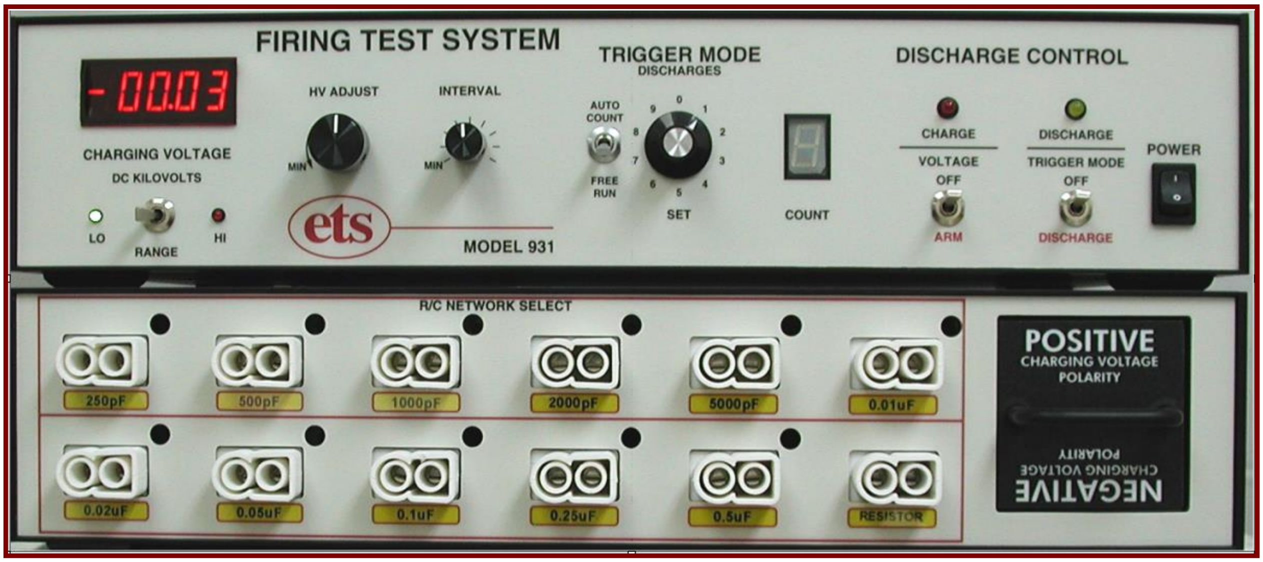
FIRING TEST SYSTEM



Model 931 - Operating Manual

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Revision History:

Revision 15: Released 2013-10-01 Initial release. Updated 2/2020: Revised warnings

Revision P: Released 2020-10-06. Reformat, add new address, switch to letter revisions.

Products described in this manual are designed and assembled in the U.S.A. by

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I. IMPORTANT SAFETY INSTRUCTIONS

CAUTION!

(Equipment containing High Voltage)

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 931 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. As an additional safety measure an external replaceable fuse is also installed. Replace this fuse only with one having the required current rating, voltage and specified type such as normal blow, slo blo (time delay), etc. **DO NOT** use makeshift fuses or short the fuse holder. This could cause a shock or fire hazard or severely damage the instrument.

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 a 30kV. In addition, equipment may contain capacitors up to 0.035 μF charged to 30kV and capacitors up to 0.5 μF charged up 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 deteriation 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 deteriation 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.

WARNING: The Firing Test Chamber IS NOT CERTIFIED to withstand any specific explosive level. The chamber when installed correctly has been found to withstand a firing of a least a 250mg device. It is up to the end user to determine whether the chamber will be satisfactory for discharges of their particular device.

WARNING: When properly setup, the Firing Test Chamber explosive force will be primarily channeled through the exhaust pipe. DO NOT COVER or BLOCK the exhaust pipe. DO NOT place hands, face, or any other part of the human body in proximity to the exhaust pipe on the back of the Firing Test Chamber.

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 CAUTION!

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.**

II. Description of Components

The Model 931 FTS, includes the following components:

Item	Qty.	Description
Control Unit	1	Aluminum enclosure that contains the low voltage power supply, discharge control and timing circuits, and the operating controls.
Discharge Unit	1	Aluminum enclosure containing the high voltage power supply, Polarity Reversing Module, R/C networks and the HV switching relay. with connectors on front panel.
Firing Test Chamber (Optional)	1	
RC Network Selectors		
Safety Plugs	12	Closure for the RC selectors to prevent corona
Keys (Optional)	2	For optional front panel lock feature.
Cable Set	1	Output Cable: 5' (1.5m) 40kV silicone, terminated with HV connector and standard banana plug with replaceable alligator clip. Ground Cable: 5' (1.5m) black rubber, terminated with standard banana plugs with replaceable alligator clip on one end. Control Signal Cable: 10' (3m) 15-pin sub-D, both ends. {Additional 10' (3m) sections can be added to increase cable length up to 40' (12m)}. Inter-unit Ground Cable: 12" (3.7m) green rubber with standard banana plugs on both ends. {Custom lengths available} Interlock Cable: 6' (1.8m) 3-conductor PVC signal cable with 3-pin DIN connector on one end and tinned leads on the other end to connect to customer supplied interlock switch. A 3-pin DIN connector is installed if the Optional Firing Test Chamber is ordered. {Custom lengths available} Power Cord: 8' (2.5m) IEC to North American 3-prong. {British 3-prong cable available} Capacitor Select Module. Resistor modules or resistor select module, if resistors are built-in.

Control Unit

Discharge Unit

Firing Test Chamber (Optional)

III. Setup Guide

Place the system on a sturdy table. Overall weight of the control unit and the discharge unit is approximately 50 pounds (23 kg). The Firing Test Chamber weighs approximately 125 pounds (57 kg).

Connect the Control Unit and Discharge Unit cables as shown below for the standard system.

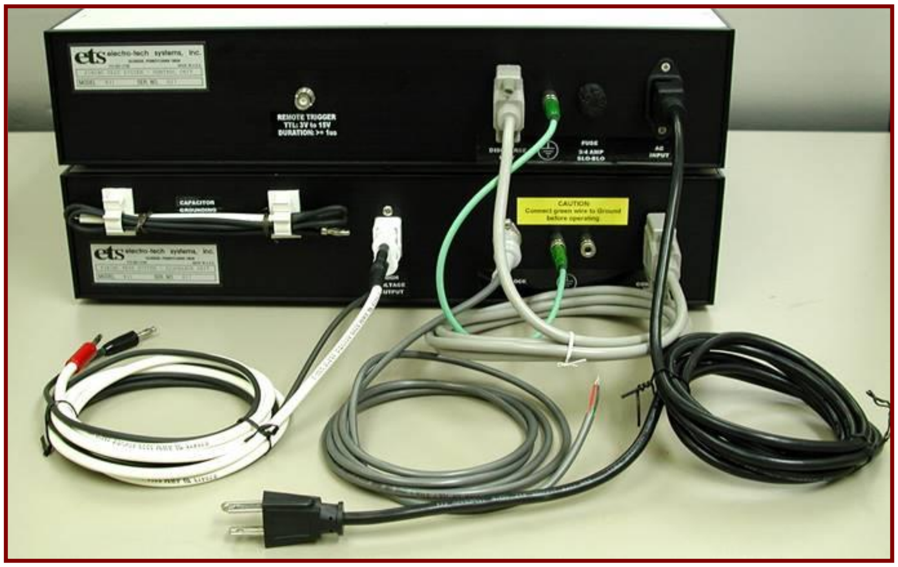


Figure 3.1 Standard System wiring

If the two units need to be separated, additional control cables can be connected in series and an appropriate length ground cable fabricated to obtain the necessary cable lengths. The recommended maximum length is four, 10’ (3m) cables.

With the Firing Test Chamber, connect the system as shown below

System wiring with Firing Test Chamber

Connect the exhaust port of the Chamber to the appropriate exhaust system. The exhaust port is a 2” NPT pipe thread fitting.

The installation of the optional Junction Box is shown below. The discharge and ground output connections of the box use standard banana jacks that allow attachment of the cables using either the screw-on capability of the jacks or standard 0.162 (4mm) banana plugs.

Cable length may vary per customer requirement

Figure 3.2 Junction Box installation

NOTE: The replaceable output cable MUST have a rating of 40kV if it is being passed through the wall of a metal firing test chamber.

The input power connector accepts the standard IEC 3-wire power cord. **The System must be plugged into a grounded power (mains) outlet.** The standard System is supplied with a North American grounded power cord. Other power cords can be provided if specified at time of order. These cords are standard items typically used for computers, TVs, etc., and the appropriate one can be obtained by the user locally.

However, if the correct power cord is not available the plug on the supplied cord can be cut off and the correct plug installed. The BLACK wire is the “HOT” lead the WHITE wire is neutral and the GREEN wire is ground.
The Model 931 Firing Test System has switching power supplies that operate from 90-260VAC, 50/60Hz. No line voltage (mains) selection is necessary.

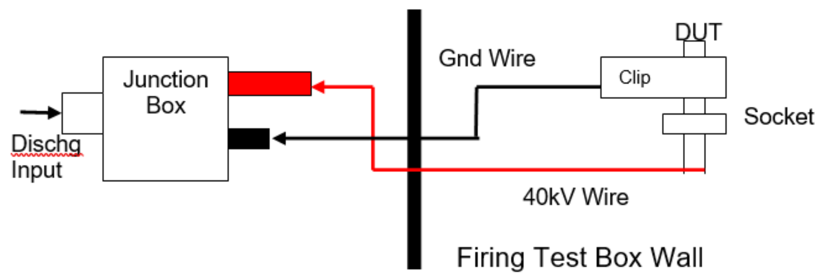
These power supplies incorporate resettable fuses. To reset, turn off the unit for at least 20 seconds, then turn it back on. If the system still does not operate contact ETS at 215-887-2196 for service. For additional safety, a 3AG 250V-3/4amp Slo-blo fuse is located on the rear panel.

Power Key Switch (Optional): A key switch can be installed to restrict use of the Model 931 to authorized personnel. If this option is a retrofit, it will be installed on the rear or right side panel and will be connected in series with the existing front panel rocker switch. However, if specified at time of order it can be configured to replace the **POWER** rocker switch.

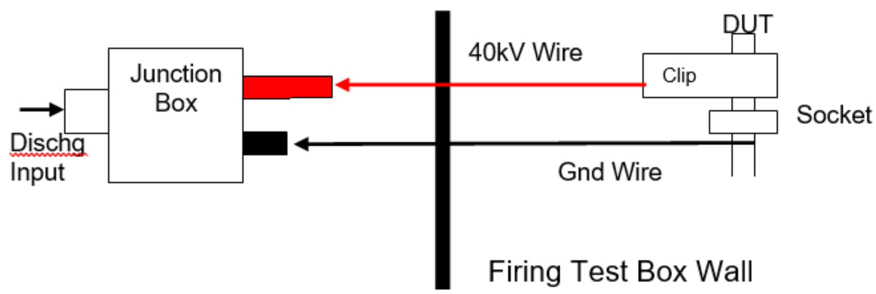
IV. Quick Start Guide

To perform a test on a device proceed as follows:

4.1 Connect the Output and Ground lead clips to the appropriate DUT (Device Under Test) pins or leads as shown in the following figures. Actual connection to the DUT will be determined by the DUT configuration.

