HOW TO PROPERLY PROTECT A DC EV CHARGER

Using Fuses for Dc Rapid Charging Systems

TECHNICAL PAPER

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1. Introduction

With EV adoption accelerating, dc EV car chargers will likely become the highest power devices that the general public interacts with outside of an industrial environment. This means that the safety of these devices is extremely important to prevent damage to valuable equipment and the user.

Electrical faults in dc EV chargers can originate internally or from the EV itself. Both scenarios can cause significant downtime of the chargers, or in severe circumstances, damage to assets and surrounding areas if adequate circuit protection is not integrated into the system design.

Dc fuses offer an efficient and effective method of protecting equipment from overcurrent, increasing reliability, and reducing downtime. Fuses can be quickly replaced without causing unnecessary downtime.

Fuses designed for the protection of dc rapid chargers are typically compact, are tolerant of demanding dc charging currents, and feature low minimum breaking capability to allow for protection at lower currents and coordination with other system devices such as dc contactors.

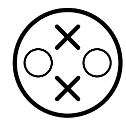
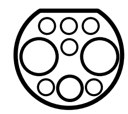
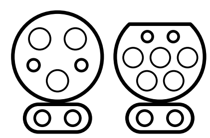
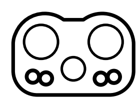
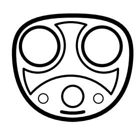
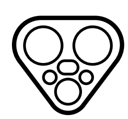
Circuit protection must be adequately sized to prevent catastrophic failure. To adequately size a dc fuse in an EV charger application, the following information is required:

- System voltage (V dc)
- System nominal current (A dc)
- System load profiles (ON/OFF cycles)
- System/circuit time constant (L/R)
- Withstand rating of surrounding components/devices
- Ambient temperature conditions
- Intended connection type (busbar, fuse holder)
- Location of component within the system
- System coordination requirements

Acronyms

AC	Alternating Current
CCS	Combined Charging System
DC	Direct Current
DCFC	Direct Current Fast Charging
DFM	Design for Manufacture
EV	Electric Vehicle
EVC	Electric Vehicle Charger
EVCI	Electric Vehicle Charging Infrastructure
IEC	International Electrotechnical Commission
IGBT	Insulated-Gate Bipolar Transistor
ISO	International Organization for Standardization
MCS	Megawatt Charging System
NEC	National Electrical Code
OCPD	Overcurrent Protective Device
OEM	Original Equipment Manufacturer
PEC	Power Electronic Converter
SOC	State of Charge
UL	Underwriters Laboratory

TABLE 1. Overview of dc charging protocols.

DC CHARGING PROTOCOL	INFORMATION	CONNECTION	RELEVANT STANDARDS
CHAdeMO	The first dc charging platform developed in 2010 by the Tokyo Electric Power Company.		CHAdeMO 3.0 IEEE 2030.1.1TM-2015 IEC 61851-23 (Annex A)
GB/T	Dc charging platform/standard developed by the Standardization Administration of China. Currently being revised as part of ChaoJi standard.		GB/T 20234.3 IEC 61851-23 (Annex B)
CCS (Combined Charging System)	Proposed by the international VDI-congress, this platform provides a combined charger, where a single charge port is capable of both ac and dc charging. Adopted by large European automotive manufacturers.		IEC 61851-23 (Annex C)
ChaoJi	A co-development between CHAdeMO and the China Electricity Council of a next- generation EV charging standard. Proposed to be up to 900 kW charging capability (1500 V dc/800 A).		ChaoJi 1/2/3 IEC PAS63454 GBT20234.4
NACS (North American Charging Standard)	Opening of the Tesla charging standard has led to development of a new charging standard utilizing the technology and covering both ac and dc charging. Proposed to be capable of up to 1 MW rated charging (1000 V/1000 A) and being adopted by large OEMs globally.		SAE J3400 UL 2202
MCS (Megawatt Charging Standard)	Standard in development for dc charging ≥ 1 MW. Based on the technology proposed by the CharIN group.		IEC 61853-23-3 (proposed 2024 release)

Dc Fast Charger
■ 380 V-600 V ac, 3-phase input; ≤1000 V dc output
Mode 4 Dc
■ Ac or dc input supply, cord or permanently connected, with control pilot & shock protection
■ Delivers dc power, bypassing the vehicle on-board charger ■ Typically provides 80 % charge of fully depleted battery within 15 to 30 minutes*

■ As defined by SAE J1772
■ As defined by IEC 61851-1
*Charge time dependent on vehicle battery capacity and charge acceptance rate

FIGURE 1. Definition of a dc EV charger and typical parameters.

2. Where Overcurrent Protection is Important in a Dc EV Charger

There are two main circuits within a dc EV charger—the power circuit and the control circuit. The control circuit monitors the systems, collecting and processing information and changing the state of the system based on these inputs. The power circuit is responsible for the electrical load itself, and this is where overload and short-circuit protection strategies need to be included.

According to IEC 61851-23, side B (dc side) of any EV charger shall include overload and short-circuit protection. Where a fuse is the selected overcurrent protective device (OCPD), it must comply with IEC 60269 (low-voltage power fuses) per IEC 61851-1 and with UL 248 (low-voltage fuses) per UL 2202.

Short circuits within an EV charger typically originate from one of the following scenarios:

- Short circuit between side B live parts (dc+ and dc-)
- Power electronic converter failure
- EV battery fault

In such a scenario, a dc EV charger must be capable of:

1. Limiting the peak current to ≤ 10 kA
2. Limit the I^2t values to:

TABLE 2. Comparison of dc charging protocols and the respective short circuit I2t limit requirements.

DC CHARGING PROTOCOL	I^2T LIMIT
CHAdeMO	400,000 A^2s
GB/T	500,000 A^2s
Combined Charging System (CCS)	1,000,000 A^2s

3. Trigger an emergency shutdown in 1 s or less after the start of the short-circuit condition.

Often, fuses are capable of melting and clearing in much less than the 1 s emergency shutdown time helping designers achieve compliance. If the emergency shutdown mechanism fails, selecting the correct type of fuse can provide backup protection to this function.

