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**STANDARD TEST PROCEDURE**

# STANDARD TEST PROCEDURE

The following pages provide generalized descriptions of the tests used by SPELLMAN HIGH VOLTAGE ELECTRONICS CORPORATION in its Quality Control program. These generalized descriptions cover tests on a large number of different models which vary widely in output voltage, output current, and other operating parameters.

Detailed test data sheets are available for most models. These individual test data sheets delineate the explicit requirements and permissible acceptance levels for each item to be tested. For additional information, please contact the SPELLMAN Sales Department.

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**WARNING!**

**DANGEROUS VOLTAGES MAY BE PRESENT ON THIS EQUIPMENT WHICH MAY BE FATAL.**

**Make certain all equipment is SECURELY grounded.**

**Do not touch connections unless equipment is off and internal and load capacitances are discharged.**

**Do not ground yourself or work under wet or damp conditions.**

**Failure to follow Safety Procedures may be fatal.**

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## 1. PURPOSE

It is the purpose of this procedure to delineate standard tests to be performed on all power supplies manufactured by Spellman High Voltage. It is not intended to be used as a stand-alone procedure and in conjunction with other procedures.
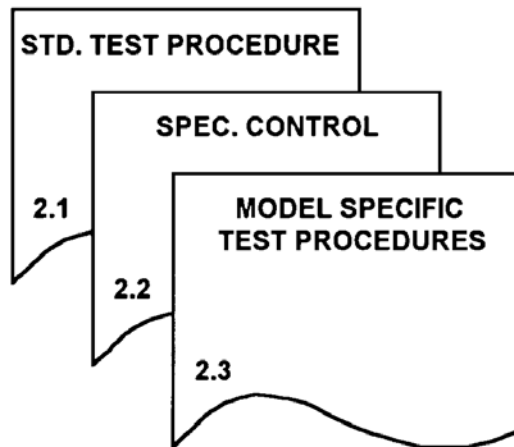
## 2. HIERARCHY



Figure 1.        Document Organization

## 2.1 Standard Test Procedure

This Standard Test Procedure describes generic test to be performed on all power supplies. This combined with the Test Data Sheet provides the parameters for verifying operation of the power supply.

## 2.2 Specification Control Drawing

A Specification Control Drawing contains additions and/or deletions to the standard test procedure.

## 2.3 Model Specific Test Procedures

Model specific test procedures Contain elements of both the standard test procedure and the specification control drawing in addition to any detailed instructions needed to verify operation of the supply.

## 3. HIGH VOLTAGE POWER SUPPLY LOADING METHODS
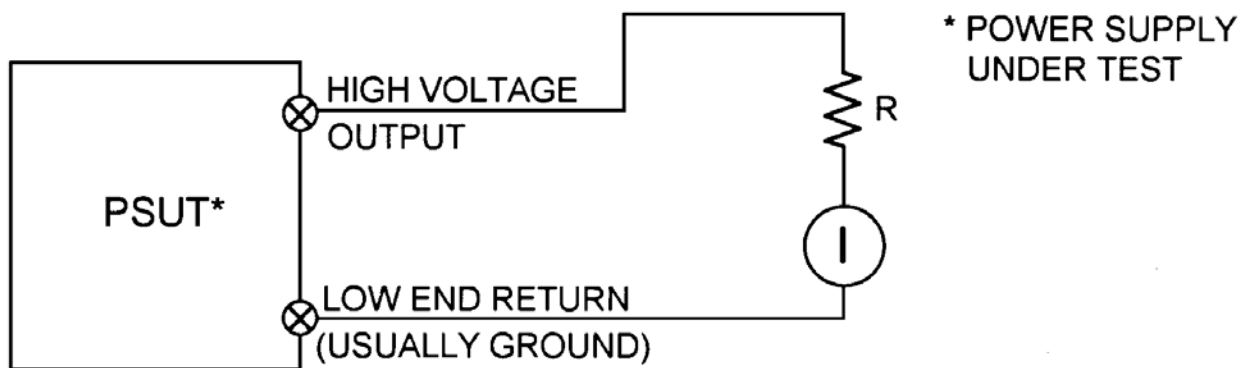
## 3.1 Constant Load



Figure 2.            Constant Load Test Set Up

Figure 2 shows a resistor, R, in series with a current meter, I, across the terminals of the PSUT.

