Grid Solutions

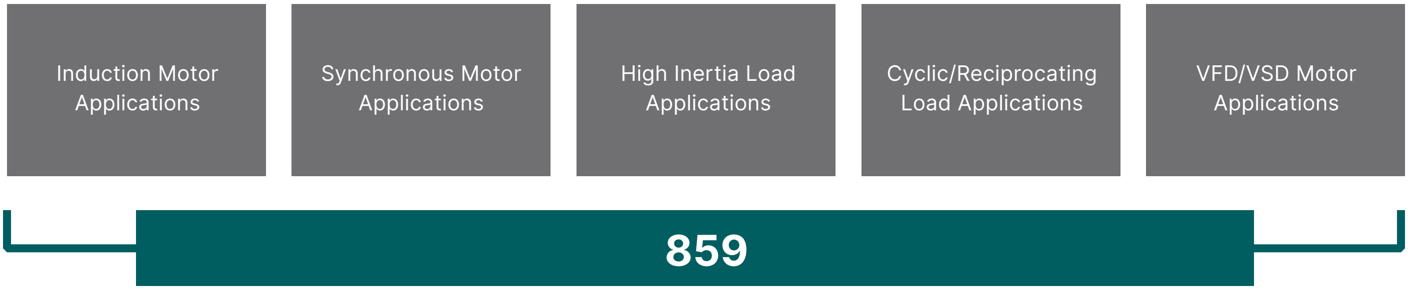
Application Note

859 ADVANCED MOTOR PROTECTION

A Comprehensive Protection Solution for Standard and Special Purpose Motor Applications

8 Series Mini Paper

GE VERNOVA



Thermal Model

The 859 offers a complete overload protection solution with its Thermal Model element to protect the motor from stator and rotor overheating. Proven by over 25 years of use in the GE Vernova Multilin 469 motor protection relay, thermal model is now enhanced and able to protect a wide range of motor applications. The main features of the 859 Thermal Model are:

- **Flexibility** – The 859 thermal model is more flexible by selecting the appropriate overload curve that matches the thermal limit of the motor in one of the three available formats: Standard Motor Curves, IEC Curves and Custom Curves (FlexCurves). An example of thermal overload "Standard" curve is shown in the figure below.
- **Simplicity** – The 859 thermal model is simple because it doesn't require motor equivalent circuit parameters and therefore is easy to configure from the motor nameplate information.
- **Adaptivity** – The Voltage Dependent (VD) overload curve feature in the model is adaptive to overload conditions during starting, acceleration, deceleration, locked rotor and starting input voltage level. The Figure below shows the VD curves for 80% and 100% of rated voltage motor starting.
- **Accuracy** – thermal model has improved accuracy due to enhanced signal processing in calculating RMS, 2-stage filtering and averaging the RMS to eliminate any oscillations. RMS currents are used in the thermal model to calculate extra heating due to harmonics in the motor input signals.
- **Security** – The thermal model biased to ensure secure operation by calculating exact replica of the motor heating in the presence of negative sequence currents, higher harmonics etc. Additionally, the thermal model is biased by the RTD's temperature that allows the 859 to protect the motor against unusual high ambient temperatures or abnormal heating.

