



COMPONENTS • POWER • EASE-OF-USE • PERFORMANCE
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TIME • VOLUME • RELIABILITY • FLEXIBILITY • LONGEVITY
TEAMWORK • PROVEN • DENSITY • QUALIFIED • COMPETITIVE
SOLUTIONS • INTEGRATION • SUPPORT • OPPORTUNITIES

Stress-Free Electrical Safety for Power Designers

David Bournier
Senior Applications Engineer
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Safety Webinar Outline

› Webinar Focus

› System Safety

- Appliance Insulation Classes
- Isolation
- Creepage and Clearance
- Hi-Pot Test Classifications
- Selection and Use of X and Y Capacitors
- Fuses

› Design for Safety

- Proactive Approach
- Contacting Vicor
- Vicor Product Safety Documentation
 - Locating Safety Certificates
 - Information Provided in the Safety Certificate

› Additional Internal and External Resources

› Q & A session

Webinar Focus

This material intended for engineers and managers

GOALS

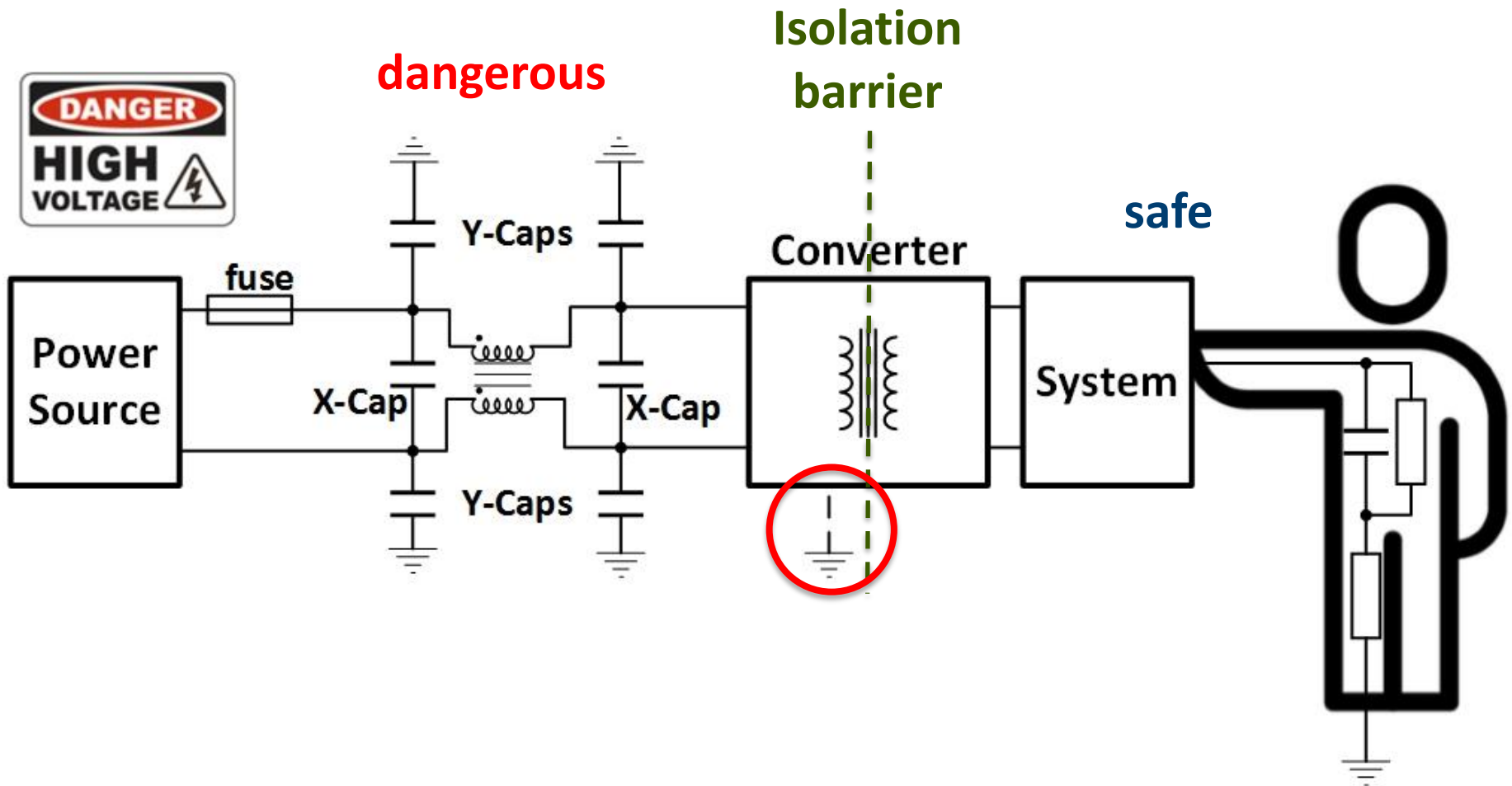
- Summarize electrical safety aspects of Vicor Power Components
- Show where to find electrical safety qualification details

WORKING APPROACH

- Vicor Global Applications team supports Customer Engineering
- ADVICE: Engage team early in the design cycle