Fuses present a simple, reliable, and cost-effective solution when compared to alternative technologies. The Littelfuse range of high-speed fuses excels at limiting fault current and energy and provides an ideal solution for dc short-circuit protection within dc EV chargers.

Note: The OCPD must also be capable of dealing with a peak fault current from an EV side fault, which is set out in standard ISO 17409:2020 to have a maximum value of 30 kA.

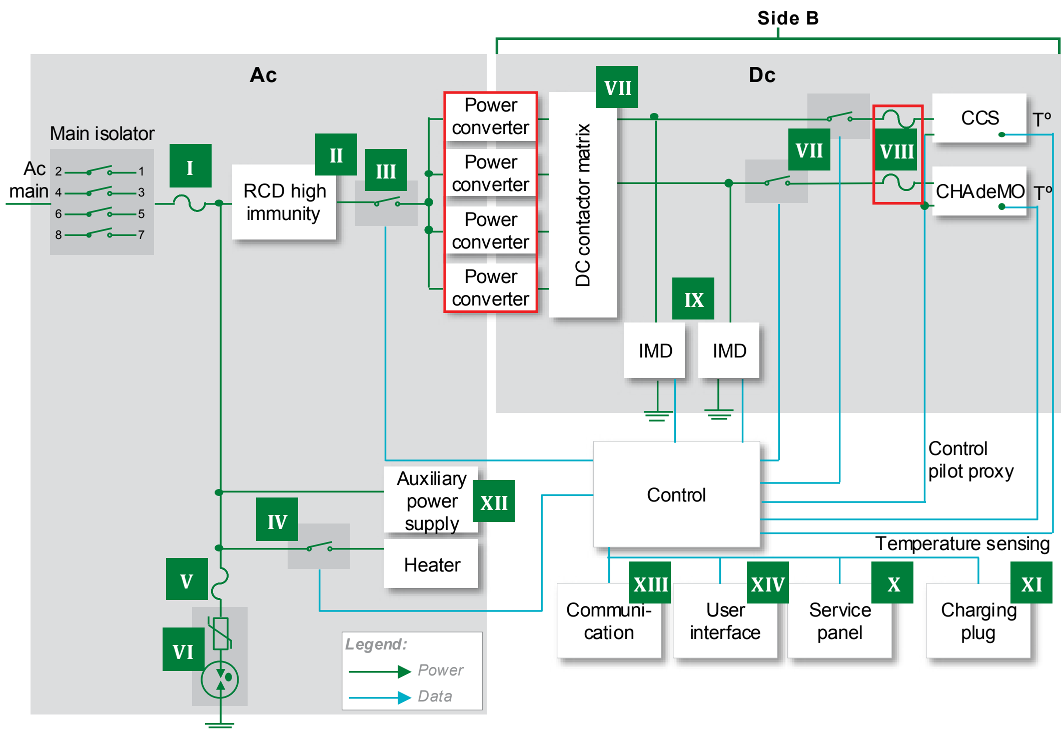


FIGURE 2. Typical dc EV charger block diagram with dc fuse locations highlighted.

In order to provide the level of protection outlined in IEC 61851-23, dc fuses are used in one or two locations. Often the power electronic converters (PECs) will include dc fuses on the dc output of the module(s). Typically, the PECs are supplied by an OEM, making it necessary for the EV charger designer to include additional short-circuit protection as part of their design at the dc EV charger output, in series with a dc contactor or relay, and the conductor itself.

This technical paper discusses the selection process for this dc output fuse. Additionally, some EV charger installations use a 'satellite' type system where converters are housed separately from the final output unit. In this case, it would be necessary to have short-circuit protection at all points in the installation.

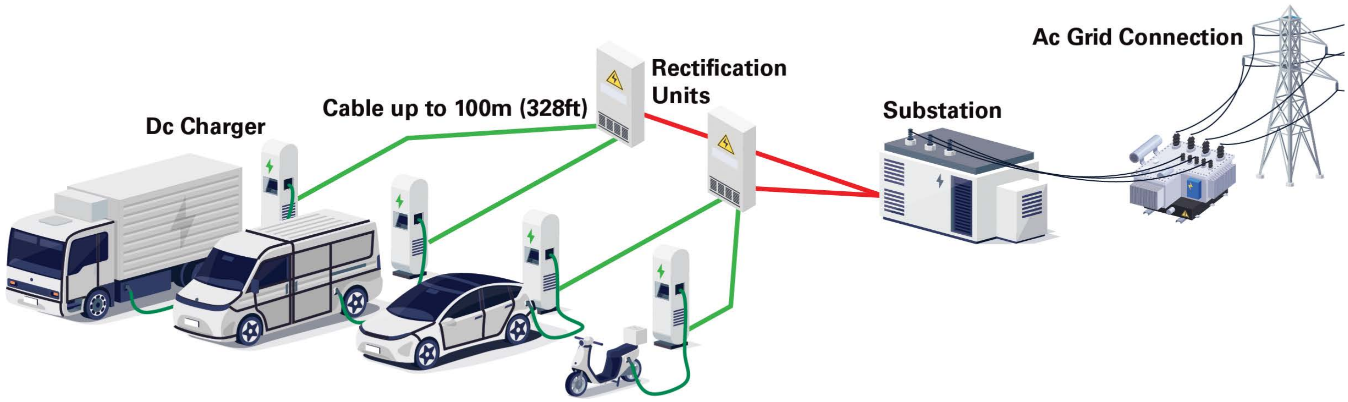


FIGURE 3. 'Satellite' style EV charger installation.

For more information on selection of fuses for PEC applications, refer to the POWR-SPEED® Fuses Application Guide from Littelfuse.

An EV charging system may require various types of circuit protection, as can be seen in **Figure 2:**

- Fuses
- Arc-flash relays
- Ground-fault relays
- Surge-protective devices

This paper focuses on the protection against overcurrents in a dc EV charger power circuit. To learn about the other types of protection for power circuits, contact the Littelfuse Techline at techline@littelfuse.com or +1 (800) TEC-FUSE (800-832-3873).