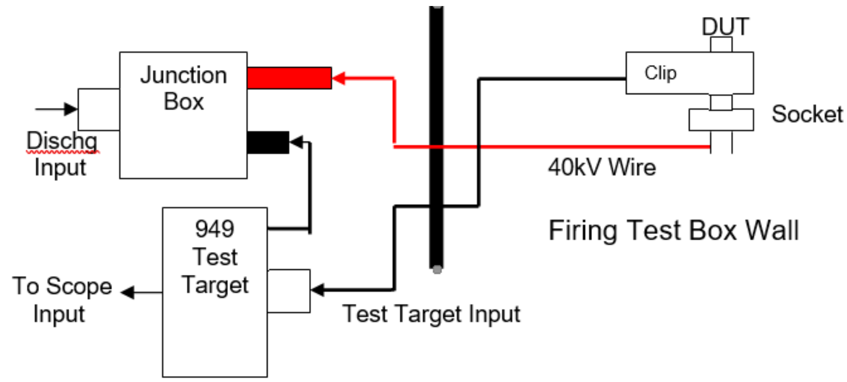


Output to pins, Gnd to case

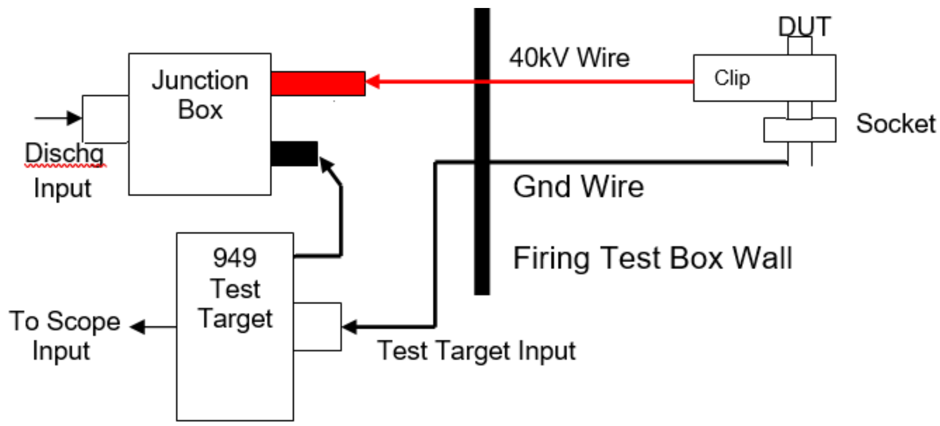


Output to case, Gnd to pins
Figure 4.1 DUT wiring connections,

If the discharge current waveform is to be monitored using the Model 949 Test Target, connect the OUTPUT wire to the desired pin or location on the DUT. Connect the GROUND side of the DUT to the Test Target input banana jack as shown below. The DUT will be connected to ground through the 2 Ohm Target resistance.



Output to pins, Gnd to case



Output to case, Gnd to pins
Figure 4.2 DUT current waveform monitoring connection

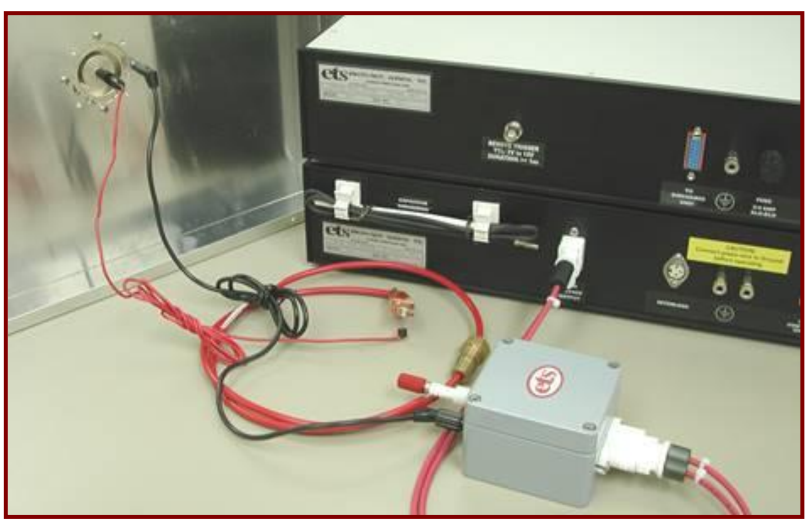


Figure 4.3 Typical current monitoring test setup with Junction Box

4.2 If the ETS Firing Test Chamber is installed, close the Firing Test Chamber door and lock it in place by moving the handle from left to right. The interlock switch will only be activated when the door is fully closed. For other test locations or chambers install the interlock cable and follow established procedures.

4.3 Select the desired R/C network. Plug the **RESISTOR SELECTOR module** into the respective resistor value connector and the **CAPACITOR SELECTOR module** into the appropriate capacitor value connector.

For units with plug-in resistor modules the required resistor is plugged into the lower right hand connector labeled **"RESISTOR"**. For units with built-in resistors plug the "**RESISTOR SELECT**" module into the appropriate resistor connector in the bottom row.

NOTE:

If the system is configured with both internal and plug-in capacitor modules, either the "SELECTOR" or the appropriate capacitor/resistor module should be used, but NOT BOTH.

Make sure the modules are seated all the way.

4.4 Select the desired voltage range. For voltages up to 5kV move the RANGE switch to the LO position (Green LED). The LO range output is 100-5500V. For voltage levels above 5kV, set the **RANGE** switch to the HI position (Red LED). The HI range output is 3-26kV. The interlock switch must be closed to activate the high voltage. For the Firing Test Chamber **the door must be fully closed and latched**.

NOTE:

The Model 931 is capable of charging capacitors up to 0.02µF (20,000pF) to 26kV. For those specifications requiring larger value capacitors, the maximum voltage specified is 5kV (Mil Std 1751A, Method 1031). The Discharge Unit incorporates an interlock system that locks out the Hi range to limit the maximum voltage applied to capacitors higher than 0.02µF to the LO range (5.5kV).

4.5 Push the **ARM** spring-loaded lever switch DOWN and hold it there throughout the charge/discharge cycle. This will activate the HV power supply. A voltage level will be displayed on the 4½-digit LED display. Rotate the **VOLTAGE ADJUST** knob (large diameter knob) until the desired voltage level is reached. This is a 10-turn potentiometer where voltage changes more rapidly as voltage is increased.

NOTE:

Charging is exponential and charge time is a function of the internal current limiting resistor and the capacitor selected (RC time constant) To reach approximately 99% of full charge can take at least 5 time constants (τ=5RC) plus other limitations in the charging circuit.

The larger the capacitance, the longer the charging time required. For large value capacitors, the charge time can take as long as several minutes (0.5µF) to reach the exact voltage setting (for example 5.00kV). Therefore, to quickly set the voltage for capacitors >0.1µf, select the 0.01µf capacitor to set the voltage level to avoid the long charging time associated with the 0.1, 0.25 and 0.5µf capacitors then switch back to the desired capacitor value.

4.6 To initiate a discharge, push the **ARM** switch DOWN and when the **CHARGING VOLTAGE** meter displays the full voltage selected depress the spring-loaded **DISCHARGE** lever switch.

To reduce the testing time for the slow charging networks (0.1, 0.25 & 0.5µF) turn the voltage up to maximum (5.5kV) and when the desired voltage is observed on the meter immediately activate the DISCHARGE switch. This will reduce the 0.5µF capacitor charging time to approximately 75 seconds. Corresponding reductions apply to the other capacitors.

There are several ways to initiate a discharge. If only a single discharge is desired, set the **AUTO** mode switch to **AUTO**. The LED counter will light. Set the **COUNTS** switch to "1". Arm the system and then depress the **DISCHARGE** lever switch when the set voltage level is reached. A single discharge will occur. If more than one discharge is desired then set the **COUNTS** selector switch to the number of discharges required up to 9. **Both the ARM and the DISCHARGE switches must be depressed during the entire CHARGE/DISCHARGE cycle(s).** If more than 9 discharges are desired the sequence must be repeated. The discharge cycle can be ended at any time by just releasing the **DISCHARGE** switch.

If the **AUTO** mode switch is set to **FREE RUN** then the system will continue to discharge at the rate set by the **INTERVAL** control until the **DISCHARGE** switch is released. If the control is set high enough single discharges can be obtained in this manner also. In either case, the operator always controls the **ARM** and **DISCHARGE** functions.

4.7 After a test has been completed, wait until the reading on the meter is <100V, then open the door by moving the handle to the left. The interlock switch will open preventing the HVPS to turn on even if the **ARM** switch is activated.

The discharge circuit incorporates a safety 25 megOhm resistor to ground at the discharge output connector inside the Discharge Unit. This resistor is in the circuit to bleed off any residual charge that may remain after a discharge. The output circuit, that is the circuit holding this charge is basically, C_{p2} which is approximately 25pF for the Firing Test Chamber device test circuit. Other configurations can increase C_{p2} to 100pF or more. The time to bleed off the residual charge is

$$T = 5RC$$

$$= 5x100x10^{6}\Omega x25\ x10^{-12}pF$$

$$= 0.125 \text{ sec. (125 milliseconds)}$$

Other output configurations could have significantly higher residual capacitance.

CAUTION:

IT IS UP TO THE USER TO DETERMINE THE PROPER SAMPLE SIZE OF A GIVEN TYPE EXPLOSIVE THAT WILL SAFELY IGNITE IN THE MODEL 931 FIRING TEST CHAMBER.

4.8 Device Testing

To test devices connect the Output lead (Red banana plug) to the desired pin or other connection of the DUT and the Ground lead (Black banana plug) to the ground connection or shell of the DUT.

If it is desired to monitor the discharge waveform, two methods can be used. The preferred method is to connect the ground side of the test circuit to the input of the ETS Model 949 Test Target. The discharge will be through the 949 to ground .

CAUTION:

OBSERVE ALL SAFETY PRECAUTIONS WHEN HANDLING ESD SENSITIVE DEVICES. MAKE SURE THE VOLTAGE METER READS LESS THAN 100 VOLTS BEFORE CONNECTING TO THE DUT.

4.9 Powder Testing

CAUTION:

WHEN TESTING POWDER, DO NOT KEEP POWDER SAMPLES NEAR THE FTS WHEN PERFORMING A TEST.

For testing powders, the optional Powder Testing Electrode Assembly is available as a freestanding unit or installed in the ETS Firing Test Chamber, as shown in Figure 4.4.

Free-standing unit

Firing Test Box installation

Figure 4.4: Powder Discharge Probe test set up

Connect the Red banana plug into the discharge electrode and the Black banana plug into the ground jack as shown in the respective figures.

