	REYNOLDS
R1	RESISTOR,VAR.10KOHMS	MALLORY,ALLEN, BRADLEY
R2	RESISTOR,FILM.3KOHMS,1/4W,2%	KOA
R3	" " 12KOHMS, " "	"
R4	" " 130KOHM, " "	"
R5	" " 270KOHM, " "	"
R6	RES,CARBON,1MOHM,1/2W,5%	AB
R7	RES.CARBON,1MOHM,1/2W,5%	AB
S1	SWITCH,DPDT,TOGGLE.	AHA
S2	" " SLIDE	SWITCHCRAFT
S3	" 3POS.ROTARY	CTRL
T1	TRANSFORMER,POWER.115VAC,50-400HZ.OR, 230VAC,50-400HZ	STANCOR(P8384) " (P8715)
T2	" HIGH VOLTAGE,25KV	AHA P/O HV MODULE (300)
W1	COAX CABLE RG213/U 6(FT)	" "
W2	CABLE,BRAID WITH CLAMP 6(FT)	" "

CIRCUIT BOARD ASSEMBLY (200)

SYMBOL	DESCRIPTION	MFGR
C1	CAPACITOR,AL.1000uF,16V	SPRAGUE
C2	" CER,.15uF,50V	CGW
C3	" AL 10,000uF,10V	SPRAGUE
C4	" CER,.15uF,50V	CGW
C5	" CER,.01uF,100V	CTL
C6	" CER,.01uF,100V	"
C7	" TANT,.47uF,35V	SPRAGUE
C8	" CER,.01uF,100V	CTL
C9	" MYLAR,.47uF,200V	SPRAGUE
C10	" CER,.15uF,50V	CGW
C11	CAPACITOR,TANT,2.2uF.20V	SPRAGUE
C12	" CER,.01uF,100V	CTL
C13	" CER,.01uF,100V	"
C14	" CER,270pF,1KV	"
C15	" TANT,3.9uF,10V	SPRAGUE
CR1	RECTIFIER,IN4004	MOT

CIRCUIT BOARD ASSEMBLY (200)

SYMBOL	DESCRIPTION	MFGR
CR2	" "	"
CR3	" "	"
CR4	" "	"
CR5	DIODE,IN459A	FSC
CR6	" " "	"
CR7	" "	"
CR8	ZENER,91V,5%,IN5270B	MOT
CR9	RECTIFIER,IN4004	"
CR10	DIODE,200V,IN459A	FSC
CR11	DIODE,200V, "	"
Q1	TRANSISTOR,NPN,3567-2	FSC
Q2	" " "	"
Q3	" " 3567-1	"
Q4	" " 3567-3	"
Q5	" " 2N5195	NSC
Q6	" " 2N5985	MOT
Q7	" " 3567-2	FSC
R1	RESISTOR,FLM,3.3KOHMS,1/4W,5%	KOA
R2	" " 15KOHMS,1/4W,2%	KOA
R3	" CER,VAR,5K,1W,2% OR SELECTED VALUES RANGE FROM 1.8KOHMS TO 3.9KOHMS.	CTS,KOA "
R4	" 150KOHMS 1/4W,2%	"
R5	" SELECTED VALUES,RANGE FROM 2.7 TO 39KOHMS	" "
R6	" " 15KOHMS "	"
R7	" " 68 OHMS "	"
R8	" "750 " ",5%	"
R9	" " " " " "	"
R10	" " 3.3KOHMS ",5%	"
R11	" " 47 " " "	"
R12	" " 10 OHMS " "	"
413	" "130 KOHMS ,2%	"
R14	" " 10 " ",5%	"
R15	" "100 " " "	"
R16	" " 3.3 " " "	"
R17	" " 1.8 " " "	"
R18	" " 10 " " "	"
R19	" SELECTED VALUES RANGE FROM 15KOHMS TO 39KOHMS.	"
R20	" 39OHMS, " "	"
UI	I.C.DUAL TIMER NE556B	SIG

HV MODULE (300)

SYMBOL	DESCRIPTION	MFGR
C1	CAPACITOR,CER,1000pf,10kv,20%	MAIDA
C2	" " " " " "	"
C3	" " " " " "	"
CR1	DIODE,HV RECTIFIER,30KV	VARO
R1	RESISTER,FLM,150KOHM,1W,5%	KDI
R2	" " " " " "	"
R3	" " " " " "	"
R4	" " " " " "	"
R5	" " " " " "	"
R6	" " " " " "	"
R7	" " " " " "	AB
R8	" " 10 " " 10	"
R9	" " " " " "	"
R10	" " " " " "	"
R11	" " " " " "	"
R12	" " " " " "	"
R13	" " " " " "	"
R14	" " " " " "	"
R15	" " " " " "	"
R16	" " " " " "	"

