



Saf-D-Grid®

Connectors for Higher Voltage IT Equipment

Rev. 090514D



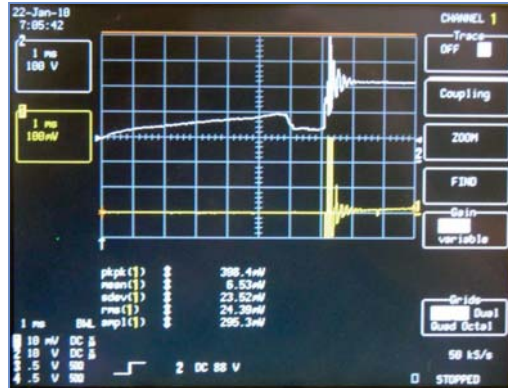
Your Best Connection



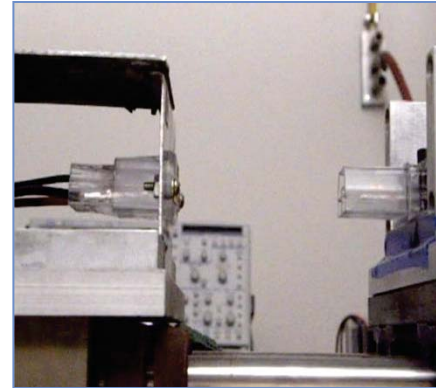
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Development



User Safety



Specifications

Electrical	
Voltage (AC/DC)	
• UL 1977 / CSA 22.2	600
• IEC	400
Current Rating (Amperes)	40
Wire Range (AWG)	#12 to #18
(mm ²)	2.5 to 0.75
Hot Plug Rated	
• 250 cycles	400V @ 440A in-rush
• 250 cycles (UL)	400V @ 20A load
Dielectric Withstanding Voltage	3,300
Operating Temperature (°C)	-20° to 80°
(°F)	-4° to 176°
Fault Current Withstand	
UL 467	14 AWG, 300A, 4 Sec.

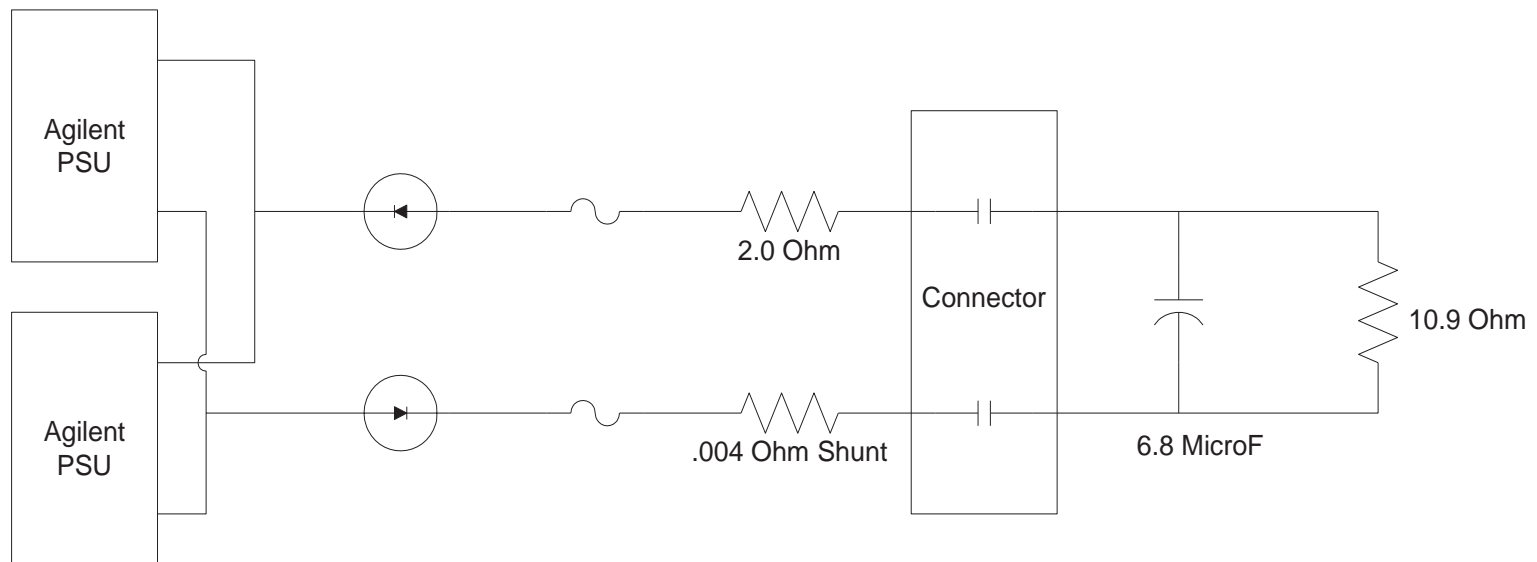
Product Models



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PRODUCT DEVELOPMENT: DC Arcing Tests

A DC Electronic Circuit was Created to Evaluate Connector Damage of Making 400V DC

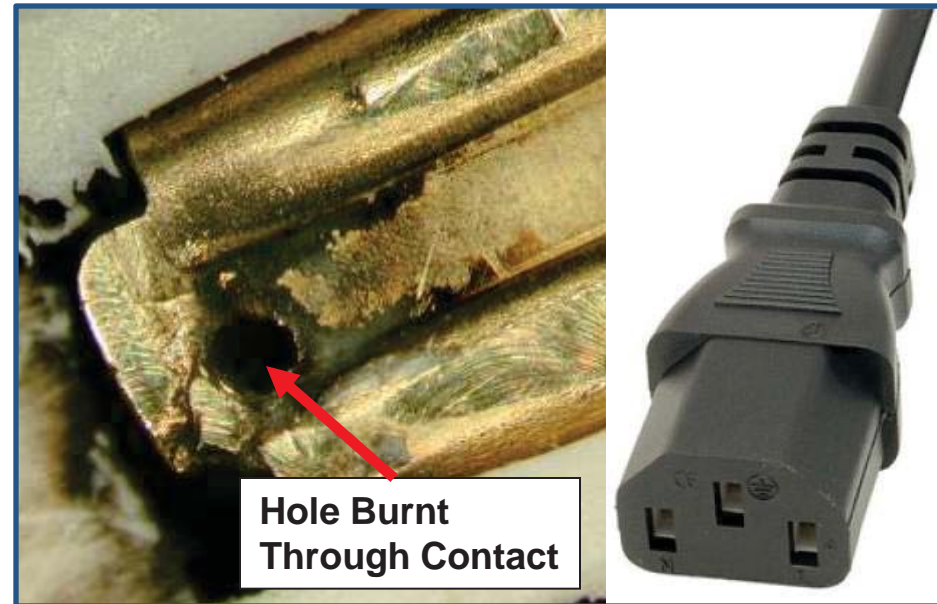


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PRODUCT DEVELOPMENT: DC Arcing Tests

Existing IEC320 Connectors Were Evaluated on 400V DC Circuit

- IEC 60320 Connectors Only Designed for AC
- Not Suitable to Survive 400VDC Arcing Damage
- Testing Resulted in a Hole Burnt Through Primary Conductive Path of Contacts



IEC320 Connector After 250 Cycles
Under Load @ 400V DC, 5A

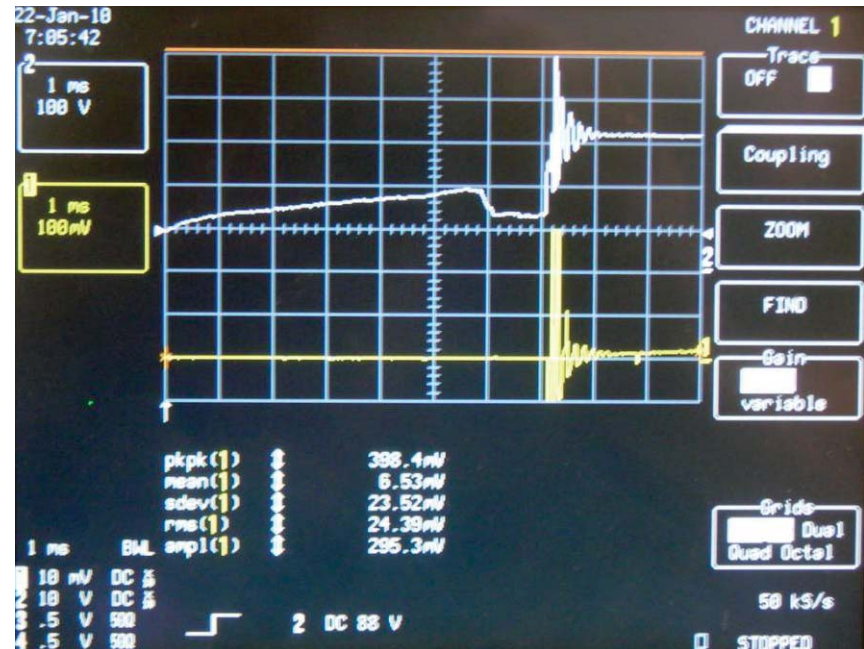


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PRODUCT DEVELOPMENT:

Inrush Current Observations

- Test Circuit was Established to Study Effects of Inrush Currents
- Inrush Currents of 300A Were Observed
- Arcing Before Closure of the Contacts Indicated by Rising Voltage
 - Prior to Closing of the Contacts
 - Prior to Charging of the EMI X-Capacitor



Voltage (white) can be observed rising across the contact arc gap before the making of the connector contacts and the charging of the filter capacitor (current in yellow). Scale is 100 amps per division.

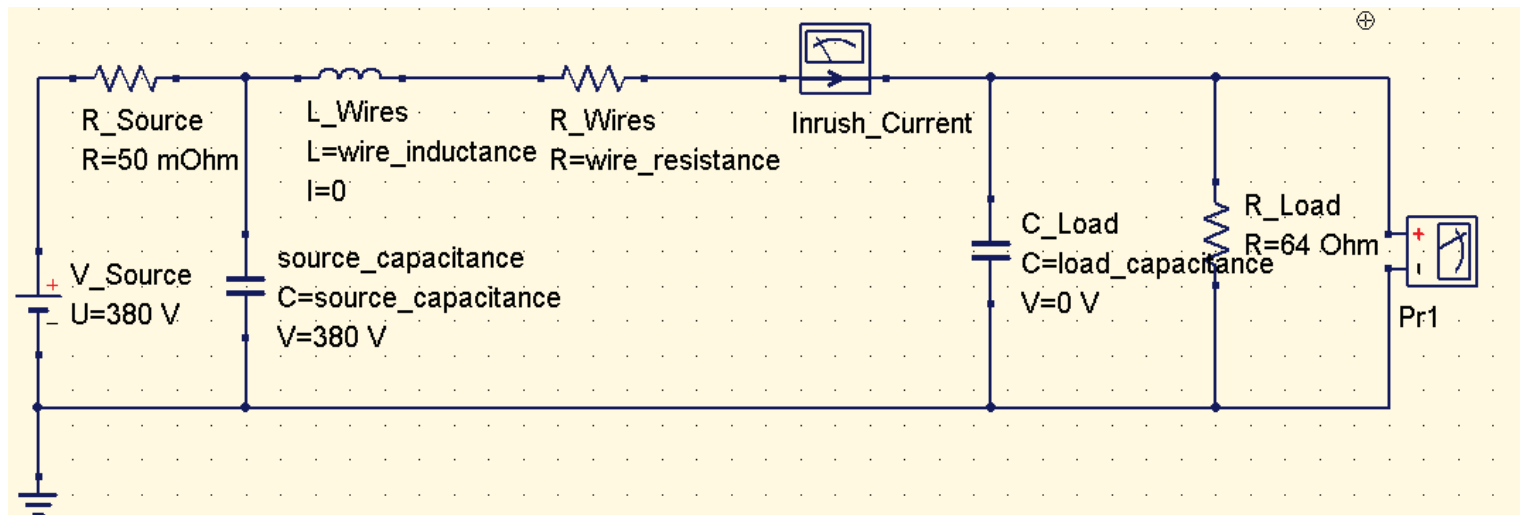


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PRODUCT DEVELOPMENT:

Predictive Analysis of Inrush Currents

- **Datacenter Modeled as Three Major Elements**
 1. Source
 2. Distribution
 3. Load
- **Each Element was Given a Variable Component:**



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PRODUCT DEVELOPMENT:

Predictive Analysis of Inrush Currents

- **Source Model:**
 - 380V Continuous
 - Variable = Capacitance: 3300, 6600 & 9900 Microfarads
- **Distribution Model:**
 - Use Typical Resistance and Impedance Values for Known Components
 - Variable = Primary Distribution Element: 0.5, 2.5, 5.0, 25 Meters
- **Load Model:**
 - Resistance 64 Ohms (6.25A)
 - Variable = EMI X-Capacitor: 0.68, 1.0, 3.3, 4.7, 6.8 Microfarads



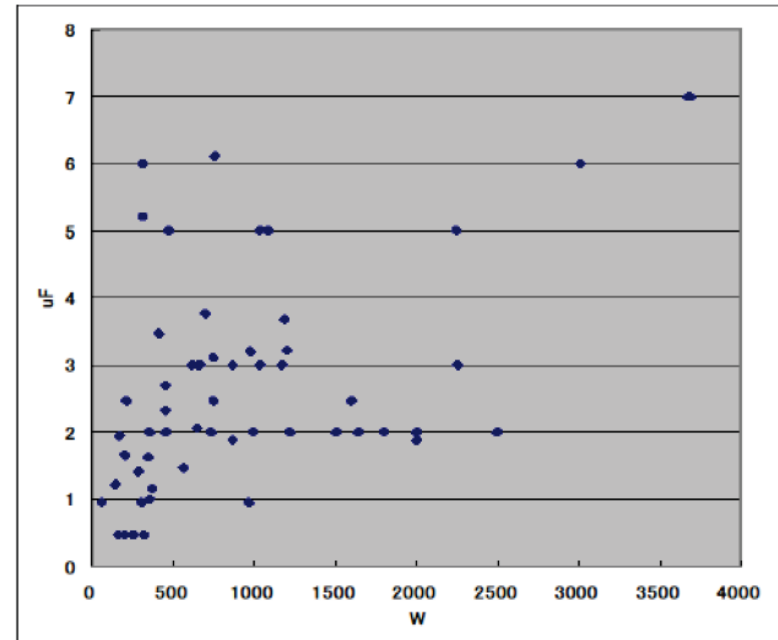
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PRODUCT DEVELOPMENT:

Predictive Analysis of Inrush Currents

Survey of IT Equipment X-Capacitor Values Conducted by NTT

- **85% of the 54 Models Surveyed had X-Capacitors Greater than 1.0 Microfarad**
- **39% of the 54 Models had X-Capacitors of 3.0 Microfarads or Greater**



Source NTT Facilities

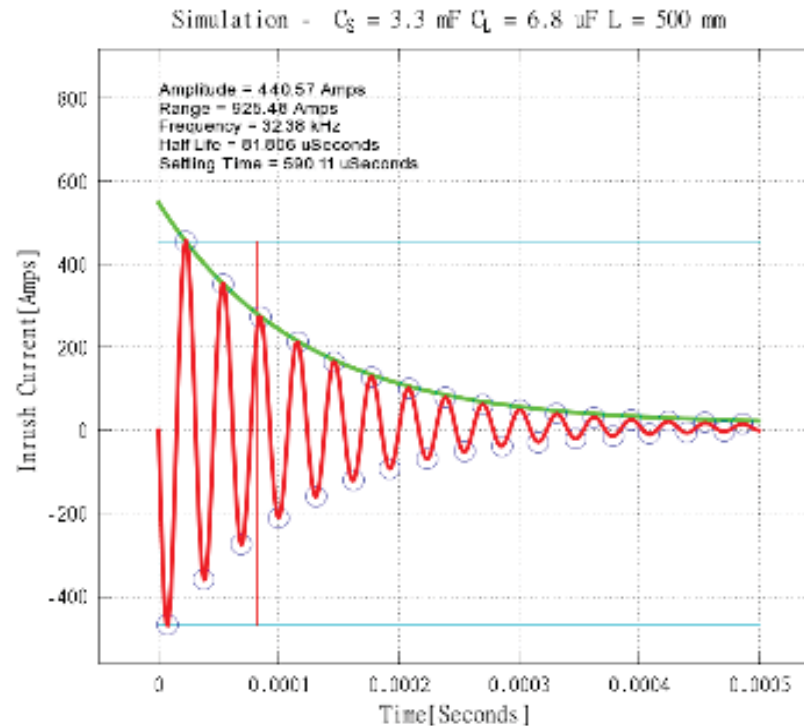


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PRODUCT DEVELOPMENT:

Predictive Analysis of Inrush Currents

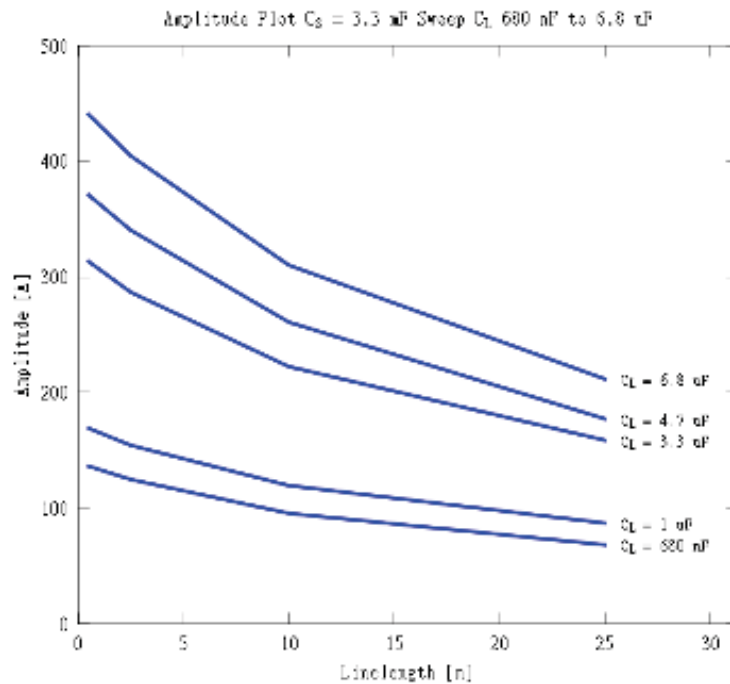
SPICE Simulation Predicts Inrush Current Range from 440 to 68 A



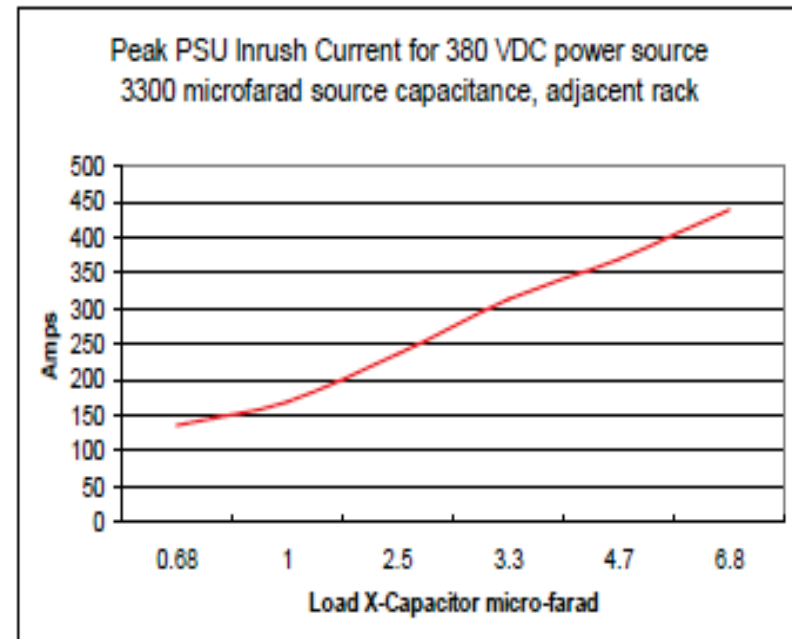
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PRODUCT DEVELOPMENT:

Predictive Analysis of Inrush Currents



Current vs Distance



Current vs X-Capacitor



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PRODUCT DEVELOPMENT:

Mitigation of Break & Make Arcing

APP Considered 3 Different Technologies to Address DC Arcing:

1) Use Contacts Having Sacrificial Arcing Area and Geometries which Naturally Suppress Arcing

- Higher cost of sacrificial contacts, but total cost lower than #2 or #3
- Simple mechanical design maximizes reliability
- Compatible with 3 wire circuitry standards

2) Use 4th Contact Pair for “Hot Swap” Secondary Circuitry of the Power Supply to Avoid Breaking Arc

- Does not support IT devices with PSU lacking “Hot Swap” capability
- Testing proved this approach does not eliminate inrush arcing & contact damage caused by charging of filter capacitors
- All standards are based on 3 wire circuitry
- Higher cost of 4 wire cable

3) Use Magnetic Arc Quenching Technology

- Not tested
- Not practical, high cost and size is not compatible with IEC 320

Option
Chosen for
Saf-D-Grid



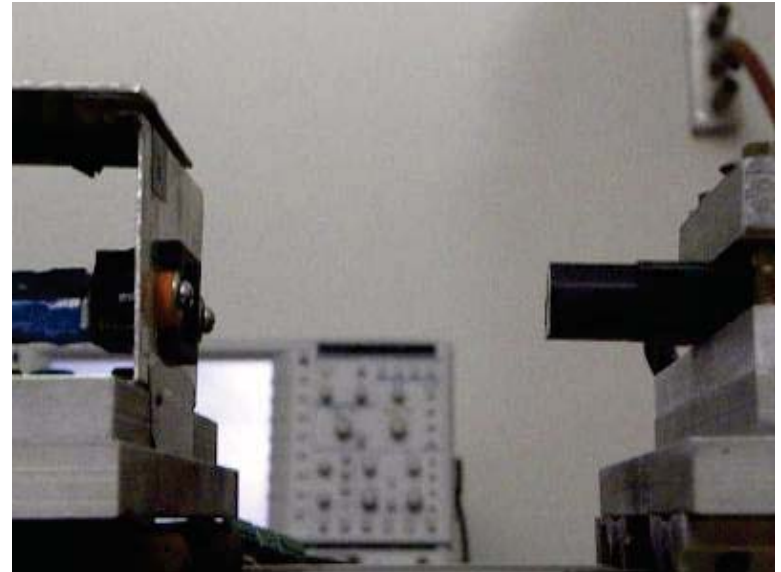
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PRODUCT DEVELOPMENT:

Evaluation of 4 Wire Arc Mitigation - Inrush Current Test

Simulated 4 Wire Circuit Test Setup:

- Test Circuit Created to Produce 400A Inrush Current Wired to a IEC320 Connector
- Connector Mated 250 cycles with No Load
- Load Engaged between Cycles (in mated condition) to De-energize EMI X-cap



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PRODUCT DEVELOPMENT:

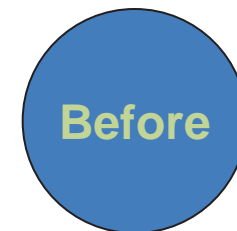
Evaluation of 4 Wire Arc Mitigation - Inrush Current Test

4 Wire Circuit Test Results:

- IEC320 Connector after 250 “No Load” Inrush Cycles
 - “Blister” damage reduces effective contact area from “circle” to “ring”
- Damage Shown can Cause Increase Contact Resistance
 - Potential for thermal runaway



Contact Area



“Circle”



“Ring”