Place a powder cup into the ground electrode. Adjust the height of the ground electrode to the distance specified from the discharge electrode needle. Lock the electrode in place with the lower locking ring.

Fill the powder cup and place it into the ground electrode then initiate the test.

If it desired to monitor the discharge waveform two methods can be used. The preferred method is to connect the ground side of the test circuit to the input of the ETS Model 949 Test Target. The discharge will be through the 949 to ground as shown in Figure 5.1-3.

V. Functionality

The Model 931 Firing Test System can produce discharge pulses from <±100 volts to >±26kV. Energy is stored in capacitor banks during the charging cycle. A discharge pulse is produced when a high voltage relay disconnects the charged capacitor bank from its charging source and reconnects it to the output of the FTS Discharge Unit. The energy storage capacitor bank is installed inside the Discharge Unit. The discharge resistors are either installed within the Discharge Unit or are contained in individual plug-in modules. Capacitor and resistor values are selected by the user and the initial configuration must be ordered at the time of purchase. Additional standard and custom capacitor and resistor modules are available. These can be plugged into either an optional SPARE capacitor input connector, combining several internal capacitors using multiple plug-in selector modules or replacing the Selector module(s) with ones containing R or C. Capacitor values ranging from 60pF to 0.5µF and resistor values ranging from 0 to 10,000 Ohms are available.

System organization is shown below.

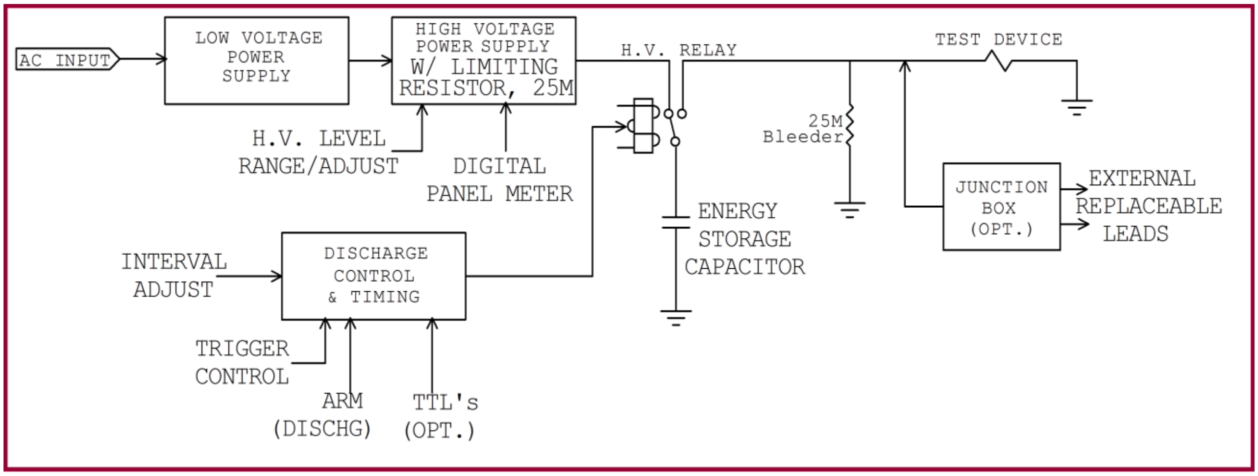


Figure 5.1 System Organization

The CHARGE/DISCHARGE cycle is accomplished using a high voltage relay. In FREE RUN, the System will continue to produce discharge pulses as long as the ARM and DISCHARGE switches are held down. The dwell time or charging period between discharge pulses is adjustable by the user from 1/3 second to about 10 seconds.

In AUTO COUNT, the user selects the number of discharge pulses desired (1 to 9) and then depresses the ARM and DISCHARGE switches. The FTS will then produce the selected number of pulses at the selected time interval between pulses. A single digit numeric readout displays the number of pulses produced from 1-9. When the DISCHARGE switch is released, the system counter resets to zero and the production of HV output pulses stops. The discharge pulse sequence is repeated each time the DISCHARGE switch is activated. (AUTO mode is only useable for capacitors up to 0.02µF because of the charge up time required for higher value capacitors.)

Capacitors below 0.02μF (20,000pF) will charge to the adjusted value in 5 seconds or less. However, capacitors 0.05μF (50,000pF) and above require considerably more than 5 seconds to fully charge to the maximum of 5kV. The 0.25μF capacitor requires approximately 90 seconds to charge to 5kV and the 0.5μF capacitor requires several minutes to charge. However, by setting the charging voltage to >5kV the exponential charging curve will pass through the 5kV level much sooner. By adjusting this over voltage level before hand when the capacitor charge reaches 5kV (or other desired voltage) the discharge relay can be triggered. This is illustrated in Figure 5.2 for 5kV, but it applies to any charging voltage setting.

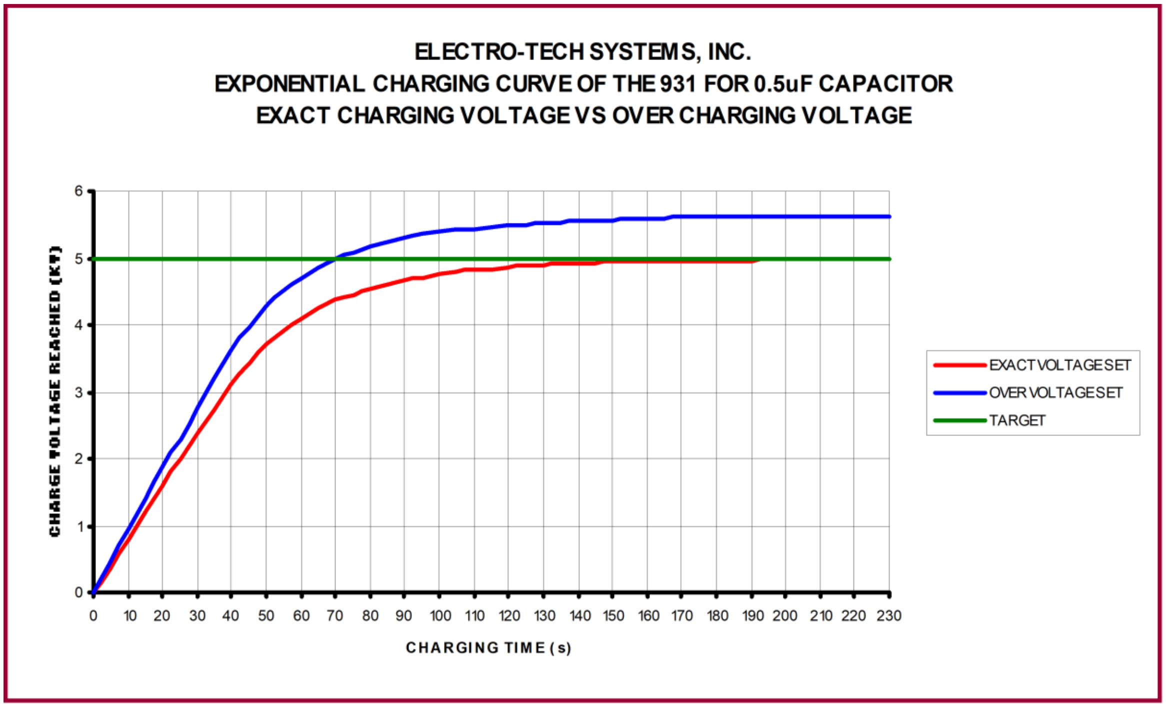


Figure 5.2: Exponential charging curve

5.1 Discharge Characteristics

The Model 931 generates discharge pulses that are similar to either the standard ESD Human Body Model (HBM) exponential waveform (R>0 Ohms) or the Machine Model (MM) waveform (R=0 Ohms). ESD standards generally specify total system capacitance consisting of the fixed capacitor plus the parasitic capacitance. For the Model 931 the parasitic capacitance, C_{p1}, is approximately 50pF. This includes the capacitance of the HV connectors and internal wiring. Figure 5.3 is an equivalent circuit of the discharge unit.

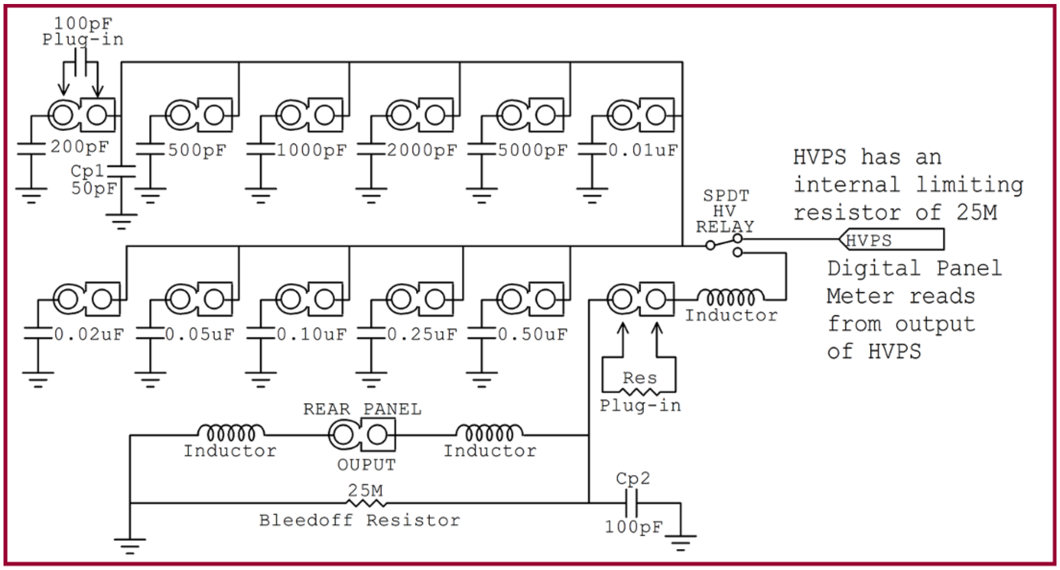


Figure 5.3 Discharge unit equivalent circuit

5.2 Actual Capacitor and Resistor Values

The capacitors used in the Model 931 consist of both capacitor banks made up using series and parallel combinations and custom capacitor modules. Each capacitor can be measured by connecting a capacitance meter to the respective capacitor selector (round pin). However, internal wiring and connections add parasitic capacitance to the circuit. This capacitance, C_{p1}, is approximately 50pF and must be added to the measured capacitance to obtain the system capacitance. Specifications may specify either the capacitor value or the system capacitance. System capacitance is the total capacitance that is discharged when the relay closes. All capacitors have a tolerance of better than ±5% and system capacitance of better than ±15% for capacitors 500pF and below and ±5% for capacitors 1000pF and above.

High Voltage resistors with a ±5% or better tolerance are used.

