



**The ability to sell power supplies, either built-in or external types, around the world depends on meeting the relevant safety standards that apply in those territories. These standards are defined and administered by national or international agencies with various government-recognized testing laboratories able to certify compliance with such statutory regulations.**

The primary goal of safety standards for power supplies used in electrical equipment is to protect against fire, electric shock and injury. Products meeting these requirements may be identified by a safety mark from the associated standards organization or by a mark indicating compliance with local legislation, within a defined economic area or trading zone.

Understanding the complexities and subtle differences between various standards and marking schemes can be daunting. This application note aims to identify the major standards that relate to power supply safety, the agencies that administer them and/or provide certification, and the marking schemes that can be used to show compliance.

## Major Safety Standards

The International Electrotechnical Commission (IEC) and the associated International Organization for Standardization (ISO) are the principle agencies responsible for electrical safety standards. Agencies such as Underwriters Laboratories (UL) and Canadian Standards Association (CSA) provide certification in North America, while similar bodies in Europe are Verband der Elektrotechnik (VDE), Technischer Überwachungs-Verein (TUV) and British Standards Institution (BSI). A product meeting an IEC standard such as IEC60950 may be identified with the standard's number prefixed instead by UL, CSA or EN (European Norm) to indicate

the country where it is certified e.g. UL60950 or EN60950. Standards like these with the same numbers but different prefixes are sometimes referred to as "harmonized standards". But while the IEC continues to pursue harmonization, regional differences remain and consequently products intended for multiple markets will need to show all of the required certifications.

## IEC60950-1:

### Safety of Information Technology Equipment

IEC60950-1 consolidates the 2005 2<sup>nd</sup> edition of this standard with its first and second amendments [from 2009 and 2013 respectively]. The standard is applicable to mains, or battery-powered information technology (IT) equipment and office machines with a rated voltage not exceeding 600 V. It is intended to prevent injury and damage to persons and property from such hazards as electric shock, fire, dangerous temperatures and mechanical instability. Note that in Germany this standard is also referenced as DIN EN60950-1 and as VDE0805.

#### Classes of Equipment

The standard identifies different classes of equipment depending on how their power supplies, especially mains units, isolate secondary circuits and accessible parts from dangerous ac mains voltages:

**Class I** equipment achieves electric shock protection through basic insulation and protective earth grounding. This requires all conductive parts that could assume a hazardous voltage in the event of basic insulation failure to be connected to a protective earth conductor.

**Class II** equipment provides protection using double or reinforced insulation and hence no ground is required.

**Class III** equipment operates from a SELV (Safety Extra Low Voltage) supply circuit, which means it inherently protects against electric shock, as it is impossible for hazardous voltages to be generated within the equipment.

Understanding the standard and the above classes of equipment requires a clear understanding of the circuit definitions, types of insulation and other terminology used in relation to power supplies.

## Circuit Definitions

### Hazardous Voltage

*Any voltage exceeding 42.2 Vac peak or 60 Vdc without a limited current circuit.*

### Extra-Low Voltage (ELV)

*A voltage in a secondary circuit not exceeding 42.4 Vac peak or 60 Vdc, the circuit being separated from hazardous voltage by at least basic insulation.*

### Safety Extra-Low Voltage (SELV) Circuit

*A secondary circuit that cannot reach a hazardous voltage between any two accessible parts or an accessible part and protective earth under normal operation or while experiencing a single fault. In the event of a single fault condition (insulation or component failure) the voltage in accessible parts of SELV circuits shall not exceed 42.4 Vac peak or 60 Vdc for longer than 200 ms. An absolute limit of 71 Vac peak or 120 Vdc must not be exceeded.*

*SELV circuits must be separated from hazardous voltages, e.g. primary circuits, by two levels of protection, which may be double insulation, or basic insulation combined with an earthed conductive barrier.*

*SELV secondaries are considered safe for operator access. Circuits fed by SELV power supply outputs do not require extensive safety testing or creepage and clearance evaluations.*

### Limited Current Circuits

*These circuits may be accessible even though voltages are in excess of SELV requirements. A limited current circuit is designed to ensure that under a fault condition, the current that can be drawn is not hazardous. Limits are detailed as follows:*

