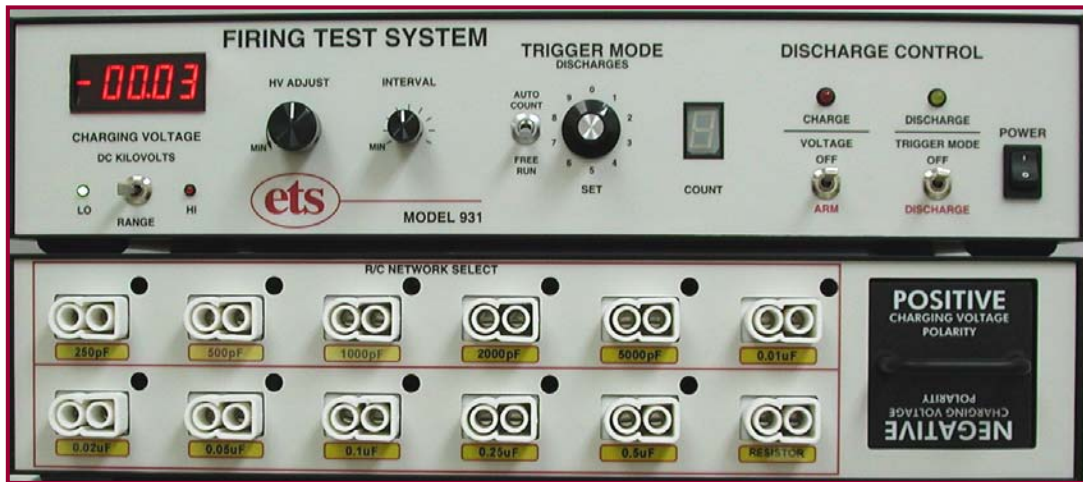


# FIRING TEST SYSTEM

## Model 931



*System shown may differ from actual system ordered*

## Operating Manual

10/13



**electro-tech systems, inc.**

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# IMPORTANT SAFETY INSTRUCTIONS

(Equipment containing HV)

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

## POWER

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

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

**FUSES:** The Model 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 as **30kV**. In addition, equipment may

contain capacitors up to **0.035  $\mu$ F charged to 30kV and capacitors up to 0.5  $\mu$ F charged up 6kV. Capacitors can retain a charge even if the equipment is turned off.**

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

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

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

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

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

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

## MAINTENANCE and SERVICE

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

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

## 1.0 INTRODUCTION

The 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.

The Model 931 Firing Test System can produce discharge pulses from  $<\pm 100$  volts to  $>\pm 26$  kV. Energy is stored in capacitor banks during the charging cycle. A discharge pulse is produced when a high voltage gas filled 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 60 pF to 0.5  $\mu$ F and resistor values ranging from 0 to 10,000 Ohms are available.

## 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  $\mu$ f

#### Method 1032

1. Maximum test voltage: 25kV
2. Resistor: 0 Ohms
3. Capacitors: 250 pF – 0.02  $\mu$ f

### Method 1033

1. Maximum test voltage: 5kV
2. Resistor: 0 Ohms
3. Capacitor: 0.02 $\mu$ f (other values are implied)

### Method 1034 (NATO Std.)

1. Maximum test voltage: 30kV
2. Resistor: 0 Ohms
3. Capacitor: 0.035 $\mu$ F (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

#### 1.1.2 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

## 2.0 DESCRIPTION

The Model 931 FTS, shown in Figure 2.0-1 consists of three separate components:

1. Control Unit
2. Discharge Unit
3. Firing Test Chamber (Optional)



a. Control and Discharge units



b. Firing Test Chamber (Optional)

Figure 2.0-1: Model 931 Firing Test System

The principle of operation of the Model 931 is illustrated in Figure 2.0-2.

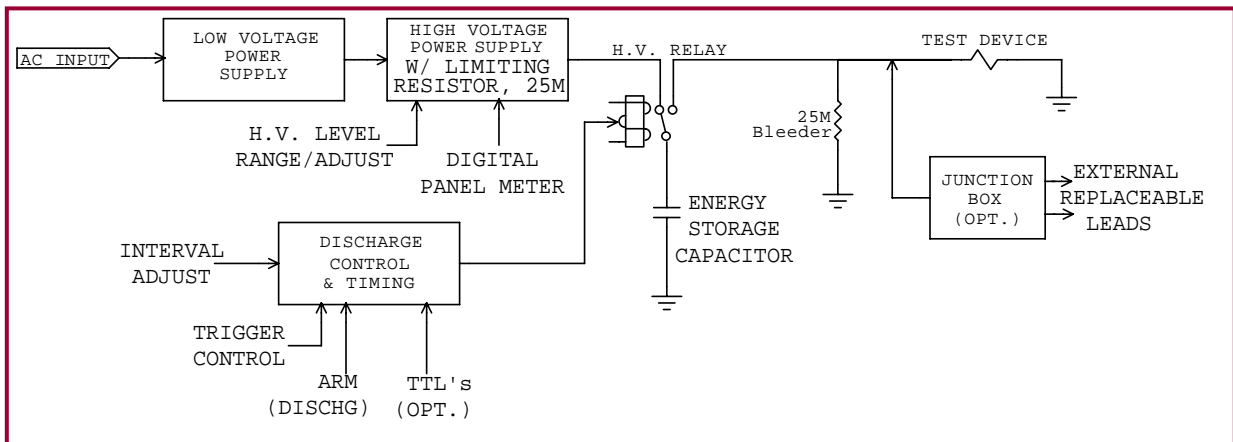


Figure 2.0-2: Simplified Block Diagram

The standard Model 931 Firing Test System is housed in two (2) units: A Control Unit that contains the low voltage power supply, discharge control and timing circuits, and the operating controls. A Discharge Unit that contains the high voltage power supply, Polarity Reversing Module, R/C networks and the HV, SPDT gas filled relay. In the standard configuration, the two units are interconnected by a detachable 10' (3m) long, 15-pin, sub D cable and a 12" (30.5cm) ground wire. Each unit is housed in an aluminum enclosure measuring 16.75"Wx3.5"Hx12"D (42.6x8.8x30.5cm).

## NOTE

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 4, 10' (3m) cables.

The CHARGE/DISCHARGE cycle is accomplished using a 35kV, SPDT gas filled 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 0.02 $\mu$ F because of the charge up time required for higher value capacitors.)

### **Remote TTL Trigger Inputs [ARM & DISCHARGE] (Optional, factory installed):**

This option parallels the function of the ARM and Discharge switches. It allows the user to both ARM and trigger the discharge relay using an external source such as a computer or pulse generator. Two BNC connectors are located on the rear panel of the Control Unit and require a **+3 to 15V, pulse**. For initiating the ARM function the length of the pulse must be compatible with the charging time required for the selected capacitor value. To initiate the Discharge function a minimum 1msec pulse is required. This Remote function only operates in the FREE RUN mode. The number of discharges is controlled by the external triggering. (The AUTO mode is controlled by an internal timing circuit).

Capacitors below 0.02 $\mu$ F (20,000pF) will charge to the adjusted value in 5 seconds or less. However, capacitors 0.05 $\mu$ F (50,000pF) and above require considerably more than 5 seconds to fully charge to the maximum of 5kV. The 0.25 $\mu$ F capacitor requires approximately 90 seconds to charge to 5kV and the 0.5 $\mu$ F 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 2.0-3 for 5kV, but it applies to any charging voltage setting.