The following are typical actual system capacitance and resistance values:

SPECIFIED		ACTUAL	
R Ω	**C pf**	**R Ω**	**C pf**
500	100	490	107
1500	250	1526	257
5000	5000	5006	4970

The energy stored in the system is calculated using the following formula:

$$E = ½(C+C_{p2})V^2 \text{ Joules}$$

or

$$E = ½\, C_{act}V^2 \text{ Joules}$$

C_{p2}. is the parasitic capacitance of the cable and accessories plugged into the output connector. For the standard configuration, this capacitance is approximately 60pF. This capacitance affects the discharge waveform characteristics such as peak voltage, rise time and ringing. The lower the capacitor and the higher the discharge resistor used the greater the affect on the initial ringing observed on the discharge pulse. For 500pF and 500 Ohms this appears as overshoot. For 500pF and 5000 Ohms this appears as high frequency ringing. Refer to the waveform examples in section VII..

When the optional Junction box is used, C_{p2}. increases to approximately 100pF at the output and when 1m tests leads are attached C_{p2}. is approximately 110pF.

5.3 Charging Voltage

The voltage applied to the capacitor is adjusted at the factory to be better than ±2% over the entire voltage range. However, as capacitance decreases the effect of parasitic capacitance, increases due to the relative closeness in value. Above 1000pF, the effect becomes insignificant. The output voltage pulse measured will be less than the DC voltage applied to the capacitor by approximately

$$V_m = CV/(C+C_{p1})$$

5.4 Discharge Pulse

The output pulse is calibrated using an IEC 61000-4-2 compatible test target (ETS Model 949) . The Model 949 is available as an external target, or installed in the Firing Test Box as shown in Figure 5.4. This method is specified for most Human Body Model applications and is referenced in MIL-STD-331C. There is no output waveform calibration method specified for the other common explosive device discharge networks.

External Test Target

Test Target installed on Firing Test Box

Figure 5.4: Test Target installations

The Model 931 output is calibrated using the current waveform method. The ETS Model 949 Test Target and an Agilent, Model DSO6102, 1 GHz oscilloscope are used to calibrate the System. However, any oscilloscope having a bandwidth of 200MHz or better is satisfactory. Typical waveforms for several networks are shown in Section VII of this manual. Actual waveforms for the specific 931 System are supplied separately as part of the System Calibration.

The output waveform using discharge resistors is calibrated to produce a discharge pulse having the correct E =IR ±10% relationship i.e. a 5kV pulse through a 500 Ohm resistor should have an average peak current value over the first 50nsec of 10±1 Amps. Fall time is a function of the R/C network used, and is calculated using t=RC (1 time constant = 37%).

NOTE:

As capacitance is reduced, the peak pulse measured is also reduced due to the effects of the stray capacitance. The above also holds true for resistances below 500 Ohms. Below 500 ohms the impedance of the circuit begins to limit the maximum current obtainable. At 150 Ohms, the waveform starts to take on the characteristics of the 0 Ohm waveform. As the discharge resistance is increased, it begins to form a tuned circuit that appears as a sharp initial spike in the first 20 nsec and then ringing over approximately the next 50 nsec. It is most noticeable at capacitances below 500pF and resistances above 1500 Ohms. Ringing is also affected by the length of the output cable.

Testing explosives is based on energy levels, which is the area under the curve of the discharge waveform. Using the actual Capacitance and current waveform levels will enable the user to accurately calculate the desired energy levels. The calibration waveforms supplied with each unit shows the full waveform and is that portion that constitutes virtually all the energy contained in the discharge. The peak current listed ignores the initial short duration overshoot and high frequency ringing observed.

The discharge energy can be calculated using the following formula:

$$E=R\ t\ \Sigma^{n}\ I^{2}$$

Where R=Discharge Resistance (500 or 5000Ω)
t =Time between samples (use time base setting on scope)
n =Total number of samples (use 1000)
I =Current increments (1000) from waveform

VI. Operational Details

Background

The Model 931 Firing Test System is an instrument that is designed to simulate the discharge produced by an electrostatically charged human body when it is brought close to an object that is at a lower potential. By use of different R & C modules the Firing Test System can also simulate the effects of other types of discharges such as a charged conductive object coming in contact with the leads of an explosive device.

Static charges are generally created when dissimilar objects are brought into contact with each other and then separated. When this situation occurs, electrons are transferred from one object to the other. If these objects are electrostatically conductive (i.e., have surface resistance less than 10^{11} Ohms) and are both connected to a third conductive body or to each other, the built-up static charge will flow from one body to the other in a short time. The resulting net charge build-up will be zero. If, on the other hand, if these same charged objects are separated by an insulator the charge build-up may not be neutralized and each body may retain its charge for a long time, particularly in a low humidity environment.

The charging of objects due to relative motion is known as the Triboelectric Effect. It can produce voltages from a few volts to tens of thousands of volts. The charge build-up depends on many factors including the amount and rate of motion, the composition of the materials involved, the secondary surfaces involved (floor, table top, air, etc.), the relative humidity level of the air surrounding the charged bodies and surface coatings used on any of the surfaces (if any). When a highly charged body is brought near a neutral body or one that has an opposite charge, a rapid discharge can occur. In many cases, this discharge is nothing more than an annoyance; however, under the right circumstances it could contain sufficient energy to ignite an explosive product, mixture or activate an explosive device such as initiator used in automotive, military and space applications.

One of the most common types of electrostatic build-ups occurs with the flow of people and material over nonconductive surfaces. Humidity conditions usually determine how static dissipative a surface is. The lower the humidity, the longer it will take a charged nonconductive object to dissipate the charge. A person walking across a carpet or tile floor on a dry day is capable of generating an electrostatic body charge in excess of 15,000 Volts. When the person comes in contact with a conductive object, he immediately discharges the accumulated charge on his body. If the charge build-up is about 3,000 Volts, the person will feel only a slight shock. However, if the charge build-up is much larger, a visible spark discharge will occur that can cause not only discomfort to the person, but with enough energy, an inadvertent ignition of an explosive product or device.

In the past, electrostatic discharges were generally of less concern than they are today. With the introduction of more and more synthetic materials, many of which are easily charged, and the development of complex electronic equipment that may contain electrostatic discharge sensitive components, plus the use of explosive initiators in consumer items such as automotive airbags and seatbelt pretensioners the effects of electrostatic discharge have become a major concern. Many electronic components can be damaged or destroyed when subjected to electrostatic discharges of less than 100 Volts. Discharges of thousands of volts can have devastating effects on electronic communication systems, medical electronics, computers, home entertainment systems locations or products where explosive environments and products are present.

It is virtually impossible to control the environment in which most of today's high technology equipment or explosive products are used. The burden falls on the manufacturer to design and build equipment, devices and formulations that can function without disruption or failure when subjected to commonly occurring electrostatic discharges. The Model 931 Firing Test System can be an invaluable aid in helping to determine the minimum energy levels required to damage equipment or ignite a particular compound or device.

Control Unit, Front Panel

Figure 6.1 shows the front panel of the system.

Figure 6.1 - Control Unit

Control Unit - Controls

6.1 **A/C Power ON/OFF**

This rocker switch controls the AC power input to the unit. When power is on, the LED Charging Voltage Meter and either the HI or LO RANGE light will light.

Figure 6.2 shows the installation of an optional key switch for controlling access to the system.

Figure 6.2: Optional AC Power key switch

6.2 **DISCHARGES SELECT** Switch

This ten-position rotary switch is used to select the number of discharge pulses the System will produce when the system is in the AUTO COUNT mode. When the DISCHARGES SELECT switch is in the 0 position, the unit will be inhibited from producing discharge pulses regardless of the position of the DISCHARGE switch. When set to position 1, the system will produce only one (1) pulse each time the DISCHARGE switch is activated, thus making controlled“ single shot” operation possible. The DISCHARGES SELECT switch setting is over-ridden when the AUTO COUNT/FREE RUN switch is in the FREE RUN position.

6.3 **AUTO COUNT/FREE RUN SELECT** Switch

This 2-position toggle switch programs the system for either FREE RUN or AUTOMATIC operation. When this switch is in the FREE RUN position, the DISCHARGES indicator is off (not illuminated) and the system will continue to produce discharge pulses as long as the TRIGGER switch is depressed.

When in the AUTO COUNT position, the DISCHARGES display will be illuminated, and the System will produce the number of discharge pulses programmed by the setting of the DISCHARGES SELECT switch each time the DISCHARGES switch is activated (1-9). If more than 9 discharges are required, the sequence is repeated until the total number of discharges are reached.

NOTE:

The AUTO COUNT mode should not be used for multiple counting in the HI RANGE when the output resistor is 0 Ohms.

TTL trigger (Optional): When installed, the **TTL signals will control the number and interval** of the pulses desired. The AUTO mode for pulses more than 1 (single shot) cannot be used with the TTL option since the Auto mode is controlled by internal charge/discharge timing circuits.

6.4 **RANGE** toggle switch.

This 2-position, toggle switch selects either the LO or the HI Range. In the LO position the usable voltage range is approximately 100 V to 5.5 kV and in the HI position the usable voltage range is approximately 3 to 26kV.

When high value capacitors >0.02μF (20,000pF) are used, they have a voltage rating of 6-8 kV. Whenever these capacitors are selected, the HI RANGE is locked out so only a maximum of 5.5 kV can be applied to these capacitors. The lockout is controlled by the plunger installed onto the CAPACITOR SELECT module that activates individual switches incorporated into the Discharge unit to allow only capacitors up to 0.02μF to be charged up to 26kV.

6.5 **HIGH VOLTAGE ADJUST** Control

This 10-turn rotary control is used to set the level of the high voltage supply to the desired charging voltage. The magnitude and polarity of the charging voltage are indicated by the 4½–digit, CHARGING VOLTAGE meter. The HIGH VOLTAGE ADJUST control is set prior to initiating a discharge sequence. This control is nonlinear where it will require more turns to adjust the low end than it takes to adjust the high end. The charging voltage level increases as this control is rotated in the clockwise direction.

6.6 **INTERVAL ADJUST** control

This rotary control allows the operator to set the time interval between discharge pulses. This interval is adjustable from a minimum of 1/3 second to over 10 seconds. Rotating the control clockwise increases the time interval between discharge pulses.

NOTE:

The charging circuit incorporates a 25 megOhm series resistor. As the value of the capacitor increases the charging time also increases by $t=5R_{chg}C$. This determines the minimum interval that can be used. For capacitors ≤0.02μF the charging time is <5 seconds. Therefore, the Auto Count mode can only be used with capacitors up to this value.

For larger capacitors, charge time becomes very long. Therefore, the discharge cycle must be operated manually. For example, to charge the 0.25μF capacitor to the desired voltage requires approximately 90 seconds.

6.7 **DISCHARGE - ARM** toggle switch

This spring-loaded toggle switch is used to turn the High Voltage on. When depressed it is in the ARM position and the voltage will be displayed on the meter and the red LED will light. This switch must be in the ARM position to perform a test.

When charging capacitors greater than .02µF the time to reach full charge becomes quite long. To speed up the charging time set the voltage to maximum (5.5kV) and when the meter indicates the desired test voltage, activate the DISCHARGE switch.

The charging time required for C=0.25µF is approximately 90 seconds and several minutes for C=0.5µF when the charging voltage is set to the desired voltage.