- *For frequencies < 1 kHz the steady state current drawn shall not exceed 0.7 mA peak ac or 2 mA dc. For frequencies above 1 kHz the limit of 0.7 mA is multiplied by the frequency in kHz but shall not exceed 70 mA.*
- *For accessible parts not exceeding 450 Vac peak or 450 Vdc, the maximum circuit capacitance allowed is 0.1 µF.*
- *For accessible parts not exceeding 1500 Vac peak or 1500 Vdc the maximum stored charge allowed is 45 µC and the available energy shall not be above 350 mJ.*

*To qualify for limited current status the circuit must also have the same segregation rules as SELV circuits.*

## Insulation and Isolation

There are five types of insulation to shield live components with hazardous voltages from other components and circuits as follows:

**1 Operational / Functional Insulation**  
*Is only necessary for the correct functioning of the equipment and does not provide any protection against electric shock.*

**2 Basic Insulation**  
*Insulation applied to live parts to provide basic protection against electric shock.*

**3 Supplementary Insulation**  
*Independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation.*

**4 Double Insulation**  
*Comprising both basic insulation and supplementary insulation.*

**5 Reinforced Insulation**  
*Single insulation system applied to live parts which provides a degree of protection against electric shock equivalent to double insulation.*

For power supplies, the minimum insulation requirements are:

**Primary to secondary:** Reinforced insulation with a minimum dielectric strength of 3000 Vrms.

**Primary to ground:** Basic insulation with a minimum dielectric strength of 1500 Vrms.

## Other Key Terminology

### Protective Earth

*Class I equipment must have a protective earth conductor, if insulated it must be green/ yellow or transparent covering. No switch or fuse is allowed. Resistance between earthed parts and the earth termination must not exceed  $0.1\Omega$ , which is tested by a current 1.5 times the current capacity of any hazardous voltage circuit at the point where failure of basic insulation would make the earthed part live. Test voltage maximum is 12 V. Test current may be ac or dc but must not exceed 25 A.*

### Clearances [through air]

*Power products are intended for general application and should be designed for worst case conditions [pollution degree 3 and mains voltages up to 264 Vac] for minimum clearances of:*

- 4.00 mm for reinforced or double insulation
- 2.00 mm for basic and supplementary insulation

*Where formal quality control processes are in place relaxation to 3.4 mm and 1.7 mm is allowed, but reinforced insulation is then subjected to 100% electric strength testing. If an air gap serves as the insulator between a hazardous voltage and the enclosure, the required clearance is 10 mm.*

[Continued from page 4]

## Creepage Distances

*Tables of creepage distances for basic insulation are given for various pollution conditions and materials, the distances depending on working voltages. These distances are doubled for reinforced insulation.*

## Flammability

*The standard requires that the equipment design:*

- *Avoids high temperatures, or shields and separates flammable materials from high temperature parts.*
- *Uses materials of low flammability both internally and for enclosures.*
- *Uses fire enclosures to limit the spread of fire.*

*Compliance can be achieved by using V-2 or better rated insulating and printed board materials throughout and ensuring adequate spacing between high temperature components and plastic and painted parts. Use of UL listed materials eliminates the necessity for exhaustive and messy flammability testing.*

## Earth Leakage Current

*For Class II equipment this shall not exceed 0.25 mA, for hand held Class I equipment 0.75 mA, and other Class I equipment 3.5 mA.*

*The test for Class II equipment requires conductive metal foil to be attached to an area not exceeding 10 x 20 cm on accessible non-conductive parts and the test is made between this and conductive parts. Tests are carried out at the most unfavorable [highest possible] supply voltage.*

## IEC60601-1: Safety of Medical Electrical Equipment

Edition 3.1 of this standard comprises the 2005 3<sup>rd</sup> edition with its 2012 amendment 1 which supersedes the 2<sup>nd</sup> edition that expired in Europe in June 2012, Canada in April 2013, and the USA in December 2013. It covers the basic safety and essential performance applicable to medical electrical equipment including surgical, monitoring and hospital equipment. IEC60601-1 follows the same requirements established in IEC60950-1 but with increased levels of protection for insulation/isolation, creepage, clearance and leakage current.

