

UL1741

**The Standard for Inverters,
Converters and Controllers for Use
In Independent Power Systems**


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Underwriters Laboratories Inc (UL)

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- **UL1741 is a product safety standard and it is not written specifically for reliability, but it includes construction requirements and tests that can lead to more reliable products**


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UL 1741

Underwriters Laboratories Inc.
Standard for Safety

Inverters, Converters,
Controllers and Interconnection
System Equipment for Use
With Distributed Energy
Resources



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UL 1741 Covers the Following Types of DG products:

- Photovoltaics, PV
- Fuel Cells
- Micro-turbines
- Wind and Hydro Turbines
- Engine Generator Set Interconnect Controllers

Most UL Equipment Safety Standards Evaluate

- Electrical Hazards
- Fire Hazards
- Mechanical Hazards
- Verification of electrical ratings
- These hazards are evaluated under MFR defined normal conditions and foreseeable abnormal conditions



VOLTS

AMPS

HZ

Construction Requirements

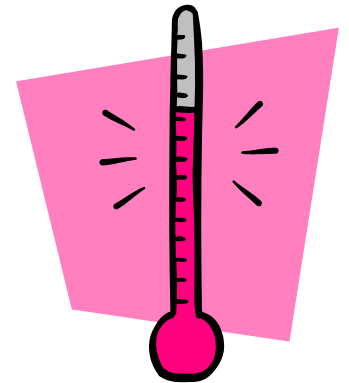
- Components are required to have appropriate electrical ratings for their application and operation.
- Enclosures (electrical and environmental)
- Electrical Spacings are required to account for:
 - Pollution degree
 - Over Voltage Category
 - Polymeric material long term electrical and mechanical characteristics.

Fire Hazards

- Verification of normal operating temperatures
- Acceptable operation of product under short circuit and overload conditions
- Compliance Criteria: Under no circumstances shall a product emit sparks, flames or molten metal

Temperature Testing

- Attempt to identify worst case electrical and environmental operating conditions within mfr rated operating parameters.
 - Max and min input and output voltage
 - Max operating ambient
 - Before and after thermal derating
 - Charging or discharging energy storage devices



Temperature Test

- Some component worst case operating conditions will be different than other component worst case operating conditions so we will record the worst case temperatures for the component and define the operating conditions.
- Testing used to characterize the power de-rating curve of the unit under test.
- Curve is tested at several points to ensure that the unit does not exceed any temperature limits or become a fire hazard at any point.