Fuse Protection for the Dc EV Charger Power Circuit

It is the responsibility of the EV charger manufacturer to ensure that the charger is compliant with the relevant standards for electrical safety for the charger and the user. This can be achieved by using a dc-rated, high-speed fuse on the output of the EV charger to protect from internal faults and faults originating from the EV itself. Per current standards, 1000 V dc is the highest battery voltage of passenger EVs. To provide protection for this application, Littelfuse has a range of fast-acting fuses capable of clearing faults at an applied voltage of 1000 V dc.

In addition to protecting the system from short-circuit faults, it is also important to ensure that there is coordination between the fuse and dc contactor on the output of the EV charger. The goal is to reduce the risk of the contactor being forced open at high currents under full voltage due to the magnetic field created by an overcurrent condition or welding of the contacts inside the contactor due to excessive current. High-speed fuses are typically designed exclusively for short-circuit faults as opposed to overloads; therefore, products developed specifically for EV charger applications should be considered.

3. How to Size Fuses for Dc Output

Due to the wide range of charger sizes, power ratings, and design architectures being used, prospective fault currents will be system dependant. The most common causes of short-circuit faults can be found in section 2. These scenarios should be considered as part of any short-circuit analysis. Typically, a challenge for the selection of this fuse is not only ensuring adequate short-circuit performance, but also coordinating with the dc contactor on the system output. Dc contactors typically have very little tolerance for opening at current above their nominal rating and have a low short-circuit withstand capability. High-speed fuses designed for EV charger applications have characteristics that can help achieve this.

Current Dimensioning

In order to calculate the appropriate current rating of the fuse, we can use the formula below to account for environmental factors:

$$I_N \geq \frac{I_L}{F_{AT} \times F_{FC} \times F_{WR} \times F_{SS} \times F_{EL}}$$

Where:

I_N = Minimum Rated Current of High-Speed Fuse

I_L = Maximum Continuous Load Current

F_{AT} = Ambient Temperature De-Rate Factor (see **Figure 4**)

F_{FC} = Forced Cooling Correction Factor

F_{WR} = Wiring Correction Factor

F_{SS} = Switching Correction Factor (see Table 3)

F_{EL} = Elevation Correction Factor

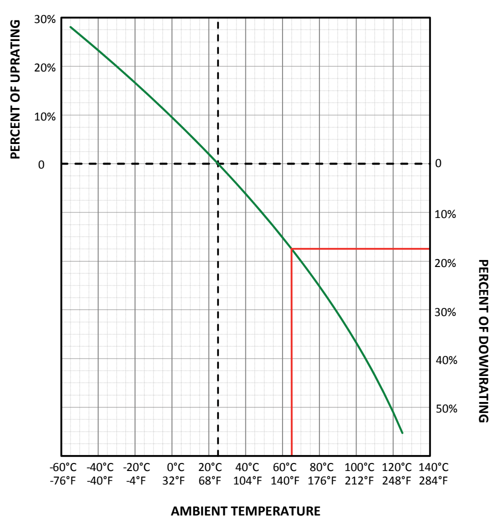


FIGURE 4. Example of a temperature de-rating curve for a Littelfuse fuse product.

Figure 4 gives an example of how to determine the thermal correction factor (F_{AT}) for a fuse. More guidance can be found on this subject in our POWR-SPEED® Fuses Application Guide. Please consult the datasheet of the product you are considering for specific thermal correction factor charts. If you have any further questions on this, contact the Littelfuse Techline at techline@littelfuse.com or +1 (800) TEC-FUSE (800-832-3873).

TABLE 3. Switching correction factor de-rating table.

FREQUENCY OF SWITCHING	SWITCHING CORRECTION FACTOR (FSS)
Less than 12 stops per year	1.00
More than one stop per month	0.95
More than two stops per week	0.90
More than one stop per day	0.85
Several stops per day	0.80

Table 3 shows typical switching correction factors that can be applied to account for the ON/OFF type load profile of an EV charger. ON/OFF cycling is particularly stressful for a fuse, and particularly the fuse elements due to the large change in temperature driven by the cyclic current. The maximum and minimum element temperature during each cycle will often give an indication of the stress accumulated by the fuse and therefore the longevity of the fuse. The most difficult cycle type would be one in which the load is ON long enough for the fuse to heat up and reach a stable temperature, and then be switched OFF long enough for the fuse to cool back down to ambient. For example, 30 minutes ON followed by 30 minutes OFF. Establishing the expected lifetime of the fuse will also be important for any maintenance schedules/guides that need to be issued to end users, enabling predictive maintenance as opposed to reactive maintenance.

Please note that these switching correction factors are subjective. It is recommended to understand the lifetime expectation of a fuse for your unique application requirements and environment.

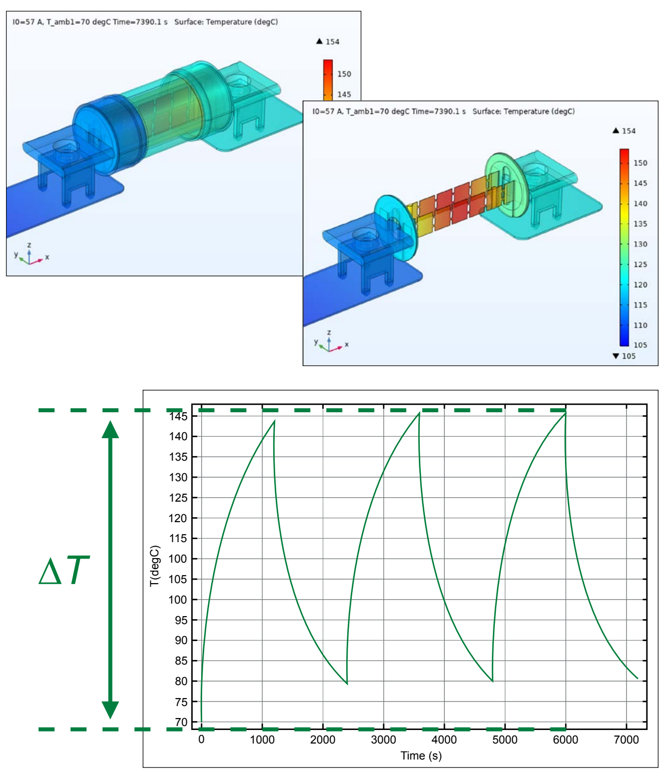


FIGURE 5. Example of a Littelfuse multiphysics simulation model and respective element temperature results.