Equipment required to meet IEC60601-1 is any equipment that will be operated within an area in which patients are normally cared for. The Patient Vicinity is the space with surfaces likely to be contacted by the patient or an attendant who can touch the patient. This encloses a space within the room 1.83 m [6 feet] beyond the perimeter of the bed [or examination table, dental chair, etc.] in its intended location, and extending vertically 2.29 m [7.5 feet] above the floor.

All IEC60601-1 power systems must have dual fused input protection with reduced leakage currents of  $\leq 300 \mu\text{A}$  to ground [earth] and  $\leq 100 \mu\text{A}$  to the chassis to meet the legislated specifications.

### Differences Between 2<sup>nd</sup> and 3<sup>rd</sup> Editions

The changes in power supply classification from 2<sup>nd</sup> edition to 3<sup>rd</sup> edition deal with definition, not performance. Both the 2<sup>nd</sup> and 3<sup>rd</sup> revisions require two mechanisms for guarding each in the event of a failure. For the area of basic electrical safety and avoiding shock hazard, the 3<sup>rd</sup> edition further divides means of protection into operator protection and patient protection. This is because the potential hazards seen by each can be quite different; an operator has access to a control panel, for example, while the patient may be “connected” via probes.

Patient leakage currents for various equipment categories were defined in the second edition as follows:

Classification Requirements		
Type B	Type BF	Type CF
Isolation: 1500 Vac	Isolation: 3000 Vac	Isolation: 4000 Vac
Creepage: 2.5 mm	Creepage: 5 mm	Creepage: 8 mm
Basic Insulation	Double Insulation	Double Insulation

2<sup>nd</sup> Edition Requirements by Classification

Instead of these classifications, the third edition requires medical device manufacturers to define the classification in terms of “Means of Operator Protection” [MOOP] and “Means of Patient Protection” [MOPP] as determined by an ISO-14971 Risk Analysis / Management process. The table below summarizes these classifications and the type of power supply solution that would be appropriate, depending on whether one or two levels of protection are required.

### IEC61010-1:

#### Safety of Measurement, Control and Laboratory Equipment

IEC61010-1 is another safety standard along similar lines to the above IEC60950 and IEC60601 standards but reflecting requirements in this instance for measurement, control and laboratory equipment, including instruments such as meter and oscilloscopes but also extending to x-ray equipment. Protecting against electrical shock, fire and mechanical or burn injury, IEC61010 also addresses hazards related to fluids, lasers and

Classification	Insulation	Isolation	Creepage	Solution
One MOOP	Basic	1500 Vac	2.5 mm	IEC60950-1 Rated Power Supply
Two MOOP	Double	3000 Vac	5.0 mm	IEC60601-1 Rated Power Supply
One MOPP	Basic	1500 Vac	4.0 mm	IEC60601-1 Rated Power Supply
Two MOPP	Double	4000 Vac	8.0 mm	IEC60601-1 Rated Power Supply plus an IEC60601-1 Rated Dc-Dc Converter

3<sup>rd</sup> Edition Requirements by Classification

UV light as well as those that may arise from the measuring circuit. Not all these hazards are directly relevant to the equipment's power supply but fortunately the latest 3<sup>rd</sup> edition of the standard separates the general equipment requirements from the more specific measurement circuits, which are now covered by IEC61010-2. The 3<sup>rd</sup> edition also defines more stringent requirements in respect to shock and fire hazards:



Shock

*Creepage, clearances, and dielectric values depend on insulation type as well as whether mains or secondary derived from mains.*



Fire

*Voltage for determining limited energy values changed to be more logical. [limited energy means a fire is unlikely]*

### IEC60065:

#### Safety of Audio, Video and Similar Electronic Apparatus

IEC60065 is intended to protect against fire, electric shock and injury, this time in respect to audio, video and similar equipment, including such examples as video projectors and electronic flash units for photographic purposes. As with the standards already discussed, not all of the protective measures are applicable to power supplies but those that relate to shock and fire require similar precautions with respect to insulation, isolation, limiting voltage and/or current, and measures to increase resistance to fire. IEC60065 references other standards such as: IEC60950-1 for SELV voltage limits, TNV [Telecommunication Network Voltages] for equipment that is not connected to the mains and IEC60695-11-10 for component flammability categories.