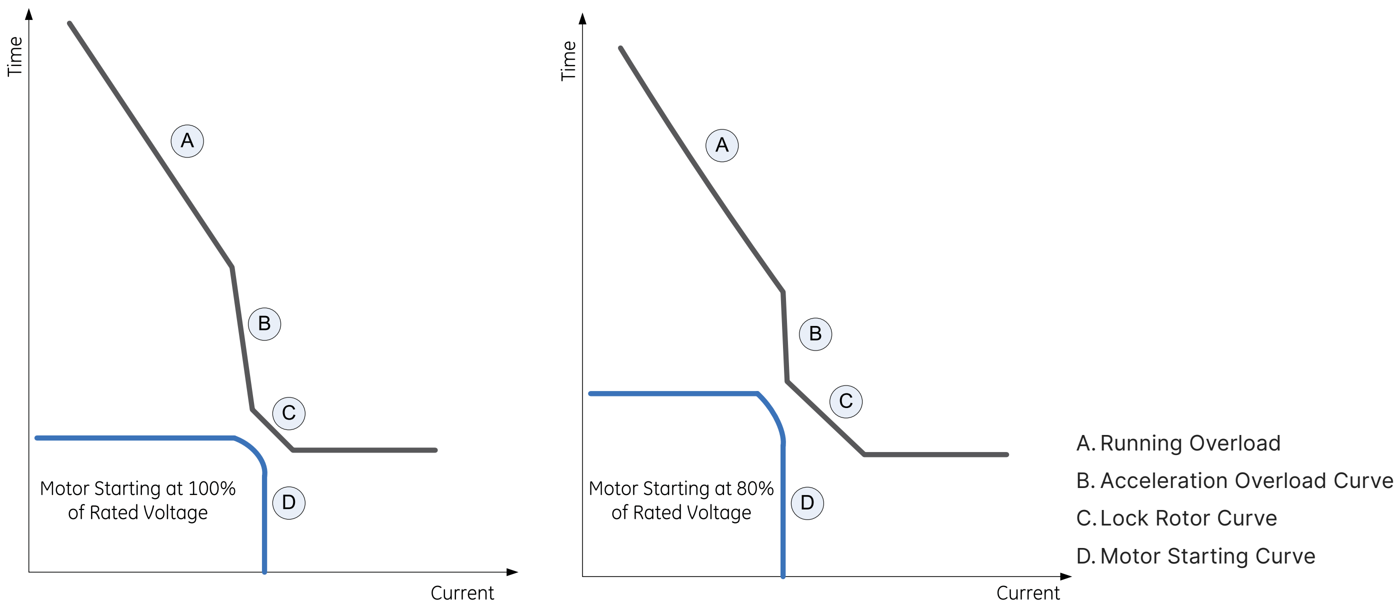


Figure 1: Voltage Dependent Overload Curves

Figure 1 illustrates the automatic switching between the 80% and 100% overload curves when motor is started with 80% and 100% of the rated voltage. This automatic switching between the curves is achieved by using the Voltage Dependent feature in thermal model.

A Voltage Dependent overload curve consists of three distinct segments, which are based on the three running conditions of the motor: the locked rotor or stall condition, motor acceleration and motor running in overload. A trip occurs when the thermal capacity (TCU) reaches 100%. When stopped, the motor can be started, if TCU decays to the allowable starting TCU level or an emergency restart is activated via an input.

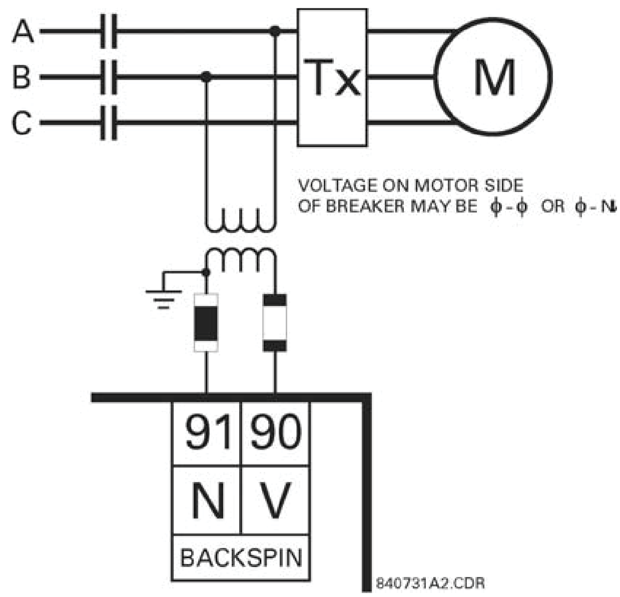
Backspin Protection

Backspin protection is typically used on down hole pump motors which can be located several kilometers underground. Check valves are often used to prevent flow reversal when the pump stops. Very often however, the flow reverses due to faulty or non existent check valves, causing the pump impeller to rotate the motor in the reverse direction. Starting the motor during this period of reverse rotation (back-spinning) may result in motor damage. Backspin detection ensures that the motor can only be started when the motor has slowed to within acceptable limits. Without backspin detection a long time delay had to be used as a start permissive to ensure the motor had slowed to a safe speed.