*CAUTION*:  The lead from the High Voltage terminal should be high voltage wire.  If high voltage wire is not available, ordinary hook-up wire may be used providing reasonable care is exercised to avoid contact with ground circuits.

Resistors must be selected with appropriate voltage and wattage ratings for the specified load requirements.  Attention must be given to the physical mounting arrangement, in order to avoid voltage breakdown.

The appropriate current meter, I, should be connected in series with the load resistor, R, in the LOW END RETURN line.  This holds the meter at safe, low voltage potentials.

## 3.2   Changing Load
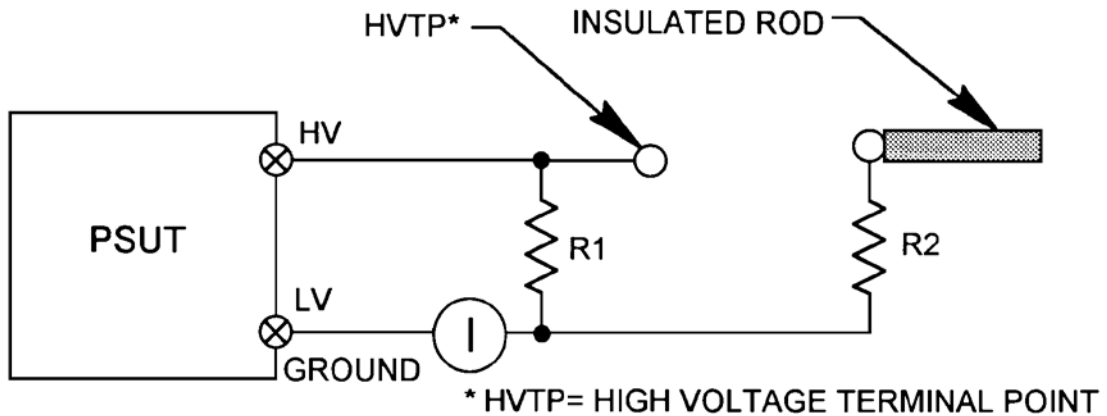
### 3.2.1      Manual Switch



**Figure 3.**          **Test Set Up for Changing Load**

Figure 3 shows resistor R1 directly connected to the PSUT  R1 is selected to load the PSUT for the minimum specified load.  For a NO LOAD condition, R1 is infinite and, thus, open circuited.

Resistor R2 is selected as required to achieve the desired load condition.   The "low end" of the load is returned to the current monitor, I.  The "high end" of the R2 resistor is connected by an appropriate lead to an insulated stick or rod ("Lexan" or other acrylic material is recommended).   A three foot length should be adequate for most applications below 100 kilovolts.  Hold this stick in your hand, making sure that you grip it at the end opposite from the lead termination.  This allows safe and easy connection of the High Voltage Terminal Point.

Note that when R2 is connected as shown, I indicates the total load current, the sum of the load in R I   and the load in R2.

When measurements are completed, the load is disconnected from the High Voltage Terminal Point, by manually removing the insulated rod from contact with the HVTP.

*NOTE*:  When not connected to the HVTP, the "high end" of R2 as well as the "low end" are both at safe, low potentials with respect to ground, and are safe to handle.