### IEC508:

#### Safety Standard for Industrial Control Equipment

IEC508, most commonly referred to as UL 508, is the safety standard for industrial control and factory automation equipment, which includes devices such as motor starters and controllers, overload relays, circuit control switches and relays, other switches for sensing (pressure, flow, proximity), transformers and rheostats and programmable controllers. UL 508 covers requirements for devices rated at 1500 V or less, and intended for use in ordinary locations at an ambient temperature of 0~40°C. UL 698 covers equipment intended for use in hazardous locations. UL 508 provides protection against short circuits, ground faults and overload as well as thermal protection and defines requirements for such things as endurance testing and accelerated aging, dielectric voltage-withstanding and leakage current limits. UL 508 focuses heavily on ratings and test limits that are not necessarily relevant to power supplies, e.g. short-circuit current ratings [SCCR] for switches and relays.

### UL 1310:

#### Safety Requirements for Class 2 Power Units

UL 1310 specifies requirements covering indoor and outdoor use Class 2 power supplies and battery chargers in applications such as lighting systems, machinery and other appliances installed in residential and industrial environments. These units utilize an isolating transformer and other components to provide either ac or dc outputs, subject to a maximum rating of 42.4 Vac peak or 60 Vdc. The standard is aimed at products

that primarily power low voltage, electrically operated devices including:

- Portable or semi-permanent direct plug-in units with 15 A blade connections for use on nominal 120 or 240 Vac mains circuits.
- Cord-and plug-connected units with a 15 or 20 A plug for 120/240 Vac mains supply.
- Units permanently connected to an input supply nominally of 600 Vac or less.

Direct plug-in and cord-connected units also include dc powered supplies operating from a vehicle battery via a cigarette lighter or equivalent dc connector or from a data port associated with information technology equipment. These units are also limited to a maximum input power of 600 W.

The safety requirements of UL 1310 are defined in terms of:

- Enclosure strength and rigidity to resist likely abuses.
- Built-in overcurrent and over-temperature protection devices.
- A maximum potential of 42.4 Vac peak / 60 Vdc for exposed wires / terminals.
- Protection from “backfeed” voltage.

Other aspects covered by the standard include: packaging, corrosion, switches, weight, dc cabling, mounting, connections, strain relief, operating temperature, humidity and environment (indoor and outdoor).

## Other Similar Equipment Safety Standards

### UL 8750: Safety for Solid-State Lighting (SSL)

UL 8750 was introduced in 2006 as legacy lighting standards did not address solid-state lighting i.e. LEDs and equipment that is an integral part of a luminaire or other lighting equipment, which operates in the visible light spectrum between 400~700 nm. The standard’s certification programs cover: LED packages, arrays and drivers; light engines and holders; integral and self-ballasted lamps; and retrofit products. Of particular note, UL 8750 calls for LED power supplies and drivers to be compliant with UL 60950-1.

### UL 879: Safety of Electric Sign Components

UL 879 covers components for use in signs and outline lighting systems intended to convey a message or outline the structural features of a building. Light sources addressed by the standard include: fluorescent, high intensity discharge (HID), neon, cold cathode lighting, light emitting diodes (LEDs) and electroluminescent lighting. Components covered include the materials used in the structure of the signs, the sign face, its frame, switch and electrical enclosures and seals/shields/barriers, etc. Electrical components relating to the illumination circuits such as lamp-holders are also included, as are electrical components such as LED power sources and electromechanical devices like sign rotation equipment. The standard does however exclude a long list of other components that would normally be covered by other safety standards.