Littelfuse has the in-house capability to run reliable multiphysics simulations of our products to produce valuable lifetime expectation data that's representative of the end use application. Reliability is becoming increasingly important for EV charging networks and, in some cases, has even become part of national legislation. To understand how Littelfuse can support your reliability and lifetime studies, please contact Littelfuse Techline at techline@littelfuse.com or +1 (800) TEC-FUSE (800-832-3873).

Figure 6 shows a chart for determining the wiring correction factor (F_{WR}). This factor is used to account for applications in which the conductors (busbar, cable connection, holder, PCB trace) are smaller than those used for product validation testing in a laboratory. In certain circumstances, increasing the conductor size can be used to help dissipate heat away from the fuse, decreasing the required current rating. An example of how to use this chart can be found in our POWR-SPEED® Fuses Application Guide.

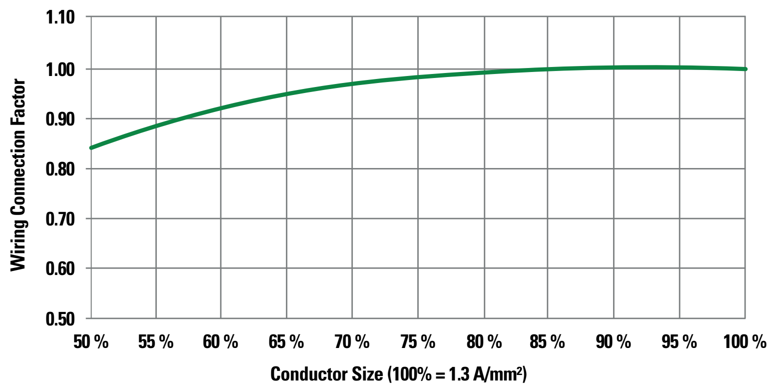


FIGURE 6. Example of wiring connection factor de-rating chart for Littelfuse products.

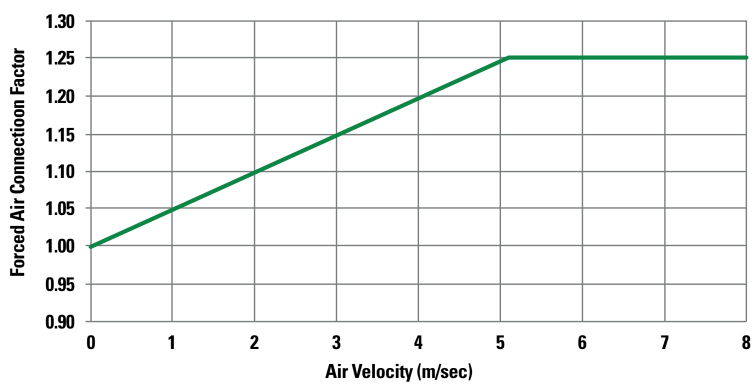


FIGURE 7. Example of forced air-cooling correction factor for Littelfuse products.

Figure 7 provides a chart for calculating the forced cooling factor (F_{FC}). Larger dc EV chargers will often be built like an industrial control panel where forced cooling/ventilation is often included within the design. Air flow across a fuse helps dissipate heat away from the fuse and can 'up-rate' the effective current rating. This can be useful in applications where high ambient temperatures cause large de-ratings to a fuse's current rating. Given the wide range of environments EV chargers will be used in, many will include forced cooling.

At elevations higher than 2000 m above sea level, lower air density impacts the way a fuse can dissipate heat compared to nominal conditions. For this reason, it is necessary to de-rate fuses in EV chargers rated for use at elevations greater than 2000 m above sea level according to the equation:

$$F_{AL} = (1 - \left(\frac{h - 2000}{100}\right) * 0.005$$

Where ‘h’ is the elevation in meters at which the EV charger would be installed.

Example: Fuse Current Dimensioning

Let’s consider a typical CCS type 2 charger with a maximum charging voltage of 920 V dc and a maximum output current of 250 A. The EV charger is expected to see ambient temperatures up to 65 °C, and have forced air cooling across the fuse of 2 m/s. The busbar being used has a cross-sectional area of 270 mm^2, providing a current density of 1.3 A/mm^2 for the fuse. It is expected that the charger will be used up to 20 times per day, and in most cases, this would be for 40 minutes ON (typical fast charge to 80% SOC) and up to 20 minutes off. The panel is intended for use up to 2000 m above sea level.

F_{AT} = 0.82 based on an ambient temperature of 70 °C (see **Figure 4**).

F_{FC} = 1.1 based on 2 m/s air speed across the fuse (see **Figure 7**).

F_{WR} = 1.0 based on current density of 1.3 A/mm^2 (see **Figure 6**).

F_{SS} = 0.8 (see **Table 3** - Switching correction factor de-rating table). For details on lifetime estimates, please consult with Littelfuse.

F_{AL} = 1.0 based on rating up to 2000 m above sea level.

$$I_N \geq \frac{250\ A}{0.82 \times\ 1.1\ \times\ 1.0 \times\ 0.8 \times 1}$$

$$I_N \geq 346\ \mathrm{A}$$

The next fuse rating > 346 A would be a 350 A fuse. For this application, a 1000 V dc 350 A fuse would be required, but in EV charger applications, there are other factors to consider.

Dc Fuse Behavior and Data

Application of fuses in dc applications is not as simple as in ac applications. In a typical ac system, the voltage will cross zero every 0.010 s (50 Hz) or 0.016 s (60 Hz), which is helpful for driving current to zero in the event of a fault. For this reason, ac fuses are tested at specific power factors and angles on the sinusoidal voltage wave, and the published data is typically expressed in terms of symmetrical root mean square (RMS) current. In dc circuit frequency, power factor and voltage zeros are not relevant. However, the ratio of inductance to resistance (L/R) or time constant must be considered. The time constant in EV charging infrastructure will be dependent upon the type and size of the installation, and this must be considered when assessing the fuse short-circuit performance. The impact of this parameter on dc fuse characteristics is discussed in the following sections.