ALL PARTS OF THE HV MODULE (300)
ARE FACTORY REPAIRABLE ONLY AND ARE LISTED FOR REFERENCE

BULLETIN 057255-1

VERIFICATION PROCEDURES
ELECTROSTATIC DISCHARGE GENERATOR MODEL ESD255

The ESD-255 Electrostatic Discharge Generator simulates the impulse waveforms produced by the electrostatic discharges of persons. The P255-1 probe simulates the conditions of an electrostatic discharge of a person through a small metal object that is hand-held, such as a coin, ring, key, or metal barrel ball point pen. The P255-2 probe simulates the discharge of a human with and through a furnishing, such as a desk-chair or push-cart.

To verify proper operation of the ESD-255 Electrostatic Discharge Generator, two basic test types are required. One to determine the accuracy of the initializing level as shown on the front panel meter; and one to determine the dynamic impulse performance of the high level discharge. An additional check for the inhibit time function is included.

1.0 INITIALIZATION LEVEL VERIFICATION.

Equipment required:

High voltage D. C. meters, capable of plus-or-minus one percent accuracy at 5,000 V DC and 20,000 V DC. The DC voltmeters must have a minimum measurement impedance of 1,000 Megohms. (The DC source impedance of the ESD-255 is approximately 200 Megohms).

1.1 MEASUREMENT PROCEDURE

a) With the output control of the ESD-255 fully counter clockwise, and the power switch set to "OFF", connect power to the input connector of the ESD-255 using the Power Cable supplied.

b) Set the ESD-255 front panel controls as follows:

"Range Switch" - Low (0-5 kV)
"Rate Switch" - 2 pps

CAUTION: HIGH VOLTAGE WITH HIGH CURRENT IMPULSES ARE PRESENT AT THE TIPS OF THE TEST PROBES. DO NOT CONTACT THE PROBE TIPS DURING TESTS AS A SHOCK WILL OCCUR!

c) Connect the P255-1 (or other ESD-255 Series) probe to the coaxial high voltage connector of the test set.

d) Connect the high voltage DC meter to the tip of the P255-1 probe and to ground of the test set ESD-255. The probe shell may be used as ground.

e) Energize the ESD-255, and adjust the front panel meter indication to 5,000 volts on the low range.

f) Observe the high voltage DC meter. The meter should correlate with indication on the ESD-255 within plus-or-minus 5%.

g) Turn the ESD-255 voltage control fully counterclockwise, and position the "range" switch to the high position.

h) Change the scale of the DC measurement voltmeter if required.

i) Adjust the indication of the ESD-255 to 20,000 volts and observe that the high voltage measurement meter correlates with the indication on the ESD-255 within plus-or-minus 5%.

CAUTION: High voltage corona may be present during this test, particularly in high environments of relative humidity. It is recommended that this test segment be performed with the ambient facility relative humidity levels under 55%. High relative humidity can alter measurements through corona.

j) Turn the level adjustment of the ESD-255 fully counter-clockwise, and turn the power switch "OFF".

k) Disconnect the P255-1 probe and replace with the P255-2 probe, or other ESD-255 probes under evaluation.

Repeat the preceeding steps b through j with P255-2 (or other) probes connected to the ESD-255.

2.0 INHIBIT TIME VERIFICATION.

The ESD-255 provides a three position switch to control the inhibit time between probe initialization cycles. This is marked 0.5, 1.0, and 2.0 (pulses enabled per second). On the detection of the leading edge of the discharge impulse, the internal power supply of the ESD-255 is inhibited for the period of time indicated on the front panel switch. (See "Theory of Operation") The inhibit time is intended for the convenience of the user, and does not effect the impulse waveform accuracy in any manner. Accordingly, only an approximate check is required to determine if the inhibit time is approximately as indicated by the switch selection.

To perform the check:

a) Set the front panel meter range switch to the "high" position.

b) Adjust the indicated voltage on the ESD-255 meter to 5,000 volts with either probe connected.

c) Set the inhibit time switch to the 0.5 pps position.

d) Discharge the ESD-255 probe to the case of the test set.

e) Time the duration of the inhibit from the zero point of the discharge to the point where the ESD-255 front panel meter starts to move.

f) At the 0.5 pps position, the approximate time should be 2.0 seconds.

g) At the 1.0 pps position, the approximate time should be 1.0 second.

h) At the 2.0 pps position, the approximate time should be 0.5 seconds. (Precise time durations are not possible due to the deflection time constants of the front panel meter).