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### 3.2.2 Electron Tube Switch
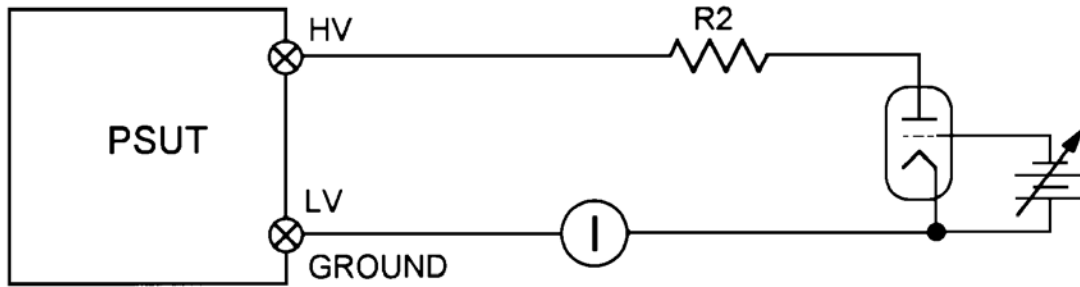
**Electron Tube Switch**



**Figure 4.       Electron Tube Switch**

The circuit of Figure 4 shows a vacuum tube used to cycle the load ON and OFF very quickly. If the grid of the tube is switched from near zero bias to a sufficient negative bias, the tube can be controlled as a switch. Rapidly cycling the load ON and OFF and observing the voltage characteristics is commonly referred to as "Dynamic Load Regulation"-   Refer to Section 5 for more details.

In addition, the tube can be controlled to provide continuous load adjustment by proper variation of the grid bias.  An easy method of attaining bias is by the use of an adjustable cathode resistor.

The manual switch explained in the previous paragraphs is applicable for power supplies with either positive or negative polarity.  The electron tube circuit of Figure 4 is shown for a high voltage power supply with positive polarity only.  A tube can be used for power supplies with negative polarity by connecting the plate end to low voltage and the cathode end to high voltage.   In this case, since the filament and grid supplies will be at high voltage, isolation techniques must be used.


### 4.       VOLTAGE CALIBRATION AND RANGE

**This paragraph describes the test set up and method  used to measure  the output voltage in accordance with the specifications of the specific test data  sheet for a given power supply.**
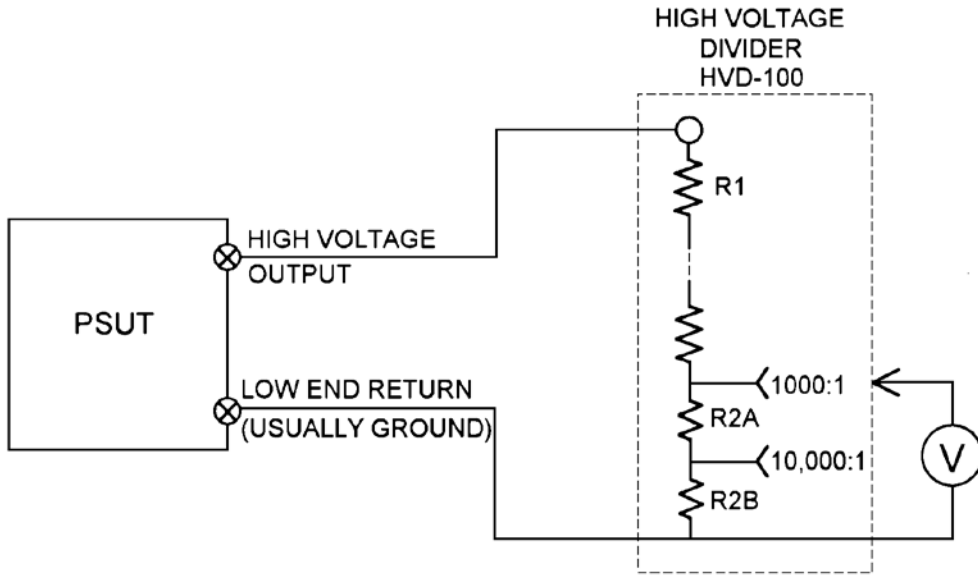
## 4.1   Test Set Up