TABLE 4. Relevant low-voltage fusing standards and the respective dc time constant requirements.

STANDARD	TYPICAL TIME CONSTANT (L/R)
IEC 60269-4	≤ 10 ms
UL 248-13	≤ 10 ms
IEC 60269-7	≤ 3 ms

Table 4 details the time constants to be used for testing low-voltage fuses to the corresponding application standards. The manufacturer shall always publish the time constant used during product validation. When selecting a fuse for your EV charger application, it is necessary to always check your application time constant against the time constant of the product. Typically, time constants in an EV charging system shall not be higher than 3 ms. Guidance for calculating side B circuit inductance is outlined in IEC 61851-23 101.1.8, and to represent a worst-case scenario, the highest feasible value should be used.

Peak Let-Thru Current

As previously stated in this document, the peak let-thru current must be limited enough that it provides protection to the surrounding components. IEC 61851-23 outlines that the EV supply equipment shall limit the peak current to ≤ 10 kA for a CCS type EV charger.

Littelfuse publishes peak let-thru current curves for its high-speed fuse products, but in dc applications this situation becomes more complex due to the relationship between the fault current and the time constant (L/R) of the dc circuit. Higher inductances in dc circuits result in slower rising fault currents and changes the melting behavior of the fuse. For this reason, peak let-thru charts for a dc application are only valid at one specific time constant.

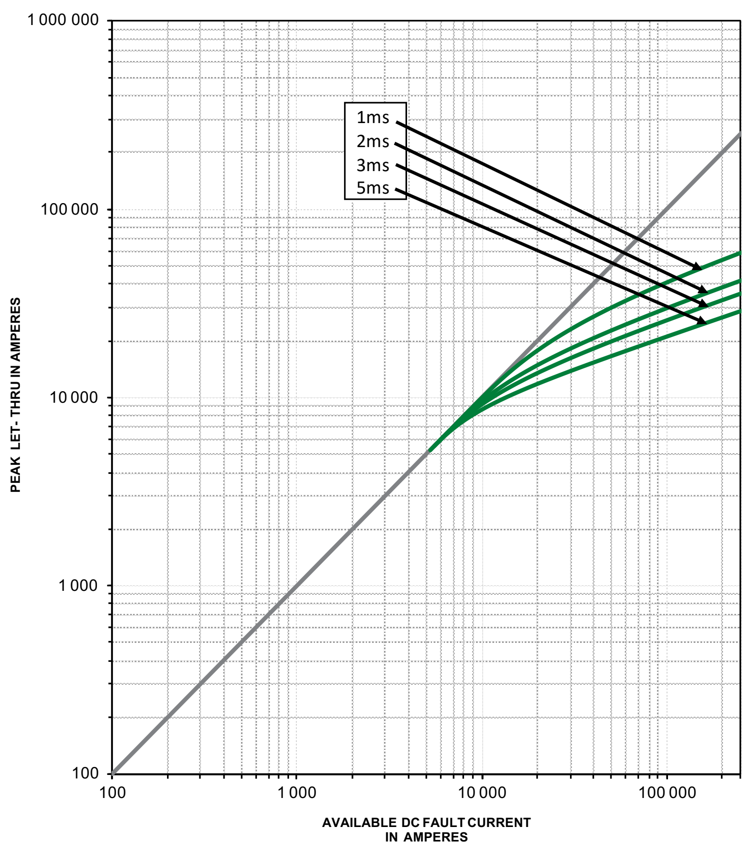


FIGURE 8. Example of peak let-thru curve at varying time constants, demonstrating the change in fuse behavior.

The Littelfuse TechLine team can produce peak let-thru curves for our range of high-speed products at different time constants upon request. To request data specific to your system, please reach out at techline@littelfuse.com or +1 (800) TEC-FUSE (800-832-3873).

Melting & Clearing I^2t

Fuses are published with two different I^2t values, pre-arcing and clearing. Pre-arcing I^2t represents the amount of energy required to melt the fuse and can therefore be used to estimate the time taken for the fuse elements to melt. For high-fault currents, this will typically remain constant (adiabatic behavior), but in applications where lower fault currents are expected or the time constant is high enough, it may differ from published data. **Figure 9** shows how different time constants can impact the rate of rise for a prospective current of 30 kA. This demonstrates why fuse performance is dependent upon the time constant of the circuit.

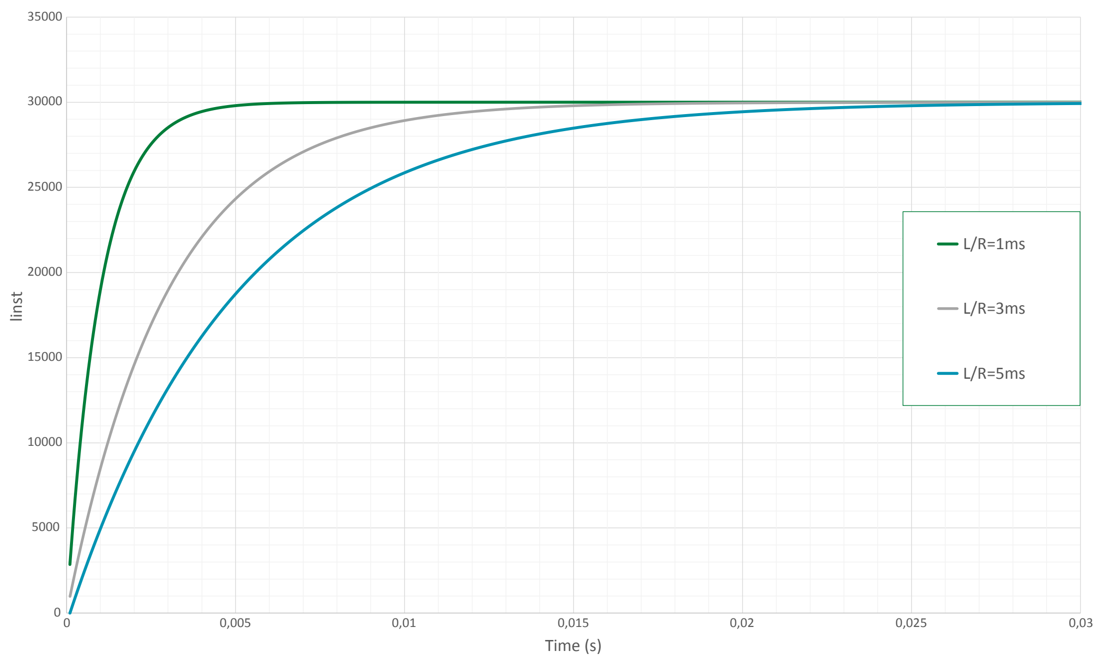


FIGURE 9. Prospective 30 kA dc fault current behavior at different time constants.

