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Understanding ITE Product Enclosure Design Requirements: Part 3

Written by Doug Massey on October 13, 2014. Posted in Understanding ITE

Part 3 – The Limited Power Source

In Part 2 of this series, we discussed which parts and circuits require a fire enclosure, and which do not. We saw that IEC 60950-1 clause 4.7 does **not** require a fire enclosure for components in secondary circuits supplied by a Limited Power Source (LPS), and mounted on V-1 or better material. In Part 2 we also raised the point that defining which circuits and parts will require a fire enclosure and which ones will not is an important first step in the product design coordination between electrical and mechanical engineering. In Part 3 of this series, we will examine LPS sources in more detail.

Defining LPS: Its Limits

LPS requirements are covered in clause 2.5 of the standard. Interestingly, LPS is not defined in clause 1.2 of the standard, the definitions section, or in clause 2.5, the LPS requirements section. I'll take a crack at writing a succinct definition for LPS:

A Limited Power Source (LPS) is a secondary circuit with an open circuit output voltage, $\boldsymbol{U}_{OC}$, not exceeding the SELV circuit limits of 42.4 V_{PEAK} or 60 V_{DC}. The maximum apparent power, ***S****, available on the output under any load condition, and the maximum fault current, $\boldsymbol{I}_{SC}$, available on the output under any load condition, (including a short-circuit), are limited to magnitudes not likely to cause ignition under fault condition in components mounted on, or circuits constructed from, suitably rated materials.*

Common Examples Of LPS

So what are some common Limited Power Sources? Very often the DC output of external AC/DC adapters comply with the LPS requirements, and the markings on the adapter may include an "LPS" marking on the nameplate. Internal AC/DC supplies with output rated < 100W meet the LPS limits.

Likewise, battery pack outputs are often LPS. It's important to note that if you intend to rely on a power supply or battery pack to provide an LPS output to power your product, don't just take the manufacturer's word for it! Ask for and examine the 60950-1 report to ensure that there is objective evidence that the LPS requirements in clause 2.5 are met.

4 Ways To Comply With Clause 2.5

Clause 2.5 gives four accepted methods for providing the current and power limitations to meet LPS:

a. Inherent power limiting;
b. Linear or non-linear impedance (a resistor or a PTC, respectively) providing power limiting;
c. A regulating network providing power limiting under both normal and single-fault conditions;
d. An overcurrent protective device (a fuse or breaker) providing power limiting.

The current (I_{SC}, in amps) and apparent power (S, in VA) limits for first three methods, (limitation without an overcurrent protective device), are presented in Table 2B of clause 2.5, while the limits for the fourth method, (limitation using an overcurrent protective device), are outlined in Table 2C. While the 60950-1 standard displays these limits in tabular format, we represent the tables graphically in this article.

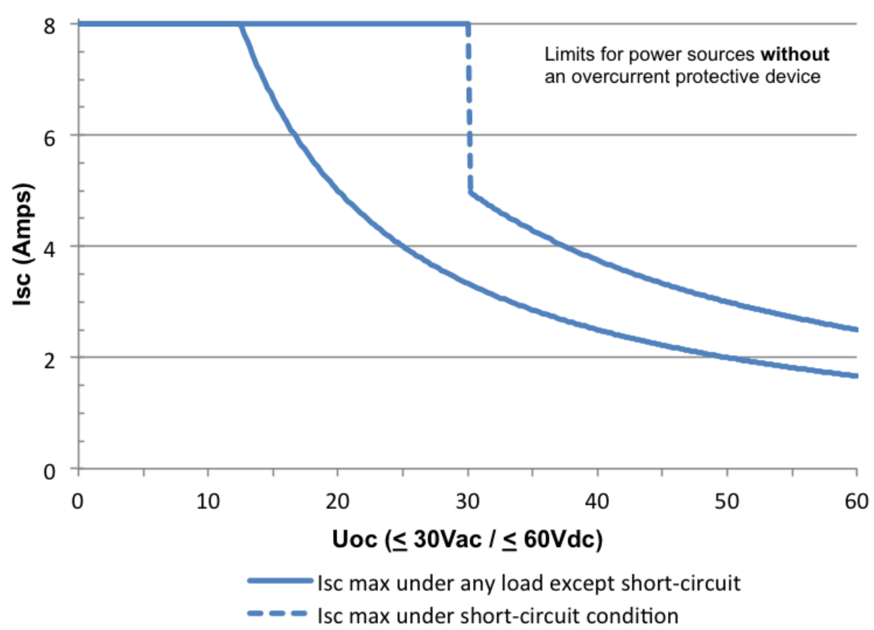
Impedance limiting method – We rarely see the use of passive, linear impedance networks employed to provide LPS because the losses associated with linear impedances are not desirable in circuit designs. Non-linear impedances, most notably positive temperature coefficient thermistors (PTCs), are widely used, and are an excellent technique for providing LPS limitations to specific circuits. Note that PTC devices used to meet LPS limits must be certified according to IEC 60730-1.