Figure 5.        Test Set Up

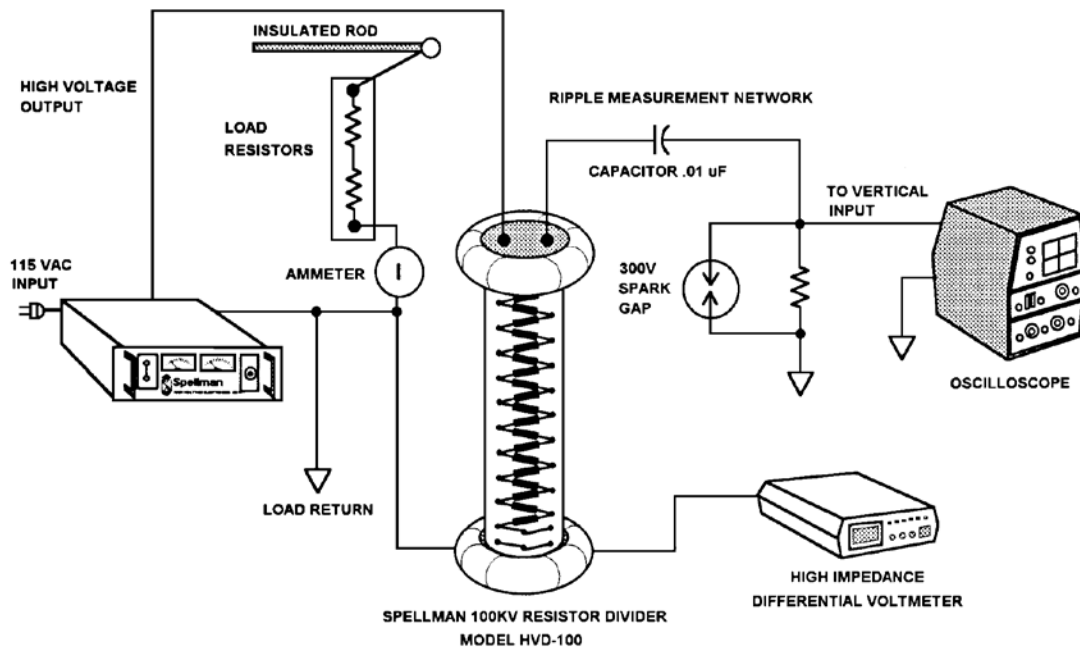## 4.2   Measurement of High Voltage Power Supply Parameters



Figure 6.        High Voltage Power Supply Test Set Up

### 4.3  Monitor Instrumentation

The instrument used to measure the divider output  voltage must have high input impedance in order to minimize the possibility of introducing errors in measurement due to the loading effects of metering instruments  on R2A or R2B (Figure 5).  Spellman uses either of two instruments described below for metering (M) in test set-up diagrams, Figure 5 or 6 depending on resolution requirements.

#### 4.3.1      John Fluke Model 8810A

Accuracy of reading including stability: ±_0.01% of input
Input impedance: 1000 Megohms (200mV, 2V, 20V ranges) Resolution:   10 ppm of range

#### 4.3.2      John Fluke Model 8840A

Accuracy of reading including stability: ±.005%
Input impedance: 10,000 Megohms (200mV,  2V, 20V ranges)
Resolution:   1 ppm of range

### 4.4  Test Method

4.4.1      Connect the HIGH VOLTAGE DIVIDER (HVD) and VOLTMETER as shown in the Test Set-up diagram, Figure 6.  The connection between the high voltage output terminal of the PSUT and the high voltage input terminal of the HIGH VOLTAGE DIVIDER should be made with high voltage lead wire.

4.4.2      Connect the PSUT to a source of input power in accordance with the unit specification.   Appropriate input voltage and current monitoring equipment should be included in the test set-up.

4.4.3      All required external adjustment controls should be connected in accordance with the unit specification.   Using the specific test data sheet which establishes the proper input voltage conditions and output voltage settings, measure the output voltage according to the above procedures.

4.4.4      Energize the PSUT, exercising reasonable precautions against high voltage hazards.

4.4.5      Measure the output voltage under desired conditions of input voltage and adjustment of voltage controls.

4.4.6      The above measurement is described for what is essentially a "NO LOAD" condition.  This is due to the fact that the SPELLMAN High Voltage Divider has an input impedance of 1000 Megohms drawing negligible load current in almost all cases.