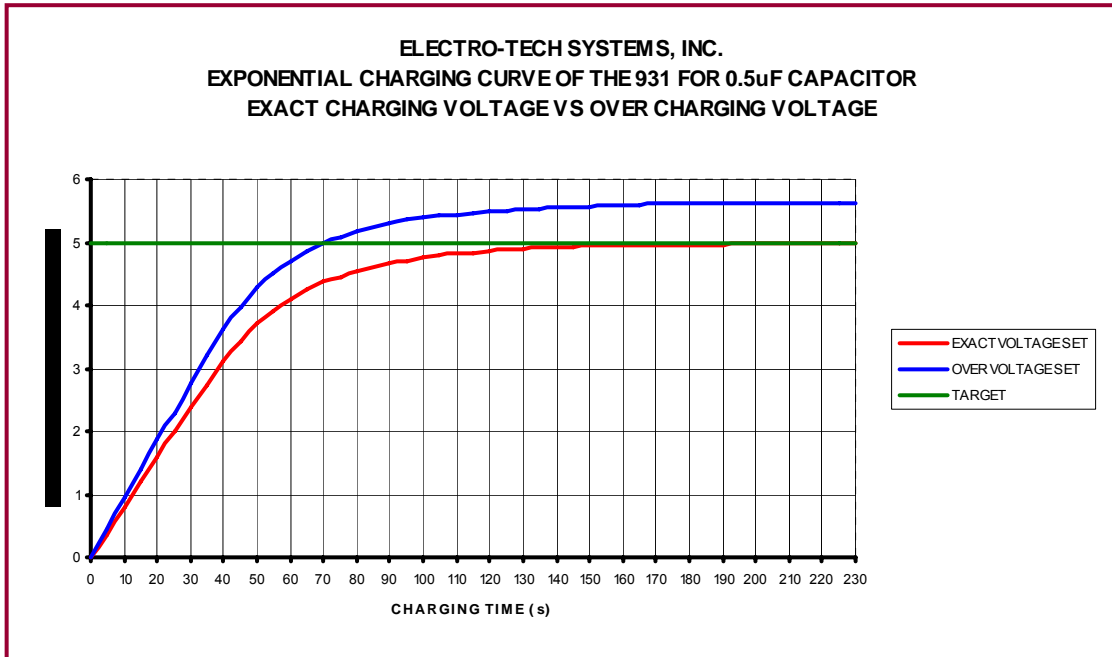


Figure 2.0-3: Exponential charging curve

## 2.1 Control Unit

### 2.1.1 Front Panel

Figure 2.1-1 shows the Control Unit front panel.



Figure 2.1-1: Control Unit front panel

#### 2.1.1.1 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 2.1a shows the installation of an optional key switch for controlling access to the system.



Figure 2.1-1a: Optional AC Power key switch

#### 2.1.1.2 **DISCHARGES SELECT** Switch

This ten (10) 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 overridden when the AUTO COUNT/FREE RUN switch is in the FREE RUN position.

#### 2.1.1.3 **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.

#### 2.2.1.4 RANGE

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  $>0.02\mu\text{F}$  (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  $0.02\mu\text{F}$  to be charged up to 26kV.

#### 2.1.1.6 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  $4\frac{1}{2}$ -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.

#### 2.1.1.7 INTERVAL ADJUST

This rotary control allows the operator to set the time interval between discharge pulses. This interval is adjustable from a minimum of  $\frac{1}{3}$  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  $t=5R_{\text{chg}}C$ . This determines the minimum interval that can be used. For capacitors  $\leq 0.02\mu\text{F}$  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 0.25 $\mu$ F capacitor to the desired voltage requires approximately 90 seconds.**

#### **2.1.1.8 DISCHARGE CONTROL**

##### **2.1.1.7.1 ARM**

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 .02 $\mu$ F 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.

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

**The charging time required for C=0.25 $\mu$ F is approximately 90 seconds and several minutes for C=0.5 $\mu$ F 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 2.0-3 and then determine the time required for the capacitor to charge up to the desired voltage. The TTL pulse timing is then set to trigger the discharge relay at the established time. The higher the overcharging the faster the capacitor will charge to the desired level.**

##### **2.1.1.7.2 TRIGGER**

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.

## 2.2.1.8 Displays

### 2.1.1.8.1 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.

### 2.1.1.8.2 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.

### 2.1.1.8 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.

### 2.1.1.9 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.

### 2.1.2 Rear Panel

The rear panel, shown in Figure 2.1-2 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.

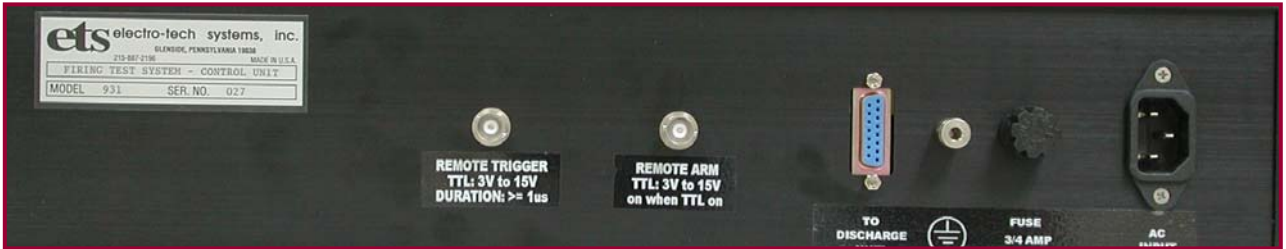


Figure 2.1-2: Control Unit rear panel

## 2.2 Discharge Unit

### 2.2.1 Front Panel

The front panel layout with the standard System D R/C network select is shown in Figure 2.2-1a and the standard R/C and selector modules are shown in Figure 2.2-2.



Figure 2.2-1: Discharge Unit front panel layout

At high voltage, corona may develop inside the capacitor select connectors. Safety plugs, as shown in Figure 2.2.1 that plug into unused connectors are now supplied as standard.



Figure 2.2-2: 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.**

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:

<u>R Ohms</u>	<u>C pF</u>
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.

## 2.2.2 Rear Panel

The rear panel, shown in Figure 2.2-3 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 2.2-3: Discharge Unit Rear Panel



## 2.3 Custom Configurations

Custom Discharge Unit configurations that are installed at the time of order such as selection of multi-pin device selectors and separate discharge units or retrofitted devices are described and added in the Appendix along with special instructions.

## 2.4 Firing Test Chamber (Optional)

An optional Firing Test Chamber (FTC), shown in Figure 2.4-1, measuring 16.75"Wx9"Hx12"D (42.6x23x30.5cm) is fabricated from 0.375" (9mm), cold rolled steel, continuously welded along all seams is available. A 0.375" (9mm) steel door with a 1/4" (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 2.4-1 Firing Test Chamber with discharge cable

Also available is a Powder Electrode Assembly for testing powders that consists of a stainless steel discharge head shown in Figure 2.4-2 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 not supplied at time of order.

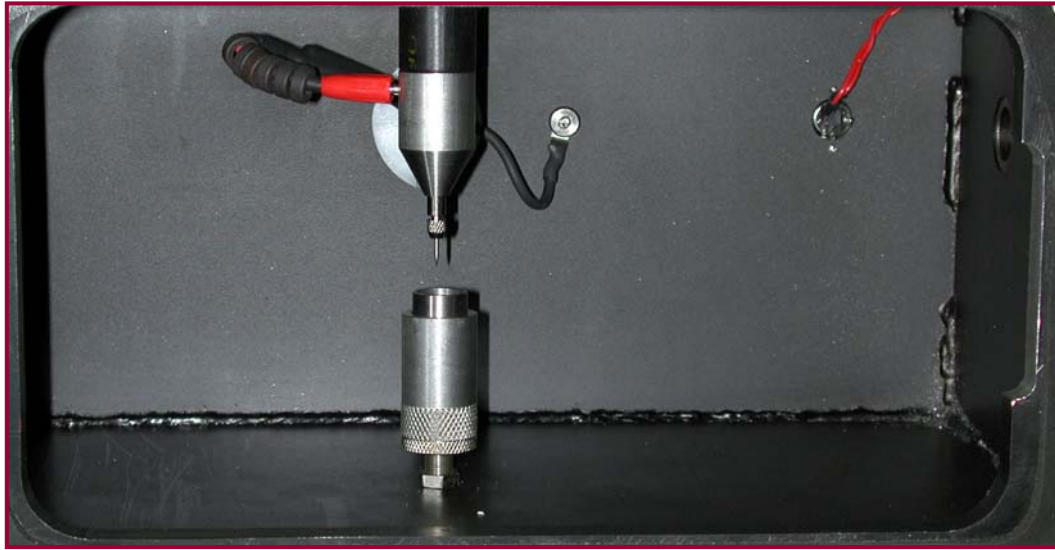


Figure 2.4-2 Powder discharge and sample holder assembly

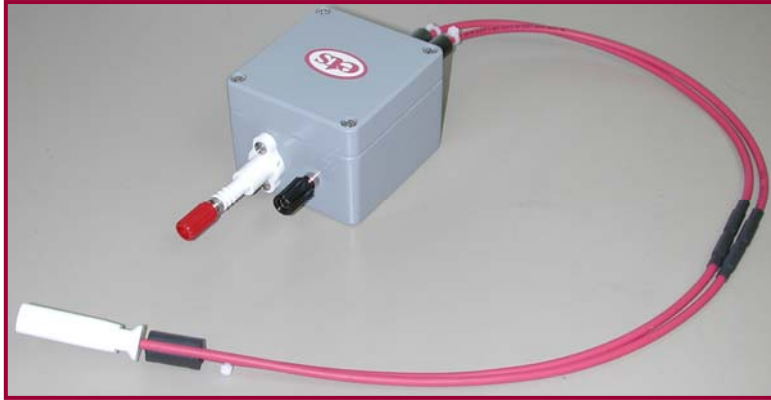
A blast shield (not shown in photos) covers the interlock connector and switch. To remove the shield remove the 2 screws securing it to the chamber located on the bottom of the unit.

