

Safety Standards UL1950 & EN60950



1- General

For the majority of DC/DC converter applications in the telecommunications and datacommunications equipment, the applicable safety standards are UL1950 (and its Canadian equivalent C22.2 No. 950-95) for North America and EN60950 for Europe.

Both are titled «Standards for Safety of Information Technology Equipment (ITE), Including Electrical Business Equipment,».

2- UL1950/EN60950 Safety Principle

These safety standards address construction issues and are intended to prevent injury to equipment operators and service personnel as well as other forms of damage caused by :

- Electric shock,
- Energy hazards,
- Fire,
- Mechanical and heat hazards,
- Radiation Hazards,
- Chemical Hazards.

Electric shock is due to current passing through the human body. Currents of the order of a milliampere can cause a reaction in persons in good health and may cause indirect danger due to involuntary reaction. Higher currents can have more damaging effects.

Voltages up to about 40Vac peak, or 60Vdc, are not generally regarded as dangerous under

dry conditions, but parts which have to be touched or handled should be at earth potential or properly insulated. It is normal to provide two levels of protection for operators to prevent electric shock.

Energy Hazards can be caused by arcing or ejection of molten metal when adjacent poles of high current supplies or high capacitance circuits are short-circuited. Protection is made by separation, by shielding or by using safety interlocks.

Fire risks may result from overloads, component failure, insulation breakdown or loose connections. Fires should not spread beyond the immediate vicinity of the source of the fire or cause damage to the surroundings of the equipment.

Mechanical and heat hazards should be prevented by providing adequate stability, by avoiding sharp edges and points or by restricting access to dangerous parts.

Radiation Hazards encountered can be sonic, radio frequency, infra-red, high intensity visible and coherent light, ionising, etc. Requirements are necessary to keep person exposures to acceptable levels.

Chemical Hazards through contact with chemicals, their vapours and fumes are required to be limited under normal and abnormal conditions.

3- Basic Definition according to UL1950, EN60950

3-1 Generic Terminology

The following terms are used frequently. The definitions given here are based on full definitions in EN 60950 but partially abbreviated to help the explanation.

Primary Circuit : An internal circuit which is directly connected to the external supply mains or other equivalent source (such as a motor-generator set) which supplies the electric power.

Secondary Circuit : A circuit which has no direct connection to primary power and derives its power from a transformer, converter or equivalent isolation device, or from a battery.

Hazardous (or Excessive) Voltage : A voltage exceeding 42.4Vac peak or 60Vdc, existing in a circuit which does not meet the requirements for a limited current circuit.

Limited Current Circuit : A circuit which is so designed and protected that, under both normal conditions and a likely fault condition, the current which can be drawn is not hazardous. Limits are detailed in the UL1950 & EN60950 standards.

Operational Insulation: The operational level of insulation acknowledges that isolation between primary and secondary circuits is required for proper operation of the device. However, there is no protection against electric shock at the output if there is a breakdown/fault in the primary-to-secondary insulation.

Basic Insulation : basic insulation provides for one layer of "basic protection" against electrical shock. Basic insulation can be used in conjunction with other supporting circuitry to ensure a SELV output, following a fault, under all possible input conditions.

Supplementary Insulation : Independent insulation applied in addition to basic insulation to ensure protection against electric shock in the event of a failure of the basic insulation.

Double Insulation : Insulation comprising both basic insulation and supplementary insulation.

Reinforced Insulation : reinforced insulation provides for 2 separate levels of protection. It ensures, without supporting circuitry, a SELV output, following a fault, under all possible input conditions.

Extra Low Voltage (ELV) Circuit : A secondary circuit with voltages between any two conductors of the ELV circuit, and between any one such conductor and earth, not exceeding 42.4 V AC peak or 60 V DC, under normal operating conditions, which is separated from hazardous voltage by at least basic insulation, and which neither meets all of the requirements for an SELV circuit nor for a limited current circuit.

Safety Extra-low Voltage (SELV) Circuit : A secondary circuit which is so designed and protected that, under normal and single fault conditions, the voltage between any two conductors and, for class I equipment, between any one such conductor and the equipment protective earthing terminal, does not exceed a safe value (42.4 Vac peak or 60 Vdc). Under single fault conditions the voltage is allowed to reach 71 Vac peak or 120 Vdc for a maximum time of 0.2 s. Note: Safety levels are specified in terms of DC and AC voltages because the different types of voltages have dangerous effects at different levels.