### UL 60079: Explosive Atmospheres

UL 60079 and its IEC and other equivalent standards cover general requirements for the construction, testing and marking of electrical equipment intended for use in explosive atmospheres. Such environments include explosive gas and combustible



dust atmospheres (either separately or together) and the standard covers the temperatures and pressures under which equipment should be designed to operate safely, taking account of the various potential ignition sources and appropriate protective measures.

### Major Safety Agencies and Product Conformance Marks Worldwide

The previous section identified many of the national and international bodies that either define regulatory requirements for product safety or provide testing and certification to assure users that the device or equipment complies with the relevant standard[s]. Consequently, conformance marking of products to show this compliance is a necessary prerequisite for their sale in most industrialized countries and may be a legal or contractual obligation.

Product marking may simply show compliance with specific standards but increasingly more general marks are used to indicate compliance with all essential or legally imposed safety requirements. CE and UL marks are two of the most widely implemented conformance marks, while there are a number of other safety marks that may be applied in different regions. These are described more fully below. To ease the issue of regional differences, the Certification Body [CB] scheme allows manufacturers who have been issued a CB test certificate by one National Certification Body [NCB] to obtain certification marks from other participating NCBs.



#### The “Conformité Européenne” or CE Mark

The CE Mark was introduced nearly 30 years ago for certain products sold within the European Economic Area to show conformity with legal requirements in respect of relevant safety, health and environmental directives. The use of the CE logo is a manufacturer’s declaration that the product meets these requirements but the logo may also include a four-digit code identifying the authorized third party [Notified Body] involved in assessing conformance. Simple CE marking is allowed under a self-certification process if the risk level of a product is considered minimal. Where a product is CE marked, it can only carry additional markings if these relate to requirements that do not overlap, conflict or distract from the CE marking. The European Commission’s website provides much more extensive information about CE Marking, see [http://ec.europa.eu/enterprise/policies/single-market-goods/cemarking/index\\_en.htm](http://ec.europa.eu/enterprise/policies/single-market-goods/cemarking/index_en.htm)



#### The Underwriters Laboratories or UL Mark

The UL Mark indicates that either Underwriters Laboratories or an equivalent nationally recognized testing laboratory [NRTL] has tested and determined that a product meets UL specified product safety requirements. This certification allows a manufacturer to show that their product is “UL Listed” by using the familiar UL logo. For power supplies this mark would be applied to external units and DIN rail-mount supplies as well as most consumer electronics including computers. Where a supply is considered to be a component part it, along with other electrical

components, may be marked with the reversed UR symbol indicating a “UL Recognized” certification. In addition to certifying products to their own safety specifications, UL also offers an assessment process to provide certification to many of the regional safety mark schemes around the world, including those summarized below.

Note also that Underwriters Laboratories of Canada [ULC] is an independent product safety testing, certification and inspection organization, which is accredited by the Standards Council of Canada. It uses the above UL logos accompanied by the letter “C”.



### TÜV Rheinland

The TÜV Rheinland Group, headquartered in Cologne, Germany, is a leading provider of technical services worldwide. It is primarily concerned with safety and quality, and operates product testing services that cover Inspection and Certification, with test marks, across a wide range of markets, including electronic components, telecoms and IT equipment.

## Regional Safety Marks

### Americas, Europe & Asia

The maps in the following section highlight some of the more notable safety marking schemes but is not all-inclusive. In addition, in Europe there are other marks applicable in the Nordic countries and other central and eastern European countries such as Denmark, Switzerland, Hungary, Ukraine and Belarus. In Asia, countries including Hong Kong and India operate their own safety marks.

## Americas



Canada



Mexico



Brazil



Argentina



### CSA Mark – Canada

The Canadian Standards Association operates the CSA marking scheme alongside UL certification to identify products acceptable in either Canada [C suffix letter] and/or the USA [US suffix].



### NOM Mark – Mexico

The NOM Mark identifies compliance with Mexico's "Normas Oficiales Mexicanas" (NOM) safety standards for household electrical appliances, IT, AV and similar equipment. ANCE is an independent body authorized to grant NOM approval in electric and gas products.