Test Damage to IEC320 Contacts Shown



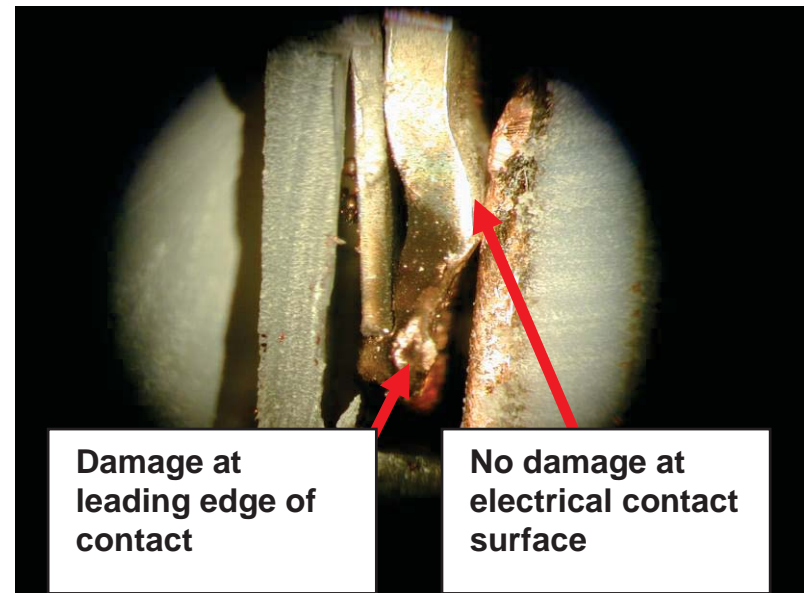
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PRODUCT DEVELOPMENT:

Evaluation of Sacrificial Contact Arc Mitigation

Saf-D-Grid® Validation Testing

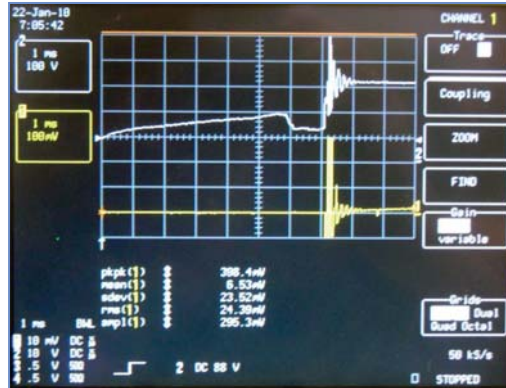
- Sacrificial Contacts Mitigate Arc Damage
- Connector Housing and Contact Geometry Minimize Arcing Distance
- Test Circuit Setup for 400A Inrush Current and 20A Load
- Connector Mated 250 Cycles Under Load
- No Damage of Plating or Contact Material in Electrical Mating Area



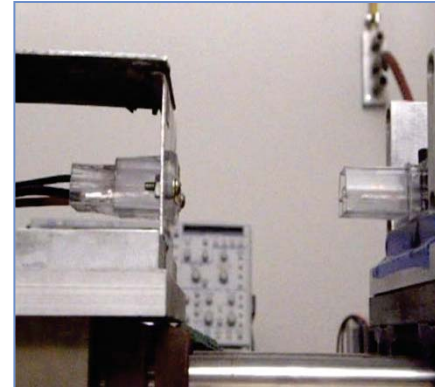
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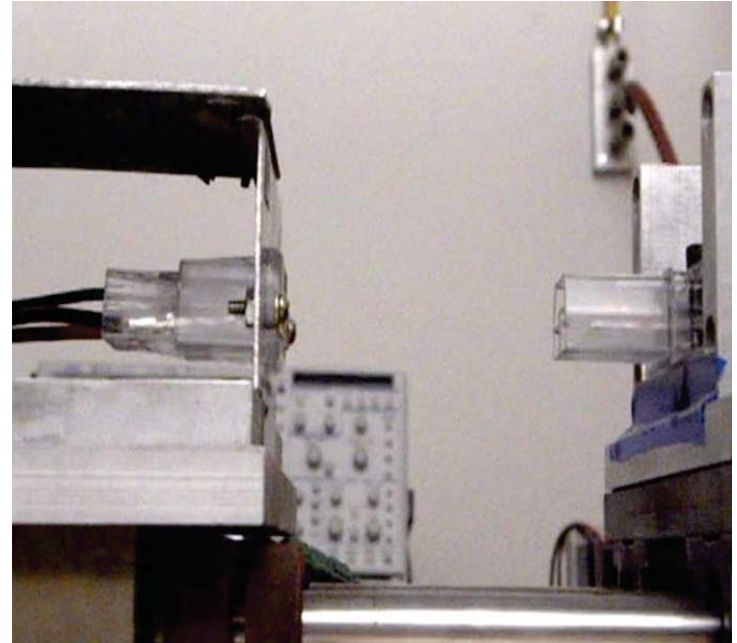
Product Models



Saf-D-Grid®

USER SAFETY: Arc Suppression & Containment

- At 400V DC, Electric Arcs Can Be Sustained for Relatively Short Distances
- Saf-D-Grid® Contacts Are Designed to Minimize Arcing
- Housing Geometries Help Extinguish Arcing
- The Contacts Have 2X Spacing Needed to Extinguish the 400V DC Arc Before the Housings Separate



[Click Image to Launch Video](#)

Note clear housings are used for demonstration purposes only. Arcing not visible with opaque material used in the actual product.



Saf-D-Grid®

USER SAFETY: Safety Standards

Saf-D-Grid® Meets Requirements of Applicable Safety Standards:

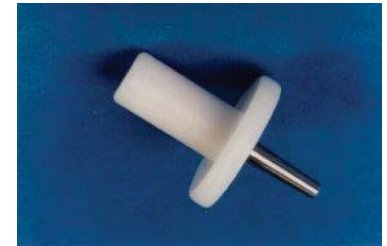
- **IEC 61984: “Connectors – safety requirements and tests”**
- **UL 1977: “Component connectors for use in data, signal, control and power applications”.**
- **IEC 60590 & UL 1950: “Information technology equipment – safety”**
- **IEC 60664: “Insulation coordination for equipment within low-voltage systems”**



Saf-D-Grid®

USER SAFETY: UL & IEC Probe Resistant

- **Applicable Safety Standards Require Protection Against Finger Access to Live Parts 50V and Above**
- **IEC and UL Evaluate This Using a Jointed Test Finger**
 - **Both Sides of Saf-D-Grid® Pass**
 - **Saf-D-Grid® May Be Used Where Capacitance Exists on Both Sides of the Connection**
 - **UPS Systems, Especially Rack-Level Backup Power**
- **UL 1950 Also Requires Protection Against a 3.0mm by 12.0mm Conical Probe**
 - **Receptacle Side of Saf-D-Grid® Passes**
 - **Saf-D-Grid® Receptacle May Be Used For PDU Outlet**



Saf-D-Grid®

USER SAFETY: Integral Latch

Integral Latch Prevents Accidental Disconnect

- **Mitigate Accidental Disconnect of Connectors Under Load**
- **Increase System Reliability By Ensuring Connectors Remain Properly Mated**
- **No External Accessory Required:**
 - Metal Bail Latch
 - Hook & Loop Fabric
- **Tactile & Audible Confirmation**



Saf-D-Grid®

USER SAFETY: Industry Standards

Saf-D-Grid® Meets Requirements of All 380-400VDC Standards:

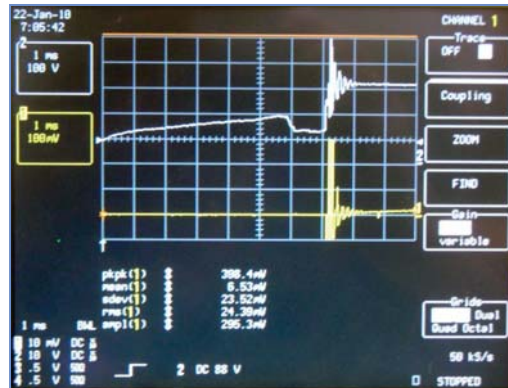
- **European Telecommunication Standards Institute (ETSI) Standard EN 300 132-3-1, Oct 2011**
- **International Telecommunications Union (ITU) Standard L.1200, May 2012**
- **China Communications Standards Association (CCSA) YD/T 2378-2011**
 - For 240V DC Currently
 - Revision Pending for Late 2014 to Include 380V DC (336V DC Nominal)
- **EMerge Alliance 380 VDC Power Distribution Standard, October 2012**
 - Saf-D-Grid® Is Listed As The Connector for IT Devices and Power Strips



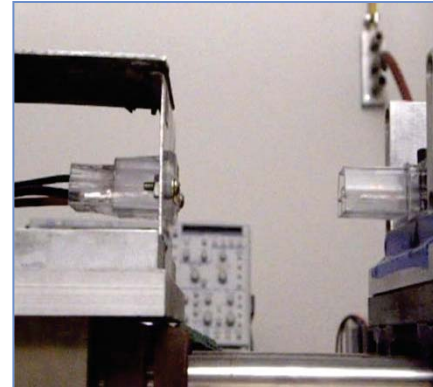
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Operating Temperature (°C)	
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(°F)	
	-4° to 176°
Fault Current Withstand	
UL 467	14 AWG, 300A, 4 Sec.

