
Overcurrent Protection

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INTRODUCTION

An overcurrent event on a synchronous generator set occurs any time the load demands more current than the nameplate rating of the generator set. The overcurrent can be caused by the starting of a large motor, the inrush associated with the charging of a transformer, a short circuit or any other number of events. Overcurrent events may be unavoidable, however, the duration of the event must be controlled to avoid damage to the generator set or other equipment. Standards or requirements vary by region and dictate the required protections for generator sets and conductors from overcurrent events, and should be referenced for site-specific requirements.

Caterpillar provides multiple options to assist our customers with meeting these requirements, along with additional provisions for Cat® EMCP generator set controls to assist in protecting the customer's asset.

The Cat EMCP 4 generator set controls have enhanced overcurrent detection algorithms that allow the user to configure how much overcurrent is allowed on a time-based approach before triggering an overcurrent event. These additional algorithm functions can be used in conjunction with the existing overcurrent protections to generate an event at any time. The enhanced overcurrent algorithm is provided with adjustable settings to enable site-specific integration.

GENERATOR SET OVERCURRENT

Before reviewing the protections, how a generator set reacts to an overcurrent event should be understood. In the instant in which an overcurrent event occurs, the generator set will provide the maximum current available from the alternator. In this instant, the current is uncontrolled by the generator set control systems and is limited by the inherent magnetics of the system.

During the first six cycles following the event, the generator set is limited by sub-transient reactance and excitation generated from the voltage regulator. Generator sets with voltage regulators that receive power from the output of the generator set (Self Excited, SE) will reduce the current quickly, while generator sets with an external source for power (Permanent Magnet, PM or Internally Excited, IE) will reduce the current at a slower rate as displayed in Figure 1.

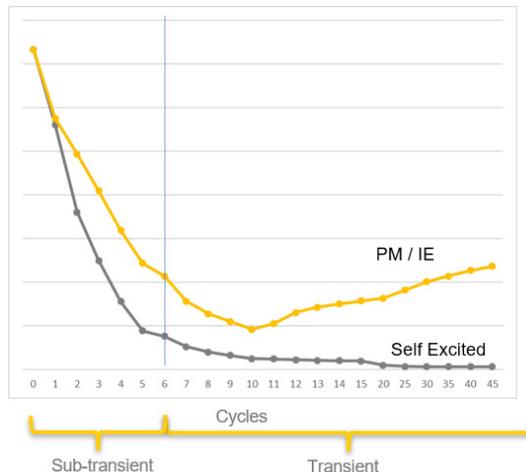


Figure 1: Generator Set Current Decrement Curves

Following the first six cycles of the overcurrent through the first five seconds, the generator set's current will be based on transient reactance and the excitation current from the voltage regulator. During this period, the SE regulators will not be able to source enough current to continue to excite the generator set and the current will continue to reduce toward zero.

The PM/IE voltage-regulator-driven generator sets will begin to recover from the initial load demand and will begin to max source current from the voltage regulator. The total available current through the transient and synchronous phases of the overcurrent event will be determined by the reactance of the generator set and the available excitation current from the voltage regulator.

IVR EXCITATION MODULE OVER-EXCITATION PROTECTION

To assist in protecting the generator set from the overcurrent event, the Cat Integrated Voltage Regulator (IVR) Excitation Module employs a built-in over-excitation protection. This protection strategy, illustrated in Figure 2, provides a continuous excitation current well below the upper limit under normal conditions.

In the event of an overcurrent condition, the excitation current will increase rapidly, known as “field forcing.” The Excitation Module will limit the field forcing current to the defined upper limit within the design guidelines outlined for the Cat generator set, typically 300 percent of rated current for a fixed period of 10 seconds.

After the fixed delay time has expired, the Excitation Module will “limit” the excitation current to a safer level that is 10 percent of the upper limit. By using over-excitation protection, Caterpillar provides the customer with the necessary overcurrent capabilities required to support the load and site fault protection coordination, while protecting the customer’s investment in the generator set.