### INMETRO Mark – Brazil

Certification of certain product groups, such as medical electrical equipment, ballasts and equipment used in hazardous locations, is mandatory in Brazil with accreditation indicated by the INMETRO Mark. The INMETRO Mark may also be used on a voluntary basis to indicate safety standards compliance for products that are not mandated e.g. IT, audio/visual equipment and home appliances.

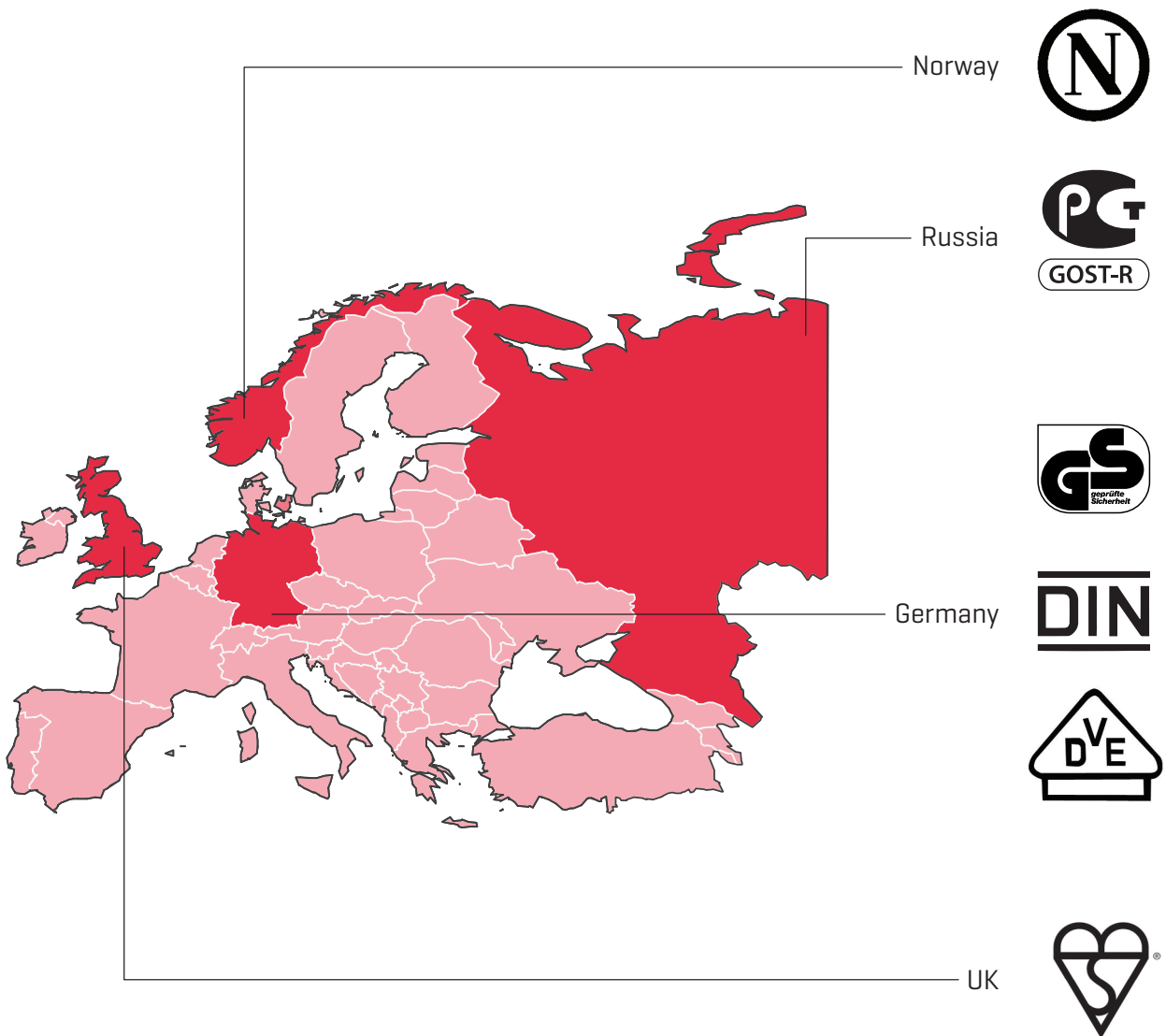


### S Mark – Argentina

Product certification to IEC-based standards is mandatory in Argentina under the auspices of its standards body IRAM with conformance indicated by the S Mark.