Product Models



Saf-D-Grid®

SPECIFICATIONS: Main Features

Attribute	Saf-D-Grid®	IEC320 C13/C14
Max. Amps	25A	10A
Max. Voltage	600V	250V
Max. Operating Temp	80°C, 176°F	70°C, 158°F
IEC320 C14 Size Compatible	Yes	Yes
AC Hot Plug Capable	25A, 400V	10A, 250V
DC Hot Plug Capable	25A, 400V	No
DC Arc Protection	Yes	No
Touch Safe Both Sides	Yes	No
Integral Latch	Yes	No



Saf-D-Grid®

SPECIFICATIONS

Electrical

Voltage (AC/DC)

- | | |
|----------------------|-----|
| • UL 1977 / CSA 22.2 | 600 |
| • IEC | 400 |

Current Rating (Amperes) 40

Wire Range (AWG) #12 to #18
(mm²) 2.5 to 0.75

Hot Plug Rated

- | | |
|-------------------|---------------------|
| • 250 cycles | 400V @ 440A in-rush |
| • 250 cycles (UL) | 400V @ 20A load |

Dielectric Withstanding Voltage 3,300

Operating Temperature (°C) -20° to 80°
(°F) -4° to 176°

Fault Current Withstand

UL 467 14 AWG, 300A, 4 Sec.

Materials (RoHS Compliant)

Housings

- | | |
|---------------------------------|--|
| • 2006G1 Series Receptacles | Hi Temp Nylon + 30% GF, UL94 V-0, Halogen Free |
| • All other Receptacles & Plugs | Polycarbonate UL94 V-0 |

Springs Stainless Steel

Contacts Copper, Silver Plate

Cable / Strain Relief Thermoplastic UL94 V-2

Protection

IEC 60529	IP20
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Saf-D-Grid®

SPECIFICATIONS

Mechanical

Contact Retention (lbf)	20
(N)	89
Plug Latch Retention (lbf)	20
(N)	89
Panel Latch Retention (lbf)	60
(N)	267
Durability	5,000 cycles - no load
Receptacle Max Wire OD (in)	0.22
(mm)	5.6
Creep & Clearance per UL & IEC 60950	
Between live parts of different polarity, earthing circuit and the mating surface.	
• Ultra Short Receptacle, Short and Standard Receptacle with Crimp Contacts	8.0 mm
• Short and Standard Receptacle with Solder or PCB Contacts	7.0 mm
Maximum PCB Thickness ^A (in)	0.093
(mm)	2.4
Mechanical Shock ^B	
IEC 60512-4-6C	50g's
Vibration, High Frequency ^B	
IEC 60512-4-6d	20g's

- ^A Applicable only to receptacles intended for termination to PCB
- ^B Tested with straight plug and standard depth receptacle with #14 AWG wire and 2003G1 contacts.



Saf-D-Grid®

SPECIFICATIONS: UL 1977 & IEC 61984

Receptacle Series	Wire Size	Conditions of Use	Agency Rating	Rated Current Amp	Rated Voltage AC / DC
Flush 2002 & Short 2005	18 AWG plug & receptacle	Disconnect Only	CNR	12	600
		Current Interrupt	UL 1977	18	600
		Disconnect Only	UL 1977	12	400
		Current Interrupt	UL 1977	12	400
Flush 2002 & Short 2005	16 AWG plug & receptacle	Disconnect Only	CNR	14	600
		Current Interrupt	UL 1977	18	600
		Disconnect Only	UL 1977	14	400
		Current Interrupt	UL 1977	14	400
Flush 2002 & Short 2005	1.5 mm ² plug & receptacle	Disconnect Only	IEC 61984 ³	14	400
		Current Interrupt	IEC 61984 ³	14	400
Flush 2002 & Short 2005	14 AWG plug & receptacle	Disconnect Only	IEC 61984 ³	25	400
		Current Interrupt	UL 1977, CNR	20	400
		Disconnect Only	IEC 61984 ³	20	400
		Current Interrupt	IEC 61984 ³	20	400
Flush 2002 & Short 2005	12 AWG plug & receptacle	Disconnect Only	CNR	30	600
		Current Interrupt	UL 1977	40	600
		Disconnect Only	UL 1977	30	400
		Current Interrupt	UL 1977	30	400
Ultra Short 2006G	18 AWG plug & receptacle	Disconnect Only	CNR	13	600
		Current Interrupt	IEC 61984	13	400
		Disconnect Only	UL 1977	21	600
		Current Interrupt	IEC 61984	13	400
Ultra Short 2006G	1.5 mm ² plug & receptacle	Disconnect Only	UL 1977, CNR	12	400
		Current Interrupt	UL 1977, CNR	12	400
Ultra Short 2006G	14 AWG plug & receptacle	Disconnect Only	IEC 61984	14	400
		Current Interrupt	IEC 61984	14	400
Ultra Short 2006G	14 AWG plug & receptacle	Disconnect Only	CNR	25	600
		Current Interrupt	IEC 61984	25	400
		Disconnect Only	UL 1977	35	600
		Current Interrupt	UL 1977, CNR	20	400
			IEC 61984	20	400

- UL 1977 ratings are for recognized components under file number E26226. Ratings may vary once final listing category is considered. Do not exceed maximum operating temperature of the connector or wire insulation. Ratings are based on an ambient temperature of 25°C.
- “CNR” indicates investigation to Canadian national standards for recognized components, C22.2 No. 182.3
- IEC 61984 certification by TUV, certification number R7212289.
- “Disconnect Only” indicates the devices are not for interrupting current.
- “Current Interrupt” indicates the devices have been investigated for the interruption of current.
- APP assembly tooling is required for UL, CSA, and other safety agency compliance. Use of unapproved tooling will void connector warranty.

³ Note: No IEC 61984 approvals for 2002N, 2002V, 2005N & 2005V series receptacles.



Saf-D-Grid®

SPECIFICATIONS: UL 817 & CCC Ratings

| UL 817 RATINGS |

Connector Type / Cable Type	Wire Size	Disconnect Only (600V Max)	Current Interrupt (400V Max)
Straight Plug / SOOW 600V	14 AWG	18	18
Straight Plug / ST 600V	18 AWG	10	10
	16 AWG	13	13
	14 AWG	18	18
Straight Plug / SJT 300V	14 AWG	18 ₁	18 ₁
IEC C20 Plug / SJT 250V	14 AWG	16 ₂	N/A
Right Angle Plug / ST 600V	18 AWG	10	10
	16 AWG	13	13
	14 AWG	18	18
T-Latch Plug / ST 600V	18 AWG	10	10
	16 AWG	13	13
	14 AWG	18	18

₁ Note: Voltage limited by wire insulation rating

₂ Note: Voltage limited by the IEC connector on the cord set

| CCC RATINGS | - Pending

Receptacle Series	Wire Size AWG	Conditions of Use	Rated Current Amp	Rated Voltage AC / DC
Ultra Short 2006G	2.5 mm ² plug & receptacle	Current Interrupt	20	400

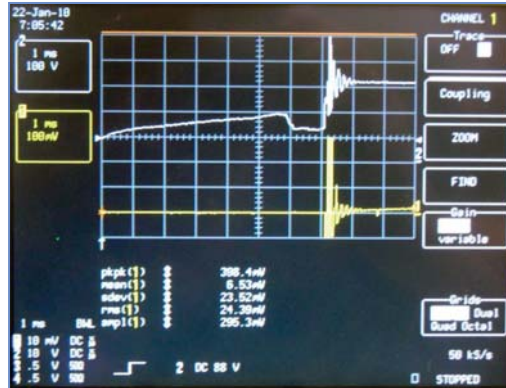
- UL 817 listed cords under UL file number E343569
- “Disconnect Only” indicates the devices are not for interrupting current
- “Current Interrupt” indicates the devices have been investigated for the interruption of current
- ₁ Note: Voltage limited by wire insulation rating
- ₂ Note: Voltage limited by the non- Saf-D-Grid® connector on the cord set
- CCC Certification to:
 - GB/T11918-2001: Part 1 (idt IEC 60309-1:1999)
 - GB/T11919-2001: Part 2 (idt IEC 60309-2:1999)
- CCC Certification is only required for connectors which are built to CCC recognized dimensional & performance standards. Saf-D-Grid was voluntarily submitted to CCC under performance only aspects of relevant standards.