Overvoltage Category : Assigns maximum expected transient voltages to nominal mains supply voltages. Examples of preferred values of such

transient voltages according to IEC 60664-1 are: 500V, 800V, 1500V, 2500V, 4000V. The maximum expected transient voltage of an overvoltage category II circuit with a nominal voltage of >150 to 300V is 2500V. A secondary circuit derived from an overvoltage category II primary circuit is considered to be subject to overvoltage category I, i.e. in case of a primary voltage of >150 to 300 V the secondary transient voltage is 1500V.

Working Voltage : The highest voltage to which the insulation under consideration is, or can be, subjected when the equipment is operating at its rated voltage under conditions of normal use.

Creepage Distance : The shortest path between two conductive parts, or between a conductive part and the bounding surface of the equipment, measured along the surface of the insulation.

Clearance : The shortest distance between two conductive parts, or between a conductive part and the bounding surface of the equipment, measured through air.

3-2 Power System Safety Requirements Terminology

Telecommunications Network Voltage (TNV) Circuit :

A secondary circuit in the equipment to which the accessible area of contact is limited and that is so designed and protected that, under normal and single fault conditions, the voltages do not exceed specified limiting values. Voltage limits after a single fault are given in Fig. 15 of IEC/EN60950 (1500 V during 1 ms, 400 V during 0.2 s, 71 V AC peak or 120 V DC continuously). TNV circuits are classified as TNV-1, TNV-2 and TNV-3 circuits:

TNV-1 Circuit : A TNV circuit whose normal operating voltages do not exceed the limits for an SELV circuit value (42.4 Vac peak or 60 Vdc) under normal operating conditions and on which overvoltages from telecommunication networks (up to 1500 V peak) are possible.

TNV-2 Circuit : A TNV circuit whose normal operating voltages exceed the limits for an SELV circuit, but do not exceed 71 Vac peak or 120 Vdc under normal operating conditions and which is not subject to overvoltages from telecommunication networks.

TNV-3 Circuit : A TNV circuit whose normal operating voltages exceed the limits for an SELV circuit, but do not exceed 71 Vac peak or 120 Vdc under normal operating conditions and on which overvoltages from telecommunication networks (up to 1500 V peak) are possible.

Class I Equipment : Equipment where protection against electric shock is achieved by using basic insulation and by providing a means of connecting to the protective earthing conductor in the building wiring those conductive parts that are otherwise capable of assuming hazardous voltages if the basic insulation fails. Note: Class I equipment may have parts with double insulation or reinforced insulation, or parts operating in SELV circuits.

Class II Equipment : Equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions, such as double insulation or reinforced insulation, are provided, there being no reliance on either protective earthing or installation conditions.

Class III Equipment : Equipment in which protection against electric shock relies upon supply from SELV circuits and in which hazardous voltages are not generated.

TN-S Power System : A power distribution system having separate neutral and protective earth conductors through-out the system.

TN-C Power System : A power distribution system in which neutral and protective functions are combined in a single conductor throughout the system.

TT Power System : A power distribution system having one point directly earthed, the exposed conductive parts of the installation being connected to earth independent of the power system.

IT Power System : A power distribution system having no direct connection to earth, the exposed conductive parts of the electrical installation being earthed.

4- Safety Consideration when using DC/DC's on a Power System

For safety agency approval of a power system in which DC/DC modules are used, the DC/DC module must be installed in compliance with requirements of the UL1950, EN60950 standards : i.e if the output circuit is operator accessible, it shall be a SELV circuit.

SELV circuits must be separated from hazardous voltages (e.g primary circuits) by two levels of protection which may be :

- double or reinforced insulation,
- or basic insulation combined with a secondary protective barrier.

Generally DC/DC Converters are power by an input bus that comes from a front-end which can be an AC/DC powered supply, a transformer, a charger or a battery.

It is the sole responsibility of the user to ensure compliance of the front-end with the relevant safety requirements.

The following table resumes some possible installation configuration using GAIA Converter DC/DC modules.

