

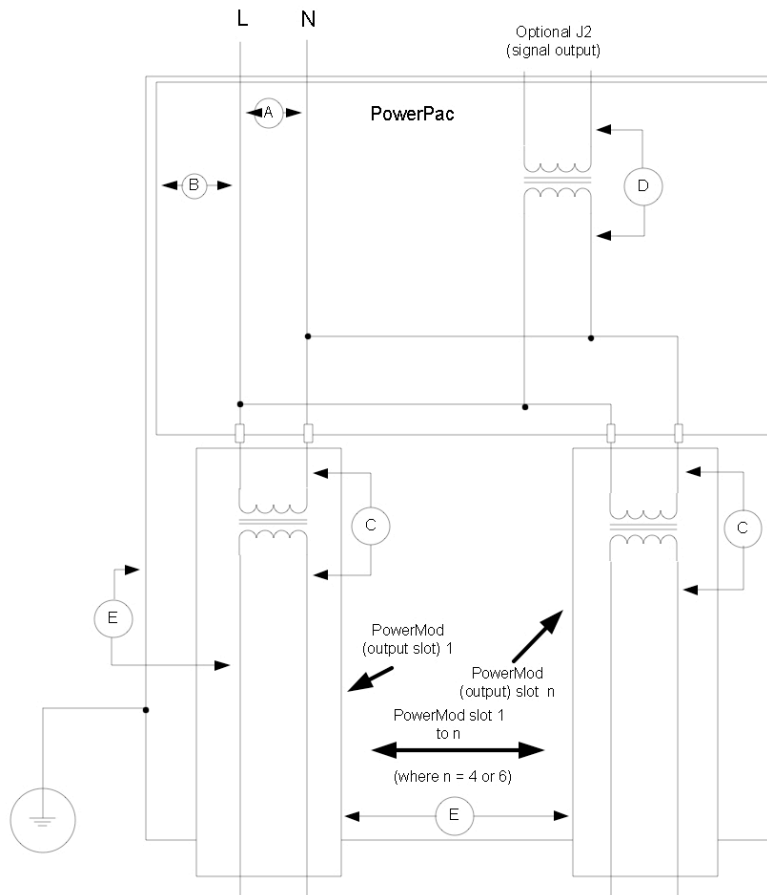
## Reinforced Isolation Testing on a Power Supply

**Abstract:** With the introduction of the EN60601 3rd edition, some aspects of the creepage and clearance requirements are now open to interpretation. The terminology has moved away from a series of specific dielectric strength values and spacing distances between parts of the product to a Means of Protection (MOP). As a result of this, the Advanced Energy application team have identified some possible avenues of confusion for our end customer base. This document will assist with the interpretation of the existing specifications, and outline how to best implement this test in a production facility with the end customer’s application.

**Dielectric Withstand Test:**

The Dielectric Withstanding Voltage test is used to determine the ability of the installed equipment to protect against electrical shock. The dielectric withstand voltage test is typically referred to as a hi-pot test, and involves applying a high voltage between the points being tested and measuring the resultant leakage current.

Fig 1 shows the various isolation levels on a the Xgen series. (These levels will typically apply to any generic power supply).



**Fig 1: Note Xgen = PowerPac + PowerMod**

A	Line to Neutral	Basic Insulation
B	Line to Chassis / Earth	Basic Insulation
C	Primary to Secondary	Reinforced Insulation
D	Primary to Secondary	Reinforced Insulation
E	Output to Chassis / Earth	Functional Insulation

**Table 1: Description of Fig isolation barrier levels.**

When testing from the primary to secondary circuits of a fully configured supply, it is possible to overstress the insulation between primary or secondary circuits and earth (or chassis). The primary circuit is connected to chassis with Y1 capacitors, while the secondary circuit is connected to chassis with 500 Vdc rated surface mount capacitors. Together, these two capacitors form a potential divider. The secondary to chassis capacitor has a capacitance that is much larger than that of the primary to chassis capacitor, and so the majority of a voltage applied from primary to secondary will be seen across the primary to earth / chassis barrier. This basic insulation is intended to support only 1500 Vac. In fact, voltages higher than 2000 Vac can cause arcing.

For this reason it is not possible to conduct a 4 kV AC isolation test from Primary to Secondary. As explained above, the vast majority of the voltage will be seen across the primary to chassis insulation. This high voltage can generate an arc from chassis to primary, and cause significant damage in one of two ways:

1. The chassis arcs to a component on the powerPac. The component is damaged by this voltage spike.
2. The chassis arcs to a point on the powerPac but does not cause component damage. While this arc does not cause damage to the primary circuit, it sharply raises the potential of the chassis. This generates a very high voltage across the secondary to chassis insulation, and damages the 500 Vdc EMI capacitor.

(It should be noted that arcing across spacing from primary circuits to ground under these conditions does not constitute a failure of the reinforced insulation). This is not limited to the Advanced Energy designed parts.