Note: This is a check for function only.

APPENDIX "A"

3.0 DYNAMIC IMPULSE VERIFICATION

Equipment Required:

1) Tektronix Model 7104 Oscilloscope System, Model 7104 with type 7A29 vertical amplifier. Either a type 7B15 or type 7B10 Time base may be used.

NOTE: It is imperative that the Oscilloscope System utilized provide a real-time bandwidth of at least 1.0 GHz with a write speed of 200 pico-seconds.

2. Hish Measurement Load Model ML-255 (0.1 volts/ Amp). See description of alternate load, Section 3.2.

3.1 MEASUREMENT PROCEDURE.

a) With the output control of the ESD-255 fully counter-clockwise, and the power switch set to "OFF",connect power to the input connector of the ESD-255.

b) Connect the P255-1 probe to the high voltage coaxial connector of the ESD-255, and ground the test set per Section 5.3 to the test bed ground plane.

c) Set the ESD-255 front panel controls as follows:

"Range Switch" - Low Scale
"Rate Switch" - 1.0 pps

d) Set the Oscilloscope to the following display requirements.

Time Base: One nanosecond/Division
Amplitude: One volt Division
Baseline position: One division from bottom of graticule
Trigger: Internal, DC coupled
Intensity: Full
Sweep: Single trace inhibited for additional traces.

e) Apply power to the ESD-255 with the P255-1 probe, and adjust the indicated meter level to 2.0 kV.

f) Discharge the P255-1 probe to the discharge surface of the ML-255 measurement load, making direct contact between the conical tip of the P255-1 and the surface of the ML-255.

NOTE: The performance of the P255-1 probe is only valid at this level with the conical tip attached.

g) Perform fine adjustments to the Ocilloscope as required to observe the waveform.

NOTE: The Ocilloscope may be susceptible to the impulse energy, resulting in an erratic horizontal sweep. The purpose of the ground plane test bed (Fig. 1) and the spacing between the Oscilloscope and the ML-255, is to provide a stable measurement reference plane, and minimize possible susceptibility from the Oscilloscope. For some Oscilloscopes additional shielding may be required.

h) The waveform produced at the 2.0 kV test level should resemble those illustrated by (Fig. 2A, 2B) as a average of twenty impulses applied to the ML-255.

i) Set the ESD-255 front panel controls as follows:

"Range Switch" - High Scale
"Rate Switch" - 1.0 pps

j) Set the oscilloscope to the following display requirements:

Time Base:	Twenty Nanoseconds per Division
Amplitude:	50 millivolts per Division
Baseline:	Trigger and Intensity as needed for display.

k) Apply power to the ESD-255 with the P255-1 probe attached and adjust the indicated meter level to 10 kV.

l) Discharge the P255-1 probe to the ML-255 surface by approaching the surface of the ML-255 and allowing contact to occur.

m) Perform fine adjustments to the oscilloscope, and observe "NOTE" in step {g}.

n) The waveform produced at the 10 kV level should resemble those illustrated by (Fig. 3A, B) as an average distribution of twenty impulses applied to the surface of the ML-255, assuming random velocities of gap closure.

NOTE: The risetime and shape of the pulse will be influenced by the velocity of probe gap closure to the load as would actually occur during real-world ESD events. In general, faster velocities will produce faster risetimes, and slower velocities will result in longer risetimes.

o) Return the level of the ESD-255 to the full counter clockwise position, and power off.

p) Disconnect the P255-1 probe and connect the P255-2 probe. Ground the probe as specified (See Section 5.4) to the test bed ground plane.

q) Repeat the steps of i), j), l), and m) above for the P255-2 probe. Reset from 1 kV to 10 kV.

r) The waveform produced at the 10 kV level with the P255-2 probe should resemble those illustrated by (Fig. 4) as an average of twenty impulses applied to the surface of the ML-255 assuming a random distribution of gap closure velocities. (Refer to steps "g" and "n")