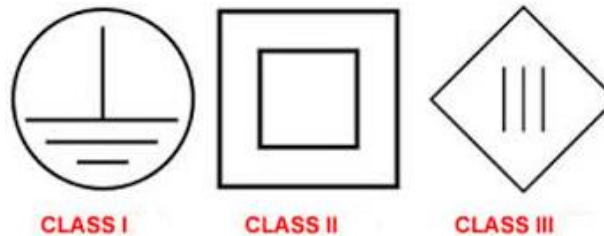
System Safety

Block diagram of a Power Supply



Appliance Insulation Classes

- › Vicor Products may be used in Class I, Class II and Class III category products



- › Class I – PE (Protective Earth) connection mandated. Basic insulation.
- › Class II –No PE connection mandated. Double or Reinforced insulation deployed.
- › Class III – Appliance designed to be sourced from SELV, no *non-SELVs* permitted internally or at the output(s) [limit of 42.4V peak]
- › Functional Insulation is used at designer's discretion

Examples

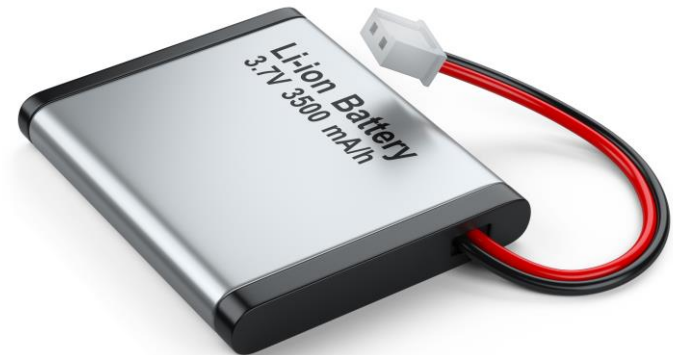
Class I
PE mandatory



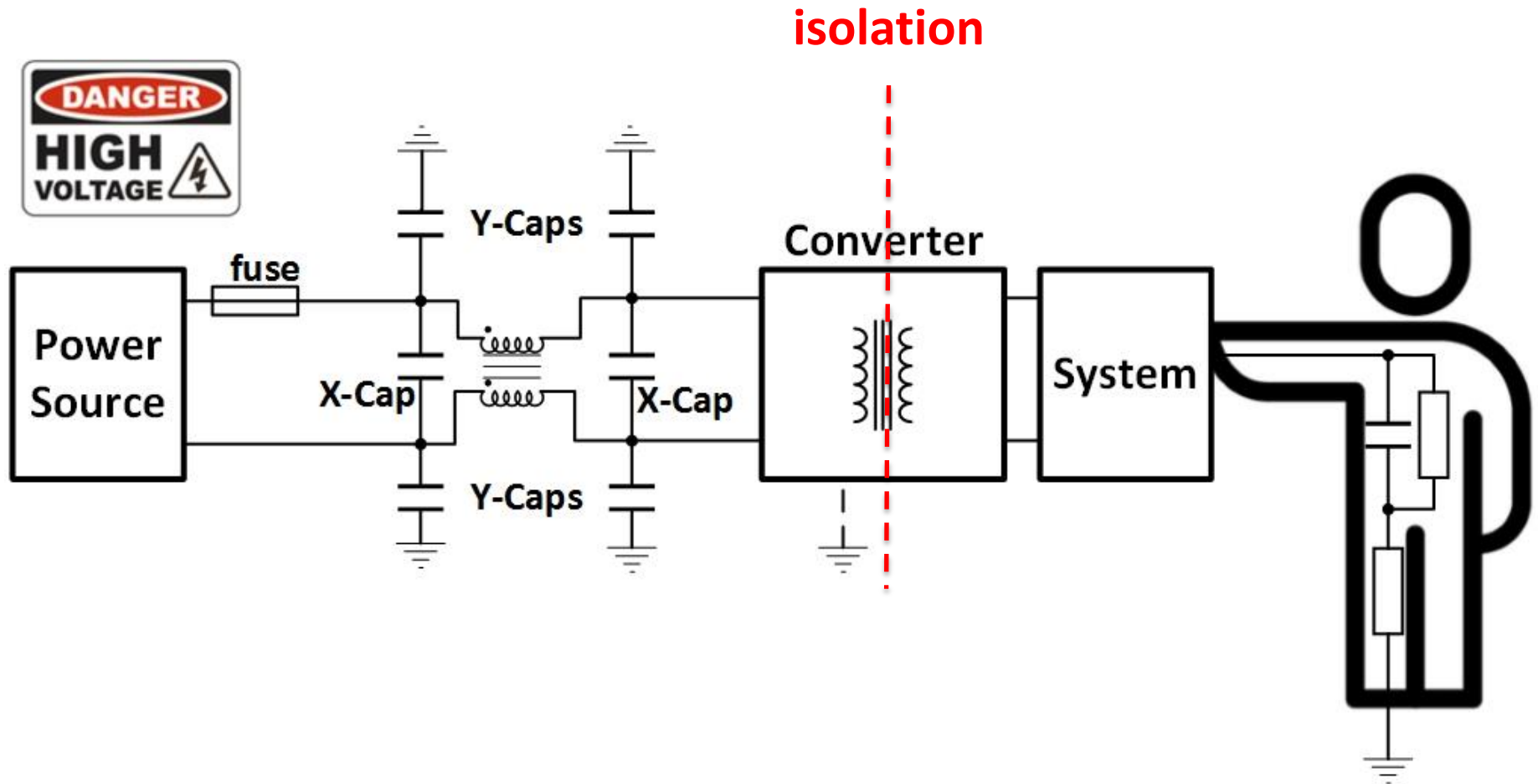
Class II
No PE connection



Class III
SELV voltage

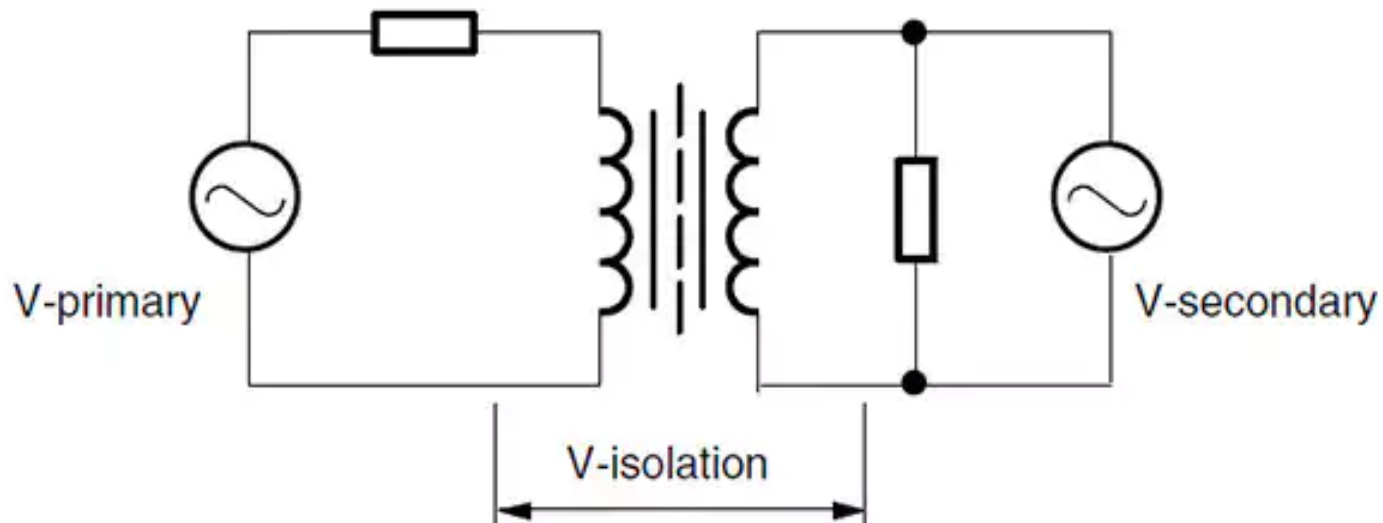


Isolation



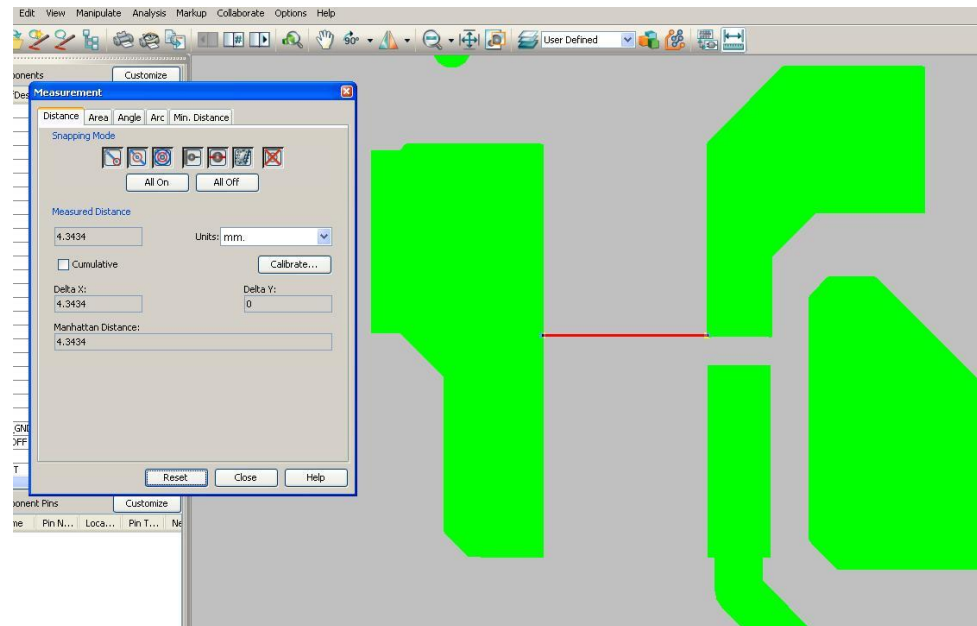
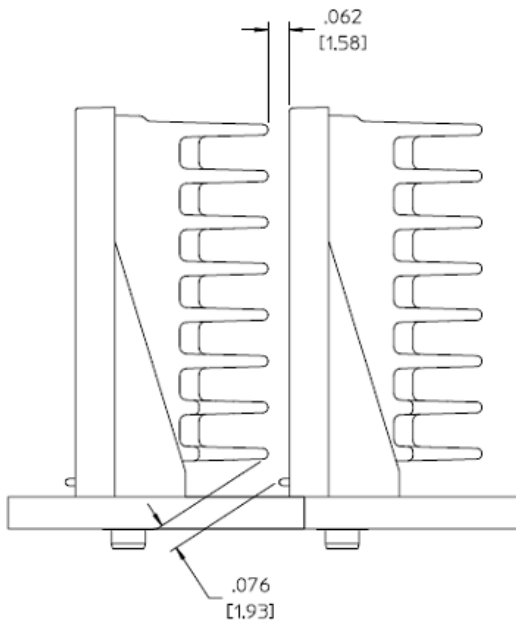
Isolation