This can be overcome by first setting the charging voltage above the desired value as shown in Figure 5.2 and then determine the time required for the capacitor to charge up to the desired voltage. The discharge switch may then be operated at the established time The higher the overcharging the faster the capacitor will charge to the desired level.

6.8 **DISCHARGE TRIGGER** toggle switch

This spring-loaded toggle switch activates the discharge relay. For single shot discharge either the AUTO COUNT switch can be set to "1" or the INTERVAL switch can be set approximately half way and the DISCHARGE switch depressed once. For multiple discharges, the switch must be held down until the number set is reached. The system automatically resets to zero when the switch is released. The yellow LED will flash each time a discharge occurs.

Displays

6.9 **DISCHARGES** Display

This 0-9, LED numeric display illuminates automatically when the AUTO COUNT/FREE RUN mode select switch is in the AUTO COUNT position and is off when it is in the FREE RUN position. It resets to zero when the DISCHARGE switch is in the OFF position (up) and displays the discharge pulse count when the DISCHARGE switch is depressed. When the discharge(s) automatically stop in the AUTO COUNT mode, the DISCHARGES display will indicate the total number of pulses produced for that test sequence. The final count will agree with the discharge number set on the SET switch. If more than 9 discharges are required then repeat the above sequence.

Remote TTL Discharge Control (Optional): When installed an external TTL signal controls a relay that parallels the Discharge switch and will automatically initiate a discharge when a TTL signal is received. The Interval control does not function when remote triggering is used.

6.10 **RANGE** Indicators

These point source LED's indicate the voltage range selected. The Green LED indicates the LO Range and the Red LED indicates the HI Range.

6.11 **CHARGE/DISCHARGE** Indicators

These two LED point source indicators illuminate during the appropriate portion of the Charge/Discharge cycle. The Red CHARGE indicator will be illuminated when the ARM switch is in the ARM position. The Yellow DISCHARGE indicator will light during the brief discharge time. Failure of either indicator to light at the appropriate time may be an indication of a system malfunction.

6.12 **CHARGING VOLTAGE** Meter

This 4½-digit LED meter indicates the magnitude and polarity of the charging supply voltage directly in Volts in the LO range and in kiloVolts (kV) in the Hi range The meter reading is the voltage applied to the selected capacitor and is related to the magnitude of the discharge pulse produced when the DISCHARGE switch is activated.

The energy stored in the capacitor bank may be calculated using this meter reading. The energy will be equal to $\frac{1}{2} CV^2$, where C is the value of the storage capacitor plus parasitic system capacitance and V is the charging voltage, as indicated by the meter.

6.13 **Control Unit Rear Panel**

The rear panel, shown in Figure 6.3 contains the IEC input power (mains) power connector, fuse holder for a 3AG style fuse, ground terminal that accepts either standard .162" banana plugs, or wire ends and a 15-pin sub D control signal connector. The optional TTL BNC input connectors for ARM and DISCHARGE are also located on this panel.

Figure 6.3: Control Unit rear panel.

6.14 **Discharge Unit Front Panel**

The front panel layout with the standard System D R/C network select is shown in Figure 6.4 and the standard R/C and selector modules are shown in Figure 6.5.

Figure 6.4: Discharge Unit front panel layout

At high voltage, corona may develop inside the capacitor select connectors. Safety plugs that plug into unused connectors are shown above. These are supplied as standard with the system.

Figure 6.5: Standard selector and R/C modules

This unit contains the High Voltage Power Supply, Polarity Reversing Module, R/C network components, 35kV High Voltage Relay and an internal 25 megOhm bleeder resistor connected to the output connector.

NOTE:

Without a firing, voltage will remain on the capacitor. A 25 megOhm, high voltage bleeder resistor is incorporated at the discharge output connector. This will enable the charge to bleed off when the DISCHARGE switch is depressed.

However, when using a Firing Test Box configured for device testing this capacitance is approximately 25pF. Longer cable lengths and other discharge electrode configurations will increase the capacitance. The residual charge will bleed off at the rate of t=5RC (125msec for the FTB configuration). If the capacitance of the device under test (DUT) is high then the bleed-off time will be longer.

The rate at which the residual charge on the capacitor bleeds off is a function of its value and the resistance in the charging circuit. The voltage remaining on the capacitor after a discharge cycle has been initiated is indicated by the meter reading. Even though the voltage on the capacitor is isolated from the output by the relay, it is recommended that the DUT not be handled until the Charging Voltage meter reads below 100 V.

6.15 **Discharge Unit - Rear Panel** Description

The rear panel, shown in Figure 6.6 consists of the 15-pin sub D control signal input, ground, safety interlock and high voltage discharge output connectors plus the bleed off cable to discharge the capacitors.

Figure 6.6: Discharge Unit Rear Panel

6.16 **Discharge Unit – Operation**

The 35kV, gas filled, SPDT high voltage relay is used to perform all charge/discharge functions. It is used in place of the approaching electrode charge/discharge configurations referred to in some specifications.

The front panel consists of the Polarity Reversing Module and two or more 2-pin high voltage selectors that enable the user to insert and/or select combinations of capacitor and resistor networks. Those R/C networks that are installed internally must be specified at time of order. When additional capacitor values below 500pF are specified, they can be incorporated into individual plug-in modules. Refer to Figure 2.2-1.

When no resistor or capacitance values are specified, the following individual R and C values are supplied for System A:

R Ohms	**C** pF
0	500
500	1000
5000	2000
5000	

These resistors are generally installed internally. However, for System D (Method 1751A) configuration the resistors are external and are installed inside individual plug-in modules.

When networks are installed internally, a selector module is used to connect the respective network to the charge/discharge circuit. When external modules are used, they plug into the **RESISTOR** connector.

To achieve the 100pF specified a separate capacitor module labeled “100pF” is inserted into the 250pF slot to convert the 250pF to 100pF.

Unused connectors, if installed, are not connected internally and are used to store network modules only. They are labeled “**NOT USED**” Figure 2.2-1 shows various configurations.

The MIL STD 1731A Discharge unit (System D) contains all the capacitors and the 0 Ohm plus 500 and 5000 Ohm resistors specified in Methods 1031, 1032 and 1033. The test voltage is limited to <6 kV for capacitors greater than 0.02μF. Method 1034 is optional and requires a special triple Capacitor Select Module that combines the 5, 10 & 20,000pF (0.005, 0.01 & 0.01μF) capacitors to achieve the 35,000pF specified.

Firing Test Chamber (Optional)

6.17 **Chamber Description**

The Firing Test Chamber (FTC) is available as an option., As shown below, the FTC measures 16.75"Wx9"Hx12"D (42.6x23x30.5cm) and is fabricated from 0.375" (9mm), cold rolled steel, continuously welded along all seams. A 0.375" (9mm) steel door with a ¼" (6 mm) rubber seal is firmly locked in place with a heavy-duty toggle latch. The door activates a recessed, "vandal-proof", stainless steel interlock switch that turns off the HVPS when it is open. A door with a 0.75" (18mm) acrylic or polycarbonate window is also available.

The rear of the unit has a 2" NPT threaded fitting for connecting an exhaust. Also on the rear are the interlock, HV discharge and ground connections. When ordered, the ETS Model 949 Test Target is also installed.

Supplied with the Firing Test Chamber is a 2-pin High Voltage connector with 12" output and ground lead cable with standard banana plugs and replaceable alligator clips.

Figure 6.7 Firing Test Chamber with discharge cable.

6.18 **Powder Electrode Assembly** (Optional)

Also available is a Powder Electrode Assembly for testing powders that consists of a stainless steel discharge head shown below with replaceable needle electrodes that is mounted to the top of the unit by a 1.25" (32 mm) Delrin insulator and an adjustable height sample holder with locking ring that accepts a 0.75" dia. (19 mm) sample cup. Six (6) cups are supplied. Additional cups can be ordered.
The 3/8-32 tapped hole to hold this unit is plugged with a 3/8-32 bolt when the Powder Electrode is not supplied at time of order.

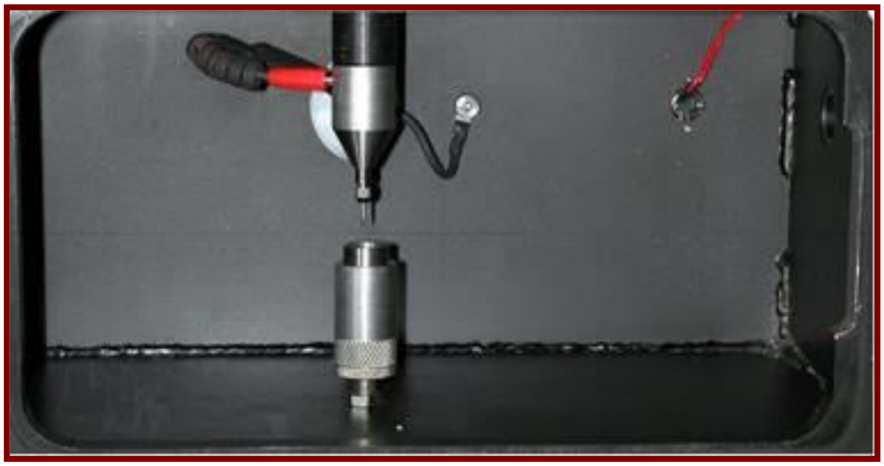


Figure 6.8 Powder discharge and sample holder assembly.

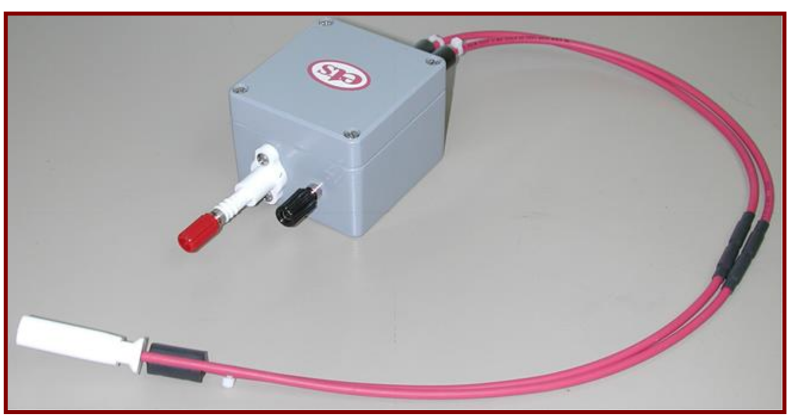
A blast shield (not shown in photos) covers the interlock connector and switch. To remove the shield remove the 2 screws securing it to the chamber located on the bottom of the unit.

NOTE:

The Firing Test Chamber is not certified to withstand any specific level. However, the chamber when installed correctly has been found to withstand a firing of a least a 250mg device. It is the responsibility of the end user to determine whether the chamber will be satisfactory for discharges of their particular device at equal or higher sizes.

6.18 **Output Connector Junction Box (**Optional, retrofit**)**

If the installation uses a different test chamber, an external Junction Box, shown in Figure 6.9 may be used. This Box acts as an interface between the Model 931 Output Cable and device (DUT) test cables. If the DUT cables and/or connectors are damaged during a test, they can easily be replaced.