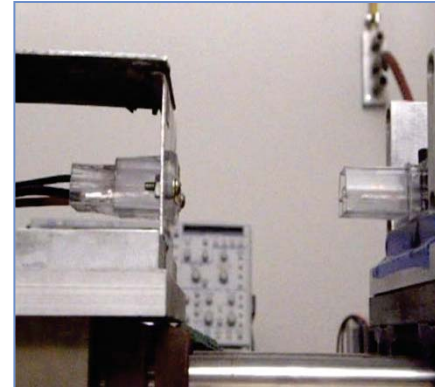
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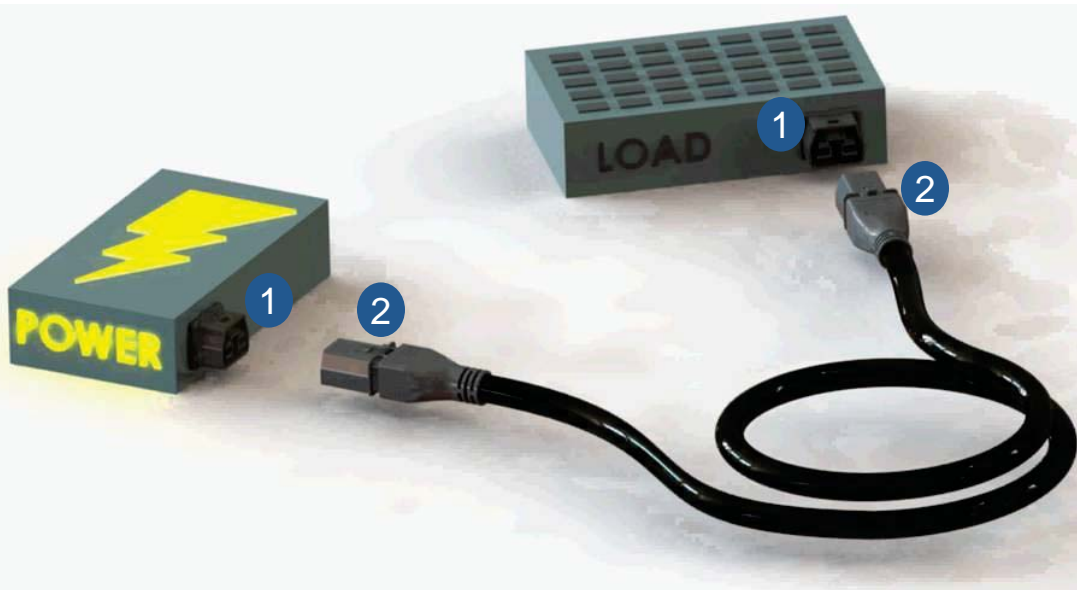
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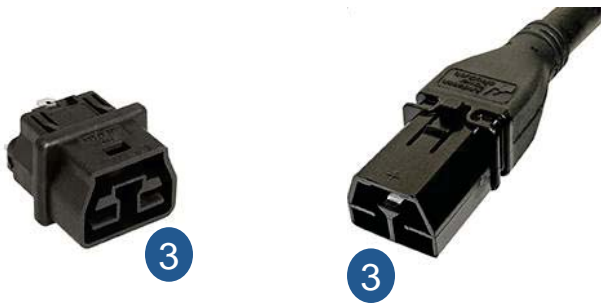


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PRODUCT MODELS: Simplified Power Connections



- 1 The Same Receptacle is Used on Both the Power & Load Sides
- 2 The Same Plug is Used on Both Sides of the Power Cord
- 3 Both Plug & Receptacle Connectors are Touch Safe



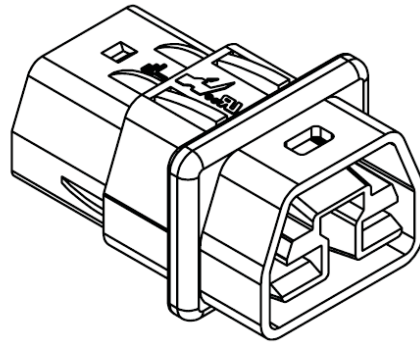
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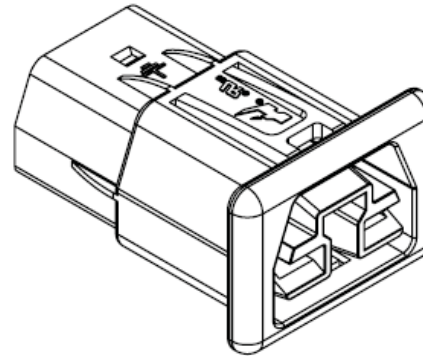
Receptacles for Crimp Termination to Wire

Click On Pictures For Drawings

Short Depth
2005G Series



Flush Mount
2002G Series



Crimp Contact
2003G1 Series



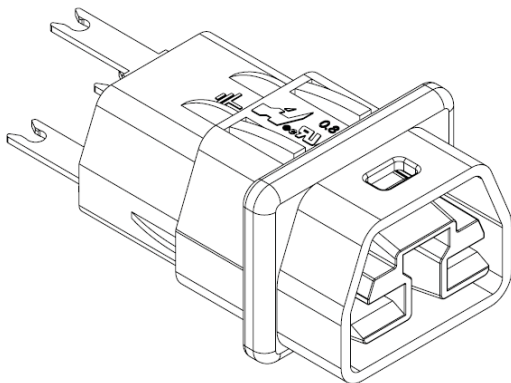
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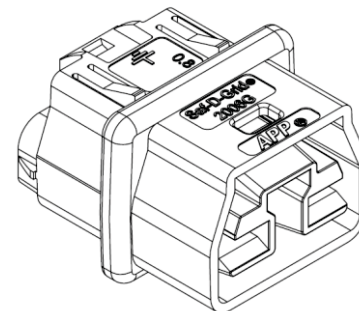
Receptacles for Solder Termination to Wire

Click On Pictures For Drawings

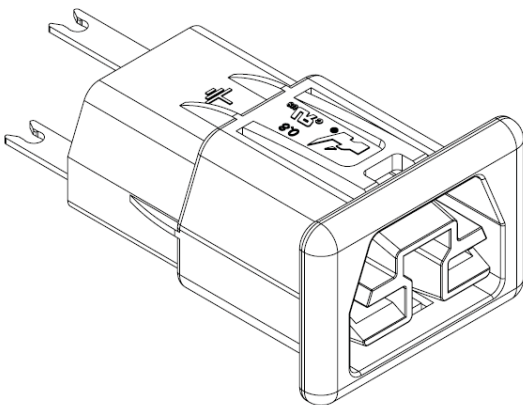
Short Depth
2005N Series



Ultra-Short Housing
2006G Series

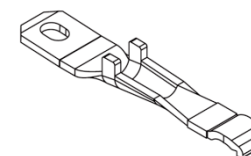


Flush Mount
2002N Series



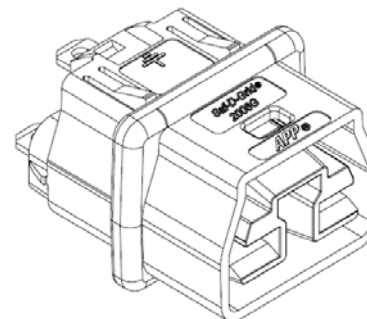
Solder Contact
2016G1-LPBK

For Ultra Short Receptacle Only



Ultra-Short Assembly
2006G Series

Includes 2016G1-LPBK Contacts inserted



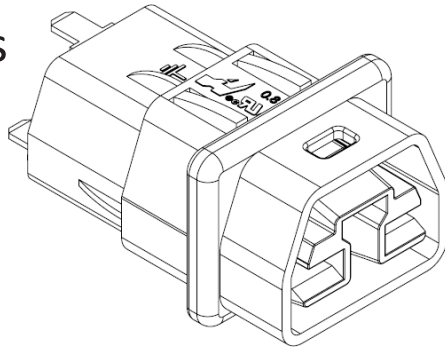
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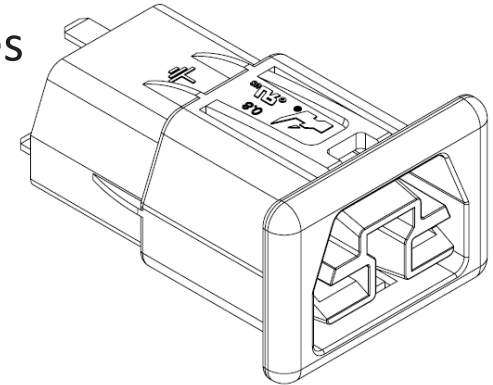
Receptacles for Solder Termination to Wire