Bus voltage range at the input of DC/DC converter	Mandatory safety status of the input DC/DC bus	DC/DC converter minimum requirements	Circuitry to achieve safety compliance	Resulting safety at the DC/DC converter output
Voltage : < 60 VDC	Basic isolation with ELV circuit	Operational insulation	Input fuse, output suppressor diode and earthed output circuit	Earthed SELV circuit
	Basic isolation with earthed SELV circuit	Operational insulation	/	SELV circuit
Hazardous voltage:>60 VDC	Basic isolation with hazardous voltage	Operational insulation	Input fuse, output suppressor diode and earthed output circuit	Earthed SELV circuit
	Double or reinforced insulation with hazardous voltage	Operational insulation	Input fuse, output suppressor diode	SELV circuit

Where :

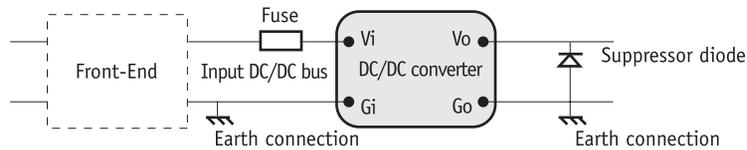
- «Mandatory safety status of the input DC/DC bus» describes the necessary input bus status entering in the DC/DC module to be compliant with safety requirements. This input bus can come from an AC/DC power supply, a transformer/rectifier, a battery charger, a simple battery, This front-end can provide :

- a basic isolation or double or reinforced isolation,
- an output voltage below 60 VDC or above 60 VDC,
- an output that can be ELV or SELV circuitry,
- an output that can be earthed or not.

It is the sole responsibility of the user to ensure compliance of the front-end with the relevant safety requirements.

- «DC/DC converter minimum requirements» describes the isolation requirements at minimum level. If the isolation of the DC/DC module is more than operational i.e supplementary or reinforced, the circuitry to achieve safety requirements is not necessary.

- «Circuitry to achieve safety compliance» : please find the schematic safety concept.



The earth connection has to be provided by the user according to the relevant safety standard, e.g. IEC/EN 60950.

The user shall provide an approved fuse (type with the lowest rating suitable for the application) in a non-earthed input line directly at the input of the DC-DC converter. For UL's purpose, the fuse needs to be UL-listed.

Each suppressor diode should be dimensioned in such a way, that in the case of an isolation fault the diode is able to limit the output voltage to SELV (<60 V) until the input fuse blows.

5- UL1950 & EN60950 Requirements for DC/DC Converter

The UL1950 & EN60950 safety standards address construction issues and are intended to prevent injury to equipment operators and service personnel as well as other forms of damage caused by electric shock, fire, energy hazards, mechanical and heat hazards, or chemical hazards.

For component-level, modular DC/DC converters, the main qualification issues concern protection against electric shock and thermal/heat hazards.

The three main areas of investigation are :

- electrical insulation,
- electric strength (i.e., isolation voltage),
- thermal insulation.

Electrical Insulation : For DC/DC converters, insulation requirements consist primarily of minimum spacings (creepage and clearance) between primary and secondary circuits including pcb traces, transformer windings, I/O capacitors, opto-couplers, etc.

The minimum-spacing requirements are eliminated or relaxed significantly if an approved "solid insulator" (encapsulate or potting compound) is used. The three distinct grades of electrical insulation are :

- Operational: The operational level of insulation acknowledges that isolation between primary and secondary circuits is required for proper operation of the device. However, there is no protection against electric shock at the output if there is a breakdown/fault in the primary-to-secondary insulation. The output is SELV only when the input is SELV.

- Basic : Basic insulation provides for one layer of "basic protection" against shock. Basic insulation can be used in conjunction with other supporting circuitry to ensure a SELV

output, following a fault, under all possible input conditions.

- Reinforced : reinforced insulation provides for 2 separate levels of protection. It ensures, without supporting circuitry, a SELV output, following a fault, under all possible input conditions.

Electric Strength : Achieving different grades of electrical insulation requires different minimum isolation voltages depending on the peak internal working voltage (usually much higher than the maximum input or output voltages) of the device. The specific voltages are defined by the UL and EN specs. One example is that a device with a peak internal working voltage of 120V must guarantee 1500Vdc isolation to qualify for BASIC insulation.

Thermal Insulation : The temperature at which a manufacturer begins to derate a given DC/DC converter (i.e., its maximum full-power temperature) and the temperature at which UL1950/EN60950 begins to derate that same device may be very different.

Transformers are usually the critical area of concern. The assorted materials that make up a transformer (wire, bobbin, tape, cores, silicone, etc.), and the manner in which those materials chemically interact at high temperatures, constitute a "thermal insulating system," and UL/EN rates such systems. Developing a thermal insulating system and subsequently having a standards agency approve it requires lengthy aging and temperature-cycling processes to determine if any of the constituent materials interact in a manner that forms contaminants.