## Europe



### ENEC Mark - Europe

The ENEC Mark is simply the mark used to denote compliance with the European Norm [EN] standards for all electrical product sectors, as tested by approved independent testing laboratories worldwide.



### Nemko Mark - Norway

Nemko is an organization similar to TUV or UL that offers product safety testing and certification to worldwide standards. Its direct services cover IT/AV, household and telecoms products but extends to other sectors such as medical equipment, and the oil and gas industry. The mark itself signifies that Nemko has tested or certified the product according to national standards official safety regulations in Norway.



### GOST-R Certification and PCT Mark - Russia

VNIIS is the agency that provides certification services for the GOST-R system that operates in the Russian Federation and Customs Union. GOST-R is mandatory for an extensive range of regulated products while the PCT Mark, used to indicate compliance with Russian standards, is recommended for regulated products where GOST-R is not mandated.



### GS Mark and DIN Mark - Germany/EU

Germany's TUV standards agency operates the GS Mark [Geprüfte Sicherheit = tested safety] to show conformity with German's Equipment and Product Safety Act [GPSG = Geräte- und Produktsicherheitsgesetz]. The GS Mark assures commercial buyers and consumers the product has been tested by an authorized institution such as TUV Rheinland. The DIN Mark is another scheme operated by TUV Rheinland certifying component compliance with DIN, EN, IEC and ISO product safety standards.



### VDE Mark – Germany

The VDE Testing and Certification Institute is another German-based independent testing organization for electric and electronic products. The VDE Mark indicates conformity with the VDE standards, European or internationally harmonized standards and confirms compliance with protective requirements of the applicable EC Directive[s].