**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 up to the end user to determine whether the chamber will be satisfactory for discharges of their particular device at equal or higher sizes.**

## **2.5 Output Connector Junction Box (Optional, retrofit)**

If the installation uses another Firing Test Chamber, an external Junction Box, shown in Figure 2.5-1 is available. 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 2.5-1: Junction Box (Optional)

## 2.6 Output Probes and Accessories

The standard FTS is supplied with the following cables and accessories:

1. Output Cable: 5' (1.5m) 40kV silicone, terminated with HV connector and standard banana plug with replaceable alligator clip.
2. Ground Cable: 5' (1.5m) black rubber, terminated with standard banana plugs with replaceable alligator clip on one end.
3. 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)}.
4. Inter-unit Ground Cable: 12" (3.7m) green rubber with standard banana plugs on both ends. {Custom lengths available}
5. 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}
6. Power Cord: 8' (2.5m) IEC to North American 3-prong. {British 3-prong cable available}
7. Capacitor Select Module.
8. Resistor modules or resistor select module, if resistors are built-in.

## 3.0 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 3.0-1 is an equivalent circuit of the discharge unit.

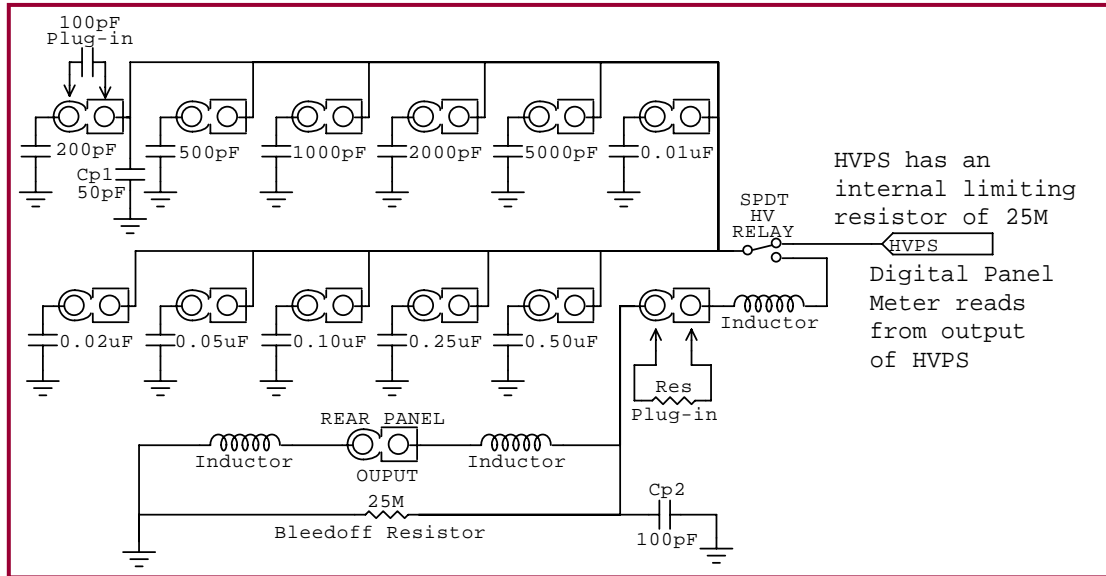


Figure 3.0-1 Discharge unit equivalent circuit

### 3.1 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  $\pm 5\%$  and system capacitance of better than  $\pm 15\%$  for capacitors 500pF and below and  $\pm 5\%$  for capacitors 1000pF and above.

High Voltage resistors with a  $\pm 5\%$  or better tolerance are used.

The following are typical actual system capacitance and resistance values:

SPECIFIED		ACTUAL	
R $\Omega$	C pf	R $\Omega$	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:

$$E = \frac{1}{2}(C+C_{p1})V^2 \text{ Joules}$$

or

$$E = \frac{1}{2} C_{act}V^2 \text{ Joules}$$

$C_{p2}$ . 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 Figures 6.0-5 and 5.

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.

### 3.2 Charging Voltage

The voltage applied to the capacitor is adjusted at the factory to be better than  $\pm 2\%$  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

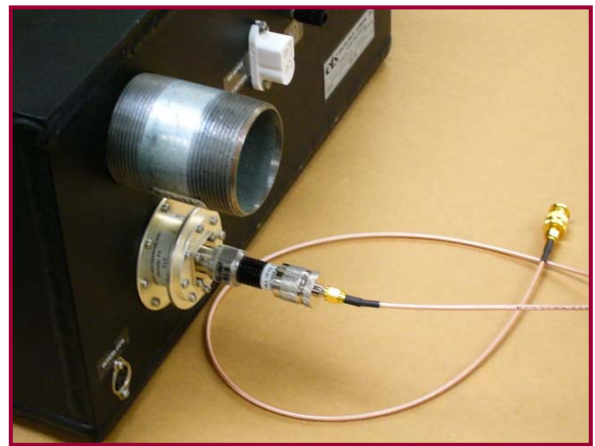
$$V_m = CV/(C+C_{p1})$$

### 3.3 Discharge Pulse Calibration

The output pulse is calibrated using an IEC 61000-4-2 compatible test target (ETS Model 949) as shown in Figure 3.3-1a. The Model 949 is also available installed in the Firing Test Box shown inf figure 3.31b. 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.



a. External Test Target



b. Test Target installed on Firing Test Box

Figure 3.3-1: Test Target installions

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 Figures 6.0-4 & 5. 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  $E = IR \pm 10\%$  relationship i.e. a 5kV pulse through a 500 Ohm resistor should have an average peak current value over the first 50nsec of  $10 \pm 1$  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:

$$E = R t \sum^n I^2$$

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

## 4.0 INSTALLATION

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.

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.**

**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.

**Location:** Place the System on a sturdy table. Overall weight including the Firing Test Chamber is approximately 50 pounds (23kg). Connect the exhaust port of the Chamber to the appropriate exhaust system. The exhaust port is a 2" NPT pipe thread fitting.

Connect the cables as shown in Figure 4.0-1 for the standard system.