- › Isolation voltage levels declared in the datasheets
- › Certain Vicor products are non-isolated – see Safety Certificates
- › Physical relief provided internal to Vicor products
- › Designers must not compromise isolation when introducing opto-coupler/transformer based feedback for regulation



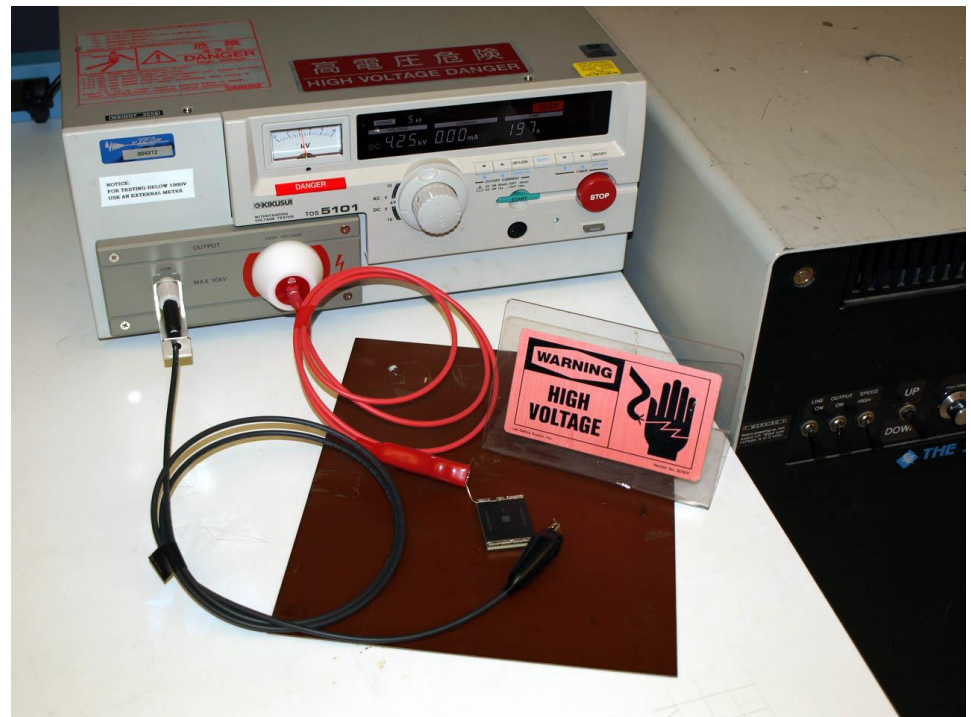
Creepage and Clearance

- › **CREEPAGE** – distance measured over an insulating surface
- › **CLEARANCE** – distance measured as a straight line through air
 - See IEC 60950-1 annex F, see also IEC 60664-1:
Insulation Coordination of Equipment with Low Voltage