The clearing I^2t of a fuse represents the typical energy seen during the melting and arcing phases of the fuse during a fault. Faults in circuits with higher inductance will store more energy by means of a magnetic field, and this will be dissipated through the fuse during the arcing phase when the arc impedance is trying to drive the current to zero leading to higher clearing I^2t. Dc clearing I^2ts are published at the rated time constant and voltage. It can be assumed that lower time constants will result in a lower clearing I^2t. System voltage will also influence the clearing I^2t of a fuse. Littelfuse provides relevant correction factors to account for system voltages that are below a product's rated voltage. See **Figure 10** for an example of this type of correction factor curve.

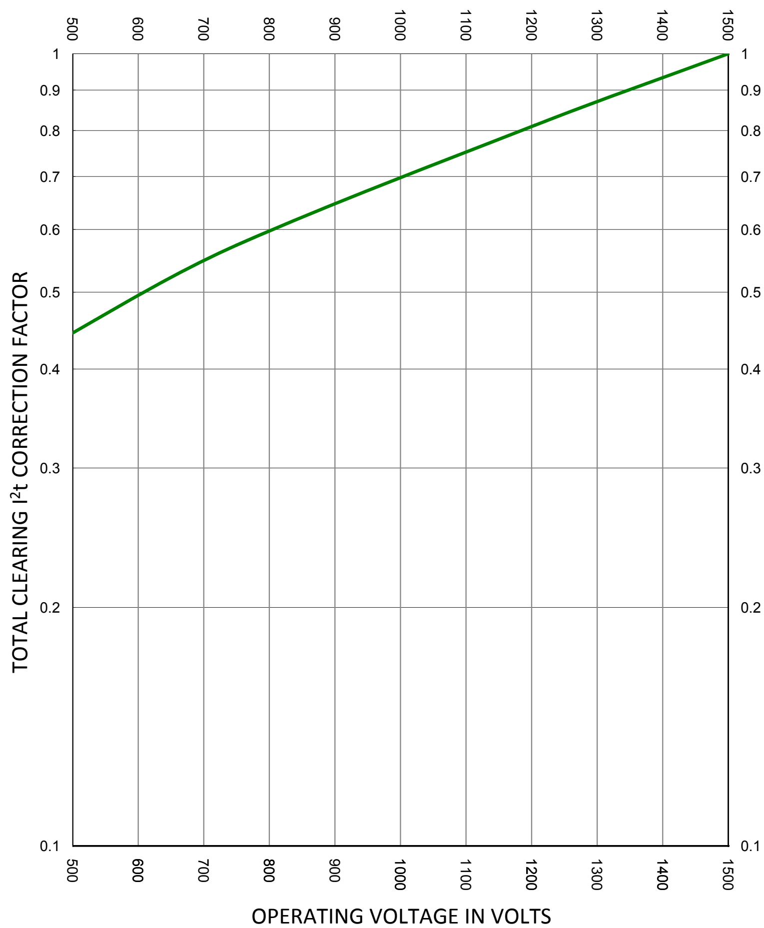


FIGURE 10. Example of an operating voltage vs clearing I^2t correction factor chart.

Compliance with IEC 61851-23 requires the I^2t to be limited to the values stated at the beginning of this section for different dc charging protocols.

Due to the variability of time constants in dc applications, it is recommended to contact the manufacturer for support on dc fusing performance. For more information on this subject, please contact Littelfuse TechLine at techline@littelfuse.com or +1 (800) TEC-FUSE (800-832-3873).

Dc Contactor Coordination

Ensuring that an EV charger can be safely disconnected in all circumstances is a necessary part of the circuit protection design. It is common to see a fuse and dc contactor used together. The combination of these components needs to be able to deal with all conditions:

- Nominal load current(s) (fuse and contactor selection process)
- Maximum overload current(s) (contactor maximum carry current and fuse minimum breaking current)
- Prospective short-circuit scenario(s) (contactor damage limit/withstand and fuse melting times)

A correctly selected dc contactor will carry the nominal current without incurring damage, but opening under full load or in overload conditions can cause severe damage to the contactor. And in some cases, enough to require replacement. Coordination of these two components is challenging but critical for safety and reliability of an EV charger. To assess a coordination strategy, the following information is required:

1. Fuse time current curve
2. Fuse minimum breaking current at system voltage
3. Contactor maximum carry current curve
4. Contactor welding curve
5. Contactor arcing damage limit curve/short circuit withstand

With this information, it is possible to check the fuse vs. contactor characteristics:

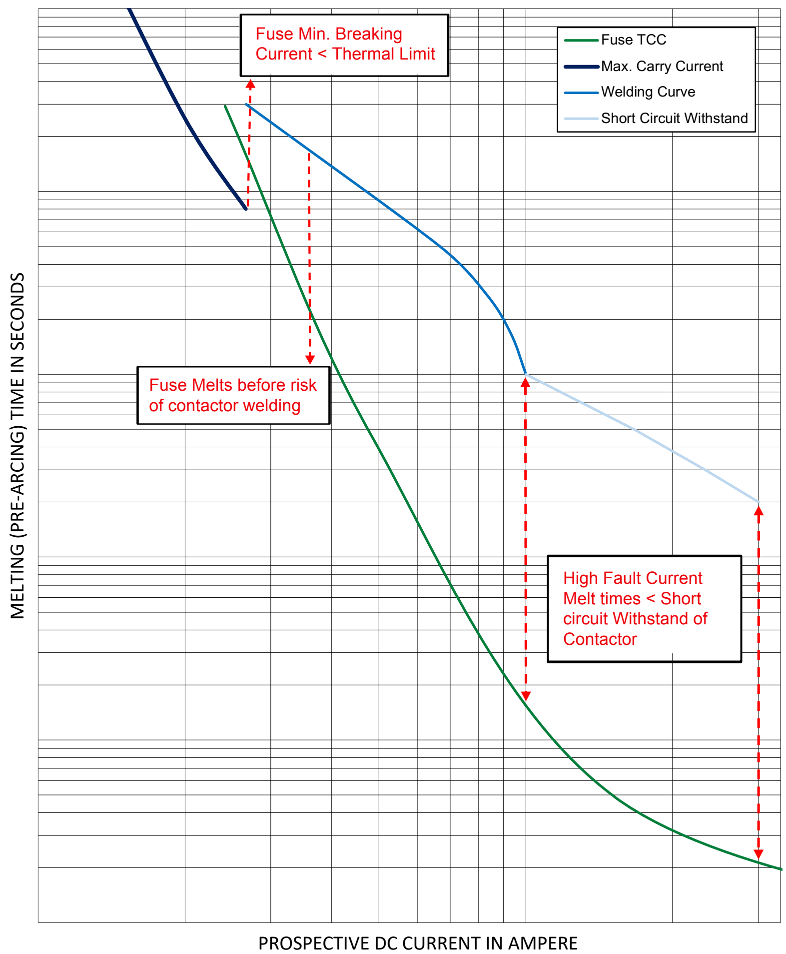


FIGURE 11. Example of a fuse TCC with contactor characteristics overlaid to check for coordination.

To ensure safety, it is necessary that:

- The dc contactor will carry nominal load currents without incurring thermal damage
- Be capable of withstanding currents ≤ minimum breaking current and time of the fuse
- Fuse shall melt before welding limit of the dc contactor is reached
- Fuse shall melt and limit currents ≥ short circuit withstand of the dc contactor

Littelfuse can provide technical support for achieving coordination between fuse and dc contactors. With our high-power testing facilities, Littelfuse can support series testing of circuit components where required. For more information, please reach out to Littelfuse TechLine at techline@littelfuse.com or +1 (800) TEC-FUSE (800-832-3873) with your test requirements.

4. Case Studies

Accelerated Life Testing for Lifetime Reliability – Case Study #1

A key dc EV charging OEM needed to ensure reliability of their system, including the fuse. Due to the cyclic nature of battery charging applications, thermal stress induced upon a fuse can be extreme. Ensuring the fuse will have sufficient life in application is extremely important for creating a reliable solution and reducing the risk of downtime of the charger.

Littelfuse was able to support this customer by utilizing internal testing capabilities to carry out accelerated lifetime testing. This testing enabled the customer to understand how the fuse would respond to their load profiles and demonstrated that the fuses will withstand the required application lifetime of 12 years. By eliminating the need for long-term testing, this technical support service was able to improve the customer's time to market and confidence in the reliability of their charging product.

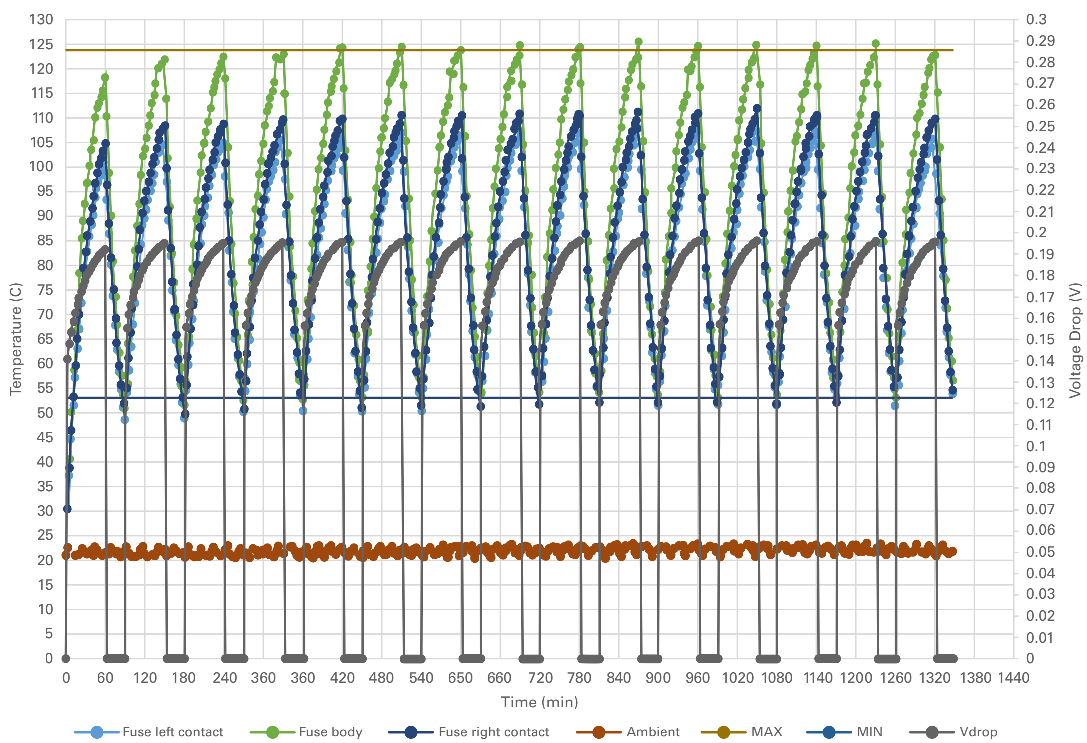


FIGURE 12. Example of accelerated lifetime test results.

Multiphysics Simulation for Reliability Studies – Case Study #2

A power supply OEM was developing new modules for use in rapid dc charging units. The fuses being considered were to be PCB mounted, which can often present challenges with temperature when being subjected to the charging cyclic loads. It was necessary to investigate the reliability of the selected fuses for the power module protection. However, performing experimental testing with customer specific setups can be challenging and time consuming, creating unnecessary costs and wasted time.

