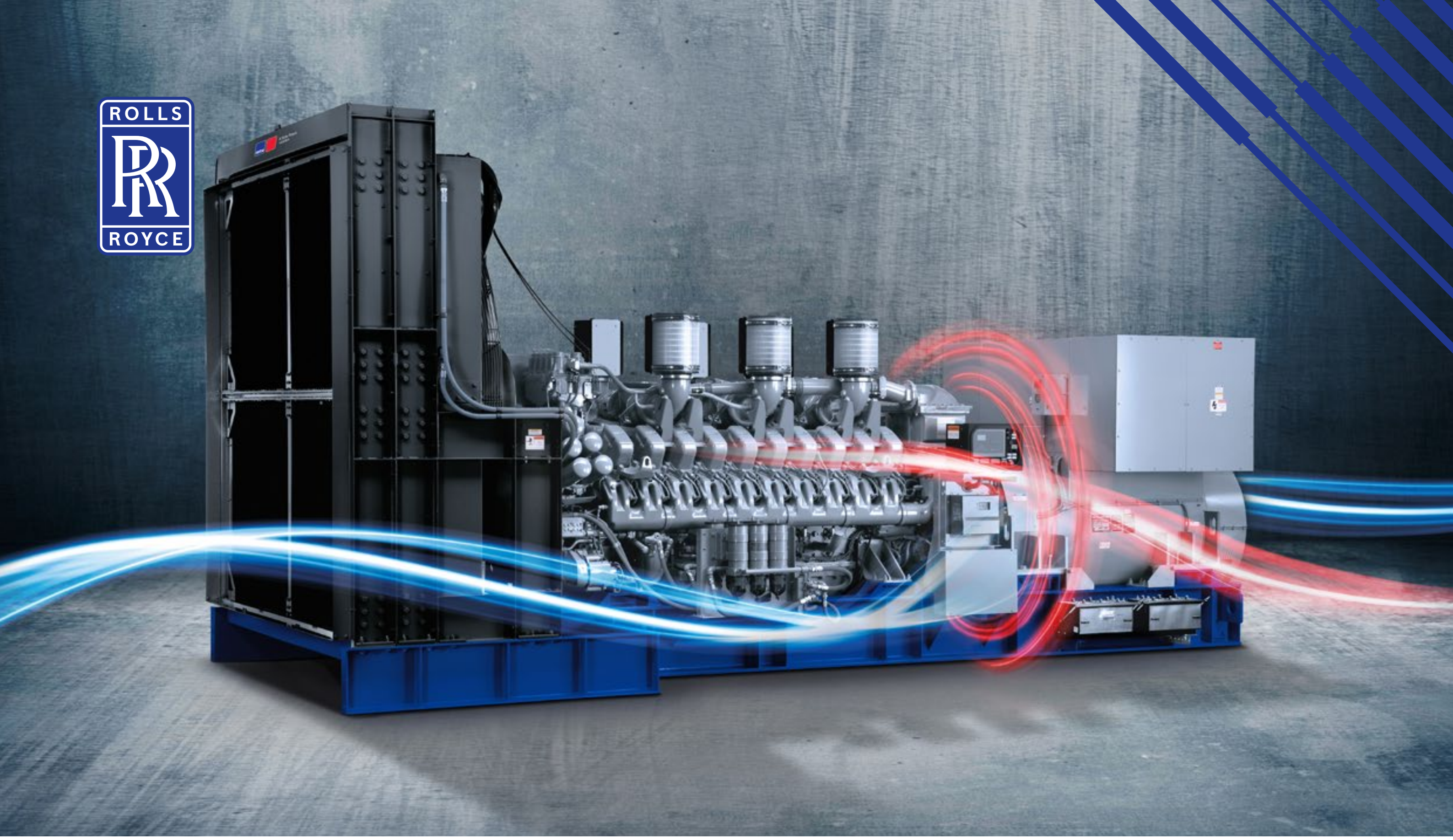

Power Generation

OVERCURRENT PROTECTION FROM GENERATOR SET CONTROLLER

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Electrical power systems are rapidly increasing in complexity and the need for flexible controls solutions is more important than ever. Controls components and programming provide critical functionality and protections to ensure the powersystem operates in a safe and reliable manner. Safety requirements demand hardware and system architecture to protect against situations including overload and short circuit events, as well as thermal damage to the generator or downstream loads.