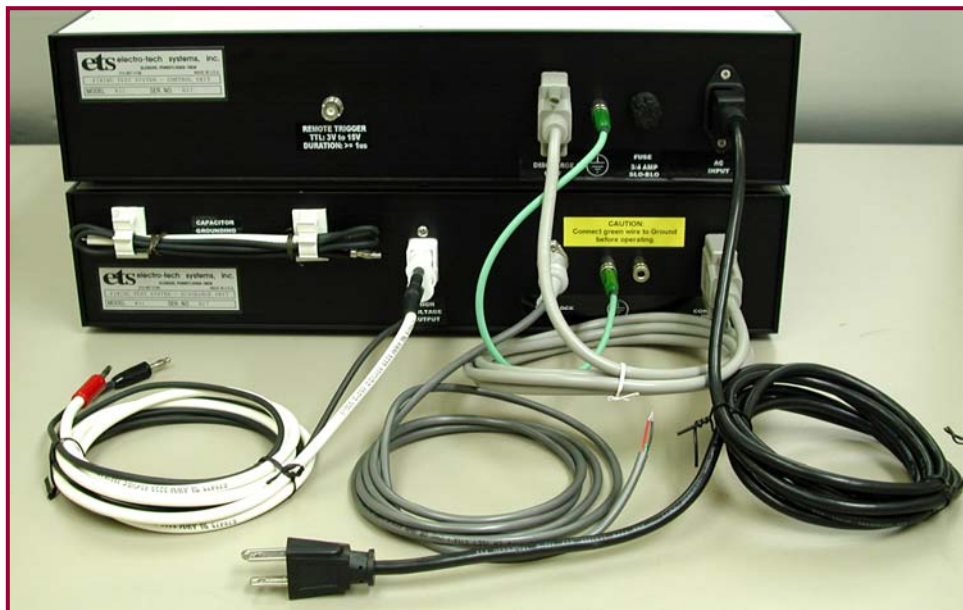


Figure 4.0-1: Standard System wiring

With the Firing Test Chamber, connect the system as shown in Figure 4.0-2

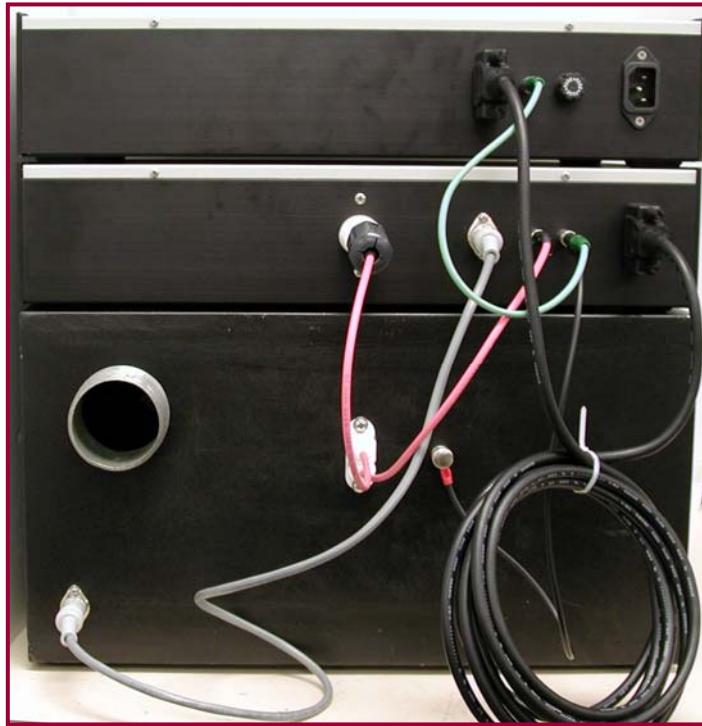


Figure 4.0-2: System wiring with Firing Test Chamber

Figure 4.0-3 shows the installation of the optional Junction Box. 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 4.0-3: 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.**

## 5.0 OPERATION

### 5.1 Sample Preparation

To perform a test on a device proceed as follows:

1. Connect the Output and Ground lead clips to the appropriate DUT (Device Under Test) pins or leads as shown in Figures 5.1-1a and b. Actual connection to the DUT will be determined by the DUT configuration.

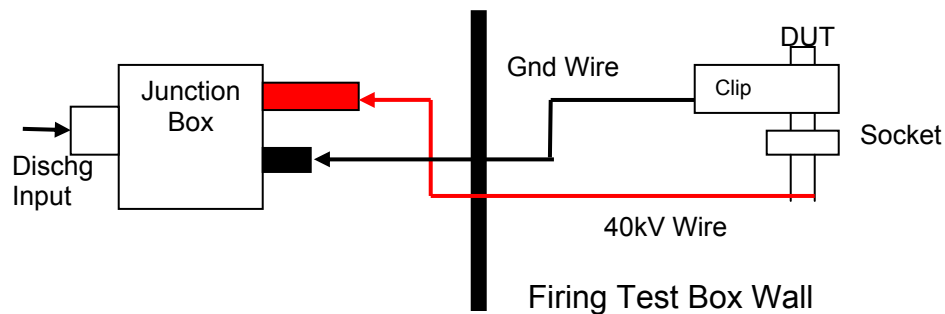


Figure 5.0-1a: DUT wiring connections Output to pins, Gnd to case

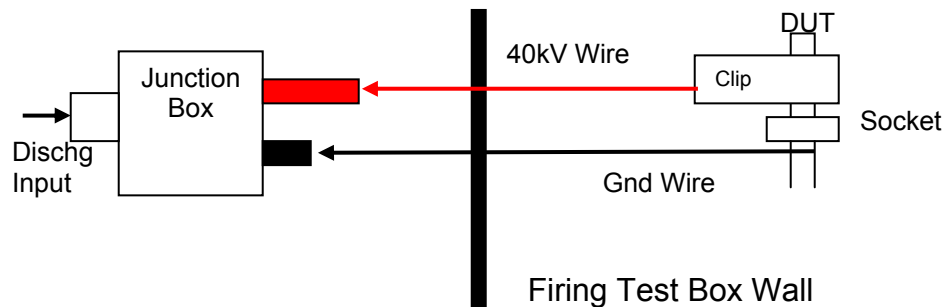


Figure 5.0-1b: DUT wiring connections, Output to case, Gnd to pins

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 in Figure 5.1-2a and b. The DUT will be connected to ground through the 2 Ohm Target resistance. A typical set up is shown in Figure 5.0-3.

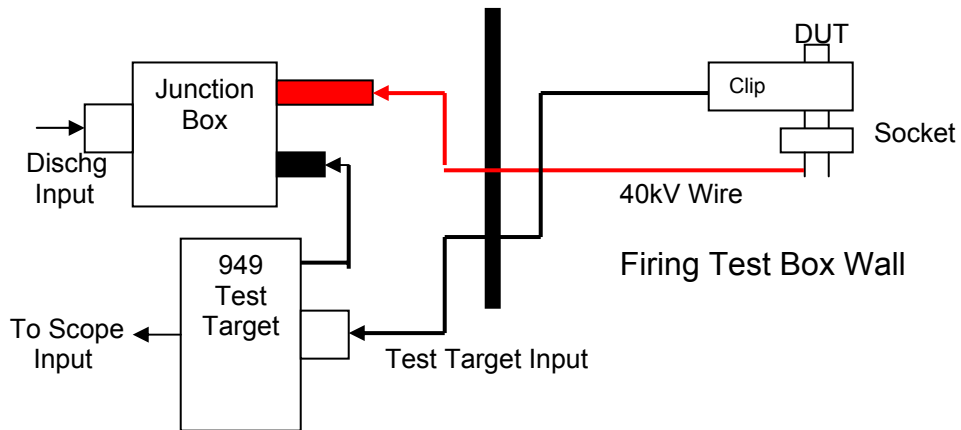


Figure 5.0-2a: DUT current waveform monitoring connection Output to pins, Gnd to case

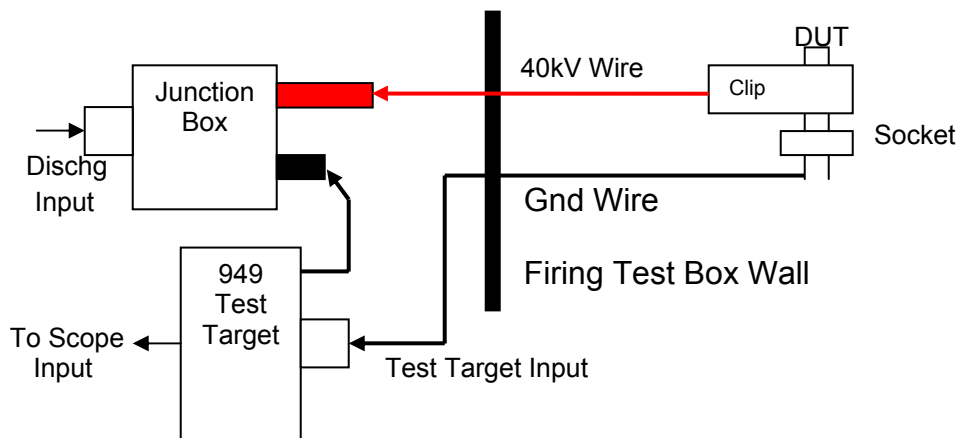


Figure 5.0-2b: DUT current waveform monitoring connection Output to case, Gnd to pins



Figure 5.0-3: Typical current monitoring test setup with Junction Box

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.
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. 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 0.02 $\mu$ F (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 0.02 $\mu$ F to the LO range (5.5kV).**

4. 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.