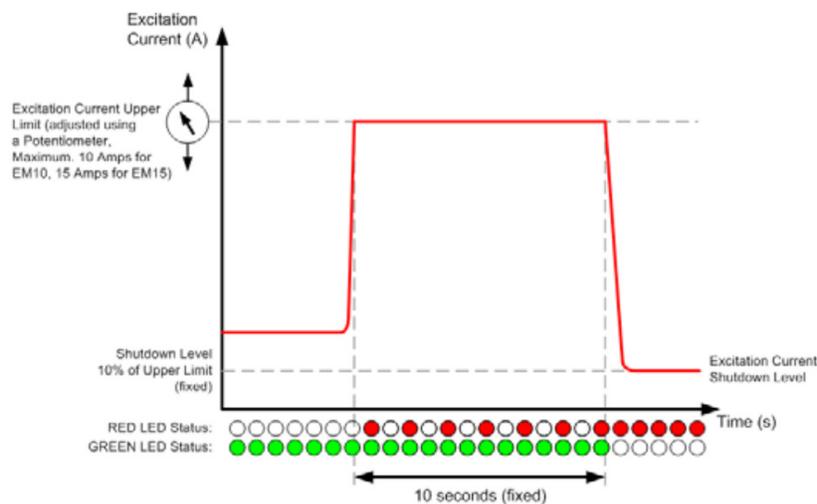


Figure 2: Over-excitation Protection

CAT® EMCP 4 OVERCURRENT PROTECTION

In addition to over-excitation, the Cat EMCP 4 enables customers to utilize adjustable definite time protection, along with inverse time curves or generator set thermal damage curve trip settings, to integrate with the customer’s overall site level protective coordination.

The inverse time curves provide customers with a slow-to-trip at low current feature and a fast-to-trip at high current feature, while the definite time protection provides a generally higher level of current for a shorter period to avoid tripping during load inrush, as displayed in Figure 3.

Utilizing the configurable settings for these values, the customer can develop custom levels of protection while being confident the generator set is operating within its capability.

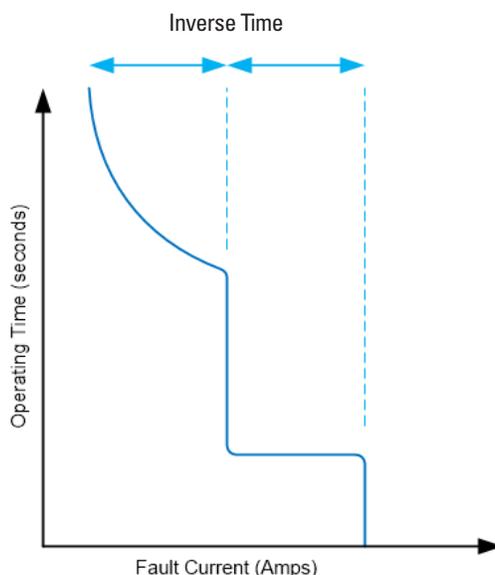


Figure 3: Overcurrent Coordination Curves

NEUTRAL GROUNDING RESISTOR

A neutral grounding resistor (NGR) is a power resistor that is connected between the neutral of a source and the system ground. An NGR may be implemented as part of a power system for several purposes, including aid in the identification of a fault. However, it is primarily used to limit currents present in a line to ground fault and prevent damage to the equipment.

While every site should be evaluated based on the unique site conditions, the protections described within this paper may be used to protect the customer's generator set without implementation of an NGR.

When utilizing the Cat protectives, the NGR would be an additional protective that can be used by a customer to increase the potential life of their generator set. As a general understanding, an overcurrent event increases the heat in the generator set and the neutral. Increasing the heat leads to reduction in the insulation life.

The overcurrent protections from Cat described in this white paper help to limit the damage and avoid a catastrophic failure; however, any overload of any amount can be seen as additional wear on the product. An NGR is a relatively low-cost option that can be recommended to limit the energy in order to help prolong the life of the product. Each site should be evaluated to determine if the addition of an NGR provides value to the customer. For any additional grounding considerations, consult applicable electrical codes and grounding standards.

CONCLUSION

The overcurrent protections available from Caterpillar provide customers with the necessary flexibility to integrate with their site protection scheme while still protecting the investment they have made in their generator set. For more information on these or other product capabilities [contact your local Cat dealer for support](#).

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