#### **How to test:**

All safety testing can be categorised into three distinct groups

1. Type Testing.
2. Production testing by Power Supply vendor.
3. Production testing during end customer production.

**Type Testing:**

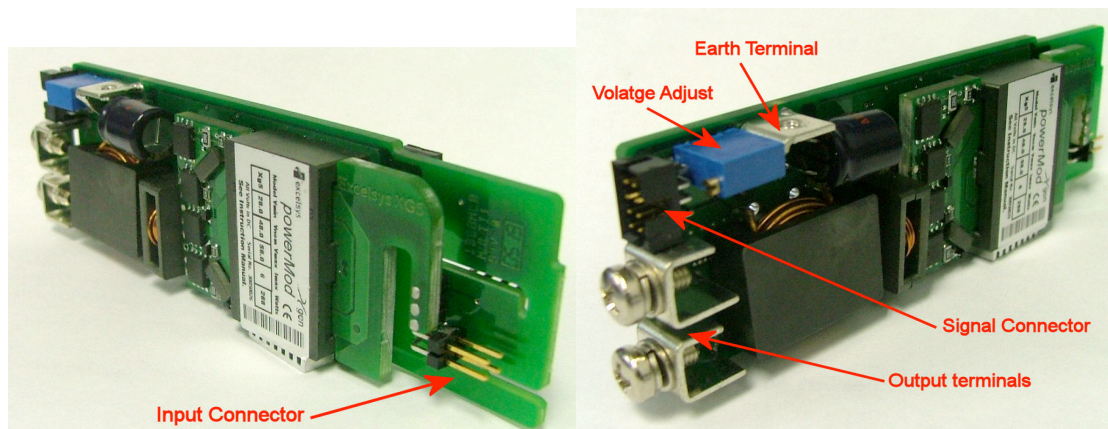
This is the testing that would typically be carried out by a safety test agency. In doing so, the safety agency is attempting to determine if the construction and design of the power supply meets the relevant safety standard. Here the safety agency can take one of two approaches. A DC equivalent of the peak AC voltage can be used to test the dielectric breakdown in lieu of the 4 kV AC. Alternatively since it is a ‘type’ test, you are permitted to remove radio frequency filter capacitors (see IEC60601-1 3<sup>rd</sup> Edition Section 8.8.3), in this case the Y capacitors between primary and chassis.

The PCB would typically be removed from the chassis during these tests. If either of the above tests are to be carried out in chassis, it is very important to thoroughly clean the chassis prior to testing. Any debris can greatly increase the chance of arcing. Please contact Advanced Energy for more details on this process.

**Production testing by Power Supply vendor:**

This will be carried out on a production line during the manufacturing process of the power supply. As previously discussed above, reinforced insulation testing cannot be carried out without overstressing basic insulation in the end product. As a result of this the standard allows for the testing of reinforced insulation separately. Power supply manufacturers are permitted to test the insulation prior to incorporation into the product. Transformers, opto-couplers, PCB’s and so on can be tested independently prior to insertion during the manufacturing process.

As part of our strict quality control, we at Advanced Energy undergo a 100% isolation test across the isolation barrier on all powerMods. Under this process we apply a hi-pot test to across the primary to secondary isolation barrier, which is located on each of the powerMods.



**Fig 2: PowerMod description**

**Safety Tests:**

<b>Test Name</b>	<b>Hi-Pot (Input to Output)</b>
<b>Settings</b>	Connect all four input pins together. Connect Vout+, Vout- and earth together.
<b>Method</b>	Apply test voltage 4400 Vac 50 Hz for 1 second between input and output. Measure leakage current I <sub>leak</sub> .
<b>Result</b>	I <sub>leak</sub>
<b>Pass criteria</b>	I <sub>leak</sub> ≤ 1 mA

**Table 2: Safety Tests carried out on 100% of PowerMods in production.**

**Production testing during end customer production:**

In the event of a customer or safety agency wishing to carry out any isolation testing in their system, in particular from primary to secondary, then the following will need to be considered.

As previously discussed, when testing from primary to secondary circuits, it is possible to overstress the basic insulation from primary to chassis, which is intended to support only 1500 Vac. Voltages higher than 2000 Vac can cause arcing from primary to chassis which can result in a catastrophic failure of the unit. Since nearly all the voltage is seen from primary to earth, this 2000 Vac is also the limit for a primary to secondary hi-pot on a fully configured unit.

Once again, this is covered in the 60601 3<sup>rd</sup> edition, section 8.8 Insulation / 8.8.3 Dielectric Strength in the Test Conditions paragraph it is stated that

***‘Alternatively, a d.c. test voltage equivalent to the peak value of the a.c. test voltage may be used.’***

**Summary Table of Max test voltages:**

Hi-pot Test	Description	Max Test Voltage on configured unit	Permitted # of repetitions (1 minute)
Line to Chassis / Earth	Basic Insulation	2 kV AC	5
Primary to Secondary	Reinforced Insulation	2 kV AC	5
Output to Chassis / Earth	Functional Insulation	500 V DC	5

**Table 3: Max Voltage & Number of repetitions on a configured unit.**

**Conclusion:**

In order to meet this customer demand of being able to verify this as part of the production process, Advanced Energy is pleased to announce the improved performance of the Xgen series. This improvement has been solely optimized so that a fully configured unit can now withstand the DC peak equivalent of the 4 kV AC isolation test from primary to secondary. (*Note: Refer directly to UL60950-1, C5.2.2 or UL60601-1 2nd Edition Section 20.4 or IEC60601-1 3rd Edition Section 8.8.3 for more information.*) In choosing this product range an in-situ DC voltage of 6 kV can be applied across the isolation barrier of a fully assembled power supply (Once the chassis has been fully prepped). This will directly address the growing demand from customers to verify the isolation barrier on their application without causing an electrical stress on internal components. When testing as a complete power supply or system the Customer must use the DC equivalent of 4 kV AC, which is 5.6 kVDC. (For margin the Xgen series have been designed to withstand a 6 kV DC test.). If you intend to implement this test please first confer with our applications engineering team, who can provide the steps required to complete this test successfully.

*About Advanced Energy*

*Advanced Energy (AE) has devoted more than three decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.*

*AE's power solutions enable customer innovation in complex semiconductor and industrial thin film plasma manufacturing processes, demanding high and low voltage applications, and temperature-critical thermal processes.*

*With deep applications know-how and responsive service and support across the globe, AE builds collaborative partnerships to meet rapid technological developments, propel growth for its customers and power the future of technology.*

*For further information on our products, please visit [www.advancedenergy.com](http://www.advancedenergy.com).*