**If the TTL Charge (ARM)/Discharge option is installed the voltage must first be adjusted as described above.**

**NOTE:**

The charge time is exponential and 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 ( $\tau=5RC$ ) 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 (0.5 $\mu$ F) to reach the exact voltage setting (for example 5.00kV). Therefore, to quickly set the voltage for capacitors >0.1 $\mu$ f, select the 0.01 $\mu$ f capacitor to set the voltage level to avoid the long charging time associated with the 0.1, 0.25 and 0.5 $\mu$ f capacitors then switch back to the desired capacitor value.

5. 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 & 0.5 $\mu$ F) 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 0.5 $\mu$ F 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.

**If the optional TTL Charge (ARM)/Discharge trigger circuit is installed,** select the **FREE RUN** mode. This cycle will then be controlled automatically once the TTL signals are received.

6. 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

$$\begin{aligned}t &= 5RC \\ &= 5 \times 100 \times 10^6 \Omega \times 25 \times 10^{-12} \text{pF} \\ &= 0.125 \text{ sec. (125 milliseconds)}\end{aligned}$$

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.**

## **5.2 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 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 5.2-1.

**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.**

### 5.3 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 as shown in Figure 5.0-3a or installed in the ETS Firing Test Chamber as shown in Figure 5.0-3b.



a. Free-standing unit



Firing Test Box installation

Figure 5.0-3: 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.

## 6.0 CALIBRATION

The Model 931 is calibrated at the factory as follows:

### 6.1 Voltage

The voltage on the capacitor is calibrated at the factory using a High Voltage Meter, with measurement accuracy of 0.10%, capable of measuring DC voltage up to 40kV. The meter input cable is plugged into the “square” side of one of the capacitor module selector connectors as shown in Figure 6.0-1. The ground lead is connected to the GND connector located on the rear panel of the Discharge unit. The Interlock switch must be closed in order to turn on the voltage.

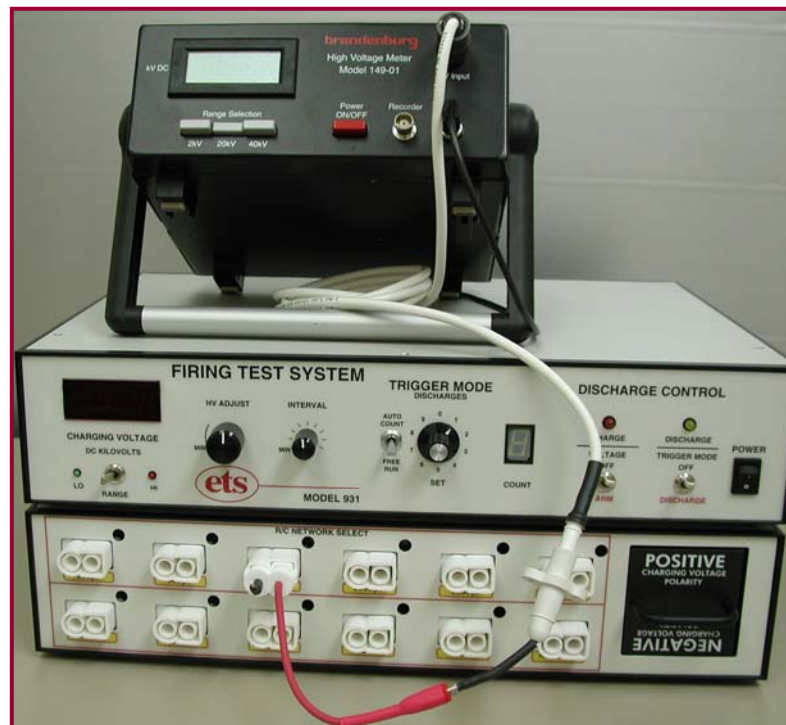


Figure 6.0-1: Measuring Voltage on capacitor

To perform this measurement 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.

### 6.2 Capacitance

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 6.0-2.



Figure 6.0-2: Measuring Capacitance

**CAUTION:**

Turn off power and make sure all capacitors are totally discharged prior to making this measurement. 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 or 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.

## 6.2 Resistance

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.

### 6.3 Discharge Waveform

1. 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 Gigasamples/sec. The connection to an external Test Target is shown in Figure 6.0-3a and to an unit installed in the Firing Test Box in Figure 6.0-3b. The Test Target, if ordered, comes complete with 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 6.0-3a: Current pulse calibration set-up, external Test Target

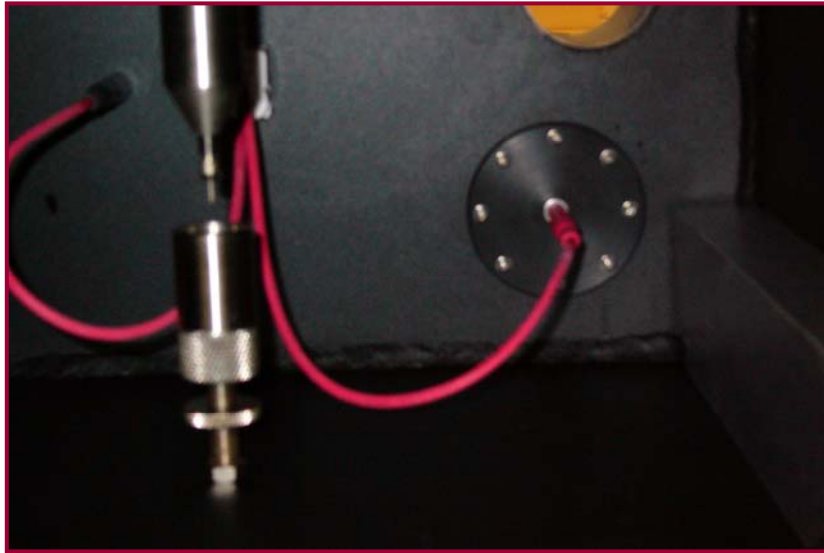


Figure 6.0-3b: Current pulse calibration set-up, Firing Test Chamber installation

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  $\mu$ sec/div depending on the R and C values. Refer to Figure 6.0-4 for appropriate scope setting for the particular RC network being measured.

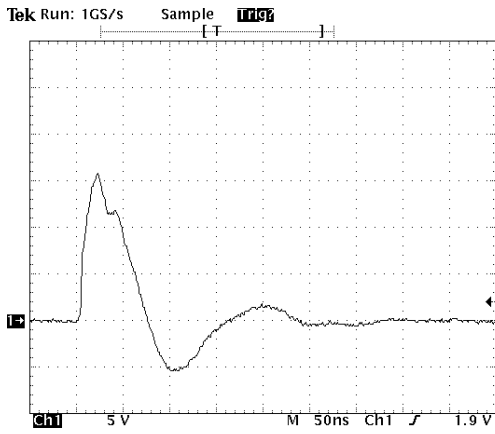
Rise times are typically 10-25 nsec.

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  $\pm 10\%$  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.

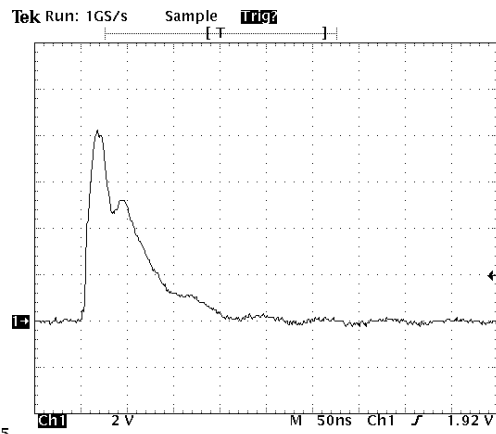
Typical waveforms for the following R/C combinations at 5kV are shown in Figure 6.0-4 and for 25kV in Figure 6.0-5:

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



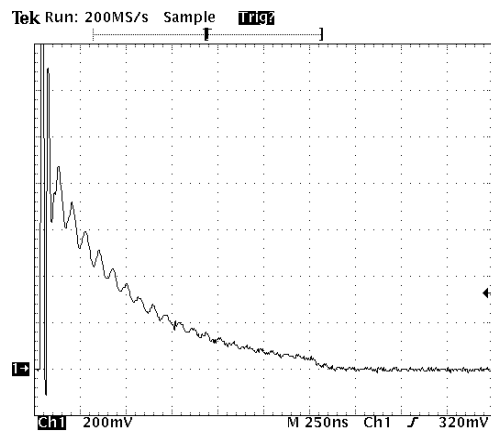
R=0Ω

30 Sep 2005 14:13:18



R=500Ω

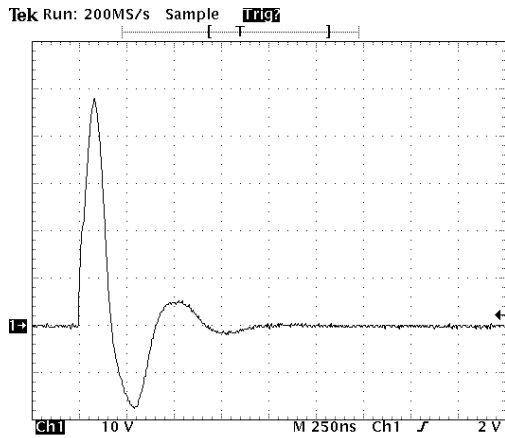
30 Sep 2005 14:16:01



R=5000Ω

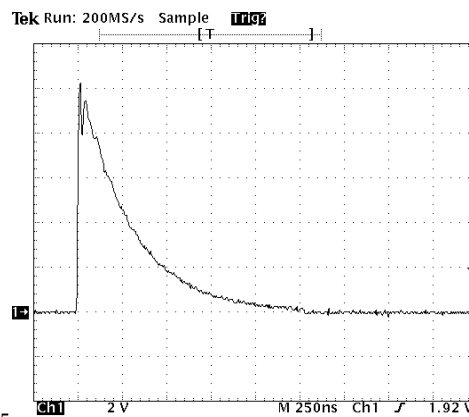
3 Oct 2005 08:54:28

Discharge waveform @ 5kV, C=100pF



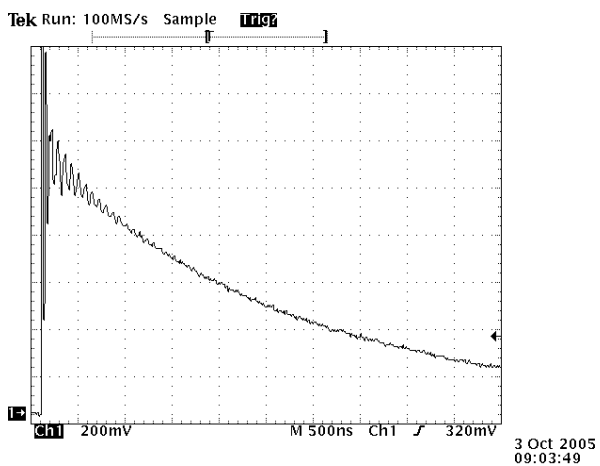
R=0Ω

30 Sep 2005 14:36:59



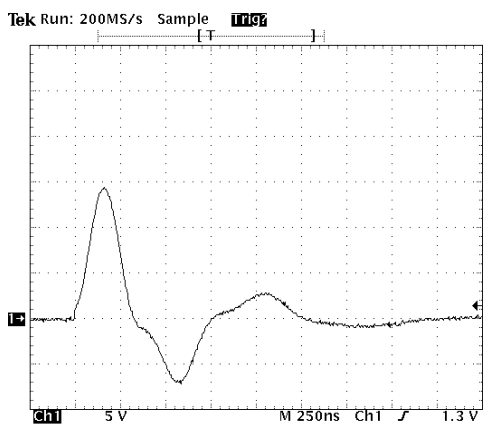
R=500Ω

30 Sep 2005 14:40:16

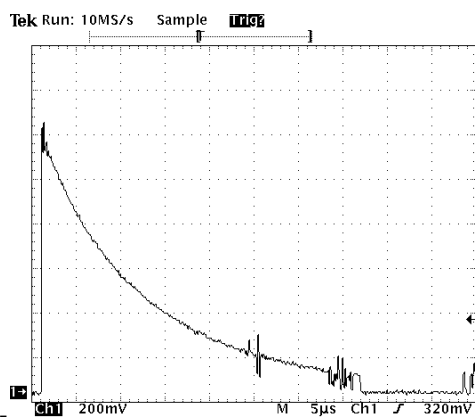


R=5000Ω

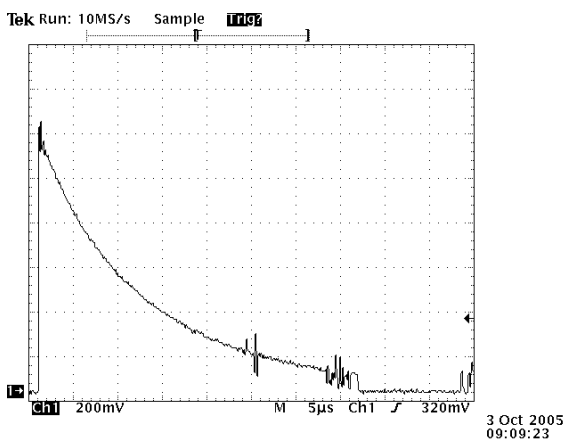
Discharge waveform @ 5kV, C=500pF



R=0Ω



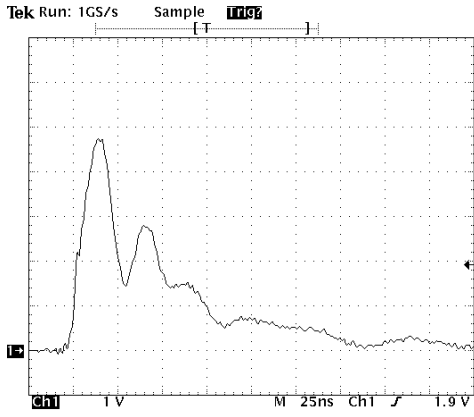
R=500Ω



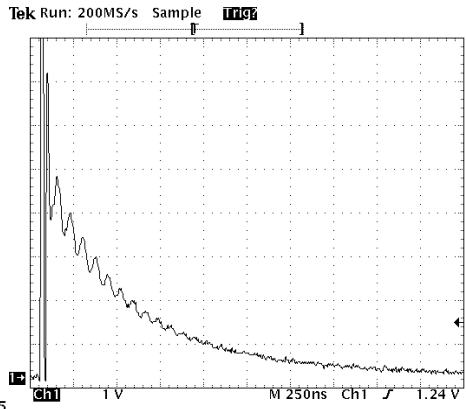
R=50000Ω

Discharge waveform @ 5kV, C=2000pF

Figure 6.0-4 Typical discharge waveforms @ 5kV

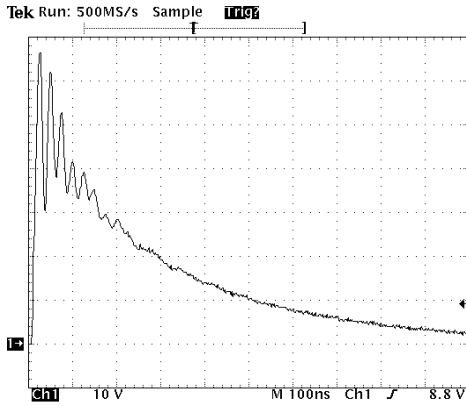


R=500Ω

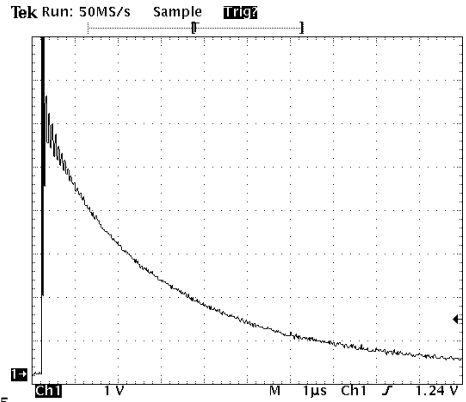


R=5000Ω

Discharge waveform @ 25kV, C=100pF

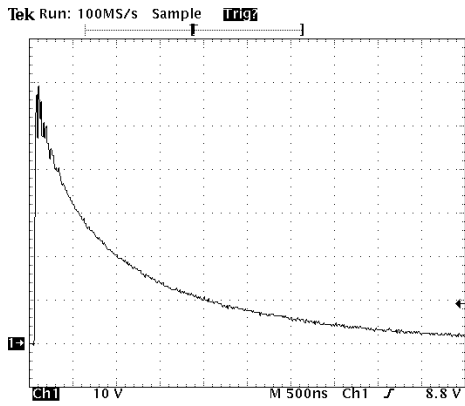


R=500Ω

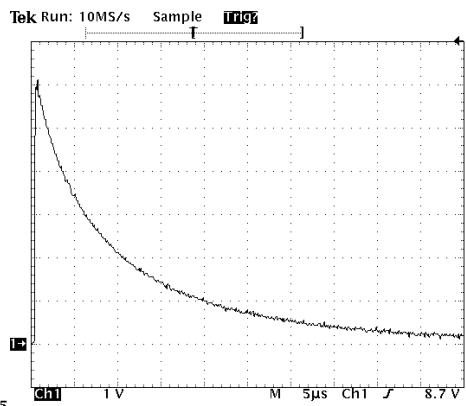