Regulating network method – This is one of the most common methods used to meet LPS limits. Overload protection on the DC output rails of a power supply is a standard design technique. However, in order to classify as an LPS output, the current and power limitations given in Table 2B must be met in both normal operating conditions, and with any single fault introduced into the regulating network circuit. Taking a typical SMPS as an example, single-fault conditions would be shorting or opening a current sense resistor in the PWM feedback loop, shorting across any pins on the optocouplers in the feedback loop, or even lifting a pin on the optocoupler to simulate loss of feedback to the PWM. The regulated output must continue to comply with the LPS limits of Table 2B under all simulated fault conditions.

Limitations Outlined in Table 2B

For each of the first three methods A, B, and C, Table 2B provides the limits according to the open circuit voltage, U_{OC}. Note that U_{OC} is the RMS voltage of the circuit; Table 2B only applies to AC power sources up to 30 V_{RMS} (42.4 V_{PEAK}). DC power sources up to 60 V are permitted.

IEC 60950-1 Table 2B



a) RMS output voltage, $\mathbf{U_{OC}}$, is measured with no load applied. Voltages shown are for substantially sinusoidal AC and ripple-free DC. For non-sinusoidal AC and DC with ripple greater than 10% of the peak, the peak voltage shall not exceed 42.4 V.

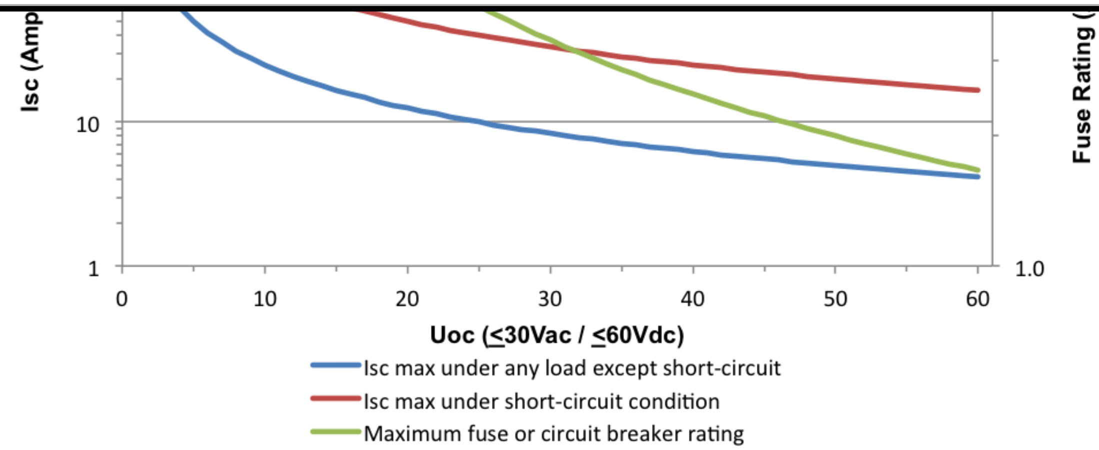
b) $\mathbf{I_{SC}}$ is the maximum output current with any non-capacitive load, including a short-circuit.

c) **S** is the maximum VA with any non-capacitive load; Table 2B allows 100 VA maximum.

d) $\mathbf{I_{SC}}$ and **S** are measured 5s after the load is applied where power limiting is by an electronic circuit, or 60s where a PTC or other limiting means is used.