Immediately after the motor is stopped, backspin detection commences, and a backspin start inhibit is activated to prevent the motor from being restarted. The motor could only be started if the measured frequency is below the minimum permissible frequency. In case of the voltage loss prior to reaching the minimum permissible frequency, the inhibit remains active until the prediction time has expired.

Backspin Voltage Inputs

The Backspin detection requires measurement of the voltage to sense the backspin frequency. 859 provides specially design backspin voltage inputs that can sense frequency range of 1Hz to 120Hz from the voltage input signal as low as 20mV upto 480V. This specially designed inputs allow the 859 relay to sense whether the motor is spinning after the primary power has been removed. The voltage inputs must be supplied by a separate VT mounted downstream (motor side) of the breaker or contactor.



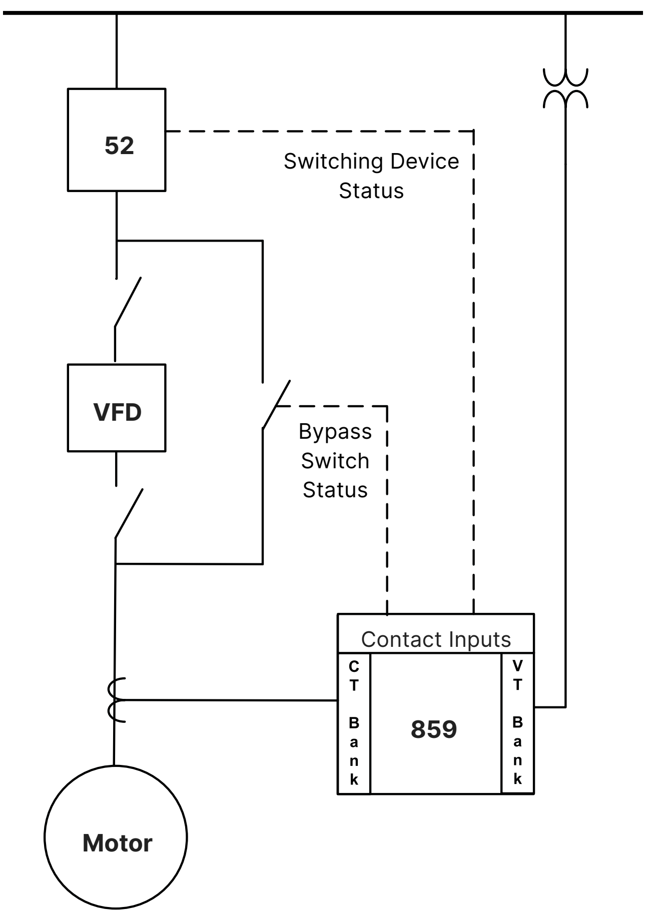
Variable Frequency Drive Motor Applications

Variable frequency drives (VFD) generate a significant distortion in motor input signals.

The 859 protection relay is enhanced to ensure secure operation of the relay due to distorted motor ac signals and online switching to/from the VFD using a bypass switch while maintaining the high sensitivity to the abnormal system/motor conditions.