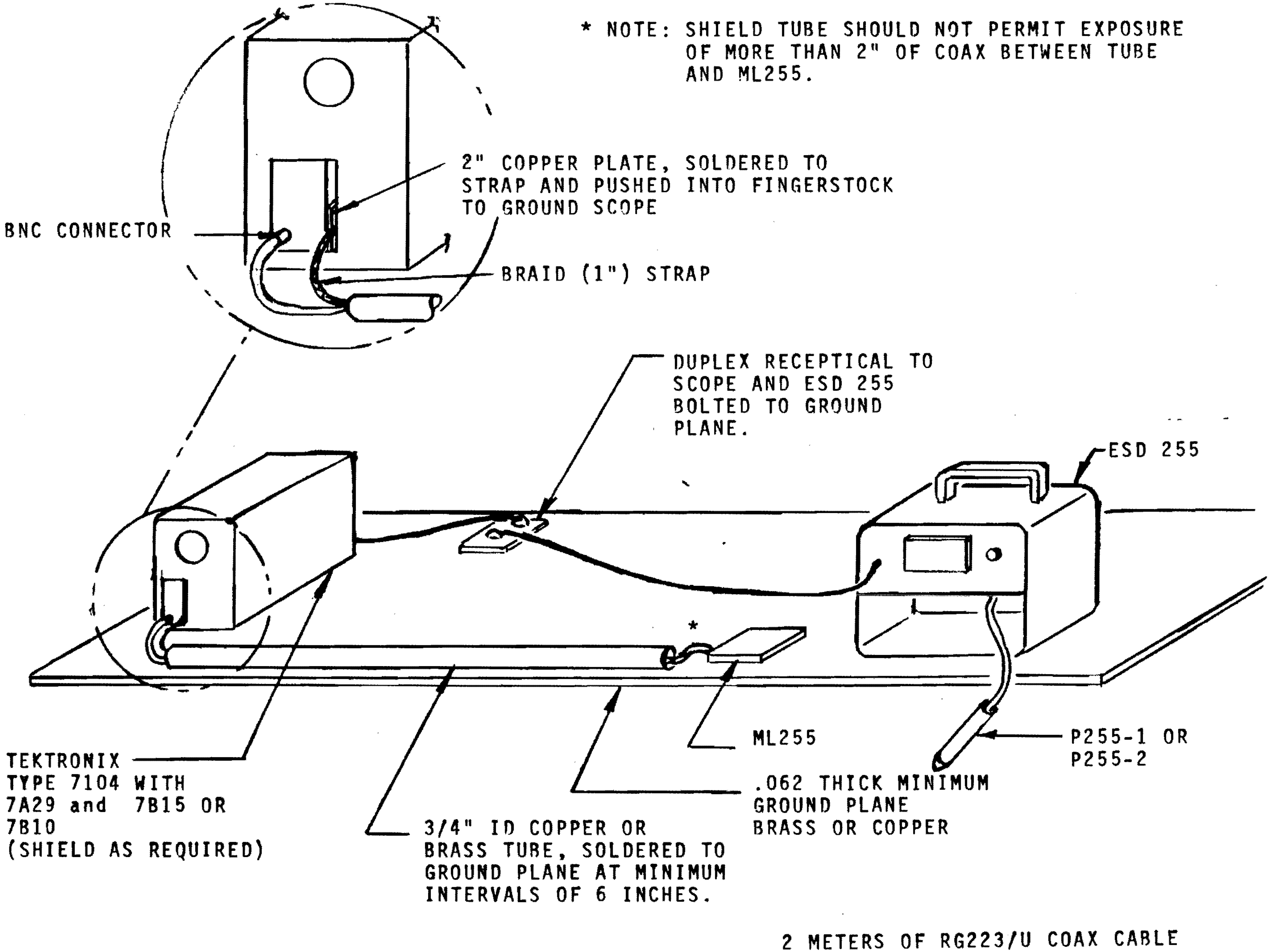


FIGURE 1. TEST ARRANGEMENT

Initialization Level: 2000 Volts

P255-1 Probe

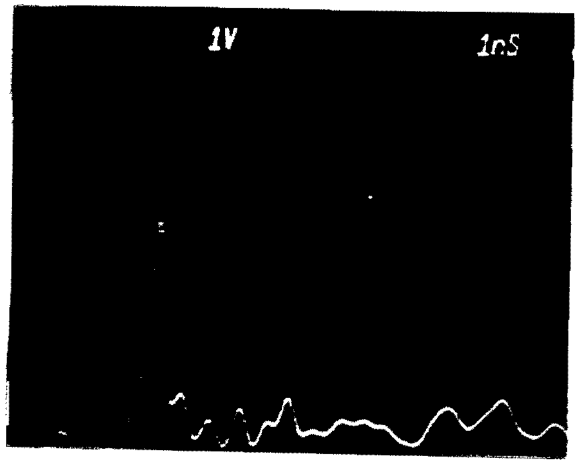


Figure 2 A

Vert: 10 Amps/Div
Time: 1 nSec/Div
Displayed:
Ip: 41 Amps
Tr: 500 pSec
Width: 50%-50%
         450 pSec