Safety

Prevention of human injury is one of the most important objectives of electrical system protection design. Protective devices must have adequate interrupting capability and energized parts shall be sufficiently enclosed or isolated so as not to expose personnel to explosion, fire, arcing or shock. Standards such as the National Electrical Code (NEC) drive minimum safety requirements for an

A Rolls-Royce solution

electrical installation. Manufacturers may implement various solutions to meet or exceed these standards including PLC controllers, generator controllers, circuit breakers, protective relays and means of electrical disconnect.

An overload event is a condition during which the ratings of power system components are exceeded for a period of time

MTU recommends circuit breakers connected between the generator and downstream loads as the default for overcurrent protection and electrical disconnecting means. In contrast, protective devices can be programmed to respond to overcurrent conditions by shutting down excitation to the generator and the engine. Utilizing protective relay methods may remove the overcurrent event but does not serve as a means for physically disconnecting the equipment from the power system. Furthermore, the overcurrent event may persist longer when relying on removal of generator excitation, compared to using a circuit breaker. This results from magnetic fields requiring time to decay and not being able to stop instantly.

Overload

Power systems are designed and constructed to provide a rated amount of electricity (amps, KVA, etc). All components in the system need to have ratings that match in order to properly coordinate and protect the system. An overload event is a condition during which the ratings of power system components are exceeded for a period of time. For example, too much load may be put on the electrical system causing more current than rated current to flow through the electrical bus. Overload events can cause damage to power system components if the event is allowed to persist for longer than the component's rating. Higher overload current magnitudes can cause damage faster than lower overload scenarios.

Circuit breakers are utilized in order to protect downstream conductors and loads from overcurrent situations. Circuit breakers trip open or break the electrical connection to the load when an overload event occurs. The trip timing, in other words how quickly this happens, can vary depending on the circuit breaker model and/or settings of the breaker's trip unit.

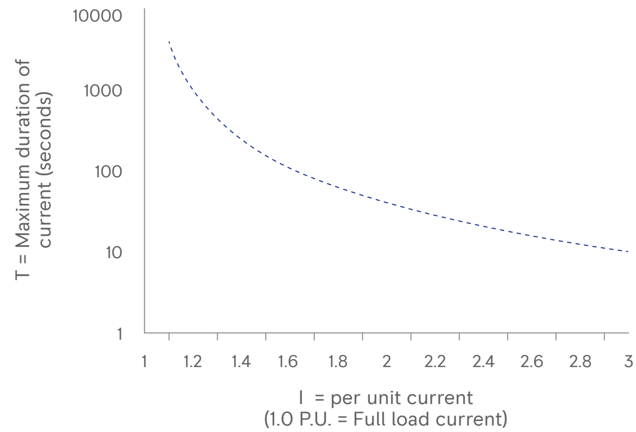
Thermal damage

Electrical insulation is a key component in power systems that must be protected in order to ensure proper operation. Heat is one of the main factors that can degrade and destroy electrical insulations. Standards, such as NEMA MG1, define classes of insulation systems that correlate to allowable temperature rise during operation of the equipment. MTU provides Class H insulation on both the main rotor and stator for low and medium voltage, which is the current industry standard.

Overloading a generator set for an extended period of time can cause excess heat in equipment. Long time settings in protective equipment can help prevent this type of insulation damage. One piece of information that is used for properly choosing these long time settings is a thermal damage curve. This type of curve defines allowable current a generator can produce with respect to time without damaging its insulation system.

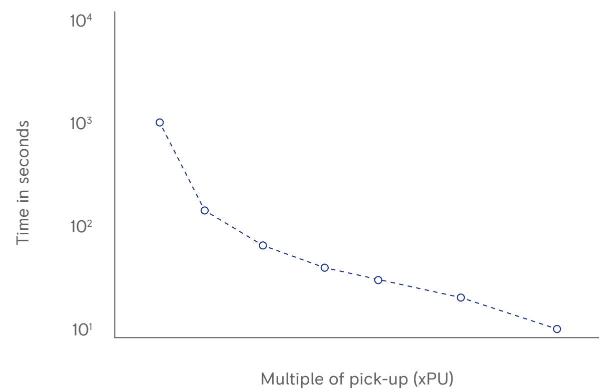
Typical thermal damage curve

Base is 3.0 P.U. current for 10 seconds from $T=40/(I-1)^2$
Windings at operating temperature