Click On Pictures For Drawings

Short Depth
2005V Series

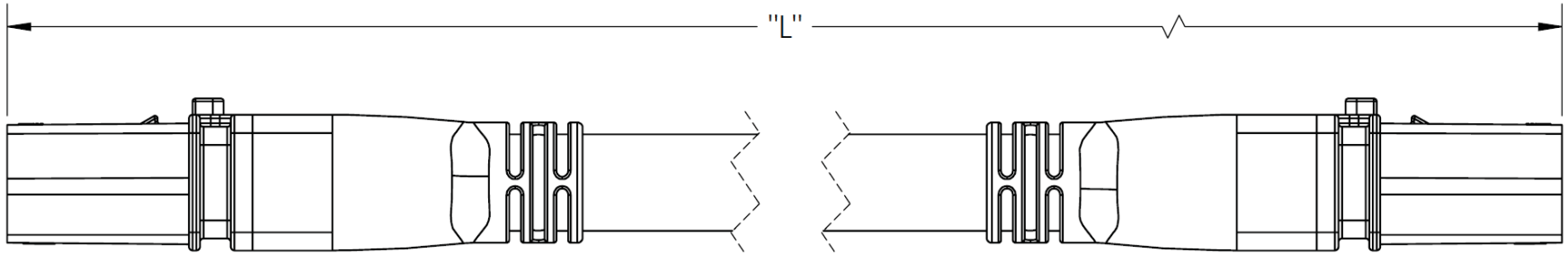


Flush Mount
2002V Series

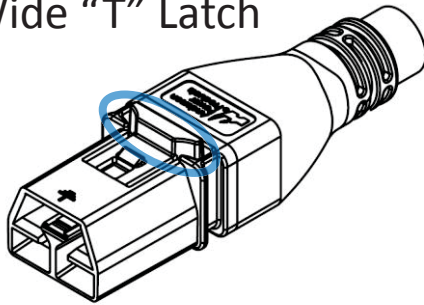


Saf-D-Grid®

PRODUCT MODELS: Double End Power Cords



Wide "T" Latch



"T" latch allows easy unlatching access around PSU handles or other obstacles

ST UL 600V

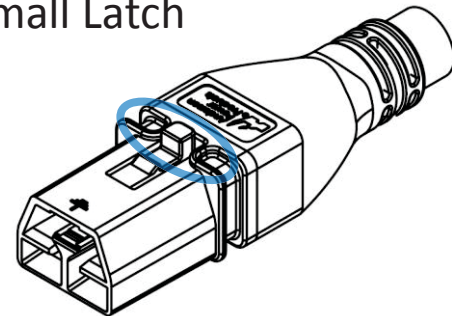
PSE 600V

H05VVF CE 300/500V

60245 IEC 57 300/500V

Click cable type for drawings

Small Latch



SOOW UL 600V

ST UL 600V

PSE 600V

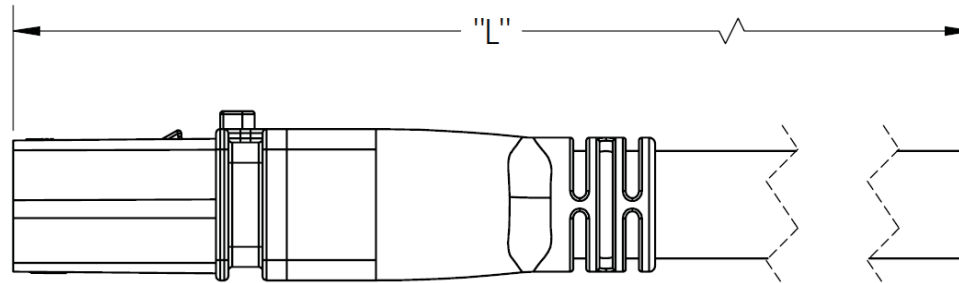
H05VVF CE 300/500V

Click cable type for drawings

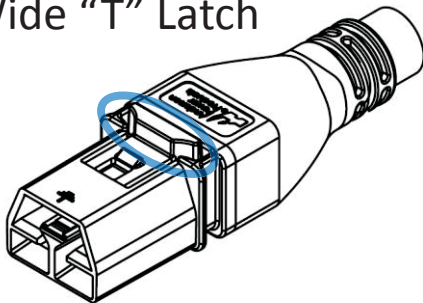


Saf-D-Grid®

PRODUCT MODELS: Single End Power Cords



Wide "T" Latch



"T" latch allows easy unlatching access around PSU handles or other obstacles

ST UL 600V

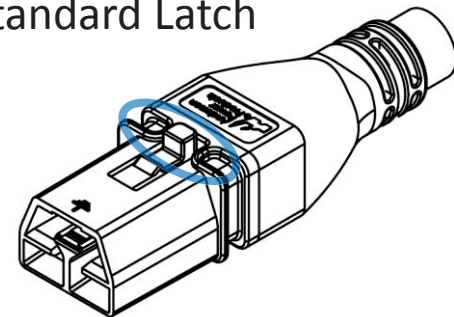
PSE 600V

H05VVF CE 300/500V

60245 IEC 57 300/500V

Click cable type for drawings

Standard Latch



SOOW UL 600V

ST UL 600V

PSE 600V

H05VVF CE 300/500V

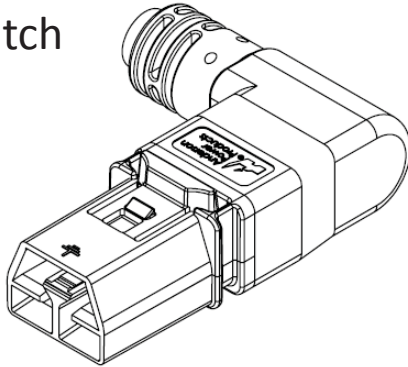
Click cable type for drawings



Saf-D-Grid®

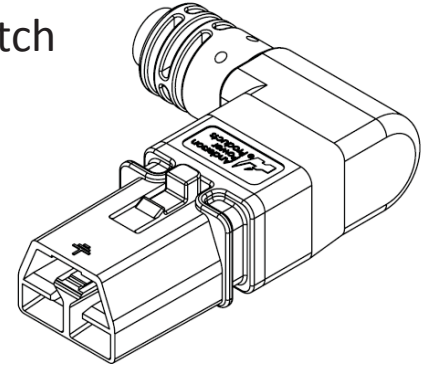
PRODUCT MODELS: Right Angle Power Cords

Wide "T" Latch



"T" latch allows easy unlatching access around PSU handles or other obstacles

Small Latch



ST UL 600V

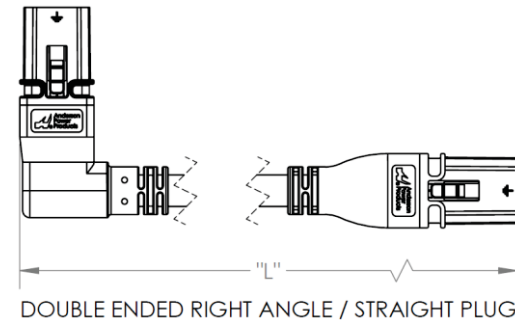
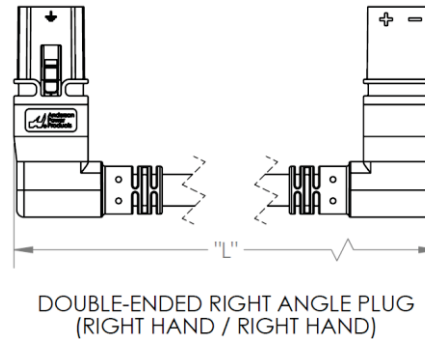
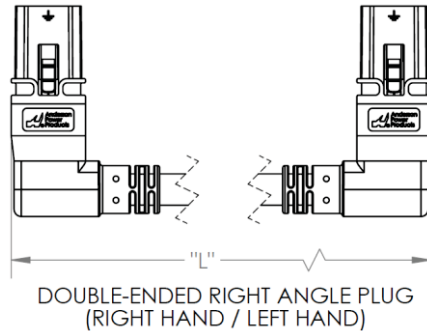
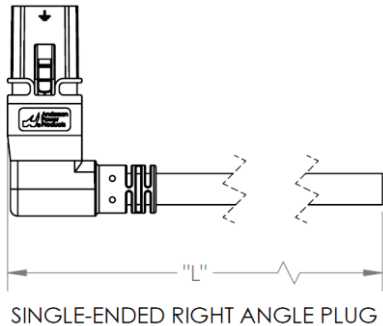
PSE 600V

Click cable type for drawings

ST UL 600V

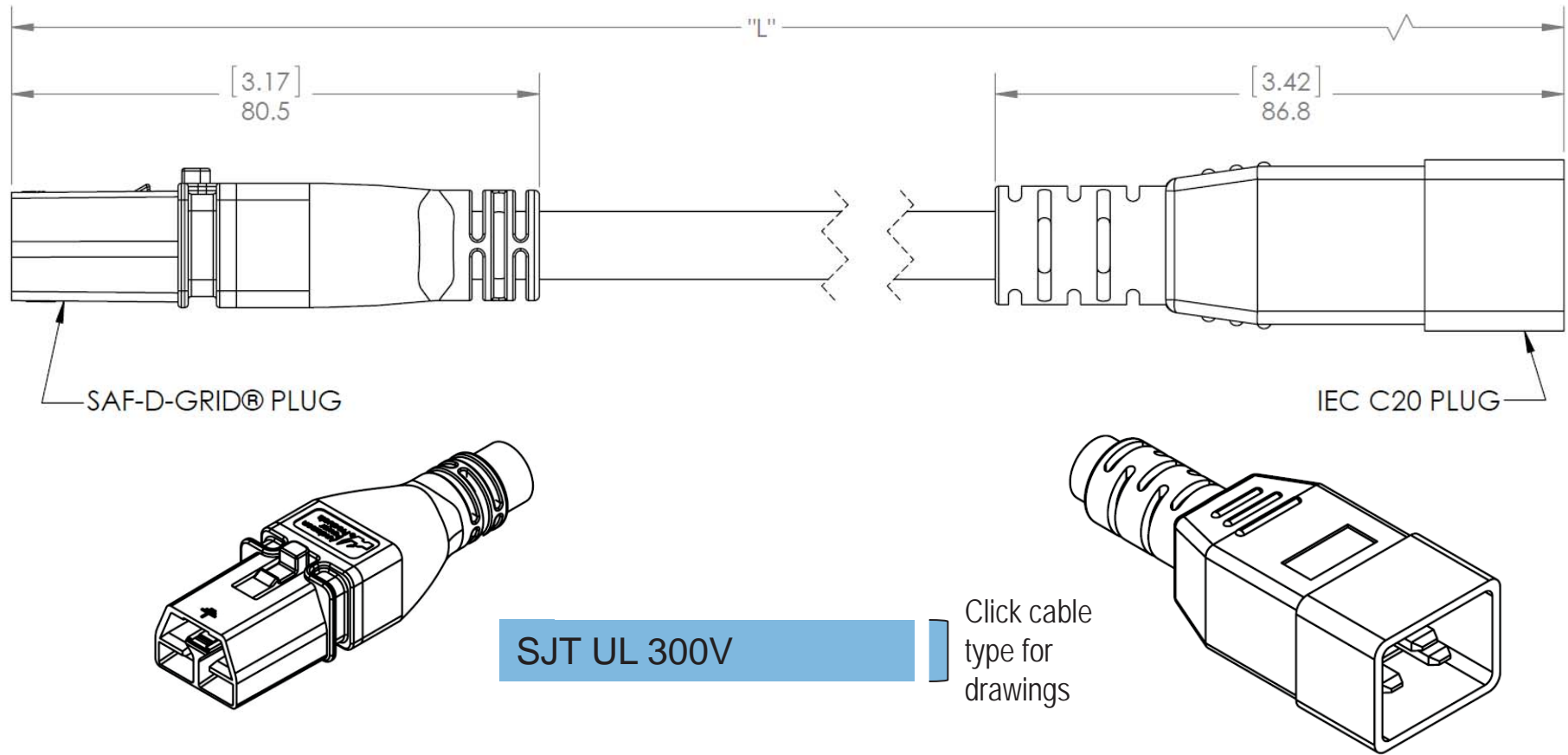
PSE 600V