Cable length will vary per customer requirement

Figure 6.9: Junction Box (Optional)

VII. Maintenance and Calibration

Maintenance

As with any electronic equipment a circuit could fail at any time. The most efficient way to handle this type of failure is to contact ETS describing the problem. ETS can then offer a course of action to fix the problem as soon as possible. Most electronic failures usually occur with an IC failure. All IC's in the Model 931 are mounted in plug-in sockets and should be readily available from electronics distributors or can be obtained from ETS. Warranty items will be supplied by ETS.

Access to the Control and Discharge units can be obtained by first removing the top cover. It is held in place by 6, #4-40 x ¼" screws. Pull the cover up to remove.

Prior to removing the cover from the Discharge unit, first make certain that the internal capacitors are discharged by connecting the supplied grounding wire to the round pin of **all capacitor select connectors** to bleed off any residual charge that may be on the capacitors.

CAUTION:

DANGEROUS VOLTAGES CAN REMAIN ON THE CAPACITORS FOR A SIGNIFICANT AMOUNT OF TIME AFTER THE SYSTEM HAS BEEN TURNED OFF, EVEN THOSE CAPACITORS NOT DIRECTLY CHARGED DURING THE LAST TEST.

NOTE:

Firing Test Chamber: Some items in the Firing Test Chamber could possibly be damaged during a test.

Parts damaged during a firing test are not covered under warranty. Replacement parts are the responsibility of the user. ETS can supply replacement parts as ordered.

Several spare clips are included with the unit. Additional clips can be ordered from ETS or obtained from a local electronics parts distributor or store.

7.1 Spare Parts

The Model 931 is a custom made system that utilizes a number of components that are specifically made per ETS specifications. The following Table lists both ETS and component manufacture name and part number for those items that may have to be replaced by the user. Components exclusive to ETS are listed with ETS Part Numbers. Standard parts are listed with manufacturer and their respective part number. In some cases such as IC, transistors, diodes, switches etc. similar parts from other manufactures can be substituted, if necessary.

(Spare Parts Table TBD)

7.2 Returning equipment to ETS

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 - SHIPPING

THE MODEL 931 UNITS ARE VERY HEAVY. SAVE ORIGINAL PACKING BOXES AND MATERIAL FOR RE-SHIPMENT. IF SHIPPING IN A DIFFERENT CONTAINER:

- **ENSURE THAT WALLS OF THE CONTAINER ARE SUITABLE FOR 50 TO 125 POUND ITEMS.**
- **ENSURE THAT THERE IS AT LEAST 2" OF FIRM COMPRESSIBLE MATERIAL (FOAM, ETC) BETWEEN ALL PARTS OF THE UNITS AND ANY OUTSIDE WALL OF THE SHIPPIING CONTAINER.**
- **DO NOT PLACE INSTRUMENTS OR ACCESSORIES INSIDE OTHER INSTRUMENTS OR CHAMBERS.**

ELECTRO-TECH SYSTEMS, INC. WILL NOT ASSUME RESPONSIBILITY FOR ADDITIONAL COST OF REPAIR DUE TO DAMAGE INCURRED DURING SHIPMENT AS A RESULT OF POOR PACKAGING.

Operational Checks

7.3 Voltage Check

CAUTION:

The following checks involve High Voltage with danger of personal shock or equipment damage. Start by fully discharging capacitors using the Ground Wire to the back panel Ground terminal.

The voltage on the capacitor is calibrated at the factory using a High Voltage Meter, capable of measuring DC voltage up to 40kV, with measurement accuracy of 0.10%. The meter input cable is plugged into the "square" side of one of the capacitor module selector connectors as shown in Figure 7.1. The ground lead is connected to the GND connector located on the rear panel of the Discharge unit, and the Interlock switch must be closed. The unit is then switched ON to make the reading.

Figure 7.1: Measuring Voltage on capacitor

To perform an operational voltage check, the user needs a high voltage meter capable of measuring voltages up to 30kV with a resolution of 10V and a measurement accuracy of at least 0.5% at 25kV. Input resistance must be at least 30,000 megOhms.

7.4 Capacitance check

CAUTION:

Turn off power and discharge all capacitors prior to making this measurement. Do not assume they are discharged. Use the Grounding Cable located on the rear of the Discharge unit by inserting the white silicone wire into ALL capacitor selector inputs. Residual charge on the capacitor will damage the capacitance meter and may result in the operator receiving a shock. With large capacitance, this can result in serious injury. Residual charge can remain for long periods of time.

The actual capacitor value is measured using a capacitance meter. The meter input connector is connected to the “round” side of the capacitor selector connector of the capacitor being measured. The other meter lead is connected to the GND connector located on the rear panel of the Discharge unit. Total system capacitance is the capacitor value plus the parasitic capacitance, C_{p1} of 50pF.

The test set up is shown in Figure 7.2.

Figure 7.2: Measuring Capacitance

7.5 Resistance Check

CAUTION:

Turn off power and <u>discharge all capacitors</u> prior to making this measurement.

The resistance is measured using a resistance meter with an accuracy of at least 1%.

1. **Resistor Selection (System A):** The resistance of the internal resistors can be measured by inserting one meter probe into the “round” side of the desired Resistor Select connector on the front panel and the other probe into the “round” side of the 0 Ohm Select connector. (All resistors are connected together at the Output connector on the rear panel. The 0 Ohm resistor is a direct connection from the Output connector to the 0 Ohm Select connector.)

2. **Resistor Module (System D):** The resistance of the Resistor module can easily be measured by inserting the meter probes into the module connector and taking a measurement.

7.6 Discharge Waveform Check

The discharge pulse is measured using an ETS Model 949 IEC Test Target and an Agilent Model DSO 6102A oscilloscope having a single shot bandwidth of 1 GHz and a sampling rate of 4 giga samples/sec. The connection to an external Test Target is shown in Figure 7.3, and to an unit installed in the Firing Test Box in Figure 7.4.

The Test Target, if ordered, comes complete with a 20db, 2W Attenuator rated at 1kW for pulses, SMA BNC cable and 50 Ohm Terminator to connect to the 1 megOhm input of the scope. The 50 Ohm terminator supplied MUST be used. Otherwise, the waveform measured will be approximately twice the actual amplitude. The conversion factor of the Test Target is 1:1 and with the attenuator, 10:1. That is, 1 Volt measured on the scope is equivalent to 1 Amp and 10 Amps respectively.

Note: Cable is coiled for illustration purposes only

Figure 7.3: Current pulse calibration set-up, external Test Target

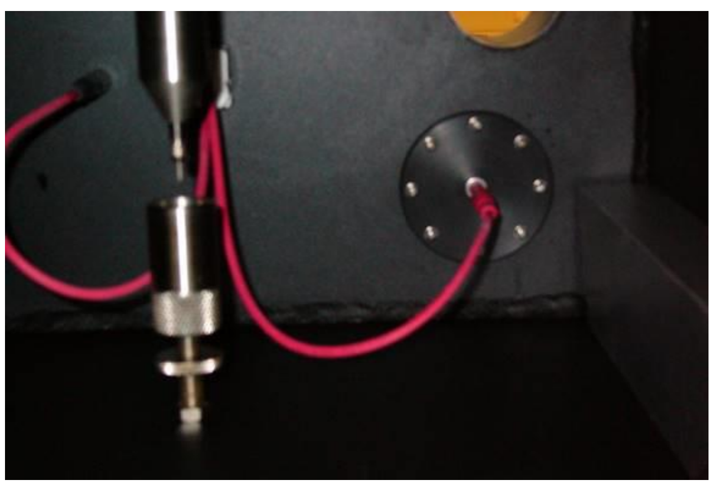


Figure 7.4: Current pulse calibration set-up

Firing Test Chamber installation

The waveform is captured using the appropriate scale for the voltage level and resistor value being measured and the appropriate time base that will range from 25 nsec/div to 10 μsec/div depending on the R and C values. Refer to Figure 7.6 for appropriate scope setting for the particular RC network being measured.

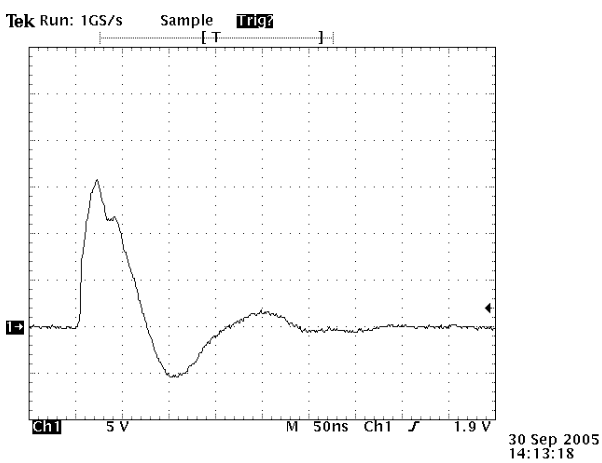
Rise times are typically 10-25 nsec.

The discharge waveform is displayed to look at the area under the curve that is used for the energy calculation. R/C networks using low capacitance (<1000pF) and high resistor values (5000 Ohms) will exhibit a large overshoot then ringing over the first 25 nsec or so. This ringing increases with output cable length and constitutes only a very small area under the discharge curve and has very little effect on the overall energy under the full curve. The average peak voltage over the first 50 nsec is within ±10% of the calculated peak current value for resistances greater than 250 Ohms. At low capacitance and resistance the overall impedance of the circuit begins to dominate the peak current measured.

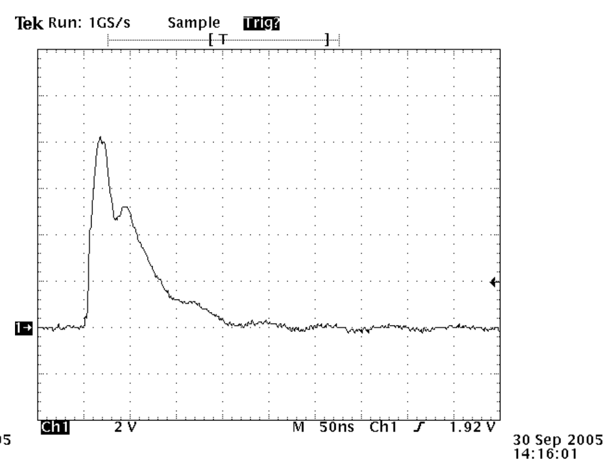
The waveform using 0 Ohms is a damped oscillation where the peak current is determined by the impedance of the circuit rather than primarily the resistance.