Measurements under load may be made as desired by connecting appropriate high voltage load resistors, or other loading devices, across the PSUT,  as seen in Figure 6.  Current meters should be connected in series with the load resistors in the grounded end to keep the meters at safe potentials.

NOTE:   See Section 3 for additional information on loading methods.

# 5.  OUTPUT VOLTAGE REGULATION, STATIC AND DYNAMIC

## 5.1  Definition

In general, most power supply manufacturers in the United States limit the use of the term "regulation" to variations in the output voltage which result directly from changes in the input power source and/or the load resistance.

"Regulation" then, as defined by Spellman, and most other manufacturers, specifically excludes variations resulting from changes in temperature and time. Thus, regulation is measured at "constant temperature" and "short" time intervals, where "short" means the time required to make the measurements.

In addition to the two basic components of regulation, i.e. LOAD REGULATION and LINE REGULATION, regulation is further differentiated as STATIC or DYNAMIC variation.

Dynamic regulation is concerned with the output voltage transient response resulting from a line or load change.   Of interest are peak deflection and recovery time.  Spellman defines recovery time as that time required to return from the peak deflection point to within 10% of the new static level.  The sketch below details this.
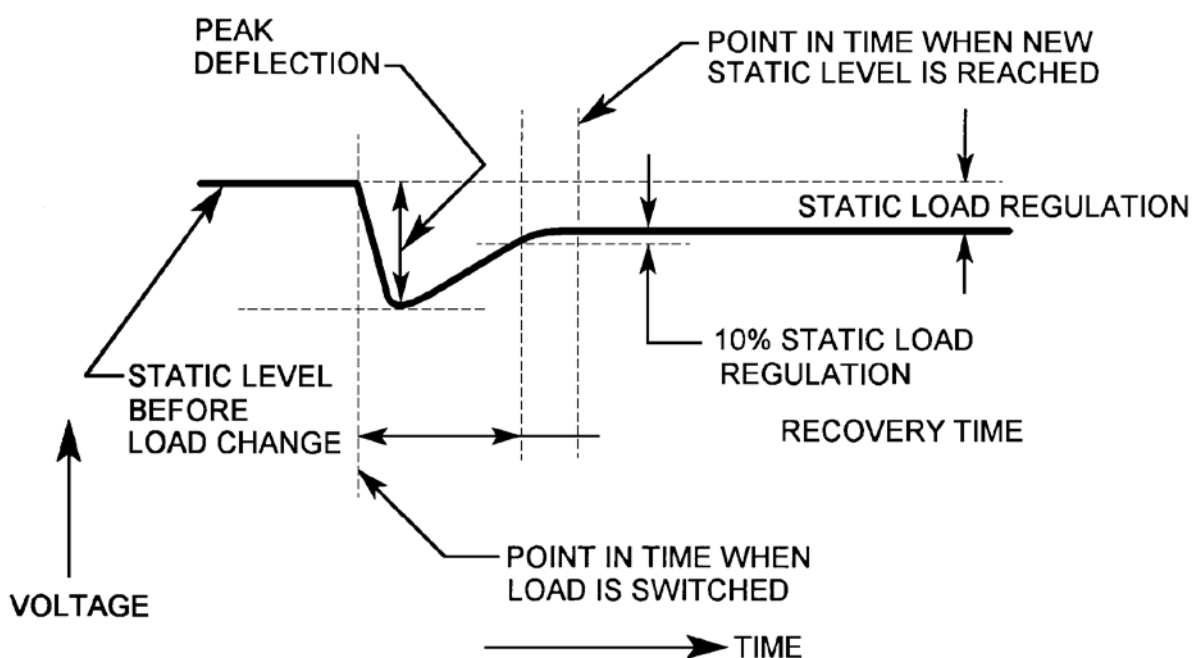


**Figure 7.**      **Static and Dynamic Regulation Waveform**

## 5.2    Test Set-Up, STATIC REGULATION

5.2.1      Connect the output voltmeter circuit as described in Section 4.

5.2.2      Connect the PSUT to a source of input power in accordance with the unit specification. Appropriate input voltage and current monitoring equipment should be included in the test set-up. Provide for input power adjustability as required by the specification.