Click cable type for drawings



Saf-D-Grid®

PRODUCT MODELS: Specialty Power Cords



Saf-D-Grid®

PRODUCT MODELS: Assembly Tooling

Tooling Available Directly from Anderson Power Products (All Customers)

Contact Part Number	Description	Hand Tool	Automated Tooling	
			Press	Applicator
2003G1	Receptacle Contact, Reeled	-	115V = TE0101 230V = TE0102	TD0104
2003G1-LPBK	Receptacle Contact, Loose Piece	1309G9	-	-

Additional Tooling Available Directly from ATS (North American Customers Only)

Contact Part Number	Description	Automated Tooling		
		Press	Air Feed	Applicator
2003G1	Receptacle Contact, Reeled	354500-1	354578-1	1852859-3

• **Contact ATS Directly to Purchase or Lease Tooling**

P.O. Box 6780, Harrisburg, PA 17112 USA
T: 877-671-2955 F: 717-810-2862
www.applicationtooling.com



Press



Hand Tool



Applicator

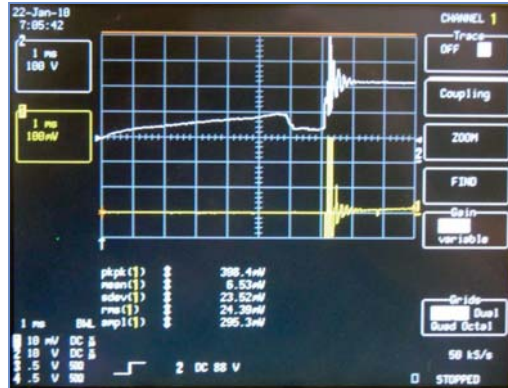
NOTE: Tooling recommended by APP is required for UL, CSA & other safety agency compliance. Use of unapproved tooling will void connector warranty.



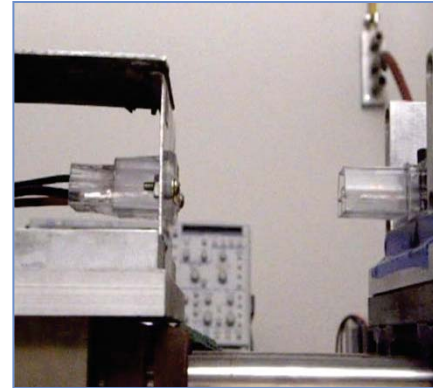
Saf-D-Grid®

TABLE OF CONTENTS: Click On Area Of Interest

Development



User Safety



Specifications

Electrical	
Voltage (AC/DC)	
• UL 1977 / CSA 22.2	600
• IEC	400
Current Rating (Amperes)	40
Wire Range (AWG)	#12 to #18
(mm ²)	2.5 to 0.75
Hot Plug Rated	
• 250 cycles	400V @ 440A in-rush
• 250 cycles (UL)	400V @ 20A load
Dielectric Withstanding Voltage	3,300
Operating Temperature (°C)	-20° to 80°
(°F)	-4° to 176°
Fault Current Withstand	
UL 467	14 AWG, 300A, 4 Sec.

Product Models



Saf-D-Grid®



YOUR BEST CONNECTION