Typical waveforms for the following R/C combinations at 5kV are shown in Figure 7.6 and for 25kV in Figure 7.7:

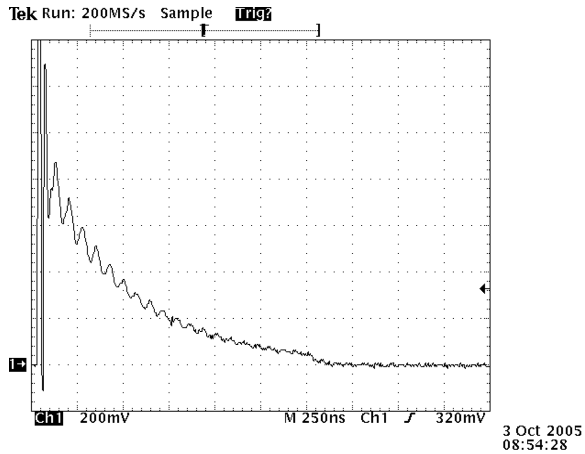
100pf & 0 (5kV only), 500, 1500 & 5000 Ohms
500pf & 0 (5kV only), 500, 1500 & 5000 Ohms
2000pf & 0 (5kV only), 500, 1500 & 5000 Ohms



R=0Ω

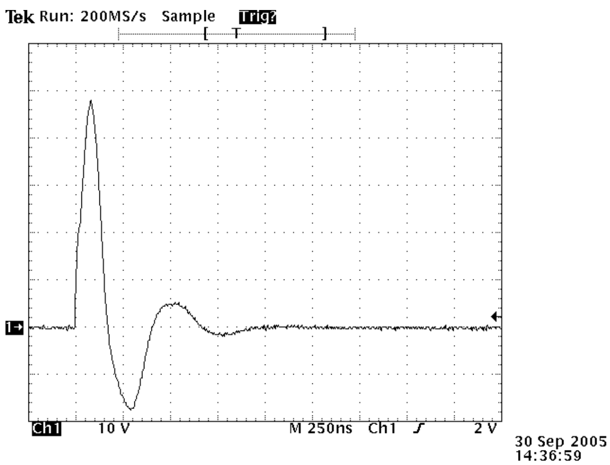


R=500Ω

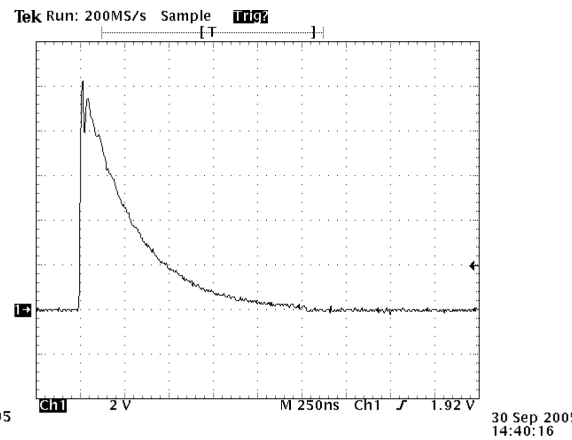


R=5000Ω

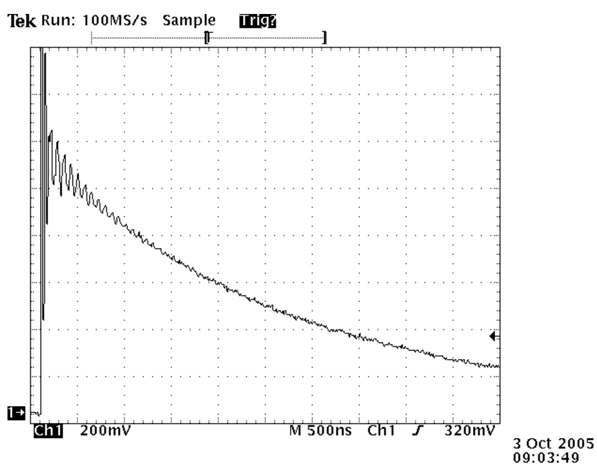
Discharge waveform @ 5kV, C=100pF



R=0Ω

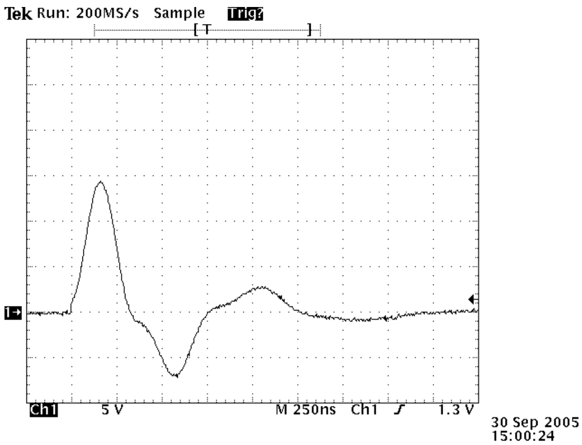


R=500Ω

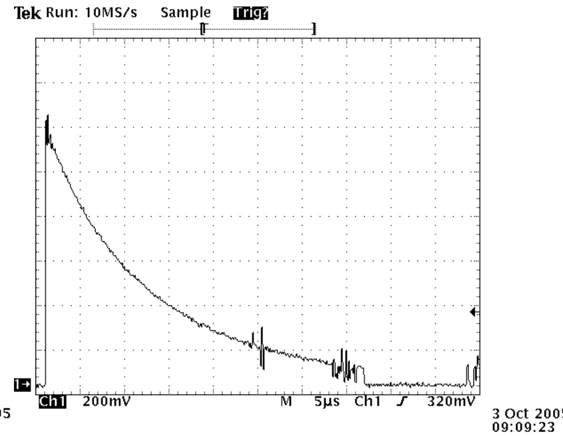


R=5000Ω

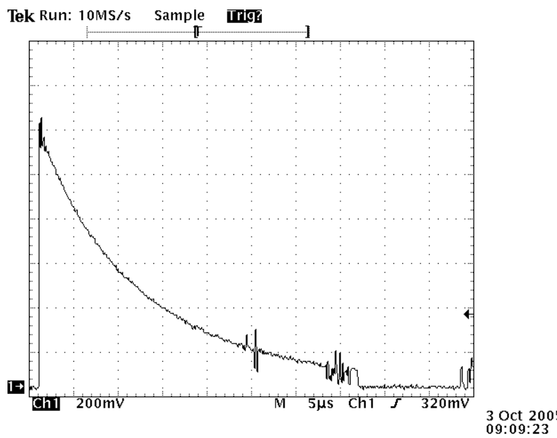
Discharge waveform @ 5kV, C=500pF



R=0Ω



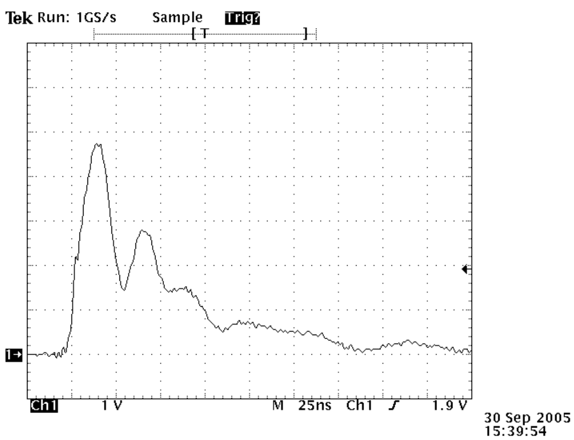
R=500Ω



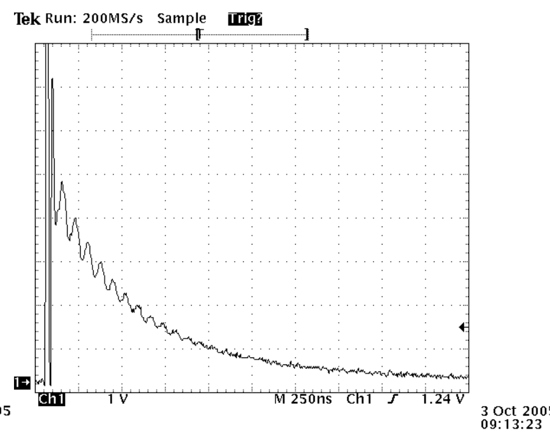
R=5000Ω

Discharge waveform @ 5kV, C=2000pF

Figure 7.6 Typical discharge waveforms @ 5kV

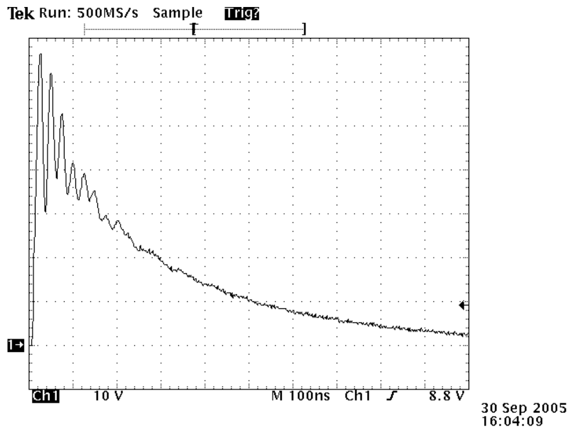


R=500Ω

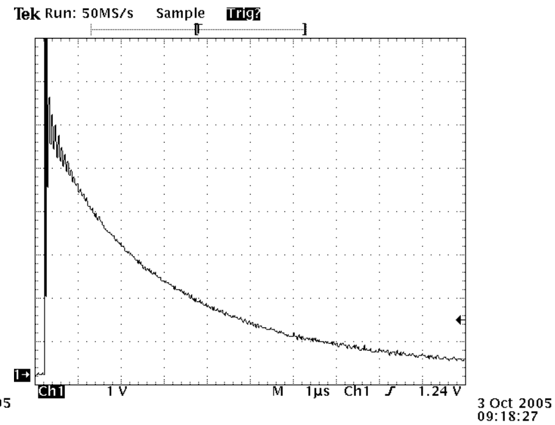


R=5000Ω

Discharge waveform @ 25kV, C=100pF

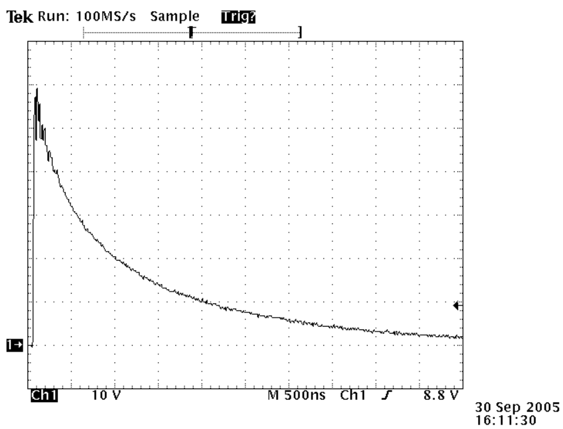


R=500Ω

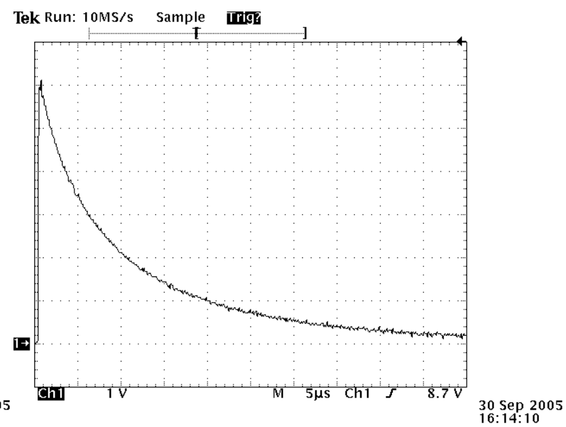


R=5000Ω

Discharge waveform @ 25kV, C=500pF



R=500



R=5000Ω

Waveform @ 25kV, C=2000pF

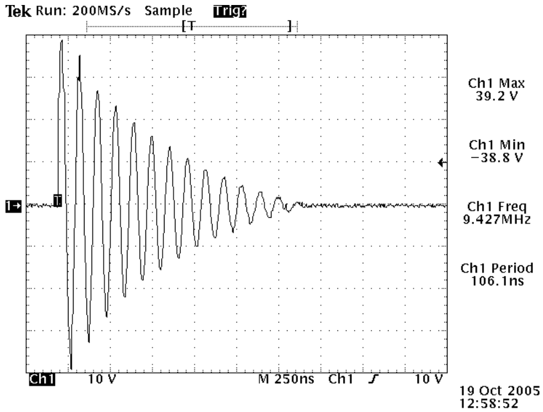
Figure 7.7 Typical discharge waveforms at 25kV

Typical waveforms for the Method 3031 discharge unit are shown in Figure 7.8.