5.2.3      Select a loading method (as described in Section 3) which is suitable to the unit specification. Make the necessary connections.

## 5.3    Test Method, STATIC LOAD REGULATION

5.3.1      With input voltage maintained constant, make the specified load change using one of the techniques of Section 3.

5.3.2      Observe the change in output voltage as read on the voltage monitor. Record for "LOAD ON".

5.3.3      Repeat for "LOAD OFF".

5.3.4      The above measurements may be made at minimum, maximum and nominal input voltage conditions in accordance with the unit specification.  They also may be made at different output voltage conditions, as specified.

## 5.4    Test Method, STATIC LINE REGULATION

5.4.1      The same set-up as in Section 5. 2 above is used.

5.4.2      With output voltage level and load condition set per specification, adjust the input voltage from minimum to maximum.

5.4.3      Observe the change in output voltage as read on the voltage monitor.  Record.

## 5.5    Test Method, DYNAMIC LOAD REGULATION

5.5.1      Connect the output voltage monitor as described in Section 5.

5.5.2      With the input voltage maintained constant at its nominal value, establish a square-wave load or pulse load condition as desired.

5.5.3      Check that the load current is switching properly by observing the current wave-shape across a current sensing resistor in the "low end" return of the power supply.

5.5.4      Observe the dynamic response of the output voltage by using a ripple checker as described in Figure 12.

5.5.5      Record the results.

### 5.6   Test Method, DYNAMIC LINE REGULATION

5.6.1   With load current maintained at a constant level, establish the necessary input voltage switching characteristic.

5.6.2   Observe the dynamic response of the output voltage by using a ripple checker as described in Figure 12.

5.6.3   Record the results.

## 6.   OUTPUT CURRENT REGULATION

6.1   This power supply parameter applies to "Constant Current" or "Current Regulated" supplies. All aspects of "regulation" as described in section 5 above apply here except for the method of measurement.
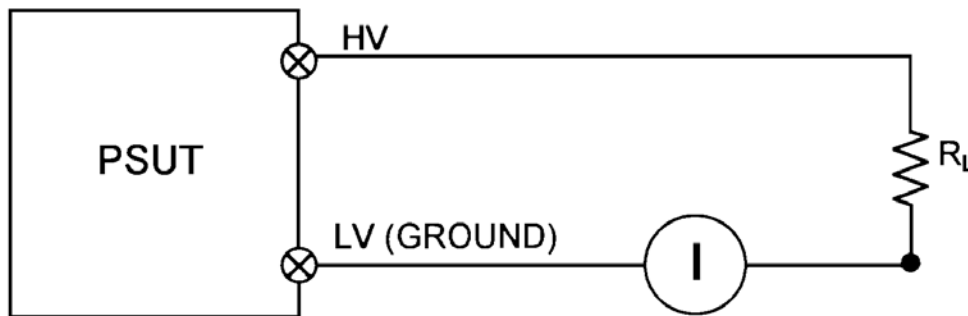


Figure 8.          Current Regulation

In Figure 8, the load resistance is represented by $R_L$.   In a current regulated supply, the load resistor, $R_L$, changes from zero, at the short circuit condition, to some finite value at the rated output voltage condition.   The supply cannot maintain regulation into an open circuit, obviously.  Thus, load changes are accomplished by "shorting" a portion of the rated load resistor.   A current meter, in series with the "low end" of the power supply is used for monitoring the current.

## 7.   CURRENT LIMIT

7.1   This power supply parameter applies to power supplies which although not current regulated, have circuits which will limit the absolute value of the output current.

7.2   Referencing Figure 8, resistor $R_L$ is shorted and the power supply is turned on.  The output current is monitored for its peak value and this value is usually II0% of the rated output current.