R=5000Ω

Discharge waveform @ 25kV, C=500pF



R=500



R=5000Ω

Waveform @ 25kV, C=2000pF

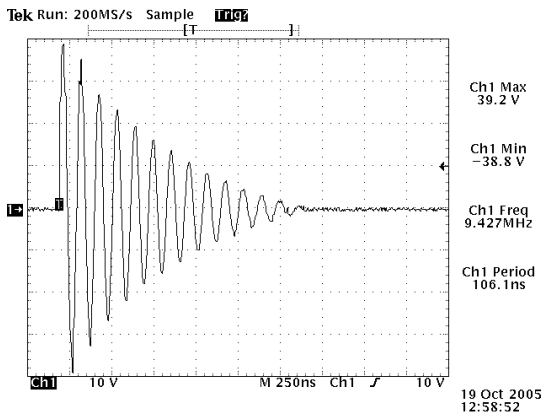
Figure 5.0-5 Typical discharge waveforms at 25kV

Typical waveforms for the Method 3031 discharge unit are shown in Figure 6.0-6.

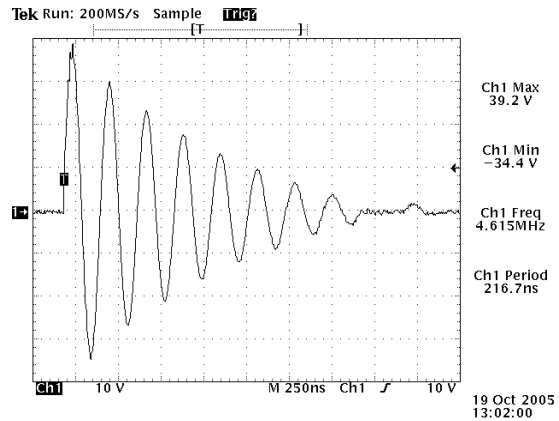
**NOTE:**

**When measuring these waveforms the current pulses can be very high. This will require an attenuator with a peak power rating of at least 1kW. Most standard attenuators are rated at 2 Watts continuous.**

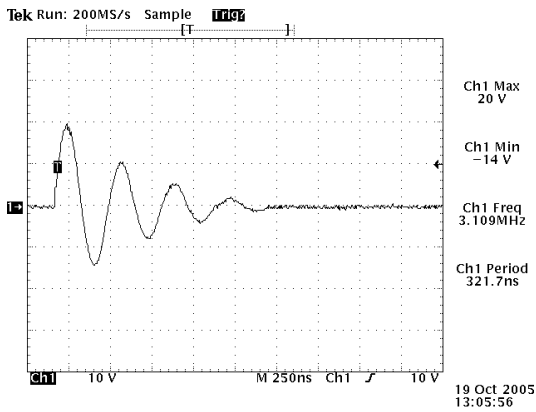
The waveforms shown in Figure 6.0.4 were taken at 1000, 500 and 250 Volts in order to be within the measurement range of the oscilloscope used. The discharge waveforms are linear and therefore, can be extrapolated out to the required 5kV test voltage.



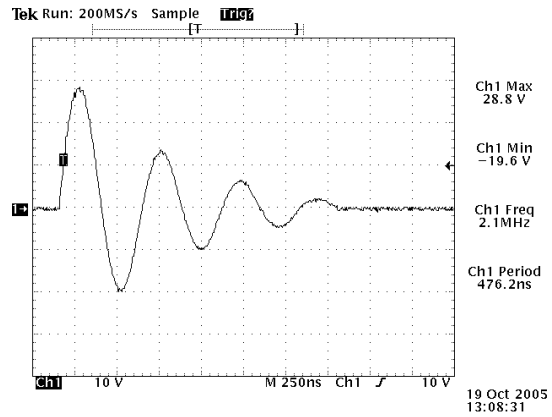
100pf @ 5kV



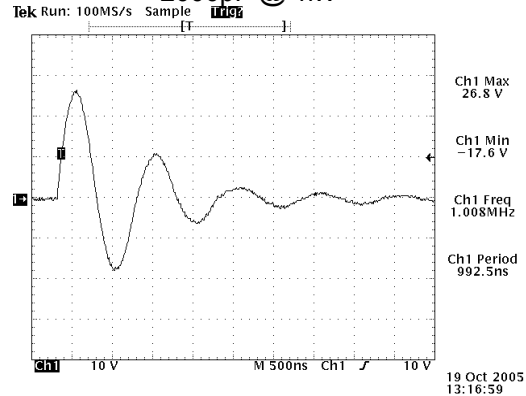
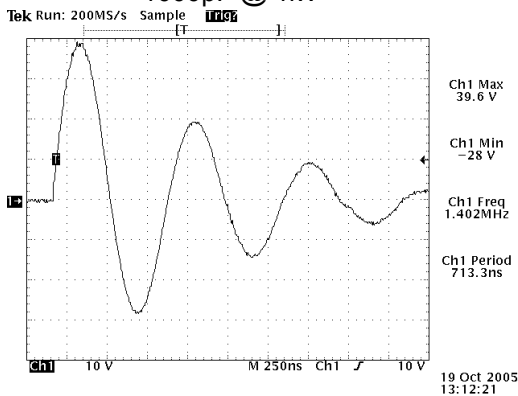
500pf @ 2.5kV