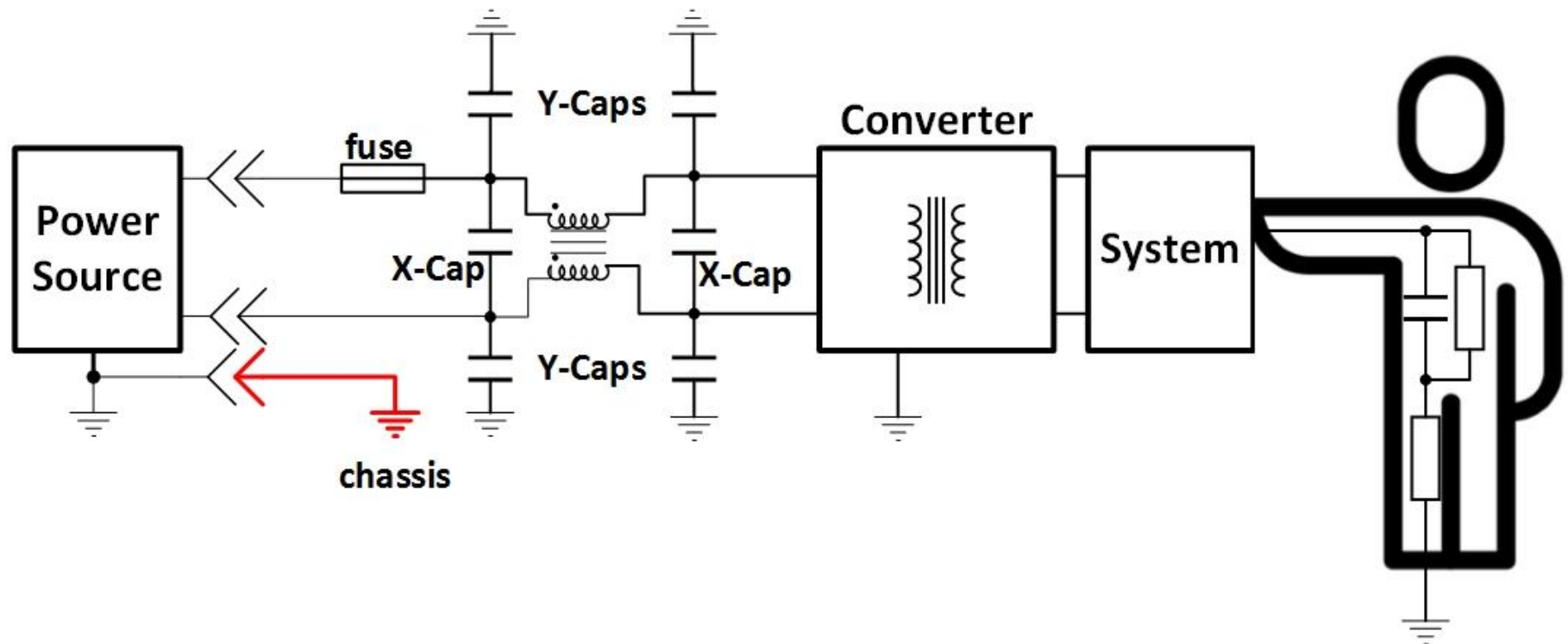
Hi-Pot Test Classifications

- › **TYPE** test is part of the product's certification – duration 60 seconds
- › **ROUTINE** test done at post-production stage 1→6 seconds typically
- › Vicor products hi-pot pre-tested
- › Test outcomes on the datasheet
- › A customer hi-pot *post production* test should be a **ROUTINE** test of short time duration