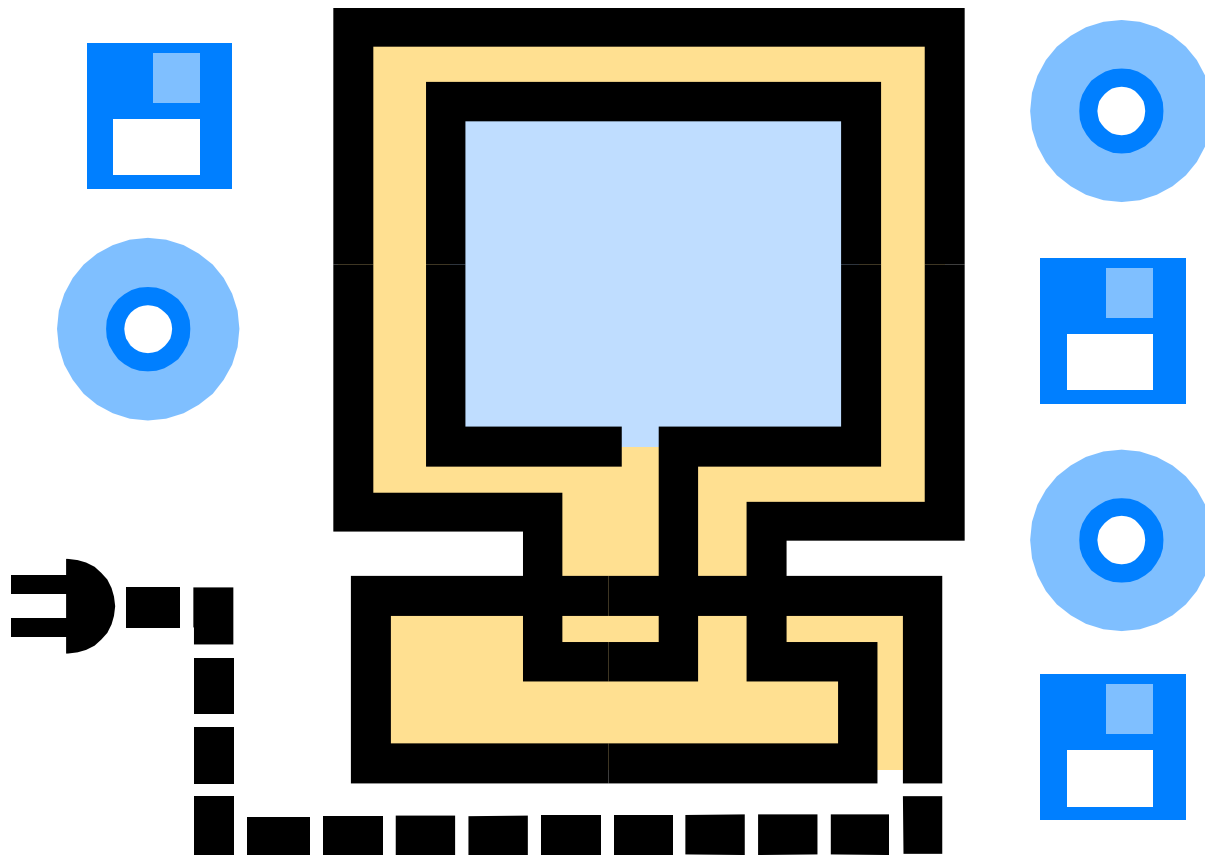
Markings, Ratings and Instructions

- Product safety and reliability are highly likely to decrease when products are installed and operated outside of the manufacturer specified electrical, mechanical and environmental ratings
 - Max input voltage
 - Max input short circuit rating
 - Max operating ambient
 - Max output over current protection rating
 - Max reverse current
 - Etc.

UL 1741 is a Unique Standard

- Performance Issues associated with the grid interactive operation of the DG products are important safety issues.
- This is unlike many other product categories covered by UL standard which normally concentrate on electric shock and fire hazards only.

Software Considerations



Software Considerations of UL 1741

- Software is viewed as the main critical component of a utility interactive inverter as the software often controls most of the utility interaction of the inverter.

Software Considerations of UL 1741

- One version of software and critical hardware are evaluated during the utility interactive testing but is viewed as a component of the inverter and identified by software version number and correlated by a checksum or CRC value.

Software Considerations of UL 1741

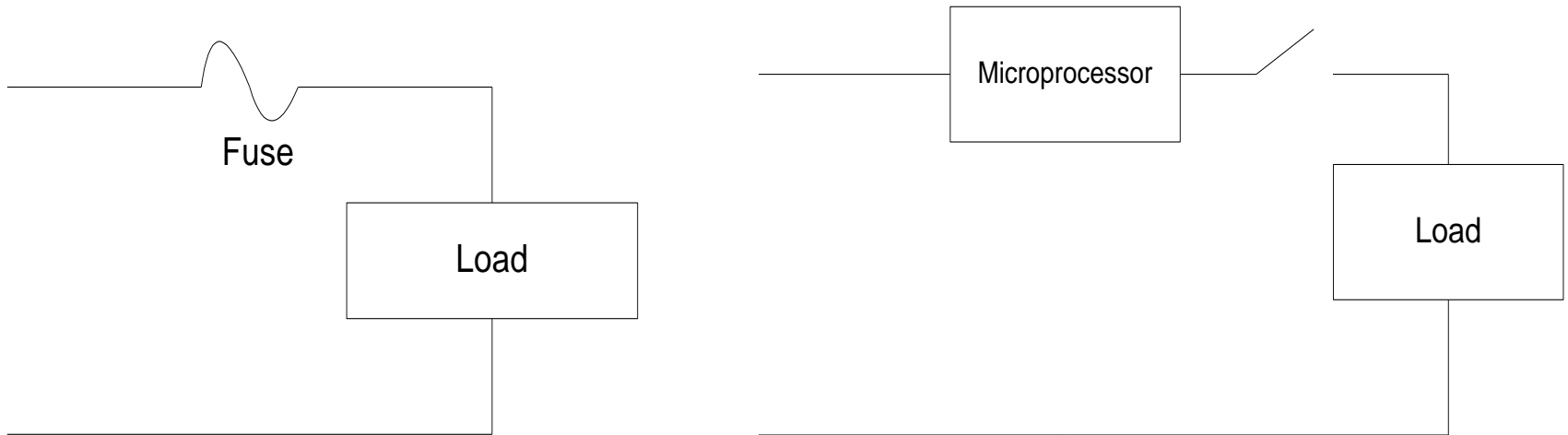
- A software investigation can be conducted by UL to evaluate some safety critical functions of the software to the UL 1998 standard – The standard for software in programmable components.
 - GFDI
 - Over-temperature protection
 - Non-isolated / transformerless inverter protection

Definition

Functional safety is part of the overall safety that depends on a system or equipment operating correctly in response to its input(s).