Main features of the 859 VFD function are:

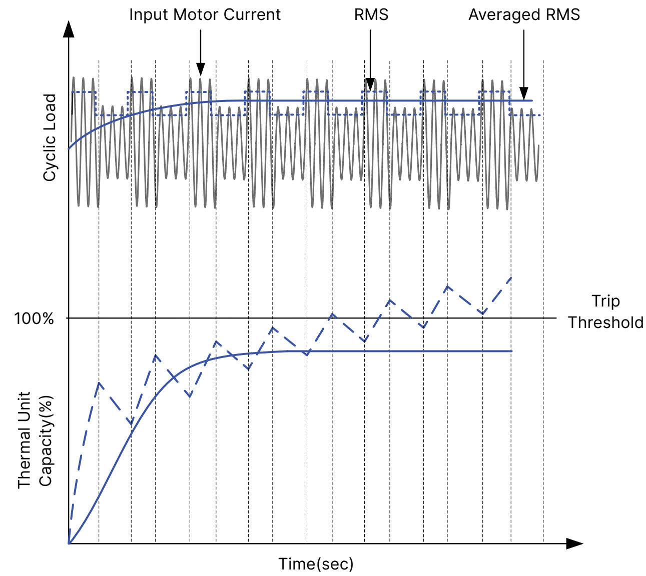
- Accurate tracking of the system frequency in the range of 3-72Hz and accurate phasor estimation over this range
- Additional filtering of the distorted input signals to achieve secure operation of the relay, while maintain the sensitivity to phase-phase and ground faults using short circuit, ground fault and differential protection.
- Ensuring thermal model accuracy by taking into account the extra heating generated by the higher harmonics due to VFD in order to achieve accurate response to the actual motor heating
- Making motor protection functions adaptive to the starting frequency on motor start and keep accurate tracking of the varying frequency during motor acceleration and deceleration



Cyclic Or Reciprocating Load Applications

The Input currents of a motor driving a cyclic load can vary from very low to above the maximum allowable current during a duty load cycle. To cope with this the 859 is adaptive to adjust to such continuously changing load current in order to get proper operation of the protection functions including thermal protection.

To better illustrate the behavior of thermal model for a cyclic load motor application, the following figure shows the calculation of thermal capacity based on the typical approach and 859 thermal overload method. The advanced 859 thermal model ensures more secure relay operation for the reciprocating or cyclic load motor applications with a number of poles between 2 to 64 poles.



Calculation of thermal capacity using:

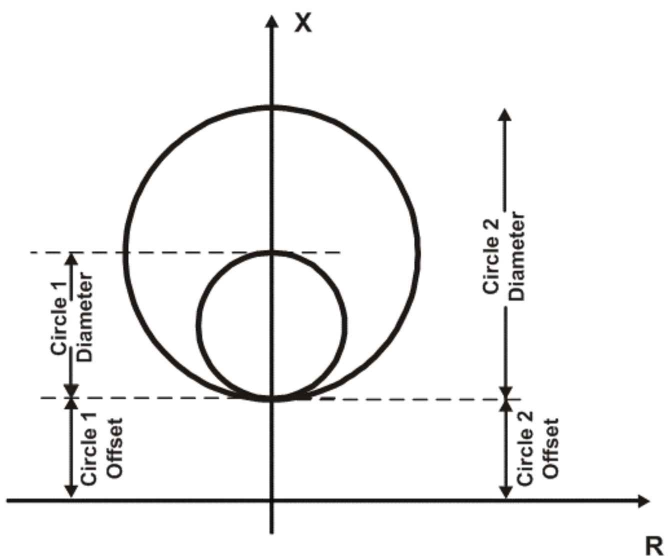
- – – Convetional thermal overload protection: Wrong Operation
- —— GE Vernova 859 thermal model: Desired Operation

Synchronous Motor Applications

859 provides functions essential to protect the synchronous motor during asynchronous operation while startup, during normal and overload operations and under fault conditions. In addition to stator protection and control, it provides protection and monitoring of exciting rotor during pull-out or loss of synchronism condition with elements like Out-of-Step, Loss-of-Field, Reactive Power, and Power Factor.