## 8.   SHORT CIRCUIT

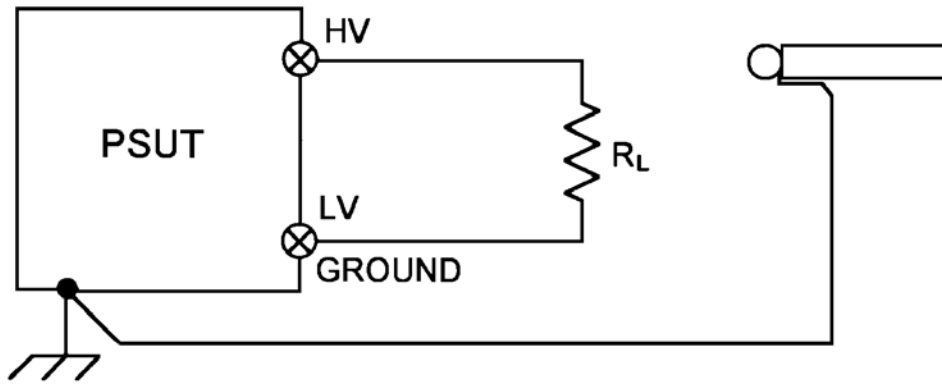8.1   This test is performed to simulate an arcing condition.

**Figure 9.**          **Short Circuit Arcing Test**

Using the Plexiglas stick with the conductor connected to ground with a #4 wire, a short circuit condition is applied to the PSUT while the PSUT is energized at full output voltage.

## 9.      INPUT CURRENT

9.1    Input current refers to the current the PSUT draws from its power source (either low voltage DC, or AC mains) during full power operation.
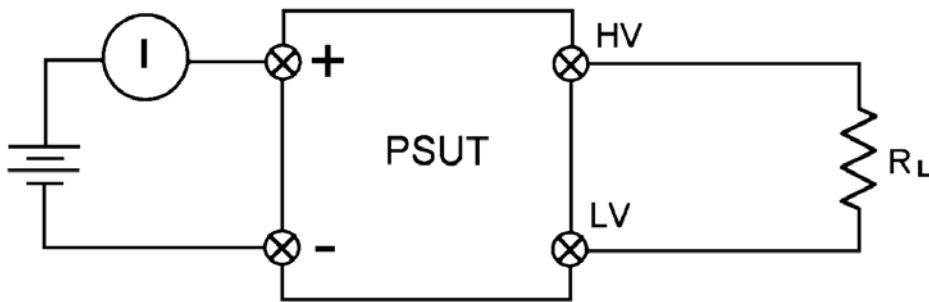


**Figure 10.**          **DC Input Current Measurement**
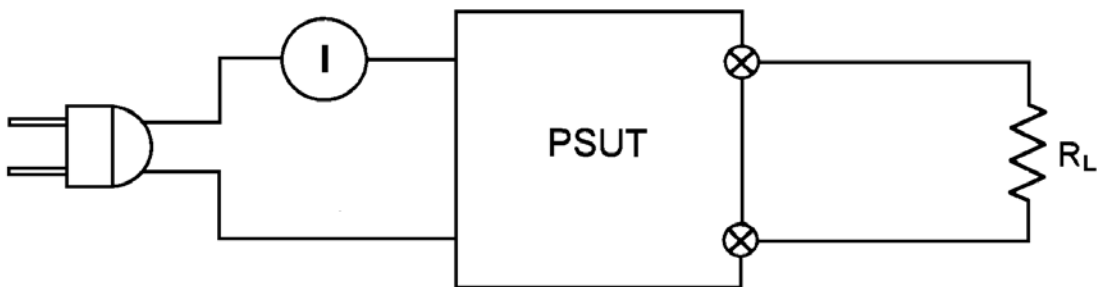


**Figure 11.**          **AC Input Current Measurement**

A digital multimeter is placed in series with either the positive output of a source or the "HOT" lead of an AC source and the power supply is energized.  The parameter is measured at 100% of rated output, at nominal input.