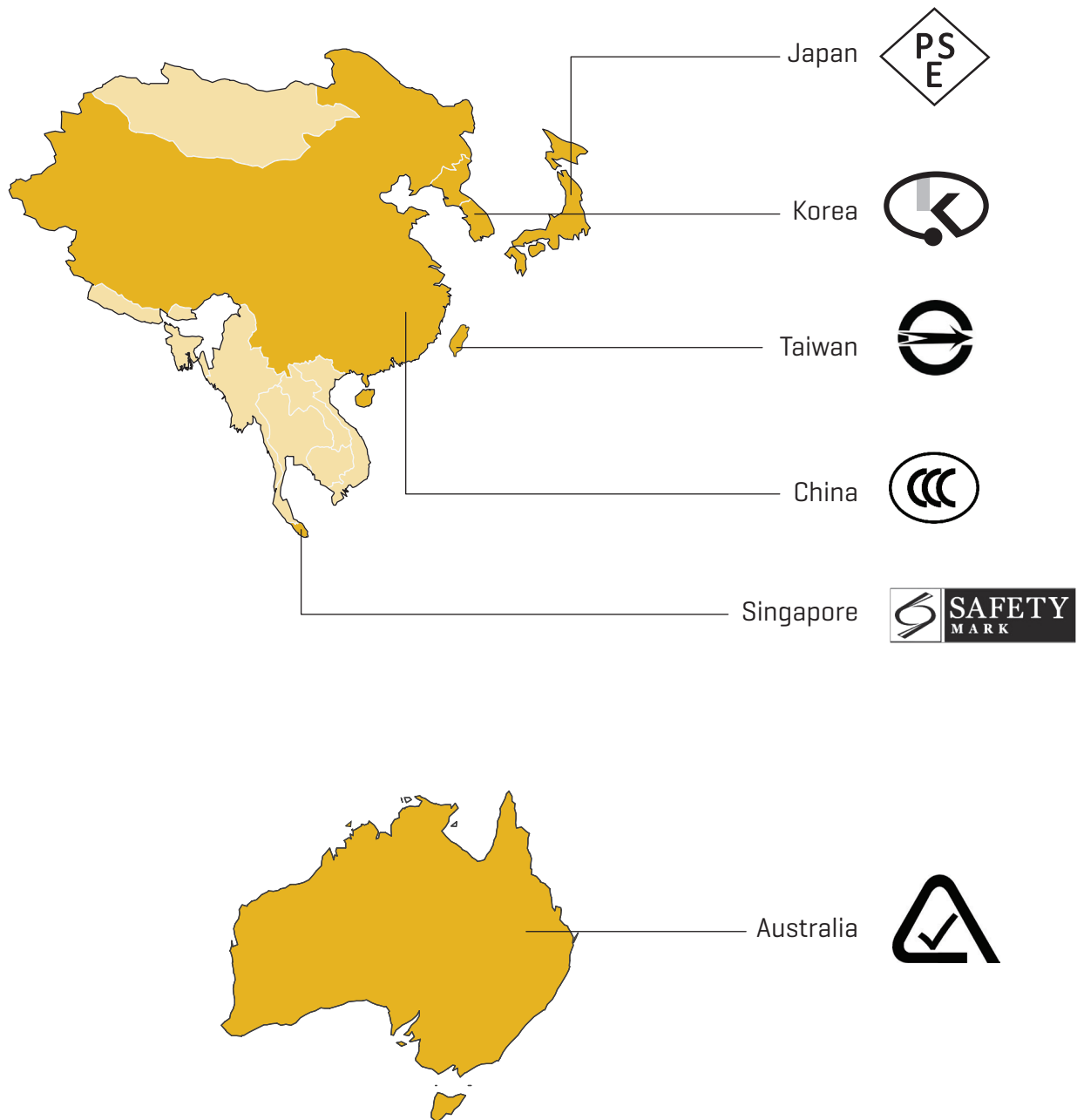


### BSI Kitemark – UK

The British Standards Institution (BSI) was the world's first national standards body and continues to be a leading global standards maker. BSI is also the UK's National Standards Body, representing UK interests worldwide. The BSI Kitemark is a voluntary certification mark, globally recognized as a symbol of trust, that shows a product or service meets applicable and appropriate British, European, International and other standards for quality, safety, performance and trust.



## AsiaPac





### DENAN PSE Mark – Japan

The PSE Mark is used to show compliance with Japan's Electrical Appliance and Material Safety Law (DENAN) as applied to various classes of product and equipment.



### EK Mark – Korea

Korea's EK Mark is administered by its Agency for Technology and Standards (MOCIE) to show compliance for mandated products with the Electrical Appliances and Materials Safety Control Law.



### BSMI Mark – Taiwan

The BSMI (Bureau of Standards, Metrology and Inspection) Certification is the approval scheme for ITE and audio/ video products in Taiwan.



### CCC Mark – China

The CCC (China Compulsory Certificate) Mark indicates compliance with Chinese laws and regulations and, as its names implies, is compulsory for any product used for commercial purposes in China.



### PSB 'SAFETY' Mark – Singapore

Singapore's safety authority, the Productivity and Standards Board (PSB), requires all controlled goods to be individually marked with the SAFETY Mark.



### RCM Tick Mark– Australia

Australia has a national standards body, Standards Australia, covering many different industry sectors including Electrotechnology and Energy, which embraces electrical/electronic equipment and appliances with relevant standards for safety. Australia's Regulatory Compliance Mark (RCM) now consolidates the previously separate C-Tick, A-Tick and RCM marks [effective from March 2013, although existing suppliers are allowed a 3-year transition period].



## Summary

Despite efforts within Europe, North America and elsewhere to bring about harmonization of safety standards for electrical equipment including power supplies, there are still very many different regulations, testing and certification procedures that may need to be taken account of in order to meet legislative requirements in the various territories where such equipment will be sold. Understanding all of these is a challenge and this application note, while it tries to present a fairly comprehensive overview of the various standards, agencies and safety marks, is certainly not a definitive guide.

CUI follows best practices to ensure its power supplies meet the highest levels of safety and performance, offering products approved to standards such as UL, ENEC, TUV and GS while also providing quality solutions that utilize the latest in efficient green power technology.

*For further information on CUI's power supplies visit [www.cui.com](http://www.cui.com).*

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