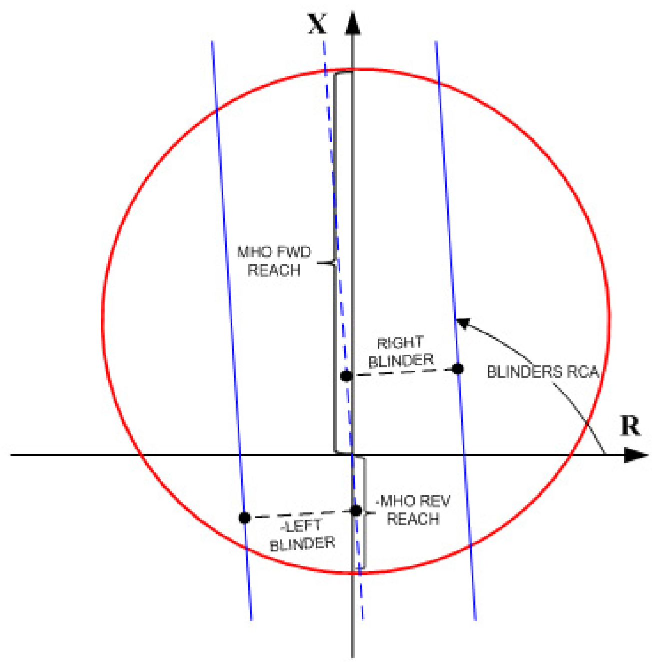
Loss-of-Excitation Protection

Complete or partial loss of excitation to the synchronous rotor can occur due to various abnormal conditions, such as field circuit open or short, loss of supply to the excitation system, or unintentional trip of a field breaker and so on. Due to loss of excitation, the synchronous machine may act as an induction machine, which may cause the machine to over-speed (above synchronous speed) and draw reactive power (Var) from the system. Therefore, Loss of Excitation (LOE) protection is applied to protect synchronous machines from over-speeding, as well as to recover systems from voltage collapse.



Out-of-Step Protection

The Out-of-step element provides an out-of-step (loss-of-synchronism or pole slip) tripping function for motors. The element measures the positive-sequence apparent impedance and traces its locus with respect to a single blinder operating characteristic with an offset mho supervisory. The purpose of the supervisory mho is to permit tripping for swings that pass through the motor and a limited portion of the system but to prevent operation on stable swings that pass through both blinders and outside the mho characteristic.

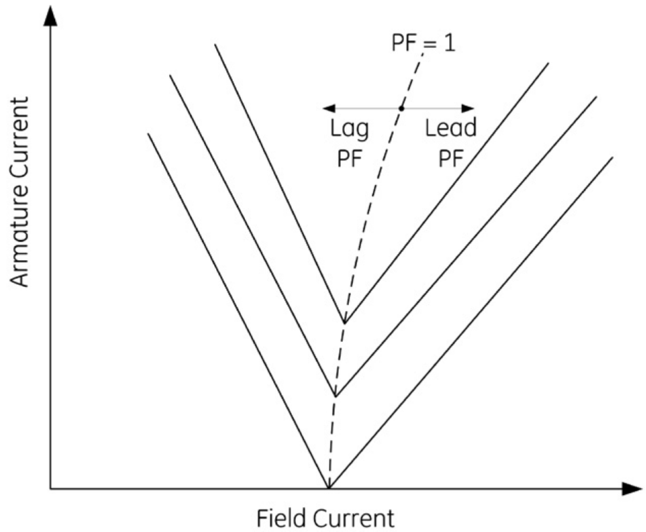


Reactive Power

In a synchronous motor application, the reactive power element can be used to detect excitation system malfunction, e.g. under excitation, loss of excitation, etc. Once the 3-phase total reactive power exceeds the positive or negative level, for the specified delay, a trip or alarm occurs indicating a positive or negative kvar condition

Power Factor

When 859 is applied to a synchronous machine; it is desirable not to trip or alarm on power factor until the field has been applied. Therefore, this feature can be blocked until the machine comes up to speed and the field is applied. From that point forward, the power factor trip and alarm elements will be active. Once the power factor is less than either the Lead or Lag level, for the specified delay, a trip or alarm will occur indicating a Lead or Lag condition. The power factor alarm can be used to detect loss of excitation and out of step.



For more information, visit
gevernova.com/grid-solutions

GE VERNOVA

GEA-33204
English
251010