The Littelfuse simulation team was able to create a digital model of the application, including the PCB traces and PCB-mounted terminal. This allowed for an accurate simulation of an actual working environment for the fuses. The simulation was run with multiple fuse designs, demonstrating how various designs would perform long term. This simulation service and support resulted in the customer confidently choosing Littelfuse as their supplier without reliability concerns with their overcurrent circuit protection.

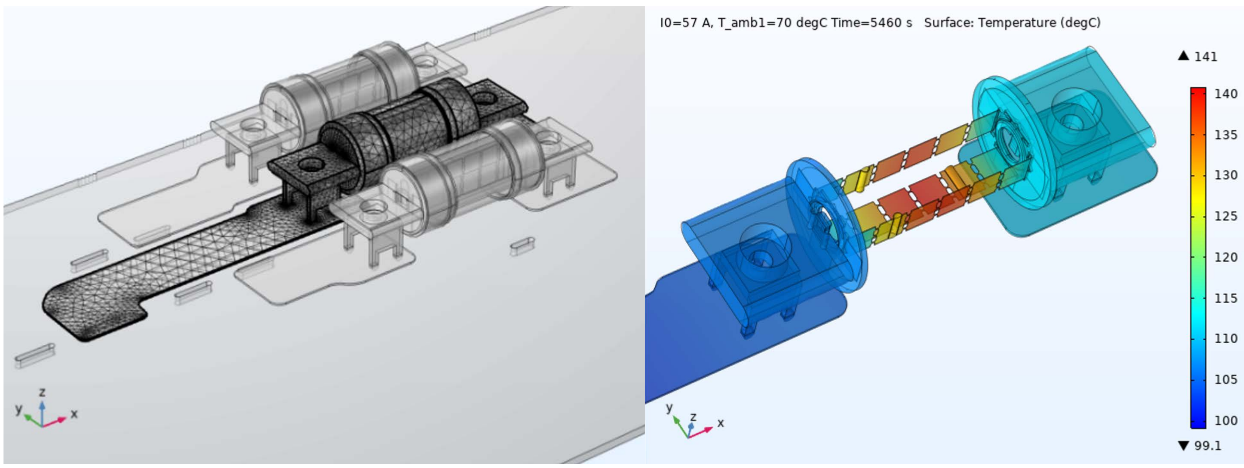


FIGURE 13. Simulation environment created with fuses.

Custom Product Engineering to Support OEMs – Case Study #3

An EV charging infrastructure OEM was requiring both ac and dc overcurrent protection for the ac/dc power modules inside a Direct Current Fast Charging (DCFC) system, but standard "off-the-shelf" solutions were too large and not able to support the customer's design for manufacturability (DFM) ambitions. To allow for a high-current fuse to be PCB-mountable, Littelfuse worked closely with the OEM's R&D team to incorporate a new attachment method requiring customized terminals. To support the customer's project, Littelfuse provided samples throughout the project, allowing them to ensure that the finished assembly would be feasible, efficient, and effective.

In addition to customizing terminals, Littelfuse was able to provide comprehensive application studies of the new components to demonstrate that the new assembly would be safe and acceptable within a liquid cooled design.

Thanks to the excellent communication and support between the customer and Littelfuse engineering, the customer has been able to realize their design ambitions and create a highly differentiated product for a competitive market.

FIGURE 14. Customized fuse for DCFC application.

5. Codes and Standards

Codes

National Electrical Code

NEC Article 625 Electric Vehicle Charging and Supply Equipment Systems

Standards

International Electrotechnical Commission

IEC 61851-1 – Electric Vehicle Conductive Charging System: General Requirements

IEC 61851-23 – Electric Vehicle Conductive Charging System: DC Electric Vehicle Supply Equipment

IEC 61851-24 – Electric Vehicle Conductive Charging System: Digital Communication between a DC EV Supply Equipment and an Electric Vehicle for Control of DC Charging

I**EC 62196** – Plugs, Socket-outlets, Vehicle Connectors and Vehicle Inlets – Conductive Charging of Electric Vehicles

IEC 60269-1 – Low-Voltage Fuse: General Requirements

IEC 60296-4 – Low-Voltage Fuses: Supplementary Requirements for Fuse-links for the Protection of Semiconductor Devices

International Organization for Standardization

ISO 17409:2020 – Electrically Propelled Road Vehicles, Conductive Power Transfer – Safety Requirements

Underwriters Laboratory

UL 2202 – DC Charging Equipment for Electric Vehicles

UL 248-1 – Low-Voltage Fuses – Part 1: General Requirements

UL 248-13 – Low-Voltage Fuses – Part 13: Semiconductor Fuses

Canadian Standards Association

CSA C22.2 - DC Charging Equipment for Electric Vehicles

China National Standards

GB/T 20234.3 – Conductive Charging of Electric Vehicle: DC Charging Coupler

CHAdeMO

CHAdeMO – Fast Charging System for Battery Electric Vehicles

6. Additional Resources

EV Charger Protective Devices

Fuses

- L60QS 10x38mm Cylindrical Fuses
- Class T Fuses
- Energy Storage Rack (ESR) Fuses
- High-Speed Semiconductor Fuses
- Surface Mount Fuses

Other Modes of Protection

- Arc-Flash Detection
- Surge Protective Devices (SPDs)
- Ground-Fault Protection
- Residual Current Monitors

Other EV Charger Products

- Dc Disconnect Switches
- Surface-Mount TVS Diodes
- Temperature Sensors

EV Charger Informational Resources

- POWR-SPEED High Speed Fuses **Application Guide**
- Fuse Fundamentals **Application Guide**
- Solutions for EV Charging Systems **SlideShare**
- Automotive Electronics **Application Guide**
- Supercharged Solutions for EV Charging
- Arc-Flash **Knowledge Center**
- Ground-Fault **Knowledge Center**

With nearly 100 years of experience in electrical components, Littelfuse is always happy to help. Speak with one of our experts directly.

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