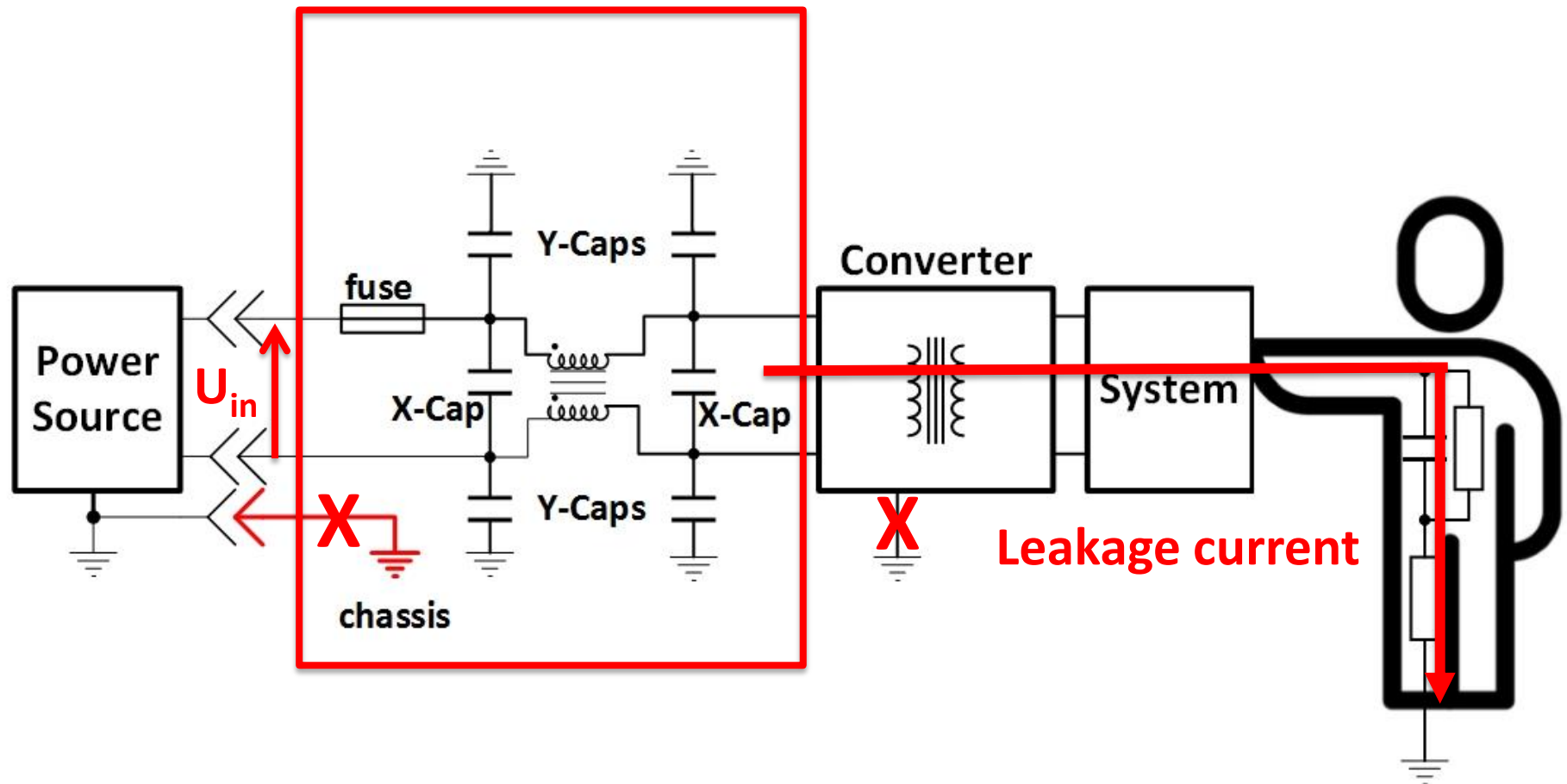


Ground Bonding Test for Class I Systems

- › Ground connection needs to be tested for Class I systems
- › Test procedure, parameters --- defined in the standards



Selection and Use of X and Y Capacitors

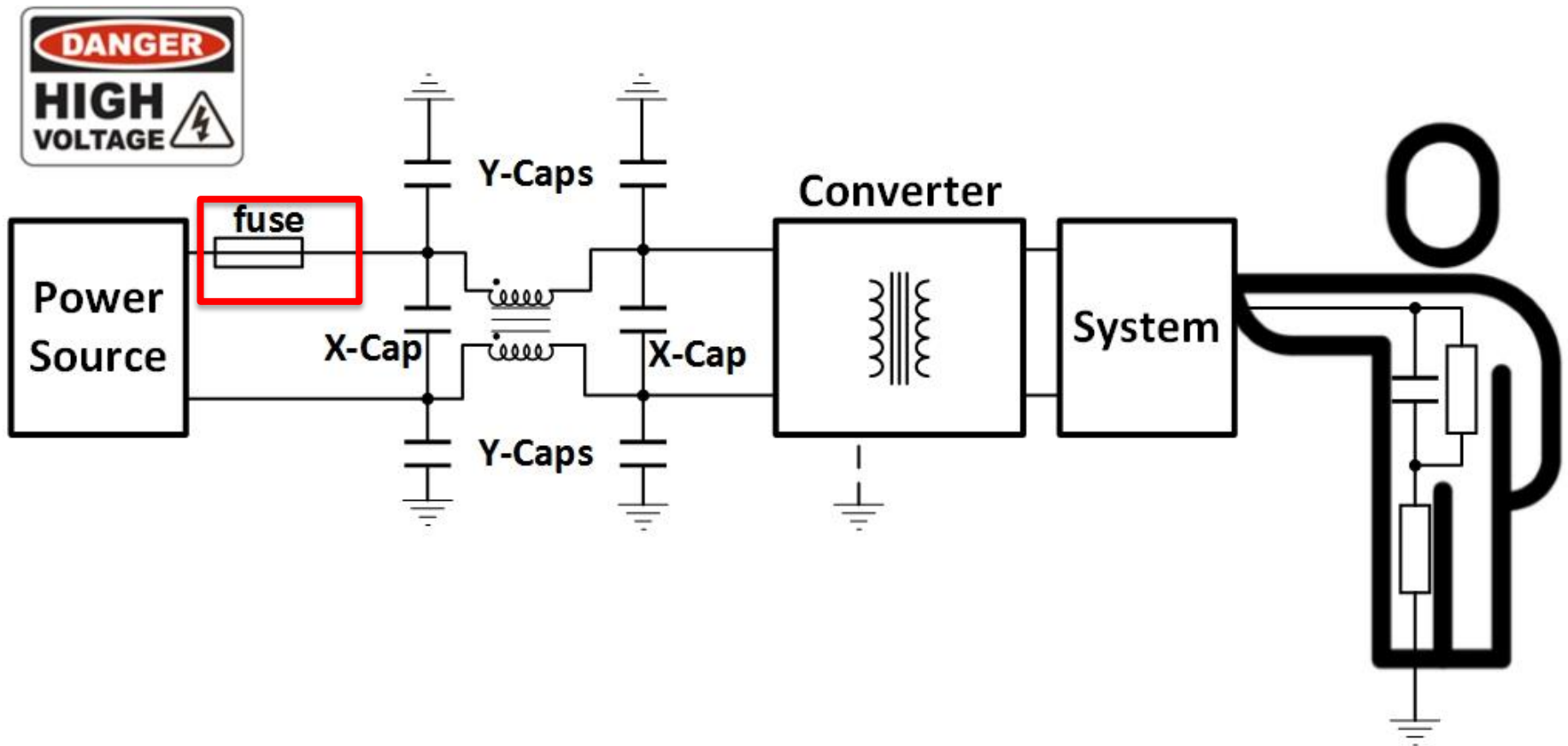


Selection and Use of X and Y Capacitors

- › Typically required for AC sourced power
- › The rationale for incorporating X and Y caps
 - Controlling converter self noise
 - Suppressing conducted and radiated emissions
 - See webinar on Vicor website:
[Simple Ideas to Make EMI a Thing of the Past](#)
- › X and Y caps impact both safety and EMI test results
- › ENEC – example of harmonized approval
- › The applicable standard IEC 60384-14