## 10.    RIPPLE

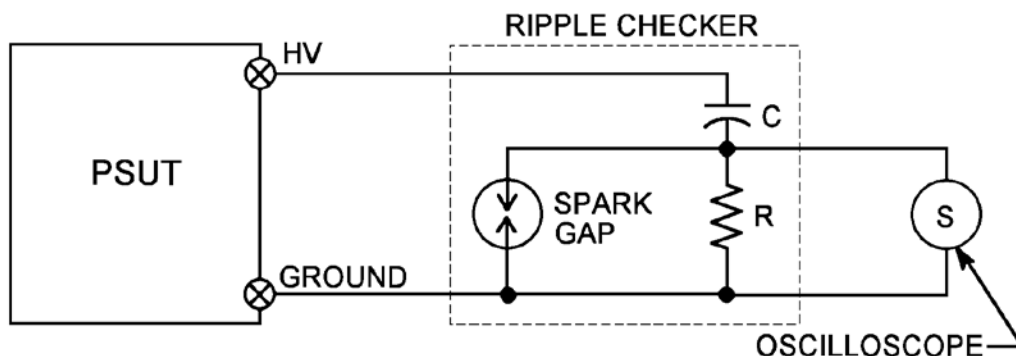### 10.1  Ripple Measurement Techniques



**Figure 12.**          **Ripple Measurement**

Figure 12 illustrates the technique of using a DC blocking capacitor, C, in series with the power supply output terminal, for the purpose of passing the AC component in the output voltage directly to the oscilloscope, S.  Resistor, R, and spark gap, SG, protect the oscilloscope against surges in the output voltage which could be transferred directly through the blocking capacitor to the scope.

The value of C and R must be selected to pass the ripple frequencies of interest with negligible attenuation.  The oscilloscope input impedance and frequency response also introduce an error which must be accounted for.

The error in 60Hz ripple measurements is small for C = 0.01uF and R=1 to 10 Megohms.  For high frequency components proportionally smaller capacitance values are acceptable.
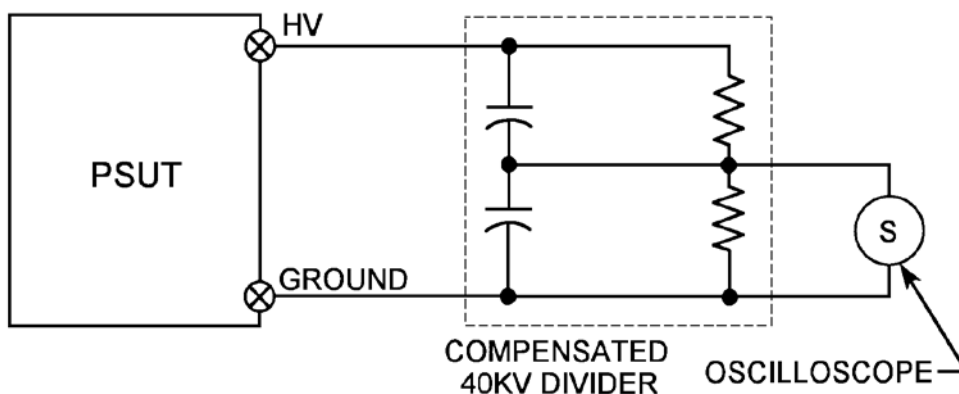


**Figure 13**          **Ripple Measurement**

Figure 13 illustrates the use of a compensated 40kV divider for ripple measurements. Although the compensated divider gives an accurate measurement, it suffers from two deficiencies. First, a true no load ripple measurement cannot be made, since the divider itself has 100 Megohms input resistance.

Second, when the power supply output ripple is relatively low, the 1000:1 divider ratio may attenuate the AC component at the divider output to a level which may be difficult to read.

**10.2  Test Method**

10.2.1     Set all operating parameters as required by the unit specified.  These operating parameters must include all the following:

> Output Voltage setting
> Load Current condition
> Input Voltage condition

10.2.2     Read the ripple in peak-to-peak volts on the oscilloscope. Record.

10.2.3     Divide the measured peak-to-peak value by 2√2 when rms readings are desired (if the ripple is sinusoidal).