The maximum output power, **S**, is limited to 100VA under all load conditions. The maximum output current, $\mathbf{I_{SC}}$, is limited to 8A maximum under any load condition **including a short circuit** (VA = 0 under short circuit conditions since there is no voltage present) for voltage up to and including 30V ac or dc, and is limited to 150/U_{OC} for DC voltages greater than 30V up to and including 60V. The graph does not plot the curve for **S**, but the I_{SC} curves reflect the 100VA limit as the product of U_{OC} x I_{SC} at each point along the curve.

Overcurrent protection device method – Another commonly used technique to provide LPS limiting is by using a fuse or circuit breaker in series with the power output. Table 2C outlines the limits for overcurrent device limited sources.



the peak voltage shall not exceed 42.4 V.

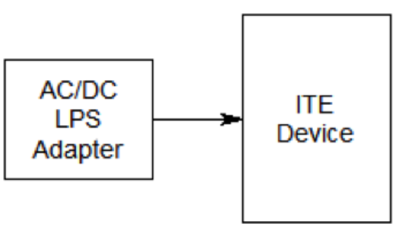
b) I_{SC} is the maximum output current with any non-capacitive load, including a short-circuit, measured at 60s after application of the load.

c) **S** is the maximum VA with any non-capacitive load, measured at 60s after application of the load. Table 2C allows 250 VA maximum.

d) Measurement of I_{SC} and **S** are made with the overcurrent protective device bypassed in order to determine the available energy during the operating time of the fuse or circuit breaker. Current limiting impedances remain in the circuit during the measurement.

In addition to maximum values for U_{OC}, I_{SC}, and S, Table 2C gives maximum ratings for the overcurrent protective device. When a fuse or circuit breaker acts as the power limiting component, I_{SC} and **S** are measured with the overcurrent protector bypassed in order to determine the available energy during the operating time of the fuse or breaker. The fuse ratings in the table are based on devices that break the circuit within 120 seconds with a current equal to 210% of the current rating specified in the table. This criterion comes from the UL standards for fuses and circuit breakers.

Putting Knowledge Into Practice: A Real-World Example



Let's look at a common real-world example. Consider an ITE device powered by an external AC/DC power adapter with an output rated 12Vdc, 5A, 60W. The internal circuits are all mounted on a printed wiring board with a V-0 flame rating. Assume that we have examined the CB Scheme report for the power adapter, and have confirmed that its output is indeed classified as LPS. We can then assume that the power limitation is provided using method C, a regulating network, as this is the commonly used technique for this case. We can also assume that the maximum short-circuit current at the output does not exceed 8A and that the maximum available power does not exceed 100VA.

Simple enough, right? Our ITE Device has an LPS input. The DC input connector on our ITE Device does not require a fire enclosure, since clause 4.7.2.2 specifically exempts connectors in secondary circuits supplied by LPS. We should not need a fire enclosure for the PCB inside, since clause 4.7.2.2 also exempts the fire enclosure requirement for components and circuits supplied by LPS and mounted on materials with V-1 or better flame rating, which our printed circuit board is. So we do not need to design a fire enclosure for our ITE Device, right?

The answer is an unequivocal, "Er, well…maybe not." Hold on, what did we not consider here?