The majority of today's DC/DC converters utilize transformers constructed with class A (i.e., unapproved) thermal insulating

systems. Such transformers are considered safety hazards whenever their internal temperatures exceed +105°C.

Most of these DC/DC converters (based on thermal measurements/calculations relating to output power and derating curves) actually require transformers that can officially withstand operating temperatures up to +130°C.

This grade of transformer requires a recognized Class B (+130°C) or Class F (+155°C) thermal insulating system. Such transformers must be assembled using an approved system or purchased, fully assembled, as a "system" from a qualified supplier. GAIA Converter purchases assembled transformers and our transformer vendors are both approved class B and Class F thermal insulating systems.

Most UL1950 & EN60950 approved DC/DC converters on the market today, under their conditions of acceptance, have a statement that says the device has OPERATIONAL insulation only. This means there is no protection against electric shock in the event of a breakdown between primary and secondary. The output is considered SELV (Safety Extra Low Voltage, <60Vdc) only when the input is SELV. If the input exceeds 60Vdc, the output will be considered hazardous under a fault condition. Any product bearing these certification marks has been qualified to the applicable safety standard by a certifying agency accredited by the relevant country(ies).

The qualification report explains how the device was tested, what safety levels it meets, and more importantly, what are its conditions of acceptance.

6- UL1950 & EN60950 Definition Responsibility and Approval Agencies

The Geneva, Switzerland-based International Electrotechnical Commission (IEC) develops «generic» technical standards for electronic products and components. Designed for use by different industries and governments around the world, IEC standards have no national orientation and no effectivity or compliance dates. The Commission has no testing facilities or enforcement powers, and the adoption of IEC standards is purely voluntary. The USA's UL1950 and Europe's EN60950 are both derived from the IEC950 safety standard.

The 18 member countries of the European Economic Area (EEA) have created CENELEC, the European Committee for Electrotechnical Standardization (Comite Europeen de Normalisation Electrotechnique). The Brussels, Belgium-based CENELEC both creates its own standards and adopts standards authored by others (such as IEC), adapting them to the needs of the European Union (EU). CENELEC issues both «European normalizing» documents (with an «EN» prefix) and «harmonizing documents» (with an «HD» prefix). CENELEC also applies effectivity, but not compliance, dates to standards.

Once CENELEC issues a standard, all member countries must adopt it in place of any existing national standards, though each country is permitted deviations from the CENELEC spec.

For most DC/DC converters, the relevant CENELEC safety specification is EN60950.

Underwriters Laboratories, Inc. UL is a USA-based, non-governmental, not-for-profit organization that establishes product-safety standards. The relevant UL safety specification for DC/DC converters is UL1950.

Canadian Standards Association CSA is

the Canadian equivalent of UL. It is an independent agency that establishes standards. Their relevant specification for DC/DC's, C22.2 No. 950-95, is identical to UL1950.

V.D.E. Verband Deutscher Elektrotechniker (Association of German Electrical Engineers) is a private German organization that, like UL and CSA, establishes product-safety standards,

B.S.I. The British Standards Institution is a quasi-governmental agency that develops standards in the United Kingdom.

Hereafter are some agencies that conduct testing according to UL1950 or EN60950 and delivered qualification form.

Underwriters Laboratories, Inc. conducts product-safety testing. Conforming products are usually designated as UL «Listed» or UL «Recognized.» UL is also an EU-accredited testing agency. The relevant UL safety spec for DC/DC converters is UL1950, and conforming products can carry the UL logo.

Canadian Standards Association conducts also product-safety testing. Their relevant specification for DC/DC's, C22.2 No. 950-95, is identical to UL1950.

V.D.E. Verband Deutscher Elektrotechniker conducts product testing, and issues certificates of approval. VDE tests for DC/DC converters are established according to EN60950.

T.U.V. Technischer Überwachungs-Verein is a testing agency only. They have been authorized by VDE to test and approve products to VDE standards. Unlike VDE, TUV has offices in the USA, and they are often hired by

US-based companies to approve products, which can then carry both the VDE and TUV logos.

L.C.I.E is the French testing Agency that carries EN60950 testing approval.

B.S.I. The British Standards Institution is a quasi-governmental agency that tests products in the United Kingdom.

B.A.B.T. The British Approvals Board for Telecommunications is a private organization that approves telecom equipment sold into the UK market. B.A.B.T. both conducts its own testing and accredits independent testing laboratories.



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