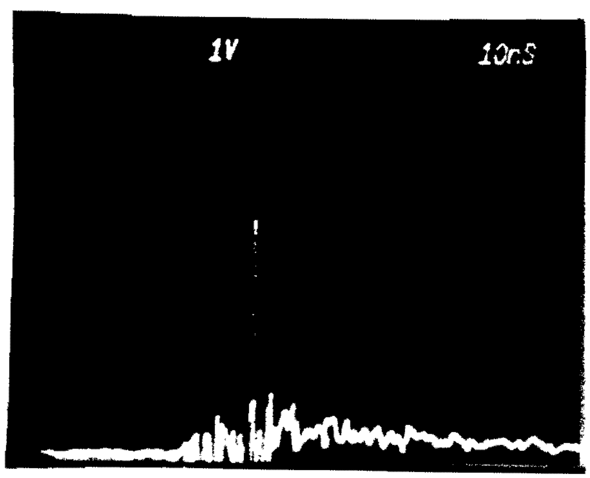


Figure 2 B

Vert: 10 amps/Div
Time: 10ns/Div
Displayed:
Ip: 42 Amps

Figure 2A and 2B

Initialization Level: 10 KV

P255-1 Probe

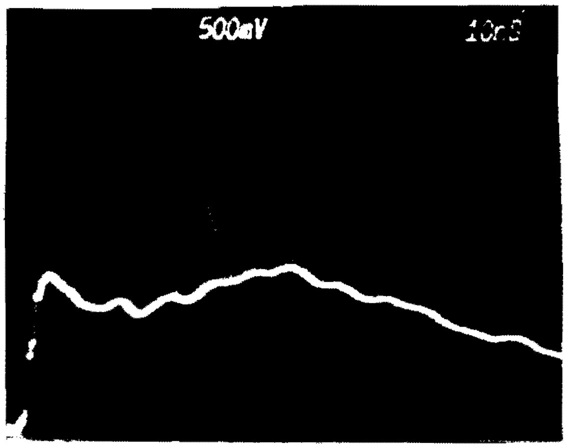


Figure 3A

Vert: 5 Amps/Div
Time: 10 nSec/Div
Displayed:
Ip: 17 Amps
Tr: 4 nSec
Width: 50%-50%
70 nSec

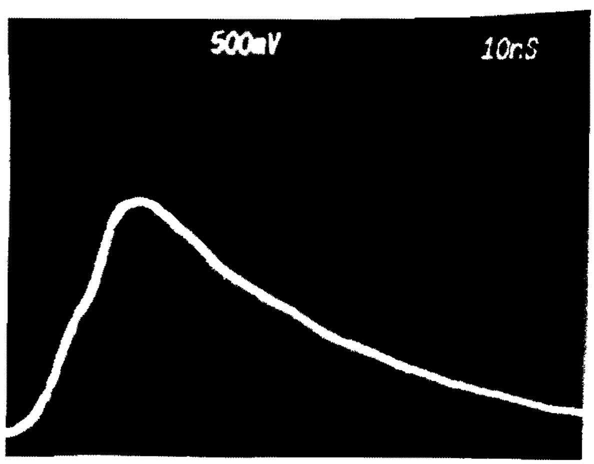


Figure 3B

Vert: 5 Amps/Div
Time: 10nSec/Div
Displayed:
Tr: 20nSec
Ip: 25 Amps

Figure 3A and 3B

Initialization Level 10KV

P255-2

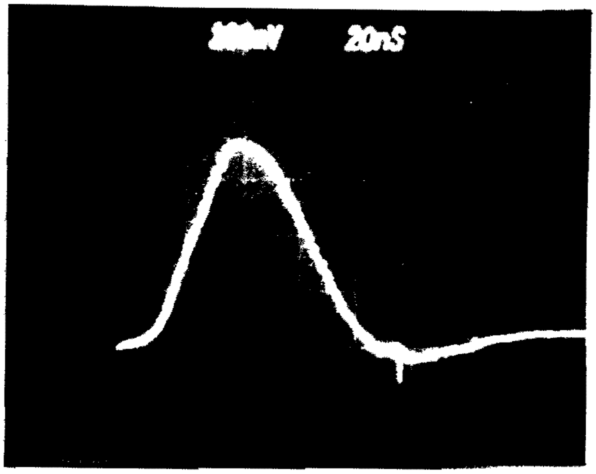


Figure 4

Vert: 10 amps/Div
Time: 20nSec/Div
Displayed:
Ip: 36 Amps
Tr: 10nSec

Figure 4