Fuses in the System



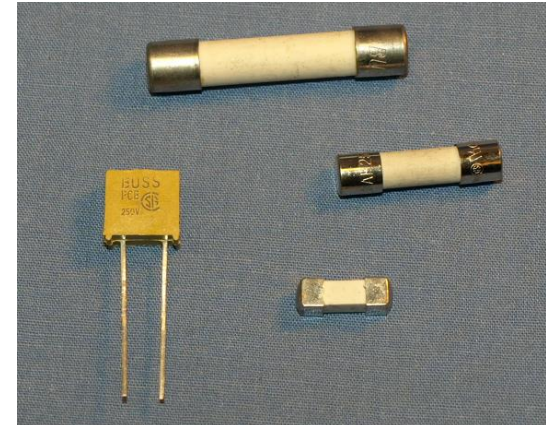
Function of the Electrical Fuse

Quickly stems large currents due to

- ground faults
- internal device failures

May prevent a fire, if not smoke

Open without hazard to user and equipment



Important criteria for a fuse

- current rating
- voltage rating
- speed of interrupt – circuit breakers will generally be slower
- energy or I^2t rating – alloy melts when subject to excess current
- derating for temperature

Design for Safety

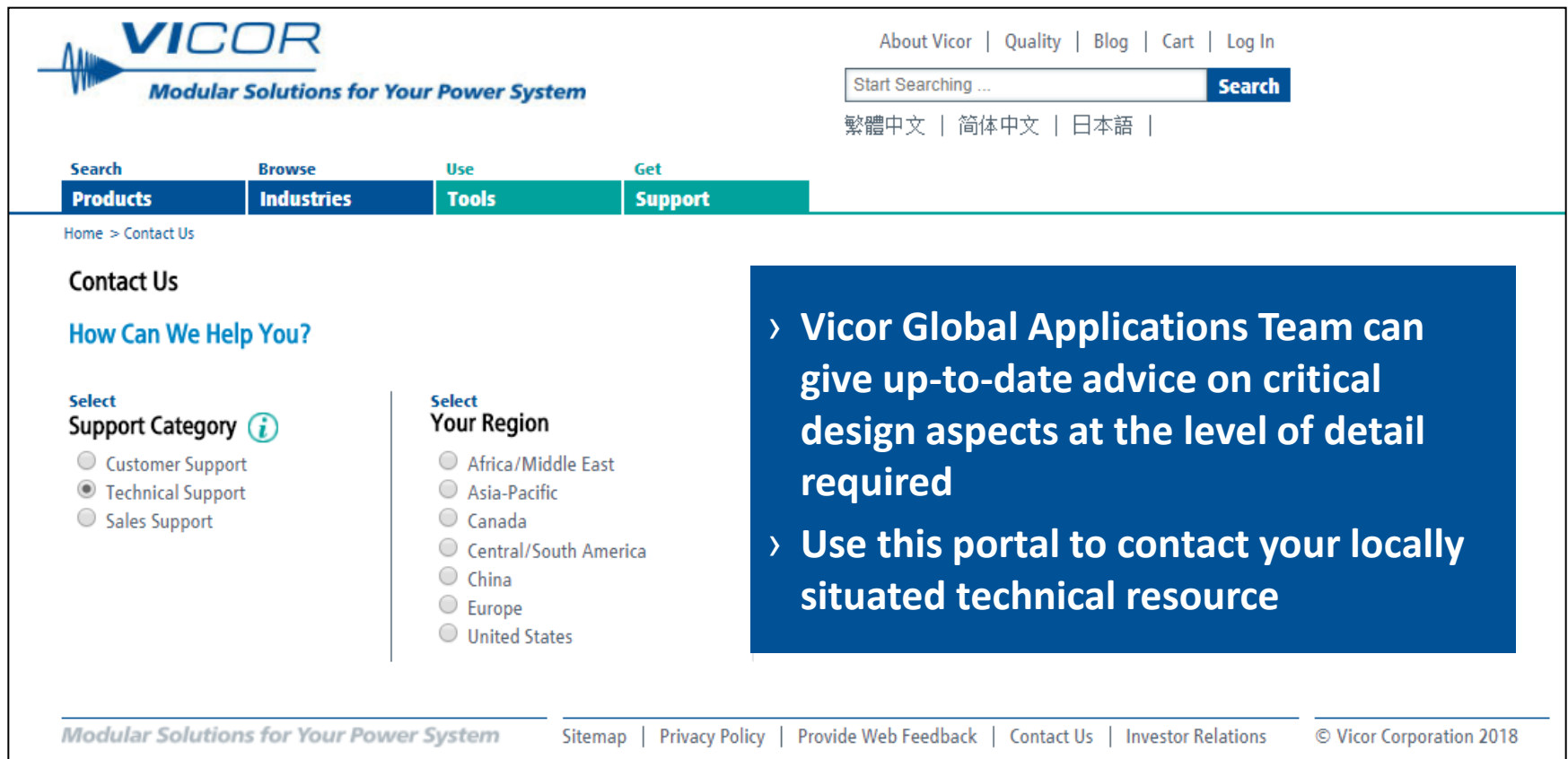
Proactive Approach

- › **To guarantee Safety** – a qualified Test House should be commissioned to review product
 - safety
 - EMC compliance

unless there is NCB approved in-house test facility
- › **Once deemed satisfactory by the Test House, the manufacturer is granted the right to attach a certification mark to the tested product**

Contacting Vicor

<http://www.vicorpower.com/contact-us>



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› Vicor Global Applications Team can give up-to-date advice on critical design aspects at the level of detail required

› Use this portal to contact your locally situated technical resource

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Vicor Product Safety Documentation

- › Most Vicor products carry Safety Marks – these are located on
 - Datasheets and sometimes on part labels too

**BCM[®] in a VIA Package
Bus Converter**

BCM4414xG0F4440yzz



BCM[®]
Ultra High Voltage
Bus Converter Module



- › Refer to Safety Certificates for recommended fuses, MOVs, X- and Y caps, other needed safety elements, product operational envelopes

Locating Safety Certificates

- › Let us locate Safety Documents for an example product
- › The PRM or Pre-Regulator Module
 - Go to the specific PRM's web portal
 - locate the Safety Certificates under Documentation tab

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Home > DC-DC > Non-Isolated Regulated > PRM

PRM™ Regulator

Specifications

- Input Voltages** 48 V (36 – 75 V)
- Output Voltage** 48 V
- Output Power** Up to 600 W
- Efficiency** Up to 97%
- Dimensions**
 - Full Chip : 32.5 x 22 x 6.73 mm
 - Half Chip : 22 x 16.5 x 6.73 mm

Description

The PRM Module is a family of zero-voltage switching (ZVS) buck-boost regulators with a wide range input voltage and a regulated, adjustable output voltage. PRMs can be used stand-alone as non-isolated voltage regulators or combined with VTM current multipliers for an isolated DC-DC solution with higher efficiency and power density than conventional DC-DC converters.