1000pF @ 1kV



2000pF @ 1kV



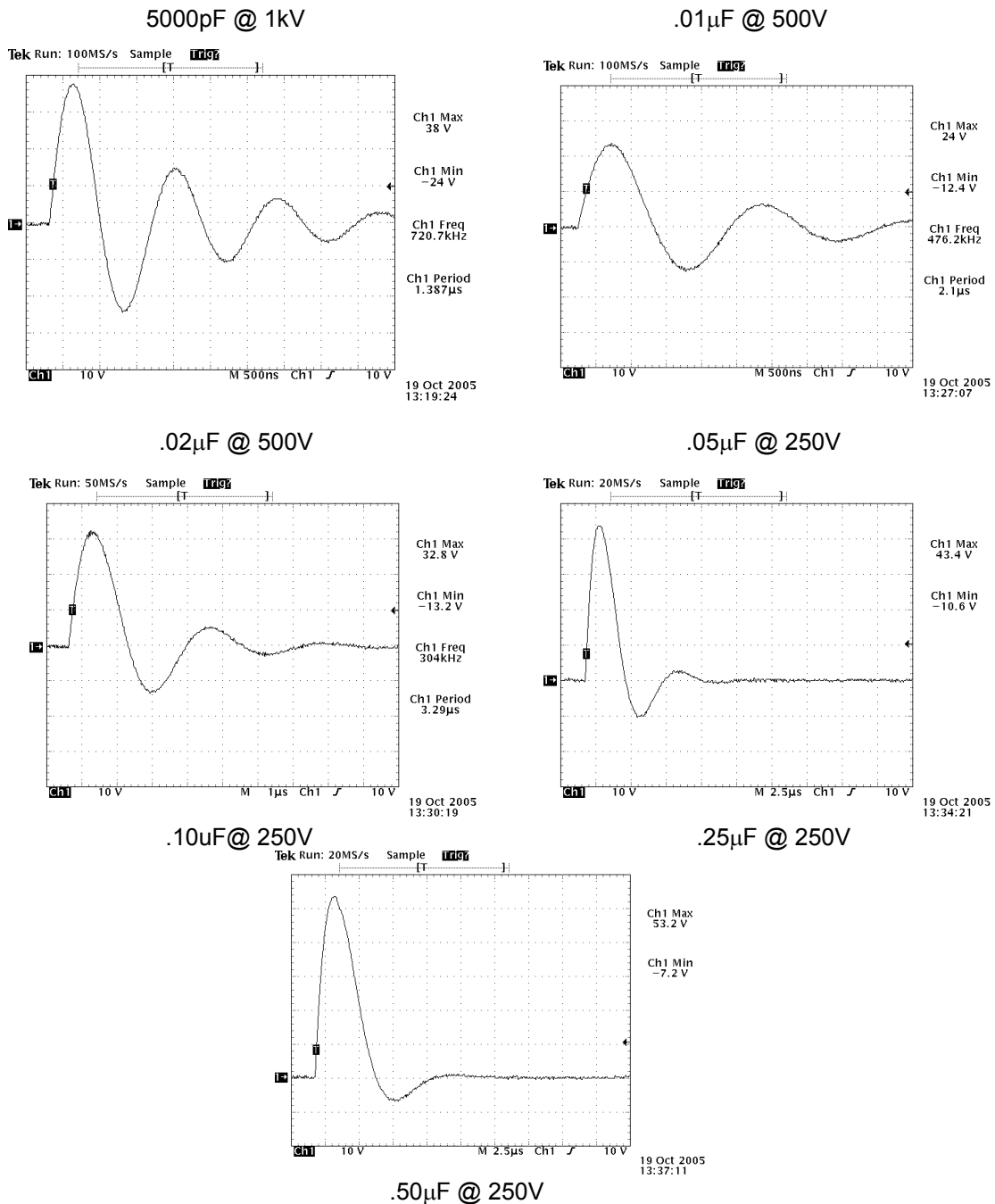


Figure 6.0-6: Discharge waveforms for MIL STD 1731A, Method 3031

## 7.0 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 1/4" 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 List

Item	Description	ETS Pt. #	Mfgr.	Mfgr Pt. #
<b>Control Unit</b>				
1	4 ½ Digit LED Panel Meter	0052-00048	Datec	40PC-1-RS-C
2	Point source LED: LO - Grn	0050-00007	Bivar	PM3GD-W6
3	HI - Red	0050-00006		PM3HD-W6
4	CHARGE: Red	0050-00003		PM5HD-W6
5	DISCHARGE: Yel	0050-00002		PM5GD-W6
6	Range Switch, DPST	0040-00065	Alcoswitch	MTF206N
7	Voltage ADJ 10-Turn Pot	0066-00001	Vishay/Spectrol	534-11203
8	INTERVAL ADJ Pot	0066-0001M	Honeywell	308N1MEG
9	AUTO/FREE RUN Sw	0040-00065	Alcoswitch	MTF206N
10	Auto SET 0-9 Rotary Sw	0040-90005	Grayhill	71AY23401
11	COUNT LED Single digit	0052-00050	Kingbright	SC56-11EWA
12	Mom. DPST Toggle Sw: ARM	0040-00066	Alcoswitch	MTF206R04
13	TRIGGER	0040-00066	Alcoswitch	MTF206R04
14	SPDT POWER Rocker Sw	0040-90014	CW Industries	GRS-4022-0013
15	Power (Mains) Input Conn	0101-00003	KOBICONN	161-0707-1-E
16	Fuse: 3AG, .75A, 250V	0102-00012	Cooper/Bussman	BK/MDL-3/4
17	15-Pin Sub D Conn (Female)	032-00082	KOBICONN	156-1315
18	12' (3.7m) Interconnect Cable	-	Open Stock	DB15M/DB15F
19	Gnd Connector	0021-00002	Concord	01-1050-1-02
20	Power Input Cable: USA	0100-00002	KOBICONN	173-63101-E
21	UK			
22	Power Supply: 36V	0108-00004	Cincon	CFM40S360
23	5, ±15V	0113-00001	Phihong	PSA4534-R
24	3AG Fuse Holder	0102-00004	Littlefuse	03420004H
<b>Circuit Bd</b>				
	IC, 8-PIN	LM555	0090-00016	Fairchild Semicond.
		CA3140	0090-00018	Intersil
		LM741	0090-00007	STM Micro Elect.
	IC, 14-Pin:	4071	0090-00018	ON Semiconductor
		4081	0090-00042	ON Semiconductor
		4511	0090-00043	ON Semiconductor
		4520	0090-00044	ON Semiconductor
		LM723	0090-00723	Texas Instrument
	Transistor: 2N3904	Q2, 3, 5, 13	Fairchild Semicond.	2N3904TFR
	2N3906	Q4, 6	Fairchild Semicond.	2N3906TAR
	TIP31C	Q1, 8, 14	Fairchild Semicond.	TIP31C
<b>TTL Ckt Bd</b>	IC: LM556	U1, 2		
(Optional)	Transistor: 2N3904	Q1	Fairchild Semicond.	2N3904TFR
	Diode: 1N4148	D1, 2	Vishay Semicond.	1N4148-TAP
	Relay, DPST: (DISCH, ARM)	RLY 1, 2	Coto	8L02-12

Item	Description	ETS Pt. #	Mfgr.	Mfgr Pt. #
<b>Dischg Unit</b>				
1	Capacitor Banks (pF): 250	6810		
2	500, 1000, 2000, 5000	6809A	Bycap	6B303-852A
3	Capacitor Banks ( $\mu$ F):			
	0.01, 0.02,	6809B	Bycap	6B303-303A
4	0.05, 0.10 0.25, 0.50	6809C	Bycap	6B502-904A
5	Capacitor Module (pF): 100	6811		
6	High Voltage Connectors	0032-00501	Alden Products	E201QX12
7	HV Driver	0112-00001		
8	HV $\pm$ 30kV Multiplier	0112-00003		
9	HV Polarity Reversing Module	5516		
10	HV SPDT 35kV Relay	00041-00002	Kilovac	K61C841
11	HI Range Inhibit Switch	0040-00305	APEM-MORS	305ZBE
12	Selector Modules (C & Inter.R)	6813		
13	Resistor Modules (External R)	6814		
14	15-Pin Sub-D Control In Conn	0032-00085	Switchcraft	156-1215
15	Discharge Output Cable (std)	6815		
16	Discharge Output Cable (FTC)	6816		
17	Discharge Output Cable (Cust)	6817		
19	25 MegOhm HV Resistor		Dale	ROX2-F-25M
<b>Accessories</b>				
<b>Firing Test C</b>				
1	Safety Interlock Switch	-	Globteck	MP0031
2	5-Pin DIN Interlock Cable Con	-	Switchcraft	502-57HB5F
3	Toggle Latch	-	Carr Lane Mfg.	CL-300-PC
4	Safety Interlock Cable	6722		
5	GND Cable	6725		
6	Gasket .25x.25" Buna-N	-	McMaster-Carr	9700K14
<b>Powder Disc</b>				
1	Powder Cups	6628		
2	Needle Electrodes	-	Keystone Elec.	3014
<b>Misc</b>				
1	Alligator Clip	-	Keystone Elec.	5044
2	Banana Plug: Red	-	Keystone Elec	6078
3	Black	-	Keystone Elec	6079
4	Junction Box:	6818		
5	HV Output Con.	0032-00501	Alden Products	E201QX12
6	HV Plug	930A Plug	Alden Products	A601
7	Banana Jack, Red	-	Keystone	6078
8	Banana Jack, Blk	-		6079
9	Safety Discharge Cable	6724		
<b>Test Target</b>				
1	20db Attenuator		Meca Electronics	612-20-1
2	Adapter, SMA Female to N Male		Emerson Aim Cambridge	29-3840
3	SMA Straight Plug to Straight Plug		Amphenol RF	135101-03-36.00
4	Adapter, SMA Female to BNC		Amphenol Connex	242103
5	50 $\Omega$ Terminator		Cal Test Electronics	CT 2944

## 8.0 WARRANTY

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

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

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

This warranty becomes null and void should the equipment, or any part thereof, be abused or modified by the customer or if used in any application other than that for which it was intended. This warranty to replace or repair is the only warranty, either expressed or implied or provided by law, and is in lieu of all other warranties. 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.

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

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

### **WARNING**

**WOODEN CRATES MUST NOT BE USED TO PACKAGE THE ELECTRONIC UNITS. PACKAGING OF DELICATE INSTRUMENTS IN WOODEN CRATES SUBSTANTIALLY INCREASES THE CONTENT'S SUSCEPTIBILITY TO SHOCK DAMAGE. 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.**