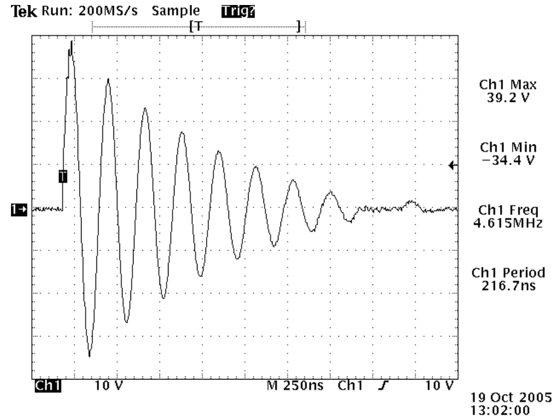
NOTE:

When measuring these waveforms the peak current pulses can be very high. Most standard attenuators state only a continuous rating such as 2 Watts. Peak capability depends on internal construction. One which has been found to work is CATTEN-0200-BNC (20dB, DC to 1GHz, 2W #1701-01) from CRYSTEK corp.

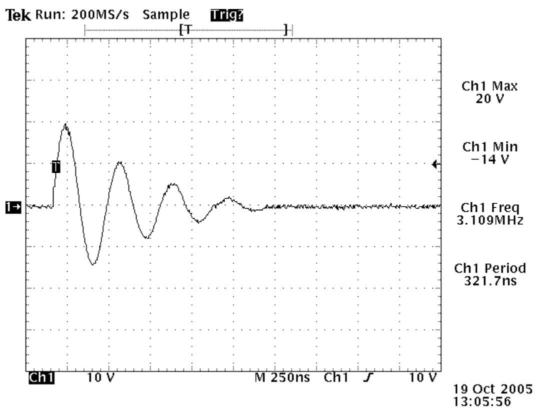
Waveforms may be taken at moderate voltages such as 1000, 500 and 250 Volts, in order to be within the measurement range of the oscilloscope used. The discharge waveforms are linear, and therefore can be extrapolated out to the required 5kV test voltage.



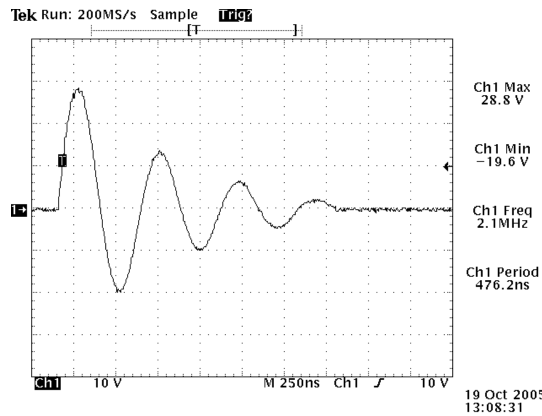
100pf @ 5kV



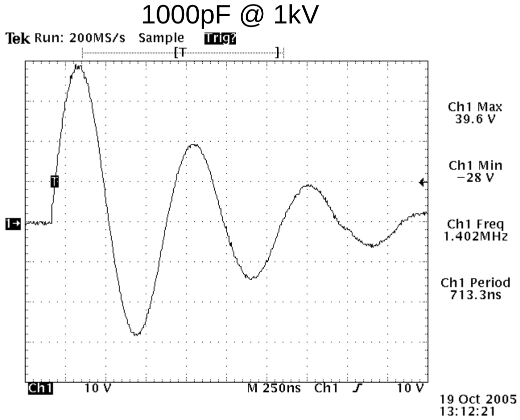
500pf @ 2.5kV



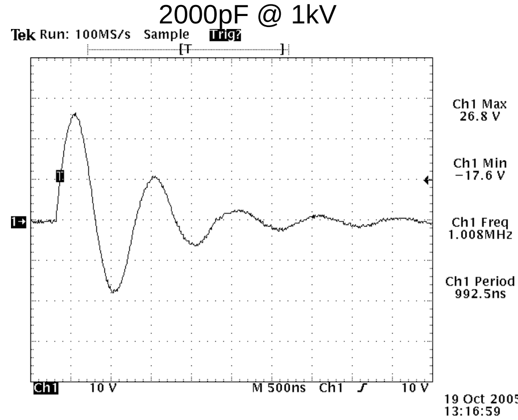
1000pF @ 1kV



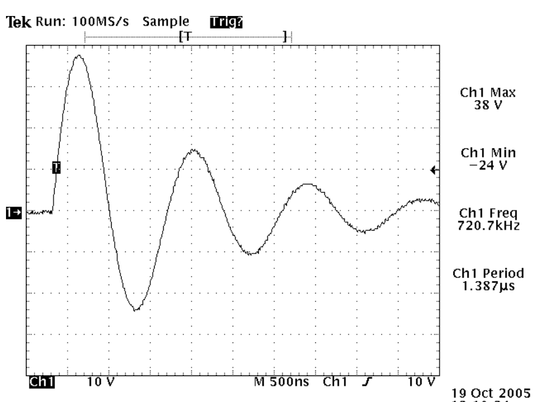
2000pF @ 1kV



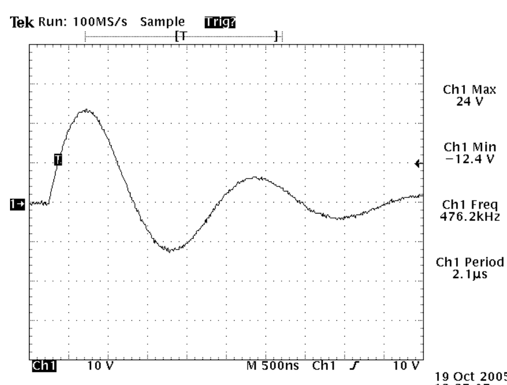
5000pF @ 1kV



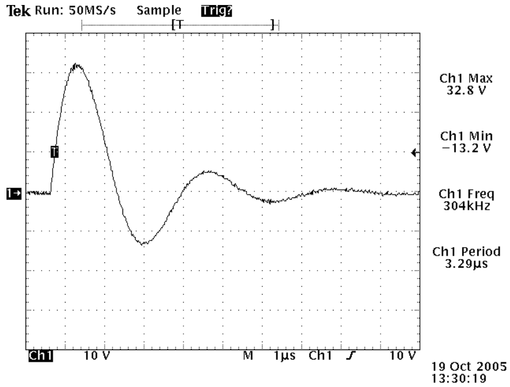
.01µF @ 500V



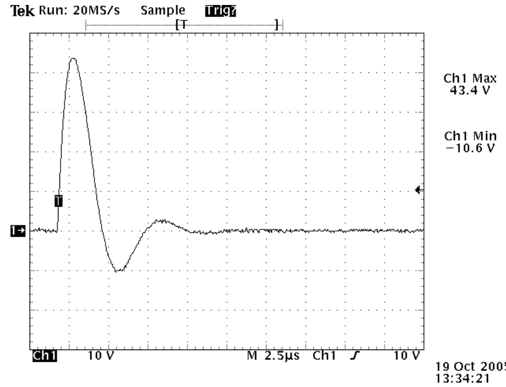
.02µF @ 500V



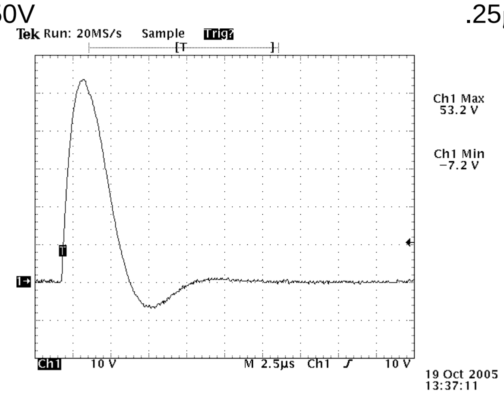
.05µF @ 250V



.10uF@ 250V



.25µF @ 250V



.50µF @ 250V

Figure 7.8: Discharge waveforms for MIL STD 1731A, Method 3031

VIII. 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 of 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. The 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.

APPENDIX A - Applicable Standards

1.1 Test Standards

Most applications require the determination of the energy threshold required to ignite explosives by electrostatic discharge of varying intensities. Resulting data can then be used to characterize the probability of initiation due to electrostatic discharge (ESD) events.

MIL-STD-1751A, Group 1030 Test Methods along with MIL-STDs 1576, Method 2205 and MIL-STD-331C, Appendix F constitute the most common test standards for electrostatic discharge sensitivity testing.

1.1.2 MIL-STD-1751A
This test standard is for testing explosive powders.

Method 1031
1. Maximum test voltage: 5kV
2. Resistor: 0 Ohms
3. Capacitors: 100, 250, 500, 1000, 2000, 5000 pf
   0.01, 0.02, 0.05, 0.1, 0.25, 0.50 µF

Method 1032
1. Maximum test voltage: 25kV
2. Resistor: 0 Ohms
3. Capacitors: 250pF – 0.02 µF

Method 1033
1. Maximum test voltage: 5kV
2. Resistor: 0 Ohms
3. Capacitor: 0.02µF (other values are implied)

Method 1034 (NATO Std.)
1. Maximum test voltage: 30kV
2. Resistor: 0 Ohms
3. Capacitor: 0.035µF (34.7nF specified)

1.1.2 MIL-STD-1576 Method 2205
This test standard is typically used to test devices.

1. Maximum test voltage: 25kV
2. Resistors: 0, 5000 Ohms
3. Capacitor: 500pF

1.12 MIL-STD-331B Notice 3
This test standard is typically used to test devices.

1. Maximum test voltage: 25kV
2. Resistors: 500, 5000 Ohms
3. Capacitor: 500pF