Family Overview »

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- ☐ Supercap Charger Atom
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- ☐ HV to Processor Application for Transportation
- ☐ Highway LED Panel
- ☐ Road Toll Stations
- ☐ Camera Array
- ☐ Submarine Power Thruster
- ☐ Electric Vehicle Fuel Cell
- ☐ Tethered Hovercraft
- ☐ 48Vout PFM and 48V ZVS Bucks
- ☐ Li-Ion Battery Cell Test System
- ☐ Laser Cutting Machine
- ☐ 24Vout PFM and 24V ZVS Bucks

PowerBench™ **Clear All** **Add >**

Features & Benefits **Diagram** **Documentation** **Packaging Options** **Related Products**

Information Provided in the Safety Certificate

- › Insulation and Isolation
- › Fuses used in original Safety Qualification Testing
- › Precautions to be adopted for integrated Vicor product

Safety Approvals

Full-Chip

- [PDF](#) cURus – UL 60950-1, CSA 60950-1 »
- [PDF](#) cTÜVus – EN 60950-1, UL 60950-1, CSA 60950-1 »
- [PDF](#) CB Certificate – IEC 60950-1 »
- [PDF](#) CE Mark – Low Voltage Directive (2014/35/EU) and RoHS Recast Directive (2011/65/EU) »

Half-Chip

- [PDF](#) cURus – UL 60950-1, CSA 60950-1 »
- [PDF](#) cTÜVus – EN 60950-1, UL 60950-1, CSA 60950-1 »
- [PDF](#) CB Certificate – IEC 60950-1 »
- [PDF](#) CE Mark – Low Voltage Directive (2014/35/EU) and RoHS Recast Directive (2011/65/EU) »

Additional Resources

› **Here are some useful Vicor links**

- [5 Things You Should Know About DC Power](#)
- [Glossary of Electrical Terminology](#)
- [Best Practices Using DC-DC Bricks](#)

› **Check out YouTube for Safety in Design of Electrical and Electronic products. Initial suggestions – search for titles containing....**

- On The Safe SIDE - BBC2 Trade Test Film
- CSA Group Product Certification
- TÜV SUD Design for Safety Compliance
- What is UL Certification?

Website Links

- › **For quick reference see links to websites associated with IEC, UL, CSA and TUV standards bodies**
 - <https://iecetech.org/>
 - <https://www.ul.com/>
 - <https://www.csagroup.org/service/certification/>
 - <https://www.tuv-sud-america.com/us-en>

Q & A Session

- › I would like to acknowledge the support and assistance of my colleagues at Vicor in preparing this outline presentation