Example (Over-current Protection)

“Older” Technology vs. “Newer” Technology



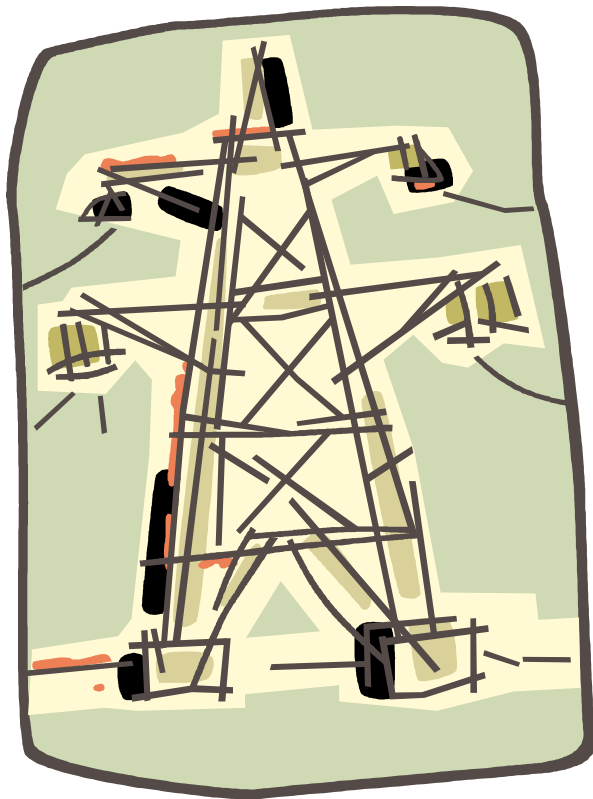
What Is Functional Safety

“Old” versus “New” UL Requirements

- Electrical Safety (Traditional UL Listing)
- Electromechanical Safety / Reliability of Performance Aspects (Traditional UL Listing + Some Aspects of Functional Safety)
- **Electronic Safety / Reliability (“New” Technologies)**
 - **Software**
 - **EMC (Dual purpose use to satisfy performance and FS)**
 - **Component Reliability (eg. No Single Points of Failure)**
 - **System Reliability**

What Is Functional Safety

Utility Compatibility and Interconnection Concerns



Conducting Utility Interactive Tests

- The Utility Interactive Tests are conducted as part of a sequence as outlined in IEEE 1547.
- The test sequence must be completed successfully with a single sample.
- These tests are conducted to ensure that the Interconnect Integrity Tests do not result in any adverse affect on the unit's ability to accurately respond to abnormal grid conditions.

IEEE 1547 Grid Interconnect Integrity Testing

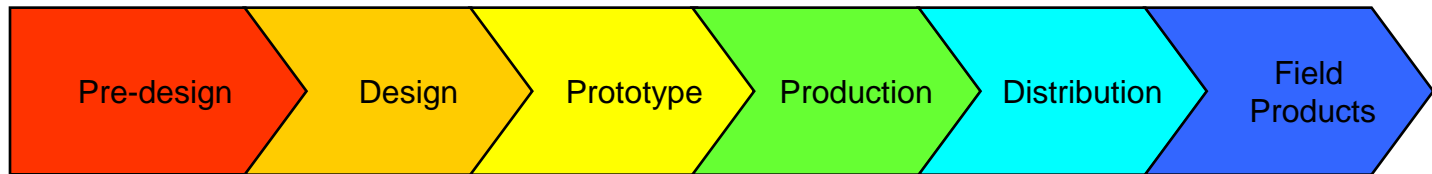
- Protection From Electromagnetic Interference or EMI Test as outlined in the standard IEEE C37.90.2. The influence of EMI shall not result in a change in state of the interconnection system.
- Surge Withstand Performance (line surges) as outlined in the standard IEEE C62.41.2

Certification and Performance Certification and the Product Development Cycle

Performance Certification

One time
Evaluation of hand picked
or hand built "Golden Samples"
Follow Up Not Required

**Without Follow Up
modules, component
and materials can
change and invalidate
performance certification**



Safety Certification

Consulting
And Training

Preliminary
Investigation

Preliminary
Investigation

Certification,
Product audits

Manufacturing
Follow Up
Inspection &
Testing

Product failure
Investigation



UL1741 Listing Certifications

- The UL1741/IEEE1547 combination of requirements are being used to evaluate grid tied DG products for both electrical safety and utility interconnection.
- This certification provides a stable platform for the CEC Inverter Efficiency program.
- It could also be leveraged for adjunct product reliability evaluations.

Questions?

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