What we might understandably have overlooked is that our ITE device has some DC-DC regulators inside which regulate the 12Vdc input down to 5Vdc and 3.3Vdc power domains. Since our 12Vdc LPS power adapter may provide up to 8A and still be within LPS limits, and our DC-DC regulators decrease the voltage to a lower level, this means that the available output current on either or both DC-DC regulators may well exceed the 8A limit, even under normal load conditions.

Remember that LPS must be evaluated and tested at each voltage conversion node.

We cannot make the assumption that an LPS input guarantees that all other circuits will also meet LPS.

Exempt From Fire Enclosure Requirements

Let's consider one more real-world example: a portable ITE device powered by a user-replaceable Li-Ion battery pack, in which the battery pack is contained within its own enclosure. Envision a typical notebook with a battery pack on the bottom side which the user can remove with no tools. Assume that the battery pack output has been evaluated and tested to comply with LPS limits, and that the DC-DC regulators inside of our portable device also all comply with LPS requirements, and all circuits are mounted on printed circuit boards with a V-0 flame rating. In this case, our ITE device is exempt from the requirement to have a fire enclosure. However, the battery pack itself will require a fire enclosure, since the protective circuits within it (which provide the LPS limiting) are themselves ***not*** LPS up to the point where the LPS criteria is met.

LPS circuits are those circuits powered by the output of a Limited Power Source. LPS circuits are connected to the load side of a fuse, circuit breaker, PTC, or regulating network. The circuits on the supply side are not powered by LPS, and must be provided with a fire enclosure.

Providing LPS limitations to part or all of the circuits in a product design gives the mechanical design more flexibility in polymeric material choices and openings in the enclosure, as a fire enclosure need not be provided for LPS-powered circuits. Again, we are emphasizing close coordination between the circuit designers and the mechanical designers in the conceptual phase of the design, in order to reduce per unit cost in production while still maintaining an acceptable degree of product safety.

In the next article in this series, we will take an in-depth look at the flame rating requirements for polymeric materials used for, in, and on product enclosures.

ACS product safety engineers can provide assistance to your design team with preliminary design and construction reviews, working remotely, at your facility, or at our Buford facility. The preliminary review output is a list of findings of non-compliances, and some suggested options to bring the product into compliance. The preliminary evaluation includes review of the product design and construction, along with review of required product markings, and required elements of the user manual / installation instructions.

ACS engineers can help your team understand specific elements of the IEC 60950-1 standard which relate to your product. We can provide safety-critical component review. We can provide a test program overview, so that you will know what tests will be performed, how many samples to provide, what operational modes and product configurations should be tested; and the support equipment you will need to provide for the testing.

When it's time for ITE product safety certification, ACS offers certification options for all regions, including Underwriters Laboratories certification for North America, TUV SUD certification for North America, and the IECEE CB Scheme certification through TUV SUD.

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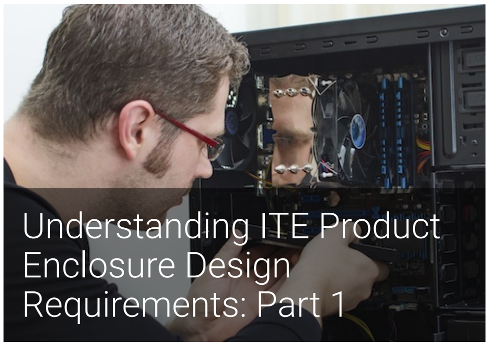

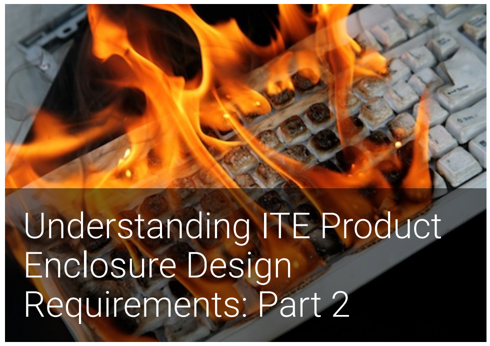

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