Time overcurrent characteristic curves

An example of an MGC overcurrent protection settings page

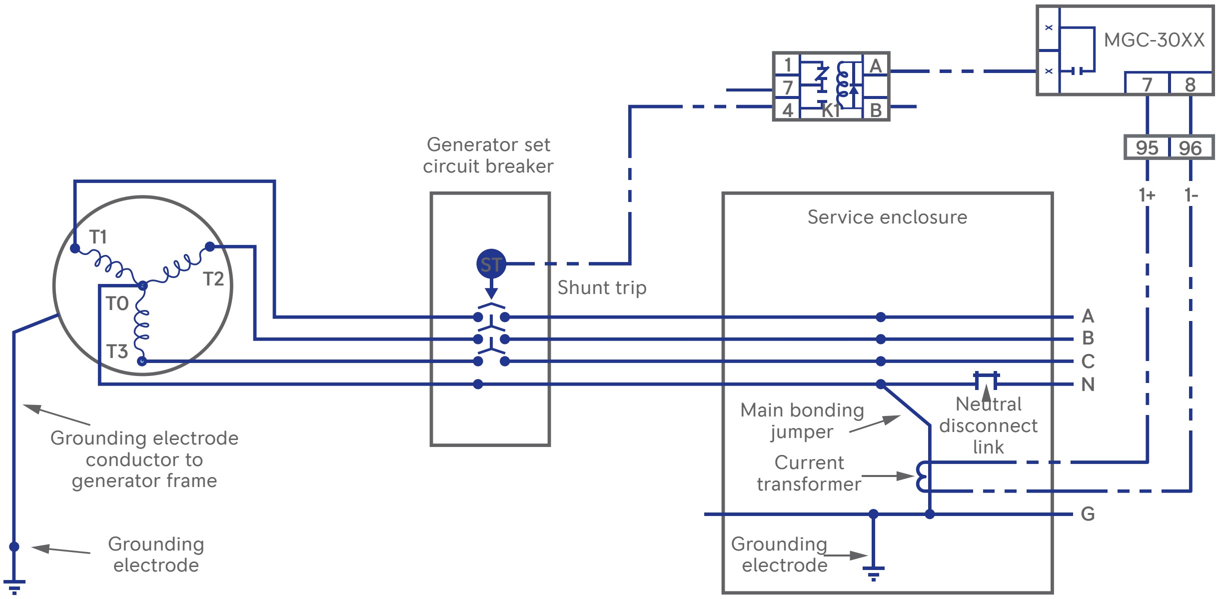


Generator set controllers can protect generator windings and leads to the line side of breakers. MTU Generator Controller (MGC) overcurrent settings can be adjusted to coordinate with generator thermal damage curves in order to limit the amount of overcurrent that can occur. The controller overcurrent protections can be set up to work in coordination with all protective elements in the system. Another potential cause of an overcurrent event is a short circuit due to misuse of equipment or insulation failure. During a short circuit, there is little to no resistance applied to the output terminals, which results in extremely high currents flowing that can quickly cause damage. Properly adjusted protective settings are critical and ensure equipment will be operated within its intended design limits. These efforts ultimately ensure safe and reliable power system operation.

Ground fault protection

A ground fault occurs when electricity flows through some path other than the intended load and through the ground in order to get back to the generator. Such an event can cause equipment damage and/or personal harm. NFPA 70, National Electric Code (NEC) 215.10 specifies that each feeder disconnect rated 1,000 amperes or more and installed on solidly grounded wye electrical systems of more than 150 volts to ground, but not exceeding 1,000 volts phase-to-phase, shall be provided with ground fault protection of equipment in accordance with the provisions of NEC 230.95. NEC 230.95(C) specifies

Residual equipment ground fault protection system



performance testing of the ground fault protection system when first installed onsite. In certain installations, such as emergency systems (NEC Article 700) and legally required standby systems (NEC Article 701), indication of ground fault conditions is required.

Historically, ground fault trip and/or indication protections were provided by the circuit breaker components. A recent market trend has been to use the generator set controller to handle ground fault protection. The Residual Equipment Ground Fault Protection System detects any stray electrical current flowing from the ground back into the neutral of the generator and will trigger an indication at the generator set controller and/or trip of the circuit breaker via a shunt trip accessory. For more details, refer to MTU's *Ground Fault Protection Systems Service Installation Guide*.

This form of ground fault protection does not provide differentiation of the location a ground fault occurred on generator sets with multiple circuit breakers or multiple generator sets in parallel. If the specific location of a ground fault location is to be determined, a custom controls protection solution is required. For custom solutions, please contact your local MTU distributor.

Conclusion

Safe and reliable power systems are a requirement in mission critical facilities. The controls and accessory equipment provide key functions in keeping equipment online and personnel safe. Several aspects were presented in order to provide an overview of common situations that can be prevented or avoided with proper electrical design accommodations including overloads, thermal damage and ground fault events. Circuit breakers used in combination with an MTU Generator Controller are recommended to protect the electrical equipment in the power system from these potential damaging events.

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